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Standard Specification for Aluminum and Aluminum-Alloy Seamless Condenser and Heat-Exchanger Tubes with Integral Fins[1]

This standard is issued under the fixed designation B 404/B 404M; 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.

1. Scope *

1.1 This specification covers externally helical, integrally finned aluminum and aluminum-alloy seamless tubes with finned or unfinned ends, with continuous fins, or with unfinned sections, in outside diameters (diameter over fins) up to 2 in. [50 mm] inclusive. See Table 1 and Table 2.

1.2 Alloy and temper designations are in accordance with ANSI H35.1 and H35.1M. The equivalent Unified Numbering System alloy designations are those of Table 1 preceded by A9, for example, A91060 for aluminum 1060 in accordance with Practice E 527.

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

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

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

2. Referenced Documents

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

2.2 *ASTM Standards:*

B 557 Test Methods for Tension Testing Wrought and Cast Aluminum- and Magnesium-Alloy Products[2]

B 557M Test Methods for Tension Testing Wrought and Cast Aluminum- and Magnesium-Alloy Products [Metric][2]

B 660 Practices for Packaging/Packing 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 Optical Emission Spectrometric Analysis of Aluminum and Aluminum Alloys by the Point-to-Plane Technique, Nitrogen Atmosphere[6]

E 716 Practices for Sampling Aluminum and Aluminum Alloys for Spectrochemical Analysis[6]

E 1251 Test Method for Optical Emission Spectrometric Analysis of Aluminum and Aluminum Alloys by the Argon Atmosphere, Point-to-Plane, Unipolar Self-Initiating Capacitor Discharge[6]

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]

2.4 *Federal Standards:*

Fed. Std. No. 123 Marking for Shipment (Civil Agencies)[7]

2.5 *Military Standards:*

MIL-STD-129 Marking for Shipment and Storage[7]

3. Terminology

3.1 *Definitions:*

3.1.1 *round tube*—a hollow wrought product that is long in relation to its cross section, which is round and has a uniform wall thickness.

3.1.2 *drawn tube*—a tube brought to final dimensions by drawing through a die.

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

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

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

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

[5] *Annual Book of ASTM Standards*, Vol 01.01.

[6] *Annual Book of ASTM Standards*, Vol 03.06.

[7] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

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

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

Alloy[D]	Silicon	Iron	Copper	Manganese	Magnesium	Chromium	Zinc	Titanium	Other Elements[E]		Aluminum
									Each	Total[F]	
1060[G]	0.25	0.35	0.05	0.03	0.03	...	0.05	0.03	0.03	...	99.60 min[H]
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										
5052	0.25	0.40	0.10	0.10	2.2–2.8	0.15–0.35	0.10	...	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 Cladding	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 shown 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] These designations were established in accordance with ANSI H35.1.
[E] *Others* includes listed elements for which no specific limit is shown as well as unlisted metallic elements. The producer may analyze samples for trace elements not specified in the specification. However, such analysis is not required and may not cover all metallic *Others* elements. Should any analysis by the producer or the purchaser establish that an *Others* element exceeds the limit of *Each* or that the aggregate of several *Others* elements exceeds the limit of *Total*, the material shall be considered non-conforming.
[F] *Other Elements*—Total shall be the sum of unspecified metallic elements 0.010 % or more, rounded to the second decimal before determining the sum.
[G] Vanadium 0.05 %, maximum.
[H] 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.

3.1.3 *seamless tube*—a tube which does not contain any line junctures resulting from the method of manufacture.

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

3.1.5 *finned tube*—a tube which has integral fins or projections protruding from its outside surface.

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

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

3.2 *Definition of Term 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),

4.1.2 Quantity of each size (number of pounds [pieces]),

4.1.3 Alloy and temper (Sections 7 and 8),

4.1.4 Description of tube ends (plain or finned),

4.1.5 Dimensions: outside diameter, wall thickness, length of unfinned ends (if applicable), root diameter and wall thickness of finned section, number of fins per unit length, fin geometry, and total tube length (Section 5),

4.2 Additionally, orders for material to this specification shall include the following information when required by the purchaser:

4.2.1 Whether identification marking is required (Section 17),

4.2.2 Whether inspection or witness of inspection and tests by the purchaser's representative is required prior to material shipment (Section 14),

4.2.3 Whether certification is required (Section 16), and

4.2.4 Whether Practices B 660 applies and, if so, the levels of preservation, packaging, and packing required (18.3).

5. Manufacture

5.1 The fins shall be produced by the cold forming of aluminum alloy drawn seamless tubes so that the fins are integral with the tube.

5.2 The fin geometry and number of fins per unit length shall be as agreed upon between the manufacturer and the purchaser (Fig. 1). The finned tubes shall normally be furnished with unfinned ends, but may be furnished with finned ends or stripped ends from which the fins have been removed by machining.

6. Responsibility for Quality Assurance

6.1 *Responsibility for Inspection and Tests*—Unless otherwise specified in the contract or purchase order, the producer is responsible for the performance of all inspection and test requirements specified herein. 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 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.

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 the 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 the material of the same mill form, alloy, temper, and nominal dimensions subjected to inspection at one time.

