



Inert Gas Fire Extinguishing Systems and Li-Ion Batteries

Updated 2026 Edition

Incorporating peer-reviewed large-scale BESS fire suppression research



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In recent years, advancements in battery technology have taken significant leaps, resulting in batteries becoming considerably more powerful. This progress has highlighted the need for enhanced safety measures concerning fire incidents in areas where batteries are stored. Although various new battery types exist, Lithium-Ion (Li-Ion) batteries are currently the most prevalent type. The following overview will address the new powerful battery types collectively referred to as Li-Ion batteries.

Li-Ion batteries contain a substantial amount of energy, and if this energy is released uncontrollably, it's known as Thermal Runaway. Thermal Runaway in Li-Ion batteries is a rapid and uncontrolled breakdown of the battery, generating high heat, often along with toxic, corrosive, and flammable gases. This can result in a severe fire. Once Thermal Runaway begins in a Li-Ion battery, it's impossible to halt the process using current technology. The focus should instead be on managing the process, controlling the release of energy to the surroundings, limiting the spread to unaffected cells and parts of the battery, as well as the room itself.

The causes of Thermal Runaway can vary but usually occur under maximum performance, battery aging (end of life cycle), poor battery management (software control), external factors like fire, physical damage, high temperatures, etc., and overcharging or overdischarging.

Thermal Runaway can be detected using smoke detectors and aspiration detection systems. To minimize the scope of an incident, early intervention in the Thermal Runaway process is crucial. Advanced aspiration systems can detect both cell emissions and small smoke particles indicating an incipient fire. In areas with batteries and strong ventilation, the aspiration system's pipe network can be strategically placed for early detection.

AN INCIDENT OF THERMAL RUNAWAY CAN BE DIVIDED INTO FOUR PHASES:

1

Initiating cell breakdown with increasing temperature and pressure.

2

Rising pressure and temperature damage cells, and gas emission increases.

3

Thermal Runaway: Rising temperature in a battery area leads to rapid spread to surrounding parts with smoke development.

4

Fire: Escalating heat spreads Thermal Runaway to other parts of the battery. Heat and gases accumulate, increasing the fire risk.

Several leading detection suppliers have developed specialized gas emission detectors for Li-Ion batteries, responsive to emissions from defective battery cells. The choice between aspiration systems suitable for gas and smoke detection and fixed gas emission detectors depends on factors like placement, ventilation, service capacity, etc.

Recent large-scale research (Meraner et al., 2026) confirms that aspirating detection at the module level provides significantly earlier warning compared to room-level or cabinet-level detection. In the experiments, the aspirating system triggered on average 19.3 minutes before any visible flame. This critical time window between initial off-gassing and flame formation can be exploited by inert gas systems such as Inergen, which can be activated safely during this pre-flame phase without causing damage to the battery system. Water-based suppression systems, in contrast, should not be deployed before flames are present – which may be up to 20 minutes after initial off-gassing – as premature activation risks unnecessary equipment damage. [Ref: Meraner et al. (2026), Sections 3.1 & 4].

An inert gas fire extinguishing system (AFES system) cannot prevent Thermal Runaway or extinguish the ensuing fire, as Thermal Runaway generates its own oxygen from gas emissions and heat. However, an inert gas system can significantly reduce the fire's scope, minimize the consequences, and control the process. By reducing the oxygen percentage in the room, the inert gas system prevents combustible materials (e.g., plastic) from igniting easily. Moreover, the system vents flammable gases and heat out of the room. If heat is not removed, the risk of spreading to other components increases significantly. If flammable gases are not ventilated, the accumulation may lead to deflagration – a risk underscored by the 2026 large-scale experiments, where explosion protection was found to be critical for any fire strategy allowing gas accumulation. [Ref: Meraner et al. (2026), Section 3.1].

After Thermal Runaway, the focus should be on limiting the scope and minimizing damages. Activating the inert gas system can control the process as the battery's energy naturally diminishes during discharge. The exact timing and amount of Inergen gas to be introduced depend on the room's size, battery capacity, battery density, room characteristics, etc. If controlled mitigation of Thermal Runaway is needed over an extended period, a ContinuOxy Inergen system can be installed. The ContinuOxy system supplements a standard Inert gas system with additional Inergen gas cylinders with longer discharge times. This maintains overpressure in the room, vents gases, and extinguishing potential fires.

While Li-Ion battery fires are rare due to manufacturers' safety focus, storing batteries in dedicated fire-segregated sections and implementing effective detection systems is recommended. Generally, placing powerful Li-Ion batteries in separate fire-segregated sections and maintaining appropriate spacing between batteries is advised to impede fire spread and facilitate effective cooling.

CONCLUSION:

Battery technology is evolving rapidly, leading to new challenges. Large-scale peer-reviewed research by Meraner et al. (2026) provides critical new evidence for BESS fire protection design:

- IG-541 was the only tested system to extinguish external flames and prevent module-to-module thermal runaway propagation – limiting the incident to a single module while all water-based systems allowed propagation to all four modules.
- Aspirating detection provides approximately 20 minutes of early warning before flame formation, enabling safe pre-flame activation of inert gas systems.
- System dimensioning based on battery-specific thermal runaway data (e.g. UL 9540A) is essential for calculating correct gas quantities and hold times.
- Inert gas systems produce no contaminated firewater run-off, avoiding the significant environmental impact documented for water-based systems.

KEY POINTS REGARDING INERT GAS SYSTEMS AND SAFEGUARDING LI-ION BATTERIES:

Pressure relief: Channels for pressure relief should be heat and corrosion-resistant and always vent gases outdoors.

Battery-specific design: To avoid or limit deflagration, the thermal runaway characteristics of the specific battery system must be considered. Most manufacturers have such documentation available through standardised tests such as UL 9540A. These data are essential for dimensioning the correct quantity of inert gas and calculating appropriate hold times. [Ref: Meraner et al. (2026), Section 4].

REFERENCES:

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EN 15004-1 – Fixed firefighting systems: Gas extinguishing systems (2024).