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Standard Specification for Aluminum and Aluminum-Alloy Seamless Pipe and Seamless Extruded Tube for Gas and Oil Transmission and Distribution Piping Systems[1]

This standard is issued under the fixed designation B 345/B 345M; 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 seamless pipe and seamless extruded tube in the aluminum and aluminum alloys (Note 1) and tempers listed in Table 1 and Table 2, respectively. Seamless pipe and seamless tube are intended for use in applications involving internal pressure.

NOTE 1—Throughout this specification use of the term *alloy* in the general sense includes aluminum as well as aluminum alloy.

NOTE 2—For drawn seamless tubes, see Specifications B 210 and B 210M; for extruded tubes, Specifications B 221 and B 221M; for drawn seamless tubes for condensers and heat exchangers, Specifications B 234 and B 234M; for seamless pipe and seamless extruded tube, B241/B 241M; for round welded tubes, Specification B 313/B 313M; for seamless condenser and heat exchanger tubes with integral fins, Specifications B 404 and B 404M; for extruded structural pipe and tube, Specification B 429; and for drawn tube for general purpose applications, Specifications B 483 and B 483M.

1.2 Alloy and temper designations are in accordance with ANSI H35.1. The equivalent Unified Numbering System alloy designations are those of Table 3 preceded by A9, for example, A93003 for aluminum alloy 3003 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 either inch-pound units or SI units are to be regarded separately as standard. Within the text, the SI units are shown in brackets. The values stated 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.

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 557 Test Methods for Tension Testing Wrought and Cast Aluminum- and Magnesium-Alloy Products[2]

B 557M Test Methods for Tension Testing Wrought and Cast Aluminum- and Magnesium-Alloy Products [Metric][2]

B 597 Practice for Heat Treatment of Aluminum Alloys[2]

B 647 Test Method for Indentation Hardness of Aluminum Alloys by Means of a Webster Hardness Gage[2]

B 648 Test Method for Indentation Hardness of Aluminum Alloys by Means of a Barcol Impressor[2]

B 660 Practices for Packaging/Packing of Aluminum and Magnesium Products[2]

B 666/B 666M Practice for Identification Marking of Aluminum Products[2]

B 807 Practice for Extrusion Press Solution Heat Treatment of Aluminum Alloys[2]

E 18 Test Methods for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials[3]

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications[4]

E 34 Test Methods for Chemical Analysis of Aluminum and Aluminum Base Alloys[5]

E 55 Practice for Sampling Wrought Nonferrous Metals and Alloys for Determination of Chemical Composition[5]

E 227 Test Method for Optical Emission Spectrometric Analysis of Aluminum and Aluminum Alloys by the Point-to-Plane Technique[5]

E 527 Practice for Numbering Metals and Alloys (UNS)[6]

E 607 Test Method for Optical Emission Spectrometric Analysis of Aluminum and Aluminum Alloys by the Point-to-Plane Technique, Nitrogen Atmosphere[7]

E 716 Practices for Sampling Aluminum and Aluminum Alloys for Spectrochemical Analysis[7]

E 1251 Test Method for Optical Emission Spectrometric Analysis of Aluminum and Aluminum Alloys by the Argon

[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] *Annual Book of ASTM Standards*, Vol 02.02.
[3] *Annual Book of ASTM Standards*, Vol 03.01.
[4] *Annual Book of ASTM Standards*, Vol 14.02.
[5] *Annual Book of ASTM Standards*, Vol 03.05.
[6] *Annual Book of ASTM Standards*, Vol 01.01.
[7] *Annual Book of ASTM Standards*, Vol 03.06.

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

TABLE 1 Tensile Property Limits for Extruded Seamless Pipe[A,B]

Alloy	Temper	Pipe Size, in.	Strength, min, ksi [MPa]		Elongation[C,D]	
			Tensile	Yield (0.2 % Offset)	in 2 in. [50 mm] or 4× Diameter, min, %	in 5 × D ($5.65\sqrt{A}$)
3003	H18	under 1	27.0 [185]	24.0 [165]	4	4
	H112	1 and over	14.0 [95]	5.0 [35]	25	22
6061	T6	under 1	38.0 [260]	35.0 [240]	8	...
		1 and over	38.0 [260]	35.0 [240]	10[E]	9
6063	T6	all	30.0 [205]	25.0 [170]	8	7
6351	T5	all	38.0 [260]	35.0 [240]	10[E]	9
	T6	all	42.0 [290]	37.0 [255]	10[F]	9

[A] The basis for establishment of mechanical property limits is given in Annex A1 of this specification.
[B] To determine conformance to this specification, each value for tensile strength and for yield strength shall be rounded to the nearest 0.1 ksi [MPa] and each value for elongation to the nearest 0.5 %, both in accordance with the rounding method of Practice E 29.
[C] Elongation of full-section and sheet-type specimens is measured in 2 in.; of cut-out round specimens, 4× specimen diameter.
[D] Elongations in 50 mm apply for pipe tested in full sections and for sheet-type specimens machined from material up through 12.5 mm in thickness having parallel surfaces. Elongations in 5 × D (at $5.65\sqrt{A}$), where D and A are diameter and cross-sectional area of the specimen, respectively, apply to round test specimens machined from thicknesses over 6.30 mm.
[E] The minimum elongation for a wall thickness up through 0.249 in. [6.3 mm] is 8 %.
[F] For wall thickness 0.124 in. [3.20 mm] and less, the minimum elongation is 8 %.

