HEAT RELEASE RATE Updates

2014 October Materials Meeting
Atlantic City, NJ

Materials Working Group

Michael Burns, FAA Tech Center

October, 2014

Federal Aviation Administration

AGENDA

- OSU
  - OSU Airflow (Tech Center OSU)
  - 2013 - 2014 RR Data
  - Hybrid Burner Project (Upper Pilot)
- HR2 Update
- Next

Bypass Air MFM

Bypass Air Mixing Valve

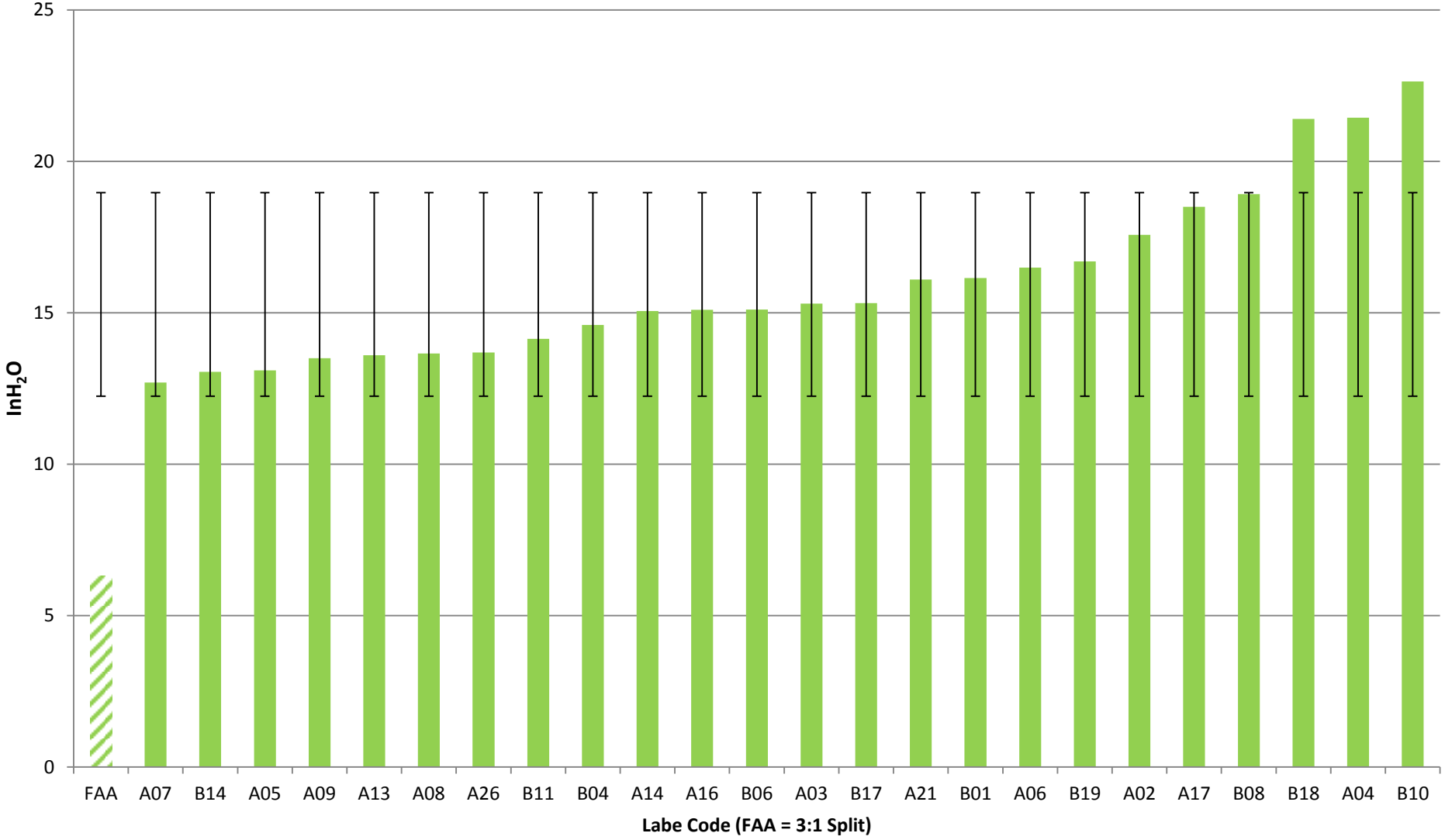
Chamber Air MFM

Orifice Meter

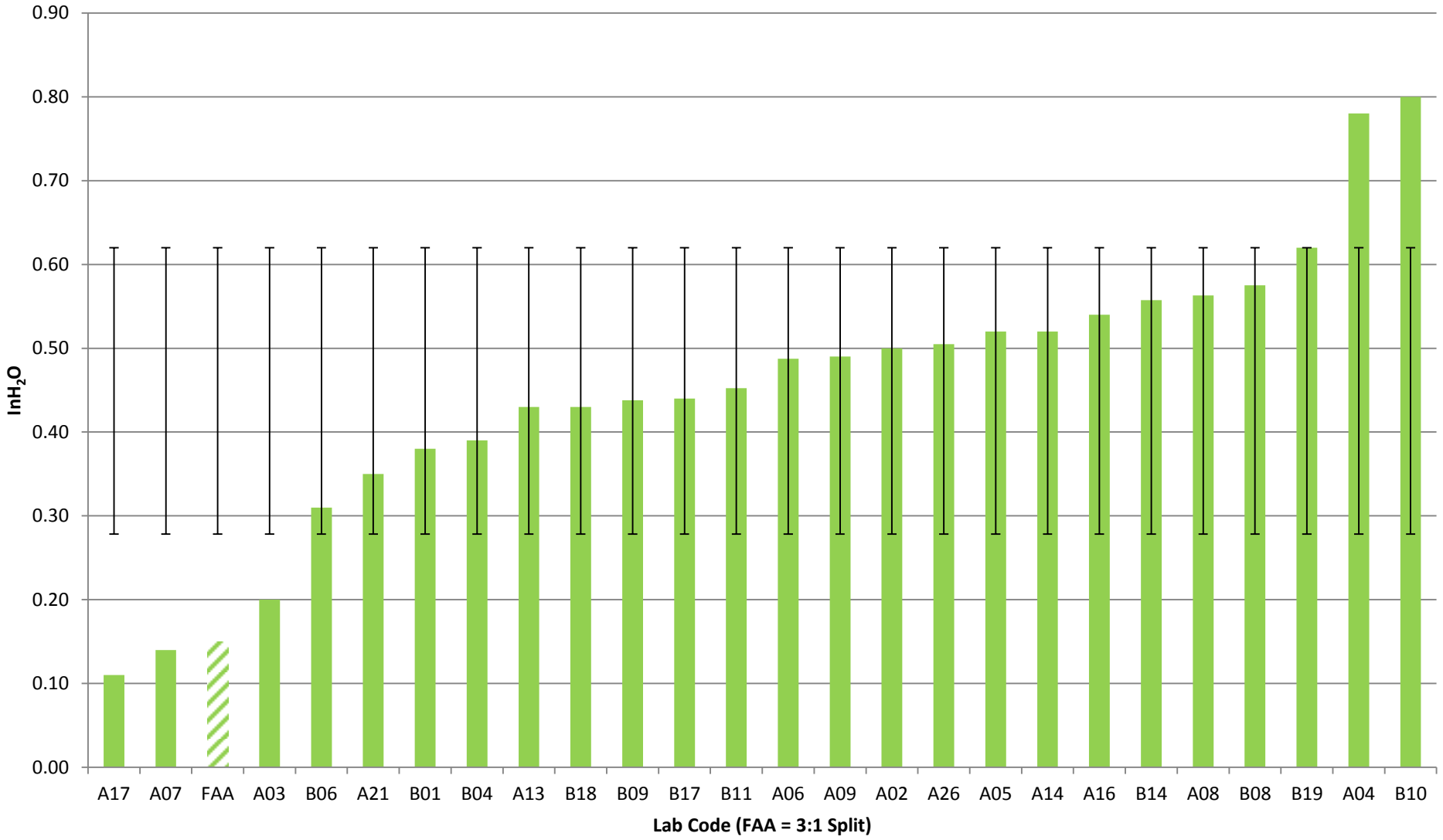
Chamber Air MFM

Description	Units	OSU Standard Configuration	OSU 75% / 25% Split
Inlet Air Temperature	℃	21.1	21.1
Inlet Air Pressure	mmHg	760	760
Bypass Flow	SCFM	54.4	63.75
Chamber Flow	SCFM	27.6	21.25
Calibration Factor	(kW/m^2) / mV	9.38	11.22
Interspace Pres.	InH_2O	0.53	0.15
Lower Plenum Pres.	InH_2O	16.9	6.3
Total Flow	SCFM	82	85
Ratio (Bypass / Chamber)	% Airflow Split	66% / 34% (2:1)	75% / 25% (3:1)
Orifice Meter Delta P	mmHg	200 (3.87 psid)	212 (4.1 psid)
Baseline mV (no flames)	mV	22.6	19.2

Lower Plenum Pressure
Mean: 15.6; Stdev: 3.4 (21.5%)



Interspace Pressure
Mean: 0.45; Stdev: 0.17 (38%)



Description		Units	OSU (Standard Configuration)	OSU (75/25 Split)
Calibration Factor		(kW/m^2) / mV	9.38	11.22
1 Liter Setpoint	Flow	L/min	0.98	1.0
	Voltage	mV	26.0	23.2
4 Liter Setpoint	Flow	L/min	3.93	3.97
	Voltage	mV	33.0	29.36
1 Liter Setpoint	Flow	L/min	0.98	1.0
	Voltage	mV	25.7	22.6
6 Liter Setpoint	Flow	L/min	5.83	5.94
	Voltage	mV	37.2	32.8
1 Liter Setpoint	Flow	L/min	0.98	1.0
	Voltage	mV	25.9	21.7
8 Liter Setpoint	Flow	L/min	7.93	7.99
	Voltage	mV	42.3	35.5
1 Liter Setpoint	Flow	L/min	0.98	1.0
	Voltage	mV	26.2	21.9
6 Liter Setpoint	Flow	L/min	5.83	5.94
	Voltage	mV	37.3	31.4
1 Liter Setpoint	Flow	L/min	0.98	1.0
	Voltage	mV	26.0	21.7
4 Liter Setpoint	Flow	L/min	3.93	3.97
	Voltage	mV	33.0	27.4

