SAE Aerospace
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AEROSPACE MATERIAL SPECIFICATION

AMS 4405

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Aluminum Alloy, Alclad Sheet (6156-T4)
1.0Si - 0.90Cu - 0.60Mn - 0.90Mg
Solution Heat Treated and Naturally Aged

(Composition similar to UNS AA6156)

RATIONALE

AMS 4405 is a new specification to cover aluminum alloy 6156-T4/T62 Alclad sheet.

1. SCOPE

1.1 Form

This specification covers an aluminum alloy procured in the form of sheet Alclad on both sides.

1.2 Application

These products have been used typically for formed structural parts requiring good formability in T4 temper and ability to develop improved resistance to fatigue crack growth and high toughness with moderate strength when aged to T62 temper, 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 canceled and no superseding document has been specified, the last published issue of that document shall apply.

2.1 SAE Publications

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.

AMS 2355	Quality Assurance Sampling and Testing, Aluminum Alloys and Magnesium Alloys, Wrought Products, Except Forging Stock and Rolled, Forged, or Flash Welded Rings
AMS 2772	Heat Treatment of Aluminum Alloy Raw Materials
ARP826	Minimizing Stress-Corrosion Cracking in Wrought Heat-Treatable Aluminum Alloy Products
AS1990	Aluminum Alloy Tempers

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 660	Packaging/Packing of Aluminum and Magnesium Products
ASTM B 666/B666M	Identification Marking of Aluminum and Magnesium Products
ASTM E 647	Measurement of Fatigue Crack Growth Rates

2.3 ANSI Publications

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

ANSI H35.2	Dimensional Tolerances for Aluminum Mill Products
ANSI H35.2M	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 AMS 2355.

TABLE 1 - COMPOSITION, CORE (6156)

Element	min	max
Silicon	0.7	1.3
Iron	--	0.20
Copper	0.7	1.1
Manganese	0.40	0.7
Magnesium	0.6	1.2
Chromium	--	0.25
Zinc	0.10	0.7
Other Elements, each	--	0.05
Other Elements, total	--	0.15
Aluminum	remainder	

TABLE 2 - COMPOSITION, CLADDING (1300)

Element	min	max
Silicon	--	0.20
Iron	--	0.30
Copper	--	0.05
Manganese	--	0.03
Magnesium	--	0.03
Zinc	0.20	0.50
Titanium	--	0.03
Other Elements, each	--	0.05
Other Elements, total	--	0.15
Aluminum	remainder	

3.2 Condition

Solution heat treated and naturally aged to T4 temper (See AS1990).

3.3 Heat Treatment

Shall be performed in accordance with AMS 2772, except the solution heat treating temperature will be 1010 to 1025 °F (543 to 552 °C).

3.4 Properties

Material shall conform to the following requirements, determined on the mill produced size in accordance with AMS 2355.

3.4.1 As Solution Heat Treated and Naturally Aged to T4

3.4.1.1 Tensile Properties

Shall be as shown in Table 3.

TABLE 3A - T4 MINIMUM TENSILE PROPERTIES, INCH/POUND UNITS

Nominal Thickness Inches	Specimen Orientation	Tensile Strength ksi	Yield Strength at 0.2% Offset ksi	Elongation in 2 inches or 4D %
Over 0.078 to 0.197, incl	Long-Transverse	40.0	24.0	15

TABLE 3B - T4 MINIMUM TENSILE PROPERTIES, SI UNITS

Nominal Thickness Millimeters	Specimen Orientation	Tensile Strength MPa	Yield Strength at 0.2% Offset MPa	Elongation in 50.8 mm or 4D %
2.00 to 5.0 mm, incl.	Long-Transverse	276	165	15

3.4.1.2 Bending

Product shall withstand, without cracking, bending at room temperature through an angle of 180 degrees around a diameter equal to the bend factor shown in Table 4 times the nominal thickness of the product with axis of bend parallel to the direction of rolling.

TABLE 4 - BENDING PARAMETERS

Nominal Thickness Inches	Nominal Thickness Millimeters	Bend Factor
0.078 to 0.197, incl	2.0 to 5.0, incl	3

3.4.1.3 Minimum Average Cladding Thickness

Shall be as shown in Table 5.

TABLE 5 - MINIMUM AVERAGE CLADDING THICKNESS

Nominal Thickness Inches	Nominal Thickness Millimeters	Cladding Thickness Per Side % of Total Thickness
0.078 to 0.197, incl	2.0 to 5.0, incl	2.0

3.4.2 Response to Precipitation Heat Treatment to T62 Temper

The product supplied in T4 temper, as received by purchaser, shall have the properties shown in 3.4.2.1 after being aged to T62 in accordance with AMS 2772 and as follows:

Age for 4 to 6 hours at 365 to 375 °F (185 to 190 °C)

3.4.2.1 Tensile Properties

Shall be as shown in Table 6.

TABLE 6A - T62 MINIMUM TENSILE PROPERTIES, INCH/POUND UNITS

Nominal Thickness Inches	Specimen Orientation	Tensile Strength ksi	Yield Strength at 0.2% Offset ksi	Elongation in 2 inches or 4D %
Over 0.078 to 0.197, incl	Transverse	52.0	47.0	8

TABLE 6B - T62 MINIMUM TENSILE PROPERTIES, SI UNITS

Nominal Thickness Inches	Specimen Orientation	Tensile Strength MPa	Yield Strength at 0.2% Offset MPa	Elongation in 50.8 mm or 4D %
2.0 to 5.0 mm, incl.	Transverse	358	324	8

3.4.2.2 Fatigue Crack Growth Rate (FCGR)

Shall not be higher than the rate (da/dN) shown in Table 7 at a DK of 30 ksi√inch (33 Mpa√m), determined in the T-L orientation in accordance with ASTM E 647, using the center-cracked tension M(T) specimen , a positive K gradient, a stress ratio R of plus 0.1, and a testing frequency between 2 to 10 Hertz.

TABLE 7 - MAXIMUM FATIGUE CRACK GROWTH RATE

Normal Thickness Inch	Normal Thickness Millimeters	da/dN inch/cycle	da/dN mm/cycle
0.078 to 0.197, incl	2.0 to 5.0, incl	2.55E-04	6.5E-03

3.5 Quality

Product, as received by purchaser, shall be uniform in quality and condition, sound, and free from foreign materials and imperfections detrimental to usage of the product.

3.6 Tolerances

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

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 products conform to specified requirements.

4.2 Classification of Tests

4.2.1 Acceptance Tests

Composition (3.1), tensile properties (3.4.1.1), bend test (3.4.1.2), response to heat treatment (3.4.2) and tolerances (3.6) are acceptance tests and, except for composition, shall be performed on each inspection lot.

4.2.2 Periodic Tests

Fatigue crack growth rate (3.4.2.2) and cladding thickness (3.4.1.3) are periodic tests and shall be performed at a frequency selected by the vendors unless frequency of testing is specified by purchaser.