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Standard Specification for Aluminum-Alloy 6201-T81 Wire for Electrical Purposes [1]

This standard is issued under the fixed designation B 398/B 398M; the number immediately following the designation indicates the year of original adoption or, in the c]

ase 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] 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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1. Scope

1.1 This specification covers aluminum-alloy 6201-T81 (hard: solution heat-treated, coldra worked, and artificially aged) round wire for electrical purposes. F

NOTE 1—The alloy and temper designations conform to ANSI H35.1 and H35.1M. Aluminum-alloy 6201 corresponds to unified numbering system alloy A96201 in accordance with Practice E 527.

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 j 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.

2. Referenced Documents

2.1 The following documents of Committee B-1 this issue in effect on Electrical Conductors, 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 557 Test Methods of Tension Testing Wrought and Cast Aluminum- and Magnesium-Alloy Products[3]

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

B 830 Specification for Uniform Test Methods and Frequency[2]

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

2.3 *ANSI Standard:*

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

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

2.4 *NIST Standard:*

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 metric tons] 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 Notes 1 and 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.

[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, 25 W. 43rd St., 4th Floor, New York, NY 10036.

[6] Available from the National Institute of Standards and Technology (NIST), 100 Bureau Dr., Stop 3460, Gaithersburg, MD 20899-3460.

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: diameter in inches or in millimetres (see 11.1),
4.1.3 Special tension test, if required (see 7.2 and 7.3),
4.1.4 Frequency of bending test (see 8.2),
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. Material and Manufacture

5.1 The aluminum alloy used shall be of such quality that wire produced from it can comply with the requirements as to chemical composition, tensile and elongation properties, bending properties, and electrical resistivity prescribed in this specification.

6. Chemical Composition

6.1 The wire shall be made from aluminum alloy 6201 as designated in ANSI H35.1 and H35.1M. The material shall conform to the chemical composition prescribed in Table 1.

7. Tensile Properties

7.1 The heat-treated, drawn, and artificially aged wire when sampled in accordance with Section 14 of this specification and tested in accordance with Test Methods B 557 and B 557M shall conform to the tensile requirements prescribed in Table 2 (Explanatory Note 3).

7.2 When requested by the purchaser, tension tests shall be made on specimens of heat-treated, drawn, and artificially aged wire containing joints made in the wire after heat treatment and prior to final drawing. Such tests shall show not less than 90 % of the minimum strength specified in Table 2 for individual test.

7.3 When requested by the purchaser, tension tests shall be made on specimens of heat-treated, drawn, and artificially aged wire containing joints made in the finished wire or during the final drawing as permitted in 12.2. Such tests shall show the tensile strength to be not less than 42 ksi (290 MPa) for cold-pressure welds and for electric-butt, cold-upset welds and not less than 15 ksi (100 MPa) for electric-butt welds. Electric-butt welds in addition shall show a minimum elongation of 6 % in 10 in. (250 mm).

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 either with ~~Specification B 398~~ or without a mandrel. No fracture shall occur. Slight surface checks shall not constitute cause for rejection.

8.2 Any coil or reel may be tested in accordance with 8.1, but the frequency of production sampling and testing shall be by agreement between the manufacturer and the purchaser.

9. Resistivity

9.1 Electrical resistivity, determined on samples selected in accordance with Section 14 of this specification and tested in accordance with Test Method B 193, shall not exceed 0.032841 $\Omega \cdot mm^2/m$ at 20°C (68°F) (Explanatory Note 2 and Table 3).

TABLE 1 Chemical Requirements[A]

Element	Composition, %
Copper, max	0.10
Iron, max	0.50
Silicon	0.50–0.9
Manganese, max	0.03
Magnesium	0.6–0.9
Zinc, max	0.10
Chromium, max	0.03
Boron, max	0.06
Other elements, each, max	0.03
Other elements, total, max	0.10
Aluminum	remainder

[A] 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 for other elements.

TABLE 2 Tensile Requirements

Diameter, in. (mm)		Tensile Strength, min		Elongation in 10 in. (250 mm) for Individual Tests, min, %
		Average for a lot	Individual Tests	
Over	Through	ksi (MPa)	ksi (MPa)	
0.1280 (3.25)	0.1878 (4.75)	46 (315)	44 (305)	3.0
0.0610 (1.50)	0.1280 (3.25)	48 (330)	46 (315)	3.0

TABLE 3 Equivalent Resistivity Values at 20°C (68°F)[A]

Material	Volume Conductivity % IACS	Resistivity Constants[A] Volume Ω·cmil/ft (Ω·mm²/m)
Copper	100	10.371 (0.017241)
Aluminum	61.0	17.002 (0.028265)
	53.5	19.385 (0.032227)
	52.5	19.755 (0.032841)

[A] The equivalent resistivity values for 100 % IACS (soft copper) were each computed from the fundamental IEC value (1/58 Ω·mm²m) 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.

