UL 1581

STANDARD FOR SAFETY

Reference Standard for Electrical Wires, Cables, and Flexible Cords

UL Standard for Safety for Reference Standard for Electrical Wires, Cables, and Flexible Cords, UL 1581

Fourth Edition, Dated October 31, 2001

Summary of Topics:

This revision to ANSI/UL 1581 dated November 29, 2023 includes revision to update outside references; 10.2, 10.3, Table 10.1, Table 50.133, Table 50.135, Table 50.136, 480.9, and 1090.1.

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

The new and revised requirements are substantially in accordance with Proposal(s) on this subject dated August 25, 2023.

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UL 1581

Reference Standard for Electrical Wires, Cables, and Flexible Cords

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This ANSI/UL Standard for Safety consists of the Fourth Edition including revisions through November 29, 2023.

The most recent designation of ANSI/UL 1581 as an American National Standard (ANSI) occurred on November 29, 2023. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

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

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INTRODUCTION

1 Scope

1.1 This standard contains specific details of the conductors, of the insulation, of the jackets and other coverings, and of the methods of sample preparation, of specimen selection and conditioning, and of measurement and calculation that are required in wire and cable standards.

1.2 The requirements for the particular materials, construction, performance, and marking of an individual type of wire, cable, or flexible cord are stated in the standard covering the finished type. They are not part of this reference standard.

1.3 In each case in which an element of this standard does not apply, the standard covering the finished type so states and specifies what does apply.

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 metric system. Equivalent – although not exactly identical – results are to be expected from applying a requirement in inch/pound or metric units. Equipment calibrated in metric units is to be used when a requirement is stated in metric terms.

3 References and Terms

3.1 The term "wire standard" as used in this standard means any standard that covers finished electrical wires, cables, or flexible cords and in which reference is made to this reference standard (UL 1581).

4 thru 9 *Reserved for Future Use*

CONDUCTORS

10 Requirements for Aluminum Conductors of an 8000 Series Alloy

10.1 These requirements cover aluminum wire in annealed and intermediate tempers using 8000 series electrical-conductor-grade aluminum alloys. These alloys are for use in solid conductors in the 6 – 4/0 AWG sizes and in round-strand and compressed- and compact-stranded conductors in the 12 AWG – 2000 kcmil sizes.

10.2 The wire shall be of a registered 8000 series electrical-conductor-grade aluminum alloy complying with ASTM B 800. The conductor diameter and cross-sectional area shall comply with Conductor Diameter and Cross-Sectional Area, Section 20. The d-c resistance of the conductors shall comply with D-C Conductor Resistance, Section 30.

10.3 The temper of the wire of the finished conductor shall be annealed (-0) or intermediate (-H1X) or (-H2X). The tensile strength and elongation (see note b to Table 10.1) of the finished stranded conductor tested as a unit or of the individual strands removed from the finished conductor or of the finished solid conductor shall comply with Table 10.1 when specimens are tested at a speed of 1 in/min or 25 mm/min using the equipment and procedure described in ASTM B 557.

Table 10.1
Mechanical properties[a] of solid and stranded conductors of an 8000 series aluminum alloy

Temper	Tensile strength	Elongation[b] in 10 inches or 250 mm
Annealed (-0)	All specimens: 11,250 ±2,750 lbf/in^2 or 78 ±19 MPa	Solid conductor: 10.0 percent minimum Stranded conductor: 10.0 percent minimum
Semi-annealed: (-H1X) and (-H2X)	Wires (strands) removed from the finished stranded conductor: 18,675 ±4,425 lbf/in^2 or 129 ±30 MPa	Solid conductor: 10.0 percent minimum Stranded conductor: 10.0 percent minimum
	All other specimens: 18,500 ±3,500 lbf/in^2 or 128 ±24 MPa	Solid conductor: 10.0 percent minimum Stranded conductor: 10.0 percent minimum

[a] For the purpose of determining compliance with the tabulated limits, test results are to be rounded as follows after specimens are tested at a speed of 1 in/min or 25 mm/min using the equipment and procedure described in ASTM B 557:
1) Each calculated value of tensile strength is to be rounded to the nearest 100 lbf/in^2 or 1 MPa.
2) Each value of elongation is to be rounded to the nearest 0.5 percent as described in the rounding method in ASTM E 29.

[b] Compliance with the elongation requirement for stranded conductors is to be determined on wires taken prior to stranding into conductors, on wires taken from a stranded conductor, or on the stranded conductor as a whole.

11 Requirements for Copper-Clad Aluminum Conductors

11.1 The requirements in this section (11.1) cover copper-clad aluminum conductors. Copper-clad aluminum conductors shall be drawn from copper-clad aluminum rod. The copper shall be metallurgically bonded to the aluminum core, shall occupy 10 percent or more of the cross section of a solid conductor and of each wire (strand) of a stranded conductor, and shall be concentric with the aluminum. The thickness of the copper shall not be less than 2.56 percent of the diameter of the solid conductor or wire (strand) as determined by microscopic examination of a polished right cross section of the round strand or round solid conductor. The tensile strength of a finished copper-clad aluminum conductor tested as a unit or of the wires (strands) from a finished stranded copper-clad aluminum conductor and of a finished solid copper-clad aluminum conductor shall not exceed 20,000 lbf/in^2 or 138 MPa when specimens are tested at the speed and using the equipment and procedure indicated in ASTM B 566. The elongation of the same specimens shall not be less than 15 percent in 10 inches or 250 mm.

12 Requirements for Copper-Clad Aluminum Conductors Used in Building Wire

12.1 General

12.1.1 The requirements in this section cover finished, copper-clad aluminum conductors and the individual strands of a finished copper-clad aluminum conductor. Copper-clad aluminum conductors shall be drawn from copper-clad aluminum rod. Copper-clad aluminum strands shall be limited to sizes 0.02257 – 0.2043 in diameter (23 – 4 AWG).

12.1.2 The aluminum core shall be an AA8000 series alloy as described in Section 10. The elemental analysis of the aluminum core shall be determined in accordance with ASTM E227. The results of the elemental analysis on the aluminum core used shall meet the requirements for an AA 8000 series alloy as described in UL 44, Chemical composition of ACM, AA 8000 series aluminum alloy conductor materials.

12.1.3 The copper shall be high-conductivity, oxygen-free copper with an oxygen content not to exceed 0.001% meeting the requirements of ASTM B152. The copper shall be metallurgically bonded to the aluminum core as determined by the methods in 12.6 and 12.7. The copper shall occupy 10 percent or more by volume of the cross section of a solid conductor and of each wire (strand) of a stranded conductor as determined by the methods in 12.8. The thickness of the copper shall not be less than 4.0 percent of the radius of the solid conductor or wire (strand).

12.2 Tensile strength and elongation test

12.2.1 The tensile strength of a finished copper-clad aluminum conductor or of the wires (strands) from a finished stranded copper-clad aluminum conductor and of a finished solid copper-clad aluminum conductor shall not exceed 20,000 lbf/in^2 or 138 MPa. The elongation of the same specimens shall not be less than 15 percent. The tensile and elongation of a finished conductor or an individual strand shall be tested in accordance with the test, Physical properties of conductors (tensile strength, elongation at break, and ultimate strength) as described in UL 2556. The test shall be conducted at a speed of 12 in/min (305 mm/min), with 10 inches (254 mm) between the benchmarks.

12.3 DC resistance test

12.3.1 The DC resistance of the finished copper-clad aluminum conductor shall not exceed 0.026813 $\Omega \cdot mm^2/m$ when tested in accordance with the method, DC Resistance as described in UL 2556.

12.4 Density test

12.4.1 The density of the copper-clad aluminum shall be 3.32 g/cm^3 (0.1200 lb/in^3) nominal when the conductor material is tested using the method described in Annex B of UL 2556.

12.5 Diameter measurement

12.5.1 The diameter of the solid conductor or any individual strands from a stranded conductor shall meet the requirements in Table 20.1 when measured in accordance with the test Conductor Diameter as described in UL 2556.

12.6 Adhesion test

12.6.1 A specimen of finished copper-clad aluminum conductor shall be fixed in a vice or other securement means. The free end of the conductor shall be flexed back and forth thru 180 degrees using any suitable means until the conductor breaks. The fractured area (not including the clamped area) shall be examined for delamination using magnification of 10X. There shall be no delamination between the copper and the aluminum.

12.7 Cohesion test

12.7.1 A specimen of a single strand of finished copper-clad aluminum conductor shall be selected. The minimum length of the specimen shall be 15 times the diameter of wire under test, plus the length required to secure both ends of the specimen. For example, a 12 AWG solid conductor has a diameter of 0.0808 inches. This would require a length of 1.212 inches (15 X 0.080) between the securement means. The specimen shall be fixed in a clamp or other securement means twisted three complete turns in one direction, untwisted to the original position, twisted three turns in the opposite direction and finally returned to the original position.

If a longer length is needed to facilitate the testing, the number of twists for a given length of wire shall be calculated from the formula:

$$Number\ of\ twists = \frac{Length\ of\ wire\ between\ securement\ means,\ in\ inches}{5\ X\ OD\ of\ wire,\ in\ inches}$$

In no case shall the number of twists be less than three.

12.7.2 After completion of the twists, the specimen shall be examined for seams or splits in the copper using 10X magnification in the area between the securement means. There shall be no seams or splits in the copper.

12.8 Copper construction

12.8.1 The surface of wire shall be free from pits, slivers, exposed aluminum, or other imperfections when examined under normal vision.

12.8.2 Three specimens of copper-clad aluminum, each specimen located at least 10 feet from the previous specimen, shall be mounted (in a suitable material if needed) so that a polished, right cross section of the conductor can be obtained. The minimum thickness at any point (MinAAP) shall be located and measured. The diameter of the overall conductor (Dc) and the diameter of the aluminum core (Da) shall be each be measured at three locations and averaged. The three measurement locations shall be at the maximum diameter, the minimum diameter and at a location bisecting the maximum and minimum diameters. The measurements shall be made using a micrometer microscope with a resolution and accuracy of 0.001 mm (0.0001 in).

12.8.3 The ratio of copper with respect to the overall radius, Rca, shall not be less than 4% of the radius of the overall conductor, where

$$Rca = 100 \times \left(\frac{MinAAP}{Dc / 2}\right)$$

Where:

MinAAP is the minimum thickness of copper at any point when measured as described in 12.8.2

Dc is the average diameter of the overall conductor

12.8.4 The percent copper volume, %Cv shall be calculated using

$$\%Cv = 100 \times \left(\frac{Dc^2 - Da^2}{Dc^2}\right)$$

Where:

Dc is the average diameter of the overall conductor

Da is the average diameter of the aluminum core

The copper shall be 10 percent or more by volume of the cross section.

13 thru 19 *Reserved for Future Use*

20 Conductor Diameter and Cross-Sectional Area

Table 20.1
Conductor dimensions

Size of conductor	Diameter of solid conductor								Cross-sectional area of conductor					
	Nominal		Minimum[c]		Maximum[c]		Minimum[d]		Nominal		Minimum			
											0.98 × Nominal[a]		0.97 × Nominal[b]	
	mils	mm	mils (0.98 x nominal)	mm	mils (1.01 x nominal)	mm	mils (0.99 x nominal)	mm	cmil	mm^2	cmil	mm^2	cmil	mm^2
AWG														
56	0.49	0.0124	0.48	0.0122	0.495	0.0126	0.485	0.0123	0.240	0.000122	0.235	0.000119	–	–
55	0.55	0.0140	0.54	0.0137	0.556	0.0141	0.545	0.0138	0.302	0.000153	0.296	0.000150	–	–
54	0.62	0.0157	0.61	0.0154	0.63	0.0159	0.614	0.0156	0.384	0.000195	0.376	0.000191	–	–
53	0.70	0.0178	0.69	0.0174	0.71	0.0180	0.69	0.0176	0.490	0.000248	0.480	0.000243	–	–
52	0.78	0.0198	0.76	0.0194	0.79	0.0200	0.77	0.0196	0.608	0.000308	0.596	0.000302	–	–
51	0.88	0.0224	0.86	0.0219	0.89	0.0226	0.87	0.0221	0.774	0.000392	0.759	0.000384	–	–
50	0.99	0.0251	0.97	0.0246	1.00	0.0254	0.98	0.0249	0.980	0.000497	0.960	0.000487	–	–
49	1.11	0.0282	1.09	0.0276	1.12	0.0285	1.10	0.0279	1.23	0.000624	1.21	0.000611	–	–
48	1.24	0.0315	1.22	0.0309	1.25	0.0318	1.23	0.0312	1.54	0.000779	1.51	0.000765	–	–
47	1.40	0.0356	1.37	0.0348	1.41	0.0359	1.39	0.0352	1.96	0.000993	1.92	0.000973	–	–
46	1.57	0.0399	1.54	0.0391	1.59	0.0403	1.55	0.0395	2.46	0.00125	2.41	0.00122	–	–
45	1.76	0.0447	1.73	0.0438	1.78	0.0452	1.74	0.0443	3.10	0.00157	3.04	0.00154	–	–
44	2.0	0.051	1.96	0.050	2.02	0.0513	1.98	0.050	4.00	0.00203	3.92	0.00199	–	–
43	2.2	0.056	2.16	0.055	2.22	0.0564	2.18	0.055	4.84	0.00245	4.74	0.00240	–	–
42	2.5	0.064	2.45	0.062	2.53	0.0641	2.48	0.063	6.25	0.00317	6.13	0.00310	–	–
AWG														
41	2.8	0.071	2.7	0.070	2.83	0.072	2.77	0.070	7.84	0.00397	7.68	0.00389	–	–

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Table 20.1 Continued

Size of conductor	Diameter of solid conductor								Cross-sectional area of conductor					
	Nominal		Minimum[c]		Maximum[c]		Minimum[d]		Nominal		Minimum			
											0.98 × Nominal[a]		0.97 × Nominal[b]	
	mils	mm	mils (0.98 x nominal)	mm	mils (1.01 x nominal)	mm	mils (0.99 x nominal)	mm	cmil	mm^2	cmil	mm^2	cmil	mm^2
40	3.1	0.079	3.0	0.077	3.13	0.080	3.07	0.078	9.61	0.00487	9.42	0.00477	–	–
39	3.5	0.089	3.4	0.087	3.54	0.090	3.47	0.088	12.2	0.00621	12.0	0.00606	–	–
38	4.0	0.102	3.9	0.100	4.04	0.103	3.96	0.101	16.0	0.00811	15.7	0.00795	–	–
37	4.5	0.144	4.4	0.112	4.55	0.115	4.46	0.113	20.2	0.0103	19.8	0.0100	–	–
36	5.0	0.127	4.9	0.125	5.05	0.128	4.95	0.126	25.0	0.0127	24.5	0.0124	–	–
35	5.6	0.142	5.5	0.139	5.7	0.144	5.5	0.141	31.4	0.0159	30.8	0.0156	–	–
34	6.3	0.160	6.2	0.157	6.4	0.162	6.2	0.158	39.7	0.0201	38.9	0.0197	–	–
33	7.1	0.180	7.0	0.177	7.2	0.182	7.0	0.179	50.4	0.0255	49.4	0.0250	–	–
32	8.0	0.203	7.8	0.199	8.1	0.205	7.9	0.201	64.0	0.0324	62.7	0.0318	–	–
31	8.9	0.226	8.7	0.222	9.0	0.228	8.8	0.224	79.2	0.0401	77.6	0.0393	–	–
30	10.0	0.254	9.8	0.249	10.1	0.257	9.9	0.251	100	0.0507	98	0.0497	–	–
29	11.3	0.287	11.1	0.282	11.4	0.290	11.2	0.284	128	0.0647	125	0.0633	–	–
28	12.6	0.320	12.3	0.312	12.7	0.323	12.5	0.318	159	0.0804	156	0.0790	–	–
27	14.2	0.361	13.9	0.353	14.3	0.363	14.1	0.358	202	0.102	198	0.100	–	–
26	15.9	0.404	15.6	0.396	16.1	0.409	15.7	0.399	253	0.128	248	0.126	–	–
25	17.9	0.455	17.5	0.444	18.1	0.460	17.7	0.450	320	0.162	314	0.159	–	–
24	20.1	0.511	19.7	0.500	20.3	0.516	19.9	0.506	404	0.205	396	0.201	392	0.199
23	22.6	0.574	22.1	0.561	22.8	0.579	22.4	0.568	511	0.259	501	0.254	496	0.251

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Table 20.1 Continued

Size of conductor	Diameter of solid conductor								Cross-sectional area of conductor					
									Nominal		Minimum			
	Nominal		Minimum[c]		Maximum[c]		Minimum[d]				0.98 × Nominal[a]		0.97 × Nominal[b]	
	mils	mm	mils (0.98 x nominal)	mm	mils (1.01 x nominal)	mm	mils (0.99 x nominal)	mm	cmil	mm^2	cmil	mm^2	cmil	mm^2
22	25.3	0.643	24.8	0.630	25.6	0.650	25.0	0.635	640	0.324	627	0.318	621	0.314
21	28.5	0.724	27.9	0.709	28.8	0.732	28.2	0.717	812	0.412	796	0.404	788	0.400
20	32.0	0.813	31.4	0.798	32.3	0.820	31.7	0.805	1020	0.519	1000	0.509	989	0.503
19	35.9	0.912	35.2	0.894	36.3	0.922	35.5	0.902	1290	0.653	1264	0.641	1251	0.633
18	40.3	1.02	39.5	1.00	40.7	1.03	39.9	1.01	1620	0.823	1588	0.807	1571	0.798
17	45.3	1.15	44.4	1.13	45.8	1.16	44.8	1.14	2050	1.04	2009	1.02	1989	1.01
16	50.8	1.29	49.8	1.26	51.3	1.30	50.3	1.28	2580	1.31	2528	1.28	2503	1.27
15	57.1	1.45	56.0	1.42	57.7	1.47	56.5	1.44	3260	1.65	3195	1.62	3162	1.60
14	64.1	1.63	62.8	1.60	64.7	1.64	63.5	1.61	4110	2.08	4028	2.04	3987	2.02
13	72.0	1.83	70.6	1.79	72.7	1.85	71.3	1.81	5180	2.63	5076	2.58	5025	2.55
12	80.8	2.05	79.2	2.01	81.6	2.07	80.0	2.03	6530	3.31	6399	3.24	6334	3.21
11	90.7	2.30	88.9	2.26	91.6	2.33	89.8	2.28	8230	4.17	8065	4.09	7983	4.04
AWG														
10	101.9	2.588	99.9	2.537	102.9	2.614	100.9	2.563	10380	5.261	10172	5.16	10069	5.103
9	114.4	2.906	112.1	2.847	115.5	2.934	113.3	2.878	13090	6.631	12828	6.50	–	–
8	128.5	3.264	125.9	3.198	129.8	3.297	127.2	3.231	16510	8.367	16180	8.20	–	–
7	144.3	3.665	141.4	3.592	145.7	3.701	142.9	3.630	20820	10.55	20404	10.34	–	–
6	162.0	4.115	158.8	4.034	163.6	4.155	160.4	4.074	26240	13.30	25715	13.03	–	–

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Table 20.1 Continued

Size of conductor	Diameter of solid conductor								Cross-sectional area of conductor					
	Nominal		Minimum[c]		Maximum[c]		Minimum[d]		Nominal		Minimum			
											0.98 × Nominal[a]		0.97 × Nominal[b]	
	mils	mm	mils (0.98 x nominal)	mm	mils (1.01 x nominal)	mm	mils (0.99 x nominal)	mm	cmil	mm²	cmil	mm²	cmil	mm²
5	181.9	4.620	178.3	4.529	183.7	4.666	180.1	4.575	33090	16.77	32428	16.43	–	–
4	204.3	5.189	200.2	5.085	206.3	5.240	202.3	5.138	41740	21.15	40905	20.73	–	–
3	229.4	5.827	224.8	5.710	231.7	5.885	227.1	5.768	52620	26.67	51568	26.14	–	–
2	257.6	6.543	252.4	6.411	260.2	6.609	255.0	6.477	66360	33.62	65033	32.95	–	–
1	289.3	7.348	283.5	7.201	292.2	7.422	286.4	7.275	83690	42.41	82016	41.56	–	–
1/0	324.9	8.252	318.4	8.087	328.1	8.334	321.7	8.171	105600	53.49	103488	52.42	–	–
2/0	364.8	9.266	357.5	9.080	368.4	9.357	361.2	9.174	133100	67.43	130438	66.08	–	–
3/0	409.6	10.40	401.4	10.20	413.7	10.51	405.5	10.30	167800	85.01	164444	83.31	–	–
4/0	460.0	11.68	450.8	11.45	464.6	11.80	455.4	11.57	211600	107.2	207368	105.1	–	–
kcmil									kcmil		kcmil			
250	–	–	–	–	–	–	–	–	250	127	245	124.1	–	–
300	–	–	–	–	–	–	–	–	300	152	294	149.0	–	–
350	–	–	–	–	–	–	–	–	350	177	343	173.8	–	–
400	–	–	–	–	–	–	–	–	400	203	392	198.6	–	–
450	–	–	–	–	–	–	–	–	450	228	441	223.5	–	–
500	–	–	–	–	–	–	–	–	500	253	490	248.3	–	–
550	–	–	–	–	–	–	–	–	550	279	539	273.1	–	–
600	–	–	–	–	–	–	–	–	600	304	588	297.9	–	–
650	–	–	–	–	–	–	–	–	650	329	637	322.8	–	–

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Table 20.1 Continued

Size of conductor	Diameter of solid conductor								Cross-sectional area of conductor					
									Nominal		Minimum			
	Nominal		Minimum[c]		Maximum[c]		Minimum[d]				0.98 × Nominal[a]		0.97 × Nominal[b]	
	mils	mm	mils (0.98 x nominal)	mm	mils (1.01 x nominal)	mm	mils (0.99 x nominal)	mm	cmil	mm^2	cmil	mm^2	cmil	mm^2
700	–	–	–	–	–	–	–	–	700	355	686	347.6	–	–
750	–	–	–	–	–	–	–	–	750	380	735	372.4	–	–
800	–	–	–	–	–	–	–	–	800	405	784	397.2	–	–
900	–	–	–	–	–	–	–	–	900	456	882	446.9	–	–
1000	–	–	–	–	–	–	–	–	1000	507	980	496.6	–	–
1100	–	–	–	–	–	–	–	–	1100	557	1078	546.2	–	–
1200	–	–	–	–	–	–	–	–	1200	608	1176	595.9	–	–
kcmil									kcmil		kcmil			
1250	–	–	–	–	–	–	–	–	1250	633	1225	620.7	–	–
1300	–	–	–	–	–	–	–	–	1300	659	1274	645.5	–	–
1400	–	–	–	–	–	–	–	–	1400	709	1372	695.2	–	–
1500	–	–	–	–	–	–	–	–	1500	760	1470	744.9	–	–
1600	–	–	–	–	–	–	–	–	1600	811	1568	794.5	–	–
1700	–	–	–	–	–	–	–	–	1700	861	1666	844.2	–	–
1750	–	–	–	–	–	–	–	–	1750	887	1715	869.0	–	–
1800	–	–	–	–	–	–	–	–	1800	912	1764	893.8	–	–
1900	–	–	–	–	–	–	–	–	1900	963	1862	943.5	–	–
2000	–	–	–	–	–	–	–	–	2000	1013	1960	993.1	–	–

Table 20.1 Continued on Next Page

Table 20.1 Continued

Size of conductor	Diameter of solid conductor								Cross-sectional area of conductor					
	Nominal		Minimum[c]		Maximum[c]		Minimum[d]		Nominal		Minimum			
											0.98 × Nominal[a]		0.97 × Nominal[b]	
	mils	mm	mils (0.98 x nominal)	mm	mils (1.01 x nominal)	mm	mils (0.99 x nominal)	mm	cmil	mm^2	cmil	mm^2	cmil	mm^2

[a] The minimums in this column apply to flexible cord and fixture wire conductors composed of 29 – 20 AWG strands. Except where specified otherwise in the wire standard, the minimums in this column also apply to solid and stranded wires and cables (regardless of strand size).

[b] For conductors in flexible cords and fixture wires in which the conductors are composed of 36 – 30 AWG strands, the minimums in this column apply.

[c] The values in these two columns apply where the wire standard (power cables principally) specifies maximum and minimum diameters for the conductor.

[d] The values in this column apply where the wire standard specifies only a minimum diameter for the conductor.

Table 20.2
Diameters over round compact-stranded conductors

Conductor size	Nominal		Minimum[a]		Maximum[a]	
	inch	mm	inches (0.98 x nominal)	mm	inches (1.01 x nominal)	mm
12 AWG	0.085	2.16	0.083	2.11	0.086	2.18
11	0.095	2.41	0.093	2.36	0.096	2.44
10	0.107	2.72	0.105	2.67	0.108	2.74
9	0.120	3.05	0.118	3.00	0.121	3.07
8	0.134	3.40	0.131	3.23	0.135	3.43
7	0.152	3.86	0.149	3.78	0.154	3.91
6	0.169	4.29	0.166	4.22	0.171	4.34
5	0.191	4.85	0.187	4.75	0.193	4.90
4	0.213	5.41	0.209	5.31	0.215	5.46
3 AWG	0.238	6.02	0.233	5.92	0.240	6.10
2	0.268	6.81	0.263	6.68	0.271	6.88
1	0.299	7.59	0.293	7.44	0.302	7.67
1/0	0.336	8.53	0.329	8.36	0.339	8.61
2/0	0.376	9.55	0.368	9.35	0.380	9.65
3/0	0.423	10.74	0.415	10.54	0.427	10.85
4/0	0.475	12.07	0.466	11.84	0.480	12.19
250 kcmil	0.520	13.21	0.510	12.95	0.525	13.34
300	0.570	14.48	0.559	14.20	0.576	14.63
350	0.616	15.65	0.604	15.34	0.622	15.80
400	0.659	16.74	0.646	16.41	0.666	16.92
450	0.700	17.78	0.686	17.42	0.707	17.96
500	0.736	18.69	0.721	18.31	0.743	18.87
550	0.775	19.69	0.760	19.30	0.783	19.89
600	0.813	20.65	0.797	20.24	0.821	20.85
650	0.845	21.46	0.828	21.03	0.853	21.67
700	0.877	22.28	0.859	21.82	0.886	22.50
750	0.908	23.06	0.890	22.61	0.917	23.29
800	0.938	23.83	0.919	23.34	0.947	24.05
900	0.999	25.37	0.979	24.87	1.009	25.63

Table 20.2 Continued on Next Page

Table 20.2 Continued

Conductor size	Nominal		Minimum[a]		Maximum[a]	
	inch	mm	inches (0.98 x nominal)	mm	inches (1.01 x nominal)	mm
1000	1.060	26.92	1.039	26.39	1.071	27.20

[a] The values in these two columns apply where the wire standard (power cables principally) specifies maximum and minimum diameters for the conductor.

Table 20.3
Diameters over round compressed concentric-lay-stranded ASTM Classes B, C, and D aluminum, uncoated copper, and coated copper conductors

Conductor size	Nominal[b]		Minimum[c]		Maximum[c]	
	inch	mm	inches (0.98 x nominal)	mm	inches (1.01 x nominal)	mm
14 AWG	0.071[a]	1.80[a]	0.070	1.79	0.072	1.83
13	0.080[a]	2.03[a]	0.078	1.98	0.081	2.06
12	0.089	2.26	0.087	2.21	0.090	2.29
11	0.100	2.54	0.098	2.49	0.101	2.57
10	0.113	2.87	0.111	2.82	0.114	2.90
9	0.126	3.20	0.123	3.12	0.127	3.23
8	0.142	3.61	0.139	3.53	0.143	3.63
7	0.159	4.04	0.156	3.96	0.161	4.09
6	0.178	4.52	0.174	4.42	0.180	4.57
5	0.200	5.08	0.196	4.98	0.202	5.13
4	0.225	5.72	0.221	5.61	0.227	5.77
3	0.252	6.40	0.247	6.27	0.255	6.48
2	0.283	7.19	0.277	7.04	0.286	7.26
1	0.322	8.18	0.316	8.03	0.325	8.26
1/0	0.362	9.19	0.355	9.02	0.366	9.30
2/0	0.405	10.3	0.397	10.08	0.409	10.39
3/0	0.456	11.6	0.447	11.35	0.461	11.71
4/0	0.512	13.0	0.502	12.75	0.517	13.13
250 kcmil	0.558	14.2	0.547	13.89	0.564	14.33
300	0.611	15.5	0.599	15.21	0.617	15.67
350	0.661	16.8	0.648	16.46	0.668	19.97

Table 20.3 Continued on Next Page

Table 20.3 Continued

Conductor size	Nominal[b]		Minimum[c]		Maximum[c]	
	inch	mm	inches (0.98 x nominal)	mm	inches (1.01 x nominal)	mm
400	0.706	17.9	0.692	17.58	0.713	18.11
450	0.749	19.0	0.734	18.64	0.756	19.20
500	0.789	20.0	0.773	19.63	0.797	20.24
550	0.829	21.1	0.812	20.62	0.837	21.26
600	0.866	22.0	0.849	21.56	0.875	22.23
650	0.901	22.9	0.883	22.43	0.910	23.11
700	0.935	23.7	0.916	23.27	0.944	23.98
750	0.968	24.6	0.949	24.10	0.978	24.84
800	1.000	25.4	0.980	24.89	1.010	25.65
900	1.060	26.9	1.039	26.39	1.071	27.20
1000	1.117	28.4	1.095	27.81	1.128	28.65
1100	1.173	29.8	1.150	29.21	1.185	30.10
1200 kcmil	1.225	31.1	1.200	30.48	1.237	31.42
1250	1.250	31.8	1.225	31.12	1.262	32.05
1300	1.275	32.4	1.250	31.75	1.288	32.72
1400	1.323	33.6	1.297	32.94	1.336	33.93
1500	1.370	34.8	1.343	34.11	1.384	35.15
1600	1.415	35.9	1.387	35.23	1.429	36.30
1700	1.459	37.1	1.430	36.32	1.474	37.44
1750	1.480	37.6	1.450	36.83	1.495	37.97
1800	1.502	38.2	1.472	37.39	1.517	38.53
1900	1.542	39.2	1.511	38.38	1.557	39.55
2000	1.583	40.2	1.551	39.40	1.599	40.61

[a] Aluminum is for use in the 12 AWG – 2000 kcmil sizes, not in the 14 and 13 AWG sizes.

