Sony 18650 Li-ion Battery Test Results

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Jan 15, 2004

Introduction

Three tests were conducted on the Sony Li-ion batteries. One test was to determine the affects of overcharging a cell. The second test was to determine the affects of over discharging a cell. The third test was to determine if the cell can survive a short circuit. The intent is to determine if the cells failed catastrophically and required special protection, enclosures, or could not be used for safety reasons.

Overcharge Test

The overcharge test was performed to determine what was required to cause the cell to fail and what kind of failure occurred. The cell was connected to a power supply. The power supply was set to five volts and the current limit was set to one ampere. The initial voltage of the cell was 3.5 volts. It was partially discharged.

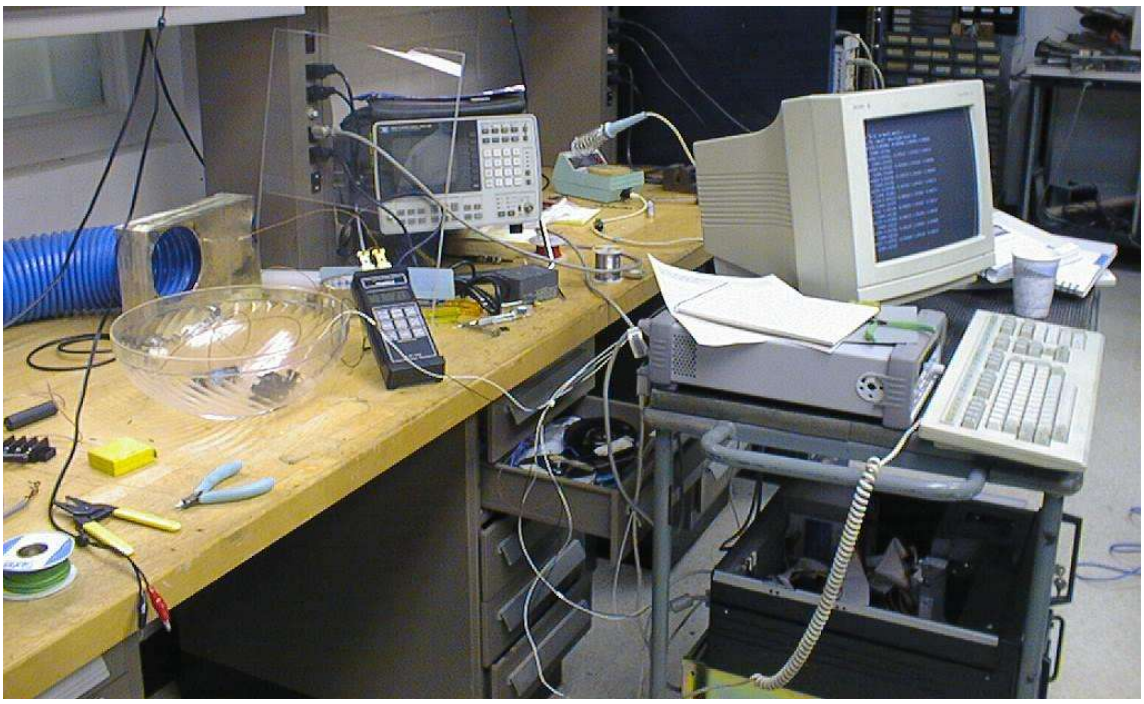

Figure 1, Experiment Configuration

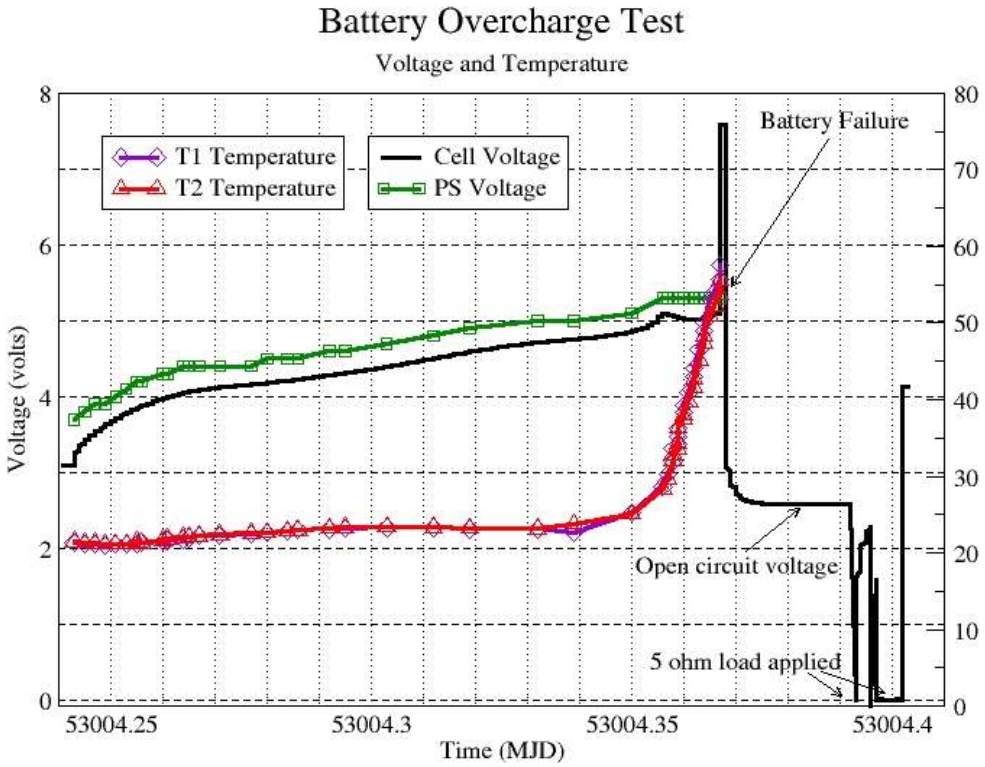

Figure 2, Overcharge Test Data

As can be seen in the plot, the cell did not have any problems being charged to 4.6 volts. After 4.6 volts, the cell temperature started rising. The temperature increase accelerated once the cell voltage was near 5 volts. The cell failed at 5.08 volts. The final temperature was 57 degrees Celsius. Failure was detected when the power supply current dropped to zero and a small pop was heard. The pop sound was the vent seal breaking which is used to relieve the pressure build up in the cell. There was no evidence of electrolyte being expelled.

Over Discharge Test

The over discharge test was performed by connecting a five ohm resistor across the cell. The voltage and temperature were monitored. The cell was allowed to be discharged to near zero volts.

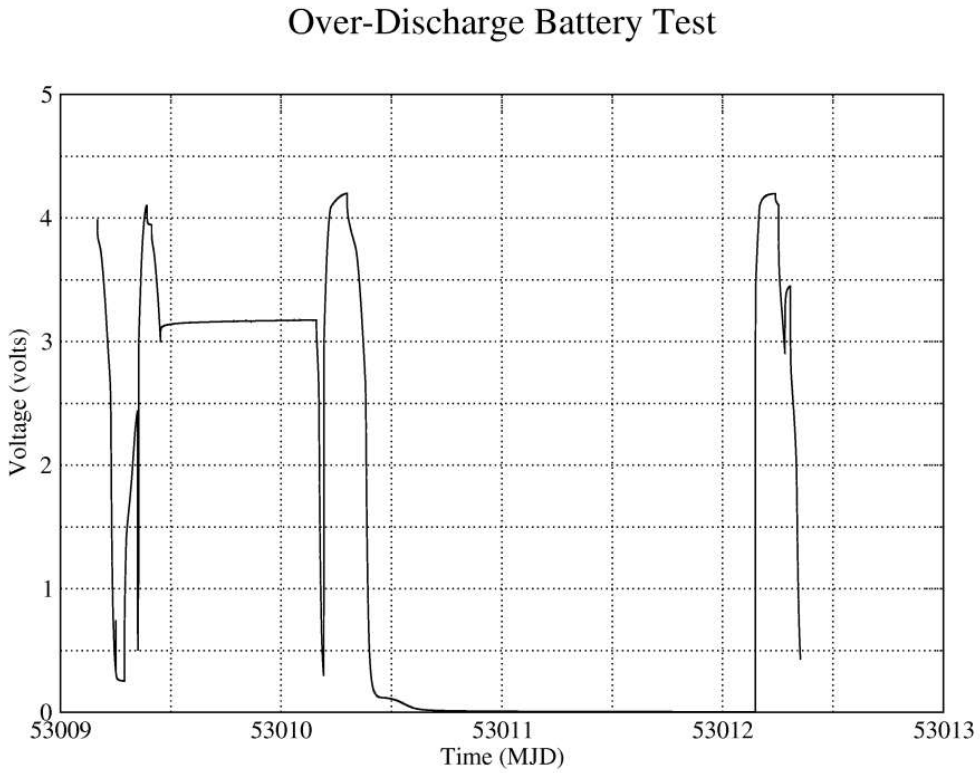

Figure 3, All the discharge/recharge cycles

The cell was discharged to about .25 volts and then recharged to 4.2 volts. During discharge and recharge there was no change in temperature. The cell did recharge successfully. The cell was discharged again to about .25 volts and recharged. No change in the characteristic of the cell was found.

For the third discharge, the five ohm load was connected across the cell for over a day. The cell was then recharged. It did recharge but this time, the temperature increased. This indicated something had changed inside the cell. The curve during recharge looks different than previous charge curves. The discharge rate is larger. This indicates that the cell was damaged and lost capacity. Toward the end of the discharge, the temperature rose a couple degrees.

