Designation: B172 – 17

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

This standard is issued under the fixed designation B172; 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 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.

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

B173 Specification for Rope-Lay-Stranded Copper Conductors Having Concentric-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 bunch-stranded members are classified 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.)

[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.

Current edition approved April 1, 2017. Published April 2017. Originally approved in 1942 to replace portions of B158 – 41 T. Last previous edition approved in 2015 as B172 – 10 (2015). DOI: 10.1520/B0172-17.

[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.

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 Tables 1-3),

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, 6.3, and Explanatory Note 3),

4.1.6 Package size (see 15.1),

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

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.

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

Area of Cross Section			Wire Diameter 0.0201 in. (0.511 mm)		Approximate Mass[B]		Uncoated Copper				Coated Copper			
							Nominal dc resistance @ 20°C		Maximum dc resistance @ 20°C		Nominal dc resistance @ 20°C		Maximum dc resistance @ 20°C	
cmil	mm^2	Size AWG	Nominal Number of Wires	Strand Construction A by B by C[C]	lb/ 1000 ft.	kg/ km	Ohm / kft	Ohm / km	Ohm / kft	Ohm / km	Ohm / kft	Ohm / km	Ohm / kft	Ohm / km
2 000 000	1013	...	4921	19 by 7 by 37	6439	9583	0.00555	0.0182	0.00566	0.0186	0.00577	0.0189	0.00589	0.0193
1 900 000	963	...	4788	19 by 7 by 36	6265	9324	0.00584	0.0192	0.00596	0.0196	0.00607	0.0199	0.00619	0.0203
1 800 000	912	...	4522	19 by 7 by 34	5917	8806	0.00616	0.0202	0.00628	0.0206	0.00641	0.0210	0.00654	0.0214
1 750 000	887	...	4389	19 by 7 by 33	5743	8547	0.00634	0.0208	0.00647	0.0212	0.00659	0.0216	0.00672	0.0220
1 700 000	861	...	4256	19 by 7 by 32	5569	8288	0.00653	0.0214	0.00666	0.0218	0.00679	0.0223	0.00693	0.0227
1 600 000	811	...	3990	19 by 7 by 30	5221	7770	0.00694	0.0228	0.00708	0.0233	0.00721	0.0237	0.00735	0.0242
1 500 000	760	...	3724	19 by 7 by 28	4873	7252	0.00740	0.0243	0.00755	0.0248	0.00769	0.0252	0.00784	0.0257
1 400 000	709	...	3458	19 by 7 by 26	4525	6734	0.00793	0.0260	0.00809	0.0265	0.00824	0.0270	0.00840	0.0275
1 300 000	659	...	3192	19 by 7 by 24	4177	6216	0.00854	0.0280	0.00871	0.0286	0.00888	0.0291	0.00906	0.0297
