

AEROSPACE MATERIAL SPECIFICATION

Submitted for recognition as an American National Standard

AMS 4132C
Superseding AMS 4132B

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ALUMINUM ALLOY FORGINGS

2.3Cu - 1.6Mg - 1.1Fe - 1.0Ni - 0.18Si - 0.07Ti (2618-T61)

Solution and Precipitation Heat Treated

UNS A92618

1. SCOPE:

1.1 Form: This specification covers an aluminum alloy in the form of die forgings, hand forgings, rolled rings, and forging stock.

1.2 Application: Primarily for rotor parts operating in service up to 450°F (230°C) and other parts operating up to 600°F (315°C) at low stresses.

2. APPLICABLE DOCUMENTS: The following publications form a part of this specification to the extent specified herein. The latest issue of Aerospace Material Specifications shall apply. The applicable issue of other documents shall be as specified in AMS 2350.

2.1 SAE Publications: Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096.

2.1.1 Aerospace Material Specifications:

AMS 2201 - Tolerances, Aluminum and Aluminum Alloy Bar, Rod, Wire, and Forging Stock, Rolled or Cold Finished

MAM 2201 - Tolerances, Metric, Aluminum and Aluminum Alloy Bar, Rod, Wire, and Forging Stock, Rolled, Drawn, or Cold Finished

AMS 2350 - Standards and Test Methods

AMS 2375 - Control of Forgings Requiring First Article Approval

AMS 2645 - Fluorescent Penetrant Inspection

AMS 2808 - Identification, Forgings

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- 2.2 ASTM Publications: Available from American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

ASTM B557 - Tension Testing Wrought and Cast Aluminum- and Magnesium-Alloy Products

ASTM B594 - Ultrasonic Inspection of Aluminum-Alloy Products for Aerospace Applications

ASTM E10 - Brinell Hardness of Metallic Materials

ASTM E34 - Chemical Analysis of Aluminum and Aluminum Alloys

- 2.3 U.S. Government Publications: Available from Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.

- 2.3.1 Military Specifications:

MIL-H-6088 - Heat Treatment of Aluminum Alloys

- 2.3.2 Military Standards:

MIL-STD-649 - Aluminum and Magnesium Products, Preparation for Shipment and Storage

3. TECHNICAL REQUIREMENTS:

- 3.1 Composition: Shall conform to the following percentages by weight, determined by wet chemical methods in accordance with ASTM E34 or by spectrographic or other analytical methods approved by purchaser:

	min	max
Copper	1.9	- 2.7
Magnesium	1.3	- 1.8
Iron	0.9	- 1.3
Nickel	0.9	- 1.2
Silicon	0.10	- 0.25
Titanium	0.04	- 0.10
Zinc	--	0.10
Other Impurities, each	--	0.05
Other Impurities, total	--	0.15
Aluminum	remainder	

- 3.2 Condition: The product shall be supplied in the following condition:

- 3.2.1 Die Forgings, Rolled Rings, and Hand Forgings 4 In. (100 mm) and Under in Nominal Thickness: Solution and precipitation heat treated.

- 3.2.2 Hand Forgings Over 4 In. (100 mm) in Nominal Thickness: As forged.

- 3.2.3 Forging Stock: As ordered by the forging manufacturer.

3.3 Heat Treatment: Die forgings and rolled rings, and hand forgings 4 in. (100 mm) and under in nominal thickness shall be solution and precipitation
Ø heat treated in accordance with MIL-H-6088 except that the soaking time at solution heat treatment temperature shall be not less than 6 hr and that the product shall be quenched in boiling water.

3.4 Properties: The product shall conform to the following requirements:

3.4.1 Forgings:

3.4.1.1 Tensile Properties: Shall be as follows, determined in accordance with ASTM B557:

3.4.1.1.1 Die Forgings:

3.4.1.1.1.1 With Grain Flow: Specimens, machined from forgings not over 4 in. (100 mm) in nominal thickness at time of heat treatment with axis of specimen in the area of gage length varying not more than 15 deg from parallel to the forging flow lines, shall have the following properties:

Tensile Strength, min	58,000 psi (400 MPa)
Yield Strength at 0.2% Offset, min	48,000 psi (330 MPa)
Elongation in 4D, min	4%
in 5D, min	3%

3.4.1.1.1.2 Across Grain Flow: Specimens, machined from forgings not over 4 in. (100 mm) in nominal thickness at time of heat treatment with axis of specimen in the area of gage length varying not more than 15 deg from perpendicular to the forging flow lines, shall have the following properties:

Tensile Strength, min	55,000 psi (380 MPa)
Yield Strength at 0.2% Offset, min	45,000 psi (310 MPa)
Elongation in 4D, min	4%
in 5D, min	3%

3.4.1.1.2 Hand Forgings: Specimens, machined from hand forgings having an
Ø essentially square or rectangular cross section not exceeding 144 sq in. (930 cm²) and heat treated in the indicated thickness, shall have properties as specified in Table I provided the as-forged thickness does not exceed 4 in. (100 mm).

