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2013/2014 OSU Round Robin Conclusion

Project Leaders

Yaw Agyei – BR&T Flammability

Mike Burns – FAA Tech Center

Acknowledgements

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- **Support within Boeing**

- BR&T Flammability (Puget Sound, SC)
- BCA Flammability
- Greg Hooker (BCA Production)
- BR&T Math Group

- **FAA Tech Center**

- Mike Burns

- **Participants**

- 40 participating labs
- 46 participating units



Agenda

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- **About 2013/2014 Round Robin**
- **Test Results**
- **Data Analysis**
- **Round Robin Conclusion**
- **Proposed Next Steps**

About Round Robin

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■ Purpose

- FTWVG collaborative effort aimed to better understand variations observed in OSU heat release testing
- Pinpoint major sources of variability in HR test method
 - Study findings used to improve current HR test method
 - Study findings to be part of HR2 test method

■ Why another Round Robin

- Strict unit preparation, calibration, testing, data analysis
- Data collection
 - Unit survey
 - Air pressure measurements
 - Heat flux density calibration
 - Calibration Constant Determination
 - Raw test data

Test Coupons

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1. Honeycomb panel with decorative – representative of aircraft interiors (10)
2. 4 Ply pre-preg laminate – phenolic resin pre-impregnated glass fabric (10)
3. Aluminum with tape – standardized coupons from Lufthansa Technik / Airbus (5)



2012 Round Robin Variability

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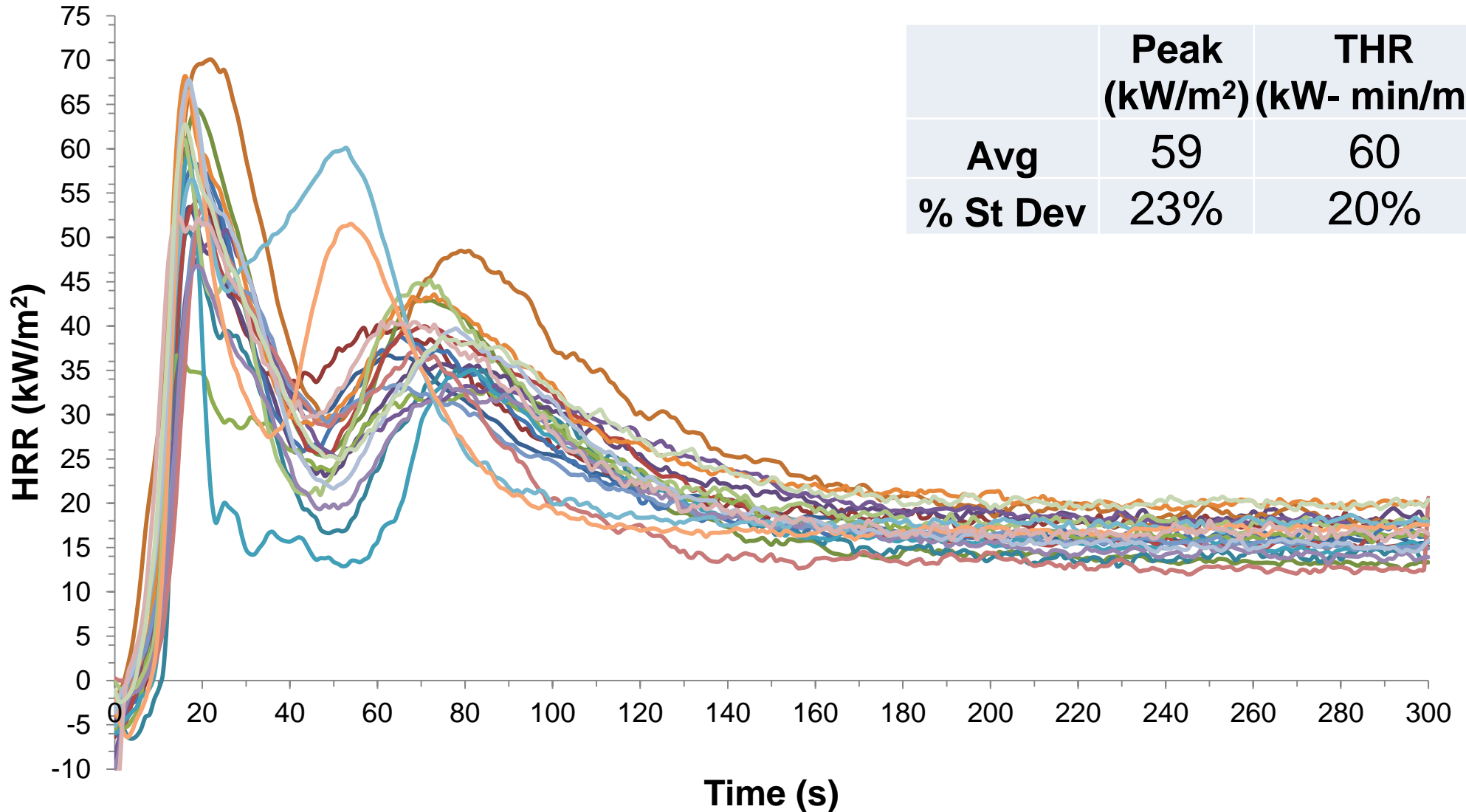
	Schneller Panel	Boeing Panel
Peak %St Dev	12%	15%
Total %St Dev	16%	13%
Higher variability observed with thermoplastics 28% - 38%		

