Discussion of Burnthrough Test Method for Aircraft Thermal Acoustic Insulation Blankets

Tim Marker

FAA Technical Center

Items Discussed at June Working Group Meeting

- Results of Round Robin VI

- Differences in burner castings, flanged vs. socket

- Differences in fuel nozzle, “F-80” vs. new style

- Impact of fuel nozzle orientation on calibration and test results

- Results of mini round robin using 6.5 gph nozzle with TexTech felt

Round Robin VI

(Initiated: Spring '04; 3 materials, 8 tests each)

Approach: Visit each lab prior to running tests, utilizing Boeing calibration tools to correct any deficiencies with equipment set-up. Once calibration is achieved, tests could be completed.

Result: Labs A, B, I, and J visited during 2004. Difficulties encountered at each lab during calibration process, preventing completion of tests.

Summary:

All labs capable of obtaining correct temperature profile.

4 of 5 labs capable of obtaining correct heat flux.

All labs: quicker burnthrough times and higher backface heat flux.

Preliminary Conclusion: A calibrated burner does not necessarily produce test results that correlate with FAATC results.

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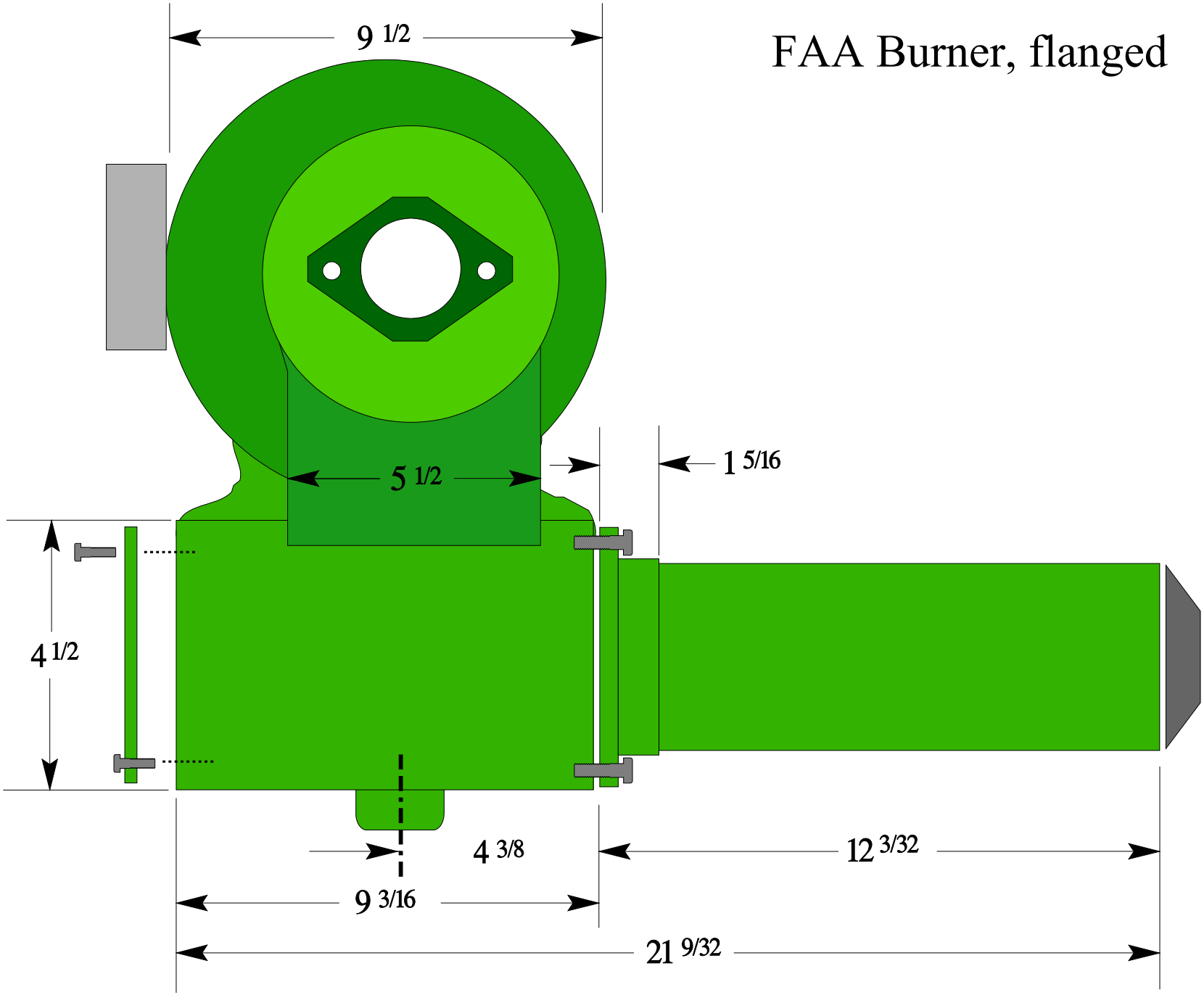
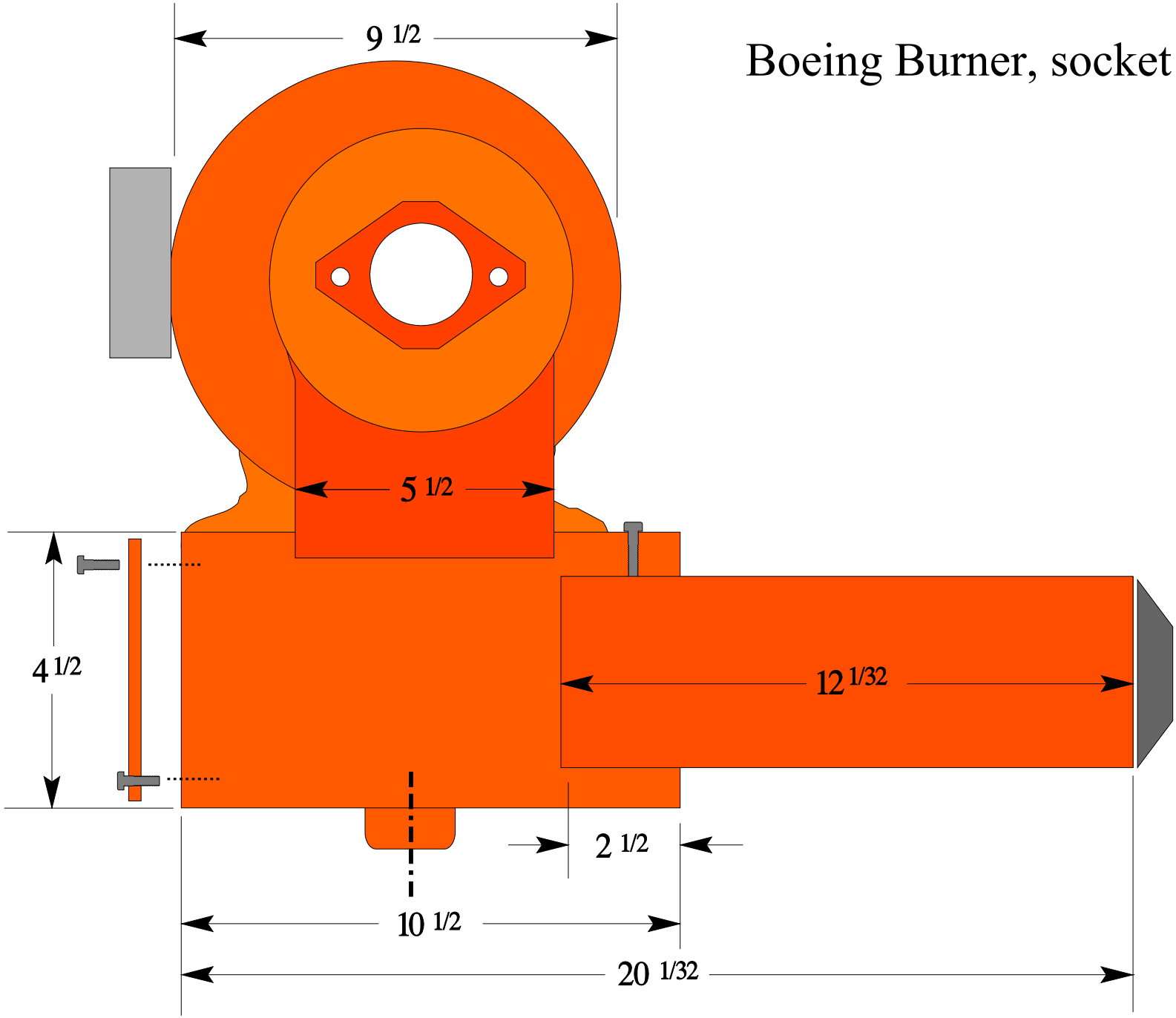
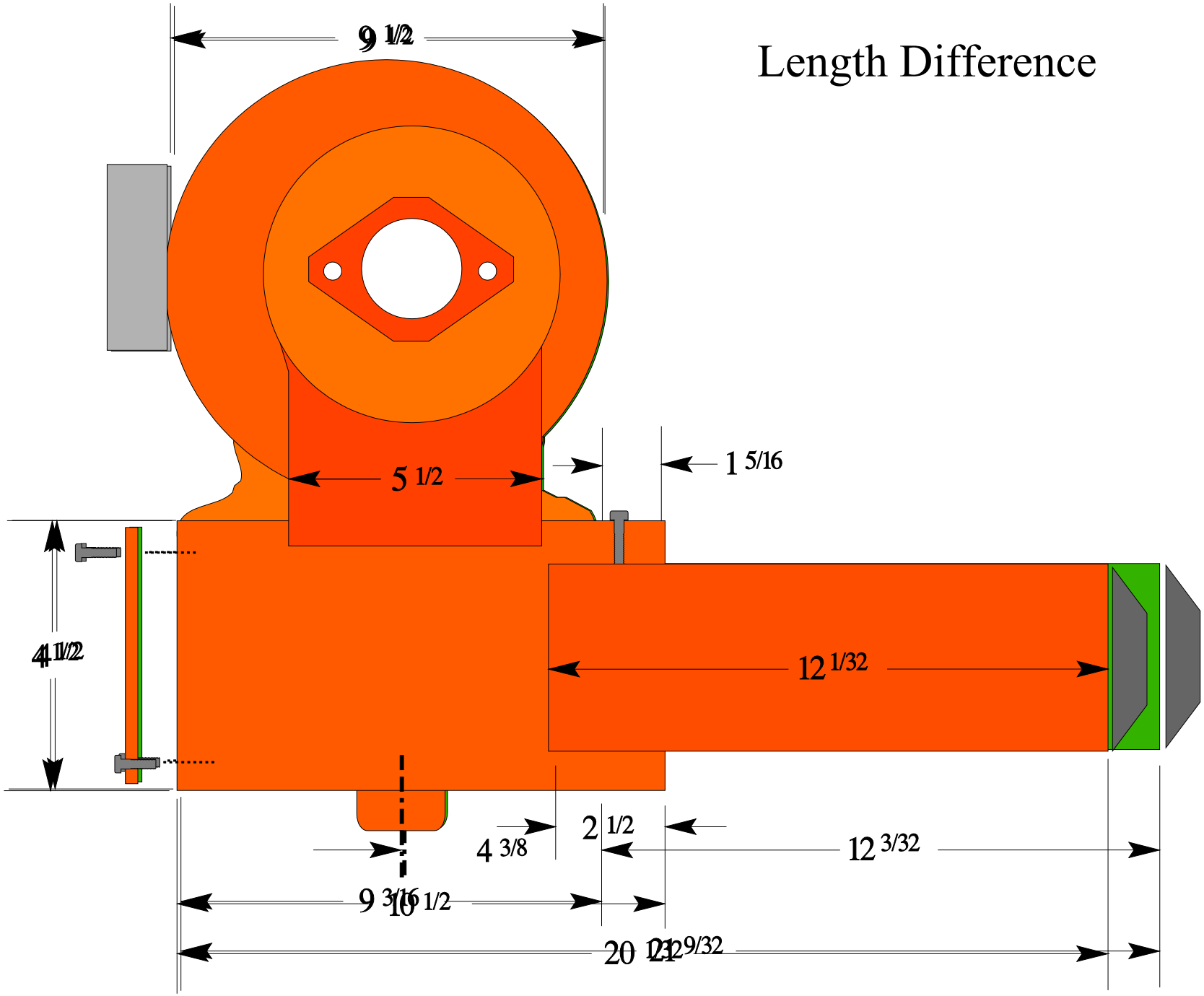
FAA Burner, flanged

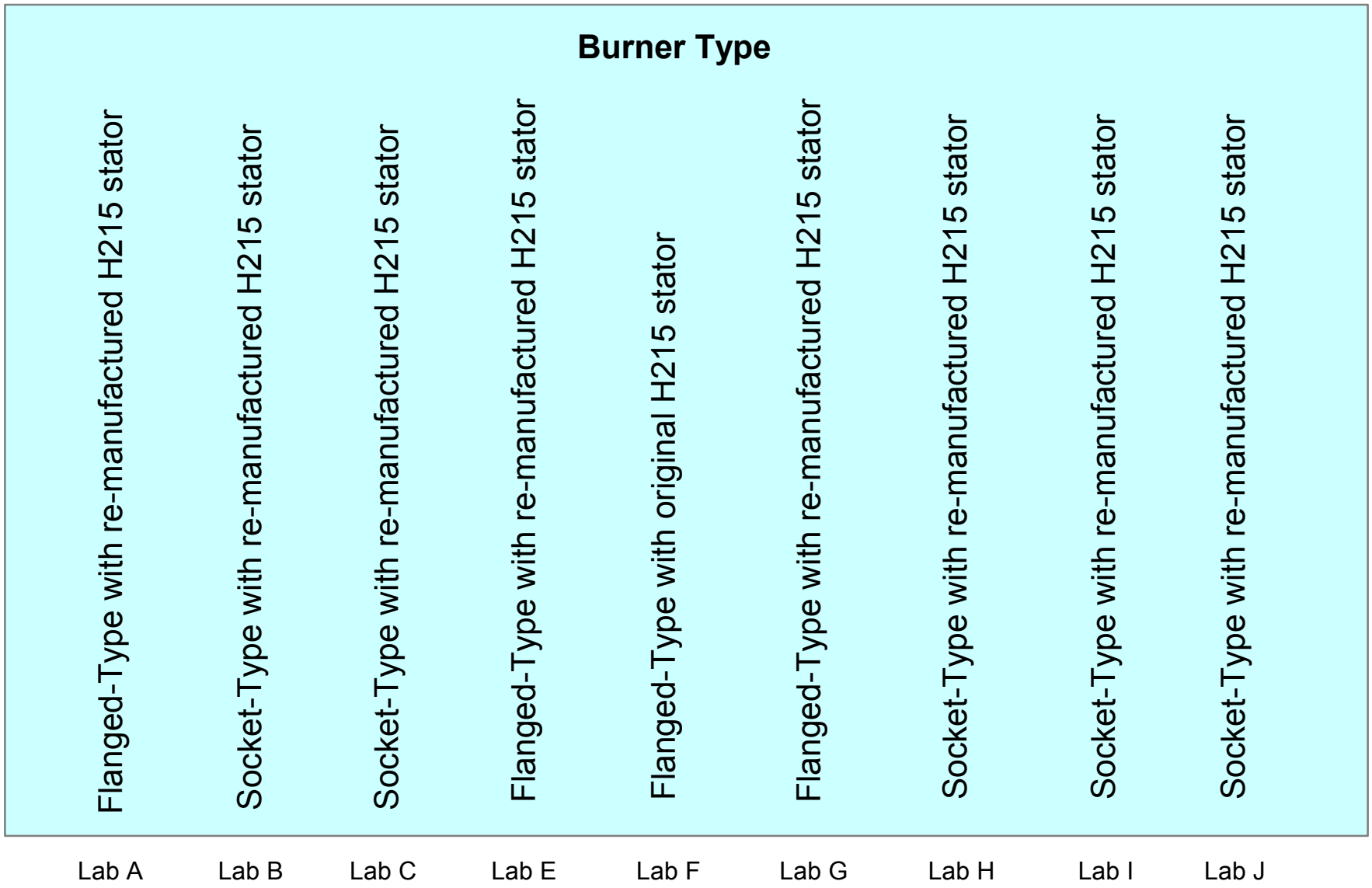


Boeing Burner, socket




Length Difference
9 1/2
5 1/2
1 5/16
4 1/2
12 1/32
4 3/8
2 1/2
12 3/32
9 3/16
10 1/2
20 23 9/32

Survey Results: 4 Flanged, 5 Socket



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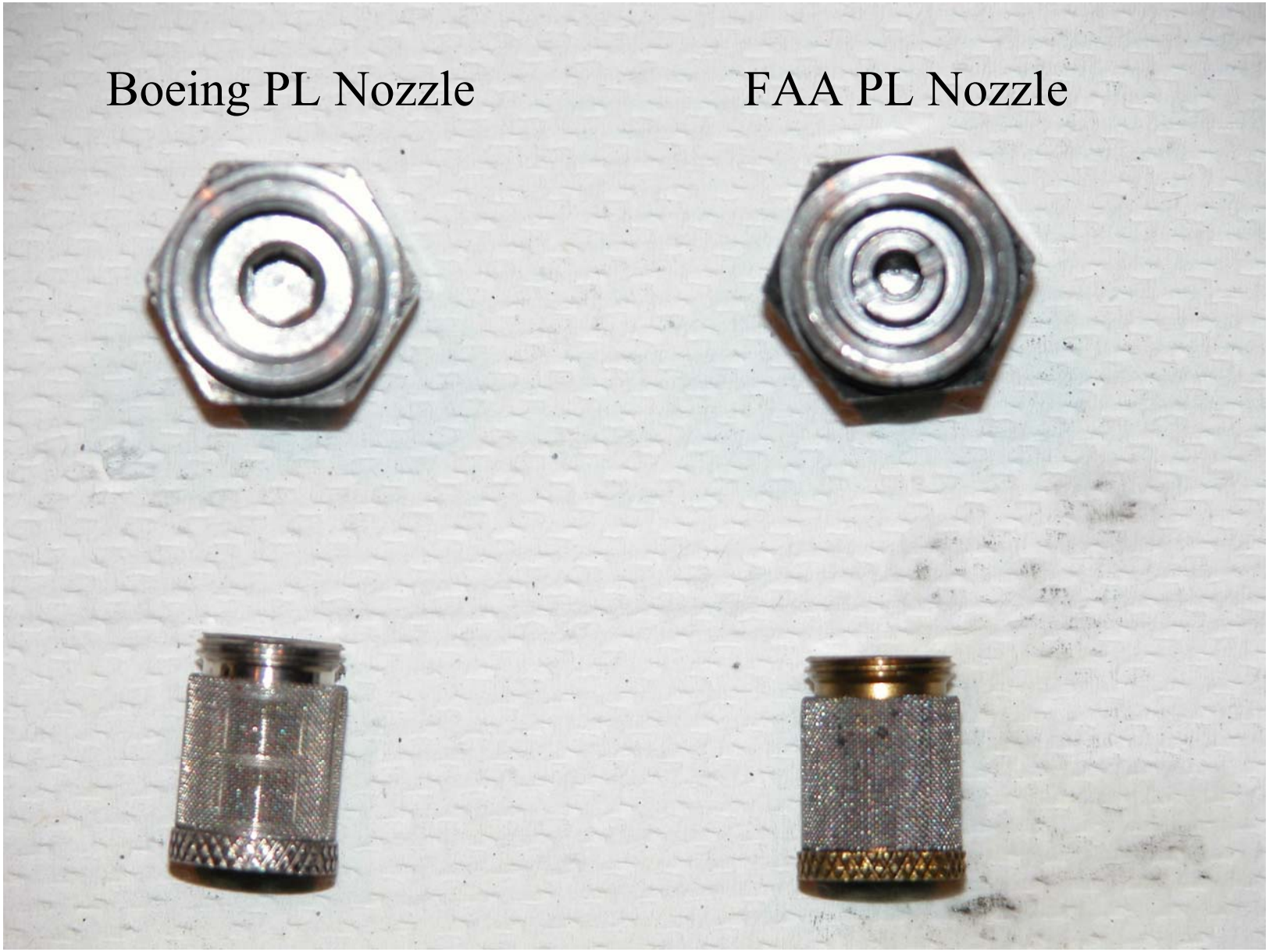
Boeing PL Nozzle

FAA PL Nozzle

Boeing PL Nozzle

FAA PL Nozzle



Boeing PL Nozzle

FAA PL Nozzle

Conclusions of FAA vs. Boeing Trials

Various types of motors do not impact heat flux or burnthrough times.

Replicate stator does not impact heat flux or burnthrough times.

Difference in housing/draft tube does not impact temperature or heat flux.

Difference in fuel nozzle impacts both heat flux and burnthrough times.

More testing needed to determine impact of housing on burnthrough time.

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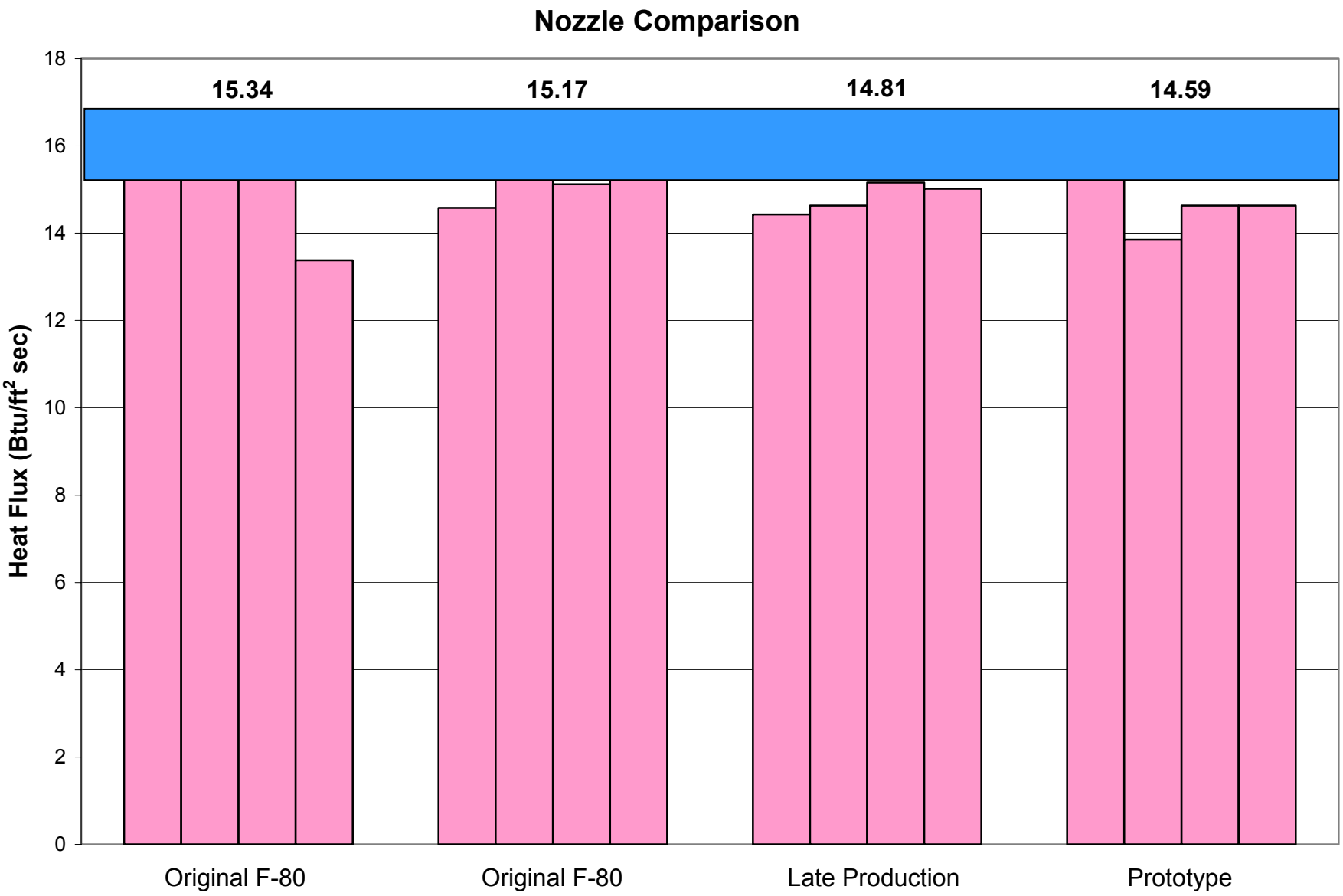
Impact of Rotation on Heat Flux for Various Nozzles



