An Extended Study into the Comparison of the Carlin and Sonic Burner

Presented by: Olivia McAvoy (Resonate Testing)

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Premise

- To evaluate the equivalency between the Carlin and Sonic burners in terms of calibration and performance using a powerplant calibrated flame
  - Aluminium strip burn through testing with Carlin and Sonic burners
  - Flame temperature and heat flux calibrations
  - Fuel flow checks

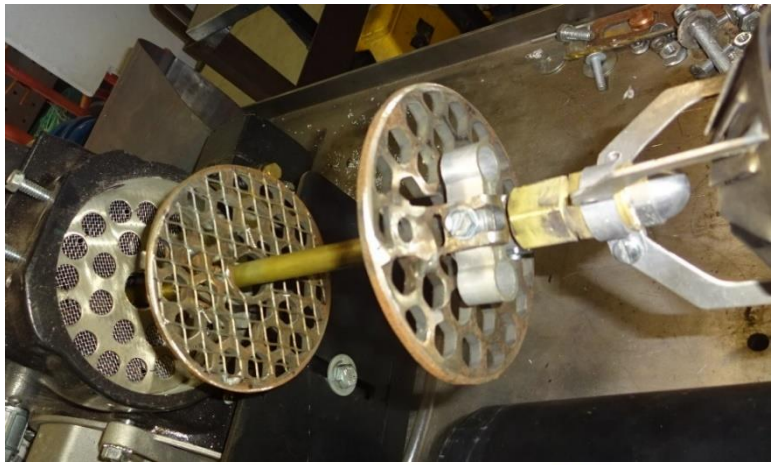
- Consider the addition of turbulator adjustment/rotation, introduced by Resonate Testing, in the Resonate Sonic MOD 3burner and review its influence in terms of calibration and performance

- Investigate how repeatable the Carlin and Sonic burners are over several years

- Can Resonate Testing directly replicate Sonic burner calibrations provided by the FAA?

Carlin 200 CRD

Engineering report 3A



Acceptable Modified Burners:

CARLIN 200 CRD, manufactured by the Carlin Company, 912 Silas Deane Highway, Wethersfield, Connecticut 06109, shown in figures 5 and 6, was modified in the following manner to produce a diffused 6-inch (vertical) by 11-inch (horizontal) sized flame with homogeneous temperature gradiant. Note: Carlin 200 CRD AS 1055 incorporates these following modifications and may be purchased directly.

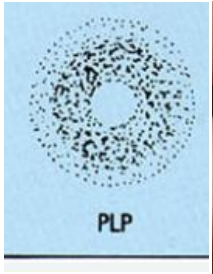
1. An 80 fuel nozzle rated at 2.25 gal/hr. and pressure adjusted to deliver 2.04 gal/hr. at 97 psig was installed.

2. The retention and throttle rings plus the support and forward extension were removed.

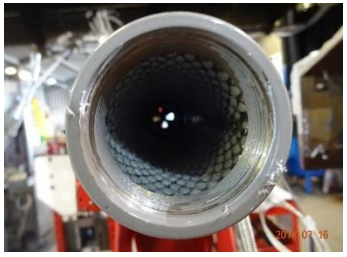
3. A flat-plate disc, approximately 4 inches in diameter and randomly punched with ten 1/2-inch holes, was installed 4 inches aft of the fuel nozzle tip. This provided support and centering of the oil delivery tube.

Sonic Burner Modification – Configuration 3

Monarch 80°PLP 2.25 GPH
– semi solid pattern



Muffler foam was removed



Added Carlin type turbulator on fuel nozzle fitting

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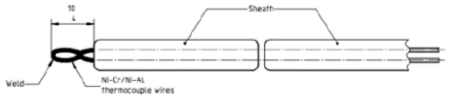
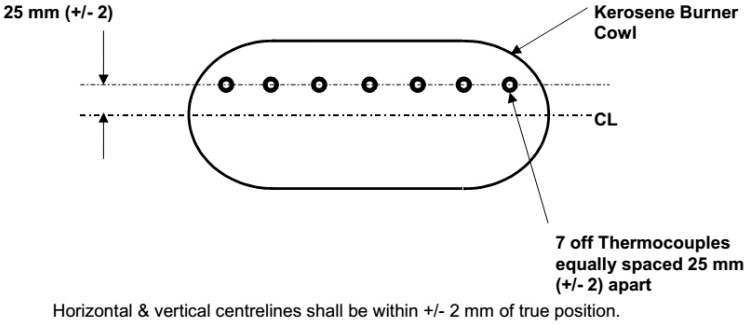
TC Rake – Temperature Calibration



NOTES
1 The diameter of the thermocouple wire shall be between 0,6 mm and 1 mm.
2 If a metal sheath is used, the maximum diameter shall not exceed 3 mm.
3 The thermocouple shall be unshielded and non-aspirated.

Figure B.1 — Details of thermocouple



Horizontal & vertical centrelines shall be within +/- 2 mm of true position.

- 7 type K thermocouples
- 1-inch apart (25mm)
- 1-inch above centreline
- 4-inches away from cone
- 3mm external sheath
- 4-6mm exposed tip
- 24 AWG (0.5mm) wire

Compliant with BS EN 60584.1 Pt4 Class 1

375°C to 1000°C
$\pm 0.004 \cdot |t| \rightarrow \pm 40°C$

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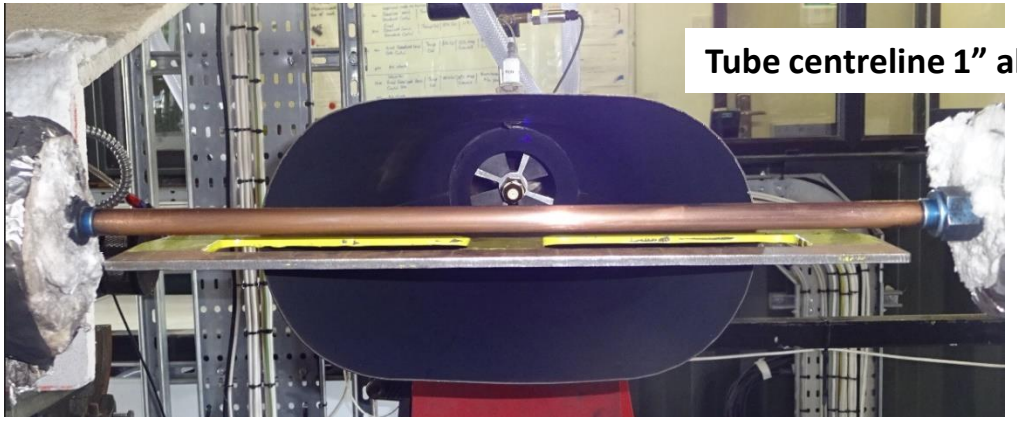
Copper Tube – Heat flux Calibration



Tube centreline 1” above burner cone centreline

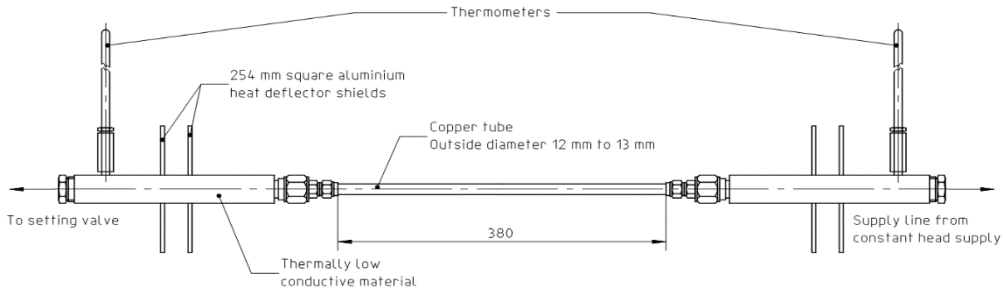
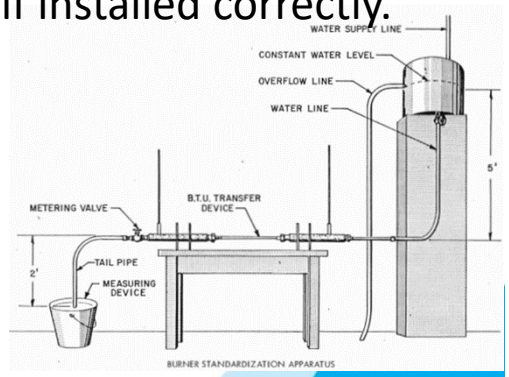


