Designation: B324 – 01 (Reapproved 2016)

Standard Specification for Aluminum Rectangular and Square Wire for Electrical Purposes[1]

This standard is issued under the fixed designation B324; 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.

1. Scope

1.1 This specification covers aluminum 1350-O, annealed, 1350-H12 or -H22 (¼ hard), 1350-H14 or -H24 (½ hard), 1350-H16 or -H26 (¾ hard), and 1350-H19 (extra hard) wire, rectangular or square in shape with rounded corners for use as electrical conductors in insulated magnet wire.

1.2 The values stated in inch-pound or SI units are to be regarded separately as standard. Each system shall be used independently of the other. Combining the values from the two systems may result in non-conformance with the specification. For conductor sizes designated by AWG or kcmil sizes, the requirements in SI units are numerically converted from the corresponding requirements in inch-pound units. For conductor sizes designated by AWG or kcmil, the requirements in SI units have been numerically converted from corresponding values stated or derived in inch-pound units. for conductor sizes designated by SI units only, the requirements are stated or derived in SI units.

1.2.1 For density, resistivity and temperature, the values stated in SI units are to be regarded as standard.

NOTE 1—The aluminum and temper designations conform to ANSI H35.1. Aluminum 1350 corresponds to Unified Numbering System A91350 in accordance with Practice E527.

2. Referenced Documents

2.1 The following documents of the issue in effect on date of material purchase form a part of this specification to the extent referenced herein:

2.2 *ASTM Standards:*[2]

B193 Test Method for Resistivity of Electrical Conductor Materials

B233 Specification for Aluminum 1350 Drawing Stock for Electrical Purposes

B279 Test Method for Stiffness of Bare Soft Square and Rectangular Copper and Aluminum Wire for Magnet Wire Fabrication

B557 Test Methods for Tension Testing Wrought and Cast Aluminum- and Magnesium-Alloy Products

B830 Specification for Uniform Test Methods and Frequency

E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

E527 Practice for Numbering Metals and Alloys in the Unified Numbering System (UNS)

2.3 *ANSI Standard:*

H35.1/H35.1(M) Standard for Alloy and Temper Designation Systems for Aluminum[3]

2.4 *American National Standards:*

NBS *Handbook 100* —Copper Wire Tables[4]

NBS *Handbook 109* —Aluminum Wire Tables[4]

3. Description of Terms Specific to This Standard

3.1 *lot*—an inspection lot shall consist of an identifiable quantity of wire subjected to inspection at one time. Each lot shall consist of units of wire of the same size and temper, manufactured under essentially the same conditions at essentially the same time. The amount in any case shall not exceed 30 000 lb (14 000 kg).

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

3.3 *sample size*—the number of production units selected.

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

4. Ordering Information

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

[1] This specification is under the jurisdiction of ASTM Committee B01 on Electrical Conductors and is the direct responsibility of Subcommittee B01.07 on Conductors of Light Metals.

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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] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

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

4.1.1 Quantity and temper of each size and shape (see Section 5),

4.1.2 Wire size; thickness and width in inches or in millimetres (see Section 7),

4.1.3 Mandrel diameter for the edgewise bend test,

4.1.4 Place of inspection if other than at place of manufacture (see 12.2),

4.1.5 Whether inspection or witness of inspection and tests by purchaser's representative is required prior to shipment (see 12.3),

4.1.6 Packaging and marking (see Section 13), and

4.1.7 Special package marking, if required (see 13.4).

5. Materials and Manufacture

5.1 *Material:*

5.1.1 The aluminum wire shall be made from rod in accordance with the requirements of Specification B233.

5.2 *Manufacture:*

5.2.1 Unless otherwise specified, the manufacturer shall have the option of producing the intermediate tempers by either strain-hardening (only for H12, H14, H16 and H19) or by strain-hardening and annealing (1350-O) or partial annealing H22, H24 and H26) (Explanatory Note 1 and ANSI H35.1/H35.1(M)).

5.2.1.1 When the manufacturer is given the option in 5.2.1, the intermediate tempers shall be specified as: H12 or H22; H14 or H24; H16 or H26.

5.2.1.2 When the manufacturer is not given the option in 5.2.1, the specific temper should be specified, for example, H19, H22, etc.

6. General Requirements

6.1 *Tensile Properties*—The wire shall conform to the requirements for tensile properties prescribed in Table 1.

6.2 *Resistivity*—The electrical resistivity of the wire shall not exceed the following values (Explanatory Note 2):

6.2.1 *All tempers except 1 350-O,*—0.028264 Ω·mm^2/m (17.002 Ω·cmil/ft) at 20°C, (61.0 Volume Conductivity % IACS).

