Designation: B 547/B 547M – 002

Standard Specification for Aluminum and Aluminum-Alloy Formed and Arc-Welded Round Tube[1]

This standard is issued under the fixed designation B 547/B 547M; 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] 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 ~~May~~ Oct. 10, 200~~0~~2. Published ~~August 2000.~~ January 2003. Originally ~~published as B 547–71.~~ approved in 1971. Last previous edition approved in 2000 as B 547–~~95~~00.

1. Scope

1.1 This specification covers aluminum and aluminum-alloy (Note 1) formed and arc-welded round tube in diameters 9 to 60 in. [230 to 1520 mm], made from formed sheet or plate, butt welded by gas-tungsten or gas-metal arc-welding methods with or without the use of filler metal.

NOTE 1—Throughout this specification use of the term *alloy* in the general sense includes aluminum as well as aluminum alloy.
NOTE 2—The requirements for the sheet and plate used are the same as in Specifications B 209 or B 209M.

1.2 Alloy and temper designations are in accordance with ANSI H35.1 [H35.1M]. The equivalent Unified Numbering System alloy designations are those of Table 1 preceded 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 standards. 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 the specification.

2. Referenced Documents

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

2.2 *ASTM Standards:*

B 209 Specification for Aluminum and Aluminum-Alloy Sheet and Plate[2]
B 209M Specification for Aluminum and Aluminum-Alloy Sheet and Plate [Metric][2]
B 557 Test Methods of Tension Testing Wrought and Cast Aluminum- and Magnesium-Alloy Products[2]
B 557M Test Methods of Tension Testing Wrought and Cast Aluminum- and Magnesium-Alloy Products [Metric][2]
~~B 597 Practice for Heat Treatment of Aluminum Alloys[2]~~
~~B 660 Practices~~ 660 Practices for Packaging/Packing of Aluminum and Magnesium Products[2]
B 666/B 666M Practice for Identification Marking of Aluminum Products[2]
B 918 Practice for Heat Treatment of Wrought Aluminum Alloys[2]
E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications[3]
E 34 Test Methods for Chemical Analysis of Aluminum and Aluminum-Base Alloys[4]
E 55 Practice for Sampling Wrought Nonferrous Metals and Alloys for Determination of Chemical Composition[4]
E 227 Test Method for Optical Emission Spectrometric Analysis of Aluminum and Aluminum Alloys by the Point-to-Plane Technique[4]
E 527 Practice for Numbering Metals and Alloys (UNS)[5]

[2] *Annual Book of ASTM Standards,* Vol 02.02.
[3] *Annual Book of ASTM Standards,* Vol 14.02.
[4] *Annual Book of ASTM Standards,* Vol 03.05.
[5] *Annual Book of ASTM Standards,* Vol 01.01.

TABLE 1 Chemical Composition Limits[A,B,C]

Alloy	Silicon	Iron	Copper	Manganese	Magnesium	Chromium	Zinc	Titanium	Other Elements[D]		Aluminum
									Each	Total[E]	
1100	0.95 Si + Fe		0.05–0.20	0.05	...	...	0.10	...	0.05	0.15	99.00 min[F]
3003	0.6	0.7	0.05–0.20	1.0–1.5	...	...	0.10	...	0.05	0.15	remainder
Alclad 3003	3003 alloy clad with 7072 alloy										
3004	0.30	0.7	0.25	1.0–1.5	0.8–1.3	...	0.25	...	0.05	0.15	remainder
Alclad 3004	3004 alloy clad with 7072 alloy										
5050	0.40	0.7	0.20	0.10	1.1–1.8	0.10	0.25	...	0.05	0.15	remainder
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
5154	0.25	0.40	0.10	0.10	3.1–3.9	0.15–0.35	0.20	0.20	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
6061	0.40–0.8	0.7	0.15–0.40	0.15	0.8–1.2	0.04–0.35	0.25	0.15	0.05	0.15	remainder
7072[G]	0.7 Si + Fe		0.10	0.10	0.10	...	0.8–1.3	...	0.05	0.15	remainder

[A]Limits are in percent maximum unless shown as a range or stated otherwise.

[B]Analysis shall be made for the elements for which limits are shown in this table.

[C]For purposes of determining conformance to these limits, an observed value or a calculated value obtained from analysis shall be rounded to the nearest unit in the last right-hand place of figures used in expressing the specified limit, in accordance with the rounding method of Practice E 29.

[D]*Others* includes listed elements for which no specific limit is shown as well as unlisted metallic elements. The producer may analyze samples for trace elements not specified in the specification. However, such analysis is not required and may not cover all metallic *Others* elements. Should any analysis by the producer or the purchaser establish that an *Others* element exceeds the limit of *Each* or that the aggregate of several *Others* elements exceeds the limit of *Total*, the material shall be considered 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]The aluminum content shall be calculated by subtracting from 100.00 % the sum of all metallic elements present in amounts of 0.010 % or more each, rounded to the second decimal before determining the sum.

[G]Composition of cladding alloy as applied during the course of manufacture. Samples from finished tube shall not be required to conform to these limits.

E 607 Test Method for Optical Emission Spectrometric Analysis of Aluminum and Aluminum Alloys by the Point-to-Plane Technique, Nitrogen Atmosphere[4]

E 716 Practices for Sampling Aluminum and Aluminum Alloys for Spectrochemical Analysis[4]

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[4]

2.3 *ANSI Standards:*

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

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

~~W3.10 Specification for Aluminum and Aluminum Alloy Welding Rods and Bar Electrodes[6]~~

2.4 *ASME Code:*

Boiler and Pressure Vessel Code; Section IX, Welding Qualifications[7]

Boiler and Pressure Vessel Code; Section VIII, Div. 1 and 2, Pressure Vessels[6]

2.5 *AWS Standard:*

A5.10 Aluminum and Aluminum Alloy Welding Rods and Bare Electrodes[6]

[6] Available from American ~~National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036.~~ Welding Society, 2501 NW 7th St., Miami, FL 33125.

[7] Available from American Society of ~~ASTM Standards, Vol 03.06.~~ Mechanical Engineers, 345 E. 47th St. New York, NY 10017.

2.6 *Federal Standard:*
Fed. Std. No. 123 Marking for Shipment (Civil Agencies)[8]
2.7 *Military Standard:*
MIL-STD-129 Marking for Shipment and Storage[8]
2.8 *~~Military~~AMS Specification:*
~~MIL-H-6088 Heat~~
AMS 2772 Heat Treatment of Aluminum Alloy Raw Materials[9]

3. Terminology

3.1 *Definitions:*
3.1.1 *tube*—a hollow round product of uniform wall thickness that is long in relation to its cross section:
3.1.2 *arc-welded tube*—a tube made from sheet or plate formed by positioning two opposite edges of the metal together and butt welded by either the gas-tungsten or gas-metal arc-welding method, with or without the use of filler metal. Individually fabricated tubes may be welded together to produce the ordered length.
3.1.3 *sheet*—a rolled product that is rectangular in cross section with thickness less than 0.250 in. but not less than 0.006 in. [over 0.15 through 6.30 mm] with slit, sheared, or sawed edges.
3.1.4 *alclad sheet and plate*—composite sheet (and plate) having on both surfaces a metallurgically bonded aluminum or aluminum alloy coating that is anodic to the core alloy to which it is bonded, thus electrolytically protecting the core alloy against corrosion.
3.1.5 *coiled sheet*—sheet in coils with slit edges.
3.1.6 *flat sheet*—sheet with sheared, slit, or sawed edges, which has been flattened or leveled.
3.1.7 *plate*—a rolled product that is rectangular in cross section with thickness not less than 0.250 in. [over 6.30 mm] with sheared or sawed edges.
3.2 *Definitions of Terms Specific to This Standard:*
3.2.1 *capable of*—The term "capable of" as used in this specification means that 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 547; for metric orders specify Specification B 547M. Do not mix units.

4.1.2 Quantity in pieces or pounds [kilograms],
4.1.3 Alloy (Section 7 and Table 1),
4.1.4 Temper (Section 9 and Table 2 [2 M]),
4.1.5 Size (outside or inside diameter, wall thickness, and length),
4.2 Additionally, orders for material to this specification shall include the following information when required by the purchaser:
4.2.1 Whether heat treatment in accordance with Practice ~~B 597~~ B 918 is required (8.2),
4.2.2 Whether tension tests of the tube are required in addition to those of the sheet or plate prior to welding (see 10.1),
4.2.3 Whether air-pressure tests are required (Section 11),
4.2.4 Whether hydrostatic tests are required (Section 12),
4.2.5 Whether weld areas of tube required "spot" or "full" radiographic examination (Section 13),
4.2.6 Whether inspection or witness of inspection and tests by the purchaser's representative is required prior to material shipment (Section 17),
4.2.7 Whether certification is required (Section 19),
4.2.8 Whether marking for identification is required (see 20.1), and whether special marking for hydrostatic and radiographic tests is required (see 20.2),
4.2.9 Whether special packaging is required (Section 21), if Practices B 660 applies, and the levels required.

5. Materials and Manufacture

5.1 The tube shall be made by roll forming (or other suitable forming) sheet or plate into a circular contour with the longitudinal edges butted together for welding, or

[8] Available from ~~American Society of Mechanical Engineers, 345 E. 47th St. New York, NY 10017.~~ Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094 Attn: NPODS.
[9] Available from ~~American Welding Society, 2501 NW 7th St., Miami, FL 33125.~~ Society of Automotive Engineers (SAE), 400 Commonwealth Dr., Warrendale, PA 15096-0001.

5.2 The sheet or plate shall be roll formed so that the edges are butted together in a helical pattern around the circumference of the tube.

5.3 The edges shall be welded together by a gas-shielded-arc process, qualified in accordance with Section IX of the ASME Boiler and Pressure Vessel Code.

