Inert Gas Fire Extinguishing Systems and Li-Ion Batteries

FIRE EATER

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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.

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.

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.

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.

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 isn't removed, the risk of spreading to other components increases. If gases aren't ventilated, an explosive fire causing substantial damage can occur.

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 Continu-Oxy Inergen system can be installed. The Continu-Oxy 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 suppresses 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 and conditions. Inert gas fire suppression systems are an effective method to curtail the extent of fires, expel flammable and toxic gases, and manage the process with minimal damage. Inert gas consists of natural air components in a different composition and doesn't react with room gases. These systems are highly reliable with minimal failure risks during incidents, and seem currently to be the most efficient systems to prevent devasting damages when Thermal Runaway occurs.

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.

Cooling with water: Water is an effective cooling method, but combining electricity and water requires caution to avoid short circuits. Steam generation can lead to overpressure, and the reaction between water and lithium can create further issues.

REFERENCES:

Danish Emergency Management Agency's "Guidelines for Fire Safety of Larger Li-Ion Battery Storage and BESS"

Euralarm: "Guidance of Integrated fire solutions for Lithium-Ion batteries"

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