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Standard Specification for Tin-Coated, Copper-Clad Steel Wire for Electronic Application[1]

This standard is issued under the fixed designation B520; 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 tin-coated copper-clad steel wire for electronic application.

1.2 Four classes of tin-coated copper-clad steel wire are covered as follows:
1.2.1 *Class T30HS*—Nominal 30 % conductivity, hard-drawn,
1.2.2 *Class T30A*—Nominal 30 % conductivity, annealed,
1.2.3 *Class T40HS*—Nominal 40 % conductivity, hard-drawn, and
1.2.4 *Class T40A*—Nominal 40 % conductivity, annealed.

1.3 The values stated in inch-pound units are to be regarded as ~~the standard. The metric equivalents of inch-pound units may be approximate. The values given in parentheses are for information only.~~standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.3.1 *Exception*—The SI values for resistivity and volume are to be regarded as standard.

1.4 The following safety hazards caveat pertains only to the test method portion, Section 6, of this specification:*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.*(**Warning—**Consideration should be given to toxicity and flammability when selecting solvent cleaners.)

2. Referenced Documents

2.1 The following documents of the issue in effect on date of material purchase form a part of this specification to the extent referenced herein:

2.2 *ASTM Standards:*[2]
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
B452 Specification for Copper-Clad Steel Wire for Electronic Application
2.3 *National Institute of Standards and Technology:*[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 (see 5.3 and Table 1),
3.1.3 Class of wire (see 1.2),
3.1.4 Package size and shipping (see 7.1.7 and Section 9), packaging inspection if required (see 9.3.3),

[1] This specification is under the jurisdiction of ASTM Committee B01 on Electrical Conductors and is the direct responsibility of Subcommittee B01.06 on Composite Conductors.

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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 Institute of Standards and Technology (NIST), 100 Bureau Dr., Stop 1070, Gaithersburg, MD 20899-1070, http://www.nist.gov.

TABLE 1 Wire Sizes

Diameter		Cross-Sectional Area at 20°C (68°F)		
in.	mm	cmil	in.^{2}	mm^2
0.0720	1.8129	5180	0.00407	2.63
0.0641	1.6128	4110	0.00323	2.08
0.0571	1.450	3260	0.00256	1.65
0.0508	1.290	2580	0.00203	1.31
0.0453	1.151	2050	0.00161	1.04
0.0403	1.024	1620	0.00128	0.823
0.0359	0.912	1290	0.00101	0.653
0.0320	0.813	1020	0.000804	0.519
0.0285	0.724	812	0.000638	0.412
0.0253	0.643	640	0.000503	0.324
0.0226	0.574	511	0.000401	0.259
0.0201	0.511	404	0.000317	0.205
0.0179	0.455	320	0.000252	0.162
0.0159	0.404	253	0.000199	0.128
0.0142	0.361	202	0.000158	0.102
0.0126	0.320	159	0.000125	0.0804
0.0113	0.287	128	0.000100	0.0647
0.0100	0.254	100	0.0000785	0.0507
0.0089	0.226	79.2	0.0000622	0.0401
0.0080	0.203	64.0	0.0000503	0.0324
0.0071	0.180	50.4	0.0000396	0.0255
0.0063	0.160	39.7	0.0000312	0.0201
0.0056	0.142	31.4	0.0000246	0.0159
0.0050	0.127	25.0	0.0000196	0.0127
0.0045	0.114	20.2	0.0000159	0.0103
0.0040	0.102	16.0	0.0000126	0.00811
0.0035	0.089	12.2	0.00000962	0.00621
0.0031	0.079	9.61	0.00000755	0.00487

3.1.5 Special package marking, if required, and

3.1.6 Place of inspection (see 9.1).

4. Material

4.1 The basis material shall consist of copper-clad steel wire conforming to the product description, quality and specification requirements of Specification B452.

4.2 The tin-coated wire shall consist of the basis wire coated with tin. The tin used for coating shall be commercially pure (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). The quality of the tin-coated wire shall be such that the finished product meets the properties and requirements in this specification.

NOTE 1—It is necessary that the coating of the tin on the wire be continuous. The test in the sodium polysulfide is for the purpose of determining whether or not the wire carries a continuous envelope of pure tin. The thickness of the tin coating is necessarily varied. Under the same conditions of tinning, the coating on all sizes of wire, excepting on fine wire, is approximately the same. The coating on fine wire is in general relatively heavier than that on coarse wire. It is not, therefore, correct to apply a larger number of cycles in the test on coarse wire than is applied to fine wire. It is probable that one cycle of the dip test would be sufficient to discover defects in tinned wire, but in order to make certain that no partially covered spots may escape attention, provision has been made for two cycles. It has been found that the tin coating on copper wire consists of two parts, an envelope of pure tin on the outside, with an intermediate layer of copper-tin alloy. This tin alloy, as well as the amount of tin present, has an effect on the resistivity of the wire. Since the relative amount of tin coating and alloy is greater on the small wire than it is on the coarser wire, the resistivity of the wire increases as the size decreases. This also accounts for the decrease in elongation due to tinning soft wire.

5. General Requirements

5.1 Tensile strength and elongation of the tin-coated wire shall conform to the requirements of Specification B452 for the applicable size and class of copper-clad steel wire.

5.2 *Resistivity*—The electrical resistivity at a temperature of 20°C shall not exceed the values prescribed in Table 2. See Note 2 for calculating electrical resistance.

NOTE 2—Relationships that may be useful in connection with the values of electrical resistivity prescribed in this specification are shown in Table 3. Resistivity units $1/58 \cdot \Omega \cdot mm^2/m$ and $0.15328 \cdot \Omega \cdot g/m^2$ at 20°C are respectively the international equivalent of volume and weight resistivity of annealed

TABLE 2 Resistivity, max at 20°C

Class of Wire	Nominal Diameter, in. (mm)	Ω·mm²/m
T30HS	0.0720 (1.829) to 0.0201 (0.511) incl	0.06743 (0.067427)
and	under 0.0201 (0.511) to 0.0113 (0.287) incl	0.07315 (0.073148)
T30A	under 0.0113 (0.287) to 0.0031 (0.079) incl	0.07642 (0.076423)
T40HS	0.0720 (1.829) to 0.0201 (0.511) incl	0.04874 (0.048742)
and	under 0.0201 (0.511) to 0.0113 (0.287) incl	0.05162 (0.051618)
T40A	under 0.0113 (0.287) to 0.0031 (0.079) incl	0.05328 (0.053280)

copper equal to 100 % conductivity. The latter term means that a copper wire 1 m in length and weighing 1 g would have a resistance of 0.15328 . This is equivalent to a resistivity value of 875.20 ·lb/mile^2, which signifies the resistance of a copper wire 1 mile in length weighing 1 lb. It is also equivalent, for example, to 1.7241 µ/cm of length of a copper bar 1 cm^2 in cross section. A complete discussion of this subject is contained in *NBS Handbook 100*. The use of five significant figures in expressing resistivity does not imply the need for greater accuracy of measurement than that specified in Test Method B193. The use of five significant figures is required for complete reversible conversion from one set of resistivity units to another.

5.3 *Dimensions and Permissible Variations*—The wire sizes shall be expressed as the diameter of the wire in decimal fractions of an inch to the nearest 0.0001 in. (0.003 mm) (Note 3). For diameters under 0.0100 in. (0.254 mm), the wire shall not vary from the specified diameter by more than plus 0.0003 in. (0.008 mm) and minus 0.0001 in. (0.003 mm) and for diameters of 0.0100 in. (0.254 mm) and over, the wire shall not vary from the specified diameter by more than plus 3 % and minus 1 %, expressed to the nearest 0.0001 in. (0.003 mm).

NOTE 3—The values of the wire diameters in Table 1 are given to the nearest 0.0001 in. (0.003 mm) and correspond to the standard sizes given in Specification B258. The use of gage numbers to specify wire sizes is not recognized in this specification because of the possibility of confusion. An excellent discussion of wire gages and related subjects is contained in "Copper Wire Tables" *NBS Handbook 100*.

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 6.2.

5.5 *Adherence of Coating*—The tin coating shall be firmly adherent to the surface of the copper-clad steel wire. 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 6.3.

5.6 *Joints*—Necessary joints in the wire and rods prior to final coating and drawing shall be made in accordance with good commercial practice. Joints made after coating shall not be allowed to remain in the final product.

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

6. Test Methods

6.1 For tensile strength, elongation, resistivity, dimensional measurement and the quality of the basis wire, the latest issue of Specification B452 shall apply and the tests shall be performed on the tin-coated wire.

6.2 *Continuity of Coating:*

6.2.1 *Specimens:*

6.2.1.1 *Length of Specimens*—Test specimens shall each have a length of about 6 in. (150 mm). They shall be tagged or marked to correspond with the coil, spool, or reel from which they were cut.

6.2.1.2 *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. (**Warning—**See 1.4.) 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.

6.2.2 *Special Solutions:*

6.2.2.1 *Hydrochloric Acid Solution (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 6.2.3 have been immersed in it for two cycles.

6.2.2.2 *Sodium Polysulfide Solution (sp gr 1.142) (Note 4)*—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