Structural Metal Bonding
At Cessna Aircraft
Discussion Points

- Cessna Experience
- Metal Bonding Process
- Process Control Philosophy
- Risk and Risk Mitigation
- Conclusions
Cessna Experience

- 1960s - Secondary structure
- 1970s - Primary structure, integral fuel tanks
- 1980s - Fully bonded airframe
- 40 Years Experience and 6000+ airplanes
Metal Bonding Process

- Phosphoric acid anodize
- Bond primer application
- Lay-up
- Bagging and tooling
- Autoclave cure
- Post-cure inspection
Phosphoric Acid Anodize

- Automated process line
  Clean, rinse, PAD, rinse, PAA, rinse, dry
- Rate issues
  Surface cleaning, water quality, solution aging
- Process control
  - Data acquisition of spec parameters: temp, time, voltage, current
  - Water break inspections
  - Current draw inspection
  - Wedge crack extension
  - Surface morphology
  - Periodic training
Bond Primer Application

- Manual airless spray
  Inspect, spray, flash, cure, inspect
- Rate issues
  Environment control, primer agitation, operator training
- Process control
  - Data acquisition of spec parameters: time, temp, RH, monitoring of air quality
  - Visual, polarized filter
  - Period operator quals
  - Visual and thickness
  - Wedge crack extension
Lay-up

- Adhesive application
  Inspect, cut, apply, inspect, assemble
- Rate issues
  Environment control, fit checks, operator training,
- Process control
  - Recording of spec parameters: temp, RH, air quality, Out-time-tracking
  - Buddy check for paper
  - Visual
  - Shop instructions
  - Controlled expendables
Bagging and Tooling

- Bagging
  Breather, sealant, bag, vacuum check
- Rate issues
  Operator training, tool maintenance
- Process control
  - Spec parameters: leak rate
Autoclave Cure

- Cure cycle
  - Load, instrument tools, leak check, start cycle, unload, debag, deflash
- Rate issues
  - Tool maintenance
- Process control
  - Data acquisition of spec parameters: temp, pressure, time, leak rate
  - Periodic shear and peel tests
Post-Cure Inspection

• Inspection
  Visual for FOD and other anomalies, ultrasonic inspection
• Rate issues
  Operator training
• Process control
  - Technician certification
  - Standards and calibration
  - Initial process qualification and subsequent requalifications for each bond assembly
Process Control Philosophy

“End of Process” inspection alone is insufficient for assuring structural integrity.
Risk

- A structural delamination and/or a bond failure can result in:
  - Safety issues
  - Customer dissatisfaction
  - Loss of confidence
    - Customers
    - FAA, other regulatory authorities
  - Degradation of reputation and Brand
  - Product liability (financial)
Risk Mitigation

- Process Control Mentality
  - Specification adherence
  - In process monitoring
  - Personnel training and qualification
  - NDI
  - Initial assembly qualification and subsequent requalifications

- Proper Facilities and Equipment
  - Process line design and control
  - Tooling design and maintenance
  - Autoclave design and control
Risk Mitigation

- Experienced and knowledgeable staff
  - Manufacturing and Facilities
  - Quality and Inspection
  - M&P and other Engineering

- Process and product improvements as a result of field experience – Lessons Learned
Conclusions

- Benefits outweigh the risks if properly managed
  - Documented and audited processes
  - Process control mentality
  - Proper facilities and equipment
  - Active maintenance programs
  - Experienced staff that understands:
    - How to do it
    - Why they are doing it