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NCAMP Process Specification
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Fabrication of NMS 128 Qualification, Equivalency, and Acceptance Test Panels (for Hexcel 8552 and 8552S prepregs)

Prepared by: Yeow Ng, John Tomblin
Edited by: Michelle Man

Reviewed by: David Boll (Hexcel), Rick Cole (Bristol Aerospace Limited), Allison Crockett (NIAR), Susan Daggett (ATK), Jim Diepenbrock, Steve Ellery (Hexcel), Ed Hooper, Larry Ilcewicz (FAA), Erkan Kececi (Cessna), David Ostrodka (FAA), Anoush Poursartip (University of British Columbia), Engin Sabuncu (Cessna)

REVISIONS

Revision	Date	Description
-	2/5/2007	Initial Release
A	6/7/2007	Added clarification to section 1. Added the following to section 4.2: “During the layup process, each ply must be laid up within +/- 1 degree of the reference edge.” Added the following to section 4.5: “The reference edge created in section 4.2 should be clearly marked on each panel.” Sections 4.3 procedure (h), added “Remove from autoclave when autoclave temperature is less than 120°F”
B	4/14/2011	Changes were made to the cover sheet only: removed “for test only” note from the cover sheet and reformatted the cover sheet. No change was made to the content of this document.
C	3/06/2022	-Temperature tolerance in section 4.4.1 and 4.4.2 corrected to ±10°F (from ±5°F) -Revision block moved up from last section in document -Header on cover page updated to current NIAR header, and general editorial changes.

Table of Contents

1. SCOPE

This process specification describes the methods of fabricating test panels using NMS 128 material. Specifically, this specification covers prepreg cutting, layup, vacuum bagging, and curing process by an autoclave.

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 and SAE 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 128	350ºF Autoclave Cure, Low Flow Toughened Epoxy Prepregs
NTP 1628Q1	Material Property Data Acquisition and Qualification Test Plan For Hexcel 8552 AS4 Plain Weave Fabric Prepreg at 193 gsm 38% RC

NTP 1628EX	[Panel Fabricator Name] Process Equivalency Test Plan For Hexcel 8552 AS4 Plain Weave Fabric Prepreg at 193 gsm 38% RC
NTP 1828Q1	Material Property Data Acquisition and Qualification Test Plan For Hexcel 8552 IM7 Unidirectional Prepreg at 190 gsm & 35% RC
NTP 1828EX	[Fabricator Name] Process Equivalence Test Plan For Hexcel 8552 IM7 Unidirectional Prepreg at 190 gsm & 35% RC
NTP 1128Q1	Material Property Data Acquisition and Qualification Test Plan For Hexcel 8552 AS4 Unidirectional Prepreg at 190 gsm & 35% RC
NTP 1128EX	[Fabricator Name] Process Equivalence Test Plan For Hexcel 8552 AS4 Unidirectional Prepreg at 190 gsm & 35% 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

2.4 SAE Publications (available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096, http://www.sae.org):

AS9100	Quality Systems – Aerospace – Model for Quality Assurance in Design, Development, Production, Installation and Servicing

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
- Richmond Aircraft Products, Inc., 13503 Pumice St., Norwalk, CA 90650
- De-Comp Composites, Inc., RR 4 Box 4460, Cleveland, OK 74020
- Or equivalent

3.2 Breather, polyester mat (non-woven), 4 to 10 oz/sq.yd., 375ºF minimum use temperature
Sources:
- Airtech International, Inc., 5700 Skylab Road, Huntington Beach, CA 92647

- Richmond Aircraft Products, Inc., 13503 Pumice St., Norwalk, CA 90650
- De-Comp Composites, Inc., RR 4 Box 4460, Cleveland, OK 74020
- Or equivalent

3.3 Breather string (optional), glass or Kevlar roving strings/threads. For example, glass threads extracted from 7781 or 1581 style glass fabric in the fill direction. Open source.

3.4 Non-porous FEP, separator/release film, 1 to 2 mils, 375ºF minimum use temperature
Sources:

- Airtech International, Inc., 5700 Skylab Road, Huntington Beach, CA 92647
- Richmond Aircraft Products, Inc., 13503 Pumice St., Norwalk, CA 90650
- De-Comp Composites, Inc., RR 4 Box 4460, Cleveland, OK 74020
- Or equivalent

3.5 Silicone rubber dam, 375ºF minimum use temperature
Sources:

- Airtech International, Inc., 5700 Skylab Road, Huntington Beach, CA 92647
- Richmond Aircraft Products, Inc., 13503 Pumice St., Norwalk, CA 90650
- De-Comp Composites, Inc., RR 4 Box 4460, Cleveland, OK 74020
- Or equivalent

3.6 Caul plates, 0.125 to 0.375 inch thick, aluminum, flat and smooth, or equivalent

3.7 Tape, pressure sensitive, 375ºF minimum use temperature
Sources:

- Airtech International, Inc., 5700 Skylab Road, Huntington Beach, CA 92647
- Richmond Aircraft Products, Inc., 13503 Pumice St., Norwalk, CA 90650
- De-Comp Composites, Inc., RR 4 Box 4460, Cleveland, OK 74020
- 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
- Richmond Aircraft Products, Inc., 13503 Pumice St., Norwalk, CA 90650
- De-Comp Composites, Inc., RR 4 Box 4460, Cleveland, OK 74020
- 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, Loctite Corporation, 1001 Trout Brook Crossing, Rocky Hill, CT 06067-3910
- ZYVAX WaterSheild, P.O. Box 825, Boca Raton, FL 33429
- Or equivalent

3.11 Release Fabric (release coated peel-ply), to be used on 0-degree unidirectional tension panels (LT) only

- Bleeder Lease A, Airtech International, Inc., 5700 Skylab Road, Huntington Beach, CA 92647
- Release Ease 234 TFP, 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.

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 128.

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.

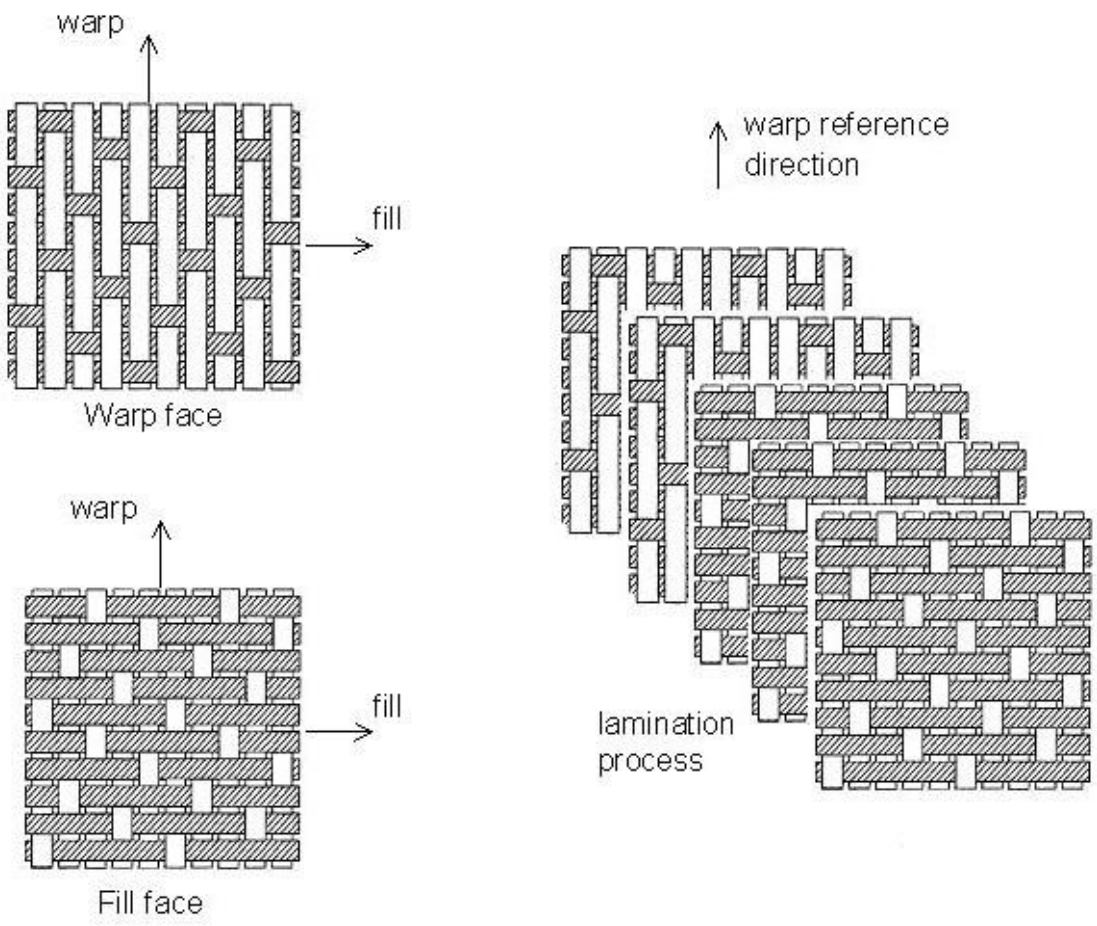


Figure 1 Example Satin Weave Showing Warp and Fill Faces Used for Ply Collation

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.

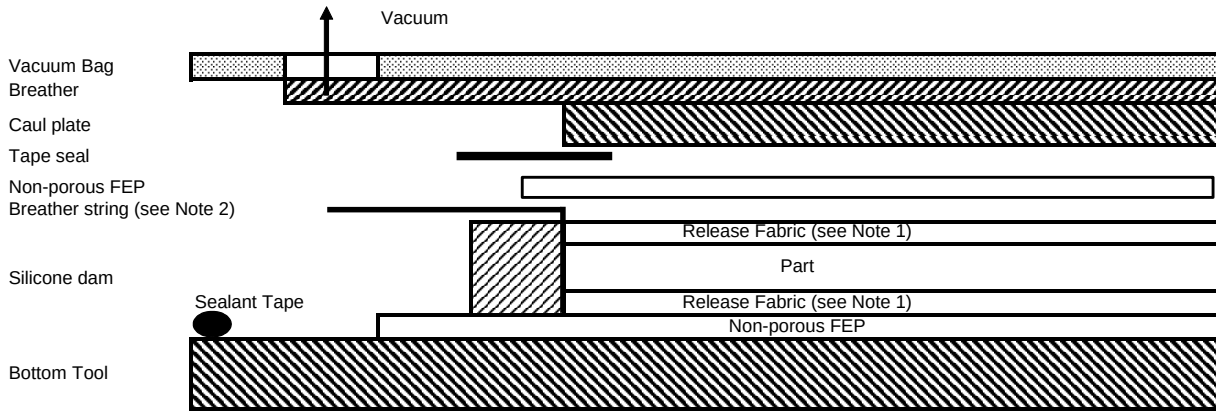
In material qualification and equivalency programs, for panel identification purpose, place a label within ½-inch from the prepreg edge with the following information: "0º direction →, Test Plan Document Number -Prepregger ID - Material Code - Fabricator ID - Test Type - Batch ID - Cure Cycle ID -Test 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.

Figure 2 shows the bagging arrangement which will be used for the manufacture of mechanical test panels. 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. Metal edge dams may be used instead of silicone dams.

Recommended Bagging Sequence (General)



Note 1: Release fabric is to be used on 0-degree unidirectional tension (longitudinal tension, LT) panels only.
Note 2: The breather string must be in the edge of the part, not layed on the top of the panel and must extend out past the seal to touch the breather pad material as shown below

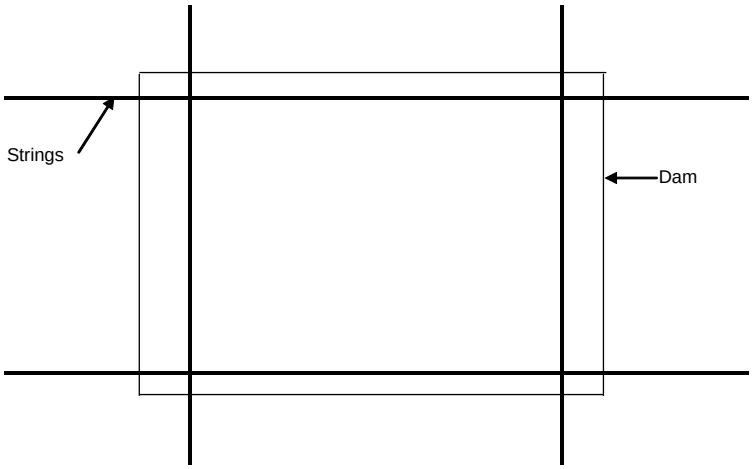


Figure 2 Bagging Technique

4.3 Baseline/Medium Cure Cycle (M)

The baseline/medium cure cycle shall be in accordance with the following process and Figure 3. For the purpose of specimen naming, this cure cycle is designated as “M.” 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 5 in.Hg in 5 minutes. All temperatures are part temperatures. Steps a through f are based on leading thermocouple, except step e is based on lagging thermocouple.

a. Pull vacuum (min 22 in Hg)
b. Heat at 1 to 8°F/min (4.5 °F/min nominal) to 355±10ºF and ramp autoclave pressure to 85-100 psig.
c. Before temperature reaches 140°F and when autoclave pressure is 20±10 psig, vent vacuum bag to atmosphere
d. From 325°F to 355±10ºF a minimum heat-up rate of 0.3 °F/min is acceptable.
e. Hold 355±10ºF for 120+60/-0 min
f. Cool down rates from cure temperature to 150°F shall be no more than 10ºF/minute.
g. Release autoclave pressure when lagging thermocouple is below 150°F or minimum 1 hour into cool down, whichever occurs sooner.
h. Remove from autoclave when autoclave temperature is less than 120°F

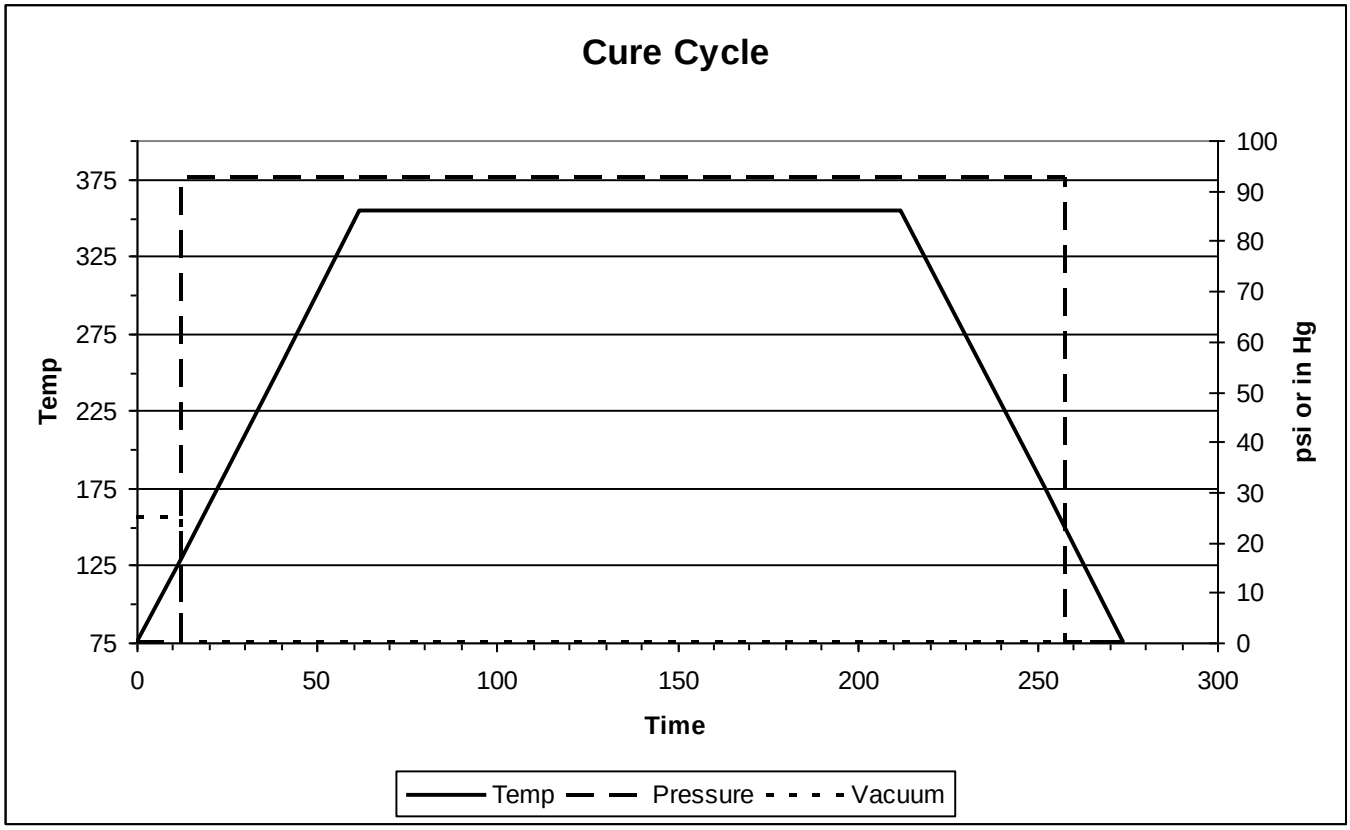


Figure 3 Baseline/Model Cure Cycle for Test Panel Fabrication

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 nominal qualification cure cycle may increase the risk of equivalency failure. The cure process as shown in Figure 4 and 5 have been used for this material system although full equivalency demonstration to the baseline cure cycle has never been attempted. 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.

4.4.1 Alternate 1 Cure cycle (unverified) (AH)

The cure process should be in accordance with the following process and Figure 4. For the purpose of specimen naming, this alternate high pressure cure cycle is designated as “AH.” Check vacuum bag integrity prior to starting cure cycle; leak rate shall not exceed 5 in.Hg in 5 minutes. All temperatures (except step h) are part temperatures. Steps a through e are based on leading thermocouple, step f based on lagging thermocouple.

a. Pull vacuum (min 22 in Hg) and apply 15±5 psig autoclave pressure
b. Heat at 1 to 5°F/min to 225°±10ºF
c. Hold 225°±10ºF for 60±10 min
d. At the end of the 225°±10ºF hold, bring autoclave to 100±10 psig - vent vacuum when pressure is 30 ± 5 psig
e. Heat at 1 to 5°F/min to 350°±10ºF
f. Hold 350°±10ºF for 120+20/-0 min
g. Cool at 5 to 7°F/min to 150°F and vent pressure when temperature reaches 150°F
h. Remove from autoclave when autoclave temperature is less than 120°F

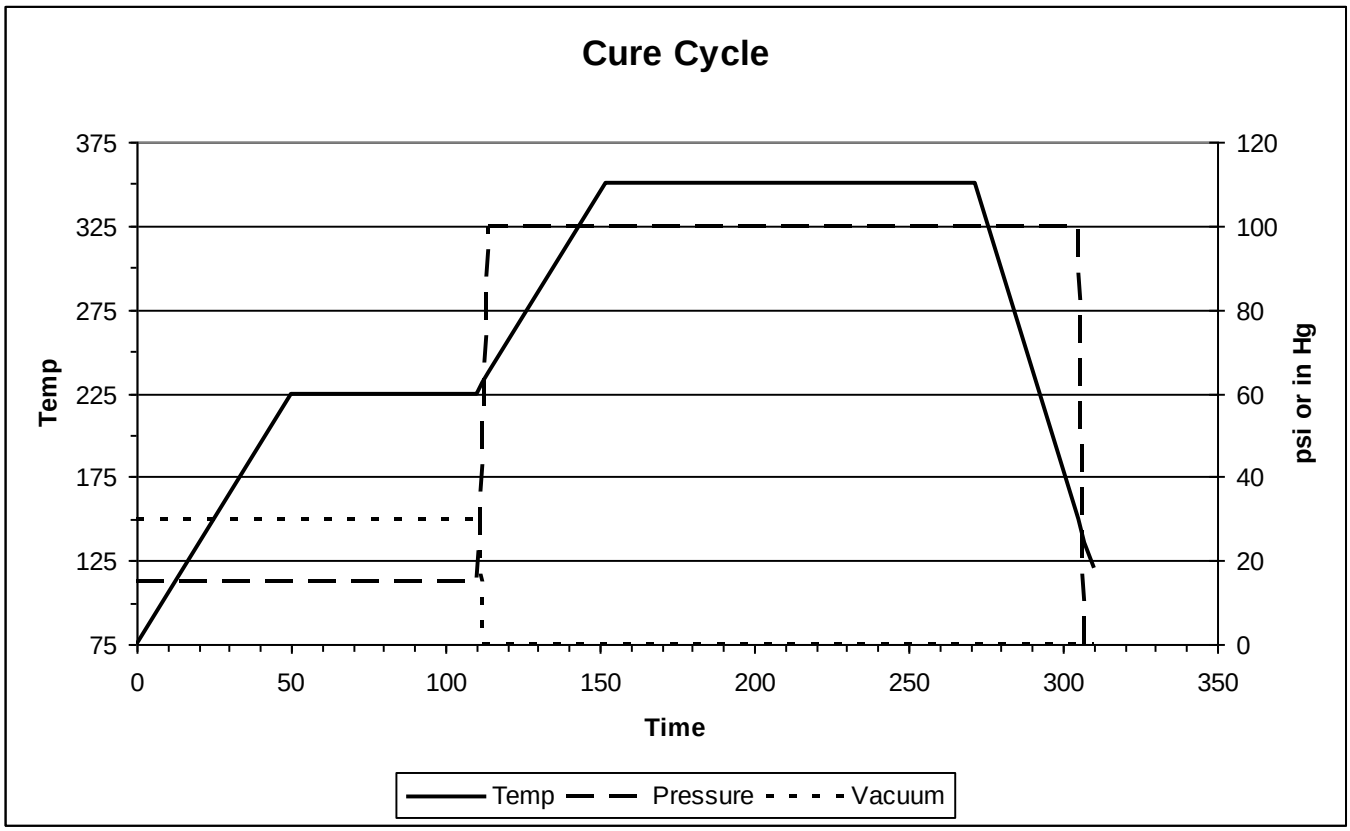


Figure 4 Alternate 1 Cure Cycle for Test Panel Fabrication

4.4.2 Alternate 2 Cure cycle (unverified) (AL)

The cure process should be in accordance with the following process and Figure 5. For the purpose of specimen naming, this alternate low pressure cure cycle is designated as "AL." Check vacuum bag integrity prior to starting cure cycle; leak rate shall not exceed 5 in.Hg in 5 minutes. All temperatures (except step h) are part temperatures. Steps a through e are based on leading thermocouple, step f based on lagging thermocouple.

a. Pull vacuum (min 22 in Hg) and apply 15 ± 5 psig autoclave pressure
b. Heat at 1 to 5°F/min to 225°±10ºF
c. Hold 225°±10ºF for 60±10 min
d. At the end of the 225°±10ºF hold, bring autoclave to 45±10 psig - vent vacuum when pressure is 25 ± 5 psig
e. Heat at 1 to 5°F/min to 350°±10ºF
f. Hold 350°±10ºF for 120+20/-0 min
g. Cool at 5 to 7°F/min to 150°F and vent pressure when temperature reaches 150°F
h. Remove from autoclave when autoclave temperature is less than 120°F

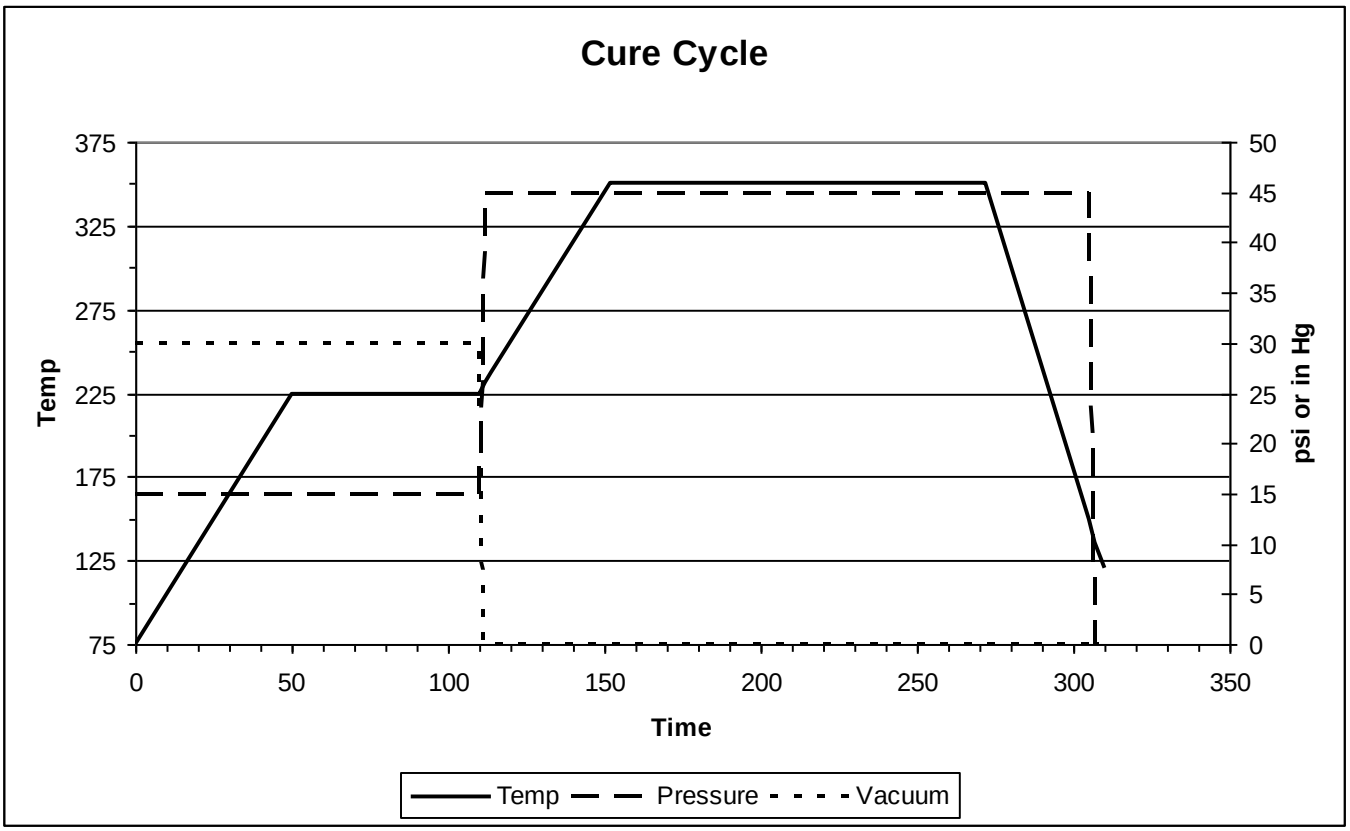


Figure 5 Alternate 2 Cure Cycle for Test Panel Fabrication

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 temperature, autoclave pressure, autoclave vacuum, and part vacuum readings through the cycle, if available, must be provided to NCAMP together with the fabricated panels. Process control testing is not required.

5.2 Ultrasonic Non-Destructive Inspection

Panel fabricator need not perform ultrasonic non-destructive inspection. The panels will be ultrasonically inspected by NCAMP.

5.3 Visual Inspection

Verify that each panel has a panel identification label. Verify that there is no obvious defect such as warpage and dry spots.

6. SHIPPING (FOR NCAMP SPONSORED QUALIFICATION AND EQUIVALENCY PROGRAMS ONLY)

Prior to shipping the panels, verify the following:

- The appropriate sections in the “Panel Data” sheet of PMC_Data_Collection_Template.xls file has been completed.
- In-process monitoring data such as part temperature, autoclave temperature, autoclave pressure, autoclave vacuum, and part vacuum readings, preferably in electronic format, is included
- FAA conformity record (if needed), is included.
- The panel names match the names listed in Appendix 2 of the test plan

Send the panels along with the in-process monitoring data and FAA conformity records to:

Wichita State University
NIAR NCAMP, Attn: Royal Lovingfoss
1845 Fairmount Ave.
Wichita, KS 67260-0093
USA
Tel: 316-978-5317