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Fire protection for Li-ion battery energy storage systems

Protection of infrastructure, business continuity and reputation

Li-ion battery energy storage systems cover a large range of applications, including stationary energy storage in smart grids, UPS etc. These systems combine high energy materials with highly flammable electrolytes.

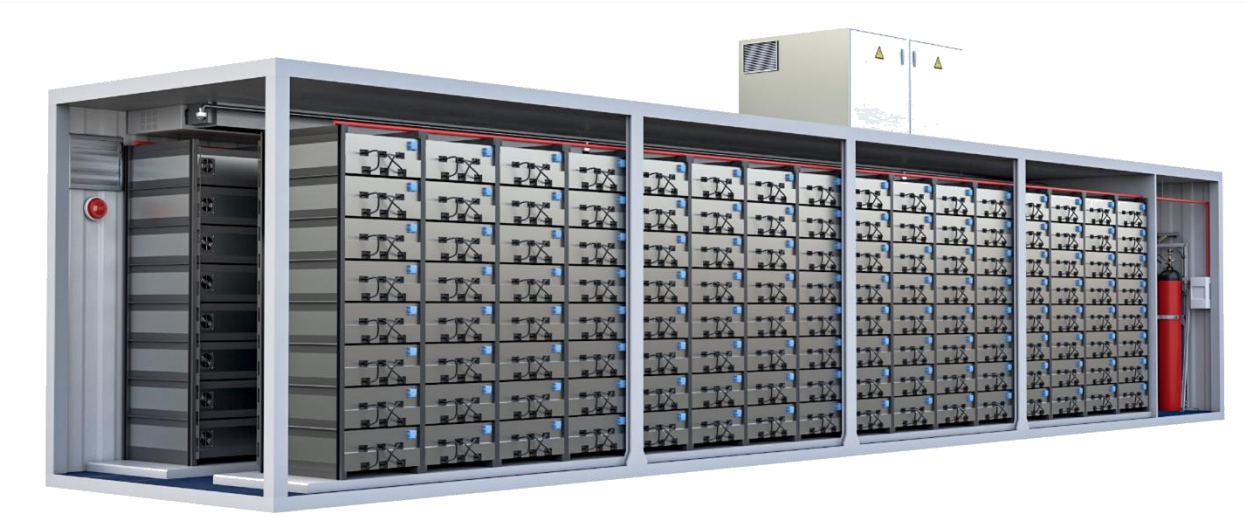
Consequently, one of the main threats for this type of energy storage facility is fire, which can have a significant impact on the viability of the installation.

- Loss of assets: a fire in a lithium-ion storage system that is not detected and dealt with in its incipient phase can easily lead to an uncontrollable event and may even lead to the complete loss of assets.
- Loss of revenue: any fire-related incident can lead to operational interruptions and consequential loss of revenue.
- Damaged reputation: even minor fire-related incidents may lead to a lack of confidence in the supplier (or the technology).

A comprehensive fire protection concept is therefore an essential pre-requisite in managing the inherent risks and ensuring business continuity.

The main focus of this application guide is stationary storage systems with a capacity of over 1 MWh. Such systems may form an integral part of the electricity supply grid or may also be installed behind the meter in commercial buildings such as offices and factories.

Content



Introduction

Highlights

- The combination of high energy densities and flammable electrolytes puts high demands on associated fire protection systems.
- Statistics[1] show that electrical fires account for over 25% of major fire losses in industrial companies.
- The importance of Li-ion battery storage systems has increased dramatically in recent years.

Since the market introduction of Lithium-ion batteries, they have been used in a wide variety of applications including stationary energy storage in smart grids.

However, this type of battery can present a considerable fire hazard. If one cell of a Li-ion battery is short-circuited or exposed to high temperatures, an exothermic reaction can be triggered resulting in a rapid and extreme rise in temperature, causing the electrolyte to combust. This effect, known as “thermal runaway”, can easily propagate to neighboring cells, resulting in large scale fire.

