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Standard Specification for Concentric-Lay-Stranded Copper and Copper-Clad Steel Composite Conductors[1]

This standard is issued under the fixed designation B229; 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 concentric-lay-stranded conductors made from uncoated hard-drawn round copper wires in combination with hard-drawn round copper-clad steel wires for general use as overhead electrical conductors.

1.2 For the purpose of this specification, conductors are classified under the following type designations (see Fig. 1):

Type A
Type C
Type D
Type E
Type EK
Type F
Type G
Type J
Type K
Type N
Type P
Type V

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.

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

B1 Specification for Hard-Drawn Copper Wire
B227 Specification for Hard-Drawn Copper-Clad Steel Wire
B354 Terminology Relating to Uninsulated Metallic Electrical Conductors
E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

2.2 *ANSI Standard:*
C 42 Definitions of Electrical Terms[3]

2.3 *National Institute of Standards and Technology:*
NBS *Handbook 100—Copper Wire Tables*[4]

3. Ordering Information

3.1 Orders for material under this specification shall include the following information:
3.1.1 Quantity of each size and type;
3.1.2 Conductor size: hard-drawn copper equivalent in circular-mil area or AWG (Section 7 and Table 1);

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[1] This specification is under the jurisdiction of ASTM Committee B01 on Electrical Conductors and is the direct responsibility of Subcommittee B01.06 on Bi-Metallic Conductors.

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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.

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

[4] Available from National Institute of Standards and Technology (NIST), 100 Bureau Dr., Stop 1070, Gaithersburg, MD 20899-1070, http://www.nist.gov.

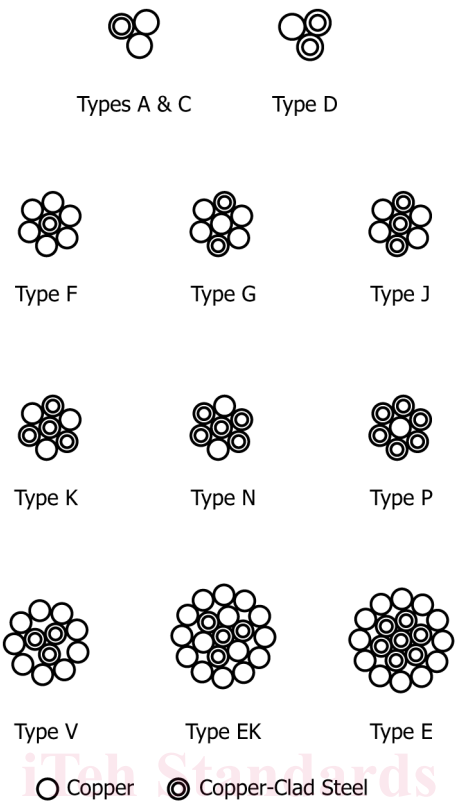

FIG. 1 Standard Types of Composite Conductors

3.1.3 Type (see 1.2, Fig. 1, and Table 1);
3.1.4 Direction of lay of outer layer, if other than left-hand (see 6.3);
3.1.5 When physical tests shall be made (see section 8.2);
3.1.6 Package size (see 14.1);
3.1.7 Special package marking, if required (Section 15);
3.1.8 Lagging, if required (see 14.2); and
3.1.9 Place of inspection (Section 13).

4. Material for Wires

4.1 The purchaser shall designate the size and type of conductor to be furnished. The position of the hard-drawn copper wires and the copper-clad steel wires in the conductor cross section shall be as shown in Fig. 1.

4.2 Before stranding, the wire used shall meet the requirements of Specifications B1 and B227 that are applicable to its type.

5. Joints

5.1 *Copper*—Welds and brazes may be made in copper rods or in copper wires prior to final drawing. Joints may not be made in the finished copper wires composing concentric-lay-stranded composite conductors containing a total of seven wires or less. In other conductors, welds and brazes may be made in the finished individual copper wires composing the conductor, but shall be not closer than 50 ft (15 m) to any other joint in the same layer in the conductor.

5.2 *Copper-Clad Steel*—Joints or splices may be made in the finished individual copper-clad steel wires composing concentric-lay-stranded conductors, provided that such joints or splices have a protection equivalent to that of the wire itself and that they do not decrease the strength of the finished stranded conductor below the minimum breaking strength shown in Table 1. Such joints or splices shall be not closer than 50 ft (15 m) to any other joint in the same layer in the conductor (Explanatory Note 1).

6. Lay

6.1 For Types A, C, and D conductors, the preferred lay is approximately 16.5 times the outside diameter of the completed conductor, but shall be not less than 13 nor more than 20 times this diameter.

6.2 For all other types, 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 1 Construction Requirements and Breaking Strength of Concentric-Lay-Stranded Copper and Copper-Clad Steel Composite Conductors

NOTE 1—*Metric Equivalents*—For conductor size, 1 cmil = 0.0005067 mm^2 (round to four significant figures); for diameter 1 mil = 0.02540 mm (round to four significant figures); for breaking strength, 1 lb = 0.45359 kg (round to four significant figures).

Conductor Size, Hard-Drawn Copper Equivalent[A]		Type	Grade 30 EHS Copper-Clad Steel Wires		Hard-Drawn Copper Wires		Rated Breaking Strength, min, lb[B]
cmil	AWG		Number of Wires	Diameter of Wires, mils	Number of Wires	Diameter of Wires, mils	
350 000	...	E	7	157.6	12	157.6	32 420
350 000	...	EK	4	147.0	15	147.0	23 850
350 000	...	V	3	175.1	9	189.3	23 480
300 000	...	E	7	145.9	12	145.9	27 770
300 000	...	EK	4	136.1	15	136.1	20 960
300 000	...	V	3	162.1	9	175.2	20 730
250 000	...	E	7	133.2	12	133.2	23 920
250 000	...	EK	4	124.2	15	124.2	17 840
250 000	...	V	3	148.0	9	160.0	17 420
211 600	0000	E	7	122.5	12	122.5	20 730
211 600	0000	G	2	194.4	5	194.4	15 640
211 600	0000	EK	4	114.3	15	114.3	15 370
211 600	0000	V	3	136.1	9	147.2	15 000
211 600	0000	F	1	183.3	6	183.3	12 290
167 800	000	E	7	109.1	12	109.1	16 800
167 800	000	J	3	185.1	4	185.1	16 170
167 800	000	G	2	173.1	5	173.1	12 860
167 800	000	EK	4	101.8	15	101.8	12 370
167 800	000	V	3	121.2	9	131.1	12 200
167 800	000	F	1	163.2	6	163.2	9980
133 100	00	K	4	178.0	3	178.0	17 600
133 100	00	J	3	164.8	4	164.8	13 430
133 100	00	G	2	154.2	5	154.2	10 510
133 100	00	V	3	108.0	9	116.7	9846
133 100	00	F	1	145.4	6	145.4	8094
105 600	0	K	4	158.5	3	158.5	14 490
105 600	0	J	3	146.7	4	146.7	10 970
105 600	0	G	2	137.3	5	137.3	8563
105 600	0	F	1	129.4	6	129.4	6536
83 690	1	N	5	154.6	2	154.6	15 410
83 690	1	K	4	141.2	3	141.2	11 900
83 690	1	J	3	130.7	4	130.7	9000
83 690	1	G	2	122.2	5	122.2	6956
83 690	1	F	1	115.3	6	115.3	5266
66 360	2	P	6	154.0	1	154.0	16 870
66 360	2	N	5	137.7	2	137.7	12 680
66 360	2	K	4	125.7	3	125.7	9730
66 360	2	J	3	116.4	4	116.4	7322
66 360	2	A	1	169.9	2	169.9	5876
66 360	2	G	2	108.9	5	108.9	5626
66 360	2	F	1	102.6	6	102.6	4233
52 620	3	P	6	137.1	1	137.1	13 910
52 620	3	N	5	122.6	2	122.6	10 390
52 620	3	K	4	112.0	3	112.0	7910
52 620	3	J	3	103.6	4	103.6	5955
52 620	3	A	1	151.3	2	151.3	4810
41 740	4	P	6	122.1	1	122.1	11 420
41 740	4	N	5	109.2	2	109.2	8460
41 740	4	D	2	161.5	1	161.5	7340
41 740	4	A	1	134.7	2	134.7	3938
33 090	5	P	6	108.7	1	108.7	9311
33 090	5	D	2	143.8	1	143.8	6035
33 090	5	A	1	120.0	2	120.0	3193
26 240	6	D	2	128.1	1	128.1	4942
26 240	6	A	1	106.8	2	106.8	2585
26 240	6	C	1	104.6[C]	2	104.6	2143
20 820	7	D	2	114.1	1	114.1	4022
20 820	7	A	1	126.6	2	89.5	2754

