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.

Designation: B298 – 12 (Reapproved 2017)

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

This standard is issued under the fixed designation B298; 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 silver-coated, soft or annealed, round copper wire, intended for use in electrical equipment, as follows:

1.1.1 *Class A*—Wire whose silver coating is at least 1.25 % of the total weight of the coated wire.

1.1.2 *Class B*—Wire whose silver coating is at least 2.50 % of the total weight of the coated wire.

1.1.3 *Class C*—Wire whose silver coating is at least 4.00 % of the total weight of the coated wire.

1.1.4 *Class D*—Wire whose silver coating is at least 6.10 % of the total weight of the coated wire.

1.1.5 *Class E*—Wire whose silver coating is at least 10.00 % of the total weight of the coated wire.

1.2 Silver-coated wire having different minimum percentages of silver by weight may be obtained by mutual agreement between the manufacturer and the purchaser. For information purposes the thickness of coating in microinches provided by the percentages listed above is shown in Table 1 (Explanatory Note 1).

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 The following precautionary caveat pertains only to the test method section 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.* For specific precautionary statements see 8.4.1.2 and Explanatory Note 2.

1.5 *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 at the time of reference form a part of this specification to the extent referenced herein:

2.2 *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

E50 Practices for Apparatus, Reagents, and Safety Considerations for Chemical Analysis of Metals, Ores, and Related Materials

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 Place of inspection (see 9.1), and

3.1.6 Packaging and Package Marking (Section 10).

3.1.7 In addition supplementary requirements shall apply only when specified by the purchaser in the inquiry, contract, or purchase order for direct procurement by agencies of the U.S. Government (see S1, S2, and S3).

[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.

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TABLE 1 Tensile Requirements

Diameter, in.	Area at 20°C		Elongation in 10 in., min, %	Thickness of Coating, µin. (For Information Only)				
	cmils	in.^{2}		Class A, 1.25 % Silver	Class B, 2.50 % Silver	Class C, 4.00 % Silver	Class D, 6.10 % Silver	Class E, 10.00 % Silver
0.1285	16 510	0.01297	30	340	680	1 090	1 659	2 720
0.1144	13 090	0.01028	30	303	605	970	1 477	2 422
0.1019	10 380	0.008155	25	270	539	864	1 316	2 157
0.0907	8 230	0.00646	25	240	480	768	1 171	1 941
0.0808	6 530	0.00513	25	214	428	684	1 043	1 710
0.0720	5 180	0.00407	25	190	381	610	930	1 524
0.0641	4 110	0.00323	25	170	339	542	828	1 357
0.0571	3 260	0.00256	25	151	302	483	737	1 209
0.0508	2 580	0.00203	25	134	269	430	656	1 075
0.0453	2 050	0.00161	25	120	240	383	585	959
0.0403	1 620	0.00128	25	107	213	341	520	853
0.0359	1 290	0.00101	25	95	190	304	464	760
0.0320	1 020	0.000804	25	85	169	270	413	677
0.0285	812	0.000638	25	75	151	241	368	603
0.0253	640	0.000503	25	67	134	214	327	536
0.0226	511	0.000401	25	60	120	191	292	478
0.0201	404	0.00317	20	53	106	170	260	425
0.0179	320	0.000252	20	47	95	151	231	379
0.0159	253	0.000199	20	42	84	135	205	337
0.0142	202	0.000158	20	...	75	120	183	301
0.0126	159	0.000125	20	...	67	107	163	267
0.0113	128	0.000100	20	...	60	96	146	239
0.0100	100	0.0000785	20	...	53	85	129	212
0.0089	79.2	0.0000622	15	...	47	75	115	188
0.0080	64.0	0.0000503	15	...	42	68	103	169
0.0071	50.4	0.0000396	15	...	...	60	92	150
0.0063	39.7	0.0000312	15	...	...	53	81	133
0.0056	31.4	0.0000246	15	...	...	47	72	119
0.0050	25.0	0.0000196	15	...	...	42	65	106
0.0045	20.2	0.0000159	15	...	...	...	58	95
0.0040	16.0	0.0000126	15	...	...	...	52	85
0.0035	12.2	0.00000962	15	...	...	...	45	74
0.0031	9.61	0.00000755	15	...	...	...	40	66
0.0028	7.84	0.00000616	10	...	...	...	...	59
0.0025	6.25	0.00000491	10	...	...	...	...	53
0.0022	4.84	0.00000380	10	...	...	...	...	47
0.0020	4.00	0.00000314	10	...	...	...	...	42

