FINAL/SCIENTIFIC TECHNICAL REPORT

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"Energy Efficiency and Environmentally Friendly Distributed Resources Energy Storage Battery"

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In collaboration with
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Executive Summary

Electro Energy, Inc. (EEI) conducted a two-phase, thirty three-month research project to develop an energy efficient and environmentally friendly bipolar nickel-metal hydride battery for distributed energy storage applications. Rechargeable batteries with long life and low cost potentially play a significant role in the energy efficiency, environmentally friendly field by reducing electricity cost and pollution. A rechargeable battery functions as a reservoir for storage for electrical energy, carries energy for portable applications, or can provide peaking energy when a demand for electrical power exceeds primary generating capabilities.

Phase I of the program commenced in January of 2002 and effort lasted through September of 2003. The program was structured where EEI contributed 20% on a cost share basis, of which EEI partnered with Rutgers University and Treibacher to meet the financial obligations. Rutgers provided technical support and consultation, as well as specialized material development and testing, while Treibacher provided critical raw materials, in the form of metal-hydride powders, and the research and development of improved hydride powders. Under this phase of the program, EEI developed standard 6" x 12" cell designs for high-power and high-energy applications. To verify the performance EEI delivered prototype battery cells and 40V, 6Ah, high-power battery modules.

Phase II of the program commenced in August of 2003, with effort lasting through October of 2004. Again the program was structured as a 20% cost share, with EEI partnering with First Energy, an Ohio based utility corporation, to meet these obligations. Under the program, First Energy would provide critical UPS and Inverter application hardware, as well as project support engineering. Through this phase of the program, EEI investigated a 3kW and 100kW UPS system comparing ultracapacitors and EEI's bipolar NiMH battery design. It was determined through a 50Ah, 48V battery system, that the bipolar NiMH provides better performance than capacitors when used under the 3kW Inverter system profile. In addition, plans were made to make a 20kW/40kWh battery system to be built and tested with a power conditioning system supplied by First Energy and EPRI PEAC. Finally under this phase, EEI built 350V, high-power capable battery modules.

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Introduction

Electro Energy, Inc. (EEI) has developed a bipolar nickel metal hydride battery whose performance characteristics could meet a variety of energy storage application needs, including high voltage/high power modules with high cycle life and high voltage/ high energy with high cycle life. There is the opportunity for electric energy cost reductions to industry and the smoothing of electric utility daily generation profiles, with the development and deployment of EEI's battery energy storage system for use on the customer or utility side of the meter.

Rechargeable batteries with long life and low cost could play a significant role in the energy efficiency, environmentally friendly field by reducing electricity cost and pollution. A rechargeable battery can function as a reservoir for storage of electrical energy, to carry electrical energy for portable applications, or to provide peaking energy when a demand for electrical power exceeds primary generating capabilities. Therefore, rechargeable batteries could serve the energy efficiency field, provide environmental benefits, and yield cost reductions to power users in many ways. Key potential applications are:

1). Wind and Solar Energy Storage
2). Utility Side Power Quality and Spinning Reserve
3). Electric Utility Energy and Power Applications
4). Customer Side Power Quality, Power Factoring and Demand Charge Reduction.

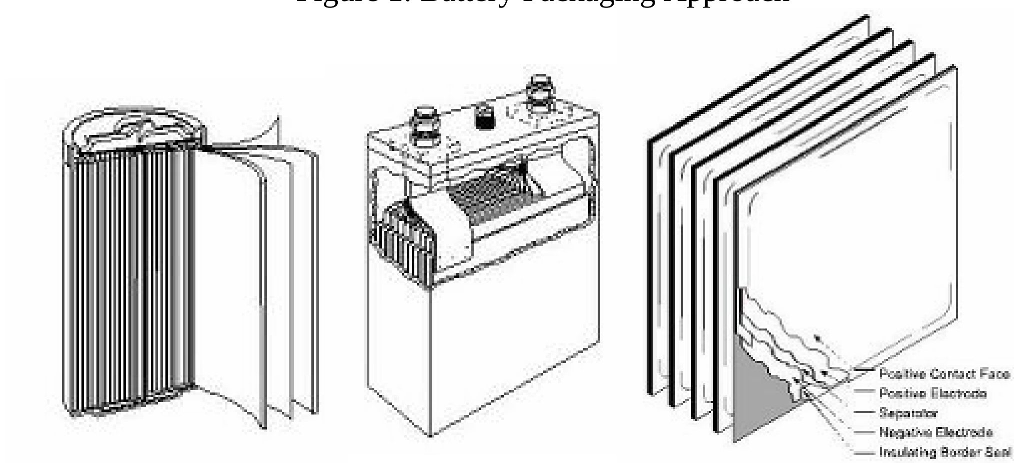
This latter application is where EEI proposed to focus this project. Industrial electric rates are typically in two components, a demand charge for the maximum peak power encountered and an electric energy cost component. It is possible to improve efficiency, reduce pollution and reduce user cost of electricity by operating a rechargeable storage battery that is charged and stores energy during the non-peak times and delivers that energy during peak demands. This would result in reducing the demand charges and reduce the peaks required from the utility grid. This is somewhat similar to utility energy storage except that in this case the customer owns and operates the storage on a dispersed basis, and the peak demands are usually less than one (1) hour. Additionally, many customers require protection from momentary power fluctuations and voltage sags that are seen increasingly as deregulation destabilizes the power grid.

The technical and economic viability of all of the above applications are controlled to a great extent by the energy, power, efficiency, life characteristics and cost of the rechargeable battery to perform in the functions required. The most dominant characteristics are first cost, life, and round trip energy efficiency. In the portable applications of electric and the hybrid electric vehicles power, cost and volume are major considerations along with weight, volume, round trip energy efficiency and life.

The market for rechargeable batteries to serve all of the above applications is modest at this point in time due to the emerging nature of many of these applications and the limitations of existing electrically rechargeable batteries. Available rechargeable batteries generally fall short of the required mix of characteristics necessary to make their performance and economics competitive with alternative approaches. Capacitors and Ultra-capacitors have significant power but do not have the necessary energy storage capability. Therefore, the driving consideration for the viability of all the systems described above is the availability of an advanced rechargeable battery that has a mix of characteristics superior to existing batteries or alternative energy systems presently available.

The cell design for the EEI technology is the wafer cell. In comparison to other mechanical designs, as show in Figure 1, the wafer cell is ideal for building high voltage batteries that need to be capable of high power. Each wafer cell is 0.040” thick and is stacked one upon the other to obtain the required voltage at 1.2 Volts/cell. The surface of each cell acts as the intercell connector providing a very large cross sectional area for current and an excellent active material utilization.

Figure 1: Battery Packaging Approach



Cylindrical Cell Prismatic Cell EEI’s BP NiMH

EEI’s cell testing has demonstrated unconventional power and capacity numbers that should be useful for many applications. Additional credits and benefits that this system would provide are:

- Backup Power - The battery could serve as a backup power supply for the customer during power outages.
- Lower Pollution, Increased Efficiency - By reducing the peak generation demand on the utility, pollution reductions would result. Typically, utility peak demands are met with less efficient gas turbines.
- Transmission Credits - Reduction in transmission line losses would occur since the transmission power level is reduced with the peak demands on the grid.
- Additional Electricity Cost Saving - If a lower off-peak electric rate were available for off-peak time charging, additional customer savings would result.
- Peaking Power Reduction - Battery would reduce power factor for companies that have daily high but short duration power demands such as electric furnaces.

Program Objective

The objective of this two-phase research program was to develop an energy efficient and environmentally friendly bipolar nickel-metal hydride battery for distributed energy storage and other utility applications, where high voltage, high power and energy are requirements. The program was divided into multiple tasks, which are discussed in this report.

Task 1: Market Study and Assessment

The phase I objective of this task was to investigate and identify applications suitable for the Electro Energy, Inc. (EEI) bipolar nickel metal hydride battery technology in the electrical power distribution network, considering time and program effort along with risk and market reward. EEI would discuss potential applications with utility and end users, and upon identification of a suitable design, would seek utility commitment for guidance purposes. In phase II of the study EEI proposed to collaborate with one to two user organizations identifying the most appropriate applications, defining the interface requirements, and testing prototype modules.

Throughout phase I and into phase II, EEI courted several utilities. Initial contacts made included Southern California Edison, Southern Company, Wisconsin Electric Power Company, and Connecticut Light and Power. Several "Utility Marketing" firms were also contacted to determine if they could assist in this effort. A visit to EEI by Southern Co. provided insight in some of the Southern Co. applications. Mostly the visit was an overview of the EEI technology, and a verbal commitment to keep each other abreast of progress.

EEI attended and presented at the DOE peer review held in Washington, DC November 19th and 20th of 2002. Conversations at and after the meeting seemed to indicate a fairly large potential market for a battery described below and for a battery that could perform a 20-35 minute discharge followed by a 40 minute recharge. In addition there seemed to be interest in a battery that could perform in place of a mechanical flywheel. EEI believes that the 20-35 minute cycle would not be ideal for the EEI battery due to limitations of cycle life, although a reasonable argument could be made if an annual replacement was allowed. Most of the applications appeared to be in the multiple MW and MWh, which are large systems and may be great opportunities for the future.

During the first phase, EEI determined that its battery possessed exceptional high power capabilities along with inexpensive packaging. Through the discussions with utilities, it was also realized that while the problems are well known to the utilities and users, the value, and possible fixes remained undefined. The specifications and requirements for the use of energy storage devices varied considerably from utility to utility. EEI determined that a utility was comfortable with gas turbines and generators, and it was unlikely that they wanted to "care" for a battery. It was concluded, however, that there was significant value in an energy storage device that was capable of high power.

In general, it appeared that a battery system that could provide high power frequently, but in low time scale (.1 to 10 seconds) while still able to completely discharge over 4 hours periodically throughout life would be advantageous to the industry, and profitable to EEI. What had not been defined, however, was the maximum power or capacity required. Initial thinking was if EEI were to enter the market it would develop a system that operates in the 400-600Volt, providing 180kW for 0.1 to 10 seconds over 300,000 cycles or 80kW providing 20Ah for 200-300 cycles or a combination of the above. This would later be more defined once a firm relationship was made with a utility to look at specific applications.

First Energy

By the end of phase I, EEI had developed a relationship with the Ohio based utility company, First Energy. First Energy had several applications for battery backup. In particular First Energy wanted a distributed energy storage system (such as at every Burger King) that would be able to either take charge over 1 hour up to 8 hours and be able to discharge at various levels. As part of the phase II objectives First Energy collaborated with EEI on a cost share basis to achieve the following scope of work:

> Evaluate the performance of the NiMH energy storage batteries with grid-interactive and UPS devices to develop integrated applications of storage for Power Quality, Load Following, and Energy Management capabilities. Test to establish equipment compatibility and performance capabilities. Comparison testing of NiMH batteries and Ultracapacitors to also be performed using the UPS devices.
>
> Develop applications for a NiMH energy storage device with a grid interactive device capable of interconnecting to the electric grid for storage and on-command discharge of electricity in grid-connect operation at prescribed energy levels. Will evaluate the ability of the integrated device to operate in stand-alone and grid connect modes. Storage capacity durations to be studied to evaluate, long term storage exceeding one half-hour, and/or multiple shorter term electrical discharge and/or recharge operations. Storage device and electrical interface to utility to be integrated and tested regarding compatibility and performance. Integrated grid interactive device with NiMH batteries to be tested with minimum NiMH storage capacity of 40kWh.
>
> Comparison testing of NiMH batteries and Ultracapacitors to be performed on UPS equipment provided by First Energy; a 100kW for 10 sec AC ride through device, and a 3kW for 10 minute UPS. First Energy would make available this equipment, recently developed through funded projects with EPRI, for evaluation with NiMH batteries. Electro Energy would test the UPS devices for performance comparison of the NiMH batteries and ultracapacitors energy storage sources.
>
> Test grid device of at least 20kW output capability for integration with a minimum energy storage capability of 40kWh of NiMH batteries.

As part of its cost share in the second year participation, First Energy had delivered to EEI a 100kVA 10 second UPS with ultracapacitors and a 3kW 10 minute UPS also with capacitors. The capacitors for both systems were manufactured by ESMA. Additionally, First Energy provided engineering interface and support (guidance) to EEI's team. The intent was to test each of these systems utilizing the ultracapacitors, and later design and build a NiMH battery to replace the capacitors and run comparison testing with each of the units.

In addition to the 3kW and 100kVA UPS systems, First Energy was interested in 40kWh, 20kW Inverter system made by Ballard. They required a 600V, battery system that was able to sustain 20kW for 2 hours.

<u>3kW System</u>

The 3kW UPS system was manufactured by UPPI, and acquired and supplied to EEI by First Energy. Eight 12V ESMA ultracapacitors were used and connected as two parallel strings of four capacitors in series. The resulting configuration had a nominal voltage of 48V. The 3kW UPS test sequence consisted of 12 individual cycle types, defined in Table 1.

Table 1: 3kW Test Sequence (Ultracapacitors and Batteries)

Cycle Type	**Load% (W)**	**Total DCG Minutes**	**Apply 5-Second Impulse Load at**
1	75% (2250W)	10	2 minute mark
2	50% (1500W)	20	4 minute mark
3	25% (750W)	40	8 minute mark
4	75% (2250W)	10	Never
5	50% (1500W)	20	12 minute mark
6	25% (750W)	40	24 minute mark
7	75% (2250W)	10	6 minute mark
8	50% (1500W)	20	Never
9	25% (750W)	40	36 minute mark
10	75% (2250W)	10	9 minute mark
11	50% (1500W)	20	18 minute mark
12	25% (750W)	40	Never

Between each discharge there was ostensibly a 2.25 hour recharge plus a 0.5 hour rest. However, in reality the unit went into trickle charge before the 2.25 hours expired, so the 0.5 hour "rest" period was just an extension of the trickle charge.

The 12 cycle types were run in groups of four on successive days, and rolled over after the 12th cycle type has been completed. Thus, Cycles 1-4 would be run on Day 1, Cycles 5-8 on Day 2, Cycles 9-12 on Day 3, then back to Cycles 1-4 on Day 4, etc., until a total of 200 cycles are run.

The following data points were recorded at 1-second intervals throughout each cycle:

- AC input voltage (from line)
- AC output voltage (to load)
- Individual DC module voltages for Modules 1-8
- Overall (total) DC string voltage
- DC current flowing in the string
- AC current flowing to the load

During integration and testing, EEI encountered numerous problems, requiring the following resolutions:

- Problem: Inaccurate module and string voltage measurements caused by the high levels of electrical noise generated by the UPS
  Resolution: Considered configuring the A/D measurement card for differential rather than single-ended measurements. This proved impossible to implement due to grounding issues with the modules. Ultimately used bypass capacitors at strategic points to minimize noise.

- Problem: Low-level thermocouple outputs overshadowed by electrical noise levels in the system.
  Resolution: Attempted using a commercial cold junction temperature compensation IC along with an amplifier and filter. In addition, temperature measurements were recorded as the average of multiple samples rather than as a single sample in order to minimize noise effects. Replaced non-shielded thermocouple wire with shielded thermocouple wire. The noise levels were still deemed unacceptable. Ultimately, a commercial thermocouple data logger was purchased and interfaced to the test program using the RS-232 port. Still using the shielded wire, the temperature measurements are now stable and reproducible.

- Problem: The only thermocouple data-logger obtainable that had the necessary dual inputs as well as a serial output did not offer an option to be powered from the AC line. The maximum battery life was specified by the manufacturer as two days, which was deemed unacceptable.
  Resolution: A simple 2.6VDC fixed-output power supply was built and interfaced to the battery terminals of the data-logger, providing continuous input power.

- Problem: The DC bus current measurements were subject to the same noise issues as the DC voltage and the temperature measurements previously discussed.
  Resolution: The passive DC current shunt originally used in the system was replaced with a clamp-on DC ammeter providing a voltage output proportional to the bus current. This output voltage was then amplified and filtered to achieve acceptable levels. The ammeter suffered from the same battery life issue as the thermocouple data-logger. This was resolved by powering the ammeter from the same 2.6V supply used by the data-logger.

- Problem: The inverter module in the UPS failed unexpectedly after being in service for several months.
  Resolution: UPPI provided telephone support and sent a replacement inverter module. The field swap-out was completed successfully. No further incidents have occurred. A new Inverter Control board was recently sent to EEI from UPPI. This will be installed by EEI in the UPS shortly.

- Problem: The number of data points generated during each set of 4 cycles exceeds the quantity that can be graphed in Excel.
  Resolution: All raw data for each set of daily cycles is being retained. However, the graphs reflect every other data point (i.e., a point every 2 seconds) rather than every point.

Results of the ultracapacitor testing and the building and testing of the EEI batteries will be discussed later, under task 6.

100kVA System

The 100 kVA UPS system was manufactured by Liebert, and acquired and supplied to EEI by First Energy. Nine 42V ESMA ultracapacitors were used and connected in series. The resulting configuration had a nominal voltage of 378V. The Liebert had a nominal voltage of 480V, and therefore a DC-DC converter was required to utilize the ultracapacitors. The 100kVA UPS test sequence consists of 12 individual cycle types, defined in Table 2.

Table 2: 100kVA Test Sequence (Ultracapacitors and Batteries)

Cycle Type	**Load% (W)**	**Total DCG (Seconds)**	**Apply 100mS Impulse Load During Discharge at**
1	75% (72kW)	10	2 second mark
2	50% (48kW)	20	4 second mark
3	25% (24kW)	40	8 second mark
4	75% (72kW)	10	Never
5	50% (48kW)	20	12 second mark
6	25% (24kW)	40	24 second mark
7	75% (72kW)	10	6 second mark
8	50% (48kW)	20	Never
9	25% (24kW)	40	36 second mark
10	75% (72kW)	10	9 second mark
11	50% (48kW)	20	18 second mark
12	25% (24kW)	40	Never

Between each discharge there is a 2.25 minute recharge plus a 1.0 hour rest.

Each group of 12 cycles was run once daily.

The following data points were recorded at 200mS intervals throughout each cycle:

- AC input voltage (from line)
- AC output voltage (to load)
- Individual DC module voltages for Modules 1-9
- Cell voltages of two individual cells in Module #3 and two individual cells in Module #5
- Overall (total) DC string voltage
- DC current flowing in the string
- AC current flowing to the load

Additionally, the internal temperature of Modules #3 and #5 were recorded every ten seconds, along with the internal cabinet temperature at points approximately halfway up and also near the top of the cabinet.

There were numerous issues with this testing from the perspectives of data acquisition as well as system operation and performance. From a system perspective, two defective capacitor modules (out of nine) needed to be replaced before even preliminary testing was performed. Subsequently, one of the two replacement modules had been identified as possibly exhibiting high internal leakage current. This prevented testing from continuing at the time.

The data acquisition portion of the testing had also proven to be a challenge. The main areas of concern were isolation of the measurement system from the extremely high voltages present in the UPS system, and also the high levels of radiated EMI that overwhelmed some of the lower-level voltage measurements. It was believed that satisfactory solutions were in place for these issues, and that testing could commence once the capacitor issues were resolved.

The issues with the capacitors, however, proved to be consistent and ultimately testing of the system utilizing the capacitors was terminated. EEI spent a substantial amount of time troubleshooting the inverter hardware and capacitors and developing software to perform testing on this system. There was considerably more time spent setting up, troubleshooting, and monitoring these systems than was originally estimated. As a result, it has been determined that no additional testing will be done on this system utilizing the capacitors.

<u>High-Voltage, High-Power System</u>
EEI also established a relationship working jointly with DOE and an outside agency (under a separate contract) to develop a 700V battery system. The 700V system would be developed under this DOE effort but tested by UD.

Task 2: Cell Development

In general, each battery application requires component development and verification specific to the required load profile. The purpose of this task was to improve the performance of the nickel metal hydride battery while improving manufacturability and lowering cost. In both phase I and II experimental investigations were done at the single cell level utilizing 6 in. by 12 in. test cell hardware with the objectives of improving energy density, power density, life, reproducibility, and reduced cost. The investigations would be driven by cost, performance, and life objectives. These initiatives are described as follows:

A. Cost Reduction

-Nickel Current Collector

1. The use of thinner foil to cut down on the amount of nickel used.
2. Nickel plated material utilizing a low-cost substrate such as steel.

B. Cost Reduction and Performance Improvements

-Nickel Hydroxide Active Material

1. Nickel Hydroxide Coating Costs
2. Alternative Nickel Hydroxide Supplier Evaluations

-Separator Material

1. Alternative Commercially Available and New Development Materials
2. EEI Inorganic Separators

-Hydride Alloy

1. Higher Power and Longer Life
2. Lower Cost
3. Extend Operation Temperature -45^{o}C to 85^{o}

C. Cell Testing

-It was planned to construct three single cells per design variable for reproducibility purposes and subject the cells to initial formation and rate capability testing over a current density range from 50 to 200 mA/cm^2. Those configurations that appeared promising would be life tested on an agreed upon simulated power/energy life cycle profile.

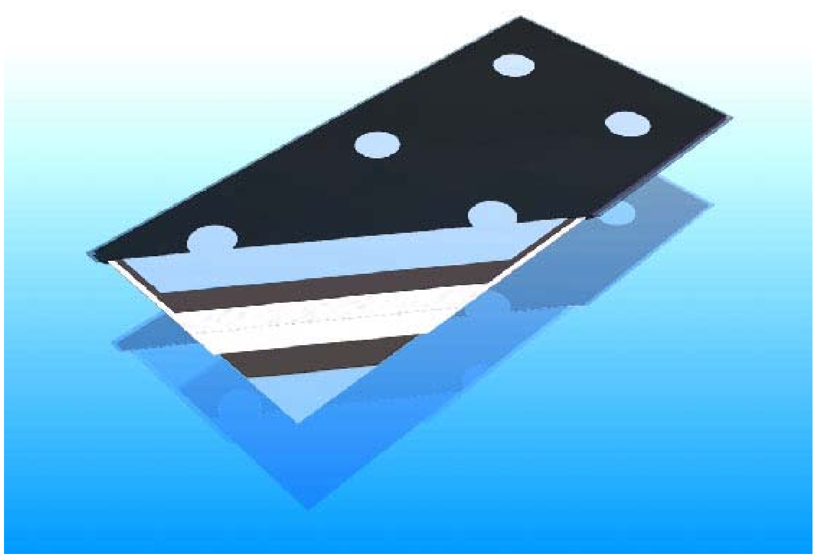
The proposed cell build and testing matrix is shown in Table 3. This served as a baseline, allowing for flexibility as results were obtained. The most favorable compositions would undergo extensive life and power testing.

Table 3: Baseline Cell Build and Test Matrix

	Cell	Test Performed	Number of Cells
Hydride Development Screening & Additives	8 groups of 3 hydride limited, flooded cells for each hydride 4 groups of 3, sealed of most promising	Power, capacity, life cycle, high and low temperature storage	36 cells 6” x 12”
Nickel Oxide Development	8 groups (3 cells of each oxide) Sealed	Power, capacity, life cycle, high and low temperature storage	24 cells 6” x 12”
Separator	6 groups (3 sealed cells of each separator)	Power, capacity, life cycle, high and low temperature storage	18 cells 6” x 12”
Positive current collector (reduce weight, cost and thickness, improve thermal management)	4 groups of best component combinations (3 sealed cells of each group)	Power, capacity, life cycle, high and low temperature storage	12 cells 6” x 12”
Negative Current Collector (reduce weight, cost and thickness improve thermal management)	4 groups (3 sealed cells of each group)	Power, capacity, life cycle, high and low temperature storage	12 cells 6” x 12”
Electrolyte	3 groups of 3 sealed cells	Power, capacity, life cycle, high and low temperature storage	9 6” x 12”

Previous to this program Electro Energy developed a baseline cell design that would be used for research and development of cells and modules. The baseline cell, referred to as a wafer, and shown in Figure 2, measures approximately 6-inch x 12-inch x 0.035-inch thick. The nominal capacity of this cell is 6 Ah, and it exhibits high rate capability.

Figure 2: EEI Baseline Bipolar NiMH Cell



Depiction of EEI wafer prototype

During this task EEI received significant support from Rutgers University and Treibacher. Rutgers provided material screening and testing of individual cells. Treibacher provided EEI with multiple hydride samples and production lots, with formulations requested and developed by both EEI and Treibacher. They also did initial material screening and characterizations.

Cell Building and Testing

A complete table of cells tested under this program, and the results of this testing, is attached in the appendix.

EEI began a study to assist in understanding high power limitations of EEI's active materials. High power is defined at >15C up to 120C rate capability. As a background, under a PNGV effort EEI developed several methods to evaluate performance data and model alternate designs. Additionally, mechanical and structural design trade-off methods evolved so that long term life and fade rates could be forecast with some materials. Under the PNGV program several hundred 6 Ah cells were constructed to meet their power requirements with a life goal of 300,000 cycles. The life cycle program was continued at EEI in anticipation of receiving this program and for internal purposes.

A cell build was initiated consisting of 90 cells (3 of each type) covering 30 variables. Nickel coating, hydride, and two separators were investigated first. Some cells performed better than others, which was believed to be the result of the nickel active material at room temperature and high rates. Several EEI processes were used, giving high power and improving with cycling.

To understand if the scale-up was the cause of the loss of performance EEI set up a nickel hydroxide coating matrix using 2 kg, 10 and 15 kg processes as well as the old three step, new three step and the latest one step process. In addition, since all incoming and process material is controlled at EEI by using vented control cells, a change has been made to also include sealed cells and cold temperature screening. The results of the various controls showed that the various coating processes do not make a significant difference up to the 10C rate in the vented configuration. This would indicate that the base material has changed. The results seemed to indicate that the 300kg of nickel hydroxide obtained from Sumotomo (Tanaka Z) was different from the last lot of material in some non-monitored parameter.

During a later build cell performance was replicated and improved over the baseline PNGV cells, as compared to an initial screening test which compares the end voltage after 10 second 200 A discharge on the nominal 6 Ah cell. The fundamental reason for why some cells perform better than others seems to be due to the nickel active material at room temperature and high rates. The base material obtained contributes along with the subsequent coating of it at EEI. What is interesting, is that several EEI processes can be used, giving high power. Additionally, the power is improved with cycling, or even additional high power pulses which may lead us to power improvements on sealed cell formations.

Throughout the program, multiple hydride alloys were investigated. Variables looked at included alloy composition, casting process, and particle size. The baseline material used was SC-1132, a Santoku America hydride, which was a rapid solidification strip-cast alloy, using a standard misch-metal based AB_5 composition. Treibacher supplied us with multiple variations of a standard composition AB_5 alloy, looking at standard mold casting, and rapid solidification strip-casting and gas atomization. After looking at numerous samples, through cell testing, EEI determined to change the baseline to a Treibacher, standard AB_5, mold cast alloy, referred to internally as LEG-757. This change was not only due to performance, but also the consistency and availability of the material was superior.

Power Testing

A majority of the cells built in this project were the 6.48Ah 6" x 12" cells designed for high power discharge pulses. The standard power test was to charge the cell to 50% State-of-Charge (SoC), and the discharge them at 100A to 500A, for 10 seconds. The minimum voltage would then be recorded, and used as the main variable to distinguish performance from cell-to-cell. Through testing, we determined that parameters such as temperature, battery SOC, discharge current, and discharge time can have a marked influence on power density measurements. The cell testing allowed EEI to determine many critical parameters, such as power capability and density. Representative graphs of the results are shown in Figures 3 through 5.

Figure 3: Initial Power Capability 10 Second Pulse 50% SOC

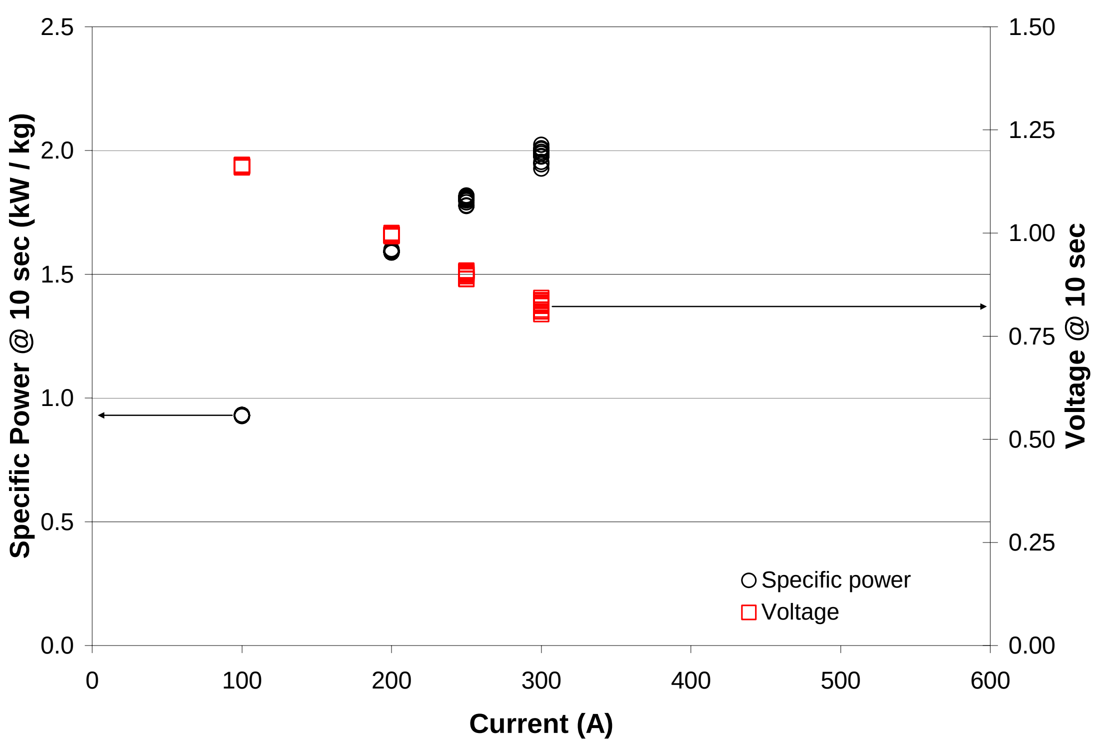


Figure 4: Initial Power Capability 1 Second Power Pulse 50% SOC

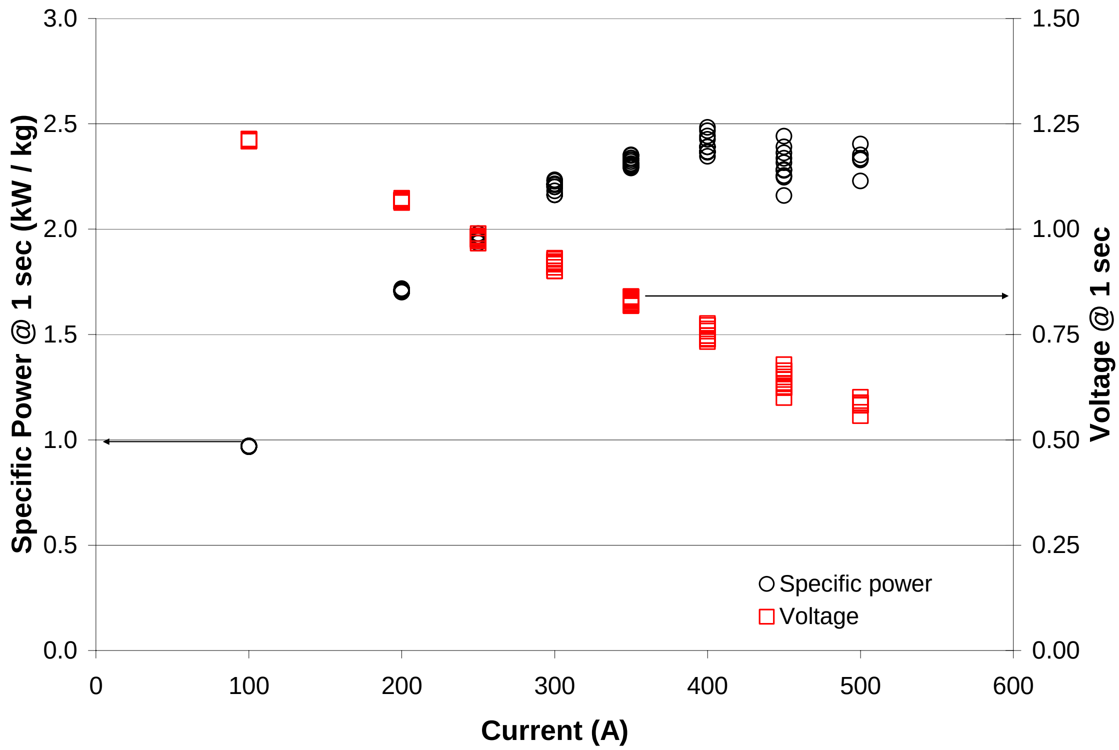
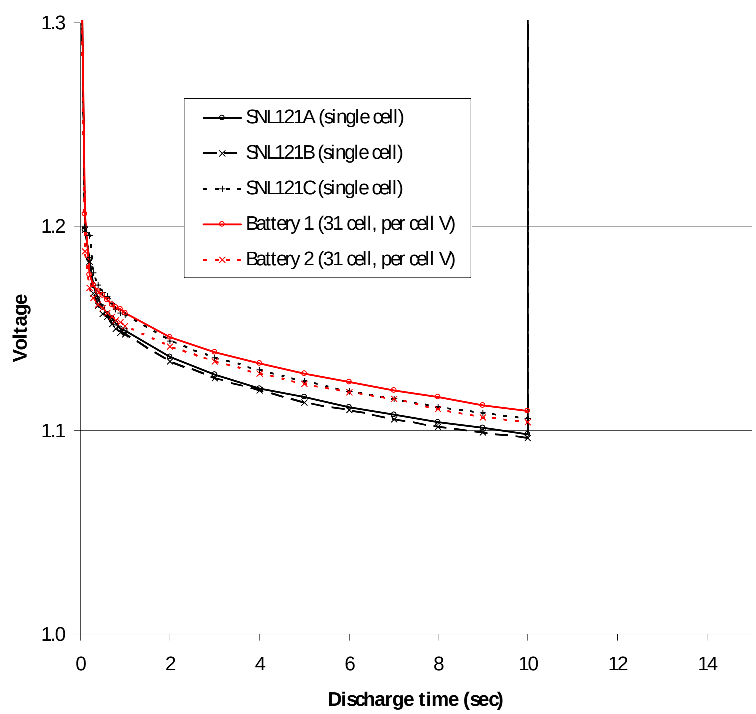


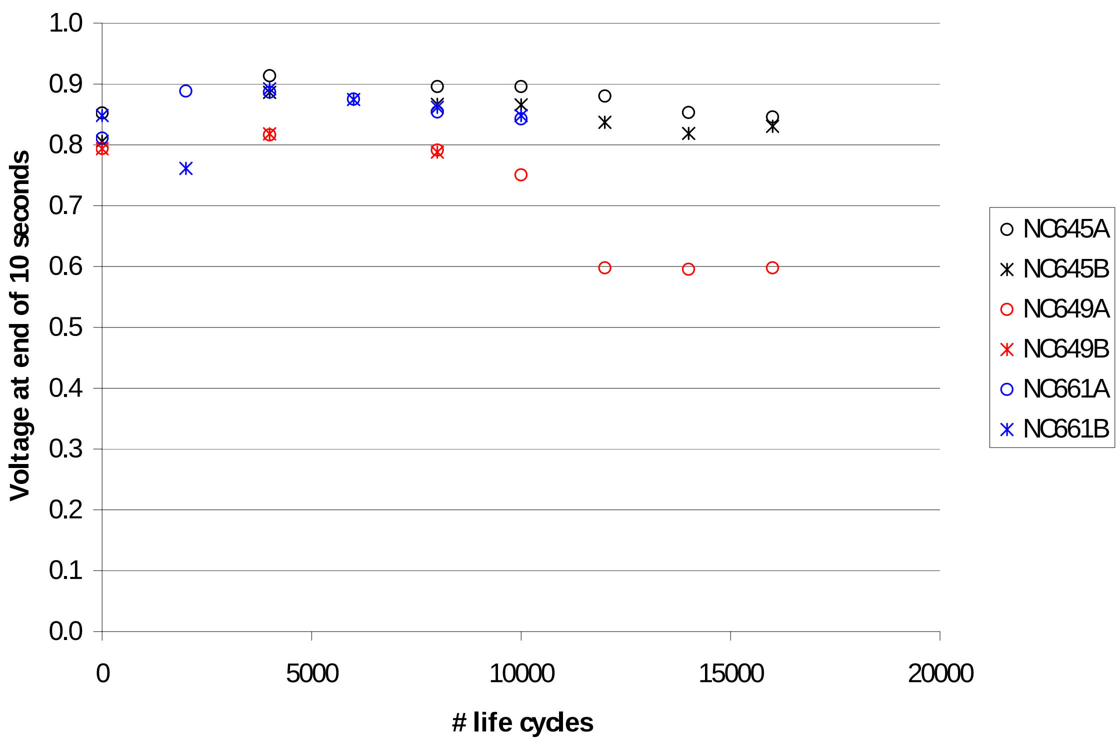
Figure 5: 100A discharges at 50% SOC: comparison between single cells and 31 cell batteries



<u>Life testing</u>

Some cells were placed on a life cycle consisting of a 40A charge for 58.5 seconds, a rest for 10 seconds, and a 40A discharge for 58.5 seconds. This corresponds to 10% SOC swings based on a theoretical capacity of 6.5Ah. Periodically, the cells were removed from the life test, and subjected to the power test of a 10 second / 200A discharge at 50% SOC. The results are given below in Figure 6. The cells are nominally identical in construction, with different batches of coated nickel hydroxide used. The nominal composition of the coated material is 12% nickel metal, 3% cobalt metal, with the balance nickel hydroxide.

Figure 6: Cell pulse power vs. number of life cycles for selected cells



<u>Alternative power profile performance</u>

It is useful to examine the performance of the cells under a variety of pulsing schemes. Both charge and discharge cycling at intermediate states of charge as well as pulsed full discharge from a full state of charge were examined.

