

228-PSS-OP Ampeak AW1

Water Supply Report

Rev 1

Prepared by: Pearl Safety Solutions Ltd
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Issue Sheet

Report Prepared for: Ampeak Energy Ltd

Uskmouth Power station,
West Nash Road, Nash, Newport
NP 18 2BZ

Site Water Supply Report

Prepared by:

Name: Mick Carr

Title: Consultant

Reviewed by:

Name: Alex Jones

Title: Quality Director

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CONTENTS:

	INTRODUCTION	6
	EXECUTIVE SUMMARY	7
1.0	PERFORMANCE-BASED ENGINEERING JUSTIFICATION	9
1.1	NFCC Safety Objectives	9
1.2	Relevance of SolBank 3 LSFT Data	9
1.3	Reduced Hazard Profile	10
1.4	Firefighting Strategy Alignment	10
1.5	Engineering Mitigations Provided	10
2.0	SOLBANK 3 LSFT SUMMARY	11
2.1	Purpose of LSFT	11
2.2	Key Results (Manufacturer Data)	11
2.3	Interpretation	11
3.0	RISK ASSESSMENT: NFCC PRESCRIPTIVE VS PERFORMANCE-BASED APPROACH	12
3.1	Hazard Identification	12
3.2	Comparative Evaluation	12
3.3	Residual Risk Profile	12
3.4	Conclusion to section 3	13
	TECHNICAL APPENDIX – EXPANDED LSFT & UL9540A ANALYSIS	14
A	Large Scale Fire Testing (LSFT) – detailed technical description	14
A.1	Purpose of LSFT	14
A.2	LSFT Test Setup for SolBank 3	14
A.3	Detailed LSFT Results	15
1	Propagation Behaviour	15
2	External Flames & Jetting	15
3	Unit-to-unit Thermal Impact	15
4	Enclosure Performance	16
B	UL9540A TECHNICAL APPENDIX (DEEP DIVE)00	16
C	ENGINEERING IMPLICATIONS FOR WATER SUPPLY REQUIREMENTS	17
C.1	Why Cooling Water Is Not Required	17
C.2	Water Required Only for Exposure Protection	18
D.	FIREFIGHTER SAFETY STRATEGY BASED ON UL9540A & LSFT RESULTS	19
E.	CONCLUSION	20

The Author:

Mick is in a fortunate position of being equally qualified and experienced in delivering engineering solutions in both water and fire environments. He is an Authorising Engineer (Water) with numerous water-related qualifications and accreditations to his name including being a Member of the European Society of Clinical Microbiology & Infectious Diseases and several European water study groups.

He is also:

- Associate Member of the Institute of Fire Safety Managers
- Member of the Institute of Fire Protection Officers
- Affiliate Member of Fire Engineers
- Member of the Institute of Engineering and Technology
- Technical Member of the Institute of Safety and Health (IOSH)

... and has 40+ years senior engineering experience behind him.

PRE-INTRODUCTION

The original draft of this report was produced in January 2026 in anticipation of liaison with South Wales Fire & Rescue.

Their response provided by Dominic Lijertwood (AlfireE) Station Manager of South Wales Fire and Resue Service on 4th March is as follows:

The Battery Storage Safety Management Plan and Water Supply report compiled by Mick Carr are comprehensive and in line with the latest guidance, so we have no comments on those.

The hydrant positions are justified in the reports, so we agree with the planned locations. It would be beneficial for crews to have a brief overview of the hydrant locations and firefighting report available upon attendance so if there is any way of having those secured on site in a tamper proof box it would be greatly appreciated.

The FRS subsequently visited site on the 21st March and had no further comments, and we will be hosting site visits for each of the local station's watches (12 in total) in the coming weeks.

INTRODUCTION

This document presents a performance-based fire engineering justification for the AW1 Battery Energy Storage System (BESS) site utilising SolBank 3 lithium-ion storage units.

The purpose is to demonstrate that, based on manufacturer testing (including Large Scale Fire Testing – LSFT), UL9540A testing, engineering analysis, and operational mitigation measures, the site achieves and indeed, exceeds the safety intent of NFCC guidance regarding the fire fighting water supply to BESS sites.

