SIEMENS

FIRE SAFETY PRODUCTS AND SYSTEMS

Fire protection for **Lithium-ion Battery Systems**

High performance battery storage brings an elevated risk for fire. Our detection and suppression technologies help you manage it with confidence.
usa.siemens.com/lithium-ion

Today's energy infrastructure is undergoing a radical transformation.

As overall demand for energy increases in our modern world – so does the use of renewable sources like wind and solar. As the use of these variable sources of energy grows – so does the use of energy storage systems. Energy storage systems are also found in standby power applications (UPS) as well as electrical load balancing to stabilize supply and demand fluctuations on the Grid. Today, lithium-ion battery energy storage systems (BESS) have proven to be the most effective type, and as a result, demand for such systems has grown fast and continues to rapidly increase.

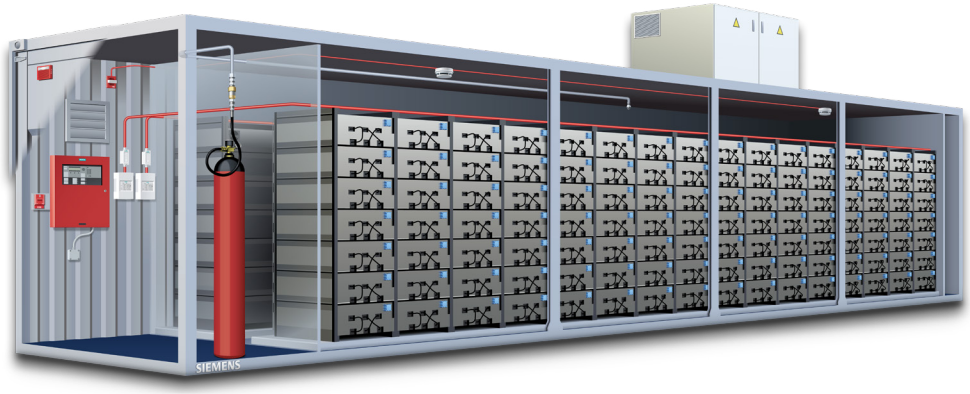
Stationary lithium-ion battery energy storage systems – a manageable fire risk

Lithium-ion storage facilities contain high-energy batteries containing highly flammable electrolytes. In addition, they are prone to quick ignition and violent explosions in a worst-case scenario. Such fires can have significant financial impact on organizations and create a deadly hazard for those on site. Rapid detection of electrolyte gas particles and nitrogen suppression system activation are the key to a successful fire protection concept. Introduced in December 2019, Siemens began offering a VdS-certified fire detection and suppression solution to protect stationary lithium-ion battery applications.*

Critical to the BESS application is early detection and suppression of a pending event. Early detection allows initiation of suppression gas to inert the local environment long before a potentially disastrous event, such as lithium-ion battery thermal runaway, can occur. By leveraging patented dual-wavelength detection technology inside each FDA241 device, Siemens fire protection has increased the level of protection in modern-day BESS facilities.

After performing hundreds of tests on li-ion batteries, we have found that the Siemens NXN nitrogen suppression agent effectively controls thermal runaway and stops it from spreading from module to module. In most cases, it even prevented cell-to-cell propagation.

Thanks to our extensive testing we can confidently say that the FDA241 can detect li-ion battery fire risks very early, even in the incipient stage, and Sinorix NXN N_2 suppression has been proven to stop the cascading effect of thermal runaway. Together, these two innovations allow lithium-ion battery hazards to become a very manageable risk.



Lithium-ion storage facilities house high-energy batteries containing highly flammable electrolytes.

*The combination of FDA241 detector and the Sinorix NXN Nitrogen suppression system are covered under VdS approval (no. S 619002). The two products have been verified to reliably detect li-ion battery gas particles at an incipient stage and effectively suppress lithium-ion battery fires. This VdS approval can be used to meet NFPA 855 requirements through equivalency allowance in NFPA 72 section 1.5. Currently there are no other global product performance standards for the detection of lithium-ion battery off-gas.

Earliest possible detection
with the FDA241 aspirating smoke detector

Our solution

Aspirating smoke detectors (ASD) continuously draw air samples from the areas requiring protection and evaluate them for the presence of particles of combustion (e.g. smoke, etc.). The active sampling of aspirated detection provides reliable fire detection in demanding application areas, where earliest possible fire detection is essential and business continuity is paramount.

