Designation: B 313/B 313M – 02ε1

Standard Specification for Aluminum and Aluminum-Alloy Round Welded Tubes[1]

This standard is issued under the fixed designation B 313/B 313M; 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.

ε[1] NOTE—Safety caveat added and editorial changes were made in November 2003

1. Scope*

1.1 This specification covers aluminum and aluminum-alloy tubes made from formed sheet and seam welded by continuous methods.

1.2 Alloy (Note 1) 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.

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

NOTE 2—For the requirements for sheet see Specification B 209.

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 two systems will result in nonconformance with the specification.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

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

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

E 607 Test Method for Atomic 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)

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

[1] This specification is under the jurisdiction of the 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 1956. Last previous edition approved in 2000 as B 313/B 313M–00.

[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.

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

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	[F]	[F]	0.05–0.20	0.05	...	...	0.10	...	0.05	0.15	99.0 min[G]
3003	0.6	0.7	0.05–0.20	1.0–1.5	...	...	0.10	...	0.05	0.15	remainder
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 clad with alloy 7072			...	...	...	...	...	...	...	...
3005	0.6	0.7	0.30	1.0–1.5	0.20–0.6	0.10	0.25	0.10	0.05	0.15	remainder
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
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
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[H]	[I]	[I]	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 attained from analysis shall be rounded to the nearest unit in the last righthand 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 this 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] Iron plus silicon shall not exceed 0.95 %.
[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] Composition of cladding alloy as applied during the course of manufacture. Samples from finished tube shall not be required to conform to these limits.
[I] Iron plus silicon shall not exceed 0.7 %.

H35.2M Dimensional Tolerances for Aluminum Mill Products (Metric)

2.4 *Military Standard:*

MIL-STD-129 Marking for Shipment and Storage[6]

2.5 *AMS Specification:*

AMS 2772 Heat Treatment of Aluminum Alloy Raw Materials[7]

2.6 *Federal Standard:*

Fed. Std. No. 123 Marking for Shipment (Civil Agencies)[6]

3. Terminology

3.1 *Definitions:*

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

3.1.2 *supplier*—includes only the category of jobbers and distributors as distinct from producers.

3.1.3 *welded tube*—a tube produced by forming and seam-welding sheet longitudinally.

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 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 313; for metric orders specify Specification B 313M. Do not mix units.

4.1.2 Quantity in pieces or pounds, [kilograms]

4.1.3 Alloy (6.1),

4.1.4 Temper (Section 8),

4.1.5 Size (outside 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 918 is required,

4.2.2 Special tension tests required other than tension tests performed on specimens taken from the sheet prior to welding (8.2),

4.2.3 Whether pressure or burst test is required and test description if methods 1, 2, or 3 of 9.1 are not suitable,

4.2.4 Whether inspection or witness of inspection and tests by the purchaser's representative is required prior to material shipment (Section 13),

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

4.2.6 Whether marking for identification is required (15.1), and

4.2.7 Whether Practices B 660 applies, if so, the levels of preservation, packaging, and, packing required (16.3).

5. Responsibility for Quality Assurance

5.1 *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. Except as otherwise specified in the contract or order, 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

[6] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.
[7] Available from Society of Automotive Engineers (SAE), 400 Commonwealth Dr., Warrendale, PA 15096-0001.

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 material conforms to prescribed requirements.

5.2 *Lot Definition*—An inspection lot shall be defined as follows:

5.2.1 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.

5.2.2 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.

