Vertical Flame Propagation Test

Presented to: International Aircraft Materials and Systems Fire Test Forum

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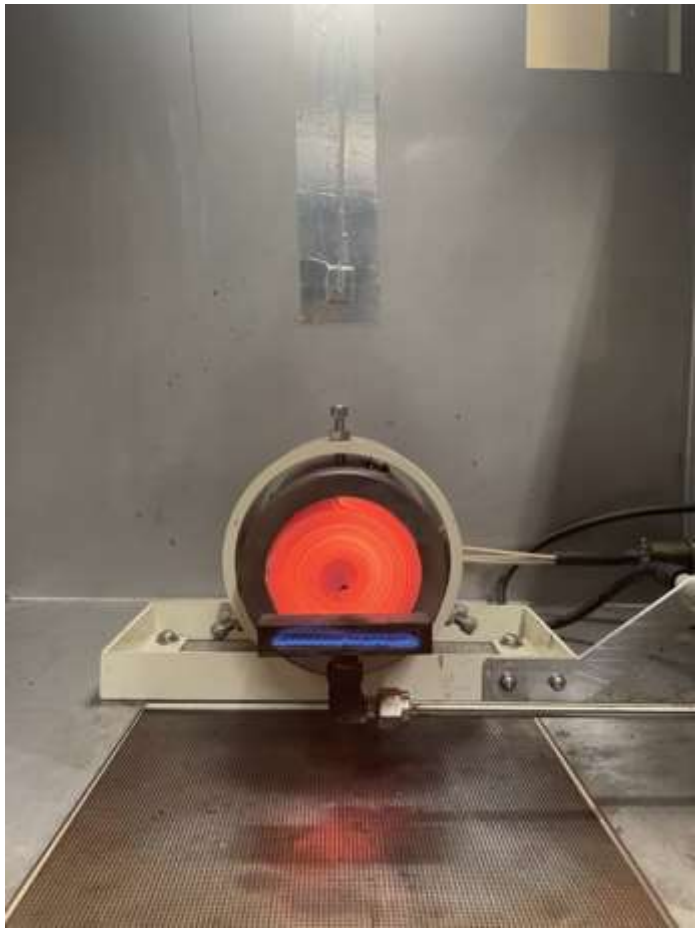
Federal Aviation Administration

Vertical Flame Propagation (VFP)

Proposed new test method for non-metallic, extensively used materials located in *inaccessible areas*, i.e.:

- Composite skin, structure, and sub-components
- Wires (insulations/jackets/sleeving)
- Duct materials



Vertical Flame Propagation Test Method

- An electric coil radiant heater is mounted vertically and opposite a 6-inch by 12-inch sample
- A methane/air ribbon burner impinges on the lower portion of the test sample, initiating material combustion while continuously exposed to the radiant heat from the heater
- The burner flame is translated away from the test sample after 30 seconds
- The test is allowed to continue until all material combustion has ceased
- The sample is then removed from the test frame and a post test burn length measurement is made

Vertical Flame Propagation Test

Marlin Engineering

Concept Equipment

Deatak

What Was Learned Previously

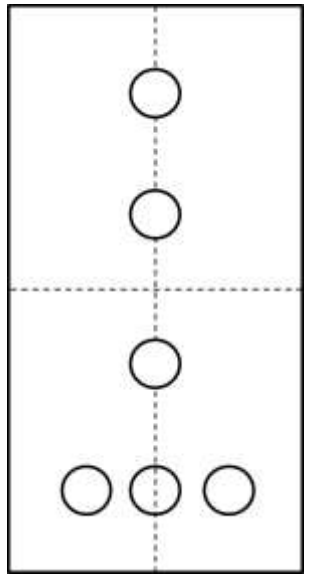
- **Heater**
  - Found that the current heater design isn’t built to last
  - Need practical requirement on build
- **Ribbon Burner**
  - Slight differences were previously found in burner construction between VFP manufacturers
  - Design issues were brought up

Radiant Heater

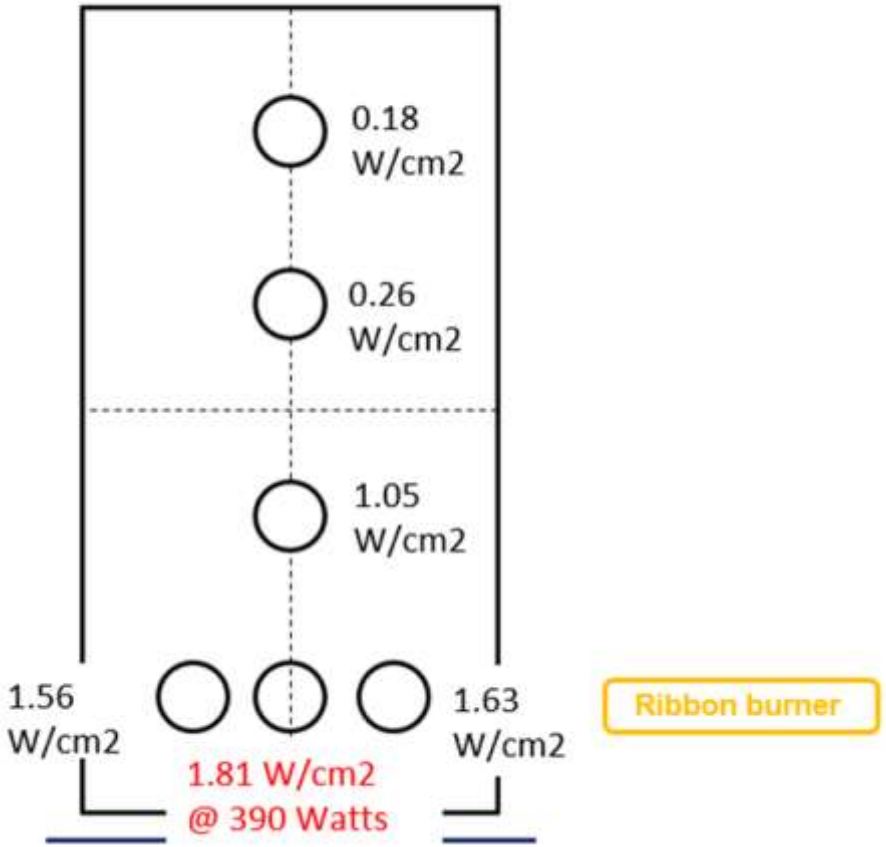
- Reset on heater design required – not the heat output
- Specific call-out of an exact heater build is desired by some and more room for varied design is desired by others
- Currently looking into requirement of build based on heat flux mapping

