Sandia National Laboratories

Energy, Climate, & Infrastructure Security

Sandia's Battery Abuse Testing Laboratory

Sandia's Battery Abuse Testing Laboratory (BATLab) is an internationally recognized leader in energy storage system safety research and is committed to serving the community and the national interest with cutting-edge research programs, the highest quality testing results, and leadership in battery safety and reliability.

Sandia tests batteries to failure to determine safety design margins. Sandia tests demonstrate the significant improvements in safety that have been realized in recent years.

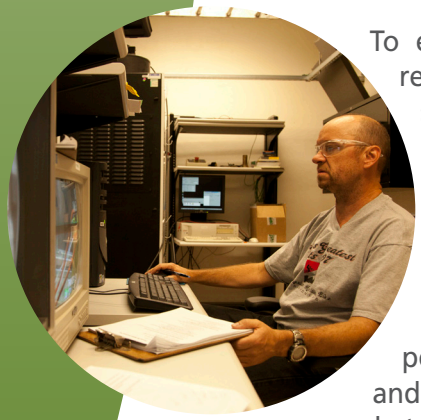
Lithium-ion (Li-ion) battery technologies offer great benefits in vehicle electrification, but an essential challenge is to ensure operational reliability and safety. Sandia plays a leading role in assuring that Li-ion batteries meet this challenge.

Vision

To enhance the nation's security and prosperity through sustainable, transformative approaches to our most challenging energy, climate, and infrastructure problems.

Sandia's decades of experience in applied materials research and development (R&D) and systems and abuse testing assists industry in implementing advanced, science-based safety features that can avoid incidents of vehicle/property damage due to poorly designed vehicle batteries. Such damage could destroy consumer confidence in plug-in hybrid electric vehicle (PHEV)/electric vehicle (EV) technologies, potentially setting back transportation electrification by years or decades.

Abuse Testing



A Sandia researcher analyzes the data from a recent battery abuse test.

To ensure the safety and reliability of battery systems, components must be stressed to extremes to determine when and how they will fail. Only when a manufacturer knows a battery's full performance envelope and its failure modes can it market a product with assured safety and reliability.

Sandia's BATLab provides comprehensive safety and reliability testing of components and systems having energies ranging from small (milliwatt-hours) to very large (kilowatt-hours). Our capabilities include mechanical (e.g., crush or penetration), electrical (e.g., overcharge or short-circuit), and thermal (e.g., high-temperature) abuse.

Characterization and Failure Analysis

Our abuse testing provides a wealth of data about a battery pack's performance under stressful conditions, but the testing data itself reveals only limited information about the system's strengths and weaknesses.

Once testing is complete and a battery's attributes and limits are determined, Sandia scientists and engineers, often working with the manufacturer's personnel, characterize and analyze the materials we tested to determine failure mechanisms and to develop a comprehensive, science-based understanding of battery failure. The more we can learn from any system failure, the better our data can assist developers in designing and modeling the next generation of batteries with improved performance, better safety, and higher reliability.

Battery Safety R&D

Sandia scientists employ state of the art experimental diagnostic tools

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and computational capabilities to develop insights and predictive models of battery failure mechanisms from the atomic scale to the battery scale (these approaches are discussed in detail in companion data sheets). These insights and models are used in tandem with data from BATLab to promote advances in next-generation battery technologies:

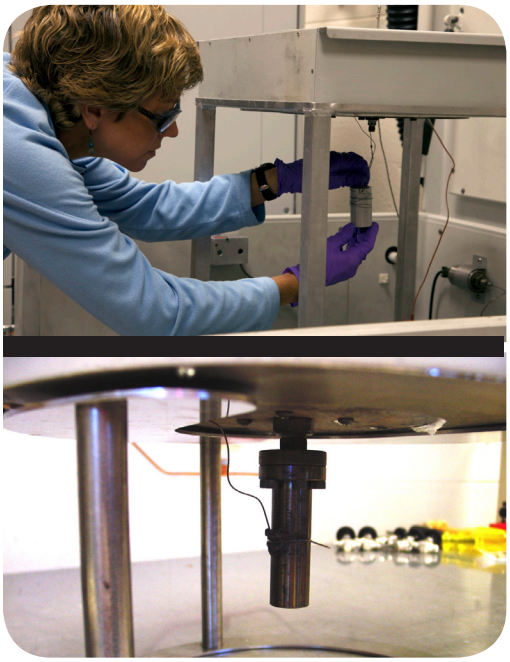
- understanding failure mechanisms in cells/battery systems for the emerging global transportation markets;
- performing safety evaluations on next generation electrode materials for Li-ion batteries;
- developing advanced electrolytes that are abuse tolerant, nonflammable, and can mitigate high-rate thermal runaway reactions;
- developing testing and analytical techniques to better understand critical safety and reliability concerns with Li-ion cells and emerging large-format cell designs.

Battery Calorimetry

PHEV/EV performance and life-cycle cost are heavily influenced by battery pack performance—including the pack's operating temperature profile. The consequences of a Li-ion battery's thermal runaway or the severity of a thermal runaway reaction must be minimized under both normal operations and abusive conditions. Uneven temperature distribution in a battery pack leads to unbalanced modules and reduced performance. Thus, manufacturers seek to develop packs that manage their thermal profile so that modules operate within the desired temperature range.

Calorimetry is used to provide accurate assessment of heat-evolution and potential thermal hazards from batteries of all sizes. The BATLab is home to one of the most extensive arrays of battery calorimetry tools equipment in the nation including

- six accelerating rate calorimeters for materials and cell-level measurements,
- two isothermal battery calorimeters,
- a modulated differential scanning calorimeter, and
- microcalorimetry for materials analysis.



A Sandia researcher prepares samples for accelerating rate calorimetry experiments.

Cell Prototyping

Advanced features designed to improve battery reliability and safety can be tested in cells fabricated in Sandia's advanced cell prototyping facility. Here, we can manufacture small lots of Li-ion cells of various sizes (including 2032 coin cells, 18650s, D-cells, and prismatic cells to 4 Ah capacity). Cells fabricated in our facility incorporate the latest advanced cathode and anode materials, electrode designs, state-of-the art separators, and electrolytes and additives designed for safety and performance improvements.

Sandia's BATLab is the leading battery safety and abuse testing facility in the world. Its work is helping to develop batteries that have a graceful failure—ensuring that if an industry partner's battery system is damaged or compromised, it's failure won't cause other problems.

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