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AEROSPACE MATERIAL SPECIFICATION

AMS 3865B
Superseding AMS 3865A

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FILAMENTS, BORON
Tungsten Substrate, Continuous

1. SCOPE:

1.1 Form: This specification covers continuous filaments consisting of boron deposited on a tungsten substrate by the hydrogen reduction of boron trichloride.

1.2 Application: Primarily for reinforcement of structural plastic and metallic composites.

2. APPLICABLE DOCUMENTS: The following publications form a part of this specification to the extent specified herein. The latest issue of Aerospace Material Specifications 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 3867 - Boron Filament Tape, Epoxy Resin Impregnated

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

ASTM D3379 - Tensile Strength and Young's Modulus for High-Modulus Single-Filament Materials
ASTM D3800 - Density of High Modulus Fibers

2.3 U.S. Government Publications: Available from Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.

2.3.1 Military Standards:

MIL-STD-794 - Parts and Equipment, Procedures for Packaging and Packing of

3. TECHNICAL REQUIREMENTS:

3.1 Material:

3.1.1 Construction: Filaments shall be formed by vapor deposition of boron from Ø boron trichloride and hydrogen on a tungsten substrate to form continuous filaments of the diameter ordered.

3.1.2 Finish: There shall be no finish compound or treatment applied to the boron filaments.

3.1.3 Splices: Splicing of boron filaments to achieve proper package lengths Ø shall be permitted in accordance with the following:

3.1.3.1 Type and Size of Splice: Overlap splice 1 to 2 in. (25 to 50 mm) Ø in length shall be achieved with uniform resin application and shall be free from agglomerates. Splices shall be capable of being drawn through a slot four times as wide as the nominal filament diameter.

3.1.3.2 Splicing Adhesive: Shall be a polyimide resin based adhesive cured Ø sufficiently to be resistant to solvents used in polyimide and epoxy resin systems and to other resin systems and their solvents.

3.1.3.3 Thermal Stability: Each splice shall support a load of 64 g ± 1 at Ø 205°C ± 5 (400°F ± 9) for not less than 10 minutes. Splices shall not emit volatiles at temperatures up to 190°C (375°F).

3.1.3.4 Quality of Splice: Shall be such that breaks or splits, or both, will Ø not occur on winding on spools or on unwinding for use.

3.1.3.5 Frequency of Splices: Average distance between splices shall be not Ø less than 1000 ft (300 m), with the shortest length between splices in any one spool not less than 500 ft (150 m).

3.1.4 Bending: Boron filaments shall withstand, without breaking, bending through an angle of 180 deg around a mandrel of the size noted below with the filament direction perpendicular to the axis of the bend.

Nominal Filament Diameter		Minimum Mandrel Diameter	
Inch	Millimetre	Inches	Millimetres
0.0040	0.100	0.625	15.75
0.0056	0.140	0.875	22.00
0.0080	0.200	1.250	31.25

3.1.5 Resin Coupling: When specified, boron filaments shall couple with an impregnating resin to meet the property requirements of an applicable resin-impregnated-product specification.

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

3.2.1 Tensile Strength: 4.5.1

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Minimum Average for each Lot	450,000 psi (3105 MPa)
Minimum Average for each Production Run (Spool, Inspection Unit)	400,000 psi (2760 MPa)
Individual Minimum	350,000 psi (2415 MPa)

3.2.2 Modulus of Elasticity in Tension: 4.5.2

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Minimum Average	58,000,000 psi (400,000 MPa)
Individual Minimum	55,000,000 psi (379,200 MPa)

3.2.3 Filament Density, max: ASTM D3800

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Nominal Diameter	
0.0040 in. (0.100 mm)	0.098 lb per cu in. (2.70 Mg/m^3)
0.0056 in. (0.140 mm)	0.094 lb per cu in. (2.60 Mg/m^3)
0.0080 in. (0.200 mm)	0.090 lb per cu in. (2.50 Mg/m^3)

3.2.4 Twist: max 1.0 turn per 10 ft (3 m) 4.5.4

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3.3 Quality: Filaments, as received by purchaser, shall be uniform in quality and condition, clean, smooth, and free from foreign material and from imperfections detrimental to usage of the filaments.

3.4 Sizes and Tolerances:

3.4.1 Filament Diameter: Unless otherwise specified, filament shall be supplied in one of the following diameters, as ordered. Filament diameter shall be determined in accordance with 4.5.3.

0.0040 in. ± 0.0002 (0.100 mm ± 0.005)
0.0056 in. ± 0.0002 (0.140 mm ± 0.005)
0.0080 in. ± 0.0002 (0.200 mm ± 0.005)

3.4.2 Length: Shall be not less than the net length ordered. Defective filament, identified but not removed from a length, shall not be counted as net length.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection: The vendor of filaments 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 filaments conform to the requirements of this specification.

4.1.1 Inspection records shall be kept complete and available to purchaser for at least seven years.

4.2 Classification of Tests:

4.2.1 Acceptance Tests: Tests to determine conformance to requirements for tensile strength (3.2.1) and filament diameter (3.4.1) are classified as acceptance tests and shall be performed on each inspection unit.

