

Submitted for recognition as an American National Standard

RODS, GLASS FIBER, POLYESTER RESIN, COATED
Pultrusion

1. SCOPE:

- 1.1 Form: This specification covers coated round rods manufactured by the pultrusion process from glass fiber roving and a weather-resistant polyester resin binder.
- 1.2 Application: Primarily for nonconductive tension elements in antenna supports where superior long-term weather resistance is required.
- 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 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

SAE Technical Board Rules provide that: "This report is published by SAE to advance the state of technical and engineering sciences. The use of this report is entirely voluntary, and its applicability and suitability for any particular use, including any patent infringement arising therefrom, is the sole responsibility of the user."

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2.2 ASTM Publications: Available from American Society of Testing and Materials, 1916 Race Street, Philadelphia, PA 19013.

- ASTM D149 - Dielectric Breakdown Voltage and Dielectric Strength of Solid 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 Unreinforced and Reinforced Plastics and Electrical Insulating Materials
- ASTM D792 - Specific Gravity (Relative Density) and Density of Plastics by Displacement
- ASTM D2289 - Tensile Properties of Plastics at High Speeds
- ASTM D2584 - Ignition Loss of Cured Reinforced Resins
- ASTM D2990 - Tensile, Compressive, and Flexural Creep and Creep Rupture of Plastics

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 Specifications:

MIL-R-60346 - Roving, Glass, Fibrous (for Prepreg Tape and Roving, Filament Winding, and Pultrusion Applications)

2.3.2 Military Standards:

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

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, glass fiber rovings and a polyester resin binder. The rods shall be coated for enhanced resistance to weathering and handling damage.

3.1.1 Roving: Shall conform to MIL-R-60346, Type I, Class 2, and shall be free of splices.

3.1.2 Resin Binder: Shall be a high-quality, weather-resistant, thermosetting polyester resin, 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 inch \pm 0.005 (0.25 mm \pm 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, occasional blisters not exceeding one in any 5 feet (1.5 m), pits, and 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 adherent to the substrate, determined in accordance with 4.5.1 and 4.5.2.

3.2 Fabrication:

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

3.2.2 Coiling: Coiling of rods (See 5.2.1) shall not be attempted until the rods have cooled to below 100°F (38°C). The coil diameter shall be not less than 300 times the rod diameter, unless rods have passed the coiled storage test in accordance with 4.5.11 utilizing a smaller coil diameter.

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

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

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

3.3.1 Tensile Strength, minimum	100,000 psi (690 MPa)	4.5.3
3.3.2 Stress-Rupture Strength, minimum	70,000 psi (483 MPa)	4.5.4
3.3.3 Flexural Strength, minimum	100,000 psi (690 MPa)	4.5.5
At 68° - 86°F (20° - 30°C)		
At -70°F ± 5 (-57°C ± 3)	90,000 psi (621 MPa)	
3.3.4 Vibration Fatigue Strength		4.5.6
At 70,000 psi (483 MPa)	Pass	
3.3.5 Dielectric Strength, minimum	100 V per mil (3.99 MV/m)	4.5.7
Dry		
Wet	40 V per mil (1.57 MV/m)	

3.3.6	Fiber Content	Preproduction Value $\pm 3\%$	4.5.8
3.3.7	Hardness, Rockwell E	Preproduction Value ± 10	4.5.9
3.3.8	Transverse Tensile Strength	Preproduction Value $\pm 20\%$	4.5.10
3.3.9	Density	Preproduction Value $\pm 10\%$	ASTM D792

3.4 Quality: Rods, as received by purchaser, shall be uniform in quality and \emptyset condition, smooth, and free from foreign materials and from imperfections detrimental to usage of the rods.

3.5 Tolerances: Shall be as follows:

3.5.1 Diameter: $\pm 3\%$ 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	+0.30, -0

3.5.3 Straightness: The departure from straightness for rods furnished in straight lengths shall not exceed ± 0.04 inch per foot (± 3.1 mm per m) of length.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection: The vendor of rods shall supply all samples \emptyset 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 rods conform to the requirements of this specification.

4.2 Classification of Tests:

- 4.2.1 Acceptance Tests: Tests to determine conformance to requirements for material (3.1), tensile strength (3.3.1), fiber content (3.3.6), hardness (3.3.7), transverse tensile strength (3.3.8), density (3.3.9), quality (3.4), and tolerances (3.5) are classified as acceptance tests and shall be performed on each lot.
- 4.2.2 Periodic Tests: Tests to determine conformance to requirements for flexural strength (3.3.3) are classified as 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 to determine conformance to all technical requirements of this specification are classified as preproduction tests except that the coiled storage test (4.5.11) is not required unless rod is to be supplied in coil diameters less than 300 times the rod diameter. These tests shall be performed prior to or on the initial shipment of the rods to a purchaser, when a change in material, 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 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: Shall be as follows:
- 4.3.1 Acceptance Tests: Shall be in accordance with Single Sampling for Normal Inspection, General Inspection Level II, with an Acceptance 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 determinations for each requirement shall be as specified in the applicable test procedure or, if not specified therein, not less than three.

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

- 4.3.1.1 A lot shall be all rod produced from the same batches of ingredients, using the same processing conditions on the same machine, in not longer than 24 hours, and presented for vendor's inspection at one time.

4.3.1.2 An inspection unit shall be each coil or 1000 feet (300 m) of rod, whichever is smaller, using both ends of each coil.

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 After ten 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 rejection occur, sampling shall be returned to that of Table II for at least ten consecutive satisfactory production lots.

4.3.2 Periodic Tests and Preproduction Tests: 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 by purchaser. 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 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, processing, or both and, when requested, sample rod. Production rod made to 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 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 not over 10X magnification, not less than 12 hours 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 one-fourth to one-third of the rod diameter. Using the point of a sharp instrument, such as a penknife or surgical blade, attempt to pry off the coating at the edges of the saw cut. If a single piece of coating having a surface area greater than 1/8 inch (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 100,000 psi (690 MPa) and the load maintained for not less than one minute without visible or audible evidence of incipient failure. A mechanical failure of the specimen initiating in an end fitting or grip prior to completion of the one-minute 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 in accordance with ASTM D2990 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 hours in an environmental chamber maintained at $160^{\circ}\text{F} + 5$ ($70^{\circ}\text{C} + 3$) 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-hour interval shall constitute an invalid test. In case of dispute between purchaser and vendor, results obtained using end fittings or grips conforming to 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 40:1.
- 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 Hertz 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 inch (12.7 mm). Tests shall be performed with the specimens under oil, using a voltage rise of 500 volts per second at a frequency of 60 Hertz. Dry specimens shall be conditioned at $77^{\circ}\text{F} + 9$ ($25^{\circ}\text{C} + 5$) and relative humidity of $50\% + 5$ for not less than 24 hours prior to testing. Wet specimens shall be tested immediately after immersion in boiling distilled water for not less than two 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 carefully blotted from the disks immediately after cutting.
- 4.5.8 Fiber Content: Shall be calculated by subtracting the resin content of a rod sample from 100%. The resin content shall be determined in accordance with ASTM D2584.
- 4.5.9 Hardness: Shall be determined in accordance with ASTM D785, Procedure A, on the faces of disk specimens prepared as in 4.5.7.1.
- 4.5.10 Transverse Tensile Strength: Shall be determined using a disk specimen having a thickness approximately equal to one-half the rod diameter, prepared in accordance with 4.5.7.1. The specimen shall be mounted on edge in a compression tool (See ASTM D695) in a testing machine, and loaded diametrically to failure in compression. The transverse tensile strength shall be calculated with the equation:

$$T = \frac{2P}{td}$$

where T = transverse tensile strength, psi (MPa)
P = maximum applied load indicated by testing machine, lbf (MN)
t = thickness of specimen, inches (m)
d = rod diameter, inches (m)

- 4.5.11 Coiled Storage Damage: Shall be determined using a coil consisting of not less than three full turns of finished rod packaged for shipment in the manner used by the vendor (See 5.2.2). The packaged coil shall be exposed for not less than 72 hours to a temperature not lower than 200°F (95°C) in a circulating-air chamber while suspended by wires from the ceiling of the chamber so that no part of the package contacts the ceiling, floor, or walls of the chamber. Inspection of the coil immediately following the exposure shall reveal no localized buckles or other structural damage in the rod which cause permanent distortion of the rod shape.

4.6 Reports:

- 4.6.1 The vendor of rod 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, and stating that the rod conforms to the other technical requirements of this specification. This report shall include the purchase order number, AMS 3812A, vendor's product identification, size, lot number, and quantity.