1 250 000	633	...	3059	19 by 7 by 23	4003	5957	0.00888	0.0291	0.00906	0.0297	0.00923	0.0303	0.00941	0.0309
1 200 000	608	...	2926	19 by 7 by 22	3829	5698	0.00925	0.0303	0.00944	0.0309	0.00962	0.0316	0.00981	0.0322
1 100 000	557	...	2793	19 by 7 by 21	3655	5439	0.0101	0.0331	0.0103	0.0338	0.0105	0.0344	0.0107	0.0351
1 000 000	507	...	2527	19 by 7 by 19	3307	4921	0.0111	0.0364	0.0113	0.0371	0.0115	0.0379	0.0117	0.0387
900 000	456	...	2261	19 by 7 by 17	2959	4403	0.0123	0.0405	0.0125	0.0413	0.0128	0.0421	0.0131	0.0429
800 000	405	...	1995	19 by 7 by 15	2611	3885	0.0139	0.0455	0.0142	0.0464	0.0144	0.0473	0.0147	0.0482
750 000	380	...	1862	19 by 7 by 14	2436	3626	0.0148	0.0485	0.0151	0.0495	0.0154	0.0505	0.0157	0.0515
700 000	355	...	1729	19 by 7 by 13	2262	3367	0.0159	0.0520	0.0162	0.0530	0.0165	0.0541	0.0168	0.0552
650 000	329	...	1596	19 by 7 by 12	2088	3108	0.0171	0.0560	0.0174	0.0571	0.0178	0.0583	0.0182	0.0594
600 000	304	...	1470	7 by 7 by 30	1906	2836	0.0183	0.0601	0.0187	0.0613	0.0191	0.0625	0.0195	0.0638
550 000	279	...	1372	7 by 7 by 28	1779	2647	0.0200	0.0656	0.0204	0.0669	0.0208	0.0682	0.0212	0.0696
500 000	253	...	1225	7 by 7 by 25	1588	2363	0.0220	0.0721	0.0224	0.0735	0.0229	0.0750	0.0234	0.0765
450 000	228	...	1127	7 by 7 by 23	1461	2174	0.0244	0.0802	0.0249	0.0817	0.0254	0.0834	0.0259	0.0850
400 000	203	...	980	7 by 7 by 20	1270	1891	0.0275	0.0902	0.0281	0.0920	0.0286	0.0938	0.0292	0.0957
350 000	177	...	882	7 by 7 by 18	1143	1701	0.0314	0.103	0.0320	0.105	0.0327	0.107	0.0334	0.109
300 000	152	...	735	7 by 7 by 15	953	1418	0.0366	0.120	0.0373	0.122	0.0381	0.125	0.0389	0.128
250 000	127	...	637	7 by 7 by 13	826	1229	0.0440	0.144	0.0449	0.147	0.0457	0.150	0.0466	0.153
211 600	107	0000	532	19 by 28	683	1017	0.0515	0.169	0.0525	0.172	0.0536	0.176	0.0546	0.180
167 800	85	000	418	19 by 22	537	799	0.0649	0.213	0.0662	0.217	0.0675	0.221	0.0689	0.225
133 100	67.4	00	342	19 by 18	439	654	0.0818	0.268	0.0834	0.273	0.0851	0.279	0.0868	0.285
105 600	53.5	0	266	19 by 14	342	508	0.103	0.338	0.105	0.345	0.107	0.352	0.109	0.359
83 690	42.4	1	210	7 by 30	267	397	0.129	0.423	0.132	0.431	0.134	0.440	0.137	0.449
66 360	33.6	2	161	7 by 23	205	305	0.163	0.533	0.166	0.544	0.169	0.555	0.172	0.566
52 620	26.7	3	133	7 by 19	169	252	0.205	0.673	0.209	0.686	0.213	0.699	0.217	0.713
41 740	21.1	4	105	7 by 15	134	199	0.258	0.848	0.263	0.865	0.269	0.882	0.274	0.900
33 090	16.8	5	84	7 by 12	107	159	0.326	1.07	0.333	1.09	0.339	1.11	0.346	1.13
26 240	13.3	6	63	7 by 9	80	119	0.411	1.35	0.419	1.38	0.427	1.40	0.436	1.43

[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 which may be desirable for specific applications. The constructions shown provide for finished, covered or non-covered, stranded conductor approximately of the area indicated. When specified by the purchaser, the number of strands 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.

TABLE 2 Construction Requirements of Class K Rope-Lay Stranded Copper Conductors Having Bunch Stranded Members[A]

Area of Cross Section			Wire Diameter 0.0100 In. (0.254 mm)		Approximate Mass[B]		Uncoated Copper				Coated Copper			
cmil	mm^2	Size AWG	Nominal Number of Wires	Strand Construction A by B by C[C]	Lb/1000 ft	Kg/km	Nominal dc resistance @ 20°C		Maximum dc resistance @ 20°C		Nominal dc resistance @ 20°C		Maximum dc resistance @ 20°C	
1,000,000	507	.....	10101	37 by 7 by 39	3272	4869	0.0111	0.0364	0.0113	0.0371	0.0119	0.0391	0.0121	0.0399
900,000	456	.....	9065	37 by 7 by 35	2936	4369	0.0123	0.0405	0.0125	0.0413	0.0132	0.0434	0.0135	0.0443
800,000	405	.....	7980	19 by 7 by 60	2585	3846	0.0139	0.0455	0.0142	0.0464	0.0149	0.0489	0.0152	0.0499
750,000	380	.....	7581	19 by 7 by 57	2455	3654	0.0148	0.0485	0.0151	0.0495	0.0159	0.0521	0.0162	0.0531
700,000	355	.....	6916	19 by 7 by 52	2240	3333	0.0159	0.0520	0.0162	0.0530	0.0170	0.0558	0.0173	0.0569
650,000	329	.....	6517	19 by 7 by 49	2111	3141	0.0171	0.0560	0.0174	0.0571	0.0183	0.0601	0.0187	0.0613
600,000	304	.....	5985	19 by 7 by 45	1938	2885	0.0185	0.0607	0.0189	0.0619	0.0199	0.0651	0.0203	0.0664
550,000	279	.....	5453	19 by 7 by 41	1766	2628	0.0202	0.0662	0.0206	0.0675	0.0217	0.0711	0.0221	0.0725
500,000	253	.....	5054	19 by 7 by 38	1637	2436	0.0222	0.0728	0.0226	0.0743	0.0238	0.0782	0.0243	0.0798
450,000	228	.....	4522	19 by 7 by 34	1465	2180	0.0247	0.0809	0.0252	0.0825	0.0265	0.0869	0.0270	0.0886
400,000	203	.....	3990	19 by 7 by 30	1292	1923	0.0277	0.0910	0.0283	0.0928	0.0298	0.0977	0.0304	0.0997
350,000	177	.....	3458	19 by 7 by 26	1120	1667	0.0317	0.104	0.0323	0.106	0.0340	0.112	0.0347	0.114
300,000	152	.....	2989	7 by 7 by 61	959	1427	0.0366	0.120	0.0373	0.122	0.0393	0.129	0.0401	0.132
250,000	127	.....	2499	7 by 7 by 51	802	1193	0.0440	0.144	0.0449	0.147	0.0472	0.155	0.0481	0.158
211,600	107	0000	2107	7 by 7 by 43	676	1006	0.0520	0.171	0.0530	0.174	0.0558	0.183	0.0569	0.187
167,800	85	000	1666	7 by 7 by 34	535	795	0.0655	0.215	0.0668	0.219	0.0703	0.231	0.0717	0.236
133,100	67.4	00	1323	7 by 7 by 27	424	632	0.0826	0.271	0.0843	0.276	0.0887	0.291	0.0905	0.297
105,600	53.5	0	1064	19 by 56	338	503	0.103	0.338	0.105	0.345	0.111	0.363	0.113	0.370
83,690	42.4	1	836	19 by 44	266	395	0.130	0.427	0.133	0.435	0.140	0.458	0.142	0.467
66,360	33.6	2	665	19 by 35	211	315	0.164	0.538	0.167	0.549	0.176	0.578	0.180	0.590
52,620	26.7	3	532	19 by 28	169	252	0.207	0.679	0.211	0.693	0.222	0.729	0.227	0.744
41,740	21.1	4	420	7 by 60	132	197	0.258	0.848	0.264	0.865	0.277	0.910	0.283	0.928
33,090	16.8	5	336	7 by 48	106	157	0.326	1.07	0.333	1.09	0.350	1.15	0.357	1.17
26,240	13.3	6	266	7 by 38	84	125	0.411	1.35	0.419	1.38	0.441	1.45	0.450	1.48
20,820	10.5	7	210	7 by 30	66	98	0.518	1.70	0.528	1.73	0.556	1.82	0.567	1.86
16,510	8.37	8	168	7 by 24	53	79	0.653	2.14	0.666	2.19	0.701	2.30	0.715	2.35
13,090	6.63	9	133	7 by 19	42	62	0.824	2.70	0.840	2.76	0.885	2.90	0.902	2.96

[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 which may be desirable for specific applications. The constructions shown provide for finished covered or non-covered stranded conductor approximately of the area indicated. When specified by the purchaser, the number of strands 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 consist of 7 bunch-stranded members with 32 wires each.

TABLE 3 Construction requirements of Class M Rope-Lay Stranded Copper Conductors Having Bunch Stranded Members[A]

Area of Cross Section			Wire Diameter 0.0063 In. (0.160 mm)		Approximate Mass[B]		Uncoated Copper				Coated Copper			
cmil	mm^2	Size AWG	Nominal Number of Wires	Strand Construction A by B by C[C]	Lb/1000 ft	Kg/km	Nominal dc resistance @ 20°C		Maximum dc resistance @ 20°C		Nominal dc resistance @ 20°C		Maximum dc resistance @ 20°C	
							Ohm/kft	Ohm/km	Ohm/kft	Ohm/km	Ohm/kft	Ohm/km	Ohm/kft	Ohm/km
1,000,000	507	. . .	25,193	61 by 7 by 59	3239	4819	0.0111	0.0364	0.0113	0.0371	0.0119	0.0391	0.0121	0.0399
900,000	456	. . .	22,631	61 by 7 by 53	2909	4329	0.0123	0.0404	0.0125	0.0413	0.0132	0.0434	0.0135	0.0443
800,000	405	. . .	20,069	61 by 7 by 47	2580	3839	0.0139	0.0456	0.0142	0.0464	0.0149	0.0489	0.0152	0.0499
750,00	380	. . .	18,788	61 by 7 by 44	2415	3594	0.0148	0.0486	0.0151	0.0495	0.0159	0.0521	0.0162	0.0531
700,000	355	. . .	17,507	61 by 7 by 41	2251	3349	0.0159	0.0522	0.0162	0.0530	0.0170	0.0558	0.0173	0.0569
650,000	329	. . .	16,226	61 by 7 by 38	2086	3104	0.0171	0.0561	0.0174	0.0571	0.0183	0.0601	0.0187	0.0613
600,000	304	. . .	14,945	61 by 7 by 35	1921	2859	0.0185	0.0607	0.0189	0.0619	0.0199	0.0651	0.0203	0.0664
550,000	279	. . .	13,664	61 by 7 by 32	1757	2614	0.0202	0.0663	0.0206	0.0675	0.0217	0.0711	0.0221	0.0725
500,000	253	. . .	12,691	37 by 7 by 49	1631	2428	0.0222	0.0728	0.0226	0.0743	0.0238	0.0782	0.0243	0.0798
450,000	228	. . .	11,396	37 by 7 by 44	1465	2180	0.0247	0.0810	0.0252	0.0825	0.0265	0.0869	0.0270	0.0885
400,000	203	. . .	10,101	37 by 7 by 39	1298	1932	0.0277	0.0909	0.0283	0.0928	0.0298	0.0977	0.0304	0.0997
350,000	177	. . .	8,806	37 by 7 by 34	1132	1685	0.0317	0.104	0.0323	0.106	0.0340	0.112	0.0347	0.114
300,000	152	. . .	7,581	19 by 7 by 57	975	1450	0.0370	0.121	0.0377	0.123	0.0397	0.130	0.0405	0.133
250,000	127	. . .	6,384	19 by 7 by 48	821	1221	0.0444	0.146	0.0453	0.149	0.0476	0.156	0.0486	0.159
211,600	107	0000	5,320	19 by 7 by 40	684	1018	0.0524	0.172	0.0534	0.175	0.0563	0.185	0.0574	0.188
167,800	85	000	4,256	19 by 7 by 32	547	814	0.0661	0.217	0.0674	0.221	0.0710	0.233	0.0724	0.238
133,100	67.4	00	3,325	19 by 7 by 25	427	636	0.0834	0.274	0.0851	0.279	0.0895	0.294	0.0913	0.299
105,600	53.5	0	2,646	7 by 7 by 54	337	501	0.104	0.341	0.106	0.348	0.112	0.367	0.114	0.374
83,690	42.4	1	2,107	7 by 7 by 43	268	399	0.131	0.430	0.134	0.440	0.141	0.463	0.144	0.472
66,360	33.6	2	1.666	7 by 7 by 34	212	316	0.166	0.545	0.169	0.555	0.178	0.583	0.181	0.595
52,620	26.7	3	1.323	7 by 7 by 27	168	251	0.209	0.686	0.213	0.699	0.224	0.736	0.229	0.751
41,740	21.1	4	1,064	19 by 56	134	200	0.261	0.856	0.266	0.873	0.280	0.919	0.286	0.937
33,090	16.8	5	836	19 by 44	105	157	0.329	1.08	0.336	1.10	0.353	1.16	0.360	1.18
26,240	13.3	6	665	19 by 35	84	125	0.415	1.36	0.423	1.39	0.446	1.46	0.454	1.49
20,820	10.5	7	532	19 by 28	67	100	0.523	1.72	0.533	1.75	0.562	1.84	0.573	1.88
16,510	8.37	8	420	7 by 60	52	78	0.653	2.14	0.666	2.18	0.701	2.30	0.715	2.35
13,090	6.63	9	336	7 by 48	42	62	0.824	2.70	0.840	2.75	0.885	2.90	0.902	2.96
10,380	5.26	10	259	7 by 37	32	48	1.04	3.41	1.06	3.48	1.12	3.66	1.14	3.73
6,530	3.31	12	168	7 by 24	21	31	1.65	5.41	1.68	5.53	1.77	5.82	1.81	5.93

[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 which may be desirable for specific applications. The constructions shown provide for finished covered or non-covered stranded conductor approximately of the area indicated. When specified by the purchaser, the number of strands 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 consist of 7 bunch-stranded members with 32 wires each.

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 Tables 1-3.

7.2 The number of individual wires may vary slightly from those shown in Tables 1-3, 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 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 B172 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 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 B172 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).

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 1-3 (Explanatory Note 7). 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.

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.

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	.981
30	.962
35	.944
40	.927
45	.911
50	.895
55	.879
60	.864
65	.850
70	.836
75	.822
80	.809
85	.797
90	.784

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 Tables 1-3 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 B263. 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 B173.

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

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 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

NOTE 7—The DC resistance, on a given construction, shall be calculated using the following formula:

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

where:

R = conductor resistance in ohms/1000 ft.,
k = increment due to stranding 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.