International Aircraft Systems Fire Protection Working Group Meeting

Updated Experimental Investigation of the NexGen Burner

Fire Test Center
University of Cincinnati, Cincinnati, OH, USA
March 20, 2015

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Project Overview

- Project Objective:
  - Investigate the sensitivity of NexGen burner assembly & internal geometry
- Previous Work
  - Old Configuration (Turbulator & Stator):
    - Effect of burner setup and calibration TC size on burner
    - Sensitivity of burner to air and fuel flow rates and temperature
    - Effect of burner orientation on burner performance
    - Comparison of fire test results between NexGen and Gas burners
  - New Configuration (FRH):
    - Fuel spray and temperature maps for different FRHs and fuel nozzles
    - Burn through and temperature maps of varying fuel/air operating settings
- Current Approach
  - Fuel nozzle spray characterization and comparison
  - Sensitivity of burner to assembly tolerance
    - Temperature distribution maps
    - Burnthrough tests (2024 Al, 24” x 24” x 1/8”)

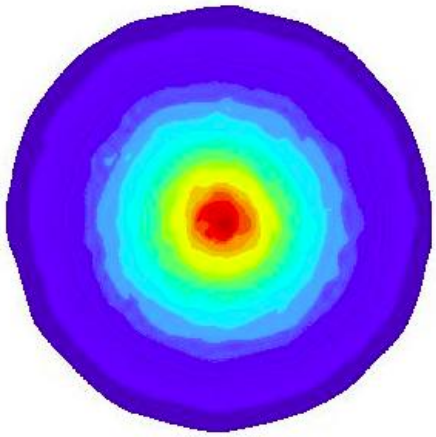
Current Approach

- Fuel Nozzle Spray Characterization
  - Pressure vs Flow Rate
  - Spray Patternation
  - Droplet Size Measurement
- Burner Assembly Sensitivity
  - Baseline test conditions used by the FAA for comparison tests:
    - Air – Pressure 50 psig, Temperature 50º ± 10ºF
    - Fuel – Pressure 100 ± 5 psig (2.5 GPH), Temperature 42º ± 10ºF
  - Effect of Fuel Nozzle Depth
    - change in depth: ±0.5”
  - Effect of Cone Depth
    - change in depth: ±2”
  - Effect of Cone Type
  - Effect of FRH Deformation

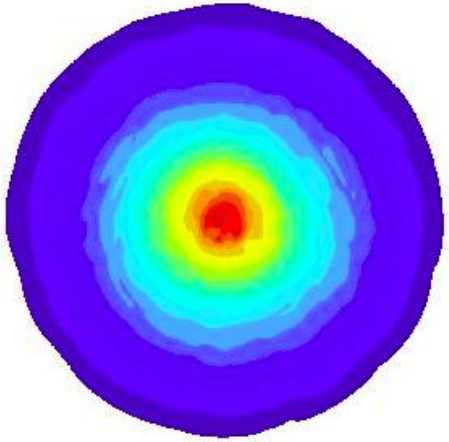
2024 Al Panel, 24x24x1/8”

Fuel Spray Characterization

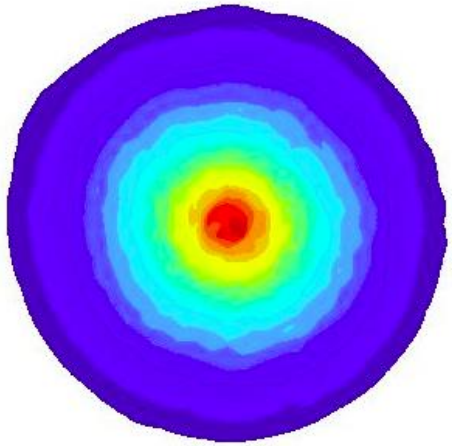
Delavan



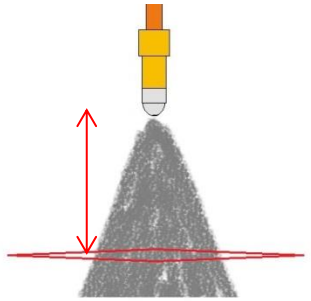
Nozzle 1



Nozzle 2

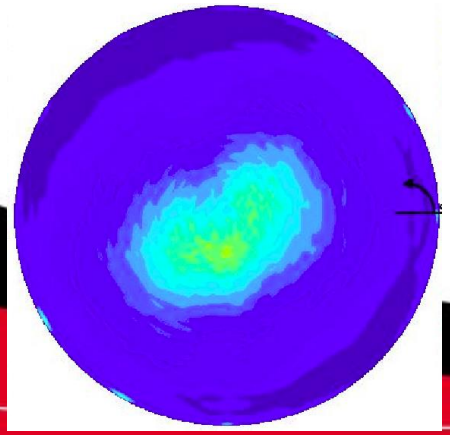


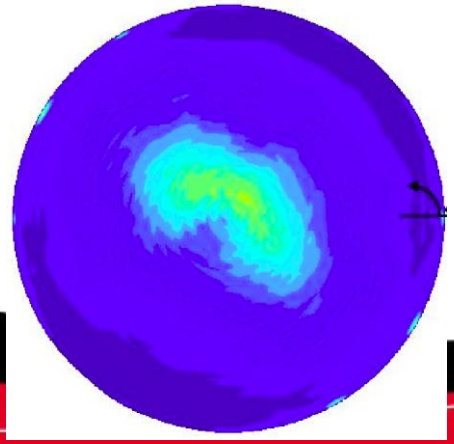
Nozzle 3

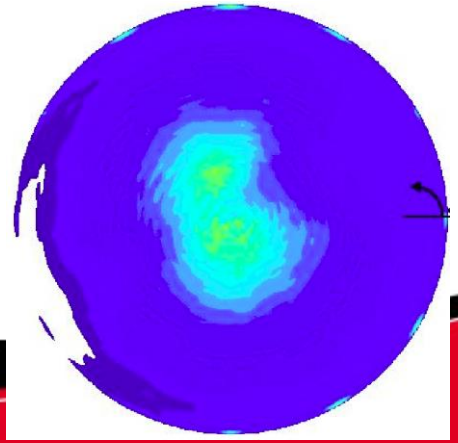


Laser Distance = 3 in.

