Impact of Reference Performance Tests on Li-Ion Cell Performance

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The U.S. Department of Energy (DOE) initiated the Advanced Technology Development (ATD) Program [1] in 1998 to address the outstanding barriers that limit the commercialization of high-power lithium-ion batteries, specifically for hybrid electric vehicle applications. As part of the program, 18650-size cells are aged using calendar- and cycle-life tests [2,3] developed under the FreedomCAR (Freedom Cooperative Automotive Research) and Vehicle Technologies Program.

Life testing is interrupted every 4 weeks for reference performance tests (RPTs), which are used to quantify changes in capacity, resistance, and power. The RPTs consist of $C_1/1$ and $C_1/25$ static capacity tests, a low-current hybrid pulse power characterization test (L-HPPC) at several temperatures, and electrochemical impedance spectroscopy (EIS) at several SOCs [4]. It has been shown that some components of this RPT sequence adversely impact aging while others appear to improve cell performance [5].

Consequently, a new RPT (i.e. mini-RPT) has been designed for the FreedomCAR Program that provides a reduced but still sufficient set of information while also reducing the impact on life. The mini-RPT consists of a single L-HPPC pulse at only two SOCs (SOC_{MAX} and SOC_{MIN}) with a $C_1/3$ discharge in between. For FreedomCAR testing, SOC_{MAX} and SOC_{MIN} have been defined as the representative operating range during normal vehicle use (80 and 40% SOC, respectively).

The Idaho National Engineering and Environmental Laboratory (INEEL) purchased commercially available PowerfLite prismatic lithium-ion cells to compare the effects of a standard FreedomCAR full RPT ($C_1/1$ and L-HPPC) to a mini-RPT. The cells are rated at 1 Ah and have a $LiCoO_2$ cathode, a graphite anode, and $LiPF_6$ salt in EC/DEC/DMC electrolyte [5]. Although these cells are not representative of the current FreedomCAR technology, they are useful for investigative purposes.

For this study, cycle-life testing is performed at 30°C and SOC_{MAX}. Figure 1 shows the average cycle-life discharge pulse resistance for the mini-RPT compared to a full RPT through 10 weeks of aging using the standard ATD profile [4]. Cycling was initially interrupted in 2 week intervals, but was extended to 4 week intervals after the third RPT to better identify longer term trends. The mini-RPT shows a much quicker recovery period since the cells do not experience a full discharge or charge. Also, the pulse resistance from the full RPT group shows a higher slope than the mini-RPT group during the 4-week cycle interval. This indicates that the mini-RPT has less of an impact on pulse resistance than the full RPT.

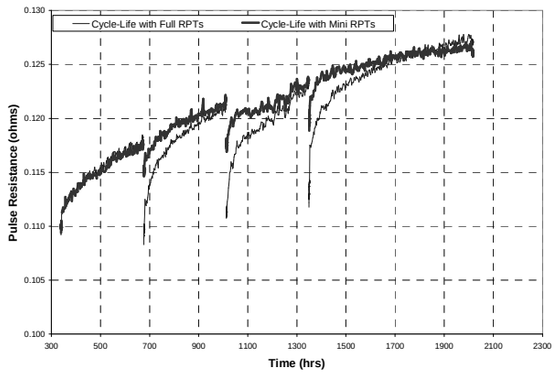

Figure 1. Pulse resistance comparison between a full RPT and mini-RPT

References

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4. Jon P. Christophersen et al., "Advanced Technology Development For Lithium-Ion Batteries: Gen 2 Performance Evaluation Interim Report," INEEL/EXT-03-00095, February 2003.
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