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NCAMP Process Specification

Fabrication of NMS 122 Qualification, Equivalency, and Acceptance Test Panels

Medium Toughness Polyaryletherketone (PAEK) Thermoplastics
Toray (Formerly TenCate) Cetex® TC1225 Low Melt (LM) Polyaryletherketone (PAEK)

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REVISIONS

Rev	By	Date	Description
-	Rachael Andrulonis, Royal Lovingfoss, John Tomblin	3/20/2018	Initial Release.
A	Rachael Andrulonis, Royal Lovingfoss, John Tomblin	8/3/2018	Updated to new fiber (T700).
B	Royal Lovingfoss, Vinsensius Tanoto	1/21/2020	• Formatting. • Removed T700 Fiber from the document. • Added LM and PAEK definition on cover page. • Updated Cover Page from “High Toughness” to “Medium Toughness” per Toray’s product description. • Removed Toray PCD reference from Section 2. • Added maximum temperature to Section 4.4 Step 4. • Added more information to Section 4.4 Step 5. • Replaced “Mold” and “Molded” with “Consolidation” and “Consolidated”.
C	Royal Lovingfoss, Vinsensius Tanoto	9/11/2023	• Revisions: Moved to after cover page. • Section 2.1: Added NMS 122/3. • Section 3.5: Added release agent. • Section 4: Added Information for NMS 122/3.
D	Royal Lovingfoss, Vinsensius Tanoto	10/30/2023	• Section 3.2: Added Polyimide Film. • Section 4.2.4: Consolidation cycle was revised.
E	Royal Lovingfoss, Vinsensius Tanoto	7/30/2025	• Updated Section 4.2.4: Consolidation cycle D for better clarity and requirements.

Table of Contents

1. SCOPE

This process specification describes the methods of fabricating test panels using Toray TC1225 Polyaryletherketone (PAEK) reinforced. These composite prepreg material systems are intended for use in the fabrication of aerospace structures and tooling substrate using various consolidation techniques. Specifically, this specification covers prepreg cutting, layup and consolidation process with a static press.

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 122	Medium Toughness Polyaryletherketone (PAEK) Thermoplastics Toray (Formerly TenCate) Cetex® TC1225 Low Melt (LM) Polyaryletherketone (PAEK)
NMS 122/1	Medium Toughness Polyaryletherketone (PAEK) Thermoplastics Toray (Formerly TenCate) Cetex® TC1225 Low Melt (LM) Polyaryletherketone (PAEK) T700 Unidirectional 145 gsm 34% RC

NMS 122/3	Medium Toughness Polyaryletherketone (PAEK) Thermoplastics Toray Advanced Composites Cetex® TC1225 Low Melt (LM) Polyaryletherketone (PAEK) T300JB 3K 5HS 280 gsm 42% RC

2.2 ISO Publications:

AS 9100	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 NMS 122/1 Materials:

3.1.1 Polyimide Film, equivalent to Upilex 50S qualified for use at 800ºF or above.
- UBE Americas Inc, 28345 Beck Road, Wixom, MI 48393
- Or equivalent

3.1.2 Caul Plates (top/bottom tool), minimum 0.250 inches thick, steel, flat and smooth, or equivalent.
- Open source

3.1.3 Fiberglass Blanket (woven 7781 FG)
- Open source

3.1.4 Kapton Tape
- Open source

3.2 NMS 122/3 Materials:

3.2.1 Release agent, Zyvax TakeOff
- Chem trend

3.2.3 Polyimide Film, equivalent to Upilex 50S qualified for use at 800ºF or above.
- UBE Americas Inc, 28345 Beck Road, Wixom, MI 48393
- Or equivalent

4. TEST LAMINATE FABRICATION

4.1 TEST LAMINATE FABRICATION (NMS 122/1)

4.1.1 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. Each ply is marked to identify warp direction. The test panel dimensions shall be sufficient to allow a minimum trim allowance of 1” on all sides.

4.1.2 Prepreg layup

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 122.

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.

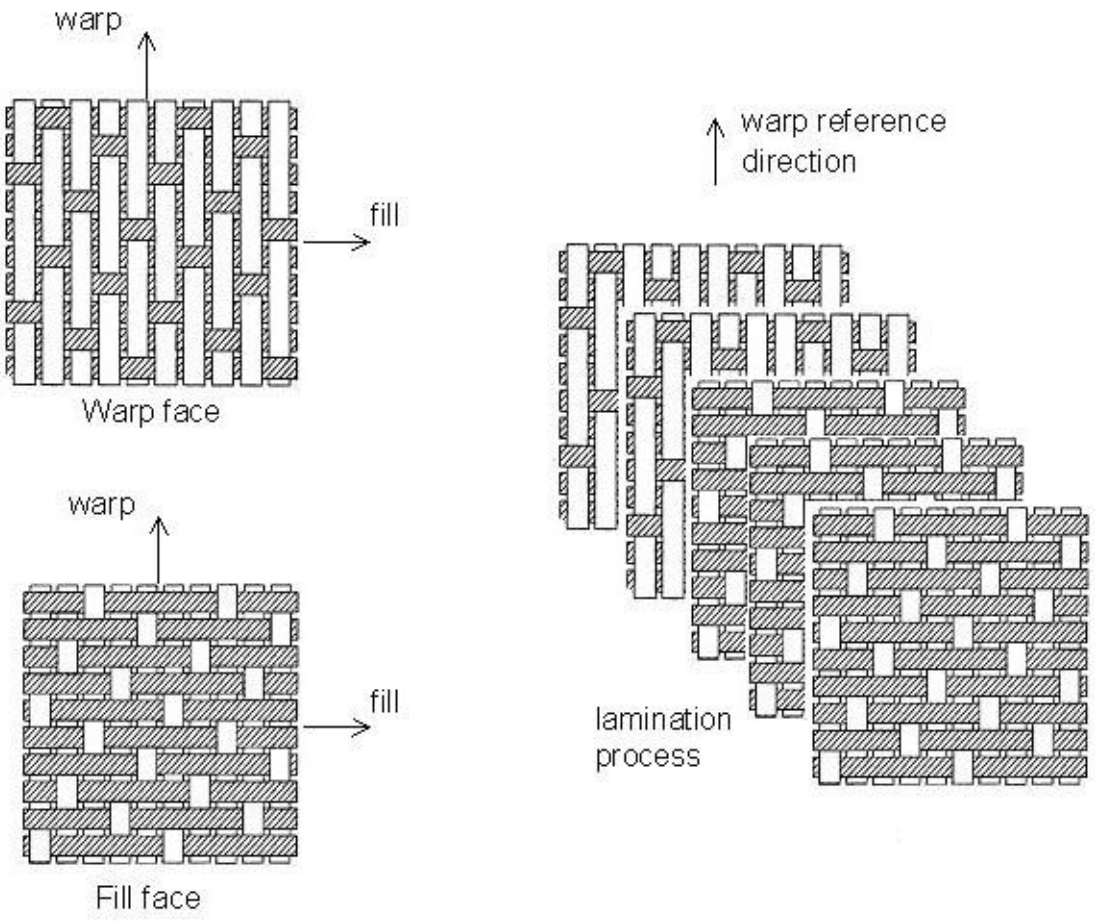

Figure 1 - Example Satin Weave Showing Warp and Fill Faces Used for Ply Collation

In order to maintain the fiber orientation, a reference edge should be created on each panel. 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 will form a straight edge on the consolidated panel. Ply splicing shall be identified at C-Scan and specimens shall not span a ply splice. This may be prevalent on 45-degree plies only.

In material qualification and equivalency programs, for panel identification purpose, place a label or mark the consolidated panel with white/silver marker 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.

4.1.3 Preparation/Setup Procedure

For single laminates a caul plate is optional (Figure 1). Choose a proper picture frame thickness to ensure that consolidated laminate and top plate combined are thicker than picture frame thickness (so press pushes on laminate not on picture frame). For multiple

panels a caul sheet is required to separate the panels (Figure 2).

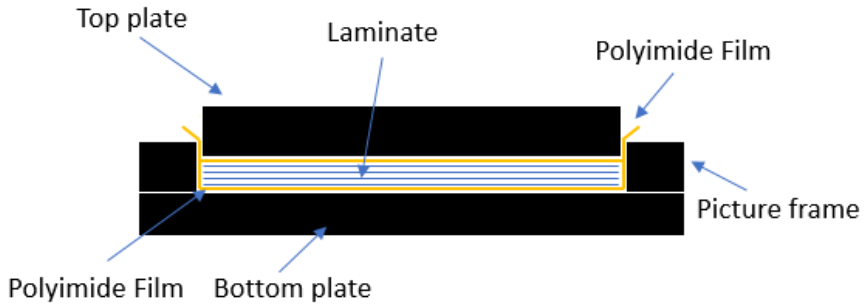

Figure 1. Consolidation Test Panels Schematic for TC1225

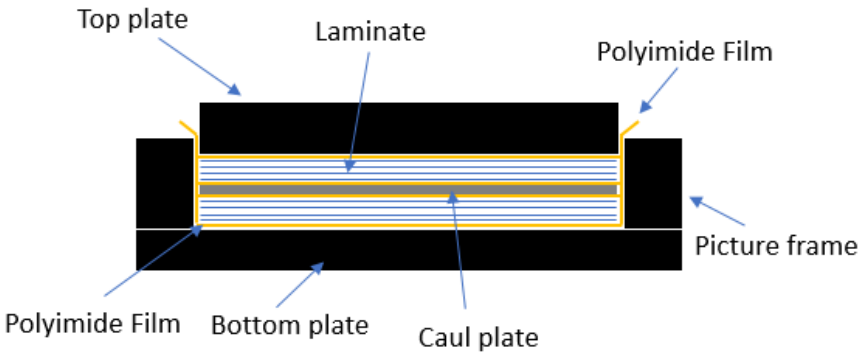

Figure 2. Consolidation Test Panels Schematic for TC1225 (Multiple panels)

- Plies shall be cut across the width using a hand knife and machinists square, shear, shear paper cutter, or automated ply cutting machine from the sample rolls aligned with ±1° to the tapes slit edge.
- Use of shop aids can be used to insure proper alignment.
- The individual ply shall be aligned to a metal reference edge and stacked with each ply tacked to the subsequent ply using either a hot soldering iron at a temperature to join the plies without charring (less than 1000°F), ultrasonic welder or equivalent thermoplastic tacking device.
- Place the panel package inside the press, place a fiberglass blanket completely covering the top plate of the package, then close the press. (The fiberglass blanket is larger than the panel package. It is four folded layers of woven 7781 Fg, held together with Kapton tape) (The use of a fiberglass blanket is optional. The fiberglass is used as a compliant layer to account for irregularities in the press)
- Compression consolidation the test panels as specified below. Each batch of prepreg shall be traceable to the consolidation cycle used to fabricate the test panel. Figures 1 and 2 shows the consolidation arrangement which will be used for the manufacture of mechanical test panels.

4.1.4 Static Press Baseline Consolidation Cycle (C)

The baseline consolidation cycle shall be in accordance with the following process. For the purpose of specimen naming, this consolidation cycle is designated as “C.” The material qualification panels are processed in accordance with the baseline consolidation cycle. All temperatures are the press platens temperatures based on the lagging thermocouple. The temperatures shall be recorded at 5 minute intervals maximum. Compression consolidation the test panels as specified below. Each batch of prepreg shall be traceable to the consolidation cycle used to fabricate the test panel.

1. Prior to consolidating the laminate, check the layup reference edge and the proper panel alignment with the static press.
2. Place laminate into press
3. Apply 30 to 50 psi (2 to 3.5 bar) of pressure to the laminate.
4. Heat to a minimum of 689°F (365°C) and a maximum of 743°F (395°C), heat-up rate is 9° to 21°F/min (5° to 12°C/min).
5. Increase pressure to 150 to 300 psi (10 to 20 bar) for a well constrained (closed) consolidation system with minimal bleed out.
6. Hold at a minimum of 689°F (365°C) for 30 minutes minimum.
7. Ensure material/laminate is at process temperature based on the lagging thermocouple of the press platens and allow for material thickness where appropriate.
8. Cool down to below 160°F (70°C) at a rate between 5° and 10°F/min (2.8° to 5.5°C/min).
9. Remove pressure and remove the laminate from the press.

4.2 TEST LAMINATE FABRICATION (NMS 122/3)

4.2.1 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. Each ply is marked to identify warp direction. The test panel dimensions shall be sufficient to allow a minimum trim allowance of 1” on all sides.

4.2.2 Prepreg layup

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 122.

The individual plies shall be aligned with the use of the selvage of the fabric. Each ply shall be tacked to the subsequent ply using either an ultrasonic welder or equivalent thermoplastic tacking device.

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 3.

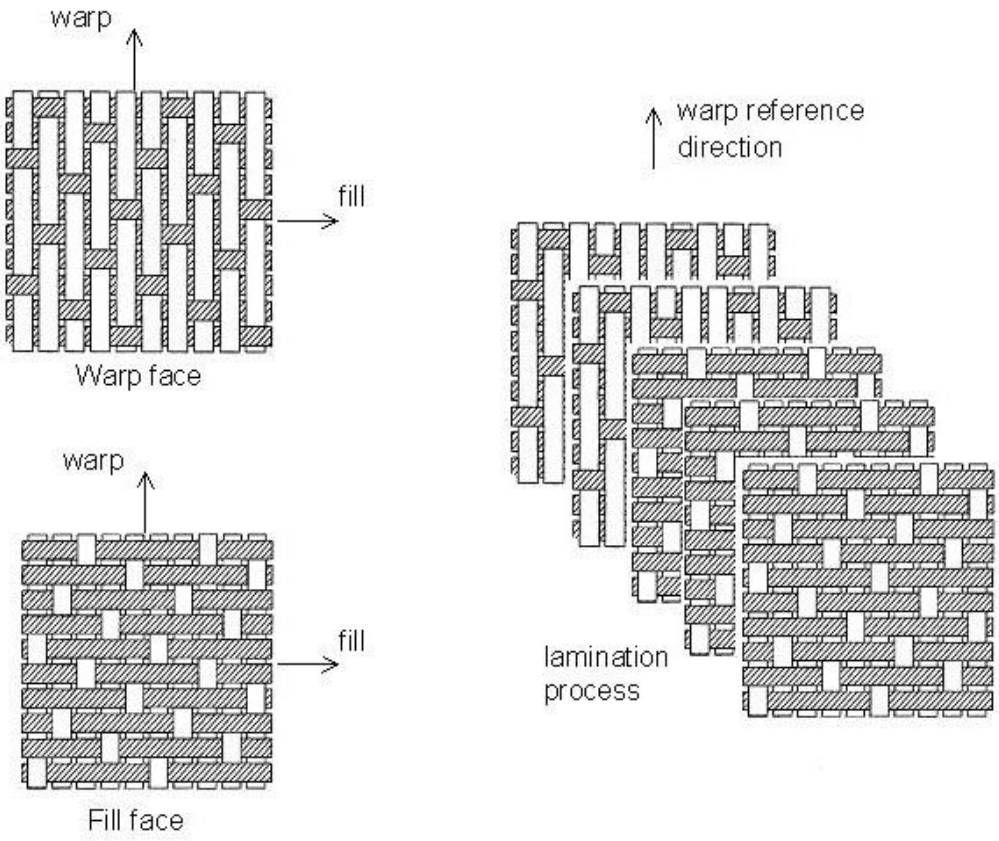

Figure 3 - Example Satin Weave Showing Warp and Fill Faces Used for Ply Collation

In order to maintain the fiber orientation, a reference edge should be created on each panel. 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° of the reference edge. Ply splicing shall be identified at C-Scan and specimens shall not span a ply splice. This may be prevalent on 45-degree plies only.

In material qualification and equivalency programs, for panel identification purpose, place a label or mark the consolidated panel with white/silver marker 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

4.2.3 Preparation/Setup Procedure

1. Select caul sheets that are free of dents, scratches and/or contaminations.
2. Apply Zyvax TakeOff on caul sheets.
3. Place the stacked layups between the caul sheets.

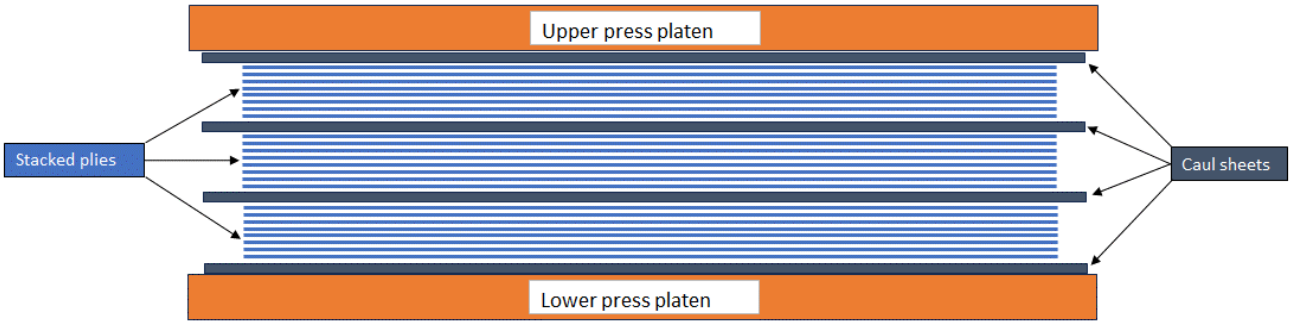

Figure 4. Consolidation Test Panels Schematic for TC1225 (Multiple panels)

4.2.4 Static Press Baseline Consolidation Cycle (D)

The baseline consolidation cycle shall be in accordance with the following process. For the purpose of specimen naming, this consolidation cycle is designated as “D”. The material qualification panels are processed in accordance with the baseline consolidation cycle. All temperatures are the press platens temperatures based on the lagging thermocouple. The temperatures shall be recorded at 5 minute intervals maximum. Compression consolidation the test panels as specified below. Each batch of prepreg shall be traceable to the consolidation cycle used to fabricate the test panel.

1. Before consolidating the laminate, check the layup reference edge and ensure proper alignment with the static press.
2. Place the laminate into the press.
3. Apply a pressure between 2 and 15 bar (29 to 218 psi) to the laminate.
4. Heat the laminate at a rate of 2° to 15°C/min (4° to 27°F/min) to a temperature between 325°C and 385°C (617°F to 725°F).
5. Begin the hold time once the target temperature is reached.
6. Maintain the temperature between 325°C and 385°C (617°F to 725°F) for a duration of 10 to 90 minutes.
7. Cool down to below 200°C (392°F) at a rate of 2° to 20°C/min (4° to 36°F/min).
8. Release the pressure and remove the laminate from the press.

Note: During the cycle, the laminate must reach at least 340°C (644°F) and experience a minimum pressure of 6 bar (87 psi) for a minimum of 10 minutes at some point to ensure proper consolidation.

4.3 Consolidated Panels

The reference edge created in section 4 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 consolidated panels so that they can be handled and packaged safely.

5. QUALITY ASSURANCE

5.1 Process Control

In-process monitoring data such as platen temperature (heating rate, dwell, cooling rate, etc.), pressure readings through the consolidation 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:-

1. Warpage
2. Dry spots
3. Butt Joint or Overlap
4. Broken Yarn/Fiber
5. Damaged Edge
6. Brown Stain
7. White Mark
8. Delamination

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.