Other Manufacturer

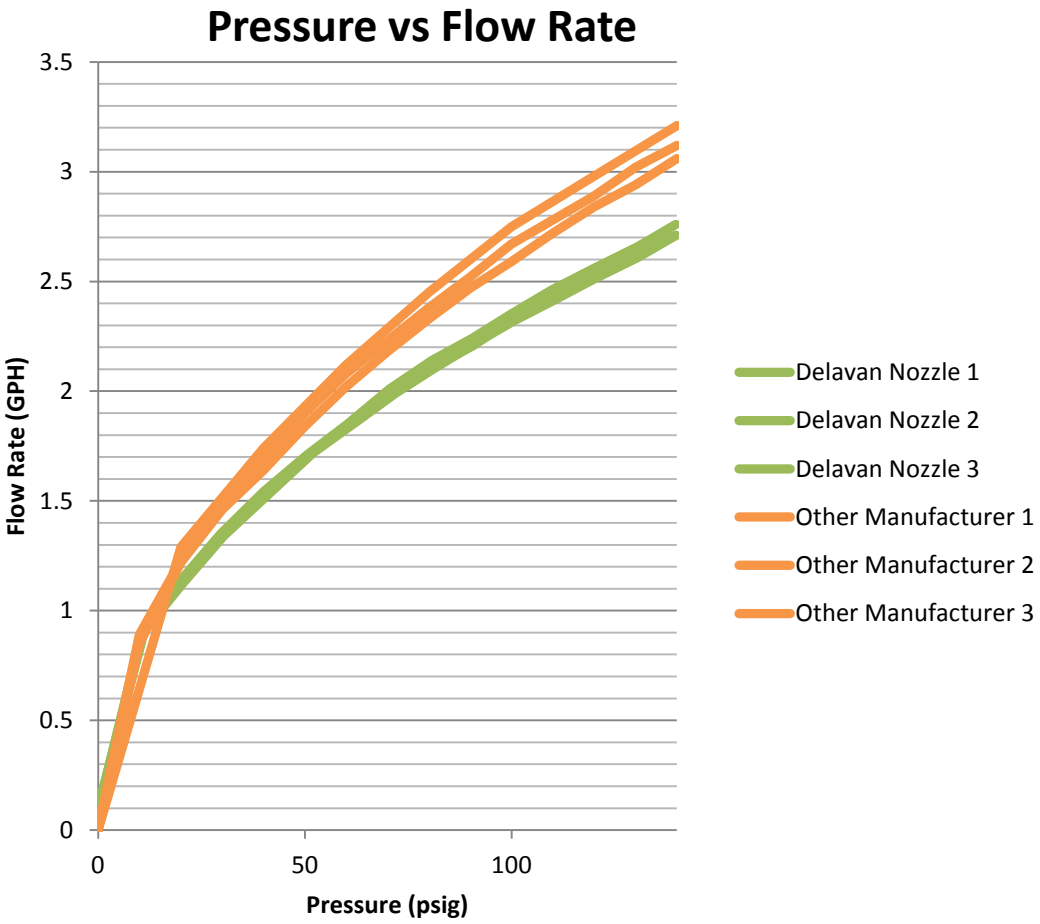


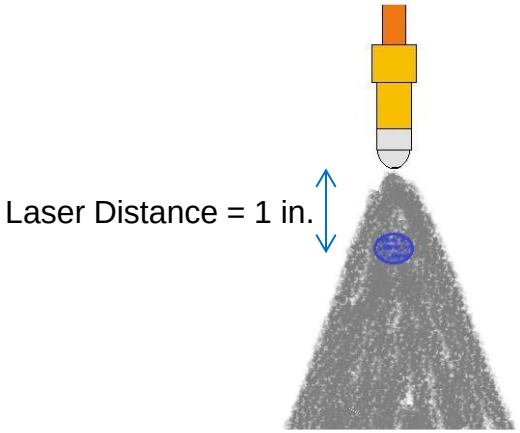




Fuel Spray Characterization

- Delavan nozzles provide more consistent spray characteristics than other manufacturers.



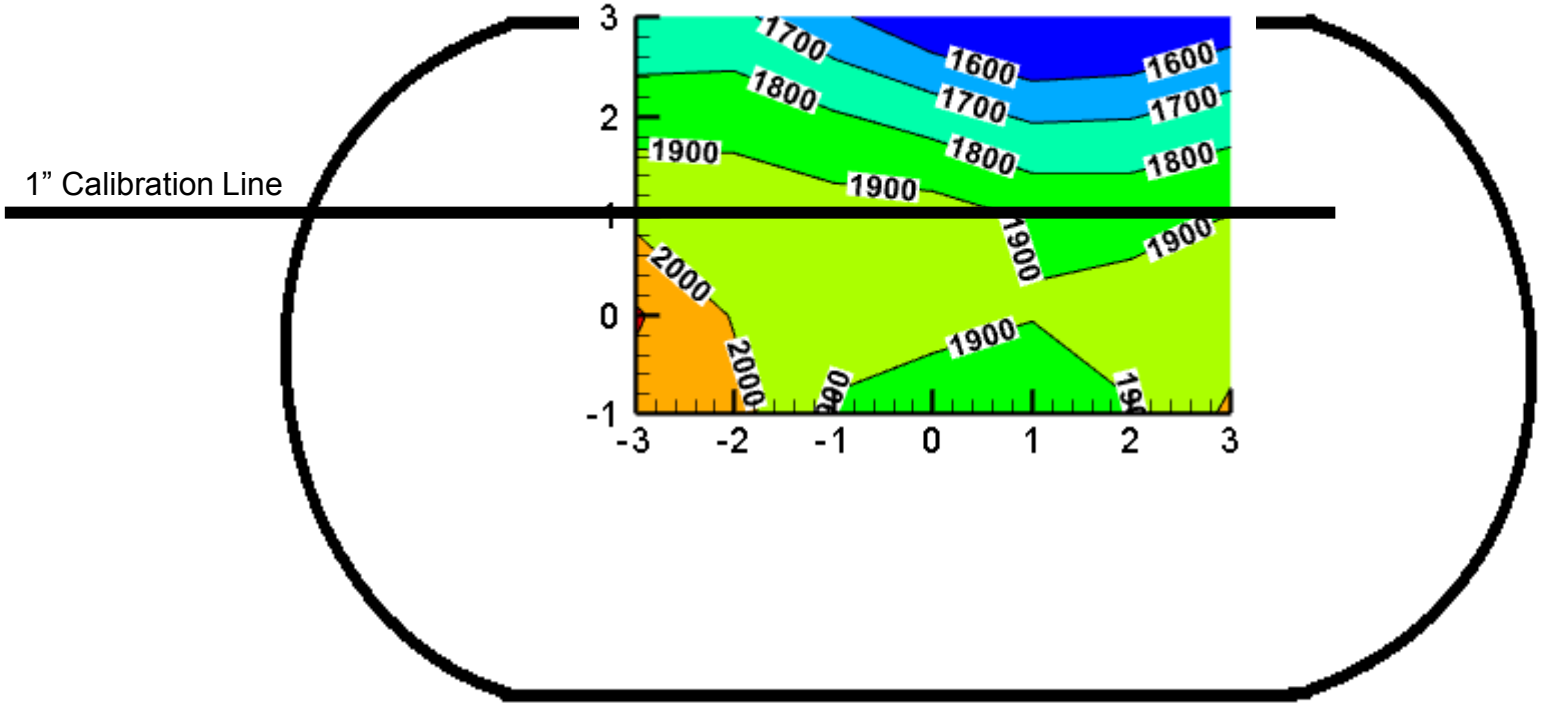


Nozzle #	Delavan SMD	Other Manufacturer SMD
1	12.7	12.4
2	13.0	14.6
3	13.2	11.3

Baseline Condition – Temperature Map

- Air Flow Settings
  - 50 psig (265 PPH), 53 ºF
- Fuel Flow Settings
  - 102 psi (2.33 GPH), 45 ºF

