Designation: B 230/B 230M – 99

Standard Specification for Aluminum 1350–H19 Wire for Electrical Purposes[1]

This standard is issued under the fixed designation B 230/B 230M; 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 Department of Defense.

1. Scope

1.1 This specification covers aluminum 1350–H19 (extra hard) round wire for electrical purposes.

1.2 The values stated in inch-pound or SI units are to be regarded separately as standard. The values in each system are not exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in nonconformance with the specification.

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

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

NOTE 2—The aluminum and temper designations conform to ANSI H35.1/H35.1M. Aluminum 1350 corresponds to UNS A91350 in accordance with Practice E 527.

NOTE 3—For definitions of terms found in this specification relating to uninsulated electrical conductors see Terminology B 354.

2. Referenced Documents

2.1 The following documents of the issue in effect on the 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 233 Specification for Aluminum 1350 Drawing Stock for Electrical Purposes[2]

B 354 Terminology Relating to Uninsulated Metallic Electrical Conductors[2]

B 557/B 557M Test Methods of Tension Testing Wrought and Cast Aluminum- and Magnesium-Alloy Products[3]

E 527 Practice for Numbering Metals and Alloys (UNS)[4]

2.3 *ANSI Standard:*

ANSI H35.1 American National Standard for Alloy and Temper Designations Systems for Aluminum[5]

ANSI H35.1M American National Standard for Alloy and Temper Systems for Aluminum [Metric][5]

2.4 *NIST Document:*

NBS Handbook 100–Copper Wire Tables[6]

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *lot*—a group of production units, up to 30 000 lb [15 000 kg] of mass, of one type and size of wire, which was produced during the same time period, under similar production conditions, and is presented for acceptance at the same time (Explanatory Note 1 and Note 2).

3.1.2 *production unit*—a coil, reel, spool, or other package of wire that represents a single usable length.

3.1.3 *sample*—the production unit or units from which a test specimen or specimens has been removed, and which is considered to have properties representative of the lot.

3.1.4 *specimen*—a length of wire removed for test purposes.

4. Ordering Information

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

4.1.1 Quantity of each size,

4.1.2 Wire size (see 11.1 and Table 1 or Table 2),

4.1.3 Special tension test, if required (see 7.2 and 7.3),

4.1.4 Frequency of bending test (see 8.1 and 14.5),

4.1.5 Special jointing procedures, if permitted (see 12.2),

4.1.6 Place of inspection (see 15.2),

4.1.7 Package size and type (see 16.1), and

4.1.8 Special package marking, if required (see 16.4).

5. Materials and Manufacture

5.1 The aluminum wire shall be made from drawing stock meeting the requirements of Specification B 233.

6. Workmanship, Finish and Appearance

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

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

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

[3] *Annual Book of ASTM Standards*, Vol 02.02.

[4] *Annual Book of ASTM Standards*, Vol 01.01.

[5] Available from American National Standards Institute Inc., 11 West 42nd St., 13th Floor, New York, NY 10036.

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

TABLE 1 Tensile Strength and Elongation Requirements

Diameter, in.	Tensile Strength, min ksi		Elongation in 10 in., min (%)	
	Average for a Lot[A]	Individual Tests	Average for a Lot	Individual Tests
0.0105 to 0.0500	25.0	23.0	. . .	. . .
0.0501 to 0.0600	29.0	27.0	1.4	1.2
0.0601 to 0.0700	28.5	27.0	1.5	1.3
0.0701 to 0.0800	28.0	26.5	1.6	1.4
0.0801 to 0.0900	27.5	26.0	1.6	1.5
0.0901 to 0.1000	27.0	25.5	1.6	1.5
0.1001 to 0.1100	26.0	24.5	1.6	1.5
0.1101 to 0.1200	25.5	24.0	1.7	1.6
0.1201 to 0.1400	25.0	23.5	1.8	1.7
0.1401 to 0.1500	24.5	23.5	1.9	1.8
0.1501 to 0.1800	24.0	23.0	2.0	1.9
0.1801 to 0.2100	24.0	23.0	2.1	2.0
0.2101 to 0.2600	23.5	22.5	2.3	2.2

[A] For wire diameters within 0.0501 to 0.2600 in., the minimum average tensile strength for a lot may be estimated from the following logarithmic equation for process control purposes to meet the requirements of this specification: Tensile strength, ksi = 17.40 – 3.84 × ln (diameter of wire, in.). Requirements stated in the table are to be used for all other purposes.

TABLE 2 Tensile Strength and Elongation Requirements

Diameter, mm	Tensile Strength, min MPa		Elongation in 250 mm, min (%)	
	Average for a Lot[A]	Individual Tests	Average for a Lot	Individual Tests
0.227 to 1.25	170.0	160.0	. . .	. . .
1.26 to 1.50	200.0	185.0	1.4	1.2
1.51 to 1.75	195.0	185.0	1.5	1.3
1.76 to 2.00	195.0	185.0	1.6	1.4
2.01 to 2.25	190.0	180.0	1.6	1.5
2.26 to 2.50	185.0	175.0	1.6	1.5
2.51 to 2.75	180.0	170.0	1.6	1.5
2.76 to 3.00	175.0	165.0	1.7	1.6
3.01 to 3.50	170.0	160.0	1.8	1.7
3.51 to 3.75	170.0	160.0	1.9	1.8
3.76 to 4.50	165.0	160.0	2.0	1.9
4.51 to 5.25	165.0	160.0	2.1	2.0
5.26 to 6.50	160.0	155.0	2.3	2.2

[A] For wire diameters within 1.26 to 6.50 mm the minimum average tensile strength for a lot may be estimated from the following logarithmic equation for process control purposes to meet the requirements of this specification: Tensile Strength, MPa = 205.88 – 27.14 × ln (diameter of wire, mm). Requirements stated in the table are to be used for all other purposes.

7. Tensile Properties

7.1 *Tensile Strength and Elongation*—The wire shall conform to the tensile strength and elongation requirements set forth in Table 1 or Table 2 (Explanatory Note 3).

7.2 When requested by the purchaser, tension tests shall be made of specimens of wire containing joints made in the drawing stock or in the wire prior to final drawing. Such tests shall indicate tensile strengths not less than 90 % of the values for individual tests shown in Table 1 or Table 2.

7.3 When requested by the purchaser, tension tests of specimens containing joints in the finished wire, or in the final drawing, if permitted, shall be made. Such tests shall indicate tensile strengths to be not less than 11.0 ksi [145 MPa] for electric-butt welded joints, and not less than 21.0 ksi [75 MPa] for cold-pressure welded joints and electric-butt, cold-upset welded joints.

8. Bending Properties

8.1 The wire shall be free of brittleness as evidenced by its ability to be coiled or looped around its own diameter with or without a mandrel. No fracture shall occur. Slight surface checks shall not constitute cause for rejection.

9. Resistivity

9.1 The electrical resistivity shall not exceed the values shown in Table 3 (Explanatory Note 4).

10. Density

10.1 For the purpose of calculating linear density, cross section, etc., the density of aluminum 1350 shall be taken as 2705 kg/m^3 [0.0975 lb/in.^{3}] at 20°C [68°F].

11. Diameter

11.1 The diameter of the wire shall be specified in inches to the nearest 0.0001 in. or the diameter of the wire shall be specified in millimetres to the nearest 0.001 mm for wires less than 1.000 mm in diameter, and to the nearest 0.01 mm for wires 1.00 mm in diameter and larger. The actual wire diameter shall not vary from the specified diameter by more than the values shown in Table 4.

12. Joints

12.1 No joints shall be made in the finished wire except as provided in 12.2. Joints may be made in the drawing stock and in the wire prior to final drawing and shall be in accordance with good commercial practice.

12.2 If agreed upon between the manufacturer and the purchaser, joints may be made during the final drawing or in the finished wire by electric-butt welding, cold-pressure welding, or electric-butt, cold-upset welding, subject to the following limitations.

12.2.1 For wire sizes from 0.0100 to 0.0555 in. [0.225 to 1.25 mm] in diameter not more than three such joints shall be present in any coil, reel, or spool of the specified nominal mass.

TABLE 3 Electrical Resistivity Requirements at 20°C (68°F) and Equivalent Copper Resistivity[A]

NOTE 1—The values in boldface are standard; other values are for information only.

	Volume Conductivity	Electrical Resistivity					
		Volume				Mass	
	%IACS	Ω·mm^2/m	μΩin.	μΩ·cm	Ω·cmil/ft	Ω·lb/mile^2	Ω·g/m^2
Average for lot	**61.2**	**0.028172**	1.1091	2.8172	16.946	434.81	0.076149
Individual tests	**61.0**	**0.028265**	1.1128	2.8265	17.002	436.23	0.076399
Copper equivalent	100.0	0.017241	0.67879	1.7241	10.371	875.20	0.15328

[A] The equivalent resistivity values for 100 % IACS conductivity were each computed from the fundamental IEC value (1/58 Ω·mm^2/m) using conversion factors each accurate to at least seven significant figures. Corresponding values for aluminum conductivities were derived from these by multiplying by the reciprocal of the conductivity ratios and, where applicable, also by the density ratios, both accurate to at least seven significant figures.

TABLE 4 Diameter Tolerances

Specified Diameter		Permissible Variations of the Mean Diameter from the Specified Diameter, Plus and Minus	
in.	mm		
0.0105 to 0.0359	up to 0.999	0.0005 in.	0.010 mm
0.0360 to 0.0999	1.00 to 2.99	0.0010 in.	0.030 mm
0.1000 to 0.2600	3.00 and over	1.0 %	1.0 %

12.2.2 For wire sizes greater than 0.0500 in. [1.25 mm] diameter, not more than 10 % of the coils, reels, or spools shall contain such joints, and no such joint shall be closer than 50 ft [15 m] to another joint or to either end of the wire. Not more than two such joints shall be present in any coil, reel or spool of the specified nominal mass.

13. Sampling

13.1 *Sampling*—Four test specimens shall be obtained, one from each of four production units (Explanatory Note 1).

14. Test Methods

14.1 *Diameter*—Measure the diameter of each specimen with a micrometer caliper graduated in 0.0001-in. increments or measure the diameter of each specimen with a micrometer caliper graduated in minimum 0.005 mm increments for wires less than 1.00 mm in diameter, or minimum 0.01-mm increments for wires 1.00 mm in diameter and larger. Take two measurements at one point, with the second measurement across the cross-sectional diameter 90° rotated from the first measurement. Average the two measurements to obtain the specimen diameter. Should the measured diameter of any specimen vary from the specified diameter by an amount greater than the tolerance permitted by Table 4, the lot shall be considered to not meet diameter requirements.

14.2 *Finish*—Make a visual surface finish inspection with the unaided eye (corrective lenses excepted). The surface finish shall meet the requirements of 6.1. Should any specimen be found unacceptable, the lot shall be considered to not meet surface finish requirements.

14.3 Tensile strength and elongation may be determined simultaneously. Obtain the tensile strength, in accordance with Test Methods B 557/B 557M, by dividing the maximum load resisted by the tensile specimen by the original cross-sectional area of the specimen, with the tensile stress to be expressed in ksi [MPa]. Elongation is the percent increase in length of the tensile test specimen as measured between gage marks originally spaced 10 in. [250 mm] apart on the specimen. Elongation measurements are not required for wires <0.0500 in. [<1.25 mm] in diameter. Should any part of the fracture take place outside the elongation gage lines, or if examination of the tensile specimen indicates a flaw, the values obtained may not be representative and a test on another section of the specimen may be run (Explanatory Note 6).

14.4 Determine the electrical resistivity in accordance with Test Method B 193.

14.5 *Test Results*—A numerical average for the tensile strength, elongation, and resistivity of the four specimens shall be calculated and shall be considered the lot average.

14.6 *Conformance Criteria*—To be considered in conformance, the lot average test results shall meet the average for a lot requirements of Table 1 or Table 2 and Table 3, and the test results of each specimen shall meet the individual tests requirements of Table 1 or Table 2 and Table 3 unless otherwise specified.

14.6.1 If the lot average results are in conformance, and all of the individual specimen results are in conformance, the lot shall be considered in conformance.

14.6.2 If the lot average result for one or more of the tested properties is not in conformance and one or more of the individual specimen results is also not in conformance, the lot shall be considered not in conformance.

14.6.3 If the lot average results are in conformance, but one or more of the individual specimen results are not in conformance, the lot shall be considered in conformance except that the production unit or units represented by the non-conforming specimen or specimens shall be rejected.

14.6.4 If the lot average results for one or more of the tested properties is not in conformance, but all the individual specimen results are in conformance, then additional test specimens and tests shall be required as follows:

14.6.4.1 An additional six test specimens shall be obtained, one each from six production units other than the four originally sampled. Tests shall be run on the six additional specimens, and a numerical average of the ten tested specimens shall be calculated and considered the lot average.

14.6.4.2 If the ten specimen lot average results are in conformance, and all ten of the individual specimen results are in conformance, the lot shall be considered in conformance.

14.6.4.3 If the ten specimen lot average results for one or more of the tested properties are not in conformance, or if one or more of the ten individual specimen results are not in conformance, the lot shall be considered not in conformance.

14.6.5 In the event a lot is rejected in accordance with 14.6.2 or 14.6.4.3, production units making up that lot may be individually tested. Acceptance of individual production units from a rejected lot shall be dependent on the individual specimen test results meeting the average for a lot requirements of Table 1 or Table 2 and Table 3.

14.7 *Bending (Brittleness)*—Specimens from any production unit may be tested, with the frequency of sampling and testing to be agreed upon by the manufacturer and the purchaser.

15. Inspection

15.1 Unless otherwise specified in the purchase contract, the manufacturer shall be responsible for the performance of all inspection and testing requirements specified.

15.2 All tests and inspections shall be made at the place of manufacture unless otherwise agreed upon by the manufacturer and the purchaser.

15.3 The manufacturer shall afford the purchaser reasonable access to the manufacturer's facilities consistent with the purchaser's need to ensure compliance with this specification.

15.4 Unless otherwise agreed upon by the manufacturer and the purchaser, conformance of the wire to the requirements specified in Sections 6, 7, 8, 9, and 11 shall be determined by sampling in accordance with Section 13 of each lot of wire presented for acceptance.

15.5 The manufacturer shall, if requested prior to inspection and testing, certify that the product as a whole was made under such uniform conditions that compliance with the requirements of this specification can be determined by the sampling, inspections, and tests performed in accordance with Section 13. (Explanatory Note 2 and Note 1).

16. Packaging and Package Marking

16.1 Package sizes and types shall be as agreed upon by the manufacturer and the purchaser at the time of placing the individual orders.

16.2 Unless otherwise specified, each coil, reel, or spool shall contain one continuous length of wire.

16.3 The wire shall be protected against damage in ordinary handling and shipping.

16.4 Each coil, reel, spool, or other package shall bear a tag showing the manufacturer's name or trademark; the product identification as Aluminum 1350–H19 wire; the size, length, and net mass of the material. Additional information shall be as agreed upon by the manufacturer and the purchaser at the time of placing the individual orders.

17. Keywords

17.1 aluminum electrical conductor; aluminum wire; electrical conductor; wire

EXPLANATORY NOTES

NOTE 1—A lot should comprise material taken from a product regularly meeting the requirements of this specification. Inspection of lots of less than 5000 lb [2500 kg] of wire cannot be justified economically. For small lots of less than 5000 lb [2500 kg] the purchaser may agree to the manufacturer's regular inspection of the product as a whole as evidence of acceptability of such small lots.

NOTE 2—Evidence of statistical control must be demonstrated. To do this, control charts, as described in Part 3 of *ASTM STP 15D*[7] may be used.

NOTE 3—The speed of testing can affect the results of the tensile strength and elongation test. In order to ensure uniformity in the test method and valid applicability of the test results to the conformance criteria, it is recommended that the rate of separation of the heads of the tensile test machine not exceed 0.5 in. for each inch or 0.5 mm for each millimeter of length between grips per minute.

NOTE 4—Relationships that may be useful in connection with the values of electrical resistivity are shown in Table 3. Resistivity units are based on the International Annealed Copper Standard (IACS) adopted by IEC in 1913, which is $\frac{1}{58}$ $\Omega \cdot mm^2/m$ at 20°C (68°F) for 100 % conductivity. The value of 0.017241 $\Omega \cdot mm^2/m$ at 20°C (68°F) 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*. 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 Table 3 were derived from the fundamental IEC value ($\frac{1}{58}$ $\Omega \cdot mm^2/m$) computed to seven significant figures and then rounded to five significant figures.

NOTE 5—Cumulative historic results secured on the product of a single manufacturer indicating a record of continual conformance of that product with the requirements of this specification are necessary to ensure that the sample can be assumed representative of the lot, and that the conformance criteria will largely ensure compliance of the lot with this specification. The sample sizes and conformance criteria are applicable only to lots produced by manufacturers that meet this requirement.

NOTE 6—Elongation measurements made and reported by the test apparatus may be used for process control purposes. However, in case of a discrepancy, measurements shall be made on a 10 in. [250 mm] specimen as stated above.

[7] *Manual on Presentation of Data and Control Chart Analysis, ASTM STP 15D*, 1976.