



AEROSPACE MATERIAL SPECIFICATION

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

AMS 3895

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Revised

BROADGOODS AND TAPE, MULTI-PLY GRAPHITE FIBER/EPOXY RESIN IMPREGNATED, UNIFORM FIBER

1. SCOPE:

- 1.1 Form: This specification covers AMS 3894 epoxy-resin-impregnated graphite-fiber broadgoods and tape in the form of multi-plyed unidirectional layers constructed from the same or uniform fibers and supplied as broadgood rolls, tape, or cut sheet. The individual ply orientation shall be as ordered.
- 1.2 Application: Primarily for fabricating high-strength and high-modulus composite parts, using either hand-layup or a machine for automated-tape-layup.

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 2825 - Material Safety Data Sheets
 - AMS 3894 - Graphite Fiber Tape and Sheet, Epoxy Resin Impregnated
 - AMS 3898 - Interleaf Carrier Material, Composite Tape
 - 2.2 U.S. Government Publications: Available from Commanding Office, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.
 - 2.2.1 Military Standards:
 - MIL-STD-794 - Parts and Equipment, Procedures for Packing and Packaging of
 - 2.3 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 Material:

- 3.1.1 The product shall consist of superimposed, unidirectional plies of epoxy-resin impregnated graphite-fiber broadgoods or tape. Each ply shall conform to the requirements of AMS 3894 and its applicable detail specification, and shall be of the orientation specified.
 - 3.1.1.1 When required by the purchase order, the broadgoods product shall be supplied in sheet form of specified length and width.

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3.1.2 Designation: Each product construction shall be identified by the fiber/impregnating resin specification number, followed by the individual ply direction in brackets, each ply indicated by the direction code, as follows: (See 8.2 for examples)

- a. Fiber/impregnation resin detail specification: 3894/*
 * = Detail Specification number, as applicable.
- b. Ply direction: 0 = longitudinal fiber direction
 45 = 45 deg from longitudinal, (right bias, often designated +45)
 90 = 90 deg or perpendicular
 135 = 135 deg from longitudinal, (left bias, often designated -45)



- c. Number of plies: (0) = One ply, longitudinal
 (0/0) = Two plies, longitudinal

3.1.2.1 Example:

3894/2 (0/45/90) = Three ply, AMS 3894/2 in each ply, longitudinal (0 deg) fiber direction in first (bottom) ply, right bias (45 deg) fiber direction in second (center) ply, and perpendicular (90 deg) fiber direction in third (top) ply.

3.2 Storage Life: The product shall meet the requirements of 3.4 when tested at any time up to 3 months from date of receipt by purchaser provided it has been stored in the original sealed bags at not warmer than -18°C (0°F).

3.3 Working Life: The product shall meet the requirements of 3.4 when tested after continuous exposure for 14 days within the relative humidity and temperature limits shown in Fig. 1.

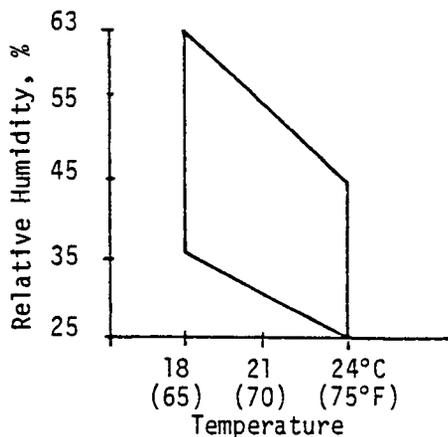


Figure 1

3.4 Properties: The product shall conform to the requirements of AMS 3894 and its applicable detail specification and the following:

3.4.1 Uncured Product: Tests shall be performed on the product supplied, after warming to above the dew point prior to opening the heat sealed bag for sampling, and in accordance with the test procedures specified herein and in AMS 3894, as applicable.

3.4.1.1 Bending: The product shall withstand, without visible material damage, bending through an angle of 180 deg around a 1.0-in. (25-mm) diameter mandrel with the 0 deg ply direction perpendicular to the axis of bend; magnification of 10X shall be used in examination for damage.

3.4.1.2 Tack, Time Adherence: Specimens shall adhere for not less than 30 min., determined in accordance with 4.5.2.

3.4.1.3 Tack, Peel Strength: Shall be the preproduction value $\pm 10\%$, determined in accordance with 4.5.3.

3.4.2 Cured Laminate: When required by purchaser, tests shall be performed on specimens cut from laminates prepared in accordance with 4.5.1.

3.5 Quality: The product shall be uniform in quality and condition, clean, and free from foreign materials and, in addition to the requirements of 3.5.1, free from internal and external imperfections detrimental to fabrication, appearance, or performance of parts.

3.5.1 Visual Inspection Criteria: In addition to the requirements specified in AMS 3894 and in the AMS 3894 applicable detail specification for each ply, visible indications of voids between plies, incorrectly positioned impregnated material (excessive gap or overlap), or irregular interleaf carrier shall be unacceptable if the total length of each area exceeds limits indicated below, determined in accordance with 4.5.4. Examination of interior plies may be made by any suitable nondestructive method, such as radiographic inspection, agreed upon by purchaser and vendor.

Imperfections	Acceptance Criteria
Ply Count and Fiber Orientation	Shall be as designated
Flatness	Shall not exceed 0.075 in. (1.90 mm) for each inch (25 mm) Shall not curl after separator has been removed
Voids between plies	None permitted
Between adjacent AMS 3894 material in the same ply	
Gap	Shall not exceed 0.040 in. (1.02 mm)
Overlap	Shall not exceed 0.030 in. (0.76 mm)
Butt Splices	None
Rimpled interleaf carrier	None, or as agreed upon by purchaser and vendor

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

3.6.1 Broadgoods Roll-Width: Shall be as specified in Table I.

TABLE I

Nominal Width Inches	Tolerance Inch	
	plus	minus
Up to 12.000, excl	0.125	0
12.000 to 30.000, excl	0.188	0
30.000 to 48.000, excl	0.250	0
48.000 and over	As agreed upon	

TABLE I (SI)

Nominal Width Millimetres	Tolerance Millimetres	
	plus	minus
Up to 305, excl	3.2	0
305 to 760, excl	4.8	0
760 to 1140, excl	6.4	0
1140 and over	As agreed upon	

3.6.2 Broadgoods Sheet - Length and Width: Shall be as specified for product width in Table I.

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 such confirmatory testing as he deems 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 (3.1.1), bending (3.4.1.1), tack (3.4.1.2 and 3.4.1.3), quality (3.5), and tolerances (3.6) are classified as acceptance tests and shall be performed on each lot.

4.2.1.1 When required by the purchaser, the acceptance tests specified in AMS 3894 and its applicable detail specification shall be performed on each lot.

4.2.2 Preproduction Tests: Tests to determine conformance to all technical requirements of this specification are classified as preproduction tests and shall be performed prior to the initial shipment of the product to a purchaser, when a change in material 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, the contracting officer, or the request for procurement.

4.3 Sampling: Shall be as follows:

4.3.1 For Acceptance Tests: Each lot of broadgoods, sheet, and tape shall be sampled at random to provide sufficient material to perform all required tests. The number of specimens for each test shall be as specified in 4.5, the applicable test procedure or, if not specified therein, not less than three.

4.3.1.1 A lot shall be all product produced in a continuous production run from the same lot(s) of AMS 3894 material under the same fixed conditions and submitted for vendor's inspection at one time. A lot or an inspection lot shall not exceed the product length specified in 5.1.1.1 and may be packaged in smaller quantities as noted in 5.1.1 or 5.1.2 under a basic lot approval as long as the lot identification is maintained.

4.3.1.2 When a statistical sampling plan and acceptance quality level (AQL) for the product have been agreed upon by purchaser and vendor, sampling shall be in accordance with such plan in lieu of sampling as in 4.3.1 and the report of 4.6.1 shall state that such plan was used.

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. Results of tests on production product 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 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 material and processing and, when requested, sample product. Production product made by the revised procedures shall not be shipped prior to receipt of approval.

4.5 Test Methods: Tests to determine conformance to this specification shall be conducted as specified herein or in the applicable test procedures specified in AMS 3894.

4.5.1 Preparation of Test Laminates: When required by purchaser, one end of each roll shall be so arranged that not less than one yard (1 m) of product shall be interleaved with a suitable nonadhering separator between each ply, in such a manner that the separate layers may be individually used for test and to make a test laminate for evaluation of cured laminate properties. Test laminates shall be prepared from the required number of plies in accordance with AMS 3894 and its applicable detail specification.

