International Aircraft Systems Fire Protection Working Group Meeting

Updated Experimental Investigation of the NexGen Burner

Fire Test Center

University of Cincinnati, Cincinnati, OH, USA

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Federal Aviation Administration

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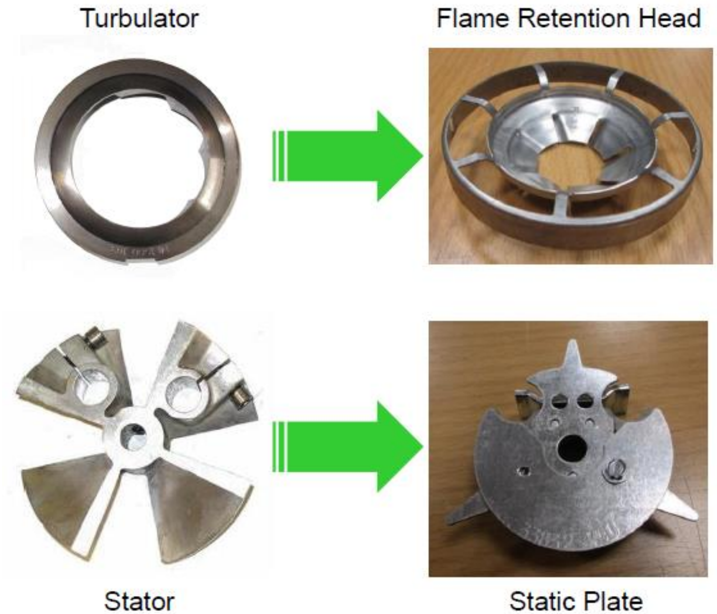
Project Overview

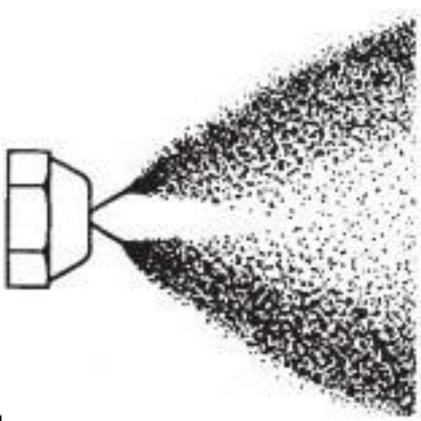
- Project Objective:
  - Develop the operating settings for NexGen burner for Powerplant fire tests
- Previous Work
  - Effect of Burner setup and calibration TC size on burner
    - Calibration and test results
  - Sensitivity of Burner to air and fuel flow rates and temperature
    - Calibration and test results
  - Effect of burner orientation on burner performance
    - Calibration, temperature maps and test results
  - Comparison of fire test results between NexGen and Gas burners
- Current Approach
  - Study of proposed burner configuration with Flame Retention Heads (FRH) and Delavan fuel nozzles
    - Fuel spray and Temperature Distribution

Updated NexGen Burner Configuration

- For the cargo liner and seat cushion tests, the NexGen burner configuration has been updated to use a Flame Retention Head (FRH) instead of the turbulator and stator. Advantage of using the FRH:
  - Generate a more efficient and complete combustion
  - Generate a more uniform, repeatable flame



- Delavan fuel nozzles selected to replace Monarch nozzles
  - More uniform fuel spray pattern, and low variability between nozzles



NexGen Burner Settings

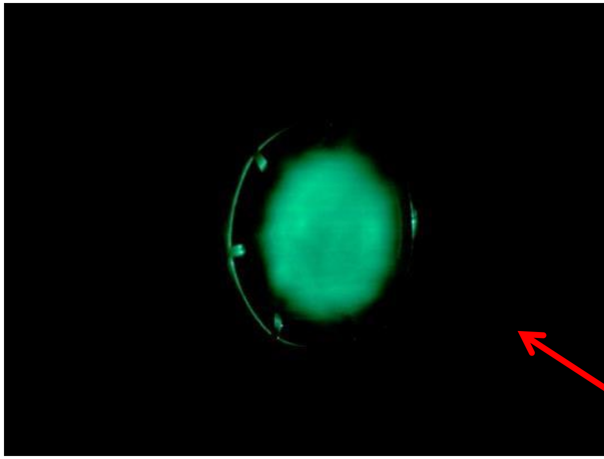
- Burner Operating Conditions
  - Orientation: Horizontal
  - Air Pressure: 60 psi
  - Air Temperature: ambient
  - Fuel pressure: 100 psi
  - Fuel Temperature: ambient
- Flame Retention Heads Tested
  - F3, F6, F12, F22, F31
- Fuel Nozzles Tested
  - Delavan 80 deg (W) nozzles
  - 2.0, 2.25 and 2.50 GPH nozzles
  - Fuel nozzles operated at design flow rates
- Calibration Distance: 4 inches

Fuel Spray - Outline

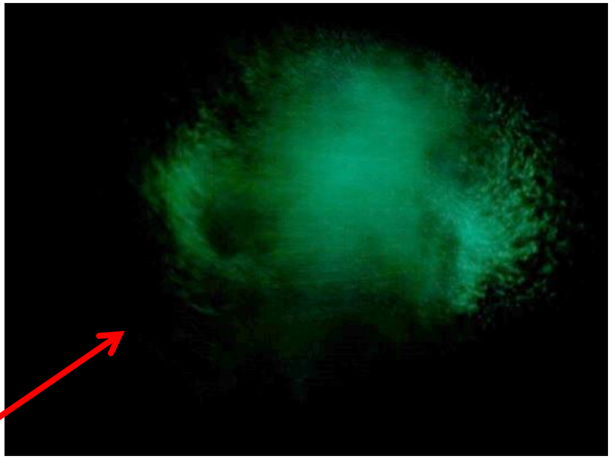
- Objective:
  - To study the fuel spray of the Delavan nozzles using the updated burner configuration with FRHs
  - To study the differences between the FRHs and the fuel nozzles

- Approach
  - Laser sheet used for spray visualization
  - High-speed camera used for visualization (3,000 fps)
  - Laser sheet moved to capture spray at different cross-section locations
  - High speed videos averaged into images detailing spray dispersion, concentration and uniformity

