



Designation: **B 174 – 9502**

Standard Specification for Bunch-Stranded Copper Conductors for Electrical Conductors¹

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

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

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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 SI values for density and resistivity stated in inch-pound or SI units are to be regarded separately as the standard. For all other properties~~ Each system shall be used independently of the ~~inch-pound~~ other. ~~Combining values are to be regarded as form the standard and two systems may result in nonconformance with the specification. 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.~~

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:

B 3 Specification for Soft or Annealed Copper Wire²

B 33 Specification for Tinned Soft or Annealed Copper Wire for Electrical Purposes²

B 172 Specification for Rope-Lay-Stranded Copper Conductors Having Bunch-Stranded Members, for Electrical Conductors²

B 189 Specification for Lead-Coated and Lead-Alloy-Coated Soft Copper Wire for Electrical Purposes²

B 263 Test Method for Determination of Cross-Sectional Area of Stranded Conductors²

B 354 Terminology Relating to Uninsulated Metallic Electrical Conductors²

2.3 American National Standard:

ANSI C42.35 Definitions of Electrical Terms³

3. Classification

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

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 2),

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 and Table 3~~, 6.3),

4.1.6 Whether separator is required (see 7.2),

² Annual Book of ASTM Standards, Vol 02.03.

³ Available from American National Standards Institute, ~~H 25 West 42nd St., 13th Floor~~, 43rd Street, New York, NY 10036.

TABLE 1 Classification and Construction Requirements of Bunch-Stranded Conductors^A

Area of Cross Section			Classification, Size, and Minimum Number of Wires							
			Class I	Class J	Class K	Class L	Class M	Class O	Class P	Class Q
cmil	mm	Size, AWG ^{Notes}	Wire Diameter	Wire Diameter	Wire Diameter	Wire Diameter	Wire Diameter	Wire Diameter	Wire Diameter	Wire Diameter
			0.0201 in. (0.511 mm) No. 24 AWG	0.0126 in. (0.320 mm) No. 28 AWG	0.0100 in. (0.254 mm) No. 30 AWG	0.0080 in. (0.203 mm) No. 32 AWG	0.0063 in. (0.160 mm) No. 34 AWG	0.0050 in. (0.127 mm) No. 36 AWG	0.0040 in. (0.102 mm) No. 38 AWG	0.0031 in. (0.079 mm) No. 40 AWG
20 820	10.5	7		52	...	...	...	...	...	...
16 510	8.37	8		41	...	...	...	...	...	...
13 090	6.63	9		33	...	...	...	...	...	...
10 380	5.26	10		26	65	104	165	...	...	...
6 530	3.31	12		...	41	65	104	...	...	...
4 110	2.08	14		...	26	41	65	104	...	...
2 580	1.31	16		...	16	26	41	65	104	165
1 620	0.821	18		...	10	16	26	41	65	104
1 020	0.517	20	B,C	...	7	10 ^B	16	26	41	65
1 020	0.517	20	B,C	...	7	10^B	16	26	41	65
640	0.324	22	D	...	...	7	...	19	...	...
404	0.205	24	D	...	...	...	7	...	19	...
253	0.128	26	D	...	...	...	...	7	...	...
159	0.0806	28	D	...	...	...	...	...	...	...

^AThe constructions shown in this table are typical of those used in the industry. It is not intended that this table preclude other constructions which may be desirable for specific applications. The constructions shown provide for a finished, non-covered, stranded conductor approximately of the area indicated. When specified by the purchaser, the number or size of wires may be increased to provide additional area to compensate for draw-down during subsequent processing.

^BAs an alternate to the construction shown for No. 20 AWG, Class K; for hook-up wire construction may consist of 8 wires 0.0100 in. (0.254 mm) diameter around 1 wire of 0.0142 in. (0.361 mm) diameter.

^CNo. 20 AWG conductor is restricted in the schedule of requirements by Underwriters' Laboratories, Inc. (UL), to usages such as types FX, FXT, X, and XT, and does not meet UL requirements for fixture wires unless such usage has been approved for specific applications.

^DThe constructions of No. 22 through No. 28 AWG conductors are listed in UL requirements for appliance wire.

4.1.7 Package size (see section 15.1),

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

4.1.9 Place of inspection (Section 13).

4.1.10 In addition, Supplementary Requirements shall apply only when specified by the purchaser in the inquiry, contract, or purchase order for direct procurement by agencies of the U.S. Government (see S1, S2, and S3).

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 2.

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

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.

~~6.6 Underwriters' Laboratories, Inc., requirements state that uncoated conductors which are to be rubber or neoprene insulated, and all conductors having lengths of lay longer than those specified by Column B of Table 2, shall be provided with a separator between the conductor and the insulation.~~

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 Table 1.

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.

TABLE 2 Maximum Length of Lay for Bunch-Stranded Conductors

Area of Cross Section		Size, AWG	Maximum Length of Lay					
			Nominal Diameter		Column A		Column BA	
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	1.62	41.15
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	1.25	31.75
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	1.00	25.40
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^B	0.80	20.32^G
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^B	0.70	17.78^G
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^B	0.60	15.24^G
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^B	0.50	12.70^G
159	0.0806	28	0.015	0.38	1.00	25.40	0.50	12.70

^AThe lengths of lay of Column B meet the requirements of the following types of flexible cords and fixture wires as defined by Underwriters' Laboratories, Inc.: Types S, SJ, SO, SJO, SJT, ST, SV, SVT, SF, SFF, SP, SPT, and HPN for sizes 10 AWG through 18 AWG and for Types FX, FXT, X, and XT for size 20 only.

^BThe lengths of lay of sizes 22 AWG through 28 of Column A meet the requirements of appliance wires (insulated using a separator) as defined by Underwriters' Laboratories, Inc.

^CThe lengths of lay of Sizes 22 AWG through 28 AWG of Column B meet the requirements of appliance wires (insulated without a separator) as defined by Underwriters' Laboratories, Inc.

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 B 3, B 33, or B 189, as applicable. For example, where the unstranded wire specification requires minimum elongation of 30 %, wire of that material removed from Specification B 174 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 B 3, B 33, or B 189, as applicable. For example, where the unstranded wire specification requires minimum elongation of 30 %, wire of that material removed from Specification B 1734 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 linear densities, mass, cross sections, etc., the density of copper shall be taken as ~~0.32117~~ lb/in.^3 (~~8.89~~ 8.89 g/cm^3) (0.32117 lb/in.^3) at 20°C (Explanatory Note 4).

10. Mass and Resistance

10.1 The ~~weight~~ 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 an increment of 2 %.

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 B 3.

11.1.2 Before stranding, tinned wire shall meet the requirements of Specification B 33.

11.1.3 Before stranding, lead-coated and lead-alloy coated wire shall meet the requirements of Specification B 189.

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 Table 1. 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 B 263. 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 B 172.

NOTE 2—For definitions of terms relating to conductors, reference should be made to ANSI C42.35 and Terminology B 354.

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 ~~value~~ density of copper is in accordance with the International Annealed Copper Standard. The corresponding value at 0°C is 8.90 g/cm³ (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.

SUPPLEMENTARY REQUIREMENTS

The following supplementary requirements shall apply only when specified by the purchaser in the inquiry, contract, or order, for agencies of the U. S. Government.

S1. Referenced Documents

S1.1 The following documents form a part of this specification to the extent specified herein. Unless otherwise specified, the issues of these documents shall be those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation.

S1.2 *Military Specifications:*⁴

MIL-C-12000 Cable, Cord, and Wire, Electric; Packaging of

S2.

Inspection

S2.1 The government shall have the right to perform any of the inspections and tests set forth in this specification when such tests are deemed necessary to ensure that the material conforms to the prescribed requirements.

S3. Packaging

S3.1 Packaging shall be in accordance with MIL-C-12000.

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