~~Designation:B33–04~~ Designation: B33 – 10

Standard Specification for ~~Tinned~~Tin-Coated Soft or Annealed Copper Wire for Electrical Purposes[1]

This standard is issued under the fixed designation B33; 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

~~1.1This specification covers tinned, round, soft, or annealed copper wire for electrical purposes.~~

~~1.2The SI values for density and resistivity are to be regarded as standard. For all other properties the inch-pound values are to be regarded as the standard and the SI units may be approximate.~~

1.1 This specification covers tin-coated, round, soft, or annealed copper wire for electrical purposes.

1.2 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.2.1 *Exceptions*—The SI values for density, resistivity, and volume are to be regarded as standard.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

B49 Specification for Copper Rod Drawing Stock for Electrical Purposes ~~B193~~

B193 Test Method for Resistivity of Electrical Conductor Materials

B258 Specification for Nominal Diameters and Cross-Sectional Areas of AWG Sizes of Solid Round Wires Used as Electrical Conductors

2.2 *Other Document:*[3]

NBS Handbook 100 Copper Wire Tables

3. Ordering Information

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

3.1.1 Quantity of each size,

3.1.2 Wire size-diameter in inches (see 5.3 and Table 1),

3.1.3 Type of copper, if special (see 4.2),

3.1.4 Package size (see 10.1),

3.1.5 Special packaging marking, if required, and

3.1.6 Place of inspection (see 7.1).

4. Material

4.1 *Tin for Coating*—The tin used for coating shall be commercially pure (Explanatory Note 1). For purposes of this specification, the tin shall be considered commercially pure if the total of other elements, exclusive of copper, does not exceed 1%. Notwithstanding the previous sentence, chemical analysis of the tin coating or of the tin used for coating shall not be required under this specification. Adequacy of the tin coating is assured by the continuity of coating and adherence of coating requirements (see 5.4 and 5.5, respectively).

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[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 National Technical Information Service (NTIS), U.S. Department of Commerce, 5285 Port Royal Rd., Springfield, VA 22161.

