

AEROSPACE MATERIAL SPECIFICATION

Submitted for recognition as an American National Standard

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Superseding AMS 4333

ALUMINUM ALLOY, DIE FORGINGS
6.2Zn - 2.3Cu - 2.2Mg - 0.12Zr (7050-T7452)
Solution Heat Treated, Compression Stress- Relieved, and Overaged

UNS A97050

1. SCOPE:

1.1 Form:

This specification covers an aluminum alloy in the form of die forgings 4 inches (102 mm) and under in nominal thickness and of forging stock.

1.2 Application:

These forgings have been used typically for machined structural parts subject to warpage during machining and requiring high strength and resistance to stress-corrosion cracking, but usage is not limited to such application.

2. APPLICABLE DOCUMENTS:

The following publications form a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order.

2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

AMS 2355 Quality Assurance Sampling and Testing, Aluminum Alloys and Magnesium Alloys, Wrought Products, Except Forging Stock, and Rolled, Forged, or Flash Welded Rings

MAM 2355 Quality Assurance Sampling and Testing, Aluminum Alloys and Magnesium Alloys, Wrought Products, Except Forging Stock, and Rolled, Forged, or Flash Welded Rings, Metric (SI) Units

AMS 2808 Identification, Forgings

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2.2 ASTM Publications:

Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM B 594	Ultrasonic Inspection of Aluminum-Alloy Wrought Products for Aerospace Applications
ASTM B 645	Plane Strain Fracture Toughness Testing of Aluminum Alloys
ASTM B 660	Packaging/Packing of Aluminum and Magnesium Products
ASTM E 399	Plane-Strain Fracture Toughness of Metallic Materials
ASTM E 1417	Liquid Penetrant Examination

2.3 U.S. Government Publications:

Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

MIL-H-6088 Heat Treatment of Aluminum Alloys

2.4 ANSI Publications:

Available from American National Standards Institute, Inc, 11 West 42nd Street, New York, NY 10036-8002.

ANSI H35.2	Dimensional Tolerances for Aluminum Mill Products
ANSI H35.2M	Dimensional Tolerances for Aluminum Mill Products (Metric)

3. TECHNICAL REQUIREMENTS:

3.1 Composition:

Shall conform to the percentages by weight shown in Table 1, determined in accordance with AMS 2355 or MAM 2355.

TABLE 1 - Composition

Element	min	max
Zinc	5.7	6.7
Copper	2.0	2.6
Magnesium	1.9	2.6
Zirconium	0.08	0.15
Iron	--	0.15
Silicon	--	0.12
Manganese	--	0.10
Titanium	--	0.06
Chromium	--	0.04
Other Impurities, each	--	0.05
Other Impurities, total	--	0.15
Aluminum	remainder	

3.2 Condition:

3.2.1 Die Forgings: Solution heat treated in accordance with MIL-H-6088, stress-relieved by (R) compressing to produce a 1 to 5% permanent set, and overaged (See 8.2). Overaging shall be performed using furnace surveys and calibration of temperature controllers and recorders 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, determined in accordance with AMS 2355 or MAM 2355:

3.3.1 Die Forgings:

3.3.1.1 Tensile Properties: Shall be as follows:

3.3.1.1.1 With Grain Flow: Specimens, machined from forgings or from prolongations on such forgings, with axis of specimen in area of gage length varying not more than 15 degrees from parallel to the forging flow lines, shall have the properties shown in Table 2.

TABLE 2A - Minimum Tensile Properties, Inch/Pound Units

Nominal Thickness At Time Of Heat Treatment Inches	Tensile Strength ksi	Yield Strength at 0.2% Offset ksi	Elongation in 4D %
Up to 2, incl	72.0	60.0	9
Over 2 to 4, incl	71.0	59.0	8

TABLE 2B - Minimum Tensile Properties, SI Units

Nominal Thickness At Time Of Heat Treatment Millimeters	Tensile Strength MPa	Yield Strength at 0.2% Offset MPa	Elongation in 4D %
Up to 51, incl	496	414	9
Over 51 to 102, incl	490	407	8

3.3.1.1.2 Across Grain Flow: Specimens, machined from forgings or from prolongations on such forgings, with axis of specimen in area of gage length varying not more than 15 degrees from perpendicular to the forging flow lines, shall have properties shown in Table 3.

TABLE 3A - Minimum Tensile Properties, Inch/Pound Units

Nominal Thickness At Time Of Heat Treatment Inches	Tensile Strength ksi	Yield Strength at 0.2% Offset ksi	Elongation in 4D %
Up to 2, incl	68.0	55.0	5
Over 2 to 4, incl	67.0	53.0	4

TABLE3B - Minimum Tensile Properties, SI Units

Nominal Thickness At Time Of Heat Treatment Millimeters	Tensile Strength MPa	Yield Strength at 0.2% Offset MPa	Elongation in 4D %
Up to 51, incl	469	379	5
Over 51 to 102, incl	462	365	4

3.3.1.1.3 Special Purpose Forgings: Tensile specimens cut from special purpose forgings shall (R) meet the tensile property requirements specified on the drawing or as agreed upon by purchaser and vendor.

3.3.1.2 Corrosion Resistance: Resistance to stress-corrosion cracking and to exfoliation-corrosion of (R) the forging heat lot is acceptable if the conditions of 3.3.1.2.1 and 3.3.1.2.2 are met.

3.3.1.2.1 Electrical Conductivity: Shall be not lower than 38.0% IACS (International Annealed Copper Standard) (22.0 MS/m).

3.3.1.2.2 Stress-Corrosion Susceptibility Factor (SCF): Shall be not greater than 32.0 (220), determined by subtracting the electrical conductivity, AA.A% IACS (12 times BB.B MS/m) from the highest actual with grain yield strength limit, XX.X ksi (YYY MPa).

Examples:

Inch/Pound Units	72.0 ksi - 38.5% IACS = 33.5	Unacceptable
	68.0 ksi - 40.2% IACS = 27.8	Acceptable
SI Units	496 MPa - 12 X 22.3 MS/m = 228.4	Unacceptable
	469 MPa - 12 x 23.3 MS/m = 189.4	Acceptable

3.3.1.2.3 Forgings not conforming to 3.3.1.2.1 and 3.3.1.2.2 may be given additional overaging and retested to determine conformance to 3.3.1.1, 3.3.1.2.1, and 3.3.1.2.2.

3.3.1.3 Stress-Corrosion Resistance: Specimens, not less than 0.750 inch (19.05 mm) in thickness cut from forgings, shall show no evidence of stress-corrosion cracking when stressed in the short-transverse direction at 35.0 ksi (241 MPa).

3.3.1.4 Fracture Toughness: When specified, forgings shall meet the values of K_{IC} shown in Table 4, determined in accordance with ASTM B 645.

TABLE 4 – K_{IC} Minimum Values

Nominal Thickness Inches	Nominal Thickness Millimeters	Specimen Orientation	Minimum K_{IC} ksi $\sqrt{\text{in}}$	Maximum K_{IC} MPa $\sqrt{\text{m}}$
0.750 to 3.500, incl	19.05 to 88.90, incl	L-T	27	29.7
		T-L	19	20.0
		S-L	19	20.9
Over 3.500 to 4.000, incl	88.90 to 101.60, incl	L-T	25	27.5
		T-L	19	20.9
		S-L	19	20.9

3.3.1.4.1 All K_Q values shall meet all requirements of ASTM E 399 for K_{IC} except that invalid K_Q values which are meaningful as defined by ASTM B 645 and which equal or exceed the K_{IC} limit (3.3.1.4) shall be evidence of acceptable fracture toughness.

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 3.3.1.1. If specimens taken from the stock prior to forging and after heat treatment in the same manner as forgings conform to the requirements of 3.3.1.1, the tests shall be accepted as equivalent to tests of a forged coupon. The forging stock supplier, however, shall not be required to use unforged coupons when performing lot conformance testing.

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, each die forging shall be subjected to ultrasonic inspection in accordance with ASTM B 594 and shall meet Class B acceptance criteria.

3.4.2 When specified, each die forging shall be subjected to fluorescent penetrant inspection in accordance with ASTM E 1417. Forgings shall be free from surface defects such as seams, laps, bursts, and quench cracks.

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

3.5 Tolerances:
(R)

Forging stock shall conform to all applicable requirements of ANSI H35.2 or ANSI H35.2M.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection:
(R)

The vendor of forgings shall supply all samples for vendor's tests and shall be responsible for the performance of all required tests. Purchaser reserves the right to sample and to perform any confirmatory testing deemed necessary to ensure that the product conforms to specified requirements.

4.2 Classification of Tests:

4.2.1 Acceptance Tests: The following requirements are acceptance tests and, except for composition, shall be performed on each inspection lot:

4.2.1.1 Composition (3.1) of the product (See AMS 2355 or MAM 2355).

4.2.1.2 Tensile properties (3.3.1.1), corrosion resistance (3.3.1.2), and, when specified, fracture toughness (3.3.1.4), ultrasonic soundness (3.4.1), and fluorescent penetrant inspection (3.4.2).

4.2.1.3 Tolerances (3.5) of forging stock.

4.2.2 Periodic Tests: The following requirements are periodic tests and shall be performed at a frequency selected by the vendor unless frequency of testing is specified by purchaser:

4.2.2.1 Stress-corrosion resistance (3.3.1.3) of forgings.

4.2.2.2 Ability of forging stock to develop required properties (3.3.2).

4.2.2.3 Grain flow of die forgings (3.4.3).

4.3 Sampling and Testing:

Shall be in accordance with AMS 2355 or MAM 2355.