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

AEROSPACE MATERIAL SPECIFICATION

AMS 4348

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Revised

HONEYCOMB CORE, ALUMINUM ALLOY, CORROSION INHIBITED
For Sandwich Construction
5052, 350 (175)

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 to temperatures up to 350°F (175°C) or for long term exposure to temperatures up to 200°F (95°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 - Flatwise Compressive Strength 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:

3.1.1 Metal: Shall be AMS 4004 (5052-H191) aluminum alloy foil of the thickness specified on the drawing or purchase order.

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.

Printed in U.S.A.

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, lb per cu ft (kg/m^3)

b. Cell size, in. (mm)

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

d. "N" for nonperforated or "P" for perforated

e. Alloy

f. Adhesive, option of supplier, unless otherwise specified

Example: Core with a nominal density of 4.3 lb per cu ft (68.9 kg/m^3) with a 1/4 in. (6.4 mm) cell size, 0.0020 in. (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 U.S. Conventional units
68.9 - 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. (0.13 mm) in diameter and spaced to vent each cell into at least three adjacent cells at least once per 1/4 in. (6.4 mm) of core thickness. When thicknesses less than 1/4 in. (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 10 nodes along a ribbon for 6 different ribbons.

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

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 C273 at 77°F ± 5 (25°C ± 3), using a 0.625-in. (15.88-mm) thick specimen.

3.4.3 Node Bond Strength: Shall be not less than 30 lb (133 N) at 77°F ± 5 (25°C ± 3) and not less than 15 lb (66.7 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 mg per sq ft (1346 mg/m^2) of exposed foil area, determined in accordance with 4.5.4.

3.5 Quality: The core, as received by the purchaser, shall be uniform in quality and free 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" (Fig. 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 (Fig. 1) shall be acceptable if the double foils are not more frequent than 1 in any 8 in. (203 mm).

3.5.5 Mismatched Nodes: The c/d ratio (See Fig. 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-in. (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 (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 size

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 in. (±0.13 mm) for machined slices up to 4.0 in. (100 mm) in nominal thickness, ±0.062 in (±1.57 mm) for machined slices over 4 in. (100 mm) in nominal thickness, and +0.25 in. (+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 in. (+6.4 mm), -0; for expanded core, tolerances shall be +2 in. (+51 mm), -0.

3.6.4 Average Cell Size: The cell size of any 10 adjacent cells shall vary not more than ±10% from nominal, determined by taking the average distance between node bonds along the "W" dimension (Fig. 1) for at least 60 cells selected at random in groups containing 10 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 in. (300 mm) apart, and another line in the principal ribbon direction (See Fig. 1).

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection: The vendor of core 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 core conforms to the requirements of this specification.

4.2 Classification of Tests:

4.2.1 Acceptance Tests: Tests to determine conformance to flatwise compressive strength (3.4.1), node bond strength (3.4.3), and density (3.4.4) requirements are classified as acceptance tests.

4.2.2 Preproduction Tests: Tests to determine conformance to all technical requirements of this specification are classified as preproduction tests.

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 as follows; a lot shall be all slices cut from a single block:

4.3.1 Acceptance Tests: Each block or 2% of the slices, selected at random, from each lot.

4.3.2 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. 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 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 C365, Method A for stabilized specimens and Method B for bare specimens. Test specimens shall be nominally 0.625 in. (15.88 mm) thick by 3.00 in. ± 0.25 (76.2 mm ± 6.4) square. The test machine loading faces shall be approximately 4 in. (100 mm) square. Spherical loading blocks, preferably the suspended self-aligning type, shall transfer the load at 0.0020 in. ± 0.0005 (0.051 mm ± 0.013) per minute. At least 6 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 0.625 x 5 x 10 in. (15.88 x 127 x 254 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 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 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 (25.4 mm ± 1.3) per min. 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 min. ± 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 in. (0.03 mm) and width and length with an accuracy of 0.010 in. (0.25 mm). Measurements shall be made using a dial gage capable of applying a 10-lb or 45-N force over a 1.5 in. (38 mm) diameter area. Density shall be calculated in lb per cu ft (kg/m^3).

4.5.4 Corrosion Resistance: Representative specimens shall be 5 in ± 1/16 (127 mm ± 1.6) long (longitudinal direction "L" (See Fig. 1)), 6 in. ± 1/16 (152 mm ± 1.6) wide (transverse direction "W"), and 0.625 in. ± 0.010 (16.87 mm ± 0.25) thick "T". The core specimens shall be weighed, using an analytical balance, to the nearest milligram. Specimens shall be dried at 350°F ± 10°F (177°C ± 3) in an electric drying oven for 16 hr ± 0.25 and allowed to cool to room temperature before weighing. The test specimen 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 horizontal approximately 90 deg 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 min. ± 0.25 at 212°F ± 2 (100°C ± 1). The solution shall consist of the following:

Phosphoric acid, 85% H_3PO_4	103 cm^3
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 ± 5 (107°C ± 3) for 30 - 40 min., cooled to room temperature, and reweighed. The stripping solution shall be discarded after 1 gal (3.785 dm^3) of the solution has dissolved 20 g of oxides or coating. Compute the weight loss as in 4.5.4.1 in U.S. Conventional Units or as in 4.5.2.2 in SI Units:

4.5.4.1 U.S. Conventional Units:

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

Where, M = Weight loss per sq ft of exposed foil area in 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 in milligrams

A = Final weight of specimen after stripping in milligrams

4.5.4.2 SI Units:

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

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

A = Final weight of specimen after stripping in milligrams

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, material specification number, 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, material specification number, 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 a statement that the core 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 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-in.(50-mm) wide red stripe to identify 350°F (175°C) core, one 0.5-in. (13-mm) wide black stripe to identify 5052 alloy, and a 0.5-in. (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 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, shall be noncorrosive, and shall have no adverse effect on the during 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 clearly legible and which will not be obliterated by normal handling.

CORE, HONEYCOMB, ALUMINUM ALLOY, CORROSION INHIBITED, 5052-H191
AMS 4348
CORE DESIGNATION_____
PURCHASE ORDER NUMBER_____
MANUFACTURER'S DESIGNATION_____
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 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 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 procurements. 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 in all quotations and when acknowledging purchase orders.

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

8. NOTES:

8.1 For direct U.S. Military procurement, purchase documents should specify 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)

8.2 Similar Specifications: This specification is the equivalent of MIL-C-7438F, Grade B Class 2 dated 13 March 1972.

TABLE I

Nominal Core Dimensions			Plate Shear Strength psi, min		Plate Shear Modulus psi, min, avg		Compression Strength psi, min	
Cell Size Inch	Foil Thickness Inch	Density lb per cu ft	Direction of Test W	L	Direction of Test W	L	Bare	Stabilized
1/8	0.0007	3.1	90	155	16000	31000	200	215
	0.0010	4.5	168	285	25000	51000	375	405
	0.0015	6.1	272	455	37000	77000	650	680
	0.0020	8.1	400	670	50000	112000	1000	1100
5/32	0.0007	2.6	70	120	12000	24000	150	160
	0.0010	3.8	125	215	20000	41000	285	300
	0.0015	5.3	215	370	31000	64000	490	535
	0.0020	6.9	328	540	42000	91000	770	800
	0.0025	8.4	420	690	52000	115000	1070	1180
3/16	0.0007	2.0	46	80	9000	17000	90	100
	0.0010	3.1	90	155	16000	31000	200	215
	0.0015	4.4	160	280	24000	50000	360	385
	0.0020	5.7	244	410	34000	70000	560	600
	0.0025	6.9	328	540	42000	91000	770	800
	0.0030	8.1	400	670	50000	112000	1000	1100
1/4	0.0007	1.6	32	60	60000	13000	60	70
	0.0010	2.3	57	100	11000	21000	120	130
	0.0015	3.4	105	180	18000	35000	240	250
	0.0020	4.3	155	265	24000	48000	350	370
	0.0025	5.2	200	360	30000	62000	500	510
	0.0030	6.0	265	445	36000	75000	630	660
	0.0040	7.9	390	650	49000	108000	970	1050
3/8	0.0007	1.0	20	32	4000	7000	20	20
	0.0010	1.6	32	60	6000	13000	60	70
	0.0015	2.3	57	100	11000	21000	120	130
	0.0020	3.0	85	145	15000	30000	190	200
	0.0025	3.7	115	200	20000	40000	270	285
	0.0030	4.2	150	255	23000	47000	335	355
	0.0040	5.4	228	380	32000	66000	500	535
	0.0050	6.5	300	500	39000	84000	700	750

TABLE I (SI)

Nominal Core Dimensions			Plate Shear Strength MPa, min		Plate Shear Modulus MPa, min, avg		Compression Strength MPa, min	
Cell Size mm	Foil Thickness mm	Density kg/m^3	Direction of Test W	Direction of Test L	Direction of Test W	Direction of Test L	Bare	Stabilized
3.2	0.018	49.7	0.621	1.069	110	214	1.379	1.482
	0.025	72.1	1.158	1.965	172	352	2.586	2.792
	0.038	97.7	1.875	3.137	255	531	4.482	4.689
	0.051	129.7	2.758	4.620	345	772	6.895	7.584
4.0	0.018	41.6	0.483	0.827	83	165	1.034	1.103
	0.025	60.9	0.862	1.482	138	283	1.965	2.068
	0.038	84.9	1.482	2.551	214	441	3.379	3.689
	0.051	110.5	2.262	3.723	290	627	5.309	5.516
	0.064	134.6	2.896	4.758	359	793	7.378	8.136
4.8	0.018	32.0	0.317	0.552	62	117	0.621	0.690
	0.025	49.7	0.621	1.069	110	214	1.379	1.482
	0.038	70.5	1.103	1.931	165	345	2.482	2.655
	0.051	91.3	1.682	2.827	234	483	3.861	4.137
	0.064	110.5	2.262	3.723	290	627	5.309	5.516
	0.076	129.7	2.758	4.620	345	772	6.895	7.584
6.4	0.018	25.6	0.221	0.414	41	90	0.414	0.483
	0.025	36.8	0.393	0.690	76	145	0.827	0.896
	0.038	54.5	0.724	1.241	124	241	1.655	1.724
	0.051	68.9	1.069	1.827	165	331	2.413	2.551
	0.064	83.3	1.379	2.482	207	427	3.448	3.516
	0.076	96.1	1.827	3.068	248	517	4.344	4.551
	0.102	126.5	2.689	4.482	338	745	6.688	7.240
9.5	0.018	16.0	0.138	0.221	28	48	0.138	0.138
	0.025	25.6	0.221	0.414	41	90	0.414	0.483
	0.038	36.8	0.393	0.690	76	145	0.827	0.896
	0.051	48.1	0.586	1.000	103	207	1.310	1.379
	0.064	59.3	0.793	1.379	138	276	1.862	1.965
	0.076	67.3	1.034	1.758	159	324	2.310	2.448
	0.102	86.5	1.572	2.620	221	455	3.448	3.689
	0.127	104.1	2.069	3.448	269	579	4.826	5.171