

ALUMINUM ALLOY FORGINGS  
5.6Zn - 2.5Mg - 1.6Cu - 0.23Cr(7175-T736)  
Solution and Precipitation Heat Treated

1. SCOPE:

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

1.1.1 This specification now includes hand forgings and should be used where AMS 4109 has been specified.

1.2 Application: Primarily for parts requiring a combination of good 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 Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, PA 15096.

2.1.1 Aerospace Material Specifications:

AMS 2350 - Standards and Test Methods

AMS 2375 - Control of Forgings Requiring First Article Approval

AMS 2645 - Fluorescent Penetrant Inspection

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 B645 - Plane Strain Fracture Toughness Testing of Aluminum Alloys

ASTM E10 - Brinell Hardness of Metallic Materials

ASTM E34 - Chemical Analysis of Aluminum and Aluminum Alloys

ASTM E399 - Plane-Strain Fracture Toughness of Metallic Materials

ASTM G47 - Determining Susceptibility to Stress-Corrosion Cracking of High Strength 7XXX 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

MIL-I-8950 - Inspection, Ultrasonic, Wrought Metals, Process for

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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                    | 5.1       | 6.1  |
| Magnesium               | 2.1       | 2.9  |
| Copper                  | 1.2       | 2.0  |
| Chromium                | 0.18      | 0.28 |
| Iron                    | --        | 0.20 |
| Silicon                 | --        | 0.15 |
| Manganese               | --        | 0.10 |
| Titanium                | --        | 0.10 |
| Other Impurities, each  | --        | 0.05 |
| Other Impurities, total | --        | 0.15 |
| Aluminum                | remainder |      |

- 3.2 Condition: Solution and precipitation heat treated in accordance with the procedures and controls of MIL-H-6088.

- 3.3 Properties: Forgings shall conform to the following requirements:

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

3.3.1.1 Die Forgings:

- 3.3.1.1.1 With Grain Flow: Test specimens, machined from forgings 6 in. (152 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 the gage length varying not more than 15 deg from parallel to the forging flow lines, shall have the properties shown in Table I.

TABLE I

| Nominal Thickness<br>At Time<br>Of Heat Treatment<br>Inches | Tensile Strength<br>psi, min | Yield Strength<br>at 0.2% Offset<br>psi, min | Elongation<br>in 2 in. or 4D<br>%, min |
|-------------------------------------------------------------|------------------------------|----------------------------------------------|----------------------------------------|
| Up to 3, incl                                               | 76,000                       | 66,000                                       | 7                                      |
| Over 3 to 4, incl                                           | 73,000                       | 63,000                                       | 7                                      |
| Over 4 to 5, incl                                           | 70,000                       | 61,000                                       | 7                                      |
| Over 5 to 6, incl                                           | 68,000                       | 58,000                                       | 7                                      |

TABLE I (SI)

| Nominal Thickness<br>At Time<br>Of Heat Treatment<br>Millimetres | Tensile Strength<br>MPa, min | Yield Strength<br>at 0.2% Offset<br>MPa, min | Elongation<br>in 50 mm or 4D<br>%, min |
|------------------------------------------------------------------|------------------------------|----------------------------------------------|----------------------------------------|
| Up to 76, incl                                                   | 524                          | 455                                          | 7                                      |
| Over 76 to 102, incl                                             | 503                          | 434                                          | 7                                      |
| Over 102 to 127, incl                                            | 483                          | 421                                          | 7                                      |
| Over 127 to 152, incl                                            | 469                          | 400                                          | 7                                      |

- 3.3.1.1.2 Across Grain Flow: Test specimens, machined from forgings 6 in. (152 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 not more than 15 deg from perpendicular to the forging flow lines, shall have the properties shown in Table II. If configuration of the forging or prolongation cannot accommodate the transverse specimen described, acceptance of the forging shall be based on testing as in 3.3.1.1.3.

TABLE II

| Nominal Thickness<br>At Time<br>Of Heat Treatment<br>Inches | Tensile Strength<br>psi, min | Yield Strength<br>at 0.2% Offset<br>psi, min | Elongation<br>in 2 in. or 4D<br>%, min |
|-------------------------------------------------------------|------------------------------|----------------------------------------------|----------------------------------------|
| Up to 3, incl                                               | 71,000                       | 62,000                                       | 4                                      |
| Over 3 to 4, incl                                           | 70,000                       | 60,000                                       | 4                                      |
| Over 4 to 5, incl                                           | 68,000                       | 58,000                                       | 4                                      |
| Over 5 to 6, incl                                           | 65,000                       | 55,000                                       | 4                                      |

TABLE II (SI)

| Nominal Thickness<br>At Time<br>Of Heat Treatment<br>Millimetres | Tensile Strength<br>MPa, min | Yield Strength<br>at 0.2% Offset<br>MPa, min | Elongation<br>in 50 mm or 4D<br>%, min |
|------------------------------------------------------------------|------------------------------|----------------------------------------------|----------------------------------------|
| Up to 76, incl                                                   | 490                          | 427                                          | 4                                      |
| Over 76 to 102, incl                                             | 483                          | 414                                          | 4                                      |
| Over 102 to 127, incl                                            | 469                          | 400                                          | 4                                      |
| Over 127 to 152, incl                                            | 448                          | 379                                          | 4                                      |

- 3.3.1.1.2.1 Elongation requirements shall not apply to 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 At Angle to Grain Flow: Test specimens, machined from forgings 6 in. (152 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 deg from parallel and also more than 15 deg from perpendicular to the forging flow line, shall have the properties shown in Table II. Such test results shall be identified as neither longitudinal nor transverse tensile test results.

- 3.3.1.2 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 6 in. (152 mm).

TABLE III

| Nominal Thickness<br>At Time<br>Of Heat Treatment<br>Inches | Specimen<br>Orientation | Tensile<br>Strength<br>psi, min | Yield Strength<br>at 0.2% Offset<br>psi, min | Elongation<br>in 2 in. or 4D<br>%, min |
|-------------------------------------------------------------|-------------------------|---------------------------------|----------------------------------------------|----------------------------------------|
| Up to 2, incl                                               | Longitudinal            | 73,000                          | 63,000                                       | 9                                      |
|                                                             | Long Trans.             | 71,000                          | 60,000                                       | 5                                      |
| Over 2 to 3, incl                                           | Longitudinal            | 73,000                          | 63,000                                       | 9                                      |
|                                                             | Long Trans.             | 71,000                          | 60,000                                       | 5                                      |
|                                                             | Short Trans.            | 69,000                          | 60,000                                       | 4                                      |
| Over 3 to 4, incl                                           | Longitudinal            | 71,000                          | 61,000                                       | 9                                      |
|                                                             | Long Trans.             | 70,000                          | 58,000                                       | 5                                      |
|                                                             | Short Trans.            | 68,000                          | 57,000                                       | 4                                      |
| Over 4 to 5, incl                                           | Longitudinal            | 68,000                          | 57,000                                       | 8                                      |
|                                                             | Long Trans.             | 67,000                          | 56,000                                       | 5                                      |
|                                                             | Short Trans.            | 66,000                          | 55,000                                       | 4                                      |
| Over 5 to 6, incl                                           | Longitudinal            | 65,000                          | 54,000                                       | 8                                      |
|                                                             | Long Trans.             | 64,000                          | 52,000                                       | 5                                      |
|                                                             | Short Trans.            | 63,000                          | 52,000                                       | 4                                      |

TABLE III (SI)

| Nominal Thickness<br>At Time<br>Of Heat Treatment<br>Millimetres | Specimen<br>Orientation | Tensile<br>Strength<br>MPa, min | Yield Strength<br>at 0.2% Offset<br>MPa, min | Elongation<br>in 50 mm or 4D<br>%, min |
|------------------------------------------------------------------|-------------------------|---------------------------------|----------------------------------------------|----------------------------------------|
| Up to 51, incl                                                   | Longitudinal            | 503                             | 434                                          | 9                                      |
|                                                                  | Long Trans.             | 490                             | 414                                          | 5                                      |
| Over 51 to 76, incl                                              | Longitudinal            | 503                             | 434                                          | 9                                      |
|                                                                  | Long Trans.             | 490                             | 414                                          | 5                                      |
|                                                                  | Short Trans.            | 476                             | 414                                          | 4                                      |
| Over 76 to 102, incl                                             | Longitudinal            | 490                             | 421                                          | 9                                      |
|                                                                  | Long Trans.             | 483                             | 400                                          | 5                                      |
|                                                                  | Short Trans.            | 469                             | 393                                          | 4                                      |
| Over 102 to 127, incl                                            | Longitudinal            | 469                             | 393                                          | 8                                      |
|                                                                  | Long Trans.             | 462                             | 386                                          | 5                                      |
|                                                                  | Short Trans.            | 455                             | 379                                          | 4                                      |
| Over 127 to 152, incl                                            | Longitudinal            | 448                             | 372                                          | 8                                      |
|                                                                  | Long Trans.             | 441                             | 359                                          | 5                                      |
|                                                                  | Short Trans.            | 434                             | 359                                          | 4                                      |

- 3.3.1.3 Special Purpose Forgings: Tensile property requirements for specimens cut from special purpose forgings or from forgings beyond the size and configuration limits of 3.3.1.1 and 3.3.1.2 shall be as specified on the drawing or as agreed upon by purchaser and vendor.
- 3.3.2 Hardness: Should be as follows, determined in accordance with ASTM E10, but forgings shall not be rejected on the basis of hardness if the applicable tensile property requirements are met:
- 3.3.2.1 Die Forgings and Hand Forgings Up to 3 In. (76 mm), Incl, in Nominal Thickness: Not lower than 135 HB/10/500, 135 HB/14.3/1000, or 140 HB/10/1000.
- 3.3.2.2 Die Forgings and Hand Forgings Over 3 In. (76 mm) in Nominal Thickness: As agreed upon by purchaser and vendor.
- 3.3.3 Conductivity: Shall be as follows, determined in accordance with ASTM B342 on the surface of the sample:
- 3.3.3.1 If the conductivity is 40% IACS (International Annealed Copper Standard) or higher and tensile properties meet specified requirements, the forgings are acceptable.
- 3.3.3.2 If the conductivity is 38 - 39.9% IACS, incl, if the tensile properties meet specified requirements, and if the yield strength does not exceed the specified minimum by more than 11,900 psi (82 MPa), the forgings are acceptable.
- 3.3.3.3 If the conductivity is below 40% IACS and the yield strength exceeds the specified minimum value by more than 11,900 psi (82 MPa), the forgings are suspect.
- 3.3.3.3.1 When forgings are suspect, they may be reprocessed or a sample of the forgings may be heated for not less than 30 min. at 870°F ± 10 (465°C ± 5) and quenched in cold water. Conductivity shall be measured within 15 min. after quenching. If the difference between this measurement and the original measurement on the forgings is 6% IACS or more, the forgings are acceptable. If the difference is less than 6% IACS, the forgings shall be reprocessed.
- 3.3.3.4 If the conductivity is below 38% IACS, the forgings are not acceptable and shall be reprocessed, regardless of property level.
- 3.3.4 Stress-Corrosion Resistance: Specimens, cut from forgings 0.750 in. (19 mm) and over in nominal thickness and processed to meet the requirements of 3.3.1 and 3.3.3, stressed in the short-transverse direction (perpendicular to grain flow) to 35,000 psi (241 MPa) for forgings 3 in. (76 mm) and under in nominal thickness and to 50% of the longitudinal (parallel to grain flow) yield strength specified in 3.3.1 for forgings over 3 in. (76 mm) in nominal thickness and held at constant strain, shall meet the requirements of ASTM G47.

- 3.3.5 Fracture-Toughness: When specified, forgings having nominal thickness of 1.50 - 6.00 in. (38.1 - 152.4 mm), incl, shall meet the following values of  $K_{Ic}$ , determined in accordance with ASTM E399. The required test directions shall be specified by the purchaser.

| Test Direction | $K_{Ic}$ , min                                   |        |
|----------------|--------------------------------------------------|--------|
|                | psi $\sqrt{\text{in.}}$ (MPa $\sqrt{\text{m}}$ ) |        |
| Die Forgings   |                                                  |        |
| L-T            | 27,000                                           | (29.7) |
| T-L            | 21,000                                           | (23.1) |
| S-L            | 21,000                                           | (23.1) |
| Hand Forgings  |                                                  |        |
| L-T            | 30,000                                           | (33.0) |
| T-L            | 25,000                                           | (27.5) |
| S-L            | 21,000                                           | (23.1) |

- 3.3.5.1 All  $K_Q$  values shall meet all validity requirements of ASTM E399 for  $K_{Ic}$ , except that invalid  $K_Q$  values which are meaningful as defined by ASTM B645 and equal to, or greater than, the appropriate value of 3.3.5 shall be evidence of acceptable fracture toughness.
- 3.3.6 Grain Flow: Shall be as specified on the drawing or as agreed upon by purchaser and vendor.
- 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, forgings shall be subjected to ultrasonic inspection in accordance with MIL-I-8950 and, unless otherwise specified, shall meet the following requirements of that specification:
- 3.4.1.1 Die forgings 0.500 to 4.000 in. (12.70 to 101.60 mm), incl, in nominal thickness and weighing not over 300 lb (136 kg) shall meet Class B.
- 3.4.1.2 Hand forgings 1.000 to 6.000 in. (25.40 to 152.40 mm), incl, in nominal thickness and weighing not more than 600 lb (272 kg) shall meet Class A.
- 3.4.1.3 Acceptance criteria for forgings exceeding the limits of 3.4.1.1 or 3.4.1.2 shall be as agreed upon by purchaser and vendor.
- 3.4.2 When specified, forgings shall be subjected to fluorescent penetrant inspection in accordance with AMS 2645. Standards for acceptance shall be as agreed upon by purchaser and vendor.

#### 4. QUALITY ASSURANCE PROVISIONS:

- 4.1 Responsibility for Inspection: The vendor of forgings 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 forgings conform to the requirements of this specification.
- 4.2 Classification of Tests: