Designation: B173 – 10

StandardSpecification for Rope-Lay-Stranded Copper Conductors Having Concentric-Stranded Members, for Electrical Conductors[1]

This standard is issued under the fixed designation B173; 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 Department of Defense.

1. Scope

1.1 This specification covers bare rope-lay-stranded conductors having concentric-stranded members made from round copper wires, either uncoated or coated with tin, lead, or lead-alloy for use as electrical conductors (Explanatory Note 1 and 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 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:*[2]

B3 Specification for Soft or Annealed Copper Wire

B8 Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft

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 rope-lay-stranded conductors having concentric-stranded members are classified as follows:

3.1.1 *Class G*—Conductors consisting of 7 to 61 rope-lay-stranded members, each of which consists of 7 to 19 concentric-stranded wires, with total conductor sizes ranging from No. 14 AWG (2.08 mm^2) to 5 000 000 cmil (2534 mm^2). (Typical use is for rubber-sheathed conductor, apparatus conductor, portable conductor, and similar applications.)

3.1.2 *Class H*—Conductors consisting of 19 to 91 rope-lay-stranded members, each of which consists of 7 to 19 concentric-stranded wires, with total conductor sizes ranging from No. 9 AWG (6.63 mm^2) to 5 000 000 cmil (2534 mm^2). Class K construction produces a conductor with greater flexibility than class G. (Typical use is for rubber-sheathed cord and applications where flexibility is required such as on take-up reels over sheaves and extra-flexible apparatus conductor.)

4. Ordering Information

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

[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.

4.1.1 Quantity of each size and class;
4.1.2 Conductor size: circular-mil area or AWG (Section 7);
4.1.3 Class (Section 3 and Tables 1 and 2);
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 14.1);
4.1.7 Special package marking, if required (Section 15);
4.1.8 Lagging, if required (see 14.2); 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 commerical practice, taking into account the size of the wire or group of wires as related to the size of the entire conductor.

5.2 Concentric-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 be not 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 between the manufacturer and the purchaser.

6.3 The length of lay of the individual wires composing the stranded members shall be not less than 8 nor more than 16 times the outside diameter of that layer. Unless otherwise specified, the direction of lay of the outer layer of wires shall be at the option of the manufacturer. The direction of lay shall be reversed in successive layers, unless otherwise agreed upon between the manufacturer and the purchaser.

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.

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 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 B173 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 B173 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 for 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. The approximate mass and electrical resistance may be determined using the standard increments shown in Explanatory Note 6. 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 of stranded conductor shall not exceed 2% over the nominal DC resistance shown in Table 1 and Table 2. When the DC

TABLE 1 Constructional and DC Resistance Requirements of Rope-Lay Stranded Copper Conductors Having Concentric-Stranded Members—Class G[A]