[b] In no case is the diameter of a compressed-stranded conductor to be more than 3 percent smaller than the diameter of the conductor determined after the conductor is assembled and before it is compressed.

[c] The values in these two columns apply where the wire standard (power principally) specifies maximum and minimum diameters for the conductor.

Table 20.3.1
Diameters over round compressed unilay-stranded ASTM Class B aluminum, uncoated copper, and coated copper conductors

Conductor size	Nominal		Minimum[a]		Maximum[a]	
	inches	mm	inches (0.98 x nominal)	mm	inches (1.01 x nominal)	mm
1 AWG	0.313	7.95	0.307	7.80	0.316	8.03
1/0	0.352	8.94	0.345	8.76	0.356	9.04
2/0	0.395	10.03	0.387	9.83	0.399	10.13
3/0	0.443	11.25	0.434	11.02	0.447	11.35
4/0	0.498	12.65	0.488	12.40	0.503	12.78
250 kcmil	0.542	13.77	0.531	13.49	0.547	13.89
300	0.594	15.09	0.582	14.78	0.600	15.24
350	0.641	16.28	0.628	15.95	0.647	16.43
400	0.685	17.40	0.671	17.04	0.692	17.58
450	0.727	18.47	0.712	18.08	0.734	18.64
500	0.766	19.46	0.751	19.08	0.774	19.66
550	0.804	20.42	0.788	20.02	0.812	20.62
600	0.840	21.34	0.823	20.90	0.848	21.54
650 kcmil	0.874	22.20	0.857	21.77	0.883	22.43
700	0.907	23.04	0.889	22.58	0.916	23.27
750	0.939	23.85	0.920	23.37	0.948	24.08
800	0.969	24.61	0.950	24.13	0.979	24.87
900	1.028	26.11	1.007	25.58	1.038	26.37
1000	1.084	27.53	1.062	26.97	1.095	27.81
1100	1.137	28.88	1.114	28.30	1.148	29.16
1200	1.187	30.15	1.163	29.54	1.199	30.45
1250	1.212	30.78	1.188	30.18	1.224	31.09
1300	1.236	31.39	1.211	30.76	1.248	31.70
1400	1.282	32.56	1.256	31.90	1.295	32.89
1500	1.327	33.71	1.300	33.02	1.340	34.04
1600	1.371	34.82	1.344	34.14	1.385	35.18
1700	1.413	35.89	1.385	35.18	1.427	36.25

Table 20.3.1 Continued on Next Page

Table 20.3.1 Continued

Conductor size	Nominal		Minimum[a]		Maximum[a]	
	inches	mm	inches (0.98 x nominal)	mm	inches (1.01 x nominal)	mm
1750	1.434	36.42	1.405	35.69	1.448	36.78
1800	1.454	36.93	1.425	36.20	1.469	37.31
1900	1.494	37.95	1.464	37.19	1.509	38.33
2000	1.533	38.94	1.502	38.15	1.548	39.32

[a] The values in these two columns apply where the wire standard (power cables principally) specifies maximum and minimum diameteers for the conductor. Otherwise, in no case is the diameter of a compressed-stranded conductor to be more than 3 percent smaller than the diameter of the conductor determined after the conductor is assembled and before it is compressed.

Table 20.4
Diameters over ASTM Class B round concentric-lay-stranded conductors

Conductor size	Nominal		Minimum[a]		Maximum[a]	
	inches	mm	inches (0.98 x nominal)	mm	inches (1.01 x nominal)	mm
30 AWG	0.0113	0.287	0.0111	0.282	0.0114	0.290
29	0.0128	0.325	0.0125	0.318	0.0129	0.328
28	0.0143	0.363	0.0140	0.356	0.0144	0.356
27	0.0161	0.409	0.0158	0.401	0.0163	0.414
26	0.0180	0.457	0.0176	0.447	0.0182	0.462
25	0.0203	0.516	0.0199	0.505	0.0205	0.521
24	0.0228	0.579	0.0223	0.566	0.0230	0.584
23	0.0256	0.650	0.0251	0.638	0.0259	0.658
22 AWG	0.0287	0.729	0.0281	0.714	0.0290	0.737
21	0.0323	0.820	0.0317	0.805	0.0326	0.828
20	0.0362	0.919	0.0355	0.902	0.0366	0.930
19	0.0407	1.03	0.0399	1.013	0.0411	1.044
18	0.0456	1.16	0.0447	1.135	0.0461	1.171
17	0.0513	1.30	0.0502	1.275	0.0518	1.315
16	0.0576	1.46	0.0564	1.433	0.0582	1.478
15	0.0647	1.64	0.0635	1.613	0.0653	1.659
14	0.0727	1.85	0.0712	1.81	0.0734	1.86
13	0.0816	2.07	0.0800	2.03	0.0824	2.09
12	0.0915	2.32	0.0897	2.28	0.0924	2.35
11	0.103	2.62	0.101	2.57	0.104	2.64
10	0.116	2.95	0.114	2.90	0.117	2.97
9	0.130	3.30	0.127	3.23	0.131	3.33
8	0.146	3.71	0.143	3.63	0.147	3.73
7	0.164	4.17	0.161	4.09	0.166	4.22
6	0.184	4.67	0.180	4.57	0.186	4.72
5	0.206	5.23	0.201	5.11	0.208	5.28
4	0.232	5.89	0.227	5.77	0.234	5.94
3	0.260	6.60	0.255	6.48	0.263	6.68

Table 20.4 Continued on Next Page

Table 20.4 Continued

Conductor size	Nominal		Minimum[a]		Maximum[a]	
	inches	mm	inches (0.98 x nominal)	mm	inches (1.01 x nominal)	mm
2	0.292	7.42	0.286	7.26	0.295	7.49
1	0.332	8.43	0.325	8.26	0.335	8.51
1/0	0.372	9.45	0.365	9.27	0.376	9.55
2/0	0.418	10.62	0.410	10.41	0.422	10.72
3/0	0.470	11.94	0.461	11.71	0.475	12.07
4/0	0.528	13.41	0.517	13.13	0.533	13.54
250 kcmil	0.575	14.61	0.564	14.33	0.581	14.76
300	0.630	16.00	0.617	15.67	0.636	16.15
350	0.681	17.30	0.667	16.94	0.688	17.48
400	0.728	18.49	0.713	18.11	0.735	18.67
450	0.772	19.61	0.757	19.23	0.780	19.81
500	0.813	20.65	0.797	20.24	0.821	20.85
550	0.855	21.72	0.838	21.29	0.864	21.95
600	0.893	22.68	0.875	22.23	0.902	22.91
650 kcmil	0.929	23.60	0.910	22.86	0.938	23.83
700	0.964	24.49	0.945	24.00	0.974	24.74
750	0.998	25.35	0.978	24.84	1.008	25.60
800	1.030	26.16	1.009	25.63	1.040	26.42
900	1.094	27.79	10.72	27.23	1.105	28.07
1000	1.152	29.26	1.129	28.68	1.164	29.57
1100	1.209	30.71	1.185	30.10	1.221	31.01
1200	1.263	32.08	1.238	31.45	1.276	32.41
1250	1.289	32.74	1.263	32.08	1.302	33.07
1300	1.314	33.38	1.288	32.72	1.327	33.71
1400	1.365	34.67	1.338	33.99	1.379	35.03
1500	1.412	35.86	1.384	35.15	1.426	36.22
1600	1.459	37.06	1.430	36.32	1.474	37.44
1700	1.504	38.20	1.474	37.44	1.519	38.58

Table 20.4 Continued on Next Page

Table 20.4 Continued

Conductor size	Nominal		Minimum[a]		Maximum[a]	
	inches	mm	inches (0.98 x nominal)	mm	inches (1.01 x nominal)	mm
1750	1.526	38.76	1.495	37.97	1.541	39.14
1800	1.548	39.32	1.517	38.53	1.563	39.70
1900	1.590	40.39	1.558	39.57	1.606	40.79
2000	1.632	41.45	1.599	40.61	1.648	41.86

[a] The values in these two columns apply where the wire standard (power cables principally) specifies maximum and minimum diameters for the conductor.

Table 20.4.1
Diameters over ASTM Class C round concentric-lay-stranded conductors

Conductor size	Nominal		Minimum[a]		Maximum[a]	
	Inches	mm	Inches (0.98 x nominal)	mm	Inches (1.01 x nominal)	mm
30 AWG	0.0115	0.292	0.0113	0.338	0.0116	0.295
29	0.0130	0.330	0.0127	0.323	0.0131	0.333
28	0.0145	0.368	0.0142	0.361	0.0146	0.371
27	0.0163	0.414	0.0160	0.406	0.0165	0.419
26	0.0182	0.465	0.0178	0.452	0.0184	0.467
25	0.0205	0.521	0.0201	0.511	0.0207	0.526
24	0.0230	0.584	0.0225	0.572	0.0232	0.589
23	0.0259	0.658	0.0254	0.645	0.0262	0.665
22	0.0290	0.737	0.0284	0.721	0.0293	0.744
21 AWG	0.0327	0.830	0.0320	0.813	0.0330	0.838
20	0.0365	0.927	0.0358	0.909	0.0369	0.937
19	0.0412	1.046	0.0404	1.026	0.0416	1.057
18	0.0460	1.168	0.0451	1.146	0.0465	1.181
17	0.0519	1.318	0.0509	1.293	0.0524	1.331
16	0.0585	1.486	0.0573	1.455	0.0591	1.501
15	0.0655	1.664	0.0642	1.631	0.0662	1.681
14	0.0735	1.867	0.0720	1.829	0.0743	1.887
13	0.0825	2.096	0.0850	2.159	0.0833	2.116

Table 20.4.1 Continued on Next Page

Table 20.4.1 Continued

Conductor size	Nominal		Minimum[a]		Maximum[a]	
	Inches	mm	Inches (0.98 x nominal)	mm	Inches (1.01 x nominal)	mm
12	0.0925	2.350	0.0907	2.304	0.0934	2.372
11 AWG – 2000 kcmil	b	b	b	b	b	b

[a] The values in these two columns apply where the wire standard (power cables principally) specifies maximum and minimum diameters for the conductor.

[b] Use Table 20.4.

Table 20.5
Nominal dimensions of round strands

AWG size of strand	Diameter		Cross-sectional area	
	Mils	mm	cmil	mm²
40	3.1	0.079	9.61	0.00487
39	3.5	0.089	12.2	0.00621
38	4.0	0.102	16.0	0.00811
37	4.5	0.144	20.2	0.0103
36	5.0	0.127	25.0	0.0127
35	5.6	0.142	31.4	0.0159
34	6.3	0.160	39.7	0.0201
33	7.1	0.180	50.4	0.0255
32	8.0	0.203	64.0	0.0324
31	8.9	0.226	79.2	0.0401
30	10.0	0.254	100	0.0507
29	11.3	0.287	128	0.0647
28	12.6	0.320	159	0.0804
27	14.2	0.361	202	0.102
26	15.9	0.404	253	0.128
25	17.9	0.455	320	0.162
24	20.1	0.511	404	0.205
23	22.6	0.574	511	0.259
22	25.3	0.643	640	0.324
21	28.5	0.724	812	0.412
20	32.0	0.813	1020	0.519

Table 20.6
Nominal strand and conductor dimensions for 19-wire combination round-wire unilay-stranded copper or aluminum conductors

AWG conductor size	Nominal strand dimensions								Conductor diameter					
	Large strand				Small strand									
	A Diameter		B Cross-sectional area		C Diameter		D Cross-sectional area		E = 3A + 2C Nominal		F = 0.98 x E Minimum[a]		G = 1.01 x E Maximum[a]	
	inch	mm	cmil	mm²	inch	mm	cmil	mm²	inch	mm	inch	mm	inch	mm
14	0.0159	0.4	253	0.128	0.0117	0.3	137	0.069	0.071	1.80	0.70	1.78	0.72	1.83
12	0.0201	0.5	404	0.205	0.0147	0.4	216	0.109	0.090	2.29	0.88	2.24	0.091	2.31
10	0.0253	0.6	640	0.324	0.0185	0.5	342	0.173	0.113	2.87	1.11	2.87	0.114	2.90
9	0.0284	0.7	807	0.408	0.0208	0.5	433	0.219	0.127	3.23	0.127	3.14	0.128	3.25
8	0.0319	0.8	1018	0.515	0.0234	0.6	548	0.277	0.143	3.63	1.40	3.56	0.144	3.66
7	0.0358	0.9	1282	0.649	0.0262	0.67	686	0.347	0.160	4.06	0.157	3.99	0.162	4.11
6	0.0402	1.0	1616	0.818	0.0294	0.7	864	0.437	0.179	4.55	0.175	4.45	0.181	4.60
5	0.0452	1.1	2043	1.034	0.0331	0.8	1096	0.555	0.202	5.13	0.198	5.03	0.204	5.18
4	0.0507	1.3	2570	1.301	0.0371	0.9	1376	0.696	0.226	5.74	0.221	5.61	0.228	5.79
3	0.0570	1.4	3249	1.644	0.0417	1.1	1739	0.880	0.254	6.45	0.249	6.32	0.257	6.53
2	0.0640	1.6	4096	2.073	0.0468	1.2	2190	1.108	0.286	7.26	0.280	7.11	0.289	7.34
1	0.0718	1.8	5155	2.609	0.0526	1.3	2767	1.400	0.321	8.15	0.316	8.03	0.324	8.23
1/0	0.0807	2.1	6512	3.296	0.0591	1.5	3493	1.768	0.360	9.14	0.353	8.97	0.364	9.25
2/0	0.0906	2.3	8208	4.154	0.0663	1.7	4396	2.225	0.404	10.26	0.396	10.06	0.408	10.36
3/0	0.1017	2.6	10343	5.234	0.0745	1.9	5550	2.809	0.454	11.53	0.445	11.30	0.459	11.66
4/0	0.1142	2.9	13042	6.600	0.0836	2.1	6989	3.537	0.510	12.95	0.500	12.70	0.515	13.08

[a] The values in these two columns apply where the wire standard (power cables principally) specifies maximum and minimum diameters for the conductor.

21 thru 29 *Reserved for Future Use*

30 D-C Conductor Resistance

30.1 The specifications for this test are located in the DC Resistance Test in the Standard for Wire and Cable Test Methods, UL 2556.

30.2 The requirements for the various materials and constructions are found in Table 30.1 – Table 30.11.

30.3 For conductor material not defined in Table 30.1 – Table 30.11 having 100 percent conductivity, the maximum resistance shall be the same as the uncoated copper.

Table 30.1
Maximum direct-current resistance of solid conductors of aluminum, copper-clad aluminum, and uncoated copper

AWG size of conductor	20°C				25°C			
	Aluminum and copper-clad aluminum		Uncoated copper		Aluminum and copper-clad aluminum		Uncoated copper	
	Ohms per 1000 ft	Ohms per 1000 m	Ohms per 1000 ft	Ohms per 1000 m	Ohms per 1000 ft	Ohms per 1000 m	Ohms per 1000 ft	Ohms per 1000 m
56	–	–	44064	144574	–	–	44880	147251
55	–	–	34986	114789	–	–	35700	117132
54	–	–	27540	90359	–	–	28050	92032
53	–	–	21624	70948	–	–	22032	72287
52	–	–	17340	56893	–	–	17748	58231
51	–	–	13668	44845	–	–	13974	45849
50	–	–	10812	35474	–	–	11016	36144
49	–	–	8588	28179	–	–	8752	28714
48	–	–	6885	22500	–	–	7018	23025
47	–	–	5396	17704	–	–	5508	18072
46	–	–	4294	14089	–	–	4376	14357
45	–	–	3417	11211	–	–	3478	11412
44	–	–	2642	8668	–	–	2693	8835
43	–	–	2183	7162	–	–	2224	7296
42	–	–	1693	5555	–	–	1724	5656
41	–	–	1346	4418	–	–	1377	4518
40	–	–	1102	3614	–	–	1122	3681
39	–	–	864	2835	–	–	880	2888
38	–	–	661	2169	–	–	674	2212

Table 30.1 Continued on Next Page

Table 30.1 Continued

AWG size of conductor	20°C				25°C			
	Aluminum and copper-clad aluminum		Uncoated copper		Aluminum and copper-clad aluminum		Uncoated copper	
	Ohms per 1000 ft	Ohms per 1000 m	Ohms per 1000 ft	Ohms per 1000 m	Ohms per 1000 ft	Ohms per 1000 m	Ohms per 1000 ft	Ohms per 1000 m
37	–	–	522	1713	–	–	532	1747
36	–	–	423	1389	–	–	431	1416
35	–	–	338	1108	–	–	344	1128
34	–	–	266	873	–	–	271	890
33	–	–	210	689	–	–	214	703
32	–	–	165	542	–	–	168	552
31	–	–	134	438	–	–	137	448
30	–	–	106	347	–	–	108	354
29	–	–	82.8	271	–	–	84.5	277
28	109	358	66.6	218	111	364	67.9	223
27	85.9	282	52.4	172	87.6	287	53.4	175
26	68.6	225	41.8	138	70.0	230	42.6	140
25	54.1	178	33.0	108	55.3	181	33.7	110
24	43.0	141	26.2	85.9	43.8	144	26.7	87.6
23	33.9	111	20.7	67.9	34.6	114	21.1	69.3
22	27.1	88.9	16.5	54.3	27.6	90.6	16.8	55.3
21	21.5	70.5	13.1	42.7	21.8	71.5	13.3	43.6
20	16.9	55.4	10.3	33.9	17.2	56.6	10.5	34.6
19	13.5	44.2	8.21	26.9	13.7	45.0	8.37	27.4
18	10.7	35.1	6.52	21.4	10.9	35.7	6.64	21.8
17	8.45	27.7	5.15	16.9	8.61	28.2	5.25	17.2
16	6.72	22.0	4.10	13.5	6.85	22.5	4.18	13.7
15	5.31	17.4	3.24	10.6	5.41	17.8	3.30	10.8
14	4.21	13.8	2.57	8.45	4.30	14.1	2.62	8.61
13	3.35	11.0	2.04	6.69	3.41	11.2	2.08	6.82
12	2.65	8.71	1.62	5.31	2.71	8.89	1.65	5.42
11	2.11	6.92	1.29	4.22	2.15	7.06	1.32	4.30
10	1.670	5.479	1.019	3.343	1.703	5.590	1.038	3.408

Table 30.1 Continued on Next Page

Table 30.1 Continued

AWG size of conductor	20°C				25°C			
	Aluminum and copper-clad aluminum		Uncoated copper		Aluminum and copper-clad aluminum		Uncoated copper	
	Ohms per 1000 ft	Ohms per 1000 m	Ohms per 1000 ft	Ohms per 1000 m	Ohms per 1000 ft	Ohms per 1000 m	Ohms per 1000 ft	Ohms per 1000 m
9	1.325	4.347	0.8084	2.652	1.352	4.435	0.8242	2.704
8	1.051	3.446	0.6407	2.102	1.071	3.515	0.6532	2.143
7	0.8328	2.733	0.5081	1.667	0.8497	2.788	0.5181	1.699
6	0.6609	2.168	0.4031	1.323	0.6741	2.211	0.4110	1.348
5	0.5242	1.720	0.3197	1.049	0.5361	1.754	0.3260	1.070
4	0.4155	1.363	0.2535	0.8315	0.4239	1.390	0.2585	0.8478
3	0.3296	1.081	0.2010	0.6595	0.3362	1.103	0.2050	0.6725
2	0.2613	0.8574	0.1594	0.5231	0.2666	0.8747	0.1626	0.5333
1	0.2073	0.6798	0.1264	0.4146	0.2113	0.6935	0.1289	0.4228
1/0	0.1643	0.5390	0.1002	0.3287	0.1676	0.5499	0.1022	0.3353
2/0	0.1304	0.4275	0.07949	0.2608	0.1329	0.4362	0.08105	0.2659
3/0	0.1033	0.3392	0.06306	0.2069	0.1055	0.3460	0.06429	0.2109
4/0	0.08196	0.2689	0.04999	0.1640	0.08361	0.2743	0.05098	0.1673

Table 30.2
Maximum direct-current resistance of solid copper conductors coated with tin or a tin/lead alloy

AWG Size of Conductor	20°C		25°C	
	Ohms per 1000 ft	Ohms per 1000 m	Ohms per 1000 ft	Ohms per 1000 m
56	45792	150244	46640	153026
55	36358	119291	37100	121725
54	28620	93902	29150	95641
53	22472	73731	22896	75122
52	18020	59124	18444	60515
51	19504	63993	14522	47747
50	11236	36865	11448	37561
49	8925	29284	9095	29840
48	7155	23476	7293	23928
47	5607	18398	5724	18780
46	4468	14642	4547	14920

Table 30.2 Continued on Next Page

Table 30.2 Continued

AWG Size of Conductor	20°C		25°C	
	Ohms per 1000 ft	Ohms per 1000 m	Ohms per 1000 ft	Ohms per 1000 m
45	3551	11651	3615	11860
44	2745	9008	2798	9182
43	2268	7443	2311	7582
42	1760	5773	1791	5878
41	1399	4591	1431	4695
40	1145	3756	1166	3826
39	898	2946	915	3001
38	687	2254	701	2299
37	543	1781	553	1815
36	440	1443	448	1471
35	351	1151	357	1172
34	277	908	282	925
33	218	716	223	730
32	172	563	175	574
31	139	456	142	466
30	110	361	112	368
29	86.1	282	87.8	289
28	69.3	227	70.6	232
27	54.5	179	55.6	182
26	43.5	143	44.3	145
25	34.4	112	35.0	115
24	27.3	89.3	27.8	91.1
23	21.5	70.6	22.0	72.0
22	17.2	56.4	17.5	57.5
21	13.6	44.4	13.8	45.3
20	10.7	35.2	10.9	36.0
19	8.54	28.0	8.70	28.6
18	6.77	22.2	6.91	22.7
17	5.37	17.6	5.47	17.9

Table 30.2 Continued on Next Page

Table 30.2 Continued

AWG Size of Conductor	20°C		25°C	
	Ohms per 1000 ft	Ohms per 1000 m	Ohms per 1000 ft	Ohms per 1000 m
16	4.26	14.0	4.35	14.2
15	3.38	11.1	3.44	11.2
14	2.68	8.78	2.72	8.96
13	2.12	6.97	2.16	7.10
12	1.68	5.53	1.71	5.64
11	1.34	4.39	1.37	4.48
10	1.060	3.476	1.080	3.545
9	0.8319	2.730	0.8483	2.784
8	0.6594	2.163	0.6724	2.206
7	0.5229	1.716	0.5332	1.749
6	0.4148	1.361	0.4230	1.388
5	0.3291	1.079	0.3356	1.101
4	0.2608	0.8559	0.2660	0.8727
3	0.2069	0.6788	0.2109	0.6922
2	0.1641	0.5384	0.1673	0.5489
1	0.1300	0.4268	0.1326	0.4352
1/0	0.1026	0.3367	0.1047	0.3433
2/0	0.08140	0.2670	0.08300	0.2723
3/0	0.06457	0.2119	0.06583	0.2160
4/0	0.05119	0.1680	0.05219	0.1713

Table 30.3
Maximum direct-current resistance of aluminum, copper-clad aluminum, and compact-stranded aluminum conductors and uncoated copper conductors: concentric-stranded ASTM Classes B, C, and D, compact-stranded, and compressed-stranded

Size of conductor	20°C				25°C			
	Aluminum and copper-clad aluminum		Uncoated copper		Aluminum and copper-clad aluminum		Uncoated copper	
	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m
30 AWG	–	–	108	354	–	–	110	361
29	–	–	84.3	277	–	–	86.0	282
28	111	364	67.9	223	113	371	69.2	227

Table 30.3 Continued on Next Page

Table 30.3 Continued

Size of conductor	20°C				25°C			
	Aluminum and copper-clad aluminum		Uncoated copper		Aluminum and copper-clad aluminum		Uncoated copper	
	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m
27	87.6	287	53.4	175	89.4	293	54.5	179
26	70.0	230	42.7	140	71.3	234	43.5	143
25	55.3	181	33.7	111	56.4	185	34.4	113
24	43.8	144	26.7	87.6	44.6	146	27.2	89.2
23	34.6	114	21.1	69.2	35.3	116	21.5	70.5
22	27.7	90.9	16.9	55.4	28.2	92.5	17.2	56.4
21	21.8	71.5	13.3	43.6	22.1	72.5	13.5	44.3
20	17.4	57.1	10.6	34.6	17.7	58.1	10.8	35.3
19	13.7	44.9	8.36	27.4	14.0	45.9	8.53	28.0
18	10.9	35.8	6.66	21.8	11.1	36.4	6.79	22.2
17	8.68	28.5	5.27	17.3	8.86	29.1	5.37	17.6
16	6.87	22.5	4.18	13.7	7.00	23.0	4.26	14.0
15	5.41	17.8	3.31	10.9	5.53	18.1	3.37	11.1
14	4.30	14.1	2.62	8.62	4.38	14.4	2.68	8.78
13	3.41	11.2	2.08	6.82	3.48	11.4	2.12	6.97
12	2.71	8.88	1.65	5.43	2.76	9.07	1.68	5.53
11	2.15	7.07	1.32	4.30	2.19	7.20	1.34	4.39
10	1.70	5.589	1.039	3.409	1.738	5.702	1.060	3.476
9 AWG	1.35	4.434	0.8245	2.705	1.379	4.524	0.8407	2.758
8	1.07	3.515	0.6535	2.144	1.092	3.585	0.6663	2.186
7	0.8495	2.787	0.5182	1.700	0.8666	2.844	0.5284	1.734
6	0.6740	2.211	0.4112	1.348	0.6876	2.256	0.4192	1.375
5	0.5346	1.754	0.3261	1.070	0.5454	1.789	0.3325	1.091
4	0.4238	1.390	0.2585	0.8481	0.4324	1.419	0.2636	0.8649
3	0.3361	1.103	0.2050	0.6727	0.3429	1.125	0.2091	0.6860
2	0.2665	0.8745	0.1626	0.5335	0.2719	0.8922	0.1659	0.5440
1	0.2113	0.6934	0.1289	0.4230	0.2156	0.7074	0.1315	0.4313

Table 30.3 Continued on Next Page

Table 30.3 Continued

Size of conductor	20°C Aluminum and copper-clad aluminum Ohms per 1000 feet	20°C Aluminum and copper-clad aluminum Ohms per 1000 m	20°C Uncoated copper Ohms per 1000 feet	20°C Uncoated copper Ohms per 1000 m	25°C Aluminum and copper-clad aluminum Ohms per 1000 feet	25°C Aluminum and copper-clad aluminum Ohms per 1000 m	25°C Uncoated copper Ohms per 1000 feet	25°C Uncoated copper Ohms per 1000 m
1/0	0.1676	0.5498	0.1022	0.3354	0.1710	0.5609	0.1042	0.3419
2/0	0.1329	0.4361	0.08108	0.2660	0.1356	0.4450	0.08267	0.2712
3/0	0.1055	0.3459	0.06431	0.2110	0.1075	0.3529	0.06558	0.2151
4/0	0.08360	0.2743	0.05099	0.1673	0.08528	0.2798	0.05200	0.1705
250 kcmil	0.07076	0.2322	0.04316	0.1416	0.07219	0.2368	0.04401	0.1444
300	0.05897	0.1935	0.03597	0.1180	0.06015	0.1974	0.03667	0.1204
350	0.05054	0.1659	0.03082	0.1011	0.05156	0.1691	0.03144	0.1031
400	0.04423	0.1450	0.02698	0.08851	0.04511	0.1480	0.02751	0.09024
450	0.03931	0.1289	0.02398	0.07867	0.04010	0.1316	0.02445	0.08021
500	0.03537	0.1161	0.02158	0.07080	0.03609	0.1184	0.02200	0.07220
550	0.03216	0.1055	0.01961	0.06436	0.03281	0.1076	0.02000	0.06563
600	0.02948	0.09673	0.01798	0.05900	0.03008	0.09867	0.01834	0.06016
650	0.02721	0.08928	0.01660	0.05447	0.02776	0.09109	0.01692	0.05553
700	0.02527	0.08291	0.01541	0.05057	0.02578	0.08458	0.01572	0.05157
750	0.02358	0.07738	0.01438	0.04721	0.02406	0.07894	0.01467	0.04812
800	0.02211	0.07254	0.01348	0.04425	0.02255	0.07400	0.01375	0.04512
900	0.01966	0.06448	0.01199	0.03933	0.02005	0.06578	0.01222	0.04011
1000	0.01769	0.05804	0.01079	0.03540	0.01804	0.05920	0.01101	0.03610
1100	0.01609	0.05275	0.009809	0.03218	0.01640	0.05383	0.01000	0.03281
1200	0.01474	0.04836	0.008992	0.02950	0.01503	0.04934	0.009169	0.03008
1250	0.01415	0.04643	0.008632	0.02833	0.01443	0.04736	0.008802	0.02888
1300	0.01357	0.04465	0.008230	0.02723	0.01388	0.04554	0.008463	0.02776
1400	0.01264	0.04145	0.007707	0.02529	0.01289	0.04229	0.007859	0.02579
1500	0.01179	0.03869	0.007193	0.02360	0.01203	0.03947	0.007335	0.02406
1600	0.01106	0.03627	0.006744	0.02212	0.01128	0.03701	0.006877	0.02256
1700 kcmil	0.01040	0.03414	0.006347	0.02083	0.01062	0.03482	0.006472	0.02124
1750	0.01011	0.03316	0.006166	0.02023	0.01031	0.03383	0.006287	0.02062
1800	0.009827	0.03224	0.005995	0.01967	0.01003	0.03290	0.006112	0.02005
1900	0.009310	0.03055	0.005679	0.01864	0.009497	0.03116	0.005791	0.01900
2000	0.008844	0.02902	0.005395	0.01770	0.009023	0.02960	0.005501	0.01804

