Society of Automotive Engineers, Inc.
TWO PENNSYLVANIA PLAZA, NEW YORK, N.Y. 10001

AEROSPACE MATERIAL SPECIFICATION

AMS 4301

Issued March 1, 1974
Revised

BORON-ALUMINUM COMPOSITE SHEET
50 v/o 5.6B, 2024-0, For Diffusion Bonding

1. SCOPE:

1.1 Form: This specification covers boron filaments and 2024-0 (AMS 4007) aluminum-base alloy foil laminated and bonded into a composite sheet.

1.2 Application: Primarily for fabrication of structural components by forming, laminating, and diffusion bonding into structural components where the composite properties of high modulus boron filaments and aluminum-base alloy matrix are desirable for use up to 500°F (260°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., Two Pennsylvania Plaza, New York, New York 10001.

2.1.1 Aerospace Material Specifications:

AMS 2350 - Standards and Test Methods
AMS 3865 - Boron Filaments, Tungsten Substrate, Continuous
AMS 4007 - Aluminum Alloy Foil, 4.4Cu - 1.5Mg - 0.06Mn (2024-0)

2.2 ASTM Publications: Available from American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103.

ASTM E345 - Tension Testing of Metallic Foil

3. TECHNICAL REQUIREMENTS:

3.1 Material: The product shall be a monolayer of boron filaments laid on and covered with 2024-0 aluminum-base alloy foil pressed and bonded to produce nominally 50% by volume each of boron filaments and aluminum-base alloy.

3.1.1 Boron Filaments: Shall conform to AMS 3865 with nominal filament diameter of 0.0056 in. (0.142 mm).

3.1.2 Aluminum-Base Alloy Foil: Shall conform to AMS 4007 of the thickness required to produce 50% by volume.

3.2 Construction:

3.2.1 Fabrication: The product shall be fabricated by collimated positioning of boron filaments on an aluminum-base alloy foil backing sheet. The boron filaments shall be secured on the foil with a suitable binder that may be driven off during the outgassing phase of subsequent diffusion bonding. Each boron filament/aluminum-base alloy monolayer shall be covered with an additional layer of foil of the same thickness as the backing foil.

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3.2.2 Filament Gaps: There shall be not more than three gaps per inch (25.4 mm) of width in any 12 in. (305 mm) of length and no gap shall have a width greater than 200% of the nominal filament spacing. Determination of the number of gaps and gap width shall be made in accordance with 3.2.2.1.

3.2.2.1 Nondestructive Evaluation: Orientation of boron filaments within the product shall be determined visually or, when specified, by low-energy X-ray techniques. Locations of nonconforming gaps, crossovers, stray filaments, splices, or broken filaments shall be marked on the product in such a manner that the defective area can be removed before further fabrication.

3.2.3 Filament Crossovers: There shall be no filament crossovers or stray filaments, determined in accordance with 3.2.2.1.

3.2.4 Spliced or Broken Filaments: Spliced or broken filaments shall not exceed 0.5% of the filament count in any 10-ft (3-m) or shorter length and shall not be closer to an adjacent filament defect than 0.50 in. (12.7 mm) laterally (transverse direction) and 6.0 in. (152 mm) along the filament axis (longitudinal direction),, determined in accordance with 3.2.2.1.

3.2.5 Boron Fiber Volume: The volume of boron fibers shall be 50% ± 3, determined by microscopic examination of the number of 0.0056 in. (0.142 mm) diameter (using actual filament diameter) filaments per inch (25.4 mm) of width in relation to the foil thicknesses. This determination can be by actual count of the filaments visually, or on the radiograph produced in 3.2.2.1, when specified.

3.3 Properties of Boron-Aluminum Sheet: The product shall conform to the following requirements; the specified values apply to the average of four determinations per test but no individual specimen shall have tensile strength or tensile modulus less than 90% of the average value specified. Tests shall be performed on specimens cut from composite panels fabricated in accordance with 3.3.1 and tested in accordance with 3.3.2. For tests at 500° F (260° C), specimens shall be held at the test temperature for not less than 30 min. before testing.

Property	At Room Temperature psi	(MPa)	At 500° F ± 10 (260° C ± 5.6) psi	(MPa)
Tensile Strength, min avg				
Longitudinal	180,000	(1241)	160,000	(1103)
Transverse	20,000	(138)	12,000	(83)
Tensile Modulus, min avg				
Longitudinal	30,000,000	(206,850)	25,000,000	(172,375)
Transverse	15,000,000	(103,425)	10,000,000	(68,950)

3.3.1 Fabrication of Test Panels: Test panels approximately 7.5 x 7.5 in. (190 x 190 mm) shall be fabricated by diffusion bonding 8 plies of as-received sheet. From these panels, longitudinal specimens (filament orientation at 0 deg (0 rad)) and transverse specimens (filament orientation at 90 deg (1.57 rad)) shall be cut. Processing conditions for diffusion bonding of each test panel shall be reported.