Figure 7 shows the sealed performance of a cell when charged and discharged at 6.0A (about the 1C rate). Reasonable values of efficiency were obtained. An interesting result is that the observed pressure continues to climb for about 15 minutes into the discharge time. This has implications concerning the levels of pressure which should be selected to control overcharge / overdischarge situations.

Figure 8 shows a cell which has been fully charged, and is then discharged with a pulse train consisting of a 3A, 5 second pulse, followed by a 5 second rest.

Figure 7: Charge/ discharge cycling of S121-2

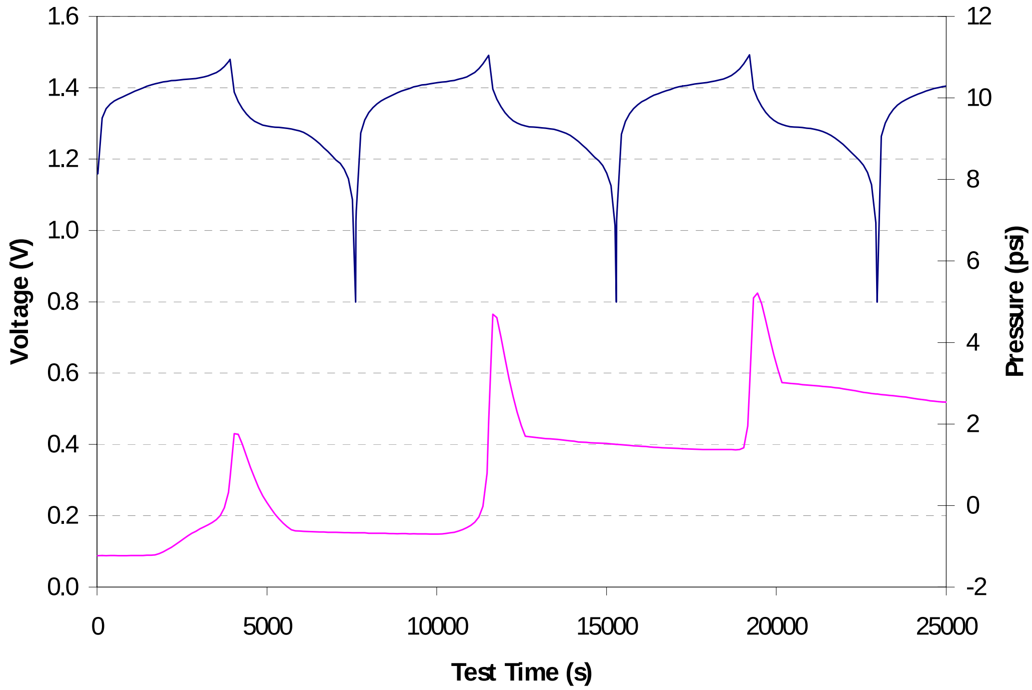
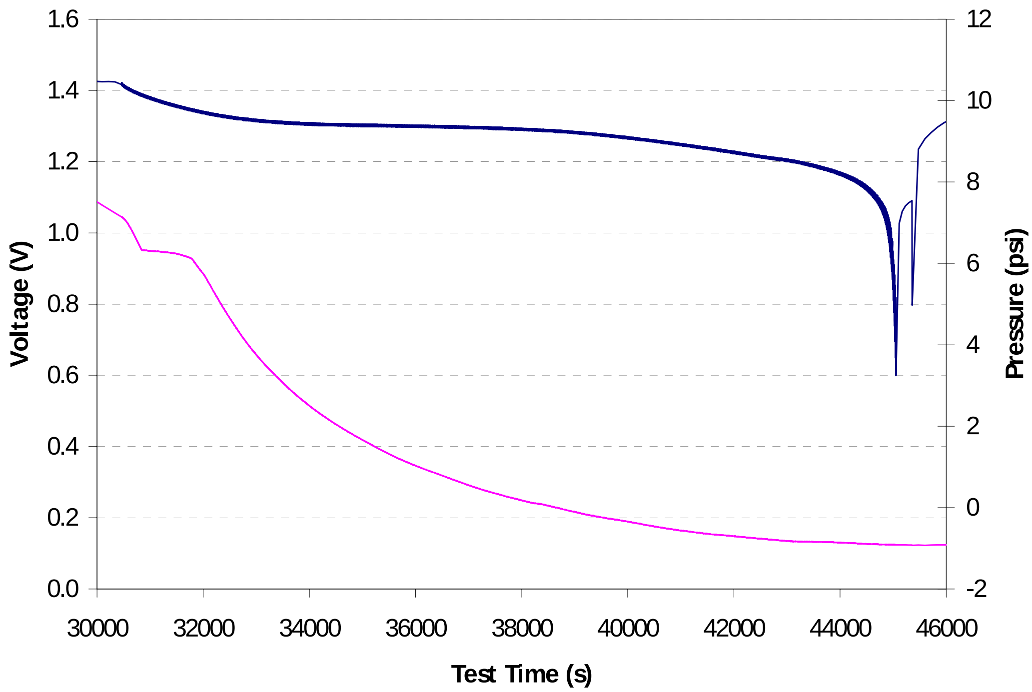


Figure 8: Pulse discharge of S121-2



Figures 9 and 10 show the pulse cycling of cell S121-3 at 50% SOC. The duty cycle was a 100A charge for 0.1 second, rest for 0.1 second, 100A discharge for 0.1 second, and rest for 0.1 second. When operated in this way, it appears that the discharge and recharge resistances are approximately equal (the delta-V's are about the same in either direction).

Figure 9: Pulse cycling of cell S121-3 at 50% SOC.

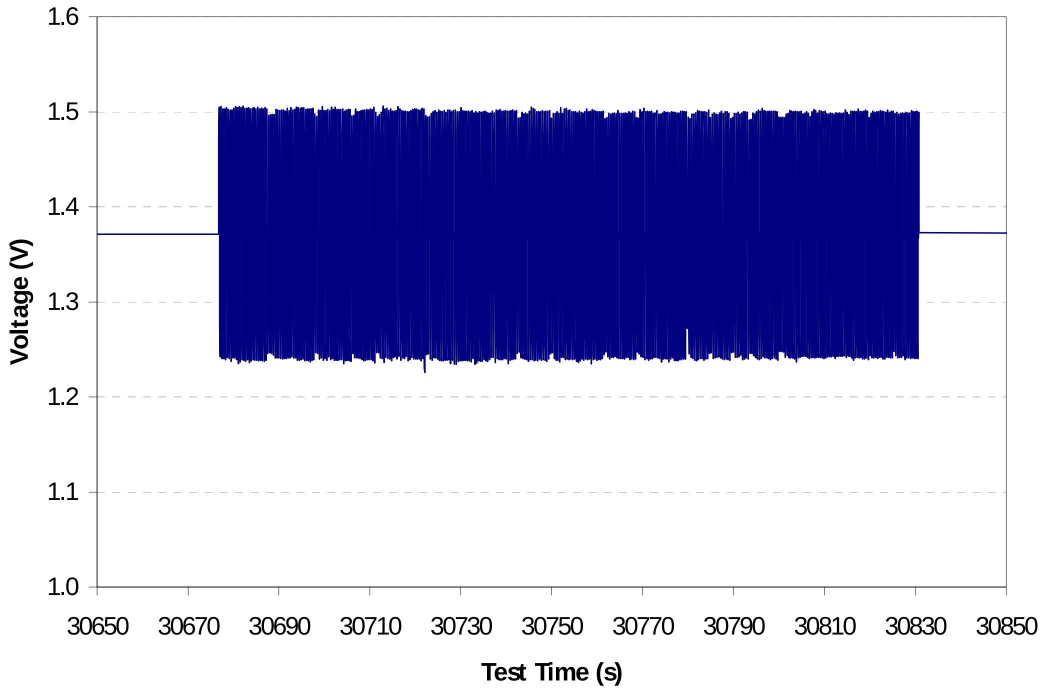
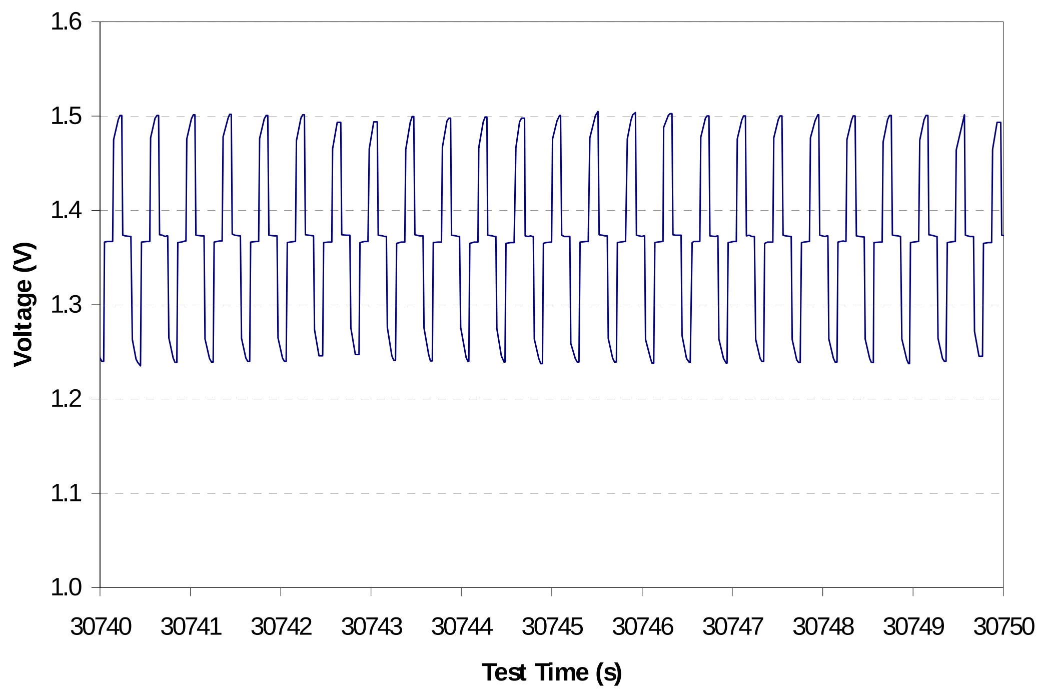


Figure 10: Pulse cycling of cell S121-3 at 50% SOC



Figures 11 and 12 show the pulse cycling of cell S121-3 at 50% SOC. The duty cycle was a 100A charge for 1.0 second, rest for 1.0 second, 100A discharge for 1.0 second, and rest for 1.0 second. This is similar to the cycles shown in Figures 9 and 10, but with the time scale increased by an order of magnitude.

Figure 11: Pulse cycling of cell S121-3 at 50% SOC

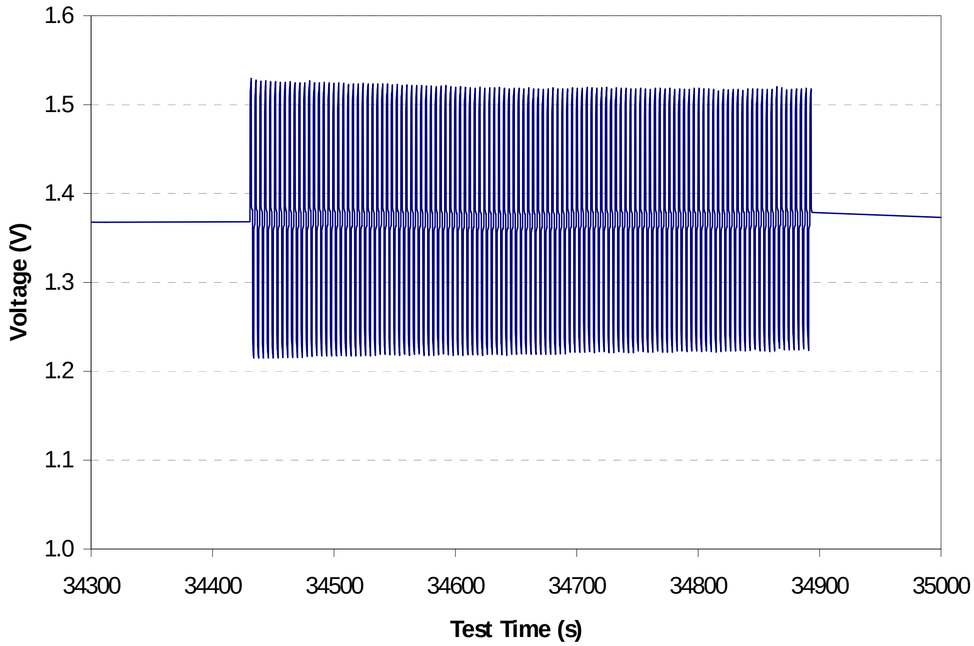
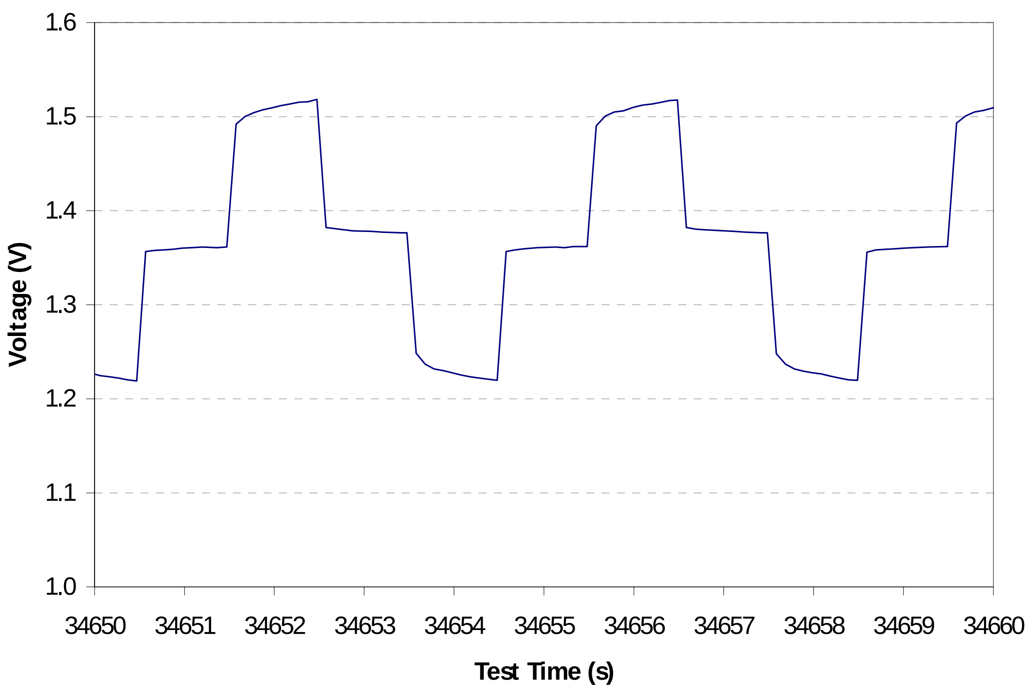


Figure 12: Pulse cycling of cell S121-3 at 50% SOC



Figures 13 and 14 show the pulse discharge of cell S121-3 starting at 100% SOC. The duty cycle was a 100A discharge for 0.1 seconds followed by rest for 0.1 seconds. Delivered capacity was 2.81Ah as measured by the test equipment. We believe that this value is too low, however, since past experience with cells discharged at constant current at 90A shows that utilizations of about 90% of theoretical capacity can be obtained. It may be that on the particular test equipment used, current overshoot or timing issues may provide an explanation.

Figures 15 and 16 show the pulse discharge of cell S121-3 starting at 100% SOC. The duty cycle was a 100A discharge for 1.0 seconds followed by rest for 1.0 seconds. This is analogous to the discharge shown in Figures 13 and 14, but with the time scales lengthened by an order of magnitude. In this case, the delivered capacity was 5.69Ah, which we believe to be a more plausible value than that of Figures 13 and 14. It is noteworthy that on either the 0.1 second time scale or the 1.0 second time scale that the overall "width" of the discharge curve is about the same in both cases (i.e. V (I=0) – V(I=100) regardless of the time scale used).

Figure 13: Pulse discharge of cell S121-3 starting at 100% SOC

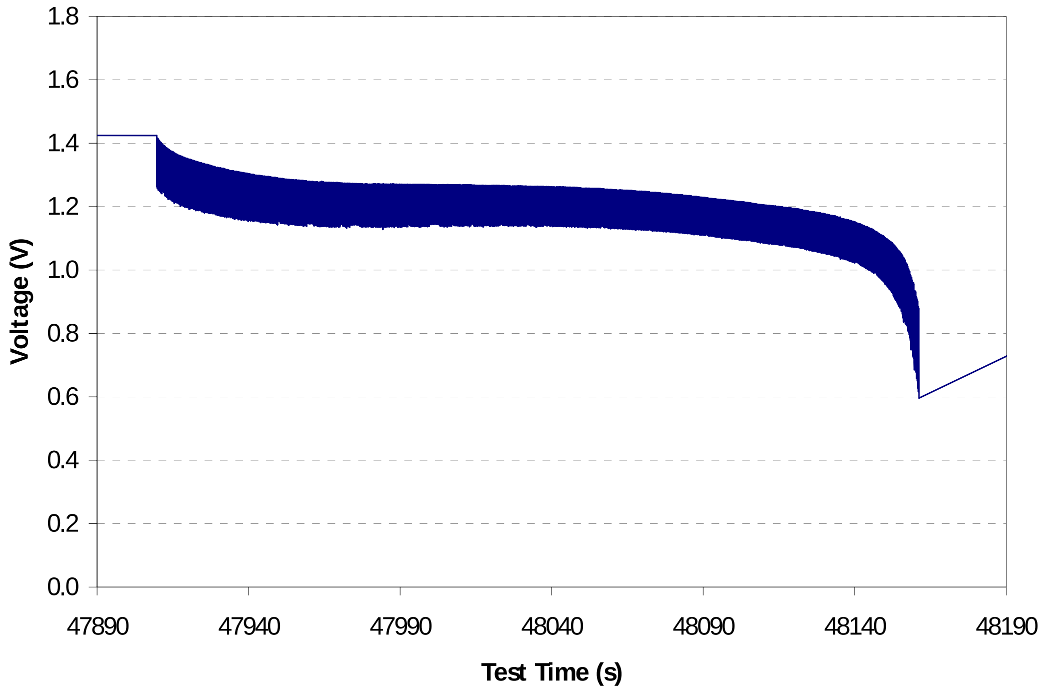


Figure 14: **Pulse discharge of cell S121-3 starting at 100% SOC**

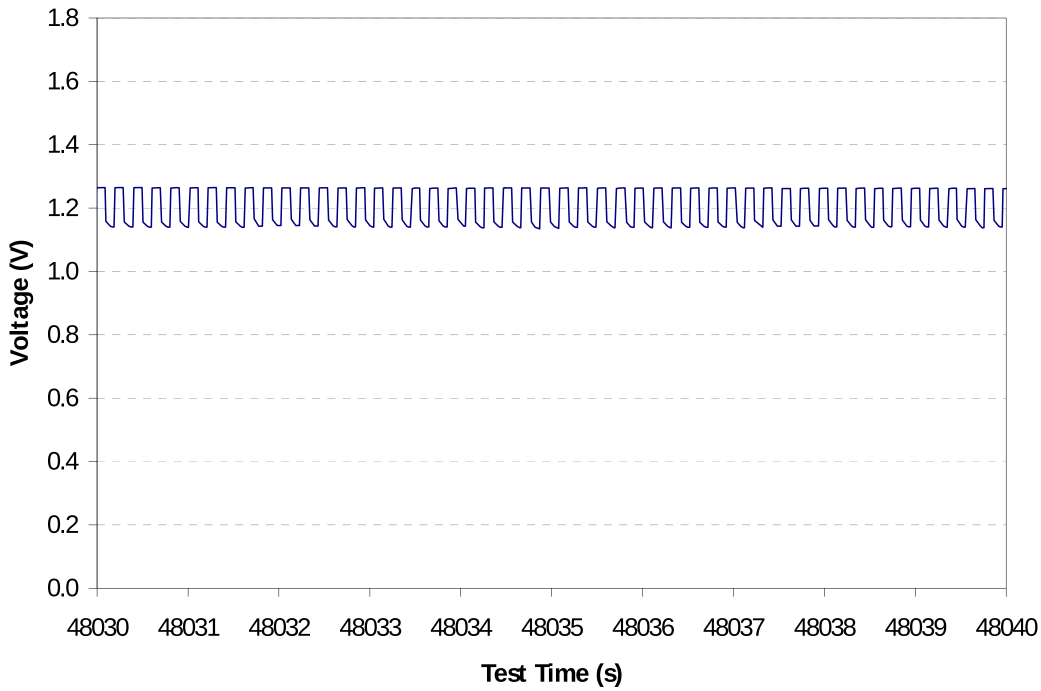


Figure 15: Pulse discharge of cell S121-3 starting at 100% SOC

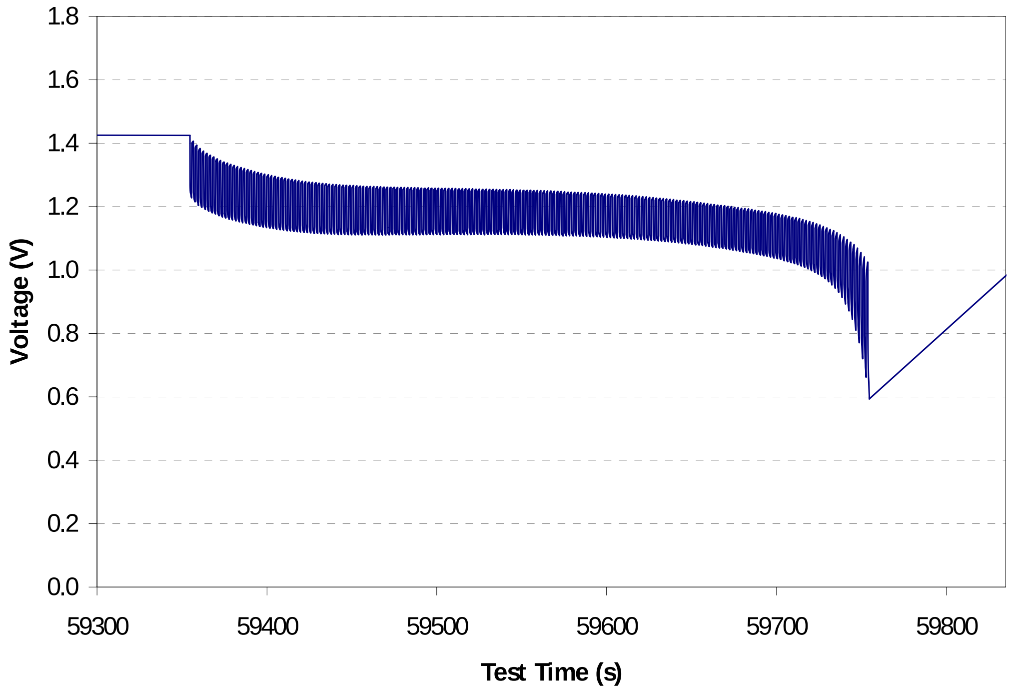
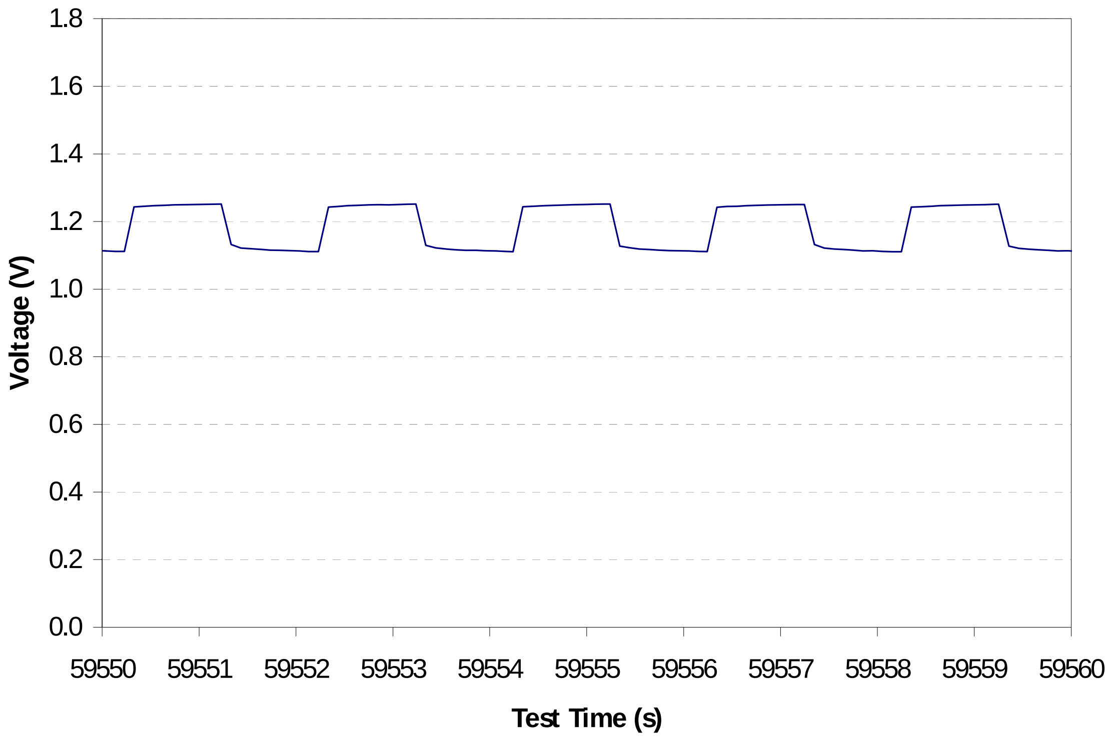


Figure 16: Pulse discharge of cell S121-3 starting at 100% SOC



EEI also conducted testing to determine the charge acceptance of cells at high current levels, as well as rate capability of cells when fully discharged. To determine the effect of capacity and cell thickness, the standard 6.48Ah cells were compared to cells of double capacity, and therefore double the thickness. Results from this group of test are shown in Figure 17 through Figure 20, and summarized in Table 4.

Figure 17: Fast Charge Study Power and Energy Design Verification (PEDV) Test 0% SOC to full charge in about 8.5 minutes 6.48 AH Th. Cell

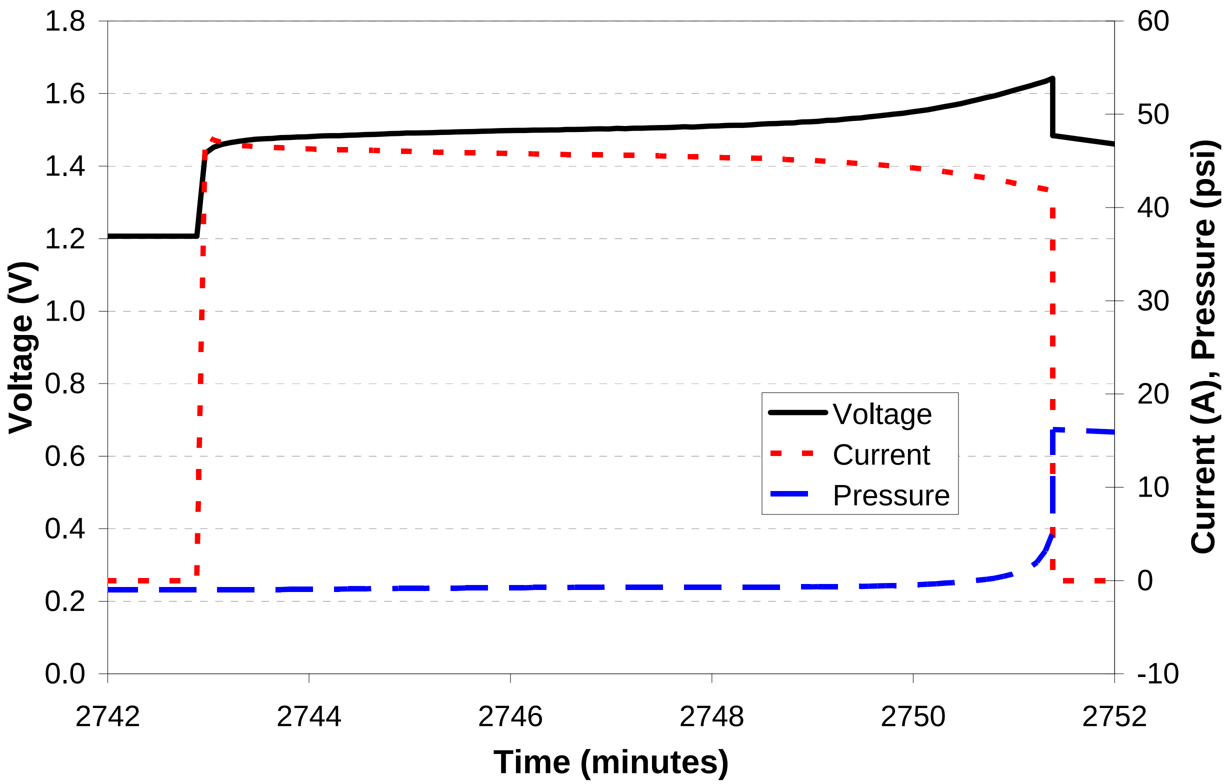


Figure 18: PEDV Discharge Test
Fully-charged condition to discharged in 4.3 minutes. A slower 3 A discharge to 0.8 V followed, to return the cell to the empty state - 6.48 Ah 6” x 12”

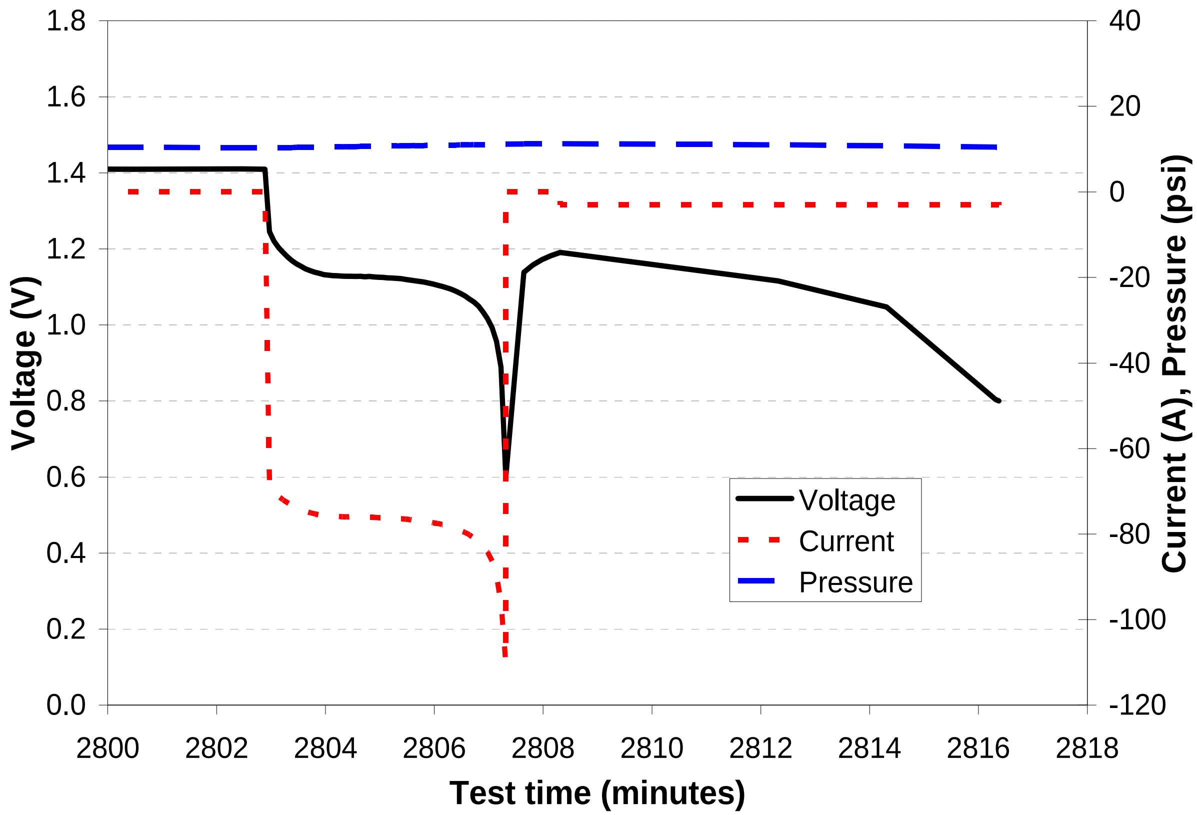


Figure 19: Fast Charge Study Power and Energy Design Verification (PEDV) Test 12.96 Ah cell charge under a PEDV regime

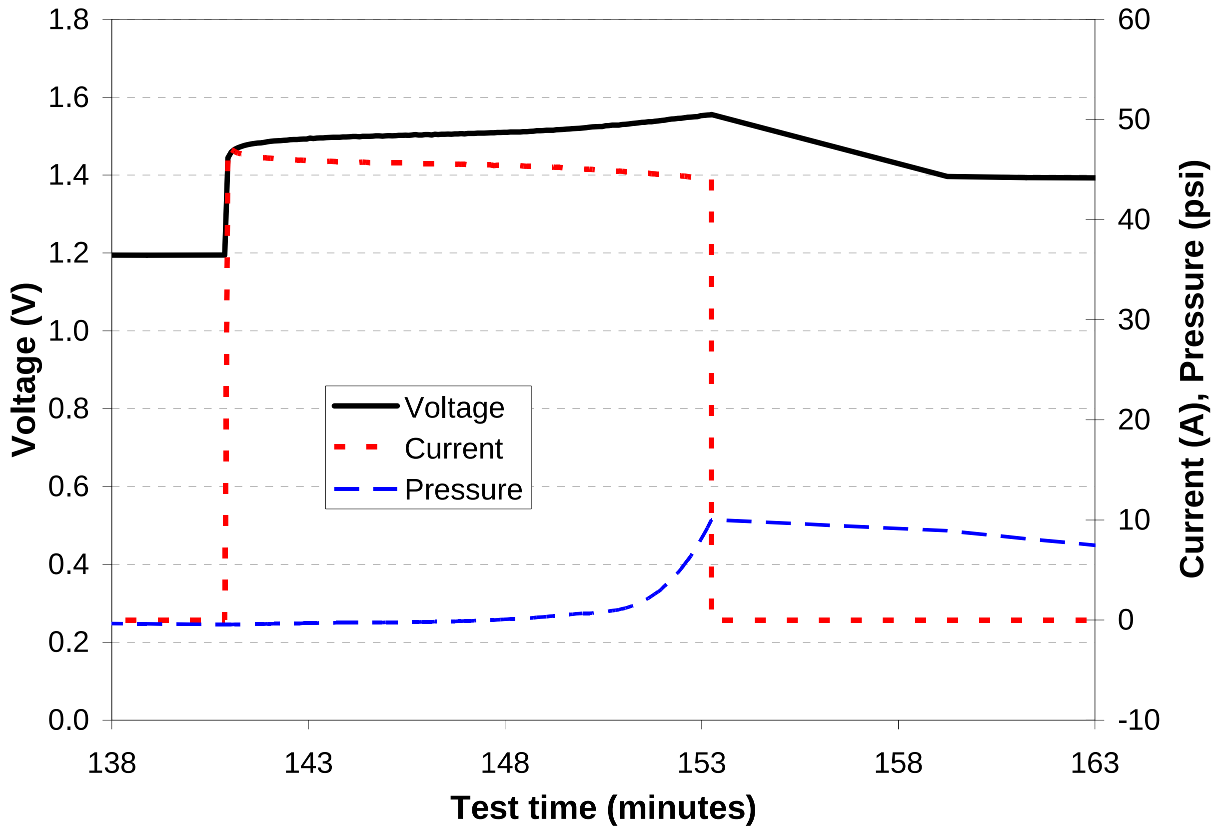


Figure 20: PEDV Discharge Test 12.96 Ah
The thicker cell was able to accept charge at the specified rate for 12.3 minutes and was able to discharge for 6 minutes. Also note that there is considerably more residual "low power" capacity in the discharge for this cell when compared with the thinner cell.

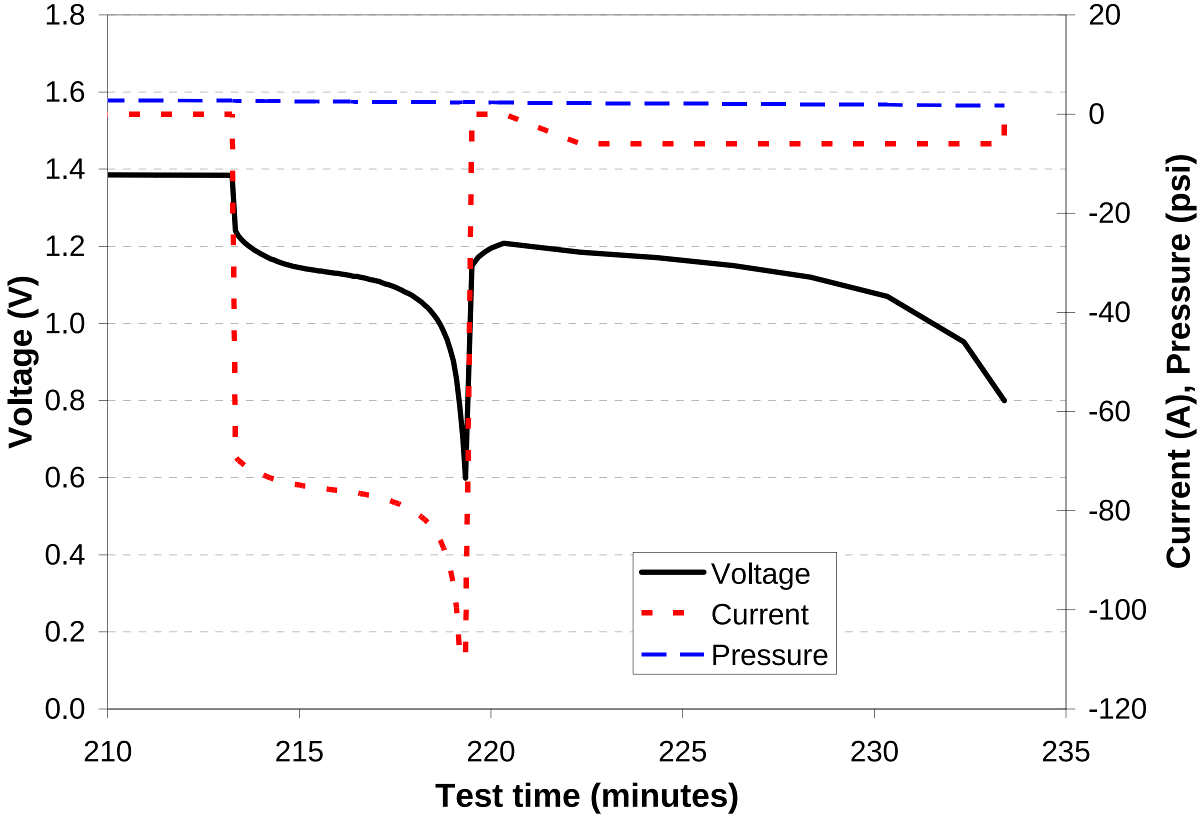


Table 4: Summary data for PEDV testing
(Note that the discharge figures are for the high power discharge only.)