5.4 Filler metal shall be in accordance with AWS Specification A 5.10.

5.5 Any butt-joint configuration (square, Vee, J, bevel-groove, etc.) may be used on either or both sides (single or double groove) at the option of the producer within the capability or limitations of his welding equipment. Whether welded from one side (square-butt or single-groove) or both sides (square-butt or double-groove) the face reinforcement and root reinforcement shall not increase the joint thickness by more than 50 % of the wall thickness or ⅛ in. [3 mm], whichever is smaller. The reinforcements may be dressed to this dimension or removed entirely at the manufacturer's option. The weld shall show complete penetration. Back welding is permitted only when (or provided that) it is part of the original welding process; it must not be employed only as a repair procedure for areas of unsatisfactory penetration. The weld bead shall show no evidence of under filling on either the root or reinforcement side. The toe of the weld shall blend smoothly into the parent material with no undercutting or overlapping. If tubing is produced by welding individually fabricated sections together, longitudinal butt welds shall be positioned so as to be at least 45° apart.

6. Quality Assurance

6.1 *Responsibility for Inspection*—Unless otherwise specified in the contract or purchase order, the producer or supplier is responsible for the performance of all inspection and test requirements specified herein. Except as otherwise specified in the contract or order, the producer or supplier 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. The purchaser shall have the right to perform any of the inspections and tests set forth in this specification where such inspections are deemed necessary to assure that the 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 all 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 all material of the same mill form, alloy, temper, and nominal dimensions subjected to inspection at one time.

TABLE 2 Mechanical Property Limits (Inch-Pound Units)[A,B,C]

Temper	Specified Thickness, in.	Tensile Strength, ksi		Yield Strength (0.2 % offset), ksi		Elongation in 2 in., or 4 × Diameter,[D] min, %
		min	max	min	max	
			Alloy 1100			
O	0.125–0.249	11.0	15.5	3.5	...	30
	0.250–0.500	11.0	15.5	3.5	...	28
H12	0.125–0.499	14.0	19.0	11.0	...	9
	0.500	14.0	19.0	11.0	...	12
H14	0.125–0.499	16.0	21.0	14.0	...	6
	0.500	16.0	21.0	14.0	...	10
H16	0.125–0.162	19.0	24.0	17.0	...	4
			Alloy 3003			
O	0.125–0.249	14.0	19.0	5.0	...	25
	0.250–0.500	14.0	19.0	5.0	...	23
H12	0.125–0.161	17.0	23.0	12.0	...	7
	0.162–0.249	17.0	23.0	12.0	...	8
	0.250–0.499	17.0	23.0	12.0	...	9
	0.500	17.0	23.0	12.0	...	10
H14	0.125–0.161	20.0	26.0	17.0	...	6
	0.162–0.249	20.0	26.0	17.0	...	7
	0.250–0.499	20.0	26.0	17.0	...	8
	0.500	20.0	26.0	17.0	...	10
H16	0.125–0.162	24.0	30.0	21.0	...	4
H112	0.250–0.499	17.0	...	10.0	...	8
	0.500	15.0	...	6.0	...	12
			Alloy Alclad 3003			
O	0.125–0.249	13.0	18.0	4.5	...	25
	0.250–0.499	13.0	18.0	4.5	...	23
	0.500	14.0[E]	19.0[E]	5.0[E]	...	23
H12	0.125–0.161	16.0	22.0	11.0	...	7
	0.162–0.249	16.0	22.0	11.0	...	8
	0.250–0.499	16.0	22.0	11.0	...	9
	0.500	17.0[E]	23.0[E]	12.0[E]	...	10
H14	0.125–0.161	19.0	25.0	16.0	...	6

