Designation: B 8 – 04

Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft[1]

This standard is issued under the fixed designation B 8; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This specification covers bare concentric-lay-stranded conductors made from round copper wires, either uncoated or coated with tin, lead, or lead alloy for general use for electrical purposes. These conductors shall be constructed with a central core surrounded by one or more layers of helically laid wires.

NOTE 1—This specification also permits conductors for use as covered or insulated electrical conductors.

NOTE 2—Sealed conductors, that are intended to prevent longitudinal water propagation and are further covered/insulated, are also permitted within the guidelines of this specification.

1.2 For the purposes of this specification, conductors are classified as follows (Explanatory Note 1 and Note 2):

1.2.1 *Class AA*—For bare conductors usually used in overhead lines.

1.2.2 *Class A*—For conductors to be covered with weather-resistant (weather-proof), slow-burning materials, and for bare conductors where greater flexibility than is afforded by Class AA is required.

1.2.3 *Class B*—For conductors to be insulated with various materials such as rubber, paper, varnished cloth, and so forth, and for the conductors indicated under Class A where greater flexibility is required.

1.2.4 *Class C and Class D*—For conductors where greater flexibility is required than is provided by Class B conductors.

1.3 The SI values for density are regarded as the standard. For all other properties, the inch-pound values are to be regarded as standard and the SI units may be approximate.

2. Referenced Documents

2.1 *ASTM Standards:* [2]

B 1 Specification of Hard-Drawn Copper Wire

B 2 Specification for Medium-Hard-Drawn Copper Wire

B 3 Specification for Soft or Annealed Copper Wire

B 33 Specification for Tinned Soft or Annealed Copper Wire for Electrical Purposes

B 172 Specification for Rope-Lay-Stranded Copper Conductors Having Bunch-Stranded Members, for Electrical Conductors

B 173 Specification for Rope-Lay-Stranded Copper Conductors Having Concentric-Stranded Members, for Electrical Conductors

B 174 Specification for Bunch-Stranded Copper Conductors for Electrical Conductors

B 189 Specification for Lead-Coated and Lead-Alloy-Coated Soft Copper Wire for Electrical Purposes[3]

B 193 Test Method for Resistivity of Electrical Conductor Materials

B 246 Specification for Tinned Hard-Drawn and Medium-Hard-Drawn Copper Wire for Electrical Purposes

B 263 Test Method for Determination of Cross-Sectional Area of Stranded Conductors

B 354 Terminology Relating to Uninsulated Metallic Electrical Conductors

B 787/B 787M Specification for 19 Wire Combination Unilay-Stranded Copper Conductors for Subsequent Insulation

3. Ordering Information

3.1 Orders for material under this specification shall include the following information:

3.1.1 Quantity of each size and class,

3.1.2 Conductor size: circular-mil area or AWG (Section 6),

3.1.3 Class (see 1.2 and Table 1),

3.1.4 Temper (see 13.2),

3.1.5 Whether coated or uncoated; if coated, designate type of coating (see 13.1 and 13.2),

3.1.6 Details of special-purpose lays, if required (see 5.4),

3.1.7 When physical tests shall be made (see 8.2 and 8.3),

3.1.8 Package size (see 8.1),

3.1.9 Lagging, if required (see section 15.2),

3.1.10 Special package marking, if required (Section 14), and

[1] This specification is under the jurisdiction of ASTM Committee B01 on Electrical Conductors and is the direct responsibility of Subcommittee B01.04 on Conductors of Copper and Copper Alloys.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

Available from American Association of State Highway and Transportation Officials (AASHTO), 444 N. Capitol St., NW, Suite 249, Washington, DC 20001.

[3] Withdrawn.

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TABLE 1 Construction Requirements of Concentric-Lay-Stranded Copper Conductors

