Designation: B 241/B 241M – 02

Used in USNRC-RDT standards

Standard Specification for Aluminum and Aluminum-Alloy Seamless Pipe and Seamless Extruded Tube[1]

This standard is issued under the fixed designation B 241/B 241M; 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[2] covers aluminum and aluminum–alloy seamless pipe in the alloys (Note 1) and tempers shown in Table 1 [Table 2] and extruded round seamless tube in the alloys and tempers shown in Table 3 [Table 4] intended for pressure applications. The standard sizes for seamless pipe are listed in Table 16.7 of ANSI H35.2 and H35.2M. Nonstandard alloys, tempers, and sizes of pipe are produced as seamless extruded tube.

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

NOTE 2—For other seamless drawn tubes, see Specification B 210 or Specification B 483. For extruded tube see Specification B 221, and for structural pipe and tube see Specification B 429.

1.2 Alloy and temper designations are in accordance with ANSI H35.1 and H35.1M. The equivalent Unified Numbering System alloy designations are those of Table 5preceded by A9, for example, A91100 for aluminum 1100 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 or SI units are to be regarded separately as standard. The SI units are shown either in brackets or in separate tables. The values stated in each system are not exact equivalents; therefore, each system must be used independently of the other. Combining values from the two systems will result in nonconformance with this specification.

2. Referenced Documents

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

2.2 *ASTM Standards:*

B 210 Specification for Aluminum and Aluminum-Alloy Drawn Seamless Tubes[3]

B 221 Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes[3]

B 429 Specification for Aluminum-Alloy Extruded Structural Pipe and Tube[3]

B 483 Specification for Aluminum and Aluminum-Alloy Drawn Tubes for General Purpose Applications[3]

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

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

B 594 Practice for Ultrasonic Inspection of Aluminum-Alloy Wrought Products for Aerospace Applications[3]

B 647 Test Method for Indentation Hardness of Aluminum Alloys by Means of a Webster Hardness Gage[3]

B 648 Test Method for Indentation Hardness of Aluminum Alloys by Means of a Barcol Impressor[3]

B 660 Practices for Packaging/Packing of Aluminum and Magnesium Products[3]

B 666/B 666M Practice for Identification Marking of Aluminum and Magnesium Products[3]

B 807 Practice for Extrusion Press Solution Heat Treatment of Aluminum Alloys[3]

B 918 Practice for Heat Treatment of Wrought Aluminum Alloys[3]

E 18 Test Methods for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials[4]

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications[5]

E 34 Test Methods for Chemical Analysis of Aluminum and Aluminum-Base Alloys[6]

E 55 Practice for Sampling Wrought Nonferrous Metals and Alloys for Determination of Chemical Composition[6]

E 227 Test Method for Optical Emission Spectrometric Analysis of Aluminum and Aluminum Alloys by the Point-to-Plane Technique[6]

[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.

Current edition approved Oct. 10, 2002. Published January 2003. Originally approved in 1949. Last previous edition approved in 2000 as B 241/B 241M–00.

[2] For ASME Boiler and Pressure Vessel Code applications see related Specification SB-241/SB-241M in Section II of that Code.

[3] *Annual Book of ASTM Standards*, Vol 02.02.

[4] *Annual Book of ASTM Standards*, Vol 03.01.

[5] *Annual Book of ASTM Standards*, Vol 14.02.

[6] *Annual Book of ASTM Standards*, Vol 03.05.

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

TABLE 1 Tensile Property Limits for Pipe, Inch-Pound Units[A,B]

Alloy	Temper	Pipe Size, in.	Tensile Strength, min, ksi	Yield Strength (0.2 % Offset), min, ksi	Elongation in 2 in. or 4 × Diameter, min, %[C]
3003	H18	Under 1	27.0	24.0	4
	H112	1 and over	14.0	5.0	25
6061	T6 (Extruded)	Under 1	38.0	35.0	8
		1 and over	38.0	35.0	10[D]
	T6 (Drawn)	Under 1	42.0	35.0	8[E]
		1 and over	38.0	35.0	10[F]
6063	T6	All	30.0	25.0	8
6351	T5	All	38.0	35.0	10[D]
	T6	All	42.0	37.0	10[G]

[A] The basis for establishment of tensile property limits is shown in Annex A1.
[B] For purposes of determining conformance with this specification, each value for tensile strength and yield strength shall be rounded to the nearest 0.1 ksi, and each value for elongation shall be rounded to the nearest 0.5 %, both in accordance with the rounding-off method of Practice E 29.
[C] Elongation of full-section and cut-out sheet-type specimens is measured in 2 in.; of round specimens, in 4 × specimen diameter.
[D] For wall thicknesses less than 0.250 in., the minimum elongation is 8 %.
[E] For wall thickness 0.050 to 0.259 in., the minimum elongation is 10 %.
[F] For wall thickness 0.260 to 0.500 in., the minimum elongation is 12 %.
[G] For wall thickness less than 0.125 in., the minimum elongation is 8 %.

TABLE 2 Tensile Property Limits for Pipe [SI Units][A,B]

Alloy[C]	Temper[C] (Product)	Pipe Size, Designation	Tensile Strength, min, MPa	Yield Strength (0.2 % Offset), min, MPa	Elongation,[C] min, %	
					in 50 mm	in 5 × Diameter ($5.65\sqrt{A}$)
3003	H18	Under 1	185	165	4	...
	H112	1 and over	95	35	25	22
6061	T6 (Extruded)	Under 1	260	240	8	...
		1 and over	260	240	10[D]	9
	T6 (Drawn)	Under 1	290	240	8[E]	...
		1 and over	260	240	10[F]	9
6063	T6	All	205	170	8	7
6351	T5	All	260	240	10[D]	9
	T6	All	290	255	10[G]	9

[A] The basis for establishment of mechanical property limits is shown in Annex A1.
[B] For purposes of determining conformance with this specification, each value for ultimate strength and yield strength shall be rounded to the nearest 1 MPa, and each value for elongation shall be rounded to the nearest 0.5 %, both in accordance with the rounding-off method of Practice E 29.
[C] Elongations in 50 mm apply for pipe tested in full-section and to sheet type specimens taken from pipes having a wall up to 12.50 mm thick. Elongations in $5D$ ($5.65\sqrt{A}$), where D and A are diameter and cross-sectional area of the specimens respectively, apply to round test specimens machined from wall thicknesses over 6.30 mm.
[D] For wall thicknesses up through 6.30 mm the minimum elongation is 8 %.
[E] For wall thicknesses over 1.25 through 6.60 mm, the minimum elongation is 10 %.
[F] For wall thicknesses over 6.60 through 12.50 mm, the minimum elongation is 12 %.
[G] For wall thicknesses up through 3.20 mm the minimum elongation is 8 %.

