

Aluminum Alloy, Extrusion
2.7Cu - 1.8Li - 0.7Zn - 0.3Mn - 0.3Mg - 0.08Zr (2099-T81)
Solution Heat Treated, Stress Relieved by Stretching 1 to 3% and Aged

RATIONALE

AMS4459 is a new specification for 2099-T81 extrusions.

1. SCOPE

1.1 Form

This specification covers an aluminum alloy in the form of extruded bars, rods, and profiles (shapes) produced with cross sectional area of 22.5 square inches (145 cm²) maximum and a circumscribing circle diameter (circle size) of 17.4 inches (44.2 cm) maximum. See 8.3 for definition of circumscribing circle size.

1.2 Application

These extrusions have been used typically for machined parts requiring high strength with high toughness but usage is not limited to such applications.

1.3 Certain processing procedures may cause this product 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 Documents

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, Aluminum Alloys and Magnesium Alloy, Wrought Products (Except Forging Stock), and Rolled, Forged, or Flash Welded Rings

AMS2772 Heat Treatment of Aluminum Alloy Raw Materials

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

AS1990 Aluminum Alloy Tempers

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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 594	Ultrasonic Inspection of Aluminum-Alloy Wrought Products for Aerospace Applications
ASTM B 660	Packaging/Packing of aluminum and Magnesium Products.
ASTM B 666/B 666M	Identification Marking of Aluminum and Magnesium Products
ASTM E 1004	Determining Electrical Conductivity Using the Electromagnetic (Eddy-Current) Method
ASTM G 34	Exfoliation Corrosion Susceptibility in 2xxx and 7xxx Aluminum Alloys (EXCO Test)
ASTM G 47	Determining Susceptibility to Stress-Corrosion Cracking of 2XXX and 7XXX Aluminum Alloy Products
ASTM G 85	Modified Salt Spray (Fog) Testing, Annex A2 (cyclic acidified salt spray test - dry bottom MASTMAASIS)

2.3 ANSI Publications

Available from American National Standards Institute, 25 West 43rd Street, New York, NY 10036-8002, Tel: 212-642-4900, www.ansi.org.

ANSI H 35.2 Dimensional Tolerances for Aluminum Mill Products

ANSI H 35.2M 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	--	0.05
Iron	--	0.07
Copper	2.4	3.0
Manganese	0.10	0.50
Magnesium	0.10	0.50
Zinc	0.4	1.0
Titanium	--	0.10
Lithium	1.6	2.0
Zirconium	0.05	0.12
Beryllium	--	0.0001
Other impurities - each	--	0.05
Other impurities - total	--	0.15
Aluminum	Remainder	

3.2 Condition

Extruded, solution heat-treated and stress-relieved by stretching to produce a nominal permanent set of 1 to 3% (target of 2%) and then artificially aged to T81 (See AS1990).

3.2.1 Product shall be supplied with an as-extruded surface finish; light polishing to remove minor surface conditions is permissible provided such conditions can be removed within specified dimensional tolerances.

3.2.2 Product may receive minor straightening, after stretching, of an amount necessary to meet the requirements of 3.6.

3.3 Heat Treatment

3.3.1 Heat Treatment procedures shall be in accordance with the requirements of AMS2772 and the following:

3.3.1.1 Solution Heat Treatment Temperature

960 to 1020 °F (516 to 549 °C).

3.3.1.2 Aging Heat Treatment

Heat to 250 °F $\pm$ 10 (121 °C $\pm$ 6), hold at temperature for a time of 10 to 14 hours, then heat to 305 °F $\pm$ 10 (152 °C $\pm$ 6), hold at temperature for a time of 14 to 19 hours, and air cool.

3.4 Properties

Product shall conform to the following requirements, determined in accordance with AMS2355 on the mill product size:

3.4.1 Tensile Properties shall be as shown in Table 2A and 2B.

TABLE 2A - MINIMUM LONGITUDINAL TENSILE PROPERTIES, INCH/POUND UNITS

Nominal Thickness Inches	Test Direction	Tensile Strength ksi	Yield Strength at 0.2% Offset ksi	Elongation in 2 inches or 4D %
0.375 to 1.300 incl	L	73.0	59.0	7
	LT	63.0	51.0	7

TABLE 2B - MINIMUM LONGITUDINAL TENSILE PROPERTIES, SI UNITS

Nominal Thickness Millimeters	Test Direction	Tensile Strength MPa	Yield Strength at 0.2% Offset MPa	Elongation in 50.8 mm or 4D %
9.53 to 33.02	L	503	407	7
	LT	434	352	7

3.4.2 Fracture Toughness

When required by purchaser (See 8.8) plane strain fracture toughness shall be tested in accordance with ASTM E 399 and ASTM B 645. The test specimens shall meet the following requirements.

- 3.4.2.1 For the L-T test orientation use a test specimen having a width (W) of 2.0 inches (50.8 mm). For plate 0.500 to 1.000 inches (12.70 to 25.40 mm) in nominal thickness, the test specimen thickness (B) is full plate thickness. For plate 1.001 to 1.300 inches (25.43 to 33.02 mm) in nominal thickness, the test specimen thickness (B) shall be 1.00 inches (25.4 mm) and the specimen is centered at mid-thickness (T/2). When allowed by the profile shape, the test specimen (especially the pre-crack and crack path) shall be located away from junctions and other areas in the extruded shape with mixed grain flow.
- 3.4.2.2 A valid K_{Ic} meeting the requirements of ASTM E 399 or a K_Q "usable for lot release" in accordance with ASTM B 645 shall meet or exceed the values shown in Table 3.
- 3.4.2.3 For material less than 0.500 inch (12.70 mm) thick, when required by customer, sample size and test method shall be agreed upon by customer and supplier.

TABLE 3 - FRACTURE TOUGHNESS PARAMETERS

Nominal Thickness Inches	Nominal Thickness Millimeters	Specimen Orientation	Minimum K_{Ic} ksi $\sqrt{\text{inch}}$	Minimum K_{Ic} MPa $\sqrt{\text{m}}$
0.500 to 1.300, incl	Over 12.70 to 33.02, incl	L-T	45	49

3.4.3 Exfoliation Corrosion Resistance

Specimens cut from extrusions shall not exhibit exfoliation corrosion at a T/10 plane greater than that illustrated by Photo 2 (EB) from Figure 2 of ASTM G 34 when specimens are exposed for 2 weeks according to the procedures in ASTM G 85 Annex A2, using the dry-bottom MASTMAASIS Test Method. The solution used for exposure by ASTM G 34, the EXCO Test, has been determined to be inappropriate for Al-Li alloys (See 8.4).

3.4.4 Stress Corrosion Cracking

Specimens from extrusions with section thickness 0.750 inches (19.05 mm) and greater tested in accordance with ASTM G 47, shall show no evidence of stress corrosion cracking when stressed in the long transverse direction (perpendicular to grain flow) to 38.4 ksi (265 MPa).

3.5 Quality

Products, as received by purchaser, shall be uniform in quality and condition, sound and free from foreign materials and from conditions detrimental to usage of the extrusions.

- 3.5.1 When required by purchaser (See 8.8), each extrusion shall be subjected to ultrasonic inspection in accordance with ASTM B 594. Extrusions, 0.500 inch (12.7 mm) and over in nominal diameter or least distance between parallel sides, weighing 600 pounds (272 kg) and under shall meet ultrasonic Class B requirements, as described in ASTM B 594.

3.6 Tolerances

Shall conform to all applicable requirements of ANSI H35.2 or ANSI H35.2M.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility

The vendor of the products shall supply all samples for vendor'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 products conform to specified requirements.