SAE Aerospace
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AEROSPACE MATERIAL SPECIFICATION

SAE AMS3960

Issued 2011-09

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 MIL-HDBK-17.

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http://www.sae.org/technical/standards/AMS3960

1. SCOPE

a. This specification establishes the requirements for a nominal 250 °F cure epoxy preimpregnated carbon fiber unidirectional tape product.

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 MIL-HDBK-17.

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 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 Density and Specific Gravity (Relative Density) of Plastics by Displacement

ASTM D2344 Short-Beam Strength of Polymer Matrix Composite Materials and their Laminate

ASTM D2734 Void Content of Reinforced Plastics

ASTM D3039 Tensile Properties of Polymeric Matrix Composite Materials

ASTM D3171 Constituent Content of Composite Materials

ASTM D3530 Volatiles Content of Composite Material Prepreg

ASTM D3532 Gel Time of Carbon Fiber-Epoxy Prepreg

ASTM D5379 Shear Properties of Composite Materials by the V-Notched Beam Method

ASTM E4 Practices for Force Verification of Testing Machines

ASTM E168 General Techniques of Infrared Quantitative Analysis

ASTM E1252 Standard Practice for Obtaining Infrared Spectra for Qualitative Analysis

2.2 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 (Tg) 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)

2.3 U.S. Government Publications

FAR & FAA Publications from FAA: Available from Federal Aviation Administration, 800 Independence Avenue, SW, Washington, DC 20591, Tel: 866-835-5322, www.faa.gov, http://207.67.203.68/F10011.

MIL-HDBK-17 available from https://assist.daps.dla.mil/quicksearch/.

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

2.4 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.

In-transit Life - The time period which extends from the date of shipment to the date of receipt and during which the prepreg material is shipped.

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 - The out-of-refrigeration time over which the material remains capable of demonstrating mechanical properties in Section 3 if laid up and compacted within its work life. Also known as open mold life. See Figure 1.

Prepreg - In the context of this specification, prepreg is epoxy resin impregnated, unidirectionally laid, 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 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 paper.

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, 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 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.

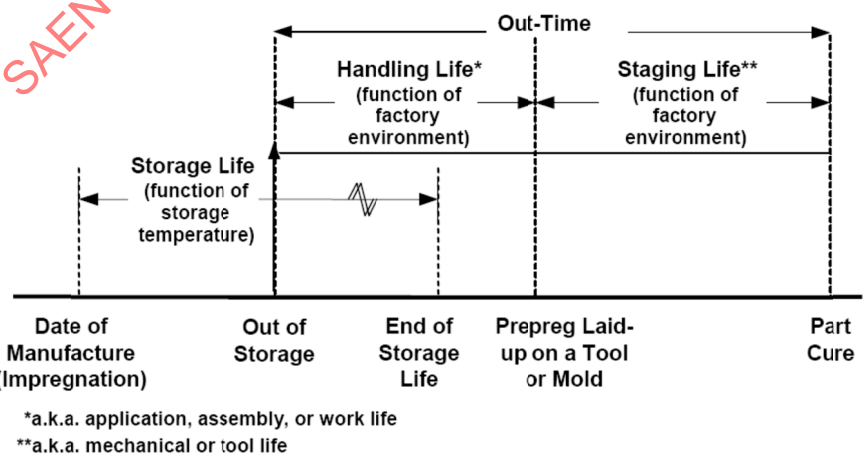

FIGURE 1 - DEFINITIONS OF STORAGE, HANDLING, STAGING LIFE AND OUT-TIME
From DOT/FAA/AR-06/10, "Guidelines and Recommended Criteria for the Development of a Material Specification for Carbon Fiber/Epoxy Fabric Prepregs

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 will 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 will 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 will 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 preimpregnated 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. Preimpregnated 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 - Unidirectional tape prepreg material may be furnished in rolls with the following widths:

1. 24.00 inch and/or 36.00 inch shall have a width tolerance of ±0.060 inch

2. 12.000 inch ± 0.030

3. 6.000 inch ± 0.020

4. 3.000 inch ± 0.020

e. 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.

f. All fiber yarns shall be collimated and parallel, within 0.03 inch per foot of length, to the centerline of the material.

g. 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.

h. The prepreg shall be free from crimped fibers and fiber crossovers.

i. 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.

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 12 inch, 24 inch and 36 inch Prepreg 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. Ninety percent 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 3 inch and 6 inch Width Prepreg Material

a. 3 and 6 inch width prepreg material supplied to this specification shall be free from defects. Prepreg not conforming to 3.2.1 shall be cut and spliced to remove defects.

b. Prepreg splicing shall be in accordance with the splicing method documented in the Process Control Document (PCD).

c. Materials from different rolls but from the same prepreg batch may be spliced. If different rolls from the same prepreg batch are spliced, then this shall be noted in the material certification report (including the roll numbers).

d. No two splices shall be closer than 50 feet, and no splice shall be closer than 50 feet to the end of the roll. No more than 10 percent of the rolls may have splices more than the following:

TABLE 2

Length of 3 inch or 6 inch Pprepreg Material	Number of Splices
Less than 850 feet	3
850 to 1250 feet	4
Greater than 1250 feet	5

e The location of all splices shall be indicated on a defect log accompanying each roll of prepreg. Splice locations shall be identified to within 3 feet relative to the outside end of the prepreg roll.

3.2.3 Prepreg Life Requirements

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. Storage Life at 40 °F - 1 month minimum from date of manufacture when stored at 40 °F or below, in a sealed container.

c. Work Life (Out Life) - 28 days minimum, from date customer takes title to the prepreg material, when exposed in a controlled environment room at a temperature of 75 °F ± 10 and 45 to 65% Relative Humidity.

3.2.4 Uncured Prepreg Physical and Chemical Properties

The prepreg material shall conform to the requirements of Table 3 when tested in accordance with the designated methods.

3.3 Composite (Cured Prepreg) Requirements

The uncured lamina shall conform to the requirements of Table 3 when tested in accordance with the designated test methods.

The cured lamina shall conform to the requirements of Tables 4 and 5 when tested in accordance with the designated test methods.

TABLE 3 - UNCURED PREPREG PHYSICAL AND CHEMICAL PROPERTIES

Prepreg Physical Properties	Requirements	Test Method Section
Resin Content, percent by weight **FL1 FL3**	35.0 ± 3.0	4.4.1
Carbon Fiber Areal Weight, g/m^2 **FL1 FL3**	150 ± 6	4.4.1
Volatile Content, percent by weight **FL1 FL3**	2.0 maximum	4.4.2
Gel Time, minutes **FL1 FL2**	5 to 25	4.4.3
Resin Flow, percent by weight **FL2**	10 minimum	4.4.4
Roll Edge alignment, inch (for 3 inches & 6 inches width prepreg product **FL1**	0.080 maximum	4.4.5
Prepreg Width, inches (for 3 inches & 6 inches width prepreg product) **FL1**	3.2.1.d	4.4.6
Puckers/Pimple (for all widths) **FL1**	3.2.1.i	4.4.7
Infrared Spectroscopy (IR) **FL1**	Report	4.4.8
High Performance Liquid Chromatography (HPLC) **FL1** (P1-P5 retention times as defined in the PCD)	P1: 6.68 ~ 12.2% P2: 7.88 ~ 9.32% P3: 4.75 ~ 7.61% P4: 57.2 ~ 65.0% P5: 12.8 ~ 16.6%	4.4.9
Differential Scanning Calorimetry (DSC)	Report	4.4.10

FL1 Required for supplier material acceptance testing.
FL2 Required for purchaser incoming material acceptance testing.
FL3 Key Characteristic that requires SPC control.

