SAE Aerospace
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AEROSPACE MATERIAL SPECIFICATION

SAE AMS 4011C

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Superseding AMS 4011B

Aluminum, Foil and Light Gage Sheet
99.45Al (1145-0)
Annealed

(Composition similar to UNS A91145)

1. SCOPE:

1.1 Form:

This specification covers aluminum in the form of foil and light gage sheet.

1.2 Application:

These products have been used typically for capacitors, electronic components, and sound/vibration damping tape, but usage is not limited to such applications.

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, 400 Commonwealth Drive, Warrendale, PA 15096-0001 or www.sae.org.

AMS 2355 Quality Assurance Sampling and Testing, Aluminum Alloys and Magnesium Alloys, Wrought Products, Except Forging Stock, and Rolled, Forged, or Flash Welded Rings

TO PLACE A DOCUMENT ORDER: **Tel: 877-606-7323 (inside USA and Canada)**
Tel: 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: custsvc@sae.org
SAE WEB ADDRESS: **http://www.sae.org**

2.2 ASTM Publications:

Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959 or www.astm.org.

ASTM B 193	Resistivity of Electrical Conductor Materials
ASTM E 252	Thickness of Thin Foil and Film by Weighing
ASTM E 345	Tension Testing of Metallic Foil

3. TECHNICAL REQUIREMENTS:

3.1 Composition:

Shall conform to the percentages by weight shown in Table 1, determined in accordance with AMS 2355.

TABLE 1 - Composition

Element	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:

Product shall be supplied as follows:

3.2.1 Foil: Annealed, having a bright finish on one side and a matte finish on the other side.

3.2.1.1 Foil shall be supplied in rolls with a dry or slick surface condition, as ordered. When a condition is not specified, either a dry or slick surface condition may be supplied.

3.2.1.1.1 The surface condition of the foil may be determined by placing drops of a water-alcohol solution 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.

3.2.2 Light Gage Sheet: Annealed, with either a bright finish or a matte finish unless a specific condition is specified by purchaser.

3.3 Properties:

The product shall conform to the following requirements:

3.3.1 Tensile Properties:

3.3.1.1 Foil: Shall be not higher than 14.0 ksi (96.5 MPa), determined in accordance with ASTM E 345 on foil under 0.006 inch (0.15 mm) in nominal thickness.

3.3.1.2 Light Gage Sheet: Shall be as shown in Table 2 for light gage sheet 0.006 to 0.030 inch (0.15 to 0.76 mm), inclusive, in nominal thickness, determined in accordance with AMS 2355.

TABLE 2A - Tensile Properties, Light Gage Sheet, Inch/Pound Units

Property	Value
Tensile Strength	8.0 to 13.0 ksi
Elongation in 2 inches, min	
Nominal Thickness	
0.006 to 0.019 inch, incl	15%
Over 0.019 to 0.030 inch, incl	20%

TABLE 2B - Tensile Properties, Light Gage Sheet, SI Units

Property	Value
Tensile Strength	55.2 to 89.6 MPa
Elongation in 50.8 mm, min	
Nominal Thickness	
0.15 to 0.48 inch, incl	15%
Over 48 to 0.76 inch, incl	20%

3.3.2 Breaking Load: Specimens, 1 inch (25 mm) wide, of single thickness product or complete specimens consisting of multiple thicknesses of product shall conform to the breaking load requirements shown in Table 3; splices shall develop not less than 80% of the specified breaking load.

TABLE 3A - Minimum Breaking Load, Inch/Pound Units

Nominal Inch	Pounds Force per Inch of Width
0.00017	1.1
0.00020	1.3
0.00023	1.4
0.00025	1.6
0.00030	1.9
0.00035	2.2
0.00040	2.6
0.00045	2.9
0.00050	3.2

TABLE 3B - Minimum Breaking Load, SI Units

Nominal Thickness Millimeters	N/m of Width
0.0043	193
0.0051	228
0.0058	245
0.0064	280
0.0076	333
0.0089	385
0.0102	455
0.0114	508
0.0127	560

3.3.2.1 Single-Thickness Tests: The average of five specimens, 1 inch (25 mm) wide clamped in testing machine jaws set at 5 inches (127 mm) apart and tested with load applied by operating testing machine at a rate of approximately 0.01 inch/inch per minute (0.01 mm/mm per minute) to slightly greater than the yield strength and then at a rate of 0.4 inch/inch per minute (0.4 mm/mm per minute) to breaking load, shall conform to requirements of 3.3.2.

3.3.2.2 Multiple-Thickness Tests: Composite specimens, 1 inch (25 mm) wide by not less than 12 inches (305 mm) long consisting of five thicknesses of foil placed between two sheets of heavy paper clamped in testing machine jaws set at 8 inches (203 mm) apart and tested to failure with load applied at a uniform rate of approximately 0.5 pounds force per second (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: Product, tested in accordance with ASTM B 193 at 60 to 80 °F (16 to 27 °C), shall meet the direct current electrical resistance requirements shown in Table 4 to an accuracy of ±0.003 ohms.

TABLE 4A - Maximum DC Electrical Resistance, Inch/Pound Units

Nominal Thickness Inch	Ohm Per Foot of Length for 1 Inch Width
0.00017	0.090
0.00020	0.077
0.00023	0.066
0.00025	0.061
0.00030	0.051
0.00035	0.044
0.00040	0.038
0.00045	0.034
0.00050	0.031

TABLE 4B - Maximum DC Electrical Resistance, SI Units

Nominal Thickness Inch	Ohm Per Foot of Length for 1 Inch Width
0.0043	0.75
0.0051	0.64
0.0058	0.55
0.0064	0.51
0.0076	0.43
0.0089	0.36
0.0102	0.32
0.0114	0.28
0.0127	0.25

3.3.4 Nominal Covering Area: Using 32 square inch (205 cm^2) specimens and a density of 0.0975 pounds per cubic inch (2700 kg/m^3), foil shall conform to requirements shown in Table 5.

TABLE 5A - Nominal Covering Area, Inch/Pound Units

Nominal Thickness Inch	Square Inch per Pound
0.00017	60,300
0.00020	51,300
0.00023	44,500
0.00025	41,000
0.00030	34,200
0.00035	29,300
0.00040	25,600
0.00045	22,800
0.00050	20,500

TABLE 5B - Nominal Covering Area, SI Units

Nominal Thickness Millimeter	m^2/kg
0.0043	85.7
0.0051	73.0
0.0058	63.3
0.0064	58.3
0.0076	48.6
0.0089	41.7
0.0102	36.4
0.0114	32.4
0.0127	29.2

3.4 Quality:

Product, 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 product. Dents, ripples, kinks, and sharp bends are acceptable provided they are located within 0.050 inch (1.27 mm) of an edge or for foil, under 0.006 inch (0.15 mm) thick, are less than 0.030 inch (0.76 mm) deep. Product shall be as free from grease and dirt as commercially practicable.

3.5 Tolerances:

Shall be as follows:

3.5.1 Thickness:

3.5.1.1 Foil: Shall not deviate from the thickness ordered by more than ±10%. When a dispute occurs between purchaser and vendor over thickness of foil, values determined by the weighing method of ASTM E 252 shall apply. For such calculations, density shall be taken as 0.0975 pounds per cubic inch (2699 kg/m^3).

3.5.1.2 Light Gage Sheet: Shall conform to the requirements shown in Table 6.

TABLE 6A - Thickness Tolerance, Plus and Minus, Inch/Pound Units

Specified Thickness Inch	Tolerance Inch
0.006 to 0.0104, incl	0.0005
Over 0.0104 to 0.0169, incl	0.001
Over 0.0169 to 0.030, incl	0.0015

TABLE 6B - Thickness Tolerance, Plus and Minus, SI Units

Specified Thickness Millimeter	Tolerance Millimeter
0.015 to 0.264, incl	0.013
Over 0.264 to 0.429, incl	0.025
Over 0.429 to 0.76, incl	0.038

3.5.2 Width:

3.5.2.1 Tolerance for foil up to 0.0059 inch (0.150 mm) thick shall be as shown in Table 7.

TABLE 7A - Width Tolerance for Foil and Light Gage Sheet, Plus or Minus, Inch/Pound Units

Nominal Width Inches	Tolerance Inch
Up to 12, excl	0.016
12 and Over	0.032

TABLE 7B - Width Tolerance for Foil and Light Gage Sheet, Plus or Minus, SI Units

Nominal Width Inches	Tolerance Inch
Up to 305, excl	0.41
305 and Over	0.81

3.5.2.2 Light Gage Sheet: Width tolerances for light gage sheet 0.006 to 0.030 inch (0.15 to 0.76 mm), inclusive, in nominal thickness shall be as shown in Table 8.

TABLE 8A - Width Tolerances, Light Gage Sheet, Inch/Pound Units

Nominal Width Inches				Tolerances Inch
	Up	to	5.99, incl	0.010
Over	5.99	to	11.99, incl	0.016
Over	11.99	to	23.99, incl	0.032
Over	23.99	to	47.99, incl	0.048
Over	47.99	to	60.00, incl	0.063
Over	60.00			0.125

TABLE 8B - Width Tolerances, Light Gage Sheet, SI Units

Nominal Width Millimeters				Tolerances Millimeters
	Up	to	152, incl	0.25
Over	152	to	305, incl	0.41
Over	305	to	609, incl	0.81
Over	609	to	1219, incl	1.22
Over	1219	to	1524, incl	1.60
Over	1524			3.18

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 the performance of all required tests. Purchaser reserves the right to sample and to perform any confirmatory testing deemed necessary to ensure that the product conforms to specified requirements.

4.2 Classification of Tests:

4.2.1 Acceptance Tests: Tests for composition (3.1), tensile strength (3.3.1.1 or 3.3.1.2 as applicable), breaking load (3.3.2), nominal covering area (3.3.4), quality (3.4), and tolerances (3.5) are acceptance tests and shall be performed on each lot.

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

4.3 Sampling and Testing:

Shall be in accordance with AMS 2355 and the following:

4.3.1 For Tensile and Breaking Load Tests: Specimens shall be cut with the axis of specimen parallel to the direction of rolling; one specimen shall be selected for each 2000 pounds (907 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 and Nominal Covering Area: Two specimens from each lot.

4.4 Reports:

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

4.5 Resampling and Retesting:

Shall be in accordance with AMS 2355.

5. PREPARATION FOR DELIVERY:

5.1 Sizes:

5.1.1 Product under 0.0010 inch (0.025 mm) in nominal thickness shall be supplied in rolls, wound on 3 inch (76 mm) ID cores. The diameter of the rolls shall be 6 to 12 inches (152 to 305 mm), inclusive.