Designation: B 355 – 95

Standard Specification for Nickel-Coated Soft or Annealed Copper Wire[1]

This standard is issued under the fixed designation B 355; 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 nickel-coated, soft or annealed, round copper wire for use in electrical equipment.

1.2 Five classes of wire are covered as follows:

1.2.1 *Class 2*—Wire whose nickel coating is at least 2 % of the total weight of the coated wire.

1.2.2 *Class 4*—Wire whose nickel coating is at least 4 % of the total weight of the coated wire.

1.2.3 *Class 7*—Wire whose nickel coating is at least 7 % of the total weight of the coated wire.

1.2.4 *Class 10*—Wire whose nickel coating is at least 10 % of the total weight of the coated wire.

1.2.5 *Class 27*—Wire whose nickel coating is at least 27 % of the total weight of the coated wire.

NOTE 1—For information purposes, the thickness of coating in microinches provided by the percentages listed in 1.2 is shown in Table 1.

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

1.4 This hazard statement applies only to Section 6, Test Methods, and to the Appendix 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.*

2. Referenced Documents

2.1 The following documents of the issue in effect at the time of reference form a part of these methods to the extent referenced herein:

2.2 *ASTM Standards:*

B 49 Specification for Copper Redraw Rod for Electrical Purposes[2]

B 193 Test Method for Resistivity of Electrical Conductor Materials[3]

B 258 Specification for Standard Nominal Diameters and Cross-Sectional Areas of AWG Sizes of Solid Round Wires Used as Electrical Conductors[3]

E 75 Test Methods for Chemical Analysis of Copper-Nickel and Copper-Nickel-Zinc Alloys[4]

2.3 *NIST:*

NBS Handbook 100—Copper Wire Tables[5]

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 Class of coating (Section 1 and Table 1),

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

3.1.5 Package size (Section 10),

3.1.6 Special packaging marking, if required, and

3.1.7 Place of inspection (see 9.1).

4. Material

4.1 The material shall be nickel-coated wire (Explanatory Note 1), of such quality and purity that the finished product shall have the properties and characteristics prescribed in this specification.

NOTE 2—Specification B 49B 49 defines copper suitable for use:

4.2 Copper 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.

[1] This specification is under the jurisdiction of ASTM Committee B-1 on Electrical Conductors and is the direct responsibility of B01.04 on Conductors of Copper and Copper Alloys.

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[2] *Annual Book of ASTM Standards*, Vol 02.01.

[3] *Annual Book of ASTM Standards*, Vol 02.03.

[4] *Annual Book of ASTM Standards*, Vol 03.05.

[5] Available from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.

TABLE 1 Tensile Requirements

Area at 20°C (68°F)			Elongation in 10 in., min,%		Thickness of Coating, µin. (For Information Only)				
Diameter, in.	cmils	in.^{2}	Classes 2, 4, 7, 9 and 10	Class 27	Class 2, 2 % Nickel	Class 4, 4 % Nickel	Class 7, 7 % Nickel	Class 10, 10 % Nickel	Class 27, 27 % Nickel
0.1285	16 510	0.01297	25	20	650	1300	2290	3300	9350
0.1144	13 090	0.01028	25	20	570	1160	2040	2940	8330
0.1019	10 380	0.008155	25	20	510	1040	1820	2620	7420
0.0907	8 230	0.00646	25	20	460	920	1620	2330	6610
0.0808	6 530	0.00513	25	20	410	820	1440	2070	5880
0.0720	5 180	0.00407	25	20	360	730	1280	1850	5240
0.0641	4 110	0.00323	25	20	320	650	1140	1650	4670
0.0571	3 260	0.00256	25	20	290	580	1020	1470	4160
0.0508	2 580	0.00203	25	20	260	510	910	1300	3700
0.0453	2 050	0.00161	25	20	230	460	810	1160	3300
0.0403	1 620	0.00128	25	20	200	410	720	1030	2930
0.0359	1 290	0.00101	25	20	180	360	640	920	2610
0.0320	1 020	0.000804	25	20	160	320	570	820	2330
0.0285	812	0.000638	25	20	140	290	510	730	2070
0.0253	640	0.000503	25	20	130	260	450	650	1850
0.0226	511	0.000401	25	20	110	230	400	580	1640
0.0201	404	0.000317	20	15	100	200	360	520	1460
0.0179	320	0.000252	20	15	90	180	320	460	1300
0.0159	253	0.000199	20	15	80	160	280	410	1160
0.0142	202	0.000158	20	15	71	140	250	360	1030
0.0126	159	0.000125	20	15	63	130	220	320	920
0.0113	128	0.000100	20	15	57	110	200	290	820
0.0100	100	0.0000785	20	15	50	100	180	260	730
0.0089	79.2	0.0000622	15	10	45	90	160	230	650
0.0080	64.0	0.0000503	15	10	40	81	140	200	580
0.0071	50.4	0.0000396	15	10	...	72	130	180	520
0.0063	39.7	0.0000312	15	10	...	64	110	160	460
0.0056	31.4	0.0000246	15	10	...	57	100	140	410
0.0050	25.0	0.0000196	15	10	...	51	89	130	360
0.0045	20.2	0.0000159	15	8	...	...	80	120	320
0.0040	16.0	0.0000126	15	8	...	...	71	100	290
0.0035	12.2	0.00000962	15	8	...	...	62	91	260
0.0031	9.61	0.00000755	15	8	...	...	55	81	230

5. *General Requirements* General Requirements

5.1 *Tensile Properties*—The nickel-coated wire shall conform to the requirements for elongation as prescribed in Table 1. For wire, the nominal diameter of which is more than 0.001 in. (1 mil) greater than a size listed in Table 1 and less than that of the next larger size, the requirements of the next larger size shall apply.

5.2 *Resistivity*—The electrical resistivity of the coated wire at a temperature of 20°C shall not exceed the values prescribed in Table 2.

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 0.1 mil (0.0001 in.) (Explanatory Note 2). The coated wire shall not vary from the specified diameter by more than the following amounts:

Nominal Diameter, in.	Permissible Variations in Diameter
Under 0.0100	+0.0003 in. (0.3 mil) –0.0001 in. (0.1 mil)
0.0100 to 0.0508, incl	+3 %, –1 %
Over 0.0508	+0.0015, –0.0005

TABLE 2 Electrical Resistivity Requirements

Class, % Nickel	Resistivity at 20°C, Ω· lb/mil^2
2	911.67
4	931.06
7	961.76
10	994.55
27	1232.7

5.4 *Continuity of Coating*—The 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 described in 6.4. Wire whose coating weight corresponds to a thickness of less than 50 µin. (0.00005 in.) (0.0013 mm) shall not be subject to this test (Explanatory Note 3).

5.5 *Adherence of Coating*—The nickel coating shall be firmly adherent to the surface of the copper. The adherence of coating on the wire shall be determined on representative samples. The adherence of coating shall be determined by the wrapping and immersion test in accordance with 6.5.

5.6 *Weight of Coating*—The weight of coating expressed as a percentage of the total weight of the wire shall be not less than 2 % for Class 2; 4 % for Class 4; 7 % for Class 7; 10 % for Class 10; and 27 % for Class 27. For ease of comparison,

the thickness of coating for these classes has been included in Table 1 (Explanatory Note 3).

5.7 *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.

5.8 *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 the best commercial practice.

6. Test Methods

6.1 *Elongation*—The elongation of wire whose nominal diameter is larger than 0.0808 in. (2.052 mm) shall be determined as the permanent increase in length at fracture, expressed as a percentage of the original length, due to the breaking of the wire in tension, measured between gage marks placed originally 10 in. (254 mm) apart on the test specimen (Explanatory Note 4). The elongation of wire whose nominal diameter is 0.0808 in. (2.052 mm) and under may be determined as just described or by measurements made between the jaws of the testing machine. Where the latter method is used, 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 in the case of specimens so marked, or between the jaws of the testing machine and not closer than 1 in. (25.4 mm) to either gage mark or either jaw.

6.2 *Resistivity*—The electrical resistivity of the material shall be determined in accordance with Test Method B 193B 193 (Explanatory Note 5).

6.3 *Dimensional Measurements*—Dimensional measurements shall be made with a micrometer caliper equipped with a vernier graduated in 0.0001 in. Each coil shall be gaged at three places, one near each end and one near the middle. From each spool approximately 12 ft (3.7 m) shall be unreeled and the wire gaged in six places between the second and twelfth foot from the end. The average of the measurements obtained shall meet the requirements of 5.3.

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 such as benzene, ether, or trichloroethylene for at least 3 min, then removed and wiped dry with a clean, soft cloth or tissue (**Precaution:** Explanatory Note 6). 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 1.142 at 15.6°C. The sodium polysulfide test solution should have sufficient strength to blacken thoroughly 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 7).

6.4.4 *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 (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 *Adherence of Coating*:

6.5.1 *Specimens*—Test specimens shall be approximately 12 in. (305 mm) in length and shall be tagged or marked to correspond with the coil, spool, or reel from which they are cut. The specimens shall be thoroughly cleaned, if required, by immersion in a suitable organic solvent such as benzene, ether or trichloroethylene for at least 3 min, then removed and dried (**Precaution:** 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 of the surface to be subjected to test. Wire sizes 0.005 in. (0.127 mm) and smaller may be cleaned after wrapping.

6.5.2 *Procedure*:

6.5.2.1 *Wrapping*—Slowly wrap the test specimen 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. (0.533 mm) and smaller, use approximately six helical turns for the test. For wire larger than 0.021 in. (0.533 mm) use approximately three turns.

6.5.2.2 *Immersion Test*—Remove the helically wrapped portion of the test specimen from the mandrel and completely immerse in the sodium polysulfide solution (see 6.4.3) for 30 s at the temperature prescribed in 6.4.4. On removal from the sodium polysulfide solution, rinse the specimen immediately in clean water and remove the excess by shaking.

6.5.2.3 *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.

6.6 *Weight of Coating*—Conformance to the weight requirement may be determined in accordance with Test Method A. In