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**Delivery Order 0028: Lithium Carbon Monofluoride Cell
Development**

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FINAL REPORT

High Rate D Cell Project

1.0 SCOPE

This document reports the work performed and the results obtained in developing materials and processes that could lead to a relatively high rate primary Li/CF_x D cell.

2.0 Initial Cell Design and Materials Trials

2.1 Pouch Cell Design

For the initial pouch cell design, it was desirable to have the anode and cathode area readily comparable to the standard EPT LCF-112 Li/CF_x DD-sized primary cell but in a form factor that would be as close as practicable to a workable D cell size in a reasonable size pouch cell. To achieve this, the width of the cathode was selected to be 1.92 inches wide. This width was selected as past work in the D cell size had shown that this was the maximum width that could be mechanically utilized in a standard size D cell can if the header used a Ziegler-type compression seal. The length of the cathode was selected to be 4.75 inches long, as with the width at a likely practical maximum for the eventual wound cell of 1.92 inches, this yielded a total cathode surface area of 117 cm², which is almost precisely 1/5th that of the standard DD LCF-112 cell. This allowed easy comparison to the baseline cell.

The initial cathode formulation was the standard mix of carbon monofluoride (CF_x), carbon black and binder as used for the LCF-112 'jellyroll' cell and using the standard coated stainless steel grid substrate, but produced at ½ the thickness used for the standard wound cell at 0.026 to 0.028 inches thick. The corresponding anode of lithium metal on stainless steel foil was produced to have far greater capacity than the cathode so that the limiting material in cell discharges would be utilization of the cathode active material. The capacity imbalance would be adjusted should work lead to practical wound cells.

In keeping with the intent of ensuring that the cathode would be the capacity/rate limiter in the cell, the pouches were constructed so that above the formed 'cell stack' area, an extra trapezoidal area was formed to act as a reservoir for additional electrolyte in excess of that initially soaked up by the cathode when the pouches were activated. In this fashion external plates and a light spring clip could be utilized to maintain modest but steady stack pressure while the electrolyte reservoir area above was not under compression and hence could be utilized to hold excess electrolyte quantity. The picture in Figure 1 on the next page shows a typical example of the pouch cells produced for test.



Figure 1 – Typical Pouch Cell

The pouching material employed was typical aluminum/polyolefin/surllyn five-layer heat-sealable pouching material available commercially. Once a cell stack comprising anode/separator/cathode/separator/anode was inserted, the area above the cell stack was sealed at a slant to form a trapezoid with a small open area at the apex. After the introduction of an excess amount of electrolyte, consisting of at least 2.5x milliliters of electrolyte to cathode capacity, the top of the pouch was sealed across the top, providing two seals for the tabs exiting the cell.

2.2 Initial Pouch Cells – Separator Trials

The LCF-112 standard cell employs two layers of separation, one a non-woven layer of polyphenylene sulfide (PPS), the other a 0.0015 inch thick layer of Celanese tri-layer (PP/PE/PP) 'shutdown' separator. The combination of separations has worked well for the comparatively low rate DD LCF-112 cell, which has maximum rate capability at room temperature of 1 ampere continuous. When activated, the standard Li/CF_x pasted cathodes will swell up to 10% in thickness. If discharged unconfined, the cathodes by end of discharge will swell up to a total of 250% of original thickness. In a wound cell, where the swelling is confined, the squeeze of the cathode increases with discharge and can 'starve' portions of the cathode of electrolyte. The relatively thick PPS layer is extremely high temperature capable, up to 350°C, and also helps act as a 'wicking' layer to aid transport of electrolyte into the cell stack, aiding in

preventing electrolyte starvation. The Celanese tri-layer microporous separation layer helps prevent particle migration and bridging between anode and cathode and in the event of cell over temperature the middle layer begins to soften and become less porous by 120°C and has become almost a solid film layer by 130°C. In this fashion it acts as a safety layer in cells.

Together the two layers of separation in the standard DD cell are approximately 0.006 inches thick. Given the relatively low rate capability of the standard cell this inter-electrode spacing is not of large consequence. However, for the planned possible higher rate D cell it was possible that this separator thickness could prove to be a detriment to rate capability. In the best case, it was hoped that the separator thickness could be reduced, either through use of thinner materials or possible elimination of the PPS layer.

The search for alternate separation materials for evaluation in the pouch cells proved frustrating, in that few materials are compatible with the CFx electrochemistry. Thinner wicking candidates of non-woven PP or PE or mixed polyolefin were sought and none thinner than the presently used PPS material could be found that were commercially available in the US. A 0.005" thick fine structured non-woven PP material was obtained from Freudenberg Company in Germany. A 0.004" thick fine structured PP non-woven was obtained from Tapyrus Company in Japan. Alternates to the Celanese tri-layer material were sought and only a Japanese Setela material made by Tonen Company and handled in the US by ExxonMobil was found that appeared to offer any possible advantage to the Celanese material.

The potential advantages to the Setela material were twofold: 1) the material was almost as strong in the TD direction as in the MD direction and 2) in spite of being 16 micron thick compared to the Celgard 25 micron was highly puncture resistant.

10 pouch cells were constructed in the initial test series. All used the same standard anode and 0.026 – 0.028 inch thick cathode as described in Paragraph 2.1. The cells were all activated with excess standard electrolyte (1.0M LiAsF₆ in dimethyl sulfite – DMSI) and differed in the separator combinations employed. Cells S/N 5 and 6 used the separator combinations employed in the standard LCF-112 cell. Pouch cells S/Ns 9 and 10 employed a layer of the microporous Setela material only. The test series is shown in the Table below:

Table 1 – First Series Pouch Cells

<u>Cell S/N</u>	<u>Separator A</u>	<u>Separator B</u>
1	Freudenberg PP	Setela 16um microporous
2	Freudenberg PP	Setela 16um microporous
3	Tapyrus PP	Setela 16um microporous
4	Tapyrus PP	Setela 16um microporous
5*	PPS non-woven	Celgard microporous (2300)

6*	PPS non-woven	Celgard microporous (2300)
7	PPS non-woven	Setela 16 um microporous
8	PPS non-woven	Setela 16 um microporous
9	None	Setela 16 um microporous
10	None	Setela 16 um microporous

*standard wound-cell separator materials

2.3 Initial Pouch Cells – Test Results

To gain a look at the rate capability of the bag cells, short (ten minute) loads were applied at increasing rates until the cells began to fall close to 2.0 V under the loads. A summary Table of the results is given below and the full Table of data is given in Appendix A at the end of this report.

Table 2 - Initial Trial Bag Cell Pulse Test Results

		100 mA load / 10 minutes	150 mA load / 10 minutes	200 mA load / 10 minutes
<u>Separation Configuration</u>	<u>S/N</u>	<u>10 min</u>	<u>10 min</u>	<u>10 min</u>
Ger. PP + Jap. u-porous	1*	2.32	2.19	2.16
Ger. PP + Jap. u-porous	2*	2.27	2.14	2.15
Jap. PP + Jap. u-porous	3*	2.22	2.12	2.08
Jap. PP + Jap. u-porous	4*	2.27	2.17	2.13
PPS + Celgard u-porous	5*^	2.26	2.20	2.13
PPS + Celgard u-porous	6*^	2.28	2.20	2.12
PPS + Jap. u-porous	7**	2.23	2.17	2.11
PPS + Jap. u-porous	8**	2.25	2.18	2.10
Jap. u-porous only	9**	2.30	2.22	2.17
Jap. u-porous only	10**	2.31	2.23	2.16

*activated 46 hours prior to pulse; **activated 6 hours prior to pulse

^separator combination used in stnd. LCF-112 cell

Cells S/N 5 and 6 closely duplicate in pouch cell form the standard wound cell configuration used in the LCF-112 cell, differing mainly in the half cathode thickness used in the pouch cells. The lowest load used, 100 mA, at the 5 to 1 scalar in surface area employed with the pouch cells, closely duplicates the effect of a 'block test' employed during the post activation processing of the LCF-112 wound cells. The 100 mA load results seen with all the cells closely approximates the voltages that would be expected from recently activated wound cells, helping to validate the pouch cell design as a reasonable predictor of wound cell results estimated from smaller bag cells.

The inter-electrode spacing with the various separation combinations employed caused little variation in the load ability of the cells, including the cells where only the 16 micron microporous separation layer was employed. This strongly suggests that at these load levels the ionic transport rate between the plates is not a major factor in the

load carrying ability. This in turn suggests that the separation layer(s) ultimately chosen for a wound cell version may be selected simply based on cost or other technical concerns such as safety. It indicated that reducing cell internal impedance would be best served by concentrating on other areas to reduce internal impedance to enhance the rate capability.

As the cathode in the cells is approximately 1/5th the size and 1/2 the thickness of the standard DD cathode, capacity was expected to be approximately 1/10th that of the DD cell at a comparable rate, or approximately 3.4-3.5 AHrs.

Capacity discharge curves for the ten test cells discharged at 35 ohm resistive load are given at the end of this report in Appendix B. The Table below summarizes the results:

Table 3 - Initial Test Cell Capacity Results

<u>Separation Configuration</u>	<u>S/N</u>	<u>Capacity</u>
German PP + Jap. u-porous	1	3.44 Ahr
German PP + Jap. u-porous	2	3.17 Ahr
Jap. PP + Jap. u-porous	3	3.49 Ahr
Jap. PP + Jap. u-porous	4	3.34 Ahr
Stnd. PPS + Celgard u-porous	5*	3.36 Ahr
Stnd. PPS + Celgard u-porous	6*	3.32 Ahr
German PPS + Jap. u-porous	7	3.01 Ahr
German PPS + Jap. u-porous	8	3.59 Ahr
Japanese u-porous only	9	3.66 Ahr
Japanese u-porous only	10	3.61 Ahr

*Pouch cell version of standard wound cell configuration

The capacity predicted for the bag cells from the DD wound design was 3.4-3.5 Ahrs, as the bag cell cathodes contain the same cathode mix as the LCF-112 cell and the overall cell cathode volume is almost exactly 1/10th that of the wound cell. The capacities delivered are in line with the prediction from the wound cell design at that scaled rate, again indicating that the pouch cells should allow a reasonable prediction of wound cell performance. Cells S/N 9 and 10 using only the Japanese Setela microporous separation layer delivered, by a slight margin, the best capacity results. They were also the cells with the highest voltages under the test load, again by a slight margin. The slightly higher operating voltage appears to explain the slight capacity advantage.

The discharge curves show a large amount of additional capacity past the 2.0V cutoff. This is an effect of the large excess of anodic lithium and electrolyte present in the pouch cell design. Since the lithium/electrolyte reaction occurs to a large extent at and below 2.0V, it is likely not practical to take advantage of this 'extra' capacity. Wound CF_x cell design experience has shown that the best overall cell performance is

achieved by balancing the anode capacity to the cathode capacity to the electrolyte quantity to ensure that when the cathode begins to fail and the cell drops towards 2.0V, that the anode and electrolyte excesses are slight and the cell continues to decay in operating voltage in a smooth manner.

3.0 Second Materials Trials

3.1 Advanced Carbons

Samples of three engineered carbon types from Superior Graphite that could potentially offer higher rate capability were built into test cells. All are extremely 'clean' carbons as far as metals content, sulfur compounds and other potential contaminants. One, SCD 315, is a purified and 'expanded' natural graphite, the second (ABG1005) is a formed partially graphitized and 'expanded' carbon black and the third is a partially graphitized nano-sized carbon (SCD205-110). The main potential advantage of all three types is that they exhibit up to an order of magnitude greater conductivity than synthetic graphite.

Table 4 – Second Cell Series - Advanced Carbon Cells

Cell S/N	Separator A	Separator B	Carbon Black
11*	Ger. PPS non-woven	Celgard u-porous (2300)	SCD 315
12*	Ger. PPS non-woven	Celgard u-porous (2300)	SCD 315
13*	Ger. PPS non-woven	Celgard u-porous (2300)	SCD 205/110
14*	Ger. PPS non-woven	Celgard u-porous (2300)	SCD 205/110
15*	Ger. PPS non-woven	Celgard u-porous (2300)	ABG 1005
16*	Ger. PPS non-woven	Celgard u-porous (2300)	ABG 1005
17	Freudenberg PP	Setela 16 um u-porous	SCD 315
18	Freudenberg PP	Setela 16 um u-porous	SCD 315

*standard wound-cell separator materials

These test cells were built to the design established in the first test cell series, using a cathode 1.92 inches wide by 4.75 inches long and using half the thickness of the parent LCF-112 cathode design. For the cathodes in these cells the Superior Graphite carbons were substituted on an exact weight basis for the standard acetylene black carbon that is standard for the parent cell. Cells 17 and 18 revisited the separation combination that had appeared to be the best combination separation by a slight margin in the first test cell series.

As with the first test cell series, short (ten minute) loads were applied at increasing rates until the cells began to fall close to 2.0 V under the loads. A summary Table of the results is given below and the full Table of data is given at the end of this report in Appendix C.

Table 5 - Second Pouch Cell Series Load Test Results

	Pouch	100 mA	150 mA	200 mA
	Cell	load / 10	load / 10	load / 10
<u>Carbon</u>	<u>S/N</u>	<u>10 min</u>	<u>10 min</u>	<u>10 min</u>
SCD 315 carbon	11*	2.20	2.07	2.00
SCD 315 carbon	12*	2.19	2.12	2.05
SCD 205/110				
carbon	13*	2.19	2.11	2.04
SCD 205/110				
carbon	14*	2.19	2.11	2.04
ABG 1005 carbon	15*	1.95	1.93	1.89
ABG 1005 carbon	16*	1.92	1.89	1.83
SCD 315 carbon	17**	2.23	2.13	2.09
SCD 315 carbon	18**	2.18	2.10	2.01

*standard wound-cell separator materials-cells were 'standard' except for carbon

**best separator combination from first test cell series

Cells S/N 11 to 16 closely duplicate in bag cell form the standard wound cell configuration used in the DD-sized LCF-112 cell, with the change being the substitution of the engineered carbons for the acetylene black normally used in this cell design and the half-thickness of the cathodes. Cells S/N 5 and 6, built and tested in the first pouch cell series, duplicate as precisely as possible the standard wound cell configuration. At the highest load of 200 mA, Cells 5 and 6 produced ten minute voltages of 2.13 and 2.12V, respectively. This performance was better than that of any of the cells using the increasingly highly engineered configurations. Although the extremely 'clean' nature of the engineered carbons was appealing, the performance appeared to be slightly inferior to that obtained using the standard acetylene black carbon material.

Cells 17 and 18 utilized the best performing two-separation configuration from last month's cells (S/Ns 1 and 2). These cells (S/Ns 1 and 2) gave ten minute 200 mA load voltages of 2.16 and 2.15V, respectively. This compares favorably to the load voltages produced by cells 17 and 18. It appears that the combination of separation and carbon produced no better results than that produced by the carbon choice alone.

3.2 Alternate Cathode Substrates

6 pouch cells were constructed in the third test series. All used the standard anode and standard electrolyte and differed in the type of cathode substrate employed. Work being conducted on a very large primary Li/CF_x cell had indicated that the resistance of the stainless steel cathode substrate current collector material has an effect on cell performance. As both stainless steel and titanium are vulnerable to formation of fluorine species of very low conductivity (such as titanium fluoride), they are typically protected from this passivating effect by being coated with a carbon-filled inert fluoropolymer. The disadvantages to this are the extra materials and labor and the

fact that the base fluoropolymers themselves are of very low conductivity. This necessitates the carbon loading in the coating materials, but the carbon only partially alleviates the low conductivity. One approach successfully tried in the large cells was to switch from stainless steel grid with high open area to thicker, perforated titanium foil for lower initial and coated resistance. As this material was available from the large cell work, this approach was tried in a pair of pouch cells. The other approach was to use the standard stainless steel grid, but to coat it with gold, a material that is highly conductive but that should be inert in the Li/CF_x electrochemical system. The pouch cell third series construction is shown in the Table below:

Table 6 – Third Cell Series – Cathode Substrate Cells

Cell S/N	Separator A	Separator B	Cathode Substrate
19	Ger. PPS non-woven*	Celgard u-porous*	Coated titanium - perforated foil
20	Ger. PPS non-woven*	Celgard u-porous*	Coated titanium - perforated foil
21	Ger. PPS non-woven*	Celgard u-porous*	Gold-plated SS grid
22	Ger. PPS non-woven*	Celgard u-porous*	Gold-plated SS grid
23	Ger. PPS non-woven*	Celgard u-porous*	Gold-plated SS grid
24	Ger. PPS non-woven*	Celgard u-porous*	Gold-plated SS grid

*standard wound-cell separator materials

As before, short (ten minute) loads were applied to the cells at increasing rates until the cells began to fall close to 2.0 V under the loads. A summary Table of the results is given on the next page and the full Table of data is given at the end of this report in Appendix D.

Table 7 - Third Pouch Cell Series Load Test Results

Cathode Substrate	Cell S/N	100 mA load / 10 minutes <u>10 min</u>	150 mA load / 10 minutes <u>10 min</u>	200 mA load / 10 minutes <u>10 min</u>
Coated Ti foil	19	2.26	2.22	2.13
Coated Ti foil	20	2.27	2.21	2.13
Au-plated SS grid	21	2.27	2.19	2.14
Au-plated SS grid	22	2.27	2.20	2.16
Au-plated SS grid	23	2.18	2.23	2.15
Au-plated SS grid	24	2.18	2.21	2.12

Neither the coated titanium foil nor the gold-plated grid produced noticeably higher voltages under load. Cells S/N 5 and 6 from the first test series duplicated as closely as possible the standard wound cell configuration using one-half the standard cathode thickness. At the highest load of 200 mA, Cells 5 and 6 produced ten minute voltages of 2.13 and 2.12V, respectively. This performance was essentially equal to that of any of the cells using the alternate substrate configurations. This was unexpected in the

case of the coated titanium foil. This foil as used for the much larger cell work would not be a really suitable material for the potential D cell, as the 0.003 substrate thickness and weight would impose a real penalty on cell energy density. However, the Ti is approximately 1/3 lower in base resistance than is stainless steel, and the increased material cross section indicated that the coated substrate resistance should have decreased by as much as 50%. That it did little if any better than the base configuration indicated that the main source of the cell resistance on the cathode side lies in the cathode matrix itself or in the cathode-to-electrolyte interface or both.

With the gold plated SS, the gold plating was expected to produce an approximately 25% drop in substrate resistance over that of the standard grid coated with a carbon-loaded fluoropolymer. Resistance measurements indicated that there was an approximately 6% gain in resistance from not using the carbon/fluoropolymer coating material and the much higher conductivity of the gold provided approximately a 20% decrease in resistance. With the ultra-heavy gauge titanium material having a 50% lower resistance than the standard stainless steel grid, and still not showing a marked increase in load voltage, it then comes as no surprise that the cells using gold plated material did not show a noticeable load voltage increase. With the large cells being worked on, the heavy Ti substrate did make a noticeable load voltage difference, but this was in cathodes that, while over 4 times as wide, were more than 20 times as long as in these test cells, giving a markedly different L/A ratio.

4.0 Fourth Series Cells - Cathode Modification Trials

4.1 Cathode Modification Test Cells

In an attempt to better the pulse ability of the cells, the standard pasted cathode procedure was modified in various ways.

In the first cathode modification, standard cathodes were produced, then densified by the addition of a second high pressure press after the cathode had been completed (cathodes 1-4). In the case of cathode 4, carbon black was brushed onto both sides of the cathode before the post-production densification pressing. Loose carbon black was then brushed from the surface before a cell was built with this cathode. In the case of cathode 5 the production process was modified by altering the step sequence so the final high pressure press occurred during the cathode processing, just before the final cathode oven sintering process.

Table 8 – Fourth Series Pouch Test Cells

Cathode by Stnd. Process				Addnl. High Pressure Press			
<u>Cath.S/N</u>	<u>Cell S/N</u>	<u>Thickness</u>	<u>Density</u>	<u>Coating</u>		<u>Thickness</u>	
<u>Density</u>							
1	25	0.026	1.17	gold		0.021	1.48
2	26	0.027	1.16	gold		0.024	1.36
3	27	0.026	1.23	Stnd.		0.022	1.51

4	28	0.026	1.21	gold		0.023*	1.43*
5	29	0.023**	1.44**	gold		N/A	N/A

*processed w/surface carbon black before additional press

**std. Cathode process modified by final heavy press done before sintering

Various other techniques were tried modifying the standard cathode procedure, but only the techniques above noticeably increased the density by producing decreased thickness (increased density) for the same amount of cathode material.

The five cathodes above were built into the standard pouch cell configuration as exemplified by S/Ns 5 and 6. For direct comparison purposes, the separators used for these cells were the standard wound cell combination of PPS non-woven and shutdown type microporous as used in the standard LCF-112 cell.

4.2 Cathode Modification Test Cell Results

To gain a look at the rate capability of the pouch cells, short (ten minute) loads were applied at increasing rates until the cells began to fall close to 2.0 V under the loads. A summary Table of the results is given below and the full Table of data is given at the end of this report in Appendix E.

Table 9 - Fourth Series Pouch Cell Pulse Test Results

Cathode Modification	Cell S/N	100 mA load / 10 minutes <u>10 min</u>	150 mA load / 10 minutes <u>10 min</u>	200 mA load / 10 minutes <u>10 min</u>
Dense cathode/gold on SS substrate	25	2.30	2.21	2.13
Dense cathode/gold on SS substrate	26	2.30	2.17	2.15
Dense cathode/coated SS substrate	27	2.22	2.20	2.18
Dense cathode w/ added surface carbon / gold on SS substrate	28	2.33	2.26	2.18
Dense cathode using mod. process/gold on SS substrate	29	2.33	2.24	2.16

Cells S/N 5 and 6, built and tested earlier, duplicate as precisely as possible the standard wound cell configuration using half-thickness for the cathodes. At the highest load of 200 ma, these 'standard' cells produced ten minute voltages of 2.13 and 2.12V, respectively. The performance of the densified cathodes was equal to or better than that of the standard cells. However, the gain in load voltage was slight. It appears

that the thinner, denser cathodes confer minor gains. If the denser cathodes are compatible with other approaches, this extra step for densification may still be worthwhile as a means of producing better rate capability in an ultimate wound cell.

The cell with the cathode where additional carbon was heavily loaded into the cathode surface possibly indicates that the electrolyte-to-cathode interface is not the controlling factor in cell impedance.

