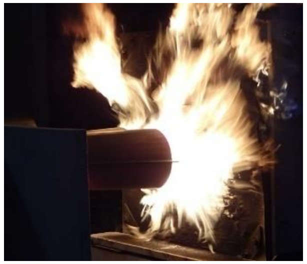
STUDY OF MODIFIED SONIC BURNER FOR POWERPLANT FIRE TESTING IN COMPARISON TO EXISTING CARLIN BURNER

2020-08-06

PRESENTED BY: DR. MARY DOWEY



BATTLE OF THE BURNERS

Resonate TESTING LIMITED

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Premise – why are we doing this study?

Premise

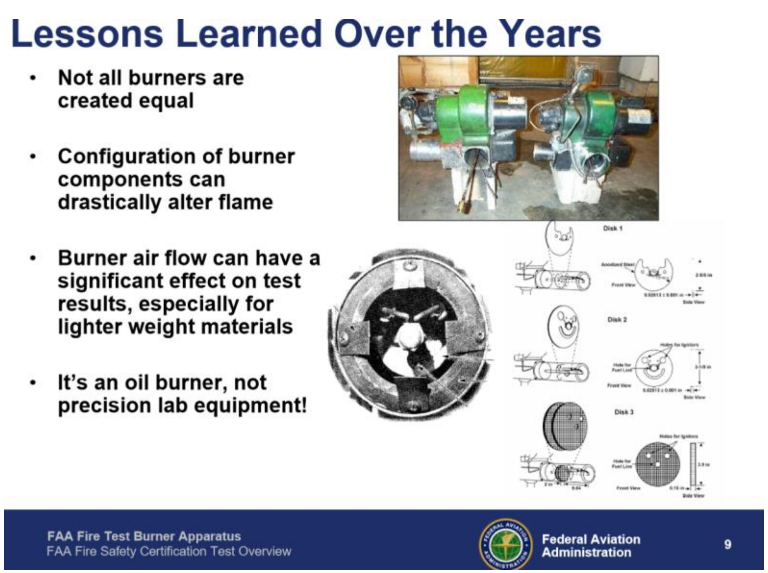
Comparison of existing and new Burners carried out to add to the body of knowledge increasing consistency between labs for powerplant/systems testing aiding in providing direction for future trials.

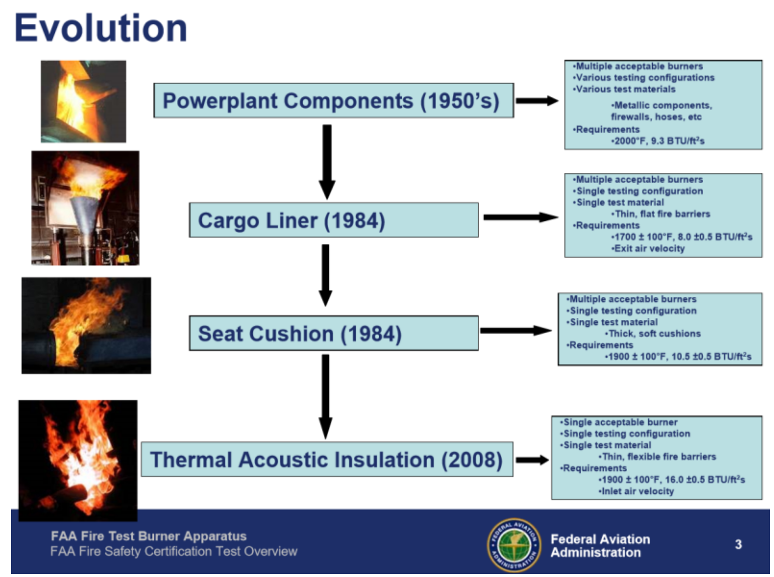
To define a basis by which burner can be compared for powerplant testing

- Aluminium panel burnthrough
- Aluminum strip burnthrough
- Burner mapping temperature and heat flux mapping to compare flame types
- Composite panel comparative damage testing

BACKGROUND AND INTRODUCTION

Burner Development by the FAA TC





FAA Fire Safety Overview

February 7 2012 – Singapore

Robert I. Ochs, FAA Fire Safety, ANG-E212

Sonic Burner

- Deemed suitable for use for materials fire testing
- Round robins show equivalent damage
- May 2009 DOT/FAA/AR-TN09/23 Robert. I. Ochs

We don’t know what we don’t know

- If you chose not to calibrate the flame for temperature or heat transfer, we will not know if it is different
- We won't know if there are hot spots in the flame
- The testing carried out has shown that changes to the burner flame do occur over time and need correcting to achieve equivalent damage
- The only benchmarks we have in powerplant fire test is the temperature average and the heat flux/heat transfer along one line

Other similar work

- **FAA Tech Centre**
  - **Round robin material testing**

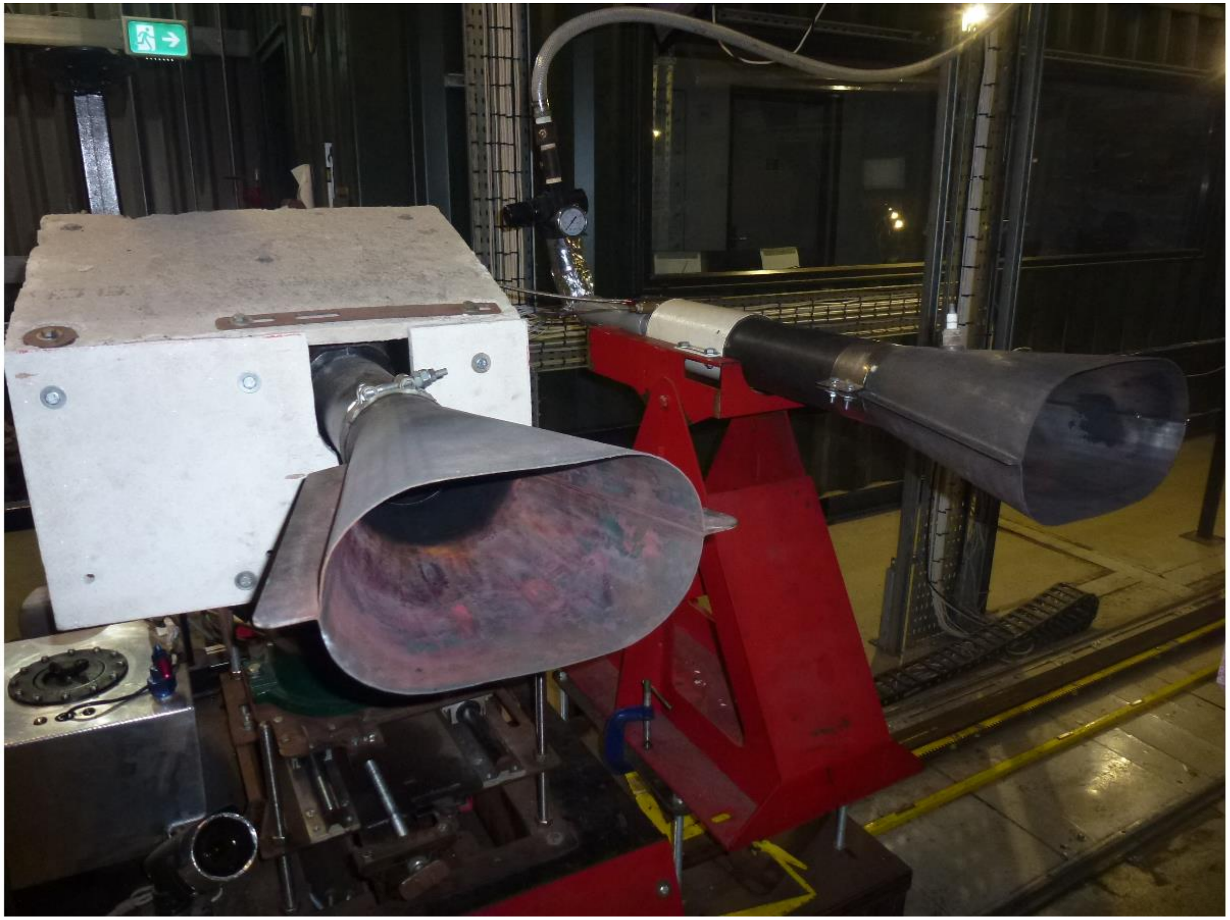
- **DGA Aeronautical Systems**
  - **Material round robin testing**
  - **Temperature and heat flux mapping for flame**

- **University of Cincinnati**
  - **burner modifications to achieve flame calibration criteria**

    the fuel nozzle was replaced by a Monarch 2.25 GPH 80° PLP nozzle. Four tabs were installed on the turbulator at the 12, 3, 6 and 9 o’clock positions, to ensure suitable fuel flow distribution. The tabs were constructed of 1/16 inch thick stainless steel sheet and were 3/4 inch × 1 inch in size (reference AC 20-104). Additionally, the burner cone was insulated with a 1/2 inch thick ceramic blanket to minimize heat loss through the cone surface.