Area of Cross Section		Size AWG	Number of Wires	Diameter of Wires		Number of Wires in Each Member	Completed Conductor[B]				Uncoated Copper				Tinned Copper			
							Nominal Diameter		Nominal Mass		Nominal DC Resistance @20C		Maximum DC Resistance @20C		Nominal DC Resistance @20C		Maximum DC Resistance @20C	
cmil	mm²			in.	mm		in.	mm	lb/1000 ft	kg/km	ohm/1000 ft	ohm/km	ohm/1000 ft	ohm/km	ohm/1000 ft	ohm/km	ohm/1000 ft	ohm/km
5 000 000	2534	. . .	1159	0.0657	1.67	19	2.957	75.1	16 052	23 888	0.00220	0.00721	0.00224	0.00735	0.00229	0.00750	0.00234	0.00765
4 500 000	2280	. . .	1159	0.0623	1.58	19	2.804	71.2	14 433	21 479	0.00244	0.00801	0.00249	0.00817	0.00254	0.00833	0.00259	0.00850
4 000 000	2027	. . .	1159	0.0587	1.49	19	2.642	67.1	12 814	19 069	0.00275	0.00902	0.00281	0.00920	0.00286	0.00938	0.00292	0.00957
3 500 000	1773	. . .	1159	0.0550	1.40	19	2.475	62.9	11 249	16 741	0.00314	0.0103	0.00320	0.0105	0.00327	0.0107	0.00334	0.0109
3 000 000	1520	. . .	1159	0.0509	1.29	19	2.291	58.2	9635	14 338	0.00366	0.0120	0.00373	0.0122	0.00381	0.0125	0.00389	0.0128
2 500 000	1267	. . .	703	0.0596	1.51	19	2.086	53.0	8012	11 924	0.00440	0.0144	0.00449	0.0147	0.00457	0.0150	0.00466	0.0153
2 000 000	1013	. . .	703	0.0533	1.35	19	1.866	47.4	6408	9536	0.00550	0.0180	0.00561	0.0184	0.00572	0.0188	0.00583	0.0192
1 900 000	963	. . .	703	0.0520	1.32	19	1.820	46.2	6099	9077	0.00579	0.0190	0.00591	0.0194	0.00602	0.0197	0.00614	0.0201
1 800 000	912	. . .	703	0.0506	1.29	19	1.771	45.0	5775	8594	0.00611	0.0200	0.00623	0.0204	0.00635	0.0208	0.00648	0.0212
1 750 000	887	. . .	703	0.0499	1.27	19	1.747	44.4	5617	8358	0.00628	0.0206	0.00641	0.0210	0.00653	0.0214	0.00666	0.0218
1 700 000	861	. . .	703	0.0492	1.25	19	1.722	43.7	5460	8125	0.00647	0.0212	0.00660	0.0216	0.00672	0.0221	0.00685	0.0225
1 600 000	811	. . .	703	0.0477	1.21	19	1.670	42.4	5132	7638	0.00687	0.0225	0.00701	0.0230	0.00715	0.0234	0.00729	0.0239
1 500 000	760	. . .	427	0.0593	1.51	7	1.601	40.7	4772	7102	0.00726	0.0238	0.00741	0.0243	0.00755	0.0248	0.00770	0.0253
1 400 000	709	. . .	427	0.0573	1.46	7	1.547	39.3	4456	6631	0.00778	0.0255	0.00794	0.0260	0.00809	0.0265	0.00825	0.0270
1 300 000	659	. . .	427	0.0552	1.40	7	1.490	37.8	4135	6154	0.00838	0.0275	0.00855	0.0281	0.00871	0.0286	0.00888	0.0292
1 250 000	633	. . .	427	0.0541	1.37	7	1.461	37.1	3972	5911	0.00871	0.0286	0.00888	0.0292	0.00906	0.0297	0.00924	0.0303
1 200 000	608	. . .	427	0.0530	1.35	7	1.431	36.3	3812	5673	0.00907	0.0298	0.00925	0.0304	0.00944	0.0310	0.00963	0.0316
1 100 000	557	. . .	427	0.0508	1.29	7	1.372	34.8	3502	5212	0.00990	0.0325	0.0101	0.0332	0.0103	0.0338	0.0105	0.0345
1 000 000	507	. . .	427	0.0484	1.23	7	1.307	33.2	3179	4731	0.01090	0.0357	0.0111	0.0364	0.0113	0.0372	0.0115	0.0379
900 000	456	. . .	427	0.0459	1.17	7	1.239	31.5	2859	4255	0.0121	0.0397	0.0123	0.0405	0.0126	0.0413	0.0129	0.0421
800 000	405	. . .	427	0.0433	1.10	7	1.169	29.7	2544	3787	0.0136	0.0447	0.0139	0.0456	0.0142	0.0464	0.0145	0.0473
750 000	380	. . .	427	0.0419	1.06	7	1.131	28.7	2383	3546	0.0145	0.0476	0.0148	0.0486	0.0151	0.0495	0.0154	0.0505
700 000	355	. . .	427	0.0405	1.03	7	1.094	27.8	2226	3313	0.0156	0.0510	0.0159	0.0520	0.0162	0.0531	0.0165	0.0542
