Designation: B234 – 04

Used in USNRC-RDT standards

Standard Specification for Aluminum and Aluminum-Alloy Drawn Seamless Tubes for Condensers and Heat Exchangers[1]

This standard is issued under the fixed designation B234; 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[2] covers aluminum-alloy (Note 1) drawn seamless round tube in straight lengths designated as shown in Table 2, for use in surface condensers, evaporators, and heat exchangers.

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

NOTE 2—For drawn seamless tubes used in general applications, see Specification B210; for extruded tubes see Specification B221; for seamless pipe see Specification B241/B241M; and for structural pipe and tube see Specification B429/B429M.

1.2 Alloy and temper designations are in accordance with ANSI H35.1. 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 E527.

1.3 A complete metric companion to Specification B234 has been developed—B234M; therefore, no metric equivalents are presented in this specification.

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

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 date of material purchase form a part of this specification to the extent referenced herein:

2.2 *ASTM Standards:*[3]

B210 Specification for Aluminum and Aluminum-Alloy Drawn Seamless Tubes

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

B241/B241M Specification for Aluminum and Aluminum-Alloy Seamless Pipe and Seamless Extruded Tube

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

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

B660 Practices for Packaging/Packing of Aluminum and Magnesium Products

B666/B666M Practice for Identification Marking of Aluminum and Magnesium Products

B881 Terminology Relating to Aluminum- and Magnesium-Alloy Products

B918 Practice for Heat Treatment of Wrought Aluminum Alloys

E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

E34 Test Methods for Chemical Analysis of Aluminum and Aluminum-Base Alloys

E55 Practice for Sampling Wrought Nonferrous Metals and Alloys for Determination of Chemical Composition

E215 Practice for Standardizing Equipment for Electromagnetic Examination of Seamless Aluminum-Alloy Tube

E527 Practice for Numbering Metals and Alloys in the Unified Numbering System (UNS)

E607 Test Method for Atomic Emission Spectrometric Analysis Aluminum Alloys by the Point to Plane Technique Nitrogen Atmosphere

E716 Practices for Sampling Aluminum and Aluminum Alloys for Spectrochemical Analysis

E1251 Test Method for Analysis of Aluminum and Aluminum Alloys by Atomic Emission Spectrometry

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

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[2] For ASME Boiler and Pressure Vessel Code applications see related Specification SB-234 in Section II of that Code.

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

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

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

Alloy	Silicon	Iron	Copper	Manganese	Magnesium	Chromium	Zinc	Titanium	Other Elements[D]		Aluminum
									Each	Total[E]	
1060	0.25	0.35	0.05	0.03	0.03	...	0.05	0.03	0.03[F]	...	99.60 min[G]
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[H]	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 otherwise stated.
[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 right-hand place of figures used in expressing the specified limit, in accordance with the rounding-off method of Practice E29.
[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] Vanadium 0.05 max.
[G] The aluminum content shall be calculated by subtracting from 100.00 % the sum of all the metallic elements present in amounts of 0.010 % or more, rounded to the second decimal before determining the sum.
[H] Composition of cladding alloy as applied during the course of manufacture. The sample from finished tube shall not be required to conform to these limits.

TABLE 2 Tensile Property Limits[A,B]

Alloy	Temper	Wall Thickness, in.	Tensile Strength, min, ksi	Yield Strength, (0.2 % offset), min, ksi	Elongation in 2 in., or 4 × Dia,[C] min, %	
					Full-Section Specimen	Cut-Out Specimen
1060	H14	0.010–0.200	12.0	10.0	...	...
3003	H14	0.010–0.024	20.0	17.0	3	...
		0.025–0.049	20.0	17.0	5	3
		0.050–0.200	20.0	17.0	8	4
	H25	0.010–0.200	22.0	19.0	...	...
Alclad 3003	H14	0.010–0.024	19.0	16.0	...	...
		0.025–0.049	19.0	16.0	5	3
		0.050–0.200	19.0	16.0	8	4
	H25	0.010–0.200	21.0	18.0	...	...
5052	H32	0.010–0.200	31.0	23.0	...	...
	H34	0.010–0.200	34.0	26.0	...	...
5454	H32	0.010–0.050	36.0	26.0	...	5
		0.051–0.200	36.0	26.0	...	8
	H34	0.010–0.050	39.0	29.0	...	4
		0.051–0.200	39.0	29.0	...	6
6061	T4	0.025–0.049	30.0	16.0	16	14
		0.050–0.200	30.0	16.0	18	16
	T6	0.025–0.049	42.0	35.0	10	8
		0.050–0.200	42.0	35.0	12	10