Labs reported average of 3 test runs.

2013/2014 Test Results

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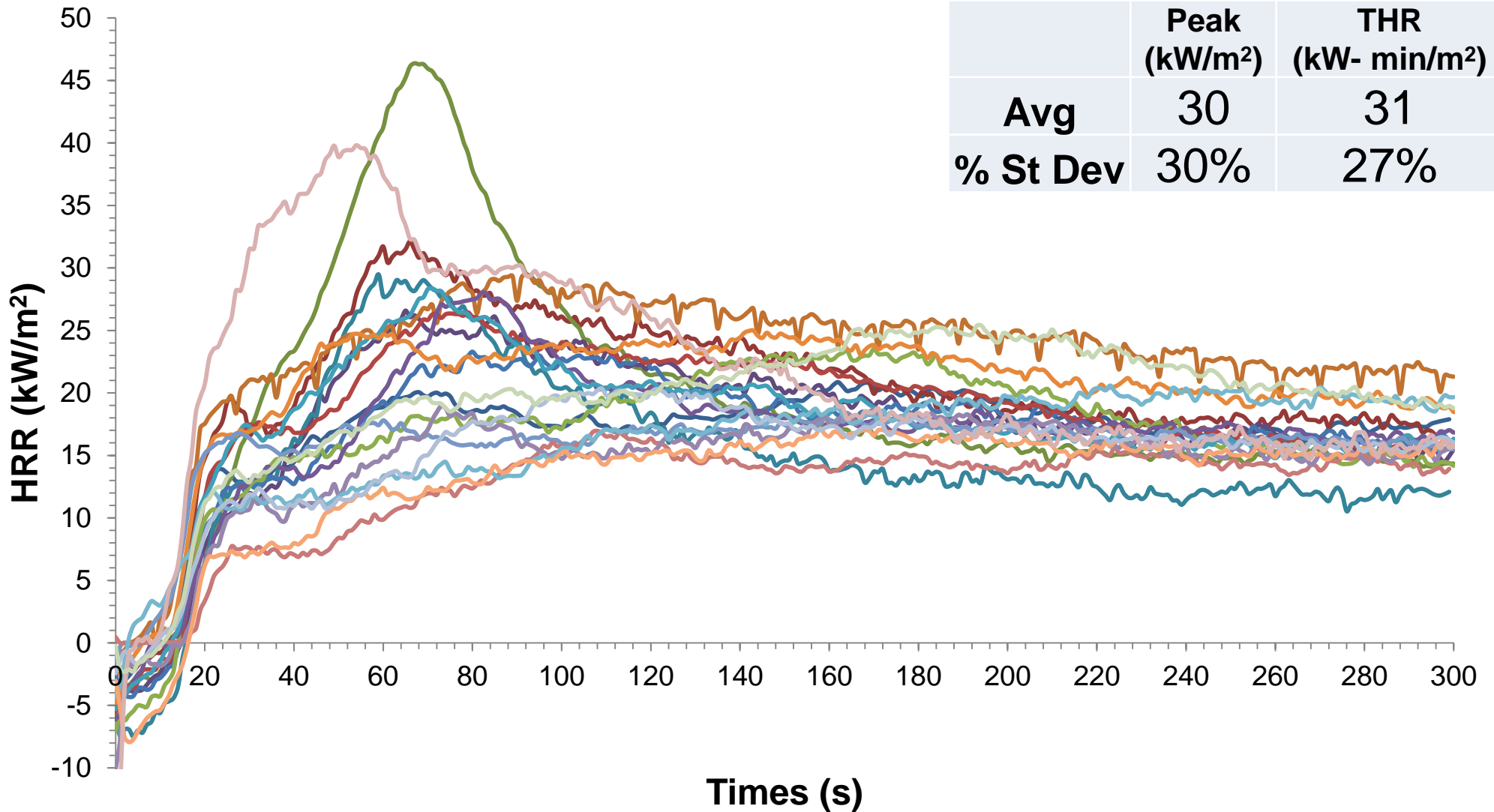
Honeycomb Panel with Decorative