Atmosphere, Point-to-Plane, Unipolar Self-Initiating Capacitor Discharge[7]

2.3 *ANSI Standards:*

B2.1 Pipe Threads (except Dryseal)[8]

B36.10 Wrought Steel and Wrought Iron Pipe[8]

H35.1 Alloy and Temper Designation Systems for Aluminum[2]

H35.1M Alloy and Temper Designation Systems for Aluminum [Metric][2]

H35.2 Dimensional Tolerances for Aluminum Mill Products[2]

H35.2M Dimensional Tolerances for Aluminum Mill Products[2]

2.4 *American Welding Society Standard:*

D 10.7 Recommended Practices for Gas Shielded Arc Welding of Aluminum and Aluminum-Alloy Pipe[9]

2.5 *Military Standard:*

MIL-STD-129 Marking for Shipment and Storage[10]

2.6 *Federal Standard:*

Fed. Std. No. 123 Marking for Shipment (Civil Agencies)[10]

3. Terminology

3.1 *Definitions:*

3.1.1 *extruded seamless pipe*—extruded seamless round tube with 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 seamless alclad tube*—a composite tube product composed of an aluminum alloy core having on either the inside or outside surface a metallurgically bonded aluminum or aluminum alloy coating that is anodic to the core, thus electrolytically protecting the core against corrosion.

3.1.3 *extruded seamless round tube*—a hollow product having a round cross section and a uniform wall thickness, brought to final dimensions by extruding from a hollow ingot.

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 or weight in pounds [kilograms],

4.1.3 Alloy (Section 7),

4.1.4 Temper (Section 9),

4.1.5 Pipe size and schedule number (pipe) (see Table 16.7 of ANSI H35.2 and Table 4 of this specification), or outside diameter and wall thickness (tube),

4.1.6 For alloy Alclad 3003, state clad inside or outside (13.1),

4.1.7 End configuration (Section 11),

4.1.8 Length (Section 12),

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

4.2.1 Whether solution treatment at the press is unacceptable (Section 8),

4.2.2 Whether inspection or witness of inspection and tests by the purchaser's representative is required prior to material shipment (Section 15),

4.2.3 Whether certification of the material is required (Section 17),

4.2.4 Whether marking for identification is required (Section 18), and

4.2.5 Whether Practices B 660 applies and if so, the levels of preservation, packaging, and packing required (Section 19).

5. Manufacture

5.1 The pipe and tube shall be produced from hollow extrusion ingot (cast in hollow form or pierced) and shall be extruded by use of the die and mandrel method.

5.1.1 At the option of the producer, the pipe and tube may be drawn after extrusion, provided all the requirements of this specification are met.

[8] Available from American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036.
[9] Available from the American Welding Society, 2501 Northwest 7th St., Miami, FL 33125.
[10] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

TABLE 2 Tensile Property Limits for Extruded Seamless Tube[A,B]

