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Standard Specification for Nickel-Coated Braid and Ribbon Flat Copper Wire Intended for use in Electronic Application[1]

This standard is issued under the fixed designation B972; 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 nickel-coated copper braid and ribbon flat wire intended for electronic application (Explanatory Note 1).

1.2 Two classes of nickel-coated braid and ribbon flat copper wire are covered as follows:

1.2.1 *Class A*—Annealed temper.

1.2.2 *Class H*—Hard-drawn.

1.3 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.

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

1.4 *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]

B1 Specification for Hard-Drawn Copper Wire

B3 Specification for Soft or Annealed Copper Wire

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:*[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-thickness and width in inches (see 5.4),

3.1.3 Class of wire (see 1.2),

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

3.1.5 Package size (see 10.1),

3.1.6 Special packaging marking, if required, and

3.1.7 Place of inspection (see 7.1).

4. Material

4.1 The material shall be nickel-coated flat wire (Explanatory Note 1) of such quality and purity that the finished product shall meet the properties and characteristics prescribed in 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—Specifications B1, B3, or B49 defines copper suitable for use.

5. General Requirements (See Section 8)

5.1 *Temper*—The nickel-coated flat wire conductor shall be provided in either hard-drawn condition (Class H) or annealed condition (class A) as agreed upon between the manufacturer and purchaser.

5.2 *Tensile and Elongation (Explanatory Note 2):*

5.2.1 *Class A*—The nickel-coated copper flat wire in the annealed condition shall conform to the elongation requirements prescribed in Table 1. See Explanatory Note 3 for equivalent round diameter calculations based on given thickness and width dimensions for the flat wire. For flat wire whose nominal equivalent round 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. No requirements for tensile strength are specified.

[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), 5285 Port Royal Rd., Springfield, VA 22161, http://www.ntis.gov.

TABLE 1 Tensile Properties[A]

Equivalent Round Diameter, in.	Area at 20°C		Elongation in 10 in., min, %
	cmils	in.^{2}	
0.0641	4 110	0.00323	25
0.0571	3 260	0.00256	25
0.0508	2 580	0.00203	25
0.0453	2 050	0.00161	25
0.0403	1 620	0.00128	25
0.0359	1 290	0.00101	25
0.0320	1 020	0.000804	25
0.0285	812	0.000638	25
0.0253	640	0.000503	25
0.0226	511	0.000401	25
0.0201	404	0.00317	20
0.0179	320	0.000252	20
0.0159	253	0.000199	20
0.0142	202	0.000158	20
0.0126	159	0.000125	20
0.0113	128	0.000100	20
0.0100	100	0.0000785	20
0.0089	79.2	0.0000622	15
0.0080	64.0	0.0000503	15
0.0071	50.4	0.0000396	15
0.0063	39.7	0.0000312	15
0.0056	31.4	0.0000246	15
0.0050	25.0	0.0000196	15
0.0045	20.2	0.0000159	15
0.0040	16.0	0.0000126	15

[A] See Explanatory Note 3 for equivalent round calculation.

5.2.2 *Class H*—The nickel-coated copper flat wire in the hard drawn condition shall conform to elongation requirements of 1 % minimum to 5 % maximum. The tensile strength shall be 55 000 psi (379 MPa) minimum.

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

5.4 *Dimensions and Permissible Variations*—The flat wire sizes shall be expressed as the thickness and width of the wire in decimal fractions of an inch to the nearest 0.0001 in. (0.0025 mm). The nickel-coated flat wire shall not vary from the specified thickness and width by more than the amounts specified in Table 3 and Table 4, respectively.

5.5 *Continuity of Coating*—The nickel coating shall be continuous. The continuity of coating on the flat wire shall be determined on representative samples taken before braiding applications or insulating. The continuity of coating shall be determined by the hydrochloric acid-sodium polysulfide test in accordance with 6.4. Wire whose coating weight corresponds to a thickness less than 50 µin. (0.00005 in.) (0.0013 mm) shall not be subject to this test (Explanatory Note 5). The thickness of coating shall be determined in accordance with Test Method A as prescribed in Appendix X1.

5.6 *Joints*—Necessary joints in the wire and rods prior to final coating and drawing shall be made in accordance with the best commercial practice. There shall be no uncoated joints 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 free of all imperfections not consistent with the best commercial practice.

TABLE 2 Electrical Resistivity Requirements

	Thickness Range, Inch (mm)	Resistivity at 20°C Ω·lb/mile^2
Class A	0.0008 to 0.0010 (0.020 to 0.025), incl	1029.7
	0.0011 to 0.0013 (0.028 to 0.033), incl	994.55
	0.0014 to 0.0018 (0.037 to 0.046), incl	972.45
	0.0019 to 0.0028 (0.048 to 0.071), incl	951.31
	0.0029 to 0.0039 (0.074 to 0.099), incl	931.07
	0.0040 to 0.0065 (0.102 to 0.165), incl	921.27
	0.0065 to 0.0100 (0.165 to 0.254), incl	911.67
Class H	Thickness Range, Inch (mm)	Resistivity at 20°C Ω·lb/mile^2
	0.0008 to 0.0010 (0.020 to 0.025), incl	1067.3
	0.0011 to 0.0013 (0.028 to 0.033), incl	1029.7
	0.0014 to 0.0018 (0.037 to 0.046), incl	1006.0
	0.0019 to 0.0028 (0.048 to 0.071), incl	983.38
	0.0029 to 0.0039 (0.074 to 0.099), incl	961.76
	0.0040 to 0.0065 (0.102 to 0.165), incl	951.31
	0.0065 to 0.0100 (0.165 to 0.254), incl	941.08