Area of Cross-Section, cmil	Size, American Wire Gage	Class AA		Class A		Class B[A]		Class C		Class D	
		Number of Wires	Diameter of Wires, mils	Number of Wires	Diameter of Wires, mils	Number of Wires	Diameter of Wires, mils	Number of Wires	Diameter of Wires, mils	Number of Wires	Diameter of Wires, mils
*5 000 000	...	...	...	169	172.0	217	151.8	271	135.8	271	135.8
4 500 000	...	...	...	169	163.2	217	144.0	271	128.9	271	128.9
4 000 000	...	...	...	169	153.8	217	135.8	271	121.5	271	121.5
3 500 000	...	...	...	127	166.0	169	143.9	217	127.0	271	113.6
*3 000 000	...	...	...	127	153.7	169	133.2	217	117.6	271	105.2
*2 500 000	...	...	...	91	165.7	127	140.3	169	121.6	217	107.3
*2 000 000	...	...	...	91	148.2	127	125.5	169	108.8	217	96.0
1 900 000	...	...	...	91	144.5	127	122.3	169	106.0	217	93.6
1 800 000	...	...	...	91	140.6	127	119.1	169	103.2	217	91.1
*1 750 000	...	...	...	91	138.7	127	117.4	169	101.8	217	89.8
1 700 000	...	...	...	91	136.7	127	115.7	169	100.3	217	88.5
1 600 000	...	...	...	91	132.6	127	112.2	169	97.3	217	85.9
*1 500 000	...	...	...	61	156.8	91	128.4	127	108.7	169	94.2
1 400 000	...	...	...	61	151.5	91	124.0	127	105.0	169	91.0
1 300 000	...	...	...	61	146.0	91	119.5	127	101.2	169	87.7
*1 250 000	...	...	...	61	143.1	91	117.2	127	99.2	169	86.0
1 200 000	...	...	...	61	140.3	91	114.8	127	97.2	169	84.3
1 100 000	...	...	...	61	134.3	91	109.9	127	93.1	169	80.7
*1 000 000	...	37	164.4	61	128.0	61	128.0	91	104.8	127	88.7
900 000	...	37	156.0	61	121.5	61	121.5	91	99.4	127	84.2
*800 000	...	37	147.0	61	114.5	61	114.5	91	93.8	127	79.4
*750 000	...	37	142.4	61	110.9	61	110.9	91	90.8	127	76.8
*700 000	...	37	137.5	61	107.1	61	107.1	91	87.7	127	74.2
650 000	...	37	132.5	61	103.2	61	103.2	91	84.5	127	71.5
*600 000	...	37	127.3	37	127.3	61	99.2	91	81.2	127	68.7
550 000	...	37	121.9	37	121.9	61	95.0	91	77.7	127	65.8
*500 000	...	19	162.2	37	116.2	37	116.2	61	90.5	91	74.1
450 000	...	19	153.9	37	110.3	37	110.3	61	85.9	91	70.3
*400 000	...	19	145.1	19	145.1	37	104.0	61	81.0	91	66.3
*350 000	...	12	170.8	19	135.7	37	97.3	61	75.7	91	62.0
*300 000	...	12	158.1	19	125.7	37	90.0	61	70.1	91	57.4
*250 000	...	12	144.3	19	114.7	37	82.2	61	64.0	91	52.4
*211 600	0000	7	173.9	7	173.9	19	105.5	37	75.6	61	58.9
*167 800	000	7	154.8	7	154.8	19	94.0	37	67.3	61	52.4
*133 100	00	7	137.9	7	137.9	19	83.7	37	60.0	61	46.7
*105 600	0	7	122.8	7	122.8	19	74.5	37	53.4	61	41.6
*83 690	1	3[B]	167.0	7	109.3	19	66.4	37	47.6	61	37.0
*66 360	2	3[B]	148.7	7	97.4	7	97.4	19	59.1	37	42.4
*52 620	3	3[B]	132.5	7	86.7	7	86.7	19	52.6	37	37.7
*41 740	4	3[B]	118.0	7	77.2	7	77.2	19	46.9	37	33.6
*33 090	5	...	...	...	...	7	68.8	19	41.7	37	29.9
*26 240	6	...	...	...	...	7	61.2	19	37.2	37	26.6
*20 820	7	...	...	...	...	7	54.5	19	33.1	37	23.7
*16 510	8	...	...	...	...	7	48.6	19	29.5	37	21.1
*13 090	9	...	...	...	...	7	43.2	19	26.2	37	18.8
*10 380	10	...	...	...	...	7	38.5	19	23.4	37	16.7
*6 530	12	...	...	...	...	7	30.5	19	18.5	37	13.3
*4 110	14	...	...	...	...	7	24.2	19	14.7	37	10.5
*2 580	16	...	...	...	...	7	19.2	19	11.7	...	...
*1 620	18	...	...	...	...	7	15.2	19	9.2	...	...
*1 020	20	...	...	...	...	7	12.1	19	7.3	...	...
*640	22	...	...	...	...	7	9.6	19	5.8	...	...
*404	24	...	...	...	...	7	7.6	19	4.6	...	...

* The sizes of conductors that have been marked with an asterisk provide for one or more schedules of preferred series, and are commonly used in the industry. The sizes not marked are given simply as a matter of reference and it is suggested that their use be discouraged.

[A] For unidirectional/unilay constructions the number of wires shown are minimum requirements.

[B] Although Class AA conductors having three strands do not conform to the construction requirements of 1.1, they are listed in this table for convenience.

3.1.11 Place of inspection (Section 15).

4. Joints

4.1 Welds and brazes may be made in rods or in wires prior to final drawing. Joints may not be made in the finished wires composing hard-drawn or medium-hard-drawn Class AA conductors of seven wires or less. In other conductors, welds and brazes may be made in the finished individual wires composing the conductor, but shall not be closer together than prescribed in Table 2.

5. Lay

5.1 For Class AA conductors composed of less than seven wires, the preferred lay is 11 times the outside diameter of the completed conductor, but shall be not less than 8 nor more than 14 times this diameter.

5.2 For Class AA conductors composed of seven wires or more, the preferred lay of a layer of wires is 13.5 times the outside diameter of that layer, but shall be not less than 10 nor more than 16 times this diameter.

TABLE 2 Minimum Distance Between Joints in the Completed Conductor

Number of Wires in Conductor	Hard or Medium-Hard					Soft
	Class AA	Class A	Class B	Class C	Class D	All Classes
3	none permitted	...	...	...	...	1 ft
7	none permitted	50 ft	50 ft	...	...	1 ft
12	50 ft	50 ft	...	...	...	1 ft
19	50 ft	50 ft	50 ft	50 ft	...	1 ft
20 to 36	50 ft	50 ft	50 ft	50 ft	...	1 ft in a layer[A]
37 to 60		25 ft	25 ft	25 ft	25 ft	1 ft in a layer[A]
61 and over	...	5 ft	5 ft	5 ft	5 ft	1 ft in a layer[A]

[A] Except as indicated, the limitations apply to closeness of joints throughout the completed conductor.

5.3 For all other classes the lay of a layer of wires shall be not less than 8 nor more than 16 times the outside diameter of that layer, except that for conductors composed of 37 wires or more, this requirement shall apply only to the two outer layers. The lay of the layers other than the two outer layers shall be at the option of the manufacturer, unless otherwise agreed upon.

5.3.1 For conductors to be used in covered or insulated wires or cables, the lay length shall be not less than 8 nor more than 16 times the outer diameter of the finished conductor. For conductors of 37 wires or more, this requirement shall apply to the wires in the outer two layers. The lay of the layers other than the two outer layers shall be at the option of the manufacturer, unless otherwise agreed upon.

5.4 Other lays for special purposes shall be furnished by special agreement between the manufacturer and the purchaser (Explanatory Note 3).

5.5 The direction of lay of the outer layer shall be left-hand, and for conductors having a nominal cross-sectional area larger than No. 8 AWG, shall be reversed in successive layers, unless otherwise specified by the purchaser.

5.5.1 For conductors to be used in covered or insulated wires or cables, the direction of lay of the outer layer shall be left hand and shall be reversed in successive layers, unidirectional, or unilay, unless otherwise agreed upon.

6. Construction

6.1 The areas of cross section, numbers, and diameters of wires in the various classes of concentric-lay-stranded conductors shall conform to the requirements prescribed in Table 1 (Explanatory Notes 3 and 10).

6.2 The diameters of the wires listed in Table 1 are nominal. Where "combination strand" is required in order to insulate the conductor properly (strands in the outer layer having a larger diameter than those in the inner layers) the diameters shall be subject to a tolerance of ±5 %, provided that the area of cross section after stranding is in accordance with Section 11.

6.3 Where compressed stranding is required in order to insulate the conductor properly, one or more layers of any stranded conductor consisting of 7 wires or more may be slightly compressed, thereby reducing the outside diameter of the conductor to the nominal values shown in Table 3, provided that the area of cross section after stranding is in accordance with Section 11.

7. Physical and Electrical Tests of Conductors Stranded of Soft Wires

7.1 Tests for the electrical properties of wires composing conductors made from soft or annealed copper wire, bare or coated, shall be made before stranding.

7.2 Tests for the physical properties of soft or annealed copper wire, bare or coated, may be made upon the wires before stranding or upon wires removed from the complete stranded conductor, but need not be made upon both. Care shall be taken to avoid mechanical injury to wire removed from the conductor for the purpose of testing.

7.3 The physical properties of wire when tested before stranding shall conform to the applicable requirements of 13.2.

7.4 The physical properties of wires removed from the completed stranded conductor shall be permitted to vary from the applicable requirements of 13.2 by the following amounts (Explanatory Note 4):

7.4.1 *Average of Results Obtained on All Wires Tested*—The minimum elongation required shall be reduced in numerical value 5 (for example, from 30 to 25 %) from the numerical requirements for the wire before stranding.

7.4.2 *Results Obtained on Individual Wires*—The elongation of individual wires shall be reduced in numerical value 15 from the minimum requirements before stranding (that is, 10 in addition to the 5 allowed in 7.4.1), but in no case shall the elongation of any individual wire be less than 5 %.

7.5 In the event that the requirements prescribed in 7.4.2 are met but those prescribed in 7.4.1 are not met, a retest shall be permitted wherein all wires of the conductor shall be tested for the purpose of final determination of conformance to 7.4.

7.6 Elongation tests to determine compliance shall not be made on the conductor as a unit.

7.7 If a tinning, lead-coating, or lead-alloy-coating test is required, it shall be made on the wires prior to stranding.

8. Physical and Electrical Tests of Conductors Stranded of Hard-Drawn or Medium-Hard-Drawn Wires

8.1 Tests for the physical and electrical properties of wires composing conductors made from hard-drawn or medium-hard-drawn wires, uncoated or coated, shall be made before but not after stranding.

8.2 At the option of the purchaser, tension and elongation tests on hard-drawn and medium-hard-drawn wires, uncoated or coated, before stranding may be waived, and the completed

TABLE 3 Diameters, Areas, and Mass of Concentric-Lay-Stranded Copper Conductors (Explanatory Note 8)

