Next Generation Fire Test Burner for Powerplant Fire Testing Applications

International Aircraft Systems Fire Protection Working Group
Atlantic City, NJ
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http://www.fire.tc.faa.gov
Background

- Currently specified oil burners are no longer commercially available
- Industry is utilizing legacy oil and propane burners
- Propane burner has been shown to be less severe than an engine flammable fluid flame
- New Technology Sonic Burner developed and approved for use in interior and fuselage testing.
  - Sonic Burner provides numerous advantages to legacy burners
- FAA Tech Center Fire Safety Branch has been tasked by Transport Standards Branch (TSB) to develop burner performance standards for the next-generation fire test burner for powerplant fire testing
  - New burner should be much easier to calibrate, provide more consistent results, and be readily available for industry use.
Task Group:
Sonic Burner Implementation
POC: S. Summer, S. Rehn

Task Group:
Regulatory Document(s) Update
(Authorities only)
POC: S. Johnson

Task Group:
AC 20-135 – Industry Recommendations
POC: J. Ostic, P. Dang

Sub-Group A:
- Burner/Flame Temperature
- Calibration Method
- TC’s (size, type, number)
- Environment/Operating Conditions
POC: J. Ostic, P. Dang

Sub-Group B:
- Post-test Burning/Backside Ignition
- Pass/Fail Criteria
POC: D. Laborie

Sub-Group C:
- Definition of Fireproof/Fire-Resistant
- Test Panel Size
POC: S. Pugliese
Current Status - Testing

• Previous round robin consisted of aluminum, PAN and copper slug calorimeter

• Searching for additional non-metallic materials to test in a round robin with objectives of
  – Utilizing results to ensure proper settings of sonic burner
  – Ensure consistency of testing within lab using sonic burner
  – Ensure repeatability across burners at various labs
Materials Previously Evaluated

- 10-ply carbon composite
- Carbon Fiber – 1-ply, 2-ply & 3-ply
- Fiberglass – 1-ply, 2-ply & 3-ply
- Garolite
- ¼” Honeycomb Panel
- Fiberglass cargo liner

All shown to not be suitable for round-robin testing
Burner Settings

- Nozzle: 80° B 2.0 gph
- Flow-checked 2.00 gph @ 102 psi
- Air Pressure: 50 psi
- Copper Tube Heat Flux (3 test average): 5111.3 Btu/hr
- Temperature check (first 3 tests with brand new 1/8” exposed-bead thermocouples

![Temperature Check Graph]

<table>
<thead>
<tr>
<th>TC</th>
<th>Test 1</th>
<th>Test 2</th>
<th>Test 3</th>
<th>TC Avg.</th>
</tr>
</thead>
<tbody>
<tr>
<td>TC 1</td>
<td>1600°F</td>
<td>1600°F</td>
<td>1600°F</td>
<td>1600°F</td>
</tr>
<tr>
<td>TC 2</td>
<td>1600°F</td>
<td>1600°F</td>
<td>1600°F</td>
<td>1600°F</td>
</tr>
<tr>
<td>TC 3</td>
<td>1600°F</td>
<td>1600°F</td>
<td>1600°F</td>
<td>1600°F</td>
</tr>
<tr>
<td>TC 4</td>
<td>1600°F</td>
<td>1600°F</td>
<td>1600°F</td>
<td>1600°F</td>
</tr>
<tr>
<td>TC 5</td>
<td>1600°F</td>
<td>1600°F</td>
<td>1600°F</td>
<td>1600°F</td>
</tr>
<tr>
<td>TC 6</td>
<td>1600°F</td>
<td>1600°F</td>
<td>1600°F</td>
<td>1600°F</td>
</tr>
<tr>
<td>TC 7</td>
<td>1600°F</td>
<td>1600°F</td>
<td>1600°F</td>
<td>1600°F</td>
</tr>
<tr>
<td>TC Avg.</td>
<td>1600°F</td>
<td>1600°F</td>
<td>1600°F</td>
<td>1600°F</td>
</tr>
</tbody>
</table>
Composite Tests

- 0.060” FR4 Glass Epoxy
  - Flame resistant material used in printed circuit boards
- Did not burn through after 15:00
Composite Tests

- 0.007” 1-Ply Unidirectional Carbon Fiber
- **Burn-through times***:
  
<table>
<thead>
<tr>
<th>Test</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test 1</td>
<td>7:35</td>
</tr>
<tr>
<td>Test 2</td>
<td>6:36</td>
</tr>
<tr>
<td>Test 3</td>
<td>9:34</td>
</tr>
</tbody>
</table>

- *Material split along grain in first few seconds, but the test was continued hoping that the fibers would burn through.
- *Fibers did not actually burn through, they just became unclamped from the top
- Material is unsuitable for round robin testing
Resonate Testing

- Composite panels supplied by Bombardier/Shorts
  - 2 plies (0°/45°), roughly 0.030” thick
- Burner calibrated to minimum avg of 2000°F across 7 T/C’s, Heat Flux >4500 btu/hr
  - stabilized on Cu tube for 1 minute
- Total of 6 panels tested
  - 3 with vibration applied at differing times during test
  - 1 with no vibration
  - 1 with a bolt installed in the middle
  - 1 with bolt installed with a 5 kg weight applied in tension
Resonate Testing
Resonate Testing
Resonate Testing
Resonate Testing
Resonate Testing
Resonate Testing

<table>
<thead>
<tr>
<th>Panel</th>
<th>TEMP (min Avg)</th>
<th>BTU/Hr</th>
<th>Burnthrough TIME</th>
<th>Vibration applied @</th>
<th>Summary</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Panel 1</td>
<td>2025</td>
<td>4696</td>
<td>00:27:16</td>
<td>20:20</td>
<td>Wednesday Afternoon.</td>
<td>Vibration applied in the expection of generating expeditated Burnthrough- No significant impact observed.</td>
</tr>
<tr>
<td>Panel 2</td>
<td>2010</td>
<td>4606</td>
<td>00:25:18</td>
<td>20:20</td>
<td>Wednesday Afternoon.</td>
<td></td>
</tr>
<tr>
<td>Panel 3</td>
<td>2011</td>
<td>4641</td>
<td>00:26:30</td>
<td>00:00</td>
<td>Thursday Morning</td>
<td>Applied vibration has no impact?</td>
</tr>
<tr>
<td>Panel 4</td>
<td>2116</td>
<td>5234</td>
<td>0:24:45</td>
<td></td>
<td>Thursday Afternoon</td>
<td>Increased BTU does not significantly affect burnthrough time</td>
</tr>
<tr>
<td>Panel 5</td>
<td>2035</td>
<td>4720</td>
<td>0:20:00</td>
<td></td>
<td>Bolt installed in center of panel</td>
<td>1 week later returned with new approach. Stopped test- Bolt making no impact</td>
</tr>
<tr>
<td>Panel 6</td>
<td>2019</td>
<td>4839</td>
<td>0:22:34</td>
<td></td>
<td>Bolt installed in center of panel with a 5kg load</td>
<td>Pull through eventually achieved!</td>
</tr>
</tbody>
</table>

**Test 4 Flame artificially high, no significant impact.**

**Test 6 Pull Through load, no significant impact.**
Composite Testing - Next Steps/Questions

• Bombardier (Shorts) will continue to support provision of the material panels: the definition to be agreed.

• Is burnthrough the proper measure of failure for this type of material? How else can we measure failure?

• It is possible that composite materials are just not suitable for round robin testing, and other options need to be explored.
  – Felt Materials (Nomex, Kevlar, PAN)
  – Varying thickness of aluminum
  – ???
Aluminum Panel Tests

- Questions arose during some Task Group meetings regarding aluminum burnthrough times
- Standards refer to aluminum as being fire-resistant (i.e. burnthrough >5mins)
- Strong desire from group to ensure that NexGen burner maintains this definition.
Aluminum Tests

- 0.125” 2024-T3 Aluminum
- No repeatability with 50 psi air pressure
- Very repeatable with 40 psi air pressure
Air Pressure Comparison

- 50 psi air had highest temperatures in previous testing
- Copper tube heat flux was relatively constant
- 40 psi air had highest copper slug heat flux
- Copper slug correlated best to aluminum burn-through times
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Current Status - Regulatory

• Draft policy memo regarding the use of the Propane Burner (mentioned at May meeting)
  – It has been decided to instead address this issue through a change to AC 20-135.
  – Anticipated release for public comment by end of year.

• Continued effort to address industry concerns and harmonize with international authorities.
Current Status - Regulatory

- **Flame Temperature Calibration**
  - Issue from industry was brought forth regarding the flame temperature requirement
  - Current requirement is a minimum average of 2000°F across 7 T/Cs
    - Tolerance on each individual T/C of ±150°F
  - This is a shift from the past requirement of an average flame temperature of 2000±150°F
  - TSB reviewed history of flame temperature requirement in attempt for a better understanding of changes and when/why they occurred.
• TSB conclusion was “The FAA has not changed our definition of the test flame. We have always intended the definition of fireproof to be 2000°F.”

• Discussions surrounding appropriate flame calibration continue within industry group.
  – Flame temperature
  – Flame Heat Flux
  – Standardized measurement methodology

• Industry group to provide recommendation and substantiation data to authorities for review.
Questions?

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