TABLE 1 *Continued*

Conductor Size, Hard-Drawn Copper Equivalent[A]		Type	Grade 30 EHS Copper-Clad Steel Wires		Hard-Drawn Copper Wires		Rated Breaking Strength, min, lb[B]
cmil	AWG		Number of Wires	Diameter of Wires, mils	Number of Wires	Diameter of Wires, mils	
16 510	8	D	2	101.6	1	101.6	3256
16 510	8	A	1	112.7	2	79.7	2233
16 510	8	C	1	80.8[C]	2	83.4	1100
11 750	9½	D	2	80.8[C]	1	80.8	1330

[A] See Explanatory Note 7.
[B] See Explanatory Note 11.
[C] Grade 40 HS (all of the other CCS wire is Grade 30 EHS).

6.3 The direction of lay of the outer layer shall be left-hand unless the direction of lay is specified otherwise by the purchaser.

6.4 The direction of lay shall be reversed in successive layers.

6.5 All wires in the conductor shall lie naturally in their true positions in the completed conductor. They shall tend to remain in position when the conductor is cut at any point and shall permit restranding by hand after being forcibly unraveled at the end of the conductor.

7. Construction

7.1 The numbers and diameters of wires in the various types of concentric-lay-stranded composite conductors shall conform to the requirements prescribed in Table 1 (Explanatory Note 2).

8. Physical and Electrical Tests

8.1 Tests for the physical and electrical properties of wires composing concentric-lay-stranded composite conductors shall be made before but not after stranding.

8.2 At the option of the purchaser or his representative, tension and elongation tests on wires before stranding may be waived, and the completed conductor may be tested as a unit. The breaking strength of the conductors so tested shall be not less than the rated strength values shown in Table 2. The free length between grips of the test specimen shall be not less than 24 in. (0.61 m), and care shall be taken to ensure that the wires in the conductor are evenly gripped during the test (Explanatory Note 3).

9. Density

9.1 For the purpose of calculating weights, cross sections, and so forth, the density of the copper shall be taken as 8.89 g/cm^3 at 20°C (Explanatory Note 4 and Table 2).

9.2 The density of both types of copper-clad-steel wire shall be taken as stated in Table 2.

10. Mass and Resistance

10.1 The mass and electrical resistance of a unit length of stranded 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 3. When greater accuracy is desired, the increment based on the specific lay of the conductor may be calculated (Explanatory Note 6). Reference information is shown in Table X1.1 in Appendix X1.

11. Variation in Area

11.1 The area of cross section of the completed conductor shall be not less than 97 % of the nominal area. The area of cross section of a conductor shall be considered to be the sum of the cross-sectional areas of its component wires at any point when measured perpendicularly to their axes (Explanatory Note 8). For the purposes of determining conformance to this standard, a measured or calculated value for cross sectional area shall be rounded to four significant figures in accordance with the rounding method of Practice E29.

12. Finish

12.1 The conductor shall be free of all imperfections not consistent with the best commercial practice.

TABLE 2 Density of Copper and Copper-Clad Steel

Units	Density at 20°C		
	Copper	30 % Copper-Clad Steel	40 % Copper-Clad Steel
Grams per cubic centimetre	8.89	8.15	8.24
Pounds per cubic inch	0.3212	0.2944	0.2975
Pounds per circular mil-foot	0.0000030270	0.0000027750	0.0000028039