



AEROSPACE MATERIAL SPECIFICATION

AMS3961™

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350 °F Autoclave Cure, Low Flow Toughened Epoxy Prepregs

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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1. SCOPE

The intent of this specification is for the procurement of the material listed on the QPL and, therefore, no qualification or equivalency threshold values are provided. Users that intend to conduct a new material qualification or equivalency program shall refer to the Quality Assurance section of this base specification, AMS3961.

All material qualification and equivalency data has been archived and is available for review upon request. Contact the CMH-17 Secretariat (www.cmh17.org) for additional information.

1.1 Form

This specification and its associated detail specifications establish the requirements for a 350 °F autoclave cure, continuous fiber (“unidirectional tape and fabric prepreg”) impregnated with a modified B-staged epoxy resin.

1.1.1 Detail Specification

This base specification contains basic fiber reinforced epoxy prepreg material requirements that apply to every product. The detail specifications contain additional or superseding properties and requirements that apply to a specific product.

1.2 Purpose

- a. The purpose of this specification is to allow procurement of a defined material corresponding to the statistically derived material properties published in CMH-17.
- b. The materials qualified to this specification are designed specifically for vacuum-bag autoclave cure in accordance with 4.5.
- c. This specification is developed based on the material properties that are available publicly. The purchaser may specify additional requirements beyond those defined in this specification, especially when the purchaser has generated additional material properties beyond those available publicly or when the application has other requirements. The additional requirements are subject to supplier review and approval.
- d. The use of this specification does not guarantee material or structural performance. Material users should be actively involved in evaluating material performance and quality including, but not limited to, performing regular purchaser quality control tests, performing periodic equivalency/additional testing, participating in material change management activities, conducting statistical process control, and conducting regular supplier audits.
- e. This material is intended for use in laminate applications with a service temperature range of -65 to 250 °F.
- f. This composite material may be used for the manufacture of primary and secondary aircraft structure.

1.3 Classification

1.3.1 Type

Type shall specify the nominal prepreg resin content. For example:

Type 35 – Nominal resin content 35% by weight

Type 38 – Nominal resin content 38% by weight

1.3.2 Class

Class shall specify prepreg product form. For example:

Class 1 – Unidirectional carbon fiber prepreg tape

Class 2 – Woven carbon fiber fabric prepreg

1.3.3 Grade

Grade shall specify nominal fiber areal weight in grams per square meter (gsm). For example:

Grade 190 – 190 gsm nominal fiber areal weight

Grade 193 – 193 gsm nominal fiber areal weight

1.3.4 Style

Style shall specify the woven fabric style (not applicable to Class 1). For example:
Style 3K-70-PW - 3k yarn, 7.0 mil nominal dry fabric thickness, plain weave

1.3.5 Fiber Type

The carbon fiber type is designated as follows:
Fiber 1: Standard Modulus (31-35 Msi)
Fiber 2: Intermediate Modulus (38-42 Msi)

1.3.6 Service Temperature Capability

The service temperature capability, used to establish the batch acceptance test temperature requirements, shall be designated as follows:

ST (Standard Temperature) - service temperature of -65 to 180 °F – All batch acceptance testing shall be performed at room temperature dry (70 °F ± 10 °F)

ET (Elevated Temperature) – service temperature of -65 to 250 °F – A portion of the batch acceptance tests shall be performed at elevated temperature dry (250 °F ± 10 °F).

Note: If no service temperature capability is identified in the product nomenclature, then “ST” shall be the default designation

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 all 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.

1.5 Change Control Management

Prepreg product shall be produced in accordance with a Process Control Document (PCD) approved by the Qualifying Agency. In general, level 1 through level 3 changes per DOT/FAA/AR-06/10 and DOT/FAA/AR-07/3 are considered major changes. Prior to implementing a change, the material supplier shall provide formal notification to the Qualifying Agency. The change may not be implemented until approval has been provided by the Qualifying Agency.

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.

