



Designation: B559 – 12 (Reapproved 2023)

Standard Specification for Nickel-Coated, Copper-Clad Steel Wire for Electronic Application¹

This standard is issued under the fixed designation B559; 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 nickel-coated, round, copper-clad steel wire for electronic application.

1.2 Nickel coatings in mass percentages of the total mass of the coated wire are as follows: 2 %, 4 %, 7 %, 10 %, and 27 %. Nickel-coated wire having different minimum mass percentages of nickel may be obtained by mutual agreement between the manufacturer and the purchaser. For information purposes, the thickness of coating in micrometers provided by the percentages listed above is shown in [Table 1](#).

1.3 Four classes of nickel-coated, copper-clad steel wire are covered as follows:

1.3.1 *Class N30HS*—Nominal 30 % conductivity, hard drawn.

1.3.2 *Class N30A*—Nominal 30 % conductivity, annealed.

1.3.3 *Class N40HS*—Nominal 40 % conductivity, hard drawn.

1.3.4 *Class N40A*—Nominal 40 % conductivity, annealed.

1.4 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.

1.4.1 *Exception*—The SI values for resistivity are to be regarded as standard.

1.5 The following safety hazards caveat pertains only to the test method described in 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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.* (**Warning**—Consideration should be given to toxicity and flammability when selecting solvent cleaners.)

¹ This specification is under the jurisdiction of ASTM Committee B01 on Electrical Conductors and is the direct responsibility of Subcommittee B01.06 on Bi-Metallic Conductors.

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1.6 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 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 Standard 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](#)

[E75 Test Methods for Chemical Analysis of Copper-Nickel and Copper-Nickel-Zinc Alloys \(Withdrawn 2010\)](#)³

2.3 *American Chemical Society*:⁴

[Standard Reagents Tests](#)

2.4 *NIST Standard*:⁵

[NBS Handbook 100 Copper Wire Tables](#)

3. Terminology

3.1 *Definitions of Terms Specific to This Standard*:

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 The last approved version of this historical standard is referenced on www.astm.org.

⁴ *ACS Reagent Chemicals, Specifications and Procedures for Reagents and Standard-Grade Reference Materials*, American Chemical Society, Washington, DC. For suggestions on the testing of reagents not listed by the American Chemical Society, see *Analar Standards for Laboratory Chemicals*, BDH Ltd., Poole, Dorset, U.K., and the *United States Pharmacopeia and National Formulary*, U.S. Pharmacopeial Convention, Inc. (USPC), Rockville, MD.

⁵ Available from National Institute of Standards and Technology (NIST), 100 Bureau Dr., Stop 1070, Gaithersburg, MD 20899-1070, <http://www.nist.gov>.

TABLE 1 Nickel Mass Percent and Thickness of Coating

Diameter		Cross-Sectional Area at 20 °C			Thickness of Nickel, μ in. (for information only)				
in.	mm	cmil	in. ²	mm ²	2.0 %	4.0 %	7.0 %	10.0 %	27.0 %
0.0720	1.829	5 180	0.00407	2.63	334	637	1 181	1 703	4 892
0.0641	1.628	4 110	0.00323	2.08	298	566	1 050	1 514	4 349
0.0571	1.450	3 260	0.00256	1.65	266	505	936	1 350	3 880
0.0508	1.290	2 580	0.00203	1.31	236	450	833	1 200	3 452
0.0453	1.151	2 050	0.00161	1.04	211	401	743	1 071	3 077
0.0403	1.024	1 620	0.00128	0.823	202	357	661	953	2 738
0.0359	0.912	1 290	0.00101	0.653	167	318	589	849	2 439
0.0320	0.813	1 020	0.000804	0.519	149	283	525	757	2 174
0.0285	0.724	812	0.000638	0.412	133	252	467	686	1 937
0.0253	0.643	640	0.000503	0.324	118	224	415	598	1 719
0.0226	0.574	511	0.000401	0.259	105	200	371	535	1 536
0.0201	0.511	404	0.000317	0.205	94	178	330	475	1 366
0.0179	0.455	320	0.000252	0.162	83	158	294	423	1 216
0.0159	0.404	253	0.000199	0.128	74	141	261	376	1 080
0.0142	0.361	202	0.000158	0.102	66	126	233	336	965
0.0126	0.320	159	0.000125	0.0804	59	112	207	298	856
0.0113	0.287	128	0.000100	0.0647	53	100	185	267	768
0.0100	0.254	100	0.0000785	0.0507	47	89	164	237	680
0.0089	0.226	79.2	0.0000622	0.0401	41	80	146	211	605
0.0080	0.203	64.0	0.0000503	0.0324	...	71	131	189	544
0.0071	0.180	50.4	0.0000396	0.0255	...	63	116	168	482
0.0063	0.160	39.7	0.0000312	0.0201	...	56	103	149	428
0.0056	0.142	31.4	0.0000246	0.0159	...	50	92	132	381
0.0050	0.127	25.0	0.0000196	0.0127	...	44	82	118	340
0.0045	0.114	20.2	0.0000159	0.0103	...	40	74	106	306
0.0040	0.102	16.0	0.0000126	0.00811	...	...	66	95	272
0.0035	0.089	12.2	0.00000962	0.00621	...	...	57	83	238
0.0031	0.079	9.61	0.00000755	0.00487	...	...	51	73	211

Iteh Standards
 (https://standards.iteh.ai)

3.1.1 *lot*—any amount of wire of one class and size presented for acceptance at one time, such amount, however, not to exceed 10 000 lb (4500 kg) (Note 1).

NOTE 1—A lot should comprise material taken from a product regularly meeting the requirements of this specification. Inspection of individual lots of less than 500 lb (230 kg) of wire cannot be justified economically. For small lots of 500 lb (230 kg) or less, the purchaser may agree to the manufacturers' regular inspection of the product as a whole as evidence of acceptability of such small lots.

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

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

4. Ordering Information

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

- 4.1.1 Quantity of each size.
- 4.1.2 Wire size (see Section 7 and Table 1).
- 4.1.3 Class of basis wire (see 1.3).
- 4.1.4 Mass percentage of nickel coating (see 1.2 and Table 1).
- 4.1.5 Package size (see 14.2 and Section 14). Packaging inspection, if required (see 9.1.3).
- 4.1.6 Special package marking, if required.
- 4.1.7 Place of inspection (see 13.1).

5. Materials and Manufacture

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

5.2 The nickel-coated wire shall consist of the basis wire coated with nickel (Note 2). The quality of the nickel-coated wire shall be such that the finished product meets the properties and requirements in this specification.

NOTE 2—Nickel on copper-clad steel wire provides a protective coating for a prevention of oxidation of the copper either during fabrication or service.

6. General Requirements

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

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

6.3 *Continuity of Coating*—The nickel coating shall be continuous. The continuity of the coating shall be determined on representative samples taken before stranding or insulating and shall be determined by the sodium polysulfide test, in accordance with 10.2. Wire whose coating weight corresponds to a thickness less than 50 μ in. (0.00005 in.) (1.3 μm) shall not be subject to this test.

6.4 *Adherence of Coating*—The nickel coating shall be firmly adhered to the surface of the copper-clad steel wire. The

TABLE 2 Resistivity

Class of Wire	Resistivity, max at 20 °C	
	Nickel Mass %	Ω -mm ² /m
N30A and N30HS	2	0.05906 (0.059062)
	4	0.05951 (0.059513)
	7	0.06021 (0.060210)
	10	0.06093 (0.060926)
	27	0.06543 (0.065433)
N40A and N40HS	2	0.04442 (0.044418)
	4	0.04490 (0.044902)
	7	0.04561 (0.045614)
	10	0.04636 (0.046362)
	27	0.05122 (0.051216)

TABLE 3 Sampling for Surface Finish and Packaging Inspection

Number of Units in Lot	Number of Units in Sample, n	Allowable Number of Defective Units, c
1 to 30, incl	all	0
31 to 50, incl	30	0
51 to 100, incl	37	0
101 to 200, incl	40	0
201 to 300, incl	70	1
301 to 500, incl	100	2
501 to 800, incl	130	3
Over 800	155	4

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 10.3.

6.5 *Mass of Coating*—The mass of nickel coating expressed in percent of the total mass of the wire shall be not less than the percentage specified and referred to in this specification or the percentage as agreed on between the manufacturer and purchaser at the time of the placing of the order. For ease of comparison, the thickness of coating for various percentages has been included in Table 1.

6.6 *Joints*—Necessary joints in the wire and rods prior to final coating and drawing shall be made in accordance with good commercial practice.

7. Dimensions, Mass, and Permissible Variations

7.1 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 +0.0003 in. (0.009 mm) and –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 +3% and –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 gauge numbers to specify wire sizes is not recognized in this specification because of the possibility of confusion. An excellent discussion of wire gauges and related subjects is contained in *NBS Handbook 100*.

8. Workmanship, Finish, and Appearance

8.1 The nickel 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.

8.2 The finish of the samples taken in accordance with Table 3 shall conform to the requirements of 8.1. The number of units in the sample showing surface defects not consistent with commercial practice shall not exceed the allowable defect number c in Table 3. Failure to meet this requirement shall constitute failure to meet the finish conformance criterion.

9. Sampling

9.1 The number of production units in a sample (Note 4) shall be as follows:

NOTE 4—Cumulative results secured on the product of a single manufacturer, indicating continued conformance to the criteria, are necessary to ensure an over-all product meeting the requirements of this specification. The sample size and conformance criteria given for the various characteristics are applicable only to lots produced under these conditions.

9.1.1 For tensile strength, elongation, resistivity, mass of coating and adhesion and other defects, the sample shall consist of four production units. For surface finish the sampling shall be in accordance with Table 3. From each unit, one test specimen of sufficient length shall be removed for the performance of required tests.

9.1.2 For dimensional measurements, the sample shall consist of a quantity of production units shown in Table 4 under heading “First Sample.”

9.1.3 For packaging inspection (when specified by the purchaser at the time of placing the order), the sample shall consist of a quantity of production units as shown in Table 3.

TABLE 4 Sampling for Dimensional Measurements

Number of Units in Lot	First Sample		Second Sample		Allowable Number of Defects in Both Samples, c_2
	Number of Units in Sample, n_1	Allowable Number of Defects in Sample c_1	Number of Units in Sample n_2	$n_1 + n_2$	
1 to 14, incl	all	0	...	...	0
15 to 50, incl	14	0	...	...	0
51 to 100, incl	19	0	23	42	1
101 to 200, incl	24	0	46	70	2
201 to 400, incl	29	0	76	105	3
401 to 800, incl	33	0	112	145	4
Over 800	34	0	116	150	4

10. Test Methods

10.1 *Tensile Properties*—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 nickel-coated wire (Explanatory **Note 2**).

10.2 *Continuity of Coating:*

10.2.1 *Specimens:*

10.2.1.1 *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.

10.2.1.2 *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 (**Warning**—See **1.5**). The specimen 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.

10.2.2 *Special Solution* (sp gr 1.142)—Make concentrated solution by dissolving sodium sulfide crystals (cp) in distilled water until the solution is saturated at about 21 °C (70 °F), and add 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. Make the test solution by diluting a portion of the concentrated solution with distilled water to a specific gravity of 1.142 at 15.6 °C (60 °F). The sodium polysulfide test solution should have sufficient strength to blacken thoroughly a piece of clean uncoated 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 (Explanatory **Note 3**).

10.2.3 *Procedure*—Immerse a length of at least 4½ in. (114 mm) from each of the clean specimens for 30 s in the sodium polysulfide solution (**10.2.2**) maintained at a temperature between 15.6 °C and 21 °C (60 °F and 70 °F). 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. (13 mm) of the cut end.

10.3 *Adherence of Coating:*

10.3.1 *Specimens*—Test specimens shall be approximately 12 in. (300 mm) in length and shall be tagged or marked to correspond with coil, spool, or reel from which they are cut. The specimens shall be thoroughly cleaned, if required, by immersion in a suitable organic solvent for at least 3 min, then removed and dried (**Warning**—See **1.5**). 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 of

the surface to be subjected to test. Wire sizes 0.005 in. (0.13 mm) and smaller may be cleaned after wrapping around the mandrel.

10.3.2 *Procedure:*

10.3.2.1 *Wrapping*—Wrap the test specimen slowly in a suitable manner in an open helix around a wire of its own diameter. Take care not to stretch the specimen during the wrapping operation. The spacing of the consecutive turns shall be approximately equal to the diameter of the wire. For wire sizes 0.021 in. (0.53 mm) and smaller, use approximately six helical turns for the test. For wire larger than 0.021 in., use approximately three turns.

10.3.2.2 *Immersion Test*—Remove the helically wrapped portion of the test specimen from the mandrel and completely immerse it in the sodium polysulfide solution (**10.2.2**) for 30 s at the temperature prescribed in **10.2.3**. On removal from the sodium polysulfide solution, rinse the specimen immediately in clean water and remove the excess by shaking.

10.3.2.3 *Examination of Specimens*—Examine the outer surface of the helically wrapped portion of the specimen under magnification not to exceed 7× diameter. Any cracking or flaking of the coating in this area shown by blackening of the copper area shall be cause for rejection. A grayish appearance of the coating after immersion shall not constitute failure.

10.4 *Mass of Coating*—Determine the conformance to the mass requirement in accordance with Test Method A. In case of disagreement, use Test Method B and the result obtained shall be final. Test Methods A and B are given in the Annex.

10.5 *Finish*—Make the surface finish inspection with the unaided eye (normal spectacles excepted).

11. Conformance Criteria (**Note 4**)

11.1 Any lot of wire, the samples of which comply with the conformance criteria of this section, shall be considered as complying with the requirements of Section **6**. Individual production units that fail to meet one or more of the following criteria shall constitute cause for rejection of the lot. The conformance criteria for each of the prescribed properties given in a Section **6** are as follows:

11.1.1 The lot shall be considered conforming if the conformance criteria of Specification **B452** have been met for tensile properties and the quality characteristics relative to the basis wire.

11.1.2 *Resistivity*—The electrical resistivity of each of the four specimens shall conform to the requirements of **Table 2**. Failure to meet these requirements shall constitute failure to meet the resistivity conformance criteria of **6.2**.

11.1.3 *Dimensions*—The dimensions of the first sample (**Table 3**) shall conform to the requirements of Section **7**. If there are no failures, the lot shall be considered as conforming to these requirements. If there are failures, but the number of these do not exceed the allowable defect number c_2 (**Table 3**) for the respective number of units in the sample, a second sample equal to n_2 shall be taken and the total defects of the $n_1 + n_2$ units shall not exceed the allowable defect number c_2 . Failure to meet this requirement shall constitute failure to meet the dimensional conformance criterion.