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NCAMP Process Specification

Fabrication of NMS 226 Qualification, Equivalency, and Acceptance Test Panels (Cytec Cycom 5250-5)

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1. SCOPE

This process specification describes the methods of fabricating test panels using Cycom 5250-5. Specifically, this specification covers prepreg cutting, layup, vacuum bagging, and curing process with an autoclave, followed by a free-standing post-cure in a forced-air convection oven.

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 226	375°F Autoclave cure, Bismaleimide Prepregs
NTP 2261Q1	Material Property Data Acquisition and Qualification Test Plan For Cytec Cycom 5250-5 T650/35 Unitape Gr 145 RC 32%

NTP 2261EX	[Panel Fabricator Name] Process Equivalency Test Plan For Cytec Cycom 5250-5 T650/35 Unitape Gr 145 RC 32%
NTP 2262Q1	Material Property Data Acquisition and Qualification Test Plan For Cytec Cycom 5250-5 6K5HS fabric with T650-35% RC
NTP 2262EX	[Panel Fabricator Name] Process Equivalency Test Plan For Cytec Cycom 5250-5 6K5HS fabric with T650-35% RC
NTP 2263Q1	Material Property Data Acquisition and Qualification Test Plan For Cytec Cycom 5250-5 3K70PW fabric with T650-36%vRC
NTP 2263EX	[Panel Fabricator Name] Process Equivalency Test Plan For Cytec Cycom 5250-5 3K70PW fabric with T650-36% RC

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, 375ºF 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.
Open source.

3.4 **Solid FEP, separator/release film**, 1 to 2 mils, 375ºF 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, 723 W. Algonquin Rd. Arlington Heights, Illinois USA 60005
- Or equivalent

3.6 Pressure Plates, to be used, 0.063 – 0.125 inch thick, aluminum, flat and smooth, or equivalent

3.7 Tape, Pressure Sensitive Mylar Tape 375ºF 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, 375ºF 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 PTFE Coated Glass Fabric, 3 or 5 mils thickness
- Taconic, 3070 Skyway Drive, Bldg 203 Santa Maria, CA 93455
- 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 226.

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.

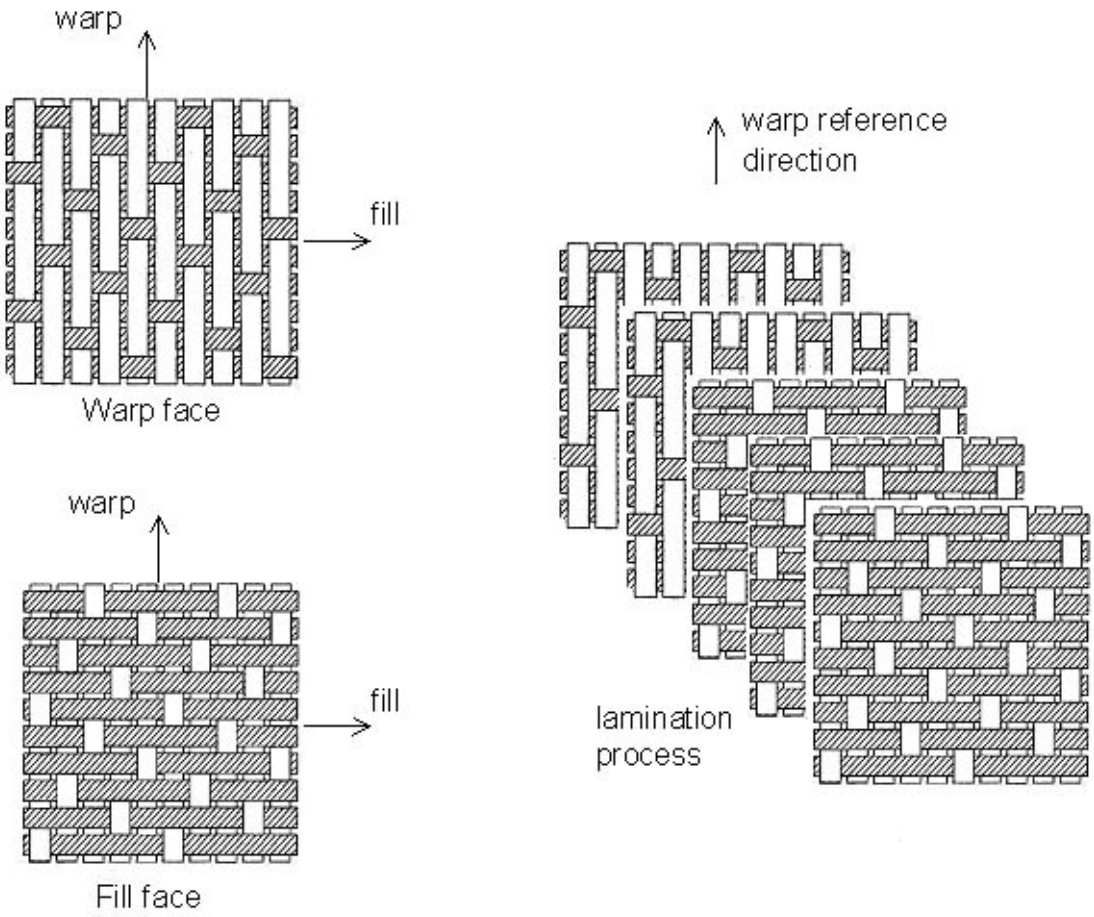


Figure 1 Example Satin Weave Showing Warp and Fill Faces Used for Ply Collation

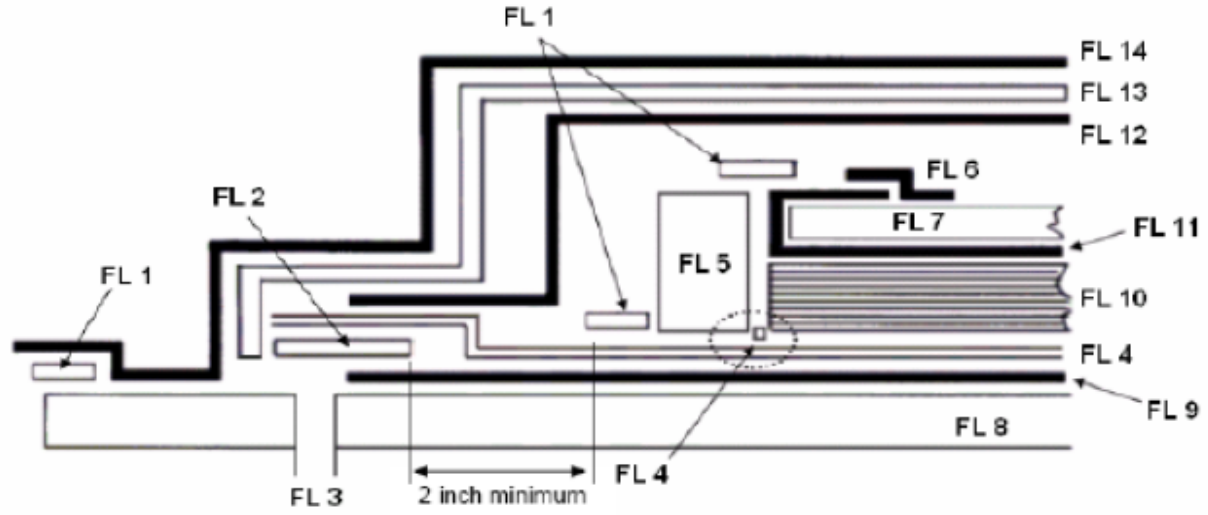
In order to maintain the fiber orientation, a reference edge should be created on each panel. During the layup process, each ply must be laid up within +/- 1 degree of the reference edge. The edge dams around the layup/prepreg will form a straight edge on the cured panel (see Figure 2). In the layup of unidirectional prepreg, plies may be butt spliced in the 90º direction; ply splicing is not allowed in the 0º 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 ½-inch from the prepreg edge with the following information: “0º direction →, Test Plan Document Number -Prepregger ID - Material Code - Fabricator ID - Test Type - Batch ID - Cure Cycle ID -Test Panel ID.” Make sure that the “0º direction →” actually points in the 0º 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 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.

BAGGING



FL1	Vacuum Sealer Tape
FL2	Edge Breather – Style 181 glass or polyester breather
FL3	Vacuum port
FL4	2 – 4 glass strings, placed around all edges of the part and extending to edge Breather
FL5	Edge Dam – Silicone rubber or equivalent. Place dam all around and butt next to the component
FL6	High temperature tape
FL7	Caul plate or pressure pad
FL8	Tool
FL9	Nonporous PTFE coated glass fabric, 3 or 5 mils thickness or parting agent applied to the tool
FL10	Component
FL11	Nonporous PTFE coated glass fabric, 3 or 5 mils thickness wrapped around to FL7 or parting agent applied to FL7
FL12	non-perforated fluorinated ethylene propylene (FEP) film in contact with edge breather
FL13	Breather – two plies of style 181 glass or 2 plies 10 oz non woven polyester
FL14	Nylon bag film, minimum of 2 mils thick

Figure 2 Bagging Procedure

Notes:

FL12 Non-perforated release film overlap 1 inch onto FL2 -2 inch edge breather to allow breather FL13 to come in contact with edge breather.

4.3 Baseline Cure Cycle (C)

The baseline cure cycle shall be in accordance with the following process. 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 8 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 vacuum at a minimum of 22 inches of Hg and 20 ± 5 Psi autoclave pressure. Heat up from Room Temperature to 250°F at a rate of 1° to 5°F per minute.
3. Vent vacuum pressure after autoclave pressure reaches 20 ± 5 Psi.
4. Once temperature reaches 250 ± 10°F, continue increasing the autoclave pressure to 85 ± 5 Psi.
5. Hold the 250°F ± 10°F temperature for 45 ± 5 minutes.
6. Heat from 250°F to 375 +/- 10 °F at 3 to 5 °F/minute.
7. Hold at 375 +/- 10 °F for 360 minutes. Start the hold when the lagging thermocouple reaches 365 °F.
8. Cool under pressure at 5ºF per minute until below ~~120ºF~~ 150ºF then release pressure.

Post cure: (Free standing in an air circulating oven)

1. Heat up RT to 450 ± 10°F. Ramp up at 3º F to 5°F per minute.
2. Hold at temperature for 360 minutes. Start the hold when the lagging part thermocouple reaches 440°F.
3. Cool down at 5°F per minute

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, autoclave/oven temperature, autoclave 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

Rev	Date	Description
-	6/13/07	Initial release
-	7/5/07	Change cure temperature from 350°F to 375°F and start the hold when lagging thermocouple reaches 365°F
-	8/27/07	Added "Start the hold when the lagging part thermocouple reaches 440°F" to section 4.3, post cure cycle step 2. Revised the sections 1, 4.3, and 5.1 for typo and clarity.
A	10/19/07	Section 4.3 Baseline Cure Cycle: Changed the following.

		Step 2. added the 20 Psi autoclave pressure Step 3. Corrected the unit PSI to Psi and remove the temperature hold. Step 4. Rephrased original procedure to clarify that increase in pressure is done at the start of dwell Step 5. The hold was removed from step 3 and placed after the step in increasing the autoclave pressure to conform to our procedure in the lab.
B	12/14/07	Revised Sec 4.2 Bagging. Changed FL9 and FL11 to specify 3 or 5 mils non-porous PTFE coated glass fabric to be used. Rename par 3.11, FL9, and FL11 from Solid parting film, use 3 or 5 mils nonporous armalon) Teflon coated release film to Nonporous PTFE coated glass fabric, 3 or 5 mils thickness.
C	7/23/08	Section 4.3 Baseline Cure Cycle: Initial cure, step 8. “Cool under pressure at 5ºF per minute until below ~~120ºF~~ 150ºF then release pressure.” This revision is approved by FAA DER Mr. Edwin Hooper through FAA Form 8110-3.