Designation: B355 – 11 (Reapproved 2016)

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

This standard is issued under the fixed designation B355; 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, 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 micro-inches provided by the percentages listed in 1.2 is shown in Table 2.

1.3 The values stated in inch-pound units are to be regarded as standard. The values given in parenthesis 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 hazard statement applies only to Section 7, 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.*

3. Referenced Documents

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

3.2 *ASTM Standards:*[2]

B49 Specification for Copper Rod 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

E75 Test Methods for Chemical Analysis of Copper-Nickel and Copper-Nickel-Zinc Alloys (Withdrawn 2010)[3]

3.3 *NIST:*

NBS Handbook 100—Copper Wire Tables[4]

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, diameter in inches (see 6.3 and Table 2),

4.1.3 Class of coating (Section 1 and Table 2),

4.1.4 Type of copper, if special (see 5.2),

4.1.5 Package size (Section 11),

4.1.6 Special packaging marking, if required, and

4.1.7 Place of inspection (see 10.1).

5. Material

5.1 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 B49 defines copper suitable for use:

5.2 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 B01 on Electrical Conductors and is the direct responsibility of 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] The last approved version of this historical standard is referenced on www.astm.org.

[4] Available from National Technical Information Service (NTIS), 5301 Shawnee Rd., Alexandria, VA 22312, http://www.ntis.gov.

TABLE 2 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

6. General Requirements

6.1 *Tensile Properties*—The nickel-coated wire shall conform to the requirements for elongation as prescribed in Table 2. For wire, the nominal diameter of which is more than 0.001 in. (0.025 mm) greater than a size listed in Table 2 and less than that of the next larger size, the requirements of the next larger size shall apply.

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

6.3 *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. (0.0025 mm) (Explanatory Note 2). The coated wire shall not vary from the specified diameter by more than the following amounts:

TABLE 2 Electrical Resistivity Requirements

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

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

6.4 *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 7.4. 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).

6.5 *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 section 7.5 for 0.0403 in. (1.024 mm) and larger sizes.

6.6 *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 2 (Explanatory Note 3).

6.7 *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.

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

7. Test Methods

7.1 *Tensile Strength and Elongation (Explanatory Note 4):*

7.1.1 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.

7.1.2 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.

7.2 *Resistivity*—The electrical resistivity of the material shall be determined in accordance with Test Method B193 (Explanatory Note 5).

7.3 *Dimensional Measurements*—Dimensional measurements shall be made with a micrometer caliper equipped with a vernier graduated in 0.0001 in. (0.0025 mm). 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 6.3.

7.4 *Continuity of Coating:*

7.4.1 *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.

7.4.2 *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 (**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.

7.4.3 *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. 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 7).

7.4.4 *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 7.4.3) 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.

7.5 *Adherence of Coating:*

7.5.1 *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 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.

7.5.2 *Procedure:*

7.5.2.1 *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.

7.5.2.2 *Immersion Test*—Remove the helically wrapped portion of the test specimen from the mandrel and completely immerse in the sodium polysulfide solution (see 7.4.3) for 30 s at the temperature prescribed in 7.4.4. On removal from the sodium polysulfide solution, rinse the specimen immediately in clean water and remove the excess by shaking.

7.5.2.3 *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.

7.6 *Weight of Coating*—Conformance to the weight requirement may be determined in accordance with Test Method A. In case of disagreement, Test Method B shall be used and the result obtained shall be final. Test Methods A and B are given in Appendix X1.

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

8. Conformance Criteria (Explanatory Note 6)

8.1 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 requirements shall be rejected. Failure of a sample group from a lot 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 Section 6 are as follows:

8.1.1 *Elongation*—The lot shall be considered conforming if the elongation of each of the selected specimens is not less than the elongation value in Table 2.

8.2 *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 criterion of 5.2.

8.3 *Dimensions*—The dimensions of the first sample (Table 3) shall conform to the requirements of 6.3. If there are no failures, the lot shall be considered as conforming to this requirement. 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.

8.4 *Continuity of Coating*—The continuity of the coating of each of the eight specimens shall conform to the requirements of 6.4. Failure of more than two specimens shall constitute failure to meet the continuity criterion. If not more than two specimens fail to meet the continuity criteria, eight additional specimens from the lot shall be tested, all of which shall conform to the continuity criteria. However, any individual production unit, the specimen from which failed to meet the continuity criteria, shall be rejected.

8.5 *Adherence of Coating*—The adherence of the coating of each of the eight specimens shall conform to the requirements of 6.5. Failure of more than two specimens shall constitute failure to meet the adherence criterion. If there is failure on not more than two, eight additional specimens from the lot shall be tested, all of which shall conform to the adherence criterion. However, any individual production unit, the specimen from which failed to meet the adherence criterion, shall be rejected.

8.6 *Weight of Coating*—The weight of coating of each of the four specimens shall conform to the requirements of 6.6. Failure of more than one specimen shall constitute failure to meet the weight criteria. If only one specimen fails to meet the weight criteria, four additional specimens from the lot shall be tested, all of which shall conform to the weight criteria. However, any individual production unit, the specimen from which failed the weight criteria, shall be rejected.

8.7 *Packaging*—Conformance to the packaging requirements specified by the purchaser shall be determined in accordance with Table 4. The number of units in the sample showing nonconformance to the requirements shall not exceed the allowable defect number, c, in Table 4. Failure to meet this requirement shall constitute failure to meet the packaging conformance criterion.

9. Density

9.1 For the purpose of calculating mass, mass per unit length, cross sections, and so forth, the density of the copper shall be taken as 8.89 g/cm^3 (0.32117 lb/in.^{3}) at 20°C (Explanatory Note 8). For the purpose of this specification the density of nickel shall be the same as copper.

10. Inspection

10.1 *General (Explanatory Note 9)*—All tests and inspections shall be made at the place of manufacture unless otherwise agreed upon between the manufacturer and the purchaser at the time of purchase. The manufacturer shall afford the inspector representing the purchaser all reasonable facilities, without charge, to satisfy him that the material is being furnished in accordance with this specification.

TABLE 3 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 First Sample, c_1	Number of Units in Sample, n_2	n_1 plus n_2	
1 to 14, incl	all	0	...	...	...
15 to 50, incl	14	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

TABLE 4 Sampling for 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

10.1.1 Unless otherwise agreed by the manufacturer and the purchaser, conformance of the wire to the various requirements listed in Section 6 shall be determined on samples taken from each lot of wire presented for acceptance.

10.1.2 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.

10.2 *Definitions for Inspection Purposes:*

10.2.1 *lot*—any amount of wire of one type and size presented for acceptance at one time, such amount, however, not to exceed 10 000 lb (Explanatory Note 10).

10.2.2 *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.

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

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

10.3.1 For elongation, resistivity, and mass per unit length of coating determinations, the sample shall consist of four production units. For continuity of coating and adhesion determinations, the sample shall consist of eight production units. From each unit, one test specimen of sufficient length shall be removed for the performance of the required test.

10.3.2 For dimensional measurements, the sample shall consist of a quantity of production units shown in Table 3 under heading "First Sample."

10.3.3 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 shown in Table 4.

11. Packaging and Package Marking

11.1 The package size shall be agreed upon by the manufacturer and the purchaser in the placing of individual orders (Explanatory Note 11). The wire shall be protected against damage in ordinary handling and shipping.

12. Keywords

12.1 coated copper wire; copper electrical conductor; copper wire; electrical conductor; electrical conductor-copper; nickel-coated copper wire; nickel-coated soft or annealed copper wire; soft copper wire

EXPLANATORY NOTES

NOTE 1—Nickel coatings on copper wire provide for:

(a) A barrier between the copper and insulation whose curing temperature in the process of fabricating is too high for use of tin-coated wires.

(b) Fair solderability for high-temperature hook-up wires which prohibit the use of tin-coated wires due to high curing temperatures used in fabricating the finished wire.

NOTE 2—The values of the wire diameters in Table 2 are given to the nearest 0.0001 in. 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 *NBS Handbook 100*.

NOTE 3—Whether the nickel is applied by electroplating or by mechanical cladding, coatings of less than 50 µin. (0.00005 in.) in thickness will not pass the "Continuity of Coating" test. See Table 2 for thickness of coatings for the various classes of coating and wire sizes.

NOTE 4—In general, tested values of tensile strength are increased and tested values of elongation are reduced with increase of speed of the moving head of the testing machine in the tension testing of copper wire. In the case of test on soft or annealed copper wire, however, the effects of speed of testing are not pronounced. Tests of soft wire made at speeds of moving head which under no-load conditions are not greater than 12 in./min do not alter the final results of tensile strength and elongation determinations to any practical extent.

NOTE 5—Relations which may be useful in connection with the values of resistivity prescribed in this specification are shown in Table 5.

TABLE 5 Equivalent Resistivity Values for Nickel-Coated Copper

	Class 2	Class 4	Class 7	Class 10	Class 27
Conductivity at 20°C (68°F) % IACS	96.0	94.0	91.0	88.0	71.0
			Volume Resistivity[A]		
Ω·cmil/ft	10.803	11.033	11.397	11.785	14.607
Ω·mm²/m	0.017960	0.018342	0.018947	0.019592	0.024284
µΩ·in.	0.70708	0.72212	0.74593	0.77136	0.95605
µΩ·cm	1.7960	1.8342	1.8947	1.9592	2.4284
			Weight Resistivity[A]		
Ω·lb/mile²	911.67	931.06	961.76	994.55	1232.7
Ω·g/m²	0.15966	0.16306	0.16844	0.17418	0.21588

[A] These equivalent values are calculated from the exact conductivity values, using the conversion methods given in Test Method B193, but using seven significant figures prior to final rounding.

NOTE 6—(**Warning—**Consideration should be given to toxicity and flammability when selecting solvent cleaners.)

NOTE 7—It is important that the polysulfide solution be a proper composition and strength at the time of test. A solution which is not saturated with sulfur or which has been made from decomposed sodium sulfide crystals may give a false indication of failure. Therefore, the requirements that the solution be tested by observing its blackening effect on a bright copper wire is significant. Significant also is the requirement that the solution be saturated with sulfur by allowing it to stand at least 24 h after preparation. Attention is called also to the necessity for the use of sodium sulfide which has not deteriorated through exposure to air; if exposure has occurred, the crystals should be tested for purity. The "Standard Reagents Tests" of the American Chemical Society are useful in this connection.

NOTE 8—The value of density of copper is in accordance with the International Annealed Copper Standard. The corresponding value at 0°C is 8.90 g/cm^3 (0.32150 lb/in.^{3}).

NOTE 9—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.

NOTE 10—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 of wire cannot be justified economically. For small lots of 500 lb or less, the purchaser may agree to the manufacturer's regular inspection of the product as a whole as evidence of acceptability of such small lots.

NOTE 11—Attention is called to the desirability for agreement between the manufacturer and the purchaser on package sizes which will be sufficiently large and yet not so heavy or bulky that the wire may likely be damaged in handling.

NOTE 12—The unit operates by anodically deplating a small surface area of the specimen in a cell containing the test solution. The cell serves as the cathode and the piece to be tested is the anode. At the start of the test and until the base metal is exposed, a voltage characteristic of the plating exists across a cell; when all of the plating has been removed from the test spot, this voltage changes sharply and assumes a new value which is now characteristic of the base metal. This rapid voltage change is the "end point" of the test, and is amplified and caused to operate a relay which turns off the instrument. The time required to dissolve the plating on the test spot is proportional to the thickness of the deposit; by correlating the area of the test spot with the current used to strip the plating, the counter is made to read directly in units of thickness. Essentially, therefore, the Electronic Thickness Tester embodies a miniature reverse-current plating cell in which the piece to be tested in the anode and the cell itself is the cathode. The test solution used is specifically designed to give 100 % anodic current efficiency. It does not attack the plating unless current is flowing through the test cell. The anode efficiency is further maintained by providing agitation of the solution in the test cell.

NOTE 13—Kocour K5000 or K6000 model thickness testers display reading in "mil" multiplied by 100 equates to the "counter readings" for K1000 models. The user of the standard should also refer to operation manual for the particular model being used.

NOTE 14—The equation given for the mass of the nickel on the wire is for most purposes sufficiently accurate. However, in the case of heavy coatings the results obtained by the use of this equation will indicate a slightly higher percentage by mass than is actually present. The more correct equation for all cases based on a density of 8.89 g/cm^3 for copper and nickel is as follows:

$$\text{Nickel, \%} = (400t/d)\left[1 - (t/d)\right]$$

where:

d = over-all wire diameter, in., and
t = thickness of plate, in.

APPENDIX

(Nonmandatory Information)

X1. DETERMINATION OF THE WEIGHT OF NICKEL ON NICKEL-COATED COPPER WIRE

TEST METHOD A—ELECTRONIC DETERMINATION (Explanatory Note 12)

X1.1 Apparatus and Reagent

X1.1.1 Electronic Thickness Tester with Accessory Unit "WT."

(*b*) Solution R-54.[5]

X1.2 Limitations of Test Method A

X1.2.1 This test method is suitable for the determination of the thickness of coatings as follows:

Wire Size, Diameter, in.	Sample Length in.
0.1285 to 0.0240	0.50
0.0239 to 0.0115	1.00
0.0114 to 0.0058	2.00
0.0057 to 0.0031	4.00

X1.3 Procedure

X1.3.1 Connect the tester to 120-V, 60-Hz supply. Insert the jack plug on accessory unit lead wire into the jack marked "WT" on the left side of the thickness tester. Turn the "Plate" selector to the setting marked "NICKEL." Turn the power on and allow a 5-min warm-up period.

X1.3.2 Fill the stainless steel beaker to within ½ to ¼ in. from the top with Solution R-54. Maintain the temperature of the solution at 20 to 25°C.

X1.3.3 Cut a straight length of the wire to be tested, approximately 4 in. longer than the required sample length. Lay the wire sample on a flat surface along a ruler and using a crayon, mark off the appropriate sample length from one end of the wire. Make this measurement as accurately as possible. Those specimens having 4-in. sample lengths should be given an open 180° bend half way between the crayon mark and the end to allow them to be submerged in the test solution without touching the beaker.

X1.3.4 Insert the wire sample into the terminal on the horizontal arm of the accessory unit, then tighten the terminal so that the wire is held firmly in a vertical position. Lower the wire into the beaker until the liquid level is *exactly* at the crayon mark. Adjust the arm so that the wire is in the approximate center of the beaker.

[5] The apparatus and reagent available from Kocour Co., 4800 S. St. Louis Ave., Chicago, IL 60632, or their equivalents, have been found suitable for this purpose.

TABLE X1.1 Thickness Factors

Wire Size, Diameter, in.	Test Length, in.	Thickness,[A] µin. (× reading)
0.1285	0.50	0.71
0.1144	0.50	0.80
0.1019	0.50	0.90
0.0907	0.50	1.01
0.0808	0.50	1.13
0.0720	0.50	1.27
0.0641	0.50	1.43
0.0571	0.50	1.61
0.0508	0.50	1.81
0.0453	0.50	2.03
0.0403	0.50	2.28
0.0359	0.50	2.56
0.0320	0.50	2.87
0.0285	0.50	3.23
0.0253	0.50	3.64
0.0226	1.00	2.04
0.0201	1.00	2.29
0.0179	1.00	2.58
0.0159	1.00	2.90
0.0142	1.00	3.25
0.0126	1.00	3.66
0.0113	2.00	2.04
0.0100	2.00	2.31
0.0089	2.00	2.60
0.0080	2.00	2.89
0.0071	2.00	3.26
0.0063	2.00	3.68
0.0056	4.00	2.07
0.0050	4.00	2.32
0.0045	4.00	2.58
0.0040	4.00	2.90
0.0035	4.00	3.32
0.0031	4.00	3.75

[A] To obtain the thickness of plating, multiply the thickness factors listed by the counter readings.

X1.3.5 Press the "Test Button" to start the test. When the test is complete the instrument will turn off. Multiply the counter readings by the factors corresponding to the size of the wire tested as listed in Table X1.1 (Explanatory Note 13). The result will be the thickness of the plating in microinches. The weight of the nickel, as a percentage of the total mass of the wire, may be calculated as follows (Explanatory Note 14):

$$\text{Nickel},\% = (t/d) \times 0.396 \times 10^{-3}$$

where:

t = thickness of plate, µin., and
d = over-all diameter of wire, in.

TEST METHOD B—GRAVIMETRIC DETERMINATION

X1.4 Procedure

X1.4.1 The percentage of nickel shall be determined on samples having 50 to 150 mg nickel content in accordance with Test Methods E75.