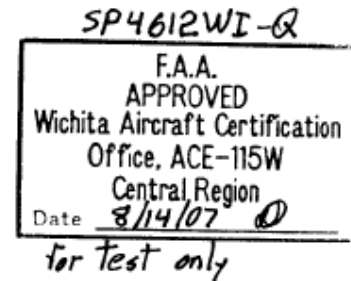




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NCAMP Process Specification

Fabrication of NMS 323 Qualification, Equivalency, and Acceptance Test Panels  
(Cytec Cycom 5215)



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## 1. SCOPE

This process specification describes the methods of fabricating test panels using Cycom 5215. Specifically, this specification covers prepreg cutting, layup, vacuum bagging, and curing process with a forced-air convection oven equipped with vacuum ports.

This specification does not contain all the necessary information typically required in a composite process specification for the fabrication of composite structures, such as personnel qualification and layup room requirements. Users should refer to their existing company process specification for such information. DOT/FAA/AR-02/110 provides guidance for the development of composite process specifications.

### 1.1 Purpose

The purpose of this process specification is to provide processing information for the fabrication of test panels for use in material qualification, equivalency, and acceptance testing. This process specification may also be used as a baseline by material users to develop a process specification for the fabrication of aerospace composite parts.

### 1.2 Health and Safety

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 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.

## 2. APPLICABLE DOCUMENTS

The following publications form a part of this specification to the extent specified herein. The latest issue of the NCAMP publications shall apply. The applicable issue of other publications shall 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 shall apply.

### 2.1 NCAMP Publications

NMS 323	Low Initial Temperature Vacuum-Bag-Only Cure, Modified Epoxy Prepregs
NTP 3223Q1	Material Property Data Acquisition and Qualification Test Plan For Cytec Cycom 5215 6K-135-5HS fabric with T650-36% RC

NTP 3223EX	[Panel Fabricator Name] Process Equivalency Test Plan For Cytec Cycom 5215 6K-135-5HS fabric with T650-36% RC
NTP 3623Q1	Material Property Data Acquisition and Qualification Test Plan For Cytec Cycom 5215 3K70PW fabric with T650-38% RC
NTP 3623EX	[Panel Fabricator Name] Process Equivalency Test Plan For Cytec Cycom 5215 3K70PW fabric with T650-38% RC
NTP 3668Q1	Material Property Data Acquisition and Qualification Test Plan For Cytec Cycom 5215 T40-800 Unitape Gr 145 RC 33%
NTP 3668EX	[Panel Fabricator Name] Process Equivalency Test Plan For Cytec Cycom 5215 T40-800 Unitape Gr 145 RC 33%

## 2.2 ISO Publications:

ISO 9000                      Quality Management Systems

## 2.3 US Government Publications:

DOT/FAA/AR-02/110      Guidelines for the Development of Process Specifications, Instructions, and Controls for the Fabrication of Fiber-Reinforced Polymer Composites

## 3. MATERIALS:

### 3.1 Vacuum bag, nylon film, 3 mils maximum, 375°F minimum use temperature

Sources:

- Airtech International, Inc., 5700 Skylab Road, Huntington Beach, CA 92647
- Or equivalent

### 3.2 Breather, 120 glass and 7781 glass

Sources:

- Any glass fabric supplier

### 3.3 Breather string, glass roving strings/threads, ECDE 75 1/0, any finish finish (may be extracted from 7781 style glass fabric).

Open source.

### 3.4 Solid FEP, separator/release film, 1 to 2 mils, 375°F minimum use temperature

Sources:

- Airtech International, Inc., 5700 Skylab Road, Huntington Beach, CA 92647
- Or equivalent

### 3.5 Boat Cloth, 3 – 4 inch wide fiberglass boat cloth, Style 1542

## Sources:

- Composites One, 11917 Altamar Place, Santa Fe Springs, CA 90670, tel: (800) 237-0087
- Or equivalent

**3.6 Pressure Plates, to be used on unidirectional laminates only**, 0.063 – 0.125 inch thick, aluminum, flat and smooth, or equivalent

**3.7 Tape**, Pressure Sensitive Mylar Tape 375°F minimum use temperature

## Sources:

- Keystone Tape, 3911 E. La Palma Ave., Suite V Anaheim, CA 92807
- Airtech International, Inc., 5700 Skylab Road, Huntington Beach, CA 92647
- Or equivalent

**3.8 Sealant tape**, compatible with nylon vacuum bag, 375°F minimum use temperature

## Sources:

- Airtech International, Inc., 5700 Skylab Road, Huntington Beach, CA 92647
- Or equivalent

**3.9 Mold** (bottom tool), 0.250 to 0.500 inch thick, aluminum, flat and smooth, or equivalent

**3.10 Release Agents**

- Frekote 44-NC, K.R. Anderson, Inc., 18330 Sutter Blvd. Morgan Hill, CA 95037

**3.11 Nonporous Teflon Coated Glass Fabric**, 3 mil

- Taconic, 3070 Skyway Drive, Bldg 203 Santa Maria, CA 93455
- Or equivalent

**3.12 Peel-ply**

- Airtech International, Inc., 5700 Skylab Road, Huntington Beach, CA 92647
- Or equivalent

## **4. TEST LAMINATE FABRICATION**

### **4.1 Prepreg cutting**

Wear non-contaminating gloves such as disposable powder-free nitrile gloves when handling the prepreg. The prepreg may be cut using conventional method (i.e. on a polyurethane table top with utility knife) or automated method. The method of cutting must not contaminate the prepreg. Fiber orientation (e.g. warp versus fill directions) must be maintained during the cutting process. All the panels have rectangular shapes; intended to help maintain warp and fill direction traceability.

### **4.2 Prepreg layup and bagging**

Wear non-contaminating gloves such as disposable powder-free nitrile gloves when

handling the prepreg. The panel layups (stacking sequences) for qualification and equivalency purposes should be in accordance with appropriate test plans. For material acceptance purpose, the panel layups should be in accordance with NMS 323.

In the case of materials which are not mid-plane symmetric, such as satin weave fabrics, plies must be orientated such as to give a mid-plane symmetric laminate as best as possible, as shown in Figure 1.

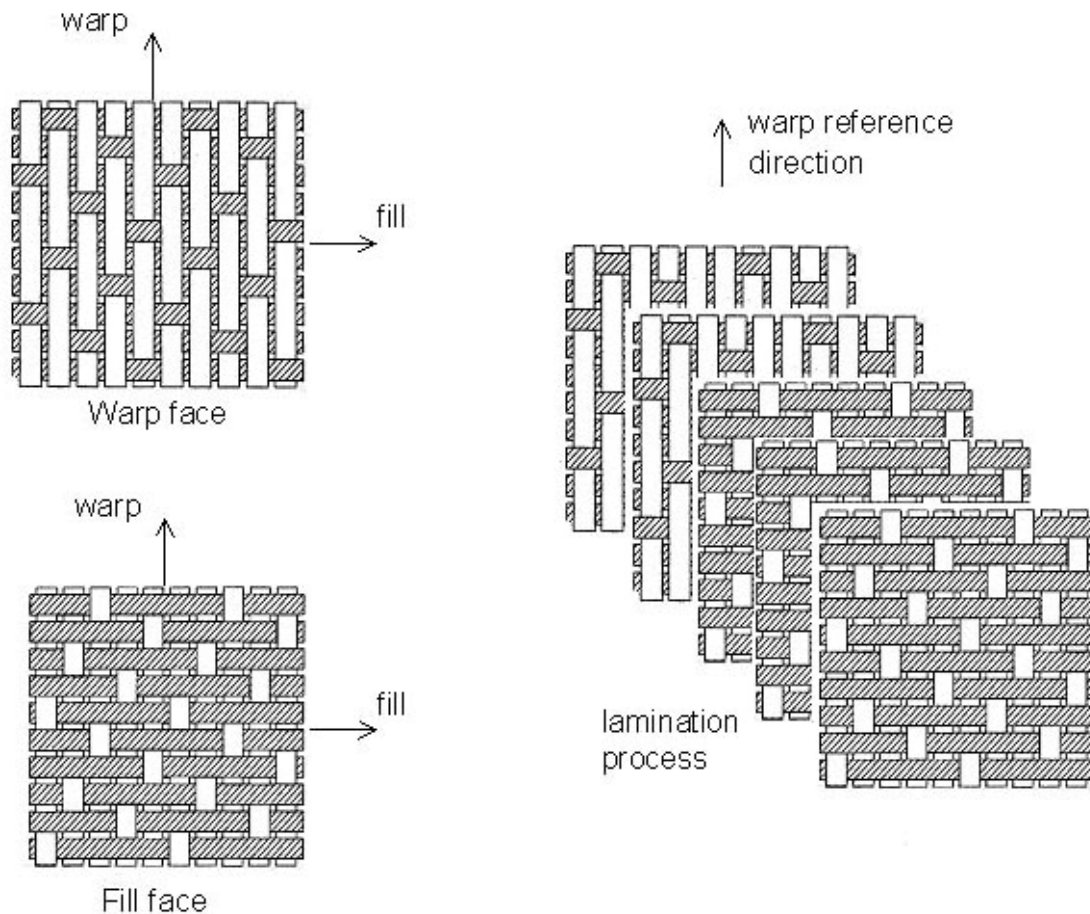


Figure 1 Example Satin Weave Showing Warp and Fill Faces Used for Ply Collation

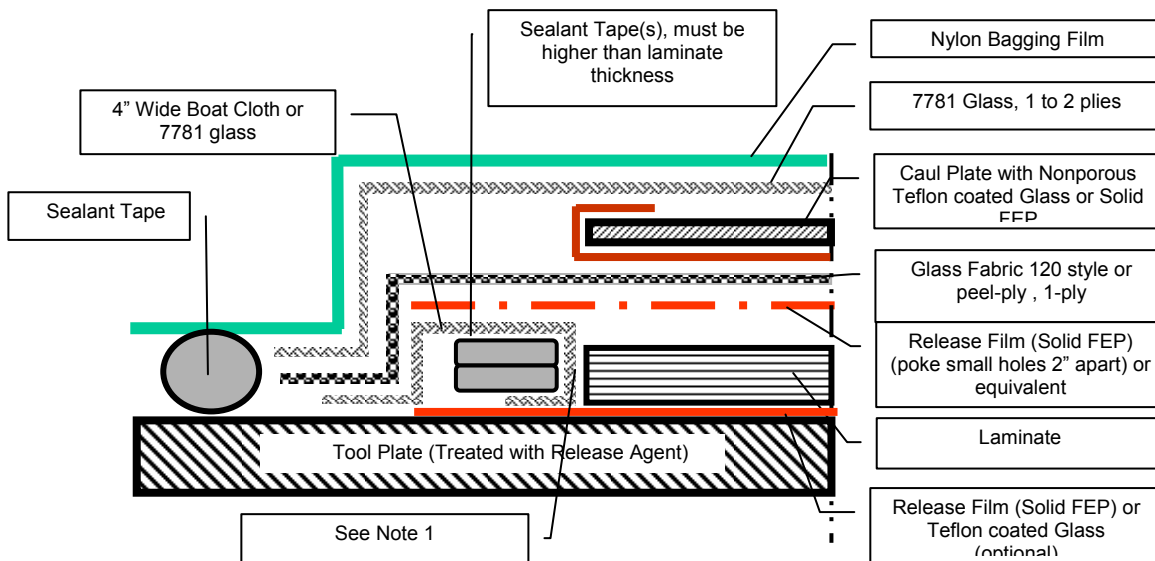
In order to maintain the fiber orientation, a reference edge should be created on each panel. During the layup process, each ply must be laid up within  $\pm 1$  degree of the reference edge. The edge dams around the layup/prepreg will form a straight edge on the cured panel (see Figure 2). In the layup of unidirectional prepreg, plies may be butt spliced in the  $90^\circ$  direction; ply splicing is not allowed in the  $0^\circ$  direction. Ply splicing is not allowed in the layup of woven fabric prepreg in any direction.

In material qualification and equivalency programs, for panel identification purpose, place a label within  $\frac{1}{2}$ -inch from the prepreg edge with the following information: " $0^\circ$  direction  $\rightarrow$ , Test Plan Document Number -Prepregger ID - Material Code - Fabricator ID - Test

Type - Batch ID - Cure Cycle ID -Test Panel ID.” Make sure that the “0° direction →” actually points in the 0° direction or warp direction. Appendix 2 of the test plan contains the panel identification information. Use a laser printer to print the labels on standard printer paper.

Figures 2 and 3 show the bagging arrangement which will be used for the manufacture of mechanical test panels from unitape and fabric prepregs, respectively. Thermocouple wires should be used to monitor and record the temperature of representative test panels. One method is to place the thermocouple junctions at the laminate mid-plane and near the edge of the laminate where they will be trimmed off after the panels have been cured. An alternative method is to place the thermocouple junctions in between the part and the caul plate (on the part but about 0.5 inch away from the edge). The latter method allows the thermocouples wires to be reused if the thermocouple junctions are wrapped with Teflon or flash-breaker tape so that they can be removed from the part after cure. Thermocouples may be placed outside the bag only if it has been previously demonstrated that there is negligible temperature difference between the inside and outside of the bag.

Release agents may be used on tool surface instead of non-porous FEP. Cork, silicone or any other type of stiff dam may be used instead of sealant tape and boat cloth as long as there are 3 – 4 glass breather strings against all the edges of the laminate between the dam and the laminate. The edge of the dams must be higher than the laminate thickness.



Notes:

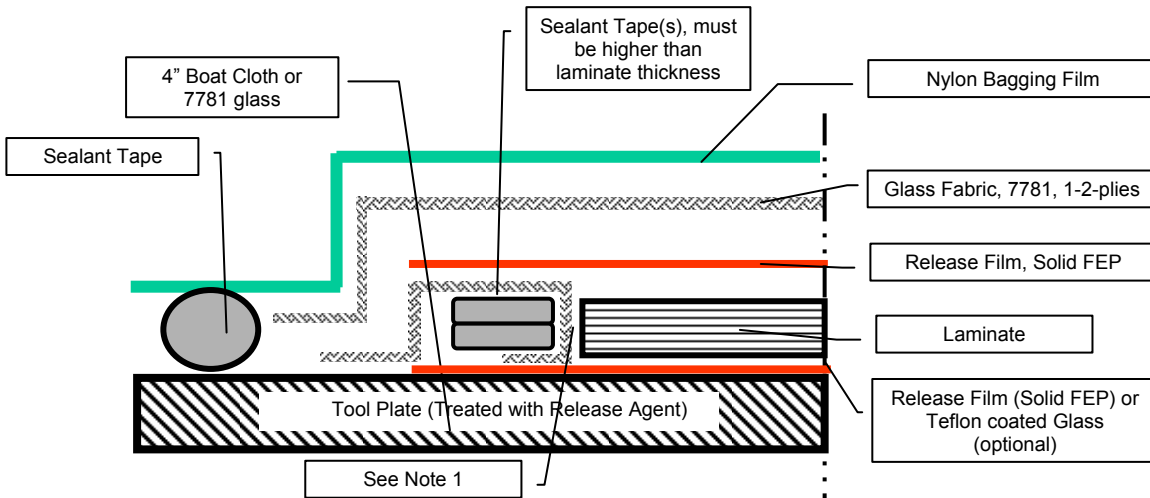
1. The sealant tape and boat cloth can be exchanged for cork, silicone or any other type of stiff dam as long as there are glass breather strings (3-4) against all the edges of the laminate. The breather strings should be placed on all edges between the dam and laminate.. The edge of the dams must be higher than the laminate thickness.
2. The tool and caul plate do not require a release film if it has been treated with a release.

For edge breathing arrangements, make sure that the dams around the laminate are higher than the laminate thickness. If not, additional sealant tapes should be added. Use the following as a reference.

Material	CPT	# of Plies	# of Sealant Tapes for Dam			
			1	2	3	4
5215 T40/800 145/33	0.0550	Ply #	< 16	17 – 32	33 – 48	> 49

**Figure 2 Bagging Technique for 5215 T40/800 145/33 49”**

**Bagging**



**Notes:**

1. The sealant tape and boat cloth can be exchanged for cork, silicone or any other type of stiff dam as long as there are glass breather strings (3-4) against all the edges of the laminate. The breather strings should be placed on all edges between the dam and laminate. The edge of the dams must be higher than the laminate thickness.
2. The tool does not require a release film if it has been treated with a release.

For edge breathing arrangements, make sure that the dams around the laminate must be higher than the laminate thickness. If not, additional sealant tapes should be added. Use the following as a reference.

Material	CPT	# of Plies	# of Sealant Tapes for Dam			
			1	2	3	4
5215 WT650 3K70PW	0.081	Ply #	< 8	9 - 16	17 - 25	> 26
5215 WT650 6K-5HS	0.0145	Ply #	< 6	7 - 12	13 - 18	> 18

**Figure 3 Bagging Technique for 5215 WT650 3K70PW 42” and 5215 WT650 6K-5HS 48”**

**4.3 Baseline Cure Cycle (C)**

The baseline cure cycle shall be in accordance with the following process. and Figure-4. For the purpose of specimen naming, this cure cycle is designated as “C.” The material qualification panels are processed in accordance with the baseline cure cycle. Check



vacuum bag integrity prior to starting cure cycle; leak rate shall not exceed 1 in.Hg in 2 minutes. All temperatures are part temperatures. Steps 1 through 7 are based on the lagging thermocouple.

1. Prior to curing the laminate, leak check the bag to ensure a good seal. No more than 1 in.Hg of vacuum over a 2 minute period allowed. Leak check by taking an initial reading after 2 minute isolation and then take a final reading after an additional 2 minutes. The difference between the 2 readings is the leak rate.
2. Apply full vacuum, within 3 in.Hg of the local atmospheric pressure (for example, apply a minimum of 21.7 in.Hg in most of Denver, Colorado where atmospheric pressure is 24.7 in.Hg). Hold at room temperature (R/T) under vacuum for a minimum of 4 hours.
3. Heat from R/T to 180 +/- 10 °F at 3 to 5 °F/minute based on the part temperature.
4. Hold at temperature for 120 -0/+20 minutes. Start the hold when the lagging thermocouple reaches 170 °F.
5. Heat from 180°F to 350 +/- 10 °F at 3 to 5 °F/minute.
6. Hold at temperature for 60-120 minutes. Start the hold when the lagging thermocouple reaches 340 °F.
7. Cool under vacuum to below 140 °F at 3 °F/minute maximum.

#### 4.4 Alternative Cure Cycles

Based on limited historical data, a resin cure kinetics model, and a viscosity model, the lamina and laminate material properties are believed to be robust to some minor changes in the cure cycle, although deviations from the baseline qualification cure cycle may increase the risk of equivalency failure. The cure cycle tolerance (i.e. upper and lower cure cycle envelope) has also not been thoroughly investigated. **Since not all properties are investigated in a typical equivalency program, users should not assume that successful equivalency demonstration also means that all other properties are equivalent; a more extensive test matrix that includes more test methods and test conditions may be necessary to thoroughly evaluate the true equivalency of the alternate cure cycle(s). Based on the popularity of the alternate cure cycle(s), NCAMP may perform more extensive testing to investigate the equivalency of the alternate cure cycle(s).**

Users who wish to use the alternate or any other cure cycles may contact NCAMP to have the cure cycles evaluated against the cure kinetics model and the viscosity model. This evaluation will provide a reasonable level of confidence about the similarities of the two cure cycles and may improve the chance of successful equivalency demonstration.

#### 4.5 Cured Panels

The reference edge created in section 4.2 should be clearly marked on each panel. This reference edge will be used as datum for subsequent machining process. Sharp edges should be removed from cured panels so that they can be handled and packaged safely. No more than 0.5-inch shall be removed inside of the original edge of the prepreg.

### 5. QUALITY ASSURANCE

**5.1 Process Control**

In-process monitoring data such as part temperature, oven temperature, vacuum, and part vacuum readings through the cycle should be in accordance with user’s applicable company process specification or an approved shop practice. For material qualification and equivalency purposes, the in-process monitoring data should be provided to the appropriate organizations in accordance with the applicable test plan. Process control testing is not required for the fabrication of test panels.

**5.2 Ultrasonic Non-Destructive Inspection**

Panel fabricator need not perform ultrasonic non-destructive inspection on the test panels. For material qualification and equivalency purposes, the panels may be ultrasonically inspected by the testing lab in accordance with the applicable test plan.

**5.3 Visual Inspection**

Verify that there is no obvious defect such as warpage and dry spots. Panels for material qualification and equivalency purposes should be labeled in accordance applicable test plan for identification purposes.

**6. SHIPPING**

For material qualification and equivalency purposes, it may be necessary to send the panels to a designated test lab. The panel shipping instruction is typically included in the applicable test plan.

**7. REVISIONS**

Revision	Date	Description
-	May 21, 2007	Initial Release
A	July 16, 2007	Added “See Note 1” to Figure 2 and Figure 3 to show the location of breather string