Table 30.4
Maximum direct-current resistance of copper conductors, concentric-stranded ASTM Class B with each strand coated with tin or a tin/lead alloy and compressed-stranded ASTM Class B with each strand coated

Size of Conductor	20°C		25°C	
	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m
30 AWG	116	381	118	387
29	90.5	297	92.3	303
28	72.8	239	74.3	244
27	57.3	188	58.5	192
26	45.8	150	46.7	153
25	36.2	119	36.9	121
24	28.7	94.2	29.2	95.8
23	22.7	74.5	23.1	75.8
22	18.1	59.4	18.5	60.7
21	14.3	46.9	14.5	47.6
20	11.2	36.7	11.4	37.4
19	8.88	29.1	9.06	29.7
18	7.06	23.2	7.19	23.6
17	5.59	18.3	5.70	18.7
16	4.45	14.6	4.53	14.9
15	3.44	11.3	3.51	11.5
14	2.73	8.96	2.78	9.14
13	2.16	7.10	2.20	7.24
12	1.72	5.64	1.75	5.75
11	1.37	4.48	1.39	4.56
10	1.080	3.546	1.102	3.615
9	0.8574	2.813	0.8742	2.868
8 AWG	0.6795	2.230	0.6929	2.274
7	0.5389	1.768	0.5495	1.802
6	0.4276	1.403	0.4359	1.430
5	0.3392	1.113	0.3458	1.134
4	0.2689	0.8820	0.2742	0.8993
3	0.2132	0.6996	0.2175	0.7133

Table 30.4 Continued on Next Page

Table 30.4 Continued

Size of Conductor	20°C		25°C	
	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m
2	0.1691	0.5548	0.1724	0.5657
1	0.1340	0.4398	0.1367	0.4485
1/0	0.1063	0.3487	0.1084	0.3556
2/0	0.08432	0.2766	0.08598	0.2820
3/0	0.06688	0.2194	0.06820	0.2238
4/0	0.05248	0.1722	0.05352	0.1755
250 kcmil	0.04488	0.1473	0.04577	0.1501
300	0.03740	0.1227	0.03814	0.1252
350	0.03206	0.1052	0.03270	0.1072
400	0.02776	0.09109	0.02831	0.09288
450	0.02467	0.08097	0.02516	0.08256
500	0.02222	0.07287	0.02264	0.07431
550	0.02040	0.06693	0.02080	0.06825
600	0.01871	0.06135	0.01907	0.06257
650	0.01709	0.05606	0.01742	0.05715
700	0.01586	0.05205	0.01618	0.05307
750	0.01481	0.04858	0.01510	0.04953
800	0.01388	0.04554	0.01416	0.04644
900	0.01234	0.04048	0.01259	0.04128
1000	0.01111	0.03643	0.01132	0.03715
1100	0.01010	0.03312	0.01029	0.03377
1200	0.009254	0.03037	0.009436	0.03096
1250	0.008884	0.02915	0.009059	0.02972
1300	0.008543	0.02803	0.008711	0.02858
1400 kcmil	0.007933	0.02602	0.008089	0.02654
1500	0.007403	0.02429	0.007549	0.02477
1600	0.006941	0.02278	0.007078	0.02322
1700	0.006533	0.02143	0.006661	0.02186
1750	0.006346	0.02082	0.006471	0.02123
1800	0.006171	0.02024	0.006291	0.02063

Table 30.4 Continued on Next Page

Table 30.4 Continued

Size of Conductor	20°C		25°C	
	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m
1900	0.005845	0.01918	0.005960	0.01955
2000	0.005552	0.01822	0.005662	0.01857

Table 30.5
Maximum direct-current resistance of copper conductors, concentric-stranded ASTM Classes C and D with each strand coated with tin or a tin/lead alloy and compressed-stranded ASTM Classes C and D with each strand coated

Size of conductor	Class C				Class D			
	20°C		25°C		20°C		25°C	
	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m
30 AWG	116	381	118	387	116	381	118	387
29	90.5	297	92.3	303	90.5	297	92.3	303
28	72.8	239	74.3	244	72.8	239	74.3	244
27	57.3	188	58.5	192	57.3	188	58.5	192
26	45.8	150	46.7	153	45.8	150	46.7	153
25	36.2	119	36.9	121	36.2	119	36.9	121
24	28.7	94.2	29.2	95.8	28.7	94.2	29.2	95.8
23	22.7	74.5	23.1	75.8	22.7	74.5	23.1	75.8
22	18.1	59.4	18.5	60.7	18.1	59.4	18.5	60.7
21	14.3	46.9	14.5	47.6	14.3	46.9	14.5	47.6
20	11.4	37.4	11.6	38.1	11.4	37.4	11.6	38.1
19	8.98	29.5	9.16	30.1	8.98	29.5	9.16	30.1
18	7.15	23.5	7.29	23.9	7.15	23.5	7.29	23.9
17	5.65	18.5	5.76	18.9	5.65	18.5	5.76	18.9
16	4.44	14.6	4.53	14.9	4.49	14.7	4.58	15.0
15	3.52	11.5	3.58	11.7	3.55	11.6	3.62	11.9
14	2.78	9.15	2.85	9.32	2.82	9.25	2.89	9.42
13	2.21	7.26	2.25	7.41	2.21	7.26	2.25	7.41
12	1.75	5.75	1.78	5.88	1.75	5.75	1.78	5.88
11	1.37	4.48	1.39	4.56	1.40	4.57	1.42	4.66
10 AWG	1.08	3.55	1.10	3.62	1.10	3.62	1.12	3.69

Table 30.5 Continued on Next Page

Table 30.5 Continued

Size of conductor	Class C				Class D			
	20°C		25°C		20°C		25°C	
	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m
9	0.857	2.82	0.874	2.87	0.875	2.88	0.892	2.93
8	0.679	2.23	0.692	2.27	0.679	2.23	0.693	2.27
7	0.539	1.76	0.550	1.81	0.539	1.76	0.550	1.81
6	0.427	1.41	0.436	1.43	0.427	1.41	0.436	1.43
5	0.339	1.11	0.346	1.13	0.339	1.11	0.346	1.13
4	0.269	0.882	0.274	0.900	0.269	0.882	0.274	0.900
3	0.213	0.700	0.217	0.713	0.213	0.700	0.217	0.713
2	0.169	0.555	0.172	0.566	0.169	0.555	0.172	0.566
1	0.134	0.440	0.137	0.449	0.134	0.440	0.137	0.449
1/0	0.106	0.349	0.108	0.355	0.106	0.349	0.108	0.355
2/0	0.0844	0.276	0.0860	0.282	0.0844	0.276	0.0860	0.282
3/0	0.0669	0.219	0.0681	0.223	0.0669	0.219	0.0681	0.223
4/0	0.0530	0.174	0.0541	0.177	0.0530	0.174	0.0541	0.177
250 kcmil	0.0449	0.147	0.0458	0.150	0.0449	0.147	0.0458	0.150
300	0.0374	0.122	0.0381	0.125	0.0374	0.122	0.0381	0.125
350	0.0320	0.105	0.0326	0.107	0.0320	0.105	0.0326	0.107
400	0.0280	0.0920	0.0286	0.0938	0.0280	0.0920	0.0286	0.0938
450	0.0249	0.0818	0.0254	0.0834	0.0249	0.0818	0.0254	0.0834
500	0.0224	0.0736	0.0228	0.0751	0.0224	0.0736	0.0228	0.0751
550	0.0204	0.0669	0.0208	0.0682	0.0204	0.0669	0.0208	0.0682
600	0.0187	0.0614	0.0191	0.0625	0.0187	0.0614	0.0191	0.0625
650	0.0172	0.0566	0.0176	0.0577	0.0172	0.0566	0.0176	0.0577
700	0.0160	0.0526	0.0163	0.0537	0.0160	0.0526	0.0163	0.0537
750	0.0150	0.0491	0.0153	0.0501	0.0150	0.0491	0.0153	0.0501
800	0.0141	0.0460	0.0143	0.0469	0.0141	0.0460	0.0143	0.0469
900	0.0124	0.0409	0.0128	0.0417	0.0124	0.0409	0.0128	0.0417
1000	0.0111	0.0364	0.0113	0.0371	0.0112	0.0368	0.0114	0.0375
1100	0.0102	0.0335	0.0104	0.0342	0.0102	0.0335	0.0104	0.0342

Table 30.5 Continued on Next Page

Table 30.5 Continued

Size of conductor	Class C				Class D			
	20°C		25°C		20°C		25°C	
	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m
1200	0.00935	0.0307	0.00954	0.0313	0.00935	0.0307	0.00954	0.0313
1250	0.00898	0.0295	0.00915	0.0300	0.00898	0.0295	0.00915	0.0300
1300	0.00863	0.0284	0.00880	0.0289	0.00863	0.0284	0.00880	0.0289
1400	0.00794	0.0260	0.00809	0.0265	0.00802	0.0263	0.00817	0.0268
1500	0.00741	0.0243	0.00755	0.0248	0.00748	0.0246	0.00763	0.0250
1600 kcmil	0.00702	0.0231	0.00715	0.0235	0.00702	0.0231	0.00715	0.0235
1700	0.00660	0.0216	0.00673	0.0220	0.00660	0.0216	0.00673	0.0220
1750	0.00642	0.0210	0.00654	0.0214	0.00642	0.0210	0.00654	0.0214
1800	0.00617	0.0202	0.00629	0.0206	0.00623	0.0205	0.00635	0.0208
1900	0.00584	0.0192	0.00596	0.0196	0.00591	0.0194	0.00602	0.0198
2000	0.00555	0.0183	0.00566	0.0186	0.00561	0.0184	0.00572	0.0188

Table 30.6
Maximum direct-current resistance of 19-wire combination round-wire unilay-stranded copper conductors

Metal coating of strands	AWG size of conductors	20°C		25°C	
		Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m
	14	2.78	9.15	2.85	9.32
	13	2.21	7.26	2.25	7.41
Each	12	1.75	5.75	1.78	5.88
	11	1.37	4.48	1.39	4.56
	10	1.08	3.55	1.10	3.62
	9	0.857	2.82	0.874	2.87
	8	0.679	2.23	0.692	2.27
Strand	7	0.539	1.76	0.550	1.81
	6	0.427	1.41	0.436	1.43
	5	0.339	1.11	0.346	1.13
	4	0.269	0.882	0.274	0.900

Table 30.6 Continued on Next Page

Table 30.6 Continued

Metal coating of strands	AWG size of conductors	20°C Ohms per 1000 feet	20°C Ohms per 1000 m	25°C Ohms per 1000 feet	25°C Ohms per 1000 m
	3	0.213	0.700	0.217	0.713
Coated	2	0.169	0.555	0.172	0.566
	1	0.1340	0.4398	0.1367	0.4485
	1/0	0.1063	0.3487	0.1084	0.3556
	2/0	0.08432	0.2766	0.08598	0.2820
	3/0	0.06688	0.2194	0.06820	0.2238
	4/0	0.05248	0.1722	0.05352	0.1755
	14	2.62	8.62	2.68	8.78
	13	2.08	6.82	2.12	6.97
Each	12	1.65	5.43	1.68	5.53
	11	1.32	4.30	1.34	4.39
	10	1.039	3.409	1.060	3.476
	9	0.8245	2.705	0.8407	2.758
	8	0.6535	2.144	0.6663	2.186
Strand	7	0.5182	1.700	0.5284	1.734
	6	0.4122	1.348	0.4192	1.375
	5	0.3261	1.070	0.3225	1.091
	4	0.2585	0.8481	0.2636	0.8649
	3	0.2050	0.6727	0.2091	0.6860
Uncoated	2	0.1626	0.5335	0.1659	0.5440
	1	0.1289	0.4230	0.1315	0.4313
	1/0	0.1022	0.3354	0.1042	0.3419
	2/0	0.08108	0.2660	0.08267	0.2712
	3/0	0.06431	0.2110	0.06558	0.2151
	4/0	0.05099	0.1673	0.05200	0.1705

Table 30.6A
Maximum direct-current resistance of 19-wire combination round-wire unilay-stranded aluminum conductors

AWG size of conductor	20°C		25°	
	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m
6	0.6716	2.204	0.6852	2.248
5	0.5326	1.748	0.5436	1.784
4	0.4224	1.386	0.4309	1.414
3	0.3351	1.100	0.3418	1.121
2	0.2656	0.8714	0.2710	0.8892
1	0.2107	0.6913	0.2149	0.7051
1/0	0.1671	0.5483	0.1705	0.5594
2/0	0.1325	0.4347	0.1351	0.4433
3/0	0.1051	0.3448	0.1072	0.3517
4/0	0.08332	0.2734	0.08501	0.2789

Table 30.7
Maximum direct-current resistance of ASTM Class G stranded conductors

Size of Conductor	Uncoated copper				Coated copper (each strand coated with tin or a tin/lead alloy)				Aluminum			
	20°C		25°C		20°C		25°C		20°C		25°C	
	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m
14 AWG	2.65	8.70	2.70	8.86	2.82	9.24	2.87	9.41	–	–	–	–
13	2.10	6.90	2.14	7.03	2.23	7.33	2.28	7.47	–	–	–	–
12	1.67	5.48	1.70	5.58	1.77	5.81	1.81	5.93	–	–	–	–
11	1.32	4.35	1.35	4.42	1.40	4.61	1.43	4.70	–	–	–	–
10	1.05	3.45	1.07	3.51	1.11	3.66	1.13	3.73	–	–	–	–
9	0.832	2.73	0.849	2.78	0.884	2.90	0.902	2.96	–	–	–	–
8	0.660	2.16	0.673	2.20	0.701	2.30	0.715	2.35	–	–	–	–
7	0.523	1.71	0.533	1.75	0.545	1.79	0.555	1.82	0.858	2.82	0.875	2.88
6	0.415	1.37	0.423	1.39	0.431	1.42	0.441	1.45	0.680	2.23	0.695	2.27
5	0.329	1.08	0.336	1.10	0.343	1.12	0.349	1.14	0.540	1.77	0.551	1.81
4	0.261	0.857	0.266	0.873	0.271	0.890	0.276	0.908	0.428	1.41	0.437	1.43
3	0.207	0.679	0.211	0.693	0.215	0.707	0.219	0.720	0.340	1.11	0.347	1.13
2	0.164	0.539	0.167	0.550	0.170	0.560	0.174	0.571	0.369	0.883	0.274	0.901
1	0.132	0.431	0.134	0.440	0.137	0.449	0.140	0.457	0.215	0.707	0.220	0.721
1/0	0.104	0.342	0.106	0.349	0.108	0.355	0.110	0.362	0.170	0.560	0.174	0.571
2/0	0.0826	0.271	0.0843	0.276	0.0860	0.282	0.0876	0.288	0.136	0.445	0.139	0.454
3/0	0.0656	0.215	0.0668	0.219	0.0681	0.223	0.0696	0.228	0.107	0.353	0.109	0.360
4/0	0.0520	0.170	0.0530	0.174	0.0541	0.177	0.0552	0.181	0.0853	0.279	0.0869	0.286

Table 30.7 Continued on Next Page

Table 30.7 Continued

Size of Conductor	Uncoated copper				Coated copper (each strand coated with tin or a tin/lead alloy)				Aluminum			
	20°C		25°C		20°C		25°C		20°C		25°C	
	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m
250 kcmil	0.0443	0.145	0.0451	0.148	0.0460	0.151	0.0469	0.154	0.0725	0.238	0.0740	0.243
300	0.0368	0.121	0.0375	0.123	0.0384	0.125	0.0391	0.129	0.0604	0.198	0.0616	0.202
350	0.0316	0.104	0.0322	0.106	0.0328	0.108	0.0335	0.110	0.0518	0.170	0.0528	0.173
400	0.0276	0.0917	0.0282	0.0924	0.0288	0.0942	0.0293	0.0962	0.0453	0.149	0.0462	0.152
450	0.0246	0.0806	0.0251	0.0822	0.0255	0.0838	0.0260	0.0855	0.0403	0.132	0.0411	0.135
500	0.0221	0.0725	0.0225	0.0704	0.0230	0.0755	0.0235	0.0769	0.0362	0.119	0.0370	0.121
550 kcmil	0.0202	0.0663	0.0206	0.0675	0.0210	0.0690	0.0214	0.0703	0.0332	0.108	0.0338	0.111
600	0.0186	0.0607	0.0189	0.0619	0.0193	0.0631	0.0196	0.0644	0.0304	0.0996	0.0310	0.102
650	0.0171	0.0561	0.0174	0.0571	0.0177	0.0583	0.0182	0.0595	0.0280	0.0919	0.0286	0.0937
700	0.0159	0.0520	0.0162	0.0530	0.0165	0.0542	0.0168	0.0552	0.0260	0.0834	0.0265	0.0871
750	0.0148	0.0486	0.0151	0.0496	0.0154	0.0505	0.0157	0.0515	0.0243	0.0797	0.0248	0.0813
800	0.0139	0.0456	0.0142	0.0464	0.0145	0.0473	0.0147	0.0483	0.0227	0.0747	0.0233	0.0762
900	0.0123	0.0405	0.0125	0.0413	0.0129	0.0421	0.0131	0.0429	0.0202	0.0664	0.0206	0.0677
1000	0.0111	0.0364	0.0113	0.0371	0.0115	0.0379	0.0117	0.0387	0.0183	0.0598	0.0186	0.0610
1100	0.0101	0.0332	0.0103	0.0338	0.0105	0.0345	0.0107	0.0351	0.0165	0.0543	0.0169	0.0554
1200	0.00926	0.0304	0.00944	0.0310	0.00963	0.0316	0.00981	0.0322	0.0152	0.0498	0.0155	0.0508
1250	0.00888	0.0292	0.00906	0.0297	0.00924	0.0303	0.00942	0.0309	0.0146	0.0478	0.0149	0.0488
1300	0.00855	0.0280	0.00871	0.0286	0.00888	0.0292	0.00906	0.0297	0.0140	0.0460	0.0143	0.0469
1400	0.00794	0.0260	0.00809	0.0265	0.00825	0.0270	0.00842	0.0276	0.0131	0.0426	0.0133	0.0436

Table 30.7 Continued on Next Page

Table 30.7 Continued

Size of Conductor	Uncoated copper				Coated copper (each strand coated with tin or a tin/lead alloy)				Aluminum			
	20°C		25°C		20°C		25°C		20°C		25°C	
	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m
1500	0.00741	0.0243	0.00755	0.0248	0.00770	0.0253	0.00785	0.0258	0.0121	0.0398	0.0123	0.0406
1600	0.00701	0.0230	0.00715	0.0235	0.00729	0.0239	0.00744	0.0244	0.0115	0.0377	0.0117	0.0385
1700	0.00660	0.0216	0.00672	0.0220	0.00686	0.0225	0.00700	0.0230	0.0108	0.0355	0.0110	0.0362
1750	0.00641	0.0210	0.00654	0.0214	0.00666	0.0218	0.00679	0.0223	0.0105	0.0345	0.0107	0.0352
1800	0.00623	0.0204	0.00635	0.0208	0.00648	0.0212	0.00661	0.0216	0.0102	0.0335	0.0104	0.0342
1900	0.00591	0.0194	0.00602	0.0198	0.00614	0.0201	0.00626	0.0205	0.00968	0.0317	0.00987	0.0323
2000	0.00561	0.0184	0.00572	0.0188	0.00583	0.0192	0.00595	0.0195	0.00919	0.0302	0.00937	0.0308

Table 30.8
Maximum direct-current resistance of ASTM Class H stranded conductors

Size of Conductor	Uncoated copper				Coated copper (each strand coated with tin or a tin/lead alloy)				Aluminum			
	20°C		25°C		20°C		25°C		20°C		25°C	
	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m
8 AWG	0.666	2.18	0.679	2.23	0.708	2.33	0.722	2.37	–	–	–	–
7	0.528	1.73	0.539	1.76	0.561	1.85	0.572	1.88	–	–	–	–
6	0.419	1.38	0.427	1.41	0.446	1.46	0.454	1.49	–	–	–	–
5	0.333	1.09	0.339	1.11	0.353	1.16	0.360	1.18	–	–	–	–
4	0.263	0.865	0.268	0.881	0.279	0.918	0.286	0.936	–	–	–	–
(wires)												
3	0.209	0.686	0.213	0.700	0.222	0.728	0.226	0.743	–	–	–	–
2 (133)	0.166	0.544	0.169	0.555	0.172	0.566	0.175	0.576	0.271	0.891	0.277	0.910
2 (259)	0.166	0.547	0.170	0.557	0.176	0.580	0.181	0.592	–	–	–	–
1	0.133	0.434	0.135	0.442	0.141	0.460	0.143	0.469	–	–	–	–
1/0	0.105	0.344	0.107	0.350	0.109	0.357	0.111	0.364	0.171	0.563	0.175	0.574
2/0	0.0830	0.272	0.0847	0.277	0.0864	0.284	0.0880	0.289	0.136	0.447	0.139	0.456
3/0 (259)	0.0659	0.216	0.0672	0.220	0.0685	0.224	0.0699	0.230	0.108	0.354	0.110	0.361
3/0 (427)	0.0662	0.217	0.0675	0.221	0.0703	0.231	0.0717	0.236	–	–	–	–
4/0 (259)	0.0522	0.171	0.0532	0.174	0.0544	0.179	0.0554	0.182	0.0857	0.280	0.0874	0.287
4/0 (427)	0.0525	0.172	0.0536	0.175	0.0546	0.180	0.0557	0.183	0.0861	0.283	0.0878	0.288
250 kcmil	0.0445	0.146	0.0453	0.149	0.0462	0.152	0.0471	0.155	0.0728	0.239	0.0743	0.244
300	0.0370	0.121	0.0377	0.123	0.0386	0.126	0.0393	0.129	0.0607	0.199	0.0619	0.203
350	0.0317	0.104	0.0323	0.106	0.0330	0.108	0.0337	0.110	0.0520	0.170	0.0530	0.174
400	0.0277	0.0911	0.0284	0.0929	0.0289	0.0948	0.0295	0.0966	0.0455	0.149	0.0464	0.152

Table 30.8 Continued on Next Page

Table 30.8 Continued

Size of Conductor	Uncoated copper				Coated copper (each strand coated with tin or a tin/lead alloy)				Aluminum			
	20°C		25°C		20°C		25°C		20°C		25°C	
	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m
450	0.0247	0.0810	0.0252	0.0826	0.0257	0.0843	0.0262	0.0859	0.0405	0.133	0.0413	0.136
500	0.0222	0.0729	0.0226	0.0744	0.0232	0.0758	0.0236	0.0773	0.0364	0.119	0.0371	0.122
550	0.0204	0.0669	0.0208	0.0682	0.0212	0.0696	0.0216	0.0709	0.0335	0.110	0.0341	0.112
600	0.0187	0.0613	0.0191	0.0625	0.0195	0.0638	0.0198	0.0650	0.0306	0.100	0.0312	0.103
650	0.0172	0.0566	0.0175	0.0577	0.0180	0.0589	0.0183	0.0600	0.0283	0.0928	0.0289	0.0947
700	0.0160	0.0525	0.0163	0.0536	0.0166	0.0547	0.0170	0.0557	0.0262	0.0862	0.0268	0.0879
750 kcmil	0.0150	0.0491	0.0152	0.0500	0.0155	0.0510	0.0158	0.0520	0.0245	0.0804	0.0250	0.0820
800	0.0140	0.0460	0.0143	0.0470	0.0146	0.0478	0.0149	0.0488	0.0230	0.0754	0.0235	0.0769
900	0.0124	0.0409	0.0128	0.0417	0.0130	0.0425	0.0133	0.0434	0.0204	0.0670	0.0208	0.0683
1000	0.0112	0.0368	0.0114	0.0375	0.0116	0.0382	0.0119	0.0390	0.0184	0.0603	0.0188	0.0615
1100	0.0102	0.0335	0.0104	0.0341	0.0106	0.0348	0.0108	0.0354	0.0167	0.0549	0.0170	0.0559
1200	0.00934	0.0307	0.00953	0.0312	0.00972	0.0319	0.00990	0.0325	0.0153	0.0503	0.0156	0.0513
1250	0.00897	0.0295	0.00915	0.0300	0.00933	0.0306	0.00952	0.0312	0.0147	0.0482	0.0150	0.0493
1300	0.00863	0.0283	0.00879	0.0289	0.00897	0.0295	0.00915	0.0300	0.0142	0.0464	0.0144	0.0473
1400	0.00801	0.0263	0.00817	0.0268	0.00833	0.0273	0.00850	0.0278	0.0132	0.0430	0.0134	0.0439
1500	0.00748	0.0245	0.00762	0.0250	0.00777	0.0255	0.00793	0.0260	0.0122	0.0402	0.0125	0.0410
1600	0.00701	0.0230	0.00715	0.0235	0.00729	0.0239	0.00744	0.0244	0.0115	0.0377	0.0117	0.0385
1700	0.00660	0.0216	0.00672	0.0220	0.00686	0.0225	0.00700	0.0230	0.0108	0.0355	0.0110	0.0362
1750	0.00641	0.0210	0.00654	0.0214	0.00666	0.0218	0.00679	0.0223	0.0105	0.0345	0.0107	0.0352

Table 30.8 Continued on Next Page

Table 30.8 Continued

Size of Conductor	Uncoated copper				Coated copper (each strand coated with tin or a tin/lead alloy)				Aluminum			
	20°C		25°C		20°C		25°C		20°C		25°C	
	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m
1800	0.00623	0.0204	0.00635	0.0208	0.00648	0.0212	0.00661	0.0216	0.0102	0.0335	0.0104	0.0342
1900	0.00591	0.0194	0.00602	0.0198	0.00614	0.0201	0.00626	0.0205	0.00968	0.0317	0.00987	0.0323
2000	0.00561	0.0184	0.00572	0.0188	0.00583	0.0192	0.00595	0.0195	0.00919	0.0302	0.00937	0.0308

Table 30.9
Maximum direct-current resistance of ASTM Class I stranded conductors

Size of Conductor	Uncoated copper				Coated copper (each strand coated with tin or a tin/lead alloy)				Aluminum			
	20°C		25°C		20°C		25°C		20°C		25°C	
	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m
10 AWG	1.04	3.41	1.06	3.48	1.08	3.55	1.10	3.62	–	–	–	–
9	0.824	2.70	0.840	2.75	0.857	2.82	0.874	2.87	–	–	–	–
8	0.654	2.14	0.666	2.18	0.679	2.23	0.693	2.27	1.07	3.52	1.09	3.59
7	0.518	1.70	0.528	1.73	0.538	1.76	0.550	1.81	0.850	2.78	0.867	2.85
6	0.419	1.38	0.427	1.41	0.436	1.43	0.445	1.46	0.687	2.25	0.701	2.31
5	0.333	1.09	0.339	1.11	0.346	1.13	0.353	1.15	0.545	1.79	0.556	1.83
4	0.263	0.865	0.268	0.881	0.274	0.900	0.279	0.917	0.432	1.42	0.441	1.45
3	0.209	0.686	0.213	0.700	0.217	0.713	0.221	0.727	0.343	1.12	0.350	1.14
2	0.166	0.544	0.169	0.555	0.172	0.566	0.175	0.576	0.271	0.891	0.277	0.910
1	0.132	0.431	0.134	0.440	0.137	0.449	0.140	0.457	0.215	0.707	0.220	0.721
1/0	0.105	0.345	0.107	0.352	0.109	0.359	0.111	0.366	0.172	0.566	0.175	0.577
2/0	0.0834	0.273	0.0851	0.279	0.0868	0.285	0.0885	0.291	0.137	0.449	0.140	0.458
3/0	0.0662	0.217	0.0675	0.221	0.0689	0.225	0.0702	0.231	0.108	0.356	0.111	0.363
4/0	0.0525	0.172	0.0536	0.175	0.0546	0.180	0.0557	0.183	0.0861	0.283	0.0878	0.288
250 kcmil	0.0449	0.147	0.0457	0.150	0.0466	0.153	0.0475	0.156	0.0735	0.242	0.0750	0.246
300	0.0373	0.122	0.0381	0.125	0.0389	0.128	0.0397	0.130	0.0613	0.201	0.0625	0.205
350	0.0320	0.105	0.0326	0.107	0.0334	0.109	0.0340	0.111	0.0525	0.172	0.0536	0.175
400	0.0280	0.0920	0.0286	0.0937	0.0292	0.0957	0.0297	0.0975	0.0460	0.151	0.0469	0.154

