NFPA TODAY - DECEMBER 03, 2021

BACK TO BLOGS LANDING PAGE

Battery Energy Storage Hazards and Failure Modes

BY BRIAN O'CONNOR

Around the globe energy storage systems are being installed at an unprecedented rate, and for good reasons. There are a lot of benefits that energy storage systems (ESS) can provide, but along with those benefits come some hazards that need to be considered. This blog will talk about a handful of hazards that are unique to energy storage systems as well as the failure modes that can lead to those hazards. While there are many different types of energy storage systems in existence, this blog will focus on the lithium-ion family of battery energy storage systems. The size of a battery ESS can also vary greatly but these hazards and failure modes apply to all battery ESS regardless of size.

HAZARDS

As with most electrical equipment there are common hazards that need to be addressed as part of operation and maintenance such as a potential for electrical shock and arc flash. These should always be accounted for when working in and around energy storage systems. More information on how to work with electrical equipment safely can be found in NFPA 70E, *Standard for Electrical Safety in the Workplace.*

Thermal Runaway – Thermal runaway is the uncontrollable self-heating of a battery cell. It begins when the heat generated within a battery exceeds the amount of heat that can be dissipated to its surroundings. The initial overheated cell then generates flammable and toxic gasses and can reach a heat high enough to ignite those gasses. This phenomenon can cascade to adjacent cells and progress through the ESS, thus the term "runaway".

Off Gassing – The gasses that ae released from battery energy storage systems are highly flammable and toxic. The type of gas released depends on the battery chemistry involved but typically includes gases such as: carbon monoxide, carbon dioxide, hydrogen, methane, ethane, and other hydrocarbons. If the gas is able to reach it's lower explosive limit before finding an ignition source then there is the potential for an explosion. An example of this occurred in Surprise, Arizona back in 2019.

Stranded Energy – Standard energy is the term used for when a battery has no safe way of discharging its stored energy. This commonly occurs after an ESS fire has been extinguished and the battery terminals have been damaged. This is a shock hazard to those working with the damaged ESS since it still contains an unknown amount of electrical energy. Stranded energy can also lead to reignition of a fire within minute, hours, or even days after the initial event.

FAILURE MODES

There are several ways in which batteries can fail, often resulting in fires, explosions and/or the release of toxic gases.

Thermal Abuse – Energy storage systems have a set range of temperatures in which they are designed to operate, which is usually provided by the manufacturer. If operating outside an acceptable temperature range, the ESS may not work as intended, may result in premature aging of the battery, and can even cause a complete failure that can lead to fire and explosions. Thermal abuse is caused by external sources, it is the result of contact with burning or overheated adjacent cells, elevated temperatures, or exposure to other external heat sources associated with both storage of the cells or the environment in which the ESS is installed.

Electrical Abuse – Electrical abuse takes place when a battery is overcharged, charged too rapidly, or externally short-circuited. This can also occur if the battery is discharged too rapidly or if the battery is over discharged below its specified end voltage. Electrical abuse can lead to an inoperable ESS, overheating, fire, and explosion.

Mechanical Abuse – Mechanical abuse occurs if the battery is physically compromised when the battery is crushed, dropped, penetrated, or otherwise distorted to failure by mechanical force.

Internal Faults – Internal faults can result from inadequate design, the use of low-quality materials, or deficiencies in the manufacturing process. It might be worth noting that the failure rate for lithium-ion cells is said to be on the order of one in a million.

Environmental Impacts – Environmental impacts can lead to battery failure. This can be the result of ambient temperature extremes, seismic activity, floods, ingress of debris or corrosive mists such as dust (deserts) or salt fog (marine locations), or rodent damage to wiring. Some locations subjected to rapid temperature variations such as in the mountains can experience dewing leading to damage within the ESS located outdoors if not well-controlled.

While there are numerous applications and advantages to using battery energy storage systems it is important to keep in mind that there are hazards associated with these installations. Understanding the hazards and what leads to those hazards is just the first step in protecting against them. Strategies to mitigate these hazards and failure modes can be found in NFPA 855, *Standard for the installation of Energy Storage Systems*.

NFPA also has a number of other energy storage system resources including the following:

- Fact sheet on ESS
- PV and ESS training
- ESS resource page
- Blog on residential ESS

Important Notice: Any opinion expressed in this column (blog, article) is the opinion of the author and does not necessarily represent the official position of NFPA or its Technical Committees. In addition, this piece is neither intended, nor should it be relied upon, to provide professional consultation or services.

TOPICS: **Electrical**, **Emergency Response**

BRIAN O'CONNOR

Technical Services Engineer

READ MORE BY BRIAN O'CONNOR