Designation: B241/B241M – 22

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 B241/B241M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

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

1. Scope*

1.1 This specification[2] covers aluminum and aluminum–alloy seamless pipe and seamless extruded round tube in the alloys and tempers shown in Table 1 [Table 2] intended for pressure applications. The standard sizes for seamless pipe are listed in Table 16.7 of ANSI H35.2 and H35.2(M). Nonstandard alloys, tempers, and sizes of pipe are produced as seamless extruded tube. Also included in this standard are seamless extruded pipe and seamless extruded tube for Oil & Gas Transmission previously covered under Specification B345/B345M.

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 Specification B210/B210M; for extruded tubes, Specifications B221 and B221M; for drawn seamless tubes for condensers and heat exchangers, Specifications B234 and B234M; for seamless condenser and heat exchanger tubes with integral fins, Specification B429/B429M; and for drawn tube for general purpose applications, Specification B483/B483M.

1.2 Alloy and temper designations are in accordance with ANSI H35.1/H35.1(M). The equivalent Unified Numbering System alloy designations are those of Table 4 preceded by A9, for example, A91100 for aluminum 1100 in accordance with Practice E527.

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

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

1.4.1 The SI units are shown either in brackets or in separate tables.

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

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:*[3]

B210/B210M Specification for Aluminum and Aluminum-Alloy Drawn Seamless Tubes

B221 Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes

B221M Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes (Metric)

B234 Specification for Aluminum and Aluminum-Alloy Drawn Seamless Tubes for Surface Condensers, Evaporators, and Heat Exchangers

B234M Specification for Aluminum and Aluminum-Alloy Drawn Seamless Tubes for Surface Condensers, Evaporators, and Heat Exchangers (Metric)

B429/B429M Specification for Aluminum-Alloy Extruded Structural Pipe and Tube

B483/B483M Specification for Aluminum and Aluminum-Alloy Drawn Tube and Drawn Pipe for General Purpose Applications

B557 Test Methods for Tension Testing Wrought and Cast Aluminum- and Magnesium-Alloy Products

B557M Test Methods for Tension Testing Wrought and Cast Aluminum- and Magnesium-Alloy Products (Metric)

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

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[2] For ASME Boiler and Pressure Vessel Code applications see related specifications 241/SB241-241M/SB241M in Section II of that code.

[3] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

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

B594 Practice for Ultrasonic Inspection of Aluminum-Alloy Wrought Products
B647 Test Method for Indentation Hardness of Aluminum Alloys by Means of a Webster Hardness Gage
B648 Test Method for Indentation Hardness of Aluminum Alloys by Means of a Barcol Impressor
B660 Practices for Packaging/Packing of Aluminum and Magnesium Products
B666/B666M Practice for Identification Marking of Aluminum and Magnesium Products
B807/B807M Practice for Extrusion Press Solution Heat Treatment for Aluminum Alloys
B881 Terminology Relating to Aluminum- and Magnesium-Alloy Products
B918/B918M Practice for Heat Treatment of Wrought Aluminum Alloys
B945 Practice for Aluminum Alloy Extrusions Press Cooled from an Elevated Temperature Shaping Process for Production of T1, T2, T5 and T10-Type Tempers
B985 Practice for Sampling Aluminum Ingots, Billets, Castings and Finished or Semi-Finished Wrought Aluminum Products for Compositional Analysis
E18 Test Methods for Rockwell Hardness of Metallic Materials
E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications
E527 Practice for Numbering Metals and Alloys in the Unified Numbering System (UNS)
E716 Practices for Sampling and Sample Preparation of Aluminum and Aluminum Alloys for Determination of Chemical Composition by Spark Atomic Emission Spectrometry
E1004 Test Method for Determining Electrical Conductivity Using the Electromagnetic (Eddy Current) Method
E1251 Test Method for Analysis of Aluminum and Aluminum Alloys by Spark Atomic Emission Spectrometry
E3061 Test Method for Analysis of Aluminum and Aluminum Alloys by Inductively Coupled Plasma Atomic Emission Spectrometry (Performance Based Method)
G47 Test Method for Determining Susceptibility to Stress-Corrosion Cracking of 2XXX and 7XXX Aluminum Alloy Products

2.3 *ANSI Standards:*
B2.1 Pipe Threads (except Dryseal)[4]
B36.10 Wrought Steel and Wrought Iron Pipe[4]
H35.1/H35.1(M) Alloy and Temper Designation Systems for Aluminum[5]
H35.2 Dimensional Tolerances for Aluminum Mill Products[5]
H35.2(M) Dimensional Tolerances for Aluminum Mill Products [Metric][5]

2.4 *American Welding Society Standard*
D10.7 Recommended Practices for Gas Shielded Arc Welding of Aluminum and Aluminum-Alloy Pipe[6]

2.5 *Federal Standard:*
Fed. Std. No. 123 Marking for Shipment (Civil Agencies)[7]

2.6 *Military Standard:*
MIL-STD-129 Marking for Shipment and Storage[7]

2.7 *AMS Specification:*
AMS 2772 Heat Treatment of Aluminum Alloy Raw Materials[8]

2.8 *CEN EN Standards*
CEN EN 14242 Aluminum and Aluminum Alloys—Chemical Analysis—Inductively Coupled Plasma Optical Emission Spectral Analysis[9]

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *alclad seamless pipe or alclad seamless round tube, n*—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 *capable of, adj*—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.

3.1.3 *extruded seamless alclad tube, n*—a composite round 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.

3.1.4 *extruded seamless pipe, n*—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."

3.1.5 *extruded seamless round tube, n*—a hollow product having a round cross section and a uniform wall thickness, brought to final dimensions by extruding from a hollow cast ingot or mandrel pierced ingot.

3.1.6 *producer, n*—the primary manufacturer of the material.

3.1.7 *seamless pipe, n*—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."

[4] Available from American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036.
[5] Available from Aluminum Association, Inc., 1400 Crystal Dr., Suite 430, Arlington, VA 22202 http://www.aluminum.org.
[6] Available from the American Welding Society, 8669 NW 36th St, Miami, FL 33166.
[7] Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098, http://dodssp.daps.dla.mil.
[8] Available from SAE International (SAE), 400 Commonwealth Dr., Warrendale, PA 15096-0001, http://www.sae.org.
[9] Available from European Committee for Standardization (CEN), 36 Rue de Stassart, B-1050, Brussels, Belgium, http://www.cenorm.be.

3.1.8 *supplier, n*—jobber or distributor as distinct from producer.

3.2 *Other Definitions*—For all other definitions of product terms, refer to Terminology B881.

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 B241; for metric orders specify Specification B241M. 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 12.55 of ANSI H35.2 and H35.2(M)), or outside diameter and wall thickness (tube). Dimensional tolerances for 14, 16, 18, and 20-in. pipe sizes (see Table 3) shall be agreed upon between the producer and purchaser and shall be specified by contract or purchase order.

4.1.6 For alloy Alclad 3003, state clad inside or outside (Section 13).

4.1.7 End configuration (Sections 15.4 and 15.5).

4.1.8 Length (Section 14).

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 (8.3),

4.2.2 Whether heat treatment in accordance with Practice B918/B918M is required (8.4),

4.2.3 Whether threaded ends are required (see 15.2),

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

4.2.5 Whether Practices B660 applies and, if so, the levels of preservation, packaging, and packing required (20.3),

4.2.6 Whether certification of the material is required (Section 21),

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

4.2.8 Whether ultrasonic inspection is required (Section 16, Table 5 [Table 6]),

4.2.9 Whether Sections 10 and 11 apply to 6063 and 6061 alloys, and

4.2.10 Whether the term "Seamless" is required in product marking in accordance with Practice B666/B666M.

4.2.11 Whether hardness screening is required (10.3, Table 5 [Table 6]).

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.