TABLE 2 Tensile 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, min,%
		min	max	min	max	
			Aluminum 1100			
O	0.032–0.050	11.0	15.5	3.5	...	25
	0.051–0.125	11.0	15.5	3.5	...	30
H12	0.032–0.050	14.0	19.0	11.0	...	6
	0.051–0.113	14.0	19.0	11.0	...	8
	0.114–0.125	14.0	19.0	11.0	...	9
H14	0.032–0.050	16.0	21.0	14.0	...	4
	0.051–0.113	16.0	21.0	14.0	...	5
	0.114–0.125	16.0	21.0	14.0	...	6
H16	0.032–0.050	19.0	24.0	17.0	...	3
	0.051–0.125	19.0	24.0	17.0	...	4
H18	0.032–0.050	22.0	...	...	...	3
	0.051–0.125	22.0	...	...	...	4
			Alloy 3003			
O	0.032–0.050	14.0	19.0	5.0	...	23
	0.051–0.125	14.0	19.0	5.0	...	25
H12	0.032–0.050	17.0	23.0	12.0	...	5
	0.051–0.113	17.0	23.0	12.0	...	6
	0.114–0.125	17.0	23.0	12.0	...	7
H14	0.032–0.050	20.0	26.0	17.0	...	4
	0.051–0.113	20.0	26.0	17.0	...	5
	0.114–0.125	20.0	26.0	17.0	...	6
H16	0.032–0.050	24.0	30.0	21.0	...	3
	0.051–0.125	24.0	30.0	21.0	...	4
H18	0.032–0.050	27.0	...	24.0	...	3
	0.051–0.125	27.0	...	24.0	...	4
			Alloy 3004			
O	0.032–0.050	22.0	29.0	8.5	...	16
	0.051–0.125	22.0	29.0	8.5	...	18
H32	0.032–0.050	28.0	35.0	21.0	...	4
	0.051–0.113	28.0	35.0	21.0	...	5
	0.114–0.125	28.0	35.0	21.0	...	6
H34	0.032–0.050	32.0	38.0	25.0	...	3
	0.051–0.113	32.0	38.0	25.0	...	4
	0.114–0.125	32.0	38.0	25.0	...	5
H36	0.032–0.050	35.0	41.0	28.0	...	3
	0.051–0.125	35.0	41.0	28.0	...	4
H38	0.032–0.050	38.0	...	31.0	...	3
	0.051–0.125	38.0	...	31.0	...	4
			Alloy Alclad 3004			
O	0.032–0.050	21.0	28.0	8.0	...	18
	0.051–0.125	21.0	28.0	8.0	...	16

TABLE 2 *Continued*

Temper	Specified Thickness, in.	Tensile Strength, ksi		Yield Strength (0.2 % offset), ksi		Elongation in 2 in., or 4× Diameter, min,%
		min	max	min	max	
H32	0.032–0.050	27.0	34.0	20.0	...	4
	0.051–0.113	27.0	34.0	20.0	...	5
	0.114–0.125	27.0	34.0	20.0	...	6
H34	0.032–0.050	31.0	37.0	24.0	...	3
	0.051–0.113	31.0	37.0	24.0	...	4
	0.114–0.125	31.0	37.0	24.0	...	5
H36	0.032–0.050	34.0	40.0	27.0	...	3
	0.051–0.125	34.0	40.0	27.0	...	4
H38	0.032–0.050	37.0	...	...	...	3
	0.051–0.125	37.0	...	...	...	4
			Alloy 3005			
O	0.032–0.050	17.0	24.0	6.5	...	18
	0.051–0.125	17.0	24.0	6.5	...	20
H12	0.032–0.050	20.0	27.0	17.0	...	2
	0.051–0.113	20.0	27.0	17.0	...	3
	0.114–0.125	20.0	27.0	17.0	...	4
H14	0.032–0.050	24.0	31.0	21.0	...	2
	0.051–0.113	24.0	31.0	21.0	...	3
	0.114–0.125	24.0	31.0	21.0	...	4
H16	0.032–0.113	28.0	35.0	25.0	...	2
	0.114–0.125	28.0	35.0	25.0	...	3
H18	0.032–0.125	32.0	...	29.0	...	2
			Alloy 5050			
O	0.032–0.113	18.0	24.0	6.0	...	20
	0.113–0.125	18.0	24.0	6.0	...	22
H32	0.032–0.050	22.0	28.0	16.0	...	4
	0.051–0.125	22.0	28.0	16.0	...	6
H34	0.032–0.050	25.0	31.0	20.0	...	4
	0.051–0.125	25.0	31.0	20.0	...	5
H36	0.032–0.050	27.0	33.0	22.0	...	3
	0.051–0.125	27.0	33.0	22.0	...	4
H38	0.032–0.050	29.0	...	...	...	3
	0.051–0.125	29.0	...	...	...	4
			Alloy 5052			
O	0.032–0.050	25.0	31.0	9.5	...	18
	0.051–0.113	25.0	31.0	9.5	...	19
	0.114–0.125	25.0	31.0	9.5	...	20
H32	0.032–0.050	31.0	38.0	23.0	...	5
	0.051–0.113	31.0	38.0	23.0	...	7
	0.114–0.125	31.0	38.0	23.0	...	9
H34	0.032–0.050	34.0	41.0	26.0	...	4
	0.051–0.113	34.0	41.0	26.0	...	6
	0.114–0.125	34.0	41.0	26.0	...	7
H36	0.032–0.125	37.0	44.0	29.0	...	4
H38	0.032–0.125	39.0	...	32.0	...	4
			Alloy 5086			
O	0.032–0.050	35.0	44.0	14.0	...	15
	0.051–0.125	35.0	44.0	14.0	...	18
H32	0.032–0.050	40.0	47.0	28.0	...	6
	0.051–0.125	40.0	47.0	28.0	...	8

TABLE 2 *Continued*

Temper	Specified Thickness, in.	Tensile Strength, ksi		Yield Strength (0.2 % offset), ksi		Elongation in 2 in., or 4× Diameter, min,%
		min	max	min	max	
H34	0.032–0.050	44.0	51.0	34.0	...	5
	0.051–0.125	44.0	51.0	34.0	...	6
H36	0.032–0.050	47.0	54.0	38.0	...	4
	0.051–0.125	47.0	54.0	38.0	...	6
			Alloy 5154			
O	0.032–0.050	30.0	41.0	11.0	...	14
	0.051–0.113	30.0	41.0	11.0	...	16
	0.114–0.125	30.0	41.0	11.0	...	18
H32	0.032–0.050	36.0	43.0	26.0	...	5
	0.051–0.125	36.0	43.0	26.0	...	8
H34	0.032–0.050	39.0	46.0	29.0	...	4
	0.051–0.125	39.0	46.0	29.0	...	6
			Alloy 5154			
H36	0.032–0.050	42.0	49.0	32.0	...	3
	0.051–0.113	42.0	49.0	32.0	...	4
	0.114–0.125	42.0	49.0	32.0	...	5
H38	0.032–0.050	45.0	...	35.0	...	3
	0.051–0.113	45.0	...	35.0	...	4
	0.114–0.125	45.0	...	35.0	...	5
			Alloy 6061			
O	0.032–0.125	...	22.0	...	12.0	16
T4	0.032–0.125	30.0	...	16.0	...	16
T6	0.032–0.125	42.0	...	35.0	...	10

[A] Determination of tensile and yield strengths across the weld are not usually made on a routine basis. However, such determination, if made would show strength about 85 % of those of the parent material except for T6 temper of 6061 which would show 30.0 ksi ultimate tensile strength.

[B] To determine conformance with the values in this table each value for tensile and 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 method of Practice E 29.

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

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

Temper	Specified Thickness, mm		Tensile Strength, MPa		Yield Strength (0.2 % offset,) MPa		Elongation min, % in 50 mm
	over	through	min	max	min	max	
			Aluminum 1100				
O	0.80	1.20	75	105	25	...	22
	1.20	3.20	75	105	25	...	30
H12	0.80	1.20	95	130	75	...	5
	1.20	3.20	95	130	75	...	8
H14	0.80	1.20	110	145	95	...	3
	1.20	3.20	110	145	95	...	5
H16	0.80	1.20	130	165	115	...	3
	1.20	3.20	130	165	115	...	4
H18	0.80	1.20	150	...	...	...	2
	1.20	3.20	150	...	...	...	4
			Alloy 3003				
O	0.80	1.20	95	130	35	...	22
	1.20	3.20	95	130	35	...	25
H12	0.80	1.20	120	160	85	...	4
	1.20	3.20	120	160	85	...	6
H14	0.80	1.20	140	180	115	...	3
	1.20	3.20	140	180	115	...	5
H16	0.80	1.20	165	205	145	...	3
	1.20	3.20	165	205	145	...	4
H18	0.80	1.20	185	...	165	...	2
	1.20	3.20	185	...	165	...	4
			Alloy 3004				
O	0.80	1.20	150	200	60	...	15
	1.20	3.20	150	200	60	...	18
H32	0.80	1.20	190	240	145	...	3

