Designation: B316/B316M – 20

Standard Specification for Aluminum and Aluminum-Alloy Rivet and Cold-Heading Wire and Rods[1]

This standard is issued under the fixed designation B316/B316M; 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 U.S. Department of Defense.

1. Scope*

1.1 This specification covers wire and rod in the alloys (Note 1) shown in Table 1 and the tempers shown in Table 2 [Table 3] and Table 4 [Table 5], suitable for manufacturing rivets and other similar items by cold-heading operations.

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

NOTE 2—For rolled or cold-finished wire and rod, see Specification B211, and for extruded wire and rod, see Specification B221.

1.2 Alloy and temper designations are in accordance with ANSI H35.1/H35.1M. The equivalent Unified Numbering System alloy designations are those of Table 1 preceded by A9, for example, A91100 for aluminum 1100 in accordance with Practice E527.

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 SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.4.1 The SI units are shown either in brackets or in separate tables.

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

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:*[2]

B211 Specification for Aluminum and Aluminum-Alloy Rolled or Cold-Finished Bar, Rod, and Wire (Metric) B0211_B0211M

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

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

B557M Test Methods for Tension Testing Wrought and Cast Aluminum- and Magnesium-Alloy Products (Metric)

B565 Test Method for Shear Testing of Aluminum and Aluminum-Alloy Rivets and Cold-Heading Wire and Rods

B660 Practices for Packaging/Packing of Aluminum and Magnesium Products

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

B918 Practice for Heat Treatment of Wrought Aluminum Alloys

B985 Practice for Sampling Aluminum Ingots, Billets, Castings and Finished or Semi-Finished Wrought Aluminum Products for Compositional Analysis

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

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

E716 Practices for Sampling and Sample Preparation of Aluminum and Aluminum Alloys for Determination of Chemical Composition by Spark Atomic Emission Spectrometry

E1004 Test Method for Determining Electrical Conductivity Using the Electromagnetic (Eddy Current) Method

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

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

E1251 Test Method for Analysis of Aluminum and Aluminum Alloys by Spark Atomic Emission Spectrometry
E3061 Test Method for Analysis of Aluminum and Aluminum Alloys by Inductively Coupled Plasma Atomic Emission Spectrometry (Performance Based Method)

2.3 *ANSI Standards:*[3]
H35.1/H35.1M Alloy and Temper Designation Systems for Aluminum
H35.2 Dimensional Tolerances for Aluminum Mill Products
H35.2M Dimensional Tolerances for Aluminum Mill Products [Metric]

2.4 *Military Standard:*[4]
MIL-STD-129 Marking for Shipment and Storage

2.5 *AMS Specification:*[5]
AMS 2772 Heat Treatment of Aluminum Alloy Raw Materials

2.6 *Federal Standard:*
Fed. Std. No. 123 Marking for Shipment (Civil Agencies)[4]

2.7 *CEN EN Standards:*[6]
EN 14242 Aluminum and Aluminum Alloys. Chemical Analysis Inductively Coupled Plasma Optical Emission Spectral Analysis

3. Terminology

3.1 *Definitions:*

3.1.1 *rod, n*—a solid product 0.375 in. or greater [over 10 mm] in diameter, that is long in relation to cross section.

3.1.2 *cold-heading rod, n*—rod of a quality suitable for use in the manufacture of cold-headed products such as rivets and bolts.

3.1.3 *rivet rod, n*—see *cold-heading rod.*

3.1.4 *wire, n*—a solid wrought product that is long in relation to its cross section, which is square or rectangular with sharp or rounded corners or edges, or is round, a regular hexagon, or a regular octagon, and whose diameter or greatest perpendicular distances between parallel faces (except for flattened wire) is less than 0.375 in. [up through 10 mm]

3.1.5 *cold-heading wire, n*—wire of a quality suitable for use in the manufacture of cold-headed products such as rivets and bolts.

3.1.6 *rivet wire, n*—see *cold-heading wire.*

4. Ordering Information

4.1 Orders for material to this specification shall include the following information:

NOTE 3—For inch-pound orders specify Specification B316; for metric orders specify Specification B316M. Do not mix units.

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 [kilograms],
4.1.3 Alloy (see 7.1),
4.1.4 Temper (see 8.1),
4.1.5 Diameter,
4.1.6 Form-coiled or straight lengths,

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

4.2.1 Whether inspection or witness of inspection and tests by the purchaser's representative is required prior to material shipment (Section 13),

4.2.2 Whether certification is required (Section 15),

4.2.3 Whether marking for identification is required (Section 16), and

4.2.4 Whether Practices B660 applies and, if so, the levels of preservation, packaging, and packing required (17.3).

5. Materials and Manufacture

5.1 The products covered by this specification shall be produced by extruding, rolling, or drawing, or a combination thereof, at the option of the producer.

