HEAT RELEASE RATE Updates

2015 June Materials Meeting
Bremen, Germany

Materials Working Group

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June, 2015

Federal Aviation Administration

AGENDA

- Upper Pilot Burner Igniter
- HR2 / OSU Round Robin Data
- HR2 Material Simulator Test Data
- Design of Experiment (DOE) Draft Test Plan Concept
- Next

Upper Pilot Hot Surface Igniter (HSI)

- Installed in FAA Fire Test Handbook for use in current OSU's (4/28/2015)

  - Placed in Supplement Bullet 5.3.8

- Optional Use (Much like the Drip Pan)
- Reduce variability within OSU heat release units with regard to the performance of the upper pilot burner

HR2 / OSU Round Robin

- Assembled larger Focus Group RR comparing HR2 (1) and Industry OSU's (9)
- Follow-on Validation Testing of HR2
- Developed and Distributed Test plan and materials to participating labs
- Completed RR Tests
- Reduced / Analyze

HR2 / OSU Round Robin

PURPOSE

- Gather and compare data using a modified heat release rate apparatus (HR2) and several modern day Ohio State University heat release rate units (OSU's).
- Assess Pass / Fail Criteria

TEST PLAN

- Intended to give participants a clear understanding of pre-test responsibilities, unit preparation and post-test instructions.

HR2 / OSU Round Robin

Participating Labs (9 - OSU's / 1 - HR2)

- Aim Altitude (England) [formerly Aim Aviation]
- Airbus (Germany)
- C&D Zodiac - La Palma (USA)
- FAA Technical Center - HR2 (USA)
- FAA Technical Center - OSU (USA)
- Govmark Organization Inc. (USA)
- Herb Curry Inc. (USA)
- ISOVOLTA Inc. (USA)
- JAMCO Pte. Ltd. (Singapore)
- Schneller (USA)

HR2 / OSU Round Robin

TESTING

- A mixed set of 8 samples per day were tested over a 5 day period.
- 2 samples from each of 4 materials were tested each day.
- Each day of testing the order of testing each pair was randomized.
- Test coupons were conditioned for 24 hours at 70 ± 3º F and 50 ± 5 % humidity before testing.

MATERIAL CONFIGURATION

Material ID	# of Coupons	Set Description
HCP	10	This control panel is to be tested first each day prior to testing materials A, B & C. HC-panel (S-glass prepreg / Kevlar Core / S-glass prepreg)
HDL	10	HC-panel with decorative Laminate
SSP	10	S2221 6” x 6” x 1/8” core panel
AL950	10	0.032” Aluminum with one ply of 3M 950 tape *Condition samples with tape backing still applied.* ***Do NOT use aluminum foil to wrap samples****. Simply pull the brown tape backing off and place in holder with retainer frame, spring plate and retention rod.*

MATERIAL CONFIGURATION

TEST MATRIX

Day #	Material ID (Testing order; 2 of each sample tested per day)			
1.	HCP	HDL	SSP	AL950
2.	HCP	SSP	AL950	HDL
3.	HCP	AL950	HDL	SSP
4.	HCP	HDL	SSP	AL950
5.	HCP	SSP	AL950	HDL

ROUND ROBIN Z-SCORE

- Statistical measurement of relationship to the average
- Score of 0 means the score is the same as the average
- Z-score can be positive or negative, indicating whether it is above or below the average and by how many standard deviations

2015 Heat Release Rate Round Robin

Chauvenet's Criterion (Data Filter)

