Designation: B 172 – 01

Standard Specification for Rope-Lay-Stranded Copper Conductors Having Bunch-Stranded Members, for Electrical Conductors[1]

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1. Scope

1.1 This specification covers bare rope-lay-stranded conductors having bunch-stranded members made from round copper wires, either uncoated or coated with tin, lead, or lead-alloy for use as electrical conductors (Explanatory Notes 1 and 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 inch-pound or SI units are to be regarded separately as standard. Each system shall be used independently of the other. Combining values from the 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.

1.3.1 For density, resistivity, and temperature, the values stated in SI units are to be regarded as standard.

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 Wire[2]

B 33 Specification for Tinned Soft or Annealed Copper Wire for Electrical Purposes[2]

B 173 Specification for Rope-Lay-Stranded Copper Conductors Having Concentric-Stranded Members, for Electrical Conductors[2]

B 189 Specification for Lead-Coated and Lead-Alloy-Coated Soft Copper Wire for Electrical Purposes[2]

B 263 Test Method for Determination of Cross-Sectional Area of Stranded Conductors[2]

B 354 Terminology Relating to Uninsulated Metallic Electrical Conductors[2]

2.3 *American National Standard:*

ANSI C42.35 Definitions of Electrical Terms[3]

3. Classification

3.1 For the purpose of this specification rope-lay-stranded conductors having bunch-stranded members are classifed as follows:

3.1.1 *Class I*—Conductors consisting of wires 0.0201 in. (0.511 mm) diameter (No. 24 AWG) to produce rope-lay-stranded conductors up to 2 000 000 cmil (1013 mm^2) in total cross-sectional area. (Typical use is for special apparatus conductor.)

3.1.2 *Class K*—Conductors consisting of wires 0.0100 in. (0.254 mm) diameter (No. 30 AWG) to produce rope-lay-stranded conductors up to 1 000 000 cmil (507 mm^2) in total cross-sectional area. (Typical use is for special portable cord and conductors.)

3.1.3 *Class M*—Conductors consisting of wires 0.0063 in. (0.160 mm) diameter (No. 34 AWG) to produce rope-lay-stranded conductors up to 1 000 000 cmil (507 mm^2) in total cross-sectional area. (Typical use is for welding conductors.)

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 4 and Table 1),

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

4.1.5 Details of special-purpose lays, if required (see 6.2 and 6.3 and Explanatory Note 3),

4.1.6 Package size (see 15.1),

4.1.7 Special package marking, if required (Section 14),

[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] *Annual Book of ASTM Standards*, Vol 02.03.

[3] Available from American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036.

TABLE 1 Construction Requirements of Rope-Lay Stranded Copper Conductors Having Bunch-Stranded Members[A]