6. Responsibility for Quality Assurance

6.1 *Responsibility for Inspection and Tests*—Unless otherwise specified in the contract or purchase order, the producer is responsible for the performance of all inspection and test requirements specified herein. The producer may use his own or any other suitable facilities for the performance of the inspection and test requirements specified herein, unless disapproved by the purchaser in the order or at the time of contract signing. The purchaser shall have the right to perform any of the inspections and tests set forth in this specification where such inspections are deemed necessary to assure that material conforms to prescribed requirements.

6.2 *Lot Definition*—An inspection lot shall be defined as follows:

6.2.1 For heat-treated tempers, an inspection lot shall consist of an identifiable quantity of material of the same mill form, alloy, temper, and nominal diameter 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 diameter subjected to inspection at one time.

7. Chemical Composition

7.1 *Limits*—The material shall conform to the chemical composition limits specified in Table 1. Conformance shall be determined by the producer by taking samples in accordance with Practices E716 when the ingots are poured, and analyzing those samples in accordance with Test Methods E1251, E3061, or EN 14242. At least one sample shall be taken for each group of ingots poured simultaneously from the same source of molten metal. If the producer has determined the chemical composition during pouring of the ingots, they shall not be required to sample and analyze the finished product.

7.2 If it becomes necessary to analyze alloy rivet and cold-heading wire and rods for conformance to chemical

[3] Available from Aluminum Association, 1400 Crystal Dr., Suite 430, Arlington, VA 22202, http://www.aluminum.org.
[4] Available from DLA Document Services, Building 4/D, 700 Robbins Ave., Philadelphia, PA 19111-5094, http://quicksearch.dla.mil.
[5] Available from SAE International (SAE), 400 Commonwealth Dr., Warrendale, PA 15096, http://www.sae.org.
[6] Available from European Committee for Standardization (CEN), Avenue Marnix 17, B-1000, Brussels, Belgium, http://www.cen.eu.

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

Alloy	Silicon	Iron	Copper	Manganese	Magnesium	Chromium	Zinc	Titanium	Other Elements[D]		Aluminum
									Each	Total[E]	
1100	0.95 Si + Fe		0.05–0.20	0.05	...	...	0.10	...	0.05	0.15	99.00 min[F]
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
2117	0.8	0.7	2.2–3.0	0.20	0.20–0.50	0.10	0.25	...	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[G]	0.15[G]	remainder
3003	0.6	0.7	0.05–0.20	1.0–1.5	...	...	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
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
6053	[H]	0.35	0.10	...	1.1–1.4	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
7050	0.12	0.15	2.0–2.6	0.10	1.9–2.6	0.04	5.7–6.7	0.06	0.05[I]	0.15[I]	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 weight [mass] percent, maximum, unless shown as a range or stated otherwise.
[B] Analysis shall be made for the elements for which limits are shown in this table.
[C] To determine conformance to these limits, an observed value or a calculated value obtained from analysis shall be rounded off to the nearest unit in the last right-hand place of figures used in expressing the specified limit, in accordance with the rounding off method of Practice E29.
[D] *Others* includes listed elements for which no specific limit is shown as well as unlisted metallic elements. The producer may analyze samples for trace elements not specified in this specification. However, such analysis is not required and may not cover all metallic *Others* elements. Should any analysis by the producer or the purchaser establish that an *Others* element exceeds the limit of *Each* or that the aggregate of several *Others* elements exceeds the limit of *Total*, the material shall be considered nonconforming.
[E] *Other Elements—Total* shall be the sum of unspecified metallic elements 0.010 % or more, rounded to the second decimal before determining the sum.
[F] 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 each, rounded to the second decimal before determining the sum.
[G] Vanadium, 0.05–0.15 %; zirconium, 0.10–0.25 %. The total for other elements does not include vanadium and zirconium.
[H] 45 to 65 % of actual magnesium content.
[I] Zirconium 0.08–0.15 %. The total for other elements does not include zirconium.
[J] In case of a discrepancy in the values listed in Table 1 with those listed in the "International Alloy Designations and Chemical Composition Limits for Wrought Aluminum and Wrought Aluminum Alloys" (known as the "Teal Sheets"), the composition limits registered with the Aluminum Association and published in the "Teal Sheets" should be considered the controlling composition. The "Teal Sheets" are available at http://www.aluminum.org/tealsheets.

composition limits, the methods of sampling and methods of analysis shall be as provided in the following:

7.2.1 *Methods of Sampling*—Samples for chemical analysis shall be taken in accordance with Practice B985.

