Loss Prevention Standards – Asset Classes

Grid Scale Battery Energy Storage Systems

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The use of Grid Scale Battery Energy Storage Systems is becoming increasingly common as organisations seek to maximize energy efficiency, cost savings, and meet their Environmental, Sustainability and Governance goals.

This Loss Prevention Standard provides guidance on reducing the potential for loss or damage from the use of such Systems.

AVIVA

Grid Scale Battery Energy Storage Systems

Introduction

Grid Scale Battery Energy Storage Systems (BESS) are an efficient means of capturing and storing energy. They can also be used to maximise the generation from renewable energy sources, such as onshore or offshore wind turbines and photovoltaic solar panel systems. Primarily, the energy stored in BESS are used to provide grid services such as frequency regulation, peak shaving, voltage support and congestion relief.

Whilst these systems have a proven track record of safe operation, a number of battery energy storage fires have been reported over recent years. The most significant being a thermal runaway event at a large BESS facility in the US in 2019 which resulted in a blast that seriously injured four firefighters. More recently, there have been thermal runway related battery energy storage fires at a number of locations in the US and Australia resulting in the loss of at least one battery energy storage system and impacting energy production at the site.

This Loss Prevention Standard provides an overview of outdoor grid scale BESS, outlines the main areas of concern, and provides useful guidance on minimising the associated risks. It excludes any type of indoor BESS and any outdoor systems that are not used for grid services. These are discussed in Aviva Loss Prevention Standard **Small Scale Battery Energy Storage Systems**.

Note: This document is focussed on Property loss prevention in relation to lithium-ion battery BESS installations and related risk management guidance. It is not intended to address Liability exposures. The presumption is that all regulatory requirements, Fire Risk Assessments, and compliance with requirements placed by the local authority having jurisdiction which would include licencing, building permissions, regulations, codes, or standards, have or will be met.

Background

Modern BESS are a type of energy storage technology, and currently the fastest dispatchable source of power on the grid. It provides more flexibility to grid infrastructure, whilst also enabling cost efficient decarbonisation of global energy systems. The rise of lithium-ion batteries has helped deployment of BESS at scale and the proportion of energy supplied by BESS installations within the UK is expected to grow to 10GWh by 2030, with global installed capacity forecasted to reach close to 2 TWh at the same time.

BESS installations, come in a range of different types of enclosures including containers, cabinets, segmented systems, and modular systems. They comprise a number of key components, namely:

- **Batteries.** The system features a number of battery racks, which will vary based upon the manufacturing design and size of the enclosure, with each rack containing a number of individual modules containing lithium-ion battery cells. The energy density depends on the size of the BESS unit, and ranges between a few hundred kWh to several MWh.

  Battery cells are available in three types:

  - ✓ **Pouch** – Typically aluminium pouches housing the electrolyte, anodes and cathodes, and separating material. Whilst providing some flexibility of packing, these types are more vulnerable to rupture, impact damage and swelling, which potentially impacts other cells and don't support extensive deep cycle functions. As such they are considered less favourable for use in grid scale BESS.

- ✓ **Prismatic** – Typically housed in an aluminium and polymer case, this cell type supports regular deep discharge, provides longer life and increased power storing capability. The aluminium may however be vulnerable to corrosion in some environments. These are the most common and favourable type for BESS.
- ✓ **Cylindrical Cells** – Traditional battery type, typically arranged in parallel to achieve the required power capability. These cell types have a shorter life compared to prismatic cells, but longer than pouch cells, and are less efficient in cell packing, matching and cell balancing.

  Note: Other battery technologies can be used, however lithium-ion is currently the most prevalent. In terms of lithium ion battery chemistry, Lithium Iron Phosphate (LFP) batteries are considered more favourable to other lithium-ion battery chemistries such as Lithium Nickle Manganese Cobalt Oxide (NMC). This is because LFP batteries are more stable, less prone to thermal runaway and have a lower risk of catching fire or exploding than NMC batteries.

- **Enclosure.** The battery racks are connected in series and parallel configurations within an enclosure. Common enclosure types include:
  - ✓ Modular/segmented – The key components are housed together within smaller individual metal cabinets, including several cabinets housing batteries, often in back to back configurations. The barriers between the modules may be beneficial in reducing the potential for fire spread between modules.
  - ✓ Cabinets – Ranging from small cabinets to larger units, these are narrower than traditional container type enclosures, allowing back to back configurations and are less energy dense per module.
  - ✓ Container - The container type enclosures range in size, typically between 6 and 12 metres and the number provided in the installation will depend on the energy generating capacity and storage requirements.

  Other design features within the enclosure includes environmental control via air conditioning; fire barriers; fire protection and fire detection devices; venting for explosion/deflagration and accessibility for ease of inspection and maintenance (more modern BESS enclosure designs are external access only).

  Note: Enclosures with large/multiple openings are preferred for accessibility and safety purposes.

- **Inverters.** The batteries produce DC current which needs to be converted into AC supply for use at the site, and/or sale to the national distributor. The inverters carry out this function and are often, but not always, located separately to the BESS enclosure e.g. some BESS include internal inverters.
- **Battery Management System.** The Battery Management System (BMS) helps ensure the batteries operate within safe appropriate charging and discharging parameters, as well as managing state of charge; measuring performance against stated Key Performance Indicators (KPI's); temperature output; cell balancing etc., to help maximise performance and minimise the risks of overheating and other safety concerns.
- **System Controller.** The controller performs a similar role to BMS, however it monitors, controls, and protects the whole BESS and its key components. It also communicates performance data to the monitoring system.
- **Cooling system.** The ability to maintain stable working temperatures within the BESS according to manufacturer's guidance is imperative and automated cooling systems linked to the BMS are essential. Methods of cooling currently comprise:
  - ✓ **Air cooling** Open systems where air is drawn into the enclosure, chilled and circulated to cool the enclosures or closed systems where cool air is drawn from the outside into a heat exchanger to cool the internal enclosure air temperature. Some systems can result in increased moisture levels within the BESS, a potential fire and decomposition risk. Air cooling is also less able to cool evenly within the BESS. It's worth noting that individual battery modules within the enclosure also have additional localised air cooling to provide better heat dissipation.

- ✓ **Liquid cooling** – Used most commonly to cool batteries locally, closed loop liquid refrigerant systems, which circulate through the enclosure are generally preferred over air cooled systems due to the lack of moisture and other contaminants generated. In some systems the design allows even cooling of individual modules. Localised liquid cooling can be used in addition to air cooling for the internal BESS enclosure in some designs.

- ✓ **Deflagration Ventilation.** During a thermal runaway event, the battery enclosure should have methods of venting off-gases comprising of volatile organic compounds (VCO) to prevent their buildup inside an enclosed space. These comprise:
  - ✓ **Passive ventilation –** Use of pressure relief panels that open once pressure inside the enclosure reaches a certain level.
  - ✓ **Active ventilation –** Use of ATEX rated fans to circulate gases out of the enclosure.
  - ✓ **Adherence to NFPA 68 – Passive Explosion Mitigation** and/or **NFPA 69 – Standard on Explosion Prevention Systems** which provides guidance on enclosure ventilation.
- **Monitoring System.** These communicate the system outputs and other relevant data, allowing the system to be supervised.
- **Transformer Equipment.** The inverter will connect to on-site Medium Voltage (MV) transformer equipment to step up the voltage from the BESS to site MV, which in turn connects to the national power distribution system via switchgear and a further step up transformer to grid voltage.

Understanding the Risks

The lithium-ion batteries used in BESS are generally safe and reliable to use. If the battery packs are manufactured to acknowledged quality standards, transported correctly and once in use are charged/discharged, cooled, and monitored appropriately, the risks of fire and explosion are low. The consequences of a fire or explosion involving lithium-ion batteries within a BESS can however be significant and concerns include:

- ✓ **Smoke/off gassing** – Combustion products are highly damaging, corrosive, and can damage buildings and assets. They are also toxic and can lead to long term health impacts and fatalities to workers.
- ✓ **Vapour Cloud Explosion** – The initial off gassing associated with lithium-ion battery failure contains a number of highly flammable gases or VCOs, which can accumulate within the enclosure and if ignited can lead to deflagration/explosion incidents, particularly if venting systems are not functioning or oxygen levels increase significantly, such as when the door to the BESS enclosure is opened.
- ✓ **Fire** – Following the initial off-gassing event, the batteries may enter thermal runaway and ignition. Lithium-ion battery fires often feature volatile and widely dispersed flaming; a 'chain reaction' effect as fire spreads between individual cells within the battery, or batteries, prolonging the burn time; and the potential for reignition from ongoing chemical battery decomposition after the initial fire.

When the temperature of lithium-ion battery cells increases in excess of safe working parameters, batteries can become unstable and enter a condition known as 'thermal runaway'. Thermal runaway typically occurs in response to damage, such as dropping or impact; manufacturing faults; overcharging; internal short circuiting; age related damage; charging issues along with use within inappropriate temperature conditions.

A thermal runaway event is characterised by:

- An increase in internal battery temperature.
- The creation of flammable gases, that are readily ignitable.
- An intense fire event.
- Production of hydrogen and combustible hydrocarbons.
- Potential for explosions (this is particularly prevalent in large scales battery systems where the production of flammable gases is very significant).
- Length – Thermal runaway events in BESS can typically last several days, or longer dependant on site/layout characteristics.

A lithium-ion battery fire normally emits significant quantities of dense and combustible hydrocarbons, which resemble smoke, and which can be prolonged in the BESS by the continued cascade of thermal runaway across the battery cells within modules and the battery rack. Any fire within a BESS enclosure is extremely difficult to extinguish and can reignite in some cases due to ongoing chemical decomposition.

Depending on water supplies, the fire size and potential for fire spread, the most favourable firefighting response is to focus on preventing spread of fire to other valuable assets in proximity via cooling of the external areas around the BESS, rather than direct extinguishment of the fire, via cooling of the external areas around the BESS. The amount of firefighting water used in tackling a BESS fire incident can be significant, with contaminated run off water presenting environmental risks requiring careful management.

