Update on CMH-17 Volume 5 Ceramic Matrix Composites

Rachael Andrulonis, Wichita State University, Wichita, KS
J. Douglas Kiser, NASA Glenn Research Center, Cleveland, OH
Kaia E. David, The Boeing Company, Huntington Beach, CA
Curtis Davies, Federal Aviation, Atlantic City Intl. Airport, NJ
Cindy Ashforth, Federal Aviation Administration, Renton, WA

41st Annual Conference on Composites, Materials and Structures
January 24, 2017
Overview

• CMH-17 Mission and Vision
• Format / Content / History Summary
• Volume 5
• Linking CMH-17 to FAA
• Publication
• Working Groups
CMH-17 Mission
The Composite Materials Handbook (CMH) 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.

- Volunteer organization that creates, publishes, and maintains engineering information and standards to support the use of composite materials and structures
- Statistically analyzed composite data and guidance
Structure of Handbook

- Volume 1  Polymer Matrix Composites: Guidelines for Characterization of Structural Materials
- Volume 2  Polymer Matrix Composites: Material Properties
- Volume 3  Polymer Matrix Composites: Materials Usage, Design and Analysis
- Volume 4  Metal Matrix Composites
- Volume 5  Ceramic Matrix Composites
- Volume 6  Structural Sandwich Composites (Initial Release)
Handbook History

- **1943** ANC Bulletin 17 Plastics for Aircraft
- **1959** MIL-HDBK-17 Plastics for Air Vehicles
- **1971** MIL-HDBK-17A Plastics for Aerospace Vehicles
- **1978** MIL-HDBK-17 Vol. 1, 2, 3, 4, 5
- **1979** Commercial Publication through ASTM
- **1986** First PMC Data Set Approved
- **1990** Secretariat Added
- **1993** MMC Coordination Group Formed
- **1996** CMC Coordination Group Formed
- **1997** MIL-HDBK-17 Vol. 1E, 3E
- **1998** Joint Meetings with ASTM D-30
- **1999** MIL-HDBK-17 Vol. 2E, 4
- **2002** MIL-HDBK-17 Vol. 1F, 2F, 3F, 4A, 5
- **2004** Joint Meetings with CACRC, SAE-P17
- **2006** Transition from Army to FAA as Primary Sponsor
- **2008** Established Roadmap to New Composite Materials
- **2009** Handbook “Release G”
- **2012** Release of Volumes 1-3 Rev G – CMH-17 Handbooks
- **2013** Release of Volumes 6, 4B – CMH-17 Handbooks
- **2017** Release of Vol. 5A – CMH-17 Handbooks
- **2018** Last CMC handbook issued ~15 years ago
- **2019** Release of Vol. 6, 4B – CMH-17 Handbooks
- **2020** Transition from Army to FAA as Primary Sponsor
- **2021** Established Roadmap to New Composite Materials
- **2022** Handbook “Release G”
- **2023** Release of Volumes 1-3 Rev G – CMH-17 Handbooks
- **2024** Release of Volumes 6, 4B – CMH-17 Handbooks

**Abbreviation Key:**
- PMC: Polymer Matrix Composites
- MMC: Metal Matrix Composites
- CMC: Ceramic matrix Composites
Ceramic Matrix Composite (CMC) Components For Commercial Aircraft Require Certification

• CMC components have begun to enter service in commercial aircraft.

• A wide range of issues must be addressed prior to certification of this hardware.

• The FAA (Federal Aviation Administration) is working with the CMC Community to identify the tasks required to support these components and to establish a timeframe for certification.

Federal Aviation Administration
Ceramic Matrix Composite (CMC) Components
For Commercial Aircraft Require Certification

• The Composite Materials Handbook-17, Volume 5 on ceramic matrix composites is being revised to support FAA certification of CMCs for hot structure and other elevated temperature applications.

• The handbook supports the development and use of CMCs through publishing and maintaining proven, reliable engineering information and standards that have been thoroughly reviewed.

• Volume 5 will contain detailed sections describing:
  - CMC Materials / Processing
  - Design / Analysis Guidelines
  - Testing Procedures
  - Data Analysis and Acceptance
The CMH-17 Organization

~ 300 total members on PMC, CMC, and MMC rosters

Handbook Chairs
Larry Ilcewicz, FAA
Curtis Davies, FAA

Executive Group
(PMC, MMC & CMC WG Chairs)

CMC Coordination Group
Curtis Davies, FAA

Secretariat
Wichita State University

PMC Coordination Group
Larry Ilcewicz, FAA
Curtis Davies, FAA

MMC Coordination Group
John Kleek, WPAFB
Brad Lerch, NASA

Permanent Working Groups

Data Review
Rajiv Naik, Pratt & Whitney

Design and Analysis
Mitch Petervary, Boeing
David Thomas, Rolls-Royce

Guidelines
Curtis Davies, FAA

Materials & Processes
Kaia David, Boeing
Doug Kiser, NASA GRC

Testing
Jennifer Pierce, UDRI
William Keith, Boeing
Greg Wilson, GE Aviation

Working groups are meeting at this conference on Wed. from 5 - 6:30 pm and on Thurs. from 12-1:30 pm (pizza lunch available)
• Handbook grouped into 4 sections – each linked to specific working groups
  – *Part A: Introduction and Guidelines*
    • Materials and Processes WG
  – *Part B: Design Supportability*
    • Design & Analysis WG
  – *Part C: Testing*
    • Testing WG
  – *Part D: Data Requirements and Data Sets*
    • Data Review WG
Linking CMH-17 to FAA Certification

Provide standardized data and information for acceptance by authorities by:

- Establishing Active CMC Working Groups
  - Sessions for each WG
  - Regular WG Telecons
  - Continually review WG charters and make necessary changes/edits
  - Work on key tasks identified and review periodically

- Periodically holding coordination meetings to discuss critical issues
  - CLEEN consortium/Cocoa Beach meetings
  - Working group meetings in conjunction with other CMC events
FAA References / Publications

• The most comprehensive means of compliance for composite structure is in Advisory Circular (AC) 20-107 “Composite Aircraft Structure”
  – Additional guidance in other ACs and Policy Statements
  – Published guidance is “one means, but not the only means” to meet the regulations; however it is typically the fastest and easiest

• FAA guidance relies heavily upon industry publications such as CMH-17
  • May build upon information in CMH-17 or reference it, as shown below
CMH-17 Vol. 5 Publication Timeline

- Initial drafts created
- Circulate within Working Groups
- Approved at the Working Group level
- Yellow Pages – multiple review cycles (~6 weeks each)
- Update sections based on Coordination Group feedback
- Working draft updated and posted on website

Vol. 5 Working Groups
1/2014 - 9/2016

Vol. 5 Working Groups
4/2016 - 12/2016

CMH-17
12/2016 - 2/2017

Vol. 5

- Testing and Design YPs are currently out for review - deadline is 12/16
- Final M&P Sections to be sent out this month.

- Final review
  - Copyright releases
  - Consistency review
  - Technical review
  - DoC Review
  - PUBLICATION
Working Group Progress

- Materials and Processes
- Design and Analysis
- Testing
- Data Review
Goals:

• To provide information on the composition, fabrication, quality control, and characterization of CMC engineering materials and structures.

• To provide a comprehensive overview of ceramic matrix composite (CMC) technology, outlining the types of CMCs, commercial aircraft applications, benefits, methods of fabrication, quality control, and supportability.

• To define the essential elements of information on composition, structure, and processing of CMCs necessary to support design, selection, fabrication, certification, and utilization of CMC structures.

• To specify the methods and procedures to be used in the characterization of ceramic matrix composites, their coatings, and their constituents. Efforts will be coordinated with the Testing Working Group.
Design and Analysis Working Group

Goals:

• To provide information on design and analysis methods and options, the level of substantiation required, and presentation formats required in validation and certification processes

• To ensure future relevancy of the handbook by maintaining an up to date survey of the current state of the art capabilities within the design, analysis and lifing communities for CMCs

Challenges:

• Creating a document that contains meaningful and valuable content for both industry and government entities while honoring the highly proprietary nature of corporate design practices
Testing Working Group

Vision Statement:
• To be the primary and authoritative source for recommended/required methods for testing characterization of CMCs & their constituents

Goals:
• To identify appropriate existing consensus standard test methods for CMCs and their constituent materials
• To assist in the identification/development of appropriate standard test methods for CMCs and their constituent materials, where no such standards exist
Vision Statement:

• Formulate guidelines & requirements for submission (batch size, etc.), documentation, analysis, and review for all CMC data that are submitted for inclusion in the handbook.

• Review the data and the analysis of data sets that are submitted for inclusion in the handbook.

• Develop formats for presentation of data in the handbook and for its storage in electronic databases.

• Develop and document statistical methods for pooling and analysis of CMC data.

Key Issues:

• Export classification of data that is submitted to the handbook
• Storage and dissemination of ITAR data
• Appropriate electronic Database choice for data storage and dissemination (with export restricted access as needed)
• Sources of new CMC data
## CMC Property Database

### Currently not ITAR restricted

<table>
<thead>
<tr>
<th>Composite Name</th>
<th>Composite Description</th>
<th>Producer</th>
</tr>
</thead>
<tbody>
<tr>
<td>9/99 EPM SiC/SiC</td>
<td>Sylramic™/BN-Si/MI SiC</td>
<td>Ceramic Composite Products</td>
</tr>
<tr>
<td>Enhanced SiC/SiC</td>
<td>CG Nicalon™/Carbon/CVI SiC</td>
<td></td>
</tr>
<tr>
<td>Carbon/SiC</td>
<td>T300/Carbon/CVI SiC</td>
<td>COI Ceramics</td>
</tr>
<tr>
<td>Hi-Nicalon/MI SiC</td>
<td>Hi-Nicalon™/BN/MI SiC</td>
<td></td>
</tr>
<tr>
<td>AS-N720-1</td>
<td>Nextel 720/alumino-silicate</td>
<td></td>
</tr>
<tr>
<td>Sylramic S-200</td>
<td>CG Nicalon™/BN/PIP Si$_3$N$_4$-SiC</td>
<td></td>
</tr>
</tbody>
</table>

- New CMC data to be included in future revisions
- Currently working with organizations to obtain data
Summary

- The *Composite Materials Handbook-17, Volume 5* on ceramic matrix composites is being revised to support FAA certification of CMCs for hot structure and other elevated temperature applications
  - CMC Materials / Processing
  - Design / Analysis Guidelines
  - Testing Procedures
  - Data Analysis and Acceptance

- WGs are currently seeking volunteers / input for future revisions

- Publication Spring 2017 through SAE International
Individuals interested in contributing to these groups should please forward their contact information to

Rachael Andrulonis (rachael@cmh17.org)

and/or talk to any Working Group member

Working groups are meeting at this conference on Wed. from 5 - 6:30 pm and on Thurs. from 12-1:30 pm (pizza lunch available)