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

# AEROSPACE MATERIAL SPECIFICATION

AMS 3811

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Revised

## RODS, ARAMID FIBER/POLYESTER RESIN, COATED
Pultrusion



1. SCOPE:

1.1 Form: This specification covers coated round rods manufactured by the pultrusion process from aramid fibers and a weather-resistant polyester resin binder.

1.2 Application: Primarily for nonconductive tension elements in antenna supports where superior long-term weather resistance and extremely light weight are required.

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 3901/4 - Yarn, Organic Fiber, For Structural Composites, OY 400 000 (2760) Tensile Strength, 17 500 000 (121) Tensile Modulus, 1420 Denier

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

ASTM D149 - Dielectric Breakdown Voltage and Dielectric Strength of Electrical Insulating Materials at Commercial Power Frequencies
ASTM D638 - Tensile Properties of Plastics
ASTM D695 - Compressive Properties of Rigid Plastics
ASTM D785 - Rockwell Hardness of Plastics and Electrical Insulating Materials
ASTM D790 - Flexural Properties of Plastics
ASTM D792 - Specific Gravity and Density of Plastics by Displacement
ASTM D2289 - Tensile Properties of Plastics at High Speeds
ASTM D2344 - Apparent Horizontal Shear Strength of Reinforced Plastics by Short Beam Method
ASTM D2648 - Measuring Time-to-Failure by Rupture of Plastics Under Tension in Various Environments

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

2.3.1 Military Standards:

MIL-STD-105 - Sampling Procedures and Tables for Inspection by Attributes
MIL-STD-794 - Parts and Equipment, Procedures for Packaging and Packing of





Printed in U.S.A.

3. TECHNICAL REQUIREMENTS:

3.1 Material: Shall be rods of circular cross section, manufactured by the pultrusion process from the necessary number of unidirectional, continuous, aramid rovings and a high-quality, weather-resistant, thermosetting polyester resin binder. The rods shall be coated for enhanced weatherability and resistance to handling damage.

3.1.1 Roving: Each roving shall have a denier of not less than 14,200, formed by gathering continuous-filament, aramid-fiber yarns together into an approximately parallel arrangement without twist. The yarns shall conform to AMS 3901/4 and shall be free of splices.

3.1.2 Resin Binder: Shall be a high-quality, weather-resistant, thermosetting polyester, cross-linked with styrene. The resin formulation may contain a catalyst, a die lubricant, and additives for enhanced weather resistance, flame retardance, and anti-tracking qualities, but it shall not contain a wetting agent or a coupling agent, and shall be free of grease, oil, dirt, and other foreign matter.

3.1.3 Coating: Shall be primarily organic, but may contain inorganic ingredients. It shall be applied uniformly over the cylindrical surfaces of the rods to a thickness of 0.010 in. ± 0.005 (0.25 mm ± 0.13).

3.1.3.1 The surfaces of coated rods shall be smooth, nonporous, and free of cracks. The coating shall not contain scratches, gouges, or other handling damage. Scuff marks and occasional blisters not exceeding one in any 5 ft (1.5 m), pits, or other manufacturing imperfections will be acceptable provided that they neither penetrate to the substrate nor protrude above the surface by more than 3% of the finished rod diameter.

3.1.3.2 The coating shall be flexible and well-adhered to the substrate, determined in accordance with 4.5.1 and 4.5.2.

3.2 Fabrication:

3.2.1 Roving Preparation: The roving shall be dried for not less than 8 hr at 250°F ± 10 (120°C ± 5), immediately prior to impregnation, and shall be maintained in the dry condition by passing through a suitable heating chamber until immersed in the resin trough.

3.2.2 Pultrusion: Pultrusion of the rods shall be performed in accordance with best practices of the pultrusion industry.

3.2.3 Coiling: Coiling of rods (See 5.2.1), shall not be attempted until the rods have cooled to below 100°F (38°C). Coiling shall be accomplished with care to ensure that no portion of the rod is bent, even momentarily, to a radius of curvature less than one-half the coil diameter. The coil diameter shall be not less than 300 times the rod diameter unless rods have passed the coiled storage test in accordance with 4.5.12 utilizing a smaller coil diameter.

3.2.3.1 Rods furnished in straight lengths (See 5.2.1) shall not be cut from coils.

3.2.4 Post Curing: When specified by purchaser, straight rods not exceeding 10 ft (3 m) in length shall be post-cured for not less than 15 hr at 275°F ± 10 (135°C ± 5). The rods shall be fully supported during post curing to avoid warping.

3.3 Properties: The product shall conform to the following requirements; tests shall be performed on the product supplied and in accordance with specified test methods, insofar as practicable:

| | | |
|---|---|---|
| 3.3.1 Tensile Strength, min | 125 000 psi (862 MPa) | 4.5.3 |
| 3.3.2 Stress-Rupture Strength, min | 70 000 psi (483 MPa) | 4.5.4 |
| 3.3.3 Flexural Strength, min | | 4.5.5 |
| At 68° - 86°F (20° - 30°C) | 95% of Qualification Value | |
| At -70°F ± 5 (-57°C ± 3) | 90% of Qualification Value | |
| 3.3.4 Vibration Fatigue Strength | | 4.5.6 |
| At 70 000 psi (483 MPa) | Pass | |
| 3.3.5 Dielectric Strength, min | | 4.5.7 |
| Dry | 70 V per mil (2.76 MV/m) | |
| Wet | 15 V per mil (0.59 MV/m) | |
| 3.3.6 Short Beam Shear Strength, min | 4500 psi (31 MPa) | 4.5.8 |
| 3.3.7 Fiber Content | Qualification Value ±3% | 4.5.9 |
| 3.3.8 Hardness, Rockwell E | Qualification Value ±10 | 4.5.10 |
| 3.3.9 Transverse Tensile Strength | Qualification Value ±20% | 4.5.11 |
| 3.3.10 Density | Qualification Value ±10% | ASTM D792 |

3.4 Quality: The product shall be uniform in quality and condition, smooth, and free from foreign materials and from internal and external imperfections detrimental to fabrication, appearance, or performance of parts.

3.5 Tolerances: Unless otherwise specified, the following tolerances shall apply:

3.5.1 Diameter: ±3% of nominal.

3.5.2 Length:

TABLE I

| Nominal Length, Feet | Tolerance, Feet |
|---|---|
| Up to 10, incl | +0.10, -0 |
| Over 10 to 50, incl | +0.25, -0 |
| Over 50 | +1.0, -0 |

TABLE I (SI)

| Nominal Length, Metres | Tolerance, Metres |
|---|---|
| Up to 3, incl | +0.03, -0 |
| Over 3 to 15, incl | +0.08, -0 |
| Over 15 | +0.3, -0 |

3.5.3 Straightness: The departure from straightness for rods furnished in straight lengths shall not exceed ±0.04 in. per ft (3.3 mm per m) of length.

4. QUALITY ASSURANCE PROVISIONS:

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

4.2 Classification of Tests:

4.2.1 Acceptance Tests: Tests to determine conformance to material (3.1), tensile strength (3.3.1), fiber content (3.3.7), hardness (3.3.8), transverse tensile strength (3.3.9), density (3.3.10), quality (3.4), and tolerance (3.5) requirements are classified as acceptance tests.

4.2.2 Periodic Tests: Tests to determine conformance to flexural strength (3.3.3) requirements are classified as periodic tests.

4.2.3 Qualification Tests: Tests to determine conformance to all technical requirements of this specification are classified as qualification tests except that the coiled storage test (4.5.12) is not required unless rod is to be supplied in coil diameters less than 300 times the nominal rod diameter.

4.2.3.1 For direct U.S. Military procurement, substantiating test data and, when requested, qualification test material shall be submitted to the cognizant qualification agency as directed by the procuring activity, the contracting officer, or the request for procurement.

4.3 Sampling:

4.3.1 Acceptance Tests: Shall be in accordance with Single Sampling for Normal Inspection, General Inspection Level II, with an Acceptable Quality Level (AQL) of 2.5 specified in MIL-STD-105, as shown in Table II. Sufficient test material shall be taken from inspection units selected at random from each production lot to perform all required tests and to allow for invalid tests. The number of specimens for each test shall be as specified in the applicable test procedure or, if not specified therein, not less than three.

4.3.1.1 Lot: Shall be all rod produced from the same batches of ingredients, using the same processing conditions on the same machine, in a period not longer than 24 hr, and submitted for vendor's inspection at one time.

4.3.1.2 Inspection Unit: Shall be each coil or 1000 ft (300 m) of rod, whichever is smaller, using both ends of each coil.

TABLE II

| Number of Inspection Units in the Lot | Number of Inspection Units from Which Samples are to be Taken | Number of Nonconforming Samples to | |
|---|---|---|---|
| | | Accept | Reject |
| 1 - 50 | 8 (4.3.1.2.1) | 0 | 1 |
| 51 - 90 | 13 | 1 | 2 |
| 91 - 150 | 20 | 1 | 2 |
| 151 - 280 | 32 | 2 | 3 |
| 281 - 500 | 50 | 3 | 4 |

4.3.1.2.1 If the number of inspection units to be sampled equals or exceeds the lot size, inspect each unit.

4.3.1.3 Reduced Inspection: After 10 consecutive lots meet Table II requirements, inspection sampling may be reduced for the product of that machine to Special Inspection Level S-1, MIL-STD-105, wherein the Single Sample Size is 3 and the Acceptance Number is 0. Should any rejections occur, sampling shall be returned to that of Table II for at least 10 consecutive satisfactory production lots.

