

Report on the
Power Output of Liquid Gallium
Suncells
at Brilliant Light Power

by

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This report outlines results I validated for three types of experiments when I visited Brilliant Light Power of Cranbury, New Jersey, on December 16-18, 2019. I was able to validate measurements for the energy input and energy output, as well as power input and power output, of hydrino reactions in the continuous power cell known as the SunCell® using liquid gallium.

Of main importance in the validation of these experiments were: observing the procedure used for carrying out the experiments, that the five experiments were carried out in full view in front of an impartial validator (myself), and the verification of the measurement of the excess power output in each of these experiments.

The three types of experiments that I ran were:

- 1) Molten Metal Calorimetry Data – 2 experiments
- 2) Calibration Data – 2 experiments
- 3) Water Bath Calorimetry Data – 1 experiment

Molten Metal Experiments

The input and output power generated by the hydrino reaction in the SunCell® was measured using the cell as a molten metal calorimeter where liquid gallium (Ga) present within the cell served as both the electrode and the working fluid used to measure the thermal energy released during the duration of the reaction. The main body of the cell consisted of a 4" x 4" x 4" cube made from Type 347 stainless steel which housed 2.5 kg of liquid Ga. The calorimetric calculations were performed using the temperature of the liquid Ga, which was measured using 2 K-Type ungrounded thermocouples rated to 1335°C.

Prior to the start of the reaction, the cell was connected to a vacuum pump and all unwanted gases were removed down to a pressure of approximately 40 mTorr. Fuel for the reaction was provided in the form of hydrogen (H₂) and oxygen (O₂) gas, which were supplied from tanks into an oxyhydrogen torch for optimal mixing. The resultant mixture was then piped into an external heated tube (~90 °C) containing granular platinum (Pt) catalyst supported on alumina to allow for spontaneous reaction into ~1% water vapor in atomic hydrogen that was flowed into the cell.

The hydrino plasma reaction within the cell was performed using 2 separate electrical systems: an electromagnetic (EM) pump system to complete the circuit between the two electrodes within the cell, and an ignition system to supply electrical input energy to initiate the reaction. The EM pump was powered by a programmable DC power supply (Model: Matsusada Precision REK10-1200) set to current control mode wherein the current output would directly control the flow rate of liquid Ga through the pump tube assembly. During typical operation, the Ga flow rate was measured to be approximately 40 cm³/sec. The ignition circuit, on the other hand, was powered by a capacitor bank comprised of 7 parallel banks of 18 capacitors (Maxwell Technologies K2 Ultracapacitor 2.85V/3400F) in series that provided a total bank voltage capability of 51.3V with a total bank capacitance of 1322.2 Farads. In typical operation, a current in the range of 6000A to 3000 A was supplied by the capacitor bank charged to 50 V. The positive and negative terminals of the capacitor bank were connected to a solid tungsten (W) anode and a liquid Ga cathode, respectively. For the ignition circuit, the electrical response was recorded on a high-sample-rate and high-resolution oscilloscope (Model: PicoScope 5000 Series) using a voltage differential probe (Model: PicoTech TA041, ±70V) and a DC Hall effect sensor (Model: GMW CPCO-4000-77-BP10, ±4kA). Examples of molten metal reaction cells can be seen in Figure 1.



Figure 1. Photographs showing two separate molten metal cells that also served as molten metal calorimeters. Cells A (left) and B (right) were used for validation and will be referenced in this report.

Voltage and current traces for the first molten metal experiment (Cell A) are shown below in Figure 2. The calculations for total electrical input energy for a given experiment were computed using a point-by-point integration over the duration of the experiment.

