



# Standard Specification for Aluminum 1350 Drawing Stock for Electrical Purposes<sup>1</sup>

This standard is issued under the fixed designation B 233; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

<sup>ε1</sup> NOTE—Editorial changes were made to sections 4.2, 7.2, 7.4 and 10.1 May 2003.

## 1. Scope

1.1 This specification covers aluminum 1350 drawing stock 0.375 in. (9.52 mm) to 1.000 in. (25.40 mm) in diameter, in the tempers shown in Table 1, for drawing into wire for electrical conductors (Explanatory Note 1 and Note 2).

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

NOTE 1—Prior to 1975, aluminum 1350 was designated as EC aluminum.

NOTE 2—The aluminum and temper designations conform to ANSI H35.1. Aluminum 1350 corresponds to unified numbering system A91350 in accordance with Practice E 527. Table 1 Table 2 Table 3 Table 4 Table 5

## 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<sup>2</sup>
- B 354 Terminology Relating to Uninsulated Metallic Electrical Conductors<sup>2</sup>
- B 557 Test Methods of Tension Testing Wrought and Cast Aluminum- and Magnesium-Alloy Products<sup>3</sup>
- B 830 Specification for Uniform Test Methods and Frequency<sup>2</sup>
- E 34 Test Methods for Chemical Analysis of Aluminum and Aluminum-Base Alloys<sup>4</sup>
- E 55 Practice for Sampling Wrought Nonferrous Metals and Alloys for Determination of Chemical Composition<sup>4</sup>

<sup>1</sup> 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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<sup>2</sup> Annual Book of ASTM Standards, Vol 02.03.

<sup>3</sup> Annual Book of ASTM Standards, Vol 02.02.

<sup>4</sup> Annual Book of ASTM Standards, Vol 03.05.

TABLE 1 Tensile Property Limits<sup>A</sup>

Temper	Tensile Strength	
	ksi	MPa
1350-O	8.5–14.0	59–97
1350-H12 and -H22	12.0–17.0	83–117
1350-H14 and -H24	15.0–20.0 <sup>A</sup>	103–138
1350-H16 and -H26	17.0–22.0 <sup>A</sup>	117–152

<sup>A</sup> Applicable to stock sizes through 0.500-in. (12.70-mm) diameter. The values to apply for larger sizes in these tempers shall be negotiated at time of inquiry.

E 227 Test Method for Optical Emission Spectrometric Analysis of Aluminum and Aluminum Alloys by the Point-to-Plane Technique<sup>4</sup>

E 527 Practice for Numbering Metals and Alloys (UNS)<sup>5</sup>

<sup>5</sup> Annual Book of ASTM Standards, Vol 01.01.

TABLE 2 Chemical Requirements<sup>A</sup>

Element	Composition, %
Silicon, max	0.10
Iron, max	0.40
Copper, max	0.05
Manganese, max	0.01
Chromium, max	0.01
Zinc, max	0.05
Boron, max	0.05
Gallium, max	0.03
Vanadium plus titanium, total, max	0.02
Other elements, each, max	0.03
Other elements, total, max	0.10
Aluminum, min	99.50

<sup>A</sup> Analysis shall regularly be made only for the elements specified in this table. If, however, the presence of other elements is suspected or indicated in amounts greater than the specified limits, further analysis shall be made to determine that these elements are not present in amounts in excess of the specified limits.

TABLE 3 Electrical Resistivity Limits

Temper	Resistivity, $\Omega$ -mm <sup>2</sup> /m, max	Equivalent Volume Conductivity, % IACS, min
1350-O	0.027899	61.8
1350-H12 and -H22	0.028035	61.5
1350-H14 and -H24	0.028080	61.4
1350-H16 and -H26	0.028126	61.3

TABLE 4 Equivalent Resistivity Values at 20°C<sup>A</sup>

Material	Volume Conductivity, % IACS	Resistivity Constants			
		Volume			
		Ω·mm <sup>2</sup> /m	Ω·cmil/ft	μΩ·in.	μΩ·cm
Copper	100	0.017241	10.371	0.67879	1.7241
Aluminum	61.3	0.028126	16.919	1.1073	2.8126
	61.4	0.028080	16.891	1.1055	2.8080
	61.5	0.028035	16.864	1.1037	2.8035
	61.8	0.027899	16.782	1.0984	2.7899

<sup>A</sup> The equivalent resistivity values for 100 % IACS conductivity were each computed from the fundamental IEC value ( 1 / 58 Ω·mm<sup>2</sup>/m) using conversion factors each accurate to at least seven significant figures. Corresponding values for other conductivities (aluminum) were derived from these by multiplying by the reciprocal of the conductivity ratios accurate to at least seven significant figures.

TABLE 5 Diameter Tolerances

Specified Diameter, in. (mm)	Tolerance, in. (mm), Plus or Minus	
	Deviation of Mean <sup>A</sup> Diameter from Specified Diameter	Deviation at Any Point from Specified Diameter
	0.375–0.500 (9.52–12.70)	0.020 (0.51)
0.501–1.00 (12.73–25.40)	0.025 (0.64)	0.035 (0.89)

<sup>A</sup> For this specification, mean diameter is the average of the maximum diameter and the minimum diameter measured in the same transverse plane along the length.

### 2.3 American National Standard:

ANSI H35.1 Alloy and Temper Designation Systems for Aluminum<sup>6</sup>

### 2.4 National Bureau of Standards:

Handbook 100, Copper Wire Tables<sup>7</sup>

## 3. Ordering Information

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

3.1.1 Quantity,

3.1.2 Diameter (see 11.1),

3.1.3 Temper (see Table 1 and Explanatory Note 1 and Note 2),

3.1.4 Whether joints are permitted (see 8.1),

3.1.5 Whether tests of joints are required and number of specimens (see 8.2),

3.1.6 Coil size and weight (see 14.2),

3.1.7 Whether wrapping of coils is required (see 14.3),

3.1.8 Special marking on tags, if required (see 14.4), and

3.1.9 Whether inspection or witness of inspection and tests by purchaser's representative is required prior to shipment (see Section 13).

## 4. Manufacture

4.1 Unless otherwise agreed upon at the time of placing the order, the manufacturer shall have the option of producing the stock from either individually cast ingots or continuously cast bars. Only one method of production shall be used on any given order.

4.2 Unless otherwise specified, the manufacturer shall have the option of supplying stock in the H2X temper when H1X is specified, and of supplying stock in the H1X temper when H2X is specified. Only one temper shall be supplied in any given order (see Explanatory Note 3 and ANSI H35.1).

## 5. Chemical Composition

5.1 The stock shall conform to the requirements of Table 2 as to chemical composition. Conformance shall be determined by the manufacturer by analyzing samples taken at the time the ingots or continuously cast bars are poured, or samples taken from the finished or semifinished product. If the manufacturer has determined the chemical composition of the material during the course of manufacture, he shall not be required to sample and analyze the finished product.

5.2 *Number of Samples*—The number of samples taken for determination of chemical composition shall be as follows:

5.2.1 When samples are taken at the time the ingots are poured, at least one sample shall be taken to represent each group of ingots poured simultaneously from the same source of molten metal.

5.2.2 When samples are taken at the time continuously cast bars are poured, at least one sample shall be taken to represent the continuously cast length poured from each furnace load of molten metal.

5.2.3 When samples are taken from the finished or semifinished product, a sample shall be taken to represent each 5000 lb (2300 kg) or fraction thereof of material in the shipment, except that no more than one sample shall be required per continuous unjointed coil.

5.3 *Methods of Sampling*—Samples for determination of chemical composition shall be taken in accordance with one of the following methods:

5.3.1 Samples for chemical analysis shall be taken from the material by drilling, sawing, milling, turning, or clipping a representative piece or pieces to obtain a weight of prepared sample not less than 75 g. Sampling shall be in accordance with Practice E 55.

5.3.2 Samples for spectrochemical and other methods of analysis shall be suitable for the form of material being analyzed and the type of analytical method used.

5.4 *Methods of Analysis*—The determination of chemical composition shall be made in accordance with suitable chemical (Test Methods E 34), spectrochemical (Test Method E 227), or other methods.

## 6. Workmanship

6.1 The stock shall be uniform in quality and temper and shall be suitable for drawing into wire.

6.2 The stock shall be clean, sound, smooth, and free of pipes, laps, cracks, kinks, twists, seams, damaged ends, excessive oil, and other injurious defects within the limits of good commercial practice.

## 7. Tensile Requirements

### 7.1 Limits:

7.1.1 The tensile strength of the respective tempers of stock shall conform to the requirements specified in Table 1. All tensile test results shall be reported.

<sup>6</sup> Available from American National Standard Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.

<sup>7</sup> Available from the National Technical Information Service, 5285 Port Royal Rd., Springfield, VA 22161.

7.1.2 The tensile strength of joints made in the finished stock shall be not less than 8500 psi (59 MPa) for 1350-O and not less than 11 000 psi (76 MPa) for the other tempers.

7.2 *Number of Specimens*—One specimen shall be taken from each coil.

7.2.1 Tests to demonstrate conformance with 7.1.2 are not required unless agreed upon at time of ordering. The number of specimens shall be as negotiated (see 8.2).

7.3 *Type of Specimens*—Tension test specimens shall be the full section of the stock, or specimens machined from it. Machined specimens shall conform to Fig. 8 of Test Methods B 557. In case of dispute, tension test specimens shall be full section.

7.4 *Test Method*— Tension tests shall be made in accordance with Test Methods B 557. When tested in full section, the free length between jaws of the testing machine shall be at least 10 in. (250 mm) (Explanatory Note 4).

