Structural Bonding Adhesive

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VP Research & Development
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Background

- Columbia 300 Program started in 1995
- Outside contour is controlled. Bond gaps take up material thickness variations.
- Allowed bond gap variation 0.0” to 0.150”
- Adhesive is based on a laminating resin developed for FAR23 application in primary structure
- Tg of more than 225F depending on post cure temperature.
- The adhesive was developed and certified under AGATE.
Wing Skin Bonding
Wing Skin Bonding
Handling Characteristics

- Substrate surface has to be primed
- Added filler in the adhesive allows vertical bondlines from 0.0 < 0.150"
- Pot life > 4 hours
- Post cure at 200F to achieve Tg of 225F
- Handle cure required if parts are manipulated prior to post cure.
## Test Matrix
### Chemical and Physical Properties

<table>
<thead>
<tr>
<th>Material</th>
<th>No</th>
<th>Test</th>
<th>Method</th>
<th>No. Tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resin and Hardener</td>
<td>1</td>
<td>Pot Life, Nominally Mixed</td>
<td>ASTM D2471</td>
<td>3x3</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Thermal Profile, Nominally Mixed</td>
<td>ASTM D3418 (DSC) or SACMA SRM 18 (DMA)</td>
<td>3x1</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Constituent Identification, Resin</td>
<td>ASTM E682 (HPLC)</td>
<td>3x1</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Constituent Identification, Resin</td>
<td>ASTM E168 (FTIR)</td>
<td>3x1</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Constituent Identification, Hardener</td>
<td>ASTM E682 (HPLC)</td>
<td>3x1</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>Constituent Identification, Hardener</td>
<td>ASTM E168 (FTIR)</td>
<td>3x1</td>
</tr>
<tr>
<td>With Fillers</td>
<td>7</td>
<td>Rex Durometer Type A Hardness Tester, Mixed w. Fillers</td>
<td>ASTM D2583</td>
<td>3x1</td>
</tr>
</tbody>
</table>
### Test Matrix

**Bonded Strength Properties**

<table>
<thead>
<tr>
<th>Substrate Material</th>
<th>Test No.</th>
<th>Bond Thickness</th>
<th>Environmental Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>CD</td>
</tr>
<tr>
<td>Glass Cloth/Epoxy Prepreg Substrate</td>
<td>1</td>
<td>.020”</td>
<td>3x6</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>.060”</td>
<td>3x6</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>.150”</td>
<td>3x6</td>
</tr>
<tr>
<td>Carbon Cloth/Epoxy Prepreg Substrate</td>
<td>3</td>
<td>.150”</td>
<td>3x6</td>
</tr>
<tr>
<td>Glass Cloth/Epoxy Wet Layup Substrate</td>
<td>3</td>
<td>.150”</td>
<td>3x6</td>
</tr>
</tbody>
</table>
Test Matrix: Creep Properties

- Test duration: 1000h
- Applied Stress: 500 psi
- Pass-Fail Criteria: <3.5% Avg., <5% Max.

<table>
<thead>
<tr>
<th>Material</th>
<th>No.</th>
<th>Bond Thickness</th>
<th>Test Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glass Prepreg Substrate with Filled Epoxy Adhesive</td>
<td>1</td>
<td>0.100”</td>
<td>CD</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>---</td>
</tr>
</tbody>
</table>
Test Panel Fabrication

- Specimen geometry to MIL-HNDBK-17-E but using composite substrate
Quality Assurance

Supplier QA
- FTIR or HPLC of Resin and Hardener
- No Strength Properties are required, because the resin is mixed with filler in-house.

Receiving Inspection
- Pot Life, ASTM D2471
- Thermal Profile via DSC or DMA
- Lap Shear Strength

Process Verification
- Glass transition temperature Tg via DSC or DMA
- Tg is representative of the amount of cure and final part strength.
IMQ Requirements : New Adhesive

- All initial Adhesive Certification Tests
- Tg requirement of allows two options:
  - Tg > Max Operating temperature(175°F) + 50°F margin.
  - OR
    - Strength at 225°F should be more than 67% of strength at 175°F
- Representative Full Scale Test.
Bonded Assembly Inspection

- Bond gap control
  - Bond rods control minimum gap
  - Dry fit to check for maximum bond gap
- NDI for voids
  - Visual Inspection for squeeze-out
  - Tap testing
  - Ultra Sound using Sonic Bondmaster
Sonic Bondmaster
Surface Preparation and Manufacturing Considerations

- As important as the adhesive qualities
- Peelply-only not sufficient
- Bead blasting for best results
- Solvent wipe required
Alternative Surface Preparation Evaluation Tests

- A version of traveling wedge test was used to evaluate various surface treatments and surface preparation methods.
- Wedge driven in to specimen vertically at 0.05 in/min and the failure modes analyzed.
- Failure Modes:
  - Cohesive
  - Adhesive
- Preliminary Conclusions
  - Bead blasting was found to remove most of the clear tape, and Teflon tape effects and was repeatable.
  - Hand sanding was found to be less reliable
Bead Blast Booth
Summary

- Lancair’s structural adhesive is customized to the manufacturing process.
- The limiting factor is the prepreg resin adhesion to the fiber.
- A room temperature curing adhesive would be most desirable. But could not be found.
- Structural certification by test or very conservative analysis due to lack of precise analytical means.
- Tg and toughness are conflicting requirements.