CMH-17
COMPOSITE MATERIALS HANDBOOK

CMH-17 Additive Manufacturing

America Makes & ANSI AMSC virtual event on Design for AM

March 31, 2021

Curtis Davies, Federal Aviation Administration

Co-Chair CMH17

What is the Composite Materials Handbook?

CMH-17
COMPOSITE MATERIALS HANDBOOK

CMH-17 Mission

The Composite Materials Handbook organization creates, publishes and maintains proven, reliable **engineering information and standards**, subjected to thorough technical review, **to support the development and use of composite materials and structures**.

CMH-17 Vision

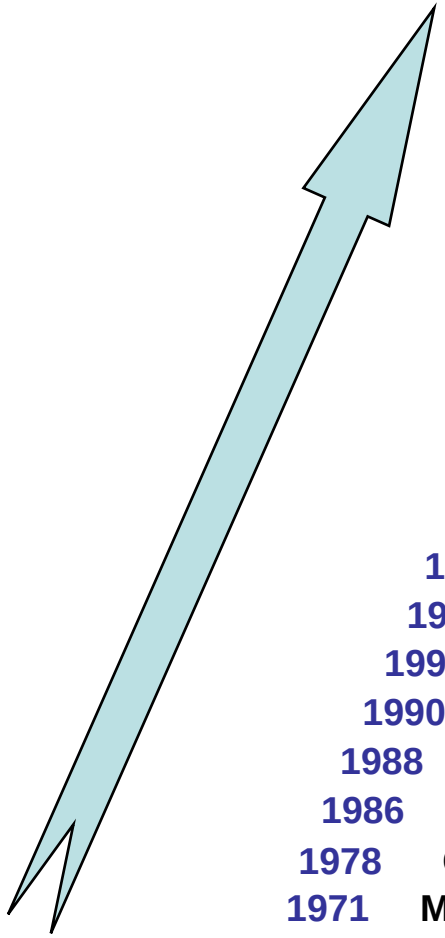
The Composite Materials Handbook will be the **authoritative worldwide focal point for technical information** on composite materials and structures.

Objectives

- The Composite Materials Handbook-17 (CMH-17) provides information and guidance necessary to design, fabricate, and use end items from advanced materials such as composites and additive manufacturing.
- Its primary purpose is the standardization of engineering methodologies (e.g. data collection, data development, design analysis, screening procedures, criteria, guidelines, quality control, etc.) related to design, fabrication, maintenance, testing, data reduction, data reporting of property data, and use of that data for current and emerging composite materials.
- In support of this objective, the Handbook includes advanced materials properties that meet specific data requirements and engineering methods that have been subject to rigorous review.
- The Handbook constitutes an overview of the field of composites and other advanced materials technology and engineering; an area which is advancing and changing rapidly. As a result, the document is constantly being updated as sections are added or modified to reflect advances in the state-of-the-art.

Handbook History

CMH-17
COMPOSITE MATERIALS HANDBOOK



2018 AM Coordination Group Formed
2018 Release of Vol. 2H – CMH-17 Handbook
2017 Release of Vol. 5A – CMH-17 Handbook
2013 Release of Vol. 6, 4B – CMH-17 Handbooks
2012 Release of Volumes 1-3 Rev G – CMH-17 Handbooks
2005 Transition from Army to FAA as Primary Sponsor
Established Roadmap to New Composite Materials Handbook "Release G"
2004 Joint Meetings with CACRC, SAE-P17
2002 MIL-HDBK-17 Vol. 1F, 2F, 3F, 4A, 5
Commercial Publication through ASTM
1999 MIL-HDBK-17 Vol. 2E,Vol. 4
1998 Joint Meetings with ASTM D-30
1997 MIL-HDBK-17 Vol. 1E,3E
1996 CMC Coordination Group Formed
1993 MMC Coordination Group Formed
1990 First PMC Data Set Approved
1988 MIL-HDBK-17B Vol. 1 Release
1986 Secretariat Added
1978 Coordination Group Formed
1971 MIL-HDBK-17A Plastics for Aerospace Vehicles
1959 MIL-HDBK-17 Plastics for Air Vehicles
1943 ANC Bulletin 17 Plastics for Aircraft

PMC: Polymer Matrix Composites
MMC: Metal Matrix Composites
CMC: Ceramic matrix Composites
AM: Additive Manufactured Materials

CMH-17 Goals

CMH-17
COMPOSITE MATERIALS HANDBOOK

The handbook has focused on three areas to meet our objectives:

1. **Provide material data**
   - Physical and mechanical properties
   - Tied to a single material specification AND a single process specification (published elsewhere, but publically available)
2. **Describe how to generate material data**
   - Material and process control
   - Test matrices
   - Statistical methods
3. **Describe how to use the materials**
   - Design guide based on:
     - Proven methods / best practices
     - Includes information on maintenance
   - Manufacturing Insights

Handbook Content Development Lifecycle

CMH-17
COMPOSITE MATERIALS HANDBOOK

Tasks driven by the Executive Committee and Scoped by the Coordination Committee, with feedback from WG sessions

Writing is done during WG sessions, but telecons also used to develop content. Review is encouraged by non-experts, a valuable asset to review content and make sure it makes sense to a novice reader.

EVERYONE can review and comment on yellow pages. Comments dispositioned during WG sessions. *If you don't understand what is being stated, there is likely a problem we need to solve.*

Review newly approved content either in WG sessions, in a forum, or in formal tutorial training.

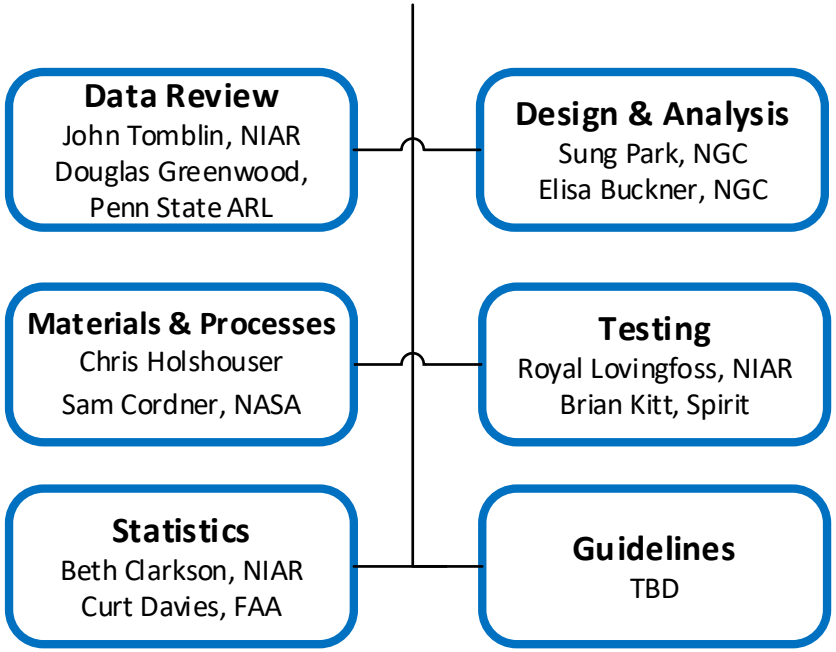
Review existing content to note when it needs to be updated. *This is another great opportunity for new members to become familiar with the content and provide feedback.*

Technical Subject Areas and Working Groups

CMH-17
COMPOSITE MATERIALS HANDBOOK

Working Groups (WG) perform the core of the technical work and section writing for the Handbook activity.

The WGs have a charter to cover a specific technical area of the Handbook. It is expected that these technical areas will continue to evolve for the duration of the Handbook activity.



CMH-17 Goals

The handbook has focused on three areas to meet our objectives:

1. **Provide material data**
   - Physical and mechanical properties
   - Tied to a single material specification elsewhere, but publically available)
2. **Describe how to generate mate**
   - Material and process control
   - Test matrices
   - Statistical methods
3. **Describe how to use the materials**
   - Design guide based on:
     - Proven methods / best practices
     - Includes information on maintenance
   - Manufacturing Insights

A major focus of CMH-17 is how to use the data developed to design, fabricate and sustain products created using the materials covered in the handbook

DESIGN AND ANALYSIS

CMH-17
COMPOSITE MATERIALS HANDBOOK

- **WG Co-Chairs**
  - **Ms. Elisa Buckner**, Northrop Grumman
  - **Mr. Sung Park**, Northrop Grumman
- Establish design and analysis guidelines, methodologies, and basic engineering requirements to increase first-time success and enable substantiation and predictive capabilities for parts fabricated with polymer based additive manufacturing processes. The early focus of the working group will be broad generalizations, followed by details unique to a select number of specific processes. When used as intended, this guidance will ensure consistent application of best practices for the design and analysis of products to be manufactured with the stated material and processes.
- <u>Objectives and Outcomes:</u>
  - Provide guidelines and requirements for the design and analysis of parts fabricated with polymer based additive manufacturing technologies, independent of specific processes.
  - Identify additional guidelines and requirements unique to specific processes.
  - Establish best practices for design definition and documentation.
  - Establish analytical verification methodologies and substantiation/prediction criteria
    - Considering end part anisotropy and inhomogeneity due to both material selection and deposition process
    - Identify test methods and/or properties required and provide to the appropriate working group(s)
  - Provide guidance on test verification methodologies

MATERIALS & PROCESSES

CMH-17
COMPOSITE MATERIALS HANDBOOK

- **WG Co-Chairs**
  - **Mr. Chris Holshouser**
  - **Mr. Sam Cordner**, NASA

- Material, Hardware, and Software operational elements that must be considered, controlled, monitored, and understood to enable successful reproduction of baseline-equivalent performance across a fleet of printers. Duplication of specs should be avoided but the essence and explanation of how spec was developed, how limits were set and why certain critical parameters were identified. Differentiation on what specs can provide and utilization of design values vs. spec minimums.

- <u>Objectives and Outcomes:</u>
  - Provide an outline critical relating to M&P for polymer AM.
  - Outline to encompass all the work completed until now, while leaving room for more complex materials in the future
  - Content completion of outline based on work done to date
  - Identify gaps in current completed work to identify additions for the n^{th} qualification and other areas of research
  - Maintenance of the sections as new qualifications are performed as well as updates to already established quals. Closed feedback loop to accommodate.

CMH-17 Goals

CMH-17
COMPOSITE MATERIALS HANDBOOK

The handbook has focused on three areas to meet our objectives:

1. **Provide material data**
   - Physical and mechanical properties
   - Tied to a single material specification AND a single process specification (published elsewhere, but publically available)
2. **Describe how to generate material data**
   - Material and process control
   - Test matrices
   - Statistical methods
3. **Describe how to use the materials**
   - Design guide based on:
     - Proven methods / best practices
     - Includes information on maintenance
   - Manufacturing Insights

TESTING

- **WG Co-Chairs**
  - **Mr. Brian Kitt**, Spirit AeroSystems
  - **Mr. Royal Lovingfoss**, Wichita State University, National Institute for Aviation Research

- Give guidance on appropriate test methods and test conditions for use with AM materials while taking into account, material type, machine capabilities, process information, industry desired data, statistical analysis requirements, and available standards.

Objectives and Outcomes**:**

- Provide a listing of appropriate test methods for AM materials; including chemical, physical, and mechanical.
- Provide explanation of test conditions; considering both environmental and process based.
- Explanation of appropriate sampling locations and techniques; in conjunction with M&P group.
- Identify gaps in available test methods and work with standard organizations and industry leaders to improve test method applicability to AM materials.
- Maintain testing section of the CMH17 AM volume.
- Work with Statistical group to ensure proper sample count and test matrix compilation for statistical analysis.

STATISTICS

- **WG Co-Chairs**
  - **Dr. Elizabeth Clarkson**, Wichita State University, National Institute for Aviation Research;
  - **Mr. Curtis R. Davies**, Federal Aviation Administration

- Analyzes and/or develops statistical procedures for composite materials evaluation and quality control, and provides other statistical support to the Handbook as requested.

- Currently, the Statistics Working Group is addressing methodology for setting specification requirement values, and is also considering new, revised, and alternate methods of calculating material basis values. Statistics is working in close coordination with the Data Review Working Group relative to this latter subject.

DATA REVIEW

- **WG Co-Chairs**
  - **Mr. Doug Greenwood**, Penn State ARL
  - **Dr. John S. Tomblin**, Wichita State University, National Institute for Aviation Research
- To provide the final technical/editorial review of all data prior to review by the full Coordination Group; provide a review of the application of the data documentation requirements to the actual data being supplied; develop formats for data presentation in the handbook; and establish the data documentation requirements for the handbook.
- Objectives and Outcomes:
  - Develop data table formats including recommended reduced data for presentation
  - Data reduction and draft data tables for Handbook.
  - Work with potential data sources for the Handbook and review documentation/pedigree of potential data sets.
  - Maintain data section of the CMH17 AM volume.
  - Work with Statistics Working Group to ensure the methods used for data analysis are captured in the Statistics chapter.

CMH-17
COMPOSITE MATERIALS HANDBOOK

For more information or to volunteer contact CMH-17 Secretariat:

info@cmh17.org