TABLE 2 Tensile Property Limits[A,B]

Temper[C]	Specified Wall Thickness, in. [mm]	Tensile Strength, ksi [MPa]		Yield Strength (0.2% Offset), min, ksi [MPa]	Elongation in 2 in. [50 mm] or 4× Diameter,[D] min, %		
		min	max		Full Section Specimen in 50 mm	Cut-Out Specimen	
						in 50 mm	In 5 × Diameter ($5.65\sqrt{A}$)[E]
			Aluminum 1060[C]				
O	0.018–0.500 [0.45–12.50]	8.5 [60]	13.5 [95]	2.5 [15]	...	...	...
H14	0.018–0.500	12.0 [85]	... [...]	10.0 [70]	...	...	...
			Alloy 3003[C]				
O	0.010–0.024 [0.25–0.63]	14.0 [95]	19.0 [130]	5.0 [35]	...	...	...
	0.025–0.049 [0.63–1.20]	14.0 [95]	19.0 [130]	5.0 [35]	30	20	...
	0.050–0.259 [1.20–6.30]	14.0 [95]	19.0 [130]	5.0 [35]	35	25	...
	0.260–0.500 [6.30–12.50]	14.0 [95]	19.0 [130]	5.0 [35]	...	30	27
H14	0.010–0.024 [0.25–0.63]	20.0 [140]	... [...]	17.0 [115]	3	...	...
	0.025–0.049 [0.63–1.20]	20.0 [140]	... [...]	17.0 [115]	5	3	...
	0.050–0.259 [1.20–6.30]	20.0 [140]	... [...]	17.0 [115]	8	4	...
	0.260–0.500 [6.30–12.50]	20.0 [140]	... [...]	17.0 [115]	...	...	...
H25	0.010–0.500 [0.25–12.50]	22.0 [150]	... [...]	19.0 [130]	...	...	...
			Alloy Alclad 3003[C]				
O	0.010–0.500 [0.25–12.50]	13.0 [90]	19.0 [130]	4.5 [30]	...	...	...
H14	0.010–0.024 [0.25–0.63]	19.0 [130]	...	16.0 [110]	...	...	...
	0.025–0.049 [0.63–1.20]	19.0 [130]	...	16.0 [110]	5	...	...
	0.050–0.259 [1.20–6.30]	19.0 [130]	...	16.0 [110]	8	4	...
	0.260–0.500 [6.30–12.50]	19.0 [130]	...	16.0 [110]	...	...	...
H25	0.010–0.500 [0.25–12.50]	21.0 [145]	...	18.0 [125]	...	...	...
			Alloy 5052[C]				
O	0.018–0.450 [0.45–11.50]	25.0 [170]	35.0 [240]	10.0 [70]	...	...	...
H32	0.018–0.450 [0.45–11.50]	31.0 [215]	...	23.0 [160]	...	...	...
H34	0.018–0.450 [0.45–11.50]	34.0 [235]	...	26.0 [180]	...	...	...
			Alloy 5454[C]				
O	0.010–0.200 [0.25–5.00]	31.0 [215]	...	12.0 [85]	...	...	...
H32	0.010–0.050 [0.25–1.20]	36.0 [250]	...	26.0 [180]	...	5	...
	0.051–0.200 [1.20–5.00]	36.0 [250]	...	26.0 [180]	...	8	...
H34	0.010–0.050 [0.25–1.20]	39.0 [270]	...	29.0 [200]	...	4	...
	0.051–0.200 [1.20–5.00]	39.0 [270]	...	29.0 [200]	...	6	...
			Alloy 6061[C]				
O	0.018–0.500 [0.45–12.50]	...	22.0 [150]	14.0 max [95 max]	15[F]	15[F]	13
T4	0.025–0.049 [0.63–1.20]	30.0 [205]	...	16.0 [110]	16[F]	14[F]	...
	0.050–0.259 [1.20–6.30]	30.0 [205]	...	16.0 [110]	18[F]	16[F]	16
	0.260–0.500 [6.30–12.50]	30.0 [205]	...	16.0 [110]	20[F]	18[F]	...
T6	0.025–0.049 [0.63–1.20]	42.0 [290]	...	35.0 [240]	10[F]	8[F]	...
	0.050–0.259 [1.20–6.30]	42.0 [290]	...	35.0 [240]	12[F]	10[F]	10
	0.260–0.500 [6.30–12.50]	42.0 [290]	...	35.0 [240]	14[F]	12[F]	...

[A] See Annex A1.

[B] To determine conformance to this specification, each value for tensile strength and for yield strength shall be rounded to the nearest 0.1 ksi [1 MPa] and each value for elongation to the nearest 0.5 %, both in accordance with the rounding method of Practice E 29.

[C] These alloy and temper designations were established in accordance with ANSI H35.1.

[D] Elongations in 50 mm apply for tube tested in full-section, for sheet type specimens, for tubes having a flat wall, and for similar curved specimens for tubes having a curved wall, up to a maximum wall thickness of 12.50 mm. Elongations in 5 D ($5.65\sqrt{A}$), where D and A are diameter and cross-sectional area of the specimens, respectively, apply to round test specimens machined from wall thicknesses over 6.30 mm.

[E] Elongation of full-section and cut-out sheet-type specimens is measured in 2 in.; of cut-out round specimens in 4 × specimen diameter.

[F] The test for elongation is not required when specimens are machined from the finned portion of tube.

7. Chemical Composition

7.1 *Limits*—The finned 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 semifinished product. If the producer of the drawn seamless tubes from which the finned tubes may be produced, or the producer of the finned tubes, has determined the chemical composition of the material during the course of manufacture, sampling and analysis of the finished product shall not be required.

NOTE 2—It is standard practice in the United States aluminum industry to determine conformance to the chemical composition limits prior to further processing of ingots into wrought products. Due to the continuous nature of the process, it is not practical to keep a specific ingot analysis identified with a specific quantity of finished material.

7.2 *Number of Samples*—The number of samples taken for determining the 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.