Understanding the mechanisms involved in how fires in Li-ion battery systems start and how they develop enables us to create an appropriate fire protection concept. In this way the inherent risks can be managed in an economically responsible manner.

In the early stages of thermal runaway electrolyte gases are released. Aspirating Smoke Detection (ASD) systems are able to detect even the smallest gas and aerosol concentrations and therefore offer the ideal solution for fire detection in Li-ion storage facilities

The first priority is to ensure early and reliable fire detection and then to deal with any incipient fire before it can develop. On no account should thermal runaway in one cell be allowed to propagate throughout the system. Targeted extinguishing using, for example, a Sinorix N_2 extinguishing system ensures that any fire damage is kept to an absolute minimum.

The fire risk is based on a combination of factors:

- Proximity to a constant ignition source (electricity) and combustible materials such as plastic in printed circuit board
- Mechanical damage and electrical surges (rapid discharging and overcharging)
- Malfunctions in the battery management system
- Age-related damage to the separator can lead to an internal short-circuit
- High air-flow rates increase the risk of fire spreading

Basic conditions

Objectives

- Identify impending thermal runaway by detecting electrolyte gas released in the event of local overheating
- Deter initial thermal runaway
- Extinguish any incipient fire rapidly and efficiently, and prevent re-ignition
- Restrict any fire damage to an individual module by preventing thermal runaway propagation

Typical fire hazards

- Mechanical damage
- Electrical surges
- Battery aging
- Manufacturing defects

Typical development of a fire

- Mechanical damage or overheating can cause an internal short-circuit in an individual cell
- A rapid and excessive rise in temperature of the cell can lead to thermal runaway
- This can easily propagate to neighboring cells, which can quickly develop into a large-scale fire

Critical Points

- Electrolyte gases released during the initial stages of thermal runaway must be detected as early as possible
- Fire damage must be restricted to a single module (by preventing thermal runaway propagation)
- High air flow cooling rates can significantly dilute the aerosol concentration (make early detection considerably more difficult)

[1] According to GDV (Gesamtverband der Deutschen Versicherungswirtschaft)

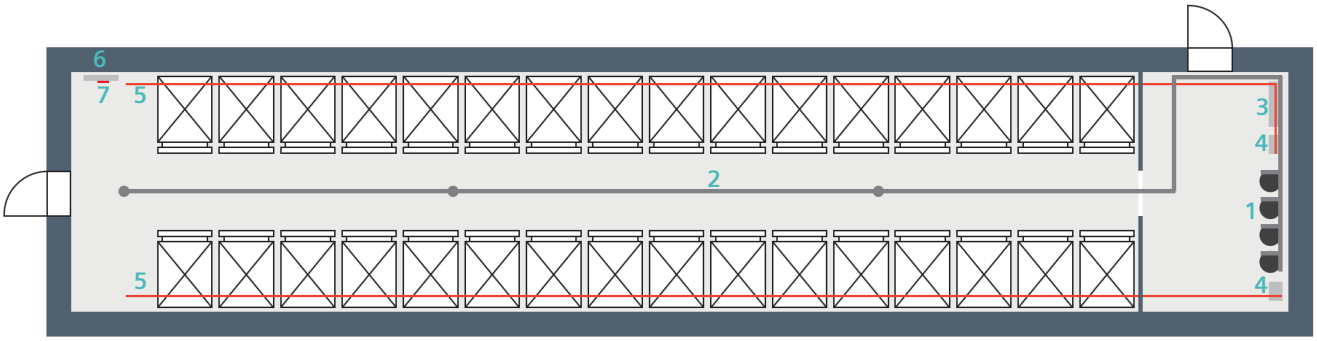
Solution

An effective fire protection system must fulfill the following requirements:

- Detect a potential thermal runaway at the earliest possible stage
- Quickly extinguish any incipient fires and prevent re-ignition
- Prevent thermal runaway propagation
- The extinguishing agent used shall not damage the sensitive technical equipment

Early detection can be provided by an Aspirating Smoke Detection (ASD system), which is able to detect the electrolyte gases generated by the excessive overheating of individual battery cells.

Targeted extinguishing using a Sinorix N_2 can then ensure rapid extinguishing and prevent re-ignition. Above all, it can prevent any possible thermal runaway propagation.



Legend

1	Extinguishing agent cylinders with nitrogen	**5**	ASD sampling pipes
2	Extinguishing piping network with nozzles	**6**	Overpressure flap
3	Fire detection and extinguishing control panel	**7**	Sounder beacon
4	ASD-evaluation unit		

Details	Comments/Notes
Automatic fire detectors Aspirating Smoke Detection system (e.g. FDA 241)	The ASD system is able to detect the release of electrolyte gases, which is an early indication of excessive local overheating. Local regulations generally require a dual ASD system to activate the automated extinguishing process. • Siemens Aspirating Smoke Detection (FDA241) provides early fire detection with excellent reliability based on **ASA***technology*. • Air samples are drawn from the areas requiring protection and evaluated for the presence of smoke and electrolyte gas in the detector chamber.
Manual call points	Manual activation of a fire alarm (via the fire detection panel) • Single or double action (depending on local regulations)
Alarming: Sounders, beacons, optical signaling	The minimum installation is a fire alarm sounder. Depending on specific needs, different options can be installed: • Sounders, sounders with additional optical signaling • Signaling signs • Warning display
Manual release extinguishing system: Manual release button	When an extinguishing system is installed, a manual release button is used to alarm and start the extinguishing process with respect to the protected area.
Pressure compensation: Overpressure flap	To prevent structural damage to the room, all gaseous extinguishing systems need pressure relief openings, which reduce the overpressure created by the release of the extinguishing agent. The size can be determined using the calculation software.
Extinguishing control	In addition to controlling the automated extinguishing system, the fire protection system triggers all other necessary control functions.
Extinguishing Sinorix N_2 extinguishing system	The Sinorix N_2 provides a safe and sustainable fire suppression and extinguishing. • Sinorix N_2 extinguishes electrical fire, stop propagation of thermal runaways and prevent secondary fires. • Effective in handling deep seated fire and the extinguishing agent itself is not dangerous to persons. • It is a total flooding system with a N_2 design concentration of 45.2%. Hence oxygen concentration remains below 11.3% or less depending on battery type • The Sinorix N_2 can reach more than 20 minutes of holding time.
Positioning of elements	ASD system ▪ The positioning of the sampling pipes must take the high air-flow rates of the cooling system into account. Positioning of the aspiration points in the air flow, for example: in front of the ventilation outlet.

Practical experience

Fire detection

One of the first indications of potential thermal runaway is the generation of electrolyte gases, caused by excessive overheating of an individual cell

The ability to detect these gases as early as possible is paramount in being able to intervene before large scale fire damage can occur. An appropriately positioned and dimensioned ASD system is able to recognize such gases at a very early stage of the thermal runaway process, in spite of the high air-flow rates typically encountered in high density battery cooling systems.

Practical experience has demonstrated that an FDA241 ASD-system (with its patented dual wavelength blue and IR sensors) can provide reliable excellent early detection.

Targeted extinguishing

Having detected a potential thermal runaway situation, the next step is to minimize any fire damage and prevent the possibility of thermal runaway propagation. Experience has shown that automated activation of an integrated Sinorix N_2 system can provide the ideal solution.

Flooding with an N_2 design concentration of 45.2% ensures that the oxygen concentration remains below 11.3%. Any developing fires are swiftly extinguished and re-ignition effectively prevented. In addition, the extinguishing agent itself does not cause any damage to equipment or present any danger to personnel.

An integrated solution

It is the "integrated" combination that makes the difference. The combination of early detection, alarming and efficient targeted extinguishing (as described above) is the most effective solution for the protection of stationary Li-ion battery energy storage systems available today.

This solution ensures optimal fire protection for battery storage systems, protecting valuable assets against potentially devastating fire-related losses.

Siemens is the first and only[2] company that is certified by VdS (VdS Schadenverhuetung GmbH) for our protection concept for stationary Li-ion battery energy storage systems.

Do you want to know more about the application? Check out our website – including White paper!
www.siemens.com/firesafety-applications

[2] Status December 2019, VdS certificate officially handed over at VdS Brandschutztage, Cologne, Germany

Aspirating Smoke Detection

For early fire detection with excellent reliability and genuine alarm guarantee

Aspirating Smoke Detection (ASD) systems from Siemens ensure reliable fire detection in demanding application areas, where very early fire detection is required and business continuity is paramount. Aspirating smoke detectors continually draw samples of air from the areas requiring protection and evaluate these samples for the presence of smoke. The high detection reliability and immunity to deceptive phenomena provided by these systems are backed up by our genuine alarm guarantee.

Learn more about **ASD** from Siemens.

ASA*technology*

For intelligent, reliable fire detection with genuine alarm guarantee

ASA*technology* is a unique technology from Siemens that converts signals into mathematical data which is compared with programmed values in real time using intelligent algorithms. The special signal analysis process is very reliable in preventing false alarms caused by deceptive phenomena, such as steam, tobacco smoke or exhaust emissions. Find out more about **Sinteso** or **Cerberus PRO** fire detectors with **ASA***technology*.

Extinguishing

For effective and environmentally friendly extinguishing

Sinorix systems with nitrogen extinguish fire efficiently and environmentally friendly. In addition, fires are extinguished quickly keeping the equipment within the protected area safe. Even after the extinguishing process, the usage of nitrogen proves to be beneficial thanks to easy refilling, which results in a fast recommissioning of the system. Find out more about **Sinorix** extinguishing systems.

Everything you need for comprehensive fire protection

Incorporated in a concept tailored to your customers´ requirements, Siemens and its Solution Partner network provide:

- Early and reliable fire detection solutions, offering an unrivalled financially backed "Genuine Alarm Guarantee".
- Fully forwards and backwards compatible systems, to ensure any system provided is equipped to integrate the latest technology Siemens has to offer.
- Clear and fast alerting and evacuation processes.

All these aspects are at the core of comprehensive fire protection. Only when these are fulfilled can you be assured that people in your buildings are safe and assets and business operations are protected.

In order to offer your customers peace of mind, Siemens and its Solution Partner network have a variety of service and solution offerings that can be tailored to an individual client's needs. To find out more about this, please visit our Web site at **siemens.com/firesafety-markets** **or** contact your local Siemens organization through the **online contact form.**

Share the experience

With our dedicated program for consulting engineers, you can benefit from our extensive application know-how and complete portfolio.

With Siemens, you can offer your customers comprehensive fire safety for any application and environmental condition. Your customers will appreciate this as it enables them to reliably protect people, assets and business processes from fire.

Backed by more than 160 years of experience in the field, our offerings for early detection, reliable alarming, orderly evacuation and safe extinguishing are based on innovative and unique technologies. They provide you with convincing arguments like maximized life safety or environmental friendliness, and open the door to strong, long-term customer relationships. And with Siemens, you gain a reliable partner at your side and benefit from our smart tools, in-depth trainings and personal support – wherever you are, wherever you go.

For more information please visit our dedicated **consultant page**.

Smart Infrastructure intelligently connects energy systems, buildings and industries to adapt and evolve the way we live and work.

We work together with customers and partners to create an ecosystem that intuitively responds to the needs of people and helps customers to better use resources.

It helps our customers to thrive, communities to progress and supports sustainable development.

Creating environments that care.
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