

FAA Composite Guidance & Relevant Resource Composite Safety Meeting & Workshop New Zealand

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Wellington, New Zealand

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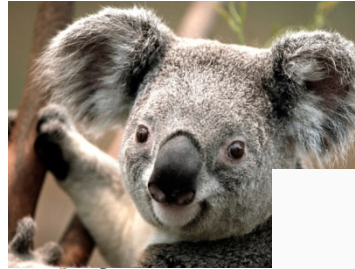
Federal Aviation
Administration



Outline

- **FAA CS&CI Document Development Process** (*same as AVS Plan Presentation*)
- **FAA Guidance and Technical Documentation**
- **AGATE Project**
- **FAA Workshops**
- **Bonded Structure Initiatives**
- **Industry Links** (e.g., CMH-17, SAE CACRC)
- **Training Development**
- **Summary**

International Composite Team Approach

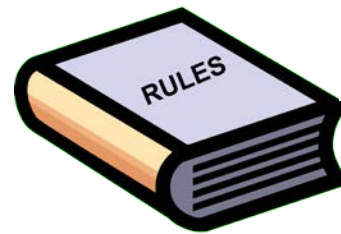


Assemble individuals known to have common interests and wear similar outfits to see if you can gain some agreement



IDENTIFY A FEW SUBJECT MATTER EXPERTS (SME) WILLING TO CONTRIBUTE

INVITE MORE EXPERTS TO THROW IN THEIR TWO CENTS



Charter a Few Pioneers to Create Standards and Educate the Masses

Publish Some Regulations and Cheat Sheets to Figure Them Out

Industry/Regulatory Working Groups

- Assembled based on certification experiences and knowledge involving new composite applications
- Provide a basis for FAA/Industry Composite Workshops
- Provide an interface with experienced members of the industry to share experiences that advance efforts of standards organizations
- **Example of an active composite working group**
 - Composite Transport Damage and Maintenance Working Group was started by FAA and EASA in 2005
 - Helped compile content for CMH-17, Revision G
 - Helped develop FAA safety awareness course content
 - Supported several FAA/Industry Composite Workshops
- **Working Groups may become officially linked to an Aviation Advisory Rulemaking Committee (ARAC) for specific tasking**
e.g., ARAC for Transport Airplane Damage-Tolerance and Fatigue Evaluation

FAA/Industry Composite Workshops

- FAA/industry workshops helped benchmark composite industry practices for several technical areas
- Workshops were also used to review progress in composite policy, guidance and training initiatives
- Many composite presentations covered technical details not publically available before the workshop
- Workshop breakout sections were used to debate technical issues and help define FAA research
- 19 workshops were held between 2000 and 2015
- Wichita State University helped conduct & archive presentations and breakout sessions from several workshops on a website

Presentations, recaps and breakout session summaries at:
<http://www.niar.wichita.edu/niarworkshops/>



FAA Composite Guidance

1. Advisory Circulars

- AC 20-107B "Composite Aircraft Structure" [9/09]
- AC 23-20 "Acceptance Guidance on Material Procurement and Process Specifications for Polymer Matrix Composite Systems" [9/03]
- AC 27-1 "Certification of Normal Category Rotorcraft" [9/08]
- AC 29-2 "Certification of Transport Category Rotorcraft" [9/08] AC 29 MG 8 "Substantiation of Composite Rotorcraft Structure" [4/06] [Note: AC 29 MG 8 is contained in AC-29-2]
- EASA AMC 20-29 "Composite Aircraft Structure" [07/10]

FAA Composite Guidance

2. Policy Statements

- Memorandum, Rotorcraft Directorate Policy, Certification Secondary Composite Structure, dated October 28, 1998
- “Policy on Acceptability of Temperature Differential between Wet Glass Transition Temperature (T_{gwet}) and Maximum Operating Temperature (MOT) for Epoxy Matrix Composite Structure” [PSACE100-2-18-1999, February 1999]
- "Static Strength Substantiation of Composite Airplane Structure" [PS-ACE100-2001-006, December 2001]
- “Material Qualification and Equivalency for Polymer Matrix Composite Material Systems“ [PS-ACE100-2002-006, September 2003]
- “Substantiation of Secondary Composite Structures" [PS-ACE100-2004-10030, April 2005]

FAA Composite Guidance

2. Policy Statements (cont.)

- “Bonded Joints and Structures -Technical Issues and Certification Considerations” [PS-ACE100-2005-10038, September 2005]
- “Acceptance of Composite Specification and Design Values Developed using the NCAMP Process” [AIR100-2010-120-003, September 2010]
- “Composite Materials - Shared Databases - Acceptance of Composite Specifications and Design Values Developed using the NCAMP Process” [EASA CM-S-002 EASA CM-S-004]

FAA Composite Guidance

2. Policy Statements (cont.)

- “Policy Memo on Guidance for Component Contractor Generated Composite Design Values for Composite Structure ” [PS-AIR-100-120-07, September 20, 2013]
- “Bonded Repair Size Limits”
[PS-AIR-20-130-01, November 2014]
- “High-Energy Wide-Area Blunt Impact for Composite Structures” [PS-ANM-25-20, Being Prepared for Final Issuance (TBD)]

FAA Composite References

3. SAD Technical Documents

- "Composite Certification Roadmap"
[ACE-100/110, October 2003]
- "Critical Technical Issues for Composite Maintenance & Repair" [ACE-100/110, September 2006]

4. FAA Technical Reports (partial list)

- "Material Qualification and Equivalency for Polymer Matrix Composite Material Systems: Updated Procedure"
[DOT/FAA/AR-03/19, September 2003]
<http://www.tc.faa.gov/its/worldpac/techrpt/ar03-19.pdf>
- "Guidelines and Recommended Criteria for the Development of a Material Specification for Carbon Fiber/Epoxy Unidirectional Prepregs" [DOT/FAA/AR-02/109, March 2003]

FAA Composite References

4. FAA Technical Reports (partial list) (cont.)

- "Guidelines for the Development of Process Specifications, Instructions, and Controls for the Fabrication of Fiber-Reinforced Polymer Composites" [DOT/FAA/AR-02/110, March 2003]
- "Guidelines for Analysis, Testing, and Nondestructive Inspection of Impact-Damaged Composite Sandwich Structures" [DOT/FAA/AR-02/121, March 2003]
- "Effects of Surface Preparation on the Long-Term Durability of Adhesively Bonded Composite Joints" [DOT/FAA/AR-03/53, July 2003]

FAA Composite References

4. FAA Technical Reports (partial list) (cont.)

- “Bonded Repair of Aircraft Composite Sandwich Structures” [DOT/FAA/AR-03/74, February 2004]
- "Assessment of Industry Practices for Aircraft Bonded Joints and Structures" [DOT/FAA/AR05/13, July 2005]

5. SAE CACRC Technical Reports (partial list)

- “Teaching Points for an Awareness Class on “Critical Issues in Composite Maintenance and Repair” [SAE Aerospace Information Report (AIR) 5719, October, 2011]

AGATE

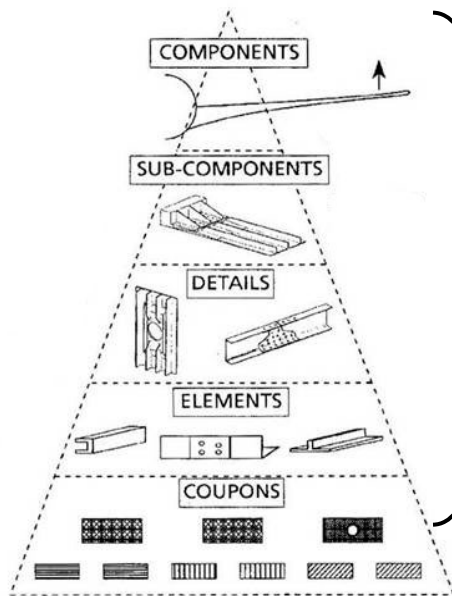
- **One example of an industry-FAA partnership (with NASA leadership) that led to new industry standards and FAA guidance is the AGATE program**
 - Advanced General Aviation Transport Experiment
 - CMH-17 Revision G
 - “Acceptance of Composite Specification and Design Values Developed using the NCAMP Process”
[AIR100-2010-120-003, September 2010]

AGATE



AGATE Materials Working Group was tasked to make composite material property data "shareable"

- like aluminum through MIL-HDBK-5*
- to reduce time and cost*
- to standardize material property data acquisition*
- MIL-HDBK-17 data does not have the necessary pedigree (no M&P specs)*



"Proprietary" at these levels

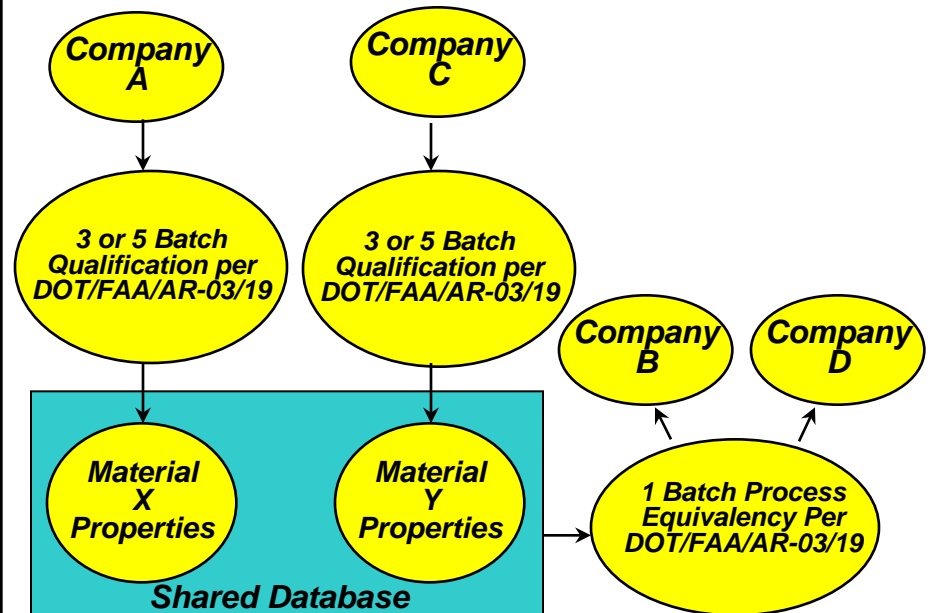
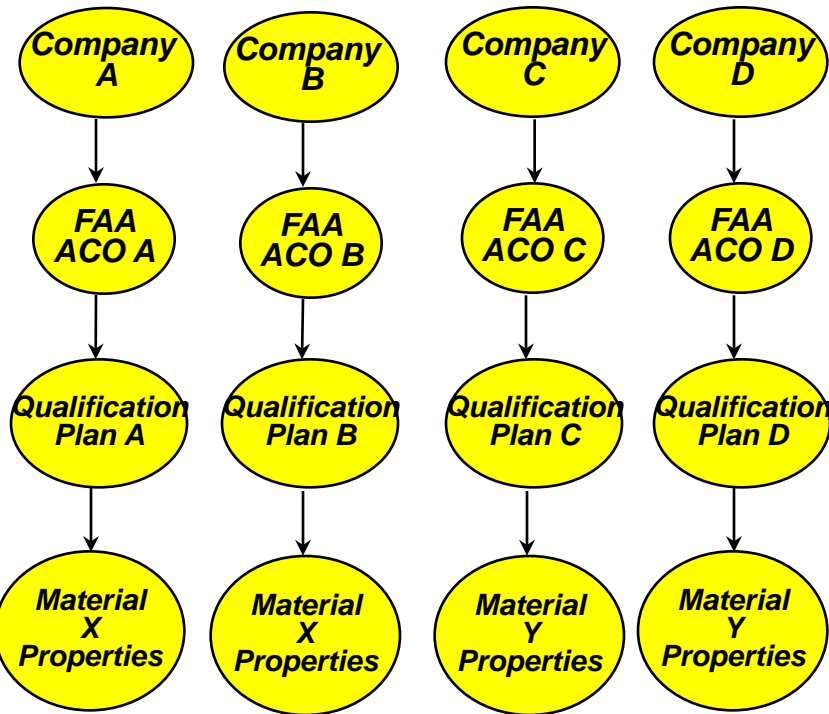
"Shared" at this level



Material Qualification Processes

Traditional Process

AGATE Shared Database Process



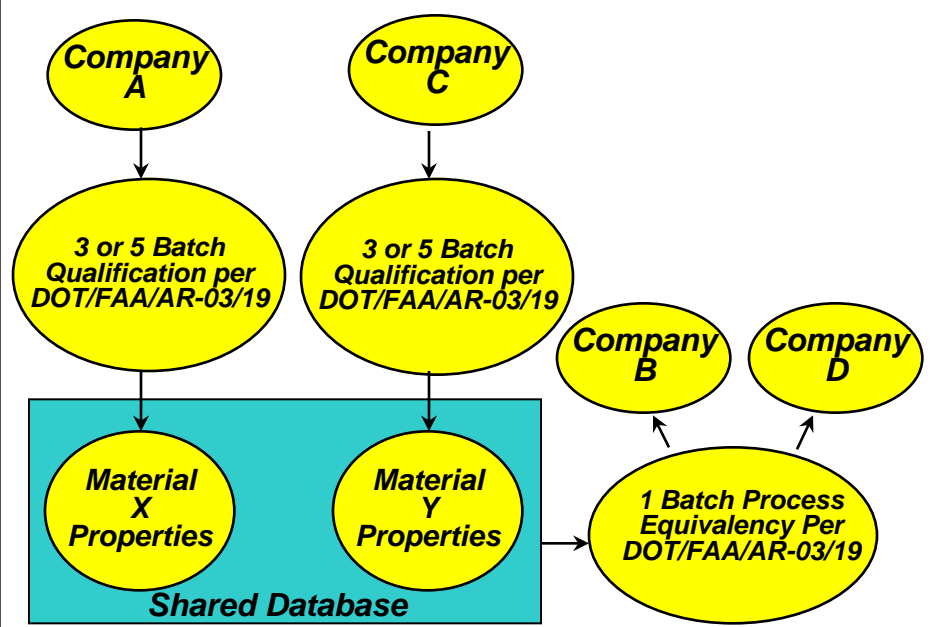
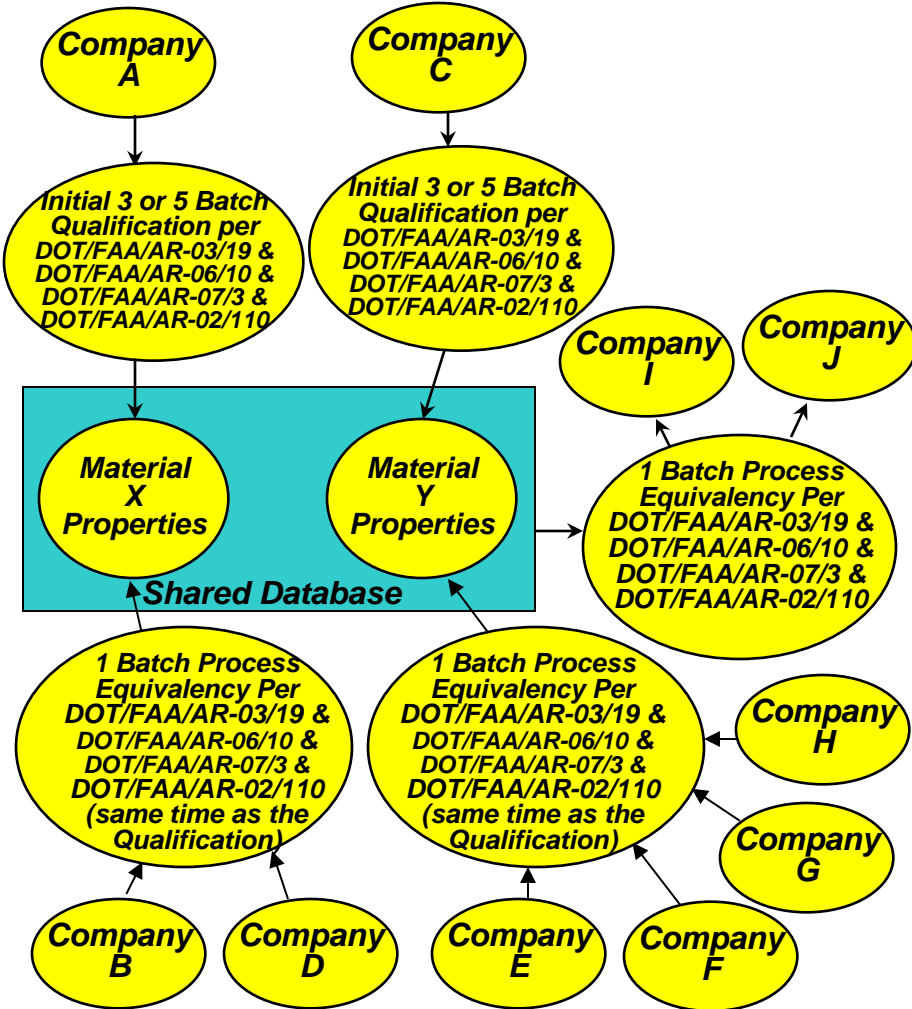
MATERIAL PROPERTIES DO NOT IMPROVE THROUGH MULTIPLE QUALS !

Note: Specification limits and allowables are derived from the same data

Material Qualification Processes

NCAMP Shared Database Process

AGATE Shared Database Process



Progress and Plans in the Bonded Structures Initiatives 2000 to 2005

Sept. 2005 Release FAA policy for Bonded Joints & Structures

Oct. to Dec. 2004 Draft FAA policy for Bonded Structures, FAA workshop in Europe, update reports

July to Sept. 2004 Draft FAA TC Bonded Structures Report to benchmark industry and outline policy

June 2004 FAA workshop to review survey and collect insights from bonding experts at Mil-17 mtg.

Feb. to May, 2004 Setup AACE research grant to survey the industry, develop 2004 workshop agenda and invite speakers

May 2003 to Jan. 2004 Identify experts to support work, develop detailed plans, and collect initial inputs at 2003 M&P workshop

Feb. 2001 TTCP document on "Certification of Bonded Structures"

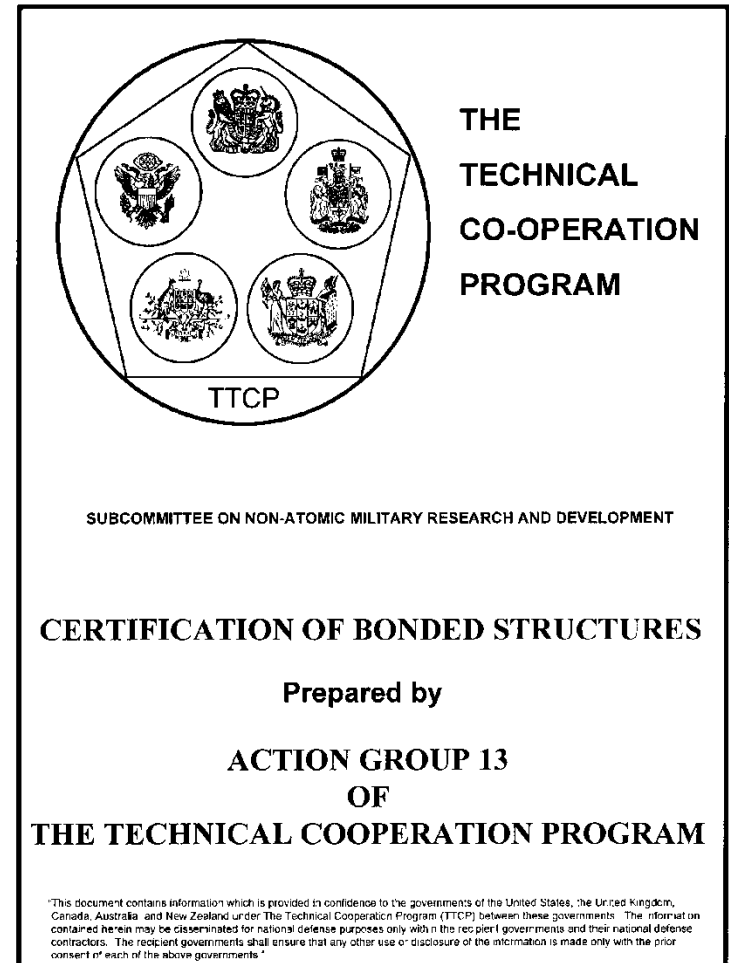
2000 to 2003 FAA research per the *"Don Oplinger Plan"*



Progress for Bonded Structures

Action Groups for Detailed Documentation

- **Some guidance for bonded structures, which comes from military and commercial aircraft experiences, are documented in a TTCP report**
 - Chairman: Jack Lincoln, WPAFB
 - Composite and metal bonding
 - Starting point for current effort
- **Mil-17 Debond & Delamination Task Group since 2000**
 - T.K. O'Brien, K. Kedward and Hyonny Kim are Co-chairman



FAA Workshops

- **Another method used by the FAA to develop guidance is to hold FAA workshops**
 - **An example is on the subject of bonded structures**
 - **In 2004: FAA conducted two workshops, collecting best industry practices (operators & manufacturers), certification & field experiences, and research studies pertinent to bonded aircraft structures -**
 - **Bonded Structures Workshop @ Seattle, WA, USA (6/16-18/2004)**
 - **Bonded Structures Workshop @ London, UK (10/26-27/2004)**
- [<http://www.niar.wichita.edu/niarworkshops/Workshops/>]**

2004 Bonded Structures Initiative

Justification and Purpose

- **Bonding applications for the manufacture & repair of aircraft structures exist throughout the industry**
 - New applications are expanding faster than the qualified workforce, making documentation and training a priority
- **Technical issues are complex and cross-functional, requiring extensive teamwork for successful applications**
 - Known production and service bonding problems highlight a need to properly document the associated technical issues

Collectively, the industry and regulatory agencies should be able to combine our bonding experiences and technical insights to the mutual benefits of improved safety and efficiency in development and certification

2004 Bonded Structure Initiative

Objectives for 2004 Workshops and Follow-on Report(s)

Primary objective

Collect & document technical details that need to be addressed for bonded structures, including critical safety issues and certification considerations

Secondary objectives

- 1) Give examples of proven engineering practices*
- 2) Identify needs for engineering guidelines, shared databases and standard tests & specs*
- 3) Provide directions for research and development*

Presentations at <http://www.niar.wichita.edu/faa/>

Technical Scope of the 2004 Bonded Structures Workshops

Regulatory Considerations

Material &
Process
Qualification
and Control

Design
Development
and Structural
Substantiation

*Bonding
applications
where at least
one side of the
joint is metal or
pre-cured composite*

Proof of structure: static strength
Fatigue and damage tolerance
Design and construction
Materials and workmanship
Durability
Material strength properties &
design values
Production quality control
Instructions for continued
airworthiness
Maintenance and repair

*Commercial
and military
applications
were reviewed*

Manufacturing
Implementation
and Experience

***General aviation, rotorcraft
and transport aircraft***

Repair
Implementation
and Experience

Small Airplane Directorate Policy for Bonded Joints & Structures



U.S. Department
of Transportation
**Federal Aviation
Administration**

*Posted to Federal Registrar for
public comments in April, 2005*

Subject: **INFORMATION:** Bonded Joints and Structures -
Technical Issues and Certification Considerations;
PS-ACE100-2005-10038

Date: *Released to Federal
Registrar in September, 2005*

From: Acting Manager, Small Airplane Directorate,
ACE-100

Reply to
Attn. of: Lester Cheng; 316-946-4111

To: See Distribution

Purpose

1. To review the critical safety/technical issues
2. To highlight some of the successful engineering practices employed in the industry
3. To present regulatory requirements and certification considerations pertinent to bonded structures



Policy for Bonded Joints & Structures

Section 3: Technical Issues

- **Material & process qualification and control**
 - Needed for materials to be bonded and the bonding process
- **Design development and structural substantiation**
 - Building block approach to test and analysis correlation has benefits for manufacturing and maintenance actions
- **Manufacturing and repair implementation**
 - A “process control mentality” is essential to successful bonding (overall quality management)
- **Service experiences**
 - Bond adhesion failures found in service justify *immediate* directed inspections and repair

Policy for Bonded Joints & Structures

Section 4: Certification Considerations

- **Design and construction**
 - Bond design & process details qualified by tests
 - Specifications to control qualified materials & bond processes
- **Structural substantiation**
 - Large scale tests needed for final validation of static strength, fatigue and damage tolerance
- **Production and repair**
 - Training and quality management of facilities, tooling & processes
- **Continued airworthiness**
 - Inspection, disposition and repair must address field issues
- **Other elements**
 - Communication between design, production and service

FAA Workshops

- **Building on above knowledge database, the FAA issued a policy statement –**
 - “Bonded Joints and Structures – Technical Issues and Certification Considerations” (PS-ACE100-2005-10038) [9/2005] [Note: Essence has been contained in AC 20-107B / AMC 20-29]
- **New Bonding Initiative in the Composite Plan**
 - Workshop held July 2014
 - Will be subject of CMH-17 Forum in August 2016
 - Will lead to an AC in 2020

Guidance Links to Industry Groups

- **Composite Materials Handbook (CMH-17)**
 - ~ 100 industry engineers meet every 8-9 months
 - CMH-17 Safety Management WG initiated in 2006
 - *FAA strategy: use CMH-17 as a forum to develop guidance and document items controlled by safety management*
- **SAE CACRC (Commercial Aircraft Composite Repair Committee)**
 - ~ 50 industry engineers meet every 6 months (~7 WG)
 - FAA industry initiatives on maintenance/repair training show good potential for collaboration
 - *FAA strategy: use CACRC as a forum to develop guidance and support industry composite maintenance standards & training efforts*

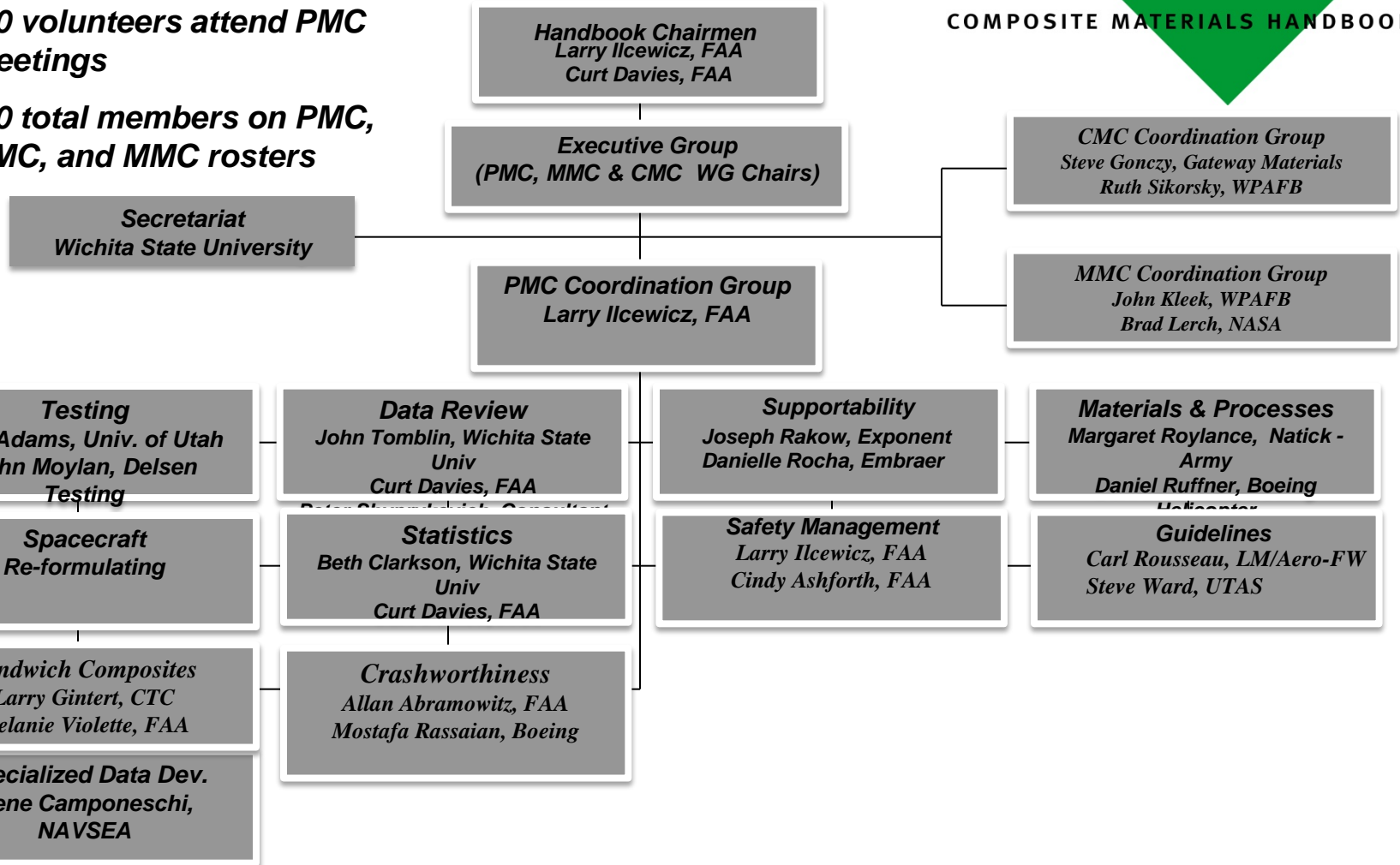


CMH-17 Organization



~ 120 volunteers attend PMC meetings

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



Permanent Working Groups



Structure of the Handbook

CMH17

COMPOSITE MATERIALS HANDBOOK

Vol. 1 Polymer Matrix Composites: *Guidelines for Characterization of Structural Materials*

Vol. 2 Polymer Matrix Composites: *Material Properties*

Vol. 3 Polymer Matrix Composites: *Materials Usage, Design and Analysis*

Volumes 1-3: Revision G
released by SAE in 2012

Vol. 4 Metal Matrix Composites

Volume 4 updated in 2013

Vol. 5 Ceramic Matrix Composites

Volume 5 to be updated in 2016

Vol. 6 Structural Sandwich Composites

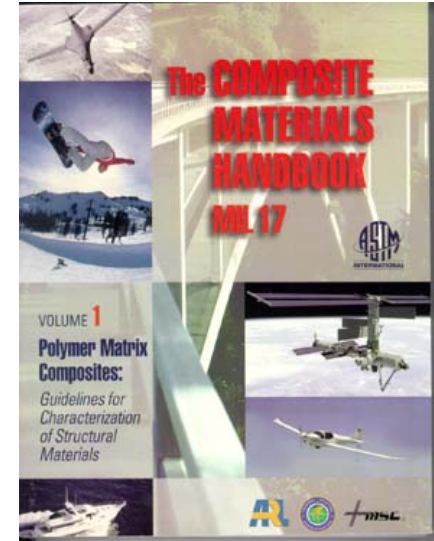
Volume 6 initial
release in 2014

Volume 1: Polymer Matrix Composites

Guidelines for Characterization of Structural Materials

Volume 1 documents material characterization data development methodology guidelines adaptable to a wide variety of needs, as well as specific requirements to be met by data published in the handbook

1. Objectives *Significant Rev. G changes in green italics*
2. **Guidelines for Property Testing of Composites**
 - Test Program Planning*
 - Recommended Test Matrices*
 - Material Testing for Submission of Data to CMH-17*
3. Evaluation of Reinforcement Fibers
4. Matrix Characterization
5. **Prepreg Materials Characterization**
6. **Lamina, Laminate and Special Form characterization**
 - Thermal/Physical/Electrical Property Tests
 - Static Uniaxial Mechanical Property Tests
 - Space Environmental Effects on Material Properties*



7. **Structural Element Characterization**
8. **Statistical Methods**
 - Revision of chapter outline*
 - Major revisions to 8.3 Calculation of Statistically-Based Material Properties*
 - Flowchart with detailed notation*

Volume 2: Polymer Matrix Composites

Material Properties

Volume 2 provides a repository of material data.

The documented property summaries for material systems provide data meeting the criteria for any of the clearly defined material data classes: robust and reduced A-Basis, robust, reduced and pooled B-Basis, mean, interim, and screening.

1. General Information

Significant Rev. G changes in green italics

Definitions

Material Orientation Codes

Presentation of Data

2. Carbon Fiber Composites

- *Complete Documentation*

- MIL-HDBK-17 Rev F Legacy Data

3. Boron Fiber Composites

- MIL-HDBK-17 Rev F Legacy Data

4. Glass Fiber Composites

- *Complete Documentation*

- MIL-HDBK-17 Rev F Legacy Data

5. Quartz Fiber Composites

- MIL-HDBK-17 Rev F Legacy Data

Appendix MIL-HDBK-17A Data

*Material & process spec info
required for new data sets to have
"Complete Documentation"*

Volume 3: Polymer Matrix Composites

Materials Usage, Design, and Analysis



Volume 3 provides technical guidance on a wide variety of disciplines related to polymer matrix composites, including the use of data for the design and evaluation of composite structures. This volume has recently undergone a major reorganization to increase usability. Four new chapters will be added for the next publication, as well as many additions and revisions throughout.

Significant Rev. G changes in green italics

1. General Information
2. ***Intro to Composite Structure Development***
3. ***Aircraft Structure Certification and Compliance***
4. Building Block Approach for Structures
5. Materials and Processes – The Effects of Variability on Composite Properties
6. Quality Control of Production Materials & Processes
7. ***Design of Composites***
8. ***Analysis of Laminates***
9. Structural Stability Analyses
10. Design and Analysis of Bonded Joints
11. Design and Analysis of Bolted Joints
12. ***Damage Resistance, Durability and Damage Tolerance***
13. ***Defects, Damage and Inspection***
14. ***Supportability, Maintenance & Repair***
15. Thick Section Composites
16. ***Crashworthiness and Energy Management***
17. ***Structural Safety Management***
18. Environmental Management



Volume 4: Metal Matrix Composites

Volume 4 covers technology and materials for metal matrix composites primarily used in aircraft engine components, spacecraft, and other high temperature applications. Material data include fiber, matrix, and composite material properties.

1. Guidelines

Test Plans for Materials Characterization

New testing sections

Corrosion and Corrosion Test Methods

2. Design Guidelines for Metal Matrix Materials

Analysis Approaches (continuous fiber MMC)

New section on Macromechanics

3. Materials Properties Data

3.1 General Information

3.2 Reinforcement Properties

SCS-6 Fiber

3.3 Properties of Matrix Materials

3.4 Fiber Coating Properties

3.5 Aluminum Matrix Composite Properties

3.6 Copper Matrix Composite Properties

Significant Rev. changes in green italics

3.7 Magnesium Matrix Composite Properties

• Corrosion Tables

3.8 Titanium Matrix Composite Properties

3.9 Other Matrix Composites

Appendix A. Typical Pushout Test Data

Appendix B. Raw Data Tables for Matrix Materials

Appendix C. Raw Data Tables for MMC Materials

Volume 6: Sandwich Composites

Volume 6 provides an updated living document describing proper design philosophy and guidance for sandwich composite structures. The primary source for this volume is MIL-HDBK-23.

Completely NEW volume including the most up to date guidance on use of sandwich composite materials and critical sections of MIL-HANDBOOK-23

- 1. General Information***
- 2. Guidelines for Property Testing***
- 3. Material Data***
- 4. Design and Analysis of Sandwich Structures***
- 5. Fabrication of Sandwich Structures***
- 6. Quality Control***
- 7. Supportability***

CMH-17 Web Site

- [http\(s\)://www.cmh17.org](http(s)://www.cmh17.org)
 - Working drafts available for active working group members
 - Access to working group bulletin boards
 - Contact information for working group chairs
 - Upcoming meeting info including agendas, discussion topics
 - Past meeting documents including presentations, minutes
- Access
 - Meeting Attendees: CMH-17 attendees receive log-in information as part of meeting registration fee (valid for 16 months)
 - Access ITAR restricted material is available as necessary
 - List of users that have access to ITAR restricted information is updated after each meeting.
 - DD2345 form or copy of government ID required for access to ITAR restricted information

Training Development Methods

- **Workshops were used to develop the FAA's Composite Maintenance Training Class**
 - Later turned into an industry specification (SAE AIR 5719)
- **Workshops held:**
 - Composite Material Qualification and Equivalency Workshop, 2000
 - Static Strength Substantiation of Composite Airplane Structure” Workshop, 2001
 - Composite Maintenance Training Workshop, 2005
 - Composite Structural Engineering Technology (CSET) Beta Workshop, 2012
 - Composite Manufacturing Technology (CMfgT) Beta Workshop 2014
 - Conduct FAA Composite Manufacturing Course Beta Test

Summary

- **The FAA has relied heavily on participation from other authorities, government agencies, and industry to develop composite policies and guidance**
- **Examples of Authority-Industry Interchange include:**
 - AGATE
 - Workshops
 - CMH-17 and CACRC
- **The FAA will continue this process moving forward in implementing the Composite Plan**