Composite System Auditing
Introduction

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  - C.A.S.E VP, Training Co-Chair, ARSS Vice-Chair
  - AS9100:2015 Rev D Lead Auditor
  - A & P License
  - 9 years
  - IAQG Auditor
Introduction Continued

← Please tell us your

- Name,
- Company,
- Title, and
- Composite Audit experience
Topics of Discussion

- Vendors
- Transporting
- Receiving Inspection
- Storage
- Work Record (Traveler)
- Metal Processing
- Bond Room/Clean Room/CCA
- Lay-up process
- Consumables
- Portable Bonder & Autoclave Process
- Process verification
- The Goal
- Check List Development
What is a “Composite”? 
A "composite" is when two or more different materials are combined together to create a superior and unique material.
The history of composites dates back to ancient times for construction applications; straw was mixed with mud to form a building material known as adobe.
Vendors

- Material Manufacture
- Authorized Distributor
- Second use Supplier (remaining material)
  - Per aircraft OEM part specifications
  - Per customer specifications
  - Per vendor developed / FAA acceptable
  - Per material manufacture specifications
Transporting

- Monitor Material Transport
  - Objective evidence
    - Temperature recorder
- Material Identification
  - Material Certs.
  - Material Label
  - Shipper
Receiving Inspection

- Review Purchase Order requirements
  - Per Material Manufacture specifications
  - Per Aircraft OEM specifications
- Verify material traceability
  - Roll, Batch, and Lot numbers
Receiving Inspection

鞬 Verify C.O.A. Certificate of Analysis
  • Material test values
  • Compliant material
  ◆ C.O.C. Certificate of Conformance
    • Compliant process
鞬 Review temperature recorder graph/chart
  ◆ Two per shipment
    • Out time may have to be reduced
Certificate of Analysis

Provides test values

<table>
<thead>
<tr>
<th>Roll Tested:</th>
<th>Date of manufacture: 3/15/02</th>
<th>Weight, PSF:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Initial</td>
<td>Aged 10 days</td>
</tr>
<tr>
<td>Penetration, 0.040&quot; min.</td>
<td>0.06</td>
<td>0.05</td>
</tr>
</tbody>
</table>

**Cure: RT->250°F, 90 MINS.**

<table>
<thead>
<tr>
<th>Tube Shear, RT</th>
<th>Initial</th>
<th>AGED 10 DAYS</th>
<th>Initial</th>
<th>AGED 10 DAYS</th>
</tr>
</thead>
<tbody>
<tr>
<td>450 psi IND.</td>
<td>1441</td>
<td>574</td>
<td>991</td>
<td>1027</td>
</tr>
<tr>
<td>1250</td>
<td>561</td>
<td></td>
<td>981</td>
<td>1098</td>
</tr>
<tr>
<td>005</td>
<td>676</td>
<td></td>
<td>968</td>
<td>1124</td>
</tr>
</tbody>
</table>

**Cure: RT->350°F, 90 MINS.**

<table>
<thead>
<tr>
<th>Tube Shear, RT</th>
<th>Initial</th>
<th>AGED 10 DAYS</th>
<th>Initial</th>
<th>AGED 10 DAYS</th>
</tr>
</thead>
<tbody>
<tr>
<td>600 psi AVE.</td>
<td>1229</td>
<td>604</td>
<td>944</td>
<td>1508</td>
</tr>
</tbody>
</table>

| Expansion 1.5-3.5X | 2.64    | 1.7          | 3.1     | 2            |
| Slump 0.625" max. | 0.048   |              | 0.058   |              |
| Water migration, 24 hrs., 10% max. | 2.5 |              | 4.65 |              |

**Shelf Life is 12 Months from Date of Manufacture, When Stored at or Below 10°F.**

This is to certify that the adhesive in this shipment meets the requirements of NRM 2-2 REV. A TY III as indicated by the above test results. This adhesive has been made in the USA, and is free from mercury or mercury compounds due to raw materials, test instruments, or manufacturing equipment.

QC INSPECTOR
SUB DATE
Temperature Recorder

- Digital temperature recorders with each shipment
Temperature Recorder/Chart

- Analog temperature recorder/chart
Temperature Recorder Chart

- Digital temperature graph
Temperature Recorder Chart

- Digital temperature printout
Storage

- Review storage requirements
  - Per material manufacture specifications
  - Per vendor developed / FAA acceptable
  - Material supported by tube ends, not contacting the floor
  - Material segregation
    - Acceptable from rejected
  - AC 43-214 7. c (1) and Nadcap AC7118 5.1.4

- (1) Material must be supported by the ends of the support tube, or in its original shipping container, to prevent flat spots on the material. Stacking of rolls on top of one another is not allowed.
Material

- Support material by the tube
Storage

→ Review storage requirements
  ◆ Review temperature chart
    • Current and historical
  ◆ High temperature alarms
  ◆ Low temperature alarms
  ◆ Loss of power alarms
Freezer

.minutes of Freezer
Material log

Review material history
- Per material manufacture specifications
- Per vendor developed / FAA acceptable
- Material traceability information
- Time in and out of the freezer, tracking
- Minimum of 8 hrs. for 0° & minimum 6 hrs. for 40°
  - No moisture on bag prior to opening the material bag
  - Ambient air temp affects the material’s thaw rate.
  - Warm to touch
Work Record (Traveler)

- Bonding
  - Work instructions
  - Maintain traceability
  - Per aircraft OEM part specifications
    - Per Air Carrier’s CAMP
  - Vendor developed / FAA accepted
Metal Processing

Skins, core, and details
- Per aircraft OEM part specifications
- Per customer specifications
- Per vendor developed / FAA acceptable
- Per material manufacture specifications
- Operation instructions
  - Phosphoric Acid Anodize (PAA) capabilities
- Calibrated timer
- Carriage system, doesn’t drip oil/grease
- Solution testing
  - Acid, Alkaline, Rinse water
  - Process verification records
Clean Line

Material staging area
Clean Line

Metal processing Line
Clean Line Controls

- Phosphoric Acid Anodize controls
Clean Room

- Positive air pressure
- Temperature and humidity controlled
- Filtered air
  - Filters changed regularly
- No Internal combustion powered engines
  - hydrocarbons!
  - Electric only
- No release agents
- No food or drink
- Lab coats, gloves, hand lotions, etc.
Clean Room

- Cleanroom, Contamination Containment Area, CCA
  - Positive pressure with air filtration
Clean Room

Cleanroom, Contamination Containment Area
Material

- Support material by the tube
Monitor Clean Room

Temperature & Humidity chart
Dust Particle collector (black tube & funnel)
Clean Room

⇝ Cleanroom, Contamination Containment Area
Clean Room

- Cleanroom, Contamination Containment Area

**BOND TOOLS BEYOND THIS POINT MUST BE FREE OF DUST AND DEBRIS**
Forklift

- No Hydrocarbons in clean room
Clean Room

- No un-cured or excessive release agents on tools
- No dust on tool surface or frame
- No hand creams
- Gloves must be worn when working with Metal and adhesives
- Materials must be cut on a urethane surface
  - No cardboard, wood, or metal; no scissors.
- No drilling / grinding
Bonding Specifications

- Laminate
  - Material manufacture specification
    - BMS8-79, 250° Prepreg Fiberglass
  - Aircraft OEM part specification
    - BMS5317, Bonding process general

- Metal bond
  - Material manufacture specification
    - BMS5-101, 250° Adhesive
  - Aircraft OEM part specification
    - BMS5514, Bonding process general

- Vendor developed / FAA acceptable
757 Spoiler

- Notice layers and direction of carbon fiber / “graphite”
Lay-up Process

- Contained in work record (Traveler)
  - or by referenced specification
    - On hand or available in work area
- Cover part prior to exiting cleanroom/CCA
- Consumable materials
  - Release cloth
  - Manifold material
  - Bagging material
  - All materials must be per process specification
Lay-up Process

Bagging (general)

- Vacuum leak = 1”Hg a minute
- 10”Hg max – High vacuum, 30Hg or less
  - Metal to metal
  - Laminates without honeycomb core
- 5”Hg max – low vacuum, 15”Hg or less
  - Laminates with honeycomb core
Blocker Door ready for vacuum bagging process
Breather Material

- Allows the evacuation of air from a vacuum bag
Valve

Valve for removing air from the vacuum bag
Trans Cowl

- Cowling ready for cure in the autoclave
Portable Bonder Topics of Discussion

- Types of Portable Bonders
- Specifications
- Operation
- Planning
- Calibration
- Process
Hot Bonder

Portable Hot Bonder
Portable Bonder Types

- Heat Lamps
- Heat pads
- Portable Bond System
Portable Bonder Specifications

- Portable Bond System
  - Per aircraft OEM part specifications
  - Per customer specifications
  - Per vendor developed / FAA acceptable
  - Per material manufacture specifications
Operation instructions

- Per Manufactures specifications
- Per Material Manufacture specifications
- Per Aircraft OEM part specifications
- Per vendor developed / FAA acceptable
Portable Bonder Calibration

- Transducers
- Chart recorder
  - Vacuum, Temp
- Gages
  - Vacuum, Temp
- Software validation
- TC wire verification
- Heat Pad survey
- Heat Lamp verification
Portable Bonder Process

➔ Set-up Bonder
  • Verify vacuum Bag (general)
    • Vacuum valves & TC wires
  • Vacuum leak = 1”Hg a minute
  • 10”Hg max or 5”Hg max

➔ Cure observation
  • Monitor cure parameters
    • Bonder output; Temp and Vacuum every 5 to 10 minutes
    • Part reading; Temp and Vacuum every 5 to 10 minutes
Portable Bonder Process

→ End cure cycle
  ◆ 10”Hg max or 5”Hg max
  ◆ Part less than 140°
Bonder Process Verification

- Cure verification
  - Chart review
  - Ramp rates & Soak times
  - Temp and Vacuum readings
    • Bonder output and part
  - Process coupon destructive test
    • Typically not required

◊ Laminates:
  - Compression
  - Flatwise tensile

◊ Metal bond:
  - Lap shear
  - Drum peel
Test Coupon

- Lab request to track destructive test results
Bonder Process Verification

➔ Work record review
- Verify material traceability & expiration dates
- Verify mechanic process sign-off & date
  • Verify mechanic’s training record
Autoclave Topics of Discussion

- Specifications
- Operation
- Planning
- Calibration
- Process
- Emergency Methods
- Equipment Safety
Autoclave

Autoclave 60’ X 10’ 450° 100psi maximum
Autoclave Controls

- Manual & Computerized
Oven
Oven Controls

→ Manual & Computerized
Autoclave Specifications

- D38558-1
  - Mechanical and Vessel design
- D38558-2
  - Instrumentation and Control
- D38558-3
  - Codes and Industry standards
Autoclave Operation

рес D6-49327
- Identify equipment and operating requirements of autoclaves

Operation instructions
- Per Material Manufacture specifications
- Per Aircraft OEM part specifications
- Developed internally, FAA Acceptable
Autoclave Calibration

- Transducers
- Chart recorder
  - PSI, Vacuum, Temp
- Gages
  - PSI, Vacuum, Temp
- Software validation
- Heat survey
Autoclave Process

- Loading autoclave
  - Verify vacuum Bag (general)
  - Vacuum valves & TC wires
  - Vacuum leak = 1”Hg a minute
  - 10”Hg max
- Cure observation
  - Monitor cure parameters
    - Clave; Temp, PSI every 10 minutes
    - Parts; Temp and Vacuum every 10 minutes
Autoclave Process

→ Unloading autoclave
  ✤ Zero PSI
  ✤ Autoclave & Parts less than 140°
Autoclave Emergency Methods

Procedures for

- Fire
  - Maintain pressure, reduce air temp, extinguish fire.
- Excessive temp
- Excessive pressure
- Blown vacuum bag
- Loss of power

- Any of the above events require Engineering evaluation/disposition of the part
Safety devices

- Man in clave switch
- Oxygen sensors
- Over pressurization alarm
- High temperature Alarm
- Prevent fires with the use an inert gas;
  - e.g. Nitrogen
Autoclave Equipment Safety

- Cyclic fatigue and corrosion
  - NDI methods ET, UT, MT
  - Door interlock mechanism
- Pressure vessel laws
  - ASME Pressure Vessel Code
  - State Pressure Vessel Code
Autoclave Process Verification

➔ Cure verification
  ◆ Chart review
  ◆ Ramp rates & Soak times
  ◆ Temp, PSI, and Vacuum readings
    • Both autoclave and parts
Autoclave Process Verification

- Cure verification
  - Process coupon destructive test
    - Laminates:
      - Compression
      - Flatwise tensile
    - Metal bond:
      - Lap shear
      - Drum peel

- Work record review
  - Verify material traceability & expiration dates
  - Verify mechanic process sign-off & date
    - Verify mechanic’s training record
What is the goal?

- Confidence in the process
  - Process control
  - Process repeatability
  - Acceptable parts
Safety! Is the Goal

- The bonding process is **critical** to flight safety!
- Regulatory compliance
  - FAR 145, Repair Station
  - FAR 145.61, Limited Rating
  - FAR 145.151, Personnel Requirements
- Customer specific requirements
  - FAR 145.205.a, Continuous Airworthiness Requirements
- AC 145-6, Repair Stations for Composite and Bonded Aircraft Structure
- Order 8110.54, Instructions for Continued Airworthiness
Audit Check List

- Develop a list that addresses the following,
  - Verify vendors / suppliers are approved
  - Verify receiving inspection
    - Purchase order, COA, Temp recorder chart
  - Verify material storage
    - Material Identification, segregation
    - Temperature charts, Alarms
    - Handling of material
  - Metal processing
    - List what process Specification is used
    - Titration test, acid, alkaline, and rinse water
Clean room

- Housekeeping (no dust & no trash)
- Good lighting
- Filtered, Positive air pressure
- Look for contaminates
- Electric motors only (No Hydrocarbons)
- Bond tools clean
- No drilling / grinding
- Gloves worn (Metal Bond and Adhesives)
Audit Check List Continued

- Portable Bonder Process
  - Per Material Manufacture specifications
  - Per Aircraft OEM part specifications
  - Per Customers specifications
  - Per Vendor developed data (FAA acceptable)
  - Review charts
    - Ramp and Cure times
    - Temp and Vacuum levels
Audit Check List Continued

- Autoclave Process
  - Per Material Manufacture specifications
  - Per Aircraft OEM part specifications
  - Per Customers specifications
  - Per Vendor developed data (FAA acceptable)
  - Review charts
    - Ramp & Cure times
    - PSI, Temp, and Vacuum levels
Audit Check List Continued

-work record review
- Review customer requirements (repair order)
- Verify instructions are per applicable data
- Verify material traceability & expiration dates
- Verify mechanic process sign-off & date
- Verify mechanic training record
- Verify equipment used
Process verification

- Sonic test (NDT)
- Coupon destructive testing
  - Laminates
    » Compression
    » Flatwise tensile
  - Metal bond
    » Lap shear
    » Drum peel
Audit Check List Recap

- Verify vendors/suppliers
- Verify receiving inspection
- Verify calibration of instruments and gages
- Verify that Equipment Safety devices - functional
- Verify work record for compliance and completion
- Verify final inspection
- Verify employee training records
  - Observe process in action
  - Interview process technicians
  - Obtain objective evidence
The following slides should aid your visual identification/ recognition during an audit of a composite bonding facility.
Prime Both

- Adhesive primer booth
Monitor Prime Booth

Temperature & Humidity chart
Tool & Part Numbers

- Tool identification and Part identification
Tool Verification

- Traceability for tool manufacture and calibration/verification
Flammability

- Proper storage of flammable materials
Notice

The following are prohibited in the Clean Room or CCA:

- Eating
- Chewing
- Drinking

Non-metallic prepregs or other non-metallic bond materials are allowed.
CCA Maintenance Shutdown

Procedure for performing processes and using materials prohibited in NPS 1402 in CCA areas.

1. Remove all exposed prepreg or adhesive material from CCA or seal in plastic bags. Remove or cover contact items used in the processing of prepregs or adhesives. This includes peel ply, backing material, and tools that come in direct contact with adhesives and prepregs.
2. Seal off CCA from other adjacent CCAs. Seal should prevent airflow between the CCAs.
3. Cover work areas immediately adjacent to where NPS 1402 prohibited processes will be performed.
4. Allow one hour after prohibited processes for dust and contaminates to settle.
5. Wipe down all work surfaces in accordance with NPS 1402 and return CCA to service.
Controlled Contamination Area (CCA) Housekeeping and Maintenance

- Do-
  - Wipe table frames daily using damp cheese cloth.
Expiration date subject to change. Exp 1 yr. after opened
What have you learned?

- The basics about composite bonding
- Rely on your auditing skills
- Review their process for adequacy
  - Per Air Carrier’s CAMP
- Verify their process for compliance
Questions?

- What haven't you learned?
- Anyone, anyone?
Thank you

- Thank you for your participation.
- Contact information

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