

### Why Battery Testing?

Battery failure can and has led to fires, release of toxic gases, and even gas explosions. It is critical to assess the consequences of different battery abuses from the perspectives of research, production, and active use. With the increased use of batteries over recent years – it has led to greater awareness of the associated safety concerns by the public as well as regulating authorities.

### The ioKinetic Difference

#### Saving Costs and Increasing Safety

We recommend only the services needed.

#### Delivering the Competitive Advantage

Our lab services are quick, efficient and reliable.

#### Our Primary Goal Is Your Satisfaction

We go the extra mile with advice and service.

Net Zero sustainability targets are encouraging the use of different energy storage media. Batteries of various chemistries and form factors are being utilized in more and more applications, from consumer electronics to power tools, automobiles, airplanes, and even human body implants. And Net Zero sustainability targets additionally are encouraging the use of different energy storage media.

It is critical to evaluate the consequence of various battery abuses from a research, production, and active use perspective.

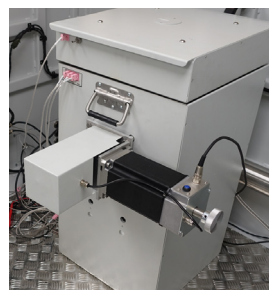
Minimize your exposure to fire, injury, property damage, and litigation with quality battery testing.

Testing can help you measure the safety and performance of batteries by simulating both normal and worst-case operating conditions using battery testing and calorimetry.

The characterization and management of chemical reactivity can help you reduce hazards that you may otherwise not be aware of and help you comply with regulatory standards.



*ioKinetic is an ISO accredited, ultramodern testing facility that can assist in minimizing your operational risks.*

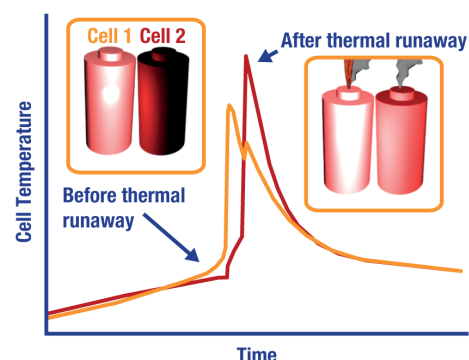


| EVX ARC CAPACITY      |                                                                                                                                                                                                                                             |
|-----------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Chamber Size</b>   | 25 cm diameter and 60 cm in depth                                                                                                                                                                                                           |
| <b>Heating Range</b>  | Ambient to 350°C                                                                                                                                                                                                                            |
| <b>Test Modes</b>     | Adiabatic, ramping, isothermal, step isothermal, true isothermal and isoperibolic                                                                                                                                                           |
| <b>Capacity Limit</b> | For open tests 150 Ah is the limit, for closed tests 25 Ah and a pressure of 4 bar is the limit. Please note that maximum testing limits may vary depending on battery chemistry and format; please contact ioKinetic for more information. |

## Battery Cell ARC Test and Overheating

An open ARC test includes a heat-wait-search which heats the cell and then waits for a period to allow an exotherm detection. This test is a very accurate and scientific method to explore onset temperatures and to distinguish between reaction phases and exotherms.

A temperature ramp can be applied to the cell from ambient to a maximum 350° until a thermal runaway reaction occurs. This test does not provide the detail on exotherms such as the heat-wait-search method.



| SAMPLING OF BATTERY FAILURE STANDARDS |                                                                                              |                                               |                    |                                                              |
|---------------------------------------|----------------------------------------------------------------------------------------------|-----------------------------------------------|--------------------|--------------------------------------------------------------|
| Regulation                            | Battery                                                                                      | Temperature                                   | Pass/Fail Criteria | Pass Criteria                                                |
| SAE J2462                             | Used in electric and hybrid automobiles.                                                     | 55°C                                          | No                 | N/A                                                          |
| UL 9540A                              | Used in solar or wind energy systems and energy storage systems.                             | Ambient                                       | No                 | No fire or explosion propagating from the battery under test |
| IEC 62619                             | Used in industrial applications more specifically considerations for internal short circuits | Maximum Use Temperature or 25°C               | Yes                | No fire or battery case rupture                              |
| UL 1973                               | Used in Light Electric Rail                                                                  | Maximum Use Temperature or 25°C               | Yes                | No fire or explosion propagating from the battery under test |
| KMVSS 18-2 & 3 (Korea)                | Requirement for HV batteries systems of electric vehicles                                    | 80°C for heat exposure<br>25°C for overcharge | Yes                | There must be no ignition or explosion                       |