TABLE 4 - CURED LAMINA PHYSICAL PROPERTIES

Lamina Physical Properties	Requirements	Test Method Section
Cured Ply Thickness, inch **FL1 FL2 FL3**	0.006 ± 0.0005	4.4.11
Laminate Density, g/cc	Report [1/]	4.4.12
Fiber Volume, percent by volume	Report [1/]	4.4.13
Resin Content, percent by volume	Report [1/]	4.4.13
Void Content, percent by volume	Report [1/]	4.4.14
Glass Transition Temperature (Tg), °F		4.4.15
73 °F ± 5 / 50% ± 5 RH	279 to 315	
145 °F ± 5 / equilibrium at 85% ± 5 RH	244 to 280	

FL1 Required for supplier material acceptance testing.
FL2 Required for purchaser incoming material acceptance testing.
FL3 Key Characteristic that requires SPC control.
[1/] Specification value will be added when available.

TABLE 5 - CURED LAMINA MECHANICAL PROPERTIES

				Normalized Qualification Test Results		Material Acceptance Requirements: Threshold Properties α = 0.01 (1%); n = 5			
Properties	Unit	Condition Temp °F ± 5 / RH % ± 5	Test Temp. °F ± 10	Ave.	Std. Dev.	Min. Ave.	Min. Ind.	Specification Limit Indiv. Value	Test Method Section
0° Tension, Ult. Str.	ksi	73/50	75 **FL1 FL2& FL3**	315	24.1	288	241		4.4.16.1
0° Tension, Modulus	Msi	73/50	75 **FL1 FL3**	18.2	0.28			17.1 to 19.3	4.4.16.1
90° Tension, Ult. Str.	ksi	73/50	75	7.09	0.59	6.41	5.26		4.4.16.1
90° Tension, Modulus	Msi	73/50	75	1.22	0.03			1.10 to 1.34	4.4.16.1
0° Compr., Ult. Str.	ksi	73/50	75 **FL1 FL2& FL3**	210	12.4	196	172		4.4.16.2
0° Compr., Modulus	Msi	73/50	75	16.3	0.06			16.1 to 16.5	4.4.16.3
90°Compr., Ult. Str.	ksi	73/50	75	28.8	1.36	27.3	24.6		4.4.16.2
90°Compr., Modulus	Msi	73/50	75	1.47	0.06			1.23 to 1.71	4.4.16.3
In-plane Shr., Ult. Str.	ksi	73/50	75	22.4	0.63	21.7	20.5		4.4.16.4
In-plane Shr., Mod.	Msi	73/50	75	0.61	0.04			0.45 to 0.77	4.4.16.4
Short Beam Strength	ksi	73/50	75 **FL1 FL2& FL3**	12.5	0.92	11.4	9.66		4.4.16.5

FL1 Required for supplier material acceptance testing.
FL2 Required for purchaser incoming material acceptance testing.
FL3 Key characteristic that requires SPC control.

4. QUALITY ASSURANCE PROVISIONS

4.1 Initial Material Qualification

Prepreg material furnished under this specification shall be a product that has been tested per this specification and the results of the tests meet the requirements of Tables 3 through 5.

Initial material qualification shall be performed in accordance with the requirements described in DOT/FAA/AR-03/19, “Material Qualification and Equivalency for Polymeric Matrix Composite Material Systems”.

Analysis and approval of initial material qualification data (including survey of prepreg manufacturer, panel manufacturer, and test lab as applicable) is the responsibility of the Qualifying Activity (or their designee). All testing shall conform to the test procedures called out herein.

In order to include the effect of processing variability within the qualification data, the manufacturing process to produce the test panels and test specimens should be representative of a minimum of two independent processing cure cycles.

A minimum of three different batches of the candidate prepreg material shall be tested for lamina properties. The three batches shall contain at least three different resin batches and two different yarn lots of carbon fiber.

4.1.1 Request for Initial Material Qualification

A request for qualification of the prepreg material shall be directed to the Qualifying Activity for this specification. The following documents shall be submitted to the Qualifying Activity for approval. It is recommended that actual qualification testing shall not start without the Qualifying Activity approval of the test plan and specifications. After successful qualification the composite material combination shall be listed in the PRI QPL AMS3960.

1. Test Plan

2. Material Specification

3. Process Specification, covering at least fabrication of test panels.. The test panel fabrication process may also be contained within the material specification. If initial qualification, may be draft with TBD for property values. This composite manufacturing process for the initial material qualification also becomes the baseline for processor equivalency evaluations to determine whether a subsequent processor is comparable to the initial qualification processor, and thus able to leverage the initial qualification per DOT/FAA/AR-03/19.

4.2 Material Equivalency and Processor Equivalency

Material equivalency programs are specified to assure that alternate prepreg manufacturing materials, processes, equipment, lines and/or locations will produce prepreg material equivalent to that initially qualified. Processor equivalency programs are used to determine if, when using the same prepreg material, a modified composite manufacturing process or new processor can fabricate cured composite panels comparable to the processor of the originally qualified material. In all cases of equivalence, an “original” database must exist that contains material properties of the originally qualified prepreg fabricated into composite panels using a baseline fabrication process.

Material equivalency is only applicable to minor changes in the prepreg constituent(s) and/or prepreg manufacturing process (and as defined by the user in the PCD). Processor equivalency is only applicable to the following types of changes (and as specified by the user in the PCD):

a. Composite material fabricated by using an identical fabrication process at a different location,

b. Composite material fabricated by an alternate process that is equivalent to the process used to fabricate the original qualification panels,

c. Composite material fabricated using an alternate process that is slightly different from the process used to fabricate the original qualification panels.

If material and/or processor equivalency cannot be established then a new qualification will be required.

4.2.1 Material Equivalency Limitations

For material equivalency to be established, all critical prepreg constituent(s) and/or manufacturing processes (as defined by the user in the PCD) must remain unchanged. For example, the following are types of changes to the prepreg material system that are considered as major changes:

a. Change of resin (for example, changing from 2510 to 3631-1 resin)

b. Change of fiber (for example, changing from T300 to T700S fiber)

c. Change of fiber form (for example, significant change in areal weight)

d. Change of tow dimension (for example, changing from 6K to 12K tow)

e. Significant change in resin content of prepreg

f. Change of sizing or coupling agent type

4.2.2 Processor Equivalency Limitations

For processor equivalency to be established, all the critical steps in the process specification used to fabricate the original and alternate material system must be equivalent, as defined by the user in the PCD. If applicable, the processor must meet the applicable CFR requirements including, but not limited to : §23.603 (a) and (b) §23.605 (a) and (b).

For example, the following are type of processor changes that are considered as minor changes:

a. Increasing the cure pressure or vacuum level for the alternate process. This includes changing from oven curing (vacuum only) to autoclave curing. Decreasing the cure pressure or vacuum level for the alternate process, however, is not allowed.

b. Minor modifications to cure parameter such as dwell time and heat-up rate.

4.2.3 Request for Equivalency Determination

A request for material equivalency shall be directed by the qualified prepreg manufacturer to the Qualifying Activity. A request for processor equivalency shall be directed by the processor to the processor's regulatory agency and/or customer. The following documents shall be submitted for approval. Actual equivalency testing shall not start without approval.

1. Test Plan (unless otherwise specified, shall be developed in accordance with requirements of DOT/FAA/AR-03/19)

2. Material Specification

3. Process Specification

A minimum of one batch of prepreg material shall be tested.

A minimum of two independent processing cure cycles shall be used for fabrication of test panels.

Equivalence to the “original” (initial qualification) database shall be determined in accordance with DOT/FAA/AR-03/19, Section 6.1.

4.3 Quality Assurance

To ensure acceptable quality throughout the processing of the prepreg material, a series of inspections are required. These inspection requirements are defined in Tables 3, 4, and 5.

