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**Prepreg Process Control Document (PCD) Preparation and
Maintenance Guide**

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DEFINITIONS

Advanced Change Notice (ACN) – Documentation of major change(s) to a PCD prior to a PCD revision. NCAMP approval is required.

Prepreg Batch – see applicable NCAMP Material Specifications (NMS).

Controlled Process Equipment – Specific manufacturing equipment approved by NCAMP for production of the prepreg. Changes to the equipment may affect the quality of the prepreg.

Controlled Process Parameters (CPP) – Critical manufacturing process parameters approved by NCAMP for production of the prepreg. Changes to the parameters may affect the quality of the prepreg. Also known as key process parameters (KPP).

General PCD Revision – A general revision to the PCD to incorporate all past major revisions (ACN) and minor revisions.

Process Control Document (PCD) – An NCAMP approved material supplier document which describes the “recipe” for the production of NMS specification prepreg. It includes details of such items as raw material names or codes, raw material sources, raw material control, significant items of processing equipment, process flow, controlled process parameters, process tolerances, and process test information.

Supplier Review Board (SRB) – A committee established by the material supplier whose purpose is to review and disposition materials which have minor discrepancies.

1. Introduction

This document serves as a guide for prepreg material suppliers to prepare and maintain a prepreg process control document (PCD). It also serves as a review, approval, and auditing guide for the NCAMP Industry Advisory Board (IAB) (material users), NCAMP Executive Governing Board (EGB), and NCAMP staff members.

A prepreg PCD is a “recipe” for the production of prepreg that conforms to NCAMP Material Specification (NMS) requirements. It is used in conjunction with prepreg material specifications to control the prepreg material properties and quality. There are many rules associated with the creation, maintenance, and usage of a PCD.

Because a prepreg PCD by nature is a highly proprietary document, sensitive information such as raw ingredient names may be coded. NCAMP members are usually required to sign a non-disclosure agreement prior to reviewing the prepreg PCD. In addition, some material suppliers may ask NCAMP members to not take notes during the review process. Some material suppliers may allow NCAMP members to take notes but require that their notes be approved by the material supplier before the end of the review period. The material supplier will explain its procedures prior to the review process. Most PCDs are reviewed at the material supplier’s site although in rare cases some material suppliers may bring the PCD to the customer for review. In any case, the material supplier is unlikely to send or provide a copy (electronic or hardcopy) of the prepreg PCD to NCAMP members.

Whenever possible, requirements that do not involve proprietary information should also be listed in applicable material specifications. Only information that is proprietary in nature should be listed in the PCD only, because a PCD is less accessible to the users.

2. Prepreg PCD Review and Approval Process

The prepreg PCD review and approval processes will generally involve the material suppliers, NCAMP IAB members, NCAMP EGB members, and NCAMP staff. NCAMP staff and material suppliers will send the PCD review invitation to NCAMP members. In general, only NCAMP IAB members who are interested in the materials (generally, those who are fabricating test panels and their customers) will be invited to the review and approval process. The review and approval process involves two steps. The first step occurs prior to and during the prepregging process of the qualification prepregs. The material suppliers will inform NCAMP IAB and NCAMP staff about the date and time to visit the prepregging facility. Prior to the prepregging process, the material supplier is required to prepare a draft prepreg PCD for each product form of each resin system using the following guidelines:

- a) The PCD has adequately specified all requirements necessary to ensure proper control of the prepreg material properties.
- b) The content of the PCD shall follow the requirements of section 4 below, except some requirements may be listed as “To Be Determined” or “TBD.”

During the review process, NCAMP members will provide comments on the draft prepreg PCD and draft NMS prepreg material specification. The material supplier will be asked to revise the PCD based on the comments. Explanations must be provided for those comments that are not incorporated, which will be reviewed in the second step.