TABLE 2 *Continued*

Temper	Specified Thickness, in.	Tensile Strength, ksi		Yield Strength (0.2 % offset), ksi		Elongation in 2 in., or 4 × Diameter,[D] min, %
		min	max	min	max	
	0.162–0.249	19.0	25.0	16.0	...	7
	0.250–0.499	19.0	25.0	16.0	...	8
	0.500	20.0[E]	26.0[E]	17.0[E]	...	10
H112	0.250–0.499	16.0	...	9.0	...	8
	0.500	15.0[E]	...	6.0[E]	...	12
		Alloy 3004				
O	0.125–0.249	22.0	29.0	8.5	...	18
	0.250–0.500	22.0	29.0	8.5	...	16
H32	0.125–0.500	28.0	35.0	21.0	...	6
H34	0.125–0.500	32.0	38.0	25.0	...	5
H36	0.125–0.162	35.0	41.0	28.0	...	4
		Alloy Alclad 3004				
O	0.125–0.249	21.0	28.0	8.0	...	18
	0.250–0.499	21.0	28.0	8.0	...	16
	0.500	22.0[E]	29.0[E]	8.5[E]	...	16
H32	0.125–0.249	27.0	34.0	20.0	...	6
	0.250–0.499	27.0	34.0	20.0	...	6
	0.500	28.0[E]	35.0[E]	21.0[E]	...	6
H34	0.125–0.249	31.0	37.0	24.0	...	5
	0.250–0.499	31.0	37.0	24.0	...	5
	0.500	32.0[E]	38.0[E]	25.0[E]	...	5
H36	0.125–0.162	34.0	40.0	27.0	...	4
		Alloy 5050				
O	0.125–0.249	18.0	24.0	6.0	...	22
	0.250–0.500	18.0	24.0	6.0	...	20
H32	0.125–0.249	22.0	28.0	16.0	...	6
H34	0.125–0.249	25.0	31.0	20.0	...	5
H36	0.125–0.162	27.0	33.0	22.0	...	4
		Alloy 5052				
O	0.125–0.249	25.0	31.0	9.5	...	20
	0.250–0.500	25.0	31.0	9.5	...	18
H32	0.125–0.249	31.0	38.0	23.0	...	9
	0.250–0.499	31.0	38.0	23.0	...	11
	0.500	31.0	38.0	23.0	...	12
H34	0.125–0.249	34.0	41.0	26.0	...	7
	0.250–0.500	34.0	41.0	26.0	...	10
H36	0.125–0.162	37.0	44.0	29.0	...	4
H112	0.250–0.499	28.0	...	16.0	...	7
	0.500	25.0	...	9.5	...	12
		Alloy 5083				
O	0.125–0.500	40.0	51.0	18.0	29.0	16
H321	0.188–0.500	44.0	56.0	31.0	43.0	12
		Alloy 5086				
O	0.125–0.249	35.0	44.0	14.0	...	18
	0.250–0.500	35.0	44.0	14.0	...	16
H32	0.125–0.249	40.0	47.0	28.0	...	8
	0.250–0.500	40.0	47.0	28.0	...	12
H34	0.125–0.249	44.0	51.0	34.0	...	6
	0.250–0.500	44.0	51.0	34.0	...	10
H36	0.125–0.162	47.0	54.0	38.0	...	6
		Alloy 5154				
O	0.125–0.500	30.0	41.0	11.0	...	18
H32	0.125–0.249	36.0	43.0	26.0	...	8
	0.250–0.500	36.0	43.0	26.0	...	12
H34	0.125–0.161	39.0	46.0	29.0	...	6
	0.162–0.249	39.0	46.0	29.0	...	7
	0.250–0.500	39.0	46.0	29.0	...	10
H36	0.125–0.162	42.0	49.0	32.0	...	5
		Alloy 5454				
O	0.125–0.500	31.0	41.0	12.0	...	18
H32	0.125–0.249	36.0	44.0	26.0	...	8
	0.250–0.500	36.0	44.0	26.0	...	12
H34	0.125–0.161	39.0	47.0	29.0	...	6
	0.162–0.249	39.0	47.0	29.0	...	7

TABLE 2 *Continued*

Temper	Specified Thickness, in.	Tensile Strength, ksi		Yield Strength (0.2 % offset), ksi		Elongation in 2 in., or 4 × Diameter,[D] min, %
		min	max	min	max	
	0.250–0.500	39.0	47.0	29.0	...	10
H112	0.250–0.499	32.0	...	18.0	...	8
	0.500	31.0	...	12.0	...	11
			Alloy 6061			
T4	0.125–0.249	30.0	...	16.0	...	16
T451[F]	0.250–0.500	30.0	...	16.0	...	18
T6	0.125–0.249	42.0	...	35.0	...	10
T6, T651[F]	0.250–0.499	42.0	...	35.0	...	10
	0.500	42.0	...	35.0	...	9

[A] To determine conformance to this specification, each value for tensile strength and for yield strength shall be rounded to the nearest 0.1 ksi, and each value for elongation shall be rounded to the nearest 0.5 % in accordance with the rounding-off method of Practice E 29.
[B] See 10.2.2 for minimum mechanical properties across the weld area of the tube.
[C] See Annex A1 for basis for establishment of mechanical property limits.
[D] Elongation of sheet type specimens is measured in 2 in.; of round specimens, in 4× specimen diameter.
[E] The tension test specimen from plate 0.500 in. and thicker is machined from the core and does not include the cladding alloy.
[F] For stress-relieved tempers (T451 and T651), characteristics and properties other than those specified may differ somewhat from the corresponding characteristics and properties of material in the basic temper.

