

**AEROSPACE
MATERIAL
SPECIFICATION**

AMS 3901A
Superseding AMS 3901

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ORGANIC FIBER (PARA-ARAMID), YARN AND ROVING, HIGH MODULUS

1. SCOPE:

- 1.1 Form: This specification and its supplementary detail specifications cover organic fibers in the form of continuous, multifilament yarn and roving.
- 1.2 Application: Primarily for use in weaving or as reinforcement in composites for structural applications.
- 1.3 Classification: The fibers shall be as specified in the applicable detail specification, wherein each material is defined by form and property characteristics. An example is shown in 8.2. The material covered by each detail specification appears as part of the title.

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

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

ASTM D1763 - Epoxy Resins

ASTM D2343 - Tensile Properties of Glass Fiber Strands, Yarns, and Rovings
Used in Reinforced Plastics

ASTM D3171 - Fiber Content of Resin-Matrix Composites by Matrix Digestion

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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 Filament Winding 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 of

3. TECHNICAL REQUIREMENTS:

3.1 Detail Specifications: The requirements for a specific product shall consist of all the requirements specified herein in addition to the requirements specified in the applicable detail specification. In case of conflict between the requirements of this basic specification and an applicable detail specification, the requirements of the detail specification shall govern.

3.2 Material:

3.2.1 Construction: The product shall consist of parallel, unidirectional, continuous, organic filaments characterized by flexibility and fineness.

3.2.2 Finish: Unless otherwise specified, the fiber shall be supplied without finish or treatment other than that listed for the weaving yarns or that allowed as residual in the detail specifications. When specified, a finish or treatment may be applied to promote compatibility of the fiber with the resin system with which it is to be used or for handling during weaving.

3.2.3 Color: Shall be essentially yellow.

3.2.4 Splices:

3.2.4.1 Mechanical Splices/Yarns: Shall be in accordance with the applicable detail specification.

3.2.4.2 Mechanical Splices/Rovings: Shall be in accordance with the applicable detail specification. Splices shall be made by air entanglement or an equivalent material or procedure approved by the procuring activity. Splices shall have 1/2 - 1 in. (12.5 - 25.0 mm) overlap.

3.3 Properties: The product, as received by purchaser, shall conform to the requirements of this specification and the applicable detail specification. Tests shall be performed on the product supplied and in accordance with applicable test procedures of this specification.

- 3.4 Quality: The product, as received by purchaser, shall be uniform in quality and condition, clean, and free from foreign material and from imperfections detrimental to usage of the product.

4. QUALITY ASSURANCE PROVISIONS:

- 4.1 Responsibility for Inspection: The vendor of the product 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 product conforms to the requirements of this specification.

4.2 Classification of Tests:

- 4.2.1 Acceptance Tests: Tests to determine conformance to requirements for construction (3.2.1), splices (3.2.4), property testing in accordance with 3.3 or as specified in the applicable detail specification, and quality (3.4) are classified as acceptance tests and shall be performed to represent each lot.

- 4.2.2 Preproduction Tests: Tests to determine conformance to all technical requirements of this specification and the applicable detail specification are classified as preproduction tests and shall be performed prior to or on the initial shipment of the product 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.

- 4.2.2.1 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, the contracting officer, or the request for procurement.

- 4.3 Sampling: Shall be in accordance with reduced sampling for normal inspection, General Inspection Level II, with an Acceptance Quality Level (AQL) of 1.5 specified in MIL-STD-105. Test specimens shall be taken from packages of yarn or balls of roving selected at random throughout the lot.

- 4.3.1 A lot shall be all product produced in a single production run from the same batch of raw materials under the same fixed conditions and presented for vendor's inspection at one time.

- 4.3.2 Inspection Unit: An inspection unit shall be each 25 lb (10 kg) of yarn or an individual package, whichever is smaller. An inspection unit of roving shall be as agreed upon by purchaser and vendor.

- 4.3.3 For Tensile Strength and Modulus of Elasticity: Three specimens from each inspection unit of yarn; five specimens from each inspection unit of roving.

4.3.4 For Denier: One specimen from each inspection unit for yarn; one specimen
Ø from each inspection unit of roving.

4.3.5 For Catenary: One specimen from each four inspection units of roving;
Ø none required for yarn.

4.4 Approval:

4.4.1 Sample material shall be approved by purchaser before material for production use is supplied, unless such approval be waived by purchaser. Results of tests on production material shall be essentially equivalent to those on the approved sample.

4.4.2 Vendor shall use ingredients, manufacturing procedures, processes, and
Ø methods of inspection on production material which are essentially the same as those used on the approved sample material. 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 material. Production material made by the revised procedure shall not be shipped prior to receipt of reapproval.

