Designation: B 211 – 02

Standard Specification for Aluminum and Aluminum-Alloy Bar, Rod, and Wire[1]

This standard is issued under the fixed designation B 211; 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[2] covers rolled or cold-finished bar, rod, and wire in alloys (Note 1) and tempers as shown in Table 2.

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

NOTE 2—The term *cold finished* is used to indicate the type of surface finish, sharpness of angles, and dimensional tolerances produced by drawing through a die.

NOTE 3—See Specification B 221 for aluminum and aluminum-alloy extruded bars, rods, wire, shapes, and tubes; and Specification B 316 for aluminum and aluminum-alloy rivet and cold-heading wire and rods.

1.2 Alloy and temper designations are in accordance with ANSI H35.1. The equivalent UNS alloy designations are those of Table 1 preceded by A9, for example, A91100 for aluminum 1100 in accordance with Practice E 527.

1.3 A complete metric companion to Specification B 211 has been developed—B 211M; 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.

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:*

B 221 Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes[3]

B 316 Specification for Aluminum and Aluminum-Alloy Rivet and Cold-Heading Wire and Rods[3]

B 557 Test Methods of Tension Testing Wrought and Cast Aluminum- and Magnesium-Alloy Products[3]

B 594 Practice for Ultrasonic Inspection of Aluminum-Alloy Wrought Products for Aerospace Applications[3]

B 660 Practices for Packaging/Packing of Aluminum and Magnesium Products[3]

B 666/B 666M Practice for Identification Marking of Aluminum and Magnesium Products[3]

B 918 Practice for Heat Treatment of Wrought Aluminum Alloys[3]

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications[4]

E 34 Test Methods for Chemical Analysis of Aluminum and Aluminum-Base Alloys[5]

E 55 Practice for Sampling Wrought Nonferrous Metals and Alloys for Determination of Chemical Composition[5]

E 227 Test Method for Optical Emission Spectrometric Analysis of Aluminum and Aluminum Alloys by the Point-to-Plane Technique[5]

E 290 Test Methods for Bend Testing of Material for Ductility[6]

E 527 Practice for Numbering Metals and Alloys (UNS)[7]

E 607 Test Method for Optical Emission Spectrometric Analysis of Aluminum and Aluminum Alloys by the Point-to-Plane Technique, Nitrogen Atmosphere[5]

E 716 Practices for Sampling Aluminum and Aluminum Alloys for Spectrochemical Analysis[5]

E 1004 Practice for Determining Electrical Conductivity Using the Electromagnetic (Eddy-Current) Method[8]

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[5]

G 47 Test Method for Determining Susceptibility to Stress-Corrosion Cracking of 2XXX and 7XXX Aluminum-Alloy Products[9]

2.3 *ANSI Standards:*

H35.1 Alloy and Temper Designation Systems for Aluminum[3]

H35.2 Dimensional Tolerances for Aluminum Mill Products[3]

[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-211 in Section II of that Code.

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

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

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

[6] *Annual Book of ASTM Standards*, Vol 03.01.

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

[8] *Annual Book of ASTM Standards*, Vol 03.03.

[9] *Annual Book of ASTM Standards*, Vol 03.02.

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

2.4 *Federal Standard:*
Fed. Std. No. 123 Marking for Shipment (Civil Agencies)[10]
2.5 *Military Standard:*
MIL-STD-129 Marking for Shipment and Storage[10]

cold working to obtain improved surface finish and dimensional tolerances.

3.1.5 *drawn wire*—wire brought to final dimensions by drawing through a die.

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

Alloy	Silicon	Iron	Copper	Manganese	Magnesium	Chromium	Zinc	Bismuth	Lead	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]
2011	0.40	0.7	5.0–6.0	...	...	...	0.30	0.20–0.6	0.20–0.6	...	0.05	0.15	remainder
2014	0.50–1.2	0.7	3.9–5.0	0.40–1.2	0.20–0.8	0.10	0.25	...	...	0.15	0.05	0.15	remainder
2017	0.20–0.8	0.7	3.5–4.5	0.40–1.0	0.40–0.8	0.10	0.25	...	...	0.15	0.05	0.15	remainder
2024	0.50	0.50	3.8–4.9	0.30–0.9	1.2–1.8	0.10	0.25	...	...	0.15	0.05	0.15	remainder
2219	0.20	0.30	5.8–6.8	0.20–0.40	0.02	...	0.10	...	...	0.02–0.10	0.05[H]	0.15[H]	remainder
3003	0.6	0.7	0.05–0.20	1.0–1.5	...	...	0.10	...	...	...	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
5056	0.30	0.40	0.10	0.05–0.20	4.5–5.6	0.05–0.20	0.10	...	...	...	0.05	0.15	remainder
Alclad 5056	5056 alloy clad with 6253 alloy				...	...	...	...	...	...	...	...	...
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
6110	0.7–1.5	0.8	0.20–0.7	0.20–0.7	0.50–1.1	0.04–0.25	0.30	...	...	0.15	0.05	0.15	remainder
6253[I]	[J]	0.50	0.10	...	1.0–1.5	0.04–0.35	1.6–2.4	...	...	...	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	0.40–0.7	0.40–0.7	0.15	0.05	0.15	remainder
7075	0.40	0.50	1.2–2.0	0.30	2.1–2.9	0.18–0.28	5.1–6.1	...	...	0.20	0.05	0.15	remainder

[A] Limits are in mass percent maximum unless otherwise shown.
[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-off method of Practice E 29.
[D] *Others* includes listed elements for which no specific limit is shown as well as unlisted metallic elements. The producer may analyze samples for trace elements not specified in the specification. However, such analysis is not required and may not cover all metallic *Others* elements. Should any analysis by the producer or the purchaser establish that an *Others* element exceeds the limit of *Each* or that the aggregate of several *Others* elements exceeds the limit of *Total*, the material shall be considered non-conforming.
[E] *Other elements*—Total shall be the sum of unspecified metallic elements 0.010 % or more each, rounded to the second decimal before determining the sum.
[F] Vanadium 0.05 % max.
[G] The aluminum content is the difference between 100.00 % and the sum of all other metallic elements and silicon present in amounts of 0.010 % or more each, rounded to the second decimal before determining the sum.
[H] Vanadium 0.05–0.15 % zirconium 0.10–0.25 %. The total for other elements does not include vanadium and zirconium.
[I] Composition of cladding alloy as applied during the course of manufacture. Samples from finished wire shall not be required to conform to these limits.
[J] 45 to 65 % of actual magnesium content.

2.6 *Aerospace Material Specification:*
AMS 2772 Heat Treatment of Aluminum Alloy Raw Materials[11]

3. Terminology

3.1 *Definitions:* Definitions:

3.1.1 *alclad wire*—wire having on its surface a metallurgically bonded aluminum or aluminum-alloy coating that is anodic to the core alloy to which it is bonded, thus electrolytically protecting the core alloy against corrosion.

3.1.2 *bar*—a solid product that is long in relation to cross section which is square or rectangular (excluding plate and flattened wire) with sharp or rounded corners or edges, or is a regular hexagon or octagon, and in which at least one perpendicular distance between parallel faces is 0.375 in. or greater.

3.1.3 *cold-finished bar*—bar brought to final dimensions by cold working to obtain improved surface finish and dimensional tolerances.

3.1.4 *cold-finished rod*—rod brought to final dimensions by

3.1.6 *flattened and slit wire*—flattened wire which has been slit to obtain square edges.

3.1.7 *flattened wire*—a solid section having two parallel flat surfaces and rounded edges produced by roll-flattening round wire.

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

3.1.9 *rod*—a solid product 0.375 in. or greater in diameter that is long in relation to cross section.

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

3.1.11 *wire*—a solid section long in relation to its cross-sectional dimensions, having a cross section that is round, hexagonal, or octagonal and whose diameter, width, or greatest distance between parallel faces is less than 0.375 in., or having a symmetrical cross section that is square or rectangular (excluding flattened wire) with sharp or rounded corners or edges.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *capable of*—The term *capable of* as used in this specification means that the test need not be performed by the producer of the material. However, should subsequent testing by the purchaser establish that the material does not meet these requirements, the material shall be subject to rejection.

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

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 9),

4.1.5 *Product Form*—Rolled or cold finished bar, rolled or cold finished rod, or wire,

4.1.6 *Geometry and Dimensions*—Diameter for rounds; distance across flats for square-cornered squares, hexagons, or octagons; width and depth for square-cornered rectangles (orders for squares, hexagons, octagons, or rectangles with rounded corners usually require a drawing),

4.1.7 Length,

4.1.8 Tensile property limits and dimensional tolerances for sized not covered in Table 2 and in ANSI H35.2, respectively.

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 (8.2),

4.2.2 Whether 7075-O material is required to develop requirements for T73 temper (see 10.1.2),

4.2.3 Whether bend testing is required for 2017, 2024, or 3003 (Section 12),

4.2.4 When specified finish of bar and rod is not required (Section 16),

4.2.5 Whether marking for identification is required (Section 17),

4.2.6 Whether ultrasonic inspection is required (Section 18, Table 3),

4.2.7 Whether inspection or witness of inspection and tests by the purchaser's representative is required prior to material shipment (Section 20),

4.2.8 Whether certification is required (Section 22), and

4.2.9 Whether Practices B 660 apply, and if so, the levels of preservation, packaging, and packing required (Section 23).

5. Manufacture

5.1 The products covered by this specification shall be produced either by hot extruding and cold finishing or by hot rolling with or without cold finishing, at the option of the producer.

TABLE 2 Mechanical Property Limits[A]

Temper	Specified Diameter or Thickness, in.	Tensile Strength, ksi		Yield Strength[B] (0.2 % offset), min, ksi	Elongation[B] in 2 in. or 4 × Diameter, min, %
		min	max		
		Aluminum 1060			
O	0.124 and under	8.0	...	...	...
	0.125 and over	8.0	...	2.5	25
H14	0.374 and under	12.0	...	10.0	...
H18	0.374 and under	16.0	...	13.0	...
		Aluminum 1100			
O	0.124 and under	11.0	15.5	...	...
	0.125 and over	11.0	15.5	3.0	25
H12	0.374 and under	14.0	...	...	...
H14	0.374 and under	16.0	...	...	...
H16	0.374 and under	19.0	...	...	...
H18	0.374 and under	22.0	...	...	...
H112	all	11.0	...	3.0	...
F	all	[C]	...	[C]	...
		Alloy 2011			
T3	0.125–1.500	45.0	...	38.0	10
	1.501–2.000	43.0	...	34.0	12
	2.001–3.500	42.0	...	30.0	12
T4 and T451[D]	0.125–8.000	40.0	...	18.0	16
T8	0.125–3.250	54.0	...	40.0	10
		Alloy 2014[E]			
O	0.124 and under	...	35.0	...	...
	0.125–8.000	...	35.0	...	12
T4, T42[F], and T451[D]	0.124 and under	55.0	...	...	...
	0.125–8.000[G]	55.0	...	32.0	16
T6, T62[F], and T651[D]	0.124 and under	65.0	...	...	...
	0.125–8.000[G]	65.0	...	55.0	8
		Alloy 2017[E]			
O	0.124 and under	...	35.0	...	...
	0.125–8.000	...	35.0	...	16
T4, T42[F], and T451[D]	0.124 and under	55.0	...	...	...
	0.125–8.000[H]	55.0	...	32.0	12
		Alloy 2024[E]			

