

AEROSPACE MATERIAL SPECIFICATION

SAE

AMS 4177C

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Submitted for recognition as an American National Standard

CORE, FLEXIBLE HONEYCOMB, ALUMINUM ALLOY For Sandwich Construction 5056, 350 (177)

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:

This honeycomb core has been used typically in contoured sandwich construction for short-term service up to 350 °F (177 °C) or for long-term service up to 200 °F (93 °C), but usage is not limited to such applications.

1.3 Safety - Hazardous Materials:

While the materials, methods, applications, and processes described or referenced in this specification may involve the use of hazardous materials, this specification does not address the hazards which may be involved in such use. It is the sole responsibility of the user to ensure familiarity with the safe and proper use of any hazardous materials and to take necessary precautionary measures to ensure the health and safety of all personnel involved.

2. APPLICABLE DOCUMENTS:

The following publications form a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order.

SAE Technical Standards Board Rules provide that: "This report is published by SAE to advance the state of technical and engineering sciences. The use of this report is entirely voluntary, and its applicability and suitability for any particular use, including any patent infringement arising therefrom, is the sole responsibility of the user."

SAE reviews each technical report at least every five years at which time it may be reaffirmed, revised, or cancelled. SAE invites your written comments and suggestions.

2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

AMS 4005 Aluminum Alloy Foil, 5.0Mg - 0.12Mn - 0.12Cr (5056-H191), Strain Hardened

2.2 ASTM Publications:

Available from ASTM, 1916 Race Street, Philadelphia, PA 19103-1187.

ASTM B 117 Salt Spray (Fog) Testing

ASTM C 273 Shear Properties in Flatwise Plane of Flat Sandwich Constructions or Sandwich Cores

ASTM C 365 Flatwise Compressive Strength of Sandwich Cores

2.3 U.S. Government Publications:

Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

MIL-STD-2073-1 DOD Materiel, Procedures for Development and Application of Packaging Requirements

FED-STD-595 Color

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 of 3.4 and 3.5.

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 Figure 1.

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

Nominal density, pounds per cubic foot (kg/m^3) (See 4.5.1)

Cell count, per linear foot (m) of transverse direction (See 4.5.2)

Foil thickness in ten-thousandths inch (μm)

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

"F" for flexible

"T" for treated

Alloy

Adhesive, option of supplier

Example in inch/pound units: Core with a nominal density of 2.1 pounds per cubic foot with a cell count of 40, 0.0014 inch foil thickness, nonperforated, flexible, treated, made of 5056 aluminum 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 5056 aluminum alloy, and bonded with required adhesive shall be numbered as follows:

34-131-36 NFT5056 (XXXX)

3.2.2 Perforation: Foil shall be nonperforated, except that, 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 inch (6.35 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, in accordance with specified test methods:

3.4.1 Stabilized Flatwise Compressive Strength: Shall be as specified in Table 1 and Table 2, determined in accordance with ASTM C 365 on six specimens 0.625 inches (15.88 mm) in thickness.

(R)

TABLE 1A - Minimum Compressive Strength at 77 °F, Inch/Pound Units

Core Designation	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 1B - Minimum Compressive Strength at 25 °C, SI Units

Core Designation	Individual Compressive Strength MPa
34-131-36 NFT5056	1.26
50-131-51 NFT5056	2.27
66-131-66 NFT5056	3.33
69-262-36 NFT5056	3.57
104-262-51 NFT5056	6.27
128-262-66 NFT5056	8.69

TABLE 2A - Minimum Compressive Strength at 347 °F, Inch/Pound Units

Core Designation	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 2B - Minimum Compressive Strength at 175 °C, SI Units

Core Designation	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	2.34
104-262-51 NFT5056	4.10
128-262-66 NFT5056	5.65

3.4.2 Shear Strength: Shall be as specified in Table 3 and Table 4, determined in accordance with (R) ASTM C 273 using five specimens 0.625 inch (15.88 mm) in thickness:

TABLE 3A - Minimum Individual Shear Strength at 77 °F, Inch/Pound Units

Core Designation	Ribbon Direction psi	Transverse Direction psi
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 3B - Minimum Individual Shear Strength at 25 °C, SI Units

Core Designation	Individual Ribbon Direction MPa	Individual Transverse Direction MPa
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

TABLE 4A - Minimum Individual Shear Strength at 347 °F, Inch/Pound Units

Core Designation	Ribbon Direction psi	Transverse Direction psi
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 4B - Minimum Individual Shear Strength at 175 °C, SI Units

Core Designation	Ribbon Direction MPa	Transverse Direction MPa
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	1.08	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 shown in Table 5, determined in accordance with 4.5.3.
(R)

TABLE 5 - Minimum Individual Node Bond Strength

Property	Cells per 40 Linear Feet	Cells per 80 Linear Feet	Cells per 131 Linear Meters	Cells per 262 Linear Meters
Node Bond Strength at room temperature	30 pounds force	35 pounds force	133N	156N

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 milligrams per square foot (1345 mg/m²) 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 three node bond breaks per square foot ($32/\text{m}^2$) with no more than two connected node breaks per square foot ($21/\text{m}^2$). The core shall have no more than four unexpanded cells per square foot of core ($43/\text{m}^2$). The core shall not have more than 10 multiple laps for each 36 x 96 inch (914 x 2438 mm) sheet of core.

3.6 Sizes and Tolerances:

3.6.1 Sizes: Length (L), width (W), and thickness (T) of each panel shall be as ordered.

3.6.2 Tolerances: Shall be as shown in Table 6.

3.6.2.1 Thickness:

TABLE 6A - Thickness Tolerances, Inch/Pound Units

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 6B - Thickness Tolerances, SI Units

Nominal Thickness Millimeters	Tolerance, Millimeters plus and minus
6.35 to 101.60, incl	0.13
Over 101.60 to 266.70, incl	1.57

3.6.2.2 Cell Count: The "W" cell-count shall be within $\pm 10\%$ of the specified value, determined in accordance with 4.5.1.
(R)

3.6.2.3 Density: The core density shall be within $\pm 10\%$ of the nominal specified density, determined in accordance with 4.5.2.
(R)

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection:

The manufacturer of the core shall supply all samples and shall be responsible for all required tests. Purchaser reserves the right to sample and to perform any confirmatory testing deemed necessary to ensure that the core conforms to the specified requirements.

4.2 Classification of Tests:

4.2.1 Acceptance Tests: Composition (3.1.1), density (3.2.1), cell count (3.2.1), foil thickness (3.2.1), compressive strength (3.4.1), shear strength (3.4.2), node bond strength (3.4.3), and flexibility (3.4.4) are acceptance tests and shall be performed on each lot of foil or core as applicable.

4.2.2 Preproduction Tests: All technical requirements are preproduction tests and shall be performed prior to or on the initial shipment of core by the manufacturer, when a change in ingredients 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, contracting officer, or request for procurement.

4.3 Sampling and Testing:

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): Acceptable to purchaser

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.

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 Manufacturer 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. If necessary to make any change in ingredients, in type of equipment for processing, or in manufacturing procedures, manufacturer shall submit for reapproval a statement of the proposed changes in ingredients 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 Cell Count: Shall be determined by actual count of cells per linear foot (meter) of transverse direction (See Figure 1). Make six determinations and report each value and the arithmetic mean.
(R)

- 4.5.2 Core Density: Shall be determined by weight of a known volume. The test specimens shall be at least 12 x 12 inches (305 x 305 mm) x core thickness. The specimen dimensions shall be measured to the nearest 0.010 inch (0.25 mm) and weighed to an accuracy of $\pm 1.0\%$. Calculate density using Equation 1 for each of three determinations, reporting each value and the arithmetic mean:
(R)

$$\begin{aligned} \text{Actual Density: pounds per cubic foot} &= \frac{3.81 (\text{weight of specimen, grams})}{(\text{Volume of specimen, cubic inches})} \text{ in inch / pound units} \\ \text{kg/m}^3 &= \frac{(\text{weight of specimen, g})}{(\text{Volume of specimen, mm}^3)} \times 10^6 \text{ in SI units} \end{aligned} \quad (\text{Eq.1})$$

- 4.5.3 Node Bond Strength: A 0.625T x 5L x 10W inch (15.88T x 127L x 254W 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 Figure 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 inches (203 mm) as this mounting method permits. The fixture shall be slotted to allow horizontal pin movement. A steady loading rate of 1.00 inch \pm 0.05 (25.4 mm \pm 1.3) per minute shall be maintained.
- 4.5.4 Flexibility Test: A 10-inch (254-mm) square specimen of the as-received thickness or a slice 0.625 inch \pm 0.005 (15.88 mm \pm 0.13) thick, whichever is thinner, shall be wrapped around a 4-inch (102-mm) diameter cylindrical mandrel at room temperature, first perpendicular and then parallel to the L direction of the core. Core under 0.625 inch (15.88 mm) in thickness shall use a mandrel in the same diametric ratio as for 0.625 inch (15.88 mm) thick core material.

- 4.5.5 Corrosion Resistance: Representative specimens shall be 5 inches $\pm 1/16$ (127 mm ± 1.6) long (longitudinal direction "L", See Figure 1), 6 inches $\pm 1/16$ (152 mm ± 1.6) wide (transverse direction "W"), and 0.625 inch ± 0.010 (15.88 mm ± 0.25) thick "T". The core specimens shall be weighed to the nearest milligram using an analytical balance. Specimens shall be dried for 16 hours ± 0.25 at 350 °F ± 10 (177 °C ± 6) in an electric drying oven 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 B 117 except that the cell axis shall be supported or suspended horizontally. 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 minutes ± 0.25 at 212°F ± 2 (100 °C ± 1). The stripping solution shall consist of the following:

Phosphoric acid, 85% H_3PO_4 : 103 milliliters
 Chromic acid: 76 grams
 Water, to make: 1 gallon (3.8 L)

The specimens shall be removed from the solution, rinsed in distilled or deionized water for at least 5 minutes, dried at 225 °F ± 5 (107 °C ± 3) for 30 to 40 minutes, cooled to room temperature, and reweighed. The stripping solution shall be discarded after 1 gallon (3.8 liters) of the solution has dissolved 20 grams of oxides or coating. Compute the weight loss using Equation 2 (inch-pound units) or Equation 3 (SI units).

4.5.5.1 Inch/Pound Units:

$$M = \frac{7.5(O-A)}{TLW} \quad \text{40 CELL} \quad M = \frac{4.2(O-A)}{TLW} \quad \text{80 CELL} \quad (\text{Eq.2})$$

where:

M = Weight loss in milligrams per square foot 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:

$$M = \frac{131 \text{ CELL}}{1323420 (O - A)} \text{ TLW} \quad M = \frac{262 \text{ CELL}}{741160 (O - A)} \text{ TLW} \quad (\text{Eq.3})$$

where:

M = Weight loss in milligrams per square meter of exposed foil area

L = Ribbon length direction, millimeters

T = Thickness measurement in direction of cell axis, millimeters

W = Transverse direction, millimeters

O = Original weight of specimen in milligrams before exposure

A = Final weight of specimen in milligrams after stripping

4.6 Reports:

The supplier of core shall furnish with each shipment a report from the manufacturer showing the results of tests to determine conformance to the acceptance test requirements and stating that the core conforms to the other technical requirements. This report shall include the purchase order number, block or lot number, AMS 4177C, manufacturer's identification, size, quantity, and, when requested, the foil lot number.

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. Results of all tests shall be reported.

5. PREPARATION FOR DELIVERY:

5.1 Identification: