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NCAMP Material Specification

*This specification is generated and maintained in accordance with NCAMP  
Standard Operating Procedures, NSP 100*

High Toughness and High Tensile Performance Epoxy Prepregs

Toray Composite Materials America, Inc. 3960

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**Distribution Statement A.** Approved for public release; distribution is unlimited.

**REVISIONS**

Rev	By	Date	Description
-	Vinsensius Tanoto and Royal Lovingfoss	3/30/2020	Initial Release
A	Vinsensius Tanoto and Royal Lovingfoss	3/3/2025	<p>All Sections: Editorial changes.</p> <p>All Sections: Replaced “shall” with “must”.</p> <p>Cover Page: Removed “Jeremiah (Jeb) Robbins (Toray)”</p> <p>Section 1.2: “allowables are available publicly” was revised to “allowables are available”</p> <p>Section 1.8: Revised and “A list of material users” was removed.</p> <p>Section 2.2: Removed ASTM D3418 and added ASTM E1356.</p> <p>Section 2.5: Added DOT/FAA/TC-15/28.</p> <p>Section 3.2.1: “No more than one resin batch must be included in any single prepreg batch unless allowed by process control document.” was revised with “One or more resin batch is allowed in one prepreg batch.”</p> <p>Section 3.3: Table 1, DSC is revised to Tg only. DSC test method was revised from ASTM D3418 to ASTM E1356. Added UHPLC. Additional clarification was added.</p> <p>Section 3.3.3: Drape requirement was removed.</p> <p>Section 3.4.1.2 and 3.4.1.3: Un-wetted and fuzz balls requirements are moved to this section from Section 3.4.2.</p> <p>Section 3.4.1.2 (b): (including the fringe of fabric prepreg) was removed.</p> <p>Section 3.4.1.3 (b): fuzz ball requirements were revised.</p> <p>Section 3.4.2: Additional information and clarification were added for multiple product forms.</p> <p>Section 3.4.2.3.3: Additional information was added.</p> <p>Section 3.4.3: Clarification and new specifications were added for multiple product forms.</p> <p>Section 3.4.3 (e): Revised to “Form 5”.</p> <p>Section 3.4.4: Clarification and new specifications were added for multiple product</p>

			<p>forms.</p> <p>Section 3.5.2: Table 3 was revised to add clarity on DMA testing and Drying information. A clarification was added to Toray's DMA procedure and CPT.</p> <p>Section 3.5.3: Typo was corrected.</p> <p>Section 3.6.2.1.1: "unverified" was removed, storage life was revised from 24 months to 36 months.</p> <p>Section 3.6.2.1.3: "unverified" was removed.</p> <p>Section 3.6.2.2: "unverified" was removed.</p> <p>Section 3.6.2.3: "unverified" was removed.</p> <p>Section 4.1: "Compression After Impact" was removed.</p> <p>Section 4.4.1.3: Clarification was added for Form 1, Form 2, Form 3, Form 4, and Form 5.</p> <p>Section 4.4.2: Clarification was added to (h), (j), (l), and (m) was added. Class 1 – Form 2 and Class 2 – Form 5 were added to (m).</p> <p>Section 4.5.2: "Compression After Impact" was removed.</p> <p>Section 4.6.2: Drape test procedure was revised.</p> <p>Section 5.1.3: "or equivalent" was added.</p> <p>Section 5.1.7: Duplicated information with 5.1.2 therefore this section was removed.</p> <p>Section 5.2.1: Temperature was revised from 0°F to 10°F.</p> <p>Section 5.2.2: This section was removed.</p> <p>Section 5.2.3: Clarification was added.</p> <p>Section 5.3.1: Temperature was revised from 0°F to 10°F.</p> <p>Section 5.3.2: This section was removed.</p> <p>Section 9: Revisions was moved to after cover page.</p>
A	Vinsensius Tanoto and Royal Lovingfoss	9/10/2025	<p>Cover Page: Distribution statement was revised from "This document is intended for proprietary use and will be distributed at the discretion of Toray Composite Materials America until such a time that it is decided the data and reports can be released for public distribution." to "Distribution Statement A. Approved for public release; distribution is unlimited."</p> <p>This is approved by Toray CMA.</p>

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## 1. SCOPE:

### 1.1 Form:

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

### 1.2 Application:

These composite prepreg material systems are intended for use in the fabrication of aerospace structures and tooling substrate. The materials are designed specifically for vacuum-bag autoclave cure in accordance with NPS 83961 baseline cure cycle “C”. They are typically used in structural applications requiring high strength and stiffness in environments up to 250°F.

Material property data including statistically based material allowables are available for the materials covered by this specification. Part fabricators that wish to utilize the material property data, allowables, and specifications may be able to do so by demonstrating the capability to reproduce the original material properties; a process known as equivalency. More information about this equivalency process including the test statistics and its limitations can be found in Section 6 of DOT/FAA/AR-03/19 and Section 8.4.1 of CMH-17-1G.

This specification is developed based on the material properties that are available publicly. The purchaser may specify additional requirements beyond those specified in this specification, especially when the purchaser has generated additional material properties beyond those available publicly or when the application requires other requirements. The additional requirements are subject to supplier review and approval.

The use of this specification does not guarantee material or structural performance. Material users should be actively involved in evaluating material performance and quality including, but not limited to, performing regular purchaser quality control tests, performing periodic equivalency/additional testing, participating in material change management activities, conducting statistical process control, and conducting regular supplier audits.

### 1.3 Classification: Each detail specification has a unique classification. Example specification callout is provided in the qualified products list of every detail specification. Prepregs must be classified to the following Types, Classes, and Grades or Styles:

- 1.3.1 Type must specify nominal prepreg resin content. For example,  
Type 33.5 – Nominal resin content 33.5 percent by weight  
Type 35 – Nominal resin content 35 percent by weight

- 1.3.2 Class must specify prepreg product general classification. For example,  
Class 1 – Unidirectional carbon fiber prepreg tape  
Class 2 – Woven carbon fiber fabric prepreg

- 1.3.3 Form must specify prepreg specific product form. For example,  
Form 1 – Unidirectional carbon fiber prepreg tape (Hand Layup Applications)  
Form 2 – Unidirectional carbon fiber prepreg tape (Automated Tape Laying Equipment)  
Form 3 – Unidirectional carbon fiber prepreg tape (Automated Fiber Placement)  
Form 4 – Woven carbon fiber fabric prepreg (Hand Layup Applications)  
Form 5 – Woven carbon fiber fabric prepreg (Automated Tape Laying Equipment)
- 1.3.4 Grade must specify nominal fiber areal weight in grams per square meter (gsm). For example,  
Grade 192 – 192 gsm nominal fiber areal weight  
Grade 196 – 196 gsm nominal fiber areal weight  
Grade 370 – 370 gsm nominal fiber areal weight
- 1.3.5 Style must specify the woven fabric style (not applicable to Class 1). For example,  
Style 12K-PW – 3K yarn, plain weave  
Style 3K-8HS – 3K yarn, 8 harness satin weave

#### **1.4 Safety – Hazardous Materials:**

While the materials, methods, applications, and processes described or referenced in this specification may involve the use of hazardous materials, this specification does not address all the hazards which may be involved in such use. It is the sole responsibility of the user to ensure familiarity with the safe and proper use of any hazardous materials and to take necessary precautionary measures to ensure the health and safety of all personnel involved.

#### **1.5 Rounding of Values:**

The following applies to all specified limits or requirements in this specification. For purposes of determining conformance with this specification, an observed value or a calculated value must be rounded “to the nearest unit” in the last right-hand digit used in expressing the specification limit, in accordance with the rounding method of ASTM E29.

#### **1.6 Qualified Products:**

This specification requires qualified products. Qualified products are listed in the Qualified Products List (QPL) of each detail specification. In accordance with the requirements of this specification, the specific fiber material and source(s), weaver(s), and the specific resin components and source(s) must be qualified as a prepreg material system. Any other combinations not listed on the QPL of the detail specification are not qualified. In addition, the production of the qualified products is controlled by an NCAMP approved process control document (PCD) as specified in 3.11.

#### **1.7 Detail Specification:**

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

superseding properties and requirements that apply to a specific product.

## 1.8 Change Control Approval:

Prepreg product must be produced in accordance with an NCAMP approved Process Control Document (PCD). Formal change notification and approval is required before a change may be implemented. In general, level 1 through level 3 changes per DOT/FAA/AR-06/10 and DOT/FAA/AR-07/3 are considered major changes. NCAMP approval is required for major changes, and is granted through Advance Change Notices (ACN). Prior to implementing a major change, the material supplier must contact NCAMP with the following information:

- a. A detailed description of the change,
- b. A draft test plan to substantiate that the change will not affect the prepreg material properties, and

In general, DOT/FAA/AR-06/10 and DOT/FAA/AR-07/3 will be used as guidelines.

## 2. APPLICABLE DOCUMENTS

The latest issue of the NCAMP publications must apply. The applicable issue of other publications must be the issue in effect on the date of the purchase order unless otherwise specified. When a referenced document has been canceled and no superseding document has been specified, the last published issue of that document must apply.

### 2.1 NCAMP Publications:

NMS 818	Carbon Fiber Tow
NPS 83961	NCAMP Process Specification, Fabrication of NMS 397 Qualification, Equivalency, and Acceptance Test Panels
NRP 101	Prepreg Process Control Document (PCD) Preparation and Maintenance Guide

### 2.2 ASTM Publications (available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959, <http://www.astm.org>)

ASTM D2344	Standard Test Method for Short-Beam Strength of Polymer Matrix Composite Materials and Their Laminates
ASTM D3039	Tensile Properties of Polymeric Matrix Composite Materials
ASTM D3529/D3529M	Standard Test Method for Matrix Solids Content and Matrix Content of Composite Prepreg
ASTM D3530/D3530M	Standard Test Method for Volatiles Content of Composite Material Prepreg
ASTM D3531	Standard Test Method for Resin Flow of Carbon Fiber-Epoxy Prepreg
ASTM D3532	Standard Test Method for Gel Time of Carbon Fiber-Epoxy Prepreg
ASTM D3776	Standard Test Methods for Mass Per Unit Area (Weight) of

	Fabric
ASTM D3878	Standard Terminology Composite Materials
ASTM D6641	Standard Test Method for Determining the Compressive Properties of Polymer Matrix Composite Laminates Using a Combined Loading Compression (CLC) Test Fixture
ASTM D5279	Standard Test Method for Plastics: Dynamic Mechanical Properties: In Torsion
ASTM D7028	Standard Test Method for Glass Transition Temperature (DMA Tg) of Polymer Matrix Composites by Dynamic Mechanical Analysis (DMA)
ASTM E29	Using Significant Digits in Test Data to Determine Conformance with Specifications
ASTM E168	General Techniques of Infrared Quantitative Analysis
ASTM E1252	Standard Practice for General Techniques for Obtaining Infrared Spectra for Qualitative Analysis
ASTM E1356	Standard Test Method for Assignment of the Glass Transition Temperatures by Differential Scanning Calorimetry

**2.3 ISO Publications:**

AS 9100                      Quality Management Systems

**2.4 SACMA Publications** (available from American Composites Manufacturers Association, 1010 N Glebe Rd., Suite 450, Arlington, VA 22201, <http://www.acmanet.org>):

SACMA SRM 10R-94	Calculation of Fiber Volume of Composite Test Laminates
SACMA SRM 23R-94	Resin Content and Fiber Areal Weight of Thermoset Prepreg with Destructive Technique
SACMA SRM 20R-94	High Performance Liquid Chromatography of Thermoset Resins

**2.5 US Government Publications:**

29 CFR 1910.1200	Hazard Communication, Occupational Safety and Health Standards
DOT/FAA/AR-03/19	Material Qualification and Equivalency for Polymer Matrix Composite Material Systems: Updated Procedure
DOT/FAA/AR-06/10	Guidelines and Recommended Criteria for the Development of a Material Specification for Carbon Fiber/Epoxy Fabric Prepregs
DOT/FAA/AR-07/3	Guidelines and Recommended Criteria for the Development of a Material Specification for Carbon Fiber/Epoxy Unidirectional Prepregs Update
DOT/FAA/TC-15/28	The Development of the Dynamic Mechanical Analyzer Calibration and Testing Procedures
MIL-D-3464	Desiccants, Activated, Bagged, Packaging Use and Static Dehumidification
MIL-PRF-131	Barrier Materials, Watervaporproof, Greaseproof, Flexible, Heat-Sealable
CMH-17	Composite Materials Handbook (formerly MIL-HDBK-17)



### **3. TECHNICAL REQUIREMENTS:**

#### **3.1 Detail Specification:**

The requirements for a specific fiber reinforced unidirectional tape and fabric epoxy prepreg product must consist of all requirements specified herein in addition to requirements specified in the applicable detail specification. In case of conflict between requirements of this basic specification and an applicable detail specification, requirements of the detail specification must govern.

#### **3.2 Constituent Material Requirements:**

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

##### **3.2.1 Epoxy Resin System:**

The resin system must be an epoxy-based resin that is capable of meeting the requirements of this specification; no separate specification exists for the resin system. Any changes to the epoxy resin system since qualification must be re-approved by NCAMP. One or more resin batch is allowed in one prepreg batch.

**3.2.2 Reinforcement:** The reinforcement requirements must be specified in the applicable detail specifications.

#### **3.3 Prepreg Physical and Chemical Property Requirements:**

##### **3.3.1 Uncured prepreg physical and chemical properties:**

The uncured prepreg material must meet the physical and chemical property requirements of Table 1 and as specified below. The material must be capable of being cut without disarray of the filaments and without other visible damage.

##### **3.3.2 Tack:**

The material must demonstrate acceptable tack when tested as specified in 4.6.1. Acceptable tack level(s) is defined in the applicable detail specifications.

Table 1 – Prepreg Physical and Chemical Properties

Property	Product Form	Test Method <sup>(1)</sup>	Number of Replicates <sup>(4)</sup>
Resin Content	Prepreg	ASTM D3529	Every master roll of every batch <sup>(2)</sup>
Fiber Areal Weight	Prepreg	ASTM D3529	Every master roll of every batch <sup>(2)</sup>
Volatile Content	Prepreg	ASTM D3530	First and last master roll of every batch <sup>(2)</sup>
Flow	Prepreg	ASTM D3531	First and last master roll of every batch <sup>(2)</sup>
Gel Time	Prepreg	ASTM D3532	First and last master roll of every batch <sup>(2)</sup>
Tack	Prepreg	See 4.6.1	First and last master roll of every batch
HPLC	Resin from Prepreg	SACMA SRM 20R-94	First and last master roll of a batch <sup>(3)</sup>
UHPLC	Resin from Prepreg	See 4.6.3	First and last master roll of a batch <sup>(3)</sup>
IR	Resin from Prepreg	ASTM E168 ASTM E1252	First and last master roll of a batch <sup>(3)</sup>
Differential Scanning Calorimetry (DSC), T <sub>g</sub>	Prepreg	ASTM E1356	First and last master roll of every batch <sup>(3)</sup>

<sup>(1)</sup> Specific procedures should be identical to those used in the original material qualification program.

<sup>(2)</sup> Three specimens should be taken across the width of the prepreg; left, center, right.

<sup>(3)</sup> One specimen from each designated location.

<sup>(4)</sup> If a batch only has one master roll, test once per master roll.

### 3.4 Visual and Dimensional Requirements:

#### 3.4.1 General:

The prepreg must be uniform in quality and must not contain defects detrimental to handling, layup, cure or structural properties.

3.4.1.1 The prepreg material must be free from foreign material, cut or broken fibers, cured resin, wrinkles, resin-rich areas, dry or boardy areas, and indications of moisture visible to the unaided eye.

3.4.1.2 Un-wetted fibers must be acceptable provided:

- Areas of un-wet fibers must be considered unacceptable if any point within the suspect area is greater than 1 mm from all fully wet fibers.
- The edge of the slit tape/prepreg must be free of un-wet fibers.
- Areas of partially wet fibers or resin rich areas must be considered

unacceptable if any point within the suspect area is greater than 4 mm from all fully wet fibers.

#### 3.4.1.3 Fuzz balls must be acceptable provided:

- a. The fuzz balls cause no apparent fiber distortion. This must be determined without removing the fuzz balls.
- b. Any fuzz ball must not exceed 1.5 inches in any direction.
- c. The accumulated number of fuzz balls, where the largest dimensioned fuzz ball is between 0.4 to 1.5 inches, shall not exceed 6 count in any 10 square feet of one side of the prepreg material.
- d. The overall thickness change due to fuzz ball is no more than 50 percent of the prepreg material nominal thickness.

#### 3.4.2 Visual Requirements:

##### 3.4.2.1 Class 1 - Form 1 Materials

3.4.2.1.1 The edge of the prepreg tape must not deviate from a straight line by more than 0.025 inch per foot of length and must be flush with the separator paper.

3.4.2.1.2 All fiber tows must be collimated and parallel, within 0.025 inch per foot of length, to the centerline of the material.

3.4.2.1.3 The length of fiber gap, parallel to the 0° direction, must not exceed 10 inches. The width of fiber gap, perpendicular to the 0° direction, must not exceed 0.030 inch. One gap 0.010 to 0.030 inch wide and not exceeding 10 inches long is acceptable in each 10 square feet of prepreg. Gaps less than 0.010 inch wide and not exceeding 10 inches long are acceptable.

3.4.2.1.4 The prepreg must be free from crimped fibers and fiber tow crossovers visible to the unaided eye.

3.4.2.1.5 The following specifies the acceptance/reject criteria for puckers and/or pimples in the unrolled condition.

TABLE 2 – Acceptance/Rejection Criteria for Puckers and/or Pimples

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

##### 3.4.2.2 Class 1 - Form 2 and Form 3 Materials

Prepreg material must be free of defects per Section 3.4.2.1.

### 3.4.2.3 Class 2 - Form 4 Materials

- 3.4.2.3.1 The prepreg material must be free from foreign material, cut or broken fibers, folded selvages that overlap nonselvage areas, cured resin, unwetted fibers, wrinkles, resin-rich areas, dry or boardy areas, and indications of moisture visible to the unaided eye.
- 3.4.2.3.2 The warp yarns must be parallel to the warp direction within 1.0 inch over any 21.0 inches.
- 3.4.2.3.3 The fill yarns must be perpendicular to the warp direction within 1.0 inch over any 21.0 inches.

### 3.4.2.4 Class 2 - Form 5 Materials

Prepreg material must be free of defects per Section 3.4.2.3.1.

### 3.4.3 Roll characteristics:

The total weight or length of material must be specified by the purchaser. Unless otherwise specified by the purchaser, individual roll net weight must not exceed 70 pounds and 115 lbs for Class 1 - Form 1 and Class 2 - Form 4 materials, respectively. Width must be as specified by the purchaser. Unless otherwise specified by the purchaser, tolerances on the width of the prepreg/material must be:

- a. Unidirectional tape (Class 1 - Form 1):  $\pm 0.250$  inch ( $\pm 6.4$  mm)
- b. Unidirectional tape (Class 1 - Form 2):  $\pm 0.020$  inch ( $\pm 0.5$  mm)
- c. Unidirectional tape (Class 1 - Form 3):  $\pm 0.005$  inch ( $\pm 0.13$  mm)
- d. Woven fabric (Class 2 - Form 4):  $\pm 1.000$  inch ( $\pm 25$  mm)
- e. Woven fabric (Class 2 - Form 5):  $\pm 0.040$  inch ( $\pm 1.0$  mm)

### 3.4.4 Material not conforming to the visible defect limitations and dimensional requirements:

- 3.4.4.1 In cases where foreign material or resin rich areas can be removed without causing any apparent deformation of the prepreg surface, they may be removed by spatula or adhesive tape. The spatula or adhesive tape must not transfer any contaminants to the prepreg product.
- 3.4.4.2 Prepreg material may be cut and spliced to remove defects. Prepreg splicing must be in accordance with splicing procedure documented in the PCD. One (1.0) linear foot of additional material must be supplied for each splice.
- 3.4.4.3 Class 1 - Form 1 and Class 2 - Form 4 Materials
  - 3.4.4.3.1 Areas not conforming to Section 3.4.1, 3.4.2, or 3.4.3 must be identified along the edge of the prepreg roll by markers. Markers must be distinguishable from the prepreg and carrier release paper and removable without damaging the prepreg material.

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

3.4.4.3.3 Successive single-point defects 3 feet or less apart must be considered as one continuous defect. For continuous defective areas, markers must be placed at the beginning, at each 2-foot maximum interval, and at the end of the continuous defect.

3.4.4.3.4 Minimum distance between defects and splices must be 15 feet (4.6 m).

3.4.4.3.5 The type, location, and length (for continuous defect) of each marked defect, and the location of the splices must be indicated on a defect log accompanying each roll of prepreg material. Defect and splice locations must be identified by markers on the prepreg roll edge.

3.4.4.3.6 Defective areas, considered as the length of the defect multiplied by the width of the roll, must not be counted toward the amount of material purchased.

3.4.4.4 Class 1 - Form 2 and Form 3, and Class 2 - Form 5 Materials

3.4.4.4.1 Prepreg material must be free of defects per Section 3.4.1 and 3.4.2.

3.4.4.4.2 Prepreg material splicing

- a. Maximum allowable splices for the rolls need to be according to the following formula, rounded to the nearest integer:

$$\# \text{ of Splices} = \frac{\text{total length of roll (ft.)}}{150 \left( \frac{\text{ft.}}{\text{Splice}} \right)}$$

- b. Minimum distance between splices is 15 feet (4.6 m). Minimum distance between splice and end or start of roll is 15 feet (4.6 m).

### 3.5 Laminate (Cured Prepreg) Requirements:

3.5.1 Test Laminate Fabrication and Baseline Cure Process:

The test laminate fabrication and baseline cure process must be in accordance with NCAMP Process Specification NPS 83961 Fabrication of NMS 397 Qualification, Equivalency, and Acceptance Test Panels. In order to facilitate individual specimen traceability, individual specimen numbering and/or skewed lines must be written or drawn across each sub-panel as shown in Figure 1.

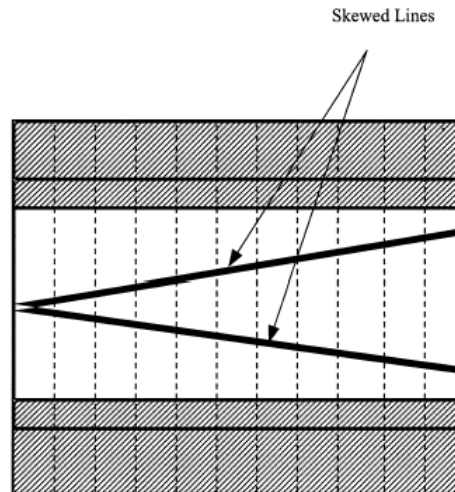


Figure 1 – Specimen Traceability Line

### 3.5.2 Cured Laminate Physical Properties:

The cured laminate physical properties listed in Table 3 must conform to the values and limits listed on the corresponding detail specification.

TABLE 3 - Cured Laminate Physical Properties

Property	Test Method <sup>(1)</sup>	Number of Replicates
Cured Ply Thickness	ASTM D3171 - Section 14.3.6 <sup>(7)</sup>	10 measurements per panel
Dry Glass Transition Temperature, T <sub>g</sub> by DMA <sup>(4)</sup>	ASTM D7028 (by flexural loading) per Toray's calibration procedure (specific to Toray's equipment) <sup>(5)</sup> ASTM D7028 (by flexural loading) per DOT/FAA/TC-15/28 calibration procedure	2 per batch

<sup>(1)</sup> Specific procedures should be identical to those used in the original material qualification program.

<sup>(4)</sup> Material supplier and purchasers may select one test method for batch release testing or receiving inspection. Drying at 250°F±5°F for 24 hours minimum prior to testing may be required if specimens are likely to have moisture.

<sup>(5)</sup> Toray uses manufacturer's DMA recommendation for calibration and conduct an instrument check using polycarbonate material to identify significant changes in equipment.

<sup>(7)</sup> Measure panel thickness using a 0.25 inch (6.35mm) diameter hemispherical anvil, spindle micrometer or equivalent tool/process. Test panel thickness measurements must be performed at least 1 inch (25.4 mm) from the laminate edge and uniformly distributed over the laminate surface and divided by the number of plies in the laminate.

### 3.5.3 Cured Laminate Mechanical Properties:

The cured laminate mechanical properties listed in Table 4 and 5 must conform to the values and limits listed on the corresponding detail specification.

TABLE 4 - Required Cured Laminate Tests for Mechanical Properties (Class 1 Only)

Property	Test Temperature	Test Method <sup>(1)</sup>	Number of Replicates
0° Tension Strength and Modulus	RT, Ambient	ASTM D3039	5
90/0° Compression Strength and Modulus	RT, Ambient	ASTM D6641	5
0° Short Beam Strength	RT, Ambient	ASTM D2344	5

<sup>(1)</sup> Specific procedures should be identical to those used in the original material qualification program.

TABLE 5 - Required Cured Laminate Tests for Mechanical Properties (Class 2 Only)

Property	Test Temperature	Test Method <sup>(1)</sup>	Number of Replicates
0° (warp) Tension Strength and Modulus	RT, Ambient	ASTM D3039	5
90° (fill) Compression Strength and Modulus	RT, Ambient	ASTM D6641	5
0° (warp) Short Beam Strength	RT, Ambient	ASTM D2344	5

<sup>(1)</sup> Specific procedures should be identical to those used in the original material qualification program.

### 3.6 Storage and Handling Requirements:

#### 3.6.1 General Requirements:

Note: Experiment to establish material out-time and storage-life is ongoing.

##### 3.6.1.1 Release Paper/poly Film:

A non-transferring separator paper with differential release may be used on the inside of the roll. Paper or release film must be used to permit easy removal of the preimpregnated material from the roll without loss of resin, tearing, shredding, fiber realignment, or other damage. The material must be capable of being cut cleanly without other visible damage. The release paper must not contaminate the prepreg except for random, sparse flecks of carrier material inherent to the prepreg manufacturing process.

##### 3.6.1.2 Material Handling:

All rolled material greater than 12 inches wide must be supported at all times by the ends of the internal fiberboard tube and kept horizontal. Unless otherwise specified by the purchaser, the fiberboard tube of prepreg wider than 12 inches must extend a minimum of 2 inches past the separator film for this purpose. The material must not be allowed to rest against any surface, and except for rolls of 12.0 inches or less in width, must not be allowed to rest in a vertical position. Wider width rolled material may be momentarily rested against a surface or in a vertical position only while being transferred to or from storage. The fiberboard tube of prepreg 12 inches or narrower must extend a minimum of 0 inch past the separator film.

##### 3.6.1.3 Thawing Rolled Materials:

Preimpregnated materials must be allowed to warm at ambient temperature until moisture does not condense on the packaging (i.e. prepreg temperature is above dew point). The material out-time must be recorded by the distributor and purchaser. The material out-time between manufacture and shipment at supplier location must be in accordance with 5.2.3.

NOTE - No form of applied or direct heat must be used to accelerate the thawing



process.

### 3.6.2 Prepreg Life Requirements:

Definitions for storage life, handling life, staging life, and out-time are shown in Figure 2. The heat history of the prepreg is controlled at the manufacturer to ensure the following material life requirements:

- 3.6.2.1 Storage Life: The prepreg rolls must be stored in sealed moisture-proof bags in a clean and dry area. The prepreg rolls must be supported at all times by the ends of the internal fiberboard tube and kept horizontal, and must not have any objects resting on top of it.
  - 3.6.2.1.1 The prepreg has a storage life of 36 months from the date of manufacture when stored in accordance with the conditions above at a maximum storage temperature of 10 °F. Temperature excursions up to 10°F above allowed maximum temperature, such as during shipping and freezer defrost cycles, for a cumulative maximum 7 days is permitted. The material must have a minimum of nine months remaining storage life at the time of shipment unless agreed upon by the purchaser.
  - 3.6.2.1.2 For purposes of tracking the storage life, the time must be measured from the date of manufacture, unless otherwise specified in the purchase order. Material that has been stored for a time period longer than the maximum storage life must not be used until tests have been performed to extend the storage life as defined by 3.6.2.1.3 or the user's process specifications.
  - 3.6.2.1.3 Storage Life Extension: Storage life may be extended by the purchaser. Storage life extension requirement is similar to receiving inspection requirement in 4.5. Each extension is for 6 months only. Storage life may be extended a maximum of one time only (refer to storage-life tests from qualification program).
- 3.6.2.2 Handling Life: The handling life of the material at 72+/-5°F and 50 +/- 10% relative humidity is 10 days. Handling life begins when the prepreg is removed from the freezer and ends when prepreg is laid onto the tool. Extension of handling life requires Material Review Board (MRB) approval by material user, which should consider the intended application, handling characteristics (tack and drape), and mechanical properties of the material.
- 3.6.2.3 Staging Life: The staging life (or mechanical life) of the material when covered with vacuum bagging materials at 72+/-5°F and 50 +/- 10% relative humidity is 32 days. Staging life begins at placement of the ply on the tool and ends when the cure cycle begins. Extension of staging life requires MRB approval, which should consider the intended application and mechanical properties of the material.
- 3.6.2.4 Out-time: Out-time begins when the prepreg is removed from freezer storage and ends when the cure cycle begins. Total out-time is the summation of handling life and staging life.

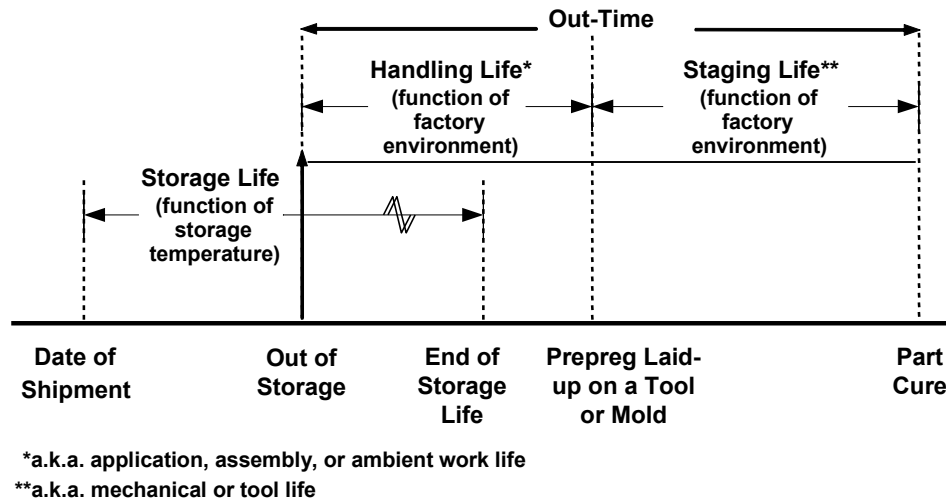


Figure 2. Definitions of Storage, Handling, Staging Life, and Out-Time

### 3.6.3 Distributors:

A material distributor must perform the same documentation of storage life and handling life as the material supplier and purchaser. If the original packaging is to be opened to allow for re-spooling into smaller units, the prepreg must be allowed to warm at ambient temperature in the unopened package until moisture does not condense on the packaging (i.e. prepreg temperature is above dew point). All out-time accumulated during warming, re-spooling, and repackaging must be subtracted from the total handling life and documented for the purchaser(s). Distributors are not allowed to extend the storage life unless explicitly allowed by the purchaser.

## 3.7 Environmental, Health, and Safety:

- 3.7.1 Equipment, materials, solutions, and emissions (if applicable) must be controlled, handled, used, and disposed of in accordance with all local, State, and Federal Government Safety, Health, and Environmental Affairs (SHEA).
- 3.7.2 The delivered prepreg system must fulfill the local requirements of the health and safety laws of the country of the purchaser. When processing the prepreg in the composite shop, there must be no health hazards or emissions that require special measures to be taken to protect the environment.
- 3.7.3 The manufacturer must inform the purchaser about the safe handling procedures of the material. The Safety Data Sheet (SDS) must be made available to the purchaser.

## 3.8 Defects During Usage:

- 3.8.1 Defects, as defined by this specification, which are not marked by the supplier but found in the prepreg material after acceptance must be cause for rejection and the defective material may be returned to the supplier. Defects caused by user mishandling, improper storage, or expiration of storage or out-life are not the responsibility of the supplier and must not be cause for rejection back to the supplier.

### **3.9 Qualification Requirements:**

Materials must be qualified in accordance with an NCAMP test plan.

### **3.10 Material Re-Qualification and Equivalency:**

3.10.1 The materials covered by this specification are subject to change control as specified in section 1.8. If any change occurs relevant to this specification or the PCD, material end-users and NCAMP reserve the right to require a re-qualification by the prepreg manufacturer to validate that the changed material is equivalent to the material in the initial qualification. The extent of the re-qualification program will depend on the nature of the change of the material or the material processing. DOT/FAA/AR-06/10 and DOT/FAA/AR-07/3 provide guidance in this area.

3.10.2 Equivalency is limited to the evaluation of minor changes in a material's constituents, manufacturing process, or fabrication (e.g. curing) process used with a material. Significant changes to the prepreg material will require a full qualification program and a separate specification.

3.10.3 It is the responsibility of the material supplier to conduct testing to demonstrate that the current material, when processed to the baseline process specification, will generate composite properties statistically equivalent to the properties of the original materials.

### **3.11 Process Control Document:**

3.11.1 The supplier must prepare and control a Process Control Document (PCD) in accordance with NRP 101. The PCD must be considered proprietary and must be protected in accordance with disclosure agreements signed by the supplier and NCAMP. The established Process Control Document (PCD) must be presented to NCAMP upon request. NCAMP must treat any information contained in the PCD as proprietary.

3.11.2 Changes to the PCD of a qualified material (as defined by DOT/FAA/AR-06/10, DOT/FAA/AR-07/3, and NRP 101) are subject to the written approval of NCAMP. Such changes may require substantial testing to demonstrate equivalency.

### **3.12 Traceability:**

Each individual material and its constituents as defined by the PCD must be identifiable at all stages of manufacture and delivery. The material manufacturer must present evidence of the material traceability upon request.

### **3.13 Manufacturer's Responsibility:**

3.13.1 The manufacturer is responsible for the development and manufacture of any material submitted in accordance with this specification. Quality control by the manufacturer must be in accordance with this specification.

- 3.13.2 Changes to the prepreg require review and approval by NCAMP in accordance with 1.8. Any testing required to validate the changes or adjustment of manufacturing materials, techniques and/or procedures is the manufacturer's responsibility.

#### **3.14 Quality Management System:**

The manufacturer's quality system must be approved as defined in AS 9100 or equivalent.

### **4. QUALITY ASSURANCE:**

#### **4.1 Responsibility for Inspection:**

Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all batch release inspection and test requirements specified herein and the purchaser is responsible for the performance of all receiving inspection tests specified herein, except HPLC, IR and DSC. The purchaser may perform reduced receiving inspection testing if the reduced sampling plan is specifically approved by the original equipment manufacturer or the certifying agency (see section 4.5.2). The supplier may use their own facilities or any commercial laboratory acceptable to NCAMP. The purchaser or NCAMP reserves the right to perform additional tests to assure that the material furnished conforms to the prescribed requirements.

#### **4.2 Classification of Tests and Inspections:**

##### **4.2.1 Qualification Tests:**

The preproduction tests performed for material qualification are those tests performed on representative samples of each specific form of material to establish a qualified product in accordance with this specification. Qualification testing must be in accordance with an NCAMP test plan.

##### **4.2.2 Batch Release Tests:**

Batch release tests must be those tests performed by the supplier on representative samples taken from each production batch of each type of material submitted by the supplier for acceptance under contract or purchase order. Specification limits are specified in the detail specification. Data and certification of data generated must accompany each shipment of material.

##### **4.2.2.1 Additional Testing:**

The purchaser reserves the right to perform additional testing to confirm the supplier's certification data, and to approve incoming material for use in the fabrication of production parts. Each roll of material may be examined by the purchaser for appearance, color uniformity, imperfections which would be detrimental for use in the fabrication of parts, and for quality of workmanship.

#### 4.2.3 Receiving Inspection Tests:

The receiving inspection tests must be those tests performed by the purchaser or approved test lab on representative samples taken from each production batch of each type of material delivered by the supplier.

#### 4.3 Supplier Statistical Process Control:

The supplier must establish and maintain procedures and requirements for an SPC system based on Key Characteristics (KC) and Key Process Parameters (KPP). The KC are the material properties required for batch release per 4.4.1. The KC monitoring, typically using control charts, must be provided to material users, certification agencies, and NCAMP staff upon request. The KPP monitoring must also be provided to material users, certification agencies, and NCAMP staff upon request, but proprietary information may be coded or normalized. Alternatively, supplier may send the KC data to NCAMP for inclusion in the NCAMP's control charts which are available to the public.

#### 4.4 Product Certification:

##### 4.4.1 Batch Release Tests:

The supplier must perform batch release tests on each batch of prepreg as specified in this section and the detail specification.

4.4.1.1 Prepreg Physical and Chemical Properties: Test in accordance with the requirements of Table 1 and the detail specification.

4.4.1.2 Laminate Physical Properties: Test in accordance with the requirements of Table 3 and the detail specification.

4.4.1.3 Laminate Mechanical Properties: Each batch of prepreg must be tested to verify compliance with the mechanical property requirements in Table 4 or 5 on at least one master roll when two or fewer are produced, or two non-adjacent master rolls when more than two are produced. This section is applicable to full width prepreg (master rolls) for hand layup applications (Class 1 - Form 1 and Class 2 - Form 4) and full width prepreg before it is slit (Class 1 - Form 2 and Form 3, and Class 2 - Form 5).

##### 4.4.2 Certification of Conformance

The supplier must furnish with each shipment one copy of a Certification of Conformance including certified test reports, confirming that all the material in the shipment complies with the requirements of this specification. The Certificate of Conformance must include the following information:

- a. Manufacturer's identification.
- b. Manufacturer's material designation.
- c. Specification number, title, revision.
- d. Purchase order number.

- e. Date, type, roll numbers and results of batch release tests, including actual individual test data and average values.
- f. Results of any retests.
- g. Prepreg batch numbers.
- h. Lot numbers of fiber, fabric, and resin used in the manufacture of the prepreg materials (available upon request).
- i. Date of manufacture (date of impregnation).
- j. Fiber lot certification test data and certificate of conformance (available upon request).
- k. List of roll numbers for each batch and the quantity (length or weight) of each roll.
- l. Roll defect/Splice log.
- m. Slit width measurements for Class 1 - Form 2, Class 1 - Form 3 and Class 2-Form 5.

**4.4.3 Records:** The following records must be available for inspection by NCAMP and purchasers

- 4.4.3.1 The supplier must keep on permanent file all records pertaining to the qualification of the candidate material.
- 4.4.3.2 The supplier must keep the following records on file, for each prepreg batch, for a minimum period of 7 years:
  - a. Full prepreg batch traceability. This traceability must extend to the particular resin and resin component batches, and fiber yarn lot(s) employed, where applicable.
  - b. All records pertaining to raw material receiving inspection and certification, in-process records, and product testing specified in the supplier PCD.
  - c. All records pertaining to the SPC.

**4.5 Receiving Inspection:** Before the prepreg material is accepted, the purchaser must perform the following:

- 4.5.1 Verification: Material must be inspected to assure that:
  - a. The material identification is correct.
  - b. The quantity is correct.
  - c. The required test data is received and meet the requirements of this specification.
  - d. The Certificate of Conformance is received.
  - e. Each shipment of prepreg meets the requirements for storage temperature between the point when the purchaser assumes ownership and the point when the material is received.
    - (1) The purchaser must document the procedure used to verify temperature exposure.
    - (2) If any exposure exceeds the maximum handling and mechanical life conditions, the material must be rejected.
    - (3) For exposures that exceed the storage temperature and are less than the maximum handling and mechanical life exposure conditions the purchaser may reject the material. If the purchaser accepts the material the time exceeding the

storage temperature must be deducted from the handling life for the material in that shipment.

#### 4.5.2 Testing:

The purchaser must repeat the supplier batch release test per 4.4.1 (except HPLC, IR and DSC) as part of the receiving inspection tests on each batch of prepreg. As use and confidence increase, the receiving inspection testing may be modified based on proven performance in cooperation with the material supplier, customer (if purchaser is supplying composite parts to another aircraft company), and appropriate certification agency.

#### 4.5.3 Re-Testing:

Two retest is allowed for each test property. Additional re-test(s) is allowed only when one or more of the following conditions exist:

- a. The initial test was performed in significant deviation to the appropriate procedure. Significant deviations are those expected to affect the measured response.
- b. In the course of layup, cure, machining, or testing, there was an occurrence known to cause or contribute to the observed test result(s).
- c. Standard statistical analysis procedures establish the suspect individual data point(s) as an outlier and there is a probable, if not provable, relationship to a deviation from required procedure.

## 4.6 Test Methods:

- 4.6.1 Tack: The purpose of this test method is to determine the level of prepreg tack through its ability to adhere to itself and to a vertical surface. Equipment needed are (1) A corrosion resistant steel plate with a commercial 2D finish and (2) A squeegee or roller.

Procedure:

- a This tack test must be performed at  $70^{\circ}\text{F} \pm 10^{\circ}\text{F}$  and 0-60% RH. Cut two 3-inch by 1-inch specimens from the slit tape/prepreg. The 3-inch dimension must be in the  $0^{\circ}$  or warp direction.
- b Attach one piece of the slit tape/prepreg specimen to the plate with light pressure using a squeegee or roller.
- c Remove the backing and apply the next strip to the first one. Tack in a similar manner. Remove the backing from the second strip.
- d Position the plate vertically.
- e Determine the tack level as follows:
  - Tack level I – Low tack, slit tape/prepreg is stiff and boardy
  - Tack level II – Dry but slight drape
  - Tack level III - Slight tack sticks to itself but not to a vertical surface. Unable to adhere to the vertical tool surface for 30 minutes.
  - Tack level IV - Good tack, slit tape/prepreg sticks to itself and vertical tool. Adhered to the vertical tool surface for more than 30 minutes.
  - Tack level V – Sticks to hands or gloves but no resin transfer.
  - Tack level VI – High tack, wet, and sloppy with resin transfer.

- 4.6.2 Drape: The drape of the prepreg must be determined at  $70^{\circ}\text{F} \pm 10^{\circ}\text{F}$  and 0-60% RH as follows:

1. Cut sufficient material to obtain 3 specimens 2 inch (50.8 mm) long by 3 inch (76.2 mm) wide minimum.
2. Bend specimens 180 degrees over a  $0.125 \pm 0.031$  inch ( $3.2 \pm 0.8$  mm) diameter mandrel at ambient temperature, stand for 15 minutes, then inspect for filament damage.
3. Repeat the test for at least 3 separate specimens.
4. Report results as “pass” or “fail”. All 3 tests must pass or material has failed to meet the drapeability requirement.

- 4.6.3 Uncured Resin Chemical Structure - Ultra High-Performance Liquid Chromatography (UHPLC)

Sample Preparation:

Place approximately 30 mg of prepreg into approximately 10 ml of UHPLC grade or similar purity acetonitrile ( $\text{CH}_3\text{CN}$ ) and agitate for approximately 15 minutes. Filter through a 0.2 micron Teflon filter into a UHPLC vial.

Operating Parameters:

Perform the test in accordance with the parameters for Ultra-High Performance Liquid Chromatography.



Column:	Waters Acquity UPLC® CSH™ Fluoro-Phenyl 1.7µm 2.1 x 100mm or equivalent
Flow Rate:	0.75 ml/min
Mobile Phase:	Reservoir A: UHPLC Grade or equivalent H <sub>2</sub> O w/ 0.01 percent by volume formic acid Reservoir B: UHPLC Grade or equivalent CH <sub>3</sub> CN
Injection Volume:	1 microliter
Detector:	UV 230 ± 1 nm
Column Temperature:	50°C

GRADIENT PROGRAM TIME, MINUTES	RESERVOIR A, PERCENT BY VOLUME	RESERVOIR B, PERCENT BY VOLUME
0.0	65	35
2.4	65	35
3.8	55	45
4.0	5	95
4.2	5	95
4.4	65	35

**Testing:**

Perform two tests on one prepared solution for each UHPLC sample.

**Calculations:**

Calculate the peak areas for each peak of interest and divide the area by peak 1 area to obtain a peak ratio for each peak of interest.

**Report:**

- (1) Review and submit the LC chromatograms for reference.
- (2) Report individual and average peak ratios.

**5. PREPARATION FOR DELIVERY:****5.1 Packaging:**

- 5.1.1 The prepreg must be rolled onto a core suitable for use at the purchaser. Suppliers uncertain as to core suitability must direct their inquiries through the purchaser prior to fabrication of material.
- 5.1.2 Each spool/roll of material must be wrapped and sealed with a non-adherent, non-contaminating moisture-proof bag to prevent penetration of moisture. The bag must be 0.004 inch (0.100 mm) thick minimum polyethylene or equivalent.
- 5.1.3 Place a minimum of four units of MIL-D-3464, Type II or equivalent desiccant in each bag prior to sealing.

- 5.1.4 The individual spool or roll must be packed in a shipping container that will be acceptable for safe transportation by common carriers and must include a packing list. The core must be supported on ends to avoid damage to the prepreg. The container must be of such design as to prevent damage or degradation to the prepreg during shipment.
- 5.1.5 The outside of each container and the inside of the roll core must be clearly marked with the following information:
- a. Title, number and revision letter of this specification
  - b. Date of manufacture (or date of shipment if specified by the detail specification)
  - c. Length of acceptable prepreg
  - d. Purchase order number and/or sales order number (may be documented in packing list instead).
  - e. Supplier's name
  - f. Supplier's prepreg batch and spool/roll number
  - g. A statement (not required on roll core) to indicate that:
    - (1) The material must be shipped at a temperature not to exceed 10°F,
    - (2) The material must be stored at a temperature not to exceed 10°F, and
    - (3) The container should not stand on end or similar statement or symbol (for prepreg wider than 12 inches only)
  - h. All material labeling must comply with OSHA Hazard Communication, 29 CFR 1910.1200.
- 5.1.6 If spools/rolls are reused, all information not applicable to the current shipment must be removed.

## **5.2 Shipping Requirements:**

- 5.2.1 The prepreg must be maintained at or below 10°F during shipment by being packed in dry ice or by refrigeration. Temperature excursions up to 10°F above allowed maximum temperature for a cumulative maximum of 7 days are permitted per section 3.6.2.1.1.
- 5.2.2 The out-of-storage time between point of manufacture and shipment from the supplier must be defined in the supplier PCD, unless explicitly approved by the purchaser for the particular batch to be shipped.
- 5.2.3 Temperature Recorders: Temperature recorders must be used as required herein to verify that the material was maintained at or below 10°F during the entire time of shipping. If the material has been exposed to temperature between 10°F and 77°F, the material handling life and staging life must be subtracted accordingly. For shipping containers not large enough to hold the prepreg material and a temperature recorder, a separate container must be used exclusively to contain the temperature recorder in a manner similar to the prepreg it represents.

- 5.2.4 For dry ice shipments, at least one temperature recorder must be positioned within at least one shipping container. The shipping container must be of such a construction to allow enough room for the prepreg, temperature recorder and dry ice. There must be enough dry ice or additional dry ice must be added during shipment to maintain the prepreg at the required shipping temperature. The shipping container must also be insulated and have a partition of suitable material to separate the temperature recorder and packaged prepreg from direct contact with the dry ice.
- 5.2.5 For refrigerated shipments, temperature recorders must be positioned within or near the shipping containers as follows: The “shipping container” must be defined as a box designated to hold one spool or one roll of prepreg material. Each refrigerated truck shipment requires two recorders, one per each of two randomly selected shipping containers. If the prepreg shipment has only one shipping container per truck, then both temperature recorders must be placed in that shipping container. Identify each container having a temperature recorder for purposes of expediting receiving inspection.

### **5.3 Receipt at Purchaser:**

- 5.3.1 Store material at or below 10°F.
- 5.3.2 For personnel safety when receiving shipments with dry ice, carbon dioxide concentration must be below permissible level (typically 30,000 ppm for short-term exposure) before entering the truck bed. Consult Occupational Safety & Health Administration (OSHA) for more safety information.

## **6. ACKNOWLEDGEMENT:**

A vendor must mention this specification number and the applicable detail specification number and their revision letters, if any, in all quotations and when acknowledging purchase orders.

## **7. REJECTION:**

Prepreg rolls not conforming to this specification and the applicable detail specification, or to modifications authorized by purchaser, will be subject to rejection.

## **8. NOTES:**

### **8.1 Definitions:**

For definitions that are not provided in this specification or other applicable NCAMP specifications, the definitions in DOT/FAA/AR-06/10 and DOT/FAA/AR-07/3 must apply. For definitions not provided in DOT/FAA/AR-06/10 and DOT/FAA/AR-07/3, the definitions in ASTM D3878 must apply. For definitions not provided in ASTM D3878, the definitions in CMH-17 (formerly MIL-HDBK-17) must apply.