Designation: B 211 – 99

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 1.

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 2 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 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 597 Practice for Heat Treatment of Aluminum Alloys[3]

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

B 666/B 666M Practice for Identification Marking of Aluminum Products[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[8]

E 716 Practices for Sampling Aluminum and Aluminum Alloys for Spectrochemical Analysis[8]

E 1004 Test Method for Electromagnetic (Eddy-Current) Measurements of Electrical Conductivity[9]

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[8]

G 47 Test Method for Determining Susceptibility to Stress-Corrosion Cracking of 2XXX and 7XXX Aluminum-Alloy Products[10]

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 B-7 on Light Metals and Alloys and is the direct responsibility of Subcommittee B07.03 on Aluminum-Alloy Wrought Products.

Current edition approved May 10, 1999. Published September 1999. Originally published as B 211 – 46 T. Last previous edition B 211 – 95a.

[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 03.06.

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

[10] *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)[11]
2.5 *Military Standard:*
MIL-STD-129 Marking for Shipment and Storage[11]
2.6 *Aerospace Material Specification:*
AMS-H-6088 Heat Treatment of Aluminum Alloys[12]

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 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.

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.

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 1 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 597 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.

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

[11] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.
[12] Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096.

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.

TABLE 1 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]			
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	...	37.0	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

TABLE 1 *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		
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	...	...
	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

TABLE 1 *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		
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 of coiled 2024-T4 wire and rod 0.125 in. and larger in thickness or diameter 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.

7. Chemical Composition

7.1 *Limits*—The bars, rods, and wire shall conform to the chemical composition limits specified in Table 2. 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.