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Standard Specification for Aluminum-Alloy Extruded Bar, Rod, Tube, Pipe, Structural Profiles, and Profiles for Electrical Purposes (Bus Conductor)¹

This standard is issued under the fixed designation B317/B317M; 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 U.S. Department of Defense.

1. Scope*

1.1 This specification covers 6101 aluminum-alloy extruded bar, rod, tube, pipe, (Schedules 40 and 80), structural profiles, and profiles in selected tempers for use as electric conductors as follows:

1.1.1 *Type B*—Hot-finished bar, rod, tube, pipe, structural profiles and profiles in T6, T61, T63, T64, T65, and H111 tempers with Type B tolerances, as shown in the “List of ANSI Tables of Dimensional Tolerances.”

1.1.2 *Type C*—Hot-finished rectangular bar in T6, T61, T63, T64, T65, and H111 tempers with Type C tolerances as listed in the tolerances and permissible variations tables.

1.2 Alloy and temper designations are in accordance with ANSI H35.1. The equivalent Unified Numbering System alloy designation in accordance with Practice E527 is A96101 for Alloy 6101.

NOTE 1—Type A material, last covered in the 1966 issue of this specification, is no longer available; therefore, requirements for cold-finished rectangular bar have been deleted.

1.3 For acceptance criteria for inclusion of new aluminum and aluminum alloys in this specification, see Annex A2.

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

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*:²

[B193 Test Method for Resistivity of Electrical Conductor Materials](#)

[B253 Guide for Preparation of Aluminum Alloys for Electroplating](#)

[B557 Test Methods for Tension Testing Wrought and Cast Aluminum- and Magnesium-Alloy Products](#)

[B660 Practices for Packaging/Packing of Aluminum and Magnesium Products](#)

[B666/B666M Practice for Identification Marking of Aluminum and Magnesium Products](#)

[B807/B807M Practice for Extrusion Press Solution Heat Treatment for Aluminum Alloys](#)

[B881 Terminology Relating to Aluminum- and Magnesium-Alloy Products](#)

[B918 Practice for Heat Treatment of Wrought Aluminum Alloys](#)

[E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications](#)

[E34 Test Methods for Chemical Analysis of Aluminum and Aluminum-Base Alloys](#)

[E55 Practice for Sampling Wrought Nonferrous Metals and Alloys for Determination of Chemical Composition](#)

[E290 Test Methods for Bend Testing of Material for Ductility](#)

[E527 Practice for Numbering Metals and Alloys in the Unified Numbering System \(UNS\)](#)

¹ This specification is under the jurisdiction of ASTM Committee B07 on Light Metals and Alloys and is the direct responsibility of Subcommittee B07.03 on Aluminum Alloy Wrought Products.

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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.

*A Summary of Changes section appears at the end of this standard

E607 Test Method for Atomic Emission Spectrometric Analysis Aluminum Alloys by the Point to Plane Technique Nitrogen Atmosphere (Withdrawn 2011)³

E716 Practices for Sampling and Sample Preparation of Aluminum and Aluminum Alloys for Determination of Chemical Composition by Spectrochemical Analysis

E1004 Test Method for Determining Electrical Conductivity Using the Electromagnetic (Eddy-Current) Method

E1251 Test Method for Analysis of Aluminum and Aluminum Alloys by Spark Atomic Emission Spectrometry

2.3 *ANSI Standards*:⁴

H35.1/H35.1 (M) Alloy and Temper Designation Systems for Aluminum

H35.2 Dimensional Tolerances for Aluminum Mill Products

H35.2 (M) Dimensional Tolerances for Aluminum Mill Products

2.4 *Military Standard*:⁵

MIL-STD-129 Marking for Shipment and Storage

2.5 *Federal Standard*:⁵

Fed. Std. No. 123 Marking for Shipment (Civil Agencies)

3. Terminology

3.1 *Definitions*:

3.1.1 Refer to Terminology **B881** for definition of product terms used in this specification.

3.1.1.1 Note: Tees, Zees, I-beams, and H-sections are rarely used as conductors.

3.2 *Definitions of Terms Specific to This Standard*:

3.2.1 *capable of*—The term *capable of* as used in this specification means that the test need not be performed by the producer of the material. However, should subsequent testing by the purchaser establish that the material does not meet these requirements, the material shall be subject to rejection.

4. Ordering Information

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

4.1.1 This specification designation (which includes the number, the year, and the revision letter, if applicable),

4.1.2 Quantity in pounds or pieces,

4.1.3 Type (**1.1.1** and **1.1.2**),

4.1.4 Temper (Section 9, **Table 2**),

4.1.5 Type of section (Section 3),

4.1.6 *Cross-Sectional Dimensions*: *Bar*—Thickness and width, or distance across flats, and edge contour (Section **13**); *Rod*—Diameter; *Pipe*—Nominal pipe size and schedule number (40 or 80); *Structural Profile*—Nominal dimensions and type of section; *Round Tube*—Outside or inside diameter and wall thickness; *Square or Sharp-Cornered Tube*—Distance across flats and wall thickness; *Round-Cornered Tube Other than Round*—A drawing is required,⁴

4.1.7 Length,

4.2 Additionally, orders for material to this specification shall include the following information when required by the purchaser:

4.2.1 Whether solution heat treatment at the extrusion press is unacceptable (**8.2**),

4.2.2 Whether witness of inspection by the purchaser's representative is required prior to material shipment (Section **16**),

4.2.3 Whether marking for identification is required (Section **18**),

4.2.4 Whether certification is required (Section **20**), and

4.2.5 Whether Practices **B660** applies and, if so, the levels of preservation, packaging, packing and marking required (Section **19**).

4.2.6 Whether pipe or tube produced through porthole or bridge dies is acceptable (Section **5**), and

4.2.7 Whether an alternative tensile sampling selection procedure is acceptable (Section **9**).

5. Manufacture

5.1 The bars, rods, tubes, pipes, structural profiles and profiles shall be produced by hot extrusion or by similar methods at the option of the producer, provided that the production method results in material that meets all requirements of this specification. Pipe or tube may be produced through porthole or bridge type dies when specified by the purchaser.

6. Quality Assurance

6.1 *Responsibility for Inspection and Tests*—Unless otherwise specified in the contract or purchase order, the producer is responsible for the performance of all inspection and test requirements specified herein. The producer may use his own or any other

³ The last approved version of this historical standard is referenced on www.astm.org.

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

⁵ Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098, <http://www.dodssp.daps.mil>.

TABLE 1 Chemical Composition Limits^{A,B,C}

Element	Alloy Designation 6101 Composition, %
Silicon	0.30–0.7
Iron	0.50
Copper	0.10
Manganese	0.03
Magnesium	0.35–0.8
Chromium	0.03
Zinc	0.10
Boron	0.06
<i>Other elements:^D</i>	
Each	0.03
Total ^E	0.10
Aluminum	remainder

^A Limits are in weight percent maximum unless shown as a range.

^B Analysis shall be made for the elements for which limits are shown in this table.

^C To determine conformance to these limits, an observed value or a calculated value obtained from analysis shall be rounded off to the nearest unit in the last right-hand place of the figures used in expressing the specified limit, in accordance with the rounding-off method of Practice E29.

^D *Others* includes all unlisted metallic elements. The producer may analyze samples for trace elements not specified in the specification. However, such analysis is not required and may not cover all metallic *Others* elements. Should any analysis by the producer or the purchaser establish that an *Others* element exceeds the limit of *Each* or that the aggregate of several *Others* elements exceeds the limit of *Total*, the material shall be considered nonconforming.

^E *Other Elements*—Total shall be the sum of unspecified metallic elements 0.010 % or more, rounded to the second decimal before determining the sum.

iTeh Standards

suitable facilities for the performance of the inspection and test requirements specified herein, unless disapproved by the purchaser in the order or at the time of contract signing. The purchaser shall have the right to perform any of the inspections and tests set forth in this specification where such inspections are deemed necessary to assure that material conforms to prescribed requirements.

6.2 *Lot Definition*—An inspection lot shall be defined as follows:

6.2.1 For heat-treated tempers, an inspection lot shall consist of an identifiable quantity of material of the same mill form, alloy, temper, and nominal dimensions traceable to a heat-treat lot or lots, and subjected to inspection at one time.