Parameter	Cell theoretical capacity	
	6.48 Ah	12.96 Ah
Charge capacity (Ah)	6.42	9.37
Charge energy (Wh)	9.71	14.14
Discharge capacity (Ah)	5.71	7.95
Discharge energy (Wh)	6.31	8.67
Scale factor for 250Wh	39.6	28.8
Scale factor for 300Wh	47.5	34.6
Battery capacity for 300Wh (Ah)	8.8	12.8

In addition to the high-power type cells described, EEI also identified a high-energy type baseline cell, ideal for applications that require sustained energy over long periods of time. This cell utilizes the same 6" x 12" envelope, but replaces the thin, low-capacity electrodes, with thicker, higher capacity electrodes. The cells have a nominal capacity of 20Ah, which is greater than 3X the capacity of the high-power cells. To improve the conductivity of the nickel electrodes, a nickel foam-based electrode is used. To serve as a baseline, EEI used nickel foam electrodes purchased from Sanyo, with the intention of ultimately producing this type of electrodes in-house.

Task 2 Conclusions
Electro Energy has fabricated a number of the baseline wafer cells utilizing the 6" x 12", 6.48Ah cell. The electrical characterization of these cells clearly demonstrates their high rate capability. From the testing these cells are able to support a continuous 500A load, which corresponds to approximately 250W at the cell level and a projected power of about 15 kW at the module level assuming a nominal operating voltage of 0.5 V per cell. During the program, four prototype cells were delivered to Sandia National Laboratories for independent device performance and evaluation.

In addition a baseline 20Ah cell was developed for high energy applications.

Task 3: Formation Studies

The formation process EEI utilized to prepare cells was laborious and time consuming. To meet the overall cost objectives determined under Task 1, a simpler process needed to be developed for high power batteries. The studies covered experimental investigations to optimize the electrolyte filling and formation process to obtain the capability to form assembled batteries or cell stacks. The goal was to fill cells with the prescribed quantity of electrolyte and reach rated performance capacity with the minimum number of formation cycles and handling steps. Alternate electrolyte quantities, techniques for filling, pre-treatments of the hydride alloy, electrodes and separators would also be evaluated. Selected single cells and stacks would be tested on simulated cycle life profiles.

This effort concentrated on reducing formation time from two weeks to less than one day. During the first phase effort several techniques were developed to speed up flooded formations, which resulted in improved life and power. EEI successfully demonstrated a 24-hour formation process to obtain rated capacity. Unfortunately, the rate capability of the resulting cell was less than desired, falling off at 4C.

A five-cell stack was built, wet with electrolyte, sealed, stacked into a lexan fixture and formed using a 3-day formation. Capacities came up to normal. The cell stack showed good C/3 and C rate discharges. Performance at -29^{o}C (remnant of F16 effort) showed lower performance compared to vented flooded formation, -40^{o}C (F-16) was 50% of vented performance, but 2 week stand loss at 50^{o}C was better, and 85^{o}C for 24 hours also looked better, about 40% of rated capacity but 90% recovered after room temperature charge and C rate discharge. This experiment showed that capacity could be obtained with a sealed formation and that the time of 1 day of 3 day did not seem to effect the performance (It was thought that longer time would help wetting), although one change was that a different electrolyte filling method was used (vacuum-pressure with measured quantity-1 minute vs. a previous vacuum gravity 2 day stand vented).

The cell pack formation initiated last month was repeated on another pack with similar results, that is, the capacities came up reaching normal capacities, but overall power was below those cells using the standard formation. This 24-cell pack was then tested at low temperature -29C. Initial low temperature performance was rather dismal but like the room temperature power tests seem to improve with power pulsing (cycling). This appears to be due to cracking and splitting of the nickel active material. This was seen in the PNGV effort also where power increased, given constant upper and lower voltage and energy constraints over the first 30,000 cycles, and then start tapering off from that higher power and energy point. This was not typical of conventional nickel electrodes, but appeared to be a real characteristic of the EEI treated nickel hydroxide.

Limited testing was performed at -40C, with limited results at 1 and 2C-rates. It would appear that both electrodes are shutting down at this temperature. Short pulses <10 seconds could be obtained, but only 10% capacity could be obtained. At room temperature and at 200A with a conventional vented formation, cells have shown better than 70% capacity at the 30 C-rate, though so this may be giving us a clue, and is a level of improvement in the cell chemistry.

There was an increase in operating cell pressure with continued cycling. This may indicate that the hydride is either being limited by too much electrolyte or the hydride did not crepitate during initial formation. Ten cells from a concluded program that were in stock will be auto-filled, sealed and formed containing differing electrolyte to determine the effect of electrolyte quantity on sealed operation pressure. One of the largest variables that EEI has is that of the purchased separator. It is known that the separator porosity varies by as much as 10%, which is probably making fill and seal capacities and operational pressures vary. Discussions with separator vendors were friendly but have not been fruitful to date. Meanwhile, EEI has developed an inorganic separator and has asked the Army to fund the manufacturing process development.

Task 4: Module Development

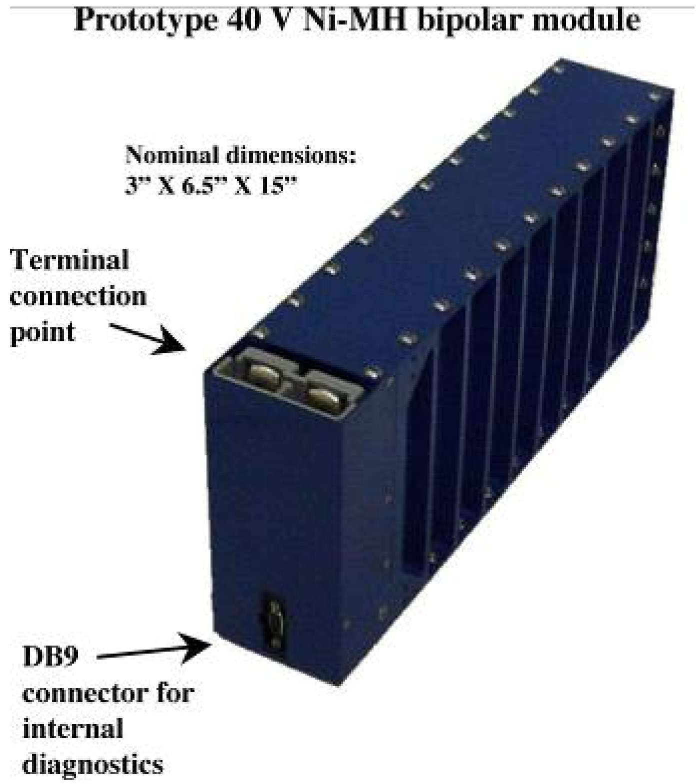
Based on the results of the single cells constructed and applications selected, EEI prepared a design incorporating components derived from the other tasks that justified evaluation. Demonstration modules would be built and tested (one by EEI and one by a selected demonstration site). The modules would be tested on simulated conditions and compared to cell level performance.

Initially, the goal of the phase I effort was to deliver a single 50V-module whose performance could be evaluated at Sandia National Laboratories (SNL) in an independent series of tests. The battery would have a capacity of 6Ah, with the cells capable of supporting 500A constant current loads. However, the testing hardware available at SNL was only capable of supporting lower voltages at these high current levels, consequently the specifications for the prototype hardware were renegotiated to 40 V, in which case the battery would be able to provide >10kW of power. An additional feature that would be included with the battery was charge/discharge protection circuitry to prevent the possibility of abuse conditions on the battery. The requirements for the additional circuitry included specifications limiting the voltage drop across the device to <0.5V during the high power loads.

<u>Phase I - 40V Battery Modules</u>

EEI completed the conceptual design of the battery prototype deliverable, which is shown in Figure 21. The electrodes to be used in this battery are the standard 6” x 12,” 6.48Ah, determined as the baseline in task 2. This device has nominal dimensions of 3” x 6.5” x 15”, the size of a small shoebox.

Figure 21: Conceptual Image of the Prototype 40V Battery Module



As seen, there are two primary connection points to the device including the primary power connection sized to carry large currents, in excess of 500A. In addition, there is a DB9 connection for internal sensors packaged within the module. An additional feature that would be included with the battery is charge/discharge protection circuitry to prevent the possibility of abuse conditions. The requirements for the additional circuitry include specifications limiting the voltage drop across the device to <0.5V during the high power loads.

<u>31-Cell and 35-Cell Battery Modules</u>

Two battery modules were developed, using 31 and 35 of the standard 6.48Ah cells. They were fabricated for testing at Sandia, where there was a limit of 50V (charging) on the test equipment there. Table 5 includes a listing of the weights of the various components of the 31-cell battery. As the table suggests, the design was not fully optimized from either a weight or volume standpoint. About half of the weight of the battery can be attributed to the cells, with the balance either in the housing, electrical buss, or other components. The packaging was designed to contain 31 or 35 cells. Polypropylene spacer material measuring 0.36" in thickness and weighing about 1 lb. was used to offset the 4 cells. Also, some of the mechanical details of the endplates as well as the current buss could be further optimized from a weight standpoint. It is feasible to assume that up to 1 kg of the 9.94 kg weight can be lost in an optimized design.

Table 5: Parts list / weight breakdown of delivered 31 cell battery

Qty	Part Description	Weight ea (g)	Total (g)	% Total
2	End Plate	708.5	1417.0	14.3%
1	U Panel & Front Plate	365.7	365.7	3.7%
2	Compression Bag	66.0	132.0	1.3%
2	.005" Cu Current Collectors	44.0	88.0	0.9%
2	.020"x 2 =.040" Cu Current Collectors	488.6	977.2	9.8%
4	.005" Insulator	6.0	24.0	0.2%
2	.180" x 2 =.360" Spacer	227.7	455.3	4.6%
56	10-32 SS Screws, Torx head	1.8	100.8	1.0%
56	10-32 SS Nuts	1.1	61.6	0.6%
1	Buss Bar Insulator / Front Screws	40.0	40.0	0.4%
2	Buss Bar	169.4	338.8	3.4%
1	Buss Bar Insulator	179.0	179.0	1.8%
4	Buss Bar Insulator screws	3.3	13.4	0.1%
4	Switch + Connector	3.8	15.2	0.2%
1	Switch D Connector	15.0	15.0	0.2%
1	Connector set (power)	249.2	249.2	2.5%
2	Connector screws (1/4-20)	5.0	10.0	0.1%
256	.005"Thick Cu Dots	1.2	299.0	3.0%
1	Thermal RTV	183.4	183.4	1.8%
31	Cells (6.2 Ah)	151.8	4705.8	47.4%
1	Front sheet metal cover	145.0	145.0	1.5%
2	Welding cable, 3" (from BB to connector)	60.0	120.0	1.2%
	Total		9935.4	100.0%

The power of the battery was evaluated by first discharging it at 4.0A to 31V (1V/cell). The battery was then charged at 0.762A for 4.25 hours. This point was defined as the 50% SOC level. A rest of 3.0 hours then followed. A pulse discharge of 100 A for 10 seconds followed, ending with a slower discharge of 4 A. The result of this test is shown in Figure 22. The voltage/time characteristic is similar (on a per cell basis) to other single cells tested at EEI. Figure 23 shows a closer "snapshot" 100A discharge pulse. The end of discharge voltage was 34.21V, or an average of 1.103V/cell.

Figure 22: Power test sequence for the 31 cell module

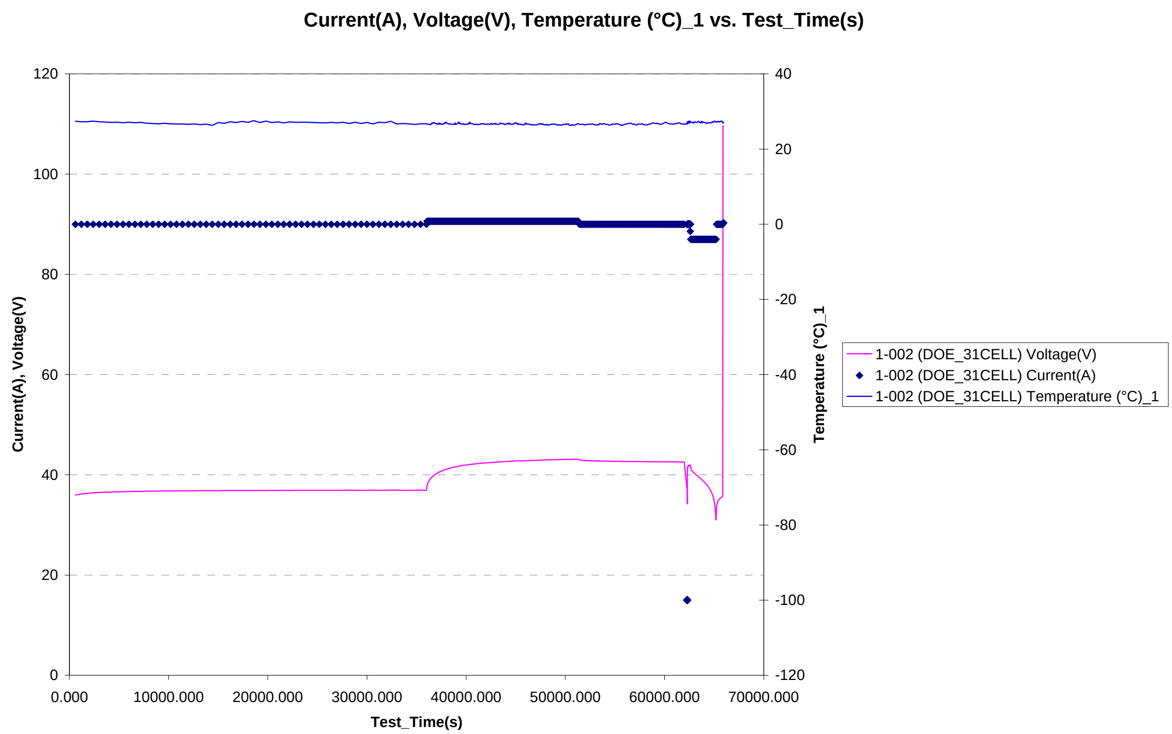
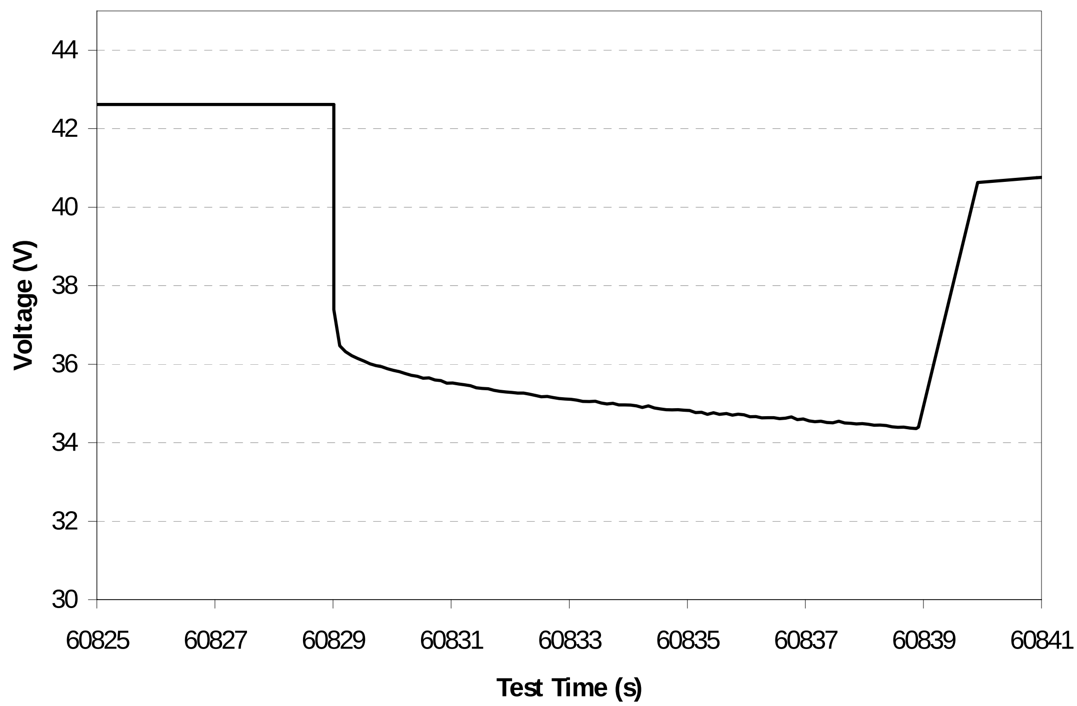


Figure 23: 100A, 10 second discharge performed at 50% SOC



A finished battery module is shown in Figure 24. Along with the modules, an external control box was also delivered. This box consisted of heavy duty relays which could connect or disconnect the battery, based on sensor reading of internal stack pressure, temperature, or battery voltage. The complete package is shown in Figure 25. A photo of the internals of the box is included in Figure 26. A fuller description of the control box, including schematics, was supplied on the delivery of the box, and will not be reproduced here.

Figure 24: 31 Cell High-Power Battery Module

Figure 25: High-Power Battery Module with Control Box

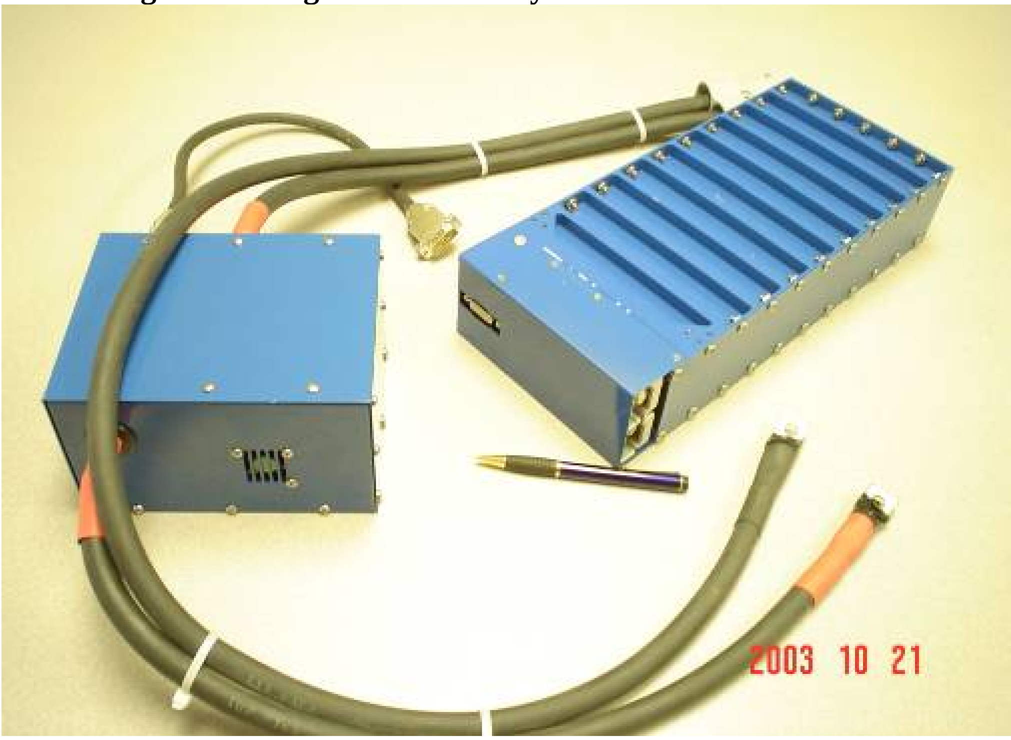
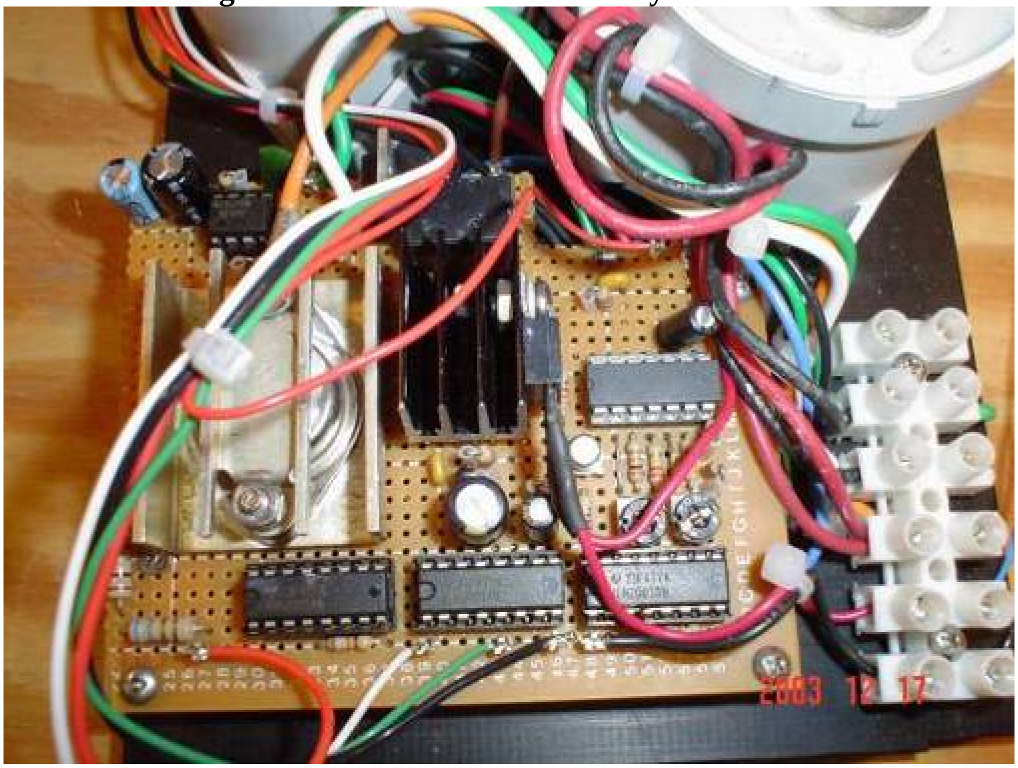


Figure 26: Internals of the battery control box



Phase II – Modules Development

In phase II of this program the scope of the battery deliverable was increased, so that much larger battery modules and systems were discussed, designed and built. A key development was to establish a relationship with another agency and jointly develop, through this program, a 350V high power battery module. Three batteries were constructed, using 255 cells of the standard 6 Ah capacity. Some evaluation of their power capability was conducted at EEI, while other evaluations preceded offsite. The design of this system is described in detail in the following section, including the baseline cell design and assembly.

350V Battery Module

Cell Design

The cells were of 6.48 Ah theoretical capacity, and used 6" x 12" electrodes. Information regarding the formulations used is given below in Table 6.

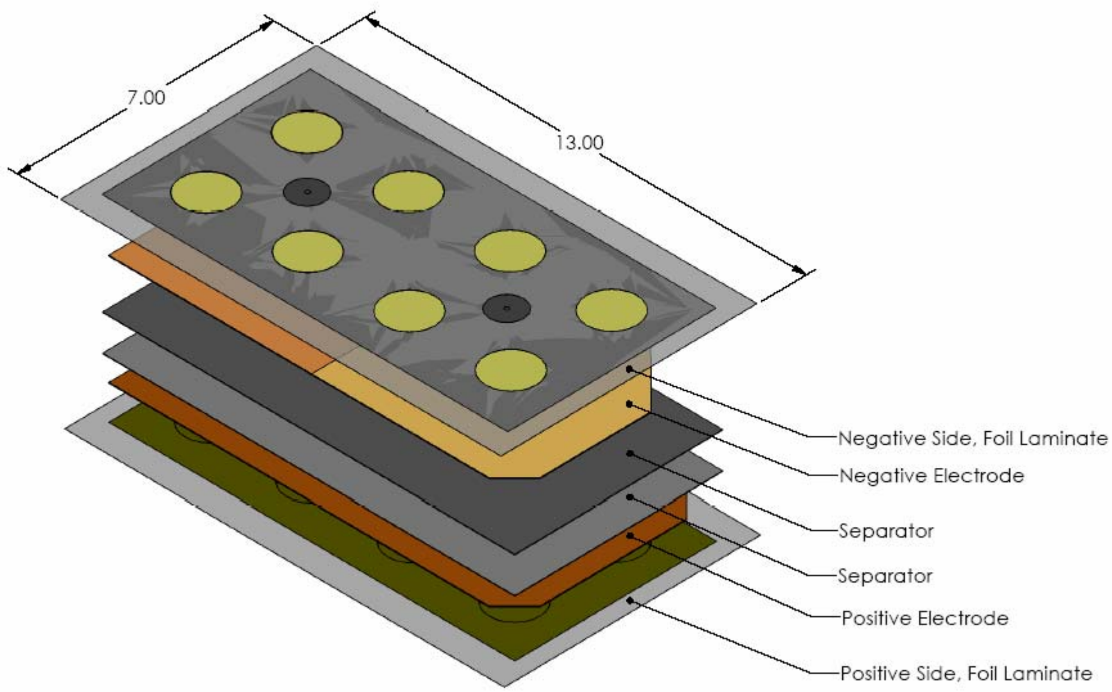
All of the electrodes were produced by a dry roll bonding process. In a manner analogous to making a pie crust, the materials are repeatedly rolled out into thin sheets, and then re-rolled, until sufficient material strength is developed.

The cell faces are composed of laminates: see Figure 27 for an exploded cell view. Each laminate is composed of a metal foil and polypropylene film. To prevent leakage, the foil is laminated to the plastic with an asphaltic tar compound. Sealing of the cells is accomplished by ultrasonic welding of the polypropylene at the cell's perimeter. Filling of the cells is accomplished through small holes on one face of the cell, which are subsequently patched. Current is passed from one cell face to the next by opening contact areas within the polypropylene film.

Table 6: Cell component information

Component	**Formulation**	**Notes**
Positive Electrode	77% coated $Ni(OH)_2$, 19% Ni210, 2% CoO, 2% TE3579	6.48Ah (based on one electron reaction)
Separator	2 layers 700 / 9	Source: SciMat, Ltd.
Negative Electrode	80% LEG-757, 19% Ni210, 1% TE3579	8.65 Ah (at 250mAh/g alloy), Source:Treibacher Auermet

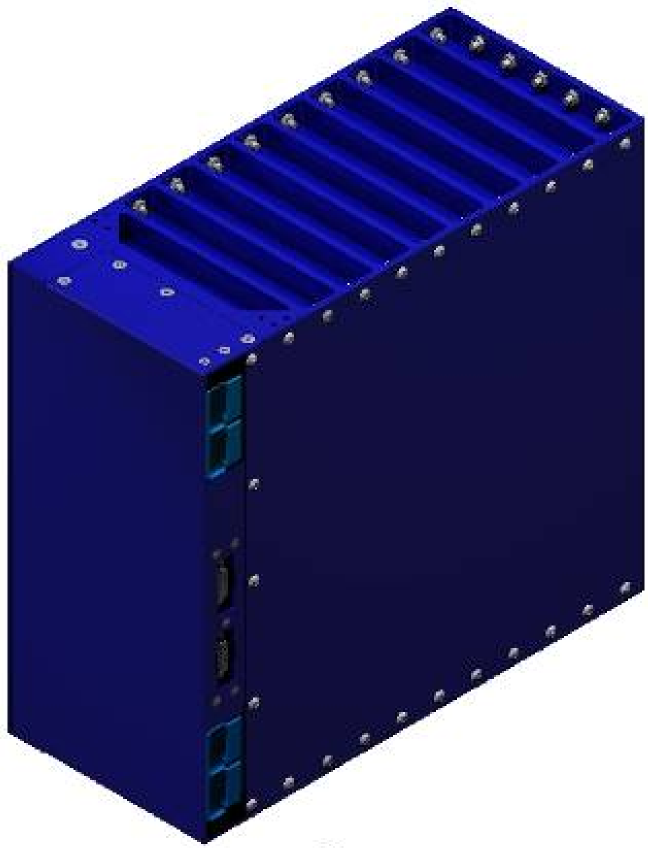
Figure 27: The various layers which comprise a single cell



Module Description

Each module contains 255 nickel metal hydride bipolar wafer cells, which were described above. A schematic of the complete module concept is shown in Figure 28. Each module is composed of 5 packs of 51 cells. Each pack has current collection, and the stacks are connected with cables, shown in Figure 29.

Figure 28: 350V, 6Ah module



The module dimensions are 6.80" x 15.08" x 13.77", detailed in Figure 30. The weight of the finished module is approximately 120 lb. A unique method of charge control by sensing the maximum pressure occurring within a group of cells is employed. This should lead enhanced performance compared with conventional battery designs, since the end of charge and end of discharge can be more precisely located.

Figure 29: 350V, 6Ah module with some internal details shown

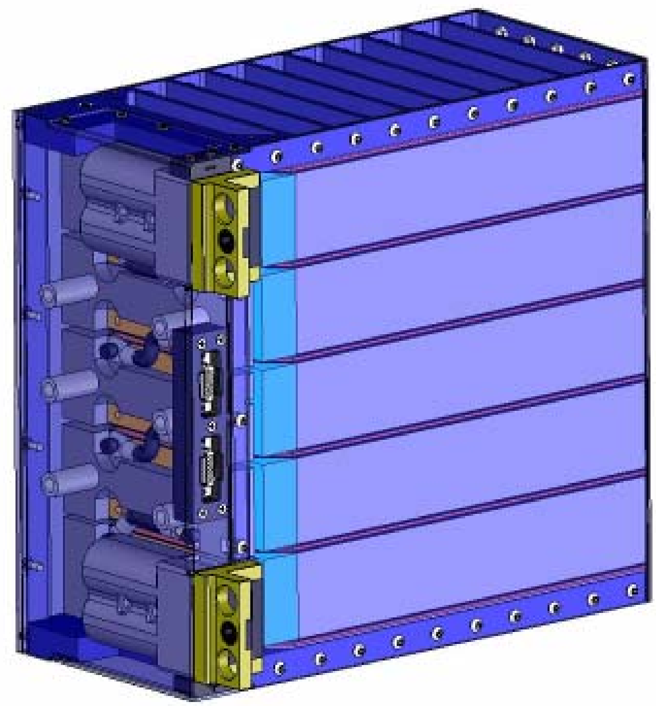
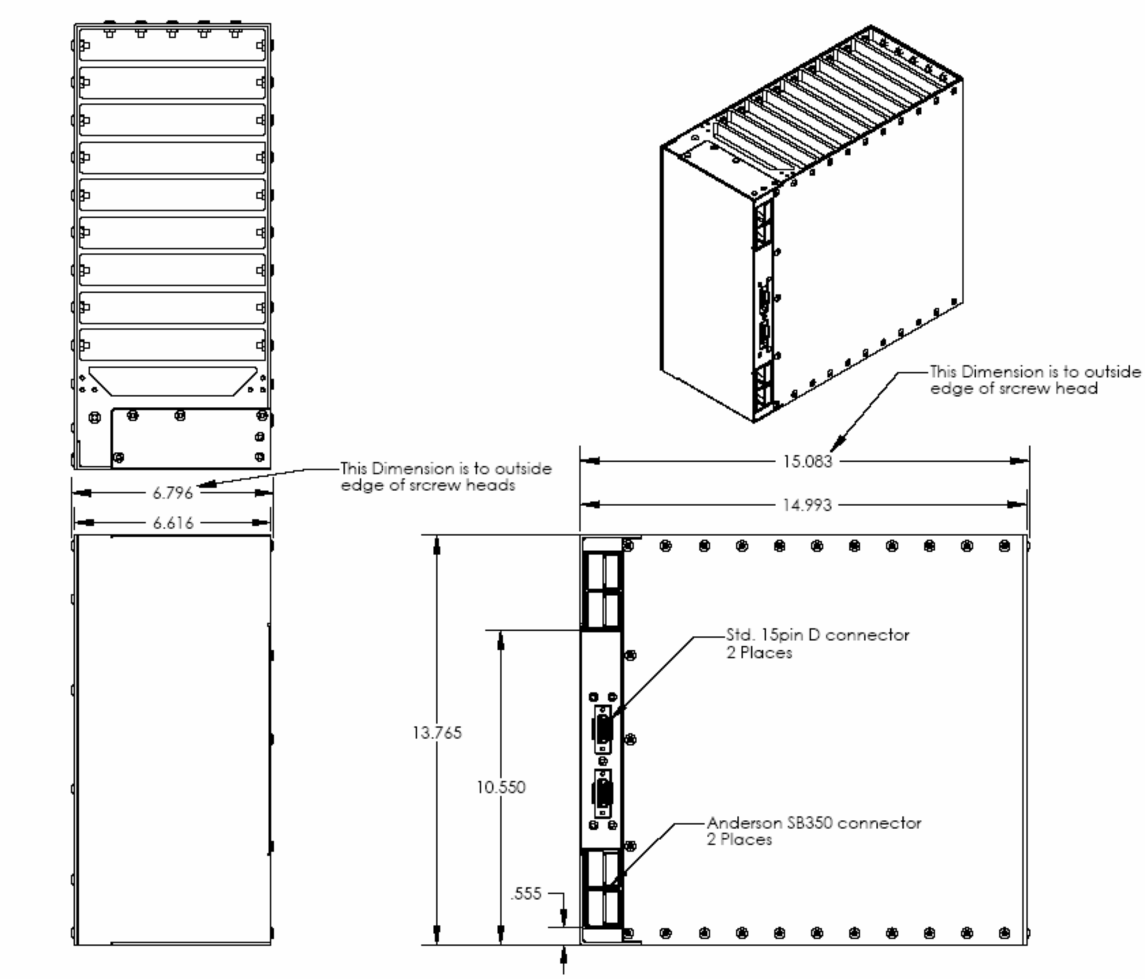


Figure 30: Dimensions of the 350V battery module



To get a better sense of the module design, it is instructive to examine the assembly sequence. First, each of the 5 packs is placed in the battery housing, which is shown in Figure 31. Before Compression, the total height of the assembly is greater than the internal space of the housing.

An endplate is then placed on the top of this assembly, and it is then compressed with a hydraulic ram to provide a uniform load on the cells. Figure 32 shows the battery module in this state. Pressure sensing switches are then installed to monitor internal cell pressure. Next, the cell packs are connected in series, with Anderson connectors used for termination. The pressure switches are connected to an RS-232 output (Figure 33). A sheet metal cover is installed, which completes the battery assembly. Figure 34 shows the finished battery.

Figure 31: 350V - 5 packs placed into the battery housing

Figure 32: 350V - battery after the top endplate has been installed and compressed

Figure 33: 350V - Battery after power and sensor connections are completed

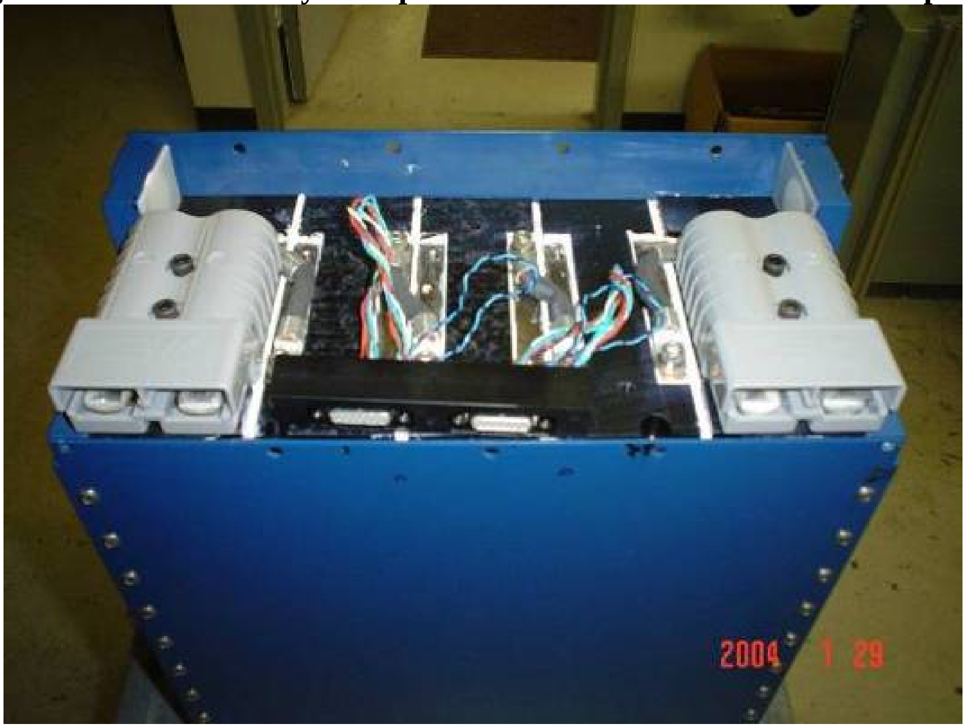


Figure 34: 350V - Finished battery

350V Module 1 Test Results

The following figures show in order the operating history of Module 1. The goals of this set of testing were to verify the basic operation of the module, and to make adjustments where necessary (such as the triggering points of the pressure charge termination switches). In general, they show that the battery will accept about 5.6 Ah of charge, and deliver 5.0 Ah of capacity. Reasonable power performance was demonstrated by discharging the battery from a state of full charge at currents ranging from 60-80A for 1 minute.

For charging, a DC power supply (Electronic Measurements, Inc. Model 500T20) rated at 500V/20A was used. For discharge, a bank of resistive heaters was used. Current was measured by a shunt rated at 50mV at 200A.

Table 7: Testing performed on 255 cell module #1

Figure #	Test condition	Current (A)	Time	Capacity (Ah)	Comment
1	Charge	2.0	2.81 h	5.62	
2	Discharge	65	1.00 m	1.10	
3	Rest	0	0.82 h	0	
4	Discharge	3.5	1.00 h	3.36	
5	Discharge	3.1	0.25 h	0.79	To 295 V
6	Charge	2.0	0.86 h	1.71	Adjustment of pressure switch
7	Charge	2.0	1.82 h	3.65	
8	Discharge	80	1.00 m	1.30	
9	Discharge	3.5	1.16 h	3.85	To 295 V
10	Charge	2.0	2.8 h	4.85	Pressure switches periodically terminating charge
11	Charge	2.0	0.6 h	0.80	After overnight stand.
12	Discharge	3.5	0.6 h	1.86	
13	Charge	2.0	2.2 h	1.82	
14	Discharge	3.5	3.1 h	-	Data acquisition failure – cannot estimate capacity

Figure 35: First charge at 2.0A. Net charge time 10,110 seconds = 5.62Ah

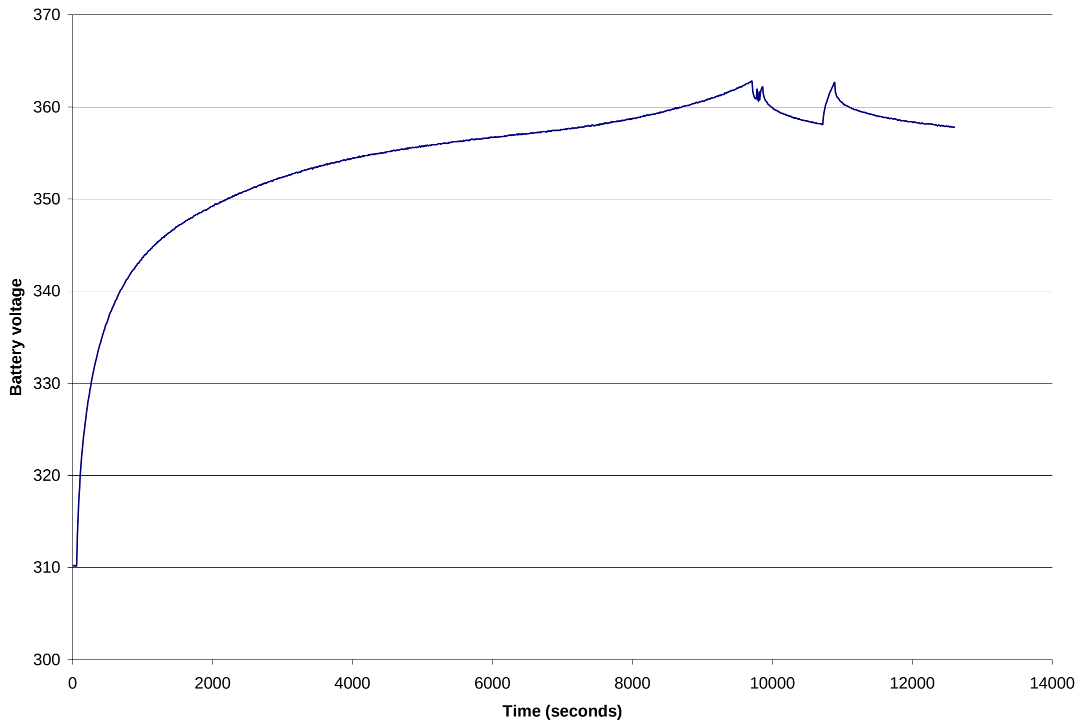


Figure 36: First high current discharge (approx 65A) after full charge Discharge time = 1 minute. Capacity removed = 1.10Ah

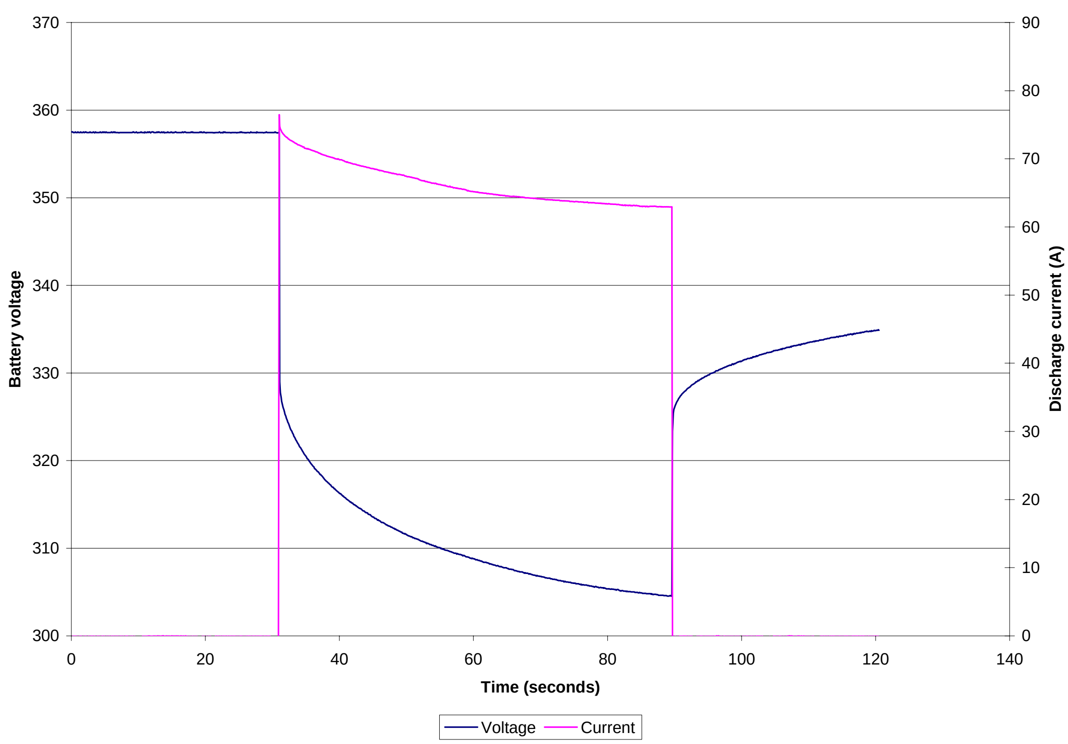


Figure 37: Rest data after 1st high current discharge

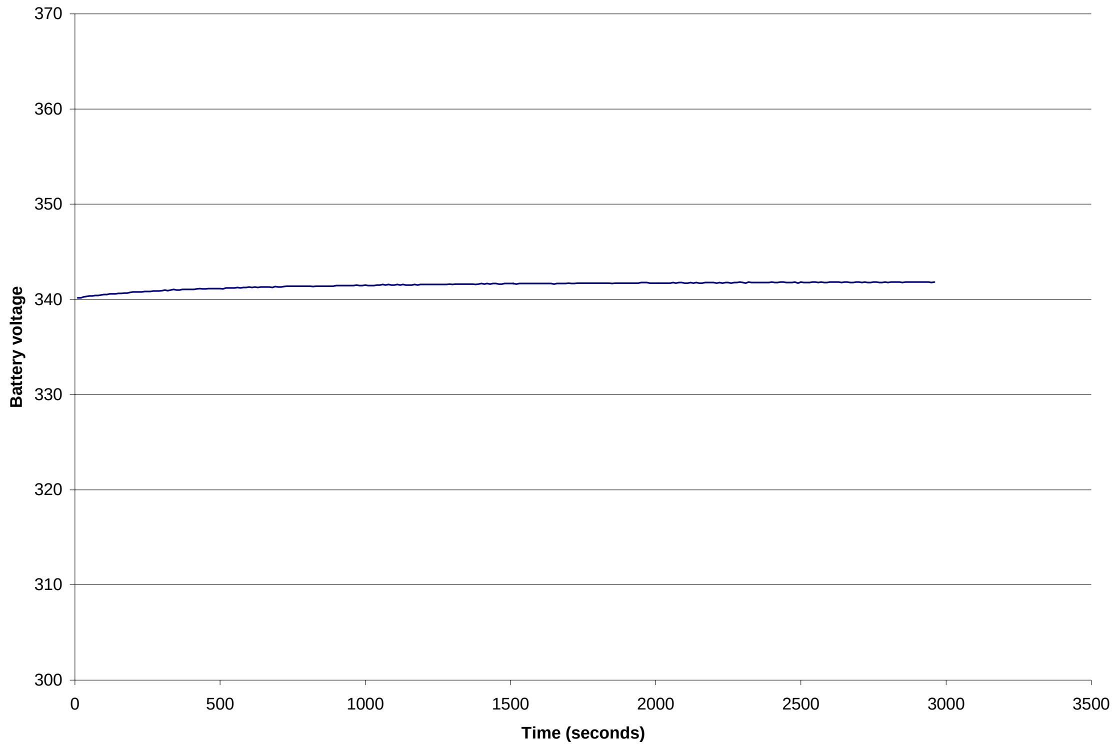


Figure 38: Low current discharge (approx 3.5A) for 1 hour after rest
Capacity removed = 3.36Ah

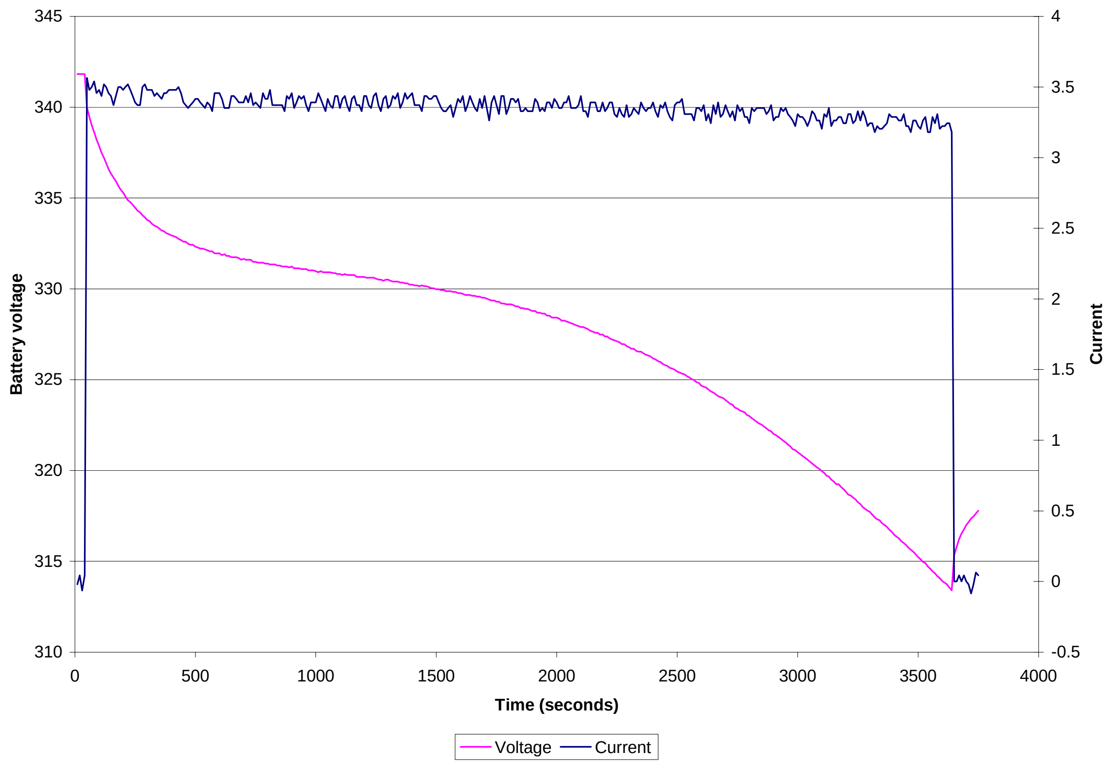


Figure 39: Discharge at low current to 295V. Capacity removed = 0.79Ah

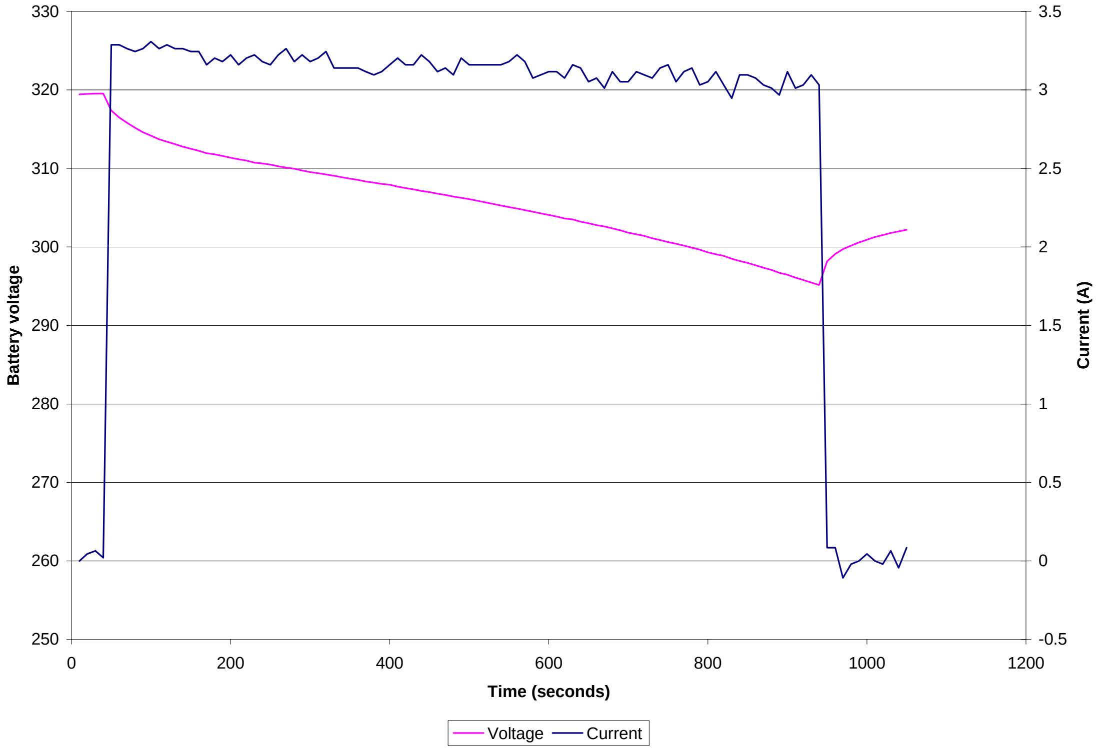


Figure 40: Second charge at 2A. Capacity input = 1.71Ah. Charge termination switch adjusted at this point.

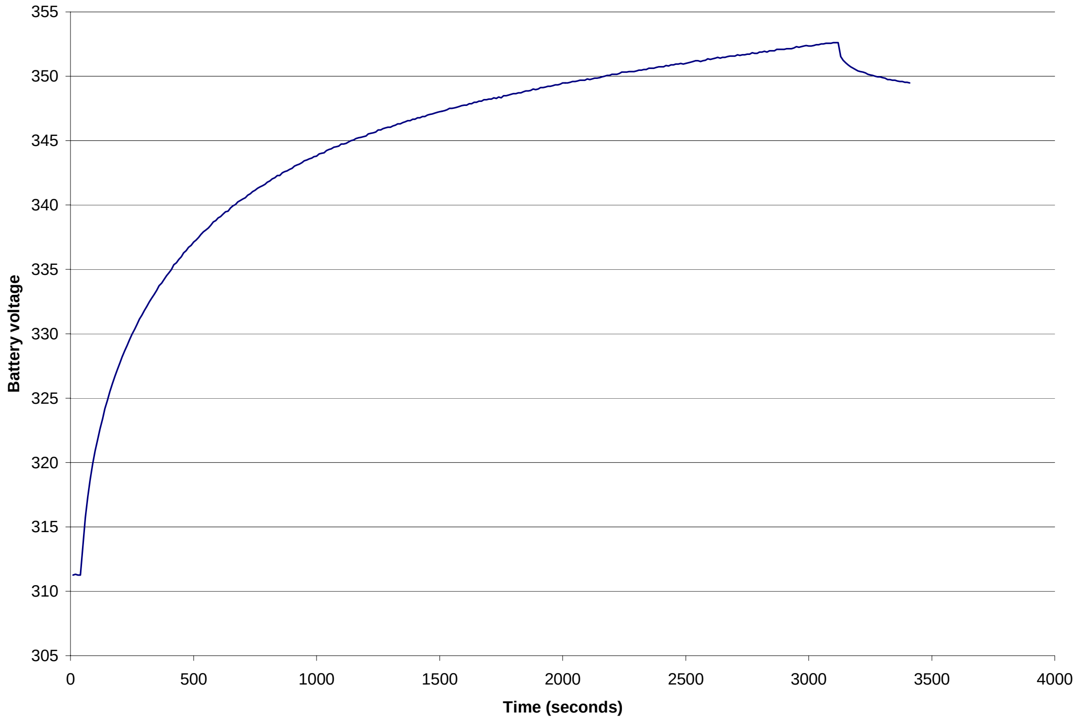


Figure 41: Continuation of charge. Charge input = 3.65Ah

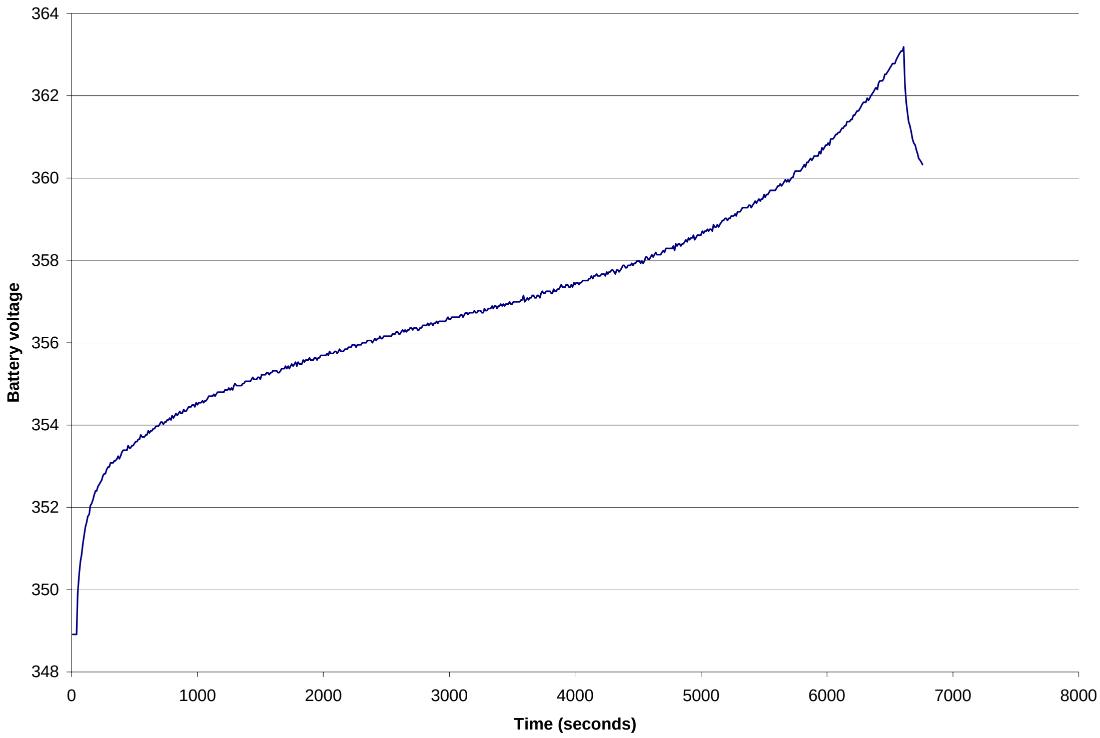


Figure 42: Discharge at high current (approx 80A) for 1 minute. Capacity removed = 1.30Ah

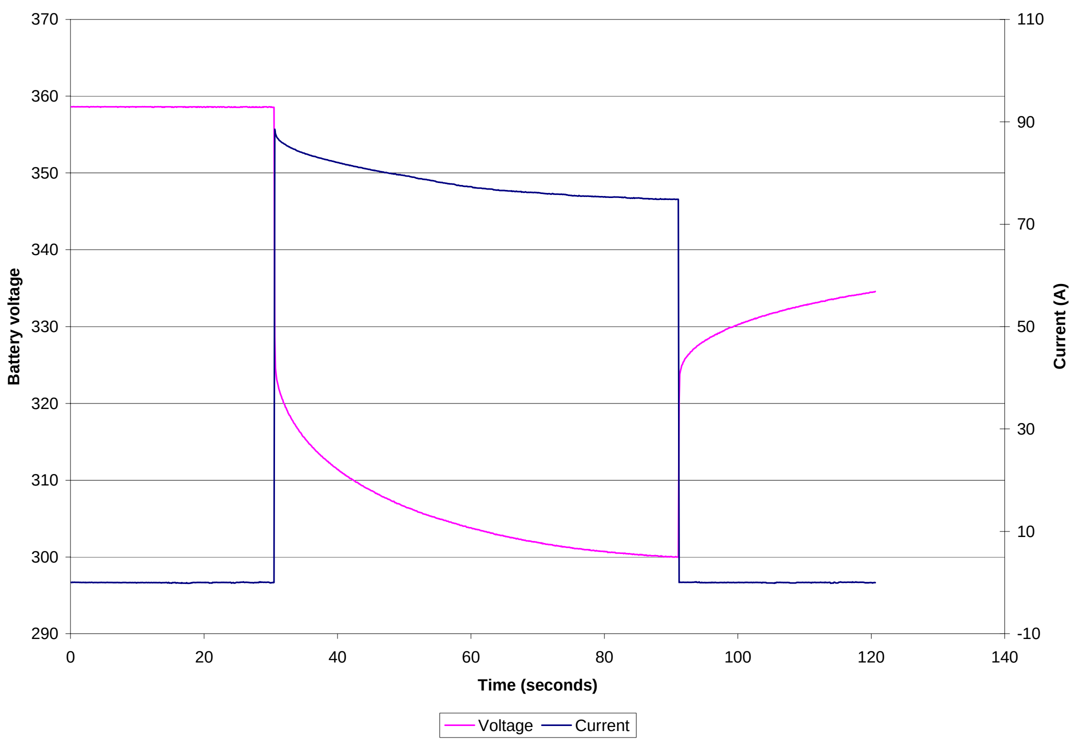


Figure 43: Discharge at low current (approx 3.5A) to 295V. Capacity removed = 3.85Ah

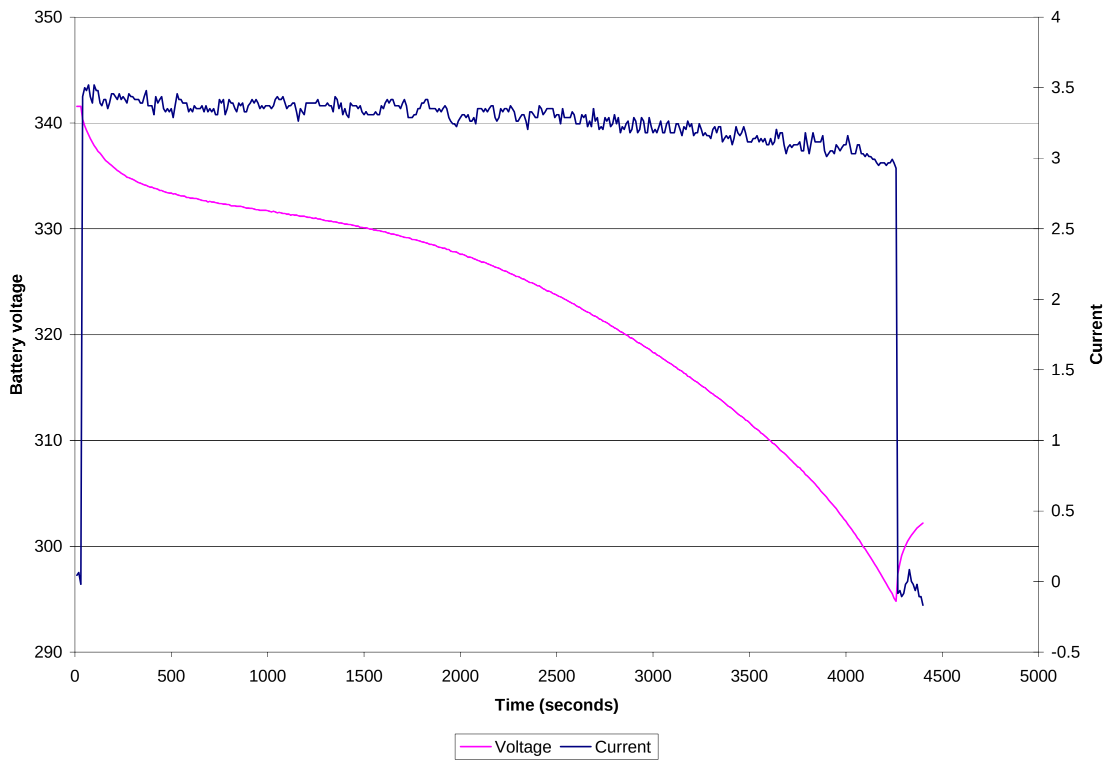


Figure 44: Battery recharge at 2A. Capacity input = 4.85Ah total

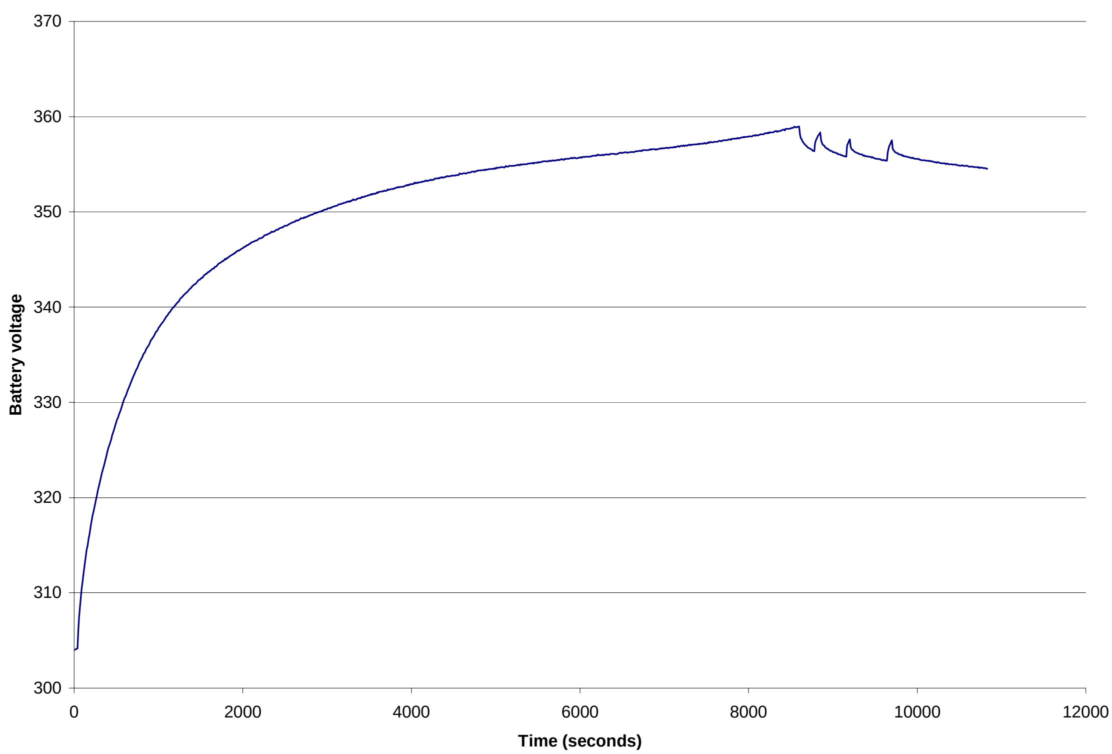


Figure 45: Continuation of charge after overnight stand. Charge input = 0.80Ah.

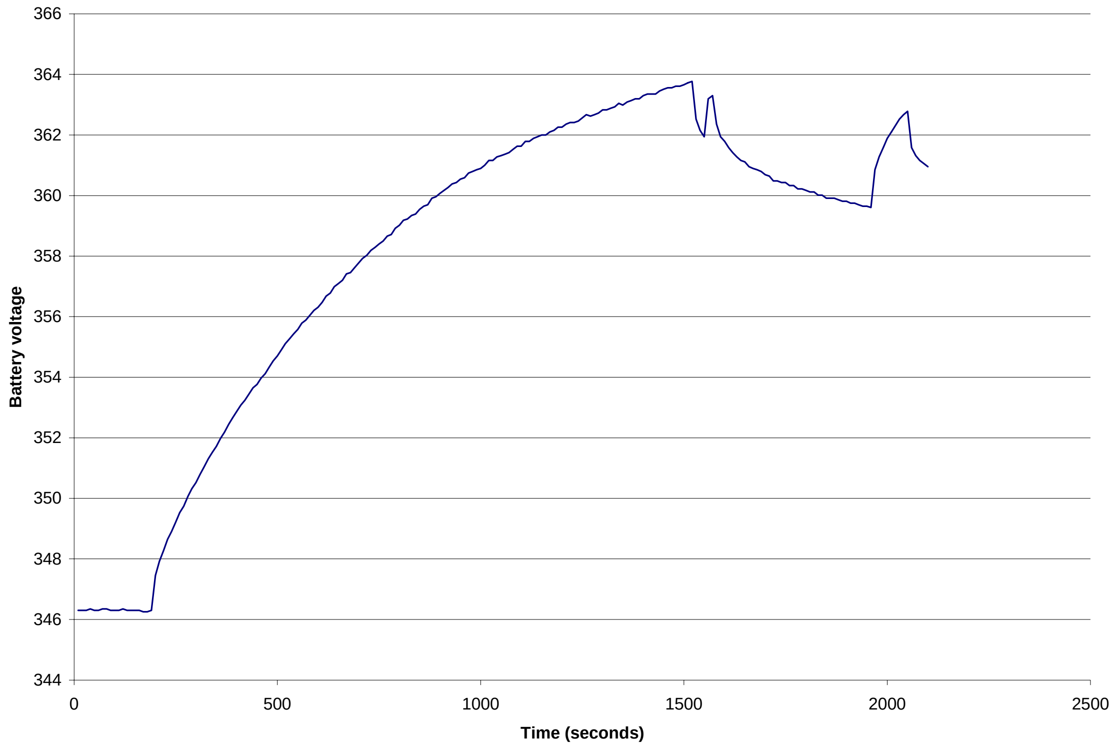


Figure 46: Partial discharge at approx 3.5A. Capacity removed = 1.86Ah

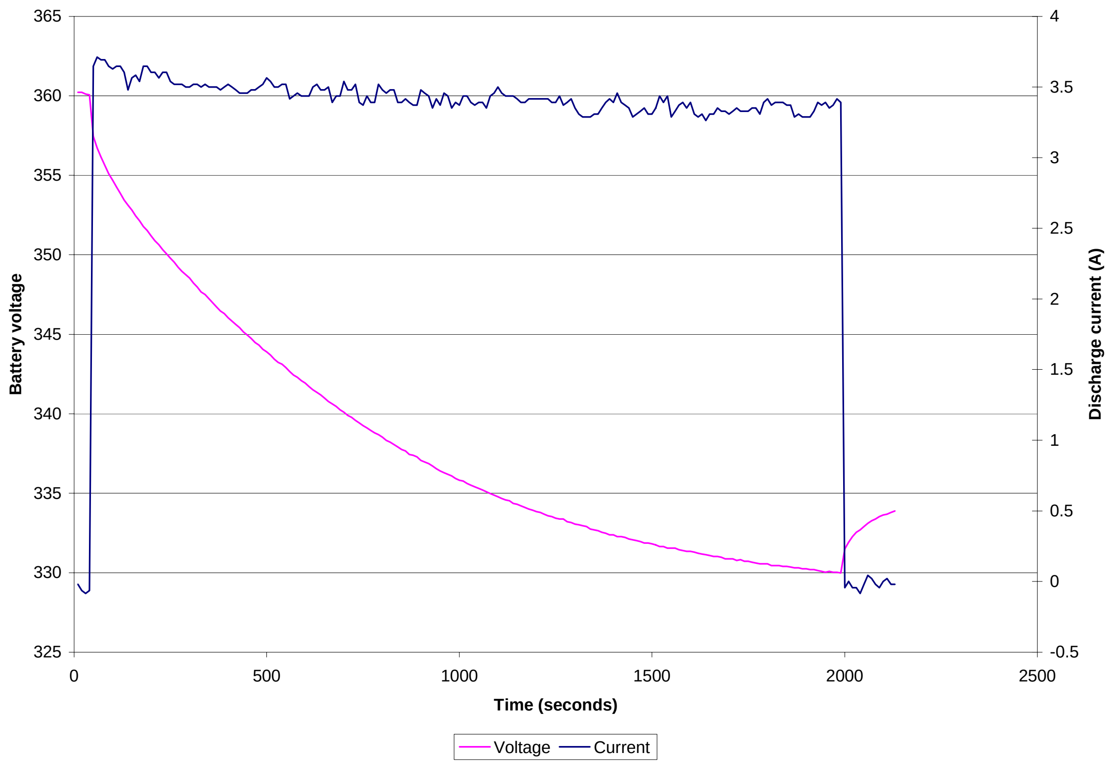


Figure 47: Recharge at 2A following partial discharge. Charge input = 1.82Ah

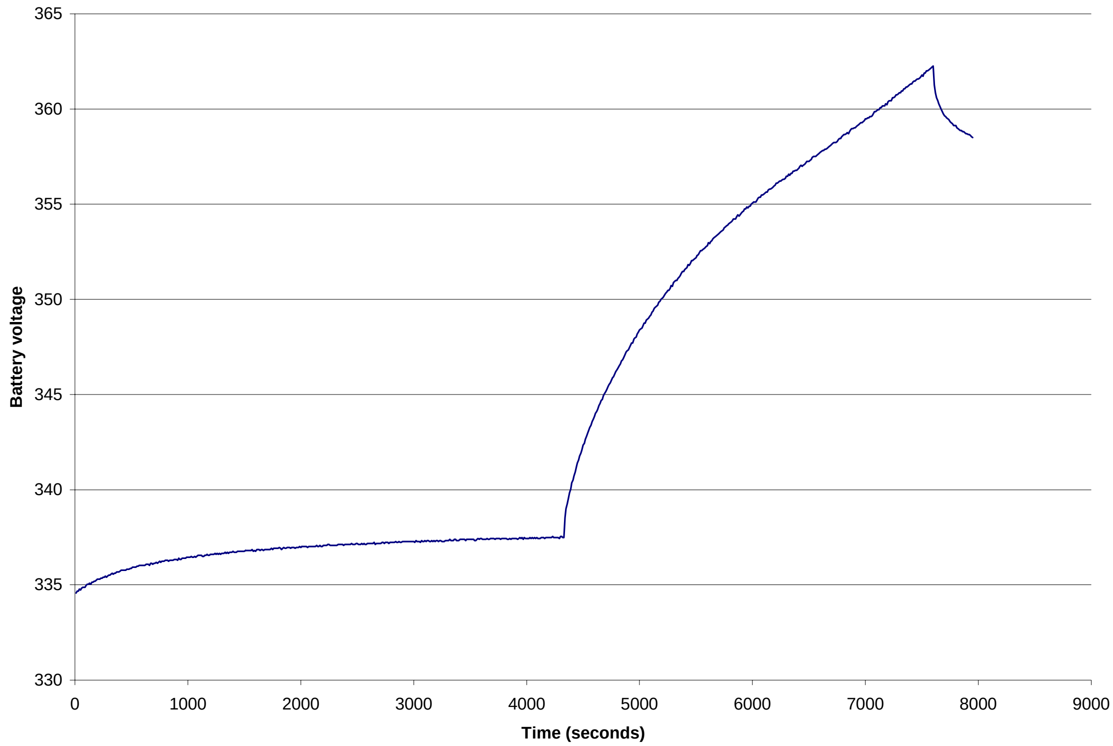
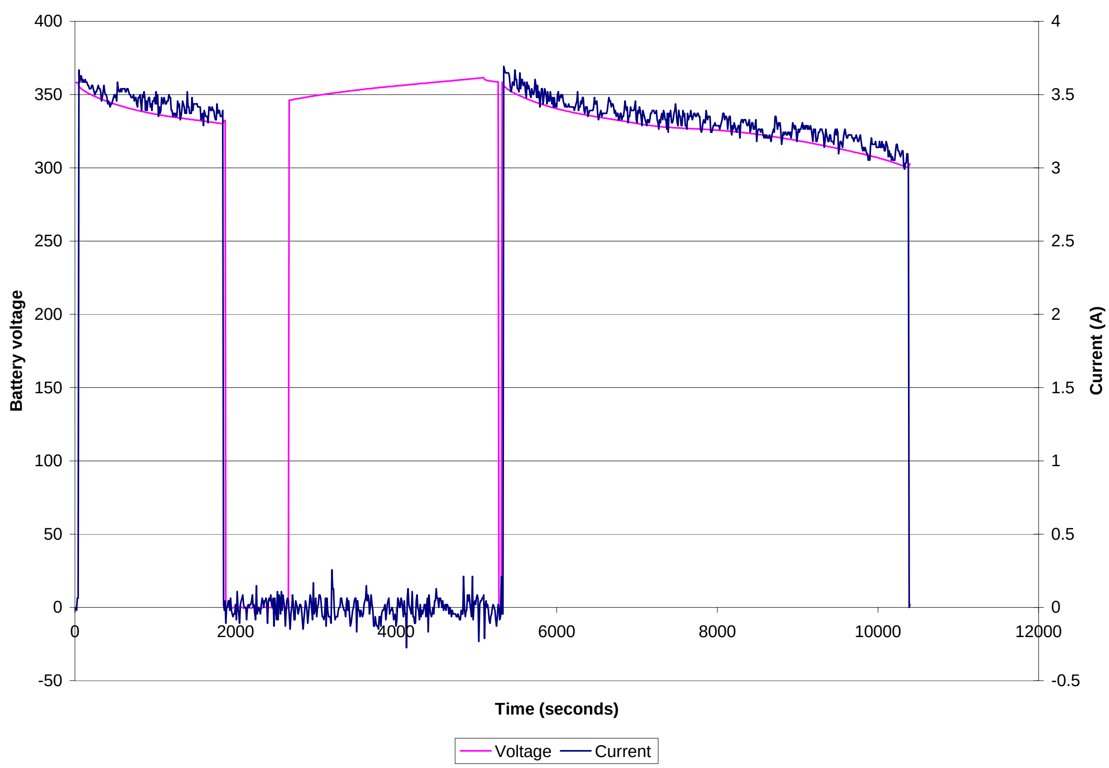


Figure 48: Discharge at low current to 295V. Data acquisition failure prevented accurate estimate of battery capacity



350V Module 2 Test Results

The following figures show in order the operating history of Module 2. The goals of this set of testing were to verify the basic operation of the module, and to make adjustments where necessary (such as the triggering points of the pressure charge termination switches). In general, they show that the battery will accept about 5.6 Ah of charge, and deliver 5.0 Ah of capacity. Reasonable power performance was demonstrated by discharging the battery from a state of full charge at currents ranging from 60-80A for 1 minute.

Table 8: Testing performed on 255 cell module #2

Figure #	Test condition	Current (A)	Time	Capacity (Ah)	Comment
15	Charge	2.0	3.3 h	5.71	Pressure switch activation
16	Discharge	77.5	1.00 m	1.24	
17	Discharge	3.29	1.21 h	4.00	
18	Rest	0	16 h	0	Overnight rest
19	Charge	2.0	2.7 h	5.40	
20	Discharge	77.2	1.00 m	1.32	
21	Discharge	3.25	1.16 h	3.65	
22	Rest	0	45 h	0	Weekend rest

Figure 49: Charge at 2A. Charge input = 5.71Ah

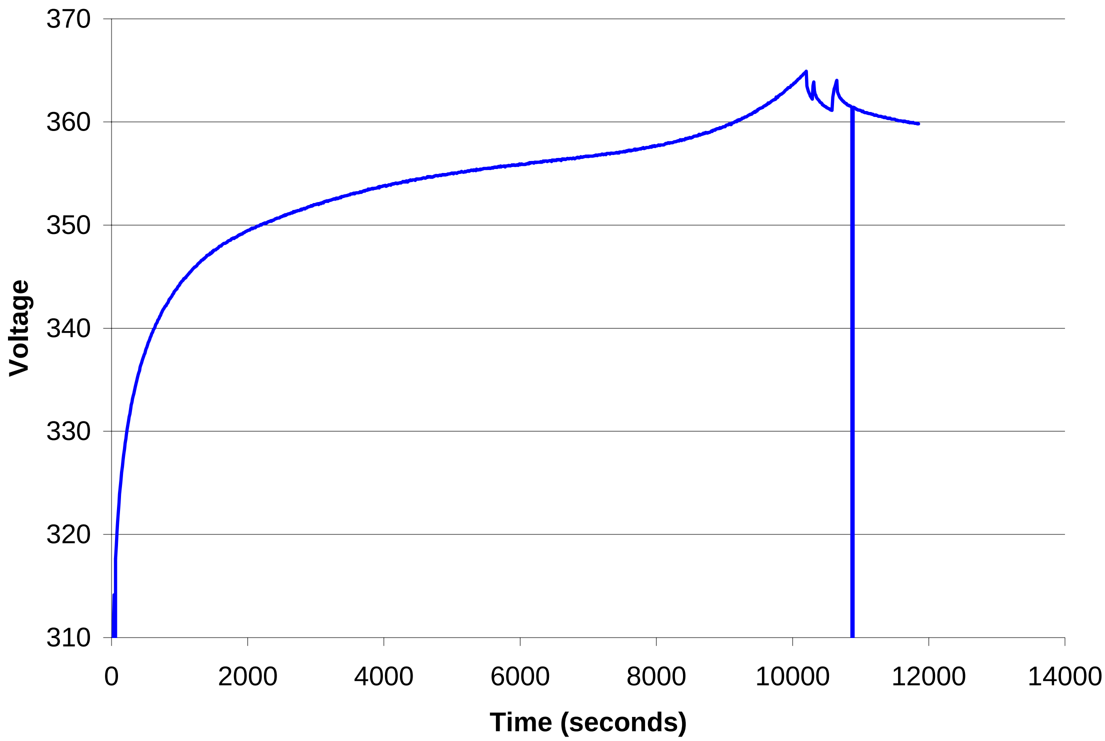


Figure 50: High current discharge (I_{avg} = 77.5A). Min voltage = 297.2V. Capacity removed = 1.24Ah

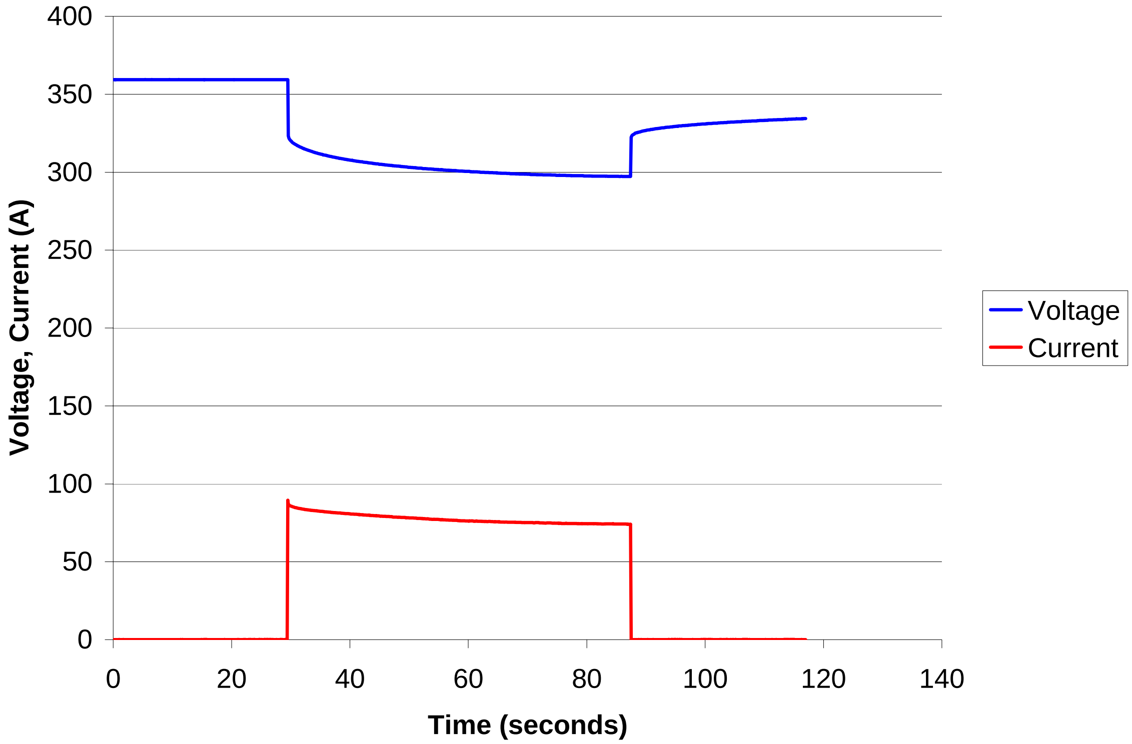


Figure 51: Low current discharge (I_{avg} = 3.29A). Capacity removed = 4.00Ah

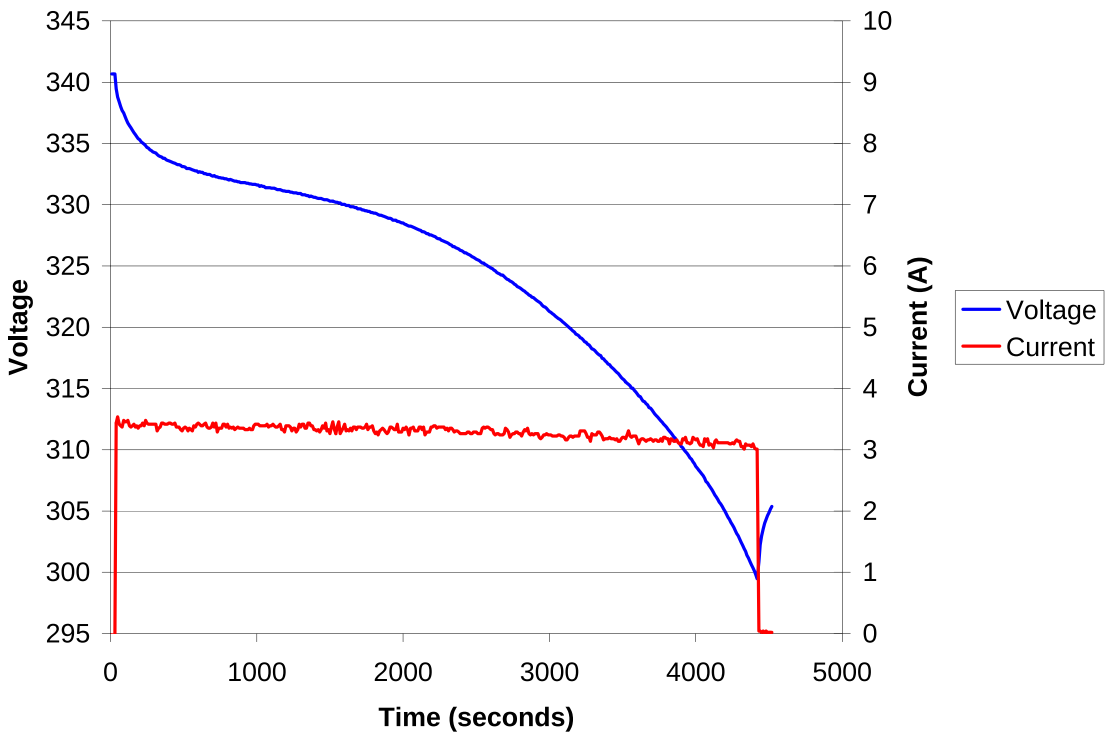


Figure 52: Overnight rest

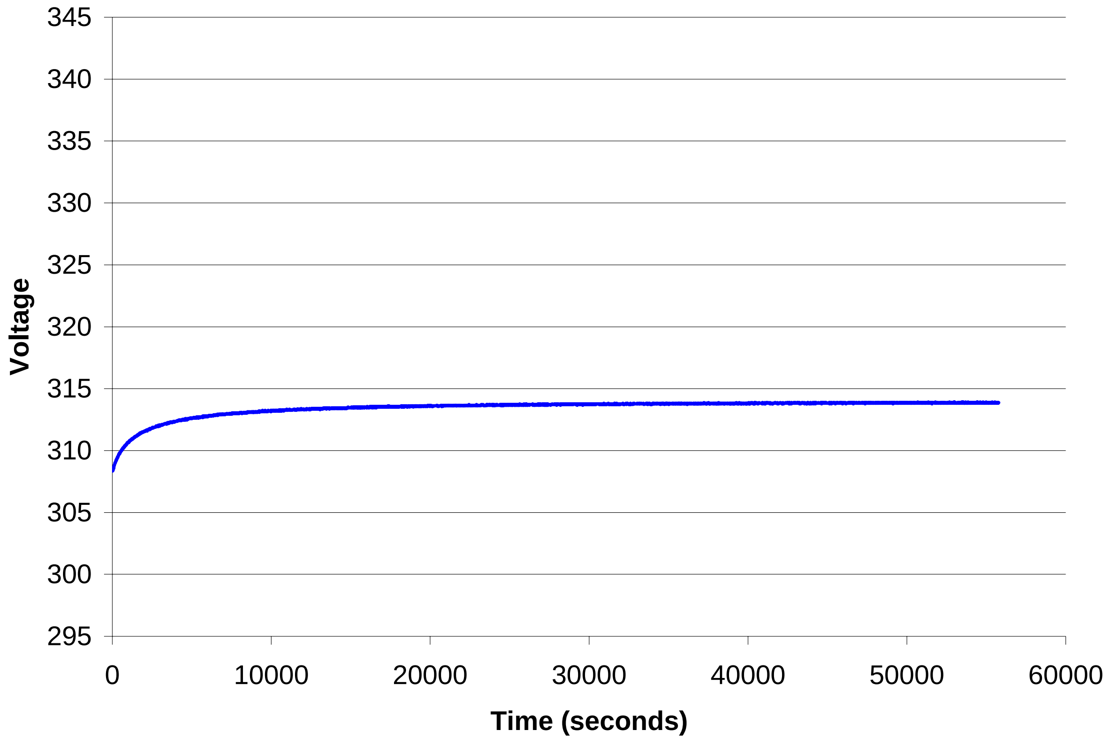


Figure 53: Charge at 2.0A. Charge input = 5.40Ah

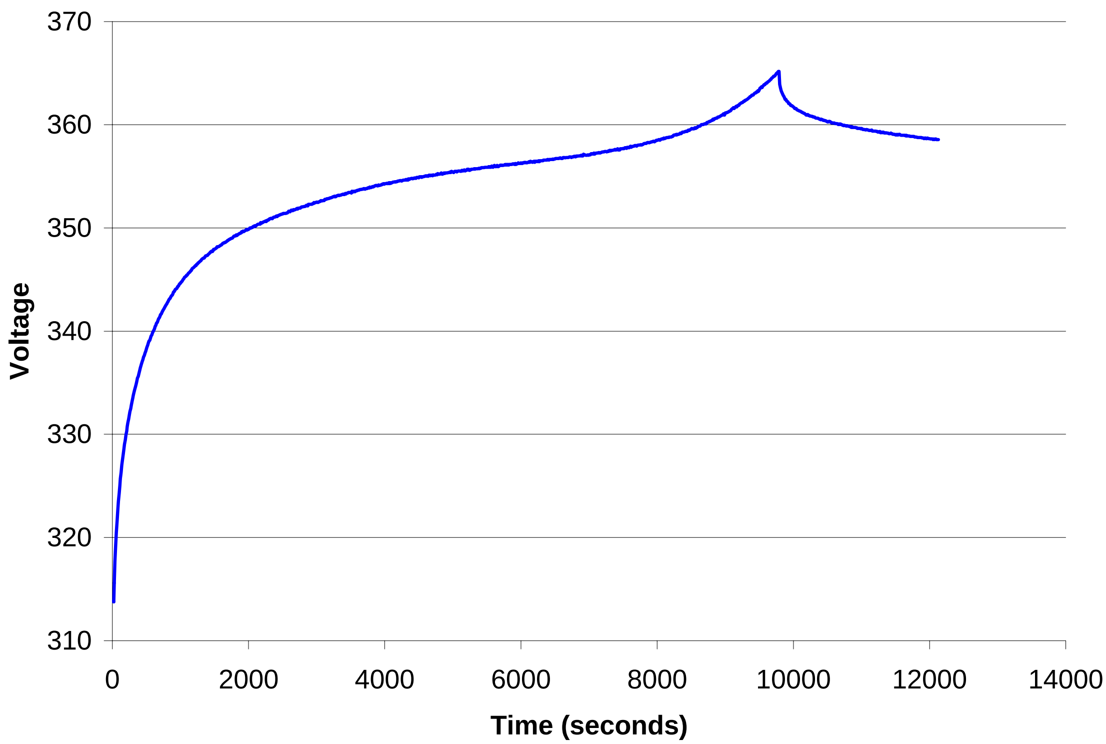


Figure 54: High current discharge (I_{avg} = 77.2A). Min voltage = 296.9V. Capacity removed = 1.32Ah

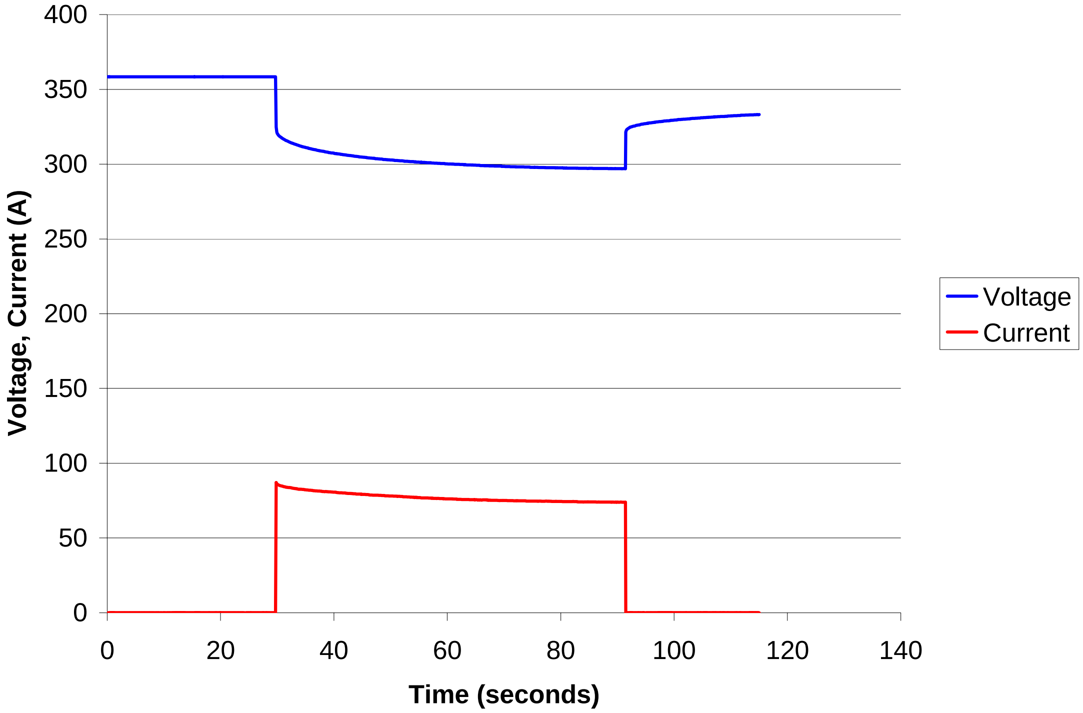


Figure 55: Low current discharge (I_{avg} = 3.25A). Capacity removed = 3.76Ah

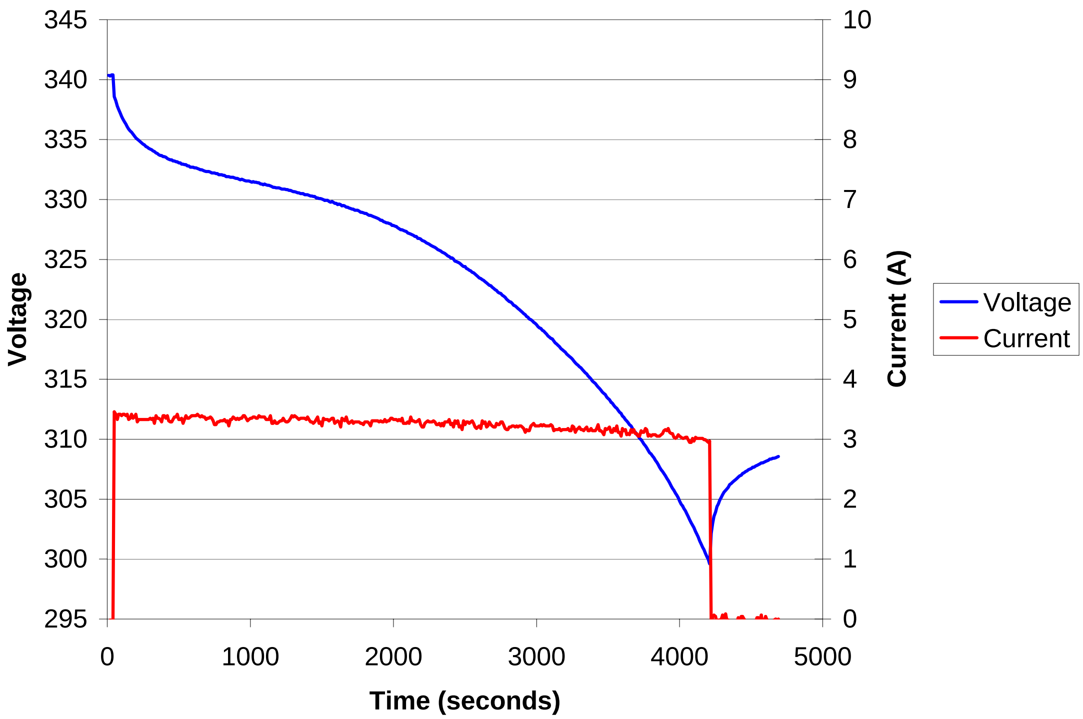
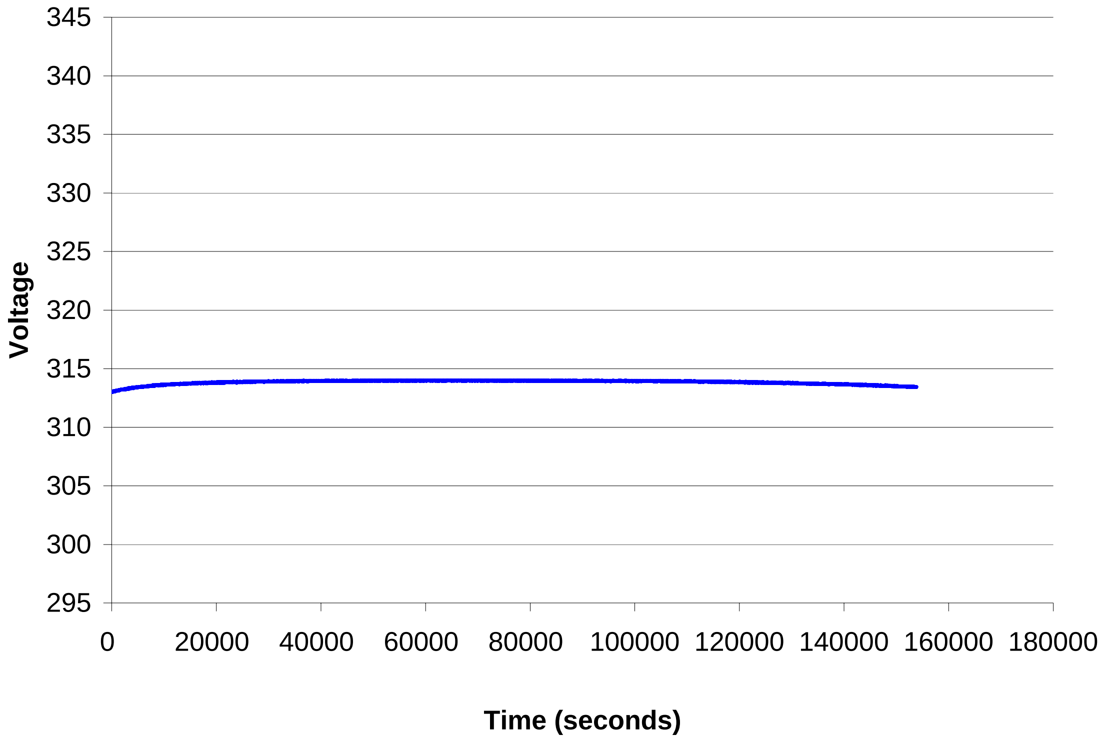


Figure 56: Rest over weekend



350V Module 3 Test Results

The following figures show in order the operating history of Module 3. The goals of this set of testing were to verify the basic operation of the module, and to make adjustments where necessary (such as the triggering points of the pressure charge termination switches). In general, they show that the battery will accept about 5.6 Ah of charge, and deliver 5.0 Ah of capacity. Reasonable power performance was demonstrated by discharging the battery from a state of full charge at currents ranging from 60-80A for one minute.

Table 9: Testing performed on 255 cell module #3

Figure #	**Test condition**	**Current (A)**	**Time**	**Capacity (Ah)**	**Comment**
23	Charge	2.0	3.3 h	6.40	Overnight rest in middle of charge
24	Discharge	113.0	1.00 m	1.89	
25	Discharge	3.86	1.00 h	3.85	
26	Charge	2.00	1.4 h	2.52	
27	Discharge	124.0	10.6 s	0.37	
28	Discharge	3.84	1.14 h	4.38	

Figure 57: Charging at 2A. Charge input total was 6.40Ah

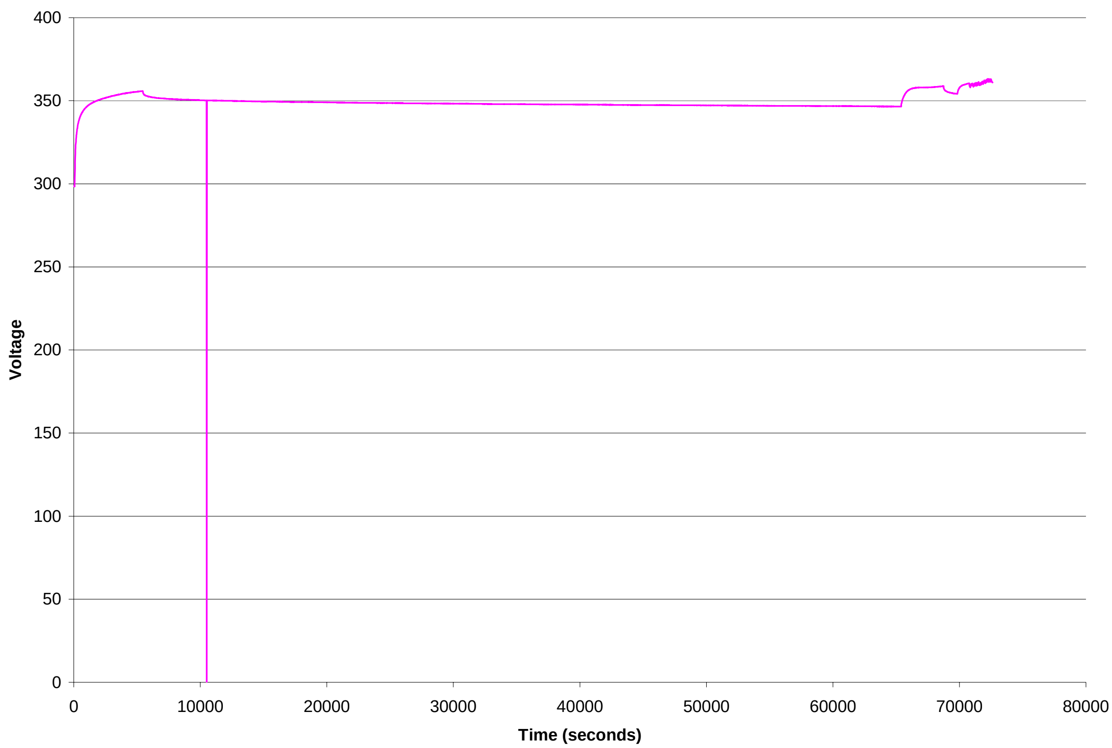


Figure 58: 1 minute discharge at average current of 113.0A

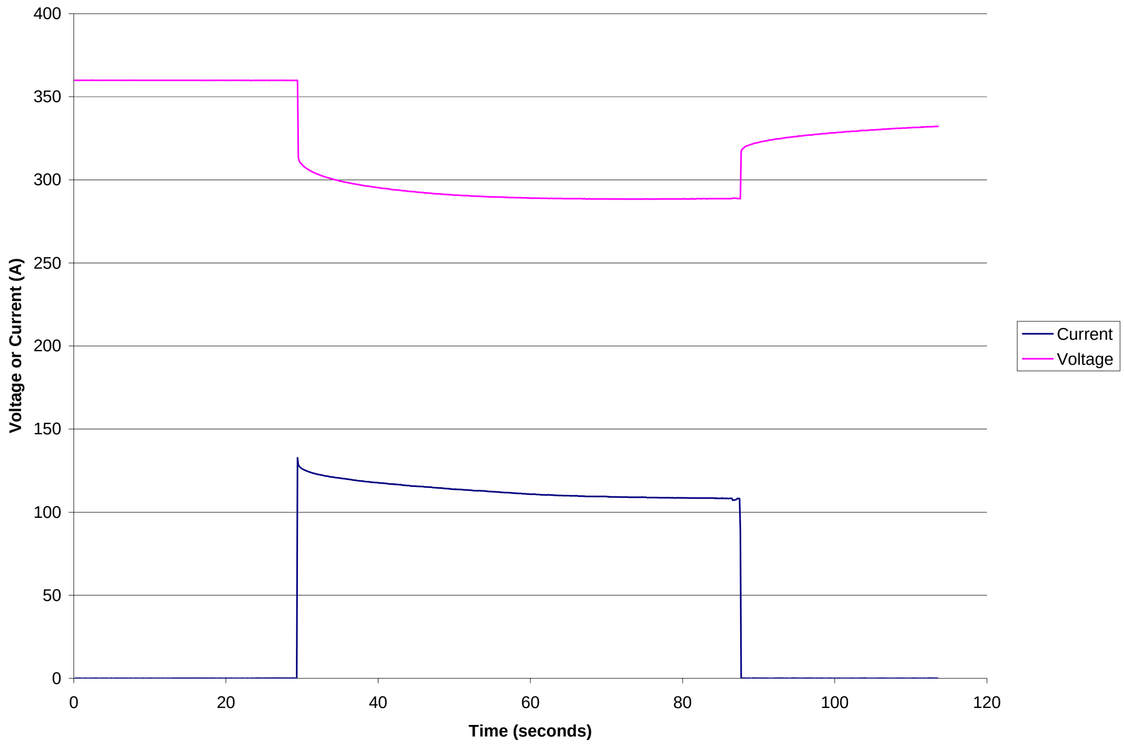


Figure 59: Low rate discharge at average I = 3.86A. Capacity = 3.25Ah

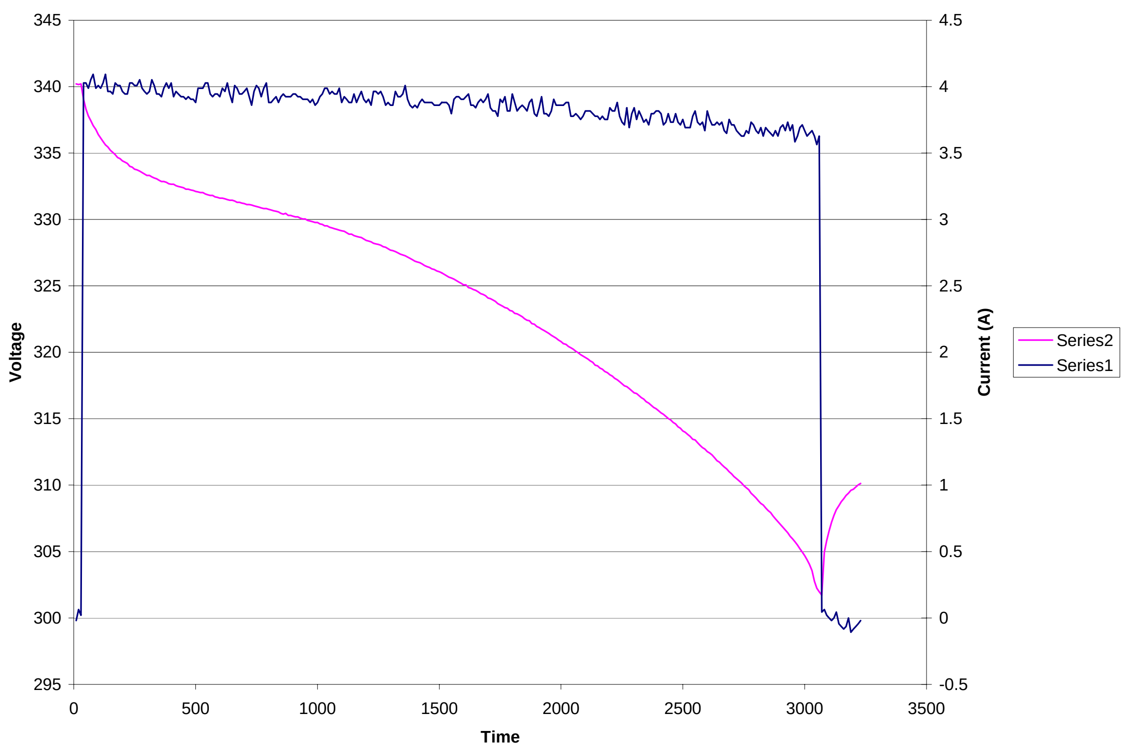


Figure 60: Recharge at 2A. Charge capacity = 2.52Ah

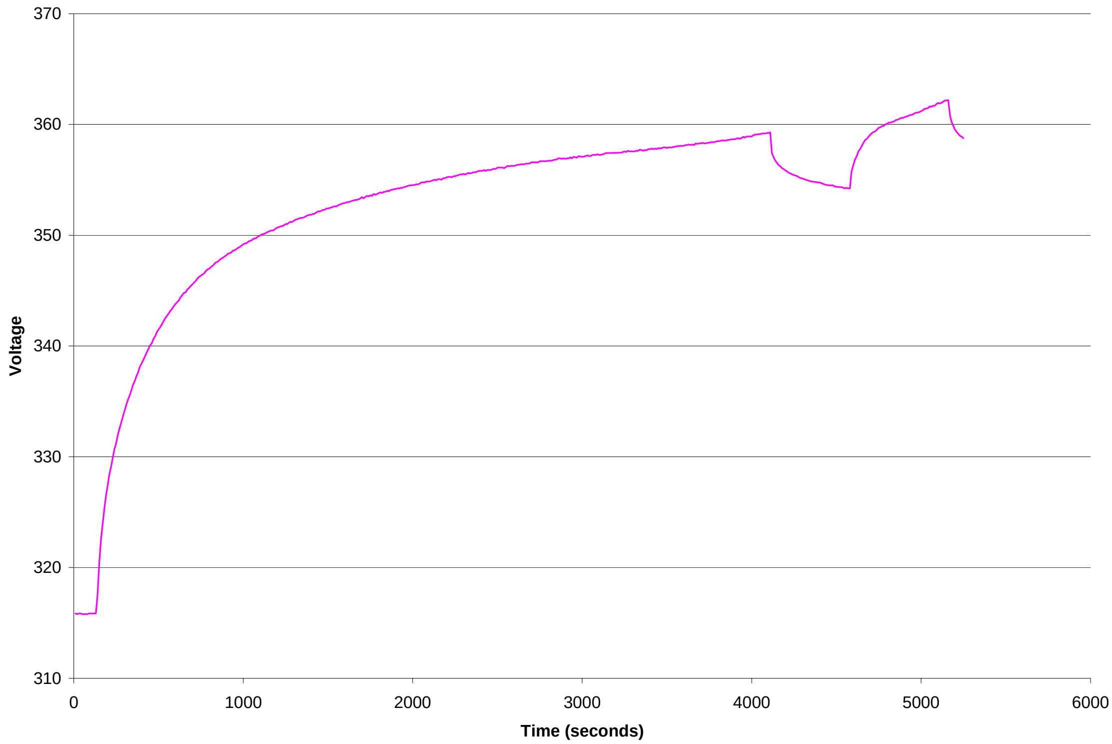


Figure 61: Discharge at average current of 124.0A for 10.6 seconds

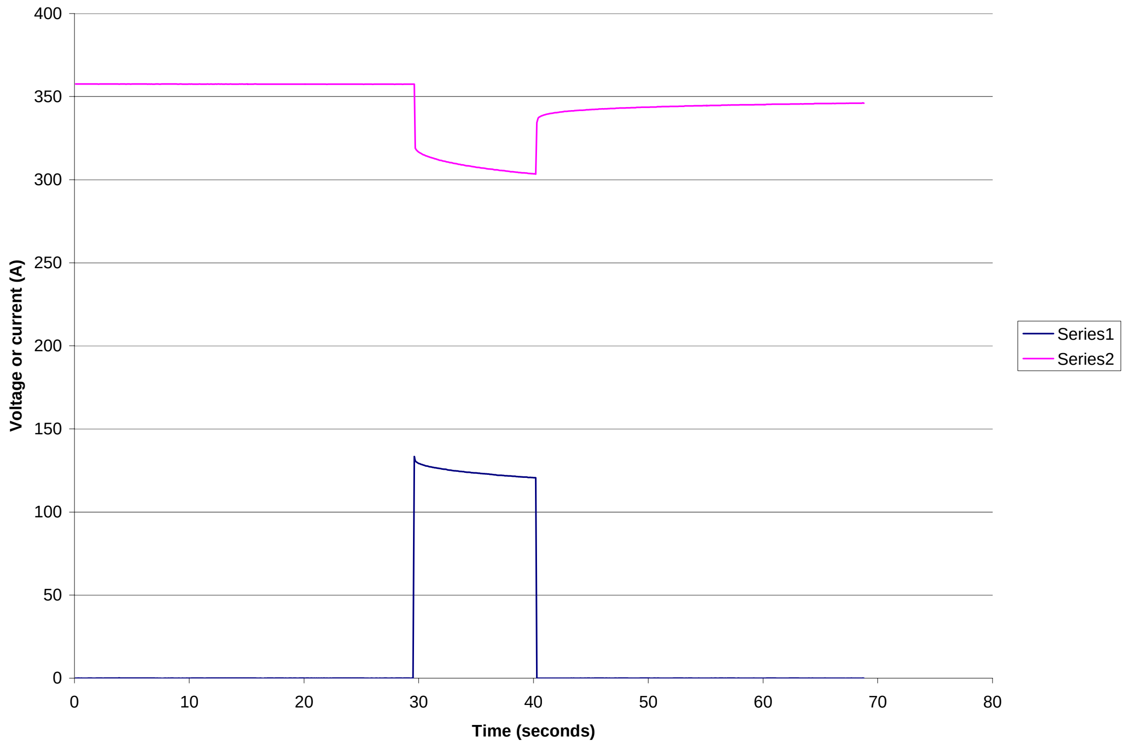
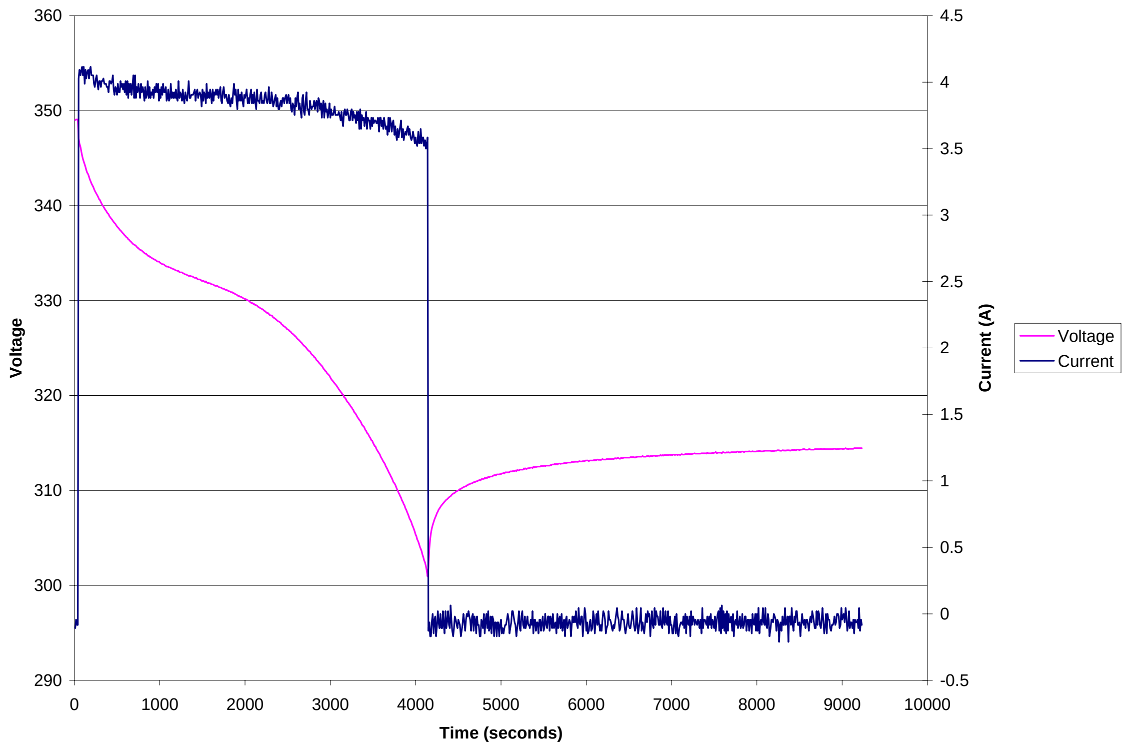


Figure 62: Discharge at average current of 3.84A. Capacity = 4.38Ah



<u>Customer Generated Test Data</u>

Figures 63 and 64 show customer generated data from the 350V modules. From these tests, we determined the power density at 100% SOC to be approximately (305V)(125A)/23L, or 1.66kW/L. The specific power was calculated as (305V)(125A)/55kg, or 0.69kW/kg @ 35°C

Figure 63: Nominal 38kW discharge pulse lasting 10 seconds resistive load

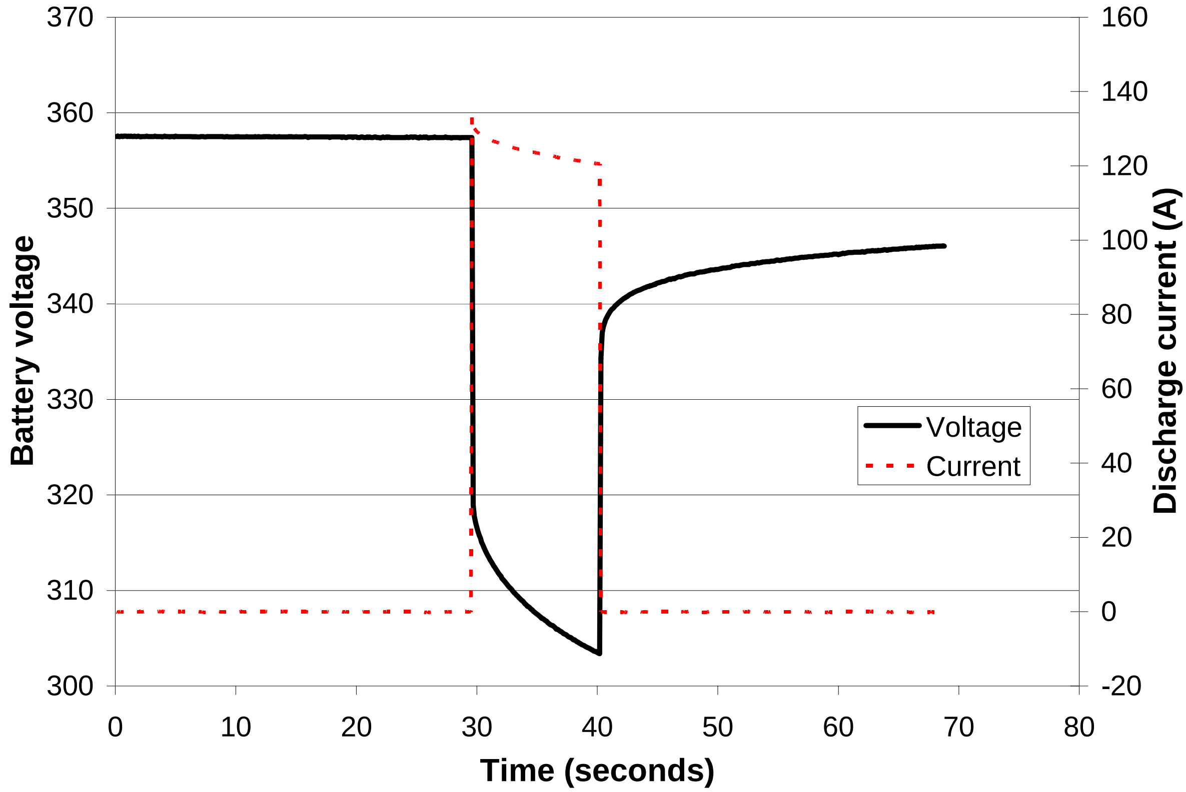
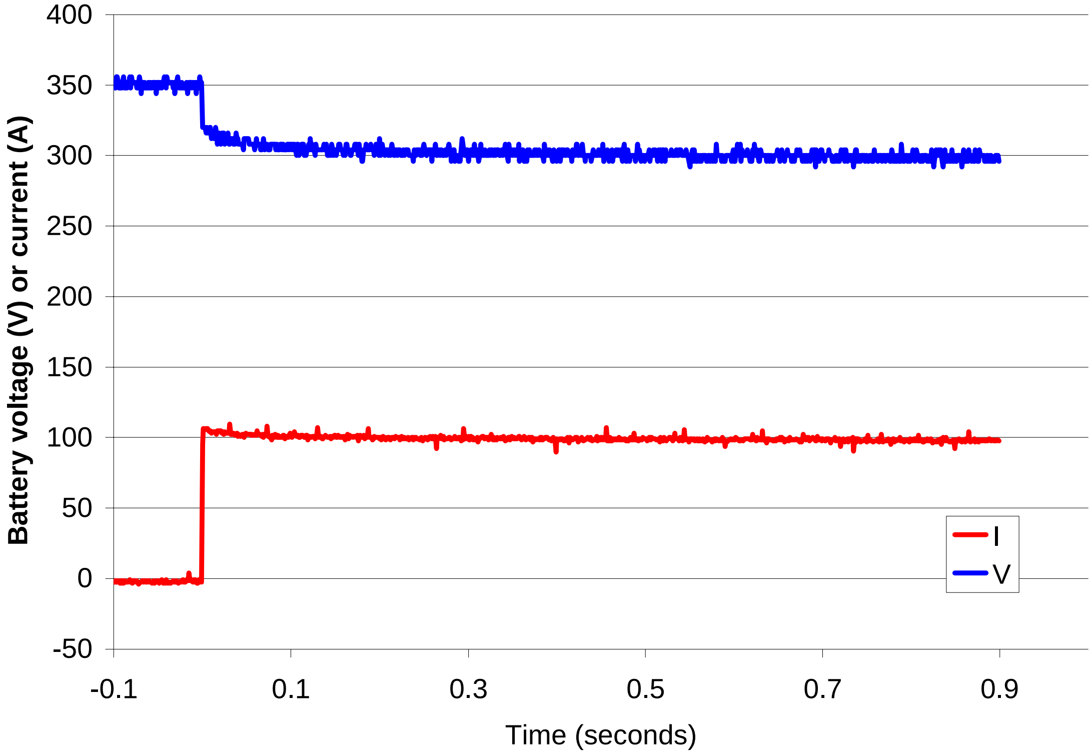


Figure 64: Customer-Generated Data 1 second 100A discharge



3kW Battery Module

Also under phase II of this program, as part as the joint effort with First Energy, EEI began the design and building of a battery to replace the ultracapacitors for the 3kW inverter system. It is based on the 350V battery design, and utilizes the same standard cell configuration. The battery, shown in Figure 65, is specified as 50Ah, 50V, 2.5kWh, 6.62” x 15” x 21.5”, 200lbs. It is comprised of ten parallel stacks of 40 power cells.

Figure 65: 3kW Battery

Testing of this battery with the 3kW inverter system was not completed under this program.

100kVA Battery System

Under phase II, EEI also began the design of the battery system to replace the ultracapacitors for the 100kVA inverter system. The initial proposed design was a battery system specified as 15Ah, 500V, 7.5 kWh. It was made up of three modules connected in parallel, with each module specified as 5Ah, 500V, 2.5kWh, 6.62” x 15” x 21.5”, 200lbs. Later it was decided that it was necessary to have only two parallel strings, and that each string would be housed in two modules made up of 5 39 cell packs connected in series. The final system would have four modules, and be rated at 10Ah, 500V, 5kWh. The modules were constructed and tested after the completion of this program.

Ballard Inverter System

Finally, under the collaboration with First Energy, EEI designed a battery system to be used with the Ballard UPS system. This was a high energy system, where we used the energy cells developed under task 2. Cells still had the standard 6” x 12” size, although had higher capacity electrodes, resulting in a nominal capacity of 20Ah. The proposed system, shown in Figure 66, consists of 1,920 cells, housed in 16 individual battery modules. Each module, shown in Figure 67, is made up of four stacks in series of 30 cells each, specified at 20Ah, 150V, 9.07” x 14.24” x 15.47”, 145lbs. These modules are arranged in four parallel strings of four modules connected in series, resulting in an 80Ah, 600V, 48kWh system. Two battery cabinets and one control cabinet make up the entire system. Each battery cabinet provides a controlled temperature, regulated by a 4,000 BTU AC unit, and contains eight modules (two strings). The control cabinet will house one charger (or two, if needed), and the charge/discharge control circuit.

This system is controlled by monitoring individual stack pressures. If a pressure switch is activated on any stack during charge, the entire string containing that stack will drop out of the system, the charge current will be throttled back to a 75% level, and the system will continue to operate utilizing the three remaining strings. If a second string drops out due to pressure, the charge current will be turned off completely until such time as the pressure in one or both strings decreases sufficiently to bring its associated string back on line. Although charging is disabled, discharge is permitted during these conditions.

If a pressure switch is activated on any stack during discharge, the entire string containing that stack will drop out of the system, but the discharge will be allowed to continue using the remaining three strings. If a second string drops out due to pressure, discharge will be terminated. However, charging under these conditions will be permitted.

The cause of the overpressure condition (charge or discharge) is determined based upon the system voltage. The control circuit firmware monitors the system voltage as well as the individual stack pressures, and uses these parameters in tandem to prevent undesirable system operation. For example, if two strings have dropped out due to charge pressure, then the system must be able to determine that even though further charging is unacceptable, performing a discharge is permitted. The opposite is true for the condition where multiple stacks have excessive pressure due to discharge.

Building and testing of this battery system were completed after this program, through a complimentary follow-on program.

Figure 66: Complete Ballard Battery System

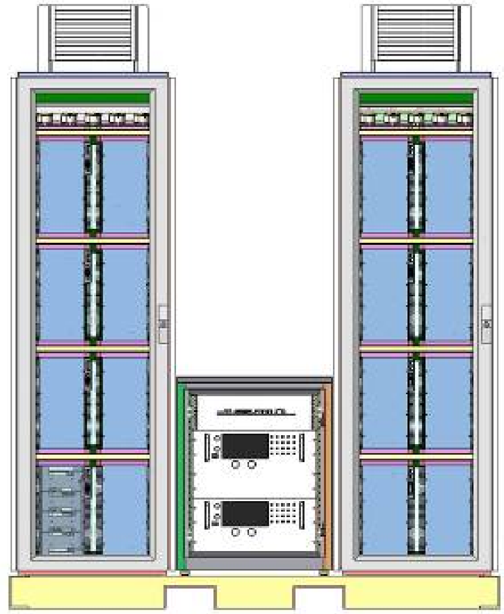
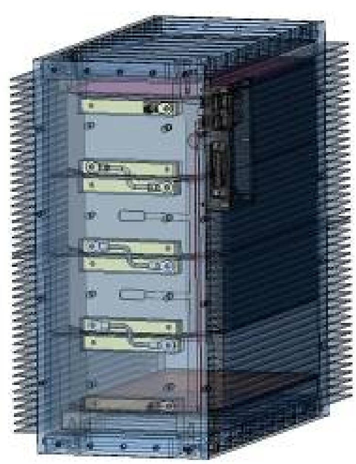


Figure 67: Individual Ballard Battery Module



Task 4 Conclusions

Under task 4 of phases I and II, EEI was able to demonstrate the building of high power systems at voltages as low as 48V, and as high as 500V. Significant progress was made in the area of module and system design as well as, control. Under this program, EEI also was able to implement the bipolar technology into a high-voltage, high-energy design.

Task 5: Manufacturing Process Development

Under this task EEI proposed to develop an industrial high power battery module, as previously discussed. This effort was to develop and demonstrate processes to lower manufacturing cost while improving reliability and performance. EEI looked at alternative methods and techniques to make electrodes, as well as to process the materials in these electrodes. In addition, EEI would investigate the production of all individual components within the cell. The overall objective was reducing processing time and improving cell-to-cell consistency in power, capacity and life.

Under a USAF ManTech effort EEI developed tooling and fixtures to demonstrate a method to automate the manufacture of roll bonded electrodes. It was necessary to adopt the process to make high-power 6” x 12” electrodes used under this program. One of the challenges in any high voltage battery system is to make electrodes uniform in thickness, capacity and performance. It was determined that the method to support the rollers during the fibrillation of the Teflon (back up bearings riding on the back of the rollers to prevent flexing of the main rollers) was causing grease and wear of both the bearings and the chromed rollers. This in turn had been putting chrome, nickel and iron into our electrodes and generally creating problems in cell performance. Several alternatives were investigated during the beginning of phase I to correct this problem.

Approximately 2000 feet of nickel active material was run through the roller system to test dimensional control/stability of the electrode output. Every 4 square inches were measured using a plane micrometer set up. The results were as EEI had hoped for, that is they were very good, with thickness control within 0.0005” overall range and generally no needle movement along the electrode length on the dial micrometer.

The test showed that the present hardened roller with a standard industrial finish was marginal due to electrode material periodically sticking to the surface causing pulling and wrap-around. The material that broke off and went around the roller and reattached to the electrode became compacted, although the finish electrode thickness was the same.

Several feet of hydride electrode was also run through the rollers with good results. Further testing was not done due to concern of damage to this roller set from the hydride material.

During year 2, all major module builds were rolled with the prototype equipment. The 350-cell module built internally with five 51-cell stacks showed remarkable voltage consistency on charge and discharge at the individual stack level. As an example, during a C/2 charge the individual stack voltages were within 0.2 Volts throughout the charge profile and had similar consistency at currents as high as 18 C-rate. It is believed that the rolling and mixing consistency through the equipment and process improvements contributed greatly to the improvement in performance.

Electroforming Nickel Foil

Another area of cost reduction is in the area of nickel foil. An effort to develop in-house capability to make extremely thin nickel foils was undertaken outside of this program. Life testing of the materials made is included under this effort as described below.

Electroforming is a plating process similar to electroplating that is commonly used for manufacturing metallic parts or foils, rather than surface coatings. Nickel sulfamate based solutions are preferred for electroforming because the solution is stable, reliable and easy to operate. Its deposits have lower stress, excellent strength, toughness, and ductility and are extremely resistant to corrosion in a wide range of environments.

During the manufacturing of nickel foil, nickel is electrodeposited onto the surface of a highly polished stainless steel mandrel. The stainless steel surface is passivated to obtain a weak adhesive bond so that the product can be separated without damage when the forming process is completed. Steel mandrels coated with a thin layer of chromium are also widely used in the industry. The mandrel is partially submerged in the nickel solution and as the mandrel slowly rotates nickel is continuously deposited on the mandrel's surface. Once sufficient thickness is attained the nickel foil is then separated from the mandrel, rinsed, dried and rolled up onto a spool.

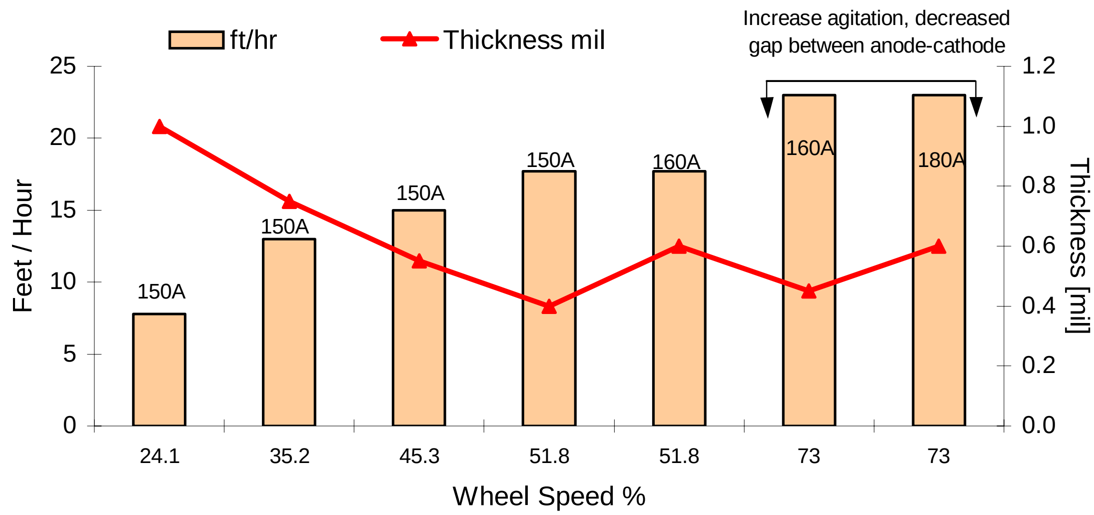
The purpose of the program is to electroform nickel foil as thin as possible in order to reduce the weight of the cell, without compromising existing foil characteristics such as ductility, strength, porosity free, and corrosion resistance.

Several nickel foil sections, pits/defect free, obtained during preliminary trials conducted in early 2002 in a steel chrome coated mandrel were selected to make control cells. At that time the test indicated that the performance of electroformed nickel foil was comparable to commercially available nickel foil. Unfortunately, during the trial the plated chromium layer of the mandrel started blistering and the mandrel needed to be sent out for chromium refinishing.

To avoid plating down time due to mandrel blistering problems a highly polished stainless steel mandrel was purchased, and at the same time several modifications to the plating tank were made to improve electroforming performance. Preliminary testing with the modified process indicated that the process had improved from the previous trial.

A baseline of nickel foils was obtained under various plating parameters with a Barret nickel sulfamate solution at 12 oz/gal of nickel. This is shown in Figure 68.

Figure 68: Electroformed Foil Baseline



Observations:

- Nickel foil thickness distribution was even along the width of the foil.
- Porosity was considerable reduced on foils with thicknesses above 0.6 mil.
- At a constant current density the thickness of the foil was considerably reduced, and porosity did increase when wheel speed was increased.
- At constant speed, an increased thickness and porosity reduction were observed when current density was increased and the gap between anode and cathode was reduced.
- Straight current lost between plating tank components previously observed were eliminated and lower voltage was obtained on all the tests.
- The addition of a bigger pump and modification of the spargers improved solution agitation and plating performance.
- Plating line stills need to have some adjustments with the spool roller and rinsing process

Additional tests indicated that thin, pore-free nickel foil can be attained at higher current density and higher speed when nickel concentration is increased from 12oz/gal to 16oz/gal. Nickel concentration at 18oz/gal increased the porosity of the foil when electroformed at 180 amps / 50% speed, believed to be caused by boric acid solubility in the solution due to high nickel concentration.

6” x 12” nickel foil sections were immersed in HNO_3 33% solution for 10 minutes then foils were visually observed. The nickel concentration in the solutions was analyzed by atomic spectromic absorption.

- Higher nickel concentration was observed with the foils obtained at higher current densities. Nickel foil dissolves faster when plated at high currents.
  200 Amp: 8.3 g/L, 210 Amp: 9.6 g/L, 210 Amp: 11.5 g/L

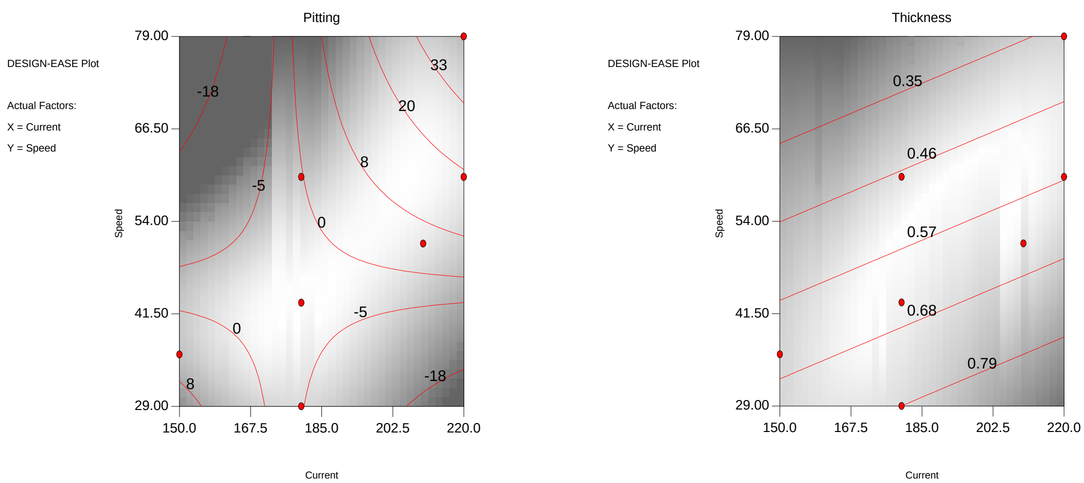
- Lower nickel concentration was observed with the foils obtained at lower current densities. Nickel foil dissolves slowly when plated at low currents.
  150 amp: 4.1 g/L, 180 amp: 4.7 g/L,

- Commercially available nickel foil used in production dissolves slowly when immersed in HNO3 33% for 10 min, 3.8 to 4.2 g/L.

To optimize electroform nickel foil manufacturing the data from tests run at 16 oz/gal was plugged into a two level factorial design (DOE), shown in Figure 69, and with the following parameters:

Factors	Parameters	Operating Conditions	
Cathode Current	150 Amp to 220 Amp	Temperature	140 ºF
Wheel Speed	30 % to 80 %	pH	4.0
Responses	Thickness, Porosity, Corrosion, Performance	Baume	39 ºBe
		Nickel	16 oz/gal
		Surfactant	0.2 %
		Boric Acid	6 oz/gal

Figure 69: Electroformed Foil Design of Experiments



Preliminary Results:

1. Porosity: The lower porosity was observed on foils obtained at 180 to 190 amps @ 40% to 51% wheel speed.

2. Thickness: Minimum thickness, pore free, ductile, nickel foil was obtained at 180 to 190 amps @ 40% to 51% wheel speed.

Follow up:

The following nickel foil samples were tested in control cells and DOE cells:

Table 10: Variables Tested in Electroformed Foil

Sample	Ni Concentration	Current Density	Wheel Speed	Thickness
#	Oz/gal	Amps	%	Mil
1	14	180	29	0.85
2	14	180	43	0.65
3	16	180	43	0.75
4	16	180	40	0.85
5	16	210	50	0.90

Nickel Hydroxide

A key variable in EEI's production process is the pre-treatment of the active $Ni(OH)_2$ material. In order to improve conductivity and allow for the production of electrodes with no conductive substrate, EEI does an electroless plating process on the material, coating each particle with a thin, porous layer of Nickel and Cobalt.

A design of experiments was done with the EN plating process, with goals to:

- Optimize the EN plated active material by studying the effects of cobalt, nickel, and hypophosphite ratios with the nickel hydroxide.
- Reduce process cost.
- Improve electrode performance.
- Extend the life of the electrode.
- Characterize specific formulas to be used for high and/or low capacity applications

Four factors were selected for the DOE:

Nickel	8 g/L to 18 g/L
Sodium hypophosphite	60 g/L to 100 g/L
Cobalt	1 g/L to 6 g/L
Nickel hydroxide	67 g/L to 100 g/L

It was determined that the formulation that provided the best overall l performance utilized material was 85% $Ni(OH)_2$, 12% Ni, and 3% Co.

Task 6: User Collaboration

EEI collaborated with First Energy, Inc. to identify the most appropriate applications, define the interface requirements, and solicit the testing of deliverable modules constructed in Task 4. First Energy provided a significant amount of cost share to this program providing an inverter for use and evaluation, and providing a capacitor system to compare with the EEI high power design. It was the common objective to develop a useful technology that was directed at solving significant high value problems in the electrical infrastructure. Under this program EEI tested and evaluated the 3 kW system using the ultracapacitors, but terminated the 100 kVA capacitor testing.

Ultracapacitor Testing for the 3kW System

The capacitor test results could be summarized as follows:

- Increasing instances of "missed" 20 minute (1500W load) and 40 minute (750W load) runtimes were noted as testing progressed

- A missed runtime occurs when the low voltage cutoff point is hit prior to the desired runtime being achieved

- Note that there were no instances of missed 10 minute (2250W load) runtimes. This is primarily because the 10 minute cycles were set up to deliver 375 WH, whereas the 20 and 40 minute cycles were set up to deliver 500 WH

- * Note: Peaks and valleys prior to Main Cycle 6 on two previous slides are mainly due to a failure to zero out the clamp-on ammeter prior to each day's run

Figure 70: 3kW System – WH to Load (Capacitor Version)

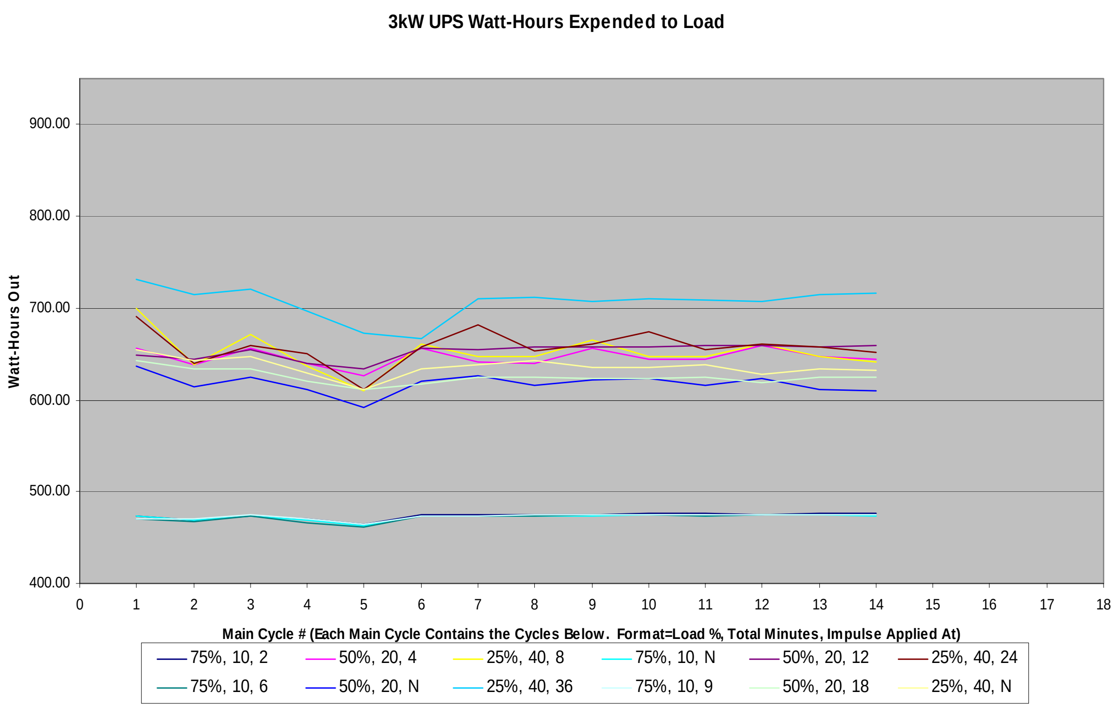
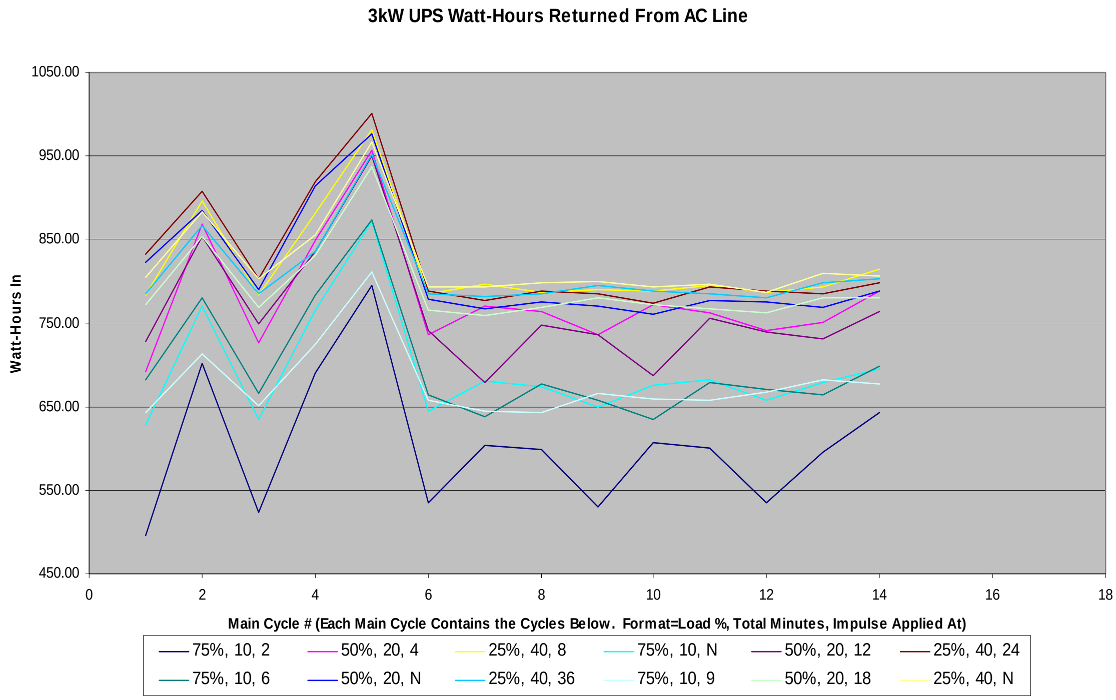


Figure 71: 3kW System – WH from Line (Capacitor Version)



First Energy evaluated the performance of EEI's NiMH energy storage batteries with grid-interactive and UPS devices to develop integrated applications of storage for power quality, load following, and energy management capabilities.

Task 7 Program Management & Reporting

This task covered the administrative and technical management of the project and related reporting requirements, including, but not limited to, project reviews and electronic reports. Throughout the program, EEI submitted monthly status reports, and participated in face-to-face reviews, as well as the DOE Peer Reviews and EESAT meetings.

Program Conclusions

Under this program, EEI was able to establish relationships with outside organizations and able to gain a better understanding of the utility and other users requirements for high-voltage and high-power or high-energy applications. Through meetings and conferences, such as the Peer Review and EESAT, EEI was able to establish itself as a player in the energy storage market for these applications. Under R&D tasks in this program, EEI established baseline cells to serve as the foundation for all applications that EEI's battery could meet the requirements. Improved formation and manufacturing processes were investigated and implemented. Finally, EEI successfully demonstrated the performance and capabilities of the high power batteries, through 40V modules and 48V, 3kW and 500V, 100kVA UPS systems, and 350V high-pulse systems. EEI's high-energy systems were designed in the form of a 600V, 40kWh, 20kW inverter battery system.

Appendix – Cell Test Data Tables

		Nickel				Hydride					
Cell #	Main Variable	Composition	Weight	Thick.	Theo. Cap	Composition	Weight	Thick.	Theo. Cap	Separator	Form. Cap. (Ah.)
SNL100a	N-P-304A	77%P304A, 20%Ni210(RSG), 2%CoO (3 Step)	37.9	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.7	0.007	7.52	2-700/9	6.34
SNL100b	N-P-304A	77%P304A, 20%Ni210(RSG), 2%CoO (3 Step)	37.8	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.5	0.007	7.52	2-700/9	6.33
SNL100c	N-P-304A	77%P304A, 20%Ni210(RSG), 2%CoO (3 Step)	37.8	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.7	0.007	7.52	2-700/9	6.32
SNL101a	N-P-305A	77%P305A, 20%Ni210(RSG), 2%CoO (3 Step)	37.9	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.6	0.007	7.52	2-700/9	6.15
SNL101b	N-P-305A	77%P305A, 20%Ni210(RSG), 2%CoO (3 Step)	38.0	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.7	0.007	7.52	2-700/9	6.14
SNL101c	N-P-305A	77%P305A, 20%Ni210(RSG), 2%CoO (3 Step)	37.8	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.8	0.007	7.52	2-700/9	6.15
SNL102a	N-P-306A	77%P306A, 20%Ni210(RSG), 2%CoO (15-20µ)	37.9	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.8	0.007	7.52	2-700/9	6.47
SNL102b	N-P-306A	77%P306A, 20%Ni210(RSG), 2%CoO (15-20µ)	37.8	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.8	0.007	7.52	2-700/9	6.47
SNL102c	N-P-306A	77%P306A, 20%Ni210(RSG), 2%CoO (15-20µ)	37.9	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.8	0.007	7.52	2-700/9	6.47
SNL103a	N-EEI-166B	77%EEI-166B, 20%Ni210(RSG), 2%CoO (1 Step)	37.9	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.8	0.007	7.52	2-700/9	6.46
SNL103b	N-EEI-166B	77%EEI-166B, 20%Ni210(RSG), 2%CoO (1 Step)	37.9	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.6	0.007	7.52	2-700/9	6.44
SNL103c	N-EEI-166B	77%EEI-166B, 20%Ni210(RSG), 2%CoO (1 Step)	37.8	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.7	0.007	7.52	2-700/9	6.45
SNL104a	N-EEI-171A	77%EEI-171A, 20%Ni210(RSG), 2%CoO (1 Step Belt)	37.9	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.8	0.007	7.52	2-700/9	6.44
SNL104b	N-EEI-171A	77%EEI-171A, 20%Ni210(RSG), 2%CoO (1 Step Belt)	37.9	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.7	0.007	7.52	2-700/9	6.46
SNL104c	N-EEI-171A	77%EEI-171A, 20%Ni210(RSG), 2%CoO (1 Step Belt)	38.0	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.6	0.007	7.52	2-700/9	6.47

	Vented	Vented	Vented	Vented	Vented	Vented	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed
Cell #	**1st Dge .8 -100A 50% Charger Room Temp**	**1st Dge .6 -100A Fully Charge Room Temo**	**1st Dge .8 -200A 50% Charge Room Temp**	**2nd Dge .6 -200A 50% Charge Room Temp**	**3rd Dge .6 -200A 50% Charge Room Temp**	**1st Dge .6 -200A Fully Charge Room Temp**	**1st Dge .8 -100A 50% Charge Room Temp**	**1st Dge .8 -200A 50% Charge Room Temp**	**2nd Dge .8 -200A 50% Charge Room Temp**	**3rd Dge .8 -200A 50% Charge Room Temp**	**4th Dge .8 -200A 50% Charge Room Temp**	**5th Dge .8 -200A 50% Charge Room Temp**	**6th Dge .8 -200A 50% Charge Room Temp**	**1st Dge .8 -250 50% Charge Room Temp**	**1st Dge .8 -300 50% Charge Room Temp**	**1st Dge .8 -350 50% Charge Room Temp**	**1st Dge .6 -400 50% Charge Room Temp**
SNL100a	1.050		0.660	0.844			1.064	0.782	0.718						0.599		
SNL100b	1.060		0.650	0.828			1.060	0.762	0.737						0.600		
SNL100c	1.050		0.670	0.848			1.070	0.792	0.669						0.600		
SNL101a	1.080		0.700	0.884			1.077	0.823	0.834						0.599		
SNL101b	1.040		0.620	0.795			1.058	0.756	0.645						0.599		
SNL101c	1.080		0.730	0.903			1.114	0.891	0.733						0.600		
SNL102a	1.120		0.730	0.919			1.118	0.890	0.895						0.670		
SNL102b	1.120		0.790	0.953			1.134	0.923	0.934						0.736		
SNL102c	1.110		0.710	0.891			1.103	0.849	0.827						0.599		
SNL103a	1.124		0.751	0.923			1.129	0.935	0.913	0.926	0.940	0.938	0.909				
SNL103b	1.138		0.821	1.008			1.159	1.001	0.975	0.983	0.996	0.991					
SNL103c	1.128		0.782	0.975			1.141	0.967	0.960	0.973	0.981	0.975					
SNL104a	1.112		0.816	0.967			1.135	0.953	0.929	0.939	0.947	0.943	0.921				
SNL104b	1.105		0.802	0.939			1.118	0.917	0.924	0.931	0.942	0.938					
SNL104c	1.111		0.797	0.954			1.136	0.954	0.892	0.908	0.919	0.917					

	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed
Cell #	**1st Dge .3 -500 50% Charge Room Temp**	**.3 -450 50% Charge Room Temp**	**.6 -400 50% Charge Room Temp**	**.8 -350 50% Charge Room Temp**	**.8 -300 50% Charge Room Temp**	**.8 -250 50% Charge Room Temp**	**.8 -200A 50% Charge Room Temp**	**After 2 Wk Stand .8 -200A 50% Charge Room Temp**	**.8 -200A After 2000 Life Cycles**	**.8 -200A After 4000 Life Cycles**	**.8 -200A After 6000 Life Cycles**	**.8 -200A After 8000 Life Cycles**	**.8 -200A After 10000 Life Cycles**	**.3 -200A 0^oC**	**.3 -200A -30^oC**	**.3 -200A -40^oC**	**-200 Before Rewet**
SNL100a														0.298	0.385		
SNL100b														0.300	0.029		
SNL100c														0.298	-0.147		
SNL101a														0.298	-0.314		
SNL101b														0.300	-0.213		
SNL101c														0.299	0.108		
SNL102a														0.298	0.286		
SNL102b														0.295	0.064		
SNL102c														0.296	0.121		
SNL103a																	
SNL103b																	
SNL103c																	
SNL104a																	
SNL104b																	
SNL104c																	

		Nickel				Hydride					
Cell #	Main Variable	Composition	Weight	Thick.	Theo. Cap	Composition	Weight	Thick.	Theo. Cap	Separator	Form. Cap. (Ah.)
SNL105a	N-EEI-174A	77%EEI-174A, 20%Ni210(RSG), 2%CoO (8/2)	35.7	0.012	6.47	80%SC1132, 19%Ni210(RSG)	37.7	0.008	7.52	2-700/9	6.42
SNL105b	N-EEI-174A	77%EEI-174A, 20%Ni210(RSG), 2%CoO (8/2)	35.7	0.012	6.47	80%SC1132, 19%Ni210(RSG)	37.7	0.008	7.52	2-700/9	6.44
SNL105c	N-EEI-174A	77%EEI-174A, 20%Ni210(RSG), 2%CoO (8/2)	35.8	0.012	6.47	80%SC1132, 19%Ni210(RSG)	37.8	0.008	7.52	2-700/9	6.45
SNL106a	N-EEI-175A	77%EEI-175A, 20%Ni210(RSG), 2%CoO (16/4)	40.1	0.013	6.49	80%SC1132, 19%Ni210(RSG)	37.6	0.007	7.52	2-700/9	6.45
SNL106b	N-EEI-175A	77%EEI-175A, 20%Ni210(RSG), 2%CoO (16/4)	40.2	0.012	6.49	80%SC1132, 19%Ni210(RSG)	37.6	0.008	7.52	2-700/9	6.46
SNL106c	N-EEI-175A	77%EEI-175A, 20%Ni210(RSG), 2%CoO (16/4)	40.2	0.012	6.49	80%SC1132, 19%Ni210(RSG)	37.6	0.007	7.52	2-700/9	6.46
SNL107a	N-EEI-159B	77%EEI-159B, 20%Ni210(RSG), 2%CoO (3 Step)	37.9	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.6	0.007	7.52	2-700/9	6.41
SNL107b	N-EEI-159B	77%EEI-159B, 20%Ni210(RSG), 2%CoO (3 Step)	37.9	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.6	0.007	7.52	2-700/9	6.42
SNL107c	N-EEI-159B	77%EEI-159B, 20%Ni210(RSG), 2%CoO (3 Step)	37.8	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.7	0.007	7.52	2-700/9	6.43
SNL108a	S1880 N-EEI148	77%EEI-148, 20%Ni210(RSG), 2%CoO (Old Sanyo)	37.8	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.8	0.007	7.52	2-1880	6.19
SNL108b	S1880 N-EEI149	77%EEI-148, 20%Ni210(RSG), 2%CoO (Old Sanyo)	37.9	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.7	0.008	7.52	2-1880	6.21
SNL108c	S1880 N-EEI150	77%EEI-148, 20%Ni210(RSG), 2%CoO (Old Sanyo)	37.8	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.7	0.008	7.52	2-1880	6.22
SNL109a	30 Ni210 N-EEI-159B	67%EEI-159B, 30%Ni210(RSG), 2%CoO	43.4	0.013	6.48	80%SC1132, 19%Ni210(RSG)	37.6	0.008	7.52	2-700/9	6.45
SNL109b	31 Ni210 N-EEI-159B	67%EEI-159B, 30%Ni210(RSG), 2%CoO	43.4	0.013	6.48	80%SC1132, 19%Ni210(RSG)	37.6	0.008	7.52	2-700/9	6.46
SNL109c	32 Ni210 N-EEI-159B	67%EEI-159B, 30%Ni210(RSG), 2%CoO	43.4	0.013	6.48	80%SC1132, 19%Ni210(RSG)	37.6	0.008	7.52	2-700/9	6.47

Cell #	Vented	Vented	Vented	Vented	Vented	Vented	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed
	1^{st} Dge .8 -100A 50% Charger Room Temp	1^{st} Dge .6 -100A Fully Charge Room Temo	1^{st} Dge .8 -200A 50% Charge Room Temp	2^{nd} Dge .6 -200A 50% Charge Room Temp	3^{rd} Dge .6 -200A 50% Charge Room Temp	1^{st} Dge .6 -200A Fully Charge Room Temp	1^{st} Dge .8 -100A 50% Charge Room Temp	1^{st} Dge .8 -200A 50% Charge Room Temp	2^{nd} Dge .8 -200A 50% Charge Room Temp	3^{rd} Dge .8 -200A 50% Charge Room Temp	4^{th} Dge .8 -200A 50% Charge Room Temp	5^{th} Dge .8 -200A 50% Charge Room Temp	6^{th} Dge .8 -200A 50% Charge Room Temp	1^{st} Dge .8 -250 50% Charge Room Temp	1^{st} Dge .8 -300 50% Charge Room Temp	1^{st} Dge .8 -350 50% Charge Room Temp	1^{st} Dge .6 -400 50% Charge Room Temp
SNL105a	1.110		0.790	0.928			1.132	0.918	0.874						0.644		
SNL105b	1.110		0.760	0.904			1.125	0.897	0.871						0.640		
SNL105c	1.100		0.760	0.917	Off Test Scrap												
SNL106a	1.080		0.770	0.921		0.918	Off Test Scrap										
SNL106b	1.110		0.780	0.922		0.920	1.139	0.940	0.921						0.717		
SNL106c	1.110		0.770	0.921		0.923	1.140	0.939	0.902						0.686		
SNL107a	1.060		0.640	0.865			1.076	0.814	0.779						0.600		
SNL107b	1.070		0.600	0.819			1.078	0.806	0.776						0.599		
SNL107c	1.060		0.600	0.811			1.064	0.782	0.724						0.600		
SNL108a	1.030		0.600	0.768			1.054	0.751	0.736						0.598		
SNL108b	1.030		0.630	0.822			1.081	0.744	0.814						0.600		
SNL108c	1.030		0.600	0.766			1.037	0.721	0.752						0.600		
SNL109a	1.080		0.600	0.853		0.828	1.087	0.833	0.736						0.598		
SNL109b	1.080		0.600	0.856		0.838	1.079	0.813	0.803						0.600		
SNL109c	1.080		0.650	0.851		0.825	1.071	0.802	0.760						0.598		

	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed
Cell #	**1st Dge .3 -500 50% Charge Room Temp**	**.3 -450 50% Charge Room Temp**	**.6 -400 50% Charge Room Temp**	**.8 -350 50% Charge Room Temp**	**.8 -300 50% Charge Room Temp**	**.8 -250 50% Charge Room Temp**	**.8 -200A 50% Charge Room Temp**	**After 2 Wk Stand .8 -200A 50% Charge Room Temp**	**.8 -200A After 2000 Life Cycles**	**.8 -200A After 4000 Life Cycles**	**.8 -200A After 6000 Life Cycles**	**.8 -200A After 8000 Life Cycles**	**.8 -200A After 10000 Life Cycles**	**.3 -200A 0°C**	**.3 -200A -30°C**	**.3 -200A -40°C**	**-200 Before Rewet**
SNL105a														0.299	0.108		
SNL105b														0.298	0.150	0.335	
SNL105c	Off Test Scrap																
SNL106a	Off Test Scrap																
SNL106b														0.300	0.187	-0.745	
SNL106c														0.295	-0.447	-0.896	
SNL107a														0.300	-0.419	-1.292	
SNL107b														0.297	-0.231	-0.984	
SNL107c														0.297	-0.069	-1.056	
SNL108a														0.298	-0.517	-1.200	
SNL108b														0.298	-0.221	-1.120	
SNL108c														0.299	-0.366	-1.044	
SNL109a														0.300	0.691	-1.470	
SNL109b														0.300	-0.423	-1.059	
SNL109c														0.300	-0.495	-1.232	

		Nickel				Hydride					
Cell #	Main Variable	Composition	Weight	Thick.	Theo. Cap	Composition	Weight	Thick.	Theo. Cap	Separator	Form. Cap. (Ah.)
SNL110a	N-77 EEI171A	77%EEI-171A, 20%Ni210(RSG), 2%CoO	37.9	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.7	0.008	7.52	2-700/9	6.44
SNL110b	N-77 EEI171A	77%EEI-171A, 20%Ni210(RSG), 2%CoO	37.9	0.013	6.48	80%SC1132, 19%Ni210(RSG)	37.6	0.008	7.52	2-700/9	6.46
SNL110c	N-77 EEI171A	77%EEI-171A, 20%Ni210(RSG), 2%CoO	37.9	0.013	6.48	80%SC1132, 19%Ni210(RSG)	37.6	0.008	7.52	2-700/9	6.26
SNL111a	N-87 EEI171A	87%EEI-171A, 10%Ni210(RSG), 2%CoO	33.6	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.6	0.007	7.52	2-700/9	6.43
SNL111b	N-87 EEI171A	87%EEI-171A, 10%Ni210(RSG), 2%CoO	33.6	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.6	0.007	7.52	2-700/9	6.42
SNL111c	N-87 EEI171A	87%EEI-171A, 10%Ni210(RSG), 2%CoO	33.6	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.6	0.008	7.52	2-700/9	6.44
SNL112a	N-97 EEI171A	97%EEI-171A, 10%Ni210(RSG), 2%CoO	30.2	0.011	6.48	80%SC1132, 19%Ni210(RSG)	37.6	0.008	7.52	2-700/9	6.40
SNL112b	N-97 EEI171A	97%EEI-171A, 10%Ni210(RSG), 2%CoO	30.1	0.011	6.48	80%SC1132, 19%Ni210(RSG)	37.5	0.008	7.52	2-700/9	6.42
SNL112c	N-97 EEI171A	97%EEI-171A, 10%Ni210(RSG), 2%CoO	30.2	0.011	6.48	80%SC1132, 19%Ni210(RSG)	37.6	0.007	7.52	2-700/9	6.42
SNL113a	D Electroformed Ni Foil-Sample#1	77%EEI-171A, 20%Ni210(RSG), 2%CoO	37.9	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.6	0.007	7.52	2-700/9	6.47
SNL113b	D Electroformed Ni Foil-Sample#1	77%EEI-171A, 20%Ni210(RSG), 2%CoO	37.9	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.9	0.007	7.52	2-700/9	6.45
SNL113c	D Electroformed Ni Foil-Sample#1	77%EEI-171A, 20%Ni210(RSG), 2%CoO	37.9	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.6	0.007	7.52	2-700/9	6.46
SNL114a	D Electroformed Ni Foil-Sample#2	77%EEI-171A, 20%Ni210(RSG), 2%CoO	37.8	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.8	0.007	7.52	2-700/9	6.45
SNL114b	D Electroformed Ni Foil-Sample#2	77%EEI-171A, 20%Ni210(RSG), 2%CoO	37.9	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.8	0.007	7.52	2-700/9	6.47
SNL114c	D Electroformed Ni Foil-Sample#2	77%EEI-171A, 20%Ni210(RSG), 2%CoO	37.9	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.8	0.007	7.52	2-700/9	6.44

	Vented	Vented	Vented	Vented	Vented	Vented	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed
Cell #	1st Dge .8 -100A 50% Charger Room Temp	1st Dge .6 -100A Fully Charge Room Temo	1st Dge .8 -200A 50% Charge Room Temp	2nd Dge .6 -200A 50% Charge Room Temp	3rd Dge .6 -200A 50% Charge Room Temp	1st Dge .6 -200A Fully Charge Room Temp	1st Dge .8 -100A 50% Charge Room Temp	1st Dge .8 -200A 50% Charge Room Temp	2nd Dge .8 -200A 50% Charge Room Temp	3rd Dge .8 -200A 50% Charge Room Temp	4th Dge .8 -200A 50% Charge Room Temp	5th Dge .8 -200A 50% Charge Room Temp	6th Dge .8 -200A 50% Charge Room Temp	1st Dge .8 -250 50% Charge Room Temp	1st Dge .8 -300 50% Charge Room Temp	1st Dge .8 -350 50% Charge Room Temp	1st Dge .6 -400 50% Charge Room Temp
SNL110a	1.050		0.602														
SNL110b	1.050		0.710														
SNL110c	0.810		N/A														
SNL111a	1.070		0.755														
SNL111b	1.060		0.740														
SNL111c	1.060		0.728														
SNL112a	1.060		0.733														
SNL112b	1.060		0.666														
SNL112c	1.060		0.743														
SNL113a	1.128		0.827	0.980	0.997		1.164	0.998						0.909	0.843	0.593	0.600
SNL113b	1.133		0.825	0.982	1.002		1.161	0.992						0.906	0.835	0.599	0.598
SNL113c	1.131		0.815	0.969	0.989		1.160	0.991						0.900			
SNL114a	1.131	0.599	0.817				1.153	0.980									
SNL114b	1.129	0.600	0.834				1.149	0.971									
SNL114c	1.131	0.598	0.838				1.152	0.977									

	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed
Cell #	**1st Dge .3 -500 50% Charge Room Temp**	**.3 -450 50% Charge Room Temp**	**.6 -400 50% Charge Room Temp**	**.8 -350 50% Charge Room Temp**	**.8 -300 50% Charge Room Temp**	**.8 -250 50% Charge Room Temp**	**.8 -200A 50% Charge Room Temp**	**After 2 Wk Stand .8 -200A 50% Charge Room Temp**	**.8 -200A After 2000 Life Cycles**	**.8 -200A After 4000 Life Cycles**	**.8 -200A After 6000 Life Cycles**	**.8 -200A After 8000 Life Cycles**	**.8 -200A After 10000 Life Cycles**	**.3 -200A $0^{o}C$**	**.3 -200A $-30^{o}C$**	**.3 -200A $-40^{o}C$**	**-200 Before Rewet**
SNL110a																	
SNL110b																	
SNL110c																	
SNL111a																	
SNL111b																	
SNL111c																	
SNL112a																	
SNL112b																	
SNL112c																	
SNL113a	0.298	0.296	0.595	0.597	0.596	0.838	0.966	0.945									
SNL113b	0.314	0.300	0.598	0.597	0.599	0.821	0.965	0.929									
SNL113c																	
SNL114a																	
SNL114b									0.826	0.755	0.611	0.619	0.600				
SNL114c									0.788								

		Nickel				Hydride					
Cell #	Main Variable	Composition	Weight	Thick.	Theo. Cap	Composition	Weight	Thick.	Theo. Cap	Separator	Form. Cap. (Ah.)
SNL115a	D Electroformed Ni Foil-Sample#3	77%EEI-171A, 20%Ni210(RSG), 2%CoO	37.8	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.6	0.007	7.52	2-700/9	6.44
SNL115b	D Electroformed Ni Foil-Sample#3	77%EEI-171A, 20%Ni210(RSG), 2%CoO	37.9	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.6	0.007	7.52	2-700/9	6.45
SNL115c	D Electroformed Ni Foil-Sample#3	77%EEI-171A, 20%Ni210(RSG), 2%CoO	38.0	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.8	0.007	7.52	2-700/9	6.46
SNL116a	D Electroformed Ni Foil-Sample#4	77%EEI-171A, 20%Ni210(RSG), 2%CoO	37.8	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.8	0.007	7.52	2-700/9	6.43
SNL116b	D Electroformed Ni Foil-Sample#4	77%EEI-171A, 20%Ni210(RSG), 2%CoO	37.7	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.7	0.007	7.52	2-700/9	6.44
SNL116c	D Electroformed Ni Foil-Sample#4	77%EEI-171A, 20%Ni210(RSG), 2%CoO	37.7	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.7	0.007	7.52	2-700/9	6.45
SNL117a	D Electroformed Ni Foil-Sample#5	77%EEI-171A, 20%Ni210(RSG), 2%CoO	37.8	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.8	0.007	7.52	2-700/9	6.44
SNL117b	D Electroformed Ni Foil-Sample#5	77%EEI-171A, 20%Ni210(RSG), 2%CoO	37.7	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.6	0.007	7.52	2-700/9	6.43
SNL117c	D Electroformed Ni Foil-Sample#5	77%EEI-171A, 20%Ni210(RSG), 2%CoO	37.7	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.6	0.007	7.52	2-700/9	6.44
SNL118a	D Electroformed Ni Foil-Sample#6	77%EEI-171A, 20%Ni210(RSG), 2%CoO	37.8	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.6	0.007	7.52	2-700/9	6.45
SNL118b	D Electroformed Ni Foil-Sample#6	77%EEI-171A, 20%Ni210(RSG), 2%CoO	37.8	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.8	0.007	7.52	2-700/9	6.43
SNL118c	D Electroformed Ni Foil-Sample#6	77%EEI-171A, 20%Ni210(RSG), 2%CoO	37.8	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.7	0.007	7.52	2-700/9	6.45
SNL119a	D Electroformed Ni Foil-Sample#7	77%EEI-171A, 20%Ni210(RSG), 2%CoO	37.9	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.8	0.007	7.52	2-700/9	6.47
SNL119b	D Electroformed Ni Foil-Sample#7	77%EEI-171A, 20%Ni210(RSG), 2%CoO	37.9	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.8	0.007	7.52	2-700/9	6.45
SNL119c	D Electroformed Ni Foil-Sample#7	77%EEI-171A, 20%Ni210(RSG), 2%CoO	37.8	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.8	0.007	7.52	2-700/9	6.44

	Vented	Vented	Vented	Vented	Vented	Vented	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed
Cell #	**1st Dge .8 -100A 50% Charger Room Temp**	**1st Dge .6 -100A Fully Charge Room Temo**	**1st Dge .8 -200A 50% Charge Room Temp**	**2nd Dge .6 -200A 50% Charge Room Temp**	**3rd Dge .6 -200A 50% Charge Room Temp**	**1st Dge .6 -200A Fully Charge Room Temp**	**1st Dge .8 -100A 50% Charge Room Temp**	**1st Dge .8 -200A 50% Charge Room Temp**	**2nd Dge .8 -200A 50% Charge Room Temp**	**3rd Dge .8 -200A 50% Charge Room Temp**	**4th Dge .8 -200A 50% Charge Room Temp**	**5th Dge .8 -200A 50% Charge Room Temp**	**6th Dge .8 -200A 50% Charge Room Temp**	**1st Dge .8 -250 50% Charge Room Temp**	**1st Dge .8 -300 50% Charge Room Temp**	**1st Dge .8 -350 50% Charge Room Temp**	**1st Dge .6 -400 50% Charge Room Temp**
SNL115a	1.131		0.835	0.988	0.994		1.155	0.983									
SNL115b	1.130		0.851	0.996	0.994		1.162	0.993						0.895	0.814	0.599	0.600
SNL115c	1.131		0.840	0.984	0.991		1.155	0.983									
SNL116a	1.136		0.859			0.600	1.161	0.994						0.904	0.824	0.599	0.597
SNL116b	1.132		0.842			0.597	1.165	1.000						0.899	0.823	0.597	0.597
SNL116c	1.130		0.840			0.599	1.160	0.989									
SNL117a	1.124		0.829	0.879	0.985		1.162	0.995						0.903	0.831	0.598	0.599
SNL117b	1.129		0.828	0.871	0.985		1.155	0.987									
SNL117c	1.128		0.828	0.884	0.987		1.162	0.993						0.809	0.828	0.596	0.596
SNL118a	1.128	0.599	0.832				1.161	0.993						0.907	0.837	0.600	0.599
SNL118b	1.127	0.600	0.856				1.153	0.977									
SNL118c	1.126	0.596	0.853				1.156	0.984									
SNL119a	1.127		0.850	0.892	0.986		1.164	0.996						0.889	0.803	0.599	0.600
SNL119b	1.123		0.836	0.869	0.981		1.156	0.985									
SNL119c	1.127		0.836	0.886	0.989		1.159	0.994						0.888	0.810	0.597	0.599

	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed
Cell #	**1st Dge .3 -500 50% Charge Room Temp**	**.3 -450 50% Charge Room Temp**	**.6 -400 50% Charge Room Temp**	**.8 -350 50% Charge Room Temp**	**.8 -300 50% Charge Room Temp**	**.8 -250 50% Charge Room Temp**	**.8 -200A 50% Charge Room Temp**	**After 2 Wk Stand .8 -200A 50% Charge Room Temp**	**.8 -200A After 2000 Life Cycles**	**.8 -200A After 4000 Life Cycles**	**.8 -200A After 6000 Life Cycles**	**.8 -200A After 8000 Life Cycles**	**.8 -200A After 10000 Life Cycles**	**.3 -200A 0°C**	**.3 -200A -30°C**	**.3 -200A -40°C**	**-200 Before Rewet**
SNL115a									0.896	0.819	0.678	0.677	0.598				
SNL115b	0.293	0.289	0.598	0.597	0.596	0.876	0.598	0.937									
SNL115c																	
SNL116a	0.299	0.321	0.597	0.599	0.596	0.874	0.598	0.934									
SNL116b	0.309	0.296	0.596	0.597	0.598	0.883	0.965	0.961									
SNL116c																	
SNL117a	0.279	0.284	0.598	0.597	0.599	0.832	0.959	0.935									
SNL117b																	
SNL117c	0.288	0.298	0.595	0.594	0.599	0.809	0.962	0.929									
SNL118a	0.290	0.293	0.598	0.597	0.598	0.839	0.959	0.944									
SNL118b									0.902	0.760	0.647	0.709	0.628				
SNL118c																	
SNL119a	0.296	0.293	0.956	0.598	0.598	0.870	0.957	0.932									
SNL119b																	
SNL119c	0.286	0.290	0.599	0.600	0.600	0.861	0.948	0.914									

		Nickel				Hydride					
Cell #	Main Variable	Composition	Weight	Thick.	Theo. Cap	Composition	Weight	Thick.	Theo. Cap	Separator	Form. Cap. (Ah.)
SNL120a	D Electroformed Ni Foil-Sample#8	77%EEI-171A, 20%Ni210(RSG), 2%CoO	37.7	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.8	0.007	7.52	2-700/9	6.45
SNL120b	D Electroformed Ni Foil-Sample#8	77%EEI-171A, 20%Ni210(RSG), 2%CoO	37.6	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.8	0.007	7.52	2-700/9	6.42
SNL120c	D Electroformed Ni Foil-Sample#8	77%EEI-171A, 20%Ni210(RSG), 2%CoO	37.7	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.8	0.007	7.52	2-700/9	6.43
SNL121a	80SC-1132 H (Ni-1132)	77%EEI-171A, 20%Ni210(RSG), 2%CoO	37.8	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.6	0.007	7.52	2.700/9	
SNL121b	80SC-1132 H (Ni-1132)	77%EEI-171A, 20%Ni210(RSG), 2%CoO	37.7	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.7	0.007	7.52	2-700/9	
SNL121c	80SC-1132 H (Ni-1132)	77%EEI-171A, 20%Ni210(RSG), 2%CoO	37.7	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.7	0.007	7.52	2-700/9	
SNL122a	80SC-1132 H (Ni-1134)	77%EEI-171A, 20%Ni210(RSG), 2%CoO	37.8	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.8	0.007	7.52	2-700/9	
SNL122b	80SC-1132 H (Ni-1134)	77%EEI-171A, 20%Ni210(RSG), 2%CoO	37.7	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.8	0.007	7.52	2-700/9	
SNL122c	80SC-1132 H (Ni-1134)	77%EEI-171A, 20%Ni210(RSG), 2%CoO	37.8	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.8	0.007	7.52	2-700/9	
SNL123a	80SC-1132 H (Ni-1129)	77%EEI-171A, 20%Ni210(RSG), 2%CoO	37.8	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.7	0.007	7.52	2-700/9	
SNL123b	80SC-1132 H (Ni-1129)	77%EEI-171A, 20%Ni210(RSG), 2%CoO	37.8	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.8	0.007	7.52	2-700/9	
SNL123c	80SC-1132 H (Ni-1129)	77%EEI-171A, 20%Ni210(RSG), 2%CoO	37.8	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.8	0.007	7.52	2-700/9	
SNL124a	H 800 LEG-757	77%EEI-171A, 20%Ni210(RSG), 2%CoO	38.0	0.012	6.48	80%LEG-757, 19%Ni210(RSG)	37.8	0.007	7.52	2-700/9	
SNL124b	H 800 LEG-757	77%EEI-171A, 20%Ni210(RSG), 2%CoO	37.8	0.012	6.48	80%LEG-757, 19%Ni210(RSG)	37.8	0.007	7.52	2-700/9	
SNL124c	H 800 LEG-757	77%EEI-171A, 20%Ni210(RSG), 2%CoO	37.7	0.012	6.48	80%LEG-757, 19%Ni210(RSG)	37.8	0.007	7.52	2-700/9	

	Vented	Vented	Vented	Vented	Vented	Vented	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed
Cell #	**1st Dge .8 -100A 50% Charger Room Temp**	**1st Dge .6 -100A Fully Charge Room Temo**	**1st Dge .8 -200A 50% Charge Room Temp**	**2nd Dge .6 -200A 50% Charge Room Temp**	**3rd Dge .6 -200A 50% Charge Room Temp**	**1st Dge .6 -200A Fully Charge Room Temp**	**1st Dge .8 -100A 50% Charge Room Temp**	**1st Dge .8 -200A 50% Charge Room Temp**	**2nd Dge .8 -200A 50% Charge Room Temp**	**3rd Dge .8 -200A 50% Charge Room Temp**	**4th Dge .8 -200A 50% Charge Room Temp**	**5th Dge .8 -200A 50% Charge Room Temp**	**6th Dge .8 -200A 50% Charge Room Temp**	**1st Dge .8 -250 50% Charge Room Temp**	**1st Dge .8 -300 50% Charge Room Temp**	**1st Dge .8 -350 50% Charge Room Temp**	**1st Dge .6 -400 50% Charge Room Temp**
SNL120a	1.121		0.821			0.597	1.151	0.972									
SNL120b	1.122		0.823			0.597	1.154	0.975									
SNL120c	1.124		0.823			0.599	1.150	0.972									
SNL121a	1.098		0.598						0.886	0.831				0.596	0.591	0.596	0.597
SNL121b	1.096		0.599											0.597	0.596	0.595	0.599
SNL121c	1.106		0.598											0.593	0.596	0.600	0.590
SNL122a	1.117		0.733						0.955	0.939				0.593	0.596	0.597	0.595
SNL122b	1.106		0.764											0.596	0.595	0.600	0.599
SNL122c	1.109		0.755											0.596	0.596	0.597	0.597
SNL123a	1.121		0.726						0.956	0.936				0.590	0.598	0.593	0.595
SNL123b	1.124		0.728											0.596	0.600	0.595	0.596
SNL123c	1.127		0.736											0.594	0.598	0.592	0.593
SNL124a	1.117		0.593						0.948	0.944				0.598	0.586	0.588	0.596
SNL124b	1.115		0.598											0.595	0.594	0.593	0.597
SNL124c	1.073		0.600											0.592	0.599	0.595	0.596

Cell #	Sealed 1st Dge .3 -500 50% Charge Room Temp	Sealed .3 -450 50% Charge Room Temp	Sealed .6 -400 50% Charge Room Temp	Sealed .8 -350 50% Charge Room Temp	Sealed .8 -300 50% Charge Room Temp	Sealed .8 -250 50% Charge Room Temp	Sealed .8 -200A 50% Charge Room Temp	Sealed After 2 Wk Stand .8 -200A 50% Charge Room Temp	Sealed .8 -200A After 2000 Life Cycles	Sealed .8 -200A After 4000 Life Cycles	Sealed .8 -200A After 6000 Life Cycles	Sealed .8 -200A After 8000 Life Cycles	Sealed .8 -200A After 10000 Life Cycles	Sealed .3 -200A 0^oC	Sealed .3 -200A -30^oC	Sealed .3 -200A -40^oC	Sealed -200 Before Rewet
SNL120a									0.932								
SNL120b									0.937	0.784	0.699	0.689	0.614				
SNL120c																	
SNL121a	0.260	0.281															0.906
SNL121b	0.294	0.284	0.597	0.596	0.596	0.600	0.844										
SNL121c	0.296	0.285	0.600	0.595	0.592	0.598	0.844										
SNL122a	0.283	0.278															0.942
SNL122b	0.288	0.287	0.596	0.598	0.598	0.596	0.912										
SNL122c	0.278	0.275	0.598	0.598	0.597	0.599	0.912										
SNL123a	0.293	0.284	0.593														0.950
SNL123b	0.282	0.268	0.593	0.596	0.598	0.566	0.940										
SNL123c	0.299	0.297	0.599	0.598	0.599	0.598	0.951										
SNL124a	0.283	0.290															0.942
SNL124b	0.287	0.289	0.595	0.595	0.593	0.596	0.917										
SNL124c	0.284	0.292	0.595	0.598	0.599	0.599	0.829										

		Nickel				Hydride					
Cell #	Main Variable	Composition	Weight	Thick.	Theo. Cap	Composition	Weight	Thick.	Theo. Cap	Separator	Form. Cap. (Ah.)
SNL125a	80 LEG-757 H (AKL-2001)	77%EEI-171A, 20%Ni210(RSG), 2%CoO	37.7	0.012	6.48	80%LEG-757, 19%Ni210(RSG)	37.8	0.007	7.52	2-700/9	
SNL125b	80 LEG-757 H (AKL-2001)	77%EEI-171A, 20%Ni210(RSG), 2%CoO	37.7	0.012	6.48	80%LEG-757, 19%Ni210(RSG)	37.7	0.007	7.52	2-700/9	
SNL125c	80 LEG-757 H (AKL-2001)	77%EEI-171A, 20%Ni210(RSG), 2%CoO	37.8	0.012	6.48	80%LEG-757, 19%Ni210(RSG)	37.8	0.007	7.52	2-700/9	
SNL126a	H ZZ2B3	77%EEI-171A, 20%Ni210(RSG), 2%CoO	37.8	0.012	6.48	80%ZZ2B3, 19%Ni210(RSG)	37.9	0.007	7.52	2-700/9	
SNL126b	H ZZ2B3	77%EEI-171A, 20%Ni210(RSG), 2%CoO	37.8	0.012	6.48	80%ZZ2B3, 19%Ni210(RSG)	37.8	0.007	7.52	2-700/9	
SNL126c	H ZZ2B3	77%EEI-171A, 20%Ni210(RSG), 2%CoO	37.8	0.012	6.48	80%ZZ2B3, 19%Ni210(RSG)	37.9	0.007	7.52	2-700/9	
SNL127a	H ZZ2B4	77%EEI-171A, 20%Ni210(RSG), 2%CoO	37.7	0.012	6.48	80%ZZ2B4, 19%Ni210(RSG)	37.8	0.007	7.52	2-700/9	
SNL127b	H ZZ2B4	77%EEI-171A, 20%Ni210(RSG), 2%CoO	37.8	0.012	6.48	80%ZZ2B4, 19%Ni210(RSG)	37.8	0.007	7.52	2-700/9	
SNL127c	H ZZ2B4	77%EEI-171A, 20%Ni210(RSG), 2%CoO	37.8	0.012	6.48	80%ZZ2B4, 19%Ni210(RSG)	37.9	0.007	7.52	2-700/9	
SNL128a	H ZZ2B7	77%EEI-171A, 20%Ni210(RSG), 2%CoO	37.8	0.012	6.48	80%ZZ2B7, 19%Ni210(RSG)	37.9	0.007	7.52	2-700/9	
SNL128b	H ZZ2B7	77%EEI-171A, 20%Ni210(RSG), 2%CoO	37.8	0.012	6.48	80%ZZ2B7, 19%Ni210(RSG)	37.9	0.007	7.52	2-700/9	
SNL128c	H ZZ2B7	77%EEI-171A, 20%Ni210(RSG), 2%CoO	37.9	0.012	6.48	80%ZZ2B7, 19%Ni210(RSG)	37.9	0.007	7.52	2-700/9	
SNL129a	H 90SC-1132	77%EEI-171A, 20%Ni210(RSG), 2%CoO	37.8	0.012	6.48	90%SC1132, 9%Ni210(RSG)	33.7	0.007	7.52	2-700/9	
SNL129b	H 90SC-1132	77%EEI-171A, 20%Ni210(RSG), 2%CoO	38.0	0.012	6.48	90%SC1132, 9%Ni210(RSG)	33.8	0.007	7.52	2-700/9	
SNL129c	H 90SC-1132	77%EEI-171A, 20%Ni210(RSG), 2%CoO	37.8	0.012	6.48	90%SC1132, 9%Ni210(RSG)	33.9	0.007	7.52	2-700/9	

Cell #	Vented 1st Dge .8 -100A 50% Charger Room Temp	Vented 1st Dge .6 -100A Fully Charge Room Temo	Vented 1st Dge .8 -200A 50% Charge Room Temp	Vented 2nd Dge .6 -200A 50% Charge Room Temp	Vented 3rd Dge .6 -200A 50% Charge Room Temp	Vented 1st Dge .6 -200A Fully Charge Room Temp	Sealed 1st Dge .8 -100A 50% Charge Room Temp	Sealed 1st Dge .8 -200A 50% Charge Room Temp	Sealed 2nd Dge .8 -200A 50% Charge Room Temp	Sealed 3rd Dge .8 -200A 50% Charge Room Temp	Sealed 4th Dge .8 -200A 50% Charge Room Temp	Sealed 5th Dge .8 -200A 50% Charge Room Temp	Sealed 6th Dge .8 -200A 50% Charge Room Temp	Sealed 1st Dge .8 -250 50% Charge Room Temp	Sealed 1st Dge .8 -300 50% Charge Room Temp	Sealed 1st Dge .8 -350 50% Charge Room Temp	Sealed 1st Dge .6 -400 50% Charge Room Temp
SNL125a	1.116		0.612						0.836	0.808				0.599	0.593	0.595	0.595
SNL125b	1.110		0.630											0.594	0.596	0.595	0.591
SNL125c	1.113		0.614											0.600	0.598	0.593	0.600
SNL126a	0.799		0.589						0.934	0.922				0.594	0.590	0.596	0.598
SNL126b	0.798		0.599											0.596	0.597	0.590	0.596
SNL126c	0.800		0.594											0.592	0.589	0.593	0.584
SNL127a	1.094		0.591						0.947	0.935				0.599	0.594	0.586	0.600
SNL127b	1.099		0.598											0.597	0.597	0.600	0.598
SNL127c	1.101		0.595											0.597	0.590	0.598	0.596
SNL128a	1.072		0.593						0.950	0.940				0.595	0.585	0.592	0.596
SNL128b	1.059		0.593											0.550	0.592	0.600	0.598
SNL128c	1.064		0.596											0.592	0.598	0.593	0.599
SNL129a	1.124		0.834						0.954	0.951				0.595	0.595	0.593	0.598
SNL129b	1.123		0.811											0.594	0.596	0.600	0.594
SNL129c	1.119		0.783											0.597	0.584	0.597	0.595

	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed
Cell #	**1st Dge .3 -500 50% Charge Room Temp**	**.3 -450 50% Charge Room Temp**	**.6 -400 50% Charge Room Temp**	**.8 -350 50% Charge Room Temp**	**.8 -300 50% Charge Room Temp**	**.8 -250 50% Charge Room Temp**	**.8 -200A 50% Charge Room Temp**	**After 2 Wk Stand .8 -200A 50% Charge Room Temp**	**.8 -200A After 2000 Life Cycles**	**.8 -200A After 4000 Life Cycles**	**.8 -200A After 6000 Life Cycles**	**.8 -200A After 8000 Life Cycles**	**.8 -200A After 10000 Life Cycles**	**.3 -200A 0°C**	**.3 -200A -30°C**	**.3 -200A -40°C**	**-200 Before Rewet**
SNL125a	0.290	0.287															0.934
SNL125b	0.281	0.281	0.595	0.595	0.596	0.598	0.924										
SNL125c	0.281	0.287	0.593	0.597	0.595	0.598	0.919										
SNL126a	0.249	0.241															0.584
SNL126b	0.282	0.246	0.592	0.599	0.593	0.577	0.585										
SNL126c	0.290	0.292	0.599	0.591	0.597	0.590	0.592										
SNL127a	0.287	0.289															0.873
SNL127b	0.271	0.273	0.595	0.596	0.599	0.600	0.597										
SNL127c	0.273	0.261	0.594	0.600	0.599	0.596	0.597										
SNL128a	0.298	0.290															0.591
SNL128b	0.299	0.285	0.596	0.595	0.599	0.594	0.600										
SNL128c	0.274	0.296	0.591	0.595	0.591	0.600	0.593										
SNL129a	0.274	0.282															0.939
SNL129b	0.286	0.290	0.594	0.596	0.599	0.593	0.880										
SNL129c	0.289	0.292	0.598	0.595	0.596	0.598	0.865										

		Nickel				Hydride					
Cell #	Main Variable	Composition	Weight	Thick.	Theo. Cap	Composition	Weight	Thick.	Theo. Cap	Separator	Form. Cap. (Ah.)
SNL130a	H 99SC-1132	77%EEI-171A, 20%Ni210(RSG), 2%CoO	37.8	0.012	6.48	99%SC-1132	30.8	0.007	7.52	2-700/9	
SNL130b	H 99SC-1132	77%EEI-171A, 20%Ni210(RSG), 2%CoO	37.7	0.012	6.48	99%SC-1132	30.8	0.007	7.52	2-700/9	
SNL130c	H 99SC-1132	77%EEI-171A, 20%Ni210(RSG), 2%CoO	37.7	0.012	6.48	99%SC-1132	30.8	0.007	7.52	2-700/9	
SNL131a	N-EEI-171A S-SANYO	77%EEI-171A, 20%Ni210(RSG), 2%CoO	37.8	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.6	0.008	7.52	SANYO-2 (0.009)	6.50
SNL131b	N-EEI-171A S-SANYO	77%EEI-171A, 20%Ni210(RSG), 2%CoO	37.8	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.6	0.008	7.52	SANYO-2 (0.009)	6.50
SNL131c	N-EEI-171A S-SANYO	77%EEI-171A, 20%Ni210(RSG), 2%CoO	38.0	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.6	0.007	7.52	SANYO-2 (0.009)	6.50
SNL132a	N-P-249B S-SANYO	77%P-249b, 20%Ni210(RSG), 2%CoO	37.8	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.8	0.008	7.52	SANYO-2 (0.009)	6.50
SNL132b	N-P-249B S-SANYO	77%P-249b, 20%Ni210(RSG), 2%CoO	37.7	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.7	0.008	7.52	SANYO-2 (0.009)	6.50
SNL132c	N-P-249B S-SANYO	77%P-249b, 20%Ni210(RSG), 2%CoO	37.8	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.6	0.007	7.52	SANYO-2 (0.009)	6.50
SNL133a	H-GAT 757 S-SANYO	77%EEI-171A, 20%Ni210(RSG), 2%CoO	38.0	0.012	6.48	80%GAT 757, 19%Ni210(RSG)	37.8	0.007	7.52	SANYO-2 (0.009)	6.50
SNL133b	H-GAT 757 S-SANYO	77%EEI-171A, 20%Ni210(RSG), 2%CoO	38.0	0.012	6.48	80%GAT 757, 19%Ni210(RSG)	37.8	0.007	7.52	SANYO-2 (0.009)	6.50
SNL133c	H-GAT 757 S-SANYO	77%EEI-171A, 20%Ni210(RSG), 2%CoO	37.9	0.012	6.48	80%GAT 757, 19%Ni210(RSG)	37.8	0.007	7.52	SANYO-2 (0.009)	6.50
SNL134a	N-T-120	77%T-120, 20%Ni210(RSG), 2%CoO				80%SC1132, 19%Ni210(RSG)				2-700/9	
SNL134b	N-T-120	77%T-120, 20%Ni210(RSG), 2%CoO				80%SC1132, 19%Ni210(RSG)				2-700/9	
SNL134c	N-T-120	77%T-120, 20%Ni210(RSG), 2%CoO				80%SC1132, 19%Ni210(RSG)				2-700/9	

	Vented	Vented	Vented	Vented	Vented	Vented	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed
Cell #	**1st Dge .8 -100A 50% Charger Room Temp**	**1st Dge .6 -100A Fully Charge Room Temo**	**1st Dge .8 -200A 50% Charge Room Temp**	**2nd Dge .6 -200A 50% Charge Room Temp**	**3rd Dge .6 -200A 50% Charge Room Temp**	**1st Dge .6 -200A Fully Charge Room Temp**	**1st Dge .8 -100A 50% Charge Room Temp**	**1st Dge .8 -200A 50% Charge Room Temp**	**2nd Dge .8 -200A 50% Charge Room Temp**	**3rd Dge .8 -200A 50% Charge Room Temp**	**4th Dge .8 -200A 50% Charge Room Temp**	**5th Dge .8 -200A 50% Charge Room Temp**	**6th Dge .8 -200A 50% Charge Room Temp**	**1st Dge .8 -250 50% Charge Room Temp**	**1st Dge .8 -300 50% Charge Room Temp**	**1st Dge .8 -350 50% Charge Room Temp**	**1st Dge .6 -400 50% Charge Room Temp**
SNL130a	1.102		0.667						0.955	0.948				0.595	0.599	0.593	0.595
SNL130b	1.108		0.593											0.590	0.596	0.587	0.595
SNL130c	1.112		0.598											0.591	0.586	0.590	0.589
SNL131a	1.112	1.126	0.862					0.925						0.771	0.600	0.600	0.588
SNL131b	1.102	1.120	0.810					0.916						0.751	0.600	0.598	0.582
SNL131c	1.116	1.126	0.846					0.932						0.735	0.599	0.598	0.595
SNL132a	1.090	1.106	0.817					0.885						0.701	0.599	0.596	0.542
SNL132b	1.086	1.087	0.808					0.849						0.673	0.598	0.582	0.537
SNL132c	1.094	1.083	0.841					0.848						0.599	0.526	0.425	0.241
SNL133a	1.098	1.134	0.738					0.939						0.714	0.599	0.598	0.593
SNL133b	1.103	1.135	0.732					0.942						0.752	0.597	0.598	0.594
SNL133c	1.090	1.136	0.733					0.945						0.764	0.598	0.598	0.599
SNL134a								0.780									
SNL134b								0.749									
SNL134c								0.795									

Cell #	Sealed 1st Dge .3 -500 50% Charge Room Temp	Sealed .3 -450 50% Charge Room Temp	Sealed .6 -400 50% Charge Room Temp	Sealed .8 -350 50% Charge Room Temp	Sealed .8 -300 50% Charge Room Temp	Sealed .8 -250 50% Charge Room Temp	Sealed .8 -200A 50% Charge Room Temp	Sealed After 2 Wk Stand .8 -200A 50% Charge Room Temp	Sealed .8 -200A After 2000 Life Cycles	Sealed .8 -200A After 4000 Life Cycles	Sealed .8 -200A After 6000 Life Cycles	Sealed .8 -200A After 8000 Life Cycles	Sealed .8 -200A After 10000 Life Cycles	Sealed .3 -200A 0^oC	Sealed .3 -200A -30^oC	Sealed .3 -200A -40^oC	Sealed -200 Before Rewet
SNL130a	0.284	0.292															0.901
SNL130b	0.299	0.276	0.599	0.592	0.597	0.598	0.826										
SNL130c	0.277	0.293	0.588	0.598	0.596	0.590	0.795										
SNL131a	0.298	0.298	0.597	0.598	0.600	0.755	0.863		0.829	0.810	0.789	0.773	0.621				
SNL131b	0.294	0.300	0.568	0.599	0.600	0.735	0.850		0.811	0.799	0.778	0.761	0.600				
SNL131c	0.296	0.296	0.586	0.599	0.599	0.739	0.854		0.817	0.783	0.749	0.716	0.599				
SNL132a	0.298	0.297	0.596	0.600	0.600	0.680	0.807		0.760	0.718	0.663	0.600	0.599				
SNL132b	0.296	0.294	0.485	0.545	0.599	0.647	0.767		0.702	0.649	0.599	0.598	0.597				
SNL132c	-0.062	0.062	0.210	0.333	0.450	0.565	0.627		0.595	0.502	0.320	0.306	0.118				
SNL133a	0.298	0.295	0.598	0.599	0.600	0.762	0.869		0.847	0.829	0.818	0.808	0.688				
SNL133b	0.294	0.296	0.593	0.597	0.598	0.761	0.872		0.850	0.831	0.807	0.813	0.682				
SNL133c	0.950	0.298	0.600	0.600	0.600	0.768	0.874		0.852	0.831	0.821	0.818	0.692				
SNL134a																	
SNL134b																	
SNL134c																	

		Nickel				Hydride					
Cell #	**Main Variable**	**Composition**	**Weight**	**Thick.**	**Theo. Cap**	**Composition**	**Weight**	**Thick.**	**Theo. Cap**	**Separator**	**Form. Cap. (Ah.)**
SNL135a	N-T-121	77%T-121, 20%Ni210(RSG), 2%CoO				80%SC1132, 19%Ni210(RSG)				2-700/9	
SNL135b	N-T-121	77%T-121, 20%Ni210(RSG), 2%CoO				80%SC1132, 19%Ni210(RSG)				2-700/9	
SNL135c	N-T-121	77%T-121, 20%Ni210(RSG), 2%CoO				80%SC1132, 19%Ni210(RSG)				2-700/9	
SNL136a	N-T-122	77%T-122, 20%Ni210(RSG), 2%CoO				80%SC1132, 19%Ni210(RSG)				2-700/9	
SNL136b	N-T-122	77%T-122, 20%Ni210(RSG), 2%CoO				80%SC1132, 19%Ni210(RSG)				2-700/9	
SNL136c	N-T-122	77%T-122, 20%Ni210(RSG), 2%CoO				80%SC1132, 19%Ni210(RSG)				2-700/9	
SNL137a	N-T-123	77%T-123, 20%Ni210(RSG), 2%CoO				80%SC1132, 19%Ni210(RSG)				2-700/9	
SNL137b	N-T-123	77%T-123, 20%Ni210(RSG), 2%CoO				80%SC1132, 19%Ni210(RSG)				2-700/9	
SNL137c	N-T-123	77%T-123, 20%Ni210(RSG), 2%CoO				80%SC1132, 19%Ni210(RSG)				2-700/9	
SNL138a	N-T-124	77%T-124, 20%Ni210(RSG), 2%CoO				80%SC1132, 19%Ni210(RSG)				2-700/9	
SNL138b	N-T-124	77%T-124, 20%Ni210(RSG), 2%CoO				80%SC1132, 19%Ni210(RSG)				2-700/9	
SNL138c	N-T-124	77%T-124, 20%Ni210(RSG), 2%CoO				80%SC1132, 19%Ni210(RSG)				2-700/9	
SNL139a	N-T-125	77%T-125, 20%Ni210(RSG), 2%CoO				80%SC1132, 19%Ni210(RSG)				2-700/9	
SNL139b	N-T-125	77%T-125, 20%Ni210(RSG), 2%CoO				80%SC1132, 19%Ni210(RSG)				2-700/9	
SNL139c	N-T-125	77%T-125, 20%Ni210(RSG), 2%CoO				80%SC1132, 19%Ni210(RSG)				2-700/9	

	Vented	Vented	Vented	Vented	Vented	Vented	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed
Cell #	1st Dge .8 -100A 50% Charger Room Temp	1st Dge .6 -100A Fully Charge Room Temo	1st Dge .8 -200A 50% Charge Room Temp	2nd Dge .6 -200A 50% Charge Room Temp	3rd Dge .6 -200A 50% Charge Room Temp	1st Dge .6 -200A Fully Charge Room Temp	1st Dge .8 -100A 50% Charge Room Temp	1st Dge .8 -200A 50% Charge Room Temp	2nd Dge .8 -200A 50% Charge Room Temp	3rd Dge .8 -200A 50% Charge Room Temp	4th Dge .8 -200A 50% Charge Room Temp	5th Dge .8 -200A 50% Charge Room Temp	6th Dge .8 -200A 50% Charge Room Temp	1st Dge .8 -250 50% Charge Room Temp	1st Dge .8 -300 50% Charge Room Temp	1st Dge .8 -350 50% Charge Room Temp	1st Dge .6 -400 50% Charge Room Temp
SNL135a								0.590									
SNL135b								0.587									
SNL135c								0.596									
SNL136a								0.739									
SNL136b								0.742									
SNL136c								0.801									
SNL137a								0.760									
SNL137b								0.799									
SNL137c								0.881									
SNL138a								0.847									
SNL138b								0.845									
SNL138c								0.868									
SNL139a								0.805									
SNL139b								0.762									
SNL139c								0.827									

		Nickel				Hydride					
Cell #	Main Variable	Composition	Weight	Thick.	Theo. Cap	Composition	Weight	Thick.	Theo. Cap	Separator	Form. Cap. (Ah.)
SNL140a	N-T-126	77%T-126, 20%Ni210(RSG), 2%CoO				80%SC1132, 19%Ni210(RSG)				2-700/9	
SNL140b	N-T-126	77%T-126, 20%Ni210(RSG), 2%CoO				80%SC1132, 19%Ni210(RSG)				2-700/9	
SNL140c	N-T-126	77%T-126, 20%Ni210(RSG), 2%CoO				80%SC1132, 19%Ni210(RSG)				2-700/9	
SNL141a	N-T-127	77%T-127, 20%Ni210(RSG), 2%CoO				80%SC1132, 19%Ni210(RSG)				2-700/9	
SNL141b	N-T-127	77%T-127, 20%Ni210(RSG), 2%CoO				80%SC1132, 19%Ni210(RSG)				2-700/9	
SNL141c	N-T-127	77%T-127, 20%Ni210(RSG), 2%CoO				80%SC1132, 19%Ni210(RSG)				2-700/9	
SNL142a	N-T-128	77%T-128, 20%Ni210(RSG), 2%CoO				80%SC1132, 19%Ni210(RSG)				2-700/9	
SNL142b	N-T-128	77%T-128, 20%Ni210(RSG), 2%CoO				80%SC1132, 19%Ni210(RSG)				2-700/9	
SNL142c	N-T-128	77%T-128, 20%Ni210(RSG), 2%CoO				80%SC1132, 19%Ni210(RSG)				2-700/9	
SNL143a	N-T-129	77%T-129, 20%Ni210(RSG), 2%CoO				80%SC1132, 19%Ni210(RSG)				2-700/9	
SNL143b	N-T-129	77%T-129, 20%Ni210(RSG), 2%CoO				80%SC1132, 19%Ni210(RSG)				2-700/9	
SNL143c	N-T-129	77%T-129, 20%Ni210(RSG), 2%CoO				80%SC1132, 19%Ni210(RSG)				2-700/9	
SNL144a	N-EEI-178A	77%EEI-178A, 20%Ni210(RSG), 2%CoO				80%SC1132, 19%Ni210(RSG)				2-700/9	
SNL144b	N-EEI-178A	77%EEI-178A, 20%Ni210(RSG), 2%CoO				80%SC1132, 19%Ni210(RSG)				2-700/9	
SNL144c	N-EEI-178A	77%EEI-178A, 20%Ni210(RSG), 2%CoO				80%SC1132, 19%Ni210(RSG)				2-700/9	

	Vented	Vented	Vented	Vented	Vented	Vented	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed
Cell #	**1st Dge .8 -100A 50% Charger Room Temp**	**1st Dge .6 -100A Fully Charge Room Temo**	**1st Dge .8 -200A 50% Charge Room Temp**	**2nd Dge .6 -200A 50% Charge Room Temp**	**3rd Dge .6 -200A 50% Charge Room Temp**	**1st Dge .6 -200A Fully Charge Room Temp**	**1st Dge .8 -100A 50% Charge Room Temp**	**1st Dge .8 -200A 50% Charge Room Temp**	**2nd Dge .8 -200A 50% Charge Room Temp**	**3rd Dge .8 -200A 50% Charge Room Temp**	**4th Dge .8 -200A 50% Charge Room Temp**	**5th Dge .8 -200A 50% Charge Room Temp**	**6th Dge .8 -200A 50% Charge Room Temp**	**1st Dge .8 -250 50% Charge Room Temp**	**1st Dge .8 -300 50% Charge Room Temp**	**1st Dge .8 -350 50% Charge Room Temp**	**1st Dge .6 -400 50% Charge Room Temp**
SNL140a								0.793									
SNL140b								0.802									
SNL140c								0.811									
SNL141a								0.815									
SNL141b								0.846									
SNL141c								0.862									
SNL142a								0.837									
SNL142b								0.869									
SNL142c								0.828									
SNL143a								0.689									
SNL143b								0.756									
SNL143c								0.812									
SNL144a								0.870									
SNL144b								0.838									
SNL144c								0.868									

		Nickel				Hydride					
Cell #	Main Variable	Composition	Weight	Thick.	Theo. Cap	Composition	Weight	Thick.	Theo. Cap	Separator	Form. Cap. (Ah.)
SNL145a	N-EEI-182A	77%EEI182A, 20%Ni210(RSG), 2%CoO				80%SC1132, 19%Ni210(RSG)				2-700/9	
SNL145b	N-EEI-182A	77%EEI182A, 20%Ni210(RSG), 2%CoO				80%SC1132, 19%Ni210(RSG)				2-700/9	
SNL145c	N-EEI-182A	77%EEI182A, 20%Ni210(RSG), 2%CoO				80%SC1132, 19%Ni210(RSG)				2-700/9	
SNL146a	N-EEI-183B	77%EEI-183B, 20%Ni210(RSG), 2%CoO				80%SC1132, 19%Ni210(RSG)				2-700/9	
SNL146b	N-EEI-183B	77%EEI-183B, 20%Ni210(RSG), 2%CoO				80%SC1132, 19%Ni210(RSG)				2-700/9	
SNL146c	N-EEI-183B	77%EEI-183B, 20%Ni210(RSG), 2%CoO				80%SC1132, 19%Ni210(RSG)				2-700/9	
SNL147a	N SANYO Pasted Foam	SANYO Pasted Foam	81.4	0.023	15.47	80%SC1132, 19%Ni210(RSG)	100.5	0.020	20.11	2-700/9	
SNL147b	N SANYO Pasted Foam	SANYO Pasted Foam	80.8	0.022	15.47	80%SC1132, 19%Ni210(RSG)	100.6	0.021	20.11	2-700/9	
SNL147c	N SANYO Pasted Foam	SANYO Pasted Foam	81.2	0.022	15.47	80%SC1132, 19%Ni210(RSG)	100.5	0.020	20.11	2-700/9	
SNL148a	N SANYO Pasted Foam	SANYO Pasted Foam	80.4	0.023	15.47	80%SC1132, 19%Ni210(RSG)	100.4	0.021	20.11	2-SANYO	
SNL148b	N SANYO Pasted Foam	SANYO Pasted Foam	80.1	0.023	15.47	80%SC1132, 19%Ni210(RSG)	100.5	0.021	20.11	2-SANYO	
SNL148c	N SANYO Pasted Foam	SANYO Pasted Foam	81.1	0.023	15.47	80%SC1132, 19%Ni210(RSG)	100.5	0.021	20.11	2-SANYO	
SNL149a	N SANYO Pasted Foam	SANYO Pasted Foam	118.9	0.033	24.40	80%SC1132, 19%Ni210(RSG)	158.5	0.033	31.72	2-700/9	
SNL149b	N SANYO Pasted Foam	SANYO Pasted Foam	118.7	0.033	24.40	80%SC1132, 19%Ni210(RSG)	158.5	0.033	31.72	2-700/9	
SNL149c	N SANYO Pasted Foam	SANYO Pasted Foam	118.6	0.033	24.40	80%SC1132, 19%Ni210(RSG)	158.5	0.033	31.72	2-700/9	

	Vented	Vented	Vented	Vented	Vented	Vented	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed
Cell #	**1st Dge .8 -100A 50% Charger Room Temp**	**1st Dge .6 -100A Fully Charge Room Temo**	**1st Dge .8 -200A 50% Charge Room Temp**	**2nd Dge .6 -200A 50% Charge Room Temp**	**3rd Dge .6 -200A 50% Charge Room Temp**	**1st Dge .6 -200A Fully Charge Room Temp**	**1st Dge .8 -100A 50% Charge Room Temp**	**1st Dge .8 -200A 50% Charge Room Temp**	**2nd Dge .8 -200A 50% Charge Room Temp**	**3rd Dge .8 -200A 50% Charge Room Temp**	**4th Dge .8 -200A 50% Charge Room Temp**	**5th Dge .8 -200A 50% Charge Room Temp**	**6th Dge .8 -200A 50% Charge Room Temp**	**1st Dge .8 -250 50% Charge Room Temp**	**1st Dge .8 -300 50% Charge Room Temp**	**1st Dge .8 -350 50% Charge Room Temp**	**1st Dge .6 -400 50% Charge Room Temp**
SNL145a								0.869									
SNL145b								0.866									
SNL145c								0.868									
SNL146a								0.844									
SNL146b								0.839									
SNL146c								0.819									
SNL147a	1.069		0.787				0.959	0.599	0.600								
SNL147b	1.048		0.730				0.986	0.616	0.600								
SNL147c	1.066		0.800				1.002	0.652	0.612								
SNL148a	1.058		0.762				0.921	0.586	0.590								
SNL148b	1.064		0.786				0.899	0.591	0.575								
SNL148c	1.063		0.793				0.895	0.600	0.581								
SNL149a	1.090		0.822				0.944	0.600	0.602								
SNL149b	1.068		0.769				0.964	0.600	0.600								
SNL149c	1.097		0.833				0.969	0.608	0.600								

		Nickel				Hydride					
Cell #	Main Variable	Composition	Weight	Thick.	Theo. Cap	Composition	Weight	Thick.	Theo. Cap	Separator	Form. Cap. (Ah.)
SNL150a	**N EEI-166B Metal Bag	77%EEI-166B, 20%Ni210(RSG), 2%CoO	37.9	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.8	0.008	7.52	2-700/9	
SNL150b	**N EEI-166B Metal Bag	77%EEI-166B, 20%Ni210(RSG), 2%CoO	37.9	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.8	0.008	7.52	2-700/9	
SNL150c	**N EEI-166B Metal Bag	77%EEI-166B, 20%Ni210(RSG), 2%CoO	37.9	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.8	0.007	7.52	2-700/9	
SNL150d	**N EEI-166B Metal Bag	77%EEI-166B, 20%Ni210(RSG), 2%CoO	37.9	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.8	0.008	7.52	2-700/9	
SNL150e	**N EEI-166B Metal Bag	77%EEI-166B, 20%Ni210(RSG), 2%CoO	37.8	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.8	0.007	7.52	2-700/9	
SNL150f	**N EEI-166B Metal Bag	77%EEI-166B, 20%Ni210(RSG), 2%CoO	37.8	0.012	6.48	80%SC1132, 19%Ni210(RSG)	37.8	0.007	7.52	2-700/9	
SNL151a	Electrode Thickness	77%EEI-166B, 20%Ni210(RSG), 2%CoO	19.0	0.007	3.26	80%SC1132, 19%Ni210(RSG)	19.0	0.003	3.80	2-700/9	
SNL151b	Electrode Thickness	77%EEI-166B, 20%Ni210(RSG), 2%CoO	19.1	0.007	3.28	80%SC1132, 19%Ni210(RSG)	18.8	0.003	3.28	2-700/9	
SNL151c	Electrode Thickness	77%EEI-166B, 20%Ni210(RSG), 2%CoO	18.9	0.007	3.24	80%SC1132, 19%Ni210(RSG)	18.8	0.003	3.24	2-700/9	
SNL152a	Electrode Thickness	77%EEI-171A, 20%Ni210(RSG), 2%CoO	18.9	0.006	3.24	80%SC1132, 19%Ni210(RSG)	18.8	0.003	3.76	2.-700/9	
SNL152b	Electrode Thickness	77%EEI-171A, 20%Ni210(RSG), 2%CoO	18.9	0.006	3.24	80%SC1132, 19%Ni210(RSG)	18.7	0.003	3.74	2-700/9	
SNL152c	Electrode Thickness	77%EEI-171A, 20%Ni210(RSG), 2%CoO	19.0	0.006	3.26	80%SC1132, 19%Ni210(RSG)	18.8	0.003	3.76	2-700/9	
SNL153a	N-EEI-193A	77%EEI-193A, 20%Ni210(RSG), 2%CoO	38.0	0.013	6.52	80%LEG757, 19%Ni210(RSG)	37.7	0.008	7.54	2-700/9	
SNL153b	N-EEI-193A	77%EEI-193A, 20%Ni210(RSG), 2%CoO	37.8	0.012	6.49	80%LEG757, 19%Ni210(RSG)	37.7	0.008	7.54	2-700/9	

Cell #	Vented	Vented	Vented	Vented	Vented	Vented	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed
	1st Dge .8 -100A 50% Charger Room Temp	**1st Dge .6 -100A Fully Charge Room Temo**	**1st Dge .8 -200A 50% Charge Room Temp**	**2nd Dge .6 -200A 50% Charge Room Temp**	**3rd Dge .6 -200A 50% Charge Room Temp**	**1st Dge .6 -200A Fully Charge Room Temp**	**1st Dge .8 -100A 50% Charge Room Temp**	**1st Dge .8 -200A 50% Charge Room Temp**	**2nd Dge .8 -200A 50% Charge Room Temp**	**3rd Dge .8 -200A 50% Charge Room Temp**	**4th Dge .8 -200A 50% Charge Room Temp**	**5th Dge .8 -200A 50% Charge Room Temp**	**6th Dge .8 -200A 50% Charge Room Temp**	**1st Dge .8 -250 50% Charge Room Temp**	**1st Dge .8 -300 50% Charge Room Temp**	**1st Dge .8 -350 50% Charge Room Temp**	**1st Dge .6 -400 50% Charge Room Temp**
SNL150a	1.138		0.797				1.134	0.915	0.932	0.939	0.939	0.940	0.932				
SNL150b	1.126		0.787				1.126	0.899	0.918	0.918	0.917	0.914	0.908				
SNL150c	1.133		0.790				1.129	0.903	0.915	0.915	0.914	0.917	0.906				
SNL150d	1.143		0.825				1.146	0.925	0.951	0.953	0.951	0.949	0.942				
SNL150e	1.133		0.873				1.126	0.921	0.913	0.910	0.911	0.915	0.904				
SNL150f	1.129		0.796				1.116	0.884	0.897	0.883	0.883	0.882	0.873				
SNL151a							0.716	0.594						0.592	0.595	0.593	0.571
SNL151b							0.800	0.596						0.592	0.595	0.561	0.572
SNL151c							0.796	0.591						0.600	0.595	0.538	0.589
SNL152a							0.797	0.584						0.562	0.591	0.567	0.583
SNL152b							0.799	0.586						0.590	0.588	0.559	0.581
SNL152c							0.797	0.599						0.597	0.586	0.569	0.587
SNL153a								0.842	0.904								
SNL153b								0.845	0.914								

	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed
Cell #	**1st Dge .3 -500 50% Charge Room Temp**	**.3 -450 50% Charge Room Temp**	**.6 -400 50% Charge Room Temp**	**.8 -350 50% Charge Room Temp**	**.8 -300 50% Charge Room Temp**	**.8 -250 50% Charge Room Temp**	**.8 -200A 50% Charge Room Temp**	**After 2 Wk Stand .8 -200A 50% Charge Room Temp**	**.8 -200A After 2000 Life Cycles**	**.8 -200A After 4000 Life Cycles**	**.8 -200A After 6000 Life Cycles**	**.8 -200A After 8000 Life Cycles**	**.8 -200A After 10000 Life Cycles**	**.3 -200A 0°C**	**.3 -200A -30°C**	**.3 -200A -40°C**	**-200 Before Rewet**
SNL150a																	
SNL150b																	
SNL150c																	
SNL150d																	
SNL150e																	
SNL150f																	
SNL151a	0.249	0.295	0.596	0.564	0.587	0.598	0.598										
SNL151b	0.296	0.234	0.590	0.586	0.579	0.584	0.599										
SNL151c	0.212	0.271	0.546	0.582	0.582	0.581	0.592										
SNL152a	0.293	0.279	0.579	0.554	0.594	0.587	0.599										
SNL152b	0.249	0.256	0.576	0.578	0.596	0.591	0.600										
SNL152c	0.246	0.221	0.589	0.598	0.599	0.596	0.595										
SNL153a																	
SNL153b																	

		Nickel				Hydride					
Cell #	Main Variable	Composition	Weight	Thick.	Theo. Cap	Composition	Weight	Thick.	Theo. Cap	Separator	Form. Cap. (Ah.)
SNL154a	N-EEI-193A	77%EEI-193A, 20%Ni210(RSG), 2%CoO	37.8	0.012	6.49	80%LEG757, 19%Ni210(RSG)	37.8	0.007	7.56	2-700/9	
SNL154b	N-EEI-193A	77%EEI-193A, 20%Ni210(RSG), 2%CoO	37.8	0.012	6.48	80%LEG757, 19%Ni210(RSG)	37.7	0.007	7.54	2-700/9	
SNL155a	N-EEI-194A	77%EEI-194A, 20%Ni210(RSG), 2%CoO	37.8	0.012	6.48	80%LEG757, 19%Ni210(RSG)	37.9	0.007	7.58	2-700/9	
SNL155b	N-EEI-194A	77%EEI-194A, 20%Ni210(RSG), 2%CoO	37.8	0.012	6.49	80%LEG757, 19%Ni210(RSG)	37.6	0.007	7.52	2-700/9	
SNL156a	N-EEI-194B	77%EEI-194B, 20%Ni210(RSG), 2%CoO	38.0	0.013	6.52	80%LEG757, 19%Ni210(RSG)	37.7	0.007	7.54	2-700/9	
SNL156b	N-EEI-194B	77%EEI-194B, 20%Ni210(RSG), 2%CoO	37.8	0.012	6.49	80%LEG757, 19%Ni210(RSG)	37.8	0.007	7.56	2-700/9	
SNL157a	N-EEI-197C	77%EEI-194B, 20%Ni210(RSG), 2%CoO	38.0	0.012	6.52	80%LEG757, 19%Ni210(RSG)	37.8	0.007	7.56	2-700/9	
SNL157b	N-EEI-197C	77%EEI-194B, 20%Ni210(RSG), 2%CoO	37.9	0.012	6.50	80%LEG757, 19%Ni210(RSG)	37.7	0.007	7.54	2-700/9	
SNL158a	H-SC1132 (N1-1132)	77%EEI-193A, 20%Ni210(RSG), 2%CoO	37.9	0.012	6.50	80%SC1132, 19%Ni210(RSG)	37.6	0.007	7.52	2-700/9	
SNL158b	H-SC1132 (N1-1132	77%EEI-193A, 20%Ni210(RSG), 2%CoO	37.9	0.012	6.50	80%SC1132, 19%Ni210(RSG)	37.6	0.007	7.52	2-700/9	
SNL159a	H-SC1132 (N1-1134)	77%EEI-193A, 20%Ni210(RSG), 2%CoO	37.9	0.012	6.50	80%SC1132, 19%Ni210(RSG)	37.7	0.007	7.54	2-700/9	
SNL159b	H-SC1132 (N1-1134)	77%EEI-193A, 20%Ni210(RSG), 2%CoO	37.9	0.012	6.50	80%SC1132, 19%Ni210(RSG)	37.6	0.007	7.52	2-700/9	
SNL160a	N-EEI-184B	77%EEI-184B, 20%Ni210(RSG), 2%CoO	37.8	0.012	6.48	80%LEG757, 19%Ni210(RSG)	37.8	0.007	7.56	2-700/9	
SNL160b	N-EEI-184B	77%EEI-184B, 20%Ni210(RSG), 2%CoO	37.9	0.012	6.50	80%LEG757, 19%Ni210(RSG)	37.6	0.007	7.52	2-700/9	

	Vented	Vented	Vented	Vented	Vented	Vented	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed
Cell #	**1st Dge .8 -100A 50% Charger Room Temp**	**1st Dge .6 -100A Fully Charge Room Temo**	**1st Dge .8 -200A 50% Charge Room Temp**	**2nd Dge .6 -200A 50% Charge Room Temp**	**3rd Dge .6 -200A 50% Charge Room Temp**	**1st Dge .6 -200A Fully Charge Room Temp**	**1st Dge .8 -100A 50% Charge Room Temp**	**1st Dge .8 -200A 50% Charge Room Temp**	**2nd Dge .8 -200A 50% Charge Room Temp**	**3rd Dge .8 -200A 50% Charge Room Temp**	**4th Dge .8 -200A 50% Charge Room Temp**	**5th Dge .8 -200A 50% Charge Room Temp**	**6th Dge .8 -200A 50% Charge Room Temp**	**1st Dge .8 -250 50% Charge Room Temp**	**1st Dge .8 -300 50% Charge Room Temp**	**1st Dge .8 -350 50% Charge Room Temp**	**1st Dge .6 -400 50% Charge Room Temp**
SNL154a								0.834	0.899								
SNL154b								0.839	0.910								
SNL155a								0.807	0.895								
SNL155b								0.752	0.865								
SNL156a								0.815	0.883								
SNL156b								0.784	0.857								
SNL157a								0.817	0.899								
SNL157b								0.784	0.868								
SNL158a								0.596	0.871								
SNL158b								0.596	0.897								
SNL159a								0.595	0.902								
SNL159b								0.632	0.918								
SNL160a								0.777	0.934								
SNL160b								0.756	0.910								

		Nickel				Hydride					
Cell #	Main Variable	Composition	Weight	Thick.	Theo. Cap	Composition	Weight	Thick.	Theo. Cap	Separator	Form. Cap. (Ah.)
SNL161a	N-EEI-185B	77%EEI-185B, 20%Ni210(RSG), 2%CoO	38.0	0.012	6.52	80%LEG757, 19%Ni210(RSG)	37.6	0.007	7.52	2-700/9	
SNL161b	N-EEI-185B	77%EEI-185B, 20%Ni210(RSG), 2%CoO	37.9	0.012	6.50	80%LEG757, 19%Ni210(RSG)	37.7	0.007	7.54	2-700/9	
SNL165a	Control N EEI-195	77% EEI-195AB, 20%Ni210, 2%CoO	37.8	0.012	6.48	80%SC-1132, 19%Ni210(RSG)	37.6	0.007	7.52	2-700/9	
SNL165b	Control N EEI-195	77%EEI-195AB, 20%Ni210, 2%CoO	37.8	0.012	6.49	80%SC-1132, 19%Ni210(DSG)	37.6	0.007	7.52	2-700/9	
SNL166a	Control N EEI-198	77%EEI-198AB, 20%Ni210, 2%CoO	37.8	0.012	6.48	80%SC-1132, 19%Ni210(RSG)	37.6	0.007	7.52	2-700/9	
SNL166b	Control N EEI-198	77%EEI-198AB, 20%Ni210, 2%CoO	37.8	0.012	6.49	80%SC-1132, 19%Ni210(RSG)	37.6	0.007	7.52	2-700/9	
SNL167a	Contol N EEI-199	77%EEI-199AB, 20%Ni210, 2%CoO	37.9	0.012	6.50	80%SC-1132, 19%Ni210(RSG)	37.7	0.007	7.54	2-700/9	
SNL167b	Control N EEI-199	77%EEI-199AB, 20%Ni210, 2%CoO	37.9	0.012	6.50	80%SC-1132, 19%Ni210(RSG)	37.6	0.007	7.52	2-700/9	
SNL168a	Control N EEI-201	77%EEI-201ABC, 20%Ni210, 2%CoO	37.8	0.012	6.48	80%SC-1132, 19%Ni210(RSG)	37.7	0.007	7.54	2-700/9	
SNL168b	Control N EEI-201	77%EEI-201ABC, 20%Ni210, 2%CoO	37.8	0.012	6.49	80%SC-1132, 19%Ni210(RSG)	37.8	0.007	7.56	2-700/9	
SNL 169a	Control H-SEC23-1519/1	77% , 20%Ni210, 2%CoO				80%SEC 23-1519/1, 19%Ni210 (RSG)				2-700/9	

	Vented	Vented	Vented	Vented	Vented	Vented	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed	Sealed
Cell #	**1st Dge .8 -100A 50% Charger Room Temp**	**1st Dge .6 -100A Fully Charge Room Temo**	**1st Dge .8 -200A 50% Charge Room Temp**	**2nd Dge .6 -200A 50% Charge Room Temp**	**3rd Dge .6 -200A 50% Charge Room Temp**	**1st Dge .6 -200A Fully Charge Room Temp**	**1st Dge .8 -100A 50% Charge Room Temp**	**1st Dge .8 -200A 50% Charge Room Temp**	**2nd Dge .8 -200A 50% Charge Room Temp**	**3rd Dge .8 -200A 50% Charge Room Temp**	**4th Dge .8 -200A 50% Charge Room Temp**	**5th Dge .8 -200A 50% Charge Room Temp**	**6th Dge .8 -200A 50% Charge Room Temp**	**1st Dge .8 -250 50% Charge Room Temp**	**1st Dge .8 -300 50% Charge Room Temp**	**1st Dge .8 -350 50% Charge Room Temp**	**1st Dge .6 -400 50% Charge Room Temp**
SNL161a								0.725	0.866								
SNL161b								0.754	0.863								
SNL165a			0.873														
SNL165b			0.885														
SNL166a			0.906														
SNL166b			0.896														
SNL167a			0.933														
SNL167b			0.922														
SNL168a			0.944														
SNL168b			0.956														
SNL 169a																	

		Nickel				Hydride					
Cell #	Main Variable	Composition	Weight	Thick.	Theo. Cap	Composition	Weight	Thick.	Theo. Cap	Separator	Form. Cap. (Ah.)
SNL 173a	Control H SEC 23-1519/5	77% , 20%Ni210, 2%CoO				80%SEC 23-1519/5, 19%Ni210 (RSG)				2-700/9	
SNL 173b	Control H SEC 23-1519/5	77% , 20%Ni210, 2%CoO				80%SEC 23-1519/5, 19%Ni210 (RSG)				2-700/9	
SNL 173c	Control H SEC 23-1519/5	77% , 20%Ni210, 2%CoO				80%SEC 23-1519/5, 19%Ni210 (RSG)				2-700/9	
SNL 174a	Control H SEC 23-1519/6	77% , 20%Ni210, 2%CoO				80%SEC 23-1519/6, 19%Ni210 (RSG)				2-700/9	
SNL 174b	Control H SEC 23-1519/6	77% , 20%Ni210, 2%CoO				80%SEC 23-1519/6, 19%Ni210 (RSG)				2-700/9	
SNL 174c	Control H SEC 23-1519/6	77% , 20%Ni210, 2%CoO				80%SEC 23-1519/6, 19%Ni210 (RSG)				2-700/9	
SNL 175a	Control H- LEG-757 (EER3001)	77%P305A, 20%Ni210(RSG), 2%CoO	38.1	0.012	6.54	80%LEG-757, 19%Ni210	37.7	0.007	7.54	2-700/9	
SNL 175b	Control H-LEG-757 (EER3001)	77%P305A, 20%Ni210(RSG), 2%CoO	38.2	0.012	6.56	80%LEG-757, 19%Ni210	38.0	0.007	7.60	2-700/9	
SNL 175c	Control H-LEG-757 (EER3001)	77%P305A, 20%Ni210(RSG), 2%CoO	38.1	0.012	6.54	80%LEG-757, 19%Ni210	38.0	0.007	7.60	2-700/9	