4.2.2 Periodic Tests: Tests to determine conformance to requirements for splice evaluation (3.1.3), bending (3.1.4), modulus of elasticity in tension (3.2.2), filament density (3.2.3), twist (3.2.4), and computation of coefficient of variation and standard deviation from tensile data (4.5.1.1) are classified as periodic tests and shall be performed periodically as criteria of process control at a selected frequency of determination agreed upon by purchaser and vendor.

4.2.3 Preproduction Tests: Tests to determine conformance to all technical requirements of this specification are classified as preproduction tests and shall be performed prior to or on the initial shipment of filaments to a purchaser, when a change in material or processing, or both, requires reapproval as in 4.4.2, and when purchaser deems confirmatory testing to be required.

4.2.3.1 For direct U.S. Military procurement, substantiating test data and, when Ø 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:

4.3.1 For Acceptance Tests: Sufficient filaments shall be taken at random from Ø each production run or inspection unit 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 therein, not less than three.

4.3.1.1 A lot shall be that quantity of boron filaments collected for shipment Ø to a single user or material processor.

4.3.1.2 An inspection unit shall be each spool of the same size filaments Ø produced in one production run manufactured in continuous operation of a single reactor from the same batches of raw materials. An inspection unit shall not exceed 5.0 lb (2.25 kg) of filaments.

4.3.1.3 When a statistical sampling plan and acceptance quality level (AQL) for Ø filaments have been agreed upon by purchaser and vendor, sampling shall be in accordance with such plan in lieu of sampling as in 4.3.1 and the report of 4.6.1 shall state that such plan was used.

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

4.4 Approval:

4.4.1 Sample filaments shall be approved by purchaser before filaments for production use are supplied, unless such approval be waived by purchaser. Results of tests on production filaments 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 filaments which are essentially the same as those used on the approved sample filaments. 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 material or processing, or both, and, when requested, sample filaments. Production filaments made by the revised procedure shall not be shipped prior to receipt of reapproval.

4.5 Test Methods:

4.5.1 Tensile Strength: Shall be determined for each continuous filament production run in accordance with ASTM D3379, using a specimen with a 1.0-in. (25-mm) gage length and tested at a load rate of 0.05 to 0.50 in. (1.2 to 12 mm) per minute. An average tensile load, $\bar{X}_{10}$, shall be determined from 10 individual tensile specimens taken from each production machine run.

4.5.1.1 Standard Deviation: Shall be calculated for each sample set as follows:

$$\text{Standard Deviation, } \sigma = \sqrt{\frac{1}{n-1}\sum_{1}^{n}(X - \bar{X}_{10})^2}$$

where: n is the number of samples

4.5.1.2 Coefficient of Variation: Shall be computed according to the following formula:

$$\text{Average Coefficient of Variation, \%} = \frac{1}{L}\sum_{1}^{L}\frac{\sigma}{\bar{X}_{10}} \times 100$$

where: L is the number of production machine runs within a specific shipment

4.5.2 Modulus of Elasticity in Tension: Shall be determined in accordance with ASTM D3379 using either sonic measurements or on tensile specimens with long gage lengths, 10 in. (250 mm) or greater, from which the stress-strain values can be obtained. In case of dispute, stress-strain measurements using long gage lengths shall be used as the referee method.

4.5.3 Filament Diameter: The diameter shall be measured optically or by other suitable means to ensure adherence to both the tolerances required in the specification and to provide the base to calculate that the minimum tensile strength requirements are met.

4.5.4 Twist: After removing, under tension, and discarding approximately 30 ft (9 m) of filament from the free end of the spool, tag the free end and unwind, without permitting to untwist, a section of filament 10 ft (3 m) long. Secure the 10 ft (3 m) length in a vertical position, in the absence of drafts. Free the lower end and count the number of revolutions made about the vertical axis by the free, lower end.

4.6 Reports:

4.6.1 The vendor of filaments shall furnish with each shipment a report showing the results of tests to determine conformance to the acceptance test requirements and, when performed, to the periodic test requirements of this specification. This report shall include the purchase order number, AMS 3865B, vendor's material designation, date of manufacture, lot number, quantity, method of determining tensile strength, and, when specified, the number and location of splices.

4.6.2 The vendor of finished or semi-finished parts shall furnish with each shipment a report showing the purchase order number, AMS 3865B, contractor or other direct supplier of filaments, supplier's material designation, part number, and quantity. When filaments for making parts are produced or purchased by the parts vendor, that vendor shall inspect each lot of filaments to determine conformance to the requirements of this specification and shall include in the report either a statement that the filaments conform or 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 filaments 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 filaments 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 Filaments: The filaments shall be supplied in continuous lengths wound on spools with cores having an outside diameter of not less than 8 in. (200 mm). Winding shall be uniform and provide for proper unreeling. Ends shall be secured.

5.1.2 Winding Pattern: Filament shall be closely wound in layers on the spools
Ø but adjacent turns within a layer need not necessarily be touching. Filament shall be wound so as to avoid producing kinks, waves, and sharp bends and shall be free to unwind without restriction caused by overlapping or wedging.

5.1.3 Liner Interleave: Filament may be wound with a paper liner interleaf
Ø inserted at the end of each layer. Liner material shall be of such stock as to impart no contaminants to the filament or filament surface which would affect composite properties.