[A] To determine conformance to this specification, each value for ultimate strength and for yield strength shall be rounded to the nearest 0.1 ksi and each value for elongation to the nearest 0.5 %, both in accordance with the rounding-off method of Practice E29.
[B] The basis for establishment of mechanical property limits is shown in Annex A1.
[C] Elongation of full-section and cut-out sheet-type specimens is measured in 2 in., of cut-out round specimens, in 4 × specimen diameter.

2.3 *ANSI Standards:*[4]
H35.1 Alloy and Temper Designation Systems for Aluminum
H35.2 Dimensional Tolerances for Aluminum Mill Products

2.4 *Federal Standard:*[5]
Fed. Std. No. 123 Marking for Shipment (Civil Agencies)

2.5 *Military Standard:*[5]
MIL-STD-129 Marking for Shipment and Storage

[4] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036.

[5] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098.

2.6 *AMS Specification:*[6]

AMS 2772 Heat Treatment of Aluminum Alloy Raw Materials

3. Terminology

3.1 Refer to Terminology B881 for definitions of product terms used in this specification.

3.2 *Definitions:*

3.3 *Definitions of Terms Specific to This Standard:*

3.3.1 *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 in pieces or pounds,

4.1.3 Alloy (Section 7),

4.1.4 Temper (Section 8),

4.1.5 Outside or inside diameter, wall thickness, and length,

4.1.6 For alloy Alclad 3003, state clad inside or outside (12.1).

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 B918 is required (9.2),

4.2.2 Whether cut ends of tube are to be deburred (Section 14),

4.2.3 Whether inspection or witness of inspection and tests by the purchaser's representative is required prior to material shipment (Section 15),

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

4.2.5 Whether marking for identification is required (Section 18), and

4.2.6 Whether Practices B660 applies and, if so, the level of preservation, packaging, and packing required (19.3).

5. Manufacture

5.1 The tube shall be produced by drawing an extruded tube made from hollow extrusion ingot (cast in hollow form or pierced) and extruded by use of the die and mandrel method.

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. The producer may use his own or any other suitable facilities for the performance of the inspection and test requirements specified herein, unless disapproved by the purchaser in the order or at the time of contract signing. The purchaser shall have the right to perform any of the inspections and tests set forth in this specification where such inspections 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 an identifiable quantity of material of the same mill form, alloy, temper, and thickness traceable to a heat-treat lot or lots, and subjected to inspection at one time.

6.2.2 For nonheat-treated tempers, an inspection lot shall consist of an identifiable quantity of material of the same mill form, alloy, temper, and thickness subjected to inspection at one time.

7. Chemical Composition

7.1 *Limits*—The tube shall conform to the chemical composition limits 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 3—It is standard practice in the United States aluminum industry to determine conformance to the chemical composition limits prior to further processing of ingots into wrought products. Due to the continuous nature of the process, it is not practical to keep a specific ingot analysis identified with a specific quantity of finished material.

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

7.2.1 When samples are taken at the time the ingots are poured, at least one sample shall be taken for each group of ingots poured simultaneously from the same source of molten metal.

7.2.2 When samples are taken from the finished or semi-finished product, a sample shall be taken to represent each 4000 lb, or fraction thereof, of material in the lot, except that not more than one sample shall be required per piece.

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

7.3.1 Samples of chemical analysis shall be taken by drilling, sawing, milling, turning, clipping, and so forth, a representative piece or pieces to obtain a prepared sample of not less than 75 g. Sampling shall be in accordance with Practice E55.

7.3.2 Sampling for spectrochemical analysis shall be in accordance with Practices E716. Samples for other methods of analysis shall be suitable for the form of material being analyzed and the type of analytical method used.

