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AEROSPACE MATERIAL SPECIFICATION

AMS 4177A
Superseding AMS 4177

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CORE, FLEXIBLE HONEYCOMB, ALUMINUM ALLOY, TREATED
For Sandwich Construction
5056, 175 (350)

1. SCOPE:

1.1 Form: This specification covers an aluminum alloy in the form of honeycomb core in a non-hexagonal, flexible cell configuration, the core being treated for increased corrosion resistance and furnished only in the expanded form.

1.2 Application: Primarily for use in contoured sandwich construction for short-term service up to 175°C (350°F) or for long-term service up to 95°C (200°F).

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 SAE, 400 Commonwealth Drive, Warrendale, PA 15096.

2.1.1 Aerospace Material Specifications:

AMS 2350 - Standards and Test Methods
AMS 4005 - Aluminum Alloy Foil, 5.0Mg - 0.12Mn - 0.12Cr (5056-H191)

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

ASTM B117 - Salt Spray (Fog) Testing
ASTM C273 - Shear Test in Flatwise Plane of Flat Sandwich Constructions or Sandwich Cores
ASTM C365 - Flatwise Compressive Strength of Sandwich Cores

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:

FED-STD-595 - Color

2.3.2 Military Standards:

MIL-STD-794 - Parts and Equipment, Procedures for Packaging and Packing of

3. TECHNICAL REQUIREMENTS:

3.1 Material:

3.1.1 Metal: Shall be AMS 4005 aluminum alloy foil.

3.1.2 Adhesive: The adhesive used to bond the foil shall be of such quality that the resultant core shall meet the requirements specified herein.

3.2 Configuration: The core material shall consist of strips of aluminum alloy foil bonded together to form cells of approximately uniform shape as shown in Fig. 1.

3.2.1 Designation: Core shall be designated according to the following numbering system:

a. Nominal density, lb per cu ft (kg/m^3) (See 4.5.1)

b. Cell count, per linear foot (metre) of transverse direction (See 4.5.2)

c. Foil thickness in ten-thousandths in. (µm)

d. "N" for nonperforated or "P" for perforated (See 3.2.2)

e. "F" for flexible

f. "T" for treated

g. Adhesive, option of supplier unless otherwise specified

Example in inch/pound units: Core with a nominal density of 2.1 lb per cu ft with a cell count of 40, 0.0014 in. foil thickness, nonperforated, flexible, treated, made of AMS 4005 alloy, and bonded with required adhesive shall be numbered as follows:

2.1-40-14 NFT5056 (XXXX)

Example in SI units: Core with a nominal density of 34 kg/m^3 with a cell count of 131, 36 µm foil thickness, nonperforated, flexible, treated, made of AMS 4005 alloy, and bonded with required adhesive shall be numbered as follows:

34-131-36 NFT5056 (XXXX)

3.2.2 Perforation: Foil shall be nonperforated, unless otherwise specified. When perforation is specified, the perforations shall be of such size and location that all cells are vented at least once for each 0.250 in. (6.25 mm) of core thickness.

3.3 Conditions: The core shall be treated for corrosion resistance.

3.4 Properties: Core shall conform to the following requirements; tests shall be performed on the core supplied and in accordance with specified test methods:

3.4.1 Stabilized Flatwise Compressive Strength: Shall be as specified in Table I and Table II, determined in accordance with ASTM C365 on three specimens.

3.4.1.1 At 25°C (77°F):

TABLE I

Core Designation in Inch/Pound Units	Minimum Individual Compressive Strength psi
2.1-40-14 NFT5056	182
3.1-40-20 NFT5056	329
4.1-40-26 NFT5056	483
4.3-80-14 NFT5056	518
6.5-80-20 NFT5056	910
8.0-80-26 NFT5056	1260

TABLE I (SI)

Core Designation in SI Units	Minimum Individual Compressive Strength MPa
34-131-36 NFT5056	1.25
50-131-51 NFT5056	2.27
66-131-66 NFT5056	3.33
69-262-36 NFT5056	3.57
104-262-51 NFT5056	6.28
128-262-66 NFT5056	8.69

3.4.1.2 At 175°C (350°F):

TABLE II

Core Designation in Inch/Pound Units	Minimum Individual Compressive Strength psi
2.1-40-14 NFT5056	119
3.1-40-20 NFT5056	215
4.1-40-26 NFT5056	315
4.3-80-14 NFT5056	340
6.5-80-20 NFT5056	595
8.0-80-26 NFT5056	820

