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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Project Overview

- Project Objective:
  - Develop the operating settings of NexGen burner for Powerplant fire tests
- 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
- Current Approach
  - Sensitivity of Burner to changes in operating conditions
    - Temperature distribution
    - Burnthrough tests (2024 Al, 24” x 24” x 1/8”)

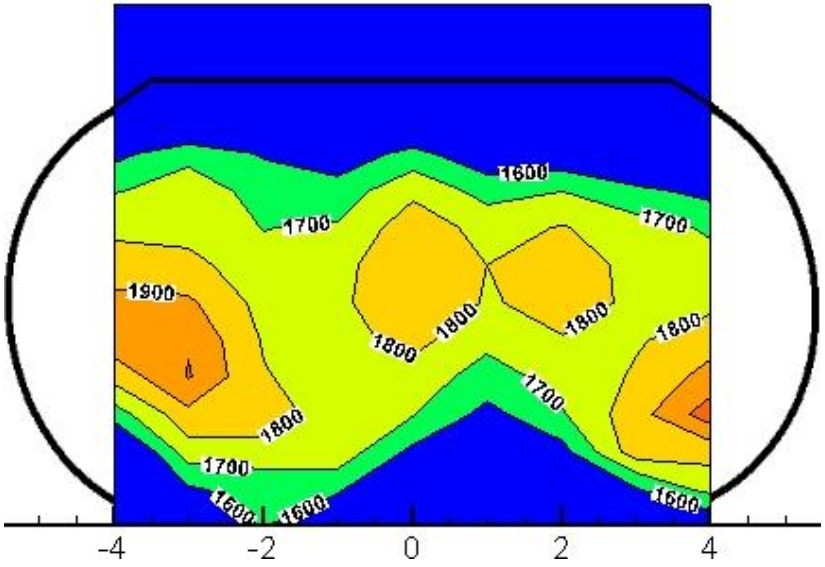
Current Approach

- Baseline Test
  - 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 Flow Rate
  - change in flow rate: ±10%
- Effect of Air Mass Flow Rate
  - change in mass flow rate: : ±10%
- Effect of Fuel Temperature
- Effect of Air Temperature
- Effect of Burner Cone Design

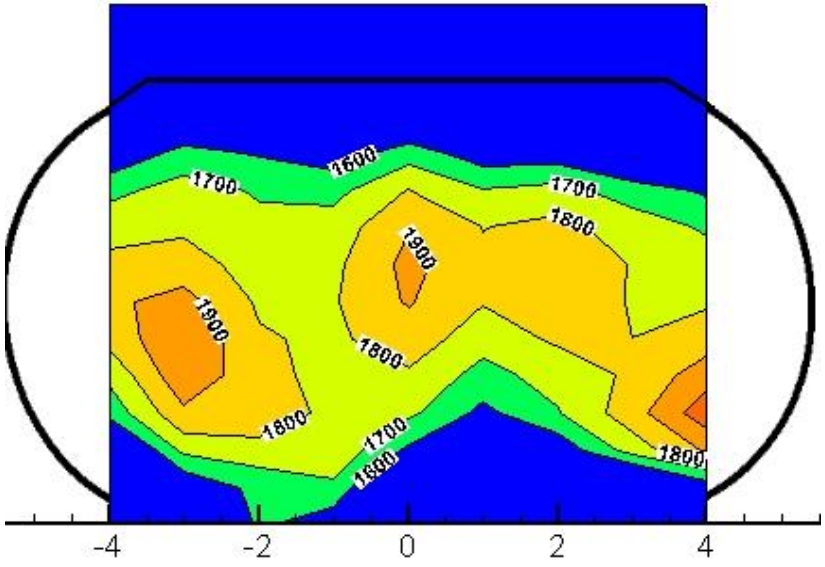
Baseline Test - Temperatures

- Air Flow Settings
  - 50 psig (265 PPH), 50 ºF
- Fuel Flow Settings
  - 105 psi (2.46 GPH), 42 ºF

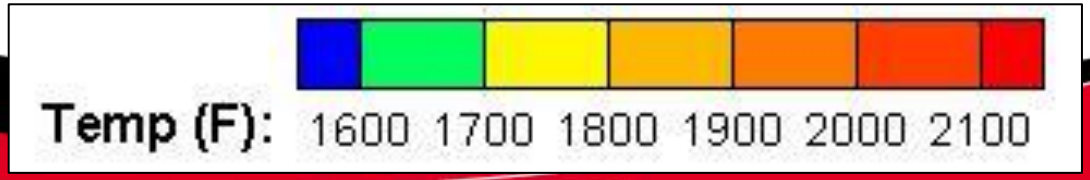
Equivalence Ratio,Φ = 0.92



Baseline



Baseline Repeat



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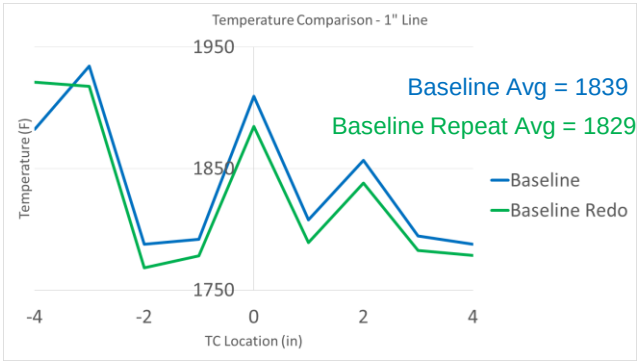
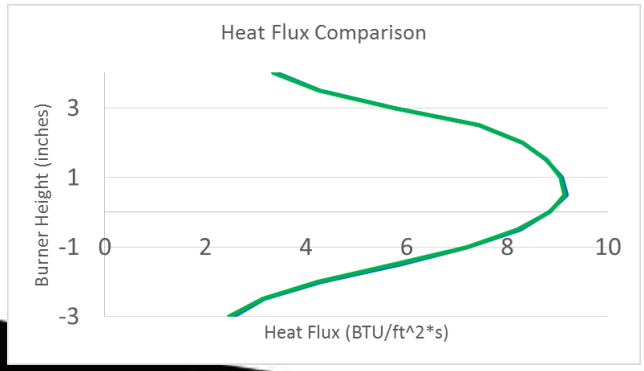
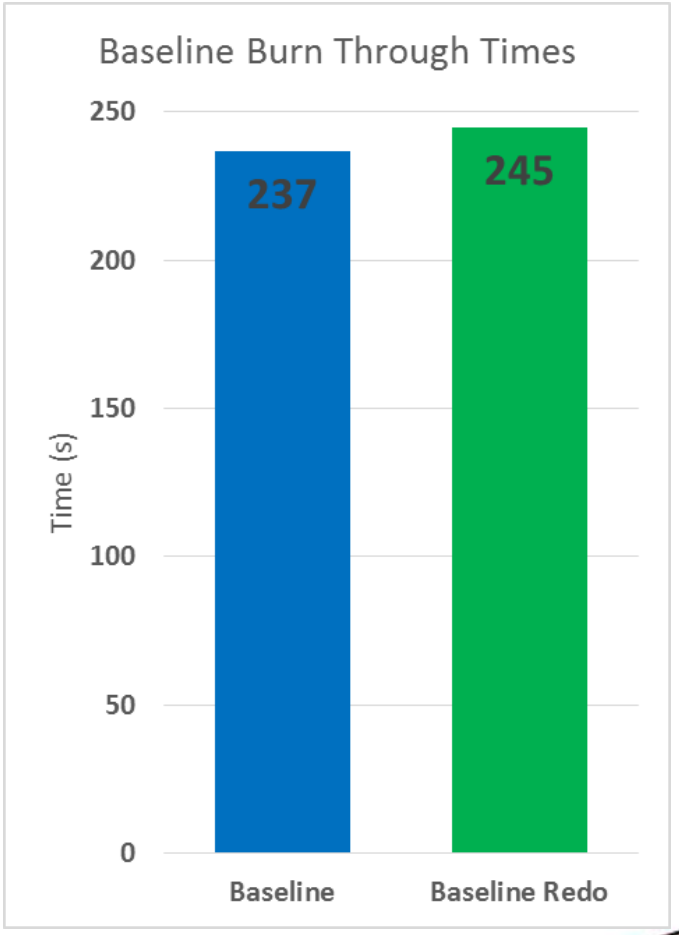
Baseline Test - Burnthrough

- Very good burnthrough repeatibility for Baseline test
  - In general, burnthrough repeatibility is ±30 sec

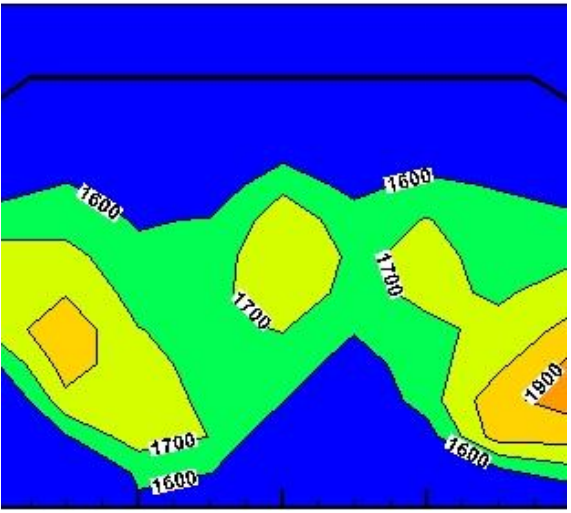




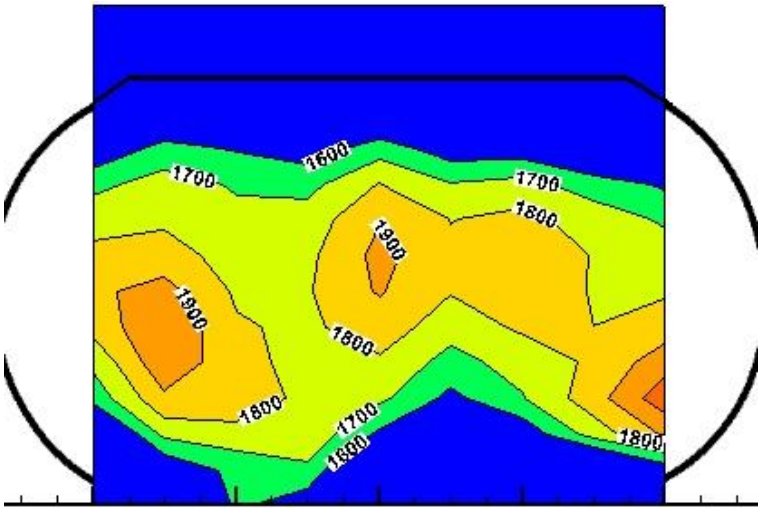


Effect of Fuel Flow Rate - Temperatures

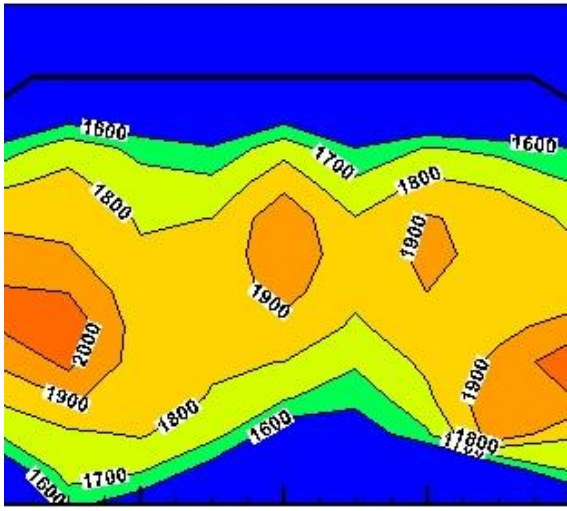
Test Condition	Air			Fuel			ϕ	Calibration (1" height)		Burnthrough (min:sec)
	P (psig)	m (PPH)	T (°F)	P (psig)	flow (GPH)	T (°F)		Avg T (°F)	HF (BT/ft^2-s)	
-10% fuel	50	265	50	**80**	2.15	42	0.8	1714	10.8	**6:05**
Baseline				**105**	2.46		0.92	1829	9.05	**4:05**
+10% fuel				**125**	2.66		0.99	1894	10.95	**2:37**



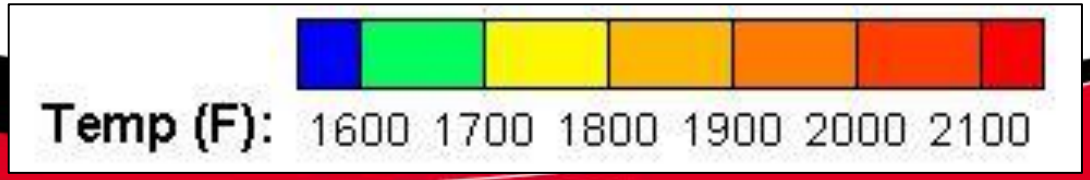
80 psig (2.15 GPH)



105 psig (2.46 GPH)



123 psig (2.66 GPH)



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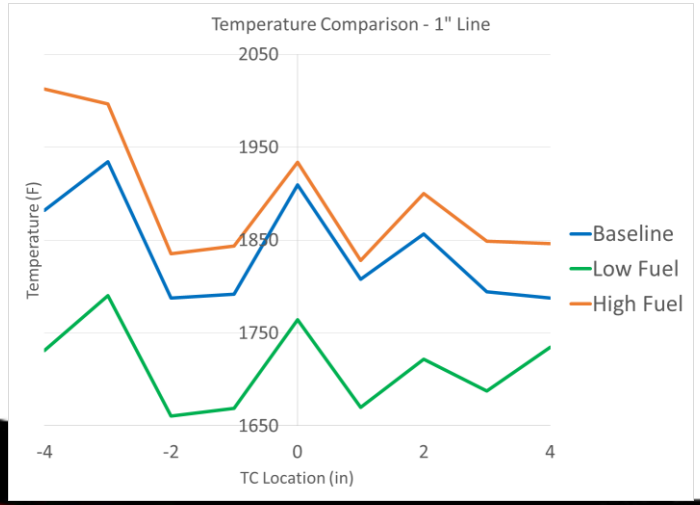
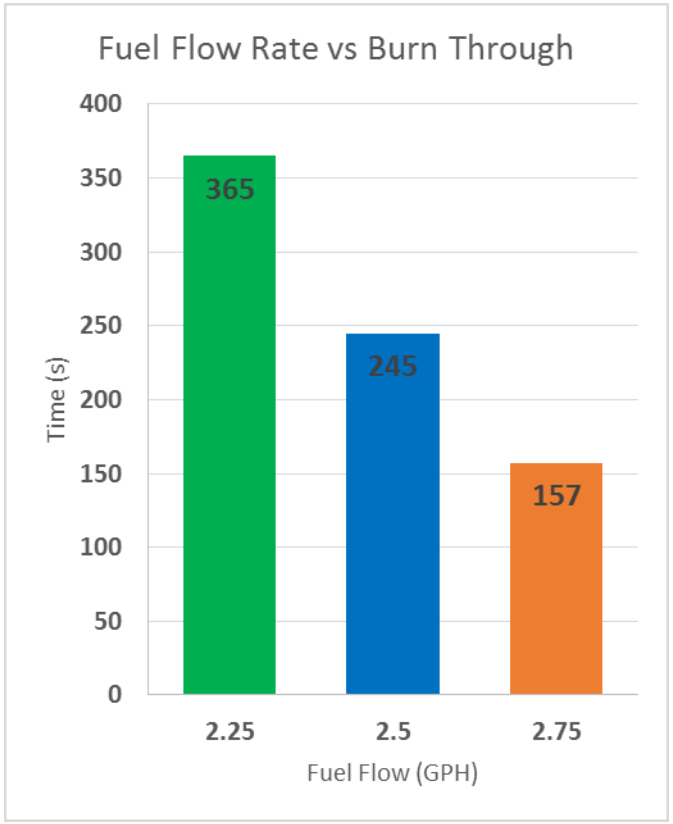
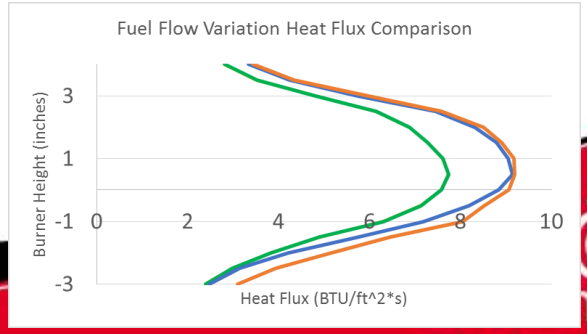
Effect of Fuel Flow Rate - Burnthrough

- Burnthrough times decrease significantly as fuel flow rate increases
- **Recommendation**: Tighter tolerance on fuel pressure (flow rate)
  - ±5% of baseline flow rate

Fuel pressure psig	Calibration (1" height)		Burnthrough (min:sec)
	Avg T (°F)	HF (BT/ft^2-s)	
80	1714	10.8	**6:05**
105	1829	9.05	**4:05**
123	1894	10.95	**2:37**

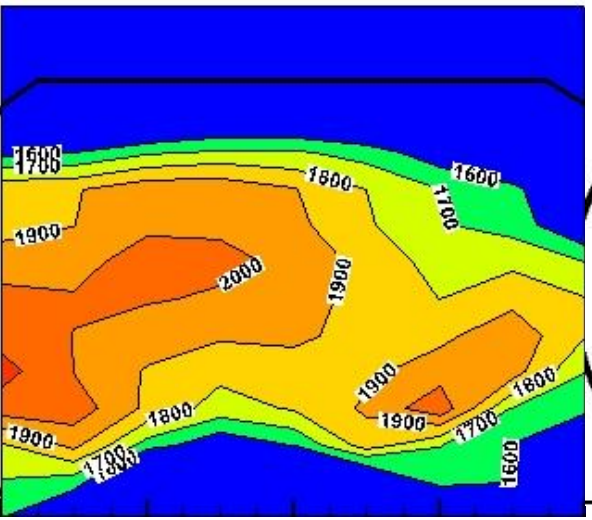




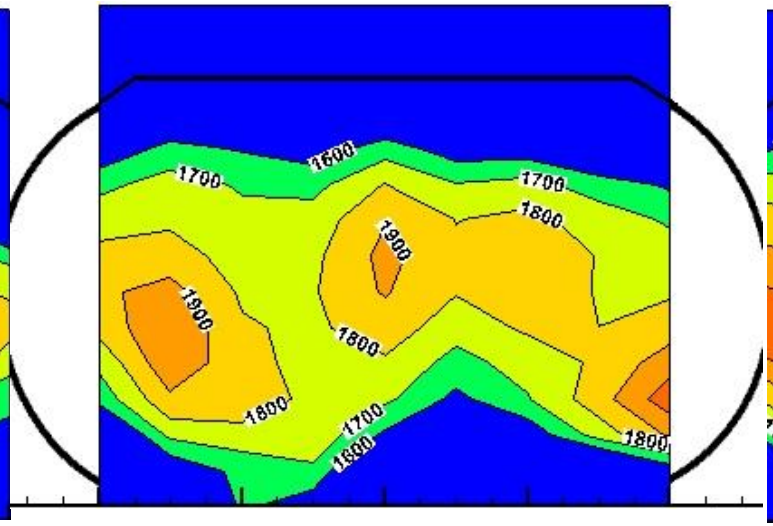


Effect of Air Mass Flow Rate - Temperatures

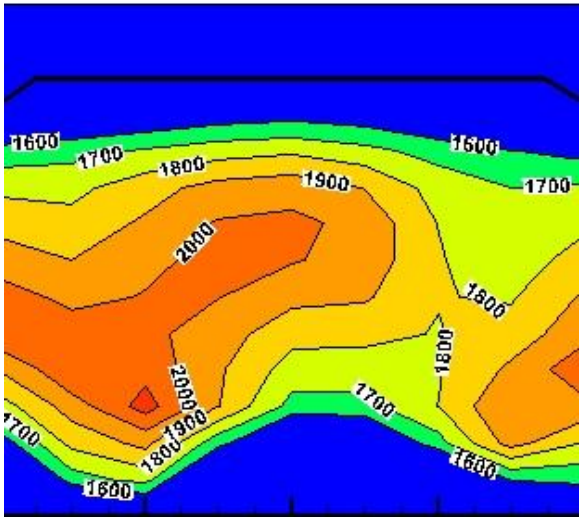
Test Condition	Air			Fuel			ϕ	Calibration (1" height)		Burnthrough (min:sec)
	P (psig)	m (PPH)	T (°F)	P (psig)	flow (GPH)	T (°F)		Avg T (°F)	HF (BT/ft^2-s)	
-10% air	43	**239**	50	105	2.46	42	1.02	1924	9.69	**2:08**
Baseline	50	**265**					0.92	1829	9.05	**4:05**
+10% air	57	**293**					0.83	1932	9.49	**4:30**



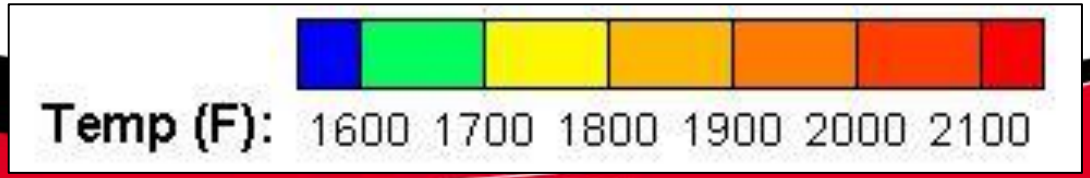
43 psig (239 PPH)



50 psig (265 PPH)



57 psig (293 PPH)



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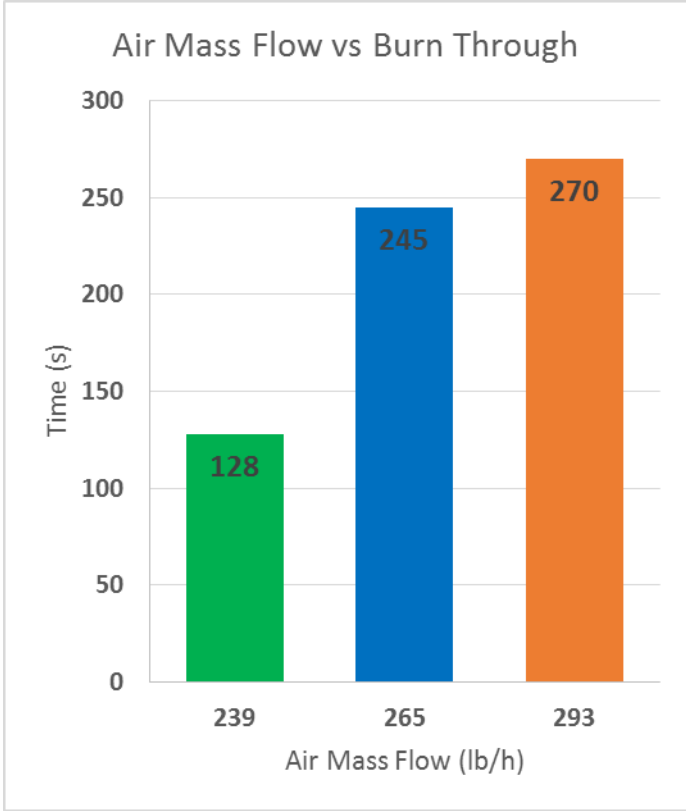
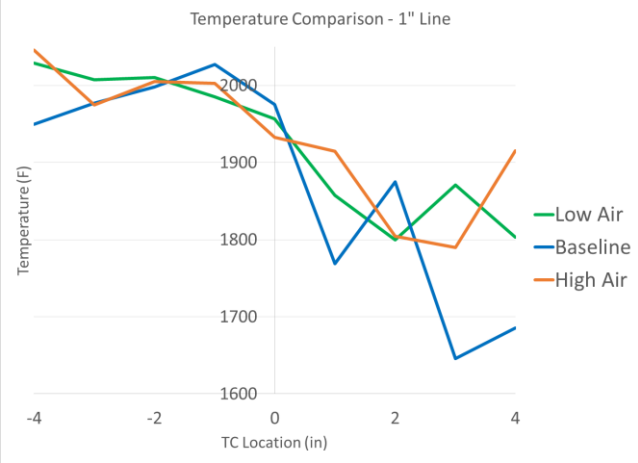
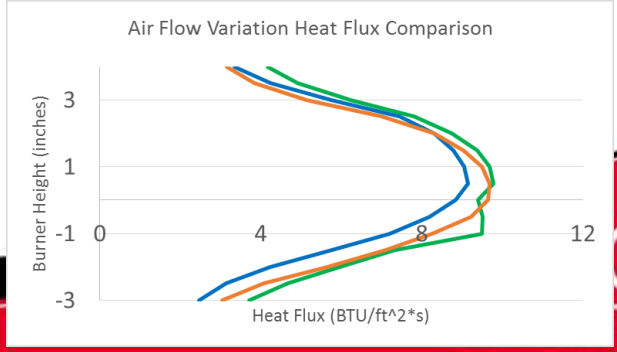
Effect of Air Mass Flow Rate - Burnthrough

- Burnthrough times decrease significantly as air mass flow rate decreases
  - No significant impact on calibration data
- **Recommendation**: Specify tolerance on air mass flow rate
  - ±5% of baseline flow rate

Air flow PPH	Calibration (1" height)		Burnthrough (min:sec)
	Avg T (°F)	HF (BT/ft^2-s)	
239	1924	9.69	**2:08**
265	1829	9.05	**4:05**
293	1932	9.49	**4:30**



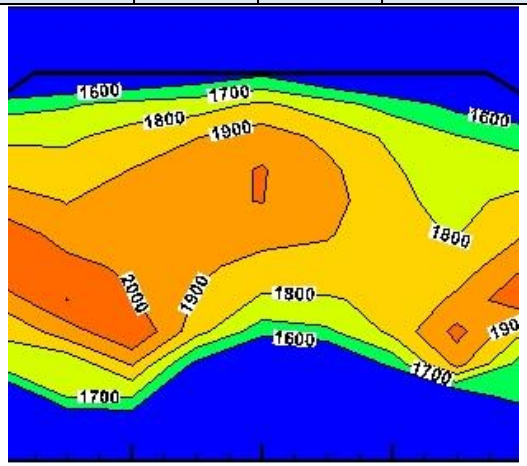




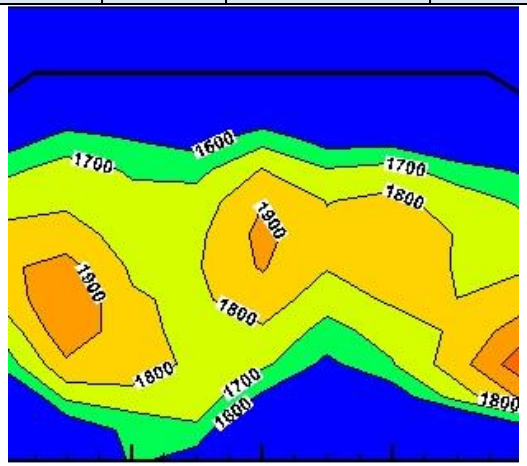
Effect of Fuel Temperature - Temperatures

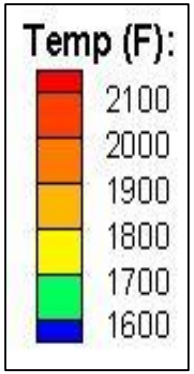
Test Condition	Air			Fuel			ϕ	Calibration (1" height)		Burnthrough
	P (psig)	m (PPH)	T (°F)	P (psig)	flow (GPH)	T (°F)		Avg T (°F)	HF (BT/ft^2-s)	(min:sec)
Cold Fuel	50	265	50	105	2.46	**30**	0.92	1932	9.34	**3:31**
Baseline						**42**	0.92	1829	9.05	**4:05**
Warm Fuel						**70**	0.92	1916	8.4	**3:09**
Hot Fuel						**90**	0.92	1870	9.91	**3:29**

30 F

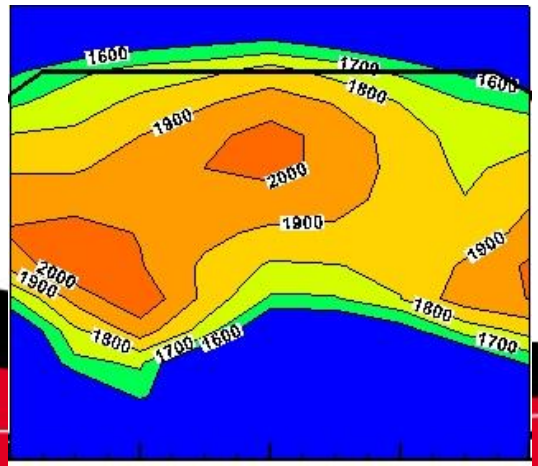


42 F - Baseline

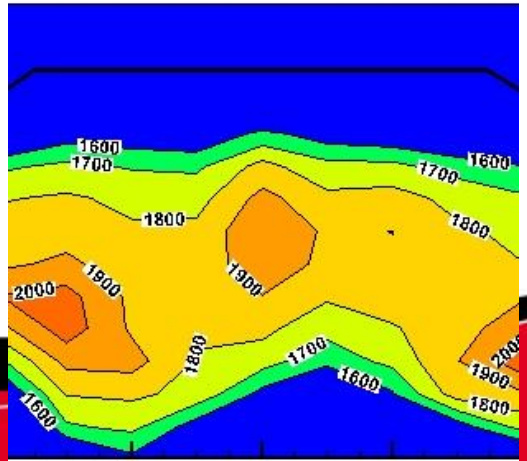




70 F



90 F



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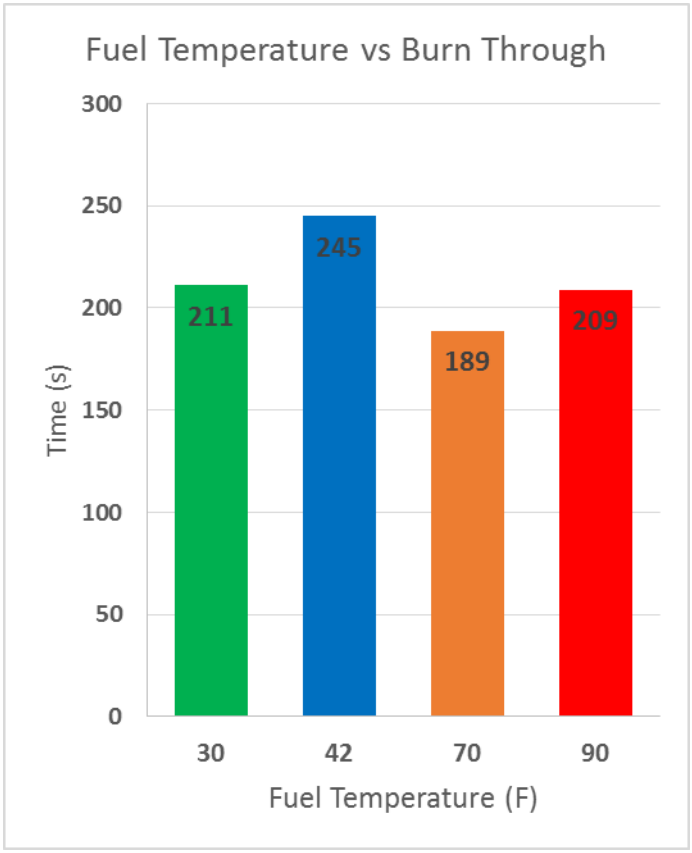
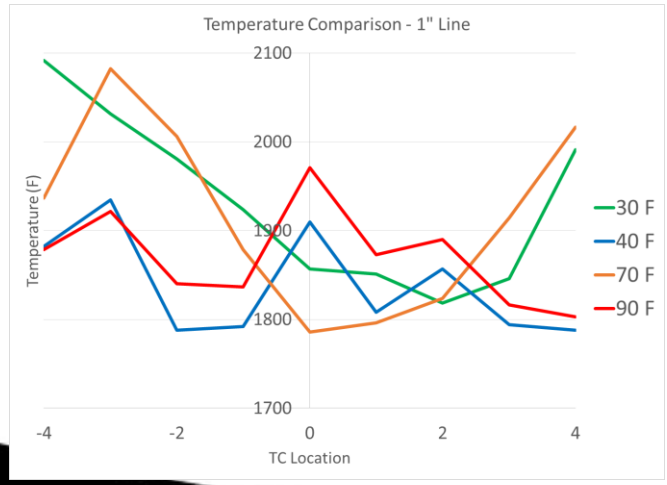
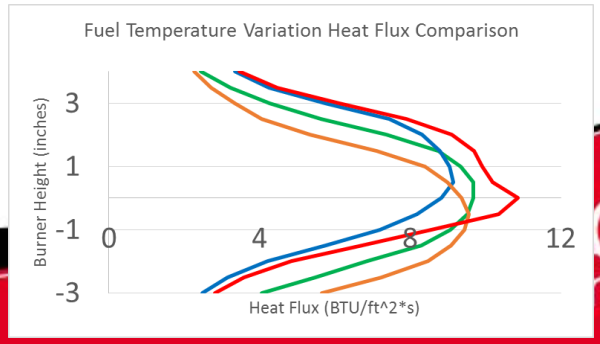
Effect of Fuel Temperature - Burnthrough

- No significant effect of fuel temperature on calibration or burnthrough

Fuel Temp °F	Calibration (1" height)		Burnthrough (min:sec)
	Avg T (°F)	HF (BT/ft^2-s)	
30	1932	9.34	**3:31**
42	1829	9.05	**4:05**
70	1916	8.4	**3:09**
90	1870	9.91	**3:29**



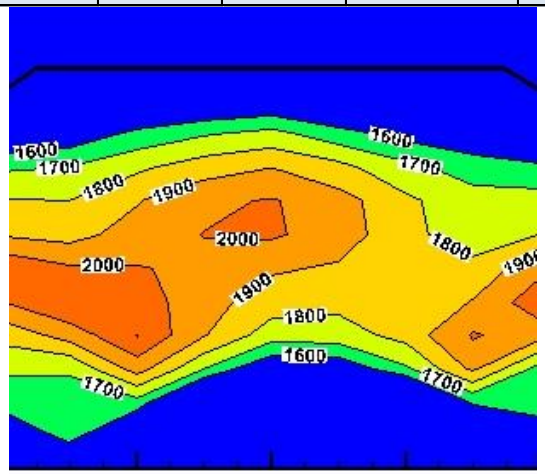




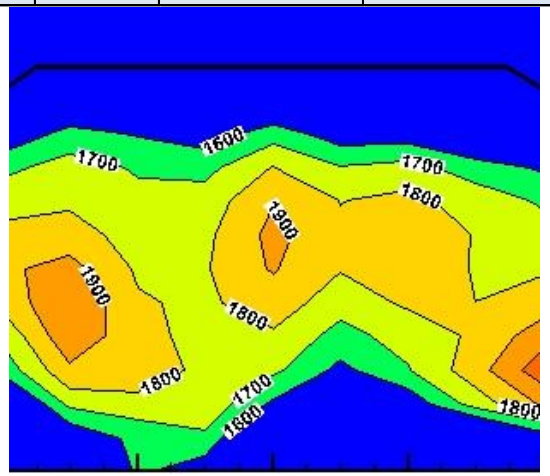
Effect of Air Temperature - Temperatures

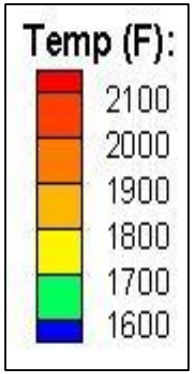
Test Condition	Air			Fuel			ϕ	Calibration (1" height)		Burnthrough
	P (psig)	m (PPH)	T (°F)	P (psig)	flow (GPH)	T (°F)		Avg T (°F)	HF (BT/ft^2-s)	(min:sec)
Cool Air	50	265	**40**	105	2.46	42	0.92	1945	10.06	**3:31**
Baseline	50		**50**					1829	9.05	**4:05**
Warm Air	52		**80**					1953	11.63	**3:05**
Hot Air	53		**100**					1878	10.25	**3:11**

40 F

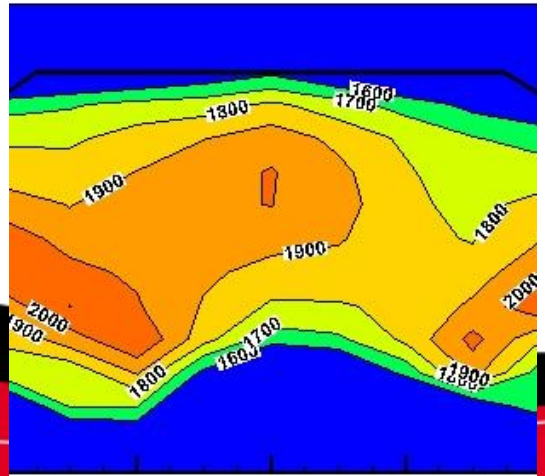


50 F Baseline

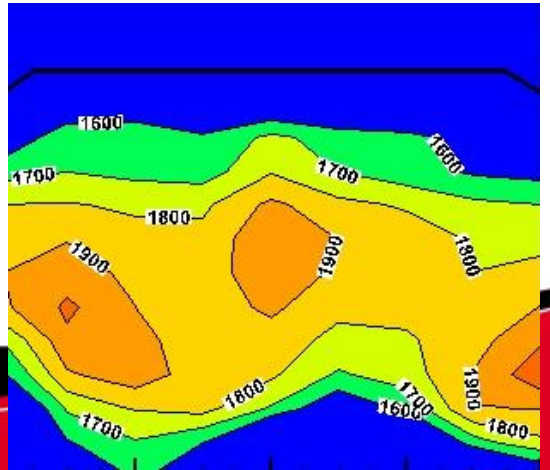




80 F



100 F



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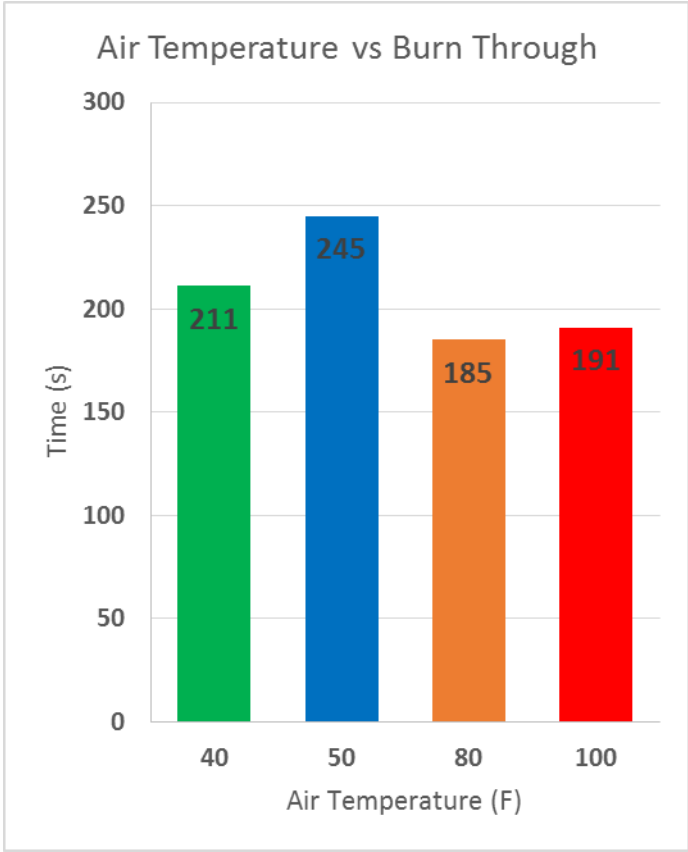
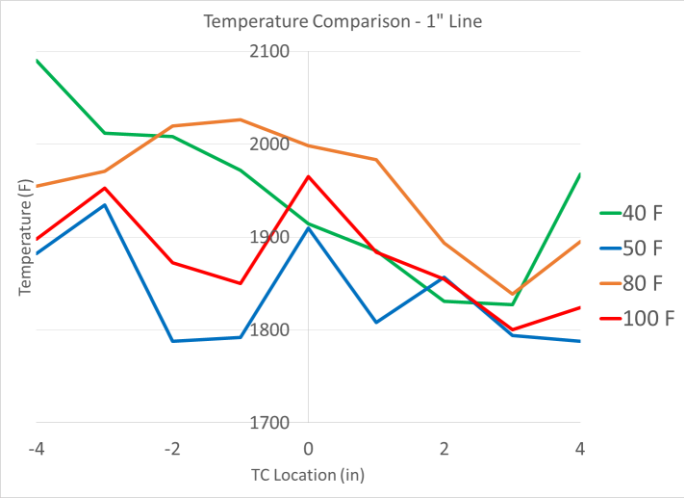
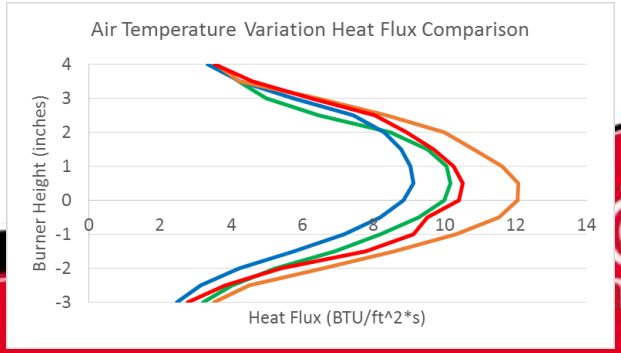
Effect of Air Temperature - Burnthrough

- No significant effect of air temperature on calibration or burnthrough

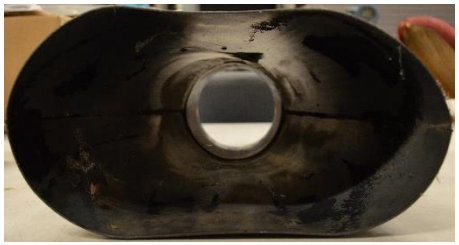
Air Temp °F	Calibration (1" height)		Burnthrough (min:sec)
	Avg T (°F)	HF (BT/ft^2-s)	
40	1945	10.06	**3:31**
50	1829	9.05	**4:05**
80	1953	11.63	**3:05**
100	1878	10.25	**3:11**

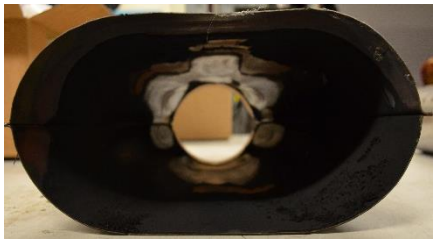


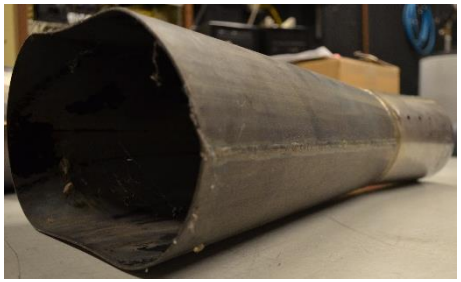




Comparison of Burner Cones







UC Cone (left):
-Inconel
-1 Piece Assembly

FAA Cone (right):
-Stainless Steel
-2 Piece Assembly

-Thickness, cone length and exit geometry identical

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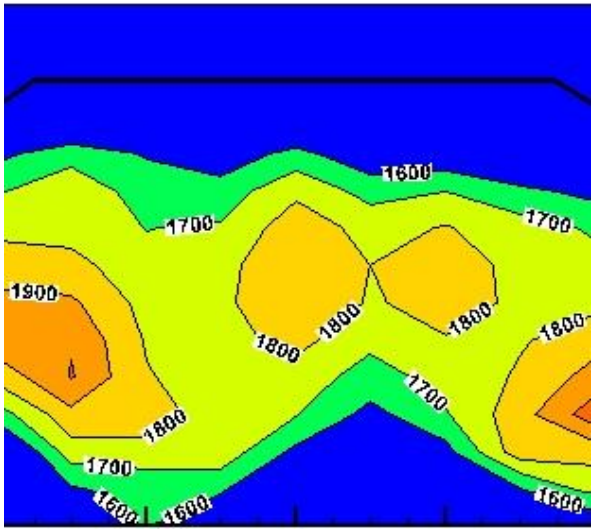
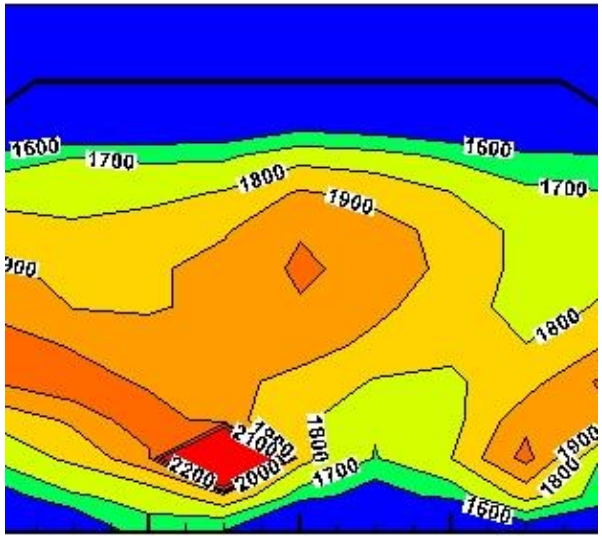
Effect of Burner Cone - Temperatures

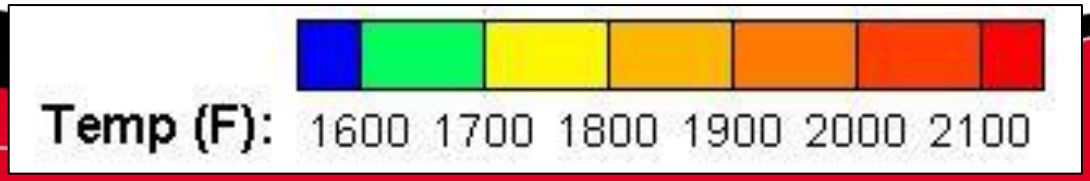
Test Condition	Air			Fuel			ϕ	Calibration (1" height)		Burnthrough (min:sec)
	P (psig)	m (PPH)	T (°F)	P (psig)	flow (GPH)	T (°F)		Avg T (°F)	HF (BT/ft^2-s)	
UC Cone	50	265	50	105	2.46	42	0.92	1829	9.05	**4:05**
FAA cone								1889	10.95	**2:57**



UC Cone



FAA Cone



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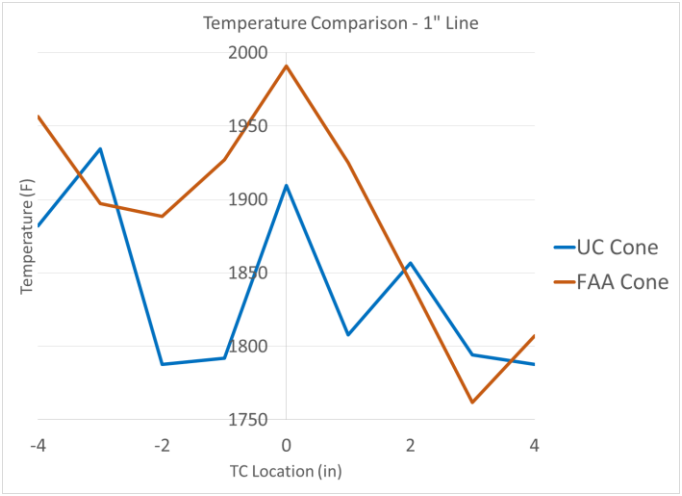
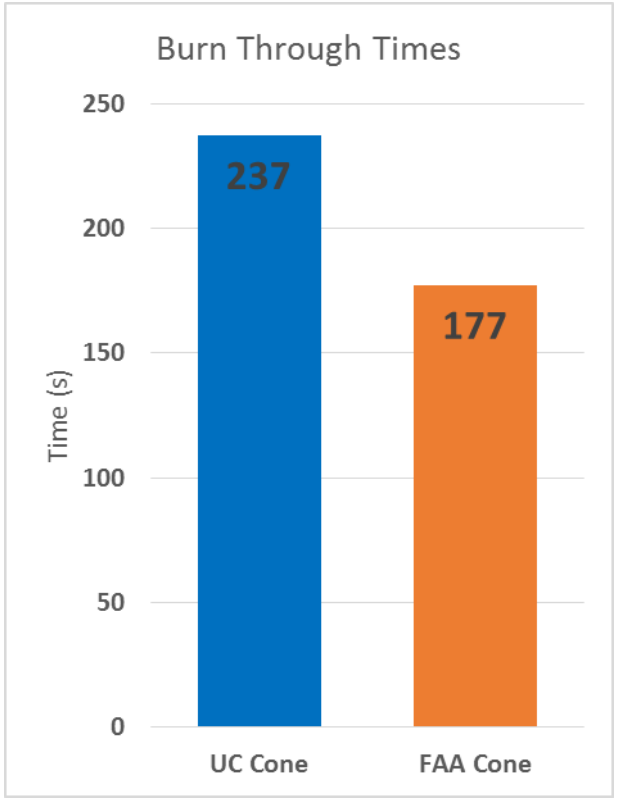
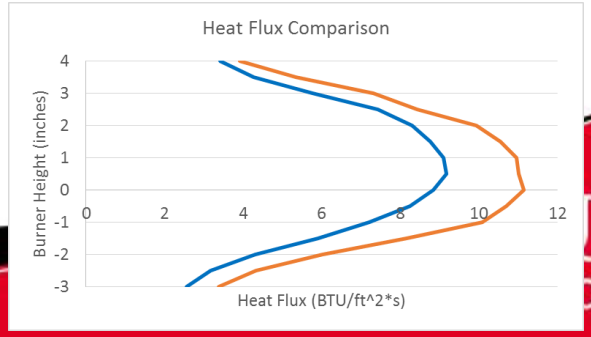
Effect of Burner Cone - Burnthrough

- Burner cone design has an impact on the calibration and burnthrough times

Test Condition	Calibration (1" height)		Burnthrough (min:sec)
	Avg T (°F)	HF (BT/ft^2-s)	
UC Cone	1829	9.05	**4:05**
FAA cone	1889	10.95	**2:57**

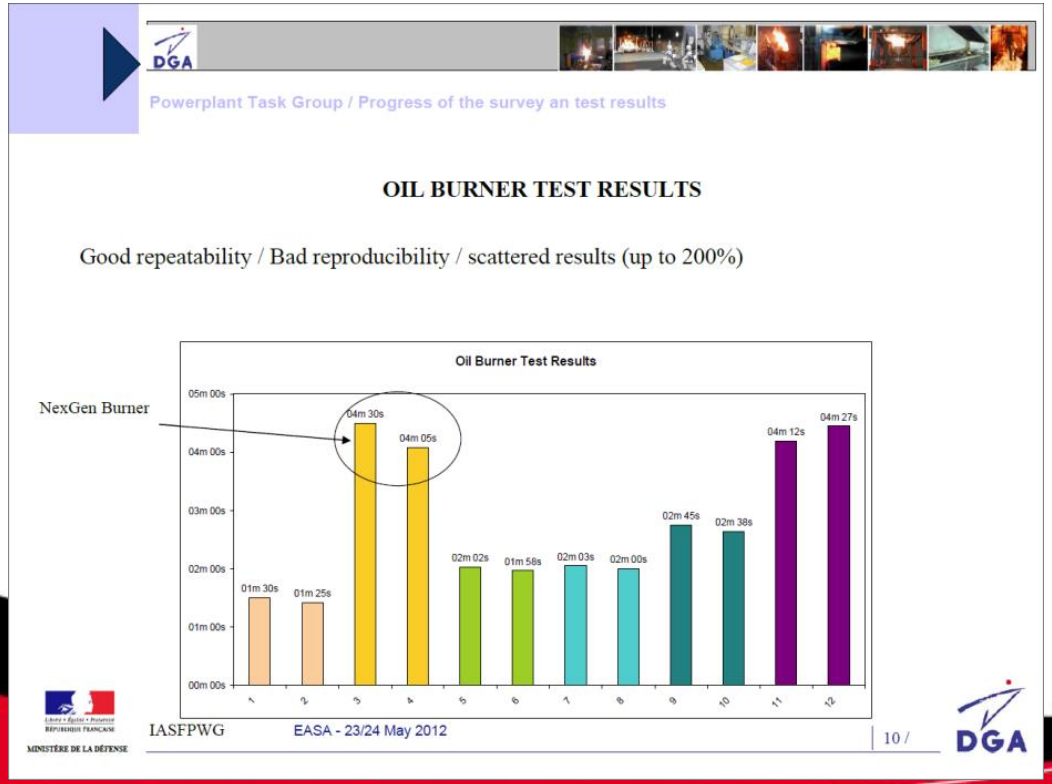




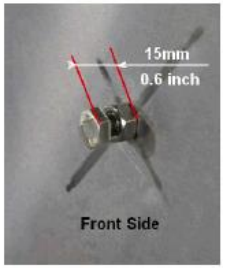


Burnthrough Time Compared to Previous Round Robin

- Maintaining recommended operating conditions of NexGen burner within 5% of fuel and air flow rate will result in 3.6 ± 1 minute burnthrough
- Current test does not have the addition of bolt-drop, resulting in slightly longer burnthrough times



Round Robin Testing:



Current Testing:

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Conclusions and Recommendations

- Conclusions
  - Fuel and Air mass flow rates have significant impact on burnthrough times
  - No significant effect of fuel and air temperatures, as long as mass flows are maintained constant
  - Burner cone design impacts the burnthrough time
  - Current burner temperature average < 2000 F, heat flux satisfies minimum requirements
  - Burnthrough time with FAA recommended operating conditions is similar to Round Robin testing on current liquid burner

- Recommendations
  - We recommend the following tolerances for burner operating conditions:
    - Fuel flow rate: ± 5% of baseline flow (± 10% of baseline pressure setting)
    - Fuel temperature: ambient conditions acceptable
    - Air mass flow rate: ± 5% of baseline flow rate
    - Air Temperature: ambient conditions acceptable as long as mass flow is constant