E 527 Practice for Numbering Metals and Alloys (UNS)[7]
E 607 Test Method for Atomic Emission Spectrometric Analysis of Aluminum and Aluminum Alloys by the Point-to-Plane Technique, Nitrogen Atmosphere[6]
E 716 Practices for Sampling Aluminum and Aluminum Alloys for Spectrochemical Analysis[6]
E 1004 Practice for Determining Electrical Conductivity Using the Electromagnetic (Eddy-Current) Method[8]
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 Discharge[6]
G 47 Test Method for Determining Susceptibility to Stress-Corrosion Cracking of 2xxx and 7xxx Aluminum Alloy Products[9]

2.3 *ANSI Standards:*

H35.1 Alloy and Temper Designation Systems for Aluminum[3]
H35.1(M) Alloy and Temper Designation Systems for Aluminum[3]
H35.2 Dimensional Tolerances for Aluminum Mill Products[3]
H35.2(M) Dimensional Tolerances for Aluminum Mill Products[3]

2.4 *Federal Standard:*

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

2.5 *Military Standard:*

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

2.6 *AMS Specification:*

AMS 2772 Heat Treatment of Aluminum Alloy Raw Materials[11]

[7] *Annual Book of ASTM Standards*, Vol 01.01.
[8] *Annual Book of ASTM Standards*, Vol 03.03.
[9] *Annual Book of ASTM Standards*, Vol 03.02.
[10] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.
[11] Available from Society of Automotive Engineers (SAE), 400 Commonwealth Dr., Warrendale, PA 15096-0001.

TABLE 3 Tensile Property Limits for Extruded Tube, Inch-Pound Units[A,B]

Temper	Specified Section or Wall Thickness, in.	Area, in.[2]	Tensile Strength, ksi		Yield Strength (0.2 % Offset), ksi		Elongation in 2 in. or 4 × Diameter, min, %[C]
			Min	Max	Min	Max	
		Aluminum 1060					
O	all	all	8.5	14.0	2.5	. . .	25
H112	all	all	8.5	. . .	2.5	. . .	25
F[D]	all	all	. . .	. . .	. . .	. . .	. . .
		Aluminum 1100					
O	all	all	11.0	15.5	3.0	. . .	25
H112	all	all	11.0	. . .	3.0	. . .	25
F[D]	all	all	. . .	. . .	. . .	. . .	. . .
		Alloy 2014					
O	all	all	. . .	30.0	. . .	18.0	12
T4, T4510[E], T4511[E]	all	all	50.0	. . .	35.0	. . .	12
T42	all	all	50.0	. . .	29.0	. . .	12
T6, T6510[E], T6511[E]	up thru 0.499	all	60.0	. . .	53.0	. . .	7
	0.500–0.749	all	64.0	. . .	58.0	. . .	7
	0.750 and over	up thru 25	68.0	. . .	60.0	. . .	7
		over 25 thru 32	68.0	. . .	58.0	. . .	6
T62	up thru 0.749	all	60.0	. . .	53.0	. . .	7
	0.750 and over	up thru 25	60.0	. . .	53.0	. . .	7
		over 25 thru 32	60.0	. . .	53.0	. . .	6
F[D]	all	all	. . .	. . .	. . .	. . .	. . .
		Alloy 2024					
O	all	all	. . .	35.0	. . .	19.0	12
T3, T3510[E], T3511[E]	up thru 0.249	all	57.0	. . .	42.0	. . .	10
	0.250–0.749	all	60.0	. . .	44.0	. . .	10
	0.750–1.499	all	65.0	. . .	46.0	. . .	10
	1.500 and over	up thru 25	70.0	. . .	48.0	. . .	10
		over 25 thru 32	68.0	. . .	46.0	. . .	8
T42	up thru 0.749	all	57.0	. . .	38.0	. . .	12
	0.750–1.499	all	57.0	. . .	38.0	. . .	10
	1.500 and over	up thru 25	57.0	. . .	38.0	. . .	10
		over 25 thru 32	57.0	. . .	38.0	. . .	8
T81, T8510[E], T8511[E]	0.050–0.249	all	64.0	. . .	56.0	. . .	4
	0.250–1.499	all	66.0	. . .	58.0	. . .	5
	1.500 and over	up thru 32	66.0	. . .	58.0	. . .	5
F[D]	all	all	. . .	. . .	. . .	. . .	. . .
		Alloy 2219					
O	all	all	. . .	32.0	. . .	18.0	12
T31, T3510[E], T3511[E]	up thru 0.499	up thru 25	42.0	. . .	26.0	. . .	14
	0.500–2.999	up thru 25	45.0	. . .	27.0	. . .	14
T62	Up thru 0.999	up thru 25	54.0	. . .	36.0	. . .	6
	1.000 and over	up thru 25	54.0	. . .	36.0	. . .	6
T81, T8510[E], T8511[E]	up thru 2.999	up thru 25	58.0	. . .	42.0	. . .	6
F[D]	all	all	. . .	. . .	. . .	. . .	. . .
		Alloy 3003					
O	all	all	14.0	19.0	5.0	. . .	25
H112	all	all	14.0	. . .	5.0	. . .	25
F[D]	all	all	. . .	. . .	. . .	. . .	. . .
		Alclad Alloy 3003					
O	all	all	13.0	18.0	4.5	. . .	25

TABLE 3 *Continued*

Temper	Specified Section or Wall Thickness, in.	Area, in.[2]	Tensile Strength, ksi		Yield Strength (0.2 % Offset), ksi		Elongation in 2 in. or 4 × Diameter, min, %[C]
			Min	Max	Min	Max	
H112	all	all	13.0	. . .	4.5	. . .	25
F[D]	all	all	. . .	. . .	. . .	. . .	. . .
			Alloy 5052				
O	all	all	25.0	35.0	10.0	. . .	. . .
F[D]	all	all	. . .	. . .	. . .	. . .	. . .
			Alloy 5083				
O	all	up thru 32	39.0	51.0	16.0	. . .	14
H111	all	up thru 32	40.0	. . .	24.0	. . .	12
H112	all	up thru 32	39.0	. . .	16.0	. . .	12
F[D]	all	all	. . .	. . .	. . .	. . .	. . .
			Alloy 5086				
O	all	up thru 32	35.0	46.0	14.0	. . .	14
H111	all	up thru 32	36.0	. . .	21.0	. . .	12
H112	all	up thru 32	35.0	. . .	14.0	. . .	12
F[D]	all	all	. . .	. . .	. . .	. . .	. . .
			Alloy 5154				
O	all	up thru 32	31.0	41.0	12.0	. . .	14
H111	all	up thru 32	33.0	. . .	19.0	. . .	12
H112	all	up thru 32	31.0	. . .	12.0	. . .	12
F[D]	all	all	. . .	. . .	. . .	. . .	. . .
			Alloy 5456				
O	all	up thru 32	41.0	53.0	19.0	. . .	14
H111	all	up thru 32	42.0	. . .	26.0	. . .	12
H112	all	up thru 32	41.0	. . .	19.0	. . .	12
F[D]	all	all	. . .	. . .	. . .	. . .	. . .
			Alloy 6061				
O	all	all	. . .	22.0	. . .	16.0	16
T1	up thru 0.625	all	26.0	. . .	14.0	. . .	16
T4, T4510[E], T4511[E]	all	all	26.0	. . .	16.0	. . .	16
T42	all	all	26.0	. . .	12.0	. . .	16
T51	up thru 0.625	all	35.0	. . .	30.0	. . .	8
T6, T62, T6510[E], T6511[E]	up thru 0.249	all	38.0	. . .	35.0	. . .	8
	0.250 and over	all	38.0	. . .	35.0	. . .	10
F[D]	all	all	. . .	. . .	. . .	. . .	. . .
			Alloy 6063				
O	all	all	. . .	19.0	. . .	. . .	18
T1[F]	up thru 0.500	all	17.0	. . .	9.0	. . .	12
	0.501–1.000	all	16.0	. . .	8.0	. . .	12
T4, T42	up through 0.500	all	19.0	. . .	10.0	. . .	14
	0.501–1.000	all	18.0	. . .	9.0	. . .	14
T5	up thru 0.500	all	22.0	. . .	16.0	. . .	8
	0.501–1.000	all	21.0	. . .	15.0	. . .	8
T52	up thru 1.000	all	22.0	30.0	16.0	25.0	8
T6, T62	up thru 0.124	all	30.0	. . .	25.0	. . .	8
	0.125–1.000	all	30.0	. . .	25.0	. . .	10
F[D]	all	all	. . .	. . .	. . .	. . .	. . .
			Alloy 6066				
O	all	all	. . .	29.0	. . .	18.0	16

TABLE 3 *Continued*

Temper	Specified Section or Wall Thickness, in.	Area, in.[2]	Tensile Strength, ksi		Yield Strength (0.2 % Offset), ksi		Elongation in 2 in. or 4 × Diameter, min, %[C]
			Min	Max	Min	Max	
T4, T4510[E] T4511[E]	all	all	40.0	. . .	25.0	. . .	14
T42	all	all	40.0	. . .	24.0	. . .	14
T6, T6510,[E] T6511[E]	all	all	50.0	. . .	45.0	. . .	8
T62	all	all	50.0	. . .	42.0	. . .	8
		Alloy 6162					
T5, T5510[E] T5511[E]	up thru 1.000	all	37.0	. . .	34.0	. . .	7
T6, T6510[E]	up thru 0.249	all	38.0	. . .	35.0	. . .	8
T6511[E]	0.250–0.499	all	38.0	. . .	35.0	. . .	10
		Alloy 6351					
T4	up thru 0.749	all	32.0	. . .	19.0	. . .	16
T6	up thru 0.124	. . .	42.0	. . .	37.0	. . .	8
	0.125–0749	. . .	42.0	. . .	37.0	. . .	10
		Alloy 7075					
O	all	. . .	. . .	40.0	. . .	24.0	10
T6, T62	up through 0.249	all	78.0	. . .	70.0	. . .	7
T6510[E]	0.250–0.499	all	81.0	. . .	73.0	. . .	7
T6511[E]	0.500–1.499	all	81.0	. . .	72.0	. . .	7
	1.500–2.999	all	81.0	. . .	72.0	. . .	7
T73	0.062–0.249	all	68.0	. . .	58.0	. . .	7
T73510	0.250–1.499	up thru 25	70.0	. . .	61.0	. . .	8
T73511	1.500–2.999	up thru 25	69.0	. . .	59.0	. . .	8
F[D]	all	all	. . .	. . .	. . .	. . .	. . .
		Alloy 7178					
O	all	up thru 32	. . .	40.0	. . .	24.0	10
	up through 0.061	all	82.0	. . .	76.0	. . .	. . .
	0.062–0.249	up thru 20	84.0	. . .	76.0	. . .	5
T6	0.250–1.499	up thru 25	87.0	. . .	78.0	. . .	5
T6510[E]	1.500–2.499	up thru 25	86.0	. . .	77.0	. . .	5
T6511[E]		over 25 thru 32	84.0	. . .	75.0	. . .	5
	2.500–2.999	up thru 32	82.0	. . .	71.0	. . .	5
T62	up thru 0.061	all	79.0	. . .	73.0	. . .	5
	0.062–0.249	up thru 20	82.0	. . .	74.0	. . .	5
	0.250–1.499	up thru 25	86.0	. . .	77.0	. . .	5
	1.500–2.499	up thru 25	86.0	. . .	77.0	. . .	5
		over 25 thru 32	84.0	. . .	75.0	. . .	5
	2.500–2.999	up through 32	82.0	. . .	71.0	. . .	5
F[D]	all	all	. . .	. . .	. . .	. . .	. . .

[A]The basis for establishment of mechanical property limits is shown in Annex A1.

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

[C]Elongation of full-section and cut-out sheet-type specimens is measured in 2 in.; of round specimens, in 4 × specimen diameter. See 9.1.1 for conditions under which measurements are not required.

[D]Tests for tensile properties in the F temper are not required.

[E]For stress relieved tempers (T3510, T3511, T4510, T4511, T5510, T5511, T6510, T6511, T73510, T73511, T8510, T8511), characteristics and properties other than those specified may differ somewhat from the corresponding characteristics and properties of material in the basic tempers.

[F]Formerly designated T42 temper. When properly aged (precipitation heat-treated) 6063-T1 extruded products are designated T5.

