SAE Aerospace
An SAE International Group

AEROSPACE MATERIAL SPECIFICATION

SAE AMS 4349 | REV. D

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Superseding AMS 4349C

Core, Honeycomb, Aluminum Alloy, Corrosion Inhibited For Sandwich Construction 5056, 350 (177)

RATIONALE

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

1. SCOPE

1.1 Form

This specification covers bonded honeycomb core made of aluminum alloy and supplied in the form of blocks, slices, or other configurations as ordered.

1.2 Application

This honeycomb core has been used typically in sandwich construction for short-term exposure up to 350 °F (177 °C) or for long-term exposure up to 200 °F (95 °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.

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.

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

TO PLACE A DOCUMENT ORDER: Tel: 877-606-7323 (inside USA and Canada)
Tel: +1 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
SAE WEB ADDRESS: http://www.sae.org

SAE values your input. To provide feedback on this Technical Report, please visit
http://www.sae.org/technical/standards/AMS4349D

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 AMS 4005 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 1.

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 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)
Cell size, inch (mm)
Foil thickness, ten-thousandths inch (μm)
“N” for nonperforated or “P” for perforated
Alloy
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 5056 aluminum alloy, and bonded with required adhesive shall be numbered as follows:

4.3 - 1/4 20N (5056) (XXXX) in inch/pound units
69 - 6.4 51N (5056) (XXXX) in SI units

3.2.2 Perforations

When perforated core is specified, the perforations shall be approximately 0.005 inch (0.13 mm) in diameter and spaced to vent each cell into at least three adjacent cells at least once for each 1/4 inch (6.4 mm) of core thickness. When thicknesses under 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 1, shall conform to the following requirements; tests shall be conducted on the core supplied in accordance with specified test methods. Properties of core having nominal dimensions other than specified in Table 1 shall be acceptable to purchaser.

3.4.1 Flatwise Compressive Strength

The minimum individual values shall be as specified in Table 1, determined in accordance with 4.5.1.

3.4.2 Plate Shear Strength and Plate Shear Modulus

Shall be as specified in Table 1, 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.

3.4.4 Core Density

Shall be within ±10% of the 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.

TABLE 1A - CORE PROPERTIES, INCH-POUND UNITS

Cell Size Inch	Nominal Foil Thickness Designated Inch	Nominal Foil Thickness Maximum Inch	Nominal Density pounds per cubic foot	Plate Shear Strength psi, min individual Direction of Test W	Plate Shear Strength psi, min individual Direction of Test L	Plate Shear Modulus ksi, min average Direction of Test W	Plate Shear Modulus ksi, min average Direction of Test L	Flatwise Compressive Strength psi, min (Individual) Bare	Flatwise Compressive Strength psi, min (Individual) Stabilized
1/8	0.0007	0.0011	3.1	110	200	16.0	31.0	250	260
	0.0010	0.0015	4.5	205	350	25.0	51.0	475	500
	0.0015	0.0022	6.1	305	535	37.0	77.0	760	825
	0.0020	0.0029	8.1	440	740	50.0	112.0	1200	1300
5/32	0.0007	0.0011	2.6	80	152	12.0	24.0	180	185
	0.0010	0.0015	3.8	155	272	20.0	41.0	360	375
	0.0015	0.0022	5.3	250	435	31.0	64.0	615	650
	0.0020	0.0029	6.9	360	610	42.0	91.0	920	1000
	0.0025	0.0034	8.4	455	775	52.0	115.0	1110	1375
3/16	0.0007	0.0011	2.0	50	105	9.0	17.0	110	120
	0.0010	0.0015	3.1	110	200	16.0	31.0	250	260
	0.0015	0.0022	4.4	198	340	24.0	50.0	460	490
	0.0020	0.0029	5.7	280	480	34.0	70.0	665	735
	0.0025	0.0034	6.9	360	610	42.0	91.0	920	1000
	0.0030	0.0042	8.1	440	740	50.0	112.0	1200	1300
1/4	0.0007	0.0011	1.6	38	78	6.0	13.0	75	80
	0.0010	0.0015	2.3	62	130	11.0	21.0	145	155
	0.0015	0.0022	3.4	130	230	18.0	35.0	300	315
	0.0020	0.0029	4.3	190	325	24.0	48.0	440	465
	0.0025	0.0034	5.2	245	425	30.0	62.0	600	645
	0.0030	0.0042	6.0	300	512	36.0	75.0	740	805
	0.0040	0.0053	7.9	430	720	49.0	108.0	1150	1265
3/8	0.0007	0.0011	1.0	25	45	4.0	7.0	25	35
	0.0010	0.0015	1.6	38	78	6.0	13.0	75	80
	0.0015	0.0022	2.3	62	130	11.0	21.0	145	155
	0.0020	0.0029	3.0	100	190	15.0	30.0	240	250
	0.0025	0.0034	3.7	150	260	20.0	40.0	335	362
	0.0030	0.0042	4.2	180	315	23.0	47.0	410	443
	0.0040	0.0053	5.4	260	450	32.0	66.0	630	680
	0.0050	0.0065	6.5	335	568	39.0	84.0	825	908

TABLE 1B - CORE PROPERTIES, SI UNITS

Cell Size mm	Nominal Foil Thickness Designated µm	Nominal Foil Thickness Maximum µm	Nominal Density kg/m^3	Plate Shear Strength MPa, min individual Direction of Test W	Plate Shear Strength MPa, min individual Direction of Test L	Plate Shear Modulus MPa, min average Direction of Test W	Plate Shear Modulus MPa, min average Direction of Test L	Flatwise Compressive Strength MPa, min (Individual) Bare	Flatwise Compressive Strength MPa, min (Individual) Stabilized
3.2	17.8	27.8	50	0.758	1.379	110	214	1.724	1.793
	25.4	38.1	72	1.413	2.413	172	352	3.275	3.448
	38.1	55.9	98	2.103	3.620	255	531	5.240	5.688
	50.8	73.7	130	3.034	5.102	345	772	8.274	8.964
4.0	17.8	27.8	42	0.552	1.048	83	165	1.241	1.276
	25.4	38.1	61	1.069	1.875	138	283	2.482	2.586
	38.1	55.9	85	1.724	2.999	214	441	4.240	4.482
	50.8	73.7	110	2.482	4.206	290	627	6.343	6.895
	63.5	86.4	135	3.137	5.344	359	793	7.633	9.481
4.8	17.8	27.8	32	0.345	0.724	62	117	0.758	0.827
	25.4	38.1	50	0.758	1.379	110	214	1.724	1.793
	38.1	55.9	70	1.365	2.344	165	345	3.172	3.329
	50.8	73.7	91	1.931	3.310	234	483	4.723	5.068
	63.5	86.4	110	2.482	4.206	290	627	6.343	6.895
	76.2	106.7	130	3.034	5.102	345	772	8.274	8.964
6.4	17.8	27.8	26	0.262	0.538	41	90	0.517	0.552
	25.4	38.1	37	0.427	0.896	76	145	1.000	1.069
	38.1	55.9	55	0.896	1.586	124	241	2.068	2.172
	50.8	73.7	69	1.310	2.241	165	331	3.034	3.206
	63.5	86.4	83	1.689	2.930	207	427	4.137	4.447
	76.2	106.7	96	2.068	3.530	248	517	5.102	5.550
	101.6	134.6	126	2.965	4.964	338	745	7.929	8.722
9.5	17.8	27.8	16	0.172	0.310	28	48	0.172	0.241
	25.4	38.1	26	0.262	0.538	41	90	0.517	0.552
	38.1	55.9	37	0.427	0.896	76	145	1.000	1.069
	50.8	73.7	48	0.690	1.310	103	207	1.655	1.724
	63.5	86.4	59	1.034	1.793	138	276	2.310	2.496
	76.2	106.7	67	1.241	2.172	159	324	2.827	3.054
	101.6	134.6	86	1.793	3.103	221	455	4.344	4.689
	127.0	165.1	104	2.310	3.916	269	579	5.688	6.261

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

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

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

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

3.5.6 The maximum requirements for imperfections visually observed in any randomly selected 12-inch (305-mm) diameter circle are shown in Table 2.

TABLE 2 - VISUAL IMPERFECTIONS

Type of Imperfection	Maximum Number for 1/8 Inch (3.2 mm) Cell Size	Maximum Number for 5/32 inch (4.0 mm) Cell Size	Maximum Number for 3/16 inch (4.8 mm) Cell Size	Maximum Number for 1/4 inch (6.4 mm) Cell Size	Maximum Number for 3/8 inch (9.5 mm) Cell Size
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 Figure 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 Length (L) and width (W) 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 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 (See Figure 1) for at least 60 cells selected at random in groups containing ten adjacent cells.

3.6.5 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 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

Flatwise compressive strength (3.4.1), node bond strength (3.4.3), and core density (3.4.4) are acceptance tests and shall be performed on each lot.

4.2.2 Preproduction Tests

All technical requirements are preproduction tests and shall be performed prior to or on the first-article 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:

4.3.1 For Acceptance 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, not less than three.

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

4.3.1.2 A statistical sampling plan, acceptable to purchaser, may be used in lieu of sampling as in 4.3.1.

4.3.2 For Preproduction Tests

Shall be acceptable to purchaser.

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

Shall be as follows:

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 0.020 inch ± 0.005 (0.51 mm ± 0.13) 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 0.625T x 5L x 10W inches (15.88T x 127L x 254W mm), shall be tested in a suitable tension fixture by mounting, without causing cell distortion, at opposite ends of the "W" dimension (See Figure 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). Thickness 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 inches ± 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 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 (107 °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 liters)

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 1 (inch/pound units) or Equation 2 (SI units).

$$M = \frac{36C\,(O - A)}{TLW} \qquad \text{(Eq. 1)}$$

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

$$M = \frac{26507C\,(O - A)}{TLW} \qquad \text{(Eq. 2)}$$

where:

M = Weight loss per square meter of exposed foil area, milligrams
C = Nominal cell size, millimeters (3.2, 4.0, 4.8, 6.4, 9.5)
T = Thickness measurement in direction of cell axis, millimeters
L = Ribbon length direction, millimeters
W = Transverse direction, millimeters
O = Original weight of specimen before exposure, milligrams
A = Final weight of specimen after stripping, milligrams

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 4349D, 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

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, two 0.5-inch (12-mm) wide black stripes to identify 5056 alloy, and a 0.5-inch (13-mm) wide colored stripe beside the second black stripe to identify the density range. The colors of the stripes shall be as specified in Table 3 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.

TABLE 3 - COLOR IDENTIFICATION

Color	FED-STD-595 Color Number	Density Range Pounds Per Cubic Foot	Density Range kg/m^3
Brown	10076	Up to 2.0, excl	Up to 32, excl
Orange	12246 or 22246	2.0 to 3.0, excl	32 to 48, excl
Blue	15102 or 25102	3.0 to 4.0, excl	48 to 64, excl
Red	11105 or 21105	4.0 to 5.0, excl	64 to 80, excl
Yellow	13655 or 23655	5.0 to 6.0, excl	80 to 96, excl
Purple	17142 or 27142	6.0 to 7.0, excl	96 to 112, excl
Green	14187	7.0 to 9.0, excl	112 to 144, excl
Brown and Green	10076 and 14187	9.0 to 11.0, excl	144 to 176, excl
Brown and Purple	10076 and 17142 or 27142	11.0 to 13.0, excl	176 to 208, excl
Orange and Blue	12246 or 22246 and 15102 or 25102	13.0 to 15.0, excl	208 to 240, excl
Blue and Red	15102 or 25102 and 11105 or 21105	15.0 to 17.0, excl	240 to 272, excl
Orange and Green	12246 or 22246 and 14187	17.0 to 19.0, excl	272 to 304, excl
Blue and Yellow	15102 or 25102 and 13655 or 23655	19.0 to 21.0, excl	304 to 336, excl
Orange and Brown	12246 or 22246 and 10076	21.0 to 23.0, excl	336 to 368, excl

Note: The term "excl" applies only to the higher figure of the specified range.