Vertical Flame Propagation (VFP)

Presented to: **International Aircraft Material Fire Test Forum**
Mobile, AL

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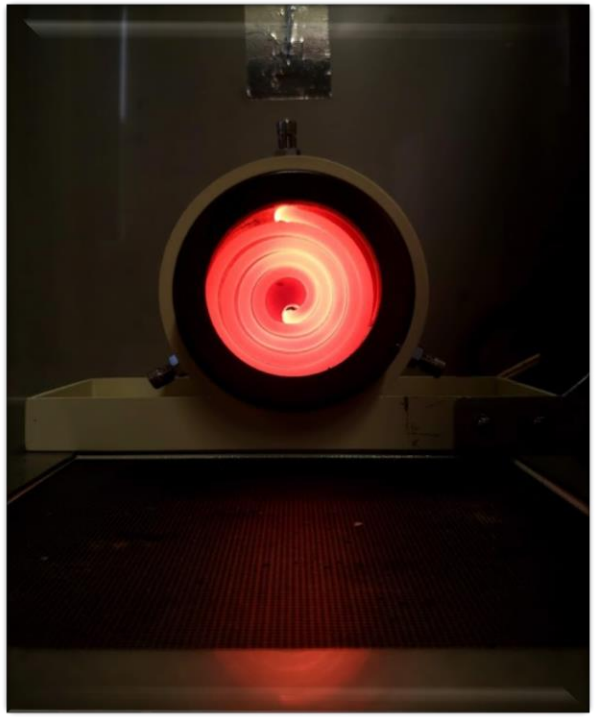
Date: **March 10-11, 2020**

Federal Aviation Administration

Vertical Flame Propagation (VFP)

Objective

- **Proposed new test method for non-metallic, extensively used materials located in *inaccessible areas*, i.e.:**
- **Composite skin, structure, and sub-components**
- **Wires**
- **Duct materials**
- **Other, tbd**



What is it?

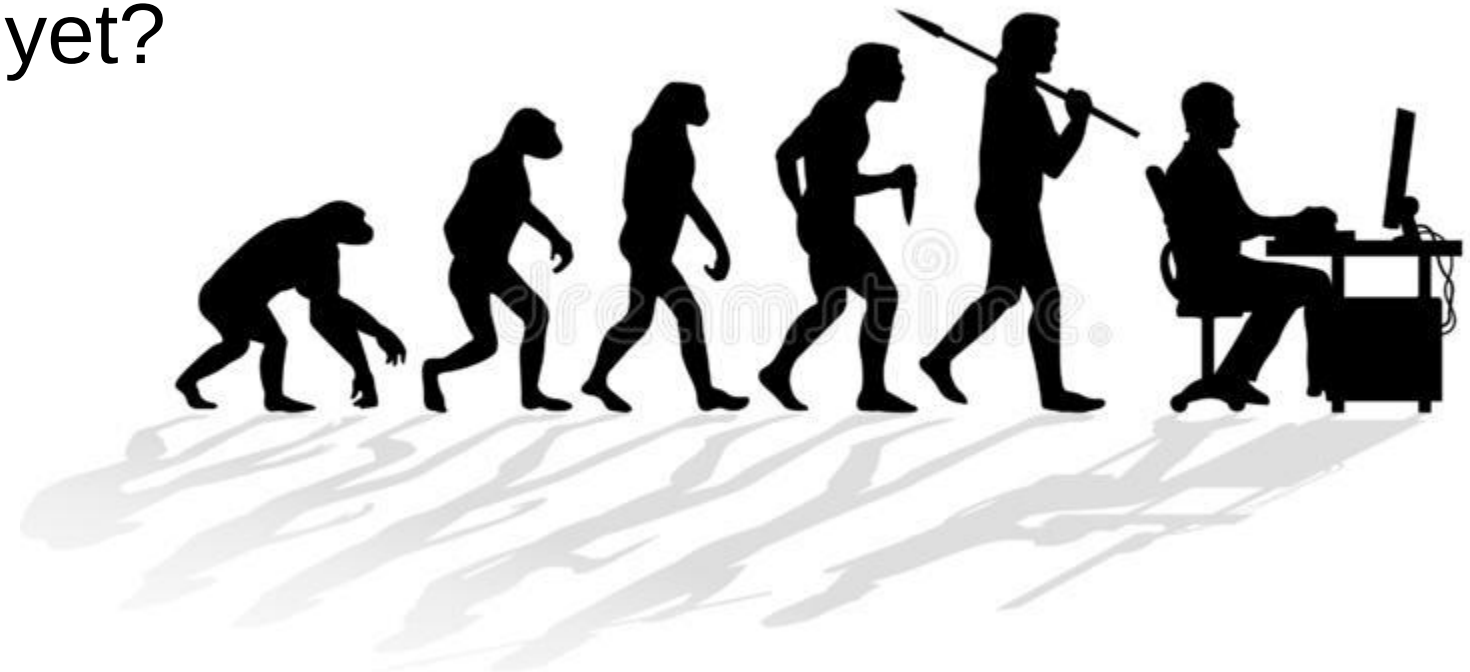
- **A way of evaluating the performance of a material against a realistic fire threat using a line burner and radiant heat source.**

