AEROSPACE MATERIAL SPECIFICATION

AMS4133™	REV. F

Issued 1972-05
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Revised 2022-06

Superseding AMS4133E

Aluminum Alloy Forgings and Rolled Rings
4.4Cu - 0.85Si - 0.80Mn - 0.50Mg (2014-T6)
Solution and Precipitation Heat Treated
(Composition similar to UNS A92014)

RATIONALE

AMS4133F is the result of a Five-Year Review and update of this specification with changes to prohibit unauthorized exceptions (3.3.1.1.4, 3.6, 4.4.2, 8.5), update form (1.1), applicable documents (Section 2, 3.2.1, 3.4.3), ordering information (8.6), and to allow the use of the immediate prior specification revision (8.4).

1. SCOPE

1.1 Form

This specification covers an aluminum alloy in the form of die forgings up to 4 inches in nominal thickness, hand forgings up to 8 inches in nominal thickness, rolled rings up to 3 inches in nominal thickness, and forging stock (see 8.6).

1.2 Application

These products have been used typically 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 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 +1 724-776-4970 (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**

For more information on this standard, visit
https://www.sae.org/standards/content/AMS4133F/

ARP823 Minimizing Stress-Corrosion Cracking in Wrought High-Strength Aluminum Alloy Products

AS7766 Terms Used in Aerospace Metals Specifications

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 B594 Ultrasonic Inspection of Aluminum-Alloy Wrought Products

ASTM B660 Packaging/Packing of Aluminum and Magnesium Products

ASTM E1417/E1417M Liquid Penetrant Testing

2.3 ANSI Accredited Publications

Copies of these documents are available online at http://webstore.ansi.org/.

ANSI H35.1/H35.1M Standard Alloy and Temper Designation System for Aluminum

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	0.50	1.2
Iron	--	0.7
Copper	3.9	5.0
Manganese	0.40	1.2
Magnesium	0.20	0.8
Chromium	--	0.10
Zinc	--	0.25
Titanium	--	0.15
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 Forgings, Hand Forgings, and Rolled Rings

Solution and precipitation heat treated in accordance with AMS2772 to the T6 temper (refer to ANSI H35.1/H35.1M).

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, 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 Parallel with Grain Flow

Specimens, machined from heat treated 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 parallel to the forging flow lines shall have the properties shown in Table 2 provided the as-forged thickness is not more than twice the heat treated thickness. Test results may be identified as longitudinal tensile properties.

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 2 Inches or 4D %
Up to 2, incl	65.0	56.0	6
Over 2 to 3, incl	65.0	55.0	6
Over 3 to 4, incl	63.0	55.0	6

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 50.8 mm or 4D %
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 Perpendicular to Grain Flow

Specimens, machined from heat treated 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 3 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. Test results may be identified as transverse tensile properties.

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 2 Inches or 4D %
Up to 1, incl	64.0	55.0	3
Over 1 to 2, incl	64.0	55.0	2
Over 2 to 4, incl	63.0	54.0	2

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 50.8 mm or 4D %
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 3 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. Test results may be identified as at angle to the grain flow.

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 4 provided the as-forged thickness does not exceed 8 inches (203 mm).

Table 4A - 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 2 Inches or 4D %
Up to 2, incl	Longitudinal	65.0	56.0	8
	Long-Trans.	65.0	56.0	3
Over 2 to 3, incl	Longitudinal	64.0	56.0	8
	Long-Trans.	64.0	55.0	3
	Short-Trans.	62.0	55.0	2
Over 3 to 4, incl	Longitudinal	63.0	55.0	8
	Long-Trans.	63.0	55.0	3
	Short-Trans.	61.0	54.0	2
Over 4 to 5, incl	Longitudinal	62.0	54.0	7
	Long-Trans.	62.0	54.0	2
	Short-Trans.	60.0	53.0	1
Over 5 to 6, incl	Longitudinal	61.0	53.0	7
	Long-Trans.	61.0	53.0	2
	Short-Trans.	59.0	53.0	1
Over 6 to 7, incl	Longitudinal	60.0	52.0	6
	Long-Trans.	60.0	52.0	2
	Short-Trans.	58.0	52.0	1
Over 7 to 8, incl	Longitudinal	59.0	51.0	6
	Long-Trans.	59.0	51.0	2
	Short-Trans.	57.0	51.0	1

Table 4B - 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 50.8 mm or 4D %
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 5.

Table 5A - Minimum tensile properties, inch/pound units

Nominal Wall Thickness at Time of Heat Treatment Inches	Specimen Orientation	Tensile Strength ksi	Yield Strength at 0.2% Offset ksi	Elongation in 2 Inches or 4D %
Up to 2.5, incl	Tangential	65.0	55.0	7
	Axial	62.0	55.0	3
Over 2.5 to 3.0, incl	Tangential	65.0	55.0	6
	Axial	62.0	52.0	2

Table 5B - Minimum tensile properties, SI units

Nominal Wall Thickness at Time of Heat Treatment Millimeters	Specimen Orientation	Tensile Strength MPa	Yield Strength at 0.2% Offset MPa	Elongation in 50.8 mm or 4D %
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 Mechanical property requirement for product outside the range covered by 1.1 or Tables 2 to 5, as applicable, shall be agreed upon between purchaser and producer and reported per 4.4.2 (see 8.6).

3.3.1.2 Hardness

Shall be not lower than 120 HB/10/500 or 125 HB/10/1000 but 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 reentrant 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 tensile properties shown in Table 6.

Table 6 - Minimum tensile properties

Property	Value
Tensile Strength	65.0 ksi (448 MPa)
Yield Strength at 0.2%, Offset	56.0 ksi (386 MPa)
Elongation in 4D	8%

3.3.3 Forging Stock

When a sample of stock is forged to a test coupon, with a degree of mechanical 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 3.3.2. If specimens taken from the stock after heat treatment in the same manner as forgings conform to the requirements of 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 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 (see 8.6).

3.4.2 When specified, die forgings, hand forgings, and rolled rings shall be ultrasonically inspected in accordance with ASTM B594 or other method acceptable to purchaser and shall meet the following requirements of ASTM B594 (see 8.6).

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 fluorescent penetrant inspection in accordance with ASTM E1417/E1417M or other method acceptable to purchaser. Standards for acceptance shall be as agreed upon by purchaser and producer (see 8.6).

3.5 Tolerances

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

3.6 Exceptions

Any exceptions shall be authorized by the purchaser and reported as in 4.4.2.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection

The producer of the product shall supply all samples for producer'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) and, when specified, visual (3.4.1), ultrasonic (3.4.2), and fluorescent penetrant inspection (3.4.3) are acceptance tests and except for composition, shall be performed on each lot.

4.2.2 Periodic Tests

Grain flow of die forgings (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 producer unless frequency of testing is specified by purchaser.

4.3 Sampling and Testing

Shall be in accordance with AMS2355 and the following:

4.3.1 Surface Imperfections (3.4.1), Ultrasonic Inspection (3.4.2), and Fluorescent Penetrant Inspection (3.4.3),

When specified, all forgings and rolled rings.

4.4 Reports

4.4.1 The producer of the product shall furnish with each shipment a report stating that the product conforms to the composition, tolerances, and when specified, visual (surface), fluorescent penetrant and/or ultrasonic nondestructive tests, and showing the numerical results of tests on each inspection lot to determine conformance to the other acceptance test requirements. This report shall include the purchase order number, inspection lot number(s), AMS4133F, size, and quantity. The report shall also identify the producer, the product form, and the size of the mill product.

4.4.2 When material produced to this specification is beyond the sizes allowed in the scope or tables, or other exceptions are taken to the technical requirements listed in Section 3, the report shall contain a statement "This material is certified as AMS4133F(EXC) because of the following exceptions:" and the specific exceptions shall be listed.

4.4.3 The producer of forging stock shall furnish with each shipment a report stating that the composition of the stock conforms to the requirements of this specification. This report shall include the purchase order number, AMS4133F, size, and quantity.

4.5 Resampling and Retesting

Shall be in accordance with AMS2355.