Certifying Bonded Structure – Adam Aircraft’s Experience
Pierre Harter, Structures Project Engineer
Adam Aircraft Industries
Englewood, CO 80112
Outline

• What does Adam Aircraft do?
• Focus on secondary bonded structure (via paste adhesive)
• Material and Process Specifications
• Adhesive Characterization and Design Allowables
• Examples of Bonded Structure
• Wrap up
A500 & A700
A500 specifications

- 6-place cabin
- 2 Continental TSIO-550 engines
- Retractable gear
- Max gross weight – 6500+ lb
- Fuel capacity – 230 gal
- Max speed – 250 KTAS/288 mph
- Max ceiling – 25,000 ft
- Pressurized 8,000-ft cabin at 25,000 ft
A500 Timeline

- 1998  Adam Aircraft Formed
- 2000 March  M309 Proof of Concept Aircraft Flew 03/21/2000
- 2000 December  Headquarters and Factory Building Complete
- 2001 March  Applied for TC
- 2001 July  Production Loft Complete
- 2001 August  First Production Tool
- 2001 October  First Development Components
- 2002 January  First Flying Components
- 2002 July  A500 First Flight 7/11/2002
- 2004  Planned Type Certificate – A500
Materials

• Composite Parts
  – Vacuum bag, oven cure prepreg system
  – Toray Composites AGATE system
  – PW Carbon fabric, uni and FG fabric

• Secondarily Bonded Assemblies
  – Paste adhesive
  – Room temp or accelerated cure
  – Some cobonded and cocured structure
  – Fasteners used in some joints
Processes

• Prep
  – Clean parts
  – Grit blast primarily, hand sanding allowed
  – Controlled environment
  – Control time to bond

• Adhesive application
  – Semkits or hand mix
  – Bond thickness control
    • Acceptable range (0.005”-0.080”)
    • Shims, Glass beads, Fixturing stops
  – Moving to automated mixing ($$)

• Curing
  – Room temp or accelerated
Quality

• **In-process Inspection**
  – Bond prep
  – Visual - Squeeze out and fillets
  – Monitor cure time

• **Process Verification**
  – Sample cups
  – Panels

• **Curing**
  – Room temp or accelerated

• **Post-inspection for voids**
  – Visual
  – Tap test on thin laminates
  – NDI for large overlaps and hard to access areas
Qualification

- Used supplier’s extensive database
- Multiple batches
- Characterize the adhesive properties
- Stress-strain behavior
- Chemical and Physical properties
- Shear strength (ASTM 1002 and 5656)
- Acceptance criteria
- Room temp and accelerated cure (150°F)
- Nominal and range of acceptable mix ratios
- With and without glass beads
Design and Allowables

• 500 psi rule of thumb
  – No data exists at small startups, have to start somewhere
  – Adhesive qualification is expensive and takes time

• Element tests – Overlap joints
  – Modified ASTM D3165 lap shear
    • Representative of the majority of bonded structure on the aircraft
    • Generate allowables for the joint’s load carrying capability
    • Vary bondline thickness – 0.005”, 0.030, 0.080 and thicker
    • Vary substrate thickness – thin, medium, thick
    • Vary overlaps – 1”, 2”, 3”
    • Bond prep – Grit and Hand
    • Environments
    • Tg? – test for strength at temps above MOL
    • Substrate failures
  – Wedge crack
    • Industry standard/consensus for composite substrates?
Bonded Structure

- Fuselage
  - 2 halves
- Wing
  - Spars, ribs, skins
- Tailbooms
  - 2 halves and internal structure
- Horizontal Tail
  - Cocured and bonded
Fuselage

- 2 halves bonded at BL0
- Wet layup doubler for redundancy
- Local fasteners
- Floors bonded
- Engine gussets cocured
- Door cobonded
Wing

- 2 spars
- Internal ribs
- Skins
- Wing tips
Tail

- **Booms/Vertical Tails**
  - Inboard and outboard skins
  - Internal structure bonded

- **Horizontal**
  - Cocured lower skin and spars
  - Bonded Upper skin
Summary

• Small startups don’t have time and money to develop costly databases – SHARE data for adhesive properties

• How does the bonded joint behave?
  – Adhesive characterization is important
  – Joint characteristics are more important
    • Thick vs thin substrate, overlap lengths and bondline thickness
  – Full-scale tests indicate hard to predict modes

• Wish-list
  – More shared data
  – Industry standards on durability tests
  – Industry standards for training – approved stations?
  – Industry standards for repair