TABLE 4 Tensile Property Limits for Extruded Tube [SI Units][A,B]

Temper	Specified Section or Wall Thickness, mm		Area, mm^2		Tensile Strength, MPa		Yield Strength (0.2 % offset), MPa		Elongation,[C] %, min	
	over	through	over	through	min	max	min	max	in 50 mm	in 5 × diameter (5.65 $\sqrt{A}$)
Aluminum 1060										
O	all		all		60	95	15	. . .	25	22
H112	all		all		60	. . .	15	. . .	25	22
F[D]	all		all		. . .	. . .	. . .	. . .	. . .	. . .
Aluminum 1100										
O	all		all		75	105	20	. . .	25	22
H112	all		all		75	. . .	20	. . .	25	22
F[D]	all		all		. . .	. . .	. . .	. . .	. . .	. . .
Alloy 2014										
O	all		all		. . .	205	. . .	125	12	10
T4, T4510[E], T4511[E]	all		all		345	. . .	240	. . .	12	10
T42[F]	all		all		345	. . .	200	. . .	12	10
T6, T6510[E], T6511[E]	. . .	12.50	all		415	. . .	365	. . .	7	6
	12.50	18.00	all	16 000	440	. . .	400	. . .	. . .	6
	18.00	. . .	. . .	20 000	470	. . .	415	. . .	. . .	6
	18.00	. . .	16 000		470	. . .	400	. . .	. . .	5
	. . .	18.00	all	. . .	415	. . .	365	. . .	7	6
	18.00	. . .	. . .	16 000	415	. . .	365	. . .	. . .	6
T62[F]	18.00	. . .	16 000	20 000	415	. . .	365	. . .	. . .	5
F[E]	all		all	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Alloy 2024										
O	all		all		. . .	240	. . .	130	12	10
T3, T3510[E], T3511[E]	. . .	6.30	all		395	. . .	290	. . .	10[H]	. . .
	6.30	18.00	all		415	. . .	305	. . .	10[H]	9[H]
	18.00	35.00	all		450	. . .	315	. . .	. . .	9
	35.00	. . .	. . .	16 000	485	. . .	360[I]	. . .	. . .	9
	35.00	. . .	16 000	20 000	470	. . .	330[J]	. . .	. . .	7
	. . .	18.00	all	. . .	395	. . .	260	. . .	12	10
	18.00	35.00	all		395	. . .	260	. . .	. . .	9
T42[F]	35.00	. . .	. . .	16 000	395	. . .	260	. . .	. . .	9
	35.00	. . .	16 000	20 000	395	. . .	260	. . .	. . .	7
T81, T8510[E], T8511[E]	1.20	6.30	all		440	. . .	385	. . .	4	. . .
	6.30	35.00	all		455	. . .	400	. . .	5	4
	35.00	. . .	. . .	20 000	455	. . .	400	. . .	. . .	4
F[D]	all		all		. . .	. . .	. . .	. . .	. . .	. . .
Alloy 2219										
O	all		all		. . .	220	. . .	125	12	10
T31, T3510[E], T3511[E]	. . .	12.50	. . .	16 000	290	. . .	180	. . .	14	12
	12.50	80.00		16 000	310	. . .	185	. . .	. . .	12
	. . .	25.00	. . .	16 000	370	. . .	250	. . .	6	5
T62[F]	25.00		. . .	20 000	370	. . .	250	. . .	. . .	5
T81, T8510[E], T8511[E]	. . .	80.00	. . .	16 000	400	. . .	290	. . .	6	5
F[E]	all		all		. . .	. . .	. . .	. . .	. . .	. . .
Alloy 3003										
O	all	. . .	all		95	130	35	. . .	25	22

TABLE 4 *Continued*

Temper	Specified Section or Wall Thickness, mm		Area, mm^2		Tensile Strength, MPa		Yield Strength (0.2 % offset), MPa		Elongation,[C] %, min	
	over	through	over	through	min	max	min	max	in 50 mm	in 5 × diameter ($5.65\sqrt{A}$)
H112	. . .	1.60	all		95	. . .	35	. . .	. . .	. . .
	1.60	. . .	all		95	. . .	35	. . .	25	22
F[D]	all		all		. . .	. . .	. . .	. . .	. . .	. . .
				Alclad Alloy 3003						
O	all		all		90	125	30	. . .	25	22
H112	all		all		90	. . .	30	. . .	25	22
F[D]	all		all		. . .	. . .	. . .	. . .	. . .	. . .
				Alloy 5052						
O	all		all		170	240	70	. . .	. . .	. . .
F[D]	all		all		. . .	. . .	. . .	. . .	. . .	. . .
				Alloy 5083						
O	all		. . .	20 000	270	350	110	. . .	14	12
H111	all		. . .	20 000	275	. . .	165	. . .	12	10
H112	all		. . .	20 000	270	. . .	110	. . .	12	10
F[D]	all		all		. . .	. . .	. . .	. . .	. . .	. . .
				Alloy 5086						
O	all		. . .	20 000	240	315	95	. . .	14	12
H111	all		. . .	20 000	250	. . .	145	. . .	12	10
H112	all		. . .	20 000	240	. . .	95	. . .	12	10
F[D]	all		all		. . .	. . .	. . .	. . .	. . .	. . .
				Alloy 5454						
O	all		. . .	20 000	215	285	85	. . .	14	12
H111	all		. . .	20 000	230	. . .	130	. . .	12	10
H112	all		. . .	20 000	215	. . .	85	. . .	12	10
F[D]	all		all		. . .	. . .	. . .	. . .	. . .	. . .
				Alloy 5456						
O	all		. . .	20 000	285	365	130	. . .	14	12
H111	all		. . .	20 000	290	. . .	180	. . .	12	10
H112	all		. . .	20 000	285	. . .	130	. . .	12	10
F[D]	all		all		. . .	. . .	. . .	. . .	. . .	. . .
				Alloy 6061						
O	all		all		. . .	150	. . .	110	16	14
T1	. . .	16.00	all		180	. . .	95	. . .	16	14
T4, T4510[E], T4511[E]	all		all		180	. . .	110	. . .	16	14
T42[F]	all		all		180	. . .	85	. . .	16	14
T51	. . .	16.00	all		240	. . .	205	. . .	8	7
T6, T62[F], T6510[E], T6511[E]	. . .	6.30	all		260	. . .	240	. . .	8	. . .
	6.30	. . .	all		260	. . .	240	. . .	10	9
F[E]	all		all		. . .	. . .	. . .	. . .	. . .	. . .
				Alloy 6063						
O	all		all		. . .	130	. . .	. . .	18	16
T1	. . .	12.50	all	. . .	115	. . .	60	. . .	12	10
	12.50	25.00	all	. . .	110	. . .	55	. . .	. . .	10
T4,T42[F]	. . .	12.50	all		130	. . .	70	. . .	14	12
	12.50	25.00	all		125	. . .	60	. . .	. . .	12
T5	. . .	12.50	all		150	. . .	110	. . .	8	7
	12.50	25.00	all		145	. . .	105	. . .	. . .	7
T52	. . .	25.00	all		150	205	110	170	8	7