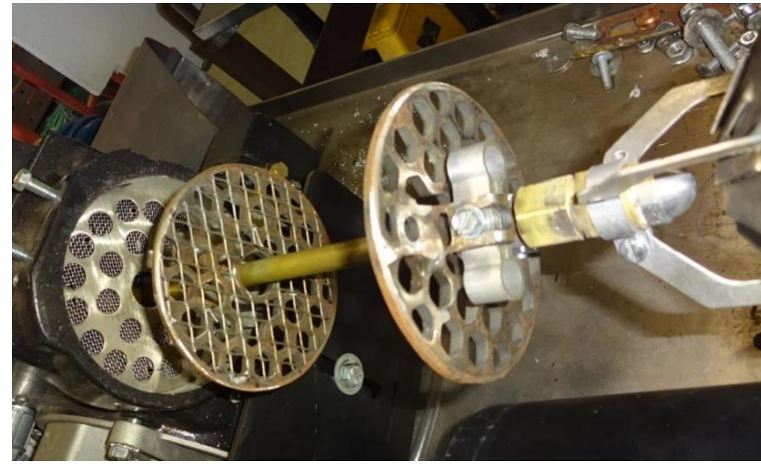
BURNER SETUP AND CONFIGURATION

Side by side Sonic and Carlin Testing



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.

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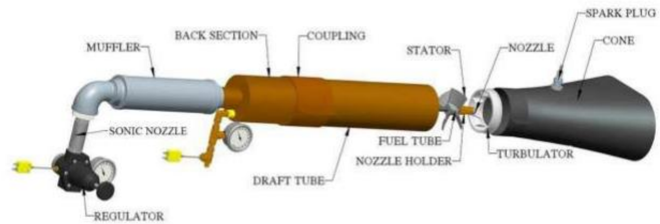
Sonic – Configuration 1



FAA FIRE TEST HANDBOOK - Chapter 7 configuration
Supplied by Marlin Engineering

Fuel Nozzle
FAATC data from presentations (as late as 2017):
    2.0 gph 80°B Delevan nozzle, 100 psi fuel, 40/50 psi air
FAATC config Resonate used for this test:
    2.0 gph <u>80°W</u> manufacturer nozzle – semi solid pattern, 100 psi fuel, 50 psi air

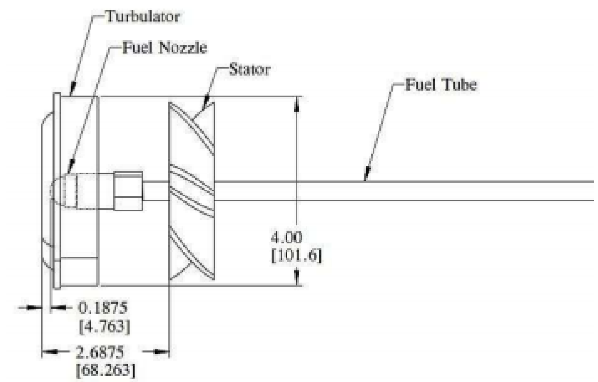
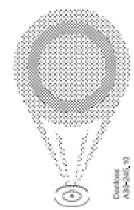


Figure 7-S-17. Typical Configuration of the Stator and Turbulator



Semi-solid

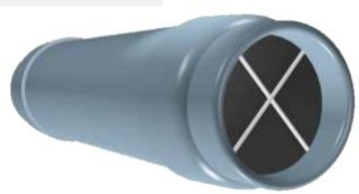
Ignitorless stator
Muffler foam retained with wire
Turbulator – no flame retention head

supplied by Marlin Engineering, part number ME1513-3.

Figure 7-S-13. Stator

supplied by Marlin Engineering, part number ME1512-1.

Figure 7-S-14. Turbulator, Front View and Back View



12. Safety Wire Affixed to inside of the Muffler for Restrainin

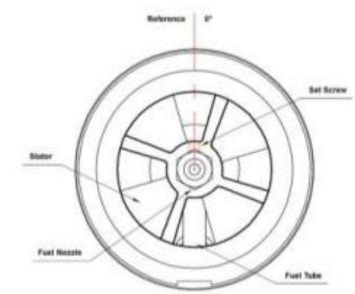


Figure 7-S-29 Stator Axial Position (looking into draft tube)

Sonic Burner Modification – Configuration 2

Objective: Produce temperature and heat flux output data which demonstrate the modified Sonic burner can replicate Carlin conditions - i.e. Sonic can be calibrated according to AC20-135 guidance using the same equipment to produce similar results to a traditional oil burner.

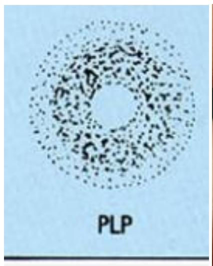
Danfoss 80°H 2.0 GPH – Hollow pattern

Added Carlin type turbulator on fuel nozzle fitting

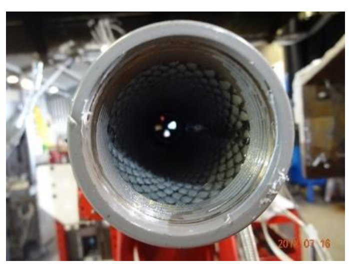
Muffler foam was removed

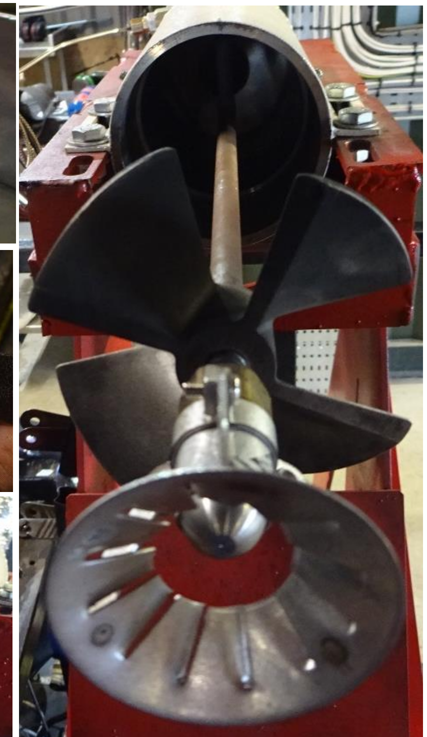
Sonic Burner Modification – Configuration 3

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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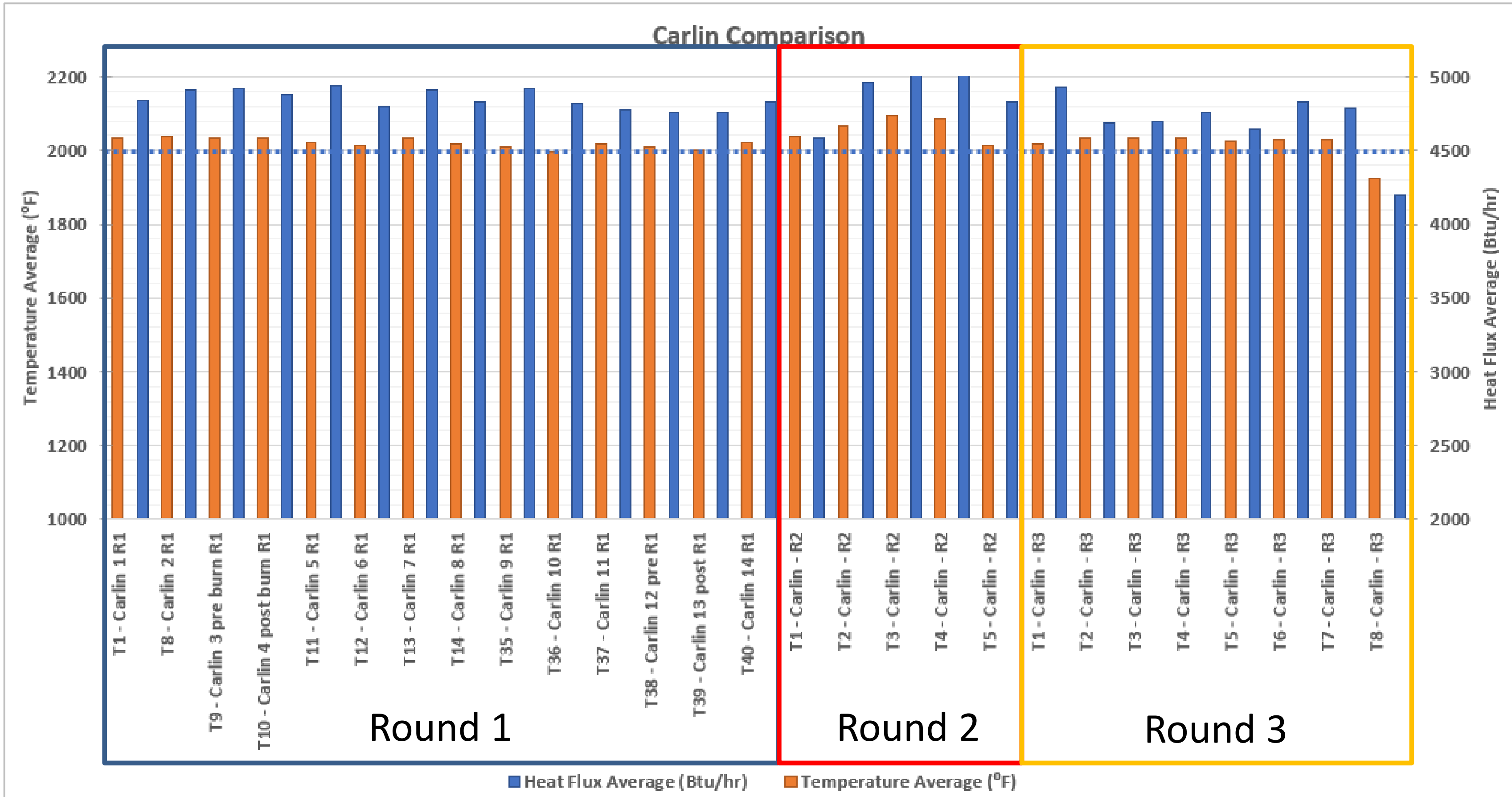
COMPARATIVE CALIBRATION DATA