TABLE 3 Mechanical Property Limits, [SI Units][A,B,C]

Temper	Specified Thickness, mm		Tensile Strength, MPa		Yield Strength, (0.2 % offset), MPa		Elongation in 50 mm, min, %
	Over	Through	max	min	min	max	
				Aluminum 1100			
0	3.15	6.30	75	105	25	...	30
	6.30	12.50	75	105	25	...	28
H12	3.15	6.30	95	130	75	...	8
	6.30	12.50	95	130	75	...	10
H14	3.15	6.30	110	145	95	...	5
	6.30	12.50	110	145	95	...	7
H16	3.15	4.00	130	165	115	...	4
				Alloy 3003			
0	3.15	6.30	95	130	35	...	25
	6.30	12.50	95	130	35	...	23
H12	3.15	6.30	120	160	85	...	6
	6.30	12.50	120	160	85	...	9
H14	3.15	6.30	140	180	115	...	5
	6.30	12.50	140	180	115	...	8
H16	3.15	4.00	165	205	145	...	4
H112	6.30	12.50	115	...	70	...	8
				Alloy Alclad 3003			
0	3.15	6.30	90	125	30	...	25
	6.30	12.50	90	125	30	...	23
H12	3.15	6.30	115	155	80	...	6
	6.30	12.50	115	155	80	...	9
H14	3.15	6.30	135	175	110	...	5
	6.30	12.50	135	175	110	...	8
H112	6.30	12.50	110	...	65	...	8
				Alloy 3004			
0	3.15	6.30	150	200	60	...	18
	6.30	12.50	150	200	60	...	16
H32	3.15	6.30	190	240	145	...	5
	6.30	12.50	190	240	145	...	6
H34	3.15	6.30	220	265	170	...	4
	6.30	12.50	220	265	170	...	5
H36	3.15	4.00	240	285	190	...	4
				Alloy Alclad 3004			
0	3.15	6.30	145	195	55	...	18
	6.30	12.50	145	195	55	...	16
H32	3.15	6.30	185	235	140	...	5
	6.30	12.50	185	235	140	...	6
H34	3.15	6.30	215	260	165	...	4
	6.30	12.50	215	260	165	...	5
H36	3.15	4.00	235	280	185	...	4
				Alloy 5050			

TABLE 3 *Continued*

Temper	Specified Thickness, mm		Tensile Strength, MPa		Yield Strength, (0.2 % offset), MPa		Elongation in 50 mm, min, %
	Over	Through	max	min	min	max	
0	3.15	6.30	125	165	40	...	20
	6.30	12.50	125	165	40	...	20
H32	3.15	6.30	150	195	110	...	6
H34	3.15	6.30	170	215	140	...	5
H36	3.15	4.00	185	230	150	...	4
				Alloy 5052			
0	3.15	6.30	170	215	65	...	19
	6.30	12.50	170	215	65	...	18
H32	3.15	6.30	215	265	160	...	7
	6.30	12.50	215	265	160	...	11
H34	3.15	6.30	235	285	180	...	6
	6.30	12.50	235	285	180	...	10
H36	3.15	4.00	255	305	200	...	4
H112	6.30	12.50	190	...	110	...	7
				Alloy 5083			
0	3.15	6.30	275	350	125	200	16
	6.30	12.50	270	345	115	200	16
H321	4.75	12.50	305	385	215	295	12
				Alloy 5086			
0	3.15	6.30	240	305	95	...	18
	6.30	12.50	240	305	95	...	16
H32	3.15	6.30	275	325	195	...	8
	6.30	12.50	275	325	195	...	12
H34	3.15	6.30	300	350	235	...	6
	6.30	12.50	300	350	235	...	10
H36	3.15	4.00	325	375	260	...	6
				Alloy 5154			
0	3.15	6.30	205	285	75	...	16
	6.30	12.50	205	285	75	...	18
H32	3.15	6.30	250	300	180	...	8
	6.30	12.50	250	300	180	...	12
H34	3.15	6.30	270	320	200	...	6
	6.30	12.50	270	320	200	...	10
H36	3.15	4.00	290	340	220	...	4
				Alloy 5454			
0	3.15	6.30	215	285	85	...	16
	6.30	12.50	215	285	85	...	18
H32	3.15	6.30	250	305	180	...	8
	6.30	12.50	250	305	180	...	12
H34	3.15	6.30	270	325	200	...	6
	6.30	12.50	270	325	200	...	10
H112	6.30	12.50	220	...	125	...	8
				Alloy 6061			
T4	3.15	6.30	205	...	110	...	16
T451[D]	6.30	12.50	205	...	110	...	18
T6	3.15	6.30	290	...	240	...	10
T651[D]	6.30	12.50	290	...	240	...	10

[A] To determine conformance to this specification, each value for tensile strength and for yield strength shall be rounded to the nearest 1 MPa, and each value for elongation to the nearest 0.5 % in accordance with the rounding-off method of Practice E 29.

[B] See 10.2.2 for minimum mechanical properties across the weld area of the tube.

[C] See Annex A1 for basis for establishment of mechanical property limits.

[D] For stress-relieved tempers (T451 and T651), characteristics and properties other than those specified may differ somewhat from the corresponding characteristics and properties of material in the basic temper.

7. Chemical Composition Requirements

7.1 *Limits*:

7.1.1 The tube shall conform to the chemical composition limits prescribed in Table 1. Conformance shall be determined by the manufacturer of the sheet and plate used to produce the tube by analyzing samples taken at the time the ingots are poured, or by the tube manufacturer on samples taken from the finished or semifinished product. If the tube manufacturer uses sheet or plate whose chemical composition has been determined by analyzing samples taken at the time the ingots were poured or 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.