Topics

Where were we?

Where are we?

Are we there yet?



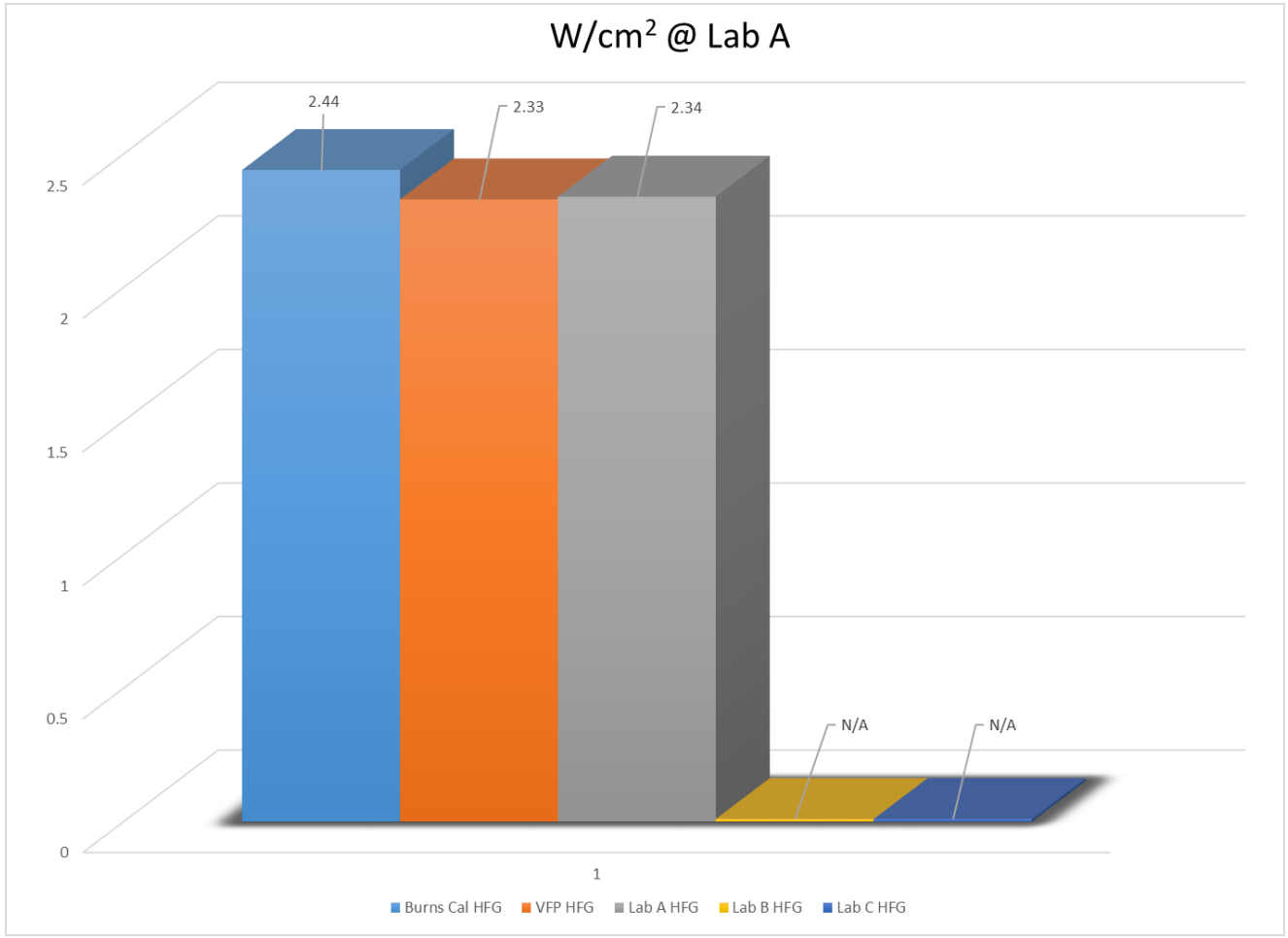
Where were we?

- **Varying diameters of ducts and their results**
  - Flat vs round
  - Varying thicknesses
- **Wire background**
- **Heater uniformity**
  - Different manufacturers = varying heat output per watt
  - Supply voltage
- **Heat flux**
  - Could HFG’s resolve design and power differences

Where are we?

- **Interlab study of HFG's**
  - 4 labs, 5 gauges
  - Set power to host gauge (reference)
  - Compared all other gauges (working)
- **Goals**
  - Determine the variability among HFG's
  - Use this deviation to evaluate HFG reliability

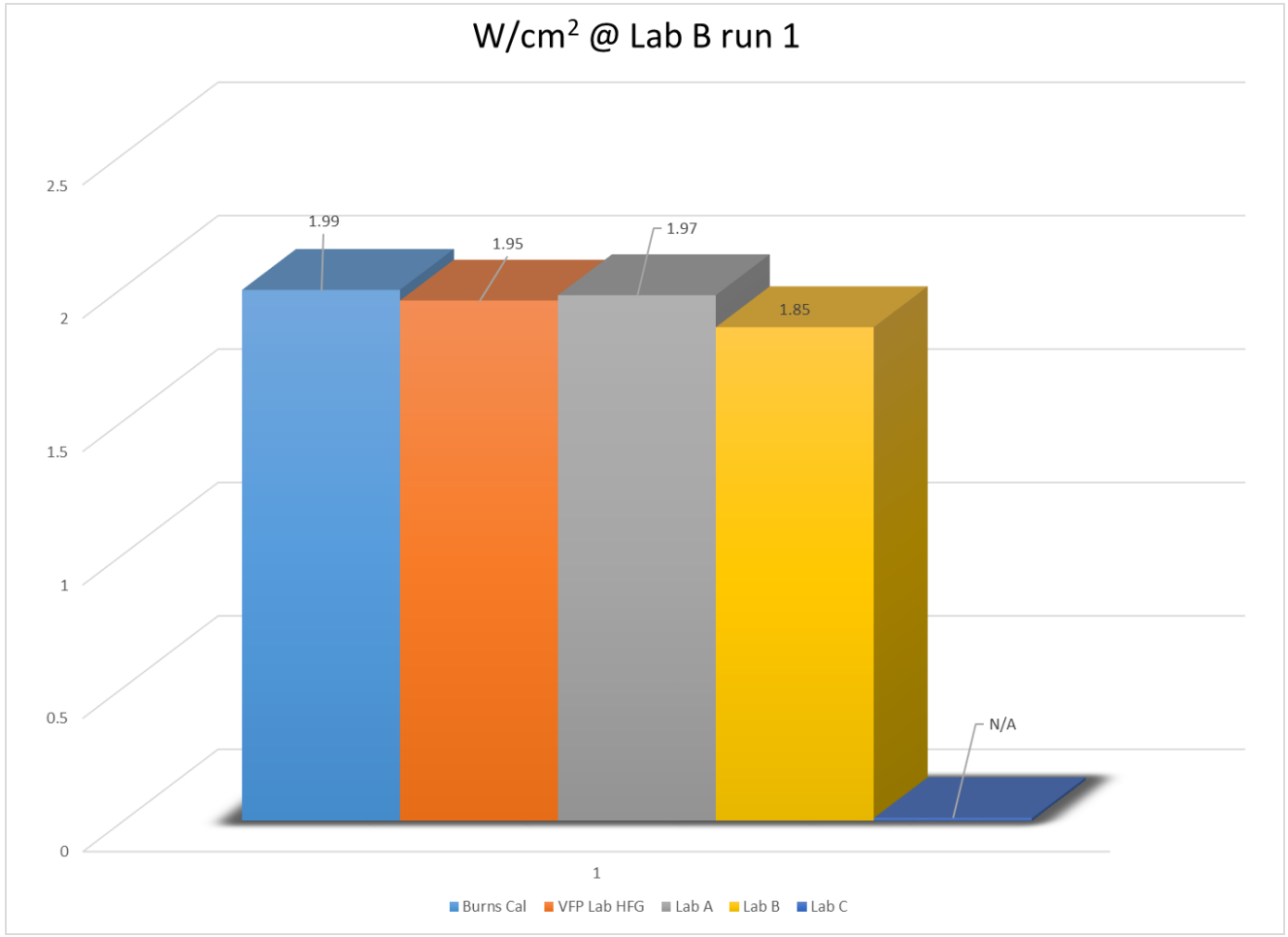
HFG Comparison



HFG Comparisons	Δ w/cm²		max Δ w/cm²
VFP Lab vs Burns Cal	-0.11		0.11
Lab A vs Burns Cal	-0.1		
Lab B vs Burns Cal			
Lab C vs Burns Cal			

