



AEROSPACE MATERIAL SPECIFICATION

AMS3960™**REV. A**Issued 2011-09
Revised 2015-08

Superseding AMS3960

(R) Advanced Composites Prepreg - Nominal 250 °F Cure - Carbon Fiber
and Epoxy Resin, Unidirectional Tape

RATIONALE

Widely distributed and available industry material specifications are required for procurement of composite materials whose allowables data is published in CMH-17.

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Documents

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1. SCOPE

- a. This specification establishes the requirements for a nominal 250 °F cure epoxy preimpregnated (prepreg) carbon fiber unidirectional tape product. The prepreg has a nominal fiber areal weight of 150 gsm, and nominal resin content of 35%.
- b. This material is intended for use in laminate applications with a service temperature of -65 to 180 °F.
- c. The composite may be used for the manufacture of primary and secondary aircraft structure.

1.1 Purpose

The purpose of this specification is to allow procurement of a defined material corresponding to the statistically derived material properties published in CMH-17 Volume II.

2. APPLICABLE DOCUMENTS

The issue of the following documents in effect on the date of the purchase order forms a part of this specification to the extent specified herein. The supplier may work to a subsequent revision of a document unless a specific document issue is specified. When the referenced document has been cancelled and no superseding document has been specified, the last published issue of that document shall apply.

2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

SAE International, "Composite Materials Handbook Volume 1 (CMH-17)," (Warrendale, SAE International, 2012), doi:10.4271/R-422.

2.2 ASTM Standards

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM D792	Specific Gravity (Relative Density) and Density of Plastics by Displacement
ASTM D2344	Apparent Interlaminar Shear Strength of Parallel Fiber Composites by Short Beam Method
ASTM D2734	Void Content of Reinforced Plastics
ASTM D3039	Tensile Properties of Polymeric Matrix Composite Materials
ASTM D3171	Fiber Content of Resin-Matrix Composites by Matrix Digestion
ASTM D3529	Matrix Solids Content and Matrix Content of Composite Prepreg
ASTM D3530	Volatiles Content of Composite Material Prepreg
ASTM D3531	Resin Flow of Carbon Fiber-Epoxy Prepreg
ASTM D3532	Gel Time of Carbon Fiber-Epoxy Prepreg
ASTM D5379	Shear Properties of Composite Materials by the V-Notched Beam Method
ASTM D7028	Glass Transition Temperature (DMA T_g) of Polymer Matrix Composites by Dynamic Mechanical Analysis (DMA)
ASTM E168	General Techniques of Infrared Quantitative Analysis

ASTM E1252 Standard Practice for General Techniques for Quantitative infrared Analysis

ASTM E2160 Heat of Reaction of Thermally Reactive Materials by Differential Scanning Calorimetry

2.3 SACMA Standards

Available from American Composites Manufacturers Association, 1010 North Glebe Road, Suite 450, Arlington, VA 22201, Tel: 703-525-0511, www.acmanet.org.

SACMA SRM 1R-94 Compressive Properties of Oriented Fiber-Resin Composites

SACMA SRM 18R-94 Glass Transition Temperature (T_g) Determination by DMA of Oriented Fiber - Resin Composites

SACMA SRM 20R-94 High Performance Liquid Chromatography of Thermoset Resins

SACMA SRM 22R-94 Resin Flow of Preimpregnated "B" Staged Material

SACMA SRM 23R-94 Resin Content and Fiber Area Weight of Thermoset Prepreg with Destructive Technique

SACMA SRM 25R-94 Onset Temperature and Peak Temperature for Composite System Resins Using Differential Scanning Calorimetry (DSC)

2.4 U.S. Government Publications

Copies of these documents are available online at <http://quicksearch.dla.mil>.

DOT/FAA/AR-03/19 Material Qualification and Equivalency for Polymer Matrix Composite Material Systems

DOT/FAA/AR-06/10 Guidelines and Recommended Criteria for the Development of a Material Specification for Carbon Fiber/Epoxy Fabric Prepregs

2.5 Performance Review Institute

Available from Performance Review Institute, 161 Thorn Hill Road, Warrendale, PA 15086-7527, Tel: 724-772-1616, www.pri-network.org.

PD2000 Governance and Administration of an Industry Managed Product Qualification Program

2.6 Definitions

ACCEPTANCE TESTING - Tests to prove that the quality aspects of subsequent prepreg batches correspond to the quality characteristics of the "original" qualified prepreg product.

BAG SIDE - The side of the panel that is cured against the vacuum bag.

BREATHER - A porous material that serves as a continuous air path over and/or around the part.

FIBER (YARN) LOT - Carbon fiber produced in one continuous manufacturing operation, under substantially identical conditions (except normal rest periods and daily shift changes).

FIBER SIZING - A polymeric coating applied to yarns to improve handling characteristics during weaving, prepregging or other fiber handling operations.

FOREIGN MATERIAL - All visually detectable material not characteristic of the prepreg, such as not carbon fiber or resin constituents.

FUZZ BALLS - The broken filaments and abraded particles that collect as loose filament bundles or balls which are occasionally incorporated onto the impregnated material.

MASTER ROLL - A subunit of a prepreg batch that has been wound on a core, until changed with another empty core, that is further processed into product rolls.

MECHANICAL LIFE - See Figure 1 for Staging Life. The out-of-refrigeration time before cure over which the material remains capable of demonstrating mechanical properties in Section 3.0 if laid up and compacted within its work (or handling) life. Also known as open mold life or tool life. For this material the mechanical life would be equal to the out time or storage life remaining after completing the layup of the part, whichever is less.

OUT-TIME - Out-Time (also known as Out-life) is defined by this document and Figure 1 as the sum of Work (Handling) and Mechanical (Staging) life.

PREPREG - In the context of this specification, prepreg is epoxy resin impregnated, unidirectionally carbon fiber filaments that, upon supply to composite parts fabricators, contain a certain amount of reactive resin mass and can be cured by heat and vacuum/pressure without further additives.

PREPREG BATCH - Prepreg product produced in one continuous manufacturing operation, under substantially identical conditions (except normal rest periods and daily shift changes), using carbon fibers traceable to a specific lot and resin mixed in the mixer in one operation or one homogenous mix, with traceability to individual component lots.

PROCESS CONTROL DOCUMENT (PCD) - A document that describes the raw materials, manufacturing processes, in process testing and alternate test methods used to document and to control variation of a supplier's product. The user should coordinate with the material supplier to establish that the PCD meets their requirements, such as: content of the PCD, what PCD changes must be reported/approved, and who approves (in writing) the PCD.

PRODUCT ROLL - A subunit of a prepreg batch in the final configuration delivered to the purchaser which meets the size requirements in 5.2.2.

PUCKERS - Areas on prepreg product where the material has locally blistered or pulled away from the separator film or release material.

QPL AGENCY - The agency responsible for maintaining the Qualified Products List (QPL).

RESIN BATCH - Resin mixed in one mixer in one operation or blended together in one homogeneous mix with traceability to individual component lots.

STORAGE LIFE - The time in storage at 10 °F or below (alternatively at 40 °F or below), while contained in sealed packaging, over which the prepreg material is capable of meeting all requirements of this specification (See Figure 1).

SURFACE RESIN STARVATION - Incomplete resin coverage of fibers at the surface of the prepreg or laminate.

TOOL SIDE - The side of the panel that is cured against the tool surface.

WORK LIFE - See Figure 1 for Handling Life. The out of refrigeration period of time during which the prepreg resin matrix retains characteristics (typically tack and drape) conducive to layup and lamination of composite components in the layup environment, and remains capable of demonstrating the mechanical properties in this specification after cure.

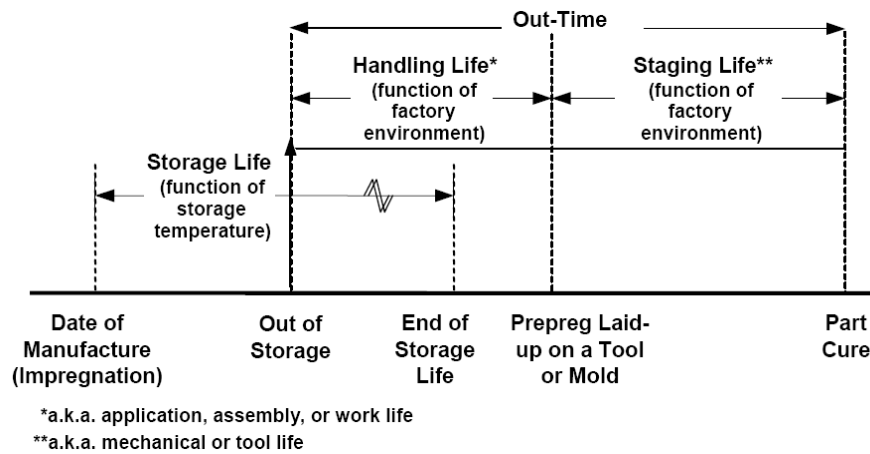


Figure 1 - Definitions of storage, handling, staging life and out-time

From DOT/FAA/AR-06/10, "Guidelines and Recommended Criteria for the Development of a Material Specification for Carbon Fiber/Epoxy Fabric Prepregs"

3. TECHNICAL REQUIREMENTS

3.1 Composition

3.1.1 Resin

- a. The resin matrix used in the manufacture of prepreg to this specification shall be 270 °F ± 10 curing modified epoxy-based thermosetting resin, the components of which shall be specified, tested, supplied and processed in accordance with the PCD.
- b. The resin shall not produce any excessive health issues or skin irritation when handled in a conventional manner, and should not produce any emissions that require special environmental measures during the processing of the prepreg product.
- c. The resin composition, resin preparation and processing of a product shall be controlled by the PCD and evaluated during material qualification.

3.1.2 Carbon Fiber

Fiber properties (and corresponding test methods) shall be controlled by the PCD, to include as a minimum the following: tensile strength and modulus, elongation at failure, yield, density, and sizing weight percent.

- a. The carbon fiber reinforcement shall be an approved semi-product of the qualified prepreg material.
- b. The fiber sizing shall be considered as an integral part of the carbon fiber.
- c. The product quality shall be controlled by the PCD and evaluated during material qualification.

3.2 Quality

3.2.1 Visual Defect Limitations and Dimensional Requirements

- a. The impregnated material shall be uniform in quality and condition. It shall not exhibit characteristics detrimental to handling, layup or structural properties.

- b. The prepreg material shall be free from cut or broken fibers, cured resin, unwetted fibers, resin-rich areas, dry or boardy areas and visible indications of moisture. Prepreg material shall be free from all foreign material except random and sparse flecks of carrier material inherent to the prepreg manufacturing process. The paper flecks shall be no greater than 0.031 inch in any direction.
- c. Fuzz balls shall be acceptable provided:
 - 1. The fuzz balls cause no apparent fiber distortion. This shall be determined without removing the fuzz balls.
 - 2. Any fuzz ball shall not exceed 1.5 inches in any direction.
 - 3. The accumulated number of fuzz balls, of which the largest dimension is between 0.4 to 1.5 inches, shall not exceed 6 in any 10 square feet of one side of the prepreg material.
 - 4. The overall thickness change due to fuzz ball shall be no more than 50% of the prepreg material nominal thickness.
- d. Dimension - prepreg material may be furnished in rolls with widths and tolerances in accordance with customer's purchase order, up to 39.4 inches wide. Contact the manufacturer for standard widths and tolerances.
- e. The fibers shall be completely and uniformly coated with resin matrix.
- f. The edge of the prepreg tape shall not deviate from a straight line by more than 0.025 inch per foot of length and shall be flush with the separator paper.
- g. All fiber yarns shall be collimated and parallel, within 0.03 inch per foot of length, to the centerline of the material.
- h. The length of any fiber gap, parallel to the 0 degree direction, shall not exceed 10 inches. The width of any fiber gap, perpendicular to 0 degree direction, shall not exceed 0.030 inch. A single gap 0.010 to 0.030 inch wide and not exceeding 10 inches long is acceptable in each 10 square feet of prepreg. Gaps less than 0.010 inch wide and not exceeding 10 inches long are acceptable.
- i. The prepreg shall be free from crimped fibers and fiber crossovers.
- j. The following specifies the acceptance/reject criteria for puckers and/or pimples in the unrolled condition. Evaluate prepreg for puckers and/or pimples in accordance with 4.4.7.
- k. Materials not conforming to the requirements of 3.2.1 may be supplied only if marked and corrected in accordance with 3.2.2.

Table 1

Largest Dimension	Frequency	Criteria
Greater than 0.50 inch	Any	Rejectable
0.25 to 0.50 inch	3 or less per 1 square foot	Acceptable
Less than 0.25 inch	All	Acceptable

3.2.2 Materials not Conforming to the Visible Defect Limitations and Dimensional Requirements

In cases where foreign material or resin rich areas can be removed without causing any apparent deformation of the prepreg surface, it may be removed by spatula or adhesive tape. The spatula or adhesive tape shall not transfer any contaminants to the prepreg product.

3.2.2.1 For Hand Lay-Up Material

- a. Areas not conforming to 3.2.1 shall be identified along the edge of the prepreg roll by markers. Markers shall be single color, distinguishable from the prepreg and carrier release paper, and removable without damaging the prepreg material.
- b. For single-point defects, use a single marker.

- c. Successive single-point defects 3 feet or less apart shall be considered as one continuous defect. For continuous defective areas, markers shall be placed at the beginning, at 2 foot (maximum) intervals, and at the end of the continuous defect.
- d. Prepreg may be cut and spliced to remove defects. Prepreg splicing shall be in accordance with the splicing procedure documented in the Process Control Document (PCD).
- e. Prepreg material shall have a roll maximum defect content of 15% by weight. The defect weight limit shall be based on the full-width weight.
- f. 90% of any roll shall not contain two successive splices or defects closer than 50 feet. The remaining 10% shall not contain two successive splices or defects closer than 15 feet.
- g. The type, location, and length (for continuous defects) of each marked defect, and the location of the splices, shall be indicated on a defect log accompanying each roll of prepreg material. Defect and splice locations shall be identified to within 3 feet relative to the outside end of the prepreg roll.
- h. Defective areas shall not be counted toward the amount purchased.

3.2.2.2 For Material Supplied for the use in Automated Tape Laying (ATL) Equipment

- a. Prepreg material supplied to this requirement shall be free from defects. Prepreg not conforming to 3.2.1 shall be cut and spliced to remove defects. Contact the material supplier for available product configurations.

3.2.3 Prepreg Life Requirements

The following exposure times shall have no detrimental effect on the handling, layup, and mechanical properties of the prepreg material. The prepreg material shall not exceed the times indicated for each of the following exposures. The prepreg material shall be capable of meeting the qualification requirements of this specification after the following exposures except for the Differential Scanning Calorimetry (DSC), Infrared Spectroscopy (IR), and High Performance Liquid Chromatography (HPLC). The DSC, IR and HPLC are only required during the initial qualification and/or initial material acceptance of the prepreg material.

- a. Storage Life at 10 °F - 12 months minimum from date of manufacture when stored at 10 °F or below, in a sealed container, at the prepreg manufacturer, and 24 months from date of manufacture when stored at 10 °F or below, in a sealed container, at the facility of the purchaser, or as specified in the purchase contract on the batch certification.
- b. Out-time (Out Life) - 28 days minimum, within the storage life of the material, when exposed in a controlled environment room at a temperature of 72 °F ± 5 and 65% maximum Relative Humidity.
- c. Work Life (Handling Life) - 10 days minimum when exposed at a temperature of 72 °F ± 5 (22.2 °C ± 2.8) and 65% (maximum) Relative Humidity.

3.2.4 Prepreg Life Extension

The Storage Life at 10°F or below maybe extended for an additional 6 months from the end of the original storage life or test date, whichever is shorter, after successfully meeting the specification requirements of Table 2, and supplier material acceptance testing of Table 3 and 4.

3.2.5 Uncured Prepreg Physical and Chemical Properties

The prepreg material shall conform to the requirements of Table 2 when tested in accordance with the designated methods.

