

ALUMINUM ALLOY FORGINGS
0.90Si - 0.62Mg - 0.25Cr (6151-T6)
Solution and Precipitation Heat Treated

UNS A96151

1. SCOPE:

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

1.2 Application: Primarily for complex-shaped parts requiring moderate strength and good forgeability of the material. Corrosion resistance of this alloy is superior to that of the copper-containing alloys.

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, ϕ determined by wet chemical methods in accordance with ASTM E34 or by spectrographic or other analytical methods approved by purchaser:

	min	max
Silicon	0.6	1.2
Magnesium	0.45	0.8
Chromium	0.15	0.35
Iron	--	1.0
Copper	--	0.35
Zinc	--	0.25
Manganese	--	0.20
Titanium	--	0.15
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: Solution and precipitation heat treated in accordance with MIL-H-6088.

3.2.2 Forging Stock: As ordered by the forging manufacturer.

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

3.3.1 Forgings:

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

3.3.1.1.1 Die Forgings:

3.3.1.1.1.1 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 meet the following requirements:

Tensile Strength, min	44,000 psi (305 MPa)
Yield Strength at 0.2 Offset, min	37,000 psi (255 MPa)
Elongation in 4D, min	10%
in 5D, min	9%

3.3.1.1.1.2 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	44,000 psi (305 MPa)
Yield Strength at 0.2% Offset, min	37,000 psi (255 MPa)
Elongation in 4D, min	6%
in 5D, min	5%

3.3.1.1.2 Rolled Rings:

3.3.1.1.2.1 Tangential: Specimens, machined from rings not over 2.5 in. (62.5 mm) in nominal thickness at time of heat treatment with axis of specimen tangential to the ring circumference (approximately parallel to the direction of rolling), shall have the following properties:

Tensile Strength, min	44,000 psi (305 MPa)
Yield Strength at 0.2% Offset, min	37,000 psi (255 MPa)
Elongation in 4D, min	5%
in 5D, min	4%

3.3.1.1.2.2 Axial: Specimens, machined from rolled rings not over 2.5 in. (62.5 mm) in nominal thickness at time of heat treatment with the axis of specimen parallel to the axis of ring (transverse to direction of rolling), shall have the following properties:

Tensile Strength, min	44,000 psi (305 MPa)
Yield Strength at 0.2% Offset, min	35,000 psi (240 MPa)
Elongation in 4D, min	4%
in 5D, min	3%

3.3.1.1.3 Large Forgings: Tensile properties of die forgings over 4 in. (100 mm) or rolled rings over 2.5 in. (62.5 mm) in nominal section thickness at time of heat treatment shall be as agreed upon by purchaser and vendor.

3.3.1.1.4 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	44,000 psi (305 MPa)
Yield Strength at 0.2% Offset, min	37,000 psi (255 MPa)
Elongation in 4D, min	14%
in 5D, min	12%

3.3.1.2 Hardness: Should be not lower than 90 HB/10/500 or 96 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.

3.3.1.3 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.

3.3.2 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 3.3.1.1.4 and 3.3.1.2. If specimens taken from the stock after heat treatment in the same manner as forgings conform to the requirements of 3.3.1.1.4 and 3.3.1.2, 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.

3.4 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.

3.4.1 Each die and rolled ring forging shall be etched by swabbing or immersing
Ø 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.

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

3.4.2 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 B594, or to both. Standards for acceptance shall be as agreed upon by purchaser and vendor.

3.5 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
Ø 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 4.5. 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 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 (3.3.1.1) and, when specified, fluorescent penetrant
Ø and ultrasonic inspection (3.4.2) of each lot of forgings.

4.2.1.3 Visual surface inspection (3.4.1) of each lot of die and rolled ring
Ø forgings.

4.2.1.4 Tolerances (3.5) 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 (3.3.1.2) of forgings.

4.2.2.2 Ability of forging stock to develop required properties (3.3.2).

4.2.3 Preproduction Tests: Tests of forgings to determine conformance to all applicable technical requirements of this specification when AMS 2375 is 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 part number, size, or 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. 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 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.