Fire Protection Association

RISCAuthority

Need to Know Guide RE1

Battery energy storage systems: commercial lithium-ion battery installations

RISK INSIGHT, STRATEGY AND CONTROL AUTHORITY

REDUCING INSURABLE RISK THROUGH RESEARCH, ADVICE AND BEST PRACTICE

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IMPORTANT NOTICE

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1 Introduction

Battery energy storage systems (BESS) are devices or groups of devices that enable energy from intermittent renewable energy sources (such as solar and wind power) to be stored and then released when customers need power most. They are constructed of successive battery packs wired together to create modules that are connected within racks to create an energy storage array. They may also be used as Uninterruptible Power Supply (UPS) systems to protect against power interruptions in places such as data centres or hospitals.

Computer controlled battery management systems (BMS) are a key element of BESS systems which manage the flow of energy to and from the BESS system and ensure that battery cells remain within their safe operating range for voltage, current, and temperature. This need-to-know guide focuses on grid-integrated commercial (non-domestic) BESS systems using lithium-ion batteries (the predominant type used for these systems), as may be found on industrial and commercial facilities. Flammable electrolytes combined with high energy, contained in lithium-ion battery cells can lead to a fire or explosion from a single-point failure.

2 Hazards

If a battery cell creates more heat than it can effectively dissipate it can result in a rapid uncontrolled release of heat energy, known as 'thermal runaway,' that can result in a fire or explosion. This can occur as a result of internal short circuit due to manufacturing defects, 'lithium plating' (formation of metallic lithium on an anode surface within a battery cell), or mechanical damage. Other possible causes of thermal runaway are exposure to heat from an external source, overcharging, over-discharging, and failure or malfunction of the BMS.

Failure modes are discussed in more detail in the RISCAuthority need-to-know guide for Lithium-ion battery use and storage.

BESS installations often use large numbers of flat 'prismatic battery cells' (rather than 'cylindrical battery cells') that are sandwiched together. These typically pose a greater risk of thermal runaway occurring than with cylindrical cells, however the protection strategies are the same.

Thermal runaway can lead to the ejection of a range of gases from battery casings, such as hydrogen (extremely flammable), carbon monoxide (toxic, asphyxiant, and flammable), and hydrogen fluoride gas (acutely toxic and corrosive).

When a battery cell vents or ruptures due to thermal runaway, immediate ignition of the emitted gases can occur (especially for batteries with a high level of charge). Alternatively, the gases may spread-out unignited, with the potential for a deflagration (very rapid combustion) or explosion if an external ignition source is encountered.

3 Risk control recommendations

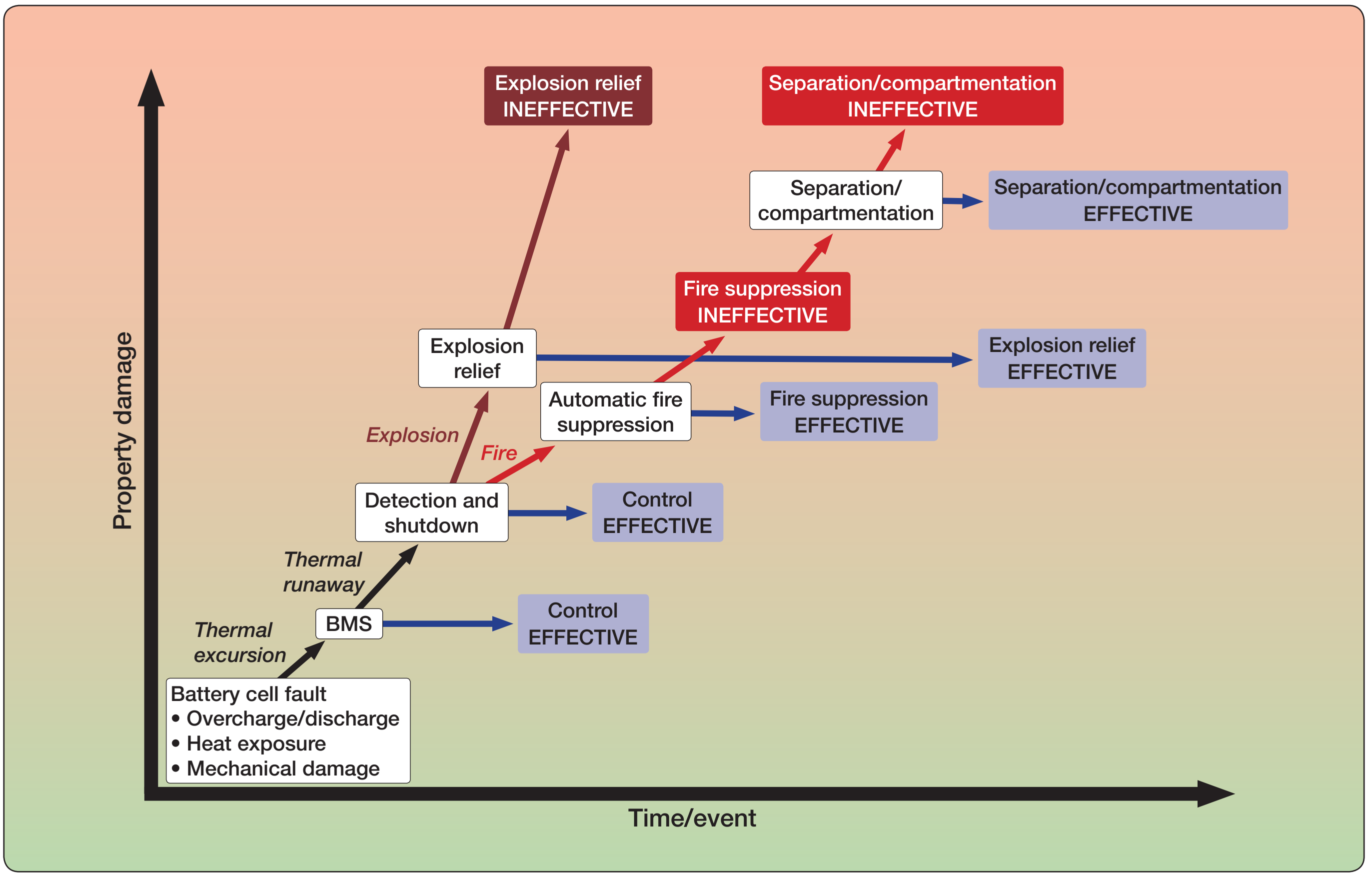
All BESS installations should be subject to a suitable fire risk assessment. Where appropriate, this should be supported with specific fire tests.