Z Score is Calculated

- # of STDEV's from population mean
- The closer to zero the better

Z Score = (Lab data – Average) / STDEV

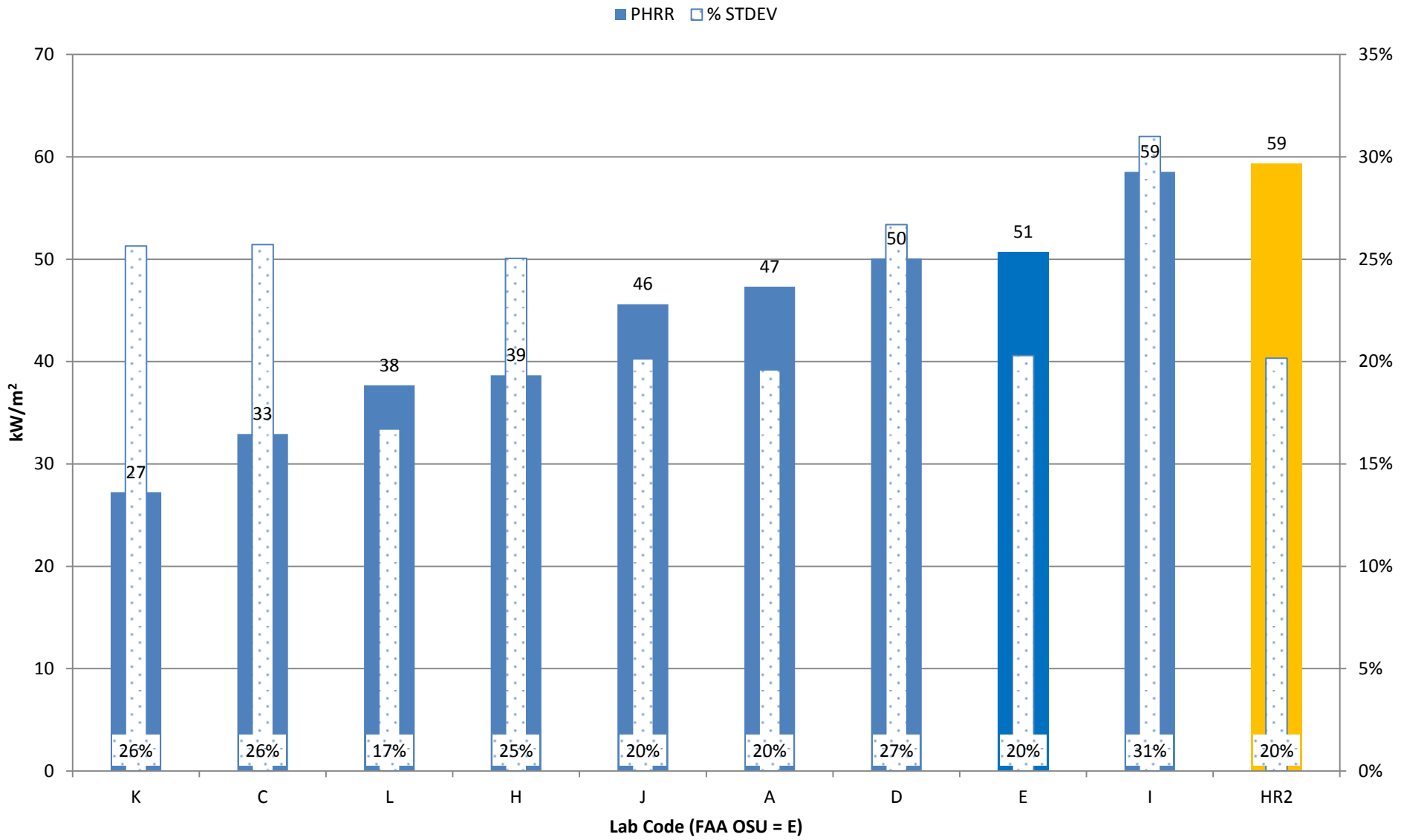
D_{max} is Calculated

- The maximum allowable deviation
- Based on the Total number of labs

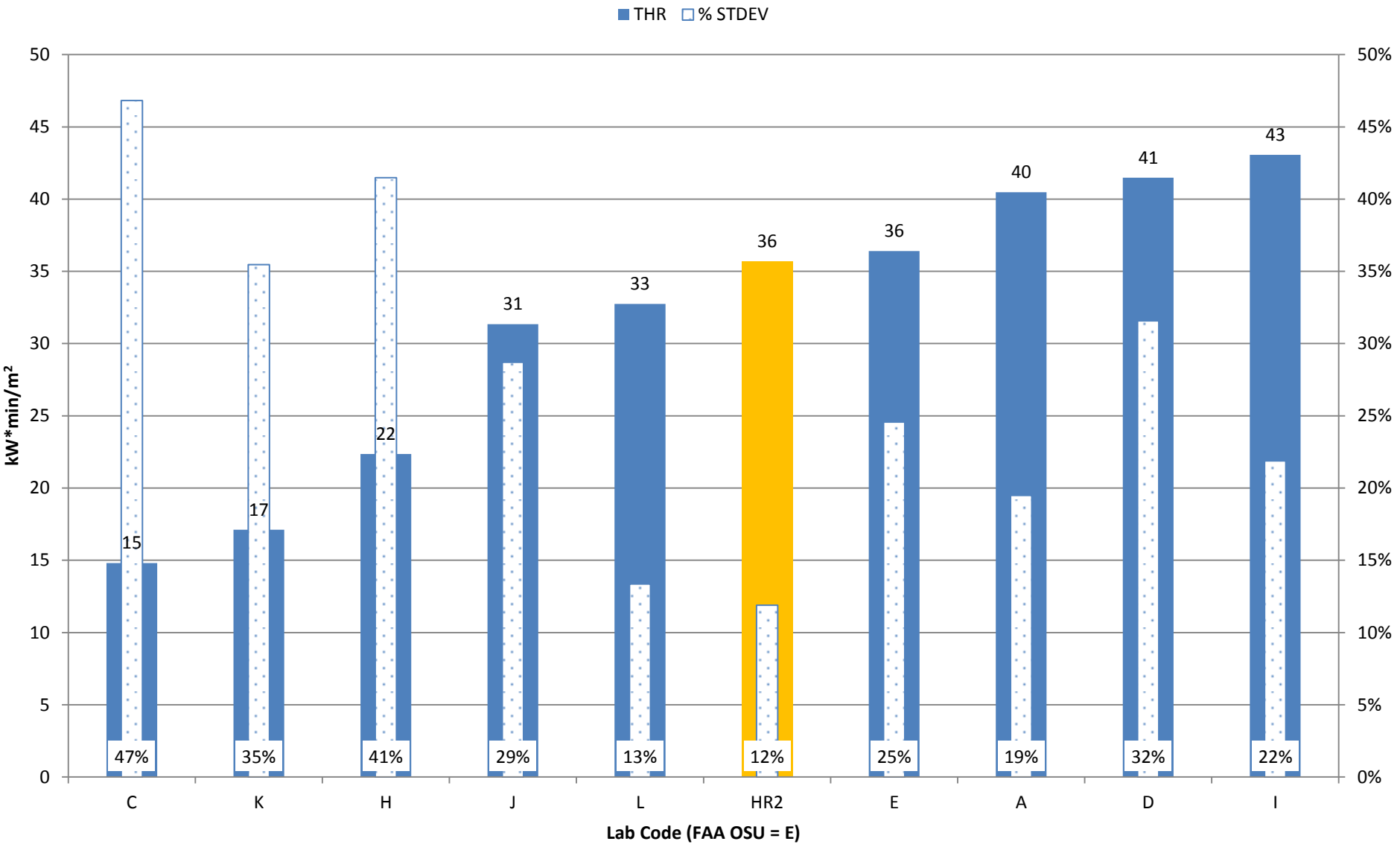
D_{max} = ABS(NORM.S.INV(1/((4 * # OF LABS))))

Data is rejected if ABS Z Score $\geq D_{max}$

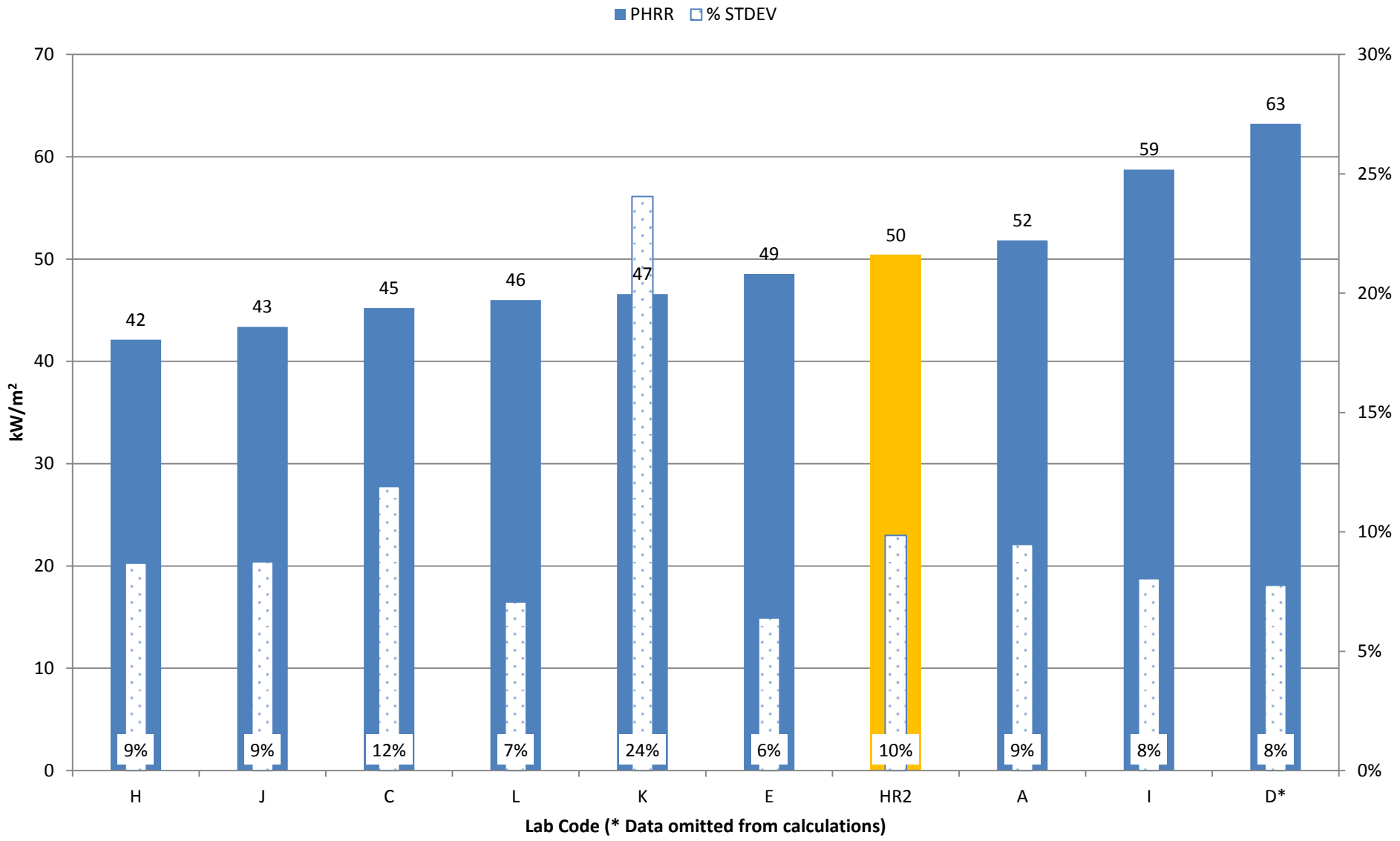
HCP Avg. Peak Heat Release Rate: 45 kW/m² @ 24 % STDEV



