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NCAMP Process Specification
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Fabrication of NMS 219 Qualification, Equivalency, and Acceptance Test Panels

Syensqo (Formerly Solvay) EP2190 prepregs

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REVISIONS:

Rev	By	Date	Pages Revised or Added
N/C	Evelyn Lian and Royal Lovingfoss	11/04/2021	Document Initial Release
A	Vinsensius Tanoto, Evelyn Lian and Royal Lovingfoss	4/1/2022	Section 3.5 – Added (Optional) Perforated, P6. Section 3.7 – Fixed a typo from 0.060” to 0.100” to 0.100” – 0.250” thick. Section 4.2 (c)(f) – Added (separator/parting film) to FEP film to match Figure 2. Section 4.2 (g) – Added (Optional) FEP film, perforated (P6). Section 4.3.1 – Revised (2) “Apply minimum 22" Hg vacuum. Do not vent vacuum during cure. Apply and maintain autoclave pressure of 85-95 psig. Positive pressure under the vacuum bag shall not exceed 5 psig.” to “Apply minimum 22" Hg vacuum. Apply and maintain autoclave pressure of 85-95 psig. Do not vent vacuum during cure; vacuum shall be 10" Hg minimum throughout ramp-up and cure hold; no vacuum pressure requirements once cool down begins.”. Section 4.4.1 – Corrected a typo and replaced Figure 4.
B	Vinsensius Tanoto and Royal Lovingfoss	8/21/2025	Section 4.3.1 – Revised (4) from “120 to 130 minutes” to “120 to 140 minutes”. Figure 3 was also updated.

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1 SCOPE

This process specification describes the methods of fabricating test panels using NMS 219 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 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 219	350°F Autoclave Cure, High Toughness Epoxy Prepregs Solvay EP2190

2.2 ISO Publications

AS9000	Quality Management System Standard

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, qualified for use at 375ºF or above

- Airtech International, Inc., 5700 Skylab Road, Huntington Beach, CA 92647
- Or equivalent

3.2 Breather

N-10 or Style 181 fiberglass, nonwoven polyester breather

- Airtech International, Inc., 5700 Skylab Road, Huntington Beach, CA 92647
- Any glass fabric supplier

3.3 Breather String

Fiberglass roving strings/threads, ECDE 75 1/3, any finish (may be extracted from 7781 style glass fabric)

- Open source

3.4 Boat Cloth

2” wide fiberglass boat cloth, Style 7500

- Composites One, 11917 Altamar Place, Santa Fe Springs, CA 90670
- Or equivalent

3.5 Solid FEP Film

Separator/Parting Film, 1 to 2 mils thick, qualified for use at 375°F or above

- Airtech International, Inc., 5700 Skylab Road, Huntington Beach, CA 92647
- Or equivalent

(Optional) Perforated, P6

- Airtech International, Inc., 5700 Skylab Road, Huntington Beach, CA 92647
- Or equivalent

3.6 Solid (Nonporous) Teflon Coated Glass Fabric

3 – 5 mil

- Taconic, 3070 Skyway Drive, Bldg 203 Santa Maria, CA 93455
- Or equivalent

3.7 Pressure (Caul) Plate

0.100” – 0.250” thick, aluminum, flat and smooth, or equivalent

- Open source

3.8 Mylar Tape

Pressure Sensitive Mylar Tape qualified for use at 375°F or above

- Keystone Tape, 3911 E. La Palma Ave., Suite V, Anaheim, CA 92807
- Airtech International, Inc., 5700 Skylab Road, Huntington Beach, CA 92647
- Or equivalent

3.9 Tacky (Sealant) Tape

Compatible with nylon vacuum bag, qualified for use at 375°F or above

- Airtech International, Inc., 5700 Skylab Road, Huntington Beach, CA 92647
- Or equivalent

3.10 Mold

(Bottom Tool), 0.250” – 0.500” thick, aluminum, flat and smooth, or equivalent

- Open source

3.11 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 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 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 warp/longitudinal directions are always larger than the fill/transverse directions; this rectangular shape helps maintain 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 Appendix 2 of appropriate test plans. For material acceptance purpose, the panel layups should be in accordance with NMS 219.

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.

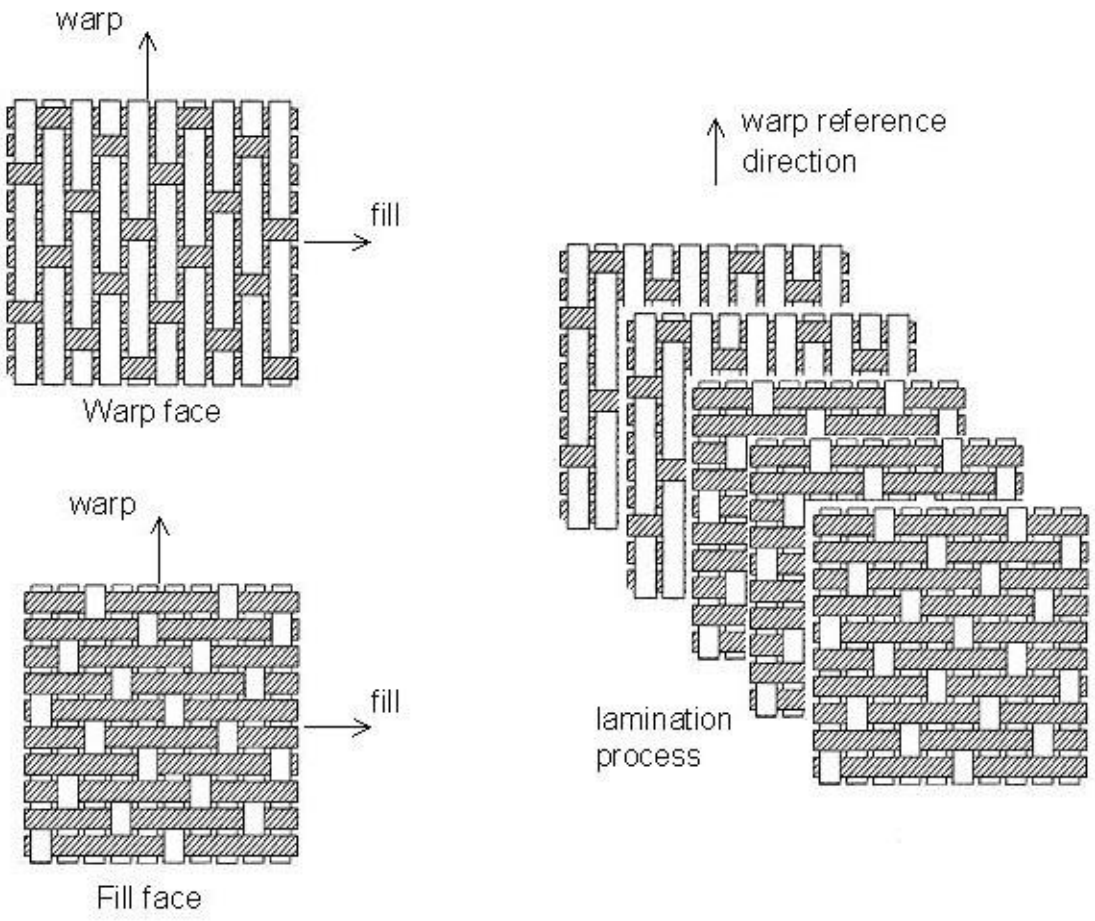

Figure 1 – Example Satin Weave Showing Warp and Fill Faces Used for Ply Collation

In order to maintain the fiber orientation, a reference edge should be created on each panel. Use a straight edge ruler/dam to ensure proper fiber orientation during layup. The reference edge marking needs to be at least 1” from the edge to allow for panel edge trim. During the layup process, each ply must be laid up within ±5° for fabric, and ±3° for tape 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 90° direction; ply splicing is not allowed in the 0° 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 with 0.5” from the prepreg edge with the following information:

0° 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 “0° direction →” marking is near to the reference edge and actually points in the 0° direction or warp direction. Appendix 2 of the test plan contains the panel identification information.

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

a. A minimum of two thermocouple wires should be used to monitor and record the panel temperature of each autoclave 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 0.250 to 0.500 inches 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.
b. Release agents may be used on the tool surface and the caul plate surface instead of solid release film (i.e. non-porous FEP film). However, Teflon coated fiberglass reduces propensity of air entrapment on the tool/bag surfaces and improves surface finish.
c. Place a solid Teflon coated fiberglass or solid FEP film (separator/parting film) on the mold. Liquid release agent may be applied on the mold in lieu of the solid Teflon coated fiberglass or solid FEP film (separator/parting film).
d. Lay first ply and room temperature debulk (vacuum bag compaction) 5-10 minutes at minimum 23" Hg vacuum. Apply dam (Figure 2) around periphery of part butted against sides of prepreg. Continue layup and room temperature debulks in accordance with the proper stacking sequences (see Appendix 2 of test plan) every 4-6 plies, 5-10 minutes at minimum 23" Hg vacuum, making sure that each ply is butt against the dam.
e. Place fiberglass breather stings along each edge of the lay-up as shown in Figure 2.
f. Place a solid FEP film (separator/parting film) over the prepreg layup. Place a caul plate on the FEP film (separator/parting film), ensuring that the caul plate is not on top of the dam. The caul plate shall be 0.100 to 0.250 inches thick and be at least 0.125 inch smaller than the prepreg on each edge.
g. (Optional) Place a solid FEP perforated (P6) film over the caul plate.
h. Place 2 plies of style 181 fiberglass cloth breather or N10 or an equivalent breather over the lay-up according to Figure 2.
i. Place a layer of nylon vacuum bagging film over the entire lay-up.
j. While applying vacuum to the bag, make sure that there is sufficient FEP film, breather, and vacuum bag to conform over the uneven surfaces to avoid bridging in the bag. Apply a minimum vacuum of 22” of Hg and hold the layup under vacuum for a minimum of 2 minutes. Isolate the system by closing the vacuum source valve. Leak check by taking an initial reading after 2 minutes of isolation and then take a final reading after an additional 2 minutes. The difference between the two readings is the leak rate. The vacuum shall not fall more than 1” of Hg in 2 minutes. If this rate is exceeded, repair the leak and recheck the leak rate.

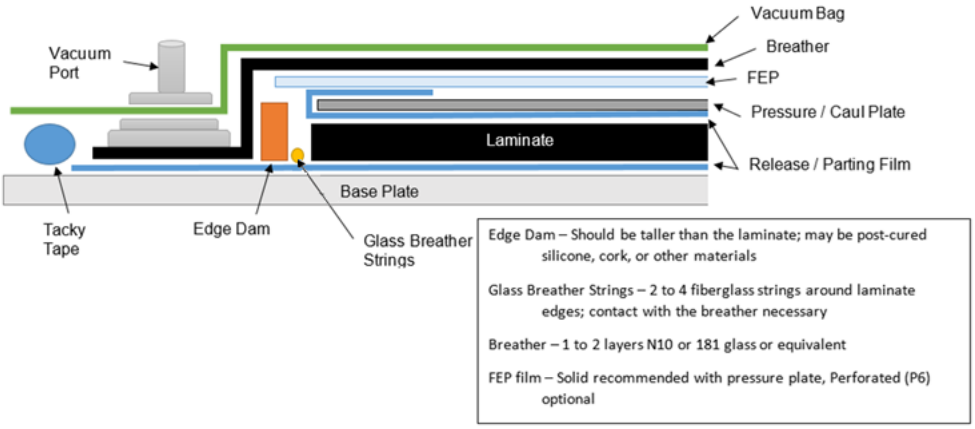

Figure 2 – Bagging Technique for NMS 219 (EP2190 Prepregs)

4.3 Baseline Cure Cycle (C)

4.3.1 Cure Cycle

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” of Hg in 2 minutes. All temperatures are panel temperatures based on the lagging thermocouple. The vacuum and temperatures shall be recorded at 5 minutes intervals maximum.

1. Prior to curing the laminate, leak check the bag to ensure a good seal per section 4.2 (i). No more than 1” of Hg of vacuum over a 2 minutes period is allowed.
2. Apply minimum 22" Hg vacuum. Apply and maintain autoclave pressure of 85-95 psig. Do not vent vacuum during cure; vacuum shall be 10" Hg minimum throughout ramp-up and cure hold; no vacuum pressure requirements once cool down begins.
3. Heat up starts simultaneously with the start of autoclave pressurization. Heat from RT to 350 ± 10 °F at 1-5°F/minute based on lagging panel temperature. If a vacuum bag leak is detected before the leading thermocouple temperature reaches 160°F, the process cycle may be aborted.
4. Hold at 350 ± 10 °F for 120 to 140 minutes. Start the hold when the lagging thermocouple reaches 340°F.
5. Cool under pressure until below 150°F at 5 °F/minute maximum. Release vacuum when the vacuum hoses are disconnected from the vacuum bag.

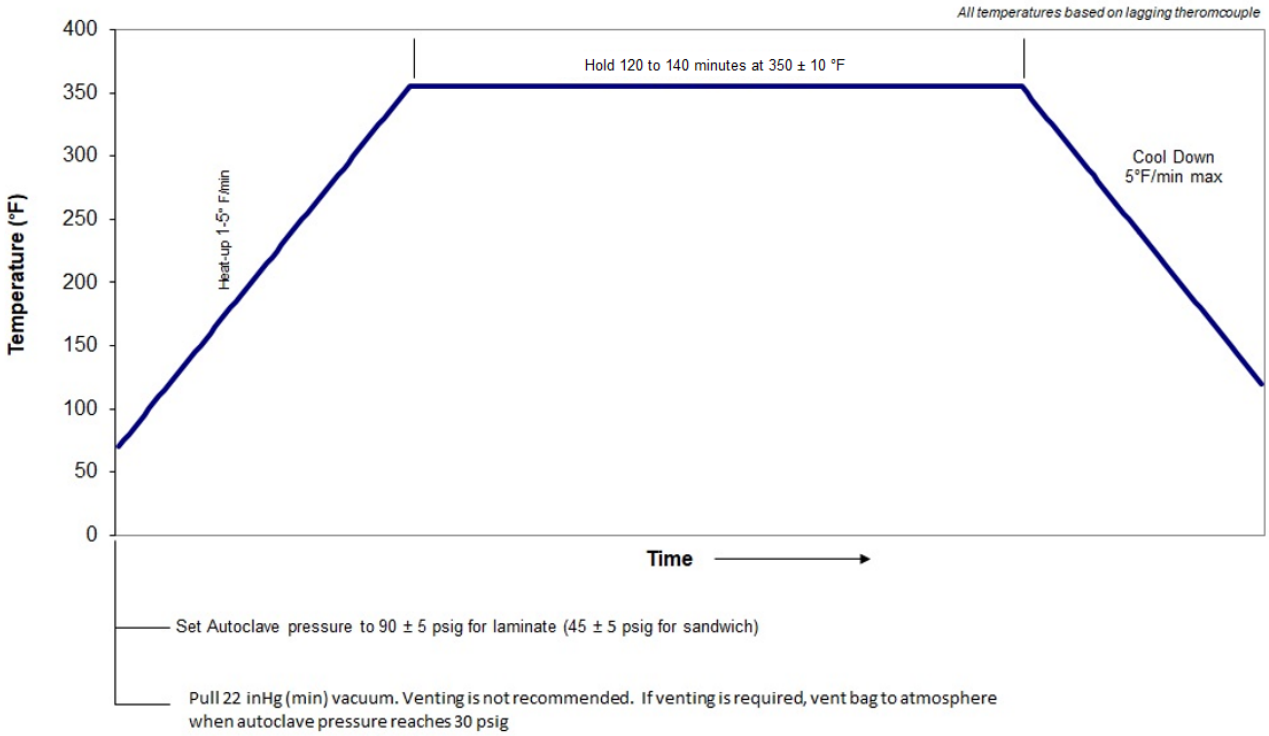

Figure 3 – Baseline Cure Cycle (C)

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 Cure Cycle

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

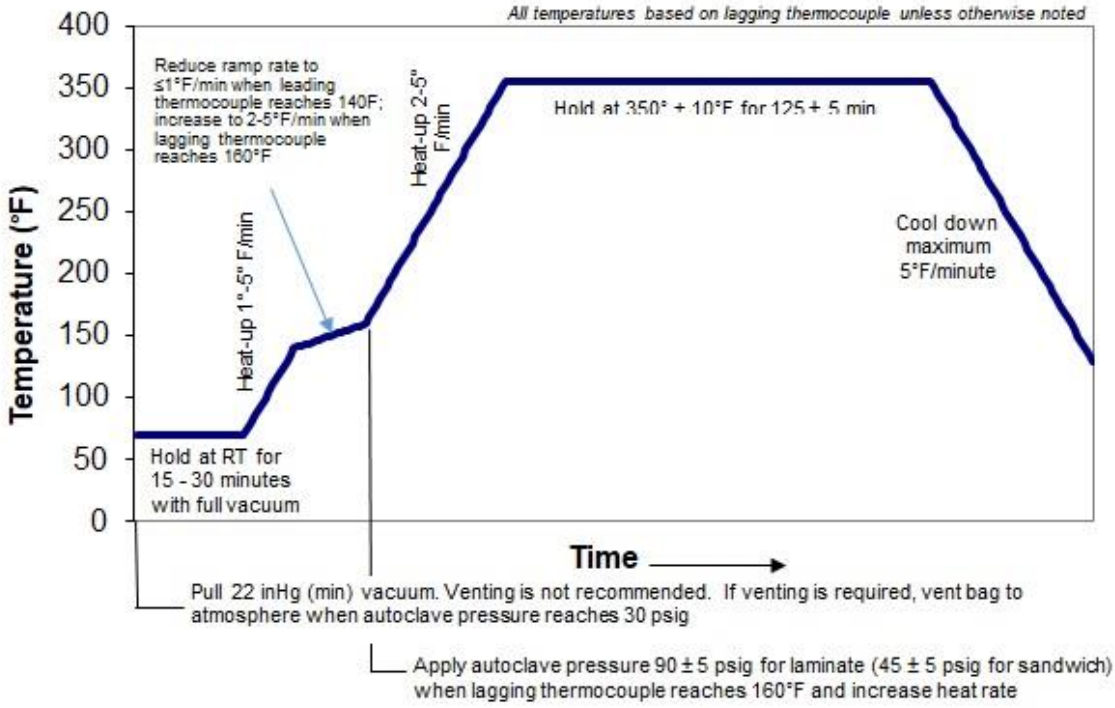

Figure 4 – Alternative Cure Cycle

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

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 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. The panel shipping instruction is typically included in the applicable test plan.