Lithium-Ion Batteries Being Evaluated for Low-Earth-Orbit Applications

The performance characteristics and long-term cycle life of aerospace lithium-ion (Li-ion) batteries in low-Earth-orbit applications are being investigated. A statistically designed test using Li-ion cells from various manufacturers began in September 2004 to study the effects of temperature, end-of-charge voltage, and depth-of-discharge operating conditions on the cycle life and performance of these cells. Performance degradation with cycling is being evaluated, and performance characteristics and failure modes are being modeled statistically. As technology improvements are incorporated into aerospace Li-ion cells, these new designs can be added to the test to evaluate the effect of the design changes on performance and life.

Cells from Lithion and Saft have achieved over 2000 cycles under 10 different test condition combinations and are being evaluated. Cells from Mine Safety Appliances (MSA) and modules made up of commercial-off-the-shelf 18650 Li-ion cells connected in series/parallel combinations are scheduled to be added in the summer of 2005. The test conditions include temperatures of 10, 20, and 30 °C, end-of-charge voltages of 3.85, 3.95, and 4.05 V, and depth-of-discharges from 20 to 40 percent. The low-Earth-orbit regime consists of a 55 min charge, at a constant-current rate that is 110 percent of the current required to fully recharge the cells in 55 min until the charge voltage limit is reached, and then at a constant voltage for the remaining charge time. Cells are discharged for 35 min at the current required for their particular depth-of-discharge condition.

Lithium-ion cells from Saft and Lithion installed in a test chamber.

Cells are being evaluated in four-cell series strings with charge voltage limits being applied to individual cells by the use of charge-control units designed and produced at the NASA Glenn Research Center (ref. 1). These charge-control units clamp the individual cell voltages as each cell reaches its end-of-charge voltage limit, and they bypass the excess current from that cell, while allowing the full current flow to the remaining cells in the pack.

The goal of this evaluation is to identify conditions and cell designs for Li-ion technology that can achieve more than 30,000 low-Earth-orbit cycles. Testing is being performed at the Naval Surface Warfare Center, Crane Division, in Crane, Indiana.

Reference

1. Reid, Concha M., et al.: Lithium-Ion Cell Charge-Control Unit Developed, Research & Technology 2004, NASA/TM--2005-213419, 2005, pp. 94-95. http://www.grc.nasa.gov/WWW/RT/2004/RP/RPC-reid.html

Find out more about this research at
http://www.grc.nasa.gov/WWW/Electrochemistry/

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