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Standard Specification for Aluminum-Alloy Extruded Structural Pipe and Tube¹

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This standard has been approved for use by agencies of the Department of Defense.

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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1. Scope *

1.1 This specification covers aluminum-alloy pipe and extruded tube in selected alloys and tempers and in standard sizes as shown in the tables in Appendix X1. This pipe and tube is intended for use in structural applications such as highway and bridge rails, chain-link fence posts, handrails, sign structures, awning supports, lighting brackets, etc. Structural pipe and tube is not intended for fluid-carrying applications involving pressure.

NOTE 1—For drawn seamless tube used in pressure applications see Specification B 210, and for seamless pipe and seamless extruded tube used in pressure applications see Specification B 241.

1.2 Alloy and temper designations are in accordance with ANSI H35.1. The equivalent Unified Numbering System alloy designations are those of Table 1 preceded by A9, for example, A96061 for alloy 6061 in accordance with Practice E 527.

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 inch-pound units are the standard. The values given in parentheses are for information only.

2. Referenced Documents

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

2.2 *ASTM Standards:*

~~B 557 Test Methods of Tension Testing Wrought 210 Specification for Aluminum and Cast Aluminum- and Magnesium-Alloy Products~~ Aluminum-Alloy Drawn Seamless Tubes²

~~B 597 Practice 241 Specification for Heat Treatment of Aluminum and Aluminum-Alloy Seamless Pipe and Seamless Extruded Tube~~²

B 557 Test Methods of Tension Testing Wrought and Cast Aluminum- and Magnesium-Alloy Products²

B 660 Practices for Packaging/Packing of Aluminum and Magnesium Products²

B 666/B 666M Practice for Identification Marking of Aluminum Products²

B 807 Practice for Extrusion Press Solution Heat Treatment of Aluminum Alloys²

B 918 Practice for Heat Treatment of Aluminum Alloys²

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications³

E 34 Test Methods for Chemical Analysis of Aluminum and Aluminum-Base Alloys⁴

E 55 Practice for Sampling Wrought Nonferrous Metals and Alloys for Determination of Chemical Composition⁴

E 227 Test Method for Optical Emission Spectrometric Analysis of Aluminum and Aluminum Alloys by the Point-to-Plane Technique⁴

E 527 Practice for Numbering Metals and Alloys (UNS)⁵

E 607 Test Method for Optical Emission Spectrometric Analysis of Aluminum and Aluminum Alloys by the Point-to-Plane Technique, Nitrogen Atmosphere⁴

E 716 Practices for Sampling Aluminum and Aluminum Alloys for Spectrochemical Analysis⁴

² *Annual Book of ASTM Standards*, Vol 02.02.

³ *Annual Book of ASTM Standards*, Vol 14.02.

⁴ *Annual Book of ASTM Standards*, Vol 03.05.

⁵ *Annual Book of ASTM Standards*, Vol 01.01.

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

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

Alloy Designation	Silicon	Iron	Copper	Manganese	Magnesium	Chromium	Zinc	Titanium	Other Elements ^D		Aluminum
									Each	Total ^E	
6061	0.40–0.8	0.7	0.15–0.40	0.15	0.8–1.2	0.04–0.35	0.25	0.15	0.05	0.15	remainder
6063	0.20–0.6	0.35	0.10	0.10	0.45–0.9	0.10	0.10	0.10	0.05	0.15	remainder

^A Limits are in 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 method of Practice E 29.

^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.

E 1251 Test Method for Optical Emission Spectrometric Analysis of Aluminum and Aluminum Alloys by the Argon Atmosphere, Point-to-Plane, Unipolar Self-Initiating Capacitor Discharge⁴

2.3 *ANSI Standards:*

H35.1 Alloy and Temper Designations Systems for Aluminum²

H35.2 Dimensional Tolerance for Aluminum Mill Products²

2.4 *Military Standards:*

MIL-STD-129; Marking for Shipment and Storage⁶

2.5 *Federal Standards:*

Fed. Std. No. 123 Marking for Shipment (Civil Agencies)⁶

3. Terminology

3.1 *Definitions:*

3.1.1 *extruded structural pipe*—extruded structural tube having certain standardized sizes of outside diameter and wall thickness commonly designated by “Nominal Pipe Sizes” and American National Standards Institute (ANSI) Schedule Numbers.