TABLE 4 *Continued*

Temper	Specified Section or Wall Thickness, mm		Area, mm^2		Tensile Strength, MPa		Yield Strength (0.2 % offset), MPa		Elongation,[C] %, min	
	over	through	over	through	min	max	min	max	in 50 mm	in 5 × diameter (5.65 $\sqrt{A}$)
T6	. . .	3.20	all		205	. . .	170	. . .	8	. . .
	3.20	25.00	all		205	. . .	170	. . .	10	9
F[D]	all		all		. . .	. . .	. . .	. . .	. . .	. . .
				Alloy 6066						
O	all		all		. . .	200	. . .	125	16	14
T4, T4510[E] T4511[E]	all		all		275	. . .	170	. . .	14	12
T42	all		all		275	. . .	165	. . .	14	12
T6, T6510[E] T6511[E]	all		all		345	. . .	310	. . .	8	7
T62	all		all		345	. . .	290	. . .	8	7
				Alloy 6162						
T5, T5510[E] T5511[E]	. . .	25.00	all		255	. . .	235	. . .	7	6
T6, T6510[E] T6511[E]	. . .	6.30	all		260	. . .	240	. . .	8	. . .
	6.30	12.50	all		260	. . .	240	. . .	10	9
				Alloy 6351						
T4	. . .	19.00	all		220	. . .	130	. . .	16	14
T6	. . .	3.20	. . .		290	. . .	255	. . .	8	
	3.20	25.00	. . .		290	. . .	255	. . .	10	9
				Alloy 7075						
O	all		all		. . .	275	. . .	165	10	9
T6, T62[F]	. . .	6.30	all		540	. . .	485	. . .	7	. . .
T62510[E]	6.30	12.50	all		560	. . .	505	. . .	7	6
T6511[E]	12.50	70.00	all		560	. . .	495	. . .	. . .	6
T73	1.60	6.30	. . .	13 000	470	. . .	400	. . .	7	. . .
T3510[E]	6.30	35.00	. . .	16 000	485	. . .	420	. . .	8	7
T3511[E]	35.00	70.00	. . .	18 000	475	. . .	405	. . .	. . .	7
F[D]	all		all		. . .	. . .	. . .	. . .	. . .	. . .
				Alloy 7178						
O	all		. . .	20 000	. . .	275	. . .	165	10	9
	. . .	1.60	all		565	. . .	525	. . .	. . .	. . .
	1.60	6.30	. . .	13 000	580	. . .	525	. . .	5	. . .
T6	6.30	35.00	. . .	16 000	600	. . .	540	. . .	5	4
T6510[E]	35.00	60.00	. . .	16 000	595	. . .	530	. . .	. . .	4
T6511[E]	35.00	60.00	16 000	20 000	580	. . .	515	. . .	. . .	4
	60.00	80.00	. . .	20 000	565	. . .	490	. . .	. . .	4
	. . .	1.60	all	13 000	545	. . .	505	. . .	. . .	. . .
	1.60	6.30	. . .	13 000	565	. . .	510	. . .	5	. . .
	6.30	35.00	. . .	16 000	595	. . .	530	. . .	5	4
T62[F]	35.00	60.00	. . .	16 000	595	. . .	530	. . .	. . .	4
	35.00	60.00	16 000	20 000	580	. . .	515	. . .	. . .	4
	60.00	80.00	. . .	20 000	565	. . .	490	. . .	. . .	4
F[D]	all	all		. . .	. . .	. . .	. . .	. . .	. . .	

[A] The basis for establishment of tensile property limits is shown in Annex A1.

[B] To determine conformance to this specification, each value for tensile strength and yield strength shall be rounded to the nearest 1 MPa and each value for elongation

to the nearest 0.5 %, both in accordance with the rounding-off method of Practice E 29.

[C] Elongation in 50 mm apply for shapes 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 D (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. See 9.1.1 for conditions under which measurements are not required.

[D] No mechanical properties are specified or guaranteed.

[E] For stress-relieved tempers (T3510, T3511, T4510, T4511, T5510, T5511, T6510, T6511, T73510, T73511, T76510, T76511, T8510, T8511), characteristics and properties offer than those specified may differ somewhat from the corresponding characteristics and properties of material in the basic tempers.

[F] Material in the T42 and T62 tempers is not available from the material producers.

3. Terminology

3.1 *Definitions:*

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

3.1.2 *extruded seamless round tube*—an extruded hollow product having a round cross section and a uniform wall thickness, which does not contain any line junctures resulting from method of manufacture.

3.1.3 *producer*—the primary manufacturer of the material.

3.1.4 *seamless pipe*—extruded or drawn seamless 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.

3.1.5 *supplier*—jobber or distributor as distinct from producer.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *capable of*—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),

NOTE 3—For inch-pound orders specify Specification B 241; for metric orders specify Specification B 241M. Do not mix units.

4.1.2 Quantity in pieces or pounds [kilograms],

4.1.3 Alloy (Section 7),

4.1.4 Temper (Section 9),

4.1.5 Pipe size and schedule number (Table 16.7 of ANSI H35.2 and H35.2M), or outside diameter and wall thickness (extruded tube), and

4.1.6 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 treatment at the press is unacceptable (8.2),

4.2.2 Whether heat treatment in accordance with Practice B 918 is required (8.3),

4.2.3 Whether pipe size under 1 shall be extruded only (5.1 and Table 1 or [Table 2], Footnote F),

4.2.4 Whether threaded ends are required (see 15.2),

4.2.5 Whether inspection or witness of inspection and tests by the purchaser's representative is required prior to material shipment (Section 16),

4.2.6 Whether marking for identification is required (Section 19), and whether marking of lot number for alloys 2014 and 2024 in the T3- and T4-type tempers and alloy 6061 in the T6-type tempers is required (19.2),

4.2.7 Whether Practices B 660 applies and, if so, the levels of preservation, packaging, and packing required (19.3),

4.2.8 Whether certification of the material is required (Section 20),

4.2.9 Requirements for tensile property and dimensional tolerance for sizes not specifically covered (9.1.2 and 14.2), and

4.2.10 Whether ultrasonic inspection is required (Section 16, Table 6 [Table 7]).

5. Materials and Manufacture

5.1 The pipe and tube shall be produced from hollow extrusion ingot (cast in hollow form, or drilled, or pierced from solid ingot) and shall be extruded by use of the die and mandrel method. Pipe and tube may be subsequently cold drawn at the option of the producer.