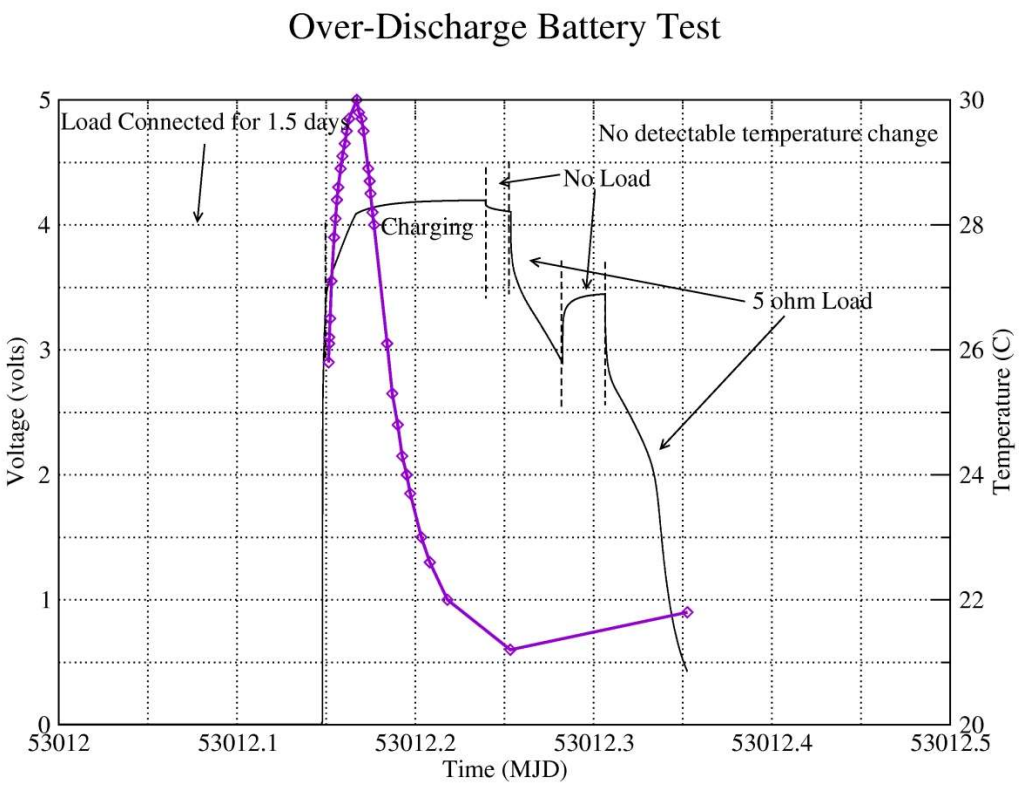

Figure 4, Damage from Over discharge

Failed cell String Test

This test was performed to determine the affects of a failed cell in a string of batteries. The failed cell was connected in series with another cell. The good cell was previously charged to 4 volts. The voltage across the two batteries started at 6 volts and dropped to near zero volts in a couple minutes. The measurement was made with a multimeter. The multimeter has an impedance of about 10 mega ohms. The multimeter was configured to measure current and the probes placed across the batteries to create a short circuit. No current was detected. This indicates the failed cell cannot pass current.

Battery Short Circuit Test

In the short circuit test, a current meter was connected across the battery to measure the current during a short circuit. At the beginning of the test, the meter was reading about 13 amperes. The digital display on the meter was flashing indicating the current was

not constant. The PTC was disconnecting the battery from the short circuit repeatedly. It is a thermal operation. When the PTC became too hot, it would disconnect and reconnect after cooling down. This occurred for about a minute and then stayed connected. At this point the battery was generating about 3 amperes of current. The current level steadily dropped to about .9 amperes where it stayed constant for about an hour. During this time, the battery temperature was increasing. The temperature increased to 72 degrees Celsius. Toward the end, the current started rising about 200 milliamperes and then dropped to near zero before the test was stopped. No physical failure was detected in the structure of the battery.

Summary

Based on the tests, the cell is quite rugged. The vent disc burst due to overcharge without any electrolyte material leaving. The cell is electrolyte starved meaning there is barely enough electrolyte to operate the cell. There is no excess free electrolyte that could escape. The over discharge test shows the cell can take abuse in over discharge. Damage seemed to occur when the cell was kept in the fully discharged state for an extended period of time which was for a day. There was no catastrophic failure during the tests. A failed cell in a string of batteries disables the whole string. The string cannot be used or charged. The short circuit test showed the cell can survive a short circuit with no catastrophic effects.

The battery charger system is designed to protect the cells from damage. The charger circuit has a temperature limit circuit. If the batteries are below or above the safe charging temperatures, the circuit will disable the charger. Each cell has a shunt regulator which will route excess voltage and current to a power resistor and transistor. The shunt regulator will not allow the voltage across each cell exceed 4.2 volts.

An over discharge circuit is included to disconnect any loads to the batteries if the cell voltage drops below 3 volts. Lastly, a 1 ampere fuse is included on the negative side of the battery to handle any short circuits or overloads.