



AEROSPACE MATERIAL SPECIFICATION

AMS4178**REV. E**

Issued 1976-01
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Reaffirmed 2013-12

Superseding AMS4178D

Core, Flexible Honeycomb, Aluminum Alloy, Treated
for Sandwich Construction
5052, 350 (177)

RATIONALE

AMS4178E has been reaffirmed to comply with the SAE five-year review policy.

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 exposure up to 350 °F (177 °C) or for long-term exposure 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 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.

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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.

AMS4004 Aluminum Alloy Foil, 2.5Mg - 0.25Cr (5052-H191), Strain Hardened

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 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 the Document Automation and Production Service (DAPS), Building 4/D, 700 Robbins Avenue, Philadelphia, PA 19111-5094, Tel: 215-697-6257, <http://assist.daps.dla.mil/quicksearch/>.

FED-STD-595 Color

3. TECHNICAL REQUIREMENTS

3.1 Material

3.1.1 Metal

Shall be AMS4004 aluminum alloy foil.

3.1.2 Adhesive

The adhesive system used for node-to-node attachment shall be such that the resultant core meets the specified requirements.

3.2 Configuration

The core material shall consist of strips of aluminum alloy foil, treated for corrosion protection, bonded together to form cells of approximately uniform shape as shown in Figure 1.

3.2.1 Designation

Core shall be designated in accordance with the following numbering system:

Nominal density, pounds per cubic foot (kg/m^3)
Cell count, per linear foot (meter) of transverse direction
Foil thickness in ten-thousandths inch (μm)
"N" for nonperforated or "P" for perforated
"F" for flexible
"T" for treated for corrosion protection
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, 0.0013 inch foil thickness, nonperforated, flexible, treated, produced from AMS4004 (5052) alloy and bonded with required adhesive shall be numbered as follows:

2.1-40-13 NFT5052 (XXXX)

Example in SI units: Core with a nominal density of 34 kg/m³ with a cell count of 131, 33 µm foil thickness, nonperforated, flexible, treated, produced from AMS4004 (5052) alloy, and bonded with required adhesive shall be numbered as follows:

34-131-33 NFT5052 (XXXX)

3.2.2 Perforations

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 Condition

The core shall be supplied in the expanded form.

3.4 Properties

Core shall conform to the following requirements; tests shall be conducted, 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 five specimens 0.625 inch (15.88 mm) in thickness.

3.4.1.1 At 77 °F (25 °C)

TABLE 1 A - COMPRESSIVE STRENGTH, INCH/POUND UNITS

Core Designation	Minimum Individual Compressive Strength psi
2.1-40-13 N or PFT5052	157
3.1-40-19 N or PFT5052	280
4.1-40-25 N or PFT5052	420
5.7-40-37 N or PFT5052	700
4.3-80-13 N or PFT5052	455
6.5-80-19 N or PFT5052	735
8.0-80-25 N or PFT5052	1120

TABLE 1B - COMPRESSIVE STRENGTH, SI UNITS

Core Designation	Minimum Individual Compressive Strength MPa
34-131-33 N or PFT5052	1.08
50-131-48 N or PFT5052	1.93
66-131-64 N or PFT5052	2.90
91-131-94 N or PFT5052	4.83
69-262-33 N or PFT5052	3.14
104-262-48 N or PFT5052	5.07
128-262-64 N or PFT5052	7.72

3.4.1.2 At 350 °F (177 °C)

TABLE 2A - COMPRESSIVE STRENGTH, INCH/POUND UNITS

Core Designation	Minimum Individual Compressive Strength psi
2.1-40-13 N or PFT5052	102
3.1-40-19 N or PFT5052	182
4.1-40-25 N or PFT5052	274
5.7-40-37 N or PFT5052	455
4.3-80-13 N or PFT5052	296
6.5-80-19 N or PFT5052	478
8.0-80-25 N or PFT5052	730

TABLE 2B - COMPRESSIVE STRENGTH, SI UNITS

Core Designation	Minimum Individual Compressive Strength MPa
34-131-33 N or PFT5052	0.70
50-131-48 N or PFT5052	1.25
66-131-64 N or PFT5052	1.89
91-131-94 N or PFT5052	3.14
69-262-33 N or PFT5052	2.04
104-262-48 N or PFT5052	3.30
128-262-64 N or PFT5052	5.03

3.4.2 Shear Strength

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

3.4.2.1 At 77 °F (25 °C)

TABLE 3A - SHEAR STRENGTH, INCH/POUND UNITS

Core Designation	Minimum Individual Shear Strength, psi Ribbon Direction	Minimum Individual Shear Strength, psi Transverse Direction
2.1-40-13 N or PFT5052	63	37
3.1-40-19 N or PFT5052	126	75
4.1-40-25 N or PFT5052	182	115
5.7-40-37 N or PFT5052	280	170
4.3-80-13 N or PFT5052	196	120
6.5-80-19 N or PFT5052	308	180
8.0-80-25 N or PFT5052	434	260

TABLE 3B - SHEAR STRENGTH, SI UNITS

Core Designation	Minimum Individual Shear Strength, MPa Ribbon Direction	Minimum Individual Shear Strength, MPa Transverse Direction
34-131-33 N or PFT5052	0.43	0.26
50-131-48 N or PFT5052	0.87	0.52
66-131-64 N or PFT5052	1.25	0.79
91-131-94 N or PFT5052	1.93	1.17
69-262-33 N or PFT5052	1.35	0.83
104-262-48 N or PFT5052	2.12	1.24
128-262-64 N or PFT5052	2.99	1.79

