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Title of Document: ALUMINUM ALLOY FORGINGS
7.7Zn-2.5Mg-1.5Cu-0.16Cr (7049-T73)
Solution and Precipitation Heat Treated

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# AEROSPACE MATERIAL SPECIFICATION

**AMS 4111B**
Superseding AMS 4111A

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## ALUMINUM ALLOY FORGINGS
## 7.7Zn - 2.5Mg - 1.5Cu - 0.16Cr (7049-T73)
## Solution and Precipitation Heat Treated

1. SCOPE:

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

1.2 Application: Primarily for parts requiring high strength and resistance to stress-corrosion cracking.

2. APPLICABLE DOCUMENTS: The following publications form a part of this specification to the extent specified herein. The latest issue of Aerospace Material Specifications (AMS) shall apply. The applicable issue of other documents shall be as specified in AMS 2350.

2.1 SAE Publications: Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096.

2.1.1 Aerospace Material Specifications:

AMS 2201 - Tolerances, Aluminum and Aluminum Alloy Bar, Rod, Wire, and Forging Stock, Rolled or Drawn
AMS 2350 - Standards and Test Methods
AMS 2375 - Control of Forgings Requiring First Article Approval
AMS 2808 - Identification, Forgings

2.2 ASTM Publications: Available from American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

ASTM B342 - Electrical Conductivity by Use of Eddy Currents
ASTM B557 - Tension Testing Wrought and Cast Aluminum- and Magnesium-Alloy Products
ASTM B594 - Ultrasonic Inspection of Aluminum-Alloy Products for Aerospace Applications
ASTM E10 - Brinell Hardness of Metallic Materials
ASTM E34 - Chemical Analysis of Aluminum and Aluminum Alloys
ASTM G47 - Determining Susceptibility to Stress-Corrosion Cracking of High Strength Aluminum Alloy Products

2.3 U.S. Government Publications: Available from Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.

2.3.1 Federal Standards:

Federal Test Method Standard No. 151 - Metals; Test Methods

2.3.2 Military Specifications:

MIL-H-6088 - Heat Treatment of Aluminum Alloys

2.3.3 Military Standards:

MIL-STD-649 - Aluminum and Magnesium Products, Preparation for Shipment and Storage

3. TECHNICAL REQUIREMENTS:

3.1 Composition: Shall conform to the following percentages by weight, determined by wet chemical methods in accordance with ASTM E34, by spectrographic methods in accordance with Federal Test Method Standard No. 151, Method 112, or by other analytical methods approved by purchaser:

| | min | max |
|---|---|---|
| Zinc | 7.2 | 8.2 |
| Magnesium | 2.0 | 2.9 |
| Copper | 1.2 | 1.9 |
| Chromium | 0.10 | 0.22 |
| Iron | -- | 0.35 |
| Silicon | -- | 0.25 |
| Manganese | -- | 0.20 |
| Titanium | -- | 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 and Hand Forgings: 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:

3.3.1 Forgings:

3.3.1.1 Tensile Properties: Shall be as follows, determined in accordance with ASTM B557:

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

| | | |
|---|---|---|
| Tensile Strength, min | 72,000 psi | (495 MPa) |
| Yield Strength at 0.2% Offset, min | 62,000 psi | (425 MPa) |
| Elongation in 4D, min | 7% | |

3.3.1.1.2 Die Forgings:

3.3.1.1.2.1 With Grain Flow: Test specimens, machined from forgings with the axis of the specimen in the area of gage length varying not more than 15 deg 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 | 72,000 | 62,000 | 7 |
| Over 2 to 4, incl | 71,000 | 61,000 | 7 |
| Over 4 to 5, incl | 70,000 | 60,000 | 7 |

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 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: Test specimens, machined from forgings with the axis of the specimen in the area of gage length varying not more than 15 deg 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.

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 | 71,000 | 61,000 | 3 |
| Over 1 to 3, incl | 70,000 | 60,000 | 3 |
| Over 3 to 4, incl | 70,000 | 60,000 | 2 |
| Over 4 to 5, incl | 68,000 | 58,000 | 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 | 490 | 420 | 3 |
| Over 25 to 75, incl | 485 | 415 | 3 |
| Over 75 to 100, incl | 485 | 415 | 2 |
| Over 100 to 125, 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 in. (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 in. (3 mm) of the trimmed flash line.

3.3.1.1.3 Hand Forgings: Test specimens, machined from forgings having an essentially square or rectangular cross-section, shall have the properties shown in Table III provided that the as-forged section thickness does not exceed 5 in. (125 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 |
|---|---|---|---|---|
| Over 2 to 3, incl | Longitudinal | 71,000 | 61,000 | 9 |
| | Long Trans. | 71,000 | 59,000 | 4 |
| | Short Trans. | 69,000 | 58,000 | 3 |
| Over 3 to 4, incl | Longitudinal | 69,000 | 59,000 | 8 |
| | Long Trans. | 69,000 | 57,000 | 3 |
| | Short Trans. | 67,000 | 56,000 | 2 |
| Over 4 to 5, incl | Longitudinal | 67,000 | 56,000 | 7 |
| | Long Trans. | 67,000 | 56,000 | 3 |
| | Short Trans. | 66,000 | 55,000 | 2 |

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 |
|---|---|---|---|---|
| 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 |

3.3.1.1.4 Special Purpose Forgings: Tensile specimens cut from special purpose forgings or from forgings beyond the size and configuration limits of 3.3.1.1.2 and 3.3.1.1.3 shall have tensile properties as specified on the drawing or as agreed upon by purchaser and vendor.

3.3.1.2 Hardness: Forgings should have hardness not lower than shown in Table IV, determined in accordance with ASTM E10, but the forgings shall not be rejected on the basis of hardness if the tensile property requirements of 3.3.1.1.2 or 3.3.1.1.3 are met.

TABLE IV

| Nominal Thickness | | Hardness | |
|---|---|---|---|
| Inches | (Millimetres) | HB/10/500 | HB/10/1000 |
| Up to 3, incl | (Up to 75, incl) | 135 | 140 |
| Over 3 to 4, incl | (Over 75 to 100, incl) | 125 | 130 |
| Over 4 to 5, incl | (Over 100 to 125, incl) | 119 | 124 |
| Over 5 | (Over 125) | As agreed upon | |

3.3.1.3 Conductivity: Shall be as follows, determined in accordance with ASTM B342 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 9,900 psi (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 9,900 psi (68 MPa), specimens excised from the forgings shall meet the requirements of 3.3.1.4 or the forgings shall be given additional artificial aging to reduce the yield strength to a point less than 9,900 psi (68 MPa) higher than the specified minimum.

3.3.1.3.4 If the conductivity is below 38% IACS, the forgings are not acceptable and shall be reprocessed, regardless of property level.

3.3.1.4 Stress-Corrosion Resistance: Specimens as in 4.3.4 from forgings 0.750 in. (19.0 mm) or greater in least dimension, stressed in the short-transverse direction (perpendicular to grain flow to 75% of the specified minimum longitudinal yield strength, shall meet the requirements of ASTM G47.

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 3.3.1.2. 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 3.3.1.2, 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 internal and external 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 B594 and, unless otherwise specified, shall meet the following requirements of that specification:

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

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

3.4.1.3 Standards for forgings exceeding the dimensional or weight limits of 3.4.1.1 or 3.4.1.2 shall be as agreed upon by purchaser and vendor.

3.5 Tolerances: Unless otherwise specified, tolerances for forging stock shall conform to all applicable requirements of AMS 2201.

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 performing all required tests. Results of such tests shall be reported to the purchaser as required by 4.5. 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 of forgings to determine conformance to requirements for composition (3.1), tensile properties (3.3.1.1), hardness (3.3.1.2), conductivity (3.3.1.3), and ultrasonic soundness (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: Tests of forgings to determine conformance to requirements for stress-corrosion resistance (3.3.1.4) and grain flow (3.3.1.5) and 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.

4.2.3 Preproduction Tests: Tests of forgings to determine conformance to all applicable technical requirements of this specification when AMS 2375 is specified are classified as preproduction tests and shall be performed prior to or on the first-article shipment of a forging to a purchaser, when a change in material or processing, or both, requires reapproval as in 4.4, and when purchaser deems confirmatory testing to be required.