7.1.2 The specific filler metal alloy shall be selected by the manufacturer from Table number A2 of AWS Specification A 5.10; however, the filler alloy selected shall ensure conformance with the requirement of 10.2.2.

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 tube or semifinished sheet or plate stock, a sample shall be taken to represent each 4000 lb [2000 kg] or fraction thereof of material in the lot from which the tube is fabricated, except that no more than one sample shall be required per piece.

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

7.3.1 Samples for chemical analysis shall be taken from the sheet or plate stock or the tube by drilling, sawing, milling, turning, or clipping a representative piece or pieces to obtain a weight of prepared sample not less than 75 g. Sampling shall be in accordance with Practice E 55.

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.

7.3.2 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.

7.4 *Methods of Analysis*—The determination of chemical composition shall be made in accordance with suitable chemical (Test Methods E 34), spectrochemical (Test Methods E 227, E 607, or E 1251), or other methods. In case of dispute, the methods of analysis shall be agreed upon between the producer and the purchaser.

8. Heat Treatment

8.1 Unless otherwise specified, producer or supplier heat treatment for the applicable tempers in Table 2 [Table 3] shall be in accordance with ~~MIL-H-6088.~~ AMS 2772.

8.2 When specified, heat treatment of applicable tempers in Table 2 [Table 3] shall be in accordance with Practice ~~B 597.~~ B 918.

9. Tensile Requirements

9.1 *Limits*—The tube shall be supplied in the alloy, temper, and size specified in the contract or order. The temper of the tubes shall be designated as that of the sheet or plate from which the tubes are formed, and the sheet or plate shall conform to the tensile property requirements prescribed in Table 2 [Table 3].

9.2 *Number of Specimens*—One tension test specimen shall be taken from a random sheet representing each 2000 lb [1000 kg] of sheet, or from random plate representing each 4000 lb [2000 kg] of plate of the same alloy, temper, and thickness, from which the tube is fabricated, or such other quantity as may be agreed upon by the producer and the purchaser.

9.3 *Test Specimens*—Tension test specimens taken from the sheet and plate of Alloys 1100, 3003, Alclad 3003, 3004, Alclad 3004, 5050, 5052, 5083, 5086, 5154, and 5454 shall be taken parallel to the direction of rolling; for sheet and plate of Alloy 6061 the specimens shall be taken perpendicular to the direction of rolling. Refer to Test Methods B 557 or B 557M for specimen geometry.

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

10. Supplementary Tensile Requirements

10.1 Tube shall be capable of meeting the requirements of 10.2. When so specified in the contract or purchase order, additional tension test specimens shall be taken at the same frequency as specified in 9.2 and tested in accordance with Test Methods B 557 or B 557M.

10.2 *Test Specimens*:

10.2.1 Longitudinal specimens in accordance with Test Methods B 557 or B 557M, shall be taken from tubes at 90° from the weld and test results shall comply with the requirements of Table 2 [Table 3] for applicable alloy and temper.

10.2.2 Specimens conforming to QW-462 of the ASME Boiler and Pressure Vessel Code, Section IX, shall be taken transversely across the weld area and test results shall comply with the requirements of Table 2 [Table 3] for the annealed (O) temper of the applicable alloy, except that the minimum tensile strength for alloy and tempers 6061-T4, T451, T6, and T651 shall be 24.0 ksi [165 MPa].

11. Pressure Tests

11.1 When specified by the purchaser at the time of placing the order, each tube shall be tested by one of the following methods at the option of the producer or supplier.

11.1.1 Each tube shall withstand, without evidence of leakage, an internal air gage pressure of not less than 60 psi [410 kPa] while immersed in water or other suitable liquid.

11.1.2 Each tube shall be tested pneumatically at not less than 90 psi [620 kPa] air gage pressure with a gage that will indicate loss of pressure. There shall not be any loss of pressure after application of 90 psi [620 kPa] for a period of not less than 15 s.

11.1.3 Each tube shall withstand, without evidence of leakage, hydrostatic gage pressure of not less than 90 psi [620 kPa].

11.1.4 When specified in the order or contract, the tube shall be subjected to other pressure or hydrostatic tests as agreed upon by the producer or supplier and the purchaser.

12. Radiographic Examination

12.1 When "full radiography" is specified, Paragraph UW-11(*a*) of Section VIII, Division 1, of the ASME Boiler and Pressure Vessel Code, shall be complied with.

12.2 When "spot radiography" is specified, all intersections of longitudinal and circumferential welds shall be radiographed. Provisions of Paragraph UW-52 of Section VIII shall be complied with for spot radiographic examination.

NOTE 6—Circumferential welds are present only when individually fabricated tubes must be welded together to produce the ordered length.