Fuel Spray development with distance

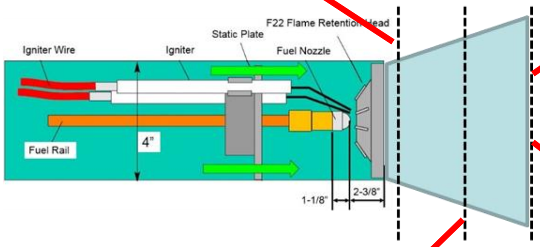


0” – Immediately after FRH

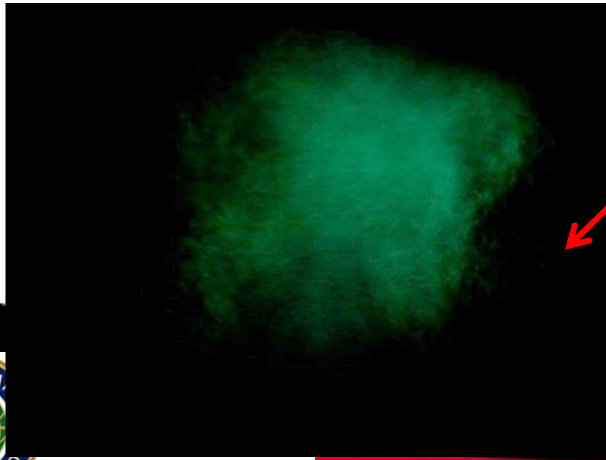


12” from FRH (cone exit plane) without cone

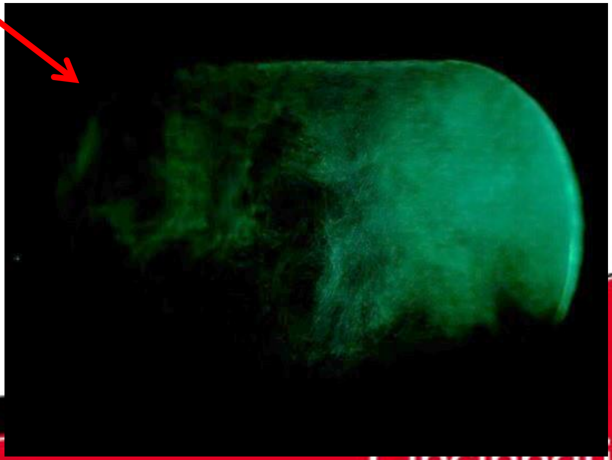
Burner Config:
- FRH 22
- 2.25 GPH nozzle



Note: Spray appears biased due to direction of laser sheet



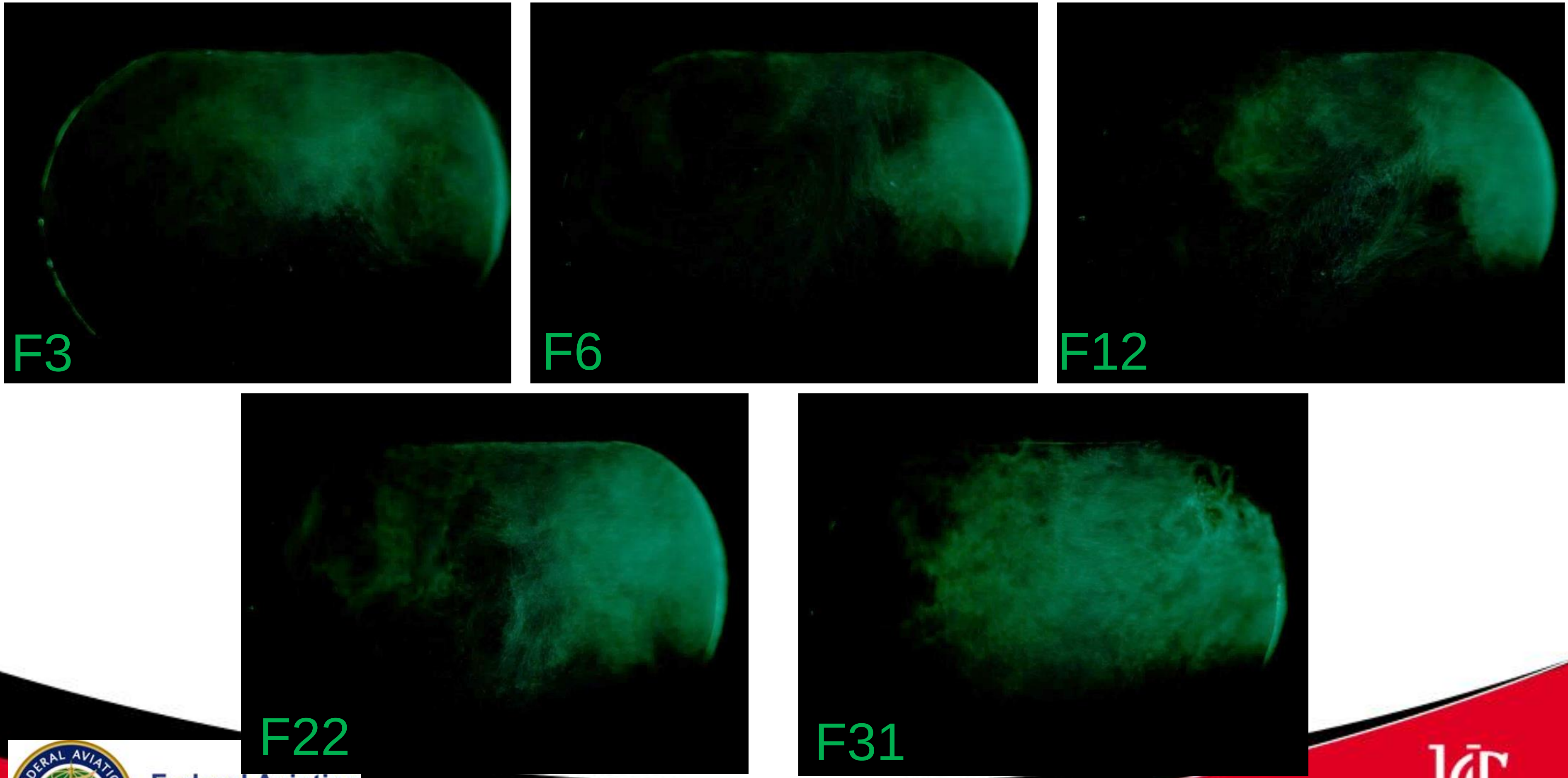
6” from FRH



12” from FRH (cone exit plane) with cone

Fuel Spray – Effect of FRH

Fuel spray becomes more uniformly distributed with increasing FRH exit area (FRH number)



Note: Spray appears biased due to direction of laser sheet

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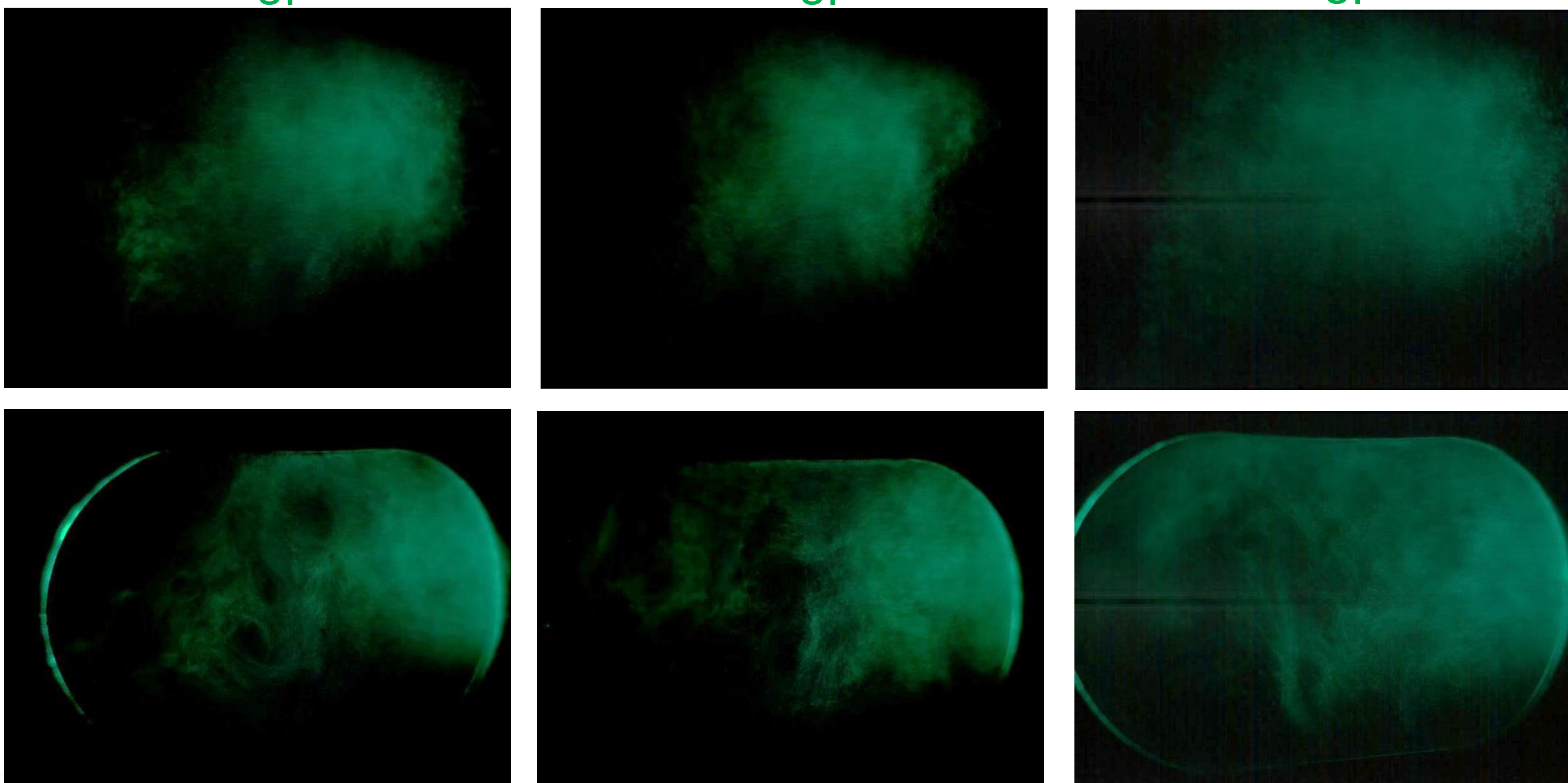
Fuel Spray – Effect of Fuel Nozzle (Fuel Flow)

As the fuel flow rate increases, the fuel spray becomes more uniform

2.0 gph | 2.25 gph | 2.5 gph

12" without cone

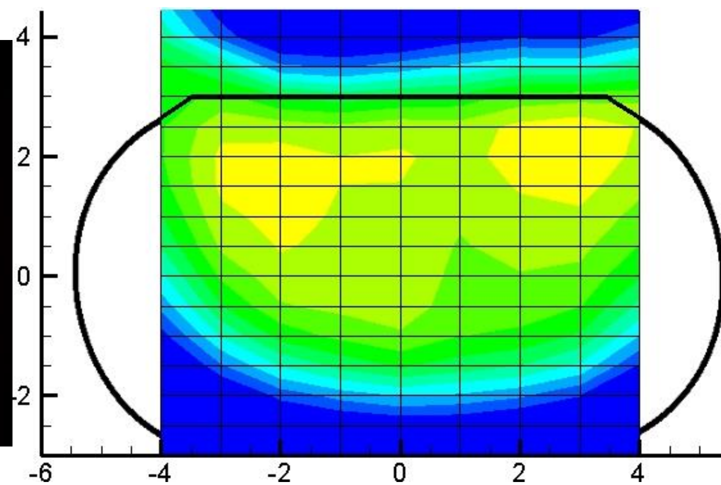
12" with cone

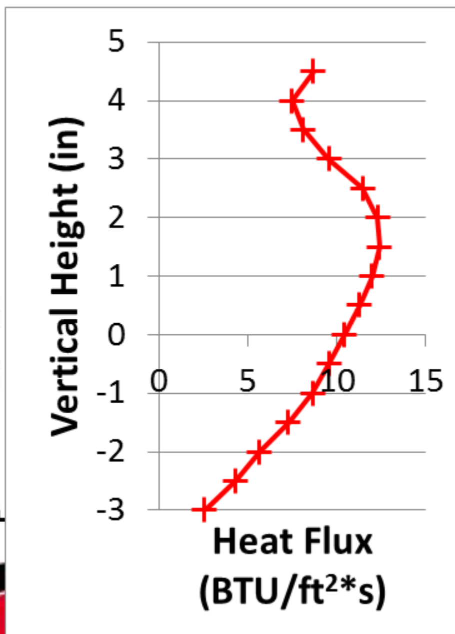


Note: Spray appears biased due to direction of laser sheet

Burner Calibration: Temperature and HF Maps

- Objective
  - To study the flame characteristics (temperature and heat flux distribution) for the updated burner using FRHs
- Approach
  - TC rake and heat flux tube traversed across burner height at 0.5 inch increments
  - 9 TCs in rake to measure a distance of 8 inches (1 inch separation)



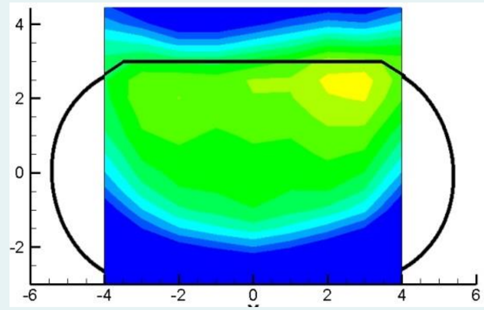
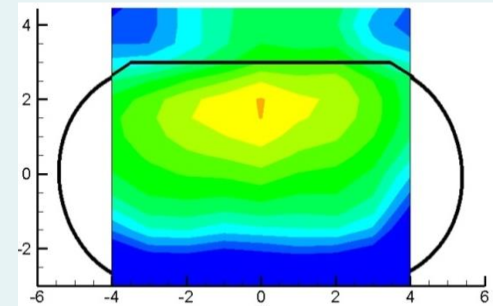
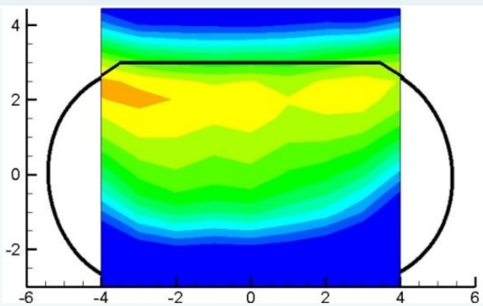
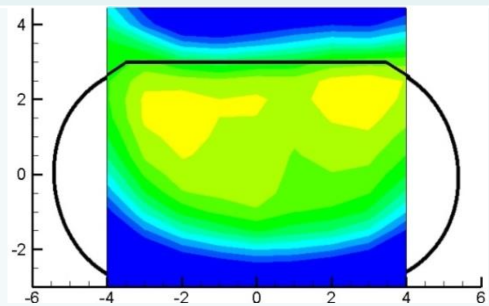
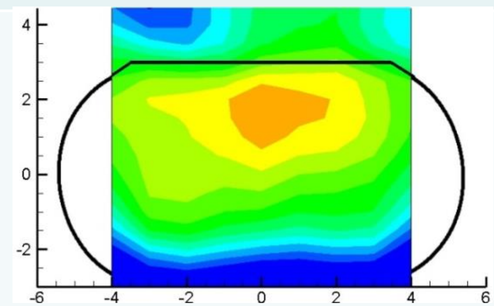
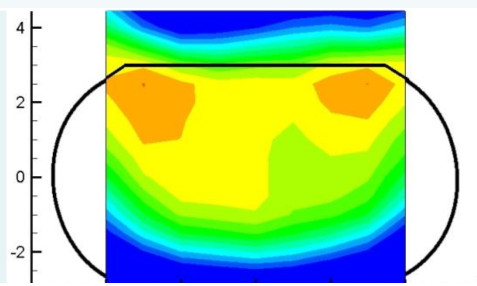
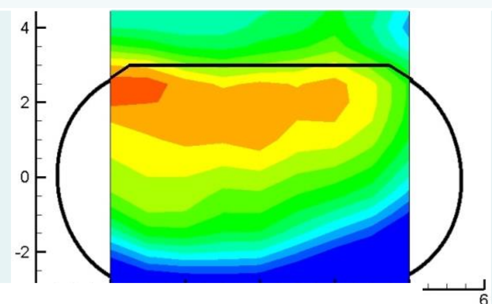


Burner Calibration: Flame Shapes

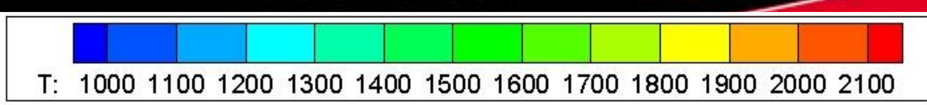
FRH->	F12	F22	F31
2.0 GPH			
2.25 GPH			
2.5 GPH			

For the larger FRHs, the flame distribution is more uniform

Burner Calibration: Temperature Maps

	F12	F22	F31
2.0 GPH			
2.25 GPH			
2.5 GPH			

F22 has a flatter temperature distribution near the center while F31 has a peaked distribution



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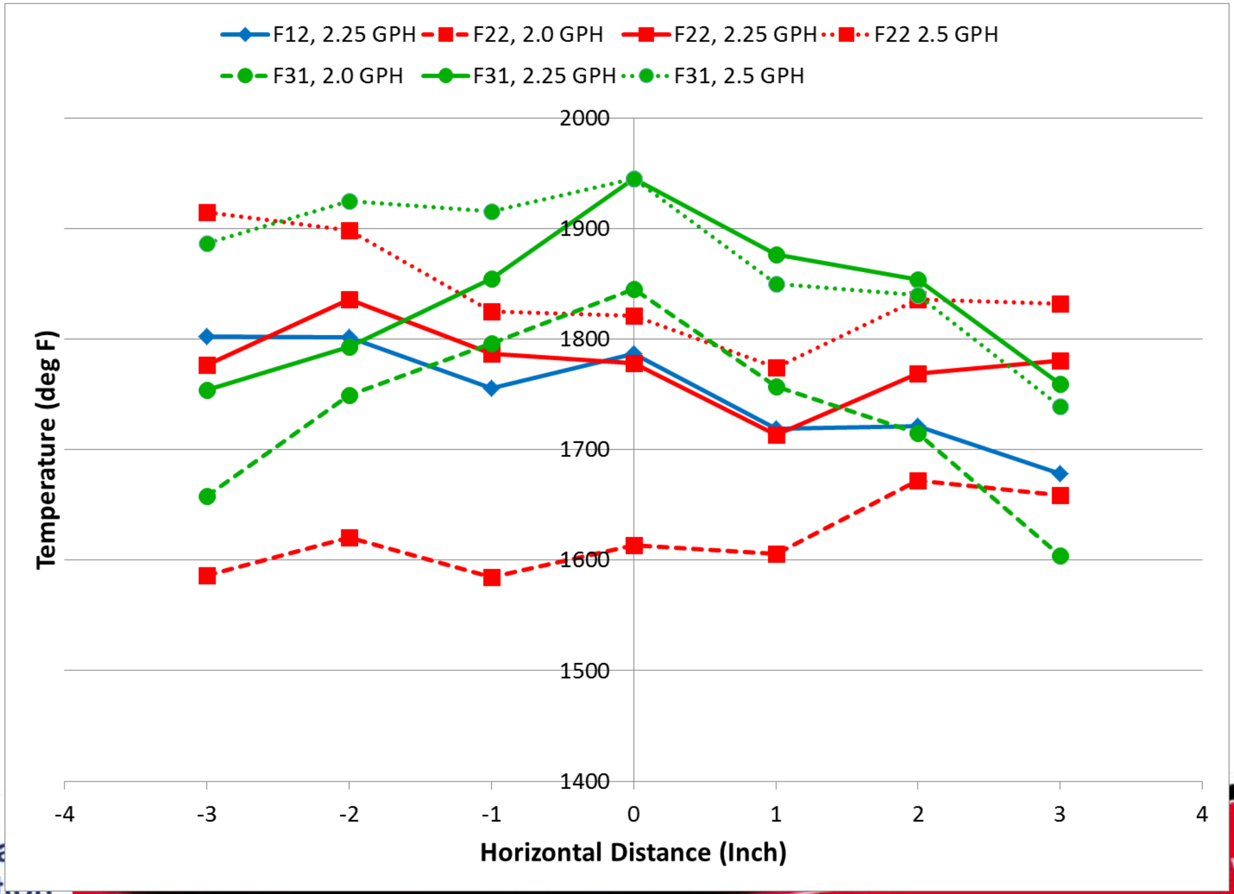
Burner Calibration: Temperature Profiles

- Flat temperature profiles observed for F22 (red)
- Peaked temperature profiles observed for F31 (green)
  - Highest average temperature observed for F31



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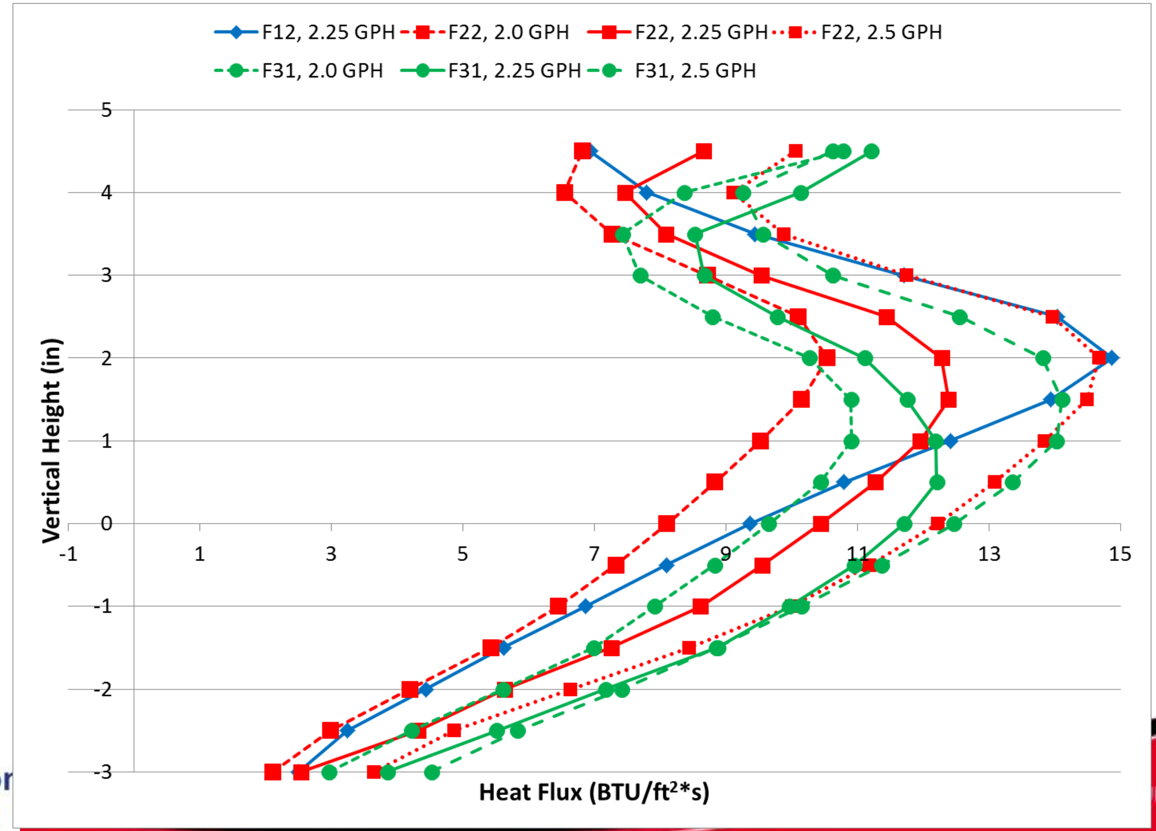
Burner Calibration: Heat Flux Profiles

- As the FRH area increases, the height of the heat flux peak from the burner centerline decreases:
  - 2 inches for F22 (red) vs 1 inch for F31 (green)
- For same fuel flow rate, peak heat flux decreases as FRH area increases
- Heat flux increases with increasing fuel flow rate



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Burner Calibration: Summary

- Summary of temperature and heat flux at 1 inch above burner centerline provided
  - For the same fuel nozzle (flow),
    - Flame temperature increases with FRH area (FRH number)
    - Heat flux increases slightly with FRH area
  - Trend of heat flux is misleading, as the height of heat flux peak changes with the FRH

Nozzle	FRH	Heat Flux (BTU/ft^2*s)	Temperature (F)
2.25 GPH	F12	12.4	1752.1
2.0 GPH	F22	9.5	1620.1
2.25 GPH		12	1777.1
2.5 GPH		13.8	1843.1
2.0 GPH	F31	10.9	1732.0
2.25 GPH		12.2	1834.0
2.5 GPH		14	1871.5

Conclusions and Recommendations

- The bigger flame retention heads provide better burner performance as the fuel spray and the flame occupies most of the cone exit area

- The F22 and F31 FRHs are possible candidates to be used in Powerplant fire tests
  - F31 has higher average temperature and a peaked temperature distribution
  - Peak heat flux observed at 2 inches for F22 and at 1 inch for F31
  - F22 is recommended as it has a flatter temperature distribution

ADDITIONAL SLIDES

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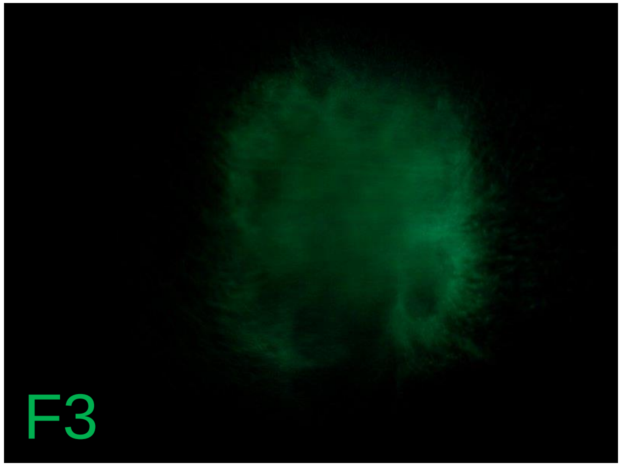
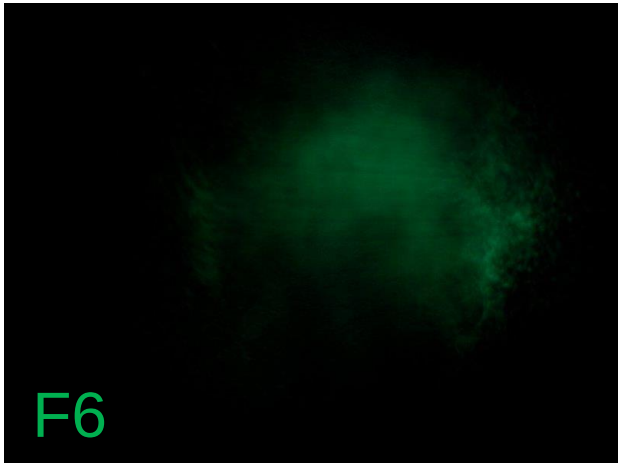
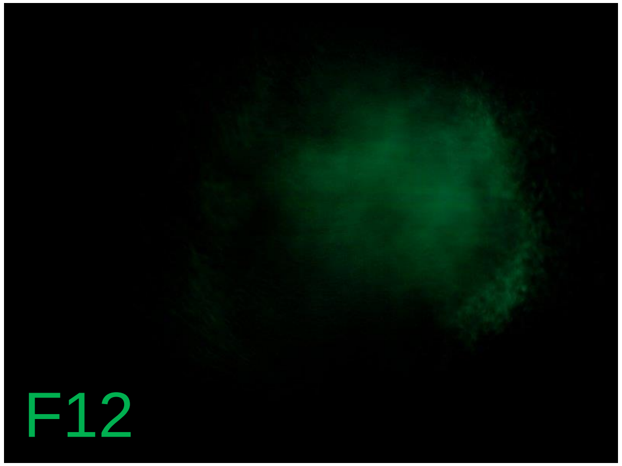
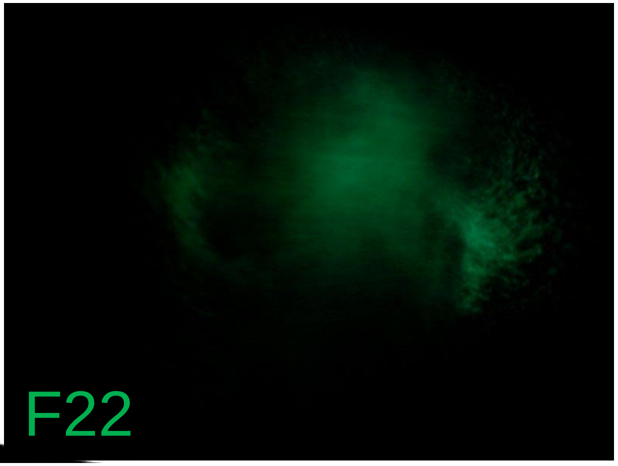
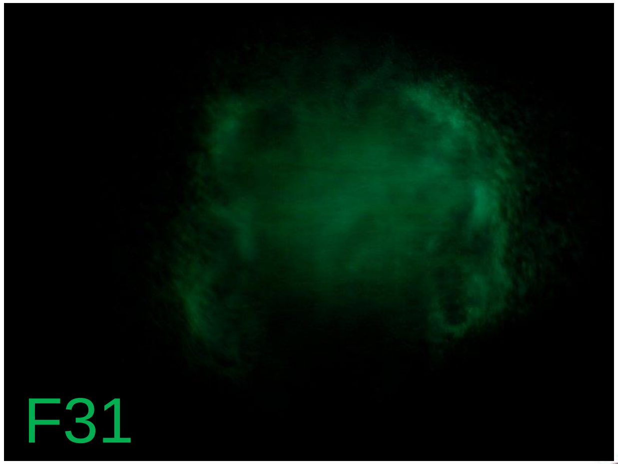
Fuel Spray – Effect of FRH (6 inch)





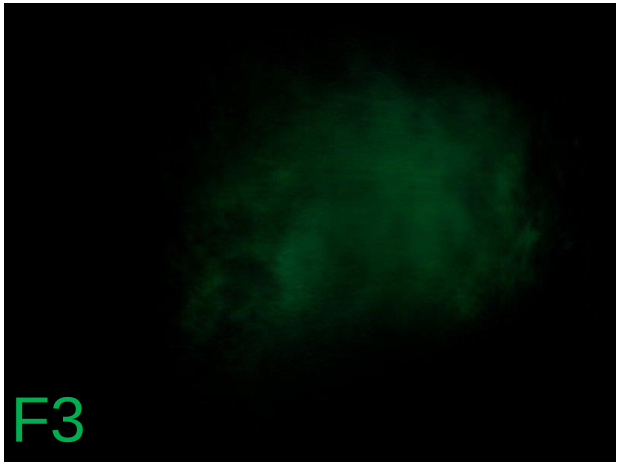


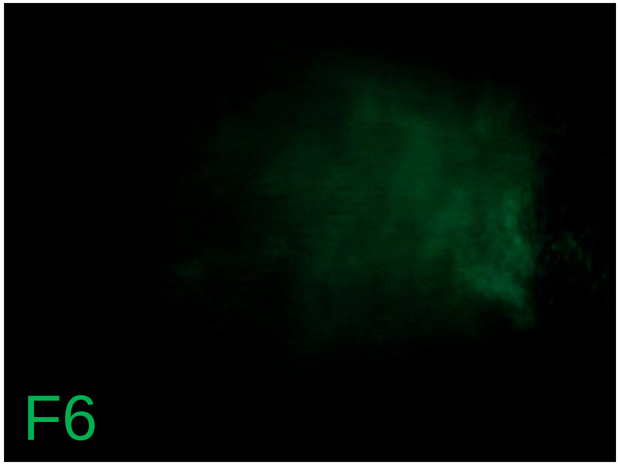


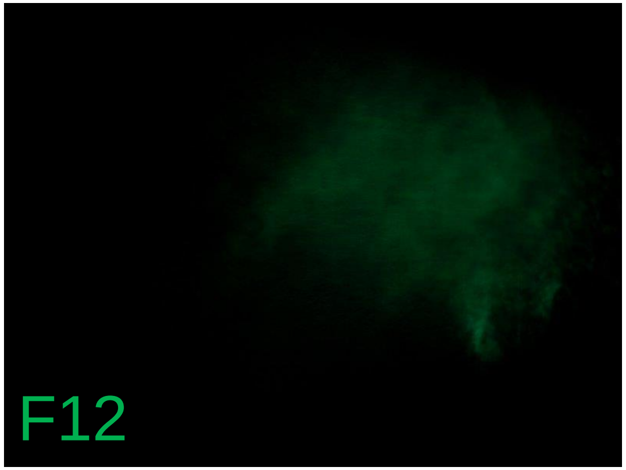


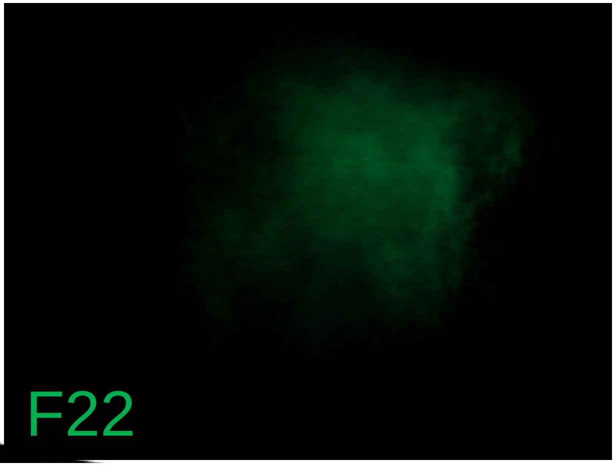
Note: Spray appears biased due to direction of laser sheet

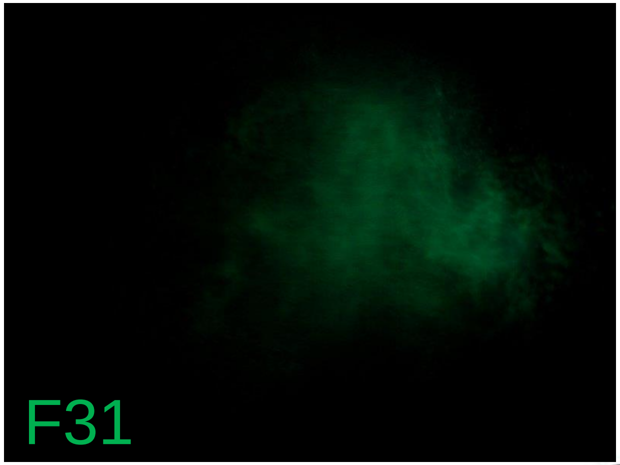
Fuel Spray – Effect of FRH (12 inch, w/o cone)











Note: Spray appears biased due to direction of laser sheet

Flame Shapes for 2.25 GPH Nozzle

F3

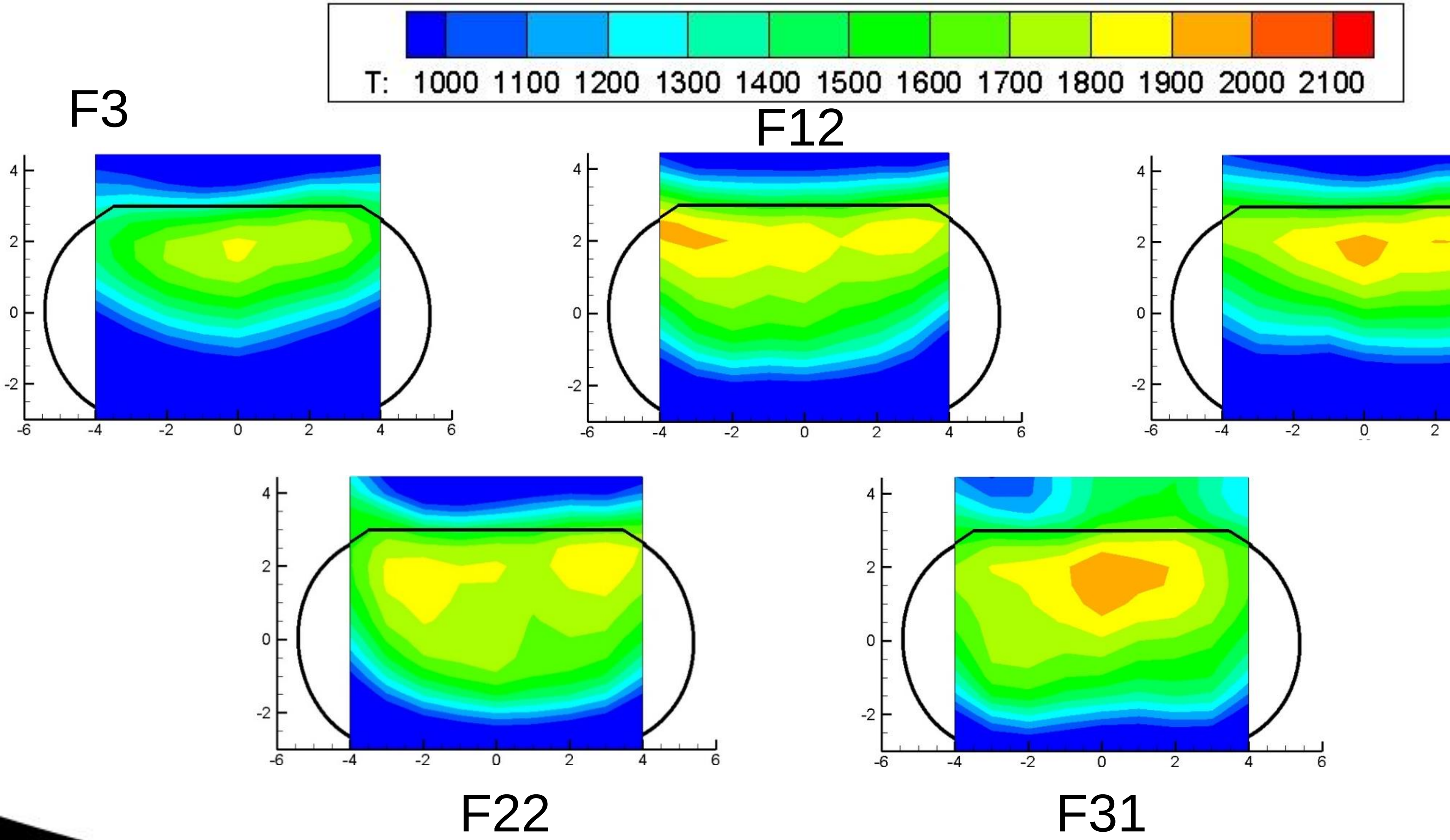
F6

F12

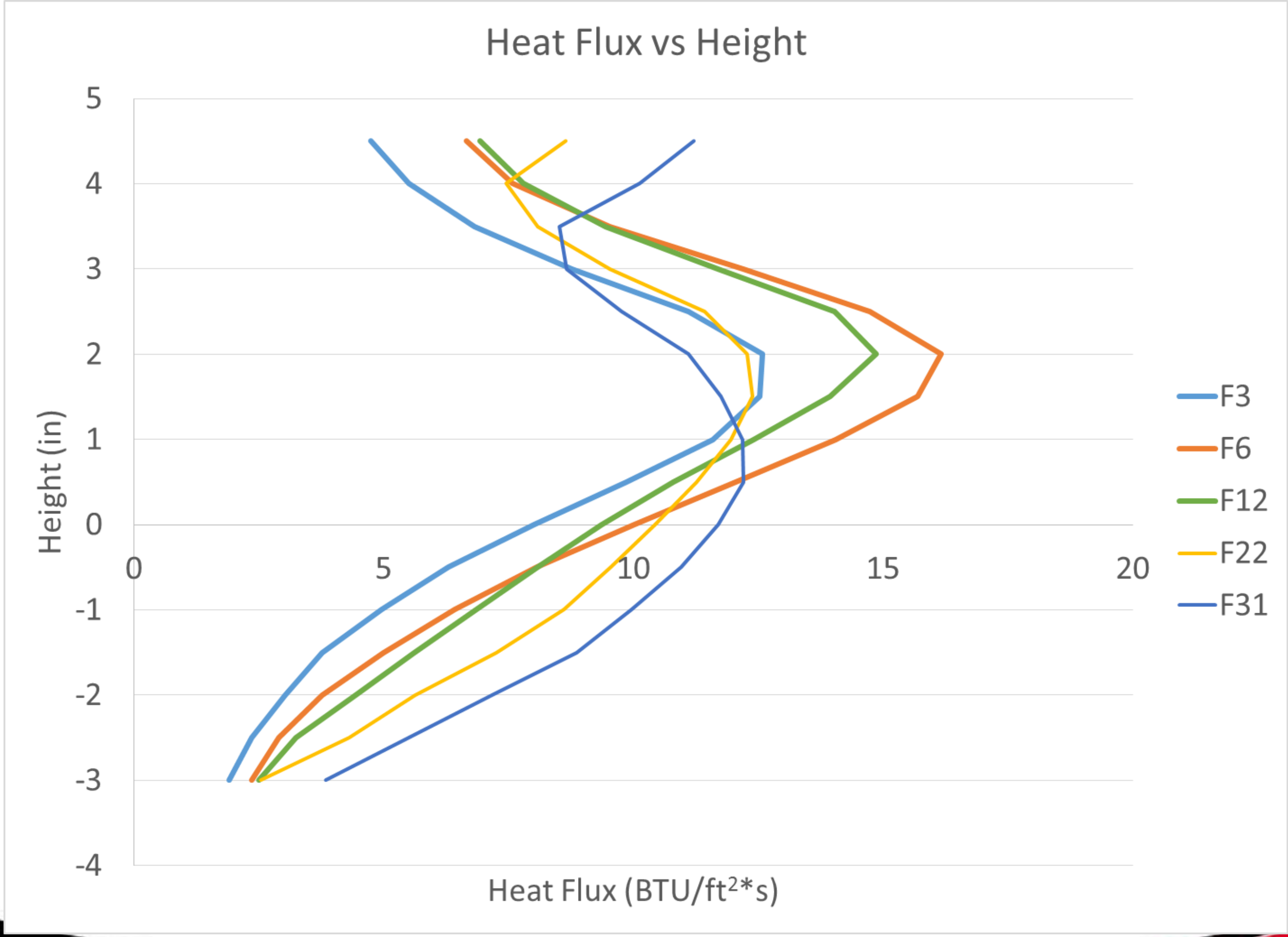
F22

F31

Temperature Maps for 2.25 GPH Nozzle



Heat Flux Profiles for 2.25 GPH Nozzle



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