- **St dev: 0.061**
- **% st dev: 2.57**
- **Set to power, not to heat flux. That update had not yet been installed to unit***

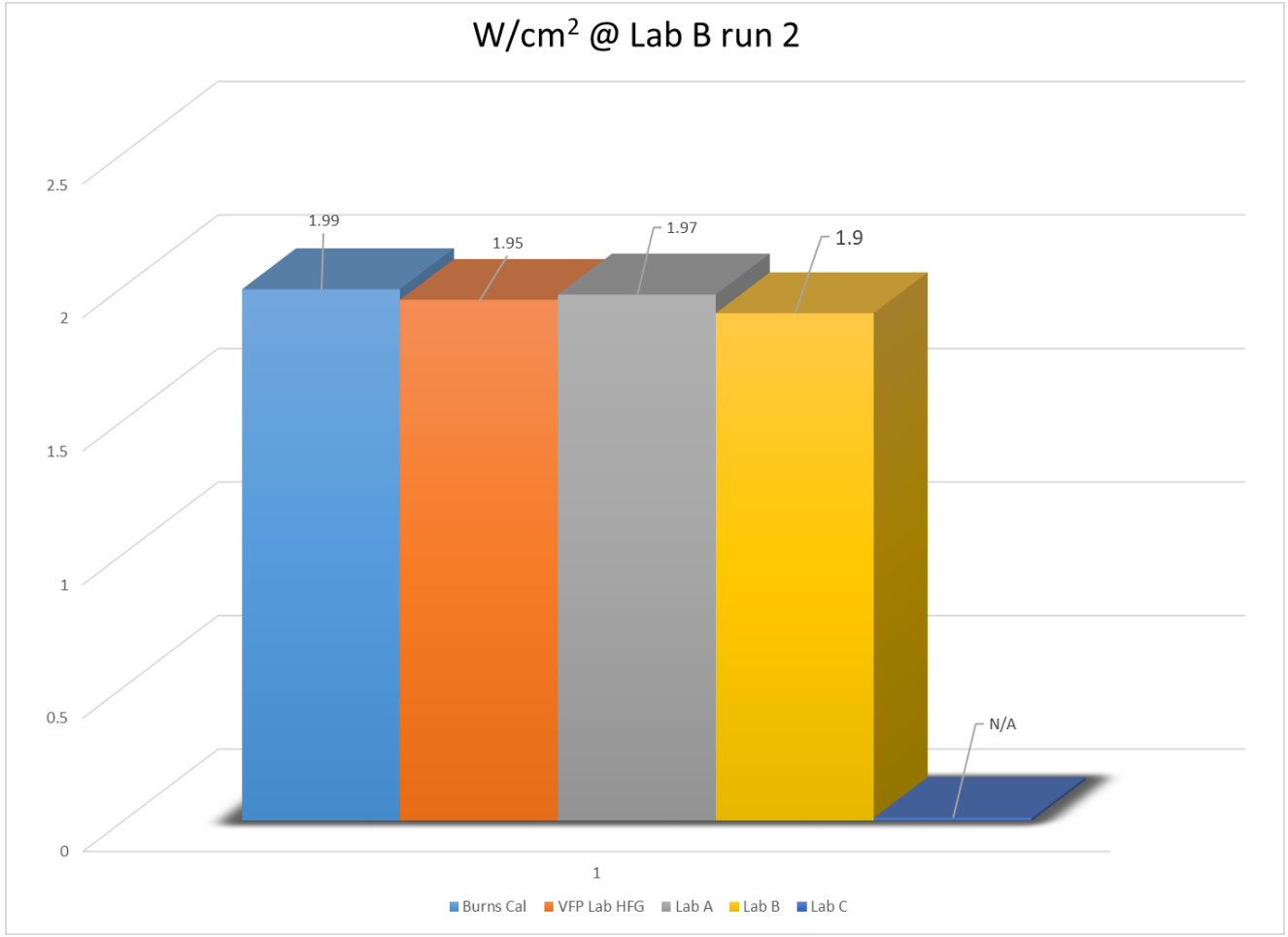
HFG Comparison



HFG Comparisons	Δ w/cm²		max Δ w/cm²
VFP Lab vs Burns Cal	-0.04		
Lab A vs Burns Cal	-0.02		
Lab B vs Burns Cal	-0.14		0.14
Lab C vs Burns Cal			

- **St dev: 0.057**
- **% st dev: 2.937**

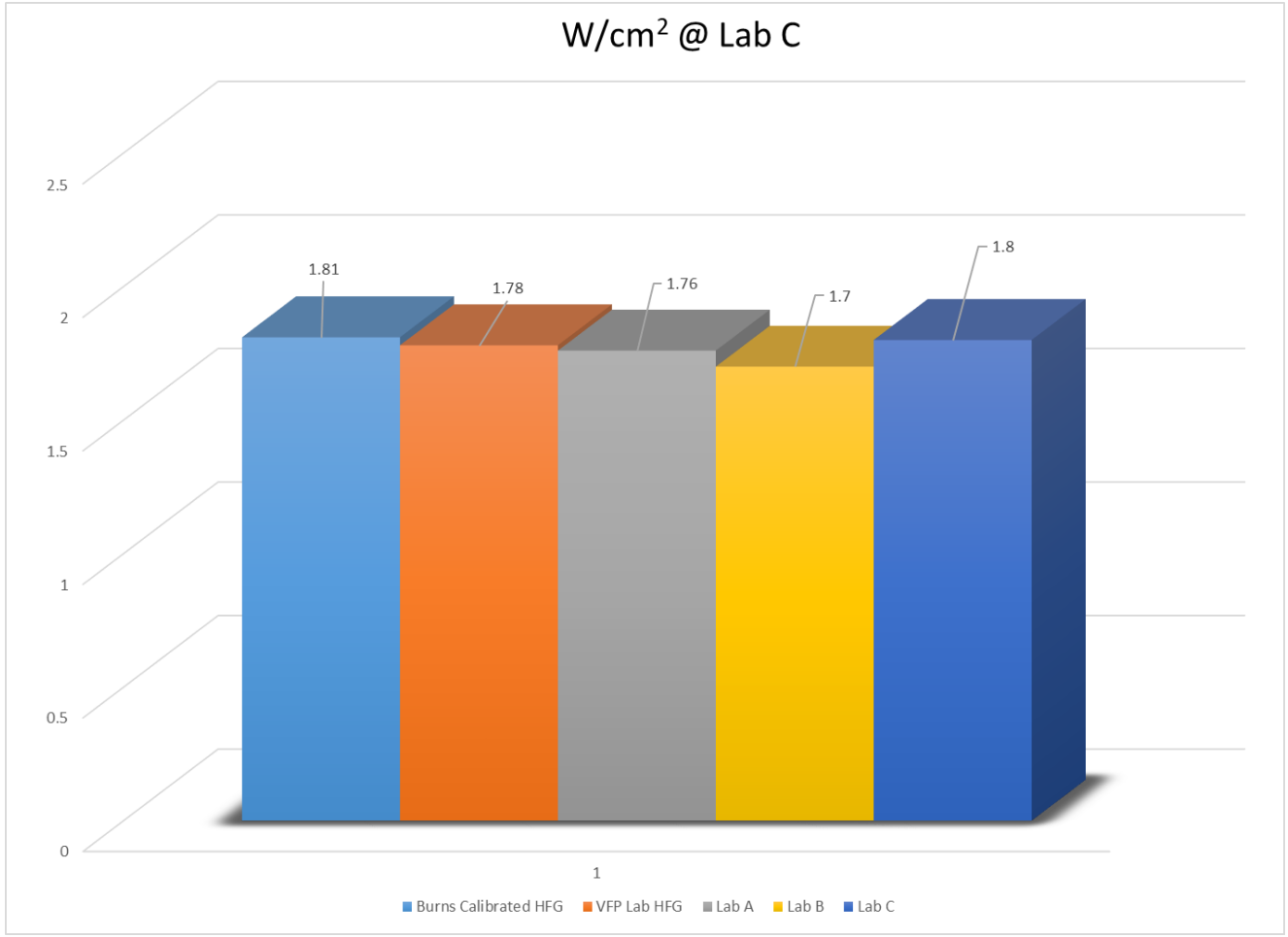
HFG Comparison



HFG Comparisons	Δ w/cm²		max Δ w/cm²
VFP Lab vs Burns Cal	-0.04		
Lab A vs Burns Cal	-0.02		
Lab B vs Burns Cal	-0.09		-0.09
Lab C vs Burns Cal			

- **St dev: 0.039**
- **% st dev: 1.98**

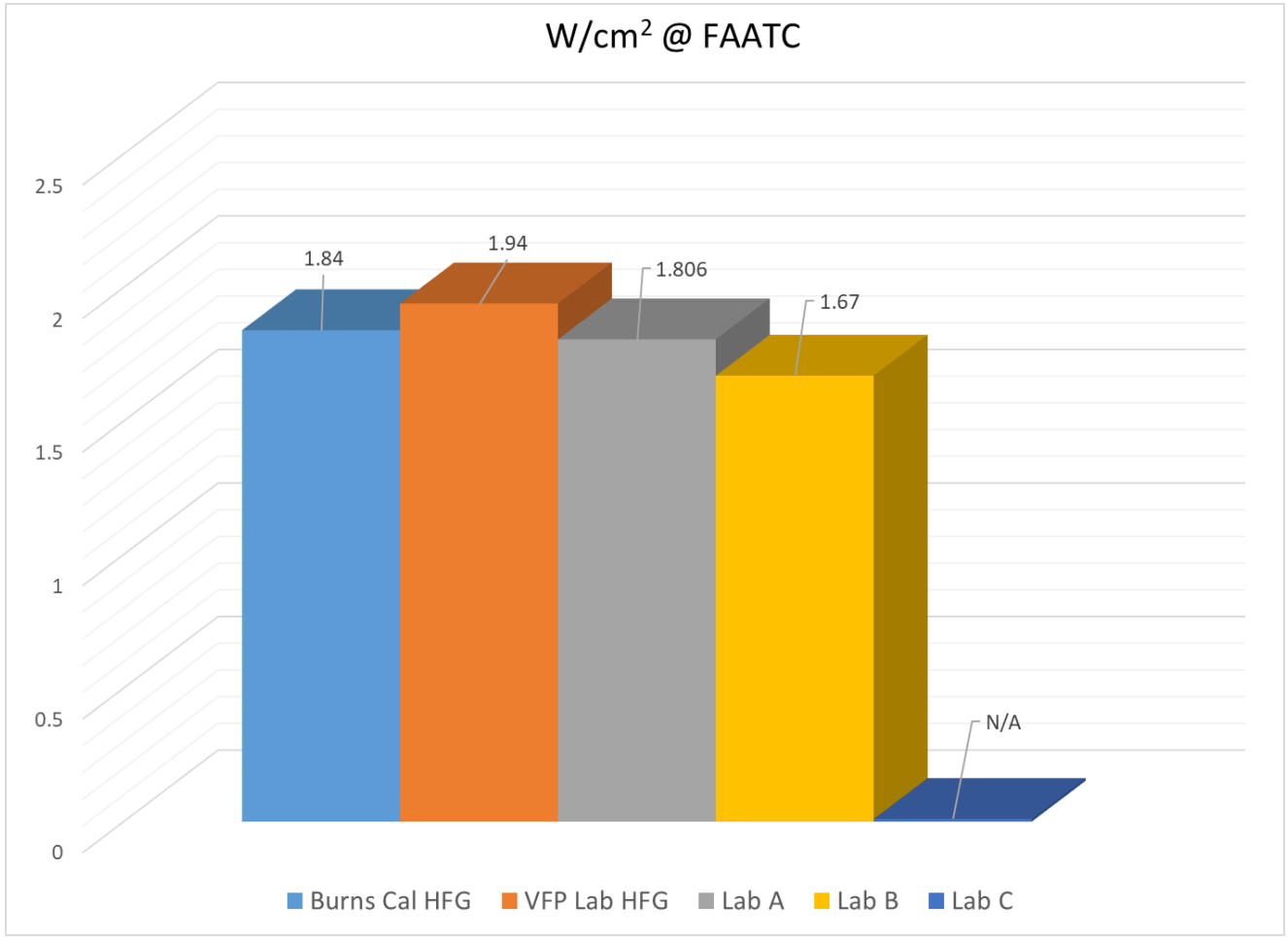
HFG Comparison



HFG Comparisons	Δ w/cm²		max Δ w/cm²
VFP Lab vs Burns Cal	-0.03		
Lab A vs Burns Cal	-0.05		
Lab B vs Burns Cal	-0.11		0.11
Lab C vs Burns Cal	-0.01		

- **St dev: 0.044**
- **% st dev: 2.463**

HFG Comparison



HFG Comparisons	Δ w/cm²		max Δ w/cm²
VFP Lab vs Burns Cal	0.1		
Lab A vs Burns Cal	-0.034		
Lab B vs Burns Cal	-0.17		0.17
Lab C vs Burns Cal			

- **St dev: 0.112**
- **% st dev: 2.566**

Conclusions

1. **Did we determine the variability of HFG's?**
   - Most gauges varied 0.03-0.1 w/cm^2
   - One gauge varied .11-.17 w/cm^2
2. **Will HFG be reliable going forward?**
   - Determine effect on burn length of these variances
   - Visit HFG manufacturer to discuss calibrations

Baseline Material Assessment

Avg Burn Length	Std Dev.	% Std Dev.
2.28”	0.23”	10.12

- **Series of tests conducted on an aircraft grade CFRP, 1/8” thick**
- **10 tests**
- **Strict 1.8 watts/cm^2**
- **Room temp 71^{o}F**

Experiment Set up

Factor	(-) Low Level	(+) High Level
Heat Flux (Watts/cm2)	1.7	1.9
Room Temp (F)	65	75

Experiment

Standard Order	Heat Flux	Room Temp	Randomize	Actual Heat Flux	Burn Length	After Flame	Room Temp	% RH	Back Wall Thermocouple Pre Test	Watts Before Test	Watts After Test
3	1.7	75	0.010730819								
9	1.7	65	0.161017441								
8	1.9	65	0.244162765								
11	1.7	75	0.363605551								
6	1.9	75	0.533051687								
4	1.9	65	0.545988063								
5	1.7	65	0.659694949								
1	1.7	65	0.663592607								
12	1.9	65	0.734122903								
10	1.9	75	0.804076379								
2	1.9	75	0.812019225								
7	1.7	75	0.866090654								

Effect on Burn Length

Experiment #1: Heat Flux (±0.2), Chamber Temp

Variable	Low	High	Avg. Effect on BL
Heat Flux (w/cm^2)	1.6	2.0	0.96”
Chamber Temp (^{o}C)	50	70	0.07”

Baseline St Dev
0.23”

Effect on Burn Length

Experiment #2: Heat Flux (±0.1), Room Temp

Variable	Low	High	Avg. Effect on BL
Heat Flux (w/cm2)	1.7	1.9	0.32”
Room Temp (^{o}C)	18.3	23.9	0.42”

Baseline St Dev
0.23”

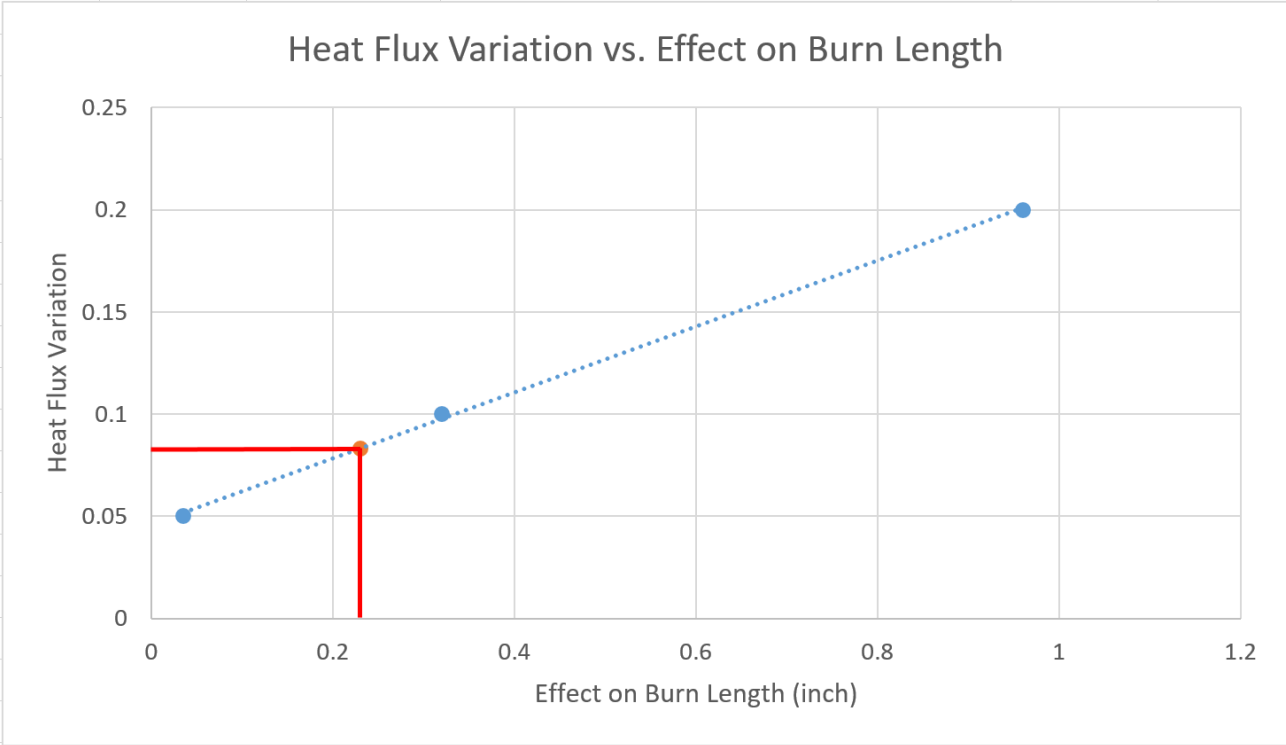
Effect on Burn Length

Experiment #3: Heat Flux (±0.05), Room Temp

Variable	Low	High	Avg. Effect on BL
Heat Flux (w/cm2)	1.75	1.85	0.04”
Room Temp (^{o}C)	19.4	22.8	0.002”

Baseline St Dev
0.23”

Conclusion

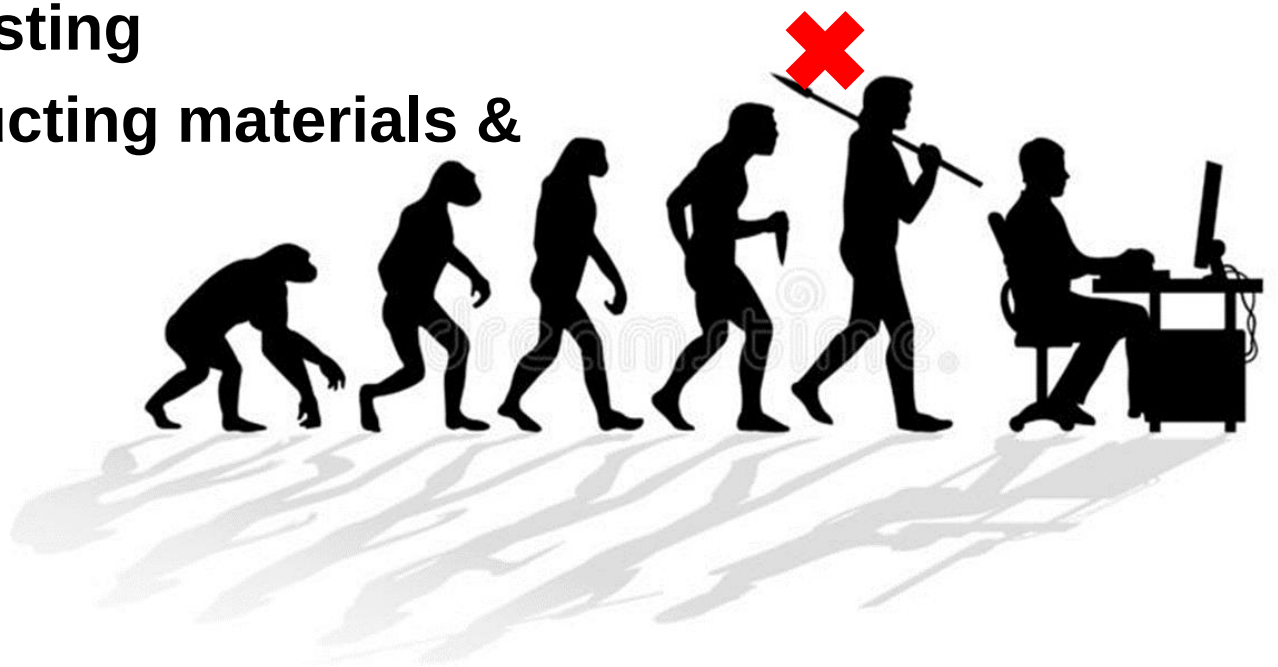


- **Relationship between heat flux variation and the effect on burnlength**
- **3 ranges shown**
- **Max heat flux variation < stdv of this material**

Are we there yet?

Not. Quite. Yet.

- **The task group will discuss and agree on a heat flux tolerance**
- **Visit HFG manufacturers to discuss calibrations**
- **Start Interlab Composite Testing**
- **Simultaneously continue ducting materials & wires**



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