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# AEROSPACE MATERIAL SPECIFICATION

Submitted for recognition as an American National Standard

AMS 4011A

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Superseding AMS 4011

## ALUMINUM FOIL
## 99.45Al (1145-0)
## Annealed

UNS A91145

1. SCOPE:

1.1 Form: This specification covers aluminum in the form of foil.

1.2 Application: Primarily for use in capacitors, electronic components, and sound/vibration damping tape.

2. APPLICABLE DOCUMENTS: The following publications form a part of this specification to the extent specified herein. The latest issue of Aerospace Material Specifications 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 2350 - Standards and Test Methods
AMS 2355 - Quality Assurance Sampling and Testing of Aluminum Alloys and Magnesium Alloys, Wrought Products (Except Forging Stock) and Flash Welded Rings
MAM 2355 - Quality Assurance Sampling and Testing of Aluminum Alloys and Magnesium Alloys, Wrought Products (Except Forging Stock) and Flash Welded Rings, Metric (SI) Units

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

ASTM B193 - Resistivity of Electrical Conductor Materials
ASTM E252 - Thickness of Thin Foil and Film by Weighing
ASTM E345 - Tension Testing of Metallic Foil





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Printed in U.S.A.

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

2.3.1 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, Ø determined in accordance with AMS 2355 or MAM 2355:

| | min | max |
|---|---|---|
| Aluminum | 99.45 | -- |
| Iron + Silicon | -- | 0.55 |
| Copper | -- | 0.05 |
| Magnesium | -- | 0.05 |
| Manganese | -- | 0.05 |
| Vanadium | -- | 0.05 |
| Zinc | -- | 0.05 |
| Titanium | -- | 0.03 |
| Other Impurities, each | -- | 0.03 |

3.2 Condition: Annealed, having a bright finish on one side and a matte finish on the other side.

3.2.1 Foil shall be supplied in rolls with a dry or slick surface condition, as ordered.

3.2.1.1 The surface condition of the foil may be determined by placing drops of water-alcohol solutions containing various percentages of alcohol on the foil and observing the wetting of the surfaces. The degree of oiliness shall be stated as wettable with 10% alcohol solution, 25% alcohol solution, etc.



3.3 Properties: Foil shall conform to the following requirements:

3.3.1 Tensile Strength: Shall be not higher than 14,000 psi (95 MPa), Ø determined in accordance with ASTM E345 on foil under 0.006 in. (0.15 mm) in nominal thickness.

3.3.2 Breaking Load: Specimens, 1 in. (25 mm) wide, of single thickness foil or complete specimens consisting of multiple thicknesses of foil shall conform to the following breaking load requirements; splices shall develop not less than 80% of the specified breaking load:

| Nominal Thickness | | Minimum Breaking Load | |
|---|---|---|---|
| Inch | Millimetre | Lb per In. of Width | N/m of Width |
| 0.00017 | 0.0042 | 1.1 | 193 |
| 0.00020 | 0.0050 | 1.3 | 228 |
| 0.00023 | 0.0058 | 1.4 | 245 |
| 0.00025 | 0.0062 | 1.6 | 280 |
| 0.00030 | 0.0075 | 1.9 | 333 |
| 0.00035 | 0.0088 | 2.2 | 385 |
| 0.00040 | 0.0100 | 2.6 | 455 |
| 0.00045 | 0.0112 | 2.9 | 508 |
| 0.00050 | 0.0125 | 3.2 | 560 |

3.3.2.1 Single-Thickness Tests: The average of five specimens, 1 in. (25 mm) wide clamped in testing machine jaws set at 5 in. (125 mm) apart and tested with load applied by operating testing machine at a rate of approximately 0.01 in./ in. per min. (0.01 mm/mm per min.) to slightly greater than the yield strength and then at a rate of 0.4 in./in. per min. (0.4 mm/mm per min.) to breaking load, shall conform to requirements of 3.3.2.

3.3.2.2 Multiple-Thickness Tests: Composite specimens, 1 in. (25 mm) wide by not less than 12 in. (300 mm) long consisting of five thicknesses of foil placed between two sheets of heavy paper clamped in testing machine jaws set at 8 in. (200 mm) apart and tested to failure with load applied at a uniform rate of approximately 0.5 lb per sec (2.2 N/s), shall conform to the requirements of 3.3.2. Breaking strength of the heavy paper, determined by testing specimens of the same type and weight of paper, shall be deducted from the composite specimen test results.

3.3.2.3 When results of tests obtained with multiple-thickness specimens do not agree with those obtained with single-thickness specimens, single-thickness test results shall apply.

3.3.3 Electrical Resistance: Foil, tested in accordance with ASTM B193 at 60° - 80°F (15° - 25°C), shall meet the following direct current electrical resistance requirements to an accuracy of ±0.003 ohms.

| Nominal Thickness | | Maximum DC Electrical Resistance Per Inch (25 mm) Width | |
|---|---|---|---|
| Inch | Millimetre | Ohm Per Foot of Length | Ohm/m of Length |
| 0.00017 | 0.0042 | 0.124 | 0.41 |
| 0.00020 | 0.0050 | 0.105 | 0.34 |
| 0.00023 | 0.0058 | 0.091 | 0.30 |
| 0.00025 | 0.0062 | 0.084 | 0.28 |
| 0.00030 | 0.0075 | 0.070 | 0.23 |
| 0.00035 | 0.0088 | 0.060 | 0.20 |
| 0.00040 | 0.0100 | 0.052 | 0.17 |
| 0.00045 | 0.0112 | 0.047 | 0.15 |
| 0.00050 | 0.0125 | 0.042 | 0.14 |

3.3.4 Nominal Covering Area: Using 32 sq in. (205 $cm^2$) specimens and a density of 0.0975 lb per cu in. (2700 $kg/m^3$), foil shall conform to the following requirements:

| Nominal Thickness | | Nominal Covering Area | |
|---|---|---|---|
| Inch | Millimetre | Sq In. Per Lb | $m^2/kg$ |
| 0.00017 | 0.0042 | 60,300 | 85.7 |
| 0.00020 | 0.0050 | 51,300 | 73.0 |
| 0.00023 | 0.0058 | 44,500 | 63.3 |
| 0.00025 | 0.0062 | 41,000 | 58.3 |
| 0.00030 | 0.0075 | 34,200 | 48.6 |
| 0.00035 | 0.0088 | 29,300 | 41.7 |
| 0.00040 | 0.0100 | 25,600 | 36.4 |
| 0.00045 | 0.0112 | 22,800 | 32.4 |
| 0.00050 | 0.0125 | 20,500 | 29.2 |

3.5 Quality: Foil, as received by purchaser, shall be uniform in quality and condition, sound, and free from holes, tears, and other discontinuities and from imperfections detrimental to usage of the foil. Dents, ripples, kinks, and sharp bends in the foil are acceptable provided they are located within 0.050 in. (1.25 mm) of an edge or are less than 0.030 in. (0.75 mm) deep. Foil shall be as free from grease and dirt as commercially practicable.

3.6 Tolerances: Shall be as follows:

3.6.1 Thickness: Shall not deviate from the thickness ordered by more than ±10%, determined by instrument measurement or by weighing method for thin foil in accordance with ASTM E252. When a dispute occurs between purchaser and vendor over thickness, values determined by the weighing method of ASTM E252 shall apply. For such calculations, density shall be taken as 0.0975 lb/cu in. (2700 $kg/m^3$).

3.6.2 Width:

| Nominal Width | | Tolerance, plus and minus | |
|---|---|---|---|
| Inch | Millimetres | Inch | Millimetre |
| Up to 12, excl | Up to 300, excl | 0.016 | 0.40 |
| 12 and Over | 300 and Over | 0.032 | 0.80 |

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection: The vendor of foil shall supply all samples Ø 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 4.4. Purchaser reserves the right to sample and to perform any confirmatory testing deemed necessary to ensure that the foil conforms to the requirements of this specification.

4.2 Classification of Tests:

4.2.1 Acceptance Tests: Tests to determine conformance to requirements for Ø composition (3.1), tensile strength (3.3.1), breaking load (3.3.2), nominal covering area (3.3.4), quality (3.5), and tolerances (3.6) are classified as acceptance tests and shall be performed on each lot.

4.2.2 Periodic Tests: Tests to determine conformance to requirements for Ø electrical resistance (3.3.3) are classified as periodic tests and shall be performed at a frequency selected by the vendor unless frequency of testing is specified by purchaser.

4.3 Sampling: Shall be in accordance with AMS 2355 or MAM 2355 and the Ø following:

4.3.1 For Tensile Testing: Specimens shall be cut with the axis of specimen Ø parallel to the direction of rolling; one specimen shall be selected for each 2000 lb (900 kg) or fraction thereof from each lot except that not more than one sample will be required from a roll.

4.3.2 For Thickness: Two specimens from each lot. Ø

4.4 Reports:

4.4.1 The vendor of foil shall furnish with each shipment a report stating that the foil conforms to the chemical composition and other technical requirements of this specification. This report shall include the purchase order number, lot number, AMS 4011A, size, and quantity.