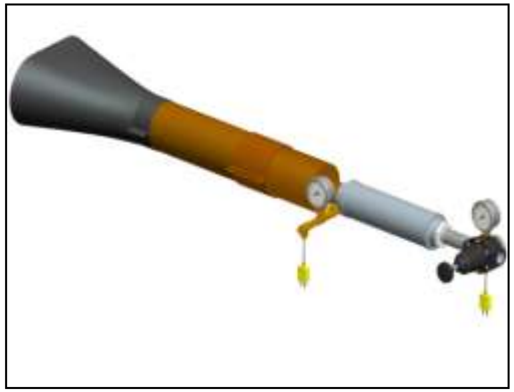
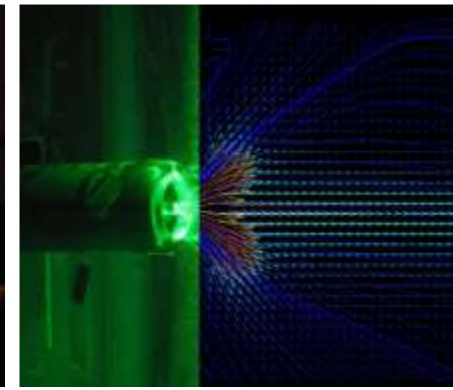
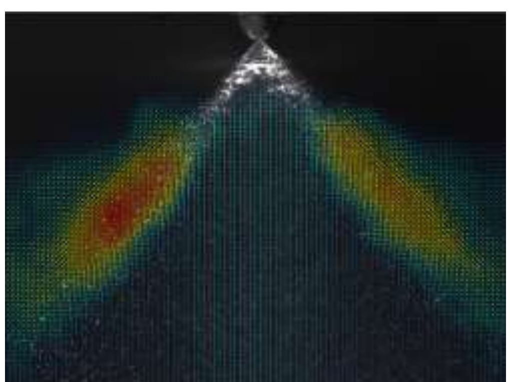
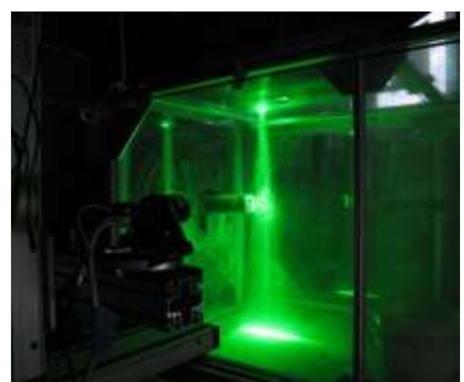
NexGen Burner Comparative Testing

Federal Aviation Administration

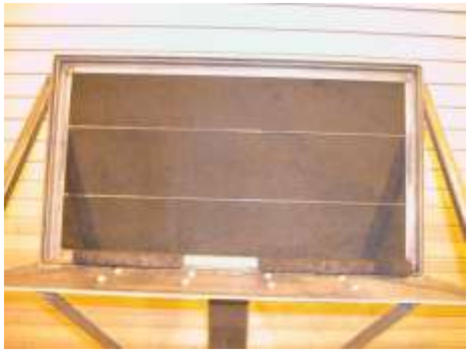


Presented to: IAMFTWG, Toulouse, France
By: Robert I. Ochs
Date: June 20-21

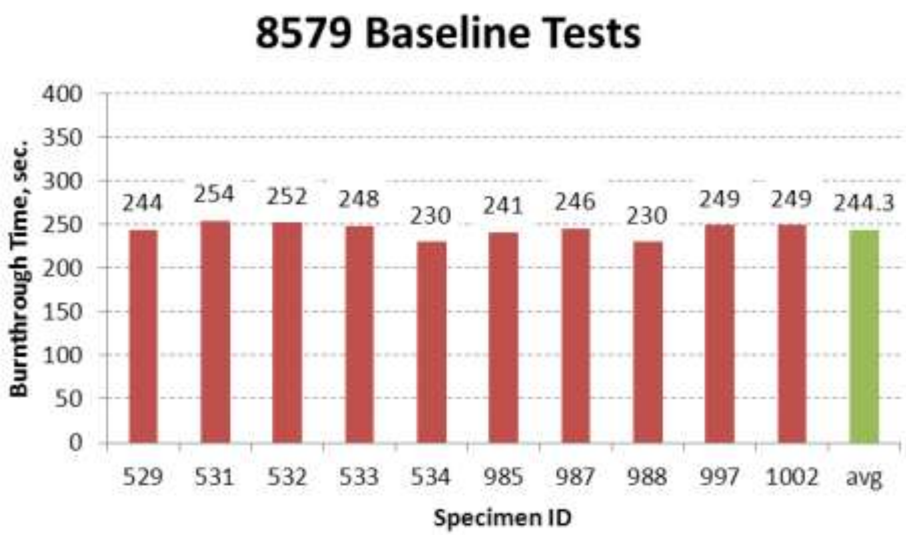





Objectives

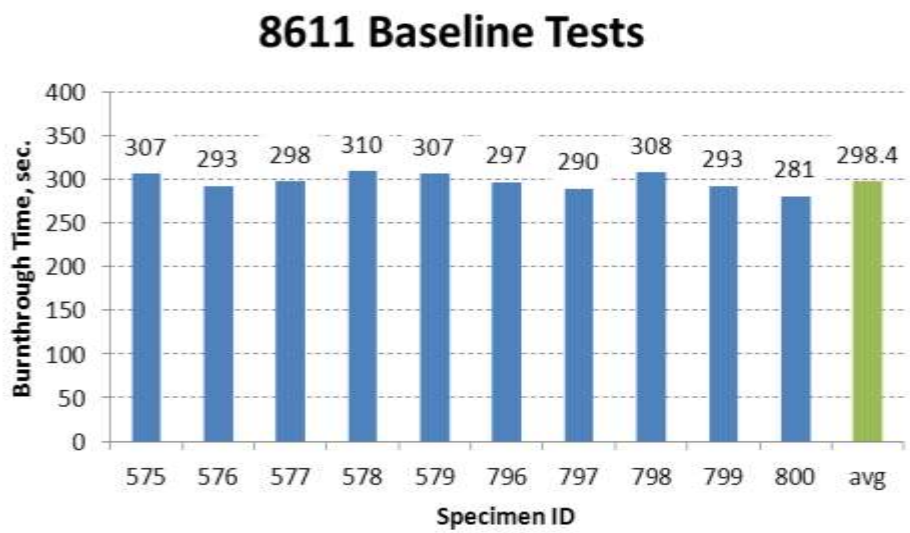
- Perform comparative burnthrough testing to determine the effect of various parameters on test results
  - Use picture frame sample holder and PAN material to determine burnthrough performance
- Test results will help to determine which parameters are most critical when specifying the burner in the new workbook




Establish Baseline Dataset

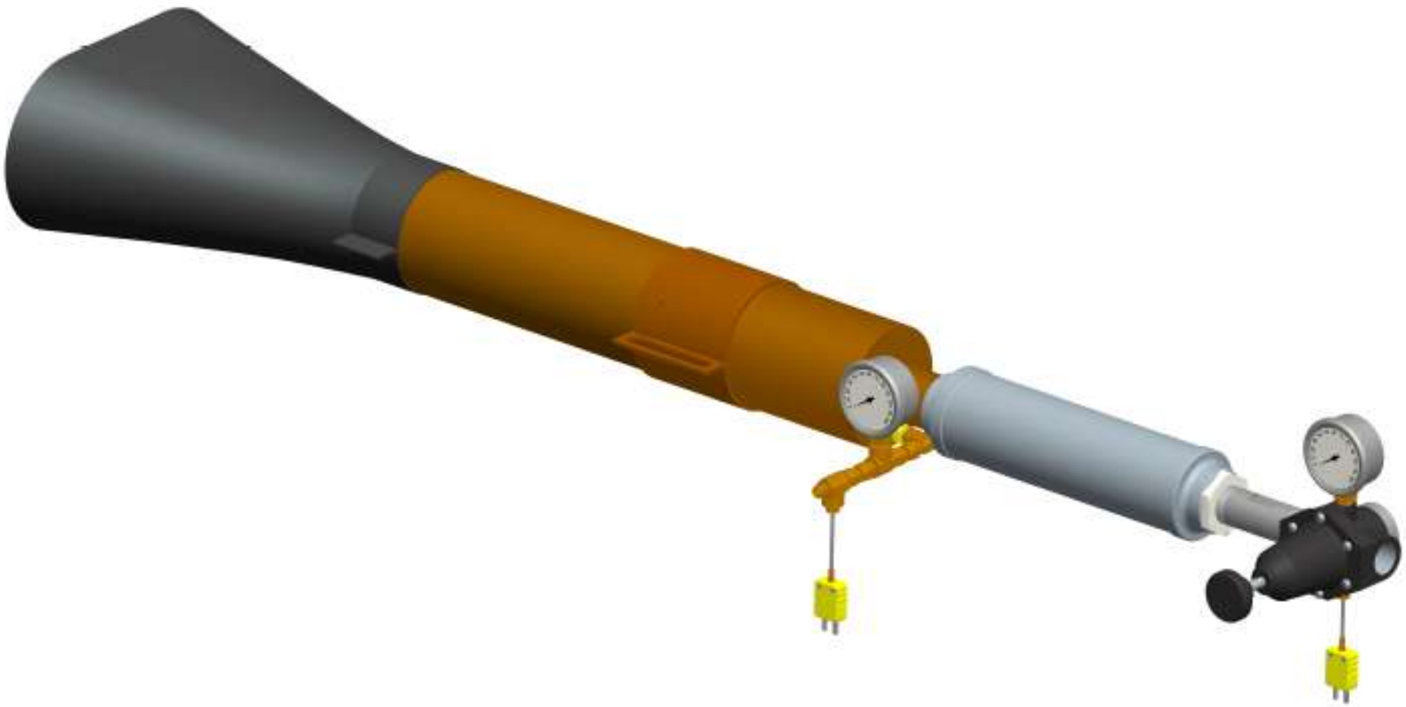


3.43% Standard Deviation

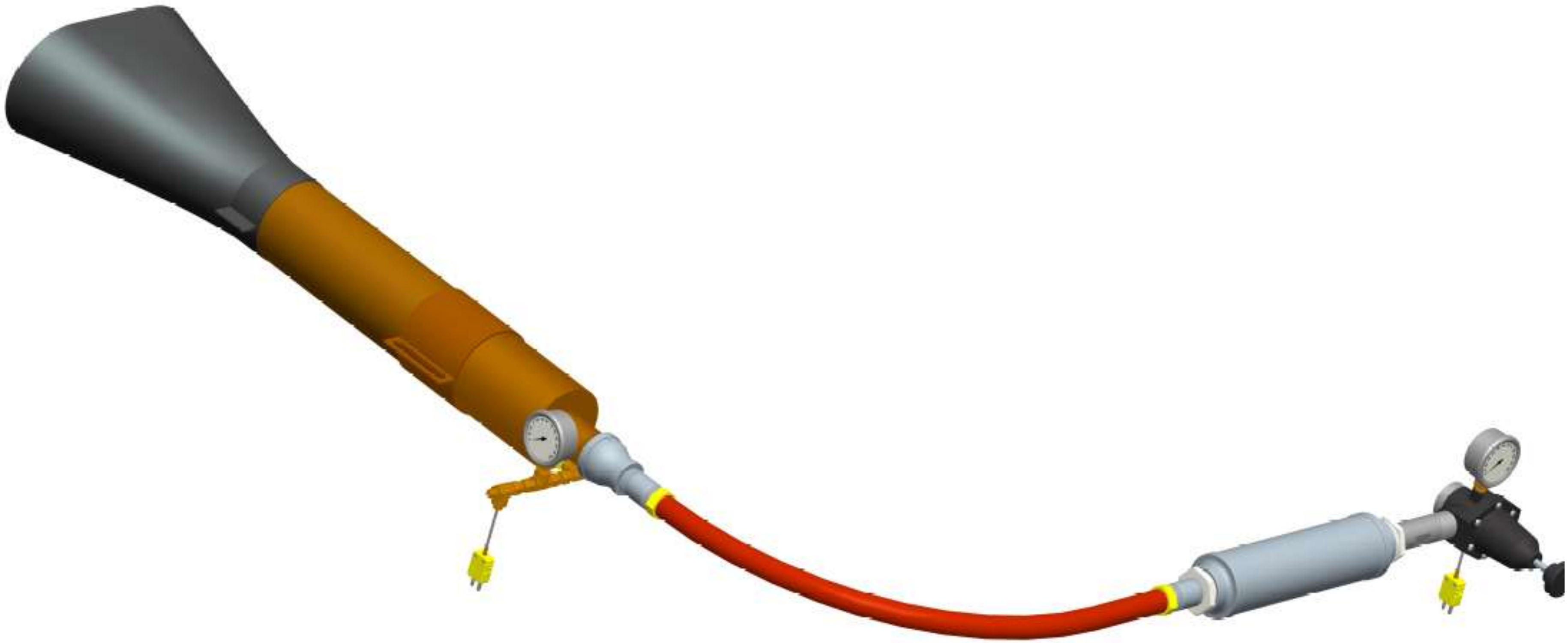


3.17% Standard Deviation

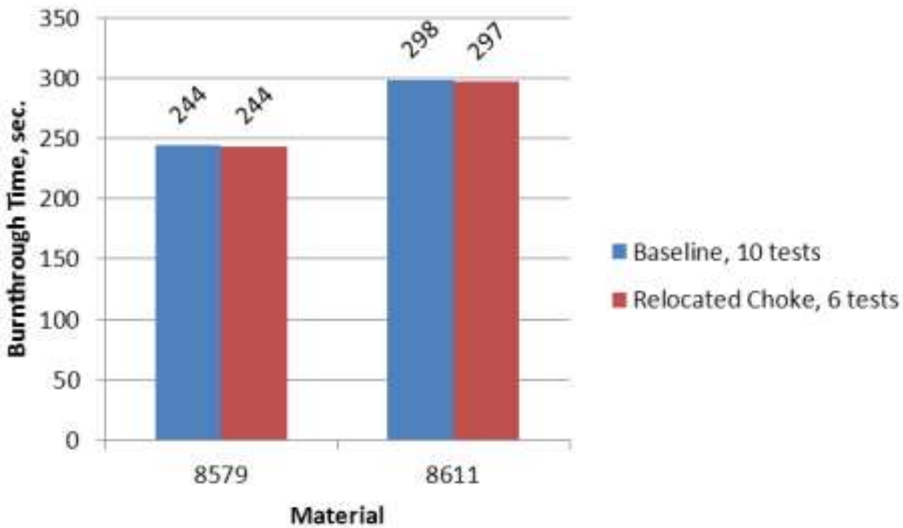
Test 1: Location of sonic choke
Standard Configuration



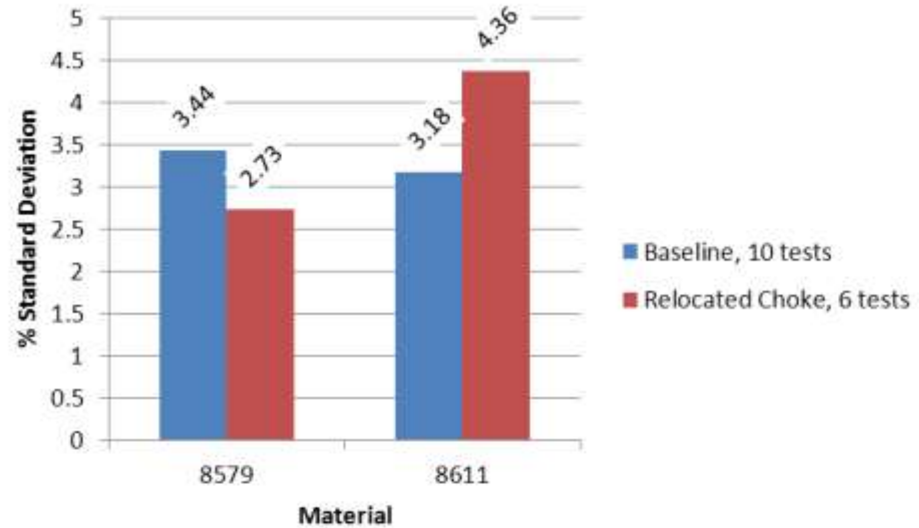
Relocated Choke



Burnthrough Time



Repeatability



Test Series 1 - Summary

- The choke was relocated approximately 6' from the burner and a curved, flexible hose was added between the muffler and the burner
- Test results indicate no noticeable deviation from the baseline configuration

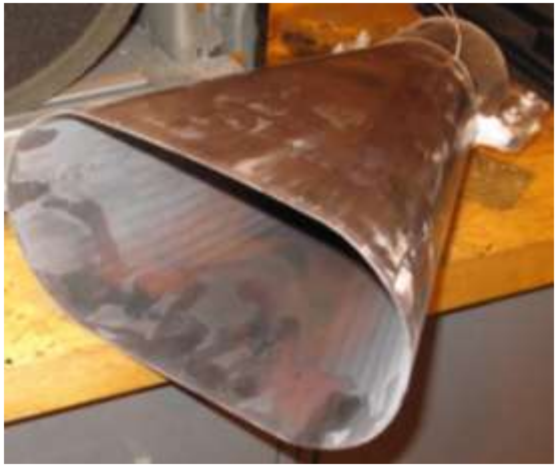
Test Series 2 – Burner Cones

- Objective is to determine which cone parameters have an effect on burnthrough time
  - Thickness
  - Flange
  - Material
  - Age
- Besides the baseline cone, three additional cones were tested (all new)
  - Baseline Cone: 0.06” thickness with recessed flange
  - Cone #1: 0.048” thickness 18 gauge 310 Stainless Steel
  - Cone #2: 0.061” thickness 321h Stainless Steel
  - Cone #3: Same as Cone #1 with 1” flange welded on exit plane

Cones

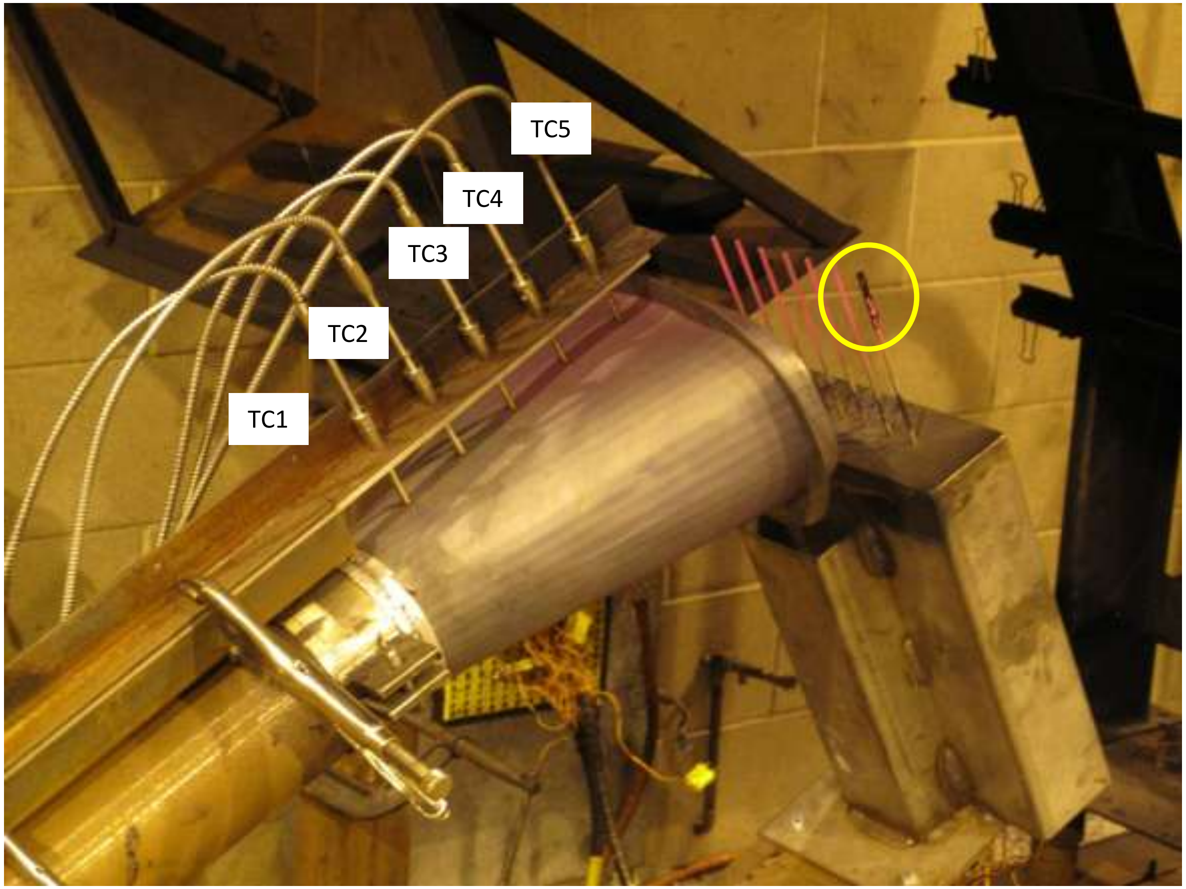
Cone #1

Cone #2

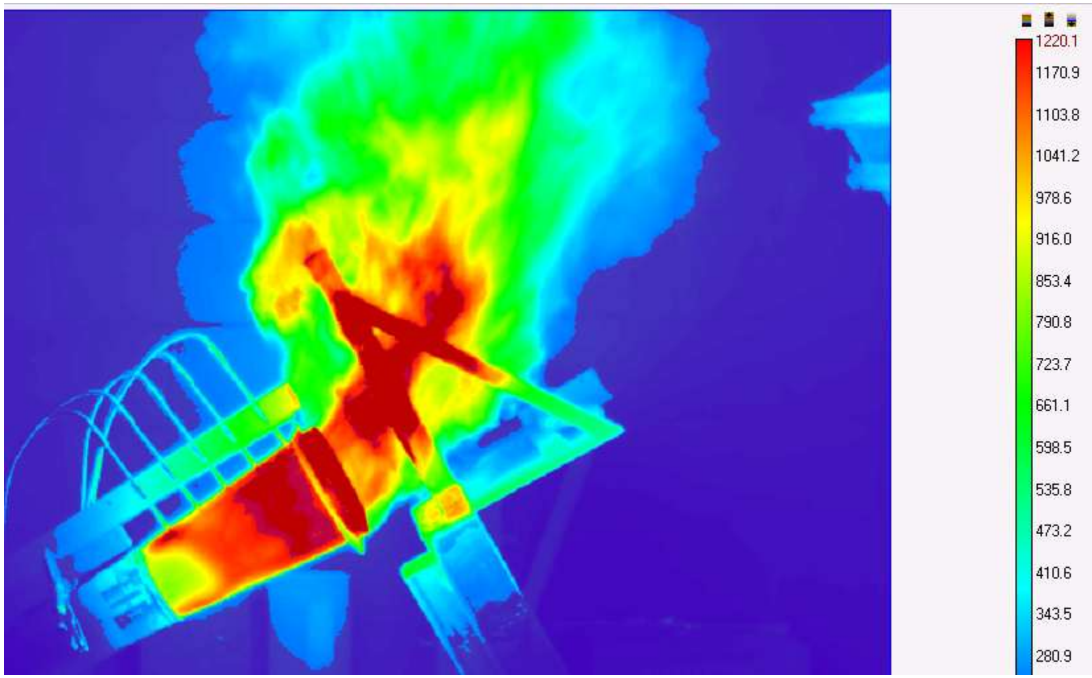


Cone #3

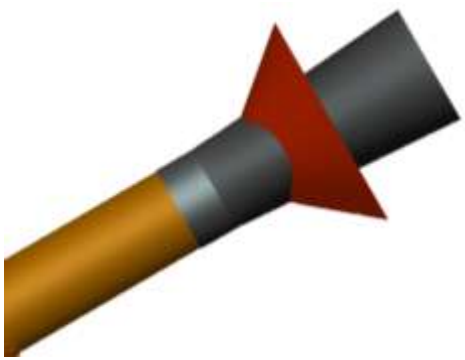
Cone Surface Temperature Measurement

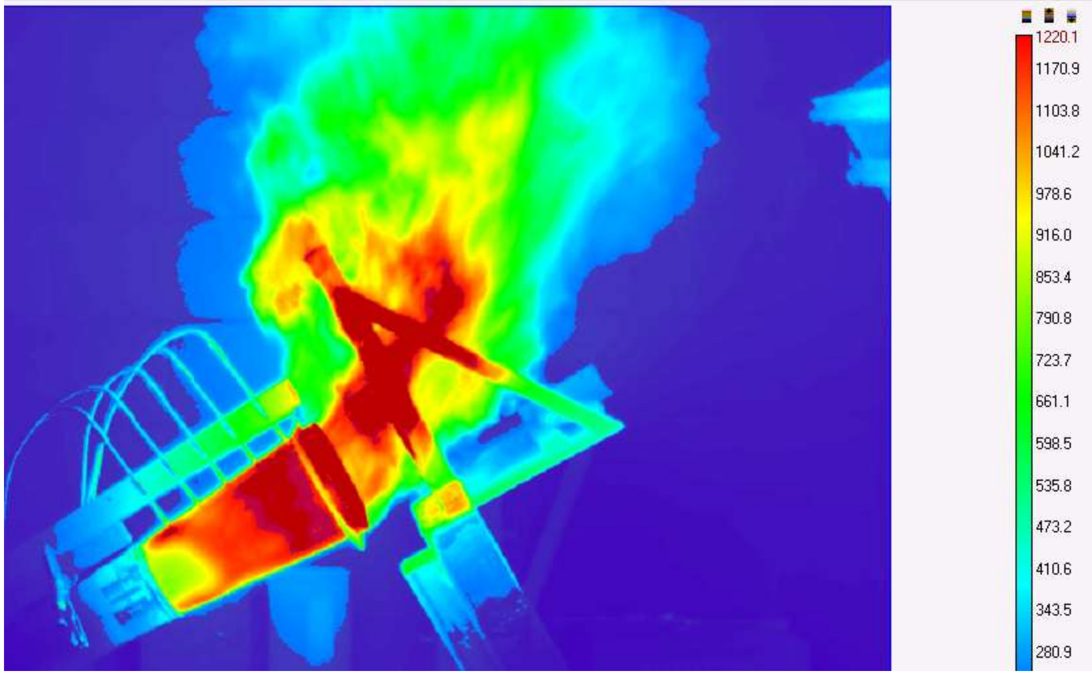


FLIR Imaging

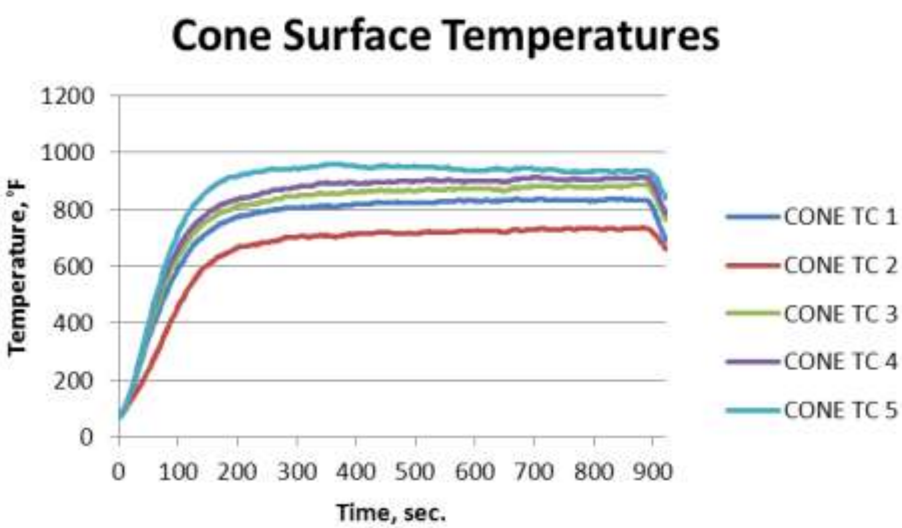


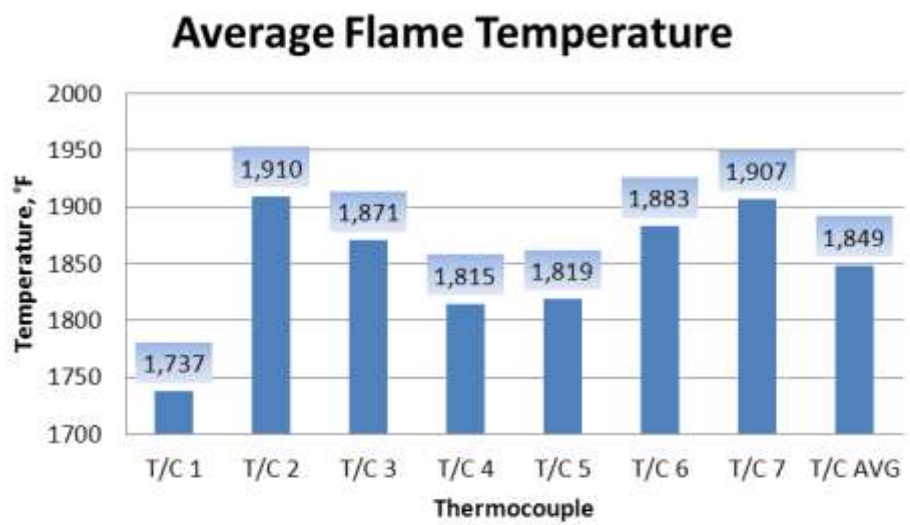
Fuel Nozzle Spray Cone Angle





Cone and Flame Temperature

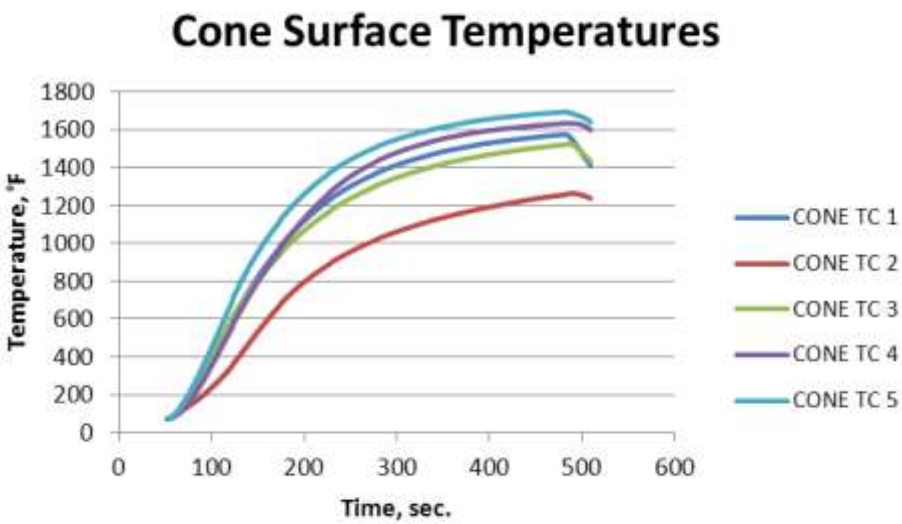


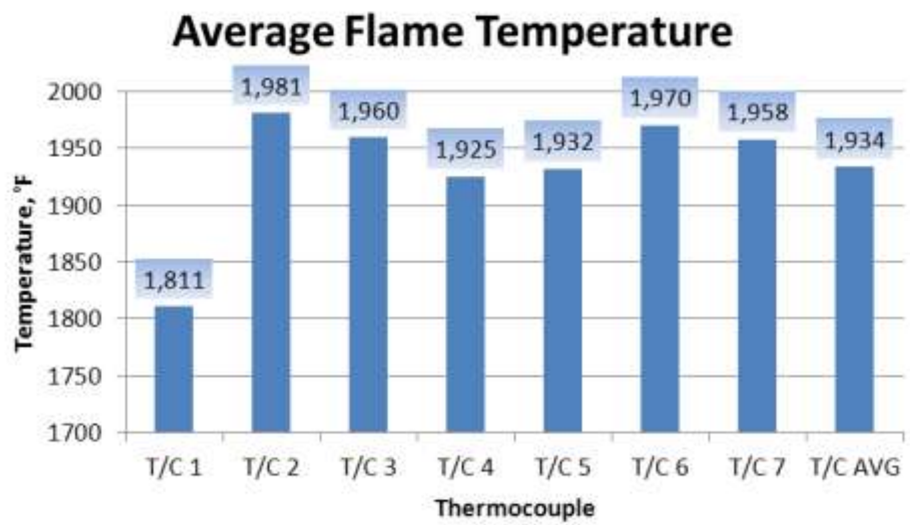


Federal Aviation Administration

Insulated Cone

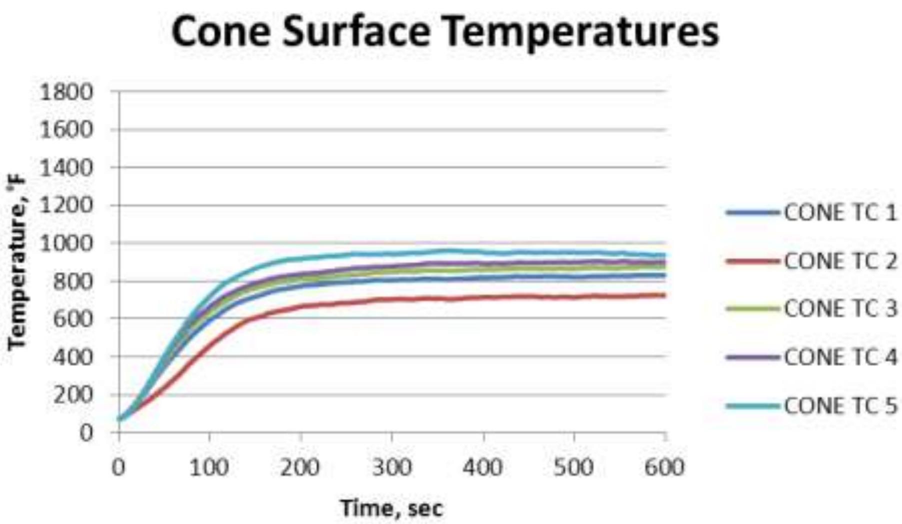
Insulated Cone



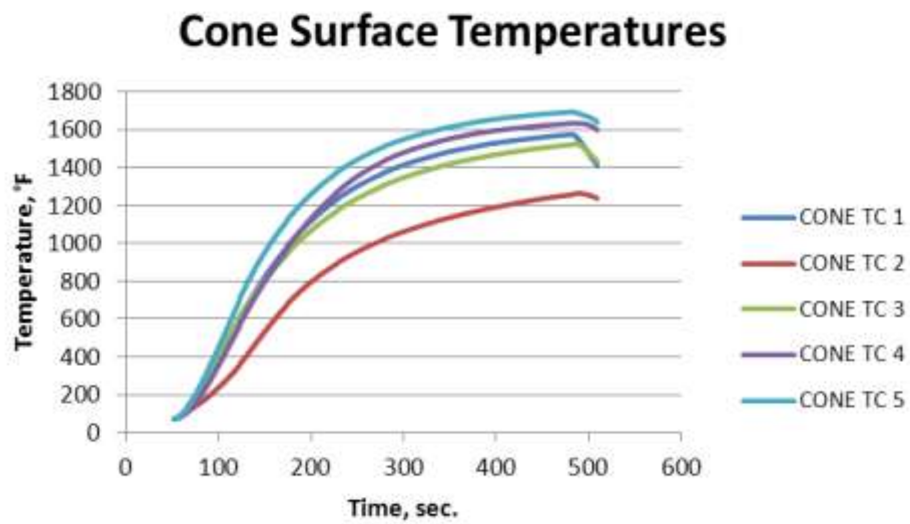


Cone Surface Temperature Comparison

Un-Insulated Cone

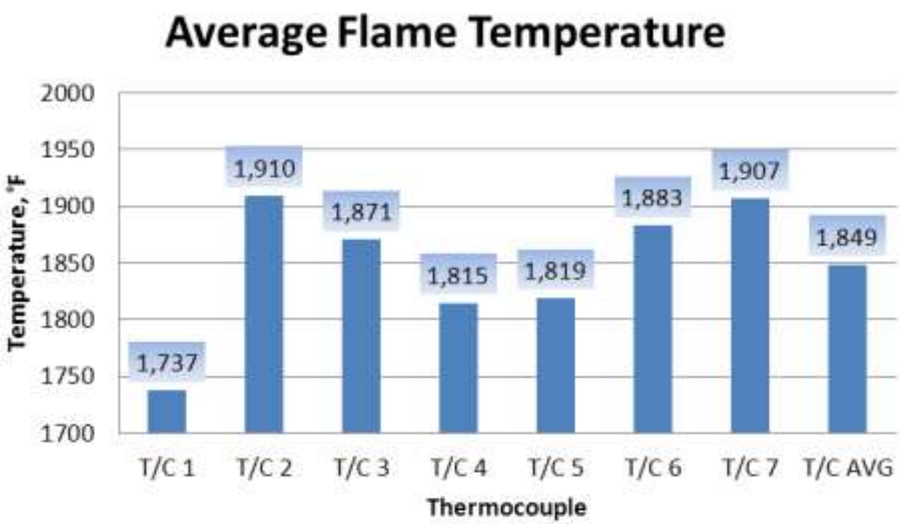


Insulated Cone

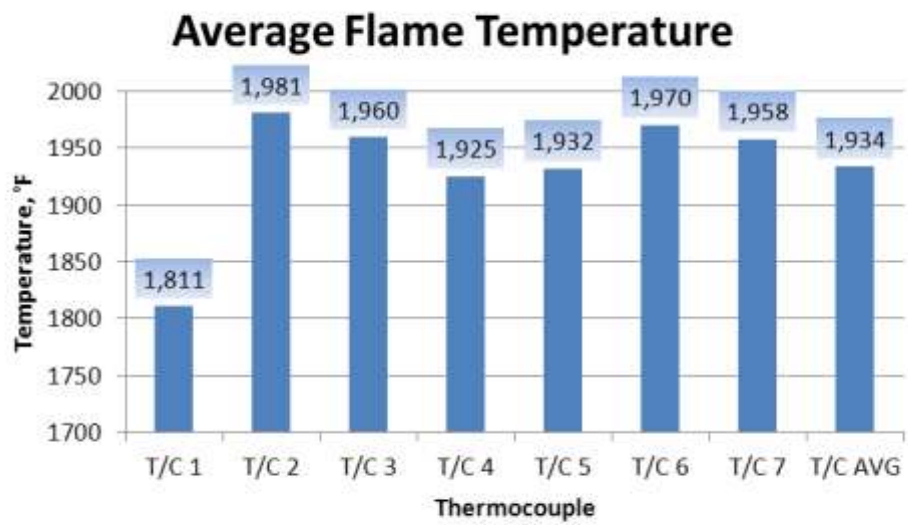


Flame Temperature Comparison

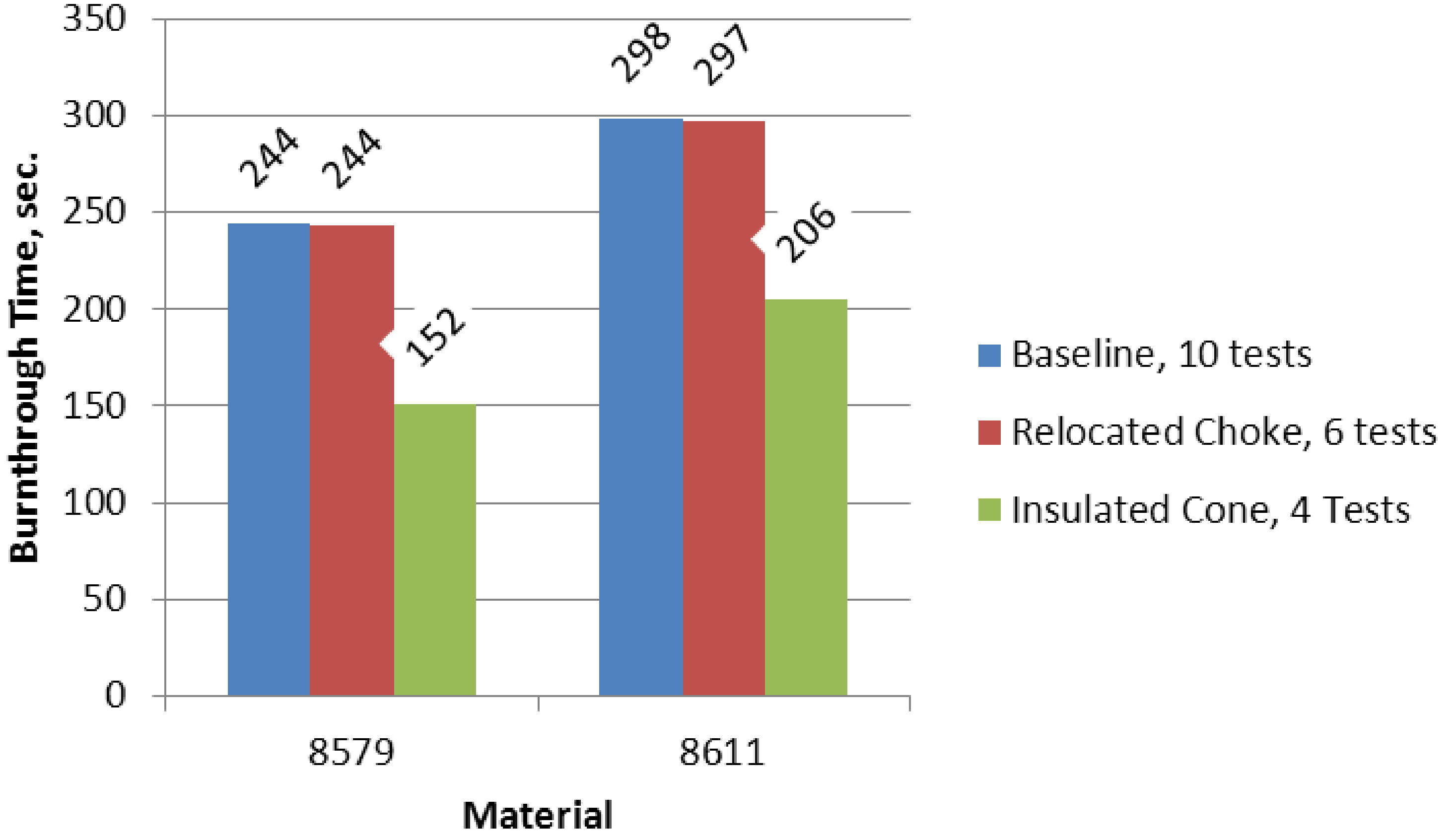
Un-Insulated Cone



Insulated Cone



Burnthrough Times

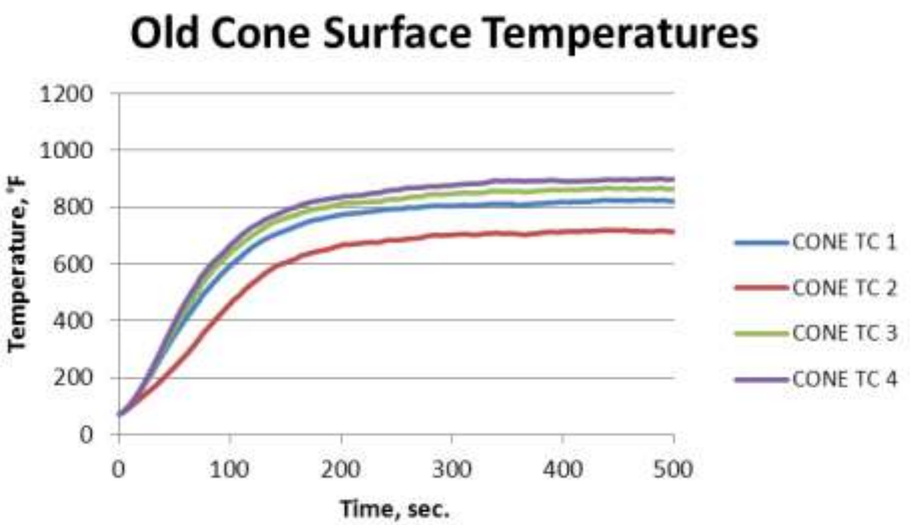


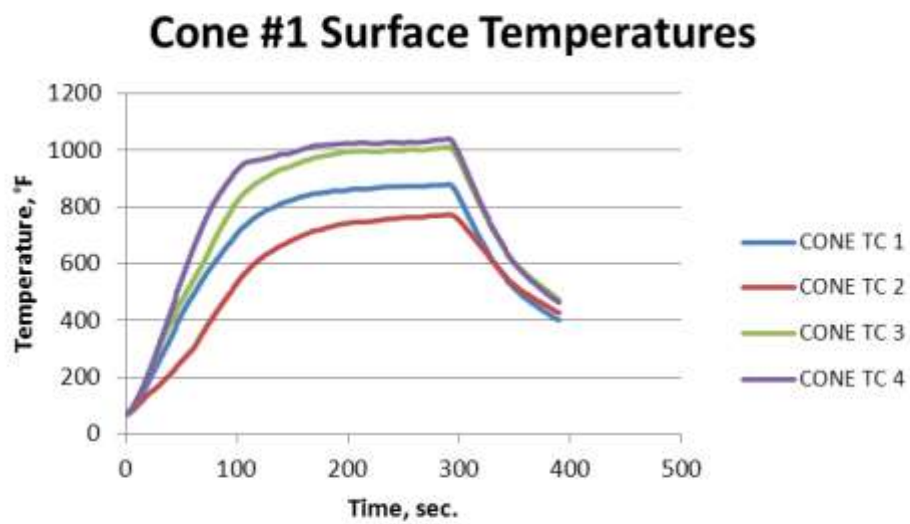
Summary - Insulated Cone

- Insulating the cone increases the average flame temperature by about 85°F
- Insulation increased the cone surface temperatures by 500-600°F
- The insulated cone burned through the PAN material significantly quicker than the un-insulated cone
  - 8579: 92 sec. quicker
  - 8611: 92 sec. quicker
- Cone insulation used as an extreme example to determine how heat loss from cone can affect burnthrough results

Installed Cone #1

0.048” thickness 18 gauge 310 Stainless Steel

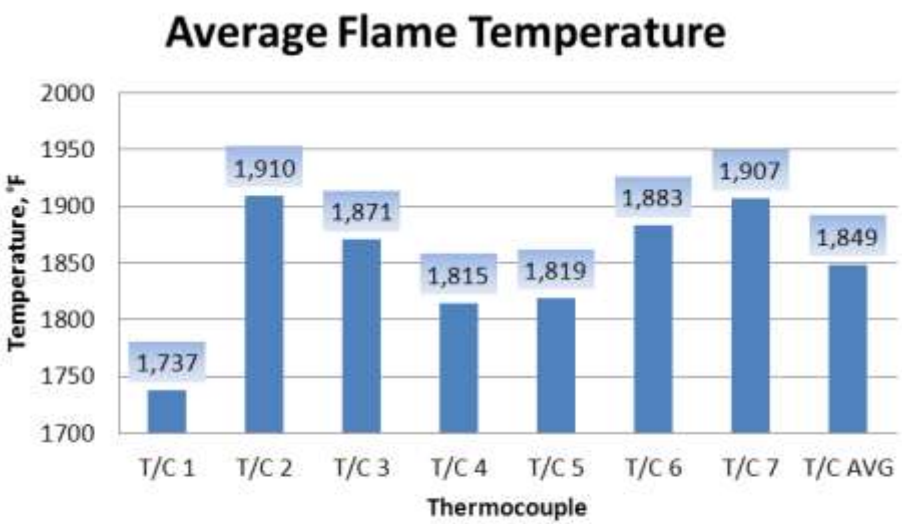




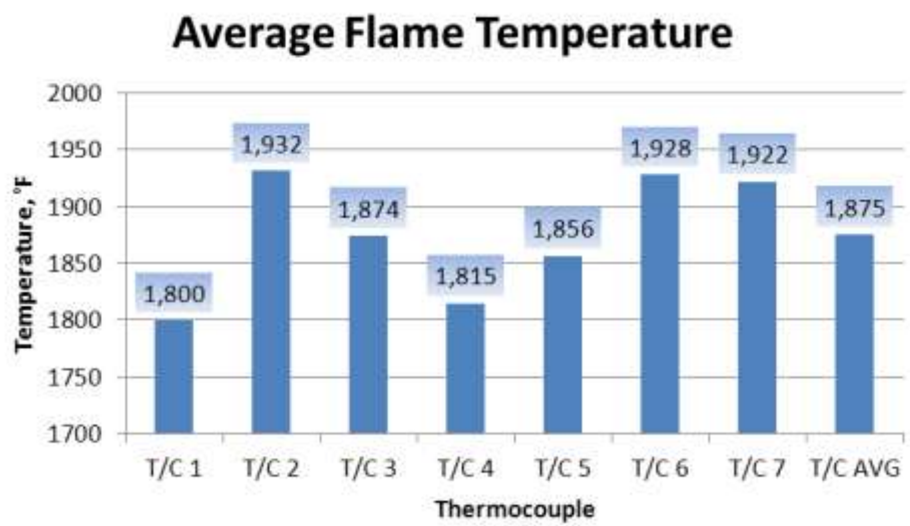
Installed Cone #1

0.048” thickness 18 gauge 310 Stainless Steel

Baseline Cone

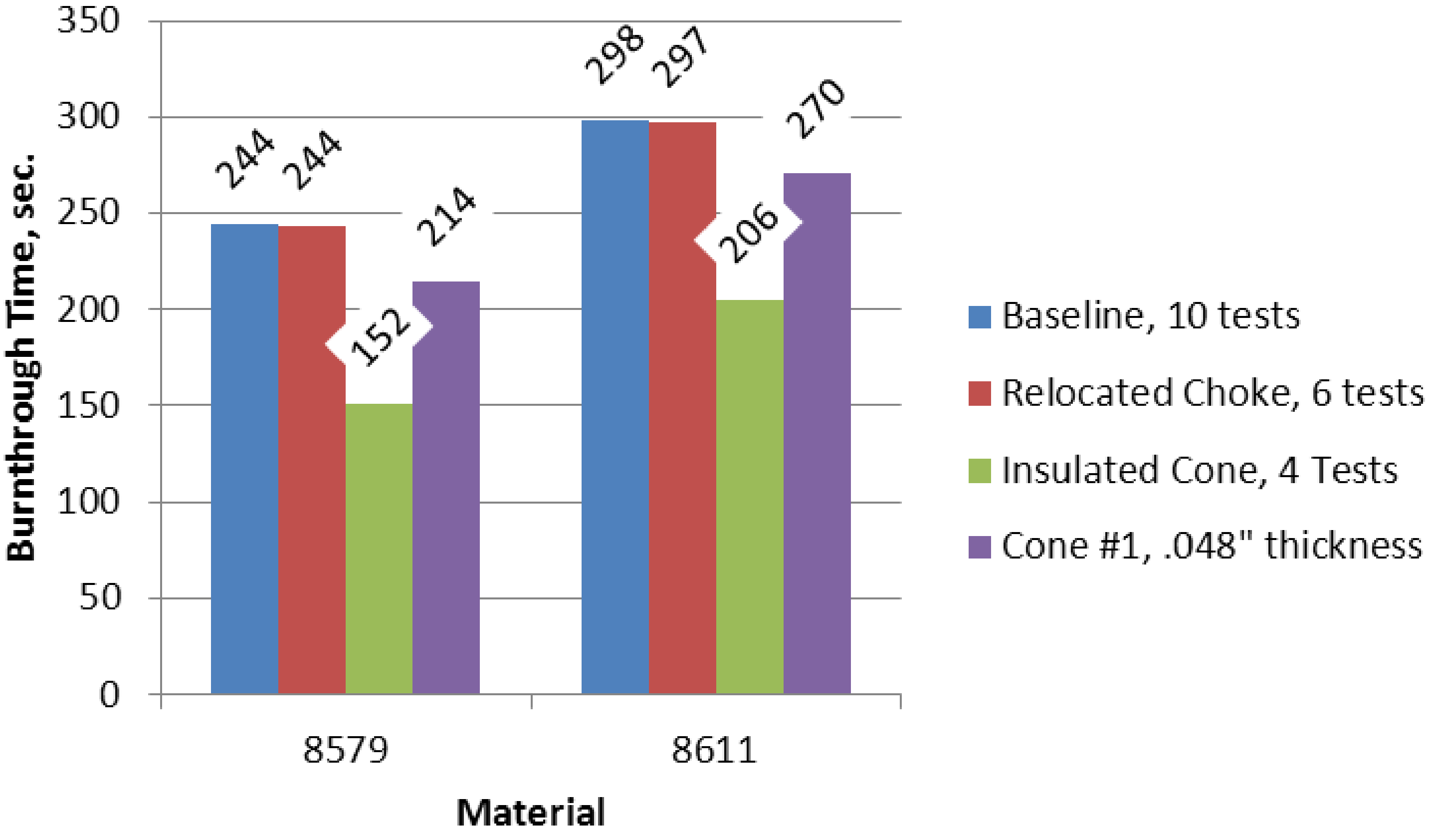


Cone #1



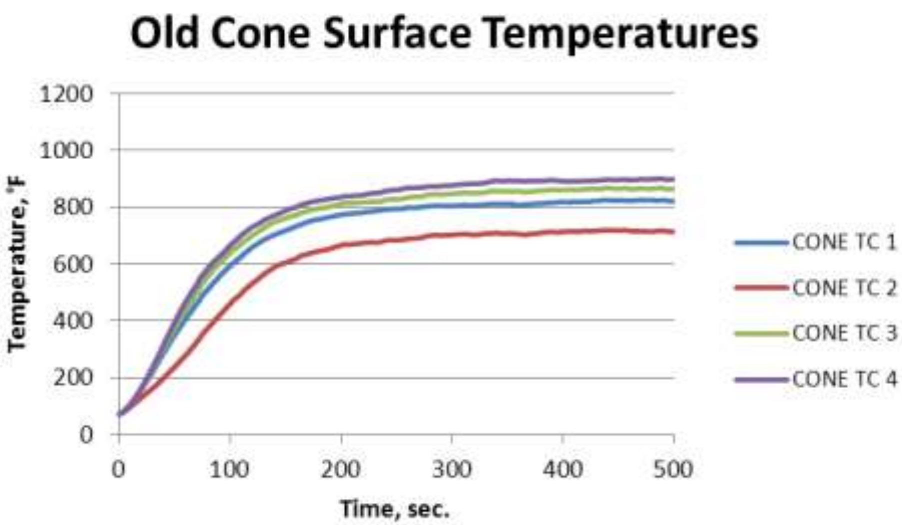
Installed Cone #1

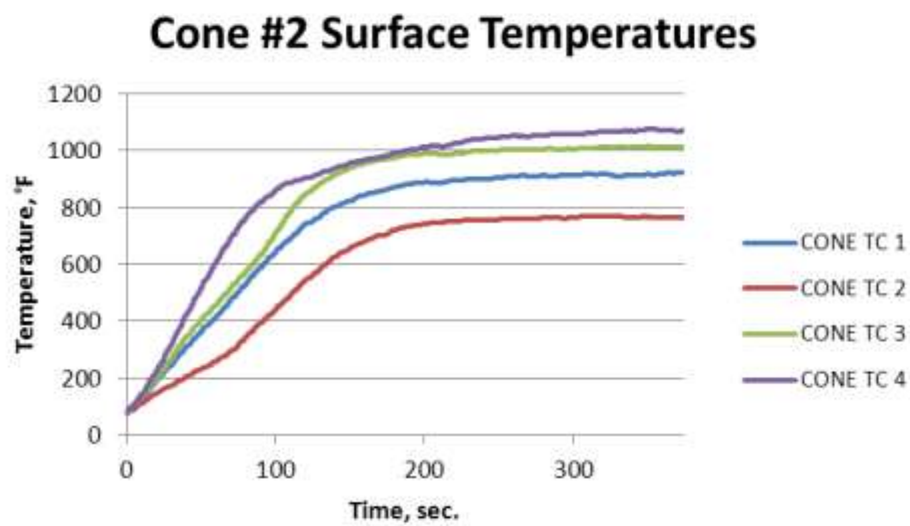
0.048” thickness 18 gauge 310 Stainless Steel



Installed Cone #2

0.061” thickness 321h Stainless Steel

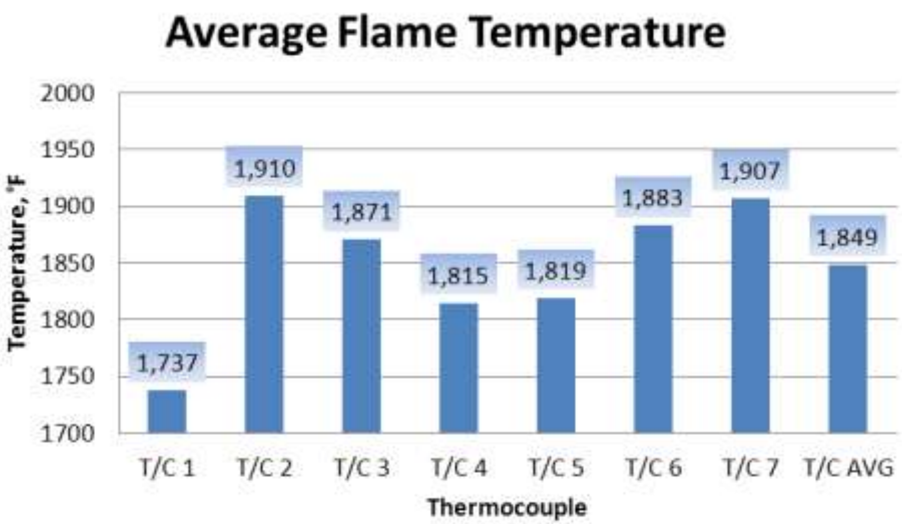




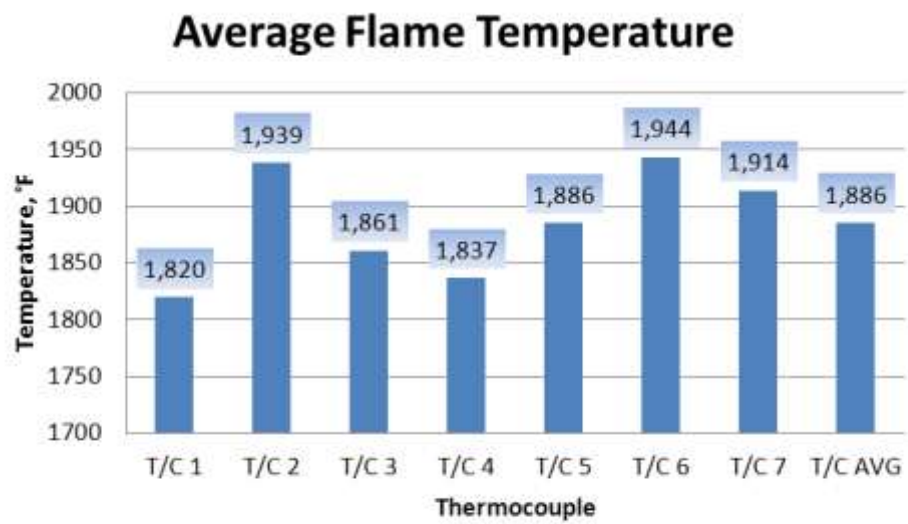
Installed Cone #2

0.061” thickness 321h Stainless Steel

Baseline Cone

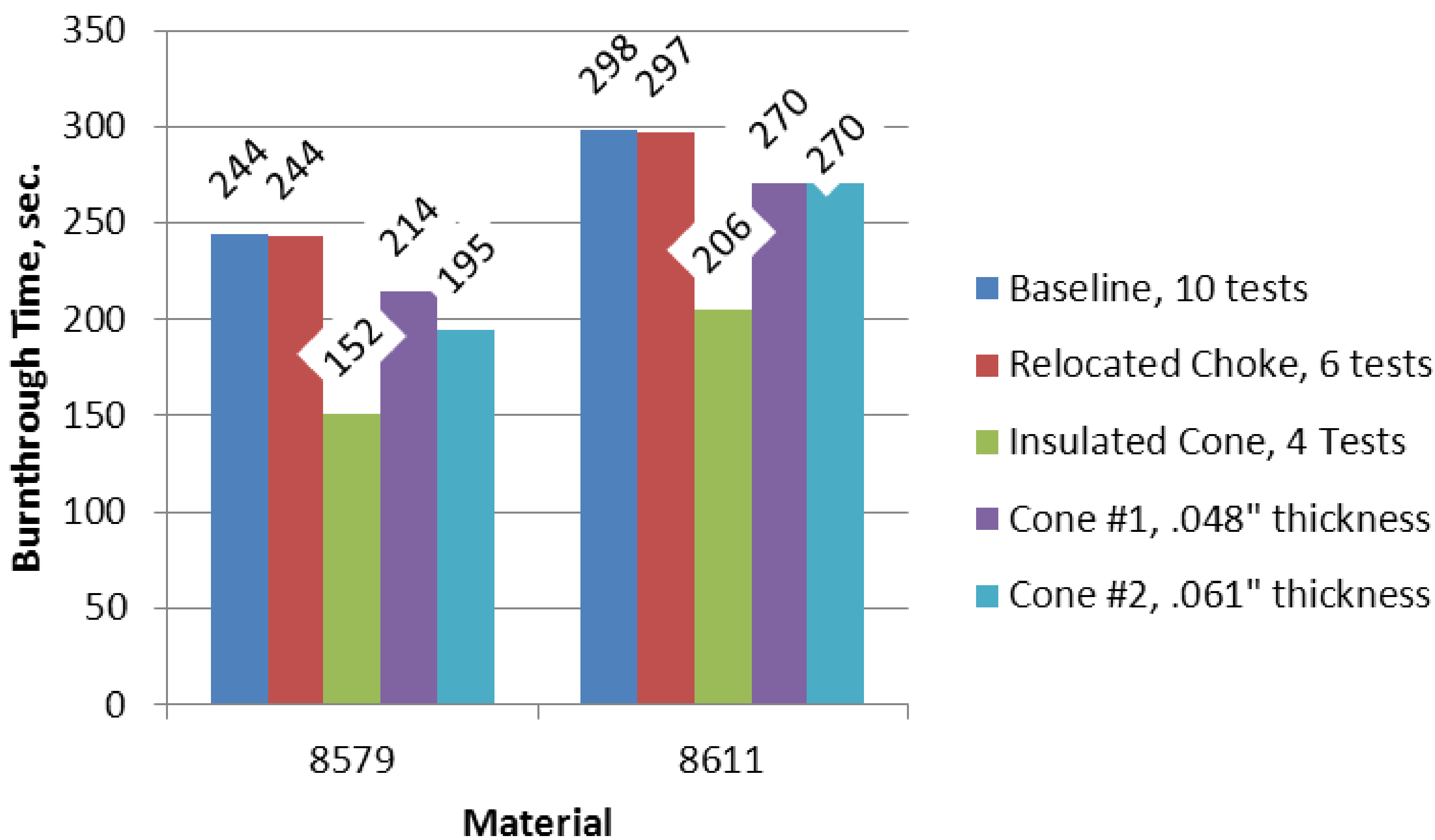


Cone #2



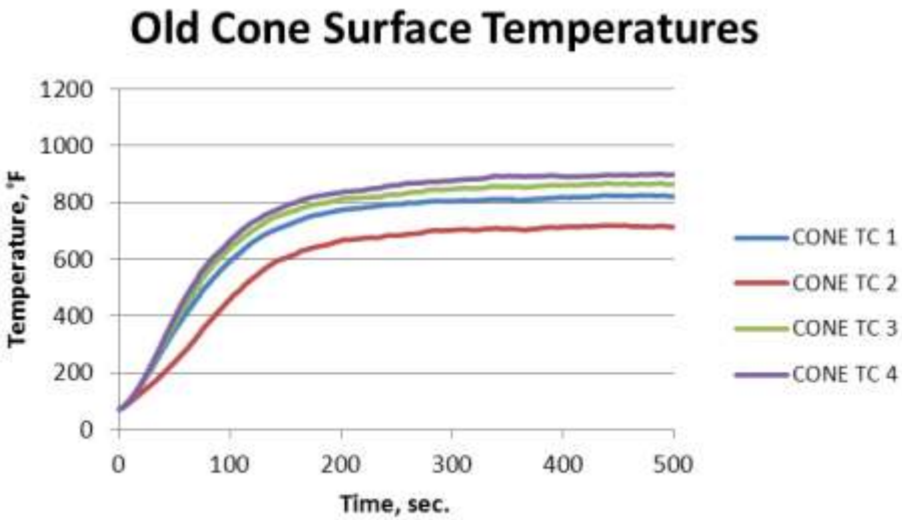
Installed Cone #2

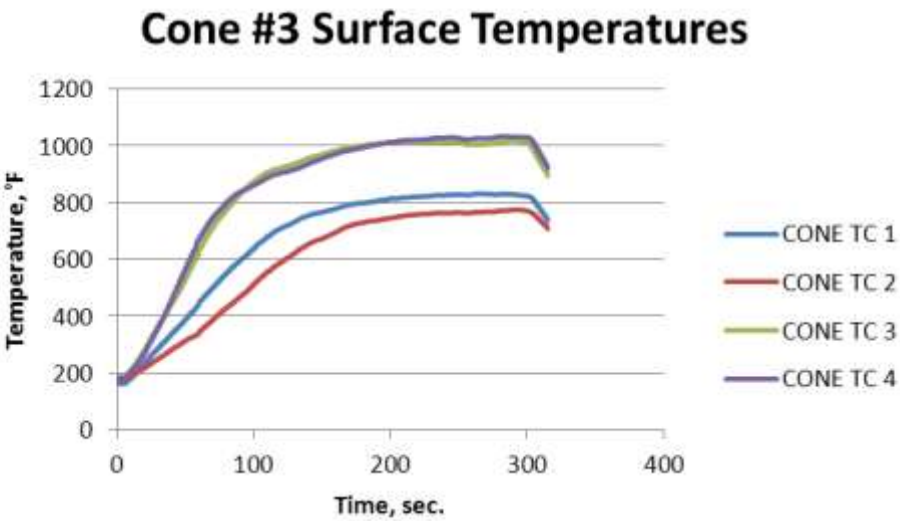
0.061" thickness 321h Stainless Steel



Installed Cone #3

Same as Cone #1 with 1” flange welded on exit plane

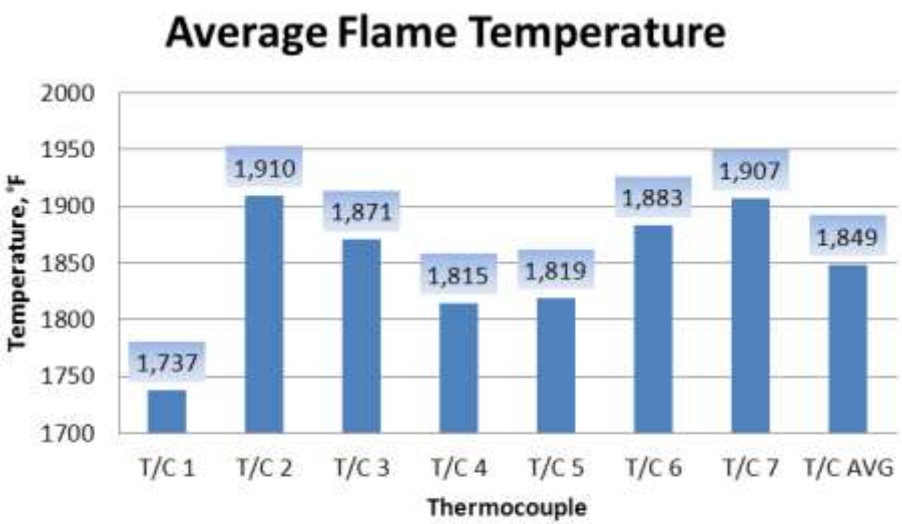




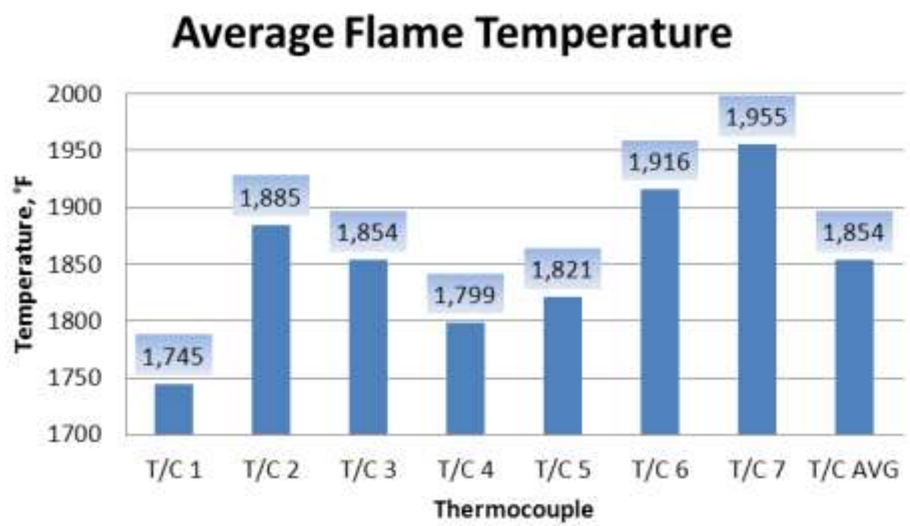
Installed Cone #3

Same as Cone #1 with 1” flange welded on exit plane

Baseline Cone

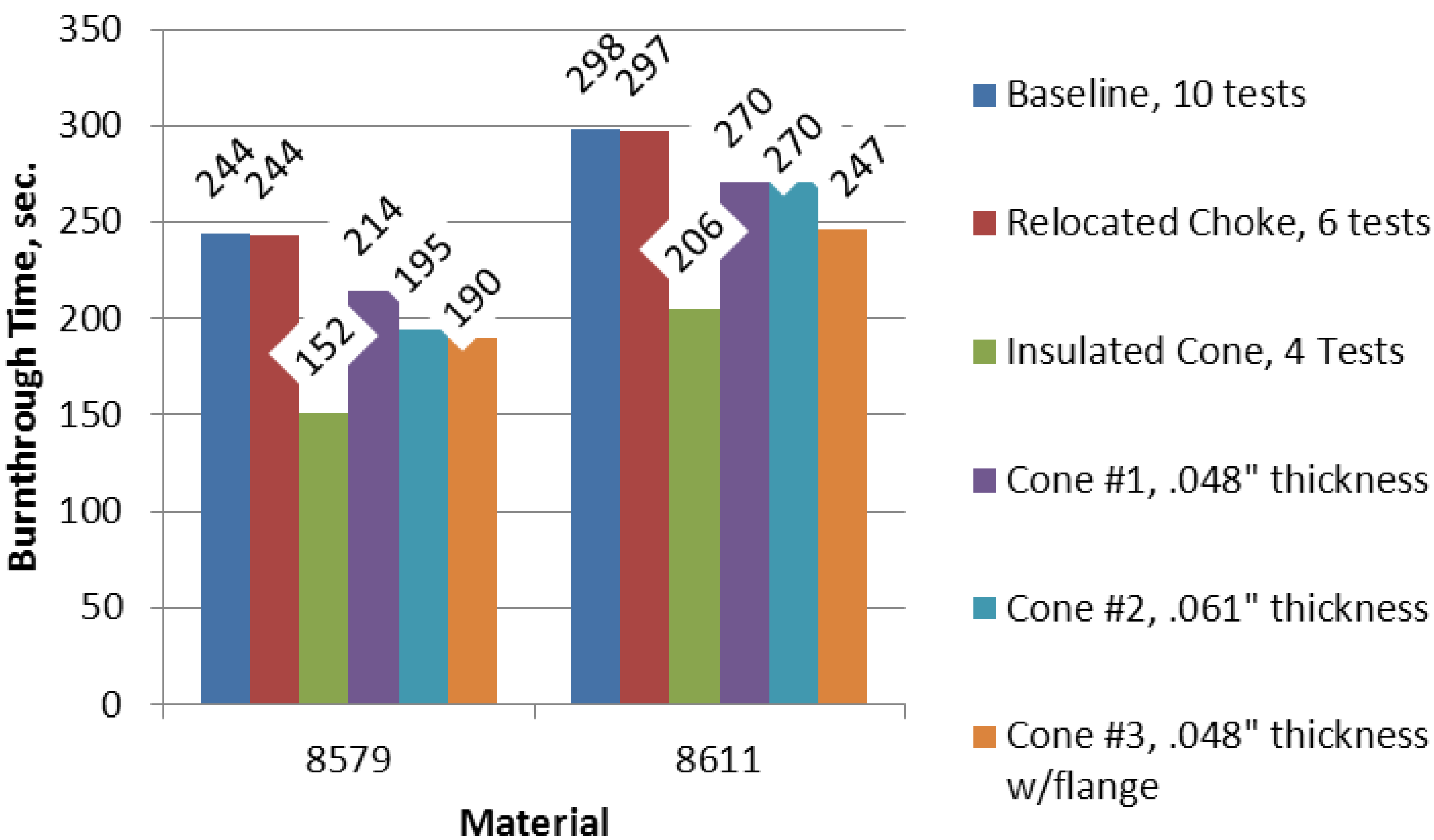


Cone #3

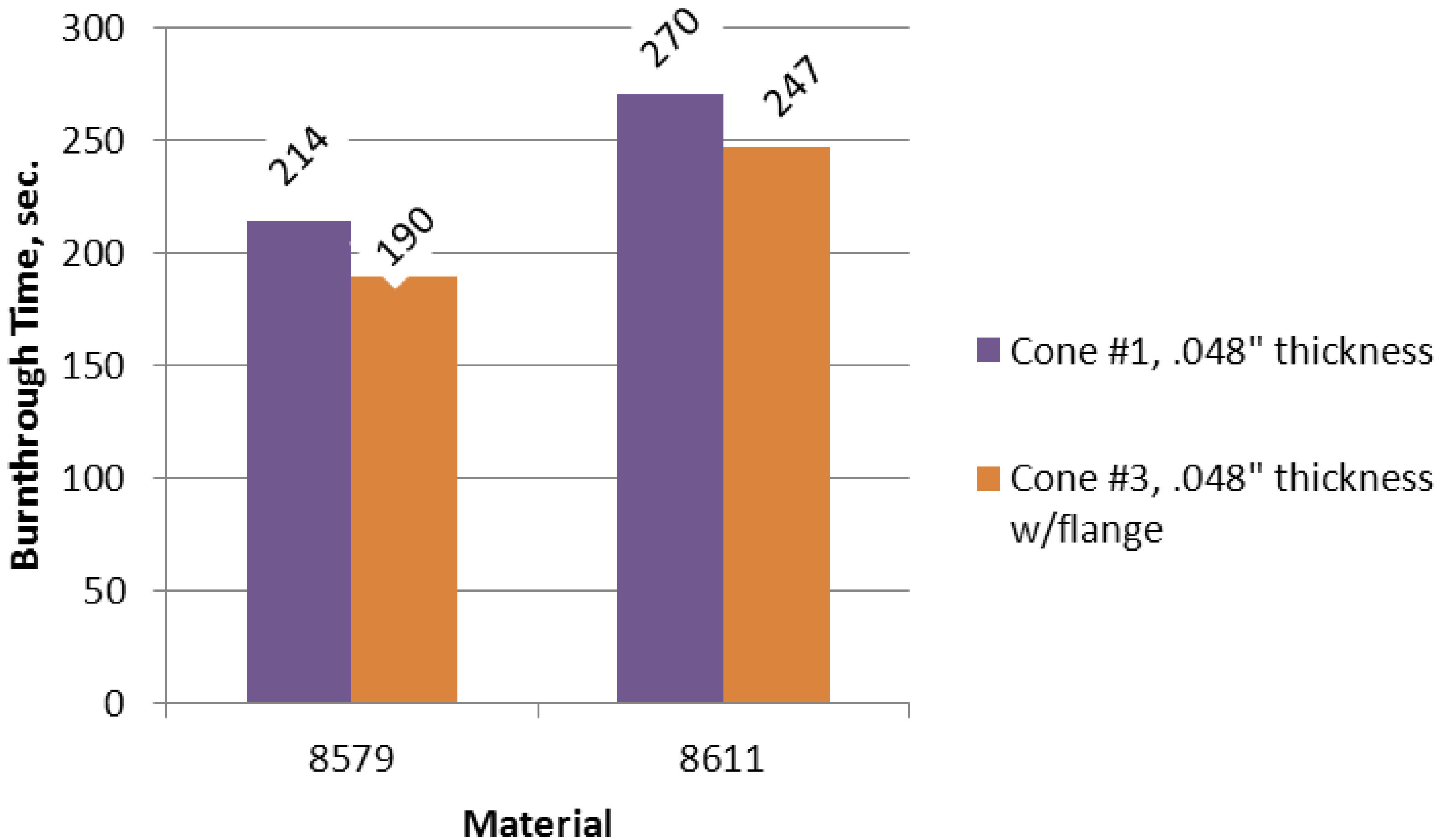


Installed Cone #3

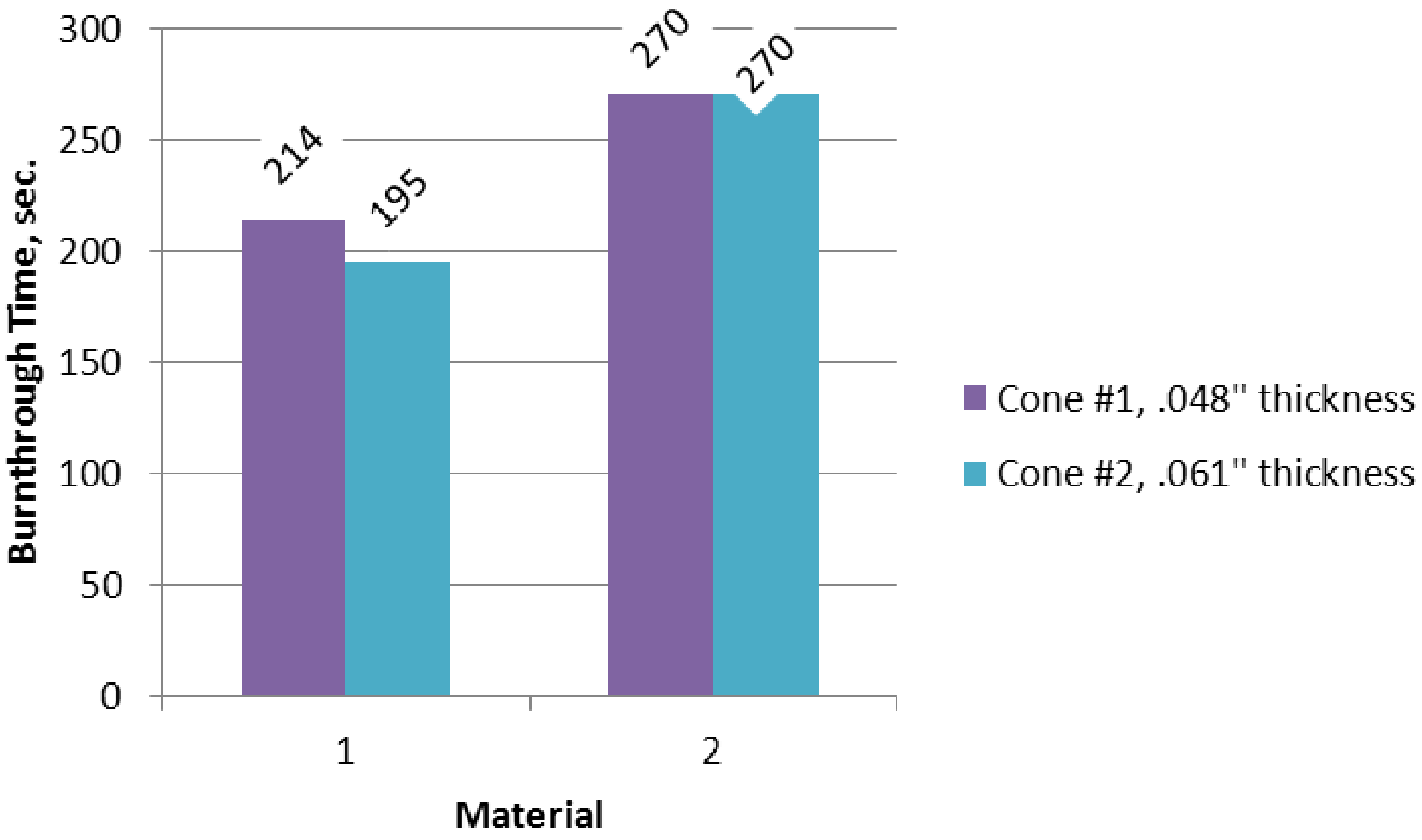
Same as Cone #1 with 1” flange welded on exit plane



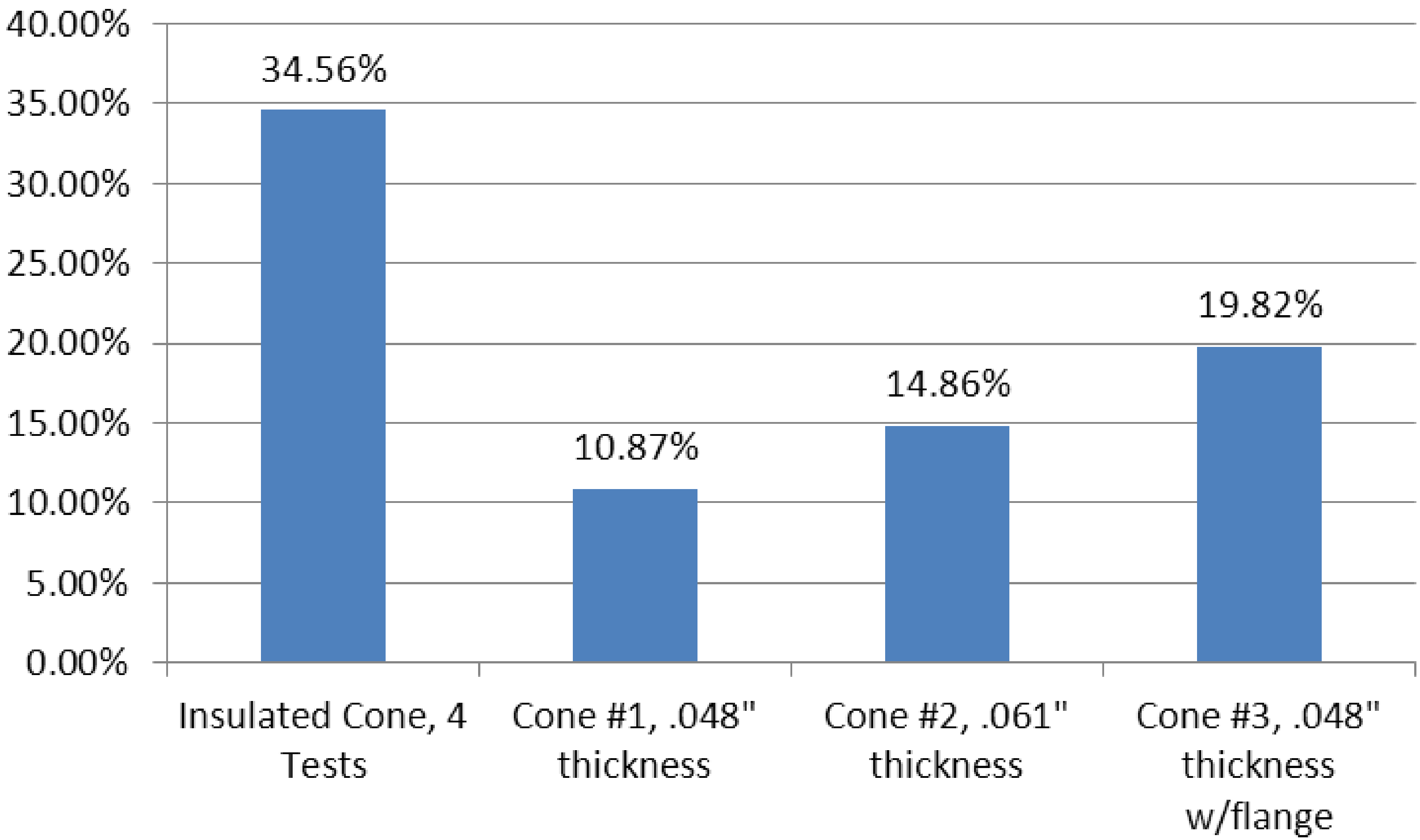
Cones #1 vs. #3 – Effect of Flange



Cones #1 vs. #2 – Effect of Thickness



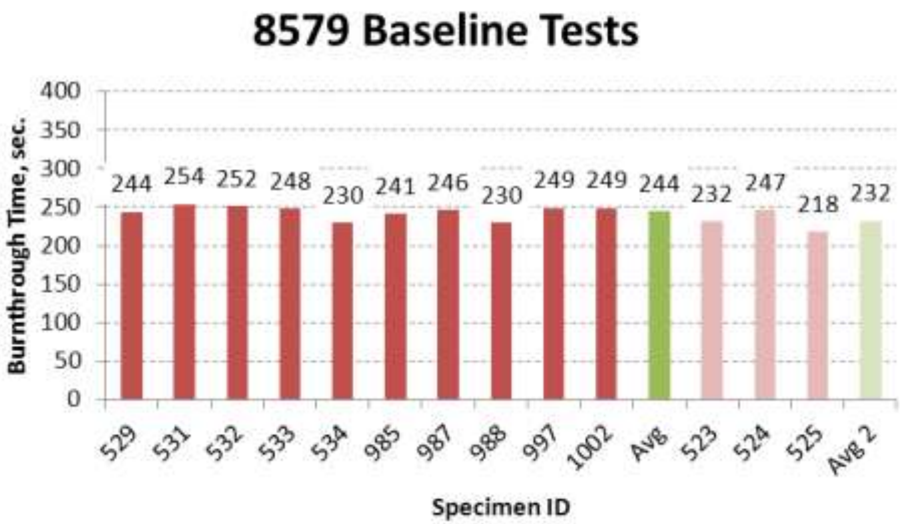
Average % Change from Baseline



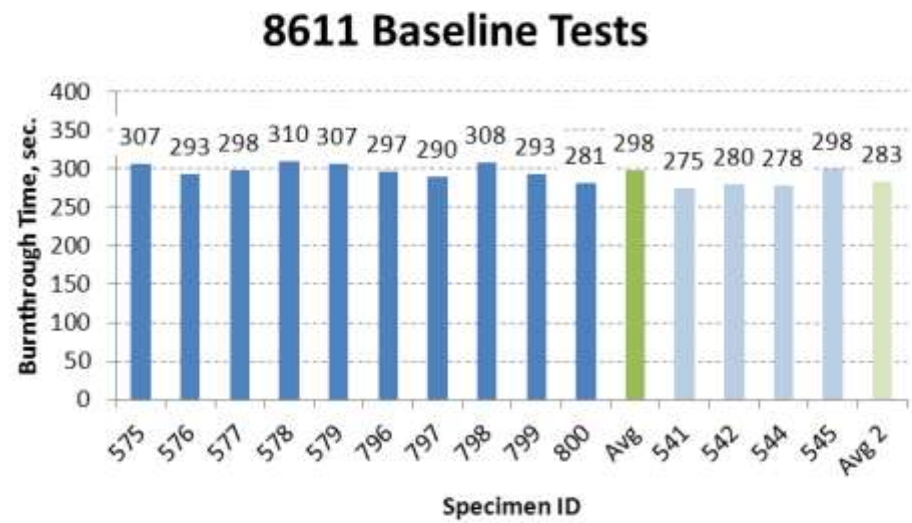
Cone Comparison - Summary

- All cases tested reduced the burnthrough time of both 8579 and 8611 from the baseline case
- In order of impact on burnthrough severity
  - Insulating outer cone surface to prevent heat loss
  - 1" flange on end of cone
  - Slightly thicker cone material
  - New cone

Re-run Baseline Tests

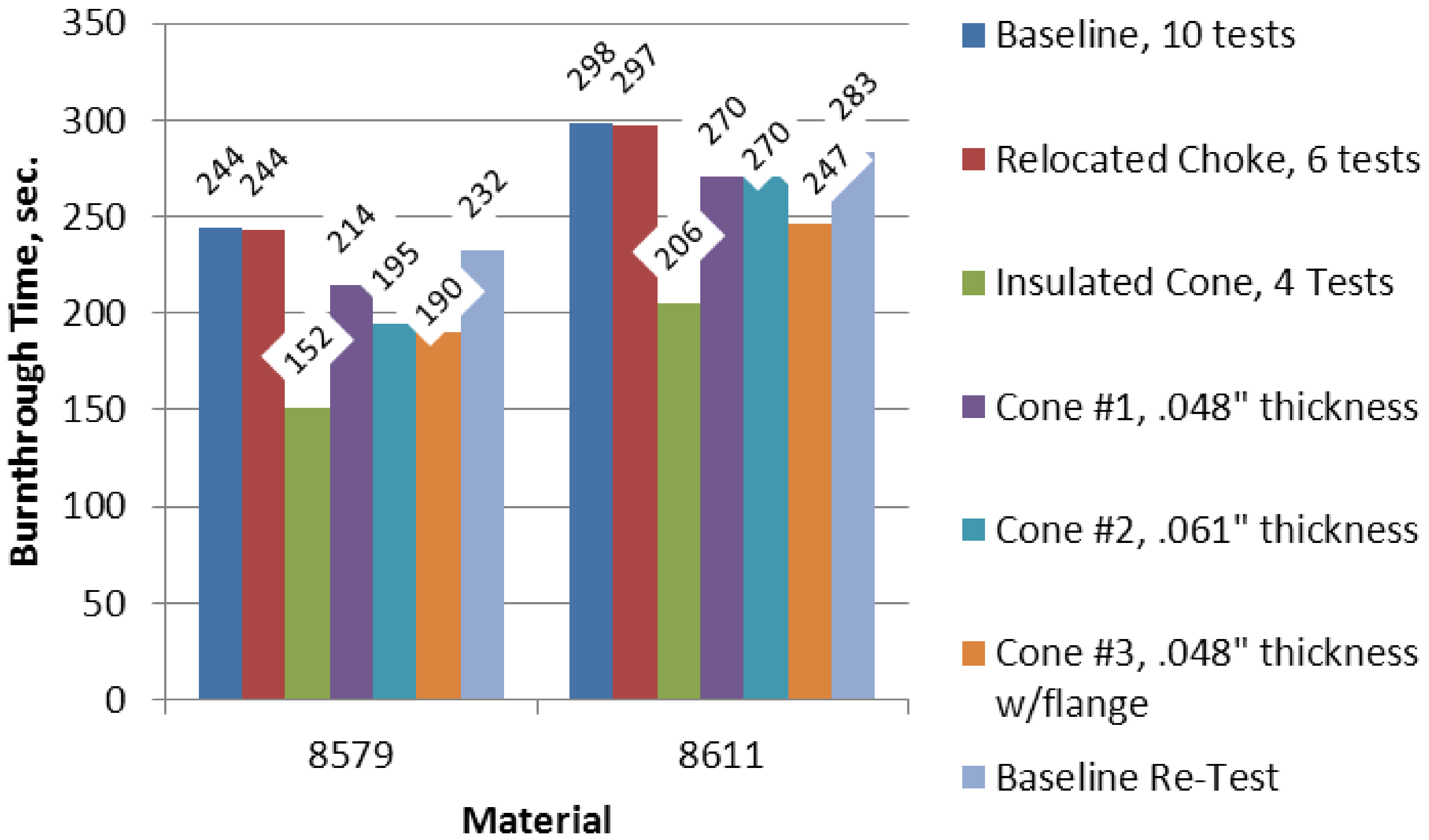


244 ± 5%
231.8<x<256.2



298 ± 5%
283<x<313

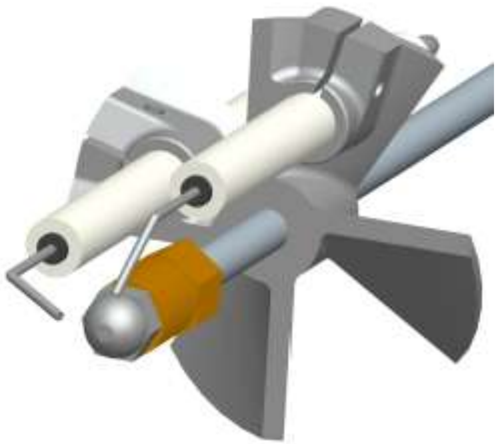
Re-run Baseline Tests



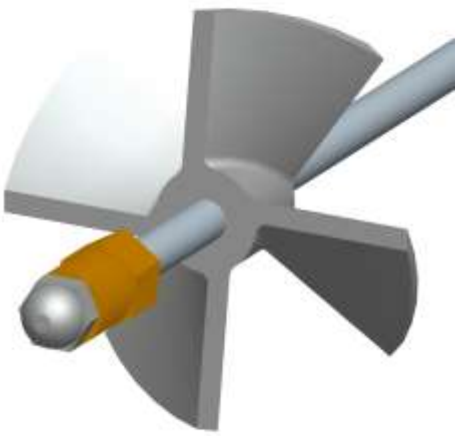
Test Series #3 - Stator

Definitions

“Old Stator”
Marlin Engineering CNC-machined reproduction of original Monarch H-215



“New Stator”
Marlin Engineering, symmetric, CNC-machined

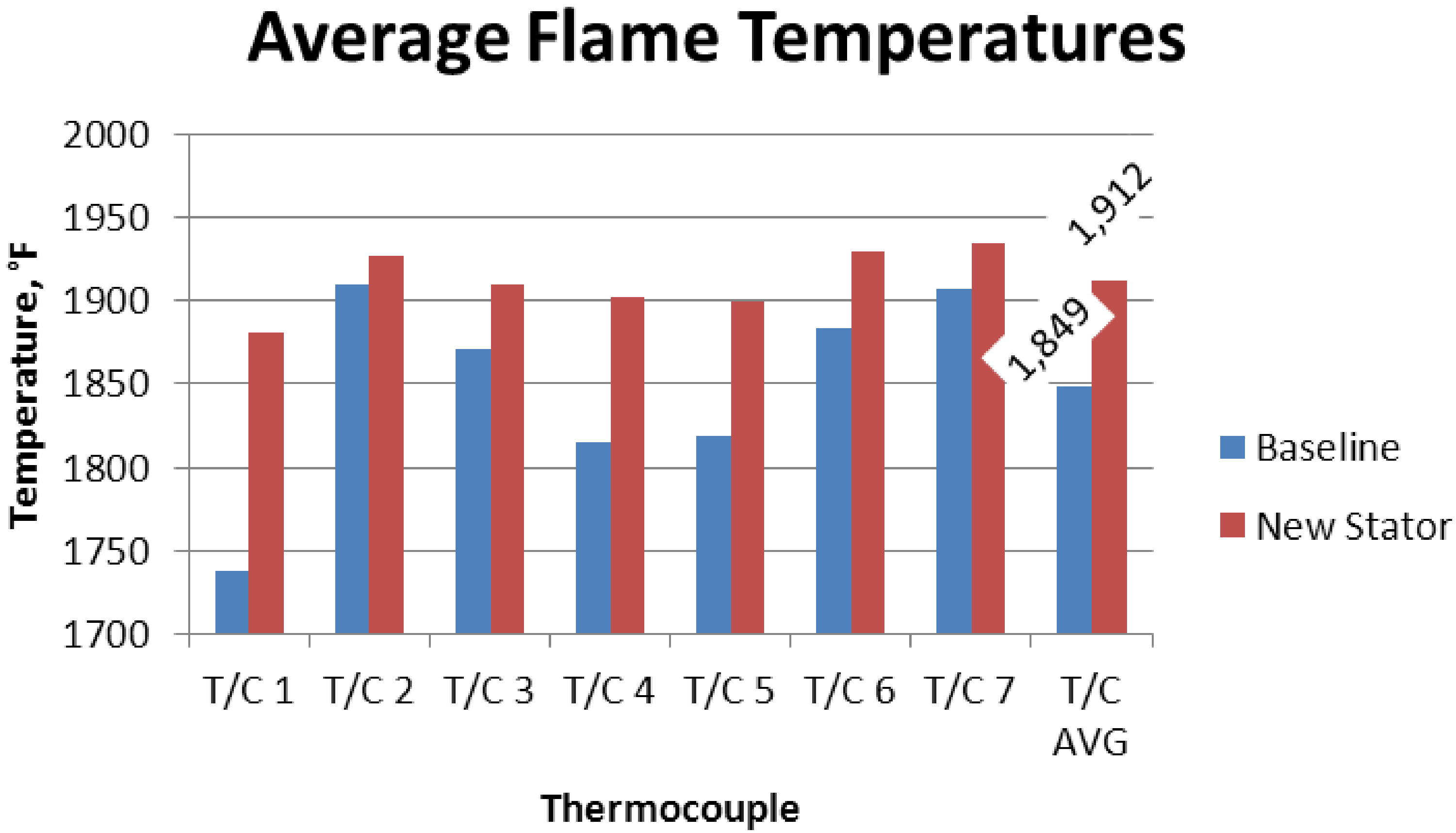


New Stator – External Ignition

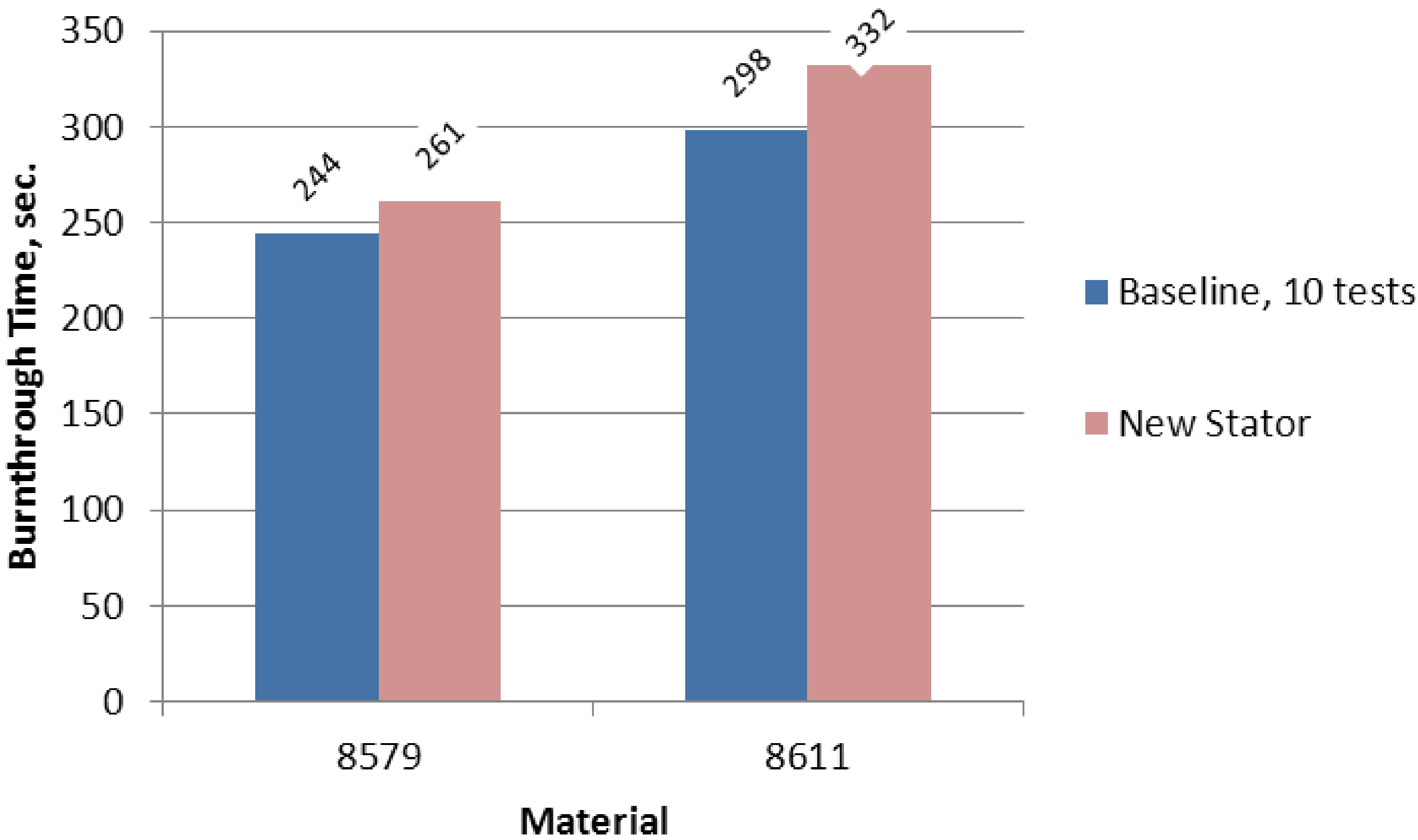
New Stator

- Initially new stator was put in exact position as old stator
  - 4” back from nozzle tip
  - Centerline between vanes aligned 35° from vertical
- Ignition wires were removed from burner completely

New Stator – Temperature Comparison



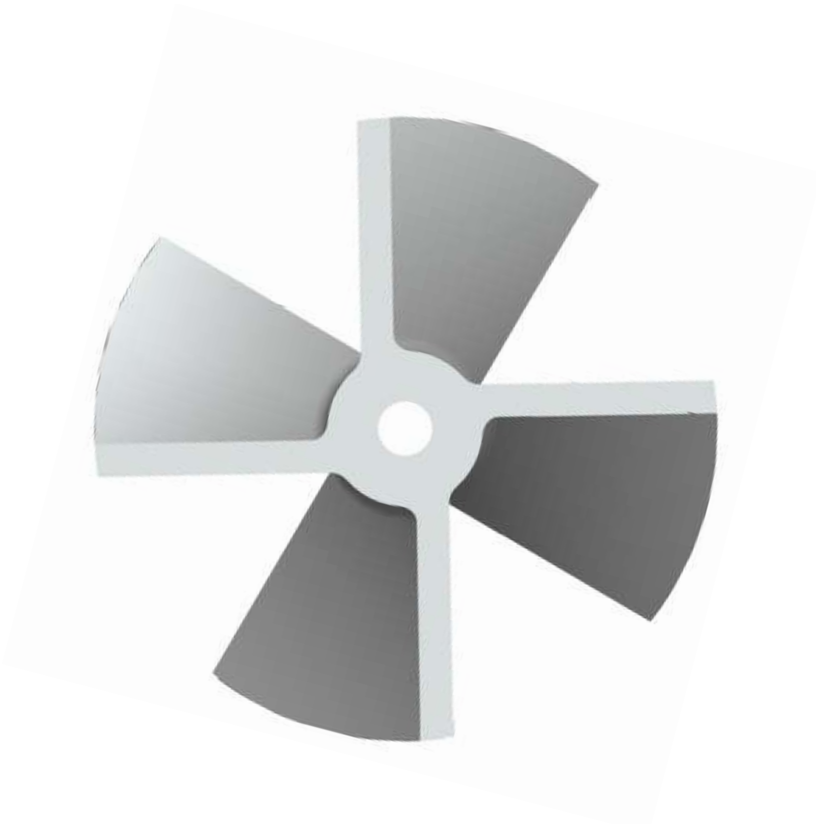
New Stator - Burnthrough

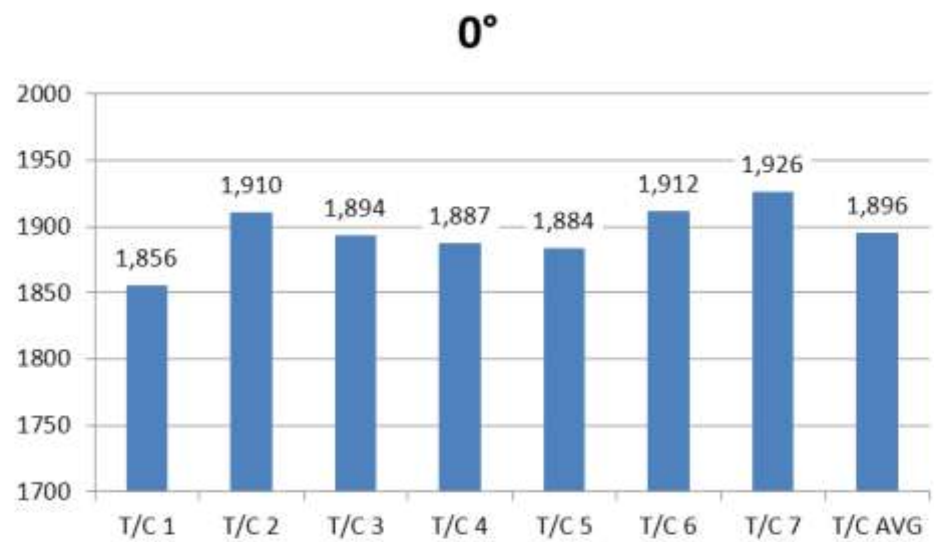


Summary of Initial New Stator Results

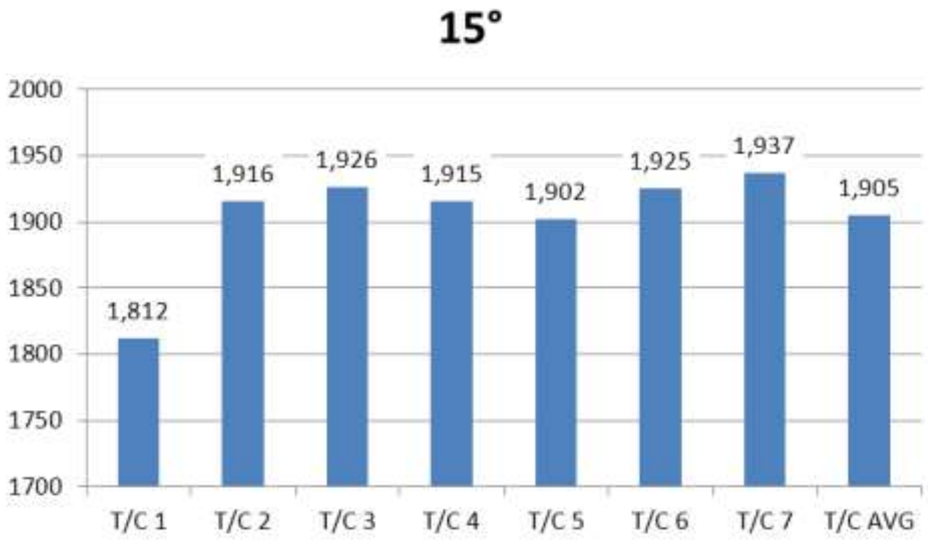
- New Stator – Flame Temperature Measurement
  - More uniform flame temperature profile
  - Significant improvement on #1 T/C
  - Over 50°F increase in average flame temperature
- New Stator – Burnthrough Tests
  - Longer overall burnthrough times for both 8579 and 8611 material
    - 8579 – 16.45 sec. longer
    - 8611 – 33.60 sec. longer

Measured Flame Temperatures - Rotation

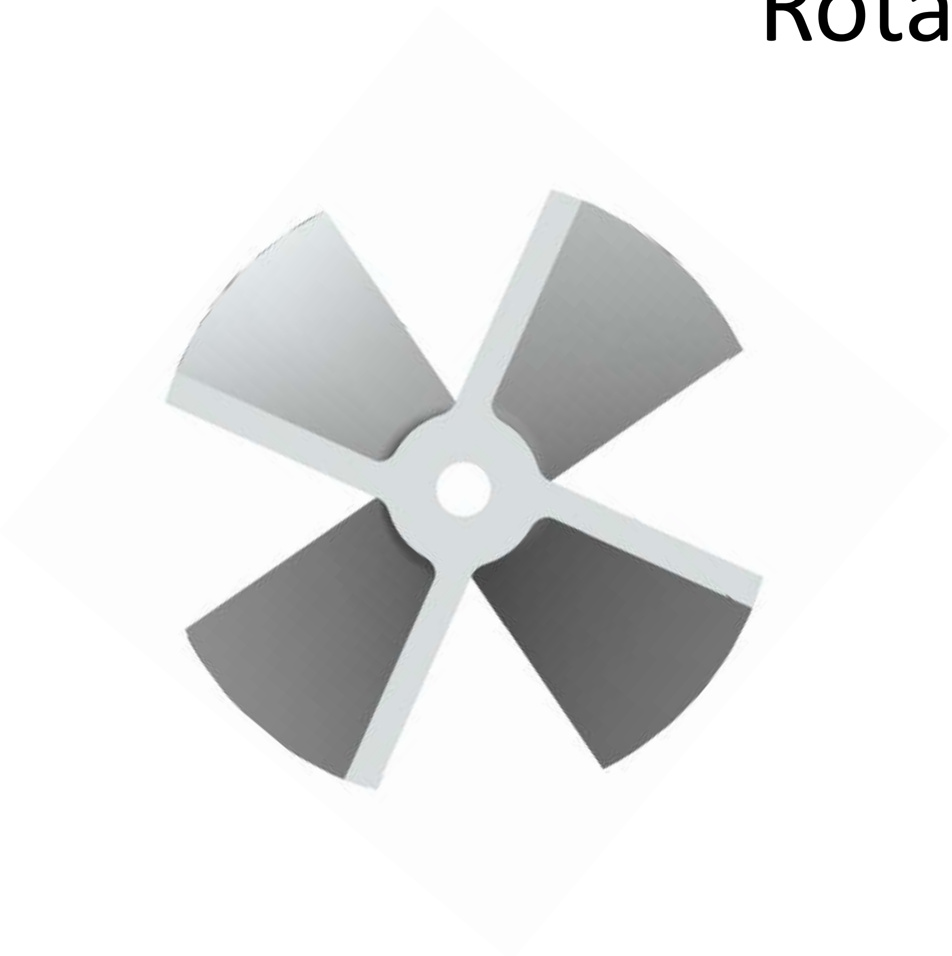


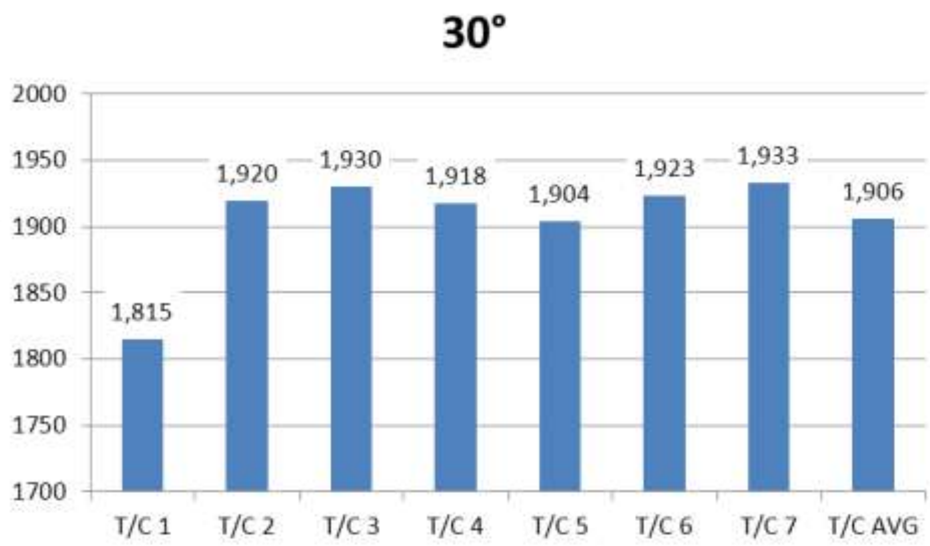


Measured Flame Temperatures - Rotation

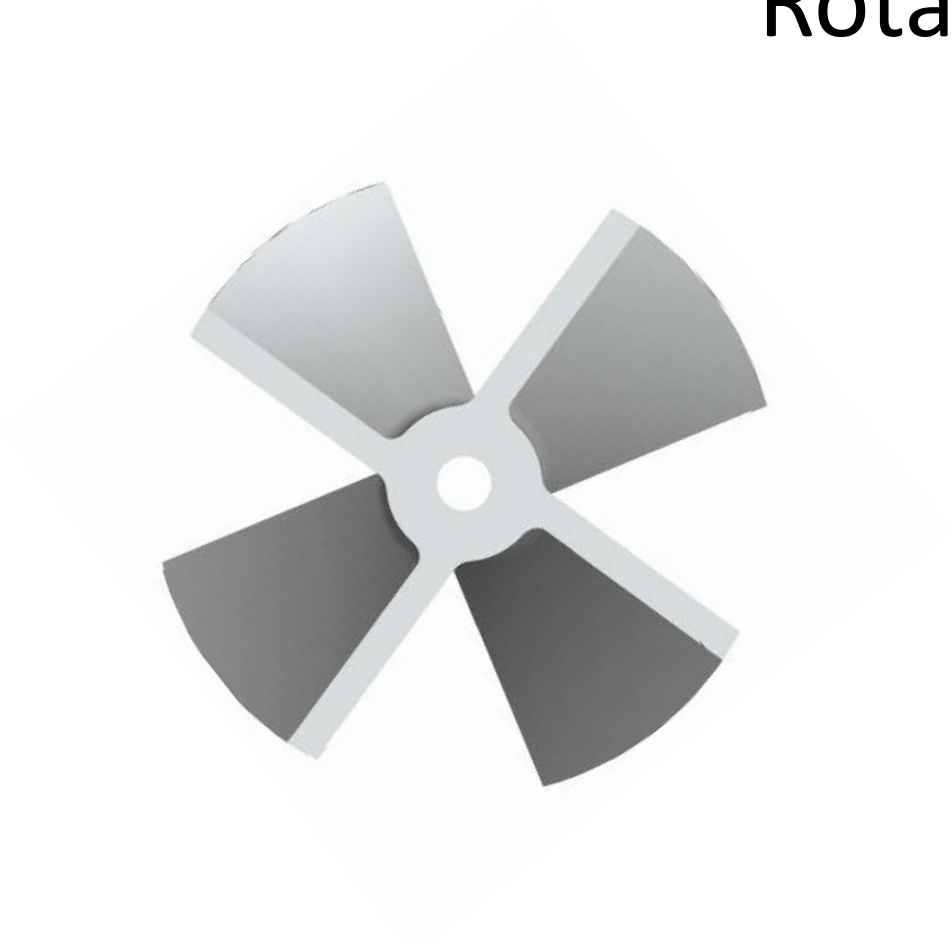


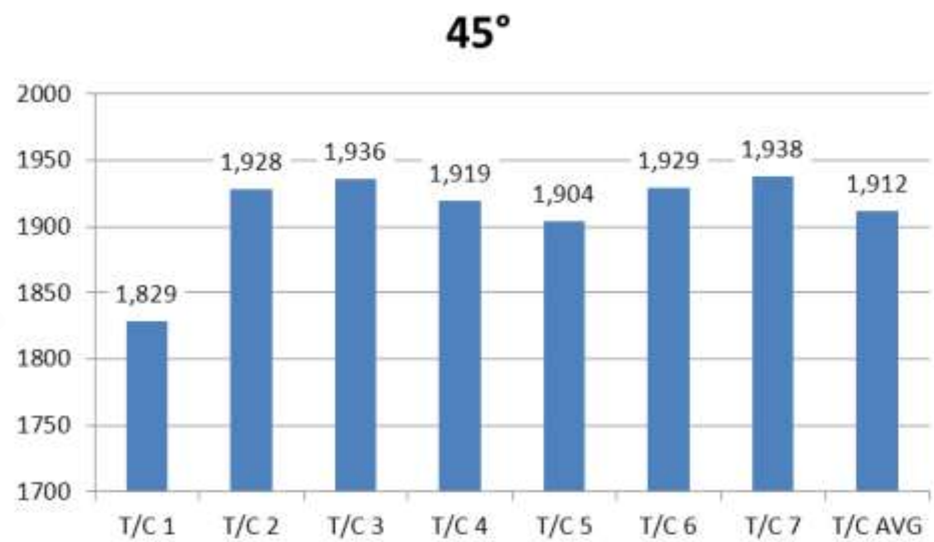
Measured Flame Temperatures - Rotation



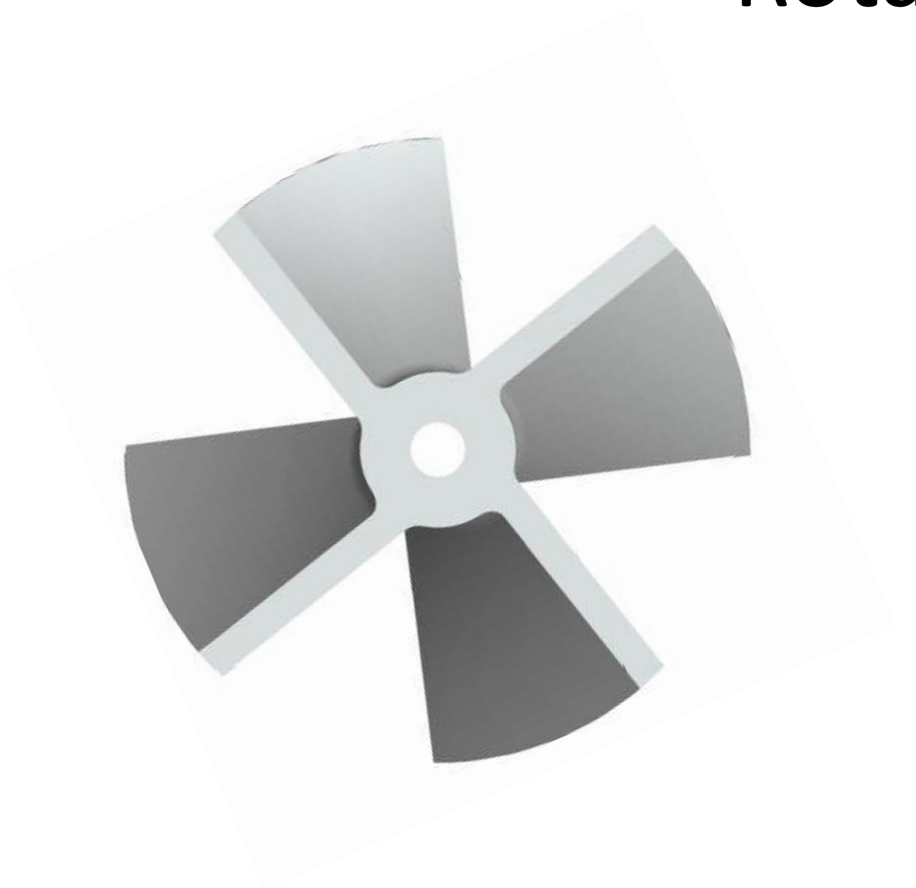


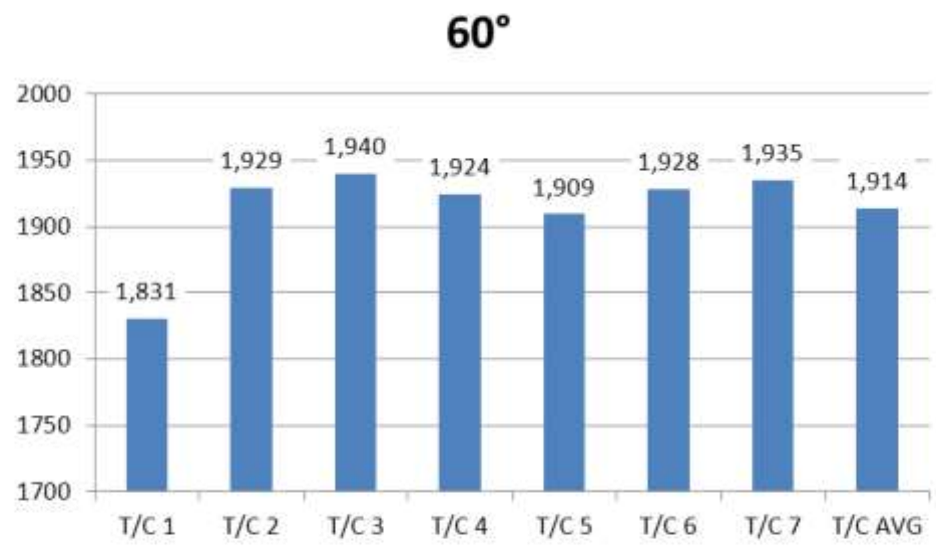
Measured Flame Temperatures - Rotation



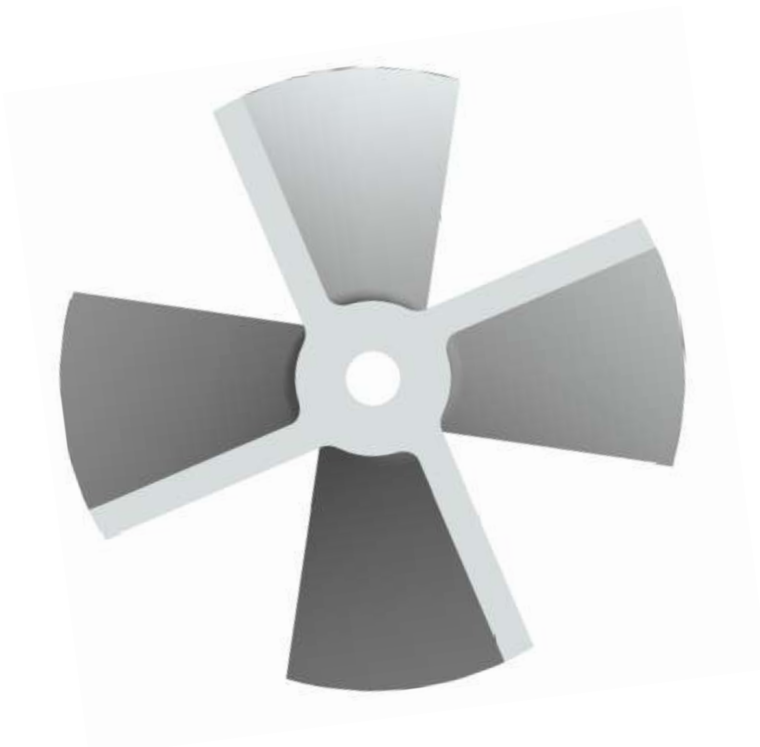


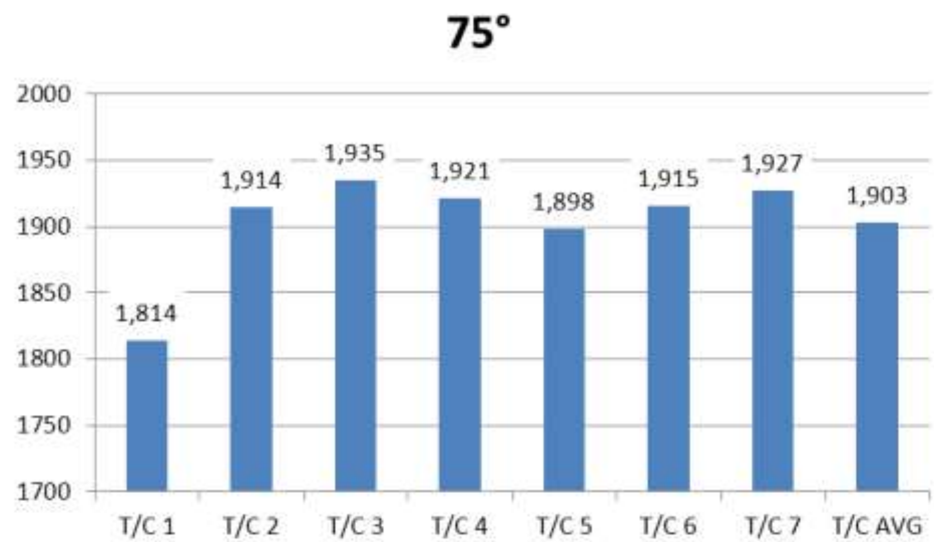
Measured Flame Temperatures - Rotation



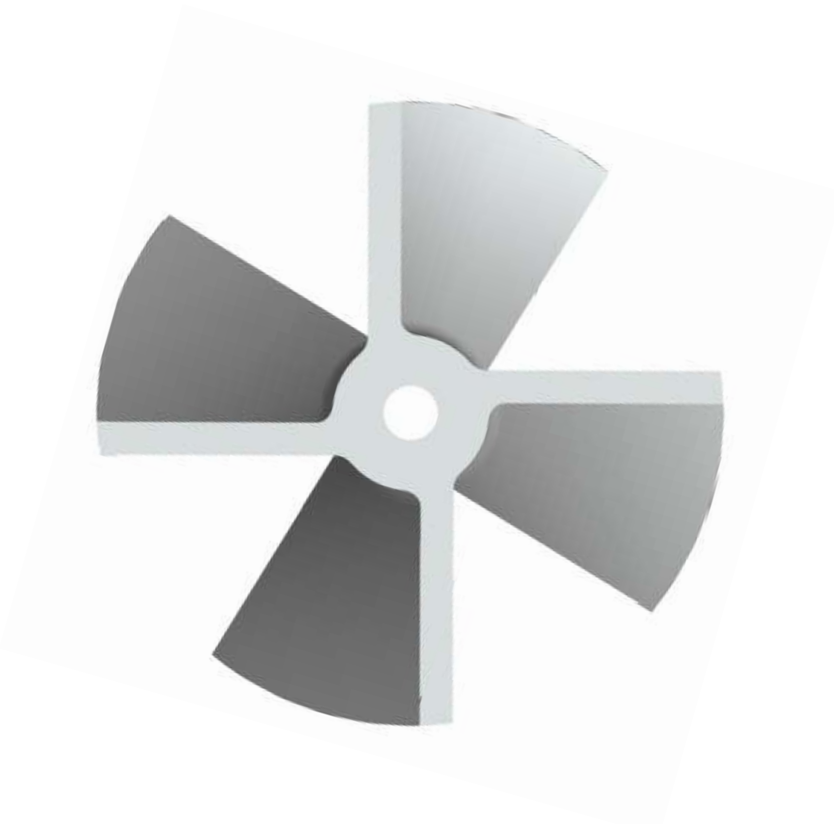


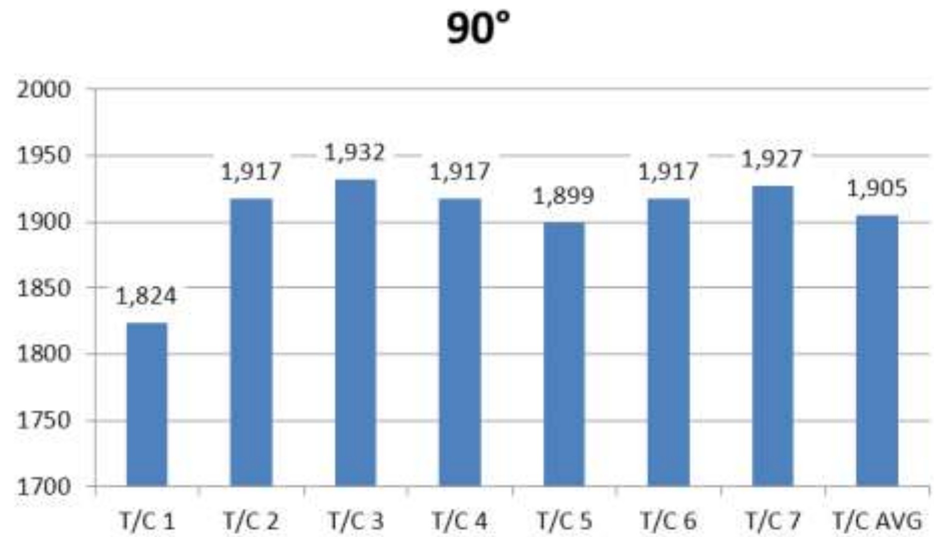
Measured Flame Temperatures - Rotation



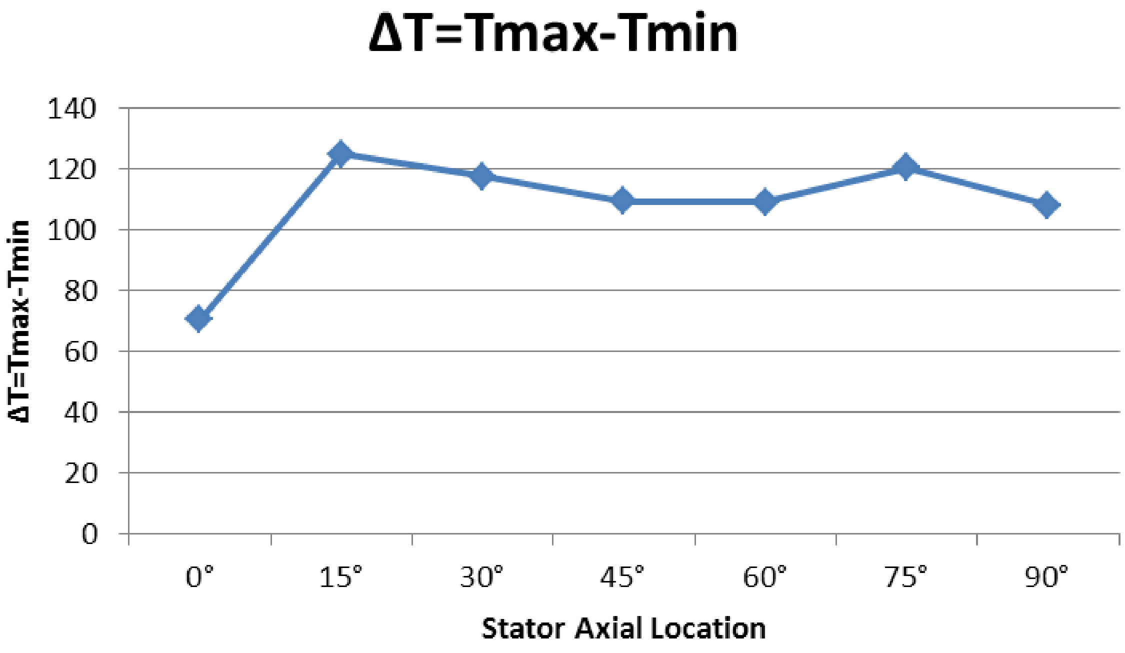


Measured Flame Temperatures - Rotation





Stator Rotation: $\Delta T = T_{max} - T_{min}$

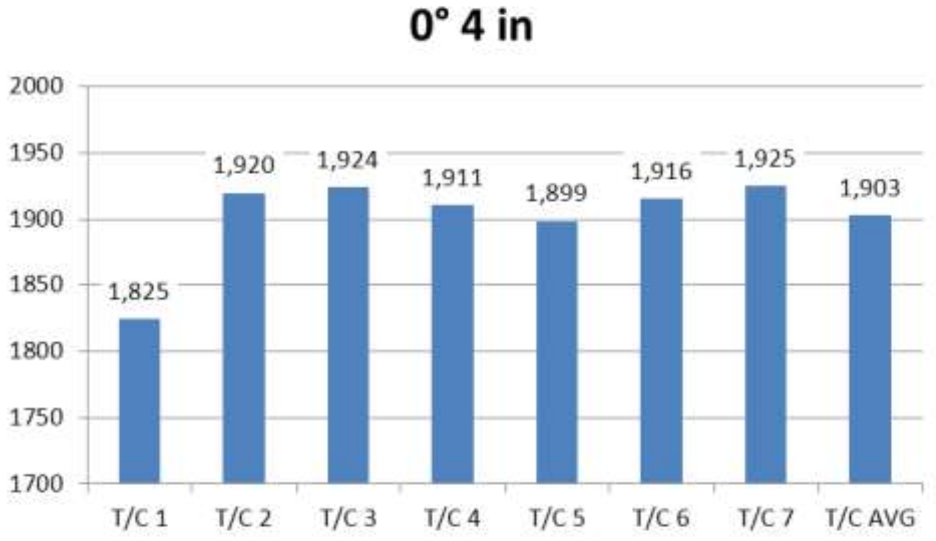


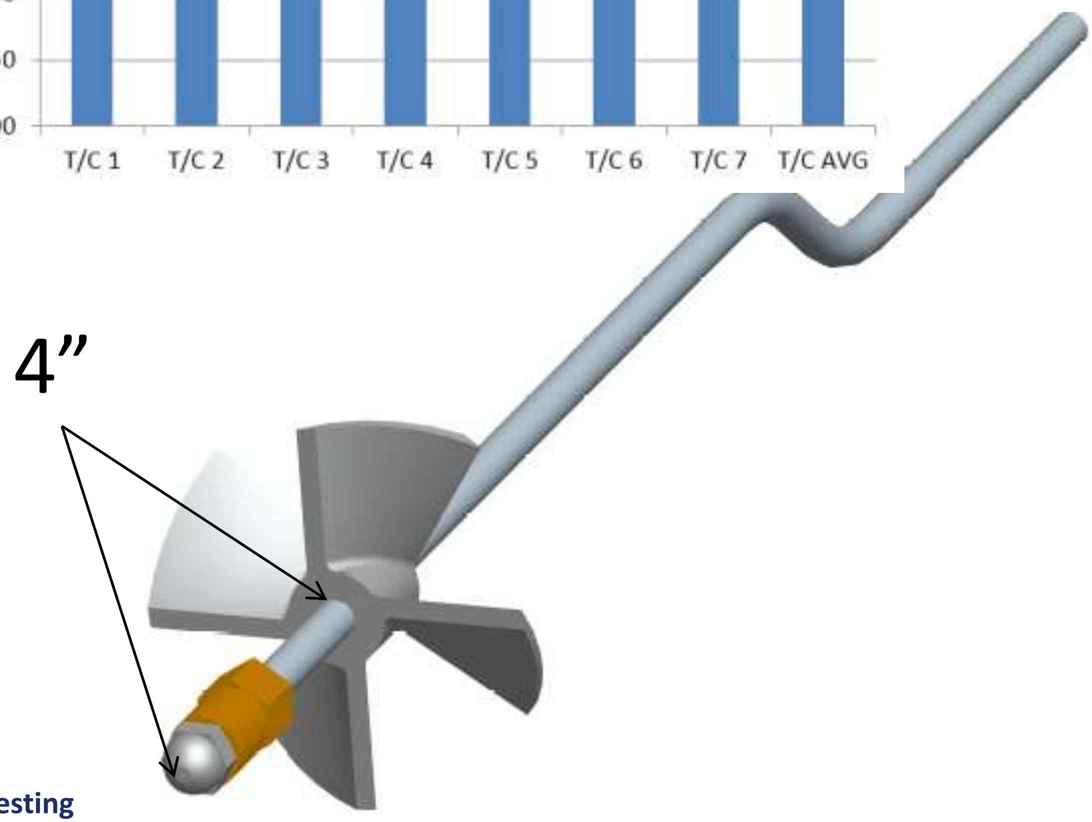
- ΔT is used to determine the uniformity of the flame temperature measurement, smaller ΔT, more uniform profile

Stator Rotation - Summary

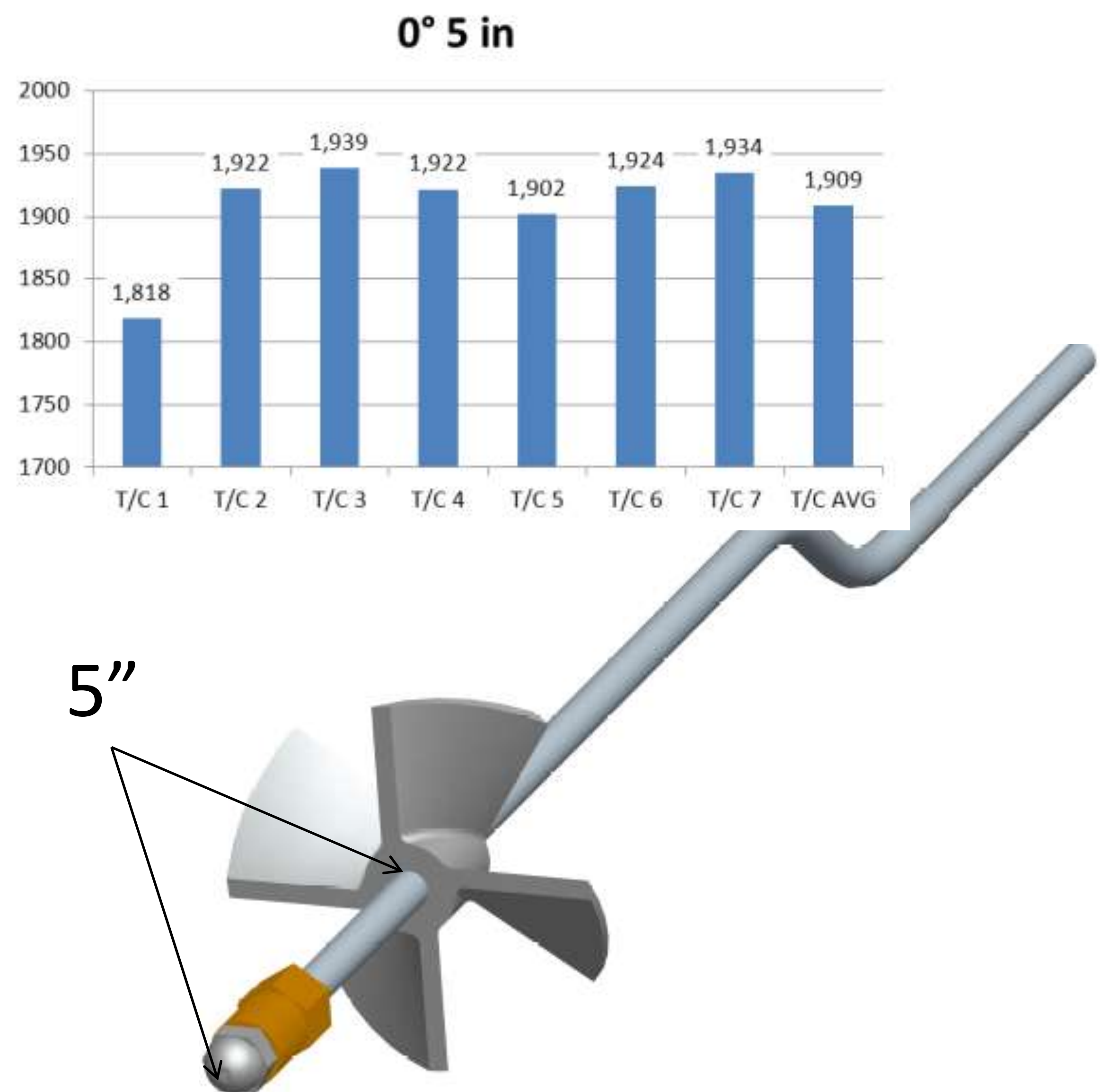
- Rotating the stator over 90° in 15° increments resulted in slightly different flame temperature profiles
- The uniformity of the flame was assessed by subtracting the minimum temperature from the maximum temperature
- The best uniformity was found at 0°, with a spread of 70.36°F

Axial Position

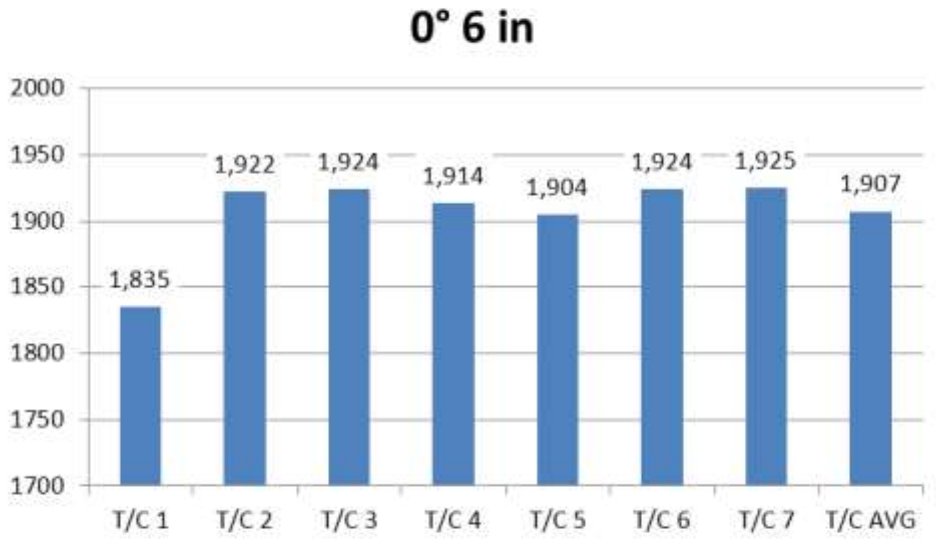


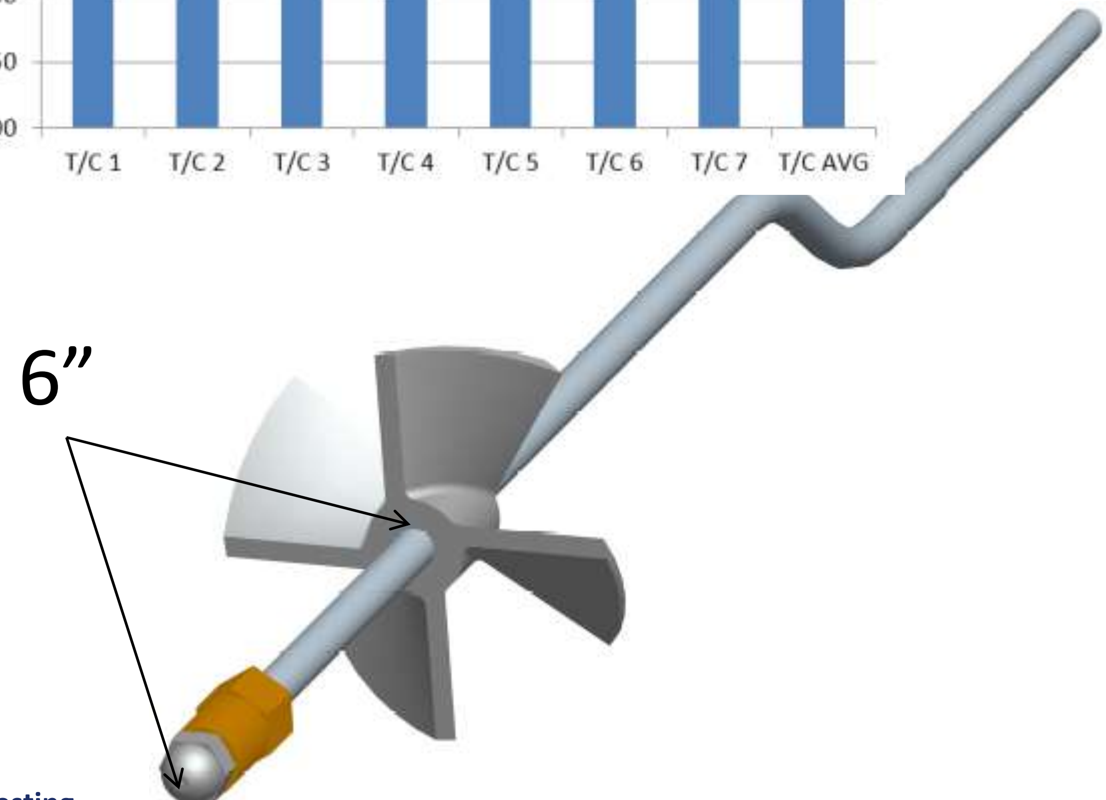


Axial Position

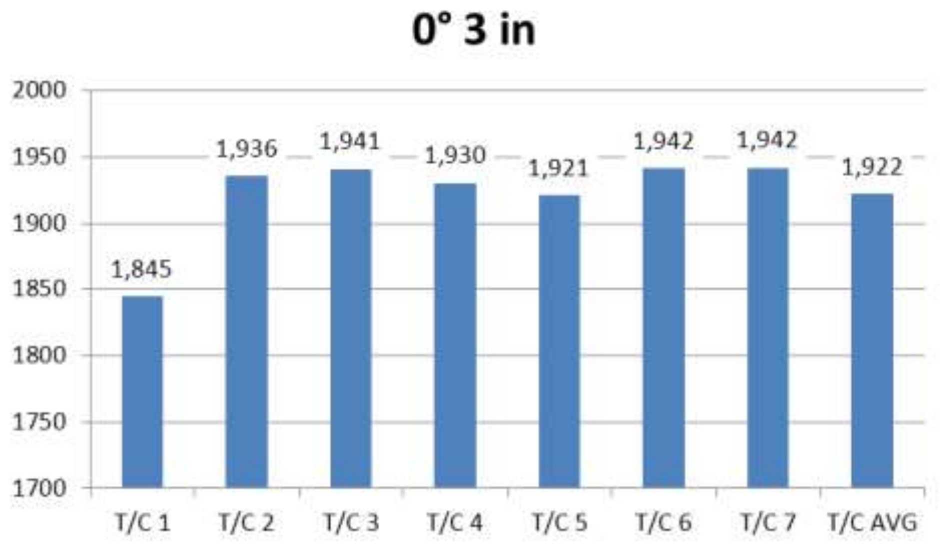


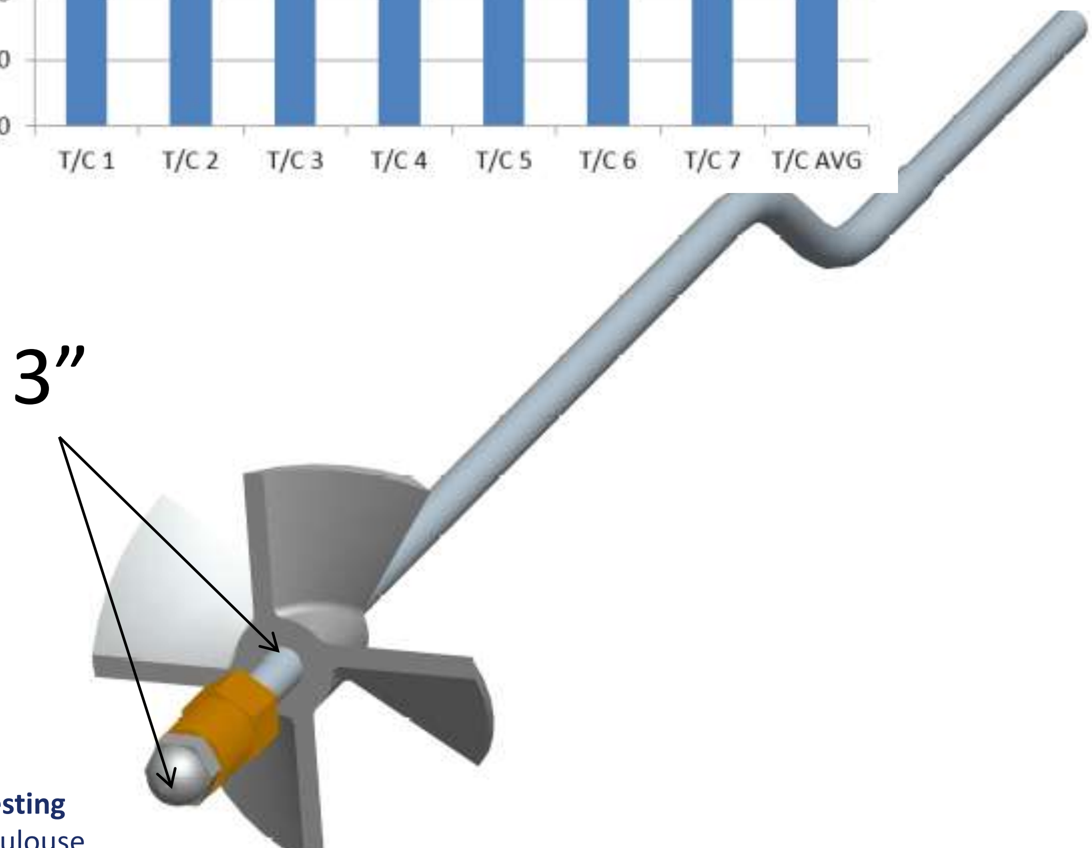
Axial Position



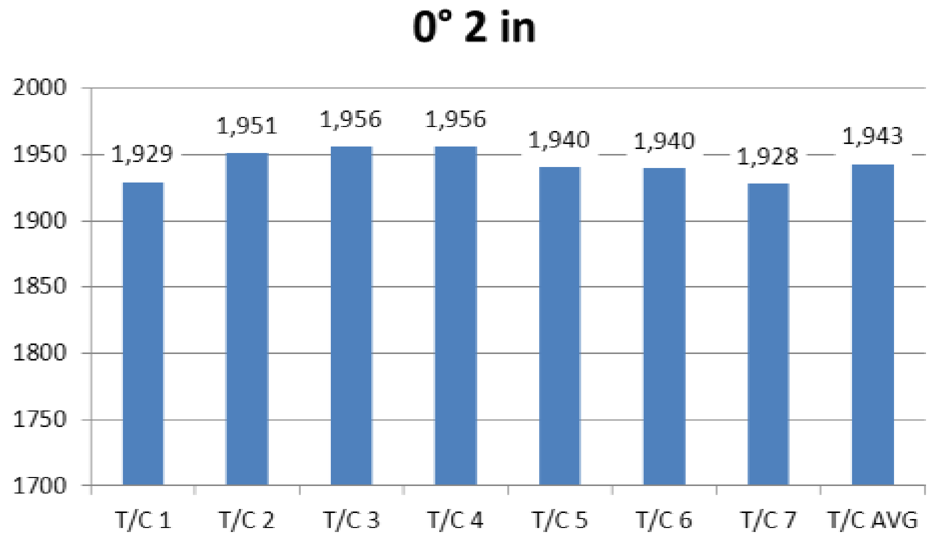


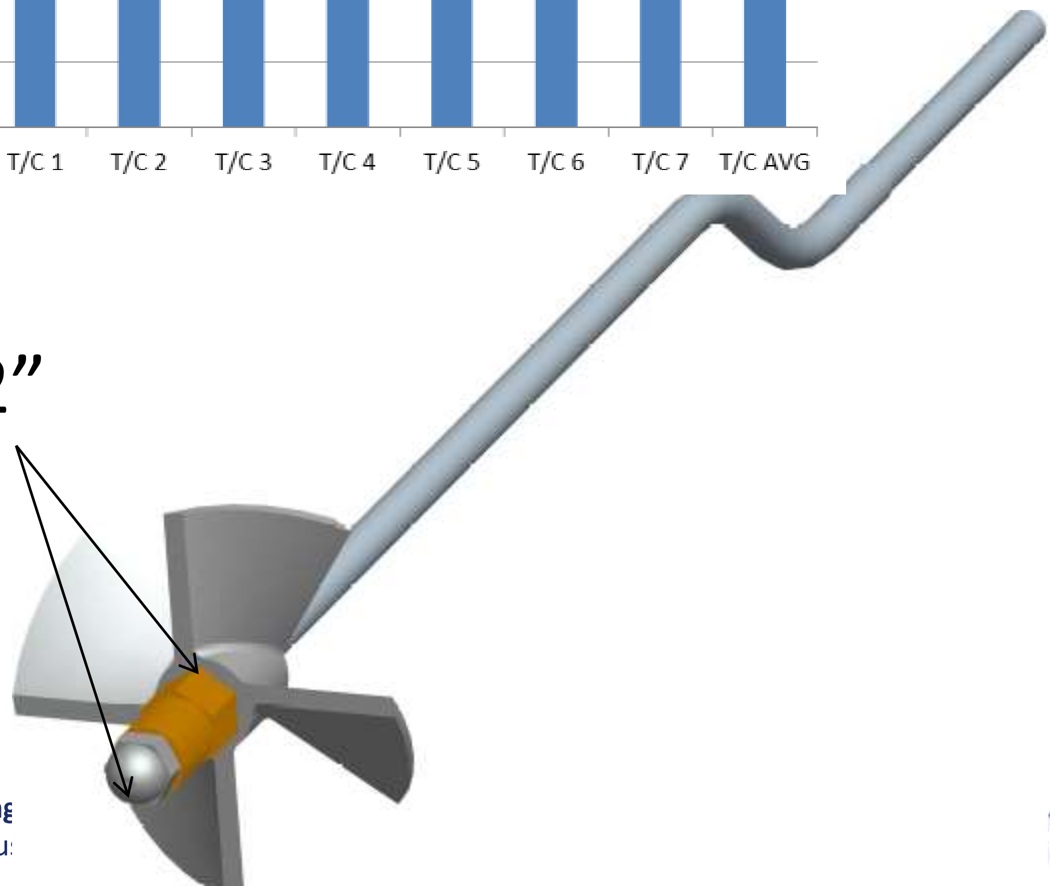
Axial Position



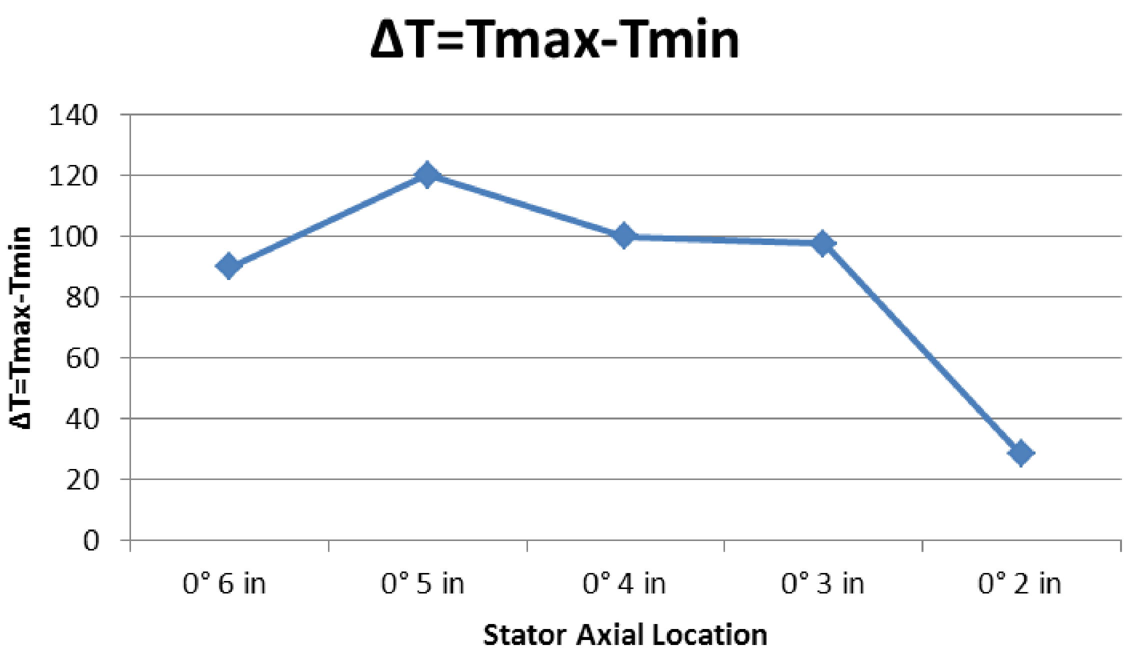


Axial Position





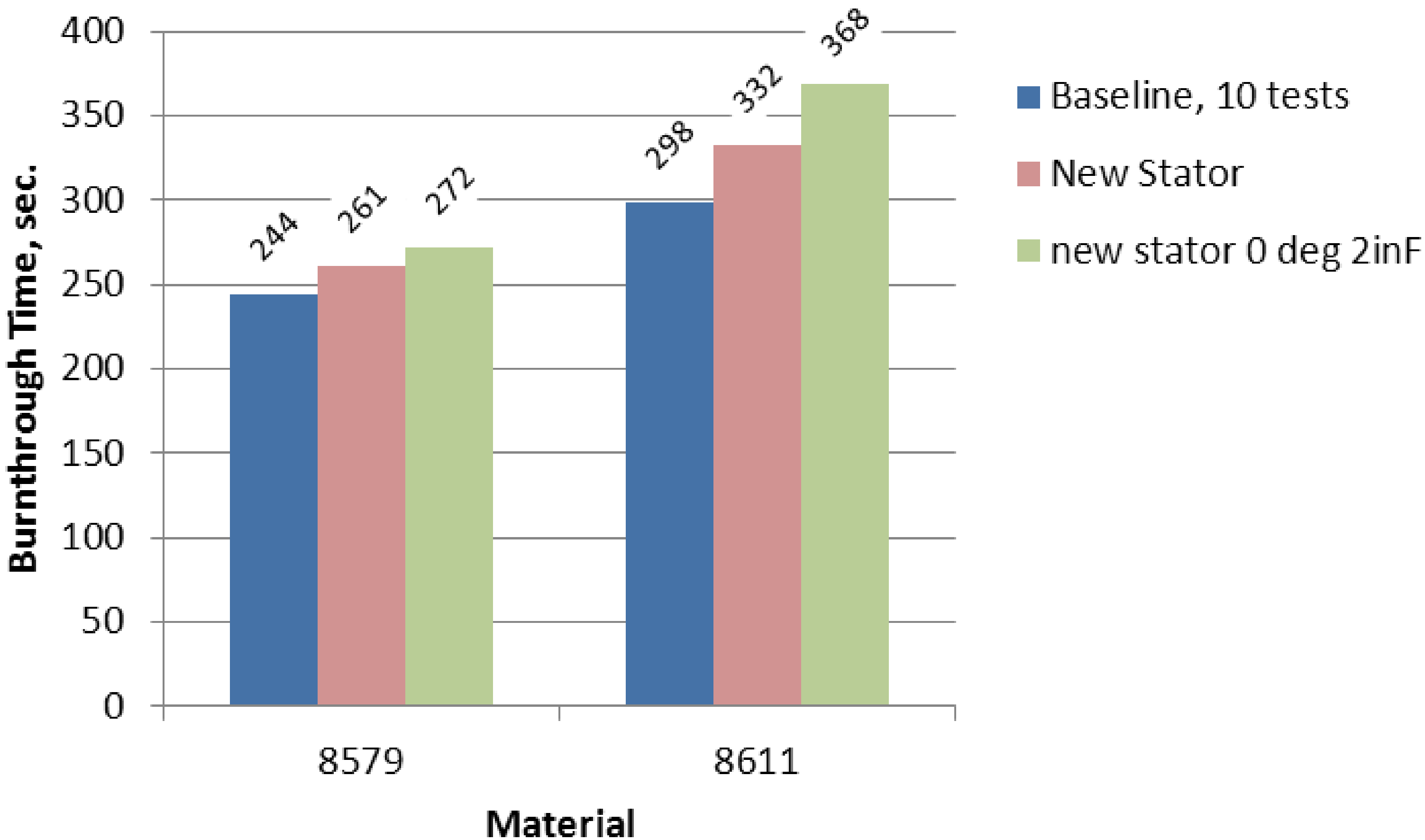
Stator Axial Location: $\Delta T=T_{max}-T_{min}$



Axial Translation – Summary

- Translating the stator on the axis of the burner over a range of 4 inches in 1 inch increments resulted in slightly different flame temperature profiles
- The overall temperatures increased as the stator was translated closer to the fuel nozzle
- The highest overall flame temperature and best uniformity was found at 2 inches back from the nozzle tip
  - T_{avg}=1942°F
  - ΔT=28°F

New Stator, 0°, 2” from nozzle tip

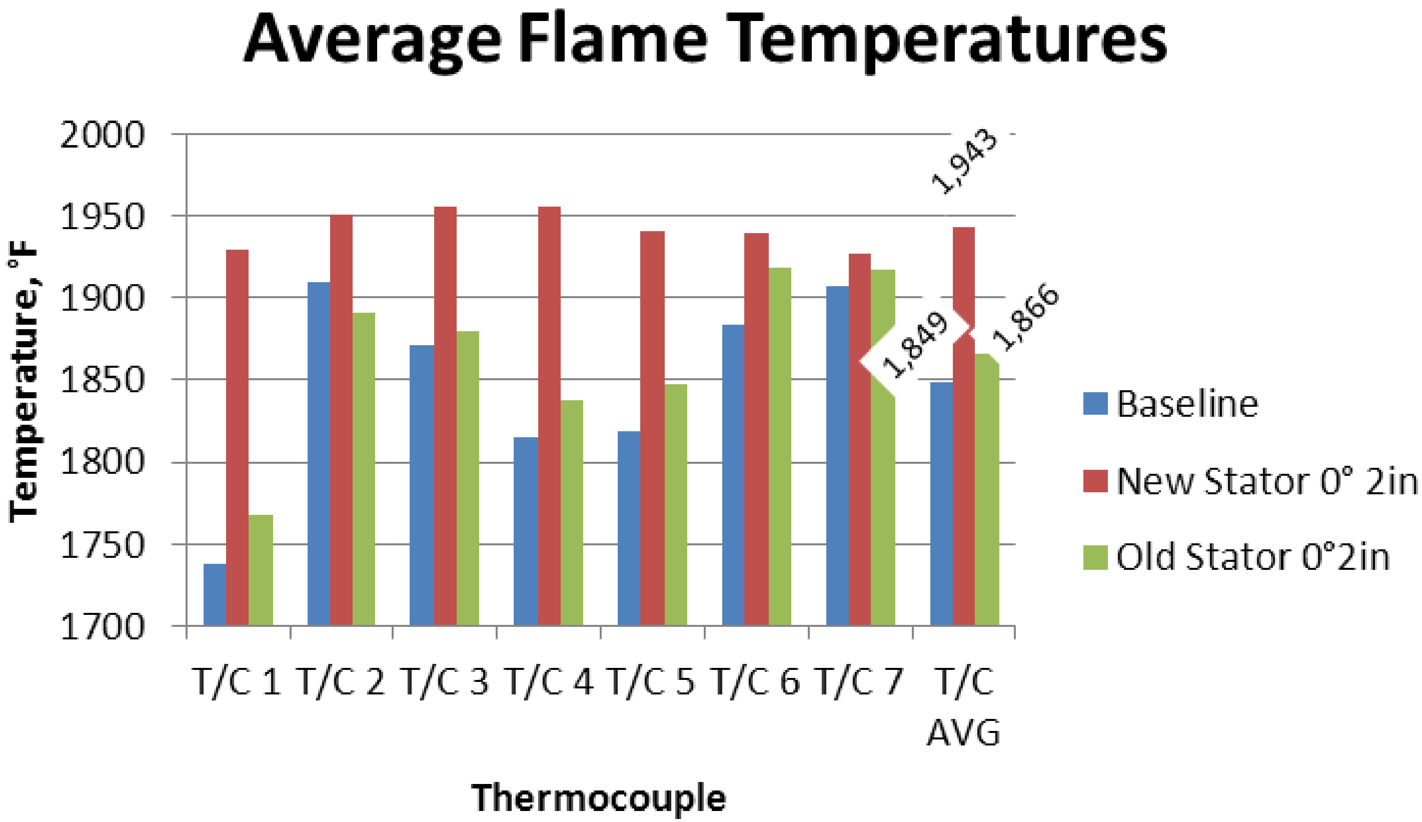


Rotation and Translation Burnthrough

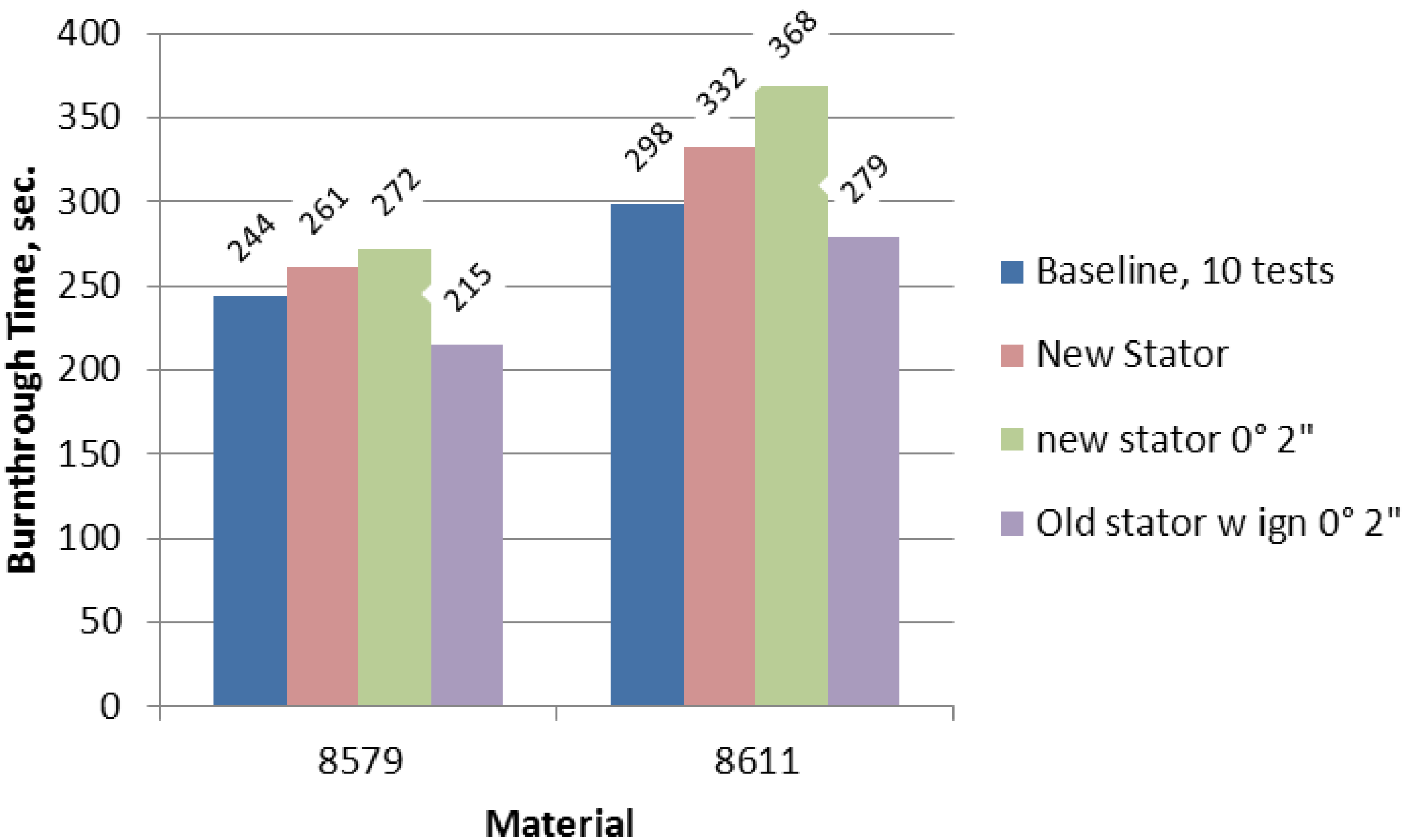
- The most uniform flame temperature profile and the highest overall measured flame temperature resulted in the longest burnthrough for both 8579 and 8611
  - 8579: 271.50
  - 8611: 368.25
- These burnthrough times are longer than the baseline test
  - 8579: 27.20 sec. longer
  - 8611: 69.85 sec. longer

Old Stator, same position as new stator, no wires

Old Stator, same position as new stator, no wires



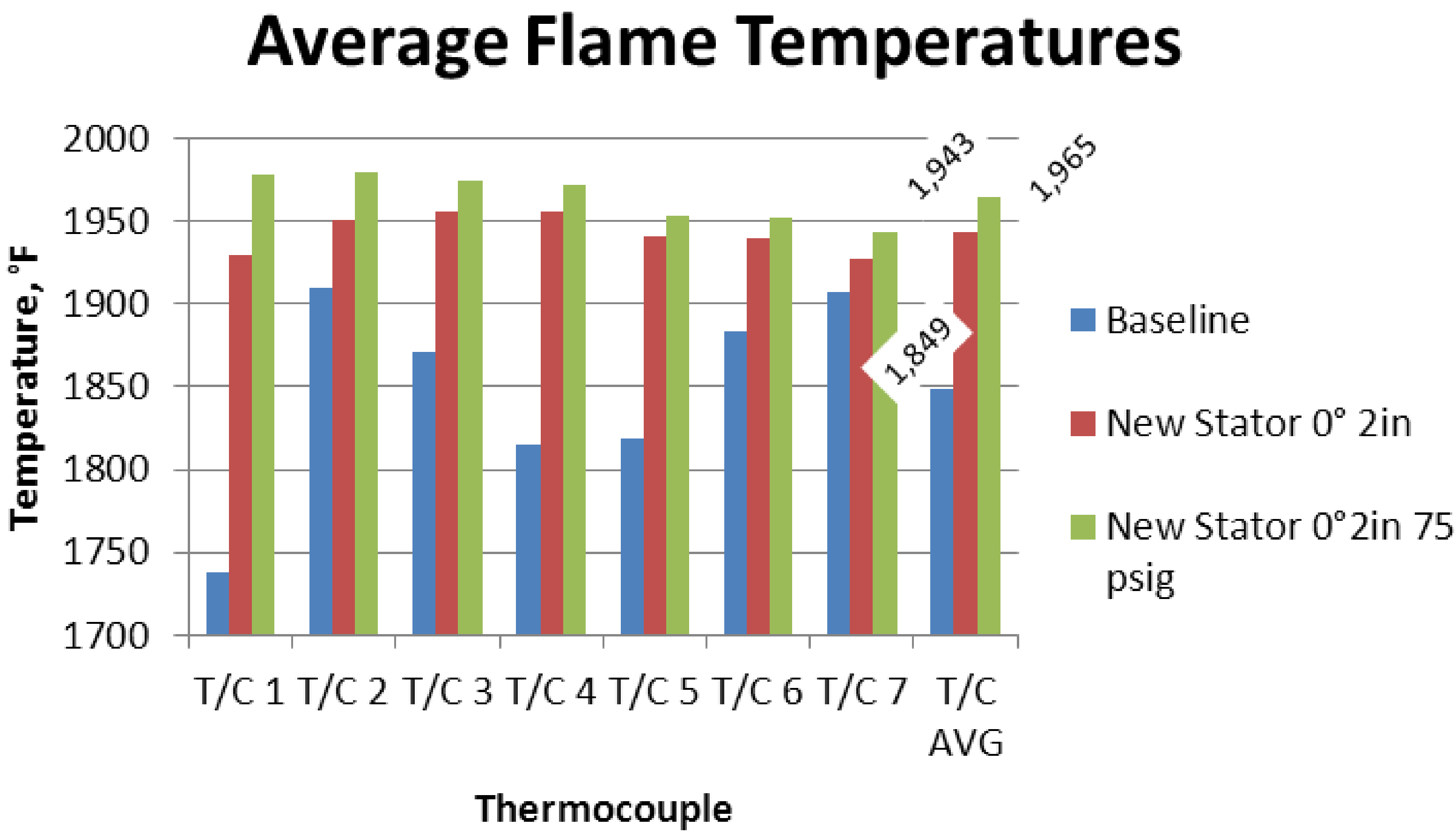
Burnthrough Times



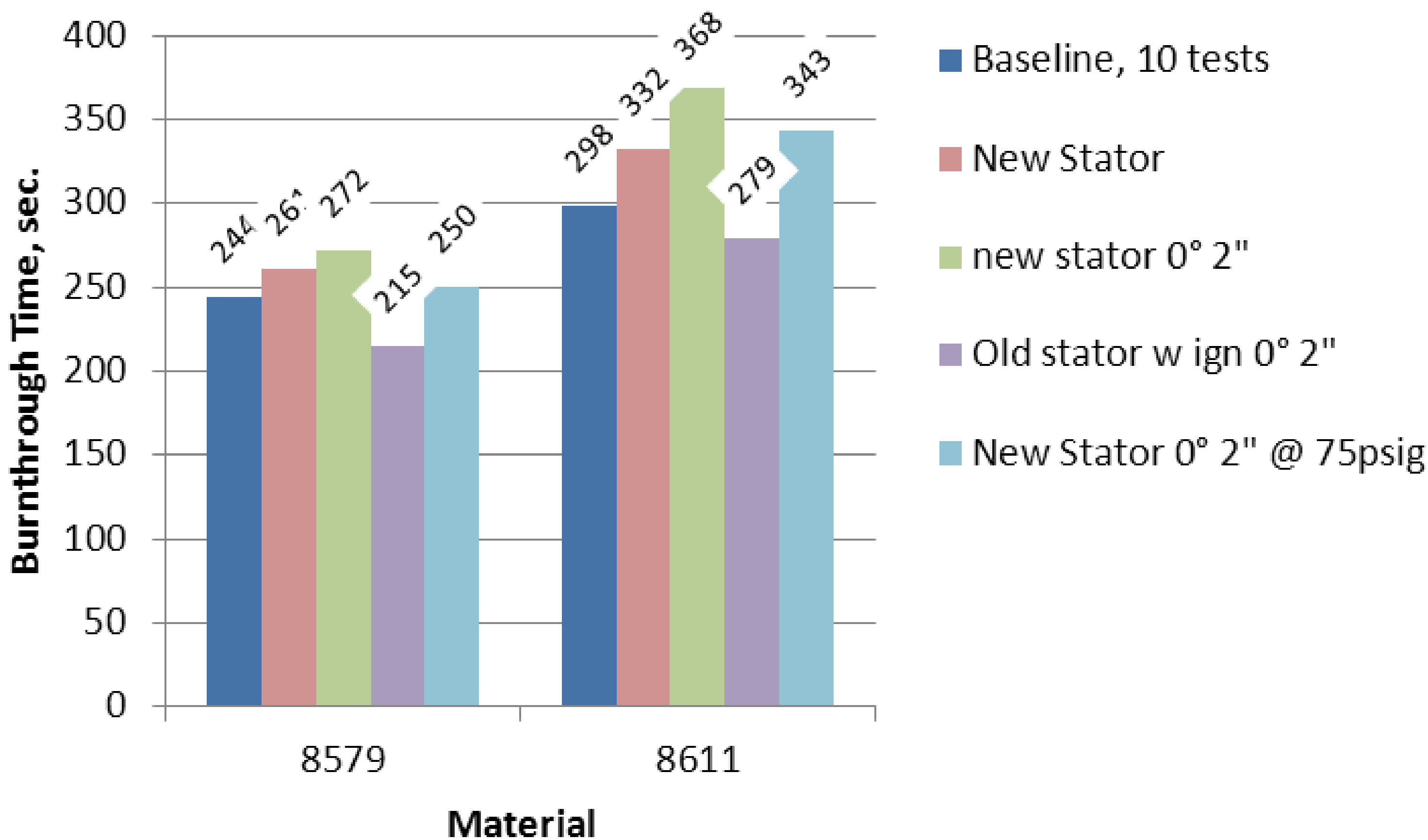
Old stator @ 2" from nozzle tip - Summary

- The old stator and igniters placed in the same position as the new stator resulted in lower flame temperatures with less uniformity
  - New Stator: T_{avg} =1942°F, ΔT=28°F
  - Old Stator: T_{avg} =1865°F, ΔT=151°F
- The old stator and igniters resulted in significantly faster burnthrough times than the new stator and the original baseline
  - 8579: 56.75 sec. quicker than new stator
  - 8611: 89 sec. quicker than new stator
- These tests are proof that the magnitude of the measured flame temperature is not indicative of burner severity

New Stator @ 75psig sonic choke inlet pressure



New Stator @ 75psig sonic choke inlet pressure



New Stator @ 75psig sonic choke inlet pressure Summary

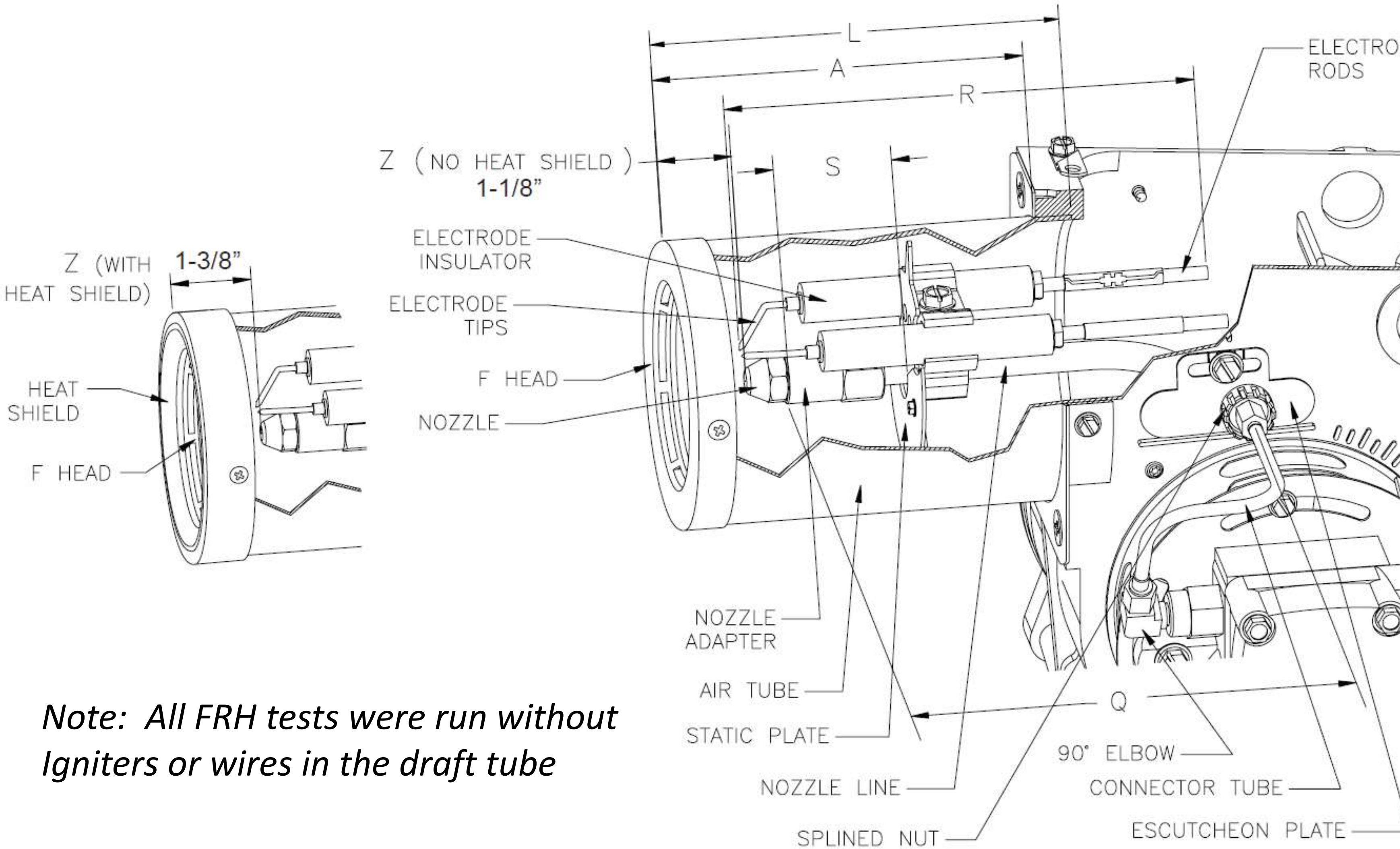
- Increasing the air pressure from 60 psig to 75 psig resulted in the 8579 being closer to the baseline, but the 8611 was still significantly longer
  - 8579: 5.95 sec longer
  - 8611: 44.6 sec longer

Flame Retention Heads (FRH)

F-12 F-22 F-31

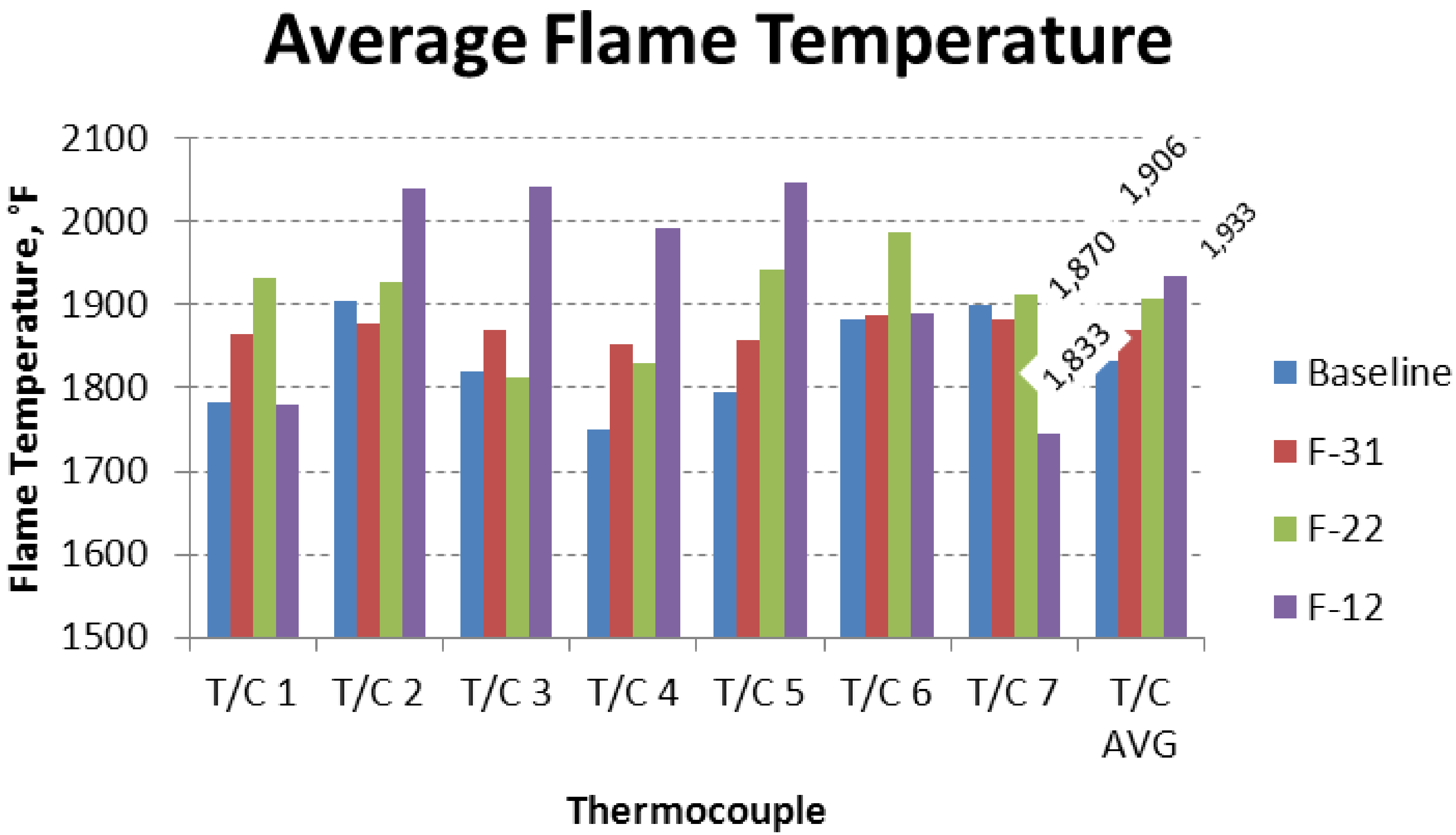
- Beckett flame retention heads were purchased from local supply store
- These heads are used on modern oil burners for more efficient burning
- The heads can be used to create inefficient fuel rich burning that we are looking for by mismatching the air flow and the fuel firing rate
- Benefits of Flame Retention Heads
  - One component replaces both the stator and turbulator
  - Reduces the amount of specification required for burner
  - Rotationally symmetric

Nozzle Depth

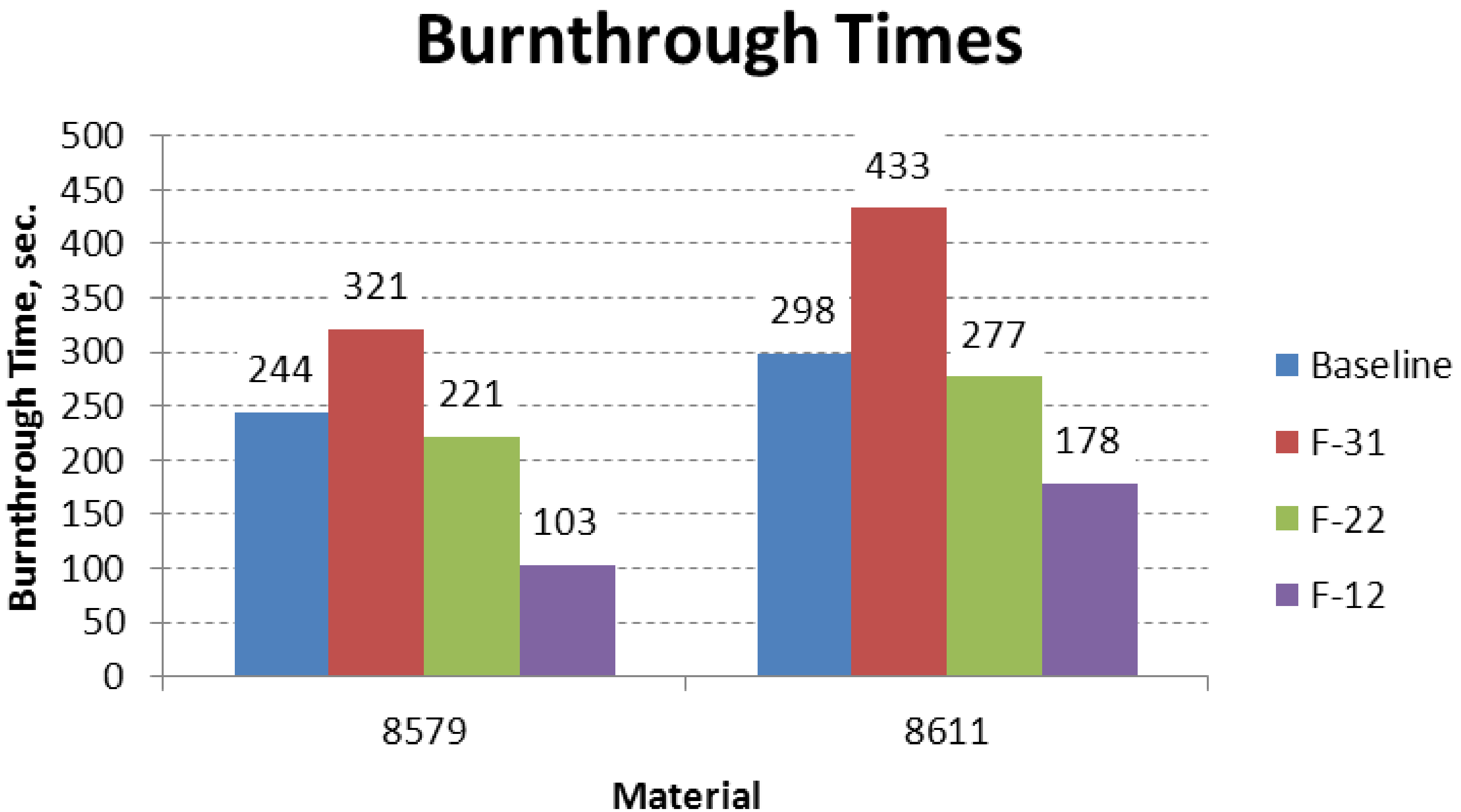


Note: All FRH tests were run without Igniters or wires in the draft tube

Flame Retention Heads



Flame Retention Heads



Flame Retention Heads - Summary

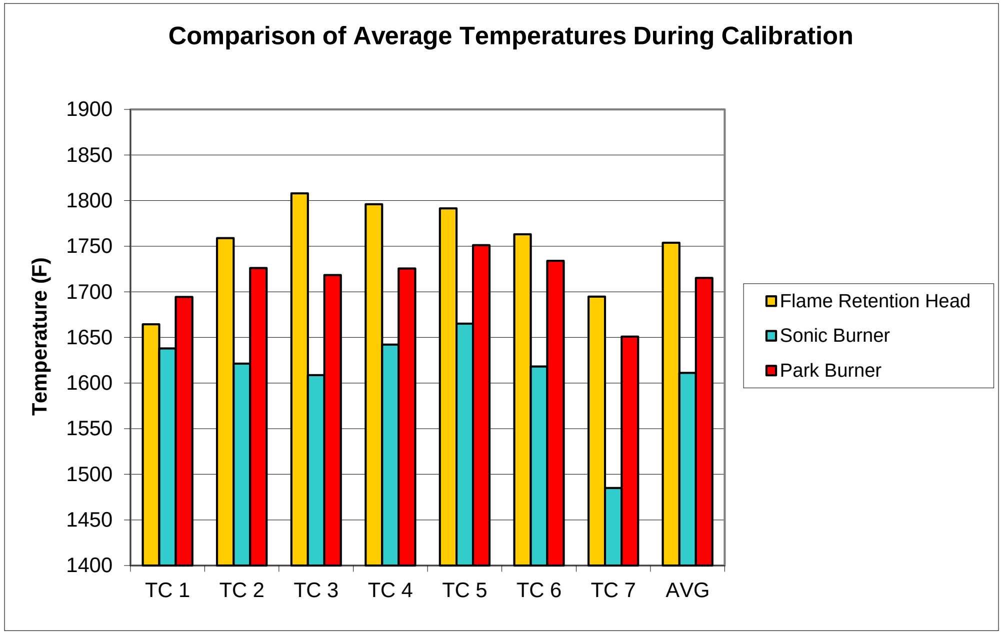
- The flame retention heads give different temperature profiles depending on the size of the coflow air passages
- Overall the flame temperatures were higher with flame retention heads than with stator and turbulator
- A wide range of burnthrough times were obtained for the different heads, generally the larger the coflow air passages, the longer the burnthrough time
- The F-22 head seems to give the closest burnthrough time to the baseline nexgen burner configuration

FRH for Cargo Liner and Seat Burners

Flame Retention Head: Description

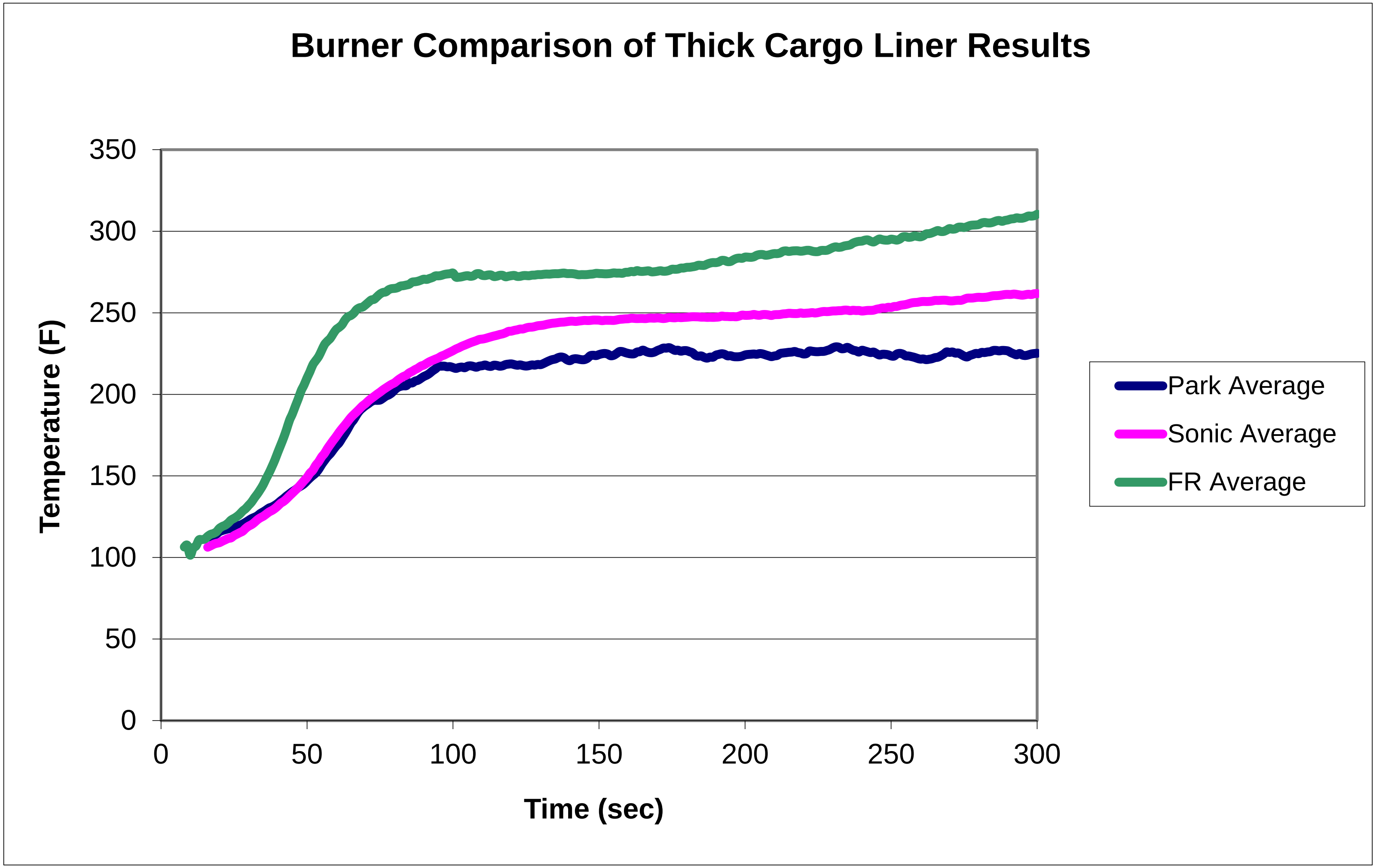
- Eliminates the need for a stator or turbulator
- Fits on end of burner draft tube
- Initial testing shows good potential

Flame Retention Head: Calibration

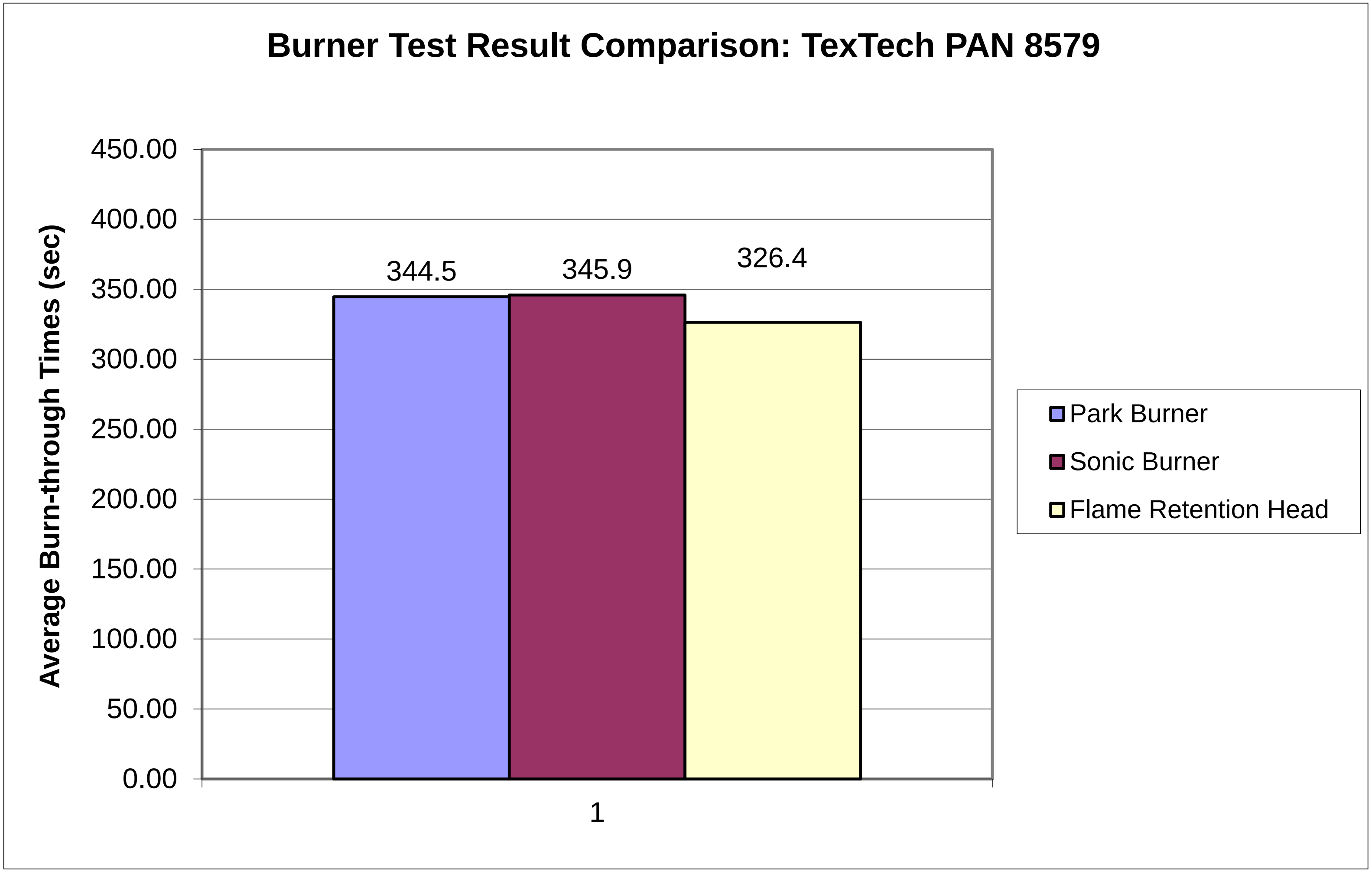


- Calibration readings are significantly higher using the flame retention head compared to sonic readings using the standard stator
- Readings also seemed more consistant from one calibration to the next

Flame Retention Head: Test Results



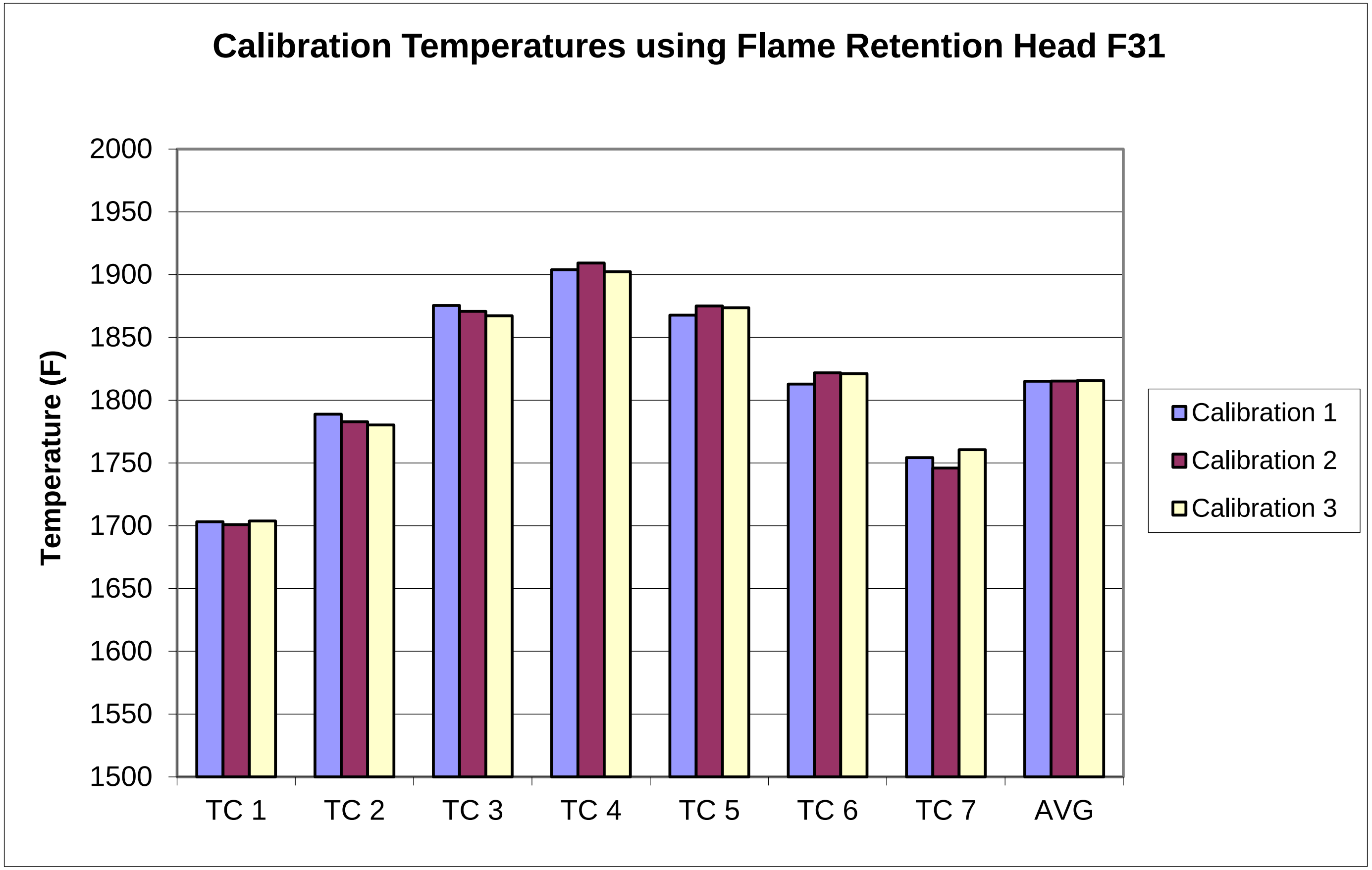
Flame Retention Head: Test Results



Cargo Liner Flame Retention Head: Conclusion

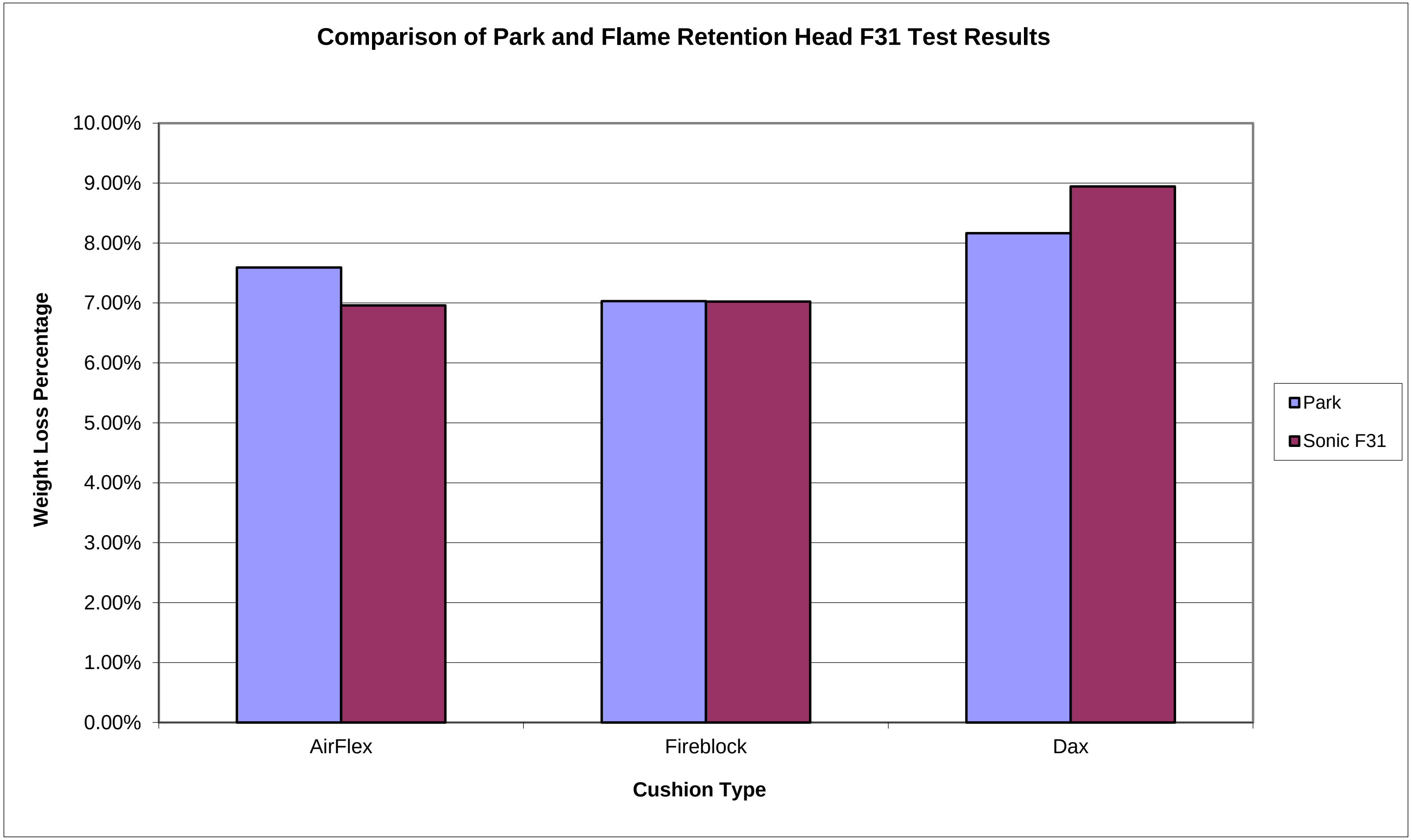
- Simplify setup and adjustments by eliminating stator and turbulator
- Capable of producing higher temperatures
- Flame temperature can be tailored by changing size of holes in flame retention head
- Head tested produced temperatures higher than the Park or sonic burner, as well as decreased burn-through time

FRH for Seat Cushion Burner

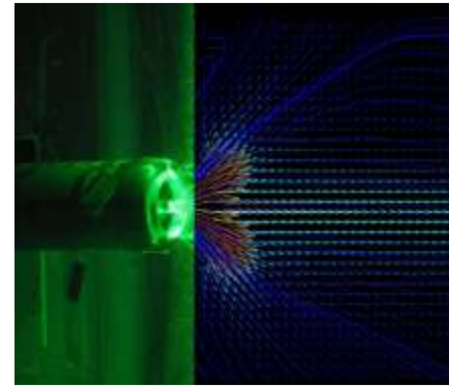


- Extremely low variation of temperature
- Less than 1°F variation of averaged temperatures

FRH for Seat Cushion Burner





Contact:
Robert I. Ochs
Fire Safety Branch
William J. Hughes Technical Center
ANG-E212; Bldg 287
Atlantic City, NJ 08405
T 609 485 4651
E robert.ochs@faa.gov

Federal Aviation Administration