4.5 Test Methods:

4.5.1 Tensile Strength of Roving: Shall be determined in accordance with ASTM D2343, Procedure A, and the following:

4.5.1.1 Roving shall be conditioned at $65^{\circ}\text{C} \pm 3$ ($150^{\circ}\text{F} \pm 5$) for not less than 8 hr prior to preparing test specimens. Because roving is hygroscopic, specimens shall be prepared from dried roving maintained at not lower than 50°C (120°F) until impregnated.

4.5.1.2 Impregnate specimens with an epoxy resin system consisting of an epoxy
Ø resin conforming to ASTM D1763, Type I, Grade I, Class I; metaphenylene diamine, and acetone in the mix ratio 100:14:10 by weight, or other alternate impregnating resin giving acceptable results. The resin shall be compatible with the fiber finish.

4.5.1.3 Cure specimens for 120 min. ± 10 at $55^{\circ}\text{C} \pm 5$ ($130^{\circ}\text{F} \pm 10$), 60 min. ± 10
Ø at $80^{\circ}\text{C} \pm 5$ ($175^{\circ}\text{F} \pm 10$), and 60 min. ± 10 at $150^{\circ}\text{C} \pm 5$ ($300^{\circ}\text{F} \pm 10$) or with other time/temperature cure schedule appropriate for the alternate resin.

4.5.1.4 Discard any breaking load results where resin content, determined in
Ø accordance with ASTM D3171, is less than 60% or greater than 70% by weight. Repeat test as necessary to provide five valid determinations. If an individual specimen within a sample unit yields a breaking load value less than 240 lb (1065 N), the results shall be checked for homogeneity as follows:

- 4.5.1.4.1 Subtract the lowest breaking load from the second lowest breaking load of the five specimens. Call this difference R_1 .
- 4.5.1.4.2 Subtract the lowest breaking load from the highest breaking load of the five specimens. Call this difference R_2 .
- 4.5.1.4.3 If R_1/R_2 is less than 0.500, the breaking loads are valid, and the sample unit is beyond specification limits. If R_1/R_2 is equal to or greater than 0.500, the low breaking load is invalid and shall be discarded, and an additional specimen shall be broken. The values from the additional specimen and the remaining four original specimens shall be used to make the evaluation for that particular ball. No further tests for invalid results shall be made on the ball.
- 4.5.1.5 Calculate the cross-sectional area of the specimen to three significant figures as follows:

$$A_o = \frac{0.155 B}{LP}$$

where: A_o = Cross-sectional area, sq in. (cm^2)

B = Two skeins weight after drying at $150^\circ\text{C} \pm 5$ ($300^\circ\text{F} \pm 10$) for not less than 15 minutes

L = Total of two skeins length, cm

P = Density of organic fiber (1.45 g/cm^3)

0.155 = The factor for converting from metric units in cm^2 to inch/pound units in square inches. Omit this factor from the equation when working with metric units.

- 4.5.1.5.1 Calculate the tensile strength by dividing the ultimate breaking load by the average cross-sectional area of the two skeins.
- 4.5.2 Modulus of Elasticity of Roving: Shall be determined in accordance with ASTM D2343 using data from 4.5.1.4 and fiber density provided by the vendor. Report the average of not less than four determinations for each sample unit. Strain gage extensometer is a preferred method for determining modulus.
- 4.5.3 Denier:
- 4.5.3.1 Measure a 900-mm length of yarn or roving, which has been dried at $105^\circ\text{C} \pm 2$ ($220^\circ\text{F} \pm 3$) for not less than 60 min., to the nearest millimetre.
- 4.5.3.2 Weigh the yarn or roving sample in grams to the nearest 10 milligrams.

4.5.3.3 Calculate the denier (weight per length) as follows:

$$\text{Denier} = \text{wt in g of 9000 m} = \text{wt of 900-mm sample} \times 10,000$$

4.5.4 Fiber Finish Content: Shall be determined as follows:

4.5.4.1 Weigh approximately 10 g of dried yarn to the nearest 0.01 gram. Yarn drying can be done in a moisture teller or by oven drying as in 4.5.3.1.

4.5.4.2 For each specimen, tare weigh to 0.0001 g a clean aluminum dish that has been rinsed with carbon tetrachloride (See 4.5.4.2.1) solvent and oven dried at $105^{\circ}\text{C} \pm 2$ ($220^{\circ}\text{F} \pm 5$) for 10 min. ± 2 .

4.5.4.2.1 Carbon tetrachloride shall be handled with suitable controls against occupational exposure and environmental release. A less toxic alternative solvent which may be used is 1,1,1-trichloroethane. In either case, the user is encouraged to practice good industrial hygiene, minimize skin contact, and provide adequate ventilation in the work area to ensure compliance with the recognized exposure limit for the solvent being used.

4.5.4.3 Remove fiber finish as follows:

4.5.4.3.1 Place yarn sample into an extraction funnel. Close stop cock and introduce 65 mL of solvent. Funnel should be sized so that this volume of solvent covers fiber sample to a depth of 0.25 in. (6 mm).

4.5.4.3.2 Soak samples for not less than 10 min., stirring each sample occasionally with a different rod.

4.5.4.3.3 Open stop cock to drain solvent into tared dish (4.5.4.2).

4.5.4.3.4 Using a rubber stopper fitted to a 2 - 3 psi (140 - 200 mbar) air line, blow solvent residue into dish.

4.5.4.3.5 Repeat 4.5.4.3.1 through 4.5.4.3.4 two additional times.

4.5.4.4 Prepare a solvent blank sample using the same volume of solvent as used in the analysis with each series of samples.

4.5.4.5 Evaporate sample cups to dryness on a steam bath.

4.5.4.6 Wipe cup bottoms and place to dry in an oven at $105^{\circ}\text{C} \pm 2$ ($220^{\circ}\text{F} \pm 5$) for 10 min. ± 2 .

4.5.4.7 Remove cups to desiccator to cool.

4.5.4.8 Reweigh cups with finish residue to nearest 0.0001 gram.

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4.5.4.9 Calculations:

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$$\text{Percent Finish on Yarn} = \frac{(C-B)-D}{A} \times 100$$

Where: A = Weight of yarn sample (4.5.4.1)
B = Weight of empty cup (4.5.4.2)
C = Weight of cup with finish residue (4.5.4.8)
D = Weight of residue in blank (4.5.4.8)
100 = Percent conversion factor

4.5.5 Catenary: Shall be determined in accordance with MIL-R-60346 on roving
Ø except that one specimen per roving ball shall be used.

4.6 Reports:

4.6.1 The vendor of the product shall furnish with each shipment a report
Ø showing the results of tests for tensile strength, modulus of elasticity, and finish weight and stating that the product conforms to the other technical requirements of this specification and the applicable detail specification. This report shall include the purchase order number, AMS 3901A and the applicable detail specification number and its revision letter, if any, vendor's material designation, finish treatment (if used), lot number, and net weight.

4.6.2 The vendor of finished or semi-finished parts shall furnish with each shipment a report showing the purchase order number, AMS 3901A and the applicable detail specification number and its revision letter, if any, 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 the applicable detail specification and shall include in the report either a statement that the material conforms 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 product may be based on the results of testing three additional specimens for each original nonconforming specimen. Except as permitted in 4.5.1.4, 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.

5. PREPARATION FOR DELIVERY:

5.1 Packaging and Identification:

5.1.1 Yarn and roving shall be supplied in continuous lengths wound on spools with cores having an outside diameter of not less than 1 in. (25 mm). Winding shall be uniform and provide for proper unreeling. Ends shall be secured.

5.1.2 Each yarn spool or roving ball shall be identified with a label attached to the inside surface of the core showing not less than the following information; characters on the label shall be of such size as to be legible and shall not be obliterated by normal handling:

MANUFACTURER'S NAME _____
MANUFACTURER'S MATERIAL DESIGNATION _____
DESCRIPTION (Denier, Type, and Merge) _____
SPOOL (BALL) NUMBER _____
(or other identification required for traceability)

5.1.3 Each spool of yarn or roving shall be wrapped individually in a material which will ensure protection from damage that may result from handling, shipping, and storage.

5.1.4 Each exterior shipping package shall be legibly marked with not less than the following information in such a manner that the markings will not smear or be obliterated during normal handling and use:

MANUFACTURER'S NAME _____
DESCRIPTION (Denier, Type, and Merge) _____
GROSS WEIGHT _____
COMMERCIAL WEIGHT _____
PACKAGE/CASE NUMBER _____

5.1.5 The individually wrapped product shall be prepared for shipment in an exterior shipping container in accordance with commercial practice and in compliance with applicable rules and regulations pertaining to the handling, packaging, and transportation of the product to ensure carrier acceptance and safe delivery. Packaging shall conform to carrier rules and regulations applicable to the mode of transportation.

5.1.6 For direct U.S. Military procurement, packaging shall be in accordance with MIL-STD-794, Level A or Level C, as specified in the request for procurement. Commercial packaging as in 5.1.1, 5.1.3, and 5.1.5 will be acceptable if it meets the requirements of Level C.

6. ACKNOWLEDGMENT: A vendor shall mention this specification number and the applicable detail specification number and their revision letters, if any, in all quotations and when acknowledging purchase orders.

7. REJECTIONS: Material not conforming to this specification or to modifications authorized by purchaser will be subject to rejection.