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

AEROSPACE MATERIAL SPECIFICATION

AMS 4111A
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UNS A97049

ALUMINUM ALLOY FORGINGS
7.7Zn - 2.5Mg - 1.5Cu - 0.16Cr (7049-T73)

1. SCOPE:

1.1 Form: This specification covers an aluminum alloy in the form of die forgings, hand forgings, and forging stock.

1.2 Application: Primarily for parts requiring high strength and resistance to stress-corrosion cracking.

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 - Control of Forgings Requiring First Article Approval
AMS 2808 - Identification, Forgings

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

ASTM B342 - Electrical Conductivity by Use of Eddy Currents
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
ASTM G47 - Determining Susceptibility to Stress-Corrosion Cracking of High Strength 7XXX Aluminum Alloy Products

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
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: The product shall be supplied in the following condition:

Ø 3.2.1 Die and Hand Forgings: Solution and precipitation 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 Forgings:

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

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	72,000 psi	(496 MPa)
Yield Strength at 0.2% Offset, min	62,000 psi	(427 MPa)
Elongation in 4D, min	7%	

3.3.1.1.2 Die Forgings:

3.3.1.1.2.1 With Grain Flow: Test specimens, machined from forgings with the axis of the specimen in the area of 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	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 51, incl	496	427	7
Over 51 to 102, incl	490	421	7
Over 102 to 127, incl	483	414	7

3.3.1.1.2.2 Across Grain Flow: Test specimens, machined from forgings with the axis of the 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.

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	421	3
Over 25 to 76, incl	483	414	3
Over 76 to 102, incl	483	414	2
Over 102 to 127, incl	469	400	2

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

3.3.1.1.3 Hand Forgings: Test specimens, machined from forgings having an essentially square or rectangular cross-section, shall have the properties shown in Table III provided that the as-forged section thickness does not exceed 5 in. (127 mm).

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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 Time of Heat Treatment Millimetres	Specimen Orientation	Tensile Strength MPa, min	Yield Strength at 0.2% Offset MPa, min	Elongation in 4D %, min
51 to 76, incl	Longitudinal	490	421	9
	Long Trans.	490	407	4
	Short Trans.	476	400	3
Over 76 to 102, incl	Longitudinal	476	407	8
	Long Trans.	476	393	3
	Short Trans.	462	386	2
Over 102 to 127, incl	Longitudinal	462	386	7
	Long Trans.	462	386	3
	Short Trans.	455	379	2

3.3.1.1.4 Special Purpose Forgings: Tensile test specimens cut from special purpose forgings or from forgings beyond the size and configuration limits of 3.3.1.1.2 and 3.3.1.1.3 shall have tensile properties as specified on the drawing or as agreed upon by purchaser and vendor.

3.3.1.2 Hardness: Forgings should have hardness not lower than shown in Table IV, determined in Ø accordance with ASTM E10, but the forgings shall not be rejected on the basis of hardness if the tensile property requirements of 3.3.1.1.2 or 3.3.1.1.3 are met.

TABLE IV

Nominal Thickness		Hardness	
Inches	(Millimetres)	HB/10/500 or HB/14.3/1000	HB/10/1000
Up to 3, incl	(Up to 76, incl)	135	140
Over 3 to 4, incl	(Over 76 to 102, incl)	125	130
Over 4 to 5, incl	(Over 102 to 127, incl)	119	124
Over 5	(Over 127)	As agreed upon	

3.3.1.3 Conductivity: Shall be as follows, determined in accordance with ASTM B 342 on the surface of sample:

3.3.1.3.1 If the conductivity is 40% IACS (International Annealed Copper Standard) or higher and tensile properties meet specified requirements, the forgings are acceptable.

3.3.1.3.2 If the conductivity is 38 - 39.9%, IACS, incl, if the tensile properties meet specified requirements, and if the longitudinal yield strength does not exceed the specified minimum value by more than 9,900 psi (68 MPa), the forgings are acceptable.

3.3.1.3.3 If the conductivity is 38 - 39.9% IACS, incl, and the longitudinal yield strength exceeds the specified minimum value by more than 9,900 psi (68 MPa), the forgings are suspect.

3.3.1.3.3.1 Forgings found to be suspect may be reprocessed or a sample of the forgings may be heated for not less than 30 min. at 875°F ± 10 (468°C ± 5) and quenched in cold water. Conductivity shall be measured within 15 min. after quenching. If the difference between this measurement and the original measurement on the forgings is 6% IACS or more, the forgings are acceptable. If the difference is less than 6% IACS, the forgings shall be reprocessed.

3.3.1.3.4 If the conductivity is below 38% IACS, the forgings are not acceptable and shall be reprocessed, regardless of property level.

3.3.1.4 Stress-Corrosion Resistance: Specimens from forgings 0.750 in. (19.0 mm) or greater in least dimension, stressed to 75% of the specified minimum longitudinal yield strength, shall meet the requirements of ASTM G47.

3.3.1.5 Grain Flow: Shall be as specified on the drawing or as agreed upon by purchaser and vendor.

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, a tensile test specimen taken from the heat treated coupon shall conform to the requirements of 3.3.1.1.1 and 3.3.1.2. If a test specimen taken from the stock after heat treatment in the same manner as forgings conforms to the requirements of 3.3.1.1.1 and 3.3.1.2, the test 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: Forgings, 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 forgings.

3.4.1 When specified, each forging (See 8.2) 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 0.500 to 4 in. (12.70 to 102 mm), incl, in nominal section thickness and weighing not over 300 lb (136 kg) shall meet Class B.

3.4.1.2 Hand forgings 1 to 5 in. (25 to 127 mm) in nominal section thickness and weighing not more than 600 lb (272 kg) shall meet Class A.

3.4.1.3 Standards for forgings exceeding the dimensional or weight limits of 3.4.1.1 or 3.4.1.2 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 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 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 Acceptance Tests: Tests to determine conformance to requirements for composition (3.1), tensile properties (3.3.1.1), hardness (3.3.1.2), conductivity (3.3.1.3), and ultrasonic soundness (3.4.1) when specified and for tolerances (3.5) of forging stock are classified as acceptance tests and shall be performed on each lot.

4.2.2 Periodic Tests: Tests of forgings to determine conformance to requirements for stress-corrosion resistance (3.3.1.4) and of forging stock to determine ability to develop required properties (3.3.2) 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 of forgings 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 on the first-article shipment of a forging 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.

4.2.3.1 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 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 the purchaser at the producer's facility.

4.3.1.1 Unless compliance with 4.3.1 is established, an analysis shall be made for each 6000 lb (2724 kg) or less of material comprising the lot except that not more than one analysis shall be required per piece.

4.3.2 Tensile Properties:

4.3.2.1 Die Forgings: At least one forging or one forging prolongation heat treated with each lot of forgings.

4.3.2.1.1 In lieu of a prolongation or separately-forged coupon, at least one tensile test specimen with the grain flow and one tensile test specimen across the grain flow shall be cut from the locations designated on the drawing from a forging representing each lot.

4.3.2.2 Hand Forgings: At least two tensile test 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. Specimens need not be taken in the longitudinal direction unless specifically required by purchaser.

4.3.3 Conductivity: Specimens shall be the samples from which the tensile test specimens are taken.