Size of Conductor,		Nominal Conductor Diameter, in.[A]						Mass		DC Resistance at 20°C[B]	
		Concentric Strand									
cmil or AWG numbers	mm^2	Class AA	Class A	Class B	Reverse Concentric Compressed Class B Diameter, in.	Unilay Compressed[C] Diameter, in.	Area, $in.^2$	lbs/1000 ft	kg/km	Ω/1000 ft	Ω/km
*5 000 000 cmil	2530	...	2.580	2.581	...	...	3.927	15 890	23 649	0.00218	0.00715
4 500 000 cmil	2280	...	2.448	2.448	...	...	3.534	14 300	21 283	0.00242	0.00794
4 000 000 cmil	2030	...	2.307	2.309	...	...	3.142	12 590	18 738	0.00270	0.00886
3 500 000 cmil	1770	...	2.158	2.159	...	...	2.749	11 020	16 401	0.00308	0.0101
*3 000 000 cmil	1520	...	1.998	1.998	...	...	2.356	9 353	13 920	0.00356	0.0117
*2 500 000 cmil	1270	...	1.823	1.824	...	...	1.963	7 794	11 600	0.00428	0.0140
*2 000 000 cmil	1010	...	1.630	1.632	1.583	1.533	1.571	6 175	9 190	0.00529	0.0174
1 900 000 cmil	963	...	1.590	1.590	1.542	1.494	1.492	5 866	8 730	0.00557	0.0183
1 800 000 cmil	912	...	1.547	1.548	1.502	1.454	1.414	5 558	8 272	0.00588	0.0193
*1 750 000 cmil	887	...	1.526	1.526	1.480	1.434	1.374	5 403	8 041	0.00604	0.0198
1 700 000 cmil	861	...	1.504	1.504	1.459	1.413	1.335	5 249	7 812	0.00622	0.0204
1 600 000 cmil	801	...	1.459	1.459	1.415	1.371	1.257	4 940	7 352	0.00661	0.0217
*1 500 000 cmil	760	...	1.411	1.412	1.370	1.327	1.178	4 631	6 892	0.00705	0.0231
1 400 000 cmil	709	...	1.364	1.364	1.323	1.282	1.100	4 323	6 435	0.00756	0.0248
1 300 000 cmil	659	...	1.314	1.315	1.275	1.236	1.021	4 014	5 974	0.00814	0.0267
*1 250 000 cmil	633	...	1.288	1.289	1.250	1.212	0.9817	3 859	5 743	0.00847	0.0278
1 200 000 cmil	608	...	1.263	1.263	1.225	1.187	0.9425	3 705	5 514	0.00882	0.0289
1 100 000 cmil	557	...	1.209	1.209	1.173	1.137	0.8639	3 396	5 054	0.00962	0.0316
*1 000 000 cmil	507	1.151	1.152	1.152	1.117	1.084	0.7854	3 088	4 596	0.0106	0.0348
900 000 cmil	456	1.092	1.094	1.094	1.060	1.028	0.7069	2 779	4 136	0.0118	0.0387
*800 000 cmil	405	1.029	1.031	1.031	1.000	0.969	0.6283	2 470	3 676	0.0132	0.0433
*750 000 cmil	380	0.997	0.998	0.998	0.968	0.939	0.5890	2 316	3 447	0.0141	0.0462
*700 000 cmil	355	0.963	0.964	0.964	0.935	0.907	0.5498	2 161	3 216	0.0151	0.0495
650 000 cmil	329	0.928	0.929	0.929	0.901	0.874	0.5105	2 007	2 987	0.0163	0.0535
*600 000 cmil	304	0.891	0.891	0.893	0.866	0.840	0.4712	1 883	2 758	0.0177	0.0581
550 000 cmil	279	0.853	0.853	0.855	0.829	0.804	0.4320	1 698	2 527	0.0192	0.0630
*500 000 cmil	253	0.811	0.813	0.813	0.789	0.766	0.3927	1 544	2 298	0.0212	0.0695
450 000 cmil	228	0.770	0.772	0.772	0.749	0.727	0.3534	1 389	2 067	0.0235	0.0771
*400 000 cmil	203	0.726	0.726	0.728	0.706	0.685	0.3142	1 235	1 838	0.0264	0.0866
*350 000 cmil	177	0.710	0.679	0.681	0.661	0.641	0.2749	1 081	1 609	0.0302	0.0991
*300 000 cmil	152	0.657	0.629	0.630	0.611	0.594	0.2356	926.3	1 378.6	0.0353	0.116
*250 000 cmil	127	0.600	0.574	0.575	0.558	0.542	0.1963	771.9	1 148.8	0.0423	0.139
* No. 0000	107	0.522	0.522	0.528	0.512	0.498	0.1662	653.1	972.0	0.0500	0.164
* No. 000	85.0	0.464	0.464	0.470	0.456	0.443	0.1318	518.1	771.1	0.0630	0.207
* No. 00	67.4	0.414	0.414	0.419	0.405	0.395	0.1045	410.9	611.5	0.795	0.261
* No. 0	53.5	0.368	0.368	0.373	0.362	0.352	0.08289	325.8	484.9	0.100	0.328
* No. 1, 3 wire	42.4	0.360	...	...	...	...	0.06573	255.9	380.9	0.127	0.417
* No. 1	42.4	...	0.328	0.332	0.322	0.313	0.06573	258.4	384.6	0.127	0.522
* No. 2, 3 wire	33.6	0.320	...	...	...	...	0.05213	202.9	301.9	0.159	0.522
* No. 2	33.6	...	0.292	0.292	0.283	...	0.05213	204.9	304.9	0.159	0.659
* No. 3, 3 wire	26.7	0.285	...	...	...	...	0.04134	160.9	239.5	0.201	0.659
* No. 3	26.7	...	0.260	0.260	0.252	...	0.04134	162.5	241.9	0.201	0.830
* No. 4, 3 wire	21.2	0.254	...	...	...	...	0.03278	127.6	189.9	0.253	0.830
* No. 4	21.2	...	0.232	0.232	0.225	...	0.03278	128.9	191.8	0.253	1.05
* No. 5	16.8	...	...	0.206	0.200	...	0.02600	102.2	152.1	0.319	1.05
* No. 6	13.3	...	...	0.184	0.178	...	0.02062	81.05	120.63	0.403	1.32
* No. 7	10.6	...	...	0.164	0.159	...	0.01635	64.28	95.67	0.509	1.67
* No. 8	8.37	...	...	0.146	0.142	...	0.01297	50.97	75.86	0.640	2.10
* No. 9	6.63	...	...	0.130	0.126	...	0.01028	40.42	60.16	0.809	2.65
* No. 10	5.26	...	...	0.116	0.113	...	0.008155	32.06	47.72	1.02	3.35
* No. 12	3.31	...	...	0.0915	0.089	...	0.005129	20.16	30.00	1.63	5.35
* No. 14	2.08	...	...	0.0726	0.071	...	0.003225	12.68	18.87	2.58	8.46
* No. 16	0.823	...	...	0.0576	...	...	0.002028	7.974	11.868	4.10	13.4
* No. 18	0.519	...	...	0.0456	...	...	0.001276	5.015	7.464	6.54	21.4
* No. 20	0.519	...	...	0.0363	...	...	0.0008023	3.154	4.694	10.3	33.8
* No. 22	0.324	...	...	0.0288	...	...	0.0005067	1.992	2.965	16.4	53.8
* No. 24	0.205	...	...	0.0228	...	...	0.0003176	1.249	1.859	26.1	85.6

* The sizes of conductors which have been marked with a single asterisk provide for one or more schedules of preferred series, and are commonly used in the industry. The sizes not marked are given simply as a matter of reference, and it is suggested that their use be discouraged.

[A] To calculate the nominal diameters of Class C or Class D conductors or of any concentric-lay-stranded conductors made from round wires of uniform diameters, multiply the diameter of an individual wire (as given in Table 1) by that one of the following factors which applies:

[B] DC resistances apply to Class B, C, and D stranding. For other classes of stranding, refer to Test Method B 193.

[C] For conductors manufactured for subsequent covering or insulating.

Number of Wires in Conductor	Factor to Calculate Conductor Diameter
3	2.155
7	3
12	4.155
19	5
37	7
61	9
91	11
127	13
169	15
217	17
271	19

hard-drawn and medium-hard-drawn conductors may be tested as a unit. The breaking strength of the bare conductors so tested shall be at least 90 % of the total of the specified minimum breaking strengths of the component wires. The maximum breaking strength of conductors made from medium-hard-drawn wires, uncoated or coated, shall be not greater than the sum of the specified maximum breaking strengths of the component wires. The minimum breaking strength of wires shall be calculated using specified nominal diameters and specified minimum tensile strengths. The maximum breaking strengths of wires shall be calculated using nominal diameters and specified maximum tensile strengths. The free length between grips of the test specimen shall be not less than 24 in., and care shall be taken to ensure that the wires in the conductor are evenly gripped during the test (Explanatory Note 5).

8.3 When requested by the purchaser at the time of placing the order, tension tests on hard-drawn and medium-hard-drawn wires, uncoated or coated, before stranding or as a unit may be waived and tests made on wires removed from the completed conductor. The test limits, based on a 10-in. gage length, for such tests shall be specified by the purchaser in the placing of individual orders (Explanatory Note 4).

8.4 If a tinning test is required, it shall be made on the wires prior to stranding.

9. Density

9.1 For the purpose of calculating mass, cross sections, and so forth, the density of the copper shall be taken as 8.89 g/cm^3(0.32117 lb/in.^{3}) at 20°C (Explanatory Note 6).

10. Mass and Resistance

10.1 The mass and electrical resistance of a unit length of stranded unsealed conductor are a function of the length of lay. The approximate mass and electrical resistance may be determined using the standard increments shown in Table 4. When greater accuracy is desired, the increment based on the specific lay of the conductor may be calculated (Explanatory Note 7).

10.2 The maximum electrical resistance of a unit length of stranded conductor shall not exceed 2 % over the nominal DC resistance shown in Table 3 (Explanatory Note 8). When the DC resistance is measured at other than 20°C, it is to be corrected by using the multiplying factor given in Table 5.

10.3 For conductors to be used in covered or insulated wires or cables, direct current (DC) resistance measurement may be used instead of the method outlined in Section 11, to determine compliance with this specification.

TABLE 4 Standard Increments Due to Stranding

Type of Conductor	Increment of Resistance and Mass %
Class AA, Sizes 1 to 4 AWG, incl.	1
Classes AA,[A] A, B, C, and D, 2 000 000 cmil and under	2
Over 2 000 000 to 3 000 000 cmil	3
Over 3 000 000 to 4 000 000 cmil	4
Over 4 000 000 to 5 000 000 cmil	5

[A] No. 0 AWG and larger.

TABLE 5 Temperature Corrections Factor for Conductor Resistance

Temperature, °C	Multiplying Factor for Conversion to 20°C
0	1.085
5	1.063
10	1.041
15	1.020
20	1.000
25	0.981
30	0.962
35	0.944
40	0.927
45	0.911
50	0.895
55	0.879
60	0.864
65	0.850
70	0.836
75	0.822
80	0.809
85	0.797
90	0.784

11. Variation in Area

11.1 The area of cross section of the completed conductor shall be not less than 98 % of the area indicated in Column 1 of Table 1. Unless otherwise specified by the purchaser, the manufacturer may have the option of determining the cross-sectional area by either of the following methods, except that in case of question regarding area compliance, the method of 11.1.2 shall be used.

11.1.1 The area of cross section of a conductor may be determined by calculations from diameter measurements, expressed to four decimal places, of its component wires at any point when measured perpendicularly to their axes.

TABLE 6 Suggested Package Lengths for Hard and Medium-Hard Class AA Conductors[A,B]

Size of Conductor, cmil or AWG numbers	Number of Wires	Nominal Shipping Unit			Approximate Dimensions of Suitable Reel		
		Approximate Length, ft	Conductor Mass, lb	Mass per Wire, lb	Flange Diameter, in.	Traverse Width, in.	Drum Diameter, in.
500 000 cmil	19	3550	5510	290	54	32	32
400 000 cmil	19	4450	5510	290	54	32	32
350 000 cmil	12	3200	3480	290	48	24	24
350 000 cmil	19[B]	5100	5510	290	54	32	32
300 000 cmil	12	3750	3480	290	48	24	24
300 000 cmil	19[B]	5950	5510	290	54	32	32
250 000 cmil	12	4500	3480	290	48	24	24
250 000 cmil	19[B]	7150	5510	290	54	32	32
No. 0000	7	3100	2030	290	42	24	30
No. 000	7	3900	2030	290	42	24	30
No. 00	7	4950	2030	290	42	24	30
No. 0	7	6250	2030	290	42	24	30
No. 1	3	4600	1170	390	36	18	24
No. 2	3	5800	1170	390	36	18	24
No. 3	3	7300	1170	390	36	18	24
No. 4	3	9200	1170	390	36	18	24

[A] These package lengths are based on conductors furnished without joints or with a minimum of joints in the finished wires composing the completed conductor.
[B] These optional construction (Class A) are included as suggestions for use when the purchase order specifies Class A construction for bare hard-drawn or medium-hard-drawn conductors.

11.1.2 The area of cross section of a conductor may be determined by Test Method B 263. In applying that method, the increment in mass resulting from stranding may be the applicable value specified in 10.1 or may be calculated from the measured component dimensions of the sample under test. In case of question regarding area compliance, the actual mass increment due to stranding shall be calculated.

12. Variation in Diameter

12.1 The average diameter of the conductor shall vary by not more than +1 or −2 % from the nominal diameters specified in Table 3.

13. Requirements for Wires

13.1 The purchaser shall designate the type of wire and the kind of coating, if any, to be used in the conductor.

13.2 Before stranding, the copper wire used shall meet all of the requirements of the following specifications of ASTM that are applicable to its type:

13.2.1 Specification B 3,
13.2.2 Specification B 33,
13.2.3 Specification B 2,
13.2.4 Specification B 1,
13.2.5 Specification B 189, and
13.2.6 Specification B 246.

13.3 In concentric-lay-stranded conductors the central core shall be made of wire of the same type and temper as the concentric layers, unless otherwise specified.

14. Inspection

14.1 Unless otherwise specified in the contract or purchase order, the manufacturer shall be responsible for the performance of all inspection and test requirements specified.

14.2 All inspections and tests shall be made at the place of manufacture unless otherwise especially agreed upon by the manufacturer and the purchaser at the time of purchase.

14.3 The manufacturer shall afford the inspector representing the purchaser all reasonable manufacturer's facilities to satisfy him that the material is being furnished in accordance with this specification.

15. Packaging and Package Marking

15.1 Package sizes for conductors shall be agreed upon by the manufacturer and the purchaser in the placing of individual orders (Explanatory Notes 9 and 11).

15.2 The conductors shall be protected against damage in ordinary handling and shipping. If heavy wood lagging is required, it shall be specified by the purchaser at the time of purchase.

15.3 The net mass, length (or lengths and number of lengths, if more than one length is included in the package), size, kind of conductor, purchase order number, and any other marks required by the purchase order shall be marked on a tag attached to the end of the conductor inside of the package. The same information, together with the manufacturer's serial number (if any) and all shipping marks required by the purchaser, shall appear on the outside of each package.

16. Keywords

16.1 concentric-lay-stranded copper conductors; concentric-lay-stranded hard; copper conductors; copper conductors for electrical purposes; medium-hard; or soft copper conductors

EXPLANATORY NOTES

NOTE 1—In this specification only concentric-lay-stranded conductor constructions are specifically designated. Requirements for certain other constructions will be found in Specifications B 172, B 173, B 174, and B 787/B 787M. Conductor constructions not included in any of these specifications should be specifically agreed upon by the manufacturer and the purchaser when placing the order.