Items Discussed at June Working Group Meeting

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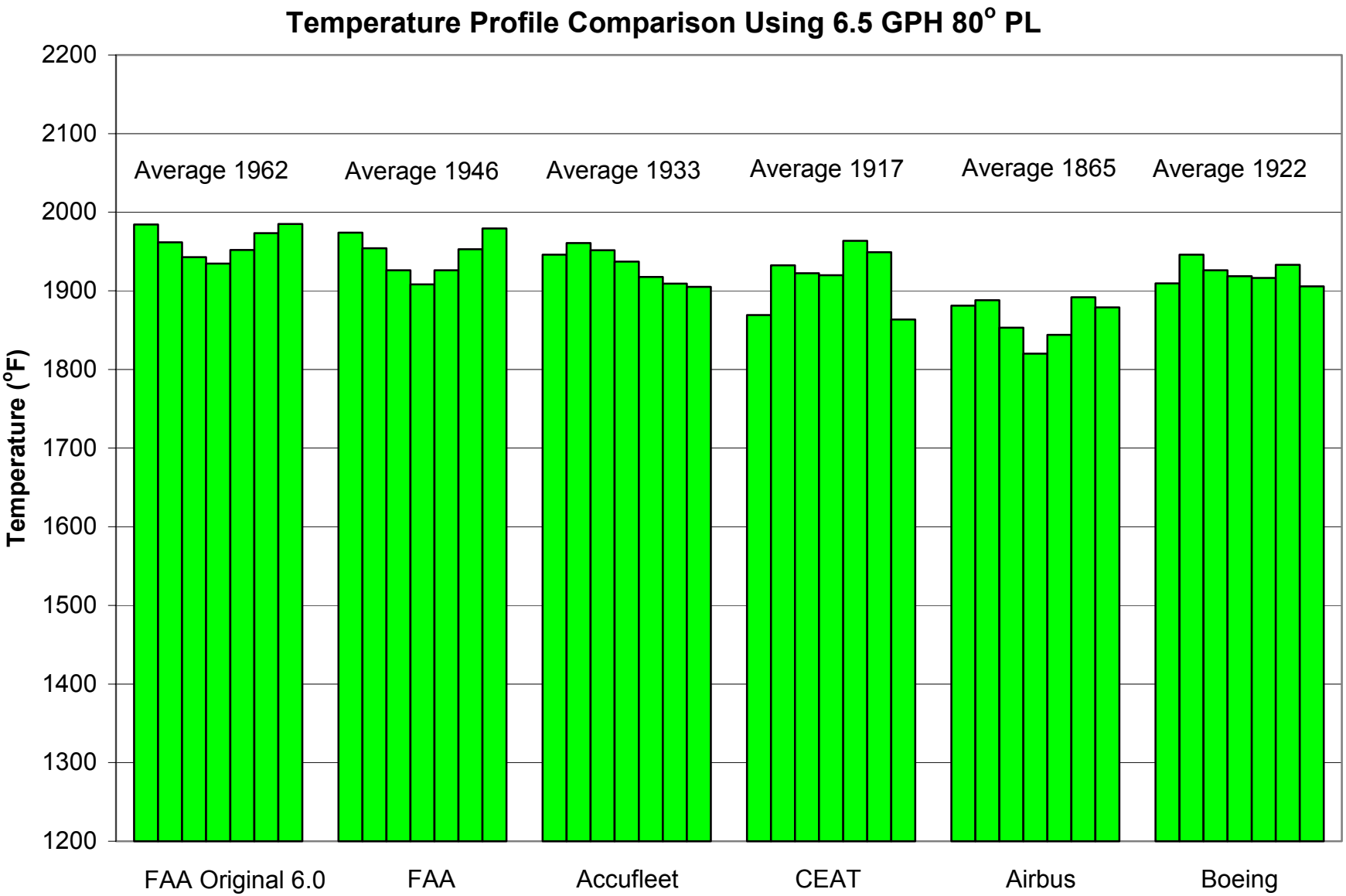
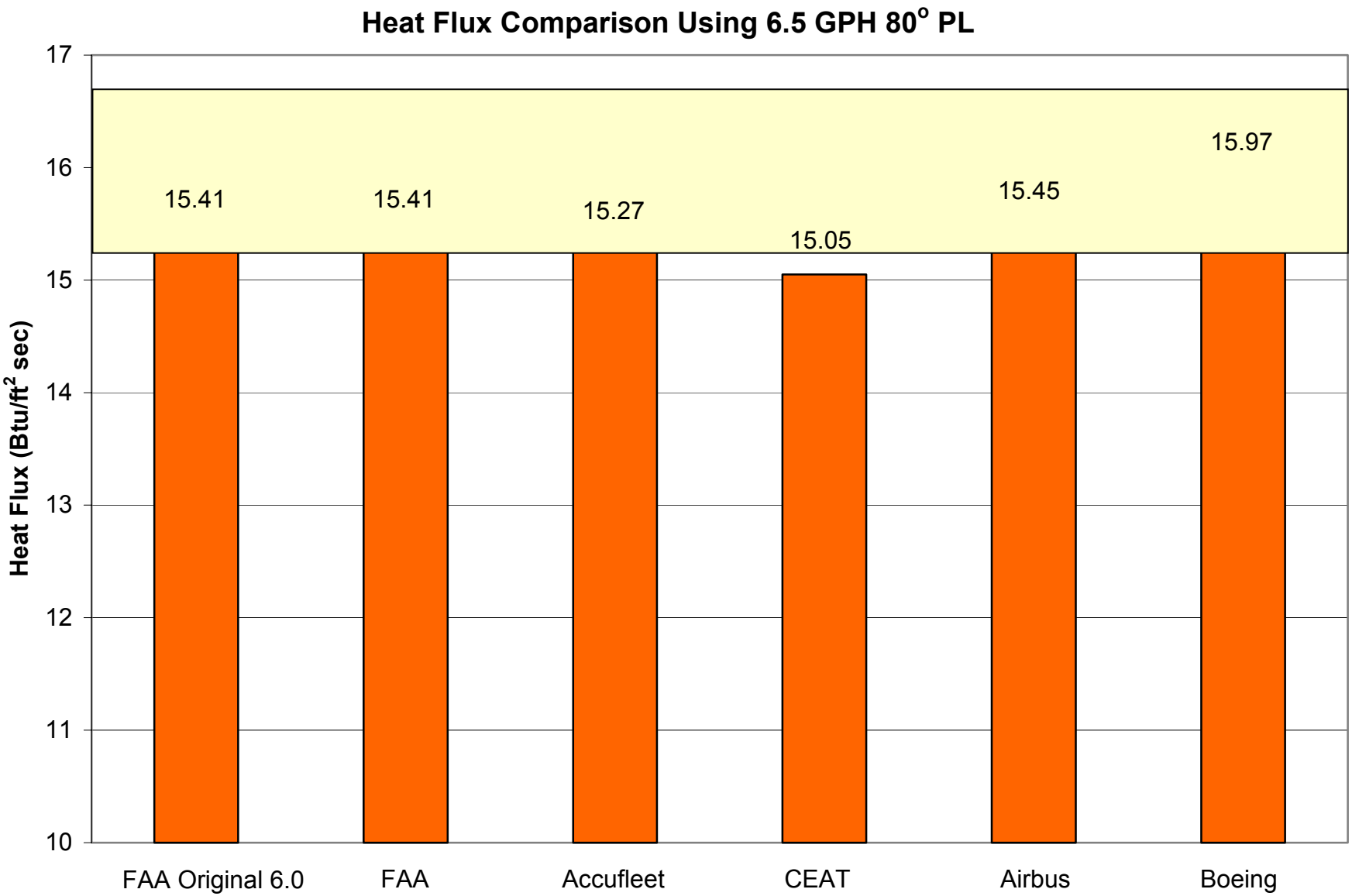
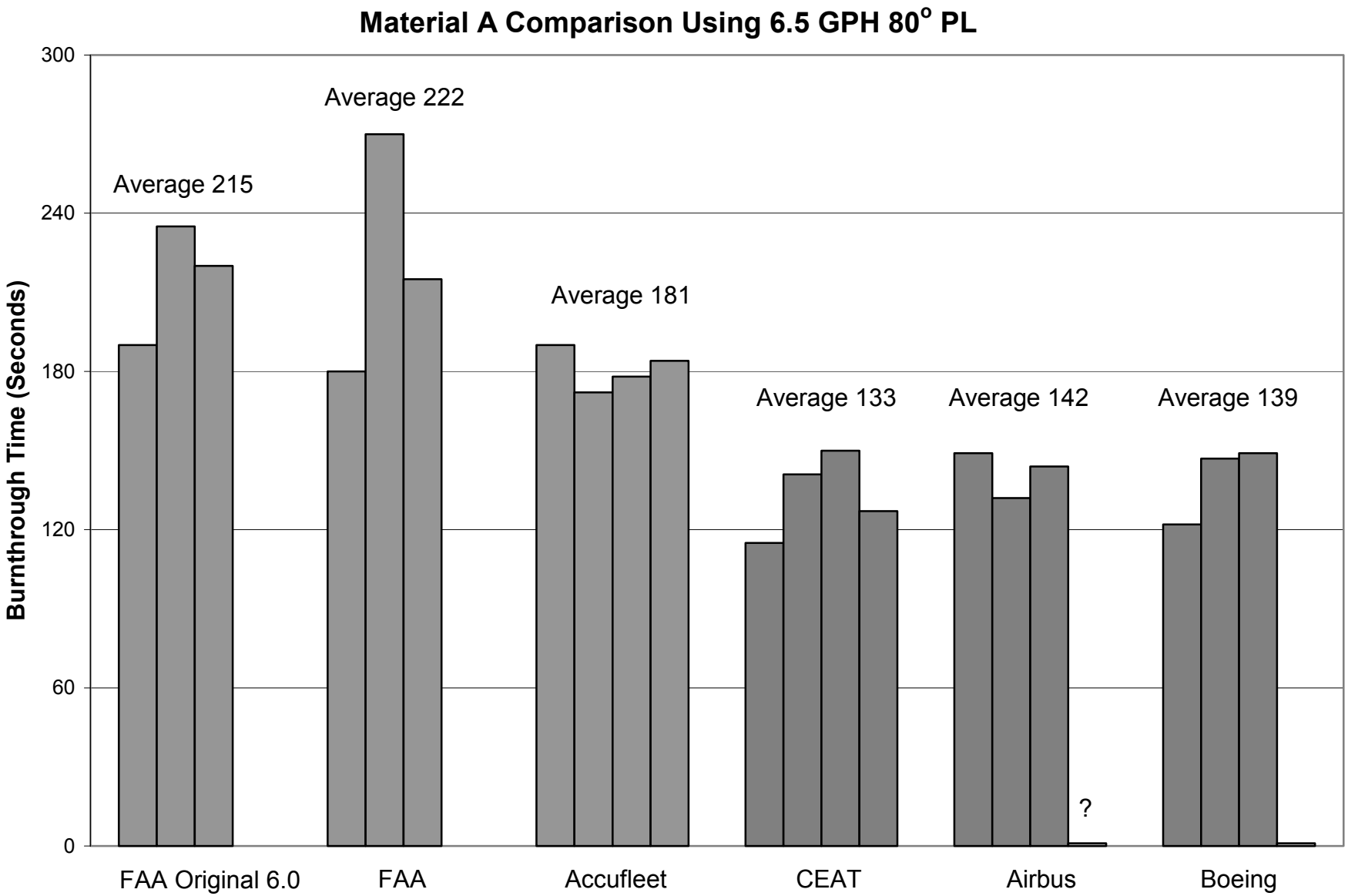

Temperature Profile Comparison Using 6.5 GPH 80° PL
Temperature (°F)
2200
2100
2000
1900
1800
1700
1600
1500
1400
1300
1200
Average 1962
Average 1946
Average 1933
Average 1917
Average 1865
Average 1922
FAA Original 6.0
FAA
Accufleet
CEAT
Airbus
Boeing


Heat Flux Comparison Using 6.5 GPH 80° PL
Heat Flux (Btu/ft2 sec)
17
16
15
14
13
12
11
10
15.41
15.41
15.27
15.05
15.45
15.97
FAA Original 6.0
FAA
Accufleet
CEAT
Airbus
Boeing


Material A Comparison Using 6.5 GPH 80° PL
Burnthrough Time (Seconds)
300
240
180
120
60
0
Average 215
Average 222
Average 181
Average 133
Average 142
Average 139
?
FAA Original 6.0
FAA
Accufleet
CEAT
Airbus
Boeing

June 2005 Mini Round Robin Summary

Material analysis indicates weight/area consistency, no impact on results.

All labs reporting were capable of obtaining correct temperature profile.

4 of 5 labs reporting were capable of obtaining correct heat flux.

3 of 5 labs still indicate a more severe test than FAA lab; quicker burnthrough times by approximately 1 minute.

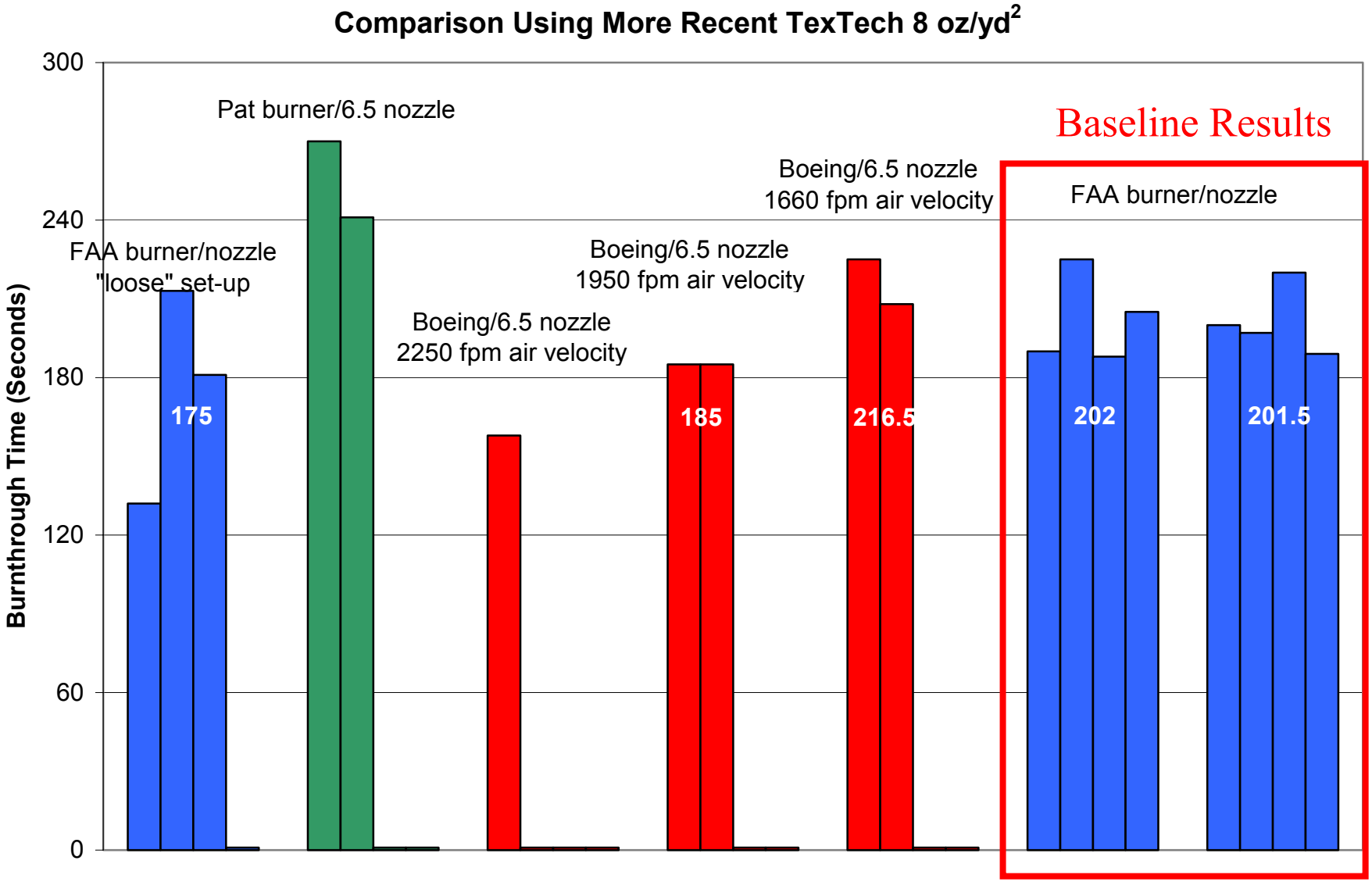
The 3 labs with a more severe result use the socket-style burner.

Planned Activities from June Meeting

FAATC: Visit Airbus and Boeing labs to assist in calibration of existing burners.

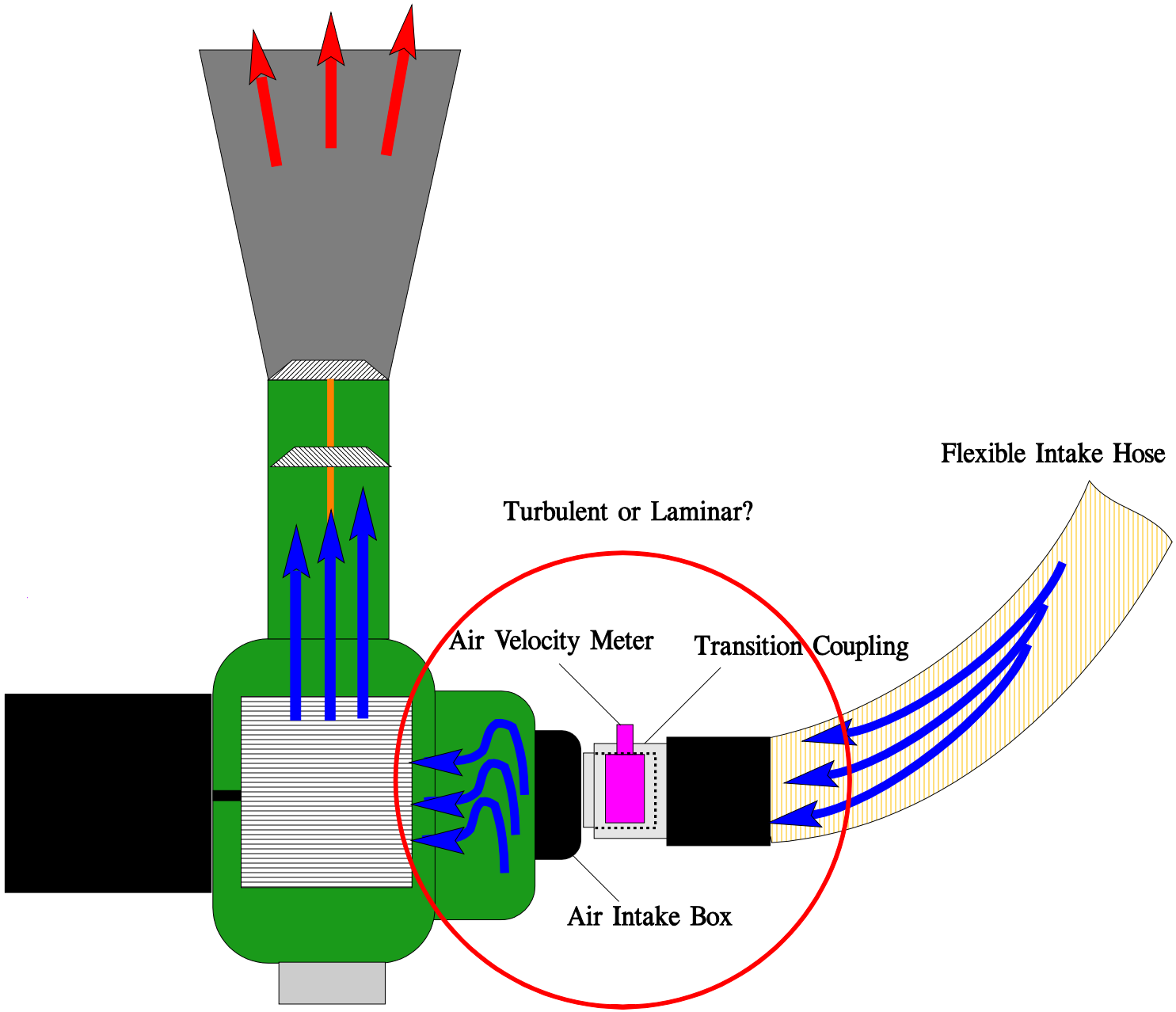
FAATC: Complete fabrication of additional flanged burners for comparison testing.

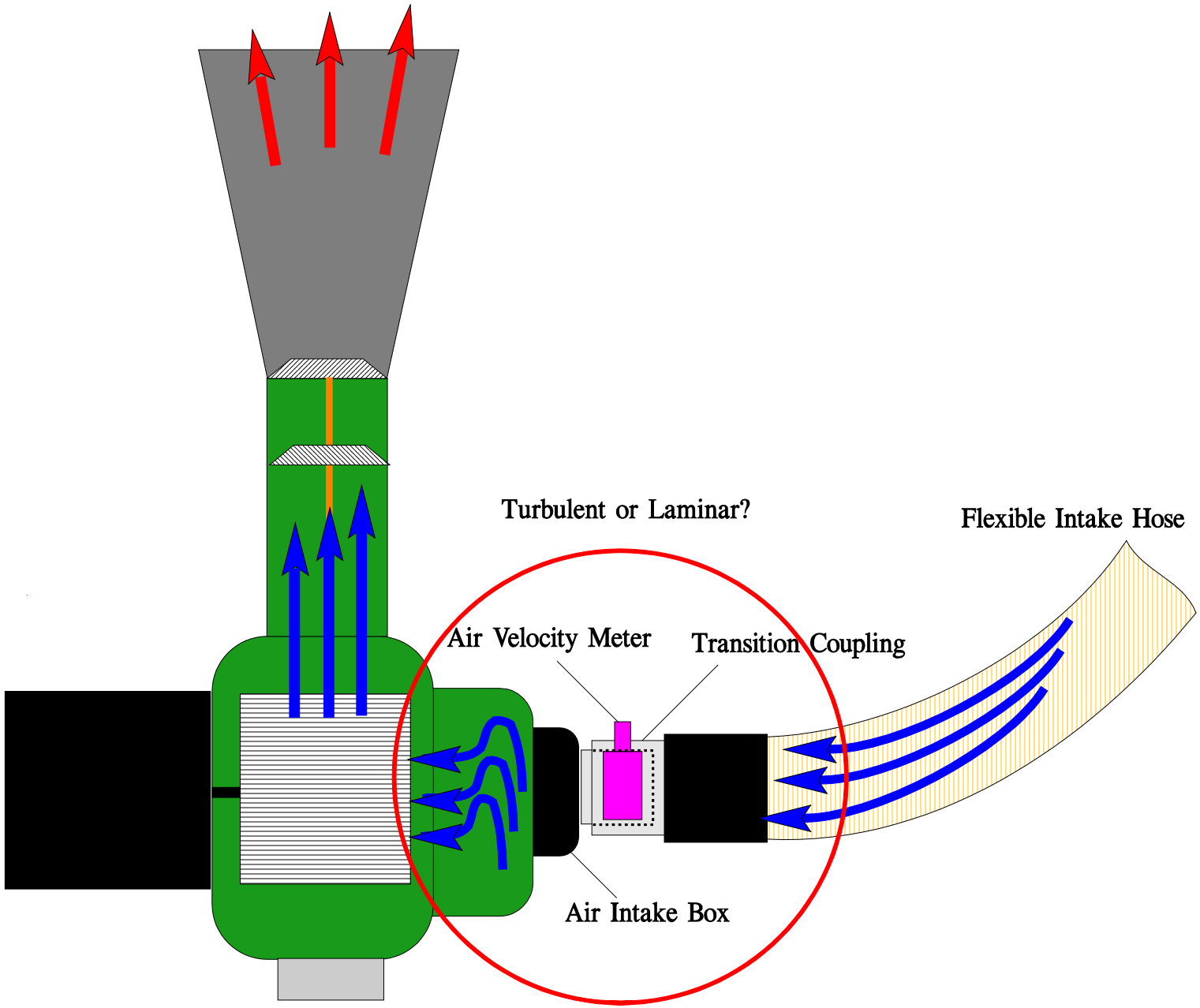
FAATC: Investigate correlation between premature failure and socket-style burner.


Comparison Using More Recent TexTech 8 oz/yd2
Burnthrough Time (Seconds)
300
240
180
120
60
0
Baseline Results
FAA burner/nozzle
"loose" set-up
175
Pat burner/6.5 nozzle
Boeing/6.5 nozzle
2250 fpm air velocity
Boeing/6.5 nozzle
1950 fpm air velocity
185
Boeing/6.5 nozzle
1660 fpm air velocity
216.5
FAA burner/nozzle
202
201.5

Effect of Location on Air Velocity Measurement

Objective: Investigate problems associated with measuring intake air velocity at its present location inside the airbox, and compare to measurements at intake of flexible duct.


Flexible Intake Hose
Turbulent or Laminar?
Air Velocity Meter
Transition Coupling
Air Intake Box


Turbulent or Laminar?
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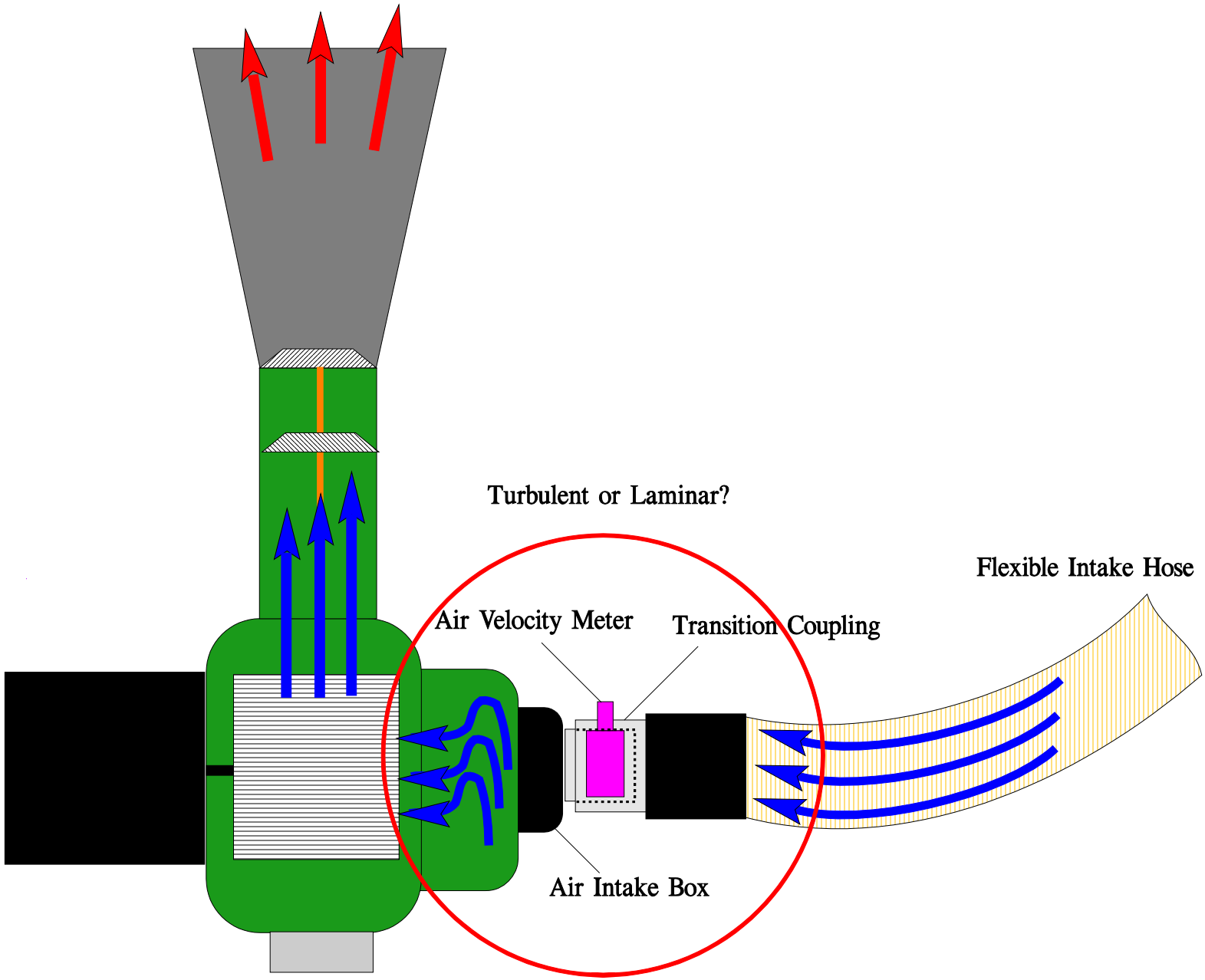
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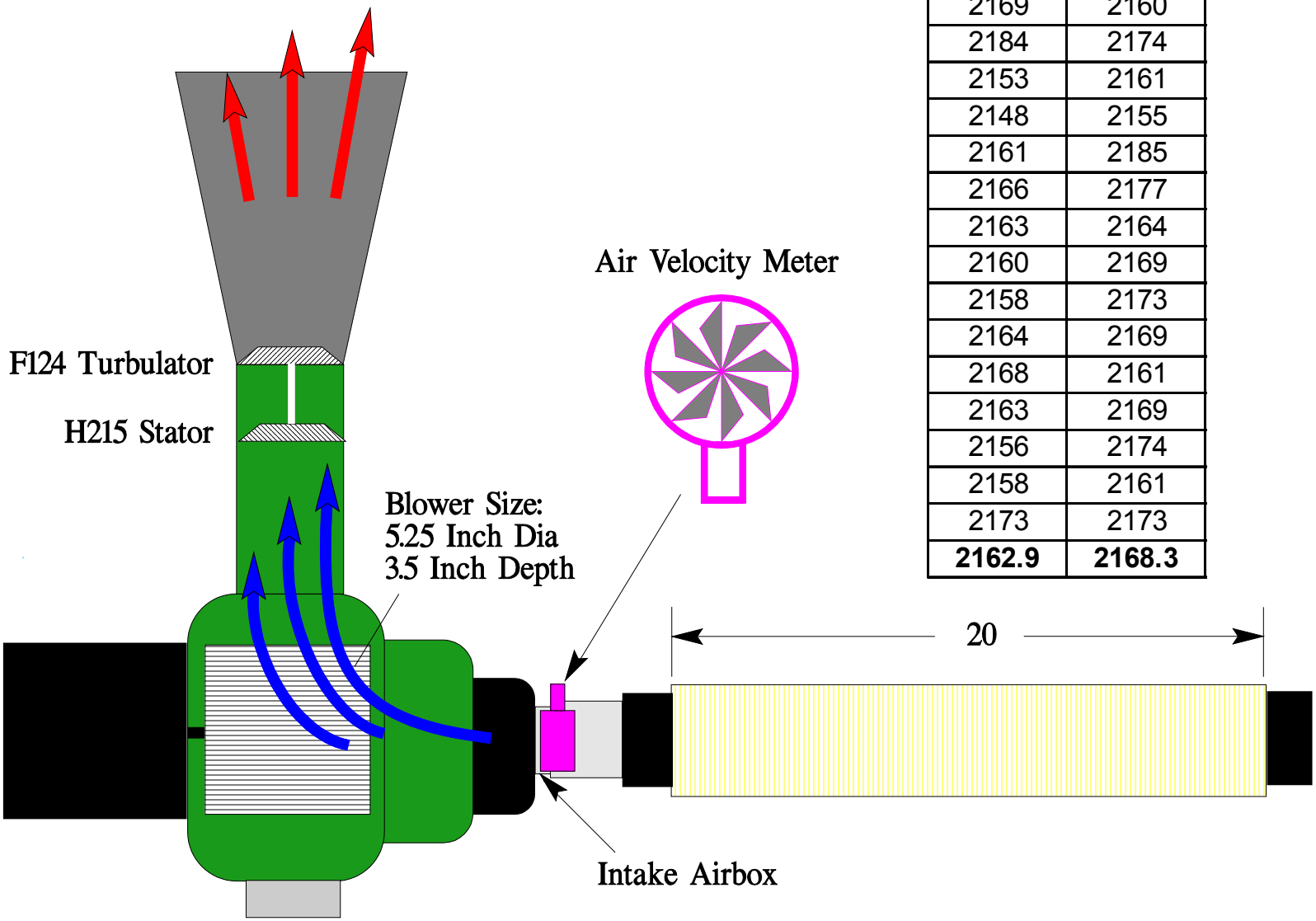
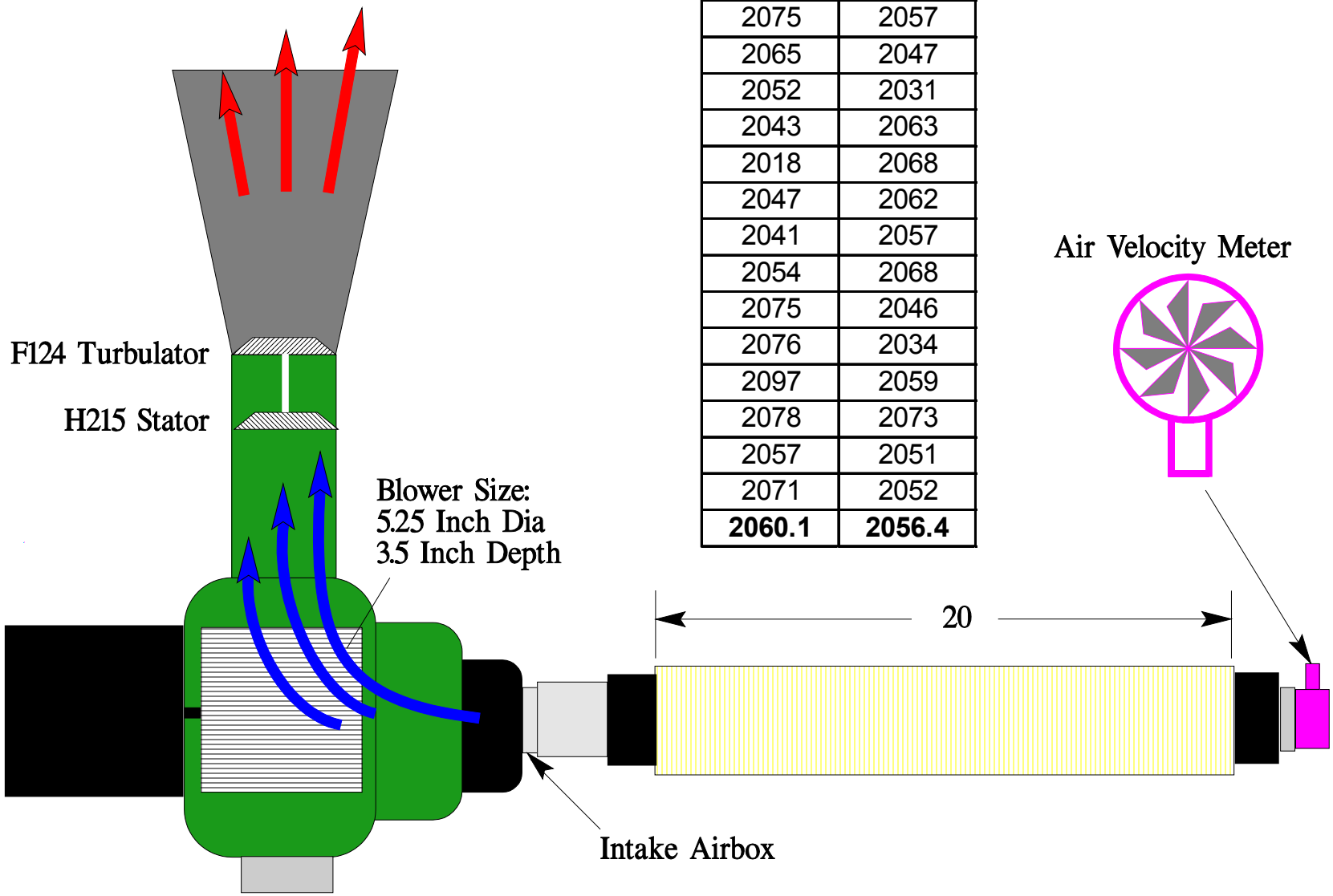


Meter in airbox	Meter in airbox
2169	2160
2184	2174
2153	2161
2148	2155
2161	2185
2166	2177
2163	2164
2160	2169
2158	2173
2164	2169
2168	2161
2163	2169
2156	2174
2158	2161
2173	2173
2162.9	**2168.3**

Meter in hose inlet	Meter in hose inlet
2052	2078
2075	2057
2065	2047
2052	2031
2043	2063
2018	2068
2047	2062
2041	2057
2054	2068
2075	2046
2076	2034
2097	2059
2078	2073
2057	2051
2071	2052
2060.1	**2056.4**



Effect of Location on Air Velocity Measurement

Meter in airbox	
2169	2160
2184	2174
2153	2161
2148	2155
2161	2185
2166	2177
2163	2164
2160	2169
2158	2173
2164	2169
2168	2161
2163	2169
2156	2174
2158	2161
2173	2173
2162.9	**2168.3**

Average = 2165.6

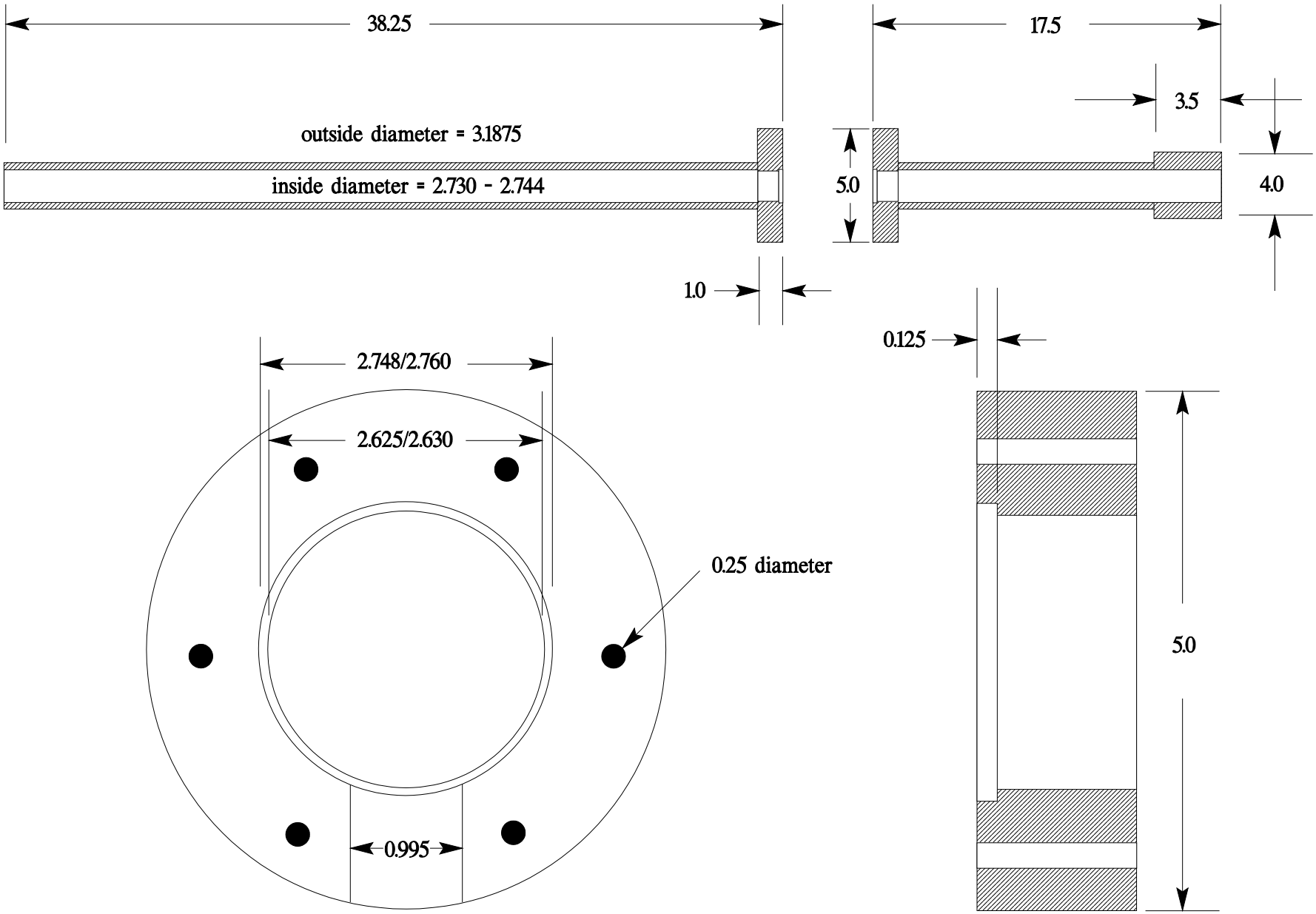
Meter in hose Inlet	
2052	2078
2075	2057
2065	2047
2052	2031
2043	2063
2018	2068
2047	2062
2041	2057
2054	2068
2075	2046
2076	2034
2097	2059
2078	2073
2057	2051
2071	2052
2060.1	**2056.4**

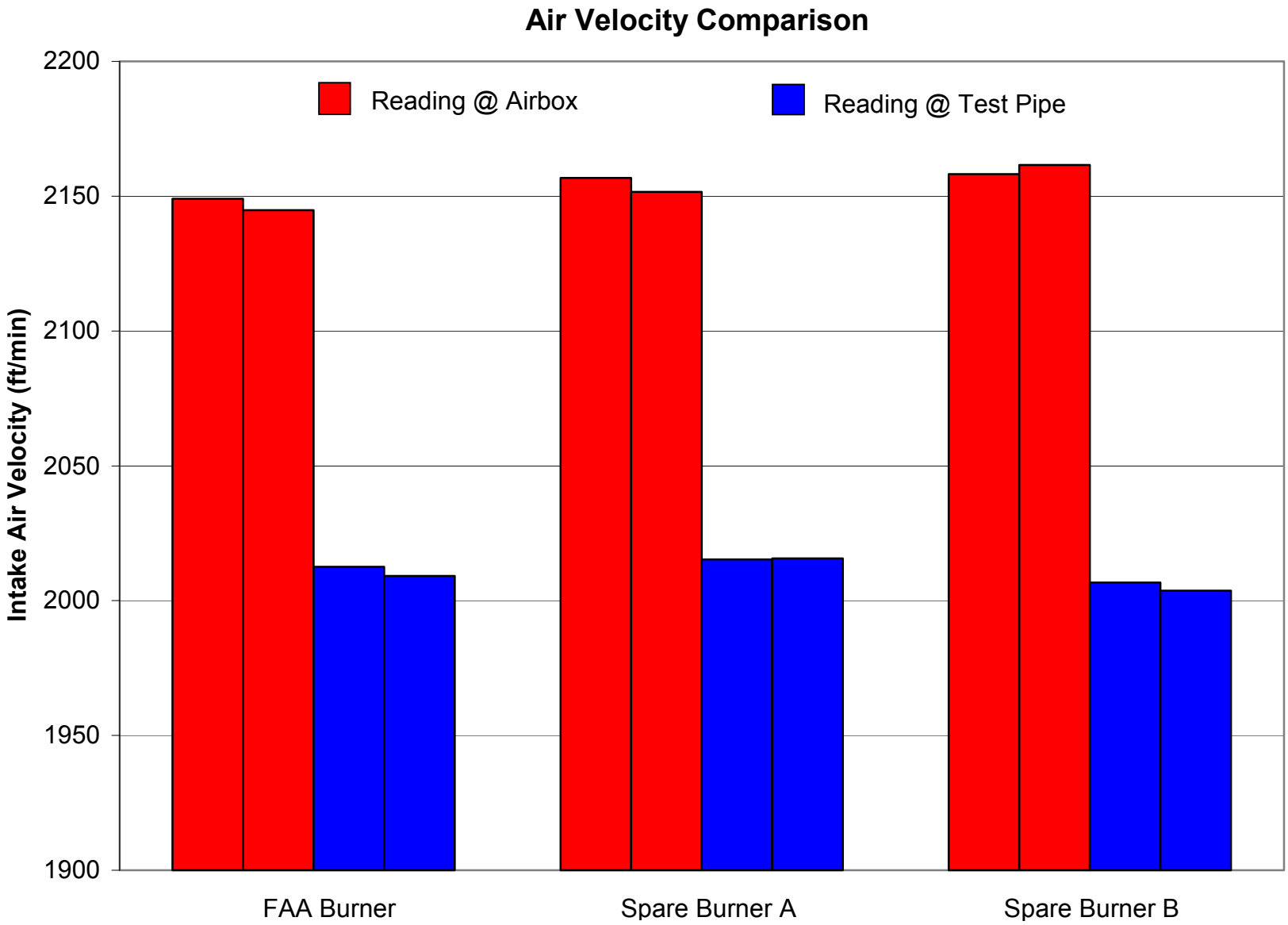
Average = 2058.3

Development of a Stream Straightening Device

Objective: Compare intake air velocity measurements taken at airbox to those obtained using a stream straightening device, while maintaining a constant intake damper setting.

Methodology: Fabricate a stream straightening device that utilizes an upstream length of at least 10 diameters, to produce a laminar flow across an in-line velocity sensor.

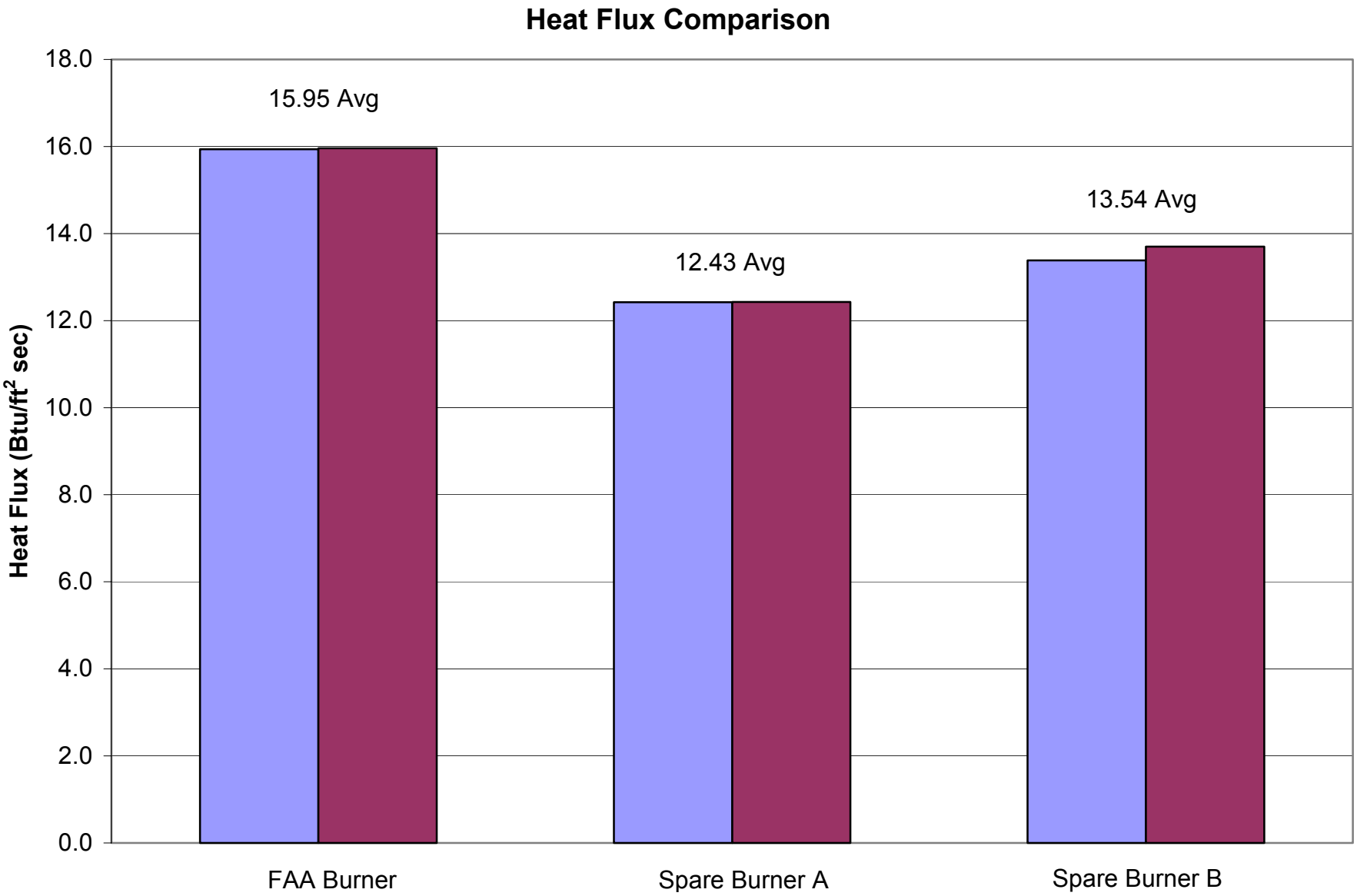

38.25
17.5
3.5
outside diameter = 3.1875
inside diameter = 2.730 - 2.744
5.0
4.0
1.0
0.125
2.748/2.760
2.625/2.630
0.25 diameter
5.0
0.995

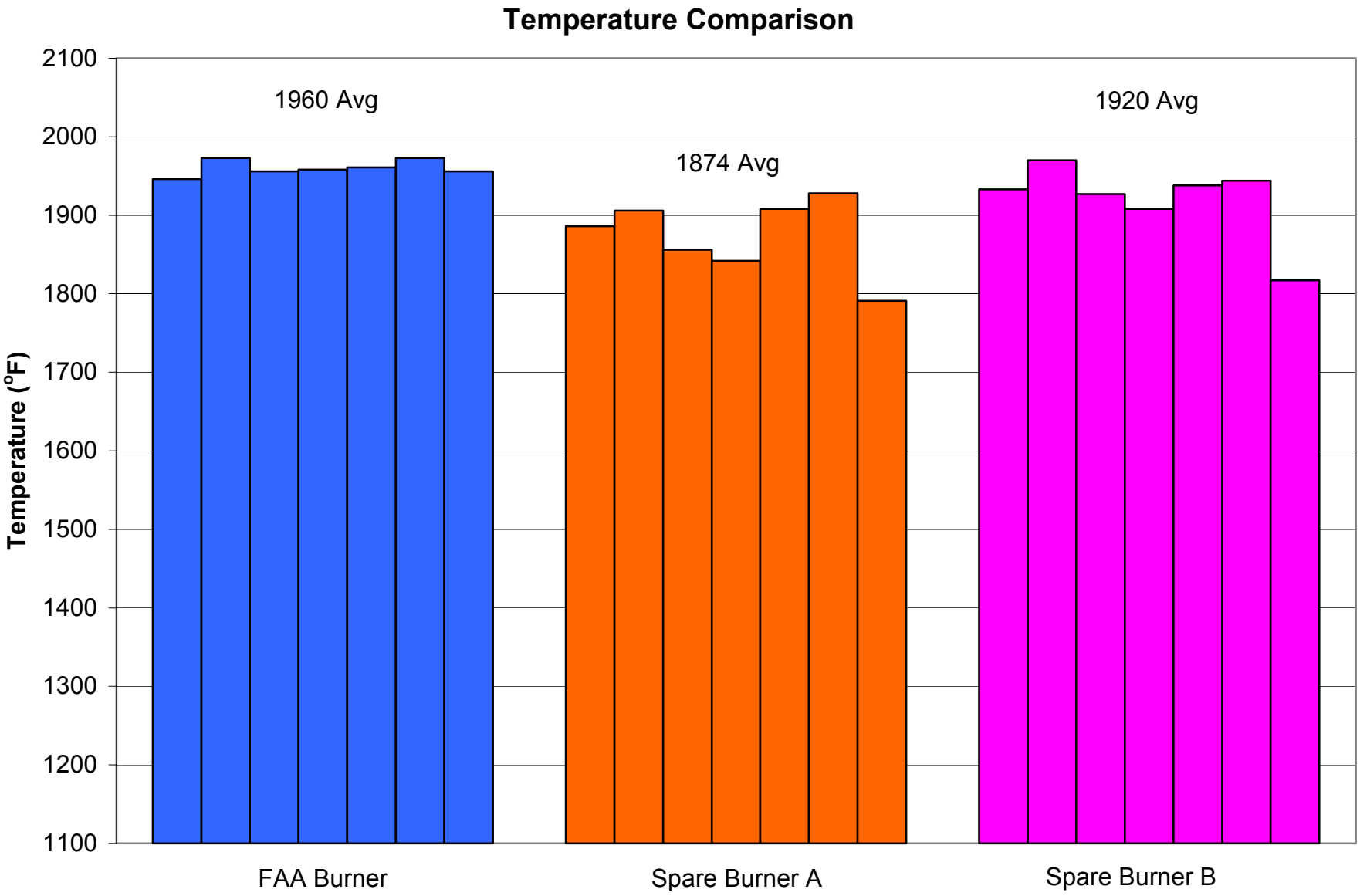

Air Velocity Comparison
Reading @ Airbox
Reading @ Test Pipe
Intake Air Velocity (ft/min)
2200
2150
2100
2050
2000
1950
1900
FAA Burner
Spare Burner A
Spare Burner B

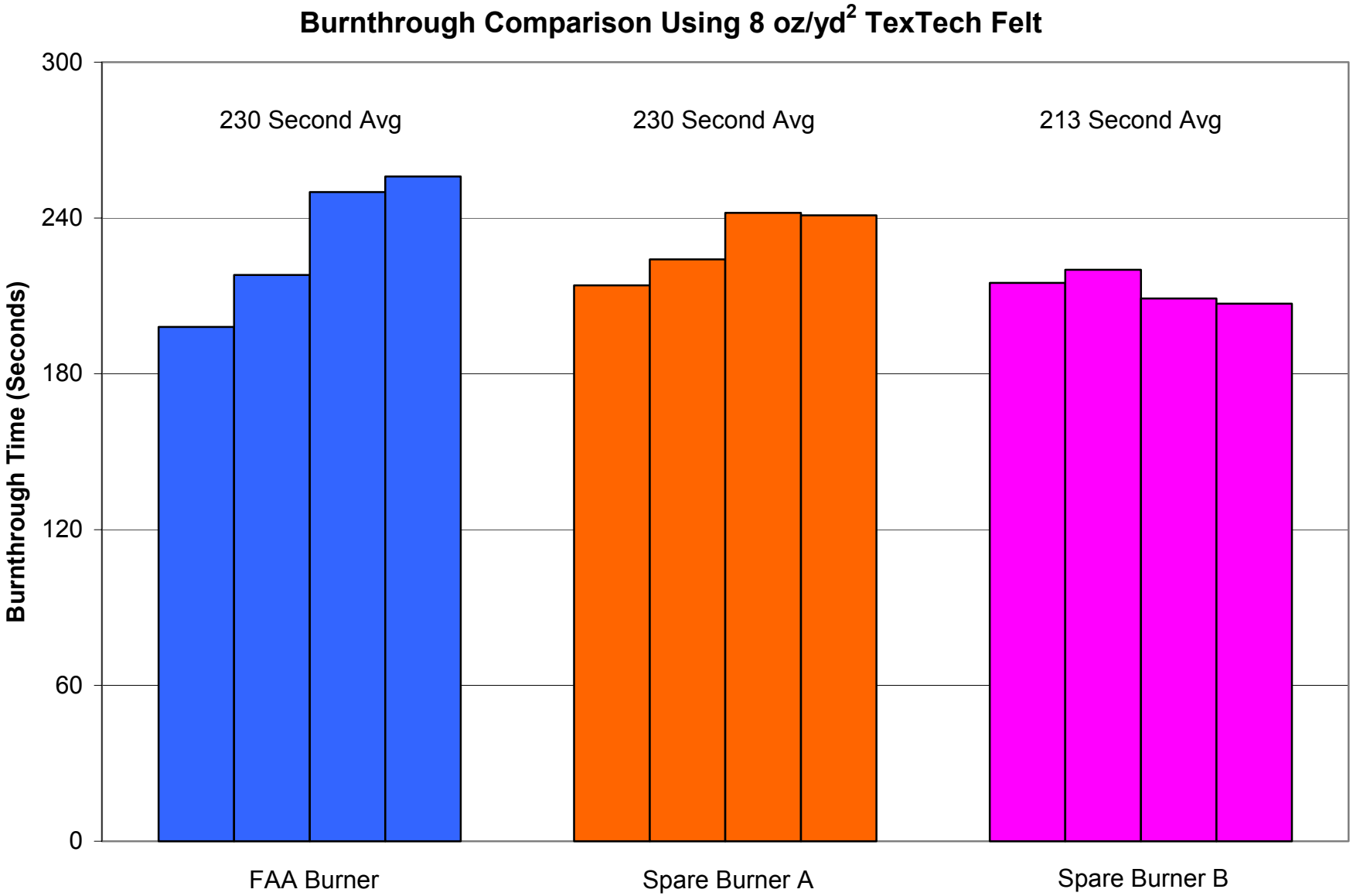
Initial Three Burner Comparison

Objective: Determine if differences exist amongst flanged burner housings, and if so, what impact they have on calibration and test results.

Methodology: Compare heat flux, temperature, and test results of three flanged burners using original FAA fuel nozzle (Monarch 6.0 gph 80^{o} “F-80” style).


Heat Flux Comparison
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Heat Flux (Btu/ft2 sec)
15.95 Avg
12.43 Avg
13.54 Avg
FAA Burner
Spare Burner A
Spare Burner B


Temperature Comparison
2100
2000
1900
1800
1700
1600
1500
1400
1300
1200
1100
Temperature (°F)
1960 Avg
1874 Avg
1920 Avg
FAA Burner
Spare Burner A
Spare Burner B


Burnthrough Comparison Using 8 oz/yd2 TexTech Felt
Burnthrough Time (Seconds)
300
240
180
120
60
0
230 Second Avg
230 Second Avg
213 Second Avg
FAA Burner
Spare Burner A
Spare Burner B

Initial Three Burner Comparison

Summary of Results: While using identical fuel nozzle in three different burners:

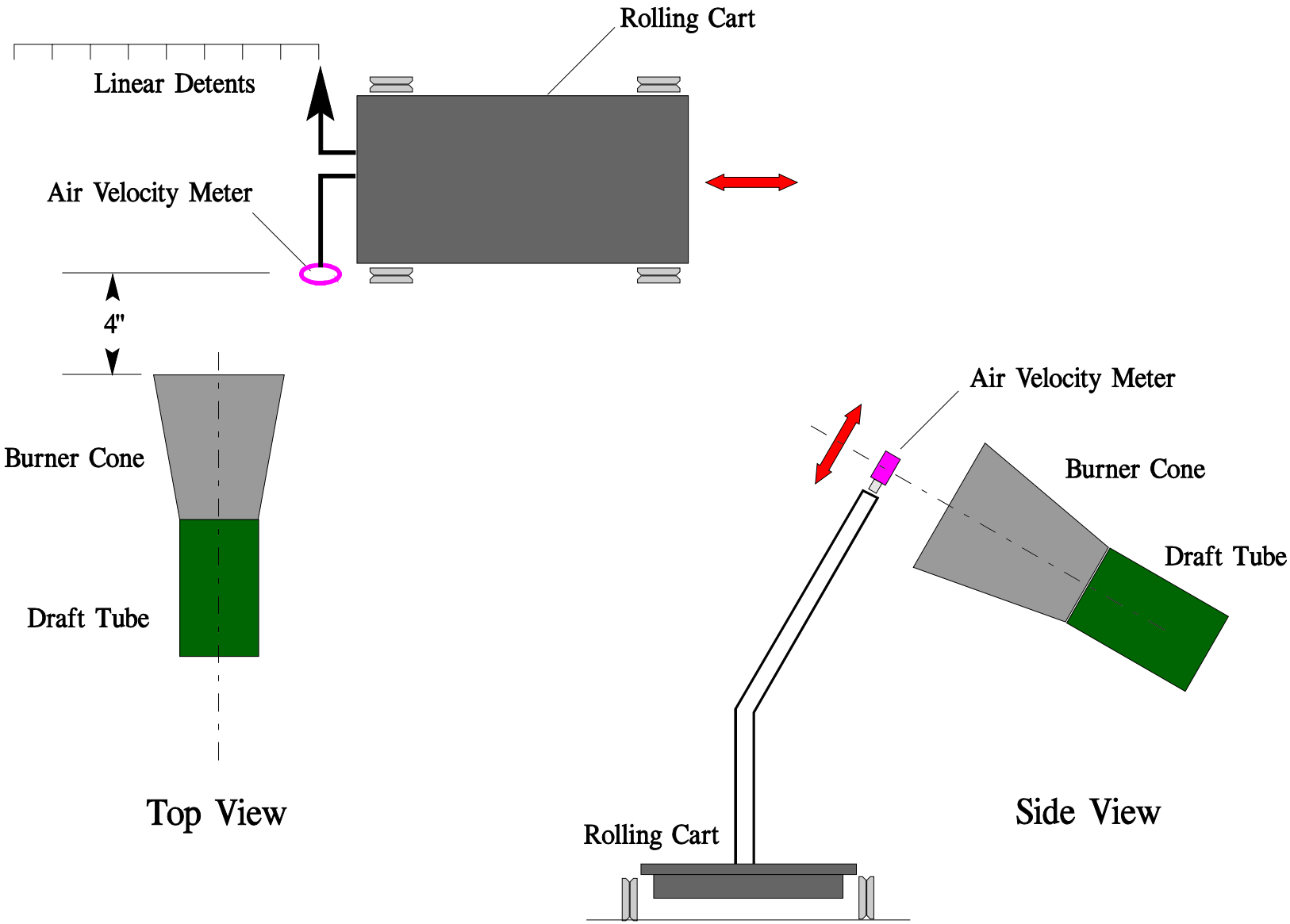
1. Calibration heat flux substantially different
2. Calibration temperature profile slightly different
3. Test results Similar

Mapping Exit Area Air Velocity

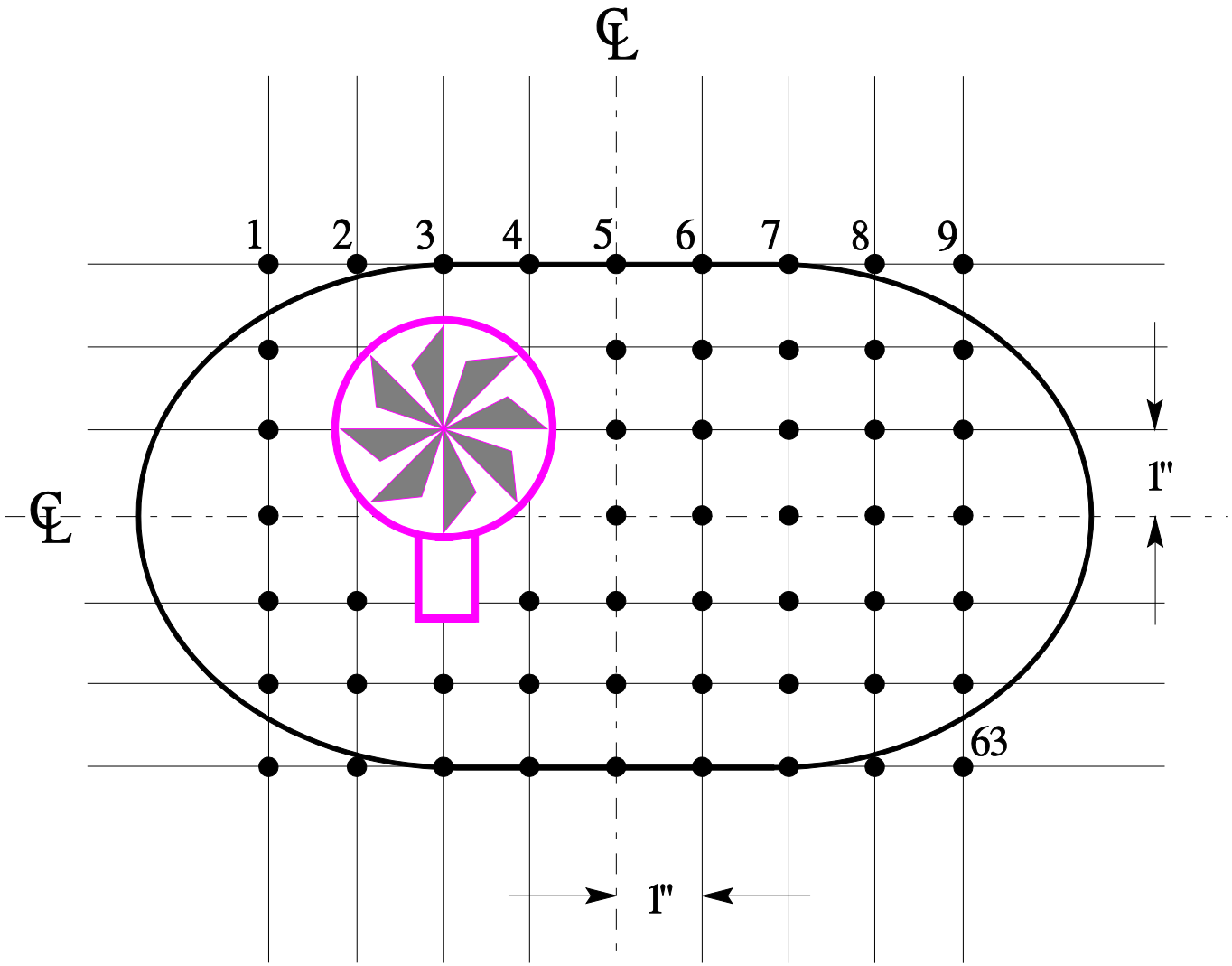
Objective: To determine cause of difference in measured heat flux during calibration process when using three identically-prepared flanged burners.

Methodology: Map exit area air velocity of each burner to determine if there is a correlation between shape of exit air and heat flux.

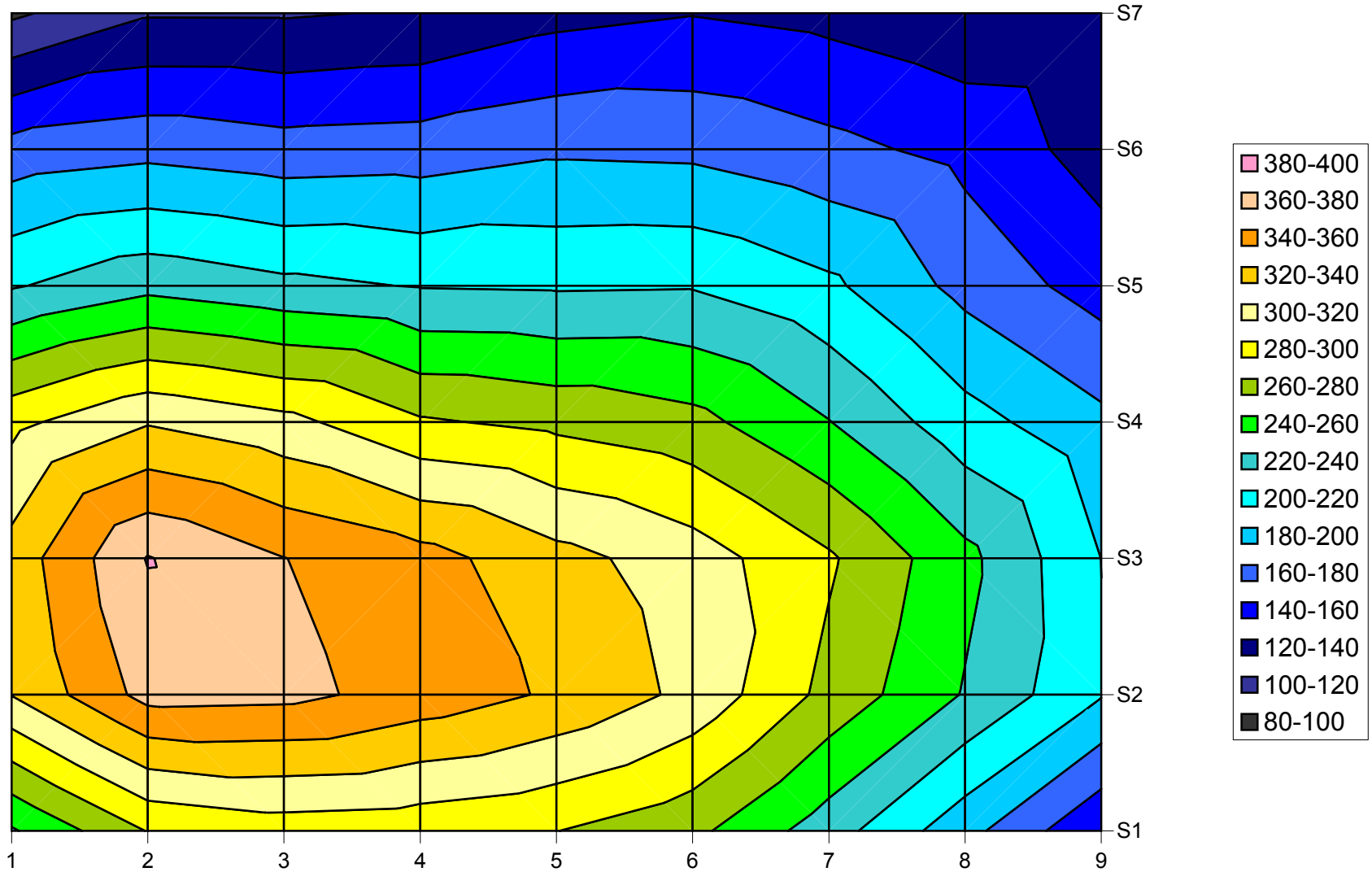
Mapping Exit Area Air Velocity



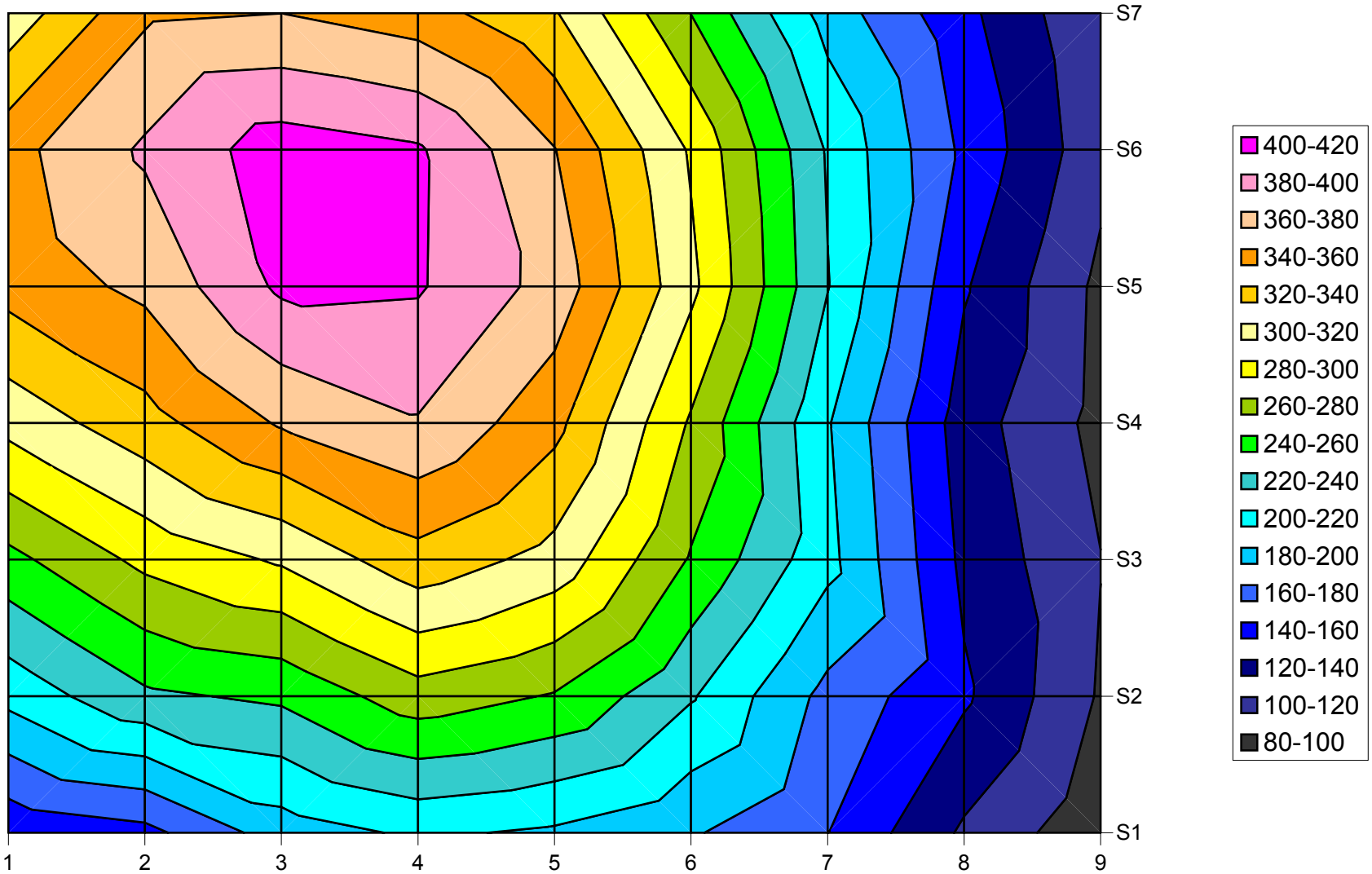
Exit Area Air Velocity Mapping



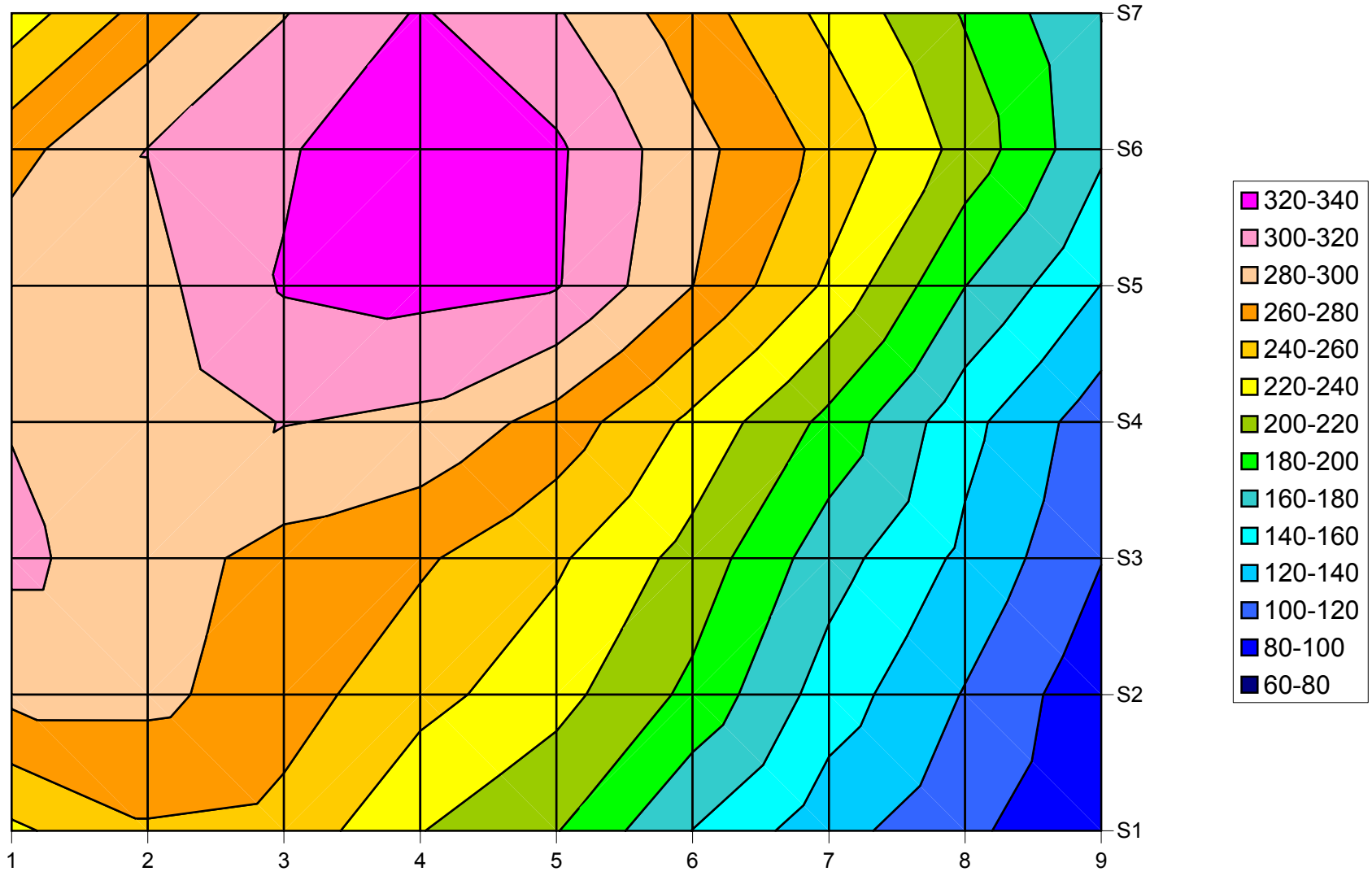
Air Velocity Map, FAA Burner



Air Velocity Map, Burner A



Air Velocity Map, Burner B



Mapping Exit Area Air Velocity

Summary of Results: While measuring exit area air velocity in three burners:

1. Air velocity maps all unique, slightly different
2. Burner A produced highest peak velocity, burner B lowest peak velocity
3. All burners show left-side bias when viewed from flame side
4. No obvious correlation between peak velocity and heat flux
5. Correlation between velocity and burnthrough location

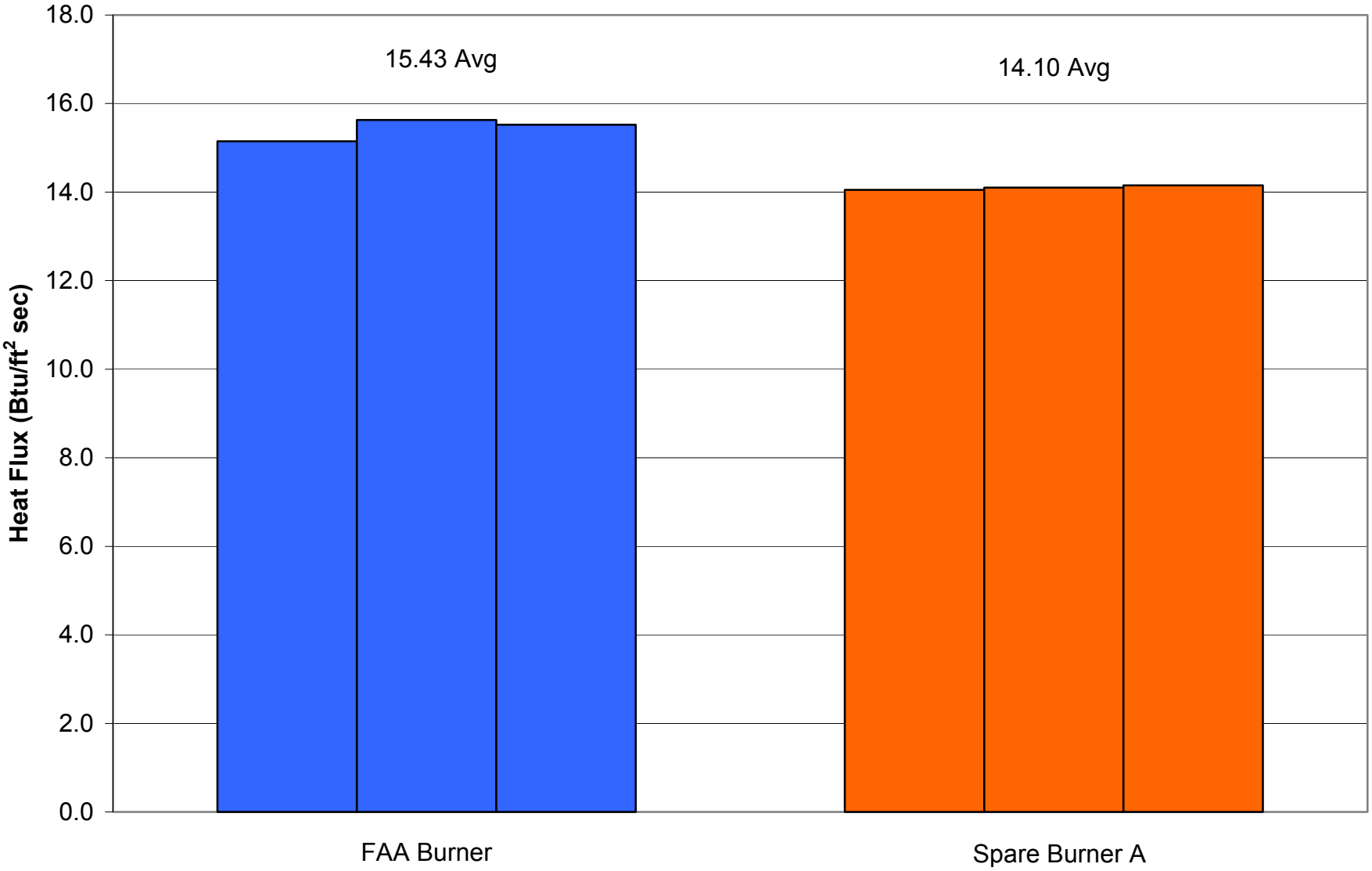
Final Three Burner Comparison

Objective: Prepare 2 spare flanged burners for industry use, and complete extensive comparison testing with original FAA burner to ensure correlation.

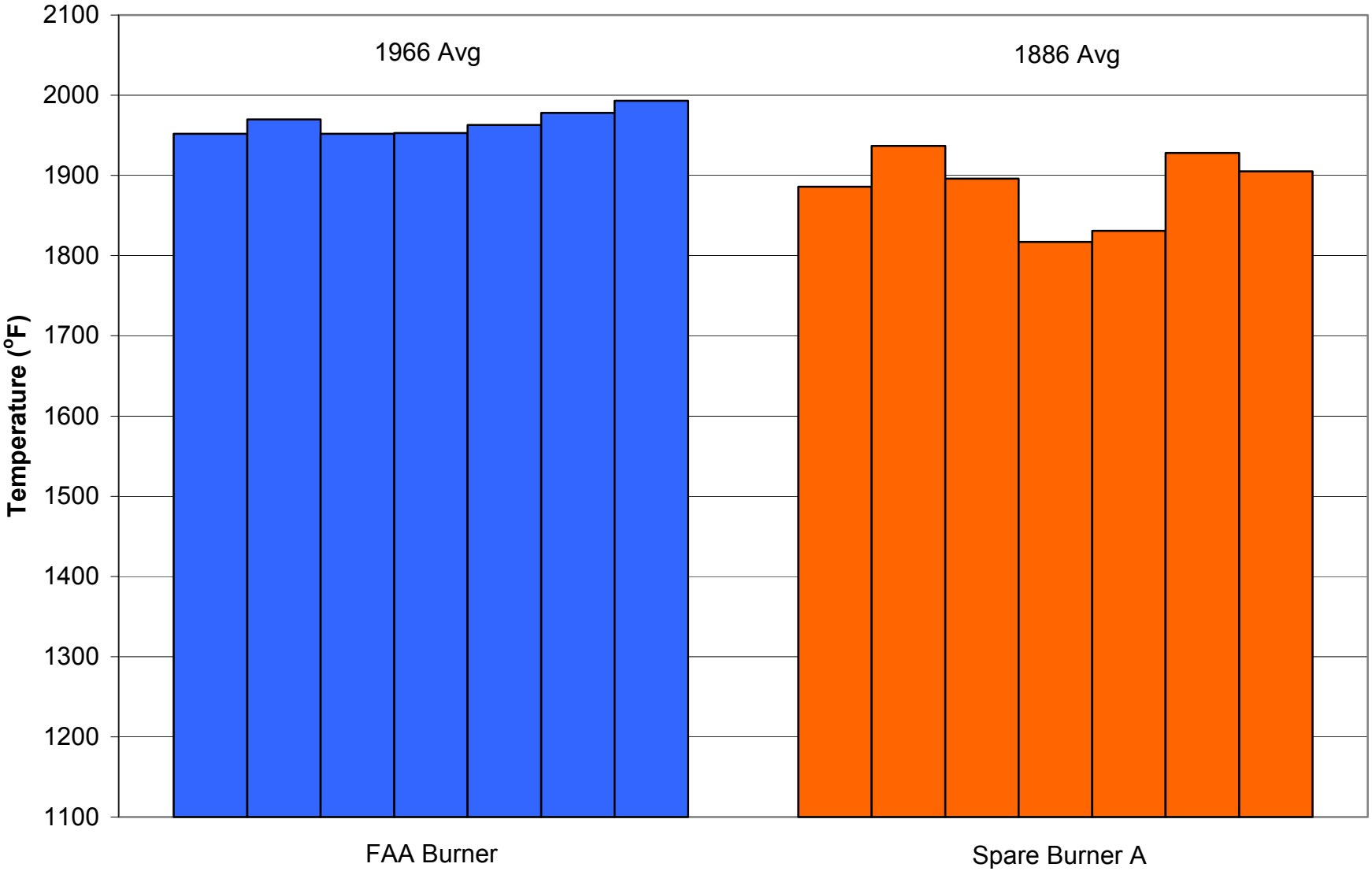
Methodology: Outfit spare burners with Monarch 6.5 gph “F-80” style fuel nozzles. Adjust fuel pressure to deliver proper 6.0 gph output, then compare heat flux, temperature, and test results.

Desired Outcome: Confirm equivalency of spare burners to original FAA burner.

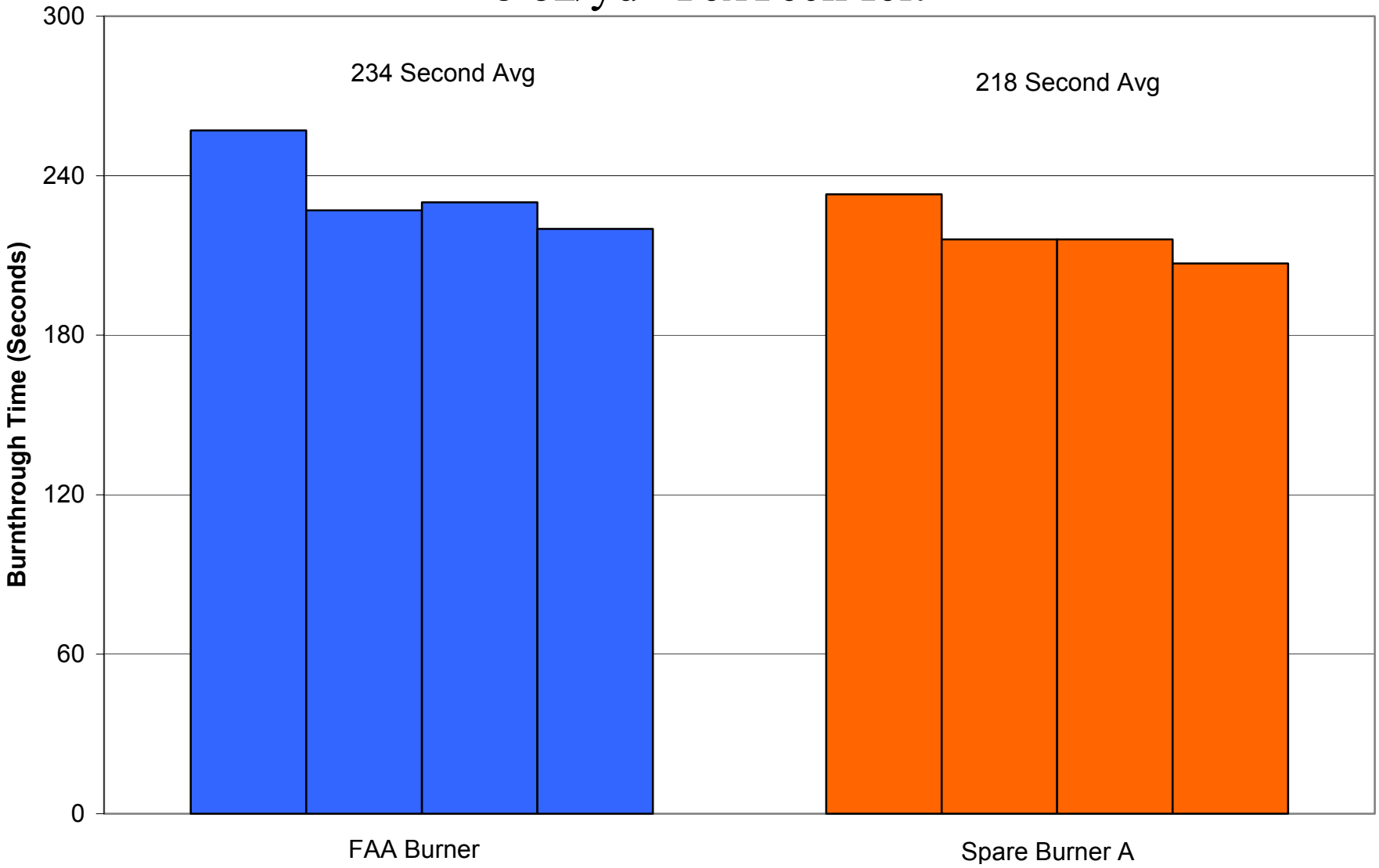
Final Burner Comparison



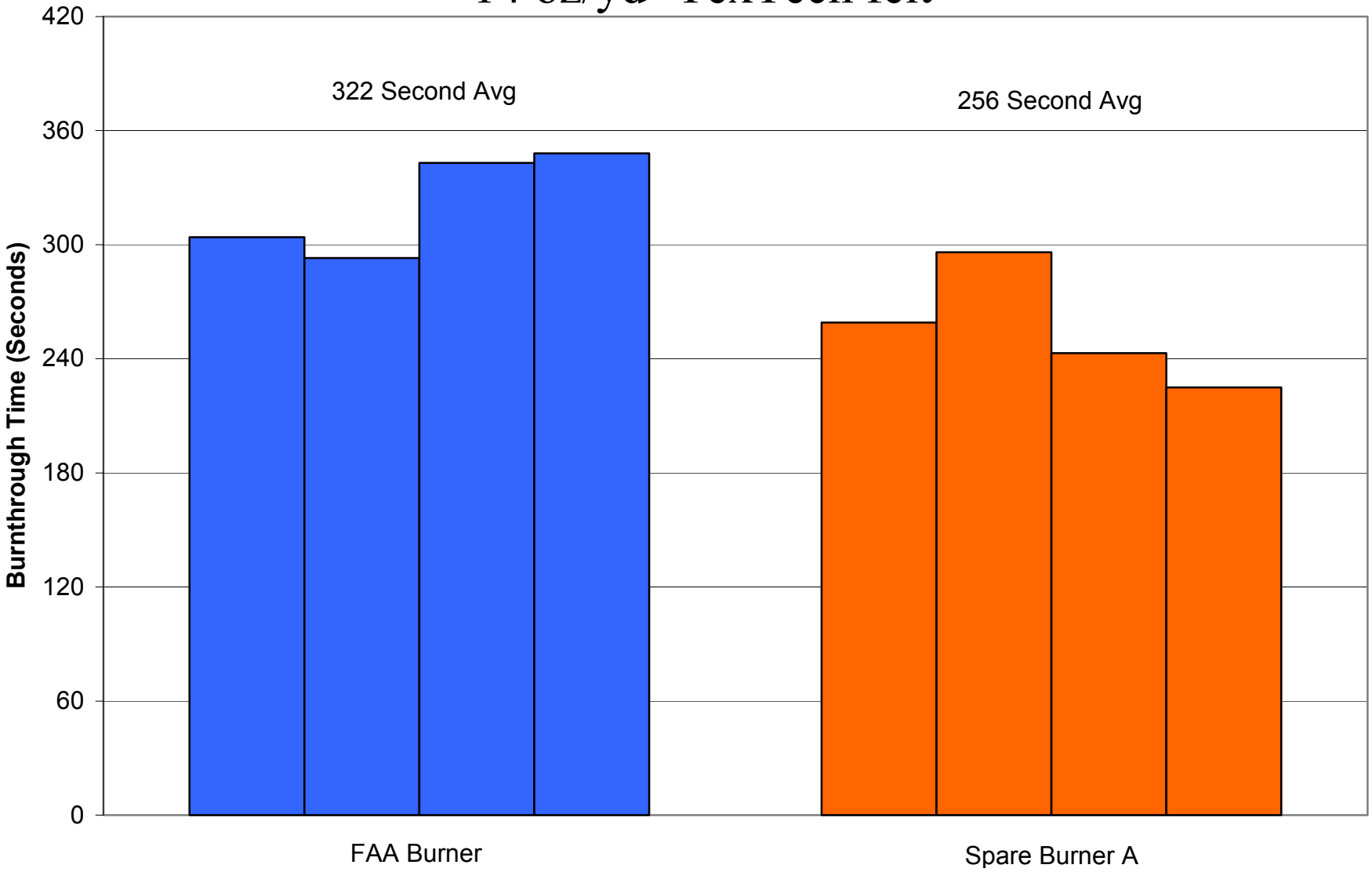
Final Burner Comparison



Final Burner Comparison
8 oz/yd^2 TexTech felt

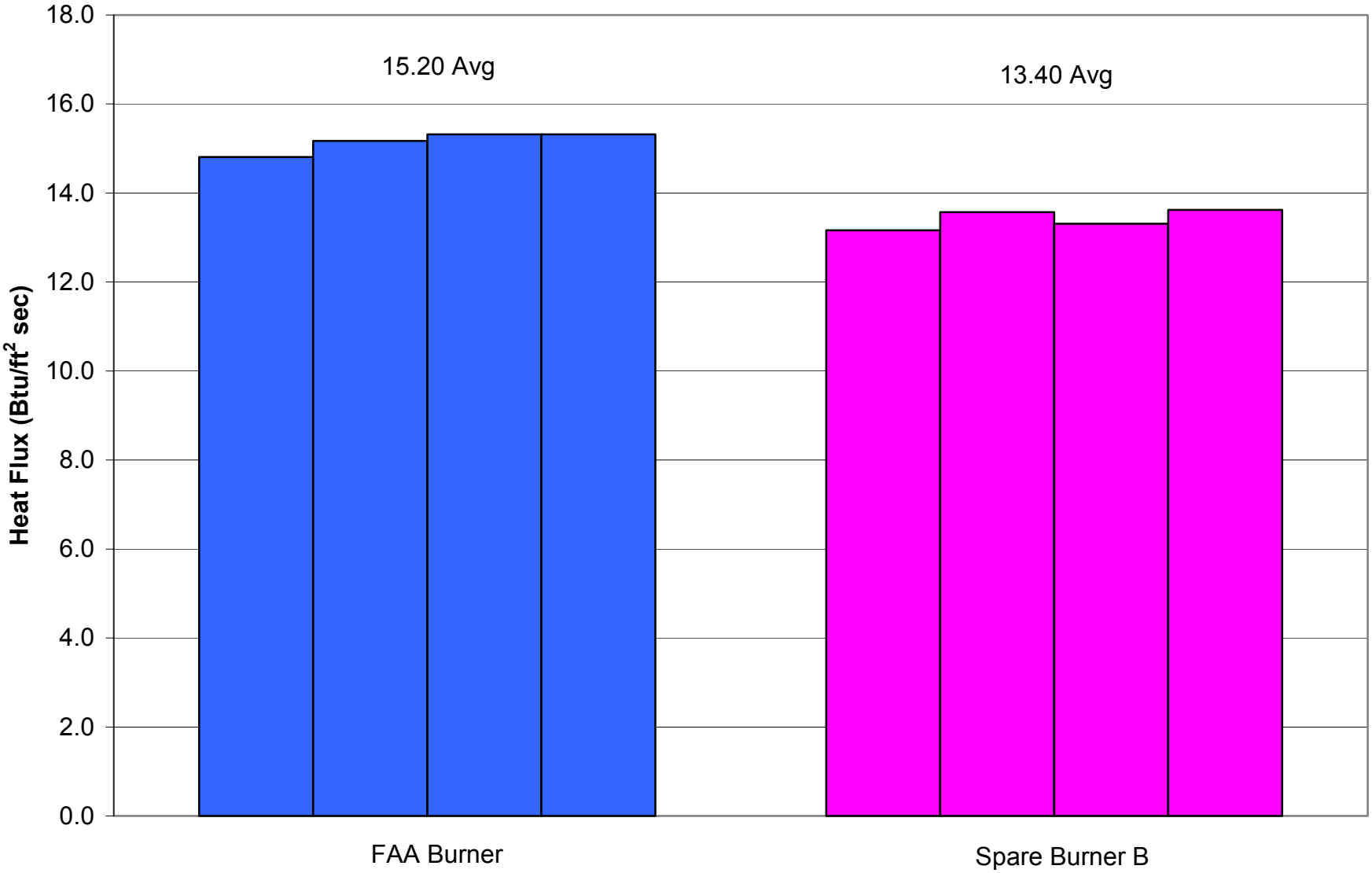


Final Burner Comparison
14 oz/yd^2 TexTech felt

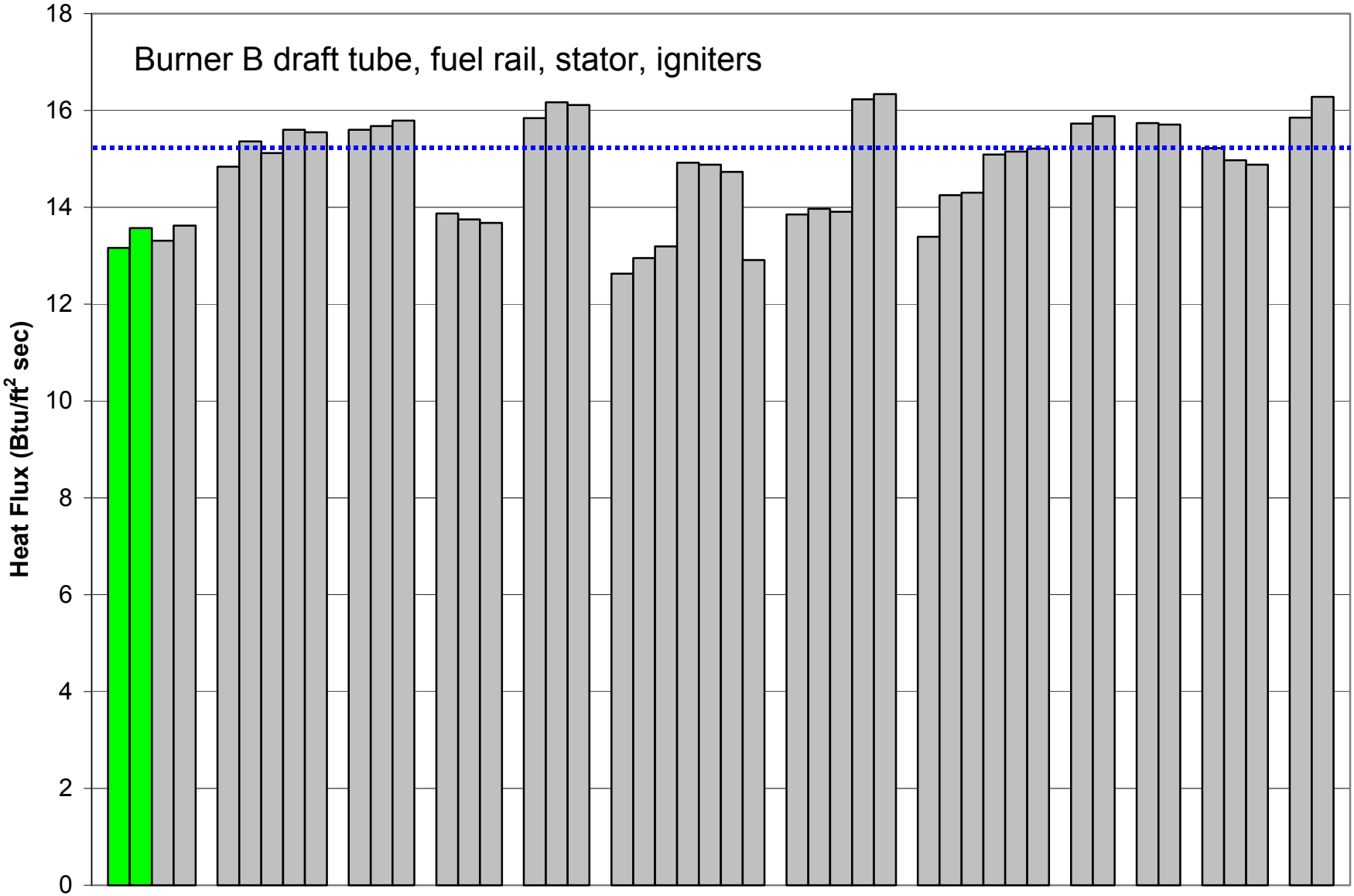



Atlantic City
Airbus

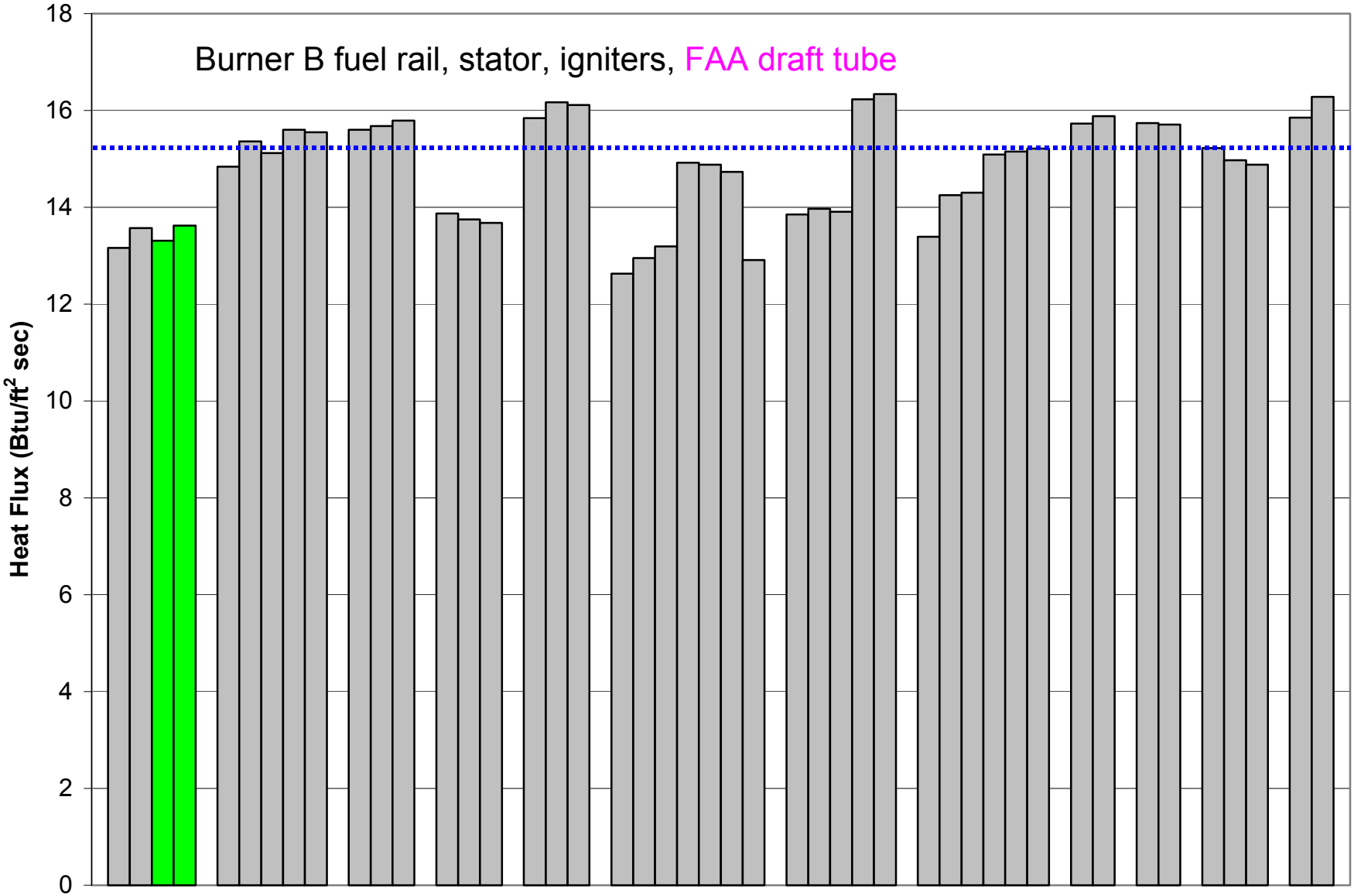
Final Burner Comparison



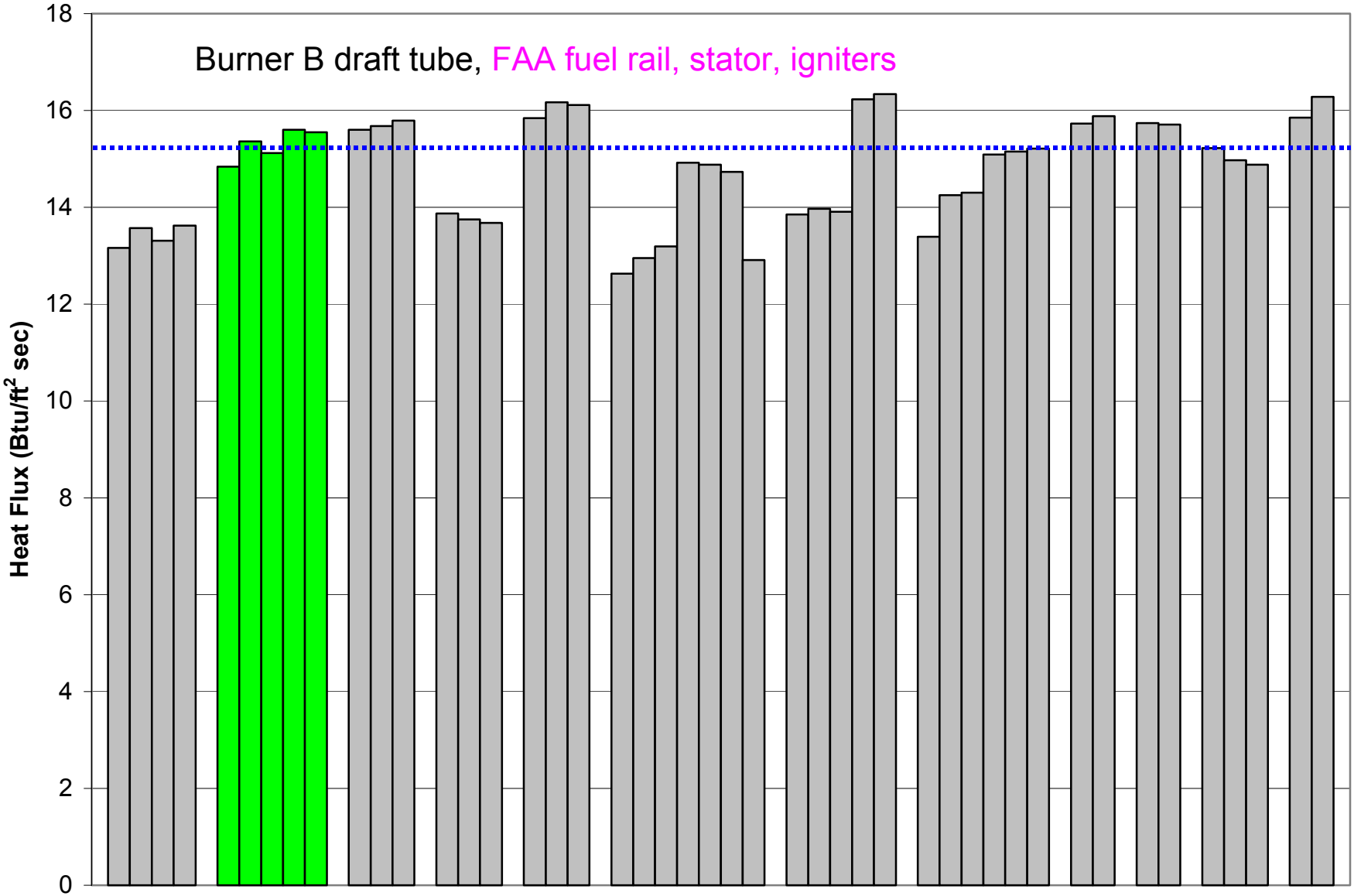
Spare Burner B Heat Flux Trials Using 6.5 gph Fuel Nozzle

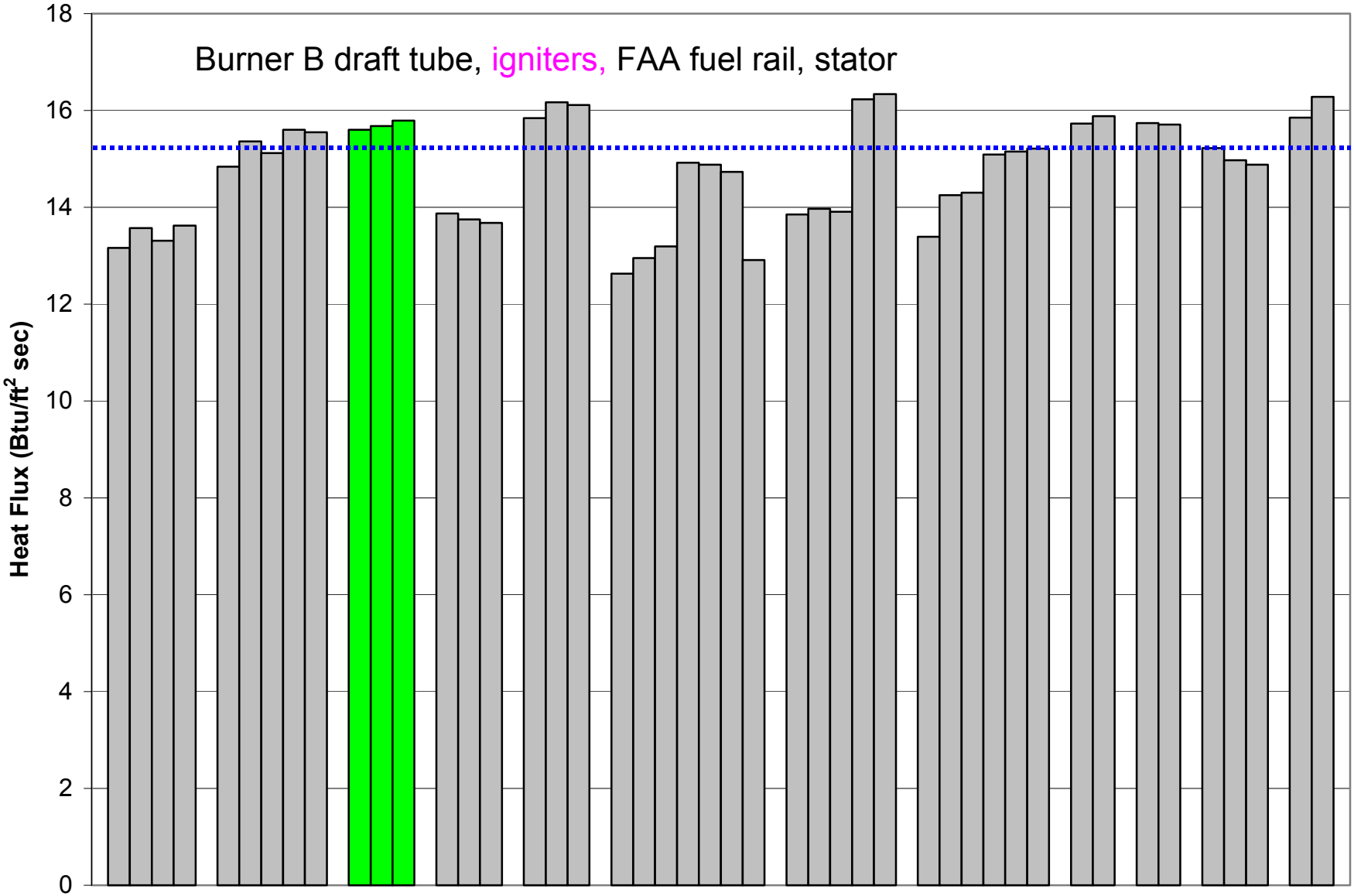


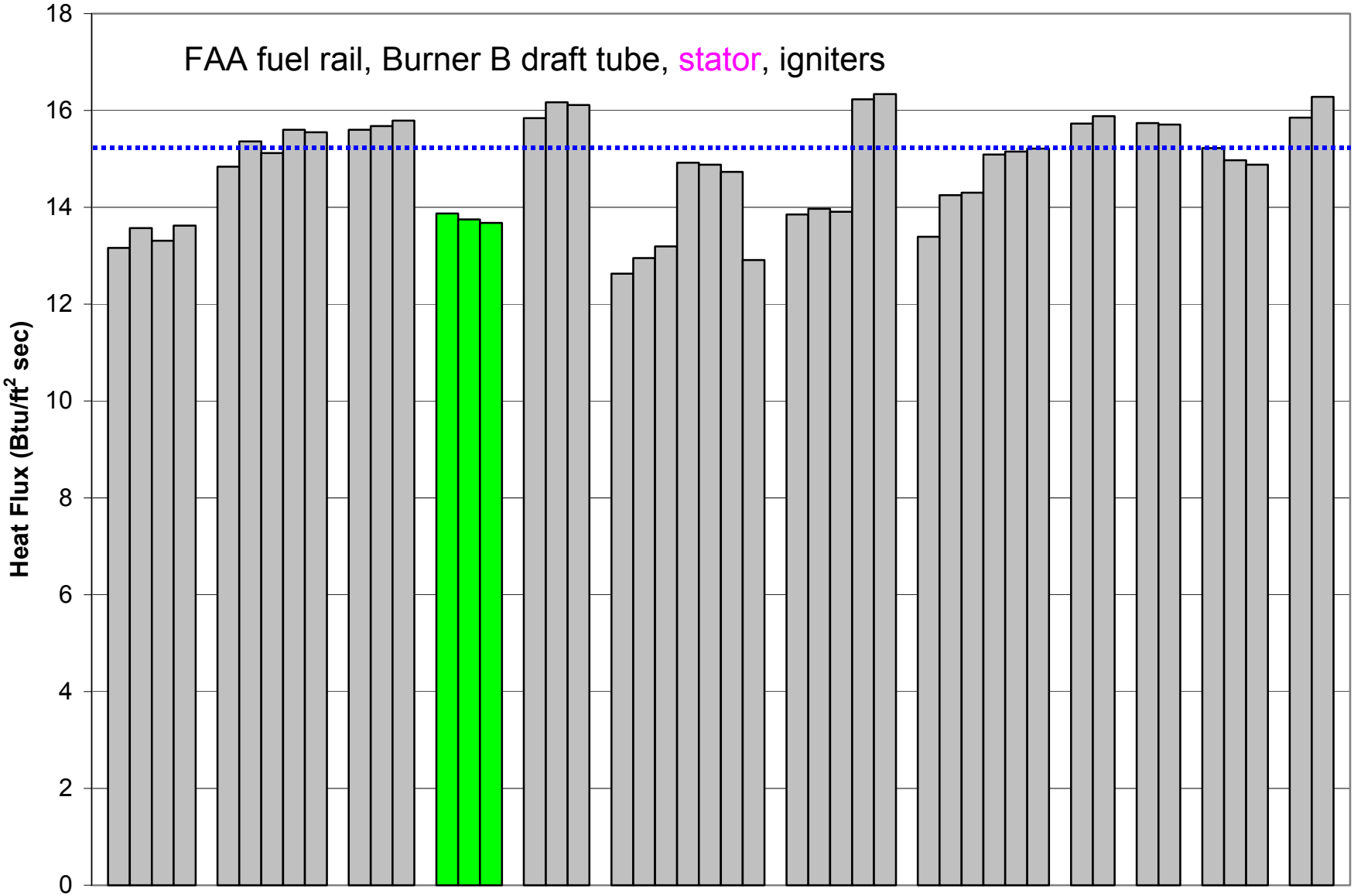
Spare Burner B Heat Flux Trials Using 6.5 gph Fuel Nozzle

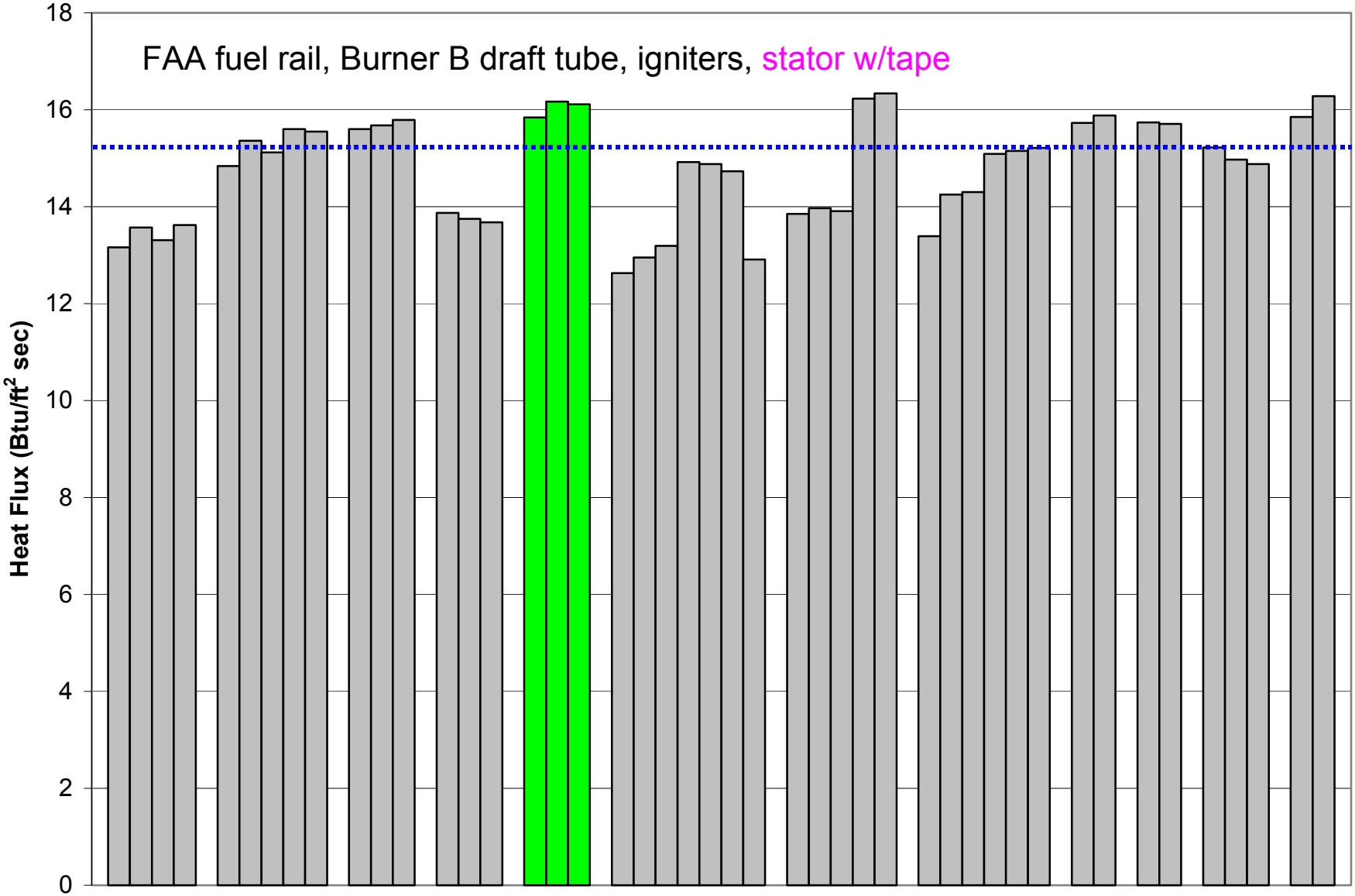


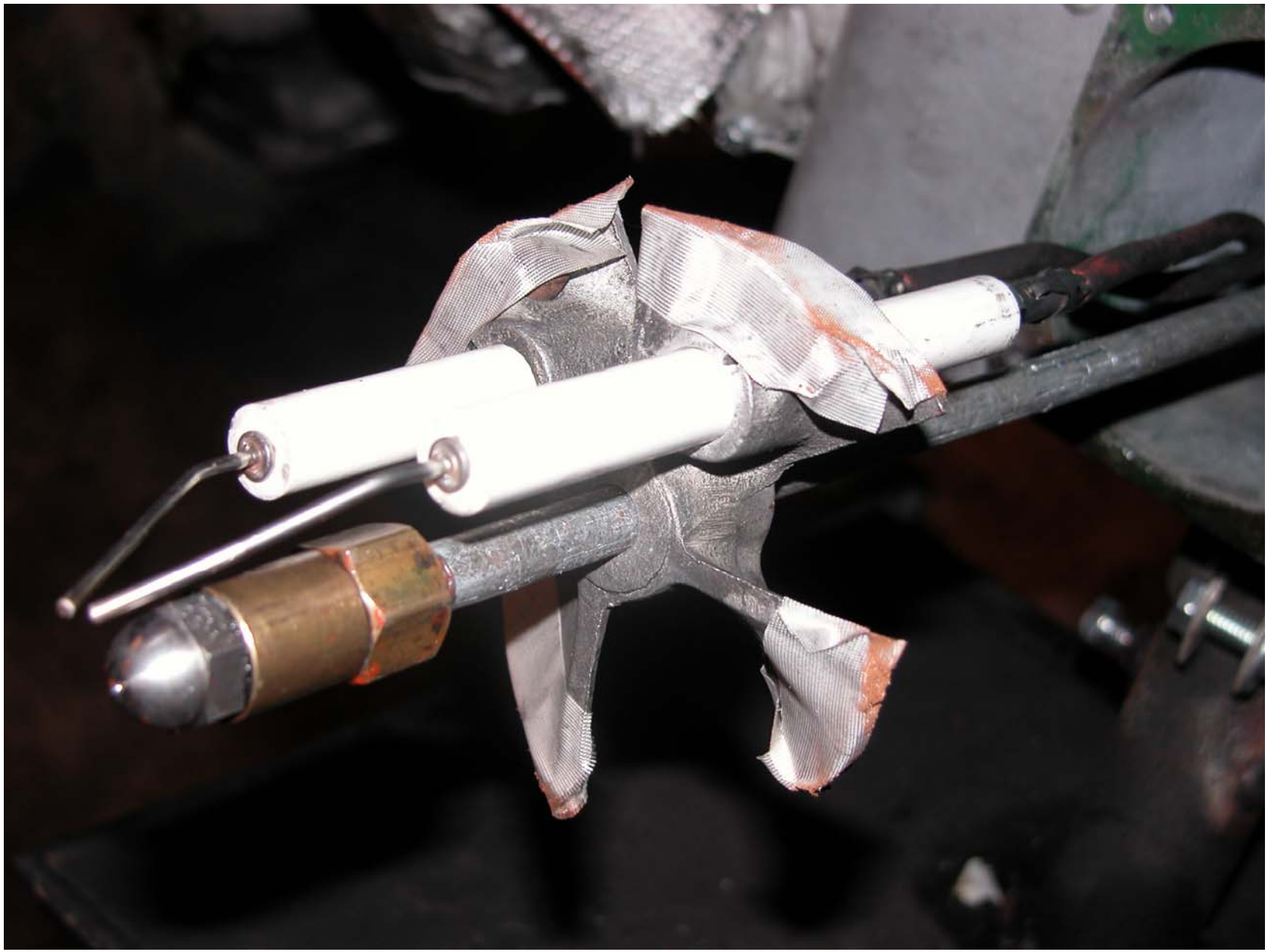
Spare Burner B Heat Flux Trials Using 6.5 gph Fuel Nozzle

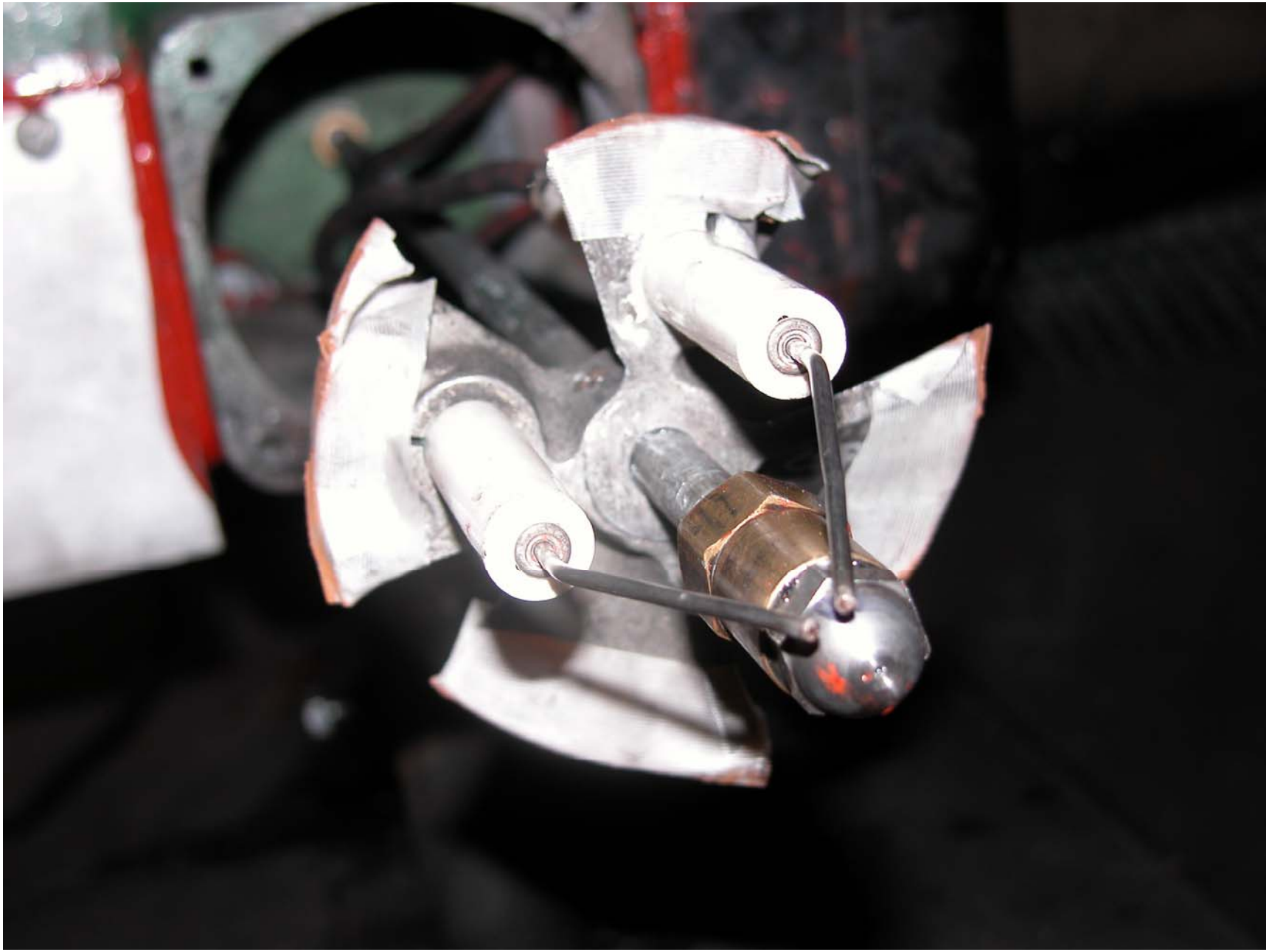


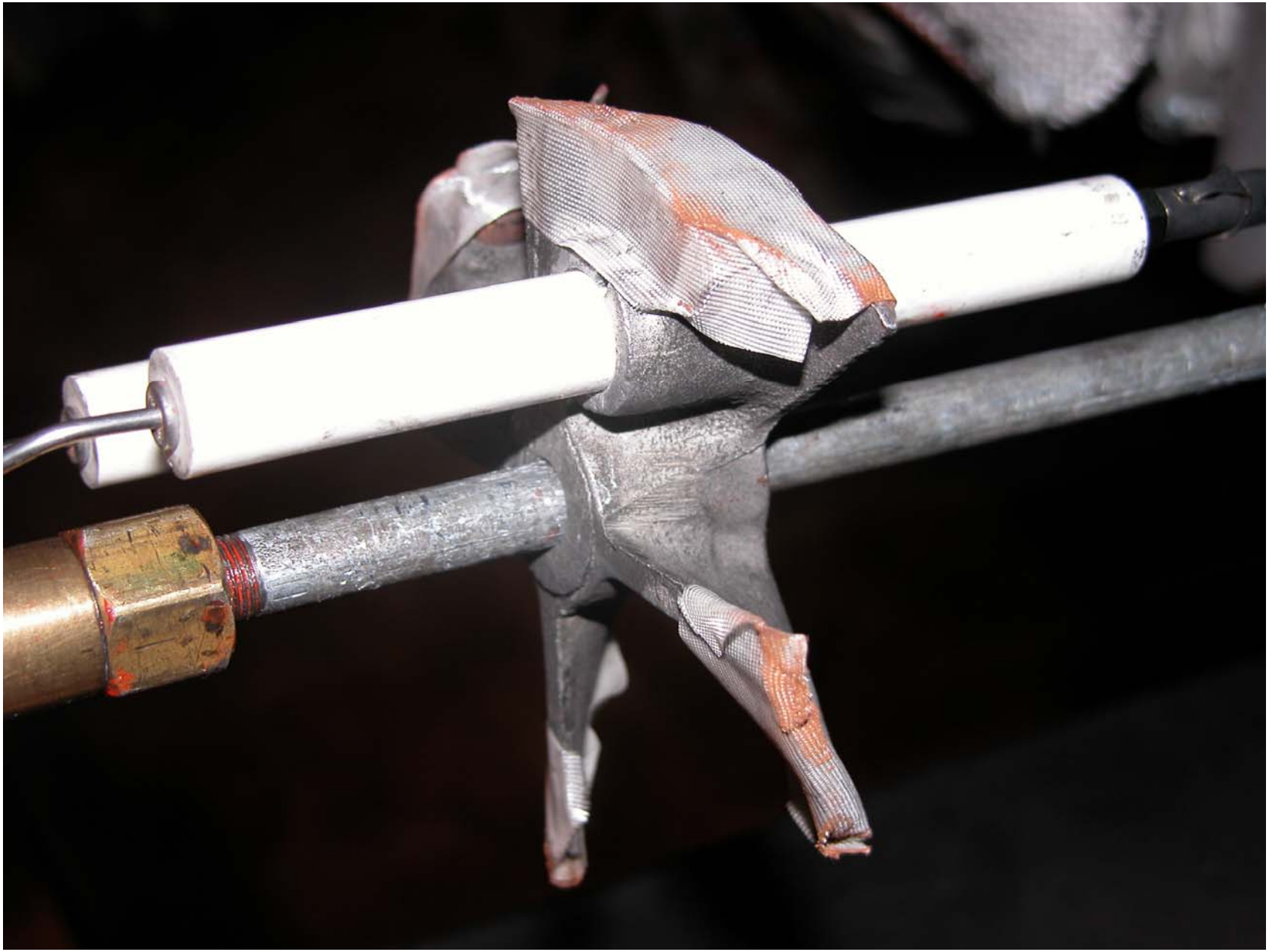

Burner B draft tube, igniters, FAA fuel rail, stator
Heat Flux (Btu/ft2 sec)
0
2
4
6
8
10
12
14
16
18

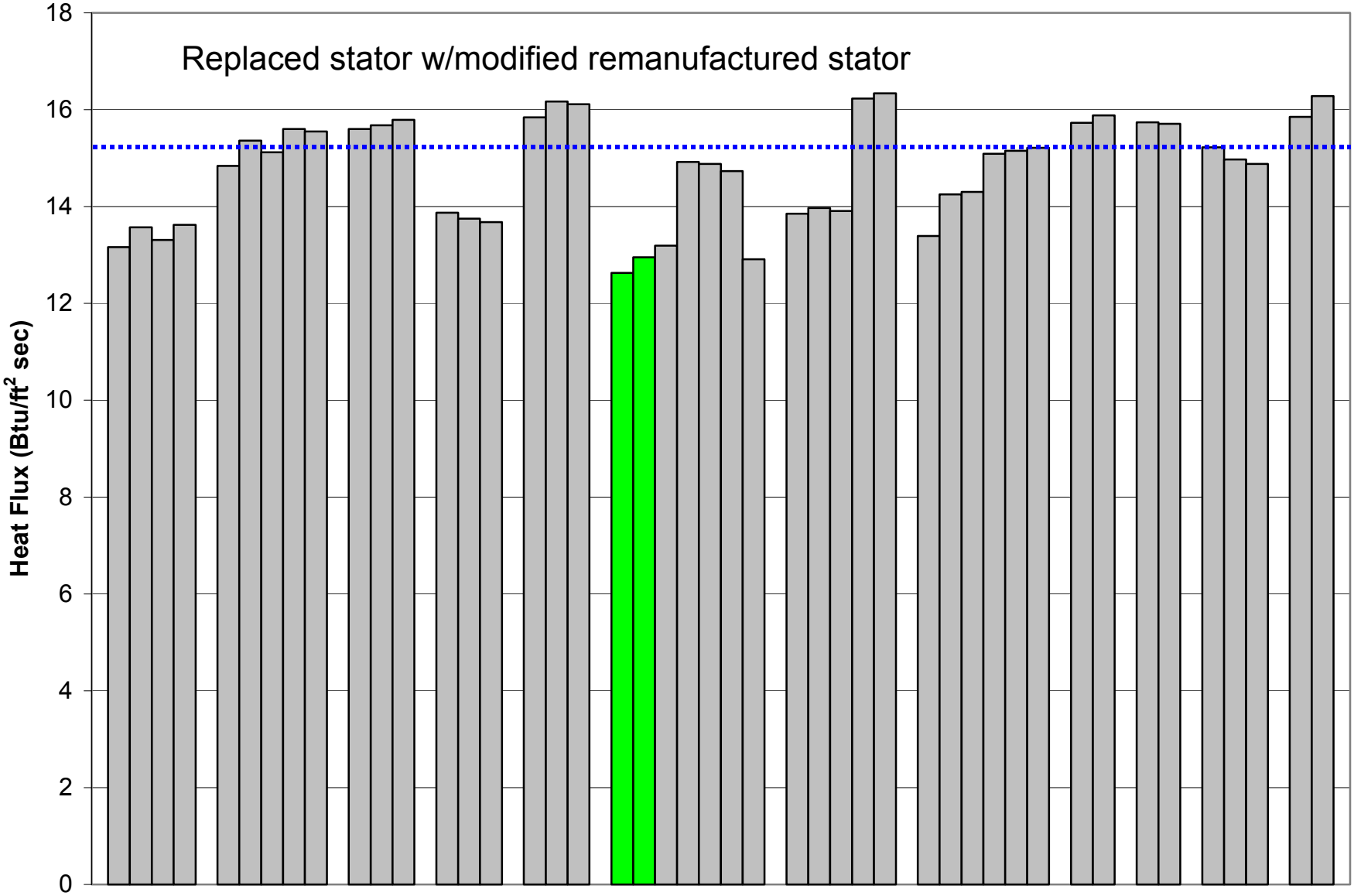

FAA fuel rail, Burner B draft tube, stator, igniters
Heat Flux (Btu/ft2 sec)
0
2
4
6
8
10
12
14
16
18

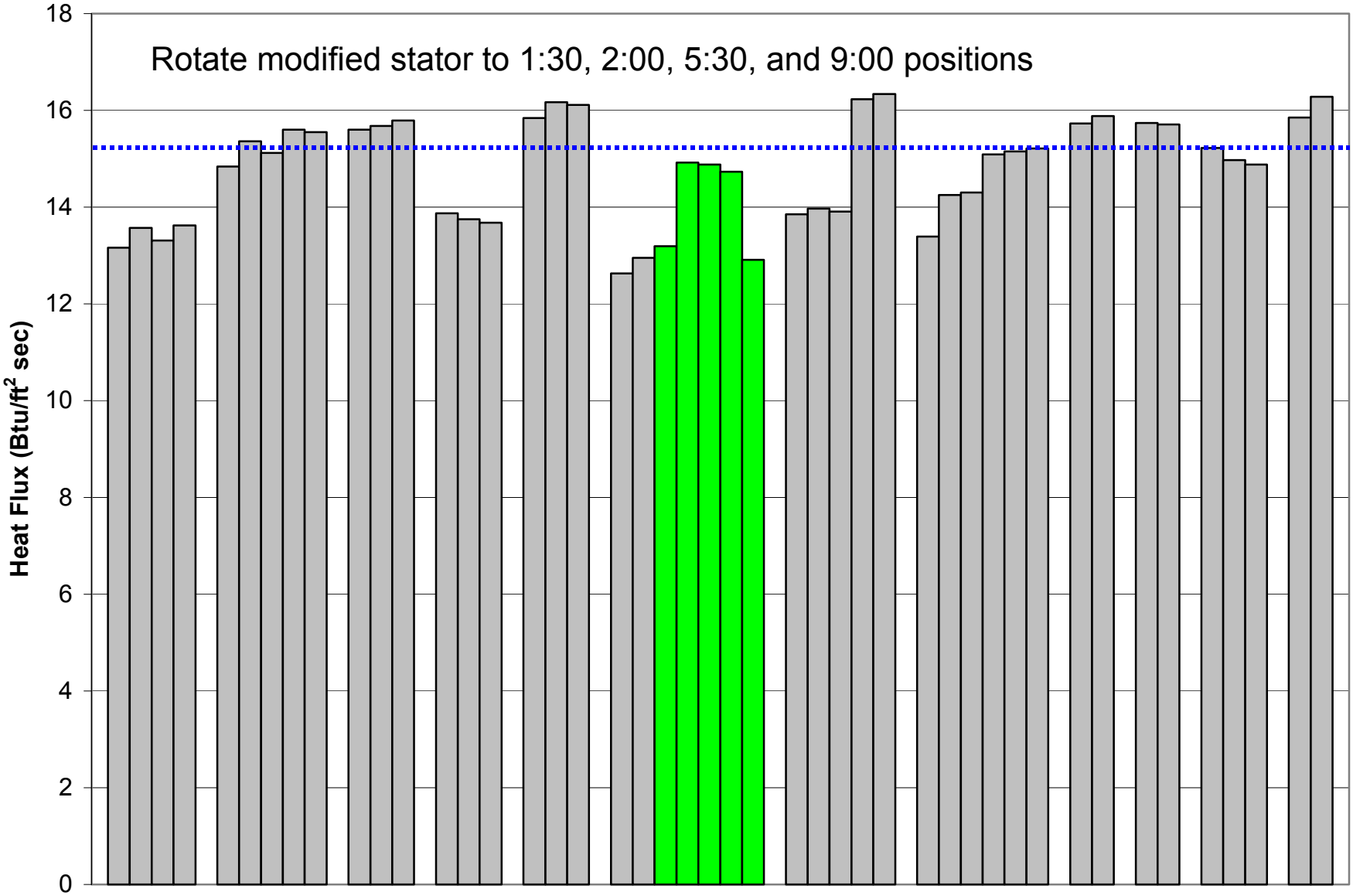

FAA fuel rail, Burner B draft tube, igniters, stator w/tape
Heat Flux (Btu/ft2 sec)
0
2
4
6
8
10
12
14
16
18

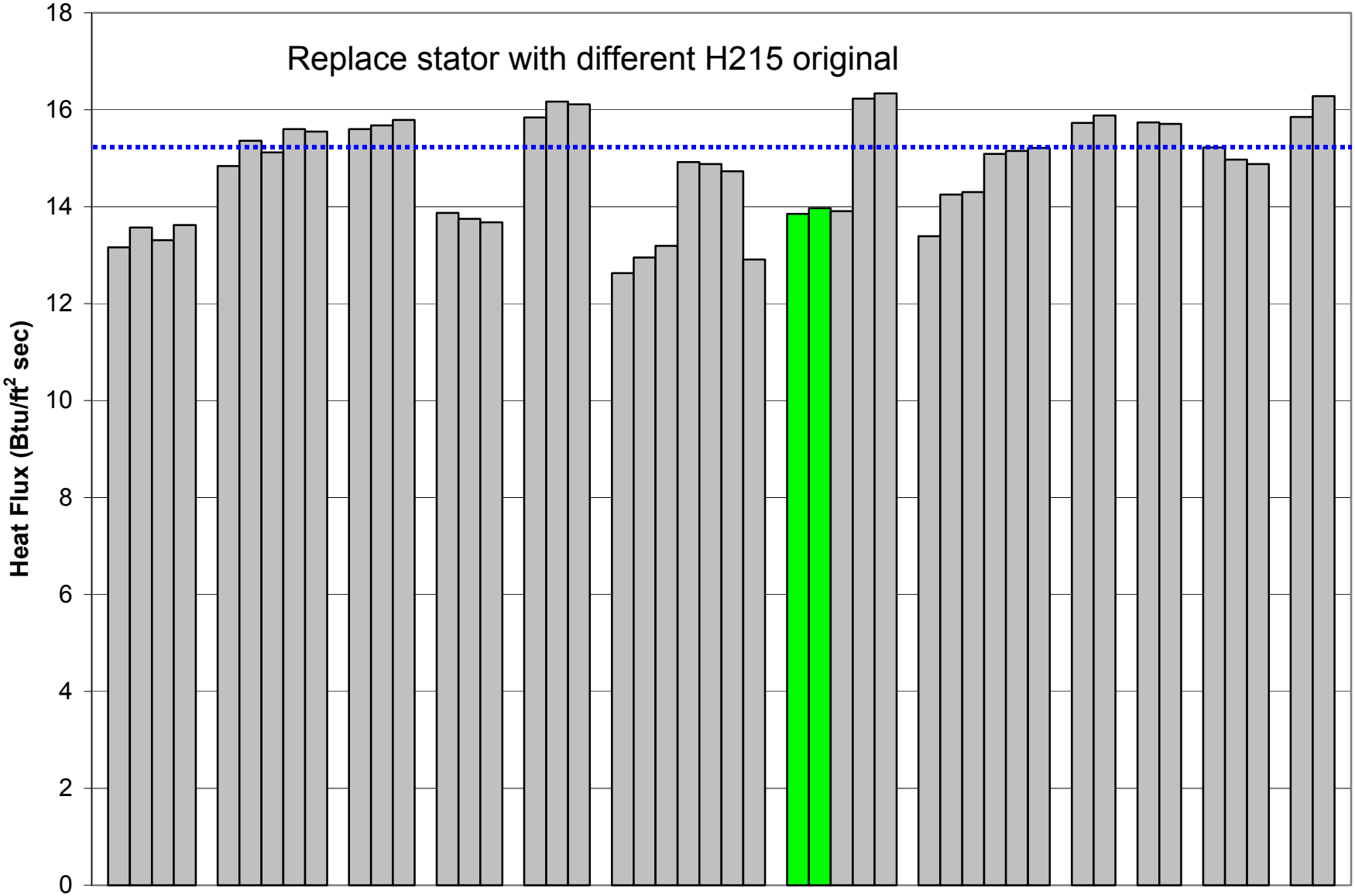


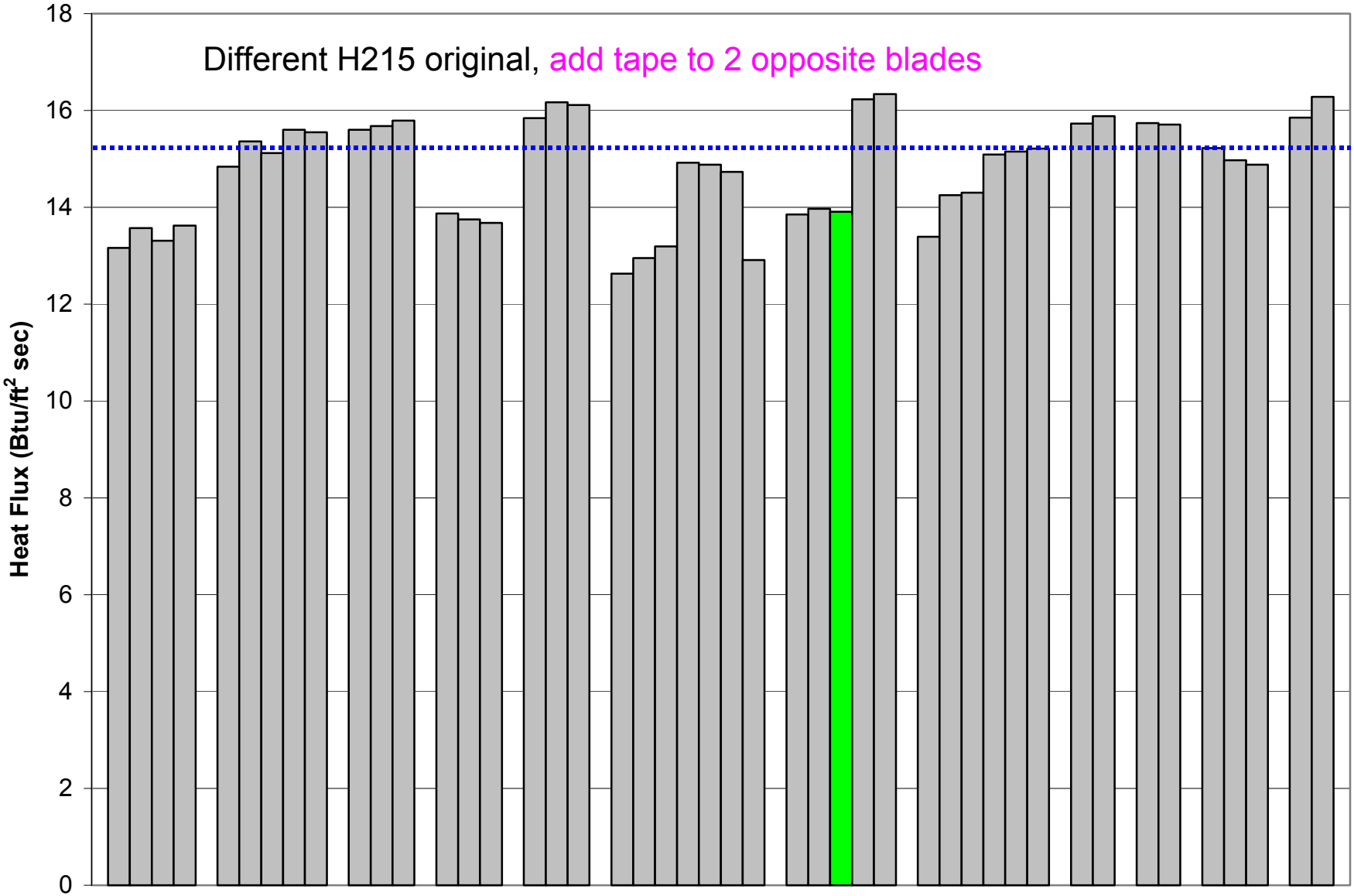


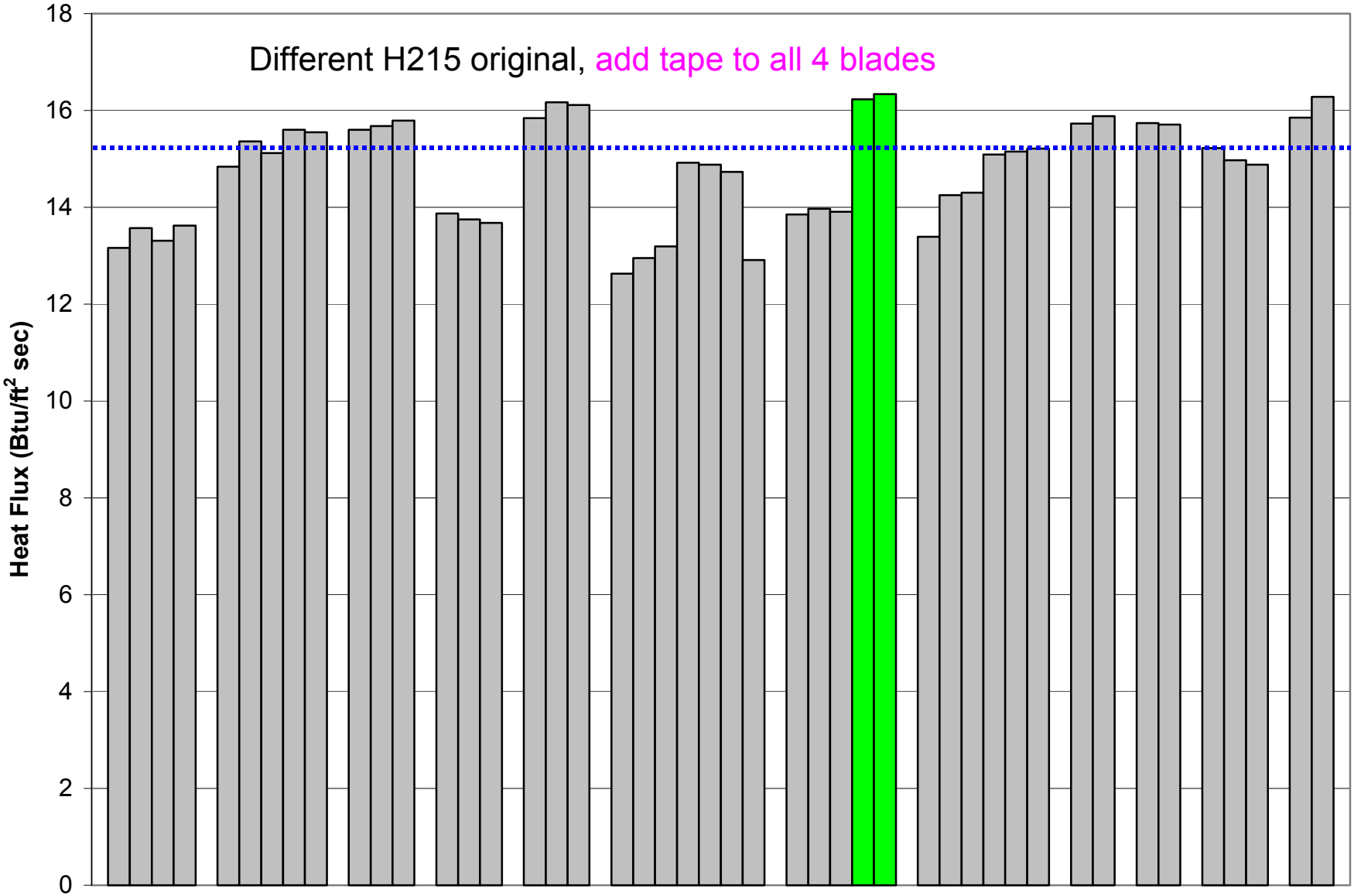


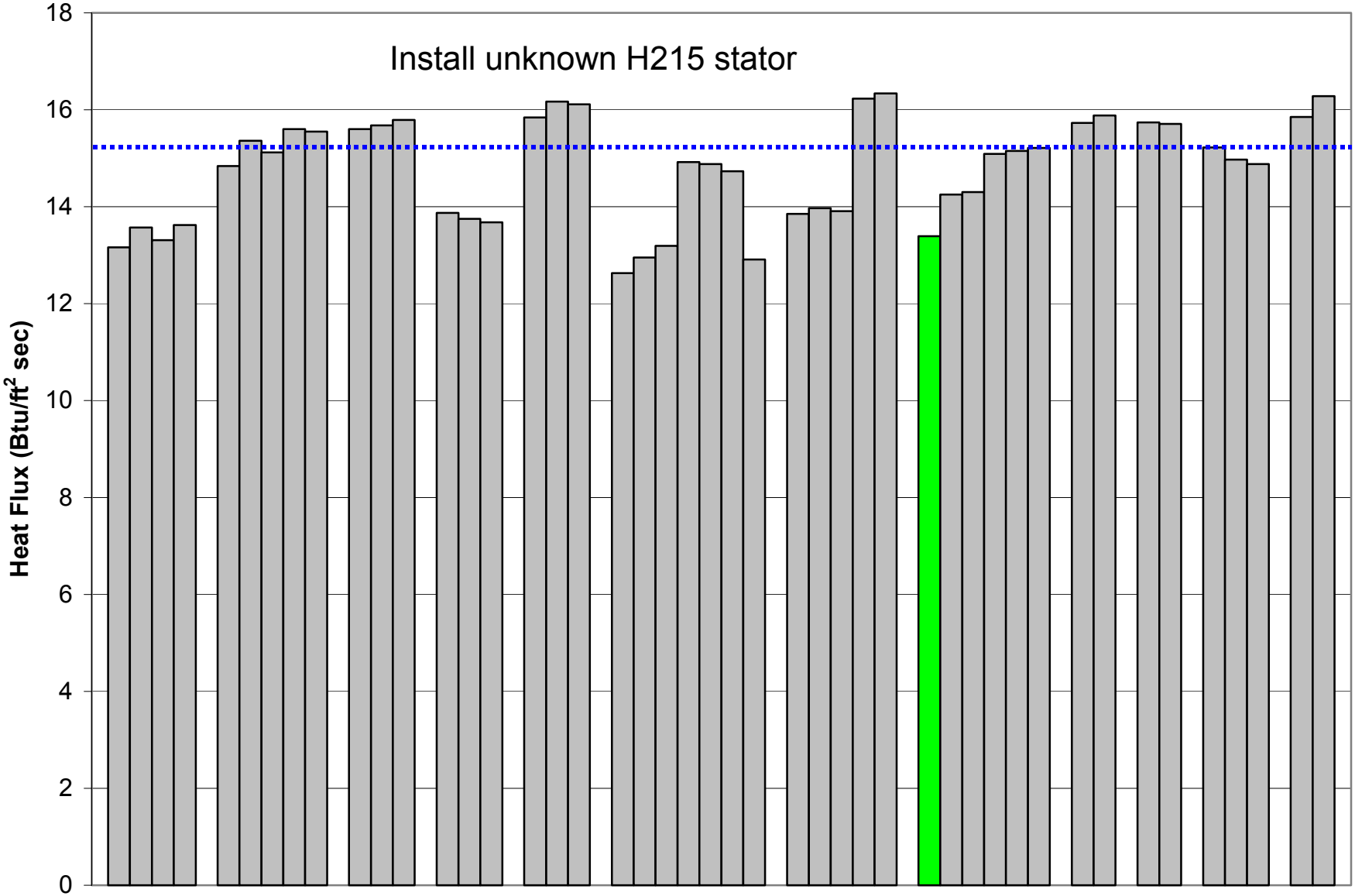

Replaced stator w/modified remanufactured stator
Heat Flux (Btu/ft2 sec)
0
2
4
6
8
10
12
14
16
18

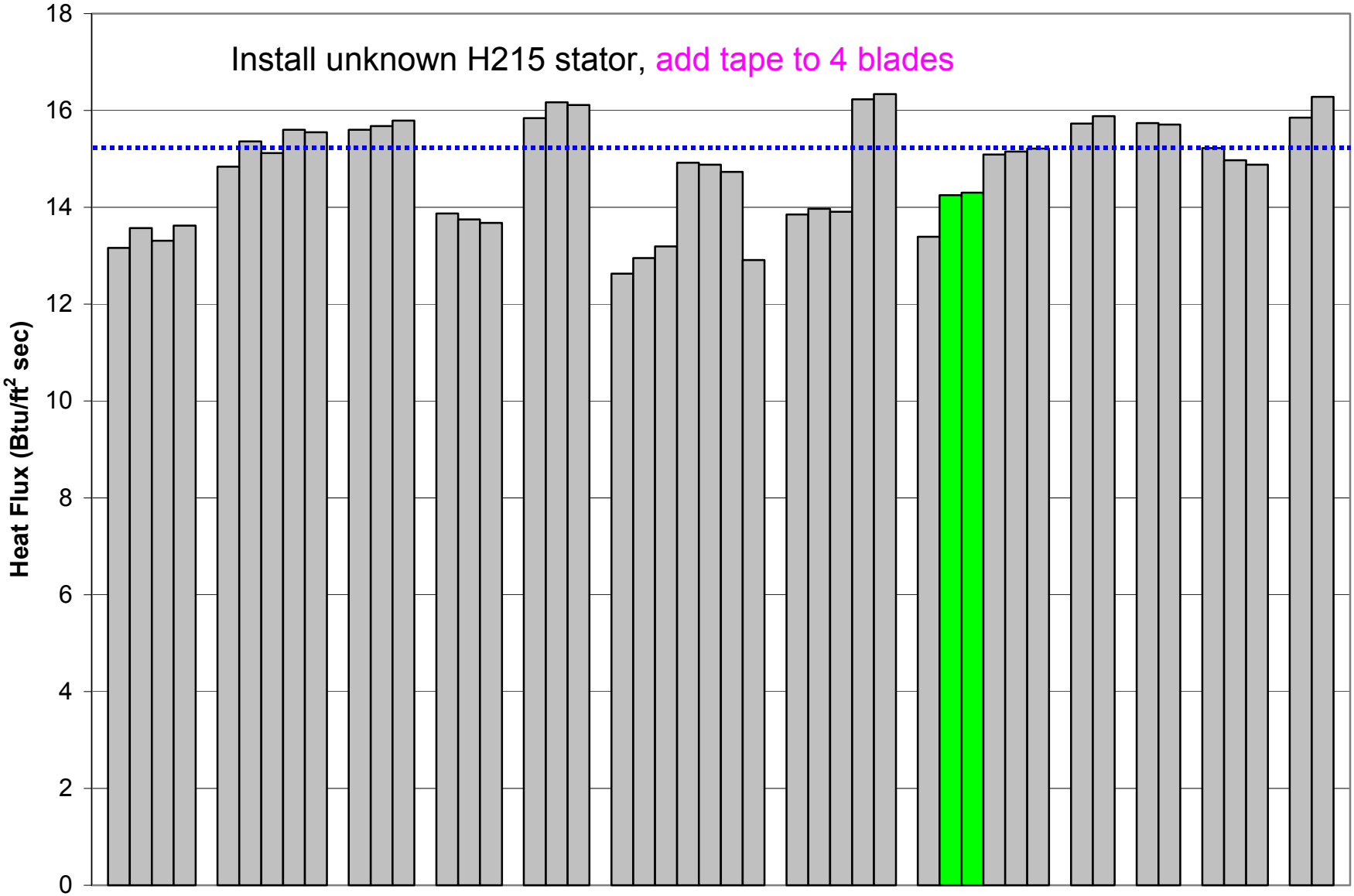

Rotate modified stator to 1:30, 2:00, 5:30, and 9:00 positions
Heat Flux (Btu/ft2 sec)
0
2
4
6
8
10
12
14
16
18

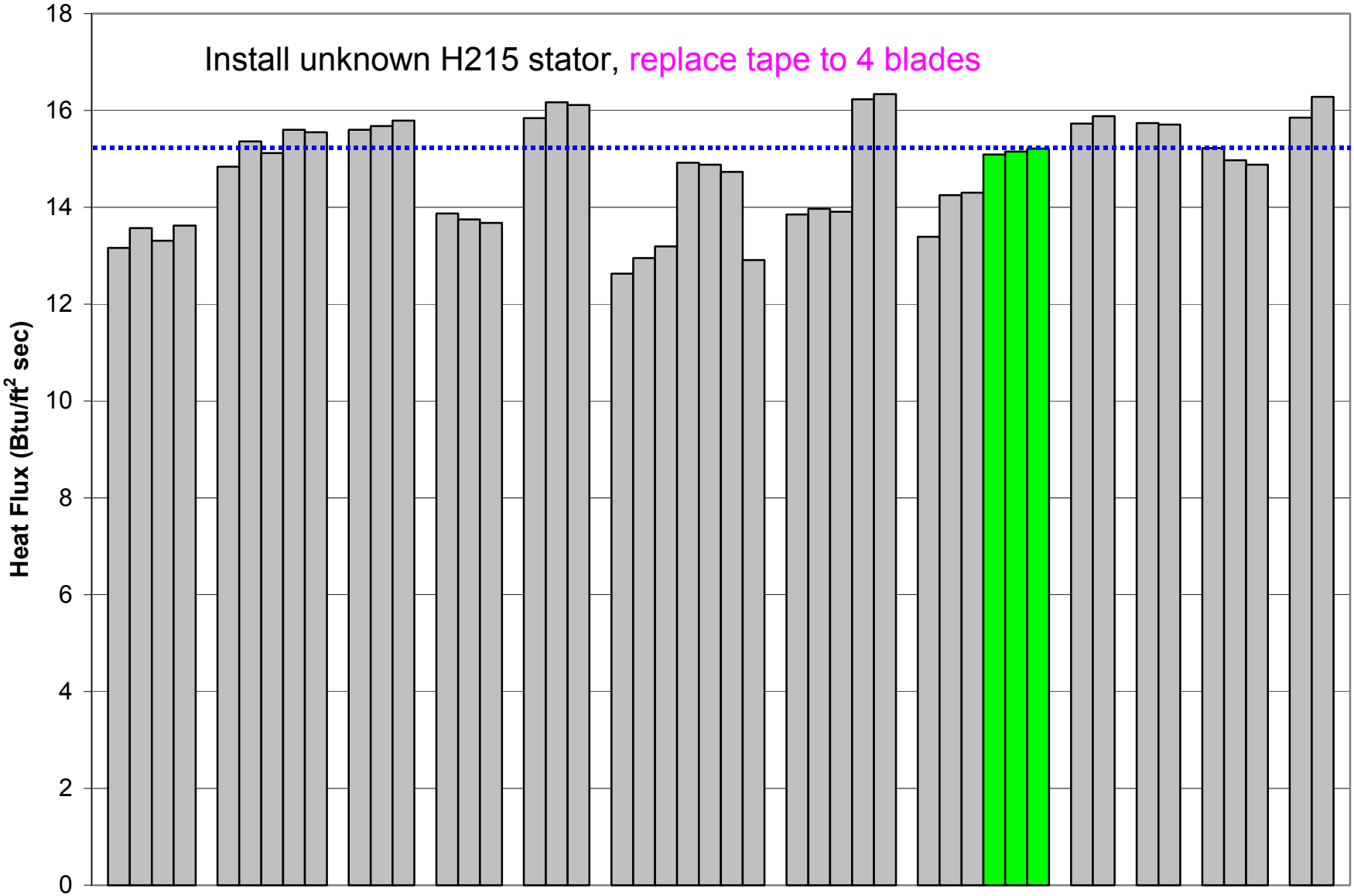

Replace stator with different H215 original
Heat Flux (Btu/ft2 sec)
0
2
4
6
8
10
12
14
16
18

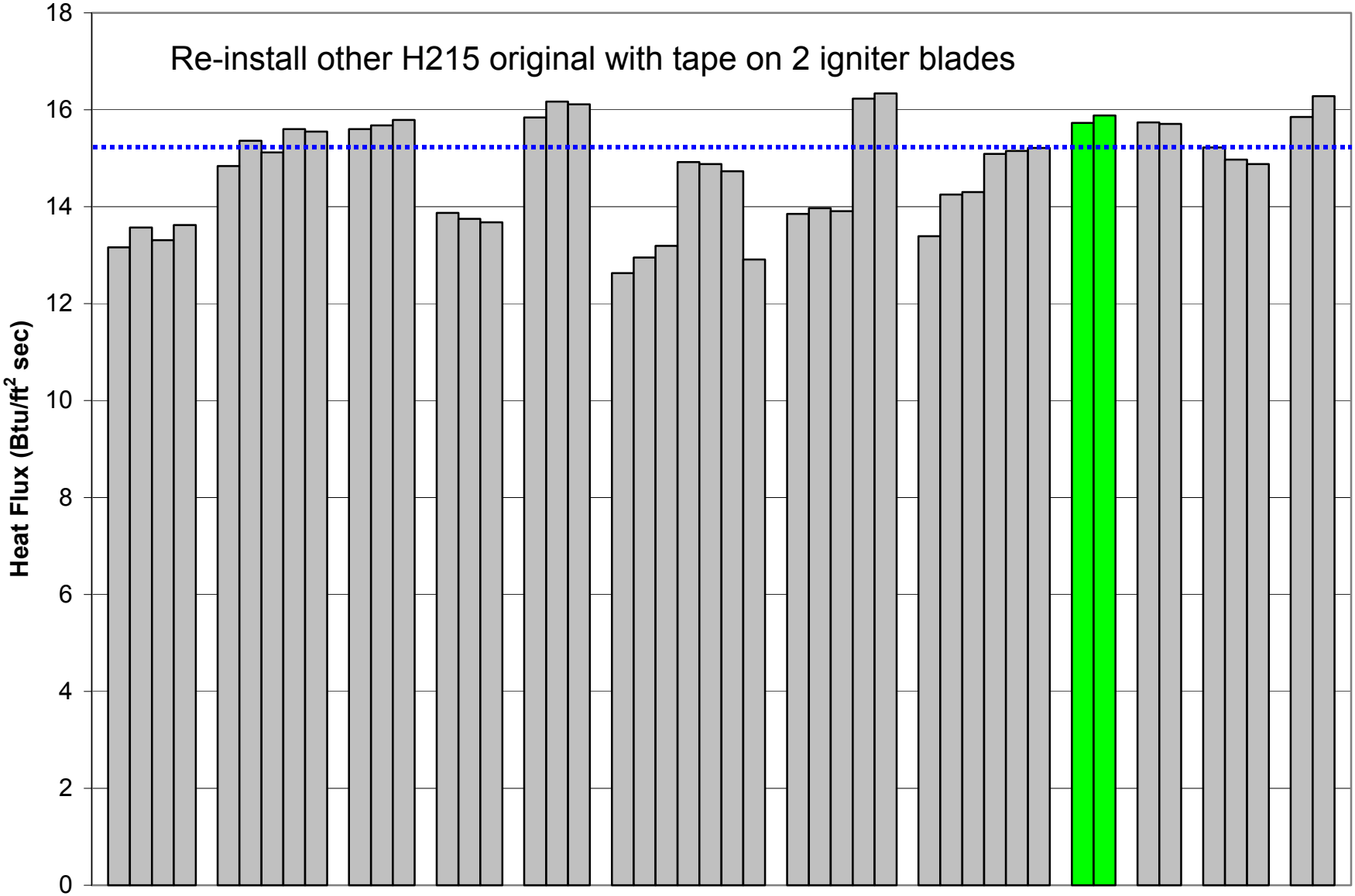

Different H215 original, add tape to 2 opposite blades
Heat Flux (Btu/ft2 sec)
0
2
4
6
8
10
12
14
16
18

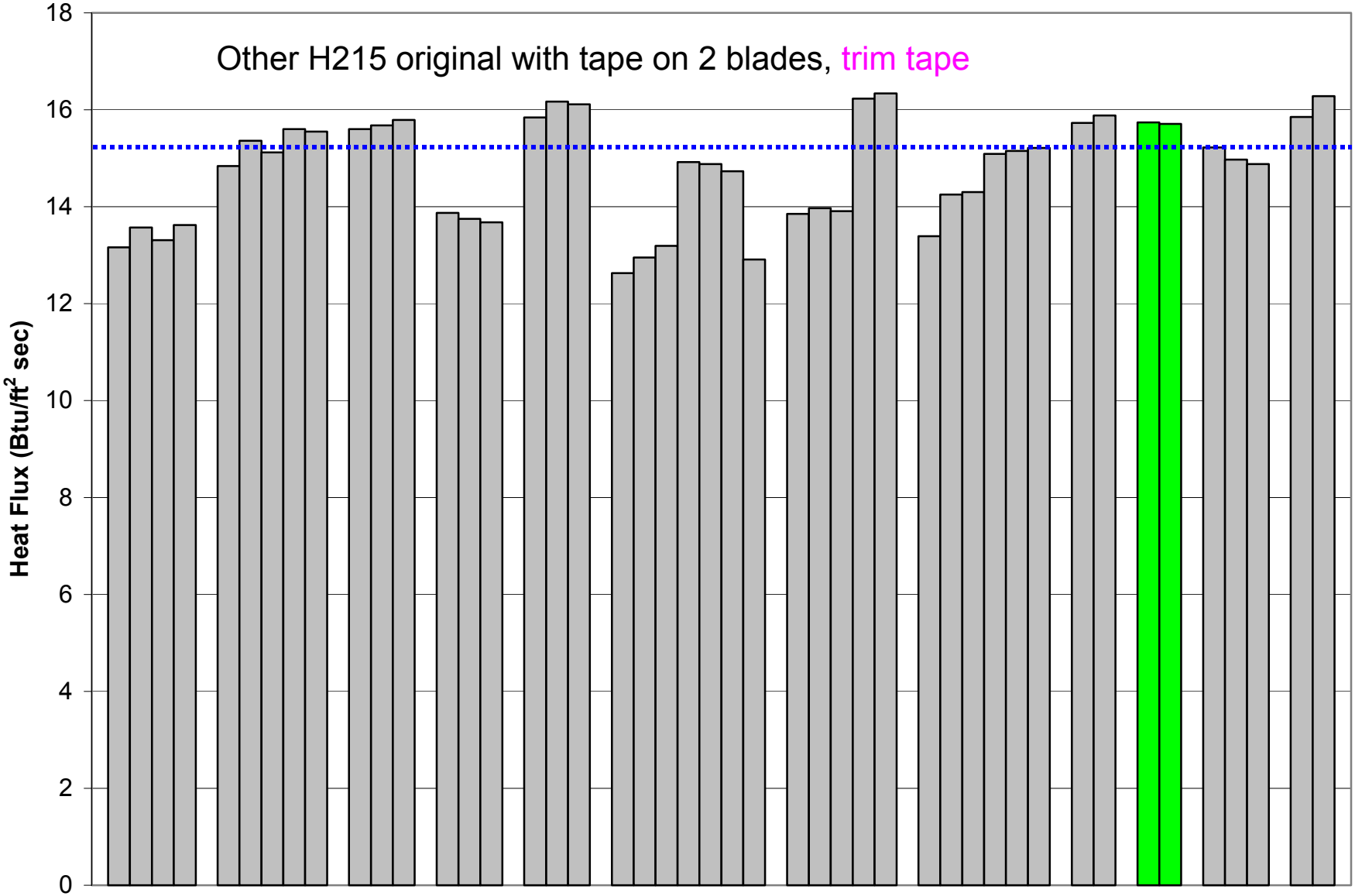

Different H215 original, add tape to all 4 blades
Heat Flux (Btu/ft2 sec)
0
2
4
6
8
10
12
14
16
18

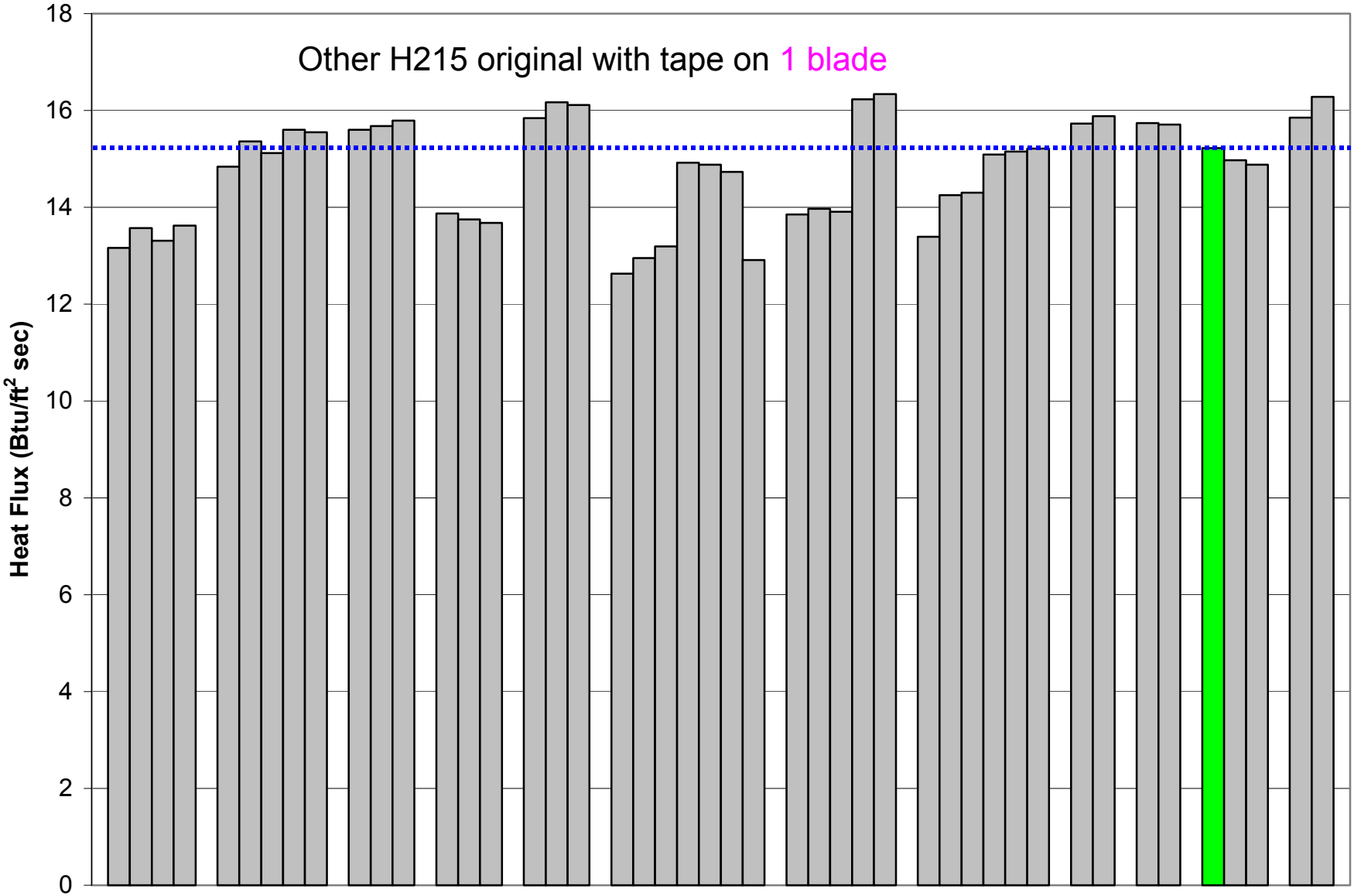

Install unknown H215 stator
Heat Flux (Btu/ft2 sec)
0
2
4
6
8
10
12
14
16
18

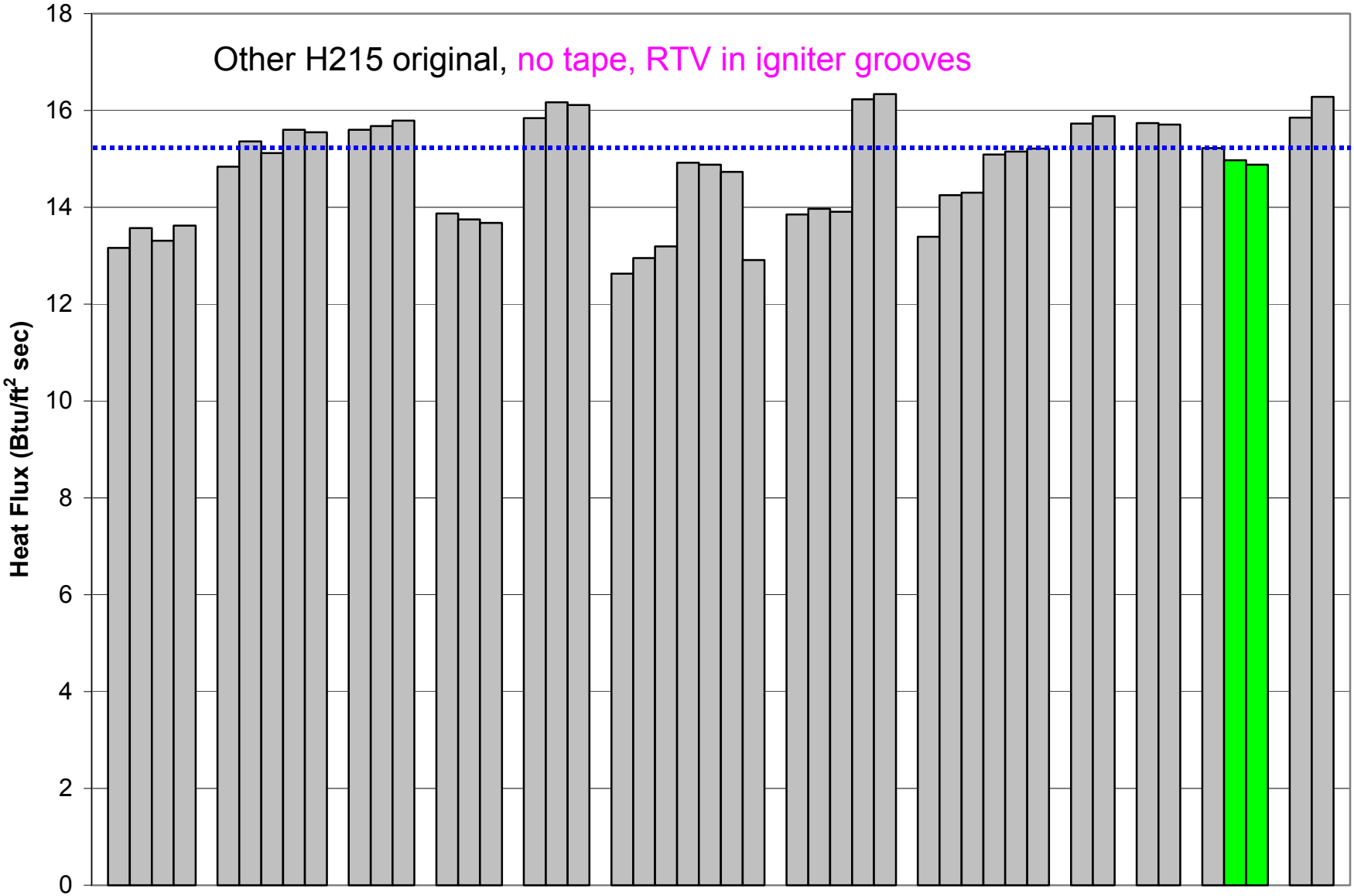

Install unknown H215 stator, add tape to 4 blades
Heat Flux (Btu/ft2 sec)
0
2
4
6
8
10
12
14
16
18

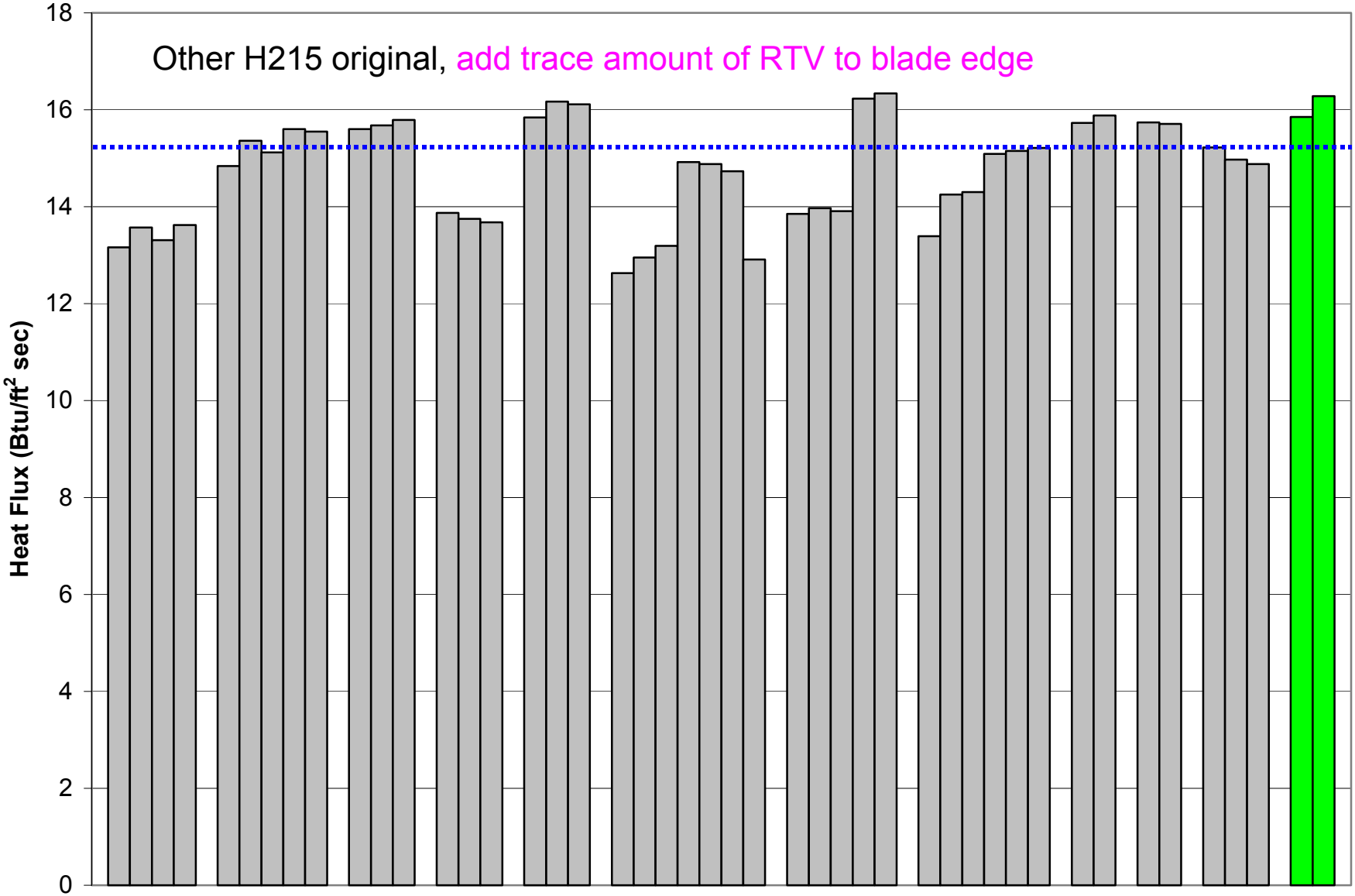

Install unknown H215 stator, replace tape to 4 blades
Heat Flux (Btu/ft2 sec)
0
2
4
6
8
10
12
14
16
18


Re-install other H215 original with tape on 2 igniter blades
Heat Flux (Btu/ft2 sec)
0
2
4
6
8
10
12
14
16
18

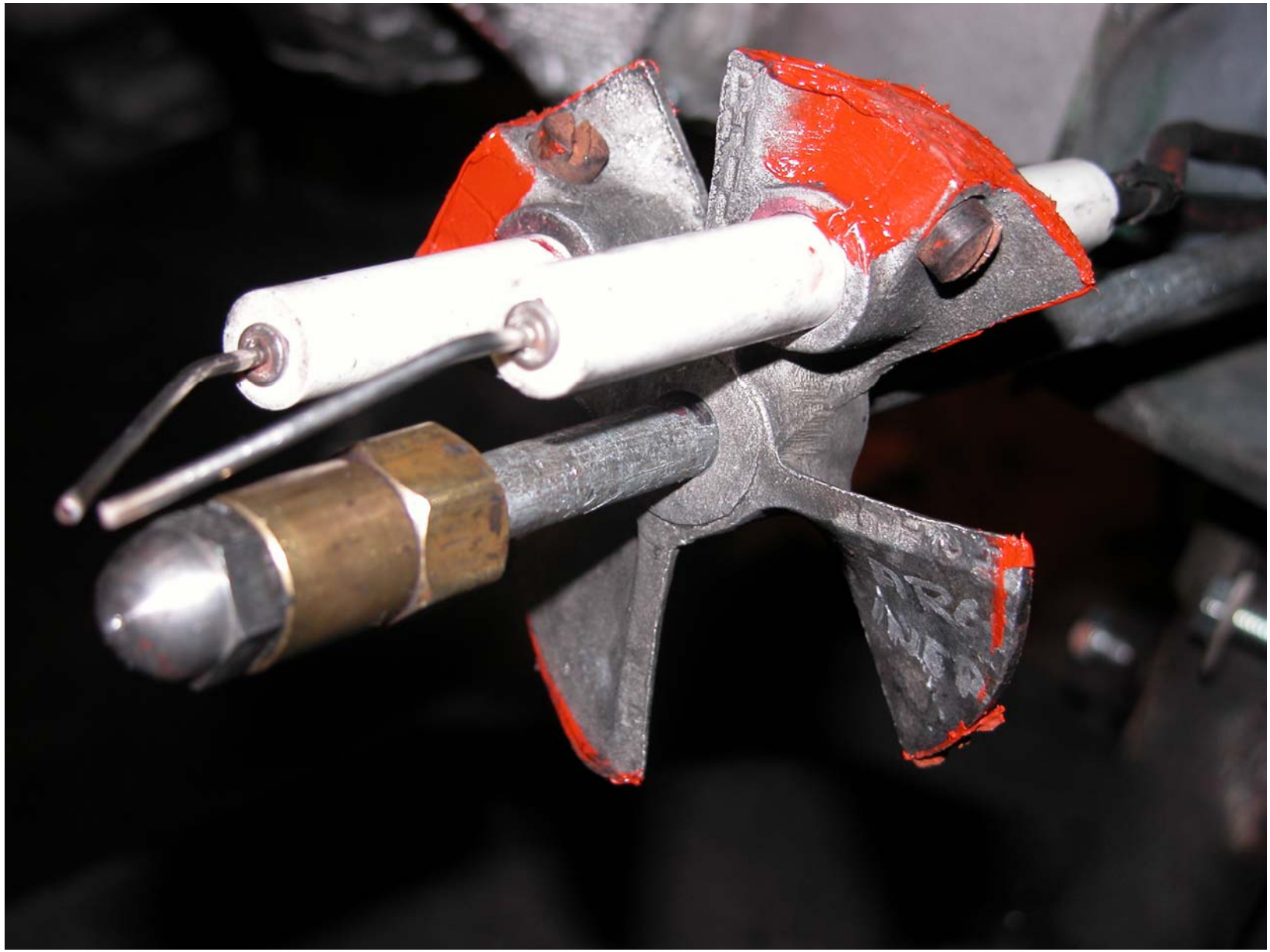

Other H215 original with tape on 2 blades, trim tape
Heat Flux (Btu/ft2 sec)
0
2
4
6
8
10
12
14
16
18


Other H215 original with tape on 1 blade
Heat Flux (Btu/ft2 sec)
0
2
4
6
8
10
12
14
16
18

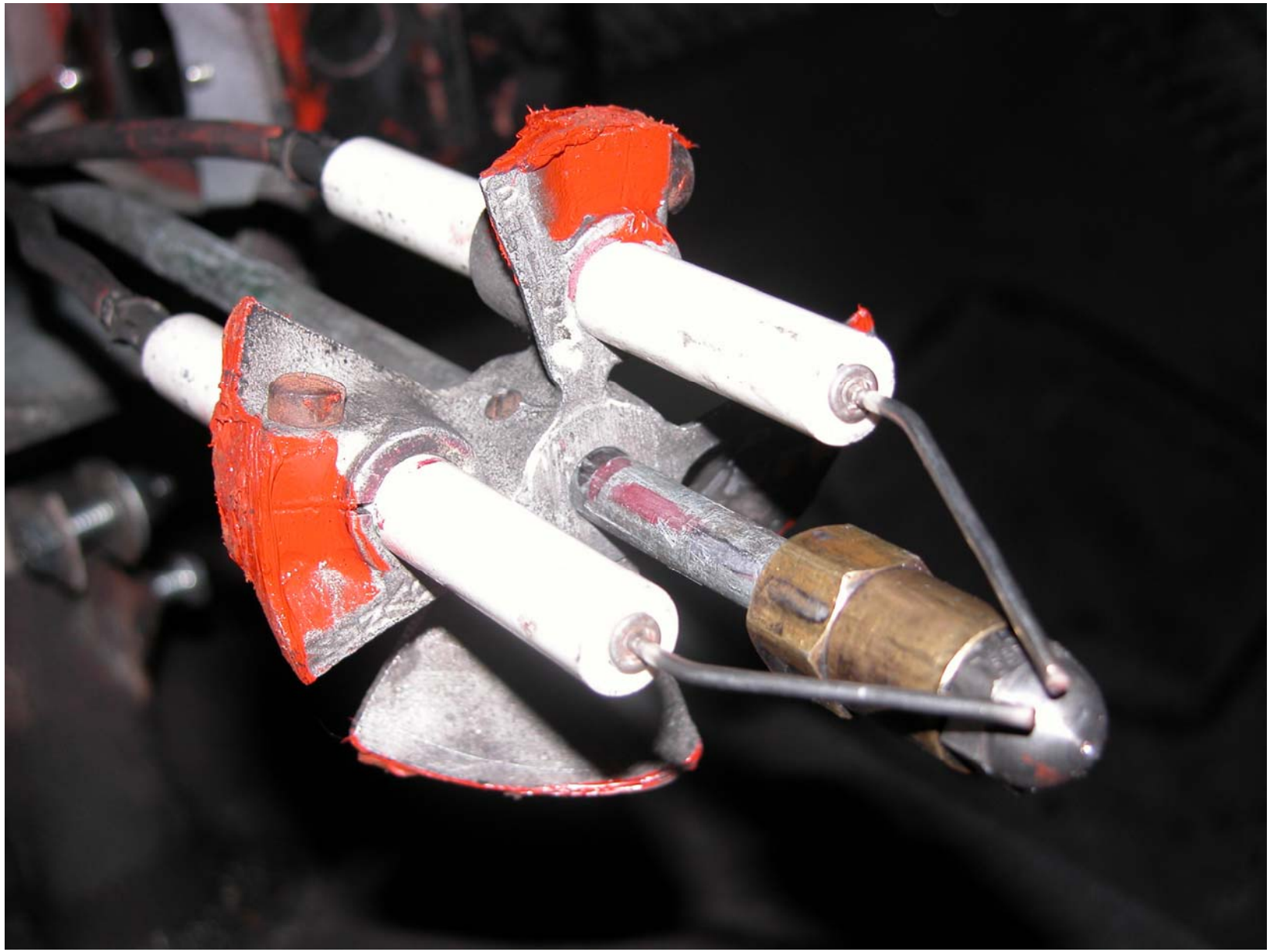

Other H215 original, no tape, RTV in igniter grooves
Heat Flux (Btu/ft2 sec)
0
2
4
6
8
10
12
14
16
18


Other H215 original, add trace amount of RTV to blade edge
Heat Flux (Btu/ft2 sec)
0
2
4
6
8
10
12
14
16
18

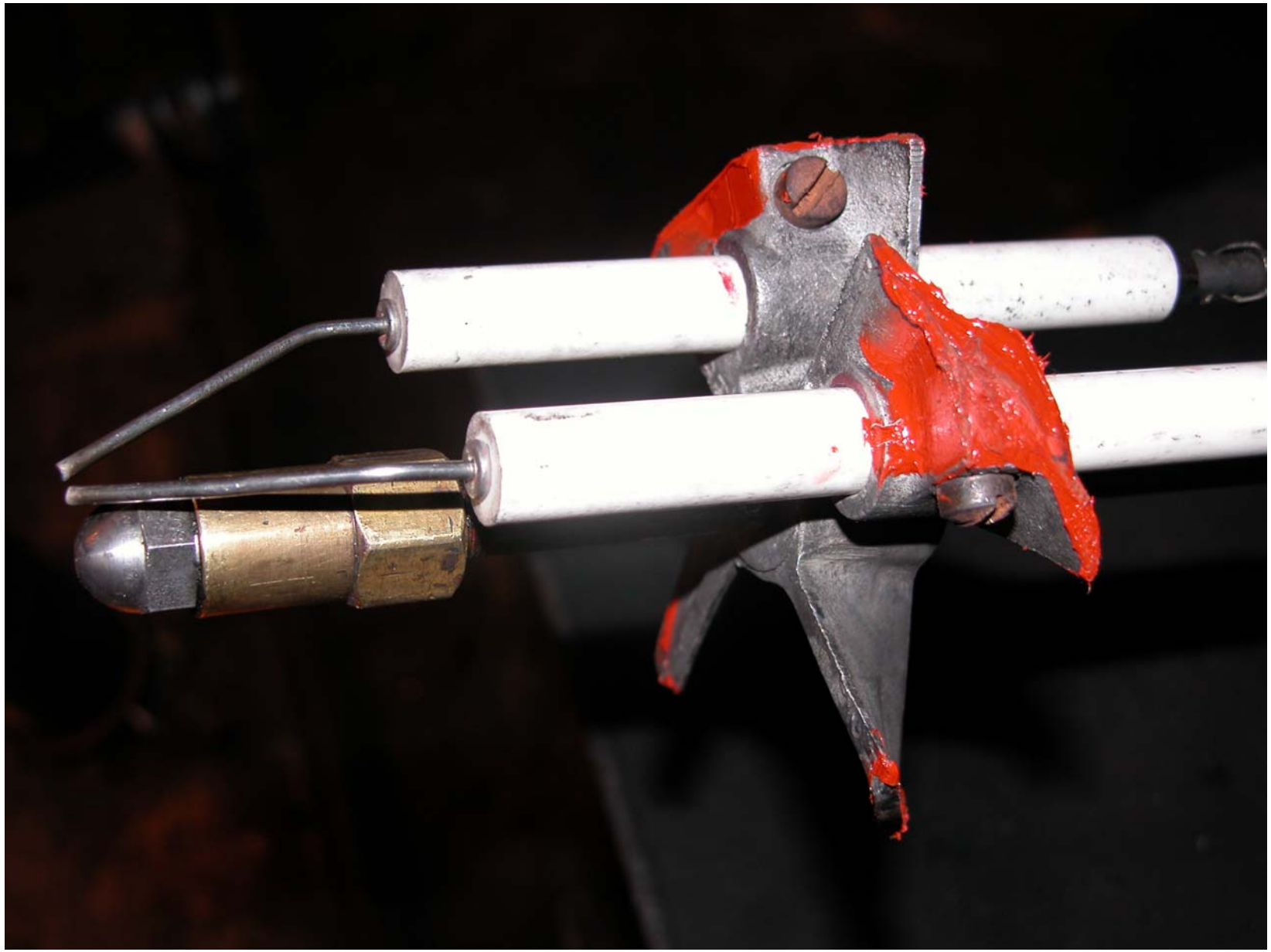
RTV Sealant Added to Blade Edge



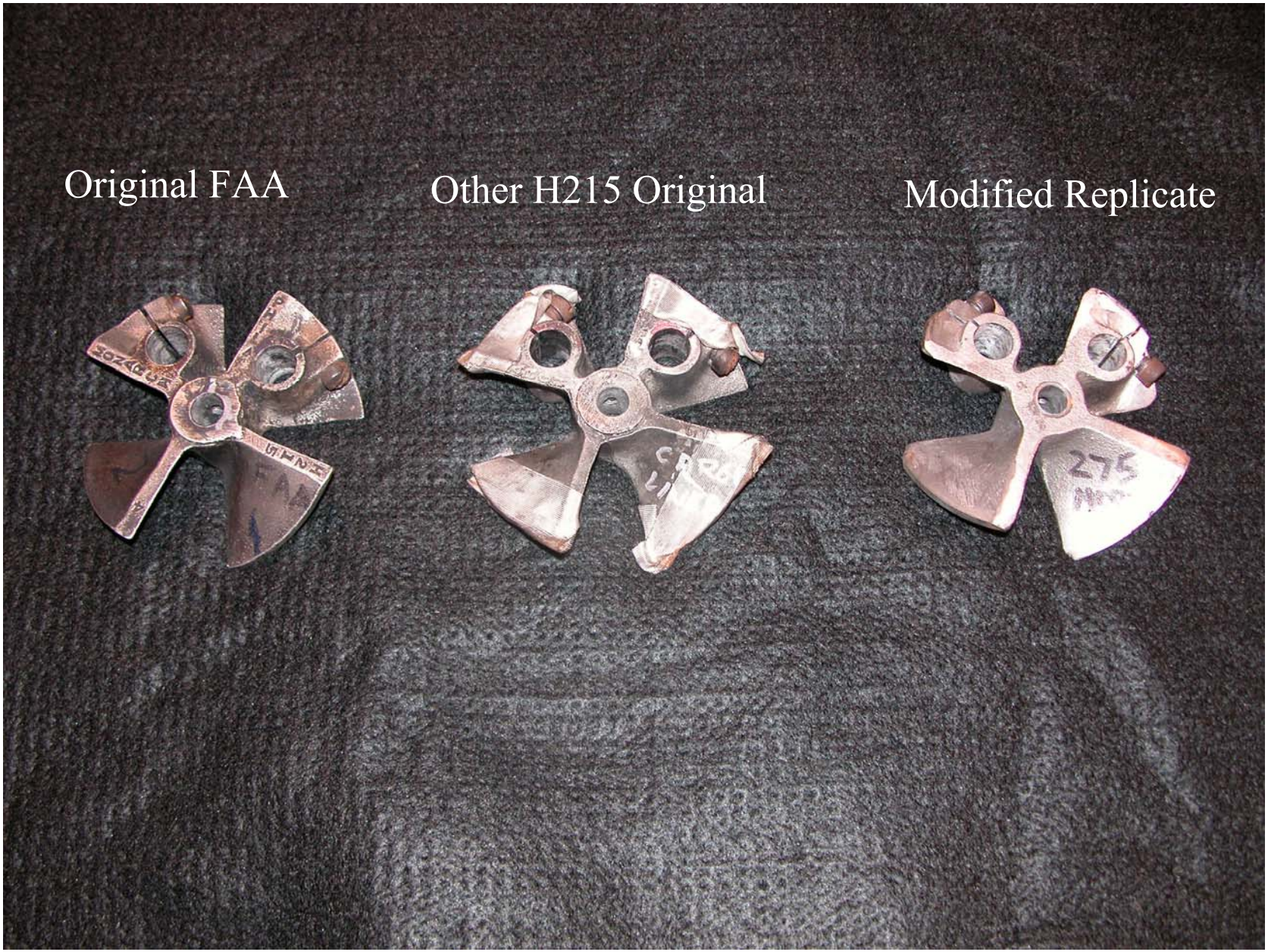
RTV Sealant Added to Blade Edge

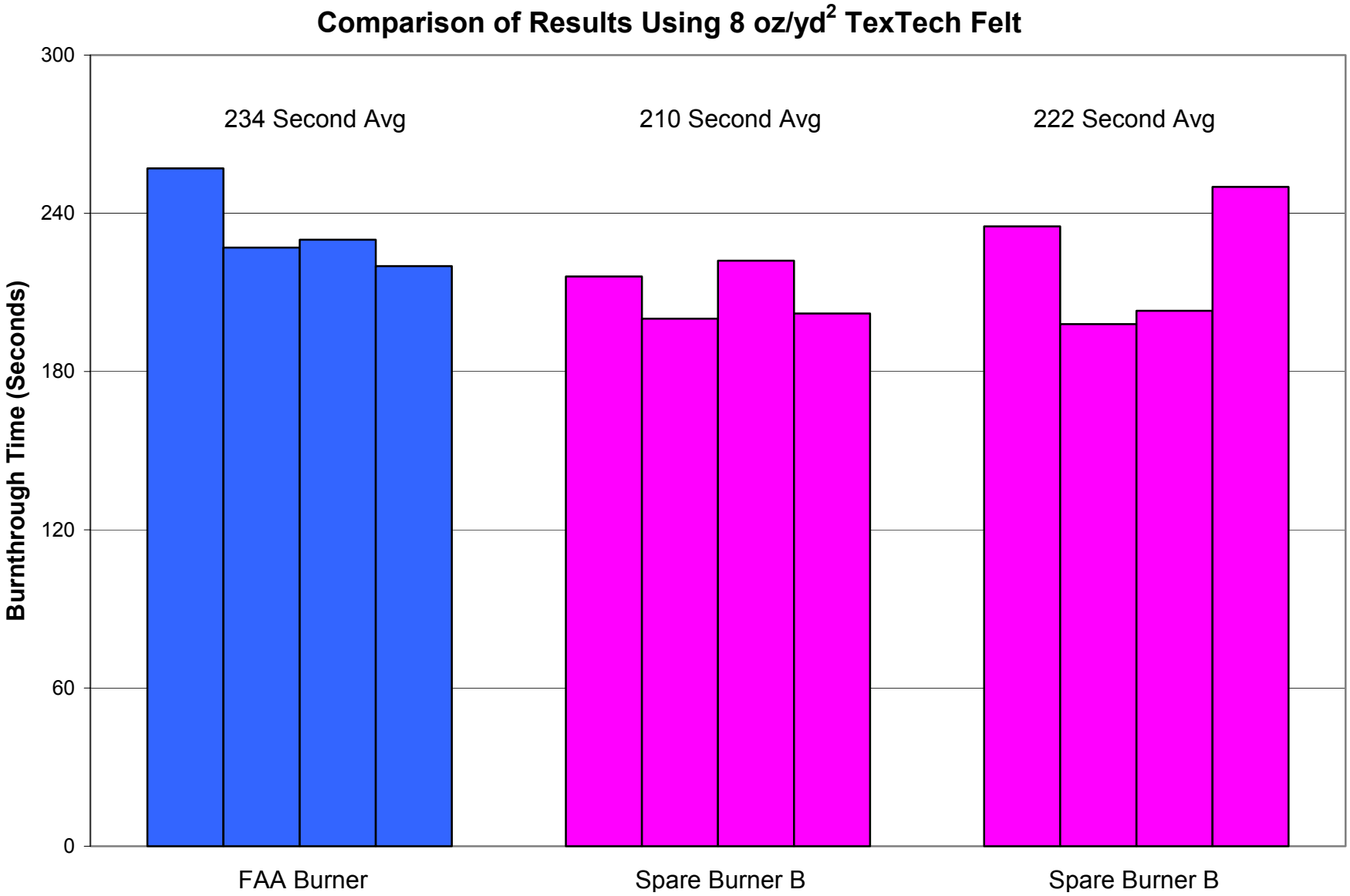


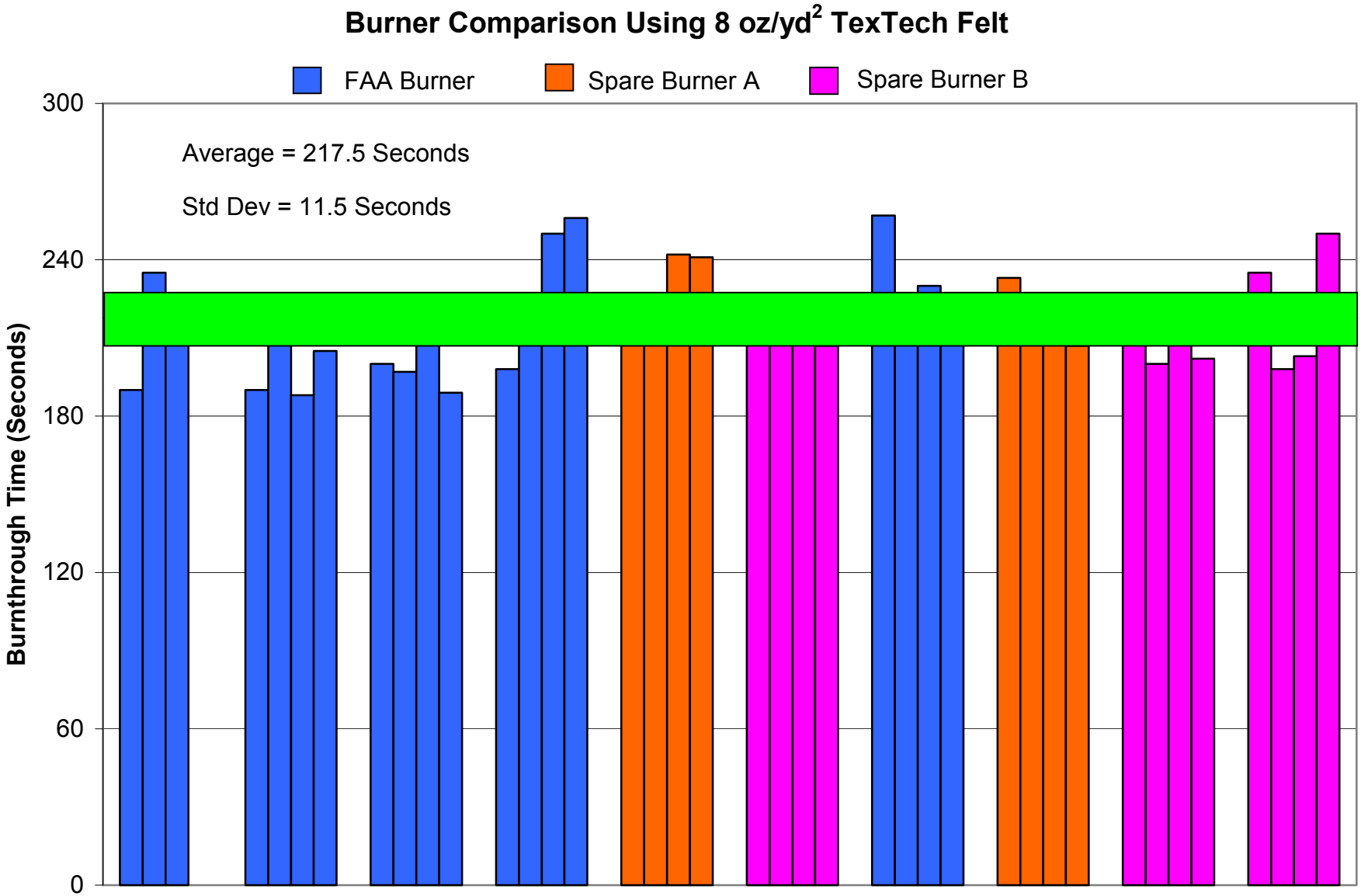
RTV Sealant Added to Blade Edge



Various Stators Used in Trials




Comparison of Results Using 8 oz/yd2 TexTech Felt
Burnthrough Time (Seconds)
300
240
180
120
60
0
234 Second Avg
210 Second Avg
222 Second Avg
FAA Burner
Spare Burner B
Spare Burner B


Burner Comparison Using 8 oz/yd2 TexTech Felt
FAA Burner
Spare Burner A
Spare Burner B
Average = 217.5 Seconds
Std Dev = 11.5 Seconds
Burnthrough Time (Seconds)
300
240
180
120
60
0

Spare Burner B Testing Summary

Testing indicates fluctuations in heat flux the result of variances in stator.

Minor adjustment of stator shape resulted in heat flux calibration.

Test results indicate equivalency to FAA results.

Conclusions and Future Considerations

Industry now in possession of equipment that correlates with FAA equipment.

Review of data suggests +/- 5% fluctuation when using flanged burner.

FAATC will receive 2 socket-style burners, continue comparison testing with FAA equipment to produce equivalency when using this apparatus.

Susceptibility of heat flux due to minor stator differences needs to be quantified; Produce a simpler, more reliable, more easily manufactured stator?