In summary, a fire within a BESS enclosure presents a number of concerns, including:

- Fire and smoke spread to other enclosures and adjacent assets, potentially leading to a catastrophic loss event.
- Prolonged and expensive clean-up operations.
- Loss of profits from energy sales or increased energy costs due to the loss of on-site energy storage capability.
- Impacts to trading during repairs and/or rebuilding works.
- Impacts to Environmental, Social and Governance (ESG) programmes and associated exposure.

General Design Considerations

Assessing the likely risk exposures during the design stage can help with planning a safe and efficient BESS and help mitigate the main risk related concerns.

- Ensure competent and experienced installers are utilised.
  - ✓ Companies, and any third party contractors, should be reputable and experienced in BESS design and installation projects.
  - ✓ Electrical engineers should be qualified to install and maintain electrical systems in compliance with national regulations, standards, or codes. In the United Kingdom this is **BS 7671: 2018 Requirements for Electrical Installations IET Wiring Regulations (18th Edition)**.
    - ▪ Specific electrical energy storage systems training courses are available to qualified electrical engineers, and any electrical engineer installing a BESS should have undergone such training and be able to provide certification upon request.

- Systems and components should be reputable and suited for the type and size of the installation.
  - ✓ The BESS should be manufactured by a reputable and experienced company and tested to be compliant with safety standard **UL 9540: Energy Storage Systems**.
  - ✓ Lithium Iron Phosphate chemistry battery systems are recommended in preference to other lithium-ion battery chemistries due to their higher thermal tolerance.
- The system should also be tested using test standard **UL 9540A: Evaluating Thermal Runaway Response**, and the results incorporated into the system design.
  - ✓ UL9540A tests do have variability - developers should satisfy themselves that cell/module performance is repeatable under a best endeavours basis.
  - ✓ Developer should obtain copy of the full UL9540A test results.
- The system should be installed in accordance with national or international regulations, standards, or codes, such as:
  - ✓ **NFPA 855 – Standard for the Installation of Energy Storage Systems.** This standard describes the requirements for large-scale fire testing and determining appropriate mitigation strategies for stationary storage systems.
  - ✓ **NFPA 68 – Passive Explosion Mitigation –** This standard outlines passive methods for mitigating against explosion within enclosures, such as containerised BESS.
  - ✓ **NFPA 69 – Standard on Explosion Prevention Systems.** This standard discusses deflagration prevention and control for enclosures.
  - ✓ **UL9540 - Energy Storage System (ESS) Requirements.** This standard defines electrical; mechanical; fluid containment; environmental performance; and system safety tests for energy storage systems. It is a system-level standard, meaning that all components that make up a BESS must be tested together.
- All BESS enclosures should be of non-combustible construction with any insulation materials also rated as non-combustible and achieve a fire resisting rating (insulation and integrity) of 120 minutes. In the United Kingdom and Europe this would be materials classified as A1 or A2 under **BS EN 13501-1 – Fire classification of construction products and building elements - Classification using data from reaction to fire tests** and REI 90 to REI 120 under **BS EN 13501-2 Fire classification of construction products and building elements - Classification using data from fire resistance and/or smoke control tests, excluding ventilation services.**
- BESS enclosures should be located on foundations which have been designed by a competent person and deemed suitable for the specific location, factoring in site ground and water conditions.
- The BESS installation should be managed through a formal Management of Change process to help ensure all stages of the change are progressed with the minimal exposure to the existing arrangements e.g., changes to layout to accommodate the facility/facilities, and any necessary risk management controls. Please refer to the Aviva Loss Prevention Standard **Managing Change** for further guidance.
- Your BESS Insurer and Broker can provide guidance on further reducing the potential for large losses and should be consulted during the early design stages.

Specific Design Considerations

Location

The location of the BESS enclosures and associated equipment is critical in managing the fire and explosion risks.

- As best practice, it is recommended that 4.5 metre separation is maintained between BESS enclosures in an installation. This spatial distance incorporates additional safety factors and is considered to provide sufficient mitigations against the effect of radiant heat and subsequent fire propagation to adjacent BESS enclosures or other equipment during a thermal runaway event. However, in alignment with industry standards which is considered the minimum requirement, spatial separation between BESS enclosures should be no less than 3m. It is expected that recommended spatial separation distances between BESS enclosures will be revised in the future as BESS energy densities increase.
- At least 1.5 metres separation should be maintained between BESS enclosures and inverters and Medium Voltage (MW) transformers which should be considered to be combustible.
- At least 10 metres separation should be maintained between BESS enclosures and switchgear rooms; High Voltage (HV) Transformers; back-up generators; fuel tanks; electrical vehicle charging facilities; sprinkler tanks and sprinkler equipment.
  - ✓ Fire and/or explosion events within a BESS can damage property in proximity. This may have significant impacts to trading depending on the criticality of the damaged equipment.
- Average wind speeds should be checked, and separation distances extended:
  - ✓ If there is a risk of strong winds supporting fire spread to adjacent enclosures, buildings, or valuable assets.
  - ✓ Or in low winds poorly dissipating smoke could lead to smoke contamination to adjacent enclosures or associated equipment.
- ✓ If adequate separation cannot be achieved:
  - ✓ Review the planned configuration and consider removal of some enclosures to increase the fire separation.
  - ✓ Consider adjusting the site layout by grouping the BESS enclosures with smaller separation distances and separate these groups by the recommended spatial distance.
  - ✓ Alternatively, where the configuration of the site layout cannot be changed, fire barriers should be installed between the BESS and the adjacent asset.
    - ▪ Any barriers used should have a fire resistance rating (insulation and integrity) of at least 120 minutes and extending at least 1m over the height and sides of the BESS enclosures.
    - ▪ **NFPA 221 - Standard for High Challenge Fire walls, fire walls, and fire barrier walls** and **BS EN 1364-1 - fire resistance tests for non-load bearing elements - walls** provide guidance on fire barrier walls.
    - ▪ The installation of fire barriers should be completed by a reputable and accredited company, such as those certificated to LPCB Loss Prevention Standard **LPS 1271: Requirements for the LPCB Approval and Listing of Companies Installing Fire or Security Doors, Door-sets, Shutters and Active Smoke/Fire Barriers** in the United Kingdom and Ireland.
- At least 10m separation should be achieved from waste management enclosures; waste receptacles; compactors; pallet stores; or areas that workers or visitors may congregate such as smoking shelters etc.
- Any building heating and ventilation system inlets sited within 10m proximity to the BESS installation should be relocated to avoid contamination and damage to the building services.
- The area between the BESS enclosures and other buildings, plant etc., should be maintained clear of vehicles, combustible items etc., to prevent the risk of fire bridging.
- BESS installations should not be installed in close proximity to critical overhead electrical or telecommunications lines, equipment, or poles.
  - ✓ Deflagration venting systems are typically located on the roof of BESS enclosures and an explosive event is likely to damage equipment sited directly over the enclosure.

- The hard standing for the BESS installation should non-combustible and suitable for the weight of the system.
  - ✓ A geotechnical report should be completed by a competent engineer/company and the landing pad built to the recommended specifications.
- All critical parts of the BESS installation should be accessible to authorised persons but adequately secured to prevent illicit or unauthorised access.
  - ✓ The whole BESS installation e.g. enclosures, inverters and transformers should be enclosed within palisade security fencing, and access gates secured to prevent unauthorised persons being in proximity.
  - ✓ Areas should be secured to support authorised access control rules, based on competency and approval.
- BESS should not be located in close proximity to watercourses or areas of environmental importance.
  - ✓ In the event of fire, run off products from firefighting can contaminate waterways and protected land.
  - ✓ If this is unavoidable, consider the risks of contamination within a specific risk assessment and ensure adequate protections such as bunding, well maintained emergency containment etc., are available to trained persons.
- Cabling and other services will need to be installed between the various components and equipment. These should be located underground in back filled cable ducting to help avoid wear and tear, impact, or weather related damage etc.
  - ✓ Where this is not achievable, appropriate cable trunking/trays should be utilised and located in areas where the risks of damage are minimised and suitably protected.

Cooling Systems

Batteries are vulnerable to damage when operating outside of their safe operating window. Batteries operating at high temperatures can start to decompose leading to an increased risk of thermal runaway, and subsequent fire or deflagration incidents.

BESS installations feature cooling systems in respect of the enclosure and the battery racks and the types in use may vary across different manufacturers.

- The optimal operating temperature within a BESS enclosure is maintained by the battery management system.
  - ✓ The battery management system should be configured to alarm and isolate the BESS if temperatures exceed specified temperature thresholds.
- The whole enclosure and all battery racks should be cooled evenly to help prevent hot spots developing.
  - ✓ The use of thermographic cameras can help identify cooling issues within the enclosure.
- The cooling systems should not be powered by the BESS system.
- Closed loop liquid cooling systems should be utilised where possible.
  - ✓ Closed loop systems help prevent external contaminants entering the enclosure.
  - ✓ Liquid cooling is extremely effective at dissipating large amounts of heat and maintaining uniform temperatures within the enclosures.
- If any air cooled systems are utilised, ensure:
  - ✓ Such a system is appropriate for the anticipated ambient air temperatures in the region. In colder climates this make take the form of an environmental temperature control system, which may provide heating and cooling as required to maintain a stable temperature in accordance with the BESS manufacturers recommendations.
  - ✓ The batteries are adequately cooled.
  - ✓ A formal housekeeping regime is in place to clean and replace air filters regularly.

- ✓ The BESS enclosure is regularly inspected to ensure moisture levels are appropriate and no wear or corrosion is developing.
    - If moisture levels are higher than anticipated, the installers should undertake a cause and effect analysis and rectify the issue promptly.
    - Replace any moisture damaged components promptly.
- Dust levels/accumulations should be monitored and BESS enclosures cleaned as necessary to ensure a sterile environment is maintained.

Note: If the BESS installation is sited in an extremely cold location, heating systems may be necessary. The BESS designer should be able to provide appropriate guidance.

Battery Management Systems

The battery management system, or BMS, is provided within the battery systems and is responsible for monitoring, managing, and optimizing the performance of the batteries, as well as balancing cell performance, current/energy flow, and operating temperatures.

- Ensure a good quality BMS is utilised. Whilst monitoring systems offer a range of features, the following are deemed critical:
    - ✓ **Real-time Monitoring**. The main parameters such as voltage, current, and temperature of the battery cells via module fan speed, ensuring optimal performance is achieved.
    - ✓ **Charging/discharging.** The BMS manages the charging and discharging cycles helping to improve battery life and performance.
    - ✓ **Charge balancing.** The BMS ensures the battery cells are charging uniformly, improving battery performance, and ensuring uniform battery balancing within the enclosure.
    - ✓ **Safety Protections.** These include overcharge and discharge issues, overcurrent, and thermal management. Upon detection the BMS can implement corrections or protection controls.
    - ✓ **Data Sharing.** The BMS will share performance data with the monitoring systems to ensure appropriate supervision and logging of issues.
- The BMS should be configured to safely isolate the BESS if prescribed high temperature thresholds are achieved, or other hazardous performance characteristics are indicated that could lead to a thermal runaway event, e.g. increased resistance.

System Controller and Monitoring

The system controller oversees the entire BESS, controlling and protecting the key components and communicating performance data to the monitoring system. The monitoring system is responsible for communicating data to key users/managers etc.

- The BESS should be monitored and configured to alert key personnel in the event of any reported performance discrepancies or deviations.
- Ensure adequate communications redundancy.
    - ✓ Dual transmission systems should be considered where provided or available.

Ventilation

The safe management of smoke and gas emissions resulting from lithium-ion battery off gassing, thermal runaway and combustion should be considered. The off gassing/thermal runaway of lithium-ion batteries produces flammable vapours and gases which result in deflagration/explosion potential. In addition, flammable gases including hydrogen can be released upon the application of firefighting water, further increasing the likelihood of a deflagration event.

BESS enclosures will feature either active or passive forms of ventilation:

Active ventilation. Active ventilation is linked to the BMS and gas detection equipment.

- BESS enclosures that feature active ventilation should be rated as suitable for use in explosive atmospheres as appropriate and interlocked to the BMS and/or gas detection to activate upon detection of early gas release or potential faults identified by the monitoring equipment.
  - ✓ This should be powered independently of the BESS enclosure, and additional back-up power should be considered to ensure autonomous operation in the event of an off gassing event.
  - ✓ This is of additional concern given the production of hydrogen gas that can be generated when firefighting water is applied to lithium-ion battery fires.
- The ventilation system should be continuous and not actuated or stopped by performance of any fire protections.

Passive ventilation. Deflagration venting, typically in the form of vent panels that open in the event of an over pressure event such as an explosion, thus relieving the pressure within the enclosure and directing the pressure and any flaming to a safe area, should be installed.

- Such systems should be designed, tested, installed, and maintained by a competent and experienced company in accordance with appropriate testing standards such as **NFPA 68 - Passive Explosion Mitigation, NFPA 69 – Standard on Explosion Prevention Systems, BS EN 14797:2006 - Explosion venting devices or FM7730 Examination Standard for Explosion Venting Devices**.
- The exhaust point of both active and passive ventilation systems' venting should be to a safe area in the open, and not located in an area where any exhausted smoke could compromise the air intake of other enclosures or buildings in proximity.

Inverters

- The inverters should be located at least 1.5m from BESS enclosures and at least 10m from buildings, other valuable assets and/or waste stores, pallets, or other combustible goods.
- Ensure the inverters are adequately IP rated for external use and not unduly exposed to harsh weather conditions or impact damage from vehicles and other moving plant.
- **UL1741 Safety of Inverters, Converters, Controllers, and Interconnection System Equipment for Use with Distributed Energy Resources** sets out the manufacturing (including software) and product testing requirements for inverters used for grid connection applications.

Transformers

- The BESS installation will feature both Medium Voltage (MV) and High Voltage (HV) transformers.
- The installation will typically feature MW transformer(s) between the BESS enclosures and the switchgear/ customer sub-station. HV transformer export from site to the Grid transformer, which is owned and managed by the Distribution Network Operator.
- An auxiliary transformer will often also be present to take power from the grid to power certain equipment within the BESS, for example the BMS, cooling equipment, security, and fire protections etc.
- All transformers should be manufactured, tested and installed to BS EN IEC 60076 - Power Transformers and be subject to a formal maintenance programme which includes condition inspection; dissolved gas analysis and insulation resistance testing.

Risk Protections

Off-Gassing Detection

These systems provide sensor and gas detection for Battery Energy Storage Systems and work by detecting gases released in the early stages of battery failure, commonly known as ‘off gassing’.

- An automatic gas detection system, designed for the detection of lithium-ion battery off gassing, could be installed within all BESS enclosures.
  - ✓ These detection systems should be interlocked to the power supply to isolate upon the immediate detection of gases and prior to thermal runaway.
  - ✓ The detection system should be suitably rated for use in potentially explosive atmospheres.
  - ✓ The gas detection systems should be subject to formal testing, servicing/calibration, and maintenance arrangements with a competent and experienced company, and this should be undertaken at least every six months, supplemented by monthly self-inspections to check for damage, faults etc.
  - ✓ An accredited fire protection installer can provide further guidance and assistance if required.

Automatic Fire Protections

- Automatically operating gaseous fire suppression systems are often installed within BESS enclosures, however, are designed to only suppress fire starting within electrical components/switchgear etc., and are not effective in suppressing lithium-ion battery fires.
  - ✓ They may also cause damage to the batteries through surface contamination of the gaseous deposits when released.
- Activation of such a protection may also increase the pressure within the enclosure and accelerate the internal enclosure environment reaching its lower explosive limit, potentially increasing the risk of early deflagration.
- Gaseous fire suppression systems are not recommended within BESS enclosures.

Automatic Sprinklers

- The installation of automatic sprinklers within BESS enclosures is also not recommended.
  - ✓ Water reacts violently with lithium and can produce hydrogen gases, increasing the deflagration/explosion potential within the BESS enclosure. Damaged batteries are more susceptible to facilitating the reaction.
  - ✓ Water demand is significant, and the sprinkler system would not be able to store/deploy enough water to effectively control the battery fire.
  - ✓ The modules and racks are also confined, potentially limiting water access to the seat of the fire.
- Further guidance on the suitability of such systems, should be obtained from your BESS Insurer and Insurance Broker.

Interlocks

- The use of interlocks may help reduce the potential for an overheating lithium-ion battery or cell to enter thermal runaway. As such, the actuation of any gas detection systems and other alarms should be interlocked to de-energise the power supplies and isolate charging equipment. The interlocks should be tested at least annually and restored following any impairment to the fire protection and alarm systems.

Lightning Protection

- The BESS should be protected against the risks of lightning damage including surge and transient surge.
- A lightning risk assessment should be completed by a competent person or company, preferably a member of a recognised quality scheme or body such as the Association of Technical Lightning and Access Specialists (ATLAS), and any lightning protection systems should be installed in accordance relevant standards, such as **BS EN 62305 pts 1 to 4 – Protection Against Lightning to determine the direct and secondary effect protection**.
- Any lightning protections should be subject to routine inspections of conductors, bonds, joints, electrodes and to ensure that any recently added services have been bonded as required.
- The lightning protections should also be subject to formal maintenance in line with OEM recommendations by an accredited company at least every 12 months.

Fire and Rescue Service

Whilst there are no defined requirements to notify the local Fire and Rescue Service of the BESS installation, such disclosure can aid the Fire and Rescue Service with deployment of firefighting resources and allow for any pre-emptive planning in respect of run off containment to be undertaken. Accordingly, you should invite the local Fire and Rescue Service to inspect the BESS installation, and surrounding area, to evaluate fire risk exposures, as well as determine access and egress routes to all high hazard onsite equipment including BESS enclosures and offer guidance is strongly recommended.

One of the most effective means of limiting the potential for fire spread between enclosures is to deploy firefighting hoses to create a 'water curtain', effectively cooling the area between enclosures to help prevent radiated heat transfer, and this should be discussed during the Fire and Rescue Service visit.

To support firefighting the water supplies available for Fire and Rescue Service use should be understood. Site management should therefore establish:

- What fire water is available.
- Static pressure flows and residual pressure test results.
- Whether additional resources, such as a private hydrant system or water storage tanks are necessary.
- The location and number of fire hydrants in the proximity of the BESS installation should be documented in an emergency response plan or shown on appropriate drawings.

Fire Extinguishers

- Fire extinguishers specified for use in tackling lithium-ion battery fires are available, however whilst potentially providing some benefit require very early application and, may not fully extinguish a developing fire involving larger lithium-ion battery arrangements or prevent the batteries reigniting. The volatility of lithium-ion battery fires and their explosive characteristics also presents significant injury risks to persons tackling such a fire in proximity, and as such their use is not recommended within BESS enclosure.
  - ✓ Fire extinguishers should only be used to aid escape/evacuation.
  - ✓ Further Guidance on fire extinguishers is provided in Aviva Loss Prevention Standard **Fire Extinguishers.**

Maintenance

- All BESS equipment including batteries, cooling, and ventilation, BMS, controller systems and monitoring systems along with associated equipment such inverters, transformers, gas detection systems, lightning protections etc., should be maintained in accordance with Original Equipment Manufacturer (OEM) and/or system installer guidelines instructions.
    - ✓ Servicing and maintenance should be undertaken in accordance with the manufacturers recommendations, typically performed twice yearly or annually by competent and experienced companies.
- The BESS maintenance company, using manufacturers guidance and performance data will replace aged or degrading cells as part of the formal maintenance programme.
    - ✓ Any damaged or faulty lithium-ion battery cells noted during self-inspections should be reported to the maintenance company immediately, and the BESS isolated pending formal inspection and repair.
- Damaged cells should be removed from the premises by the maintenance company following replacement works.
    - ✓ Removed battery cells/modules should be safely segregated from enclosures, buildings, valuable assets, and combustible items such as waste stores, pallets etc., pending removal. At least 10m separation is recommended.

Self-Inspections

In addition to servicing and maintenance, regular visual inspections need to be completed for signs of wear, tear, damage, cooling system leaks, water ingress etc. To help support this, the self-inspections should include:

- External inspection of BESS enclosure, including openings vents, footings, security locks, protective seals etc.
- External checks of the cabling systems, inverter(s), and transformer(s) for signs of damage, leaks, corrosion, water ingress etc.
- Visual inspection of the battery racks and modules for evidence of damage, leaking, corrosion etc.
- Visual inspection of electrical wiring, joints, connectors, and junction boxes for evidence of wear, fraying, loose connectors.
- Visual inspection of the ventilation and cooling systems to ensure correct functionality.
    - ✓ Liquid cooled systems should be checked for signs of leaks, loss of pressure and repaired/topped up as necessary.
    - ✓ Air cooled system checks should include filters, airflow, and dust depositing.
- Check of any gas and fire detection systems and automatic fire suppression systems present for signs of damage, leaks, pressure reduction, or other performance issues.
- Thermographic cameras should be used to check for overheating or unusual hot spots and any issues raised with the maintenance company.
- The use of acoustic imaging cameras should be considered for identification of leaks in liquid cooling systems.
- Ensure general housekeeping arrangements meet expected standards.
    - ✓ Remove any combustible materials or waste from within BESS enclosures or within 10m of the installation.
- There are no alarm or fault lights.

Note: The frequency of the above will be based on the exposure and nature of the installation but should be completed at least monthly.

Emergency Response

Given the risks associated with BESS/lithium-ion battery fires, an emergency response plan should be produced specifically developed to outline key responsibilities and actions in an emergency event.

The emergency response rules should be formally documented, and appropriate training provided.

Note: The explosive potential of lithium-ion batteries is increased when enclosed within compartments, particularly when oxygen levels increase suddenly, such as when compartment doors are opened. Access into such compartments during a fire event should ideally be limited to appropriately trained persons.

Impairments

Ensure any impairments relating to gas detection and protection systems including interlocks are reported to your Insurer and Insurance Broker. Temporary changes may be necessary to some arrangements whilst impairments are ongoing.

Business Continuity

Every business should have a formal Business Continuity Plan in place. This should be reviewed to ensure disaster recovery and continuity arrangements remain adequate following the installation of the BESS. Any actions generated should be addressed promptly.

Security

Perimeter Security

The BESS installation should be adequately secured to prevent unauthorised access.

- Three metre proprietary security fencing certificated to LPS 1175: Issue 8.1 Requirements and Testing Procedures for the LPCB Certification and Listing of Intruder Resistant Building Components, Strongpoints, Security Enclosures and Free-Standing Barriers and achieving a security rating of at least B3 should be considered around the installation perimeter.
- Fencing types not achieving certification to LPS1175, whilst not providing a defined security resistance, may be suitable for lower risk sites. Such fencing, which includes 'V-Mesh' fencing types should be installed to a height of at least 2.5 metres and preferably in compliance with BS1722 Part 14: Fences Specification for Open Mesh Steel Panel Fences.
- Entrance gates and gate posts should be of similar construction to the security fencing and be secured with good quality padlocks and heavy-duty chains. Padlocks should be in compliance with BS EN 12320:2012 Building hardware. Padlocks and padlock fittings. Requirements and test methods and achieve a CEN grade 4 or 5 rating. If possible, a steel protective lock housing of at least 4mm thickness should be fabricated to access gates to help prevent lock tampering. Keys for entrance gate padlocks should not be kept on site and any padlock combination codes changed regularly. Digital combination type key safes are vulnerable to attack and are not recommended.

Video Surveillance Security Systems

- For standalone sites, a detector activated Video Surveillance System (VSS) monitored by an accredited Remote Video Response Centre (RVRC) and achieving level 1 police response should be considered.
  - ✓ The VSS should be positioned to cover all points of the site perimeter, site entrance, BESS enclosures and the associated key equipment and buildings.
  - ✓ To achieve level 1 police response, the system will need to be installed, maintained, and monitored to the requirements of **BS8418: Design, Installation, Commissioning and Maintenance of Detection-Activated Video Surveillance Systems (VSS)**. **Code of Practice**.
  - ✓ To ensure the best quality of service, the Installer and RVRC should be members of a UKAS third-party accreditation/approval scheme, such as those provided by the National Security Inspectorate (NSI), or the Security Systems and Alarms Inspection Board (SSAIB). This is required for police response.
  - ✓ The incorporation of an audio challenge facility, which would allow the RVRC to issue warnings to any unauthorised persons attempting to access the site or behaving suspiciously, should be considered.
  - ✓ Should there be anticipated delays in police response in some localities, it may be more appropriate to utilise a security company to provide keyholder and VSS detection response services, rather than rely on police response.
  - ✓ Regular security patrols of the site by the security company can also provide a significant deterrent to intruders.
  - ✓ Any such providers should be members of the Security Industry Authority and provide their services in accordance with the requirements of **BS 7984-3:2020 Keyholding and Response Services - Provision of Mobile Security Services. Code of Practice.** They should also be members of a UKAS third-party accreditation scheme, such as those provided by the National Security Inspectorate (NSI), or the Security Systems and Alarms Inspection Board (SSAIB).

  Note: Staff keyholding and site response to VSS detection alerts is not recommended, unless in accompaniment of approved security guarding or the police.

- Specifications for any proposed detection security systems should be submitted to your BESS Insurer and Broker for review.

Cyber Security

- Cyber security exposures should be reviewed to ensure appropriate protections and procedures are incorporated including data access approval management.
- Refer Aviva Loss Prevention Standard **Cyber Security - Top 12 Tips to Protect Against Cyber Attacks** for further guidance.

Other Security

All outdoor equipment cabinets for inverters etc., should be securely locked, and any switch/control panels also secured to prevent malicious interference.

Key Action Steps

- Use reputable equipment and installers.
- Engage early in the design phase with your BESS Insurer and Broker.
- Ensure gas detection systems, appropriate for BESS/lithium-ion batteries are installed and interlocked to isolate the BESS safely upon activation.
- Ensure appropriate deflagration/explosion venting is in place.
- Routinely check the BMS, controller and monitoring systems are fully functional with no faults or performance issues.
- Complete monthly self-inspections to ensure:
  - ✓ Equipment and charging locations are in good order (Use thermographic camera where appropriate).
  - ✓ Gas detection, monitoring and interlocks are in normal working order.
  - ✓ Housekeeping arrangements are satisfactory.
- Ensure preventative maintenance and servicing schedules are strictly adhered to and corrective actions are tackled promptly. Any faults or breakdowns should also be remedied promptly.
- Introduce emergency procedures and provide appropriate training to workers and other relevant persons such as visitors and contractors.
- Invite the local Fire and Rescuer Service to site to familiarise themselves with the BESS installation and consider their emergency response.
- Review Disaster Recovery and Business Continuity plans.

Checklist

A separate **Battery Energy Storage Systems - Checklist** is available which can be tailored to your own organisation.

Specialist Partner Solutions

Aviva Risk Management Solutions can offer access to a wide range of risk management products and services at preferential rates via our network of Specialist Partners.

- Thermographic imaging and PAT testing: PASS
- Automatic fire detection and portable extinguishers: SECOM
- Business continuity: Horizonscan

For more information please visit: Aviva Risk Management Solutions – Specialist Partners

Sources and Useful Links

- EPRI BESS Failure Incident Database
- BS EN 62305 - Protection against lightning.
- BS 7430:2011+A1:2015 Code of Practice for protective Earthing of Electrical Installations.
- LPS 1204 : Issue 3.2 Requirements for Firms Engaged in the Design, Installation, Commissioning and Servicing of Gas Extinguishing and Condensed Aerosol Systems.
- BAFE SP203-3 Fixed Gaseous Fire Extinguishing Systems
- BS EN 15004 - Fixed firefighting systems. Gas extinguishing systems

- BS ISO 14520-1 Gaseous fire-extinguishing systems – Physical properties and system design – Part 1: General requirements.
- MIS 3012 – The Battery Standard.
- BS 7671: 2018 Requirements for Electrical Installations IET Wiring Regulations (18th Edition).
- UL 9540 Energy Storage Systems and Equipment.
- UL 9540A Standard for Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems
- BS EN IEC 62619:2022 Secondary cells and batteries containing alkaline or other non-acid electrolytes. Safety requirements for secondary lithium cells and batteries, for use in industrial applications.
- BS EN IEC 63056:2020 Secondary cells and batteries containing alkaline or other non-acid electrolytes. Safety requirements for secondary lithium cells and batteries for use in electrical energy storage systems
- BS EN 62620:2015+A1:2023 Secondary cells and batteries containing alkaline or other non-acid electrolytes. Secondary lithium cells and batteries for use in industrial applications
- NFPA 855 – Standard for the Installation of Energy Storage Systems.
- NFPA 68 Standard on Explosion Protection by Deflagration Venting
- NFPA 69 Standard on Explosion Prevention Systems
- FM Property Loss Prevention Data Sheets 5-33 lithium-ion Battery Energy Storage Systems
- EN 13501-1 Fire classification of Construction Products and Building Elements - Classification Using Data from Reaction to Fire Tests.
- BS EN 14797:2006 Explosion Venting Devices
- FM 7730 Examination Standard for Explosion Venting Devices

Additional Information

Relevant Loss Prevention Standards include:

- **Battery Energy Storage Systems Checklist**
- **Small Scale Battery Energy Storage Systems**
- **Business Continuity**
- **Contamination Following a Fire**
- **External Building Areas - Usage and Safety**
- **Fire Safety Inspections**
- **Heat and Smoke Venting Systems**
- **Managing Change - Property**
- **Smoke Contamination**
- **Thermographic Surveys**
- **Cyber Security - Top 12 Tips to Protect Against Cyber Attacks**
- **Cyber Security - Ransomware**

To find out more, please visit Aviva Risk Management Solutions or speak to one of our advisors.

Email us at riskadvice@aviva.com or call 0345 366 6666.*

*The cost of calls to 03 prefixed numbers are charged at national call rates (charges may vary dependent on your network provider) and are usually included in inclusive minute plans from landlines and mobiles. For our joint protection telephone calls may be recorded and/or monitored.

Please Note

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