Designation: B174 – 17

Standard Specification for Bunch-Stranded Copper Conductors for Electrical Conductors[1]

This standard is issued under the fixed designation B174; 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.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope

1.1 This specification covers bare bunch-stranded conductors made from round copper wires, either uncoated or coated with tin, lead, or lead-alloy for use as electrical conductors (Explanatory Note 1 and Explanatory Note 2).

1.2 Coated wires shall include only those wires with finished diameters and densities substantially equal to the respective diameters and densities of uncoated wires.

1.3 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.3.1 For conductor sizes designated by AWG or kcmil, the requirements in SI units have been numerically converted from corresponding values, stated or derived, in inch-pound units. For conductor sizes designated by SI units only, the requirements are stated or derived in SI units.

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 The following documents of the issue in effect at the time of reference form a part of this specification to the extent referenced herein:

2.2 *ASTM Standards:*[2]

B3 Specification for Soft or Annealed Copper Wire

B33 Specification for Tin-Coated Soft or Annealed Copper Wire for Electrical Purposes

B172 Specification for Rope-Lay-Stranded Copper Conductors Having Bunch-Stranded Members, for Electrical Conductors

B189 Specification for Lead-Coated and Lead-Alloy-Coated Soft Copper Wire for Electrical Purposes

B193 Test Method for Resistivity of Electrical Conductor Materials

B263 Test Method for Determination of Cross-Sectional Area of Stranded Conductors

B354 Terminology Relating to Uninsulated Metallic Electrical Conductors

2.3 *American National Standard:*

ANSI C42.35 Definitions of Electrical Terms[3]

3. Classification

3.1 For the purpose of this specification bunch-stranded conductors are classified as shown in Tables 1 and 2.

4. Ordering Information

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

4.1.1 Quantity of each size and class,

4.1.2 Conductor size: circular-mil area or AWG (see 7.1),

4.1.3 Class (Section 3 and Table 3),

4.1.4 Whether coated or uncoated; if coated, designate type of coating (see 11.1),

4.1.5 Maximum length of lay (see 6.3),

4.1.6 Whether separator is required (see 7.2),

[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.

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

TABLE 1 A Classification and Construction Requirements of Bunch-Stranded Conductors[A] —Class I Bunch Stranded Conductors

Area of Cross Section			Classification, Size, and Minimum Number of Wires	Uncoated Copper				Coated Copper			
		Size, AWG	Class I Nominal Wire Diameter 0.0201 In. (0.511 mm)	Nominal dc resistance @20C	Maximum dc resistance @20C	Nominal dc resistance @20C	Maximum dc resistance @20C	Nominal dc resistance @20C	Maximum dc resistance @20C	Nominal dc resistance @20C	Maximum dc resistance @20C
cmil	mm		24 AWG	ohm/kft	ohm/kft	ohm/km	ohm/km	ohm/kft	ohm/kft	ohm/km	ohm/km
20820	10.5	7	52	0.508	0.518	1.67	1.70	0.528	0.539	1.73	1.77
16510	8.37	8	41	0.641	0.654	2.10	2.14	0.666	0.679	2.19	2.23
13090	6.63	9	33	0.808	0.824	2.65	2.70	0.840	0.857	2.76	2.81
10380	5.26	10	26	1.02	1.04	3.34	3.41	1.06	1.08	3.48	3.55

TABLE 1 B Classification and Construction Requirements of Bunch-Stranded Conductors—Class J Bunch Stranded Conductors[A]

Area of Cross Section			Classification, Size, and Minimum Number of Wires	Uncoated Copper				Coated Copper			
		Size, AWG	Class J Nominal Wire Diameter 0.0126 In. (0.320 mm)	Nominal dc resistance @20C	Maximum dc resistance @20C	Nominal dc resistance @20C	Maximum dc resistance @20C	Nominal dc resistance @20C	Maximum dc resistance @20C	Nominal dc resistance @20C	Maximum dc resistance @20C
cmil	mm		28 AWG	ohm/kft	ohm/kft	ohm/km	ohm/km	ohm/kft	ohm/kft	ohm/km	ohm/km
10380	5.26	10	65	1.02	1.04	3.34	3.41	1.08	1.10	3.54	3.61
6530	3.31	12	41	1.62	1.65	5.31	5.42	1.72	1.75	5.64	5.76
4110	2.08	14	26	2.57	2.62	8.44	8.61	2.73	2.79	8.96	9.14
2580	1.31	16	16	4.10	4.18	13.5	13.7	4.35	4.44	14.3	14.6
1620	0.821	18	10	6.53	6.66	21.4	21.9	6.94	7.07	22.8	23.2
1020	0.517	20	7	10.4	10.6	34.0	34.7	11.0	11.2	36.1	36.8

