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NCAMP Process Specification
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Fabrication of NMS 250 Qualification, Equivalency, and Acceptance Test Panels (TenCate BT250E-6 prepregs)

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1. SCOPE

This process specification describes the methods of fabricating test panels using NMS 250 prepregs. Specifically, this specification covers prepreg cutting, layup, vacuum bagging, and curing process with an oven equipped with vacuum ports. In addition to the instructions contained in this specification, users are advised to obtain hands-on guidance directly from the prepreg manufacturer.

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. 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 Publication

NMS 250	NCAMP Material Specification for TenCate BT250E-6 Epoxy Prepregs

2.2 ISO Publication:

ISO 9000	Quality Management Systems

2.3 SAE Publication:

AS 9100	Quality Management Systems - Requirements for Aviation, Space and Defense Organizations

2.4 US Government Publication:

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 6 film, 3 mils, -80 to 400ºF
- Airtech International, Inc., 5700 Skylab Road, Huntington Beach, CA 92647
- De-Comp Composites Inc., RR4 Box 4460, Cleveland, OK 74020
- Or equivalent

3.2 Breather, 2.0 to 10 oz/yd^2, nonwoven polyester felt, or equivalent
- Airtech International, Inc., 5700 Skylab Road, Huntington Beach, CA 92647
- De-Comp Composites Inc., RR4 Box 4460, Cleveland, OK 74020
- Or equivalent

3.3 Breather string, glass roving strings/threads, any finish (may be extracted from 7781 style glass fabric)
- Open source

3.4 Solid FEP film, separator/release film, 1 to 2 mils thick, 375ºF minimum use temperature
- Airtech International, Inc., 5700 Skylab Road, Huntington Beach, CA 92647
- Or equivalent

3.6 Pressure (Caul) Plate, 0.125 – 0.2500 inch thick, flat and smooth. Aluminum, composites, or steel.
- Open source

3.7 Tape, Pressure Sensitive Flashbreaker Tape 375°F minimum use temperature
- D574 or equivalent #75 Blue Silicone, De-Comp Composites Inc., RR 4Box 4460, Cleveland, OK 74020
- Or equivalent

3.8 Tacky (Sealant) tape, Solid FEP, separator/release film, 1 to 2 mils, 375ºF minimum use temperature
- Airtech International, Inc., 5700 Skylab Road, Huntington Beach, CA 92647
- Or equivalent

3.9 Mold (bottom tool), 0.125-0.250 inch thick, aluminum, flat and smooth, or equivalent
- Open source

3.10 Release Agents, Frekote 700-NC
- K.R. Anderson Inc. 18330 Sutter Blvd., Morgan Hill, CA 95037
- Or equivalent

3.11 Peel-ply, Uncoated
- Airtech International Inc., 5700 Skylab Rod, Huntington Beach, CA 92647
- Or equivalent

4. TEST LAMINATE FABRICATION

4.1 Thawing rolled materials

Preimpregnated materials shall be allowed to warm to ambient temperature before opening bag. The materials shall be considered to be at ambient temperature when moisture no longer condenses on the outside of the bag. Rolled material may be left at ambient temperature in a sealed bag overnight for the following day's use. The material out-time shall be recorded on a cumulative out-time log.

All rolled material shall be supported horizontally at all times by the ends of the internal fiberboard tube. Rolled material shall not be allowed to rest against any surface, and shall not be allowed to rest in a vertical position. Rolled material may be momentarily rested against a surface or in a vertical position only while being transferred to or from storage.

NOTE: No form of applied or directed heat shall be used to accelerate the thawing process.

4.2 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 glass or non-contaminating polyurethane table top with utility knife) or automated method. The method of cutting must not contaminate the prepreg. **The prepreg shall be cut a minimum of ½" larger on each edge than the required panel dimensions.** Fiber orientation (e.g. warp versus fill directions) must be maintained during the cutting process. All the panels should have rectangular shapes; intended to help maintain warp and fill direction traceability.

4.3 Prepreg lay up 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 (see also associated reports). For material acceptance purpose, the panel layups should be in accordance with NMS 250.

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.

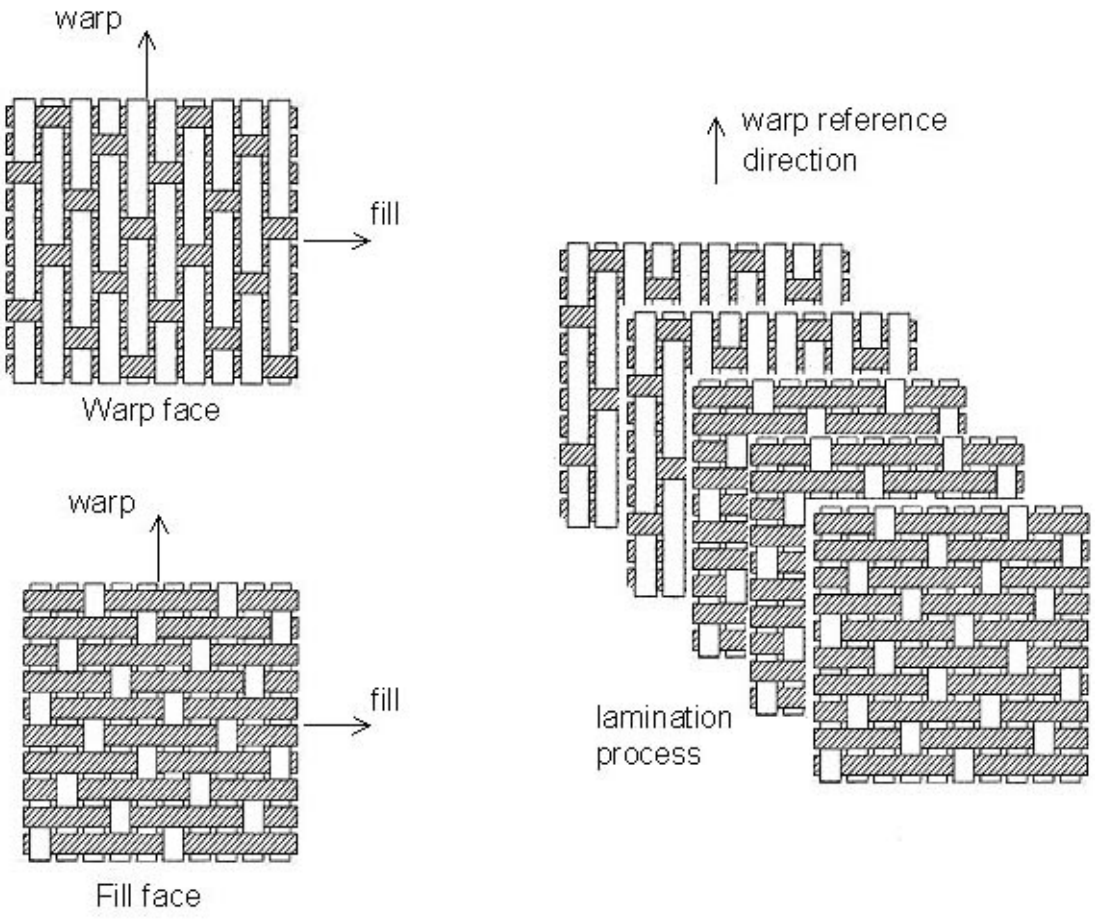

Figure 1 - Example Satin Weave Showing Warp and Fill Faces Used for Ply Collation

In order to maintain the fiber orientation, a reference edge should be indicated on each panel. Use a straight edge ruler/dam to ensure proper fiber orientation during layup. During the layup process, each ply must be laid up within ±5° for fabric, and ±3° for tape of the reference edge. In the layup process 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 →” marking is near to the reference edge and actually points in the 0º direction or warp direction. Use a laser printer or print the labels on standard printer paper.

Figure 2 shows the bagging arrangement which is used for the manufacture of mechanical test panels from unitape and fabric prepregs.

4.3.1 Reference Edge

One edge of each panel, perpendicular to the 0° direction, will be molded against aluminum or steel edge reference bar to facilitate sub panel and specimen cutting and machining.

4.3.2 Caul Plate

The caul sheet will contain scribe lines parallel to the 0° direction and will be butted against the edge reference bar. The caul sheet will not extend beyond the edge of the layup. If peel ply or 120 style glass is used in place of the caul sheet, breather shall not be placed directly over the part(s) so as to prevent “breather mark-off”.

4.3.3 Thermocouple

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 alternate method is to place the thermocouple junctions on the part. The latter method allows the thermocouple 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

4.3.4 Debulk

A pressure debulk shall be done every 4-7plies (based overall panel thickness) to help consolidate plies. Fabricate debulk bag similar to Figure 2. Breather strings are not required for debulks. It is recommended that a caul plate the same size of the laminate be used to prevent the edge of the laminate from curling.

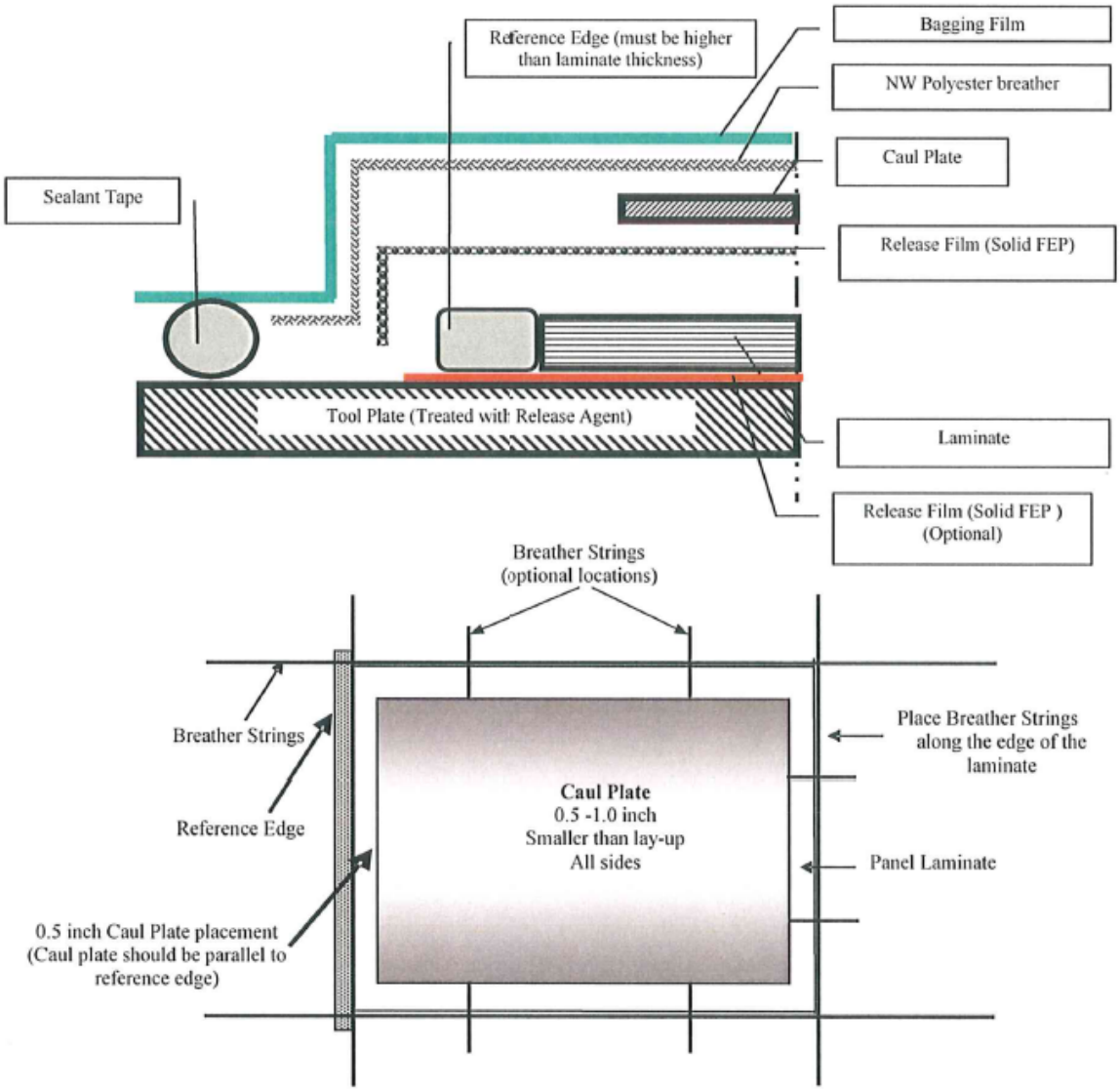

FIGURE 2. BAGGING TECHNIQUE

4.3 Baseline Cure Cycle (C)

The temperature cure cycle follows the cure profile described below and illustrated in Figure 3:

1. Insert the bagged layup into an oven not exceeding 120° F.
2. Connect vacuum line(s) and thermocouples.
3. Confirm thermocouples are functioning and applied vacuum meets the requirements of Section 4.3.3 and check for vacuum leak(s) per Section 4.5.
4. Maintain full vacuum of 22 inches Hg minimum throughout the cure.
5. Heat the oven to achieve the part temperature and ramp rate of 3°F±2°F (1.7°C±1.1°C) per minute to 250°F - 280°F (121°C – 138°C). Dwell the part temperature per for 120 – 150 minutes.
6. Cool the part(s) in the oven under full vacuum per <10°F (<6 °C) per minute to ambient or maximum part temperature of 120°F and demold.

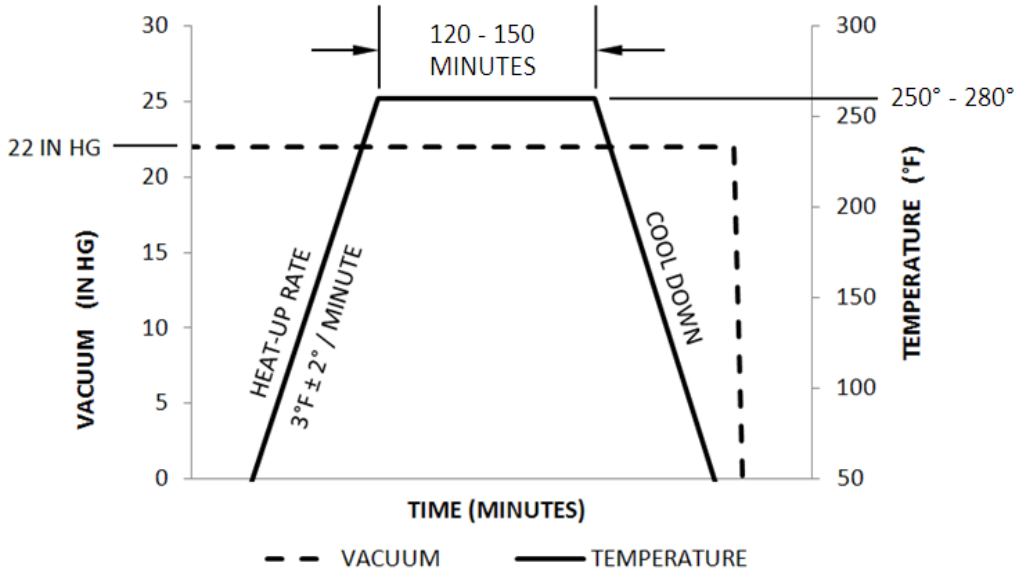

Figure 3 – Cure Cycle Profile

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 and TenCate 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.

Alternative cure cycles are feasible and may include the addition of positive pressure and/or the addition of interim temperature holds and temperature ramp rates. All alternative cures shall be qualified by appropriate equivalency testing.

4.5 Vacuum Requirements

The quality of vacuum, especially for final cure, has been found to have a profound effect on the quality of oven/vacuum bag cured laminates. The minimum required vacuum level

is 22” Hg under average conditions with an assumed ambient barometric pressure of 30” Hg. The requirement may be reduced for lower barometric pressure levels due to altitude or atmospheric conditions, the required vacuum gauge reading being reduced by the difference between the actual ambient barometric pressure and 30” Hg.

Tools larger than 3 ft^2 or longer than 5 feet shall have at least two vacuum connections at opposite ends or corners of the tool. Tools longer than 7 feet shall have at least one vacuum connection every 3 feet of tool length.

Prior to the start of the cure cycle, vacuum bag shall be checked for leak rate by applying full vacuum (minimum 22” Hg) then removing the vacuum source. The maximum leak rate of the bag shall not exceed five inches mercury (Hg) over a minimum five minute period as measured immediately after removing the vacuum source. It is recommended the vacuum gauge be located as far as possible from the vacuum source by a “dead end” gauge.

For vacuum bag cure processes, vacuum level shall be verified and recorded minimum at start and end of cure. An analog vacuum gauge located in line at the source manifold will suffice.

4.6 Cured Panels

The reference edge 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 inches shall be removed inside 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 before being cured as long as the panels are being fabricated in an approved controlled environment.

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 shall be ultrasonically inspected by the testing lab in accordance with the applicable test plan.

5.3 Visual Inspection

Verify that there are no obvious defects such as warpage or dry spots. Panels for

material qualification and equivalency purposes should be labeled in accordance with the 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 as specified in the applicable test plan. The panel shipping instruction should also be included in the applicable test plan.

7. REVISIONS

Revision	Date	Description
-	10/20/2017	Initial Release