2014 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

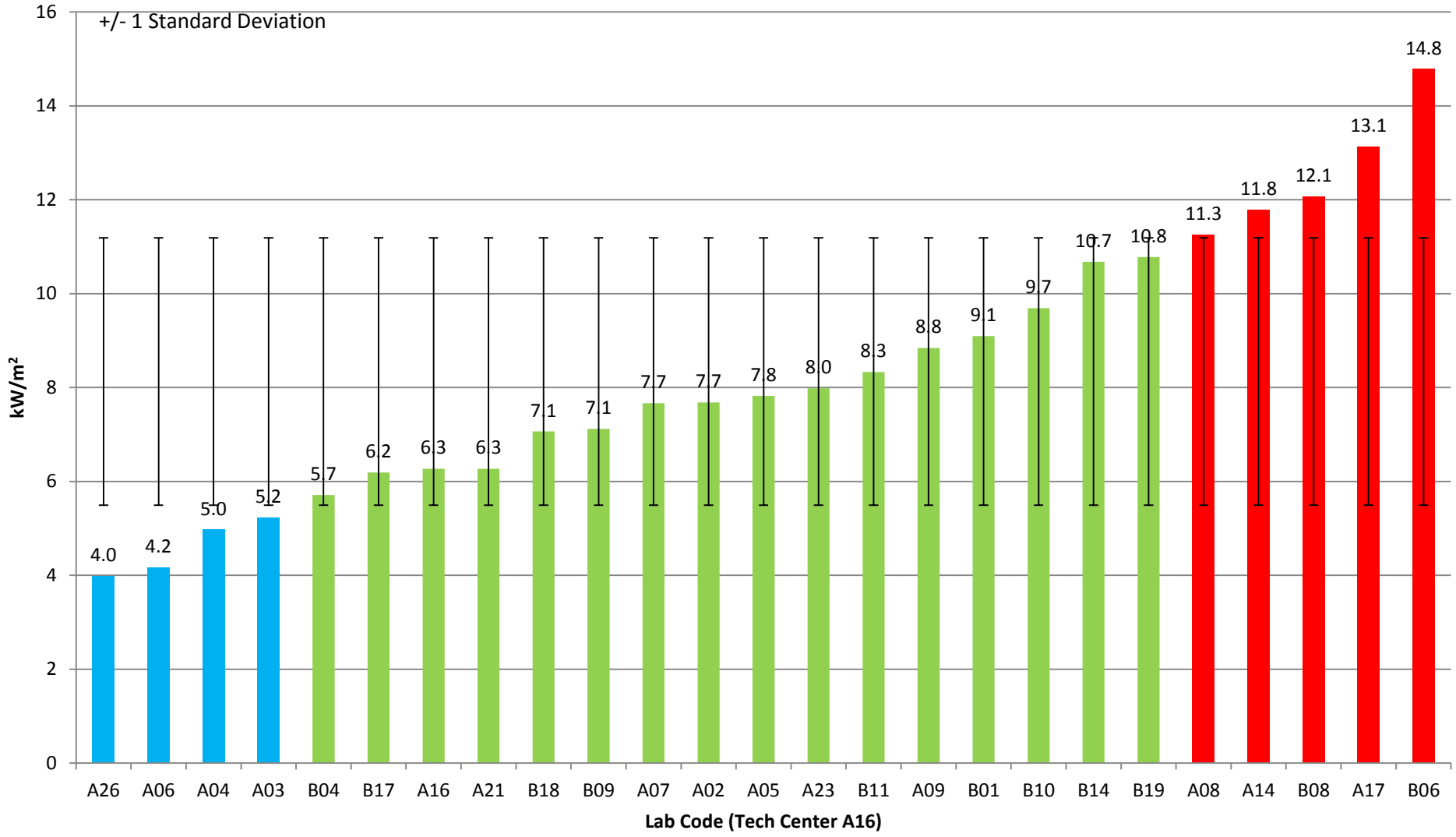
- The maximum allowable deviation
- Based on the Total number of labs

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

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

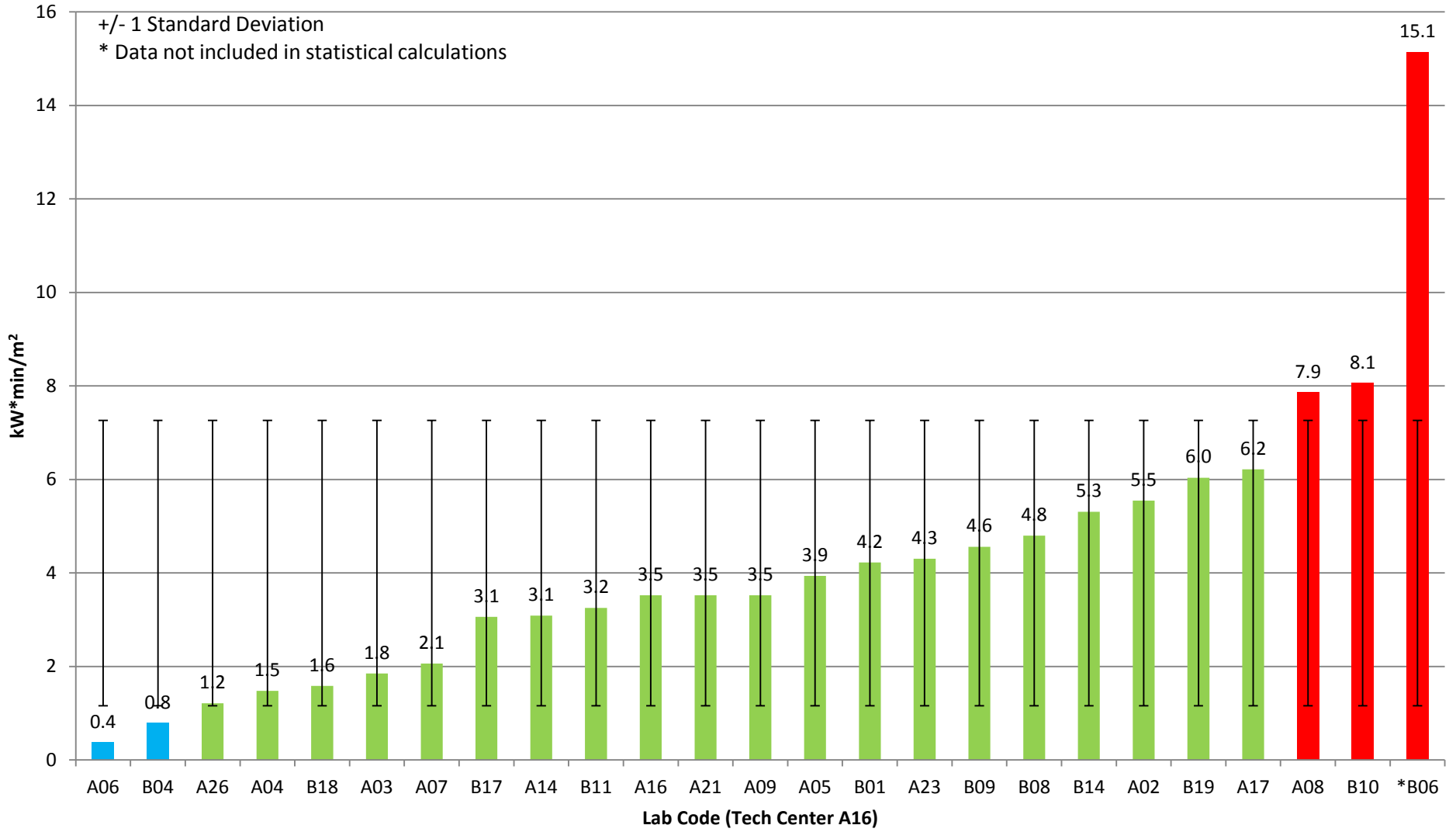
Baseline Peak Heat Release Rate

Population: 26; Valid Results: 26; Mean: 8.3; Stdev: 2.8 (34%)



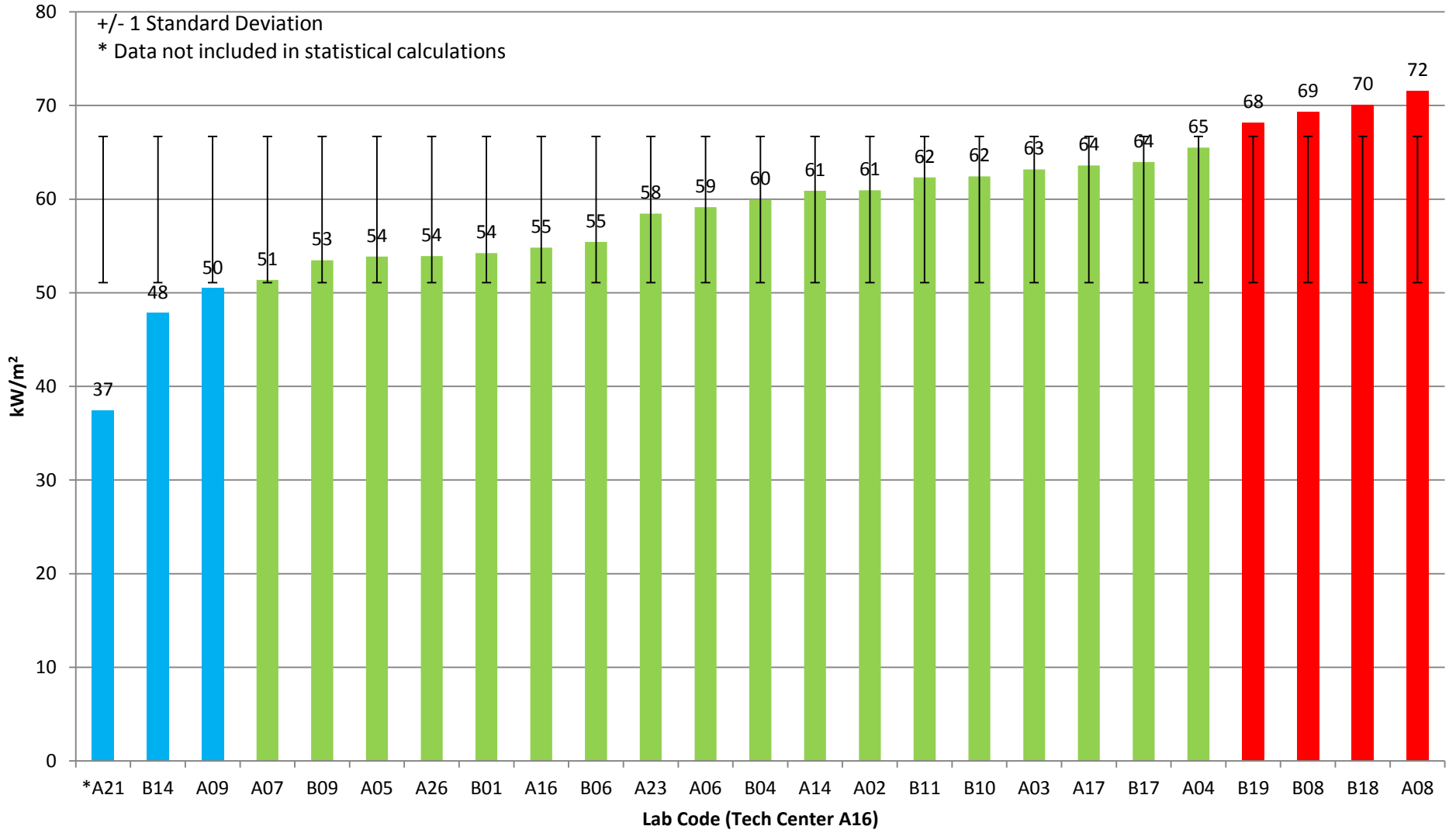
Baseline Total Heat Release

Population: 25; Valid Results: 24; Mean: 3.8; Stdev: 2.1 (55%)



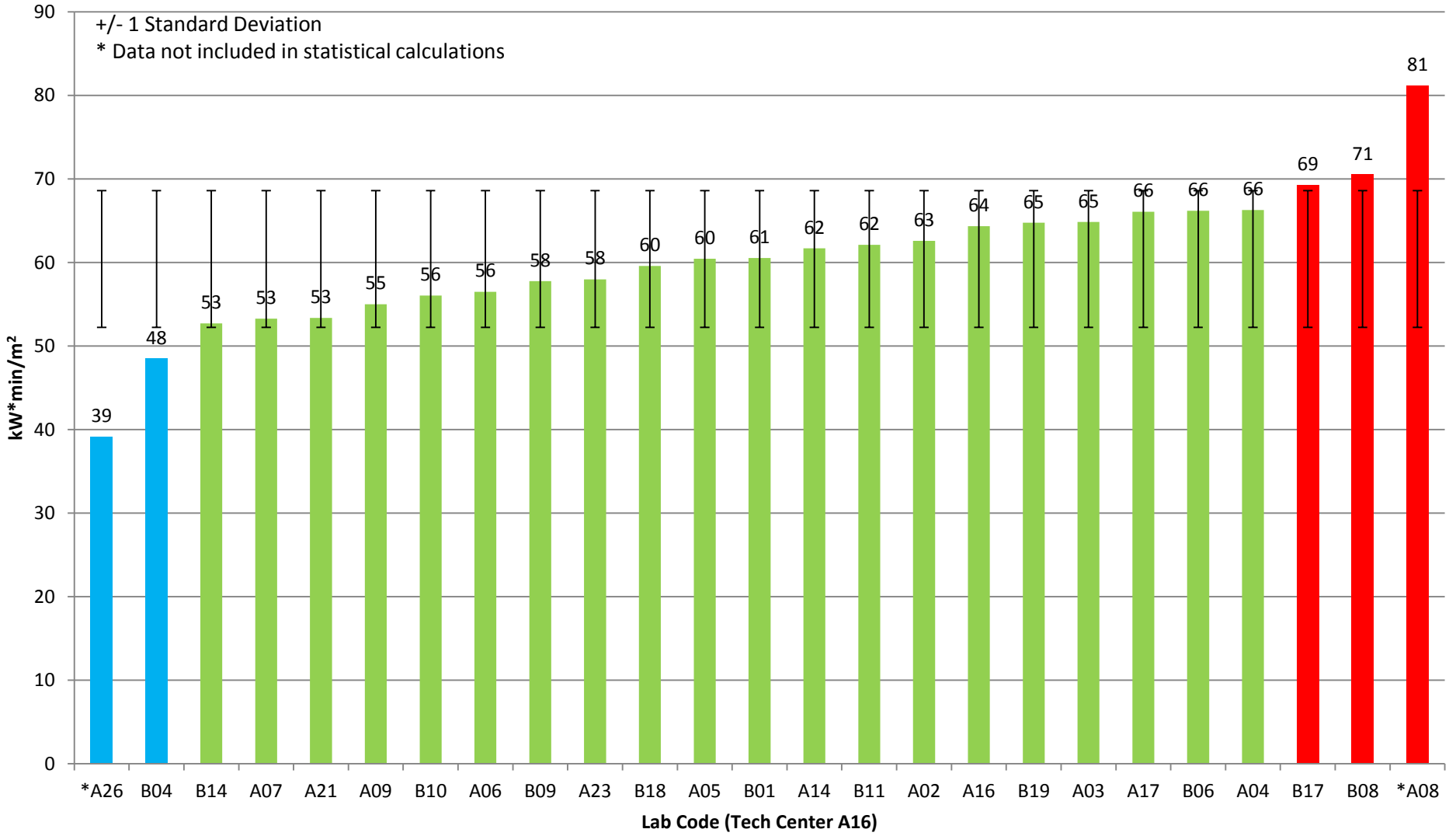
Sample #1 Peak Heat Release Rate

Population: 25; Valid Results: 24; Mean: 60; Stdev: 7 (11%)



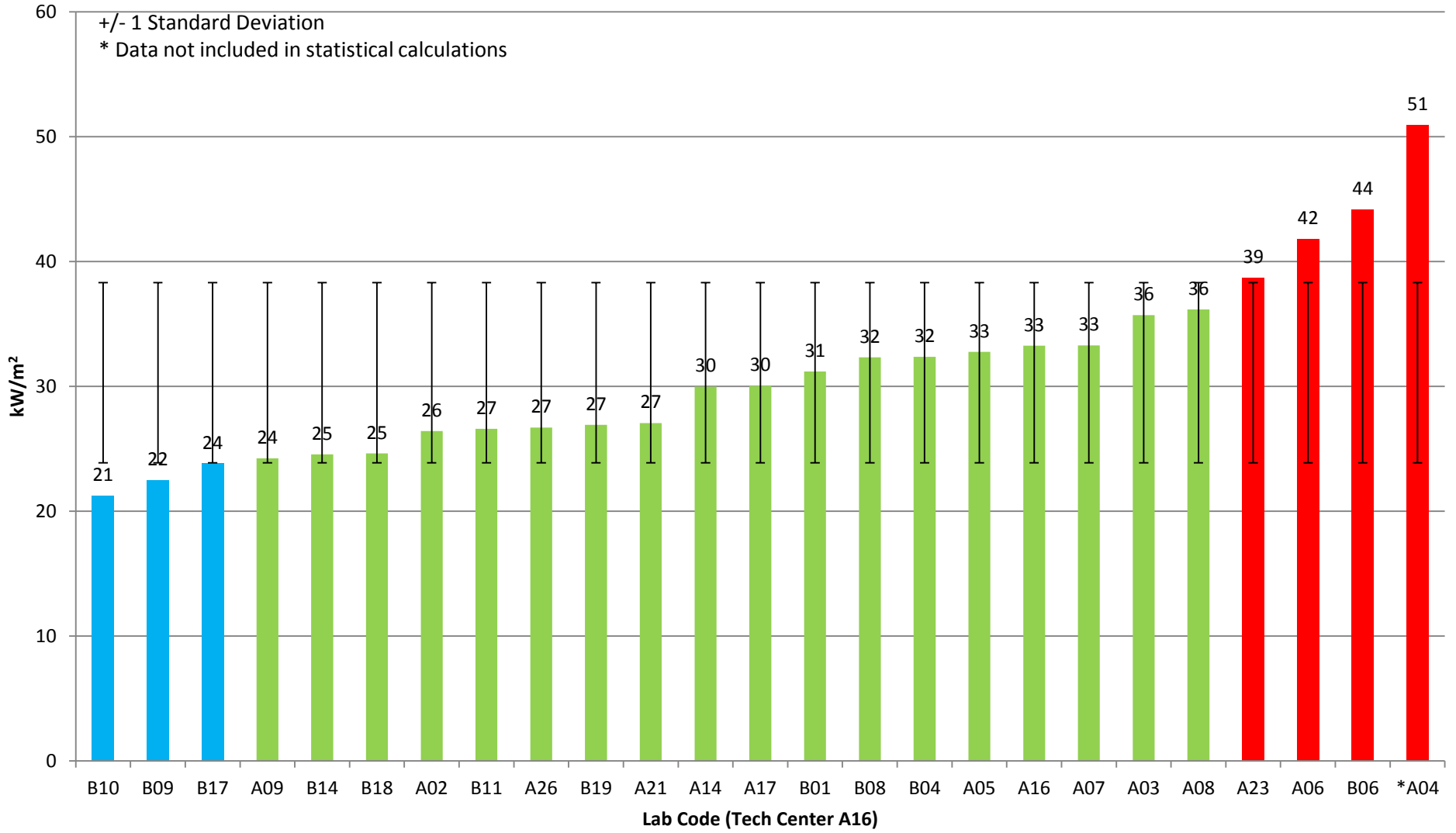
Sample #1 Total Heat Release

Population: 25; Valid Results: 23; Mean: 60; Stdev: 6 (9%)



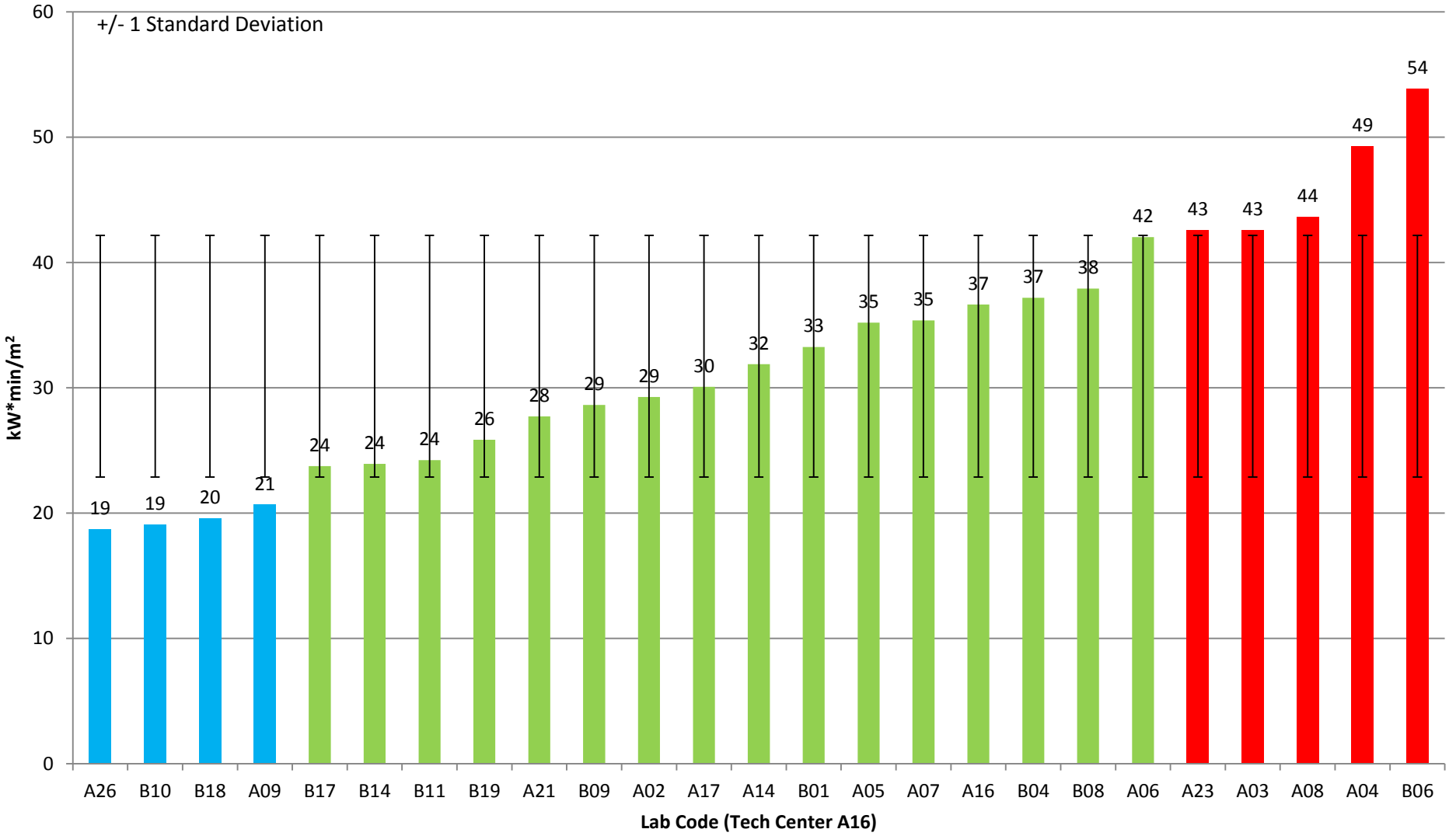
Sample #2 Peak Heat Release Rate

Population: 25; Valid Results: 24; Mean: 30; Stdev: 6 (20%)



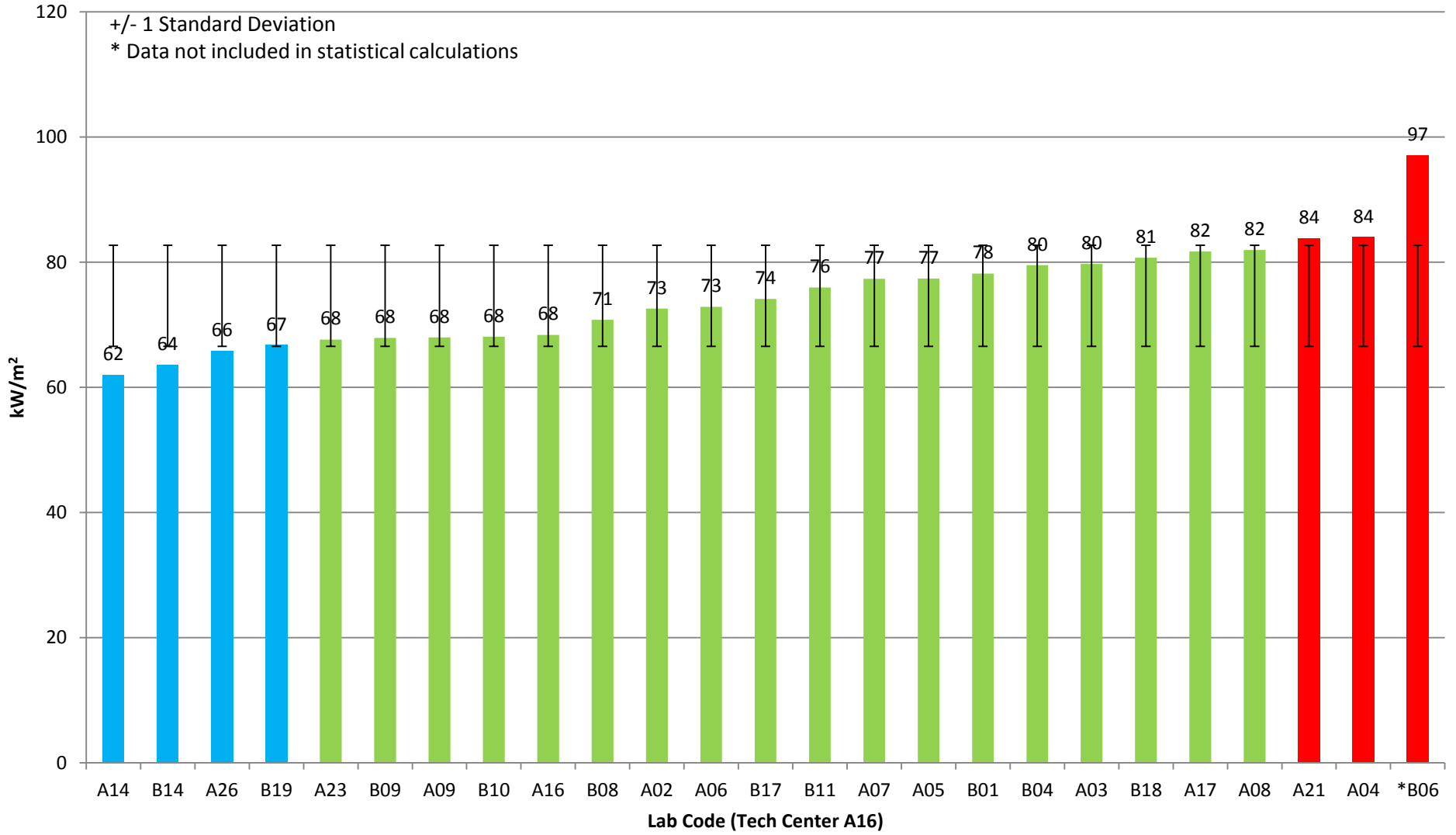
Sample #2 Total Heat Release

Population: 26; Valid Results: 26; Mean: 33; Stdev: 10 (30%)



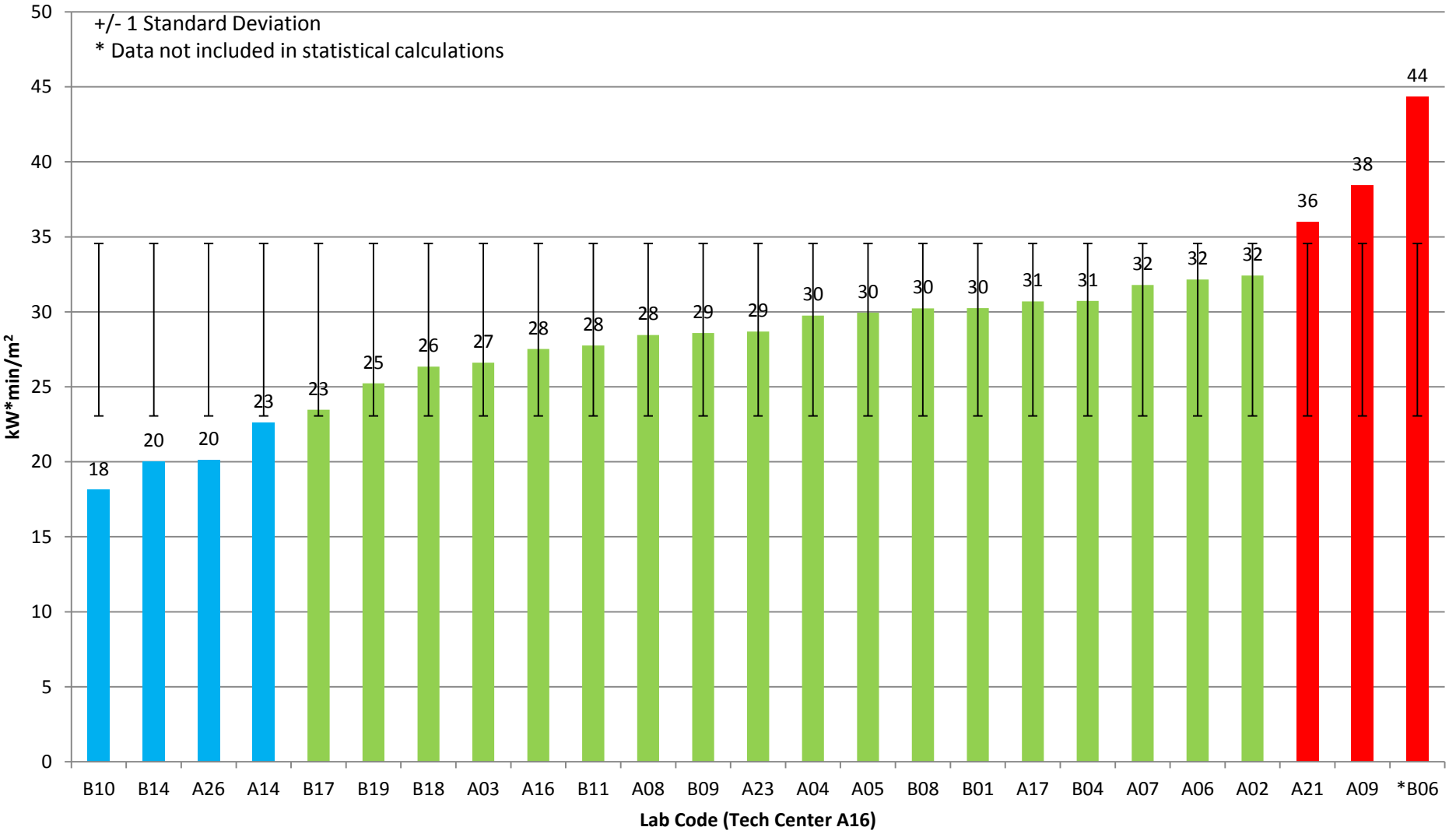
Sample #3 Peak Heat Release Rate

Population: 25; Valid Results: 24; Mean: 74; Stdev: 7 (9%)

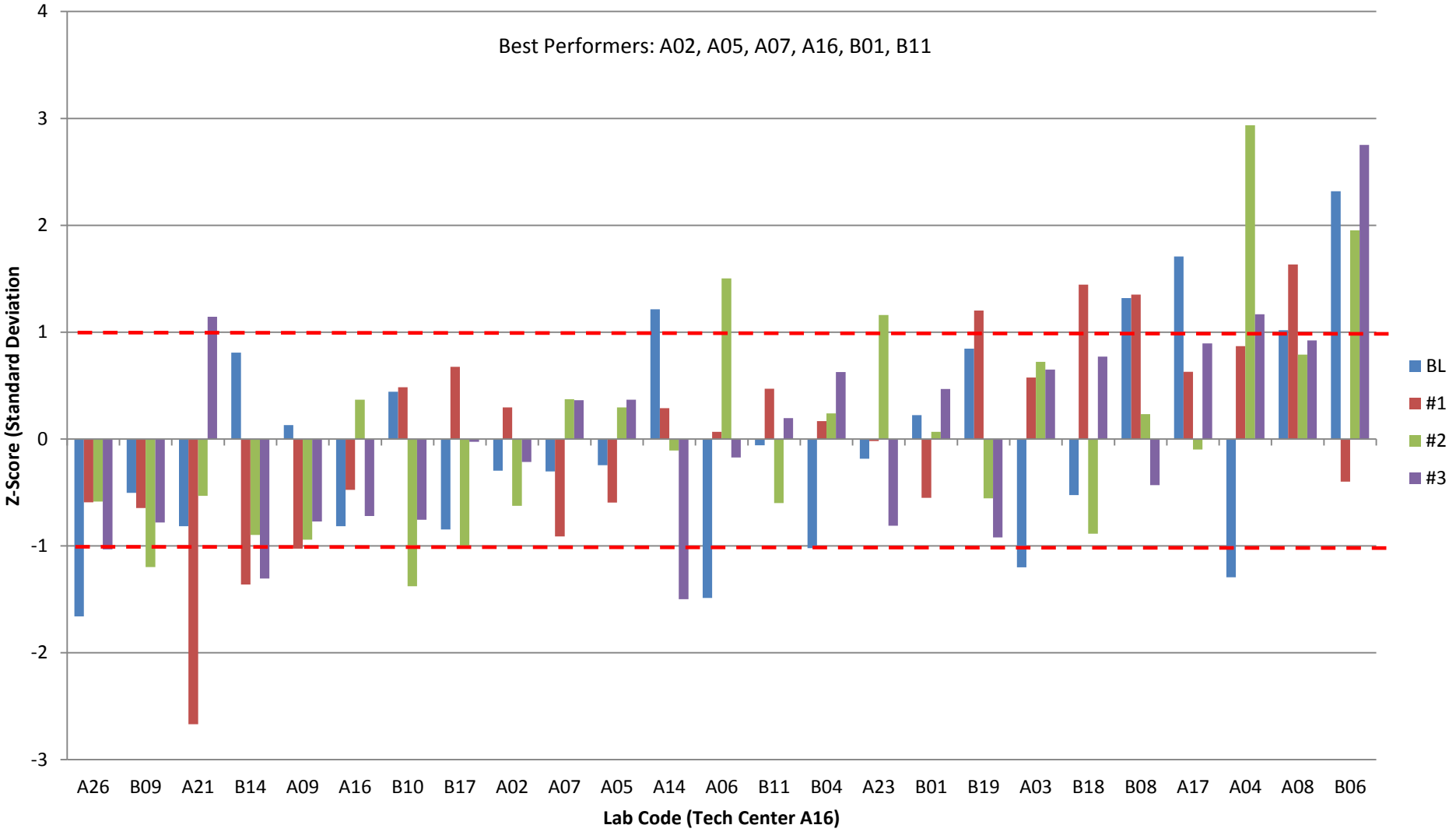


Sample #3 Total Heat Release

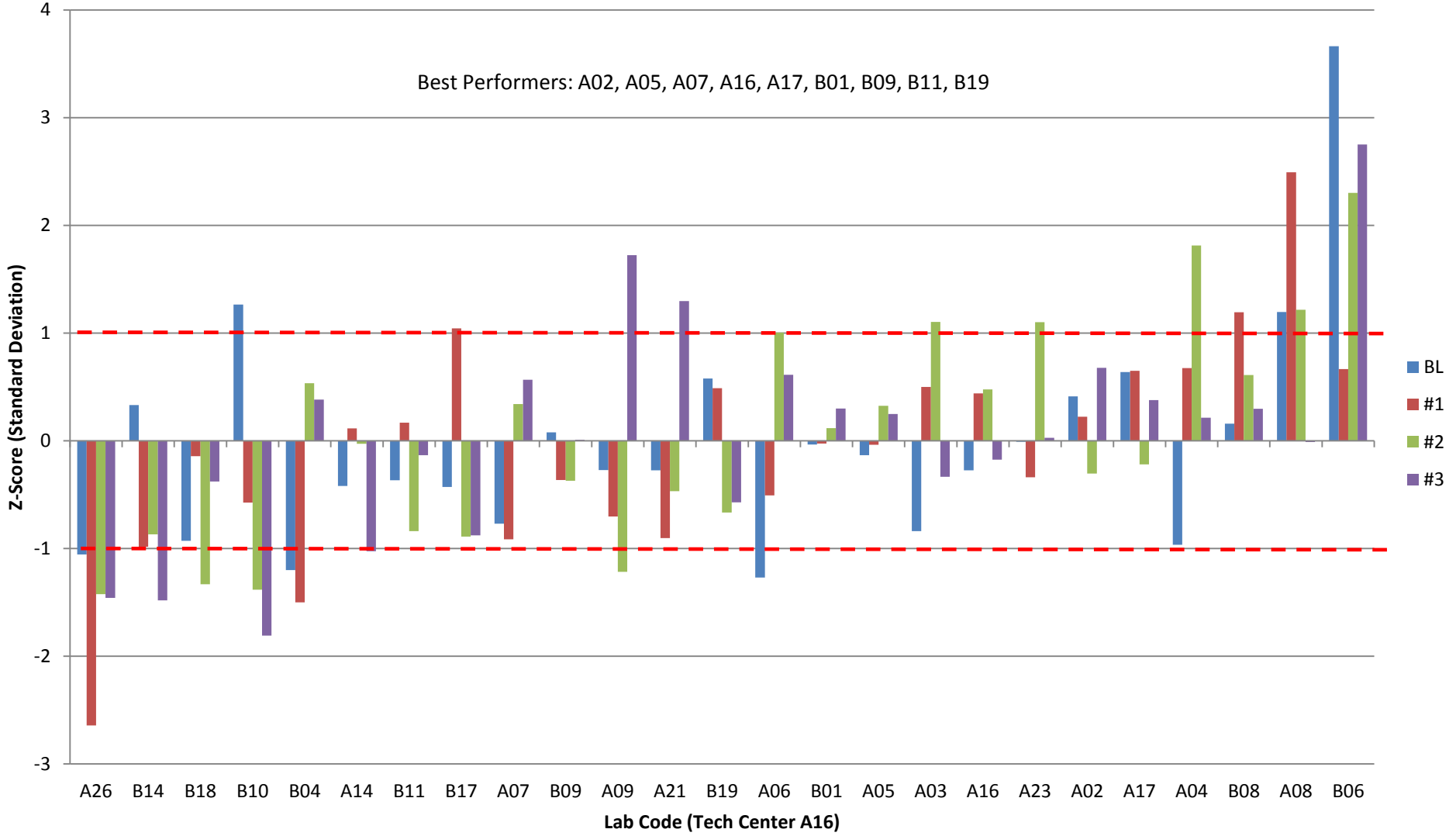
Population: 25; Valid Results: 24; Mean: 28; Stdev: 5 (17%)



Z-Score Summary for Peak Heat Release Rate
(The closer to zero the better)



Z-Score Summary for Total Heat Release
(The closer to zero the better)



HYBRID BURNER PROJECT

6 Participating Labs:

- Schneller, Inc. (USA)
- Herb Curry, Inc. (USA)
- Isovolta (USA)
- FAA Technical Center (USA)
- DGA (France)
- Aim Composites (England)

HYBRID BURNER PROJECT

SCOPE

- 1/8” steel rod positioned 5/8” from the upper pilot burner flamelet holes (3/4” from centerline of burner tube to centerline of rod)
- Rod is continuously heated by the flamelets (heat sink)
- Auto-ignite upper pilot burner flamelets should they temporarily be impacted by the effects of off-gassing products

HYBRID BURNER PROJECT

PURPOSE

- Reduce variability within OSU heat release units with regard to the performance of the upper pilot burner.
- Support the potential use of this configuration in the new HR2 (next generation heat release rate apparatus).
- This project is for research purposes only to assess the performance of the Hybrid Burner configuration.
- Test plan intended to give participants a clear understanding of pre-test responsibilities, unit preparation and post-test instructions.

HYBRID BURNER PROJECT

SOME QUESTIONS TO BE ANSWERED

Does the Hybrid Burner Configuration:

- Have an impact on the 4-corner uniformity (specifically the upper 2 corners)?
- Have an impact on the Calibration Factor?
- Have an impact on Peak / 2-Minute Total heat release?
- Have an impact on baseline millivolt values (prior to testing)?

HYBRID BURNER PROJECT

SOME QUESTIONS TO BE ANSWERED (Cont'd)

Does the Hybrid Burner Configuration:

- Improve test results (repeatability / reproducibility)?
- Allow for more valid test results than the standard burner?
- Is the bracketry that supports the hot surface ignition (HSI) rod adequate? Better design to be considered?

HYBRID BURNER PROJECT

FAA Tech Center:	**Supply test coupons and equipment to participating labs**
	Generate lab codes for each participant
	Reduce, analyze and present consolidated data
Participating labs:	**Follow procedures to prepare unit**
	Conduct heat release testing with / without Hybrid Burner configuration
	Send RAW heat release data and record sheets to Tech Center

HYBRID BURNER PROJECT

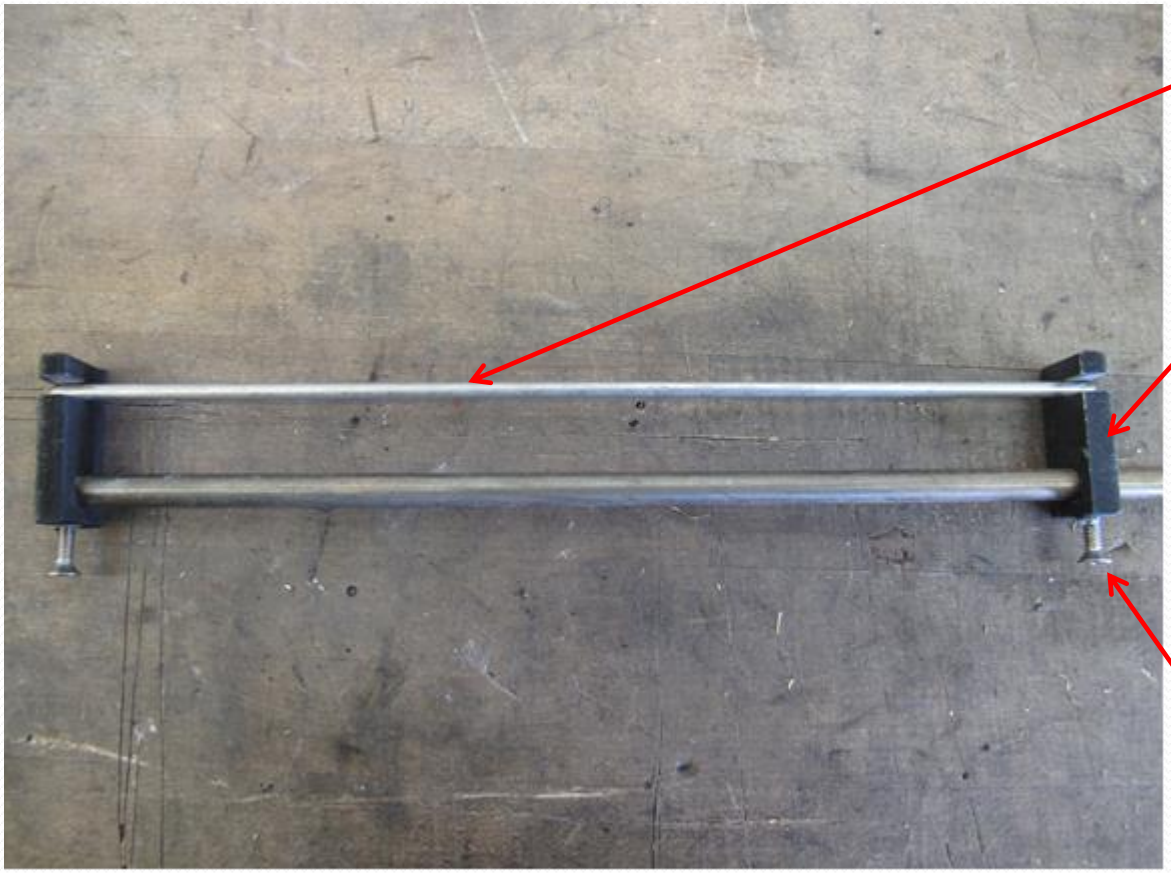
TEST COUPONS

- Test coupons per heat release requirements of FAR 25.853 Appendix F.
- Test all coupons provided.
- Condition coupons for 24 hours at 70 ± 3℉ and 50 ± 5 % humidity before testing.
- Test the “glossy side” of each specimen.
- No specific orientation for Samples A and C (Grey and Black material).
- Test Sample B in the vertical orientation (Wood Paneling material).

HYBRID BURNER PROJECT

THERMOPLASTIC TEST COUPONS (KYDEX)					
SAMPLE A		**SAMPLE B**		**SAMPLE C**	
STD. BURNER	HYBRID BURNER	STD. BURNER	HYBRID BURNER	STD. BURNER	HYBRID BURNER
5 COUNT	5 COUNT	5 COUNT	5 COUNT	5 COUNT	5 COUNT

HYBRID BURNER PROJECT



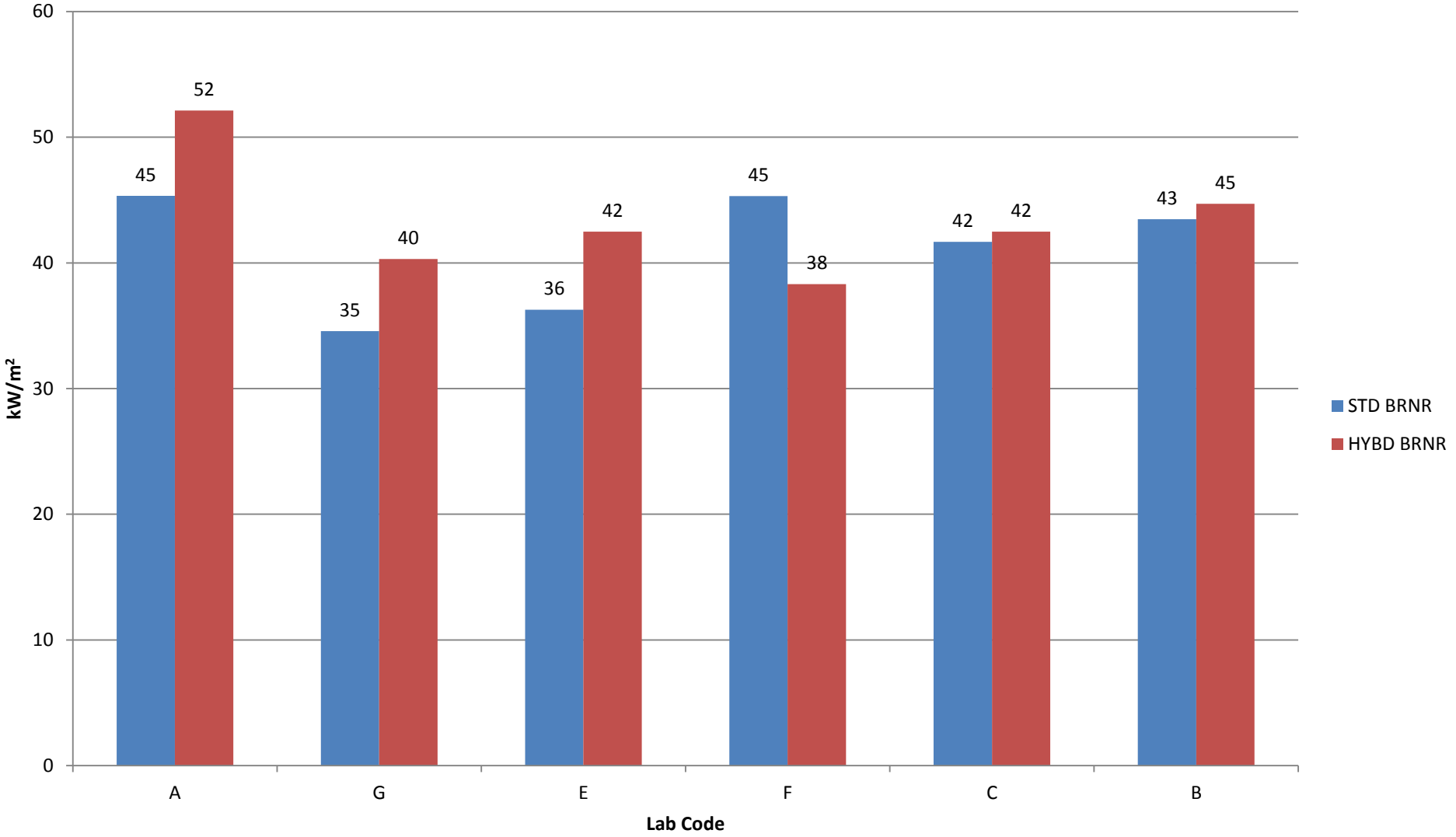
HYBRID BURNER PROJECT

Brackets angled slightly to position rod in flames

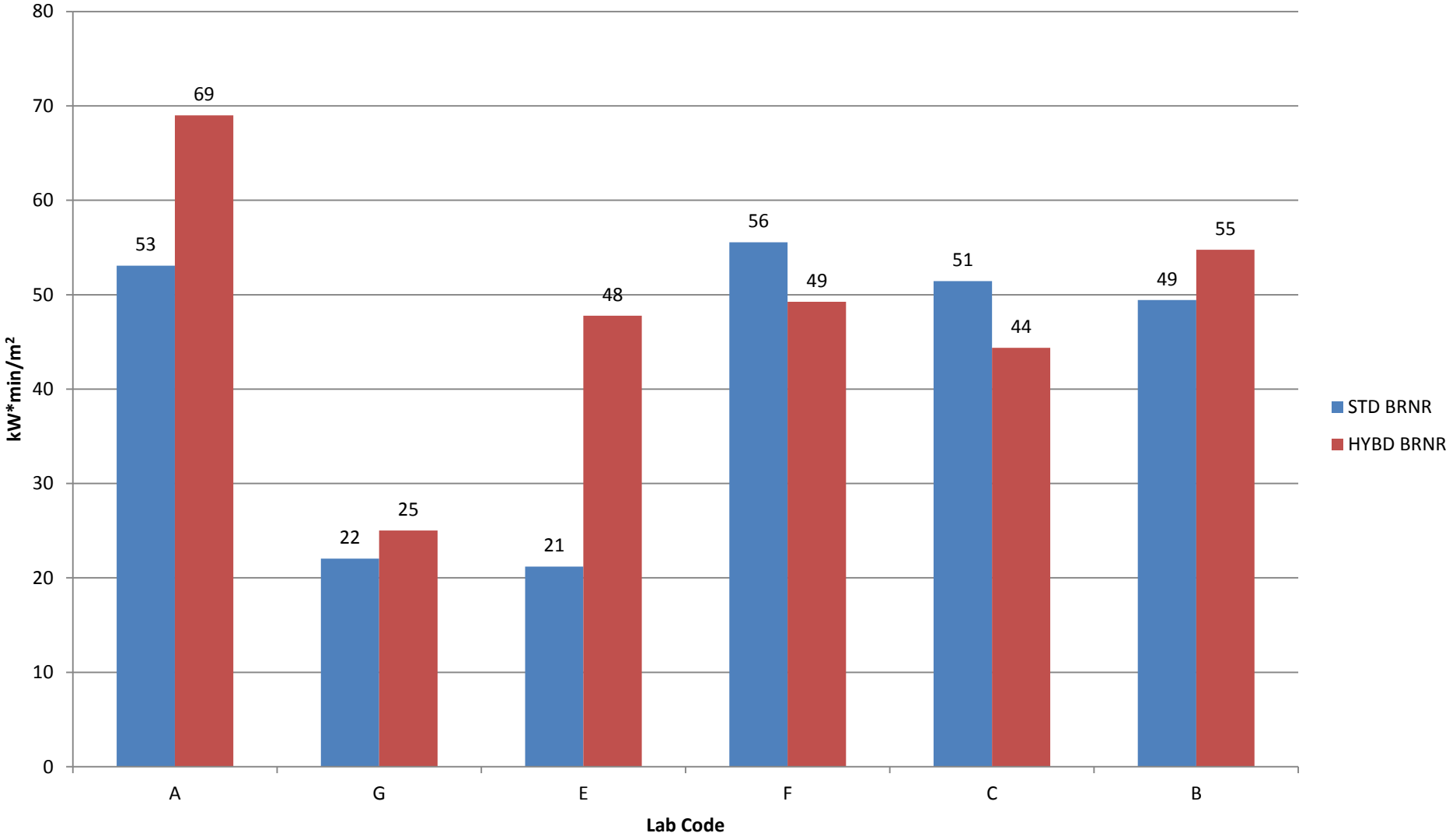
HYBRID BURNER PROJECT

PROCESS	
Standard Configuration	Clean / Prep Unit
	Set Heat Flux
	Verify 4-Corner Uniformity
	Determine Calibration Constant (Thermopile)
	Conduct Testing
Hybrid Configuration	Clean / Prep Unit
	Install Brackets / Rod
	Set Heat Flux
	Verify 4-Corner Uniformity (No Adjustments)
	Determine Calibration Constant (Thermopile)
	Repeat Testing

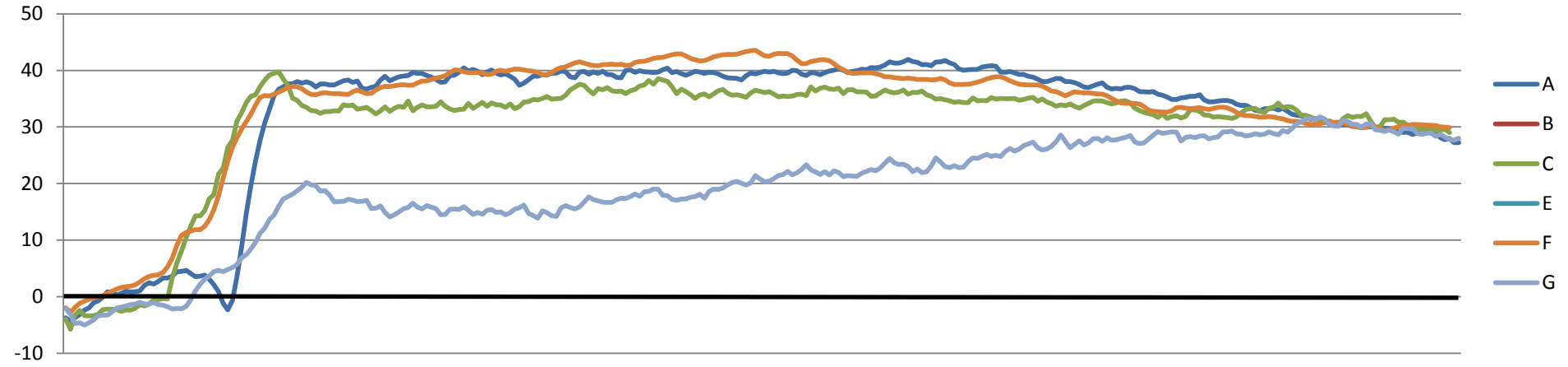
Sample A (Peak Heat Release Rate)
STD: 16% / HYBD: 13% (Avg. % STDEV)



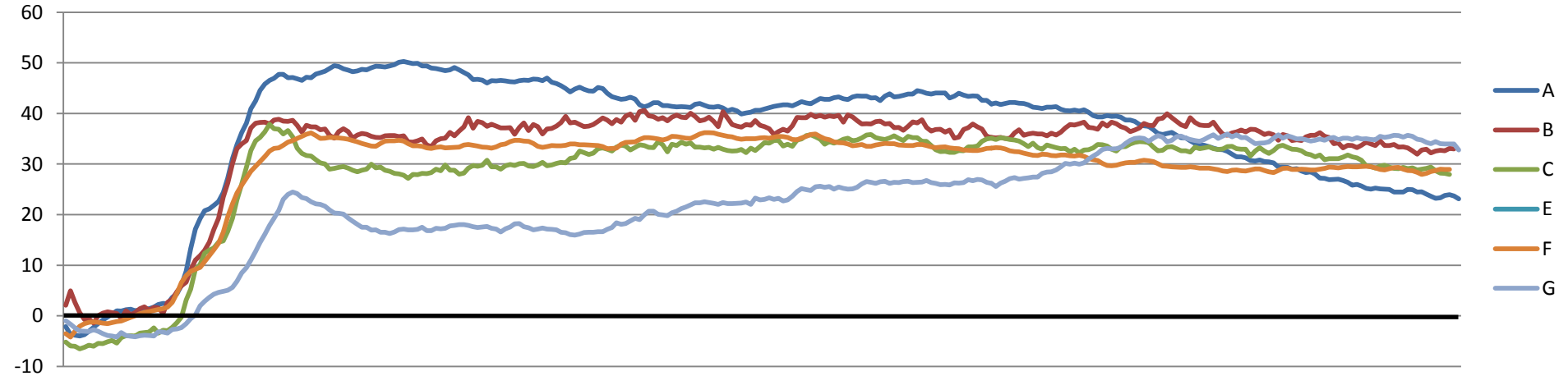
Sample A (2-Min Total Heat Release)
STD: 25% / HYBD: 19% (Avg. % STDEV)



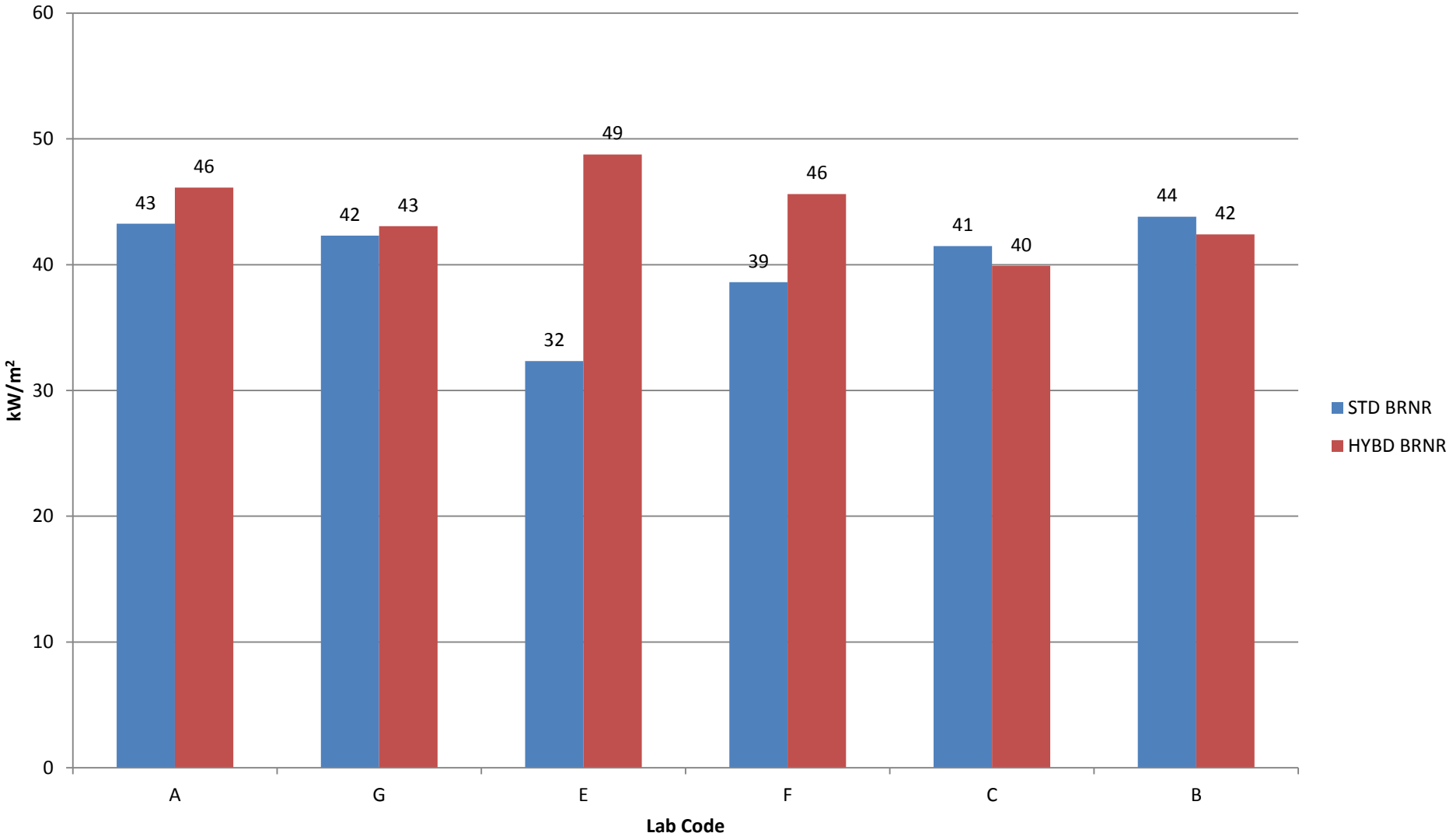
Sample A (STD)
Valid Test Results: 18/30 (60%)



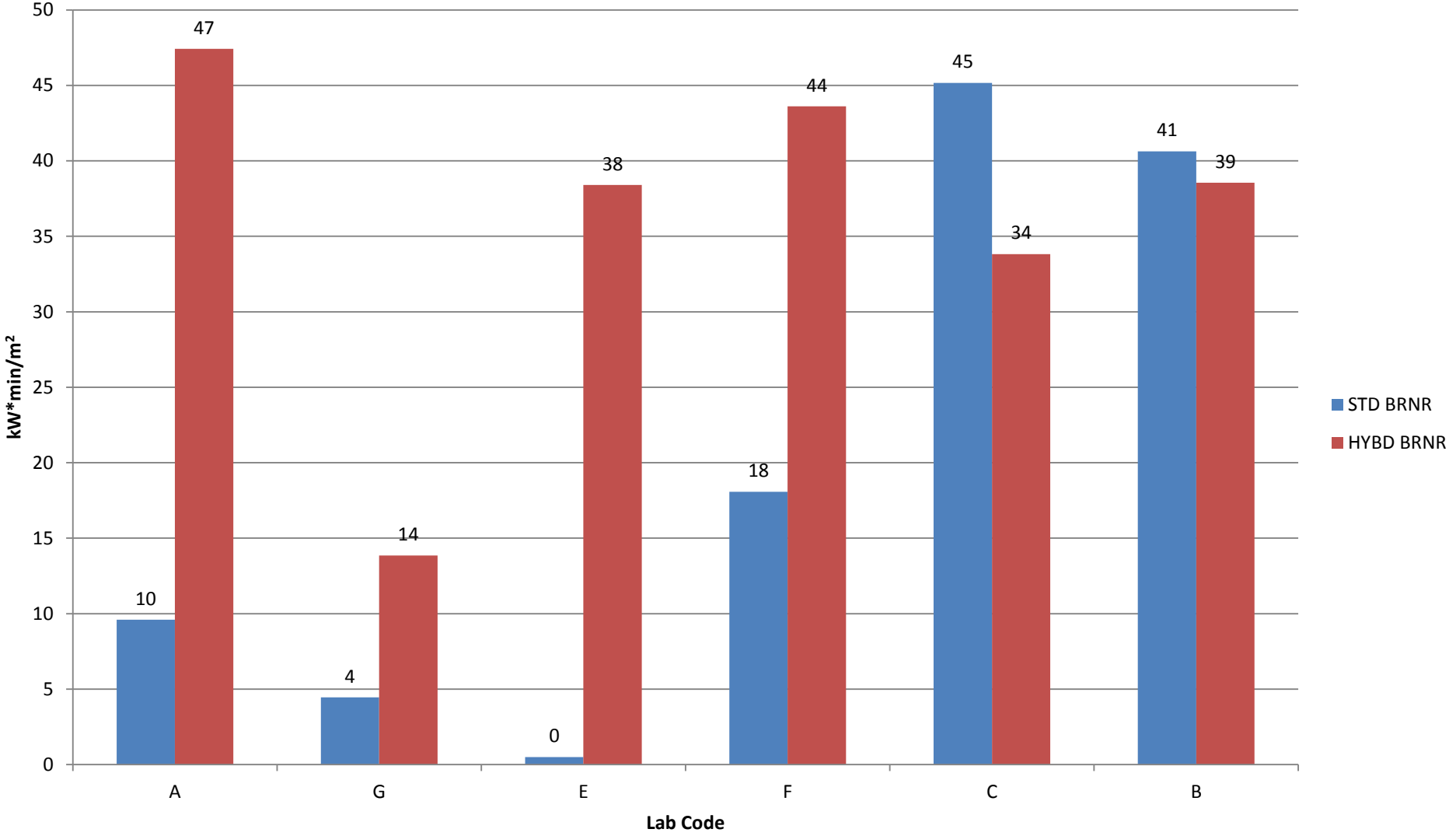
Sample A (HYBD)
Valid Test Results: 29/30 (97%)



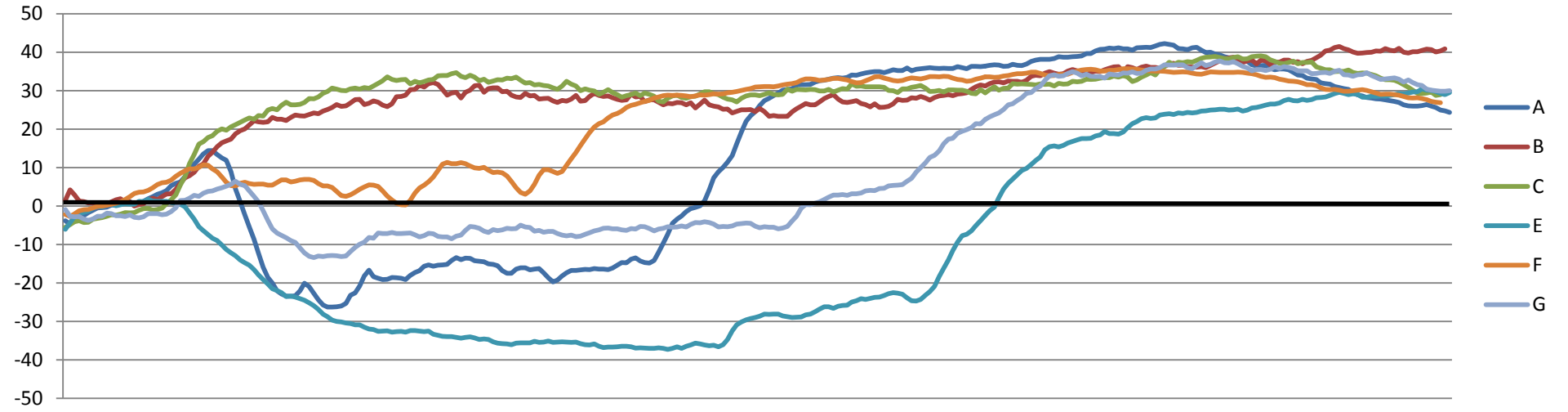
Sample B (Peak Heat Release Rate)
STD: 12% / HYBD: 14% (Avg. % STDEV)



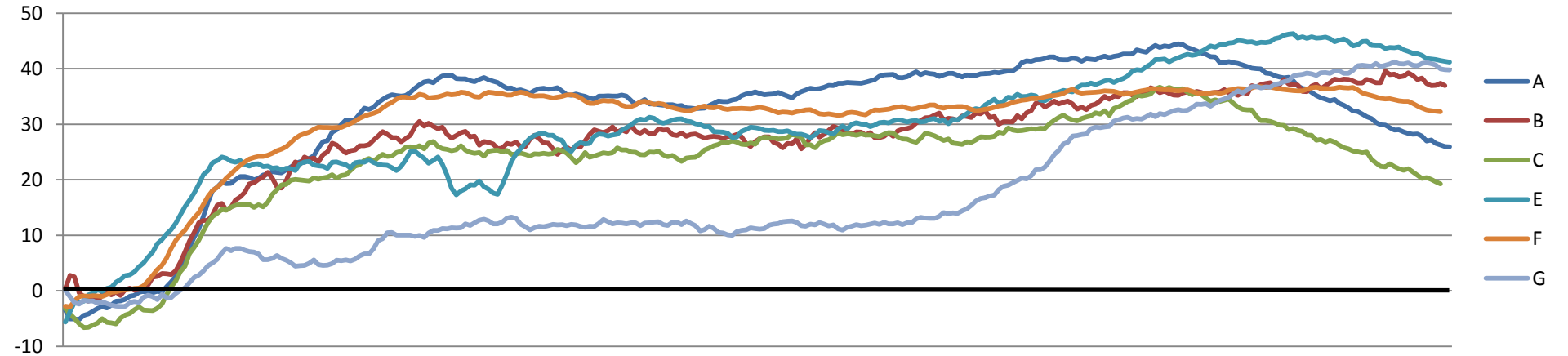
Sample B (2-Min Total Heat Release)
STD: 58% / HYBD: 15% (Avg. % STDEV)



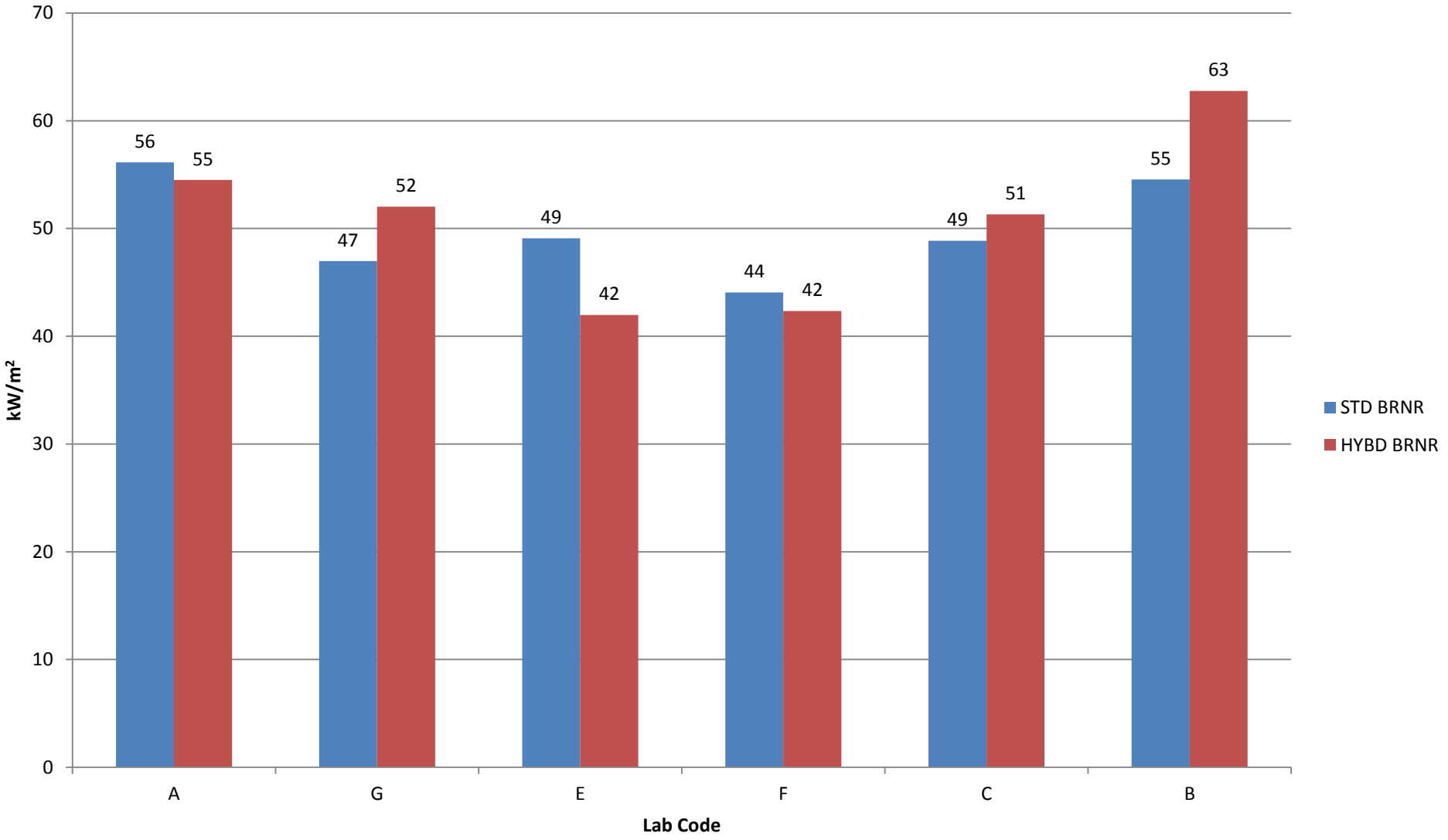
Sample B (STD)
Valid Test Results: 10/30 (33%)



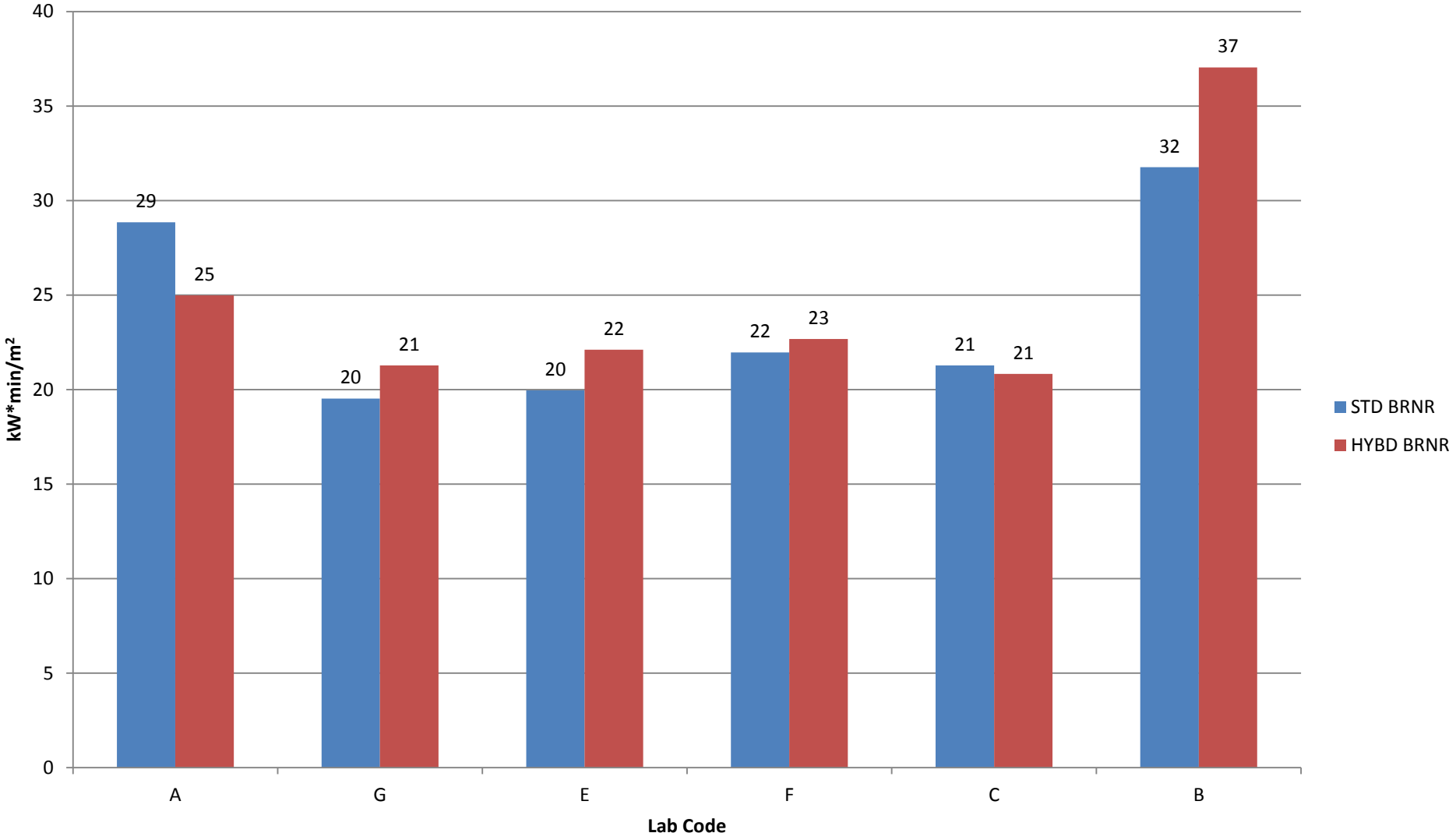
Sample B (HYBD)
Valid Test Results: 26/30 (87%)



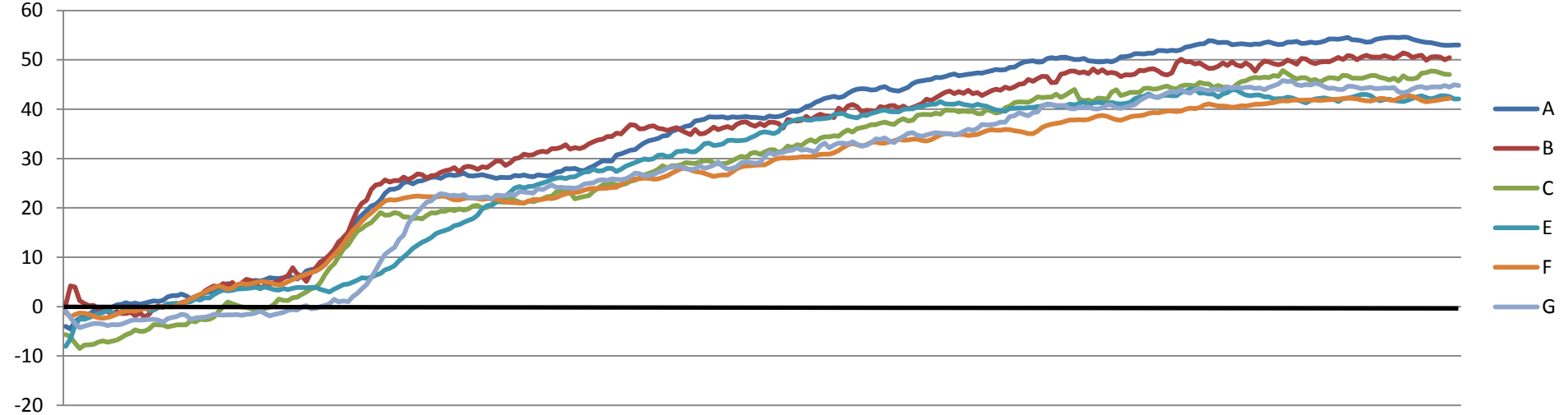
Sample C (Peak Heat Release Rate)
STD: 10% / HYBD: 13% (Avg. % STDEV)



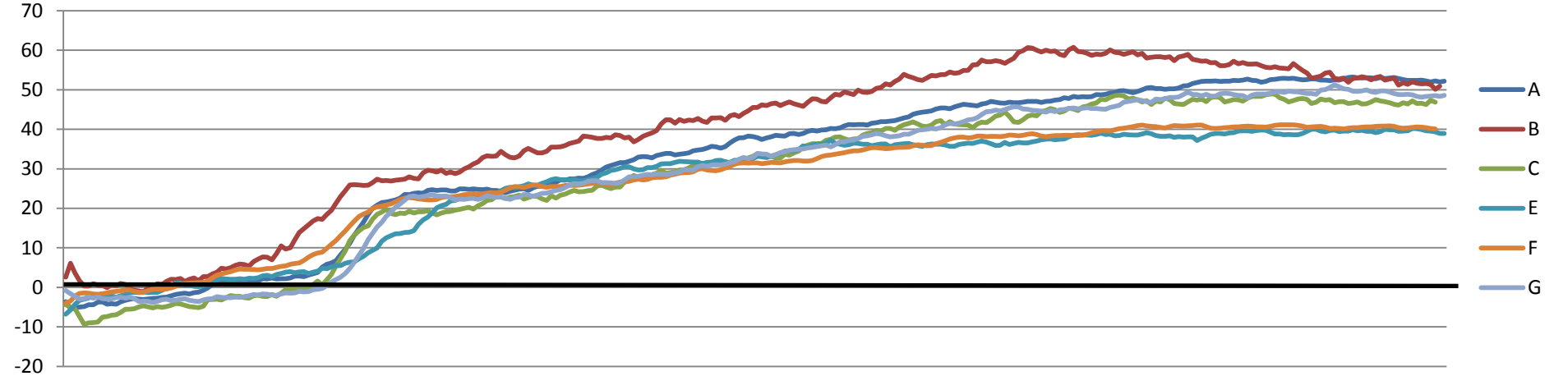
Sample C (2-Min Total Heat Release)
STD: 13% / HYBD: 8% (Avg. % STDEV)



Sample C (STD)
Valid Test Results: 29/30 (97%)



Sample C (HYBD)
Valid Test Results: 30/30 (100%)



HYBRID BURNER PROJECT SUMMARY

- Easy to install
- Minimal impact to calibration factor, uniformity and baseline mV values
- For FR off-gassing materials:
  - PHRR minimally impacted
  - Measurable differences observed in THRs
- Improvement in number of valid test results

HR2 UPDATE

NEXT

- Hybrid Burner
  - Is the bracketry supporting the hot surface ignition (HSI) rod adequate?
  - Better design to be considered?
- HR2
  - Startup Testing
  - OSU Comparative Testing

QUESTIONS?

Which vehicle is spelled the same forwards and backwards?

Answer: Racecar