AEROSPACE MATERIAL SPECIFICATION

AMS3915	REV. A

Issued 2013-02
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Superseding AMS3915

(R) Advanced Composites Prepreg – Nominal 250 °F Cure – Glass Fiber and Epoxy Resin, 7781 Weave Fabric

RATIONALE

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

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TO PLACE A DOCUMENT ORDER: **Tel: 877-606-7323 (inside USA and Canada)**
Tel: +1 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
SAE WEB ADDRESS: **http://www.sae.org**

SAE values your input. To provide feedback on this Technical Report, please visit
http://www.sae.org/technical/standards/AMS3915A

1. SCOPE

1.1 Form

This specification establishes the requirements for a nominal 250 °F cure epoxy preimpregnated 7781 glass fabric. The prepreg has a nominal fiber areal weight of 294 gsm, and nominal resin content of 38%.

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 Volume II.

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.

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.

AMS-C-9084 Cloth, Glass, Finished, for Resin Laminates

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

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 D792 Density and Specific Gravity (Relative Density) of Plastics by Displacement

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

ASTM D2734 Void Content of Reinforced Plastics

ASTM D3039 Tensile Properties of Polymeric Matrix Composite Materials

ASTM D3171 Constituent Content of Composite Materials

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 E4 Practices for Force Verification of Testing Machines

ASTM E1252 Standard Practice for Obtaining Infrared Spectra for Qualitative 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 (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)

2.4 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 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.

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 setup with warp and fill yarns meeting the requirements of AMS-C-9084 with traceability to individual yarn lots and coated with the fiber finish that is specified.

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

FIBER (YARN) LOT – Glass 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 degrees.

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 glass 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, glass fiber 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 glass fiber fabric 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.

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 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.

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 degree.

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 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.

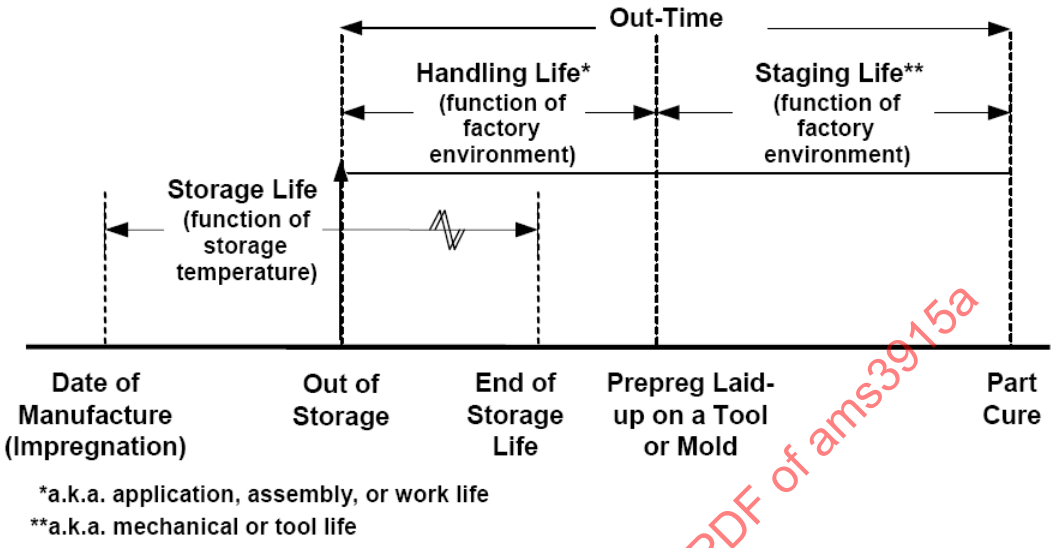


Figure 1 – Definitions of storage, handling, and staging life and out-time
From DOT/FAA/AR-06/10, "Guidelines and Recommended Criteria for the Development of a Material Specification for Carbon Fiber/Epoxy Fabric Prepregs"

3. TECHNICAL REQUIREMENTS

3.1 Composition

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 shall 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 the product shall be controlled by the PCD and evaluated during material qualification.

3.1.2 Glass 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 finish weight percent.

a. The glass fiber reinforcement shall be an approved constituent of the qualified prepreg material.

b. The fiber finish shall be considered as an integral part of the glass fiber.

c. The product quality shall be controlled by the PCD and evaluated during material qualification.

d. The glass fiber shall meet the requirements of AMS-C-9084, Type VIIIB, Class 2.

3.2 Quality

3.2.1 Visual Defect Limitations and Dimensional Requirements

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 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 carrier material 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 0.8 inches in any direction.

    3. The accumulated area of the fuzz shall not exceed 3 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. Dimension – The measured width of the prepreg material without selvage shall be 38 inches ± 1 wide. Selvage edge shall not exceed 1.5 inches. Selvage edge shall not be thicker than the body of the fabric prepreg.

e. The fibers shall be completely and uniformly coated with resin matrix.

f. The warp and fill yarns shall be perpendicular to each other and parallel to the warp and fill directions of the preimpregnated cloth within 1.5 inches in any 19 inches of the cloth width or length or 3.0 inches over the full width (38 inches) of the cloth.

g. The preimpregnated fabric shall be free from wrinkles, smashes, fabric splices, hard spots and curled or folded selvages that overlap non-selvage areas.

h. Materials not conforming to the requirements of 3.2.1 may be supplied only if marked and corrected in accordance with 3.2.2.

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

a. 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.

b. 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 material, and removable without damaging the prepreg material.

c. For single-point defects, use a single marker.

d. 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.

e. Each crease, cut, tear, smash, fabric splice, and weave separation shall be marked. Fabric weaving defects shall be remarked after impregnation only if the fabric quality requirements of 3.2.1 are not met.

f. Prepreg may be cut and spliced to remove defects. Prepreg splicing shall be in accordance with splicing procedure documented in the Process Control Document (PCD).

g. 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.

h. 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.

i. The type, location, and length (for a continuous defect) 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.

j. Defective areas shall not be counted toward the amount purchased.

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, initial material acceptance of the prepreg material, and shelf life at 10 °F or below.

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.

d. 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 1, and supplier material acceptance testing of Table 2 and 3.

3.2.4 Uncured Prepreg Physical and Chemical Properties

The prepreg material shall conform to the requirements of Table 1 when tested in accordance with the designated methods.

Table 1 – Uncured prepreg physical and chemical properties

Prepreg Physical/Chemical Properties		Requirements		Test Method Section
Resin Content, percent by weight **FL1 FL3**		38.0 ± 3.0		4.4.1
Glass Fiber Areal Weight, g/m2 **FL1 FL3**		294 ± 18		4.4.1
Volatile Content, percent by weight **FL1**		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
Infrared Spectroscopy (IR) **FL1**		Report		4.4.5
Tack, Tack Level		Report		4.4.6
Drape, Angle		Report		4.4.7
		Method I	Method II	
High Performance Liquid	P1	6.68 ~ 12.2 %	5.68 ~ 11.2%	
Chromatography (HPLC) **FL1 FL3**	P2	7.88 ~ 9.32 %	6.68~8.13 %	
(P1-P5 retention times as defined	P3	4.75 ~ 7.61 %	4.52~7.40 %	4.4.8
in the PCD)	P4	57.2 ~ 65.0 %	59.2~67.0 %	
	P5	12.8 ~ 16.6 %	13.3~17.0 %	
Differential Scanning Calorimetry (DSC)		Report		4.4.9

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

3.3 Composite (Cured Prepreg) Requirements

The cured lamina shall conform to the requirements of Tables 2 and 3 when tested in accordance with the designated test methods.

Table 2 – Cured lamina physical properties

Lamina Physical Properties	Requirements	Test Method Section
Cured Ply Thickness, inch **FL1 FL2 FL3**	0.0104 ± 0.0011	4.4.10
Laminate Density, g/cc	Report	4.4.11
Fiber Volume, percent by volume	Report	4.4.12
Resin Content, percent by volume	Report	4.4.12
Void Content, percent by volume	Report	4.4.13
Glass Transition Temperature (Tg), °F		4.4.14
70 °F ± 5 / 50 ± 5 % RH	272 to 308	
145 °F ± 5 / equilibrium at 85 ± 5 % RH	243 to 279	

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

Table 3 - 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 ± 5	Ave.	Std. Dev.	Min. Ave.	Min. Ind.	Specification Limit Indiv. Value	Test Method Section
0 degree Tension, Ult. Str. *	ksi	70/50	70	64.1	2.19	61.6	57.4		4.4.15.1
0 degree Tension, Modulus *	Msi	70/50	70	3.42	0.03			3.32 to 3.56	4.4.15.1
90 degree Tension, Ult. Str. **	ksi	70/50	70 **FL1 FL2& FL3**	50.4	2.21	47.9	43.6		4.4.15.1
90 degree Tension, Modulus **	Msi	70/50	70 **FL1 & FL3**	3.30	0.02			3.15 to 3.47	4.4.15.1
0 degree Compr., Ult. Str. *	ksi	70/50	70	76.2	4.14	71.5	63.5		4.4.15.2
0 degree Compr., Modulus *	Msi	70/50	70	3.82	0.08			3.40 to 4.28	4.4.15.3
90 degree Compr., Ult. Str. **	ksi	70/50	70 **FL1 FL2& FL3**	65.4	2.84	62.2	56.7		4.4.15.2
90 degree Compr., Modulus **	Msi	70/50	70	3.61	0.11			3.22 to 4.02	4.4.15.3
In-plane Shr., Ult. Str.	ksi	70/50	70 **FL4**	18.4	0.38	18.0	17.3		4.4.15.4
In-plane Shr., Mod.	Msi	70/50	70 **FL4**	0.63	0.05			0.43 to 0.83	4.4.15.4
0 degree Short Beam Strength *	ksi	70/50	70 **FL1 FL2FL 3 & FL4**	8.71	0.58	8.05	6.94		4.4.15.5

FL1 Required for supplier material acceptance testing.
FL2 Required for purchaser incoming material acceptance testing.
FL3 Key characteristic that requires SPC control.
FL4 Properties not normalized
* Warp
** Fill

3.4 Qualified Product/Materials List

3.4.1 Prepregs that qualify are placed on a Qualified Product or Material list maintained by the QPL publisher. To qualify, the product or material shall meet the tests specified in 3.1 through 3.3 performed in accordance with the provisions of 15.4.

3.4.2 Qualification shall be in accordance with the provisions of 3.4.4.

3.4.3 Recertification of qualification is required every 5 years. Recertification consists of a letter certifying that there have been no changes in the material ingredients, manufacturing processes or site of production since prepreg qualification (other than those already reviewed and approved by the QPL Agency) and that the product meets all of the requirements of this specification.

3.4.4 Qualification testing, review of test results, approval, re-approval and recertification of qualification for QPL listing shall be in accordance with PD2000 or equivalent and the instructions from the responsible QPL agency.

3.4.5 Prepreg furnished to this specification will be listed or approved for listing on the qualified products list (QPL) in accordance with the provisions of 15.4. Changes in product formulation raw material, basic methods of manufacturer, or plant site, for qualified prepreg, listed or approved for listing on the QPL are not permitted without first notifying the responsible QPL agency to assess the need for requalification and/or revision to the QPL.

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 1 through 3.

Initial material qualification shall be performed in accordance with the requirements described in DOT/FAA/AR-03/19, “Material Qualification and Equivalency for Polymer 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 QPL Agency (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 shall 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 three different resin batches and at least two different yarn lots of fabric.

4.1.1 Request for Initial Material Qualification

A request for qualification of the prepreg material shall be directed to the QPL Agency for this specification. The following documents shall be submitted to the QPL Agency for approval. It is recommended that actual qualification testing not start without the QPL Agency approval of the test plan and specifications. After successful qualification the composite material (fiber/resin combination) shall be listed in the PRI-QPL-AMS3915.

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, it 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

The manufacturer shall use ingredients, manufacturing procedures, and methods of inspection on production prepreg which are the same as those used on the qualification sample as controlled by the PCD. If it is necessary to make changes in ingredients, type of equipment for processing, or manufacturing procedures, the manufacturer shall submit a statement of the proposed changes for re-approval. When requested, a sample of the prepreg shall be submitted in accordance with the provisions of 3.4.4. Product manufactured using the revised procedure shall not be shipped prior to re-approval of qualification in writing.

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 or in the PCD). Processor equivalency is only applicable to the following types of changes (and as specified by the user or in the PCD).

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

4.2.1 Material 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. 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.

For material equivalency to be established, all critical prepreg constituent(s) and/or manufacturing processes (as defined by the user or in the PCD) must remain unchanged. Per DOT/FAA/AR-06/10, 5 levels of material and process changes are defined with the testing and notification requirements as follows:

Level 0 Change
Level 0 changes are those that do not affect the prepreg material. Examples are typographical or grammatical errors to the specification or PCD, changes to the names of incoming materials due to company name change, or use of an alternate storage facility with identical storage environments. No end-user notification is necessary for these changes.

Level 1 Change
Level 1 changes are considered minor changes which may require internal validation beyond normal batch acceptance testing on the same or similar materials, and were found to have no effect on the material. Examples of these types of changes may be a change in backing material or other in-process aids, alternate vendor for raw materials (2nd source) with adequate justification, or changes to packaging methods or materials. Notification to end-users is necessary, and approval by the Qualifying Agency is recommended when a change is expected to impact established production flow.

Level 2 Change
Level 2 changes are considered major by the Qualifying Agency, as these changes may potentially impact the material performance. These changes may be approved with less than full equivalency testing. These changes will require that the material supplier conduct tests to an extent that establishes the requirements listed in the material and processing specifications will not change.

Typical examples of level 2 changes are:

- Change in feedstock or precursor to resin ingredients
- Change in feedstock or precursor to fiber ingredients
- Second source of chemically and physically similar raw materials that have not been shown to be chemical equivalents
- Changes to test methods that reduce variability
- Modifications to process equipment or processes that do not change KCs or KPPs
- Addition of new, but similar processing equipment

Using the material equivalency requirements contained in the specification, the equivalency criteria outlined in CMH-17, or the statistical procedures given in DOT/FAA/AR-03/19 may be used to verify that the data from the altered material is equivalent to the baseline database for the material.

A new revision letter for the applicable material specification or PCD should be used when this level or higher change is incorporated. Current end-users must be notified of these changes, and approval of the Qualifying Agency shall be obtained prior to incorporation.

Level 3 Change
These are major changes which are subjected to a full equivalency test program. Level 3 major changes are those that have the possibility of changing either the part processing characteristics or the cured lamina/laminate properties in such a way to cause a shift from the average values established for the material. The supplier should develop and deliver to the Qualifying Agency a test plan, a description of the change, and suggested modifications to the material and process specifications. Some end-users may request, with justification, tests beyond those of an equivalency trial.

Typical examples of level 3 changes are:

- Change in fiber manufacturing process
- Change in fiber size type, size level, finish, or coupling agents
- Change in resin chemical characteristics (e.g., non-equivalent resin ingredient)
- Change in viscosity of major resin components
- Change in manufacturing site for fiber, resin, or fabric-Introduction of alternate weaver using same fiber and weave
- Change in resin mixing, filming, or prepreg processing that impact KCs or KPPs
- Change in cure cycle (e.g., temperature, dwell time, or pressure)
- Change in nominal resin content (small, difference of less than 2% in resin content by weight)
- Change in nominal number of filaments per tow (small, difference of less than 200 filaments per tow)

Tests that validate level 3 changes should involve a minimum of one batch of prepreg. In addition, any other critical properties that are expected to be affected by the change should be included in the test plan.

Using the material equivalency requirements contained in the specification, the equivalency criteria outlined in CMH-17, or the statistical procedures given in DOT/FAA/AR-03/19 may be used to verify that the data from the altered material is equivalent to the baseline database for the material. If equivalency to the original data cannot be confirmed then the change will not be allowed and thus elevated to a Level 4 status.

A new revision letter for the applicable material specification or PCD should be used when the change is incorporated. Current end-users will be notified of these changes, and approval by the Qualifying Agency obtained prior to incorporation.

Level 4 Change
Level 4 is a major change, where equivalency tests will not suffice for links to a previous material characterization. Level 4 changes require a new product identification (new specification designation), and a new qualification test program. Level 3 or lower material changes that fail to demonstrate equivalency is typically considered level 4 changes. Some changes will be considered level 4 changes regardless of the results of equivalency results, due their significant potential effect on material properties or on part fabrication processing.

Typical examples of level 4 changes are:

- Fundamental change in resin composition
- Change in nominal resin content (large, difference of 3% or more in resin content by weight)
- Change in nominal number of filaments per tow (e.g., 12K filaments per tow to 3K)
- Change in nominal fiber or fabric areal weight (e.g., 150 to 190 g/m^2), that significantly changes cured ply thickness
- Change in fiber type (e.g., T700 to T300)
- Change in type of fabric weave (e.g., plain weave to eight-harness satin)
- Addition of conductive tracers to the fabric (e.g., for lightning protection or other special purpose)

4.2.2 Processor Equivalency

Processor equivalency is only applicable to the following types of changes (and as specified by the user or in the PCD):

a. Laminates fabricated by using an identical fabrication process at a different location.

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

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

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 or in the PCD. If applicable, the processor must meet the applicable CFR requirements including, but not limited to: 14 CFR §23.603 (a) and (b) 14 CFR §23.605 (a) and (b). If processor equivalency cannot be established then a new qualification will be required.

For example, the following are types 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 QPL Agency. 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, 6.1.

4.3 Production 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 1, 2 and 3.

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

4.3.1 Statistical Process Control

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

a. Key characteristics are specified in Tables 1, 2 and 3.

b. The process for selecting and documenting KPPs 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 KPPs and shall document the KPPs in the Process Control Document (PCD).

b. KPP's 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 KCs and KPPs.

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 Reduced Testing

a. 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 QPL Agency shall be required and documented in the QPL.

4.3.2 Product Certification

4.3.2.1 Certification Testing

The prepreg manufacturer's Test Laboratories (or outside lab acceptable to the manufacturer and the purchaser) shall perform tests on each batch of prepreg material as specified by flagnotes in Tables 1, 2 and 3. 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 the start and end of the prepreg batch.

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

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 2.

c. Cured Lamina Mechanical Properties - Each prepreg batch shall be tested to verify compliance with the requirements of Table 3, 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. All required individual and averaged test 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 attached to the roll container.

e. IR spectrographs shall be included in the report.

f. HPLC chromatographs shall be included in the report.

g. A copy of the glass fabric lot certification to the requirements of AMS-C-9084, if requested on the purchase order.

h. A statement that the material meets all the requirements of this specification.

4.3.2.3 Records

a. All records that pertain to the data published in CMH-17 for the candidate material shall be kept on permanent file by the QPL Agency or their designee.

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

1. Full prepreg batch traceability. The traceability shall include the mix resin and resin component batches, and glass fiber yarn and weave 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 an 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, chemical, and mechanical properties as specified by flag notes in Tables 1, 2 and 3. 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) 90 degrees (fill) Tension, Strength at 70 °F ± 10, dry condition (5 specimens per prepreg batch)

(c) 90 degrees (fill) Compression, Strength at 70 °F ± 10, dry condition (5 specimens per prepreg batch)

(d) 0 degrees (warp) Short Beam Shear at 70 °F ± 10, 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 Tables 1, 2 or 3 shall be rejected subject to the retest condition specified in 4.4.14.

d. Purchaser Quality Assurance shall verify that each shipment of prepreg material meets the requirements for shipping and storage temperature per 5.2.6 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 (a), 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, the QPL Agency, or an authorized representative of the material purchasers. 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 a 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 material 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 70 °F ± 10.

e. Any retest of suspect data shall be subjected to the requirement specified in 4.4.16.

4.4.1 Resin Content and Fiber Areal Weight

a. Cut 3 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 or Methylene Chloride.

d. Test in accordance with SACMA SRM 23R-94, Method A or ASTM D3529.

e. Record results of the individual specimens and their average. Test values shall meet the requirements of Table 1.

4.4.2 Volatile Content

a. Cut 3 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 1.

4.4.3 Gel Time

a. Perform the gel time on 3 specimens in accordance with ASTM D3532.

b. Record results of the individual specimens and their average. Test values shall meet the requirements of Table 1.

4.4.4 Resin Flow

a. Perform the resin flow on 3 specimens in accordance with SACMA SRM 22R-94 or ASTM D3531.

b. Record results of the individual specimens and their average. Test values shall meet the requirements of Table 1.

4.4.5 Infrared Spectroscopy (IR)

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

Extract resin from a 0.30 g (nominal) sample of prepreg with 5 ml (nominal) of spectrophotometric grade acetone at room temperature.

Place a few drops of this solution on a salt plate or equivalent material. Allow the acetone to evaporate.

Obtain spectra from a least two spots on the salt plate/window. Specimen rotation may be used to meet this requirement. An acceptable spectrum while in transmission has the strongest absorbing peak between 10 to 30%; an acceptable spectrum while in absorbance mode has the strongest absorbing peak between 0.5 to 1.0 absorbance units. Adjust film thickness by re-applying wet resin solution until dry film thickness provides an acceptable spectrum.

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.

4.4.6 Tack

a. Tack shall be determined at 72 °F ± 5 (22.2 °C ± 2.8) and 65% maximum relative humidity.

b. Cut two 3 x 1 inch (76.2 x 25.4 mm) specimens from the prepreg. The 3 inch (76.2 mm) dimension shall be in the 0 degree or warp direction.

c. Attach one specimen to the 2D finish steel plate with light pressure using a squeegee or roller.

d. Remove carrier material and apply the second specimen directly to the first. Apply light pressure using a squeegee or roller. Remove carrier material from second specimen.

e. Position plate vertically and observe prepreg behavior to determine the appropriate tack level.

f. Tack levels are as follows:

Tack Level 1: No tack to tool and low tack to self.

Tack Level 2: Low tack to tool and self.

Tack Level 3: Slight tack to tool, acceptable tack to self. Adheres to tool for less than 30 minutes.

Tack Level 4: Acceptable tack to tool, good tack to self. Adheres to tool for more than 30 minutes.

Tack Level 5: High level of tack, sticks to gloves with no resin transfer.

Tack Level 6: High level of tack, sticks to gloves with residual resin transfer

g. Report Tack Level

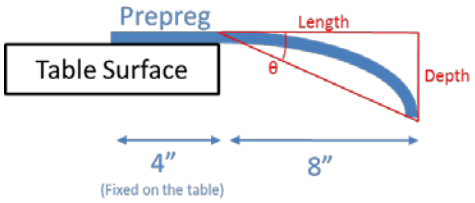
4.4.7 Drape

a. Drape shall be determined at 72 °F ± 5 (22.2 °C ± 2.8) and 65% maximum relative humidity.

b. Cut three 12 x 1 inch (305 x 25.4 mm) specimens with the 0 degree or warp in the 12 inch (305 mm) dimension.

c. Remove carrier material and fixture in place 4 inches (102 mm) of the material on a flat table, allowing the rest of the material to hang off the table. Wait 5 minutes before making drape determination.

d. Using a framing square, measure the amount of vertical sag and horizontal length of the specimen.



e. Calculate the drape angle using the following formula:

$$\text{Drape Angle} = \tan^{-1}\left(\frac{\text{Depth}}{\text{Length}}\right)$$

f. Report Drape Angle, in degrees.

4.4.8 High Performance Liquid Chromatography (HPLC)

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

a. Sample Analysis

Sample Preparation:

Place approximately 30 mg of prepreg into approximately 10 ml of HPLC grade or similar purity acetonitrile (CH3CN) and agitate for approximately 15 minutes. Filter through a 0.45 micron Teflon filter.

b. Operating Parameters:

Perform the test in accordance with the parameters for Method I or Method II:

1. Method I

Column:Waters micro-Bondpak C18 or equivalent

Column length, 30 cm

Packing Material, 10 microns

Flow Rate: 1.5 ml/min

Mobile Phase: Reservoir A: HPLC grade or equivalent CH3CN

Reservoir B: premix a ratio of 1:1 of HPLC grade or equivalent

CH3CN and HPLC grade or equivalent H20

Injection Volume: 15 microliters

Detection: UV 230 nm

Attenuation: 0.2 AUFS

Time, Minutes	Gradient Program Reservoir A Percent by Volume	Reservoir B Percent by Volume
0	0	100
18	0	100
20	60[a]	40
27	60[a]	40
29	0	100
35	0	100

2. Method II

Column:Symmetry C18 3.5µm or equivalent

Column Temperature, 30 °C

Column length, 150 mm

Packing Material, 3.5 microns

Flow Rate: 1.8 ml/min

Mobile Phase: Reservoir A: HPLC grade or equivalent CH_3CN

Reservoir B: HPLC grade or equivalent H_2O

Injection Volume: 10 microliters

Detection: UV 230 nm

Time, Minutes	Gradient Program Reservoir A Percent by Volume	Reservoir B Percent by Volume
0.00	46.0	54.0
10.00	46.0	54.0
10.50	55.0	45.0
13.00	55.0	45.0
13.50	100.0	0
14.00	100.0	0
14.50	46.0	54.0
16.00[b]	46.0	54.0

3. A next injection delay of 2 minutes is used to ensure full re-equilibration of the mobile phase at 46% Acetonitrile: 54% Water

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.

4.4.9 Differential Scanning Calorimetry (DSC)

a. Perform the DSC, specifically the onset and peak temperatures, in accordance with SACMA SRM 25R-94 or ASTM E2160.

b. Submit the thermographs for reference.

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

4.4.10 Cured Ply Thickness Test

a. Using a ¼ 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 at least 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 2.

4.4.11 Laminate Density Test

a. Perform the laminate density in accordance with ASTM D792 Method B (using ethanol). At least 3 specimens shall be machined and tested from every mechanical test panel.

b. Calculate the density as follows:

$$\rho_c = \rho_L * \left(\frac{W_1}{W_1 - W_2} \right)$$

where:

ρc = Laminate density, g/cc

ρL = density of ethanol or water, g/cc

W1 = weight of sample in air, g

W2 = weight of sample in ethanol or water, g

c. Record the individual values and the average.

4.4.12 Fiber Volume/Resin Content Test

a. Perform the fiber volume and resin content in accordance with ASTM D3171. At least three specimens shall be machined and tested from every mechanical test panel.

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

$$V_F = \rho_c * \left(\frac{W_{CF}}{\rho_f} \right)$$

where:

V_F = Calculated fiber volume, %

ρ_c = Laminate density, g/cc

W_{CF} = fibrous glass fiber residue by acid digestion, %

ρ_f = Nominal glass fiber density, g/cc

$$V_R = \rho_c * \left(\frac{100 - W_{CF}}{\rho_r} \right)$$

where:

VR = Calculated resin content, %

ρc = Laminate density, g/cc

WCF = fibrous glass fiber residue by acid digestion, %

ρr = Nominal cured resin density, g/cc

c. Record the individual values and the average.

4.4.13 Void Content Test

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

b. Calculate the void content as follows:

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

where:

VV = Void content, %

ρC = Laminate density, g/cc

WCF = fibrous glass fiber residue by acid digestion, %

ρF = Nominal fiber density, g/cc

ρR = Nominal cured resin density, g/cc

4.4.14 Glass Transition Temperature Test

a Perform glass transition temperature (Tg) measurements in accordance with SACMA SRM 18R- 94 or ASTM D7028, with laminate T_G (dry) specimens omitting the bone drying procedure and replacing with conditioning at 72 °F ± 5 and ambient RH for a minimum of 40 hours prior to test.

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 2.

4.4.15 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 the 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 shall be exposed to temperature range of 70 °F ± 10 until testing.

e. Tensile and compressive properties shall be normalized by the following equation, per DOT/FAA/AR-03/19 using the nominal cured ply thickness in Table 3, before checking for compliance to the requirements of Table 4.

$$Normalized\ Value = Test\ Value\ x\ \frac{CPT_{Specimen}}{CPT_{Nominal}}$$

4.4.15.1 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. In the event of a dispute, the adhesive used during the initial qualification shall be used.

c. Test 5 specimens per batch for strength and/or modulus 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 3.

4.4.15.2 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 12 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 adhesive or equivalent. In the event of a dispute, the adhesive used during the initial qualification shall be used.

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

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