



AEROSPACE MATERIAL SPECIFICATION

Society of Automotive Engineers, Inc.
400 COMMONWEALTH DRIVE, WARRENDALE, PA. 15096

AMS 4178

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Revised

CORE, FLEXIBLE HONEYCOMB, ALUMINUM ALLOY, TREATED For Sandwich Construction 5052, 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: Primarily for use in contoured sandwich construction for short term use up to 350° F (177° C) or for long term use up to 200° F (93° C).

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 Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, PA 15096.

2.1.1 Aerospace Material Specifications:

AMS 2350 - Standards and Test Methods

AMS 4004 - Aluminum Alloy Foil, 2.5Mg - 0.25Cr (5052-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 Construction or Sandwich Cores

ASTM C365 - Compressive Strength, Flatwise, of Sandwich Cores

2.3 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 and Fabrication: Shall be as follows:

3.1.1 Metal: Shall be AMS 4004 aluminum alloy foil.

SAE Technical Board rules provide that: "All technical reports, including standards approved and practices recommended, are advisory only. Their use by anyone engaged in industry or trade is entirely voluntary. There is no agreement to adhere to any SAE standard or recommended practice, and no commitment to conform to or be guided by any technical report. In formulating and approving technical reports, the Board and its Committees will not investigate or consider patents which may apply to the subject matter. Prospective users of the report are responsible for protecting themselves against liability for infringement of patents."

- 3.1.2 Bonding Material: The adhesive used to bond the foil shall be of such quality that the resultant core shall meet the requirements specified.
- 3.1.3 Metal Finish: The core shall be treated for corrosion resistance.
- 3.1.4 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.
- 3.1.5 Perforation: Unless otherwise specified, the foil shall be nonperforated. 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. (6.35 mm) of core thickness.
- 3.1.6 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 (meter) of transverse direction (See 4.5.2)
 - c. Foil thickness in ten-thousandths in. (μm)
 - d. "N" for nonperforated or "P" for perforated (See 3.1.5)
 - e. "F" for flexible
 - f. "T" for treated
 - g. Adhesive, option of supplier unless otherwise specified.

Example: 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 4004 alloy and bonded with required adhesive shall be numbered as follows:

2.1 - 40 - 14 NFT5052 (XXXX) in U.S. Conventional Units,
34 - 131 - 36 NFT5052 (XXXX) in SI Units.

- 3.2 Properties: The product shall conform to the following requirements; tests shall be performed on the product supplied and in accordance with specified test methods:

- 3.2.1 Stabilized Flatwise Compressive Strength: Shall be as follows, determined on three specimens in accordance with ASTM C365:

- 3.2.1.1 At 77° F (25° C):

Core Designation	Minimum Individual Compressive Strength		Core Designation, SI
	psi	(MPa)	
2.1 - 40 - 13 NFT5052	157	(1.080)	34 - 131 - 36 NFT5052
3.1 - 40 - 19 NFT5052	280	(1.930)	50 - 131 - 51 NFT5052
4.1 - 40 - 25 NFT5052	420	(2.900)	66 - 131 - 66 NFT5052
5.7 - 40 - 37 NFT5052	700	(4.830)	91 - 131 - 94 NFT5052
4.3 - 80 - 13 NFT5052	455	(3.140)	69 - 262 - 36 NFT5052
6.0 - 80 - 19 NFT5052	735	(5.070)	96 - 262 - 51 NFT5052
8.0 - 80 - 25 NFT5052	1120	(7.730)	128 - 262 - 66 NFT5052

3.2.1.2 At 350° F (176.7° C):

Core Designation	<u>Minimum Individual Compressive Strength</u>		Core Designation, SI
	psi	(MPa)	
2.1 - 40 - 13 NFT5052	102	(0.703)	34 - 131 - 36 NFT5052
3.1 - 40 - 19 NFT5052	182	(1.260)	50 - 131 - 51 NFT5052
4.1 - 40 - 25 NFT5052	274	(1.890)	66 - 131 - 66 NFT5052
5.7 - 40 - 37 NFT5052	455	(3.140)	91 - 131 - 94 NFT5052
4.3 - 80 - 13 NFT5052	296	(2.040)	69 - 262 - 36 NFT5052
6.0 - 80 - 19 NFT5052	478	(3.300)	96 - 262 - 51 NFT5052
8.0 - 80 - 25 NFT5052	730	(5.040)	128 - 262 - 66 NFT5052

3.2.2 Shear Strength: Shall be as follows, determined on five specimens in accordance with ASTM C273 using a 0.625 in. (15.88 mm) thick specimen:

3.2.2.1 At 77° F (25° C)

Core Designation	<u>Minimum Shear Strength</u>			
	<u>Ribbon Direction</u>		<u>Transverse Direction</u>	
	psi	(MPa)	psi	(MPa)
2.1 - 40 - 13 NFT5052	63	(0.434)	37	(0.255)
3.1 - 40 - 19 NFT5052	126	(0.869)	75	(0.517)
4.1 - 40 - 25 NFT5052	182	(1.260)	115	(0.793)
5.7 - 40 - 37 NFT5052	280	(1.930)	170	(1.170)
4.3 - 80 - 13 NFT5052	196	(1.350)	120	(0.828)
6.0 - 80 - 19 NFT5052	308	(2.120)	180	(1.240)
8.0 - 80 - 25 NFT5052	434	(2.990)	260	(1.790)

3.2.2.2 At 350° F (176.7° C):

Core Designation	<u>Minimum Shear Strength</u>			
	<u>Ribbon Direction</u>		<u>Transverse Direction</u>	
	psi	(MPa)	psi	(MPa)
2.1 - 40 - 13 NFT5052	41	(0.283)	24	(0.166)
3.1 - 40 - 19 NFT5052	82	(0.565)	49	(0.338)
4.1 - 40 - 25 NFT5052	118	(0.814)	75	(0.517)
5.7 - 40 - 37 NFT5052	182	(1.255)	111	(0.765)
4.3 - 80 - 13 NFT5052	127	(0.877)	78	(0.538)
6.0 - 80 - 19 NFT5052	200	(1.379)	117	(0.807)
8.0 - 80 - 25 NFT5052	282	(1.944)	169	(1.170)

3.2.3 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:

	<u>Cells Per Linear Foot</u>		<u>Cells Per Linear Meter</u>	
	40	80	131	263
Node Bond Strength at room temperature, lb, min	30	35	-	-
N, min	-	-	133	156

- 3.2.4 Flexibility: A core slice shall lie flat without crimping, permanent distortion, or delamination when flexed as specified in 4.5.4.
- 3.2.5 Corrosion Resistance: The core shall show a weight loss not greater than 125 mg per sq ft (1346 mg/m^2) of exposed foil area, determined in accordance with 4.5.5.
- 3.3 Quality: Core shall be free from imperfections that would adversely affect the properties of the end item. 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 ($32/\text{m}^2$) with no more than 2 connected node breaks per sq ft ($21/\text{m}^2$). The core shall have no more than 4 unexpanded cells per sq ft of core ($43/\text{m}^2$). The core shall not have more than 10 multiple laps per sheet 36 x 96 in. (914 x 2438 mm) of core.
- 3.4 Sizes: Length, width, and thickness of each panel shall be as ordered.
- 3.5 Tolerances: Unless otherwise specified, tolerances shall be as follows:
- 3.5.1 Thickness:

TABLE I

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 I (SI)

Nominal Thickness Millimetres	Tolerance, Millimetres plus and minus
6.35 to 101.60, incl	0.13
Over 101.60 to 266.70, incl	1.58

3.5.2 Cell Count: $\pm 10\%$

3.5.3 Density: $\pm 10\%$

4. QUALITY ASSURANCE PROVISIONS:

- 4.1 Responsibility for Inspection: The vendor of the product shall supply all samples and shall be responsible for performing all required tests. Results of such tests shall be reported to the purchaser as required by 4.6. Purchaser reserves the right to perform such confirmatory testing as he deems necessary to ensure that the product conforms to the requirements of this specification.
- 4.2 Classification of Tests:
- 4.2.1 Acceptance Tests: Tests to determine conformance to composition (3.1.1), density, cell count, and foil thickness (3.1.6), compressive strength (3.2.1.1 and 3.2.1.2), shear strength (3.2.2.1 and 3.2.2.2), node bond strength (3.2.3), and flexibility (3.2.4) requirements are classified as acceptance or routine control tests.
- 4.2.2 Qualification Tests: Tests to determine conformance to all technical requirements of this specification are classified as qualification or periodic control tests.