Table 30.9 Continued on Next Page

Table 30.9 Continued

Size of Conductor	Uncoated copper				Coated copper (each strand coated with tin or a tin/lead alloy)				Aluminum			
	20°C		25°C		20°C		25°C		20°C		25°C	
	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m
450	0.0249	0.0817	0.0254	0.0833	0.0259	0.0850	0.0264	0.0867	0.0408	0.134	0.0417	0.137
500	0.0224	0.0735	0.0228	0.0751	0.0234	0.0765	0.0238	0.0780	0.0367	0.120	0.0375	0.123
550	0.0204	0.0669	0.0208	0.0682	0.0212	0.0696	0.0216	0.0709	0.0335	0.110	0.0341	0.112
600	0.0187	0.0613	0.0191	0.0625	0.0195	0.0638	0.0198	0.0650	0.0306	0.100	0.0312	0.103
650	0.0174	0.0571	0.0177	0.0582	0.0182	0.0594	0.0185	0.0606	0.0286	0.0936	0.0292	0.0956
700	0.0162	0.0530	0.0165	0.0541	0.0168	0.0552	0.0171	0.0563	0.0265	0.0870	0.0270	0.0887
750 kcmil	0.0151	0.0495	0.0154	0.0505	0.0157	0.0515	0.0160	0.0525	0.0248	0.0812	0.0252	0.0828
800	0.0142	0.0464	0.0144	0.0473	0.0147	0.0482	0.0150	0.0493	0.0232	0.0761	0.0237	0.0776
900	0.0125	0.0413	0.0129	0.0420	0.0131	0.0429	0.0134	0.0438	0.0206	0.0676	0.0210	0.0691
1000	0.0113	0.0371	0.0115	0.0378	0.0117	0.0387	0.0120	0.0394	0.0186	0.0610	0.0190	0.0621
1100	0.0103	0.0338	0.0105	0.0344	0.0107	0.0351	0.0109	0.0358	0.0168	0.0554	0.0172	0.0565
1200	0.00944	0.0310	0.00962	0.0315	0.00981	0.0322	0.0101	0.0328	0.0155	0.0507	0.0158	0.0517
1250	0.00906	0.0297	0.00923	0.0303	0.00941	0.0310	0.00960	0.0315	0.0149	0.0487	0.0151	0.0497
1300	0.00871	0.0286	0.00887	0.0292	0.00906	0.0297	0.00923	0.0303	0.0143	0.0468	0.0146	0.0477
1400	0.00809	0.0265	0.00824	0.0270	0.00840	0.0275	0.00858	0.0282	0.0133	0.0435	0.0136	0.0444
1500	0.00755	0.0248	0.00769	0.0252	0.00784	0.0257	0.00801	0.0262	0.0123	0.0406	0.0126	0.0414
1600	0.00708	0.0233	0.00721	0.0237	0.00735	0.0242	0.00750	0.0246	0.0116	0.0380	0.0118	0.0389
1700	0.00666	0.0218	0.00679	0.0222	0.00693	0.0227	0.00706	0.0232	0.0109	0.0358	0.0111	0.0365
1750	0.00647	0.0212	0.00660	0.0216	0.00672	0.0220	0.00685	0.0225	0.0106	0.0348	0.0108	0.0355

Table 30.9 Continued on Next Page

Table 30.9 Continued

Size of Conductor	Uncoated copper				Coated copper (each strand coated with tin or a tin/lead alloy)				Aluminum			
	20°C		25°C		20°C		25°C		20°C		25°C	
	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m
1800	0.00629	0.0206	0.00642	0.0210	0.00654	0.0214	0.00667	0.0218	0.0103	0.0339	0.0105	0.0345
1900	0.00596	0.0196	0.00608	0.0199	0.00619	0.0203	0.00631	0.0207	0.00977	0.0320	0.00997	0.0326
2000	0.00566	0.0186	0.00577	0.0190	0.00589	0.0193	0.00600	0.0197	0.00928	0.0304	0.00947	0.0310

Table 30.10
Maximum direct-current resistance of ASTM Class K stranded conductors

Size of conductor	Uncoated copper				Coated copper (each strand coated with tin or a tin/lead alloy)			
	20°C		25°C		20°C		25°C	
	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m
14 AWG	2.62	8.61	2.67	8.78	2.82	9.25	2.88	9.42
13	2.08	6.84	2.12	6.97	2.23	7.34	2.28	7.48
12	1.65	5.43	1.68	5.53	1.77	5.82	1.81	5.94
11	1.31	4.30	1.33	4.39	1.40	4.61	1.44	4.71
10	1.04	3.41	1.06	3.48	1.11	3.66	1.14	3.73
9	0.840	2.75	0.857	2.82	0.903	2.96	0.920	3.02
8	0.666	2.18	0.679	2.23	0.715	2.35	0.729	2.40
7	0.528	1.73	0.539	1.76	0.567	1.87	0.578	1.90
6	0.419	1.38	0.427	1.41	0.450	1.48	0.459	1.51
5	0.333	1.09	0.339	1.11	0.357	1.17	0.364	1.19
4	0.263	0.865	0.268	0.881	0.283	0.928	0.289	0.947
3	0.211	0.693	0.215	0.706	0.226	0.744	0.232	0.758
2	0.167	0.549	0.170	0.560	0.180	0.590	0.184	0.601
1	0.133	0.436	0.136	0.444	0.143	0.467	0.145	0.476
1/0	0.105	0.345	0.107	0.352	0.113	0.370	0.115	0.377
2/0	0.0843	0.276	0.0859	0.282	0.0904	0.297	0.0922	0.303
3/0	0.0668	0.219	0.0681	0.223	0.0717	0.236	0.0731	0.240
4/0	0.0530	0.173	0.0541	0.177	0.0569	0.187	0.0580	0.191
250 kcmil	0.0449	0.147	0.0457	0.150	0.0481	0.158	0.0491	0.161
300	0.0373	0.122	0.0381	0.125	0.0401	0.132	0.0409	0.135
350	0.0323	0.106	0.0329	0.108	0.0347	0.114	0.0354	0.116
400	0.0283	0.0928	0.0289	0.0947	0.0304	0.0997	0.0310	0.102
450	0.0252	0.0825	0.0256	0.0842	0.0270	0.0886	0.0275	0.0904
500	0.0226	0.0743	0.0231	0.0757	0.0243	0.0798	0.0248	0.0813
550	0.0206	0.0675	0.0210	0.0688	0.0221	0.0725	0.0225	0.0740
600	0.0189	0.0619	0.0193	0.0631	0.0203	0.0664	0.0207	0.0677
650	0.0174	0.0571	0.0177	0.0582	0.0187	0.0613	0.0191	0.0625

Table 30.10 Continued on Next Page

Table 30.10 Continued

Size of conductor	Uncoated copper				Coated copper (each strand coated with tin or a tin/lead alloy)			
	20°C		25°C		20°C		25°C	
	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m
700	0.0162	0.0530	0.0165	0.0541	0.0173	0.0569	0.0177	0.0580
750	0.0151	0.0495	0.0154	0.0505	0.0162	0.0531	0.0165	0.0542
800	0.0142	0.0464	0.0144	0.0473	0.0152	0.0499	0.0155	0.0508
900	0.0125	0.0413	0.0129	0.0420	0.0135	0.0443	0.0138	0.0452
1000	0.0113	0.0371	0.0115	0.0378	0.0121	0.0399	0.0124	0.0407

Table 30.11
Maximum direct-current resistance of ASTM Class M stranded conductors

Size of conductor	Uncoated copper				Coated copper (each strand coated with tin or a tin/lead alloy)			
	20°C		25°C		20°C		25°C	
	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m
14 AWG	2.62	8.61	2.67	8.78	2.82	9.25	2.88	9.42
13	2.10	6.89	2.13	7.03	2.26	7.40	2.31	7.54
12	1.68	5.53	1.71	5.64	1.81	5.94	1.85	6.05
11	1.33	4.39	1.36	4.47	1.44	4.71	1.46	4.79
10	1.06	3.48	1.08	3.55	1.14	3.73	1.16	3.80
9	0.840	2.75	0.857	2.82	0.898	2.96	0.920	3.02
8	0.666	2.18	0.679	2.23	0.715	2.35	0.729	2.40
7	0.533	1.75	0.544	1.78	0.572	1.88	0.584	1.92
6	0.423	1.39	0.431	1.42	0.455	1.49	0.463	1.52
5	0.336	1.10	0.343	1.12	0.360	1.18	0.367	1.20
4	0.266	0.873	0.271	0.887	0.286	0.937	0.292	0.956
3	0.213	0.699	0.217	0.704	0.226	0.744	0.232	0.758
2	0.169	0.554	0.172	0.565	0.182	0.595	0.185	0.607
1	0.134	0.440	0.137	0.448	0.144	0.472	0.147	0.481
1/0	0.106	0.349	0.108	0.355	0.114	0.374	0.116	0.381
2/0	0.0851	0.276	0.0867	0.282	0.0913	0.300	0.0931	0.305
3/0	0.0674	0.221	0.0687	0.225	0.0724	0.238	0.0738	0.242
4/0	0.0534	0.175	0.0546	0.179	0.0574	0.189	0.0585	0.192

Table 30.11 Continued on Next Page

Table 30.11 Continued

Size of conductor	Uncoated copper				Coated copper (each strand coated with tin or a tin/lead alloy)			
	20°C		25°C		20°C		25°C	
	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m	Ohms per 1000 feet	Ohms per 1000 m
250 kcmil	0.0453	0.149	0.0462	0.151	0.0487	0.159	0.0496	0.162
300	0.0377	0.123	0.0385	0.125	0.0405	0.133	0.0413	0.136
350	0.0323	0.106	0.0329	0.108	0.0347	0.114	0.0354	0.116
400l	0.0283	0.0928	0.0289	0.0947	0.0304	0.0997	0.0310	0.102
450	0.0252	0.0825	0.0256	0.0842	0.0261	0.0858	0.0267	0.0875
500	0.0226	0.0743	0.0231	0.0757	0.0243	0.0798	0.0248	0.0813
550	0.0206	0.0675	0.0210	0.0688	0.0221	0.0725	0.0225	0.0740
600	0.0189	0.0619	0.0193	0.0631	0.0203	0.0664	0.0206	0.0677
650	0.0174	0.0571	0.0177	0.0582	0.0187	0.0613	0.0191	0.0625
700	0.0162	0.0530	0.0165	0.0541	0.0173	0.0569	0.0177	0.0580
750	0.0151	0.0495	0.0154	0.0505	0.0162	0.0531	0.0165	0.0542
800	0.0142	0.0464	0.0144	0.0473	0.0152	0.0499	0.0155	0.0508
900	0.0125	0.0413	0.0129	0.0420	0.0135	0.0443	0.0138	0.0452
1000	0.0113	0.0371	0.0115	0.0378	0.0121	0.0399	0.0123	0.0407

31 thru 39 *Reserved for Future Use*

INSULATION AND JACKET MATERIALS

40 General

40.1 The chemical composition of an insulating or jacketing material is not specified.

40.2 The methods of preparation of samples, of selection and conditioning of specimens, and of making the measurements and calculations for ultimate elongation and tensile strength are indicated under the heading Physical Properties Tests of Insulation and Jacket in this standard (see Sections 400 – 481).

41 thru 46 *Reserved for Future Use*

47 Index Table

47.1 Table 47.1 is an index to most of the materials that are for use as insulation and jackets in the various types of wire, cable, and flexible cord. The materials are grouped alphabetically by their generic designations. Physical properties requirements are given in the indicated tables(s) or paragraphs in Specific Materials, Section 50 of this standard, either for the particular insulation or jacket material from an individual type as specified in the applicable wire standard or for the generic material type.

47.2 *Deleted*

47.3 *Deleted*

Table 47.1
Index to insulation and jacket materials

Material	Applicable table(s) or paragraphs in this standard
CP	
Insulations and jackets from Type USE-2 and USE cable;	Table 50.1
power-limited circuit cable; cable for power-limited fire-alarm circuits; other cables; and jacket from CATV cables	
Jacket from cable for deep-well submersible water pumps	Table 50.10
105°C insulation and jacket	Table 50.22
90°C insulation and jacket	Table 50.23
60°C jacket	Table 50.24
CPE	
90°C Thermoplastic jacket from CATV cables, power-limited circuit cable,	Table 50.28
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Thermoset jacket from CATV cables, power-limited circuit cable,	Table 50.29
cable for power-limited fire-alarm circuits, Type USE and USE-2 cables, and other cables,	
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Jacket from cable for deep-well submersible water pumps	Table 50.31
90°C insulation	Table 50.32
90°C insulation and jacket	Table 50.23
105°C thermoset insulation and jacket	Table 50.33
75°C and 90°C insulation from Type USE and USE-2 cables	Table 50.34
ECA	
300°C Insulations and jackets from appliance-wiring material	Table 50.40
ECTFE and ETFE	
ETFE insulation from Type Z and ZW wires	Table 50.63
and from 150°C Type ZF and ZFF wires and insulation and jacket from power-limited circuit cable, cable for power-limited fire-alarm circuits, and other cables; and jacket from CATV cables	
200°C insulation	Table 50.64
EP	
75°C and 90°C EPDM insulation and jacket	Table 50.52
75°C insulation	Table 50.54

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Material	Applicable table(s) or paragraphs in this standard
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60°C and 75°C insulation and jacket	Table 50.24
125°C insulation	Table 50.56
EPCV	
90°C Insulation	Table 50.62
EVA	
75°C insulation and jacket	Table 50.246
90°C insulation and jacket	Table 50.247
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FEP	
Insulation and jacket from power-limited circuit-cable, cable for power-limited fire-alarm circuits, and other cables; and insulation from Types FEP and FEPB; jacket from CATV cables	Table 50.73
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90°C insulation and jacket	Table 50.134
FRPP	
Insulation from power-limited circuit cable and cable for power-limited fire-alarm circuits; jacket from CATV cables	Table 50.139.1
MFA	
Insulations and jackets from appliance-wiring material	Table 50.137
mPPE	
90°C and 105°C insulations and jackets from appliance-wiring material	Table 50.77
mPPE-PE	
80°C Insulations and jackets from appliance-wiring material	Table 50.76
NBR/PVC	
75°C Jacket from power-limited circuit cable, cable for power-limited fire-alarm circuits, and other cable	Table 50.80
90°C Jacket from CATV cables, power-limited circuit cable, cable for power-limited fire-alarm circuits, and other cables	Table 50.83

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90°C jacket from Type USE-2 and USE cables	Table 50.99
75°C jacket from Type USE cable	Table 50.100
90°C insulation and jacket	Table 50.23
60°C and 75°C insulation and jacket	Table 50.24
90°C jacket	Table 50.98
Neoprene	
90°C jacket from Type USE and USE-2 cables	Table 50.99
75°C jacket Type USE cable	Table 50.100
Jacket from cable for deep-well submersible water pumps	Table 50.112
60°C insulation	Table 50.120
60°C jacket	Table 50.122
75°C jacket and jacket from CATV cables, power-limited circuit cable, cable for power-limited fire-alarm circuits, and other cables	Table 50.123
90°C jacket from CATV cables, power-limited circuit cable, cable for power-limited fire-alarm circuits, and other cables	Table 50.124
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PFA	
Insulation from Type PFA and PFAH wires, jacket from CATV cables, and insulation and jacket from other wires and cables	Table 50.137
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PP	
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90°C insulation	Table 50.155
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60°C, 75°C, 90°C, 105°C insulation and jacket;	Table 50.182
insulation and jacket from power-limited circuit cable and cable from power-limited fire-alarm circuits, and from other cables; jacket from CATV cables	
60°C, 75°C, 90°C, 105°C insulation and jacket from medium- and low-power broadband cables rated for 60°C, 75°C, 90°C, and 105°C.	Table 50.142
Thermoplastic insulation other than PVC from Type NM cables	Table 50.144
SRPVC (semirigid PVC)	
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PVC/TPU	
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Type TFE, PTF, and PTFF wires and PTFE (TFE) insulation from power-limited circuit cable and cable for power-limited fire-alarm circuits	
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60°C jacket	Table 50.196
75°C insulation	Table 50.198
75°C insulation	Table 50.199
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75°C SBR/NR insulation	Table 50.54
60°C and 75°C SBR/NR insulation and jacket	Table 50.24
SBR/IIR/NR – see "Rubber"	
Silicone rubber	
Insulation from Type SA	Table 50.205

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Material	Applicable table(s) or paragraphs in this standard
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Insulation and insulation from power-limited circuit cable, cable for power-limited fire-alarm circuits, from other cables, and jackets for CATV cables	Table 50.210
TFE	
PTFE insulation and PTFE insulation from power-limited circuit cable,	Table 50.219
from cable for power-limited fire-alarm circuits, from other cables, and from Type TFE wire	
THV	
80°C jackets from appliance-wiring material	Table 50.221
TPE	
105°C insulation and jacket from power-limited circuit	Table 50.223
cable and from cable for power-limited fire-alarm circuits, and from other cables; and 105°C insulation and jacket, and 105°C jacket from CATV cables	
90°C insulation and jacket from power-limited circuit cable	Table 50.224
and from cable for power-limited fire-alarm circuits, and from other cables; and 90°C insulation and jacket; 90°C jacket from CATV cables	
TPES	
Insulations and jackets from appliance-wiring material	Table 50.226
TPU	
60°C, 75°C, and 80°C insulations and jackets from appliance-wiring material	Table 50.227
90°C insulations and jackets from appliance-wiring material	Table 50.227.1
105°C insulations and jackets from appliance-wiring material	Table 50.227.2
XL	
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75°C jacket from Type USE cable	Table 50.229
Jacket from cable for deep-well submersible water pumps	Table 50.230
XL insulation from Type RFHH-2, RFHH-3,	Table 50.231
and power-limited circuit cable, cable for power-limited fire-alarm circuits, and other cables; jackets from CATV cables	
90°C	Table 50.237
105°C	Table 50.245
XLPO insulation	
125°C insulation	Table 50.232
150°C insulation	Table 50.232
105°C insulation or jacket from power-limited circuit-cable, cable for power-limited fire-alarm circuits, and other cables	Table 50.233

48 thru 49 *Reserved for Future Use*

50 Specific Materials

Table 50.1
Physical properties of 90°C and 75°C CP[a] jackets from CATV cables and insulations and jackets from Type USE and USE-2 cables; power-limited circuit cable; cable for power-limited fire-alarm circuits; and other cables

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)	Minimum tensile strength
Unaged	200 percent	1500 lbf/in^2 or 10.3 MPa
Aged in a full-draft circulating-air oven for 168 h:		
At 121.0 ±1.0°C (249.8 ±1.8°F) for specimens of 90°C insulation or jacket from power-limited circuit cable, or Type USE-2 cable or	50 percent of the result with unaged specimens	85 percent of the result with unaged specimens
At 113.0 ±1.0°C (235.4 ±1.8°F) for specimens of 75°C insulation or jacket from power-limited circuit cable, cable for power-limited fire-alarm circuits, or from Type USE cable	50 percent of the result with unaged specimens	85 percent of the result with unaged specimens
Aged in oil for 18 h at 121.0 ±1.0°C (249.8 ±1.8°F)	60 percent of the result with unaged specimens	60 percent of the result with unaged specimens

[a] CP designates a thermoset compound whose characteristic constituent is chlorosulfonated polyethylene.

Table 50.10
Physical properties of CP[a] jacket from cable for deep-well submersible water pumps

Condition of specimens at time of measurement	Maximum set in recovery test (1-inch or 25-mm bench marks stretched to 3 inches or 75 mm)	Minimum ultimate elongation (1-inch or 25-mm bench marks)	Minimum tensile strength
Unaged	25 percent (1/4 inch or 6.2 mm)	300 percent (3 inches or 75 mm)	1500 lbf/in^2 or 10.3 MPa
Aged in a full-draft circulating-air oven for 168 h at 70.0 ±1.0°C (158.0 ±1.8°F)	Not measured	70 percent of the result with unaged specimens	70 percent of the result with unaged specimens
Aged in oil for 18 h at 121.0 ±1.0°C (249.8±1.8°F)	Not measured	60 percent of the result with unaged specimens	60 percent of the result with unaged specimens

[a] CP designates a thermoset compound whose characteristic constituent is chlorosulfonated polyethylene.

Table 50.20
Physical properties of Class 24 90°C (194°F) CP[a] insulation and jacket

Table deleted

Table 50.21
Physical properties of Class 26 60°C (140°F) CP[a] jacket

Table deleted

Table 50.22
Physical properties of 105°C CP [a] insulation and jacket

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)	Minimum tensile strength
Unaged	200 percent (2 inches or 50 mm)	1200 lbf/in^2 or 8.27 MPa
Aged in a full-draft circulating-air oven for 168 h at 136.0 ±1.0°C (276.8 ±1.8°F)	100 percent (1 inch or 25 mm)	1200 lbf/in^2 or 8.27 MPa
60°C oil-resistant insulation or jacket: Aged in oil for 18 h at 121.0 ±1.0°C (249.8 ±1.8°F)	60 percent of the result with unaged specimens	60 percent of the result with unaged specimens

[a] CP designates a thermoset compound whose characteristic constituent is chlorosulfonated polyethylene.

Table 50.23
Physical properties of 90°C CP[a], CPE[b], and NBR/PVC[c] insulations and jacket

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)	Minimum tensile strength
Unaged	200 percent (2 inches or 50 mm)	1200 lbf/in^2 or 8.27 MPa
Aged in a full-draft circulating-air oven for 168 h at 121.0 ±1.0°C (249.8 ±1.8°F)	100 percent (1 inch or 25 mm)	1200 lbf/in^2 or 8.27 MPa
60°C oil-resistant insulation or jacket: Aged in oil for 18 h at 121.0 ±1.0°C (249.8 ±1.8°F)	60 percent of the result with unaged specimens	60 percent of the result with unaged specimens

[a] CP designates a thermoset compound whose characteristic constituent is chlorosulfonated polyethylene.

[b] CPE designates a thermoset compound whose characteristic constituent is chlorinated polyethylene.

[c] NBR/PVC designates a thermoset compound whose characteristic constituents are acrylonitrile butadiene rubber and polyvinyl chloride.

Table 50.24
Physical properties of 60°C and 75°C CP[a], EPDM[b], NBR/PVC[c], neoprene[d], and SBR/NR[e] insulations and jackets

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)		Minimum tensile strength	
	60°C compound	75°C compound	60°C compound	75°C compound
Unaged	200 percent (2 inches or 50 mm)		1500 lbf/in^2 or 10.3 MPa	
Aged in a full-draft circulating-air oven for 168 h at 70.0 ±1.0°C (158.0 ±1.8°F)	65 percent of the result with unaged specimens where the sum of the tensile and elongation percentages is at least 140. Otherwise, 70 percent of the result with unaged specimens	Not measured	65 percent of the result with unaged specimens where the sum of the tensile and elongation percentages is at least 140. Otherwise, 70 percent of the result with unaged specimens	Not measured
Aged in a full-draft circulating-air oven for 240 h at 100.0 ±1.0°C (212.0±1.8°F)	Not measured	50 percent of the result with unaged specimens	Not measured	70 percent of the result with unaged specimens
60°C oil-resistant jacket: Aged in oil for 18 h at 121.0 ±1.0°C (249.8 ±1.8°F)	60 percent of the result with unaged specimens			

[a] CP designates a thermoset compound whose characteristic constituent is chlorosulfonated polyethylene.

[b] EPDM designates a thermoset compound whose characteristic constituent is a terpolymer of ethylene, propylene, and small amount of nonconjugated diene.

[c] NBR/PVC designates a thermoset compound whose characteristic constituents are acrylonitrile butadiene rubber and polyvinyl chloride.

[d] Neoprene designates a thermoset compound whose characteristic constituent is polychloroprene.

[e] SBR/NR designates a thermoset compound whose characteristic constituent is SBR, NR (natural rubber), or a blend of the two.

Table 50.28
Physical properties of 90°C thermoplastic CPE[a] jacket from CATV cables, power-limited circuit cable, cable for power-limited fire-alarm circuits, and other cables

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)	Minimum tensile strength
Unaged	150 percent (1-1/2 inches or 38 mm)	1400 lbf/in^2 or 9.65 MPa
Aged in a full-draft circulating-air oven for 168 h at 121.0 ±1.0°C (249.8 ±1.8°F)	50 percent of the result with unaged specimens	85 percent of the result with unaged specimens

[a] CPE designates a thermoplastic compound whose characteristic constituent is chlorinated polyethylene.

Table 50.29
Physical properties of 90°C thermoset CPE[a] jacket from CATV cables, power-limited circuit cable, cable for power-limited fire-alarm circuits, and Type USE-2 cables

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)	Minimum tensile strength
Unaged	250 percent (2-1/2 inches or 62.5 mm)	1500 lbf/in^2 or 10.3 MPa
Aged in a full-draft circulating-air oven for 168 h at 121.0 ±1.0°C (249.8 1.8°F)	60 percent of the result with unaged specimens	85 percent of the result with unaged specimens
Aged in oil for 18 h at 121.0 ±1.0°C (249.8±1.8°F)	60 percent of the result with unaged specimens	60 percent of the result with unaged specimens

[a] Thermoset CPE designates a thermoset compound whose characteristic constituent is chlorinated polyethylene.

Table 50.30
Physical properties of 75°C thermoset CPE[a] jacket from CATV cables, power-limited circuit cable, cable for power-limited fire-alarm circuits, Type USE cable, and other cables

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)	Minimum tensile strength
Unaged	200 percent (2-1/2 inches or 62.5 mm)	1500 lbf/in^2 or 10.3 MPa
Aged in a full-draft circulating-air oven for 168 h at 113.0 ±1.0°C (235.4 ±1.8°F)	60 percent of the result with unaged specimens	85 percent of the result with unaged specimens
Aged in oil for 18 h at 121.0 ±1.0°C (249.8 ±1.8°F)	60 percent of the result with unaged specimens	60 percent of the result with unaged specimens

[a] Thermoset CPE is described in note [a] to Table 50.29.

Table 50.31
Physical properties of thermoset CPE[a] jacket from cable for deep-well submersible water pumps

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)	Minimum tensile strength
Unaged	200 percent (2-1/2 inches or 62.5 mm)	1500 lbf/in^2 or 10.3 MPa
Aged in a full-draft circulating-air oven for 168 h at 113.0 ±1.0°C (235.4 ±1.8°F)	60 percent of the result with unaged specimens	85 percent of the result with unaged specimens
Aged in oil for 18 h at 121.0 ±1.0°C (249.8 ±1.8°F)	60 percent of the result with unaged specimens	60 percent of the result with unaged specimens

[a] Thermoset CPE is described in note [a] to Table 50.29.

Table 50.32
Physical properties of 90°C thermoset CPE[a] insulation

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)	Minimum tensile strength
Unaged	200 percent (2 inches or 50 mm)	1200 lbf/in^2 or 8.27 MPa
Aged in a full-draft circulating-air oven for 168 h at 121.0 ±1.0°C (249.8 ±1.8°F)	100 percent (1 inch or 25 mm)	1200 lbf/in^2 or 8.27 MPa
60°C oil-resistant insulation or jacket:		
Aged in oil for 18 h at 121.0 ±1.0°C (249.8 ±1.8°F)	60 percent of the result with unaged specimens	60 percent of the result with unaged specimens

[a] Thermoset CPE designates a thermoset compound whose characteristic constituent is chlorinated polyethylene.

Table 50.33
Physical properties of 105°C thermoset CPE[a] insulation and jacket

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)	Minimum tensile strength
Unaged	250 percent (2-1/2 inches or 62.5 mm)	1200 lbf/in^2 or 8.27 MPa
Aged in a full-draft circulating-air oven for 168 h at 136.0 ±1.0°C (276.8 ±1.8°F)	50 percent of the result with unaged specimens	80 percent of the result with unaged specimens
60°C oil-resistant jacket:		
Aged in oil for 18 h at 121.0 ±1.0°C (249.8 ±1.8°F)	60 percent of the result with unaged specimens	60 percent of the result with unaged specimens

[a] Thermoset CPE designates a thermoset compound whose characteristic constituent is chlorinated polyethylene.

Table 50.34
Physical properties of 90°C and 75°C thermoset CPE[a] insulations from Type USE and USE-2 cables

Condition of specimens at time of measurement	Minimum ultimate elongation (1–inch or 25–mm bench marks)	Minimum tensile strength
Unaged	200 percent	1500 lbf/in^2 or 10.3 MPa
Aged in a full-draft circulating-air oven for 168 h:		

Table 50.34 Continued on Next Page

Table 50.34 Continued

Condition of specimens at time of measurement	Minimum ultimate elongation (1–inch or 25–mm bench marks)	Minimum tensile strength
At 121.0 ±1.0°C (249.8 ±1.8°F) for specimens of 90°C insulation or jacket from power-limited circuit cable, Type USE-2 cable	50 percent of the result with unaged specimens	85 percent of the result with unaged specimens
At 113.0 ±1.0°C (235.4 ±1.8°F) for specimens of 75°C insulation or jacket from power-limited circuit cable, cable for power-limited fire-alarm circuits, or from Type USE cable	50 percent of the result with unaged specimens	85 percent of the result with unaged specimens
Aged in oil for 18 h at 121.0 ±1.0°C (249.8 ±1.8°F)	60 percent of the result with unaged specimens	60 percent of the result with unaged specimens

[a] Thermoset CPE designates a thermoset compound whose characteristic constituent is chlorinated polyethylene.

Table 50.40
Physical properties of 300°C ECA[a] insulations and jackets from appliance-wiring material

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)[b]	Minimum tensile strength[b]
Unaged	210 percent (2.1 inches or 53 mm)	2700 lbf/in^2 or 18.6 MPa
Aged in a full-draft circulating-air oven for 30 days at 311 ±2.0°C (592 ±3.6°F)	85 percent of the result with unaged specimens	120 percent of the result with unaged specimens

[a] ECA designates a thermoplastic material epitaxial co-crystallized alloy perfluoropolymer.

[b] ECA is to be tested at a speed of 20 ±1 in/min or 500 ±25 mm/min.