Detail Specifications

AMS3961/1 350 °F Autoclave Cure, Low Flow Toughened Epoxy Prepregs, Type 38, Class 2, Grade 193, Style 3K-70-PW, Fiber 1

AMS3961/2 350 °F Autoclave Cure, Low Flow Toughened Epoxy Prepregs, Type 35, Class1, Grade 190, Fiber 2

AMS3961/3 350 °F Autoclave Cure, Low Flow Toughened Epoxy Prepregs, Type 35, Class 1, Grade 190, Fiber 1

(CMH-17) Composite Materials Handbook

2.2 ASTM Publications

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 D2344	Short-Beam Strength of Polymer Matrix Composite Materials and their Laminates
ASTM D3039	Tensile Properties of Polymeric Matrix Composite Materials
ASTM D3529/D3529M	Matrix Solids Content and Matrix Content of Composite Prepreg
ASTM D3530/D3530M	Volatiles Content of Composite Material Prepreg
ASTM D3531	Standard Test Method for Resin Flow of Carbon Fiber-Epoxy
ASTM D3532	Gel Time of Carbon Fiber-Epoxy Prepreg
ASTM D3776	Mass per Unit Area (Weight) of Fabric
ASTM D3878	Standard Terminology Composite Materials
ASTM D6641	Compressive Properties of Polymer Matrix Composite Laminates Using a Combined Loading Compression (CLC) Test Fixture
ASTM E168	General Techniques of Infrared Quantitative Analysis
ASTM E1252	Standard Practice for Obtaining Infrared Spectra for Qualitative Analysis

2.3 ISO Publications

Available from American National Standards Institute, 25 West 43rd Street, 4th Floor, New York, NY 10036, Tel: 212-642-4900, www.ansi.org.

ISO 9000 Quality Management Systems

2.4 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 10R-94	Calculation of Fiber Volume of Composite Test Laminates
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 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)

2.5 U.S. Government Publications

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

29 CFR 1910.1200	Hazard Communication, Occupational Safety and Health Standards
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
DOT/FAA/AR-07/3	Guidelines and Recommended Criteria for the Development of a Material Specification for Carbon Fiber/Epoxy Unidirectional Prepregs Update
MIL-D-3464	Desiccants, Activated, Bagged, Packaging Use and Static Dehumidification
MIL-PRF-131	Barrier Materials, Watervaporproof, Greaseproof, Flexible, Heat-Sealable

2.6 Definitions

For definitions that are not provided in this specification or other applicable AMS specifications, the definitions in DOT/FAA/AR-06/10 or DOT/FAA/AR-07/3 shall apply. For definitions not provided in DOT/FAA/AR-06/10, the definitions in ASTM D3878 shall apply. For definitions not provided in ASTM D3878, the definitions in CMH-17 shall apply.

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.

CREASE – A condition of the surface of the prepreg where the nominal thickness is not appreciably changed but the material is permanently formed into a ridge.

FABRIC BATCH – Fabric woven from one warp loom set.

FIBER FINISH – A coating material applied to the fiber in order to promote resin adhesion.

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

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

FILL – The crosswise yarns running at 90 degrees to the warp of the fabric reinforcements, also known as weft or 90°.

FOLD – A condition in which the prepreg is laid back over itself.

FOREIGN MATERIAL – All visually detectable material not characteristic of the prepreg, such as not 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 over which the material remains capable of demonstrating mechanical properties in Section 3.0 if laid up and compacted within its work 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 laup of the part, whichever is less.

PREPREG – In the context of this specification, prepreg is epoxy resin impregnated, carbon fiber or fabric 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 fiber or fabric traceable to a specific lot and resin mixed in 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.

QUALIFYING AGENCY – The responsible agency for 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.

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

SELVAGE – The woven edge portion of a fabric parallel to the warp; usually has an increased number of ends/inch.

SMASH – A place in the fabric where a number of warp or filling yarns have been broken.

STORAGE LIFE – The time in storage at 0 °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.

STREAKS – Resin-rich or resin-starved areas on the prepreg surface.

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.

WARP – The roll length direction, continuous fibers from the warp loom set, etc. Also known as 0°.

WRINKLE – A ridge or crease on a prepreg surface caused by crumpling or folding.

WORK LIFE – See Figure 1 for Handling Life. The out-of-refrigeration time over which the prepreg material maintains its tack and drape (between 45 and 65% relative humidity) prior to being incorporated into a part, and remains capable of demonstrating the mechanical properties in this specification. Also known as out life.

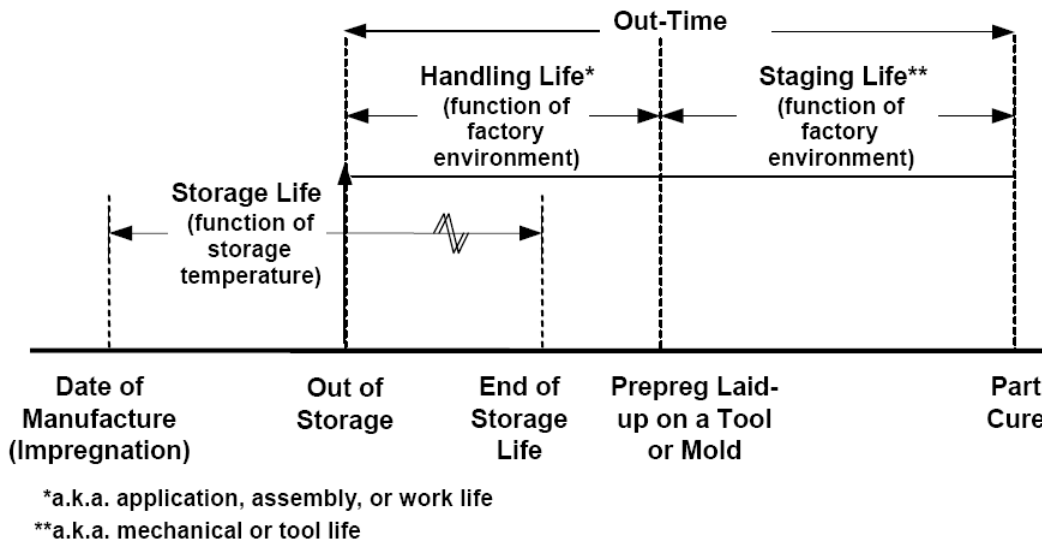


Figure 1 – Definitions of storage, handling, and staging life and out-time

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

Material supplied in accordance with this specification shall consist of epoxy resin and fiber. The definitions of fiber lot, resin batch, and prepreg batch are in accordance with 2.6, DOT/FAA/AR-06/10 and DOT/FAA/AR-07/3.

3.1.1 Resin

- The resin matrix used in the manufacture of prepreg to this specification shall be 355 ± 10 °F curing modified epoxy-based thermosetting resin, the components of which shall be specified, tested, supplied and processed in accordance with the PCD.
- The resin shall not produce any excessive health issues or skin irritation when handled in a conventional manner, and shall not produce any emissions that require special environmental measures during the processing of the prepreg product.
- The resin composition, resin preparation and processing of the product shall be controlled by the PCD and evaluated during material qualification.
- No separate specification exists for the resin system. Any changes to the epoxy resin system since qualification shall be re-approved by the Qualifying Agency.

3.1.2 Reinforcement

Fiber properties (and corresponding test methods) shall be controlled by the PCD and the detail specification.

- The fiber reinforcement shall be an approved constituent of the qualified prepreg material.
- The fiber finish shall be considered as an integral part of the fiber.

- c. The product quality shall be evaluated during materials qualification and controlled by the PCD and the detail specification.
- d. No separate specification exists for the fiber reinforcement. Any changes to the fiber after qualification shall be re-approved by the Qualifying Agency.

3.2 Quality

3.2.1 Visual Defect Limitations and Dimensional Requirements (Class 1)

- a. The preimpregnated 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 foreign material, cut or broken fibers, cured resin, unwetted fibers, wrinkles, resin-rich areas, dry or boardy areas, and indications of moisture visible to the unaided eye.
- 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 area of the fuzz shall not exceed 6 square inches in any 10 square foot area of the prepreg material.
 - 4. The overall thickness change due to a fuzz ball shall be no more than 50% of the prepreg material nominal thickness.
- d. 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.
- e. All prepreg tape fiber tows shall be collimated and parallel, within 0.025 inch per foot of length, to the centerline of the material.
- f. In prepreg tape the length of fiber gap, parallel to the 0° direction, shall not exceed 10 inches. The width of fiber gap, perpendicular to the 0 degree direction, shall not exceed 0.030 inch. One 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.
- g. The prepreg shall be free from crimped fibers and fiber tow crossovers visible to the unaided eye.
- h. The following specifies the acceptance/reject criteria for puckers and/or pimples in the unrolled condition.

Table 1 – Acceptance/rejection criteria for puckers and/or pimples

Largest Dimension	Frequency	Criteria
Greater than 0.5 inch	Any	Rejectable
0.25 to 0.50 inch	3 or less per 1 sq. ft	Acceptable
Less than 0.25 inch	All	Acceptable