The second step occurs after the qualification program has been completed and all the test results are available. Material suppliers and NCAMP staff will work together to establish requirements previously listed as "TBD" and/or revise the other PCD requirements based on the test results. NCAMP members will be invited to review the PCD again. This second review will happen over a period of about 2-3 weeks where NCAMP members who wish to participate must coordinate directly with the material suppliers. The explanations for comments not incorporated in the first step will be provided to all the reviewers. At the end of the review process, NCAMP staff must ensure that all comments have been incorporated into the PCD. Any comment not incorporated in the PCD must be resolved with the individual commenter. Material suppliers may create separate PCDs for individual NCAMP IAB members with unique requirements. NCAMP staff must also make sure that the PCD requirements are in agreement with the corresponding NMS material and detail specification requirements.

3. Facility Audit

A facility audit will be conducted by material users and NCAMP staff. Facility audits typically include:

- a) Review of the supplier's facility, where the supplier must be able to show that the PCD(s) and applicable material specification(s) are followed, and
- b) Review of the supplier's quality system

Facility audits should be conducted when the material is initially qualified (usually concurrently with initial PCD review and approval process) and then at least every three years. A facility audit is also required when there are significant changes to the manufacturing facility, as determined by NCAMP through change notification.

4. Content of a PCD

A PCD should describe the raw ingredients and the entire manufacturing process. Specifically, the PCD should include the following information:

4.1 Raw Ingredients and Consumable Materials

- a. Specify all raw ingredients and consumable materials including the procurement specification/document, approved suppliers, and their addresses. Due to the proprietary nature of the PCD, the names of the raw ingredients may be coded.
- b. List the fiber procurement specification and/or tests conducted on the fiber and note the requirements for acceptance or rejection.

- c. Specify the raw ingredient and consumable material quality control tests and requirements.
- d. Specify the raw ingredient and consumable material packaging and marking requirements.
- e. Specify raw ingredient and consumable material storage conditions and corresponding shelf-life. Specify shelf-life revalidation procedures, if applicable.

4.2 Manufacturing Process and Control

- a. Employee training and qualification requirements shall be described in the PCD or a related document. It is advisable that employees be briefed through a meeting by the engineer or manager in charge prior to the manufacturing process to ensure that they are fully aware of the preparation procedures, process parameters, set-points, and the requirements of the PCD. Procedures to check equipment calibration dates and raw ingredient expiration dates should be part of every preparation process.
- b. Describe the general manufacturing process and procedures. Specifically:
 - Provide diagrams to show the equipment and settings, the flow of the manufacturing process, including where in-process monitoring, inspection, and testing takes place.
 - Identify all Controlled Process Equipment by line, model, and serial numbers.
 - Define all Controlled Process Parameters along with their target values and tolerances. For example, provide the target value and tolerance on weight measurements for each manufacturing step.
 - Provide the order and means of combining the subcomponents (portions of the prepreg resin) and give the time-temperature profile with the control tolerances employed.
 - List the tests and control limit requirements on the finished resin system prior to manufacture of the prepreg.
 - Define the time-temperature history of the resin in the filming and fiber impregnation processes and the control tolerances employed. Note that prepreg properties are the result of cumulative time-temperature history from all the process steps. As a result, not all combinations of upper or lower tolerance limits will yield acceptable prepreg properties. For example, a prepreg produced using the upper time and temperature limits of every process step may not yield acceptable tack level. The supplier should be aware of the cumulative time-temperature effects of every step on the prepreg properties. Thermal and rheological testing/analysis tools may be used to simulate process steps and ageing and measure properties such as sub-ambient glass transition temperature and resin cure rheology.
 - Define the prepreg backing release material.
 - Describe acceptance inspection procedures used to evaluate the finished prepreg and state the acceptance/rejection criteria.
 - Describe any foreseeable rework procedures, if applicable.
- c. Freezer storage and out-time condition/time shall be defined.

- d. Other process parameters required to operate the equipment shall include target and tolerance values.
- e. Where applicable, tolerances should be set based on a Type I error probability of 1 percent with one retest as described in section 6 of DOT/FAA/AR-03/19. Where such method of establishing tolerances is inappropriate, the tolerance must be reasonable and able to provide adequate controls.
- f. Where applicable, alarm devices must be present to ensure that operators are alerted when actual process measurements fall outside the permissible tolerance limits.
- g. Actual in-process measurements must be taken at proper intervals and become part of the manufacturing records.
- h. The supplier shall maintain records of all prepreg batches traceable to the raw ingredient lot numbers for a minimum of eight years. This includes all relevant certification and inspection records, and manufacturing process records.

4.3 Approval of Raw Ingredient Suppliers During Initial Qualification Program

This section describes the guidelines for the approval of raw ingredient suppliers during the initial material qualification process. In general, the raw ingredient suppliers used to fabricate the original qualification prepregs are considered approved suppliers. Up to three suppliers of the same ingredient may be included in the PCD if:

- a. The raw material from the second and third supplier is chemically and physically *identical*, which may be difficult to prove. There shall be compelling data verifying that the alternate material is identical to the original material.
- b. Prior evaluation suggests that the raw material from the second and third supplier is chemically and physically *similar* and each source of the material is used to produce at least one batch of qualification material.

The use of more than one raw material supplier may increase batch-to-batch variability if the materials are not truly identical. If significant batch-to-batch variability is detected during the qualification program, the extent of which the second and/or third raw material had influenced the variability must be investigated. In some cases, additional batches of material may need to be tested.

4.4 Approval of Controlled Process Equipment During Initial Qualification Program

This section describes the guidelines for approval of Controlled Process Equipment during the initial material qualification process. In general, the equipment used to fabricate the original qualification prepregs are considered approved equipment. If second or third equipment is desired, it may be included in the PCD if:

- a. The second or third equipment is *identical* and is not primary prepregging equipment (e.g. grinder for additives). There shall be compelling evidence and data to prove that the second or third equipment is identical.
- b. Prior evaluation suggests that the second or third equipment is *similar* and output is identical, and the alternate equipment is used to produce at least one batch of qualification material.

The additional equipment cannot be allowed if:

- a. The equipment changes the time-temperature history of the resin.
- b. The equipment is expected to change any characteristic of the material.

Using more than one piece of equipment may increase batch-to-batch variability if the equipment is not truly identical. If significant batch-to-batch variability is detected during the qualification program, the extent of which the second and/or third equipment had influenced the variability must be investigated. In some cases, additional batches of material may need to be tested.

5. Non-Conforming Material and Disposition

5.1 Minor Discrepancy

Prepregs which do not conform with the PCD may be regarded as having minor discrepancies provided that the prepregs are produced using approved Controlled Process Equipment and meet all applicable Controlled Process Parameters and NMS requirements. Material supplier shall establish a Supplier Review Board (SRB) to evaluate the discrepancy. The SRB is a committee established by the material supplier which consists of at least two senior staff members with the purpose of reviewing and dispositioning materials which have minor discrepancies. At least one member of the SRB must have an in-depth understanding of the product chemistry and possible impact on the product usability and material property. "Use-as-is" disposition must be justified by test and/or past experience (one retest is typically allowed). Every member of the SRB must agree that the discrepancy has no effect on the prepreg's properties and handling qualities, and the disposition must be signed by all the SRB members. The material shall be regarded as having major discrepancy if at least one SRB member disagrees.

5.2 Major Discrepancy

Prepregs that fail to meet NMS requirements, produced outside of Controlled Process Parameters, or produced using unapproved Controlled Process Equipment are regarded as having major discrepancies and shall be segregated. There must be justification (typically backed by evidence such as in-process monitoring data or test data) to ensure that the discrepancy does not extend into previously accepted prepregs.

The prepregs may be reworked (if applicable) and accepted in accordance with the procedures in PCD or written instructions of the SRB, provided that:

- a. Traceability is maintained for all rework procedures, if rework is performed.
- b. Compliance with applicable NMS requirements is demonstrated through subsequent acceptance testing and/or inspection.
- c. Purchaser agrees to the rework procedures and subsequent testing and/or inspection results. A description of the rework procedures along with subsequent acceptance testing results shall accompany the prepreg certificate of conformance which is provided to the purchaser.

Otherwise, the prepreg shall not be certified to the NMS material specification.

6. Revisions and Change Control

The supplier shall maintain a good record of all PCD revisions, associated ACN, and minor changes and be able to reconstruct the PCD to any point in the last eight years. DOT/FAA/AR-07/3 and DOT/FAA/AR-06/10, section 6.1, should be used as guidelines for managing changes.

Minor Changes – Changes that do not affect the materials such as typographical error corrections. In general, Level 0 Changes per DOT/FAA/AR-07/3 and DOT/FAA/AR-06/10 are considered minor changes. No notification to NCAMP or the purchaser is required.

Major Changes – Changes that may affect the quality or properties of the prepreg. In general, Level 1 Changes through Level 3 Changes per DOT/FAA/AR-07/3 and DOT/FAA/AR-06/10 are considered major changes. NCAMP approval is required, and is granted through an ACN.

6.1 Advanced Change Notice (ACN)

ACNs are interim documents used to approve major changes to the PCD. Appendix 1 of this document contains the ACN form. Prior to implementing a major change, the supplier shall provide NCAMP with a detailed description of the proposed change(s) in an ACN or a draft test plan along with any data (if available) to substantiate that the change will not affect the prepreg material properties. The documents may be distributed to NCAMP staff, the material users, and certification agencies (typically the FAA) so some proprietary information may be coded. NCAMP staff will review the documents to ensure that they comply with DOT/FAA/AR-07/3 and DOT/FAA/AR-06/10 requirements. In cases where the topics are unfamiliar to the NCAMP staff, NCAMP may hire an expert to provide independent opinion on the change notice. To ensure that the opinion remains impartial, NCAMP will typically remove all references to company names from the documents so that the subject matter expert will provide his/her opinion based purely on a “hypothetical” situation. The material supplier may also ask that its non-disclosure agreements (NDAs) with NCAMP be extended to the expert. It is the material suppliers’ responsibility to ensure that NDAs are signed with the material users if non-disclosure contract protection is required. In addition, the material supplier must advise NCAMP if an NDA is required with the certification agencies.

NCAMP will schedule a meeting to communicate the proposed change(s) with all stakeholders. NCAMP will be the facilitator of the meeting, which will be held over the internet using a service such as GoToMeeting®. The material supplier will typically forward the meeting invitation, data, and draft test plan to all the material users. NCAMP will distribute those materials to the certification agencies. All attendees are encouraged to review the documents before the meeting. Meeting minutes will be sent to all attendees and the FAA.

As the meeting facilitator, NCAMP will ensure that the meeting stays focused within the following format:

- a) NCAMP will first provide an introduction of the change notice, explain the activities that have taken place to date, such as the draft test plan and necessary steps needed to take place in order to approve or disapprove the change.
- b) If the existing information (e.g. data) is sufficient to substantiate the change (i.e. no further testing is required), the material supplier will create an ACN and upon reaching consensus, NCAMP will sign the ACN to approve the change on behalf of the members. The supplier has the responsibility to revise relevant section(s) of the PCD in accordance with the approved ACN.
- c) If the existing information is insufficient and a test plan is needed to substantiate the change, the discussion will focus on the test plan content (i.e. what tests are needed, how many specimens are needed, etc.). The material supplier will be responsible for revising the test plan. NCAMP will review the revised test plan to ensure that all agreed-upon action-items have been incorporated. The testing may require conformity by a FAA DAR and be witnessed by a FAA DER. After the testing has been completed, the material supplier will create an ACN and a second meeting will be set up to approve or disapprove the change. In some cases, additional testing will be needed. Upon reaching consensus, NCAMP will sign the ACN to approve or disapprove the change on behalf of the members. The supplier has the responsibility to revise relevant section(s) of the PCD in accordance with the approved ACN.
- d) If the group feels that an expert opinion is needed in the decision making process, NCAMP has a limited budget to hire such an expert. To ensure that the opinion remains impartial, NCAMP will typically remove all references to company names from the documents so that the subject matter expert will provide his/her opinion based purely on a “hypothetical” case. The material supplier may also ask that their NDA with NCAMP be extended to the subject matter expert. Another meeting may be scheduled when the subject matter expert opinion is received, if needed.
- e) If the change is deemed too major (e.g. level 4 changes), the group may decide to disapprove the change during the first meeting.

It is important to note that 100% stakeholder participation is not required to reach a consensus; so all stakeholders should make an effort to participate in the change management activities. Also, the material suppliers have the responsibility to comply with the requirements of DOT/FAA/AR-07/3 and DOT/FAA/AR-06/10 and ensure that material properties published in the original qualification program remain unchanged; other test methods/properties that are unique to a specific user or application may not be the responsibility of the material supplier.

It is desired to reach 100% stakeholder agreement when approving or disapproving changes. However, if 100% agreement cannot be reached due to some unique material application requirements by a minority of user(s), special arrangements between the supplier and user(s) may be made outside of NCAMP. In general, NCAMP’s decision is driven by the majority’s opinion.

The material supplier has the option to retract the material change request at any time. The major change cannot be implemented until the ACN is signed.

6.2 General PCD Revision

The material supplier will revise the PCD to incorporate all past ACNs and minor changes when there are a significant number of changes which make the document difficult to follow. A new general PCD revision is also warranted when there is a revision to the corresponding material specification. The content of all Major and Minor Changes made to the PCD during the general PCD revision shall be summarized in the revision control block. Whenever possible, major changes should be proposed and approved through ACNs because the process requires involvement of other NCAMP members.

7. Other Requirements

The corresponding material specification will contain additional requirements. Material suppliers shall determine that the PCD is tailored to meet the material specification requirements.

8. References

1. Boeing D6-53356 Requirements for Process Control Documents for Suppliers of Nonmetallic Raw Materials, Rev NEW
2. DOT/FAA/AR-07/3 – Guidelines and Recommended Criteria for the Development of a Material Specification for Carbon Fiber/Epoxy Unidirectional Prepregs Update
3. DOT/FAA/AR-06/10 - Guidelines and Recommended Criteria for the Development of a Material Specification for Carbon Fiber/Epoxy Fabric Prepregs
4. DOT/FAA/AR-03/19 – Material Qualification and Equivalency for Polymer Matrix Composite Material Systems: Updated Procedure
5. Draft SAE ARP XXX Composite Material Qualification and Control, SAE AMS P-17, Version 1

9. Revisions

Revision	Date	Description
-	6/7/2006	Initial Release
A	3/28/2007	Added section 4.3 and 4.4
B	2/22/2008	Added ACN Form (Appendix 1). Revised section 5.1 to agree with existing aerospace standard practice. Replaced DOT/FAA/AR-02/109 with DOT/FAA/AR-07/3 and added DOT/FAA/AR-06/10 as references. Revised section 6.1 ACN process.

**APPENDIX 1: ADVANCED CHANGE NOTICE (ACN)
National Center for Advanced Materials Performance (NCAMP)**

To be completed by material supplier:

ACN NO.: DATE:	REQUESTED BY:
MATERIAL SPECIFICATION NO.:	SECTION TO BE CHANGED:
REASON FOR CHANGE:	
CURRENT DOCUMENTATION:	
PROPOSED CHANGE:	
COMPANY:	BY: _____ (TECHNICAL) _____ (OPERATIONS/PRODUCTION) _____ (QUALITY ASSURANCE)
COMMENTS:	

To be completed by NCAMP:

NCAMP STAFF:	LEVEL OF CHANGE:
APPROVED ()	BY: _____ DATE: _____ <i>(upon reaching consensus with material users and the FAA only)</i>
DISAPPROVED ()	TITLE: _____
DATE OF INCORPORATION:	
COMMENTS:	