3.1.2 *extruded structural tube*—a hollow product having a round cross section and a uniform wall thickness, brought to final dimensions by extruding through a bridge-type die or by similar methods, at the option of the producer.

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 pieces, pounds, or feet,

4.1.3 Size and schedule number for pipe; outside diameter and wall thickness for extruded tube (see tables in Appendix X1) and length in feet,

4.1.4 Alloy (Section 8) and temper (Section 9),

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

4.2.1 Whether inspection or witness of inspection and tests by the purchaser’s representative is required prior to material shipment (Section 13),

4.2.2 Whether certification of the material by the manufacturer is required (Section 15),

4.2.3 Whether marking for identification is required (Section 16), and

4.2.4 Whether Practices B 660 applies and, if so, the levels of preservation, packaging, and packing required (Section 17).

5. Materials and Manufacture

5.1 The pipe or tube may be produced by extrusion through a bridge-type die or by other methods at the option of the producer, provided that the resulting products comply with the requirements in this specification.

6. Special Characteristics

6.1 Unless otherwise specified, the pipe or tube shall be supplied with square-cut ends.

7. Responsibility for Quality Assurance

7.1 *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. Except as otherwise specified in the

contract or order, the producer may use his own or any other suitable facilities for the performance of the inspection and test requirements specified herein, unless disapproved by the purchaser at the time the order is placed. 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 ensure that material conforms to prescribed requirements.

7.2 *Lot Definition*—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.

8. Chemical Composition

8.1 Limits:

8.1.1 The material shall conform to the chemical composition limits prescribed in Table 1. The producer shall determine conformance by analyzing samples taken when the ingots are poured, or analyzing samples taken from the finished or semifinished product. If the producer 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.

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.

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

8.2.1 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.

8.2.2 When samples are taken from the finished or semi-finished product, a sample shall be taken to represent each 4000 lb (1814 kg), or fraction thereof, of material in the lot, except that not more than one sample shall be required per piece.

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

8.3.1 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.

8.3.2 Sampling for spectrochemical analysis shall be in accordance with Practices E 716. Samples for other methods of analysis shall be suitable for the form of material being analyzed and the type of analytical method used.

8.4 *Methods of Analysis*—The determination of chemical composition shall be made in accordance with suitable chemical (Test Methods E 34), spectrochemical (Test Methods E 227, E 607, and E 1251), 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.

9. Tensile Properties

9.1 *Limits*—The material shall conform to the tensile property requirements specified in Table 2.

9.2 Number of Specimens:

9.2.1 For material having a nominal weight of less than 1 lb/linear ft (1.7 kg/linear m) one tension test specimen shall be taken for each 1000 lb (454 kg) or fraction thereof in the lot.

9.2.2 For material having a nominal weight of 1 lb or more/linear ft, one tension test specimen shall be taken for each 1000 ft (305 m) or fraction thereof in the lot.

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

Alloy Temper	Specified Wall Thickness, in.	Tensile Strength, min, ksi (MPa) ^D	Yield Strength, min, ksi (MPa) ^D	Elongation in 2 in. or 4 × Diameter, min, % ^E
6061-T6	up thru 0.249	38.0 (262)	35.0 (241)	8
	0.250 and over	38.0 (262)	35.0 (241)	10
6063-T6	up thru 0.124	30.0 (207)	25.0 (172)	8
	0.125–1.000	30.0 (207)	25.0 (172)	10

^A To determine conformance to this specification, each value for tensile strength and for yield strength shall be rounded-off to the nearest 0.1 ksi and each value for elongation to the nearest 0.5 percent, both in accordance with the rounding-off method of Practice E 29.