The FDA241 detects lithium-ion electrolyte vapor (also known as off-gas particles) early, as much as five times faster than competitive detection technologies, and reliably thanks to its patented dual-wavelength optical detection technology. The FDA241 is the ideal solution for early detection of electrical fires. In addition to controlling the automated extinguishing system, the fire protection system triggers all other necessary battery management system control functions.

Siemens aspirated smoke and particle detection

A patented smoke and particle detection technology which excels at smoke and lithium-ion battery off-gas detection.

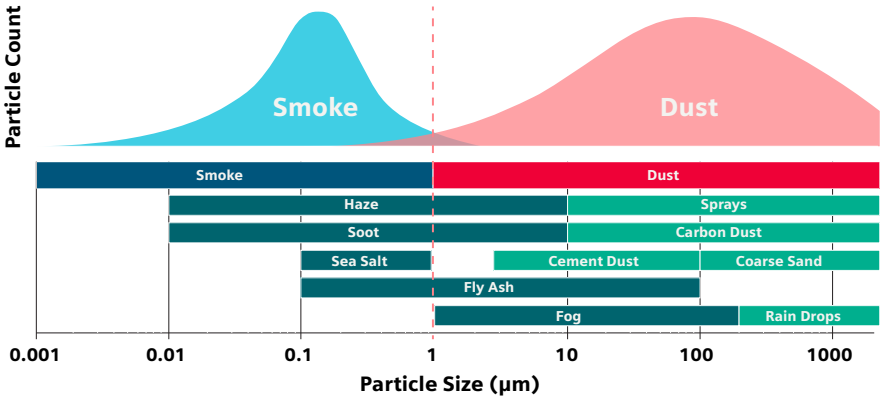
How does ASD detection work?

As depicted below the blue and red curves graphically represent the particle distribution across the range of particle sizes detected using dual-wavelength technology. The various particle types can be categorized as large particles (greater than 1 micron) best detected by infrared light scattering, and small particles (less than 1 micron), including smoke, that are effectively detected by blue light scattering. In the patented dual-wavelength detection chamber, the red and blue light scatter signals are accurately combined using precision algorithms to detect by-products of fire and lithium-ion battery electrolyte off-gas particles. These same algorithms reject the effects of deceptive phenomena – providing resistance to unwanted alarm conditions not found in other smoke detection technologies.

It is important to note that Siemens' patented dual-wavelength technology is not a gas detector. It leverages infrared and blue light energy to accurately perform particle detection. Targeted lithium-ion off-gas particles are not pure gases – they are by-products of overheated lithium-ion electrolytes. These vaporized electrolyte particles fall within the blue region making it easily detectable by the FDA241 unit.

All these facts add up to increased value in Siemens FDA smoke and lithium-ion off-gas detection technology providing 5 times faster detection for the safety of lithium-ion battery energy storage systems.

This chart illustrates the array of particles commonly found within an ambient environment. These particles range from gases on the far-left end (smallest particles – smaller than 0.001 microns) to sand on the far right (largest particles larger than 100 microns).



The ideal suppression solution

Combine early detection with Sinorix NXN N_2 for total li-ion protection

Our suppression solution

The Sinorix NXN N_2 pre-engineered nitrogen suppression system is the latest generation of inert gas extinguishing technology from Siemens. This solution combines high pressure nitrogen gas with an easy-to-deploy system.

Why is nitrogen the ideal solution for lithium-ion suppression?

