Composite Manufacturing and Quality Control

Boeing Commercial Airplanes
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787 Material Usage Overview

- Carbon laminate
- Carbon sandwich
- Fiberglass
- Aluminum
- Aluminum/steel/titanium pylon
Composite properties in the final part are a function of a consistent, quality raw material AND a consistent process

• This drives differences from metals

• Results in greater emphasis on qualifications, PCDs, & quality control issues

• Results in differences of where and how allowables are performed
Boeing Materials Specifications
(BMS)
Boeing Materials Specifications
BMS Sections

1 Scope
2 Classification
3 References
4 Definitions
5 Material Requirements
6 Qualification
7 Quality Control
8 Material Test Methods
9 Material Identification
10 Packaging and Marking
Key Aspects of a BMS

- Controls purchasing of materials and is used by Boeing, Partners, and Suppliers
- Becomes part of a legal contract between Purchaser and a raw material Supplier
- Controls materials to give consistent properties and characteristics
- Materials are qualified and listed on a Qualified Products List (QPL)
Material Property Requirements (Section 5)

- **Prepreg Physical Properties**
  - Resin Content *
  - Areal Weight *
  - Volatiles *
  - Flow
  - Gel Time

- **Prepreg Chemical Properties**
  - Resin Components (IR) *
  - Chemical Structure (HPLC) *

* Required Supplier and/or Purchaser acceptance test
Material Property Requirements (Section 5) cont.

- **Laminate Physical Properties**
  - Per Ply Thickness *
  - Fiber Volume
  - Porosity

- **Laminate Mechanical Properties**
  - Tension, ultimate strength, and modulus *
  - Compression, ultimate strength and modulus *
  - Open Hole Compression strength
  - Open Hole Tension strength
  - Compression After Impact *
  - Shear modulus after fluid exposures

* Required Supplier and/or Purchaser acceptance test
Quality Control in the BMS (Section 7)

- Ongoing quality testing relies on prepreg physical tests, chemical/thermal tests, laminate physical tests, and mechanical tests
- A subset of qualification tests is chosen, based on key characteristics and most critical properties to monitor
- Both the Supplier and the Purchaser perform testing
- Purchaser testing: (1) Verifies Supplier test results and (2) Ensures that material has not changed during shipping
- Time/temperature sensitive materials shipped with temperature recorders
- Moving toward the Supplier performing all acceptance testing
Boeing Process Specifications (BAC)
Purposes of a BAC

1. Statement of Engineering requirements to manufacture parts
2. Contains process control information and QA provisions to ensure Engineering design/reliability is met
3. Contains procedures for Manufacturing to follow during fabrication of non-end-item inspectable parts

A BAC is not a recipe for building a part

Composite parts rely on ME, M&PT, and Manufacturing to achieve compliance with drawings/specs and to translate requirements into best practices for achieving the final part
Materials Control (Section 5) and Facilities Control (Section 6)

- **Materials Control**
  - Lists materials incorporated into parts
  - Controls contact materials – parting films, mold releases, gloves, markings, etc.
  - Controls non-contact materials – bagging materials, solvents, breathers, tapes, etc.
  - Defines storage requirements & storage life, revalidation requirements, handling & mechanical life

- **Facilities Control**
  - Controlled contamination environment requirements and restrictions
  - Controls autoclaves, ovens, equipment
Quality Control (Section 10)

- Provides direction for Quality Assurance regarding verification of equipment, materials incorporated, and processing into parts
- Contains the part acceptance and rework criteria
- Contains nondestructive inspection (NDI) requirements
Processor and Part Qualifications
Processor Qualification

- The Boeing method to demonstrate compliance with FAA requirements
- Separate step from Part Qualification
- Facility Survey – Review of equipment, QA system, materials/parts control, and inspection capabilities to ensure that the facility can produce acceptable parts
- Process Capability Tests – Processor demonstrates ability to build panels and perform mechanical tests, showing their process can meet the requirements
- SPC involves using control charts and capability indices to monitor process stability and conformance
- Personnel Certification – A means of formal control for designated operations or activities
- NDI Certification
- Repair Certification
Preproduction Verification (PPV)

- PPV is an Engineering requirement via drawing callout
- Requirements are found in the process specification
- PPV is performed for cost and schedule risk mitigation
- PPV verifies the readiness of a Processor’s system to produce consistently acceptable structure
- Allows for destructive evaluation of composite parts
- Requirement is levied on parts that meet one or more of the following:
  - Complex design
  - Complex tooling
  - New, unproven fabrication process
  - New materials with little production history
- Boeing team reviews and approves the Processor’s plans for PPV, conducts an audit of the fabrication process, and approves PPV results
- PPV is one means of ensuring that the fabrication process is ready prior to FPQ
First Part Qualification (FPQ)

- FPQ verifies that fabrication and inspection procedures of the first production part are in compliance with drawings/specifications
- Allows Boeing to correct deficiencies in a Processor’s procedures before the start of production
- Allows Boeing to audit a Processor’s procedures
- FPQ for composites is a fly-away part, unlike FPQ in metal bond where the part undergoes destructive evaluation
- Performed for cost and schedule risk mitigation
- Demonstrates a Processor’s ability to fabricate and inspect all parts in that family of parts
- FPQ is normally a requirement for all CFRP parts
First Article Inspection (FAI)

- FAI is a requirement implemented, authorized, and performed by QA
- FAI is a complete, documented physical and functional end-item inspection process
- Verifies that the Processor can produce articles conforming to all drawing, specification, planning, and all other documentation and contract requirements