^B Specimens shall be tested parallel to the direction of working.

^C The basis for establishment of mechanical property limits is shown in Annex A1.

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

^E Elongation of full-section and cut-out sheet-type specimens is measured in 2 in.; of cut-out round specimens, in 4 × specimen diameter.

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

9.3 *Test Specimens*—Geometry of test specimens and the location in the product from which they are taken shall be as specified in Test Methods B 557.

9.4 *Test Methods*—The tension test shall be made in accordance with Test Methods B 557.

10. Heat Treatment

10.1 Except as noted in 10.2, producer or supplier heat treatment shall be in accordance with Practice ~~B 597~~ B 918.

10.2 Alloys 6061 and 6063 may be solution heat treated and quenched at the extrusion press in accordance with Practice B 807 for the production of T6 temper.

11. Dimensional Tolerances

11.1 Variations from the specified dimensions for the type of material ordered shall not exceed the permissible variations prescribed in the following tables of ANSI H35.2:

Table No.	Title
12.1	Diameter, Round Extruded Tube Except for T3510, T4510, T6510, T73510, T76510, and T8510 Tempers
12.3	Wall Thickness, Round Extruded Tube
12.5	Length, Round Extruded Tube
12.7	Straightness, Round Extruded Tube in Straight Lengths
16.1	Outside Diameter, Pipe
16.2	Wall Thickness, Pipe
16.3	Weight, Pipe
16.4	Length, Pipe
16.5	Straightness, Pipe

11.2 The maximum and minimum wall thicknesses, outside diameters and nominal weights of standard sizes of pipe are shown in Table 3.

12. General Quality

12.1 The pipe or tube shall be supplied in the mill finish, with plain ends, and shall be of uniform quality and temper, sound and free from injurious defects. Discoloration that is characteristic of proper solution heat treatment shall not be cause for rejection.

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

13. Source Inspection

13.1 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.

13.2 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.

14. Retest and Rejection

14.1 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.

TABLE 3 Standard Structural Pipe Diameters, Wall Thicknesses, Weights

Nominal Pipe Size, in.	ANSI Schedule No. ^A	OD, in.			ID, in.		Wall Thickness, in.			Weight, ^B lb/ft	
		Nominal	Min ^C	Max ^C	Nominal	Nominal	Min	Max ^D	Nominal	Max	
½	40	0.840	0.809	0.855	0.622	0.109	0.095	...	0.294	0.317	
	10	1.050	1.019	1.065	0.884	0.083	0.071	0.095	0.297	...	
¾	40	1.050	1.019	1.065	0.824	0.113	0.099	...	0.391	0.422	
	10	1.315	1.284	1.330	1.097	0.109	0.095	0.123	0.486	...	
1	40	1.315	1.284	1.330	1.049	0.133	0.116	...	0.581	0.627	
	10	1.660	1.629	1.675	1.442	0.109	0.095	0.123	0.625	...	
1¼	40	1.660	1.629	1.675	1.380	0.140	0.122	...	0.786	0.849	
	10	1.900	1.869	1.915	1.682	0.109	0.095	0.123	0.721	...	
1½	40	1.900	1.869	1.915	1.610	0.145	0.127	...	0.940	1.015	
	10	2.375	2.344	2.406	2.157	0.109	0.095	0.123	0.913	...	
2	40	2.375	2.351	2.399	2.067	0.154	0.135	...	1.264	1.365	
	10	2.875	2.844	2.906	2.635	0.120	0.105	0.135	1.221	...	
2½	40	2.875	2.846	2.904	2.469	0.203	0.178	...	2.004	2.164	
	10	3.500	3.469	3.531	3.260	0.120	0.105	0.135	1.498	...	
3	40	3.500	3.465	3.535	3.068	0.216	0.189	...	2.621	2.830	
	10	4.000	3.960	4.040	3.548	0.226	0.198	...	3.151	3.403	
3½	40	4.000	3.960	4.040	3.548	0.226	0.198	...	3.151	3.403	
4	40	4.500	4.455	4.545	4.026	0.237	0.207	...	3.733	4.031	

^A Schedule 40 is also designated as "standard pipe."