TABLE 1 C Classification and Construction Requirements of Bunch-Stranded Conductors—Class K Bunch Stranded Conductors[A]

Area of Cross Section			Classification, Size, and inimum Number of Wires	Uncoated Copper				Coated Copper			
		Size, AWG	Class K Nominal Wire Diameter 0.0100 In. (0.254 mm)	Nominal dc resistance @20C	Maximum dc resistance @20C	Nominal dc resistance @20C	Maximum dc resistance @20C	Nominal dc resistance @20C	Maximum dc resistance @20C	Nominal dc resistance @20C	Maximum dc resistance @20C
cmil	mm		30 AWG	ohm/kft	ohm/kft	ohm/km	ohm/km	ohm/kft	ohm/kft	ohm/km	ohm/km
10380	5.26	10	104	1.02	1.04	3.35	3.41	1.09	1.12	3.58	3.65
6530	3.31	12	65	1.62	1.65	5.31	5.42	1.74	1.77	5.71	5.82
4110	2.08	14	41	2.57	2.62	8.43	8.60	2.76	2.82	9.06	9.24
2580	1.31	16	26	4.10	4.18	13.5	13.7	4.40	4.49	14.4	14.7
1620	0.821	18	16	6.53	6.66	21.4	21.9	7.01	7.15	23.0	23.5
1020	0.517	20	10[B]	10.4	10.6	34.1	34.8	11.1	11.4	36.4	37.1
640	0.324	22	7	16.5	16.9	54.1	55.2	17.7	18.1	58.1	59.2

[A] The constructions shown in these tables are typical of those used in the industry. It is intended that these tables preclude other constructions which may be desirable for specific applications. The constructions shown provide for a finished stranded conductor approximately of the area indicated. When specified by the purchaser, the number or sizes of wire may be increased to provide additional area to compensate for draw-down during subsequent processing.

[B] As an alternate to the construction shown for 20 AWG, Class K; for hook-up wire construction may consist of 8 wires 0.0100 in. (0.254 mm) diameter around wire of 0.0142 in. (0.361 mm) diameter.

4.1.7 Package size (see section 14.1),

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

4.1.9 Place of inspection (Section 13).

TABLE 2 Classification and Construction Requirements of Bunch-Stranded Conductors—Class L, M, O, P and Q Bunch Stranded Conductors[A]

Area of Cross Section		Size, AWG	Classification, Size, and Minimum Number of Wires					Uncoated Copper				Coated Copper			
			Class L	Class M	Class O	Class P	Class Q	Nominal dc resistance @20C	Maximum dc resistance @20C	Nominal dc resistance @20C	Maximum dc resistance @20C	Nominal dc resistance @20C	Maximum dc resistance @20C	Nominal dc resistance @20C	Maximum dc resistance @20C
			Nominal Wire Diameter 0.0080 In. (0.511 mm)	Nominal Wire Diameter 0.0063 In. (0.320 mm)	Nominal Wire Diameter 0.0050 In. (0.254 mm)	Nominal Wire Diameter 0.0040 In. (0.320 mm)	Nominal Wire Diameter 0.0031 In. (0.254 mm)								
cmil	mm		32 AWG	34 AWG	36 AWG	38 AWG	40 AWG	ohm/kft	ohm/kft	ohm/km	ohm/km	ohm/kft	ohm/kft	ohm/km	ohm/km
10380	5.26	10	165	...	...	...	...	1.02	1.04	3.34	3.41	1.09	1.12	3.58	3.65
6530	3.31	12	104	...	...	...	...	1.62	1.65	5.31	5.42	1.74	1.77	5.71	5.82
4110	2.08	14	65	104	...	...	...	2.57	2.62	8.43	8.60	2.76	2.82	9.06	9.24
2580	1.31	16	41	65	104	165	...	4.10	4.18	13.5	13.7	4.40	4.49	14.4	14.7
1620	0.821	18	26	41	65	104	165	6.53	6.66	21.4	21.9	7.00	7.15	23.0	23.4
1020	0.517	20	16	26	41	65	104	10.4	10.6	34.1	34.8	11.1	11.4	36.4	37.1
640	0.324	22	...	19	...	...	...	16.5	16.9	54.1	55.2	17.7	18.1	58.1	59.2
404	0.205	24	7	...	19	...	...	26.2	26.7	86.0	87.7	28.1	28.7	92.2	94.0
253	0.128	26	...	7	...	...	...	41.8	42.6	137	140	44.9	45.8	147	150

[A] The constructions shown in this table are typical of those used in the industry. It is intended that this table preclude other constructions which may be desirable for specific applications. The constructions shown provide for a finished stranded conductor approximately of the area indicated. When specified by the purchaser, the number or sizes of wire may be increased to provide additional area to compensate for draw-down during subsequent processing.

TABLE 3 Maximum Length of Lay for Bunch-Stranded Conductors

Area of Cross Section		Size, AWG	Maximum Length of Lay					
			Nominal Diameter		Column A		Column B	
cmil	mm		in.	mm	in.	mm	in.	mm
20 820	10.5	7	0.167	4.24	3.00	76.20	3.00	76.20
16 510	8.37	8	0.149	3.78	2.75	69.85	2.75	69.85
13 090	6.63	9	0.133	3.38	2.50	63.50	2.50	63.50
10 380	5.26	10	0.118	3.00	2.50	63.50	2.50	63.50
6 530	3.31	12	0.093	2.36	2.00	50.80	2.00	50.80
4 110	2.08	14	0.074	1.88	2.00	50.80	1.75	44.45
2 580	1.31	16	0.059	1.50	2.00	50.80	1.50	38.10
1 620	0.821	18	0.047	1.19	2.00	50.80	1.25	31.75
1 020	0.517	20	0.037	0.94	2.00	50.80	1.00	25.40
640	0.324	22	0.030	0.76	1.30	33.02	0.80	20.32
404	0.205	24	0.024	0.61	1.20	30.48	0.70	17.78
253	0.128	26	0.019	0.48	1.00	25.40	0.60	15.24
159	0.0806	28	0.015	0.38	1.00	25.40	0.50	12.70

5. Joints

5.1 Necessary joints in wires shall be made in accordance with accepted commercial practice.

5.2 Joints shall be so constructed and so disposed throughout the conductor that the diameter or configuration of the completed conductor is not substantially affected, and so that the flexibility of the completed conductor is not adversely affected.

6. Lay

6.1 Conductors of the same size and description furnished on one order shall have the same lay.

6.2 The direction of lay shall be at the option of the manufacturer unless otherwise specified.

6.3 Unless otherwise specified by the purchaser, the length of lay of bare or coated bunch-stranded conductors shall conform to the requirements of Column B of Table 3.

6.4 When specified, for constructions other than those listed in Footnote *A* of Tables 1 and 2, the length of lay shall conform to the requirements of Column A of Table 3.

6.5 Conductors of an intermediate nominal area in circular mils shall conform to the requirements for length of lay of the next smaller conductor.

7. Construction

7.1 The area of cross section, and the number and diameter of wires for a variety of strand constructions in general use are shown in Tables 1 and 2.

7.2 If a separator is required to be furnished with the conductor, it shall be at the option of the manufacturer unless otherwise specified by the purchaser as to requirements for the kind and thickness of material and its application details.

8. Physical and Electrical Tests

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

8.2 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 completed stranded conductors, but need not be made upon both. Care shall be taken to avoid mechanical injury and stretching when removing wires from the conductor for the purpose of testing.

8.3 The physical properties of wire when tested before stranding shall conform to the applicable requirements of 11.1.

8.4 The physical properties of wires removed from the completed stranded conductor shall be permitted to vary from the applicable requirements of 11.1 by the following amounts (Explanatory Note 3):

8.4.1 *Average of Results Obtained on All Wires Tested*—The percent minimum elongation may be reduced by the value of 5 % from the values required for unstranded wires as specified by Specifications B3, B33, or B189, as applicable. For example, where the unstranded wire specification requires minimum elongation of 30 %, wire of that material removed from Specification B174 stranded conductor shall meet a minimum elongation value of 25 %, a value 5 % reduction.

8.4.2 *Results Obtained on Individual Wires*—The percent minimum elongation may be reduced by the value of 15 % from the values required for unstranded wires as specified by Specifications B3, B33, or B189, as applicable. For example, where the unstranded wire specification requires minimum elongation of 30 %, wire of that material removed from Specification B174 stranded conductor shall meet a minimum elongation value of 15 %. If the reduction results in minimum elongation of less than 5 %, a minimum of 5 % shall apply.

8.5 In the event that the requirements prescribed in 8.4.2 are met, but those prescribed in 8.4.1 are not met, a retest shall be permitted wherein all wires of a conductor of 100 wires or less, or 100 wires selected at random throughout a conductor of more than 100 wires shall be tested for the purpose of final determination of conformance to 8.4.

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

8.7 If a tinning, lead-coating, or lead-alloy-coating 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, etc., the density of copper shall be taken as 8.89 g/cm^3 (0.32117 lb/in.^{3}) at 20°C (Explanatory Note 4).

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 (Explanatory Note 6).

10.2 The maximum electrical resistance of a unit length of stranded conductor shall not exceed 2 %over the nominal DC resistance shown in Tables 1 and 2 (Explanatory Note 5). When the DC resistance is measured at other than 20°C, it is to be corrected by using the multiplying factor given in Table 4.

10.3 For conductors to be used in covered or insulated wires or cables, direct current (DC) resistance measurements shall be used instead of the method outlined in Section 12, to determine compliance with this specification.

11. Requirements for Wires

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

11.1.1 Before stranding, uncoated wire shall meet the requirements of Specification B3.

TABLE 4 Temperature Correction Factors 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

11.1.2 Before stranding, tinned wire shall meet the requirements of Specification B33.

11.1.3 Before stranding, lead-coated and lead-alloy coated wire shall meet the requirements of Specification B189.

11.2 These requirements shall not prohibit the manufacture of conductors from uncoated hard-drawn wires which are annealed after stranding.

12. Variation in Area

12.1 The calculated area of cross-section of a stranded conductor expressed in circular mils shall be the product of the square of the specified diameter in mils of the individual wires times the number of wires prescribed.

NOTE 1—The calculated area of such cables as may incorporate more than one size of component wires should be the sum of the areas of the different sizes of wires.

12.2 The area of cross section of a completed stranded conductor designated as an AWG size shall be not less than 98 % of the area indicated in Column 1 of Tables 1 and 2. The area of cross section of a completed conductor not designated as an AWG size shall be not less than 98 % of a calculated value as prescribed in 12.1.

12.3 The area of cross section of a conductor shall be determined by Test Method B263. In applying this method, the increment of linear density resulting from stranding shall be the applicable value specified in Section 10.

13. Inspection

13.1 All tests and inspection shall be made at the place of manufacture unless otherwise especially agreed upon between the manufacturer and the purchaser at the time of purchase. The manufacturer shall afford the inspector representing the purchaser all reasonable facilities, to satisfy him that the material is being furnished in accordance with this specification.

14. Packaging and Package Marking

14.1 Package size for conductors shall be agreed upon between the manufacturer and the purchaser in the placing of individual orders.

14.2 The conductors shall be protected against damage in ordinary handling and shipping.

14.3 The net mass, length (or 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.

15. Keywords

15.1 bunch-stranded copper conductors; copper electrical conductor; electrical conductor; electrical conductor—copper; stranded copper conductor

EXPLANATORY NOTES

NOTE 1—In this specification only bunch-stranded conductors are designated. Requirements for rope-lay-stranded conductors constructed with *bunch-stranded* members will be found in Specification B172.

NOTE 2—For definitions of terms relating to conductors, reference should be made to ANSI C42.35 and Terminology B354.

NOTE 3—Wires removed from stranded conductors and straightened for tests will have altered physical properties due to cold working of the material. The reduced elongation requirement for wires removed from stranded conductors reflects this condition.

NOTE 4—The density of copper is in accordance with the International Annealed Copper Standard. The corresponding value at 0°C is 8.90 g/cm^3 (0.32150 lb/in.^{3}. Density calculations involving coated wire should consider the variation of coated wire density from the density of uncoated copper wire. The relative affect of the coating density on the overall wire density becomes greater as wire diameters decrease.

NOTE 5—The DC resistance, on a given construction, shall be calculated using the following formula:

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

where:

R = conductor resistance in ohms/1000 ft,
k = increment due to stranding (1.02) from Explanatory Note 6,
p = volume resistivity in ohms-cmil/ft determined in accordance with Test Method B193, and
A = cross-sectional area of conductor in kcmil determined in accordance with Section 12.

NOTE 6—1.02 is the value which approximates the incremental increase in mass and resistance of single bunch constructions as a result of stranding. This value is sufficiently accurate for most purposes and may be used when a more precise value is not available.