Lithium Ion Battery Safety

by Christopher J. Orendorff and Dan Doughty, Guest Editors

Increasing global demand for oil and concerns surrounding climate change have fueled recent policy decisions and technology developments in alternative energy and energy storage solutions. Of these storage solutions, lithium-ion battery research and engineering has enabled the increase in lithium-ion battery scale from Ah-sized batteries for portable electronics to cargo container sized MWh battery systems developed for utility storage. Products are now emerging for transportation (mass transit, military, personal vehicles) and utility/grid storage (load leveling, integration of renewable energy sources). However, lithium-ion cells are not without their trade-offs between the amount of storage capacity and safety. Issues related to lithium-ion safety and cell recalls are well documented for the consumer electronics industry. Increasing the scale of lithium-ion batteries by 6-9 orders of magnitude to meet the transportation and utility storage demands comes with the potential for higher consequence safety incidents. How safe is safe enough for an electric vehicle? For a NASA space mission? For a utility company's distributed energy site? What is clear is that a rash of safety incidents with lithium-ion batteries on this scale could damage public perception and delay widespread adoption of this exciting, and promising technology.

The challenges associated with safely and responsibly increasing the scale of lithium-ion should not be understated. We have literally taken a technology suitable for powering a flashlight and engineered it to power buses, passenger vehicles, and even a rover across Mars. Aside from the basic chemistry, the larger scale applications of energy storage systems are far more complex than for consumer electronics, with more advanced control electronics components, sensor/monitoring hardware, thermal management, and different packaging requirements. Moreover, the failure modes of large lithium-ion batteries are a function of their application and will likely be different than for portable electronics. It stands to reason that how we approach safety of these large batteries should also be different. The need for inherently safe cells with high specific energy, robust testing methods, and high qualification standards is greater now than ever before.

How safe is safe enough? It is a difficult question to answer. Safety, in general, is difficult to quantify and perfection is the goal. Safety is often improved only when reacting to correct an already present hazard or to respond to an incident. However, a number of researchers, cell developers and manufactures are focusing on safety. They are taking the necessary measures to develop lithium-ion cells and batteries with improved safety performance. In fact, their effort has proven that steps can be taken during the design and development of these battery systems to improve their safety performance. Advances in materials chemistry, packing, cell design, and system controls have all led to improved safety of commercial large scale battery storage systems.

This issue of *Interface* addresses some of the most challenging issues related to inherent lithium-ion cell safety and the progress that has been made in recent years. Dan Doughty and E. Peter Roth provide an introduction to battery safety followed by articles authored by our colleagues covering electrolyte safety performance (E. Peter Roth and Christopher J. Orendorff), battery safety qualification (Judith Jeevarajan and Clint Winchester), modeling of abuse tolerance in lithium-ion batteries (Bob Spotnitz and Rick Muller), and finally, the role of separators in battery safety (Christopher J. Orendorff).

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About the Guest Editors

Daniel H. Doughty has been involved with battery R&D, testing, and evaluation since 1992. During his 35 year career in science and technology, he spent 27 years at Sandia National Laboratories, the last 14 years of which he managed the battery R&D group that was responsible for battery safety and abuse tolerance testing. After leaving Sandia in December 2006, he spent over two years as Vice-President for Product Safety for SION Power Corp., a company in Tucson, Arizona focused on commercializing Li-sulfur rechargeable batteries. Dr. Doughty is President and founder of Battery Safety Consulting Inc., a company dedicated to providing expert and independent consulting services for a wide range of battery safety issues. He was the Chair of the Society of Automotive Engineers Committee which revised and updated the SAE Recommend Test Procedure J2464, "Electric and Hybrid Electric Vehicle Rechargeable Energy Storage System (RESS) Safety and Abuse Testing," published November 2009. He may be reached at dhdoughty@batterysafety.net.

Christopher J. Orendorff is Principal Investigator of the Battery Safety R&D Program at Sandia National Laboratories. This program at Sandia is focused on developing inherently safe lithium-ion technologies for the transportation market through materials development, mechanistic understanding of battery abuse and failure, and full spectrum testing of cells and battery systems. Before joining Sandia in 2006, Dr. Orendorff earned BS degrees in chemistry and biochemistry from Purdue University in 1999, his PhD in analytical chemistry from the University of Arizona in 2003, and was a post-doc at the University of South Carolina. He may be reached at corendo@sandia.gov.