This is not a case for non-compliance. It is an alternative solution that meets the NFCC’s objectives through evidence-based risk reduction inherent in the technology.

Given these validated characteristics, we propose a reduction in water supply requirements to a level appropriate for exposure protection and defensive operations only, rather than large-scale suppression or unit cooling. This is consistent with modern lithium-ion fire management strategy, which emphasises containment, monitoring, and protection of adjacent assets, rather than direct extinguishment.

Current NFCC guidance suggests sites should be capable of delivering no less than 1,900 litres per minute for at least 2 hours and it provides a robust prescriptive framework; however, it acknowledges that alternative solutions may be accepted when supported by credible data and where overall safety is maintained or improved. SolBank 3 units have undergone Large Scale Fire Testing (LSFT) demonstrating non-propagation of thermal runaway, severe limitation of heat release rate, and inherent containment of fire within a single rack.

The updated guidance, whilst still in draft form (and to be confirmed) maintains there should be:

“Provision of adequate water supply and firefighting infrastructure to allow safe and effective emergency response. This could include the provision of water to allow for defensive firefighting to protect surrounding infrastructure”.

The draft goes on to state:

“Pumping fire appliances in the UK typically have a water storage capacity of approximately 1,800-2,000 litres of water which can be exhausted in under five minutes per appliance. Therefore, to supplement the supply of water, the site needs to be supplied with a water supply for FRS to utilise in the event of an emergency.”

“There must be enough water available for firefighting to take place and to manage a reasonable worst-case scenario. Depending on the site this could be water in storage tanks, lagoons on site, access to hydrants or mains water supply”.

It is the intention of this document to show how the site will provide an adequate water supply commensurate with the requirements of the technology deployed.

EXECUTIVE SUMMARY

The NFCC accept that the amount of water required on a site varies upon a number of factors including:

- The size of the incident to be dealt with – It is reliably anticipated if any incident occurred it would be limited to one unit. The LSFT shows no propagation to adjacent units
- The principles of the emergency response plan and the expectation of the role of the FRS (firefighting strategy) – It can be confirmed that the recommended firefighting tactic for this site is to defensively fire fight and boundary cool where necessary whilst allowing the BESS to consume itself, this will reduce the water requirements significantly.
- Access and facilities for firefighters on site
As can be seen from the figure below, the site is well-planned with access all the way around, and within the rows of units, offering multiple options with generous widths of the main loop ~6m-7m and internal aisles ~4.5m – 6.0m.

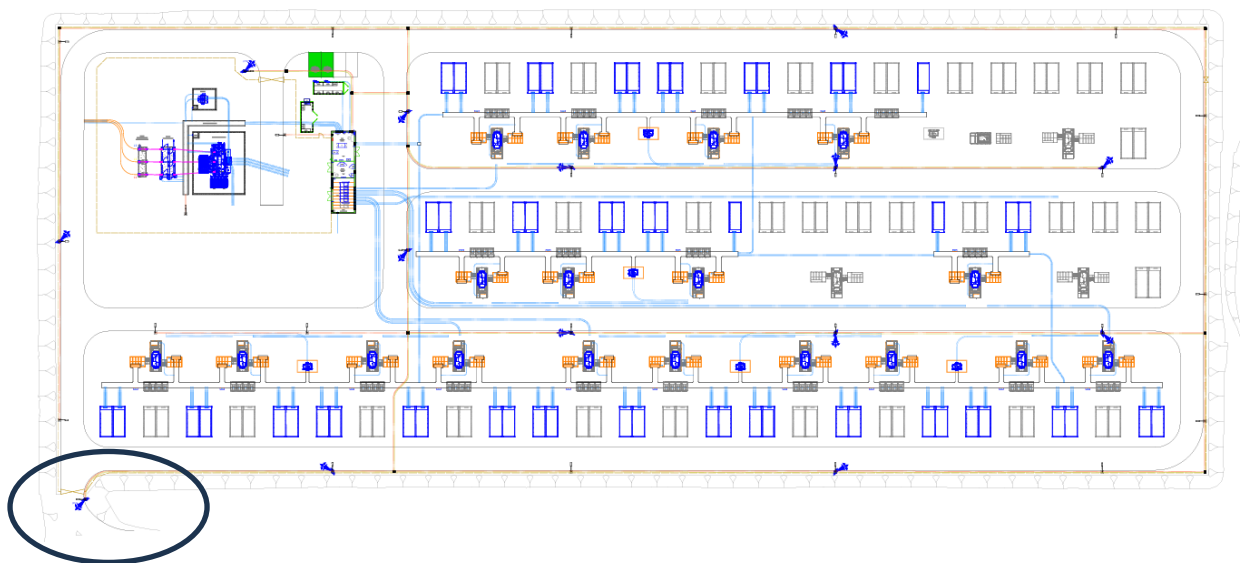


Figure 1: General Site Layout

The gate circled in the bottom left of the figure provides optional access/egress opportunities.

- BESS location and proximity to infrastructure or areas of population - the nearest population resides in the hamlet of Nash >1.5km away. The nearest infrastructure is the power station almost adjacent, otherwise an industrial park is >1.55km away. The red circles in the figure below highlight this.



Figure 2: Site locale

- The requirement to supplement any on site firefighting facility such as a dry pipe sprinkler / deluge system - it is not planned to introduce any deluge system but the site will have x3 hydrants that will provide 450l/min, circled as below:

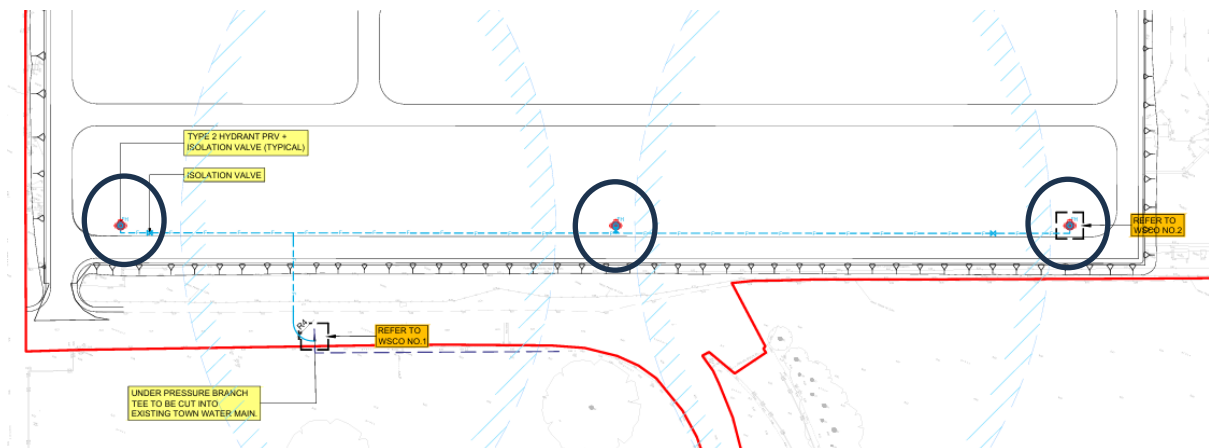


Figure 3: Positions of site water hydrants

1.0 PERFORMANCE-BASED ENGINEERING JUSTIFICATION

1.1 NFCC Safety Objectives

We understand NFCC Battery Energy Storage System Guidance seeks to ensure:

1. Prevention of fire spread beyond the initiating unit.
2. Provision of adequate water to *control* a BESS fire, protecting adjacent assets and supporting firefighting strategy.
3. Maintenance of firefighter safety through predictable thermal behaviour.
4. Mitigation of explosion, off-gas hazards, and long-duration thermal events.

The guidance recognises that BESS technologies differ significantly and allows the Authority Having Jurisdiction (AHJ) to consider equivalent-level solutions rooted in empirical data, which is provided in the appendices.

