HEAT RELEASE RATE Updates

2019 March Materials Meeting
Savannah, GA USA

Materials Working Group

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March, 2019

Federal Aviation Administration

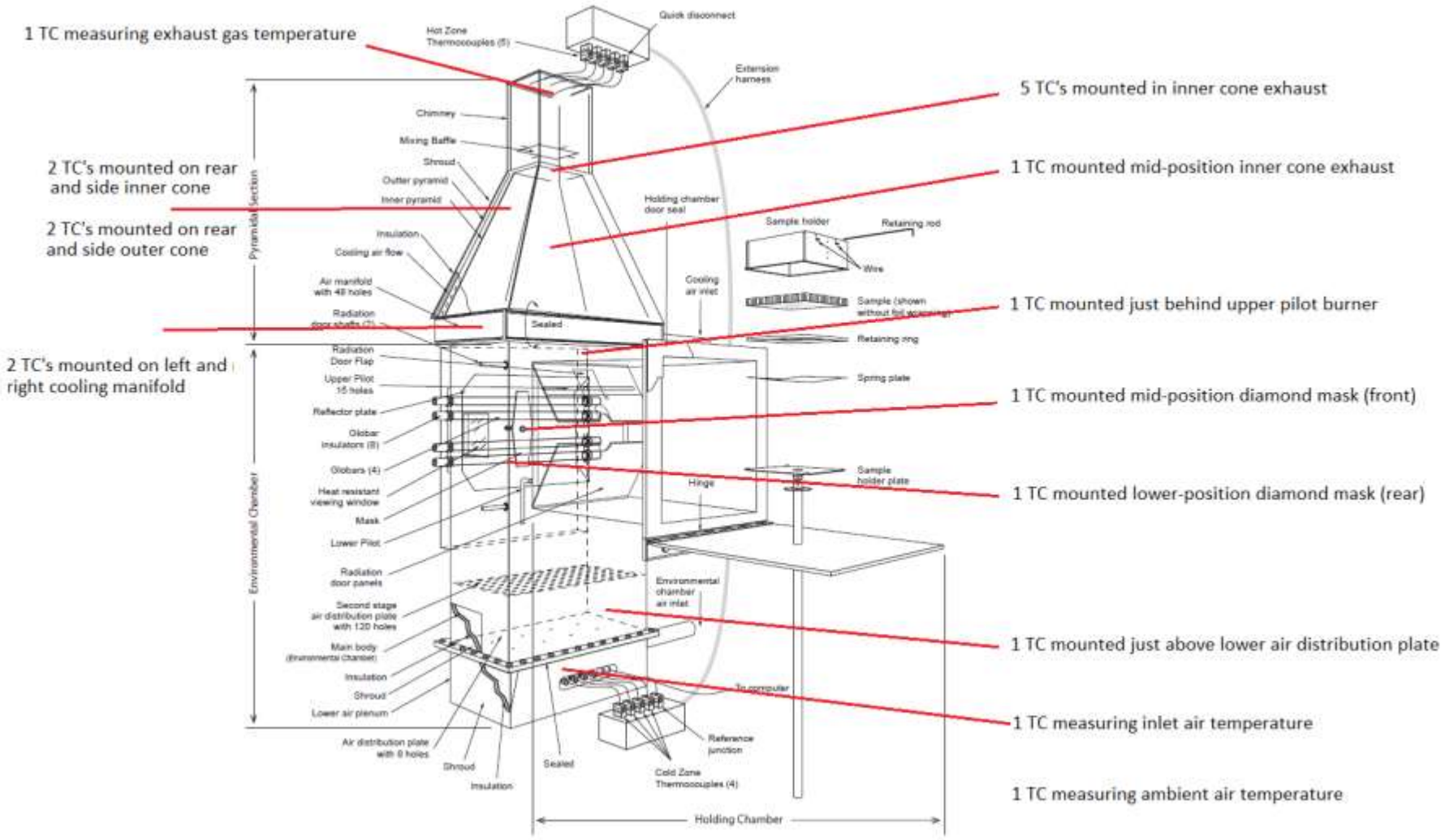
AGENDA

- Background
- Bypass Flow in Heat Release Rate Apparatus
- HR2 / OSU Temperature Data
- HR2 Calibration / Calibration repeatability
- Recommendation for Voltage Monitors
- New Prototype Heater Development Update
- Next

Background

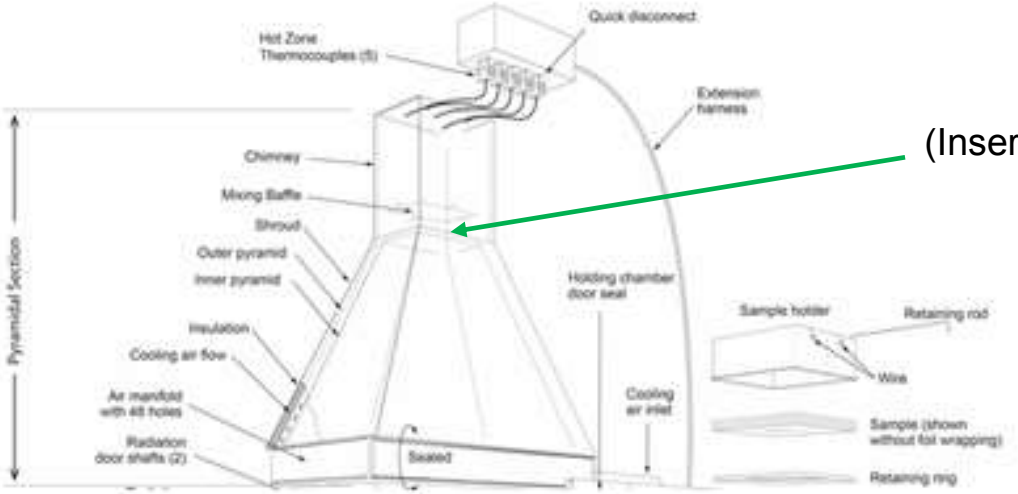
- Initiative: Too improve OSU (HR2 development)
- Goal: Improve Repeatability / Reproducibility
- Objective: Makes things simple, easy and standardized
- Where are we at today?
  - Concerns were raised over the exhaust section of the HR2 (non-cooled as compared to the OSU)
  - Is the HR2 hotter or produce higher HR values than OSU?
  - More data was requested by task group members as a way of moving forward

OSU TC Instrumentation



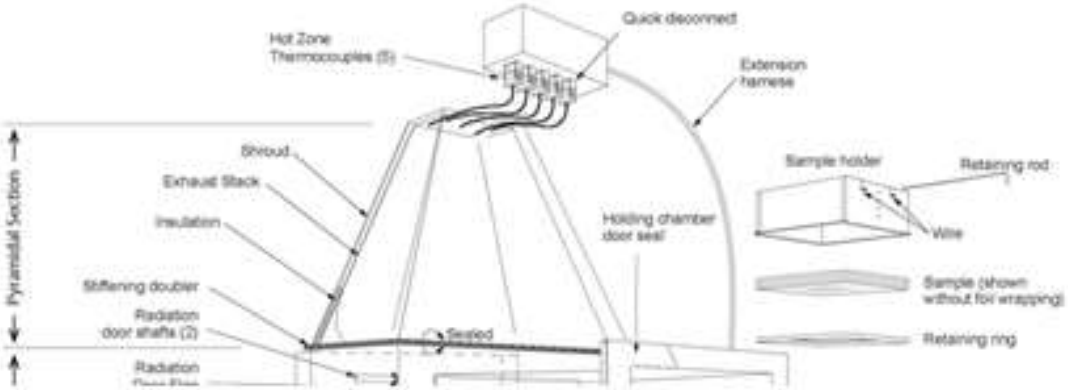
Bypass Cooling Effect in Heat Release Rate Apparatus

Cooled Exhaust



(Inserted 5 TC's here)