13. Cladding Thickness

13.1 For Alclad 3003 and Alclad 3004, each 7072 plate which is bonded to the Alloy 3003 or 3004 ingot or slab preparatory to rolling to the specified thickness of sheet or plate, shall be of the composition shown in Table 1.

13.2 When the thickness of the cladding is to be determined on finished tubes, transverse cross sections of at least three tubes from the lot, approximately ¾ in. [20 mm] in length, shall be mounted to expose an edge perpendicular to the axis of the tube and polished for examination with a metallurgical microscope. The cladding thickness shall be measured under a magnification of 100×, at four points around the circumference 90° apart but excluding the weld area, in each sample. The cladding thickness shall be taken as the average of the measurements in five fields approximately 0.1 in. [2.5 mm] apart in each sample. The average cladding thickness on each clad surface shall be not less than 4 % of the specified composite thickness.

14. Dimensional Tolerances

14.1 Variations from the specified dimensions for the tube ordered shall not exceed the amounts prescribed in Table 4 [Table 5], Table 6 [Table 7], Table 8, and Table 9.

14.2 *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 tubes shall be specified 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 the producer and purchaser. Grinding to remove minor surface imperfections shall not be cause for rejection provided the ground area conforms to the minimum tolerances of Table 6 [Table 7]. Discoloration that is characteristic of proper solution heat treatment shall not be cause for rejection.

15.2 Each 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 or supplier may use a system of statistical quality control for such examinations.

TABLE 4 Diameter and Circumferential Tolerances

Specified Inside Diameter, in.	Specified Wall Thickness, in.	Maximum Permissible Ovality in Free State—Difference between Major and Minor Axes, in.	Permissible Deviation of Outside Circumference from theoretical, in., plus and minus
9 to 12 excl	0.125–0.188	½	⅛
12 to 16 excl	0.125–0.250	½	3/16
12 to 16 excl	0.251–0.312	¼	3/16
16 to 20 excl	0.125–0.311	½	3/16
16 to 20 excl	0.312–0.375	¼	3/16
20 to 24 excl	0.125–0.311	½	¼
20 to 24 excl	0.312–0.500	¼	¼
24 to 30 excl	0.125–0.311	½	¼
24 to 30 excl	0.312–0.500	¼	¼
30 to 36 excl	0.125–0.187	[A]	¼
30 to 36 excl	0.188–0.311	½	¼
30 to 36 excl	0.312–0.500	⅜	¼
36 to 48 excl	0.125–0.311	[A]	¼
36 to 48 excl	0.312–0.500	½	¼
48 to 60 incl	0.125–0.311	[A]	¼
48 to 60 incl	0.312–0.438	¾	¼
48 to 60 incl	0.439–0.500	¾	5/16

[A] Tube is not sufficiently rigid to permit diametrical measurement in free state.

TABLE 5 Diameter and Circumferential Tolerances, [SI Units]

Specified Inside Diameter, mm		Specified Wall Thickness, mm		Maximum Permissible Ovality in Free State Distance between Major and Minor Axes, mm	Permissible Deviation of Outside Circumference from Theoretical, mm plus and minus
Over	Through	Over	Through		
225	300	3.15	5.00	12.5	3.5
300	400	3.15	6.30	12.5	5
300	400	6.30	8.00	6.5	5
400	500	3.15	8.00	12.5	5
400	500	8.00	10.00	6.5	5
500	600	3.15	8.00	13	6.5
500	600	8.00	12.50	7	6.5
600	750	3.15	8.00	13	6.5
600	750	8.00	12.50	7	6.5
750	900	3.15	5.00	[A]	6.5
750	900	4.80	8.00	13	6.5
750	900	8.00	12.50	10	6.5
900	1200	3.15	8.00	[A]	6.5
900	1200	8.00	12.50	13	6.5
1200	1500	3.15	8.00	[A]	6.5
1200	1500	8.00	11.00	19	6.5
1200	1500	11.00	12.50	19	8

[A] Tube is not sufficiently rigid to permit diametrical measurement in free state.

TABLE 6 Wall Thickness Tolerances for Rolled and Welded Round Tube (Exclusive of Weld Bead), (Inch-Pound Units)[A,B]

Specified Wall Thickness, in.		Permissible Deviation of Thickness at Any Point from Specified Wall Thickness, plus and minus, in. Specified inside Diameter, in.							
Over	Through	Up Through 12	Over 12 Through 18	Over 18 Through 25	Over 25 Through 31	Over 31 Through 37	Over 37 Through 43	Over 43 Through 50	Over 50 Through 56
0.124	0.126	0.0045	0.0055	0.007	0.009	0.011	0.013	...	...
0.126	0.158	0.0055	0.007	0.009	0.011	0.013	0.015	...	...
0.158	0.197	0.007	0.009	0.011	0.013	0.015	0.018	...	...
0.197	0.248	0.009	0.011	0.013	0.015	0.018	0.022	0.027	...
0.248	0.315	0.012	0.014	0.015	0.018	0.022	0.027	0.035	0.043
0.315	0.394	0.015	0.017	0.020	0.023	0.027	0.033	0.041	0.051
0.394	0.500	0.023	0.023	0.027	0.032	0.035	0.043	0.053	0.065

[A] Not applicable to the weld area of the tube.
[B] These tolerances apply to tube butt welded longitudinally.

