# Advanced General Aviation Transport Experiments

# Material Qualification Methodology for Field Repair/Wet Layup Composite Material Systems

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## 1.0 INTRODUCTION

### 1.1 Scope

This specification defines the Material and Quality Assurance requirements for structural laminating materials; including both the reinforcements and resin.

### 1.2 Abbreviations and Definitions

| | |
|---|---|
| Shelf Life - | Allowable storage time from the date of shipment to date of cure for perishable materials, usually dependent upon storage temperature. |
| MRB - | "Material Review Board" A forum by which non-conforming materials are reviewed and dispositioned. Attended by Engineering and Quality department representatives. |
| Mat. Qual. - | "Material Qualification" |
| Sup. - | "Supplier" |
| QA - | "Quality Assurance" |
| Rec. Insp. - | "Receiving Inspection" |
| Proc. Verf. - | "Process Verification" |
| RTD - | "Room Temperature Dry" |
| HW - | "Hot Wet" |
| CD - | "Cold Dry" |
| HD - | "Hot Dry" |
| RTW - | "Room Temperature Wet" |

### 1.3 Standard Tolerances

The following standard tolerances apply to the rest of this document, unless otherwise noted:

<table>
<tr><th colspan="5">TABLE OF STANDARD TOLERANCES</th></tr>
<tr><td>TEMPERATURE<br>± 5°F and ± 3°C</td><td rowspan="2">TIME<br>Minutes ± 1<br>Seconds ± 1<br>Hours ± 0.5</td><td rowspan="2">WEIGHT<br>.X ± .05<br>.XX ± .005<br>X ± .25<br>XX ± 0.5<br>XXX ± 5</td><td rowspan="2">DIMENSIONS<br>.X ± .05<br>.XX ± .005<br>X ± .25<br>XX ± .5<br>XXX or more ± 5</td><td rowspan="2">ANGLES<br>X = ± 2.0º<br>.X = ± 1.0º</td></tr>
<tr><td>HUMIDITY<br>± 5% RH</td></tr>
</table>

## 2.0 MATERIAL REQUIREMENTS

### 2.1 General

#### 2.1.1 Resin

The resin used in the manufacture of materials under this specification shall be a thermosetting, low-pressure laminating epoxy. The component materials of the resin shall be formulated such that when fully cured it shall not be corrosive to metals, but shall be resistant to water, fuel, oil, grease, and hydraulic fluid degradation.

2.1.2 Fiber Reinforcements

The fibers shall meet the strength requirements of Table 2.1. Finish (sizing) shelf life must be documented on all fiber certs, unless applied and documented by the weaver. The fibers must be used (i.e. coated with resin and cured) within the shelf life of the finish.

**Table 2.1 Continuous Fiber Required Properties**

| Type | Tensile (ksi) | Tensile Modulus (Msi) | Shelf Life (unless documented by weaver) |
|---|---|---|---|
| Carbon | 500 minimum | 32 -38 | 6 months minimum from date of shipment |
| Glass | 450 minimum | 9.5 - 10.5 | |

2.1.3 Woven Fabric

Cloth used in the manufacture of laminates to this specification shall meet the requirements of Table 2.2. All measurements listed have a tolerance of +/- 5%. Finish (sizing) shelf life must be documented on all fabric certs, unless applied and documented by the fiber manufacturer. The fabric must be used (i.e. coated with resin and cured) within the shelf life of the finish.

**Table 2.2 Woven Fabric Requirements**

| Type | Style | Weave | Weight ($oz/yd^2$) | Thk (mil) | Count Warp x Fill | Yarn Warp x Fill | Shelf Life (unless documented by fiber mfg.) |
|---|---|---|---|---|---|---|---|
| Glass | 7781 | 8-HS | 8.9 | 9.0 | 57 x 54 | 75 1/0 x 75 1/0 | 6 months minimum from date of shipment |
| Carbon | -- | Plain | 5.7 | 9.0 | 12.5 x 12.5 | 3K x 3K | |

## 2.2 Chemical and Physical Properties of Epoxy

Table 2.1 defines the properties to be evaluated, the required test methods, the specimen conditioning, and the required results. Environmental conditioning is defined in Section 4.3. Mixing instructions are in Appendix A. Applicability of each test is in Section 3.0 together with pass/fail criteria for each property.

**Table 2.3 Chemical and Physical Properties**

| Property | Test Method | Cond. | Min. | Max. |
|---|---|---|---|---|
| Pot Life, Nominally Mixed | ASTM D2471 | RTD | Generated for each Material System | |
| Thermal Profile, Nominally Mixed and fully cured | ASTM D3418 (DSC) | RTD | Max Operating Temperature + 50°F | n/a |
| Constituent Identification, Resin | ASTM E682 (HPLC) | RTD | Generated for each Material System | |
| Constituent Identification, Resin | ASTM E168 (FTIR) | RTD | Generated for each Material System | |
| Constituent Identification, Hardener | ASTM E682 (HPLC) | RTD | Generated for each Material System | |

| | | | |
|---|---|---|---|
| Constituent Identification, Hardener | ASTM E168 (FTIR) | RTD | Generated for each Material System |

### 2.2.1 Pot Life

Mix a 450-gram sample in a glass beaker for three minutes using a glass stir rod of approximately 1/8-inch diameter. Do not hold the can so as to warm the contents during mixing. After three minutes, transfer 400 grams of the sample to a one-pint can. Use the remaining 50 grams for other chemical and physical tests, if desired.

Place the can on a nonconducting surface in still air at RTD conditions. Probe the specimen every 15 seconds for the first 5 minutes, every 30 seconds for the next 5 minutes, every minute for the next 20 minutes and every 5 minutes for the next 60 minutes, and every 15 minutes thereafter, recording time and temperature. When the epoxy no longer adheres to the end of the probe, record that time as gel time. During initial material qualification only, continue recording time and temperature until the temperature starts to drop. Record the highest temperature reached and the corresponding time.

### 2.2.2 DSC

A small sample of nominally mixed, fully cured epoxy weighing approximately 20 mg is placed in the calorimeter and heated from 30 to 250°C at a rate of 10°C/minute under nitrogen purge. Record miliwatts versus temperature. Measure the extrapolated temperatures $T_f$, $T_m$ and $T_e$. Record $T_g$ as the $T_m$ temperature. Note that after the 10°C/minute scan, the test is complete. It is not necessary to hold at temperature, quench, and perform a second scan at 20°C/minute.

### 2.2.3 HPLC

Perform the HPLC with a quaternary pump. Prepare a 3-mg sample in Acetonitrile and water. Record peaks, noting area, type, width and percent area.

### 2.2.4 FTIR

Place a sample weighing approximately 20 mg in a small vial. Add 2 to 5 ml of acetone to the sample. Cover the vial and agitate the solvent and the resin or hardener. Allow the sample to soak for a minimum of 15 minutes. Using a capillary tube, extract the resin solvent mixture and apply to the surface of a polished salt plate (preferably KBr). As soon as the solvent has evaporated analyze the sample over a spectral range of 4000 to 500 $cm^{-1}$. Depending upon the sample, 16 to 200 scans of the spectrum may be required to optimize spectral resolution. It also may be necessary to deposit more or less sample on the salt plate. A spectra between 0.3 and 0.8 A is of ideal concentration. Mark all peaks and print spectra in the absorption mode. Also print a table of all peaks and integrated areas.

## 2.3 Mechanical Properties – Structural Laminates

All laminates certified under this specification which will be used in a structural application must meet the mechanical property requirements of this section.

The laminate mechanical properties, required test methods, specimen conditioning, and the required results are listed in Tables 2.4 and 2.5. Detailed definitions of test sample conditioning can be found in Section 4.4. Applicability of each test is detailed in Section 3.0 together with pass/fail criteria for each property

In the first columns, the values are directly as-measured, and are not normalized by any factors such as fiber areal weight, ply thickness, etc.  The values in the last columns are normalized by ply thickness.

The normalized values are calculated as:

$$V_N = \frac{t_m}{t_{avg}} V_M$$

where:

$V_N$ = Normalized Value
$V_M$ = Measured Value
$t_{avg}$ = average thickness per ply for all panels (determined for each material system)
$t_m$ = measured thickness per ply for specimen

## Table 2.4  Glass Cloth Laminate Mechanical Properties

| | | Measured | | | Normalized | | |
|---|---|---|---|---|---|---|---|
| **Property** | **Cond.** | **Mean** | **Std. Dev.** | **B-Basis** | **Mean** | **Std. Dev.** | **B-Basis** |
| Tg via DMA | RTD | Defined by End User 225°F | -- | -- | -- | -- | -- |
| | RTW | | -- | -- | -- | -- | -- |
| Poisson's Ratio | CD | Generated for each Material System | | | -- | -- | -- |
| | RTD | | | | -- | -- | -- |
| | HD | | | | -- | -- | -- |
| | HW | | | | -- | -- | -- |
| 90° Tension Strength (ksi) | CD | Generated for each Material System | | | Generated for each Material System | | |
| | RTD | | | | | | |
| | HD | | | | | | |
| | HW | | | | | | |
| 90° Compression Strength (ksi) | CD | Generated for each Material System | | | Generated for each Material System | | |
| | RTD | | | | | | |
| | HD | | | | | | |
| | HW | | | | | | |
| In-Plane Shear Strength (ksi) | CD | Generated for each Material System | | | -- | -- | -- |
| | RTD | | | | -- | -- | -- |
| | HD | | | | -- | -- | -- |
| | HW | | | | -- | -- | -- |
| Short Beam Shear (ksi) | RTD | Generated for each Material System | | | -- | -- | -- |
| | | **Mean** | **Min.** | **Max.** | **Mean** | **Min.** | **Max.** |
| 90° Tension Modulus (Msi) | CD | Generated for each Material System | | | Generated for each Material System | | |
| | RTD | | | | | | |
| | HD | | | | | | |
| | HW | | | | | | |
| 90° Compression Modulus (Msi) | CD | Generated for each Material System | | | Generated for each Material System | | |
| | RTD | | | | | | |
| | HD | | | | | | |
| | HW | | | | | | |
| In-Plane Shear Modulus (Msi) | CD | Generated for each Material System | | | -- | -- | -- |
| | RTD | | | | -- | -- | -- |
| | HD | | | | -- | -- | -- |
| | HW | | | | -- | -- | -- |

### Table 2.5 Carbon Cloth Laminate Mechanical Properties

| | | Measured | | | Normalized | | |
|---|---|---|---|---|---|---|---|
| **Property** | **Cond.** | **Mean** | **Std. Dev.** | **B-Basis** | **Mean** | **Std. Dev.** | **B-Basis** |
| Tg via DMA | RTD | Defined by End User 225°F | -- | -- | -- | -- | -- |
| | RTW | | -- | -- | -- | -- | -- |
| Poisson's Ratio | CD | Generated for each Material System | | | -- | -- | -- |
| | RTD | | | | -- | -- | -- |
| | HD | | | | -- | -- | -- |
| | HW | | | | -- | -- | -- |
| 90° Tension Strength (ksi) | CD | Generated for each Material System | | | Generated for each Material System | | |
| | RTD | | | | | | |
| | HD | | | | | | |
| | HW | | | | | | |
| 90° Compression Strength (ksi) | CD | Generated for each Material System | | | Generated for each Material System | | |
| | RTD | | | | | | |
| | HD | | | | | | |
| | HW | | | | | | |
| In-Plane Shear Strength (ksi) | CD | Generated for each Material System | | | -- | -- | -- |
| | RTD | | | | -- | -- | -- |
| | HD | | | | -- | -- | -- |
| | HW | | | | -- | -- | -- |
| Short Beam Shear (ksi) | RTD | Generated for each Material System | | | -- | -- | -- |
| | | **Mean** | **Min.** | **Max.** | **Mean** | **Min.** | **Max.** |
| 90° Tension Modulus (Msi) | CD | Generated for each Material System | | | Generated for each Material System | | |
| | RTD | | | | | | |
| | HD | | | | | | |
| | HW | | | | | | |
| 90° Compression Modulus (Msi) | CD | Generated for each Material System | | | Generated for each Material System | | |
| | RTD | | | | | | |
| | HD | | | | | | |
| | HW | | | | | | |
| In-Plane Shear Modulus (Msi) | CD | Generated for each Material System | | | -- | -- | -- |
| | RTD | | | | -- | -- | -- |
| | HD | | | | -- | -- | -- |
| | HW | | | | -- | -- | -- |

### 2.3.1 DMA

Subject a laminate sample measuring approximately 20mm by 8 mm by laminate thickness to a three point bending test by means of 10mm knife-edge and 15 mm bending platform. The $0^0$ direction should be parallel to the 20mm direction. Perform the test at 1hz while heating the sample at a rate of 5°C/min from 50°C to 250°C. Operate equipment under dynamic force control, using a static force of 550 mN and dynamic force of 500 mN Record storage modulus, loss modulus, and tan delta as a function of temperature. The $T_g$ shall be calculated as the maximum in Tan $\delta$.

### 2.3.2 Fiber Volume and Void Content

Use a sample weighing between 1 and 5 grams.

First calculate specific density using ASTM D792. Weigh the specimen, immerse in water at 23±2°C and reweigh. Determine the density.

Next calculate fiber volume and resin content using D2584 for glass laminates or D3171 Procedure B for carbon laminates. Procedure B can be used as long as: fiber blanks are digested along with the samples to ensure that the acid is not attacking the fibers; and the fibers are checked after the tests to ensure that they are not sticky (implying that not all of the matrix/filler was digested).

For glass, dry the specimen and recondition to 75±5°F and 50±10% RH for a minimum of 40 hours. Reweigh and measure the specimen and place in a crucible. Place a 4” x 4” sample of laminate in a crucible. If desired, heat the crucible and specimen in a Bunsen flame until the contents ignite and burn until only ash and carbon remain. Then place the crucible in a muffle furnace at 1050°F ± 50°F until all carbonaceous material has disappeared. Alternatively, the crucible may be directly placed in the muffle furnace until the contents are burned and all carbonaceous material has disappeared. Determine the resin content, fiber weight and volume as percentages.

For carbon, dry the specimen and recondition to 75±5°F and 50±10% RH for a minimum of 40 hours. Reweigh and measure the specimen and calculate fiber volume and resin content using D3171 Procedure B. Procedure B can be used as long as: fiber blanks are digested along with the samples to ensure that the acid is not attacking the fibers; and the fibers are checked after the tests to ensure that they are not sticky (implying that not all of the matrix/filler was digested).

Next calculate void content using D2734. Calculate the theoretical density of the composite. Then calculate the void content as a volume percentage.

### 2.3.3 Tension Strength, Modulus and Poisson’s Ratio

Modulus, Poisson’s ratio and strength tests should be performed at the same time. The specimens which are used for both modulus and strength measurements should be tested first so that any test-induced bending can be measured with strain gages and corrected in the grips before testing strength specimens (where bending isn’t measured).

Prepare specimens as 10” x 1” rectangles with the 90° direction in the 10” dimension. Add 2.5” – 3” tabs, 0.062 inch thick, of G-10 glass/epoxy (or other suitable filled epoxy material). Cure tabs at 200°F or less for 6 hours or less. Determine cross-sectional area at three places in the gage section and report the specimen area as the average of these three measurements.

When measuring only tensile strength, collect load/strain data using either a strain transducer or an extensometer. A Class B extensometer is allowable for this application. When also measuring Poisson’s ratio, instrument the specimen to measure strain in both longitudinal and lateral directions. When also measuring elastic modulus, instrument the specimen to measure longitudinal strain on opposite faces of the specimen to allow for correction due to any bending of the specimen. An active gage length of 0.25 inch is recommended. The gage length should never be less than 0.125 inch. In a repeating weave, the active gage length should be at least as great as the characteristic repeating unit of the weave. If possible, a gage length of three times the repeating unit of the weave is preferable. Gage preparation should not damage or expose the fibers, nor should cleaning chemicals be used which will react with the epoxy. Isopropyl alcohol is suitable for cleaning and wet abrading. Proper gage resistance and excitation should be selected to prevent gage heating effects. At elevated or cold temperature conditions, temperature compensation of the gage and leadwires should be done. Transverse sensitivity should also be corrected for.

Control speed of testing using strain control at a rate of 0.01/min. If strain control is not available, set the speed of testing from trial and error runs (on dummy coupons, if necessary) so that failure is produced within 1 to 10 minutes. Measure ultimate strain and set crosshead speed to approximate desired strain rate. Start at a crosshead speed of 0.05 in./min and modify from there.

Load specimen and record load vs. strain or displacement. Calculate ultimate tensile stress, tensile modulus of elasticity with strain gage data, and Poisson's ratio by chord method. All data should be to three significant digits. Record failure method. Failures that do not occur in the specimen gage length should be omitted and retested.

If the strains recorded from the back-to-back strain gages (during modulus testing) show percent bending is greater than 3%, the test should be repeated. Determine modulus from the average of both gages to three significant digits.

### 2.3.4 Compression Strength and Modulus

Perform test under SACMA SRM 1. When testing compression strength, tabs are added to the specimen of G-10 glass/epoxy (or other suitable filled epoxy material). Cure tabs at 200°F or less for 6 hours or less. Strain is irrelevant, and crosshead displacement can be used for test control at a rate of 0.05 in/min until failure. Determine ultimate strength to three significant digits.

When testing compression modulus, a strain gage must be placed in the center of the specimen on each side. An active gage length of 0.25 inch is recommended. The gage length should never be less than 0.125 inch. In a repeating weave, the active gage length should be at least as great as the characteristic repeating unit of the weave. If possible, a gage length of three times the repeating unit of the weave is preferable. Gage preparation should not damage or expose the fibers, nor should cleaning chemicals be used which will react with the epoxy. Isopropyl alcohol is suitable for cleaning and wet abrading. Proper gage resistance and excitation should be selected to prevent gage heating effects. At elevated or cold temperature conditions, temperature compensation of the gage and leadwires should be done. Transverse sensitivity should also be corrected for.

When testing compression modulus, load at .05 in/min up to 5000 microstrain. Record load and microstrain at 3000 and 1000 microstrain. If the strains recorded from the back-to-back strain gages vary by more than 10%, the test should be repeated. Determine modulus from the average of both gages to three significant digits.

### 2.3.5 In-Plane Shear Strength and Modulus

This is also known as the Iosipescu Shear Test. A coupon in the form of a rectangular flat strip with symmetrical, centrally located v-notches is loaded in a mechanical testing machine by a special fixture. The specimen is inserted into the fixture with the notch located along the line-of-action of loading by means of an alignment tool that references the fixture. The two halves of the fixture are compressed by a testing machine while monitoring load. The relative displacement between the two fixture halves loads the notched specimen. By placing two strain gage elements, oriented at ±45° to the loading axis, in the middle of the specimen (away from the notches) and along the loading axis, the shear response of the material can be measured.

Cut specimens to standard size. Panels are 0/90 laminates, as preferred for 1-2 material plane testing. The 3" dimension on the specimen should align with the 0° direction of the panel. Tabs may be used per ASTM D5379.

When only measuring strength, collect load and displacement data using either crosshead displacement or an extensometer. A Class B extensometer is allowable for this application.

When measuring shear modulus, two gage elements are required, centered about the loading axis in the gage section of the specimen and mounted at ±45° to the loading axis. The gages may be wired as separate signals or together as a half-bridge. Special Iosipescu shear gages are available and recommended for this test. In a repeating weave, the active gage length should be at least as great as the characteristic repeating unit of the weave. If possible, a gage length of three times the repeating unit of the weave is preferable. Gage preparation should not damage or expose the fibers, nor should cleaning chemicals be used which will react with the epoxy. Isopropyl alcohol is suitable for cleaning and wet abrading. Proper gage resistance and excitation should be selected to prevent gage heating effects. At elevated or cold temperature conditions, temperature compensation of the gage and leadwires should be done. Transverse sensitivity should also be corrected for.

Control speed of testing using strain control at a rate of 0.01/min. If strain control is not available, set the speed of testing from trial and error runs (on dummy coupons, if necessary) so that failure is produced within 1 to 10 minutes. Measure ultimate strain and set crosshead speed to approximate desired strain rate. Start at a crosshead speed of 2 mm/min and modify from there.

Load specimen and record load vs. strain and load versus head displacement (or extensometer displacement) continuously until failure. Make sure failure mode is acceptable, as shown in the ASTM standard. Failures that do not occur in an acceptable manner should be omitted and retested. Calculate ultimate shear strength and shear modulus of elasticity to three significant digits.

### 2.3.6 Short Beam Shear

Horizontal shear test specimen is center-loaded in bending. The specimen ends rest on two supports that allow lateral motion, the load being applied by means of a loading nose directly centered on the midpoint of the test specimen.

Specimen size is defined by length-to-thickness ratios. The specimen is a flat laminate, not a ring. Measure the panel thickness. Calculate the specimen length along the 0° direction as approximately 7 times the thickness. Specimen width should be 6.4±0.1 mm. Load the specimen with a 5:1 span/thickness ratio so that the loading dowel is in contact with the 1-2 plane of the material (i.e. the "height" of the specimen is the thickness of the panel). Load at 0.05 in/min until failure. Record failure mode as either shear or tensile. If a tensile failure is generated, reduce the length/thickness ratio of the next specimen by a factor of 0.5 until a shear failure is generated. Record failure mode as either shear or tensile. If a tensile failure is generated, reduce the length/thickness ratio of the next specimen until a shear failure is generated. Record final length/thickness ratio and use for remaining specimens. Only shear failures shall be counted in final recording of apparent shear strength.

## 2.4 Bearing Strength Properties

All laminates certified under this specification which will be used in a structural application must meet the bearing strength requirements of this section.

Bolted joint strength is determined using ASTM D953. The laminate configuration including orientation, thickness, and hole diameter is defined in Table 2.6 and 2.7. The thickness generated by the ply schedule is approximate. Specimens should follow the ply schedule exactly. The actual thickness of the panels will be measured at the time of testing.

The values in tables 2.6 and 2.7 are directly as-measured, and are not normalized by any factors such as fiber areal weight, ply thickness, etc. After testing, the results may be normalized by ply thickness and presented in additional tables.

**Table 2.6 Glass Cloth Bearing Strength Properties, As-Measured**

| Ply Schedule / Thickness | Bolt Dia. | Condition | Mean | Std. Dev. | B-Basis |
|---|---|---|---|---|---|
| $(45/0/45)_S$ / (0.060 in.) | 0.187 in. | CD | Generated for each Material System | | |
| | | RTD | | | |
| | | HW | | | |
| $(45/0/45)_S$ / (0.060 in.) | 0.250 in. | CD | Generated for each Material System | | |
| | | RTD | | | |
| | | HW | | | |
| $[0/45)_5]_S$ / (0.200 in.) | 0.250 in. | CD | Generated for each Material System | | |
| | | RTD | | | |
| | | HW | | | |
| $[0/45)_5]_S$ / (0.200 in.) | 0.375 in. | CD | Generated for each Material System | | |
| | | RTD | | | |
| | | HW | | | |

**Table 2.7 Carbon Cloth Bearing Strength Properties, As-Measured**

| Ply Schedule / Thickness | Bolt Dia. | Condition | Mean | Std. Dev. | B-Basis |
|---|---|---|---|---|---|
| **$(45/0/45)_S$ / (0.060 in.)** | 0.187 in. | CD | Generated for each Material System | | |
| | | RTD | | | |
| | | HD | | | |
| | | HW | | | |
| **$(45/0/45)_S$ / (0.060 in.)** | 0.250 in. | CD | Generated for each Material System | | |
| | | RTD | | | |
| | | HD | | | |
| | | HW | | | |
| **$[0/45)_5]_S$ / (0.200 in.)** | 0.250 in. | CD | Generated for each Material System | | |
| | | RTD | | | |
| | | HD | | | |
| | | HW | | | |
| **$[0/45)_5]_S$ / (0.200 in.)** | 0.375 in. | CD | Generated for each Material System | | |
| | | RTD | | | |
| | | HD | | | |
| | | HW | | | |

### 2.4.1 Bearing Strength

During specimen manufacture, the ratio of e/d, where e is the distance from the bolt centerline to any edge of the specimen and d is the bolt diameter, shall be greater than or equal to 2.5. Only steel pins will be used.

The standard bearing strength corresponds to a hole deformation of 4% of its diameter. However, this deformation may not be achieved in cases where premature failure is encountered. The criteria for calculating the bearing strength should be recorded with the test data.

## 2.5 Fire Resistance Properties

All laminates certified under this specification that will be used in the cabin without upholstery covers, must meet the fire resistance requirements of this section.

When the laminate is used in the baggage compartment, FAR 23.787(d) must be met. The laminate must be *at least* flame resistant. When the laminate is used in the passenger compartment, FAR 23.853(a) must be met. Again, the laminate must be *at least* flame resistant. When the laminate is used on the cabin side of the firewall, FAR 23.853(f) must be met. The laminate must be self extinguishing or be located at such a distance from the firewall, or otherwise protected, so that ignition will not occur if the firewall is subjected to a flame temperature of not less than 2000°F for 15 minutes..

FAR Part 23 does not specify a test that will demonstrate flame resistance. AC23-2 describes a horizontal burn test, which will be required under this specification.

Compliance with any self-extinguishing test (vertical burn test per Part 23 Appendix F (e) with either a 12- or 60-second flame application time), will be considered to exceed the requirements of flame resistance.

Table 2.8 defines the fire resistance properties to be evaluated, the required test methods, and the required results. Applicability of each test is in Section 3.0. Environmental conditions (Cond.) are defined in Section 4.3.

When a material is tested to these conditions, record the required properties and average the results. The average must fall below the maximum (Max.) values.

Materials that may have different flammability characteristics in different directions, must have separate tests with sets of specimens cut from each direction showing the greatest difference (e.g. warp and fill).

**Table 2.8 Fire Resistance Properties**

| Test | Method | Cond. | Property | Max. |
|---|---|---|---|---|
| Flame Resistant | AC 23-2 Paragraph b | RTD | Determine the average burn rate of the three specimens, using the time required to travel along a minimum of 10 inches of each specimen. If the specimens do not support combustion after the ignition flame is applied for 15 seconds, if the average burn rate of the three specimens does not exceed 4 inches per minute, or if the flame extinguishes itself and subsequent burning without a flame does not extend into the undamaged areas, the material is acceptable. | |
| Self-Extinguishing | FAR 23 Appendix F (d) 60-second flame application time | RTD | Flame Time | 15 sec. |
| | | | Drip Extinguishing Time | 3 sec. |
| | | | Burn Length | 6 in. |

2.5.1 Flame Resistant

Perform the horizontal burn test per AC23-2, Paragraph b.

2.5.2 Self-Extinguishing Test

Perform the vertical self-extinguishing test in accordance with FAR 23 Appendix F (d) (also detailed in Chapter 1 of the Aircraft Material Fire Test Handbook). Use a 60-second flame application time.

## 3.0 QUALITY ASSURANCE PROVISIONS

To insure acceptable quality throughout the process from material production to component fabrication, a series of inspections are required. These inspection requirements are defined in Tables 3.1 – 3.4.

In Table 3.1, the required number of specimens for each test are defined as “# x #”. The numbers refer to the number of material batches and quantity of specimens, respectively. For example “3 x 6” refers to three batches of material and six specimens per batch for a total requirement of 18 specimens.

In Tables 3.2 – 3.5, the number of samples per test is designated by a letter and number. The letter designation refers to the Batch Code while the number refers to the number of specimens tested. Thus “B6” refers to 6 samples from batch “B”.

Descriptions of Batch Code identification can be found in Section 4.1. Detailed descriptions of the test methods can be found in Sections 2.2 - 2.5. Descriptions of environmental conditioning (Cond.) can be found in Section 4.4. Mixing instructions can be found in Appendix A.

To replace a fiber or cloth, while leaving the resin unchanged or to change a resin formulation while leaving the fiber and fabric unchanged, the basic guidelines of Mil-HDBK-17E Table 2.3.4.1.6(b) will be followed. Exact test matrices will have to be worked out at the time of replacement, based upon information provided at that time, and documented in a test report.

If any single chemical or physical test specimen “fails” the pass/fail criteria, the test may be repeated once on a new specimen without reporting the failure. If there are two specimen failures, they must both be reported. If any single mechanical test specimen “fails” the pass/fail criteria, the specimen shall be evaluated for defects that would have caused premature failure. If any are found, the test may be repeated once on a new specimen without reporting the failure. If there are two failures, they must both be reported. If there is a failing mean value for any type of test, it is permissible to retest up to two more sets (“set” defined as either 1x1 or 1x3) specimens to increase the mean. No retests are automatically allowed for failures generated under fire resistance testing.

**Table 3.1 Chemical and Physical Tests**

| Property | Cond. | Mat. Qual. | Sup. QA | Rec. Insp. | Proc. Verf. |
|---|---|---|---|---|---|
| Pot Life, Nominally Mixed | RTD | 3x1 | - | 1x1 | - |
| Thermal Profile via DSC, After Cure | RTD | 3x1 | - | - | 1x1 |
| Constituent Identification via HPLC, Resin | RTD | 3x1 | - | - | - |
| Constituent Identification via FTIR, Resin | RTD | 3x1 | 1x1** | ** | - |
| Constituent Identification via HPLC, Hardener | RTD | 3x1 | - | - | - |
| Constituent Identification via FTIR, Hardener | RTD | 3x1 | 1x1** | ** | - |

** If the supplier is not able to provide FTIR data as part of Supplier QA, then an FTIR scan should be taken for each batch in the Receiving Inspection process.

## Table 3.2 Structural Laminate Mechanical Tests

| Property | Cond. | Mat. Qual. | Sup. QA | Rec. Insp. | Proc. Verf. |
|---|---|---|---|---|---|
| Fiber Volume and Void Content | RTD | * | - | * | * |
| Thermal Profile via DMA from Cured Laminate | RTD | B3 | - | - | - |
| DSC or DMA from Cured Laminate | RTD | - | - | - | B1 |
| 90° Tension Strength | RTD | A4, B4, C4 | - | - | - |
| 90° Tension Strength and Modulus | RTD | - | - | B3 | - |
| 90° Tension Strength, Modulus and Poisson's Ratio | RTD | A2, B2, C2 | - | - | - |
| 90° Compression Strength | RTD | A6, B6, C6 | - | - | - |
| 90° Compression Modulus | RTD | A2, B2, C2 | - | - | - |
| In-Plane Shear Strength | RTD | A4, B4, C4 | - | - | - |
| In-Plane Shear Strength and Modulus | RTD | A2, B2, C2 | - | - | - |
| Short Beam Shear | RTD | A6, B6, C6, D6 | - | B3 | B3 |
| 90° Tension Strength | CD | B4 | - | - | - |
| 90° Tension Strength and Modulus | CD | B2 | - | - | - |
| 90° Compression Strength | CD | B6 | - | - | - |
| 90° Compression Modulus | CD | B2 | - | - | - |
| In-Plane Shear Strength | CD | B4 | - | - | - |
| In-Plane Shear Strength and Modulus | CD | B2 | - | - | - |
| 90° Tension Strength | HW | A4, B4, C4, D4 | - | - | - |
| 90° Tension Strength and Modulus | HW | A2, B2, C2, D2 | - | - | - |
| 90° Compression Strength | HW | A6, B6, C6, D6 | - | - | - |
| 90° Compression Modulus | HW | A2, B2, C2, D2 | - | - | - |
| In-Plane Shear Strength | HW | A4, B4, C4, D4 | - | - | - |
| In-Plane Shear Strength and Modulus | HW | A2, B2, C2, D2 | - | - | - |
| 90° Tension Strength | HD | A4, B4, C4 | - | - | - |
| 90° Tension Strength and Modulus | HD | A2, B2, C2 | - | - | - |
| 90° Compression Strength | HD | A6, B6, C6 | - | - | - |
| 90° Compression Modulus | HD | A2, B2, C2 | - | - | - |
| In-Plane Shear Strength | HD | A4, B4, C4 | - | - | - |
| In-Plane Shear Strength and Modulus | HD | A2, B2, C2 | - | - | - |

*A single Fiber Volume and Void Content will be run on each panel prior to mechanical testing.

**Table 3.3 Bearing Strength Tests**

| Ply schedule / (Thickness) | Bolt Dia. | Cond. | Mat. Qual. | Sup. QA | Rec. Insp. | Proc. Verf. |
|---|---|---|---|---|---|---|
| $(45/0/45)_{SYM}$ / (0.060 in.) | 0.187 in. | RTD | B6 | - | - | - |
| $(45/0/45)_{SYM}$ / (0.060 in.) | 0.250 in. | RTD | B6 | - | - | - |
| $[(0/45)_5]_{SYM}$ / (0.200 in.) | 0.250 in. | RTD | B6 | - | - | - |
| $[(0/45)_5]_{SYM}$ / (0.200 in.) | 0.375 in. | RTD | B6 | - | - | - |
| $(45/0/45)_{SYM}$ / (0.060 in.) | 0.187 in. | HW | B6 | - | - | - |
| $(45/0/45)_{SYM}$ / (0.060 in.) | 0.250 in. | HW | B6 | - | - | - |
| $[(0/45)_5]_{SYM}$ / (0.200 in.) | 0.250 in. | HW | B6 | - | - | - |
| $[(0/45)_5]_{SYM}$ / (0.200 in.) | 0.375 in. | HW | B6 | - | - | - |
| $(45/0/45)_{SYM}$ / (0.060 in.) | 0.187 in. | CD | B6 | - | - | - |
| $(45/0/45)_{SYM}$ / (0.060 in.) | 0.250 in. | CD | B6 | - | - | - |
| $[(0/45)_5]_{SYM}$ / (0.200 in.) | 0.250 in. | CD | B6 | - | - | - |
| $[(0/45)_5]_{SYM}$ / (0.200 in.) | 0.375 in. | CD | B6 | - | - | - |

**Table 3.4 Fire Resistance Tests**

| Laminate Location | Test | Cond. | Mat. Qual. | Sup. QA | Rec. Insp. | Proc. Verf. |
|---|---|---|---|---|---|---|
| Baggage Compartment or Passenger Cabin | Flame Resistant, Vertical or Horizontal | RTD | B3 | - | - | - |
| Passenger Cabin, Near Firewall | Self-Extinguishing | RTD | B3 | - | - | - |

## 3.1 Initial Material Qualification

Material qualification is the responsibility of the end user. All testing is to be performed by the end-user or at a independent test facility approved by the end user.

Unless otherwise specified, a supplier must first qualify their material to this specification by meeting all of the applicable qualification requirements listed in Section 2.1 and Tables 3.1 – 3.4. Specifically, when a new resin system is to be certified, it must meet the requirements of Section 2.1.1 and Tables 3.1 – 3.3 and Table 3.4, if applicable. When a new structural laminate cloth is to be certified, it must meet the requirements of Sections 2.1.2 and 2.1.3 as well as Tables 3.2 and 3.3. When a new laminate cloth is to be certified for use in the cabin without upholstery, it must meet the requirements of Table 3.4.

The supplier shall submit a qualification test plan prior to qualifying a new material. This plan must be approved by the end-user's engineering department before actual testing begins. Successful qualification to this specification does not relieve the supplier of his obligation to meet the continuing Quality Requirements in Section 3.2. All test data and a final report must be delivered to the end-user's engineering department prior to qualification approval.

Evaluate initial material qualification test results using the methods in Table 3.5.

**Table 3.5 Accept/Reject Criteria for Initial Material Qualification**

| Property | Accept/Reject Criteria |
|---|---|
| Pot Life, Nominally Mixed | Report only |
| Constituent Identification via HPLC, Resin | Report only |
| Constituent Identification via FTIR, Resin | Report only |
| Constituent Identification via HPLC, Hardener | Report only |
| Constituent Identification via FTIR, Hardener | Report only |
| Tg via DSC, mixed resin after full cure | Minimum must be equal to maximum operating temperature plus 50°F |
| Tg via DMA, cured laminate | Minimum must be equal to maximum operating temperature plus 50°F |
| Fiber Volume and Void Content, cured laminate | Report only |
| Tensile Strength | Failure for a Decrease in Mean or Minimum Individual per DOT/FAA/AR-00/47 |
| Tensile Modulus | Failure for a Change in Mean per DOT/FAA/AR-00/47 |
| Poisson's Ratio | Report only |
| Compression Strength | Failure for a Decrease in Mean or Minimum Individual per DOT/FAA/AR-00/47 |
| Compression Modulus | Failure for a Change in Mean per DOT/FAA/AR-00/47 |
| In-Plane Shear Strength | Failure for a Decrease in Mean or Minimum Individual per DOT/FAA/AR-00/47 |
| In-Plane Shear Modulus | Failure for a Change in Mean per DOT/FAA/AR-00/47 |
| Apparent Interlaminar Shear Strength (Short-Beam Shear) | Failure for a Decrease in Mean or Minimum Individual per DOT/FAA/AR-00/47 |
| Bearing Strength | Failure for a Decrease in Mean or Minimum Individual per DOT/FAA/AR-00/47 |

The fire resistance properties measured in initial material qualification testing must be less than the maximum allowables.

If any values fail to meet the requirements of this specification, the material is considered not suitable for use.

## 3.2 Supplier's Quality Assurance

Supplier Quality Assurance is the responsibility of the material supplier.

Quality Assurance inspection and testing in accordance with the requirements of Table 3.1 must be performed by the supplier prior to shipment of a resin system under this specification. All test results and a certification stating that materials shipped under this specification meet the requirements must accompany the shipments.

Evaluate Supplier QA test results using the methods in Table 3.6.

**Table 3.6 Accept/Reject Criteria for Supplier QA**

| Property | Accept/Reject Criteria |
|---|---|
| Constituent Identification via FTIR, Resin | Generated for each Material System |
| Constituent Identification via FTIR, Hardener | Generated for each Material System |

If any test value fails to meet the requirements, the batch represented by the failing sample will be identified as non-conforming and submitted to the Material Review Board for disposition.

### 3.3 Receiving Inspection

Receiving Inspection is the responsibility of the end-user. All testing shall be performed at the end user's facility or a test facility approved by the end user.

Upon receipt of any materials under this specification, The end user will perform verification testing in accordance with Tables 3.1 and 3.2. Specifically, when epoxy resin is received, it will be tested to the chemical and physical requirements in Table 3.1. In addition, a panel will be laid up using whatever approved structural cloth is in stock and mechanical testing performed per Table 3.2. When a cloth used in a structural laminate is received, a panel will be laid up using whatever approved resin is in stock and tested under Table 3.2.

A sample for receiving inspection testing shall be taken, as a minimum, as one from each batch. For example if five different batches of material are received on the same shipment than five sets of samples must be taken, one for each batch. If the same batch is received in more than one shipment, the first shipment shall be tested in full. Additional shipments of the same batch will not be tested.

Evaluate receiving inspection test results using the methods in Table 3.7.

**Table 3.7 Accept/Reject Criteria for Receiving Inspection**

| Property | Accept/Reject Criteria |
|---|---|
| Pot Life, Nominally Mixed | Between the minimum and maximum in Appendix A. |
| Tensile Strength | Failure for a Decrease in Mean or Minimum Individual per DOT/FAA/AR-00/47 |
| Tensile Modulus | Each sample must be between Mean ± 7% |
| Short Beam Shear Strength | Failure for a Decrease in Mean or Minimum Individual per DOT/FAA/AR-00/47 |

If any test value fails to meet the requirements in the tables, the resin or cloth batch represented by the failing sample will all be identified as non-conforming and submitted to the Material Review Board for disposition.

### 3.4 Process Verification

Process Verification is the responsibility of the end-user. All testing shall be performed at the end user's facility or a test facility approved by the end user.

To insure consistent quality throughout the manufacturing Process, the end-user shall test process verification coupons in accordance with Table 3.2. The process verification coupons will be made as one per batch of material per oven run.

Evaluate process verification test results using the methods in Table 3.8.

**Table 3.8 Accept/Reject Criteria for In-Process Verification**

| Property | Accept/Reject Criteria |
|---|---|
| Tg from DSC, cured sample | 225°F minimum |
| Fiber Volume and Void Content | Report Only |
| Apparent Interlaminar Shear Strength (Short-Beam Shear) | Failure for a Decrease in Mean or Minimum Individual per DOT/FAA/AR-00/47 |

If any test value fails to meet the requirements, the components made with the same batch material in the same oven run will be identified as non-conforming and submitted to the Material Review Board for disposition.

## 4.0 TEST SPECIMEN REQUIREMENTS

### 4.1 Batch Definitions

For initial material qualification, as well as other tests, laminates have been defined in terms of Batch Code. For initial material qualification, four batches of panels will be tested per type of cloth. Panel batch preparation has been designed to encompass all variables within wet layup processing. Three resin and hardener batches are used in chemical/physical testing and in preparing the four sets of panels.

Table 4.1 defines which hardener/resin systems will be used on the four panel batches. $R_1$, $R_2$, and $R_3$ refer to the three batches of resin. $H_1$, $H_2$, and $H_3$ refer to the three batches of hardener that will be used.

**Table 4.1 Resin Batch Identification, Initial Material Qualification**

| Panel Batch | Resin and Hardener System |
|---|---|
| A | $R_1 + H_1$ |
| B | $R_2 + H_2$ |
| C | $R_3 + H_3$ |
| D | $R_1 + H_1$ |

Table 4.2 defines how the four batches of panels will be processed. Definitions for each of the process variables follow the table.

**Table 4.2 Panel Processing**

| Panel Batch | Resin Content | Fiber Content (by weight %) | | Curing Agent Content | Cure Cycle |
|---|---|---|---|---|---|
| | | Glass | Carbon | | |
| A | Nominal | 62 ± 1 | 53 ± 1 | Minimum | Minimum |
| B | Nominal | 62 ± 1 | 53 ± 1 | Nominal | Nominal |
| C | Nominal | 62 ± 1 | 53 ± 1 | Maximum | Over |
| D | Maximum | 54 ± 1 | 45 ± 1 | Nominal | Nominal |

Panel Batch A ...................Minimum curing agent content in combination with the minimum cure cycle and nominal resin content.

Panel Batch B ................... Nominal curing agent content in combination with the nominal cure cycle and nominal resin content.

Panel Batch C ................... Maximum curing agent content in combination with an over cure cycle and nominal resin content.

Panel Batch D ................... Nominal curing agent content in combination with the nominal cure cycle and maximum resin content.

Nominal Resin Content ..... Layup with 62 ± 1% glass fiber by weight and 53 ± 1% carbon fiber by weight.

Max Resin Content............ Layup with 54 ± 1% glass fiber by weight and 45 ± 1% carbon fiber by weight.

Curing Agent Content........ Nominal, Minimum and Maximum in Appendix A.

Minimum Cure Cycle......... Nominal cure cycle temperature minus 30°F with nominal cure time minus 1 hour.

Over Cure Cycle................ Nominal cure cycle temperature plus 30°F plus three extra nominal cure cycle times.

## 4.2 Sample Preparation

To maintain consistency of results, all specimens generated at the end user shall be sampled and processed in accordance with the following requirements.

When conducting initial material qualification, all chemical, physical, laminate, and bolted joint tests can be performed from the epoxy and cured panels required in Section 4.2.1. When conducting incoming receiving inspection, all chemical, physical, and laminate tests can be performed from the epoxy and cured panels required in Section 4.2.2. When conducting in-process verification tests all laminate tests can be performed from the panel in Section 4.2.3. Otherwise, when performing a single test, prepare the panel or epoxy as described in the appropriate test plan.

Entire panels are to be submitted for testing and test specimens shall be prepared by the testing facility.

### 4.2.1 Initial Material Qualification

When conducting initial material qualification, the materials listed in Table 4.3 need to be provided to the test laboratory. Layup and process panels per process specifications. Package epoxy and panels in accordance with Section 4.3.

**Table 4.3 Initial Material Qualification Panel Requirements**

| Batch | Material | Min. Size | No. Plies[1] | No. Panels | Test |
|---|---|---|---|---|---|
| 1 | Resin | 500 g | n/a | n/a | All chemical and physical tests in Table 3.1. |
| | Hardener | * | n/a | n/a | All chemical and physical tests in Table 3.1. |
| 2 | Resin | 500 g | n/a | n/a | All chemical and physical tests in Table 3.1. |
| | Hardener | * | n/a | n/a | All chemical and physical tests in Table 3.1. |
| 3 | Resin | 500 g | n/a | n/a | All chemical and physical tests in Table 3.1. |
| | Hardener | * | n/a | n/a | All chemical and physical tests in Table 3.1. |
| A | Laminates | 18”x18” | 12 | 4 | 90° Tension, 90° Compression, Short Beam Shear |
| | | 18”x18” | 12 | 2 | In-Plane Shear |
| B | Laminates | 12”x12” | 6 | 6 | Bearing Strength, 0.060” nominal thickness. |
| | | 12”x12” | 20 | 6 | Bearing Strength, 0.200” nominal thickness. |
| | | 18”x18” | ** | 1 | Flame Resistance *or* Self-Extinguishing |
| | | 18”x18” | 12 | 5 | 90° Tension, 90° Compression, Short Beam Shear |
| | | 18”x18” | 12 | 2 | In-Plane Shear |
| C | Laminates | 18”x18” | 12 | 4 | 90° Tension, 90° Compression, Short Beam Shear |
| | | 18”x18” | 12 | 2 | In-Plane Shear |
| D | Laminates | 18”x18” | 12 | 2 | 90° Tension, 90° Compression, Short Beam Shear |
| | | 18”x18” | 12 | 1 | In-Plane Shear |

*Package enough hardener to mix with required resin volume under nominal mixing ratios.
**Use layup representative of interior laminate.

### 4.2.2 Incoming Receiving Inspection

When conducting incoming receiving inspection, the materials listed in Table 4.4 or 4.5 need to be provided to the test laboratory. Cut the plies from random areas no closer than two inches to any edge and representative of the entire batch of material. Lay up the laminate test panel as $[0]_{12}$. Process the panels in accordance with process specifications using a clearly marked reference edge. Package the laminate and epoxy in accordance with Section 4.3.

**Table 4.4 Incoming Receiving Inspection Requirements, Resin**

| Material | Min. Size | No. Plies | No. Panels | Test |
|---|---|---|---|---|
| Resin | 500 g | n/a | n/a | All chemical and physical tests in Table 3.1. |
| Hardener | * | n/a | n/a | All chemical and physical tests in Table 3.1. |
| Laminate | 12”x12” | 12 | 1 | 90° Tension, Short Beam Shear |

*Package enough hardener to mix with required resin volume under nominal mixing ratios.

**Table 4.5 Incoming Receiving Inspection Requirements, Cloth**

| Material | Min. Size | No. Plies | No. Panels | Test |
|---|---|---|---|---|
| Laminate | 12”x12” | 12 | 1 | 90° Tension, Short Beam Shear |

[1] Layup schedule (orientation, etc.) defined with the pertinent test method in DOT/FAA/AR-00/47.

### 4.2.3 In-Process Verification

When conducting in-process verification test, the materials listed in Table 4.6 need to be provided to the test laboratory. Lay up and process panel in accordance with process specifications. Package the laminate and epoxy in accordance with Section 4.3.

**Table 4.6 In-Process Verification Requirements**

| Material | Min. Size | No. Plies | No. Panels | Test |
|---|---|---|---|---|
| Laminate | 6”x6” | 12 | 1 | DSC, Short Beam Shear |

### 4.2.4 Fire Resistance

The same specimen size can be used for either of the fire-resistance tests in Table 3.5.

Specimens tested shall be cut from a section simulating a fabricated part, e.g., cut from a model of the fabricated part. For parts that may have different flammability characteristics in different directions (e.g. textiles), separate sets of specimens, cut from each direction showing the greatest difference (e.g. warp and fill), shall be provided and tested. If the part construction is used in several thicknesses, the minimum and maximum thicknesses shall be tested.

Fabricated units, such as sandwich panels, shall not be separated into individual component layers for testing.

Cut 18”x18” plies from random areas no closer than two inches from any edge and representative of the entire batch of material. Select the number of plies and orientation to represent the interior laminate. For example, the laminate might consist of 1 ply of surface cloth Type 120 followed by four plies of 7725 glass cloth. If the part thickness is greater than 1/8 inch, the thickness used for the test specimen shall not exceed 1/8 inch. Lay up and process panel per process specifications.

This panel will yield enough material for a minimum of six specimens. Identify and package in accordance with Section 4.3.

## 4.3 Sample Identification and Packaging

Each panel or container of neat resin or hardener are to be placed in a plastic bag, sealed, and marked with the following information as a minimum:

- Test requested.
- Receiving record number.
- Supplier’s product designation.
- Supplier’s batch number.
- Date of test request.
- Person requesting test.
- Work order number on laminates.
- Warp and fill directions on laminates.

- Reference edge (fine line) on laminates.

### 4.4 Test Conditions

Wet conditions are defined to be long-term exposure at 85%RH. Service temperature is -65 to 175°F. There are four conditions a material may be tested at, as shown in Table 4.7. They are: Room Temperature and Dry (RTD); Hot and Wet (HW); Hot and Dry (HD); and Cold and Dry (CD).

**Table 4.7 Environmental Conditions**

| Condition | Temperature (°F) | Humidity (%RH) |
|---|---|---|
| RTD | 65 - 75 | 40 - 60 |
| HW | 170 - 180 | 80 - 90 |
| HD | 170 - 180 | 40 - 60 |
| CD | -70 - -60 | ambient |

Environment conditions must be recorded at the time of all tests.

4.4.1 Room Temperature and Dry (RTD)

RTD specimens will be conditions to simulate common environmental conditions. Maintain specimens in an environment of 70±5°F and 50±10%RH for a minimum of 24 hours prior to testing.

4.4.2 Hot and Wet (HW)

HW specimens will be conditioned to simulate the long-term exposure condition of 75°F and 85% RH followed a short term, high-temperature excursion. Accelerated conditioning of the specimens at 85±5%RH and 145±5°F will be used until moisture equilibrium is achieved. Traveler coupons (approximately 1" x 1" x specimen thickness) will be used to establish the weight measurements to alleviate any specimen tabbing effects. Effective moisture equilibrium is achieved when the average moisture content of the material changes by less then 0.05% within a span of 7±0.5 days for two consecutive readings and may be expressed by:

$$\frac{W_i - W_{i-1}}{W_b} < 0.0005$$

Where: $W_i$ = weight at current time

$W_{i-1}$ = weight at previous time

$W_b$ = baseline weight prior to conditioning

These samples are not dried prior to conditioning. If the traveler coupons pass the criteria for two consecutive readings, the specimens may be removed from the environmental chamber and placed in a sealed bag along with a moist paper towel for a maximum of 14 days until mechanical testing. Strain gaged specimens may be removed from the controlled environment for two hours for application of gages. Place a specimen in the test chamber at 175±5°F. Start the test two minutes (+1, -0) after a thermocouple in direct contact with the specimen reaches 175°F. Total time at 175°F shall not exceed five minutes before the start of the test.

4.4.3 Hot and Dry (HD)

HD specimens will be conditioned to simulate the highest service temperature with low humidity. Place the specimen in the test chamber and hold at 175±5°F for two minutes (+1, -0) prior to testing. Total time at 175°F shall not exceed five minutes before the start of the test.

4.4.4 Cold and Dry (CD)

CD specimens will be conditioned to simulate the lowest service temperature with low humidity. Place the specimen in the test chamber and hold at -65±5°F. Start the test two minutes (+1, -0) after a thermocouple in direct contact with the specimen reaches -65°F. Total time at -65°F shall not exceed five minutes before the start of the test. Humidity need not be recorded for this test.

## 5.0 PACKAGING AND STORAGE

### 5.1 Packaging

Resin and hardener shall be furnished in containers not exceeding 30 pounds total. Packaging shall at a minimum provide protection against corrosion, deterioration, and damage during shipment. Providing these and the specific carrier's requirements are met, packaging in accordance with the supplier's commercial practice shall be acceptable. The container shall be identified with the following information as a minimum:

- Material Type, e.g. "Epoxy Resin"
- Manufacture's Designation
- Manufacture's Batch Number
- Material Specification Number
- Date of Manufacture
- Date of Shipment
- Shelf Life (Expiration Date)
- Special Storage and Handling Requirements

### 5.2 Storage

All resin and hardener supplied under this specification shall be stored in their original shipping containers for a maximum of 24 months until ready for use at temperatures between 60° and 85°F. Twenty-four months from the date of manufacture, the resin or hardener shelf life expires. Prior to expiration, shelf life may be automatically extended 6 months by testing to both the Supplier QA and Incoming Receiving Requirements in Tables 3.1 and 3.2 and by obtaining a certificate of re-conformance from the supplier (will generally require sending some of the material back to the supplier for them to test). The six-month extension starts from the date of testing. After the material expires, the material must be tagged by QA as non-conforming, and set aside for MRB dispositioning. The shelf life of an expired resin or hardener can also be extended an additional six months by testing to both the Supplier QA and Incoming Receiving Requirements in Tables 3.1 and 3.2 and by obtaining a certificate of re-conformance from the supplier. The six-month extension again starts from the day of testing.

Once open, the resin and hardener shall be used within a six-month period of time. Open resin and hardener must also be stored between 60° and 85°F.

A visual inspection is required prior to each use. If any clouding or crystals are visible, the material must be tagged for disposition by the MRB. If it is determined that the crystals are a result of the resin or hardener being exposed to temperatures below 60°F, then the material may be warmed up per the manufacturer's instructions and be dispositioned to use thereafter. If the clouding or crystals were generated by a chemical reaction, then the material will be considered not suitable for use and will be scrapped.

Fabrics supplied under this specification shall be stored in their original shipping containers until ready for use. Average storage temperature shall be 65°F with intermittent minimum and maximum temperatures per the manufacturer's recommendations. Sizing shelf life, if there is one, shall be tracked and the material used (i.e. laminated with resin) within its shelf life.

## 6.0 APPROVED MATERIALS

All materials supplied under this specification that have successfully completed the Initial Material Qualification requirements of Section 3.1 are listed in Appendix A.

## 7.0 REFERENCES


(1) SAE AMS 2980/1. Technical Specification: Carbon Fiber Fabric and Epoxy Resin Wet Lay-Up Repair Material. Part 1 – General Requirements. SAE, Warrendale, PA. November, 1996.

(2) ASTM D 695. Standard Test Method for Compressive Properties of Rigid Plastics. ASTM, Philadelphia, PA. 1991.

(3) ASTM D 792. Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement. ASTM, Philadelphia, PA. 1991.

(4) ASTM D 953. Standard Test Method for Bearing Strength of Composites. ASTM, Philadelphia, PA. 1995.

(5) ASTM D 2344. Test Method for Apparent Interlaminar Shear Strength of Parallel Fiber Composites by Short-Beam Method. ASTM, Philadelphia, PA. 1989.

(6) ASTM D 2471 Standard Test Method for Gel Time and Peak Exothermic Temperature of Reacting Thermosetting Resins. ASTM, Philadelphia, PA. 1994.

(7) ASTM D 2583. Standard Test Method for Indentation Hardness of Rigid Plastics by Means of a Barcol Impressor. ASTM, West Conshohocken, PA. 1995.

(8) ASTM D 2584. Standard Test Method for Ignition Loss of Cured Reinforced Resins. ASTM, Philadelphia, PA. 1994.

(9) ASTM D 2734. Standard Test Methods for Void Content of Reinforced Plastics. ASTM, Philadelphia, PA. 1994.

(10) ASTM D 3039. Test Method for Tensile Properties of Polymer Matrix Composite Materials. ASTM, Philadelphia, PA. 1995.

(11) ASTM D 3171. Test Method for Fiber Content of Resin-Matrix Composites by Matrix Digestion. ASTM, Philadelphia, PA. 1990.

(12) ASTM D 3418. Standard Test Method for Transition Temperatures of Polymers by Thermal Analysis. ASTM, Philadelphia, PA. 1988.

(13) ASTM D 5379. Test Method for Shear Properties of Composite Materials by the V-Notched Beam Method. ASTM, Philadelphia, PA. 1993.

(14) ASTM E 168. Standard Practices for General Techniques of Infrared Quantitative Analysis. ASTM, Philadelphia, PA. 1992.

(15) ASTM E 682. Standard Practice for Liquid Chromatography Terms and Relationships. ASTM, Philadelphia, PA. 1992.

(16) SACMA SRM 1. Recommended Test Method for Compressive Properties of Oriented Fiber-Resin Composites. SACMA, 1988.

(17) Federal Aviation Administration. Code of Federal Regulations Part 23, Amendments 23.1 – 23.46, Appendix F. May 7, 1994.

(18) Federal Aviation Administration. Aircraft Material Fire Test Handbook. FAA. Atlantic City, NJ. September, 1990.

(19) Flammability Tests. FAA AC23-2. August, 1984.

# APPENDIX A. APPROVED MATERIALS

All materials approved for use under this specification are listed in Table A.1 along with sources of supply. Alternative sources may be used but no substitutions for materials or finishes may be made without written approval from engineering. Approved interior laminates are listed in Table A.2.

**Table A.1 Approved Materials, Structural Laminates**

| Material | Product Designation | Supplier | Date Approved |
|---|---|---|---|
| **Structural Fabrics** | | | |
| Glass | | | |
| Carbon | | | |
| | | | |
| Resin | | | |
| Hardener | | | |

**Table A.2 Approved Interior Laminates**

| Laminate | Fire Resistance Level | Date Approved |
|---|---|---|
| TBD | TBD | TBD |

Additional data on approved materials are listed below.

1. TBD Resin.

   Approved Curing Agent Content:
   Nominal: TBD wt%  Min: TBD wt%  Max: TBD wt%

   Minimum: TBD  Maximum: TBD

   Approved FTIR Data, Resin and Hardener:
   TBD.

   HPLC data is to be collected only.

   Approved Cure Cycles:
   The Nominal Cure Cycle listed below should be followed. Any deviations within the limits defined by Under Cure Cycle or Over Cure Cycle are allowed.

   **Nominal Cure Cycle:**

   Individual instructions required for each material system, following the guidelines in Section 4.1.

   **Minimum Cure Cycle:**

   Individual instructions required for each material system, following the guidelines in Section 4.1.

   **Over Cure Cycle:**

Individual instructions required for each material system, following the guidelines in Section 4.1.

Material Data attached.

2. 7781 Glass Cloth

   TBD

3. 3K Plain Weave Carbon Cloth

   TBD