TABLE 2 *Continued*

Temper	Specified Diameter or Thickness, in.	Tensile Strength, ksi		Yield Strength[B] (0.2 % offset), min, ksi	Elongation[B] in 2 in. or 4 × Diameter, min, %
		min	max		
O	0.124 and under	...	35.0	...	...
	0.125–8.000	...	35.0	...	16
T36	0.124 and under	69.0	...	...	...
	0.125–0.375	69.0	...	52.0	10
T4[I]	0.124 and under	62.0	...	...	...
	0.125–0.499	62.0	...	45.0[I]	10
	0.500–4.500[G]	62.0	...	42.0[I]	10
	4.501–6.500[J]	62.0	...	40.0	10
	6.501–8.000[J]	58.0	...	38.0	10
T42[F]	0.124 and under	62.0	...	...	...
	0.125–1.000	62.0	...	40.0	10
	1.001–6.500[G]	62.0	...	40.0	10
T351[D]	0.500–6.500[G]	62.0	...	45.0	10
T6	0.124 and under	62.0	...	...	...
	0.125–6.500[G]	62.0	...	50.0	5
T62[F]	0.124 and under	60.0	...	...	...
	0.125–6.500[G]	60.0	...	46.0	5
T851[D]	0.500–6.500[G]	66.0	...	58.0	5
		Alloy 2219			
T851[D]	0.500–2.000	58.0	...	40.0	4
	2.001–4.000	57.0	...	39.0	4
		Alloy 3003			
O	all	14.0	19.0	5.0	25
H12	0.374 and under	17.0	...	...	...
H14	0.374 and under	20.0	...	...	...
H16	0.374 and under	24.0	...	...	...
H18	0.374 and under	27.0	...	...	...
H112	all	14.0	...	5.0	...
F	all	[C]	...	[C]	...
		Alloy 5052			
O	0.124 and under	...	32.0	...	...
	0.125 and over	25.0	32.0	9.5	25
H32	0.124 and under	31.0	...	...	...
	0.125–0.374	31.0	...	23.0	...
H34	0.374 and under	34.0	...	26.0	...
H36	0.124 and under	37.0	...	...	...
	0.125–0.374	37.0	...	29.0	...
H38	0.374 and under	39.0	...	...	...
F	all	[C]		[C]	...
		Alloy 5056			
O	0.124 and under	...	46.0	...	...
	0.125 and over	...	46.0	...	20
H111	0.374 and under	44.0	...	...	...
H12	0.374 and under	46.0	...	...	...
H32	0.374 and under	44.0	...	...	...
H14	0.374 and under	52.0	...	...	...
H34	0.374 and under	50.0	...	...	...
H18	0.374 and under	58.0	...	...	...
H38	0.374 and under	55.0	...	...	...
H192	0.374 and under	60.0	...	...	...
H392	0.374 and under	58.0	...	...	...
		Alclad Alloy 5056			
H192	0.374 and under	52.0	...	...	...
H392	0.374 and under	50.0	...	...	...
H393	0.120–0.192	54.0	...	47.0	...
		Alloy 5154			
O	all	30.0	41.0	11.0	25
H32	0.374 and under	36.0	...	...	...
H34	0.374 and under	39.0	...	...	...
H36	0.374 and under	42.0	...	...	...
H38	0.374 and under	45.0	...	...	...
H112	all	30.0	...	11.0	...
		Alloy 6061[E]			
O	0.124 and under	...	22.0	...	...

TABLE 2 *Continued*

Temper	Specified Diameter or Thickness, in.	Tensile Strength, ksi		Yield Strength[B] (0.2 % offset), min, ksi	Elongation[B] in 2 in. or 4 × Diameter, min, %
		min	max		
	0.125–8.000	...	22.0	...	18
T4 and T451[D]	0.124 and under	30.0	...	...	...
	0.125–8.000[H]	30.0	...	16.0	18
T42[F]	0.125–8.000[H]	30.0	...	14.0	18
T6, T62[F], and T651[D]	0.124 and under	42.0	...	...	...
	0.125–8.000[H]	42.0	...	35.0	10
T89 and T94	0.374 and under	54.0	...	47.0	...
		Alloy 6110			
T9	0.374 and under	65.0	...	63.0	2
		Alloy 6262			
T6 and T651[D]	0.125–8.000[G]	42.0	...	35.0	10
T9	0.125–2.000	52.0	...	48.0	5
	2.001–3.000	50.0	...	46.0	5
		Alloy 7075[E]			
O	0.124 and under	...	40.0	...	...
	0.125–8.000	...	40.0	...	10
T6, T62	0.124 and under	77.0	...	66.0	...
	0.125–4.000[K]	77.0	...	66.0	7
T651	0.124 and under	77.0	...	66.0	...
	0.125–4.000[K]	77.0	...	66.0	7
	4.001–6.000	75.0	...	64.0	7
	6.001–7.000	73.0	...	62.0	7
T73 and T7351[D]	0.124 and under	68.0	...	...	...
	0.125–4.000	68.0	...	56.0	10
	4.001–5.000	66.0		55.0	8

Temper	Specified Diameter or Thickness, in.	Bend Diameter Factor, N
	Alloy 2017	
T4, T42, and T451	0.124 and under	3[L]
	0.125–8.000[H]	6[L]
	Alloy 2024	
O	0.124 and under	1
T351, T4, T42	0.124 and under	3
	0.125–6.500	6
	Alloy 3003	
O	all	0
H12	0.374 and under	2
H14	0.374 and under	2
H16	0.374 and under	8

[A] To determine conformance to this specification, each value for tensile strength and for yield strength shall be rounded to the nearest 0.1 ksi and each value for elongation to the nearest 0.5 %, both in accordance with the rounding-off method of Practice E 29. The basis for establishment of tensile property limits is shown in Annex A1.

[B] The measurement of yield strength and elongation is not required for wire less than 0.125 in. in thickness or diameter.

[C] There are no tensile requirements for material in the F temper but it usually can be expected that material 1½ in. or less in thickness or diameter (except sections over 4 in. in width) will have a strength about equivalent to the H14 or H34 temper. As size increases the strength decreases to nearly that of the O temper.

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

[E] Also available in the F temper for which no properties are specified and no tension tests are performed but for which tests are performed for confirmation of heat-treat response as required by Section 10.

[F] Material in the T42 or T62 tempers is not available from the materials producers. These properties can usually be obtained by the user when material is properly solution heat treated or solution and precipitation heat treated from the O or F temper. These properties also apply to samples of material in the O or F temper that are solution heat treated or solution and precipitation heat treated by the producer to determine that the material will respond to proper heat treatment. Properties attained by the user, however, may be lower than those listed if the material has been formed or otherwise cold or hot worked, particularly in the O temper, prior to solution heat treatment.

[G] Properties listed for this full size increment are applicable to rod. Properties listed are also applicable to square, rectangular, hexagonal, or octagonal bar having a maximum thickness of 4 in. and a maximum cross-sectional area of 36 in.^{2}.

[H] For bar, maximum cross-sectional area is 50 in.^{2}.

[I] Minimum yield strength for 2024-T4 wire and rod 0.125 in. and larger in thickness or diameter, produced in coil form for both straight length and coiled products, is 40.0 ksi.

[J] Properties listed for this size increment are applicable to rod only.

[K] For rounds, maximum diameter is 4 in.; for square, hexagonal, or octagonal bar, maximum thickness is 3½ in.; for rectangular bar, maximum thickness is 3 in. with corresponding maximum width of 6 in.; for rectangular bar less than 3 in. in thickness, maximum width is 10 in.

[L] Bend diameter factor values stated for this full size increment apply to T4 product only. Values listed also apply to T451 product in the 0.500–8.000 in. size range.

6. 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 ensure 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 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 bars, rods, and wire shall conform to the chemical composition limits specified in Table 1. Conformance shall be determined by the producer by analyzing samples taken at the time the ingots are cast, or samples taken from the finished or semifinished product. If the producer 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 4—It is standard practice in the United States aluminum industry to determine conformance to the chemical composition limits prior to further processing of ingots into wrought products. Due to the continuous nature of the process, it is not practical to keep a specific ingot analysis identified with a specific quantity of finished material.

7.2 *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 cast, at least one sample shall be taken for each group of ingots cast 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, or fraction thereof, in the lot, except that no more than one sample shall be required per piece.

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

7.3.1 Samples for chemical analysis shall be taken from the material by drilling, sawing, milling, turning, clipping, etc., 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.

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.

NOTE 5—It is difficult to obtain a reliable analysis of each of the components of clad materials using material in its finished state. A reasonably accurate determination of the core composition can be made if the cladding is substantially removed prior to analysis. The cladding composition is more difficult to determine because of the relatively thin layer and because of diffusion of core elements to the cladding. The correctness of cladding alloy used can usually be verified by a combination of metallographic examination and spectrochemical analysis of the surface at several widely separated points.

7.4 *Method 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 purchaser and the producer.

8. Heat Treatment

8.1 Unless otherwise specified in 8.2, producer or supplier heat treatment for the applicable tempers in Table 2 shall be in accordance with AMS 2772.

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

9. Tensile Properties of Material As Supplied

9.1 *Limits*—The bar, rod, and wire shall conform to the tensile requirements in Table 2.

9.2 *Number of Specimens*:

9.2.1 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. Only one specimen shall be taken from any one piece when more than one piece is available.

9.2.2 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. Only one specimen shall be taken from any one piece when more than one piece is available.

9.3 *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.

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

10. Producer Confirmation of Heat-Treat Response

10.1 In addition to the requirements of 9.1, material in Alloys 2014, 2017, 2024, and 6061 produced in the O or F temper (within the size limits specified in Table 2) 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 2 for T42 temper material. The heat-treated samples may be tested prior to four days natural aging, but if they fail to conform to the T42 temper properties, the tests may be repeated after completion of four days natural aging without prejudice.

10.1.1 Alloy 7075 material produced in the O or F temper (within the size limits specified in Table 2) shall, after proper solution heat treatment and precipitation heat treatment, conform to the properties specified in Table 2 for T62 temper material.

