Li Ion Cells 89 – 92 Activity Summary

Battery Description: 4 cells of Thundery-sky Lithium ion, model LP90A (I believe). 90Ahr (rated) cells.

Cell #89 had I believe three charge/discharge cycles put on it before I started charging and discharging the cells as a group.

6/7/03 & 6/9/03
Charge the cells in parallel. Placed a 50A/50mV shunt and a few feet of 2AWG wire in series with each cell. This was to attempt to balance the currents across the cells. The charge algorithm was basically CV of 4.30V, but the voltage was sensed before the series resistance of the shunt and wiring. So the actual cell voltage depended on the current flowing into that particular cell. Cell 89 was removed a little before the charge terminated as its current had dropped down below 1.0A.

6/9/03
Discharged the cells in series. Discharge current is 27A. Capacity removed is 72.3Ahr. Temperature of cell 90 peaked at about 55°C. Discharge was terminated when Cell 90 voltage reached 2.85V.

6/10/03
Charged the cells in parallel using the same method that was used on 6/7 & 6/9. The capacity returned to each cell varies for each cell (Cell 89 72.1Ahr, Cell 90 74.4Ahr, Cell 91 73.1Ahr, Cell 92 73.8Ahr). This method isn't very practical in real life, and the series impedance required to limit the peak current seems a bit excessive.

6/11/03
Discharge cells in series. Discharge current is 27A. Discharge was stopped when Cell 90 reached 2.99V. Total capacity removed was 66.8Ahr. Maximum temperature was 55°C in Cell 90, only 50°C in Cell 92. Cell 90 does have a much higher series resistance than the other cells.

6/13/03
Charged the cells in series with the following algorithm: CC 12A, CV 17.11V to a finish current of 1.0A. The total Ahr in is 65.0Ahr, total charge time is 9.1 hours. This the first try with charging the cells in series. Cells don't seem to require any balancing. The cell temperature peaked at about 30°C.

6/14/03
Discharged cells in series. Discharge current started at 30A. I checked the cell impedance at ~-5Ahr. The total Ahr removed was 77.7 Ahr. I tried to increase the total capacity removed from the cells by decreasing the load current as the cell voltages got to low. Cell 90 was the limiting factor. The temperature of the cells peaked at about 57°C, quite warm considering the current level. I'll try cooling the cells in the next discharge.

6/16/03
Charged the cells in series with the following algorithm: CC 12A, CV 17.11V to a finish current of 1.6A. The total Ahr in is 75.9Ahr. The cell temperatures peaked at about 30°C, same as last charge cycle. At this current level seems to be no issue in cell voltage that would require balancing. Cell 90 peaks at about 4.29V. This charge level makes for a very long charge cycle 9 hours.

6/17/03
Discharged the cells in series. Placed two desk type fans blowing on the cells. Discharge current was 30A. I checked the cell impedance twice during the discharge. Charge removed during discharge was 68.0Ahr. Discharge was terminated when Cell 90 reached 2.73V. It is very interesting to note how the cell resistances changed between the test at –10 Ahr and –58 Ahr. The increase in cell resistance wasn't uniform at all. Even though I had two fans blowing directly on the cells the cell temperature still increased to 43°C. Although it looks like there could be a substantial benefit (if not a necessity) to keeping cells cool during discharge I am wondering how this might be accomplished. Also very interesting to note how quickly the cell temperature increased during the first resistance check when I took the current upto 80A.

6/18/03
Charged the cells in series with the following algorithm: CC 16A, CV 17.11V to a finish current of 1.05A. The total Ahr in is 69.0Ahr. The temperature rise in the cells peaked at about 32°C from a starting temperature of 23°C. Interesting to note that the cells seem to not have any issues during charging that would require balancing even at this higher charge current. Cell to cell voltage difference at termination of charge was 13mV. No cell exceeded 4.30V. The charge time of 8.3 hours is shorter than at 12A, but not noticeably and there was less charge put back in on this charge cycle.

6/19/03
Discharge the cells in series at a CC of 27A. Goal was to do a capacity check under the same conditions as some of the other curves. I let the cells discharge a little further than I had meant to, cell 90 reached 2.60V. Cell temperature rise was very comparable to the other tests with Cell 90 reaching a peak of 58°C. A cell resistance check was done at ~-18Ahr.

Summary of Series Resistance Tests

All resistances are in milliohms

Test Condition	Cell 89 Resistance	Cell 90 Resistance	Cell 91 Resistance	Cell 92 Resistance
6/19/03 –18Ahr	10.0	14.5	12.7	12.8
6/17/03 Fan on cells, -10Ahr	9.3	14.5	10.7	11.1d
6/17/03 Fan on cells, -58Ahr	14.5	17.0	13.9	15.0
6/14/03 –5Ahr	9.9	16.9	12.3	12.3

Summary of Cell Capacity taken at a cell voltage of 3.00V (in Ahr)

Test Date/Condition	Cell 89	Cell 90	Cell 91	Cell 92
6/19/03, Discharge at 27A	67.6	61.2	67.9	66.4
6/17/03, Discharge at 30A w/ fan	60.9	51.1	58.2	56.3
6/14/03, Discharge at 30A	No Data	64.3	No Data	No Data
6/11/03, Discharge at 27A	No Data	65.9	No Data	No Data
6/9/03, Discharge at 27A	~72.3	66.7	~72.3	~72.3

* the No Data points are because the cell voltage never was allowed to drop down to 3.00V

Summary of Cell Capacity taken at a cell voltage of 3.10V (in Ahr)

Test Date/Condition	Cell 89	Cell 90	Cell 91	Cell 92
6/19/03, Discharge at 27A	59.7	50.3	58.5	56.3
6/17/03, Discharge at 30A w/ fan	51.4	39.4	46.5	45.0
6/14/03, Discharge at 30A	62.8	55.2	63.9	62.9
6/11/03, Discharge at 27A	66.3	55.5	66.8	66.2
6/9/03, Discharge at 27A	68.3	59.3	68.3	67.4