SAE Aerospace
An SAE International Group

AEROSPACE MATERIAL SPECIFICATION

SAE AMS 3894E

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Superseding AMS 3894D

Carbon Fiber Tape and Sheet
Epoxy Resin Impregnated

1. SCOPE:

1.1 Form: This specification and its supplementary detail specifications cover tape and sheet fabricated using carbon fibers impregnated with epoxy resin.

1.2 Application: Primarily for fabricating high-strength and high-modulus composite parts, using either hand-layup or a machine for automated-tape-layup.

1.3 Classification: The tapes and sheets shall be as specified in the applicable detail specifications, wherein each product is defined by property characteristics and continuous service temperature. An example is shown in 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.

TO PLACE A DOCUMENT ORDER:
Tel: 877-606-7323 (inside USA and Canada)
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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 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
AMS 2825 - Material Safety Data Sheets
AMS 3892 - Fibers, Carbon, Tow and Yarn, for Structural Composites
AMS 3898 - Interleaf Carrier Material, Composite Tape

2.2 ASTM Publications: Available from ASTM, 1916 Race Street, Philadelphia, PA 19103.

ASTM D 792 - Specific Gravity (Relative Density) and Density of Plastics by Displacement
ASTM D 1505 - Density of Plastics by the Density-Gradient Technique
ASTM D 2344 - Apparent Interlaminar Shear Strength of Parallel Fiber Composites by Short Beam Method
ASTM D 2734 - Void Content of Reinforced Plastics
ASTM D 3039 - Tensile Properties of Fiber-Resin Composites
ASTM D 3171 - Fiber Content of Resin-Matrix Composites by Matrix Digestion
ASTM D 3410 - Compressive Properties of Unidirectional or Crossply Fiber-Resin Composites
ASTM D 3529 - Resin Solids Content of Carbon Fiber-Epoxy Prepreg
ASTM D 3530 - Volatiles Content of Carbon Fiber-Epoxy Prepreg
ASTM D 3531 - Resin Flow of Carbon Fiber-Epoxy Prepreg
ASTM D 3532 - Gel Time of Carbon Fiber-Epoxy Prepreg

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 Standards:

MIL-STD-794 - Parts and Equipment, Procedures for Packaging and Packing of

2.4 AIA Publications: Available from National Standards Association, Inc., 1321 14th Street, N.W., Washington, DC 20005.

NAS 992 - Reel, Composite Filament Tape, Automated Machine Layup

3. TECHNICAL REQUIREMENTS:

3.1 Detail Specifications: The requirements for a specific product shall consist of all the 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, unidirectional carbon fibers meeting the requirements of AMS 3892 and its applicable detail specification, impregnated with an epoxy resin meeting the requirements of the applicable detail specification, and arranged in a single in-plane layer.

3.2.2 Ends: The product shall contain no unspliced yarn or tow ends. Splices in the same yarn or tow shall be not less than 10 feet (3 m) apart. Splices in adjacent yarns or tows shall be not less than 12 inches (305 mm) apart.

3.2.3 Storage Life: The product, when packaged in water resistant, heat-sealed bags, shall meet the requirements of the applicable detail specification after storage at standard conditions as specified therein.

3.2.4 Working Life: The product shall meet the requirements of the applicable detail specification after exposure for a continuous period at the relative humidity and temperature specified therein.

3.2.5 Bending: The product shall withstand, without visible material damage, bending through an angle of 180 degrees around a 1.0 inch (25 mm) diameter mandrel with the fiber direction perpendicular to the axis of bend; 10X magnification shall be used in examination for damage.

3.3 Properties of Uncured Impregnated Material: The as-received product shall conform to the requirements of this specification and the applicable detail specification, determined on the product as-supplied in accordance with test procedures specified herein.

3.4 Properties of Cured Laminate: Test laminates shall conform to the requirements of this specification and the applicable detail specification, determined on specimens cut from laminates prepared in accordance with 4.5.

3.5 Quality: The product, as received by purchaser, shall be uniform in quality and condition, free from foreign material and, except as specified in 3.5.1, free from imperfections detrimental to usage of the product.

3.5.1 Visual Imperfection Criteria: Visible indications of dry spots, voids, crimps, crossed or broken fibers, twisted fibers, irregular carrier, over-impregnation or incomplete impregnation areas are not acceptable if the total length of each area exceeds limits indicated below for the total tape length of the roll:

Imperfections	Criteria
Filaments not wetted	1%, maximum
Tape not parallel to center line	Parallel within ± 0.5 degree
Crimps	1%, maximum
Wrinkle	None permitted
Unspliced yarn or tow	None permitted
End-butt spliced yarn or tow	None permitted
Cured resin particles	None permitted
Foreign materials	None permitted
Color uniformity	Natural Color
Twists (3.5.1.1)	2%, maximum
Scrim distortion (when scrim is present)	To be determined
Rippled interleaf	To be determined
Resin starved areas	To be determined
Fiber crossover	To be determined

3.5.1.1 Does not refer to twists inherent in the product.

3.6 Tolerances:

3.6.1 Width: Shall be as specified in Table I.

TABLE I

Nominal Width Inches	Tolerance Inch
Up to 1.000, excl	As agreed upon
1.000 to 3.000, excl	+0, -0.025
3.000	+0, -0.050
Over 3.000	±0.040 for each 3.000 inches of width

TABLE I(SI)

Nominal Width Millimetres	Tolerance Millimetres
Up to 25.40, excl	As agreed upon
25.40 to 76.20, excl	+0, -0.64
76.20	+0, -1.27
Over 76.20	±1.02 for each 76.20 mm of width

3.6.2 Fiber Alignment and Spacing: Individual fibers, yarns, and tows shall be parallel to the tape center line within ±0.5 degree along their entire **length. Open space between fibers, yarns, and tows shall each be not more than 0.040 inch (1.02 mm) wide.**

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 and the applicable detail specification.

4.2 Classification of Tests:

4.2.1 Acceptance Tests: Tests for construction (3.2.1), ends (3.2.2), bending (3.2.5), properties of uncured impregnated material (3.3), longitudinal **flexural strength, modulus of elasticity in flexure, and interlaminar** shear strength of cured laminate, all at room temperature (3.4), quality (3.5), and tolerances (3.6) are acceptance tests and shall be performed on each lot.

4.2.2 Preproduction Tests: Tests for all technical requirements of this specification and the applicable detail specification are preproduction tests and shall be performed prior to or on the initial shipment of a product 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.**

4.2.2.1 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, contracting officer, or request for procurement.

4.3 Sampling and Testing: Shall be as follows; the number of specimens to be 0 sampled shall be the minimum number of specimens tested:

4.3.1 For Acceptance Tests:

4.3.1.1 Each Roll: Sufficient product shall be taken from each roll to perform 0 tests for fiber and resin content (3.2.1), ends (3.2.2), bending (3.2.5), quality (3.5), and tolerances (3.6) of the uncured product.

4.3.1.2 Each Lot: Sufficient product shall be taken at random to perform tests 0 to determine compliance to the requirements for uncured material (3.3).

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

4.3.1.3 Each 5000 Square Feet (465 m^2): Sufficient product shall be taken at random from each lot to perform tests for longitudinal flexural strength, modulus of elasticity in flexure, and interlaminar shear strength of cured laminate at room temperature (3.4).

4.3.2 For Preproduction Tests: As agreed upon by purchaser and vendor.

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 product.

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

4.5 Test Methods: Tests to determine conformance to the requirements of this specification and the applicable detail specifications shall be conducted as follows:

Requirement	Minimum Number of Specimens per Test	Test Procedure
Volatile Content	1	ASTM D 3530
Resin Solids Content	2	ASTM D 3529
Resin Flow	1	ASTM D 3531
Gel Time	1	ASTM D 3532
Tack, Time Adherence	1	4.5.2
Tack, Peel Strength	1	4.5.3
Visual Imperfections	1	4.5.4
Tensile Strength and Modulus of Elasticity	4	ASTM D 3039
Compressive Strength and Modulus of Elasticity	4	ASTM D 3410
Flexural Strength and Modulus of Elasticity	4	4.5.5
Interlaminar Shear Strength	4	ASTM D 2344
Density	3	4.5.6
Void Content	3	ASTM D 2734
Fiber Content	3	ASTM D 3171

4.5.1 Preparation of Test Laminates: Test laminates of suitable thickness and area shall be prepared from sufficient plies of impregnated product oriented unidirectionally and cured in an autoclave, or equivalent, at a temperature and pressure to provide optimum properties. Details of time, temperature, rate of heating, and pressures used in the cure cycle shall be noted in the report. The resultant laminate shall be uniform in thickness within ±0.003 inch (± 0.08 mm) and shall have a fiber volume of 60% ± 3. The thickness per ply shall be within ±0.0004 inch (±0.010 mm) of the nominal cured thickness, determined from the equation:

$$T = \frac{A}{B}$$

Where, T = Thickness per ply in inches (mm)
A = Thickness of test panel in inches (mm)
B = Number of plies in panel

4.5.2 Tack, Time Adherence:

4.5.2.1 Cut two pieces of product, approximately 1 x 3 inches (25 x 76 mm), retaining the protective film until immediately before using the specimens. Fiber direction shall be parallel to the 1 inch (25 mm) dimension. For product under 3 inches (76 mm) in nominal width, butt together sufficient pieces of the panel to produce a 3 inch (76 mm) wide specimen.