TABLE 3 Permissible Variations in Thickness

Nominal Thickness Range, Inch (mm)	Tolerance, Inch (mm)
0.0010 to 0.0014 (0.025 to 0.036)	+/- 0.0002 (0.005)
0.0015 to 0.0019 (0.038 to 0.048)	+/- 0.0003 (0.008)
0.0020 to 0.0049 (0.051 to 0.124)	+/- 0.0004 (0.010)
0.0050 to 0.0100 (0.127 to 0.254)	+/- 0.0005 (0.013)

TABLE 4 Permissible Variations in Width

Nominal Width Range, Inch (mm)	Tolerance, Inch (mm)
0.0100 to 0.0499 (0.254 to 1.27)	+/- 0.0013 (0.033)
0.0500 to 0.0699 (1.27 to 1.78)	+/- 0.0015 (0.038)
0.0700 to 0.0999 (1.78 to 2.54)	+/- 0.0020 (0.051)
0.1000 to 0.1249 (2.54 to 3.17)	+/- 0.0030 (0.076)
0.1250 to 0.1500 (3.18 to 3.81)	+/- 0.0040 (0.102)

6. Test Methods

6.1 *Tensile Strength and Elongation (Explanatory Note 6):*

6.1.1 The tensile strength, expressed in pounds per square inch, shall be obtained by dividing the maximum load carried by the specimen during the tension test by the original cross-sectional area of the specimen. Tensile strength and elongation may be determined simultaneously on the same specimen.

6.1.2 The elongation of the flat wire may be determined by measurements made between the jaws of the tensile testing machine. 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 the jaws of the testing machine and not closer than 1 in. (25.4 mm) to the jaw.

6.2 *Resistivity (Explanatory 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 for width and thickness 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. Any measurement taken exceeding the dimensions and permissible variation requirements in 5.4 shall constitute failure to meet the dimensional conformance criterion.

6.4 *Continuity of Coating:*

6.4.1 *Length of Specimens*—Test specimens shall each 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 or tissue (**Caution:** Explanatory Note 7). The specimens thus cleaned shall be kept wrapped in a clean, dry cloth or tissue 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 Solution (sp gr 1.142)*—A concentrated solution shall be made by dissolving sodium sulfide crystals (cp) in distilled water until the solution is saturated at about 21°C, 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 ambient temperature of 15.6 °C. The sodium polysulfide test solution should have sufficient strength to thoroughly blacken a piece of clean uncoated copper wire in 5 s. A portion of the test solution used for testing samples shall not be considered to be exhausted until it fails to blacken a piece of clean copper as described above (Explanatory Note 8).

6.4.4 *Procedure*—Immerse a length of at least 4.5 in. (114 mm) from each of the clean specimens for 30 s in the sodium polysulfide solution (see 6.4.3) maintained at a temperature between 15.6 and 21°C. After the immersion, immediately wash the specimens in clean water and wipe dry with a clean, soft cloth or tissue. After immersion and washing, examine the specimens to ascertain if copper exposed through openings in the nickel coating has been blackened by action of the sodium polysulfide. Examine the specimen with the normal eye against a white background. Consider the specimens 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.

6.5 *Finish*—Surface-finish inspection shall be made with the unaided eye (normal spectacles excepted).

7. Inspection

7.1 *General (Explanatory Note 9)*—Unless otherwise specified in the contract or purchaser order, the manufacturer shall be responsible for the performance of all inspection and test requirements specified.

7.1.1 All inspections and tests shall be made at the place of manufacture unless otherwise especially agreed upon between the manufacturer and the purchaser at the time of purchase.

7.1.2 The manufacturer shall afford the inspector representing the purchaser all reasonable manufacturer's facilities to satisfy him that the material is being furnished in accordance with this specification.

7.1.3 Unless otherwise agreed upon between the purchaser and the manufacturer, conformance of the wire to the various requirements listed in Section 5 shall be determined on samples taken from each lot of wire presented for acceptance.

7.1.4 The manufacturer shall, if requested prior to inspection, certify that all wire in the lot was made under such conditions that the product as a whole conforms to the requirements of this specification as determined by regularly made and recorded tests.

7.2 *Definitions Applicable to Inspection:*

7.2.1 *lot*—any amount of wire of one type and size presented for acceptance at one time.

7.2.2 *sample*—a quantity of production units (coils, reels, and so forth) selected at random from the lot for the purpose of determining conformance of the lot to the requirements of this specification.

7.2.3 *specimen*—a length of wire removed for test purposes from any individual production unit of the sample.

7.3 *Sample Size (Explanatory Note 9)*—The number of production units in a sample shall be as follows:

7.3.1 A full (100 % inspection) will be completed at every set-up prior to running the order.

7.3.2 For elongation, resistivity, dimensional measurements, continuity of coating, and thickness of coating determinations, the sample shall consist of sequential production units from the lot.

7.3.3 For surface-finish inspection and for packaging inspection (when specified by the purchaser at the time of placing the order) the sample shall consist of sequential production units from the lot.

8. Conformance Criteria (Explanatory Note 9)

8.1 Any lot of wire, the samples of which comply with the conformance criteria of Section 5, shall be considered as complying with the requirements of this standard. Individual production units that fail to meet one or more of the requirements shall be rejected. If a failure of an individual production unit occurs, material which was made between the non-conforming unit and the last production unit which passed the conformance criteria must be inspected for the non-conforming characteristic.