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INTERNATIONAL
400 Commonwealth Drive, Warrendale, PA 15096-0001

AEROSPACE MATERIAL SPECIFICATION

SAE AMS-4133 | REV C

Issued 1972-05-15
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Superseding AMS-4133B

Submitted for recognition as an American National Standard

ALUMINUM ALLOY FORGINGS AND ROLLED RINGS
4.4Cu - 0.85Si - 0.80Mn - 0.50Mg (2014-T6)
Solution and Precipitation Heat Treated

UNS A92014

1. SCOPE:

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

1.2 Application: Primarily for aircraft structural members requiring moderately high strength. Certain design and processing procedures may cause these forgings and rolled rings to become susceptible to stress-corrosion cracking; ARP823 recommends practices to minimize such conditions.

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.

2.1.1 Aerospace Material Specifications:

AMS-2201 - Tolerances, Aluminum and Aluminum Alloy Bar, Rod, Wire, and Forging Stock, Rolled or Cold Finished
MAM-2201 - Tolerances, Metric, Aluminum and Aluminum Alloy Bar, Rod, Wire, and Forging Stock, Rolled, Drawn, or Cold Finished
AMS-2355 - Quality Assurance Sampling and Testing of Aluminum Alloys and Magnesium Alloys, Wrought Products (Except Forging Stock) and Flash Welded Rings
MAM-2355 - Quality Assurance Sampling and Testing of Aluminum Alloys and Magnesium Alloys, Wrought Products (Except Forging Stock) and Flash Welded Rings, Metric (SI) Units
AMS-2645 - Fluorescent Penetrant Inspection
AMS-2808 - Identification, Forgings

2.1.2 Aerospace Recommended Practices:

ARP823 - Minimizing Stress-Corrosion Cracking in Wrought Heat-Treatable Aluminum Alloy Products

2.2 ASTM Publications: Available from ASTM, 1916 Race Street, Philadelphia, PA 19103-1187.

ASTM B 660 - Packaging/Packing of Aluminum and Magnesium Products

2.3 U.S. Government Publications: Available from Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

2.3.1 Military Specifications:

MIL-H-6088 - Heat Treatment of Aluminum Alloys

2.3.2 Military Standards:

MIL-STD-2154 - Inspection, Ultrasonic, Wrought Metals, Process for

3. TECHNICAL REQUIREMENTS:

3.1 Composition: Shall conform to the following percentages by weight, Ø determined in accordance with AMS-2355 or MAM-2355:

	min	max
Copper	3.9	5.0
Silicon	0.50	1.2
Manganese	0.40	1.2
Magnesium	0.20	0.8
Iron	--	0.7
Zinc	--	0.25
Titanium	--	0.15
Chromium	--	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:

3.2.1 Die Forgings, Hand Forgings, and Rolled Rings: 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, Ø determined in accordance with AMS-2355 or MAM-2355:

3.3.1 Die Forgings, Hand Forgings, and Rolled Rings:

3.3.1.1 Tensile Properties: Shall be as follows:

3.3.1.1.1 Die Forgings:

3.3.1.1.1.1 With Grain Flow: Specimens, machined from forgings 4 inches (102 mm) Ø and under in nominal thickness at time of heat treatment or from prolongations on such forgings, with axis of 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 I provided the as-forged thickness is not more than twice the heat treated thickness.

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	65,000	56,000	6
Over 2 to 3, incl	65,000	55,000	6
Over 3 to 4, incl	63,000	55,000	6

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	448	386	6
Over 51 to 76, incl	448	379	6
Over 76 to 102, incl	434	379	6

3.3.1.1.1.2 Across Grain Flow: Specimens, machined from forgings 4 inches (102 mm) and under in nominal thickness at time of heat treatment or from prolongations on such forgings, with axis of 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 II provided the as-forged thickness is not more than twice the heat treated thickness. If configuration of the forging or prolongation cannot accommodate the transverse specimen described, acceptance of the forging shall be based on testing as in 3.3.1.1.1.3.