Non-Cooled Exhaust



Dual and Single Flow Configuration

OSU Configuration

Chamber Flow: 21.3 SCFM

Bypass Cooling Flow: 63.7 SCFM

Total Flow: 85 SCFM

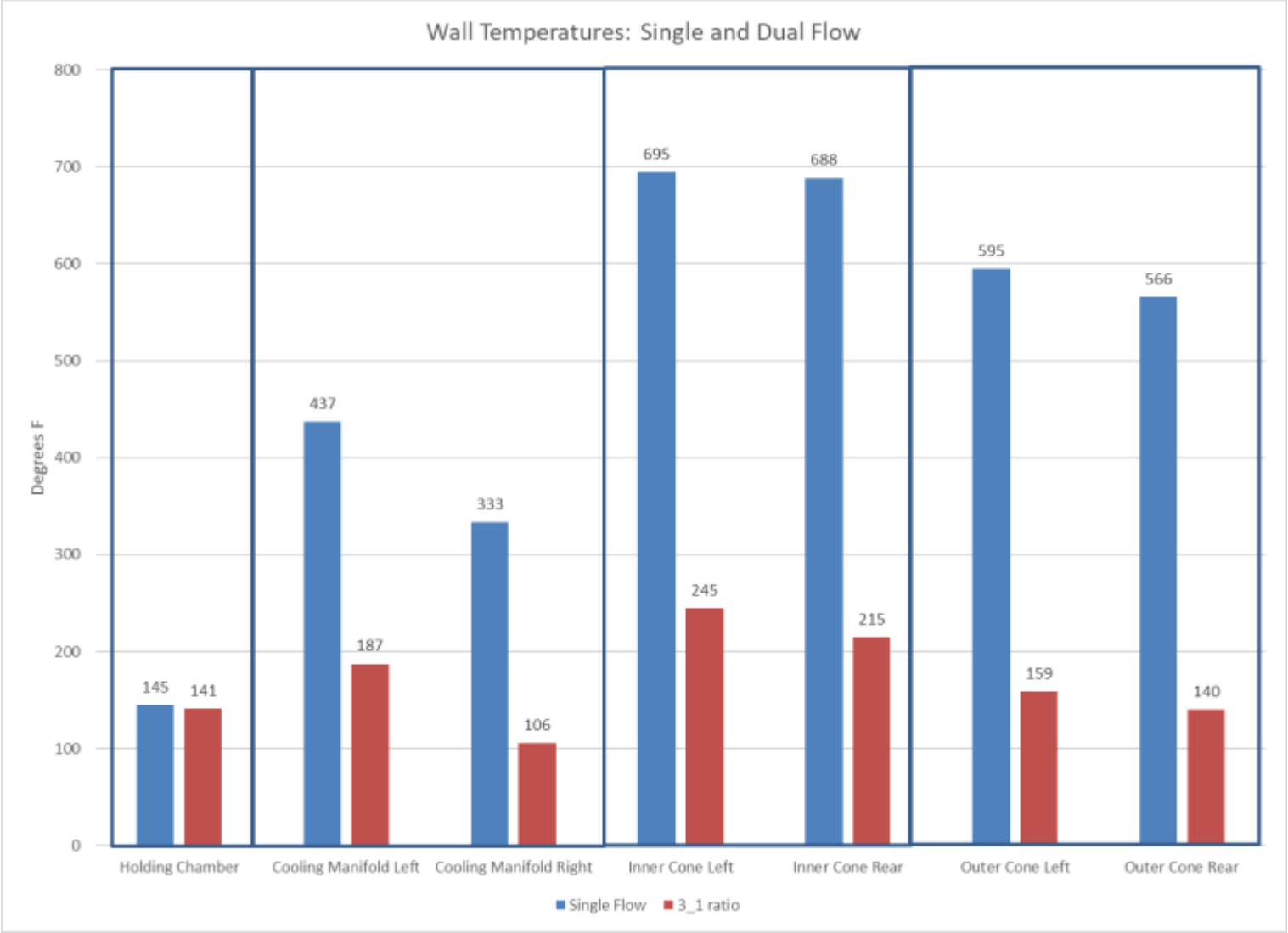
OSU Configuration (simulating HR2)

Chamber Flow: 21.3 SCFM

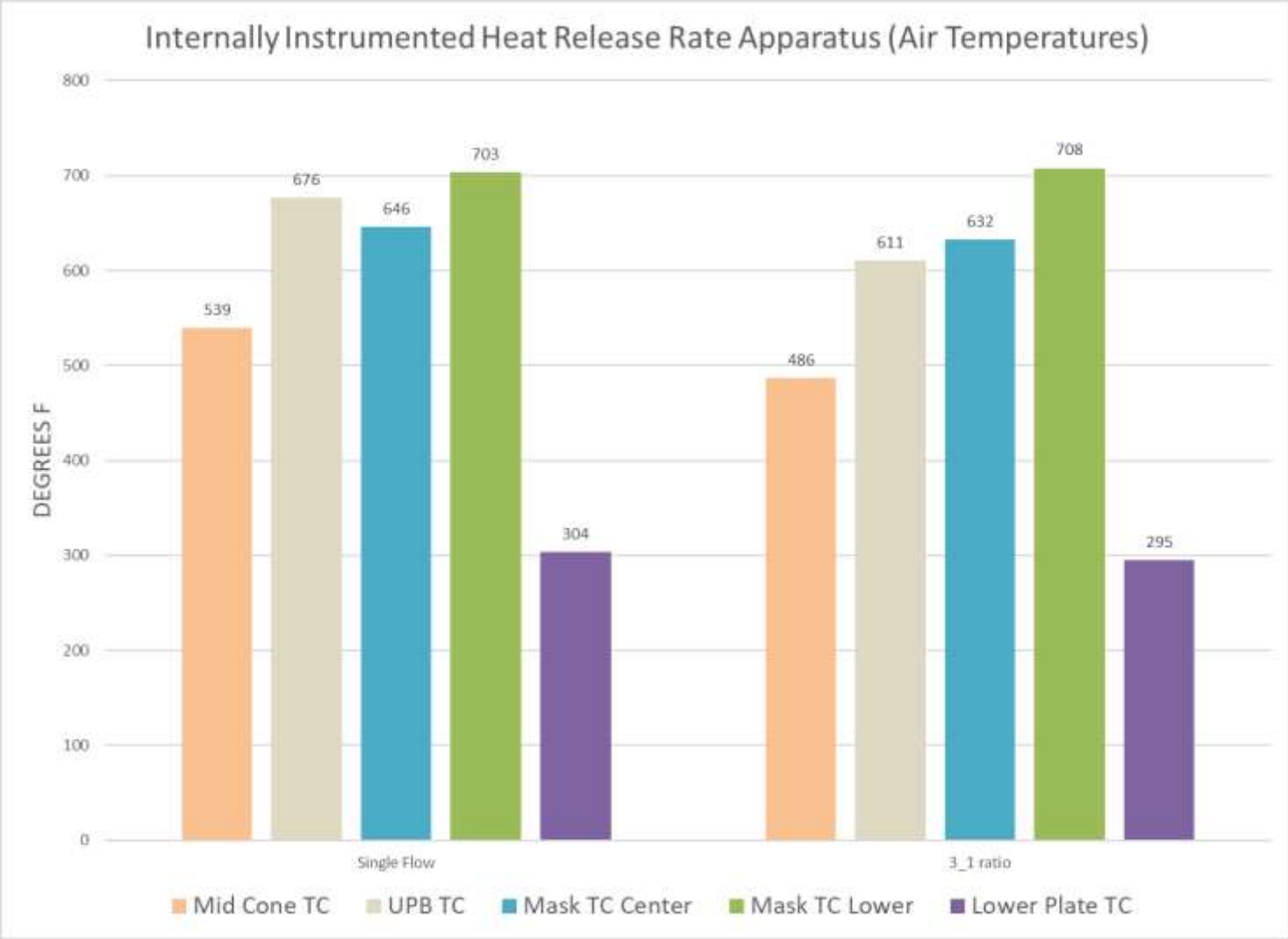
Bypass Cooling Flow: None

Total Flow: 21.3 SCFM

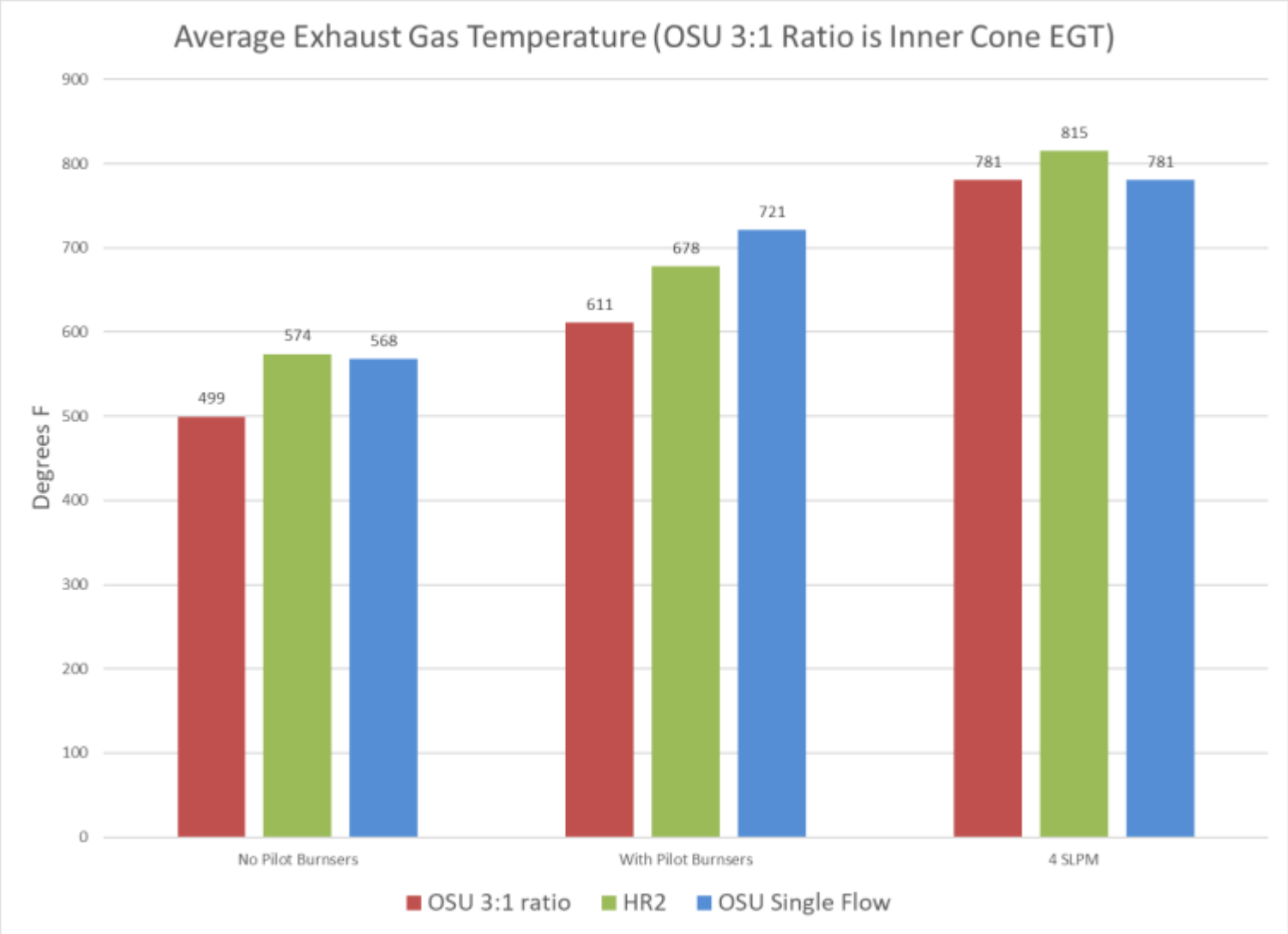
OSU Metal Temperatures (no flame)



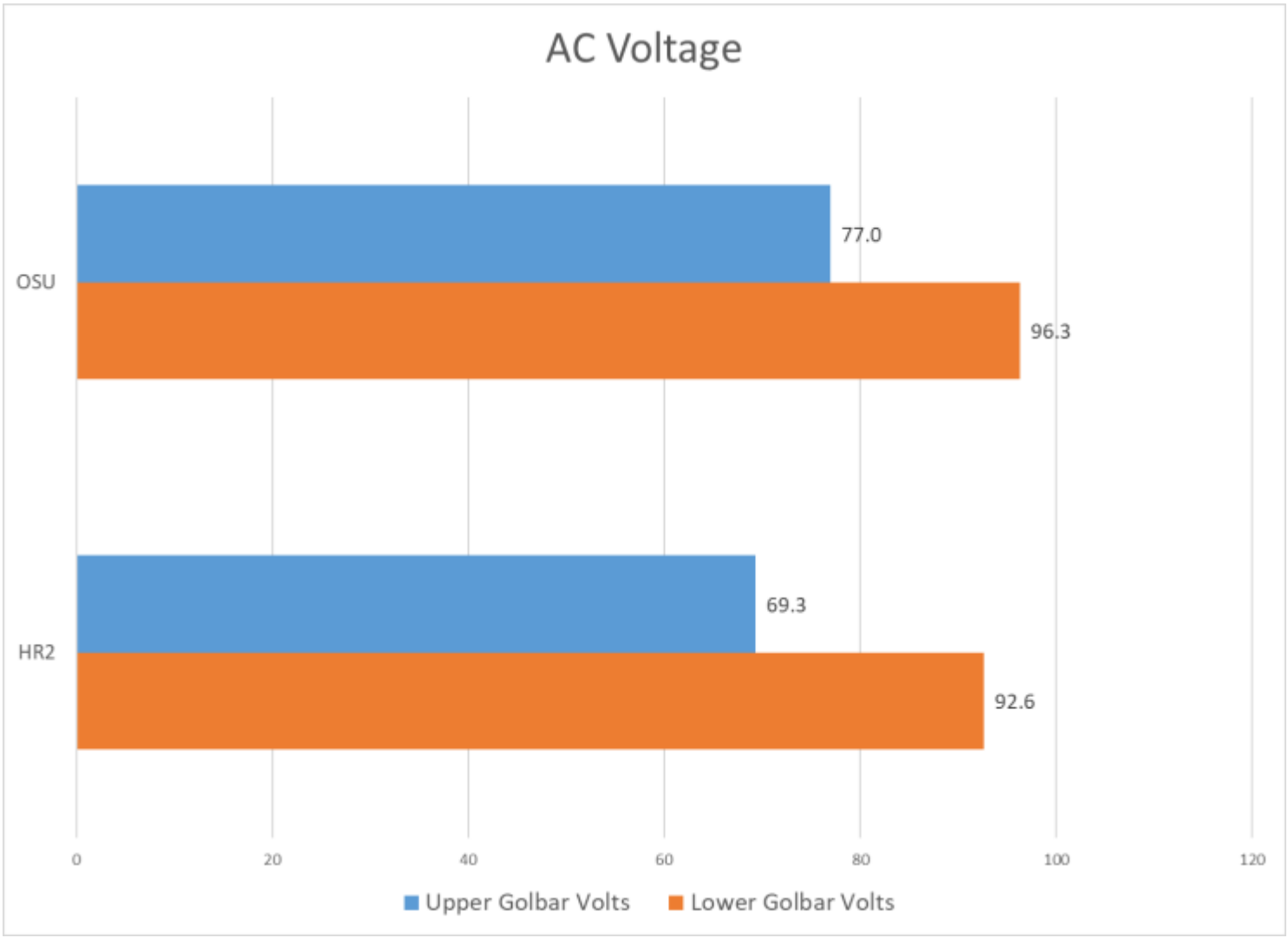
OSU Internal Temperatures



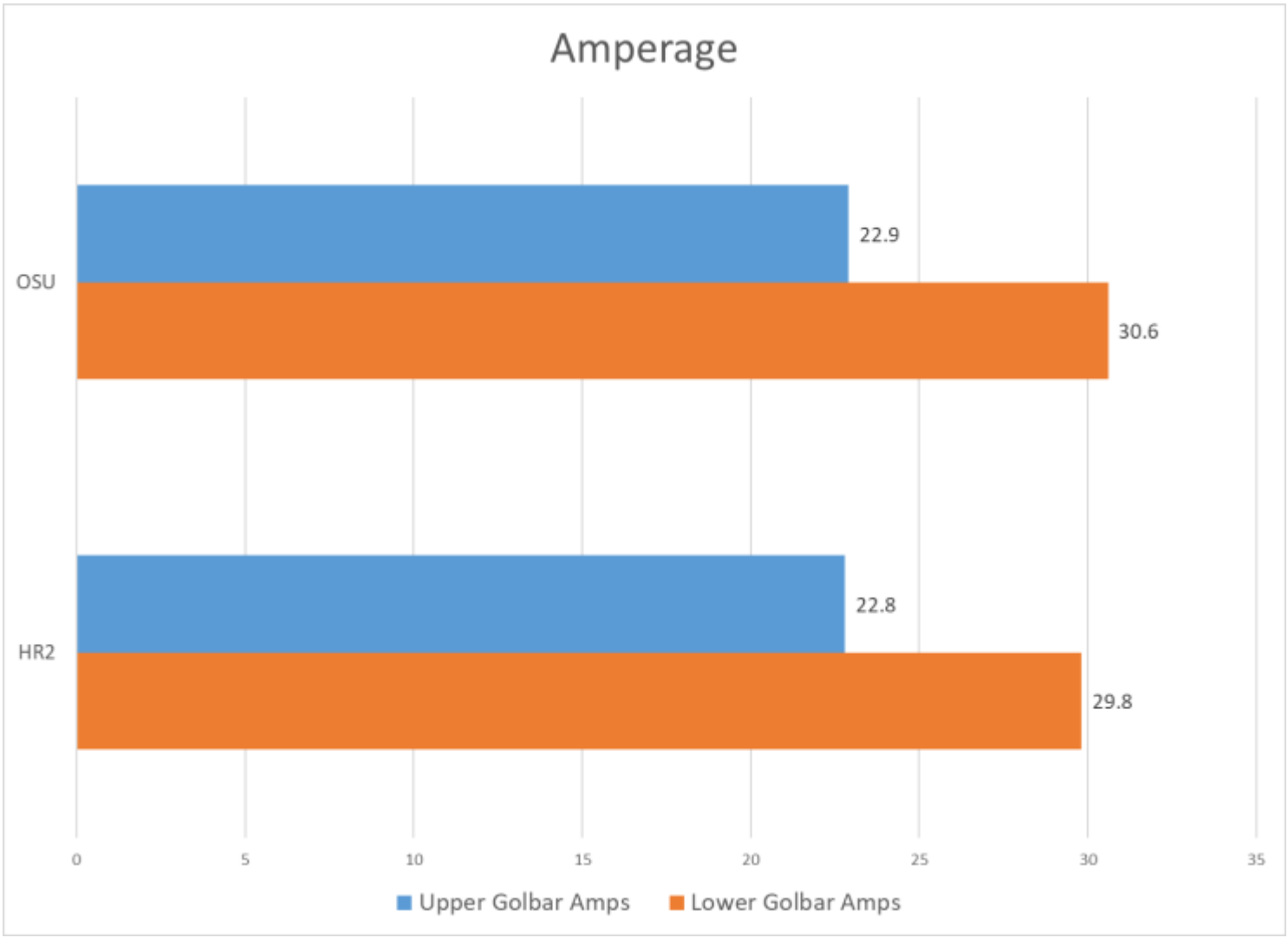
OSU Exhaust Gas Temperatures



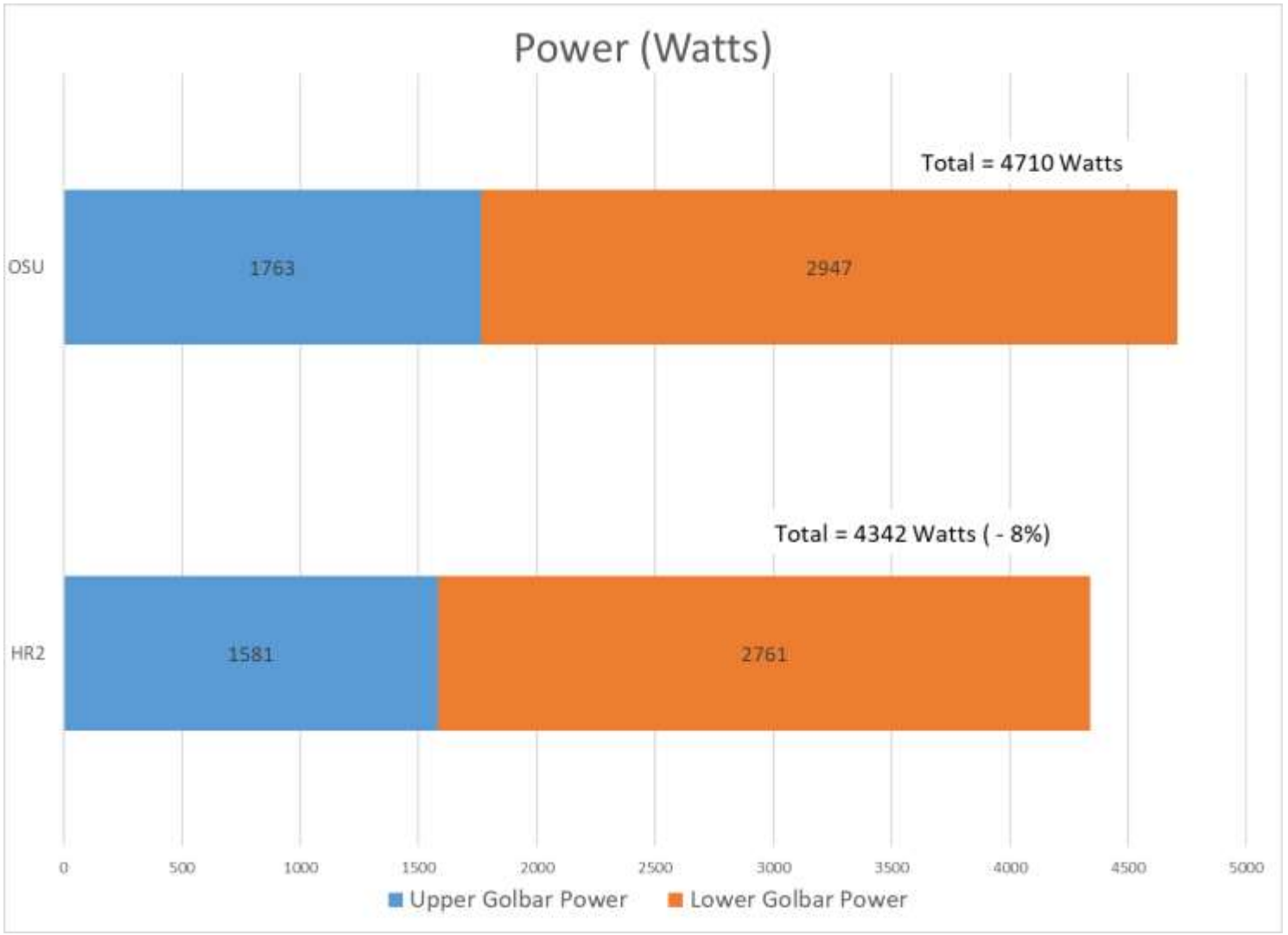
HR2 / OSU Power Data



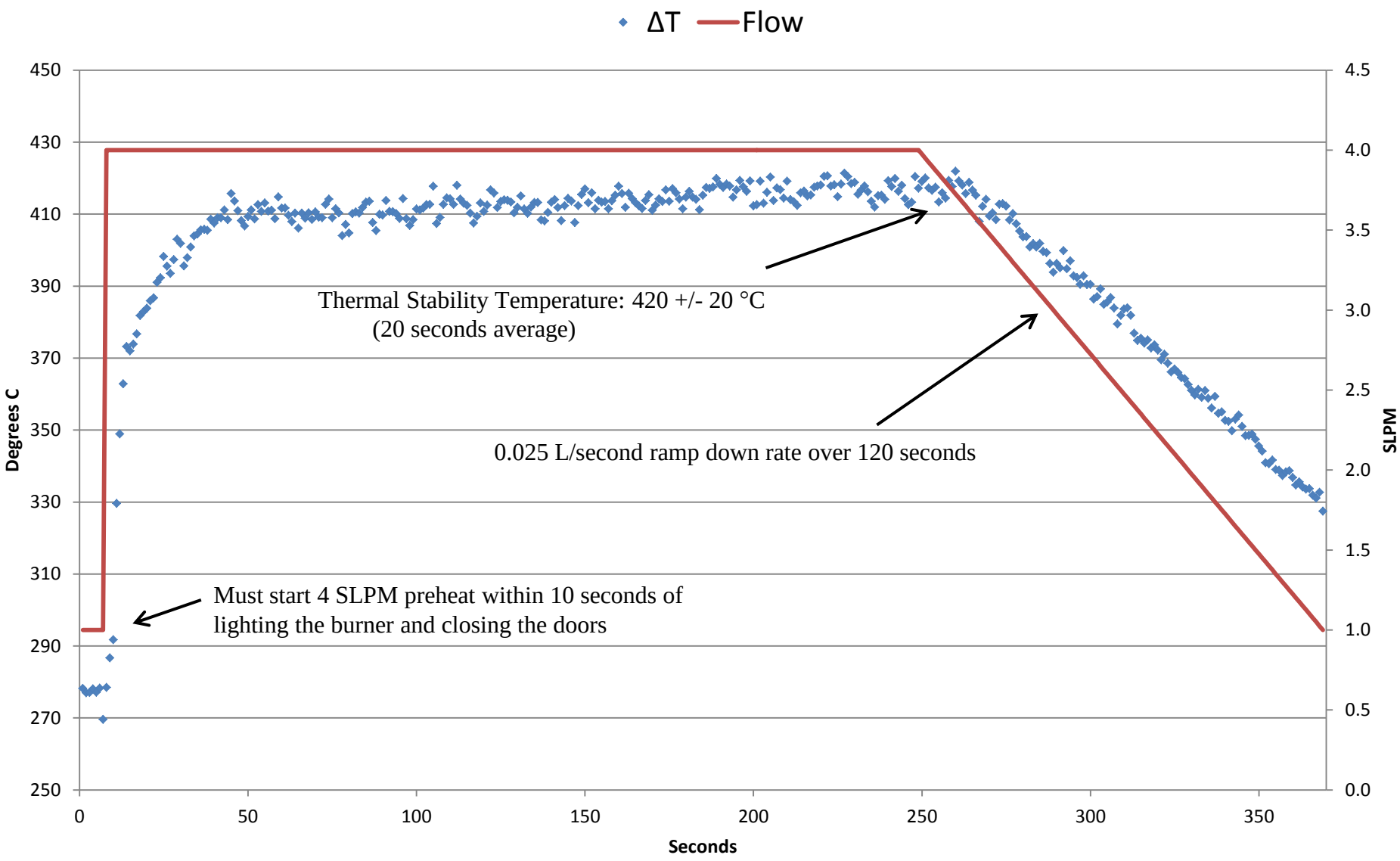
HR2 / OSU Power Data



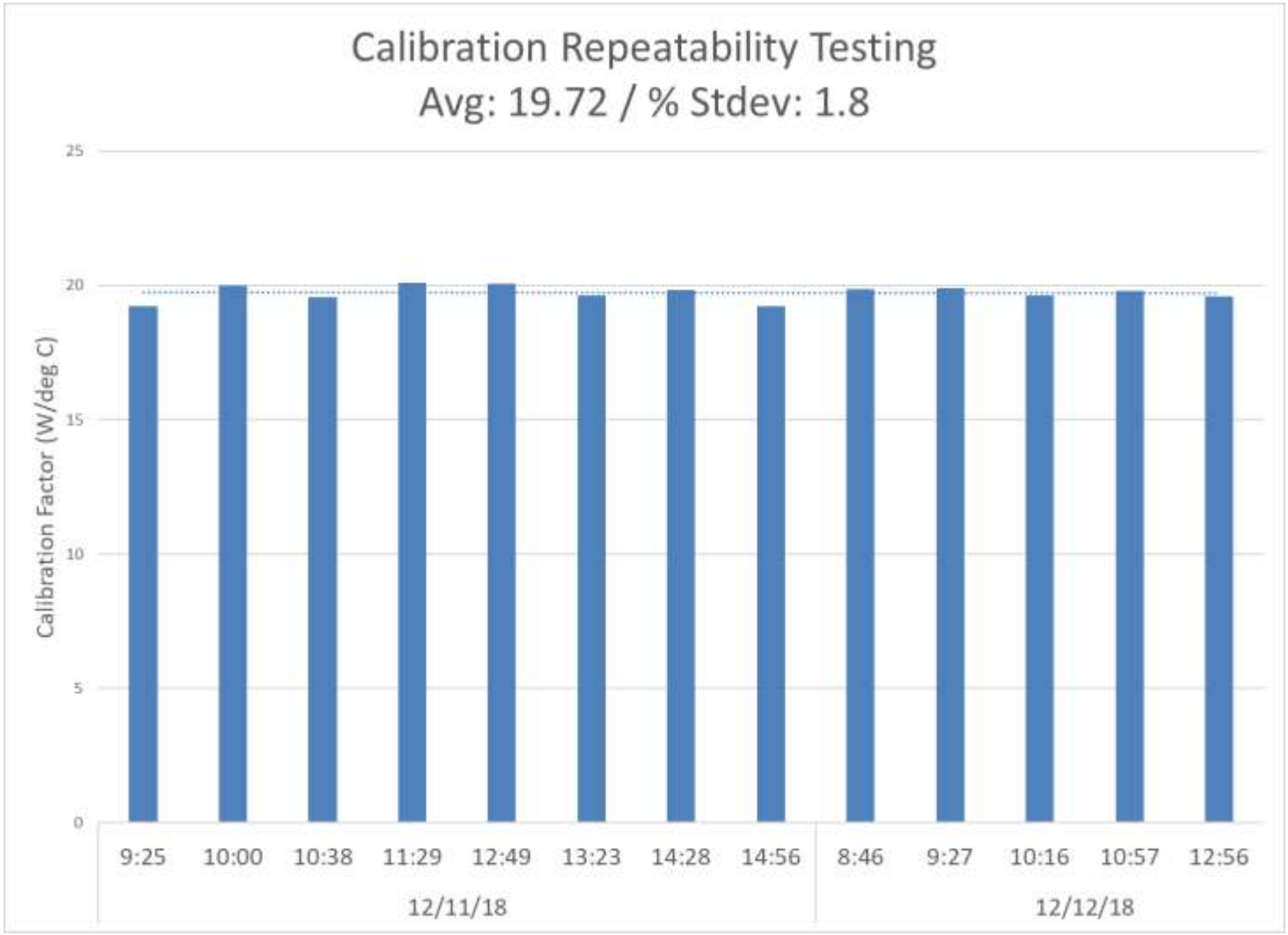
HR2 / OSU Power Data



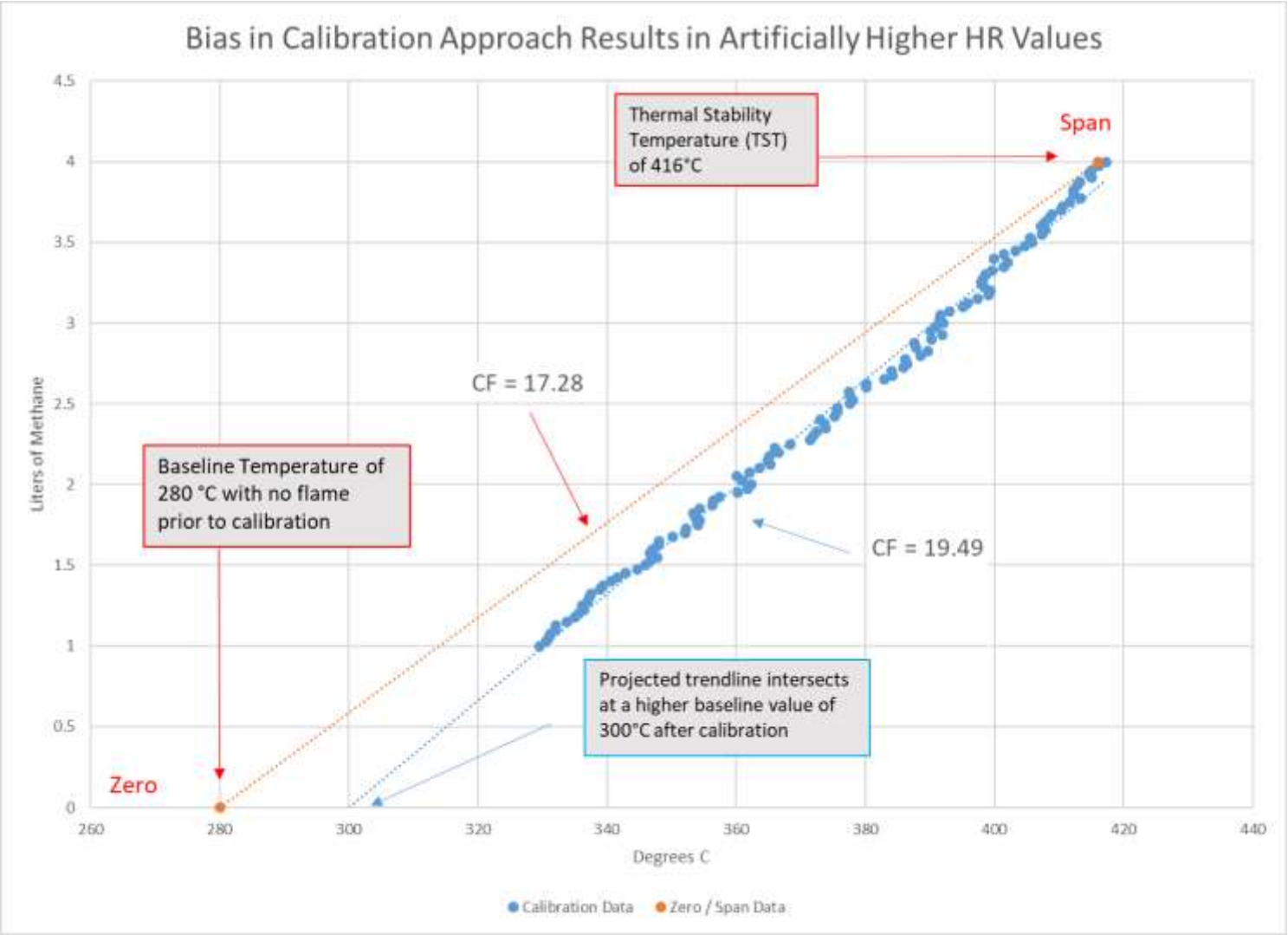
Ramp Down Calibration Profile (6 Total Minutes)



HR2 Ramp Down Calibration



HR2 Status


Bias in Calibration Approach Results in Artificially Higher HR Values
Thermal Stability Temperature (TST) of 416°C
Span
CF = 17.28
CF = 19.49
Baseline Temperature of 280 °C with no flame prior to calibration
Projected trendline intersects at a higher baseline value of 300°C after calibration
Zero
Liters of Methane
Degrees C
Calibration Data
Zero / Span Data

Calculating Theoretical Heat Release Rate

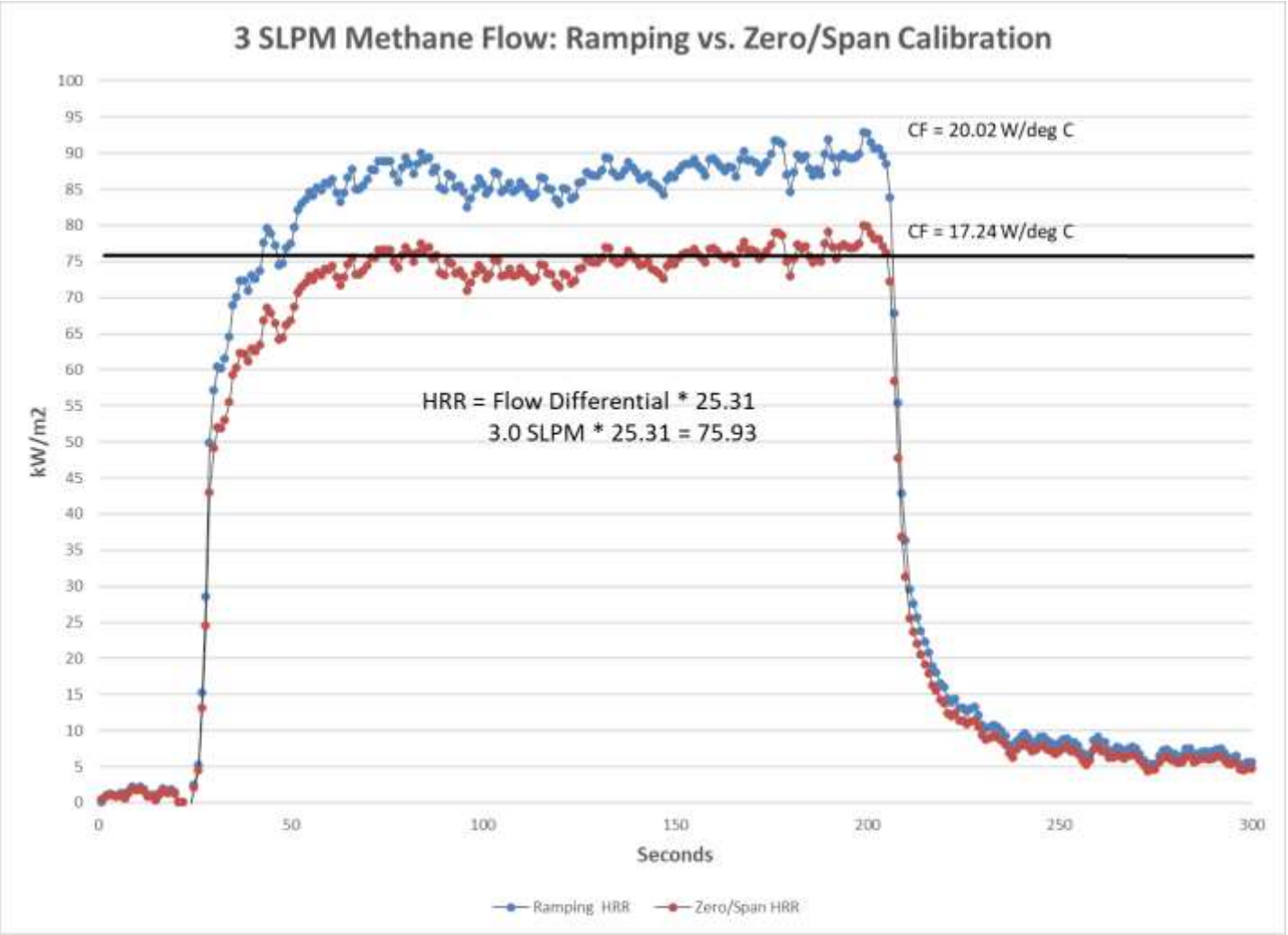
- $\mathrm{CF} = \frac{(210.8 - 22)}{(22.41 * 0.01433 * 1000)} * \frac{\Delta \mathrm{L}}{\Delta \mathrm{mV}} = \frac{\mathrm{kW}}{\mathrm{mV}}$

- $\frac{\mathrm{CF}\left(\frac{\mathrm{kW}}{\mathrm{mV}}\right)}{\frac{\Delta \mathrm{L}}{\Delta \mathrm{mV}}} = 0.589714 = \frac{\mathrm{kW}}{\mathrm{L}}$

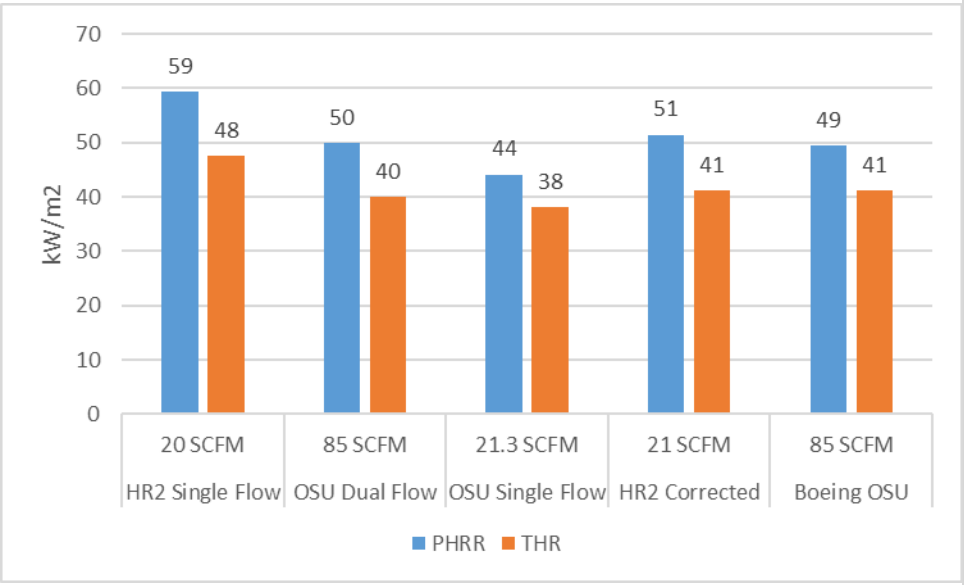
- $\text{Theoretical HRR} = \frac{0.587914 \frac{\mathrm{kW}}{\mathrm{L}}}{0.02323\ \mathrm{m}^2} = 25.31 = \frac{\frac{\mathrm{kW}}{\mathrm{L}}}{\mathrm{m}^2}$

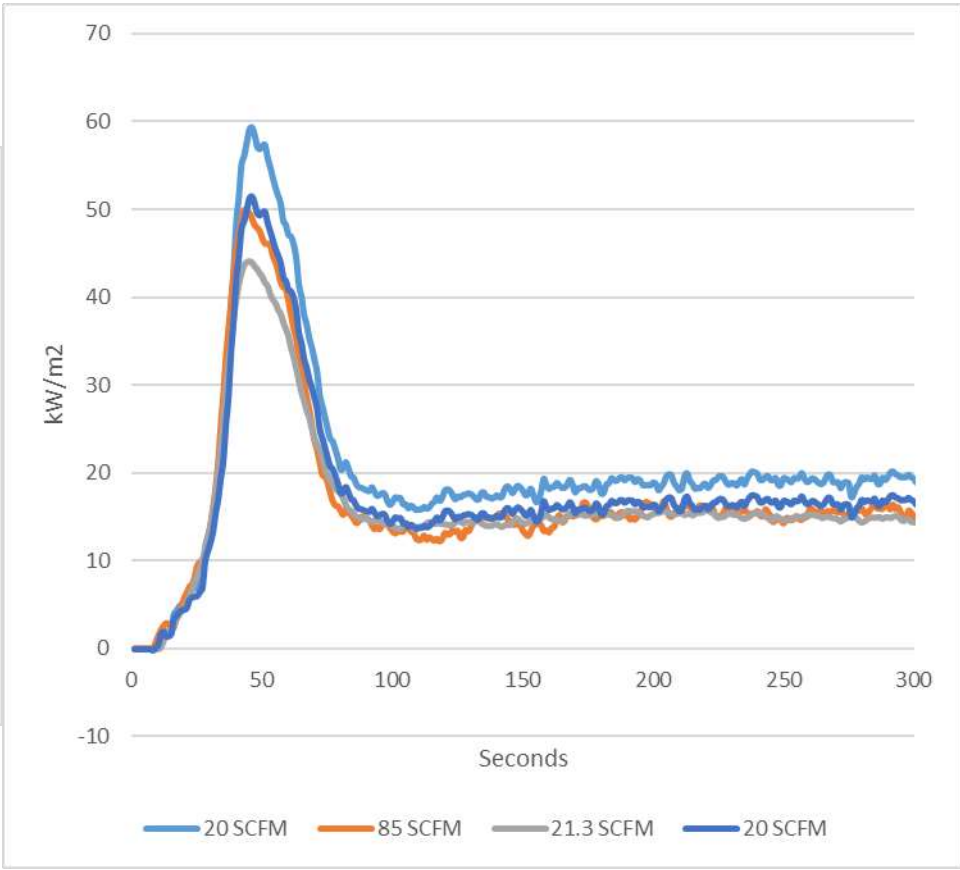
- $\text{Theoretical HRR} = \text{Flow delta(L)} * 25.31 \frac{\frac{\mathrm{kW}}{\mathrm{L}}}{\mathrm{m}^2} = \frac{\mathrm{kW}}{\mathrm{m}^2}$

Calculating Theoretical Heat Release Rate

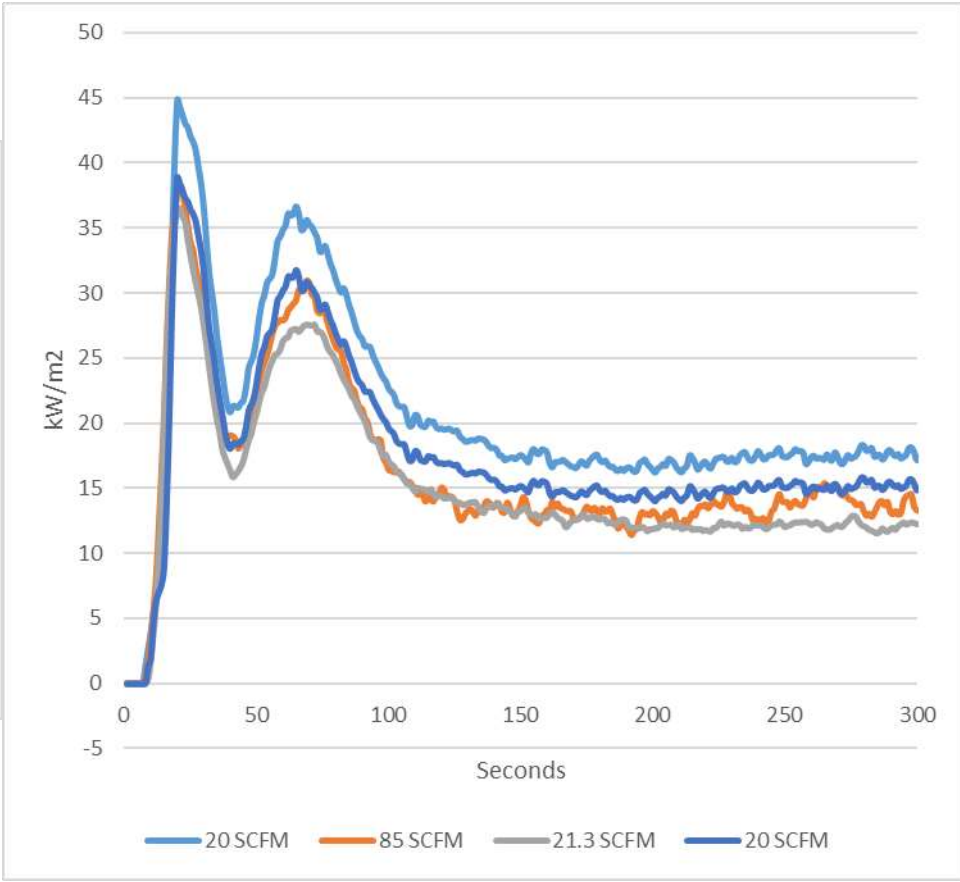


Schneller Panel Test Data

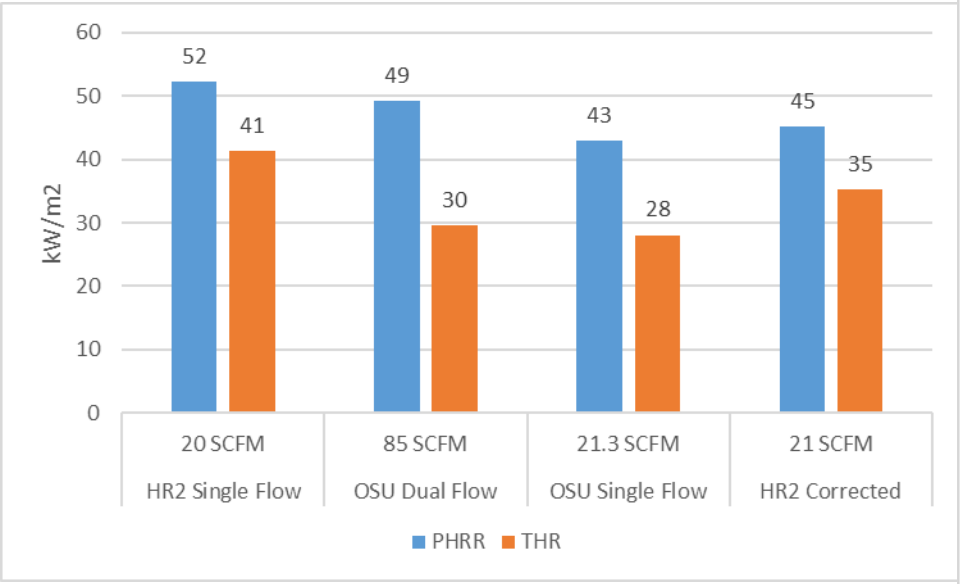


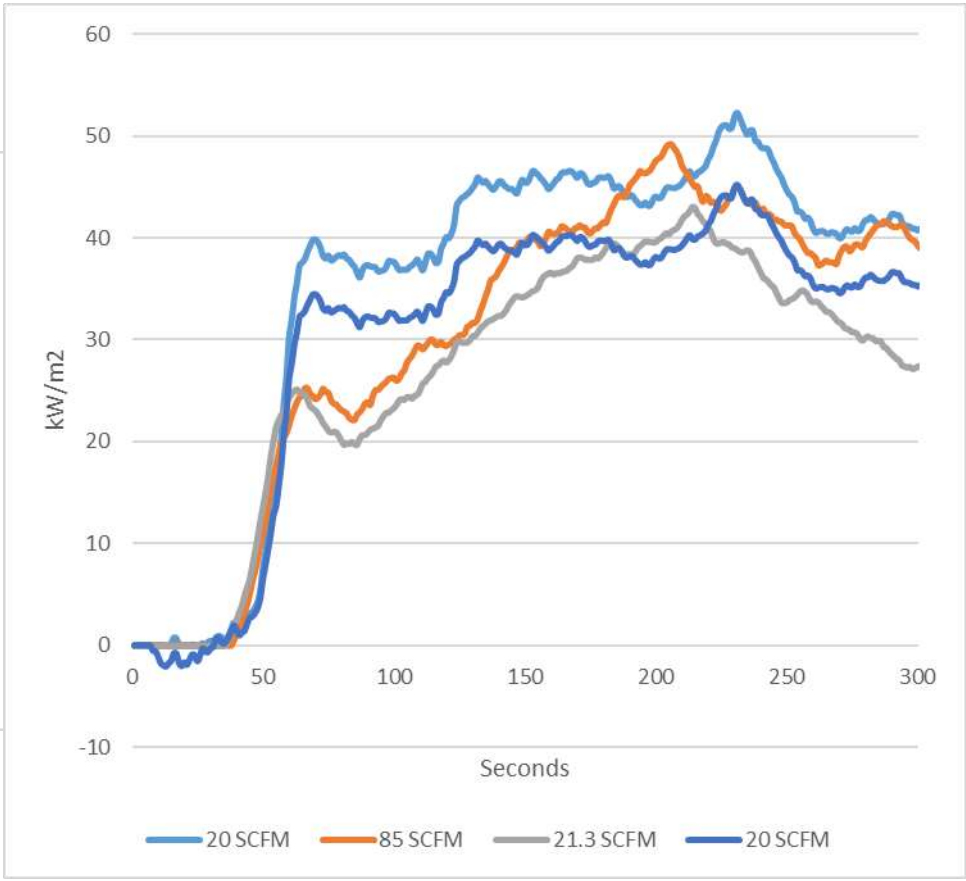


Honeycomb Panel w/ White Dec



Ultem 9085


60
50
40
30
20
10
0
kW/m2
52
41
49
30
43
28
45
35
20 SCFM
HR2 Single Flow
85 SCFM
OSU Dual Flow
21.3 SCFM
OSU Single Flow
21 SCFM
HR2 Corrected
PHRR
THR


60
50
40
30
20
10
0
-10
kW/m2
0
50
100
150
200
250
300
Seconds
20 SCFM
85 SCFM
21.3 SCFM
20 SCFM

HR2 Calibration

Research new zero/span calibration approach

- **Confirm heat flux / Remove calibration assembly / Close all doors**
- **Start Calibration program**
- **ZERO: 4 minute hold then average T'pile last 20 seconds**
- **Light burner @ 3 SLPM**
- **SPAN: 4 minute hold then average T'pile last 20 seconds**

HR2 Calibration

- **Thermal Stability Temperature (TST) Criteria will change since we are only flowing 3 SLPM Methane**

  Old: 420 +/- 20 Degrees C / New: 380 +/- 15 Degrees C

- **Calibration complete (Ramping down of gas flow removed)**
- **Calculate Zero / Span slope & new calibration factor**
- **Calibration Factor Range Criteria will change**

  Old: 18 +/- 2 W/deg C / New: 17 +/- 2 W/deg C

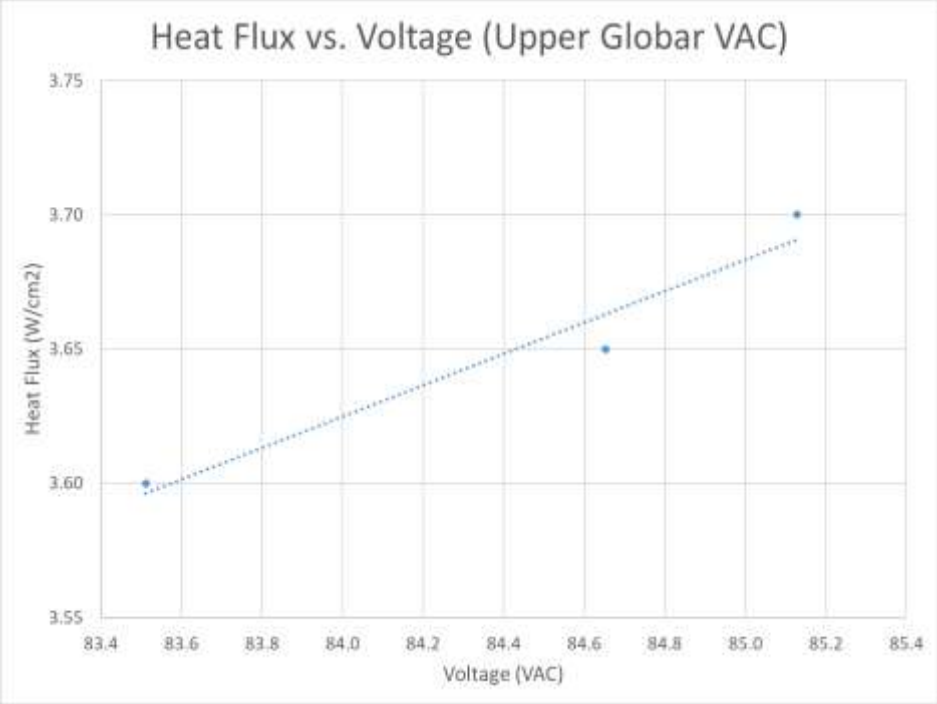
*** Possibly incorporate a 90% thermal response time criteria**

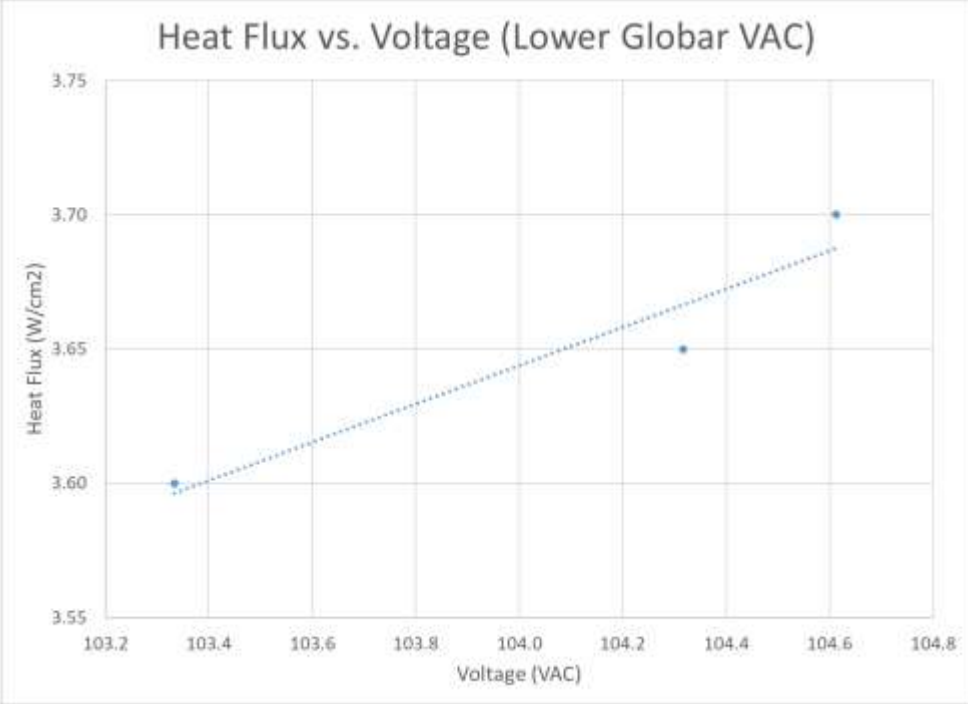
Globar Voltage Monitors?

- **Not too many labs monitor globar voltage or current throughout the day**
- **TC installed DP20 voltage monitors (x2) on OSU & HR2**
- **Easy to install**

- **Maintain confidence in power even after HFG's are removed just prior to testing**

Globar Voltage Monitors?





Min/Max = 1.6 VAC Delta

Min/Max = 1.3 VAC Delta

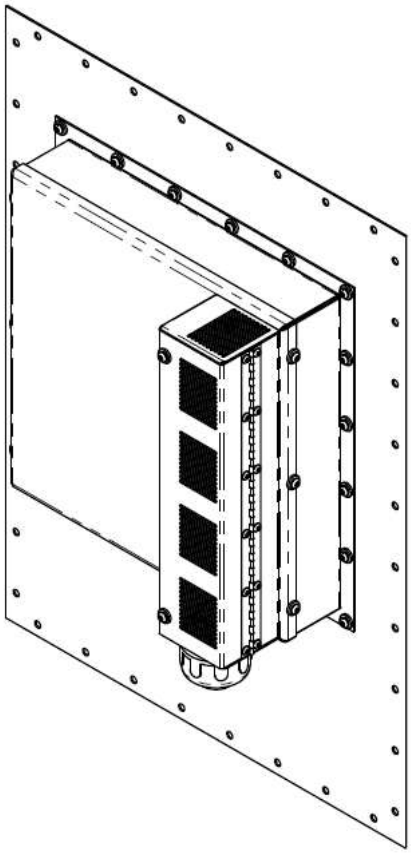
HR2 Status

New Prototype Heater Development

- Dimensions: 10” W x 10” H x 2” D
- Zones: 3 (Upper / Center / Lower)
- Flush mounted glass with rear wall (sealed)
  - Removed from air stream (internally)
- Replaces the following components:
  - Globar pan (Globar end penetrations), Diamond-shaped Mask & Rear Reflector Plate

HR2 Status

New Prototype Heater Development



NEXT

- Continue working calibration R&D as needed
- Continue new prototype heater development for globar replacement
- Complete TRL activities
- Task group participant input requested

Questions?