4.5.2.2 Remove the protective film from one face of one specimen and apply the specimen to the center of a clean piece of austenitic, corrosion-resistant steel sheet with a commercial 2D finish, any thickness by approximately 4 x 8 inches (102 x 203 mm). Apply light pressure with a squeegee or roller over the backing film. Remove the backing film and apply the second specimen to the first, in exactly the same manner, making sure the opposing faces of the specimens are not covered with protective backing film. The second layer of narrow material shall be so positioned that the butt joints do not coincide with those of the first layer. Remove the protective film from the exposed surface of the specimens and maintain the test plate and the long dimension of the test specimen in a vertical position for not less than 30 minutes at 21° - 27°C (70° - 81°F) and 50 - 70% relative humidity.

4.5.2.3 Report results as pass or fail. If a specimen fails to adhere for the test period, record the elapsed time at failure.

4.5.3 Tack, Peel Strength: Shall be determined as agreed upon by purchaser and vendor.

4.5.4 Visual Imperfections: Shall be determined as follows:

4.5.4.1 Allow a sample of the product approximately 15 feet (4.6 m) in length, lying flat on the table, to be exposed to standard environmental conditions for 10 - 30 minutes prior to inspection.

4.5.4.2 Inspection aids and measuring devices of applicable accuracy may be used as required.

4.5.4.3 Report the results of the inspection of each sample.

4.5.5 Flexural Strength and Modulus of Elasticity:

4.5.5.1 Specimen Preparation: The specimens, taken from the laminate prepared in 4.5.1, shall be 0.080 inch (2.03 mm) nominal thickness, 0.500 inch ± 0.010 (12.70 mm ± 0.25) wide, and 3.00 inches ± 0.03 (76.2 mm ± 0.8) long. Specimen edges shall be ground with abrasive finer than No. 400 (38 µm) grit to the required length and width dimension. The fiber direction of the specimen shall be parallel to the longitudinal axis of the specimen. Other specimen configurations are acceptable provided that the fiber direction is parallel to the longitudinal axis of the specimen, the thickness of the specimen is equal to, or less than, the width of the specimen, and the length of the specimen Is sufficient to provide a span equal to 32 ± 2 times the thickness.

4.5.5.2 Test Procedure: The specimen shall be loaded to failure at a crosshead speed of 0.050 inch ± 0.005 (1.27 mm ± 0.13) per minute in a testing machine with fixture and instrumentation as indicated in Fig. 1. The deflectometer shall be of the linear differential transformer type. Necessary adjustments shall be made so that the deflectometer pushrod is midway between the supports ±0.03 inch (±0.8 mm). The span length shall be 32 ± 2 times the specimen thickness.

4.5.5.3 Calculation Using Inch/Pound Units of Measure: Flexural strength and modulus shall be calculated from the following equations:

$$\text{Flexural Strength, psi} = \frac{3PL}{4bt^2}$$

$$\text{Flexural Modulus of Elasticity, psi} = \frac{11}{64}\,\frac{L^3(\Delta P)}{bt^3(\Delta\delta)}$$

where,
- P = Load at failure, pounds force
- L = Span, inches
- b = Width, inches
- t = Thickness, inches
- ΔP = Increment of load, pounds force
- Δδ = Increment of deflection, inches (at midspan)
- $\frac{\Delta P}{\Delta\delta}$ = Slope of initial straightline portion of the load deflection curve, pounds force/inch

4.5.5.4 Calculation Using SI Units of Measure: Flexural strength and modulus shall be calculated from the following equations:

$$\text{Flexural Strength, MPa} = \frac{3PL}{4bt^2}$$

$$\text{Flexural Modulus of Elasticity, MPa} = \frac{11}{64}\,\frac{L^3(\Delta P)}{bt^3(\Delta\delta)}$$

where, P = Load at failure, N
L = Span, mm
b = Width, mm
t = Thickness, mm
ΔP = Increment of load, N
$\Delta\delta$ = Increment of deflection, mm (at midspan)
$\frac{\Delta P}{\Delta\delta}$ = Slope of initial straightline portion of the load deflection curve, N/mm

4.5.6 Density: Shall be determined in accordance with ASTM D 792 using a suitable liquid or in accordance with ASTM D 1505 on the test laminate prepared as specified in 4.5.1.

4.6 Reports: The vendor of the product shall furnish with each shipment a report showing the results of tests to determine conformance to the acceptance test requirements of this specification and the applicable detail specification, including identification of the resin system used, cure cycle and fiber volume of the test laminate, and stating that the product conforms to the other technical requirements of this specification and the applicable detail specification. This report shall include thae purchase order number, AMS 3894D and its applicable detail specificataion number and revision letter if any, vendor's material designation, lot numaber, spool or sheet numbers, date of manufacture, quantity (tape width and length, or sheet width and length and number of sheets), and location of test samples within the lot and spool or sheet.

4.6.1 A material safety data sheet conforming to AMS 2825, or equivalent, shall be supplied to each purchaser prior to, or concurrent with, the report of preproduction test results or, if preproduction testing be waived by purchaser, concurrent with the first shipment of impregnated sheet or tape for production use. Each request for modification of formulation shall be accompanied by a revised data sheet for the proposed formulation.

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, prepared from the original panel or a newly-prepared panel, for each original nonconforming specimen. 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. Results of all tests shall be reported.

5. PREPARATION FOR DELIVERY:

5.1 Packaging and Identification:

5.1.1 Tape for Hand Layup: Shall be interleaved with a nonadherent film and wound on spools having a hub diameter not less than 8 inches (203 mm). Winding shall be uniform and shall provide for proper unreeling. Each spool shall contain 600 - 3000 feet (183 - 914 m) except that, in any one shipment, up to 20% of the spools may contain lengths as short as 350 feet (107 m). Tape ends shall be secured.

5.1.1.1 Location of visually imperfect areas and of splices shall be plainly identified on the product by suitaable markers visible on the spool or reel and on the package. The total length of such areas in each roll shall be itemized in the applicable inspection report. Visually imperfect areas shall not be counted in conforming to any requirements for length.

5.1.2 Tape for Machine Layup: Shall be interleaved with a nonadherent film conforming to the specified detail specification of AMS 3898 and wound on NAS 992 reels of the type, size, and class specified (See 8.4). Quantity on each reel and marking of visually imperfect areas and of splices shall be as specified in 5.1.1.

5.1.2.1 The tape shall be placed on the interleaf (carrier) material within ±0.015 inch (±0.38 mm) of the center line of the interleaf or centered between the perforations (sprocket hole guides) by the same tolerance if perforated carrier is specified. If tape and interleaf are specified to have the same width, the tape shall be placed within 0.015 inch (0.38 mm) of the center line of the interleaf or no greater than 0.030 inch (0.76 mm) from an edge and shall not extend beyond the edge of the interleaf.

5.1.3 Sheet: Shall be supplied flat with a suitable nonadherent protective covering or separator film on each face.

5.1.4 Each reel or spool of tape and each sheet shall be identified, with not less than the following information, by attached removable tags using characters of such height as to be legible and which will not be obliterated by normal handling:

CARBON FIBER TAPE (or SHEET), EPOXY-RESIN-IMPREGNATED
AMS 3894/*_____
INTERLEAF MATERIAL, AMS 3898/*_____(when applicable)
NAS 992 REEL, TYPE_____ SIZE_____, CLASS_____ (when applicable)
MANUFACTURER'S IDENTIFICATION_____
PURCHASE ORDER NUMBER_____
DATE OF MANUFACTURE_____
LOT AND REEL, SPOOL, OR SHEET NUMBERS_____
TAPE WIDTH_____
QUANTITY_____

*Insert number of applicable detail specification.

5.1.5 Each reel or spool and each sheet shall be sealed in a bag of suitable nonadherent material to resist penetration of moisture or loss of impregnating resin solvent.

5.1.6 Packaging of protected reels and sheets shall be accomplished in such a manner as to ensure that the product, during shipment and storage, will be protected against damage from exposure to moisture, weather, or any other normal hazard.

5.1.7 Each package shall be permanently and legibly marked with not less than the following information:

CARBON FIBER TAPE (OR SHEET), EPOXY-RESIN-IMPREGNATED
AMS 3894/*
PURCHASE ORDER NUMBER_____
MANUFACTURER'S IDENTIFICATION_____
LOT AND PACKAGE NUMBERS_____
TAPE WIDTH_____
QUANTITY_____
PERISHABLE - STORE BELOW_____ (See applicable detail specification)

*Insert number of applicable detail specification.

5.1.8 Packages of the product shall be prepared for shipment 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.