International Aircraft Materials Fire Test Working Group Meeting

Seat Cushion and Cargo Liner Oil Burner Update

Presented to: International Aircraft Materials Fire Test Working Group

By: Tim Salter, FAA Technical Center

Date: June 3-4, 2015, Bremen, Germany
Introduction

• Air Pressure Regulator Update
• Sonic Burner Cone Alloy Study
• Cargo Liner Round Robin
• Seat Cushion Round Robin
• Test Cell Airflow Study
• Plans for Future Work
Air Pressure Regulator

- Constant air pressure control is crucial for repeatable burner test results

- Many regulators commercially available not suitable for use with the NexGen burner due to inconsistent air pressure regulation

- Handbook requires air pressure maintain 45 +/- 1 psi
Air Pressure Regulator

- Previously recommend McMaster-Carr regulator part # 49305K23 with an operating range of 0-55 psi (shown right)

- Testing revealed this regulator is not suited well for use with the NexGen burner

- Air pressure readings measured at the ¼” NPT port on the side of the regulator differed from readings measured downstream of the regulator but before the sonic orifice as much as 7 psi
Air Pressure Regulator

- Air pressure at the sonic orifice will determine the mass flow rate of air.

- Air pressure measurement taken at the sonic orifice and pressure regulator should be identical.

- A more suitable regulator is available from MSC.com having part # 73535627, Parker 1” heavy duty regulator model R119-08CG/M2 (shown right).
Cone Alloy Study

- Current rule for burner cone alloy is 16Ga, 310 stainless steel
- SS cones have deformed up to ½ inch after only one heat cycle
- Recent study involved testing 625 Inconel and Hastelloy X alloy cones
- Testing involved running the burner for 5 minutes, cool-down for 5 minutes with burner air on, then measure the cone in four different locations (A, B, C, D), and repeat for 10 heat cycles
Cone Alloy Study
Cone Alloy Study

Hastelloy Cone Dimensions

<table>
<thead>
<tr>
<th>Heat Cycles</th>
<th>Dimension (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>6.20</td>
</tr>
<tr>
<td>1</td>
<td>6.25</td>
</tr>
<tr>
<td>2</td>
<td>6.30</td>
</tr>
<tr>
<td>3</td>
<td>6.35</td>
</tr>
<tr>
<td>4</td>
<td>6.40</td>
</tr>
<tr>
<td>5</td>
<td>6.45</td>
</tr>
<tr>
<td>6</td>
<td>6.50</td>
</tr>
<tr>
<td>7</td>
<td>6.55</td>
</tr>
<tr>
<td>8</td>
<td>6.60</td>
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<tr>
<td>9</td>
<td>6.65</td>
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<tr>
<td>10</td>
<td>6.70</td>
</tr>
<tr>
<td>11</td>
<td>6.75</td>
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</tbody>
</table>

Maximum Deformation

<table>
<thead>
<tr>
<th>A (in)</th>
<th>B (in)</th>
<th>C (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.12</td>
<td>0.17</td>
<td>0.14</td>
</tr>
</tbody>
</table>

Heat Cycles
Cone Alloy Study

Inconel Cone Dimensions

Maximum Deformation

<table>
<thead>
<tr>
<th>Dimension (in)</th>
<th>A (in)</th>
<th>B (in)</th>
<th>C (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimension (in)</td>
<td>0.07</td>
<td>0.07</td>
<td>0.08</td>
</tr>
</tbody>
</table>

Heat Cycles

Seat Cushion and Cargo Liner Oil Burner Update
IAMFTWG, June 3-4, 2015, Bremen, Germany
Cone Alloy Study

Hastelloy Cone

- A: 6.213” → 6.315”
- B: 6.240” → 6.387”
- C: 6.192” → 6.313”
- D: 11.000” → 10.813”

Inconel Cone

- A: 6.268” → 6.310”
- B: 6.471” → 6.530”
- C: 6.256” → 6.320”
- D: 10.938” → 10.875”

*Dimensions shown are initial measurements taken before exposure to flame and final measurements after 10 heat cycles after the cone was allowed to cool to ambient temperature*
Cone Alloy Study

- Most deformation occurs after only the first heat cycle

- It may be possible to alter the initial design of the cone in order to accommodate deformation

- Inconel tends to deform significantly less compared to 310 stainless steel

- The cost of an Inconel cone is approximately 25%-30% more compared to a 310 SS cone

- Initial cost may be offset by the working life span of the cone
Cargo Liner Round Robin

- The igniterless stator and turbulator NexGen sonic burner was used for this study

- 4 labs currently participating
  - 3 labs have completed testing and returned results

- 2 different cargo liner types supplied for testing
  - 5 of each liner type for a total of 10 liner samples
Sonic and Park Comparison

**Average Temperature Measured 4-Inches above 0.035'' Woven Fiberglass Polyester Reinforced Cargo Liner Samples**

- **Temperature (F)**
  - 0.0
  - 50.0
  - 100.0
  - 150.0
  - 200.0
  - 250.0
  - 300.0
  - 350.0
  - 400.0

- **Time (sec)**
  - 0
  - 60
  - 120
  - 180
  - 240
  - 300

**Graph Details**
- **Sonic**
- **Park**
Cargo Liner Round Robin Results

Average Temperature Measured 4-Inches above 0.035" Woven Fiberglass Polyester Reinforced Cargo Liner Samples

[Graph showing temperature over time for different labs]
Sonic and Park Comparison

Average Temperature Measured 4-Inches above 0.013" Woven Fiberglass Reinforced Phenolic Cargo Liner Samples

Temperature (°F) vs. Time (sec)

- Sonic
- Park
Cargo Liner Round Robin Results

Average Temperature Measured 4-Inches above 0.013" Woven Fiberglass Reinforced Phenolic Cargo Liner Samples
Cargo Liner Round Robin

- The current cargo liner interlab study is on-going

- Additional materials will be supplied to participating labs for further testing and aid in burner and test cell research

- These additional supplied materials are intended to burn-through unlike the liner materials already tested

- The final results of this study will be presented at the materials working group meeting in Atlantic City, NJ on dates October, 19-20
Seat Cushion Round Robin

- The igniterless stator and turbulator NexGen sonic burner was used for this study

- 5 labs currently participating
  - 2 labs have completed testing and returned results

- 3 different cushion types supplied for testing
  - 3 of each cushion type for a total of 9 cushion sample sets
Sonic and Park Comparison

Average Cushion Set Weight Loss %

<table>
<thead>
<tr>
<th></th>
<th>Sonic</th>
<th>Park</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fire Hardened 1</td>
<td>4.09%</td>
<td>7.98%</td>
</tr>
<tr>
<td>Fireblocked</td>
<td>4.36%</td>
<td>7.37%</td>
</tr>
<tr>
<td>Fire Hardened 2</td>
<td>3.37%</td>
<td>8.78%</td>
</tr>
</tbody>
</table>
Seat Cushion Round Robin Results

Average Cushion Set Weight Loss %

<table>
<thead>
<tr>
<th>Lab</th>
<th>Fire Hardened 1</th>
<th>Fireblocked</th>
<th>Fire Hardened 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>4.09%</td>
<td>3.37%</td>
<td>4.36%</td>
</tr>
<tr>
<td>B</td>
<td>8.81%</td>
<td>4.86%</td>
<td>5.86%</td>
</tr>
<tr>
<td>C</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>D</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>E</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>
Seat Cushion Round Robin

- FAA test results using the NexGen sonic burner configured with the igniterless stator resulted in weight loss % approximately half of expected result.

- This may be due to less turbulent airflow using an igniterless stator and lack of internal ignition wires.

- Testing will be repeated with another oil burner supplied by Marlin Engineering.
Test Cell Airflow Study

- A pair of NIST certified hot-wire anemometers were recently acquired by the FAA Fire Safety Branch

- The new equipment will be used for an in-depth study of how test cell configuration and ventilation airflow may affect test results related to oil burner test methods
Test Cell Airflow Study

- Initial testing was performed with one anemometer attached to the seat cushion test frame

- The hot-wire portion of the measurement device was located 3 inches forward from the upper corner of the seat test frame, and approximately centered under the ventilation hood

- Airflow measurements were taken in the vertical direction
Test Cell Airflow Study

Average Fireblocked Cushion Test Results

- Fan Low = ~75 ft/min
- Fan High = ~125 ft/min

<table>
<thead>
<tr>
<th></th>
<th>% Weight Loss</th>
<th>Vertical Front Burn (in)</th>
<th>Vertical Back Burn (in)</th>
<th>Horz Top Burn (in)</th>
<th>Horz Bottom Burn (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fan Low</td>
<td>3.37</td>
<td>7.250</td>
<td>0.000</td>
<td>5.750</td>
<td>5.583</td>
</tr>
<tr>
<td>Fan High</td>
<td>3.94</td>
<td>9.000</td>
<td>0.000</td>
<td>8.000</td>
<td>9.667</td>
</tr>
</tbody>
</table>
Test Cell Airflow Study

Average Temperature Measured 4-Inches above 0.035" Woven Fiberglass Polyester Reinforced Cargo Liner Samples

*Airflow in the cargo liner test cell has not yet been measured using the hot-wire anemometers*
Test Cell Airflow Study

• Test results for seat cushion indicate increased weight loss and burn lengths when airflow is increased

• Test results for cargo liner indicate decreased temperatures measured 4-inches above the liner sample

• These test results suggest ventilation airflow may significantly impact test results for oil burner test methods
Future Work

• Provide additional test materials to participating cargo liner RR labs, and complete testing

• Complete seat cushion RR
  – FAA will run additional tests using Marlin Engineering burner

• Begin study of test cell configuration and airflow
  – Purpose of study is to provide guidance to test labs based on test cell configuration and ventilation hood airflow

• Updated chapter 7 in the Handbook will be available in the near future
Questions?