

Expanding the Temperature Range of High Power Lithium-Ion Chemistry

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ABSTRACT

Lithium-ion batteries provide high specific energy, high power capability and long term reliability when compared to other types of battery cell chemistries. In addition, they are effective in a diverse array of industrial applications including commercial, aerospace and medical.

Quallion has begun to analyze the military aircrafts power profile with state of the art (SOA) commercial grade high power lithium-ion cells. Although the SOA chemistry can meet the power profiles at room temperature, the cells cannot meet the performance requirements for low temperature mission profiles and high temperature storage. To address this, Quallion has manufactured lithium ion test cells to evaluate new electrolytes and other high power components for these applications.

INTRODUCTION

Lithium-ion batteries constitute a safe and reliable power source for use in military applications. Lithium-ion batteries provide high specific energy, high power capability and long term reliability when compared to other types of battery cell chemistries, and are effective in a diverse array of industrial applications including aerospace, commercial and medical. Rechargeable lithium-ion batteries have decreased the size and weight of portable electronics (i.e. laptops and cell phones) while simultaneously providing superior cycle life and energy density versus previous technologies. In switching to lithium ion rechargeable batteries from nickel metal hydride or nickel-cadmium, expanded operational capacity, elimination of the memory effect of charge and discharge cycling, as well as weight savings could all be envisioned.

Quallion has begun to analyze the requirements for military aircrafts with state of the art (SOA) commercial grade high power lithium-ion cells. Although the SOA chemistry can meet the power profiles at room temperature, the cells cannot meet the minimum voltage

requirements for low temperature mission profiles. Therefore, the following paper describes the performed on SOA commercial cells and some preliminary results of some low temperature testing on Quallion developed cells.

MAIN SECTION

1.1 Low Temperature Testing with Commercial Cells for Military Aircraft Missions

1.1.1 Cell Testing @ 0°C

Quallion has conducted preliminary cell testing for a military aircraft battery mission profile, in which Quallion scaled down the power requirements to the individual cell level. **Figure 1** represents the military aircraft's normal cycling at 0°C. Since 2.45V per cell is the minimum system requirement, the cells remained above this voltage and passed.

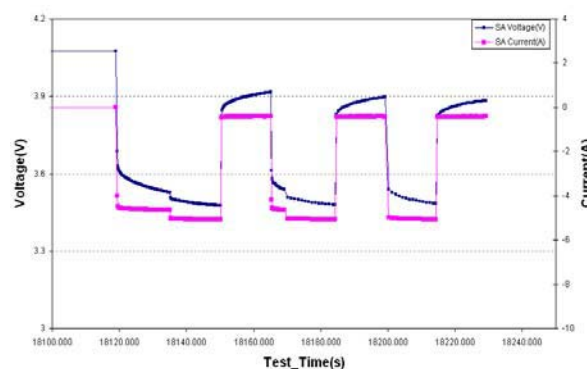


Figure 1. Normal cycling event at 0°C.

Figure 2 displays the military aircraft emergency fill-in profile for the battery at 0°C. Although the cell passed

the current profile, during one of the pulses the voltage was close to the minimum 2.45V voltage level.

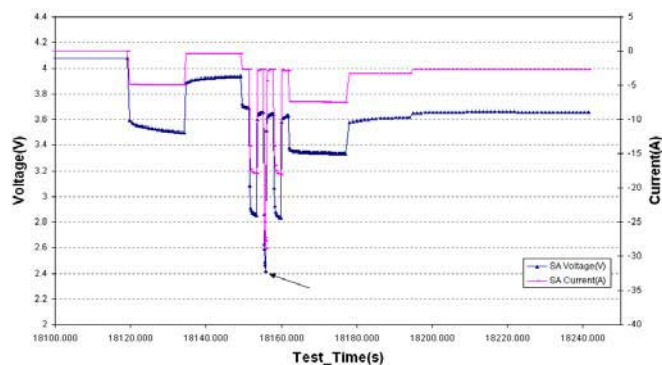


Figure 2. Emergency Fill-in event at 0°C.

Figure 3 displays one military aircraft IPP start at 30A for 15 seconds at 0°C. As shown, the cell remained above the 2.45V minimum voltage cut-off.

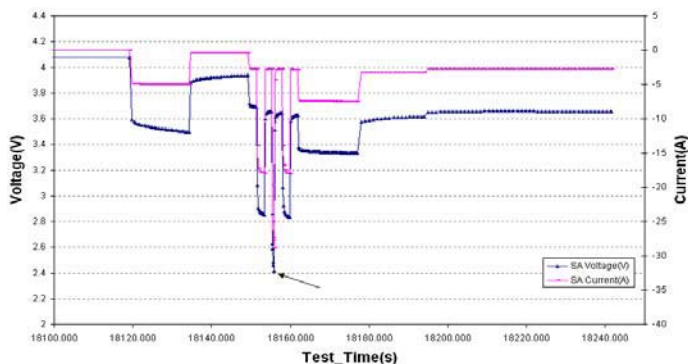


Figure 3. IPP start at 30A for 15 seconds at 0°C.

1.1.2 Cell Testing @ -26°C

As shown in Section 1.1.1, SOA high power commercial cells can meet military aircraft mission profiles at temperatures above 0°C. However at temperatures below freezing, SOA commercial cells have difficulty in remaining above the minimum voltage cut-off.

Figure 4 displays the military aircraft's normal cycle mission profile at -26°C, in which the individual cell failed to remain above 2.45V during the normal cycle mission profile.

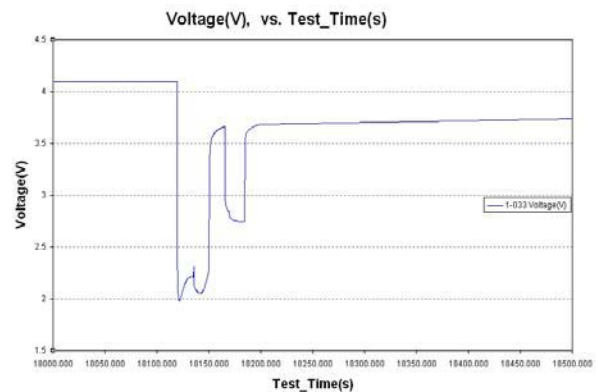


Figure 4. Individual cell @ -26°C, normal cycle test.

Therefore the -40°C requirement for military aircrafts cannot be met by current SOA commercial lithium-ion cells. Through this initial testing, Quallion is in development of a lithium-ion cell that can meet the -40°C to 71°C high power requirements for military aircrafts.

1.2 Low Temperature Results on Quallion Developed Cells

Using a novel electrolyte, Quallion manufactured test cells to verify its low temperature performance against the military aircraft's mission profile. Based on the -26°C mission profile, Quallion achieved the following results in Figure 5, in which the figure compares the displays the current commercial SOA 18650's and 26650's -26°C capability. This test represents an approximate 10C discharge rate at -26°C.

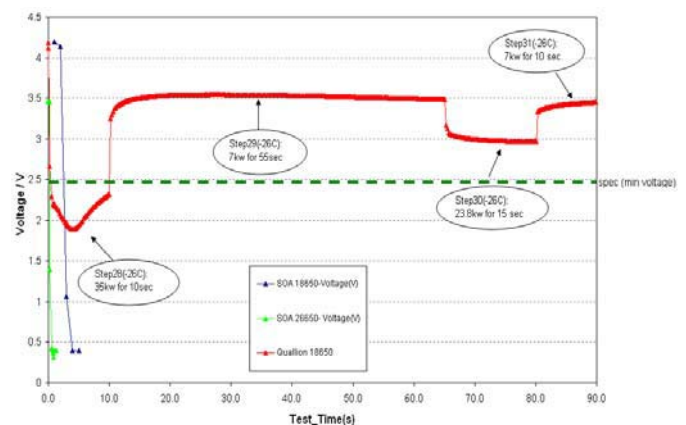


Figure 5. Comparison of -26°C mission profile with Quallion made cells with novel electrolyte to the current SOA 18650 and 26650 cells.