Area of Cross Section		Size AWG	Class I				Class K				Class M			
			Wire Diameter 0.0201 in. (0.511 mm)		Approximate Mass[B]		Wire Diameter 0.0100 in. (0.254 mm)		Approximate Mass[B]		Wire Diameter 0.0063 in. (0.160 mm)		Approximate Mass[B]	
cmil	mm		Nominal Number of Wires	Strand Construction[C]	lb/ 1000 ft.	kg/ km	Nominal Number of Wires	Strand Construction[C]	lb/ 1000 ft.	kg/ km	Nominal Number of Wires	Strand Construction[C]	lb/ 1000 ft.	kg/ km
2 000 000	1013	...	4921	19 by 7 by 37	6439	9583	...				...			
1 900 000	963	...	4788	19 by 7 by 36	6265	9324	...				...			
1 800 000	912	...	4522	19 by 7 by 34	5917	8806	...				...			
1 750 000	887	...	4389	19 by 7 by 33	5743	8547	...				...			
1 700 000	861	...	4256	19 by 7 by 32	5569	8288	...				...			
1 600 000	811	...	3990	19 by 7 by 30	5221	7770	...				...			
1 500 000	760	...	3724	19 by 7 by 28	4873	7252	...				...			
1 400 000	709	...	3458	19 by 7 by 26	4525	6734	...				...			
1 300 000	659	...	3192	19 by 7 by 24	4177	6216	...				...			
1 250 000	633	...	3059	19 by 7 by 23	4003	5957	...				...			
1 200 000	608	...	2926	19 by 7 by 22	3829	5698	...				...			
1 100 000	557	...	2793	19 by 7 by 21	3655	5439	...				...			
1 000 000	507	...	2527	19 by 7 by 19	3307	4921	10 101	37 by 7 by 39	3272	4869	25 193	61 by 7 by 59	3239	4819
900 000	456	...	2261	19 by 7 by 17	2959	4403	9065	37 by 7 by 35	2936	4369	22 631	61 by 7 by 53	2909	4329
800 000	405	...	1995	19 by 7 by 15	2611	3885	7980	19 by 7 by 60	2585	3846	20 069	61 by 7 by 47	2580	3839
750 000	380	...	1862	19 by 7 by 14	2436	3626	7581	19 by 7 by 57	2455	3654	18 788	61 by 7 by 44	2415	3594
700 000	355	...	1729	19 by 7 by 13	2262	3367	6916	19 by 7 by 52	2240	3333	17 507	61 by 7 by 41	2251	3349
650 000	329	...	1596	19 by 7 by 12	2088	3108	6517	19 by 7 by 49	2111	3141	16 226	61 by 7 by 38	2086	3104
600 000	304	...	1470	7 by 7 by 30	1906	2836	5985	19 by 7 by 45	1938	2885	14 945	61 by 7 by 35	1921	2859
550 000	279	...	1372	7 by 7 by 28	1779	2647	5453	19 by 7 by 41	1766	2628	13 664	61 by 7 by 32	1757	2614
500 000	253	...	1225	7 by 7 by 25	1588	2363	5054	19 by 7 by 38	1637	2436	12 691	37 by 7 by 49	1631	2428
450 000	228	...	1127	7 by 7 by 23	1461	2174	4522	19 by 7 by 34	1465	2180	11 396	37 by 7 by 44	1465	2180
400 000	203	...	980	7 by 7 by 20	1270	1891	3990	19 by 7 by 30	1292	1923	10 101	37 by 7 by 39	1298	1932
350 000	177	...	882	7 by 7 by 18	1143	1701	3458	19 by 7 by 26	1120	1667	8806	37 by 7 by 34	1132	1685
300 000	152	...	735	7 by 7 by 15	953	1418	2989	7 by 7 by 61	959	1427	7581	19 by 7 by 57	975	1450
250 000	127	...	637	7 by 7 by 13	826	1229	2499	7 by 7 by 51	802	1193	6384	19 by 7 by 48	821	1221
211 600	107	0000	532	19 by 28	683	1017	2107	7 by 7 by 43	676	1006	5320	19 by 7 by 40	684	1018
167 800	85.0	000	418	19 by 22	537	799	1666	7 by 7 by 34	535	795	4256	19 by 7 by 32	547	814
133 100	67.4	00	342	19 by 18	439	654	1323	7 by 7 by 27	424	632	3325	19 by 7 by 25	427	636
105 600	53.5	0	266	19 by 14	342	508	1064	19 by 56	338	503	2646	7 by 7 by 54	337	501
83 690	42.4	1	210	7 by 30	267	397	836	19 by 44	266	395	2107	7 by 7 by 43	268	399
66 360	33.6	2	161	7 by 23	205	305	665	19 by 35	211	315	1666	7 by 7 by 34	212	316
52 620	26.7	3	133	7 by 19	169	252	532	19 by 28	169	252	1323	7 by 7 by 27	168	251
41 740	21.1	4	105	7 by 15	134	199	420	7 by 60	132	197	1064	19 by 56	134	200
33 090	16.8	5	84	7 by 12	107	159	336	7 by 48	106	157	836	19 by 44	105	157
26 240	13.3	6	63	7 by 9	80	119	266	7 by 38	84	125	665	19 by 35	84	125
20 820	10.5	7	...				210	7 by 30	66	98	532	19 by 28	67	100
16 510	8.37	8	...				168	7 by 24	53	79	420	7 by 60	52	78
13 090	6.63	9	...				133	7 by 19	42	62	336	7 by 48	42	62
10 380	5.26	10	...				...				259	7 by 37	32	48
6530	3.31	12	...				...				168	7 by 24	21	31

[A] The constructions shown in this table are typical of those used in the industry. It is not intended that this table preclude other constructions using the same total number of wires which may be desireable 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.