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 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 and tests are deemed necessary to ensure 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 specified in Table 5. Conformance shall be determined by analyzing samples taken when the ingots are

TABLE 5 Chemical Composition Limits[A,B,C]

Alloy	Silicon	Iron	Copper	Manganese	Magnesium	Chromium	Zinc	Titanium	Other Elements[D]		Aluminum
									Each	Total[E]	
1060	0.25	0.35	0.05	0.03	0.03	...	0.05	0.03	0.03[F]	...	99.60 min[G]
1100	0.95 Si + Fe		0.05–0.20	0.05	...	...	0.10	...	0.05	0.15	99.00 min[G]
2014	0.50–1.2	0.7	3.9–5.0	0.40–1.2	0.20–0.8	0.10	0.25	0.15[H]	0.05	0.15	remainder
2024	0.50	0.50	3.8–4.9	0.30–0.9	1.2–1.8	0.10	0.25	0.15[H]	0.05	0.15	remainder
2219	0.20	0.30	5.8–6.8	0.20–0.40	0.02	...	0.10	0.02–0.10	0.05[I]	0.15[I]	remainder
3003	0.6	0.7	0.05–0.20	1.0–1.5	...	...	0.10	...	0.05	0.15	remainder
Alclad 3003[J]	...	...	...	...	...	...	...	...	...	...	...
5052	0.25	0.40	0.10	0.10	2.2–2.8	0.15–0.35	0.10	...	0.05	0.15	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
5454	0.25	0.40	0.10	0.50–1.0	2.4–3.0	0.05–0.20	0.25	0.20	0.05	0.15	remainder
5456	0.25	0.40	0.10	0.50–1.0	4.7–5.5	0.05–0.20	0.25	0.20	0.05	0.15	remainder
6061[K]	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
6066	0.9–1.8	0.50	0.7–1.2	0.6–1.1	0.8–1.4	0.40	0.25	0.20	0.05	0.15	remainder
6162	0.40–0.8	0.50	0.20	0.10	0.7–1.1	0.10	0.25	0.10	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[L]	0.7 Si + Fe		0.10	0.10	0.10	...	0.8–1.3	...	0.05	0.15	remainder
7075	0.40	0.50	1.2–2.0	0.30	2.1–2.9	0.18–0.28	5.1–6.1	0.20[M]	0.05	0.15	remainder
7178	0.40	0.50	1.6–2.4	0.30	2.4–3.1	0.18–0.28	6.3–7.3	0.20	0.05	0.15	remainder

[A] Limits are in weight [mass] 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-off 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 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.
[F] Vanadium 0.05 % maximum.
[G] 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.
[H] A maximum limit of 0.20 % for zirconium + titanium is permitted upon agreement between the purchaser and producer.
[I] Vanadium 0.05–0.15 %; zirconium, 0.10–0.25 %. The total for other elements does not include vanadium and zirconium.
[J] Alloy 3003 clad with alloy 7072.
[K] Beginning in the 1965 issue, the requirements for alloy 6062 were combined with alloy 6061 by revision of the minimum chromium content of 6061 from 0.15 to 0.04. This action cancelled alloy 6062.
[L] Cladding on alclad 3003.
[M] A maximum limit of 0.25 % for zirconium + titanium is permitted upon agreement between the purchaser and producer.

TABLE 6 Ultrasonic Discontinuity Limits[A] for Seamless Extruded Tube, Inch-Pound Units

Alloy	Wall Thickness, in.	Max Weight per Piece, lb	Max Width: Thickness Ratio	Discontinuity Class[B]
2024	0.500 & over	600	10:1	B
7075	0.500–1.499	600	10:1	B
7178	1.500 & over	600	10:1	A

[A] Discontinuities in excess of those listed in this table shall be allowed, subject to the approval of the procuring activity, if it is established that they will be removed by machining or that they are in noncritical areas.
[B] The discontinuity class limits are defined in Section 11, Discontinuity Class Limits, of Practice B 594.

TABLE 7 Ultrasonic Discontinuity Limits[A] for Seamless Extruded Tube, [SI Units]

Alloy	Wall Thickness, mm		Max Mass per Piece, kg	Max Width: Thickness Ratio	Discontinuity Class[B]
	Over	Through			
2024	12.50	...	300	10:1	B
7075	12.50	35.00	300	10:1	B
7178	35.00	...	300	10:1	A

[A] Discontinuities in excess of those listed in this table shall be allowed, subject to the approval of the procuring activity, if it is established that they will be removed by machining or that they are in noncritical areas.
[B] The discontinuity class limits are defined in Section 11, Discontinuity Class Limits, of Practice B 594.

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 4—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, in the shipment, 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 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 5—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 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 test 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 T3, T4, T6, T7, and T8-type tempers, except as noted in 8.2 or unless otherwise specified in 8.3, in accordance with AMS 2772.

8.2 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.

8.3 When specified, heat treatment for the production of T3, T4, T6, T7, and T8-type tempers shall be in accordance with Practice B 918.

9. Tensile Properties

9.1 *Limits*—The material shall conform to the tensile property requirements specified in Table 1 [Table 2] and Table 3 [Table 4] as applicable.

9.1.1 The elongation requirements shall not be applicable to the following:

9.1.1.1 Material of such dimensions that a standard test specimen cannot be taken in accordance with Test Methods B 557 [B 557M].

9.1.1.2 Tubes less than 0.062 in. [up through 1.60 mm] in wall thickness.

9.1.2 Tensile property limits for sizes not covered in Table 3 and [Table 4] shall be as agreed upon between the producer and purchaser and shall be so specified in the contract or purchase order.

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 1 lb or more/linear ft [over 1.7 kg/linear m], one tension test specimen shall be taken for each 1000 ft [300 m] or fraction thereof in the lot.

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

9.3 *Test Methods*—The tension tests shall be made in accordance with Test Methods B 557 [B 557M].

10. Producer Conformation of Heat Treatment Response

10.1 The producer shall determine that heat treatable alloys supplied in the O or F tempers (within the size limits specified in Table 3 and [Table 4]) respond to heat treatment in accordance with the following:

10.1.1 Alloys 2014, 2024, 6061, and 6063 shall, after proper solution heat treatment and natural aging for not less than 4 days at room temperature, conform to the properties specified in Table 3 and [Table 4] for T42 temper material. The heat-treated samples may be tested prior to 4 days natural aging but if they fail to conform to the T42 temper properties, the tests may be repeated after completion of the 4 days natural aging without prejudice.

10.1.2 Alloys 2024, 2219, 6061, 6063, 7075, and 7178 shall, after proper solution heat treatment and precipitation heat treatment, conform to the properties specified in Table 3 and [Table 4] for T62 temper material.

10.2 *Number of Specimens*—The number of specimens from each lot of O and F temper material shall be as specified in 9.2.

10.3 *Quality Assurance Screening of Extrusion Press Heat Treated Pipe and Tube*—Pipe and tube heat-treated at the extrusion press shall conform to all the requirements of Section 9. In addition, hardness tests shall be performed on each extruded length or, with the approval of the purchaser, on samples selected in accordance with a mutually agreeable sampling plan. The minimum hardness control value shall be in accordance with Table 8 [Table 9] for pipe and with Table 10 [Table 11] for tube for the type of hardness tester used. The specific type of hardness tester 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.

10.3.1 Individual pieces within a lot that fail to conform to the minimum applicable hardness values may be accepted provided that samples from the two pieces exhibiting the lowest minimum hardness values are tension tested and found to conform to the requirements of Table 1 [Table 2] for pipe or Table 3 [Table 4] for tube.

