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SAE The Engineering Society For Advancing Mobility Land Sea Air and Space®
400 Commonwealth Drive, Warrendale, PA 15096-0001

AEROSPACE MATERIAL SPECIFICATION

Submitted for recognition as an American National Standard

AMS 4132D

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Superseding AMS 4132C

ALUMINUM ALLOY DIE AND HAND FORGINGS, ROLLED RINGS, AND FORGING STOCK
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 (232°C) and other parts operating up to 600°F (316°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 SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order.

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 2355 - Quality Assurance Sampling and Testing of Aluminum Alloys and Magnesium Alloys, Wrought Products (Except Forging Stock) and Flash Welded Rings
MAM 2355 - Quality Assurance Sampling and Testing of Aluminum Alloys and Magnesium Alloys, Wrought Products (Except Forging Stock) and Flash Welded Rings, Metric (SI) Units
AMS 2645 - Fluorescent Penetrant Inspection
AMS 2808 - Identification, Forgings

2.2 ASTM Publications: Available from ASTM, 1916 Race Street, Philadelphia, PA 19103.

ASTM B 594 - Ultrasonic Inspection of Aluminum-Alloy Products for Aerospace Applications
ASTM B 660 - Packaging/Packing of Aluminum and Magnesium Products

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

3. TECHNICAL REQUIREMENTS:

3.1 Composition: Shall conform to the following percentages by weight, Ø determined in accordance with AMS 2355 or MAM 2355:

	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 and Rolled Rings, and Hand Forgings 4 Inches (102 mm) and Under in Nominal Thickness: Solution and precipitation heat treated.

3.2.2 Hand Forgings Over 4 Inches (102 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 inches Ø (102 mm) and under in nominal thickness shall be solution and precipitation heat treated in accordance with MIL-H-6088 except that the product shall be quenched in boiling water.

3.4 Properties: The product shall conform to the following requirements, Ø determined in accordance with AMS 2355 or MAM 2355:

3.4.1 Forgings:

3.4.1.1 Tensile Properties: Shall be as follows:

3.4.1.1.1 Die Forgings:

3.4.1.1.1.1 With Grain Flow: Specimens, machined from forgings not over 4 inches (102 mm) in nominal thickness at time of heat treatment with axis of specimen in the area of gage length varying not more than 15 degrees from parallel to the forging flow lines, shall have the following properties:

Tensile Strength, minimum	58,000 psi (400 MPa)
Yield Strength at 0.2% Offset, minimum	48,000 psi (331 MPa)
Elongation in 4D, minimum	4%
in 5D, minimum	3%

3.4.1.1.1.2 Across Grain Flow: Specimens, machined from forgings not over 4 inches (102 mm) in nominal thickness at time of heat treatment with axis of specimen in the area of gage length varying not more than 15 degrees from perpendicular to the forging flow lines, shall have the following properties:

Tensile Strength, minimum	55,000 psi (379 MPa)
Yield Strength at 0.2% Offset, minimum	45,000 psi (310 MPa)
Elongation in 4D, minimum	4%
in 5D, minimum	3%

3.4.1.1.2 Hand Forgings: Specimens, machined from forgings having an essentially square or rectangular cross section not exceeding 144 square inches (929 cm^2) and heat treated in the indicated thickness, shall have properties as specified in Table I provided the as-forged thickness does not exceed 4 inches (102 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-Trans.	55,000	42,000	5
Over 2 to 3, incl	Longitudinal	57,000	46,000	7
	Long-Trans.	55,000	42,000	5
	Short-Trans.	52,000	42,000	4
Over 3 to 4, incl	Longitudinal	56,000	45,000	7
	Long-Trans.	53,000	40,000	5
	Short-Trans.	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 in 4D	Elongation %, min in 5D
Up to 51, incl	Longitudinal	400	324	7	6
	Long-Trans.	379	290	5	4
Over 51 to 76, incl	Longitudinal	393	317	7	6
	Long-Trans.	379	290	5	4
	Short-Trans.	359	290	4	3
Over 76 to 102, incl	Longitudinal	386	310	7	6
	Long-Trans.	365	276	5	4
	Short-Trans.	352	269	4	3

3.4.1.1.2.1 Short-transverse property requirements of Table I apply only to thicknesses 2.375 inches (60.32 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 inches (102 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, minimum	55,000 psi (379 MPa)
Yield Strength at 0.2% Offset, minimum	41,000 psi (283 MPa)
Elongation in 4D, minimum	6%
in 5D, minimum	5%

3.4.1.1.3.2 Axial: Specimens, machined from rolled rings not over 4 inches (102 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 and Rings: Tensile properties of forgings or rolled Ø rings over 4 inches (102 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, minimum	58,000 psi (400 Mpa)
Yield Strength at 0.2% Offset, minimum	48,000 psi (331 MPa)
Elongation in 4D, minimum	6%
in 5D, minimum	5%

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

3.4.1.3 Grain flow of die forgings, except in areas which contain flash-line end grain, shall follow the general contour of the forgings showing no evidence of re-entrant grain flow.

3.4.2 Forging Stock: When a sample of stock is forged to a test coupon having a Ø degree of mechanical working not greater than the forging 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 forging and rolled ring 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, die 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 forging or rolled ring.

3.5.2 When specified, die forgings and rolled rings shall be subjected to Ø fluorescent penetrant inspection in accordance with AMS 2645, to ultrasonic inspection in accordance with ASTM B 594, or 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 required tests. Results of such tests shall be reported to the purchaser as required by 4.4. 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 for the following requirements are 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) of each lot of die forgings, hand forgings, Ø and rolled rings and, when specified, fluorescent penetrant and/or ultrasonic inspections (3.5.2) of each lot of die forgings and rolled rings.

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

4.2.1.4 Tolerances (3.6) of forging stock.

4.2.2 Periodic Tests: Tests for the following requirements are 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 and rolled rings.

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

4.3 Sampling and Testing: Shall be in accordance with AMS 2355 or MAM 2355 and Ø 4.3.1; the number of specimens to be sampled shall be the minimum number of specimens tested. A lot shall be all forgings and rolled rings 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-hour period. The maximum lot size for forgings and rolled rings heat treated in a continuous furnace shall be 6000 pounds (2722 kg).