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	64,000	55,000	3
Over 1 to 2, incl	64,000	55,000	2
Over 2 to 4, incl	63,000	54,000	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	441	379	3
Over 25 to 51, incl	441	379	2
Over 51 to 102, incl	434	372	2

3.3.1.1.1.2.1 Elongation requirements shall not apply to specimens having a gage length diameter less than 0.250 inch (6.35 mm) or to specimens machined from locations in immediate proximity to an abrupt change in thickness or from locations such that any part of the specimen gage length is located within 1/8 inch (3.2 mm) of the trimmed flash line.

3.3.1.1.1.3 At Angle to Grain Flow: Specimens, machined from forgings 4 inches, (102 mm) and under in nominal thickness at time of heat treatment or from prolongations on such forgings, with the axis of specimen in the area of gage length varying more than 15 degrees from parallel and also more than 15 degrees from perpendicular to the forging flow lines, shall have the properties shown in Table II provided the as-forged thickness is not more than twice the heat treated thickness. Such test results shall be identified as neither longitudinal nor transverse tensile properties.

3.3.1.1.2 Hand Forgings: Specimens, machined from forgings 8 inches (203 mm) and under in nominal thickness at time of heat treatment and having an essentially square or rectangular cross-section, shall have the properties shown in Table III provided the as-forged thickness does not exceed 8 inches (203 mm).

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
Up to 2, incl	Longitudinal	65,000	56,000	8
	Long-Trans.	65,000	56,000	3
Over 2 to 3, incl	Longitudinal	64,000	56,000	8
	Long-Trans.	64,000	55,000	3
	Short-Trans.	62,000	55,000	2
Over 3 to 4, incl	Longitudinal	63,000	55,000	8
	Long-Trans.	63,000	55,000	3
	Short-Trans.	61,000	54,000	2
Over 4 to 5, incl	Longitudinal	62,000	54,000	7
	Long-Trans.	62,000	54,000	2
	Short-Trans.	60,000	53,000	1
Over 5 to 6, incl	Longitudinal	61,000	53,000	7
	Long-Trans.	61,000	53,000	2
	Short-Trans.	59,000	53,000	1
Over 6 to 7, incl	Longitudinal	60,000	52,000	6
	Long-Trans.	60,000	52,000	2
	Short-Trans.	58,000	52,000	1
Over 7 to 8, incl	Longitudinal	59,000	51,000	6
	Long-Trans.	59,000	51,000	2
	Short-Trans.	57,000	51,000	1

TABLE III (SI)

Nominal Thickness at Time of Heat Treatment Millimetres	Specimen Orientation	Tensile Strength MPa, min	Yield Strength at 0.2% Offset MPa, min	Elongation in 4D %, min
Up to 51, incl	Longitudinal	448	386	8
	Long-Trans.	448	386	3
Over 51 to 76, incl	Longitudinal	441	386	8
	Long-Trans.	441	379	3
	Short-Trans.	427	379	2
Over 76 to 102, incl	Longitudinal	434	379	8
	Long-Trans.	434	379	3
	Short-Trans.	421	372	2
Over 102 to 127, incl	Longitudinal	427	372	7
	Long-Trans.	427	372	2
	Short-Trans.	414	365	1
Over 127 to 152, incl	Longitudinal	421	365	7
	Long-Trans.	421	365	2
	Short-Trans.	407	365	1
Over 152 to 178, incl	Longitudinal	414	359	6
	Long-Trans.	414	359	2
	Short-Trans.	400	359	1
Over 178 to 203, incl	Longitudinal	407	352	6
	Long-Trans.	407	352	2
	Short-Trans.	393	352	1

3.3.1.1.3 Rolled Rings: Specimens, machined from rings 3.0 inches (76 mm) and under in nominal wall thickness at time of heat treatment with axis of specimen approximately tangential to the ring OD (axis parallel to direction of rolling) or with axis approximately parallel to axis of the ring (transverse to direction of rolling), shall have the properties shown in Table IV.