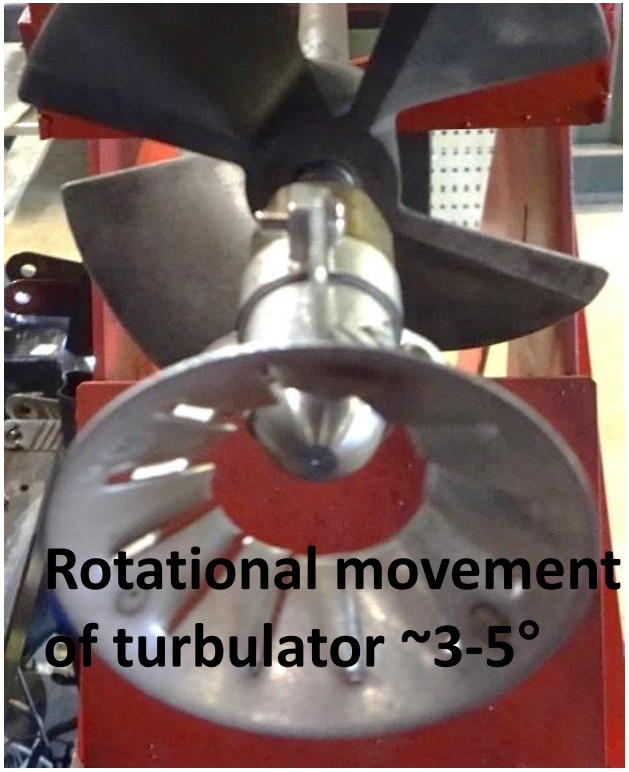
Figure B.4 — Overall view of the mounting of the standard heat flux density measuring tube

RTD’s for temp measurement offer a better solution than Glass bulb thermometers if installed correctly.

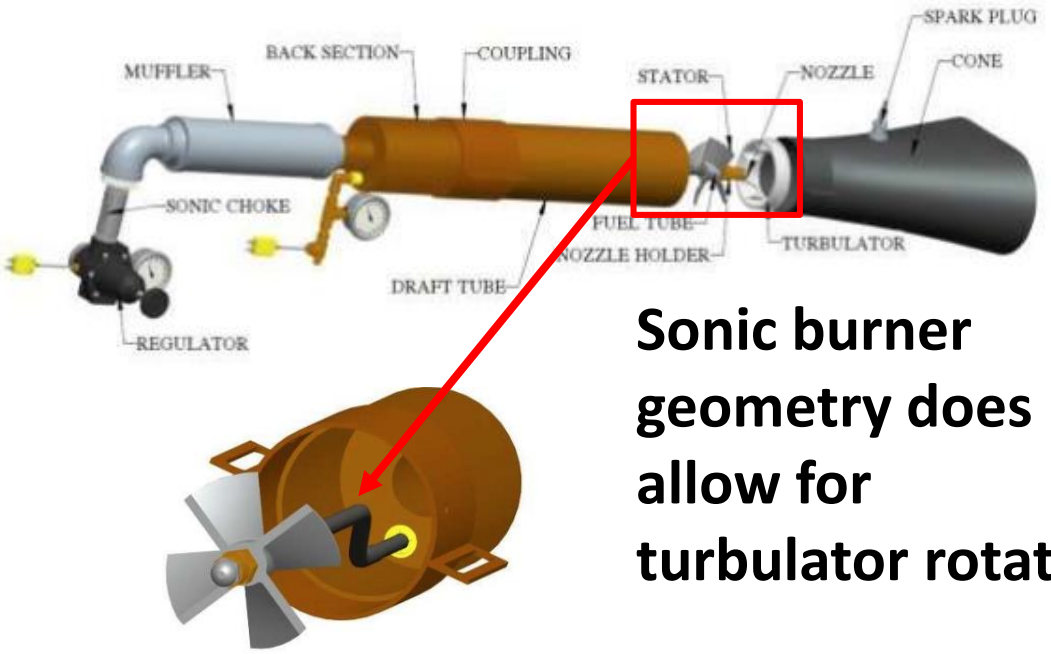


- 500 lb/hr, 1 US gallon, 3.8 litre per minute flow water
- 50-71°F input temp,
- minimum of 9°F temperature increase required

Turbulator Rotation in the Sonic Burner?



Rotational movement of turbulator ~3-5°



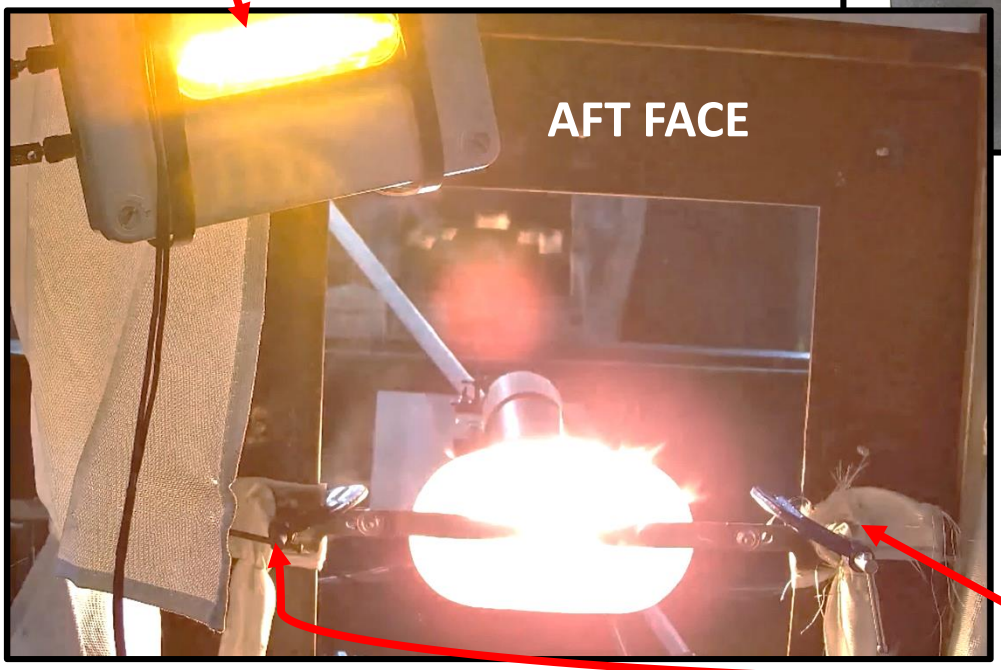
Sonic burner geometry does not allow for turbulator rotation