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.

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 non-heat 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. Composition

7.1 *Limits*—The pipe or tube shall conform to the composition limits specified in Table 4. Conformance shall be determined by the producer, by taking samples in accordance with Practices E716, when the ingots are poured, and analyzing those samples in accordance with Test Methods E1251, E3061, or EN 14242. At least one sample shall be taken for each group of ingots poured simultaneously from the same source of molten metal. If the producer has determined the composition during pouring of the ingots, they shall not be required to sample and analyze the finished product.

7.2 If it becomes necessary to analyze the finished or semi-finished product for conformance to chemical composition limits, the methods of sampling and methods of analysis shall be as provided in the following:

7.2.1 *Methods of Sampling*—Samples for chemical analysis shall be taken in accordance with Practice B985.

7.2.2 *Methods of Analysis*—Analysis shall be performed in accordance with Test Methods E1251, E3061, or CEN EN 14242 (ICP method).

NOTE 4—It is standard practice in the United States aluminum industry to determine conformance to the 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.

TABLE 1 Tensile Property Limits, 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[F, G]	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[F, G]	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[F, G]	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

TABLE 1 *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	
T62[F, G]	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
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	all	30.0	41.0	11.0		. . .
H112	all	all	30.0	. . .	11.0		. . .
Alloy 5454							
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 6005							
T1	up thru 0.500	all	25.0		15.0		16
T5	up thru 0.124	all	38.0		35.0		8
	0.125–1.000	all	38.0		35.0		10
Alloy 6005A							
T1	up thru 0.249	all	25.0		14.5		15
T5	up thru 0.249	all	38.0		31.0		7
	0.250–0.999	all	38.0		31.0		9
T61	up thru 0.249	all	38.0		35.0		8
	0.250–1.000	all	38.0		35.0		10

TABLE 1 *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	
			Alloy 6013				
T6, T6511	0.200-0.499	all	49.0		46.0		8
	0.500-0.749	all	49.0		46.0		8
	0.750-2.000	all	49.0		45.0		8
			Alloy 6026				
T6, T6510 T6511	0.400-1.300	all	49.0		38.0		6
			Alloy 6041				
T6, T6511	0.400–2.000	all	45.0		40.0		10
			Alloy 6042				
T5, T5511	0.400–0.499	all	38.0		35.0		10
	0.500–1.800	all	42.0		35.0		10
			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^{F,G}	all	all	26.0	. . .	12.0	. . .	16
T51	up thru 0.625	all	35.0	. . .	30.0	. . .	8
T6, T62^{F,G}, 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^H	up thru 0.500	all	17.0	. . .	9.0	. . .	12
	0.501–1.000	all	16.0	. . .	8.0	. . .	12
T4, T42^{F,G}	up thru 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^{F,G}	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 6064				
T6, T6511	0.400–2.000	all	42.0		38.0		10
			Alloy 6066				

TABLE 1 *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	
O	all	all	. . .	29.0	. . .	18.0	16
T4, T4510[E] T4511[E]	all	all	40.0	. . .	25.0	. . .	14
T42[F, G]	all	all	40.0	. . .	24.0	. . .	14
T6, T6510,[E] T6511[E]	all	all	50.0	. . .	45.0	. . .	8
T62[F, G]	all	all	50.0	. . .	42.0	. . .	8
Alloy 6070							
T6, T62[F, G]	up thru 2.999	up thru 32	48.0		45.0	6	5
Alloy 6082							
T6	0.200–1.000	all	45.0		38.0		8
Alloy 6105							
T1	up thru 0.500	all	25.0		15.0		16
T5	up thru 0.500	all	38.0		35.0		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 6262							
T6, T6511	all	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
	0.125–0.749	. . .	42.0	. . .	37.0	. . .	10
Alloy 7075							
O	all	. . .	. . .	40.0	. . .	24.0	10
T6, T62[F, G]	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	. . .	. . .	. . .	. . .	. . .

