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NCAMP Process Specification
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Fabrication of NMS 397 Qualification, Equivalency, and Acceptance Test Panels

Toray Composite Materials America, Inc. 3960 prepregs

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REVISIONS

Revision	Date	Description
-	3/30/2020	Initial Release
A	9/9/2020	Section 3 – Edge Dam is added. Section 3.2 – Airtech breather is added. Section 4.2 (Figure 2) – Bagging scheme is updated revised to incorporate optional edge dam Section 4.2 – Thermocouple section was re-organized. Section 4.2 “Procedure” was revised. Section 4.3 (1) – Revised to reference Section 4.2(j). Section 4.4.1 – Designated Cure “O” was added. Section 4.4.1 (1) – Added to reference Section 4.2(j). All - “shall” was replaced with “must”.
A	9/10/2025	Cover Page: Distribution statement was revised from “This document is intended for proprietary use and will be distributed at the discretion of Toray Composite Materials America until such a time that it is decided the data and reports can be released for public distribution.” to “Distribution Statement A. Approved for public release; distribution is unlimited.” This is approved by Toray CMA. Revisions Table were moved to the beginning of the document.

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1. SCOPE

This process specification describes the methods of fabricating test panels using NMS 397 prepregs. Specifically, this specification covers prepreg cutting, layup, vacuum bagging, and curing process with an autoclave 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 must apply. When a referenced document has been canceled and no superseding document has been specified, the last published issue of that document must apply.

2.1 NCAMP Publication

NMS 397	High Toughness and High Tensile Performance Epoxy Prepregs

2.2 ISO Publication:

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

2.3 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 (Film), IPPLON KM1300 2mil, qualified for use at 375ºF or above, or equivalent
- Airtech International, Inc., 5700 Skylab Road, Huntington Beach, CA 92647
- Or equivalent

3.2 Breather, Polyspun 2.1OZ or equivalent
- Filtration Systems, 8506 Herrington CT, Pevely, MO 63070
- N10 (10oz/yards) polyester, Airtech – *if caul plate is utilized.*
- Or equivalent

3.3 Breather String, T30M, or glass roving or equivalent
- Hexcel, or open source glass roving, 281 Tresser Blvd Stamford, CT 06901
- Or equivalent

3.4 Solid FEP (Film), A4000V220300, qualified for use at 375ºF or above
- Airtech International, Inc., 5700 Skylab Road, Huntington Beach, CA 92647
- Or equivalent

3.5 Pressure (Caul) Plate, aluminum, composite or steel, flat and smooth, or equivalent
- Open source

3.6 Edge Dam
- Tacky (Sealant) tape (refer to Section 3.7)
- Silicone Rubber with Shore A hardness of 60 (typical, or equivalent) rated at 400°F (open source)
- Solid piece of wood wrapped in Teflon tape: Saint-Gobain CHR 2285 High Modulus PTFE pressure sensitive tape (or equivalent)
- Aluminum bar (open source)

3.7 Mylar Tape, Flashbreaker 2 Tape for use at 375ºF or above
- Airtech International, Inc., 5700 Skylab Road, Huntington Beach, CA 92647
- Or equivalent

3.8 Tacky (Sealant) tape, 51271642, 1/8” x ½”, qualified for use at 375ºF or above
- ITW Polymer Sealants North America, 111 S. Nursery Road Irving, TX 75060
- Or equivalent

3.9 Mold (bottom tool), 0.125 - 0.35 inch thick flat aluminum, composite or steel, flat and

smooth, or equivalent
- Open source

3.10 Release Agents, Frekote 44-NC, Frekote 55-NC, Frekote 700-NC
- Henkel, One Henkel Way, Rocky Hill, CT 06067
- 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 glass or non-contaminating polyurethane table top with utility knife) or automated method. The method of cutting must not contaminate the prepreg. **The prepreg must be cut a minimum of 1" larger on each edge than the required panel dimensions. The required panel dimensions are specified in Appendix 2 of applicable test plan or work instruction.** Fiber orientation (e.g. warp versus fill directions) must be maintained during the cutting process. In Appendix 2 of applicable test plan, the flat panels will always be rectangular; this rectangular shape helps maintain direction traceability.

4.2 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 Appendix 2 of appropriate test plans. For material acceptance purpose, the panel layups should be in accordance with NMS 397.

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.

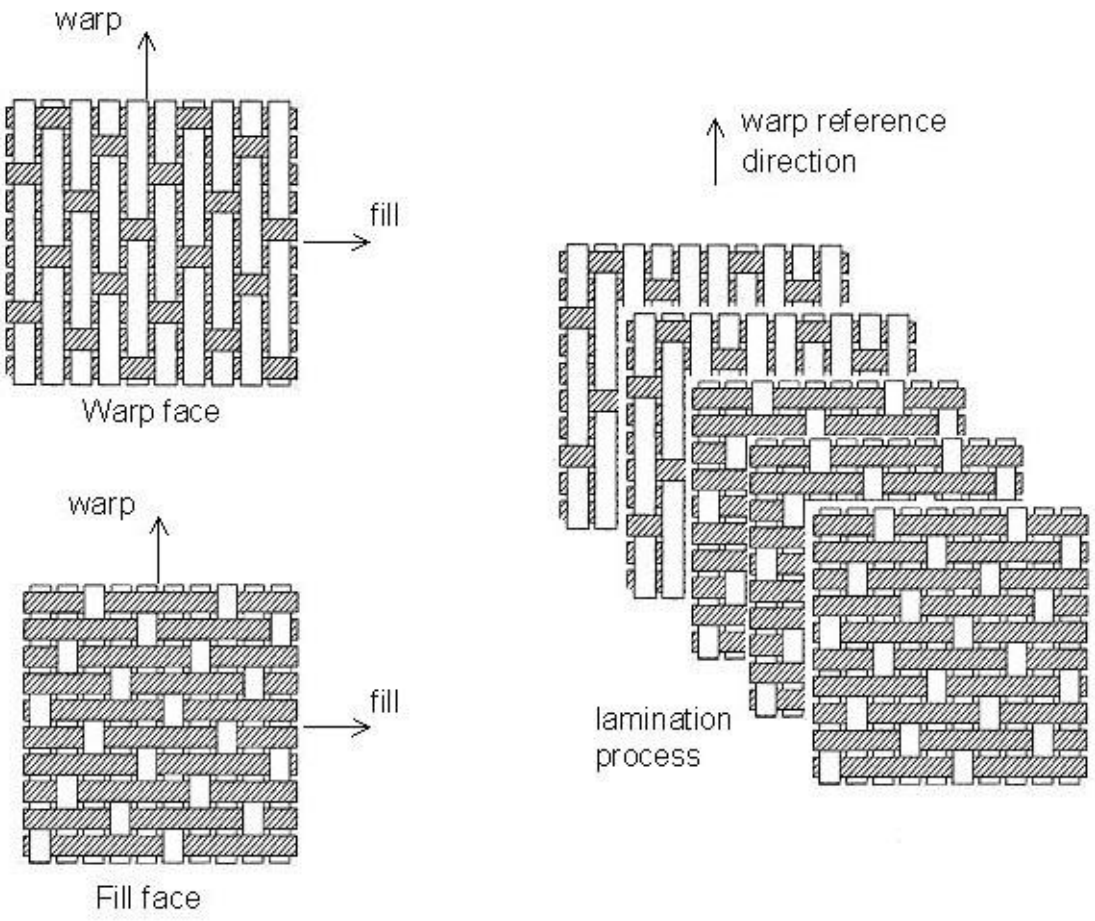


Figure 1 - Example Satin Weave Showing Warp and Fill Faces Used for Ply Collation

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. Appendix 2 of the test plan contains the panel identification information.

A minimum of two thermocouple wires should be used to monitor and record the panel temperature of each cure cycle run. 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 on the part about 0.25-0.50 inch away from the edge. The latter method allows

the thermocouples wires to be reused if the thermocouple junctions are wrapped with Teflon or Mylar 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.

Procedure:

Figure 2 shows the bagging arrangement which will be used for the manufacture of mechanical test panels.

a. Place a solid FEP film on the mold. Liquid release agent may be applied on the mold in lieu of the solid FEP film.
b. Place a straight edge ruler/dam on the mold/layup surface and secure it with tape. Begin laying up in accordance with the proper stacking sequences (see Appendix 2 of test plan or appropriate specifications), making sure that each ply is butt against the edge ruler/dam and thermocouples are placed in the panels as necessary.
c. Place edge breather, 2mm (breather string) wide glass yarn along the two edges of the prepreg laminate.
d. (Optional) If lay-up is done on a separate surface from the mold, transfer the panel to the mold and place edge dam if necessary.
e. (Optional) If lay-up is done directly on the mold, remove edge ruler/dam from the mold if necessary.
f. Place a solid FEP film over the prepreg layup.
g. (Optional) Place a caul plate on the solid FEP film.
h. Place a layer of surface breather over the entire lay-up.
i. Place a layer of vacuum bag film over the entire surface breather.
j. While applying vacuum to the bag, make sure that there is sufficient solid FEP film, breather, and vacuum bag to conform over the uneven surfaces to avoid bridging in the bag. Apply a minimum vacuum of 28” of Hg (or within 2” of Hg of the local atmospheric pressure) and hold the layup under vacuum for a minimum of 5 minutes. Isolate the system by closing the vacuum source valve. Leak check by taking an initial reading after 5 minutes of isolation and then take a final reading after an additional 5 minutes. The difference between the two readings is the leak rate. The vacuum must not fall more than 2” of Hg (6.77 kPa) in 5 minutes. If this rate is exceeded, repair the leak and recheck the leak rate.

Note: it is recommended to use caul plate in Step f when edge ruler/dam in Step d is utilized. However, caul plate (Step f) may be utilized without edge ruler/dam (Step d) depending on the panel complexities such as ILT angle panels.

Note: it is recommended to debulk every 3-4 plies.

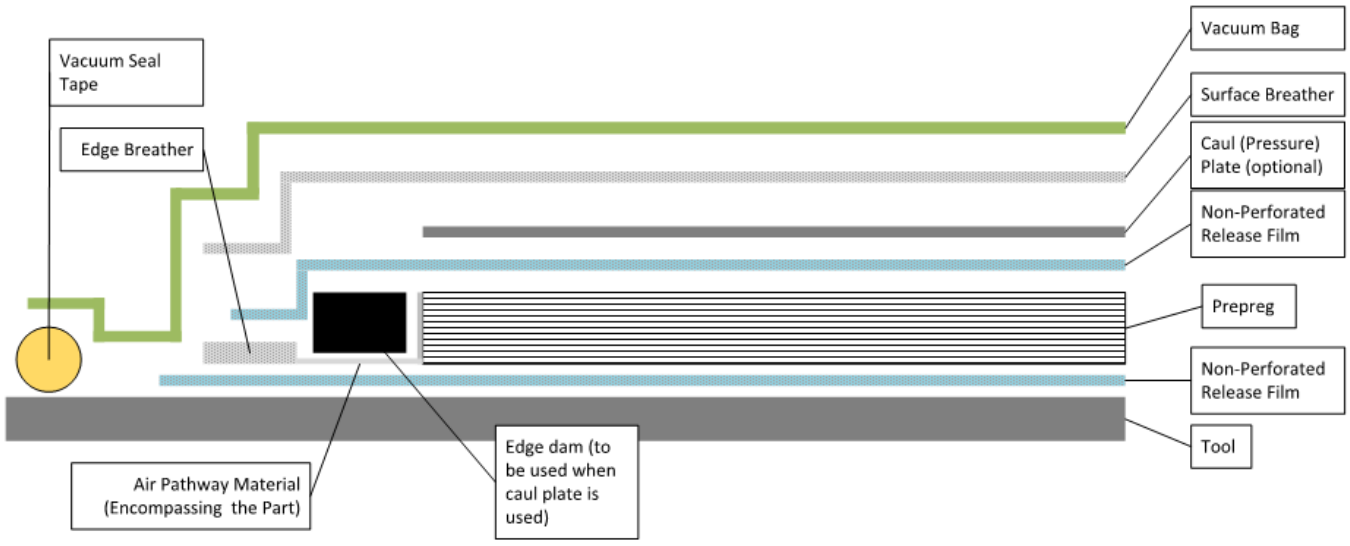
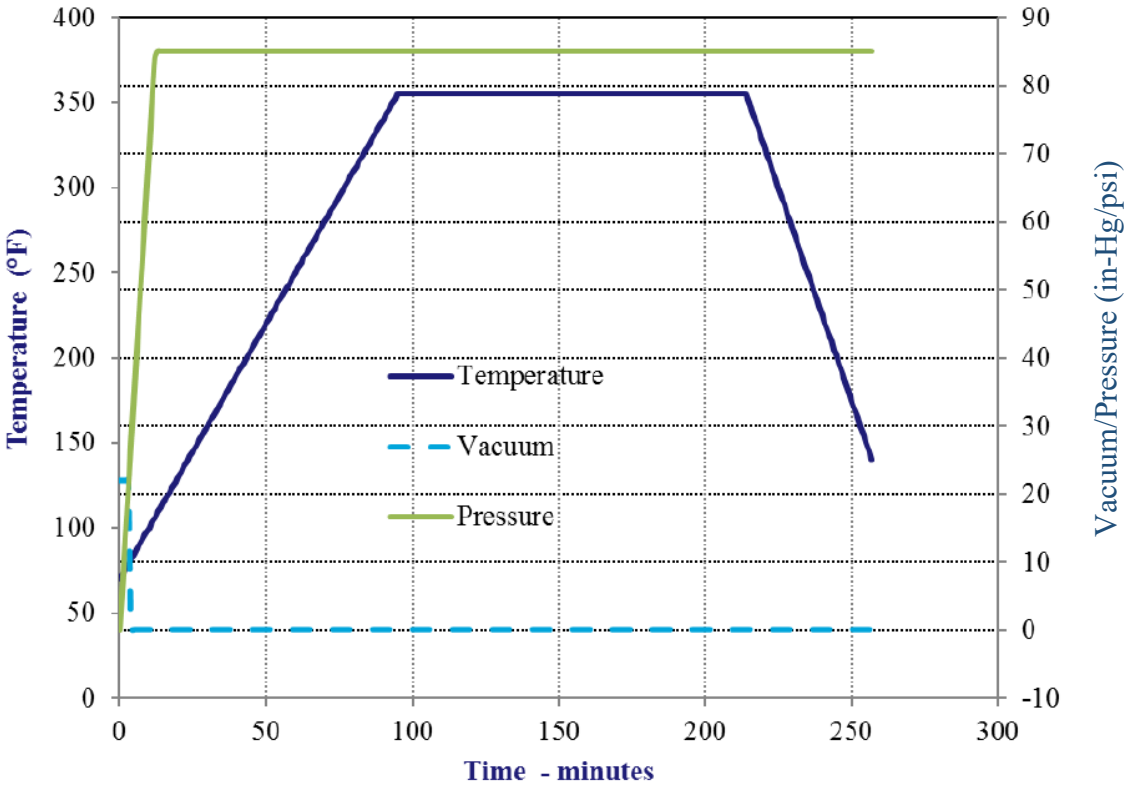


Figure 2 - Bagging Technique for NMS 397

4.3 Baseline Autoclave Cure Cycle (C)

The baseline cure cycle must 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 each vacuum bag assembly for leak before beginning the cure cycle per Section 4.2(j). All temperatures are panel temperatures based on the lagging thermocouple. The vacuum and temperatures must be recorded at 5 minute intervals maximum.



1. Check each vacuum bag assembly for leak before beginning the cure cycle per Section 4.2(j).
2. Apply 85 +15/-0 psi (586 +103/-0 kPa) autoclave pressure to the laminate.
3. Vent the vacuum bag when the autoclave pressure reaches 20psi (138 kPa).
4. Apply the temperature ramp to 355 ± 10°F (179.4 ± 5.6°C) at rate of 3.0 ± 2.0 °F (1.67 ± 1.11°C) per minute.
5. Maintain the cure temperature at 355 ± 10°F (179.4 ± 5.6°C) for 120 – 180 minutes.
6. Cool vessel to 140°F (60°C) or lower at a maximum rate of 5°F (2.8°C) per minute before removing pressure.
7. Remove the bagged panels from the curing vessel and de-bag for inspection.

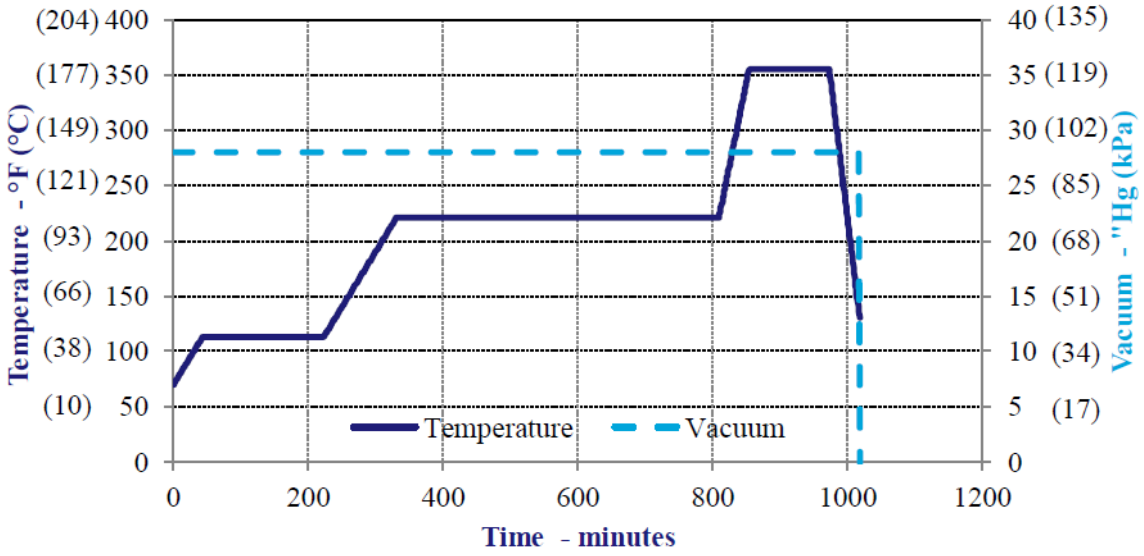
4.4 Alternative Cure Cycles

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.

4.4.1 Alternative Out of Autoclave Cure Cycle (O) (unverified)

This cure cycle may not show a successful equivalency demonstration to Qualification baseline autoclave cure cycle (C). Users may contact NCAMP if this cure cycle is being considered.



1. Check each vacuum bag assembly for leak before beginning the cure cycle per Section 4.2(j).
2. Apply vacuum of 28 inHg (710 mmHg) minimum. Maintain vacuum for at least three hours prior to beginning cure cycle and throughout the cure cycle.
3. Heat the part temperature to 113 ± 10°F (45 ± 5°C) at a ramp rate of 1.0°F/min (0.5°C/min); with an allowable range of 0.2 to 2.0°F/min (0.1 to 1.0°C/min).
4. Hold for a minimum of 180 minutes at 113 -10°F/+18°F (45 -5°C/+10°C).
5. Heat the part temperature to 221 ± 6°F (105 ± 3°C) at a ramp rate of 1.0°F/min (0.5°C/min); with an allowable range of 1°F to 3.0°F/min (0.5 to 1.7°C/min).
6. Hold for 480 +240/0 minutes at 221 ± 6°F (105 ± 3°C).
7. Heat the part temperature to 355 ± 10°F (180 ± 5°C) at a ramp rate of 3°F/min (1.7°C/min); with an allowable range of 1.0 to 5.0°F/min (0.5 to 2.7°C/min).
8. Hold for 120 +30/0 minutes at 355 ± 10°F (180 ± 5°C).
9. Cool to 150°F (65°C) or lower at a maximum ramp rate of 5°F/min (2.7°C/min).

4.5 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.

5. QUALITY ASSURANCE

5.1 Process Control

In-process monitoring data such as part temperature, autoclave 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 is not required to 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 and/or panel fabricator in accordance with the applicable test plan. Panel fabricator is to provide ultrasonic non-destructive inspection images electronically to NCAMP if the panels are not inspected by testing lab.

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.