TABLE 3 *Continued*

Temper	Specified Thickness, mm		Tensile Strength, MPa		Yield Strength (0.2 % offset,) MPa		Elongation min, % in 50 mm
	over	through	min	max	min	max	
	1.20	3.20	190	240	145	...	5
H34	0.80	1.20	220	265	170	...	3
	1.20	3.20	220	265	170	...	4
H36	0.80	1.20	240	285	190	...	3
	1.20	3.20	240	285	190	...	4
H38	0.80	1.20	260	...	215	...	2
	1.20	3.20	260	...	215	...	4
			Alloy Alclad 3004				
O	0.80	1.20	145	195	55	...	15
	1.20	3.20	145	195	55	...	18
H32	0.80	1.20	185	235	140	...	3
	1.20	3.20	185	235	140	...	5
H34	0.80	1.20	215	260	165	...	3
	1.20	3.20	215	260	165	...	4
H36	0.80	1.20	235	280	185	...	3
	1.20	3.20	235	280	185	...	4
H38	0.80	1.20	255	...	...	...	2
	1.20	3.20	255	...	...	...	4
			Alloy 3005				
O	0.80	1.20	115	165	45	...	17
	1.20	3.20	115	165	45	...	20
H12	0.80	1.20	140	190	115	...	2
	1.20	3.20	140	190	115	...	3
H14	0.80	1.20	165	215	145	...	2
	1.20	3.20	165	215	145	...	3
H16	0.80	1.20	190	240	170	...	2
	1.20	3.20	190	240	170	...	2
H18	0.80	1.20	220	...	200	...	2
	1.20	3.20	220	...	200	...	2
			Alloy 5050				
O	0.80	1.20	125	165	40	...	19
	1.20	3.20	125	165	40	...	20
H32	0.80	1.20	150	195	110	...	5
	1.20	3.20	150	195	110	...	6
H34	0.80	1.20	170	215	140	...	4
	1.20	3.20	170	215	140	...	5
H36	0.80	1.20	185	230	150	...	3
	1.20	3.20	185	230	150	...	4
H38	0.80	1.20	200	...	...	...	3
	1.20	3.20	200	...	...	...	4
			Alloy 5052				
O	0.80	1.20	170	215	65	...	17
	1.20	3.20	170	215	65	...	19
H32	0.80	1.20	215	265	160	...	5
	1.20	3.20	215	265	160	...	7
H34	0.80	1.20	235	285	180	...	4
	1.20	3.20	235	285	180	...	6
H36	0.80	3.20	255	305	200	...	4
H38	0.80	3.20	270	...	220	...	4
			Alloy 5086				
O	0.80	1.20	240	305	95	...	16
	1.20	3.20	240	305	95	...	18
H32	0.80	1.20	275	325	195	...	6
	1.20	3.20	275	325	195	...	8
H34	0.80	1.20	300	350	235	...	5
	1.20	3.20	300	350	235	...	6
H36	0.80	1.20	325	375	260	...	4
	1.20	3.20	325	375	260		6
			Alloy 5154				
O	0.80	1.20	205	285	75	...	13
	1.20	3.20	205	285	75	...	16
H32	0.80	1.20	250	300	180	...	6
	1.20	3.20	250	300	180	...	8
H34	0.80	1.20	270	320	200	...	5
	1.20	3.20	270	320	200	...	6

TABLE 3 *Continued*

Temper	Specified Thickness, mm		Tensile Strength, MPa		Yield Strength (0.2 % offset,) MPa		Elongation min, % in 50 mm
	over	through	min	max	min	max	
H36	0.80	1.20	290	340	220	...	4
	1.20	3.20	290	340	220	...	4
H38	0.80	1.20	310	...	240	...	3
	1.20	3.20	310	...	240	...	4
Alloy 6061							
O	0.80	3.20	...	150	...	85	16
T4	0.80	3.20	205	...	110	...	16
T6	0.80	3.20	290	...	240	...	10

[A] Determinations of tensile and yield strengths across the weld are not usually made on a routine basis. However, such determination, if made would show strengths about 85 % of those of the parent material except for T6 temper of 6061 which would show about 205 MPa tensile strength.

[B] To determine conformance with the values in this table each value for tensile and yield strengths shall be rounded to the nearest 1 MPa and each value for elongation to the nearest 0.5 %, both in accordance with the rounding method of Practice E 29.

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

6. Chemical Composition

6.1 The tubes shall conform to the chemical composition limits prescribed in Table 1. Conformance shall be determined by the producer by analyzing samples taken at the time the ingots are poured, or samples taken from the finished or semi-finished 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.

6.2 *Number of Samples*—The number of samples taken for determination of chemical composition shall be as follows:

6.2.1 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.

6.2.2 When samples are taken from the finished or semifinished product, a sample shall be taken to represent each 4000 lb [2000 kg] or fraction thereof, of material in the lot, except that not more than one sample shall be required per piece.

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

6.3.1 Samples for chemical analysis shall be taken from bare and alclad sheet and plate 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.

6.3.2 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.

6.4 *Methods of Analysis*—The determination of chemical composition shall be made in accordance with suitable chemical (Test Methods E 34), or spectrochemical (Test Methods E 227, E 607, and E 1251), methods. Other methods may be used only when no published ASTM method is available. In case of dispute, the methods of analysis shall be agreed upon between the producer and purchaser.

7. Heat Treatment

7.1 Unless specified in 7.2, producer or supplier heat treatment for the applicable tempers in Table 2 [Table 3] shall be in accordance with AMS 2772.