[B] Values for the mass of the completed conductor are approximate. The mass values are based upon the standard stranding increments listed in Explanatory Note 6.

[C] Strand Construction—#A by #B by #C: where #C is the number of wires in each bunch-stranded member; #B is the number of bunch stranded members which make-up each rope-stranded member; and #A (where used) is the number of rope-stranded members in the conductor. Where #A is not given, the conductor consists of one rope-stranded member. For example, 19 by 7 by 32 indicates a construction consisting of 19 rope-stranded members, each of which consists of 7 bunch-stranded members with 32 wires each.

4.1.8 Lagging, if required (see 15.2), and

4.1.9 Place of inspection (Section 13).

5. Joints

5.1 Necessary joints in wires or in groups of wires shall be made in accordance with accepted commercial practice, taking into account the size of the wire or group of wires as related to the size of the entire conductor.

5.2 Bunch-stranded members or rope-stranded members forming the completed conductor may be joined as a unit by soldering, brazing, or welding.

5.3 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 (Explanatory Note 3)

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

6.2 The length of lay of the outer layer of the rope-lay-stranded conductor shall not be less than 8 nor more than 16 times the outside diameter of the completed conductor. The length of lay of the other layers shall be at the option of the manufacturer unless specifically agreed upon. The direction of lay of the outer layer shall be left-hand, unless the direction of lay is specified otherwise by the purchaser. The direction of lay of the other layers shall be reversed in successive layers, unless otherwise agreed upon by the manufacturer and the purchaser.

6.3 The length of lay of the bunch-stranded and rope-stranded members shall be not more than 30 times the outside diameter of the member. The direction of lay shall be at the option of the manufacturer unless specifically agreed upon.

6.4 In very flexible conductors, such as welding conductor, the direction of lay of the stranded members forming rope-lay-stranded conductor may be in the same, rather than in reversed, directions as prescribed above.

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 The number of individual wires may vary slightly from those shown in Table 1 provided the nominal cross-sectional area of the conductor at any point be not less than that specified.

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 4):

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 172 stranded conductor shall meet a minimum elongation value of 25 %.

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 172 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 5).

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).

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 that 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 (see Note 1).

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 for sizes 211 600 cmil (107 mm^2) and smaller. The area of cross section of a completed stranded conductor not designated as an AWG size shall be not less than 98 % of a calculated value obtained 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 may be the applicable value listed in Explanatory Note 6, or may be calculated from the measured component dimensions of the sample under test. In case of question regarding area compliance, the actual linear density increment due to stranding shall be calculated.

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, without charge, to satisfy him that the material is being furnished in accordance with this specification.

14. Product Marking

14.1 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. Packaging and Package Marking

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

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.

16. Keywords

16.1 copper electrical conductor; electrical conductor; electrical conductor—copper; rope-lay-stranded copper conductors; stranded copper conductor

EXPLANATORY NOTES

NOTE 1—In this specification only rope-lay-stranded conductors constructed with bunch-stranded members are designated. Requirements for rope-lay-stranded conductors constructed with *concentric-lay-stranded* members will be found in Specification B 173.

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

NOTE 3—Certain types of insulated conductors may require a shorter lay than other conductors. It is expected that departures from the provision of this specification because of special requirements relative to length of lay, direction of lay, and direction of lay of successive layers will be agreed upon between the manufacturer and the purchaser.

NOTE 4—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 5—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 ^{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 6—The following values approximate the incremental increase in mass and the incremental decrease in resistance of rope-lay stranded conductor as a result of stranding. The values are sufficiently accurate for most purposes and may be used when more precise values are not available. They are as follows:

Construction	Increment of Linear Density and Resistance, %
Rope-lay-stranded conductors (Classes I, K, and M):	
7 by bunch-stranded members	4
19 by bunch-stranded members	5
7 by 7 by bunch-stranded members	6
19 by 7 by bunch-stranded members	7
37 by 7 by bunch-stranded members	7
61 by 7 by bunch-stranded members	7