^B Based on a density of 0.098 lb/in.³, the density of 6061 alloy. For alloy 6063 multiply by 0.99.

^C For schedule 10, these values apply to mean outside diameter.

^D For schedule 40, maximum wall thickness is controlled by weight tolerance.

14.2 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.

14.3 Material in which defects are discovered subsequent to inspection may be rejected.

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

15. Certification

15.1 The producer or supplier shall, on request, furnish to the purchaser a certificate stating that each lot has been sampled, tested, and inspected in accordance with this specification, and has met the requirements.

16. Identification Marking of Product

16.1 When specified on the purchase order or contract, all pipe and tube shall be marked in accordance with Practice B 666/B 666M.

16.2 The requirements specified in 16.1 are minimum; marking systems that involve added information, larger characters, and greater frequencies are acceptable under this specification.

17. Packaging and Package Marking

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

17.2 Each shipping container shall be marked with the purchase order number, material size, specification number, alloy and temper, gross and net weights, and the producer's name or trademark.

17.3 When specified in the contract or purchase order, material shall be preserved, packaged, and packed in accordance with the requirements of Practices B 660. The applicable levels shall be as specified in the contract or order. Marking for shipment of such material shall be in accordance with Fed. Std. No. 123 for civil agencies and MIL-STD-129 for military agencies.

18. Keywords

18.1 aluminum alloy; extruded pipe; extruded tube

ANNEXES

(Mandatory Information)

A1. BASIS FOR INCLUSION OF PROPERTY LIMITS

A1.1 Limits are established at a level at which a statistical evaluation of the data indicates that 99 % of the population obtained from all standard material meets the limit with 95 % confidence. For the products described, mechanical property limits for the respective size ranges are based on the analyses of at least 100 data from standard production material with no more than ten data from a given lot. All tests are performed in accordance with the appropriate ASTM test methods. For informational purposes, refer to "Statistical Aspects of Mechanical Property Assurance" in the Related Material section of the *Annual Book of ASTM Standards*, Vol 02.02.

A2. ACCEPTANCE CRITERIA FOR INCLUSION OF NEW ALUMINUM AND ALUMINUM ALLOYS IN THIS SPECIFICATION

A2.1 Prior to acceptance for inclusion in this specification, the composition of wrought or cast aluminum or aluminum alloy shall be registered in accordance with ANSI H35.1. The Aluminum Association⁷ holds the Secretariat of ANSI H35 Committee and administers the criteria and procedures for registration.

A2.2 If it is documented that the Aluminum Association could not or would not register a given composition, an alternative procedure and the criteria for acceptance shall be as follows:

⁷ Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

⁷ The Aluminum Association, 900 19th Street, NW, Washington, DC 20006.

A2.2.1 The designation submitted for inclusion does not utilize the same designation system as described in ANSI H35.1. A designation not in conflict with other designation systems or a trade name is acceptable.

A2.2.2 The aluminum or aluminum alloy has been offered for sale in commercial quantities within the prior twelve months to at least three identifiable users.

A2.2.3 The complete chemical composition limits are submitted.

A2.2.4 The composition is, in the judgment of the responsible subcommittee, significantly different from that of any other aluminum or aluminum alloy already in the specification.

A2.2.5 For codification purposes, an alloying element is any element intentionally added for any purpose other than grain refinement and for which minimum and maximum limits are specified. Unalloyed aluminum contains a minimum of 99.00 % aluminum.

