AEROSPACE MATERIAL SPECIFICATION

AMS4146	REV. G

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Superseding AMS4146F

Aluminum Alloy Forgings and Rolled or Forged Rings
1.0Mg - 0.60Si - 0.28Cu - 0.20Cr (6061 - T4)
Solution Heat Treated and Naturally Aged
(Composition similar to UNS A96061)

RATIONALE

This document has been reaffirmed to comply with the SAE five-year review policy.

1. SCOPE

1.1 Form

This specification covers an aluminum alloy in the form of die forgings, hand forgings, rolled or forged rings, and forging stock.

1.2 Application

These products have been used typically for parts which will be welded or brazed to assemblies and then given further heat treatment to develop the full strength of which the alloy is capable, but usage is not limited to such applications.

1.2.1 Corrosion resistance of this alloy is generally superior to that of aluminum alloys containing copper as a principle alloying element.

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.

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/AMS4146G

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.

AMS2201	Tolerances, Aluminum and Aluminum Alloy Bar, Rod, Wire, and Forging Stock, Rolled or Cold Finished
AMS2355	Quality Assurance, Sampling and Testing, Aluminum Alloys and Magnesium Alloy, Wrought Products, Except Forging Stock, and Rolled, Forged, or Flash Welded Rings
AMS2645	Fluorescent Penetrant Inspection
AMS2770	Heat Treatment of Wrought Aluminum Alloy Parts
AMS2808	Identification, Forgings
AMS-H-6088	Heat Treatment of Aluminum Alloys

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 B 660	Packing/Packaging of Aluminum and Magnesium Products

3. TECHNICAL REQUIREMENTS

3.1 Composition

Shall conform to the percentages by weight as shown in Table 1, determined in accordance with AMS2355.

TABLE 1 - COMPOSITION

Element	min		max
Magnesium	0.8	-	1.2
Silicon	0.40	-	0.8
Copper	0.15	-	0.40
Chromium	0.04	-	0.35
Iron	--		0.7
Zinc	--		0.25
Manganese	--		0.15
Titanium	--		0.15
Other Impurities, each	--		0.05
Other Impurities, total	--		0.15
Aluminum	Remainder		

3.2 Condition

The product shall be supplied in the following condition:

3.2.1 Die Forgings, Hand Forgings, and Rolled Rings

Solution heat treated in accordance with AMS-H-6088 and naturally aged.

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 Die Forgings, Hand Forgings, and Rolled Rings

3.3.1.1 As Solution Heat Treated and Naturally Aged

3.3.1.1.1 Hardness

Shall be 50 - 80 HB/10/500 or 55 - 85 HB/10/1000 but product shall not be rejected on the basis of hardness if tensile properties after precipitation heat treatment meet all requirements of 3.3.1.2.1.

3.3.1.2 After Precipitation Heat Treatment

Shall be as follows after being precipitation heat treated to T62 temper in accordance with AMS2770:

3.3.1.2.1 Tensile Properties

Shall be as follows:

3.3.1.2.1.1 Test Specimens

Specimens machined from separately forged coupons or from stock representing the forgings and, in either case, heat treated with the forgings, shall have the properties in Table 2:

TABLE 2 - TENSILE PROPERTIES

Property	Minimum
Tensile Strength	38.0 ksi (262 MPa)
Yield Strength at 0.2% Offset	35.0 ksi (241 MPa)
Elongation in 4D	10%

3.3.1.2.1.2 Die Forgings

3.3.1.2.1.2.1 With Grain Fl ow

Specimens, machined from forgings 4 inches (102 mm) and under in nominal thickness with axis of specimen in area of gage length varying not more than 15 degrees from parallel to forging flow lines, shall have properties specified in Table 2 except that elongation may be as low as 7%.

3.3.1.2.1.2.2 Across Grain Flow

Specimens, machined from forgings 4 inches (102 mm) and under in nominal thickness with axis of specimen area of gage length varying not more than 15 degrees from perpendicular to forging flow lines, shall have properties specified in Table 2 except that elongation may be as low as 5%.