TABLE IV

Nominal Wall 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
Up to 2.5, incl	Tangential	65,000	55,000	7
	Axial	62,000	55,000	3
Over 2.5 to 3.0, incl	Tangential	65,000	55,000	6
	Axial	62,000	52,000	2

TABLE IV (SI)

Nominal Wall Thickness at Time of Heat Treatment Millimetres	Specimen Orientation	Tensile Strength MPa, min	Yield Strength at 0.2% Offset MPa, min	Elongation in 4D %, min
Up to 64, incl	Tangential	448	379	7
	Axial	427	379	3
Over 64 to 76, incl	Tangential	448	379	6
	Axial	427	359	2

3.3.1.1.4 Special Purpose Forgings: Tensile property requirements for specimens cut from special purpose forgings or from forgings or rolled rings beyond the size and configuration limits of 3.3.1.1.1, 3.3.1.1.2, and 3.3.1.1.3 shall be as specified on the drawing or as agreed upon by purchaser and vendor.

3.3.1.2 Hardness: Should be not lower than 120 HB/10/500 or 125 HB/10/1000 but Ø the forgings or rolled rings 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 areas which contain flash-line end grain, shall follow the general contour of the forgings showing no evidence of re-entrant grain flow.

3.3.2 Test Specimens: Specimens machined from separately-forged coupons or from forging stock representing the forgings and, in either case, heat treated with the forgings, shall have the following tensile properties:

Tensile Strength, minimum	65,000 psi (448 MPa)
Yield Strength at 0.2% Offset, minimum	56,000 psi (386 MPa)
Elongation in 4D, minimum	8%

3.3.3 Forging Stock: When a sample of stock is forged to a test coupon, with a Ø degree of mechnical working not greater than that of the forgings, and heat treated in the same manner as forgings, specimens taken from the heat treated coupon shall conform to the requirements of 3.3.1.2 and 3.3.2. If specimens taken from the stock after heat treatment in the same manner as forgings conform to the requirements of 3.3.1.2 and 3.3.2, 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 When specified, each die forging and rolled ring shall be etched to Ø 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.

3.4.2 When specified, die forgings, hand forgings, and rolled rings shall be Ø ultrasonically inspected in accordance with MIL-STD-2154 or other method acceptable to purchaser and shall meet the following requirements of MIL-STD-2154:

3.4.2.1 Die Forgings: Class B.

3.4.2.2 Hand Forgings and Rolled Rings: Class A.

3.4.3 When specified, each forging and rolled ring shall be subjected to Ø fluorescent penetrant inspection in accordance with AMS-2645 or other method acceptable to purchaser. Standards for acceptance shall be as agreed upon by purchaser and vendor.

3.5 Tolerances: Forging stock shall conform to all applicable requirements of AMS-2201 or MAM-2201.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection: The vendor of the product shall supply all Ø samples for vendor's tests and shall be responsible for performing all required tests. Purchaser reserves the right to sample and to perform any confirmatory testing deemed necessary to ensure that the product conforms to the requirements of this specification.

4.2 Classification of Tests:

4.2.1 Acceptance Tests: Tests for tensile properties (3.3.1.1), hardness Ø (3.3.1.2), and, when specified, visual (3.4.1), ultrasonic (3.4.2), and fluorescent penetrant inspection (3.4.3) 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 (3.3.3) 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 AMS-2355 or MAM-2355 and Ø the following:

4.3.1 Hardness (3.3.1.2): All die forgings and rolled rings. Ø

4.3.2 Surface Imperfections (3.4.1), Ultrasonic Inspection (3.4.2), and Fluorescent Penetrant Inspection (3.4.3), When Specified: All forgings and rolled rings.