7.2.2 *Methods of Analysis*—Analysis shall be performed in accordance with Test Methods E1251, E3061, or EN 14242.

7.3 Other methods of analysis or in the case of dispute may be by agreement between the producer and the purchaser.

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.

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.

8. Mechanical Properties

8.1 *Tensile Properties of Material as Supplied*—The material shall conform to the tensile strength requirements specified in Table 2 [Table 3].

8.2 *Mechanical Properties of Material after Heat Treatment*—In addition to the requirements of 8.1, heat-treatable material ordered in the annealed or strain-hardened tempers and subsequently solution heat treated (T4) or solution and precipitation heat treated (T6, T61, T62, T7, or T73), shall conform to the requirements of Table 4 [Table 5] for either tensile strength or shear strength, at the producer's option. However, the material shall be capable of meeting both the tensile and shear strength requirements.

8.3 *Number of Specimens:*

8.3.1 One tension test specimen shall be taken for each 1000 lb or fraction thereof in the lot to determine compliance with 8.1. Only one specimen shall be taken from any one piece.

8.3.2 The number of tests to determine compliance with 8.2 shall be the same as in 8.3.1.

8.4 *Test Methods:*

8.4.1 The tension tests shall be made in accordance with Test Methods B557 [B557M].

8.4.2 The shear tests shall be made in accordance with Test Method B565.

9. Heat Treatment

9.1 Unless specified in 9.2, producer or supplier heat treatment for the applicable tempers in Table 4 shall be in accordance with AMS 2772.

9.2 When specified, heat treatment for the applicable tempers in Table 4 shall be in accordance with Practice B918.

10. Stress-Corrosion Resistance

10.1 For lot acceptance purposes, resistance to stress-corrosion cracking for each lot of 7050-T7 and 7075-T73 material shall be established by testing the previously selected tension-test samples to the criteria shown in Table 6.

TABLE 2 Tensile Property Limits (Inch-Pound Units)[A,B]

Alloy	Temper	Diameter, in.	Tensile Strength, ksi	
			min	max
1100	O	up through 1.000	...	15.5
	H14	up through 1.000	16.0	21.0
2017	O	up through 1.000	...	35.0
	H13	up through 1.000	30.0	40.0
2024	O	up through 1.000	...	35.0
	H13	up through 1.000	32.0	42.0
2117	O	up through 1.000	...	25.0
	H15	up through 1.000	28.0	35.0
	H13	up through 1.000	25.0	32.0
2219	0	up through 1.000	...	32.0
	H13	up through 1.000	28.0	38.0
3003	O	up through 1.000	...	19.0
	H14	up through 1.000	20.0	26.0
5005	O	up through 1.000	...	20.0
	H32	up through 1.000	17.0	23.0
5052	O	up through 1.000	...	32.0
	H32	up through 1.000	31.0	37.0
5056	O	up through 1.000	...	46.0
	H32	up through 1.000	44.0	52.0
6053	O	up through 1.000	...	19.0
	H13	up through 1.000	19.0	26.0
6061	O	up through 1.000	...	22.0
	H13	up through 1.000	22.0	30.0
7050	O	up through 1.000	...	40.0
	H13	up through 1.000	34.0	44.0
7075	O	up through 1.000	...	40.0
	H13	up through 1.000	36.0	46.0

[A] To determine conformance to this specification, each value for tensile strength shall be rounded to the nearest 0.1 ksi in accordance with the rounding-off method of Practice E29.
[B] See Annex A1 for basis of mechanical property limits.

TABLE 3 Tensile Property Limits [SI Units][A,B]

Alloy	Temper	Specified Diameter, mm		Tensile Strength, MPa	
		over	Up through	min	max
1100	O	...	25.00	...	110
	H14	...	25.00	110	145
2017	O	...	25.00	...	240
	H13	...	25.00	205	275
2024	O	...	25.00	...	240
	H13	...	25.00	220	290
2117	O	...	25.00	...	175
	H15	...	25.00	190	240
	H13	...	25.00	170	220
2219	0	...	25.00	...	220
	H13		25.00	190	260
3003	O	...	25.00	...	130
	H14	...	25.00	135	180
5005	O	...	25.00	...	140
	H32	...	25.00	115	160
5052	O	...	25.00	...	220
	H32	...	25.00	215	255
5056	O	...	25.00	...	320
	H32	...	25.00	300	360
6053	O	...	25.00	...	130
	H13	...	25.00	130	180
6061	O	...	25.00	...	155
	H13	...	25.00	150	210
7050	O	...	25.00	...	275
	H13	...	25.00	235	305
7075	O	...	25.00	...	275
	H13	...	25.00	245	320

[A] To determine conformance to this specification, each value for tensile strength shall be rounded off to the nearest 1 MPa in accordance with the rounding-off method of Practice E29.
[B] The basis for establishment of mechanical property limits is shown in Annex A1.