NOTE 6—It may be necessary in the case of 6xxx—naturally aged tempers to allow for the elapse of four days subsequent to heat treatment for the material to attain its expected strength. Material in these tempers that has been tested for mechanical properties prior to an elapse of four days and fails may be retested after four days without prejudice.

11. Heat Treatment and Reheat Treatment Capability

11.1 As-received material in the O or F temper in alloys 2014, 2024, 6061, and 6063 (within the size limits specified in Table 3 [Table 4] and without the imposition of cold work) shall be capable of attaining the properties specified in Table 3

TABLE 8 Hardness Screening Values for Seamless Extruded Tube, Inch-Pound Units[A]

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

[A] See 10.3.
[B] Alternate minimum hardness values and hardness testing devices may be used provided agreement is reached between the purchaser and supplier or producer.
[C] 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.

TABLE 9 Hardness Screening Values for Seamless Extruded Tube [SI Units][A]

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

[A] See Section 10.3.
[B] Alternative minimum hardness values and hardness testing devices may be used provided agreement is reached between the purchaser and supplier or producer.
[C] 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.

TABLE 10 Hardness Screening Values for Seamless Pipe, Inch-Pound Units[A]

Alloy and Temper	Pipe Size, in.	Wall Thickness, in.	Hardness Number, min[B,C]		
			Webster	Barcol	Rockwell E
6061-T6	less than 1 in.	0.050 and over	16	...	...
	1 in. and over	0.050 to 0.075	15	76	89
		0.076 to 0.499	15	76	89
		0.500 through 1.000	15	76	...
6063-T6	All	0.050 through 1.000	12	72	75
6351-T5	All	0.050 through 1.000	15	76	89
-T6	All	0.050 through 1.000	16	...	...

[A] See 10.3.
[B] Alternate minimum hardness values and hardness testing devices may be used provided agreement is reached between the purchaser and supplier or producer.
[C] 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.

TABLE 11 Hardness Screening Values for Seamless Pipe [SI Units][A]

Alloy and Temper	Pipe Size Designation	Wall Thickness, mm	Hardness Number, Minimum[B,C]		
			Webster	Barcol	Rockwell E
6061-T6	Less than 1	1.25 and over	16	...	...
	1 and over	1.25 through 1.50	15	76	89
		over 1.50 through 12.5	15	76	89
		over 12.5 through 25.0	15	76	...
6063-T6	All	over 1.25 through 25.0	12	72	75
6351-T5	All	over 1.25 through 25.0	15	76	89
-T6	All	over 1.25 through 25.0	16	...	...

[A] See 10.3.
[B] Alternative minimum hardness values and hardness testing devices may be used provided agreement is reached between the purchaser and supplier or producer.
[C] 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.

[Table 4] for T42 temper material, upon being properly solution heat-treated and natural aged for not less than 4 days at room temperature.

11.2 As-received material in the O or F temper in alloys 2014, 2219, 6061, 6063, 7075, and 7178 (within the size limits specified in Table 3 [Table 4] and without the imposition of cold work) shall be capable of attaining the properties specified in Table 3 [Table 4] for T62 tempers, upon being properly solution and precipitation heat-treated.

11.3 Material in alloys and tempers 2014-T4, T4510, T4511, T6, T6510, and T6511 and 2024-T3, T3510, T3511, T81, T8510, and T8511 shall be capable of attaining the properties specified in Table 3 [Table 4] for the T42 temper, upon being properly resolution heat-treated and natural aged for not less than 4 days at room temperature.

11.4 Material in alloys and tempers 2219-T31, T3510, T3511, T81, T8510, and T8511, 7075-T6, T6510 and T6511 and 7178-T6, T6510 and T6511 shall be capable of attaining the properties specified in Table 3 [Table 4] for T62 tempers, upon being properly resolution heat-treated and precipitation heat-treated.

11.5 Material in T31, T3510, T3511, T4, T4510, and T4511 tempers shall be capable of attaining the properties specified in Table 3 [Table 4] for the T81, T8510, T8511, T6, T6510, and T6511 tempers, respectively, upon being properly precipitation heat-treated.

12. Stress-Corrosion Resistance

12.1 Alloy 7075 extruded tube in the T73-type tempers shall be capable of exhibiting no evidence of stress-corrosion cracking when subjected to the test specified in 12.2.

12.1.1 For lot-acceptance purposes, resistance to stress-corrosion cracking for each lot shall be established by testing the previously selected tension-test samples to the criteria shown in Table 12 [Table 13].

12.1.2 For surveillance purposes, each month the producer shall perform at least one stress-corrosion test in accordance with 12.2 on each of the T73-type tempers for each thickness range 0.750 in. [20.00 mm] and over listed in Table 3 [Table 4] produced that month. Each sample shall be taken from material considered acceptable in accordance with lot-acceptance criteria of Table 8 [Table 9]. A minimum of three adjacent replicate specimens shall be taken from each sample and tested. The producer shall maintain records of all lots so tested and make them available for examination at the producer's facility.

12.2 The stress-corrosion cracking test shall be performed on extruded tube with wall thickness 0.750 in. [20.00 mm] and over as follows:

12.2.1 The stress-corrosion test shall be made in accordance with Test Method G 47.

12.2.2 Specimens shall be stressed in tension in the short transverse direction with respect to the grain flow and held at constant strain. The stress level shall be 75 % of the specified minimum yield strength.

12.2.3 There shall be no visual evidence of stress-corrosion cracking in any specimen, except that the retest provisions of 17.2 shall apply.

13. Cladding

13.1 The aluminum alloy coating of clad tube shall comprise the inside surface (only) of the tube and its thickness shall be approximately 10 % of the total wall thickness of the tube.

13.2 When the thickness of the coating is to be determined on finished tube, transverse cross sections of at least three tubes from the lot shall be polished for examination with a metallurgical microscope. Using a magnification of 100 ×, the coating thickness at four points, 90° apart, in each sample shall be measured and the average of all measurements shall be taken as the thickness. In the case of tube having a diameter larger than can properly be mounted for polishing and examination, the portions of the cross section polished for examination may consist of an arc about ½ in. [13 mm] in length.

