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DESIGNING EFFECTIVE THERMAL MANAGEMENT SYSTEMS FOR LITHIUM ION BATTERY ASSEMBLIES INTENDED FOR HUMAN SPACEFLIGHT APPLICATIONS

Abstract

Lithium ion (Li-ion) batteries provide lightweight and energy dense solutions for aerospace. The National Aeronautics and Space Administration (NASA) explores the safe utilization of Li-ion batteries for various human spaceflight applications; noteworthy examples include the storage of energy collected by solar panels on the International Space Station (ISS), power supply for the extra vehicular mobility unit (EMU) which supports astronauts during extra-vehicular activities (EVAs) and Orion exploration vehicle energy storage. Thermal related safety concerns are addressed through the development of robust thermal management systems which mitigate the effects of thermal runaway and prevent cell-to-cell propagation. Thermal runaway is typically caused by thermal, electrochemical, or mechanical failures. These failure mechanisms lead to elevated temperatures which initiate exothermic decomposition reactions. The Arrhenius behavior of these reactions eventually leads to thermal instability and explosion. This study focuses on some of the testing and analysis activities conducted by NASA which focus on characterizing thermal runaway events and the possibility of cell-to-cell propagation of battery pack assemblies constructed with large counts of smaller commercial Li-ion cells (e.g. the widely used 18650 cell format). Collectively, testing is conducted on assemblies in the order of the hundreds of watts. Various testing involves triggering a single cell of a given battery assembly into runway via patch heater and monitoring the thermal and electrical performance via sensors. The primary goal is to demonstrate that the thermal management system prevents cell-to-cell propagation. The data gathered during testing is used to support the further development of robust battery pack thermal management systems. Thermal runaway experiment data also allows NASA analysts to construct test-correlated computational models capable of predicting the probability of cell-to-cell propagation occurring for any number of design iterations. Ultimately, present full-scale testing is yielding highly favorable results with extrapolated understanding available later this year.