

AEROSPACE MATERIAL SPECIFICATION

Submitted for recognition as an American National Standard

AMS 4321

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ALUMINUM ALLOY FORGINGS
7.7Zn - 2.5Mg - 1.5Cu - 0.16Cr (7049-01)
High Temperature Annealed

UNS A97049

1. SCOPE:

- 1.1 Form: This specification covers an aluminum alloy in the form of die forgings and hand forgings.
- 1.2 Application: Primarily for parts to be machined prior to final heat treatment requiring a combination of dimensional stability and accentuation of ultrasonic response, and to achieve maximum mechanical properties with high resistance to stress-corrosion cracking after solution and precipitation heat treatment to T73 temper.
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 2350 - Standards and Test Methods
AMS 2355 - Quality Assurance Sampling and Testing of Aluminum Alloys and Magnesium Alloys, Wrought Products (Except Forging Stock) and Flash Welded Rings
MAM 2355 - Quality Assurance Sampling and Testing of Aluminum Alloys and Magnesium Alloys, Wrought Products (Except Forging Stock) and Flash Welded Rings, Metric (SI) Units
AMS 2375 - Control of Forgings Requiring First Article Approval
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 B594 - Ultrasonic Inspection of Aluminum Alloy Wrought Products for Aerospace Applications

ASTM G34 - Exfoliation Corrosion Susceptibility in 2XXX and 7XXX Series Aluminum Alloys (EXCO Test)

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, determined in accordance with AMS 2355 or MAM 2355:

	min	max
Zinc	7.2	- 8.2
Magnesium	2.0	- 2.9
Copper	1.2	- 1.9
Chromium	0.10	- 0.22
Iron	--	0.35
Silicon	--	0.25
Manganese	--	0.20
Titanium	--	0.10
Other Impurities, each	--	0.05
Other Impurities, total	--	0.15
Aluminum	remainder	

3.2 Condition: High temperature annealed (at solution heat treat temperature) in accordance with MIL-H-6088 except that forgings shall be ambient air cooled to room temperature.

3.3 Properties: Shall be as follows, determined in accordance with AMS 2355 or MAM 2355:

3.3.1 As Annealed: The conductivity within any one forging shall not vary more than 3% IACS (International Annealed Copper Standard (1.7 MS/m)).

3.3.2 After Heat Treatment to the T73 Temper: Forgings shall have the following properties after being solution and precipitation heat treated in accordance with AMS 2770 to the -T73 temper.

3.3.2.1 Tensile Properties:3.3.2.1.1 Die Forgings:

3.3.2.1.1.1 With Grain Flow: Specimens, machined from forgings not over 5 in. (125 mm) in nominal thickness with as-forged thickness not more than twice the heat treated thickness, with axis of specimen in the area of gage length varying not more than 15 deg from parallel to the forging flow lines or from prolongations on such forgings shall have the properties specified 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	72,000	62,000	7
Over 2 to 4, incl	71,000	61,000	7
Over 4 to 5, incl	70,000	60,000	7

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	495	425	7
Over 50 to 100, incl	490	420	7
Over 100 to 125, incl	485	415	7

3.3.2.1.1.2 Across Grain Flow: Specimens, machined from forgings not over 5 in. (125 mm) in nominal thickness with as-forged thickness not more than twice the heat treated thickness, with axis of specimen in the area of gage length varying not more than 15 deg from perpendicular to the forging flow lines or from prolongations on such forgings shall have the properties specified in Table II.

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	71,000	61,000	3
Over 1 to 3, incl	70,000	60,000	3
Over 3 to 4, incl	70,000	60,000	2
Over 4 to 5, incl	68,000	58,000	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	490	420	3
Over 25 to 75, incl	485	415	3
Over 75 to 100, incl	485	415	2
Over 100 to 125, incl	470	400	2

3.3.2.1.2 Hand Forgings: Specimens, machined from forgings having an essentially square or rectangular cross-section or from prolongations on such forgings shall have the properties shown in Table III provided the as-forged section thickness does not exceed 5 in. (125 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
Over 2 to 3, incl	Longitudinal	71,000	61,000	9
	Long Trans.	71,000	59,000	4
	Short Trans.	69,000	58,000	3
Over 3 to 4, incl	Longitudinal	69,000	59,000	8
	Long Trans.	69,000	57,000	3
	Short Trans.	67,000	56,000	2
Over 4 to 5, incl	Longitudinal	67,000	56,000	7
	Long Trans.	67,000	56,000	3
	Short Trans.	66,000	55,000	2

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
50 to 75, incl	Longitudinal	490	420	9
	Long Trans.	490	405	4
	Short Trans.	475	400	3
Over 75 to 100, incl	Longitudinal	475	405	8
	Long Trans.	475	395	3
	Short Trans.	460	385	2
Over 100 to 125, incl	Longitudinal	460	385	7
	Long Trans.	460	385	3
	Short Trans.	455	380	2

3.3.2.1.3 Special Purpose Forgings: Tensile specimens cut from special purpose forgings or from forgings beyond the size and configuration limits of 3.3.2.1.1 and 3.3.2.1.2 or from prolongations on such forgings shall have tensile properties as specified on the drawing or as agreed upon by purchaser and vendor.

3.3.2.1.4 Section thickness at time of heat treatment shall determine the minimum mechanical properties provided the original as-forged thickness does not exceed the maximum thickness of 5 in. (125 mm) in Tables II and III. When the maximum thickness is over 5 to 8 in. (125 to 200 mm), the applicable thickness to establish properties shall be not less than one-half the original forged thickness.

3.3.2.2 Hardness: Forgings should have hardness not lower than shown in Table IV but forgings shall not be rejected on the basis of hardness if the tensile property requirements of 3.3.2.1.1 or 3.3.2.1.2 are met.

TABLE IV

Nominal Thickness		Hardness	
Inches	Millimetres	HB/10/500	HB/10/1000
Up to 3, incl	Up to 75, incl	135	140
Over 3 to 4, incl	Over 75 to 100, incl	125	130
Over 4 to 5, incl	Over 100 to 125, incl	119	124
Over 5	Over 125	As Agreed Upon	As Agreed Upon

3.3.2.3 Exfoliation-Corrosion Resistance: Specimens cut from forgings shall show a level of exfoliation-corrosion less than that pictured in Photo B, Fig. 2, of ASTM G34-72 at any plane.

3.3.2.4 Corrosion Resistance: Shall be as follows, determined in accordance with AMS 2355 or MAM 2355.

3.3.2.4.1 Indicator Test:

- 3.3.2.4.1.1 If the conductivity is 40.0% IACS (International Annealed Copper Standard) (23.2 MS/m) or higher and tensile properties meet specification requirements, the forgings are acceptable.
- 3.3.2.4.1.2 If the conductivity is 38.0 - 39.9% IACS (22.0 - 23.1 MS/m), incl, if the tensile properties meet specified requirements, and if the yield strength in the principal test direction does not exceed the specified minimum value by more than 9,900 psi (68 MPa), the forgings are acceptable.
- 3.3.2.4.1.3 If the conductivity is 38.0 - 39.9% IACS (22.0 - 23.1 MS/m), incl, and yield strength in the principal test direction exceeds the specified minimum by more than 9,900 psi (68 MPa), the forgings shall be given additional artificial aging and be retested.

3.3.2.4.2 Alternate Immersion Test: Specimens from forgings 0.750 in. (18.75 mm) and greater in least dimension shall show no evidence of stress-corrosion cracking when stressed in the short-transverse direction to 75% of the minimum yield strength specified for the principal test direction.

3.3.2.5 Stress-Corrosion Resistance: Specimens from forgings 0.750 in, (18.75 mm) and over in least dimension shall show no evidence of stress-corrosion cracking when stressed in the short-transverse direction to 75% of the specified minimum longitudinal yield strength.

3.4 Quality: Forgings, 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 forgings.

3.4.1 Grain flow of die forgings, except in areas which contain flash-line end grain, shall follow the general contour of the forgings, showing no evidence of re-entrant flow.

3.4.2 All hand forgings and, when specified, each die forging shall be subjected to ultrasonic inspection (See 8.1) in accordance with ASTM B594 and shall meet the following requirements:

3.4.2.1 Die forgings 0.500 to 4 in. (12.50 to 100 mm), incl, in nominal section thickness and weighing not over 300 lb (135 kg) shall meet Class B.

3.4.2.2 Hand forgings 1 to 5 in. (25 to 125 mm) in nominal section thickness and weighing not more than 600 lb (270 kg) shall meet Class A.

3.4.2.3 Acceptance standards for forgings exceeding the dimensional or weight limits of 3.4.2.1 or 3.4.2.2 shall be as agreed upon by purchaser and vendor.

4. QUALITY ASSURANCE PROVISIONS:

- 4.1 Responsibility for Inspection: The vendor of forgings 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 forgings conform to the requirements of this specification.
- 4.2 Classification of Tests:
- 4.2.1 Acceptance Tests: Tests to determine conformance to requirements for composition (3.1), corrosion resistance indicator test (3.3.2.4.1), tensile properties (3.3.2.1), grain flow (3.4.1) and, when specified, ultrasonic soundness (3.4.2) are classified as acceptance tests and shall be performed on each lot.
- 4.2.2 Periodic Tests: Tests to determine conformance to requirements for hardness (3.3.2.2) and resistance to stress corrosion alternate immersion test (3.3.2.4.2) 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 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, substantiating tests 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 annealed in the same batch furnace load or in a continuous furnace consecutively during an 8-hr period.
- 4.3.1 Prolongations, which shall remain attached to the -01 forgings that they represent or remnants of the forging from the forger's capability testing shall be identified for traceability to their production lot. These prolongations or remnants shall accompany the lot of forgings to the machine parts supplier to verify subsequent final heat treatment.
- 4.3.2 For Acceptance Tests: In accordance with AMS 2355 or MAM 2355.
- 4.3.3 For Periodic Tests and 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.