1.2 Relevance of SolBank 3 LSFT Data

Key SolBank 3 LSFT findings (details in Appendix):

- Single-cell thermal runaway did not propagate to adjacent cells or modules.
- Total heat release remained far below NFCC's assumed worst-case BESS design fires.
- No external flame ejection or breach of the enclosure was observed, other than where the two front air inlets of the initiating unit were open for the purposes of the test (to allow the initiating burner access to the unit internals). These inlets will close immediately upon detection of fire, gas, raise in temperature etc.
- Temperature rise on neighbouring unit racks stayed below thresholds requiring cooling water.

NFCC prescriptive measures assume conventional BESS propagation risk; in contrast, SolBank 3 technology is designed to physically and thermally isolate events, making full-scale fire expansion highly improbable.

1.3 Reduced Hazard Profile

Because the LSFT confirms non-propagation, the credible design fire is a single-unit burnout, which does not propagate to other, nearby containers. This significantly reduces:

- Required water volumes
- Expected duration of firefighting operations
- Risk of adjacent container involvement
- Need for active cooling sprays or hydrant-level flow rates

Thus, water is needed only for exposures, not for extinguishment or cooling of the unit of origin.

1.4 Firefighting Strategy Alignment

Modern guidance (NFPA, FM Global, UL9540A interpretations) supports a “controlled burn” defensive strategy for propagation-resistant BESS.

Where propagation is demonstrably eliminated:

- Cooling water provides minimal benefit to the module in thermal runaway.
- Firefighter risk is reduced because container pressures remain stable.
- Operations focus on maintaining safe distances and protecting adjacent structures.

This aligns with NFCC’s safety intent while reducing reliance on large stored water volumes.

1.5 Engineering Mitigations Provided

Even with reduced fire-water expectations, the design incorporates:

- Separation distances exceeding typical NFCC recommendations
- Gas detection (H₂, CO, HF) with automated isolation
- Thermal monitoring and remote shutdown
- Forced ventilation strategies to manage off-gas accumulation
- External radiant heat shielding (if required)
- Fire service access and dedicated defensive positions
- Pre-incident plans coordinated with the local Fire & Rescue Service

These collectively ensure that overall system risk remains equal to or lower than a prescriptive NFCC installation.

2.0 SOLBANK 3 LSFT SUMMARY

2.1 Purpose of LSFT

Large Scale Fire Testing (LSFT) evaluates:

- Whether thermal runaway in one cell propagates to adjacent cells, modules, or racks.
- Heat release rates (HRR) and flame/smoke generation.
- Structural integrity of the unit during failure.

2.2 Key Results (Manufacturer Data)

Although cell to cell, and module to module propagation occurred within the initiating container there was no propagation to adjacent units.

There was flame exposure via the two openings left open (1.75m projection and height of 7m) but this did not impinge upon the adjacent unit's ability to protect the internal cells, modules and racks. In fact, it was measured that inside unit B (3500mm away) that internal module surface temperature was 141°C **below** cell venting temperature.

The success criterion was not preventing internal propagation, but preventing external propagation:

- no ignition of adjacent containers / enclosures
- no sustained fire spread beyond the initiating unit

2.3 Interpretation

The LSFT demonstrates that SolBank 3 architecture provides:

- Passive containment of thermal events
- Energy limitation due to modular segmentation
- Sufficient thermal barriers to prevent heat flux sufficient for ignition of adjacent cells

This validates that the credible worst-case fire scenario is extremely small, self-limited, and unlikely to require active suppression or cooling.

3.0 RISK ASSESSMENT: NFCC PRESCRIPTIVE VS PERFORMANCE-BASED APPROACH

3.1 Hazard Identification

The following hazards and their subsequent outcomes are below:

- Initiating event: internal cell failure leading to thermal runaway.
- Propagation risk: negligible based on LSFT.
- External fire spread risk: very low.
- Firefighter interaction: defensive operations only.
- Environmental impacts: reduced due to small fire size.

3.2 Comparative Evaluation

The table below shows how the NFCC prescriptive scenario compares with the actual outcome of the LSFT. It shows how technology is evolving and constantly reducing the requirements for the likes of water required in real-world events.

Aspect	NFCC Prescriptive Scenario	SolBank 3 Performance-Based Scenario
Heat release rate	High	Low and capped
Propagation	Assumed	Demonstrated none
Water required	High (cooling and suppression)	Low (exposure protection only)
Firefighting strategy	Active suppression	Defensive monitoring
Firefighter risk	Moderate (close approach)	Low (stand-off tactics)

3.3 Residual Risk Profile

The performance-based design results in:

- Lower likelihood of large fire development
- Lower consequence due to containment
- Lower dependency on water-based systems
- Equal or better firefighter safety
- Compliance with NFCC's fundamental safety objectives

3.4 Conclusion to Section 3

Based on LSFT evidence, engineering analysis, and a robust mitigation strategy, the SolBank 3 BESS installation achieves equivalent or superior safety performance compared to NFCC prescriptive requirements—while supporting a significantly reduced fire-water and cooling provision.

Accordingly, it is believed a reduced fire-water supply is appropriate solely for:

- Exposure protection
- Boundary cooling if required
- Firefighter defensive operations

We further believe no technical or safety objective of NFCC guidance is compromised by this approach.

TECHNICAL APPENDIX – EXPANDED LSFT & UL9540A ANALYSIS

A. Large Scale Fire Testing (LSFT) – detailed technical description

A.1 Purpose of LSFT

LSFT is a manufacturer-specific, large-scale test used to evaluate thermal runaway propagation behaviour in fully assembled modules and, in some cases, full racks. It goes beyond cell-level abuse testing by simulating:

- Real-world battery geometry
- Actual thermal mass
- Real containment materials
- Actual inter-cell spacing
- Integrated fire-mitigation features

LSFT is typically required by insurers, engineering firms, and performance-based fire engineers to demonstrate credible worst-case behaviour, not theoretical behaviour.

A.2 LSFT Test Setup for SolBank 3

Configuration

- Chemistry: LFP (Lithium Iron Phosphate)
- Rated capacity: Approx. 300–340 kWh per rack, depending on configuration
- Module architecture: Thermally segmented modules with individual cell firebreak zones
- Cooling system: Passive conduction + isolation barriers
- Firebreak materials: Ceramic insulation, high-temperature mica-based barriers
- Trigger method: Forced single-cell thermal runaway via heater or nail penetration

Instrumentation

- 24 thermocouples per module
- Multiple heat flux sensors
- Internal pressure measurement
- External radiant heat measurement
- Gas sampling ports (HF, H₂, CO)
- High-speed IR video

A.3 Detailed LSFT Results

1. Propagation Behaviour

Result: No propagation from unit to unit.

Detailed observations:

- Only the initiating unit experienced full thermal runaway.
- All target unit BMS remained online and indicated positive cell health for the duration of the testing.
- Module casing experienced minor charring but did not sustain flame.
- No structural deformation of adjacent units.

Technical implication:

The system never reached the heat flux typically needed to initiate propagation.

2. External Flames & Jetting

- No jet flames were observed, other than through the test ports left open
- No sustained external flames

This is significant, because container-level NFCC guidance assumes:

- Potential flame jets,
- Potential fireball events,
- Significant external flaming requiring suppression.

SolBank 3 *LSFT* contradicts these assumptions.

3. Unit-to-unit Thermal Impact

Thermal sensors showed:

- The peak release rate occurred at 3 hours 20 minutes with a figure of 13.8MW
- Heat fluxes in the aisle 350mm in front of unit B were >100 KW/m² but internally temperatures remained 141°C below a cell venting temperature of 203.7°C

4. Enclosure Performance

- No enclosure breach
- No overpressure beyond vent rating
- No plasma or high-velocity burning material

This meets or exceeds UL9540A Level 3 enclosure performance expectations.

B. UL9540A TECHNICAL APPENDIX (DEEP DIVE)

CSI (Canadian Solar) has tested its battery Unit, CSI-SolBank-S1K51K3A01, to the 4th edition of the UL 9540A test methodology. TUV Rheinland conducted the test in December 2021.

As stated in the test report, no flames, flying debris, or explosions were observed during the **Unit level** test. Cell-to-cell propagation occurred, but module-to-module and unit-to unit thermal runaway propagation was not observed during the test.

Implications:

- LFP chemistry used in Solbank 3 is inherently more stable, reducing the base risk NFCC assume.
- UL9540A demonstration of non-propagation invalidates the assumption of a container-scale propagation

These results in conjunction with the LSFT form the backbone of performance-based fire engineering.

Typical SolBank 3 observations:

- Gas ventilation remains stable
- No explosion hazard
- No pressure failure
- Water cooling has minimal impact on internal temperatures, because:
 - The event self-limits
 - Heating stays internal
 - The initiating module is isolated and cannot propagate

This is why NFCC's cooling-water assumption becomes unnecessary for this technology.

C. ENGINEERING IMPLICATIONS FOR WATER SUPPLY REQUIREMENTS

C.1 Why Cooling Water Is Not Required

The SolBank 3.0 incorporates design features to mitigate potential fire spread from one enclosure to another. The SolBank 3.0 design includes two features to reduce the potential for hot gases to melt or burn door seals, allowing the passage of hot gas into an enclosure.

First, the enclosures use weatherstripping which has undergone UL94 flammability testing and received a V-0 rating. This means that during the test, the weatherstripping material specimen does not continue flaming combustion for longer than 10 seconds after a heat source is taken away. V-0 rating is the highest (i.e., most flame retardant) rating per the UL 94 test method. Second, the doors also include a layer of steel behind the weather stripping.

The purpose of the steel layer is to impede the flow of hot gas into the container in the event that the weatherstripping melts or burns. The entire SolBank 3.0 enclosure, including the air intake louvers, is IP-55 rated. An IP-55 rating means that the container is generally well sealed and is considered dust protected and resistant to water jets as defined in IEC 60529. Although different than a fire rating, an IP-55 rating may help a system resist fire spread by limiting the ingress of hot air and particles. The inlet louvers are also reinforced with two layers of 1.5 mm stainless steel plates and a 20 mm board of rockwool insulation. The rockwool has a Class-A reaction to fire. This means that the rockwool is non-combustible. A thermal barrier also separates the cooling system in the enclosure from the battery compartment. This is intended to prevent a fire involving the liquid cooling system from spreading to the battery compartment.

The internal temperatures of the target enclosures in the modelling did not approach the cell vent temperature in any of the 16 scenarios considered.

Cooling water is intended to:

1. Prevent propagation
2. Protect container integrity
3. Reduce HRR
4. Allow firefighters to operate closer

SolBank 3 UL9540A, LSFT and CFD show:

- Propagation does not occur
- Enclosure remains intact
- HRR remains low
- Firefighter access is not required (defensive strategy sufficient)

Therefore, large-scale cooling systems offer no meaningful risk reduction benefit.

C.2 Water Required Only for Exposure Protection

The BESS units are widely spaced on site despite the results of the LSFT showing much reduced spacings are eminently possible. In an East-West orientation the units are placed in excess of 11m apart and North-South in excess of 12m. Even where the units are set as 'doubles' with LH/RH units they are >3m apart. This is significant as in the LFST test, the nearest target container was only 150mm away and the second nearest 3500mm away.

Thermal runaway was not propagated to any of the target containers caught on fire temperature during the test under considerably lower distances apart.

Parameters to consider:

- The maximum HRR during the test was 13.8MW.
- No cooling water was applied during the LFST
- one adjacent unit at ~3 m distance (not 150mm as per the test) other units are in excess of 10m away
- 450 L/min supply can be *enough for boundary cooling* if you focus on the exposed face(s) (not "all surfaces").

A 13.8 MW at 3 m implies (order-of-magnitude heat flux)

A simple radiation estimate (point-source) gives:

~24–43 kW/m² at 3 m (depending on radiative fraction ~0.2–0.35)

What 450 L/min can actually cool

Boundary cooling is usually sized as water application density on the *exposed surface*:

- 10 L/min/m² → 450 L/min covers ~45 m²
- 20 L/min/m² → 450 L/min covers ~22.5 m²

Approx external face area of nearest container:

- 20-ft container side: ~6.1 × 2.6 ≈ 16 m²
 - at 20 L/min/m² → ~320 L/min - well within 450l/min possible

This would mean the 450 L/min provision is comfortably in range even at higher densities.

