



AEROSPACE MATERIAL SPECIFICATION

AMS-A-22771™**REV. D**

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Superseding AMS-A-22771C

Aluminum Alloy Forgings, Heat Treated

RATIONALE

AMS-A-22771D stabilizes this document because it is no longer state of the art and other documents contain similar but not necessarily equivalent requirements.

STABILIZED NOTICE

AMS-A-22771D has been declared "STABILIZED" by SAE AMS Committee D Nonferrous Alloys. This document was stabilized because this document contains mature technology that is not expected to change and thus no further revisions are anticipated. Previously this document was revised. The last technical update of this document occurred in September, 2012. Users of this document should refer to the cognizant engineering organization for disposition of any issues with reports/certifications to this specification; including exceptions listed on the certification.

NOTE: In many cases, the purchaser may represent a sub tier supplier and not the cognizant engineering organization.

AMS Committee D recommends that the following similar but not identical specifications be used for the "STABILIZED" specification.

AMS4107	Aluminum Alloy Die Forgings (7050-T74) Solution Heat Treated and Overaged
AMS4108	Aluminum Alloy, Hand Forgings, 6.2Zn - 2.3Cu - 2.2Mg - 0.12Zr (7050-T7452) Solution Heat Treated, Compression Stress-Relieved, and Overaged
AMS4111	Aluminum Alloy Forgings, 7.7Zn - 2.5Mg - 1.5Cu - 0.16Cr (7049-T73), Solution and Precipitation Heat Treated
AMS4126	Aluminum Alloy, Die and Hand Forgings and Rolled Rings, 5.6Zn - 2.5Mg - 1.6Cu - 0.23Cr (7075-T6) Solution and Precipitation Heat Treated
AMS4127	Aluminum Alloy, Forgings and Rolled Or Forged Rings, (6061-T6) Solution and Precipitation Heat Treated
AMS4131	Aluminum Alloy, Die and Hand Forgings, 5.6Zn - 2.5Mg - 1.6Cu - 0.23Cr (7075-T74), Solution Heat Treated and Aged
AMS4132	Aluminum Alloy, Die and Hand Forgings, Rolled Rings, and Forging Stock, 2.3Cu - 1.6Mg - 1.1Fe - 1.0Ni - 0.18Si - 0.07Ti (2618-T61), Solution and Precipitation Heat Treated

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Documents
Document Sharing Hub

AMS4133	Aluminum Alloy Forgings and Rolled Rings, 4.4Cu - 0.85Si - 0.80Mn - 0.50Mg (2014-T6), Solution and Precipitation Heat Treated
AMS4141	Aluminum Alloy Die Forgings, 5.6Zn - 2.5Mg - 1.6Cu - 0.23Cr (7075-T73), Solution and Precipitation Heat Treated
AMS4143	Aluminum Alloy Forgings and Rolled or Forged Rings, 6.3Cu - 0.30Mn - 0.18Zr - 0.10V - 0.06Ti (2219-T6), Solution and Precipitation Heat Treated
AMS4144	Aluminum Alloy, Hand Forgings and Rolled Rings, 6.3Cu - 0.30Mn - 0.18Zr - 0.10V - 0.06Ti (2219-T852/T851), Solution Heat Treated, Mechanically Stress Relieved, and Precipitation Heat Treated
AMS4147	Aluminum Alloy Forgings, 5.6Zn - 2.5Mg - 1.6Cu - 0.23Cr (7075-T7352) Solution Heat Treated, Stress Relieved by Compression, and Overaged
AMS4149	Aluminum Alloy, Die and Hand Forgings 5.6Zn - 2.5Mg - 1.6Cu - 0.23Cr (7175-T74) Solution and Precipitation Heat Treated
AMS4179	Aluminum Alloy Forgings 5.6Zn - 2.5Mg - 1.6Cu - 0.23Cr (7175-T7452) Solution Heat Treated, Stress Relieved, and Precipitation Heat Treated
AMS4247	Aluminum Alloy, Hand Forgings, 7.7Zn - 2.4Mg - 1.6Cu - 0.16Cr (7049-T7352) Solution Heat Treated, Stress Relieved by Compression, and Precipitation Heat Treated
AMS4248	Aluminum Alloy Hand Forgings and Rolled Rings, 1.0Mg - 0.60Si - 0.28Cu - 0.20Cr (6061-T652), Solution Heat Treated, Stress Relief Compressed, and Precipitation Heat Treated
AMS4310	Aluminum Alloy, Rolled or Forged Rings 5.6Zn - 2.5Mg - 1.6Cu - 0.23Cr (7075-T651, 7075-T652) Solution Heat Treated, Mechanically Stress Relieved and Precipitation Heat Treated
AMS4311	Aluminum Alloy, Rolled or Forged Rings, 5.6Zn - 2.5Mg - 1.6Cu - 0.23Cr (7075-T7351, 7075-T7352), Solution Heat Treated, Mechanically Stress Relieved, and Precipitation Heat Treated
AMS4312	Aluminum Alloy, Rolled or Forged Rings 1.0Mg - 0.60Si - 0.28Cu - 0.20Cr (6061-T651, 6061-T652) Solution Heat Treated, Mechanically Stress Relieved and Precipitation Heat Treated
AMS4314	Aluminum Alloy, Rings, Rolled Or Forged 4.5Cu - 0.85Si - 0.80Mn - 0.50Mg (2014-T651, 2014-T652) Solution Heat Treated, Mechanically Stress Relieved and Precipitation Heat Treated
AMS4323	Aluminum Alloy, Hand Forgings 5.6Zn - 2.5Mg - 1.6Cu - 0.23Cr (7075-T7452) Solution Heat Treated, Stress Relieved, and Precipitation Heat Treated

NOTICE

The initial SAE publication of this document was taken directly from U.S. Military Standard MIL-A-22771D. This SAE Standard may retain the same part numbers established by the original military document. Any requirements associated with Qualified Products Lists (QPL) may continue to be mandatory for DoD contracts. Requirements relating to QPLs have not been adopted by the SAE for this standard and are not part of this SAE document.

1. SCOPE

This specification has previously been widely used and may be required for production or processing of existing designs in the future. The Aerospace Materials Division, however, does not recommend this specification for future use in new designs (See 6.7).

1.1 Scope

This specification covers the requirements for heat treated aluminum alloy die forgings, hand forgings, and ring forgings, produced under additional mechanical property control to ensure known mechanical properties for parts used in aerospace critical applications. This specification also covers the requirements for forgings furnished in the F or O1 conditions which will ultimately be used in the heat treated condition.

1.2 Classification

The aluminum alloy forgings shall be furnished in the following alloys, tempers, and forms, as specified (See 6.2.):

1.2.1 Alloys and Tempers

2014-F, O1, T6, T652	6061-F, O1, T6, T652	7049-F, O1, T73, T7352
2219-F, O1, T6, T852	6151-F, O1, T6, T652	7050-F, O1, T74, T7452
2618-F, O1, T61		7075-F, O1, T6, T652, T73, T7352, T74, T7452
		7175-F, O1, T74, T7452, T7454

1.2.2 Form

Forgings shall be furnished in the form of die forgings, hand forgings or ring forgings. If the form is not specified, manufacturers may use any form of forging most convenient.

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 of Aluminum Alloys and Magnesium Alloys, Wrought Products (Except Forging Stock), and Rolled, Forged, or Flash Welded Rings
AMS2430	Shot Peening, Automatic
AMS2644	Inspection Material, Penetrant
AMS2658	Hardness and Conductivity Inspection of Wrought Aluminum Alloy Parts
AMS2772	Heat Treatment of Aluminum Alloy Raw Materials
AMS-STD-2154	Inspection, Ultrasonic, Wrought Metals, Process for

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 660	Packaging/Packing of Aluminum and Magnesium Products
ASTM E 1417	Liquid Penetrant Testing
ASTM G 47	Determining Susceptibility to Stress-Corrosion Cracking of 2XXX and 7XXX Aluminum Alloy Products

2.3 Aerospace Industries Association Publications

Available from the Aerospace Industries Association, 1000 Wilson Boulevard, Suite 1700, Arlington, VA 22209-3928, www.aia-aerospace.org.

