



BATTERY FIRE PLUME PRECURSORS IN ENCLOSED SPACES

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Why do we Care?

Understanding battery fire precursors is essential for first responders addressing battery energy storage system incidents, researchers and developers working on battery technologies, manufacturers and owners of consumer electronics, and all individuals responsible for lithium-ion batteries—including those in ground, air, and sea logistics such as truck drivers and pilots.



What can we do with this information?

Battery fires can ignite quickly, releasing toxic gases and intense heat—especially dangerous in confined spaces where people work and valuable equipment is stored. By detecting early warning signs of these fires, we protect what matters most: our people, our assets, and our surrounding area. Informed decisions help us meet strict safety standards, drive innovation in grid storage, and portable electronics, and reduce harmful emissions. Together, we can create safer spaces, foster cutting-edge battery technologies, and safeguard our planet—because safety and innovation go hand in hand.

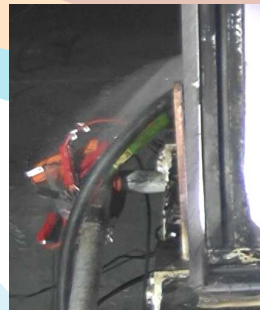
Pressure Changes

This Lithium Cobalt Oxide battery cell has puffed up into a pillow-like shape prior to thermal runaway initiated by indentation. Pouch Cells go through pressure changes during regular usage—expanding and contracting during charge and discharge, with potential additional expansion preceding thermal runaway.



Vapor Formation

This Lithium Iron Phosphate battery was abused by overcharging. Prior to properly venting out of the vent hole and prior to ignition, laminar vapor falls from the box where the cell lies. Many of these early vapors are assumed to be a decomposition byproduct of electrolyte organic solvents such as DMC and DEC. They can be colorless/odorless and can creep along the floor. They are sometimes striated from smoke that is generated. These can be explosive gases and can be toxic to humans, with extreme respiratory risks.



Understanding Overt Precursors



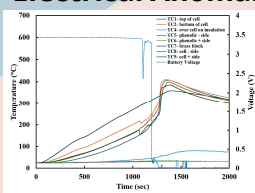
Continuous monitoring of area near the battery using technology such as FTIR (shown below) or Mass Spectroscopy (The Hiden Mass Spectroscopy instrument shown on the left is in a Mobile Battery Abuse Laboratory) can give us information about precursors, such as an increase in certain gases, or even a decrease in certain gas

Acoustic Signs

When a Lithium Ion battery has been pierced or is venting prior to thermal runaway a “teapot kettle” whistle noise can be heard. This is a recognizable noise that is somewhat form agnostic. Sometimes you can hear the “liquid spraying onto a surface” sound during venting. For cylindrical cell propagation you can hear “popping” like popcorn as cells vent in series.



Electrical Anomalies This Lithium Cobalt Oxide pouch battery cell shows a voltage dip that recovers prior to thermal runaway. This cell was abused by heat soaking it and then subjecting it to indentation. This phenomena—of voltage decreasing and then recovering has been seen in other cells more dramatically. Other electrical anomalies could come from externally short-circuiting the cell by touching opposing tabs. Cells that read zero voltage could actually have full state of charge (with a potentially larger energy envelope during failure) due to the tabs pulling away from the interior components.



Olfactory Signals

Lithium Ion Battery Smells including sweet, fruity, acetone or sharp smells could indicate electrolyte leakage. The electrolyte may be leaking due to damage, venting prior to thermal runaway, or from damage. It may also have a musty salty smell from prior damage and electrolyte leakage or the resulting corrosion.



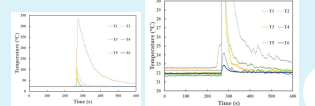
Liquid Electrolyte Spewing at time of Cell Venting

Gas Emissions (Off-Gassing)

This Lithium Ion Energy Storage Battery Abuse was initiated with heat. After venting, but prior to ignition, smoke rises as it exits the rack. Gas emissions prior to and after thermal runaway may be visible or invisible.



Thermal Anomalies



This cell shows some temperature increase prior to thermal runaway.

Cells may generate noticeable heat prior to self-ignition. They may also go into thermal runaway earlier if failing at a temperature higher or lower than ambient.