TABLE 12 Lot Acceptance Criteria for Resistance to Stress Corrosion, Inch-Pound Units

Alloy and Temper	Lot Acceptance Criteria: Electrical Conductivity[A], % IACS	Lot Acceptance Criteria: Level of Tensile Properties	Lot Acceptance Status
7074–T73, T73510, and T73511	40.0 or greater	per specified requirements	acceptable
	38.0 thru 39.9	per specified requirements and yield strength does not exceed minimum by more than 11.0 ksi	acceptable
	38.0 thru 39.9	per specified requirements but yield strength exceeds minimum 12.0 ksi or more	unacceptable[B]
	less than 38.0	any level	unacceptable[B]

[A] Sampling for electrical conductivity tests shall be the same as for tensile tests as specified in 9.2. Test specimens may be prepared by machining a flat, smooth surface of sufficient width for proper testing. For small sizes of tubes, a cut-out portion may be flattened and the conductivity determined on the surface. Chemical milling may be used on flat surface samples. The electrical conductivity shall be determined in accordance with Practice E 1004 in the following locations:

Wall Thickness, in.	Location
Up thru 0.100	surface of tensile sample
0.101 thru 0.500	subsurface after removal of approximately 10 % of thickness of tensile sample
0.501 thru 1.500	subsurface at approximately center of wall thickness on a plane parallel to the longitudinal center line of the material
Over 1.500	subsurface on tensile test sample surface which is closest to the center of the wall thickness and on a plane parallel to the extrusion surface

[B] When material is found to be unacceptable, it shall be reprocessed (additional precipitation heat treatment, or re-solution heat treatment, stress relieving, straightening and precipitation heat treatment, when applicable).

TABLE 13 Lot Acceptance Criteria for Resistance to Stress Corrosion, [SI Units]

Alloy and Temper	Lot Acceptance Properties		Lot Acceptance Status
	Electrical Conductivity[A], % IACS	Level of Mechanical Properties	
7075-T73, T73510, and T73511	40.0 or greater	per specified requirements	acceptable
	38.0 to 39.9	per specified requirements and yield strength does not exceed minimum by more than 82 MPa	acceptable
	38.0 to 39.9	per specified requirements but yield strength exceeds minimum by 83 MPa or more	unacceptable[B]
	less than 38.0	any level	unacceptable[B]

[A] Sampling for electrical conductivity tests shall be the same as for tensile tests as specified in 0.2. Test specimens may be prepared by matching a flat, smooth surface of sufficient width for proper testing. For small sizes of tubes, a cut-out portion may be flattened and the conductivity determined on the surface. Chemical milling may be used on flat surface samples. The electrical conductivity shall be determined in accordance with Practice E 1004 in the following locations:

Wall Thickness, mm		Location
Over	Through	
. . .	2.50	surface of tensile sample
2.50	12.50	subsurface after removal of approximately 10 % of thickness of tensile sample
12.50	40.00	subsurface at approximately center of wall thickness on a plane parallel to the longitudinal center line of the material
40.00	. . .	subsurface on tensile test sample surface which is closest to the center of the wall thickness and on a plane parallel to the extrusion surface

[B] When material is found to be unacceptable, it shall be reprocessed (additional precipitation heat treatment or re-solution heat treatment, stress relieving, straightening, and precipitation heat treatment, when applicable).

14. Dimensional Tolerances

14.1 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 [H35.2M]:

Table No.	Title
12.	Extruded Tube
12.1	Diameter, Round Tube
12.3	Wall Thickness, Round Tube
12.5	Length
12.7	Straightness, Tube in Straight Lengths
12.9	Squareness of Cut Ends
16.	Pipe
16.1	Outside Diameter
16.2	Wall Thickness
16.3	Weight
16.4	Length, Plain End Pipe
16.7	Diameters, Wall Thicknesses, Weights

14.2 Tolerances for tempers and sizes not included in ANSI H35.2 [H35.2M] shall be as agreed upon between producer and purchaser and shall be so specified in the contract or purchase order.

14.3 *Sampling for Inspection*—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 When so specified in the contract or order, both ends of each length of pipe, or extruded tube except pipe of alloy 3003, temper H112, shall be threaded using an American National Standard Taper Pipe Thread. The variation from standard, when tested with the standard working gage, shall not exceed ±1½ turns. The threaded ends shall be free from burrs and suitably protected against damage in transit.

15.3 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.

16. Internal Quality

16.1 When specified by the purchaser at the time of placing the contract or order, each tube 0.500 in. or greater [over 12.50 mm] in thickness, in alloys 2024, 7075, and 7178 shall be tested ultrasonically in accordance with Practice B 594 to the discontinuity acceptance limits of Table 6 [Table 7].

17. Source Inspection

17.1 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.

17.2 When such inspections 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.

18. Retest and Rejection

18.1 If any material fails to conform to all of the applicable requirements of this specification, the inspection lot shall be rejected.

18.2 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.

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

18.4 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.

19. Identification Marking of Product

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

19.2 In addition, alloys 2014, 2024, 2219, 7075, and 7178 in the T6-, T73-, and T8-type tempers and, when specified, alloys 2014 and 2024 in the T3- and T4-type tempers and alloy 6061 in the T4- and T6-type tempers shall also be marked with the lot number in at least one location on each piece.

19.3 The requirements specified in 19.1 and 19.2 are minimum marking systems that involve added information; larger characters and greater frequencies are acceptable under this specification.

20. Packaging and Package Marking

20.1 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 upon. The type of packaging and gross weight of containers shall, unless otherwise agreed upon, be at the producer'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.

20.2 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.

20.3 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 civilian agencies and MIL-STD-129 for military agencies.

21. Certification

21.1 The supplier or producer 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.

22. Keywords

22.1 aluminum alloy; seamless extruded tube; seamless pipe

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. 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 or H35.1(M). The Aluminum Association[12] 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 or H35.1(M). 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.

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

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.

A3. PART OR IDENTIFYING NUMBERS (PINs) FOR USE BY THE DEPARTMENT OF DEFENSE

A3.1 Part numbers are essential to maintain the integrity of the Department of Defense cataloging system as multiple National Stock Numbers (NSN) exist for this product.

A3.2 Part numbers shall be formulated by selecting from the options in this specification as follows:

B241	–XXXX	-XXXX	-XX	-XX	-XX
Document Identifier	Alloy	Temper	Pipe size in 0.25 in. increments	Schedule size	Length in feet

A3.3 *Examples of Part Numbers*:
B429–6063–T6–03–40–20 indicates a Specification B 429 standard structural pipe in 6063 alloy and T6 temper that is ¾-in. pipe size, ANSI schedule 40, with a 20–ft length.
B429–3003–H112–04–10–10 indicates a Specification B 429 standard structural pipe in 3003 alloy and H112 temper that is 1-in. pipe size, ANSI schedule 10, with a 10–ft length.

SUMMARY OF CHANGES

This section identifies the principal changes to this standard that have been incorporated since the last issue.
(*1*) Replaced Practice B 597 with Practice B 918 in 2.2, 4.2.2 and 8.3.
(*2*) Replaced MIL-H-6088 with AMS 2772 in 2.6 and 8.1.