Designation: B 483/B 483M – 00

Standard Specification for Aluminum and Aluminum-Alloy Drawn Tubes for General Purpose Applications[1]

This standard is issued under the fixed designation B 483/B 483M; 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. Scope *

1.1 This specification covers aluminum and aluminum-alloy drawn tubes in straight lengths and coils for general purpose applications in the alloys (Note 2), and tempers shown in Table 1. Coiled tubes are generally available only as round tubes with a wall thickness not exceeding 0.083 in. [2.00 mm] and only in non-heat-treatable alloys.

NOTE 1—For drawn seamless tubes, see Specifications B 210 and B 210M, for tubes to be used in condensers and heat exchangers, Specifications B 234 and B 234M, and for seamless pipe, Specification B 241/B 241M.

NOTE 2—Throughout this specification use of the term *alloy* in the general sense includes aluminum as well as aluminum alloy.

1.2 Alloy and temper designations are in accordance with ANSI H35.1 and H35.1M. The equivalent Unified Number System alloy designations are those of Table 2 preceded by A9, for example A91060 for aluminum 1060 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 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 date of order acceptance 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 597 Practice for Heat Treatment of Aluminum Alloys[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]

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 215 Practice for Standardizing Equipment for Electromagnetic Testing of Seamless Aluminum-Alloy Tube[5]

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)[6]

E 607 Test Method for Optical Emission Spectrometric Analysis of Aluminum and Aluminum Alloys by the Point-to-Plane Technique, Nitrogen Atmosphere[7]

E 716 Practices for Sampling Aluminum and Aluminum Alloys for Spectrochemical Analysis[7]

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[7]

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]

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

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

2.4 *Military Standard:*

[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 03.03.

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

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

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

MIL-STD-129 Marking for Shipment and Storage[8]

2.5 *Military Specification:*

MIL-H-6088 Heat Treatment of Aluminum Alloys[8]

2.6 *Federal Standard:*

Fed. Std. No. 123 Marking for Shipment (Civil Agencies)[8]

3. Terminology

3.1 *Definitions:*

3.1.1 *tube*—a hollow wrought product that is long in relation to its cross section, that is round, a regular hexagon, a regular octagon, elliptical, or square or rectangular with sharp or rounded corners, and that has uniform wall thickness except as may be affected by corner radii.

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

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

3.1.4 *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 in pieces or pounds,

4.1.3 Alloy (7.1),

4.1.4 Temper (8.1),

4.1.5 Cross-sectional dimensions (outside diameter and wall thickness, or inside diameter and wall thickness for round tube; for tube other than round, square, rectangular, hexagonal, or octagonal with sharp corners, a drawing is required),

4.1.6 Length (straight or coiled),

4.1.7 Nominal inside diameter of coils and weight or maximum outside diameter, if applicable,

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

4.2.1 Whether heat treatment shall be in accordance with Practice B 597 (9.2),

4.2.2 Whether testing for leaks is required (11.1),

4.2.3 Whether specified number of leaks are allowed, and the manner of marking leaks (11.1.3.2),

4.2.4 Whether inside cleanliness test is required on coiled tubes (12.2), and frequency of testing required,

4.2.5 Whether inspection or witness of inspection and tests by the purchaser's representative is required prior to material shipment (15.1),

4.2.6 Whether marking for identification is required (17.1),

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

4.2.8 Whether certification of the material by the producer is required (Section 19).

5. Manufacture

5.1 The tube may be produced by drawing tube stock produced by extrusion through a bridge-type die or by die and mandrel methods, at the option of the producer, provided that the production method results in material that meets all requirements of this specification.

5.2 The ends of coils shall be crimped or otherwise sealed to avoid contamination during shipment.

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

7. Chemical Composition

7.1 *Limits*—The tubes shall conform to the composition in Table 2. 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 has determined the 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 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 semifinished product, a sample shall be taken to represent each 4000 lb [2000 kg] or fraction thereof of material in the lot, except that no more than one sample shall be required per piece.

7.3 *Methods of Sampling*—Samples for determination of

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

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 material by drilling, sawing, milling, turning, or clipping a representative piece or pieces to obtain a prepared sample of not less than 75 g. Sampling shall be in accordance with Practice E 55.

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), 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.

8. Tensile Properties

8.1 *Limits*—Tube shall conform to the tensile properties in Table 1.

8.2 *Number of Specimens*:

8.2.1 For tubes having a nominal weight of less than 1 lb/linear ft [1.7 kg/linear m], one tension test specimen shall be taken for each 1000 lb [500 kg] or fraction thereof in a lot.

8.2.2 For tubes having a nominal weight of 1 lb [1.7 kg] or more/linear ft [m], one tension test specimen shall be taken for each 1000 ft [300 m] or fraction thereof in a lot.

8.3 *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 and B 557M.

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

9. Heat Treatment

9.1 Unless specified in 9.2, producer or supplier heat treatment for the applicable tempers in Table 1 shall be in accordance with MIL-H-6088.

9.2 When specified, heat treatment of applicable tempers in Table 1 shall be in accordance with Practice B 597.

10. Heat Treatment and Reheat Treatment Capability

10.1 As-received material in the O or F temper and in alloys 6061 and 6063 (within the size limitations specified in Table 1 and without the imposition of cold work) shall, after proper solution heat treatment and natural aging for not less than 4 days at room temperature, conform to the properties specified in Table 1 for T42 temper material.

10.2 Material in alloy and tempers 6063-T4 and T6 shall, after proper resolution heat treatment and natural aging for not less than 4 days at room temperature, conform to the properties specified in Table 1 for the T42 temper.

NOTE 4—6061-T4 and T6 are excluded from this paragraph because experience has shown the reheat treated material may develop large recrystallized grains and may fail to develop the tensile properties shown in Table 1.

10.3 Material in T4 and T42 tempers shall, after proper precipitation heat treatment, conform to the properties specified in Table 1 for the T6 and T62 tempers, respectively.

TABLE 1 Tensile Property Limits[A,B]

Temper	Specified Wall Thickness,[C] in. [mm]	Tensile Strength, ksi [MPa]		Yield Strength[D] (0.2% Offset), ksi [MPa], min	Elongation in 2 in. [50 mm] or 4× Diameter,[E] min, %		
		min	max		Full-Section Specimen	Cut-Out Specimen	
						in 50 mm	In 5 × Diameter ($5.65\sqrt{A}$)[F]
Aluminum 1060							
O	0.018–0.500 [0.45–12.50]	8.5 [60]	13.5 [95]	2.5 [15]	...	...	...
H12	0.018–0.500 [0.45–12.50]	10.0 [70]	... [...]	4.0 [30]	...	...	...
H14	0.018–0.500 [0.45–12.50]	12.0 [85]	... [...]	10.0 [70]	...	...	...
H18	0.018–0.500 [0.45–12.50]	16.0 [110]	... [...]	13.0 [90]	...	...	...
H113[G]	0.018–0.500 [0.45–12.50]	8.5 [60]	... [...]	2.5 [15]	...	...	...
Aluminum 1100							
O	0.018–0.500 [0.45–12.50]	11.0 [75]	15.5 [105]	3.5 [25]	...	...	...
H12	0.018–0.500 [0.45–12.50]	14.0 [95]	... [...]	11.0 [75]	...	...	...
H14	0.018–0.500 [0.45–12.50]	16.0 [110]	... [...]	14.0 [85]	...	...	...
H16	0.018–0.500 [0.45–12.50]	19.0 [130]	... [...]	17.0 [115]	...	...	...
H18	0.018–0.500 [0.45–12.50]	22.0 [150]	... [...]	20.0 [140]	...	...	...
H113[G]	0.018–0.500 [0.45–12.50]	11.0 [75]	... [...]	3.5 [25]	...	...	...
Aluminum 1435[H]							
O	0.018–0.500 [0.45–12.50]	9.5 [65]	14.0 [100]	3.0 [20]	...	...	...
H12	0.018–0.500 [0.45–12.50]	12.0 [85]	... [...]	7.0 [50]	...	...	...
H14	0.018–0.500 [0.45–12.50]	14.0 [95]	... [...]	12.0 [85]	...	...	...
H16	0.018–0.500 [0.45–12.50]	16.0 [110]	... [...]	14.0 [95]	...	...	...
H18	0.018–0.500 [0.45–12.50]	19.0 [135]	... [...]	16.0 [110]	...	...	...
Alloy 3003							

