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Designation: B 247 – 00

Standard Specification for Aluminum and Aluminum-Alloy Die Forgings, Hand Forgings, and Rolled Ring Forgings[1]

This standard is issued under the fixed designation B 247; 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 aluminum-alloy (Note 1) die forgings, hand forgings, and rolled ring forgings as shown in Tables 1-3 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 B 211. For forging stock supplied as extruded bar or rod see Specification B 221.

1.2 Alloy and temper designations are in accordance with ANSI H35.1. The equivalent Unified Numbering System alloy designations are those of Table 4 preceded by A9, for example, A91100 for aluminum 1100 in accordance with Practice E 527E 527.

1.3 For acceptance criteria for inclusion of new aluminum and aluminum alloys in this specification, see Annex A2.

1.4 A complete metric standard to Specification B 247 has been developed—Specification B 247M; therefore, no metric equivalents are presented in this specification.

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]

E 10 Test Method for Brinell Hardness of Metallic Materials[4]

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications[5]

E 34 Test Methods for Chemical Analysis of Aluminum and Aluminum Base Alloys[6]

E 55 Practice for Sampling Wrought Nonferrous Metals and Alloys for Determination of Chemical Composition[6]

E 165 Practice for Liquid Penetrant Examination[7]

E 227 Test Method for Optical Emission Spectrometric Analysis of Aluminum and Aluminum Alloys by the Point-to-Plane Technique[6]

E 527 Practice for Numbering Metals and Alloys (UNS)[8]

E 607 Test Method for Optical Emission Spectrometric Analysis of Aluminum and Aluminum Alloys by the Point-to-Plane Technique, Nitrogen Atmosphere[9]

E 716 Practices for Sampling Aluminum and Aluminum Alloys for Spectrochemical Analysis[9]

E 1004 Test Method for Electromagnetic (Eddy-Current) Measurements of Electrical Conductivity[7]

E 1251 Test Method for Optical Emission Spectrometric Analysis of Aluminum and Aluminum Alloys by the Argon Atmosphere, Point-to-Plane, Unipolar Self-Initiating Capacitor Discharge[9]

G 47 Test Method for Determining Susceptibility to Stress-Corrosion Cracking of High-Strength Aluminum-Alloy Products[10]

2.3 *ANSI Standard:*

H35.1 Alloy and Temper Designation Systems for Aluminum[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-247 in Section II of that Code.

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

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

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

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

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

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

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

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

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

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2.4 *Military Standards:*

MIL-STD-129 Marking for Shipment and Storage[11] (referenced in MIL-STD-649 and applies only to direct shipments to Department of Defense agencies).

MIL-STD-410 Nondestructive Testing Personnel Qualification and Certification (Eddy Current, Liquid Penetrant, Magnetic Particle, Radiographic and Ultrasonic)[11]

2.5 *Military Specification:*

MIL-H-6088 Heat Treatment of Aluminum Alloys[11]

2.6 *Federal Standard:*

Fed. Std. No. 123 Marking for Shipment (Civil Agencies)[11]

3. Terminology

3.1 *Definitions:*

3.1.1 *forging*—a metal part worked to a predetermined shape by one or more processes such as hammering, upsetting, pressing, rolling, etc.

3.1.2 *die forging*—a forging formed to the required shape and size by working in impression dies.

3.1.3 *blocker-type forging*—a die forging made in a single set of die impressions to the general contour of a finished part.

3.1.4 *hand forging*—a forging worked between flat or simply shaped dies by repeated strokes or blows and manipulation of the piece.

3.1.5 *rolled ring forging*—a cylindrical product of relatively short height, circumferentially rolled from a hollow section.

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:

4.1.1 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 8),

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

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 (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 (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 (8.3.3),

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

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

4.2.6 Whether heat treatment in accordance with Practice B 597B 597 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 6),

4.2.9 Whether liquid-penetrant inspection is required (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 B 660B 660 applies and, if so, the levels of preservation, packaging, and packing required (Section 20).

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 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 inspection 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 a 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 5 lb or less the maximum weight of a lot shall be 2000 lb, and for heavier forgings it shall be 6000 lb.

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 4. Conformance shall be determined by the producer by analyzing samples taken when the ingots are poured, or samples taken from the finished or

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

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semifinished product. If the producer has determined the chemical composition during the course of manufacture, he shall not be required to sample and analyze the finished product.

NOTE 3—It is standard practice in the United States aluminum industry to determine conformance to the 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 poured, at least one sample shall be taken for each group of ingots poured simultaneously from the same source of molten metal.

7.2.2 When samples are taken from 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.

7.2.3 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.

7.3 *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, or clipping a representative piece or pieces to obtain a prepared sample not less than 75 g. Sampling shall be in accordance with Practice E 55E 55.

7.3.2 Sampling for spectrochemical analysis shall be in accordance with Practice E 716E 716. Samples for other methods of analysis shall be taken by methods suitable for the form of material being analyzed and the type of analytical method used.

7.4 *Methods of Analysis*—The determination of chemical composition shall be made in accordance with suitable chemical (Test Methods E 34E 34) or spectrochemical (Test Methods E 227, E 607, and E 1251E 227E 607E 1251) methods. Other methods may be used only when no published ASTM test method is available. In case of dispute, the methods of analysis shall be agreed upon between the producer and 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.

8.1.2 Hand forgings shall conform to the tensile requirements in Table 1.

8.1.3 Rolled ring forgings shall conform to the tensile property requirements in Table 3.

8.2 *Number of Specimens*:

8.2.1 For die forgings, hand forgings, and rolled ring forgings, there shall be at least one tension specimen taken from each lot (see 6.2).

8.2.1.1 For die forgings, when specified, a grain-flow pattern and tensile-property survey shall be made on a forging representative of the first production parts (see 8.3.2). It shall be repeated after any major change in forging technique.

8.3 *Test Specimen*:

8.3.1 For die forgings, unless otherwise specified by the purchaser at the time of placing the order, test specimens shall be prepared with the axis of the specimen as nearly parallel to the direction of maximum metal flow as possible, and, at the option of the forging producer, by one of the following methods:

8.3.1.1 *Method 1*—Machined from a section of the stock used in making the forgings.

8.3.1.2 *Method 2*—Machined from a coupon forged from the stock.

8.3.1.3 *Method 3*—Machined from a prolongation of the forging.

8.3.1.4 *Method 4*—Machined from one of the forgings in the lot.

NOTE 4—Test specimens obtained by Method 1, 2, or 3 will usually have different properties from those obtained by Method 4. Samples obtained by Methods 1, 2, or 3 indicate only the general strength level of the forging that would be obtained with proper heat treatment.

8.3.1.5 Specimens representing heat-treated forgings shall be heat-treated with the forgings they represent or shall be machined from coupons that have been so treated.

8.3.2 If required, a die forging representative of the first production parts shall be selected after forging techniques have been established, and shall be tested as follows:

8.3.2.1 Tension test specimens shall be taken in two directions: (*1*) substantially parallel to, and (*2*) not parallel to the forging flow lines. The locations shall be as indicated on the forging engineering drawing or, if not indicated, from generally representative areas.

8.3.2.2 A sample forging shall be sectioned at the locations of the specimens, to show the grain flow.

8.3.3 For hand forgings, the specimens shall be taken from a prolongation of the forgings or from a forging chosen to represent the lot. Tests will regularly be made only in the long transverse and short transverse directions, but when required by the purchaser tests shall also be made in the longitudinal direction.

8.3.4 For rolled ring forgings, the specimens shall be taken from a prolongation of the forging or from a forging chosen to represent the lot. Unless otherwise specified, rolled ring forging sections shall be taken from an area representative of the center of mass where size permits. Tests will regularly be made only in the tangential and axial directions, but when required by the purchaser tests shall also be made in the radial direction for informational purposes.

8.4 *Test Methods:*

8.4.1 The tension tests shall be made in accordance with Test Methods B 557B 557.

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8.4.2 If required when the specified elongation is less than 3 % and the elongation measured in the usual manner is less than 4 %, the elongation of round tension specimens shall be measured in accordance with 7.6.4 of Test Methods B 557B 557.

8.4.3 Brinell hardness tests shall be made in accordance with Test Method E 10E 10, by applying a 500-kgf load on a 10-mm ball for 10 to 15 s. Other equivalent combinations of load and ball or alternative methods of testing may be used if desired provided that, in case of dispute, the results secured with the 500-kgf load and 10-mm ball shall be the basis of acceptance.

9. Heat Treatment

9.1 Unless otherwise specified in 9.2, heat treatment for the applicable tempers designated in Tables 2-3 shall be in accordance with MIL-H-6088.

9.2 When specified, heat treatment for the applicable tempers in Tables 2-3 shall be in accordance with Practice B 597B 597.

10. Producer Confirmation of Heat-Treat Response

10.1 In addition to the requirements of Section 8, die forgings in alloys 2014, 2018, 2025, 2218, 2219, 2618, 4032, 6061, 6066, 6151, 7075, and 7076 produced in the 01 and F tempers (within the size limits specified in Table 2) shall, after proper solution heat treatment and precipitation heat treatment, conform to the tensile properties specified in Table 2 for T6 temper forgings except for 2018, 2218, 2618, and 7076 for which T61 temper requirements apply.

10.2 In addition to the requirements of Section 8, hand forgings in alloys 2014, 2219, 2618, 6061, and 7075 produced in the 01 and F tempers (within the size limits specified in Table 1) shall, after proper solution heat treatment and precipitation heat treatment, conform to the tensile properties specified in Table 1 for T6 temper forgings except for 2618 for which T61 temper requirements apply.

10.3 Alloys 7049, 7050, and 7175 die and hand forgings in the F and O tempers and, when specified, 7075 die and hand forgings in the 01 and F tempers (within the size limits specified in Tables 2 and 1, respectively) shall, after proper solution heat treatment and precipitation heat treatment, conform to the tensile properties specified in Tables 2 and 1, as applicable for T73 type temper, and Section 12.

10.4 In addition to the requirements of Section 8, rolled ring forgings in alloys 2014, 2219, 2618, 6061, 6151, and 7075 produced in F and 01 tempers (within the size limits specified in Table 3) shall, after proper heat treatment, conform to the tensile properties specified in Table 3 for T6 temper forgings except for 2618 for which T61 temper requirements apply.

10.5 *Number of Specimens*—One specimen from each lot of 01 and F temper die forgings, hand forgings, and rolled ring forgings shall be tested to verify conformance with 10.1-10.4, as applicable.

11. Heat-Treatment and Reheat-Treatment Capability

11.1 As-received die and hand forgings in the 01 and F tempers in alloys 2014, 2018, 2025, 2218, 2219, 2618, 4032, 6061, 6066, 6151, 7075, and 7076 (within the size limitations specified in Tables 2 and 1) shall, after proper solution heat treatment and precipitation heat treatment, be capable of conforming to the tensile properties specified in Tables 2 and 1 for the T6 temper except for 2018, 2218, 2618, and 7076 for which T61 temper requirements apply.

11.2 Alloy 7075 die and hand forgings in T6, T652, T73, and T7352 tempers shall, after proper resolution heat treatment and precipitation heat treatment, be capable of conforming to the tensile properties specified in Tables 2 and 1 for the T6 temper.

11.3 Die forgings in alloy 2014-T4 shall, after proper precipitation heat treatment, be capable of conforming to the tensile properties specified in Table 2 for the T6 temper.

11.4 As-received rolled ring forgings in the F and 01 tempers in alloys 2014, 2219, 2618, 6061, 6151, and 7075 (within the size limits specified in Table 3) shall, after proper solution heat treatment and precipitation heat treatment, be capable of conforming to the tensile properties specified in Table 3 for the T6 temper except for 2618 for which T61 temper requirements apply.

12. Stress-Corrosion Resistance

12.1 Alloys 7049 and 7075 in the T73-type tempers and alloys 7050 and 7175 in the T74-type tempers shall be capable of exhibiting no evidence of stress-corrosion cracking when subjected to the test specified in 12.2.

12.1.1 For lot acceptance purposes, resistance to stress-corrosion cracking of each lot of alloys 7049, 7050, 7075, and 7175 in the applicable tempers shall be established by testing the previously selected tension-test samples to the criteria shown in Table 5.

12.1.2 For surveillance purposes, each month the producer shall perform at least one test for stress-corrosion resistance in accordance with 12.2.2 on each of the applicable alloy-tempers for each thickness range 0.750 in. and over produced that month. Each sample shall be taken from material considered acceptable in accordance with the lot acceptance criteria of Table 5. 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 for examination at the producer's facility.

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

12.2.1 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 as follows:

12.2.1.1 For T73-type tempers: 75 % of the minimum yield strength or the minimum longitudinal yield strength specified in Table 2 or Table 1 as applicable.

12.2.1.2 For T74-type tempers: 35.0 ksi for die and hand forgings up through 3.000 in., and 50 % of the minimum longitudinal yield strength specified in Table 1 for hand forgings over 3.000 in.

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

12.2.3 There shall be no visual evidence of stress-corrosion cracking in any specimen, except that the retest provision of 17.2 shall apply.

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13. Dimensional Tolerances

13.1 The forgings shall conform to the shape and dimensions specified in the contract or order within such dimensional tolerances as may be specified in the contract, order, or referenced drawings.

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TABLE 1 Mechanical Property Limits for Hand Forging[A,B]

Alloy and Temper	Thickness,[C] in.	Direction	Tensile Strength, min, ksi	Yield Strength (0.2 % Offset), min, ksi	Elongation in 2 in. or 4 × Diameter, min, %
2014-T6	up through 2.000	longitudinal	65.0	56.0	8
		long transverse	65.0	56.0	3
	2.001–3.000	longitudinal	64.0	56.0	8
		long transverse	64.0	55.0	3
		short transverse	62.0	55.0	2
	3.001–4.000	longitudinal	63.0	55.0	8
		long transverse	63.0	55.0	3
		short transverse	61.0	54.0	2
	4.001–5.000	longitudinal	62.0	54.0	7
		long transverse	62.0	54.0	2
		short transverse	60.0	53.0	1
	5.001–6.000	longitudinal	61.0	53.0	7
		long transverse	61.0	53.0	2
		short transverse	59.0	53.0	1
	6.001–7.000	longitudinal	60.0	52.0	6
		long transverse	60.0	52.0	2
		short transverse	58.0	52.0	1
	7.001–8.000	longitudinal	59.0	51.0	6
		long transverse	59.0	51.0	2
		short transverse	57.0	51.0	1
2014-T652	up through 2.000	longitudinal	65.0	56.0	8
		long transverse	65.0	56.0	3
	2.001–3.000	longitudinal	64.0	56.0	8
		long transverse	64.0	55.0	3
		short transverse	62.0	52.0	2
	3.001–4.000	longitudinal	63.0	55.0	8
		long transverse	63.0	55.0	3
		short transverse	61.0	51.0	2
	4.001–5.000	longitudinal	62.0	54.0	7
		long transverse	62.0	54.0	2
		short transverse	60.0	50.0	1
	5.001–6.000	longitudinal	61.0	53.0	7
		long transverse	61.0	53.0	2
		short transverse	59.0	50.0	1
	6.001–7.000	longitudinal	60.0	52.0	6
		long transverse	60.0	52.0	2
		short transverse	58.0	49.0	1
	7.001–8.000	longitudinal	59.0	51.0	6
		long transverse	59.0	51.0	2
		short transverse	57.0	48.0	1
2219-T6	up through 4.000	longitudinal	58.0	40.0	6
		long transverse	55.0	37.0	4
		short transverse[D]	53.0	35.0	2
2219-T852	up through 4.000	longitudinal	62.0	50.0	6
		long transverse	62.0	49.0	4
		short transverse[D]	60.0	46.0	3
2618-T61	up through 2.000	longitudinal	58.0	47.0	7
		long transverse	55.0	42.0	5
		short transverse[D]	52.0	42.0	4

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