TABLE II (SI)

Core Designation in SI Units	Minimum Individual Compressive Strength MPa
34-131-36 NFT5056	0.82
50-131-51 NFT5056	1.48
66-131-66 NFT5056	2.17
69-262-36 NFT5056	2.35
104-262-51 NFT5056	4.10
128-262-66 NFT5056	5.66

3.4.2 Shear Strength: Shall be as specified in Table III and Table IV, determined in accordance with ASTM C273 using five specimens 0.625 in. (16 mm) in thickness:

3.4.2.1 At 25°C (77°F):

TABLE III

Core Designation in Inch/Pound Units	Minimum Shear Strength, psi	
	Ribbon Direction	Transverse Direction
2.1-40-14 NFT5056	74	42
3.1-40-20 NFT5056	151	90
4.1-40-26 NFT5056	217	132
4.3-80-14 NFT5056	235	138
6.5-80-20 NFT5056	364	213
8.0-80-26 NFT5056	506	307

TABLE III (SI)

Core Designation in SI Units	Minimum Shear Strength, MPa	
	Ribbon Direction	Transverse Direction
34-131-36 NFT5056	0.51	0.29
50-131-51 NFT5056	1.04	0.62
66-131-66 NFT5056	1.50	0.91
69-262-36 NFT5056	1.62	0.95
104-262-51 NFT5056	2.51	1.47
128-262-66 NFT5056	3.49	2.12

3.4.2.2 At 175°C (350°F):

TABLE IV

Core Designation in Inch/Pound Units	Minimum Shear Strength, psi	
	Ribbon Direction	Transverse Direction
2.1-40-14 NFT5056	48	30
3.1-40-20 NFT5056	97	59
4.1-40-26 NFT5056	141	86
4.3-80-14 NFT5056	156	91
6.5-80-20 NFT5056	236	139
8.0-80-26 NFT5056	330	200

TABLE IV (SI)

Core Designation in SI Units	Minimum Shear Strength, MPa	
	Ribbon Direction	Transverse Direction
34-131-36 NFT5056	0.33	0.21
50-131-51 NFT5056	0.67	0.41
66-131-66 NFT5056	0.97	0.59
69-262-36 NFT5056	1.05	0.63
104-262-51 NFT5056	1.63	0.96
128-262-66 NFT5056	2.28	1.38

3.4.3 Node Bond Strength: Shall be as follows, determined in accordance with 4.5.3; in case of partial delamination at the specified minimum load, the delamination shall be less than 10% of the total stress-section of the core slice:

	Cells Per Linear Foot		Cells Per Linear Metre	
	40	80	131	263
Node Bond Strength at room temperature, min	30 lb	35 lb	133 N	156 N

3.4.4 Flexibility: A core slice shall lie flat without crimping, permanent distortion, or delamination when flexed as specified in 4.5.4.

3.4.5 Corrosion Resistance: The core shall show a weight loss not greater than 125 mg per sq ft (1345 mg/m^2) of exposed foil area, determined in accordance with 4.5.5.

3.5 Quality: Core, as received by purchaser, shall be free from imperfections detrimental to usage of the core. Core shall be clean and free from grease, oil, trim scraps, and impurities. The foil edges of the core shall be free from notches, crush lines, and rolled metal. The core shall have no more than 3 node bond breaks per sq ft (32/m^2) with no more than 2 connected node breaks per sq ft (21/m^2). The core shall have no more than 4 unexpanded cells per sq ft of core (43/m^2). The core shall not have more than 10 multiple laps per sheet 36 x 96 in. (900 x 2400 mm) of core.

3.6 Sizes and Tolerances:

3.6.1 Sizes: Length, width, and thickness of each panel shall be as ordered.

3.6.2 Tolerances: Unless otherwise specified, tolerances shall be as follows:

3.6.2.1 Thickness:

TABLE V

Nominal Thickness Inches	Tolerance, Inch plus and minus
0.250 to 4.000, incl	0.005
Over 4.000 to 10.500, incl	0.062

TABLE V (SI)

Nominal Thickness Millimetres	Tolerance, Millimetres plus and minus
6.25 to 100.00, incl	0.12
Over 100.00 to 265.00, incl	1.60

3.6.2.2 Cell Count: ±10%.

3.6.2.3 Density: ±10%.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection: The vendor of the core shall supply all samples for vendor's tests and shall be responsible for performing all Ø required tests. Results of such tests shall be reported to the purchaser as required by 4.6. Purchaser reserves the right to sample and to perform any confirmatory testing deemed necessary to ensure that the core conforms to the requirements of this specification.

4.2 Classification of Tests:

4.2.1 Acceptance Tests: Tests to determine conformance to requirements for composition (3.1.1), density, cell count, and foil thickness (3.2.1), Ø compressive strength (3.4.1.1 and 3.4.1.2), shear strength (3.4.2.1 and 3.4.2.2), node bond strength (3.4.3), and flexibility (3.4.4) are classified as acceptance tests and shall be performed on each lot of foil or core as applicable.

4.2.2 Preproduction Tests: Tests to determine conformance to all technical requirements of this specification are classified as preproduction tests Ø and shall be performed prior to or on the initial shipment of core to a purchaser, when a change in material and/or processing requires reapproval as in 4.4.2, and when purchaser deems confirmatory testing to be required.

4.2.2.1 For direct U.S. Military procurement, substantiating test data and, when requested, preproduction test material shall be submitted to the cognizant agency as directed by the procuring activity, the contracting officer, or the request for procurement.

4.3 Sampling: Shall be in accordance with the following schedule:

Composition (3.1.1)	Each lot of foil
Density (3.2.1)	Each lot of core
Cell Count (3.2.1)	Each lot of core
Foil Thickness (3.2.1)	Each lot of core
Compressive Strength (3.4.1)	Each lot of core
Shear Strength (3.4.2)	Each lot of core
Node Bond Strength (3.4.3)	Each lot of core
Flexibility (3.4.4)	Each lot of core
Corrosion Resistance (3.4.5)	As agreed upon by purchaser and vendor

4.3.1 A lot of foil shall be all foil of one alloy in a single shipment from the foil producer.

4.3.2 A lot of core shall be all product fabricated at one time to form a block of expanded core 36 x 96 in. (900 mm x 2400 mm) in nominal size.

4.4 Approval:

4.4.1 Sample core shall be approved by purchaser before core for production use is supplied, unless such approval be waived by purchaser. Results of tests on production core shall be essentially equivalent to those on the approved sample.

4.4.2 Vendor shall use ingredients, manufacturing procedures, processes, and methods of inspection on production core which are essentially the same as those used on the approved sample core. If necessary to make any change in ingredients, in type of equipment for processing, or in manufacturing procedures, vendor shall submit for reapproval a statement of the proposed changes in material and/or processing and, when requested, sample core. Production core made by the revised procedure shall not be shipped prior to receipt of reapproval.

4.5 Test Methods:

4.5.1 Core Density: Shall be determined by weight of a known volume. The test specimens shall be at least 3 x 3 in. (75 x 75 mm) x core thickness. The specimen dimensions shall be measured to the nearest 0.010 in. (0.25 mm) and weighed to an accuracy of ±1.0%. Calculate density as follows for each of three determinations, reporting each value and the arithmetic mean:

$$\text{Actual Density, lb per cu ft} = \frac{3.81\ (\text{weight of specimen, g})}{(\text{Volume of specimen, cu in.})} \quad \text{in inch/pound units}$$

$$\text{kg/m}^3 = \frac{(\text{weight of specimen, g})}{(\text{Volume of specimen, mm}^3)} \times 10^6 \quad \text{in SI units}$$

4.5.2 Cell Count: Shall be determined by actual count of cells per linear foot (metre) of transverse direction (See Fig. 1). Make three determinations and report each value and the arithmetic mean.

4.5.3 Node Bond Strength: A 0.625 x 5 x 10 in. (16 x 125 x 250 mm) core slice shall be tested in a suitable core tension fixture by mounting, without causing cell distortion, at opposite ends of the "W" dimension (See Fig. 1) with round pins. Pins shall be as large as cell size permits and engage all cells of a continuous row. Opposite pins shall be in mirror image alignment at a distance as near to 8 in. (200 mm) as this mounting method permits. The fixture shall be slotted to allow horizontal pin movement. A steady loading rate of 1.00 in. ± 0.05 (25.0 mm ± 1.2) per min. shall be maintained.

4.5.4 Flexibility Test: A 10-in. (250 mm) square test specimen of the as-received thickness or a slice 0.625 in. ± 0.005 (16 mm ± 0.12) thick, whichever is thinner, shall be wrapped around a 4-in. (100 mm) diameter cylindrical mandrel at room temperature, first perpendicular and then parallel to the L direction of the core. Core under 0.625 in. (16 mm) in thickness shall use a mandrel in the same diametric ratio as for 0.625-in. (16-mm) thick core material.

4.5.5 Corrosion Resistance: Representative specimens shall be 5 in. ± 1/16 (125 mm ± 1.5) long (longitudinal direction, See Fig. 1), 6 in. ± 1/16 (150 mm ± 1.5) wide (transverse direction), and 0.625 in. ± 0.010 (16 mm ± 0.25) thick. The core specimens shall be weighed, using an analytical balance, to the nearest milligram. Specimens shall be conditioned at 175°C ± 5 (350°F ± 10) in an electric drying oven for 16 hr ± 0.25 and allowed to cool to room temperature before weighing. The test specimens shall be subjected to a 5% salt spray test in accordance with ASTM B117 except that the cell axis (W-L axis) shall be supported or suspended approximately 90 deg from the vertical. At the end of 30-days exposure, the specimens shall be removed and rinsed thoroughly in clear, running water for not less than 5 minutes. Immediately following rinsing, the specimens shall be stripped by immersion in a phosphoric-chromic acid solution for 5 min. ± 0.25 100°C ± 1 (at 212°F ± 2). The solution shall consist of the following:

Phosphoric acid, 85% H_3PO_4	103 mL
Chromic acid	76 g
Water, to make	1 gal (3.785 L)

The specimens shall be removed from the solution, rinsed in distilled or deionized water for not less than 5 min., dried at 105°C ± 3 (225°F ± 5) for 30 - 40 min., cooled to room temperature, and reweighed. The stripping solution should be discarded after 1 gal (3.785 L) of the solution has dissolved 20 g of oxides or coating. An unexposed specimen shall be used as a blank to determine the weight loss of this treatment. Both exposed and unexposed specimens shall be stripped. The weight loss of the exposed specimen shall exceed the weight loss of the unexposed specimen by not more than the value specified in 3.4.5. Compute the weight loss as in 4.5.5.1 or 4.5.5.2.

4.5.5.1 Inch/Pound Units:

40 CELL

$$M = \frac{7.5\ (O - A)}{TLW}$$

80 CELL

$$M = \frac{4.2\ (O - A)}{TLW}$$

where, M = Weight loss in milligrams per sq ft of exposed foil area
L = Ribbon length direction, inches
T = Thickness measurement in direction of cell axis, inch
W = Transverse direction, inches
O = Original weight of specimen in milligrams before exposure
A = Final weight of specimen in milligrams after stripping

4.5.5.2 SI Units:

131 CELL

$$M = \frac{1323420\ (O - A)}{TLW}$$

262 CELL

$$M = \frac{741160\ (O - A)}{TLW}$$

where, M = Weight loss in milligrams per m^2 of exposed foil area
L = Ribbon length direction, millimetres
T = Thickness measurement in direction of cell axis, millimetres
W = Transverse direction, millimetres
O = Original weight of specimen in milligrams before exposure
A = Final weight of specimen in milligrams after stripping

4.6 Reports:

4.6.1 The vendor of core shall furnish with each shipment three copies of a report showing the results of tests to determine conformance to the acceptance test requirements and stating that the core conforms to the other technical requirements of this specification. This report shall include the purchase order number, AMS 4177A, vendor's product designation, size, quantity, block or lot number, and, when requested, the foil lot number.

4.6.2 The vendor of finished or semi-finished parts shall furnish with each shipment three copies of a report showing the purchase order number, AMS 4177A, contractor or other direct supplier of core, supplier's material designation, part number, and quantity. When core for making parts is produced or purchased by the parts vendor, that vendor shall inspect each lot of core to determine conformance to the requirements of this specification and shall include in the report either a statement that the core conforms or copies of laboratory reports showing the results of tests to determine conformance.

4.7 Resampling and Retesting: If any specimen used in the above tests fails to meet the specified requirements, disposition of the core may be based on the results of testing three additional specimens, cut from the same block, for each original nonconforming specimen. Failure of any retest specimen to meet the specified requirements shall be cause for rejection of the core represented and no additional testing shall be permitted. Results of all tests shall be reported.

5. PREPARATION FOR DELIVERY:

5.1 Identification: