



AEROSPACE MATERIAL SPECIFICATION

AMS3865

REV. C

Issued 1969-11
Revised 1991-07
Reaffirmed 2013-07

Superseding AMS3865B

Filaments, Boron
Tungsten Substrate, Continuous

RATIONALE

AMS3865C has been reaffirmed to comply with the SAE five-year review policy.

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.
- 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 following publications form a part of this specification to the extent specified herein. The applicable issue of referenced publications shall be the issue in effect on the date of the purchase order.

2.1 ASTM Publications:

Available from ASTM, 1916 Race Street, Philadelphia, PA 19103-1187.

ASTM D 3379 - Tensile Strength and Young's Modulus for High-Modulus Single-Filament Materials

ASTM D 3800 - Density of High Modulus Fibers

2.2 U.S. Government Publications:

Available from Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

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2.3.1 Military Standards:

MIL-STD-2073-1 - DOD Materiel, Procedures for Development and Application of Packaging Requirements

3. TECHNICAL REQUIREMENTS:

3.1 Material:

3.1.1 Construction: Filaments shall be formed by vapor deposition of boron from 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 shall be permitted in accordance with the following:

3.1.3.1 Type and Size of Splice: Overlap splice 1 to 2 inches (25 to 51 mm) 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-base adhesive cured sufficiently to withstand processing and manufacturing process parameters.

3.1.3.3 Thermal Stability: Each splice shall support a load of 64 grams \pm 1 at 205°C \pm 5 (401°F \pm 9) for not less than 10 minutes. Splices shall not emit volatiles at temperatures up to 190°C (374°F).

3.1.3.4 Quality of Splice: Shall be such that breaks and/or splits will 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 less than 1000 feet (305 m), with the shortest length between splices in any one spool not less than 500 feet (152 m).

3.1.4 Bending: Boron filaments shall withstand, without breaking, bending through an angle of 180 degrees 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 | Millimeter | Inches | Millimeters |
| 0.0040 | 0.102 | 0.625 | 15.88 |
| 0.0056 | 0.142 | 0.875 | 22.22 |
| 0.0080 | 0.203 | 1.250 | 31.75 |

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

| | |
|--|--------------------|
| Minimum Average for each Lot | 450 ksi (3103 MPa) |
| Minimum Average for each Production Run (Spool, Inspection Unit) | 400 ksi (2758 MPa) |
| Individual Minimum | 350 ksi (2413 MPa) |

3.2.2 Modulus of Elasticity in Tension: 4.5.2

| | |
|--------------------|---------------------|
| Minimum Average | 58,000ksi (400 GPa) |
| Individual Minimum | 55,000ksi (379 GPa) |

3.2.3 Filament Density, maximum: ASTM D 3800

Nominal Diameter

| | |
|------------------------|--|
| 0.0040 inch (0.102 mm) | 0.098 pound/cubic inch (2.71 Mg/m ³) |
| 0.0056 inch (0.142 mm) | 0.094 pound/cubic inch (2.60 Mg/m ³) |
| 0.0080 inch (0.203 mm) | 0.090 pound/cubic inch (2.49 Mg/m ³) |

3.2.4 Twist, maximum: 1.0 turn per 10 feet (3 m) 4.5.4

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

3.4 Sizes and Tolerances:

3.4.1 Filament Diameter: 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 inch ± 0.0002 (0.102 mm ± 0.005) |
| 0.0056 inch ± 0.0002 (0.142 mm ± 0.005) |
| 0.0080 inch ± 0.0002 (0.203 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. 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 for tensile strength (3.2.1) and filament diameter (3.4.1) are acceptance tests and shall be performed on each inspection unit.

4.2.2 Periodic Tests: Tests 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 standard deviation from tensile data (4.5.1.1) are periodic tests and shall be performed at a frequency selected by the vendor unless frequency of testing is specified by purchaser.

4.2.3 Preproduction Tests: Tests for all technical requirements are preproduction tests and shall be performed prior to or on the initial shipment of filaments 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.

4.2.3.1 For direct U.S. Military procurements 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 as follows:
0

4.3.1 For Acceptance Tests: Sufficient filaments shall be taken at random from 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 from a single production run collected for shipment to a single user or material processor.

4.3.1.2 An inspection unit shall be each spool of the same size filaments 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 pounds (2.27 kg) of filaments.

4.3.1.3 When a statistical sampling plan has 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 shall state that such plan was used.

4.3.2 For Preproduction Tests: As agreed upon by 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 ingredients and/or processing, 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 D 3379, using a specimen with a 1.0-inch (25-mm) gage length and tested at a load rate of 0.05 to 0.50 inch per minute (0.02 to 0.22 mm/s). 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:

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

where: n is the number of samples

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

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

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 D 3379 using either sonic measurements or on tensile specimens with long gage lengths, 10 inches (254 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 tolerance requirements of 3.4.1 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 feet (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 feet (3 m) long. Secure the 10-foot (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: The vendor of filaments shall furnish with each shipment a report 0 showing the results of tests to determine conformance to the acceptance test requirements and, when performed, to the periodic test requirements. This report shall include the purchase order number, lot number, AMS 3865C, vendor's identification, date of manufacture, quantity, method of determining tensile strength, and, when specified, the number and location of splices.
- 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. 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 inches (203 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 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 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.