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HR 2 Calibration Factor Averaging

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Fire Test Forum – Spring Meeting, April 2021

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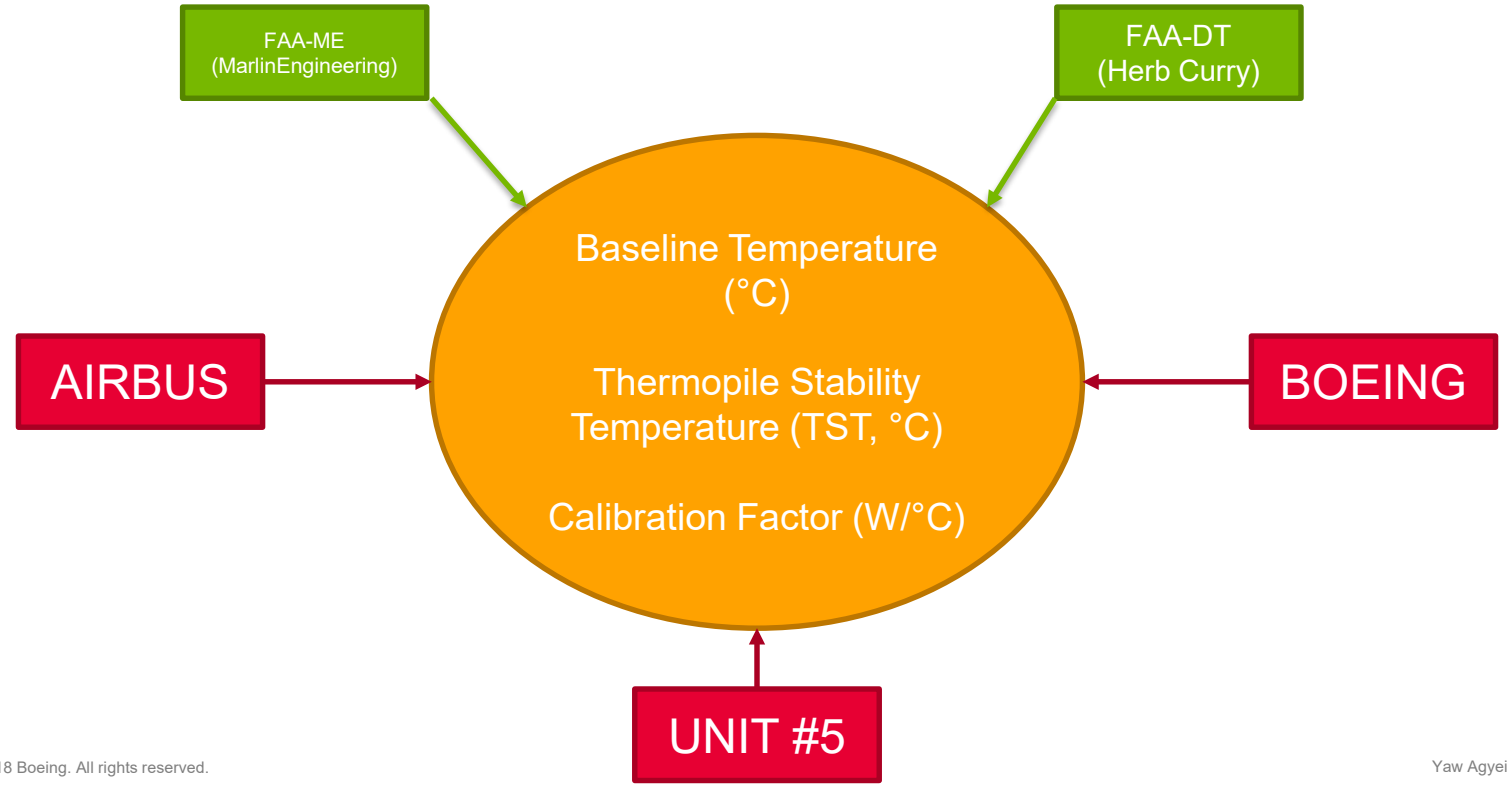
Agenda

1. Operating Response Specification Limits Recap
   - Establishing Specification Limits
   - New HR 2 Unit Validation
   - Daily HR 2 Operations Assessment
2. Reducing Calibration Factor Variation Impact on Heat Release Properties
   - Simple Moving Average Method Proposal
   - Simple Moving Average Sensitivity Analysis
3. Summary / Q&A

Operating Response Specification Limits Recap

Establish operating response specification limits using TRL 6 Phase 1 unit assessment data - minimum of 5 units

- Minimum of 100 data points from each unit
- 99-95% Tolerance intervals: 95% confidence that 99% of the population will fall within range



Operating Response Specification Limit Recap

New HR 2 Unit Validation

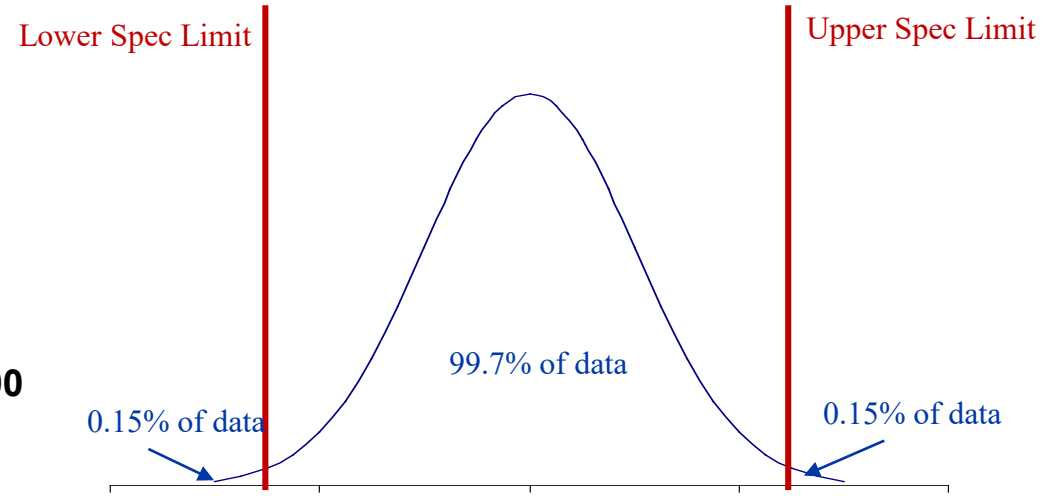
- After installation of new unit, conduct unit assessment to validate new unit.
  1. Conduct minimum of 100 methane calibrations
  2. Record baseline temperature, thermopile stability temperature, calibration factor
  3. Determine mean and standard deviation for each response
  4. Compute process capability index (CpK) for each response
     - Defines the ability of the HR 2 unit to produce a response that meets test method specification limits

$$\mathrm{CpK} = \min\left(\frac{\bar{x} - \mathrm{LSL}}{3s}, \frac{\mathrm{USL} - \bar{x}}{3s}\right)$$

Required CPK for 0.30% out of spec rate, n=100

90% Confidence = 1.112

95% Confidence = 1.146



CpK info provided by Katy Wrenn, Lindsay Jones – BR&T Applied Math Group

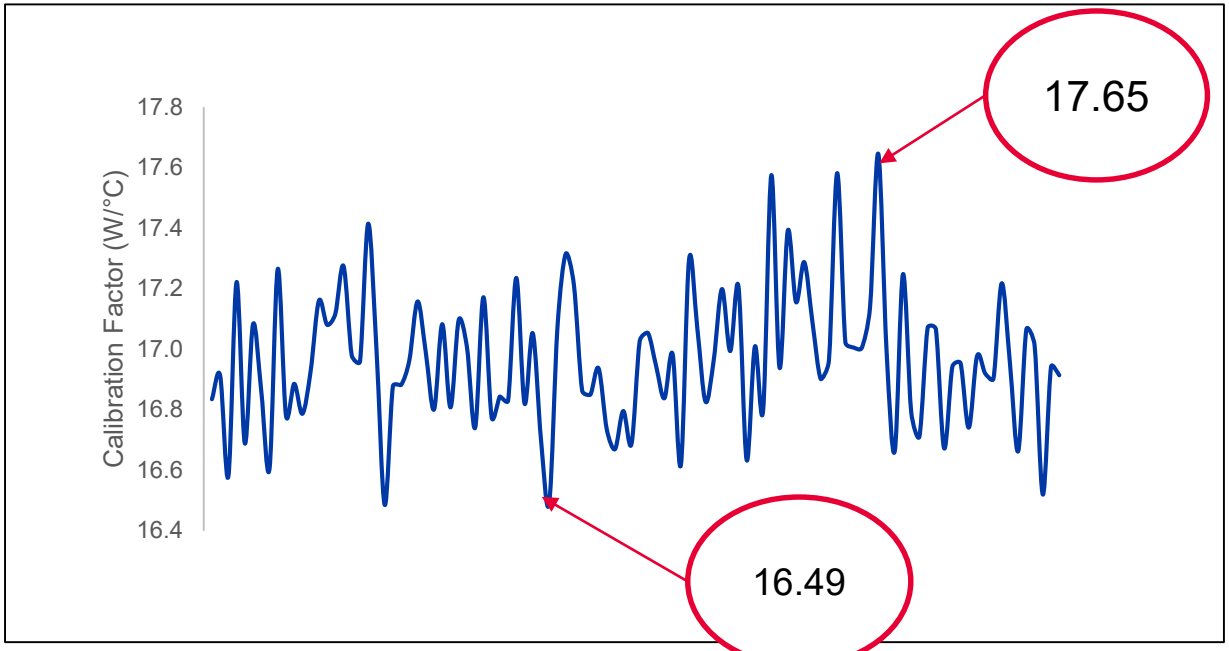
Operating Response Specification Limit Recap

Daily HR 2 Operations Assessment

- Critical operating responses must fall within specification limits for all testing
  - Baseline temperature (°C)
  - Thermopile Stability Temperature (TST, °C)
  - Calibration factor (W/°C)

Calibration Factor Correction

- Calibration Factor (K_h)
  - Proportionality constant, determined by performing the calibration procedure.
  - Correlates the heat released by a specimen when burned to the known heat content of methane.
  - Calibration procedure conducted weekly and after each repair or maintenance of the apparatus that may affect the unit's response.
  - May vary significantly, variations significantly impact heat release properties



Range = 1.16 W/°C

7.03 % Difference

Data from FAA-DT unit response assessment experiment, 104 calibrations conducted by Mike Burns at FAA Tech Center

Calibration Factor Correction

Calibration Factor Impact on Heat Release Properties

- Calibration factor directly proportional to HRR
- % change in CF = % change in HRR

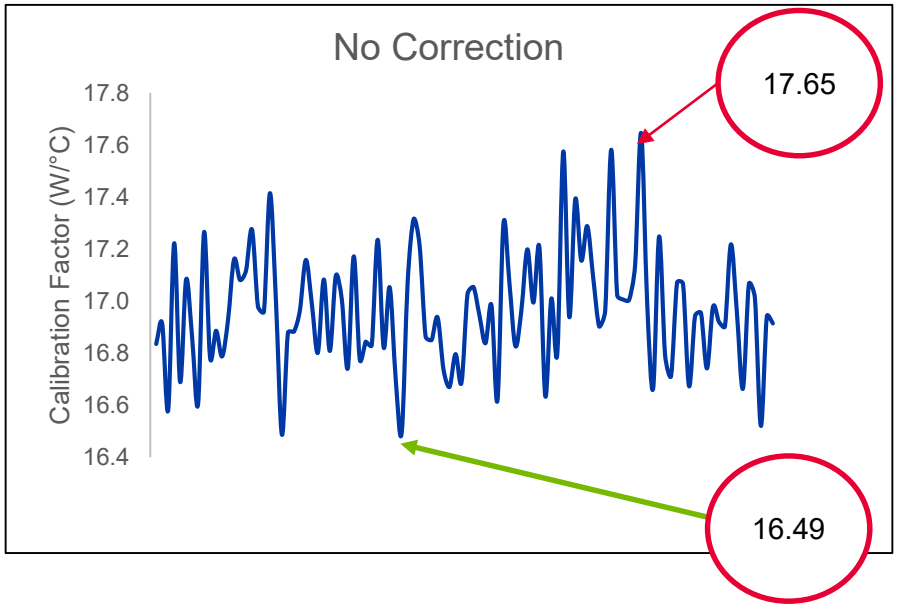
- HR 2 TRL 6 Phase 2 Testing Example:
  - FAA-DT unit
  - Schneller specimen
  - Calculated CF on 1st day of testing = 17.28 W/°C

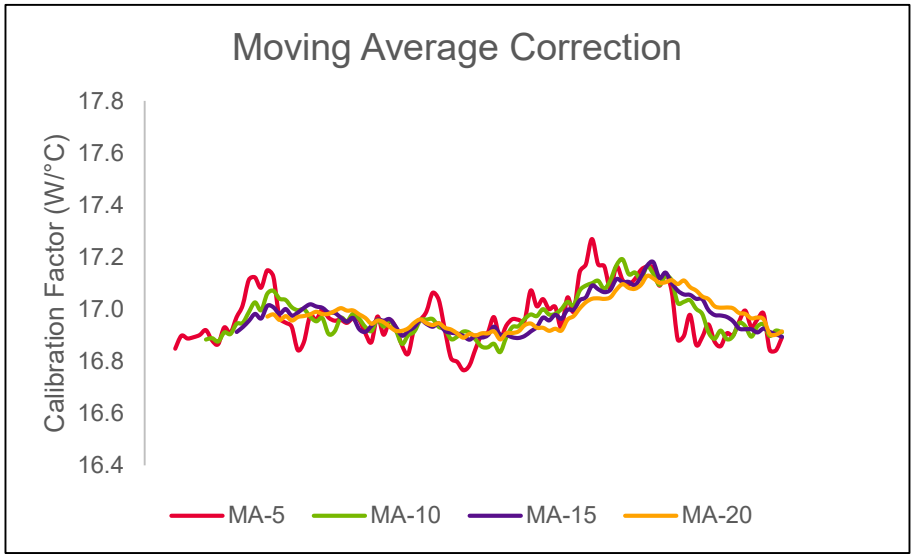
	Min	Actual	Max
Calibration Factor (W/°C)	16.49	17.28	17.65
% difference	*-4.6%*	-	*2.1%*
Peak HR (kW/m^2)	44.3	46.4	47.4
2-Min Total (kW-min/m^2)	33.7	35.3	36.1

Calibration Factor Correction

Mike Burn's proposal

- Use simple moving average to compute applied calibration factor
  - Offers stable calibration factor value over time
  - Calibration factor less prone to whipsawing up and down
  - More representative of instrument's performance over time



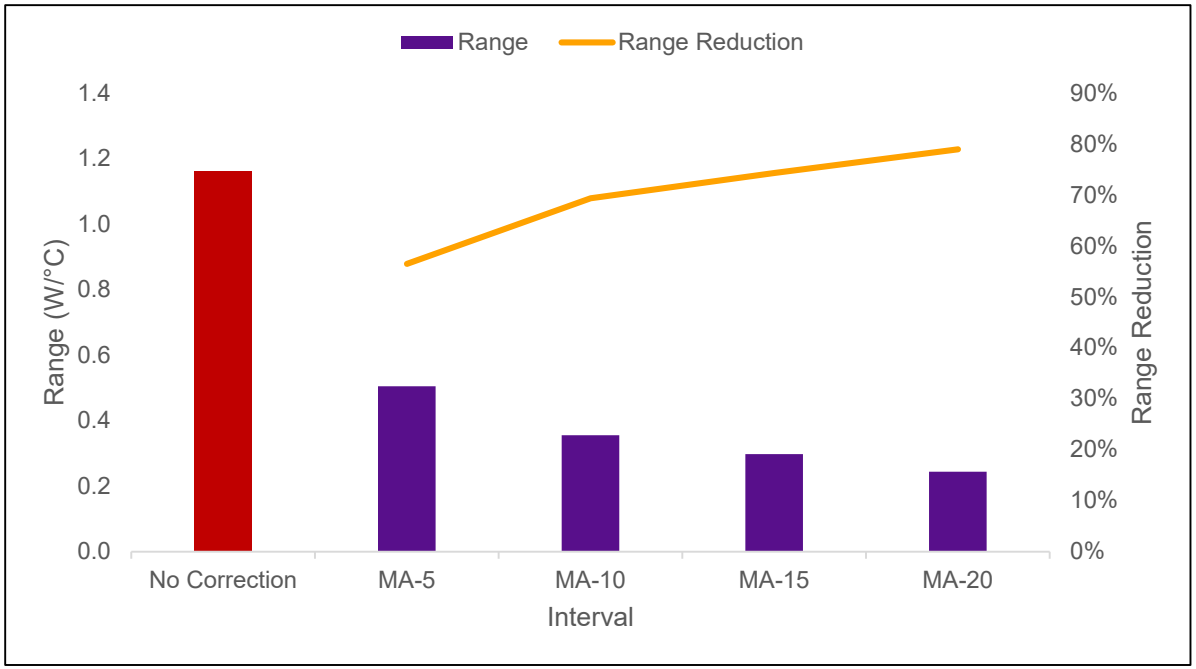


Data from FAA-DT unit response assessment experiment, 104 calibrations conducted by Mike Burns at FAA Tech Center

Calibration Factor Correction

Moving Average Sensitivity Analysis

- Determine most practical moving average interval
- Sets the interval for moving average calculation
- 56% range reduction using moving average interval of 5 – best option



Data from FAA-DT unit response assessment experiment, 104 calibrations conducted by Mike Burns at FAA Tech Center

Summary

1. Operating Response Specification Limits Recap
   - Established using TRL 6 Phase 1 data from minimum of 5 units
   - New unit validated using CpK analysis
   - Critical responses must fall within specification limits for testing

2. Reducing Calibration Factor Impact Variation on Heat Release Properties
   - Adopting moving average, interval of 5, to compute applied calibration factor to reduce calibration factor variation on heat release properties.