### Battery Nail Penetration/Crush Abuse

Nail penetration tests are an add-on to the standard battery test. A nail penetrates the cell casing or is mechanically crushed to evaluate the potential for an internal short circuit. Nail speeds are from 0.5 mm/sec to 8cm/sec. Though thermal runaway is quick in a nail penetration abuse test, ioKinetic can capture data at high frequencies.



### Battery External Short Circuit

The external short circuit add-on allows a remote shorting of the cells inside the open ARC chamber to induce a thermal runaway. This option is designed to carry a load of up to 2,700 A for 10s.

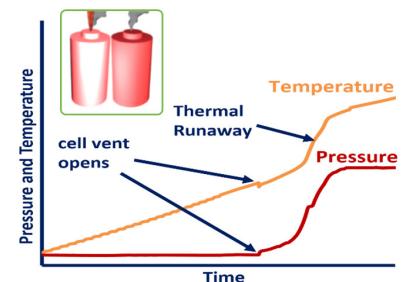


### Battery Overcharge & Voltage Measurement

This open ARC test tracks rapid heating of cell during overcharge procedure to maintain adiabaticity. The voltage can be measured via a calorimeter add on during abuse tests.

### Closed Test/Gas Collection

To conduct a closed test, the cell is placed into a sealed canister which is then placed into the calorimeter chamber. Gases resulting from the test are captured inside the gas collection canister. Pressure and cell voltage are measured providing information about the condition of the cell throughout the test.



### Capacity Measurements & Secondary Tests

Thermal management designs require a definition of average cell heat capacity. Energy yielded during the thermal runaway can be calculated via the exotherm detection in the ARC and then applying the average heat capacity measurement.

Secondary tests help meet cell level compliance for UL9540A tests such as explosion severity, gas chromatography mass spectrometry, and flammability measurements.





## Battery Safety Testing

### Additional Services

Our exclusive partnership with ioMosaic Corporation allows us to expand our process safety and laboratory services to include:

- Kinetic modeling of battery component runaway
- Battery hazard analysis for installations and battery transportation
- Deflagration modeling for battery systems
- Thermal explosion modeling

Battery hazard and modeling services allow a full lifecycle of study to understand the fundamental behavior of a battery system, the conditions required for an event to occur, and then performing a detailed event analysis of the event. Our partnership with ioMosaic allows us the opportunity to enable the mitigation of risk that would otherwise be overestimated resulting in costly redesign and re-installations.

### Hazard Analysis Tools

Process Safety Office® PHAGlobal® is the most useful and cost-effective PHA/DHA tool on the market. PHAGlobal® simplifies the recording of findings and tracking follow-up

from PHAs and their results. PHAGlobal® makes it easier to comply with codes and standards, such as OSHA PSM, EPA RMP and NFPA, that require PHAs.

### About ioKinetic

ioKinetic is a worldwide, ISO accredited testing facility. Our testing services include the complete safety solution. We provide an array of testing services (chemical reactivity, combustible dust testing, and battery testing) to a broad range of industries, such as: chemical, oil and gas, pharmaceutical, agricultural, biotechnical, explosives, food and beverage, lumber and sawmill facilities, etc. Our services also include training and consulting for all your process safety management needs. Our exclusive partnership with ioMosaic Corporation allows us to expand our service and product offerings to encompass expert testimony services, as well as access to industry gold standard software.

Our experts not only provide you with timely, reliable and reproducible data, but we will also only recommend the services that are 'right' for your company's safety efforts. Time and again our clients have acknowledged that we 'go the extra mile' with regard to our service. We provide more than laboratory testing services, we provide peace of mind. For more information, visit [www.ioKinetic.com](http://www.ioKinetic.com) or call us at **1-844-ioKinetic**.