NOTE 4—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] Available from Society of Automotive Engineers (SAE), 400 Commonwealth Dr., Warrendale, PA 15096-0001.

7.4 *Methods of Analysis*—The determination of chemical composition shall be made in accordance with suitable chemical (Test Methods E34), or spectrochemical, (Test Methods E607 and E1251) 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.

8. Tensile Properties of Material as Supplied

8.1 *Limits*—The tube shall conform to the tensile property requirements in Table 2.

8.2 *Number of Specimens*:

8.2.1 For material having a nominal weight of less than 1 lb/linear ft, one tension test specimen shall be taken for each 1000 lb, or fraction thereof, in the lot.

8.2.2 For material having a nominal weight of 1 lb or more/linear ft one tension test specimen shall be taken for each 1000 ft, or fraction thereof, in the lot.

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

8.3 *Test Methods*—The tension tests shall be made in accordance with Test Methods B557.

9. Heat Treatment

9.1 Unless otherwise specified in 9.2, producer or supplier heat treatment for the applicable tempers in Table 2 shall be in accordance with AMS 2772.

9.2 When specified, heat treatment of applicable tempers in Table 2 shall be in accordance with Practice B918.

10. Leak Test

10.1 Each length of tube 1.5 in. or less in diameter shall be tested by either of the following methods, at the option of the producer or supplier, consistent with the size limitations indicated:

10.1.1 *Method 1*—Applicable to tube with a wall thickness of 0.200 in. max. Each tube shall be subjected to an internal air gage pressure of 250 psi for 5 s while immersed in a suitable liquid. Any evidence of leakage shall be cause for rejection.

10.1.2 *Method 2*—Applicable to tube with a wall thickness of 0.083 in. maximum, as covered by Practice E215. Each tube shall be subjected to an eddy current test in accordance with the procedures described in Practice E215. Reference standards described in Annex A1 and Annex A2 shall be used to standardize the equipment. These same reference standards or secondary standards having equivalent eddy current response shall also serve to define acceptance-rejection limits. Tubes that produce eddy current indications less than those from the 2*A* holes of the applicable reference standard or an equivalent secondary standard shall be acceptable. Any tube having a discontinuity that produces an eddy current indication equal to or greater than those from the 2*A* holes of the applicable reference standard or an equivalent secondary standard shall be rejected.

11. Expansion Test

11.1 The tube ends shall be capable of being flared, without showing cracks or ruptures visible to the unaided eye when corrected for normal vision, by forcing a steel pin having a taper of 1.5 in./ft into the tube until the inside diameter has been increased 20 %.

12. Cladding

12.1 The aluminum alloy cladding of Alclad 3003 tube shall, as specified, comprise either the inside surface (only) and its thickness shall be approximately 10 % of the total wall thickness, or the outside surface (only) in which case its thickness shall be approximately 7 % of the total wall thickness.

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

13. Dimensional Tolerances

13.1 Variations from the specified wall thickness, length, outside diameter, straightness, and squareness of cut ends shall not exceed the tolerances specified in the tables of ANSI H35.2 (see Table 3).

13.2 *Sampling for Inspection*—Examination for dimensional conformance shall be made to ensure conformance to the tolerance specified.

14. General Quality

14.1 Unless otherwise specified, the material shall be supplied in the mill finish and shall be uniform as defined by the requirements of this specification and shall be commercially sound. Any requirement not so covered is subject to negotiation between producer and purchaser.

14.2 Grinding to remove minor surface imperfections shall not be cause for rejection, provided the repaired area is within dimensional tolerances.

14.3 When so specified on the purchase order, the cut ends of each tube shall be deburred by the use of a wire wheel, file, or other suitable tool or device.

14.4 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 may use a system of statistical quality control for such examinations.

TABLE 3 Tables of ANSI H35.2

Table No.	Title
12.36	Heat-Exchanger Tube Wall Thickness
12.37	Heat-Exchanger Tube Length
12.34	Heat-Exchanger Tube Outside Diameter, Heat-Treatable Tube
12.35	Heat-Exchanger Tube Outside Diameter, Non-Heat-Treatable Tube
12.38	Heat-Exchanger Tube Straightness
12.39	Heat-Exchanger Tube Squareness of Cut Ends