[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 E29.

[C] Elongation of full-section and cut-out sheet-type specimens is measured in 2 in.; for round specimens, in 4 × specimen diameter. See 9.1.1 for conditions under which measurements are not required.
[D] No mechanical properties are specified, guaranteed, or provided.
[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] 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.
[G] Material in the T42 and T62 tempers is not available from the material producers.
[H] Formerly designated T42 temper. When properly aged (precipitation heat-treated) 6063-T1 extruded products are designated T5.

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.

8. Heat Treatment

8.1 For the production of T1, T2, T5, and T10-type tempers, producer or supplier heat treatment shall be in accordance with Practice B945.

8.2 For the production of T3, T4, T6, T7, and T8-type tempers, except as noted in 8.3 or 8.4, shall be in accordance with AMS 2772.

8.3 Unless otherwise specified (4.2.1), alloys 6005A, 6041, 6061, 6063, 6064, 6162, 6082, and 6351 may be solution heat treated and quenched at the extrusion press in accordance with Practice B807/B807M for the production of T3, T4, T6, T7, T8, and T9-type tempers, as applicable.

8.4 When specified (4.2.2), heat treatment for the production of T3, T4, T6, T7, T8, and T9-type tempers shall be in accordance with Practice B918/B918M.

9. Tensile Properties

9.1 *Limits*—The material shall conform to the tensile property requirements specified in Table 1 [Table 2] 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 B557 [B557M].

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 1 [Table 2] 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 B557 [B557M].

10. Producer Confirmation 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 1 [Table 2]) respond to heat treatment in accordance with the following:

10.1.1 Alloys 2014 and 2024 shall, after proper solution heat treatment and natural aging for not less than four days at room temperature, conform to the properties specified in Table 1 [Table 2] for T42 temper material. The heat-treated samples may be tested prior to four days natural aging but if they fail to conform to the T42 temper properties, the tests may be repeated after completion of the four days natural aging without prejudice. Alloys 6061 and 6063 may be required to meet the same requirements per 4.2.9, ordering information, when required by the purchase agreement.

10.1.2 Alloys 2024, 2219, and 7075 shall, after proper solution heat treatment and precipitation heat treatment, conform to the properties specified in Table 1 [Table 2] for T62 temper material. Alloys 6061 and 6063 may be required to meet the same requirements per 4.2.9, ordering information, when required by the purchase agreement.

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. When specified (4.2.11), 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 5 [Table 6] for tube and pipe 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 B647, B648, or E18, as applicable.

TABLE 2 Tensile Property Limits [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 or $5.65\sqrt{A}$
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	all		all		345	. . .	240	. . .	12	10
T4510[E], T4511[E]										
T42[F, G]	all		all		345	. . .	200	. . .	12	
T6	. . .	12.50	all		415	. . .	365	. . .	7	6
T6510[E], T6511[E]	12.50	18.00	all		440	. . .	400	. . .	. . .	6
	18.00	. . .	. . .	16 000	470	. . .	415	. . .	. . .	6
	18.00	. . .	16 000	20 000	470	. . .	400	. . .	. . .	5
T62[F, G]	. . .	18.00	all	. . .	415	. . .	365	. . .	7	6
	18.00	. . .	. . .	16 000	415	. . .	365	. . .	. . .	6
	18.00	. . .	16 000	20 000	415	. . .	365	. . .	. . .	5
F[D]	all		all	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Alloy 2024										
O	all		all		. . .	240	. . .	130	12	10
T3	. . .	6.30	all		395	. . .	290	. . .	10	. . .
T3510[E]	6.30	18.00	all		415	. . .	305	. . .	10	9[H]
T3511[E]	18.00	35.00	all		450	. . .	315	. . .	. . .	9
	35.00	. . .	. . .	16 000	485	. . .	330	. . .	. . .	9
	35.00	. . .	16 000	20 000	470	. . .	315	. . .	. . .	7
T42[F, G]	. . .	18.00	all	. . .	395	. . .	260	. . .	12	10
	18.00	35.00	all		395	. . .	260	. . .	. . .	9
	35.00	. . .	. . .	16 000	395	. . .	260	. . .	. . .	9
	35.00	. . .	16 000	20 000	395	. . .	260	. . .	. . .	7
T81	1.20	6.30	all		440	. . .	385	. . .	4	. . .
T8510[E]	6.30	35.00	all		455	. . .	400	. . .	5	4
T8511[E]	35.00	. . .	. . .	20 000	455	. . .	400	. . .	. . .	4
F[D]	all		all		. . .	. . .	. . .	. . .	. . .	. . .
Alloy 2219										
O	all		all		. . .	220	. . .	125	12	10

TABLE 2 *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 or 5.65$\sqrt{A}$
T31	. . .	12.50	. . .	16 000	290	. . .	180	. . .	14	12
T3510[E] T3511[E]	12.50	80.00		16 000	310	. . .	185	. . .	. . .	12
T62[F, G]	. . .	25.00	. . .	16 000	370	. . .	250	. . .	6	5
	25.00		. . .	20 000	370	. . .	250	. . .	. . .	5
T81 T8510[E] T8511[E]	. . .	80.00	. . .	16 000	400	. . .	290	. . .	6	5
F[D]	all		all		. . .	. . .	. . .	. . .	. . .	. . .
Alloy 3003										
O	all	. . .	all		95	130	35	. . .	25	22
H112	. . .							. . .	. . .	. . .
	all	. . .	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 5154										
O	all		all		205	285	75			. . .
H112	all		all		205	. . .	75			. . .
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		. . .	. . .	. . .	. . .	. . .	. . .

TABLE 2 *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 or $5.65\sqrt{A}$
Alloy 6005										
T1	. . .	12.50	all		170	. . .	105	. . .	16	14
T5	. . .	3.20			260	. . .	240	. . .	8	. . .
	3.20	25.00			260	. . .	240	. . .	10	9
Alloy 6005A										
T1	. . .	6.30	all		170	. . .	100	. . .	15	
T5	. . .	6.30	all		260	. . .	215	. . .	7	
	6.30	25.00	all		260	. . .	215	. . .	9	8
T61	. . .	6.30	all		260	. . .	240	. . .	8	
	6.30	25.00	all		260	. . .	240	. . .	10	9
Alloy 6013										
T6, T6511	5.00	12.50	all		340		315		8	. . .
	12.50	20.00	all		340		315		. . .	7
	20.00	50.00			340		310		. . .	7
Alloy 6026										
T6, T6510 T6511	10.00	30.00	all		340		260		6	8
Alloy 6041										
T6, T6511	10.00	50.00			310	. . .	275	. . .	10	9
Alloy 6042										
T5, T5511	10.00	12.50	all		260	. . .	240	. . .	10	
	12.50	50.00	all		290	. . .	240	. . .		9
Alloy 6061										
O	all		all		. . .	150	. . .	110	16	14
T1	. . .	16.00	all		180	. . .	95	. . .	16	14
T4	all		all		180	. . .	110	. . .	16	14
T4510[E]										
T4511[E]										
T42[F, G]	all		all		180	. . .	85	. . .	16	14
T51	. . .	16.00	all		240	. . .	205	. . .	8	7
T6, T62[F, G]	. . .	6.30	all		260	. . .	240	. . .	8	. . .
T6510[E]	6.30	. . .	all		260	. . .	240	. . .	10	9
T6511[E]										
F[D]	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, G]	. . .	12.50	all		130	. . .	70	. . .	14	12
	12.50	25.00	all		125	. . .	60	. . .	. . .	12