3.3.1.2.1.3 Hand Forgings

Specimens, machined from forgings 8 inches (203 mm) and under in nominal thickness shall have properties specified in Table 3; tests need not be made in the longitudinal direction unless specifically required by purchaser.

TABLE 3A - TENSILE PROPERTIES

Nominal Thickness Inches	Specimen Orientation	Tensile Strength ksi, min	Yield Strength at 0.2% Offset ksi, min	Elongation in 4D %, min
Up to 4, incl	Longitudinal	38.0	35.0	10
	Long Trans.	38.0	35.0	8
	Short Trans.	37.0	33.0	5
Over 4 to 8, incl	Longitudinal	37.0	34.0	8
	Long Trans.	37.0	34.0	6
	Short Trans.	35.0	32.0	4

TABLE 3B - TENSILE PROPERTIES (SI)

Nominal Thickness Millimeters	Specimen Orientation	Tensile Strength MPa, min	Yield Strength at 0.2% Offset MPa, min	Elongation in 5D %, min
Up to 102, incl	Longitudinal	262	241	9
	Long Trans.	262	241	7
	Short Trans.	255	228	4
Over 102 to 203, incl	Longitudinal	255	234	7
	Long Trans.	255	234	5
	Short Trans.	241	221	3

3.3.1.2.1.4 Rolled Rings

3.3.1.2.1.4.1 Tangential

Specimens, machined from rings 2.50 inches (63.5 mm) and under in nominal thickness with axis of specimen tangential to ring OD (axis parallel to direction of rolling), shall have properties specified in Table 2.

3.3.1.2.1.4.2 Axial

Specimens, machined from rings 2.50 inches (63.5 mm) and over in nominal thickness with axis of specimen approximately parallel to axis of the ring (axis transverse to direction of rolling), shall have properties as specified in Table 2 except that elongation may be as low as 8%.

3.3.1.2.1.5 Other Forgings

Tensile property requirements for die forgings, hand forgings, and rolled rings having nominal thickness greater than specified above shall be as agreed upon by purchaser and vendor.

3.3.1.2.2 Hardness

Should be not lower than 80 HB/10/500 or 85 HB/10/1000 but the product shall not be rejected on the basis of hardness if the applicable tensile property requirements are met.

3.3.1.3 Grain flow of die forgings, except in area which contains flash-line end grain, shall follow the general contour of the forgings- showing no evidence of reentrant grain flow.

3.3.2 Forging Stock

When a sample of stock is forged to a test coupon having a degree of mechanical working not greater than the forging and heat treated in the same manner as forgings, specimens taken from the heat treated coupon shall conform to the requirements of Table 2 and 3.3.1.2.2. If specimens taken from the stock after heat treatment in the same manner as forgings conform to the requirements of Table 2 and 3.3.1.2.2, the tests shall be accepted as equivalent to tests of a forged coupon.

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 Each die forging and, when specified, each rolled or forged ring shall be etched to produce a surface suitable for visual inspection. Surfaces shall be evaluated for defects such as seams, laps, bursts, and quench cracks. Surface imperfections which can be removed so that they do not reappear on re-etching and the required section thickness can be maintained are acceptable.

3.4.1.1 When approved by purchaser, a sampling plan may be used in lieu of etching each forging.

3.4.2 When specified, die forgings, hand forgings, and rolled forged rings shall be subjected to fluorescent penetrant inspection in accordance with AMS2645, to ultrasonic inspection in accordance with ASTM B 594, or to both. Standards for acceptance shall be as established by purchaser.

3.5 Tolerances

Forging stock shall conform to all applicable requirements of AMS2201.

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

Tests of the product for composition (3.1); of forgings for requirements for hardness as solution heat treated (3.3.1.1.1) and tensile properties after precipitation heat treatment (3.3.1.2.1); and of forging stock for tolerances (3.5) are acceptance tests and shall be performed on each lot.

4.2.2 Periodic Tests

Tests of die forgings for grain flow (3.3.1.3) and of forging stock to determine ability to develop required properties (3.3.2) are 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 in accordance with AMS2355. A lot shall be all forgings or rolled rings 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 eight-hour period. The maximum lot size for forgings and rolled rings heat treated in a continuous furnace shall be 6000 pounds (2722 kg).