3.3.2 Tensile Tests:

3.3.2.1 Tensile Test Specimens: Tensile test specimens for longitudinal and transverse property determination shall be prepared from test panels fabricated in accordance with 3.3.1. Specimen configuration, gage length, and rate of loading shall be shown in the report.

3.3.2.2 Test Procedures: Tensile tests shall be in accordance with ASTM E345 and as follows:

3.3.2.2.1 Extensometer: An extensometer shall be used for a 1.00-in. (25.4-mm) gage length capable of being used to failure at small strains (0.010 in. or 0.25 mm). The extensometer shall preferably be of the LVDT type. An X-Y recorder shall be used to plot a load-extension curve directly from the load cell and extensometer.

3.3.2.2.2 Cyclic Loading: All longitudinal specimens shall be cycled from 0 to 1000 lb (0 to 4448 N) at 0.05 in. (1.27 mm) per min., to set the grips. Transverse specimens shall not be cycled.

3.3.2.2.3 Tensile Modulus Determination: Strain gages may be used when determining modulus of elasticity in tension.

3.4 Filament Strength After Diffusion Bonding: Boron filaments shall be evaluated for embrittlement or other degradation caused by diffusion bonding. Evaluation shall be made by the bend test of 3.4.2 or, if tensile testing is specified or in case of question on the results of the bend test, by the tensile test of 3.4.3. If tensile testing is used, the average boron filament strength shall be not less than 400,000 psi (2760 MPa). Not less than 10 individual filaments, obtained as in 3.4.1, from each diffusion bonded panel prepared in accordance with 3.3.1. shall be evaluated.

3.4.1 Filament Extraction: Extract filaments from test panels as follows:

3.4.1.1 Cut a full length of panel sufficiently wide to yield approximately 25 filaments.

3.4.1.2 Completely submerge the panel section in a suitable sodium hydroxide solution and allow to stand until the matrix is completely dissolved. If necessary, spent solvent may be carefully removed and fresh solvent added.

3.4.1.3 After matrix is completely dissolved, separate the filaments from the solution and rinse with distilled water.

3.4.1.4 Examine the filaments for breakage.

3.4.1.5 Dry the filaments in an oven or desiccator.

3.4.2 Bend Test: Each boron filament shall withstand, without breaking, bending through an angle of 180 deg (3.14 rad) around a 1.00 in. ± 0.01 (25.4 mm ± 0.3) diameter mandrel with the filament direction perpendicular to the axis of the bend. Test not less than 10 filaments from each prepared panel. All filaments tested must pass. In case of question on the bend test results, conduct the tensile strength tests in accordance with 3.4.3.

3.4.3 Tensile Test: Tensile test not less than 10 individual filaments in accordance with AMS 3865. If breaks occur in the grips, test additional filaments until 10 valid results have been obtained. Report the arithmetic mean of the 10 results and the individual values for each valid specimen, the gage length used, the gripping method, and the rate of loading.

3.5 Quality: The product shall be uniform in quality and condition, clean, smooth, as free from foreign material as commercially practicable, and free from imperfections detrimental to fabrication, appearance, or performance of parts.

3.6 Sizes and Tolerances:

3.6.1 Thickness Increments: Shall be determined by filament spacing and foil thickness of each face, developed to produce 50% by volume each of boron filaments and aluminum-base alloy foil after diffusion bonding.

3.6.2 Width: Shall not deviate from the ordered width by more than +0.125 in. (+3.18 mm), -0.

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 4.4. Purchaser reserves the right to perform such confirmatory testing as he deems necessary to assure 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 material (3.1), construction (3.2), and quality (3.5) 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.

4.3 Sampling: Each lot shall be examined for conformance to the acceptance test requirements specified herein.

4.3.1 Lot: A lot shall be all boron-aluminum composite sheet fabricated under the same fixed conditions and submitted for inspection at one time.

4.4 Reports:

4.4.1 The vendor of the product shall furnish with each shipment three copies of a report showing the results of tests made on the product to determine conformance to the acceptance test requirements of this specification, including a statement of conformance of the boron filaments and aluminum-base alloy foil to the requirements of the applicable material specifications, X-ray techniques when used for nondestructive evaluation, and a statement that the product conforms to all other technical requirements of this specification. This report shall include the purchase order number, material specification number, vendor's material designation, lot number, date of manufacture, form or part number, and quantity.

4.4.2 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 material, supplier'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.

4.5 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 Packaging and Identification:

5.1.1 Each sheet shall be wrapped in heavy gage polyethylene film or other suitable protective material 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.

5.1.2 Each sheet or container shall be identified by attached removable tags using characters of such size as to be clearly legible and which will not be obliterated by normal handling. Each tag shall show the following information: