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Standard Specification for High Performance Tin-Coated Annealed Copper Wire Intended for Electrical and Electronic Application for Solderability[1]

This standard is issued under the fixed designation B965; 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.

1. Scope

1.1 This specification covers tin-coated annealed copper wire intended for electrical and electronic applications where solderability is a requirement.

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 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 Standards:*

IPC/ECA J-STD-002 Solderability Test for Component Leads, Lugs, Terminals and Wires[3]

NBS Handbook 100 Copper Wire Tables[4]

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 shall be electroplated for the coating and 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 %. Not withstanding the previous sentence, chemical analysis of the tin coating or of the tin used for coating shall not be required under this specification.

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.

5. General Requirements (See Section 8)

5.1 *Tensile Strength and Elongation (Explanatory Note 4)*—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. (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 3)*—The electrical resistivity of tinned wire at a temperature of 20°C shall not exceed the values prescribed in Table 2.

[1] This test method 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 IPC, 3000 Lakeside Drive, Suite 309S, Bannockburn, IL 60015, http://www.ipc.org, and ECA 2500 Wilson Blvd., Arlington, VA 22201, http://www.ec-central.org.

[4] Available from National Technical Information Service (NTIS), 5285 Port Royal Rd., Springfield, VA 22161, http://www.ntis.gov.

TABLE 1 Tensile Requirements

Diameter		Area at 20°C			Elongation
in.	mm	cmil	in.^{2}	mm^2	in 10 in. (250 mm), % min
0.4600	11.684	211 600	0.1662	107.0	30
0.4096	10.404	167 800	0.1318	85.0	30
0.3648	9.266	133 100	0.1045	67.4	30
0.3249	8.252	105 600	0.08291	53.5	30
0.2893	7.348	83 690	0.06573	42.4	25
0.2576	6.543	66 360	0.05212	33.6	25
0.2294	5.827	52 620	0.04133	26.7	25
0.2043	5.189	41 740	0.03278	21.2	25
0.1819	4.620	33 090	0.02599	16.8	25
0.1620	4.115	26 240	0.02061	13.3	25
0.1443	3.665	20 820	0.01635	10.5	25
0.1285	3.264	16 510	0.01297	8.37	25
0.1144	2.906	13 090	0.01028	6.63	25
0.1019	2.588	10 380	0.008155	5.26	20
0.0907	2.304	8 230	0.00646	4.17	20
0.0808	2.052	6 530	0.00513	3.31	20
0.0720	1.829	5 180	0.00407	2.63	20
0.0641	1.628	4 110	0.00323	2.08	20
0.0571	1.450	3 260	0.00256	1.65	20
0.0508	1.290	2 580	0.00203	1.31	20
0.0453	1.151	2 050	0.00161	1.04	20
0.0403	1.024	1 620	0.00128	0.823	20
0.0359	0.912	1 290	0.00101	0.654	20
0.0320	0.813	1 020	0.000804	0.517	20
0.0285	0.724	812	0.000638	0.411	20
0.0253	0.643	640	0.000503	0.324	20
0.0226	0.574	511	0.000401	0.259	20
0.0201	0.511	404	0.000317	0.205	15
0.0179	0.455	320	0.000252	0.162	15
0.0159	0.404	253	0.000199	0.128	15
0.0142	0.361	202	0.000158	0.102	15
0.0126	0.320	159	0.000125	0.081	15
0.0113	0.287	128	0.000100	0.065	15
0.0100	0.254	100	0.0000785	0.051	10
0.0089	0.226	79.2	0.0000622	0.040	10
0.0080	0.203	64.0	0.0000503	0.032	10
0.0071	0.180	50.4	0.0000396	0.026	10
0.0063	0.160	39.7	0.0000312	0.020	10
0.0056	0.142	31.4	0.0000246	0.016	10
0.0050	0.127	25.0	0.0000196	0.013	10
0.0045	0.114	20.2	0.0000159	0.010	10
0.0040	0.102	16.0	0.0000126	0.0081	10
0.0035	0.089	12.2	0.00000962	0.0062	10
0.0031	0.079	9.61	0.00000755	0.0049	10

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. (0.0025 mm). The 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.

5.5 *Thickness of Coating*—The wire shall have adequate free tin (Explanatory Note 1) to insure meeting solderability requirements as prescribed in 5.8. The thickness of coating shall be at the manufacturer's discretion or as agreed upon between the manufacturer and purchaser to insure compliance to 5.8 and further processing for solderability performance after insulation.

5.6 *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 after electroplating and prior to final drawing. The adherence of coating shall be determined by the wrapping test in accordance with 6.6.

5.7 *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.

5.8 *Solderability*—The solder must cover greater than 95 % of the surface of the specimen and show evidence of good wetting and of bonding. The solderability shall be tested in accordance with 6.7.

5.9 *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 4):*

6.1.1 No test for tensile strength shall be required.

6.1.2 The elongation of wire with a nominal diameter greater than 0.0808 in. (2.052 mm) shall be determined as the permanent increase in length due to the breaking of the wire in tension. The elongation shall be measured between gage marks placed originally 10 in. (242 mm) apart upon the test specimen and expressed in percent of the original length.

6.1.3 The elongation of wire with a nominal diameter equal to or less than 0.0808 in. (2.053 mm) may be determined as described above or by measurements made between the jaws of the testing machine. When 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. (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 or jaws of the testing machine, depending on method used, and not closer than 1 in. (25.4 mm) to either gage mark or jaw.

6.2 *Resistivity (Explanatory Note 3)*—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 micrometer 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

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 Diameter

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 %

end and one near the middle. The average of the three measurements shall determine compliance with the requirements.

6.4 *Continuity of Coating:*

6.4.1 *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.

6.4.2 *Treatment of Specimens*—The specimens shall be thoroughly cleaned by immersion in a suitable organic solvent for at least 3 min; then removed and wiped dry with a clean, soft cloth (**Caution**—see Explanatory Note 5). 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.

6.4.3 *Special Solutions Required:*

6.4.3.1 *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 have been immersed in it for two cycles.

6.4.3.2 *Sodium Polysulfide Solution (sp gr 1.142) (Explanatory Note 6)*—A concentrated solution shall be made by dissolving sodium sulfide crystals (cp) 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 1.135 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. The test solution used for testing samples shall be considered exhausted if it fails to blacken a piece of clean copper as described above.

6.4.4 *Procedure:*

6.4.4.1 *Immersion of Specimens*—Immerse a length of at least 4-1/2 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, wash, and wipe dry; (2) immerse the specimen for 30 s in the sodium polysulfide solution described in 6.4.2, 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.

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

6.4.4.3 *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		Maximum Number of Specimens to be Tested for 2 Cycles in 180 mL of Acid Solution
in.	mm	
0.460 to 0.141, incl	11.7 to 3.6, incl	2
Under 0.141 to 0.0851, incl	Under 3.6 to 2.2, incl	4
Under 0.0851 to 0.0501, incl	Under 2.2 to 1.3, incl	6
Under 0.0501 to 0.0381, incl	Under 1.3 to 0.97, incl	10
Under 0.0381 to 0.0301, incl	Under 0.97 to 0.76, incl	12
Under 0.0301 to 0.0030, incl	Under 0.76 to 0.076, incl	14