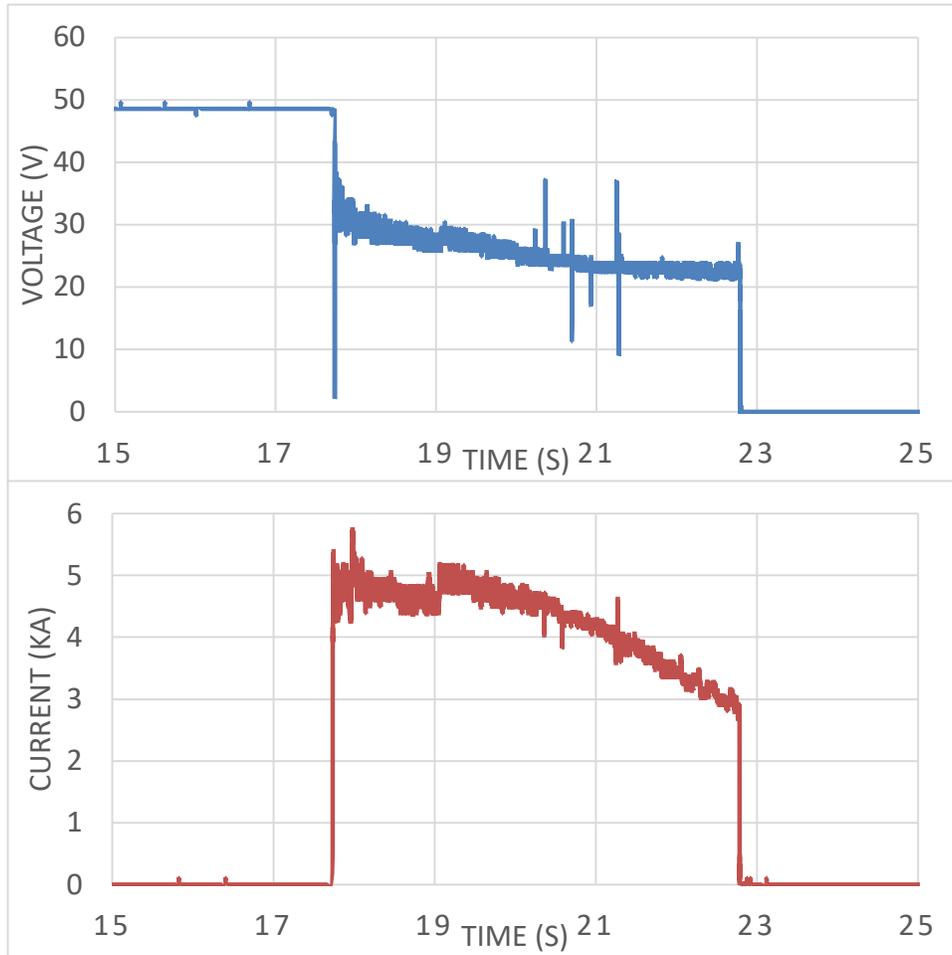


Figure 2. Voltage (blue) and current (red) traces recorded on Cell A during validation.

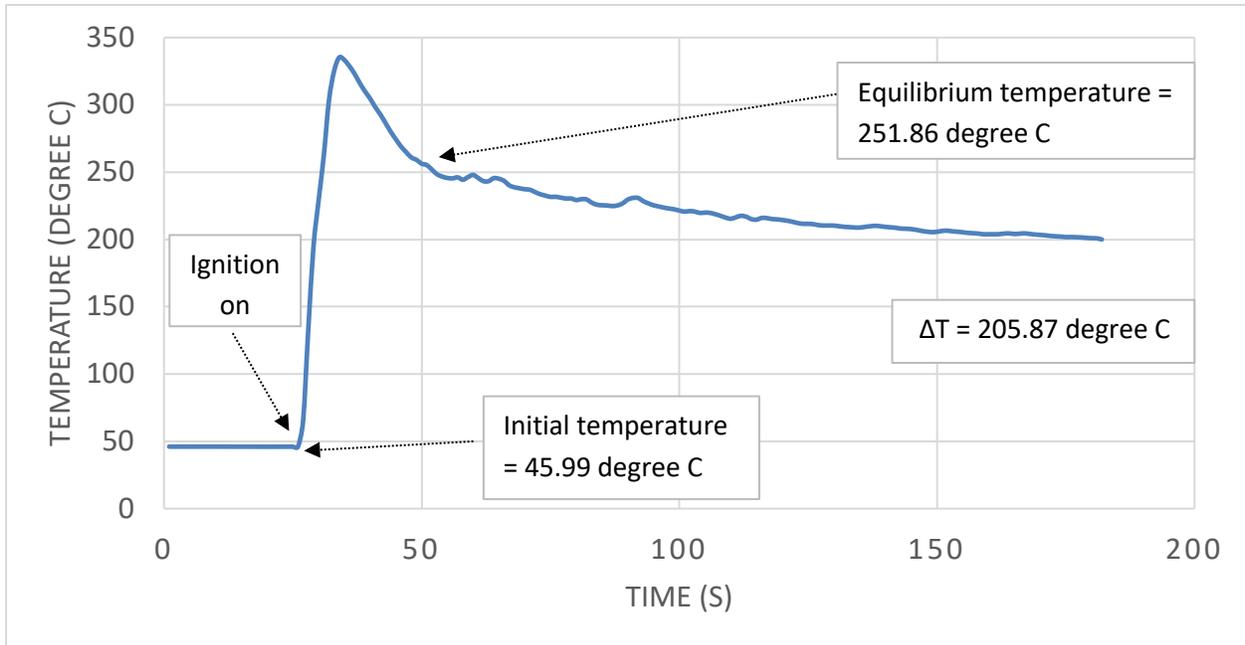


Figure 3. Cell A temperature plot showing timestamps for ignition start and final temperature at equilibrium.

Figure 3 shows the temperature curve of the cell and the gallium within. The point of ignition is marked, and it can be seen that a rapid rise in gallium temperature occurred thereafter. After ignition was shut down, the EM pump was left running to circulate the liquid Ga and equalize any thermal gradients. This equilibrium temperature is used to calculate the change in temperature due to reaction and thus, the output energy by using the thermal energy equation:

$$Q = mC_p\Delta T$$

where m is the mass of each component within the cell [kg], C_p is its specific heat capacity [kJ/kg·K] and ΔT is the difference between final equilibrium temperature and the initial temperature [K]. Thus, the total output energy was determined by adding the cumulative energy values of all components within the cell, as can be seen in Table 1.

Table 1. List of individual weights and corresponding specific heats of various cell components used to calculate the output energy generated within the molten metal calorimeter.

Component	Weight (kg)	Specific heat (kJ/(kg×°C))
gallium	2.7	0.383
Stainless steel cell	6.4	0.5024
Stainless steel flange lid component	1.26	0.5024
Tungsten electrode component	1.52	0.1339
Copper electrode component	0.369	0.39
Boron Nitride electrode component	0.22	0.85
Tungsten liner	2	0.1339

To improve the accuracy of the output energy calculations, the thermal losses from the cell wall exterior to the surroundings had to be considered. Therefore, experiments were conducted where the cell was resistively heated at various temperatures and the rate of heat loss was calculated from the cooling curve. These empirically determined values were then used as a calibration factor for the calorimetric measurements. Calibration factor experiments show that we lose 20% of the total output energy from ignition start to the time taken to reach the equilibrium temperature. In short, we can multiply output energy by a factor of 1.25, to account for this loss. Examples of the calibration experiments can be found in the Appendix. Experimental data and calculations from Cell A used for validation can be seen below in Table 2.