4. Materials and Manufacture

4.1 The material shall be silver-coated copper wire (Explanatory Note 2), of such quality and purity that the finished product shall have the properties and characteristics prescribed in this specification.

NOTE 1—The following specifications define copper suitable for use: Specification B49.

4.2 Copper of special qualities, forms, or types, as may be agreed upon between the manufacturer and the purchaser, and that will conform to the requirements prescribed in this specification may also be used.

5. General Requirements

5.1 *Tensile Properties*—The silver-coated wire shall conform to the requirements for elongation prescribed in Table 1. No requirements for tensile strength are specified. For wire whose nominal 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.

5.2 *Resistivity*—The electrical resistivity of the coated wire at a temperature of 20°C shall not exceed 875.20 ohms·lb/mile^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 0.0001 in. (0.0025 mm) (Explanatory Note 3). The coated wire shall not vary from the specified diameter by more than the following amounts:

Nominal Diameter, in.	Permissible Variations in Diameter, plus and minus
Under 0.0100	0.0001 in.(0.1 mil)
0.0100 or over	1 %

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, in accordance with 8.4. Wire whose coating weight corresponds to a thickness less than 40µ in. (0.00004 in.) shall not be subject to this test (Explanatory Note 4).

5.5 *Weight of Coating*—The weight of coating expressed in percent of the total weight of the wire shall be not less than 1.25 % for Class A; 2.50 % for Class B; 4.00 % for Class C; 6.10 % for Class D; and 10.00 % for Class E. When coatings other than these classes are required, the weight of the coating shall be not less than that specified. For ease of comparison, the thickness of coating for these classes has been included in Table 1 (Explanatory Note 4).

5.6 *Joints*—Necessary joints in the wire and rods prior to final plating and drawing shall be made in accordance with the best commercial practice. Joints made after plating 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 the best commercial practice.

6. Conformance Criteria (Explanatory Note 5)

6.1 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 5. 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 5 are as follows:

6.1.1 *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 1.

6.2 *Resistivity*—The electrical resistivity of each of the four specimens shall conform to the requirements of 5.2. Failure to meet these requirements shall constitute failure to meet the resistivity conformance criterion.

6.3 *Dimensions*—The dimensions of the first sample (Table 2) shall conform to the requirements of 5.3. If there are no failures, the lot conforms to this requirement. If there are failures, but the number of these do not exceed the allowable defect number, c_2 (Table 2), 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 plus 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.

6.4 *Continuity of Coating*—The continuity of the coating of each of the eight specimens shall conform to the requirements of 5.4. 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.

6.5 *Weight of Coating*—The weight of coating of each of the four specimens shall conform to the requirements of 5.5. 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 criterion. However, any individual production unit, the specimen from which failed the weight criteria, shall be rejected.

6.6 *Packaging*—Conformance to the packaging requirements specified by the purchaser shall be determined in accordance with Table 3. The number of units in the sample showing nonconformance to the requirements shall not exceed the allowable defect number, c, in Table 3. Failure to meet this requirement shall constitute failure to meet the packaging conformance criterion.

7. Density

7.1 For the purpose of calculating weights, cross-sections, etc., the density of the copper shall be taken as 8.89 g/cm^3 (0.32117 lb/in.^{3}) at 20°C (Explanatory Note 6). The density of silver shall be taken as 10.5 g/cm^3(0.1 mil) (0.37933 lb/in.^{3}).

8. Test Methods

8.1 *Tensile Strength and Elongation:*

8.1.1 No test for tensile strength shall be required.

8.1.2 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 (see Explanatory Note 7). 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.

8.1.3 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.

8.2 *Resistivity*—The electrical resistivity of the material shall be determined in accordance with Test Method B193

TABLE 2 Sampling for Dimensional Measurements and Surface Finish

Number of Units in Lot	First Sample		Second Sample		Allowable Number of Defects in Both Sample 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	$n_1 + n_2$	
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 3 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

(Explanatory Note 8). The purchaser may accept certification that the wire was drawn from rod stock meeting the International Standard for Annealed Copper in lieu of resistivity tests on the finished wire.

8.3 *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 5.3.

8.4 *Continuity of Coating:*

8.4.1 *Specimens:*

8.4.1.1 *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.

8.4.1.2 *Treatment of Specimens*—Thoroughly clean the specimens by immersion in a suitable organic solvent for at least 3 min; then remove and wipe dry with a clean, soft cloth (**Warning:** See Explanatory Note 2). Keep the specimens thus cleaned wrapped in a clean, dry cloth until tested. Do not handle that part of the specimen to be immersed in the test solution. Take care to avoid abrasion by the cut ends.

8.4.2 *Special Solutions:*

8.4.2.1 *Sodium Polysulfide Solution (sp gr 1.142)*—Make a concentrated solution 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. Make the test solution by diluting a portion of the concentrated solution with distilled water to a specific gravity of 1.135 to 1.145 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. 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 9):

8.4.2.2 *Hydrochloric Acid Solution (sp gr 1.088)*—Dilute commercial HCl (sp gr 1.12) with distilled water to a specific gravity of 1.088 measured at 15.6°C. A portion of the HCl solution having a volume of 180 mL shall be considered exhausted if it fails to remove within 15 s the discoloration of the silver due to the polysulfide immersion.

8.4.3 *Procedure:*

8.4.3.1 *Immersion in Polysulfide Solution*—Immerse a length of at least 4½ in. (114 mm) from each of the clean specimens for 30 s in the sodium polysulfide solution, described in 8.4.2.1, maintained at a temperature between 15.6 and 21°C.

8.4.3.2 *Washing*—After the immersion, thoroughly wash the specimens in clean water and wipe dry with a clean, soft cloth.

8.4.3.3 *Immersion in Hydrochloric Acid*—After washing, immediately immerse the specimen 15 s in the HCl solution described in 8.4.2.2, thoroughly wash in clean water, and wipe dry with a clean, soft cloth.

8.4.3.4 *Examination of Specimens*—After immersion and washing examine the specimens to ascertain if copper exposed through openings in the silver coating has been blackened by action of the sodium polysulfide. Examine the specimen with the unaided eye (normal spectacles excepted) against a white background. The specimens shall be considered 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.

8.5 *Weight of Coating*—Conformance to the weight requirement for various classes and diameters of wire is best determined by using test equipment that is specifically designed for this purpose. These devices offer superior accuracy while performing the measurement in a variety of manners.

NOTE 2—The accuracy of the testing is reliant upon adherence to the procedures for testing that have been developed by the manufacturers as their standard test regimen. There are thickness testing machines available that can be used to perform this measurement. The use of these devices should be at the mutual agreement of the manufacturer and the purchaser.

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

9. Inspection

9.1 *General (Explanatory Note 5)*—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 to satisfy him that the material is being furnished in accordance with this specification.

9.1.1 Unless otherwise agreed by the manufacturer and the purchaser, 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.

9.1.2 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.

9.2 *Terms Applying to Inspection:*

9.2.1 *Lot*—A lot is any amount of wire of one type and size presented for acceptance at one time, such amount, however, not to exceed 10 000 lb (4540 kg) (Explanatory Note 10).

9.2.2 *Sample*—A sample is 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.

9.2.3 *Specimen*—A specimen is a length of wire removed for test purposes from any individual production unit of the sample.

9.2.4 *Sample Size*—The number of production units in a sample (Explanatory Note 5) shall be as follows:

9.2.4.1 For elongation, resistivity, and weight of coating determinations, the sample shall consist of four production units. For continuity of coating 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.

9.2.4.2 For dimensional measurements and surface finish, the samples shall consist of a quantity of production units shown in Table 2 under the heading "First Sample."