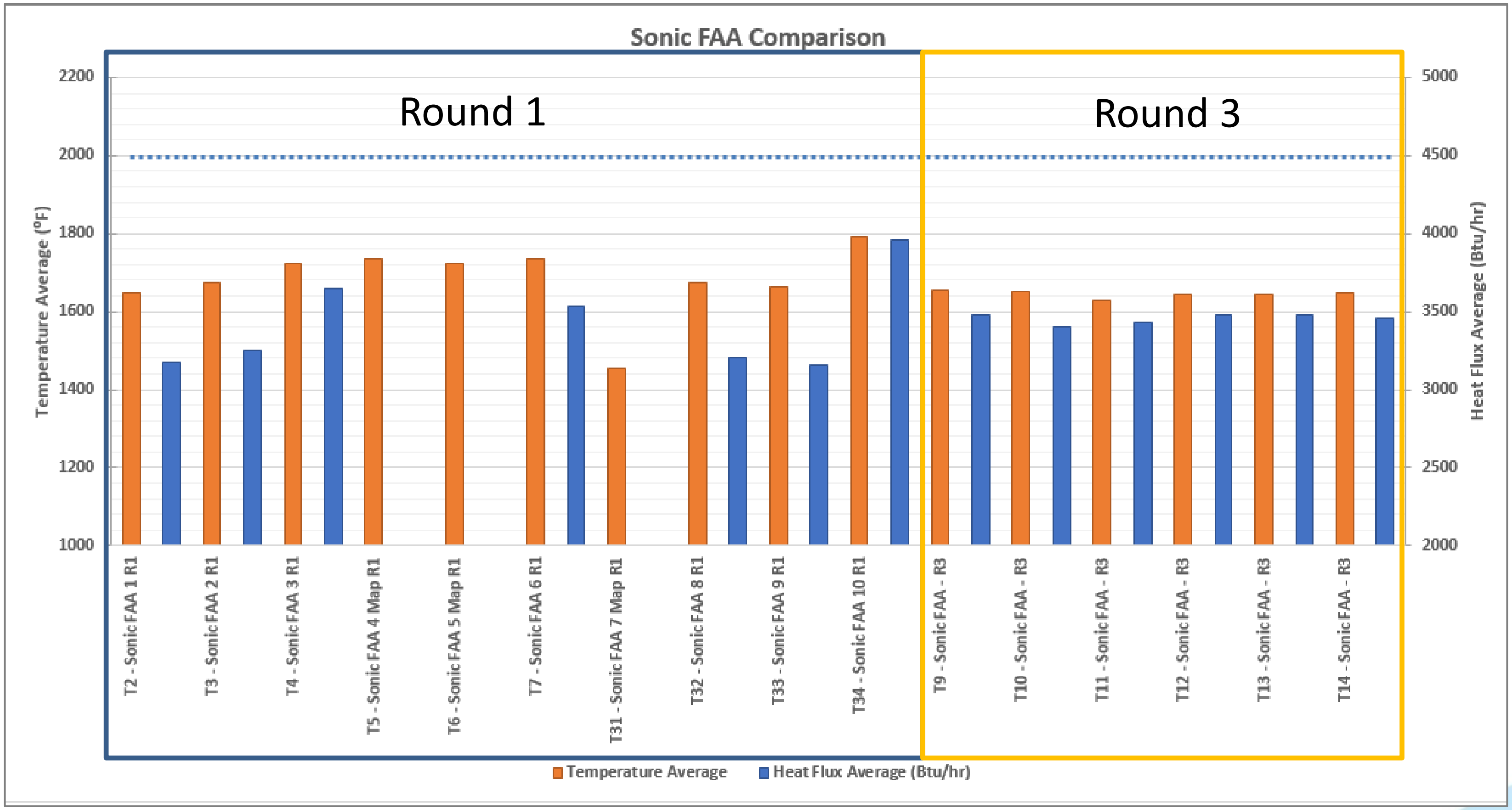
Summary of Carlin Calibration Data

Fuel pressure ranging from 80 psi to 120psi



Summary of Sonic Config 1

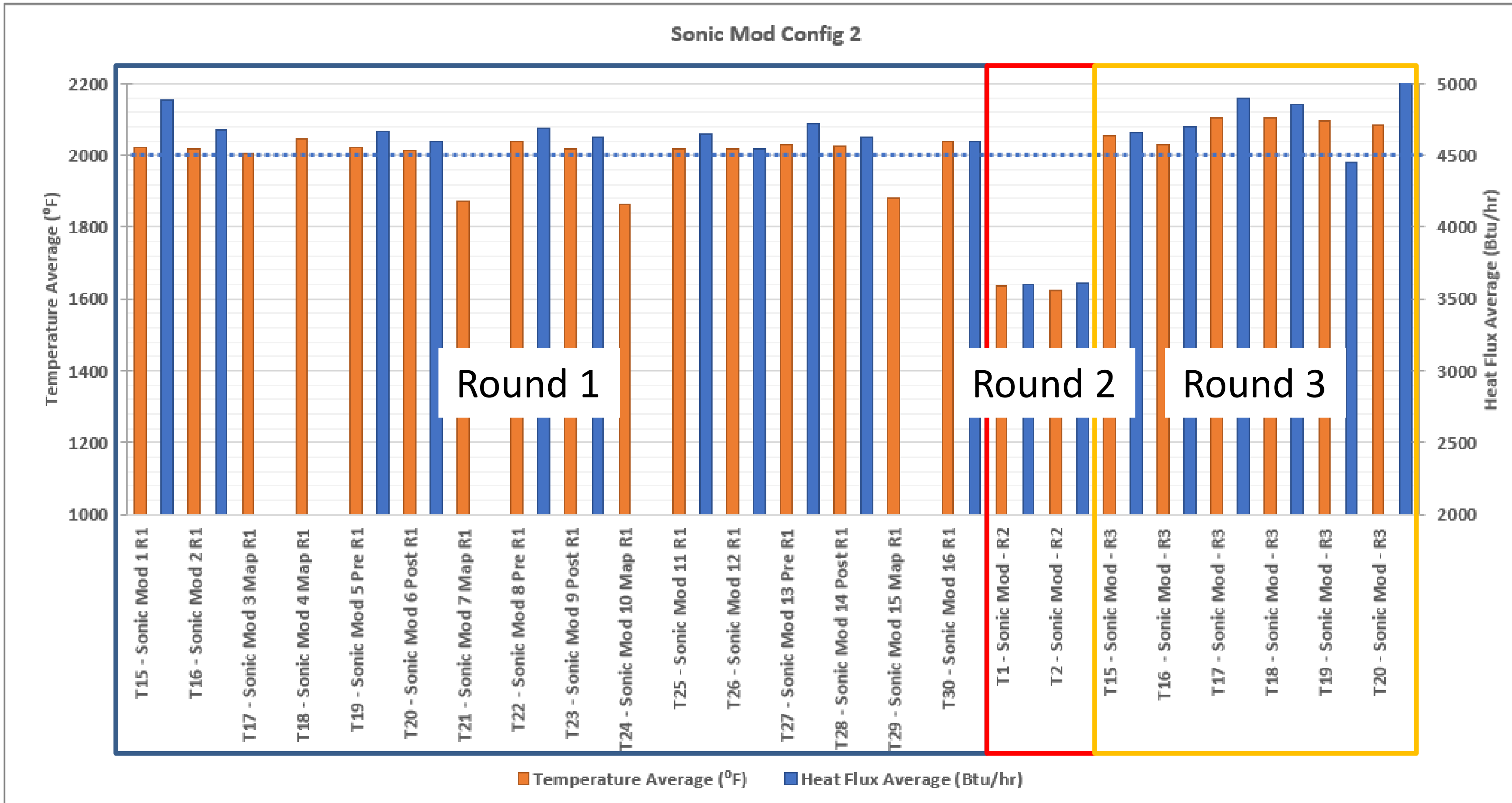
Fuel: 100psi   Air: 50psi



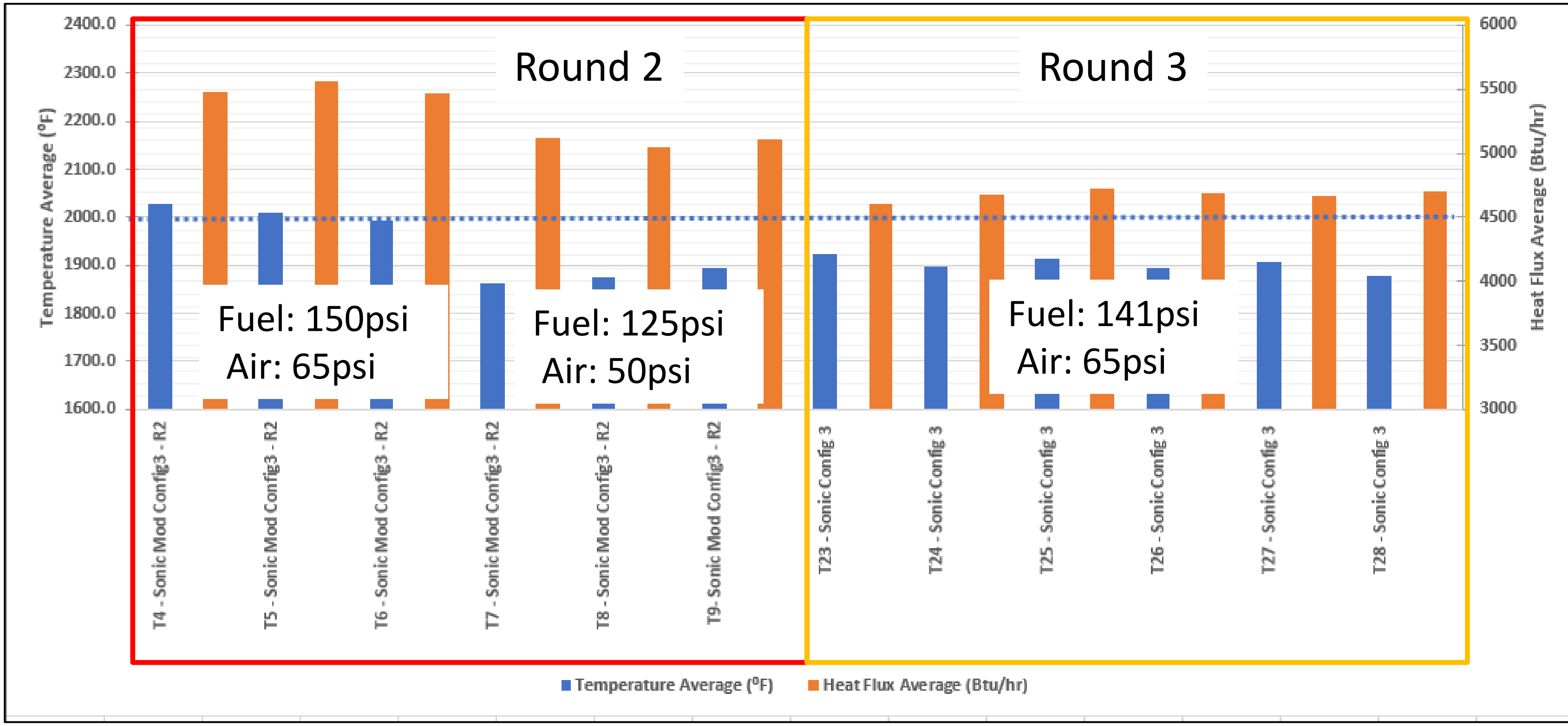
Summary of Sonic Mod Config 2

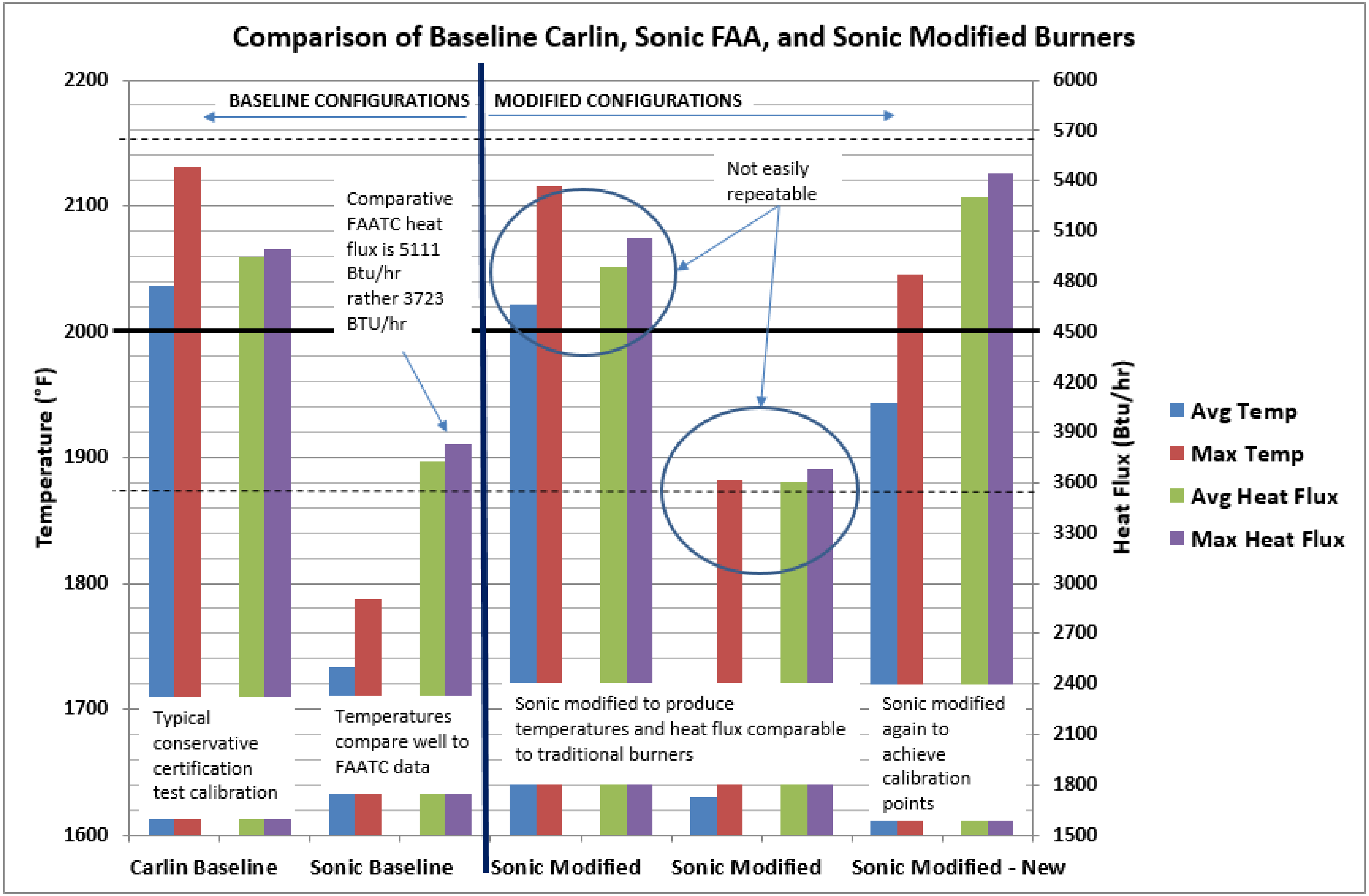
Fuel: 147psi Air: 62psi

Fuel: 145psi Air: 50psi



Summary of Sonic Mod Config 3




Comparison of Baseline Carlin, Sonic FAA, and Sonic Modified Burners
BASELINE CONFIGURATIONS
MODIFIED CONFIGURATIONS
Comparative FAATC heat flux is 5111 Btu/hr rather 3723 BTU/hr
Not easily repeatable
Typical conservative certification test calibration
Temperatures compare well to FAATC data
Sonic modified to produce temperatures and heat flux comparable to traditional burners
Sonic modified again to achieve calibration points
Temperature (°F)
Heat Flux (Btu/hr)
2200
2100
2000
1900
1800
1700
1600
6000
5700
5400
5100
4800
4500
4200
3900
3600
3300
3000
2700
2400
2100
1800
1500
Carlin Baseline
Sonic Baseline
Sonic Modified
Sonic Modified
Sonic Modified - New
Avg Temp
Max Temp
Avg Heat Flux
Max Heat Flux

TEMPERATURE AND HEAT TRANSFER MAPPING – FLAME CHARACTERISATION

11 TC Map – 1” vertical Increments & 1” TC spacing

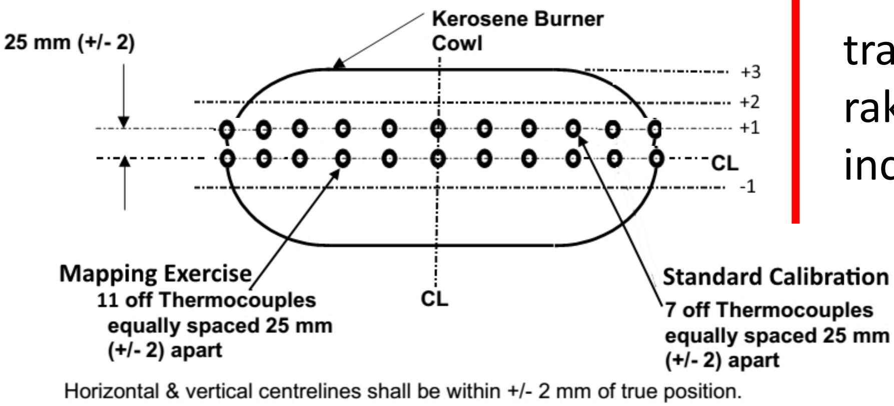
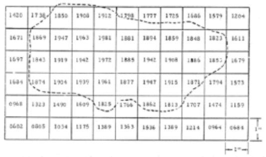


FIGURE 2 - FLAME TEMPERATURE MEASUREMENT POSITIONS FOR KEROSENE BURNER

transitioning rake with 1” increments.

Flame temperature mapping

- Engineering Report 3A CARLIN 200 CRD

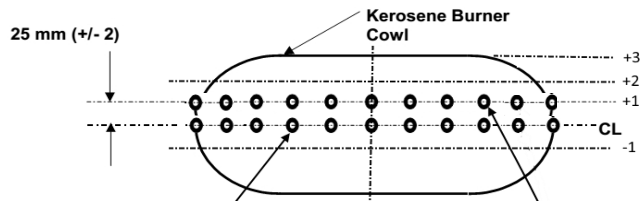


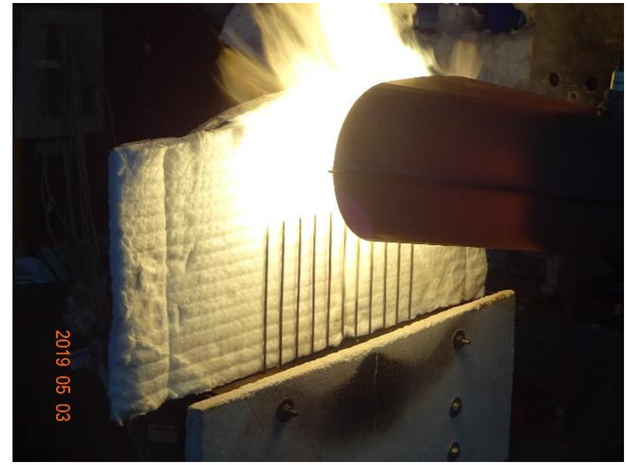
Burner Map looking into the Burner [°F] - Max Values

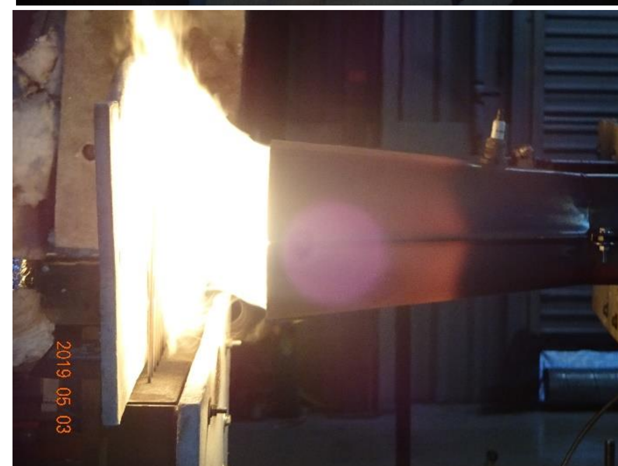
	TC 1	TC 2	TC 3	TC 4	TC 5	TC 6	TC 7	TC 8	TC 9	TC 10	TC 11	AVERAGE Central 7 TC's
Level 6	1420.0	1738.0	1850.0	1908.0	1912.0	1798.0	1777.0	1725.0	1686.0	1579.0	1204.0	1808.0
Level 5	1671.0	1869.0	1947.0	1963.0	1981.0	1881.0	1894.0	1859.0	1848.0	1823.0	1611.0	1910.4
Level 4	1697.0	1843.0	1919.0	1942.0	1972.0	1885.0	1942.0	1908.0	1886.0	1852.0	1679.0	1922.0
Level 3	1634.0	1874.0	1904.0	1936.0	1961.0	1877.0	1947.0	1915.0	1871.0	1794.0	1573.0	1915.9
Level 2	968.0	1323.0	1490.0	1609.0	1825.0	1766.0	1862.0	1813.0	1707.0	1474.0	1159.0	1724.6
Level 1	602.0	805.0	1034.0	1175.0	1389.0	1363.0	1536.0	1389.0	1214.0	964.0	684.0	1300.0

11 TC Map – 1” vertical Increments & 1” TC spacing- fire board/firewool

Transitioning rake with 1” increments.







Carlin vs Sonic – Config 3 – Round 3

- the same nozzle and similar turbulator

BURNER AIR PRESSURE: 56PSI **FUEL:**145PSI

Carlin

Burner Map looking into the Burner [°F] - Max Values — NO BOARD

	TC 1	TC 2	TC 3	TC 4	TC 5	TC 6	TC 7	TC 8	TC 9	TC 10	TC 11	AVERAGE Central 7 TC's
Level 6	1668.3	1795.1	1869.8	1934.0	1955.0	1985.0	1978.2	1955.0	1928.2	1831.3	1603.1	1943.6
Level 5	1805.9	1875.1	2005.6	2083.2	2096.6	2149.0	2174.2	2128.1	1983.7	1880.4	1769.2	2088.6
Level 4	1630.6	1845.4	1949.1	2025.3	2085.2	2138.0	2187.8	2117.3	1995.8	1890.0	1771.2	2071.2
Level 3	1140.7	1632.8	1730.4	1654.2	1626.4	1704.4	1822.9	1886.4	1878.9	1743.7	1462.3	1757.6
Level 2	660.4	1058.0	1185.5	1082.1	1007.1	1080.2	1255.6	1384.5	1414.8	1129.2	831.5	1201.4
Level 1	416.8	632.4	700.5	668.7	636.2	690.7	795.9	843.8	864.4	675.2	470.8	742.9

Burner Map looking into the Burner [°F] - Max Values — FIREBOARD

	TC 1	TC 2	TC 3	TC 4	TC 5	TC 6	TC 7	TC 8	TC 9	TC 10	TC 11	AVERAGE Central 7 TC's
Level 6	1806.4	1820.0	1885.2	1912.0	1980.5	2055.4	2055.8	2011.0	1996.7	1961.7	1934.6	1985.2
Level 5	1765.5	1832.0	1914.4	1953.3	1991.0	2056.1	2128.8	2126.6	2084.9	2058.3	2019.7	2036.5
Level 4	1701.4	1773.6	1899.3	1938.2	1973.4	2015.7	2117.9	2123.2	2086.6	2082.2	2044.4	2022.1
Level 3	1654.9	1708.9	1826.0	1859.5	1876.1	1889.0	1927.3	1964.2	1968.4	1934.1	1906.2	1901.5
Level 2	1566.7	1591.7	1642.9	1685.5	1754.2	1802.1	1793.2	1773.4	1790.2	1757.0	1767.0	1748.8
Level 1	1299.5	1308.3	1359.9	1435.8	1502.7	1594.4	1615.1	1600.6	1616.3	1542.8	1533.0	1532.1

Burner Map looking into the Burner [°F] - Max Values — FIREWOOL

	TC 1	TC 2	TC 3	TC 4	TC 5	TC 6	TC 7	TC 8	TC 9	TC 10	TC 11	AVERAGE Central 7 TC's
Level 6	1622.6	1713.1	1786.0	1857.4	1968.6	2063.4	2061.4	2023.8	2012.7	1987.2	1933.3	1967.6
Level 5	1565.9	1684.6	1783.1	1851.7	1957.5	2067.1	2109.3	2110.7	2109.3	2094.2	2016.9	1998.4
Level 4	1573.0	1646.3	1746.2	1778.6	1842.7	1959.0	2090.4	2107.4	2097.8	2110.2	2078.3	1946.0
Level 3	1575.4	1620.2	1706.1	1725.3	1770.3	1813.1	1867.3	1931.3	1966.1	1950.7	1902.2	1825.6
Level 2	1548.7	1581.5	1610.4	1634.8	1677.7	1752.5	1729.7	1694.6	1717.7	1679.6	1713.2	1688.2
Level 1	1358.8	1398.8	1436.4	1469.1	1537.1	1590.1	1595.6	1564.1	1583.1	1549.0	1589.9	1539.3

Carlin

Sonic MOD Configuration 3

Burner Map looking into the Burner [°F] - Max Values — NO BOARD

	TC 1	TC 2	TC 3	TC 4	TC 5	TC 6	TC 7	TC 8	TC 9	TC 10	TC 11	AVERAGE Central 7 TC's
Level 6	1469.1	1499.1	1596.2	1769.9	1951.9	2071.2	2109.1	2102.6	2080.0	1933.2	1782.1	1954.4
Level 5	1186.8	1264.6	1366.8	1646.4	1950.5	2158.8	2241.4	2224.8	2151.8	1964.3	1847.3	1962.9
Level 4	929.5	996.7	1164.3	1410.3	1829.6	2108.4	2253.3	2204.2	2106.6	1873.2	1683.1	1868.1
Level 3	643.4	732.8	876.4	1156.3	1522.6	1797.6	2011.6	1972.0	1836.9	1535.8	1256.3	1596.2
Level 2	535.0	602.0	663.2	821.1	1128.2	1420.2	1611.3	1561.4	1431.1	1112.6	869.0	1233.8
Level 1	455.2	498.2	543.1	576.6	718.5	843.0	933.1	911.5	832.8	637.4	492.3	765.5

Burner Map looking into the Burner [°F] - Max Values — FIRE BOARD

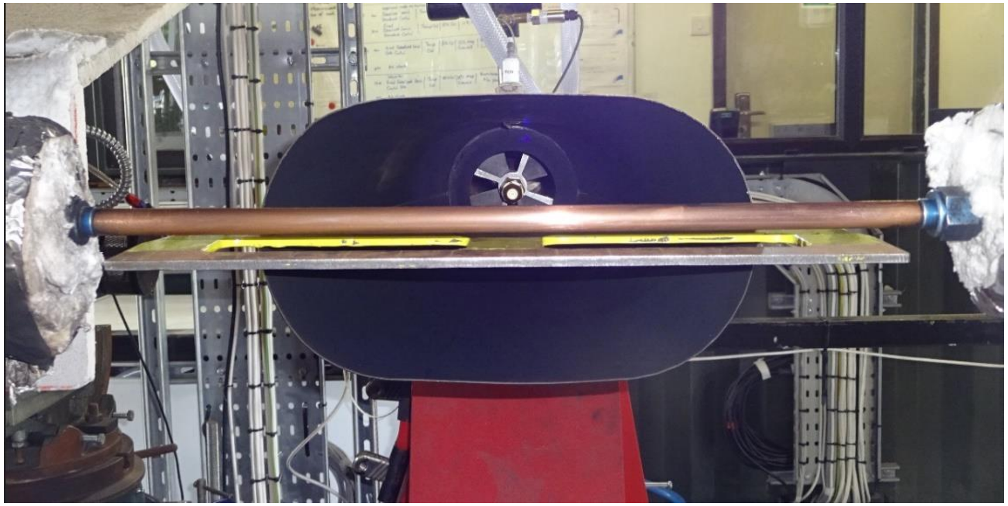
	TC 1	TC 2	TC 3	TC 4	TC 5	TC 6	TC 7	TC 8	TC 9	TC 10	TC 11	AVERAGE Central 7 TC's
Level 6	1885.0	1953.6	2042.3	2034.4	2095.1	2170.3	2231.6	2209.7	2187.9	2111.8	2039.7	2138.8
Level 5	1905.9	1980.1	2050.9	2058.1	2101.4	2203.3	2259.3	2229.3	2197.5	2130.8	2071.7	2157.1
Level 4	1909.7	1980.2	2060.3	2077.5	2124.2	2217.3	2279.8	2253.3	2223.2	2142.4	2079.5	2176.5
Level 3	1902.3	1965.5	2036.0	2091.9	2143.5	2242.7	2272.5	2224.5	2194.4	2109.8	2046.4	2172.2
Level 2	1779.2	1846.6	1886.3	1996.9	2091.9	2169.5	2153.4	2104.5	2091.9	2030.1	1981.8	2070.6
Level 1	1566.1	1668.4	1686.4	1774.3	1869.6	1922.7	1909.5	1924.5	1928.1	1866.2	1866.7	1859.3

Burner Map looking into the Burner [°F] - Max Values — FIRE WOOL

	TC 1	TC 2	TC 3	TC 4	TC 5	TC 6	TC 7	TC 8	TC 9	TC 10	TC 11	AVERAGE Central 7 TC's
Level 6	1814.9	1895.5	1945.8	2005.2	2095.4	2144.3	2187.2	2153.1	2191.6	2133.7	2086.6	2103.2
Level 5	1820.5	1930.4	1984.5	2015.9	2095.2	2206.8	2216.8	2167.7	2200.9	2149.7	2128.7	2126.8
Level 4	1861.7	1982.2	2067.4	2084.6	2157.1	2243.5	2250.3	2204.2	2218.0	2162.7	2169.5	2175.0
Level 3	1846.0	1986.0	2074.9	2102.7	2185.8	2264.4	2247.5	2200.5	2204.7	2138.9	2171.8	2182.9
Level 2	1768.7	1966.6	2089.1	2114.4	2171.7	2244.8	2221.7	2174.4	2170.8	2116.9	2125.1	2169.6
Level 1	1601.1	1834.1	1937.5	2025.9	2093.7	2125.5	2069.7	2036.1	2039.8	1970.7	1960.8	2046.9

Sonic MOD Configuration 3

Heat Flux (BTU/hr) Map – 1” vertical Increments

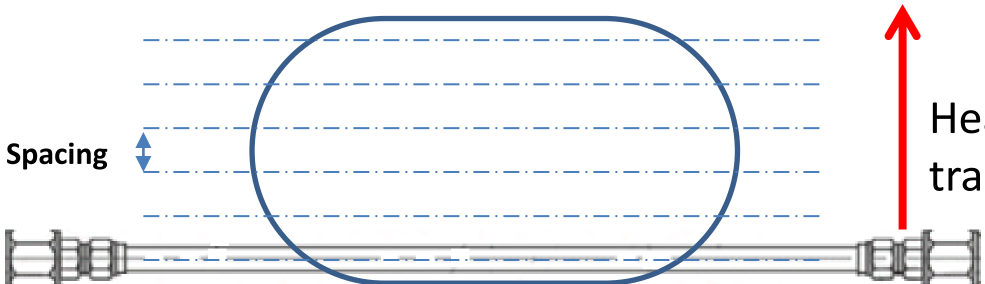


Burner BTU Map looking into the Burner [BTU/hr] - Average Values

Level 6 - 5.5 inch	3448.3
Level 5 - 4.5 inch	4452.0
Level 4 - 3.5 inch	4733.5
Level 3 - 2.5 inch	3833.7
Level 2 - 1.5 inch	2211.4
Level 1 - 0.5 inch	800.6

At each level : 1mins warm up was allowed and 3 mins of data recorded after this

1” Spacing

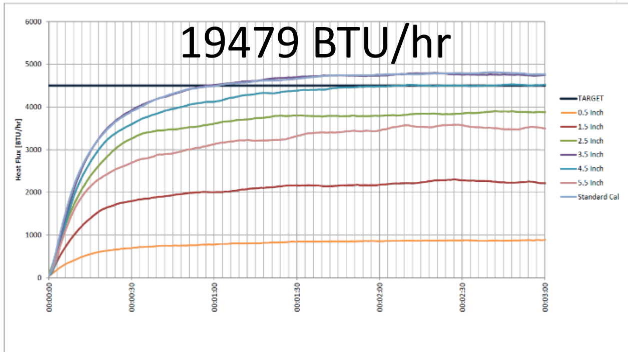


Heat flux Mapping: Copper tube transitioned in 1” increments vertically

Copper tube cleaned between levels

BTU/hr Mapping Summary

T8 - Carlin 2



Carlin Burn 2b BTU Map

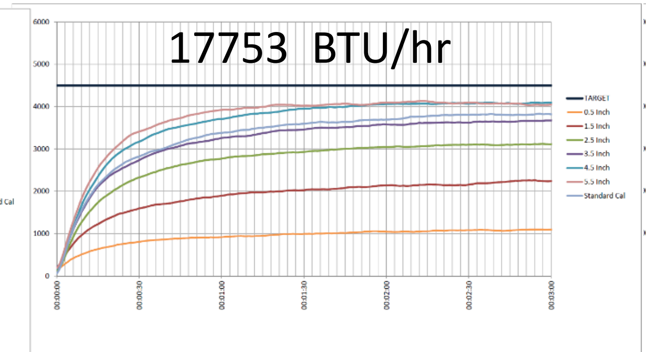
Burner BTU Map looking into the Burner [BTU/hr] - Peak Values

Level 6 - 5.5 inch	3585.2
Level 5 - 4.5 inch	4530.0
Level 4 - 3.5 inch	4800.1
Level 3 - 2.5 inch	3901.3
Level 2 - 1.5 inch	2304.1
Level 1 - 0.5 inch	885.9

Burner BTU Map looking into the Burner [BTU/hr] - Average Values

Level 6 - 5.5 inch	3448.3
Level 5 - 4.5 inch	4452.0
Level 4 - 3.5 inch	4733.5
Level 3 - 2.5 inch	3833.7
Level 2 - 1.5 inch	2211.4
Level 1 - 0.5 inch	800.6

T7 – Sonic Config 1



Sonic - FAA Burn 5 BTUmap

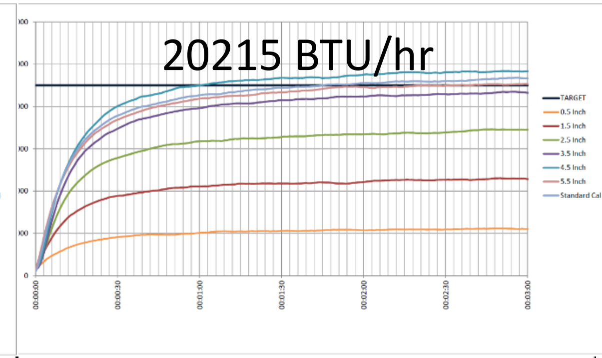
Burner BTU Map looking into the Burner [BTU/hr] - Peak Values

Level 6 - 5.5 inch	4131.9
Level 5 - 4.5 inch	4095.4
Level 4 - 3.5 inch	3673.6
Level 3 - 2.5 inch	3119.1
Level 2 - 1.5 inch	2260.9
Level 1 - 0.5 inch	1098.4

Burner BTU Map looking into the Burner [BTU/hr] - Average Values

Level 6 - 5.5 inch	4052.6
Level 5 - 4.5 inch	4001.0
Level 4 - 3.5 inch	3541.2
Level 3 - 2.5 inch	3011.6
Level 2 - 1.5 inch	2106.9
Level 1 - 0.5 inch	1040.0

T27 – Sonic Config 2



Sonic ModV3 Burn4 BTU Map

Burner BTU Map looking into the Burner [BTU/hr] - Peak Values

Level 6 - 5.5 inch	4536.6
Level 5 - 4.5 inch	4841.0
Level 4 - 3.5 inch	4350.6
Level 3 - 2.5 inch	3459.5
Level 2 - 1.5 inch	2304.6
Level 1 - 0.5 inch	1115.4

Burner BTU Map looking into the Burner [BTU/hr] - Average Values

Level 6 - 5.5 inch	4462.6
Level 5 - 4.5 inch	4778.4
Level 4 - 3.5 inch	4261.2
Level 3 - 2.5 inch	3380.5
Level 2 - 1.5 inch	2242.3
Level 1 - 0.5 inch	1090.3

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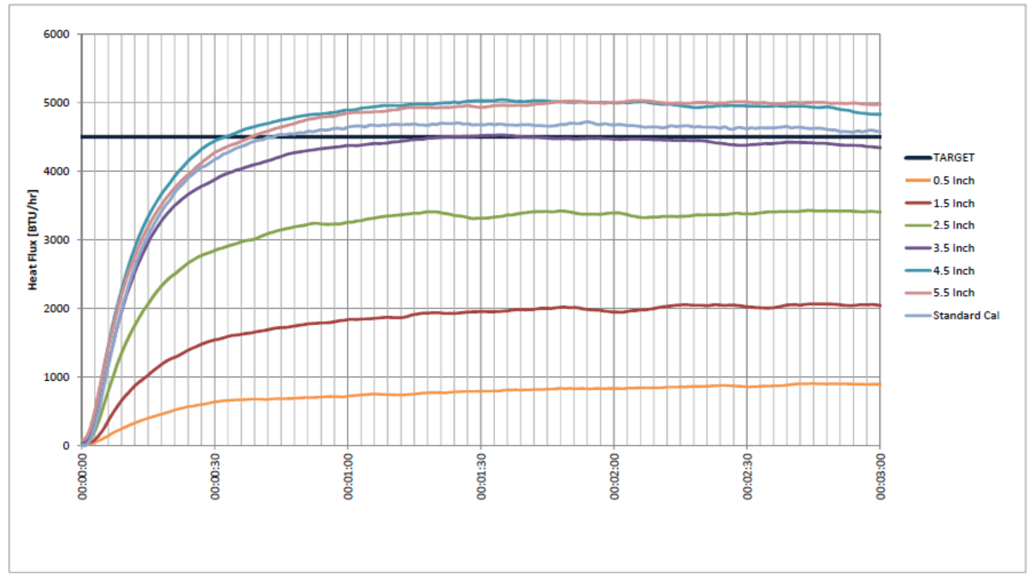
Sonic - Config 3

Cal Avg: 4721 BTU/hr

Burner BTU Map looking into the Burner [BTU/hr] - Peak Values

Level 6 - 5.5 inch	5032.7
Level 5 - 4.5 inch	5041.8
Level 4 - 3.5 inch	4529.5
Level 3 - 2.5 inch	3427.8
Level 2 - 1.5 inch	2066.6
Level 1 - 0.5 inch	903.6



Cal Avg: 4784 BTU/hr

Burner BTU Map looking into the Burner [BTU/hr] - Peak Values

Level 6 - 5.5 inch	5262.2
Level 5 - 4.5 inch	5181.6
Level 4 - 3.5 inch	4464.6
Level 3 - 2.5 inch	3292.9
Level 2 - 1.5 inch	1843.1
Level 1 - 0.5 inch	778.9

Burner Map looking into the Burner [°F] - Max Values NO BOARD

	TC 1	TC 2	TC 3	TC 4	TC 5	TC 6	TC 7	TC 8	TC 9	TC 10	TC 11	AVERAGE Central 7 TC's
Level 6	1469.5	1519.4	1603.6	1755.1	1956.9	2057.9	2099.8	2092.2	2101.0	1951.4	1786.7	1952.4
Level 5	1210.4	1261.1	1376.4	1650.2	1943.8	2161.5	2241.3	2219.1	2168.4	1980.2	1863.9	1965.8
Level 4	868.2	996.8	1138.7	1416.5	1831.3	2126.1	2240.0	2214.4	2129.7	1873.1	1705.4	1870.9
Level 3	607.2	679.8	802.6	1024.8	1417.7	1733.6	1975.8	1993.7	1917.4	1611.9	1383.3	1552.2
Level 2	448.2	527.7	593.9	711.8	1024.5	1334.4	1501.0	1478.8	1409.6	1121.3	895.4	1150.6
Level 1	340.6	394.2	435.7	461.7	596.1	741.5	871.0	834.9	742.2	588.5	448.1	669.0

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MATERIAL BURNTHROUGH DATA

Composite Panel Burnthough

- **Composite panels supplied by Bombardier/Shorts**
  - 2 plies (0°/45°), roughly 0.030″ thick
- **Burner calibrated to minimum avg of 2000°F across 7 T/C's, Heat Flux >4500 btu/hr**
  - stabilized on Cu tube for 1 minute
- **Total of 6 panels tested**
  - 3 with vibration applied at differing times during test
  - 1 with no vibration
  - 1 with a bolt installed in the middle
  - 1 with bolt installed with a 5 kg weight applied in tension

Resonate Testing

	TEMP (min Avg)	BTU/Hr	Burnthrough TIME	Vibration applied @	Summary	Comment
Panel 1	2025	4696	00:27:16	20:20	Wednesday Afternoon.	Vibration applied in the expection of generating expeditated Burnthrough- No significant impact observed.
Panel 2	2010	4606	00:25:18	20:20	Wednesday Afternoon.	
Panel 3	2011	4641	00:26:30	00:00	Thursday Morning Applied vibration has no impact?	Vibration 4G applied from start. NO IMPACT- Vibration discontinued.
Panel 4	2116	5234	0:24:45	No Vibe	Thursday Afternoon Increased BTU does not significantly affect burnthrough time	Excess Flame temp and BTU/hr applied. NO IMPACT.
Panel 5	2035	4720	0:20:00		Bolt installed in center of panel	1 week later returned with new approach. Stopped test- Bolt making no impact
Panel 6	2019	4839	0:22:34		Bolt installed in center of panel with a 5kg load	Pull through eventually achieved!

Test 4 Flame artificially high, no significant impact.

Test 6 Pull Through load, no significant impact.

Resonate Testing

Resonate Testing

Aluminium Panel Burnthrough

T9 - Carlin Panel 3
(**<u>2:23 second BT)</u>**

T19 - Sonic Mod 5
(**<u>3:16 second BT</u>**)

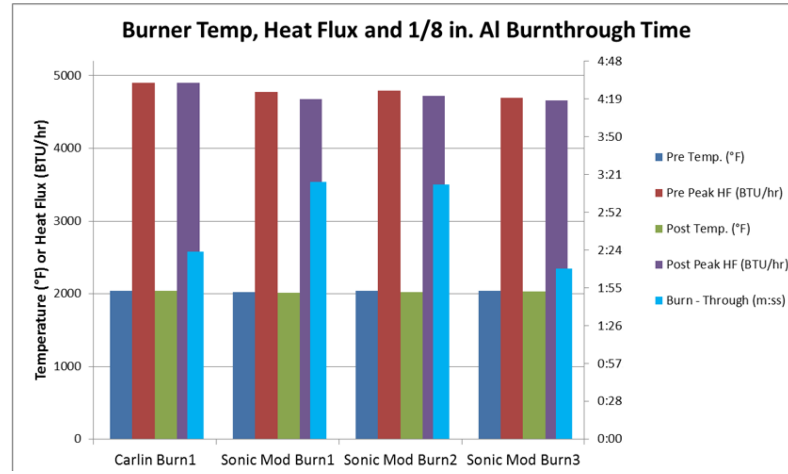
T22 - Sonic Mod 8
(**<u>3:14 second BT</u>**)

T30 - Sonic Mod 16
(**<u>2:10 second BT</u>**)

Aluminium Panel Burnthrough

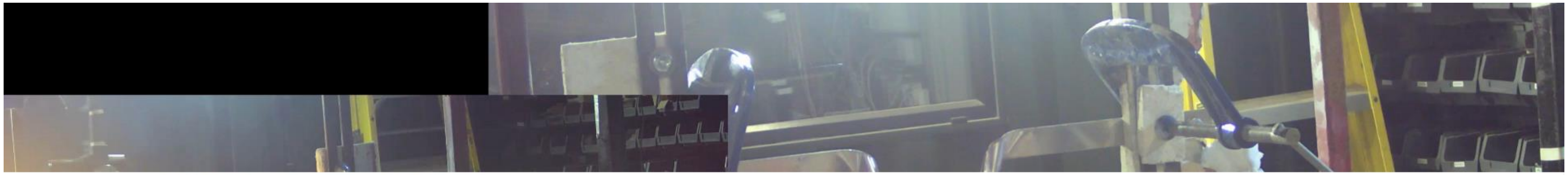
Burn Times for 1/8 in. Thick Aluminum

Burn #	Burner / Config.	Pre-Test Avg. Temp. (°F)	Pre-Test Avg. Heat Flux (BTU/hr)	Post-Test Avg. Temp. (°F)	Post-Test Avg. Heat Flux (BTU/hr)	Burn - Through Time (m:ss)
1 – T9	Carlin Baseline July 17	2033	4922 0:39 to 4500	2035	4875 0:41 to 4500	2:23
2 – T19	Sonic Mod. P_f=147, P_a=61.5 July 19	2022	4670 1:29 to 4500	2014	4599 1:45 to 4500	3:16
3 – T22	Sonic Mod. P_f=147, P_a=61.5 July 19	2040	4693 1:33 to 4500	2019	4630 2:35 to 4500	3:14
4 – T30	Sonic Mod. P_f=147, P_a=61.5 July 20	2039	4685 2:13 to 4500	2030	4662 2:42 to 4500	2:10



- Difficulty determining burn through time
- Skin tension of ALU
- Oxidised layer/impurities on surface
- Ultimately too many variables

Aluminium strip burnthrough testing



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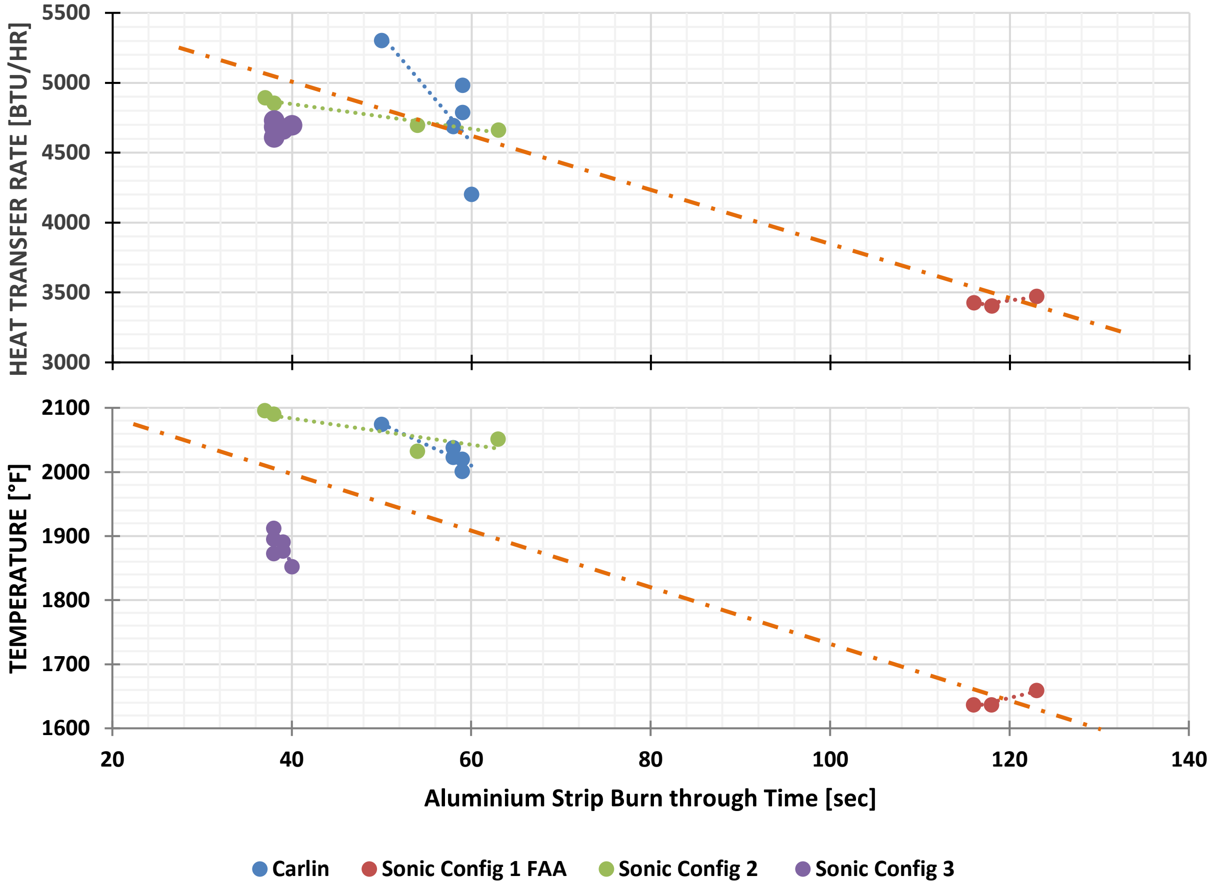
Temperature and heat transfer calibrations

-Effect on Burnthrough time



Summary of Observations

- Sonic can be modified from current configuration to achieve traditional burner like output
  - Similar to work FAATC conducted with flame retention
  - Can calibrate sonic burner according to current AC20-135 guidance and equipment
  - Does not take advantage of the expected Sonic burner repeatability – but have we seen this?

- Tools developed to achieve greater understanding of burner outputs
  - 2D HD temperature maps
    - with and without impingement surface
  - BTU mapping
  - All to better qualify burner flames for comparison during any research effort
    - Ensure that we know where the hottest part of the flame is and the highest energy and relate that to calibration sensor location.

- Do not draw major conclusions from shallow data sets.
  - We always need to assess the significance of our data. This is particularly important when talking about repeatability or reliability.

Future Work:

Collaboration planned going forward with a small group of other Labs looking at:

– Is there a configuration on the sonic burner that we can dial in the inputs and achieve consistent calibration parameters for powerplant testing

- Sensitivity study of burner parameters – could potentially further simplify set up
- Studying the modified Sonic Burner with off-the-shelf parts

– Is there a better way to determine equivalent damage to compare the sonic with incumbent burners

- Additional mapping ideas/plate thermocouples/slug calorimeter/
- Composite panels?
- Better understanding individual burner limitations and sources of variability

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For further information on capabilities of **Resonate Testing Ltd** please do not hesitate to contact:

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