U. S. Department of Justice

Fire Research Laboratory
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Test record

ASCLD/LAB–*International* Testing Accreditation
Certificate ALI-217-T

Title	Halogen Lamp Testing		
Test Type	Custom		
Lab Number	14F0037-2	**Author**	
Test dates	8/27/15, 8/28/15, 8/31/15	**No. Tests**	9

Introduction

A series of nine experiments were conducted to observe and characterize the operation temperatures and heat flux of a halogen torchiere luminaire. The experiments were documented using thermocouples, a heat flux gauge, and still photography and were conducted in the Electrical Engineering Laboratory of the Bureau of Alcohol, Tobacco, Firearms and Explosives Fire Research Laboratory (ATF FRL) located in Beltsville, MD.

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NOTE : All dimensional measurements taken in English units were later converted to metric units. Any inconsistencies between the two units are due to rounding errors when the English units were converted to metric.

Experiment Set Up

The experiments were designed to characterize the temperature and energy produced by a 300 watt halogen luminaire. The experiments were conducted in open air under ambient conditions. Three thermocouples and one heat-flux gauge were used to measure temperature and heat flux (Figure 1).

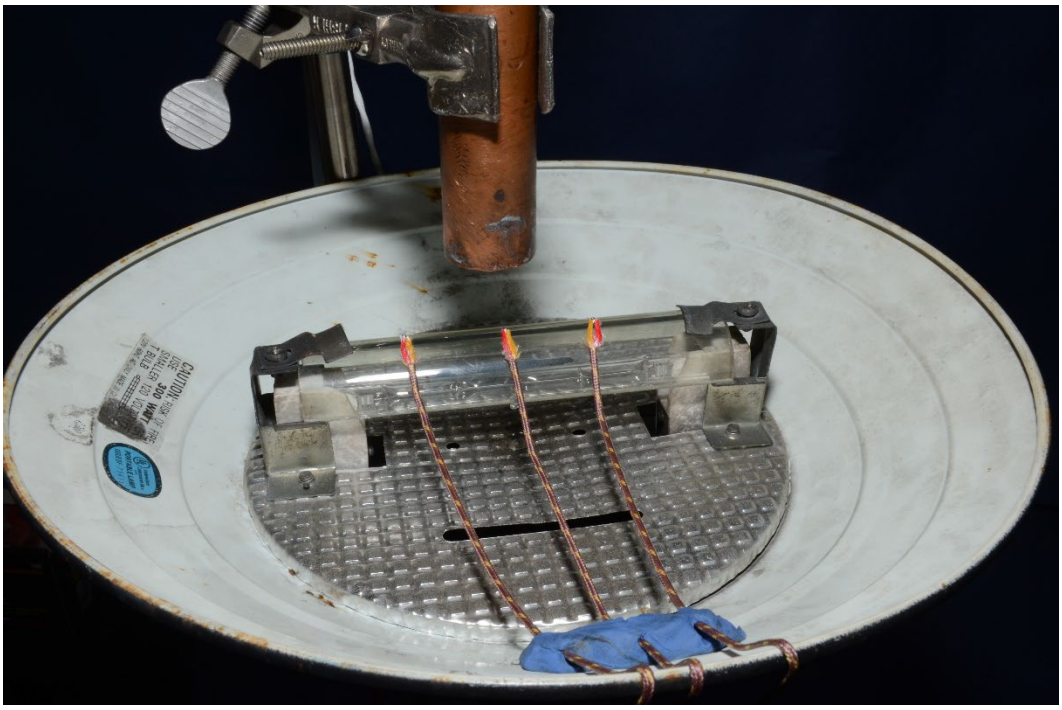


Figure 1: Overall testing setup with thermocouples and heat-flux gauge. (61654_543385)

Luminaire Details

The luminaire consisted of a weighted base with a tubular upright stand (Figure 2). The base was approximately 26 cm (10.25 inch) in diameter, and had a hole in the center for the power cord to pass through into the stand. The stand consisted of three metal tubes that were approximately 3.25 cm (1.25 inch) in diameter and approximately 54.5 cm (21.5 inch) long. The switch was located approximately 6 cm (2.38 inch) from the bottom of the top tube. The lamp assembly consisted of a metal bowl-shaped reflector that was approximately 28 cm (11 inch) in diameter and 8 cm (3 inch) deep.

Figure 2 - Halogen luminaire used for testing. (61654_543434)

A Philips 300 watt T3 halogen lamp was installed in the luminaire (Figure 3).

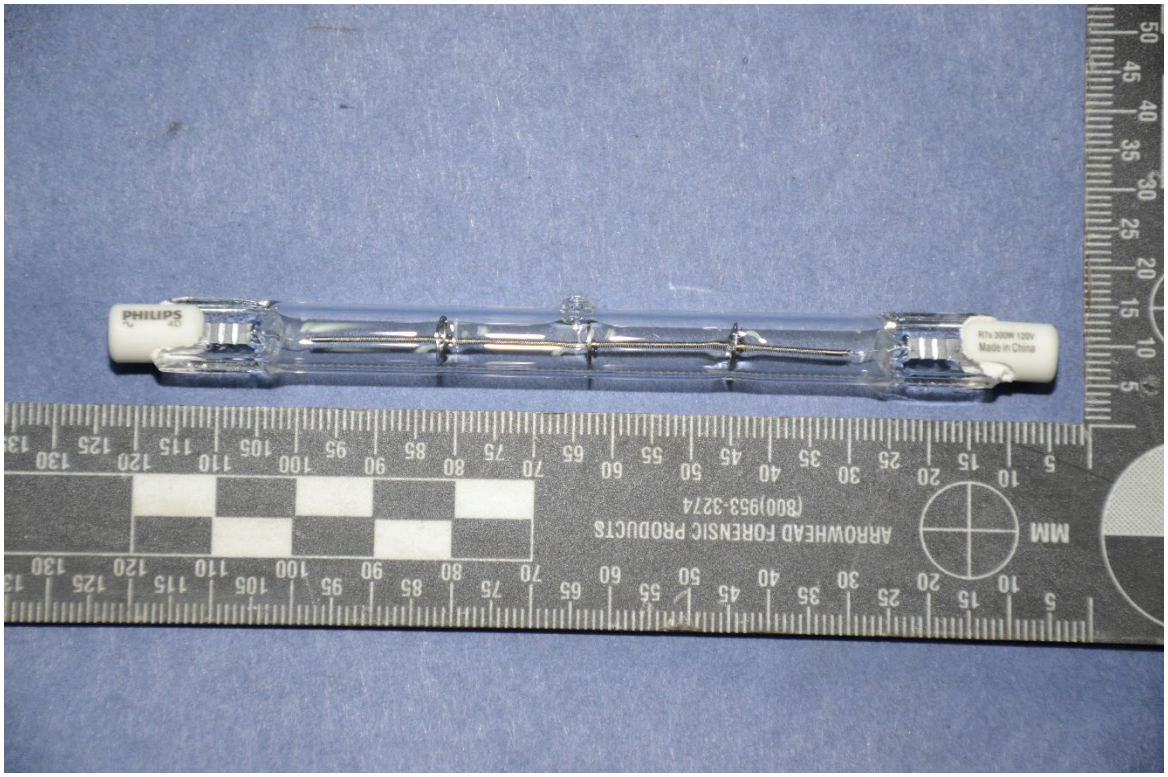


Figure 3 - Halogen lamp used for testing. (61654_543456)

A clear crystal shield was installed (by the manufacturer) to prevent combustible materials from coming into contact with the lamp (Figure 4). The shield was approximately 12 cm (4.75 inch) long and had a radius of approximately 1.5 cm (0.6 inch).

Figure 4 - Crystal shield. (61654_543450)

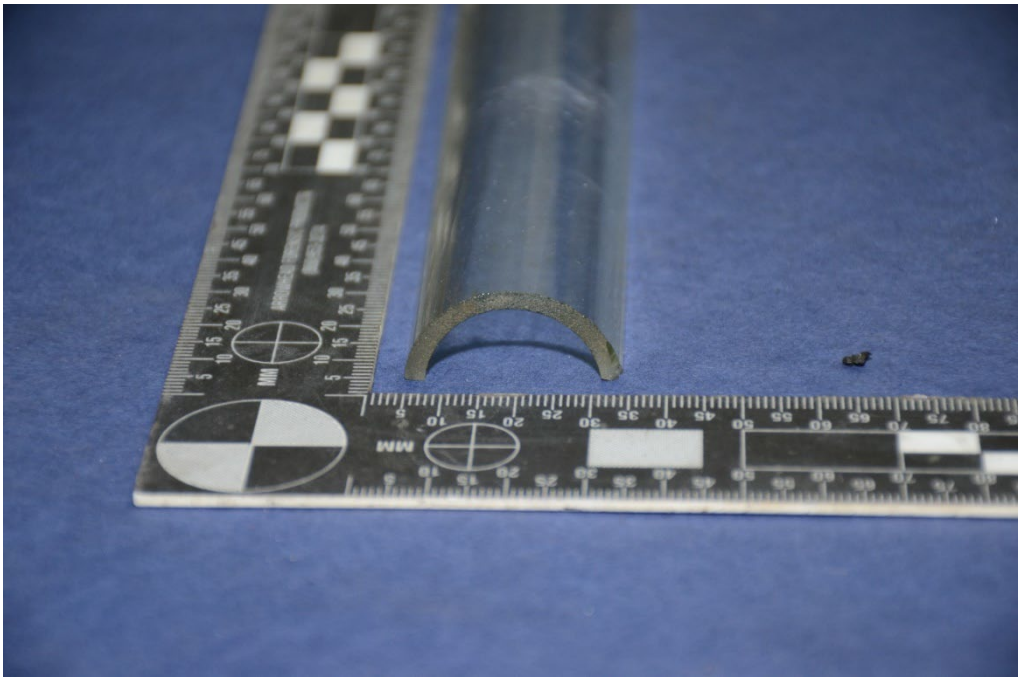


Figure 5 - Crystal shield. (61654_543451)

Experiment Details

Experiment Variables

Three variables were examined: appliance (luminaire) power setting, the presence/absence of the crystal lamp shield, and the appliance orientation (horizontal / vertical). One experiment was conducted to examine each of the eight variable combinations. The conditions for each experiment are described in Table 1. Experiment 61727 was stopped at 517 seconds because heat from the lamp the caused clay holding the thermocouples in place to melt. This experiment was repeated in experiment 61736.

Table 1 - Experiment Details

Experiment ID	Experiment Date	Luminaire Setting	Lamp Shield	Orientation
61655	8/27/2015	Low	In Place	Upright
61666	8/27/2015	High	In Place	Upright
61669	8/28/2015	Low	Removed	Upright
61672	8/28/2015	High	Removed	Upright
61709	8/28/2015	Low	Removed	Horizontal
61727	8/28/2015	High	Removed	Horizontal
61736	8/31/2015	High	Removed	Horizontal
61737	8/31/2015	Low	In Place	Horizontal
61738	8/31/2015	High	In Place	Horizontal

Experiment Procedures

Nine experiments were conducted in this test series. In each experiment data collection was started, and a short time later the appliance was energized. The appliance remained energized for approximately 60 minutes. After 60 minutes the appliance was de-energized; measurements continued for another 15 minutes while the appliance cooled.

Instrumentation

Three Type K thermocouples were used to measure temperature. The thermocouples were held in place using a small amount of clay, as shown in Figure 1. For the experiments with the shield in place, the thermocouples were installed to measure the air temperature immediately adjacent to the shield. The thermocouples were installed such that the hot junction was directly above the shield (Figure 6 - Figure 7). For the experiments without the shield, the thermocouples were installed to measure the air temperature immediately adjacent to the lamp. The thermocouples were installed such that the hot junction was directly above the lamp. In these experiments the heat flux gauge was placed approximately 2.5 cm (1 inch) above the lamp.

One water-cooled Schmidt-Boelter heat flux gauge was used. When the shield was in place, the heat flux gauge was placed approximately 2.5 cm above the shield. (Figure 6 - Figure 8).

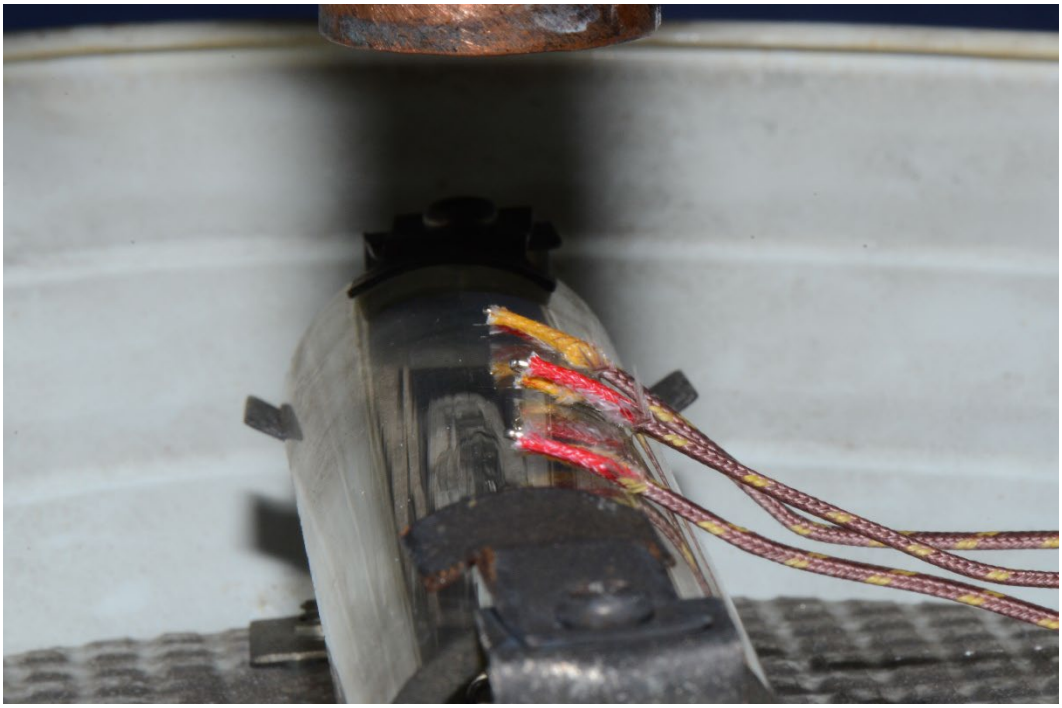


Figure 6: Thermocouples placed on top of the protective shield, in line with the center of the lamp. (61654_543389)

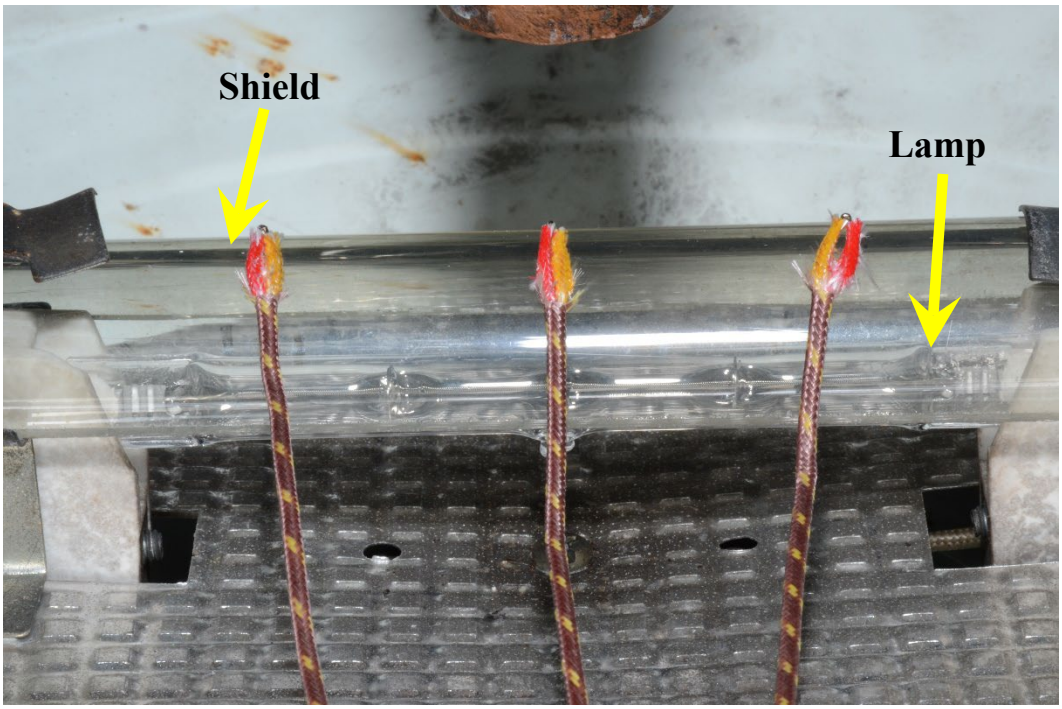


Figure 7: Thermocouples along the length of the lamp. (61654_543391)

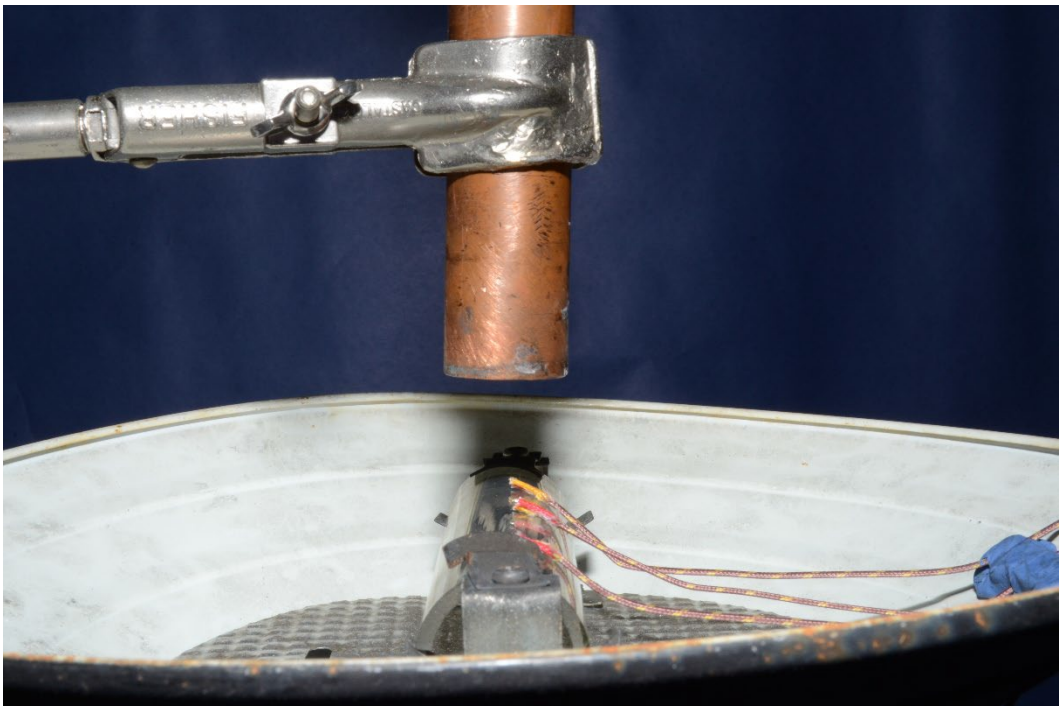


Figure 8: Heat flux gauge over the center of the lamp. (61654_543387)

Laboratory Conditions

The ambient laboratory temperature, barometric pressure, and relative humidity were measured during the experiment(s). The laboratory conditions were measured using an industrial probe and microserver. The probe measures the ambient conditions using capacitive digital sensors. The sensor probe has surface mounted circuitry which responds to changes in the environment and outputs a digital signal. The Laboratory Conditions were measured in accordance with the method defined in FRL Laboratory Instruction "LI017 Laboratory Conditions" [1].
The following table provides a description of the instrumentation used to collect the ambient laboratory conditions measurements during the experiments.

Table 2. Lab Conditions Description

Description	Manufacturer	Model
MOBILE	OMEGA	IBTHX-D

Thermocouples

Thermocouples are temperature measurement sensors that consist of two dissimilar metals joined at one end (a junction) that produces a small thermo-electrical voltage when the wire is heated. The change in voltage is interpreted as a change in temperature

[2]. There are many configurations of thermocouples which affect the temperature range, ruggedness, and response time. The information required to identify these factors for the thermocouples that were used during the experiment(s) conducted for this test series is provided in the "Thermocouple Measurement Description" table. Thermocouples used during this test series were used in accordance with the method defined in FRL laboratory instruction "LI001 Thermocouple" [3].

The following table provides a description of the instrumentation used to collect the temperature measurements during the experiments. The "Description" column describes the location of the temperature measurement. The "Thermocouple Type" describes the characteristics of the thermocouple used.

Table 3. Thermocouple Measurement Description

Description	Thermocouple type
Right	Type K, Glass Ins., 24 AWG wire
Middle	Type K, Glass Ins., 24 AWG wire
Left	Type K, Glass Ins., 24 AWG wire

Heat Flux Transducers

A heat flux transducer is a device that measures the rate of absorbed incident energy, and expresses it on a per unit area basis. The operating principle of the Schmidt-Boelter heat flux transducer(s) used during this test series is based on one-dimensional heat conduction through a solid. Temperature sensors are placed on a thin, thermally conductive sensor element, and applying heat establishes a temperature gradient across the element. The heat flux is proportional to the temperature difference across the element according to Fourier's Law [4].

There are many configurations of heat flux transducers which affect range, size, mode and sensitivity. The information required to identify these factors for the heat flux transducer(s) that were used during the experiment(s) conducted for this test series is provided in the "Heat Flux Measurement Description" table. Heat flux transducers were used in accordance with the method defined in FRL laboratory instruction "LI002 Heat Flux Transducer" [5].

The following table provides a description of the transducer used to collect heat flux measurements during the experiment(s). The "Description" column typically describes the location of the heat flux transducer. Heat flux mode indicates whether the total heat flux was measured or just the radiation fraction.

Table 4. Heat Flux Measurement Description

Description	Heat Flux Mode
25 kw HF gauge	Total

Set Up Photos

The following shows photographs of the experiment setup.

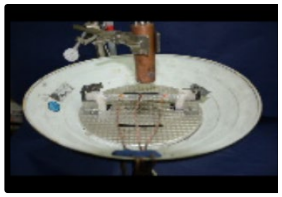


Figure 9.
61655_543392

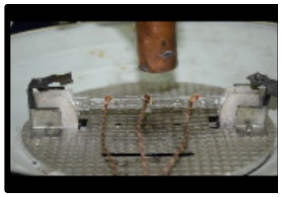


Figure 10.
61655_543393

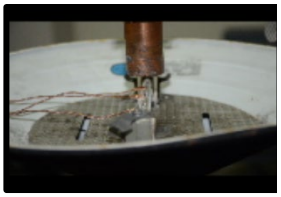


Figure 11.
61655_543394

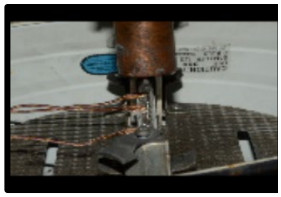


Figure 12.
61655_543395

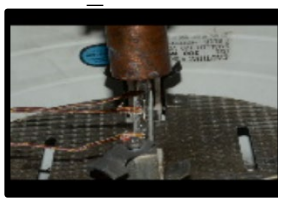


Figure 13.
61655_543396

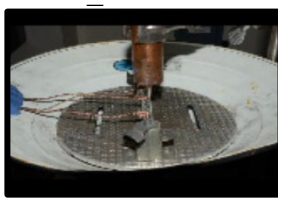


Figure 14.
61655_543397


Figure 15.
61655_543398


Figure 16.
61655_543399


Figure 17.
61669_543400

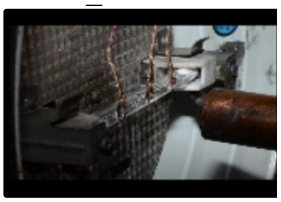

Figure 18.
61669_543401


Figure 19.
61669_543402


Figure 20.
61669_543403


Figure 21.
61669_543404


Figure 22.
61669_543405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61669_543406


Figure 24.
61669_543407


Figure 25.
61669_543408


Figure 26.
61669_543409

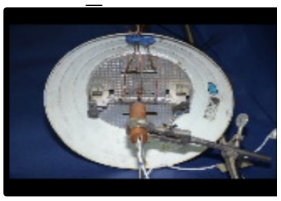
Figure 27.
61669_543410


Figure 28.
61669_543411

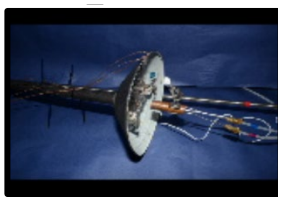
Figure 29.
61669_543412


Figure 30.
61669_543413


Figure 31.
61669_543414


Figure 32.
61669_543415

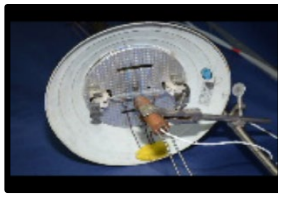

Figure 33.
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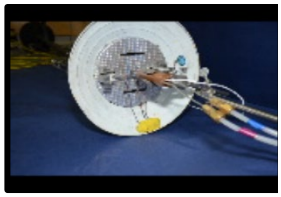

Figure 34.
61669_543417

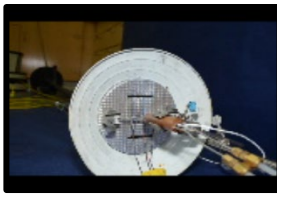

Figure 35.
61669_543418

Figure 36.
61669_543419

Figure 37.
61736_543422

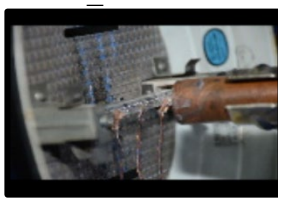

Figure 38.
61736_543423

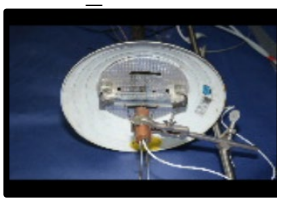

Figure 39.
61736_543424

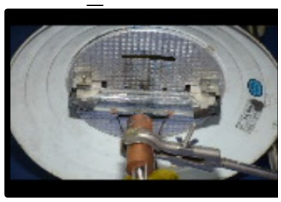

Figure 40.
61736_543425

Figure 41.
61736_543426

Figure 42.
61736_543427

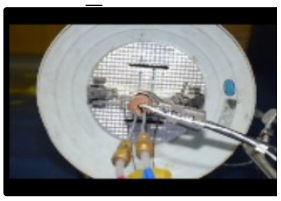

Figure 43.
61736_543428

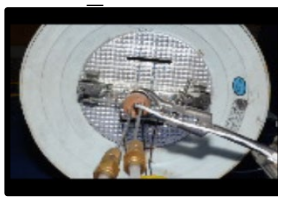

Figure 44.
61736_543429

Experiment Photographs

Digital Cameras are used within the FRL to record digital still photographs during experiments. Digital Cameras used during this test series were used in accordance with the method defined in FRL Laboratory Instruction "LI003 Digital Cameras" [6].

Results for Test 1 (ID 61655)

The following table provides a summary of the temperature results. The "Initial" column provides the measured temperature at the beginning of the test. The maximum temperature recorded during the test is provided in the "Max" column. The remaining columns provide the calculated maximum average temperatures.

Table 5. Temperature Value Result Summary

Description	Initial (C)	Max (C)	30 second maximum average (C)	60 second maximum average (C)	300 second maximum average (C)	600 second maximum average (C)
Right	21	199	196	195	192	191
Middle	20	220	217	217	213	209
Left	20	182	180	178	176	175

The following chart(s) present a time-dependent representation of the instantaneous temperatures measured during the experiment.

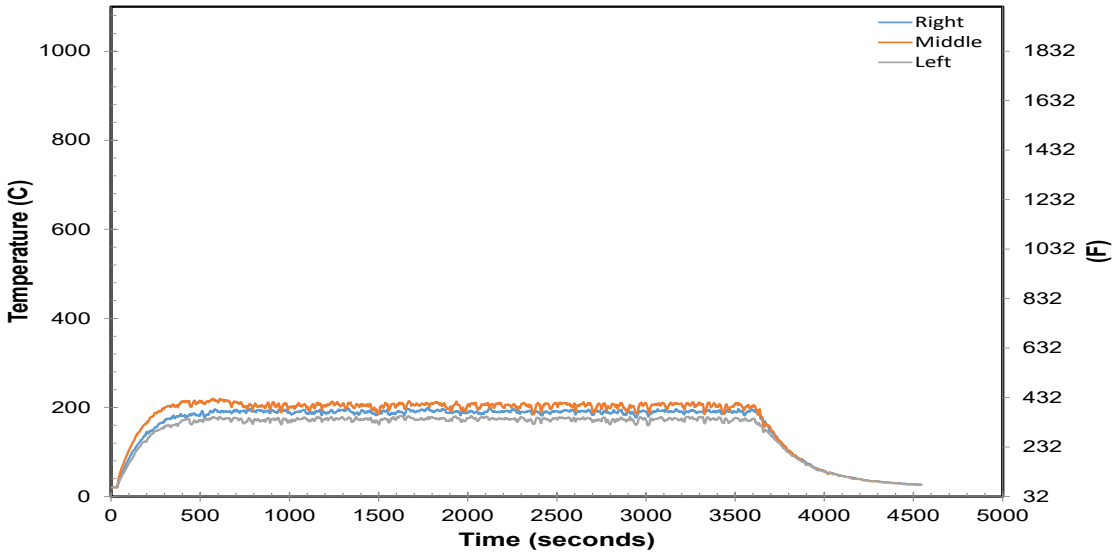

Figure 45. Temperature

The following table provides a summary of the heat flux results. The "Description" column typically describes the location of the heat flux transducer. The time at which the heat flux first changes by a pre-determined amount is provided in the "Time of Initial Change" column. The pre-determined amount of change in heat flux is provided in the "Initial Change Amount" column. The maximum heat flux recorded during the test is provided in the "Maximum" column. The "Maximum Average" columns are calculated over four pre-determined time spans.

Table 6. Heat Flux Result Summary

Description	Time of Initial Change (s)	Initial Change Value (kW/m²)	Maximum (kW/m²)	30 second maximum average (kW/m²)	60 second maximum average (kW/m²)	300 second maximum average (kW/m²)	600 second maximum average (kW/m²)
25 kw HF gauge	100	5	7.1	6.3	6.2	5.9	5.8

The following chart shows a time dependent representation of the instantaneous heat flux measured during the experiment.

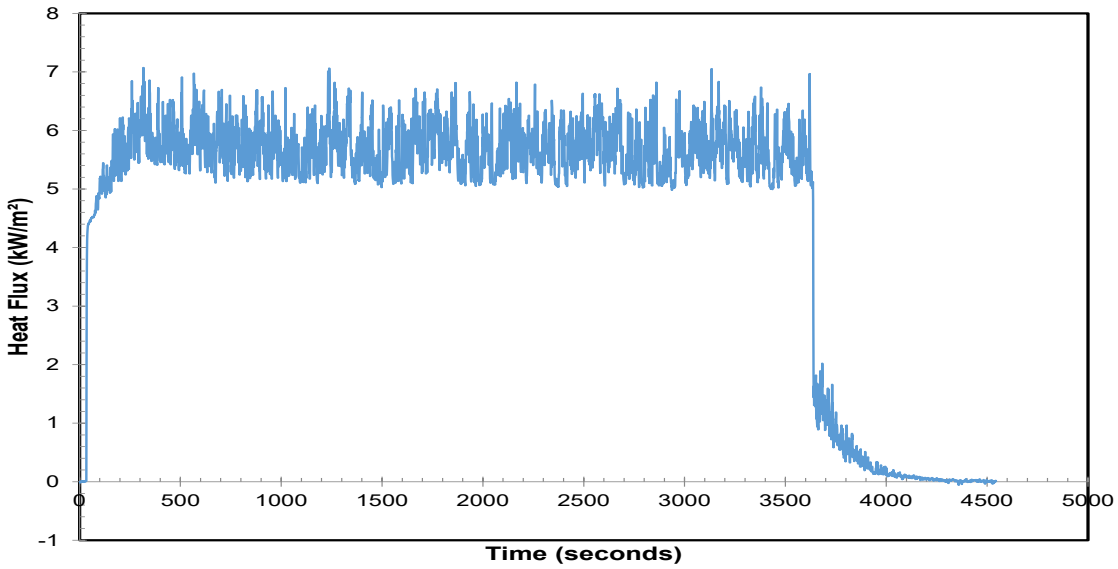

Figure 46. Heat Flux

Results for Test 2 (ID 61666)

The following table provides a summary of the temperature results. The "Initial" column provides the measured temperature at the beginning of the test. The maximum temperature recorded during the test is provided in the "Max" column. The remaining columns provide the calculated maximum average temperatures.

Table 7. Temperature Value Result Summary

Description	Initial (C)	Max (C)	30 second maximum average (C)	60 second maximum average (C)	300 second maximum average (C)	600 second maximum average (C)
Right	21	240	232	231	227	224
Middle	21	272	267	265	257	253
Left	21	230	226	223	220	218

The following chart(s) present a time-dependent representation of the instantaneous temperatures measured during the experiment.

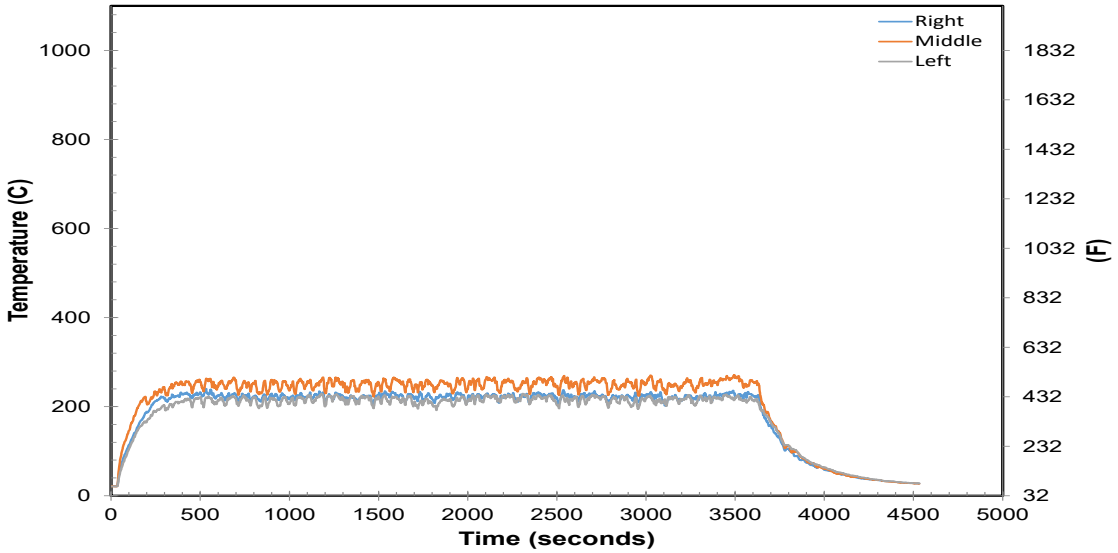

Figure 47. Temperature

The following table provides a summary of the heat flux results. The "Description" column typically describes the location of the heat flux transducer. The time at which the heat flux first changes by a pre-determined amount is provided in the "Time of Initial Change" column. The pre-determined amount of change in heat flux is provided in the "Initial Change Amount" column. The maximum heat flux recorded during the test is provided in the "Maximum" column. The "Maximum Average" columns are calculated over four pre-determined time spans.

Table 8. Heat Flux Result Summary

Description	Time of Initial Change (s)	Initial Change Value (kW/m²)	Maximum (kW/m²)	30 second maximum average (kW/m²)	60 second maximum average (kW/m²)	300 second maximum average (kW/m²)	600 second maximum average (kW/m²)
25 kw HF gauge	37	5	11.8	10.4	10.1	9.8	9.8

The following chart shows a time dependent representation of the instantaneous heat flux measured during the experiment.

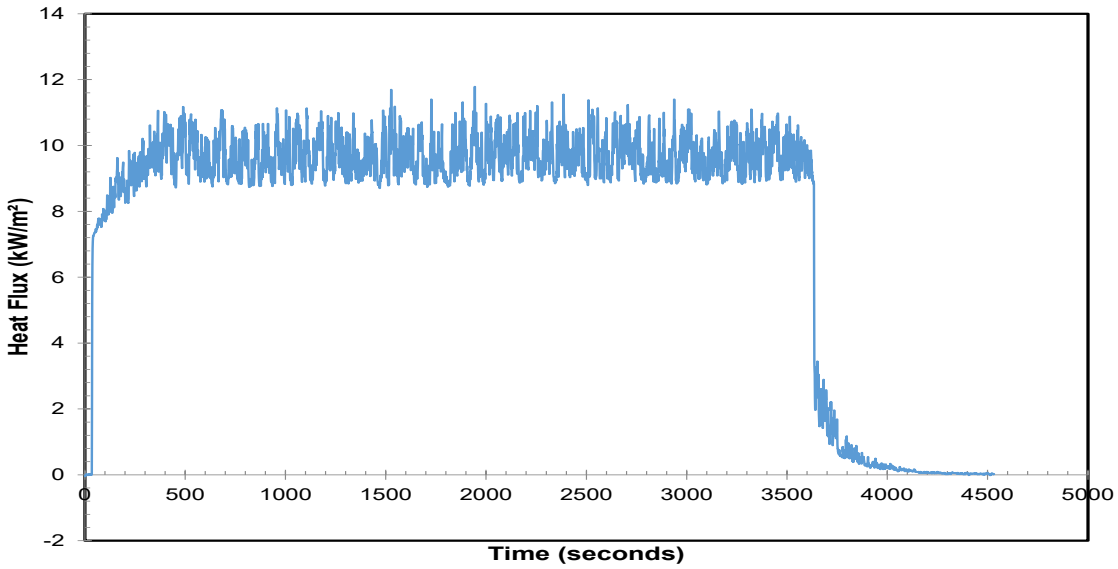

Figure 48. Heat Flux

Results for Test 3 (ID 61669)

The following table provides a summary of the temperature results. The "Initial" column provides the measured temperature at the beginning of the test. The maximum temperature recorded during the test is provided in the "Max" column. The remaining columns provide the calculated maximum average temperatures.

Table 9. Temperature Value Result Summary

Description	Initial (C)	Max (C)	30 second maximum average (C)	60 second maximum average (C)	300 second maximum average (C)	600 second maximum average (C)
Right	21	328	322	319	317	316
Middle	20	279	275	275	266	259
Left	20	324	321	320	317	312

The following chart(s) present a time-dependent representation of the instantaneous temperatures measured during the experiment.

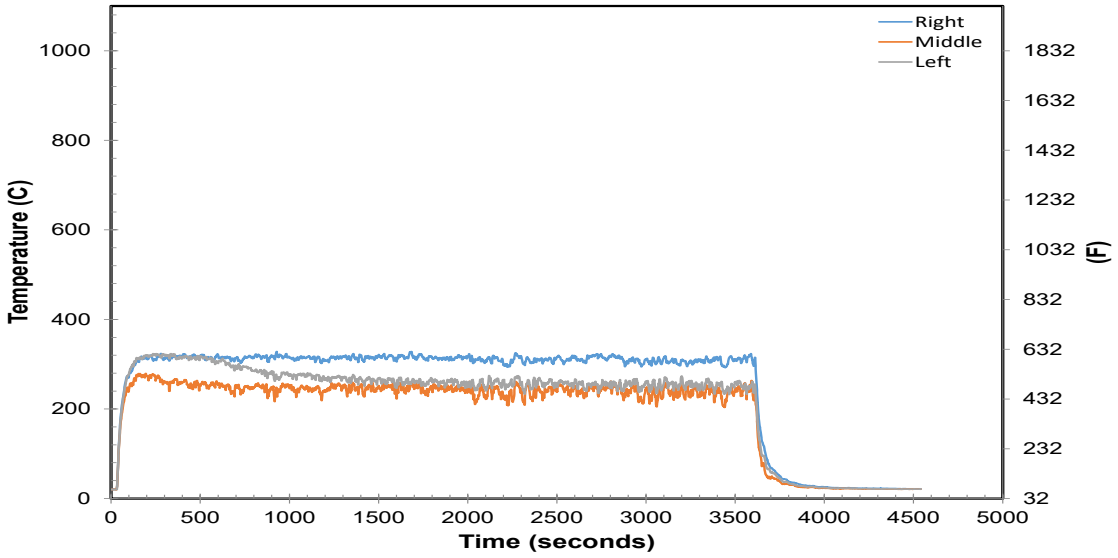

Figure 49. Temperature

The following table provides a summary of the heat flux results. The "Description" column typically describes the location of the heat flux transducer. The time at which the heat flux first changes by a pre-determined amount is provided in the "Time of Initial Change" column. The pre-determined amount of change in heat flux is provided in the "Initial Change Amount" column. The maximum heat flux recorded during the test is provided in the "Maximum" column. The "Maximum Average" columns are calculated over four pre-determined time spans.

Table 10. Heat Flux Result Summary

Description	Time of Initial Change (s)	Initial Change Value (kW/m²)	Maximum (kW/m²)	30 second maximum average (kW/m²)	60 second maximum average (kW/m²)	300 second maximum average (kW/m²)	600 second maximum average (kW/m²)
25 kw HF gauge	34	5	16.2	14.6	14.4	14.1	14

The following chart shows a time dependent representation of the instantaneous heat flux measured during the experiment.

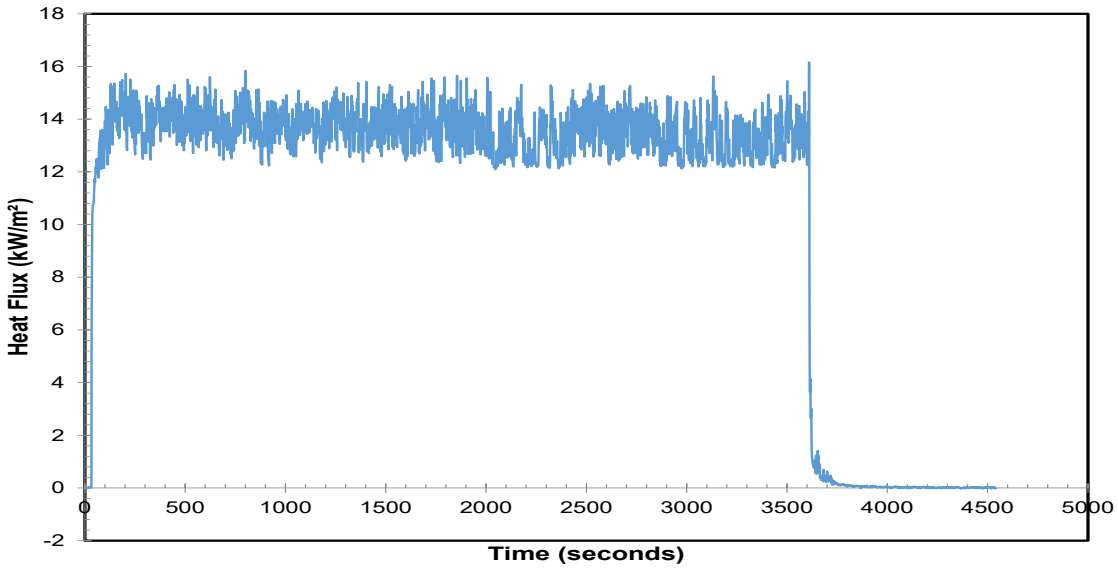

Figure 50. Heat Flux

Results for Test 4 (ID 61672)

The following table provides a summary of the temperature results. The "Initial" column provides the measured temperature at the beginning of the test. The maximum temperature recorded during the test is provided in the "Max" column. The remaining columns provide the calculated maximum average temperatures.

Table 11. Temperature Value Result Summary

Description	Initial (C)	Max (C)	30 second maximum average (C)	60 second maximum average (C)	300 second maximum average (C)	600 second maximum average (C)
Right	21	426	421	418	410	407
Middle	21	375	368	365	353	350
Left	21	386	375	371	359	345

The following chart(s) present a time-dependent representation of the instantaneous temperatures measured during the experiment.

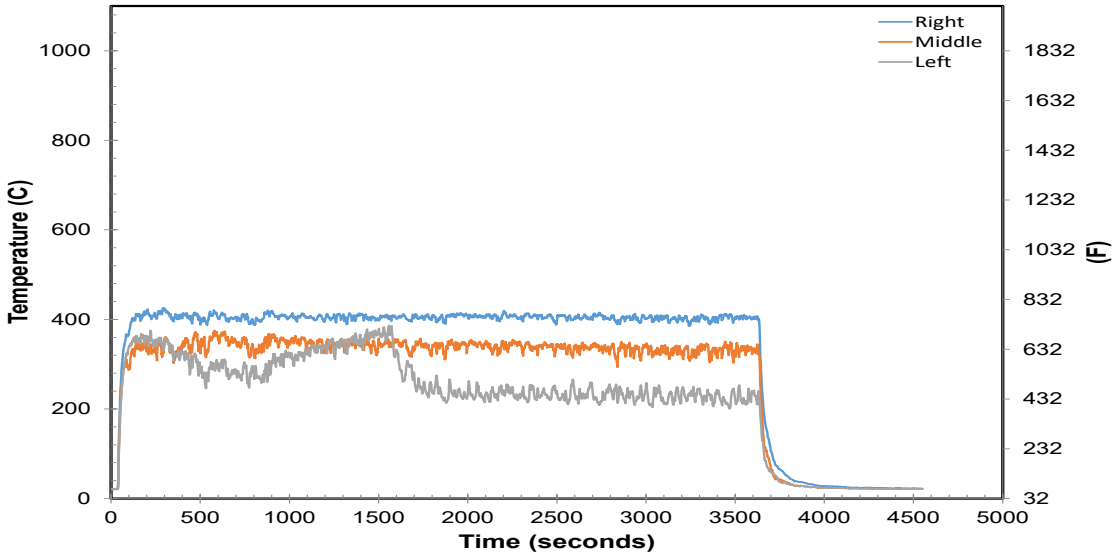

Figure 51. Temperature

The following table provides a summary of the heat flux results. The "Description" column typically describes the location of the heat flux transducer. The time at which the heat flux first changes by a pre-determined amount is provided in the "Time of Initial Change" column. The pre-determined amount of change in heat flux is provided in the "Initial Change Amount" column. The maximum heat flux recorded during the test is provided in the "Maximum" column. The "Maximum Average" columns are calculated over four pre-determined time spans.

Table 12. Heat Flux Result Summary

Description	Time of Initial Change (s)	Initial Change Value (kW/m²)	Maximum (kW/m²)	30 second maximum average (kW/m²)	60 second maximum average (kW/m²)	300 second maximum average (kW/m²)	600 second maximum average (kW/m²)
25 kw HF gauge	39	5	24.9	23.4	23.2	22.9	22.8

The following chart shows a time dependent representation of the instantaneous heat flux measured during the experiment.

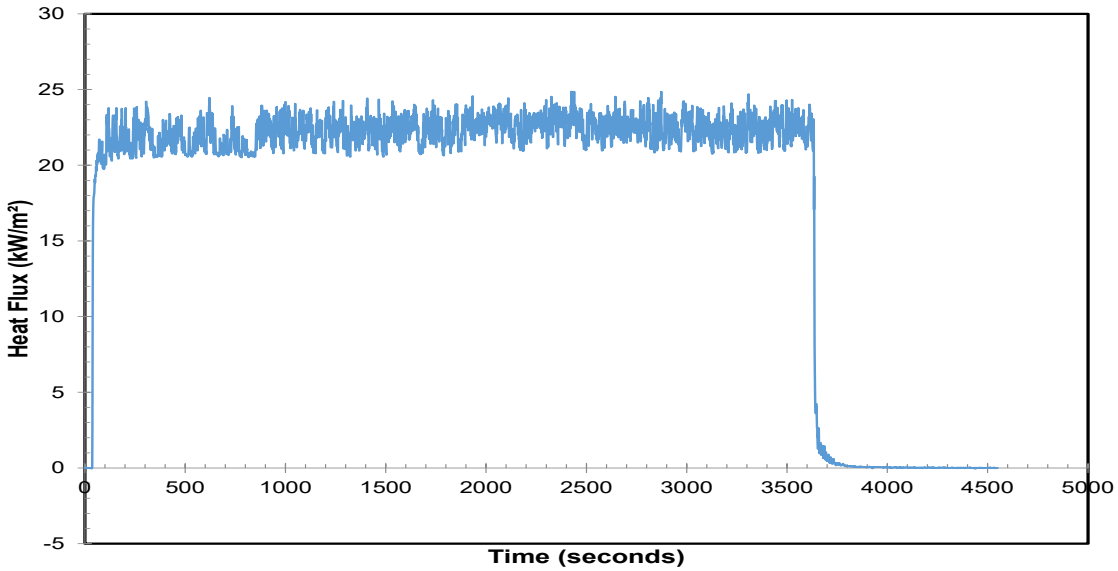

Figure 52. Heat Flux

Results for Test 5 (ID 61709)

The following table provides a summary of the temperature results. The "Initial" column provides the measured temperature at the beginning of the test. The maximum temperature recorded during the test is provided in the "Max" column. The remaining columns provide the calculated maximum average temperatures.

Table 13. Temperature Value Result Summary

Description	Initial (C)	Max (C)	30 second maximum average (C)	60 second maximum average (C)	300 second maximum average (C)	600 second maximum average (C)
Right	21	286	284	282	272	255
Middle	21	302	298	296	291	286
Left	20	283	282	280	213	151

The following chart(s) present a time-dependent representation of the instantaneous temperatures measured during the experiment.

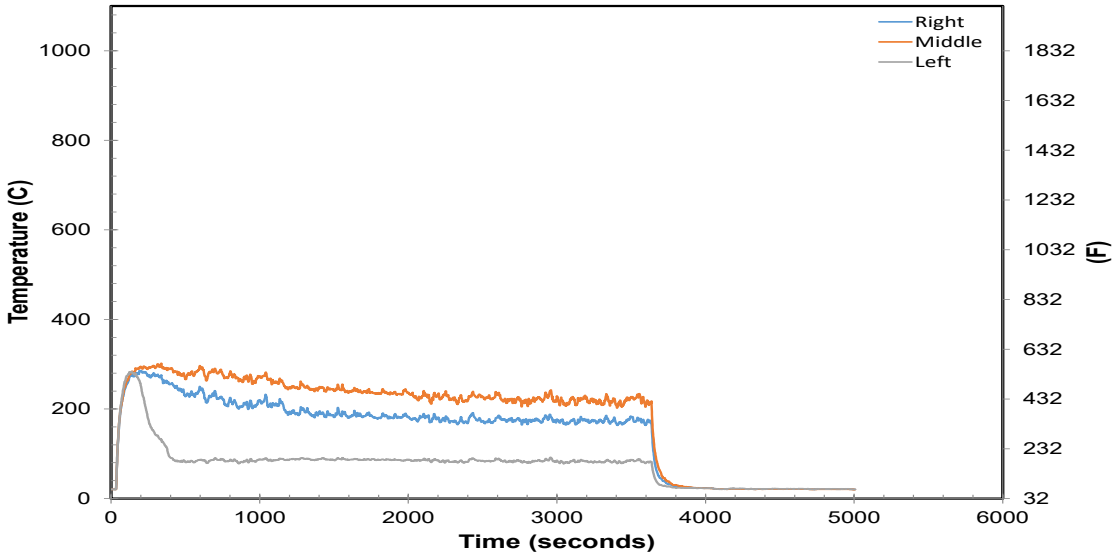

Figure 53. Temperature

The following table provides a summary of the heat flux results. The "Description" column typically describes the location of the heat flux transducer. The time at which the heat flux first changes by a pre-determined amount is provided in the "Time of Initial Change" column. The pre-determined amount of change in heat flux is provided in the "Initial Change Amount" column. The maximum heat flux recorded during the test is provided in the "Maximum" column. The "Maximum Average" columns are calculated over four pre-determined time spans.

Table 14. Heat Flux Result Summary

Description	Time of Initial Change (s)	Initial Change Value (kW/m²)	Maximum (kW/m²)	30 second maximum average (kW/m²)	60 second maximum average (kW/m²)	300 second maximum average (kW/m²)	600 second maximum average (kW/m²)
25 kw HF gauge	35	5	12.8	10.7	10.7	10.6	10.4

The following chart shows a time dependent representation of the instantaneous heat flux measured during the experiment.

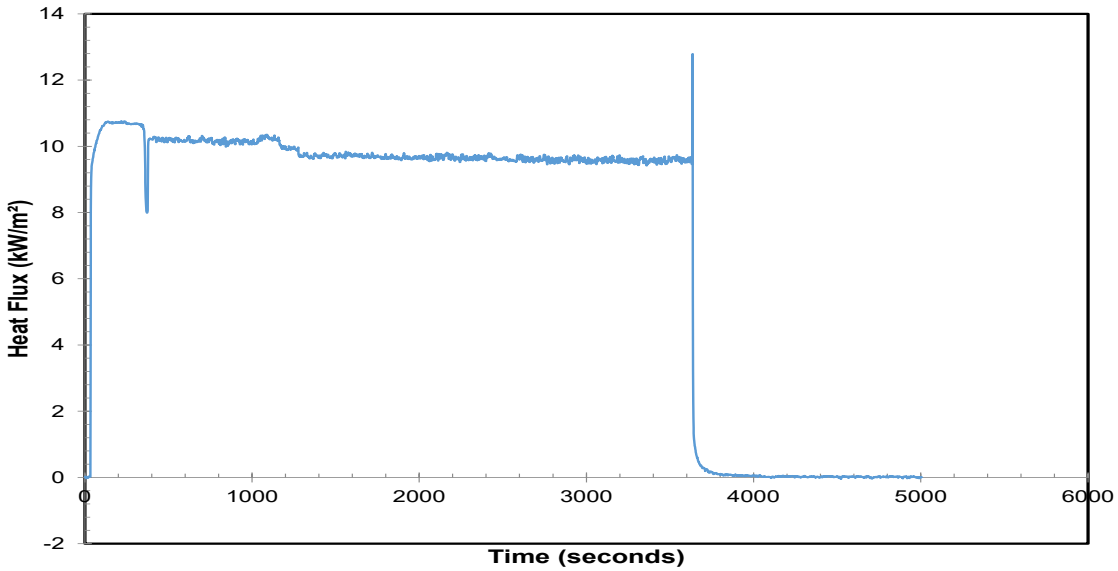

Figure 54. Heat Flux

Results for Test 6 (ID 61727)

The following table provides a summary of the temperature results. The "Initial" column provides the measured temperature at the beginning of the test. The maximum temperature recorded during the test is provided in the "Max" column. The remaining columns provide the calculated maximum average temperatures.

Table 15. Temperature Value Result Summary

Description	Initial (C)	Max (C)	30 second maximum average (C)	60 second maximum average (C)	300 second maximum average (C)	600 second maximum average (C)
Right	21	350	345	339	293	196
Middle	20	444	440	439	415	268
Left	20	323	312	307	283	187

The following table shows which thermocouple(s) were taken out of service during the experiment.

Table 16. Out of Service Times

Description	Time out of service (s)
Right	517
Middle	517
Left	517

The following chart(s) present a time-dependent representation of the instantaneous temperatures measured during the experiment.

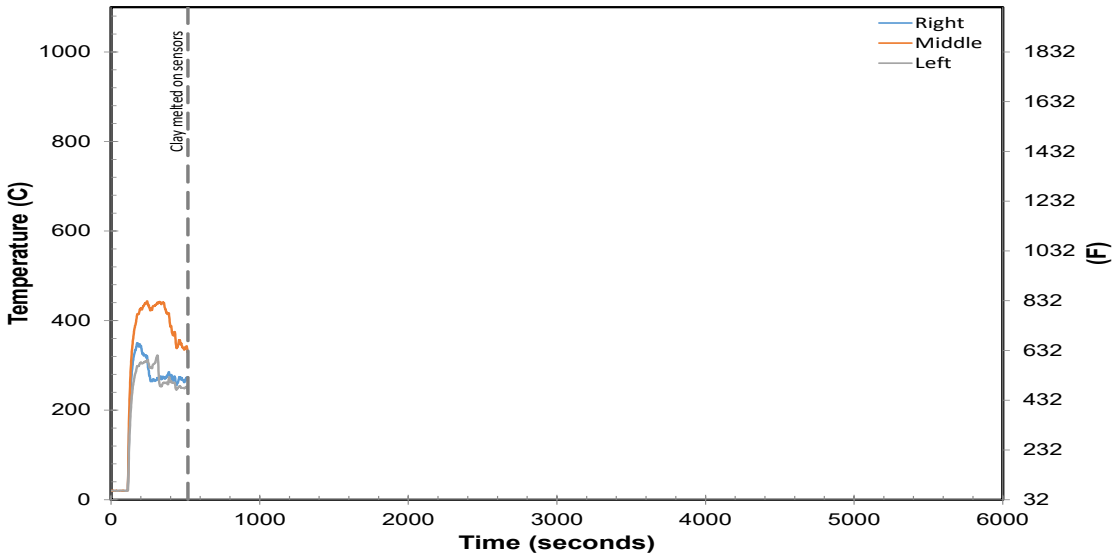

Figure 55. Temperature

The following table provides a summary of the heat flux results. The "Description" column typically describes the location of the heat flux transducer. The time at which the heat flux first changes by a pre-determined amount is provided in the "Time of Initial Change" column. The pre-determined amount of change in heat flux is provided in the "Initial Change Amount" column. The maximum heat flux recorded during the test is provided in the "Maximum" column. The "Maximum Average" columns are calculated over four pre-determined time spans.

Table 17. Heat Flux Result Summary

Description	Time of Initial Change (s)	Initial Change Value (kW/m²)	Maximum (kW/m²)	30 second maximum average (kW/m²)	60 second maximum average (kW/m²)	300 second maximum average (kW/m²)	600 second maximum average (kW/m²)
25 kw HF gauge	113	5	19.1	19.1	19.1	18.4	12.2

The following table shows which heat flux transducers(s) were taken out of service during the experiment(s). The "Description" column typically describes the location of the heat flux transducer. If the heat flux measurement has to be discontinued during a test the "Out of Service Time" and "Out of Service Reason" columns report the test time and reason why the heat flux measurement was removed, respectively

Table 18. Out of Service Times

Description	Serial number	Out of service time (s)
25 kw HF gauge	1227922	517

The following chart shows a time dependent representation of the instantaneous heat flux measured during the experiment.

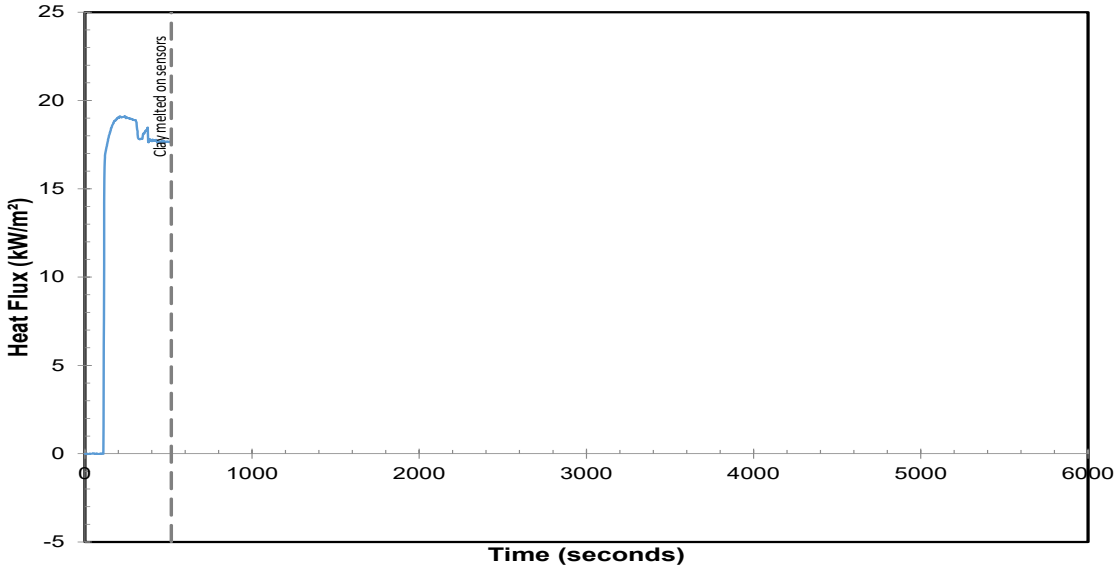

Figure 56. Heat Flux

The following table lists selected events that occurred during the experiment.

Table 19. Experiment Events

Description	Time (s)
Clay melted on sensors	517

The following figures show all of the still photographs uploaded into the FireTOSS system. The caption below each figure provides the picture's filename as well as any description and elapsed test time associated with the picture.

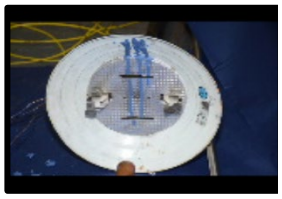

Figure 57.
61727_543420

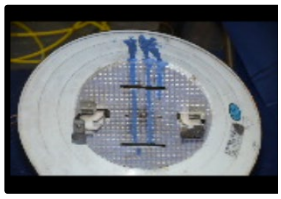

Figure 58.
61727_543421

Results for Test 7 (ID 61736)

The following table provides a summary of the temperature results. The "Initial" column provides the measured temperature at the beginning of the test. The maximum temperature recorded during the test is provided in the "Max" column. The remaining columns provide the calculated maximum average temperatures.

Table 20. Temperature Value Result Summary

Description	Initial (C)	Max (C)	30 second maximum average (C)	60 second maximum average (C)	300 second maximum average (C)	600 second maximum average (C)
Right	21	434	431	428	425	423
Middle	21	466	462	460	451	447
Left	20	344	340	338	334	331

The following chart(s) present a time-dependent representation of the instantaneous temperatures measured during the experiment.

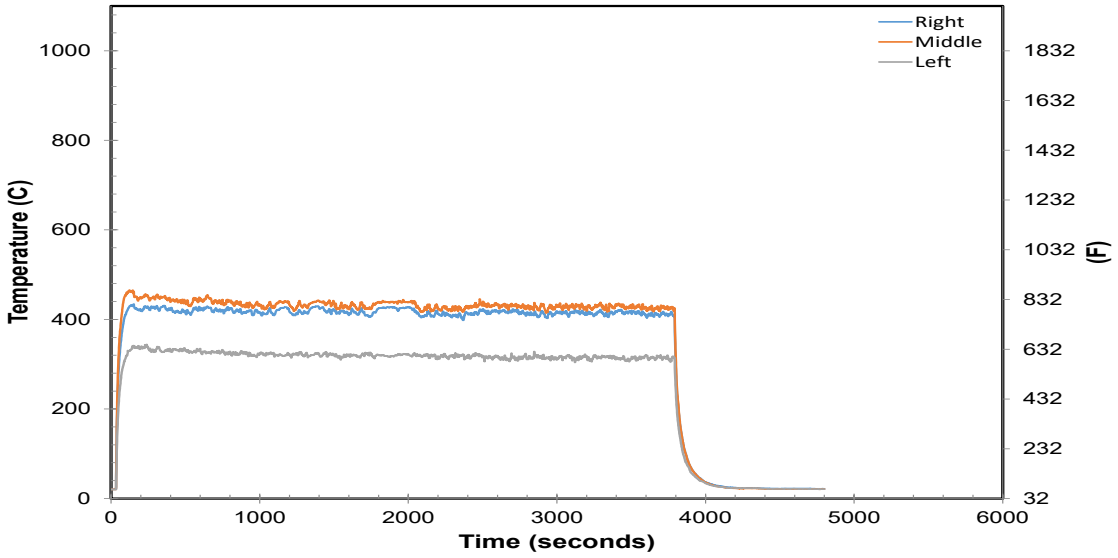

Figure 59. Temperature

The following table provides a summary of the heat flux results. The "Description" column typically describes the location of the heat flux transducer. The time at which the heat flux first changes by a pre-determined amount is provided in the "Time of Initial Change" column. The pre-determined amount of change in heat flux is provided in the "Initial Change Amount" column. The maximum heat flux recorded during the test is provided in the "Maximum" column. The "Maximum Average" columns are calculated over four pre-determined time spans.

Table 21. Heat Flux Result Summary

Description	Time of Initial Change (s)	Initial Change Value (kW/m²)	Maximum (kW/m²)	30 second maximum average (kW/m²)	60 second maximum average (kW/m²)	300 second maximum average (kW/m²)	600 second maximum average (kW/m²)
25 kw HF gauge	34	5	18.8	18.8	18.7	18.7	18.6

The following chart shows a time dependent representation of the instantaneous heat flux measured during the experiment.

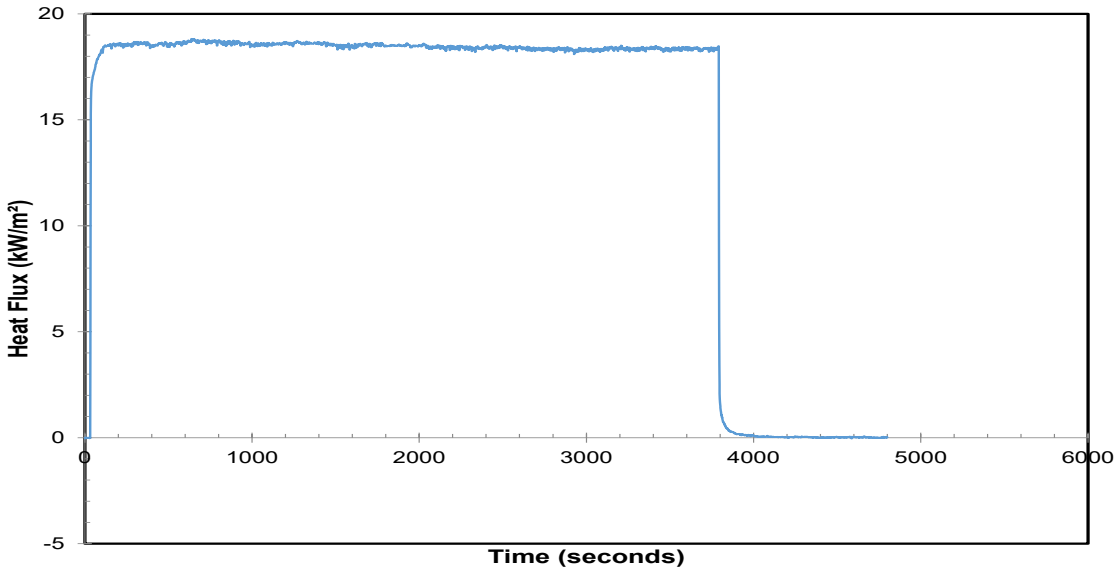

Figure 60. Heat Flux

Results for Test 8 (ID 61737)

The following table provides a summary of the temperature results. The "Initial" column provides the measured temperature at the beginning of the test. The maximum temperature recorded during the test is provided in the "Max" column. The remaining columns provide the calculated maximum average temperatures.

Table 22. Temperature Value Result Summary

Description	Initial (C)	Max (C)	30 second maximum average (C)	60 second maximum average (C)	300 second maximum average (C)	600 second maximum average (C)
Right	21	126	125	125	122	121
Middle	21	162	159	158	154	153
Left	21	107	105	105	104	103

The following chart(s) present a time-dependent representation of the instantaneous temperatures measured during the experiment.

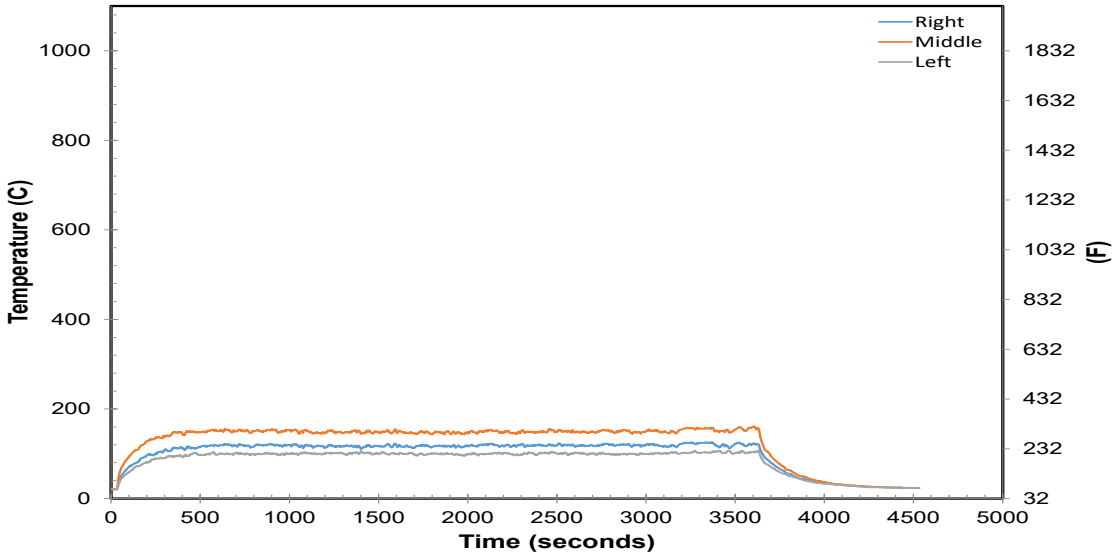

Figure 61. Temperature

The following table provides a summary of the heat flux results. The "Description" column typically describes the location of the heat flux transducer. The time at which the heat flux first changes by a pre-determined amount is provided in the "Time of Initial Change" column. The pre-determined amount of change in heat flux is provided in the "Initial Change Amount" column. The maximum heat flux recorded during the test is provided in the "Maximum" column. The "Maximum Average" columns are calculated over four pre-determined time spans.

Table 23. Heat Flux Result Summary

Description	Time of Initial Change (s)	Initial Change Value (kW/m²)	Maximum (kW/m²)	30 second maximum average (kW/m²)	60 second maximum average (kW/m²)	300 second maximum average (kW/m²)	600 second maximum average (kW/m²)
25 kw HF gauge	38	5	6.7	6.1	6.1	6.1	6

The following chart shows a time dependent representation of the instantaneous heat flux measured during the experiment.

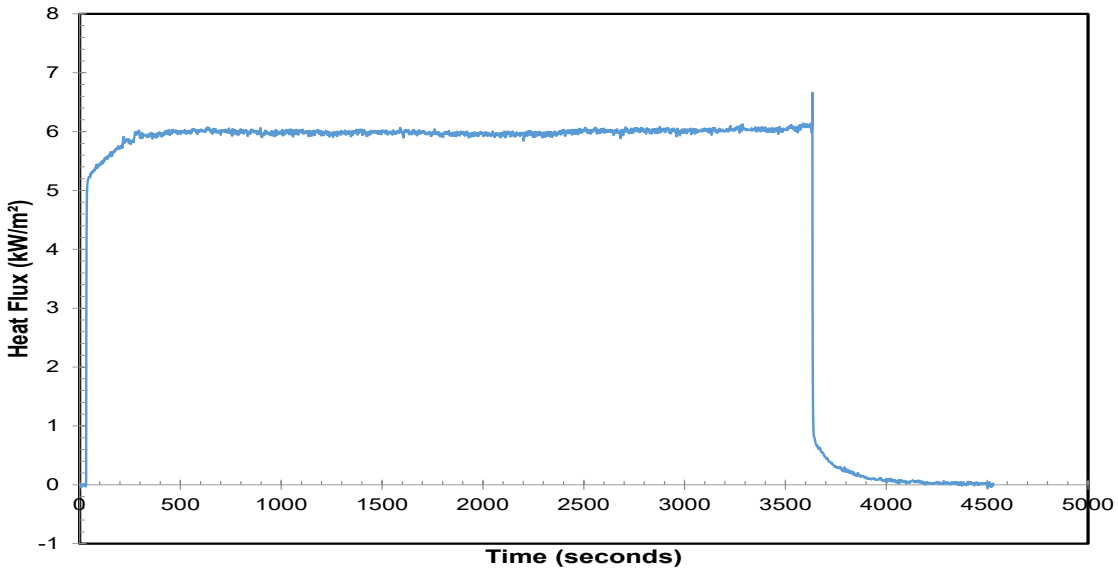

Figure 62. Heat Flux

Results for Test 9 (ID 61738)

The following table provides a summary of the temperature results. The "Initial" column provides the measured temperature at the beginning of the test. The maximum temperature recorded during the test is provided in the "Max" column. The remaining columns provide the calculated maximum average temperatures.

Table 24. Temperature Value Result Summary

Description	Initial (C)	Max (C)	30 second maximum average (C)	60 second maximum average (C)	300 second maximum average (C)	600 second maximum average (C)
Right	22	183	182	182	181	181
Middle	22	222	220	219	216	216
Left	21	155	152	151	150	150

The following chart(s) present a time-dependent representation of the instantaneous temperatures measured during the experiment.

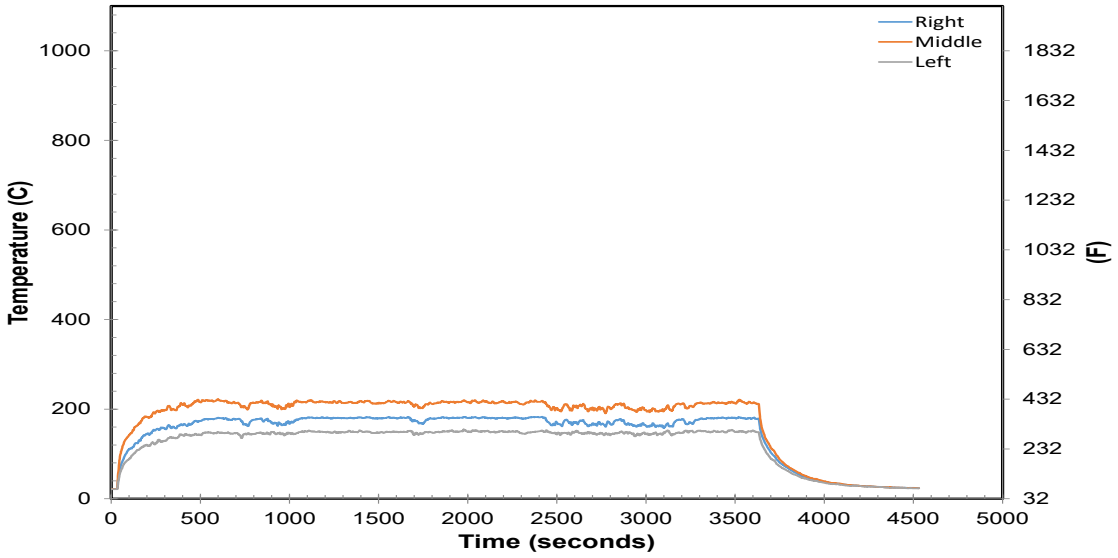

Figure 63. Temperature

The following table provides a summary of the heat flux results. The "Description" column typically describes the location of the heat flux transducer. The time at which the heat flux first changes by a pre-determined amount is provided in the "Time of Initial Change" column. The pre-determined amount of change in heat flux is provided in the "Initial Change Amount" column. The maximum heat flux recorded during the test is provided in the "Maximum" column. The "Maximum Average" columns are calculated over four pre-determined time spans.

Table 25. Heat Flux Result Summary

Description	Time of Initial Change (s)	Initial Change Value (kW/m²)	Maximum (kW/m²)	30 second maximum average (kW/m²)	60 second maximum average (kW/m²)	300 second maximum average (kW/m²)	600 second maximum average (kW/m²)
25 kw HF gauge	34	5	11.4	11.3	11.3	11.2	11.2

The following chart shows a time dependent representation of the instantaneous heat flux measured during the experiment.

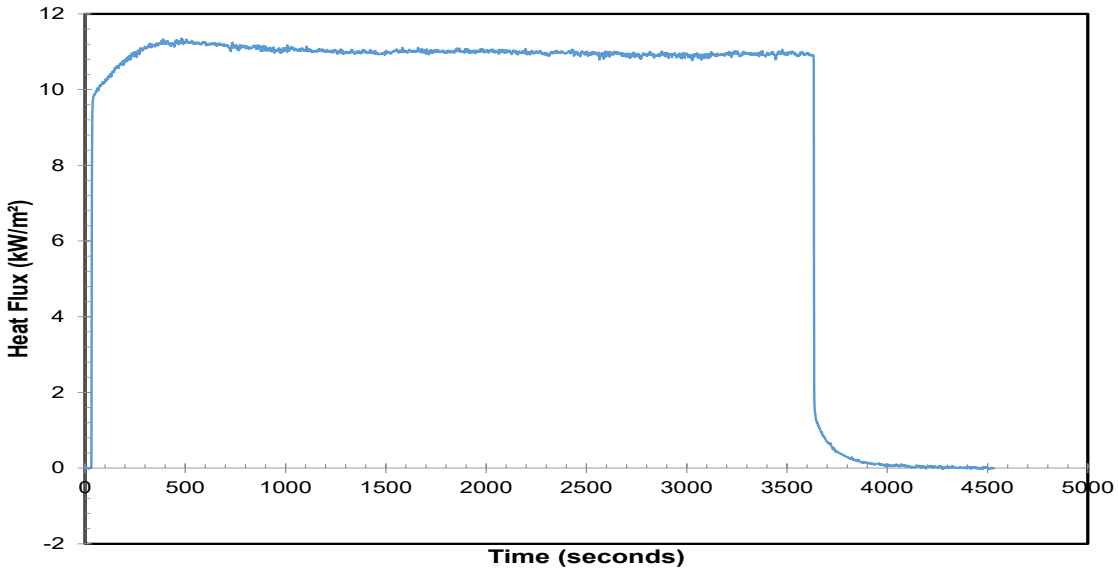

Figure 64. Heat Flux

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1. Laboratory Instruction LI017 – Laboratory Conditions, Bureau of Alcohol, Tobacco, Firearms and Explosives - Fire Research Laboratory, Beltsville, MD.

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3. Laboratory Instruction LI001 - Thermocouple, Bureau of Alcohol, Tobacco, Firearms and Explosives – Fire Research Laboratory, Beltsville, MD.
4. Barnes, A., "Heat Flux Sensors Part 1: Theory," Sensors, January 1999.
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6. Laboratory Instruction LI003 - Digital Cameras, Bureau of Alcohol, Tobacco, Firearms and Explosives - Fire Research Laboratory, Beltsville, MD