

AEROSPACE MATERIAL SPECIFICATION

SAE AMS4333

REV. C

Issued 1988-10
Revised 2009-09

Superseding AMS 4333B

Aluminum Alloy, Die Forgings
6.2Zn - 2.3Cu - 2.2Mg - 0.12Zr (7050-T7452)
Solution Heat Treated, Compression Stress-Relieved, and Overaged
(Composition similar to UNS A97050)

RATIONALE

AMS4333C corrects an error in Table 4.

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 issue of the following documents in effect on the date of the purchase order forms a part of this specification to the extent specified herein. The supplier may work to a subsequent revision of a document unless a specific document issue is specified. When the referenced document has been cancelled and no superseding document has been specified, the last published issue of that document shall apply.

2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

AMS2355	Quality Assurance, Sampling and Testing, Aluminum Alloys and Magnesium Alloys, Wrought Products, Except Forging Stock, and Rolled, Forged, or Flash Welded Rings
AMS2772	Heat Treatment of Aluminum Alloy Raw Materials
AMS2808	Identification, Forgings
AS1990	Aluminum Alloy Tempers

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SAE WEB ADDRESS:

2.2 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM B 594 Ultrasonic Inspection of Aluminum-Alloy Wrought Products for Aerospace Applications
ASTM B 645 Linear-Elastic Plane Strain Fracture Toughness Testing of Aluminum Alloys
ASTM B 660 Packaging/Packing of Aluminum and Magnesium Products
ASTM E 399 Linear Elastic Plane-Strain Fracture Toughness (K_{1c}) of Metallic Materials
ASTM E 1417 Liquid Penetrant Testing

2.3 ANSI Publications

Available from American National Standards Institute, 25 West 43rd Street, New York, NY 10036-8002, Tel: 212-642-4900, www.ansi.org.

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 AMS2355.

TABLE 1 - COMPOSITION

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

3.2 Condition

3.2.1 Die Forgings

Solution heat treated in accordance with AMS2772, stress-relieved by compressing to produce a 1 to 5% permanent set, and overaged to the T7452 temper (See AS1990) (See 8.2).

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 AMS2355 on the mill produced size.

3.3.1 Die Forgings

3.3.1.1 Tensile Properties

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

TABLE 3B - 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 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 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 percent 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 percent 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_{1C} shown in Table 4, determined in accordance with ASTM B 645.

TABLE 4 — K_{1C} MINIMUM VALUES

Nominal Thickness Inches	Nominal Thickness Millimeters	Specimen Orientation	Minimum K_{1C} ksi $\sqrt{\text{inch}}$	Minimum K_{1C} MPa $\sqrt{\text{m}}$
0.750 to 3.500, incl	19.05 to 88.90, incl	L-T	27	29.7
		T-L	19	20.9
		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_{1C} except that invalid K_Q values which are meaningful as defined by ASTM B 645 and which equal or exceed the K_{1C} 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 conditions 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 testing 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 reentrant grain flow.

3.5 Tolerances

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

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 AMS2355).
- 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 AMS2355 and the following:

- 4.3.1 Tensile specimens machined from forgings shall be excised from the area specified on the engineering drawing.