9.2.4.3 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 3.

10. Packaging and Package Marking

10.1 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.

11. Keywords

11.1 copper wire silver-coated; silver-coated annealed copper wire; silver-coated copper electrical equipment wire; silver-coated soft copper wire

EXPLANATORY NOTES

NOTE 1—Silver 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 the use of tin-coated wires.

(b) A low-contact resistance between the strands of outer conductors of coaxial conductors used in high-frequency circuits.

(c) A lost radio-frequency resistance of conductors used in high-frequency circuits (skin effect).

(d) Good 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—**Warning:** Consideration shall be given to toxicity and flammability when selecting solvent cleaners.

NOTE 3—The values of the wire diameters in Table 1 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*.[3]

NOTE 4—Whether the silver is applied by electroplating or by mechanical cladding, coatings less than 40 µin. (0.00004 in.) in thickness will not pass the" Continuity of Coating" test. See Table 1 for thickness of coatings for the various classes of coating and wire sizes.

NOTE 5—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 6—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 7—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 tests 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 8—Resistivity units are based on the International Annealed Copper Standard (IACS) adopted by IEC in 1913, which is 1/58 Ω·mm^2/m at 20°C for 100 % conductivity. The value of 0.017241 Ω·mm^2/m and the value of 0.15328 Ω·g/m^2 at 20°C are respectively the international equivalent of volume and weight resistivity of annealed copper equal (to 5 significant figures) 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 Ω. This is equivalent to a resistivity value of 875.20 Ω·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 µΩ/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* of the National Institute of Standards and Technology.[3] 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 reasonably accurate reversible conversion from one set of resistivity units to another. The equivalent resistivity values in Table 4 were derived from the fundamental IEC value (1/58 Ω· mm^2/m) computed to 7 significant figures and then rounded to 5 significant figures.

NOTE 9—It is important that the polysulfide solution be of a proper composition and strength at the time of test. A solution that is not saturated with sulfur or that has been made from decomposed sodium sulfide crystals may give a false indication of failure. Therefore, the requirement 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 the solution to stand at least 24 h after preparation. Attention is called also to the necessity for the use of sodium sulfide that has not deteriorated through exposure to air; and 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 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

TABLE 4 Resistivity Relations

Conductivity at 20°C %	100.00
Ω·lb/mile^2	875.20
Ω·g/m^2	0.15328
Ω·cmil/ft	10.371
Ω·mm^2/m	0.017241
µΩ·in.	0.67879
µΩ·cm	1.7241

[3] Available from National Technical Information Service (NTIS), 5285 Port Royal Rd., Springfield, VA 22161, http://www.ntis.gov.

acceptability of such small lots.

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

NOTE 12—*Principle of Operation of the Electronic Thickness Tester*—The unit operates by anodically deplating a small surface area of the specimen in a cell containing the test solution. The cell serves as 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 the cell; when all 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 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 is 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—When used for "wire testing," Kocour K5000 or K6000 model thickness testers should be set "to read in MIL." That display reading in "mil" when multiplied by 100 equates to the "counter readings" for K1000 models. The user of the standard should refer to the operation manual for the particular model being used.

NOTE 14—The equation given for the weight of the silver 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 percent weight than is actually present. The more correct equation for all cases based on a density of 10.5 g/cm^3 for silver and 8.89 g/cm^3 for copper is as follows:

$$\text{Silver } \% = 472.43/[1.7243 + d/t + t/(d - t)]$$

where:

d = overall wire diameter, in., and
t = thickness of plate, in.

APPENDIXES

(Nonmandatory Information)

X1. METHOD A—ELECTRONIC DETERMINATION (EXPLANATORY NOTE 12)

X1.1 Apparatus and Reagent

X1.1.1 Electronic Thickness Tester with Accessory Unit" WT."[4]

X1.1.2 Solution R-48.[4]

X1.2 Limitations of Method A

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

Wire Size	Sample Length, in.
0.0720 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 110-V, 60Hz, ac. Insert the jack plug on accessory unit lead wire into the jack according to the manufacturer's instructions on the *left* side of the thickness tester. Turn "Plate" selector to setting marked "Silver." Turn 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-48. 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. 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.

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 silver, in percent of the total weight of the wire, may be calculated as follows (Explanatory Note 14):

$$\text{Silver, } \% = t/d \times 0.47243 \times 10^{-3}$$

where:

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

X1.4 Precautions

X1.4.1 Make no adjustments at the specimen while instrument is in operation. If an adjustment is necessary, stop the test by pressing the" Stop" button, make the adjustment, and repeat the test with a new sample.

X1.4.2 Avoid spilling test solutions into the accessory unit.

X1.4.3 Wire samples must be clean. If the wire is lacquered, remove the lacquer with a solvent before testing.

[4] The above named apparatus and reagent is the product of Kocour Company, 4800 So. St. Louis Ave., Chicago, IL 60632.

TABLE X1.1 Thickness Factors

NOTE 1—The thickness factor for sizes not shown in Table X1.1 may be calculated by the following equation:

$$F = (aD^{b}/\text{test length})$$

where:

D = wire diameter,
b = −1.0044,
a = 0.0453, and
F = thickness factor.

Wire Size, Diam, in.	Test Length, in.	Thickness, 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

X1.4.4 Do not store test solutions in the stainless steel beaker. After daily use or after a series of tests have been completed, return the test solution to a re-use storage bottle, and rinse the beaker thoroughly with water and dry it. Do not return used solutions to the original stock solution. Use a separate bottle for the used solution.

X1.4.5 Test solutions may be reused. The extent to which the solutions become exhausted depends upon the number and size of the parts tested, as well as upon the thickness of the deposits which are stripped. In general, solutions may be reused approximately eight or ten times, or until erratic results are obtained, before discarding.

X1.4.6 The minimum thickness of deposit which can be tested on a particular gage of wire is determined by multiplying the factor for the wire gage by 5.

X2. METHOD B—GRAVIMETRIC DETERMINATION

X2.1 Apparatus

X2.1.1 The apparatus and reagents used shall conform to Practices E50.

X2.1.2 *Beaker,* 600-mL, of chemically resistant glass.[5]

X2.1.3 *Filtering Crucible,* No. 10 porosity (pore size, 4.4 µm), conforming to the requirements prescribed for Apparatus No. 2 in Section 7 of Practices E50.

X2.2 Reagents

X2.2.1 The reagents described in the X2.2.1.1 through X2.2.1.4 shall conform to Sections 3 and 4 of Practices E50.

X2.2.1.1 *Nitric Acid* (1 + 4).

X2.2.1.2 *Nitric Acid Wash Solution* (1 + 99).

X2.2.1.3 *Sodium Chloride Solution* (100 g NaCl/L).

X2.2.1.4 *Alcohol Wash Solution (1 + 1)*—Mix equal volumes of special denatured alcohol and water.

X2.3 Procedure

X2.3.1 Weigh, to the nearest 0.1 mg, a portion of the sample of silver-coated wire of a length equivalent to 10 to 40 mg of silver. Transfer the sample to a 600-mL chemically resistant glass beaker and add 20 mL of HNO_3 (1 + 4)/gram of sample. Cover the beaker, warm gently until solution is complete, and boil to expel brown fumes. Dilute the solution with distilled water, using approximately 50 mL of water/g of sample. Heat to boiling, remove from the hot plate, and add slowly, with rapid stirring, 10 mL of NaCl solution. Boil the solution 2 to 3 min to coagulate the AgCl precipitate. Allow to cool and the precipitate to settle.

X2.3.2 Filter, using a tared, No. 10 porosity filtering crucible. Wash free of copper salts with HNO_3 wash solution,

[5] Borosilicate has been found satisfactory for this purpose.

followed by two to four washings with alcohol wash solution. Dry in an oven at 205°C to constant weight. Cool and weigh as AgCl.

X2.3.3 *Calculation*—Calculate the weight of the coating as a percentage of the total weight of the wire as follows:

$$\text{Silver, } \% = \left[(A \times 0.7526)/B\right] \times 100$$

where:

A = AgCl, g, and
B = sample used, g.

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