Table 50.42
Physical properties of EP[a] insulation from Type RHW-2, RH, RHW, and RHH wires

(Deleted)

Table 50.52
Physical properties of 75°C and 90°C EPDM[a] insulations and jackets

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)			Minimum tensile strength		
	Insulation		Jacket	Insulation		Jacket
	75°C	90°C	75°C	75°C	90°C	75°C
Unaged	250 percent (2-1/2 inches or 62.5 mm)	250 percent (2-1/2 inches or 62.5 mm)	300 percent (3 inches or 75 mm)	700 lbf/in^2 or 4.83 MPa	700 lbf/in^2 or 4.83 MPa	1500 lbf/in^2 or 10.3 MPa
Aged in a full-draft circulating-air oven for 240 h at 100.0	50 percent of the result with unaged specimens	Not measured	50 percent of the result with unaged specimens	70 percent of the result with unaged specimens	Not measured	70 percent of the result with unaged specimens

Table 50.52 Continued on Next Page

Table 50.52 Continued

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)			Minimum tensile strength		
	Insulation		Jacket	Insulation		Jacket
	75°C	90°C	75°C	75°C	90°C	75°C
±1.0°C (212.0 ±1.8°F)						
Aged in a full-draft circulating-air oven for 240 h at 121.0 ±1.0°C (249.8 ±1.8°F)	Not measured	50 percent of the with unaged specimens	Not measured	Not measured	50 percent of the result with unaged specimens	Not measured

[a] EPDM designates a thermoset compound whose characteristic constituent is a terpolymer of ethylene, propylene, and a small amount of nonconjugated diene.

Table 50.53
Physical properties of Class 35 105°C (221°F) EP[a] insulation

Table deleted

Table 50.54
Physical properties of 75°C EPDM[a] and SBR/NR[b] insulations and jackets

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)	Minimum tensile strength
Unaged	250 percent (2-1/2 inches or 62.5 mm)	600 lbf/in^2 or 4.14 MPa (MN/m^2) or
Aged in a full-draft circulating-air oven for 240 h at 100.0 ±1.0°C (212.0 ±1.8°F)	50 percent of the result with unaged specimens	70 percent of the result with unaged specimens

[a] EPDM designates a thermoset compound whose characteristic constituent is a terpolymer of ethylene, propylene, and a small amount of nonconjugated diene.

[b] SBR/NR designates a thermoset compound whose characteristic constituent is SBR, NR (natural rubber), or a blend of the two.

Table 50.55
Physical properties of 90°C and 105°C EP [a] insulations

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)	Minimum tensile strength
Unaged	200 percent (2 inches or 50 mm)	700 lbf/in^2 or 4.83 MPa
Aged in a full-draft circulating-air oven for the specified time at the specified temperature[b]	50 percent of the result with unaged specimens	50 percent of the result with unaged specimens

Table 50.55 Continued on Next Page

Table 50.55 Continued

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)	Minimum tensile strength
60°C oil-resistant insulation:		
Aged in oil for 18 h at 121.0 ±1.0°C (249.8 ±1.8°F)	60 percent of the result with unaged specimens	60 percent of the result with unaged specimens

[a] EP designates a thermoset compound whose characteristic constituent is a copolymer (EPM) of ethylene and propylene; a terpolymer (EPDM) of ethylene, propylene, and a small amount of nonconjugated diene; or a blend of EPM and EPDM.

[b] The oven time and temperature are to be as follows:

Temperature rating of material	Specified oven time and temperature h	Temperature
90°C	240	121.0 ±1.0°C (294.8 ±1.8°F)
105°C	168	136.0 ±1.0°C (276.8 ±1.8°F)

Table 50.56
Physical properties of 125°C[a] EPDM insulation and jacket

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm) bench marks	Minimum tensile strength
Unaged	250 percent (2-1/2 inches or 62.5 mm)	1200 lbf/in^2 or 8.27 MPa
Aged in a full-draft circulating-air oven for 168 h at 158 ±1.0°C (316 ±1.8°F)	65 percent of the result with unaged specimens	85 percent of the result with unaged specimens

[a] EPDM designates a thermoset compound whose characteristic constituent is terpolymer of ethylene, propylene, and a small amount of nonconjugated diene.

Table 50.62
Physical properties of EPCV[a] insulation

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)	Minimum tensile strength
Unaged	225 percent (2-1/4 inches or 56.2 mm)	1200 lbf/in^2 or 8.27 MPa
Aged in a full-draft circulating-air oven for 168 h at 121.0 ±1.0°C (249.8 ±1.8°F)	75 percent of the result with unaged specimens	75 percent of the result with unaged specimens

[a] EPCV designates a thermoset compound whose characteristic constituent is a covulcanizate of ethylene and propylene (EP) with a polyethylene (PE).

Table 50.63
Physical properties of ETFE[a] insulation from Type Z and ZW wires and from 150°C Type ZF and ZFF wires; ECTFE[a] and ETFE[a] insulation or jacket from power-limited circuit cable, cable for power-limited fire-alarm circuits, and other cables; and ECTFE[a] and ETFE[a] jackets from CATV cables

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)[b,c]	Minimum tensile strength[b,c]
Unaged	100 percent (1 inch or 25 mm)	5000 lbf/in^2 or 34.5 MPa
Aged in a full-draft circulating-air oven for 168 h at 180.0 ±1.0°C (356.0 ±1.8°F)	75 percent of the result with unaged specimens	85 percent of the result with unaged specimens or 5000 lbf/in^2 or 34.5 MPa

[a] ECTFE and ETFE designate thermoplastic materials whose characteristic constituent is either a copolymer of ethylene and tetrafluoroethylene (ETFE) or a copolymer of ethylene and chlorotrifluoroethylene (ECTFE). The material is uncompounded ECTFE or ETFE to which a small amount of pigment, lubricant, or both, is or is not added.

[b] ECTFE and ETFE are to be tested at a speed of 2.0 ±0.2 in/min or 50 ±5 mm/min.

[c] With band-marking inks in place or removed prior to the aging of specimens.

Table 50.64
Physical properties of 200°C ETFE[a] insulation

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)[b,c]	Minimum tensile strength
Unaged	200 percent (2 inches or 50 mm)	2000 lbf/in^2 or 13.79 MPa
Aged in a full-draft circulating-air oven for 168 h at 232.0 ±2.0°C (449.6 ±3.6°F)	85 percent of the result with unaged specimens	80 percent of the result with unaged specimens

[a] ETFE designates a thermoplastic material whose characteristic constituent is a copolymer of ethylene and tetrafluoroethylene. The material is uncompounded ETFE to which a small amount of pigment, lubricant, or both, is or is not added.

[b] ETFE is to be tested at a speed of 2.0 ±0.2 in/min or 50 ±5 mm/min.

[c] With band-marking inks in place or removed prior to the aging of specimens.

Table 50.70
Physical properties of 200°C FEP[a] jacket from CATV cables, jacket or insulation from power-limited circuit cable, from cable for power-limited fire-alarm circuits, or other cables; and insulation from Type FEP and FEPB wires

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)[b]	Minimum tensile strength[b]
Unaged	200 percent (2 inches or 50 mm)	2500 lbf/in^2 or 17.2 MPa
Aged in a full-draft circulating-air oven for 168 h at 232.0 ±1.0°C (449.6 ±1.8°F)	75 percent of the result with unaged specimens	75 percent of the result with unaged specimens

Table 50.70 Continued on Next Page

Table 50.70 Continued

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)[b]	Minimum tensile strength[b]
[a] FEP designates a thermoplastic material whose characteristic constituent is a copolymer of tetrafluoroethylene and hexafluoropropylene. The material is uncompounded FEP to which it is appropriate to add a small amount of pigment, lubricant, or both. [b] FEP is to be tested at a speed of 20 ±1 in/min or 500 ±25 mm/min.		

Table 50.73
Physical properties of FEP[a] insulation

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)[b]	Minimum tensile strength
Unaged	200 percent (2 inches or 50 mm)	2500 lbf/in^2 or 17.2 MPa
Aged in a full-draft circulating-air oven for 96 h at 232.0 ±1.0°C (449.6 ±1.8°F)	75 percent of the result with unaged specimens	75 percent of the result with unaged specimens
[a] FEP designates a thermoplastic material whose characteristic constituent is a copolymer of tetrafluoroethylene and hexafluoropropylene. The material is uncompounded FEP to which it is appropriate to add a small amount of pigment, lubricant, or both. [b] FEP is to be tested at a speed of 20 ±1 in/min or 500 ±25 mm/min.		

Table 50.76
Physical properties of 80°C mPPE-PE[a] insulations and jackets

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)	Minimum tensile strength
Unaged	125 percent (1-1/4 inches or 31.3 mm)	2000 lbf/in^2 13.79 MPa
Aged in a full-draft circulating-air oven for 168 h at 113.0 ±1.0°C (235.4 ±1.8°F)	65 percent of the result with unaged specimens	80 percent of the result with unaged specimens
[a] mPPE-PE designates a compounded thermoplastic material whose characteristic constituents are: Poly (2,6-dimethyl-1,4-phenylene ether) blended with polyethylene. Polyethylene content to be no more than 50 percent.		

Table 50.77
Physical properties of 90°C and 105°C mPPE[a] insulations and jackets

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)	Minimum tensile strength
Unaged	175 percent (1-3/4 inches or 44.4 mm)	3100 lbf/in^2 or 21.37 MPa
90°C mPPE insulations and jackets		

Table 50.77 Continued on Next Page

Table 50.77 Continued

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)	Minimum tensile strength
Aged in a full-draft circulating-air oven for 168 h at 121.0 ±1.0°C (249.8 ±1.8°F)	65 percent of the result with unaged specimens	85 percent of the result with unaged specimens
105°C mPPE insulations and jackets		
Aged in a full-draft circulating-air oven for 168 h at 136.0 ±1.0°C (276.8 ±1.8°F	50 percent of the result with unaged specimens	85 percent of the result with unaged specimens

[a] mPPE designates a compounded thermoplastic material whose characteristic constituent is: Poly (2,6-dimethyl-1,4-phenylene ether).

Table 50.80
Physical properties of 75°C NBR/PVC[a] thermoset jacket from power-limited circuit cable, cable for power-limited fire-alarm circuits, and other cables

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm Bench Marks)	Minimum tensile strength
Unaged	200 percent (2 inches or 50 mm)	1500 lbf/in[a] or 10.3 MPa
Aged in a full-draft circulating-air oven for 240 h at 100.0 ±1.0°C (212.0 ±1.8°F)	50 percent of the result with unaged specimens	70 percent of the result with unaged specimens
Aged in oil for 18 h at 121.0 ±1.0°C (249.8±1.8°F)	60 percent of the result with unaged specimens	60 percent of the result with unaged specimens

[a] NBR/PVC designates a thermoset compound whose characteristic constituents are acrylonitrile butadiene rubber and polyvinyl chloride.

Table 50.83
Physical properties of 90°C NBR/PVC[a] thermoset jacket from CATV cables, power-limited circuit cable, cables for power-limited fire-alarm circuits, and other cables

Condition of specimens at time of measurement	Maximum set in recovery test (1-inch or 25-mm bench marks stretched to 3 inches or 75 mm)	Minimum ultimate elongation (1-inch or 25-mm bench marks)	Minimum tensile strength
Unaged	31 percent (5/16 inch or 7.8 mm)	250 percent (2-1/2 inches or 62.5 mm)	1200 lbf/in^2 or 8.27 MPa
Aged in a full-draft circulating air oven for 240 h at 121.0 ±1.0°C (249.8±1.8°F)	Not measured	50 percent (1/2 inch or 12.5 mm)	900 lbf/in^2 or 6.21 MPa
Aged in oil for 18 h at 121.0 ±1.0°C (249.8±1.8°F)	Not measured	60 percent of the result with unaged specimens	60 percent of the result with unaged specimens

[a] NBR/PVC designates a thermoset compound whose characteristic constituents are acrylonitrile butadiene rubber and polyvinyl chloride.

Table 50.87
Physical properties of NBR/PVC[a] thermoset jacket from cable for deep-well submersible water pumps

Condition of specimens at time of measurement	Maximum set in recovery test (1-inch or 25-mm bench marks stretched to 3 inches or 75 mm)	Minimum ultimate elongation (1-inch or 25-mm bench marks)	Minimum tensile strength
Unaged	31 percent (5/16 inch or 7.8 mm)	300 percent (3 inches or 75 mm)	1500 lbf/in^2 or 10.3 MPa
Aged in a full-draft circulating-air oven for 168 h at 70.0 ±1.0°C (158.0 ±1.8°F)	Not measured	70 percent of the result with unaged specimens	70 percent of the result with unaged specimens
Aged in oil for 18 h at 121.0 ±1.0°C (249.8±1.8°F)	Not measured	60 percent of the result with unaged specimens	60 percent of the result with unaged specimens

[a] NBR/PVC thermoset is described in note [a] to Table 50.83.

Table 50.96
Physical properties of 60°C NBR/PVC[a] thermoset jacket

Condition of specimens at time of measurement	Maximum set in recovery test (1-inch or 25-mm bench marks stretched to 3 inches or 75 mm)	Minimum ultimate elongation (1-inch or 25-mm bench marks)	Minimum tensile strength
Unaged	31 percent (5/16 inch or 7.8 mm)	300 percent (3 inches or 75 mm)	1500 lbf/in^2 or 10.3 MPa
Aged in a full-draft circulating-air oven for 168 h at 70.0 ±1.0°C (158.0 ±1.8°F)	Not measured	70 percent of the result with unaged specimens	70 percent of the result with unaged specimens
60°C oil-resistant jacket: Aged in oil for 18 h at 121.0 ±1.0°C (249.8 ±1.8°F)	Not measured	60 percent of the result with unaged specimens	60 percent of the result with unaged specimens

[a] NBR/PVC designates a thermoset compound whose characteristic constituents are acrylontrile butadiene rubber and polyvinyl chloride.

Table 50.97
Physical properties of 90°C (194°F) and 75°C NBR/PVC[a] thermoset insulations and jackets

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)		Minimum tensile strength	
	75°C compound	90°C compound	75°C compound	90°C compound
Unaged	200 percent (2 inches or 50 mm)		1500 lbf/in^2 or 10.3 MPa	

Table 50.97 Continued on Next Page

Table 50.97 Continued

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)		Minimum tensile strength	
	75°C compound	90°C compound	75°C compound	90°C compound
Aged in a full-draft circulating-air oven for 240 h at 100.0 ±1.0°C (212.0 ±1.8°F)	50 percent of the result with unaged specimens	Not measured	70 percent of the result with unaged specimens	Not measured
Aged in a full-draft circulating air oven for 168 h at 121.0 ±1.0°C (249.8 ±1.8°F)	Not measured	100 percent (1 inch or 25 mm)	Not measured	1200 lbf/in^2 or 8.27 MPa
60°C oil-resistant insulation or jacket:				
Aged in oil for 18 h at 121.0 ±1.0°C (249.8 ±1.8°F)	60 percent of the result with unaged specimens		60 percent of the result with unaged specimens	

[a] NBR/PVC designates a thermoset compound whose characteristic constituents are acrylonitrile butadiene rubber and polyvinyl chloride.

Table 50.98
Physical properties of 90°C NBR/PVC[a] thermoset jacket

Condition of specimens at time of measurement	Maximum set in recovery test (1-inch or 25-mm bench marks stretched to 3 inches or 75 mm)	Minimum ultimate elongation (1-inch or 25-mm bench marks)	Minimum tensile strength
Unaged	31 percent (5/16 inch or 7.8 mm)	250 percent (2-1/2 inches or 62.5 mm)	1200 lbf/in^2 or 8.27 MPa
Aged in a full-draft circulating-air oven for 240 h at 121.0 ±1.0°C (249.8 ±1.8°F)	Not measured	50 percent (1/2 inch or 12.5 mm)	900 lbf/in^2 or 6.21 MPa
60°C oil-resistant jacket:			
Aged in oil for 18 h at 121.0 ±1.0°C (249.8 ±1.8°F)	Not measured	60 percent of the result with unaged specimens	60 percent of the result with unaged specimens

[a] NBR/PVC designates a thermoset compound whose characteristic constituents are acrylontrile butadiene rubber and polyvinyl chloride.

Table 50.99
Physical properties of 90°C neoprene[a] and NBR/PVC[b] jackets from Type USE-2 and USE cables

Condition of specimens at time of measurement	Maximum set in recovery test (1-inch or 25-mm bench marks stretched to 3 inches or 75 mm)	Minimum ultimate elongation (1-inch or 25-mm bench marks)	Minimum tensile strength
Unaged	19 percent (3/16 inch or 4.8 mm)	300 percent (3 inches or 75 mm)	1800 lbf/in^2 or 12.4 MPa
Aged in a full-draft circulating-air oven for 240 h at 121.0 ±1.0°C (249.8 ±1.8°F)	Not measured	50 percent (1/2 inch or 12.5 mm)	900 lbf/in^2 or 6.2 MPa
Aged in oil for 18 h at 121.0 ±1.0°C (249.8 ±1.8°F)	Not measured	60 percent of the result with unaged specimens	60 percent of the result with unaged specimens

[a] Neoprene designates a thermoset compound whose characteristic constituent is polychloroprene.

[b] NBR/PVC designates a thermoset compound whose characteristic constituents are acrylonitrile butadiene rubber and polyvinyl chloride.

Table 50.100
Physical properties of 75°C neoprene[a] or NBR/PVC[b] jacket from Type USE cable

Condition of specimens at time of measurement	Maximum set in recovery test (1-inch or 25-mm bench marks stretched to 3 inches or 75 mm)	Minimum ultimate elongation (1-inch or 25-mm bench marks)	Minimum tensile strength
Unaged	19 percent (3/16 inch or 4.8 mm)	300 percent (3 inches or 75 mm)	1800 lbf/in^2 or 12.4 MPa
Aged in a full-draft circulating-air oven for 240 h at 100.0 ±1.0°C (212.0 ±1.8°F)	Not measured	50 percent of the result with unaged specimens	70 percent of the result with unaged specimens
Aged in oil for 18 h at 121.0 ±1.0°C (249.8 ±1.8°F)	Not measured	60 percent of the result with unaged specimens	60 percent of the result with unaged specimens

[a] Neoprene designates a thermoset compound whose characteristic constituent is polychloroprene.

[b] NBR/PVC designates a thermoset compound whose characteristic constituents are acrylonitrile butadiene rubber and polyvinyl chloride.

Table 50.105
Physical properties of neoprene[a] jacket from Type RH and RHW wires

Table deleted

Table 50.108
Physical properties of neoprene[a] jacket from Type RHW-2 and RHH wires

Table deleted

Table 50.112
Physical properties of neoprene[a] jacket from cable for deep-well submersible water pumps

Condition of specimens at time of measurement	Maximum set in recovery test (1-inch or 25-mm bench marks stretched to 3 inches or 75 mm)	Minimum ultimate elongation (1-inch or 25-mm bench marks)	Minimum tensile strength
Unaged	19 percent (3/16 inch or 4.8 mm)	300 percent (3 inches or 75 mm)	1500 lbf/in^2 or 10.3 MPa
Aged in a full-draft circulating-air oven for 168 h at 70.0 ±1.0°C (158.0 ±1.8°F)	Not measured	70 percent of the result with unaged specimens	70 percent of the result with unaged specimens
Aged in oil for 18 h at 121.0 ±1.0°C (249.8±1.8°F)	Not measured	60 percent of the result with unaged specimens	60 percent of the result with unaged specimens

[a] Neoprene thermoset is described in note [a] to Table 50.120.

Table 50.120
Physical properties of 60°C neoprene[a] insulation

Conditions of specimens at time of measurement	Maximum set in recovery test (1-inch or 25-mm bench marks stretched to 3 inches or 75 mm)	Minimum ultimate elongation (1-inch or 25-mm bench marks)	Minimum tensile strength
Unaged	19 percent (3/16 inch or 4.8 mm)	250 percent (2-1/2 inches or 62.5 mm)	1200 lbf/in^2 or 8.27 MPa
Aged in a full-draft circulating- air oven for 168 h at 70.0 ±1.0°C (158.0 ±1.8°F)	Not measured	65 percent of the result with unaged specimens	75 percent of the result with unaged specimens
60°C oil-resistant insulation			
Aged in oil for 18 h at 121.0 ±1.0°C (249.8 ±1.8°F)	Not measured	60 percent of the result with unaged specimens	60 percent of the result with unaged specimens

[a] Neoprene designates a thermoset compound whose characteristic constituent is polychloroprene.

Table 50.121
Physical properties of Class 14 60°C (140°F) neoprene[a] insulation
Table deleted

Table 50.122
Physical properties of 60°C neoprene[a] jacket

Condition of specimens at time of measurement	Maximum set in recovery test (1-inch or 25-mm bench marks stretched to 3 inches or 75 mm)	Minimum ultimate elongation (1-inch or 25-mm bench marks)	Minimum tensile strength
Unaged	19 percent (3/16 inch or 4.8 mm)	300 percent (3 inches or 75 mm)	1500 lbf/in^2 or 10.3 MPa
Aged in a full-draft circulating-air oven for 168 h at 70.0 ±1.0°C (158.0 ±1.8°F)	Not measured	70 percent of the result with unaged specimens	70 percent of the result with unaged specimens
60°C oil-resistant jacket			
Aged in oil for 18 h at 121.0 ±1.0°C (249.8 ±1.8°F)	Not measured	60 percent of the result with unaged specimens	60 percent of the result with unaged specimens

[a] Neoprene designates a thermoset compound whose characteristic constituent is polychloroprene.

Table 50.123
Physical properties of 75°C neoprene[a] jacket from CATV cables, power-limited circuit cable, cable for power-limited fire-alarm circuits, and other cables

Conditions of specimens at time of measurement	Maximum set in recovery test (1-inch or 25-mm bench marks stretched to 3 inches or 75 mm)	Minimum ultimate elongation (1-inch or 25-mm bench marks)	Minimum tensile strength
Unaged	19 percent (3/16 inch or 4.8 mm)	300 percent (3 inches or 75 mm)	1500 lbf/in^2 or 10.3 MPa
Aged in a full-draft circulating-air oven for 240 h at 100.0 ±1.0°C (212.0 ±1.8°F)	Not measured	50 percent of the result with unaged specimens	70 percent of the result with unaged specimens
60°C oil-resistant insulation			
Aged in oil for 18 h at 121.0 ±1.0°C (249.8 ±1.8°F)	Not measured	60 percent of the result with unaged specimens	60 percent of the result with unaged specimens

[a] Neoprene designates a thermoset compound whose characteristic constituent is polychloroprene.

Table 50.124
Physical properties of 90°C neoprene[a] jacket from CATV cables, power-limited circuit cable, cable for power-limited fire-alarm circuits, and other cables

Condition of specimens at time of measurement	Maximum set in recovery test(1-inch or 25-mm bench marks stretched to 3 inches or 75 mm)	Minimum ultimate elongation (1-inch or 25-mm bench marks)	Minimum tensile strength
Unaged	25 percent (1/4 inch or 6.2 mm)	250 percent (2-1/2 inches or 62.5 mm)	1200 lbf/in^2 or 8.27 MPa
Aged in a full-draft circulating- air oven for 240 h at 121.0 ±1.0°C (249.8 ±1.8°F)	Not measured	50 percent (1/2 inch or 12.5 mm)	900 lbf/in^2 or 6.21 MPa
60°C oil-resistant insulation or jacket:			
Aged in oil for 18 h at 121.0 ±1.0°C (249.8 ±1.8°F)	Not measured	60 percent of the result with unaged specimens	60 percent of the result with unaged specimens

[a] Neoprene designates a thermoset compound whose characteristic constituent is polychloroprene.

Table 50.125
Physical properties of 90°C neoprene[a] and NBR/PVC[b] insulations and jackets

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)	Minimum tensile strength
Unaged	250 percent (2-1/2 inches or 62.5 mm)	1200 lbf/in^2 or 8.27 MPa
Aged in a full-draft circulating-air oven for 240 h at 121.0±1.0°C (249.8 ±1.8°F)	50 percent (1/2 inch or 12.5 mm)	900 lbf/in^2 6.21 MPa
60°C oil-resistant insulation or jacket:		
Aged in oil for 18 h at 121.0 ±1.0°C (249.8±1.8°F)	60 percent of the result with unaged specimens	60 percent of the result with unaged specimens

[a] Neoprene designates a thermoset compound whose characteristic constituent is polychloroprene.

[b] NBR/PVC designates a thermoset compound whose characteristic constituents are acrylonitrile butadiene rubber and polyvinyl chloride.

Table 50.133
Physical properties of 75°C LDFRPE[a] and HDFRPE[b] jackets from CATV cables and insulations from power-limited circuit cable and cable for power-limited fire-alarm circuits

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)[c]	Minimum tensile strength[c]
Unaged	100 percent (1 inch or 25 mm)	1200 lbf/in^2 or 8.27 MPa
Aged in a full-draft circulating-air oven for 48 h at 100.0 ±1.0°C (212.0 ±1.8°F)	75 percent of the result with unaged specimens	75 percent of the result with unaged specimens

[a] LDFRPE designates a compound whose characteristic constituent is thermoplastic polyethylene, with the base resin (uncolored material) having a nominal density in the range of 0.910 – 0.925 g/cm^3 (resin identified as Type I in ASTM D 1248) and a high molecular weight.

[b] HDFRPE designates high-density polyethylene, a compound whose characteristic constituent is thermoplastic polyethylene, with a base resin (uncolored material) having a nominal density in the range of 0.941 – 0.959 g/cm^3 (resin identified as Type III in ASTM D 1248) and a high molecular weight.

[c] FRPE is to be tested at a speed of 2.0 ±0.2 in/min or 50 ±5 mm/min.

Table 50.134
Physical properties of 90°C FRPE[a] insulation and jacket

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)[b]	Minimum tensile strength[b]
Unaged	110 percent (1.1 inches or 28.0 mm)	1300 lbf/in^2 or 9.0 MPa
Aged in a full-draft circulating-air oven for 168 h at 121.0 ±1.0°C (249.0 ±1.8°F)	50 percent of the result with unaged specimens	85 percent of the result with unaged specimens

[a] FRPE designates a thermoplastic compound whose characteristic constituent is thermoplastic polyethylene, with the base resin (uncolored, unfilled material) having a nominal density in the range of 0.910 – 0.959 g/cm^3 (910 – 959 kg/m^3) and a high molecular weight.

[b] FRPE is to be tested at a speed of 2.0 ± 0.2 in/min or 50 ± 5mm/min.

Table 50.135
Physical properties of 75°C thermoplastic HDPE[a] insulation from single-conductor Type USE cable

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks) [b]	Minimum tensile strength[b]
Unaged	300 percent (3 inches or 75 mm)	2000 lbf/in^2 13.79 MPa
Aged in a full-draft circulating-air oven for 168 h at 113.0 ±1.0°C (235.4 ±1.8°F)	60 percent of the result with unaged specimens	70 percent of the result with unaged specimens

[a] HDPE designates a high-density-polyethylene compound whose characteristic constituent is thermoplastic polyethylene, with the base resin (uncolored, unfilled material) having a nominal density in the range 0.941– 0.959 g/cm^3 (resin identified as Type III in ASTM D 1248) and a high molecular weight.

[b] HDPE is to be tested at a speed of 2.0 ±0.2 in/min or 50 ±5 mm/min.

Table 50.136
Physical properties of 75°C LDPE[a] insulation from power-limited circuit cable, from cable for power-limited fire-alarm circuit cables, and physical properties of 75°C HDPE[b] insulation from power-limited circuit cable

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)[c]	Minimum tensile strength[c]
Unaged solid LDPE insulation	LDPE tube from air-gap coaxial member: 300 percent (3 inches or 75 mm) All other solid LDPE insulation: 350 percent (3-1/2 inches or 87.5 mm)	All solid LDPE insulation: 1400 lbf/in^2 or 9.65 MPa
Unaged solid HDPE insulation	300 percent (3 inches or 75 mm)	2400 lbf/in^2 or 16.5 MPa
All solid LDPE and HDPE insulation:		
Aged in a full-draft circulating-air over for 48 h at 100.0 ±1.0°C (212.0 ±1.8°F)	75 percent of the result with unaged specimens	75 percent of the result with unaged specimens

[a] LDPE designates a compound whose characteristic constituent is thermoplastic polyethylene, with the base resin (uncolored, unfilled material) having a nominal density in the range of 0.910 – 0.925 g/cm^3 (resin identified as Type I in ASTM D 1248) and a high molecular weight.

[b] HDPE designates a high-density-polyethylene compound whose characteristic constituent is thermoplastic polyethylene, with the base resin (uncolored, unfilled material) having a nominal density in the range of 0.941 – 0.959 g/cm^3 (resin identified as Type III in ASTM D 1248) and a high molecular weight.

[c] HDPE is to be tested at a speed of 2.0 ±0.2 in/min or 50 ±5 mm/min. LDPE is to be tested at a speed of 20 ±1 in/min or 500 ±25 mm/min.

Table 50.137
Physical properties of PFA[a] jacket from CATV cables, PFA[a] insulation from Type PFA and PFAH wires, and PFA[a] insulation or jacket from other wires and cables, also of 200°C and 250°C MFA[b] insulations and jackets from appliance-wiring material

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)[c]	Minimum tensile strength[c]
Unaged	200 percent (2 inches or 50 mm)	2500 lbf/in^2 or 17.2 MPa
200°C PFA insulation from Type PFA wire and insulation or jacket from CATV cables and from other wires and cables, also 200°C MFA insulation or jacket from appliance-wiring material	85 percent of the result with unaged specimens	85 percent of the result with unaged specimens
Aged in a full-draft circulating-air oven for 96 h at 260.0 ±2.0°C (500.0 ±3.6°F)		
250°C PFA insulation from Type PFAH wire and from other wires and cables, also 250°C MFA insulation or jacket from appliance-wiring material	85 percent of the result with unaged specimens	85 percent of the result with unaged specimens

Table 50.137 Continued on Next Page

Table 50.137 Continued

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)[c]	Minimum tensile strength[c]
Aged in a full-draft circulating-air oven for 168 h at 287.0 ±2.0°C (549.0 ±3.6°F)		

[a] PFA designates a thermoplastic material whose characteristic constituent is the fluoropolymer resin perfluoroalkoxy. The material is uncompounded PFA to which a small amount of pigment, lubricant, or both is or is not added.

[b] MFA designates a thermoplastic material whose characteristic constituent is the fluoropolymer resin methylfluoroalkoxy. The material is uncompounded MFA to which a small amount of pigment, lubricant, or both is or is not added.

[c] PFA and MFA are to be tested at a speed of 20 ±1 in/min or 500 ±25 mm/min.

Table 50.138
Physical properties of 300°C PFA[a] insulations and jackets

Condition of specimens at time of measurement	Maximum ultimate elongation 1-inch or 25-mm benchmarks[b]	Minimum tensile strength[b]
Unaged	275 percent (2.75 inches or 70 mm)	2755 lbf/in^2 or 19.0 MPa
Aged in a full-draft circulating-air oven for 30 days at 311 ±2.0°C (592 ±3.6°F)	100 percent of the result with unaged specimens	100 percent of the result with uaged specimens

[a] PFA designates a thermoplastic material whose characteristic constituent is the fluoropolymer resin perfluoroalkoxy. The material is uncompounded PFA to which a small amount of pigment lubricant or both is or is not added.

[b] PFA is to be tested at a speed of 20 ±1 in/min or 500 ±25 mm/min.

Table 50.139
Physical properties of 75°C and 60°C PP[a] (polypropylene) insulation from power-limited circuit cable and from cable for power-limited fire-alarm circuits; and 75°C PP[a] jacket from CATV cables

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)[b]	Minimum tensile strength[b]
Unaged	150 percent (1-1/2 inches or 38 mm)	3000 lbf/in^2 or 20.7 MPa
Aged in a full-draft circulating-air oven for 240 h (75°C or 167°F insulation) or for 168 h (60°C or 140°F insulation) at 100.0 ±1.0°C (212.0 ±1.8°F)	70 percent of the result with unaged specimens	70 percent of the result with unaged specimens

[a] PP designates a thermoplastic compound whose characteristic constituent is polypropylene, the crystalline copolymer of ethylene and propylene.

[b] PP is to be tested at a speed of 2.0 ±0.2 in/min or 50 ±5 mm/min.

Table 50.139.1
Physical properties of 75°C and 60°C FRPP (flame retardant polypropylene) insulation from power-limited circuit cable and from cable for power-limited fire-alarm circuits; and 75°C FRPP[a] jacket from CATV cables

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)[b]	Minimum tensile strength[b]
Unaged	100 percent (1 inch or 25 mm)	1200 lbf/in^2 or 8.3 MPa
Aged in a full-draft circulating-air oven for 48 h (75°C or 167°F insulation, or 60°C or 140°F insulation) at 100.0 ±1.0°C (212.0 ±1.8°F)	75 percent of the result with unaged specimens	75 percent of the result with unaged specimens

[a] FRPP designates a thermoplastic compound whose characteristic constituent is polypropylene, the crystalline copolymer of ethylene and propylene.

[b] FRPP is to be tested at a speed of 2.0 ±0.2 in/min or 50 ±5 mm/min.

Table 50.140
Physical properties of PVC[a] insulation from Type TW wire

Table deleted

Table 50.142
Physical properties of PVC[a] insulations and jackets from medium- and low-power broadband cables rated for 105, 90, 75, and 60°C

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)	Minimum tensile strength
Unaged	100 percent (1 inch or 25 mm)	2000 lbf/in^2 or 13.79 MPa
105°C insulations and jackets:	Die-cut and other specimens:	Die-cut and other specimens:
Aged in a full-draft circulating-air oven for 168 h at 136.0 ±1.0°C (276.8 ±1.8°F)	50 percent of the result with unaged specimens	85 percent of the result with unaged specimens
90°C insulations and jackets:	Die-cut and other specimens:	Die-cut and other specimens:
Aged in a full-draft circulating air oven for 168 h at 121.0 ±1.0°C (249.8 ±1.8°F)	50 percent of the result with unaged specimens	85 percent of the result with unaged specimens
75°C insulations and jackets:	Die-cut and other specimens:	Die-cut and other specimens:
Aged in a full-draft circulating-air oven for 240 h at 100.0 ±1.0°C (212.0 ±1.8°F)	50 percent of the result with unaged specimens	85 percent of the result with unaged specimens
60°C insulations and jackets:	Die-cut and other specimens:	Die-cut and other specimens:
Aged in a full-draft circulating-air oven for 168 h at 100.0 ±1.0°C (212.0 ±1.8°F)	50 percent of the result with unaged specimens	75 percent of the result with unaged specimens

[a] PVC designates a thermoplastic compound whose characteristic constituent is polyvinyl chloride or a copolymer of vinyl chloride and vinyl acetate.

Table 50.144
Physical properties of insulation of thermoplastic other than PVC from Type NM cables

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)		Minimum tensile strength
Unaged	Values as established for the particular commercial or proprietary compound used		
Insulation from conductors of NM (nylon removed before aging):	Die-cut specimens:	Other specimens:	All specimens:
Aged in a full-draft circulating-air oven for 168 h at 136.0 ±1.0°C (276.8 ±1.8°F)	45 percent of the result with unaged specimens	65 percent of the result with unaged specimens	75 percent of the result with unaged specimens

Table 50.145
Physical properties of PVC[a] insulation from Type THW and THWN wires
Table deleted

Table 50.150
Physical properties of PVC[a] insulation from gasoline- and oil-resistant Type TFN, and TFFN

Condition of PVC specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)	Minimum tensile strength
Unaged (nylon removed)	150 percent (1-1/2 inches or 38 mm)	2000 lbf/in^2 or 13.79 MPa
Conditioned by immersion in water-saturated ASTM Reference Fuel C for 30 d at 23.0 ±1.0°C (73.4 ±1.8°F) with nylon intact during immersion and removed prior to testing	65 percent of the result with unaged specimens	75 percent of the result with unaged specimens

[a] PVC designates a thermoplastic compound whose characteristic constituent is polyvinyl chloride or a copolymer of vinyl chloride and vinyl acetate.

Table 50.155
Physical properties of PVC insulation from Type TFN and TFFN fixture wires

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)	Minimum tensile strength
Unaged	150 percent (1-1/2 inches or 37.5 mm)	2000 lbf/in^2 or 13.79 MPa
Aged in a full-draft circulating-air oven for 168 h at 136.0 ±1.0°C (276.8 ±1.8°F) with nylon jacket removed before aging	Die-cut specimens: 45 percent of the result with unaged specimens Other specimens:	All specimens: 75 percent of the result with unaged specimens

Table 50.155 Continued on Next Page

Table 50.155 Continued

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)	Minimum tensile strength
	65 percent of the result with unaged specimens	
[a] PVC designates a thermoplastic compound whose characteristic constituent is polyvinyl chloride or a copolymer of vinyl chloride and vinyl acetate.		

Table 50.156
Physical properties of oil-resistant TFN and TFFN PVC[a] insulation

Oil-resistant rating of wire	Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)
75°C (167°F)	Aged in oil for 60 d at 75.0 ±1.0°C (167.0 ±1.8°F)	65 percent of the result with unaged specimens
60°C (140°F)	Aged in oil for 96 h at 100.0 ±1.0°C (212.0 ±1.8°F)	50 percent of the result with unaged specimens
[a] PVC is described in note [a] to Table 50.155.		

Table 50.160
Physical properties of PVC insulation from Type TBS wire

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)	Minimum tensile strength
Unaged	100 percent (1 inch or 25 mm)	1500 lbf/in^2 or 10.3 MPa
Aged in a full-draft circulating-air oven for 168 h at 121.0 ±1.0°C (249.8 ±1.8°F) with all materials over the thermoplastic insulation removed before aging	Die-cut specimens: 45 percent of result with unaged specimens Other specimens: 65 percent of result with unaged specimens	Die-cut specimens: 70 percent of the result with unaged specimens Other specimens: 70 percent of the result with unaged specimens
[a] PVC designates a thermoplastic compound whose characteristic constituent is polyvinyl chloride or a copolymer of vinyl chloride and vinyl acetate.		

Table 50.165
Physical properties of Class 11 60°C (140°F) PVC[a] insulation
Table deleted

Table 50.166
Physical properties of Class 11 60°C (140°F) PVC[a] insulation and jacket
Table deleted

Table 50.167
Physical properties of Class 11 60°C (140°F) PVC[a] jacket
Table deleted

Table 50.169
Physical properties of Class 11 60°C (140°F) PVC[a] insulation and jacket
Table deleted

Table 50.172
Physical properties of Class 11 60°C (140°F) PVC[a] jacket
Table deleted

Table 50.175
Physical properties of PVC[a] jacket from cable for deep-well submersible water pumps

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)	Minimum tensile strength
Unaged	100 percent (1 inch or 25 mm)	1500 lbf/in^2 or 10.3 MPa
Aged in a full-draft circulating-air oven for 168 h at 100.0 ±1.0°C (212.0 ±1.8°F)	Die-cut specimens: 45 percent of the result with unaged specimens Other specimens: 65 percent of the result with unaged specimens	Die-cut Specimens: 65 percent of the result with unaged specimens Other specimens: 65 percent of the result with unaged specimens

[a] PVC designates a thermoplastic compound whose characteristic constituent is polyvinyl chloride or a copolymer of vinyl chloride and vinyl acetate.

Table 50.179
Physical properties of NM Cable PVC[a] jacket

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)	Minimum tensile strength
Unaged	100 percent (1 inch or 25 mm)	1500 lbf/in^2 or 10.3 MPa
Aged for 240 h in a full-draft circulating-air oven at 100.0 ±1.0°C (212.0 ±1.8°F)	Die-cut specimens: 45 percent of the result with unaged specimens Other specimens: 65 percent of the result with unaged specimens	Die-cut specimens: 70 percent of the result with unaged specimens Other specimens: 70 percent of the result with unaged specimens

[a] Designates a thermoplastic compound whose characteristic constituent is polyvinyl chloride or a copolymer of vinyl chloride and vinyl acetate.

Table 50.180
Physical properties of Class 12 90°C (194°F) PVC[a] insulation and jacket
Table deleted

Table 50.181
Physical properties of Class 12 105°C (221°F) PVC[a] insulation and jacket
Table deleted

Table 50.182
Physical properties of 60°C, 75°C, 90°C, and 105°C PVC[a] jackets from CATV cables, and insulations and jackets from power-limited circuit cable, from cable for power-limited fire-alarm circuits, or from other cables

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)	Minimum tensile strength
Unaged	100 percent (1 inch or 25 mm)	1500 lbf/in^2 or 10.3 MPa
Aged in a full-draft circulating-air oven for the specified time at the specified temperature[b]	Die-cut specimens: 45 percent of the result with unaged specimens Other specimens:	Die-cut specimens: 70 percent of the result with unaged specimens Other specimens:

Table 50.182 Continued on Next Page

Table 50.182 Continued

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)	Minimum tensile strength
	65 percent of the result with unaged specimens	70 percent of the result with unaged specimens
60°C oil-resistant jacket:		
Aged in oil for 168 h at 60.0 ±1.0°C (140.0 ±1.8°F)	75 percent of the result with unaged specimens	75 percent of the result with unaged specimens
60°C oil-resistant insulation:		
Aged in oil for 168 h at 60.0 ±1.0°C (140.0 ±1.8°F)	85 percent of the result with unaged specimens	85 percent of the result with unaged specimens
60°C oil-resistant uses other than in flexible cords and elevator cables:		
Aged in oil for 60 d at 60.0 ±1.0°C (140 ±1.8°F)	75 percent of the result with unaged specimens	75 percent of the result with unaged specimens
75°C oil resistant insulation		
Aged in oil for 60 d at 75.0 ±1.0°C (167 ±1.8°F)	65 percent of the result with unaged specimens	65 percent of the result with unaged specimens

[a] PVC designates a thermoplastic compound whose characteristic constituent is polyvinyl chloride or a copolymer of vinyl chloride and vinyl acetate.

[b] The oven time and temperature are to be as follows:

Temperature rating of material	Specified oven time and temperature h	°C (°F)
60°C	168	100.0 ±1.0°C (212.0±1.8°F)
75°C	240	100.0 ±1.0°C (212.0 ±1.8°F)
90°C	168	121.0 ±1.0°C (249.8 ±1.8°F)
105°C	168	136.0 ±1.0°C (276.8 ±1.8°F)

Table 50.183
Physical properties of 105°C, 90°C, 75°C, and 60°C semirigid PVC[a] insulations and 75°C and 60°C jackets from CATV cables, from power-limited circuit cable, from cable for power-limited fire-alarm circuits, and from other cables

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)[b]	Minimum tensile strength[b]
Unaged	100 percent (1 inch or 25 mm)	3000 lbf/in^2 or 20.7 MPa

Table 50.183 Continued on Next Page

Table 50.183 Continued

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)[b]	Minimum tensile strength[b]
Aged in a full-draft circulating-air oven for the specified time[c] at the specified temperature[c]	70 percent of the result with unaged specimens[d]	70 percent of the result with unaged specimens[d]

[a] Semirigid PVC (SRPVC) designates a partially plasticized thermoplastic compound whose characteristic constituent is polyvinyl chloride or a copolymer of vinyl chloride and vinyl acetate.

[b] Semirigid PVC is to be tested at a speed of 2.0 ±0.2 in/min or 50 ±5 mm/min.

[c] The oven time and temperature are to be as follows:

Temperature rating of material	Specified oven time and temperature h	°C (°F)
105°C	168	136.0 ±1.0°C (276.8±1.8°F)
90°C	168	121.0 ±1.0°C (249.8 ±1.8°F)
75°C	168	113.0 ±1.0°C (235.4 ±1.8°F)
60°C	168	100.0 ±1.0°C (212.0 ±1.8°F)

[d] As an alternative to testing for retention of tensile strength and elongation, it is appropriate to wind aged specimens of the 60°C insulation in place on the conductor onto a mandrel as described under "Flexibility" in the applicable wire Standard. Unaged specimens are to be tested for tensile strength and elongation. Where aged specimens that are tested for retention of tensile strength and elongation show results that do not comply, it is appropriate to use the flexibility procedure described under "Flexibility" as a referee test.

Table 50.184
Physical properties of 60°C, 75°C, and 80°C insulations and jackets of a blend of PVC[a] and TPU[a]

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)[b]	Minimum tensile strength[b]
Unaged	100 percent (1 inch or 25 mm)	1500 lbf/in^2 or 10.3 MPa
Specimens of 60°C material: Aged in a full-draft-circulating-air oven for 168 h at 100.0 ±1.0°C (212.0 ±1.8°F)	Die-cut specimens: 45 percent of the result with unaged specimens Other specimens: 65 percent of the result with unaged specimens	70 percent of the result with unaged specimens
Specimens of 75°C material: Aged in a full-draft-circulating-air oven for 240 h at 100.0 ±1.0°C (212.0 ±1.8°F)	Die-cut specimens: 45 percent of the result with unaged specimens Other specimens: 65 percent of the result with unaged specimens	70 percent of the result with unaged specimens
Specimens of 80°C material:	Die-cut specimens:	70 percent of the result with unaged specimens

Table 50.184 Continued on Next Page

Table 50.184 Continued

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)[b]	Minimum tensile strength[b]
Aged in a full-draft-circulating-air oven for 168 h at 113.0 ±1.0°C (235.0 ±1.8°F)	45 percent of the result with unaged specimens Other specimens: 65 percent of the result with unaged specimens	

[a] PVC designates a thermoplastic compound whose characteristic constituent is polyvinyl chloride or a copolymer of vinyl chloride and vinyl acetate. TPU designates thermoplastic polyurethane, a compounded thermoplastic elastomer material whose main constituent is a polyester- or polyether-based urethane linear polymer resin characterized by soft amorphous segments containing hard crystalline microdomains.

[b] A blend of PVC and TPU is to be tested at a speed of 20 ±1 in/min or 500 ±25 mm/min.

Table 50.185
Physical properties of 150°C and 125°C PVDF[a] and PVDF copolymer[b] jackets from CATV cables; and insulations and jackets from power-limited circuit cable and from cable for power-limited fire-alarm circuits

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)[c]	Minimum tensile strength[c]
Unaged	100 percent (1 inch or 25 mm)	3500 lbf/in^2 or 24.1 MPa
Specimens of 150°C material:		
Aged in a full-draft circulating-air oven for 60 d at 158.0 ±1.0°C (316.4 ±1.8°F)	50 percent of the result with unaged specimens	50 percent of the result with unaged specimens
Specimens of 125°C material:		
Aged in a full-draft circulating-air oven for 168 h at 158.0 ±1.0°C (316.4 ±1.8°F)	See note[d]	See note[d]
or		
as an option for PVDF copolymer only: aged in a full-draft circulating-air oven for 30 d at 136.0 ±1.0°C (276.8 ±1.8°F)	See note[d]	See note[d]

[a] PVDF designates a thermoplastic material whose characteristic constituent is the homopolymer resin polyvinylidene fluoride. The material is uncompounded PVDF to which it is appropriate to add a small amount of pigment, lubricant, or both.

[b] PVDF copolymer designates a thermoplastic material whose characteristic constituent is a copolymer of polyvinylidene fluoride and hexafluoropropylene. The material is the uncompounded polymer to which it is appropriate to add a small amount of pigment, lubricant, or both.

[c] PVDF and PVDF copolymer are to be tested at a speed of 2.0±0.2 in/min or 50 ±5 mm/min.

[d] Aged specimens of the jacket, of the foamed insulation in place on the conductor, or the solid insulation in place on the conductor are to be wound onto a mandrel as described under "Flexibility" in the applicable wire Standard. Unaged specimens of the jacket and of the solid insulation are to be tested for tensile strength and elongation. Jacket damage after aging caused by outgassing of lower-temperature insulated conductors within the cable does not constitute noncomplying performance.

Table 50.186
Physical properties of 150°C and 125°C Flexible PVDF jackets[a]

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)[b]	Minimum tensile strength[b]
Unaged	100 percent (1 inch or 25 mm)	2500 lbf/in^2 or 17.2 MPa 24.1 MPa
Specimens of 150°C material:		
Aged in a full-draft circulating-air oven for 60 d at 158 ±1.0°C (316.4 ±1.8°F)	50 percent of the result with unaged specimens	50 percent of the result with unaged specimens
Specimens of 125°C material:		
Aged in a full-draft circulating-air oven for 168 h at 158.0 ±1.0°C (316.4 ±1.8°F)	See note[c]	See note[c]
or		
Aged in a full-draft circulating-air oven for 30 d at 136 ±1.0°C (276.8 ±1.8°F)	See note[c]	See note[c]

[a] Flexible PVDF copolymer designates a thermoplastic material whose characteristic constituent is a copolymer of polyvinylidene fluoride and hexafluoropropylene having a flexural modulus below 60,000 psi when tested per ASTM D790. The material is the uncompounded polymer to which it is appropriate to add a small amount of pigment, lubricant, or both.

[b] Flexible PVDF copolymer is to be tested at a speed of 2.0 ±0.2 in/min or 50 ±5 mm/min.

[c] Aged specimens of the jacket, of the foamed insulation in place on the conductor, or the solid insulation in place on the conductor are to be wound onto a mandrel as described under “Flexibility” in the applicable wire Standard. Unaged specimens of the jacket and of the solid insulation are to be tested for tensile strength and elongation. Jacket damage after aging caused by outgassing of lower-temperature insulated conductors within the cable does not constitute noncomplying performance.

Table 50.189
Physical properties of SBR/IIR/NR[a] insulation from Type USE and USE-2 wires

Condition of specimens at time of measurement	Maximum set for 75°C (167°F) compounds – inapplicable for 90°C (194°F) compounds (1-inch or 25-mm bench marks stretched to 2-1/2 inches or 62.5 mm)	Maximum set for 90°C (194°F) compounds – inapplicable for 75°C (167°F) compounds (1-inch or 25-mm bench marks stretched to 3 inches or 75 mm)	Minimum ultimate elongation (1-inch or 25-mm bench marks)	Minimum tensile strength
Unaged	25 percent (1/4 inch or 6.2 mm)	25 percent (1/4 inch or 6.2 mm)	300 percent (3 inches or 75 mm)	700 lbf/in^2 or 4.83 MPa
75°C (167°F) compounds aged in a full-draft circulating-air oven for 240 h at 100.0 ±1.0°C (212.0 ±1.8°F)	Not measured	–	50 percent of the result with unaged specimens	70 percent of the result with unaged specimens

Table 50.189 Continued on Next Page

Table 50.189 Continued

Condition of specimens at time of measurement	Maximum set for 75°C (167°F) compounds – inapplicable for 90°C (194°F) compounds (1-inch or 25-mm bench marks stretched to 2-1/2 inches or 62.5 mm)	Maximum set for 90°C (194°F) compounds – inapplicable for 75°C (167°F) compounds (1-inch or 25-mm bench marks stretched to 3 inches or 75 mm)	Minimum ultimate elongation (1-inch or 25-mm bench marks)	Minimum tensile strength
90°C (194°F) compounds aged in a full-draft circulating-air oven for 168 h at 121.0 ±1.0°C (249.8 ±1.8°F)	–	Not measured	60 percent of the result with unaged specimens	60 percent of the result with unaged specimens

[a] SBR/IIR/NR designates a thermoset compound whose characteristic constituent is SBR, IIR (butyl rubber), blends of SBR and IIR, or blends of SBR and/or IIR with NR (natural rubber). These thermosets are for use where subjected to 75°C (167°F) and lower temperatures as insulation on NBR/PVC-, CP-, Thermoset CPE-, XL-, or neoprene-jacketed or fibrous-covered Type USE wire and where subjected to 90°C (194°F) and lower temperatures as insulation on CP-, Thermoset CPE-, NBR/PVC, XL-, or neoprene-jacketed or fibrous-covered Type USE-2 wire.

Table 50.193
Physical properties of Class 2 60°C (140°F) SBR/NR[a] insulation

Table deleted

Table 50.194
Physical properties of Class 3 60°C (140°F) SBR/NR[a] insulation

Table deleted

Table 50.195
Physical properties of Class 4 60°C (140°F) SBR/NR[a] insulation

Table deleted

Table 50.196
Physical properties of 60°C SBR/NR[a] insulation

Condition of specimens at time of measurement	Maximum set in recovery test (1-inch or 25-mm bench marks stretched to 3 inches or 75 mm)	Minimum ultimate elongation (1-inch or 25-mm bench marks)	Minimum tensile strength
Unaged	19 percent (3/16 inch or 4.8 mm)	300 percent (3 inches or 75 mm)	1500 lbf/in^2 or 10.3 MPa
Aged in a full-draft circulating-air oven for 168 h at 70.0 ±1.0°C (158.0 ±1.8°F)	Not measured	65 percent of the result with unaged specimens where the sum of tensile plus elongation percentages is at least 140 percent. Otherwise, 70 percent of the result with unaged specimens.	

[a] SBR/NR designates a thermoset compound whose characteristic constituent is SBR, NR (natural rubber), or a blend of the two.

Table 50.197
Physical properties of Class 7 75°C (167°F) SBR/NR[a] insulation

Table deleted

Table 50.198
Physical properties of 75°C SBR/NR[a] insulation

Condition of specimens at time of measurement	Maximum set in recovery test (1-inch or 25-mm bench marks stretched to 2-1/2 inches or 62.5 mm)	Minimum ultimate elongation (1-inch or 25-mm bench marks)	Minimum tensile strength
Unaged	25 percent (1/4 inch or 6.2 mm)	250 percent (2-1/2 inches or 62.5 mm)	600 lbf/in^2 or 4.14 MPa
Aged in a full-draft circulating-air oven for 240 h at 100.0 ±1.0°C (212.0 ±1.8°F)	Not measured	50 percent of the result with unaged specimens	70 percent of the result with unaged specimens

[a] SBR/NR designates a thermoset compound whose characteristic constituent is SBR, NR (natural rubber), or a blend of the two.

Table 50.199
Physical properties of 75°C SBR/NR[a] jacket

Condition of specimens at time of measurement	Maximum set in recovery test (1-inch or 25-mm bench marks stretched to 2-1/2 inches or 62.5 mm)	Minimum ultimate elongation (1-inch or 25-mm bench marks)	Minimum tensile strength
Unaged	19 percent (3/16 inch or 4.8 mm)	300 percent (3 inches or 75 mm)	1500 lbf/in^2 or 10.3 MPa
Aged in a full-draft circulating-air oven for 240 h at 100.0 ±1.0°C (212.0 ±1.8°F)	Not measured	50 percent of the result with unaged specimens	70 percent of the result with unaged specimens

[a] SBR/NR designates a thermoset compound whose characteristic constituent is SBR, NR (natural rubber), or a blend of the two.

Table 50.200
Physical properties of 60°C SBR/NR[a] insulation

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)	Minimum tensile strength (test not required for insulation less than 30 mils or 0.76 mm thick)
Unaged	200 percent (2 inches or 50 mm)	500 lbf/in^2 or 3.45 MPa
Aged in a full-draft circulating-air oven for 168 h at 70.0 ±1.0°C (158.0 ±1.8°F)	65 percent of the result with unaged specimens	60 percent of the result with unaged specimens

[a] SBR/NR designates a thermoset compound whose characteristic constituent is SBR, NR (natural rubber), or a blend of the two.

Table 50.205
Physical properties 200°C silicone rubber[a] insulation from Type SA wire

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)	Minimum tensile strength
Unaged	250 percent (2-1/2 inches or 62.5 mm)	800 lbf/in^2 or 5.52 MPa
Aged in a full-draft circulating-air oven for 60 d at 210.0 ±1.0°C (410.0 ±1.8°F)	25 percent of the result with unaged specimens	60 percent of the result with unaged specimens

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

Table 50.206
Physical properties of silicone rubber[a] insulation from Type RFHH-3 wire

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)	Minimum tensile strength
Unaged	250 percent (2-1/2 inches or 62.5 mm)	800 lbf/in^2 or 5.52 MPa
Aged in a full-draft circulating-air oven for 60 d at 136.0 ±1.0°C (276.8 ±1.8°F)	65 percent of the result with unaged specimens	75 percent of the result with unaged specimens

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

Table 50.210
Physical properties 200°C and 150°C silicone rubber[a] jackets from CATV cables and insulations from power-limited circuit cable, from cable for power-limited fire-alarm circuits, and from other cables

Temperature rating of insulation	Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)	Minimum tensile strength
150°C or 200°C	Unaged	100 percent (1 inch or 25 mm)	500 lbf/in^2 or 3.45 MPa
150°C	Aged in a full-draft circulating-air oven for 60 d at 158.0 ±1.0°C (316.4 ±1.8°F)	50 percent (1/2 inch or 12.5) or 25 percent of the result with unaged specimens	500 lbf/in^2 or 3.45 MPa or 60 percent of the result with unaged specimens
200°C	Aged in a full-draft circulating-air oven for 60 d at 210.0 ±1.0°C (410.0 ±1.8°F)	50 percent (1/2 inch or 12.5 mm) or 25 percent of the result with unaged specimens	500 lbf/in^2 or 3.45 MPa or 60 percent of the result with unaged specimens

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

Table 50.219
Physical properties of 250°C PTFE[a] (TFE[a]) jacket from CATV cables and insulations from power-limited circuit cable, from cable for power-limited fire-alarm circuits, from other cables, and from Type PTF, PTFF, and TFE wires

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)	Minimum tensile strength
Unaged	175 percent (1-3/4 inches or 43.8 mm)	4000 lbf/in^2 or 27.6 MPa
Aged in a full-draft circulating-air oven for 60 d at 260.0 ±1.0°C (500.0 ±1.8°F)	85 percent of the result with unaged specimens	85 percent of the result with unaged specimens

[a] PTFE (TFE) designates a thermoplastic material whose characteristic constituent is either the homopolymer tetrafluoroethylene (TFE) or a copolymer of TFE with no more than 1 percent by weight of another fluoropolymer. The material is uncompounded PTFE (TFE) to which a small amount of pigment, lubricant, or both is or is not added.

[b] PTFE (TFE) is to be tested at a speed of 20 ±1 in/min or 500 ±25 mm/min.

Table 50.221
Physical properties of 80°C THV[a] jacket from appliance-wiring material

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)[b]	Minimum tensile strength[b]
Unaged	375 percent (3-3/4 inches or 93.8 mm)	3200 lbf/in^2 or 22.1 MPa
Aged in a full-draft circulating-air oven for 168 h at 113.0 ±1.0°C (235.0 ±1.8°F)	80 percent of the result with unaged specimens	75 percent of the result with unaged specimens

[a] THV is a thermoplastic material whose characteristic constituent is a terpolymer of tetrafluoroethylene, hexafluoropropylene, and vinylidene fluoride. The material is uncompounded THV to which a small amount of pigment, lubricant, or both is or is not added.

[b] THV is to be tested at a speed of 20 ±1 in/min or 500 ±25 mm/min.

Table 50.223
Physical properties of 105°C TPE[a] jacket from CATV cables; insulations and jackets from power-limited circuit cable, from cable for power-limited fire-alarm circuits; and of 105°C TPE[a] insulation and jacket

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)	Minimum tensile strength	
		Insulation	Jacket
Unaged	200 percent (2 inches or 50 mm)	800 lbf/in^2 or 5.52 MPa	1200 lbf/in^2 or 8.27 MPa
Aged in a full-draft circulating-air oven for 168 h at 136.0 ±1.0°C (276.8 ±1.8°F)	75 percent of the result with unaged specimens	75 percent of the result with unaged specimens	75 percent of the result with unaged specimens
60°C oil-resistant jacket or insulation:			
Aged in oil for 168 h at 60.0 ±1.0°C (140.0 ±1.8°F)	75 percent of the result with unaged specimens	75 percent of the result with unaged specimens	75 percent of the result with unaged specimens

[a] TPE designates an extensible compound whose characteristic constituent is a thermoplastic elastomer.