NOTE 2—For definitions of terms relating to conductors, refer to Terminology B 354.

NOTE 3—Certain types of insulated conductors may require a shorter lay than other conductors. It is expected that special requirements regarding length of lay will be specified by the purchaser in such instances.

NOTE 4—Wires unlaid from conductors manifestly will have different physical and electrical properties from those of the wire when prepared for cabling, on account of the deformation brought about by laying and again straightening for test.

NOTE 5—To test stranded conductors for tensile strength successfully as a unit requires an adequate means of gripping the ends of the test specimen. Various means are available, such as a long tube or socket into which the conductor may be soldered, or in which, after insertion, the conductor may be swaged or pressed without serious distortion. Ordinary jaws or clamping devices usually are not suitable. The conductor testing facilities of many commercial laboratories are limited to a breaking strength of 30 000 lb (13 600 kg) or less. Consequently, it may not be feasible to test the very large-sized conductors as a unit. Where such is imperative, special arrangements for the testing shall be agreed upon between the manufacturer and the purchaser.

NOTE 6—The value of density of copper is in accordance with the International Annealed Copper Standard. The corresponding value at 0°C is 8.90 g/cm (0.32150 lb/in.). As pointed out in the discussion of this subject in *NBS Handbook 100*[4], there is no appreciable difference in values of density of hard-drawn and annealed copper wire. In calculations involving density it must be borne in mind that the apparent density of coated wire is not constant but a variable function of wire diameter. The smaller the diameter, the greater the percentage of coating present and hence the greater departure from the density of copper.

NOTE 7—The increment of mass or electrical resistance of a complete concentric-lay-stranded conductor, *k*, in percent, is calculated as follows:

$$k = 100\,(m - 1)$$

where *m* is the lay factor, and is the ratio of the mass or electrical resistance of a unit length of stranded conductor to that of a solid conductor of the same cross-sectional area or of a stranded conductor with infinite length of lay, that is, all wires parallel to the conductor axis. The lay factor *m* for the completed stranded conductor is the *numerical average* of the lay factors for each of the individual wires in the conductor, including the straight core wire, if any (for which the lay factor is unity). The lay factor, m_{ind}, for any given wire in a concentric-lay-stranded conductor is

$$m_{ind} = \sqrt{1 + (9.8696/n^2)}$$

where n = length of lay/diameter of helical path of wire.

The derivation of the above is given in *NBS Handbook 100*.[3]

NOTE 8—The DC resistance, on a given construction, shall be calculated using the following formula:

$$R = \left(\frac{k}{100} + 1\right)\rho/A$$

where:

R = conductor resistance in ohms/1000 ft,
k = increment due to stranding from Table 4 and Explanatory Note 7,
ρ = volume resistivity in ohms·cmil/ft determined in accordance with Test Method B 193, and
A = cross-sectional area of conductor in kcmil determined in accordance with Section 11.

NOTE 9—It is of some importance that hard-drawn and medium-hard-drawn Class AA conductors be placed on reels having drum diameters sufficiently large that the bending will not unduly modify the physical properties of the completed conductor. It is suggested that consideration be given to standardizing on reel dimensions approximately as prescribed in Table 6 for such conductors when ordered in the lengths shown. The drum diameters are not intended to indicate definite minimum desirable diameters for the associated conductors, there being considerable leeway in this dimension for most conductor sizes and constructions.

NOTE 10—For the convenience of the users of this specification Table 3 has been prepared giving the approximate diameters, areas, dc resistance, and mass per unit length of the various constructions referred to in Table 1.

NOTE 11—Because of the prohibition of joints in hard-drawn or medium-hard-drawn Class AA conductors of seven wires or less, it is necessary that the lengths of conductors specified in the purchase order be such as practicably may be furnished by the manufacturer. In general, the maximum practicable length of such conductors is determined by the mass of one of the component wires which can be placed on a spool or bobbin in the stranding machine. It is suggested that consideration be given to standardizing package lengths of Class AA conductors as prescribed in Table 6, which is based on a constant mass for the individual wires composing the conductor. To cooperate with the manufacturer in avoiding the accumulation of excessive amounts of scrap wire, it is suggested that package sizes permit ordinary variations of ±10 % in package lengths, and that occasional short lengths be permitted, such packages to be distinctly marked.

[4] *NBS Handbook 100*, available from the National Technical Information Service, 5285 Port Royal Road, Springfield, Va 22161.

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