The required number of test specimens and test methods for material acceptance, for each test property, shall be defined in 4.4.

4.3.1 Statistical Process Control

A Statistical Process Control (SPC) shall be established. The prepreg manufacturer’s Quality Assurance (QA) Section shall maintain the procedures and requirements for the SPC, based upon key characteristics (KC) and key process parameters (KPP), in accordance with the requirements of this specification.

a. Key characteristics are specified in Table 3, 4, and 5.

b. The process for selecting and documenting KPP is described in 4.3.1.1.

4.3.1.1 Key Process Parameters

a. The prepreg manufacturer’s Technical Section has responsibility in the selection of KPP and shall document the KPP in the Process Control Document (PCD).

b. KPPs shall include those parameters that have the greatest influence on the KCs and performance of the prepreg material.

c. The prepreg manufacturer’s Technical Section shall establish the nominal target value and tolerance limits for each KPP. The inspection method and monitoring frequency for each KPP shall be documented in the PCD.

4.3.1.2 Analysis Review

a. The prepreg manufacturer’s QA Section shall conduct SPC analysis of the KC and KPP.

b. The procedures used to establish and calculate the control limits shall be documented in the PCD.

c. If statistical analysis determines that a KC or KPP is out of control:

    1. The cause(s) shall be investigated.

    2. The causes of variation shall be eliminated and statistical control reestablished.

    3. Material produced while the process is out of control, but still meeting the requirements of this specification, shall have the out of control condition noted on the batch certifications if requested on the purchase order.

d. If a KC is not capable, the prepreg manufacturer’s Technical Section shall take corrective action to establish capability.

e. The prepreg manufacturer’s QA Section shall document all corrective actions affecting the process and assure the effectiveness of the actions.

4.3.1.3 Reduce Testing

a. Reduced testing plan may be established based on the capability of the KCs and the performance of the KPPs.

b. The plan which describes reduced testing shall be documented in the PCD.

c. Before the implementation of the reduced testing plan, approval of the customers shall be required and will be described in their purchase contracts.

4.3.2 Product Certification

4.3.2.1 Certification Testing

The prepreg manufacturer's Test Laboratories shall perform tests on each batch of prepreg material as specified by flagnotes in Tables 3, 4, and 5. The following sampling plan shall be used unless an alternate sampling plan is listed in the purchase contract.

a. Uncured Prepreg Physical and Chemical Properties

    1. Resin content and fiber areal weight shall be performed on a representative sample from the start of every master roll.

    2. Volatile content and gel time shall be performed on representative samples from start and end of the prepreg batch

    3. HPLC and IR shall be performed on a representative sample, once per prepreg batch.

    4. Puckers and pimples test shall be performed on one representative roll of the prepreg batch.

    5. Roll edge alignment and tape width shall be performed on 6 inch and 3 inch width prepreg rolls that were manufactured at the start of each master roll. Sample shall be taken from the final winding of the rolls.

b. Cured Lamina Physical Properties - Each mechanical test panel fabricated from each prepreg batch shall be tested to verify compliance with the requirements of Table 4.

c. Cured Lamina Mechanical Properties - Each prepreg batch shall be tested to verify compliance with the requirements of Table 5, with sampling of one roll per batch.

4.3.2.2 Certification Reports

The supplier shall provide a certification report for each prepreg batch delivered. The report shall include the following:

a. Individual and averaged values, along with test requirements.

b. The prepreg batch identification, prepreg roll number and date of manufacture.

c. The current specification revision.

d. Prepreg roll defect(s) log shall be prepared in accordance with 3.2.2 for each shipment, with a copy attach to the roll container.

e. IR spectrographs shall be included in the report.

f. HPLC chromatograph shall be included in the report.

g. A copy of the carbon fiber lot certification report if requested on the purchase order.

4.3.2.3 Records

a. All records that pertain to the data published in MIL-HDBK-17 for the candidate material shall be kept on permanent file by the Qualifying Activity or their designee.

b. The following records for each prepreg batch shall be kept on file by the material supplier for a period of 10 years:

    1. Full prepreg batch traceability. The traceability shall include the mix resin and resin component batches, and carbon fiber yarn lots.

    2. All records of raw material receiving inspection and certification, in-process materials and prepreg product material acceptance testing specified in the PCD.

    3. All records on SPC specified in the PCD.

c. All records shall be available for inspection by authorized representative of SAE or customers once a nondisclosure agreement is in place.

4.3.3 Purchaser Quality Control

4.3.3.1 Incoming Material Acceptance Test

a. Purchaser Quality Assurance shall perform tests on each prepreg batch. The tests shall verify compliance with the physical and chemical, and mechanical properties as specified by flagnotes in Tables 3, 4, and 5. The test frequency shall be once per batch and shall consist of the following tests:

    1. Visual examination (each portion of each roll from which mechanical test panels are fabricated and/or material sampled).

    2. Uncured Prepreg Physical Properties

        a. Gel time (3 specimens per prepreg batch)

        b. Resin flow (3 specimens per prepreg batch)

    3. Cured Lamina Physical and Mechanical Properties

        a. Cured ply thickness (10 random measurements on each mechanical test panel)

        b. 0 degree Tension, Strength at 75 °F, dry condition (5 specimens per prepreg batch)

        c. 0 degree Compression, Strength at 75 °F, dry condition (5 specimens per prepreg batch)

        d. Short Beam Shear at 75 °F, dry condition (5 specimens per prepreg batch)

b. Purchaser Quality Assurance shall review the supplier test certification submitted with prepreg material shipments and perform any additional inspection or testing necessary to assure the prepreg material meets all the requirements of this specification.

c. Material that fails any of the requirements called out in Table 3, 4, and 5 shall be rejected subject to the retest condition specified in 4.4.17.

d. Purchaser Quality Assurance shall verify that each shipment of prepreg material meets the requirements for storage temperature between the point when the purchaser assumes ownership and the point when the prepreg material is received.

1. The purchaser shall document the procedure used to verify temperature exposure.

2. If any exposure exceeds the conditions in 3.2.3, then the prepreg material shall be rejected.

3. If storage conditions cannot be verified, material in that shipment shall be tested in accordance with 4.3.3.1, with additional testing of a representative sample from the shipment of prepreg material for HPLC, IR and DSC.

4.3.3.2 Records

a. Purchaser Quality Assurance shall maintain records of actual test data including individual and average values. The records shall state whether the material was accepted or rejected. If rejected, the reason for rejection shall be documented.

b. Purchaser Quality Assurance shall maintain all test data and records for a period of at least 2 years (or as required by the user's regulatory agency and/or customer). Such records shall be kept on file and readily available for review by SAE or authorized representative of customers. A nondisclosure agreement may be required.

4.4 Material Test Methods

a. Rolls of prepreg material stored at lower than room temperature shall be contained in a sealed bag. Allow the prepreg material to warm to room temperature before taking a sample. Sealed bags shall not be opened if condensation forms on the surface of the bags after being wiped dry.

b. Remove sufficient quantity of prepreg material from each representative roll to perform all required tests. Reseal the roll and sample(s) in moisture-proof bags before returning the roll to storage. Discard any dried, moisture-affected, or contaminated prepreg material from each roll to be sampled. Minimize out time from refrigerated storage.

c. Use the test methods described below.

d. Test condition at room temperature shall be 75 °F ± 10.

e. Any retest of suspect data shall be subjected to the requirement specified in 4.4.17.

4.4.1 Resin Content and Carbon Fiber Areal Weight

a. Cut three each, 100 mm ± 0.05 X 100 mm ± 0.05, uncured prepreg samples across the width of the prepreg ply. Use full width prepreg before slitting to width as test material if available.

b. Calculate the area of each specimen to the nearest 0.1 square millimeter.

c. Place the test specimens in separate beakers with N-Methyl Pyrrolidone.

d. Test in accordance with SACMA SRM 23-94, Method A.

e. Record results of the individual specimens and their average. Test values shall meet the requirements of Table 3.

4.4.2 Volatile Content

a. Cut three each test specimens across the width of uncured prepreg and perform volatile content in accordance with ASTM D3530.

b. Record results of the individual specimens and their average. Test values shall meet the requirements of Table 3.

4.4.3 Gel Time

a. Perform the gel time on three specimens in accordance with ASTM D3532.

b. Record results of the individual specimens and their average. Test values shall meet the requirements of Table 3.

4.4.4 Resin Flow

a. Perform the resin flow in accordance with SACMA SRM 22-94.

b. Record results of the individual specimens and their average. Test values shall meet the requirements of Table 3.

4.4.5 Roll Edge Alignment (3 and 6 inch Width Prepreg)

a. Press or flat drop the roll, edge down, on a flat surface to maximize tape edge contact with flat surface.

b. Traverse a 3/16 inch diameter ball-tipped indicator reading in inches, across each quadrant of the upper roll edge to measure the apparent high and low points of the upper edge surface.

c. Record the largest difference between all readings as the roll edge alignment. Each roll shall meet the requirements of Table 3.

4.4.6 Prepreg Tape Width (3 and 6 inch Width Prepreg)

a. Measure the width of the prepreg with carrier release paper combination to an accuracy of 0.002 inch using a venier caliper or suitable device.

b. Record the average of three readings from one end of each roll in the sample.

c. Each roll shall meet the requirements specified in 3.2.1.d.

4.4.7 Prepreg Puckers/Pimples

a. Place the prepreg material to be examined for puckers and pimples in an environment between 60 and 80 °F and a Relative Humidity of 45 to 55%.

b. Cut approximately 5 lineal feet sample.

c. Let the test prepreg sample, with carrier release paper on the prepreg sample, lay with the prepreg side up on a flat surface for 30 minutes exposed to the ambient air.

d. Visually inspect 1 square foot of the prepreg sample for puckers and pimples.

e. Section 3.2.1.i specifies the accept/reject criteria for puckers and pimples.

4.4.8 Infrared Spectroscopy (IR)

a. Perform the infrared spectroscopy in accordance with ASTM E1252 and ASTM E168.

b. Review and submit the IR spectra. The spectra should be compared with the spectra obtained during the qualification process to detect any contaminants or significant changes in the formulation.

4.4.9 High Performance Liquid Chromatography (HPLC)

a. Perform the HPLC in accordance with SACMA SRM 20R-94.

b. Review and submit the HPLC chromatographs. The chromatographs should be compared with the chromatographs obtained during the qualification to assure that correct resolution of peaks was achieved and to detect any contaminants or significant changes in formulation.

4.4.10 Differential Scanning Calorimetry (DSC)

a. Perform the DSC, specifically the onset and peak temperatures, in accordance with SACMA SRM 25R-94.

b. Submit the thermographs for reference.

c. Report the individual and average prepreg onset and peak temperatures.

4.4.11 Cured Ply Thickness Test

a. Using a 1/4 inch diameter hemispherical anvil and spindle micrometer, measure the panel thickness a minimum of 10 determinations for each mechanical test panel. Test panel thickness measurements shall be performed 1 inch from the laminate edge.

b. The cured ply thickness shall be the average of the test panel thickness determinations uniformly distributed over the laminate surface and divided by the number of plies in the laminate.

c. Record the individual values and the average.

d. The average value shall meet the requirements of Table 4.

4.4.12 Laminate Density Test

a. Perform the laminate density in accordance with ASTM D792 Method A. Specimens shall be machined from every mechanical test panel.

b. Calculate the density as follows:

$$\rho_c = \rho_L * \left(\frac{W_1}{W_1 - W_2} \right) \quad \text{(Eq. 1)}$$

where:

ρ_c = Laminate density, g/cc
ρ_L = density of ethanol or water, g/cc
W_1 = weight of sample in air, g
W_2 = weight of sample in ethanol or water, g

4.4.13 Fiber Volume/Resin Content Test

a. Perform the fiber volume and resin content in accordance with ASTM D3171. Specimens shall be machined from every mechanical test panel.

b. Calculate the fiber volume and resin content as follows:

$$V_F = \rho_c * \left(\frac{W_{CF}}{\rho_f} \right) \quad \text{(Eq. 2)}$$

where:

V_F = Calculated fiber volume
% ρ_c = Laminate density
g/cc W_{CF} = Fibrous carbon fiber residue by acid digestion
% ρ_f = Nominal carbon fiber density, g/cc

$$V_R = \rho_c * \left(\frac{100 - W_{CF}}{\rho_r} \right) \quad \text{(Eq. 3)}$$

where:

V_R = Calculated resin content
% ρ_c = Laminate density, g/cc
W_{CF} = Fibrous carbon fiber residue by acid digestion
% ρ_r = Nominal cured resin density, g/cc

4.4.14 Void Content Test

a. Perform the void content in accordance with ASTM D2734. Specimens shall be machined from every mechanical test panel.

b. Calculate the void content as follows:

$$V_V = 100 - \left[\rho_C * \left(\frac{100 - W_{CF}}{\rho_R} + \frac{W_{CF}}{\rho_F} \right) \right] \quad \text{(Eq. 4)}$$

where:

V_V = Void content
% ρ_c = Laminate density
g/cc W_{CF} = Fibrous carbon fiber residue by acid digestion
% ρ_f = Nominal carbon fiber density
g/cc ρ_r = Nominal cured resin density, g/cc

4.4.15 Glass Transition Temperature Test

a. Perform glass transition temperature (Tg) measurements in accordance with SACMA SRM 18R- 94.

b. Test three specimens per batch of prepreg material.

c. Record the values of individual specimens and their average.

d. The test results shall meet the requirements of Table 4.

4.4.16 Lamina Mechanical Property Tests

a. For qualification testing, the number of test specimens for each lamina test property shall be in accordance with DOT/FAA/AR-03/19 or test plan.

b. Mechanical property testing shall be performed using test machines certified to ASTM E4.

c. Test specimens shall be machined to ±1 degree of the fiber test direction.

d. Specimens to be tested in the “dry”, as fabricated condition should be exposed to temperature range of 65 to 75 °F until testing.

e. Mechanical property calculations shall be normalized in the same manner as the qualification data per DOT/FAA/AR-03/19 to the cured ply thickness shown in Table 4, before checking for compliance to the requirements of Table 5.

4.4.16.1 Tension Tests

a. Fabricate tension test panel in accordance with 4.5.

b. Tab, machine and test the tension specimens in accordance with ASTM D3039. Tabs shall be bonded using one ply of Hysol EA9628 or equivalent adhesive capable of preventing tab delamination failure prior to coupon failure.

c. Test 5 specimens per batch for material acceptance testing.

d. Record the values of individual specimens, their average and standard deviation.

e. Test values shall meet the requirements specified in Table 5.

4.4.16.2 Compression Strength Test

a. Fabricate compression strength test panel in accordance with 4.5.

b. Tabs shall be fabricated from the same prepreg material covered by this specification, with the 0-degree direction in the longitudinal direction of the test specimens. Tabs shall be of nine plies of prepreg material.

c. Tab, machine and test the compressive strength specimens in accordance with SACMA SRM 1R- 94. Tabs shall be bonded using one ply of Hysol EA9628 or equivalent.

d. Test 5 specimens per batch for material acceptance testing.

e. Record the values of individual specimens, their average and standard deviation.

f. Test values shall meet the requirements specified in Table 5.