Table 2. Summary of total energy and power balance for Cell A during validation.

ΔT of cell and gallium (degree C)	205.87
gallium energy (kJ)	268.1
SS cell energy (kJ)	960.2
Output energy (kJ)	1228.3
Total output energy including heat losses = Output energy \times 1.25 (kJ)	1535.3
Total input energy (kJ)	554.7

Duration (s)	Input energy (kJ)	Output energy (kJ)	Input power (kW)	Output power (kW)	Gain	Excess power (kW)
5.055	554.7	1535.3	109.7	303.7	2.77	194.0

Similarly, a second molten metal experiment was performed with Cell B; its corresponding data and calculations can be seen in Figures 4-5 and Table 3.

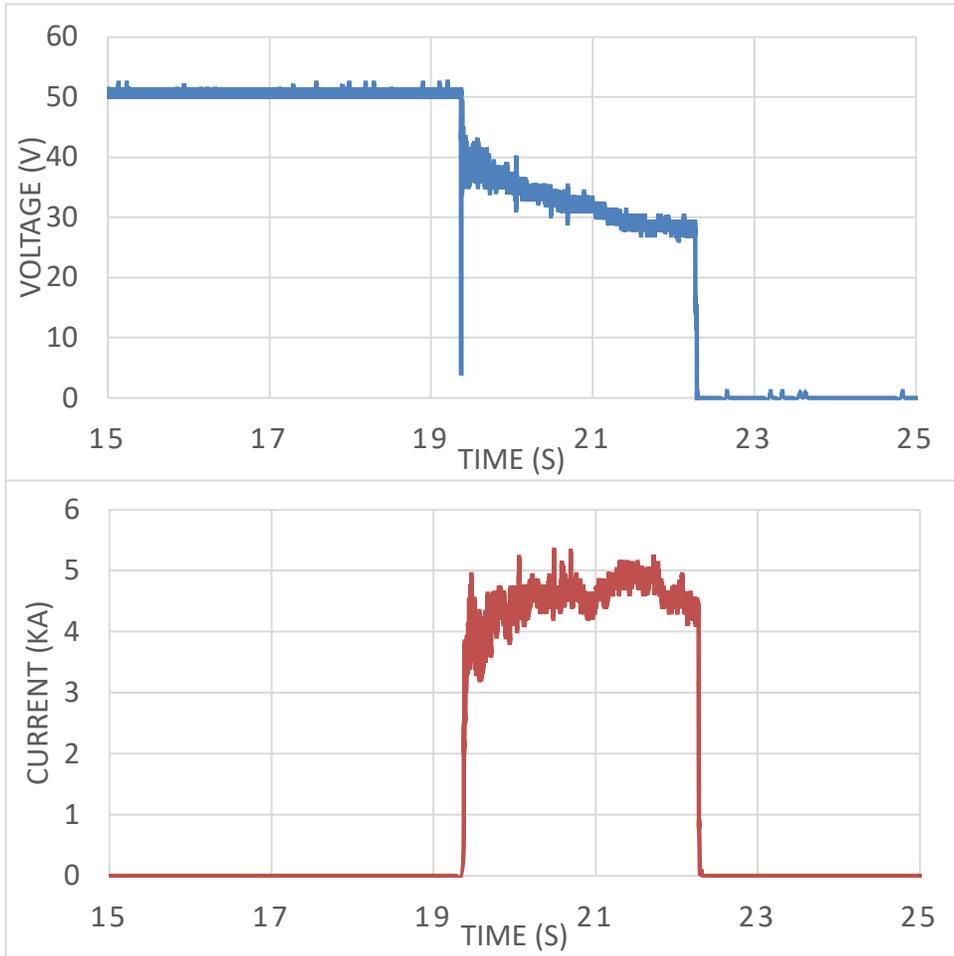


Figure 4. Voltage (blue) and current (red) traces recorded on Cell B during validation.