Temper	Specified Wall Thickness, in. [mm]	Area, in.^{2}[mm^2]	Tensile Strength, ksi [MPa] min	Tensile Strength, ksi [MPa] max	Yield Strength (0.2 % offset) ksi [MPa], min	Elongation[C,D] in 2 in. [50 mm] or 4 × D min,%	Elongation[C,D] in 5 × D (5.65 $\sqrt{A}$)[E]
			Aluminum 1060[F]				
O	all	all	8.5 [60]	14.0 [95]	2.5 [15]	25	22
H112	all	all	8.5 [60]	... [...]	2.5 [15]	25[G]	22[G]
			Alloy 3003[F]				
O	all	all	14.0 [95]	19.0 [130]	5.0 [35]	25	22
H112	all	all	14.0 [95]	... [...]	5.0 [35]	25	22
			Alloy Alclad 3003[F]				
O	all	all	13.0 [90]	18.0 [125]	4.5 [30]	25	22
H112	all	all	13.0 [90]	... [...]	4.5 [30]	25	22
			Alloy 5083[F]				
O	all [130.00]	up through 32.0 [20 000]	39.0 [270]	51.0 [350]	16.0 [110]	14	12
H111	all [130.00]	up through 32.0 [20 000]	40.0 [275]	... [...]	24.0 [165]	12	10
H112	all [130.00]	up through 32.0 [20 000]	39.0 [270]	... [...]	16.0 [110]	12	10
			Alloy 5086[F]				
O	all [130.00]	up through 32.0 [20 000]	35.0 [240]	46.0 [315]	14.0 [95]	14	12
H111	all [130.00]	up through 32.0 [20 000]	36.0 [250]	... [...]	21.0 [145]	12	10
H112	all [130.00]	up through 32.0 [20 000]	35.0 [240]	... [...]	14.0 [95]	12	10
			Alloy 6061[F]				
O[H]	all	all	... [...]	22.0 [150]	16.0[I] [...]	16	14
T1	[16.00]	all	[180]	... [...]	[95]	16	14
T4, *T4510*[J], *T4511*[J]	all	all	26.0 [180]	... [...]	16.0 [110]	16	14
T42[J]	all	all	26.0 [180]	... [...]	12.0 [85]	16	14
T51	[16.00]	all	[240]	... [...]	[205]	8	7
T6, *T62*[K], *T6510*[J], *T6511*[J]	up through 0.249 [6.30]	all	38.0 [260]	... [...]	35.0 [240]	8	...
	0.250 and over [6.30]	all	38.0 [260]	... [...]	35.0 [240]	10	9
			Alloy 6063[F]				
O[H]	all	... [all]	... [...]	19.0 [130]	... [...]	18	16
T1[K]	up through 0.500 [12.50]	all	17.0 [115]	... [...]	9.0 [60]	12	10
	0.501–1.000 [12.50–25.00]	all	16.0 [110]	... [...]	8.0 [55]	12 [...]	10
T4, T42[L]	up through 0.500 [12.50]	all	19.0 [130]	... [...]	10.0 [70]	14	12
	0.501–1.000 [12.50–25.00]	all	18.0 [125]	... [...]	9.0 [60]	14 [...]	12
T5	up through 0.500 [12.50]	all	22.0 [150]	... [...]	16.0 [110]	8	7
	0.501–1.000 [12.50–25.0]	all	21.0 [145]	... [...]	15.0 [105]	8 [...]	7
T52	up through 1.000 [25.00]	all	22.0 [150]	30.0 [205]	16.0[M] [110]	8	7
T6, T62[L]	up through 0.124 [3.20]	all	30.0 [205]	... [...]	25.0 [170]	8	...
	0.125–1.000 [3.20–25.00]	all	30.0 [205]	... [...]	25.0 [170]	10	7
			Alloy 6070[F]				
T6, T62[L]	up through 2.999	up through 32	48.0 [330]	... [...]	45.0 [310]	6	5
			Alloy 6351[F]				
T4	all	all	32.0 [220]	... [...]	19.0 [130]	16	14
T6	up through 0.124	...	42.0 [290]	... [...]	37.0 [255]	8	...
	0.125–0.749	...	42.0 [290]	... [...]	37.0 [255]	10	9

[A] The basis of establishment of mechanical property limits is given in Annex A1 of this specification.

[B] To determine conformance to this specification, each value for ultimate tensile strength and for yield strength shall be rounded to the nearest 0.1 ksi [MPa] and each value for elongation to the nearest 0.5 %, both in accordance with the rounding method of Practice E 29.

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

[D] For material of such dimensions that a standard test specimen cannot be taken, or for material thinner than 0.062 in., the test for elongation is not required.

[E] Elongations in 50 mm apply for tube tested in full section and for sheet-type specimens machined from material up through 12.5 mm in thickness having parallel surfaces. Elongations in 5× diameter (5.65 $\sqrt{A}$), where *D* and *A* are diameter and cross-sectional area of the specimen, respectively, apply to round test specimens machined from thickness over 6.30 mm. For tube of such dimensions that a standard test specimen cannot be taken, the test for elongation is not required.

[F] These alloys are also produced in the F temper, for which no mechanical properties are specified.

[G] Maximum tensile strength and minimum elongation apply to tubes having diameters from 1.000 in. to 4.500 in. and wall thickness from 0.050 in. to 0.169 in. only. Minimum elongation applies to tubes having diameters from 25.00 to 115.00 mm and wall thickness over 1.30 through 4.30 mm only.

[H] Upon heat treatment, annealed (0 temper) material shall be capable of developing the mechanical properties applicable to T42 temper material, and upon solution and precipitation heat treatment shall be capable of developing the mechanical properties applicable to T62 temper material.

[I] Yield strength is maximum [110 MPa] max.

[J] For stress-relieved tempers (T4510, T4511, T6510 and T6511) characteristics and properties other than those specified may differ somewhat from the corresponding characteristics and properties of material in the basic temper.

