Society of Automotive Engineers, Inc.
400 COMMONWEALTH DRIVE, WARRENDALE, PA. 15096

AEROSPACE MATERIAL SPECIFICATION

AMS 4146B
Superseding AMS 4146A
Issued 6-30-60
Revised 7-15-77

UNS A96061

ALUMINUM ALLOY FORGINGS
1.0Mg - 0.60Si - 0.28Cu - 0.20Cr (6061-T4)

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 forged parts which will be welded or brazed to assemblies and then given further heat treatment to develop the full strength of which the alloy is capable. Corrosion resistance of this alloy is superior to that of alloys having copper as the principal alloying element.

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) 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 - Approval and Control of Critical Forgings
AMS 2630 - Ultrasonic Inspection
AMS 2645 - Fluorescent Penetrant Inspection
AMS 2770 - Heat Treatment of Aluminum and Aluminum Alloys
AMS 2808 - Identification, Forgings

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-Base Alloys

2.3 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

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 approved analytical methods:

	min	max
Magnesium	0.8	1.2
Silicon	0.40	0.8
Copper	0.15	0.40
Chromium	0.04	0.35
Iron	--	0.7
Zinc	--	0.25
Manganese	--	0.15
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, Hand Forgings, and Rolled Rings: Solution 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 Die Forgings, Hand Forgings, and Rolled Rings:

3.3.1.1 As Solution Heat Treated:

3.3.1.1.1 Hardness: Shall be 50 - 80 HB/10/500, 50 - 80 HB/14.3/1000, or 55 - 85 HB/10/1000, determined in accordance with ASTM E10.

3.3.1.2 After Precipitation Heat Treatment: Shall be as follows after being precipitation heat treated in accordance with AMS 2770:

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

3.3.1.2.1.1 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, shall have the following properties:

Tensile Strength, min	38,000 psi (262 MPa)
Yield Strength at 0.2% Offset, min	35,000 psi (241 MPa)
Elongation in 2 in. (50.8 mm) or 4D, min	10%

3.3.1.2.1.2 Die Forgings, With Grain Flow: Test specimens, machined from forgings not over 4 in. (102 mm) in nominal thickness with the axis of specimen in the area of gage length within 15 deg of parallel to the forging flow lines, shall have properties as specified in 3.3.1.2.1.1 except that elongation may be as low as 7%, unless otherwise agreed upon by purchaser and vendor.

3.3.1.2.1.3 Die Forgings, Across Grain Flow: Test specimens, machined from forgings not over 4 in. (102 mm) in nominal thickness with the axis of specimen in the area of gage length varying more than 15 deg from parallel to the forging flow lines, shall have properties as specified in 3.3.1.2.1.1 except that elongation may be as low as 5%, unless otherwise agreed upon by purchaser and vendor.

3.3.1.2.1.4 Rolled Rings, Tangential: Test specimens, machined from rings not over 2.5 in. (64 mm) in nominal thickness with axis of specimen tangential to ring OD (axis parallel to direction of rolling), shall have properties as specified in 3.3.1.2.1.1, unless otherwise agreed upon by purchaser and vendor.

3.3.1.2.1.5 Rolled Rings, Axial: Test specimens, machined from rings not over 2.5 in. (64 mm) in nominal thickness with axis of specimen parallel to axis of ring (axis transverse to direction of rolling), shall have properties as specified in 3.3.1.2.1.1 except that elongation may be as low as 8%, unless otherwise agreed upon by purchaser and vendor.

3.3.1.2.1.6 Hand Forgings: Test specimens, machined from forgings not over 8 in. (203 mm) in nominal thickness shall have properties as specified in Table I; 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 2 in. or 4D %, min
Up to 4, incl	Long.	38,000	35,000	10
	Long Trans.	38,000	35,000	8
	Short Trans.	37,000	33,000	5
Over 4 to 8, incl	Long.	37,000	34,000	8
	Long Trans.	37,000	34,000	6
	Short Trans.	35,000	32,000	4

TABLE I (SI)

Nominal Thickness Millimetres	Specimen Orientation	Tensile Strength MPa, min	Yield Strength at 0.2% Offset MPa, min	Elongation in 50.8 mm or 4D %, min
Up to 102, incl	Long.	262	241	10
	Long Trans.	262	241	8
	Short Trans.	255	228	5
Over 102 to 203, incl	Long.	255	234	8
	Long Trans.	255	234	6
	Short Trans.	241	221	4

3.3.1.2.1.7 Other Forgings: Tensile property requirements for forgings, hand forgings, and rings having nominal thickness greater than specified above shall be as agreed upon by purchaser and vendor.

3.3.1.2.2 Hardness: Should be not lower than 80 HB/10/500, 80 HB/14.3/1000, or 85 HB/10/1000, determined in accordance with ASTM E10, but the product shall not be rejected on the basis of hardness if the tensile property requirements are met.

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 3.3.1.2.1.1 and 3.3.1.2.2. If specimens taken from the stock after heat treatment in the same manner as forgings conform to the requirements of 3.3.1.2.1.1 and 3.3.1.2.2, 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 Ø Quality: The product, as received by the 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 Ø When specified, die forgings, hand 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 conform to all applicable requirements of AMS 2201.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Ø Responsibility for Inspection: The vendor of the product shall supply all samples 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 perform such confirmatory testing as he deems necessary to ensure that the product conforms to the requirements of this specification.

4.2 Classification of Tests:

4.2.1 Ø Acceptance Tests: Test of the product to determine conformance to composition (3.1) requirements; of forgings to determine conformance to tensile property (3.3.1.2.1), hardness as solution heat treated (3.3.1.1.1), and tensile property after precipitation heat treatment (3.3.1.1.2.1) requirements, and of forging stock to determine conformance to tolerance (3.5) requirements are classifed as acceptance tests.

4.2.2 Ø Periodic Tests: Tests of forging stock to determine ability to develop required properties (3.3.2) as classified as periodic tests.

4.2.3 Ø Preproduction Tests: Tests of forgings and rolled rings to determine conformance to all technical requirements of this specification are classified as preproduction tests.

4.2.3.1 Ø 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 in a continuous furnace consecutively during an 8-hr period.

4.3.1 Ø 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.

4.3.1.1 Ø Unless compliance with 4.3.1 is established, an analysis shall be made for each 6,000 lb (2724 kg) or less of material comprising the lot except that not more than one analysis shall be required per piece.