10. Density

10.1 For the purpose of calculating mass, mass per unit length, mass cross sections, etc., the density of aluminum-alloy 6201 shall be taken as 2690 kg/m^3(0.097 lb/in.^{3}) at 20°C.

11. Diameter and Permissible Variations

11.1 The diameter of the wire shall be expressed in decimal fractions of an inch using four places of decimals or in millimetres using two places of decimals.

11.2 Ten percent, but not less than five coils or spools (or all if the lot is less than five) from any lot of wire shall be gaged at three places. If the material is in coil form, one gaging shall be made near each end and one near the middle.

11.3 The permissible variations in diameter are as follows:

Specified Diameter, in. (mm)	Permissible Variations of Mean Diameter from Specified Diameter, plus and minus
0.1878 to 0.1000 (4.75 to 2.55), incl	1 %
Under 0.1000 to 0.0612 (2.55 to 1.50), incl	0.0010 in. (0.03 mm)

12. Joints

12.1 Unless otherwise specified at the time of placing the order, wire shall be supplied in one continuous length of reel, coil, or spool. Joints may be made in the drawing stock or wire after heat treatment and prior to final drawing by electric-butt welding, by cold-pressure welding, or by electric-butt, cold-upset welding in accordance with good commercial practice. Unless otherwise specified, no joints shall be made during final drawing or in the finished wire.

12.2 If agreed upon between the manufacturer and the purchaser, joints may be made during final drawing or in the finished wire by cold-pressure welding, by electric-butt, cold-upset welding, or by electric-butt welding. Following welding, electric-butt welds shall be annealed for a distance of at least 6 in. (150 mm) on each side of the weld. Not more than 10 % of the reels, coils, or spools shall contain such joints and no joint shall be closer than 50 ft (15 m) to another or to either end of the wire, and not more than two such joints shall be present in any reel, coil, or spool of the nominal specified mass.

13. Workmanship, Finish and Appearance

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

14. Sampling, Testing, and Conformance Criteria

14.1 *Sampling*—Four test specimens shall be obtained, one from each of four production units or in accordance with Specification B 830 (see Explanatory Note 2).

14.2 *Tensile strength, elongation, and resistivity*:

14.2.1 *Test Methods*:

14.2.1.1 Tensile strength and elongation may be determined simultaneously. Obtain the tensile strength, using Test Methods B 557, by dividing the maximum load resisted by the tensile specimen, with the tensile stress to be expressed in kips (1000 lbf.) per square inch (ksi). Elongation is the percent increase in length of the tensile specimen as measured between gage marks originally spaced 10 in. (254 mm) apart on the specimen. Elongation measurements are not required for wire less than 0.0500 in.

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.

14.2.1.2 Determine the electrical resistivity using Test Method B 193.

14.2.2 *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.

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

14.2.3.1 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.

14.2.3.2 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.

14.2.3.3 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 nonconforming specimen or specimens shall be rejected.

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

(1) An additional six test specimens shall be obtained, one each from six production units other than the four originally sampled. Test 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.

(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.

(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.

(4) In the event a lot is rejected in accordance with 14.2.3.2 or (*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 Tables 2 and 3.

14.3 *Bending (brittleness)*—Specimens from any production unit may be tested, with the frequency of sampling and testing to be agreed upon between 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 between 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 between the manufacturer and the purchaser, conformance of the wire to the requirements specified in Sections 7, 8, 9, 11, and 13 shall be determined by sampling in accordance with Section 14 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 sampling, inspections, and tests performed in accordance with Section 14 (Explanatory Note 2).

16. Packaging, and Package Marking

16.1 Package sizes shall be agreed upon between the manufacturer and the purchaser in the placing of individual orders.

16.2 Unless otherwise specified, the wire shall be supplied in one continuous length on each reel, coil, or spool.

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

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

17. Keywords

17.1 aluminum alloy 6201-T81 wire; aluminum alloy wire; aluminum wire; electrical conductor-aluminum; electrical conductors

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—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 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 [0.5 mm for each mm] of length between grips/min.

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