TABLE 1 *Continued*

Temper	Specified Wall Thickness,[C] in. [mm]	Tensile Strength, ksi [MPa]		Yield Strength[D] (0.2% Offset), ksi [MPa], min	Elongation in 2 in. [50 mm] or 4× Diameter,[E] min, %		
		min	max		Full-Section Specimen	Cut-Out Specimen	
						in 50 mm	In 5 × Diameter ($5.65\sqrt{A}$)[F]
O	0.018–0.500 [0.45–12.50]	14.0 [95]	19.0 [130]	5.0 [35]	...	...	...
H12	0.018–0.500 [0.45–12.50]	17.0 [120]	... [...]	12.0 [85]	...	...	...
H14	0.018–0.500 [0.45–12.50]	20.0 [140]	... [...]	17.0 [115]	...	...	...
H16	0.018–0.500 [0.45–12.50]	24.0 [165]	... [...]	21.0 [145]	...	...	...
H18	0.018–0.500 [0.45–12.50]	27.0 [185]	... [...]	24.0 [165]	...	...	...
H113[G]	0.018–0.500 [0.45–12.50]	14.0 [95]	... [...]	5.0 [35]	...	...	...
			Alloy 3102[H]				
O	0.018–0.049 [0.63–1.20]	11.0 [75]	17.0 [115]	3.5 [25]	30[I]	20[I]	
	0.050–0.065 [1.20–1.70]	11.0 [75]	17.0 [115]	3.5 [25]	35	25	
						...	
						...	
			Alloy 5005[H]				
O	0.018–0.500 [0.45–12.50]	15.0 [105]	21.0 [145]	5.0 [35]	...	...	...
			Alloy 5050[H]				
O	0.018–0.500 [0.45–12.50]	18.0 [125]	24.0 [165]	6.0 [40]	...	...	...
H32	0.018–0.500 [0.45–12.50]	22.0 [150]	... [...]	16.0 [110]	...	...	...
H34	0.018–0.500 [0.45–12.50]	25.0 [170]	... [...]	20.0 [140]	...	...	...
H36	0.018–0.500 [0.45–12.50]	27.0 [185]	... [...]	22.0 [150]	...	...	...
H38	0.018–0.500 [0.45–12.50]	29.0 [200]	... [...]	24.0 [165]	...	...	...
			Alloy 5052[H]				
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]	...	...	
H36	0.018–0.450 [0.45–11.50]	37.0 [355]	... [...]	29.0 [200]	...	...	
H38	0.018–0.450 [0.45–11.50]	39.0 [270]	... [...]	31.0 [215]	...	...	
			Alloy 6061				
O	0.018–0.500 [0.45–12.50]	... ...	22.0 [150]	14.0 [95] max	15	15	13
T4	0.025–0.049 [0.63–1.20]	30.0 [205]	... [...]	16.0 [110]	16	14	...
	0.050–0.259 [1.20–6.30]	30.0 [205]	... [...]	16.0 [110]	18	16	...
	0.260–0.500 [6.30–12.50]	30.0 [205]	... [...]	16.0 [110]	20	18	16
T42[J]	0.025–0.049 [0.63–1.20]	30.0 [205]	... [...]	14.0 [95]	16	14	...
	0.050–0.259 [1.20–6.30]	30.0 [205]	... [...]	14.0 [95]	18	16	...
	0.260–0.500 [6.30–12.50]	30.0 [205]	... [...]	14.0 [95]	20	18	16
T6, T62[J]	0.025–0.049 [0.63–1.20]	42.0 [290]	... [...]	35.0 [240]	10	8	...
	0.050–0.259 [1.20–6.30]	42.0 [290]	... [...]	35.0 [240]	12	10	...
	0.260–0.500 [6.30–12.50]	42.0 [290]	... [...]	35.0 [240]	14	12	10
			Alloy 6063				
O	0.018–0.500 [0.45–12.50]	... [...]	19.0 [130]	... [...]	...	...	...
T4, T42[J]	0.025–0.049 [0.63–1.20]	22.0 [150]	... [...]	10.0 [70]	16	14	...
	0.050–0.259 [1.20–6.30]	22.0 [150]	... [...]	10.0 [70]	18	16	...
	0.260–0.500 [6.30–12.50]	22.0 [150]	... [...]	10.0 [70]	20	18	16
T6, T62[J]	0.025–0.049 [0.63–1.20]	33.0 [230]	... [...]	28.0 [195]	12	8	...
	0.050–0.259 [1.20–6.30]	33.0 [230]	... [...]	28.0 [195]	14	10	...
	0.260–0.500 [6.30–2.50]	33.0 [230]	... [...]	28.0 [195]	16	12	10
T83	0.025–0.259 [0.63–6.30]	33.0 [230]	... [...]	30.0 [205]	5	...	...
T831	0.025–0.259 [0.63–6.30]	28.0 [195]	... [...]	25.0 [170]	5	...	...
T832	0.025–0.049 [0.63–1.20]	41.0 [285]	... [...]	36.0 [250]	8	5	...
	0.050–0.259 [1.20–6.30]	40.0 [275]	... [...]	35.0 [240]	8	5	...
			Alloy 6262				
T6, T62[J]	0.025–0.049 [0.63–1.20]	42.0 [290]	... [...]	35.0 [240]	10	8	...
	0.050–0.259 [1.20–6.30]	42.0 [290]	... [...]	35.0 [240]	12	10	...
	0.260–0.500 [6.30–12.50]	42.0 [290]	... [...]	35.0 [240]	14	12	10
T9	0.025–0.375 [0.63–10.00]	48.0 [330]	... [...]	44.0 [305]	5	4	3

[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 [MPa] and each value for elongation to the nearest 0.5 %, both in accordance with the rounding method of Practice E 29.
[C] Coiled tube is generally available with a maximum wall thickness of 0.083 in. [2.00 mm] and only in nonheat-treatable alloys.
[D] Yield strength to be determined only on straight tube.
[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] 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 $5D\ (5.65\sqrt{A})$, where D and A are diameter and cross-sectional area specimens, respectively, apply to round test specimens machined from wall thickness over 6.30 mm.
[G] The H113 temper applies to other than round tube which is fabricated from annealed round tube.
[H] In this alloy tube other than round is produced only in the F (as drawn) and O tempers. Properties for F temper are not specified or guaranteed.
[I] For specified wall thickness under 0.025 in. [0.63 mm] elongation is not required.
[J] Material in the T42 or T62 tempers is not available from the material producers.

TABLE 2 Chemical Composition Limits[A,B,C]

Alloy	Composition, %										
	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]
1100	0.95 Si + Fe		0.05–0.20	0.05	...	...	0.10	...	0.05	0.15	99.00 min[G]
1435	0.15	0.30–0.50	0.02	0.05	0.05	...	0.10	0.03	0.03[F]	...	99.35 min[G]
3003	0.6	0.7	0.05–0.20	1.0–1.5	...	...	0.10	...	0.05	0.15	remainder
3102	0.40	0.7	0.10	0.05–0.40	...	...	0.30	0.10	0.05	0.15	remainder
5005	0.30	0.7	0.20	0.20	0.50–1.1	0.10	0.25	...	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
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
6063	0.20–0.6	0.35	0.10	0.10	0.45–0.9	0.10	0.10	0.10	0.05	0.15	remainder
6262	0.40–0.8	0.7	0.15–0.40	0.15	0.8–1.2	0.04–0.14	0.25	0.15	0.05[H]	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 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] Vanadium 0.05 %, maximum.
[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] Bismuth and lead each 0.40–0.7 %.

11. Test for Leaks

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

11.1.1 *Method 1*—Tubes 1.500 in. [40 mm] or less in diameter shall be tested pneumatically at not less than 60 psig [400 kPa] air pressure while immersed in water or other suitable liquid. Any evidence of leakage shall be cause for rejection.

11.1.2 *Method 2*—Tubes 1.500 in. [40 mm] or less in diameter shall be tested pneumatically at not less than 90 psig [600 KPa] air pressure gith a gage which will indicate loss of pressure. There shall not be any loss of pressure during a test period of at least 15-s duration.

11.1.3 *Method 3*—Tubes shall be subjected to an eddy current test in accordance with the procedures described in Practice E 215. Reference standards or secondary standards having equivalent eddy current response shall serve to define acceptance-rejection limits.

11.1.3.1 *For straight lengths* of tube reference standards described in Appendixes X1 and X2 of Practice E 215 shall be used to standardize the equipment. Tubes 1.500 in. [40 mm] or less in diameter and maximum wall thickness of 0.083 in. [2.00 mm] that produce eddy current indications less than those from the 2A 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 2A holes of the applicable reference standard or an equivalent secondary standard shall be rejected.

11.1.3.2 For *coiled tube* secondary standards having an equivalent eddy current response to No. 70 (0.028-in. [0.70-mm] diameter) and No. 60 (0.040-in. [1.00-mm] diameter) drill holes shall be used to standardize the equipment. Tubes 0.188 to 1 in. [5 to 25 mm] incl, in diameter and maximum wall thickness of 0.083 in. [2.00 mm] that produce eddy current indications less than those from the No. 60 hole of the secondary standard shall be acceptable. Any tube that produces an indication equal to or greater than those from the No. 60 hole of the secondary standard shall be rejected. Set-up procedures shall include a check to ensure that tubes containing defects giving responses equal to or greater than that from No. 60 hole are rejected at the speed of inspection. Tube in long coils may contain up to a specified number of defects per coil when agreed between the producer and purchaser. In a case where a specified number of defects per coil is allowed, the need for marking such defects in a coil shall be handled as

agreed by the producer and purchaser.

12. Special Requirements for Coiled Tubes

12.1 *Expansion Test*—Coiled tube in the annealed temper only shall be capable of being expanded on a hardened ground tapered steel pin having an included angle of 60°, to the following amounts, without signs of cracks, ruptures, or other defects clearly visible to the unaided eye:

Nominal Outside Diameter, in. [mm]	Expansion of Outside Diameter, %
Up through 0.750 [20.00]	40
0.751 [20.00] and over	30

NOTE 5—Other expansion capabilities may be required in special cases but shall be the subject of negotiation between the producer and the purchaser.

12.2 *Inside Cleanliness Requirements and Test*—When specified by the purchaser at the time of placing the order, the inside of coiled tube, in the annealed temper only, shall be sufficiently clean so that when a test sample of a minimum of 375 in.^{2}[0.240 m^2] (except that not more than 50 ft [15 m] of tube shall be required) internal surface is washed with 1,1,1-trichloroethane or trichloroethylene or equivalent, the residue remaining upon evaporation of the solvent shall not exceed 0.002 g/ft^2(0.14 × 10^{-4} g/in.^{2}) [0.02 g/m^2] of interior surface.

12.2.1 To perform the test a measured quantity of the solvent should be pulled through the tube into a flask which is, in turn, attached to an aspirator or vacuum pump. The solvent shall then be transferred to a weighed container (crucible, evaporating dish, or beaker). The solvent in the container shall be evaporated to dryness on a low-temperature hot plate or steam bath. Overheating of the container should be avoided to prevent charring of the residue. The container shall then be dried in an oven at 100 to 110°C for 10 min, cooled in a desiccator, and weighed. A blank determination shall be run on the measured quantity of solvent, and the gain in weight for the blank shall be subtracted from the weighings of the residue sample. The corrected weight shall then be calculated in grams of residue per unit internal area of tube.

12.2.2 The quantity of the solvent used may vary with the size of tube being examined. A minimum quantity of 100 mL should be used for diameters up to 0.500 in. [12.5 mm] and should be increased proportionately for the larger sizes. The quantity of solvent used for the blank run shall be the same as that used for the actual examination of the tube sample.

12.2.3 In performing the test, care must be exercised to clean the outside surface of the end of the sample to be immersed in the solvent. The sample must be prepared in such a manner as to prevent the inclusion in the residue of aluminum chips or dust, resulting from the cutting of the sample.

13. Dimensional Tolerances

13.1 Variations from the specified or nominal dimensions shall not exceed the permissible variations prescribed in the tables of ANSI H35.2 listed in Table 3.

13.2 Examinations for dimensions shall be made to assure conformance to the tolerances 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 the producer and purchaser.

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

TABLE 3 Index to Tables of Permissible Variations

Table No.	Title
11.1	Diameter, Round Tube
11.2	Width and Depth, Square, Rectangular, Hexagonal and Octagonal Tube
11.3	Diameter Oval, Elliptical, and Streamline Tube
11.4	Corner Radii
11.5	Wall Thickness, Round and Other-than-Round Tube
11.6	Straightness
11.7	Twist
11.8	Length
11.9	Flatness, (Flat Surfaces) Other-than-Round Tube
11.10	Squareness of Cut Ends
11.11	Angularity
11.12	Surface Roughness
11.13	Dents

15. Source Inspection

15.1 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.

15.2 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.

16. Retest and Rejection

16.1 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.

16.2 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.

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

16.4 If material is rejected by the purchaser, the producer or supplier is responsible only for replacement of the material to the purchaser. As much as possible of the rejected material shall be returned to the producer or supplier by the purchaser.

17. Identification Marking of Product

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

17.2 The requirements specified in 17.1 are minimum; marking systems that involve added information, larger characters, and greater frequencies are acceptable under this specification.

18. Packaging and Package Marking

18.1 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.

18.2 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.

18.3 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 application 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.

19. Certification

19.1 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.

20. Keywords

20.1 aluminum alloy; drawn 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 this metric 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[9] 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. 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

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

0.10 through 0.55 % (It is customary to express limits of 0.30 through 0.55 % as 0.X0 or 0.X5)	0.XX
Over 0.55 % (except that combined Si + Fe limits for 99.00 % minimum aluminum must be expressed as 0.XX or 1.XX)	0.X, X.X, etc.

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.

SUMMARY OF CHANGES

The following principal changes in this revision are recorded for the convenience of the user:
(1) Deleted references to Test Method E 101.