4.3.2 Periodic Tests: The frequency and sampling plan for periodic tests shall be as agreed upon by purchaser and vendor.

4.3.3 Qualification Tests: Shall be as agreed upon by purchaser and vendor.

4.4 Approval:

4.4.1 Sample rod shall be approved by purchaser before rod for production use is supplied, unless such approval be waived. Results of tests on production rod 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 rod which are essentially the same as those used on the approved sample rod. If any change is necessary in ingredients, in type of processing, or in manufacturing procedures, vendor shall submit for reapproval a statement of the proposed changes in material and processing and, when requested, sample rod. Production rod made by the revised procedure shall not be shipped prior to receipt of reapproval.

4.5 Test Methods:

4.5.1 Coating Flexibility: Shall be determined in accordance with ASTM D2289 using a specimen of full-diameter rod having length not exceeding 50 times the rod diameter. The specimen shall be subjected to an axial tensile stress of 70 000 psi (483 MPa) using a testing speed which attains the required tensile load in not more than one second. Any loading method which meets this requirement may be used, including high-speed testing machines and drop weights. The specimen shall be examined, using magnification not over 10X, not less than 12 hr after the load is removed. Hairline cracks in the coating in a direction transverse to the rod axis or other evidence of coating damage are not acceptable.

4.5.2 Coating Adhesion: Shall be determined using a specimen of full-diameter rod. A transverse saw cut shall be made on the surface of the specimen, to a depth of 1/4 to 1/3 of the rod diameter. Using the point of a sharp instrument, such as a penknife or surgical blade, at the edges of the saw cut, attempt to pry off the coating. If a single piece of coating having a surface area greater than 1/8 in. (3 mm) square can be flaked off cleanly from the substrate, the rod is not acceptable.

4.5.3 Tensile Strength: Shall be determined in accordance with ASTM D638. The specimen shall be a full-diameter rod having length not less than 100 times the rod diameter, to which high-performance end fittings or grips have been attached. The specimen shall be loaded to a tensile stress of not less than 125 000 psi (862 MPa) and the load maintained for not less than one min. without visible or audible evidence of incipient failure. A mechanical failure of the specimen initiating in an end fitting or grip prior to the completion of the one-min. interval shall constitute an invalid test. In case of dispute between purchaser and vendor, results obtained using end fittings or grips conforming to the vendor's specifications shall govern.

4.5.4 Stress-Rupture Strength: Stressed exposure to simulated weather conditions shall be determined in accordance with ASTM D2648 and as follows:

4.5.4.1 The specimen shall be a full-diameter rod having length not less than 50 times the rod diameter, to which suitable end fittings or grips have been attached. The specimen, not including the end fittings or grips, shall be exposed for not less than 240 hr in an environmental chamber maintained at 160°F ± 5 (71°C ± 3) and saturated humidity conditions, while under a constant load sufficient to produce an initial tensile stress of 70 000 psi (483 MPa). The rod shall exhibit no structural damage, deterioration, or other evidence of incipient failure. A mechanical failure of the specimen initiating in an end fitting or grip prior to completion of the 240 hr interval shall constitute an invalid test. In case of dispute between purchaser and vendor, results obtained using end fittings or grips conforming to the vendor's specifications shall govern.

4.5.5 Flexural Strength: Shall be determined in accordance with ASTM D790 using specimens of full-diameter rod, three-point loading, and a span-to-diameter ratio of 40.

4.5.6 Vibration Fatigue Strength: Shall be determined using a full-diameter rod having length not less than 300 times the rod diameter subjected to forced, transverse vibration at a resonance frequency between 45 and 90 Hz while under an axial tensile stress of 70 000 psi (483 MPa). The double amplitude of vibration at an anti-node point shall be not less than twice the rod diameter. Specimens shall exhibit no evidence of damage after 100 000 000 cycles.

4.5.7 Dielectric Strength: Shall be determined in accordance with ASTM D149, short time test, using disk specimens having length approximately equal to the rod diameter or 0.50 in. (12.7 mm). Tests shall be performed with the specimens under oil, using a voltage rise of 500 V/sec at a frequency of 60 Hertz. Dry specimens shall be conditioned at 77°F ± 9 (25°C ± 5) and relative humidity of 50% ± 5 for not less than 24 hr prior to testing. Wet specimens shall be tested immediately after immersion in boiling distilled water for not less than 2 hours.

4.5.7.1 Disk specimens shall be cut from full-diameter rod using a water-cooled, diamond cut-off saw, or equivalent, to obtain faces which are smooth and parallel, perpendicular to the rod axis, and not frayed at the edges. The water shall be blotted from the disks carefully, immediately after cutting.

4.5.8 Short Beam Shear Strength: Shall be determined in accordance with ASTM D2344 using specimens of square cross-section machined from full-diameter rod.