6.2.2 *For 1350-O*—0.027898 Ω·mm^2/m (16.782 Ω·cmil/ft) at 20°C, (61.8 Volume Conductivity % IACS).

6.3 *Joints*—The finished wire shall not contain joints except such as have passed through drawing dies or an equivalent rolling operation. Necessary joints in the wire and rods prior to final drawing or rolling shall be made in accordance with good commercial practice.

6.4 *Bending Properties*—1350-O wire shall be capable of being bent edgewise through 180° around a mandrel without cracking under normal conditions of edgewise bending during manufacturing operations. The mandrel diameter shall be as agreed upon between the manufacturer and the user, and shall be not less than one half the nominal width of the material being bent. In cases where the mandrel diameter used is less than 5/32 in. (3.97 mm) or the thickness of the wire is less than 0.020 in. (0.51 mm) or the ratio of width to thickness of the wire is greater than 12 to 1, the edgewise bending properties of the wire shall be as agreed upon between the user and the manufacturer (see Explanatory Note 3 and Explanatory Note 4).

6.5 *Low Stress Elongation (LSE)*—The annealed wire (0 temper) shall have a minimum LSE valve of 1 % determined in accordance with Test Method B279. LSE test results are affected by small amounts of cold working. The specified 1 % minimum LSE value applies only to bare wires for further processing.

7. Dimensions and Permissible Variations

7.1 The dimensions shall be expressed in decimal fractions of an inch or in millimetres (Explanatory Notes 5-8).

7.1.1 The thickness shall not vary from that specified by more than the amounts shown in Table 2.

7.1.2 The width shall not vary from that specified by more than the amount shown in Table 3.

7.2 The wire shall have rounded corners or rounded edges as specified in Table 4 and as shown in Fig. 1. Where rounded corners are required, the corners of the wire shall be rounded within the limits of radii 25 % under and 25 % over (as determined by a radius gage) those values specified in Table 4.

8. Workmanship, Finish, and Appearance

8.1 The wire shall be free of all imperfections not consistent with good commercial practice.

9. General Methods and Conditions

9.1 *Nominal Cross-Sectional Areas*—Nominal cross-sectional areas in square mils or square millimetres shall be calculated by subtracting the area reductions due to the rounded corners or rounded edges (see Table 5 and Table 6). Values so derived shall be rounded off in accordance with 9.4 to the same number of significant figures as used in expressing the nominal dimensions, but in no case to less than three significant figures.

TABLE 1 Tensile Requirements

NOTE 1—For purposes of determining conformance with these specifications, each calculated value of tensile strength shall be rounded off to the nearest 0.1 ksi, in accordance with the rounding method of Practice E29.

Temper	Tensile Strength			
	Max		Min	
	ksi	MPa	ksi	MPa
–0	14.0	97	8.5	59
–H12, – H22	17.0	117	12.0	83
–H14, – H24	20.0	138	15.0	103
–H16, – H26	22.0	152	17.0	117
–H19	29.0	200	22.0	152

TABLE 2 Permissible Variations in Thickness

Specified Thickness, in. (mm)	Permissible Variations in Thickness, in. (mm), plus and minus
0.280 to 0.098 (7.10 to 2.50), incl	1 %
Under 0.098 to 0.025 (2.50 to 0.63), incl	0.001 (0.025)

TABLE 3 Permissible Variations in Width

Specified Width, in. (mm)	Permissible Variations in Width in. (mm), plus and minus
0.520 (12.5) and over	1 %[A]
Under 0.520 to 0.315 (12.5 to 8.00), incl	0.003 (0.076)
Under 0.315 to 0.098 (8.00 to 2.50), incl	1 %
Under 0.098 to 0.063 (2.50 to 1.60), incl	0.001 (0.025)

[A] But not to exceed 0.016 in. (0.406 mm).

9.2 *Nominal Mass and Lengths*—Nominal linear density and lengths shall be calculated from the nominal wire dimensions in accordance with the following equations and shall be rounded off in the final values only, in accordance with 9.4, to the same number of significant figures as used in expressing the nominal dimensions, but in no case less than three significant figures.

$$\text{Mass per Unit Length lb/ft} = 1.17 \times A \times 10^{-6}$$

$$\text{kg/km} = 2.705 \times A_1$$

$$\text{Length ft/lb} = (0.8547 \times 10^6)/A$$

$$\text{km/kg} = (0.36969)/A_1$$

where:

A = nominal cross-sectional area obtained in accordance with 9.1, mil^2, and

A_1 = nominal cross-sectional area obtained in accordance with 9.1, mm^2.