6.2.2 For nonheat-treated tempers, an inspection lot shall consist of an identifiable quantity of material of the same mill form, alloy, temper, and nominal dimensions subjected to inspection at one time.

7. Chemical Composition

7.1 *Limits*—The material shall conform to the chemical composition limits in Table 1. Conformance shall be determined by the producer by analyzing samples taken at the time ingots are poured, or samples taken from the finished or semifinished product. If chemical composition has been determined during the course of manufacture, analysis of the finished product shall not be required.

NOTE 2—It is standard practice in the United States aluminum industry to determine conformance to the chemical composition limits prior to further processing of ingots into wrought products. Due to the continuous nature of the process, it is not practical to keep a specific ingot analysis identified with a specific quantity of finished material.

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

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

7.2.2 When samples are taken from the finished or semifinished product, a sample shall be taken to represent each 4000 lb (1800 kg), or fraction thereof, in the lot, except that not more than one sample shall be required per piece.

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

7.3.1 Samples for chemical analysis shall be taken from the material by sawing, milling, turning, or clipping a representative piece or pieces to obtain a prepared sample of not less than 75 g. Sampling shall be in accordance with Practice E55.

7.3.2 Sampling for spectrochemical analysis shall be in accordance with Practices E716. Samples for other methods of analysis shall be taken by methods suitable for the form of material being analyzed and the type of analytical method used.

7.4 *Methods of Analysis*—The determination of chemical composition shall be made in accordance with suitable chemical (Test Methods E34) or spectrochemical (Test Methods E607 and E1251), methods. Other methods may be used only when no published ASTM method is available. In case of dispute, the methods of analysis shall be agreed upon between the producer and purchaser.

TABLE 2 Tensile Property Limits^{A,B,C}

Temper	Specified Thickness, in. [mm]	Tensile Strength, ksi [MPa]		Yield Strength, (0.2 % offset), ksi [MPa]	
		min	max	min	max
T6	0.125–0.500 [3.20–12.50]	29.0 [200]	...	25.0 [170]	...
T61	0.125–0.749 [3.20–18.00]	20.0 [140]	...	15.0 [105]	...
	0.750–1.499 [18.01–35.00]	18.0 [125]	...	11.0 [75]	...
	1.500–2.000 [35.01–50.00]	15.0 [105]	...	8.0 [55]	...
T63 ^D	0.125–1.000 [3.20–25.00]	27.0 [185]	...	22.0 [150]	...
T64	0.125–1.000 [3.20–25.00]	15.0 [105]	...	8.0 [55]	...
	0.125–0.749 [3.20–20.00]	25.0 [170]	32.0 (221)	20.0 [140]	27.0 [185]
H111	0.250–2.000 [6.30–50.00]	12.0 [85]	...	8.0 [55]	...

^A To determine conformance to this specification, each value shall be rounded off to the nearest 0.1 ksi (1 MPa) for strength in accordance with the rounding-off method of Practice E29.

^B For explanation of SI unit MPa, see Appendix X2.

^C See Annex A1.

^D Formerly designated T62 temper.

8. Heat Treatment

8.1 Except as noted in 8.2, heat treatment shall be in accordance with Practice B918.

8.2 Unless otherwise specified, Alloy 6101 may be solution heat-treated and quenched at the extrusion press in accordance with Practice B807/B807M in the production of T6-type tempers.

9. Tensile Properties of Material as Supplied

9.1 *Limits*—The material shall conform to the tensile properties in Table 2.

9.2 *Number of Specimens*:

9.2.1 For material having a nominal weight of less than 1 lb/linear ft [up through 1.7 kg/linear m], one tension test specimen shall be taken for each 1000 lb [500 kg], or fraction thereof, in the lot.

9.2.2 For material having a nominal weight of greater than 1 lb/linear ft [over 1.7 kg/linear m], one tension test specimen shall be taken for each 1000ft [300 m], or fraction thereof, in the lot.

9.2.3 Other procedures for selecting samples may be employed if agreed upon between the producer and the supplier or purchaser.

9.3 The geometry of test specimens and the location in the product from which they are taken shall conform to Test Methods B557.

9.4 *Test Methods*—The tensile testing shall be in accordance with Test Method B557.

9.5 *Retests*—When there is evidence that the test specimen is defective or is not representative of the lot of material, retesting shall be performed in accordance with Sections 8 and 9 of Test Method B557.

10. Bend Properties

10.1 *Limits*:

10.1.1 *Flatwise Bends*—Bars shall be capable of being bent at room temperature through an angle of 90° around a pin or mandrel having a radius equal to N times its thickness without developing cracks or ruptures visible to the unaided eye corrected for normal vision. For a flatwise bend, the pin or mandrel shall be 90° from the working (extrusion) direction, and across the greater (width) dimension of the bar. The required 90° bend shall be in the working (extrusion) direction. This is a longitudinal bend as defined and shown in E290, Fig. 1. Surface roughening (“orange peel” appearance) is not considered to be an injurious defect. The value of N is specified in Table 3 for specific tempers and thicknesses.

10.1.2 *Edgewise Bends*—Bars in the T64 and H111 tempers having a maximum thickness of ¼ in. (6.4 mm) and a maximum width of 2 in. (50.8 mm) shall be capable of being bent edgewise at room temperature through an angle of 90° to an inside bend radius equal to one half the bar width without developing cracks or ruptures visible to the unaided eye corrected for normal vision. For an edgewise bend, the pin or mandrel shall be 90° from the working (extrusion) direction, and across the lesser (thickness) dimension of the bar. This is also a longitudinal bend as defined and shown in E290, Fig. 1. An edgewise bend shall be considered satisfactory if the thickness within the vicinity of any localized thinning is not less than 90 % of the maximum thickness within the center 60° of the bend when measured only along the outer edge of the bend.



TABLE 3 Flatwise Bend Radii

Temper	Specified Thickness, in.[mm]	Bend Factor, N^A
T6	0.125–0.375 [3.20–10.00]	2
	0.376–0.500 [10.01–12.50]	2½
T61	0.125–0.500 [3.20–12.50]	1
	0.501–0.749 [12.51–20.00]	2
	0.750–1.000 [20.01–25.00]	3
	1.001–1.625 [25.01–40.00]	4
T63 ^B	0.125–0.375 [3.20–10.00]	1
	0.376–1.000 [10.01–12.50]	1½
	0.501–1.000 [12.51–25.00]	2½
T64	0.125–0.750 [3.20–20.00]	1
	0.751–1.000 [20.01–25.00]	2
T65	0.125–0.500 [3.20–12.50]	1
	0.501–0.749 [12.51–20.00]	2
H111	0.250–0.750 [6.30–20.00]	1
	0.751–1.000 [20.01–25.00]	2

^A Applicable to widths up through 6 in. (152 mm) in the T6, T61, T63, and T65 tempers and to widths up through 12 in. (305 mm) for all other listed tempers.

^B Formerly designated T62 temper.

10.2 *Number of Specimens*—The number of specimens (test frequency) shall be the same as for tension tests as required in 9.2.

10.3 *Test Specimens*—Bend test specimens (bar only) shall be a full section of the material with a minimum length of 12 in. (305 mm).

10.4 *Test Methods*—Bend tests shall be made in accordance with Test Method E290.

11. Density

11.1 The density of 6101 alloy shall be taken as 0.0975 lb/in.³ (2700 kg/m³).

12. Electrical Properties

12.1 *Limits*—The material shall conform to the maximum resistivity requirements specified in Table 4.

12.2 *Number of Specimens*—The number of specimens (test frequency) shall be the same as for tension tests as required in 9.2.

12.3 *Test Specimens*—The specimens shall, when practical, be a full section of the material but may be of suitable size and shape for the test instrument.

12.4 *Test Methods*—Resistivity or conductivity shall be determined in accordance with Test Method B193 or Practice E1004, provided that in case of dispute, the results obtained by Test Method B193 shall be the basis for acceptance.

13. Edge Contours

13.1 Unless specified otherwise, bar shall be furnished with square corners. When specified, bar shall be furnished with rounded corners, rounded edges or full rounded edges, as shown in Table 16.17 of ANSI H35.2 [H35.2 (M)].

TABLE 4 Resistivity and Conductivity Limits

Temper	Weight Resistivity at 20°C, max, $\Omega \cdot \text{g}/\text{m}^2$	Volume Conductivity at 20°C, min, percent of IACS ^A
T6	0.0846	55.0
T61	0.0817	57.0
T63	0.0831	56.0
T64	0.0782	59.5
T65	0.0824	56.5
H111	0.0789	59.0

^A International Annealed Copper Standard.

14. Dimensional Tolerances

14.1 Rectangular bar ordered to Type C dimensional tolerances shall conform to the thickness tolerances in [Table 5](#), width tolerances in [Table 6](#), and flatness tolerances in [Table 7](#). In addition, the bar shall conform to the requirements for straightness, corner or edge radii, twist, length, squareness of cut ends, or angularity prescribed in the tables of ANSI H35.2 [H35.2 (M)] (see [Table 8](#)).

14.1.1 Rectangular bar and rod ordered to Type B dimensional tolerances shall conform to the applicable tables of ANSI H35.2 [H35.2M] (see [Table 8](#)).

14.2 Tube, pipe, structural profiles, and profiles shall conform to the permissible variations prescribed in the applicable tables of ANSI H35.2 [H35.2M] (see [Table 8](#)).

14.3 *Number of Samples*—Examination for dimensional conformance shall be made to ensure conformance to the tolerance specified.

15. General Quality

15.1 Unless otherwise specified, the material shall be supplied in the mill finish and shall be uniform as defined by the requirements of this specification and shall be commercially sound. Any requirement not so covered is subject to negotiation between producer and purchaser.

15.2 The material shall be capable of being satisfactorily electroplated in accordance with the provisions of Guide [B253](#).

15.3 Each bar, rod, tube, pipe, structural profile and profile shall be examined to determine conformance to this specification with respect to general quality and identification marking. On approval of the purchaser, the producer may use a system of statistical quality control for such examinations.

16. Source Inspection

16.1 If the purchaser desires that his representative inspect or witness the inspection and testing of the material prior to shipment, such agreement shall be made by the purchaser and producer as part of the purchase contract.

16.2 When such inspection or witness of inspection and testing is agreed upon, the producer shall afford the purchaser's representative all reasonable facilities to satisfy him that the material meets the requirements of this specification. Inspection and tests shall be conducted so there is no unnecessary interference with the producer's operations.

17. Rejection and Retest

17.1 If any material fails to conform to all of the applicable requirements of this specification, it shall be cause for rejection of the inspection lot.

17.2 When there is evidence that a failed specimen was not representative of the inspection lot and when no other sampling plan is provided or approved by the purchaser through the contract or purchase order, at least two additional specimens shall be selected to replace each test specimen that failed. All specimens so selected for retest shall meet the requirements of the specification or the lot shall be subject to rejection.

17.3 Material in which non-conforming conditions are discovered subsequent to inspection may be rejected.

17.4 If material is rejected by the purchaser, the producer or supplier is responsible only for replacement of the material to the purchaser. As much as possible of the rejected material shall be returned to the producer or supplier.

18. Identification Marking of Product

18.1 When specified on the purchase order or contract, all bar, rod, tube, pipe, structural profiles and profiles shall be marked in accordance with Practice [B666/B666M](#).

18.2 Marking systems that involve added information, larger characters, and greater frequencies are acceptable under this specification when agreed upon between the producer and purchaser.

19. Packaging and Package Marking

19.1 The material shall be packaged to provide adequate protection during normal handling and transportation and each package shall contain only one size or shape and temper of material unless otherwise agreed. The type of packing and gross weight of containers shall, unless otherwise agreed, be at the producer or supplier's discretion, provided they are such as to ensure acceptance by common or other carriers for safe transportation at the lowest rate to the delivery point.

TABLE 5 Type C Thickness Tolerance for Rectangular Bar

Specified Thickness, in. [mm]	Tolerance, Plus and Minus, in. [mm]
0.125–0.500 [3.20–12.50]	0.005 [0.130]