4.5.2 Tack, Time Adherence:

4.5.2.1 Cut two pieces of product approximately 1 x 3 in. (25 x 75 mm), retaining the protective film until immediately before using the specimens. The 0-deg oriented unidirectional ply (plies) shall be parallel to the 1-in. (25-mm) dimension.

4.5.2.2 Remove the protective film from one face of one specimen and apply the product 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 in. (100 x 200 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 pieces are not covered with protective backing film. The second layer of narrow product 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 product and maintain the test plate and the long dimension of the test specimen in a vertical position for not less than 30 min. at 20° - 30°C (68° - 86°F) and 50 - 70% relative humidity.

- 4.5.2.3 Report results as pass or fail. If the specimen fails to adhere for the test period, record the elapsed time at which the specimen separates fully from the steel sheet.
- 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 ft (4.5 m) in length lying flat on the table, to be exposed to standard environmental conditions for 10 - 30 min. 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.
- 4.6 Reports:
- 4.6.1 The vendor of the product shall furnish with each shipment three copies of a report showing the results of tests to determine conformance to the acceptance test requirements of this specification, including the identification of the resin system used, the cure cycle and fiber volume of the test laminate when required, and stating that the product conforms to the other technical requirements of this specification. This report shall include the purchase order number, AMS 3895, product designation (3.1.2), vendor's material designation, lot number, spool, roll, or sheet numbers, date of manufacture, quantity (broadgoods width and length, or sheet width and length and number of sheets), and location of test samples within the lot and spool, roll, or sheet.
- 4.6.1.1 The vendor of the product shall also furnish with each shipment three copies of a report stating that each ply of the product conforms to the acceptance test requirements of AMS 3894 and its applicable detail specification.
- 4.6.1.2 A material safety data sheet conforming to AMS 2825 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 product for production use. Each request for modification of formulation shall be accompanied by a revised data sheet for the proposed formulation.
- 4.6.2 The vendor of finished or semi-finished parts shall furnish with each shipment three copies of a report showing the purchase order number, AMS 3895, contractor or other direct supplier of the product, supplier's material designation, part number, and quantity. When product for making parts is produced or purchased by the parts vendor, that vendor shall inspect each lot of product to determine conformance to the requirements of this specification, and shall include in the report a statement that the product conforms, or shall include 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. When applicable, these specimens shall be cut from additional or newly prepared panels using the same procedures and curing cycles as used on the original panels. 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 Broadgoods for Hand Layup:

5.1.1.1 Broadgoods in each roll shall be interleaved with a suitable non-adherent film and wound on spools having a hub diameter not less than 24 in. (610 mm). Winding shall be uniform and shall provide for proper unreeling. Each spool shall contain the following lengths of product except that, in any one shipment, up to 20% of the spools may contain lengths as short as 60% of the shorter length for each plied construction. Broadgoods ends shall be secured. Spooled broadgoods shall be packaged in sealed bags of nonadherent material to prevent penetration of moisture or loss of impregnating resin solvent.

Construction Plies	Product Length	
	Feet	Metres
2	330 - 660	90 - 200
3	200 - 440	60 - 135
4	150 - 330	45 - 100
5	120 - 260	35 - 80
6	100 - 220	30 - 70
7	85 - 190	25 - 60

5.1.1.2 Broadgoods sheet shall be supplied flat and shall be protected on both sides by nonadhering separator film conforming to the specified detail specification of AMS 3898. Sheets shall be packaged separately, or as specified in 5.1.1.1 and 5.1.1.3, in sealed bags of suitable non-adherent material to prevent penetration of moisture or loss of impregnating resin solvent.

5.1.1.3 Location of visually imperfect areas and of splices shall be plainly identified on the product by suitable 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. Quantity on each reel and marking of visually imperfect areas and of splices shall be as specified in 5.1.1.3.

5.1.2.1 Placement: The tape shall be placed on the interleaf (carrier) material within ± 0.015 in. (± 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 in. (0.38 mm) of the center line of the interleaf or not greater than 0.030 in. (0.76 mm) from the edge and shall not extend beyond the edge of the interleaf.

5.1.3 Broadgoods, rolls or sheet, and tape, shall be maintained at not higher than -18°C (0°F) during shipment and storage.