

AEROSPACE  
 MATERIAL  
 SPECIFICATION

**AMS 4144C**  
 Superseding AMS 4144B

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## ALUMINUM ALLOY HAND FORGINGS AND RINGS

6.3Cu - 0.30Mn - 0.18Zr - 0.10V - 0.06Ti (2219-T852)

 Solution Heat Treated, Stress Relief Compressed, and Precipitation Heat Treated  
 UNS A92219
1. SCOPE:
 1.1 Form: This specification covers an aluminum alloy in the form of hand forgings and rolled rings.

 1.2 Application: Primarily for structural parts subject to warpage during machining. May be welded in the -T852 condition but properties are improved by re-heat treatment to -T6 temper after welding. Certain design and fabricating procedures may cause these products 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 and Aerospace Recommended Practices 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 2350 - Standards and Test Methods

AMS 2375 - Control of Forgings Requiring First Article Approval

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 of 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:

3.1.2 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	5.8	6.8
Manganese	0.20	0.40
Zirconium	0.10	0.25
Vanadium	0.05	0.15
Titanium	0.02	0.10
Iron	--	0.30
Silicon	--	0.20
Zinc	--	0.10
Magnesium	--	0.02
Other Impurities, each	--	0.05
Other Impurities, total	--	0.15
Aluminum		remainder

3.2 Condition: Solution heat treated, stress-relieved by compressing, and precipitation heat treated. The compressing in the solution heat treated condition shall produce a permanent set of 1 - 5%. Heat treatments shall be performed in accordance with MIL-H-6088.

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 Hand Forgings: Specimens machined from hand forgings 17 in. (425 mm) and under in nominal thickness shall conform to the requirements of Table I. Tests may be waived for any test direction having a dimension less than 2 in. (50 mm). Tests need not be made in the longitudinal direction unless specifically required by purchaser.

TABLE I

Nominal Thickness Inches	Specimen Orientation	Tensile strength psi, min	Yield Strength at 0.2% Offset psi, min	Elongation in 4D %, min
Up to 4, incl	Longitudinal	62,000	50,000	6
	Long Trans.	62,000	49,000	4
	Short Trans.	60,000	46,000	3
Over 4 to 6, incl	Longitudinal	58,000	44,000	6
	Long Trans.	56,000	42,000	4
	Short Trans.	56,000	41,000	3
Over 6 to 8, incl	Longitudinal	57,000	43,000	6
	Long Trans.	55,000	41,000	4
	Short Trans.	55,000	40,000	3
Over 8 to 10, incl	Longitudinal	56,000	42,000	6
	Long Trans.	54,000	41,000	3
	Short Trans.	54,000	39,000	3
Over 10 to 12, incl	Longitudinal	54,000	41,000	6
	Long Trans.	53,000	40,000	3
	Short Trans.	53,000	39,000	2
Over 12 to 14, incl	Longitudinal	53,000	40,000	6
	Long Trans.	52,000	40,000	3
	Short Trans.	52,000	38,000	2
Over 14 to 17, incl	Longitudinal	51,000	39,000	6
	Long Trans.	50,000	39,000	3
	Short Trans.	50,000	37,000	2

TABLE I (SI)

Nominal Thickness Millimetres	Specimen Orientation	Tensile strength MPa, min	Yield Strength at 0.2% Offset MPa, min	Elongation %, min	
				in 4D	in 5D
Up to 100, incl	Longitudinal	425	345	6	5
	Long Trans.	425	340	4	3
	Short Trans.	415	315	3	2
Over 100 to 150, incl	Longitudinal	400	305	6	
	Long Trans.	385	290	4	
	Short Trans.	385	285	3	
Over 150 to 200, incl	Longitudinal	395	295	6	
	Long Trans.	380	285	4	
	Short Trans.	380	275	3	
Over 200 to 250, Incl	Longitudinal	385	290	6	
	Long Trans.	370	285	3	
	Short Trans.	370	270	3	
Over 250 to 300, incl	Longitudinal	370	285	6	
	Long Trans.	365	275	3	
	Short Trans.	365	270	2	
Over 300 to 350, incl	Longitudinal	365	275	6	
	Long Trans.	360	275	3	
	Short Trans.	360	260	2	
Over 350 to 425, incl	Longitudinal	350	270	6	
	Long Trans.	345	270	3	
	Short Trans.	345	255	2	

3.3.1.1.1 Tensile properties of specimens machined from forgings over 17 in. (425 mm) in nominal thickness shall be as agreed upon by purchaser and vendor.

3.3.1.2 Rolled Rings:

3.3.1.2.1 Tangential: Specimens machined from rings 2.5 in. (62.5 mm) and under in nominal thickness with axis of specimen tangential to the ring OD (axis parallel to the direction of rolling) shall have the following properties:

Tensile Strength, min	60,000 psi (415 MPa)
Yield Strength at 0.2% Offset, min	48,000 psi (330 MPa)
Elongation in 4D, min	6%

3.3.1.2.2 Axial: Specimens machined from rings 2.5 in. (62.5 mm) and under in nominal radial thickness with axis of specimen parallel to axis of ring (axis transverse to direction of rolling) shall conform to the following requirements:

Tensile Strength, min	60,000 psi (415 MPa)
Yield Strength at 0.2% Offset, min	46,000 psi (315 MPa)
Elongation in 4D, min	4%

3.3.1.2.3 Tensile properties of specimens machined from rings over 2.5 in. (62.5 mm) in nominal radial thickness shall be as agreed upon by purchaser and vendor.

3.3.1.3 Grain flow of hand forgings, except in areas which contain end grain, shall follow the general contour of the forging and shall show no evidence of re-entrant flow.

3.3.2 Hardness: Should be not lower than 115 HB/10/500 or 122 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 tensile property requirements are met.

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 When specified, forgings and rolled rings shall be subjected to a caustic etch followed by visual examination of the product surfaces for defect indications, to ultrasonic inspection in accordance with ASTM B594, or to both. Standards for acceptance shall be as agreed upon by purchaser and vendor.

#### 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 to determine conformance to all technical requirements of this specification are classified as acceptance tests and shall be performed on each lot.

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4.2.2 Preproduction Tests: Tests to determine conformance to all technical requirements of this specification when AMS 2375 is specified are classified as preproduction tests and shall be performed on the first-article shipment of a forging or rolled ring 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.

4.2.2.1 For direct U.S. Military procurement, 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; the maximum lot size for forgings or rolled rings 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 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 Hand Forgings: At least two tensile specimens shall be taken from a forging or forging prolongation representing the lot. One specimen shall be taken in the long-transverse direction and the other in the short-transverse direction.

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 taken tangential to the ring OD and the other parallel to the axis of the ring.

4.3.2 For 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.