2013/2014 Test Results

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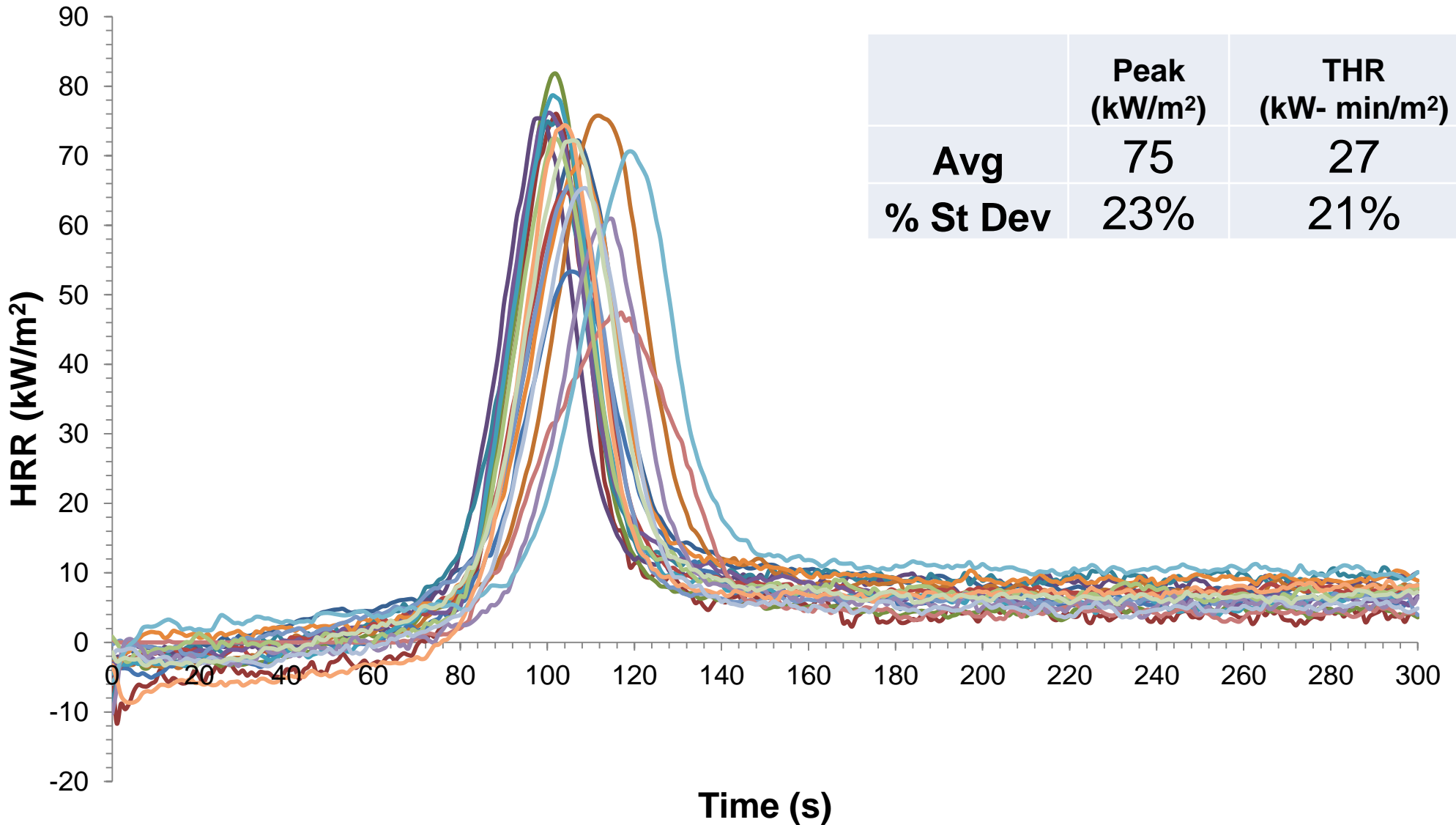
4-Ply Pre-Preg Laminate



2013/2014 Test Results

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Aluminum with Tape



Round Robin Comparison

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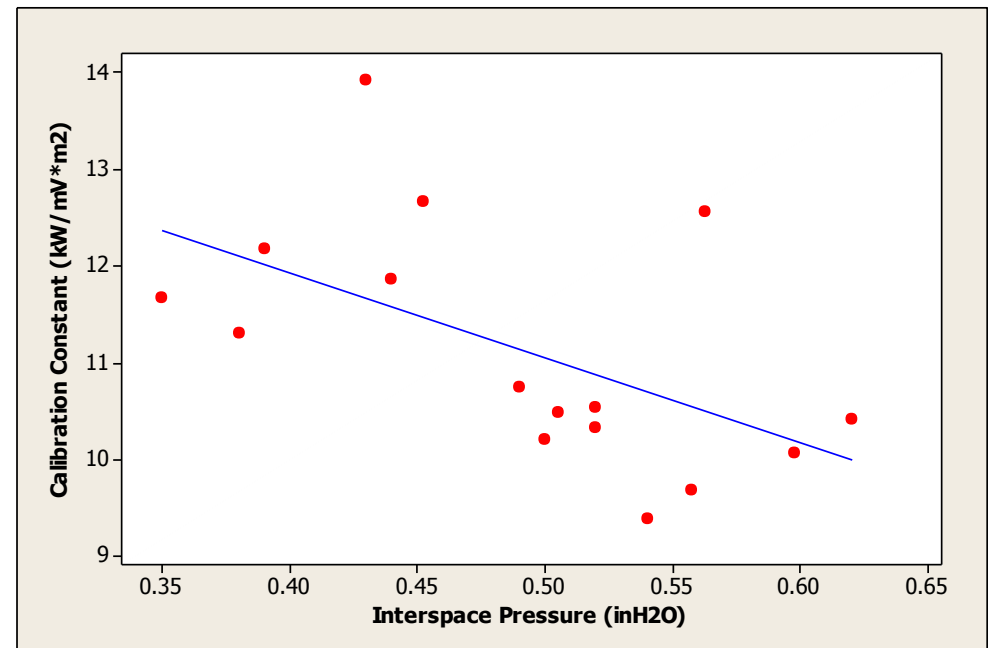
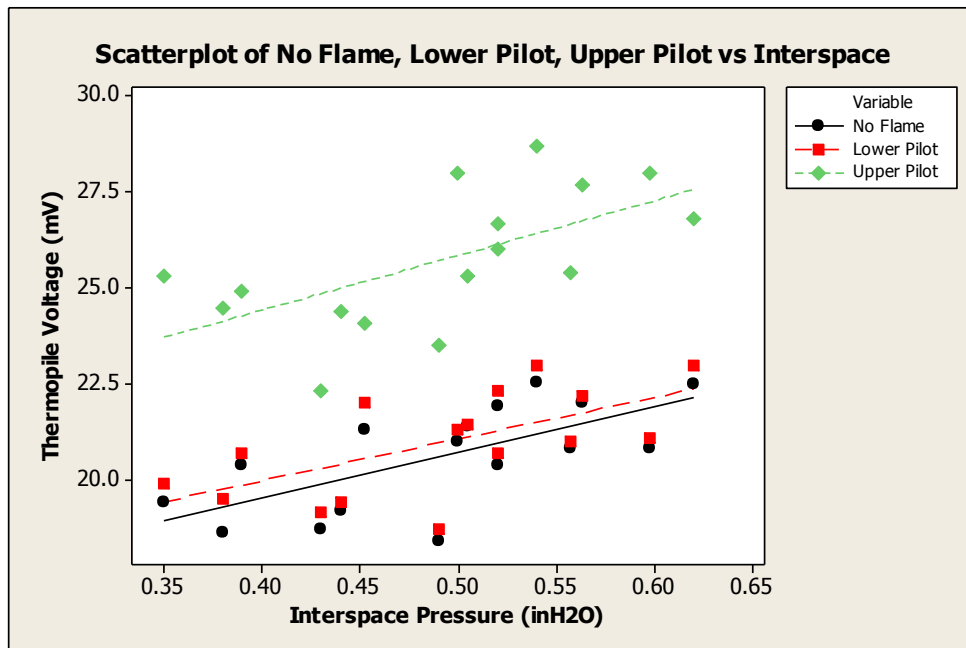
2012	Schneller Panel	Boeing Panel
Peak %St Dev	12%	15%
Total %St Dev	16%	13%
Data from 3 test runs		
Higher variability observed with thermoplastics 28% - 38%		

2013/2014	Honeycomb Panel with Dec	Aluminum with Tape
Peak %St Dev	23%	20%
Total %St Dev	23%	21%
Data from 10 test runs		
Higher variability observed with pre-preg laminate 27% - 30%		

Data Analysis

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- **Weak or NO correlation observed between test results and many measured/recorded parameters**
- **Correlation observed with Interspace Pressure and other parameters**
 - No Flame (46%), Lower Pilot (39.8%) and Upper Pilot (38.5%) thermopile voltages
 - Calibration Constant (30.3%)
 - Ratio of Delta (70%)



Calibration Constant (k_h)

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■ Primary factors

- Lab environment
- Change in flow rates
- Change in thermopile voltage

$$k_h = 25.31 \times \frac{273}{T_a} \times \frac{(P_a - P_v)}{760} \times \frac{(F_1 - F_0)}{(V_1 - V_0)} \text{ kW / m}^2 - \text{mv}$$

Constant (Lab Environment)

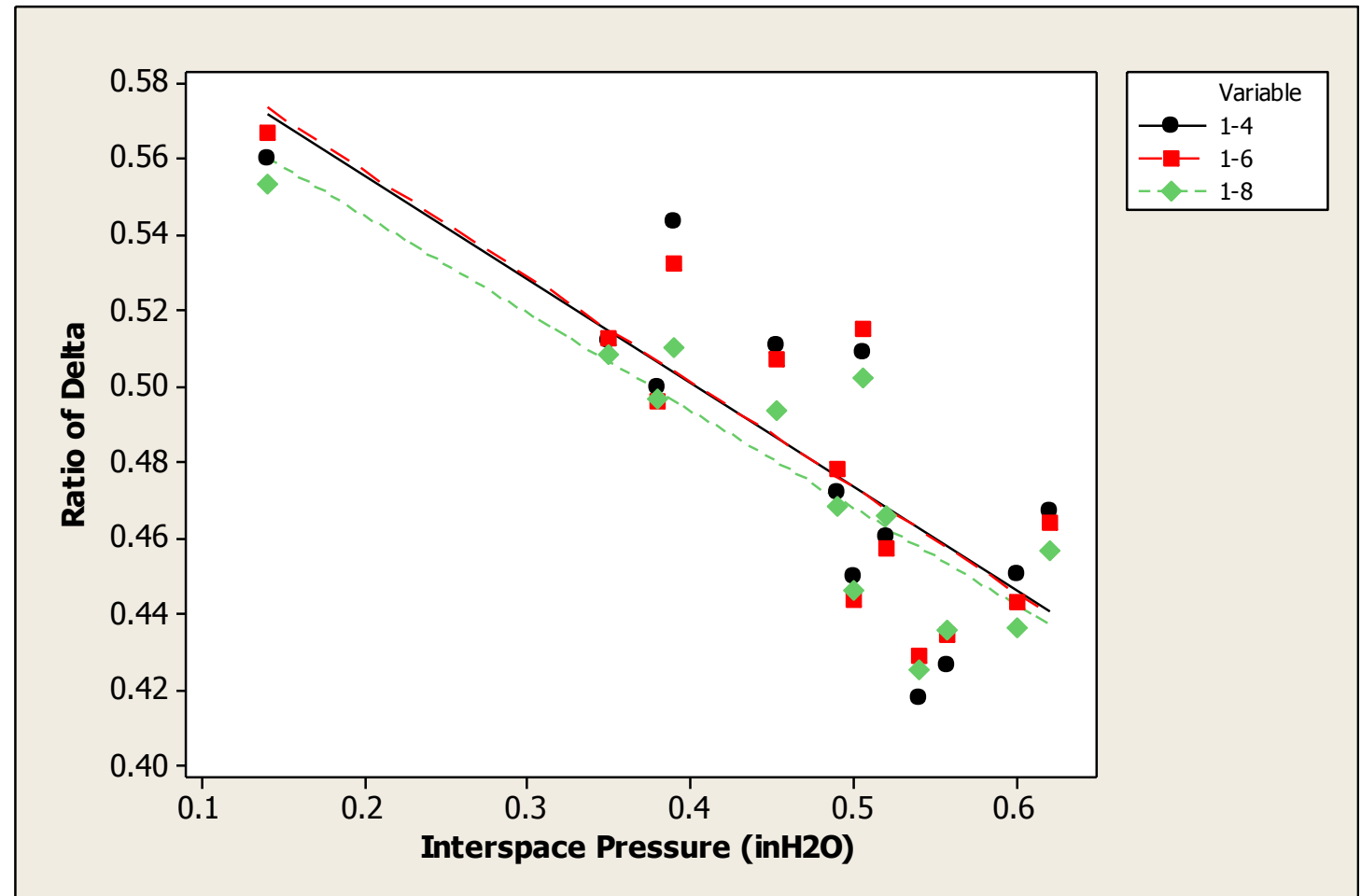
Ratio of Delta = $\frac{(F_1 - F_0)}{(V_1 - V_0)}$

Data Analysis – Ratio of Delta

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■ Strong correlation observed between interspace pressure and Ratio of Delta

- 1-4 = 64%
- 1-6 = 70%
- 1-8 = 76%



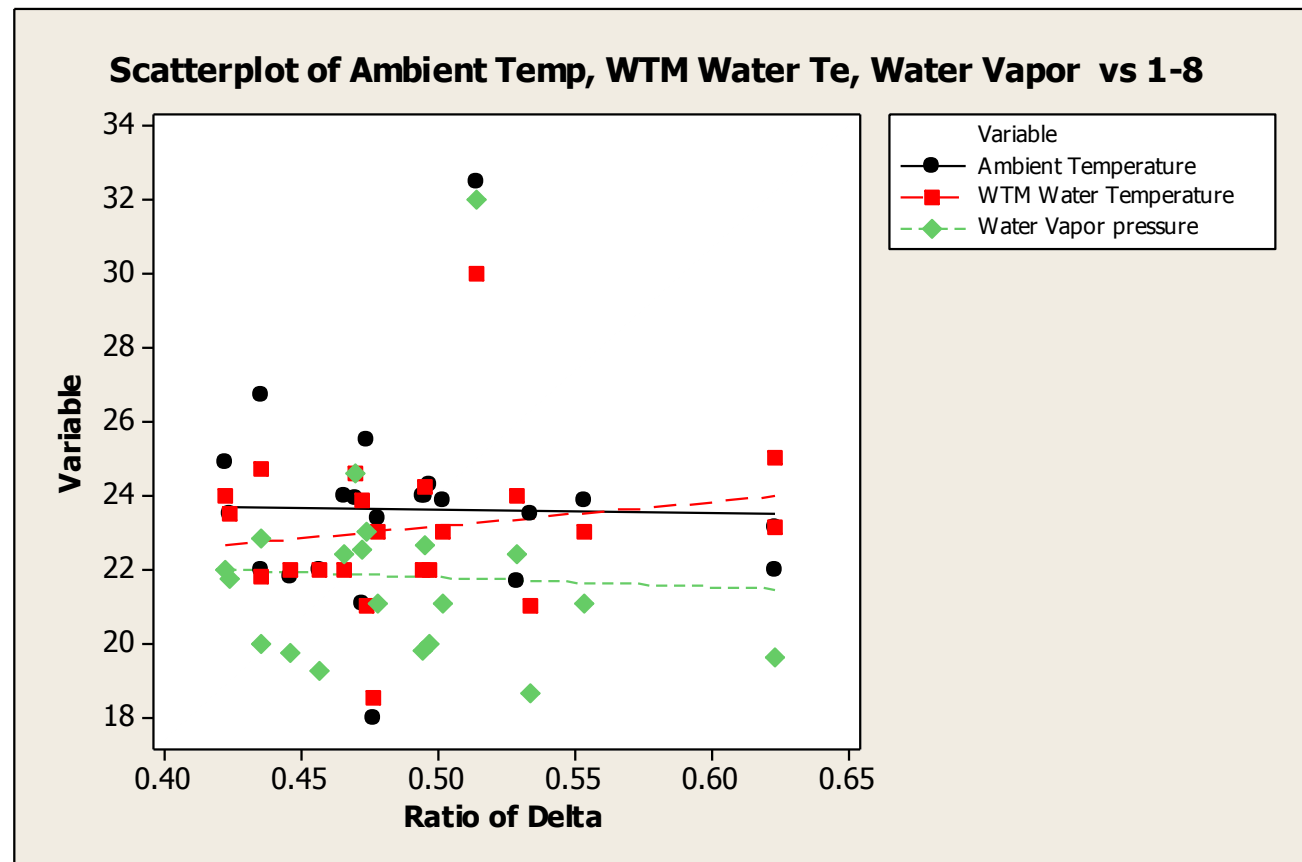
Outliers removed – not within Mike's suggested range

Data Analysis – Ratio of Delta

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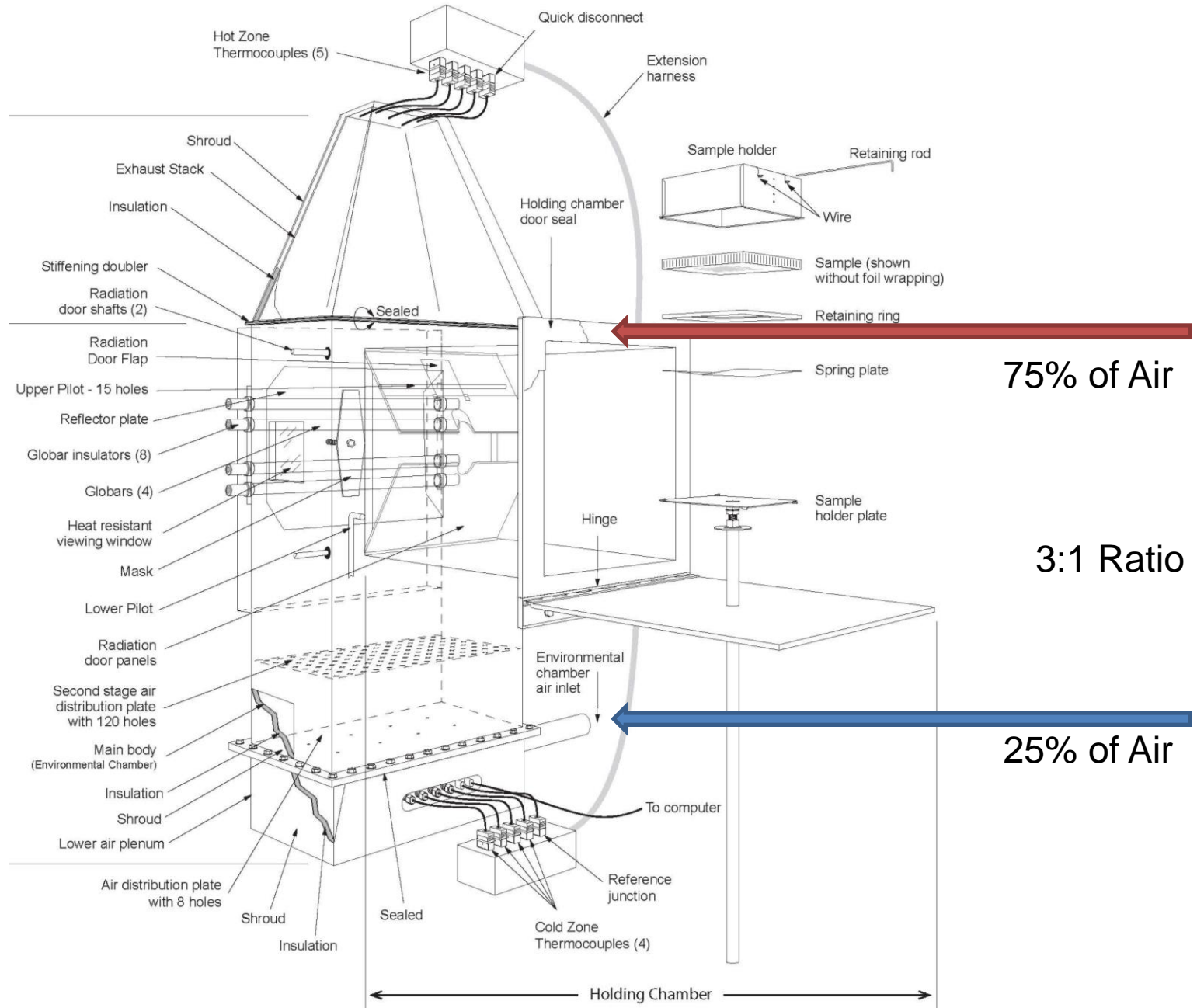
- **No / weak correlation observed between ratio of delta and other variables used to determine calibration constant**
 - Ambient Temperature = 0.0%
 - WTM Water Temperature = 2.8%
 - Water Vapor Pressure = 0.2%

Lab environment differences not a factor



OSU Air Flow

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Ratio of Delta

- **Flow rates are consistent for all units**

- Flow rates are accurate for most units
- Flow rates are proportional
- Wet Test Meter not a factor

	Δ Flow Rates (L/min)		
	1-4	1-6	1-8
Avg	2.99	4.98	6.98
% St Dev	3%	2%	3%

- **Variations observed for change in thermopile voltage for all units**

- Thermopile voltages varies
- Possibly due to air flow / air flow split

	Δ Thermopile Voltage (mV)		
	1-4	1-6	1-8
Avg	6.18	10.20	14.28
% St Dev	13%	11%	10%

Round Robin Conclusion

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- **2013/2014 OSU Round Robin observed variability higher than previous Round Robin.**
 - Attempts to control unit preparation, calibration, testing, and calculations methods had no noticeable effects on reducing variability.
- **Correlation observed between interspace pressure and thermopile voltages**
 - No Flame, Lower Pilot, Upper Pilot
 - Calibration constant
 - Lab environment or wet test meter not a factor
 - Strong correlation between ratio of delta and interspace pressure
- **Unit air flow / air flow split = possible major variability factor**
 - High variations observed for measured thermopile voltages (10-13%)

Proposed Next Steps

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- **Determine air flow split for all Round Robin participants**

- **Determine change in thermopile voltages for a unit with an air flow split ratio of 3:1**
 - Currently in work at Boeing South Carolina
 - **Chris Ballew / Theo Spanos – Project Leaders (BR&T SC)**
 - Mike Burns – FAA Tech Center
 - Yaw Agyei – BR&T PS
 - Hank Lutz – BR&T PS
 - Yonas Behboud – BR&T PS

- Test plan will be shared with FTWVG at future meetings