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NCAMP Process Specification
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# Fabrication of NMS 4708 Qualification, Equivalency, and Acceptance Test Panels (Newport NB 4708)

NCAMP Project Number: NPN030901

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# 1. SCOPE

This process specification describes the methods of fabricating test panels using Newport's NB 4708 resin matrix. Specifically, this specification covers prepreg cutting, layup, vacuum bagging, and the curing process in 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. Refer to the MSDS for NB/NCT 4708 prepregs for additional information.

# 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 4708 | 265°F Cure High Performance Epoxy Prepregs |
| NTP 4708Q1 | Material Property Data Acquisition and Qualification Test Plan for Newport NCT 4708 MR60H G300 Unitape. |

| | |
|---|---|
| NTP 4708Q2 | Material Property Data Acquisition and Qualification Test Plan for Newport NCT 4708 MR40 G150 Unitape. |

**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
- National Aerospace Supply Co., 33155 Camino Capistrano, Unit C, San Juan Capistrano, CA 92675. (Distributor).

**3.2 Breather:** Style 7781 glass fabric, or Airweave® N-10
Sources:
- Any glass fabric supplier
- National Aerospace Supply Co.

**3.3 Breather string:** Glass roving strings/threads, any finish (e.g. 20 end S-2 strands, or strings may be extracted from 7781 style glass fabric).
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
- National Aerospace Supply Co.

**3.5 Boat Cloth:** 3 – 4 inch wide fiberglass boat cloth, Style 1542
Sources:
- Composites One, 11917 Altamar Place, Santa Fe Springs, CA 90670.

**3.6 Caul Plates** (Pressure Plates)**:** 0.04” thick, stainless steel, flat and smooth, or equivalent.

**3.7 Tape:** Pressure Sensitive Mylar or polyester 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
- National Aerospace Supply Co.
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**3.8 Sealant tape:** Compatible with nylon vacuum bag, 375ºF minimum use temperature
Sources:
- Airtech International, Inc., 5700 Skylab Road, Huntington Beach, CA 92647
- National Aerospace Supply Co.

**3.9 Tool Plate** (bottom tool)**:** 0.25" to 0.50" thick, aluminum, flat and smooth, or equivalent.

**3.10 Release Agent:** Frekote 44-NC, Manufactured by Henkel Corp.
Sources:
- K.R. Anderson, Inc., 18330 Sutter Blvd. Morgan Hill, CA 95037

**3.11 Porous Teflon Coated Glass Fabric:** 3 mils
Sources:
- Taconic, 3070 Skyway Drive, Bldg 203 Santa Maria, CA 93455
- National Aerospace Supply Co.

**3.12 Perforated FEP release film, 0.045" diam. hole size, 0.5"- 2" centers**
Sources:
- Airtech International, Inc., 5700 Skylab Road, Huntington Beach, CA 92647
- National Aerospace Supply Co.

**3.13 Tape,double sided:** Varying width, as required.
Sources: Any tape supplier.

**3.14 Peel Ply:** Release fabric, Bleeder Lease® B or similar.
Sources:
- Airtech International, Inc., 5700 Skylab Road, Huntington Beach, CA 92647
- National Aerospace Supply Co.

**3.15 Dams:** Red, silicone rubber, high temperature, ~0.5-1" in width, varying thicknesses.
Sources:
- McMaster-Carr Supply Co.

## 4. TEST LAMINATE FABRICATION

### 4.1 Prepreg cutting

Wear non-contaminating gloves such as disposable powder-free nitrile or latex gloves when handling the prepreg. The prepreg may be cut using a conventional method (i.e. on a polyurethane or glass table top with a utility knife) or an 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. Most of 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 or latex 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 4708.

**Removal of volatiles and entrapped air to minimize void content is essential in the manufacture of high quality laminates. This is especially critical for a vacuum bag-only cure process. As part of the panel layup process, a vacuum debulking technique should be used for 3-5 minutes after every 2 plies, preferably on a tool plate (with vacuum connection) to avoid constant transfer of the laminate stack to other debulking equipment. It is recommended to use porous Teflon coated glass and porous peel ply on both sides of the laminate during this process. Following completion of the bagging process, the laminate(s) should be kept under full vacuum for 1-4 hours (preferably overnight) prior to initiating the cure cycle.**

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.

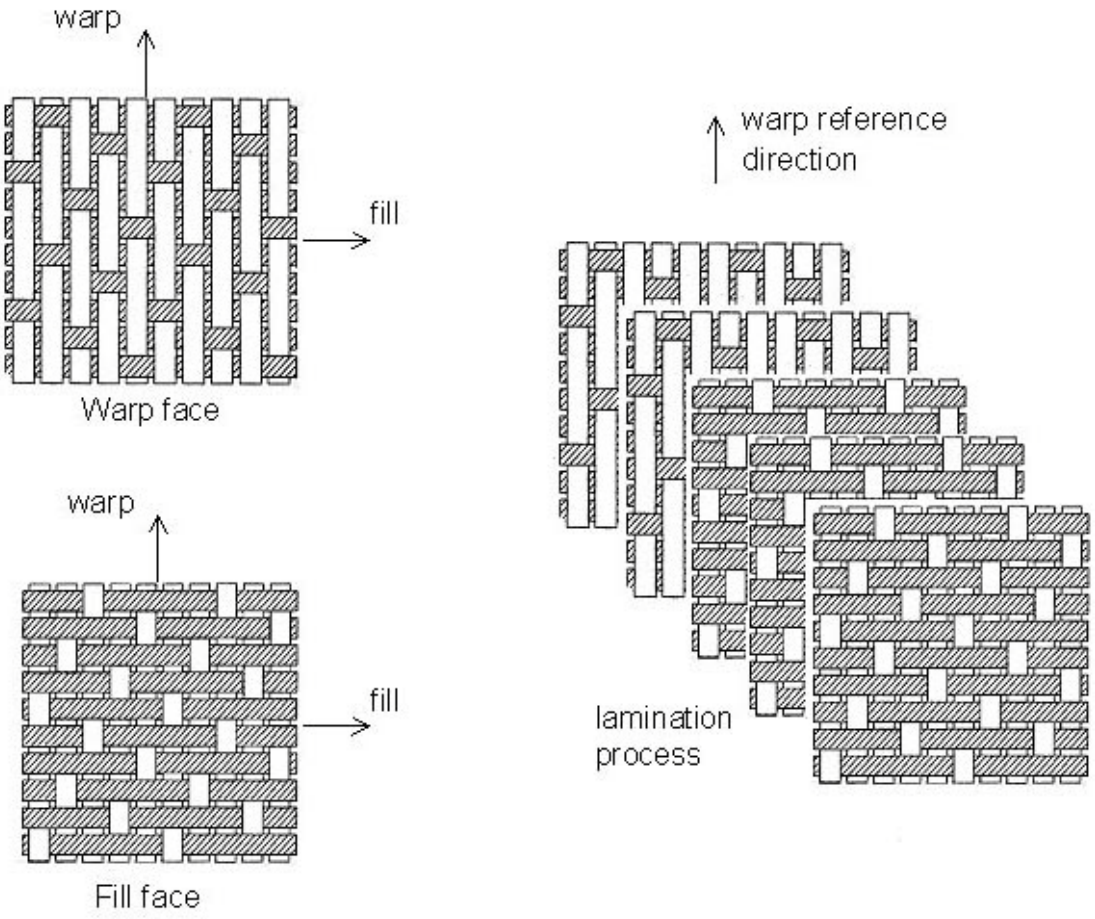



Figure 1. Example of Satin Weave Showing Warp and Fill Faces Used for Ply Collation

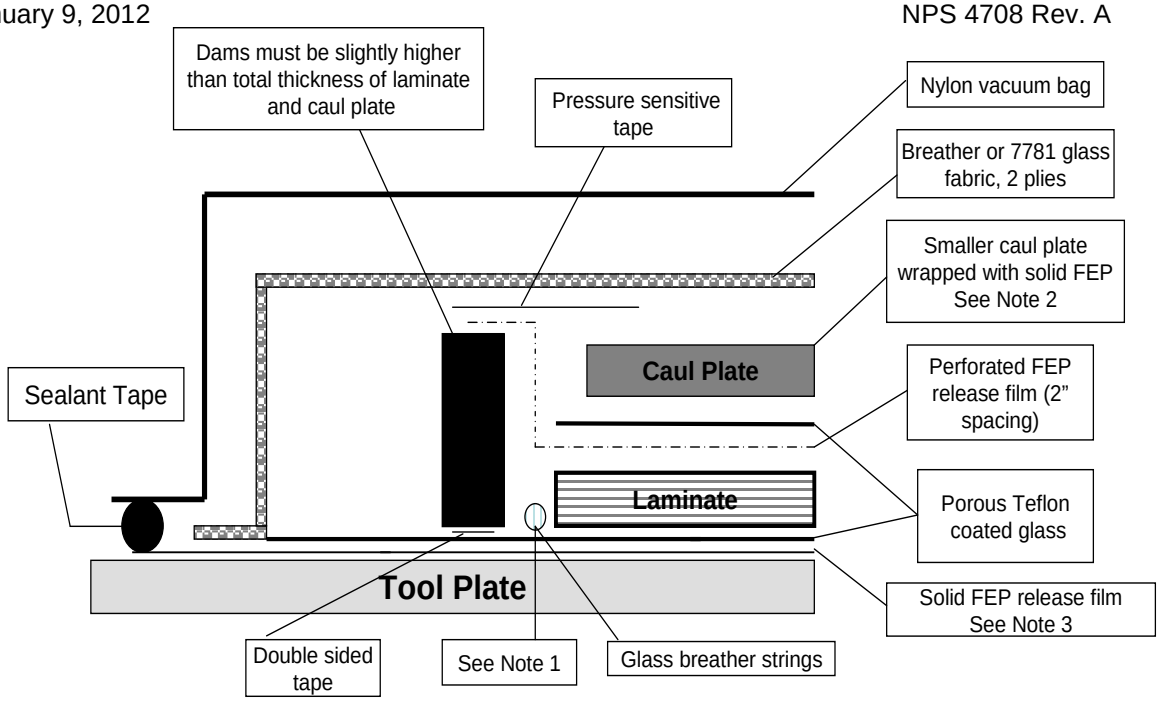
In order to maintain the fiber orientation, a reference edge should be created on each panel. During the layup process, each ply must be laid up within ± 1° of the reference edge. The edge dams around the layup/prepreg will form a straight edge on the cured panel (see Figure 2). In the layup of unidirectional 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 0.5" 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.

Figure 2 shows the bagging arrangement which will be used for the manufacture of mechanical test panels from unitape and fabric prepregs. 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" 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 the tool surface instead of non-porous FEP. Cork, silicone rubber (preferred) or any other type of stiff material may be used as dams. To facilitate removal of entrapped volatiles, they may be wrapped with 7781 glass/boat cloth or, preferably 3 – 4 glass breather strings may be placed against all edges of the laminate between the dam and the laminate. All breather strings must connect to the vacuum path. **The edge of the dams must be slightly higher than the total height of the laminate and the caul (pressure) plate.**

For optimum laminate quality, the caul (pressure) plate should be smaller than the actual laminate size by 0.25"-0.5" on each side. Recommended plates are stainless steel, of 0.04" (1 mm) thickness.




Notes:

1. Dams can consist of various materials (sealant tape, cork, other stiff materials, but silicone rubber is preferred). For volatile removal they can be wrapped with 7781 glass cloth, or alternatively, 3-4 glass breather strings can be placed against all edges between the dam and the laminate as shown in Fig.2. All materials must connect to the vacuum path. The edge of the dams must be slightly higher than the total thickness of the laminate and the caul (pressure) plate.
2. For optimum laminate quality, the caul (pressure) plate should be smaller than the actual laminate size by 0.25"-0.5" on each side. Recommended plates are made of stainless steel, 0.04" (1 mm) thick.
3. The tool does not require a release film if it has been treated with a release agent.

**Figure 2 Bagging Assembly for NB/NCT 4708 Prepregs**

## 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" Hg in 2 minutes. All temperatures are part temperatures. Steps 1 through 5 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" 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 two readings is the leak rate.
2. Apply full vacuum, within 1.5" Hg of the local atmospheric pressure. Hold at room temperature (RT) under vacuum for a minimum of 4 hours (preferably overnight).
3. Heat from RT to 265±10°F at 0.5 to 5°F/minute (depending on laminate thickness) based on the part temperature.
4. Hold at temperature for 120±10 minutes. Start the hold time when the lagging thermocouple reaches 255°F.
5. 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 an alternate cure cycle(s). Based on the popularity of an 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.

## 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

The panel fabricator need not perform ultrasonic non-destructive inspection on the test panels. For material qualification and equivalency purposes, the panels must 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 and 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.