## 8. Joints

8.1 The stock shall be furnished in continuous-length coils without joints, unless otherwise agreed upon between the manufacturer and purchaser at the time of ordering. When joints are permitted, the joints shall be made by electric-butt welding, by cold-pressure welding, or by electric-butt, cold-upset welding.

8.2 When requested by the purchaser and agreed to by the manufacturer at the time of ordering, the tensile strength of joints in finished stock shall be determined (see 7.2.1).

## 9. Resistivity

9.1 The electrical resistivity of the stock in the temper supplied shall conform to the requirements specified in Table 3 (Explanatory Note 3).

9.2 *Number of Specimens*—One specimen is required per 30 000 lb (14 000 kg) lot.

9.3 *Test Method*— The resistivity tests shall be made on full-section samples of the stock in accordance with Test Method B 193.

## 10. Density

10.1 For the purpose of calculating mass per unit length, weight, cross section, etc., the density of aluminum 1350 shall be taken as 0.0975 lb/in.<sup>2</sup>(2705 kg/m<sup>3</sup>) at 20°C.

## 11. Diameter and Permissible Variations

11.1 The diameter of the stock shall be specified in decimal fractions of an inch using three places of decimals or in millimetres using two places of decimals.

11.2 The diameter of the stock shall be determined on at least 10 % of the coils in a lot. The diameter shall not vary from that specified by more than the permissible variations specified in Table 5.

## 12. Number of Tests and Retests

12.1 If a sample fails to conform to the requirements of Sections 7 and 9, two additional samples from the same coil shall be tested. If either of these samples fails to conform, that coil and the lot represented by the sample is subject to rejection. However, the lot may be resubmitted for inspection by testing every coil for the failed characteristic and sorting out the defective coils.

12.2 If a coil fails to conform to the permissible diameter variations specified in Table 5, each coil in the lot shall be gaged and the nonconforming coils shall be rejected.

## 13. Inspection

13.1 Unless otherwise specified in the contract or purchase order, the manufacturer shall be responsible for the performance of all inspection and test requirements specified.

13.2 All inspections and tests shall be made at the place of manufacture unless otherwise especially agreed to between the manufacturer and the purchaser at the time of the purchase.

13.3 The manufacturer shall afford the inspector representing the purchaser all reasonable manufacturer's facilities to satisfy him that the material is being furnished in accordance with this specification.

13.4 An inspection lot shall consist of an identifiable quantity of stock subjected to inspection at one time. Each lot shall consist of stock of the same size and temper manufactured under essentially the same conditions at essentially the same time.

## 14. Packaging and Marking

14.1 The material shall be shipped in coils.

14.2 Coil size and mass shall be agreed upon by the manufacturer and the purchaser at the time of placing the order.

14.3 Coils will be wrapped for shipment only when specified in the contract or order. The quality and application of the wrapping material shall be adequate to protect rods from damage incident to normal handling and shipment.

14.4 Each coil shall bear a tag showing the manufacturer's name or trademark, size, aluminum number, and temper of material. If additional information is to be required on the tags, it shall be arranged with the manufacturer at the time of purchase.

## 15. Statistical Process Control

15.1 When statistical process control (SPC) is used, the statistical sampling of each lot shall comply with Specification B 830. The process control ratio (CPK) shall not be less than 1.3. Control charts following the form and style of ASTM Manual 7 shall be provided, if requested, to the customer with each order that is representative of the processes used in the manufacture of the product.

## 16. Keywords

16.1 aluminum; aluminum drawing stock; aluminum wire; drawing stock; wire

**EXPLANATORY NOTES**

NOTE 1—The selection of the proper temper of stock will depend on the size of wire to be drawn, the wire properties desired, and the wire drawing practices employed.

NOTE 2—For definitions of terms relating to conductors, reference should be made to Terminology B 354.

NOTE 3—The H1X tempers (strain-hardened only) and the H2X tempers (strain-hardened and partially annealed) of stock are considered equally suitable for electrical purposes.

NOTE 4—In tension tests, the values obtained may be affected by testing speed. It is recommended that for conformance criteria the testing speed should not exceed 0.5 in./in. (0.5 mm/mm) of gage length or distance between grips per minute.

NOTE 5—Relationships that may be useful in connection with the values of electrical resistivity prescribed in Table 3 are shown in Table 4.

Resistivity units are based on the International Annealed Copper Standard (IACS) adopted by IEC in 1913, which is  $\frac{1}{58} \Omega \cdot \text{mm}^2/\text{m}$  at 20°C for 100 % conductivity. The value of  $0.017241 \Omega \cdot \text{mm}^2/\text{m}$  at 20°C is the international equivalent of volume resistivity of annealed copper equal to 100 % conductivity. A complete discussion of this subject is contained in *NBS Handbook 100*, Copper Wire Tables. 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 reasonably accurate reversible conversion from one set of resistivity units to another. The equivalent resistivity values in the table were derived from the functional IEC value ( $\frac{1}{58} \Omega \cdot \text{mm}^2/\text{m}$ ) computed to seven significant figures and then rounded to five significant figures.

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