

ALUMINUM ALLOY FORGINGS
4.5Cu - 0.85Si - 0.80Mn - 0.50Mg (2014-T6)
Solution and Precipitation Heat Treated
Improved Yield Strength

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 applications, such as aircraft structural members, requiring material with moderately high strength. Certain design and processing procedures may cause these forgings to become susceptible to stress corrosion cracking; ARP 823 recommends practices to minimize such conditions.

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

- 2.1 SAE Publications: Available from Society of Automotive Engineers, Inc., 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 Drawn
AMS 2350 - Standards and Test Methods
AMS 2375 - Control of Forgings Requiring First Article Approval
AMS 2630 - Ultrasonic Inspection
AMS 2645 - Fluorescent Penetrant Inspection
AMS 2808 - Identification, Forgings

2.1.2 Aerospace Recommended Practices:

ARP 823 - Minimizing Stress Corrosion Cracking in Wrought Heat Treatable Aluminum Alloy Products

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

ASTM B557 - Tension Testing of Wrought and Cast Aluminum- and Magnesium-Alloy Products
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 Federal Standards:

Federal Test Method Standard No. 151 - Metals; Test Methods

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2.3.2 Military Specifications:

MIL-H-6088 - Heat Treatment of Aluminum Alloys

2.3.3 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, by spectrographic methods in accordance with Federal Test Method Standard No. 151, Method 112, or by other analytical methods approved by purchaser:

	min	max
Copper	3.9	5.0
Silicon	0.50	1.2
Manganese	0.40	1.2
Magnesium	0.20	0.8
Iron	--	0.7
Zinc	--	0.25
Titanium	--	0.15
Chromium	--	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 Forgings and Rolled Rings: Solution and precipitation heat treated in accordance with MIL-H-6088.

3.2.2 Stock for Forging or Rolled Rings: As ordered by the forging or rolled ring manufacturer.

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

∅ 3.3.1 Tensile Properties: Shall be as follows, determined in accordance with ASTM B557:

3.3.1.1 Die Forgings:

3.3.1.1.1 Test Specimens: Test 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 forgings, shall have the following properties:

Tensile Strength, min	65,000 psi (448 MPa)
Yield Strength at 0.2% Offset, min	56,000 psi (386 MPa)
Elongation in 4D, min	8%

3.3.1.1.2 With Grain Flow: Test specimens machined from forgings with the axis of the specimen in the area of the gage length varying not more than 15 deg from parallel to the forging flow lines shall have the properties shown in Table I.

TABLE I

Nominal Thickness At Time of Heat Treatment Inches	Tensile Strength psi, min	Yield Strength at 0.2% Offset psi, min	Elongation in 4D %, min
Up to 2, incl	65,000	56,000	6
Over 2 to 3, incl	65,000	55,000	6
Over 3 to 4, incl	63,000	55,000	6

TABLE I (SI)

Nominal Thickness At Time of Heat Treatment Millimetres	Tensile Strength MPa, min	Yield Strength at 0.2% Offset MPa, min	Elongation in 4D %, min
Up to 51, incl	448	386	6
Over 51 to 76, incl	448	379	6
Over 76 to 102, incl	434	379	6

3.3.1.1.3 Across Grain Flow: Test specimens machined from forgings with the axis of the specimen in the area of the gage length varying not more than 15 deg from perpendicular to the forging flow lines shall have the properties shown in Table II, provided the as-forged thickness is not more than twice the heat treat thickness.

TABLE II

Nominal Thickness At Time of Heat Treatment Inches	Tensile Strength psi, min	Yield Strength at 0.2% Offset psi, min	Elongation in 4D %, min
Up to 1, incl	64,000	55,000	3
Over 1 to 2, incl	64,000	55,000	2
Over 2 to 4, incl	63,000	54,000	2

TABLE II (SI)

Nominal Thickness At Time of Heat Treatment Millimetres	Tensile Strength MPa, min	Yield Strength at 0.2% Offset MPa, min	Elongation in 4D %, min
Up to 25, incl	441	379	3
Over 25 to 51, incl	441	379	2
Over 51 to 102, incl	434	372	2

3.3.1.2 Rolled Rings: Test specimens machined from rolled rings with axis tangential to the ring OD (axis parallel to direction of rolling) or with axis parallel to the axis of the ring (transverse to direction of rolling) shall have the properties shown in Table III.

TABLE III

Nominal Wall 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 2.5, incl	Tangential	65,000	55,000	7
	Axial	62,000	55,000	3
Over 2.5 to 3.0, incl	Tangential	65,000	55,000	6
	Axial	62,000	52,000	2

TABLE III (SI)

Nominal Wall Thickness At Time of Heat Treatment Millimetres	Specimen Orientation	Tensile Strength MPa, min	Yield Strength at 0.2% Offset MPa, min	Elongation in 4D %, min
Up to 64, incl	Tangential	448	379	7
	Axial	427	379	3
Over 64 to 76, incl	Tangential	448	379	6
	Axial	427	359	2

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3.3.1.3 Hand Forgings: Test specimens machined from hand forgings having an essentially square or rectangular cross section, shall have the properties shown in Table IV, provided the as-forged section thickness does not exceed 8.0 in. (203 mm).

TABLE IV

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	65,000	56,000	8
	Long Trans.	65,000	56,000	3
Over 2 to 3, incl	Longitudinal	64,000	56,000	8
	Long Trans.	64,000	55,000	3
	Short Trans.	62,000	55,000	2
Over 3 to 4, incl	Longitudinal	63,000	55,000	8
	Long Trans.	63,000	55,000	3
	Short Trans.	61,000	54,000	2
Over 4 to 5, incl	Longitudinal	62,000	54,000	7
	Long Trans.	62,000	54,000	2
	Short Trans.	60,000	53,000	1
Over 5 to 6, incl	Longitudinal	61,000	53,000	7
	Long Trans.	61,000	53,000	2
	Short Trans.	59,000	53,000	1
Over 6 to 7, incl	Longitudinal	60,000	52,000	6
	Long Trans.	60,000	52,000	2
	Short Trans.	58,000	52,000	1
Over 7 to 8, incl	Longitudinal	59,000	51,000	6
	Long Trans.	59,000	51,000	2
	Short Trans.	57,000	51,000	1

TABLE IV (SI)

Nominal Thickness At Time of Heat Treatment Millimetres	Specimen Orientation	Tensile Strength MPa, min	Yield Strength at 0.2% Offset MPa, min	Elongation in 4D %, min
Up to 51, incl	Longitudinal	448	386	8
	Long Trans.	448	386	3
Over 51 to 76, incl	Longitudinal	441	386	8
	Long Trans.	441	379	3
	Short Trans.	428	379	2
Over 76 to 102, incl	Longitudinal	434	379	8
	Long Trans.	434	379	3
	Short Trans.	421	372	2
Over 102 to 127, incl	Longitudinal	428	372	7
	Long Trans.	428	372	2
	Short Trans.	414	365	1
Over 127 to 152, incl	Longitudinal	421	365	7
	Long Trans.	421	365	2
	Short Trans.	407	365	1
Over 152 to 178, incl	Longitudinal	414	358	6
	Long Trans.	414	358	2
	Short Trans.	400	358	1
Over 178 to 203, incl	Longitudinal	407	352	6
	Long Trans.	407	352	2
	Short Trans.	393	352	1

- 3.3.1.4 Other Forgings or Rolled Rings: Tensile specimens machined from forgings or rolled rings having configuration or size limitations not covered by this specification shall conform to tensile property requirements specified on the drawing or as agreed upon by purchaser and vendor.
- 3.3.1.5 Stock for Forgings or Rolled Rings: When a sample of stock is forged to a test coupon and heat treated in the same manner as forgings or rolled rings, a tensile specimen taken from the heat treated coupon shall have properties not lower than those specified in 3.3.1.1.1. If a test specimen taken from the stock after heat treatment in the same manner as forgings or rolled rings has properties not lower than those specified in 3.3.1.1.1, the test shall be accepted as equivalent to tests of a forged coupon.
- 3.3.2 Hardness: Forgings and rolled rings should have hardness not lower than 120 HB/10/500, 120 HB/14.3/1000, or 125 HB/10/1000, determined in accordance with ASTM E10, but forgings and rolled rings shall not be rejected on the basis of hardness if the applicable tensile property requirements are met.
- 3.3.3 Grain Flow: Shall be as specified on the drawing or as agreed upon by purchaser and vendor.
- 3.4 Quality: The product, as received by purchaser, shall be uniform in quality and condition, sound, and free from foreign materials and from internal and external imperfections detrimental to usage of the product.
- 3.4.1 When specified, forgings and rolled rings shall be subjected to fluorescent penetrant inspection in accordance with AMS 2645 and/or to ultrasonic inspection in accordance with AMS 2630. Standards for acceptance shall be as agreed upon by purchaser and vendor.
- 3.5 Tolerances: Unless otherwise specified, tolerances for forging stock shall be in accordance with all applicable requirements of AMS 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 4.5. 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 of forgings and rolled rings to determine conformance to all technical requirements of this specification and of stock for forgings or rolled rings to determine conformance to requirements for composition (3.1) are classified as acceptance tests and shall be performed on each lot.
- 4.2.2 Preproduction Tests: Tests of forgings and rolled rings to determine conformance to all applicable requirements of this specification when AMS 2375 is specified are classified as pre-production tests and shall be performed on the first-article shipment of a forging or rolled ring to a purchaser, when a change in material or processing requires reapproval as in 4.4, and when purchaser deems confirmatory testing to be required.
- 4.2.2.1 For direct U.S. Military procurement of forgings and rolled rings, substantiating test data and, when requested, preproduction forgings or rolled rings 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 or rolled rings of the same nominal cross-section and configuration heat treated in the same batch furnace load or charged consecutively in not more than 8-hr continuous furnace operation: