AEROSPACE MATERIAL SPECIFICATION

AMS4111	REV. E

Issued 1970-11
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Revised 2014-12

Superseding AMS4111D

Aluminum Alloy Forgings
7.7Zn - 2.5Mg - 1.5Cu - 0.16Cr (7049-T73)
Solution and Precipitation Heat Treated
(Composition similar to UNS A97049)

RATIONALE

AMS4111E corrects errors in referenced paragraphs (3.3.1.3.3, 3.3.1,3.4, 4.2.1, 4.2.2), revises Properties (3.3.1.2) and Reports (4.4), and clarifies test specimens taken from prolongations, forging stock or separately forged coupons (3.3.1.1.1).

1. SCOPE

1.1 Form

This specification covers an aluminum alloy in the form of die forgings or hand forgings up to 5 inches (125 mm) in thickness, and forging stock of any size (See 8.5).

1.2 Application

These products have been used typically for parts requiring high strength and resistance to stress-corrosion cracking, but usage is not limited to such applications.

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 canceled 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

TO PLACE A DOCUMENT ORDER: **Tel: 877-606-7323 (inside USA and Canada)**
Tel: +1 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
SAE WEB ADDRESS: **http://www.sae.org**

SAE values your input. To provide feedback on this Technical Report, please visit
http://www.sae.org/technical/standards/AMS4111E

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 Products for Aerospace Applications

ASTM E 10 Brinell Hardness of Metallic Materials

ASTM E 1004 Electrical Conductivity Using the Electromagnetic (Eddy Current) Method

ASTM G 47 Determining Susceptibility to Stress-Corrosion Cracking of High Strength Aluminum Alloy Products

2.3 ANSI Publications

Available from American National Standards Institute, 25 West 43rd Street, 4th Floor, New York, NY 10036, 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	--	0.25
Iron	--	0.35
Copper	1.2	1.9
Manganese	--	0.20
Magnesium	2.0	2.9
Chromium	0.10	0.22
Zinc	7.2	8.2
Titanium	--	0.10
Other Elements, each	--	0.05
Other Elements, total	--	0.15
Aluminum	remainder	

3.2 Condition

The product shall be supplied in the following condition:

3.2.1 Die and Hand Forgings

Solution and precipitation heat treated in accordance with AMS2772 to the T73 temper.

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:

3.3.1 Forgings

3.3.1.1 Tensile Properties

Shall be as follows:

3.3.1.1.1 Test Specimens

In the absence of a prolongation, test specimens machined from separately forged coupons or from forging stock, two inches thick or less, representing the forgings and, in either case, heat treated with the forgings represented shall have the properties shown in Table 2. Test specimens machined from prolongations of die forgings shall have the properties shown in Tables 3 and 4; prolongations of hand forgings shall have the properties shown in Table 5.

TABLE 2 - Minimum Tensile Properties

Property	Value
Tensile Strength	72 ksi (495 MPa)
Yield Strength at 0.2% Offset	62 ksi (425 MPa)
Elongation in 4D	7%

3.3.1.1.2 Die Forgings

3.3.1.1.2.1 With Grain Flow

Specimens, machined from forgings with the axis of the specimen in the area of gage length varying not more than 15 degrees from parallel to the forging flow lines, shall have the properties shown in Table 3 provided the as-forged thickness is not more than twice the heat treated thickness.

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	72	62	7
Over 2 to 4, incl	71	61	7
Over 4 to 5, incl	70	60	7

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

3.3.1.1.2.2 Across Grain Flow

Specimens, machined from forgings with the axis of the specimen in the area of gage length varying not more than 15 degrees from perpendicular to the forging flow lines, shall have the properties shown in Table 4 provided the as-forged thickness is not more than twice the heat treated thickness.

TABLE 4A - 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 1, incl	71	61	3
Over 1 to 3, incl	70	60	3
Over 3 to 4, incl	70	60	2
Over 4 to 5, incl	68	58	2

TABLE 4B - 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 1, incl	490	420	3
Over 1 to 3, incl	485	415	3
Over 3 to 4, incl	485	415	2
Over 4 to 5, incl	470	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 inch (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 inch (3 mm) of the trimmed flash line.

3.3.1.1.3 Hand Forgings

Specimens, machined from forgings having an essentially square or rectangular cross-section, shall have the properties shown in Table 5 provided that the as-forged section thickness does not exceed 5 inches (125 mm).

