

**AEROSPACE
MATERIAL
SPECIFICATION**

AMS 4133B

Superseding AMS 4133A

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UNS A92014

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

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 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 Drawn

AMS 2350 - Standards and Test Methods

AMS 2375 - Control of Forgings Requiring First Article Approval

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

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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 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

- 2.3.2 Military Specifications:

MIL-H-6088 - Heat Treatment of Aluminum Alloys

MIL-I-8950 - Inspection, Ultrasonic, Wrought Metals, Process for

- 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 Forgings and Rolled Rings:

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 4 in. (100 mm) and under in nominal thickness at time of heat treatment or from prolongations on such forgings, with the axis of 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 provided the as-forged thickness is not more than twice the heat treated thickness.

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 50, incl	450	385	6
Over 50 to 75, incl	450	380	6
Over 75 to 100, incl	435	380	6

- 3.3.1.1.1.2 Across Grain Flow: Specimens, machined from forgings 4 in. (100 mm) and under in nominal thickness at time of heat treatment or from prolongations on such forgings, with the 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 properties shown in Table II provided the as-forged thickness is not more than twice the heat treated thickness. If configuration of the forging or prolongation cannot accommodate the transverse specimen described, acceptance of the forging shall be based on testing as in 3.3.1.1.1.3.

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	440	380	3
Over 25 to 50, incl	440	380	2
Over 50 to 100, incl	435	370	2

- 3.3.1.1.1.2.1 Elongation requirements shall not apply to specimens having a gage length diameter less than 0.250 in. (6.25 mm) or to specimens machined from locations in immediate proximity to an abrupt change in thickness or from locations such that any part of the specimen gage length is located within 1/8 in. (3 mm) of the trimmed flash line.

- 3.3.1.1.1.3 At Angle to Grain Flow: Specimens, machined from forgings 4 in. (100 mm) and under in nominal thickness at time of heat treatment or from prolongations on such forgings, with the axis of specimen in the area of gage length varying more than 15 deg from parallel and also 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 treated thickness. Such test results shall be identified as neither longitudinal nor transverse tensile properties.

3.3.1.1.2 Hand Forgings: Specimens, machined from forgings 8 in. (200 mm) and under in nominal thickness at time of heat treatment and having an essentially square or rectangular cross-section, shall have the properties shown in Table III provided that the as-forged thickness does not exceed 8 in. (200 mm).

TABLE III

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 III (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 50, incl	Longitudinal	450	385	8
	Long Trans.	450	385	3
Over 50 to 75, incl	Longitudinal	440	385	8
	Long Trans.	440	380	3
Over 75 to 100, incl	Short Trans.	430	380	2
	Longitudinal	435	380	8
	Long Trans.	435	380	3
Over 100 to 125, incl	Short Trans.	420	370	2
	Longitudinal	430	370	7
	Long Trans.	430	370	2
Over 125 to 150, incl	Short Trans.	415	365	1
	Longitudinal	420	365	7
	Long Trans.	420	365	2
Over 150 to 175, incl	Short Trans.	405	365	1
	Longitudinal	415	360	6
	Long Trans.	415	360	2
Over 175 to 200, incl	Short Trans.	400	360	1
	Longitudinal	405	350	6
	Long Trans.	405	350	2
	Short Trans.	395	350	1

3.3.1.1.3 Rolled Rings: Specimens, machined from rings 3.0 in. (7.5 mm) and under in nominal wall thickness at time of heat treatment with axis of specimen approximately tangential to the ring OD (axis parallel to direction of rolling) or with axis approximately parallel to the axis of the ring (transverse to direction of rolling, shall have the properties shown in Table IV.

TABLE IV

Wall Elongation 4D min	Nominal Thickness at Time of Heat Treatment Inches	Specimen Orientation	Tensile Strength psi, min	Yield Strength at 0.2% Offset psi, min	in %,
	Up to 2.5, incl	Tangential	65,000	55,000	7
		Axial	62,000	55,000	3
	Over 2 to 3.0, incl	Tangential	65,000	55,000	6
		Axial	62,000	52,000	2

TABLE IV(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 65, incl	Tangential	450	380	7
	Axial	425	380	3
Over 65 to 75, incl	Tangential	450	380	6
	Axial	425	380	2

3.3.1.1.4 Special Purpose Forgings: Tensile property requirements for specimens cut from special purpose forgings or from forgings beyond the size and configuration limits of 3.3.1.1.1, 3.3.1.1.2, and 3.3.1.1.3 shall be as specified on the drawing or as agreed upon by purchaser and vendor.

3.3.1.2 Hardness: Should be not lower than 120 HB/10/500 or 125 HB/10/1000, determined in accordance with ASTM E10, but the forgings or rolled rings shall not be rejected on the basis of hardness if the applicable tensile property requirements are met.

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

Tensile Strength, min	65,000 psi (450 MPa)
Yield Strength at 0.2% Offset, min	56,000 psi (385 MPa)
Elongation in 4D, min	8%

3.3.3 Stock for Forging or Rolled Rings: When a sample of stock is forged to a test coupon and heat treated in the same manner as forgings and rolled rings, specimens taken from the heat treated coupon shall conform to the requirements of 3.3.1.2 and 3.2.2. If specimens taken from the stock after heat treatment in the same manner as forgings and rolled rings conform to the requirements of 3.3.1.2 and 3.3.2, 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 internal and external imperfections detrimental to usage of the product.

3.4.1 When specified, forgings and rolled rings shall be subjected to ultrasonic inspection in accordance with MIL-I-8950 and, unless otherwise specified, shall meet the following requirements of that specification:

3.4.1.1 Die forgings and rolled rings 0.500 to 4.000 in. (12.50 to 100.00 mm), incl, in nominal thickness and weighing not over 300 lb (135 kg) shall meet Class B.

- 3.4.1.2 Hand forgings 1.000 to 6.000 in. (25.00 to 150.00 mm), incl, in nominal
Ø thickness and weighing not more than 600 lb (270 kg) shall meet Class A.
- 3.4.1.3 Acceptance criteria for forgings or rolled rings exceeding the limits of
Ø 3.4.1.1 or 3.4.1.2 shall be as agreed upon by purchaser and vendor.
- 3.4.2 When specified, forgings and rolled rings shall be subjected to
fluorescent penetrant inspection in accordance with AMS 2645. 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
Ø conformance to requirements for tensile properties (3.3.1.1), hardness
(3.3.1.2), and, when specified, ultrasonic and fluorescent penetrant
inspection (3.4.1 and 3.4.2) and of forging stock to determine conformance
to requirements for composition (3.1) are classified as acceptance tests
and shall be performed on each lot.
- 4.2.2 Periodic Tests: Tests of stock for forging or rolled rings to determine
Ø ability to develop specified properties (3.3.3) are classified as periodic
tests and shall be performed at a frequency selected by the vendor unless
frequency of testing is specified by purchaser.
- 4.2.3 Preproduction Tests: Tests of forgings and rolled rings to determine
conformance to 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 or
rolled ring to a purchaser, when a change in material and/or processing
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 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.