TABLE I

Nominal Thickness At Time of Heat Treatment Inches	Specimen Orientation	Tensile Strength psi, min	Yield Strength at 0.2% Offset psi, min	Elongation in 4D %, min
Up to 2, incl	Longitudinal	58,000	47,000	7
	Long-Transverse	55,000	42,000	5
Over 2 to 3, incl	Longitudinal	57,000	46,000	7
	Long-Transverse	55,000	42,000	5
	Short-Transverse	52,000	42,000	4
Over 3 to 4, incl	Longitudinal	56,000	45,000	7
	Long-Transverse	53,000	40,000	5
	Short-Transverse	51,000	39,000	4

TABLE I (SI)

Nominal Thickness At Time of Heat Treatment Millimetres	Specimen Orientation	Tensile Strength MPa, min	Yield Strength at 0.2% Offset MPa, min	Elongation %, min	
Up to 50, incl	Longitudinal	400	325	7	6
	Long-Transverse	380	290	5	4
Over 50 to 75, incl	Longitudinal	395	315	7	6
	Long-Transverse	380	290	5	4
	Short-Transverse	360	290	4	3
Over 75 to 100, incl	Longitudinal	385	310	7	6
	Long-Transverse	365	275	5	4
	Short-Transverse	350	270	4	3

3.4.1.1.2.1 Short-transverse property requirements of Table I apply only to
Ø thicknesses 2.375 in. (60 mm) and over.

3.4.1.1.3 Rolled Rings:

3.4.1.1.3.1 Tangential: Specimens, machined from rolled rings not over 4 in. (100 mm) in nominal thickness at time of heat treatment with the axis of specimen tangential to the ring circumference (approximately parallel to the direction of rolling), shall have the following properties:

Tensile Strength, min	55,000 psi (380 MPa)
Yield Strength at 0.2% Offset, min	41,000 psi (285 MPa)
Elongation in 4D, min	6%
in 5D, min	5%

3.4.1.1.3.2 Axial: Specimens, machined from rolled rings not over 4 in. (100 mm) in nominal thickness at time of heat treatment with the axis of specimen parallel to the axis of the ring (transverse to direction of rolling), shall have properties as specified in 3.4.1.1.3.1 except that elongation may be as low as 5% in 4D or 4% in 5D.

3.4.1.1.4 Large Forgings: Tensile properties of forgings over 4 in. (100 mm) in nominal section thickness shall be as agreed upon by purchaser and vendor.

3.4.1.1.5 Test Specimens: Specimens, machined from separately-forged coupons or from forging stock representing the forgings and, in either case, heat treated with the forgings or machined from prolongations on heat treated die forgings, shall have the following properties:

Tensile Strength, min	58,000 psi (400 Mpa)
Yield Strength at 0.2% Offset, min	48,000 psi (330 MPa)
Elongation in 4D, min	6%
in 5D, min	5%

3.4.1.2 Hardness: Should be not lower than 115 HB/10/500 or 120 HB/10/1000, determined in accordance with ASTM E10, but forgings shall not be rejected on the basis of hardness if the applicable tensile property requirements are met.

3.4.1.3 Grain Flow: Except in areas of die forgings which contain end grain, the grain flow shall follow the general contour of the forging, showing no evidence of re-entrant flow.

3.4.2 Forging Stock: When a sample of stock is forged to a test coupon and heat treated in the same manner as forgings, specimens taken from the heat treated coupon shall conform to the requirements of 3.4.1.1.5. If specimens taken from the stock after heat treatment in the same manner as forgings conform to the requirements of 3.4.1.1.5, the tests shall be accepted as equivalent to tests of a forged coupon. The forging stock supplier, however, shall not be required to conduct such tests.

3.5 Quality: The product, as received by purchaser, shall be uniform in quality and condition, sound, and free from foreign materials and from imperfections detrimental to usage of the product.

3.5.1 Each die and rolled ring forging shall be etched by swabbing or immersing in an aqueous solution of sodium hydroxide, thoroughly rinsing in water, followed by washing in nitric acid or chromic-sulfuric acid solution or equivalent solution which will produce a surface suitable for visual inspection. Surfaces shall be evaluated for defects and, if defects can be removed so that they do not reappear on re-etching and if the required section thickness is maintained, forgings and rolled rings are acceptable.

3.5.1.1 When approved by purchaser, a sampling plan may be used in lieu of etching each die and rolled ring forging.

3.5.2 When specified, forgings shall be subjected to fluorescent penetrant inspection in accordance with AMS 2645, to ultrasonic inspection in accordance with ASTM B594, or to both. Standards for acceptance shall be as agreed upon by purchaser and vendor.

3.6 Tolerances: Forging stock shall conform to all applicable requirements of AMS 2201 or MAM 2201.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection: The vendor of the product shall supply all samples for vendor's tests and shall be responsible for performing all
Ø required tests. Results of such tests shall be reported to the purchaser as required by 4.5. Purchaser reserves the right to sample and to perform any confirmatory testing deemed necessary to ensure that the product conforms to the requirements of this specification.

4.2 Classification of Tests:

4.2.1 Acceptance Tests: Tests to determine conformance to the following
Ø requirements are classified as acceptance tests and shall be performed on each lot:

4.2.1.1 Composition (3.1) of the product.

4.2.1.2 Tensile properties (3.4.1.1) and, when specified, fluorescent penetrant
Ø and ultrasonic inspections (3.5.2) of each lot of forgings.

4.2.1.3 Visual surface inspection (3.5.1) of each lot of die and rolled ring
Ø forgings.

4.2.1.4 Tolerances (3.6) of forging stock.
Ø

4.2.2 Periodic Tests: Tests to determine conformance to the following
Ø requirements are classified as periodic tests and shall be performed at a frequency selected by the vendor unless frequency of testing is specified by purchaser:

4.2.2.1 Hardness (3.4.1.2) of forgings.

4.2.2.2 Ability of forging stock to develop required properties (3.4.2).

4.2.3 Preproduction Tests: Tests of forgings to determine conformance to all applicable technical requirements of this specification when AMS 2375 is
Ø specified are classified as preproduction tests and shall be performed prior to or on the first-article shipment of a forging to a purchaser, when a change in material, processing, or both requires reapproval as in 4.4, and when purchaser deems confirmatory testing to be required.

4.2.3.1 For direct U.S. Military procurement of forgings, substantiating test data and, when requested, preproduction forgings shall be submitted to the cognizant agency as directed by the procuring activity, the contracting officer, or the request for procurement.

4.3 Sampling: Shall be as follows; a lot shall be all forgings of the same nominal cross section and configuration heat treated in the same batch-furnace load or quenched from a continuous furnace consecutively during an 8-hr period. The maximum lot size for forgings heat treated in a continuous furnace shall be 6000 lb (2700 kg).

4.3.1 For Acceptance Tests:

4.3.1.1 Composition: At least one sample shall be taken by the producer from each group of ingots poured simultaneously from the same source of molten metal. Complete ingot analysis records shall be available to purchaser at the producer's facility.

4.3.1.1.1 Unless compliance with 4.3.1.1 is established, an analysis shall be made for each 6000 lb (2700 kg) or less of alloy comprising the lot except that not more than one analysis shall be required per piece.

4.3.1.2 Tensile Properties:

4.3.1.2.1 Die Forgings: At least one separately-forged coupon or one forging prolongation heat treated with each lot of forgings.

4.3.1.2.1.1 In lieu of a prolongation or separately-forged coupon, tensile specimens shall be cut from the location designated on the drawing from a forging representing each lot.

4.3.1.2.2 Hand Forgings: At least two tensile specimens taken from a forging or forging prolongation representing the lot. One specimen shall be in the long-transverse direction and the other in the short-transverse direction.

4.3.1.2.3 Rolled Rings: At least two tensile specimens shall be taken from a ring or ring prolongation representing the lot; one specimen shall be tangential to the ring OD and the other parallel to the axis of the ring.

4.3.1.3 Nondestructive Testing: As agreed upon by purchaser and vendor.

4.3.2 For Periodic Tests and Preproduction Tests: As agreed upon by purchaser and vendor.

4.4 Approval: When specified, approval and control of forgings shall be in accordance with AMS 2375.

4.5 Reports: