SAE The Engineering Society For Advancing Mobility Land Sea Air and Space®
INTERNATIONAL
400 Commonwealth Drive, Warrendale, PA 15096-0001

AEROSPACE MATERIAL SPECIFICATION

SAE AMS 3901C

Issued JUN 1974
Revised SEP 1998

Superseding AMS 3901B

Submitted for recognition as an American National Standard

Organic Fiber (Para-Aramid), Yarn and Roving, High Modulus

1. SCOPE:

1.1 Form:

This specification and its supplementary detail specifications covers organic fibers in the form of continuous, multifilament yarn and roving.

1.2 Application:

These products have been used typically in weaving or as reinforcement in composites for structural applications, but usage is not limited to such applications. Each application should be considered individually.

1.3 Classification:

The fibers shall be as specified in the applicable detail specification, wherein each product is defined by form and property characteristics. An example is shown in Section 8.2 The product covered by each detail specification appears as part of the title.

1.4 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 SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order.

QUESTIONS REGARDING THIS DOCUMENT: (724) 772-7161 FAX: (724) 776-0243
TO PLACE A DOCUMENT ORDER: (724) 776-4970 FAX: (724) 776-0790
SAE WEB ADDRESS: http://www.sae.org

2.1 ASTM Publications:

Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM D 885	Testing Tire Cords, Tire Cord Fabrics, and Industrial Filament Yarns Made from Man-Made Organic Base Fibers
ASTM D 1907-89	Yarn Number by the Skein Method
ASTM D 2343-67	Tensile Properties of Glass Fiber Strands, Yarns, and Rovings Used in Reinforced Plastics

2.2 ANSI Publications:

Available from ANSI, 11 West 42nd Street, New York, NY 10036-8002.

ANSI/ASQ Z1.4 Sampling Procedures and Tables for Inspection by Attributes

3. TECHNICAL REQUIREMENTS:

3.1 Detail Specifications:

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

3.2 Material:

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

3.2.2 Finish: 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 for handling during weaving.

3.2.3 Color: Shall be essentially yellow.

3.2.4 Splices: Shall be in accordance with the applicable detail specification.

3.2.4.1 Splices shall be made by air entanglement or an equivalent material or procedure approved by the procuring activity. Splices shall have 1/2 to 1 inch (12.7 to 25.4 mm) overlap.

3.3 Properties:

The product 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 specified ASTM test methods insofar as practicle.

3.4 Quality:

Product, as received by purchaser, shall be uniform in quality and condition, and free from foreign materials and free from imperfections detrimental to usage of the product.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection:

The manufacturer shall supply all samples and shall be responsible for the performance of all required tests. 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: Requirements for construction (see 3.2.1), splices (see 3.2.4), property testing in accordance with 3.3 or as specified in the applicable detail specifications, and quality (see 3.4) are acceptance tests and shall be performed on each lot.

4.2.2 Preproduction Tests: All technical requirements are preproduction tests and shall be performed prior to or on the initial shipment of the product by the manufacturer, when any change in ingredients and/or processing requires reapproval as in 4.4.2 and when purchaser deems confirmatory testing to be required.

4.3 Sampling and Testing:

Shall be as follows:

4.3.1 Roving: Shall be in accordance with ANSI/ASQ Z1.4. Test specimens shall be taken from balls of roving selected at random throughout the lot.

4.3.2 Yarn: Shall be in accordance with a statistically valid plan designed to monitor and maintain targeted process control and product property distribution.

4.3.3 A lot of roving shall be all product produced in a single 24-hour production run or a single production run under the same fixed conditions and presented for manufacturer's inspection at one time.

4.3.4 A lot of yarn shall be all product produced in a single 24-hour production run from the same batch of raw materials and presented for manufacturer's inspection at one time.

4.3.5 Inspection Unit: An inspection unit shall be each individual package.

4.3.6 For Tensile Strength and Modulus of Elasticity: A minimum of five specimens from each inspection unit.

4.3.7 For Linear Density: One specimen from each inspection unit.

4.3.8 For Catenary: One specimen from the beginning and the end of each creel stocking for roving; none required for yarn.

4.4 Approval:

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

4.4.2 Manufacturer of the product shall make no significant change in material, processes, or control factors from those on which the approval was based, unless the change is approved by the cognizant engineering organization. A significant change is one which, in the judgment of the cognizant engineering organization, could affect the properties or performance of the product.

4.5 Test Methods:

Shall be as follows:

4.5.1 Tensile Strength and Modulus of Elasticity: Shall be determined in accordance with ASTM D 885 or ASTM D 2343-67, Procedure A, with the following modifications to the procedure in ASTM D 2343-67.

4.5.1.1 The preparation of the fibers can be done according to either of the following two methods:

4.5.1.1.1 Method 1: Fiber shall be conditioned at 50 °C ± 3 (122 °F ± 5) for not less than eight hours prior to preparing test specimens. Because fiber is hydroscopic, specimens shall be prepared from oven-dried fiber maintained at not lower than 50 °C (122 °F) until impregnated.

4.5.1.1.2 Method 2: Fiber shall be dried at 50 °C ± 3 (122 °F ± 5) for not less than three hours prior to conditioning the fiber at 20 °C ± 2 (68 °F ± 4) and 65% RH ± 2 for not less than sixteen hours before the impregnation will be done or the twisted fiber will be tested.

4.5.1.2 Impregnate specimens with an epoxy resin that gives acceptable results. The resin shall be compatible with the fiber finish.

4.5.1.3 Cure specimens for 120 minutes ± 10 at 55 °C ± 5 (131 °F ± 9); 60 minutes ± 10 at 80 °C ± 5 (176 °F ± 9); and 60 minutes ± 10 at 150 °C ± 5 (302 °F ± 9) or with other time/temperature cure schedule appropriate for the resin.

4.5.1.4 Calculate the cross-sectional area of the specimen to three significant figures as shown in Equation 1 or Equation 2:

$$A = \frac{0.155 * B}{L * P} \quad \text{(Eq. 1)}$$

$$A = \frac{0.155 * D}{P} \quad \text{(Eq. 2)}$$

where:

A = Cross-sectional area, square inch (cm^2),
B = Weight of two skeins, g, after drying at 150 °C ± 5 (302 °F ±9) for not less than 15 minutes.
D = Linear Density of the specimen in den (g/9000 m) or dtex (g/10000 m),
L = Total length of two skeins, cm,
P = Density of organic fiber (1.4 g/cm^3), and
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.

4.5.1.4.1 Calculate the tensile strength by dividing the ultimate breaking load by the average cross-sectional area of the two skeins.

4.5.2 Linear Density: Shall be determined in accordance with ASTM D 1907-89, Option 5 or as follows:

4.5.2.1 Measure a 45-m length of yarn or a 18-m length of roving. Dry fiber at 300 °C ± 3 (572 °F ± 5) for 20 to 30 minutes or at 105 °C ± 2 (221 °F ± 4) for at least three hours. Cool in a conditioned atmosphere for at least 10 minutes.

4.5.2.2 Immediately weigh the fiber sample to the nearest milligram.

4.5.2.3 Calculate the linear density according to one of the following methods:

4.5.2.3.1 Method 1: Calculate the linear density as shown in Equation 3 and Equation 4:

Yarn Linear Density (den) = 45-m sample weight * 200 * finish factor (Eq. 3)

Roving Linear Density (den) = (18-m sample weight) * 500 * finish factor (Eq. 4)

where finish factor is:

0.9880 is 1.2% finish,
0.9920 for 0.8% finish,
0.9940 for 0.6% finish, and
0.9960 for 0.4% finish.

4.5.2.3.2 Method 2: Calculate the linear density as shown in Equation 5:

$$\text{Linear Density (tex)} = (A/B) * 1000 \quad \text{(Eq. 5)}$$

where:

A = weight of skein conditioned per method 2 of section 4.5.1.1.2 g
B = length of skein, m.

4.5.3 Fiber Finish Content: Shall be determined by either of the two methods as follows:

4.5.3.1 Method 1: Nuclear Magnetic Resonance (NMR)

4.5.3.1.1 Reel a sample skein to the length specified in Table 1.

4.5.3.1.2 Dry the sample at 100 °C ± 3 (212 °F ± 5) for 15 minutes ± 1.

4.5.3.1.3 Remove skeins from oven and begin weighing immediately to the nearest 0.001 gram.

4.5.3.1.4 When the skein is weighed, put it into a clear sample tube. Cap the open end of the tube. Samples must be weighed, placed in the sample tube, and capped within 30 minutes of removal from the oven.

4.5.3.1.5 Place each sample tube in a Nuclear Magnetic Resonance (NMR) test instrument and measure the finish level.

TABLE 1 - Sample Lengths

Linear Density, denier	Sample Length, m
195/200	81
380/400	40.5
600	28.125
720/750	22.5
840/850	19.125
900	18
1000	15.75
1140/1150	14.625
1420/1435/1500	10.125
2160/2250	6.75
2840/3000	4.5

4.5.3.2 Method 2: Soak and Blow Method

4.5.3.2.1 Weigh approximately 10 grams of oven-dried fiber (or 5 grams for the automated extraction unit) to the nearest 0.0001 gram. Fiber drying can be done in a moisture teller or by oven-drying as in 4.5.2.1. Fiber drying isn't necessary if moisture is corrected for in the calculation of the fiber finish content (see 4.5.3.2.4.9).

4.5.3.2.2 For each specimen, tare a balance with a clean aluminum dish that has been rinsed with a solvent suitable for removal of fiber finish and oven-dried at 105 °C ± 2 (221 °F ± 4) for 10 minutes ± 2.

