Designation: B247M – 09

StandardSpecification for Aluminum and Aluminum-Alloy Die Forgings, Hand Forgings, and Rolled Ring Forgings (Metric)[1]

This standard is issued under the fixed designation B247M; 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 aluminum-alloy (Note 1) die forgings, hand forgings, and rolled ring forgings as shown in Table 2, Table 3 and Table 4 and in Section 10 for heat-treatable alloy forgings supplied in the F and 01 tempers. The maximum thicknesses for forgings within the scope of this specification are as indicated in those tables.

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

NOTE 2—For forging stock supplied as rolled or cold-finished bar or rod see Specification B211M. For forging stock supplied as extruded bar or rod see Specification B221M.

1.2 Alloy and temper designations are in accordance with ANSI H35.1/H35.1(M). 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 This specification is the SI companion to Specification B247.

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

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

B247 Specification for Aluminum and Aluminum-Alloy Die Forgings, Hand Forgings, and Rolled Ring Forgings

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

B594 Practice for Ultrasonic Inspection of Aluminum-Alloy Wrought Products

B660 Practices for Packaging/Packing of Aluminum and Magnesium Products

B881 Terminology Relating to Aluminum- and Magnesium-Alloy Products

B918 Practice for Heat Treatment of Wrought Aluminum Alloys

E10 Test Method for Brinell Hardness of Metallic Materials

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

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

E165 Practice for Liquid Penetrant Examination for General Industry

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

E607 Test Method for Atomic Emission Spectrometric Analysis Aluminum Alloys by the Point to Plane Technique Nitrogen Atmosphere (Withdrawn 2011)[3]

E716 Practices for Sampling and Sample Preparation of Aluminum and Aluminum Alloys for Determination of Chemical Composition by Spectrochemical Analysis

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

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

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

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[2] For 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.

[3] The last approved version of this historical standard is referenced on www.astm.org.

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

G47 Test Method for Determining Susceptibility to Stress-Corrosion Cracking of 2XXX and 7XXX Aluminum Alloy Products

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

Alloy	Silicon	Iron	Copper	Manganese	Magnesium	Chromium	Nickel	Zinc	Titanium	Zirconium	Other Elements[D]		Aluminum, min
											Each	Total[E]	
1100	0.95 Si + Fe		0.05–0.20	0.05	...	...	...	0.10	...	...	0.05	0.15	99.00[F]
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[G]	...	0.05	0.15	remainder
2018	0.9	1.0	3.5–4.5	0.20	0.45–0.9	0.10	1.7–2.3	0.25	...	...	0.05	0.15	remainder
2025	0.50–1.2	1.0	3.9–5.0	0.40–1.2	0.05	0.10	...	0.25	0.15	...	0.05	0.15	remainder
2218	0.9	1.0	3.5–4.5	0.20	1.2–1.8	0.10	1.7–2.3	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	0.10–0.25	0.05[H]	0.15[H]	remainder
2618	0.10–0.25	0.9–1.3	1.9–2.7	...	1.3–1.8	...	0.9–1.2	0.10	0.04–0.10	...	0.05	0.15	remainder
3003	0.6	0.7	0.05–0.20	1.0–1.5	...	...	...	0.10	...	...	0.05	0.15	remainder
4032	11.0–13.5	1.0	0.50–1.3	...	0.8–1.3	0.10	0.50–1.3	0.25	...	...	0.05	0.15	remainder
5083	0.40	0.40	0.10	0.40–1.0	4.0–4.9	0.05–0.25	...	0.25	0.15	...	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
6066	0.9–1.8	0.50	0.7–1.2	0.6–1.1	0.8–1.4	0.40	...	0.25	0.20	...	0.05	0.15	remainder
6151	0.6–1.2	1.0	0.35	0.20	0.45–0.8	0.15–0.35	...	0.25	0.15	...	0.05	0.15	remainder
7049	0.25	0.35	1.2–1.9	0.20	2.0–2.9	0.10–0.22	...	7.2–8.2	0.10	...	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	0.08–0.15	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[I]	...	0.05	0.15	remainder
7076	0.40	0.6	0.30–1.0	0.30–0.8	1.2–2.0	...	...	7.0–8.0	0.20	...	0.05	0.15	remainder
7175	0.15	0.20	1.2–2.0	0.10	2.1–2.9	0.18–0.28	...	5.1–6.1	0.10	...	0.05	0.15	remainder

[A] Limits are in 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] 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 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 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 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 metallic elements present in amounts of 0.010 % or more each, rounded to the second decimal before determining the sum.
[G] Upon agreement between purchaser and producer or supplier, a zirconium-plus-titanium limit of 0.20 % maximum is permitted.
[H] Vanadium, 0.05–0.15 %. The total for other elements does not include Vanadium.
[I] Upon agreement between purchaser and producer or supplier, a zirconium-plus-titanium limit of 0.25 % maximum is permitted.

2.3 *ANSI Standard:*
H35.1/H35.1(M) Alloy and Temper Designation Systems [4]

2.4 *ISO Standards:*
ISO 209-1:1989 Wrought Aluminum and Aluminum Alloys—Chemical Composition and Form of Product[5]
ISO 2107:1983 Aluminum, Magnesium and their Alloys—Temper Designations[5]

2.5 *Military Standards:*
MIL-STD-129 Marking for Shipment and Storage[6] (referenced in MIL-STD-649 and applies only to direct shipments to Department of Defense agencies)

2.6 *SAE:*
AMS 2772 Heat Treatment of Aluminum Alloy Raw Materials[7]

2.7 *Federal Standard:*
Fed. Std. No. 123 Marking for Shipment (Civil Agencies)[6]

2.8 *National Aerospace Standard:*
NAS 410 Certification and Qualification of Nondestructive Test Personnel[8]

2.9 *Other Standards:*
CEN EN 14242 Aluminum and Aluminum Alloys, Chemical Analysis. Inductively Coupled Plasma Optical Emission Spectral Analysis[9]

3. Terminology

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

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 the 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] Available from Aluminum Association, Inc., 1525 Wilson Blvd., Suite 600, Arlington, VA 22209, http://www.aluminum.org.
[5] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.
[6] Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098, http://www.dodssp.daps.mil.
[7] Available from Society of Automotive Engineers (SAE), 400 Commonwealth Dr., Warrendale, PA 15096-0001, http://www.sae.org.
[8] Available from Aerospace Industries Association of America, Inc. (AIA), 1000 Wilson Blvd., Suite 1700, Arlington, VA 22209-3928, http://www.aia-aerospace.org.
[9] Available from European Committee for Standardization (CEN), 36 rue de Stassart, B-1050, Brussels, Belgium, http://www.cen.eu/esearch.

TABLE 2 Mechanical Property Limits for Die Forgings[A,B]

Alloy and Temper	Specified Thickness, mm		Specimen Axis Parallel to Direction of Grain Flow[C]					Specimen Axis Not Parallel to Direction of Grain Flow[C]				Brinell Hardness[D], min
					Elongation, min,%					Elongation, min, % Forgings		
	Over	Through	Tensile Strength[E], MPa	Yield Strength[E] (0.2 % Offset), min, MPa	Forgings		Separate Test Coupon (from stock or forged)[F]	Tensile Strength[E], min, MPa	Yield Strength[E] (0.2 % Offset), min, MPa			
					in 50 mm	in 5× Diameter $(5.65\sqrt{A})^G$	in 5× Diameter $(5.65\sqrt{A})^G$			in 50 mm	in 5× Diameter $(5.65\sqrt{A})^G$	
1100-H112	...	100.00	75	30	18	16	22	...	...	...	...	20
2014-T4	...	100.00	380	205	11	9	14	...	...	...	...	100
2014-T6	...	25.00	450	385	6	5	7	440	380	3	2	125
	25.00	50.00	450	385	6	5	...	440	380	2	1	125
	50.00	80.00	450	380	6	5	...	435	370	2	1	125
	80.00	100.00	435	380	6	5	...	435	370	2	1	125
2018-T61	...	100.00	380	275	7	6	9	...	...	...	...	100
2025-T6	...	100.00	360	230	11	9	14	...	...	...	...	100
2218-T61	...	100.00	380	275	7	6	9	...	...	...	...	100
2219-T6	...	100.00	400	260	8	7	9	385	250	4	3	100
2618-T61	...	100.00	400	310	4	3	5	380	290	4	3	115
3003-H112	...	100.00	95	35	18	16	22	...	...	...	...	25
4032-T6	...	100.00	360	290	3	2	4	...	...	...	...	115
5083-H111	...	100.00	290	150	14	12	12	270	140	12	10	...
5083-H112	...	100.00	275	125	16	14	14	270	110	14	12	...
6061-T6	...	100.00	260	240	7	6	9	260	240	5	4	80
6066-T6	...	100.00	345	310	8	7	10	...	...	...	...	100
6151-T6	...	100.00	305	255	10	9	12	305	255	6	5	90
7049-T73	...	25.00	495	425	7	6	9	490	420	3	2	135
	25.00	50.00	495	425	7	6	9	485	415	3	2	135
	50.00	80.00	490	420	7	6	9	485	415	3	2	135
	80.00	100.00	490	420	7	6	9	485	415	2	1	135
	100.00	130.00	485	415	7	6	9	470	400	2	1	135
7050-T74[H]	...	50.00	495	425	7	6	9	470	385	5	4	135
	50.00	100.00	490	420	7	6	9	460	380	4	3	135
	100.00	130.00	485	415	7	6	9	455	370	3	2	135
	130.00	150.00	485	405	7	6	9	455	370	3	2	135
7075-T6	...	25.00	515	440	7	6	9	490	420	3	2	135
	25.00	50.00	510	435	7	6	...	490	420	3	2	135
	50.00	80.00	510	435	7	6	...	485	415	3	2	135
	80.00	100.00	505	425	7	6	...	485	415	2	1	135
7075-T73	...	80.00	455	385	7	6	...	425	365	3	2	125
	80.00	100.00	440	380	7	6	...	420	360	2	1	125
7075-T7352	...	80.00	455	385	7	6	...	425	350	3	2	125
	80.00	100.00	440	365	7	6	...	420	340	2	1	125
7076-T61	...	100.00	485	415	10	9	10	460	400	3	2	140
7175-T74[H]	...	80.00	525	455	7	6	9	490	425	4	3	...
7175-T7452[H]	...	80.00	505	435	7	6	9	470	380	4	3	...
7175-T7454[H]	...	80.00	515	450	7	6	9	485	420	4	3	...

[A] To determine conformance to this specification, each value for tensile strength and yield strength shall be rounded to the nearest 1 MPa and each value for elongation to the nearest 0.5 % (or the nearest 0.1 % if measured in accordance with 7.8.4 of Test Method B557M), in accordance with the rounding-off method of Practice E29.
[B] For the basis for establishment of strength property limits, see Annex A1.
[C] These values apply to standard specimens. For the heat-treatable alloys the thicknesses shown are the maximum thickness at time of heat treatment for which the indicated properties apply. Forgings machined prior to heat treatment shall develop the properties applicable to the heat-treated thickness provided the as-forged thickness is not more than twice the heat-treated thickness.
[D] For information only. The hardness is usually measured on the surface of a forging using a 500-kgf load and 10-mm ball.
[E] Tensile property test requirements in any direction are limited to a minimum material dimension of 50 mm because of the difficulty in obtaining a tension test specimen suitable for routine control testing.
[F] These values apply to standard 12.5-mm diameter test specimens machined from the stock used in making the forgings, or from separately forged coupons representative of the forgings.
[G] *A* represents cross-sectional area of the specimen.
[H] Beginning with the 1985 issue the T736, T73652, and T73654 tempers were replaced by the T74, T7452, and T7454 tempers respectively as applicable to alloys 7050 and 7175.

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 kilograms,

4.1.3 Alloy (Section 7),

4.1.4 Temper (Section 8),

4.1.5 Dimensions (Section 13). A drawing is required for die forgings and for hand forgings whose shapes are not simple rectangles,

TABLE 3 Mechanical Property Limits for Rolled Ring Forgings[A,B,C]

Alloy and Temper	Maximum Heat Treat Section Thickness, mm		Direction	Tensile Strength, min, MPa[D]	Yield Strength (0.2 % Offset), min, MPa[D]	Elongation, min,%	
	Over	Through				in 50 mm	in 5× Dia. $(5.65\sqrt{A})^{E}$
2014-T6 and 2014-T652[F]	...	65.00	tangential	450	380	7	6
			axial	425	380	3	2
			radial[G]	415	360	2	1
	65.00	80.00	tangential	450	380	6	5
			axial	425	360	2	1
			radial[G]	...	...	...	...
2219-T6	...	65.00	tangential	385	275	6	5
			axial	380	255	4	3
			radial[G]	365	240	2	1
2618-T61	...	65.00	tangential	380	285	6	5
			axial	380	285	5	4
			radial[G]	...	...	...	...
6061-T6 and 6061-T652[F]	...	65.00	tangential	260	240	10	9
			axial	260	240	8	7
			radial[G]	255	230	5	4
	65.00	90.00	tangential	260	240	8	7
			axial	260	240	6	5
			radial[G]	255	230	4	3
6151-T6 and 6151-T652[F]	...	65.00	tangential	305	255	5	4
			axial	305	240	4	3
			radial[G]	290	240	2	1
7075-T6 and 7075-T652[F]	...	50.00	tangential	505	425	7	6
			axial	495	420	3	2
			radial[G]	470	400	2	1
	50.00	90.00	tangential	490	415	6	5
			axial	485	405	3	2
			radial[G]	...	...	...	...

[A] To determine conformance to this specification each value for tensile strength and yield strength shall be rounded to the nearest 1 MPa and each value for elongation to the nearest 0.5 % (or the nearest 0.1 % if measured in accordance with 7.8.4 of Test Method B557M), in accordance with the rounding-off method of Practice E29.
[B] Tensile property test requirements in any direction are limited to a minimum material dimension of 50.00 mm because of the difficulty in obtaining a tension test specimen suitable for routine control testing.
[C] Applicable only to rings which have an OD-to-wall thickness ratio of 10/1 or greater. Those having a smaller ratio shall be the subject of agreement between the purchaser and producer.
[D] The basis for establishment of mechanical property limits is shown in Annex A1.
[E] *A* represents cross-sectional area of the specimen.
[F] Forgings may be available in the T651 temper but shall be the subject of agreement between the purchaser and producer.
[G] Radial properties are not specified requirements. For wall thicknesses over 50 mm, they will be determined when specifically requested for informational purposes only.

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

4.2.1 For die forgings, whether tensile property and grain flow survey shall be made (see 8.2.1.1),

4.2.2 For die forgings, whether tension tests are required using specimens not parallel to the direction of grain flow and whether such test specimens shall be prepared by a specific method (see 8.3.1),

4.2.3 For hand forgings, whether tension tests shall be made in other than the long transverse and short transverse directions (see 8.3.3),

4.2.4 For rolled ring forgings, whether tension tests shall be made in the radial direction (see 8.3.4),

4.2.5 Whether it is required in tension tests that small elongations shall be measured by a special procedure (see 8.4.2),

4.2.6 Whether heat treatment in accordance with Practice B918 is required (9.2),

4.2.7 Whether 7075-F material shall meet the requirements for T73 temper (10.3),

4.2.8 Whether ultrasonic inspection is required (Section 14 and Table 4),

4.2.9 Whether liquid-penetrant inspection is required (see 15.3),

4.2.10 Whether inspection or witness of inspection and tests by the purchaser's representative is required prior to material shipment (Section 16),

4.2.11 Whether certification is required (Section 18),

4.2.12 Whether hand forgings shall be marked for identification (Section 19), and

4.2.13 Whether Practices B660 applies and, if so, the levels of preservation, packaging, and packing required (Section 20).

TABLE 4 Ultrasonic Discontinuity Limits for Die and Hand Forgings[A]

Alloy	Product	Thickness, mm		Maximum Mass per Piece, kg	Discontinuity Class[B]
		Over	Through		
2014 2219 7049 7050 7075 7175	Die Forgings	12.50	100.00	150	B
2014 2219 7049 7050 7075 7175	Hand Forgings	25.00	200.00	300	A

[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 B594.

5. Materials and Manufacture

5.1 The forgings may be manufactured by pressing, hammering, or rolling, 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 their 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 forgings of the same shape or group of forgings of similar size and shape of the same alloy and heat-treated in the same furnace charge. If forgings are heat-treated in a continuous furnace, forgings charged consecutively during continuous operation of the furnace shall be considered a furnace charge; for such forgings weighing 2.5 kg or less the maximum mass of a lot shall be 1000 kg; and for heavier forgings it shall be 3000 kg.

6.2.2 For nonheat-treated tempers, an inspection lot shall consist of an identifiable quantity of forgings of similar size and shape of the same alloy and temper subjected to inspection at one time.

7. Chemical Composition

7.1 *Limits*—The forgings shall conform to the chemical composition limits specified in Table 1. Conformance shall be determined by the producer by analyzing samples taken when the ingots are poured in accordance with E716 and analyzed in accordance with E607, E1251, E34, or EN 14242CEN EN 14242. 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 *Sampling During Pouring of Ingots*—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.

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

7.3 If it becomes necessary to analyze forgings for conformance to chemical composition limits, the method used to sample forgings for the determination of chemical composition shall be by agreement between the producer and the purchaser. Analysis shall be performed in accordance with E716, E607, E1251, E34, or EN 14242 (ICP method). The number of samples taken for determination of chemical composition shall be as follows:

7.3.1 When samples are taken from forgings each weighing 5 lb or less, a sample shall be taken to represent each 2000 lb or fraction thereof of material in the lot.

7.3.2 When samples are taken from forgings each weighing more than 5 lb, a sample shall be taken to represent each 6000 lb or fraction thereof of material in the lot.

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

8. Mechanical Properties of Material as Supplied

8.1 *Limits:*

8.1.1 Die forgings shall conform to the tensile requirements in Table 2.

8.1.1.1 Die forgings shall be capable of conforming to the Brinell hardness requirements in Table 2 when measured at or near the surface, except that in case of question the basis for acceptance shall be conformance with the specified minimum tensile requirements of Table 2.