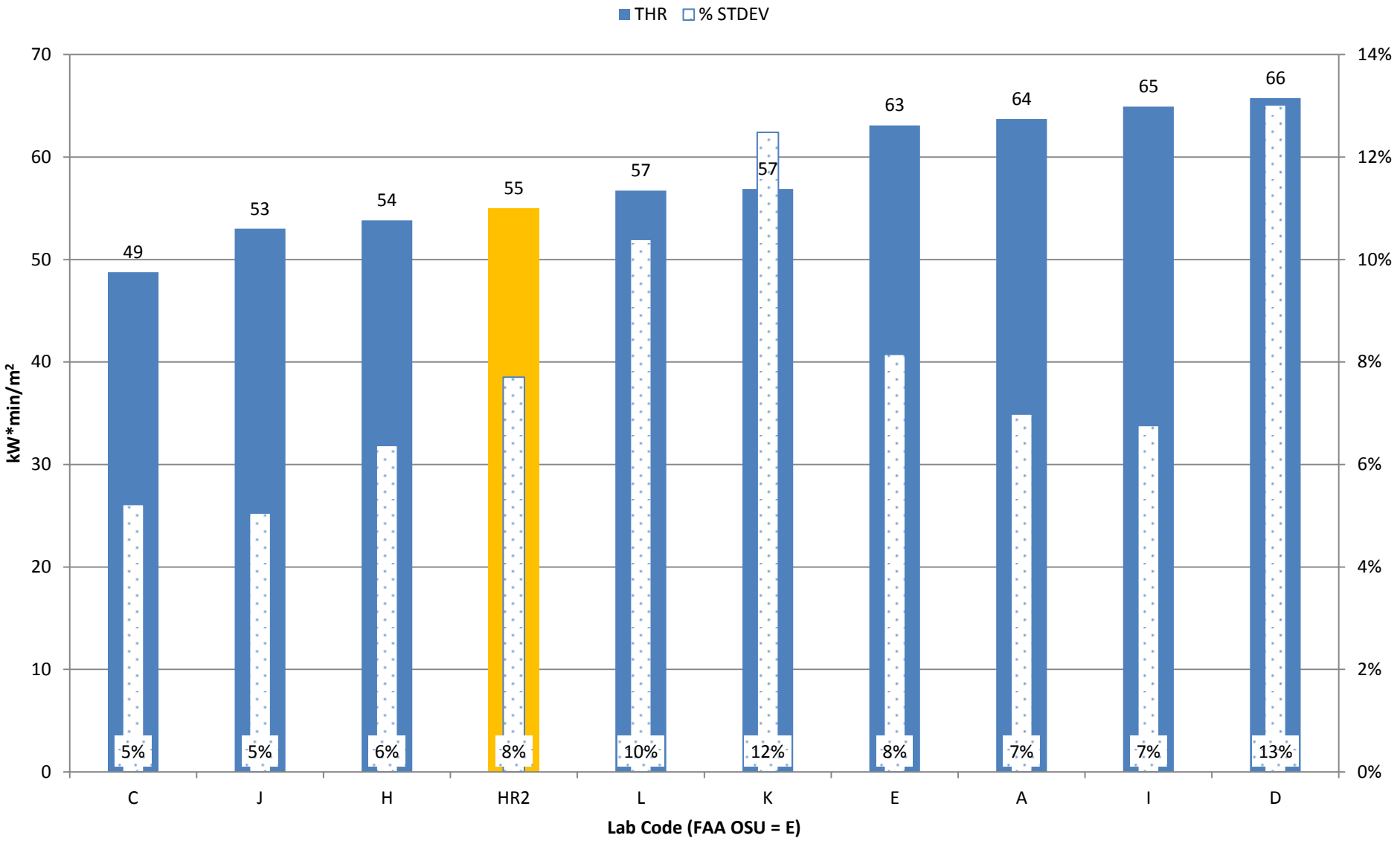
HCP Avg. 2-Minute Total Heat Release: 32 kW*min/m² @ 32 % STDEV



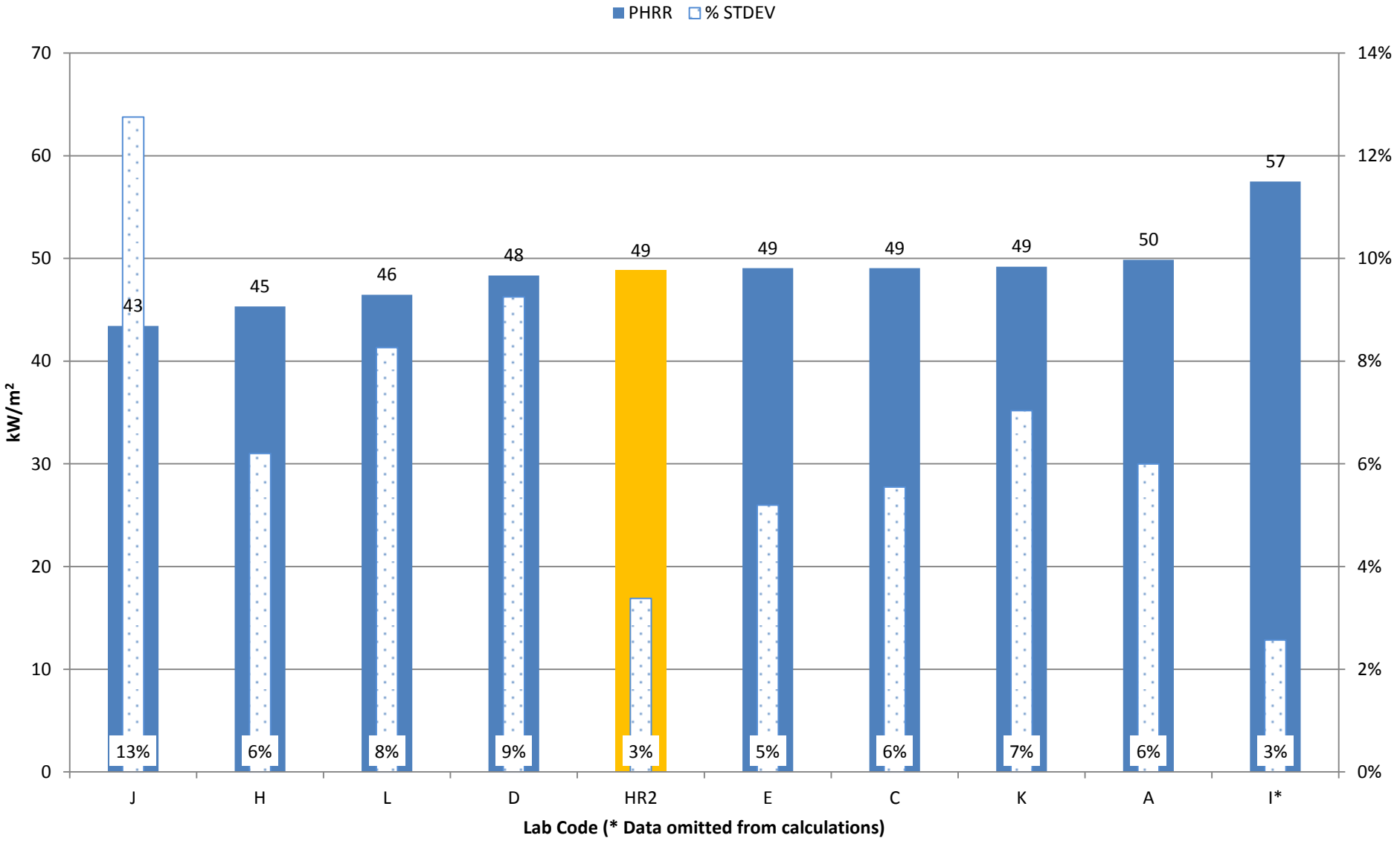
HDL Avg. Peak Heat Release Rate: 48 kW/m² @ 11 % STDEV



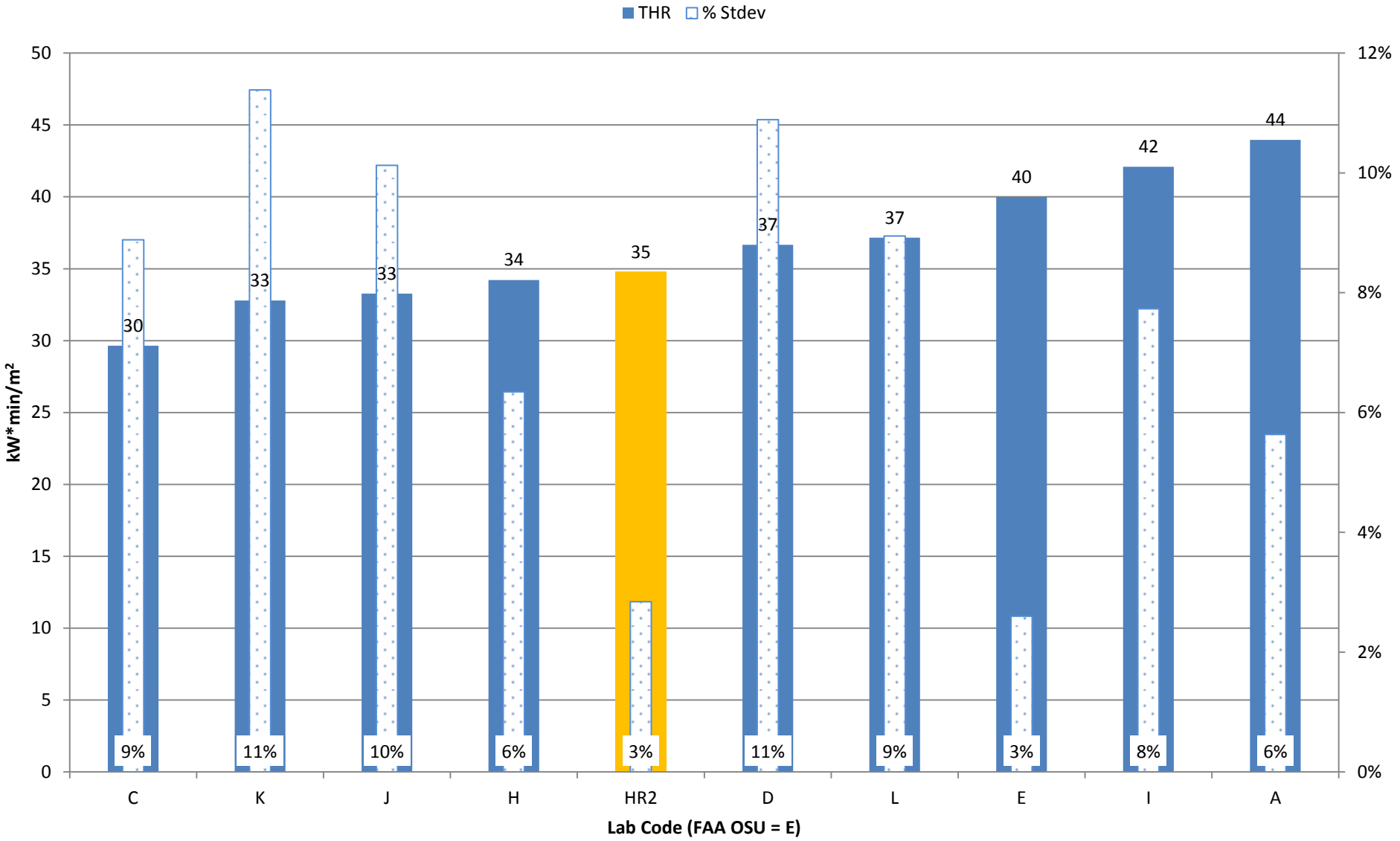
HDL Avg. 2-Minute Total Heat Release: 58 kW*min/m² @ 10 % STDEV



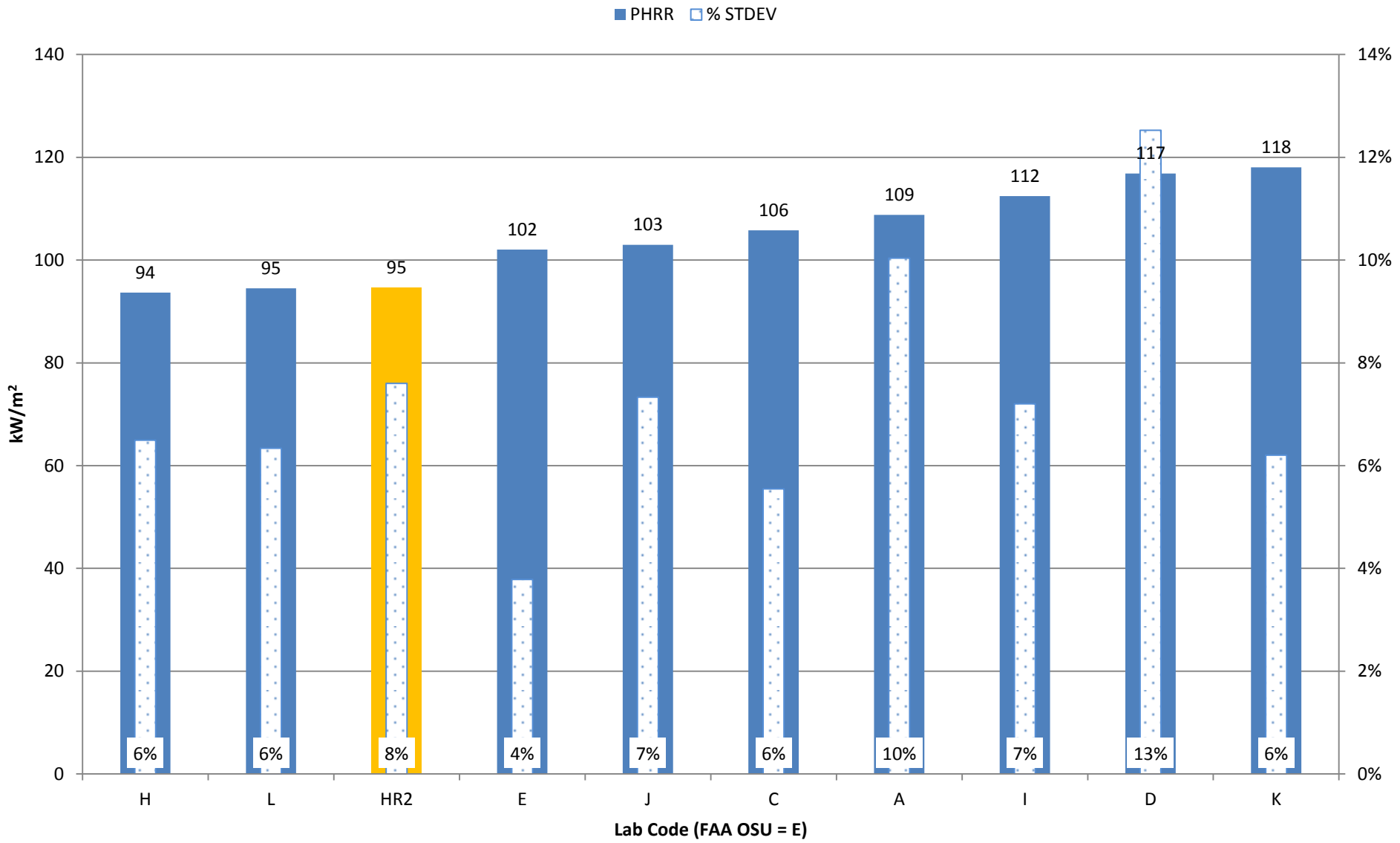
SSP Avg. Peak Heat Release Rate: 48 kW/m² @ 5 % STDEV



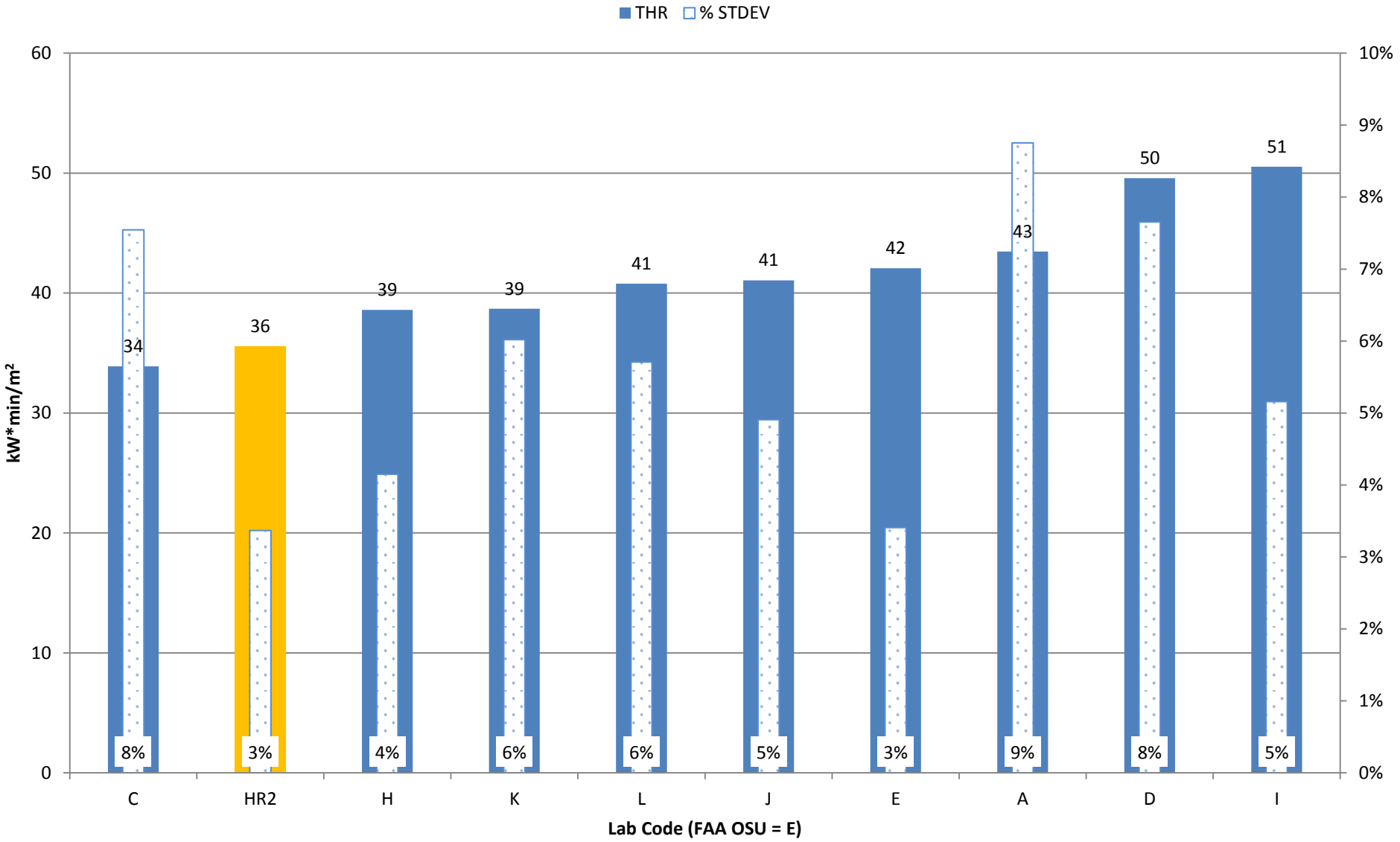
SSP Avg. 2-Minute Heat Release Rate: 36 kW*min/m² @ 12 % STDEV



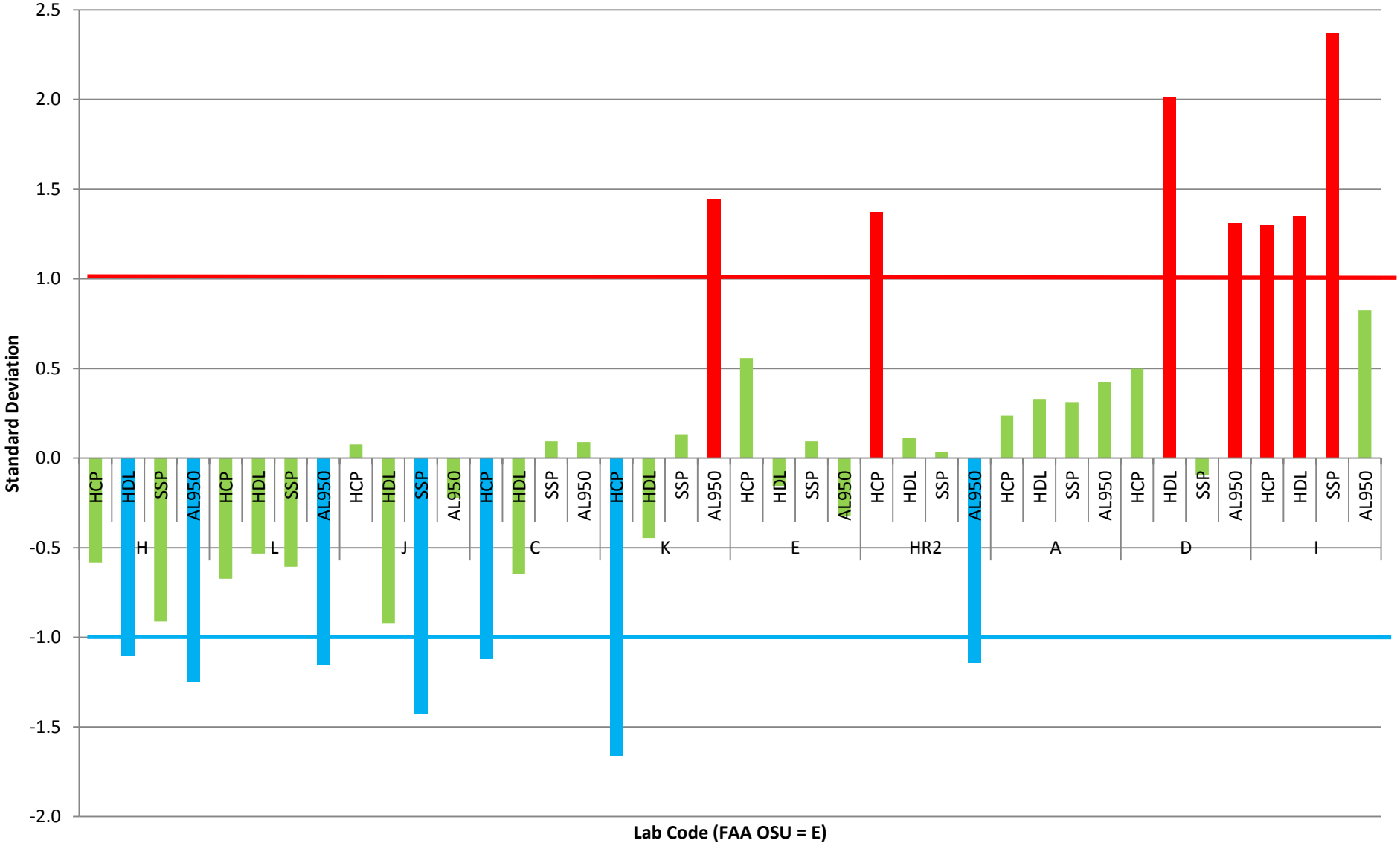
AL950 Avg. Peak Release Rate: 105 kW/m² @ 9 % STDEV



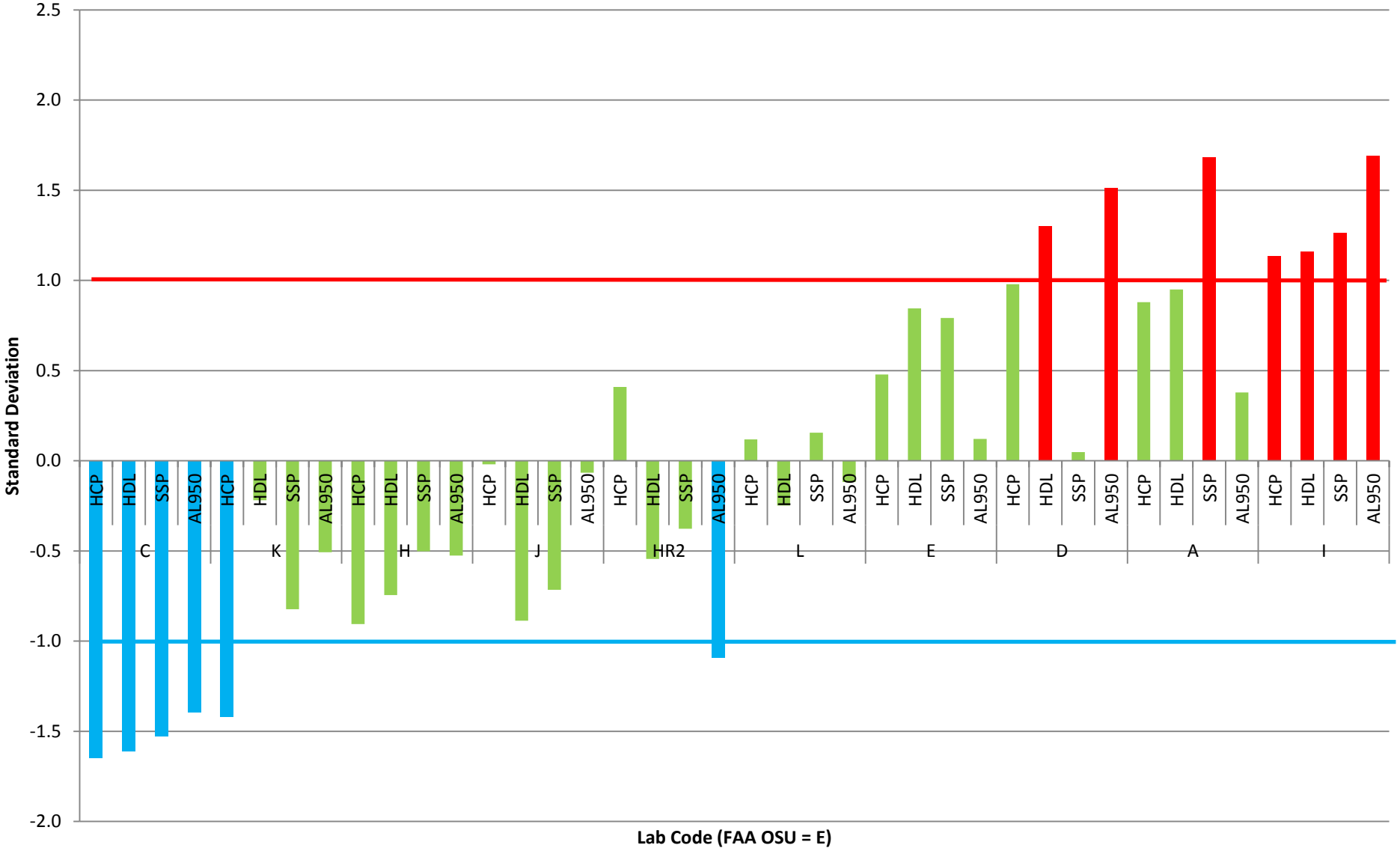
AL950 Avg. 2-Minute Total Heat Release: 41 kW*min/m² @ 13 % STDEV



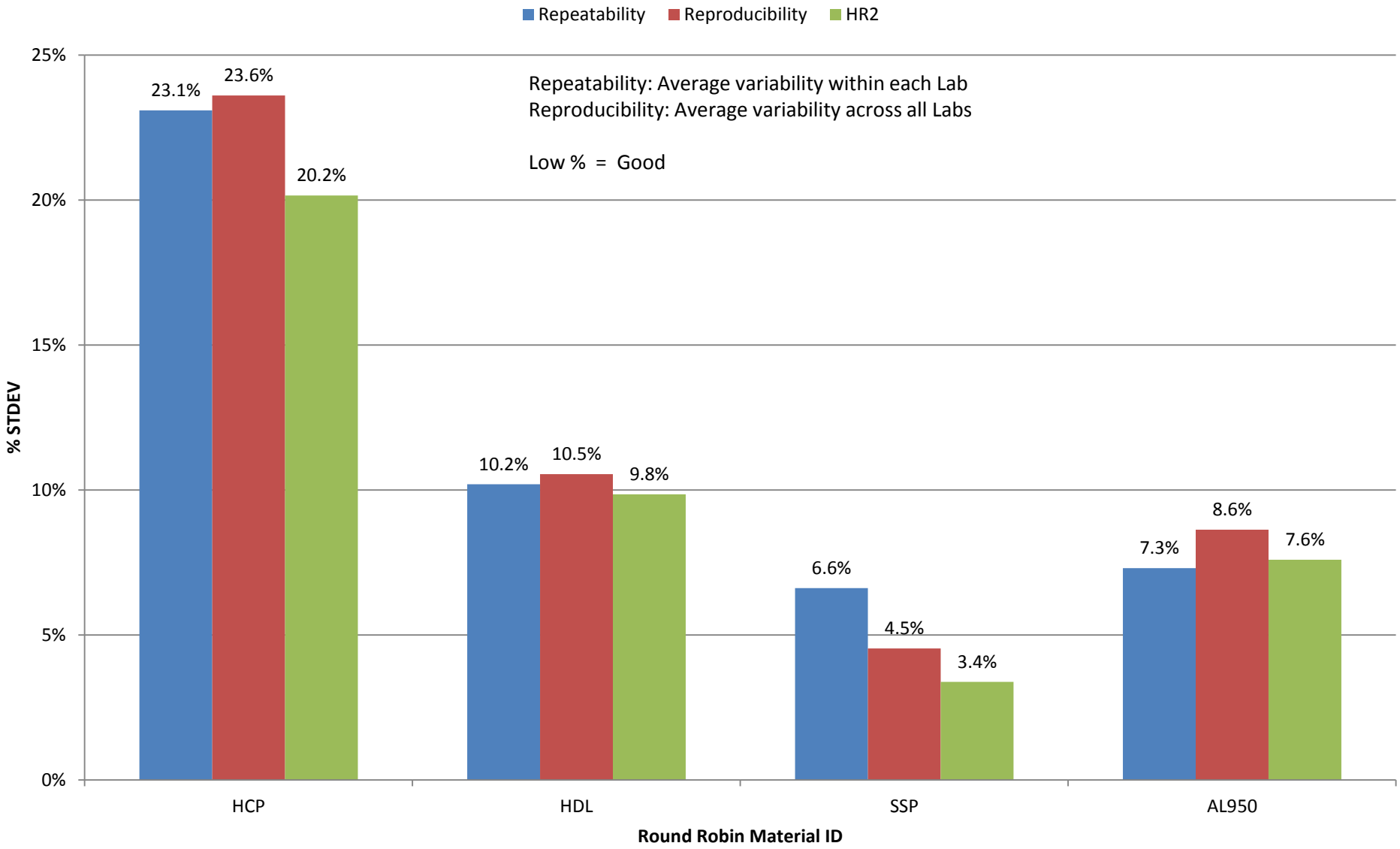
PEAK HEAT RELEASE RATE Z-SCORE (SORTED BY AVERAGE)



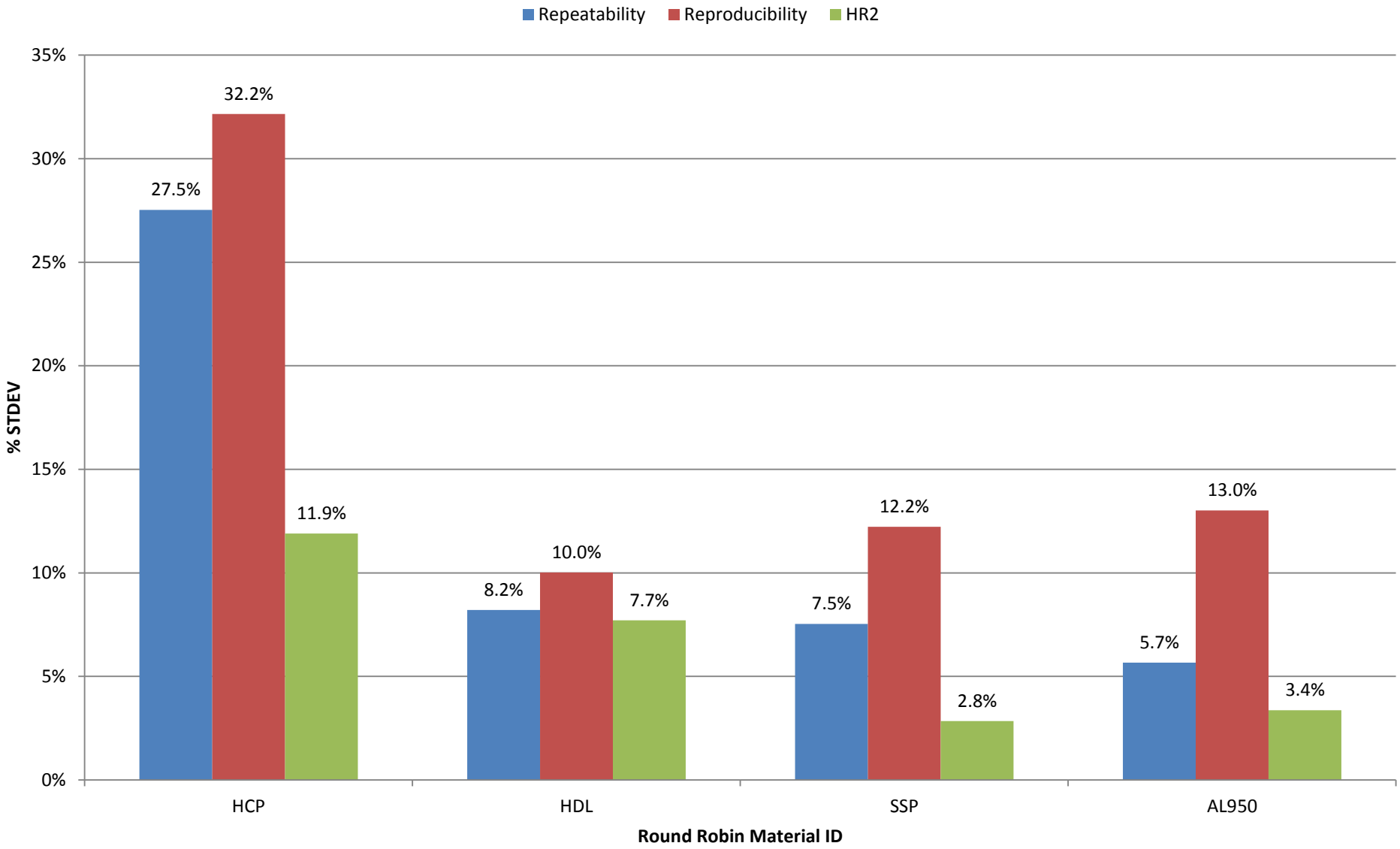
2-MINUTE TOTAL HEAT RELEASE Z-SCORE (SORTED BY AVERAGE)



PEAK HEAT RELEASE RATE VARIABILITY



2-MINUTE TOTAL HEAT RELEASE VARIABILITY



CONCLUSION

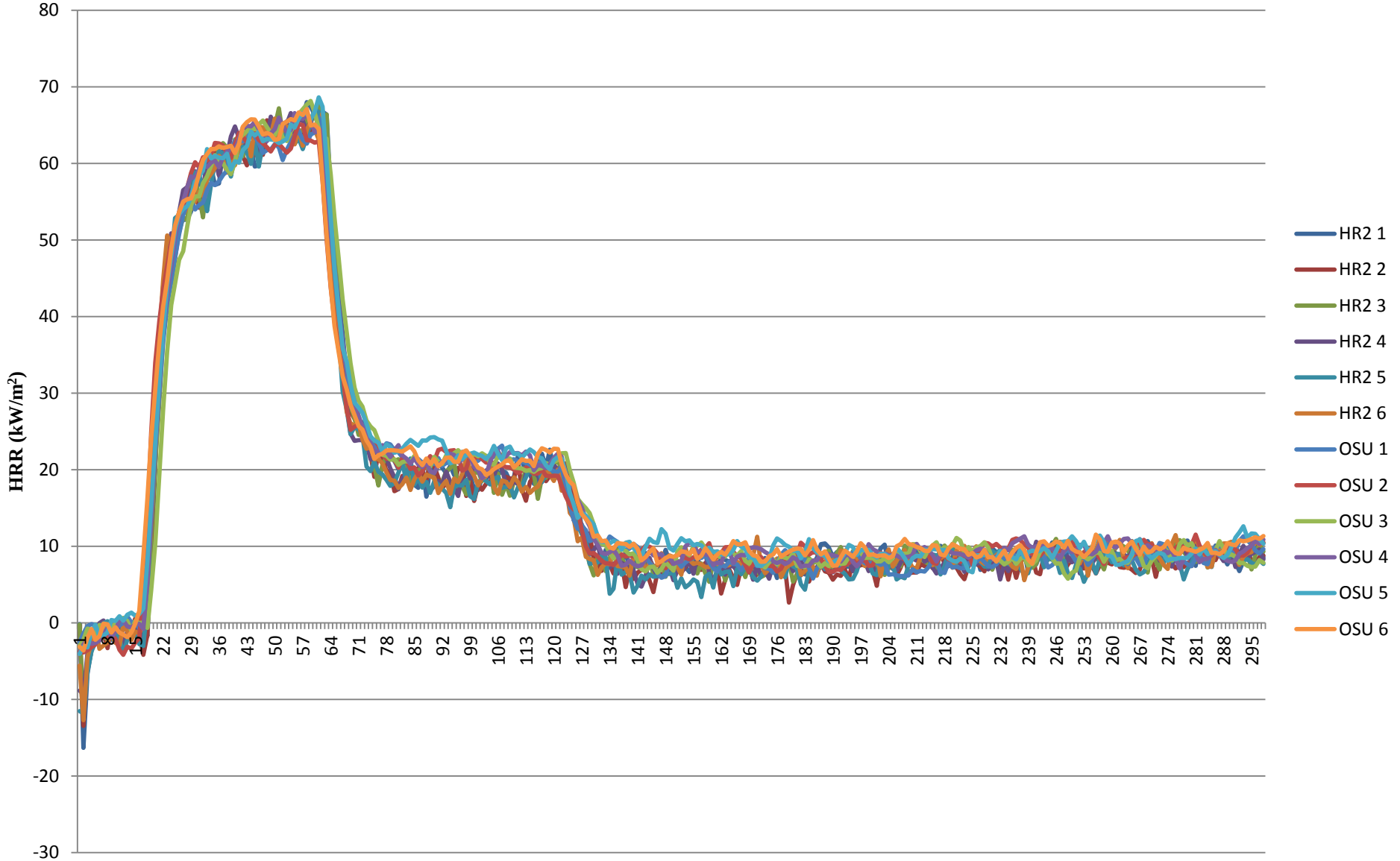
- HR2 Data (PHRR & THR) Fit well within the average of all machines tested
- Observed Improvement in Repeatability
- Reproducibility is still an unknown

MATERIAL SIMULATOR TEST

(Empty Sample Holder Inserted in Holding Chamber for 1 minute)

- START TEST
- 0:00:00 - Flow rate 1.5 L/min for 15 seconds
- 0:00:15 - Set flow rate to 4 L/min for 45 seconds
- 0:00:60 - Set flow rate to 2 L/min for 60 seconds
- 0:02:00 - Set flow rate to 1.5 L/min for 3 minutes
- 0:05:00 - End Test

Material Simulator Test Using a Mass Flow Meter (Methane Gas)



HR2 Simulator Test Data

OSU Simulator Test Data

RUN	PHRR	TTP	THR	PHRR	TTP	THR
1	68	57	65	66	64	64
2	66	57	63	65	59	65
3	68	60	64	68	62	64
4	67	59	65	67	58	65
5	67	59	63	69	64	66
6	67	61	64	67	61	65
AVG	**67**	**59**	**64**	**67**	**61**	**65**
STDEV	**0.6**	**1.6**	**0.8**	**1.3**	**2.5**	**0.8**
% STDEV	**0.9%**	**2.7%**	**1.2%**	**2.0%**	**4.1%**	**1.3%**

DOE Draft Test Plan Concept

- Randomize 4 main parameters
- Use Material Simulator Test to study impacts on data

Parameter	DESCRIPTION	Min.	Avg.	Max.
System Air Flow rates	SCFM	19	20	21
System Air Temperatures	°F	70	72.5	75
Heat Flux (W/cm^2)	Center	3.60	3.65	3.70
Upper Pilot	Air (L/min)	0.98	1.0	1.2
	Methane (L/min)	1.3	1.5	1.7

NEXT

- Complete DOE Test Plan
- Begin DOE Testing
- Possibly use the material simulator test on other OSU machines

Questions?