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

- 4.3 Sampling: Sampling and testing the product shall be in accordance with the following schedule:

Composition	Each lot of foil
Density	Each lot of core
Foil Thickness	Each lot of core
Cell Count	Each lot of core
Node Bond Strength	Each lot of core
Flexibility	Each lot of core
Compressive Strength	Each lot of core
Shear Strength, Longitudinal (Ribbon Direction)	Each lot of core
Shear Strength, Transverse	Each lot of core
Corrosion Resistance	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. (914 mm x 2.44 m) 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. 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 any change is necessary 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 processing and, when requested, sample revised core. No production core made by the revised procedure shall 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. (76 x 76 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 $\pm 1.0\%$. Calculate density as follows for each of 3 determinations per test, reporting each value and the arithmetic mean:

$$\text{Actual Density, lb per cu ft} = \frac{3.81 (\text{weight of specimen, g})}{(\text{Volume of specimen, cu in.})} \text{ in U.S. Conventional Units}$$

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

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

- 4.5.3 Node Bond Strength: A 5/8 x 5 x 10 in. (15.88 x 127 x 254 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. (203 mm) as this mounting method permits. The fixture shall be slotted to allow horizontal pin movement. A steady loading rate of 1.00 in. $\pm$ 0.05 (25.4 mm $\pm$ 1.3) per min. shall be maintained.
- 4.5.4 Flexibility Test: A 10-in. (254-mm) square test specimen of the as received thickness or a slice 0.625 in. $\pm$ 0.005 (15.88 mm $\pm$ 0.13) thick, whichever is thinner, shall be wrapped around a 4.0-in. (102-mm) diameter cylindrical mandrel at room temperature, first perpendicular then parallel to the L direction of the core. Core material less than 0.625 in. (15.88 mm) thick shall use a mandrel in the same diametric ratio as for 0.625 in. (15.88 mm) thick core material.
- 4.5.5 Corrosion Resistance: Representative specimens shall be 5 in. $\pm$ 1/16 (127 mm $\pm$ 1.6) long (longitudinal direction, See Fig. 1), 6 in. $\pm$ 1/16 (152 mm $\pm$ 1.6) wide (transverse direction), and 0.625 in. $\pm$ 0.010 (15.88 mm $\pm$ 0.25) thick. The core specimens shall be weighed, using an analytical balance, to the nearest milligram. Specimens shall be conditioned at 350° F $\pm$ 10° F (176.7° C $\pm$ 5.6) in an electric drying oven for 16 hr $\pm$ 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 (1.57 rad) from the vertical. 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 min. $\pm$ 1/4 at 212° F $\pm$ 2 (100° C $\pm$ 1.1). The solution shall consist of the following:

Phosphoric acid, 85% H ₃ PO ₄	103 ml
Chromic acid	76 g
Water, to make	1 gal (3.785 dm ³)

The specimens shall be removed from the solution, rinsed in distilled or deionized water for at least 5 min., dried at 225° F $\pm$ 5 (107.2° C $\pm$ 2.8) for 30 - 40 min., cooled to room temperature, and reweighed. The stripping solution should be discarded after 1 gal (3.785 dm³) 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 3.2.5. Compute the weight loss as in 4.5.5.1 in U.S. Conventional units or as in 4.5.5.2 in SI units:

4.5.5.1 U.S. Conventional Units:

F40 CELL	F80 CELL
$M = \frac{7.5 (O - A)}{TLW}$	$M = \frac{4.2 (O - A)}{TLW}$

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

4.5.5.2 SI Units:

F40 CELL

F80 CELL

$$M = \frac{1323430 (0 - A)}{TLW}$$

$$M = \frac{741160 (0 - A)}{TLW}$$

where, M = Weight loss per m² of exposed foil area in milligrams

L = Ribbon length direction, millimetres

T = Thickness measurement in direction of cell axis, millimetres

W = Transverse direction, millimetres

O = Original weight of specimen before exposure in milligrams

A = Final weight of specimen after stripping in milligrams

4.6 Reports:

- 4.6.1 The vendor of the core shall furnish with each shipment three copies of a report of the results of tests made on the product 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, material specification number, vendor's product designation, foil lot number, core lot number, and quantity.
- 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, material specification number, manufacturer's material designation, part number, and quantity. When material for making parts is produced or purchased by the parts vendor, that vendor shall inspect each lot of material to determine conformance to the requirements of this specification, and shall include in the report a statement that the material conforms, or shall include 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 product may be based on the results of testing three additional specimens for each original nonconforming specimen. Failure of any retest specimen to meet the specified requirements shall be cause for rejection of the product represented and no additional testing shall be permitted. Results of all tests shall be reported.

5. PREPARATION FOR DELIVERY:

5.1 Identification:

- 5.1.1 Color Identification: Each block or slice of core shall be identified on the edges by parallel stripes: One 2-in. (51-mm) wide red stripe to designate 350° F (177° C) core; one 1/2-in. (12.7-mm) wide black stripe to identify the 5052 alloy, and a 1/2-in. (12.7-mm) wide colored stripe on the side of the black stripe to identify the density range. The color of the density stripe shall be as specified in Table II and shall approximately match the listed color numbers of FED-STD-595. This group of parallel identification stripes shall be repeated at intervals of not more than 2 ft (610 mm). The color shall be produced by adding a dye to an adhesive which is compatible with the core. Stripes shall be painted or sprayed on the edges of core blocks or slices. The dye shall retain its color through the curing cycles and shall be noncorrosive. The dye shall have no adverse effect on the curing or the strength of the adhesive used for construction of the core material or the adhesive used with the core material in the fabrication of sandwich components.

TABLE II

Color	FED-STD-595 Color No.	DENSITY COLOR CODE	
		Aluminum Alloy 5052 ⁽¹⁾ Nominal Density lb per cu ft	Aluminum Alloy 5052 ⁽¹⁾ Nominal Density kg/m ³
Orange	12246 or 22246	2.1	34
Blue	15102 or 25102	3.1	50
Red	11105 or 21105	4.1 and 4.3	66 and 69
Purple	17142 or 27142	6.0	96
Green	14187	8.0	128

(1) One black stripe matching FED-STD-595, Color No. 17308 or 27308.

- 5.1.2 Each piece of core shall be color identified in accordance with 5.1.1 and identified with the following information applied to a durable tag, using characters of such size as to be clearly legible and which will not be obliterated by normal handling:

CORE, HONEYCOMB, FLEXIBLE, ALUMINUM ALLOY, 5052H191, TREATED
AMS 4178

CORE CLASSIFICATION _____

PURCHASE ORDER NUMBER _____

DATE OF MANUFACTURE _____

CORE LOT NUMBER _____

MANUFACTURER'S DESIGNATION _____

QUANTITY _____

SIZE _____

FOIL LOT NUMBER _____

5.2 Packaging:

- 5.2.1 Core shall be packaged and shipped in outer containers in such a manner as to ensure that the product, during shipment and storage, will not be permanently distorted and will be protected against damage from exposure to weather or any normal hazard.

- 5.2.2 Containers shall be prepared for shipment in accordance with commercial practice to ensure carrier acceptance and safe transportation to the point of delivery. Packaging shall conform to carrier rules and regulations applicable to the mode of transportation.

- 5.2.3 Each container shall be legibly marked with the following information:

CORE, HONEYCOMB, FLEXIBLE, ALUMINUM ALLOY, 5052H191, TREATED
AMS 4178

CORE DESIGNATION _____

PURCHASE ORDER NUMBER _____

DATE OF MANUFACTURE _____

CORE LOT NUMBER _____

MANUFACTURER'S DESIGNATION _____

QUANTITY _____

SIZE _____

FOIL LOT NUMBER _____