FAA Composite Guidance & Relevant Resource

Composite Safety Meeting & Workshop
New Zealand

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Lester Cheng
Wellington, New Zealand
March 01-04, 2016
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.

Chart a few pioneers to create standards and educate the masses.

Publish some regulations and cheat sheets to figure them out.

Composite Safety Meeting & Workshop
CAA of NZ, Wellington, NZ; March 01-04, 2016
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 publicly 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/
1. Advisory Circulars

- AC 20-107B "Composite Aircraft Structure" [9/09]
- 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]
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 (Tgwet) 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]
2. Policy Statements (cont.)


- “Acceptance of Composite Specification and Design Values Developed using the NCAMP Process” [AIR100-2010-120-003, September 2010]

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)]
3. SAD Technical Documents

- "Composite Certification Roadmap” [ACE-100/110, October 2003]

4. FAA Technical Reports (partial list)

  

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]
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]
• 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 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)

“Shared” at this level

“Proprietary” at these levels
Material Qualification Processes

Traditional Process

<table>
<thead>
<tr>
<th>Company A</th>
<th>FAA ACO A</th>
<th>Qualification Plan A</th>
<th>Material X Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Company B</td>
<td>FAA ACO B</td>
<td>Qualification Plan B</td>
<td>Material X Properties</td>
</tr>
<tr>
<td>Company C</td>
<td>FAA ACO C</td>
<td>Qualification Plan C</td>
<td>Material Y Properties</td>
</tr>
<tr>
<td>Company D</td>
<td>FAA ACO D</td>
<td>Qualification Plan D</td>
<td>Material Y Properties</td>
</tr>
</tbody>
</table>

AGATE Shared Database Process

<table>
<thead>
<tr>
<th>Company A</th>
<th>3 or 5 Batch Qualification per DOT/FAA/AR-03/19</th>
</tr>
</thead>
<tbody>
<tr>
<td>Company C</td>
<td>3 or 5 Batch Qualification per DOT/FAA/AR-03/19</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Company B</th>
<th>Company D</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Batch Process Equivalency Per DOT/FAA/AR-03/19</td>
<td></td>
</tr>
</tbody>
</table>

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

MATERIAL PROPERTIES DO NOT IMPROVE THROUGH MULTIPLE QUALS!
Material Qualification Processes

NCAMP Shared Database Process

- Company A
  - Initial 3 or 5 Batch Qualification per DOT/FAA/AR-03/19 & DOT/FAA/AR-06/10 & DOT/FAA/AR-07/3 & DOT/FAA/AR-02/110
  - Material X Properties
    - Shared Database
    - 1 Batch Process Equivalency Per DOT/FAA/AR-03/19 & DOT/FAA/AR-06/10 & DOT/FAA/AR-07/3 & DOT/FAA/AR-02/110 (same time as the Qualification)

- Company C
  - Initial 3 or 5 Batch Qualification per DOT/FAA/AR-03/19 & DOT/FAA/AR-06/10 & DOT/FAA/AR-07/3 & DOT/FAA/AR-02/110
  - Material Y Properties
    - Shared Database
    - 1 Batch Process Equivalency Per DOT/FAA/AR-03/19 & DOT/FAA/AR-06/10 & DOT/FAA/AR-07/3 & DOT/FAA/AR-02/110 (same time as the Qualification)

- Company I
  - 1 Batch Process Equivalency Per DOT/FAA/AR-03/19 & DOT/FAA/AR-06/10 & DOT/FAA/AR-07/3 & DOT/FAA/AR-02/110

- Company J
  - 1 Batch Process Equivalency Per DOT/FAA/AR-03/19 & DOT/FAA/AR-06/10 & DOT/FAA/AR-07/3 & DOT/FAA/AR-02/110 (same time as the Qualification)

AGATE Shared Database Process

- Company A
  - 3 or 5 Batch Qualification per DOT/FAA/AR-03/19

- Company C
  - 3 or 5 Batch Qualification per DOT/FAA/AR-03/19

- Company B
  - 1 Batch Process Equivalency Per DOT/FAA/AR-03/19

- Company D
  - 1 Batch Process Equivalency Per DOT/FAA/AR-03/19
Progress and Plans in the Bonded Structures Initiatives 2000 to 2005

- **Feb. 2000** TTCP document on “Certification of Bonded Structures”
- **2000 to 2003** FAA research per the “Don Oplinger Plan”
- **May 2003** Identify experts to support work, develop detailed plans, and collect initial inputs at 2003 M&P workshop
- **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
- **July to Sept. 2004** Draft FAA TC Bonded Structures Report to benchmark industry and outline policy
- **Oct. to Dec. 2004** Draft FAA policy for Bonded Structures, FAA workshop in Europe, update reports
- **Sept. 2005** Release FAA policy for Bonded Joints & Structures
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/](http://www.niar wichita.edu/faa/)
Technical Scope of the 2004 Bonded Structures Workshops

Material & Process Qualification and Control

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

Manufacturing Implementation and Experience

Design Development and Structural Substantiation

Commercial and military applications were reviewed

Regulatory Considerations

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

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

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

Date: DRAFT

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

To: See Distribution

Posted to Federal Registrar for public comments in April, 2005

Released to Federal Registrar in September, 2005

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

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

- Testing
  - Dan Adams, Univ. of Utah
  - John Moylan, Delsen Testing
- Spacecraft Re-formulating
- Sandwich Composites
  - Larry Gintert, CTC
  - Melanie Violette, FAA
- Specialized Data Dev.
  - Gene Camponeschi, NAVSEA
- Data Review
  - John Tomblin, Wichita State Univ
  - Curt Davies, FAA
- Statistics
  - Beth Clarkson, Wichita State Univ
  - Curt Davies, FAA
- Crashworthiness
  - Allan Abramowitz, FAA
  - Mostafa Rassaian, Boeing
- Supportability
  - Joseph Rakow, Exponent
  - Danielle Rocha, Embraer
- Safety Management
  - Larry Ilcewicz, FAA
  - Cindy Ashforth, FAA
- Materials & Processes
  - Margaret Roylance, Natick - Army
  - Daniel Ruffner, Boeing
- Guidelines
  - Carl Rousseau, LM/Aero-FW
  - Steve Ward, UTAS

Executive Group (PMC, MMC & CMC WG Chairs)

Handbook Chairmen
- Larry Ilcewicz, FAA
- Curt Davies, FAA

PMC Coordination Group
- Larry Ilcewicz, FAA

CMC Coordination Group
- Steve Goncey, Gateway Materials
  - Ruth Sikorsky, WPAFB

MMC Coordination Group
- John Kleek, WPAFB
  - Brad Lerch, NASA
Structure of the 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

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

*Significant Rev. G changes in green italics*
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
   - 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
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
   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

Significant Rev. changes in green italics
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.

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

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