Heat Flux Mapping Upon Sample

- Ideal for the requirement of *build* for the heater, not frequent calibration for the user
- The user would still calibrate the heater with the same location currently being utilized



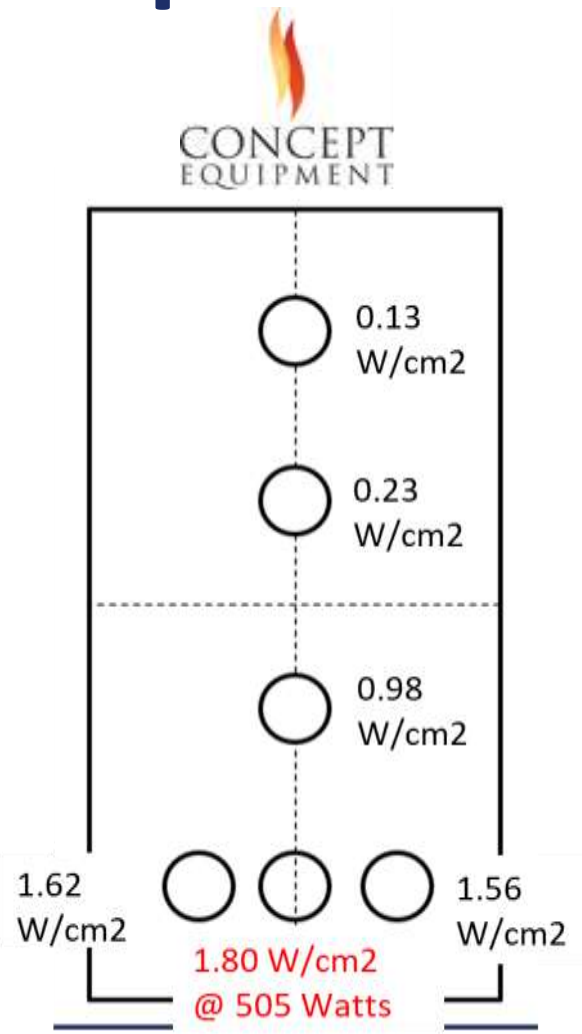
Heat Flux Mapping Upon Sample



Display of a Different Heater Meeting Req.

Concept Equipment Ltd.

- Concept Equipment utilized their smoke test heater design in the VFP to display the practicality of meeting a performance-based criteria for the heater
- Gives room for different heater designs, within some parameters still being defined (ex. Housing diameter, location of heater, etc.)



Comparison of Heaters

Preliminary Measurements

Note: Readings on the left begin with 1.81 W/cm2 and on the right with 1.80 W/cm2. This affects how close the readings are.

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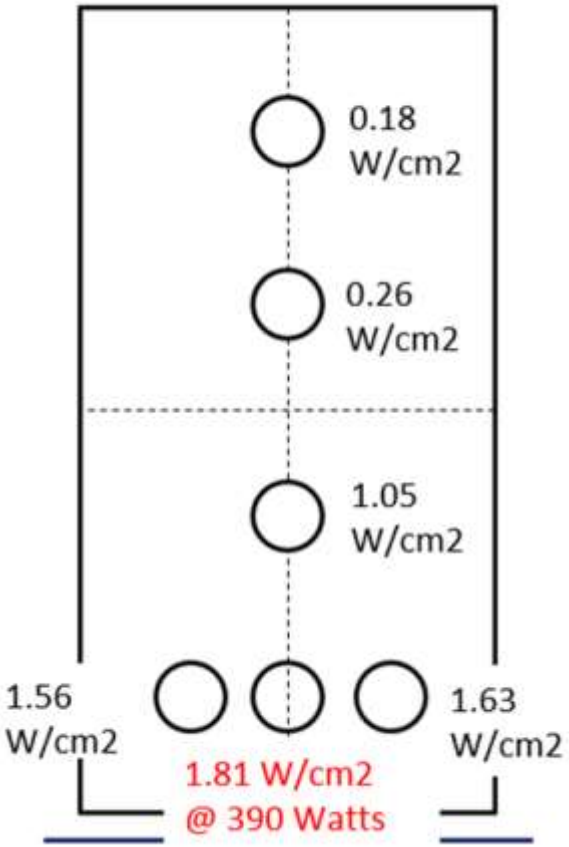
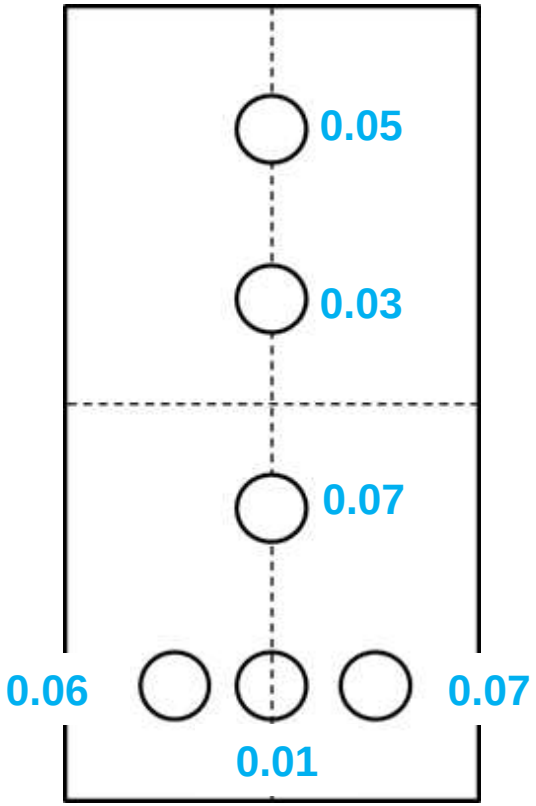
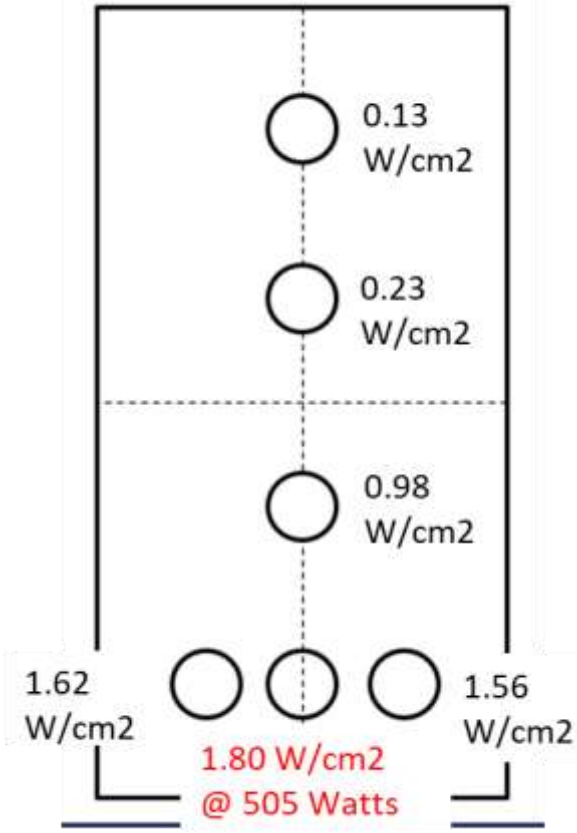


Compared



CONCEPT EQUIPMENT



Comparison of Heaters

Preliminary Measurements

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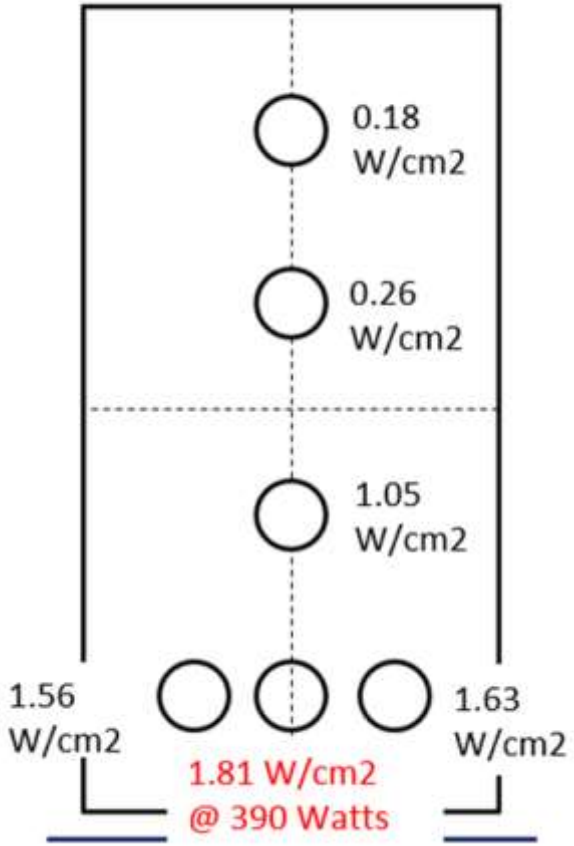

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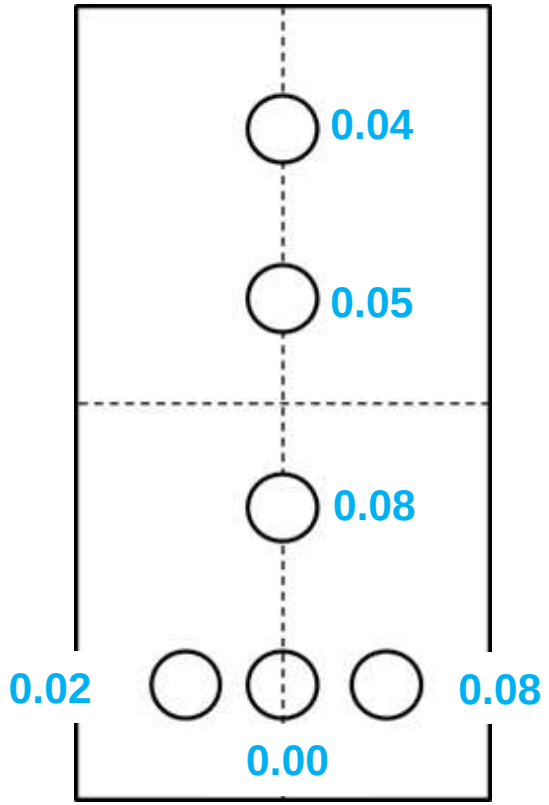

Boeing

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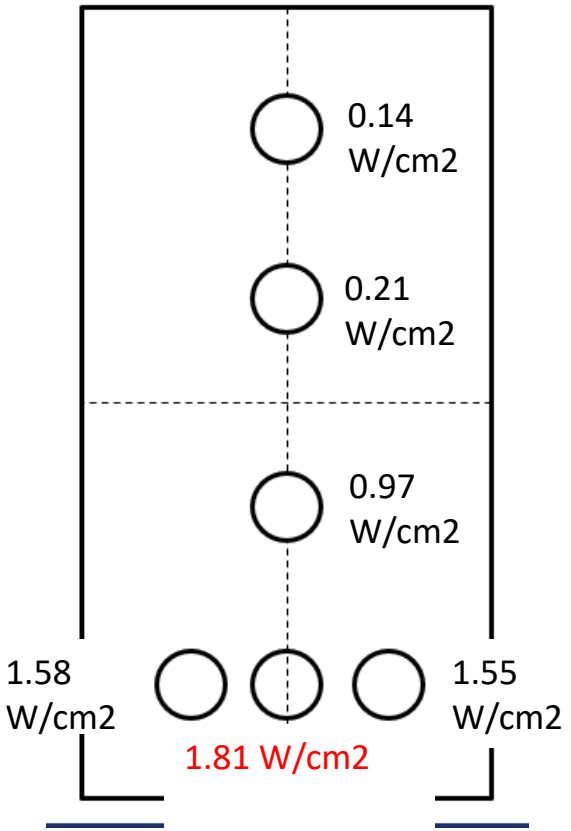
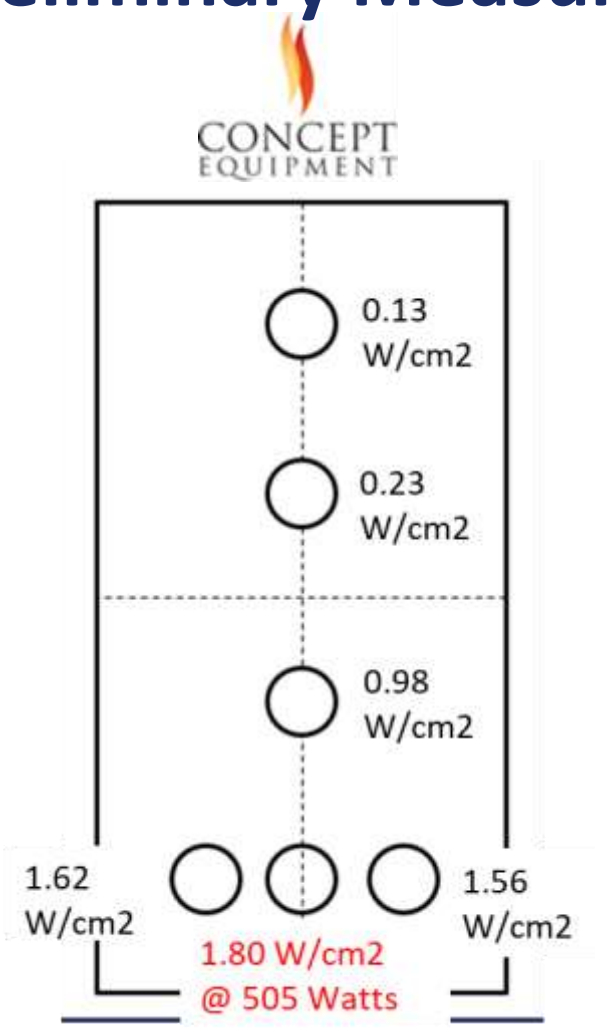


Comparison of Heaters

Preliminary Measurements



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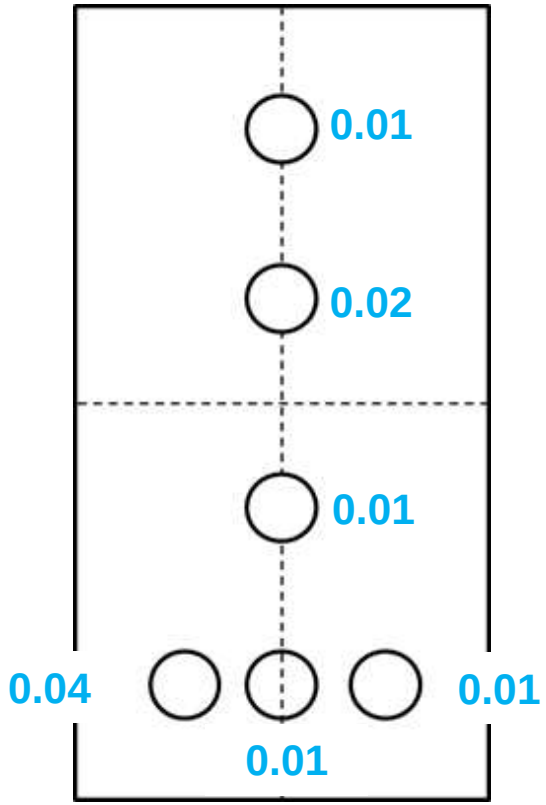

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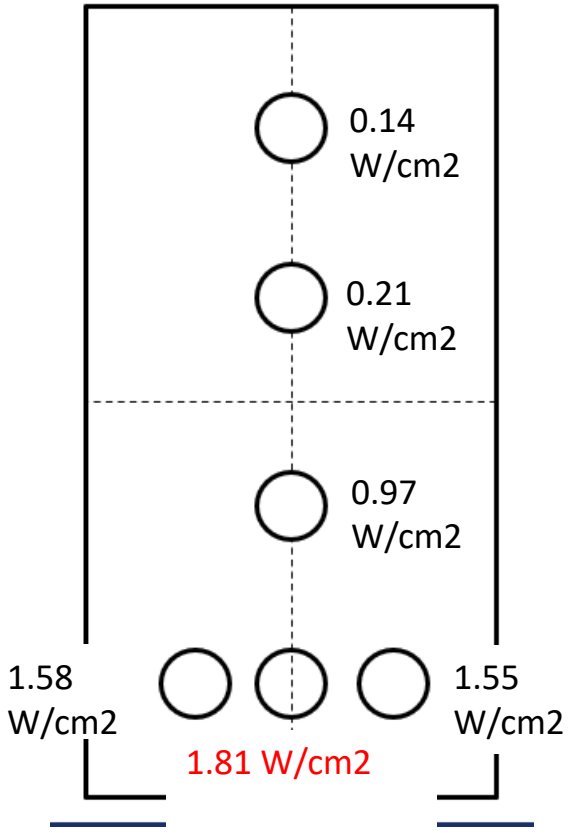

Task Group Discussion

- *Presentation from Boeing on their results*
- Current opposing views on what is best to move forward for the VFP heater:
  - Specifically designed or called-out heater
  - Heater required through measured heat output
- This discussion will be beneficial to find a common ground moving forward
- **VFP Task Group Sessions Thursday April 18, Borgward Saal**
  - 8:30-10:00 session 1
  - 10:30-12:00 session 2

VFP Ribbon Burner

- It was noted that there were some differences in the VFP ribbon burner design between VFP manufacturers
  - **Baffle Plate**: VFP manufacturers noted that the baffle plate inside the ribbon burner should be removed to reduce variables
  - **Burner Length**: The length of the burner was requested to be made longer to make room for clean out port plug and prevent tapering at the edge of flame

Ribbon Burner

- Baffle vs No Baffle
- Issues noted by Manufacturers:
  - Issues could arise when replacing the baffle plate inside the ribbon burner on an angle
  - Manufacturers believe the baffle plate may restrict flow of pre-mixed fuel and result in unburned gasses

Image provided by Ray Bashford, Concept Equipment

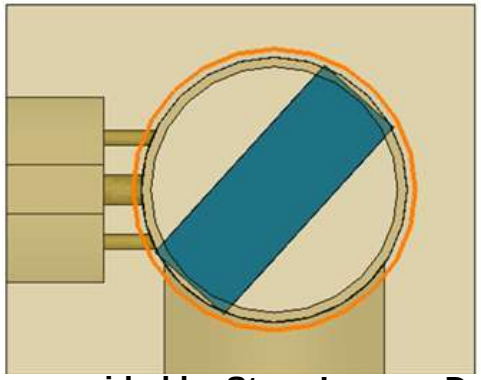

Image provided by Steve Larson, Deatak

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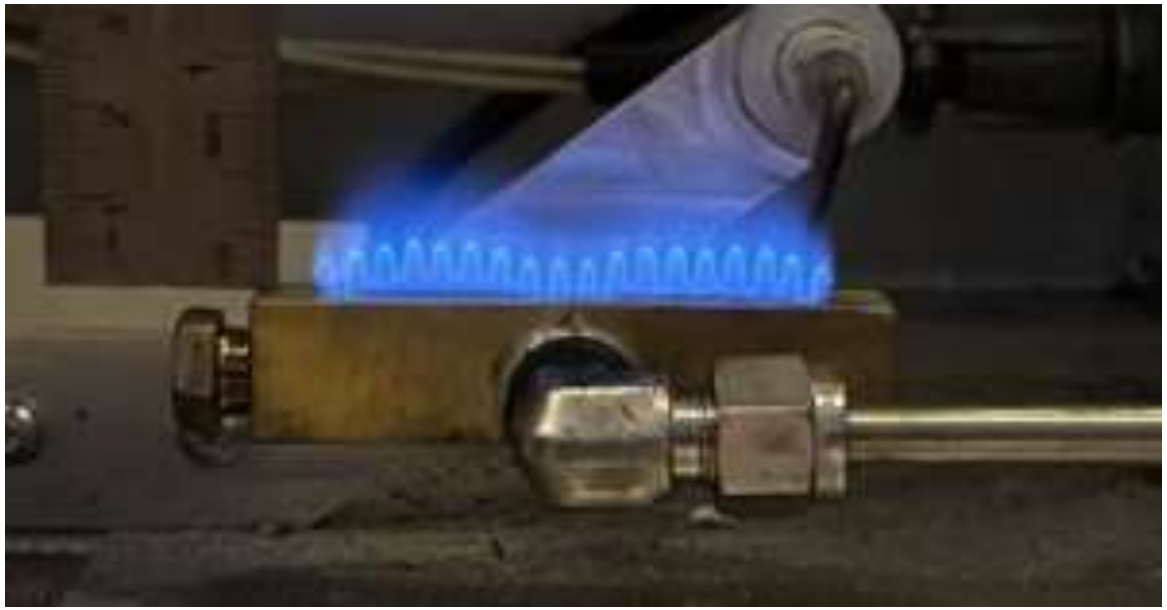
Ribbon Burner – Baffle vs No Baffle

With Baffle

Without Baffle

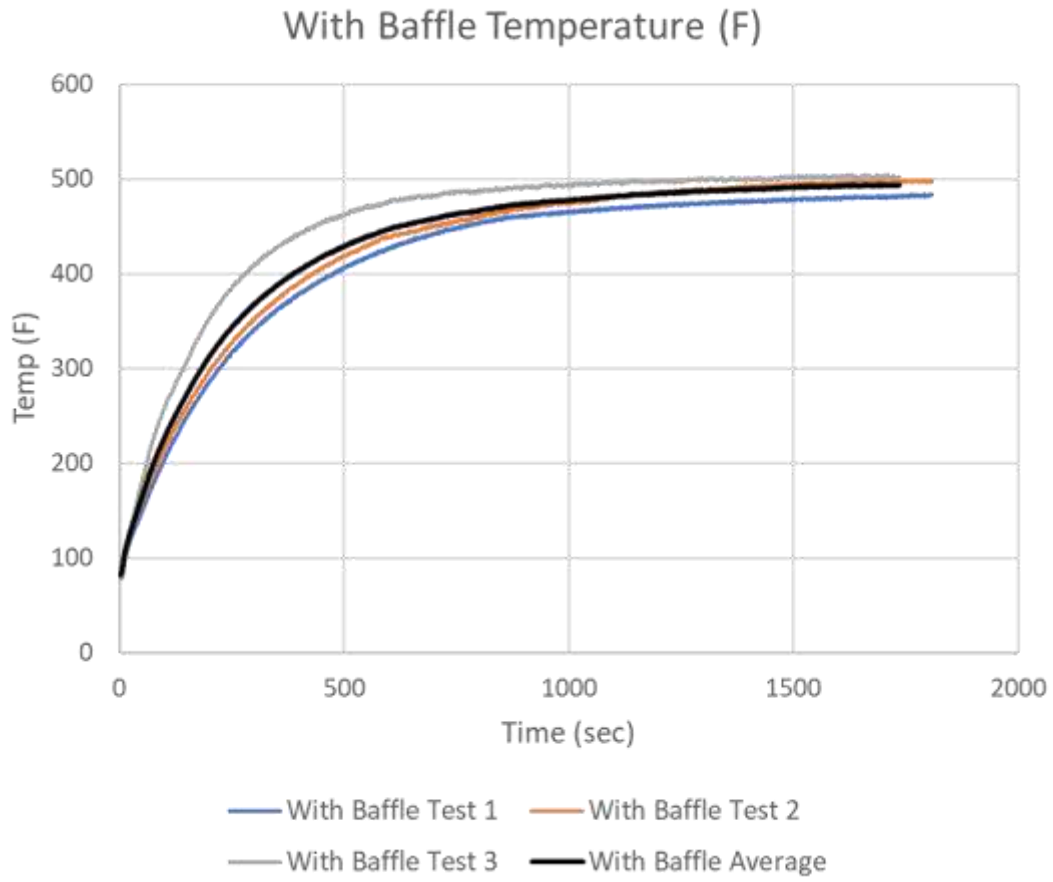


Burns Plate

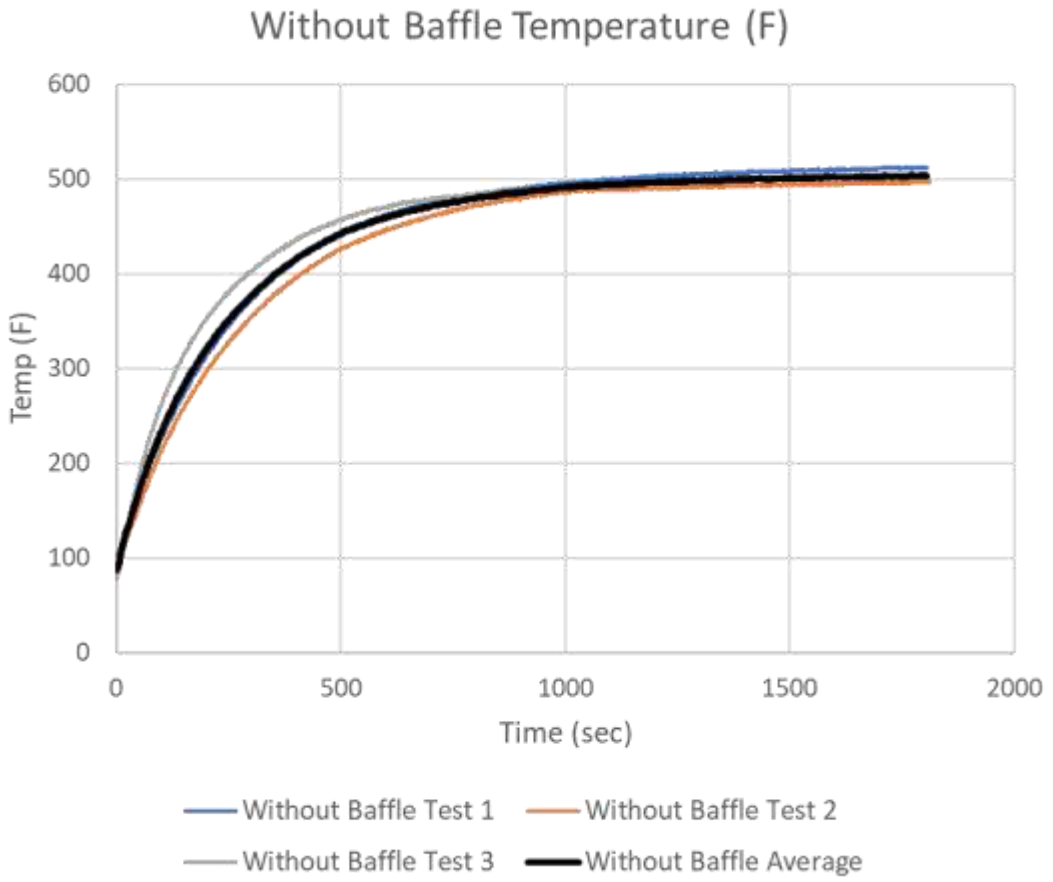
- Copper plate with thermocouple embedded
- Measured temperature of plate for 30 minutes
- Compared the stabilized plate temperature between baffle and no baffle ribbon burner flame

Ribbon Burner – Baffle vs No Baffle

Avg of final 100 seconds = 493 F



Avg of final 100 seconds = 503 F



Ribbon Burner Updated Design

- No baffle plate
- ¼ inch longer to properly fit plug for cleanout port without intruding on gas exit holes
- All VFP manufacturers worked together to develop one burner design for all three to use

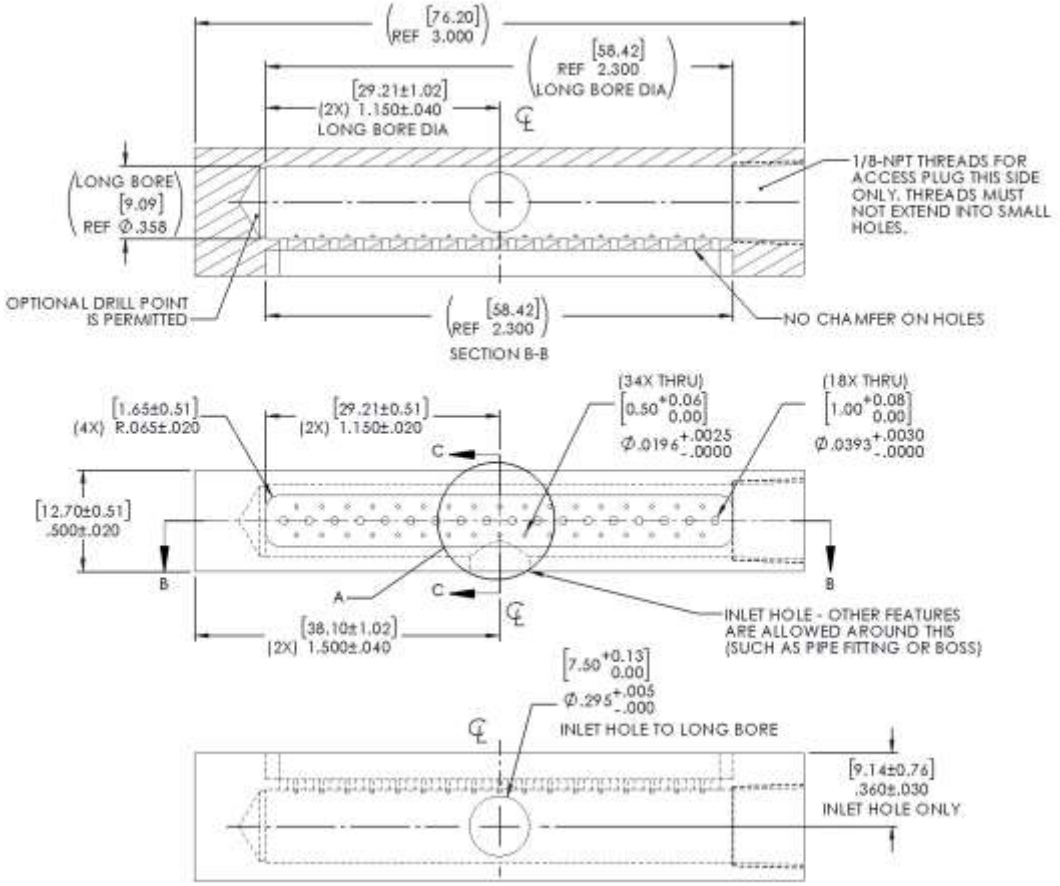
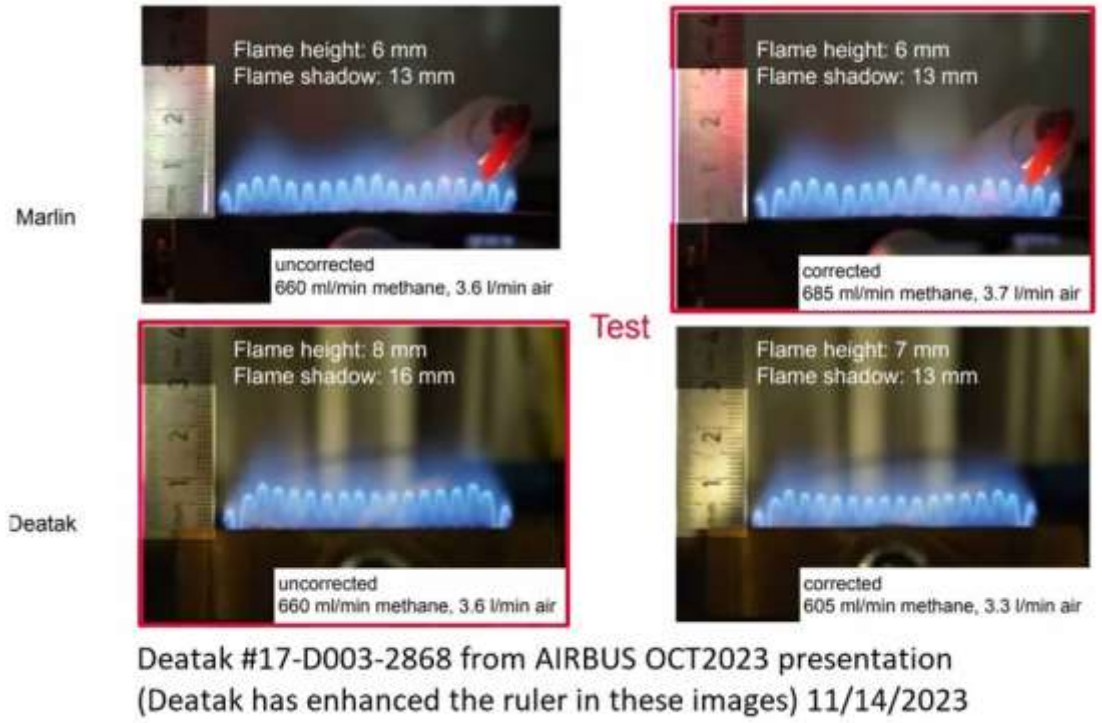


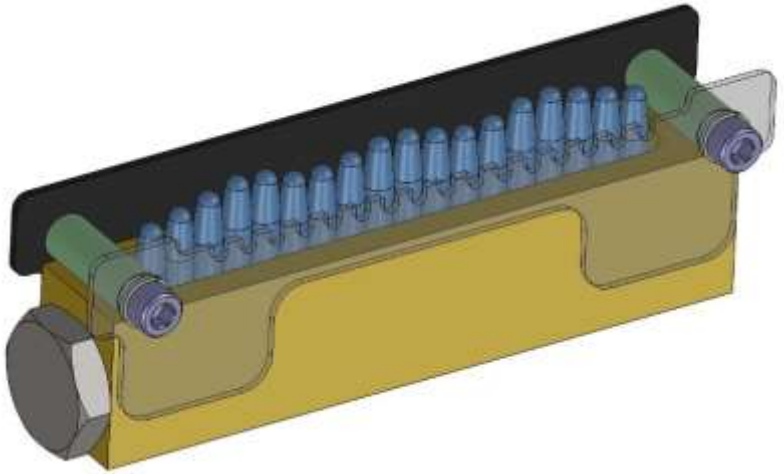
Image provided by Steve Larson, Deatak

Flame Check

A potential option for ensuring the flame is correct moving forward



Deatak #17-D003-2868 from AIRBUS OCT2023 presentation
(Deatak has enhanced the ruler in these images) 11/14/2023



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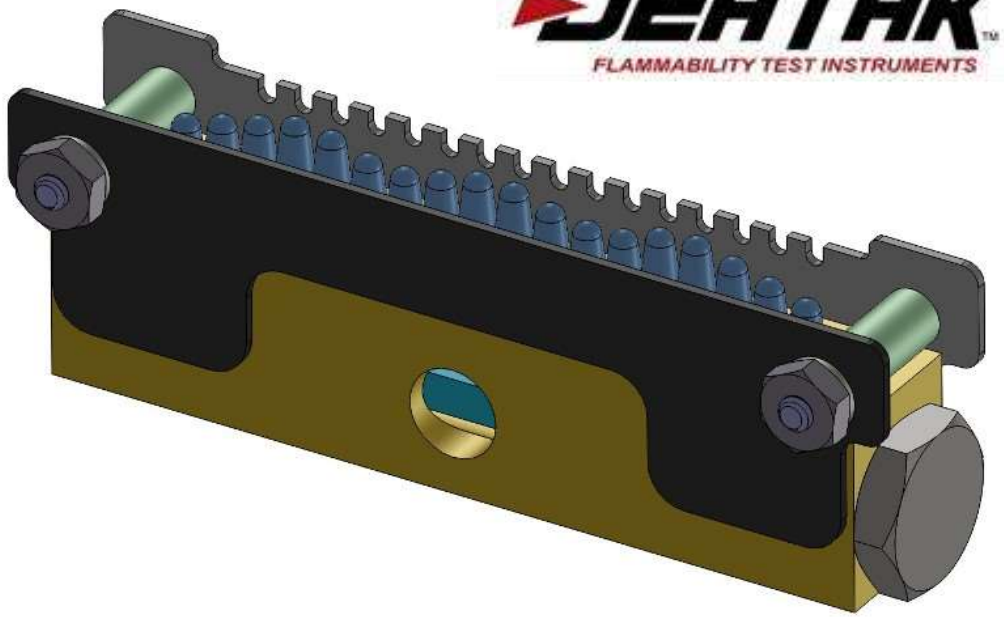

Summary

- Radiant Heater
  - The current heater design needs to be updated
  - Measured the heat flux upon the sample face as a potential requirement for the build of a new heater
  - Open for discussion during task group session
- Ribbon Burner
  - Design has been updated so that all VFP manufacturers are now building the same design ribbon burner
    - No baffle plate in new design
    - ¼” longer ribbon burner

Questions?

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