9.3 *Density*—For the purpose of calculating linear density, (Note 2), cross sections, etc., the density of aluminum 1350 shall be taken as 0.0975 lb/in.^{3} (2705 kg/m^3) at 20°C.

NOTE 2—The term mass per unit length is used in the standard as being technically correct, and it replaces the terms "weight" or "linear density."

9.4 *Rules for Rounding-Off*—All calculations for the standard nominal dimensions and properties shall be rounded in the final value only, in accordance with the rounding method of Practice E29.

9.5 For the purpose of this specification, all wire dimensions and properties shall be considered as occurring at the internationally standardized reference temperature of 20°C. When measurements are made at temperatures other than this, corrections shall be applied to bring the results to the reference temperature.

10. Sampling Plan and Conformance Criteria

10.1 *Sampling Plan*—Determine the conformance of the material to the requirements of Sections 6, 7, and 8 by statistical sampling and inspection of each lot of wire presented for inspection in accordance with Specification B830.

10.2 *Conformance Criteria:*

10.2.1 Failure of a specimen to conform to the applicable requirements of Section 6, 7, and 8 shall constitute failure of the production unit from which the specimen was taken.

10.2.2 Any lot of wire that has been sampled in accordance with 10.1 and from which the number of specimens failing to comply with the requirements of Sections 6, 7, and 8 does not equal or exceed the appropriate reject number of the sampling table used shall be considered as complying with the requirements of Sections 6, 7, and 8.

10.2.3 Rejected lots may be screened to remove nonconforming production units by testing one specimen from each production unit in the lot for the failing characteristic.

11. Test Methods

11.1 *Tensile Strength*—The tensile strength, when tested in accordance with Test Methods B557, shall be obtained by dividing the maximum load carried by the specimen during the tension test by the cross-sectional area of the specimen obtained in 9.1 (Explanatory Note 9).

11.1.1 If any part of the fracture takes place in the jaws of the tensile machine, or if an examination indicates that there was external damage, the value obtained may not be representative of the material. In such cases, the test may be discarded and a new test made.

11.2 *Resistivity*—The electrical resistivity of the wire shall be determined by resistance measurements in accordance with Test Method B193 (Explanatory Note 2 and Table 7).

11.2.1 Nominal resistance and other values derived from the resistivity units shall be calculated from the nominal wire dimensions in accordance with the following equations and all values so derived shall be rounded off in the final value only, in accordance with 9.4, to the same number of significant figures as used in expressing the nominal dimensions, but in no case to less than three significant figures.

11.2.1.1 *All tempers except 1350-O:*

d-c resistance at 20°C,

$$\Omega/\text{ft} = 13.353/A$$
$$\Omega/\text{km} = 28.264/A_1$$

d-c resistance at 20°C,

$$\Omega/\text{lb} = (11.413 \times 10^6)/A^2$$
$$\Omega/\text{kg} = 10.449/A_1^2$$

Length at 20°C,

$$\text{ft}/\Omega = 0.07489 \times A$$
$$\text{km}/\Omega = 0.03538 \times A_1$$

Mass at 20°C,

$$\text{lb}/\Omega = 0.087619 \times A^2 \times 10^{-6}$$
$$\text{kc}/\Omega = 0.095703 \times A_1^2$$

11.2.1.2 *1350-O:*

d-c resistance at 20°C,

$$\Omega/\text{ft} = 13.181/A$$
$$\Omega/\text{km} = 27.898/A_1$$

d-c resistance at 20°C,

$$\Omega/\text{lb} = (11.266 \times 10^6)/A^2$$
$$\Omega/\text{kg} = 10.313/A_1^2$$

Length at 20°C,

$$\text{ft}/\Omega = 0.075867 \times A$$
$$\text{km}/\Omega = 0.03584 \times A_1$$

Mass at 20°C,

$$\text{lb}/\Omega = 0.088763 \times A^2 \times 10^{-6}$$
$$\text{kg}/\Omega = 0.096965 \times A_1^2$$

where:

A = nominal cross-sectional area of the wire obtained in accordance with 9.1, mil^2.

A_1 = nominal cross-sectional area of the wire obtained in accordance with 9.1, mm^2.

11.3 *Dimensional Measurements*—Samples of coils, reels or spools shall be gaged at each end for both width and thickness. If the inner end is not accessible, the gaging representing the