A2.2.6 Standard limits for alloying elements and impurities are expressed to the following decimal places:

Less than 0.001 %	0.000X
0.001 to but less than 0.01 %	0.00X
0.01 to but less than 0.10 %	
Unalloyed aluminum made by a refining process	0.0XX
Alloys and unalloyed aluminum not made by a refining process	0.0X
0.10 through 0.55 %	0.XX
(It is customary to express limits of 0.30 through 0.55 % as 0.X0 or 0.X5)	
Over 0.55 %	0.X, X.X, etc.
(except that combined Si + Fe limits for 99.00 % minimum aluminum must be expressed as 0.XX or 1.XX)	

A2.2.7 Standard limits for alloying elements and impurities are expressed in the following sequence: Silicon; Iron; Copper; Manganese; Magnesium; Chromium; Nickel; Zinc (Note A2.1); Titanium; Other Elements, Each; Other Elements, Total; Aluminum (Note A2.2).

NOTE A2.1—Additional specified elements having limits are inserted in alphabetical order of their chemical symbols between zinc and titanium, or are specified in footnotes.

NOTE A2.2—Aluminum is specified as *minimum* for unalloyed aluminum and as a *remainder* for aluminum alloys.

APPENDIXES
(Nonmandatory Information)
X1. STANDARD SIZES OF STRUCTURAL PIPE AND TUBE

X1.1 Standard sizes of aluminum-alloy structural pipe and tube are given in Table X1.1 and Table X1.2.

TABLE X1.1 Standard Structural Pipe Sizes^A

Pipe Size, in.	Schedule No.	Alloy & Temper	
		6061-T6	6063-T6
1/2	10	...	X
	40	...	X
3/4	10	...	X
	40	...	X
1	10	...	X
	40	X	X
1 1/4	10	X	X
	40	X	X
1 1/2	10	X	X
	40	X	X
2	10	X	X
	40	X	X
2 1/2	10	X	X
	40	X	X
3	10	X	X
	40	X	X
3 1/2	40	X	X
4	40	X	X

^A Available size is indicated by "X."

TABLE X1.2 Standard Structural Tube Sizes^A

Outside Diameter, OD, in.	Wall Thickness, in.	Nominal Weight, lb/ft	Alloy and Temper	
			6061-T6	6063-T6
1.500	0.125	0.631	X	X
	0.188	0.911	X	X
	0.250	1.150	X	...
2.000	0.125	0.866	X	X
	0.188	1.260	X	X
	0.250	1.620	X	...
2.500	0.125	1.100	X	X
	0.188	1.610	X	X
	0.250	2.080	X	...
3.000	0.125	1.330	X	X
	0.188	1.950	X	X
	0.250	2.540	X	...
3.500	0.125	1.560	X	X
	0.188	2.300	X	X
	0.250	3.000	X	...
4.000	0.125	1.790	X	X
	0.188	2.650	X	X
	0.250	3.460	X	...
4.500	0.125	2.020	X	X
	0.188	2.990	X	X
	0.250	3.390	X	...
5.000	0.125	2.250	X	...
	0.188	3.340	X	...
	0.250	4.390	X	...
5.500	0.188	3.690	X	...
	0.250	4.850	X	...
6.000	0.188	4.040	X	...

^A Available size is indicated by "X."

X2. METRIC EQUIVALENTS

X2.1 The SI unit for strength properties now shown is in accordance with the International System of Units (SI). The derived SI unit for force is the newton (N), which is defined as that force which when applied to a body having a mass of one kilogram gives it an acceleration of 1 m/s² (N = kg·m/s²). The derived SI unit for pressure or stress is the newton per square metre (N/m²), which has been named the pascal (Pa) by the General Conference on Weights and Measures. Since 1 ksi = 6 894 757 Pa the metric equivalents are expressed as megapascal (MPa), which is the same as MN/m² and N/mm².

SUMMARY OF CHANGES

This section identifies the principal changes to this standard that have been incorporated since the last issue.

- (1) ~~Deleted references~~ Replaced Practice B 597 with Practice B 918 in 2.2 and 10.1.
- (2) Added B 210 and B 241 to Test Method E-101. Referenced Documents.

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