[K] Formerly designated T42 temper. Properly aged precipitation heat-treated 6063-T1 extruded products are designated T5.

[L] While material in the T42 and T62 tempers is not available from the material producer, the properties are listed to indicate those which can usually be obtained by the user when the material is properly solution heat treated or solution and precipitation heat treated from the O (annealed) or F (as-fabricated) tempers. These properties apply when samples of material supplied in the O or F temper are heat treated by the producer to the T42 or T62 tempers to determine that the material will respond to proper thermal treatment. Properties attained by the user, however, may be lower than those listed if the material has been formed or otherwise cold or hot worked, particularly in the annealed temper, prior to solution heat treatment.

[M] Maximum yield strength is 25.0 ksi [170 MPa].

TABLE 3 Chemical Composition[A,B,C]

Alloy	Composition, %											
	Silicon	Iron	Copper	Manganese	Magnesium	Chromium	Zinc	Vanadium	Titanium	Other Elements[D]		Aluminum
										Each	Total[E]	
1060	0.25	0.35	0.05	0.03	0.03	...	0.05	0.05	0.03	0.03	...	99.60
3003	0.6	0.7	0.05–0.20	1.0–1.5	...	...	0.10	...	...	0.05	0.15	min[F]
Alclad 3003	3003 alloy clad inside or outside with 7072 alloy											remainder
5083	0.40	0.40	0.10	0.40–1.0	4.0–4.9	0.05–0.25	0.25	...	0.15	0.05	0.15	remainder
5086	0.40	0.50	0.10	0.20–0.7	3.5–4.5	0.05–0.25	0.25	...	0.15	0.05	0.15	remainder
6061[G]	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
6070	1.0–1.7	0.50	0.15–0.40	0.40–1.0	0.50–1.2	0.10	0.25	...	0.15	0.05	0.15	remainder
6351	0.7–1.3	0.50	0.10	0.40–0.8	0.40–0.8	...	0.20	...	0.20	0.05	0.15	remainder
7072[H]	0.7 Si + Fe		0.10	0.10	0.10	...	0.8–1.3	...	...	0.05	0.15	remainder

[A] Limits are in percent maximum unless shown as a range or stated otherwise.
[B] Analysis shall be made for the elements for which limits are shown in this table.
[C] For purposes of determining conformance to these limits, an observed value or a calculated value obtained from analysis shall be rounded to the nearest unit in the last right-hand place of figures used in expressing the specified limit, in accordance with the rounding method of Practice E 29.
[D] *Others* includes listed elements for which no specific limit is shown as well as 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 non-conforming.
[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.
[F] The aluminum content shall be calculated by subtracting from 100.00 % the sum of all metallic elements present in amounts of 0.010 % or more each, rounded to the second decimal before determining the sum.
[G] In 1965 the requirements for Alloy 6062 were combined with those of Alloy 6061 by revision of the minimum chromium content from 0.15 to 0.04. For this reason, Alloy 6062 was cancelled.
[H] Composition of cladding alloy as applied during the course of manufacture. The sample from finished tube shall not be required to conform to these limits.

TABLE 4 Nominal Size and Weight[A] of Aluminum-Alloy Pipe

Nominal Pipe Size, in.[B]	Schedule Number[C]	Nominal Outside Diameter, in. [mm]	Nominal Wall Thickness, in. [mm]	Nominal Weight per Foot, lb [kg/m][A]
14	10	14.000 [356]	0.250 [6.35]	12.70 [18.83]
	20		0.312 [7.92]	15.78 [23.38]
	30		0.375 [9.52]	18.88 [27.98]
	40		0.438 [11.13]	21.95 [32.56]
	60		0.594 [15.04]	29.42 [43.50]
	80		0.750 [19.05]	36.71 [54.45]
16	10	16.000 [406]	0.250 [6.35]	14.55 [21.53]
	20		0.312 [7.92]	18.08 [26.74]
	30		0.375 [9.52]	21.65 [32.02]
	40		0.500 [12.70]	28.63 [42.37]
	60		0.656 [16.66]	37.19 [55.02]
	80		0.844 [21.44]	47.26 [69.94]
18	40	18.000 [457]	0.562 [14.27]	36.21 [53.59]
20	40	20.000 [508]	0.594 [15.09]	42.59 [63.09]

[A] Based on density of 0.098 lb/in.^{3} [270].
[B] Other pipe sizes with outside diameters listed in Table 2 of ANSI B36.10 may be considered covered by this specification if agreed upon between the producer and the purchaser.
[C] ANSI B36.10.

6. Responsibility for 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 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 pipe and tube shall conform to the chemical composition limits in Table 3. Conformance shall be determined by analyzing samples taken at the time the ingots are poured, or 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 3—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 [2000 kg] or fraction thereof of material in the lot, except