10.1.2 When specified, 7075-O material (within the size limits specified in Table 2) shall, after proper solution and precipitation heat treatment, conform to the properties specified for T73 temper in Table 2 and Section 13.

10.2 *Number of Specimens*—The number of specimens from each lot of O temper material and F temper material to verify conformance with 10.1 shall be as specified in 9.2.

11. Heat Treatment and Reheat Treatment Capability

11.1 As-received material in the O or F temper and in Alloys 2014, 2017, 2024, and 6061 (within the size limitation specified in Table 2 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 2 for T42 temper material.

TABLE 3 Ultrasonic Discontinuity Limits for Rolled or Cold-Finished Bar[A]

Alloys	Size			
	Thickness, in.	Maximum Weight per Piece, lb	Maximum Width to Thickness Ratio	Discontinuity Class[B]
2014, 2219 2024, 7075 }	0.500–1.499	600	...	B
	1.500–3.000	600	...	A
	3.001–6.000	1000	...	B

[A] Discontinuities in excess of those listed in this table shall be allowed if it is established that they will be removed by machining or that they are in noncritical areas.

[B] The discontinuity class limits are defined in Section 11 of Practice B 594.

11.2 As-received Alloy 7075 material in the O or F temper (within the size limitation specified in Table 2 and without the imposition of cold work) shall, after proper solution and precipitation heat treatment, conform to the properties specified in Table 2 for T6 and T62 tempers.

11.3 Material in Alloys and Tempers 2014-T4, T451, T6, T651; 2017-T4, T451; 2024-T4, T6, T351, and T851, 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 2 for the T42 temper.

NOTE 6—Beginning with the 1975 revision 6061-T4, T6, T451, and T651, were deleted from this paragraph because experience has shown the reheat-treated material tends to develop large recrystallized grains and may fail to develop the expected level of properties.

11.4 Alloy 7075 material in T6, T651, T73, and T7351 tempers shall, after proper resolution heat treatment and precipitation heat treatment, conform to the properties specified in Table 2 for T6 and T62 tempers.

11.5 Material in T3, T4, T42, T351, and T451 tempers shall, after proper precipitation heat treatment, conform to the properties specified in Table 2 for the T8, T6, T62, T851 and T651 tempers, respectively.

12. Bend Properties

12.1 When bend testing is specified for the alloys, tempers, and dimensions as listed with Bend Diameter Factor, N, values in Table 2; bend test specimens shall be prepared and tests shall be made in accordance with the applicable requirements of Test Methods E 290. Bend test samples shall be bent cold without cracking through an angle of 180° around a pin having a diameter equal to N times the product diameter or least thickness of the specimen.

13. Stress-Corrosion Resistance

13.1 Alloy 7075 in the T73-type tempers shall be capable of exhibiting no evidence of stress-corrosion cracking when subjected to the test specified in 13.2.

13.1.1 For lot-acceptance purposes, resistance to stress-corrosion cracking for each lot of material shall be established by testing the previously selected tension-test samples to the criteria shown in Table 4.

13.1.2 For surveillance purposes, each month the producer shall perform at least one test for stress-corrosion resistance in accordance with 13.2 in the T73 type temper, for each thickness range 0.750 in. and over listed in Table 2, produced that month. Each sample shall be taken from material considered acceptable in accordance with lot-acceptance criteria of Table 4. A minimum of three adjacent replicate specimens shall be taken from each sample and tested. The producer shall maintain records of all lots so tested and make them available

TABLE 4 Lot Acceptance Criteria for Resistance to Stress Corrosion

Lot Acceptance Criteria			
Alloy and Temper	Electrical Conductivity,[A] % IACS	Level of Mechanical Properties	Lot Acceptance Status
7075-T73 and T7351	40.0 or greater	per specified requirements	acceptable
	38.0 through 39.9	per specified requirements and yield strength does not exceed minimum by more than 11.9 ksi	acceptable
	38.0 through 39.9	per specified requirements but yield strength exceeds minimum by 12.0 ksi or more	unacceptable[B]
	less than 38.0	any level	unacceptable[B]

Product[A,B]	Thickness, in.	Location
Rolled or cold finished from rolled stock	all	surface of tension-test sample
Cold finished from extruded stock	up through 0.100	surface of tension-test sample
	over 0.100 through 0.500	subsurface after removing approximately 10 % of the thickness by machining
	over 0.500 through 1.500	subsurface at approximate center of thickness on a plane parallel to the longitudinal centerline of the material
	over 1.500	subsurface of tension-test sample surface that is closest to the center of the material and on a plane parallel to the extrusion surface

[A] The electrical conductivity shall be determined in accordance with Practice E 1004 in the following locations:

[B] When material is found to be unacceptable, it shall be reprocessed (additional precipitation heat treatment or re-solution heat treatment, stress relieving and precipitation heat treatment, when applicable).

for examination at the producer's facility.

13.2 The stress-corrosion cracking test shall be performed on material 0.750 in. and over in thickness as follows:

13.2.1 Specimens shall be stressed in tension in the short transverse direction with respect to grain flow and held at constant strain. The stress level shall be 75 % of the specified minimum yield strength.

13.2.2 The stress-corrosion test shall be made in accordance with Test Method G 47.

13.2.3 There shall be no visual evidence of stress-corrosion cracking in any specimen, except that the retest provisions of 21.2 shall apply.

14. Cladding Thickness

14.1 The aluminum-alloy coating of Alclad 5056 wire shall have a minimum average thickness corresponding to 16 % of the total cross-sectional area of the wire.

14.2 When the area of the coating is to be determined on finished wire, transverse cross sections of at least three wires from the lot shall be mounted to expose a transverse cross section and polished for examination with a metallurgical microscope. Using at least 100× magnification, the coating area in each sample shall be measured by use of a planimeter on the projected image, and the average of the measurements shall be taken as the area.

15. Dimensional Tolerances

15.1 Variations from specified dimensions for the material ordered shall not exceed the permissible variations specified in the following tables of ANSI H35.2.

Table No.	Title
9.1	Diameter, Round Wire and Rod
9.5	Thickness and Width, Rectangular Wire and Bar
9.6	Distance Across Flats, Square, Hexagonal and Octagonal Wire and Bar
9.7	Thickness and Width, Flattened Wire (Round Edge)
9.8	Thickness and Width, Flattened and Slit Wire
9.9	Length, Specific and Multiple
9.10	Twist, Bar in Straight Lengths
9.11	Straightness, Rod and Bar in Straight Lengths Other than Screw Machine Stock
9.13	Flatness—Flat Surfaces
9.14	Angularity
9.15	Squareness of Saw Cuts

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

16. Finish

16.1 Unless otherwise specified, rod up to and including 3 in. in diameter and bar up to and including 2 in. thick (with maximum width for rectangles of 4 in.) shall be supplied cold finished. Rod and bar in larger sizes may be furnished either as rolled or cold finished, at the producer's or supplier's discretion.

17. Identification Marking of Product

17.1 When specified in the contract or purchase order all material shall be marked in accordance with Practice B 666/B 666M. In addition, 2000 and 7000 series alloys furnished in the T6, T651, T73, T7351 or T851 tempers shall also be marked with the lot number in at least one location on each piece.

18. Internal Quality

18.1 When specified by the purchaser at the time of placing the order, each bar 0.500 in. or greater in thickness or smallest dimension in Alloys 2014, 2024, 2219, and 7075 shall be tested in accordance with Practice B 594 to the discontinuity acceptance limits of Table 3.

19. General Quality

19.1 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 the purchaser.

19.2 Each inspection lot of bar, rod, and wire 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.

20. Source Inspection

20.1 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.

20.2 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.

21. Rejection and Retest

21.1 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.

21.2 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 re-test shall meet the requirements of the specification or the lot shall be subject to rejection.

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

21.4 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.

22. Certification

22.1 The producer or supplier shall, on request, furnish to the purchaser a certificate of inspection stating that each lot has been sampled, tested, and inspected in accordance with this specification, and has been found to meet the requirements.

23. Packaging and Package Marking

23.1 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 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.

23.2 Each shipping container shall be marked with the purchase order number, material size, specification number, alloy and temper, gross and net weight, and the producer's name and trademark.

23.3 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.

24. Keywords

24.1 aluminum alloy; rolled or cold-finished bar; rolled or cold-finished rod; rolled or cold-finished wire

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.

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[12] 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 the 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.

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

B 211 – 02

SUMMARY OF CHANGES

Committee B07 has identified the location of selected changes to this standard since the last issue (B 211–99) that may impact the use of this standard.

(1) Replaced Practice B 597 with Practice B 918 in 2.2, 4.2.1, and 8.2.

(2) Added Specifications B 221 and B 316 to Referenced Documents.