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AEROSPACE MATERIAL SPECIFICATION

Submitted for recognition as an American National Standard

AMS 4348B

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Superseding AMS 4348A

CORE, HONEYCOMB, ALUMINUM ALLOY, CORROSION INHIBITED
For Sandwich Construction
5052, 350 (177)

1. SCOPE:

1.1 Form: This specification covers one type of honeycomb core made of aluminum alloy and supplied in the form of blocks, slices, or other configurations as ordered. The core is treated to increase corrosion resistance.

1.2 Application: Primarily for use in sandwich construction for short-term exposure up to 350°F (177°C) or for long-term exposure 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 SAE publications 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 4004 - Aluminum Alloy Foil, 2.5Mg - 0.25Cr (5052-H191), Strain Hardened

2.2 ASTM Publications: Available from ASTM, 1916 Race Street, Philadelphia, PA 19103.

ASTM B 117 - Salt Spray (Fog) Testing
ASTM C 273 - Shear Test 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 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 4004 aluminum alloy foil of the thickness specified on the part drawing or purchase order except that maximum foil thickness shall be as specified in Table I.

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

3.2 Configuration: The core material shall consist of strips of aluminum alloy foil treated for corrosion protection, bonded together such that cells approximately hexagonal in shape are formed when fully expanded (See Fig. 1).

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

a. Nominal density, pounds per cubic foot (kg/m^3)
b. Cell size, inch (mm)
c. Foil thickness, ten-thousandths inch (μm)
d. "N" for nonperforated or "P" for perforated
e. Alloy
f. Adhesive, option of supplier

Example: Core with a nominal density of 4.3 pounds per cubic foot (69 kg/m^3) with a 1/4 inch (6.4 mm) cell size, 0.0020 inch (51 μm) foil thickness, nonperforated, made of AMS 4004 alloy, and bonded with required adhesive shall be numbered as follows:

4.3 - 1/4 20N (5052) (XXXX) in inch/pound units
69 - 6.4 51N (5052) (XXXX) in SI units

3.2.2 Perforations: When perforated core is specified, the perforations shall be approximately 0.005 in. (0.12 mm) in diameter and spaced to vent each cell into at least three adjacent cells at least once 1/4 inch (6.4 mm) of core thickness. When thicknesses 1/4 inch (6.4 mm) are furnished, there shall be at least one perforation per cell into each of three adjacent cells.

3.2.3 Cell Pitch: Shall be 1.733 times the nominal cell size, +20%, - 10%, measured by taking the average distance between ten nodes along a ribbon for six different ribbons.

3.3 Condition: Core shall be supplied in the expanded form; it shall be clean, free of contamination, and treated for corrosion resistance.

3.4 Properties: Core having nominal dimensions as specified in Table I shall conform to the following requirements; tests shall be conducted on the core supplied and in accordance with specified test methods. Properties of core having nominal dimensions other than specified in Table I shall be as agreed upon by purchaser and vendor.

3.4.1 Flatwise Compressive Strength: The minimum individual values shall be as specified in Table I, determined in accordance with 4.5.1.

3.4.2 Plate Shear Strength and Plate Shear Modulus: Shall be as specified in Table I, determined in accordance with ASTM C 273 at 77°F ± 5 (25°C ± 3), using a 0.625-inch (15.88-mm) thick specimen.

3.4.3 Node Bond Strength: Shall be not less than 30 pounds force (133 N) at 77°F ± 5 (25°C ± 3) and not less than 15 pounds force (67 N) at 350°F ± 5 (177°C ± 3), determined in accordance with 4.5.2. In case of partial delamination at the minimum specified load, the delamination shall be less than 10% of the total stress section of the core slice.

3.4.4 Core Density: Shall be within ±10% of the nominal specified density, determined in accordance with 4.5.3.

3.4.5 Corrosion Resistance: Core specimens shall show a weight loss not greater than 125 milligrams per square foot (1345 mg/m^2) of exposed foil area, determined in accordance with 4.5.4.

3.5 Quality: The core, as received by purchaser, shall be uniform in quality and condition, sound, and free from foreign materials and from imperfections detrimental to usage of the core.

3.5.1 Cleanliness: The core shall be free from corrosion, oil, and other contamination detrimental to bonding.

3.5.2 Discoloration: A change in color of core material shall be acceptable provided the color change occurs in a line parallel to "L" (Figure 1), indicative of a change in foil material where more than one foil coil is used in the manufacture of a core block.

3.5.3 Flatness: Expanded core shall make total facing contact with a flat surface under uniform pressure without resulting in any damage that would cause core rejection.

3.5.4 Double Foils: Expanded core splices which have double foils (two ribbons bonded together which cause uneven expansion in the "L" direction (Figure 1) shall be acceptable if the double foils are not more frequent than one in any 8 inches (203 mm).

3.5.5 Mismatched Nodes: The c/d ratio (See Figure 2) of mismatched nodes shall be 0.00 to 0.25.

3.5.6 Visual Imperfections: The following maximum requirements apply for imperfections observed in any randomly selected 12-inch (305-mm) diameter circle.

	Maximum Number for Cell Size, Inch (mm), Shown				
Type of Imperfection	1/8 (3.2)	5/32 (4.0)	3/16 (4.8)	1/4 (6.4)	3/8 (9.5)
Mismatched Nodes	70	55	40	25	10
Loose Metal or Flakes (See 3.5.6.1)	35	28	20	12	5
Split Cell Walls	0	0	0	0	0
Buckled Cell Walls	0	0	0	0	0
Unbonded Nodes	2	2	2	2	2

3.5.6.1 Flakes are excess metal attached to foil edges which do not interfere with measurements of core thickness.

3.6 Sizes and Tolerances:

3.6.1 Size: Core shall be supplied in the size ordered with core dimensions as shown in Fig. 1, where,

T = Thickness, depth, or height dimension measured parallel to the core cell axis
L = Longitudinal or ribbon (length) dimension measured along the direction of a ribbon
W = Width dimension measured normal to the ribbon direction

3.6.2 Core Thickness: Shall be ± 0.005 inch (±0.13 mm) for machined slices up to 4.0 inches (102 mm) in nominal thickness, ±0.062 inch (±1.57 mm) for machined slices over 4 inches (102 mm) in nominal thickness, and +0.25 inch (+6.4 mm), -0.00 for raw block.

3.6.3 "L" and "W": Length and width of unexpanded core shall be as ordered, +0.25 inch (+6.4 mm), -0; for expanded core, tolerances shall be +2 inches (+51 mm), -0.

3.6.4 Average Cell Size: The cell size of any ten adjacent cells shall vary not more than ±10% from nominal, determined by taking the average distance between node bonds along the "W" dimension (Figure 1) for at least 60 cells selected at random in groups containing ten adjacent cells.

3.6.5 Ribbon Direction: All ribbons shall be parallel to each other within 10 degrees. The ribbon direction shall be determined by measuring the angle between one line through two nodes on the same ribbon ("L" direction), 12 inches (305 mm) apart, and another line in the principal ribbon direction (See Figure 1).

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection: The vendor of core shall supply all samples for vendor's tests 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 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 for flatwise compressive strength (3.4.1), node bond strength (3.4.3), and density (3.4.4) are acceptance tests and shall be performed on each lot.

4.2.2 Preproduction Tests: Tests for all technical requirements of this specification are preproduction tests and shall be performed prior to or on the first-article shipment of core to a purchaser, 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; the number Ø of specimens to be sampled shall be the minimum number of specimens tested:

4.3.1 For Acceptance Tests: Each block or 2% of the slices, selected at random, from each lot; a lot shall be all slices cut from a single block:

4.3.2 For Preproduction Tests: As agreed upon by purchaser and vendor.

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 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 Flatwise Compressive Strength: Shall be determined at 77°F ± 5 (25°C ± 3) in accordance with ASTM C 365, Method A for stabilized specimens and Method B for bare specimens. Test specimens shall be nominally 0.625 inch (15.88 mm) thick by 3.00 inches ± 0.25 (76.2 mm ± 6.4) square. The test machine loading faces shall be approximately 4 inches (102 mm) square. Spherical loading blocks, preferably the suspended self-aligning type, shall transfer the load at 0.0020 inch ± 0.0005 (0.051 mm ± 0.013) per minute. At least six specimens shall be tested for each product. The flatwise compressive strength shall be computed by dividing the maximum load by the cross-sectional area of the specimen. Report all values.

4.5.2 Node Bond Strength: A core slice, nominally 0.625 x 5 x 10 inches (15.88 x 127 x 254 mm), shall be tested in a suitable tension fixture by mounting, without causing cell distortion, at opposite ends of the "W" dimension (See Fig. 3) 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 ± 0.05 (25.4 mm ± 1.3) per minute shall be maintained. Specimens shall be brought to temperature equilibrium before testing; elevated temperature tests shall be conducted at the specified temperature after holding at that temperature for 15 minutes ± 1.

4.5.3 Core Density: Shall be determined on blocks and slices from their weight and dimensions to an accuracy within 1%. Thickness shall be measured with an accuracy of 0.001 inch (0.025 mm) and width and length with an accuracy of 0.010 inch (0.25 mm). Measurements shall be made using a dial gage capable of applying a 10-pound force (44-N) over a 1.5-inch (38-mm) diameter area. Density shall be calculated in pounds per cubic foot (kg/m^3).

4.5.4 Corrosion Resistance: Representative specimens shall be 5 inches ± 1/16 (127 mm ± 1.6) long (longitudinal direction "L" (See Figure 1)), 6 inches ± 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 (W-L axis) shall be supported or suspended horizontally approximately 90 degrees from 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 minutes ± 0.25 at 212°F ± 2 (100°C ± 1). The solution shall consist of the following:

Phosphoric acid, 85% H_3PO_4	103 millilitres
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 - 40 minutes, cooled to room temperature, and reweighed. The stripping solution shall be discarded after 1 gallon (3.8 L) of the solution has dissolved 20 grams of oxides or coating. Compute the weight loss as in 4.5.4.1 in inch/pound units or as in 4.5.2.2 in SI units:

4.5.4.1 Inch/Pound Units:

$$M = \frac{36C\ (O-A)}{TLW}$$

Where, M = Weight loss per square foot of exposed foil area, milligrams

C = Nominal cell size, inch (1/8, 5/32, 3/16, 1/4, 3/8)

T = Thickness measurement in direction of cell axis, inch

L = Ribbon length direction, inches

W = Transverse direction, inches

O = Original weight of specimen before exposure, milligrams

A = Final weight of specimen after stripping, milligrams

4.5.4.2 SI Units:

$$M = \frac{26507C\ (O-A)}{TLW}$$

Where, M = Weight loss per m^2 of exposed foil area, milligrams

C = Nominal cell size, millimetres (3.2, 4.0, 4.8, 6.4, 9.5)

T = Thickness measurement in direction of cell axis, millimetres

L = Ribbon length direction, millimetres

W = Transverse direction, millimetres

O = Original weight of specimen before exposure, milligrams

A = Final weight of specimen after stripping, milligrams

4.6 Reports: The vendor of core shall furnish with each shipment a report Ø 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 4348B, product designation, size, quantity, block or lot number, 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 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-inch (51-mm) wide red stripe to identify 350°F (177°C) core, one 0.5-inch (13-mm) wide black stripe to identify 5052 alloy, and a 0.5-inch (13-mm) wide colored stripe along side the black stripe to identify the density range. The colors of the stripes shall be as specified in Table II and shall approximately match the color numbers of FED-STD-595. The group of parallel identification stripes shall be repeated at intervals not greater than 2 feet (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, shall be noncorrosive, and shall have no adverse effect on the curing or the strength of the adhesive used for construction of the core or the adhesive used with the core in fabricating sandwich components.

5.1.2 Labeling: Each piece of core and each interior and exterior container shall be identified with not less than the following information, applied to a durable tag or label, using characters of such size as to be legible and which will not be obliterated by normal handling.

CORE, HONEYCOMB, ALUMINUM ALLOY, CORROSION INHIBITED, 5052, 350 (177)
AMS 4348B
CORE DESIGNATION _____
PURCHASE ORDER NUMBER _____
MANUFACTURER'S IDENTIFICATION _____
BLOCK OR CORE LOT NUMBER _____
PART NUMBER OR SIZE (T x L x W) _____
QUANTITY _____

5.2 Packaging:

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

5.2.2 Containers of core shall be prepared for shipment in accordance with commercial practice and in compliance with applicable rules and regulations pertaining to the handling, packaging, and transportation of the core to ensure carrier acceptance and safe delivery. Packaging shall conform to carrier rules and regulations applicable to the mode of transportation.

5.2.3 For direct U.S. Military procurement, packaging shall be in accordance with MIL-STD-794, Level A or Level C, as specified in the request for procurement. Commercial packaging as in 5.2.1 and 5.2.2 will be acceptable if it meets the requirements of Level C.

6. ACKNOWLEDGMENT: A vendor shall mention this specification number and its revision letter in all quotations and when acknowledging purchase orders.

7. REJECTIONS: Core not conforming to this specification, or to modifications authorized by purchaser, will be subject to rejection.

8. NOTES:

8.1 Marginal Indicia: The phi (Ø) is used to indicate technical changes from the previous issue of this specification.

8.2 Dimensions and properties in inch/pound units and the Fahrenheit temperatures are primary; dimensions and properties in SI units and the Celsius temperatures are shown as the approximate equivalents of the primary units and are presented only for information.

8.3 For direct U.S. Military procurement, purchase documents should specify not less than the following:

Title, number, and date of this specification
Cell size and density of core desired
Size of core slices or blocks desired
Quantity of core desired
Applicable level of packaging (See 5.2.3).

8.4 Similar Specifications: MIL-C-7438, Grade B, is listed for information only and shall not be construed as an acceptable alternate unless all requirements of this AMS are met.

8.5 Core meeting the requirements of this specification has been classified under Federal Supply Classification (FSC) 5680.

8.6 This specification is under the jurisdiction of AMS Committee "CC".

TABLE I

Cell Size Inch	Nominal Core Dimensions, Foil Thickness, Designated Inch	Nominal Core Dimensions, Foil Thickness, Maximum Inch	Density lb per cu ft	Plate Shear Strength psi, min, Direction of Test W	Plate Shear Strength psi, min, Direction of Test L	Plate Shear Modulus psi, min, avg, Direction of Test W	Plate Shear Modulus psi, min, avg, Direction of Test L	Compression Strength psi, min, Bare	Compression Strength psi, min, Stabilized
	0.0007	0.0011	3.1	90	155	16000	31000	200	215
	0.0010	0.0015	4.5	168	285	25000	51000	375	405
1/8	0.0015	0.0022	6.1	272	455	37000	77000	650	680
	0.0020	0.0029	8.1	400	670	50000	112000	1000	1100
	0.0007	0.0011	2.6	70	120	12000	24000	150	160
	0.0010	0.0015	3.8	125	215	20000	41000	285	300
5/32	0.0015	0.0022	5.3	215	370	31000	64000	490	535
	0.0020	0.0029	6.9	328	540	42000	91000	770	800
	0.0025	0.0034	8.4	420	690	52000	115000	1070	1180
	0.0007	0.0011	2.0	46	80	9000	17000	90	100
	0.0010	0.0015	3.1	90	155	16000	31000	200	215
	0.0015	0.0022	4.4	160	280	24000	50000	360	385
3/16	0.0020	0.0029	5.7	244	410	34000	70000	560	600
	0.0025	0.0034	6.9	328	540	42000	91000	770	800
	0.0030	0.0042	8.1	400	670	50000	112000	1000	1100
	0.0007	0.0011	1.6	32	60	6000	13000	60	70
	0.0010	0.0015	2.3	57	100	11000	21000	120	130
	0.0015	0.0022	3.4	105	180	18000	35000	240	250
1/4	0.0020	0.0029	4.3	155	265	24000	48000	350	370
	0.0025	0.0034	5.2	200	360	30000	62000	500	510
	0.0030	0.0042	6.0	265	445	36000	75000	630	660
	0.0040	0.0053	7.9	390	650	49000	108000	970	1050
	0.0007	0.0011	1.0	20	32	4000	7000	20	20
	0.0010	0.0015	1.6	32	60	6000	13000	60	70
	0.0015	0.0022	2.3	57	100	11000	21000	120	130
3/8	0.0020	0.0029	3.0	85	145	15000	30000	190	200
	0.0025	0.0034	3.7	115	200	20000	40000	270	285
	0.0030	0.0042	4.2	150	255	23000	47000	335	355
	0.0040	0.0053	5.4	228	380	32000	66000	500	535
	0.0050	0.0065	6.5	300	500	39000	84000	700	750

TABLE I (SI)

Cell Size	Nominal Core Dimensions: Foil Thickness Designated	Foil Thickness Maximum	Density	Plate Shear Strength MPa, min: Direction of Test W	Plate Shear Strength MPa, min: Direction of Test L	Plate Shear Modulus MPa, min, avg: Direction of Test W	Plate Shear Modulus MPa, min, avg: Direction of Test L	Compression Strength MPa, min: Bare	Compression Strength MPa, min: Stabilized
mm	µm	µm	kg/m^3	W	L	W	L	Bare	Stabilized
	17.8	27.9	50	0.621	1.069	110	214	1.379	1.482
	25.4	38.1	72	1.158	1.965	172	352	2.586	2.792
3.2	38.1	55.9	98	1.875	3.137	255	531	4.482	4.688
	50.8	73.7	130	2.758	4.619	345	772	6.895	7.584
	17.8	27.9	42	0.483	0.827	83	165	1.034	1.103
	25.4	38.1	61	0.862	1.482	138	283	1.965	2.068
4.0	38.1	55.9	85	1.482	2.551	214	441	3.378	3.689
	50.8	73.7	110	2.262	3.723	290	627	5.309	5.516
	63.5	86.4	135	2.896	4.757	359	793	7.377	8.136
	17.8	27.9	32	0.317	0.552	62	117	0.621	0.689
	25.4	38.1	50	0.621	1.069	110	214	1.379	1.482
4.8	38.1	55.9	70	1.103	1.931	165	345	2.482	2.654
	50.8	73.7	91	1.682	2.827	234	483	3.861	4.137
	63.5	86.4	110	2.262	3.723	290	627	5.309	5.516
	76.2	106.7	130	2.758	4.619	345	772	6.895	7.584
	17.8	27.9	26	0.221	0.414	41	90	0.414	0.483
	25.4	38.1	37	0.393	0.689	76	145	0.827	0.896
6.4	38.1	55.9	54	0.724	1.241	124	241	1.655	1.724
	50.8	73.7	69	1.069	1.827	165	331	2.413	2.551
	63.5	86.4	83	1.379	2.482	207	427	3.447	3.516
	76.2	106.7	96	1.827	3.068	248	517	4.344	4.551
	101.6	134.6	126	2.689	4.482	338	745	6.688	7.239
	17.8	27.9	16	0.138	0.221	28	48	0.138	0.138
	25.4	38.1	26	0.221	0.414	41	90	0.414	0.483
	38.1	55.9	37	0.393	0.689	76	145	0.827	0.896
9.5	50.8	73.7	48	0.586	1.000	103	207	1.310	1.379
	63.5	86.4	59	0.793	1.379	138	276	1.862	1.965
	76.2	106.7	67	1.034	1.758	159	324	2.310	2.448
	101.6	134.6	86	1.572	2.620	221	455	3.447	3.689
	127.0	165.1	104	2.069	3.447	269	579	4.826	5.171