4.5.3.2.3 If using the automated extraction unit, see 4.5.3.2.4. Otherwise, remove the fiber finish as follows:

4.5.3.2.3.1 Place fiber sample into an extraction funnel. Close stock 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 inch (6.4 mm).

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

4.5.3.2.3.3 Open stop cock to drain solvent into tared dish (see 4.5.3.2.2).

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

4.5.3.2.3.5 Repeat Sections 4.5.3.2.3.1 through 4.5.3.2.3.4 two additional times.

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

4.5.3.2.3.7 Evaporate sample cups to dryness on a steam bath.

4.5.3.2.3.8 Wipe cup bottoms and dry in an oven at 105 °C ± 2 (221 °F ± 4) for 10 minutes ± 2.

4.5.3.2.3.9 Remove cups to desiccator to cool.

4.5.3.2.3.10 Reweigh cups with finish residue to nearest 0.0001 g.

4.5.3.2.3.11 Calculations: As shown in Equation 6.

$$\text{Percent Finish on Yarn} = \frac{(C - B) - D}{A} \times 100 \qquad \text{(Eq. 6)}$$

where:

A = Weight of yarn sample, g (see 4.5.3.2.1),
B = Weight of empty cup, g (see 4.5.3.2.2),
C = Weight of cup with finish residue, g (see 4.5.3.2.3.10),
D = Weight of residue in blank, g (see 4.5.3.2.3.10), and
100 = Percent conversion factor.

4.5.3.2.4 Remove the fiber finish using the automated extraction unit as follows:

4.5.3.2.4.1 Place the fiber sample into the extraction unit. Add 400 mL of solvent. Funnel should be sized so that this volume of solvent covers the sample completely.

4.5.3.2.4.2 Soak samples for not less than 35 minutes in the boiling stand. The hot plate needs a temperature above the boiling point of the solvent and the unit must have a cooling vessel above the sample.

4.5.3.2.4.3 Position the sample in the extraction stand above the solvent for a minimum of 10 minutes.

4.5.3.2.4.4 Evaporate the solvent from the aluminum dish for 30 minutes.

4.5.3.2.4.5 Blow nitrogen gas over the dish for 10 minutes.

4.5.3.2.4.6 Dry in an oven at 105 °C ± 2 (221 °F ± 4) for 30 minutes ± 2.

4.5.3.2.4.7 Remove cups to desiccator to cool.

4.5.3.2.4.8 Reweigh cups with finish residue to nearest 0.0001 g.

4.5.3.2.4.9 Calculations: Shall be as shown in Equation 7.

$$\text{Percent Finish on Yarn} = \frac{(C - B)^* F}{A} \times 100 \qquad \text{(Eq. 7)}$$

where:

A = Weight of yarn sample, g (see 4.5.3.2.1),
B = Weight of empty cup, g (see 4.5.3.2.2),
C = Weight of cup with finish residue, g (see 4.5.3.2.4.8),
F = Factor for the correction of moisture content (for example; a moisture content of 6% means a correction factor of F = 0.94), and
100 = Percent conversion factor.

4.5.4 Catenary of Roving: Shall be determined as follows:

4.5.4.1 Place roving ball on a horizontal spindle so that the ball will unwind in the counter-clockwise direction when the yarn is pulled. Strip off a minimum of 12 feet (4 m) of the threadline from outside of the ball.

4.5.4.2 With the yarn in the center of the package, tie an overhand knot approximately 1 foot (300 mm) from the roving ball while keeping the threadline tight.

4.5.4.3 Tie a loop with a slip knot formation between the overhand knot and the end of the threadline. Both knots must be pulled tight.

4.5.4.4 Pull the threadline until the knot is approximately 50 feet (12 m) from the package.

4.5.4.5 Attach a two pound (one kg) weight into the loop formed above. Shake the threadline several times to separate threadlines before lowing the weight.

4.5.4.6 Lower the weight until the threadline is coming off the center of the ball.

4.5.4.7 Tap the threadline firmly four times with a ruler to separate threadlines. The yarn should be tapped in the middle of the 50-foot (12-m) span.

4.5.4.8 Measure the separation between the top threadline and the lowest threadline. Do not include the threadline thickness in the catenary measurement. Record the catenary results to the closest 0.1 inch (0.05 mm).

4.6 Reports:

The supplier of the product shall furnish with each shipment a report from the manufacturer showing the results of tests to the acceptance test requirements and stating that the product conforms to the other technical requirements. This report shall include the purchase order number, lot number, AMS 3901C, manufacturer's identification number and quantity.

4.7 Resampling and Retesting:

If any specimen used in the above tests fails to meet the specified requirements, it shall be cause for rejection of the product. The only time a specimen that fails the specific requirement can be retested is when there is a known, assignable cause for the failure (for example, test instrument settings incorrect). Results of all tests shall be reported.

5. PREPARATION FOR DELIVERY:

5.1 Packaging and Identification:

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