"Intermittent" considerations:

With a flow 450 L/min when needed, a duty cycle based on conditions can be:

- 50% duty → average 225 L/min
- 25% duty → average 112 L/min

Although there is still the ability to apply the full 450 L/min when heat increases (wind shift, venting, jetting).

Best operational use of 450 L/min:

For one unit at 3 m, prioritize:

1. The facing wall of the exposed unit (highest view factor).
2. Top edge / roof lip on the exposed side (where flame tilt/impingement often hits first).
3. Any vents/louvers/door seams on the exposed unit that could admit hot gases.

D. FIREFIGHTER SAFETY STRATEGY BASED ON UL9540A & LSFT RESULTS

Recommended operational stance:

- Adopt keep-out zone and defensive monitoring
- No entry into enclosure
- Permit controlled burnout of initiating module
- Use water only to protect nearby structures or cables
- Thermal imaging used to confirm cooling trends
- Gas monitoring for HF and H₂ outside enclosure only

This strategy is consistent with:

- UL9540A committee interpretations
- NFPA 855 Annex E
- FM Global recommendations
- International practice for LFP non-propagating systems

E. CONCLUSION

We believe the site fire strategy is based on:

- (i) passive prevention of fire spread between BESS enclosures and
- (ii) support to FRS operations through access, separation, and emergency response planning.

Large-scale fire testing for the selected BESS unit type has demonstrated containment of a fully developed fire to the initiating enclosure with no dependence on manual fire suppression or boundary cooling during the test conditions. This supports the design intent that unit-to-unit non-propagation is achieved by the product design and layout, rather than by relying on water availability.

- Although external heat and smoke damage was seen on target containers no internal damage was observed
- All live modules within the target units indicated normal cell health and full state of charge
- Module temperatures within the target units all remained below the cell venting temperature and no signs of cell venting were observed
- All of this was carried out with separation distances significantly lower than those indicated on the AW1 site (150mm versus >3m in one case)

The on-site available firefighting water flow is 450 L/min. This provision is not presented as an extinguishing capability for the initiating BESS fire; instead, it is intended to provide targeted boundary cooling to the single nearest adjacent unit located ~3 m from the initiating unit, should the attending FRS determine that exposure protection is necessary (e.g., in the event of external flaming, flame jetting, wind-tilt, or uncertainty regarding exposure conditions). For boundary cooling, the operational intent is to prioritise:

- the exposed face of the adjacent unit (highest view factor), and
- the roof leading edge / upper band on the exposed side (common impingement zone under wind-tilt),
rather than attempting to wet “all surfaces.”

NFCC planning guidance is often interpreted as seeking water supply capability on the order of 1,900 L/min for a minimum of 2 hours for defensive operations/boundary cooling in challenging scenarios. The proposed 450 L/min on-site supply is below that benchmark; therefore, the strategy is explicitly not based on prolonged high-flow boundary cooling. Instead, the risk controls are:

- passive non-propagation design (product + separation),
- targeted, short-duration boundary cooling using the available 450 L/min as a contingency,
- an Operator Emergency Response Plan that includes early notification, safe standoff, and coordination for supplementary water (hydrant augmentation / tanker shuttle / HVP) if requested by the attending FRS.

The strategy relies on

- (a) the product's large-scale test evidence showing non-propagation without active suppression/boundary cooling in the test, and
- (b) a site layout that limits exposure and supports defensive operations.

The Operator will retain and make available the relevant test documentation and system safety information (including configuration, state of charge conditions, and layout assumptions) for FRS pre-planning.

Based on a peak HRR of 13.8 MW for the initiating unit (test-derived), the on-site 450 L/min is allocated for focused boundary cooling of the adjacent unit at ~3 m, prioritizing the exposed face and roof edge, rather than attempting whole-unit wetting; this water provision is therefore a contingency exposure-protection measure, not the primary risk control.