5.0 Fifth Series Cells – Alternate Cathodes

5.1 Extruded/Laminated Test Cells

Another part of the Technologies Division of EPT, the EaglePicher Energy Products group, located in Vancouver, British Columbia, Canada has been working on Li/CF_x cells on IR&D funds to take advantage of their Li/MnO₂ expertise and equipment. Having achieved what they felt were good results in their efforts, they have shared with EPT Product Development the technology employed and sampled cathode material to us for trial in our CF_x high rate D cell effort. The cathode technology used by EP Energy Products is substantially different from that employed to date by Product Development. The EP Energy Products approach is a quasi-extruded and then laminated electrode that is dried as it moves down the laminating line, in contrast to Product Development's wet pasted cathode method.

In the fifth build of pouch cells, one trio of cells was constructed like the standard pouch cell using the DD wound cell separators, electrolyte and anodes but EP Energy Products laminated/extruded cathodes on stainless steel grid substrate. A second trio was constructed similarly using the EP Energy Products laminated/extruded cathodes on aluminum grid substrate. A third trio of cells was similarly constructed using the SBF web-coated cathode material on aluminum foil substrate. All used the standard LCF-112 electrolyte.

Table 10 - Fifth Series Pouch Cells

Cell S/N	<u>Separation Configuration</u>	<u>Cathode Configuration</u>
30	Std. PPS + Celgard u-porous	EP En. Prod. On SS
31	Std. PPS + Celgard u-porous	EP En. Prod. On SS
32	Std. PPS + Celgard u-porous	EP En. Prod. On SS
33	Std. PPS + Celgard u-porous	Prototype SBF Web-Coated
34	Std. PPS + Celgard u-porous	Prototype SBF Web-Coated
35	Std. PPS + Celgard u-porous	Prototype SBF Web-Coated
36	Std. PPS + Celgard u-porous	EP En. Prod. On Al
37	Std. PPS + Celgard u-porous	EP En. Prod. On Al
38	Std. PPS + Celgard u-porous	EP En. Prod. On Al

5.2 Extruded/Laminated & Web-Coated Cathode Test Cell Results

As before, the pouch cells were subjected to steadily increasing short load segments to observe the voltage capability of the cells under the increasing loads. A summary of the results for the fifth series of test cells are given in the Table below. The complete Table of test results is given at the end of this report in Appendix F.

Table 11 - Fifth Series Pouch Cell Load Test Results

Cathode Configuration	Cell S/N	100 mA load / 10 minutes <u>10 min</u>	150 mA load / 5 minutes <u>5 min</u>	200 mA load / 5 minutes <u>5 min</u>	250 mA load / 10 minutes <u>10 min</u>	300 mA load / 5 minutes <u>5 min</u>
EP On SS	30	2.29	2.18	2.13	2.14	2.02
EP On SS	31	2.30	2.20	2.16	2.18	2.09
EP On SS	32	2.31	2.28	2.26	2.27	2.19
SBF Web Coated	33	2.14*	1.87	1.63	--	--
SBF Web Coated	34	2.17*	1.98	1.88	--	-
SBF Web Coated	35	2.20*	2.10	2.02	--	--
EP On Al	36	2.35	2.31	2.30	2.32	2.25
EP On Al	37	2.36	2.32	2.29	2.31	2.23
EP On Al	38	2.36	2.32	2.29	2.33	2.24

*5 minute Load

Cathode Configuration	Cell S/N	350 mA load / 5 minutes <u>5 min</u>	400 mA load / 5 minutes <u>5 min</u>	450 mA load / 5 minutes <u>5 min</u>	500 mA load / 10 minutes <u>10 min</u>	560 mA load / 5 minutes <u>5 min</u>
EP On SS	30	1.95	--	--	--	--
EP On SS	31	2.02	1.99	--	--	--
EP On SS	32	2.10	2.05	--	--	--
EP On Al	36	2.19	2.16	2.12	2.12	2.08
EP On Al	37	2.17	2.15	2.11	2.12	2.09
EP On Al	38	2.18	2.17	2.14	2.13	2.11

Cathode Conf.	Cell S/N	600 mA load / 5 minutes <u>5 min</u>	660 mA load / 5 minutes <u>5 min</u>
EP On Al	36	2.07	2.03
EP On Al	37	2.06	2.02
EP On Al	38	2.08	2.05

The results for the cell trios using the EP Energy Products-produced cathodes were excellent. These cells exhibited the sought-for substantially lower matrix resistance

such that the resistance differential between the otherwise identical stainless steel-gridded cathodes and the aluminum-gridded cathodes showed up very clearly. The relative resistance of stainless steel is 75 micro-ohm-cm and the resistance of the aluminum is 2.8 micro-ohm-cm. The identical construction cells using the aluminum-gridded cathodes exhibited current carrying capability of a level that makes full-sized cells a viable possibility.

Using the 600 ma short load results as a current baseline, these result in the pouch cells project that a D sized cell of similar construction should be able to run at a 1.5 amp level above 2.0V and represents a significant advance in current carrying capability over the present wound DD sized LCF-112 cell.

6.0 Sixth Series Cells – Alternate Electrolytes

6.1 Extruded/Laminated Cathodes w/Alternate Electrolytes Test Cells

In the sixth build of pouch cells, all three of the cell groups were constructed like the prior (fifth) cell series using the EP Energy Products laminated/extruded cathodes on aluminum grid substrate from a second sample lot of the cathode material. In this regard all the cells were built to the same design as the best cells built and tested in the last build. The one area in which they differed from the prior build was in using more conductive tabbing for the cathodes – using nickel in place of stainless steel for lowered ohmic loss. One trio of cells was activated with the standard 1.0M LiAsF₆ in dimethyl sulfite (DMSI) electrolyte, a second quartet was activated with 1.0M LiPF₆ in DMSI and the third cell trio was activated with 1.0M LiPF₆ in PC/DME (30%/70%). In this fashion the first cell trio was a near-exact duplicate of the best group of the fifth series (S/Ns 36-38), allowing for consistency comparison.

Table 12 - Sixth Series Pouch Cells

<u>Cell S/N</u>	<u>Electrolyte</u>	<u>Cathode Configuration</u>
39	1.0M LiAsF ₆ in DMSI	EP En. Prod. On Al, Ni Tab
40	1.0M LiAsF ₆ in DMSI	EP En. Prod. On Al, Ni Tab
41	1.0M LiAsF ₆ in DMSI	EP En. Prod. On Al, Ni Tab
42	1.0M LiPF ₆ in DMSI	EP En. Prod. On Al, Ni Tab
43	1.0M LiPF ₆ in DMSI	EP En. Prod. On Al, Ni Tab
44	1.0M LiPF ₆ in DMSI	EP En. Prod. On Al, Ni Tab
45	1.0M LiPF ₆ in DMSI	EP En. Prod. On Al, Ni Tab
46	1.0M LiPF ₆ in PC/DME	EP En. Prod. On Al, Ni Tab
47	1.0M LiPF ₆ in PC/DME	EP En. Prod. On Al, Ni Tab

6.2 Extruded/Laminated Cathodes w/Alternate Electrolytes Test Cell Results

As before, the pouch cells were subjected to steadily increasing short load segments to observe the voltage capability of the cells under the increasing loads. A summary of the results for the sixth series of test cells is given in the Table below. The complete Table of test results is given at the end of this report in Appendix G.

Table 13 - Sixth Series Pouch Cell Pulse Test Results

<u>Electrolyte</u>	<u>Cell S/N</u>	200 mA load / 5 minutes	250 mA load / 5 minutes	300 mA load / 5 minutes	350 mA load / 5 minutes	400 mA load / 5 minutes
LiAsF ₆ in DMSI	39	2.34	2.31	2.29	2.25	2.23
LiAsF ₆ in DMSI	40	2.25	2.25	2.25	2.22	2.21
LiAsF ₆ in DMSI	41	2.19	2.16	2.14	2.11	2.09
LiPF ₆ in DMSI	42	2.11	2.07	2.04	2.02	2.01
LiPF ₆ in DMSI	43	2.13	2.12	2.11	2.09	2.08
LiPF ₆ in DMSI	44	2.16	2.16	2.15	2.13	2.12
LiPF ₆ in DMSI	45	2.12	2.12	2.09	2.06	2.04
LiPF ₆ in PC/DME	46	2.28	2.03	2.23	2.20	2.27
LiPF ₆ in PC/DME	47	2.25	2.25	2.23	2.19	2.24
LiPF ₆ in PC/DME	48	2.22	2.15	2.07	2.02	2.09

<u>Electrolyte</u>	<u>Cell S/N</u>	450 mA load / 5 minutes	500 mA load / 5 minutes	550 mA load / 5 minutes	600 mA load / 5 minutes	650 mA load / 5 minutes
LiAsF ₆ in DMSI	39	2.18	2.16	2.13	2.16	2.15
LiAsF ₆ in DMSI	40	2.18	2.15	2.13	2.14	2.12
LiAsF ₆ in DMSI	41	2.05	2.02	1.99	1.99	-
LiPF ₆ in DMSI	42	1.96	-	-	-	-
LiPF ₆ in DMSI	43	2.03	2.02	1.98	-	-
LiPF ₆ in DMSI	44	2.09	2.08	1.98	-	-
LiPF ₆ in DMSI	45	2.00	2.00	2.04	-	-
LiPF ₆ in PC/DME	46	2.23	2.21	2.06	-	-
LiPF ₆ in PC/DME	47	2.19	2.15	1.99	-	-
LiPF ₆ in PC/DME	48	2.03	1.93	-	-	-

<u>Electrolyte</u>	<u>Cell S/N</u>	700 mA load / 5 minutes	750 mA load / 5 minutes
LiAsF ₆ in DMSI	39	2.14	2.05
LiAsF ₆ in DMSI	40	2.11	2.00

The results for all the cell groups using the EP Energy Products-produced aluminum-gridded cathode are good. The 'baseline' cell trio using standard electrolyte (S/Ns 39-41) held up to high rate at least as well as the original trio produced and tested in the fifth cell series (S/Ns 36-38). The original cell trio had dropped near 2.0V by 660 ma, while it took 750 ma to do the same for the present trio of cells. This may have been aided by a 'rest period' the second cell trio got. Testing time ran out on a Friday when the cells were at 550 ma. The additional rest time over the weekend may have helped these cells perform a bit better as this possibly allowed more time for electrolyte to soak into the cathode, and the cells also may have been aided by the nickel tabbing used on the cathodes for this latest test series. It certainly showed that the cells last month were not a fluke test result as they appear to be repeatable.

The results for the alternate electrolytes tried were good, but none of the cells with alternates performed as well as those prepared with the standard electrolyte. Both the cells using PC/DME base and DMSI base, both with LiPF₆ electrolyte salt had dropped near or to the 2.0V cutoff by 550 ma. The graph below shows the average cell voltage at the end of the five minute load periods:

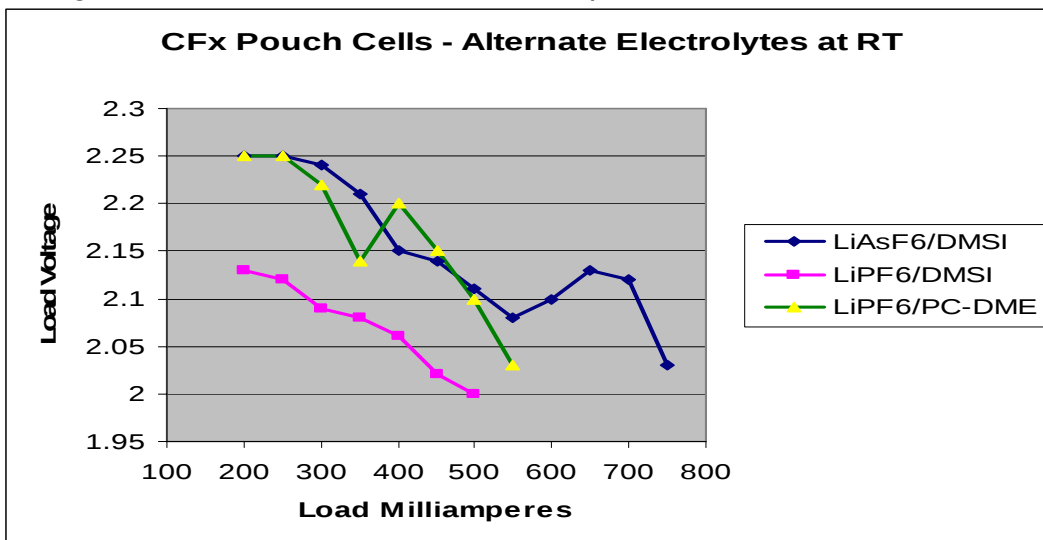


Figure 2 – Alternate Electrolyte Load Results
6.3 Extruded/Laminated Cathodes w/Alt. Electrolytes at 0°C

Testing on the sixth matrix of cells was expanded to gain some idea of the pulse ability of the design and the alternate electrolyte possibilities against cold temperature. The cells were cold soaked overnight at 0°C, then the pulse regimes were repeated, starting at a 200 ma draw as the room temperature testing had shown that this current level was not enough to begin stressing the cells. As before, the current was stepped up in 50 ma increments until the cells began dropping below the 2.0V level, indicating that they could not adequately support the imposed current draw. The results for the sixth series of test cells at 0°C are given in the Table below. The complete Table of test results is given at the end of this report in Appendix H.

Table 14 - Sixth Series Pouch Cell Pulse Test Results at 0°C

		200 mA load / 5 minutes / 0°C	250 mA load / 5 minutes / 0°C	300 mA load / 5 minutes / 0°C	350 mA load / 5 minutes / 0°C	400 mA load / 5 minutes / 0°C
<u>Electrolyte</u>	<u>Cell S/N</u>					
LiAsF ₆ in DMSI	39	2.33	2.20	2.17	2.12	2.10
LiAsF ₆ in DMSI	40	2.34	2.20	2.17	2.12	2.08
LiAsF ₆ in DMSI	41	2.18	2.07	2.02	1.94	--
LiPF ₆ in DMSI	42	2.10	2.03	1.98	2.02	--
LiPF ₆ in DMSI	43	2.20	2.12	2.09	2.02	2.00
LiPF ₆ in DMSI	44	2.20	2.11	2.08	2.02	1.98
LiPF ₆ in DMSI	45	2.14	2.05	2.01	1.93	--
LiPF ₆ in PC/DME	46	2.24	2.14	2.09	2.00	1.93
LiPF ₆ in PC/DME	47	2.21	2.08	2.01	1.93	--
LiPF ₆ in PC/DME	48	2.10	1.98	--	--	--

		450 mA load / 5 minutes / 0°C	500 mA load / 5 minutes / 0°C	550 mA load / 5 minutes / 0°C
<u>Electrolyte</u>	<u>Cell S/N</u>			
LiAsF ₆ in DMSI	39	2.04	2.01	1.98
LiAsF ₆ in DMSI	40	2.04	2.01	1.98
LiAsF ₆ in DMSI	41	--	--	--
LiPF ₆ in DMSI	42	--	--	--
LiPF ₆ in DMSI	43	1.94	--	--
LiPF ₆ in DMSI	44	--	--	--
LiPF ₆ in DMSI	45	--	--	--
LiPF ₆ in PC/DME	46	--	--	--
LiPF ₆ in PC/DME	47	--	--	--
LiPF ₆ in PC/DME	48	--	--	--

At the 0°C test temperature, the individual cells exhibited more variability than they had at room temperature. Cell No. 41 using the standard electrolyte 1.0M LiAsF₆ in DMSI and cell No. 48 using the electrolyte 1.0M LiPF₆ in PC/DME were more than 0.1V lower in load voltage than the other cells of their electrolyte group. By 350 ma test current, all of the cell groups had one or more cells that were just below or very near 2.0V under the load. The next current increment 'washed out' these cells. At 450 ma, all the cells from the alternate electrolyte groups had passed below 2.0V, and the two remaining cells of the standard electrolyte group were not holding much above 2.0V. As the two final cells of the standard group held on through 500 ma, testing was concluded at the 550 ma level with the two standard cells holding at 0.02V below 2.0V.

The standard cells did not do badly at 0°C, but the amount of voltage drop-off indicates that cold temperature rate performance will be a significant challenge. A graph of the performance of the test cell groups at the 0°C test is given below, using the average end-of-period voltage for the test groups.

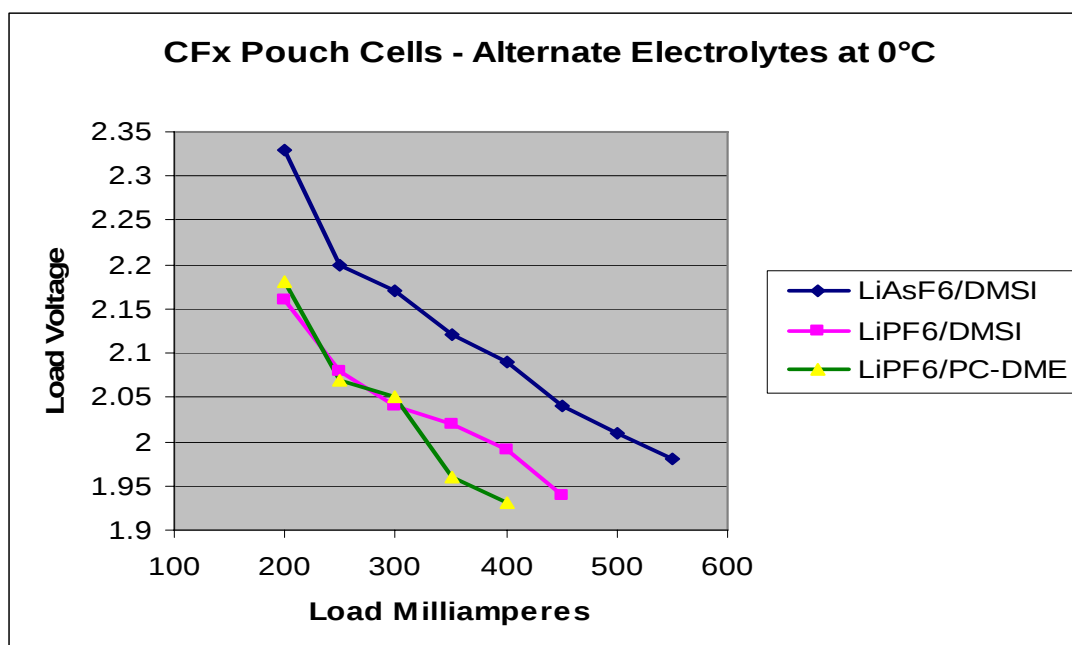


Figure 3 – Alternate Electrolyte Cells at 0°C

7.0 Results Summary & Discussion

The early work resulted in a pouch cell that closely duplicated the physical characteristics of the standard Li/CF_x DD cell LCF-112 using a cathode made by the same technology but at one half the thickness of the standard cell. This version proved to be very comparable to the standard cell at a 1/5th scalar. Attempts were then made to modify the performance to improve the rate capability of the pouch cell.

Alternate separations were tested, including employing only a single 16 micron layer of micro-porous polypropylene. These changes produced only a slight improvement in rate capability. This indicated that the approximately 0.006 inch inter-electrode spacing gap between the plates produced when the standard PPS non-woven separator and a 25 micron thick layer of micro-porous PP/PE/PP 'shutdown' separator are employed was not a controlling factor in the cell impedance. Should the project proceed to Phase 2 work in full sized wound D cells, it would be worth revisiting the use of the thin micro-porous separation layer as this did prove to have a slight advantage in rate capability and enhanced cell discharge capacity. With the cathode optimized for improved rate as has been proved possible this performance advantage might well widen further.

Attempts to improve cathode internal conductivity using highly structured engineered carbons produced no improvement over the use of the standard acetylene black long employed as a conductivity enhancer. As the alternate carbons investigated provided no improvement in rate capability, the use of increased percentages of conductive

carbons was not pursued. As well, cathode substrates more conductive than the standard coated stainless steel grid were investigated, including gold-plated stainless steel grid and coated titanium perforated foil. These produced no significant increase in rate capability.

Numerous methods to modify the wet-pasting technique employed to produce the cathodes were attempted, and those that produced thinner electrodes were tested in pouch cells. However, these produced only marginally superior results. Given that the likely final extrusion/lamination method employed to produce cathodes involves several densification steps, it may or may not be worthwhile pursuing additional post-processing densification steps if the program goes on to full sized cell construction.

A parallel effort was undertaken to produce cathodes by web coating using a PVDF-bound doctor blade technique akin to that used with lithium ion cells. The process was optimized to the point that physically viable electrode material was produced. EPT pouch cell trials of early material were disappointing in that the cells with 0.005 inch overall thickness web-coated cathodes and standard DMSI electrolyte were dropped below 2.0V by a load of 200 ma. The web-coating work has proceeded beyond this stage, but it is unlikely that final cathode material will reach EPT in time to be incorporated into test cells in Phase 1.

Cathode material produced by a Technologies sister plant, and employing a quite different method of production (extrusion/lamination) from the standard wet-pasted technique used by Product Development proved to be key in having the characteristics needed to produce a viable high rate cell. Contrary to our own experience using nickel or aluminum cathode substrates, which is that substantial attack occurs on the base metal, the extruded/laminated electrodes are still showing no signs of corrosive attack after many months of storage, and have performed at a level in pouch cells that makes going forward to full sized D cells practical with a good likelihood of success.

Pouch cells produced with Al substrate-based cathodes produced current capabilities that project Li/CF_x D cells that should run at 2 amperes.

8.0 Recommendations for Future Efforts

It is recommended that Phase 2 be initiated to proceed with work on the full sized D cell. The final web-coated cathode material should be evaluated at least in the pouch cell vehicle. Main effort should initially focus on establishing the performance baseline for an initial wound cell design, then efforts made to further improve the rate capability. One promising area in the improvement effort would be to see if from a cell storability standpoint a more conductive anode substrate can be employed to replace the 316L stainless steel foil that was used as a standard in the Phase 1 pouch cell work. With the rate improvement afforded by the Al-substrate extruded/laminated cathodes, a switch with the anode to nickel or even copper substrates could yield good results. A further look at the single-layer separation possibility should be done if the cell safety is not compromised. Further work in the full sized cells to establish the optimum electrolyte solution and salt should be performed, and the storability/safety of the cell designs should be investigated to ensure that a viable design is being base lined.

It would also be desirable to establish the cathode extrusion/lamination process at the US plant where Product Development resides to have a local source for the cathode material.

Appendix A

Initial Test Cells Load Results

Pouch Cell Short Loads**Initial Pouch Cell Series: 100 ma Load/10 Minutes**

<u>S/N</u>	<u>OCV</u>	<u>1 min</u>	<u>2 min</u>	<u>3 min</u>	<u>4 min</u>	<u>5 min</u>	<u>6 min</u>	<u>7 min</u>	<u>8 min</u>	<u>9 min</u>	<u>10 min</u>
1*	3.30	2.32	2.31	2.31	2.31	2.30	2.31	2.31	2.32	2.32	2.32
2*	3.30	2.31	2.29	2.28	2.28	2.27	2.27	2.27	2.27	2.27	2.27
3*	3.31	2.27	2.24	2.23	2.23	2.23	2.22	2.22	2.22	2.22	2.22
4*	3.30	2.29	2.28	2.27	2.27	2.26	2.26	2.26	2.27	2.27	2.27
5*	3.30	2.30	2.26	2.26	2.26	2.25	2.25	2.25	2.25	2.25	2.26
6*	2.95	2.28	2.28	2.28	2.28	2.28	2.28	2.28	2.28	2.28	2.28
7**	3.26	2.24	2.23	2.23	2.23	2.23	2.22	2.23	2.23	2.23	2.23
8**	3.27	2.28	2.25	2.25	2.24	2.24	2.24	2.24	2.24	2.25	2.25
9**	3.27	2.32	2.30	2.30	2.30	2.29	2.29	2.29	2.30	2.30	2.30
10**	2.99	2.35	2.32	2.31	2.30	2.30	2.30	2.30	2.30	2.30	2.31

*activated 46 hours prior to pulse

**activated 6 hrs prior to pulse

150 mA load / 10 minutes

<u>S/N</u>	<u>OCV</u>	<u>1 min</u>	<u>2 min</u>	<u>3 min</u>	<u>4 min</u>	<u>5 min</u>	<u>6 min</u>	<u>7 min</u>	<u>8 min</u>	<u>9 min</u>	<u>10 min</u>
1	3.20	2.20	2.19	2.18	2.19	2.18	2.18	2.19	2.19	2.19	2.19
2	3.17	2.11	2.11	2.11	2.12	2.12	2.12	2.13	2.13	2.14	2.14
3	3.17	2.10	2.09	2.09	2.10	2.10	2.11	2.11	2.11	2.12	2.12
4	3.17	2.14	2.14	2.14	2.14	2.15	2.15	2.16	2.16	2.17	2.17
5	3.18	2.16	2.16	2.16	2.17	2.18	2.18	2.19	2.19	2.19	2.20
6	3.12	2.21	2.20	2.19	2.19	2.19	2.19	2.20	2.20	2.20	2.20
7	3.19	2.15	2.14	2.15	2.15	2.16	2.17	2.17	2.17	2.17	2.17
8	3.21	2.15	2.15	2.15	2.15	2.16	2.16	2.17	2.17	2.18	2.18
9	3.18	2.20	2.19	2.20	2.20	2.21	2.21	2.21	2.22	2.22	2.22
10	3.15	2.21	2.20	2.20	2.21	2.21	2.21	2.22	2.22	2.22	2.23

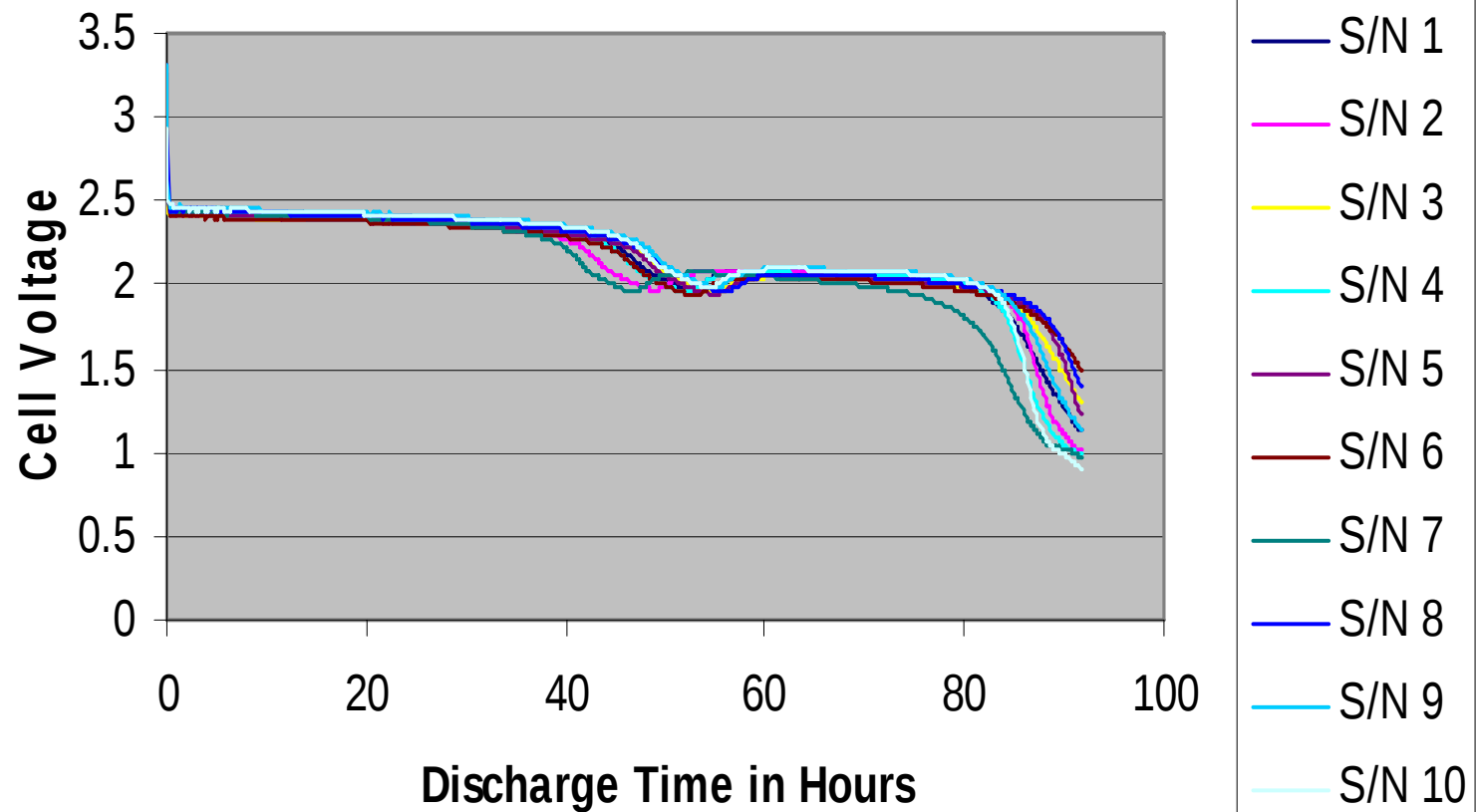
200 mA load / 10 minutes

<u>S/N</u>	<u>OCV</u>	<u>1 min</u>	<u>2 min</u>	<u>3 min</u>	<u>4 min</u>	<u>5 min</u>	<u>6 min</u>	<u>7 min</u>	<u>8 min</u>	<u>9 min</u>	<u>10 min</u>
1	3.04	2.16	2.16	2.16	2.16	2.16	2.16	2.16	2.16	2.16	2.16
2	3.02	2.13	2.12	2.13	2.13	2.13	2.13	2.14	2.14	2.14	2.15
3	3.03	2.07	2.07	2.07	2.07	2.07	2.07	2.08	2.08	2.08	2.08
4	3.02	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13
5	3.00	2.11	2.11	2.11	2.12	2.12	2.12	2.13	2.13	2.13	2.13
6	2.98	2.11	2.11	2.11	2.11	2.12	2.12	2.11	2.12	2.12	2.12
7	3.04	2.10	2.09	2.09	2.09	2.10	2.10	2.10	2.10	2.10	2.11
8	3.05	2.08	2.08	2.08	2.08	2.09	2.09	2.09	2.10	2.10	2.10
9	3.04	2.15	2.14	2.15	2.15	2.15	2.16	2.16	2.16	2.17	2.17
10	2.86	2.14	2.13	2.14	2.14	2.14	2.15	2.15	2.15	2.16	2.16

Appendix B

Initial Test Cells Discharge Graph

Initial Pouch Cells at 35 Ohm



Appendix C

Second Cell Series Load Results

Pouch Cell Short Loads - 2nd Build

100 mA load / 10 minutes

Date: 4-30-04

<u>S/N</u>	<u>OCV</u>	<u>1 min</u>	<u>2 min</u>	<u>3 min</u>	<u>4 min</u>	<u>5 min</u>	<u>6 min</u>	<u>7 min</u>	<u>8 min</u>	<u>9 min</u>	<u>10 min</u>
11*	3.34	2.08	2.09	2.12	2.15	2.16	2.17	2.18	2.19	2.19	2.20
12	3.43	1.99	2.05	2.09	2.12	2.14	2.15	2.16	2.17	2.18	2.19
13	3.45	2.01	2.06	2.10	2.12	2.13	2.14	2.15	2.17	2.18	2.19
14	3.46	2.02	2.07	2.10	2.11	2.14	2.16	2.16	2.17	2.18	2.19
15	3.43	1.82	1.87	1.89	1.91	1.92	1.93	1.93	1.94	1.94	1.95
16	3.43	1.79	1.85	1.87	1.89	1.90	1.90	1.90	1.91	1.92	1.92
17*	3.35	2.14	2.16	2.17	2.19	2.20	2.20	2.21	2.22	2.22	2.23
18	3.43	1.99	2.08	2.10	2.11	2.13	2.14	2.16	2.17	2.18	2.18

150 mA load / 10 minutes

Date: 4-30-04

<u>S/N</u>	<u>OCV</u>	<u>1 min</u>	<u>2 min</u>	<u>3 min</u>	<u>4 min</u>	<u>5 min</u>	<u>6 min</u>	<u>7 min</u>	<u>8 min</u>	<u>9 min</u>	<u>10 min</u>
11	3.01	2.03	2.03	2.03	2.04	2.04	2.05	2.05	2.06	2.06	2.07
12	3.19	2.07	2.08	2.08	2.09	2.10	2.10	2.11	2.11	2.12	2.12
13	3.19	2.07	2.07	2.08	2.08	2.08	2.09	2.10	2.10	2.10	2.11
14	3.23	2.06	2.06	2.06	2.07	2.08	2.09	2.09	2.10	2.10	2.11
15	3.23	1.81	1.81	1.82	1.84	1.85	1.87	1.88	1.90	1.92	1.93
16	3.23	1.79	1.81	1.81	1.83	1.83	1.85	1.86	1.88	1.89	1.89
17	3.11	2.09	2.09	2.10	2.10	2.11	2.12	2.13	2.13	2.13	2.13
18	3.13	2.16	2.06	2.06	2.07	2.08	2.08	2.08	2.09	2.09	2.10

200 mA load / 10 minutes

Date: 4-30-04

<u>S/N</u>	<u>OCV</u>	<u>1 min</u>	<u>2 min</u>	<u>3 min</u>	<u>4 min</u>	<u>5 min</u>	<u>6 min</u>	<u>7 min</u>	<u>8 min</u>	<u>9 min</u>	<u>10 min</u>
11	3.00	1.99	1.99	1.99	1.99	1.99	1.99	1.99	2.00	2.00	2.00
12	3.04	2.03	2.03	2.03	2.04	2.04	2.04	2.05	2.05	2.05	2.05
13	3.07	2.02	2.02	2.03	2.03	2.03	2.03	2.03	2.04	2.04	2.04
14	3.07	2.02	2.02	2.02	2.03	2.03	2.03	2.04	2.04	2.04	2.04
15	3.07	1.86	1.86	1.86	1.86	1.87	1.88	1.88	1.89	1.89	1.89
16	3.08	1.77	1.76	1.77	1.78	1.79	1.80	1.81	1.81	1.82	1.83
17	3.01	2.06	2.05	2.06	2.06	2.07	2.07	2.08	2.08	2.09	2.09
18	3.10	1.97	1.98	1.98	1.99	1.99	2.00	2.00	2.01	2.01	2.01

* Cell S/N's 11 and 17 had an initial pulse on 4-29-04, the timer was messed up on the load box
they both received approximately 3 minute 100 mA pulse the day before the above results

Appendix D

Third Cell Series Load Results

3rd Build Pouch Cell Short Loads

100 mA load / 10 minutes

Date:5-19-04

<u>S/N</u>	<u>OCV</u>	<u>1 min</u>	<u>2 min</u>	<u>3 min</u>	<u>4 min</u>	<u>5 min</u>	<u>6 min</u>	<u>7 min</u>	<u>8 min</u>	<u>9 min</u>	<u>10 min</u>
19	3.33	2.24	2.23	2.24	2.24	2.24	2.24	2.25	2.26	2.26	2.26
20	3.33	2.22	2.22	2.22	2.22	2.22	2.23	2.23	2.25	2.27	2.27
21	3.30	2.27	2.27	2.27	2.27	2.27	2.27	2.27	2.27	2.27	2.27
22	3.30	2.28	2.28	2.28	2.28	2.27	2.27	2.27	2.27	2.27	2.27
23	3.28	2.19	2.18	2.18	2.18	2.18	2.18	2.18	2.18	2.18	2.18
24	3.29	2.18	2.18	2.18	2.18	2.18	2.17	2.18	2.18	2.18	2.18

150 mA load / 10 minutes

Date: 5-19-04

<u>S/N</u>	<u>OCV</u>	<u>1 min</u>	<u>2 min</u>	<u>3 min</u>	<u>4 min</u>	<u>5 min</u>	<u>6 min</u>	<u>7 min</u>	<u>8 min</u>	<u>9 min</u>	<u>10 min</u>
19	2.91	2.14	2.15	2.15	2.18	2.18	2.19	2.21	2.21	2.21	2.22
20	2.98	2.16	2.18	2.18	2.19	2.19	2.20	2.20	2.21	2.21	2.21
21	2.99	2.13	2.13	2.16	2.17	2.17	2.18	2.18	2.18	2.19	2.19
22	3.00	2.17	2.17	2.18	2.18	2.17	2.18	2.18	2.19	2.19	2.20
23	2.99	2.19	2.19	2.20	2.20	2.21	2.21	2.22	2.22	2.22	2.23
24	2.99	2.18	2.18	2.18	2.19	2.19	2.20	2.20	2.20	2.20	2.21

200 mA load / 10 minutes

Date: 5-20-04

<u>S/N</u>	<u>OCV</u>	<u>1 min</u>	<u>2 min</u>	<u>3 min</u>	<u>4 min</u>	<u>5 min</u>	<u>6 min</u>	<u>7 min</u>	<u>8 min</u>	<u>9 min</u>	<u>10 min</u>
19	3.18	2.12	2.11	2.11	2.11	2.11	2.11	2.12	2.12	2.12	2.13
20	3.18	2.14	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13
21	3.19	2.15	2.14	2.13	2.13	2.14	2.14	2.14	2.14	2.14	2.14
22	3.19	2.14	2.14	2.14	2.14	2.15	2.15	2.15	2.15	2.16	2.16
23	3.18	2.16	2.15	2.14	2.14	2.15	2.15	2.15	2.15	2.15	2.15
24	3.18	2.13	2.11	2.11	2.12	2.12	2.12	2.12	2.12	2.12	2.12

Appendix E

Fourth Cell Series Load Results

Pouch Cell Short Loads - 4th Build

100 mA load / 10 minutes

Date: 6-9-04

<u>S/N</u>	<u>OCV</u>	<u>1 min</u>	<u>2 min</u>	<u>3 min</u>	<u>4 min</u>	<u>5 min</u>	<u>6 min</u>	<u>7 min</u>	<u>8 min</u>	<u>9 min</u>	<u>10 min</u>
25	3.34	2.30	2.28	2.29	2.29	2.29	2.29	2.29	2.30	2.30	2.30
26	3.31	2.31	2.29	2.29	2.29	2.29	2.29	2.29	2.29	2.30	2.30
27	3.36	2.20	2.19	2.20	2.21	2.21	2.21	2.22	2.22	2.22	2.22
28	3.35	2.35	2.33	2.33	2.33	2.33	2.33	2.33	2.33	2.33	2.33
29	3.34	2.34	2.32	2.32	2.33	2.32	2.33	2.32	2.33	2.33	2.33

150 mA load / 10 minutes

Date: 6-9-04

<u>S/N</u>	<u>OCV</u>	<u>1 min</u>	<u>2 min</u>	<u>3 min</u>	<u>4 min</u>	<u>5 min</u>	<u>6 min</u>	<u>7 min</u>	<u>8 min</u>	<u>9 min</u>	<u>10 min</u>
25	3.08	2.21	2.20	2.20	2.20	2.20	2.21	2.21	2.21	2.21	2.21
26	2.98	2.13	2.12	2.13	2.14	2.14	2.15	2.16	2.13	2.16	2.17
27	2.99	2.16	2.17	2.17	2.17	2.18	2.18	2.19	2.19	2.19	2.20
28	3.00	2.25	2.24	2.24	2.24	2.25	2.25	2.25	2.25	2.26	2.26
29	3.00	2.22	2.21	2.21	2.22	2.22	2.23	2.23	2.23	2.24	2.24

200 mA load / 10 minutes

Date: 6-9-04

<u>S/N</u>	<u>OCV</u>	<u>1 min</u>	<u>2 min</u>	<u>3 min</u>	<u>4 min</u>	<u>5 min</u>	<u>6 min</u>	<u>7 min</u>	<u>8 min</u>	<u>9 min</u>	<u>10 min</u>
25	3.03	2.13	2.13	2.12	2.13	2.13	2.13	2.13	2.13	2.13	2.13
26	2.98	2.15	2.14	2.14	2.14	2.14	2.14	2.15	2.15	2.15	2.15
27	3.00	2.17	2.17	2.17	2.17	2.18	2.18	2.18	2.18	2.18	2.18
28	3.02	2.17	2.17	2.16	2.16	2.16	2.17	2.17	2.17	2.17	2.18
29	3.00	2.16	2.15	2.15	2.15	2.15	2.15	2.16	2.16	2.16	2.16

Appendix F

Fifth Cell Series Load Results

5th Build Pouch Cell Short Loads-

100 mA load / 10 minutes

Date:11-23-04

<u>S/N</u>	<u>OCV</u>	<u>1 min</u>	<u>2 min</u>	<u>3 min</u>	<u>4 min</u>	<u>5 min</u>	<u>6 min</u>	<u>7 min</u>	<u>8 min</u>	<u>9 min</u>
30	3.37	2.61	2.51	2.39	2.33	2.30	2.29	2.29	2.29	2.29
31	3.23	2.54	2.42	2.34	2.31	2.30	2.29	2.29	2.29	2.29
32	3.11	2.54	2.45	2.36	2.33	2.32	2.31	2.31	2.31	2.31
33	3.40	2.11	2.14	2.15	2.15	2.14	--	--	--	--
34	3.25	2.10	2.14	2.16	2.17	2.17	--	--	--	--
35	3.25	2.11	2.16	2.18	2.19	2.20	--	--	--	--
36	3.40	2.61	2.44	2.36	2.34	2.34	2.33	2.34	2.34	2.35
37	3.40	2.60	2.44	2.36	2.34	2.34	2.34	2.34	2.35	2.35
38	3.39	2.58	2.41	2.35	2.34	2.34	2.34	2.34	2.35	2.35

150 mA load / 5 minutes

Date: 11-23-04

<u>S/N</u>	<u>OCV*</u>	<u>1 min</u>	<u>2 min</u>	<u>3 min</u>	<u>4 min</u>	<u>5 min</u>	<u>6 min</u>	<u>7 min</u>	<u>8 min</u>	<u>9 min</u>
30	2.99	2.18	2.16	2.17	2.17	2.18	--	--	--	--
31	3.07	2.20	2.18	2.19	2.20	2.20	--	--	--	--
32	2.98	2.27	2.27	2.27	2.28	2.28	--	--	--	--
33	2.87	2.01	1.98	1.94	1.91	1.87	--	--	--	--
34	3.03	2.02	2.01	2.00	1.99	1.98	--	--	--	--
35	3.04	2.10	2.10	2.10	2.10	2.10	--	--	--	--
36	3.04	2.30	2.30	2.31	2.31	2.31	--	--	--	--
37	3.04	2.29	2.29	2.30	2.31	2.32	--	--	--	--
38	3.01	2.29	2.30	2.30	2.31	2.32	--	--	--	--

*recovery OCV only as loads run close together

Fifth Cell Series Load Tests Cont'd

200 mA load / 5 minutes

Date: 11-23-04

<u>S/N</u>	<u>OCV*</u>	<u>1 min</u>	<u>2 min</u>	<u>3 min</u>	<u>4 min</u>	<u>5 min</u>	<u>6 min</u>	<u>7 min</u>	<u>8 min</u>	<u>9 min</u>
30	2.95	2.12	2.12	2.12	2.13	2.13	--	--	--	--
31	2.94	2.14	2.14	2.15	2.16	2.16	--	--	--	--
32	2.94	2.25	2.25	2.25	2.26	2.26	--	--	--	--
33	2.94	1.72	1.69	1.66	1.64	1.63	1.63	--	--	--
34	2.95	1.88	1.88	1.87	1.88	1.88	--	--	--	--
35	2.95	2.02	2.02	2.02	2.02	2.02				
36	2.91	2.27	2.28	2.29	2.29	2.30				
37	2.93	2.28	2.28	2.28	2.29	2.29				
38	2.90	2.27	2.27	2.28	2.29	2.29				

250 mA load / 10 minutes

Date: 12-01-04

<u>S/N</u>	<u>OCV</u>	<u>1 min</u>	<u>2 min</u>	<u>3 min</u>	<u>4 min</u>	<u>5 min</u>	<u>6 min</u>	<u>7 min</u>	<u>8 min</u>	<u>9 min</u>	<u>10 min</u>
30	3.29	2.16	2.13	2.12	2.12	2.13	2.13	2.13	2.13	2.13	2.14
31	3.32	2.22	2.18	2.17	2.17	2.18	2.18	2.18	2.18	2.18	2.18
32	3.34	2.35	2.26	2.25	2.25	2.26	2.26	2.26	2.27	2.27	2.27
36	3.37	2.36	2.30	2.30	2.30	2.31	2.31	2.31	2.32	2.32	2.32
37	3.35	2.35	2.29	2.29	2.29	2.29	2.30	2.30	2.30	2.31	2.31
38	3.37	2.38	2.31	2.30	2.31	2.31	2.31	2.32	2.32	2.32	2.33

300 mA load / 5 minutes

Date: 12-01-04

<u>S/N</u>	<u>OCV*</u>	<u>1 min</u>	<u>2 min</u>	<u>3 min</u>	<u>4 min</u>	<u>5 min</u>	<u>6 min</u>	<u>7 min</u>	<u>8 min</u>	<u>9 min</u>	<u>10 min</u>
30	3.00	2.03	2.02	2.02	2.02	2.02	--	--	--	--	--
31	3.00	2.10	2.09	2.09	2.08	2.09					
32	2.98	2.20	2.19	2.19	2.19	2.19					
36	3.06	2.26	2.25	2.25	2.24	2.25					
37	3.05	2.24	2.23	2.23	2.23	2.23					
38	3.06	2.26	2.25	2.25	2.24	2.24					

*recovery OCV only as loads run close together

Fifth Cell Series Load Tests Cont'd

350 mA load / 5 minutes

<u>S/N</u>	<u>OCV*</u>	<u>1 min</u>	<u>2 min</u>	<u>3 min</u>	<u>4 min</u>	<u>5 min</u>	Date: 12-01-04 <u>6 min</u>	<u>7 min</u>	<u>8 min</u>	<u>9 min</u>	<u>10 min</u>
30	2.93	1.96	1.95	1.95	1.95	1.95	--	--	--	--	--
31	2.92	2.02	2.02	2.02	2.02	2.02					
32	2.89	2.11	2.10	2.10	2.10	2.10					
36	2.94	2.18	2.18	2.18	2.18	2.19					
37	2.95	2.17	2.16	2.17	2.17	2.17					
38	2.94	2.18	2.17	2.18	2.18	2.18					

400 mA load / 5 minutes

<u>S/N</u>	<u>OCV*</u>	<u>1 min</u>	<u>2 min</u>	<u>3 min</u>	<u>4 min</u>	<u>5 min</u>	Date: 12-01-04 <u>6 min</u>	<u>7 min</u>	<u>8 min</u>	<u>9 min</u>	<u>10 min</u>
30	--	--	--	--	--	--	--	--	--	--	--
31	2.87	1.98	1.98	1.99	1.99	1.99					
32	2.87	2.04	2.04	2.04	2.05	2.05					
36	2.90	2.14	2.14	2.15	2.15	2.16					
37	2.91	2.14	2.13	2.14	2.15	2.15					
38	2.90	2.14	2.15	2.16	2.16	2.17					

450 mA load / 5 minutes

<u>S/N</u>	<u>OCV*</u>	<u>1 min</u>	<u>2 min</u>	<u>3 min</u>	<u>4 min</u>	<u>5 min</u>	Date: 12-01-04 <u>6 min</u>	<u>7 min</u>	<u>8 min</u>	<u>9 min</u>	<u>10 min</u>
36	2.99	2.10	2.10	2.11	2.11	2.12					
37	3.00	2.09	2.10	2.10	2.11	2.11					
38	2.99	2.11	2.12	2.13	2.14	2.14					

500 mA load / 5 minutes

<u>S/N</u>	<u>OCV*</u>	<u>1 min</u>	<u>2 min</u>	<u>3 min</u>	<u>4 min</u>	<u>5 min</u>	Date: 12-01-04 <u>6 min</u>	<u>7 min</u>	<u>8 min</u>	<u>9 min</u>	<u>10 min</u>
36	2.96	2.09	2.10	2.11	2.11	2.12					
37	2.96	2.09	2.10	2.11	2.11	2.12					
38	2.96	2.10	2.11	2.12	2.12	2.13					

*recovery OCV only as loads run close together

Fifth Cell Series Load Tests Cont'd

560 mA load / 5 minutes

<u>S/N</u>	<u>OCV*</u>	<u>1 min</u>	<u>2 min</u>	<u>3 min</u>	<u>4 min</u>	<u>5 min</u>
36	2.85	2.03	2.04	2.06	2.07	2.08
37	2.85	2.06	2.07	2.07	2.08	2.09
38	2.85	2.07	2.09	2.10	2.10	2.11

Date: 12-01-04

6 min 7 min 8 min 9 min 10 min

600 mA load / 5 minutes

<u>S/N</u>	<u>OCV*</u>	<u>1 min</u>	<u>2 min</u>	<u>3 min</u>	<u>4 min</u>	<u>5 min</u>
36	2.86	2.02	2.04	2.05	2.06	2.07
37	2.88	2.02	2.04	2.05	2.05	2.06
38	2.94	2.04	2.05	2.06	2.07	2.08

Date: 12-01-04

6 min 7 min 8 min 9 min 10 min

660 mA load / 5 minutes

<u>S/N</u>	<u>OCV*</u>	<u>1 min</u>	<u>2 min</u>	<u>3 min</u>	<u>4 min</u>	<u>5 min</u>
36	2.94	1.98	2.00	2.01	2.02	2.03
37	2.95	1.99	2.01	2.01	2.02	2.02
38	2.95	2.01	2.03	2.03	2.04	2.05

Date: 12-01-04

6 min 7 min 8 min 9 min 10 min

Appendix G

Sixth Cell Series Load Results

6th Build Pouch Cell Short Loads			(constant current pulse system)				
200 mA load / 5 minutes				Date:12-16-04			
S/N	Electrolyte	OCV	1 min	2 min	3 min	4 min	5 min
39*	1.0M LiAsF6 in DMSI	2.97	2.34	2.33	2.33	2.33	2.34
40*	"	3.15	2.32	2.24	2.24	2.24	2.25
41	"	3.41	2.27	2.20	2.18	2.19	2.19
42	1.0M LiPF6 in DMSI	3.59	2.16	2.09	2.09	2.10	2.11
43	"	3.59	2.24	2.12	2.11	2.12	2.13
44	"	3.58	2.30	2.17	2.15	2.15	2.16
45	"	3.59	2.23	2.12	2.10	2.11	2.12
46	1.0M LiPF6 in PC/DME	3.54	2.28	2.24	2.25	2.27	2.28
47	"	3.41	2.16	2.17	2.20	2.23	2.25
48	"	2.90	2.22	2.20	2.20	2.21	2.22

*these two cells received accidental short charging load

250 mA load / 5 minutes				Date: 12-16-04			
S/N	Electrolyte	OCV**	1 min	2 min	3 min	4 min	5 min
39	1.0M LiAsF6 in DMSI	2.97	2.30	2.30	2.30	2.30	2.31
40	"	3.05	2.22	2.23	2.24	2.24	2.25
41	"	3.11	2.18	2.16	2.16	2.16	2.16
42	1.0M LiPF6 in DMSI	3.37	2.05	2.04	2.05	2.06	2.07
43	"	3.33	2.11	2.10	2.11	2.11	2.12
44	"	3.29	2.16	2.13	2.14	2.15	2.16
45	"	3.30	2.12	2.10	2.10	2.11	2.12
46	1.0M LiPF6 in PC/DME	3.12	1.98	2.00	2.01	2.02	2.03
47	"	3.13	2.22	2.22	2.23	2.24	2.25
48	"	3.11	2.15	2.15	2.16	2.15	2.15

**OCVs reflect recovery point OCVs as loads were run close together

6th Build Pouch Cells Short Loads Cont'd

300 mA load / 5 minutes			Date: 12-16-04				
S/N	Electrolyte	OCV**	1 min	2 min	3 min	4 min	5 min
39	1.0M LiAsF6 in DMSI	3.10	2.29	2.28	2.29	2.29	2.29
40	"	2.91	2.23	2.23	2.24	2.24	2.25
41	"	3.22	2.15	2.14	2.14	2.14	2.14
42	1.0M LiPF6 in DMSI	3.43	2.07	2.03	2.03	2.03	2.04
43	"	3.39	2.12	2.09	2.10	2.10	2.11
44	"	3.35	2.17	2.13	2.14	2.14	2.15
45	"	3.41	2.14	2.09	2.08	2.09	2.09
46	1.0M LiPF6 in PC/DME	3.10	2.22	2.22	2.22	2.23	2.23
47	"	3.09	2.22	2.22	2.22	2.23	2.23
48	"	3.10	2.09	2.07	2.07	2.06	2.07

**OCVs reflect recovery point OCVs as loads were run close together

350 mA load / 5 minutes			Date: 12-17-04				
S/N	Electrolyte	OCV**	1 min	2 min	3 min	4 min	5 min
39	1.0M LiAsF6 in DMSI	3.10	2.33	2.29	2.29	2.25	2.25
40	"	3.15	2.21	2.21	2.21	2.21	2.22
41	"	2.96	2.12	2.11	2.11	2.11	2.11
42	1.0M LiPF6 in DMSI	3.04	2.03	2.02	2.02	2.02	2.02
43	"	2.99	2.09	2.08	2.08	2.08	2.09
44	"	3.02	2.12	2.12	2.12	2.13	2.13
45	"	3.10	2.06	2.06	2.06	2.06	2.06
46	1.0M LiPF6 in PC/DME	3.12	2.18	2.19	2.19	2.19	2.20
47	"	3.12	2.18	2.18	2.19	2.19	2.19
48	"	3.13	2.03	2.01	2.01	2.01	2.02

**OCVs reflect recovery point OCVs as loads were run close together

6th Build Pouch Cells Short Loads Cont'd

400 mA load / 5 minutes			Date: 12-17-04				
S/N	Electrolyte	OCV**	1 min	2 min	3 min	4 min	5 min
39	1.0M LiAsF6 in DMSI	2.93	2.23	2.22	2.23	2.23	2.23
40	"	2.98	2.20	2.20	2.20	2.20	2.21
41	"	3.01	2.10	2.09	2.09	2.09	2.09
42	1.0M LiPF6 in DMSI	3.13	2.02	2.02	2.01	2.01	2.01
43	"	3.07	2.09	2.08	2.08	2.08	2.08
44	"	2.96	2.12	2.12	2.12	2.12	2.12
45	"	3.06	2.05	2.04	2.04	2.04	2.04
46^	1.0M LiPF6 in PC/DME	3.40	2.29	2.26	2.26	2.26	2.27
47^	"	3.39	2.26	2.24	2.24	2.24	2.24
48^	"	3.35	2.17	2.13	2.11	2.10	2.09

^S/N 8, 9 and 10 loads performed on 12/20/04

**OCVs for cells 1-7 reflect recovery point OCVs as loads were run close together

450 mA load / 5 minutes			Date: 12-17-04				
S/N	Electrolyte	OCV**	1 min	2 min	3 min	4 min	5 min
39	1.0M LiAsF6 in DMSI	2.96	2.18	2.18	2.18	2.18	2.18
40	"	3.00	2.17	2.17	2.17	2.17	2.18
41	"	3.03	2.06	2.05	2.04	2.05	2.05
42	1.0M LiPF6 in DMSI	3.09	1.99	1.98	1.96	1.96	1.96
43	"	3.04	2.04	2.03	2.03	2.03	2.03
44	"	3.00	2.09	2.09	2.09	2.09	2.09
45	"	3.00	2.02	2.01	2.00	2.00	2.00
46^	1.0M LiPF6 in PC/DME	3.04	2.23	2.23	2.23	2.23	2.23
47^	"	3.04	2.20	2.19	2.19	2.19	2.19
48^	"	3.06	2.04	2.02	2.02	2.03	2.03

^S/N8, 9 and 10 loads performed on 12/20/04

**OCVs for cells reflect recovery point OCVs as loads were run close together

6th Build Pouch Cells Short Loads Cont'd

500 mA load / 5 minutes			Date: 12-17-04				
S/N	Electrolyte	OCV**	1 min	2 min	3 min	4 min	5 min
39	1.0M LiAsF6 in DMSI	2.97	2.15	2.15	2.15	2.15	2.16
40	"	3.01	2.15	2.15	2.15	2.15	2.15
41	"	3.03	2.03	2.01	2.01	2.02	2.02
42	1.0M LiPF6 in DMSI	--	--	--	--	--	--
43	"	3.09	2.04	2.02	2.02	2.02	2.02
44	"	3.05	2.09	2.08	2.08	2.08	2.08
45	"	3.08	2.01	2.00	2.00	2.00	2.00
46^	1.0M LiPF6 in PC/DME	3.02	2.22	2.21	2.21	2.21	2.21
47^	"	3.00	2.18	2.16	2.16	2.15	2.15
48^	"	3.22	1.96	1.93	1.93	1.93	1.93

^S/N 8, 9 and 10 loads performed on 12/20/04

**OCVs for cells reflect recovery point OCVs as loads were run close together

550 mA load / 5 minutes			Date: 12-17-04				
S/N	Electrolyte	OCV**	1 min	2 min	3 min	4 min	5 min
39	1.0M LiAsF6 in DMSI	2.92	2.12	2.12	2.12	2.12	2.13
40	"	2.95	2.12	2.12	2.12	2.12	2.13
41	"	2.96	1.98	1.98	1.98	1.98	1.99
42	1.0M LiPF6 in DMSI	--	--	--	--	--	--
43	"	2.91	2.00	1.99	1.99	1.98	1.98
44	"	2.90	2.00	1.99	1.98	1.98	1.98
45	"	2.90	2.05	2.04	2.04	2.04	2.04
46^	1.0M LiPF6 in PC/DME	3.16	2.06	2.06	2.06	2.06	2.06
47^	"	3.17	1.98	1.98	1.98	1.98	1.99
48^	"	--	--	--	--	--	--

^S/N 8, 9 and 10 loads performed on 12/20/04

**OCVs for cells reflect recovery point OCVs as loads were run close together

6th Build Pouch Cells Short Loads Cont'd

600 mA load / 5 minutes			Date: 12-20-04				
S/N	Electrolyte	OCV	1 min	2 min	3 min	4 min	5 min
39	1.0M LiAsF6 in DMSI	3.35	2.22	2.16	2.15	2.15	2.16
40	"	3.28	2.17	2.14	2.14	2.14	2.14
41	"	3.28	2.02	1.99	1.99	1.99	1.99

650 mA load / 5 minutes			Date: 12-20-04				
S/N	Electrolyte	OCV**	1 min	2 min	3 min	4 min	5 min
39	1.0M LiAsF6 in DMSI	2.89	2.14	2.14	2.14	2.14	2.15
40	"	2.93	2.11	2.10	2.11	2.11	2.12

**OCVs for cells reflect recovery point OCVs as loads were run close together

700 mA load / 5 minutes			Date: 12-20-04				
S/N	Electrolyte	OCV**	1 min	2 min	3 min	4 min	5 min
39	1.0M LiAsF6 in DMSI	2.88	2.14	2.13	2.14	2.14	2.14
40	"	2.87	2.09	2.09	2.10	2.10	2.11

**OCVs for cells reflect recovery point OCVs as loads were run close together

750 mA load / 5 minutes			Date: 12-20-04				
S/N	Electrolyte	OCV**	1 min	2 min	3 min	4 min	5 min
39	1.0M LiAsF6 in DMSI	3.03	2.06	2.05	2.05	2.05	2.05
40	"	3.07	2.00	1.99	1.99	1.99	2.00

**OCVs for cells reflect recovery point OCVs as loads were run same day as previous load

Appendix H

Sixth Cell Series Load Results at 0°C

6th Build Pouch Cell Short Loads			(constant current pulse system)				
200 mA load / 5 minutes @ 0°C				Date:1-11-05			
S/N	Electrolyte	OCV	1 min	2 min	3 min	4 min	5 min
39	1.0M LiAsF6 in DMSI	3.57	2.71	2.52	2.36	2.34	2.33
40	"	3.45	2.73	2.52	2.42	2.37	2.34
41	"	3.37	2.47	2.34	2.25	2.21	2.18
42	1.0M LiPF6 in DMSI	3.63	2.45	2.26	2.17	2.13	2.10
43	"	3.63	2.64	2.39	2.29	2.24	2.20
44	"	3.30	2.48	2.34	2.26	2.22	2.20
45	"	3.63	2.60	2.32	2.22	2.16	2.14
46	1.0M LiPF6 in PC/DME	3.56	2.51	2.36	2.30	2.26	2.24
47	"	3.50	2.45	2.32	2.26	2.22	2.21
48	"	3.45	2.34	2.21	2.15	2.12	2.10

250 mA load / 5 minutes @ 0°C				Date: 1-11-05			
S/N	Electrolyte	OCV*	1 min	2 min	3 min	4 min	5 min
39	1.0M LiAsF6 in DMSI	2.86	2.29	2.23	2.21	2.20	2.20
40	"	2.88	2.29	2.24	2.22	2.21	2.20
41	"	2.90	2.14	2.10	2.09	2.08	2.07
42	1.0M LiPF6 in DMSI	3.04	2.07	2.05	2.04	2.04	2.03
43	"	2.96	2.17	2.13	2.12	2.12	2.12
44	"	2.97	2.17	2.14	2.12	2.11	2.11
45	"	3.01	2.11	2.08	2.07	2.06	2.05
46	1.0M LiPF6 in PC/DME	2.97	2.15	2.14	2.14	2.14	2.14
47	"	2.97	2.12	2.10	2.09	2.09	2.08
48	"	2.98	2.05	2.03	2.01	1.98	1.98

*OCVs reflect recovery point OCVs as loads were run close together

6th Build Pouch Cell Short Loads at 0°C Cont'd

300 mA load / 5 minutes @ 0°C				Date: 1-11-05			
<u>S/N</u>	<u>Electrolyte</u>	<u>OCV*</u>	<u>1 min</u>	<u>2 min</u>	<u>3 min</u>	<u>4 min</u>	<u>5 min</u>
39	1.0M LiAsF6 in DMSI	2.80	2.21	2.18	2.18	2.18	2.17
40	"	2.82	2.18	2.17	2.17	2.17	2.17
41	"	2.87	2.05	2.04	2.04	2.03	2.02
42	1.0M LiPF6 in DMSI	2.93	2.02	2.00	1.99	1.98	1.98
43	"	2.91	2.10	2.09	2.09	2.09	2.09
44	"	2.91	2.11	2.09	2.08	2.08	2.08
45	"	2.95	2.05	2.03	2.03	2.02	2.01
46	1.0M LiPF6 in PC/DME	2.96	2.10	2.09	2.09	2.09	2.09
47	"	2.96	2.06	2.04	2.03	2.03	2.01
48	"	--	--	--	--	--	--

*OCVs reflect recovery point OCVs as loads were run close together

350 mA load / 5 minutes @ 0°C				Date: 1-11-05			
<u>S/N</u>	<u>Electrolyte</u>	<u>OCV*</u>	<u>1 min</u>	<u>2 min</u>	<u>3 min</u>	<u>4 min</u>	<u>5 min</u>
39	1.0M LiAsF6 in DMSI	2.82	2.15	2.13	2.13	2.13	2.12
40	"	2.84	2.14	2.12	2.12	2.12	2.12
41	"	2.88	1.98	1.96	1.95	1.94	1.94
42	1.0M LiPF6 in DMSI	2.85	2.05	2.04	2.03	2.03	2.02
43	"	2.85	2.05	2.04	2.03	2.03	2.02
44	"	2.86	2.05	2.04	2.03	2.03	2.02
45	"	2.85	1.98	1.97	1.95	1.94	1.93
46	1.0M LiPF6 in PC/DME	2.92	2.02	2.01	2.01	2.00	2.00
47	"	2.92	1.96	1.95	1.94	1.94	1.93
48	"	--	--	--	--	--	--

*OCVs reflect recovery point OCVs as loads were run close together

6th Build Pouch Cell Short Loads at 0°C Cont'd

400 mA load / 5 minutes @ 0°C				Date: 1-11-05			
<u>S/N</u>	<u>Electrolyte</u>	<u>OCV*</u>	<u>1 min</u>	<u>2 min</u>	<u>3 min</u>	<u>4 min</u>	<u>5 min</u>
39	1.0M LiAsF6 in DMSI	2.77	2.12	2.11	2.11	2.10	2.10
40	"	2.80	2.10	2.09	2.09	2.08	2.08
41		--	--	--	--	--	--
42	1.0M LiPF6 in DMSI	--	--	--	--	--	--
43	"	2.82	2.03	2.02	2.01	2.00	2.00
44	"	2.82	2.01	2.00	1.99	1.98	1.98
45		--	--	--	--	--	--
46	1.0M LiPF6 in PC/DME	2.89	1.96	1.95	1.94	1.93	1.93
47		--	--	--	--	--	--
48		--	--	--	--	--	--

*OCVs for cells reflect recovery point OCVs as loads were run close together

450 mA load / 5 minutes @ 0°C				Date: 1-11-05			
<u>S/N</u>	<u>Electrolyte</u>	<u>OCV*</u>	<u>1 min</u>	<u>2 min</u>	<u>3 min</u>	<u>4 min</u>	<u>5 min</u>
39	1.0M LiAsF6 in DMSI	2.74	2.05	2.05	2.04	2.04	2.04
40	"	2.76	2.05	2.05	2.04	2.04	2.04
41		--	--	--	--	--	--
42	1.0M LiPF6 in DMSI	--	--	--	--	--	--
43	"	2.79	1.97	1.96	1.95	1.94	1.94
44		--	--	--	--	--	--
45		--	--	--	--	--	--

*OCVs for cells reflect recovery point OCVs as loads were run close together

500 mA load / 5 minutes @ 0°C				Date: 1-11-05			
<u>S/N</u>	<u>Electrolyte</u>	<u>OCV*</u>	<u>1 min</u>	<u>2 min</u>	<u>3 min</u>	<u>4 min</u>	<u>5 min</u>
39	1.0M LiAsF6 in DMSI	2.68	2.02	2.02	2.01	2.01	2.01
40		2.71	2.02	2.01	2.01	2.01	2.01

*OCVs for cells reflect recovery point OCVs as loads were run close together

6th Build Pouch Cell Short Loads at 0°C Cont'd

550 mA load / 5 minutes @ 0°C				Date: 1-11-05			
<u>S/N</u>	<u>Electrolyte</u>	<u>OCV*</u>	<u>1 min</u>	<u>2 min</u>	<u>3 min</u>	<u>4 min</u>	<u>5 min</u>
39	1.0M LiAsF6 in DMSI	2.65	1.99	1.98	1.98	1.98	1.98
40	"	2.67	1.99	1.99	1.98	1.98	1.98

*OCVs for cells reflect recovery point OCVs as loads were run close together