TABLE 7 Wall Thickness Tolerances for Rolled and Welded Round Tube (Exclusive of Weld Bead), [SI Units][A,B]

Specified Wall Thickness, mm		Permissible Deviation of Thickness at Any Point from Specified Wall Thickness, plus and minus, mm Specified inside Diameter, mm							
Over	Through	Up Through 320	Over 320 Through 480	Over 480 Through 640	Over 640 Through 800	Over 800 Through 950	Over 950 Through 1110	Over 1110 Through 1270	Over 1270 Through 1430
3.15	3.20	0.11	0.14	0.18	0.23	0.28	0.33	...	...
3.20	4.00	0.14	0.18	0.23	0.28	0.33	0.38	...	...
4.00	5.00	0.18	0.23	0.28	0.33	0.38	0.46	...	...
5.00	6.30	0.23	0.28	0.33	0.38	0.46	0.56	0.69	...
6.30	8.00	0.30	0.36	0.38	0.46	0.56	0.69	0.89	1.10
8.00	10.00	0.38	0.43	0.51	0.58	0.69	0.84	1.05	1.30
10.00	12.50	0.58	0.58	0.69	0.81	0.89	1.10	1.35	1.65

[A] Not applicable to the weld area of the tube.
[B] These tolerances apply to tube butt welded longitudinally.

16. Source Inspection

16.1 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.

16.2 When such inspection or witness of inspection and testing is agreed upon, the producer shall afford the purchaser's representative all reasonable facilities to satisfy him that the material meets the requirements of this specification. Inspection and test shall be conducted so there is no unnecessary interference with the producer's operations.

17. Retest and Rejection

17.1 If any material fails to conform to all of the applicable requirements of this specification, it shall be cause for rejection of the inspection lot.

17.2 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

TABLE 8 Length Tolerances for Rolled and Welded Round Tube

Specified Wall Thickness, in. [mm]	over	through	Permissible Variation from Specified Length, in. [mm], for Lengths up Through 10 ft [3 m]
0.125–0.249	[3.15]	[6.30]	± ⅛ [4]
0.250–0.500	[6.30]	[12.50]	+ ⅜ [10]

TABLE 9 Straightness Tolerances for Rolled and Welded Round Tube

Permissible deviation from straight: ½ in. in any 10 ft [13 mm in any 3 m]

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.

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

17.4 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.

18. Certification

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

19. Identification Marking

19.1 When specified in the contract or purchase order, all material shall be marked in accordance with Practice B 666/B 666M. In addition, material furnished in the T4, T451, T6, and T651 tempers shall also be identified by a lot number marked in at least one location on each piece.

19.2 Tubes tested radiographically shall also be identified as “Spot Radiographed” or “Full Radiographed.”

20. Packaging and Package Marking

20.1 Unless otherwise specified in the contract or purchase order, the material shall be packaged to provide adequate protection during normal handling and transportation and each package shall contain only one size and alloy of material unless otherwise agreed. The type of packaging and gross weight [mass] of the containers shall, unless otherwise agreed, be at the producer’s or supplier’s discretion, provided they are such as to ensure acceptance by common or other carriers for safe transportation at the lowest rate to the delivery point.

20.2 Each shipping container shall be marked with the purchase order number, material size, specification number, alloy and temper, gross and net weights [masses], and the producer’s or supplier’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 civil agencies and MIL-STD-129 for Military agencies.

21. Keywords

21.1 aluminum alloy; arc-welded tube

ANNEXES

(Mandatory Information)

A1. BASIS FOR INCLUSION OF PROPERTY LIMITS

A1.1 Limits are established at a level at which a statistical evaluation of the data indicates that 99 % of the population obtained from all standard material meets the limit with 95 % confidence. For the products described, mechanical property limits for the respective size ranges are based on the analyses of at least 100 data from standard production material with no more than ten data from a given lot. All tests are performed in accordance with the appropriate ASTM test methods. For informational purposes, refer to "Statistical Aspects of Mechanical Property Assurance" in the Related Material section of the *Annual Book of ASTM Standards*, Vol 02.02. Metric mechanical property limits in this issue were derived from the inch-pound system limits that were developed under the above principles. As test data on metric dimensioned specimens are accumulated, some refinement of limits, particularly for elongations measured in 5D, can be anticipated.

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

A2.1 Prior to acceptance for inclusion in this specification, the composition of wrought or cast aluminum or aluminum alloy shall be registered in accordance with ANSI H35.1. The Aluminum Association[10] 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.

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 this 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.

[10] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094 Attn: NPODS.
[10] The Aluminum Association, 900 19th Street, Washington, DC 20006.