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

8. Tensile Properties

8.1 *Limits*—The temper of the tubes shall be that of the sheet from which the tubes are formed, and the sheet shall conform to the tensile property requirements prescribed in Table 2 [Table 3].

8.2 The following tension tests are capability tests and will be required only when so specified on the contract or purchase order.

8.2.1 Tubes shall be capable of compliance with the tensile and yield strength requirements prescribed in Table 2 [Table 3] when a full-section specimen tube is tested.

8.2.2 Longitudinal specimens cut from tubes 2 in. [50 mm] or greater in diameter and 90° from the weld shall be capable of meeting the requirements of Table 2 [Table 3].

8.2.3 Longitudinal specimens cut from the weld area of tubes shall be capable of meeting not less than 80 % of the tensile and yield requirements applicable to the parent material prescribed in Table 2 [Table 3].

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

8.4 *Test Specimens*—Geometry of test specimens and the location in the product from which they are taken shall be as specified in Test Methods B 557 [B 557M].

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

9. Pressure Tests

9.1 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:

9.1.1 *Method 1*—Each tube shall withstand without evidence of leakage an internal air pressure of not less than 60 psig [400 kPa] while immersed in water or other suitable liquid.

9.1.2 *Method 2*—Each tube shall be tested pneumatically at not less than 90 psig [600 kPa] air pressure for not less than 15 s while one end is sealed without evidence of any loss of pressure as measured by a gage.

9.1.3 *Method 3*—Each tube shall withstand without evidence of leakage hydrostatic pressure of not less than 90 psig [600 kPa].

9.2 When specified in the order or contract, tubes will be subjected to other pressure or burst tests as agreed upon by the producer and the purchaser.

10. Cladding Thickness

10.1 For Alclad 3004, the aluminum or aluminum-alloy plates which are bonded to the alloy ingot or slab preparatory to rolling to the specified thickness of sheet shall be of the composition shown in Table 1 and shall each have a minimum thickness not less than 5 % of the total composite sheet thickness.

10.2 When the thickness of the cladding is to be determined on finished material, not less than three transverse samples approximately ¾ in. [20 mm] in length shall be mounted to expose a transverse cross section and polished for examination with a metallurgical microscope. Using a magnification of 100×, the maximum and minimum coating thickness shall be measured in each of five fields approximately 0.1 in. [2.5 mm] apart along both sides of the cross section. The average of the ten thickness measurements on each side is the average coating thickness, and shall be not less than 80 % of the thickness calculated from the above requirements.

11. Dimensional Tolerances

11.1 Variations from the specified dimensions shall not exceed the permissible variations prescribed in the following tables of ANSI H35.2 [H35.2M]

Table No.	Title
15.1	Diameter
15.3	Wall Thickness
15.4	Length
15.7	Squareness of Cut Ends

11.2 All tubes, except those in the annealed temper, shall not vary from straight by an amount greater than that prescribed in Table 15.5 of ANSI H35.2 [H35.2M]. Tubes in the annealed temper shall be reasonably straight and free from kinks and sharp bends.

12. General Quality

12.1 Unless otherwise agreed upon by the producer and the purchaser, tubes shall be supplied in the mill finish and shall be of uniform quality and temper, clean, sound, and free from injurious defects. Grinding to remove minor surface imperfections shall not be cause of rejection. Discoloration that is characteristic of proper solution heat treatment shall not be cause for rejection.

13. Source Inspection

13.1 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.

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

14. Retest and Rejection

14.1 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.

14.2 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.

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

14.4 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.

15. Identification Marking of Product

15.1 When specified in the contract or purchase order all tubes in straight lengths shall be marked in accordance with Practice B 666/B 666M.

15.2 The requirements specified in 15.1 are minimum; marking systems that involve added information, larger characters, and greater frequencies are acceptable under this specification.

16. Packaging and Package Marking

16.1 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. The type of packing and gross weight of containers shall, unless otherwise agreed upon, be at the producer's or supplier'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.

16.2 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.

16.3 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.

17. Certification

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

18. Keywords

18.1 aluminum alloy; welded tubes

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 SI units 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[8] 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.

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

SUMMARY OF CHANGES

This section identifies the principal changes to this standard that have been incorporated since the last issue.
(1) Added ASTM safety caveat to 1.5.
(2) Replaced Practice B 597 with Practice B 918 in 2.2 and added wording “Wrought.”
(3) Changed Practice B 597 to Practice B 918 in 4.2.1.
(4) Replaced MIL-H-6088 with AMS 2772 in 2.5 and 7.1.