650 000	329	. . .	427	0.0390	0.99	7	1.053	26.7	2064	3072	0.0168	0.0550	0.0171	0.0561	0.0174	0.0572	0.0177	0.0583
600 000	304	. . .	427	0.0375	0.95	7	1.013	25.7	1908	2840	0.0181	0.0595	0.0185	0.0607	0.0189	0.0619	0.0193	0.0631
550 000	279	. . .	427	0.0359	0.91	7	0.969	24.6	1749	2603	0.0198	0.0650	0.0202	0.0663	0.0206	0.0676	0.0210	0.0690
500 000	253	. . .	259	0.0439	1.12	7	0.922	23.4	1579	2350	0.0217	0.0711	0.0221	0.0725	0.0225	0.0740	0.0230	0.0755
450 000	228	. . .	259	0.0417	1.06	7	0.876	22.3	1425	2120	0.0241	0.0790	0.0246	0.0806	0.0251	0.0822	0.0255	0.0838
400 000	203	. . .	259	0.0393	1.00	7	0.825	21.0	1265	1883	0.0271	0.0889	0.0276	0.0907	0.0282	0.0924	0.0288	0.0942
350 000	177	. . .	259	0.0368	0.93	7	0.773	19.6	1109	1651	0.0310	0.102	0.0316	0.104	0.0322	0.106	0.0328	0.108
300 000	152	. . .	259	0.0340	0.86	7	0.714	18.1	947	1409	0.0361	0.119	0.0368	0.121	0.0376	0.123	0.0384	0.125
250 000	127	. . .	259	0.0311	0.79	7	0.653	16.6	792	1179	0.0434	0.142	0.0443	0.145	0.0451	0.148	0.0460	0.151
211 600	107	0000	133	0.0399	1.01	7	0.599	15.2	667	992	0.0510	0.167	0.0520	0.170	0.0530	0.174	0.0541	0.177
167 800	85.0	000	133	0.0355	0.90	7	0.533	13.5	528	785	0.0643	0.211	0.0656	0.215	0.0668	0.219	0.0681	0.223
133 100	67.4	00	133	0.0316	0.80	7	0.474	12.0	418	622	0.0810	0.266	0.0826	0.271	0.0843	0.276	0.0860	0.282
105 600	53.5	0	133	0.0282	0.72	7	0.423	10.7	333	495	0.102	0.335	0.104	0.342	0.106	0.348	0.108	0.355
83 690	42.4	1	133	0.0251	0.64	7	0.377	9.6	264	393	0.129	0.423	0.132	0.431	0.134	0.440	0.137	0.449
66 360	33.6	2	49	0.0368	0.93	7	0.331	8.4	207	308	0.161	0.528	0.164	0.539	0.167	0.549	0.170	0.560
52 620	26.7	3	49	0.0328	0.83	7	0.295	7.5	164	245	0.203	0.666	0.207	0.679	0.211	0.693	0.215	0.707
41 740	21.1	4	49	0.0292	0.74	7	0.263	6.7	130	194	0.256	0.840	0.261	0.857	0.266	0.873	0.271	0.890
33 090	16.8	5	49	0.0260	0.66	7	0.234	5.9	103	154	0.323	1.06	0.329	1.08	0.336	1.10	0.343	1.12
26 240	13.3	6	49	0.0231	0.59	7	0.208	5.3	81.5	121	0.407	1.34	0.415	1.37	0.423	1.39	0.431	1.42
20 820	10.5	7	49	0.0206	0.52	7	0.185	4.7	64.8	96.5	0.513	1.68	0.523	1.71	0.534	1.75	0.545	1.79
16 510	8.37	8	49	0.0184	0.47	7	0.166	4.2	51.7	77.0	0.647	2.12	0.660	2.16	0.687	2.25	0.701	2.30
13 090	6.63	9	49	0.0163	0.41	7	0.148	3.8	40.6	60.4	0.816	2.68	0.832	2.73	0.867	2.84	0.884	2.90
10 380	5.26	10	49	0.0146	0.37	7	0.131	3.3	32.6	48.5	1.03	3.38	1.05	3.45	1.09	3.59	1.11	3.66

TABLE 1 *Continued*

Area of Cross Section		Size AWG	Number of Wires	Diameter of Wires		Number of Wires in Each Member	Completed Conductor[B] Nominal Diameter		Completed Conductor[B] Nominal Mass		Uncoated Copper Nominal DC Resistance @20C		Uncoated Copper Maximum DC Resistance @20C		Tinned Copper Nominal DC Resistance @20C		Tinned Copper Maximum DC Resistance @20C	
cmil	mm^2			in.	mm		in.	mm	lb/1000 ft	kg/km	ohm/1000 ft	ohm/km	ohm/1000 ft	ohm/km	ohm/1000 ft	ohm/km	ohm/1000 ft	ohm/km
6530	3.31	12	49	0.0115	0.29	7	0.104	2.6	20.2	30.1	1.64	5.37	1.67	5.48	1.74	5.70	1.77	5.81
4110	2.08	14	49	0.0092	0.23	7	0.083	2.1	12.9	19.2	2.60	8.53	2.65	8.70	2.79	9.15	2.85	9.33

[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 that 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.

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