Battery Thermal Analysis and Testing

Providing Industry with World Class Solutions

NREL Offers Integrated Solutions

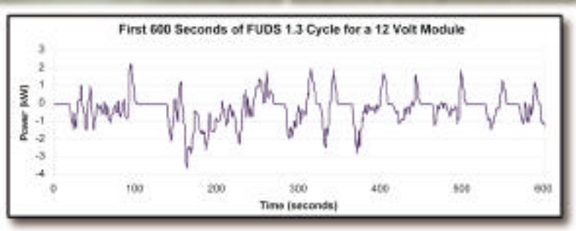
Battery thermal management and analysis are key to enhancing performance and extending the life of battery systems for electric and hybrid vehicles (EVs and HEVs). State-of-the-art on-site facilities and years of experience allow engineers at the National Renewable Energy Laboratory (NREL) to provide solutions for battery thermal control and packaging challenges.

Battery Cyclers for Performance and Life-Cycle Tests

We use several types of battery cyclers to perform these tests. Our ABC-150 battery cycler was specifically manufactured by AeroVironment for cycling EV and HEV battery modules and packs. Fast-switching FTN Bitrode battery cyclers are capable of testing cells and modules. We use these devices to cycle battery cells, modules, and packs through a variety of EV and HEV driving profiles, such as the Federal Urban Driving Schedule (FUDS) and the General Dynamic Stress Test (GDST). These and other profiles are used to analyze battery performance and to obtain life-cycle data.

Operating Range of Cyclers:

Cycler	Voltage	Current	Power
ABC-150	4-420 VDC	-500 to +500 ADC	± 125 kW
FTN-200-6	0-6 VDC	-200 to +200 ADC	± 1.2 kW
FTN-300-48	0-48 VDC	-300 to +300 ADC	± 14.4 kW



A power profile delivered to a module by the ABC-150 cycler

Calorimeter for Measuring Heat Generation and Capacity

Calorimetry Sciences Corporation custom designed and fabricated our heat conduction battery calorimeter. This unique calorimeter measures heat generation from full-size modules under a variety of loads delivered by cyclers. It could also be used to measure the heat capacity of modules at various temperatures.

Specifications:

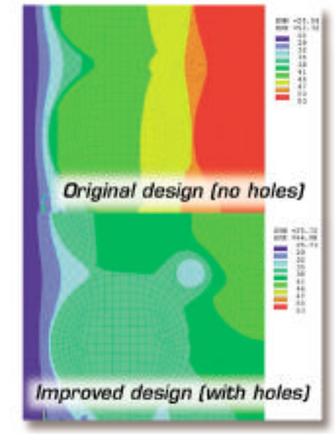
- The bath temperature operation ranges from -30°C to +60°C.
- Heat generation rates can be measured from 40 mW to 100 W.
- Thermal energy levels as small as 10 joules can be measured with better than ± 5% accuracy.
- The calorimeter chamber can hold batteries as large as 39 cm long, 21 cm wide by 20 cm high.

Fast-switching FTN Bitrode battery cycler

Computer-Aided Engineering Analysis

We use state-of-the-art software (ANSYS) to conduct thermal finite element analysis. These analyses allow us to determine two-dimensional or three-dimensional transient or steady-state thermal responses of a single battery module or battery packs under a variety of conditions. We have the capability to use computational fluid dynamic (CFD) tools such as FLOTRAN or FLUENT to analyze complex fluid flow behavior in battery packs.

Improved Optima HEV module



Cooling holes NREL added to improve thermal behavior in Optima Batteries' HEV battery modules

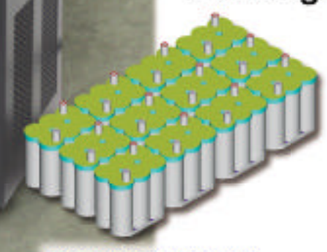
Thermal imaging for understanding the thermal behavior of modules and battery packs

Calibration setup for temperature-sensitive paint

Thermal Imaging

Thermal imaging provides useful information on the thermal performance of modules and packs. This technique can also be used as a tool to quickly identify hot and cold spots and temperature variations in a battery module or pack. We use both infrared and liquid crystal (temperature-sensitive paint) thermography.

Packing (Structural/Fabrication)

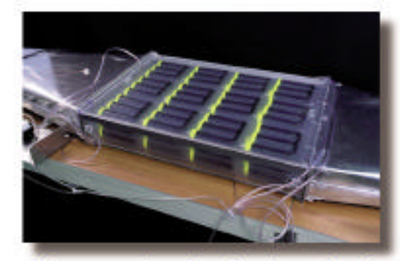


Computer-aided design of an HEV battery pack

Our team is experienced in using computer-aided engineering tools to provide solutions for configuring modules in a pack. Using finite element analysis software, we also provide structural solutions for modules and packs. We have fabricated packs for fluid flow, heat transfer, and battery cycling tests.

Fluid Flow and Heat Transfer Techniques

We have unique experimental techniques to measure the heat transfer rate between the battery module surfaces and the heating/cooling fluid. In addition, we can evaluate the pack pressure drop versus flow rate for fan/pump selection, and conduct tests for flow uniformity, such as fluid flow visualization (fog/dye) and performance assessment of a pack design.



A battery pack undergoing thermal testing

Our capabilities include:

- *Unique battery calorimetry*
- *Heat transfer experiments*
- *Battery performance/life-cycle testing*
- *Infrared imaging*
- *Liquid crystal thermography*
- *Flow visualization*
- *Finite element thermal analysis*
- *Computer-aided engineering*
- *Structural/packaging analysis*
- *Computational fluid dynamics*

*"I am very impressed with the expertise demonstrated by **NREL** in thermal analysis and testing, but even more so in how they have utilized their talents to advance **EV/HEV** battery technology in a practical way."*

– Dennis Corrigan,
Vice President
Ovonic Battery Company

Contact us today for more information
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