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Standard Specification for Tin-Coated, Copper-Clad Steel Wire for Electronic Application[1]

This standard is issued under the fixed designation B 520; 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.

ϵ^1 NOTE—Editorial changes were made throughout in March 1998.

1. Scope

1.1 This specification covers tin-coated copper-clad steel wire for electronic application.

1.2 Four classes of tin-coated copper-clad steel wire are covered as follows:

1.2.1 *Class T30HS*— Nominal 30 % conductivity, hard-drawn,

1.2.2 *Class T30A*—Nominal 30 % conductivity, annealed,

1.2.3 *Class T40HS*— Nominal 40 % conductivity, hard-drawn, and

1.2.4 *Class T40A*—Nominal 40 % conductivity, annealed.

1.3 The values stated in inch-pound units are to be regarded as the standard. The metric equivalents of inch-pound units may be approximate. The values given in parentheses are for information only.

1.4 The following safety hazards caveat pertains only to the test method portion, Section 6, 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.* Specific hazard statements are given in Note 1.

NOTE 1—**Precaution:** Consideration should be given to toxicity and flammability when selecting solvent cleaners.

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:*

B 193 Test Method for Resistivity of Electrical Conductor Materials[2]

B 258 Specification for Standard Nominal Diameters and Cross-Sectional Areas of AWG Sizes of Solid Round Wires Used as Electrical Conductors[2]

B 452 Specification for Copper-Clad Steel Wire for Electronic Application[2]

2.3 *National Institute of Standards and Technology:*

NBS *Handbook 100—Copper Wire Tables*[3]

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 (see 5.3 and Table 1),

3.1.3 Class of wire (see 1.2),

3.1.4 Package size and shipping (see section 7.8 and Section 9), packaging inspection if required (see 9.3.3),

3.1.5 Special package marking, if required, and

3.1.6 Place of inspection (see 9.1).

4. Material

4.1 The basis material shall consist of copper-clad steel wire conforming to the product description, quality and specification requirements of Specification B 452.

4.2 The tin-coated wire shall consist of the basis wire coated with tin. The tin used for coating shall be commercially pure (Note 2). For purposes of this specification, the tin shall be considered" commercially pure" if the total of other elements, exclusive of copper, does not exceed 1 %. Notwithstanding the previous sentence, chemical analysis of the tin coating or of the tin used for coating shall not be required under this specification. Adequacy of the tin coating is assured by the continuity of coating and adherence of coating requirements (see 5.4 and 5.5). The quality of the tin-coated wire shall be such that the finished product meets the properties and requirements in this specification.

NOTE 2—It is necessary that the coating of the tin on the wire be continuous. The test in the sodium polysulfide is for the purpose of determining whether or not the wire carries a continuous envelope of pure tin. The thickness of the tin coating is necessarily varied. Under the same conditions of tinning, the coating on all sizes of wire, excepting on fine wire, is approximately the same. The coating on fine wire is in general relatively heavier than that on coarse wire. It is not, therefore, correct to apply a larger number of cycles in the test on coarse wire than is applied

[1] This specification is under the jurisdiction of ASTM Committee B-1 on Electrical Conductors and is the direct responsibility of Subcommittee B01.06 on Composite Conductors.

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

[3] Available from the National Institute of Standards and Technology, (NIST), Gaithersburg, MD 20899.

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TABLE 1 Wire Sizes

Diameter		Cross-Sectional Area at 20°C (68°F)		
in.	mm	cmil	$in.^2$	mm^2
0.0720	1.8129	5180	0.00407	2.63
0.0641	1.6128	4110	0.00323	2.08
0.0571	1.450	3260	0.00256	1.65
0.0508	1.290	2580	0.00203	1.31
0.0453	1.151	2050	0.00161	1.04
0.0403	1.024	1620	0.00128	0.823
0.0359	0.912	1290	0.00101	0.653
0.0320	0.813	1020	0.000804	0.519
0.0285	0.724	812	0.000638	0.412
0.0253	0.643	640	0.000503	0.324
0.0226	0.574	511	0.000401	0.259
0.0201	0.511	404	0.000317	0.205
0.0179	0.455	320	0.000252	0.162
0.0159	0.404	253	0.000199	0.128
0.0142	0.361	202	0.000158	0.102
0.0126	0.320	159	0.000125	0.0804
0.0113	0.287	128	0.000100	0.0647
0.0100	0.254	100	0.0000785	0.0507
0.0089	0.226	79.2	0.0000622	0.0401
0.0080	0.203	64.0	0.0000503	0.0324
0.0071	0.180	50.4	0.0000396	0.0255
0.0063	0.160	39.7	0.0000312	0.0201
0.0056	0.142	31.4	0.0000246	0.0159
0.0050	0.127	25.0	0.0000196	0.0127
0.0045	0.114	20.2	0.0000159	0.0103
0.0040	0.102	16.0	0.0000126	0.00811
0.0035	0.089	12.2	0.00000962	0.00621
0.0031	0.079	9.61	0.00000755	0.00487

to fine wire. It is probable that one cycle of the dip test would be sufficient to discover defects in tinned wire, but in order to make certain that no partially covered spots may escape attention, provision has been made for two cycles. It has been found that the tin coating on copper wire consists of two parts, an envelope of pure tin on the outside, with an intermediate layer of copper-tin alloy. This tin alloy, as well as the amount of tin present, has an effect on the resistivity of the wire. Since the relative amount of tin coating and alloy is greater on the small wire than it is on the coarser wire, the resistivity of the wire increases as the size decreases. This also accounts for the decrease in elongation due to tinning soft wire.

5. General Requirements

5.1 Tensile strength and elongation of the tin-coated wire shall conform to the requirements of Specification B 452 for the applicable size and class of copper-clad steel wire.

5.2 *Resistivity*— The electrical resistivity at a temperature of 20°C shall not exceed the values prescribed in Table 2. See Note 3 for calculating electrical resistance.

TABLE 2 Resistivity, max at 20°C

Class of Wire	Nominal Diameter, in. (mm)	$\Omega \cdot mm^2/m$
T30HS	0.0720 (1.829) to 0.0201 (0.511) incl	0.06743 (0.067427)
and	under 0.0201 (0.511) to 0.0113 (0.287) incl	0.07315 (0.073148)
T30A	under 0.0113 (0.287) to 0.0031 (0.079) incl	0.07642 (0.076423)
T40HS	0.0720 (1.829) to 0.0201 (0.511) incl	0.04874 (0.048742)
and	under 0.0201 (0.511) to 0.0113 (0.287) incl	0.05162 (0.051618)
T40A	under 0.0113 (0.287) to 0.0031 (0.079) incl	0.05328 (0.053280)

NOTE 3—Relationships that may be useful in connection with the values of electrical resistivity prescribed in this specification are shown in Table 3. Resistivity units $\frac{1}{58} \Omega \cdot mm^2/m$ and 0.15328 $\Omega \cdot g/m^2$ at 20°C are respectively the international equivalent of volume and weight resistivity of annealed copper equal 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 $\Omega \cdot lb/mile^2$, 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*. 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 B 193. The use of five significant figures is required for complete reversible conversion from one set of resistivity units to another.

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. (0.003 mm) (Note 4). For diameters under 0.0100 in. (0.254 mm), the wire shall not vary from the specified diameter by more than plus 0.0003 in. (0.008 mm) and minus 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 plus 3 % and minus 1 %, expressed to the nearest 0.0001 in. (0.003 mm).

NOTE 4—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 B 258. 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 "Copper Wire Tables" *NBS Handbook 100*.

5.4 *Continuity of Coating*—The tin coating shall be continuous. The continuity of coating on the wire shall be determined on representative samples taken before stranding or insulating. The continuity of tinning shall be determined by the hydrochloric acid-sodium polysulfide test in accordance with 6.2.

5.5 *Adherence of Coating*—The tin coating shall be firmly adherent to the surface of the copper-clad steel wire. The 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 6.3.

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

6. Test Methods

6.1 For tensile strength, elongation, resistivity, dimensional measurement and the quality of the basis wire, the latest issue of Specification B 452 shall apply and the tests shall be performed on the tin-coated wire.

6.2 *Continuity of Coating*:

6.2.1 *Specimens*:

6.2.1.1 *Length of Specimens*—Test specimens shall each

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TABLE 3 Equivalent Resistivity Values

Class and Size, in. (mm)	Volume Conductivity at 20°C % IACS	Resistivity Equivalents at 20°C					
		Volume				Mass	
		Ω-mm²/m	Ω-c mil/ft	μΩ-in.	μΩ-cm	Ω-lb/mile²	Ω-g/m²
T30A and T30HS 0.0720 (1.829) to 0.0201 (0.511)	25.570	0.067427	40.56	2.6546	6.7427	3137.9	0.54953
Under 0.0201 (0.511) to 0.0113 (0.287)	23.570	0.073148	44.00	2.8799	7.3148	3404.1	0.59616
Under 0.0113 (0.287) to 0.0031 (0.079)	22.560	0.076423	45.97	3.0088	7.6423	3556.5	0.62285
T40A and T40HS 0.0720 (1.829) to 0.0201 (0.511)	35.372	0.048742	29.32	1.9190	4.8742	2268.3	0.39725
Under 0.0201 (0.511) to 0.0113 (0.287)	33.401	0.051618	31.05	2.0322	5.1618	2402.2	0.42069
Under 0.0113 (0.287) to 0.0031 (0.079)	32.359	0.053280	32.05	2.0977	5.3280	2479.5	0.43423

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.

6.2.1.2 *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. (**Precaution**—See Note 1.) 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 by the cut ends.

6.2.2 *Special Solutions*:

6.2.2.1 *Hydrochloric Acid Solution* (sp gr 1.088)—Commercial HCl (sp gr 1.12) shall be diluted with distilled water to a specific gravity of 1.088 measured at 15.6°C (60°F). A portion of HCl solution having a volume of 180 mL shall be considered to be exhausted when the number of test specimens prescribed in Table 4 of a size as indicated in 6.2.3 have been immersed in it for two cycles.

6.2.2.2 *Sodium Polysulfide Solution* (sp gr 1.142) (Note 5)—A concentrated solution shall be made by dissolving sodium sulfide cp crystals in distilled water until the solution is saturated at about 21°C (70°F), 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 (60°F). The sodium polysulfide test solution should have sufficient strength to blacken thoroughly a piece of clean untinned 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.

TABLE 4 Limiting Number of Test Specimens for Coating Tests

Nominal Diameter, in. (mm)	Maximum Number of Specimens to be Tested for Two Cycles in 180 mL of Acid Solution
0.0720 (1.829) to 0.0501 (1.273) incl	6
Under 0.0501 (1.273) to 0.0381 (0.968) incl	10
Under 0.0381 (0.968) to 0.0301 (0.765) incl	12
Under 0.0301 (0.765) to 0.0031 (0.079) incl	14

NOTE 5—It is important that the polysulfide solution be of 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 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 which 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.

6.2.3 *Procedure*:

6.2.3.1 *Immersion of Specimens*—Immerse a length of at least 4½in. (115 mm) from each of the clean specimens, in accordance with the following cycles, in test solutions maintained at a temperature between 15.6 and 21°C (60 and 70°F): (*1*) immerse the specimen for 1 min in the HCl solution described in 6.2.2, wash, and wipe dry; (*2*) immerse the specimen for 30 s in the sodium polysulfide solution described in 6.2.2, wash, and wipe dry; (*3*) immerse the specimen for 1 min in the HCl solution, wash, and wipe dry; (*4*) immerse the specimen for 30 s in the sodium polysulfide solution, wash, and wipe dry.

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

6.2.3.3 *Examination of Specimens*—After immersion and washing, examine the specimens with the unaided eye (normal spectacles excepted) to ascertain if copper exposed through openings in the tin coating has been blackened by action of the sodium polysulfide. 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. (13 mm) of the cut end.

6.3 *Adherence of Coating*:

6.3.1 *Specimens*:

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6.3.1.1 *Length of Specimens*—Test specimens shall be approximately 12 in. (300 mm) in length and shall be tagged or marked to correspond with the coil, spool, or reel from which they are cut.

6.3.1.2 *Treatment of Specimens*—The specimens shall be thoroughly cleaned, if required, by immersion in a suitable organic solvent such as benzene, ether, or trichlorethylene for at least 3 min, then removed and dried. (**Precaution**—See Note 1.) The specimens thus cleaned shall be kept wrapped in a clean dry cloth until tested. That part of the specimens 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 of sizes 0.005 in. (0.127 mm) and smaller may be cleaned after wrapping around the mandrel.

6.3.2 *Procedure* :

6.3.2.1 *Wrapping*—Slowly wrap the test specimen in a suitable manner in an open helix around a polished mandrel having rounded ends and a diameter not to exceed four times the nominal diameter of the specimen. 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 sizes 0.021 in. (0.533 mm) and smaller, not more than six helical turns shall be used for the test, and for wire larger than 0.021 in. (0.533 mm), not more than three turns shall be used.

6.3.2.2 *Immersion Test*— Remove the helically wrapped portion of the test specimen from the mandrel and completely immerse in the sodium polysulfide solution (see 6.2.2) for 30 s at the temperature prescribed in 6.2.3. On removal from the sodium polysulfide solution, rinse the specimen immediately in clean water and remove the excess by shaking.

6.3.2.3 *Examination of Specimens*—Visually examine the outer peripheral surface of the helically wrapped portion of the specimen. For wires 0.021 in. and smaller, a magnification not greater than three times may be used. Any cracking or parting of the coating in this area shown by blackening of the copper shall be cause for rejection. A grayish appearance of the coating after immersion shall not constitute failure.

7. Conformance Criteria (Note 6)

NOTE 6—Cumulative results secured on the product of a single manufacturer indicating continued conformance to the criteria, are necessary to ensure an over-all product criteria given for the various characteristics are applicable only to lots produced under these conditions.

7.1 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 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:

7.1.1 *Tensile Properties*—The lot shall be considered conforming if the conformance criteria of Specification B 452 have been met for tensile properties and the quality characteristics relative to the basis wire.

7.1.2 *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 criterion of 5.2.

7.1.3 *Dimensions*—The dimensions of the first sample (Table 5) shall conform to the requirements of 5.3. 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 5) 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.

7.1.4 *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 criterion, eight additional specimens from the lot shall be tested, all of which shall conform to the continuity criterion. However, any individual production unit, the specimen from which failed to meet the continuity criterion, shall be rejected.

7.1.5 *Adherence of Coating*—The adherence of the coating of each of the eight specimens shall conform to the requirements of 5.5. Failure of more than two specimens shall constitute failure to meet the adherence criterion. If not more than two specimens fail to meet the adherence criterion, 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.

7.1.6 *Finish*—The finish of the samples taken in accordance with Table 5 shall conform to the requirements of 5.7. The number of units in the sample showing surface defects not consistent with commercial practice shall not exceed the

TABLE 5 Sampling for Dimensional Measurements

Number of Units in Lot	First Sample		Second Sample		
	Number of Units in Sample n_1	Allowable Number of Defects in Sample c_1	Number of Units in Sample n_2	$n_1 + n_2$	Allowable Number of Defects in Both Samples, c_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

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allowable defect number c, in Table 6. Failure to meet this requirement shall constitute failure to meet the finish conformance criterion.

7.1.7 *Packaging*—Conformance to the packaging requirements specified by the purchaser shall be determined in accordance with Table 6. The number of units in the sample showing conformance to the requirements shall not exceed the allowable defect number c, in Table 6. Failure to meet this requirement shall constitute failure to meet the packaging conformance criterion.

8. Density

8.1 For the purpose of calculating mass, cross section, etc., the density of the wire shall be taken as 0.29444 lb/in.^{3} (8.15 g/cm^3) at 20°C for the material covered by this specification.

9. Inspection

9.1 *General*—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 the purchase. The manufacturer shall afford the inspector representing the purchaser all reasonable facilities necessary to ensure that the material is being furnished in accordance with this specification (Note 5).

9.1.1 Unless otherwise agreed to between 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 *Description of Inspection Terms*:

9.2.1 *Lot*—A lot is 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 7).

NOTE 7—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 manufacturer's regular inspection of the product as a whole as evidence of acceptability of such small lots.

TABLE 6 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

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.

9.3 *Sample Size*— The number of production units in a sample (Note 6) shall be as follows:

9.3.1 For tensile strength, elongation, resistivity, and adherence of coating, the sample shall consist of four production units (Note 8). For surface finish the sampling shall be in accordance with Table 6. From each unit, one test specimen of sufficient length shall be removed for the performance of required tests.

NOTE 8—It is known that the rate of loading during tension testing affects the performance of the sample to a greater or lesser extent depending upon many factors. 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 case of tests on soft or annealed 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 (300 mm/min) do not alter the final results of tensile strength and elongation determinations to any practical extent. In the case of hard-drawn wire, these effects are pronounced when the speed of the moving head is excessive. It is suggested that tests be made at speeds of moving head which, under no-load conditions, are not greater than 3 in./min (76 mm/min), but in no case at a speed greater than that at which correct readings can be made.

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

9.3.3 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 as shown in Table 6.

10. Packaging and Shipping

10.1 The package size shall be agreed upon by the manufacturer and the purchaser in the placing of individual orders (Note 9). The wire shall be protected against damage in ordinary handling and shipping.

NOTE 9—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.

11. Keywords

11.1 clad steel electrical conductor; copper-clad steel electrical conductor; electrical conductor; tin-electrical/electronic application; tin-coated; copper-clad steel wire

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