

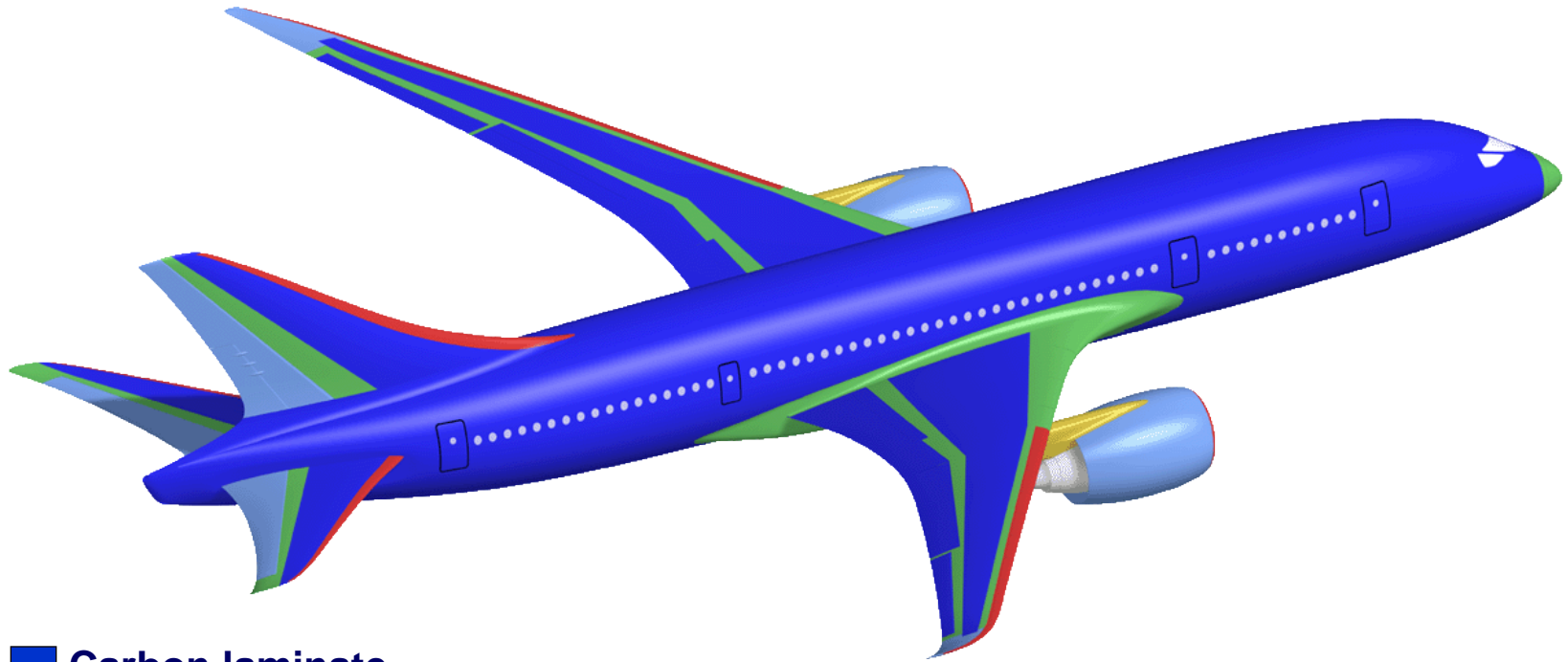


Composite Manufacturing and Quality Control



Boeing Commercial Airplanes
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787 Material Usage Overview



- Carbon laminate
- Carbon sandwich
- Fiberglass
- Aluminum
- Aluminum/steel/titanium pylon

Outline

- **Specification Overview**
- **Material Specifications**
- **Process Specifications**
 - **Processor and Part Qualification**

Key to Understanding Composites

- **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)

Boeing Process Specifications

BAC Sections

- 1 Scope
- 2 Classification**
- 3 References
- 4 Contents
- 5 Materials Control**
- 6 Facilities Control**
- 7 Definitions
- 8 Manufacturing Control**
- 9 Maintenance Control
- 10 Quality Control**
- 11 Requirements
- 12 Test Methods
- 13 Qualification

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**