Table 50.224
Physical properties of 90°C TPE[a] jacket from CATV cables; insulations and jackets from power-limited circuit cable, from cable for power-limited fire-alarm circuits; and from other cables using TPE[a] insulation and jacket

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)	Minimum tensile strength	
		Insulation	Jacket
Unaged	200 percent (2 inches or 50 mm)	800 lbf/in^2 or 5.52 MPa	1200 lbf/in^2 or 8.27 MPa
Aged in a full-draft circulating-air oven for 168 h at 121.0 ±1.0°C (249.8 ±1.8°F)	75 percent of the result with unaged specimens	75 percent of the result with unaged specimens	75 percent of the result with unaged specimens
60°C oil-resistant jacket or insulation:			
Aged in oil for 168 h at 60.0 ±1.0°C (140.0 ±1.8°F)	75 percent of the result with unaged specimens	75 percent of the result with unaged specimens	75 percent of the result with unaged specimens

[a] TPE designates an extensible compound whose characteristic constituent is a thermoplastic elastomer.

Table 50.226
Physical properties of 60°C, 75°C, and 80°C TPES[a] insulations and jackets from appliance-wiring material

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)[b]	Minimum tensile strength[b]
Unaged	100 percent (1 inch or 25 mm)	1500 lbf/in^2 or 10.3 MPa
Specimens of 60°C material:	65 percent of the result with unaged specimens	70 percent of the result with unaged specimens
Aged in a full-draft circulating-air oven for 168 h at 100.0 ±1.0°C (212.0 ±1.8°F)		
Specimens of 75°C material:	65 percent of the result with unaged specimens	70 percent of the result with unaged specimens
Aged in a full-draft circulating-air oven for 240 h at 100.0 ±1.0°C (212.0 ±1.8°F)		
Specimens of 80°C material:	65 percent of the result with unaged specimens	70 percent of the result with unaged specimens
Aged in a full-draft circulating-air oven for 168 h at 113.0 ±1.0°C (235.0 ±1.0°F)		

[a] TPES designates a compounded thermoplastic material whose characteristic constituent is a polyester such as PBT (polybutylene terepthalate) or PET (polyethylene terepthalate), their individual copolymers, blends of any of these, PBT/polycarbonate blend, or PBT/TEEE (thermoplastic elastomer ether ester) blend.

[b] TPES is to be tested at a speed of 20 ±1 in/min or 500 ±25 mm/min.

Table 50.227
Physical properties of 60°C, 75°C, and 80°C TPU[a] insulations and jackets from appliance-wiring material

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)[b]	Minimum tensile strength[b]
Unaged	100 percent (1 inch or 25 mm)	1500 lbf/in^2 or 10.3 MPa
Specimens of 60°C material: Aged in a full-draft-circulating-air oven for 168 h at 100.0 ±1.0°C (212.0 ±1.8°F)	Die-cut specimens: 45 percent of the result with unaged specimens Other specimens: 65 percent of the result with unaged specimens	70 percent of the result with unaged specimens
Specimens of 75°C material: Aged in a full-draft-circulating-air oven for 240 h at 100.0 ±1.0°C (212.0 ±1.8°F)	Die-cut specimens: 45 percent of the result with unaged specimens Other specimens: 65 percent of the result with unaged specimens	70 percent of the result with unaged specimens
Specimens of 80°C material: Aged in a full-draft–circulating-air oven for 168 h at 113.0 ±1.0°C (235.0 ±1.8°F)	Die-cut specimens: 45 percent of the result with unaged specimens Other specimens: 65 percent of the result with unaged specimens	70 percent of the result with unaged specimens

[a] TPU designates thermoplastic polyurethane, a compounded thermoplastic elastomer material whose main constituent is a polyester- or polyether-based urethane linear polymer resin characterized by soft amorphous segments containing hard crystalline microdomains.

[b] TPU is to be tested at a speed of 20 ±1 in/min or 500 ±25 mm/min.

Table 50.227.1
Physical properties of 90°C TPU[a] insulations and jackets from appliance-wiring material

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)[b]	Minimum tensile strength[b]
Unaged	300 percent (3 inches or 75 mm)	1875 lbf/in^2 or 12.9 MPa
Aged in a full-draft-circulating-air oven for 168 h at 121.0 ±1.0°C (249.8 ±1.8°F)	70 percent of the result with unaged specimens	65 percent of the result with unaged specimens

[a] TPU designates thermoplastic polyurethane, a compounded thermoplastic elastomer material whose main constituent is a polyester- or polyether-based urethane linear polymer resin characterized by soft amorphous segments containing hard crystalline microdomains.

[b] TPU is to be tested at a speed of 20 ±1 in/min or 500 ±25 mm/min.

Table 50.227.2
Physical properties of 105°C TPU[a] insulations and jackets from appliance-wiring material

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)[b]	Minimum tensile strength[b]
Unaged	450 percent (4-1/2 inches or 112.5 mm)	2500 lbf/in^2 or 17.2 MPa
Aged in a full-draft-circulating-air oven for 168 h at 136.0 ±1.0°C (276.8 ±1.8°F)	85 percent of the result with unaged specimens	35 percent of the result with unaged specimens

[a] TPU designates thermoplastic polyurethane, a compounded thermoplastic elastomer material whose main constituent is a polyester- or polyether-based urethane linear polymer resin characterized by soft amorphous segments containing hard crystalline microdomains.

[b] TPU is to be tested at a speed of 20 ±1 in/min or 500 ±25 mm/min.

Table 50.228
Physical properties of 90°C XL[a] jacket from Type USE-2 and USE cable

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)	Minimum tensile strength
Unaged	150 percent (1-1/2 inches or 37.5 mm)	1500 lbf/in^2 or 10.3 MPa
Aged in a full-draft-circulating-air oven for 168 h at 121.0 ±1.0°C (249.8 ±1.8°F)	70 percent of the result with unaged specimens	70 percent of the result with unaged specimens

[a] XL designates a thermoset compound whose characteristic constituent is XLPE (cross-linked polyethylene), XLPVC (cross-linked polyvinyl chloride), XLEVA (cross-linked ethylene vinyl acetate), or blends thereof. It is appropriate to accomplish the cross-linking either chemically or by irradiation.

Table 50.229
Physical properties of 75°C XL[a] jacket from Type USE cable

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)	Minimum tensile strength
Unaged	150 percent (1-1/2 inches or 37.5 mm)	1500 lbf/in^2 or 10.3 MPa
Aged in a full-draft-circulating-air oven for 168 h at 113.0 ±1.0°C (235.4 ±1.8°F)	70 percent of the result with unaged specimens	70 percent of the result with unaged specimens

[a] XL designates a thermoset compound whose characteristic constituent is XLPE (cross-linked polyethylene), XLPVC (cross-linked polyvinyl chloride), XLEVA (cross-linked ethylene vinyl acetate), or blends thereof. It is appropriate to accomplish the cross-linking either chemically or by irradiation.

Table 50.230
Physical properties of XL[a] jacket from cable for deep-well submersible water pumps

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)	Minimum tensile strength
Unaged	150 percent (1-1/2 inches or 37.5 mm)	1500 lbf/in^2 or 10.3 MPa
Aged in a full-draft-circulating-air oven for 168 h at 100.0 ±1.0°C(212.0 ±1.8°F)	70 percent of the result with unaged specimens	70 percent of the result with unaged specimens

[a] XL designates a thermoset compound whose characteristic constituent is XLPE (cross-linked polyethylene), XLPVC (cross-linked polyvinyl chloride), XLEVA (cross-linked ethylene vinyl acetate), or blends thereof. It is appropriate to accomplish the cross-linking either chemically or by irradiation.

Table 50.231
Physical properties of 90°C and 75°C XL[a] jackets from CATV cables and insulations and jacket from power-limited circuit cable, from cable for power-limited fire-alarm circuits, and from other cables; and XL[a] insulation from Type RFHH-2 and RFHH-3 wires

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)	Minimum tensile strength
Unaged	150 percent (1-1/2 inches or 37.5 mm)	1500 lbf/in^2 or 10.3 MPa
Aged in a full-draft-circulating-air oven for 168 h:		
At 121.0 ±1.0°C (249.8 ±1.8°F) for specimens of 90°C insulation or jacket from power-limited circuit cable, from cable for power-limited fire-alarm circuits, or of 90°C insulation from Type RFHH-2 and RFHH-3 wires	70 percent of the result with unaged specimens	70 percent of the result with unaged specimens
At 113.0 ±1.0°C (235.4 ±1.8°F) for specimens of 75°C insulation or jacket from power-limited circuit cable or RHH and 228.1 from cable for power-limited fire-alarm circuits	70 percent of the result with unaged specimens	70 percent of the result with unaged specimens

[a] XL designates a thermoset compound whose characteristic constituent is cross-linked polyethylene (XLPE), cross-linked polyvinyl chloride (XLPVC), cross-linked ethylene vinyl acetate (XLEVA), or blends thereof, with the cross-linking achieved either chemically or by irradiation.

Table 50.232
Physical properties of 125°C and 150°C XLPO[a] insulations

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)	Minimum tensile strength
Unaged	300 percent (3 inches or 75 mm)	2000 lbf/in^2 or 13.79 MPa
125°C insulation:		
Aged in a full-draft-circulating-air oven for 168 h at 158.0 ±1.0°C (316.4 ±1.8°F)	80 percent of the result with unaged specimens	80 percent of the result with unaged specimens

Table 50.232 Continued on Next Page

Table 50.232 Continued

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)	Minimum tensile strength
150°C insulation:		
Aged in a full-draft-circulating-air oven for 168 h at 180.0 ±1.0°C (356.0 ±1.8°F)		

[a] XL designates a thermoset polyolefin compound whose characteristic constituent is XLPE (cross-linked polyethylene), XLEVA (cross-linked ethylene vinyl acetate), or a blend of the two. It is appropriate to accomplish the cross-linking either chemically or by irradiation.

Table 50.233
Physical properties of 105°C XLPO[a] insulation or jacket from power-limited circuit cable, from cable for power-limited fire-alarm circuits, and from other cables

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)	Minimum tensile strength[b]
Unaged	150 percent (1-1/2 inches or 37.5 mm)	2000 lbf/in^2 or 13.79 MPa
Aged in a full-draft-circulating-air oven for 168 h at 136.0 ±1.0°C (276.8 ±1.8°F)	70 percent of the result with unaged specimens	85 percent of the result with unaged specimens

[a] XLPO designates a thermoset polyolefin compound whose characteristic constituent is XLPE (cross-linked polyethylene), XLEVA (cross-linked ethylene vinyl acetate), or a blend of the two. It is appropriate to accomplish the cross-linking either chemically or by irradiation.

[b] XLPO is to be tested at a speed of 20 ±1 in/min or 500 ±25 mm/min.

Table 50.237
Physical properties of 90°C XL[a] insulation

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)	Minimum tensile strength
Unaged	150 percent (1-1/2 inches or 37.5 mm)	1500 lbf/in^2 or 10.3 MPa
Aged in a full-draft-circulating-air oven for 168 h at 121.0 ±1.0°C (249.8 ±1.8°F)	45 percent of the result with unaged specimens	70 percent of the result with unaged specimens

[a] XL designates a thermoset compound whose characteristic constituent is cross-linked polyethylene (XLPE), cross linked polyvinyl chloride (XLPVC), cross-linked ethylene vinyl acetate (XLEVA), or blends thereof. It is appropriate to accomplish this cross-linking either chemically or by irradiation.

Table 50.241
Physical properties of 75°C XL[a] insulation

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)	Minimum tensile strength
Unaged	150 percent (1-1/2 inches or 37.5 mm)	1500 lbf/in^2 or 10.3 MPa
Aged in a full-draft-circulating-air oven for 168 h at 113.0 ±1.0°C (235.4 ±1.8°F)	70 percent of the result with unaged specimens	70 percent of the result with unaged specimens

[a] XL designates a thermoset compound whose characteristic constituent is cross-linked polyethylene (XLPE), cross linked polyvinyl chloride (XLPVC), cross-linked ethylene vinyl acetate (XLEVA), or blends thereof. It is appropriate to accomplish this cross-linking either chemically or by irradiation.

Table 50.245
Physical properties of 105°C XL[a] insulation

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)	Minimum tensile strength
Unaged	150 percent (1-1/2 inches or 37.5 mm)	1500 lbf/in^2 or 10.3 MPa
Aged in a full-draft-circulating-air oven for 168 h at 136.0 ±1.0°C (276.8 ±1.8°F)	45 percent of the result with unaged specimens	70 percent of the result with unaged specimens

[a] XL designates a thermoset compound whose characteristic constituent is cross-linked polyethylene (XLPE), cross linked polyvinyl chloride (XLPVC), cross-linked ethylene vinyl acetate (XLEVA), or blends thereof. It is appropriate to accomplish this cross-linking either chemically or by irradiation.

Table 50.246
Physical properties of 75°C Thermoplastic EVA[a] insulation and jacket

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)	Minimum tensile strength
Unaged	100 percent (1 inch or 25 mm)	1200 lbf/in^2 or 8.27 MPa
Aged in a full-draft circulating-air oven for: 48 h at 100.0 ±1.0°C (212 ±1.8°F)	75 percent of the result with unaged specimens	75 percent of the result with unaged specimens

[a] Thermoplastic EVA designates either:

a) An EVA copolymer, or

b) EVA copolymer blended with polyolefin compound(s). The compound contains at least 5 percent vinyl acetate as a percentage of the total polymer content.

Table 50.247
Physical properties of 90°C Thermoplastic EVA[a] insulation and jacket

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)	Minimum tensile strength
Unaged	110 percent (1.1 inches or 28 mm)	1300 lbf/in^2 or 9.0 MPa
Aged in a full-draft circulating-air oven for: 168 h at 121.0 ±1.0°C (249.8 ±1.8°F)	50 percent of the result with unaged specimens	85 percent of the result with unaged specimens

[a] Thermoplastic EVA designates either:

a) An EVA copolymer, or

b) EVA copolymer blended with polyolefin compound(s). The compound contains at least 5 percent vinyl acetate as a percentage of the total polymer content.

Table 50.248
Physical properties of 105°C Thermoplastic EVA[a] insulation and jacket

Condition of specimens at time of measurement	Minimum ultimate elongation (1-inch or 25-mm bench marks)	Minimum tensile strength
Unaged	140 percent (1.4 inches or 35.6 mm)	1550 lbf/in^2 or 10.3 MPa
Aged in a full-draft circulating-air oven for: 168 h at 136.0 ±1.0°C (276.8 ±1.8°F)	50 percent of the result with unaged specimens	85 percent of the result with unaged specimens

[a] Thermoplastic EVA designates either:

a) An EVA copolymer, or

b) EVA copolymer blended with polyolefin compound(s). The compound contains at least 5 percent vinyl acetate as a percentage of the total polymer content.

51 thru 199 *Reserved for Future Use*

METHODS

CONDUCTOR DIMENSIONS AND RESISTANCE

200 Conductor Diameter

200.1 The specifications for this test are located under Conductor Diameter in the Standard for Wire and Cable Test Methods, UL 2556.

200.2 Each minimum and maximum diameter in Table 20.1, Table 20.2, Table 20.3, Table 20.3.1, Table 20.4, Table 20.4.1, and Table 20.6 is an absolute minimum or maximum. For the purpose of determining whether the conductor does or does not comply with the diameter requirement(s), the unrounded average of the two micrometer readings is to be compared directly with whichever of the following applies:

a) Both the 0.98 x nominal minimum and the 1.01 x nominal maximum where the wire standard specifies these diameter limits for the solid or stranded conductor.

b) The 0.99 x nominal minimum in Table 20.1 where the wire standard specifies only a minimum diameter for a solid conductor.

201 thru 209 *Reserved for Future Use*

210 Conductor Cross-Sectional Area by the Weight Method

210.1 The specifications for this test are located under Cross sectional area by mass (weight) method in the Standard for Wire and Cable Test Methods, UL 2556.

210.2 *Deleted*

210.3 *Deleted*

Table 210.1
Minimum weight of specimens of stranded conductors for which k is 2[a,b]
Table deleted

Table 210.2
Percentage increase (k) in weight for type of strands
Table deleted

210.4 *Deleted*

211 thru 219 *Reserved for Future Use*

220 D-C Conductor Resistance

220.1 The specifications for this test are located under DC Resistance in the Standard for Wire and Cable Test Methods, UL 2556.

220.2 *Deleted*

220.3 *Deleted*

220.4 *Deleted*

220.5 *Deleted*

220.6 *Deleted*

220.7 *Deleted*

220.8 *Deleted*

220.9 *Deleted*

Table 220.1
Factors for adjusting d-c resistance of conductors[a]
Table deleted

221 thru 227 ***Reserved for Future Use***

WIRE BRAID AND SERVING COVERAGE

228 Measurements and Calculations

228.1 Calculations for braid coverage are found in Calculation of coverage of shielding (wraps and braids), Annex G, in the Standard for Wire and Cable Test Methods, UL 2556.

228.2 *Deleted*

228.3 *Deleted*

228.4 *Deleted*

228.5 *Deleted*

Table 228.1
Coverage calculations for a wire braid
Table deleted

Table 228.2
Coverage calculations for a wire serving (spiral shield or reverse spiral shield)
Table deleted

229 thru 239 ***Reserved for Future Use***

THICKNESSES OF INSULATION AND JACKET

240 Thicknesses of Insulation on Thermoplastic- and Thermoset-Insulated Wires and Cable

Average thickness

240.1 The specifications for this test are located in Thickness, in the Standard for Wire and Cable Test Methods, UL 2556.

240.2 *Deleted*

240.3 *Deleted*

240.4 *Deleted*

240.5 *Deleted*

240.6 *Deleted*

240.7 Where the results obtained via the procedures described in UL 2556 do not comply, a micrometer microscope or other optical instrument calibrated to read directly to at least 0.0001 inch or 0.001 mm is to be used to measure the maximum and minimum thicknesses of insulation directly at five points. To accomplish this, five sections 4 inches or 100 mm long are to be cut from the sample with one of the five points at the center of each section. Without damaging or stressing the insulation, the conductor and any separator are to be removed and the five tubes of insulation are to be cut in two at their centers. Each cut is to be clean and perpendicular to the longitudinal axis of the tube. This yields ten specimens for measurement; however, measurements are to be made on only five specimens – on one specimen from each tube. The clean-cut end of each of the five specimens is to be viewed through the instrument and the maximum and minimum thicknesses of each are to be found and recorded to the nearest 0.0001 inch or 0.001 mm. The average of the ten measurements is to be calculated and then rounded to the nearest 0.001 inch or 0.01 mm and compared with the average thickness specified in the wire standard. The results of this procedure with the optical instrument are to be taken as conclusive.

Minimum thickness at any point

240.8 *Deleted*

240.9 *Deleted*

240.10 *Deleted*

240.11 *Deleted*

240.12 *Deleted*

240.13 *Deleted*

240.14 Where the results obtained via the procedures described in UL 2556 do not comply, a micrometer microscope or other optical instrument calibrated to read directly to at least 0.0001 inch or 0.001 mm is to be used to view the clean-cut end of one of the two specimens. The point of minimum thickness is to be located and the thickness reading is to be recorded. The recorded value is to be rounded to the nearest 0.001 inch or 0.01 mm and compared with the minimum thickness at any point specified for the construction in the wire standard. The results of this procedure with the optical instrument are to be taken as conclusive.

241 thru 249 ***Reserved for Future Use***

250 Thicknesses of Insulation on Flexible Cord and on Fixture Wire

250.1 The specifications for this test are located in Thickness, in the Standard for Wire and Cable Test Methods, UL 2556.

250.2 *Deleted*

250.3 *Deleted*

250.4 *Deleted*

250.5 Where the results of measurements by these methods do not comply, referee measurements are to be made by means of an optical device calibrated to read directly to at least 0.0001 inch or 0.001 mm.

When measured by means of an optical device, it is appropriate for the average thickness of insulation on a stranded conductor to be 3 mils or 0.08 mm less than specified for the construction in the wire standard.

250.6 *Deleted*

250.7 *Deleted*

250.8 *Deleted*

250.9 *Deleted*

250.10 Where the results of these measurements do not comply, referee measurements are to be made by means of an optical device calibrated to read directly to at least 0.0001 inch or 0.001 mm. When measured by means of an optical device, it is appropriate for the minimum thickness at any point of the insulation on a stranded conductor to be 3 mils or 0.08 mm less than specified for the construction in the wire standard.

250.11 *Deleted*

251 thru 259 *Reserved for Future Use*

260 Thicknesses of Jacket on Thermoplastic- and Thermoset-Insulated Wires and Cables

260.1 The specifications for this test are located in Thickness, in the Standard for Wire and Cable Test Methods, UL 2556.

260.2 *Deleted*

260.3 *Deleted*

260.4 *Deleted*

260.5 *Deleted*

260.6 *Deleted*

260.7 *Deleted*

260.8 Where the results obtained via the procedures described in 260.1 do not comply, a micrometer microscope or other optical instrument calibrated to read directly to at least 0.0001 inch or 0.001 mm is to be used to locate and measure the maximum and minimum thicknesses on each of the slices. The maximum and minimum thicknesses of each slice are to be recorded to the nearest 0.0001 inch or 0.001 mm. The average of the four measurements is to be calculated and then rounded to the nearest 0.001 inch or 0.01 mm and compared with the average thickness of the jacket specified for the construction in the wire Standard. The smallest of the four measurements is to be rounded to the nearest 0.001 inch or 0.01 mm and compared with the minimum thickness of the jacket specified for the construction in the wire standard. The results of this procedure with the optical instrument are to be taken as conclusive.

261 thru 279 *Reserved for Future Use*

280 Thicknesses of Jacket on Flexible Cord, Fixture Wire, and Elevator Cable

280.1 The specifications for this test are located in Thickness, in the Standard for Wire and Cable Test Methods, UL 2556. Where the results of measurements by this method do not comply, referee measurements are to be made by means of an optical device calibrated to read directly to at least 0.0001 inch or 0.001 mm.

280.2 *Deleted*

280.3 *Deleted*

281 thru 399 *Reserved for Future Use*

PHYSICAL PROPERTIES TESTS OF INSULATION AND JACKET

400 General

400.1 The specifications for this test are located in Physical Properties, in the Standard for Wire and Cable Test Methods, UL 2556.

401 thru 419 *Reserved for Future Use*

420 Apparatus

Section 420 deleted

421 thru 439 *Reserved for Future Use*

440 Preparation of Specimens

Section 420

441 thru 459 *Reserved for Future Use*

460 Recovery

460.1 The recovery test is to be conducted using specimens that have not been subjected previously to any test. Each specimen is to be clamped in position, with both marks visible between the grips. The grips are to be adjusted symmetrically to distribute the tension uniformly over the cross section of the specimen. The movable grip is to be adjusted to make the test piece taut, not under tension. The temperature of the ambient air is to be recorded.

460.2 The grips are to be separated at a rate of 20 ±1 in/min or 500 ±25 mm/min until the specified elongation is reached. The specimen is to be held in the stretched position for 2 min, released immediately without snapping back, rested for 2 min, and the distance between the marks is then to be measured to the nearest 0.01 inch or 0.1 mm and is to be recorded. Just before releasing the specimen, the distance between the marks is to be observed again. Where it has decreased because of slipping of the specimen in the grips, the test is to be repeated with another specimen.

461 thru 469 *Reserved for Future Use*

470 Ultimate Elongation and Tensile Strength

470.1 The specifications for this test are located in Physical Properties, Ultimate Elongation and Tensile Strength, in the Standard for Wire and Cable Test Methods, UL 2556.

470.2 *Deleted*

470.3 *Deleted*

470.4 *Deleted*

470.5 *Deleted*

470.6 *Deleted*

470.7 *Deleted*

470.8 *Deleted*

Figure 470.1

Cross sections of samples after longitudinal cutting

Figure deleted

470.9 *Deleted*

470.10 *Deleted*

471 thru 479 *Reserved for Future Use*

480 Accelerated Aging

General

480.1 The specifications for this test are located in Physical Properties, Short term oven aging, in the Standard for Wire and Cable Test Methods, UL 2556.

480.2 *Deleted*

Air-oven aging

480.3 *Deleted*

480.4 *Reserved for Future Use*

Oil immersion

480.5 The specifications for this test are located in Physical Properties, Oil Resistance, in the Standard for Wire and Cable Test Methods, UL 2556.

480.6 *Deleted*

480.7 *Deleted*

480.8 For specimens of oil-resistant Type TFN and Type TFFN fixture wires, the immersion vessel is to be a test tube having an overall diameter of at least 1 inch or 25 mm and a length that facilitates immersion of a straight specimen at least 6 inches or 150 mm long. The tube is to be filled with oil and placed in a bath or a full-draft circulating-air oven having an automatic temperature control that maintains the specimens at the specified temperature. Specimens of finished wire with or without the conductor removed are to be bent at the center to form a narrow U and are then to be suspended vertically in the oil, with the ends of each specimen projecting above the oil. The specimens are to be immersed without removal of the nylon jacket. After immersion for the specified length of time, each specimen is to be cut in half at the center of the U bend to result in two specimens for physical tests from each length immersed.

Gasoline immersion

480.9 The specifications for this test are located in Physical Properties, Gasoline Resistance, in the Standard for Wire and Cable Test Methods, UL 2556. The immersion vessel and specimens for the immersion tests of gasoline-resistant Type TFN and TFFN fixture wires are to be as indicated in 480.8, with 1 inch or 25 mm of tap water at the bottom and the remainder of the vessel filled with ASTM Reference Fuel C, which is described in ASTM D 471.

480.10 *Deleted*

480.11 *Deleted*

481 Long-Term Aging

481.1 The specifications for this test are located in Dry temperature rating of new materials (long-term aging test), in the Standard for Wire and Cable Test Methods, UL 2556.

481.2 *Deleted*

481.3 *Deleted*

481.4 *Deleted*

481.5 *Deleted*

481.6 *Deleted*

481.7 *Deleted*

481.8 *Deleted*

481.9 *Deleted*

Table 481.1
Oven temperature and time for short-term aging
Table deleted

481.10 *Deleted*

481.11 *Deleted*

481.12 *Deleted*

481.13 *Deleted*

481.14 *Deleted*

482 thru 489 ***Reserved for Future Use***

COMPOUND ANALYSIS

Polyvinyl Chloride (PVC) Compounds

490 Infrared Spectroscopy

490.1 GENERAL – Infrared Analysis is to be used to provide a method for the identification of PVC wire and cable compounds. Interpretation of infrared spectral transmittance is to be used to identify the composition of a compound by comparing the compound's infrared spectra to the spectra of materials having known compositions.

490.2 The analysis is to be performed with a Fourier Transform Infrared (FTIR) Spectrophotometer and/or a Dispersive Infrared Spectrophotometer. The results are to be recorded as a plot of the percent transmittance of the infrared radiation through the sample versus the number of wavelengths in one centimeter [the reciprocal wavelength (cm^{-1}) or "wavenumber"] of the radiation. Percent transmittance is to be expressed on the ordinate and wavenumber on the abscissa. The infrared spectra obtained by the methods described is to consist of a wavenumber range of at least 4000– 400 reciprocal centimeters.

490.3 SAMPLE PREPARATION / TEST PROCEDURE– The PVC compound is to be separated into solvent-soluble and solvent-insoluble fractions by use of a centrifuge and/or by filtration. Stabilized (peroxide-inhibited) tetrahydrofuran (THF) **See 490.4**, or other solvents with demonstrated comparable solubilities, are to be used. Stabilized (peroxide-inhibited) THF is the solvent of choice and centrifugation is the preferred fraction-separation method of choice. The solvents are to be readily evaporable by gentle heating and are not to react with the PVC material. The THF stabilizer/peroxide inhibitor component shall not be present in quantities detectable in the infrared spectra. Precautions are to be taken for the safe handling, storage, and disposal of each solvent employed.

490.4 PARTICULAR CAUTIONS WITH THF, AN ETHER– Tetrahydrofuran (THF) is indicated as a solvent in Infrared Spectroscopy, Section 490, Elemental Analysis, Section 492, and Gel Permeation Chromatography, Section 493 of this standard, and use of ***stabilized*** THF is specified. **Unstabilized THF shall not be used.** Stabilization of an ether inhibits the formation of peroxides, which are explosive when concentrated. Peroxides often concentrate as an ether is stored or exposed to air for a prolonged period; as an ether is distilled, heated to dryness, or otherwise evaporates; as heat/shock/friction are applied; and upon disposal in a manner in which incompatible materials are mixed.

490.5 The solvent-soluble compound fraction is to be cast on an optically transparent potassium bromide (KBr) crystal. The crystal is to be placed in an explosion-proof oven to evaporate the solvent, leaving a thin film of the soluble compound fraction on the KBr crystal. The crystal is then to be placed directly into the sample holder of the instrument for recording the infrared spectrum.

490.6 The insoluble portion is to be washed with additional solvent, centrifuged, and then decanted to remove the soluble compound components (resin, plasticizer, and the like). The insoluble portion is to be placed in an explosion-proof oven to evaporate the solvent. After drying, the insolubles are to be mixed with powdered spectroscopic-grade potassium bromide (KBr) and ground in a vibrating ball mill. A quantity of this mixture that produces a disk typically 1 mm thick and 1/2 inch or 12.7 mm in diameter is then to be placed in an evacuable die. The die is to be put under a vacuum and mechanical pressure of 10,000 – 15,000 lbf/in^2 or 69 – 103 MPa or 7 – 11 kgf/mm^2 is to be applied. The pressed disk is to be removed from the die, put into a disk holder, and then placed directly into the sample holder of the instrument for recording the infrared spectrum.

490.7 In the event that the PVC compound is not soluble in stabilized THF or hot ortho-dichlorobenzene, the IR spectrum is to be created from the preparation techniques described in Infrared Spectroscopy, Section 494 of this standard.

490.8 Pyrolytic Gas Chromatography (Section 495) is appropriate in place of Infrared Analysis of the PVC compound where the compound is not soluble in stabilized THF or in ortho-dichlorobenzene and the IR sample preparation techniques described in Infrared Spectroscopy, Section 494, are not effective.

490.9 REPORT – The individual spectra are to include all of the following:

a) Complete identification of the PVC material tested – including the designation for the material and the form and color of the sample.

b) The name and/or tradename of the material manufacturer and the assigned code (file number).

c) The sample preparation procedure or preparation code.

d) The instrument parameters (number of scans, resolution, slit program, and the like).

e) The test date and operator identification.

491 Determination of the Ash Content

491.1 GENERAL – This method is to be used to determine the amount of noncombustible components in a PVC wire and cable material. This is similar to the direct-calcination procedure (Method A) described in ISO 3451-89, Part 5, covering methods for the ash-content analysis of polyvinyl chloride (PVC) materials.

491.2 MATERIALS AND EQUIPMENT – The following equipment is to be used in conducting the test:

a) An analytical balance capable of weighing to the nearest 0.1 mg.

b) Silica or platinum crucibles of a size fillable to no more than half way by the test portion.

c) A fume hood over the burner specified in (d) and a fume hood over the furnace specified in (e).

d) Burner apparatus consisting of a Bunsen burner with a tripod and a clay triangle for supporting the crucible above the burner flame.

e) A muffle furnace controlled thermostatically to a temperature of 850 ±50°C (1562 ±90°F).

f) A desiccator containing an effective drying agent that does not react with the ash components.

491.3 TEST PROCEDURE – A sample of the PVC compound (typically 4 – 5 grams) is to be placed in a weighed crucible that has been dried to a constant weight. The weight of the dried crucible plus the sample is to be recorded. Under the fume hood, the crucible is to be heated using the burner apparatus in a manner that burns the sample slowly and does not result in any loss of the ash. When the smoking ceases, the crucible is to be placed in a muffle furnace under an operating fume hood and heated at 850 ±50°C (1562 ±90°F) for 30 min. The crucible is to be removed from the furnace, cooled in a desiccator, and weighed. The crucible is to be returned to the furnace for an additional 30 min and then is to be cooled and reweighed. This calcination procedure is to be repeated until constant mass is reached – that is, until the results of two consecutive weighings do not differ by more than 0.5 mg. However, the duration of heating in the furnace is not to exceed a total of 3 h. Where a constant mass is not attained in 3 h, the mass (weight) after 3 hours is to be used for calculating the results.

491.4 At least two determinations are to be performed and the mean of the results calculated. Where the individual test results differ from one another by more than 10 percent of the mean, the procedure is to be repeated until two successive results do not differ by more than 10 percent of the mean.

491.5 CALCULATIONS – The ash content is to be calculated in percent by dividing the weight of the residue after ignition at 850 ±50°C (1562 ±90°F) by the original weight of the sample and multiplying by 100. The average of the results of the two or more determinations is to be recorded as the ash content.

491.6 REPORT – The report is to include each of the following:

a) Complete identification of the PVC material tested – including the designation for the material and the form and color of the sample.

b) The name and/or trade name of the material manufacturer and the assigned code (file number).

c) The weights recorded to the nearest 0.1 mg.

d) The average ash content calculated to the nearest 0.1 percent.

e) The test date(s) and operator identification.

492 Elemental Analysis

492.1 GENERAL – Elemental Analysis is to be used to provide quantitative data on the lead, cadmium, barium, or zinc content of a PVC wire and cable compound. The heat stabilizer system typically consists of compounds of one or more of these metals.

492.2 The analysis is to be performed on an atomic absorption (AA) spectrophotometer by the flame technique, or an inductively coupled plasma (ICP) spectrophotometer. The instrument is to be calibrated using standards of known metallic content. The sample solutions are then to be analyzed and the values derived by plotting the readings on the calibration curve.

492.3 One of three sample preparation methods is to be used as described in this section. Where the Perchloric/Nitric Acid Digestion method (Method 1) cannot be used, Method 2 or Method 3 is to be employed. In either case, quantitative metal content comparisons are to be made between data derived only from the same sample preparation method.

492.4 Precautions are to be taken for the safe handling, storage, and disposal of each solvent and acid employed.

492.5 SAMPLE PREPARATION METHOD 1 (PERCHLORIC / NITRIC ACID DIGESTION FOR LEAD, CADMIUM, ZINC, AND BARIUM) – Under an operating fume hood, the PVC sample (250 – 325 mg) is to be digested on a hot plate in an equal mixture of concentrated perchloric acid (69 – 72 percent) **See 492.6** and concentrated nitric acid (69 – 71 percent). This digestion is to proceed over moderate heat in an oxidizing state until all of the polymeric and other carbon-based materials are decomposed. The solution is to be cooled. The solution is then to be filtered. The digestion beaker and filter paper are to be washed with several portions of hot, dilute nitric acid. The filtrate and washings are to be diluted to a known volume and analyzed.

492.6 PARTICULAR CAUTIONS WITH PERCHLORIC ACID, AN OXIDIZING MATERIAL – Perchloric acid is indicated as half of the digestive mixture in 492.5 of this Standard, and use in a ***concentrated*** (69 – 72 percent) form is specified. Perchloric acid can ignite upon contact with combustible material or a dehydrating agent or upon disposal in a manner in which incompatible materials are mixed. Perchloric acid in any concentration destroys living tissue upon contact.

492.7 SAMPLE PREPARATION METHOD 2 (NITRIC ACID DIGESTION OF THE THF-INSOLUBLE PORTION FOR LEAD, CADMIUM, AND ZINC) – The PVC sample (250 – 325 mg) is to be dissolved in a test tube using stabilized tetrahydrofuran (THF) **See 490.4** or another solvent with demonstrated comparable compound component solubilities for Pb, Cd, Zn, and Ba recoveries. The solution is to be centrifuged to separate the insolubles. The THF/PVC resin solution is to be decanted, and the insoluble portion washed with additional solvent, centrifuged, and decanted to remove the soluble compound components. The insoluble pellet is then to be dried in an explosion-proof oven. After drying, the pellet is to be dissolved in dilute nitric acid and the solution is to be filtered. The tube and filter are to be washed several times with hot, dilute nitric acid. The sample is to be diluted to a known volume and analyzed.

492.8 SAMPLE PREPARATION METHOD 2 (HYDROCHLORIC ACID DIGESTION OF THE SAMPLE ASH FOR BARIUM) – The PVC sample (1.0 – 1.2 g) is to be ashed slowly using a ceramic crucible in a muffle furnace by raising the temperature from 250°C to 650°C in steps. The final temperature is to be held for 30 min. The ash is to be digested with a hot, 50-percent solution of hydrochloric acid. The solution is then to be filtered. The crucible and filter are to be washed several times with hot, 10-percent hydrochloric acid. The sample solution is to be diluted to a known volume and analyzed.

492.8.1 SAMPLE PREPARATION METHOD 3 [MICROWAVE FURNACE ASSISTED HYDROCHLORIC AND NITRIC ACID (W/ HYDROGEN PEROXIDE) DIGESTION FOR LEAD, CADMIUM, ZINC AND BARIUM] – In a suitable vessel, the PVC sample (250 – 355 mg) is digested with a microwave furnace in a mixture (approximately 25/60/15) of concentrated hydrochloric acid (34 – 37 percent), concentrated nitric acid (67 –70 percent) and hydrogen peroxide (approximately 30 percent) until all of the polymeric and other carbon-based materials are decomposed. After the solution has cooled, the solution is then to be filtered. The microwave digestion beaker and filter paper are to be washed with several portions of water. The filtrate and washings are to be diluted to a known volume and analyzed.

492.9 REPORT – The report is to include each of the following:

a) The sample preparation method used (Method 1, Method 2 or Method 3) and complete identification of the PVC material tested – including the designation for the material and the form and color of the sample.

b) The measurement instrument used [atomic absorption (AA) spectrophotometer by the flame technique or inductively coupled plasma (ICP) spectrophotometer).

c) The name and/or tradename of the material manufacturer and the assigned code (file number).

d) The sample weight, initial volume including any dilutions, and the AA spectrophotometer response.

e) The type of metal and its content in the material expressed in parts per thousand of the compound.

f) The test date(s) and operator identification.

493 Gel Permeation Chromatography

493.1 GENERAL – Gel Permeation Chromatography (GPC) is a type of liquid chromatography that employs a porous gel as a separation medium. GPC typically is used to analyze large compounds such as polymers that are not appropriate for traditional chromatographic separation media. The method described here is designed to analyze the organic-soluble non-resin PVC wire and cable compound components (for example, plasticizers) that appear within the working range of the column bank.

493.2 This analysis is to be performed with small-particle-and-pore-size cross-linked spherical polystyrene/divinylbenzene matrix-column packing material. Compound components that appear within the working range of the column bank are to be evaluated. Refractive Index and Ultraviolet detection are to be used for qualitative evaluations. Quantitative evaluations are to be performed by the internal standard method (relative to a plasticizer standard) employing refractive-index detection. Relative quantitative calculation is to be derived from detector responses of the sample and from the plasticizer/internal standard calibration curve. For the chromatograph mobile phase and as the solvent for sample and standards preparation, stabilized tetrahydrofuran (THF) **See** **490.4** or another solvent with demonstrated comparable PVC resin and compound component solubilities, chromatographic resolutions, and detector responses is to be used. Comparisons are to be made between data derived only from use of the same solvents.

493.3 Precautions are to be taken for the safe handling, storage, and disposal of each solvent employed.

493.4 STANDARDS PREPARATION – The standards are to consist of three stabilized tetrahydrofuran (THF) solutions containing different concentrations of a typical vinyl-compound plasticizer and identical concentrations (approximately 0.2 percent by volume) of the internal standard. The plasticizer concentrations are to represent typically 5, 25, and 50 percent of the sample mass diluted to the same volume.

493.5 SAMPLE PREPARATION – A sample of the PVC compound (typically 250 mg) is to be combined with stabilized THF and the internal standard. The compound/internal standard/THF solution is to be agitated to dissolve the resin and then is to be transferred to a volumetric flask. Additional portions of stabilized THF are to be added to the initial compound/internal standard/THF container and agitated to extract any residual compound components or internal standard. The washes are to be added to the volumetric flask and brought to a final concentration near 5 mg/ml (compound/stabilized THF). The volumetric solution is then to be filtered to remove particulates before entering the sample loop of the chromatograph.

493.6 REPORT – The report is to contain each of the following:

a) Complete identification of the PVC material tested – including the designation for the material and the form and color of the sample.

b) The name and/or tradename of the material manufacturer and the assigned code (file number).

c) The sample weights, dilution volumes, detector responses, and calibration curve slopes.

d) A refractive index chromatogram including all of the evaluated components.

e) The average relative percent of compound results of the quantified components to the nearest 0.01 percent.

f) The test date(s) and operator identification.

Other compounds

494 Infrared Spectroscopy

494.1 The Infrared Spectroscopy scan of each material shall be performed in accordance with the test, "Infrared Spectroscopy", specified in the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A.

494.2 *Deleted.*

494.3 *Deleted.*

494.4 *Deleted.*

494.5 *Deleted.*

494.6 *Deleted.*

494.7 *Deleted.*

495 Pyrolytic Gas Chromatography

495.1 GENERAL – The Pyrolytic Gas Chromatography of each material shall be performed in accordance with the test, "Pyrolytic Gas Chromatography", specified in the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A.

495.2 This identification technique is to be used where infrared analysis is not effective, as when the nature of certain resins or additives makes it difficult to prepare specimens for the infrared method. Typically, this applies to materials with a high carbon black or metallic content.

495.3 *Deleted.*

495.4 *Deleted.*

496 Thermogravimetry

496.1 The decomposition scan of each material shall be performed in accordance with the test, "Thermogravimetry", specified in the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A.

496.2 *Deleted.*

496.3 *Deleted.*

497 Differential Scanning Calorimetry

497.1 The transition temperatures of each material shall be performed in accordance with the test, "Differential Scanning Calorimetry", specified in the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A.

497.2 *Deleted.*

497.3 *Deleted.*

498 thru 499 ***Reserved for Future Use***

CONDUCTOR CORROSION

500 General

500.1 The specifications for this test are located in Copper corrosion, in the Standard for Wire and Cable Test Methods, UL 2556.

501 thru 519 ***Reserved for Future Use***

INSULATION FALL-IN

520 Test

520.1 The specifications for this test are located in Fall-In of extruded materials, in the Standard for Wire and Cable Test Methods, UL 2556.

521 thru 539 ***Reserved for Future Use***

HEAT SHOCK

540 Test

540.1 The specifications for this test are located in Heat Shock, in the Standard for Wire and Cable Test Methods, UL 2556.

Note – When a mandrel specified in the product standard is not available, it shall be permitted to use a mandrel with a smaller diameter. However, in the event of non-compliant results, the wire or cable shall be re-tested using the mandrel size specified in the product standard.

540.2 *Deleted*

541 thru 559 ***Reserved for Future Use***

DEFORMATION

560 Test

560.1 The specifications for this test are located in Deformation, in the Standard for Wire and Cable Test Methods, UL 2556.

560.2 *Deleted*

560.3 *Deleted*

560.4 *Deleted*

Figure 560.1

Deformation test apparatus with specimens in place

Added weights are not shown

Figure deleted

560.5 *Deleted*

560.6 *Deleted*

560.7 *Deleted*

560.8 *Deleted*

560.9 *Deleted*

561 thru 579 *Reserved for Future Use*

COLD BEND

580 Test

580.1 The specifications for this test are located in Cold Bend, in the Standard for Wire and Cable Test Methods, UL 2556.

Note – When a mandrel specified in the product standard is not available, it shall be permitted to use a mandrel with a smaller diameter. However, in the event of non-compliant results, the wire or cable shall be re-tested using the mandrel size specified in the product standard.

581 thru 582 *Reserved for Future Use*

FLEXIBILITY AT LOW TEMPERATURE

583 Test

583.1 After cooling for 4 h to –25.0 ±2.0°C (–13.0 ±3.6°F), finished cable shall be undamaged by the bending described in 583.2 – 583.15.

583.2 Two straight specimens at least 30 inches or 760 mm long are to be cut from a sample length of finished cable without bending the cut ends of any conductor. Both specimens are to be bent (see 583.12) around one diameter of mandrel (see 583.3) where the cable is round. Where the cable is flat, two different diameters of mandrel (see 583.3) are required, one of the specimens being bent flatwise around the smaller mandrel and the other being bent edgewise around the larger mandrel.

583.3 A series of mandrels is to be stocked in which the diameters are either within 1 mil of being integral multiples of 200 mils (0.2 inch) or within 0.01 mm of being integral multiples of 5 mm. The method by which the particular diameter or diameters of mandrel for a test are to be determined is explained in 583.4–583.9. Measurements for use in the determination are to be made on only one of the specimens of cable.

583.4 In testing a round cable, the diameter over the outer surface of the cable is to be measured. In testing a flat cable, measurements are to be made of the lengths of the major and minor axes over the outer surface of the cable. The instruments specified in 583.5 and 583.6 for making these measurements are to be calibrated to facilitate estimation of each measurement to 0.1 mil or 0.001 mm.

583.5 A dead-weight dial micrometer is to be used to measure a diameter or length of axis that is not larger than 0.500 inch or 12.7 mm. The anvil and presser foot are to be 0.078 inch or 1.98 mm wide and 0.375 inch or 9.52 mm long. The foot is to exert a total of 10 ±2 gf or 0.10 ±0.02 N on a specimen.

583.6 A machinist's micrometer caliper with a ratchet is to be used to measure a diameter or length of axis that is longer than 0.500 inch or 12.7 mm. The surfaces of the anvil and the end of the spindle are to be flat.

583.7 The measurements are to be made in a plane that is perpendicular to the longitudinal axis of the cable. Except in the case indicated in 583.8, at least four measurements are to be made of each length of axis or diameter. Each measurement is to be estimated to the nearest 0.1 mil or 0.001 mm and recorded. The largest and smallest recorded measurements of the diameter or of each length of axis are to be identified as such on the data sheet, and the two are to be averaged. Each average is to be recorded.

583.8 Where, on the smaller cables, only one measurement of the length of the major axis is practical, the single measurement is to be recorded as the average length of the major axis.

583.9 The two diameters of mandrel that are to be used with a flat cable are to be determined by first multiplying the average length of the major axis by 20 and multiplying the average length of the minor axis by 4. The single diameter of mandrel that is to be used with a round cable is to be determined by first multiplying the average diameter by 6.

583.10 The apparatus for this test is to consist of a sharp knife for opening the cable; round metal cylinders for use as the mandrels specified in 583.3 – 583.9; and a dry-ice cabinet or a mechanical refrigerator, either one of which is to be capable of sustained operation at a low temperature of −25.0 ±2.0°C (−13.0 ±3.6°F). The mandrels are to be secured within the cold chamber in a manner that enables the bending operation to be conducted in the chamber and at the low temperature, and facilitates the release of mandrels from the chamber while the bent specimens are securely in place on them.

583.11 The cold chamber is to be precooled to the low temperature before the specimens are placed in the chamber. Both straight specimens are to be cooled for 4 h to the low temperature.

583.12 After the full period of cooling, each specimen is to be bent for 180° around the applicable mandrel (see 583.3) while both the mandrel and specimen are maintained at the low temperature. While in the bent position, each specimen is to be secured to the mandrel. The assemblies of mandrel and specimen are then to be removed from the chamber and, while it is still on the mandrel, the overall covering is to be examined for the damage described in 583.15.

583.13 A separate specimen is to be used for each size of mandrel, and no specimen is to be bent more than once.

583.14 Both specimens are to be cut open and their interiors examined for the damage described in 583.15.

583.15 Any cable from which a specimen exhibits any of the damage described in this paragraph does not comply. There are not to be ruptures of any fibrous material in the cable. There is not to be a part, split, or crack larger than 1/16 inch or 1.5 mm in the tape-and-finish outer covering on Type SE cable. In the absence of rubbing, there is not to be any flaking of the treating or finishing compounds used with the fibrous outer layer of a layered covering. No cracks, tears, or splits are to be in the insulation, any individual jacket over the insulation, in any web, or in any overall jacket. Circumferential depressions in the outer surface of a jacket or the insulation indicate cracks on the inside surface. Circumferential depressions in a fluoropolymer surface are yield marks (locally stronger points) rather than indicators of cracking.

584 thru 592 ***Reserved for Future Use***

IMPACT AT ABNORMALLY LOW TEMPERATURE

593 Test

593.1 Specimens are to be impacted on anvils consisting of 8-inch or 203-mm lengths of 2x4 spruce lumber having no surface imperfections or knots. The wood anvil is to be inspected after each specimen is impacted and replaced where it shows any indentations.

593.2 The impact energy is to be provided by a weight of 3 lb or 1.36 kg in the form of a circular steel cylinder having a diameter of 1 inch or 25 mm and a flat impact face that is perpendicular to the longitudinal axis of the weight and has rounded edges.

593.3 The impact specimens are to consist of ten separate 5-inch or 130-mm sections cut from a straight sample length of the finished wire or cable.

593.4 The specimens and wood anvils are to be cooled for at least 4 h in a cold chamber maintained at a temperature of −40.0 ±2.0°C (−40.0 ±3.6°F). The impact weight and the remainder of the test apparatus are to be in thermal equilibrium with the surrounding air in the test room at a temperature of 24.0 ±8.0°C (75.2 ±14.4°F).

593.5 At the conclusion of at least 4 h of cooling, one of the wood anvils is to be removed from the cold chamber and is to be secured to a concrete floor, the building framework, or another solid support that does not absorb the impact. The impact weight is to be supported with its lower face horizontal. A vertical line through the centers of gravity of the impact weight and the stationary anvil is to be coincident with a vertical line through the dimensional center of the lower face of the impact weight and the dimensional center of the upper face of the stationary anvil. A set of rails or other vertical guide(s) is to constrain the impact weight and keep its lower face horizontal while the weight is falling and after it has struck the wire or cable. The rails or other guide(s) are not to interfere with the free fall of the impact weight. The top of the guide(s) is to have a means for releasing the impact weight to fall freely from any chosen height and strike the wire or cable. The weight is also to be kept from striking the wire or cable more than once during each drop.

593.6 One of the test specimens of the wire or cable is to be removed from the cold chamber and is to be tested as follows without delay and within 15 s of being removed from the chamber. Insulating gloves are to be worn by the person conducting the test. The time in seconds between removal of the specimen from the chamber and the impact is to be noted and recorded. The impact weight is to be secured several specimen diameters (several times the length of the minor axis in the case of a flat cable) above the anvil and the specimen is to be placed and held on the cold anvil with the longitudinal axis of the specimen horizontal, perpendicular to the longitudinal axis of the anvil, and in the vertical plane containing the coincident vertical lines described in 593.5. In the case of a flat cable, the specimen is to be flatwise on the anvil. The position of the impact weight is to be adjusted to place the lower face of the weight 36 inches or 915 mm above the upper surface of the specimen. The impact weight is to be released from this height, is to fall freely in the guides, is to strike the specimen once, and is then immediately to be raised up to and secured at the 36-inch or 915-mm height. After warming in still air at a temperature of 24.0 ±8.0°C (75.2 ±14.4°F) for 24 h, the specimen is to be examined for cracks, ruptures, and like damage in each of its nonmetallic components – insulation, jacket, other covering, etc. The examinations are to be made with normal or corrected vision without magnification.

593.7 Each of the remaining nine specimens is to be tested in succession as described in 593.6 for a total of ten strikes. The wire or cable does not comply where more than two out of ten specimens show any cracking, rupturing, or like damage.

594 *Reserved for Future Use*

CRUSHING RESISTANCE

595 Test

595.1 The specifications for this test are located in Crush Resistance, method 2 (drill rod and plate), in the Standard for Wire and Cable Test Methods, UL 2556.

595.2 *Deleted*

595.3 The wire does not comply where the average of the ten crushing forces is less than 225 lbf or 1000 N or 102 kgf.

596 thru 600 *Reserved for Future Use*

601 Crushing-Resistance Test of Round Type NM Cable

601.1 The cable is to be crushed between flat, horizontal steel plates in a compression machine whose jaws close at the rate of 0.50 ±0.05 in/min or 10 ±1 mm/min. Each plate is to be 2 inches or 50 mm wide. The cable, the apparatus, and the surrounding air are to be in thermal equilibrium with one another at a temperature of 23.0 ±5.0°C (73.4 ±9.0°F) throughout the test.

601.2 The cable is to be tested in a continuous length of at least 100 inches or 2.55 m, with the cable being crushed at ten points along that length. The first test is to be conducted 9 inches or 230 mm from one end of the test length and the nine remaining tests are to be conducted at succeeding intervals of at least 9 inches or 230 mm down the length of the cable.

601.3 The insulated circuit conductors and the two steel plates are to be connected to low-voltage indicators (buzzers or the like) and to power supplies for the purpose of indicating a short circuit between circuit conductors or between any circuit conductor and the steel plates. The grounding conductor in the test length of the cable is to be out of the circuit.

601.4 The upper steel plate in the compression machine is to be raised several cable diameters above the lower plate, and the cable at the first test point is to be placed and held on the lower plate with the longitudinal axis of the cable horizontal, perpendicular to the longitudinal axes of the plates, and in the vertical plane that laterally bisects the plates. The upper steel plate is to be moved down until it is snug against the cable. The downward motion of the plate is then to be continued at the rate of 0.50 ±0.05 in/min or 10 ±1 mm/min increasing the force on the cable until one or more of the indicators signal that contact has occurred between the circuit conductors or between one or more of the circuit conductors and ground. The force indicated by the dial on the compression machine at the moment of contact is to be recorded.

601.5 The length of cable being tested is to be advanced to and crushed at each of the successive test points for a total of ten crushes. The average of the ten crushing trials is to be calculated and recorded.

602 thru 619 *Reserved for Future Use*

620 Crushing-Resistance Test of Types XHHW-2, XHHW, and XHH

620.1 The specifications for this test are located in Crush Resistance, method 1 (two steel plates), in the Standard for Thermoset-Insulated Wires and Cables, UL 44.

621 thru 699 *Reserved for Future Use*

DIELECTRIC TESTS

700 Dielectric Breakdown Test of Types XHHW-2, XHHW, and XHH after Glancing Impact

700.1 The specifications for this test are located in Dielectric Breakdown after Glancing Impact, in the Standard for Thermoset-Insulated Wires and Cables, UL 44.

700.2 *Deleted*

Figure 700.1

Glancing-impact apparatus

Figure deleted

700.3 *Deleted*

700.4 *Deleted*

700.5 *Deleted*

700.6 *Deleted*

701 thru 719 *Reserved for Future Use*

720 Dielectric Breakdown Test of Types XHHW-2, XHHW, and XHH after Scoring

720.1 *Deleted*

720.2 *Deleted*

Figure 720.1

Scoring Apparatus

Figure deleted

Figure 720.2

Scoring tool

Figure deleted

720.3 *Deleted*

720.4 *Deleted*

720.5 *Deleted*

720.6 *Deleted*

721 thru 759 *Reserved for Future Use*

760 Dielectric Voltage-Withstand Test of Straight Foil-Wrapped Specimens

760.1 The test specimen is to be a 60-inch or 1500-mm straight length of finished wire with its center 36-inch or 915-mm section wrapped tightly with metal foil. The potential is to be applied between the conductor and the foil.

760.2 The wire is to be stressed by means of an isolation transformer that complies with 820.1.

760.3 The applied potential is to be increased from near zero at a uniform or nearly uniform rate that is not less than 100 percent of the voltage rating of the wire or cable in 60 s, and is not more than 100 percent in 10 s (the rate of increase is not to exceed 500 V/s in any case). The increase is to continue in this manner until the voltage reaches the specified rms test potential. Where this level is reached without breakdown, the voltage is to be held constant at the specified level for 5 min and is then to be reduced to near zero at the rate mentioned above. The wire or cable does not comply where breakdown occurs at less than the potential specified in the wire standard while the applied potential is being increased or decreased or in less than 5 min at the potential specified in the wire standard.

761 thru 779 *Reserved for Future Use*

780 Dielectric Voltage-Withstand Test of Foil-Wrapped U-Bend Specimens

780.1 A 15-inch or 380-mm specimen is to be bent 90° around a mandrel having the same diameter as the specimen. Two bends in the same plane are to be made 2 inches or 50 mm apart near the center of the specimen, and pressure is to be applied to keep the specimen from slipping. Metal foil is then to be wrapped tightly around a 5-inch or 125-mm section of the U-bend specimen, including both bends.

Note – When a mandrel specified in the product standard is not available, it shall be permitted to use a mandrel with a smaller diameter. However, in the event of non-compliant results, the wire or cable shall be re-tested using the mandrel size specified in the product standard.

780.2 The specimen is then to be tested as indicated in 760.2 and 760.3. The test time is to be 60 s. The wire does not comply where there is a dielectric breakdown or where the overall braid ruptures because of the bending.

781 thru 799 *Reserved for Future Use*

800 Dielectric Voltage-Withstand Test for Cord Conductors

800.1 The specifications for this test are located in Dielectric-Voltage Withstand, method 2, in the Standard for Wire and Cable Test Methods, UL 2556.

800.2 *Deleted*

800.3 *Deleted*

801 thru 819 *Reserved for Future Use*

820 Dielectric Voltage-Withstand Test of Coils and Reels in Water

820.1 The specifications for this test are located in Dielectric Voltage Withstand, method 1, in the Standard for Wire and Cable Test Methods, UL 2556.

820.2 *Deleted*

820.3 *Deleted*

820.4 *Deleted*

820.5 *Deleted*

821 thru 829 *Reserved for Future Use*

830 Dielectric Voltage-Withstand Tests for Power-Limited Circuit Cable and for Cable for Power-Limited Fire-Alarm Circuits

830.1 The equipment is to consist of either a d-c power supply complying with 830.2 or an a-c power supply complying with 830.3, and also a circuit breaker, current meter, or other means for indicating a heavy flow of current in the test circuit. The maximum current output of which the d-c or a-c supply is capable shall enable routine testing of full reels of the cable without tripping of the circuit breaker by the charging current.

830.2 For a d-c test, the power supply is to have an output potential of the voltage specified for a d-c test of the cable type. Any ripple shall not exceed 1 percent. After a fault, the test potential shall recover to the specified voltage before testing another conductor.

830.3 For an a-c test, the test potential is to be supplied by a 48 – 62 Hz isolation transformer whose output is continuously variable from near zero to an rms potential of at least the specified voltage. With a specimen in the circuit, the output potential is to have a crest factor (peak voltage divided by rms voltage) equal to 95 – 105 percent of the crest factor of a pure sine wave over the upper half of the output range. The output voltage is to be monitored continuously by a voltmeter that, where of the analog rather than digital type, shall have a response time that does not introduce a lagging error greater than 1 percent of full scale at 50 V/s, and that has an overall accuracy that does not introduce an error exceeding 5 percent.

830.4 The full test potential is to be applied for the specified number of seconds between each conductor and the earth-grounded cable elements (all other conductors and any shield(s) and/or metal covering connected together and to earth ground). During each application, observation is to be made to determine whether there is any current leakage or rupture of the insulation as indicated by such means as the tripping of the circuit breaker or a deflection of the needle of the current meter. At least once every 24 h, the test leads are to be connected together and the circuit is to be closed to make certain that the current-indicating means is functioning as intended and that the circuit is complete. Where multiple test leads are used, each shall be tested.

831 thru 899 *Reserved for Future Use*

SPARK TEST

900 Method

900.1 The specifications for this test are located in Spark, in the Standard for Wire and Cable Test Methods, UL 2556.

900.2 *Deleted*

900.3 *Deleted*

900.4 *Deleted*

900.5 *Deleted*

900.6 *Deleted*

900.7 *Deleted*

900.8 *Deleted*

Table 900.1
Maximum center-to-center spacings of bead chains
Table deleted

900.9 *Deleted*

900.10 *Deleted*

900.11 *Deleted*

900.12 *Deleted*

900.13 *Deleted*

Table 900.2
Formula for maximum speed of wire in terms of electrode length L
Table deleted

900.14 *Deleted*

900.15 *Deleted*

900.16 *Deleted*

900.17 *Deleted*