TABLE 5A - Minimum Tensile Properties, Inch/Pound Units

Nominal Thickness at Time of Heat Treatment Inches	Specimen Orientation	Tensile Strength ksi	Yield Strength at 0.2% Offset ksi	Elongation in 4D %
Over 2 to 3, incl	Longitudinal	71	61	9
	Long Trans.	71	59	4
	Short Trans.	69	58	3
Over 3 to 4, incl	Longitudinal	69	59	8
	Long Trans.	69	57	3
	Short Trans.	67	56	2
Over 4 to 5, incl	Longitudinal	67	56	7
	Long Trans.	67	56	3
	Short Trans.	66	55	2

TABLE 5B - Minimum Tensile Properties, SI Units

Nominal Thickness at Time of Heat Treatment Millimeters	Specimen Orientation	Tensile Strength MPa	Yield Strength at 0.2% Offset MPa	Elongation in 4D %
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

3.3.1.2 Mechanical properties outside the range covered by Tables 2, 3, 4 and 5 shall be agreed upon between purchaser and producer.

3.3.1.3 Conductivity

Shall be as follows, determined in accordance with ASTM E 1004 on the surface of sample:

3.3.1.3.1 If the conductivity is 40.0% 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 38.0 - 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 9.9 ksi (68 MPa), the forgings are acceptable.

3.3.1.3.3 If the conductivity is 38.0 - 39.9% IACS and the longitudinal yield strength exceeds the specified minimum by more than 9.9 ksi (68 MPa), specimens excised from the forgings shall meet the requirements of 3.3.1.3 or the forgings shall be given additional artificial aging to reduce the yield strength to a point less than 9.9 ksi (68 MPa) higher than the specified minimum.

3.3.1.3.4 If the conductivity is below 38% IACS, the forgings are not acceptable. Forgings may be additionally aged in accordance with AMS2772 and the conductivity (3.3.1.3) and tensile properties (3.3.1.1) retested; if the requirements are met the product is acceptable.

3.3.1.4 Stress-Corrosion Resistance

Specimens as in 4.3.4 from forgings 0.750 inch (19.0 mm) or greater in least dimension, stressed in the short-transverse direction (perpendicular, within ±15 degrees to the longitudinal grain flow and perpendicular, within ±15 degrees, to the parting plane) to 75% of the specified minimum longitudinal yield strength, shall meet the requirements of ASTM G 47.

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, specimens taken from the heat treated coupon shall conform to the requirements of 3.3.1.1.1 and 3.3.1.3. If specimens taken from the stock after heat treatment in the same manner as forgings conform to the requirements of 3.3.1.1.1 and 3.3.1.3, 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 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 When specified, each forging (See 8.2) shall be subjected to ultrasonic inspection in accordance with ASTM B 594 and, unless otherwise specified, shall meet the following requirements of that specification.

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

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

3.5 Tolerances

Tolerances for 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 the product 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

Composition (3.1), tensile properties (3.3.1.1), conductivity (3.3.1.3), and ultrasonic inspection (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

Stress-corrosion resistance (3.3.1.4) and grain flow (3.3.1.5) and tests 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.

4.3 Sampling and Testing

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-hour period.

4.3.1 Composition

At least one sample shall be taken by the producer from each group of ingots cast 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-pound (2700-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

One or more forgings or forging prolongations heat treated with each lot of forgings.

4.3.2.1.1 In lieu of a prolongation or separately-forged coupon, one or more tensile specimens with the grain flow and one or more tensile specimens 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 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 specimens are taken.

4.3.4 Stress-Corrosion Resistance

Samples shall be taken from a forging or forging prolongation. Specimens shall be not less than 0.750 inch (19 mm) cube.

4.4 Reports

4.4.1 The vendor of forgings shall furnish with each shipment a report stating that the chemical composition conforms to the requirements of this specification and, showing the numerical results of tests on each lot to determine conformance to the other acceptance test requirements, and stating that the forgings conform to the other technical requirements of this specification. This report shall include the purchase order number, lot number, AMS4111E, size or part number, and quantity.

4.4.1.1 When the product size is outside the range covered by Tables 2, 3, 4 or 5, the report shall contain a statement to that effect.

4.4.2 The vendor of forging stock shall furnish with each shipment a report stating that the chemical composition of the stock conforms to the requirements of this specification. This report shall include the purchase order number, AMS4111E, size, and quantity.

4.5 Resampling and Retesting

If any specimen used in the above tests fails to meet the specified requirements, disposition of the product may be based on the results of testing two additional specimens for each original nonconforming specimen. Retest specimens from forgings shall be taken from as close as possible to the same location in the same forging or a second forging from the same lot as was the original unacceptable specimen. Failure of any retest specimen to meet the specified requirements shall be cause for rejection of the product represented. Results of all tests shall be reported.

5. PREPARATION FOR DELIVERY

5.1 Identification

The product shall be identified as follows:

5.1.1 Forgings

In accordance with AMS2808.

5.1.2 Forging Stock

As agreed upon by purchaser and vendor.