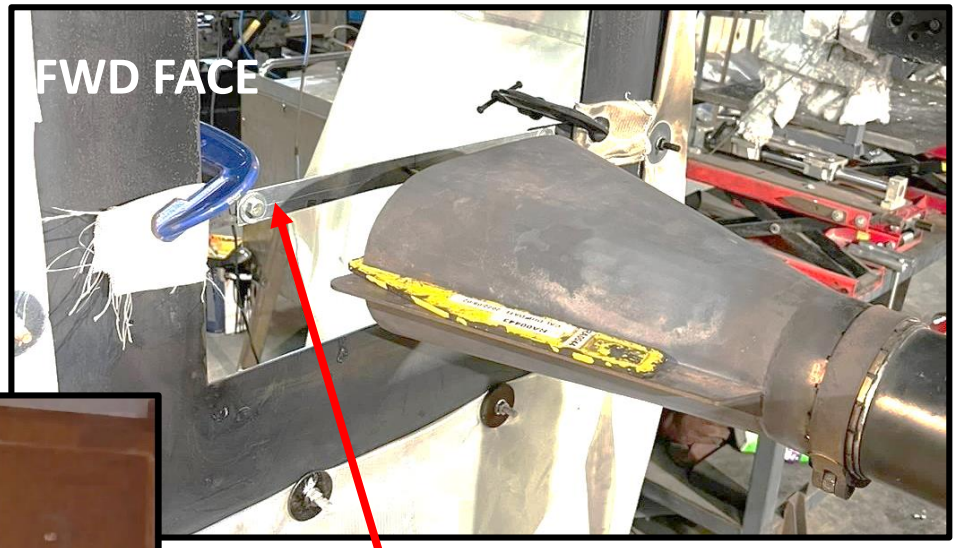
Note: Resonate took cone off, adjusted rotation of turbulator by hand, placed cone back on and ran trials

Carlin burner geometry allows for easy rotation of turbulator

Test Setup

Light to indicate when burn through occurs





Aluminium strip
- cheap, quick alternative to aluminium panel testing

Crocodile clips attached to aluminium strip and power supply. Protected with fire wool.

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Aluminium strips – Burn Through Test

AL2024-T3 3mm thick strips

	Burner	Fuel Pressure (psi)	Air Pressure (psi) / Airflow (ft/min)	Average burn through times (secs)	Average temp (°F)	Average heat flux (BTU/hr)
1	Carlin - 2022	95	2180ft/min	51	2015	4681
2	Sonic - MOD 3	100	52	51	1628	3765
3	Sonic - MOD 3 - 2022	145	56	41	1779	4385
4	Sonic - MOD 3 - 2022 with turbulator adjustment	145	56	37	1960	5055

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Aluminium Strip Burn Through Trial

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3mm aluminium strip burn through test – Carlin burner
Fp: 95 psi, Airflow: 2180 ft/min

Test	Alu thickness	Burner	Fuel Pressure (psi)	Air Pressure (psi)	Burn through time (secs)	Flame Temp °F	Heat flux (BTU/hr)
9	3mm	Carlin - 2022	95	2180ft/min	51	2015	4681
10					52	2015	4681
11					51	2015	4681
12					50	2015	4681
13					51	2015	4681
14					49	2015	4681

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Aluminium Strip Burn Through Trial

[redacted]

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[redacted]

3mm aluminium strip burn through test – Sonic burner
Fp: 145 psi, Airflow: 56 psi

Test	Alu thickness	Burner	Fuel Pressure (psi)	Air Pressure (psi)	Burn through time (secs)	Flame Temp °F	Heat flux (BTU/hr)
16	3mm	Sonic - MOD 3 - 2022	145	56	42	1779	4385
17					41	1779	4385
18					42	1779	4385
19					40	1779	4385
20					42	1779	4385

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Aluminium Strip Burn Through Trial

3mm aluminium strip burn through test – Sonic burner
Fp: 145 psi, Airflow: 56 psi
<u>with turbulator rotation</u>

Test	Alu thickness	Burner	Fuel Pressure (psi)	Air Pressure (psi)	Burn through time (secs)	Flame Temp °F	Heat flux (BTU/hr)
27	3mm	Sonic - MOD 3 - 2022 with turbulator rotation	145	56	37	1960	5055
28					37	1960	5055
29					37	1960	5055

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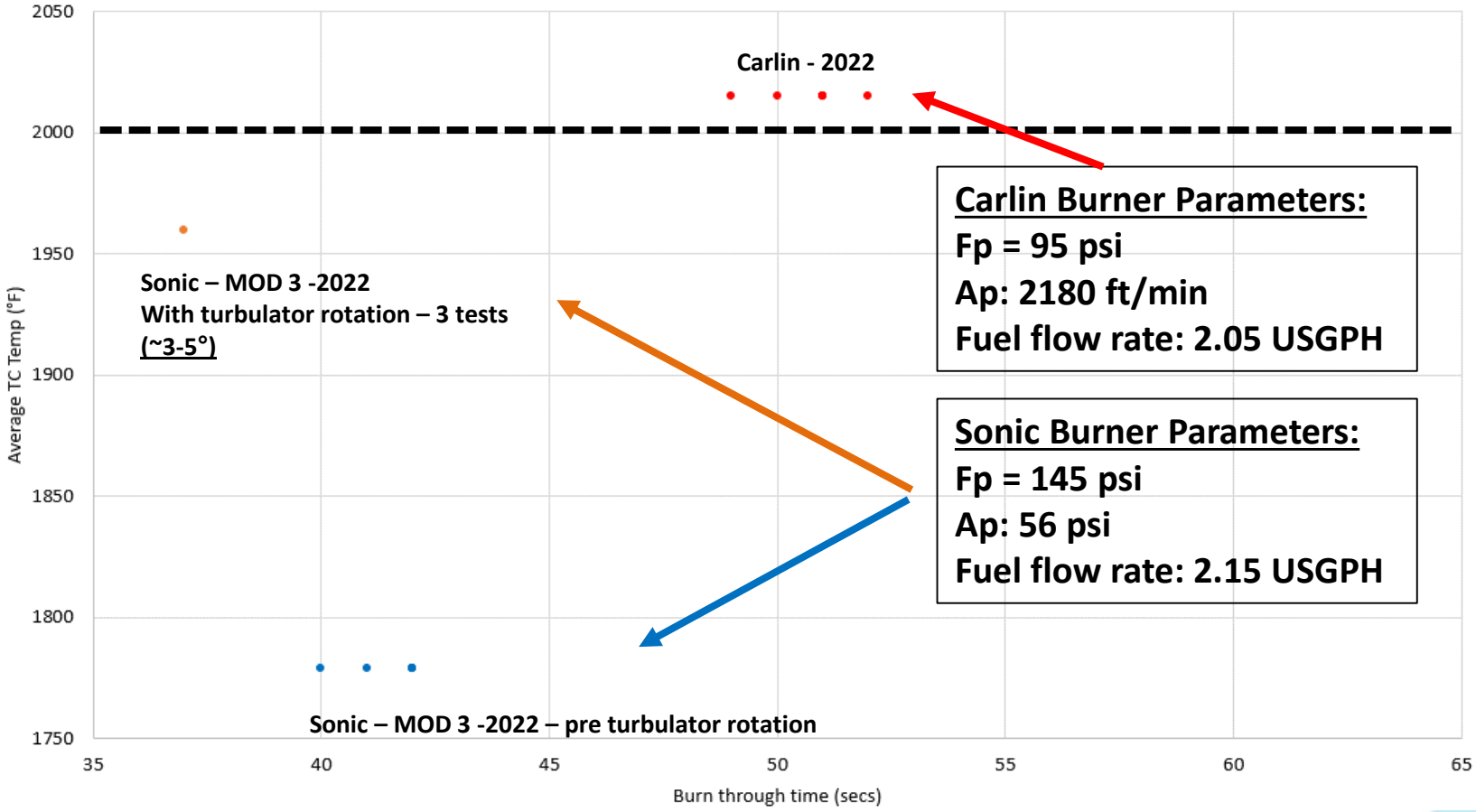
Aluminium Strips – Burn Through Test

AL2024-T3 3mm thick panels

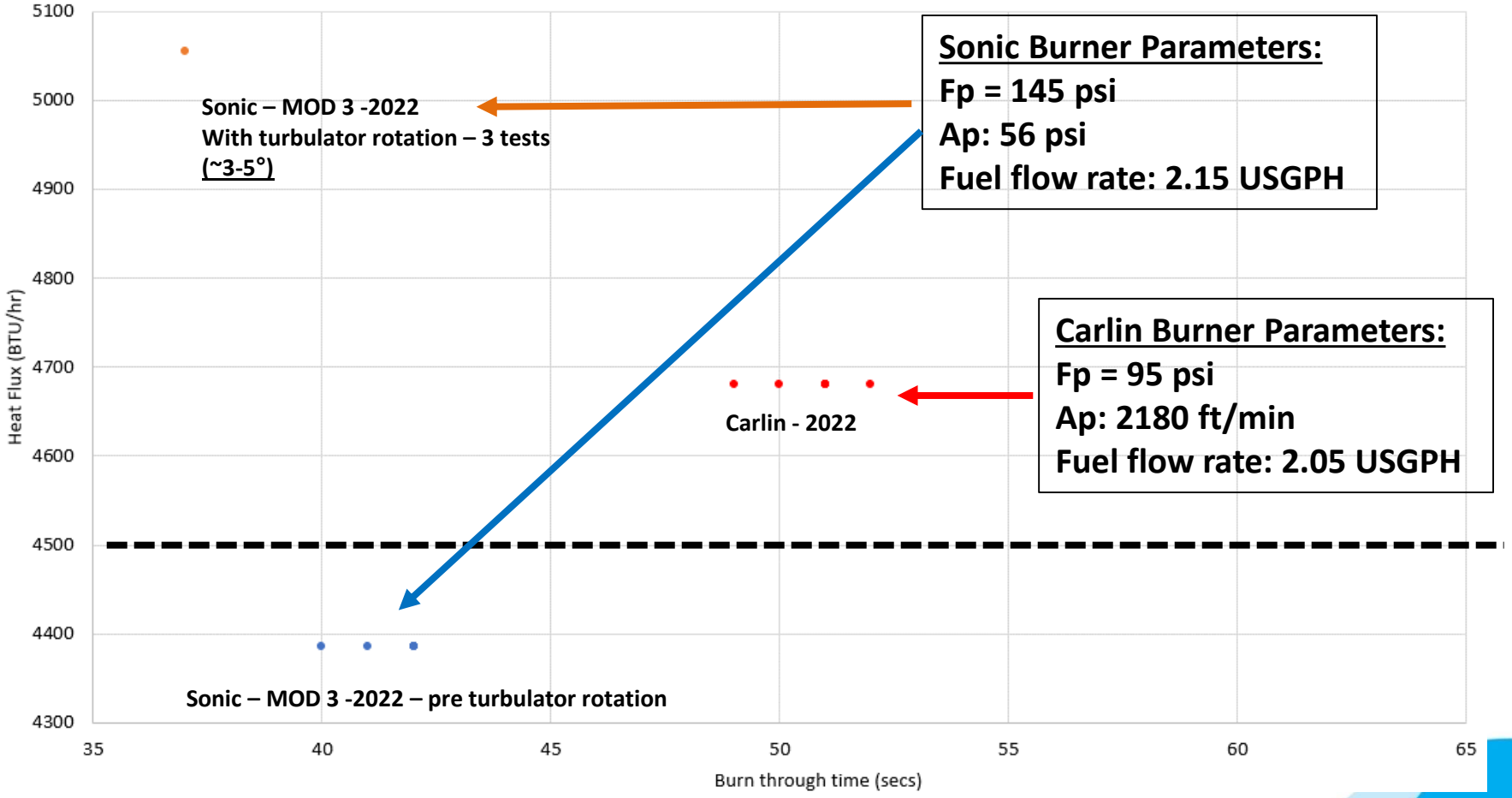
Flame temperature (°F) vs burn through time (seconds)



Aluminium Strips – Burn Through Test

AL2024-T3 3mm thick panels

Heat flux (BTU/hr) vs burn through time (seconds)



Sonic Burner Parameters:
Fp = 145 psi
Ap: 56 psi
Fuel flow rate: 2.15 USGPH

Carlin Burner Parameters:
Fp = 95 psi
Ap: 2180 ft/min
Fuel flow rate: 2.05 USGPH

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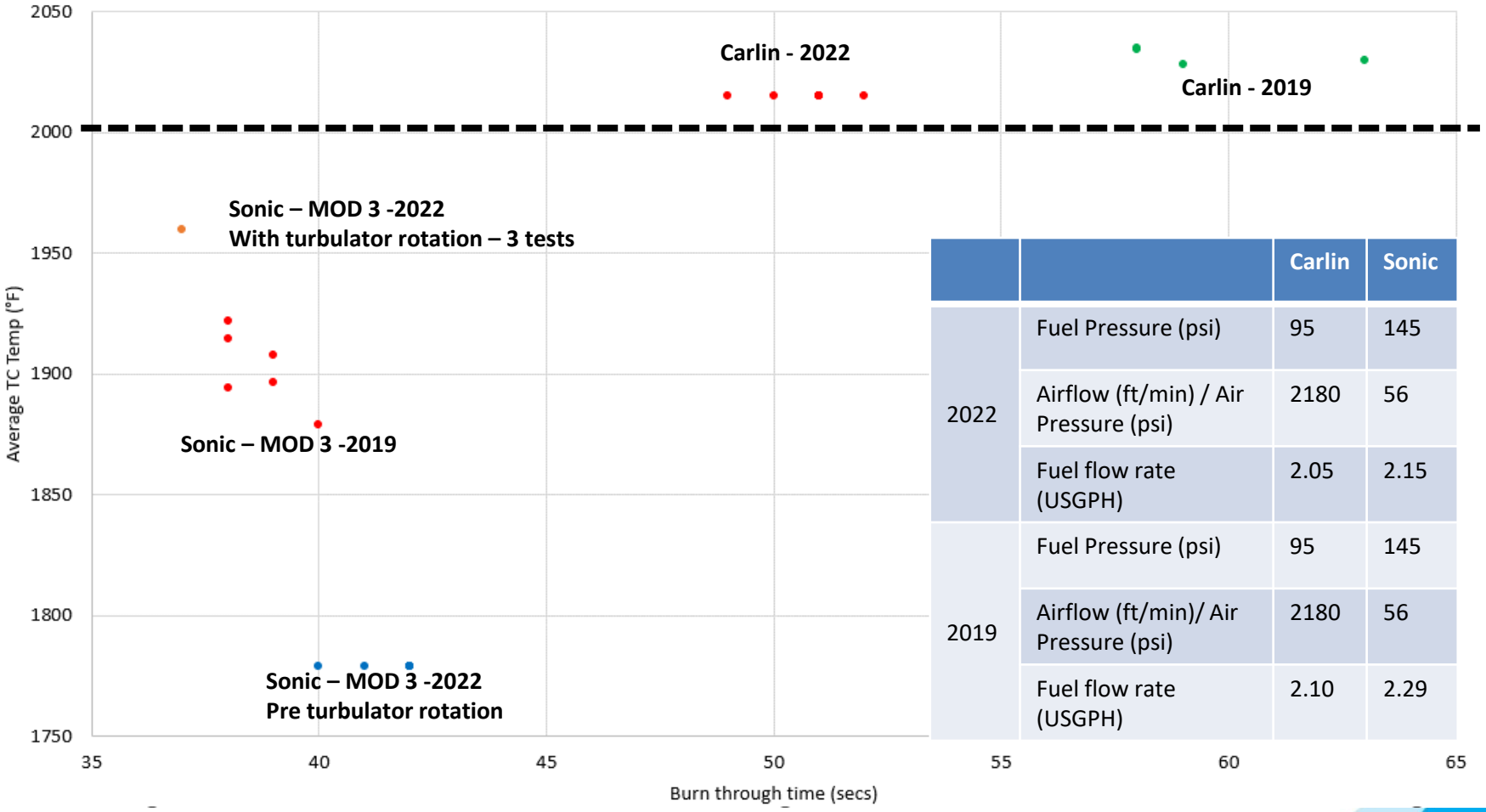
2022 VS 2019

Flame temperature (°F) vs burn through time (seconds)



		Carlin	Sonic
2022	Fuel Pressure (psi)	95	145
	Airflow (ft/min) / Air Pressure (psi)	2180	56
	Fuel flow rate (USGPH)	2.05	2.15
2019	Fuel Pressure (psi)	95	145
	Airflow (ft/min)/ Air Pressure (psi)	2180	56
	Fuel flow rate (USGPH)	2.10	2.29

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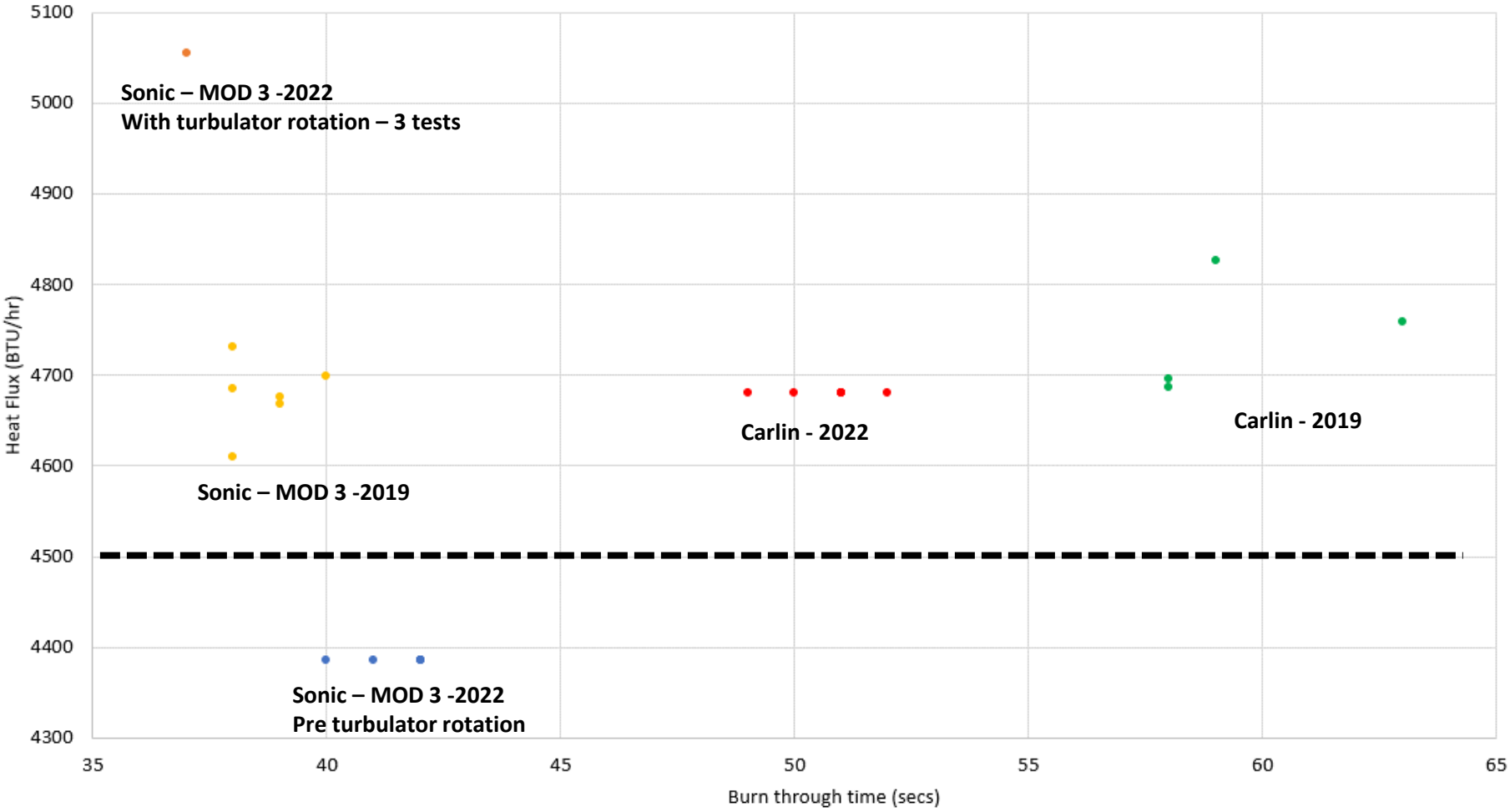
2022 VS 2019

Heat flux (BTU/hr) vs burn through time (seconds)



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SONIC BURNER CALIBRATIONS

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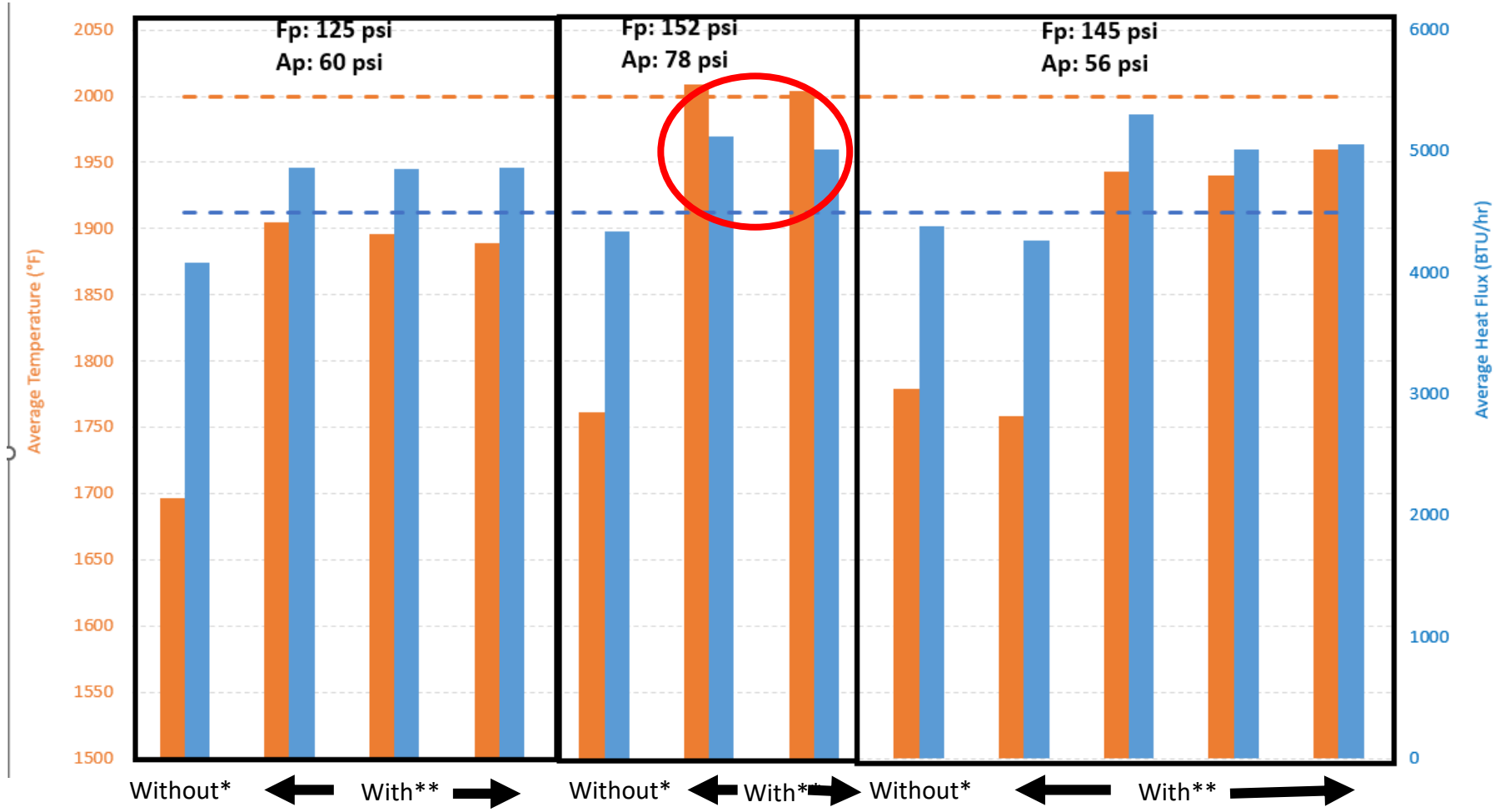
Sonic Burner Calibration Data – June 2022

Run	Fuel pressure (psi)	Air pressure (psi)	Fuel flow rate (USGPH)	Average temp (°F)	Average heat flux (BTU/hr)	Pre/Post Turbulator move
1	100	50	1.8	1615	3638	Pre
2				1630	3647	
3				1610	3716	
4				1628	3765	
5	125	60	1.99	1697	4086	Pre
6				1905	4861	Post
7				1896	4859	
8				1889	4865	
9	145	56	2.15	1758	4262	Pre
10				1779	4385	
11				1943	5307	Post
12				1940	5020	
13				1960	5055	
14	152	78	2.2	1761	4337	Pre
15				2009	5127	Post
16				2004	5011	

Sonic Burner Calibrations – June 2022



*without turbulator rotation

** with turbulator rotation

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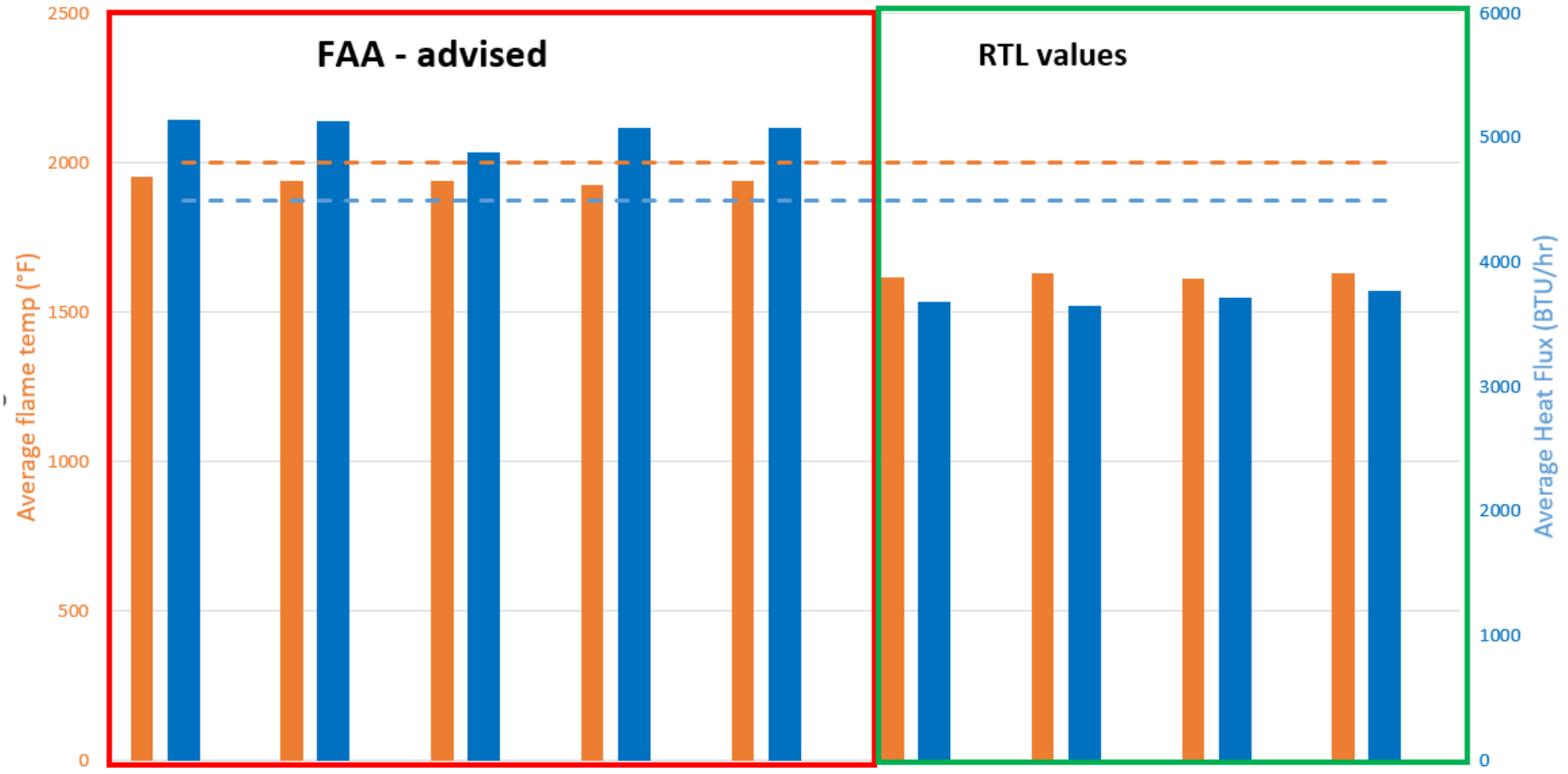
RTL Replication of FAA Sonic Burner Calibrations Comparison

Fp: 100 psi Ap: 52 psi



*FAA Sonic Burner config as per Chapter 7 of FAA fire test handbook but with Delevan type – W 80deg spray pattern and flow rating of 2.5 UGPHG using 1/16” thermocouples

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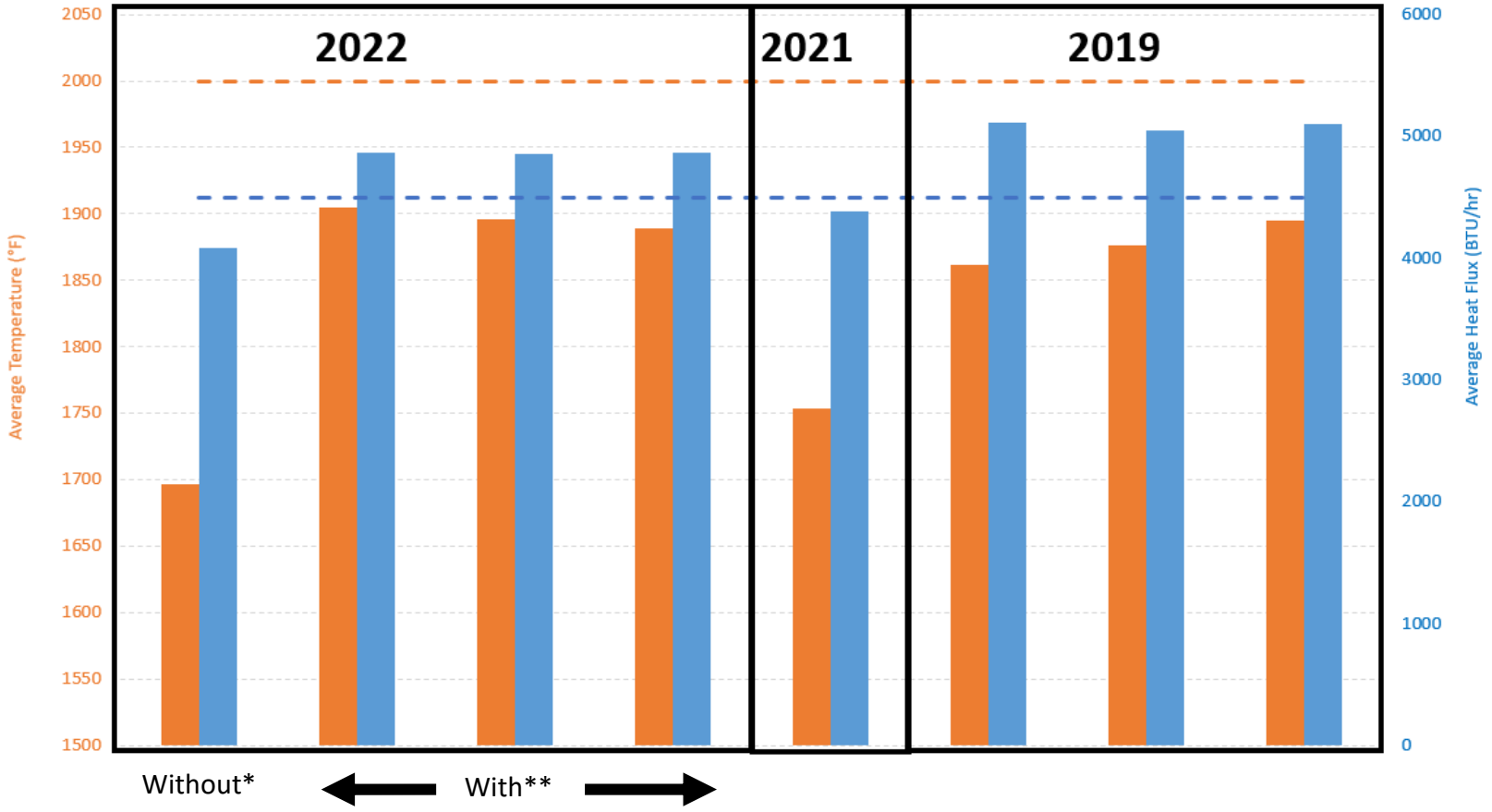
Sonic Burner *June 2022 vs Feb 2021 vs April 2019*

Fuel Pressure: 125 psi, Air Pressure: 60 psi



*without turbulator rotation

** with turbulator rotation

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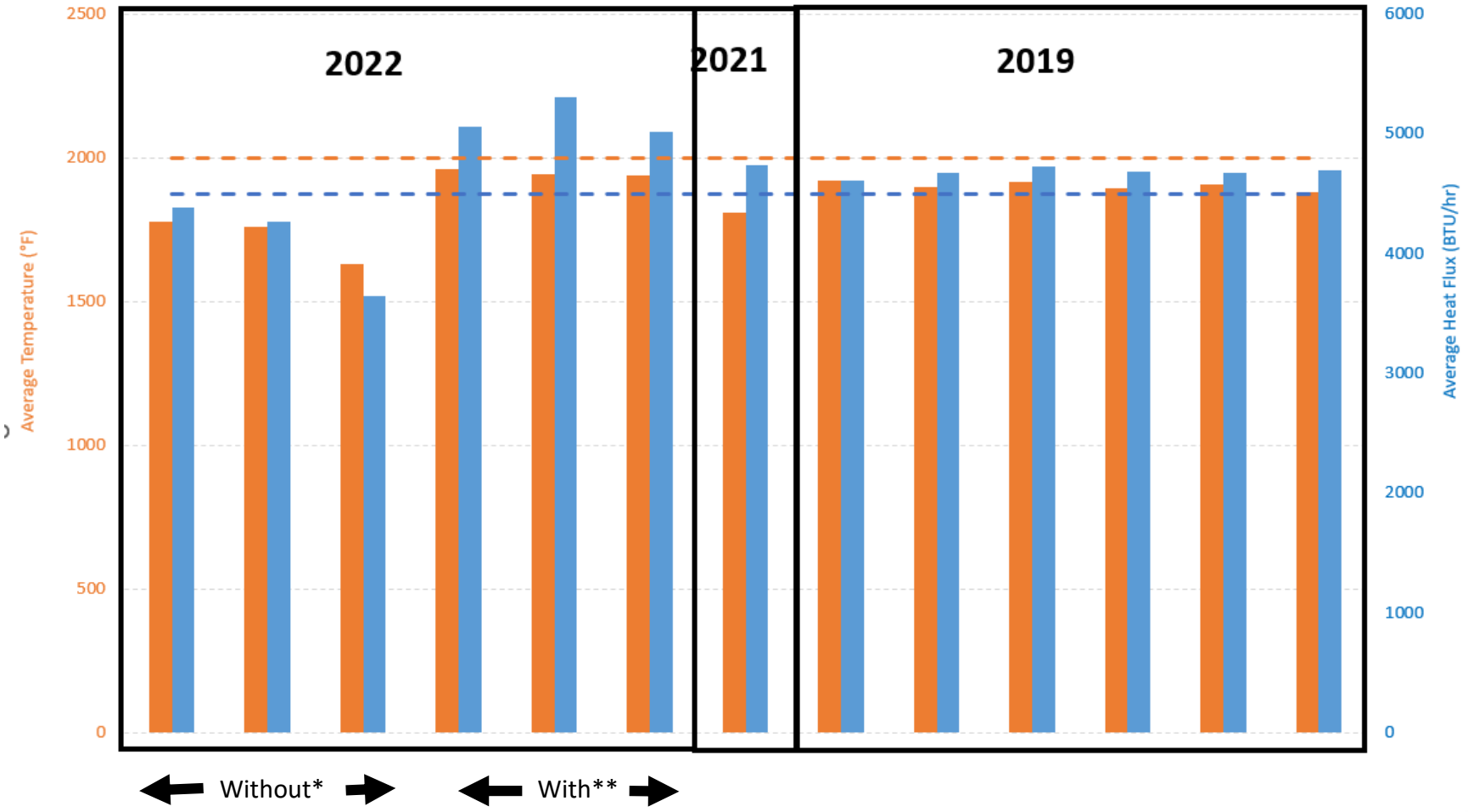
Sonic Burner *June 2022 vs Feb 2021 vs April 2019*

Fuel Pressure: 145 psi, Air Pressure: 56 psi



*without turbulator rotation

** with turbulator rotation

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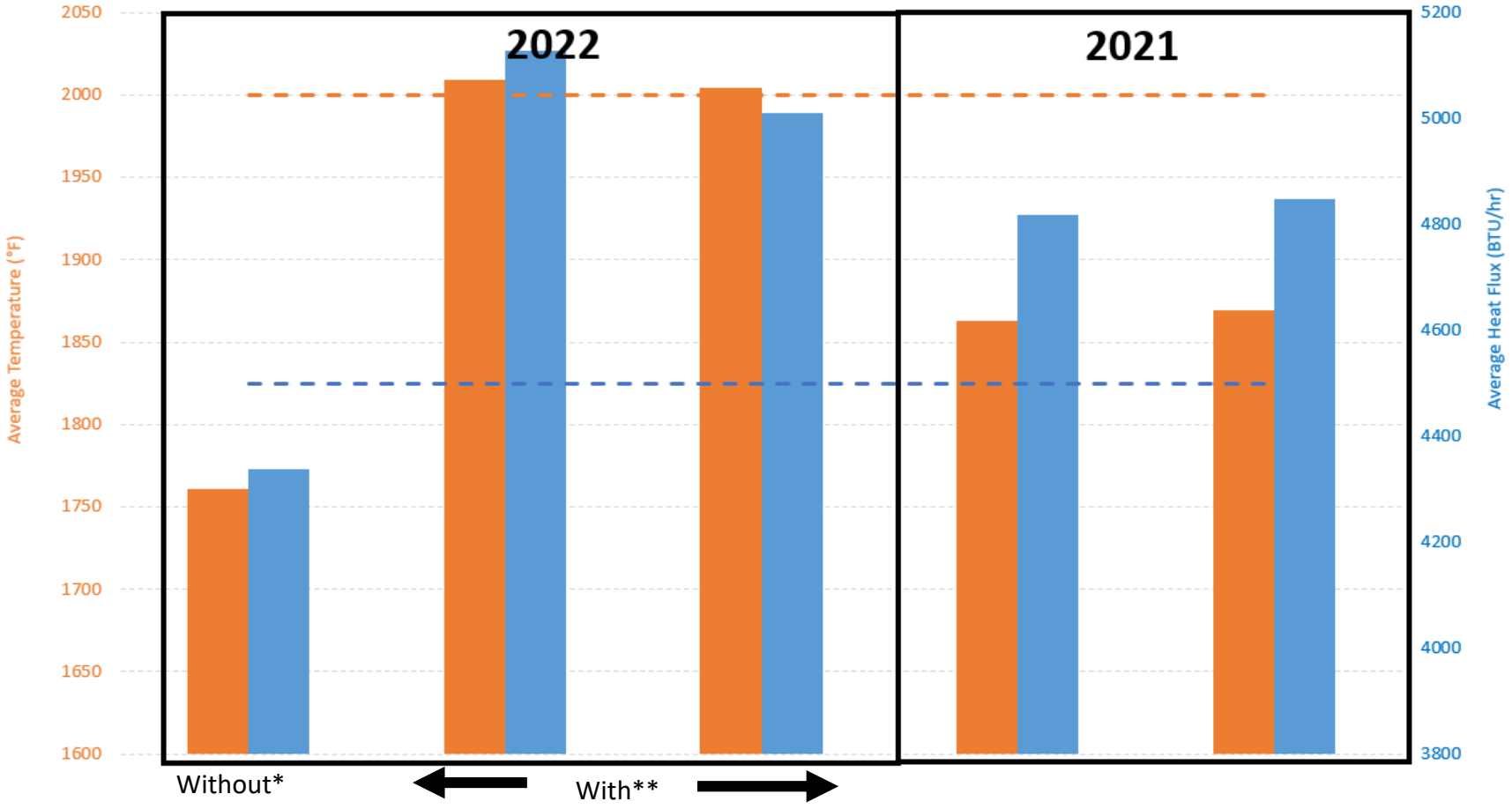
Sonic Burner *June 2022 vs Feb 2021*

Fuel Pressure: 152 psi, Air Pressure: 78 psi



*without turbulator rotation

** with turbulator rotation

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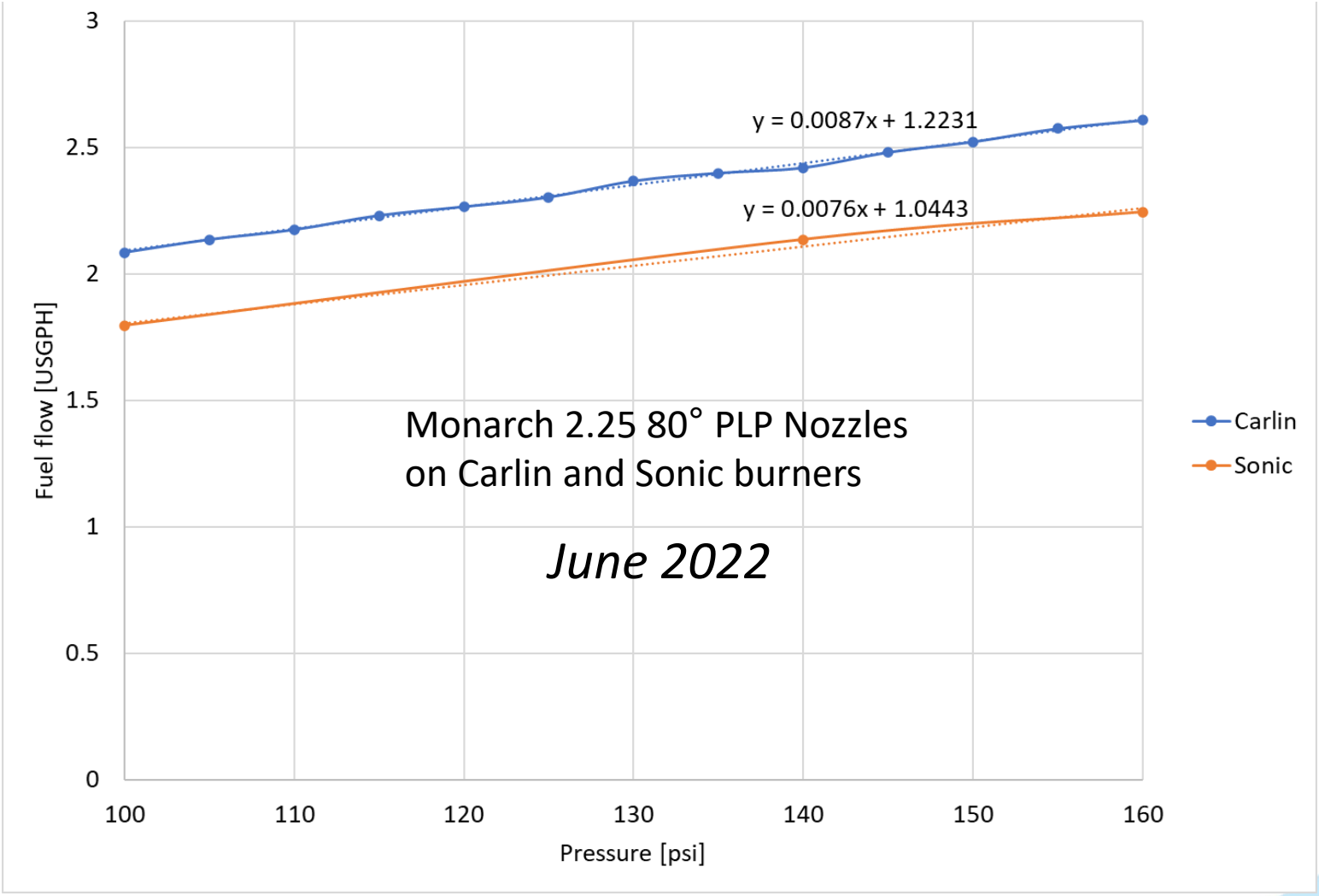
FUEL FLOW RATE CHECKS

Carlin vs Sonic Fuel Flow Rate Comparison



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Summary

- Importance of the (Resonate Testing) RES MOD 3 turbulator and its ability for rotation in the Sonic burner
  - Geometry of the Sonic burner doesn't allow for easy rotation of turbulator – adding variability
  - With turbulator rotation, the Sonic flame temperature increased by approx. 200°F and heat flux increased by on approx. 700/800 BTU/hr.
  - Despite the turbulator rotation, the Sonic cannot achieve a calibrated flame.

- Repeatability and equivalency of burners?
  - Carlin has repeatable flame calibrations (with constant work and adjustment)
  - Sonic demonstrates levels of repeatable damage, which is consistently more severe than the Carlin..
  - With the addition of the turbulator rotation, this further increased performance repeatability and calibrations of the Sonic burner
  - The Sonic burner is shown to be more severe, as burn through times occurred on average 10 seconds quicker than the Carlin. This is despite the fact the Sonic burner calibration being 200 °F and 300 BTU/hr lower than the Carlin calibration.

- In order for the Sonic to meet flame calibration standards it needs to run at 152psi fuel pressure, meaning 2.20 USGPH fuel flow rate. Carlin burner can reach a flame calibration at 95psi, running at 2.05 USGPH.
  - At this point the Sonic burner has a 7% increase in fuel consumption
  - Carlin burner fuel flow value is closer to Engineering report 3A fuel flow value (2.04 USGPH @97psi), than the Sonic burner (1.78 USGPH @97psi)
  - As a result, the flame from Sonic burner produces a more severe test, in terms of burn through time

- Resonate Testing were unable to directly reproduce FAA sonic burner flame calibrations

Future Work

- Continue work with the FAA to build repeatability and commonality
  - Same configuration and run with FAA supplied nozzle (Delevan)
- Build on aluminium strip burn through trials – gather more data
- Measure airflows of both burners at the end of the blast tube, so we have a direct comparison of mass flow of air
- Build upon Sonic burner calibration data, including flame temperature mapping with the addition of turbulator rotation
- Explore other Sonic burner configurations

THANK YOU FOR LISTENING

ANY QUESTIONS?

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