Discussion of Burnthrough Test Method for Aircraft Thermal Acoustic Insulation Blankets

Tim Marker
FAA Technical Center
Items Discussed at June Working Group Meeting

- Results of Round Robin VI

- Differences in burner castings, flanged vs. socket

- Differences in fuel nozzle, “F-80” vs. new style

- Impact of fuel nozzle orientation on calibration and test results

- Results of mini round robin using 6.5 gph nozzle with TexTech felt
Round Robin VI
(Initiated: Spring ‘04; 3 materials, 8 tests each)

**Approach**: Visit each lab prior to running tests, utilizing Boeing calibration tools to correct any deficiencies with equipment set-up. Once calibration is achieved, tests could be completed.

**Result**: Labs A, B, I, and J visited during 2004. Difficulties encountered at each lab during calibration process, preventing completion of tests.

**Summary**:
- All labs capable of obtaining correct temperature profile.
- 4 of 5 labs capable of obtaining correct heat flux.
- All labs: quicker burnthrough times and higher backface heat flux.

**Preliminary Conclusion**: A calibrated burner does not necessarily produce test results that correlate with FAATC results.
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• Impact of fuel nozzle orientation on calibration and test results

• Results of mini round robin using 6.5 gph nozzle with TexTech felt
FAA Burner, flanged
Boeing Burner, socket
<table>
<thead>
<tr>
<th>Burner Type</th>
<th>Lab A</th>
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Survey Results: 4 Flanged, 5 Socket
Items Discussed at June Working Group Meeting

• Results of Round Robin VI

• Differences in burner castings, flanged vs. socket

• Differences in fuel nozzle, “F-80” vs. new style

• Impact of fuel nozzle orientation on calibration and test results

• Results of mini round robin using 6.5 gph nozzle with TexTech felt
Boeing PL Nozzle

FAA PL Nozzle
Boeing PL Nozzle  FAA PL Nozzle
Conclusions of FAA vs. Boeing Trials

Various types of motors do not impact heat flux or burnthrough times.

Replicate stator does not impact heat flux or burnthrough times.

Difference in housing/draft tube does not impact temperature or heat flux.

Difference in fuel nozzle impacts both heat flux and burnthrough times.

More testing needed to determine impact of housing on burnthrough time.
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Impact of Rotation on Heat Flux for Various Nozzles

**Nozzle Comparison**

<table>
<thead>
<tr>
<th>Nozzle</th>
<th>Heat Flux (Btu/ft² sec)</th>
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<tbody>
<tr>
<td>Original F-80</td>
<td>15.17</td>
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<tr>
<td>Original F-80</td>
<td>15.34</td>
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<tr>
<td>Late Production</td>
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<td>Prototype</td>
<td>14.59</td>
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Heat flux values indicate the performance of different nozzles under rotation, with original prototypes generally performing better.
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Temperature Profile Comparison Using 6.5 GPH 80° PL

Temperature (°F)

- FAA Original 6.0
- FAA
- Accufleet
- CEAT
- Airbus
- Boeing

Average 1962  Average 1946  Average 1933  Average 1917  Average 1865  Average 1922
Heat Flux Comparison Using 6.5 GPH 80° PL

Heat Flux (Btu/ft² sec)

<table>
<thead>
<tr>
<th>FAA Original 6.0</th>
<th>FAA</th>
<th>Accufleet</th>
<th>CEAT</th>
<th>Airbus</th>
<th>Boeing</th>
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<tr>
<td>15.41</td>
<td>15.41</td>
<td>15.27</td>
<td>15.05</td>
<td>15.45</td>
<td>15.97</td>
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</table>
Material A Comparison Using 6.5 GPH 80° PL

Burnthrough Time (Seconds)

FAA Original 6.0
FAA
Accufleet
CEAT
Airbus
Boeing

Average 215
Average 222
Average 181
Average 133
Average 142
Average 139
June 2005 Mini Round Robin Summary

Material analysis indicates weight/area consistency, no impact on results.

All labs reporting were capable of obtaining correct temperature profile.

4 of 5 labs reporting were capable of obtaining correct heat flux.

3 of 5 labs still indicate a more severe test than FAA lab; quicker burnthrough times by approximately 1 minute.

The 3 labs with a more severe result use the socket-style burner.
Planned Activities from June Meeting

**FAATC:** Visit Airbus and Boeing labs to assist in calibration of existing burners.

**FAATC:** Complete fabrication of additional flanged burners for comparison testing.

**FAATC:** Investigate correlation between premature failure and socket-style burner.
Comparison Using More Recent TexTech 8 oz/yd²

Baseline Results

- Boeing/6.5 nozzle: 1660 fpm air velocity
  - FAA burner/nozzle: 216.5 seconds
  - Pat burner/6.5 nozzle: 240 seconds
  - "loose" set-up: 175 seconds

- Boeing/6.5 nozzle: 2250 fpm air velocity
  - FAA burner/nozzle: 202 seconds
  - Pat burner/6.5 nozzle: 185 seconds

- Boeing/6.5 nozzle: 1950 fpm air velocity
  - FAA burner/nozzle: 201.5 seconds
  - Pat burner/6.5 nozzle: Unspecified
Effect of Location on Air Velocity Measurement

**Objective:** Investigate problems associated with measuring intake air velocity at its present location inside the airbox, and compare to measurements at intake of flexible duct.
Fl24 Turbulator

H215 Stator

Blower Size: 5.25 Inch Dia 3.5 Inch Depth

Intake Airbox

Air Velocity Meter

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<thead>
<tr>
<th>Meter in airbox</th>
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<td>2169</td>
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Blower Size: 5.25 Inch Dia 3.5 Inch Depth

F124 Turbulator

H215 Stator

Intake Airbox

Air Velocity Meter

20
Effect of Location on Air Velocity Measurement

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Average = 2165.6

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Average = 2058.3
Development of a Stream Straightening Device

**Objective:** Compare intake air velocity measurements taken at airbox to those obtained using a stream straightening device, while maintaining a constant intake damper setting.

**Methodology:** Fabricate a stream straightening device that utilizes an upstream length of at least 10 diameters, to produce a laminar flow across an in-line velocity sensor.
Initial Three Burner Comparison

**Objective:** Determine if differences exist amongst flanged burner housings, and if so, what impact they have on calibration and test results.

**Methodology:** Compare heat flux, temperature, and test results of three flanged burners using original FAA fuel nozzle (Monarch 6.0 gph 80ø “F-80” style).
Heat Flux Comparison

Heat Flux (Btu/ft² sec)

- FAA Burner: 15.95 Avg
- Spare Burner A: 12.43 Avg
- Spare Burner B: 13.54 Avg
Burnthrough Time (Seconds)

FAA Burner: 230 Second Avg
Spare Burner A: 230 Second Avg
Spare Burner B: 213 Second Avg
Summary of Results: While using identical fuel nozzle in three different burners:

1. Calibration heat flux substantially different
2. Calibration temperature profile slightly different
3. Test results Similar
Mapping Exit Area Air Velocity

**Objective:** To determine cause of difference in measured heat flux during calibration process when using three identically-prepared flanged burners.

**Methodology:** Map exit area air velocity of each burner to determine if there is a correlation between shape of exit air and heat flux.
Mapping Exit Area Air Velocity

Top View

Side View

Linear Detents

Air Velocity Meter

Rolling Cart

4"

Burner Cone

Draft Tube
Exit Area Air Velocity Mapping
Air Velocity Map, Burner A
Air Velocity Map, Burner B
Mapping Exit Area Air Velocity

Summary of Results: While measuring exit area air velocity in three burners:

1. Air velocity maps all unique, slightly different

2. Burner A produced highest peak velocity, burner B lowest peak velocity

3. All burners show left-side bias when viewed from flame side

4. No obvious correlation between peak velocity and heat flux

5. Correlation between velocity and burnthrough location
Final Three Burner Comparison

**Objective:** Prepare 2 spare flanged burners for industry use, and complete extensive comparison testing with original FAA burner to ensure correlation.

**Methodology:** Outfit spare burners with Monarch 6.5 gph “F-80” style fuel nozzles. Adjust fuel pressure to deliver proper 6.0 gph output, then compare heat flux, temperature, and test results.

**Desired Outcome:** Confirm equivalency of spare burners to original FAA burner.
Final Burner Comparison

![Bar chart comparing temperatures for FAA Burner and Spare Burner A]

- **1966 Avg**
  - FAA Burner: Temperature (°F)
  - Spare Burner A: Temperature (°F)

- **1886 Avg**
  - FAA Burner: Temperature (°F)
  - Spare Burner A: Temperature (°F)
Final Burner Comparison
8 oz/yd² TexTech felt

Burnthrough Time (Seconds)

- FAA Burner: 234 Second Avg
- Spare Burner A: 218 Second Avg
Final Burner Comparison
14 oz/yd² TexTech felt

- **FAA Burner S**
- **Spare Burner A**

- 322 Second Avg
- 256 Second Avg

Burnthrough Time (Seconds)
Spare Burner B Heat Flux Trials Using 6.5 gph Fuel Nozzle

Burner B draft tube, fuel rail, stator, igniters

Heat Flux (Btu/ft² sec)
Spare Burner B Heat Flux Trials Using 6.5 gph Fuel Nozzle

Burner B fuel rail, stator, igniters, FAA draft tube
Spare Burner B Heat Flux Trials Using 6.5 gph Fuel Nozzle

Burner B draft tube, FAA fuel rail, stator, igniters
Heat Flux (Btu/ft² sec)

Burner B draft tube, igniters, FAA fuel rail, stator
FAA fuel rail, Burner B draft tube, stator, igniters
Heat Flux (Btu/ft² sec)

- FAA fuel rail
- Burner B draft tube
- Igniters
- Stator w/tape

Graph showing the heat flux values.
Replaced stator w/modified remanufactured stator
Rotate modified stator to 1:30, 2:00, 5:30, and 9:00 positions
Replace stator with different H215 original.
Different H215 original, add tape to 2 opposite blades
Different H215 original, add tape to all 4 blades
Install unknown H215 stator
Install unknown H215 stator, add tape to 4 blades
Install unknown H215 stator, replace tape to 4 blades
Re-install other H215 original with tape on 2 igniter blades
Other H215 original with tape on 2 blades, trim tape
Other H215 original with tape on 1 blade
Other H215 original, no tape, RTV in igniter grooves
Other H215 original, add trace amount of RTV to blade edge
RTV Sealant Added to Blade Edge
RTV Sealant Added to Blade Edge
RTV Sealant Added to Blade Edge
Various Stators Used in Trials

Original FAA

Other H215 Original

Modified Replicate
Comparison of Results Using 8 oz/yd² TexTech Felt

- 234 Second Avg
- 210 Second Avg
- 222 Second Avg

Bar charts showing burnthrough times for different burners:
- FAA Burner
- Spare Burner B
- Spare Burner B
Burner Comparison Using 8 oz/yd² TexTech Felt

Average = 217.5 Seconds
Std Dev = 11.5 Seconds
Spare Burner B Testing Summary

Testing indicates fluctuations in heat flux the result of variances in stator.

Minor adjustment of stator shape resulted in heat flux calibration.

Test results indicate equivalency to FAA results.
Conclusions and Future Considerations

Industry now in possession of equipment that correlates with FAA equipment.

Review of data suggests +/- 5% fluctuation when using flanged burner.

FAATC will receive 2 socket-style burners, continue comparison testing with FAA equipment to produce equivalency when using this apparatus.

Susceptibility of heat flux due to minor stator differences needs to be quantified; Produce a simpler, more reliable, more easily manufactured stator?