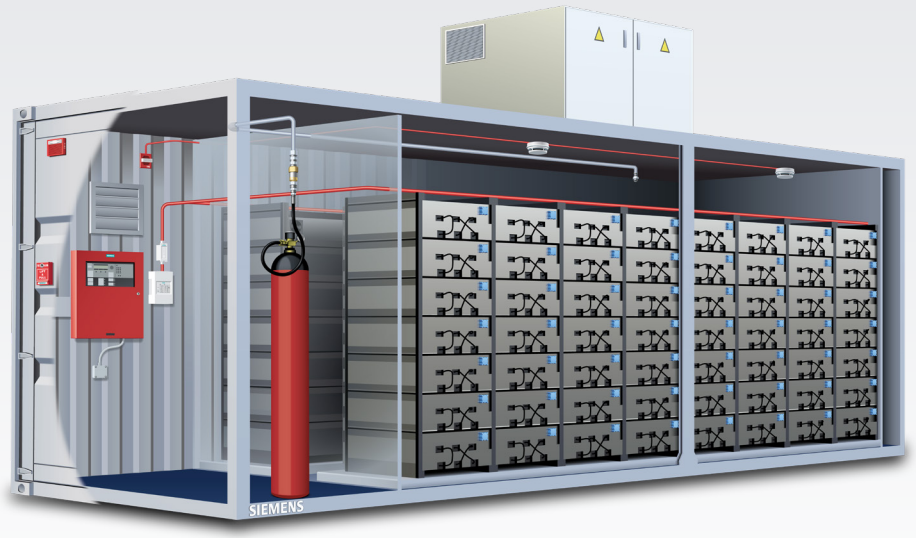
1. To permeate hidden or covered spaces, like a battery rack, gaseous solutions, such as nitrogen, are most suitable. Liquids and powders must be avoided.
2. Only natural extinguishing gases should be considered so that the production of dangerous and/or harmful decomposition agents is avoided.
3. Unlike gases that are extremely dangerous to persons, like CO_2, nitrogen provides a higher degree of safety since it is abundantly present in Earth's atmosphere (comprising 78% of the air we breath).
4. Sinorix NXN N_2 is targeted to modern lithium-ion batteries which do not contain metallic-lithium, so it's a cost efficient solution and avoids more costly gases like argon to suppress. Nitrogen suppression is the best solution to effectively protect lithium-ion battery fire hazards.

The Sinorix advantage

By using high-pressure nitrogen cylinders (4351 PSI), the Sinorix NXN N_2 solution has a smaller footprint, allowing for better utilization of space in smaller enclosures (e.g. a 20' BESS unit).

Since this is pre-engineered, the solution provides a significant advantage in today's fast paced and demanding environment. There is no need for hydraulic calculations or extra software licenses. By using this system, savings on engineering and installation are significant compared to other suppression systems.

Having been installed around the globe over many years with great success, you can have confidence in the Sinorix NXN N_2 system and its proven track record.



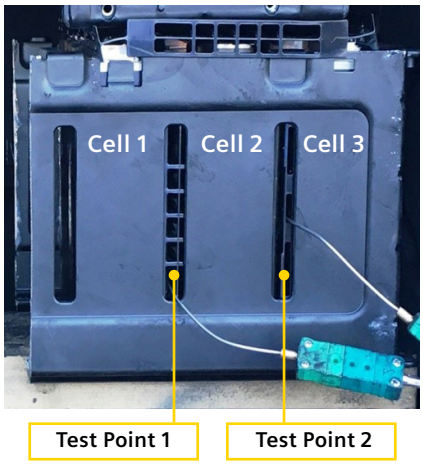
Breaking the thermal runaway cycle

Take advantage of Sinorix NXN N_2 pre-engineered suppression system

The history of success with lithium-ion

This IG-100 gas system, Sinorix NXN N_2, isn't just the best theoretical option, it's the best proven option, for lithium-ion battery protection.

Consider the following experiment we performed in our lab in Altenrhein, Switzerland. We tested a variety of lithium-ion batteries from six major manufacturers. Surprisingly, all of the tests resulted with the same conclusion – the Siemens nitrogen solution works at stopping the cascading effect of the thermal runaway fire cycle.



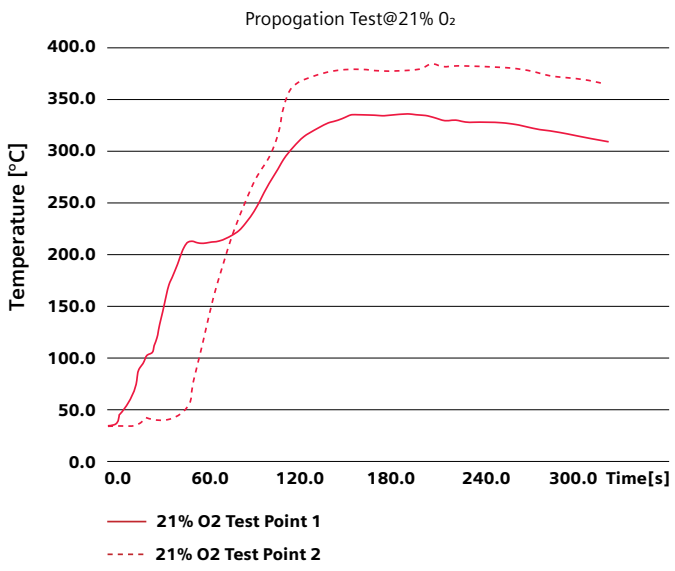
Test summary

The image on the left shows one of the lithium-ion battery banks we used in our test procedure. We punctured cell 1 to create a short-circuit event, thereby mimicking, in an accelerated fashion, what would occur in the field with a battery that sustained abuse over time.

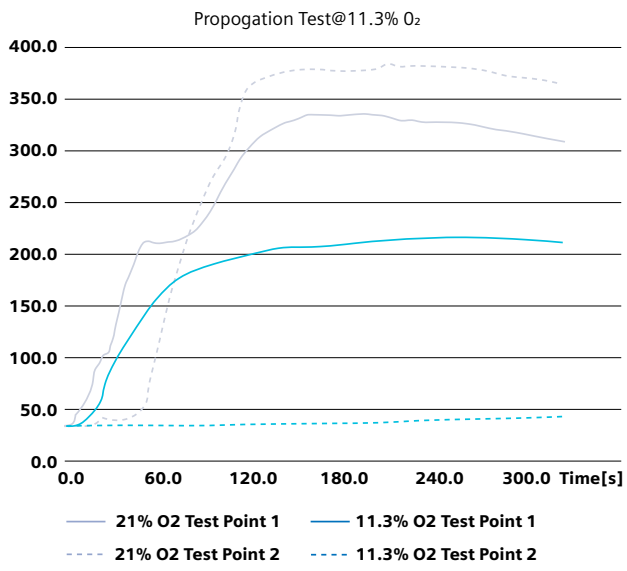
By measuring the temperature near the short-circuited battery cell with *Test Point 1*, the temperature increase in a normal oxygen rich (21%) environment was recorded with a solid red line in Graph A below. The temperature at *Test Point 2* was recorded with the dotted line. Notice the heat transfer event that occurs at timestamp 90 seconds – this is the point when thermal runaway has cascaded from one cell to other cells, after this cross-over point occurs, controlling the fire becomes practically impossible.

The same test was performed in an environment inerted by nitrogen (0^2<11.3%). See the results of this test in Graph B below with the blue lines. Can you spot the difference?

Graph A - Normal Oxygen Environment



Graph B - High Nitrogen Environment



High performance solution for lithium-ion battery protection

Leverage industry leading FDA241 detection and Sinorix NXN N_2 suppression

Benefits of FDA241 very early warning detection

- FDA is an active device – continually drawing samples of air from the protected space.
- Dual-wavelength particle detection technology reliably identifies battery events.
- Intelligent classification of airborne particles provides high immunity to deceptive phenomena.
- Offers three levels of detector operation "Ultra-sensitive, Auto-discrimination and Robust".
- Offers powerful built-in features such as dust discrimination and 4-20 mA output for real time monitoring.

Benefits of nitrogen based suppression

- Nitrogen is a clean and eco-friendly inert gas.
- Sinorix NXN N_2 does not contain or create any harmful decomposition agents, like hydrofluorocarbons.
- Since it is abundantly available in the atmosphere, it is relatively inexpensive when compared to other extinguishing gases.
- After discharge, Nitrogen has a fantastic minimum holding time of approximately 30 minutes in a room of basic integrity.
  - In rooms with high integrity, our tests found that gas concentration could be maintained for many hours, giving the fire brigade more valuable time to respond.
- Nitrogen does not damage assets, nor does it require any cleanup that might occur with other solutions, like water or powder systems.
- In a nitrogen rich environment, a battery cell undergoing thermal runaway experiences a torch effect, burning out the combustible within in a controlled setting, preventing the thermal runaway condition from spreading to other nearby cells and/or modules.

Features and benefits

- Siemens FDA detectors use patented dual-wavelength detection technology for differentiation between smoke and deceptive phenomena to reliably provide incipient detection of lithium-ion battery off-gas particles.
- Sinorix NXN N_2 pre-engineered suppression system prevents cascading effect of thermal runaway. Specifically, in our testing it has been shown to stop cell-to-cell propagation of thermal runaway in cylindric and prismatic type li-ion battery cells, and stop module-to-module prorogation in pouch type li-ion cells.
- VdS approved lithium-ion battery fire protection solution limits damage to critical assets and facilities.
- Designed for detection and suppression even in the most demanding environmental conditions.

Applications

- Lithium-ion battery energy storage systems (BESS)
  - Solar generation facilities
  - Wind generation facilities
- UPS applications – lithium-ion battery based
  - Telecommunication facilities
  - Computer rooms
  - Data centers
  - Hospitals
  - Clean rooms
- Demand management applications (load balancing)
  - Critical manufacturing facilities
  - Industrial plants
  - Distribution centers / warehouses
  - Transportation facilities / Metro stations

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