NCAMP-DRAM Standard Operating Procedure (SOP)

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1 Introduction

1.1 Background

Historically, companies using advanced materials such as polymer matrix composites in aerospace structural applications have performed independent material qualification and data acquisition programs due to a lack of shared material property data for certified applications. To combat this lack of data, in 1995 the Federal Aviation Administration (FAA) partnered with CMH-17 (then MIL-HDBK-17) and the National Aeronautics and Space Administration (NASA) to create the Advanced General Aviation Transport Experiment (AGATE) program. This program developed a composite material property shared database process which covered the original material qualification, material property data acquisition, and qualification processes. The AGATE process was recognized as an acceptable means of showing compliance with 14 CFR Part 23.613 through FAA Small Airplane Directorate's policy memorandum (Policy Statement Number ACE-00-23.613-01; Volume 65, Number 114).

Due to the success and sunset of AGATE, the National Center for Advanced Materials Performance (NCAMP) was established with the purpose of refining and enhancing the AGATE process to a self-sustaining level serving the entire aerospace industry in partnership with NASA, CMH-17, FAA, and SAE (Society of Automotive Engineers). Since 2010 (FAA Memorandum AIR100-2010-120-003), the NCAMP process has been recognized as an acceptable means of showing compliance with §§2x.603(a) & (b) of CFR parts 23, 25, 27, 29 and with §33.15 and §33.17. NCAMP continues to support their founding organizations, and more, since its inception in 2005.

To build upon the framework and pedigree established by AGATE and NCAMP, NCAMP-DRAM (Defense Rapid Advanced Manufacturing) was formed to support the need for rapid publication of an advanced, pedigreed, material database for U.S. defense interests. NCAMP-DRAM will build upon the infrastructure and success of AGATE and NCAMP with the Department of Defense (DoD) leading the Regulatory Governing Board (RGB) with Wichita State University's (WSU) National Institute for Aviation Research (NIAR).

1.2 Purpose

The intent of this document is to describe the standard operating procedures (SOP) employed by NCAMP-DRAM for material property data acquisition, material qualification, material allowable generation, and material qualification processes. The structure of NCAMP-DRAM is specifically designed to be inclusive for multiple types of advanced materials. To allow for this flexibility while still providing the proper material property data acquisition and allowable generation processes, each disparate advanced material process will have an appendix to this SOP. When available, these appendices will outline the requirements to generate basic material property data with sufficient pedigree and control for submission, approval, and appropriate dissemination. Regardless of the disparate advanced

material process selected, each qualification process will involve qualifying materials into material procurement specifications while establishing process control documents (PCDs) and process specifications necessary to ensure consistent and reliable material properties. While NCAMP-DRAM provides a means of compliance, it is not the only means and may be referenced and utilized where appropriate.

NCAMP-DRAM is an organization within NIAR and operates independently of other NIAR laboratories and research initiatives.

1.3 Scope

The intent of NCAMP-DRAM is to promote the rapid publication of advanced, pedigreed, material data for US defense interests which may be used in design applications and certification. However, it is not anticipated that the data provided will fulfill all the design needs of every project. Each user will need to assess the data available against the specific properties, environments, and loading situations of their individual projects.

1.4 Usage and Limitations

Each material qualification and material property data acquisition program use unique sets of test plan and material & process specifications. Materials either produced by distinctly different process specifications or that adhere to different material specifications will be treated as separate material sets. Deviation from the original material specification may change the material properties and render the material property data and/or allowables invalid. The material specification along with its PCD is designed to control material property. Material specifications and PCDs may be revised over time, so material users should use the same material specification and participate in material specification/PCD change management activities. Minor deviation from the original process specification is anticipated, especially for complex parts, but the deviation must be justified by analysis and/or test, as required by the certifying agencies involved.

The use of NCAMP-DRAM material and process specifications does not guarantee material or structural performance. Material users must institute at a minimum, but not limited to, required quality control including, perform regular purchaser quality control tests, perform periodic qualification testing, participate in material change management activities, conduct statistical process control actions defined in their specification, and conduct regular supplier audits to properly implement NCAMP-DRAM specifications.

Care must be taken when utilizing material allowables derived using NCAMP-DRAM procedures. NCAMP-DRAM does not guarantee that all the data necessary to design and certify a part is provided by the data defined within the NCAMP-DRAM database. The applicability and accuracy of NCAMP-DRAM material property data, material allowables, and specifications must be evaluated on case-by-

case bases by the applicant and certifying agencies. The material allowables published by NCAMP-DRAM may not be directly usable as design values which satisfy all regulatory requirements. In such cases, additional tests are required to supplement NCAMP-DRAM data in order to derive a complete set of design values for a given program. The amount of additional testing is dependent on the complexity and criticality of the part being designed. NCAMP-DRAM assumes no liability whatsoever, expressed or implied, related to the use of the material property data, material allowables, and specifications.

1.5 Definitions of Key Terms

Advanced Materials Performance Enabling Data (AMPED): Online composite and advanced material properties database linking manufacturing and process information, and material properties.

Material Allowable: A bulk (physical, static, or dynamic) material property derived from the statistical reduction of data from a stable process. The amount of data required to derive these values is governed by the statistical significance or basis and methods. Application of material allowables may require additional considerations for use in design.

Material Design Values: A material or structural property that is established to represent the finished part property. These numbers are typically based on material allowables and adjusted, using building block tests as necessary to account for the range of part geometric features (e.g., holes, notches, surface finish) and in-service environmental conditions (e.g., temperature, moisture, and fluid). Design values are used in analysis to compute structural design margin (i.e., margin of safety.)

Initial Material Qualification: The process of qualifying a material data set which includes at least one of the following: material allowables, design values, material specification. Data types may be, but are not limited to, static properties, physical properties, dynamic properties, and corrosion properties. In the NCAMP-DRAM process, material qualification and material allowable generation are conducted concurrently; the same data is used to generate material allowables and establish material specification limits and design values.

Workbench for Additive Materials: A DoD owned and directed tool which houses additive qualification data such as material data, specifications and pedigree information.

1.5.1 Acronyms

AMPED	Advanced Materials Performance Enabling Data
CMH-17	Composite Materials Handbook – 17
DRAM	Defense Rapid Advanced Manufacturing
MAB	Manufacturers Advisory Board
MMPDS	Metallic Materials Properties Development and Standardization

NCAMP	National Center for Advanced Materials Performance
NIAR	National Institute for Aviation Research
PCD	Process Control Document
RGB	Regulatory Governing Board
SAB	Suppliers Advisory Board
WAM	Workbench for Additive Materials
WSU	Wichita State University

2. NCAMP-DRAM Organizational Structure and Process

2.1 Overview of Organization

The NCAMP-DRAM Organizational Structure, as shown in Figure 1, was established to create effective and efficient relationships among all stakeholders. Participating members within the NCAMP-DRAM organization are required to maintain regular communication with all the members through meetings and news-bulletins. The NCAMP-DRAM organization bears the responsibility to ensure that every member's feedback and comment is given fair consideration.

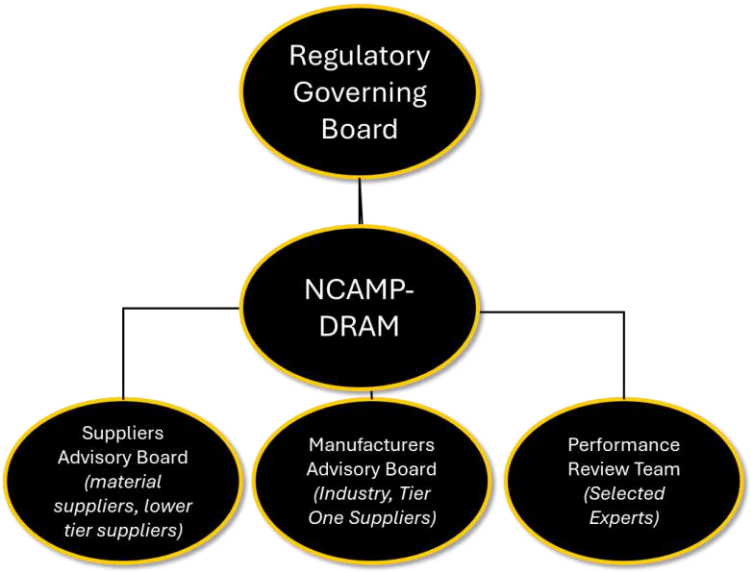

Figure 1: *NCAMP-DRAM Organizational Structure*

2.2 Regulatory Governing Board (RGB)

The Regulatory Governing Board consists of individuals from the Department of Defense (DoD) and WSU-NIAR. The established RGB will provide guidance across all advanced material processes covered under the NCAMP-DRAM SOP. The RGB's primary role is to approve the material data and standards published by NCAMP-DRAM. RGB also advises WSU-NIAR related to the NCAMP-DRAM procedures, such as this SOP and its associated appendices, and advises WSU-NIAR to ensure NCAMP-DRAM activities are meeting the defense industrial base

industry needs. NCD 110 Operating Procedures and Bylaws for NCAMP-DRAM Regulatory Governing Board (RGB) describes the approach and procedures to conducting business within RGB.

2.3 NCAMP-DRAM Organization

The NCAMP-DRAM organization will include representatives from WSU-NIAR who are responsible to guide, direct, and maintain operations in accordance with this SOP. The NCAMP-DRAM organization will ensure the SOP is followed ensuring publications issued under NCAMP-DRAM are appropriately vetted

2.3.1.1 Ballot Rules and Procedures

All ballots may be in the form of a webpage, Adobe Acrobat File, or email. Detailed information about the purpose of the ballot must be provided to the voting member. The votes will be considered by the RGB and NCAMP-DRAM staff for the purpose of making a final decision on the proposed material data or standard.

Members will be given two a minimum of two weeks for review and to provide comments. NCAMP-DRAM will then incorporate the comments, and if necessary, schedule teleconferences or meetings to discuss the revision (members may request meetings to discuss). After comments are resolved, the members will be asked to vote (e.g. **affirmative, negative, or abstain)** on the revision. The ratio of affirmative to negative votes must be at least 75% for the revision to stand. The voting process is optional for editorial, typographical error, and computational corrections. Changes requested by RGB members designed to meet regulatory requirements are also exempt from this voting process.

2.4 Manufacturers Advisory Board (MAB)

The Manufacturers Advisory Board (MAB) will be included when required by the RGB. The MAB consists of companies that are contract manufacturers (CM), primes, and tier-1 suppliers. Each advanced material process will have its own MAB, and some MAB members may cross into multiple advanced material processes. Each MAB member must designate an individual to serve as a company representative on the NCAMP-DRAM MAB. The representative serves as the official point-of-contact between the RGB and the company for activities such as voting and document review. MAB plays an important role in ensuring that the NCAMP-DRAM process, procedures, material properties, and specifications meet application requirements. Each MAB member has the responsibility to provide feedback and comments to NCAMP-DRAM staff to ensure that the NCAMP-DRAM deliverables meet their individual needs. If an MAB does not provide response to document reviews within the allotted timeline, their input may not be included. NCD 120 Operating Procedures and Bylaws for NCAMP-DRAM Manufacturers Advisory Board (MAB) describes the approach and procedures to conducting business within MAB.

2.5 Suppliers Advisory Board (SAB)

The Suppliers Advisory Board (SAB) will be included when required by the RGB. The SAB consists of material suppliers, tier-2, and tier-3 suppliers. Each advanced material process will have its own SAB, and some SAB members may cross into multiple advanced material processes. The primary function of SAB is to provide NCAMP-DRAM with the latest material and process technology for inclusion in the material property shared database. SAB participates in NCAMP-DRAM document review process and plays an important role in establishing quality standards for NCAMP-DRAM materials. Material suppliers have the responsibility to provide feedback to NCAMP-DRAM, especially those related to material specification requirements. If a SAB does not provide response to document reviews within the allotted timeline, their input may not be included NCD 130 Operating Procedures and Bylaws for NCAMP Suppliers Advisory Board (SAB) describes the approach and procedures to conducting business within SAB.

2.6 Performance Review Team (PRT)

The Performance Review Team (PRT) will be included when required by the RGB. The PRT consists of subject matter experts if required. Each advanced material process will have its own unique PRT membership. A majority of the individuals in PRT are consultants. PRT members have the responsibility to be impartial and maintain high degree of integrity, sound judgment, and objectivity when performing the assigned tasks. Regardless of the employment (direct employee or hired consultant) status, an individual performing the duties under the PRT is expected to be able to perform those duties without undue pressure from the company seeking their services in that capacity.

2.7 Process

Regardless of the manufacturing method seeking approval, the NCAMP-DRAM process remains the same. Figure 2 provides a depiction of the process for acceptance and publication of documents, specifications, or standards under the NCAMP-DRAM organization. Requirements and guidance unique to the advanced material process seeking approval and publication will be denoted within the appropriate appendix when available.

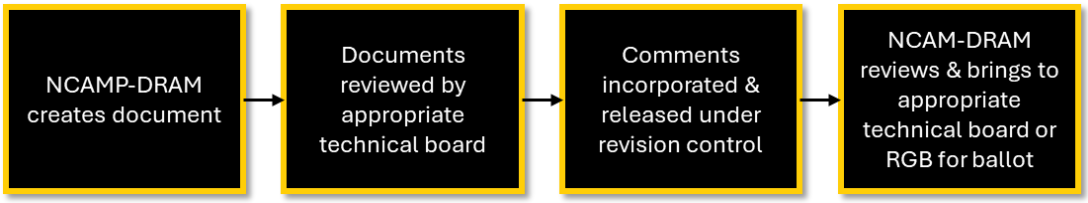

Figure 2: *NCAMP-DRAM Process*

3. Core NCAMP-DRAM Documents

NCAMP-DRAM will review and issue documents that fall within either Initial Material Qualification data, material metadata, material data, material allowables and design

values, or standards and specifications. Each advanced material specific appendix will provide requirements and guidance within these categories when available. Documents created and issued under NCAMP-DRAM will bear the prefix:

- NCD-ME = NCAMP-DRAM Metals
- NCD-PO = NCAMP-DRAM Polymers
- NCD-CP = NCAMP-DRAM Composites
- NCD-CE = NCAMP=DRAM Ceramics

If any document anticipating publication under NCAMP-DRAM holds proprietary information, NCAMP-DRAM will ensure the proprietary information is properly managed through the NCAMP-DRAM review, approval, and publication process.

3.1 Initial Material Qualification (IMQ)

The initial material qualification and property data acquisition process is dependent upon the advanced manufacturing method leveraged. The IMQ dataset requirements and guidance will be outlined within the appropriate advanced manufacturing appendix of this SOP when available. Whenever possible, IMQ datasets approved under the NCAMP-DRAM organization will be published in either the Workbench for Additive Materials (WAM) or Advanced Materials Performance Enabling Data (AMPED) databases.

3.2 Material Metadata

The metadata elements, often referred to as pedigree data, required for each test sample will be unique to the specific advanced manufacturing process. The specific metadata pedigree requirements and guidance are outlined within the appropriate advanced material appendix when available.

3.3 Material Data

Material data requirements are dictated by advanced manufacturing process method and material data classification. The specific material data requirements and guidance are outlined within the appropriate advanced material appendix when available.

3.4 Material Allowables and Design Values

Material allowable and design value statistics and method of determination will be unique to each advanced manufacturing process and material classification.

3.5 Standards and Specifications

All types of specifications and standards may be published with NCAMP-DRAM. Below are listed some of the most typical types, however NCAMP-DRAM is not limited to the publication of these specifications and standards. The inter-relationship between and guidance for content within the standards and specifications is provided within the appropriate advanced material appendix.

- Material Specifications
- Process Specifications

- Process Control Documents (PCDs)
- Raw Material Specifications
- Material Testing Specifications
- Qualification Specifications
- Procedural and Guidance Standards

4. Acceptance of data developed outside of NCAMP-DRAM

Materials previously qualified for certified applications, commercial or military, may be incorporated into the NCAMP-DRAM organization if pedigree information and material control requirements are deemed sufficient by the NCAMP-DRAM RGB.

5. NCAMP-DRAM Revision Control

Revisions to NCAMP-DRAM publications must be in accordance with Figure 3:Flowchart of NCAMP-DRAM Document Revision Process. NCAMP-DRAM begins the process by creating draft document(s) with "Track Changes" turned on, along with a detailed description and reason for the change. The documents will be shared with members of the RGB for their notification of the start of the revision process.

The appropriate technical board (RGB, PRT, SRB or MRB) will be given a minimum of two (2) weeks to review and provide comments. NCAMP-DRAM will incorporate the comments and, if necessary, schedule a teleconference or meeting to discuss the revision. Members may request a teleconference or meeting to discuss the revision. After the comments have been resolved, the members will be asked to vote (e.g. affirmative, negative, or abstain) on the revision. The ratio of affirmative to negative votes must be at least 75% for the revision to stand. This voting process is optional for editorial, typographical error, and computational corrections. Changes requested by RGB members designed to meet regulatory requirements are also exempted from this voting process.

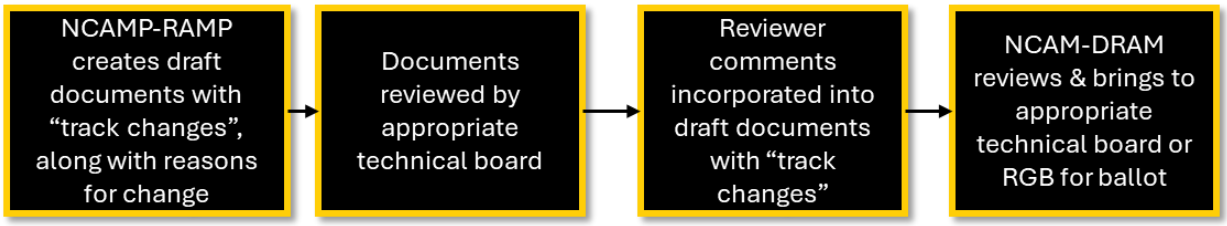

Figure 3: *Flowchart of NCAMP-DRAM Document Revision Process*