Equivalence Ratio,Φ = 0.87



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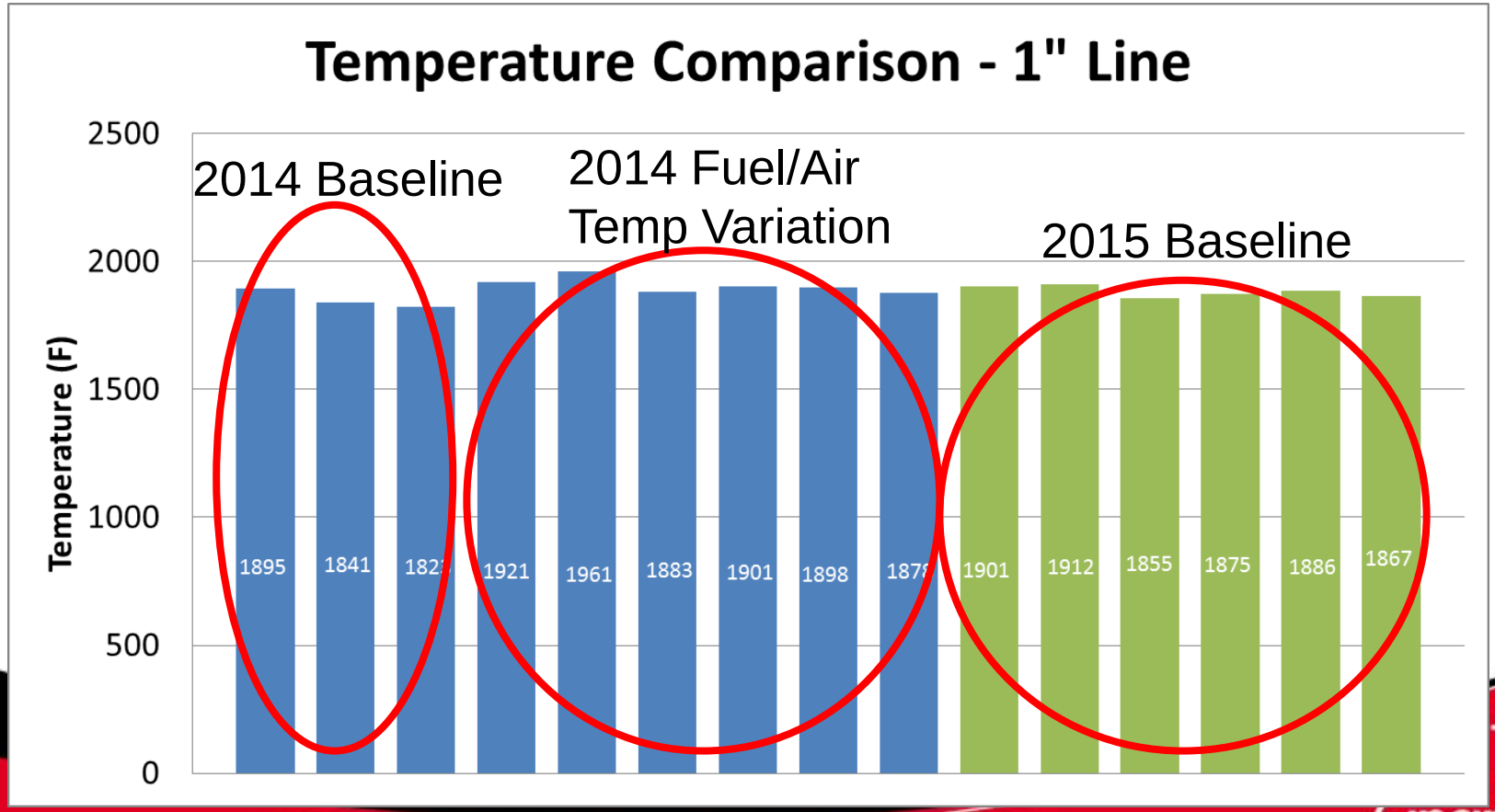
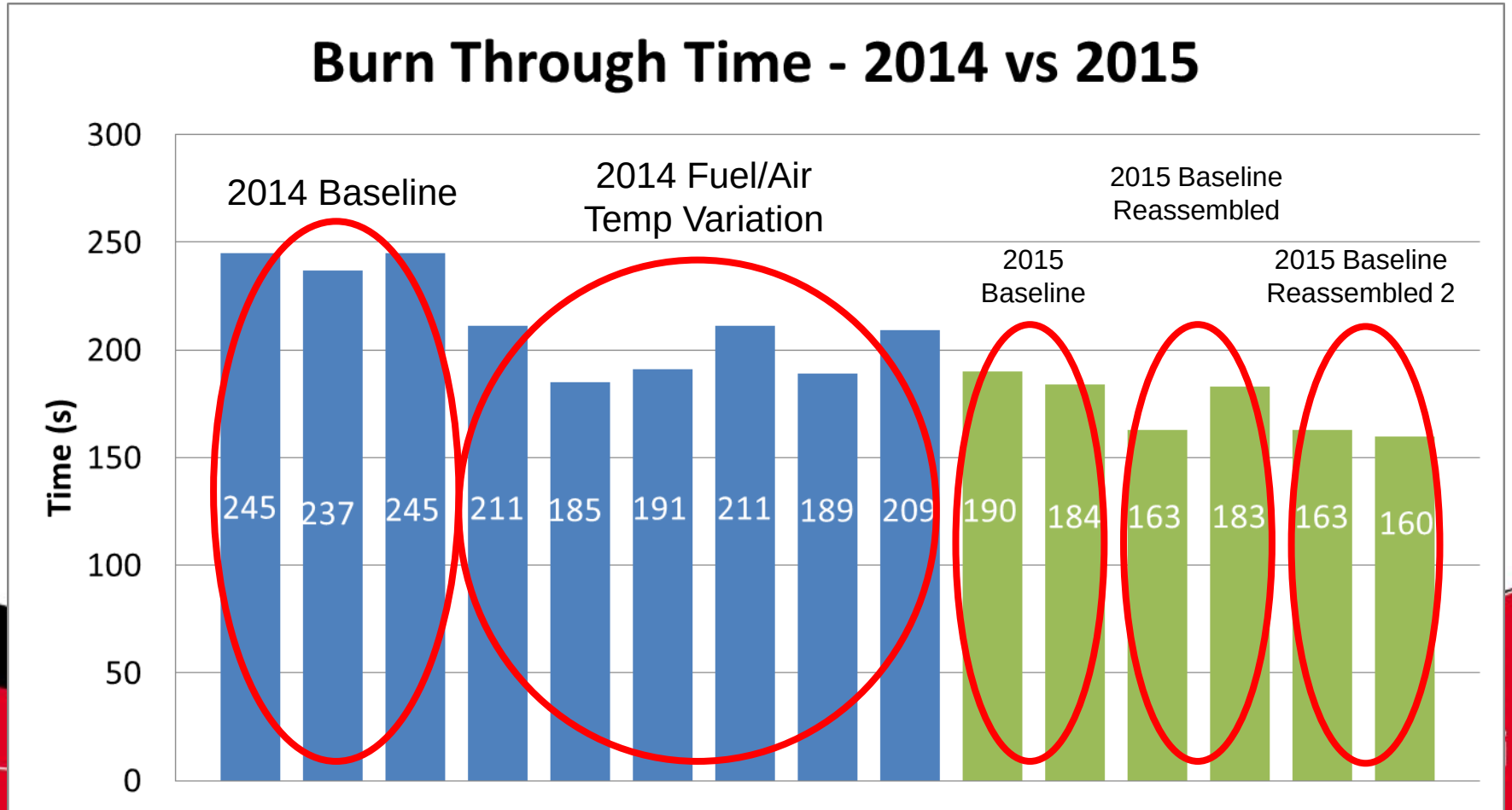
Baseline Condition – Repeatability

- Temperatures at 1” calibration line are fairly consistent from test to test & year to year.

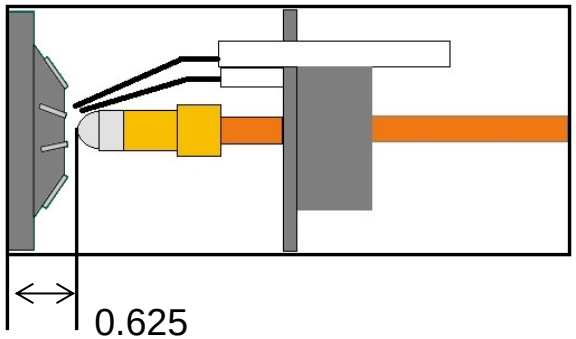


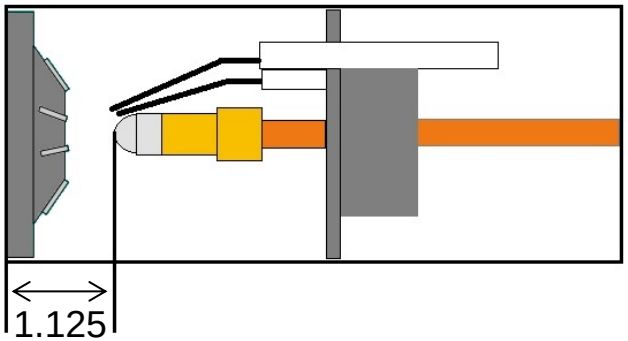
Baseline Condition – Repeatability

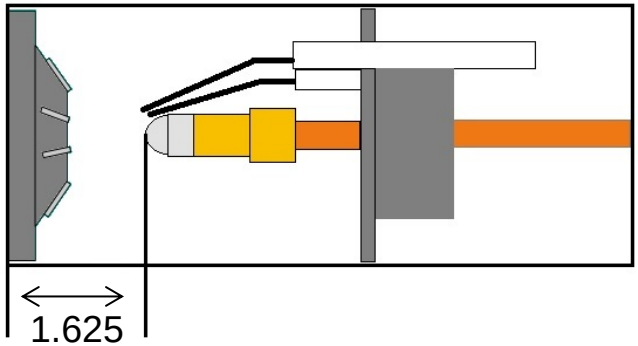
- Very good burnthrough repeatibility for Baseline test
  - In general, burnthrough is 185 ±30 sec
  - Some change in burnthrough times observed after burner reassembly
  - 2014 baseline burnthrough data was an outlier, cause is being investigated

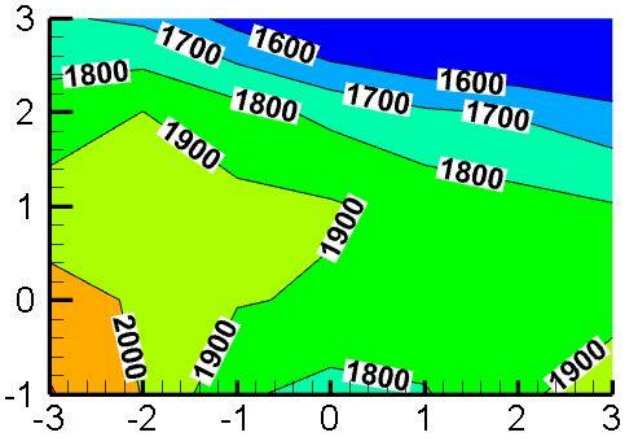


Effect of Nozzle Depth - Temperatures

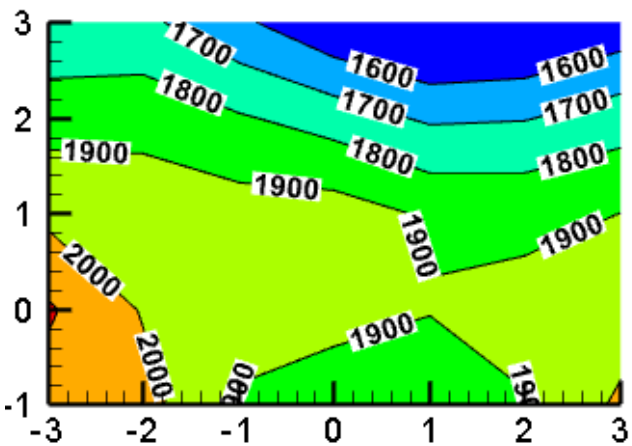




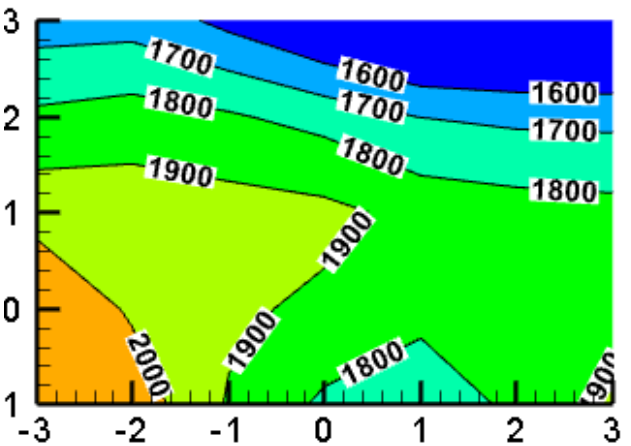




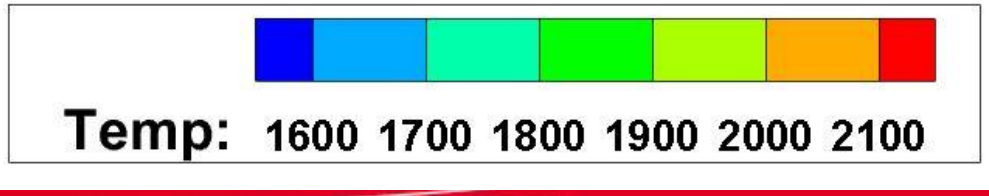
-0.5”



Baseline



+0.5”



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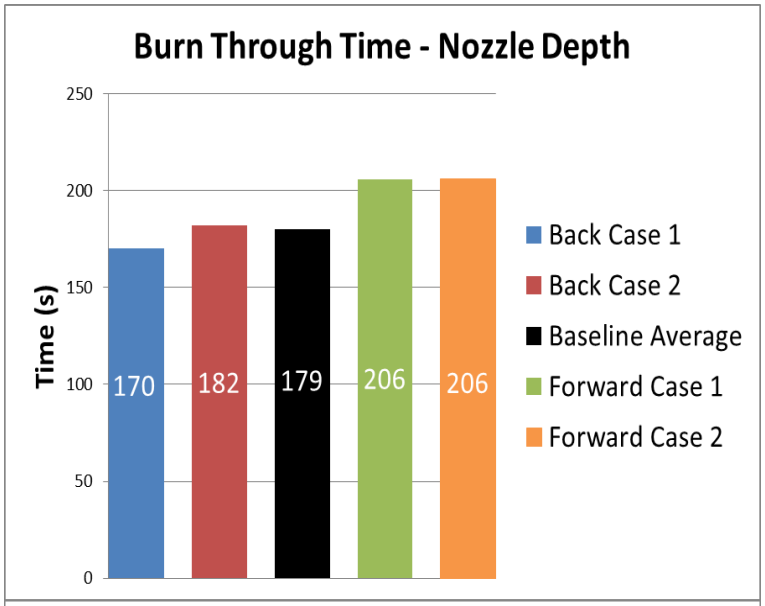
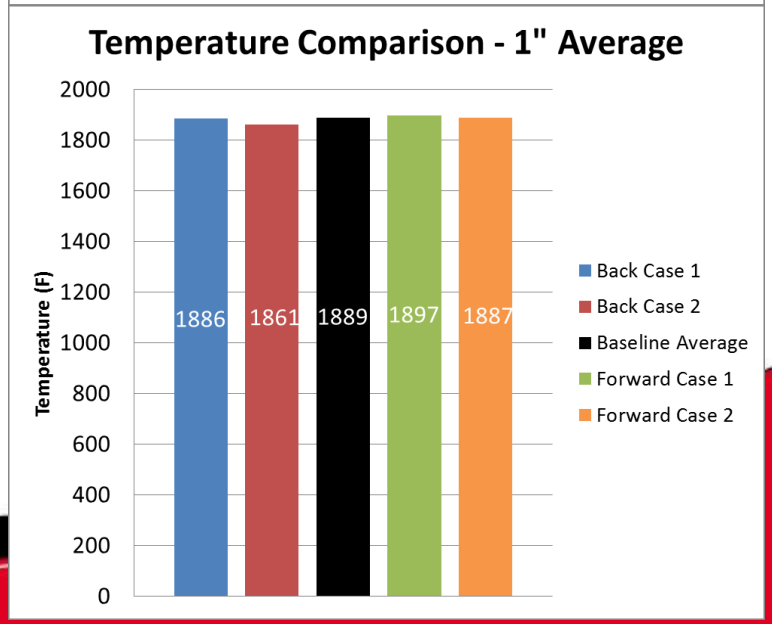
Effect of Nozzle Depth - Burnthrough

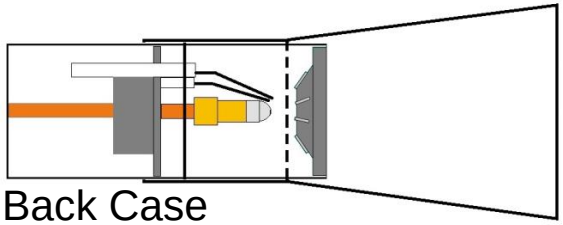
- Slight increase of burn through times with increasing depth. Within normal burn through mean and tolerance (185 ± 30 sec)
- **Recommendation**: Fuel nozzle depth tolerance of ±0.25”

Nozzle Depth inches	Avg T (°F) 1" height	Burnthrough (sec)
-0.5	1874	176
0	1889	180
0.5	1892	206

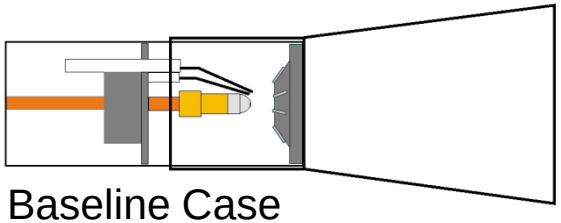




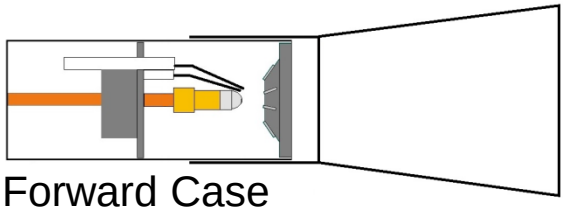
Effect of Cone Depth - Temperatures



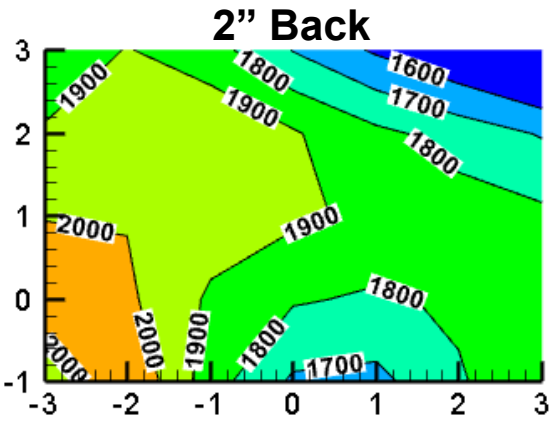
Back Case

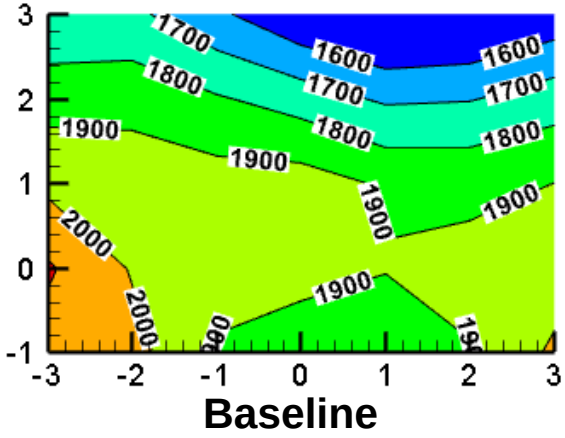


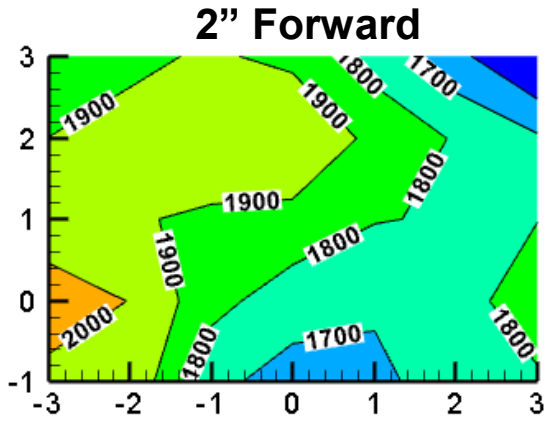
Baseline Case

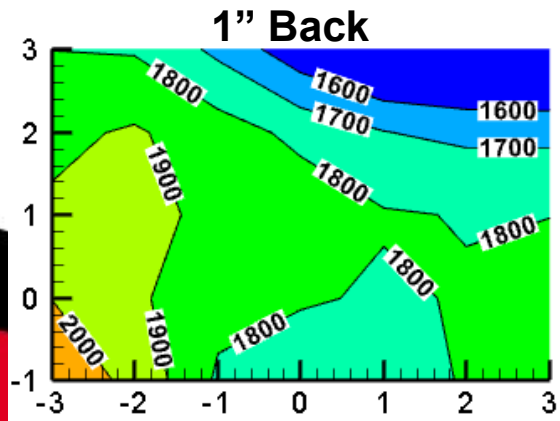


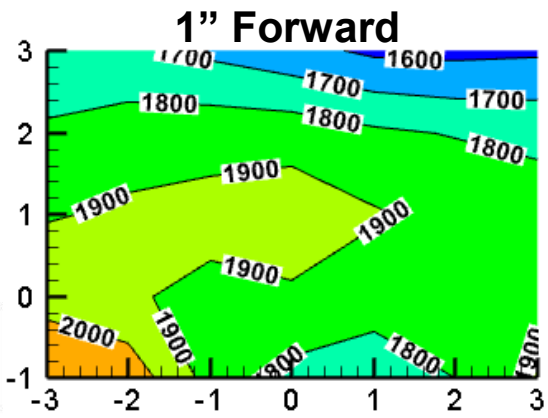
Forward Case

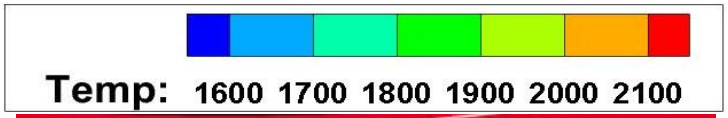








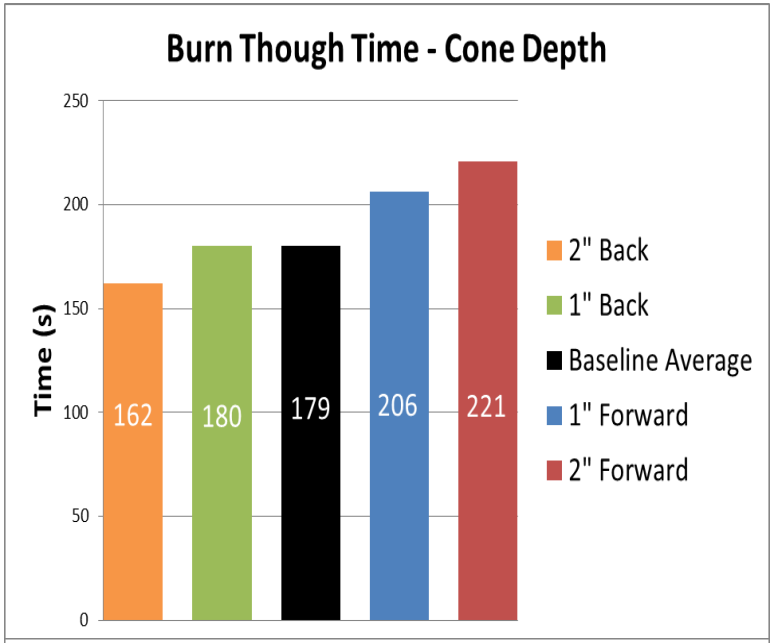


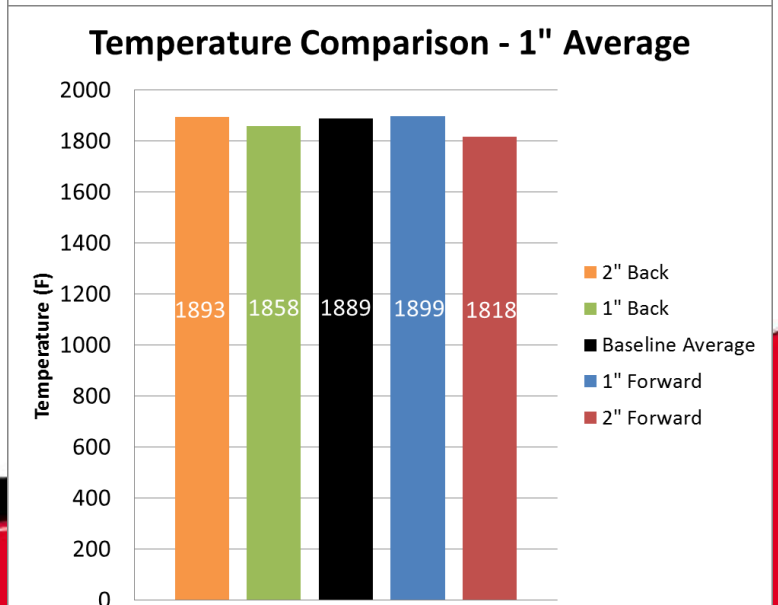


Effect of Cone Depth- Burnthrough

- Burn through time is shown to diverge as cone depth changes from baseline position
- **Recommendation**: Cone position tolerance of ±1”

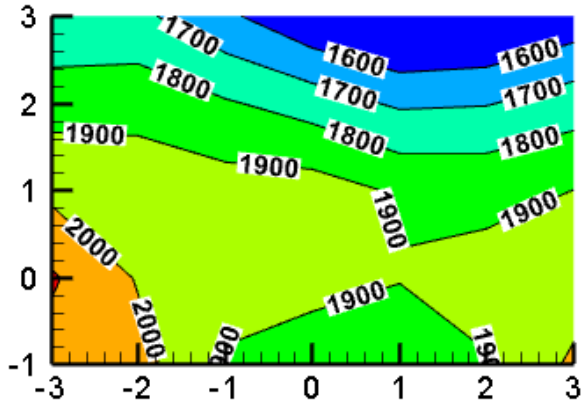
Test Condition	Avg T (°F) 1" height	Burnthrough (sec)
2" Back	1893	162
1" Back	1858	180
Baseline	1889	180
1" Forward	1899	206
2" Forward	1818	221

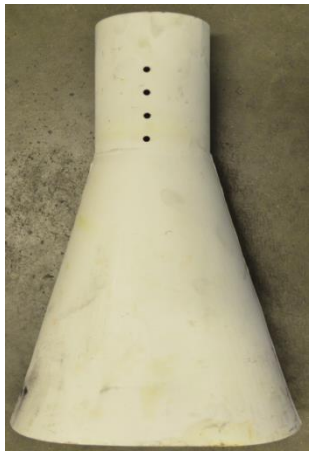




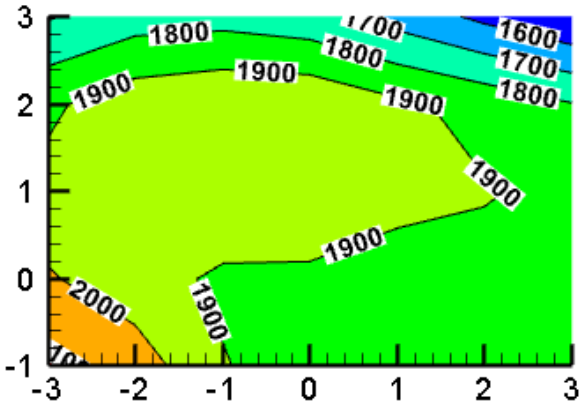
Effect of Cone Type - Temperatures

Baseline (Stainless)

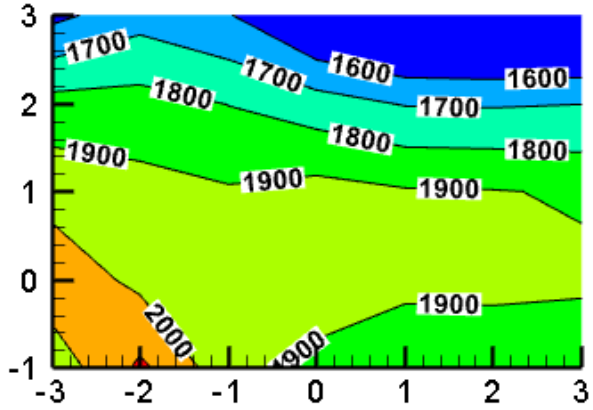




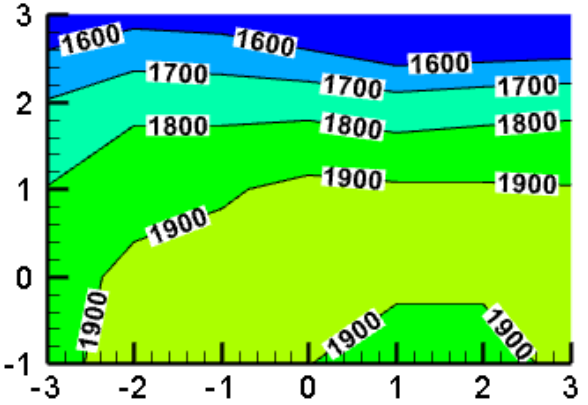
Ceramic Coated Stainless



Inconel



FAA Cone



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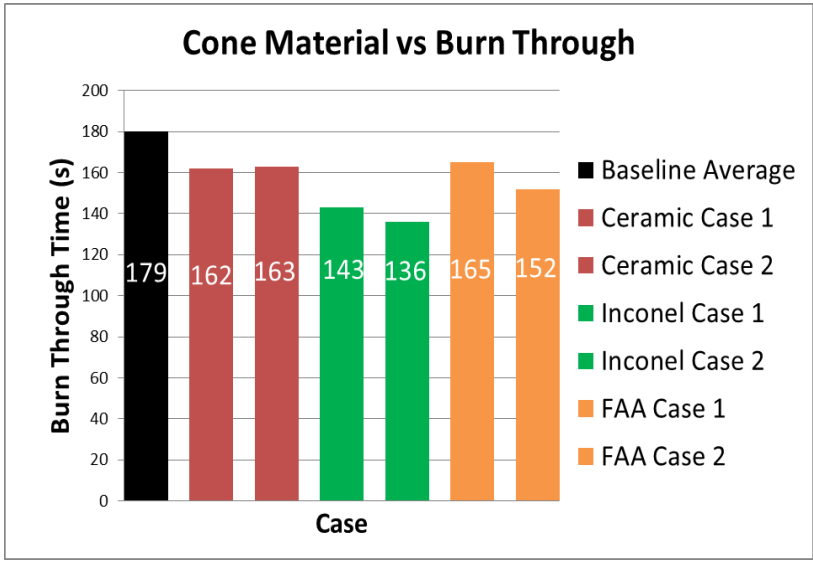
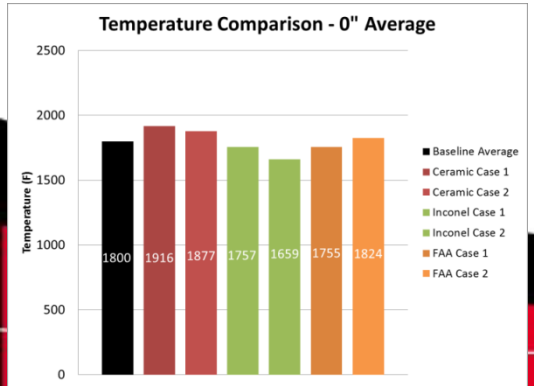
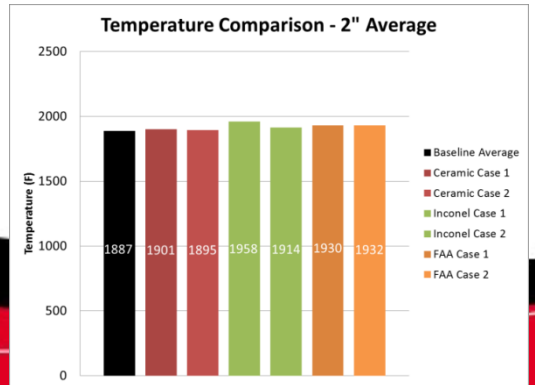
Effect of Cone Type - Burnthrough

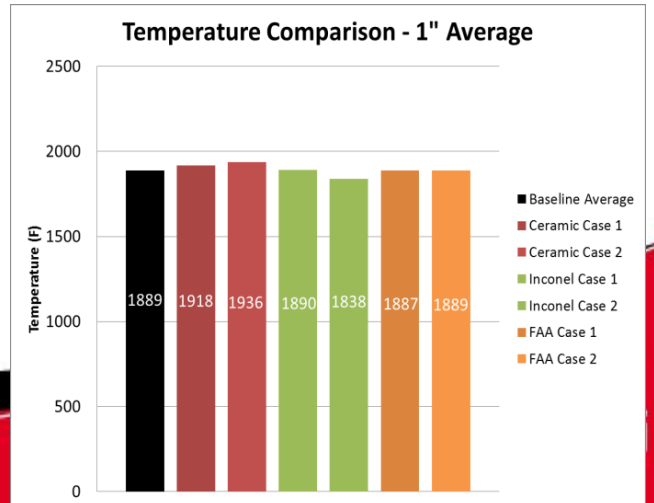
- Cone material and construction is demonstrated to have moderate impact on burn through times.
  - All cones except inconel have burnthrough times within tolerance
  - Cause for variation for inconel cone is under investigation
- **Recommendation:** Cone material and construction should be well defined.



Test Condition	Temperature Average (°F)			Burnthrough (sec)
	0"	1"	2"	
Baseline	1800	1889	1887	180
Ceramic	1896	1927	1898	162
Inconel	1708	1864	1936	140
FAA Cone	1790	1888	1931	159

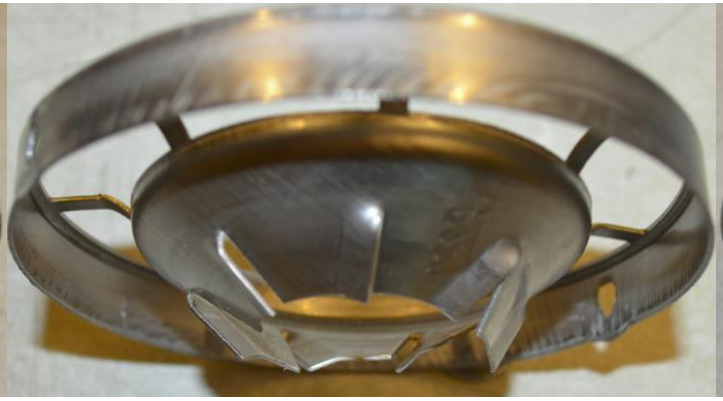




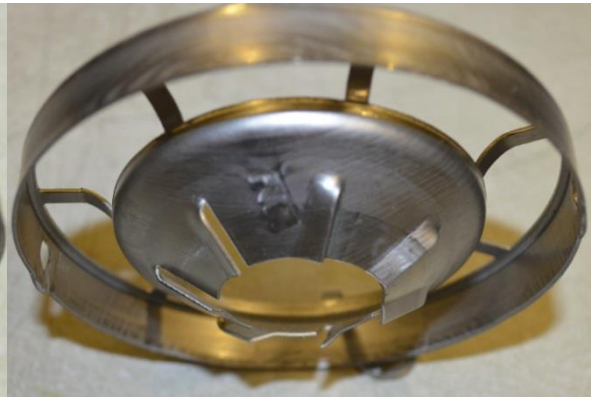


Effect of FRH Deformation - Temperatures

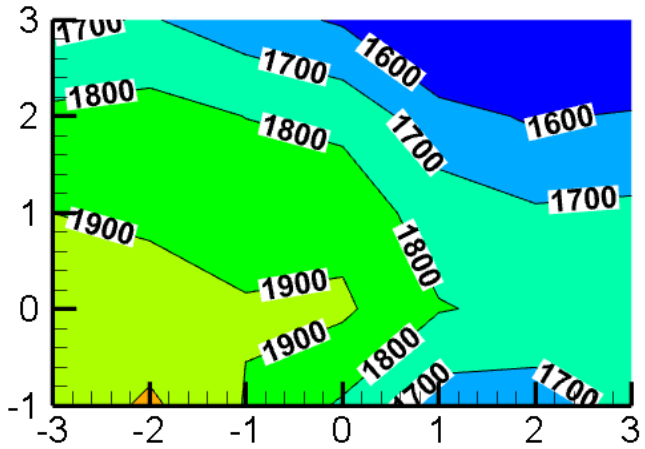
Severe Deformation

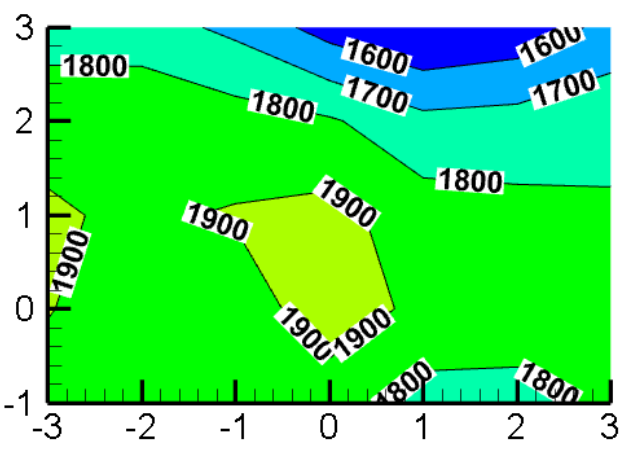


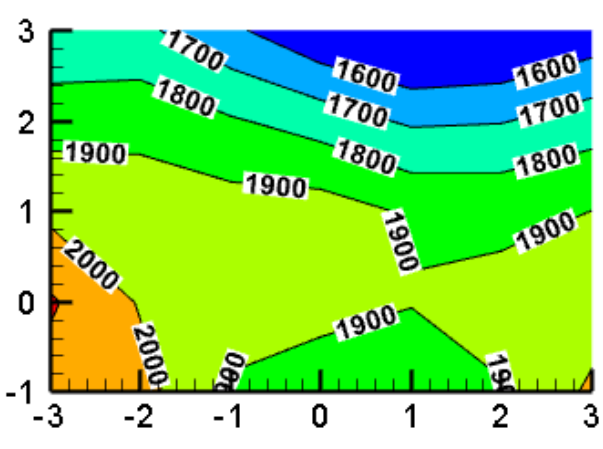
Slight Deformation

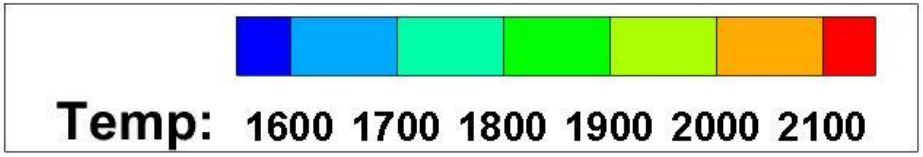


Baseline









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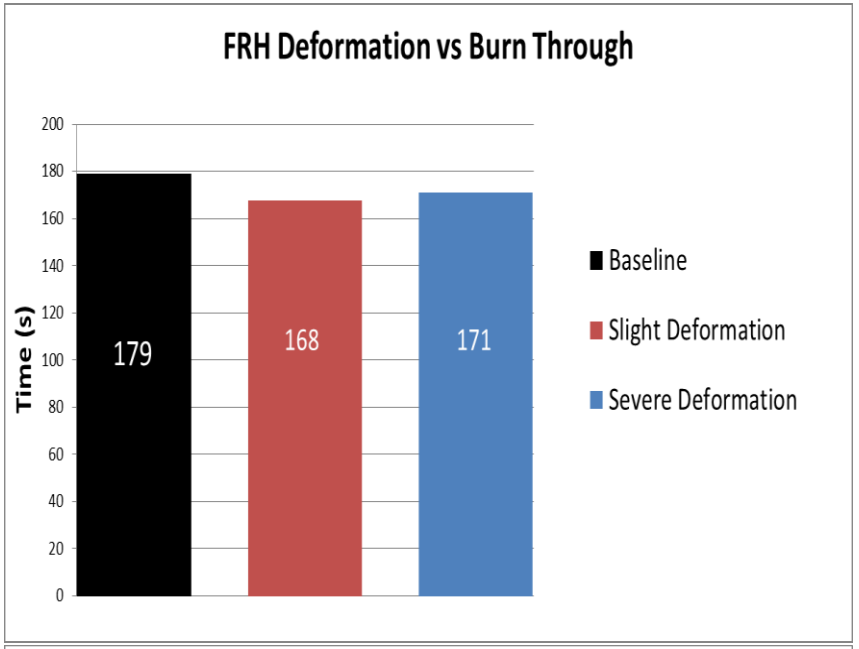
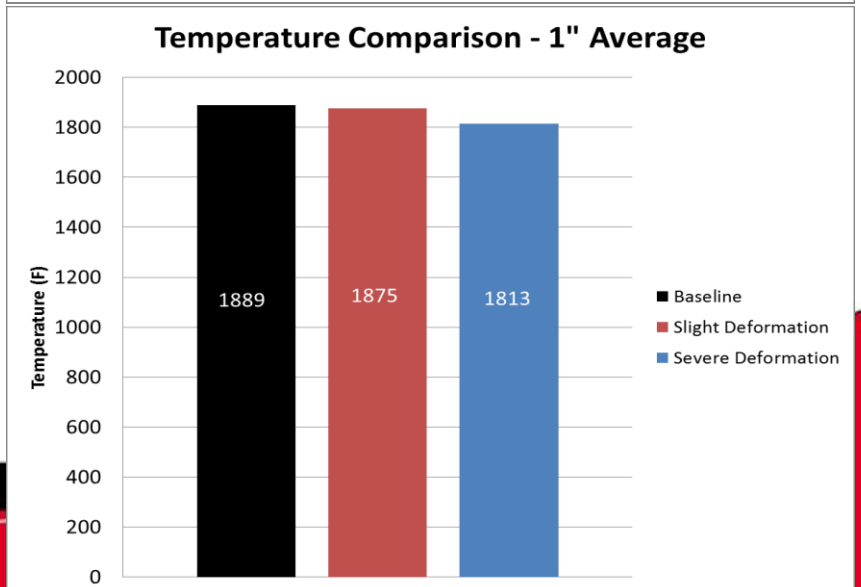
Effect of FRH Deformation - Burnthrough

- Deformation of hardware, expected with normal wear and tear, does not impact burnthrough times

Test Condition	Avg T (°F) 1" height	Burnthrough (sec)
Baseline	1889	180
Slight Deformation	1875	168
Severe Deformation	1813	171





Conclusions and Recommendations

- Conclusions
  - Delavan nozzles are shown to be more consistent and have better spray characteristics than other manufacturers.
  - Nozzle insertion depth may not have an effect on temperature calibration but noticeable changes in burn through times result.
  - Cone depth shown to have negligible effect on temperature calibration, though with distinct differences in burn through times.
  - Cone material and construction demonstrated to have moderate effect on burn through times.
  - Severely deformed flame retention heads have an impact on temperature calibration, though no evidence of impact on burn through results.
- Recommendations
  - Fuel nozzle insertion depth tolerance of ±0.25”
  - Cone position tolerance of ±1”
  - Standardization of cone material and construction