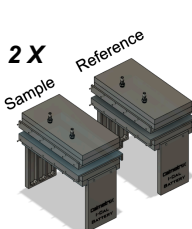


### I-CAL BATTERY FOR THE MEASUREMENT OF THERMAL PROPERTIES IN BATTERY CELLS

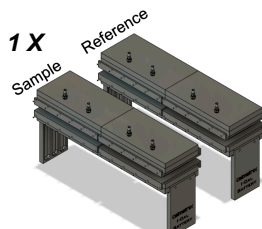
#### About Isothermal Calorimetry in Material Science.

Batteries have become ubiquitous both in industry and consumer markets, with fast growth markets such as Electric Vehicles or portable devices. The fast development cycle for new batteries calls for laboratory instrumentation to study the performance and ageing of batteries during charge and discharge cycles, as well as in standby mode. Isothermal calorimeters measure the heat rate of battery cells in different operational states while keeping the temperature around the battery constant, thereby providing a continuous monitoring of the battery's thermal properties.

#### I-Cal Battery: flexible design for multiple battery cell types and sizes.



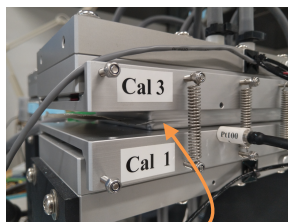
Cells < 300 mm length



Cells between 300 mm and 600 mm length

The I-Cal Battery's clever modular design allows for testing of a variety of battery cells, including prismatic, pouch and cylindric, including 18650, 21700 and 26650-type cells and more. For prismatic and pouch cells, I-Cal Battery can accommodate any size up to 600 mm in length and 135 mm in width. Two cells with less than 300 mm in length can be tested simultaneously, while cells with lengths between 300 mm and 600 mm can only be tested one by one.

The I-Cal Battery is thermostated by a precision liquid thermostat, which can be supplied by Calmetrix or it can be connected to any thermostat model provided by a third party. The thermostated liquid is divided equally between all calorimeters in a manifold; similarly, the return liquid is collected by a manifold and brought back to the thermostat. The stability of the instrument is a function of the temperature stability of the thermostat and for most measurements the temperature of the liquid leaving the thermostat will typically stay within a few hundredths of a °C.



Pouch cell

Each active sample is matched by an identical twin reference to optimize the precision and drastically reduce noise during measurements. The battery cells are placed between two plate-shaped calorimeter units, each equipped with a large number of heat flow sensors to increase their sensitivity and at the same time keep the battery cell temperature down. The battery is mounted in compression by springs that are connected between the upper and lower calorimeter units. The springs allow dimensional changes of the battery cell and other parts of the setup without creating excessive stress on the heat flow sensors or on the battery cell itself.

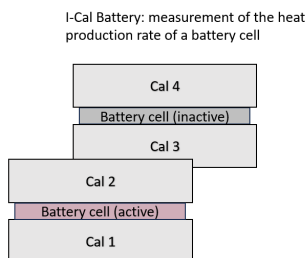
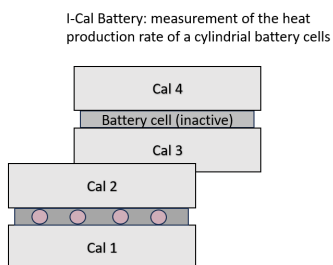
#### Applications: modes of use.

I-Cal Battery is a flexible instrument that can be used to measure a variety of a battery's thermal properties, such as the heat produced (or consumed) in a battery cell during charging-discharging cycles, but also for entropy measurements and measurements of physical properties of battery cells (heat capacity, through-plane thermal conductivity, in-plane thermal conductivity). And it is ideally suited to assess the energetics of phase changes in PCMs (Phase Changing Materials).

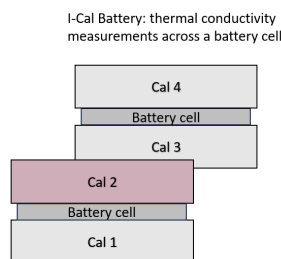
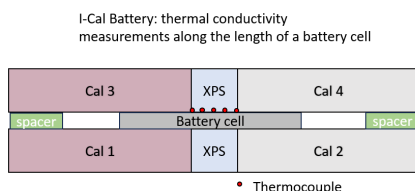


Most common applications and uses:

### Heat production rate of a battery cell

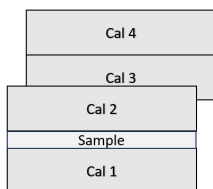


### Thermal conductivity



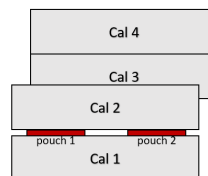
### Heat Capacity

I-Cal Battery: heat capacity measurements



### Thermal properties of PCM pouches

I-Cal Battery: measurement on PCM pouches



## Specifications

Specifications			
<b>I-Cal Battery calorimeter</b>			
Operating Voltage	110 - 240 VAC - 50/60Hz	Max Sample size	600 mm L x 135 mm W
Number of Test Channels		Precision	3 mW at 5 W (0.06%)
<i>Cylindrical cells (18650, 21700 and 26650-type)</i>	2	Calibration method	Active reference cell
<i>Prismatic or pouch cells less than 300 mm length</i>	2	Random noise	< +/- 4 µW/g
<i>Prismatic and pouch cells between 300 and 600 mm length</i>	1	Dimensions	100 cm x 100 cm x 85 cm
Heat rate measurement range	10 mW - 50 W	Software & file type	Data acquisition, txt / csv file
<b>Liquid circulating temperature control unit (if supplied by Calmetrix)</b>			
Operating temperature	-20 °C to 175 °C	Dimensions	25 x 45 x 70 cm
Temperature stability	+/- 0.03 °C	Weight	30 kg
Flow rate	8 to 25 l/min.	Available voltages	100 V, 115 V, 230 V 50/60 Hz

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