3.4.2.2 At 350 °F (177 °C)

TABLE 4A - SHEAR STRENGTH, INCH/POUND UNITS

Core Designation	Minimum Individual Shear Strength, psi Ribbon Direction	Minimum Individual Shear Strength, psi Transverse Direction
2.1-40-13 N or PFT5052	41	24
3.1-40-19 N or PFT5052	82	49
4.1-40-25 N or PFT5052	118	75
5.7-40-37 N or PFT5052	182	111
4.3-80-13 N or PFT5052	127	78
6.5-80-19 N or PFT5052	200	117
8.0-80-25 N or PFT5052	282	169

TABLE 4B - SHEAR STRENGTH, SL UNITS

Core Designation	Minimum Individual Shear Strength, psi Ribbon Direction	Minimum Individual Shear Strength, psi Transverse Direction
34-131-33 N or PFT5052	0.28	0.17
50-131-48 N or PFT5052	0.57	0.34
66-131-64 N or PFT5052	0.81	0.52
91-131-94 N or PFT5052	1.25	0.77
69-262-33 N or PFT5052	0.88	0.54
104-262-48 N or PFT5052	1.38	0.81
128-262-64 N or PFT5052	1.94	1.17

3.4.3 Node Bond Strength

Shall be as shown in Table 5, determined in accordance with 4.5.1.

TABLE 5 - MINIMUM INDIVIDUAL NODE BOND STRENGTH

Property	Cells per Linear Foot 40	Cells per Linear Foot 80	Cells per Linear Meter 131	Cells per Linear Meter 262
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 4.5.2.

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 4.5.3.

3.4.6 Cell Count

Shall be within ±10% of the specified cell count, determined in accordance with 4.5.5.

3.4.7 Density

Shall be within ±10% of the specified density, determined in accordance with 4.5.4.

3.5 Quality

The core, as received by purchaser, shall be free from imperfections detrimental to usage. 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 2 connected node breaks per square foot ($22/\text{m}^2$). The core shall have no more than 4 unexpanded cells per square foot of core ($43/\text{m}^2$). The core shall not have more than 10 multiple laps per sheet 36 x 96 inch (914 x 2438 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

Shall be as shown in Table 6.

3.6.2.1 Thickness

TABLE 6A - 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 - TOLERANCES, SI UNITS

Nominal Thickness Millimeters	Tolerance, Millimeters plus and minus
6.25 to 101.60, incl	0.13
Over 101.60 to 266.70, incl	0.062

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection

The manufacturer of 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 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), flexibility (3.4.4), and quality (3.5) 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.

4.3 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
Quality (3.5)

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

4.3.2 A core lot shall be each block or all slices cut from a single block.

4.3.3 For Acceptance Tests

For composition, one sample from each lot of foil; for other tests each block or 2% of the slices from each lot shall be sampled at random to provide sufficient core to perform all required tests. The number of determinations for each requirement shall be as specified in the applicable test procedure or, if not specified therein, not less than three.

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 Node Bond Strength

A 0.625T x 5 x 10L inch (15.88T x 127L x 254W mm) core slice shall be tested in a suitable 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 shall engage all cells of a continuous row. Opposite pins shall be in a 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.

4.5.2 Flexibility Test

A 10-inch (254-mm) square specimen 0.625 inch $\pm$ 0.005 (15.88 mm $\pm$ 0.13) thick, 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.

Representative specimens shall be 5 inches $\pm$ 1/16 (127 mm $\pm$ 1.6) (R) long (longitudinal direction "L", See Figure 1), 6 inches $\pm$ 1/16 (152 mm $\pm$ 1.6) wide (transverse direction "W"), and 0.625 inch $\pm$ 0.010 (15.88 mm $\pm$ 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 $\pm$ 0.25 at 350 °F $\pm$ 10 (177 °C $\pm$ 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 at least 5 minutes. Immediately following rinsing, the specimens shall be stripped by immersion in a phosphoric-chromic acid solution for 5 minutes $\pm$ 0.25 at 212 °F $\pm$ 2 (100 °C $\pm$ 1). The stripping solution shall consist of the following:

Phosphoric acid, 85% H ₃ PO 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 220 °F $\pm$ 5 (104 °C $\pm$ 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. 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 using Equation 1 (inch-pound units) or Equation 2 (SI units).

4.5.2.1 Inch/Pound Units

$$M = \frac{40 \text{ CELL}}{7.5 (0 - A)} \frac{TLW}{TLW} \quad M = \frac{80 \text{ CELL}}{4.2 (0 - A)} \frac{TLW}{TLW} \quad (\text{Eq. 1})$$

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

0 = Original weight of specimen in milligrams before exposure

A = Final weight of specimen in milligrams after stripping

4.5.2.2 SI Units

$$M = \frac{1,323,420 (0 - A)}{TLW} \quad \text{131 CELL} \quad M = \frac{741,160 (0 - A)}{TLW} \quad \text{262 CELL} \quad (\text{Eq. 2})$$

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

0 = Original weight of specimen in milligrams before exposure

A = Final weight of specimen in milligrams after stripping

4.5.3 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 in accordance with Equation 3 or 4 for each of three determinations per test, reporting each value and the average.

$$\text{Actual Density, pounds per cubic foot} = \frac{3.81 (\text{Weight of specimen, grams})}{(\text{Volume of specimen, cubic inches})} \text{ in inch / pound units} \quad (\text{Eq. 3})$$

$$\text{Actual Density, kg / m}^3 = \frac{(\text{Weight of specimen, grams})}{(\text{Volume of specimen, mm}^3)} \times 10^6 \text{ in SI units} \quad (\text{Eq. 4})$$

4.5.4 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 average.

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, AMS4178E, 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.