NAS-410	Nondestructive Testing Personnel Qualification and Certification
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2.4 Aluminum Association Publications

Available from The Aluminum Association Inc., 1525 Wilson Blvd. Suite 600, Arlington, VA 22209, www.aluminum.org.

International Alloy Designations and Chemical Composition Limits for Wrought Aluminum and Wrought Aluminum Alloys (Teal Sheets)

2.5 Order of Precedence

In the event of a conflict between the text of the specification and the references cited herein, the text of this specification shall take precedence.

3. REQUIREMENT

3.1 Chemical Composition

The chemical composition of the forgings shall be as specified in Table 1 (See 4.4.1). In case of a discrepancy in the values listed in Table 1 with those listed in the "International Alloy Designations and Chemical Composition Limits for Wrought Aluminum and Wrought Aluminum Alloys" (known as the "Teal Sheets"), the composition limits registered with the Aluminum Association and published in the "Teal Sheets" should be considered the controlling composition.

3.2 Heat Treatment

Unless otherwise specified, forgings shall be heat treated in accordance with AMS2772. Forgings of alloy 7175 shall be heat treated in a manner that the heat treated forgings shall conform to all the requirements of this specification (See 6.2.10). Discoloration due to heat treatment shall not be cause for rejection.

3.3 Mechanical Properties

3.3.1 Die Forgings

Mechanical properties of die forgings as determined in accordance with 4.4.2 shall conform to the applicable properties specified in Tables 2 and 3. When die forgings are machined before heat treatment to sizes within the maximum section thickness specified in Tables 2 and 3, the mechanical properties in these tables are applicable, provided the as-forged thickness shall be not more than twice the heat treated thickness. For as-forged thickness greater than twice the heat treated thickness, the properties shall be as agreed between the contractor and the forging supplier or between the acquiring activity and the forging supplier or contractor (See 6.3.1).

3.3.1.1 Mechanical Property Control of First Production Parts

After forging techniques have been established, a forging representative of the first production parts shall be tested. Tensile test specimens shall be taken from location both in the direction parallel to, within ± 15 degrees of flow lines, and not parallel to the forging flow lines. The specimen location should be indicated on the forging engineering drawing. If the specimen locations are not indicated on the forging engineering drawing, they shall be taken from areas representative of thick and thin sections. The flow lines shall be determined as specified in 4.4.7. The mechanical properties shall be as specified in Table 2 and 3. For forgings too small to yield suitable test specimens, the tension test shall be waived or negotiated between the contractor and the forging supplier or between the acquiring activity and the forging supplier or contractor (See 6.3.1). This mechanical property control shall be repeated after any major change in the forging process, forging stock size or forging stock.

3.3.1.2 Mechanical Property Control of Production Parts

Samples for mechanical properties of production lots subsequent to the first production lot shall be taken as specified in AMS2355 and shall conform to the requirements of Table 2 and 3.

3.3.2 Hand Forgings

The mechanical properties of hand forgings as determined in accordance with 4.4.2 shall conform to the applicable properties specified in Table 4. The properties specified in Table 4 apply to hand forgings that are essentially rectangular in cross section. The requirement of long transverse and short transverse properties applies also to squares, even though transverse dimensions are equal. The forging process shall be controlled such that, the long transverse direction shall be perpendicular to the original stock axis, or both short transverse or long transverse properties shall meet the long transverse properties requirements. The direction of the long transverse properties shall be identified as specified in 3.8. For forgings too small to yield suitable test specimens, the method of tensile test shall be waived or negotiated between the contractor and forging supplier or between the acquiring activity and the forging supplier or contractor (See 6.3.1).

3.3.2.1 Large Hand Forgings

For hand forgings (1) of greater thickness or (2) heat treated in section thickness greater than covered by this specification, or (3) when the purpose of conditions under which the forging is to be used so dictates, the requirements shall be as specified in the contract, order or drawing. In such cases, the mechanical properties of test specimens taken from locations indicated on the drawing shall be as specified in the contract, order or drawing (See 6.3.1).

3.3.2.2 Machined Hand Forgings

When hand forgings are machined before heat treatment, the section thickness at time of heat treatment shall determine the minimum mechanical properties as long as the original (as forged) thickness does not exceed the maximum thickness for the alloy as shown in Table 4. When the maximum thickness in Table 4 is exceeded by not more than 3 inches, the applicable thickness to establish properties shall be not less than half the original forged thickness.

3.3.3 Special Purpose Forgings

Biscuits, octagons, mandrel rings, and contour hand forgings shall be classified as special purpose forgings. Mechanical properties of special purpose forgings shall be as negotiated between the contractor and the forging supplier or between the acquiring activity and the forging supplier or contractor (See 6.3.1). Testing to confirm mechanical properties shall be in accordance with 4.4.2.

3.3.4 Rolled Ring Forgings

The mechanical properties of rolled ring forgings shall be determined in accordance with 4.4.2 and shall conform to applicable properties specified in Table 5. For forgings too small to yield suitable test specimens, the method of tensile test shall be waived or negotiated between the contractor and the forging supplier or between the acquiring activity and the forging supplier or contractor (See 6.3.1).

3.3.5 Forging Supplied in "F" or "O1" Conditions

The mechanical properties of forgings supplied in "F" or "O1" conditions shall meet the requirements of Tables 2, 3, 4, and 5, or as required by drawing or contract order when heat treated to specified tempers in accordance with AMS2772.

3.4 Stress-Corrosion Cracking

3.4.1 Resistance to Stress-Corrosion Cracking

Forgings of alloys 7049, 7050, 7075, and 7175 supplied in the T73, T7352, T74, T7452, and T7454 tempers shall meet the following acceptance criteria, as applicable, and shall exhibit no evidence of stress-corrosion cracking when subjected to test specified in 4.4.8.

3.4.2 Acceptance Criteria for Stress-Corrosion Cracking by Conductivity Test

The capability of individual lots (See 4.3.1) to resist stress-corrosion cracking shall be determined by testing as specified in 4.4.9, and using the acceptance criteria specified as follows for the applicable aluminum alloy and temper.

3.4.2.1 7049-T73 and 7049-T7352

The acceptance criteria for the 7049-T73 and 7049-T7352 aluminum alloy forgings shall be as follows:

- a. If the electrical conductivity is 40.0 percent International Annealed Copper Standards (IACS) or greater and the tensile properties meet the minimum specified value, the lot is acceptable.
- b. If the electrical conductivity is 38.0 to 39.9 percent IACS, inclusive, and the longitudinal yield strength does not exceed the specified minimum by more than 9.9 ksi, the lot is acceptable.

- c. If the electrical conductivity is 38.0 to 39.9 percent IACS, inclusive, and the longitudinal yield strength exceeds the specified minimum by 10.0 ksi or more, the lot is acceptable provided it passes the stress-corrosion test specified in 4.4.8.
- d. If the electrical conductivity is less than 38.0 percent IACS, the lot is unacceptable.

3.4.2.2 7050-T74 and 7050-T7452

The acceptance criteria for the 7050-T74 and 7050-T7452 aluminum alloy forgings shall be as follows:

- a. If the electrical conductivity is 38.0 percent IACS or greater and the longitudinal yield strength (XX.X ksi) minus the electrical conductivity (XX.X percent IACS) is equal to or less than 32.0, the lot is acceptable. For die forgings only, the maximum yield strength shall also be 72 ksi.
- b. If the electrical conductivity is 38.0 percent IACS or greater and the longitudinal yield strength (XX.X ksi) minus the electrical conductivity (XX.X percent IACS) is greater than 32.0, the lot is acceptable provided it passes the stress-corrosion test specified in 4.4.8.
- c. If the electrical conductivity is less than 38.0 percent IACS, the lot is unacceptable.

3.4.2.3 7075-T73, 7075-T7352, 7075-T74, 7075-T7452, 7175-T74, 7175-T7452, and 7175-T7454

The acceptance criteria for the 7075-T73, 7075-T7352, 7075-T74, 7075-T7452, 7175-T74, 7175-T7452, and 7175-T7454 aluminum alloy forgings shall be as follows:

- a. If the conductivity is 40.0 percent IACS or higher and tensile properties meet the minimum values specified herein, the forgings shall be considered satisfactory.
- b. If the electrical conductivity is 38.0 to 39.9 percent IACS, inclusive, if tensile properties meet the minimum limits specified herein, and the longitudinal yield strength does not exceed the specified minimum by more than 11.9 ksi, the forgings shall be considered satisfactory.
- c. If conductivity is below 40.0 percent IACS and the longitudinal yield strength exceeds the specified minimum value by 12.00 ksi or more, the lot is unacceptable.
- d. If the conductivity is below 38.0 percent IACS, the material shall be considered unsatisfactory and must be reprocessed, regardless of property level.

3.5 Indications

3.5.1 Surface Indications

Forgings shall be free of surface defects such as seams, laps, bursts and quench cracks, when inspected as specified in 4.4.4 and 4.4.5.

3.5.2 Internal Indications

Limits of acceptability for ultrasonic inspection shall be in accordance with AMS-STD-2154, Class A for hand and ring forgings and Class B for die forgings, unless limits for acceptability of finished forgings are otherwise specified. Where forging thickness or configuration will not permit ultrasonic inspection, the forging stock shall be ultrasonically inspected to Class A limits as agreed upon by the contractor and the forging supplier. When die forgings are to be used in applications requiring a quality level higher than Class B limits, or for alloys not covered herein, the requirements shall be negotiated among the contractor, forging supplier and acquisition authority (See 4.4.6 and 6.2.1).

3.6 Grain-Flow Characteristics

The grain-flow pattern shall conform to specified forging drawing approved by the acquiring activity (See 6.3.1). Precaution should be taken to avoid simultaneous occurrence of sharply re-entrant flow lines and high tensile stresses in the region of the parting line (See 4.4.7 and 6.3.1).

3.7 Tolerances

The forgings shall conform to the shape and dimensions specified in the contract or purchase order within such variations as may be shown on the drawings (See 6.3.1).

3.8 Marking of Forgings

Forgings shall be marked with the commercial alloy designation and temper, ultrasonic symbol and the basic specification number in characters that are clearly legible and that shall not be obliterated by ordinary handling. For squares, the marking shall be on the face that is parallel to the direction of the long transverse properties but perpendicular to the direction of short transverse properties. The marking shall not be applied by the impression method, or by an electroetch or engraving method, unless it can be determined that all detrimental effects will be removed by subsequent machining. When specified (See 6.3.1), the marking of the commercial alloy designation, temper and basic specification number shall be continuous along the forging length (See 4.4.3).

3.9 Workmanship

The forgings shall be of uniform forging quality and condition, free from blisters, fins, folds, seams, laps, cracks, segregations, spongy areas or other indications which would adversely affect their serviceability. Apparent surface defects may be removed as required, provided section thicknesses, as defined by the drawing, can be maintained. Forgings shall not be repaired by plugging or welding.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection

Unless otherwise specified in the contract or purchase order, the contractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or purchase order, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.2 Classification of Inspections

The inspection requirements specified herein are classified as quality conformance inspections (See 4.3.2).

4.3 Sampling

Sampling for each inspection shall be in accordance with AMS2355. Unless otherwise specified, the sample unit shall be one finished forging and for Section 5 inspection, one container ready for shipment.

4.3.1 Lot

A lot shall consist of forgings of the same shape, same size, same alloy, and heat treated and aged in the same furnace charge. If forgings are heat treated in a continuous furnace, forgings charged consecutively during continuous operation of the furnace shall be considered a furnace charge; for such forgings weighing 5 pounds or less, the maximum weight of a lot shall be 2000 pounds, and for larger forgings, it shall be 6000 pounds.