Designation: B 345/B 345M – 00

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	... 9
	0.250 and over [6.30]	all	38.0 [260]	... [...]	35.0 [240]	10	
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

that no 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 drilling, sawing, milling, turning, or clipping a representative piece or pieces to obtain a sample of not less than 75 g. Sampling shall be in accordance with Practice E 55.

7.3.2 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.

NOTE 4—It is difficult to obtain a reliable analysis of each of the components of clad materials using material in its finished state. A reasonably accurate determination of the core composition can be made if the cladding is substantially removed prior to analysis. The cladding composition is more difficult to determine because of the relatively thin layer and because of diffusion of core elements to the cladding. The correctness of cladding alloy used can usually be verified by a combination of a metallographic examination and spectrochemical analysis of the surface at several widely separated points.

7.4 *Methods of Analysis*—The determination of chemical composition shall be made in accordance with suitable chemical (Test Methods E 34), or 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 the purchaser.

8. Heat Treatment

8.1 Producer or supplier heat treatment for the production of T1 and T5-type tempers shall be in accordance with Practice B 807, and for the production of T4 and T6-type tempers, except as noted in 8.2, shall be in accordance with Practice B 597.

8.2 Unless otherwise specified, alloys 6061, 6063, and 6351 may be solution heat treated and quenched at the extrusion press in accordance with Practice B 807 for the production of T4 and T6-type tempers, as applicable.

9. Tensile Properties

9.1 *Limits*—The material shall conform to the tensile property requirements in Table 1 or Table 2 as applicable.

9.2 *Number of Specimens*:

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

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

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

9.3 *Test Specimens*:

9.3.1 Geometry of test specimens and the location in the product from which they are taken shall be as specified in Test Methods B 557 and B 557M.

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

9.5 *Retests*—Retests may be performed in accordance with Test Methods B 557 and B 557M.

10. Quality Assurance Screening of Extrusion Press HeatTreated Pipe and Tube

10.1 Pipe and tube heat treated at the extrusion press shall conform to all requirements of Section 9. In addition, hardness tests shall be performed on each extruded length or with the approval of the purchaser on pieces selected in accordance with a mutually acceptable sampling plan. The minimum hardness control value shall be in accordance with Table 5 for pipe and with Table 6 for tube for the type of hardness tester used. The specific type of hardness tester used shall be left to the discretion of the producer, but the test method shall be in accordance with Test Methods B 647, B 648, or E 18, as applicable.

10.2 Individual pieces within a lot that fail to conform to the minimum applicable hardness values may be accepted provided that the samples from two pieces exhibiting the lowest minimum hardness values are tension tested and found to conform to the requirements of Table 1 for pipe or Table 2 for tube.

11. End Bevels, Threads, and Grooves

11.1 When specified in the order or contract, the ends of each length of pipe shall be beveled, threaded, or grooved in accordance with 11.1.1-11.1.3.

11.1.1 Beveled ends shall be agreed upon between the producer and the purchaser.

NOTE 5—Many end configurations have been developed such as the V groove, which appear to be superior to the straight bevel under many

TABLE 5 Hardness Screening Values[A,B] for Seamless Pipe

Alloy and Temper	Pipe Size	Wall Thickness, in. [mm]	Minimum Hardness Number[C]		
			Webster	Barcol	Rockwell E
6061-T6	less than 1 in.	0.050 [1.25] and over	16	...	...
	1 in. and over	0.050 [1.25] thru 0.075 [1.50]	15	76	89
		0.076 [over 1.50] thru 0.499 [12.5]	15	76	89
		0.500 [over 12.5] thru 1.000 [25.0]	15	76	...
6063-T6	all	all [over 1.25 thru 25.0]	12	72	75
6351-T5	all	all [over 1.25 thru 25.0]	15	76	89
6351-T6	all	0.050 thru 1.000 [1.25 thru 25.0]	16	...	...

[A] See 10.1.

[B] The hardness values shown do not guarantee material will pass the applicable mechanical property requirements but are for informational purposes only. It is the responsibility of the user of this specification to establish the relationship between the hardness values and tensile properties.

[C] Alternative minimum hardness values and hardness testing devices may be used provided agreement is reached between the purchaser and supplier or producer.

TABLE 6 Hardness Screening Values[A,B] for Seamless Extruded Tube

Alloy and Temper	Specified Wall Thickness, in. [mm]	Minimum Hardness Number[C]		
		Webster	Barcol	Rockwell E
6061-T4	0.050 [1.25] and over	...	64	...
T6	0.050 [1.25] thru 0.075 [1.50]	15	76	89
	0.076 thru 0.499 [over 1.50 thru 12.5]	15	76	89
	0.500 thru 1.000 [over 12.5 thru 25.0]	15	76	...
6063-T1	0.050 thru 0.500 [1.25 thru 12.5]	...	50	...
T4	0.050 thru 0.500 [1.25 thru 12.5]	...	60	...
T5	0.050 thru 0.500 [1.25 thru 12.5]	...	65	...
T6	0.050 thru 0.500 [1.25 thru 12.5]	12	72	75
6351-T6	0.050 thru 0.749 [1.25 thru 19.00]	16	...	...
	0.050 thru 1.000	16	...	...

[A] See 10.1.
[B] The hardness values shown do not guarantee material will pass the applicable mechanical property requirements but are for informational purposes only. It is the responsibility of the user of this specification to establish the relationship between the hardness values and tensile properties.
[C] Alternative minimum hardness values and hardness testing devices may be used providing agreement is reached between the purchaser and supplier or producer.

circumstances. The "modified vee" described in AWS D10.7 is one example.

11.1.2 Threaded ends shall be in accordance with ANSI B2.1. The threaded ends shall be free from burrs and suitably protected from damage in handling. Threading of pipe made of nonheat-treatable alloys in a temper softer than H14 is not recommended.

11.1.3 Grooved ends shall be as specified by the purchaser.

12. Dimensional Tolerances

12.1 Except for length, 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.

12.1.1 Index to tables in ANSI H35.2 of permissible variations for pipe 12 in. and smaller:

Table No. 16.1 Outside Diameter
Table No. 16.2 Wall Thickness
Table No. 16.3 Weight
Table No. 16.5 Straightness
Table No. 16.7 Diameter, Wall Thickness, Weight

12.1.2 Index to tables of permissible variations for extruded seamless tube:

Table No. 12.1 Diameter
Table No. 12.3 Wall Thickness
Table No. 12.7 Straightness
Table No. 12.9 Squareness of Cut Ends

12.2 Nominal sizes and weights of 14, 16, 18, and 20-in. pipe are given in Table 4. Tolerances for these sizes shall be as agreed upon.

12.3 *Length Tolerance*— Eighty-five percent or more of the ordered quantity shall be the specified length plus or minus 1 in. [25 mm]. Fifteen percent of the ordered quantity may be a minimum of 90 % of the specified length, unless other agreement is made between the purchaser and producer.

12.4 *Number of Samples*—Examinations for dimensions shall be made to ensure conformance to the tolerance specified.

13. Cladding

13.1 The cladding of alloy Alclad 3003 shall comprise either the inside surface only or the outside surface only as specified.

13.2 Alclad 3003 shall be fabricated in such a manner as to give the following approximate cladding thickness:

Alloy and Cladding	Approximate Thickness of Cladding, percent of specified wall thickness
Alclad 3003 (clad inside)	10
Alclad 3003 (clad outside)	7

13.3 When the thickness of the cladding is to be determined on finished material, transverse cross sections of at least three pieces from the lot shall be polished for examination with a metallurgical microscope. Under a magnification of 100×, the cladding thickness at four points, 90° apart, in each sample shall be measured, and the average of the twelve measurements shall be taken as the thickness. In the case of the pipe having a diameter larger than can be properly mounted for polishing and examination, each portion of the cross section polished for examination may consist of an arc about ½ in. [12 mm] in length.

14. General Quality

14.1 Pipe and tube shall be supplied in the mill finish and shall be of uniform quality and temper, sound, and free from injurious defects. Dents and surface finish conditions which do not detract from its usefulness for piping systems shall not be cause for rejection. Grinding to remove minor surface defects is permitted if the dimensional tolerances are met.

14.2 Discoloration that is characteristic of proper solution heat treatment shall not be cause for rejection.

14.3 Each 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.

15. Source Inspection

15.1 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 the producer as part of the purchase contract.

15.2 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.

16. Retest and Rejection

16.1 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.

16.2 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 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.

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

16.4 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.

17. Certification

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

18. Identification Marking of Product

18.1 When specified in the contract or purchase order, all pipe and tube shall be marked in accordance with Practice B 666/B 666M, and the marking legend shall include the word "seamless."

18.2 The foregoing requirements are minimum; marking systems which involve added information, larger characters, and greater frequencies are acceptable under this specification.

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, alloy, and temper 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.

19.2 Each shipping container shall be marked with the purchase order number, size, schedule number, if applicable, specification number, alloy and temper, gross and net weights, and the producer's name or trademarks.

19.3 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 application 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.

20. Keywords

20.1 aluminum alloy; extruded tube; seamless pipe; seamless 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 analysis 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. Mechanical property limits in this metric issue were derived from the inch-pound system limits that were developed under the above principles. As test data on metric dimensioned specimens are accumulated, some refinement of limits, particularly for elongations measured in 5D, can be anticipated.

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 Association[11] 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:

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

[11] The Aluminum Association, 900 19th Street, NW, Washington, DC 20006.

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 0.10 through 0.55 %	0.0X
(It is customary to express limits of 0.30 through 0.55 % as 0.X0 or 0.X5.)	0.XX
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.

APPENDIX

(Nonmandatory Information)

X1. GENERAL INFORMATION ON MINIMUM TENSILE PROPERTIES OF WELDED MATERIAL

X1.1 Table X1.1 lists the minimum tensile properties of welded aluminum alloys.

TABLE X1.1 Minimum Tensile Properties of Welded Aluminum Alloys[A]
(Gas Tungsten Arc or Gas Metal Arc Welding with No Postweld Heat Treatment)

Alloy and Temper	Tensile Strength, ksi [MPa]	Yield Strength,[B] ksi [MPa]
3003-H12, H14, H16, H18	14 [95]	7 [50]
Alclad 3003-H12, H14, H16, H18	13 [90]	6 [40]
5083-H111	39 [270]	21 [145]
5086-H111	35 [240]	18 [125]
H112	35 [240]	14 [95]
6061-T6, T651[C,D]	24 [165]	20 [140]
T6, T651[E]	24 [165]	15 [105]
6063-T5, T52, T6[C,D]	17 [115]	11 [75]
6070-T6[C,D]	24 [165]	20 [140]
6351-T6[C,D]	24 [165]	20 [140]

[A] Filler wires used and minimum tensile strengths for all alloys except 6070 and 6351 are those covered by ASME Standards and published in Aluminum Association "Aluminum Construction Manual."

[B] 0.2 % offset in 10-in. [250-mm] gage length across weld.

[C] These values apply to pipe and tube of all nominal thicknesses when welded with 5183, 5356, or 5556 alloy filler wire. These values also apply to pipe and tube of nominal wall thickness 0.375 in. [10.00 mm] and less when welded with 4043, 5154, 5254 or 5554 alloy filler wire.

[D] For pipe and tube smaller than 4 in. [100 mm] in diameter, or having *D*/*t* ratios less than 15, the strength values may be lower than the values shown.

[E] These values apply to pipe and tube of nominal wall thickness over 0.375 in. [10.00 mm] when welded with 4043, 5154, 5254, or 5554 alloy filler wire.

SUMMARY OF CHANGES

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

(1) Deleted references to Test Method E 101.