TABLE 1 Tensile Requirements

Diameter		Area at 20°C			Elongation in 10 in. (250 mm), % min
in.	mm	cmil	$in.^2$	mm^2	
0.4600	11.6840	211600.00	0.166190	107.2193	30
0.4600	11.684	211600	0.1662	107.0	30
0.4096	10.4038	167772.16	0.131768	85.0114	30
0.4096	10.404	167800	0.1318	85.0	30
0.3648	9.2659	133079.04	0.104520	67.4321	30
0.3648	9.266	133100	0.1045	67.4	30
0.3249	8.2525	105560.01	0.082907	53.4880	30
0.3249	8.252	105600	0.08291	53.5	30
0.2893	7.3482	83694.49	0.065733	42.4086	25
0.2893	7.348	83690	0.06573	42.4	25
0.2576	6.5430	66357.76	0.052117	33.6240	25
0.2576	6.543	66360	0.05212	33.6	25
0.2294	5.8268	52624.36	0.041331	26.6652	25
0.2294	5.827	52620	0.04133	26.7	25
0.2043	5.1892	41738.49	0.032781	21.1492	25
0.2043	5.189	41740	0.03278	21.2	25
0.1819	4.6203	33087.61	0.025987	16.7657	25
0.1819	4.620	33090	0.02599	16.8	25
0.1620	4.1148	26244.00	0.020612	13.2980	25
0.1620	4.115	26240	0.02061	13.3	25
0.1443	3.6652	20822.49	0.016354	10.5509	25
0.1443	3.665	20820	0.01635	10.6	25
0.1285	3.2639	16512.25	0.012969	8.3669	25
0.1285	3.264	16510	0.01297	8.37	25
0.1144	2.9058	13087.36	0.01027879	6.6315	25
0.1144	2.906	13090	0.01028	6.63	25
0.1019	2.5883	10383.61	0.00815527	5.2615	20
0.1019	2.588	10380	0.008155	5.26	20
0.0907	2.3038	8226.49	0.00646107	4.1684	20
0.0907	2.304	8230	0.00646	4.17	20
0.0808	2.0523	6528.64	0.00512758	3.3081	20
0.0808	2.052	6530	0.00513	3.31	20
0.0720	1.8288	5184.00	0.00407150	2.6268	20
0.0720	1.829	5180	0.00407	2.63	20
0.0641	1.6281	4108.81	0.00322705	2.0820	20
0.0641	1.628	4110	0.00323	2.08	20
0.0571	1.4503	3260.41	0.00256072	1.6521	20
0.0571	1.450	3260	0.00256	1.65	20
0.0508	1.2903	2580.64	0.00202683	1.3076	20
0.0508	1.290	2580	0.00203	1.31	20
0.0453	1.1506	2052.09	0.00161171	1.0398	20
0.0453	1.151	2050	0.00161	1.04	20
0.0403	1.0236	1624.09	0.00127556	0.8229	20
0.0403	1.024	1620	0.00128	0.823	20
0.0359	0.9119	1288.81	0.00101223	0.6530	20
0.0359	0.912	1290	0.00101	0.653	20
0.0320	0.8128	1024.00	0.00080425	0.5189	20
0.0320	0.813	1020	0.000804	0.519	20
0.0285	0.7239	812.25	0.00063794	0.4116	20
0.0285	0.724	812	0.000638	0.412	20
0.0253	0.6426	640.09	0.00050273	0.3243	20
0.0253	0.643	640	0.000503	0.324	20
0.0226	0.5740	510.76	0.00040115	0.2588	20
0.0226	0.574	511	0.000401	0.259	20
0.0201	0.5105	404.01	0.00031731	0.2047	15
0.0201	0.511	404	0.000317	0.205	15
0.0179	0.4547	320.41	0.00025165	0.1624	15
0.0179	0.455	320	0.000252	0.162	15
0.0159	0.4039	252.81	0.00019856	0.1281	15
0.0159	0.404	253	0.000199	0.128	15
0.0142	0.3607	201.64	0.00015837	0.1022	15
0.0142	0.361	202	0.000158	0.102	15
0.0126	0.3200	158.76	0.00012469	0.0804	15
0.0126	0.320	159	0.000125	0.080	15
0.0113	0.2870	127.69	0.00010029	0.0647	15
0.0113	0.287	128	0.000100	0.065	15
0.0100	0.2540	100.00	0.00007854	0.0507	10
0.0100	0.254	100	0.0000785	0.051	10
0.0089	0.2261	79.21	0.00006221	0.0401	10
0.0089	0.226	79.2	0.0000622	0.040	10

4.2 *Copper-Base Metal*—The base metal shall be copper of such quality and purity that the finished product shall have properties and characteristics prescribed in this specification.

NOTE 1—Specification B49 defines copper suitable for use.

4.3 Copper bars of special qualities, forms, or types, as may be agreed upon between the manufacturer and the purchaser, and which will conform to the requirements prescribed in this specification, may also be used.

5. General Requirements (See Section 8) }

5.1 *Tensile Strength and Elongation (Explanatory* Note 2 *and* Note 3*)*—The tinned wire shall conform to the requirements for elongation prescribed in Table 1. No requirements for tensile strength are specified. For wire whose nominal diameter is more than 0.001 in. ~~(1 mil)~~ (0.025 mm) greater than a size listed in Table 1, but less than that of the next larger size, the requirements of the next larger size shall apply.

5.2 *Resistivity (Explanatory* Note 1 *and* Note 4*)*—The electrical resistivity of tinned wire at a temperature of 20°C shall not exceed the values prescribed in Table 2.

5.3 *Dimensions and Permissible Variations (Explanatory* Note 2*)*—The wire sizes shall be expressed as the diameter of the wire in decimal fractions of an inch to the nearest 0.0001 in. ~~(0.1 mil) or in millimetres to the nearest 0.0025 mm.~~ (0.0025 mm). The ~~tinned~~tin-coated wire shall not vary from the specified diameter by more than the amounts prescribed in Table 3.

5.4 *Continuity of Coating*—The tin coating shall be continuous. The continuity of coating on the wire shall be determined on representative samples taken before stranding or insulating. The continuity of tinning shall be determined by the hydrochloric acid-sodium polysulfide test in accordance with ~~6.4~~6.3.

5.5 *Adherence of Coating*—The tin coating shall be firmly adherent to the surface of the copper. The adherence of coating on the wire shall be determined on representative samples taken before stranding or insulating. The adherence of coating shall be determined by the wrapping and immersion test in accordance with ~~6.5.~~ 6.4 for 0.0320 in. (0.813 mm) and larger sizes.

5.6 *Joints*—Necessary joints in the completed wire and in the wire and rods prior to final drawing shall be made in accordance with the best commercial practice.

5.7 *Finish*—The coating shall consist of a smooth continuous layer, firmly adherent to the surface of the copper. The wire shall be free of all imperfections not consistent with the best commercial practice.

6. Test Methods

6.1 *Tensile Strength and Elongation (Explanatory* Note 5*)*—~~No~~ :

6.1.1 No test for tensile strength shall be required.

6.1.2 The elongation of wire ~~whose~~ with a nominal diameter ~~is larger~~ greater than 0.0808 in. (2.052 mm) ~~in diameter~~ shall be determined as the permanent increase in ~~length, expressed in percent of the original length,~~ length due to the breaking of the wire in ~~tension,~~ tension. The elongation shall be measured between gage marks placed originally 10 in. (254 mm) apart upon the test specimen and expressed in percent of the original length.

6.1.3 The elongation of wire ~~whose~~ with a nominal diameter ~~is~~ equal to or less than 0.0808 in. ~~and under~~(2.053 mm) may be determined as described above or by measurements made between the jaws of the testing machine. When ~~the latter method is used,~~ measurements are made between the jaws, the zero length shall be the distance between the jaws at the start of the tension test and be as near 10 in. ~~as practicable and the~~ (254 mm) as practicable. The final length shall be the distance between the jaws at the time of rupture. The fracture shall be between gage marks ~~in the case of specimens so marked~~ or ~~between the~~ jaws of the testing machine, depending on method used, and not closer than 1 in. (25.4 mm) to either gage mark or ~~either~~ jaw.

6.2 ~~*Resistivity (Expanatory* Note 4*)*—The electrical resistivity of the material shall be determined in accordance with Test Method B193. The purchaser may accept certification that the wire was drawn from rod stock meeting the international standard for annealed copper instead of resistivity tests on the finished wire.~~

~~6.3~~*Dimensional Measurements*—Dimensional measurements shall be made with a micromet~~r~~er caliper equipped with a vernier graduated in 0.0001 in. (0.0025 mm). Measurements shall be made on at least three places on each unit selected for this test. If accessible, one measurement shall be taken on each end and one near the middle. The average of the three measurements shall determine compliance with the requirements.

~~6.4~~6.3 *Continuity of Coating*:

TABLE 2 Electrical Resistivity Requirements

Nominal Diameter		Resistivity at 20°C	
in.	mm	Ω·lb/mile^2	Ω·g/m^2
0.460 to 0.290, incl	11.7 to 7.4, incl	896.15	0.15695
Under 0.290 to 0.103, incl	Under 7.4 to 2.6, incl	900.77	0.15776
Under 0.103 to 0.0201, incl	Under 2.6 to 0.51, incl	910.15	0.15940
Under 0.0201 to 0.0111 incl	Under 0.51 to 0.28, incl	929.52	0.16279
Under 0.0111 to 0.0030, incl	Under 0.28 to 0.076, incl	939.51	0.16454

TABLE 3 Permissible Variations in Diamter

Nominal Diameter of Wire		Permissible Variations in Diameter			
		in.		mm	
in.	mm	plus	minus	plus	minus
Under 0.0100	Under 0.25	0.0003	0.00010	0.0076	0.0025
0.0100 and over	0.25 and over	3 %	1 %	3 %	1 %

~~6.4.1~~

6.3.1 *Specimens*:

~~6.4.1.1~~

6.3.1.1 *Length of Specimens*—Test specimens shall have a length of about 6 in. (152 mm). They shall be tagged or marked to correspond with the coil, spool, or reel from which they were cut.

~~6.4.1.2~~

6.3.1.2 *Treatment of Specimens*—The specimens shall be thoroughly cleaned by immersion in a suitable organic solvent ~~such as benzene, ether, or trichloroethylene~~ for at least 3 min; then removed and wiped dry with a clean, soft cloth (**Caution-**see Explanatory Note 6). The specimens thus cleaned shall be kept wrapped in a clean, dry cloth until tested. That part of the specimen to be immersed in the test solution shall not be handled. Care shall be taken to avoid abrasion by the cut ends.

~~6.4.2~~

6.3.2 *Special Solutions Required*:

~~6.4.2.1~~

6.3.2.1 *Hydrochloric Acid Solution (HCl) (sp gr 1.088)*—Commercial HCl (sp gr 1.12) shall be diluted with distilled water to a specific gravity of 1.088 measured at 15.6°C (60°F). A portion of HCl solution having a volume of 180 mL shall be considered to be exhausted when the number of test specimens prescribed in Table 4 of a size as indicated in ~~6.4.3~~ 6.3.3 have been immersed in it for two cycles.

~~6.4.2.2~~

6.3.2.2 *Sodium Polysulfide Solution (sp gr 1.142) (Explanatory* Note 7)—A concentrated solution shall be made by dissolving sodium sulfide cp crystals in distilled water until the solution is saturated at about 21°C (70°F), and adding sufficient flowers of sulfur (in excess of 250 g/L of solution) to provide complete saturation, as shown by the presence in the solution of an excess of sulfur after the solution has been allowed to stand for at least 24 h. The test solution shall be made by diluting a portion of the concentrated solution with distilled water to a specific gravity of ~~1.142~~ 1.135 to 1.145 at 15.6°C (60°F). The sodium polysulfide test solution should have sufficient strength to blacken thoroughly a piece of clean untinned copper wire in 5 s. ~~A portion of the~~ The test solution used for testing samples shall ~~not~~ be considered ~~to be~~ exhausted ~~until~~if it fails to blacken a piece of clean copper as described above.

~~6.4.3~~6.3.3 *Procedure*:

~~6.4.3.1~~

6.3.3.1 *Immersion of Specimens*—Immerse a length of at least 4-½ in. (114 mm) from each of the clean specimens, in accordance with the following cycles, in test solutions maintained at a temperature between 15.6 and 21°C (60 and 70°F): (*1*) Immerse the specimen for 1 min in the HCl solution described in ~~6.4.2~~6.3.2, wash, and wipe dry; (*2*) immerse the specimen for 30 s in the sodium polysulfide solution described in ~~6.4.2~~6.3.2, wash, and wipe dry; (*3*) immerse the specimen for 1 min in the HCl solution, wash, and dry; (*4*) immerse the specimen for 30 s in the sodium polysulfide solution, wash, and wipe dry.

~~6.4.3.2~~

6.3.3.2 *Washing Specimens*—After each immersion, immediately wash the specimens thoroughly in clean water and wipe dry with a clean, soft cloth.

~~6.4.3.3~~

6.3.3.3 *Examination of Specimens*—After immersion and washing, examine the specimens to ascertain if copper exposed through openings in the tin coating has been blackened by action of the sodium polysulfide. The specimens shall be considered to have failed if, by such blackening, exposed copper is revealed. No attention shall be paid to blackening within 0.5 in. (12.7 mm) of the cut end. A grayish brown appearance of the coating shall not constitute failure.

TABLE 4 Limiting Number of Test Specimens for Coating Tests

Nominal Diameter, in.	Maximum Number of Specimens to be Tested for 2 Cycles in 180 mL of Acid Solution
0.460 to 0.141, incl	2
Under 0.141 to 0.0851, incl	4
Under 0.0851 to 0.0501, incl	6
Under 0.0501 to 0.0381, incl	10
Under 0.0381 to 0.0301, incl	12
Under 0.0301 to 0.0030, incl	14