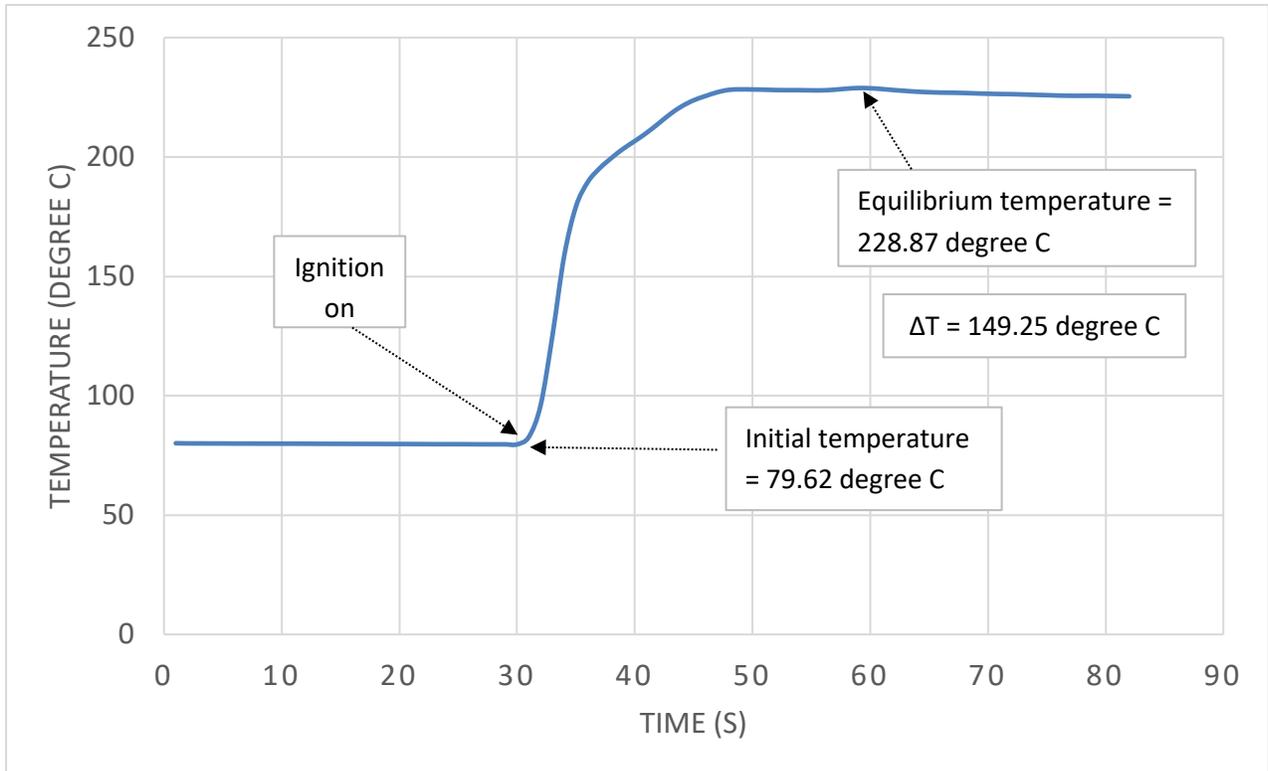


Figure 5. Cell B temperature plot showing timestamps for ignition start and final temperature at equilibrium.

Table 3. Summary of total energy and power balance for Cell B during validation.

ΔT of cell and gallium (degree C)	149.25
gallium energy (kJ)	142.9
SS cell energy (kJ)	703.6
Output energy (kJ)	846.5
Total output energy including heat losses = Output energy \times 1.25 (kJ)	1058.1
Total input energy (kJ)	422.1

Duration (s)	Input energy (kJ)	Output energy (kJ)	Input power (kW)	Output power (kW)	Gain	Excess power (kW)
2.917	422.1	1058.1	144.7	362.8	2.50	218.1

During the running of the calorimetric experiments, I was allowed to observe the entire experiment from the ignition of the reaction cell, to taking the data, to asking questions about the procedure and the data taking. I was able to inspect the reaction cell both before and after the running of the experiments. The power gain from these molten metal experiments were in the range 2.50-2.77. In other words, the experiment is producing 2.50-2.79 times the power input. This is an incredible amount of excess power being produced, namely 194-218 kW of power.

Executive Summary

Brilliant Light Power has discovered a novel power source, the liquid gallium SunCell®, which produces a large excess of heat. These input power and output power numbers have been validated by me and are correct. I have also been given access to the data files taken during the two molten metal experiments for this validation. As for the gallium, there is no chemical reaction at all responsible for this excess power. Testing shows that there's 100% gallium before and there's 100% gallium after in the cell. All of the observed energy in these cases must come from the HOH hydrino plasma reaction occurring in the reaction cell. The gains for the two molten metal experiments reported here were in the range 2.50-2.79 at excess power levels of 194-218 kW. I am led to the conclusion that the generation of the large net excess power in the liquid gallium SunCell® experiment is real and reproducible.

Water Bath Calorimeter

In order to evaluate the absolute output energy produced by the Brilliant Light Power's SunCell®, the entire cell assembly was submerged in a water bath and operated submerged to obtain a calorimetric determination of the thermal energy produced by the hydriino reaction.

The primary enclosure for the water bath was comprised of a cylindrical tank (22" diam. x 36" tall) made out of 1/8" thick high-density polyethylene (HDPE) inserted inside a larger HDPE tank (27.5" diam. x 44" tall) where the space in between the tanks was filled with mineral fiber wool insulation to limit thermal losses to the surrounding environment. The inner tank also contained a water circulator (Franklin Electronics Little Giant 5-MSP 125 W) fitted with a plastic manifold to create water jets directed at the cell walls to provide cooling by forced convection and to prevent the formation of any heat gradients within the water bath for increased accuracy in the calorimetric measurements. The temperature of the water bath was measured using two high-accuracy digital thermistors (Model: Parr 6775A Digital Thermometer) with a resolution of 0.001°C. A typical setup for the water bath experiment is shown below in Figure 6.

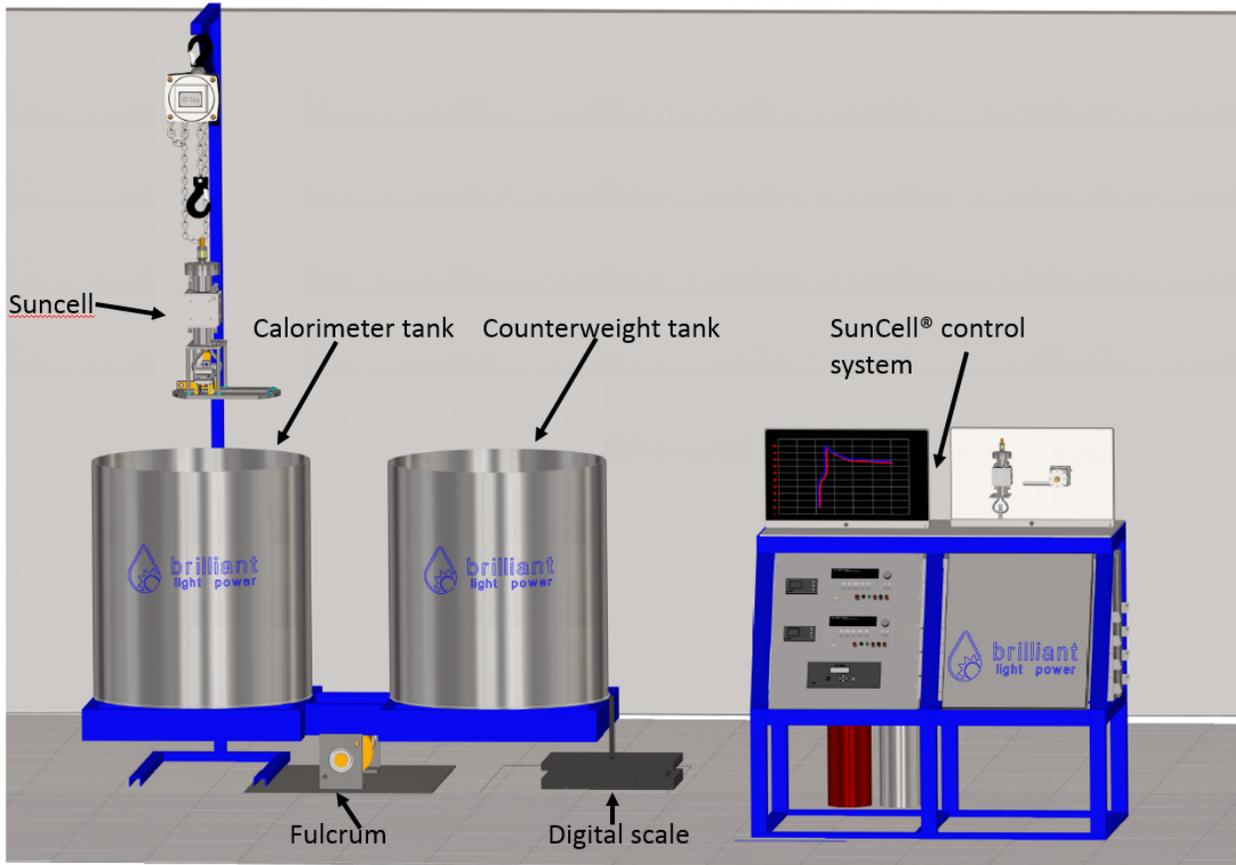


Figure 6A. Schematic showing the water bath calorimetry system for validation runs performed on the SunCell®.



Figure 6B. Photograph showing the water bath calorimetry system for validation runs performed on the SunCell®.

For all experiments, the tank was filled with 40 gallons of deionized (DI) water measured with a flow meter (Carlson Model #062JLP, accurate to 0.01 gal +/- 1.5%). The accuracy of the flow meter was verified by independently measuring the weight of the water on a digital scale with an accuracy of ± 0.1 kg. This entire quantity of water was first heated to above 32°C to prevent the solidification of the liquid Ga within the cell when submerged. The electrical conductivity of the water was carefully monitored between every experiment using a handheld water conductivity meter (Model: Ohaus ST20C-B) to monitor the potential for external cell corrosion when in contact with elevated-temperature, aerated water. A conductivity value under 15 $\mu\text{S}/\text{cm}$ was deemed as acceptable, with the DI water being replaced if the threshold was exceeded.

During the experiment, input power was also delivered via a capacitor bank comprised of 4 parallel banks of 18 capacitors (Maxwell Technologies K2 Ultracapacitor 2.85V/3400F) in series that provided a total bank voltage capability of 51.3V with a total bank capacitance of 755.6 Farads. A current in the range of 4000A to 2000 A was supplied by the capacitor bank charged to 50 V. The power input was calculated using point-by-point integration over the duration of the experiment. Voltage and current data for the water bath experiment can be seen in Figure 7.

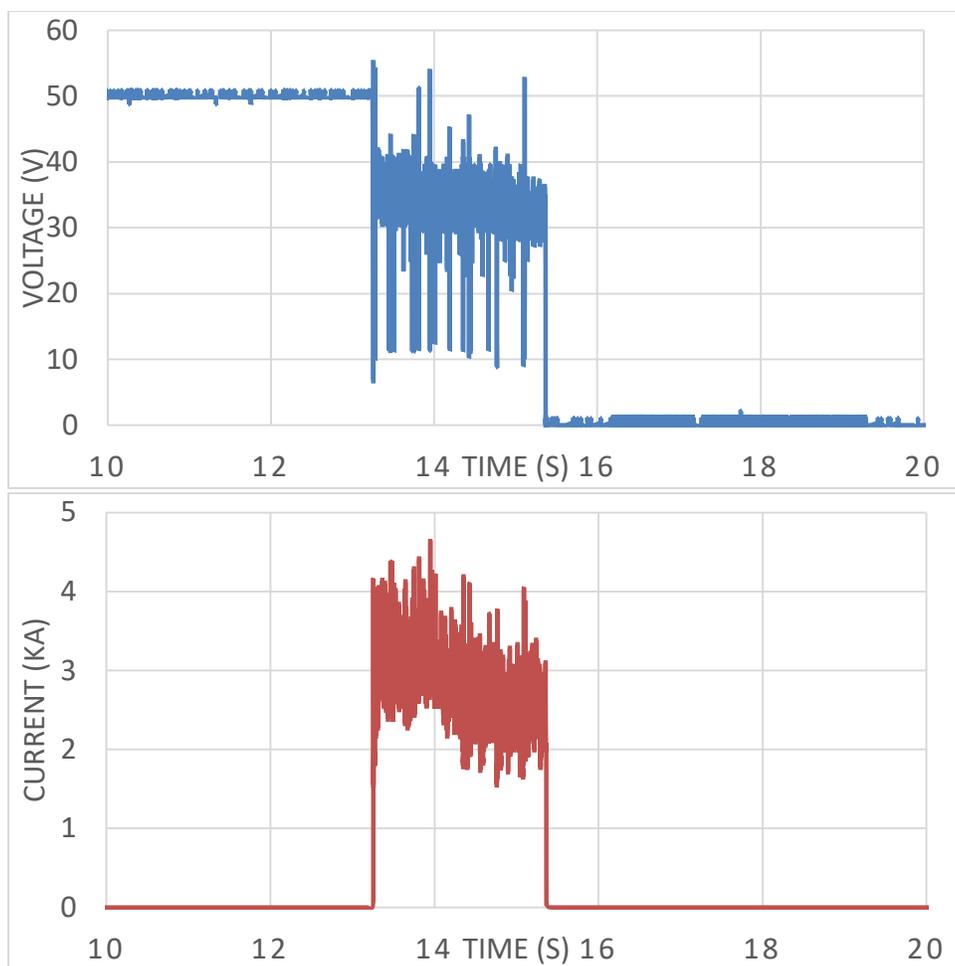


Figure 7. Voltage (blue) and current (red) traces recorded for water bath calorimetry during validation.

During the experiments, it was observed that the intense thermal power generated by the hydrino reaction rapidly heated the exterior wall of the cell to give rise to immediate flash boiling on the cell wall-water interface. The boiling created a significant amount of steam bubbles that floated to the surface of the water bath and escaped. Therefore, the calorimetric measurement of power balance comprised two separate components, (i) heat inventory of the water due to heating determined from the water mass, heat capacity, and the change in temperature during the experiment, and (ii) heat of vaporization due to water boil off determined by the heat of water vaporization and mass loss to steam.

The water weight loss (± 0.5 g) was determined using a mechanical balance comprising a 1st class lever wherein a steel frame measuring 66" long x 28" wide was mounted on a cylindrical shaft with 2 rolling bearings, which functioned as a fulcrum. The calorimeter was placed on one side of the lever, while an identical tank filled with about 200 kg of water was placed on the other side as a counterweight. The two tanks were fixed in place on the frame such that the moments on either side of the fulcrum were balanced.

To perform a gravimetric measurement of water loss in the calorimeter, the cell was first removed from the calorimeter and water was added to the counterweight tank until the weight in both tanks was

perfectly balanced. A digital scale (MyWeigh® i5500) with an accuracy of $\pm 0.1\text{g}$ was then placed under the counterweight and the amount of water in the tanks was adjusted such that the counterbalance was slightly heavier than the calorimeter tank and the scale would read a stable, non-zero number. Since the scale balances the torques on the arms of the lever in proportion to the weight differential, the reading on the scale was calibrated by removing water from the calorimeter tank in measured aliquots and recording the corresponding change in weight on the scale. This data was used to form a calibration curve to minimize the error in the scale readings. The cell was then placed in the calorimeter tank and then run under plasma conditions.

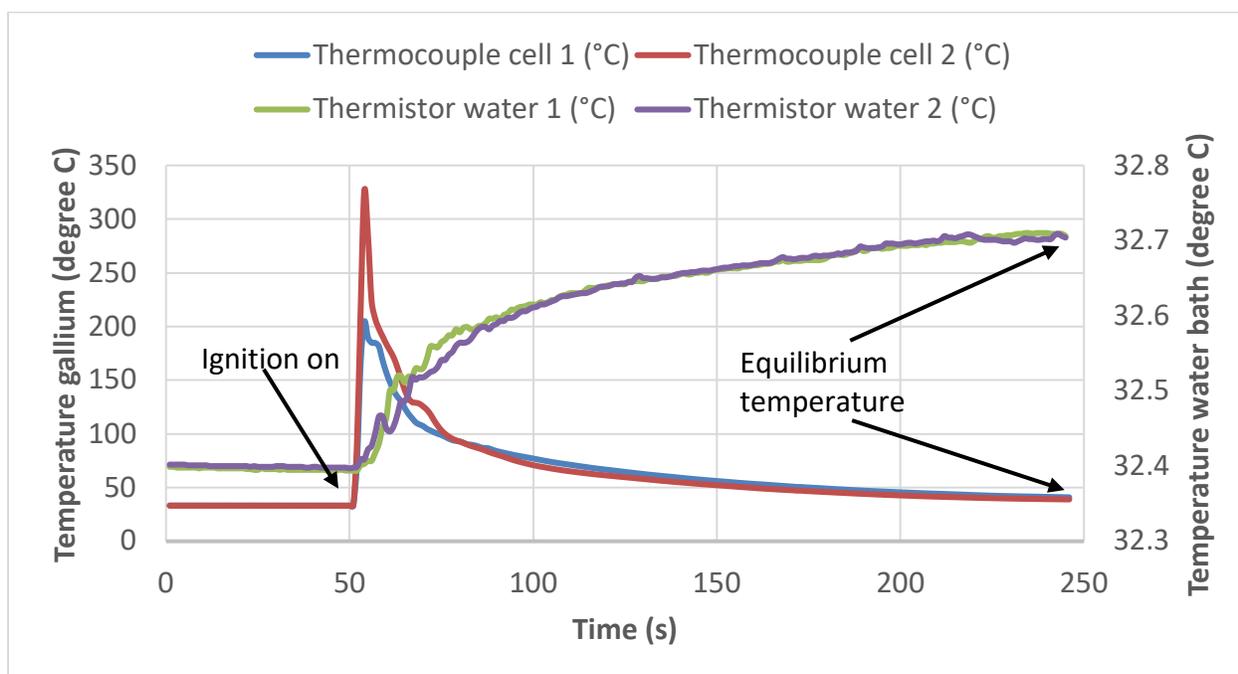


Figure 8. Cell and water bath temperature traces for experiment run during validation.

After the test was completed, the cell was left to cool down until the cell and the water bath were at the equilibrium temperature, as shown in Figure 8. The final temperature recorded at this stage was then used to calculate the heat capacity energy captured by the calorimeter. Measured water bath temperatures are listed in Table 4. Subsequently, the cell was removed from the calorimeter tank and the net change in weight on the scale was recorded. This change in weight was then compared to the calibration curve to find an accurate measurement of water loss ($\pm < 1\%$), which was then used to calculate the enthalpy term due to vaporization.

Table 4. List of water bath temperatures used for calorimetric measurements.

Initial Temperature - Thermistor 1	32.394 °C
Initial Temperature - Thermistor 2	32.397 °C
Final Temperature - Thermistor 1	32.706 °C

Final Temperature - Thermistor 2	32.704°C
Average Initial Temperature	32.3955 °C
Average Final Temperature	32.705°C
Average Temperature Change = ΔT	0.3095°C

An additional factor in the total energy balance that required consideration was the thermal contribution from the water circulator in the tank over the entire duration of the experiment. In typical operation, the water circulator was running since the point of ignition of the hydrino plasma reaction until the cell temperature and water bath temperature had reached equilibrium. A calibration experiment was performed in which the circulator alone was run for a known duration in a water bath with an identical setup to that in the experiments to determine its heat input into the water bath. This contribution was then subtracted from the total output energy that was determined by the sum of the heat capacity energy and the enthalpy due to vaporization of the cell, as determined by the methods given above. The detailed calculations with results are shown below in Tables 5 and 6.

Table 5. Detailed calculations used to determine input and output energy for water bath calorimeter.

Water Volume	40.47 gal
Water Weight = a	153.20 kg
Specific Heat of Water = b	4.186 kJ/(kg×degree C)
Total Energy Absorbed by Water ($Q = mC_p\Delta T = a*b*\Delta T = x$)	198.48 kJ
Weight of water Lost due to Boiling Recorded on Scale	160.0 gm
Weight of water Lost due to Boiling Removing One-Time Handling Impact (Subtracted 10 gm)	150.0 gm
Actual weight of water Lost due to Boiling (Multiplying with Correction Factor 1.79) = c	268.5 gm
Heat of Vaporization of Water = d	2454 kJ/(kg*degree C)
Total Energy Lost due to Boiling = c*d = y	658.89 kJ
Energy Contribution due to Water Pumps Used for Mixing (1 pump, 200 W over 195 sec) = z	-39.00 kJ
Total Output Energy = x+y+z	818.38 kJ
Total Input Energy Calculated by V-I Trapezoidal Integration	192.95 kJ

Table 6. Summary of total energy and power balance as determined by water bath calorimetry during validation.

Duration (s)	Input energy (kJ)	Output energy (kJ)	Input power (kW)	Output power (kW)	Power Gain	Net Excess Power (kW)
2.115	192.95	818.38	91.23	386.94	4.24	295.71

During the running of the actual experiments, I was allowed to observe the entire experiment from the loading of the cell into the water bath calorimeter, to taking the data, to measuring the weight of the water lost to vaporization, to asking questions about the procedure and the data taking. I was able to inspect the reaction cell both before and after the running of the experiment. The power gain from this experiment

was 4.24. In other words, the experiment produced 4.24 times the power input and an incredible amount of excess power, namely 295.71 kW of power.

Executive Summary

Brilliant Light Power has discovered a novel power source, the liquid gallium SunCell®, which produces a large excess of heat. These input power and output power numbers have been validated by me and are correct. I have been given access to the data files taken during the experiments for this validation. Also, as for the gallium, there is no chemical reaction at all responsible for this excess power. Testing shows that there's 100% gallium before and there's 100% gallium after in the cell. All the observed energy in these cases must come from the HOH hydrino plasma reaction occurring in the reaction cell. The power gain of the hydrino reaction determined using water bath calorimetry reported herein was 4.24 times at an excess power level of 296 kW. I am led to the conclusion that the generation of the large net excess power in the liquid gallium SunCell® experiment is real and reproducible.

Appendix

Calibration 1 data for resistive heating with hydrino reactions suppressed through unfavorable gas composition. Equilibrium temperature was taken after around 25 seconds of mixing after ignition off.

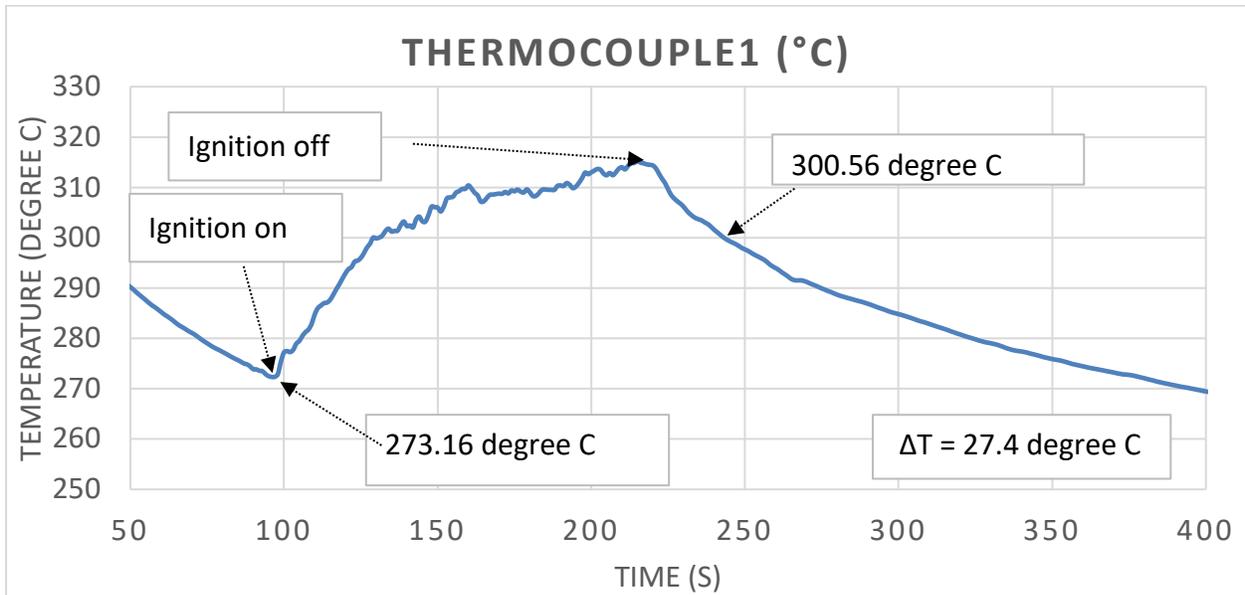


Table 7. Summary of total energy and power balance for calibration 1 run during validation.

ΔT of cell and gallium (degree C)	27.4
gallium energy (kJ)	35.7
SS cell energy (kJ)	127.8
Output energy (kJ)	163.5
Total input energy (kJ)	264.5

Input energy (kJ)	Output energy (kJ)	Gain
264.5	163.5	0.62

Calibration 2 data for resistive heating with hydrino reactions suppressed through unfavorable gas composition. Equilibrium temperature was taken after around 25 seconds of mixing after ignition off.

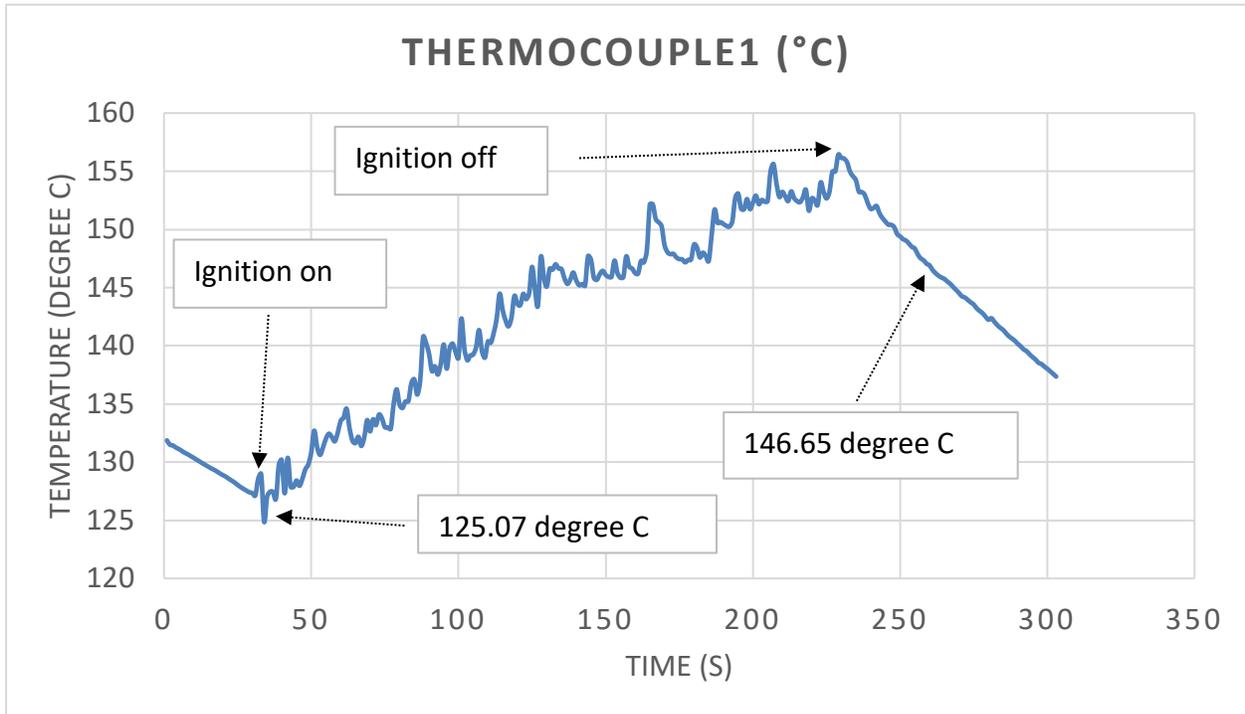


Table 8. Summary of total energy and power balance for calibration 2 run during validation.

ΔT of cell and gallium (degree C)	21.58
gallium energy (kJ)	22.3
SS cell energy (kJ)	100.5
Output energy (kJ)	122.8
Total input energy (kJ)	169.4

Input energy (kJ)	Output energy (kJ)	Gain
169.4	122.8	0.73

For calibration, the gains are less than 1, indicating less energy was output than was input. No excess power was produced under calibration conditions.