TABLE 4 Mechanical Property Limits of Heat-treatable Alloys (After Heat Treatment) (Inch-Pound Units)[A,B]

Alloy	Temper	Diameter, in.	Tensile Strength min, ksi	Yield Strength[C] (0.2 % offset) min, ksi	Elongation[C] in 2 in., or 4 × Diameter min,%	Shear Strength min, ksi
2017	T4	0.063–1.000	55.0	32.0	12	33.0
2024	T42	0.063–0.124	62.0	...	...	37.0
		0.125–1.000	62.0	40.0	10	37.0
2117	T4	0.063–1.000	38.0	18.0	18	26.0
2219	T6	0.063–1.000	55.0	35.0	6	30.0
6053	T61	0.063–1.000	30.0	20.0	14	20.0
6061	T6	0.063–1.000	42.0	35.0	10	25.0
7050	T7	0.063–1.000	70.0	58.0	10	39.0
7075	T6	0.063–1.000	77.0	66.0	7	42.0
7075	T73	0.063–1.000	68.0	56.0	10	41.0

[A] To determine conformance to this specification, each value for tensile strength, yield strength, and shear strength shall be rounded off to the nearest 0.1 ksi, and each value for elongation shall be rounded to the nearest 0.5 %, both in accordance with the rounding-off method of Practice E29.
[B] See Annex A1 for basis of mechanical property limits.
[C] The measurement of elongation and yield strength is not required for wire less than 0.125 in. in diameter.

TABLE 5 Mechanical Property Limits of Heat-treatable Alloys (After Heat Treatment) [SI Units][A,B]

Alloy	Temper	Specified Diameter, mm		Tensile Strength min, MPa	Yield Strength[C] 0.2 % offset min, MPa	Elongation[C], min, % in 5 × Diameter $5.65\sqrt{A}$[D]	Shear Strength min, MPa
		over	through				
2017	T4	1.60	25.00	380	220	10	225
2024	T42	1.60	3.20	425	...	...	255
		3.20	25.00	425	275	9	255
2117	T4	1.60	25.00	260	125	16	180
2219	T6	1.60	25.00	380	240	5	205
6053	T61	1.60	25.00	205	135	12	135
6061	T6	1.60	25.00	290	240	9	170
7050	T7	1.60	25.00	485	400	9	270
7075	T6	1.60	25.00	530	455	6	290
7075	T73	1.60	25.00	470	385	9	280

[A] To determine conformance to this specification, each value for tensile strength, yield strength, and shear strength shall be rounded off to the nearest 1 MPa and each value for elongation shall be rounded to the nearest 0.5 %, both in accordance with the rounding-off method of Practice E29.
[B] The basis for establishment of mechanical property limits is shown in Annex A1.
[C] The measurement of elongation and yield strength is not required for wire 3.20 mm and less in diameter.
[D] *A* is the cross-sectional area of the specimen.

TABLE 6 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
7050-T7	41.0 and greater	In accordance with specified requirements	Acceptable
	40.0 through 40.9	In accordance with specified requirements and longitudinal yield strength does not exceed 69.0 ksi [475 MPa]	
	40.0 through 40.9	In accordance with specified requirements but longitudinal yield strength exceeds 69.0 ksi	Unacceptable[B]
	Less than 40.0	Any level	
7075-T73	40.0 and greater	In accordance with specified requirements	Acceptable
	38.0 through 39.9	In accordance with specified requirements and longitudinal yield strength does not exceed minimum by more than 11.9 ksi [82 MPa]	
	38.0 through 39.9	In accordance with specified requirements but longitudinal yield strength exceeds minimum by 12 ksi or more [more than 82 MPa]	Unacceptable[B]
	Less than 38.0	Any level	

[A] The electrical conductivity shall be determined on the surface of the tensile-test sample in accordance with Practice E1004.
[B] When material is found to be unacceptable, it shall be reprocessed (additional precipitation heat treatment or re-solution heat treatment and precipitation heat treatment).