Property insurers should be involved at an early stage in discussions to agree on a suitable fire strategy for BESS installations. The potential for both property loss and business interruption should be considered.

The fire protection and mitigation strategy should be determined on a case-by-case basis, based on battery type, BESS location, layout, compartment construction, system criticality, and other relevant factors. It should be multilayered and include a combination of; good design, thermal runaway avoidance, early detection, and automatic suppression. Manual fire control provision and planning, including water-supplies, should be commensurate with BESS and other site fire hazards.

Specific risk control measures to help minimise the risk or consequence of BESS fires include:

1. BESS rooms and buildings shall be dedicated-use, i.e. not used for any other purpose and accessible only by those required to operate, maintain, test, or inspect the BESS equipment.
2. Locate BESS systems in non-combustible containers or enclosures at least 3 metres‡ from other equipment, buildings, structures, and storage. This distance shall only be reduced when:
   a) a suitable fire-barrier (minimum 1-hour fire rated) is installed between the BESS unit and exposed buildings/structures,
   b) exposed surfaces (typically exposed walls) are fire-resisting and blank (i.e. no openings), or
   c) BESS enclosures are constructed with fire-resisting blank walls and roofs.
3. Walk-in containers and other enclosures used to house BESS equipment should not exceed the dimensions of long "high cube" shipping containers, i.e. maximum dimensions, 16.2m long, 2.6m wide, 2.9m high.
4. BESS systems should be at least 15 metres from building HVAC air inlets.
5. Where installation of BESS equipment in rooms forming part of buildings with other occupancy types cannot be avoided, these should be separated from other areas by minimum 2-hour fire rated construction.
6. The BMS should be configured to monitor potential failure conditions that could lead to a thermal runaway and shut-down and isolate BESS units where any such conditions are detected.
7. For critical and significant BESS installations, install early detection of off-gases/electrolyte-vapour from thermal runaway events, interlocked to shut-down and disconnect the BESS. This may be combined with deployment of an extinguishing agent flooding system (based on the fire control strategy).



8. Provide smoke detection systems for all BESS equipment rooms and compartments, interlocked to shut down and disconnect the BESS. This may be combined with deployment of an extinguishing agent flooding system (based on the fire control strategy). Arrangements may be integrated with "7" above.
9. BESS areas within sprinklered buildings and all BESS installations where sprinkler protection forms part of the fire strategy, should be provided with sprinkler protection, designed to provide a minimum density of discharge of 12.2mm/min over an assumed fire area of 230m^2 (or area of room if smaller).
10. BESS rooms and enclosures should be provided with suitably designed explosion overpressure venting.
11. Suitable procedures shall be implemented to routinely inspect and test BESS thermal runaway and fire mitigation alarms and systems.

Primary reference: NFPA 855 *Standard for the Installation of Stationary Energy Storage Systems*, 2020.

‡ Greater separation distances may be appropriate from critical buildings and installations and to meet specified strategic spatial fire separation expectations.

Note: Whilst automatic fire suppression is unlikely to extinguish fire in individual battery cells that are undergoing thermal runaway, fire suppression can reduce fire intensity and assist in slowing and limiting fire propagation across battery modules and racks.

It may be acceptable to reduce some of the above risk control measures where large scale testing, such as testing to UL9540A or equivalent, demonstrates that adjusted mitigation measures are adequate.

4 References

- *Fire Protection Strategies for Energy Storage Systems*, Fire Protection Engineering (journal), issue 94, February 2022
- UL 9540A, the Standard for Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems, 2018
- *Domestic Battery Energy Storage Systems*. A review of safety risks BEIS Research Paper Number 2020/037, Department for Business, Energy & Industrial Strategy

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