

RED FIRE ENGINEERS

Renewable Energy

696 Castlereagh Highway,
Beryl, NSW 2852

Fire Safety Study – V4

RED FIRE ENGINEERS PTY LTD ABN 52 164 239 212

FIRE SAFETY ENGINEERING
RISK MANAGEMENT

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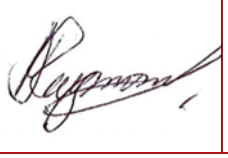
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Summary of Main Findings and Recommendations

RED Fire Engineers Pty Ltd has been appointed by Samsung C&T to develop a fire safety study (FSS) for the proposed BESS Bellambi Heights located at 696 Castlereagh Highway, Beryl, NSW 2852.

Click or tap here to enter text.Section B27 of the development consent (as per Section 4.38 of the Environmental Planning & Assessment Act 1979 (NSW Legislation, 1979) has requested that prior to commencing construction, a fire safety study (FSS) for the development must be prepared and meet the requirements of FRNSW. The purpose of this report is to meet that requirement and be consistent with the NSW Department's Hazardous Industry Planning Advisory Paper No. 2 'Fire Safety Study' guideline (HIPAP2) and evaluate the consequences of identified hazards with respect to fire behaviour, radiant heat transmission, atmospheric dispersion, and explosive potential (credible worst case fire scenarios).

The report outlines proposed control measures to address these risks. Where the context of this site and its associated hazards alignment with the scope / intent of recognised Standards these have been adopted. Where these Standards are not practicable or appropriate, requirements or Standards are adapted to account for the specific characteristics of the site.

The primary objectives of these measures are to protect members of the public, site personnel, emergency responders, and to minimize facility and property damage. While considerations for reducing environmental impact and supporting business continuity are included, these aspects are not the primary focus of this analysis.

This version of the FSS is Version 3, provided in response to FRNSW comments and a meeting held with FRNSW on 12 May 2026. It should be read with the FRNSW comments and response to those comments provided in Appendix H. The only changes to the design other than those in response to FRNSW comments is the change of the Auxiliary Transformers from dry-type to oil filled. This change has been made due to equipment availability, and the analysis for those transformers has been updated to match.

Key findings of this study, as summarized in Table 1, provide insights into areas requiring actions. These findings are specifically based on the consequence analysis associated with the initial risk assessment, focusing on the potential risks and consequences of the site without control measures—emphasizing how severe the impacts could be.

Table 1: Key findings

Parameter	Finding
Fire Hydrant System	The current fire hydrant system design will need adjustments to the hydrant locations to allow for safe brigade operations. This typically requires that every BESS be provided with coverage achievable from 2 different hydrants (using 2 lengths of hose), and neither of those hydrants being within 10 m of a fire affected BESS or other equipment.
Fire spread between BESS	Based on the large scale fire test (LSFT) fire spread between BESS units is unlikely to occur, meaning that losses should be limited to a single BESS in most circumstances.

Parameter	Finding
BESS Internal Aerosol Fire Extinguishing System	The BESS units come with an OEM installed aerosol fire extinguishing system in the battery bays. Though this system is provided, it is not a requirement of the FSS. Nonetheless, to avoid the system causing any faults, it must be maintained in accordance with the manufacturers specifications. The system is not readily removable from the unit, and is not expected to pose an additional hazard, as such it is permitted to be retained. The outcomes of this FSS remain valid if in the future the aerosol system is removed, as it has not been relied upon for any of the FSS findings.
BESS Internal Dry Pipe Sprinkler System	The BESS units come with an OEM installed internal dry pipe sprinkler system in the battery bays. Though this system is provided, it is not a requirement of the FSS. Nonetheless, to avoid the system causing any faults, it must be maintained in accordance with the manufacturers specifications. The system is not readily removable from the unit, and is not expected to pose an additional hazard, as such it is permitted to be retained. Whilst it is not expected to be used by the responding fire brigade, the connection point must still be compatible and therefore must comply with FRNSW Technical Information *FRNSW compatible storz hose connections*. It is not expected that fire brigade would approach the container and connect to this system, and it is not relied upon.
Storage of spare modules	A dedicated battery energy storage system (BESS) enclosure will be provided on site for the storage of spare battery modules only. The enclosure will not be electrically connected nor operational but will function solely as a passive storage unit. The spare modules will be stored inside the enclosure, and the enclosure will be located external to the main buildings (location TBC). This unit may be connected only for monitoring and as required for maintenance charging, it is not to be active as part of the overall BESS site. As the unit is non-operational, no charging, discharging, or active energy transfer will occur. The arrangement should allow for physical separation from occupied structures and the operational BESS enclosures on site to support fire safety management consistent with storage-only use. The location, and any specific storage requirement details for this non-connected storage unit shall be detailed in a separate Consultant Advice Note (CAN) or Dangerous Goods Assessment Report (DGAR).
Dangerous Goods Assessment Report (DGAR)	The only expected significant stored dangerous goods are spare modules in the above referenced BESS and minor storage of substances in the O&M buildings. The exact quantities cannot be confirmed at this stage, therefore, a list of goods and estimated quantities is detailed in Section 4.3. To support this, a separate dangerous goods assessment report (DGAR) may need to be undertaken and the recommended safety measures implemented for the site. This report can be conducted by RED (RED Fire Engineers Pty Ltd); but it would be a separate document as it will be completed post FSS. The DGAR will set out the expected safety measures for any DG storage. Proposed storage arrangements will be investigated and will provide adequate protection for occupants, emergency responders, and the facility, without the

Parameter	Finding
	need for additional extraordinary fire safety measures beyond those identified within the FSS report.
Fire Water Requirements	BB1 and BB2 much each be provided with a fire hydrant system to AS 2419.1 for open yards. This ultimately includes each having a static water supply (fire water tanks) of not less than 144 kL (each for BB1 and BB2).
Separation Distances	Maintaining separation distances as relied upon by this FSS is key to ensuring that the outcomes of this document remain valid. As such, the distances as summarised in Table 2 are requirements of this FSS. Reductions in distances will require an updated Fire Safety Study and resubmission to FRNSW.

Table 2 shows the separation distances assumed on site as part of this FSS. These are inherently requirements of this FSS for the analysis to be accurate.

The listed values are typically the minimum that occur on site based on the current plans, in some cases the actual minimum from the drawings has been further reduced to allow for construction tolerances. For instance, the LSFT for the BESS permits front to front spacing of 3.5 m, the design drawings show 4.61 m, and the table indicates a minimum of 4.3 m to allow some flexibility on site.

Some values are not shown because the site arrangement doesn't permit them directly. For instance, the PCS are located end to end, not face to face. Similarly, the distance from the BESS to the O&M isn't shown as these are separated by a road and additional space, nearly 20 m apart. Further this is not exhaustive of every single item on site.

Table 2 Separation Distances

Equipment	Dimension Description	Minimum Spacing Value
BESS to BESS	Front to front	>4.3 m on site (LSFT based on 3.5 m)
BESS to BESS	Back to back	0.25 m on site (LSFT based on 0.15 m)
BESS to BESS	End to end	0.2 m on site (LSFT based on 0.15 m)
BESS to far side of road	Any part of a BESS to the far edge of the roadway	10 m
BESS to MV Kiosk	Front of BESS to MV Kiosk	> 4 m
BESS to PCS	End of BESS to face of PCS	3.2 m
PCS to far side of road	Any part of a PCS to the far edge of the roadway	10 m
PCS to MV Kiosk	Any part of PCS to MV Kiosk	> 10 m
PCS to PCS	End to end	> 3 m
BESS to Hardstand	Face of BESS to brigade hardstand adjacent the booster	> 15 m
Auxiliary Transformer (Aux TX) to Aux TX	End to end	> 10 m

Equipment	Dimension Description	Minimum Spacing Value
Switch room to Aux TX	Any points	> 5 m
Aux TX to O&M Building	Any points	> 9 m

Control measures were developed based on identified risks and aligned with relevant standards and best practices. Table 2 shows a summary of the accepted control measures. For a list of all control measures considered, refer to Section 7 for the control measure analysis. For further details on the recommended control measures refer to Section 9.

Table 3: Accepted Control Measures

#	CM Title	System Description
CM1	Safe Practices	Sets out safe work procedures and policies which would limit the potential for an incident to occur, as well as the safe response to an incident. Emergency response plan, operational procedures, and the like to instruct any staff present how to safely conduct business at the site.
CM2	Two-way communication	Two-way communication between the operator and the remote operator / site manager so that an incident can be rapidly notified, and procedures activated.
CM3	Portable fire extinguishers	Dry powder, ABE, portable fire extinguishers shall be provided across the site. Fire extinguishers are to be shown on an emergency plan and documented within the ESIP. These portable fire extinguishers are to meet AS 2444:2001 (Standards Australia, 2017). Where portable fire extinguishers are stored outside, they shall be within weather-proof cabinets.
CM5	Fire Brigade	Arrangements for fire brigade notification, access, and intervention at the site.
CM6	Selection of systems	Selection of: - fire protection systems appropriate to the site hazards and risk profile - appropriate equipment suitable for purpose - equipment to be suitable for operating conditions
CM7	Installation and Maintenance of the system	Installation and ongoing maintenance of equipment and fire protection systems in accordance with relevant Australian Standards.
CM8	Arrangement of the system	Physical layout and arrangement of any fire protection systems and equipment across the site.
CM9	Vegetation fuel load	Management of vegetation and other combustible fuel loads to reduce the potential for fire spread.
CM10	Site Security	Measures to maintain site security and control unauthorised access.
CM11	First Aid kit	Provision and maintenance of first aid kits to support initial treatment of injuries.
CM12	Personal protective equipment (PPE)	Provision and use of appropriate personal protective equipment (PPE) by site personnel.
CM13	Site wide incident notification	Processes for site-wide incident notification, escalation and communication.
CM14	Fire truck access	Provision and maintenance of suitable fire truck access routes and hardstand areas.

#	CM Title	System Description
CM15	BESS unit door management	The BESS units are to be closed and locked on site. A heavy-duty lock of industrial standard will be applied to the enclosures to ensure vandals and trespassers are unable to breach the container and leave the door open. Access to these doors is to be granted as required by the principal contractor – keys are to be kept in a locked box on site.
CM16	Landscaping	Landscaping design and maintenance to minimise fire and ember attack risk. Design to ensure water / storm water drainage can flow into the collection pond.
CM17	Water drainage and containment	Water drainage and containment systems to manage contaminated firewater and runoff.
CM18	System monitoring	Monitoring of key systems and alarms to identify abnormal conditions at an early stage. System sensors data to be shared with the RMS operator, with notification related to potential / actual incidents.
CM19	RMS incident support	Arrangements for coordination and support from RMS during incidents.
CM20	Impact protection / Speed Limit	Impact protection measures and speed controls on access tracks to reduce BESS collision risk.
CM21	Lightning protection	Lightning protection systems to minimise the risk of ignition from lightning strikes.
CM22	Ember attack protection	Protection measures against ember attack, including shielding and exclusion zones. Refer to landscaping.
CM23	BESS unit explosion ventilation	Explosion relief and ventilation provisions for BESS units to limit overpressure effects.
CM24	Arc flash assessment	Assessment of arc flash hazards and implementation of appropriate controls.
CM25	Vibration protection – BESS unit	Measures to limit vibration impacts on BESS units and associated equipment.
CM26	Cyber-attack protection	Cyber security controls to protect critical systems from malicious attacks.
CM29	Fire Indicator Panel (FIP)	Fire indicator panel (FIP) to receive, display and transmit fire and fault signals.
CM30	Dangerous goods and chemical cabinets	Use of dangerous goods and chemical storage cabinets compliant with relevant Standards.
CM31	Self-bunded tanks	Use of self-bunded tanks to provide integral spill containment for stored liquids.
CM32	Bunding – Diesel generators and tanks	Bunding arrangements for diesel generators and tanks to contain leaks and spills.
CM33	Diesel generator enclosure	Enclosure of diesel generators to limit fire spread and protect adjacent equipment.
CM34	Diesel generator fire isolation	Fire isolation measures for diesel generators to separate them from other plant and structures.
CM35	Emergency services	Access and procedures of when to call emergency services.
CM36	Fire and smoke detection and alarm system	Fire and smoke detection and alarm system covering relevant plant and building areas.
CM37	Automatic power shutoff to switch & control room	Automatic power shut-off to switch and control rooms under defined emergency conditions.

#	CM Title	System Description
CM39	Management Plans	Preparation and implementation of management plans covering safety and emergency response.
CM40	Access to meteorological data	Access to meteorological data to support emergency planning and response decisions.
CM41	Site housekeeping	Site housekeeping measures to control combustible waste and maintain clear access.
CM42	'No Trespassing' signage	Control of site access through signage and defined entry points.
CM43	Rodent and vermin protection	Measures to manage rodent and vermin activity that may affect equipment and cabling.
CM44	Site Access	Provision and control of site access for personnel, contractors and visitors.
CM45	Fire Hydrant System	Provision of a fire hydrant system to supply firefighting water for the site.
CM46	Dangerous Goods Assessment Report (DGAR)	Conduct Dangerous Goods Assessment Report (DGAR) within the O&M buildings [BB1 & BB2] to evaluate the risks associated with hazardous substances.
CM49	External Wall construction [BB1 – O&M building]	External wall construction of the O&M building / affected façade be comprised of non-combustible materials in accordance with the NCC requirements

I, Seungwan Ha, from Samsung as a representative of the Development Team and Client, have reviewed and endorsed all of the control measures set out in Table 2 and the further details in Section 9.

Signature  Date 25/06/2026

After the endorsement of this fire safety study, it will be used to develop site specific emergency plan and emergency service information pack to satisfy condition B30 as per the development consent.

On the basis that the recommendations in this study are implemented, commissioned, and all fire safety measures undergo routine maintenance in accordance with manufacturer's recommendations and AS 1851:2012 (Standards Australia, 2012), it is our professional opinion that fire safety can be effectively managed at this site.

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1 Introduction

1.1 Background

1.1.1 RED Fire Engineers Pty Ltd has been appointed by Samsung C&T to develop a fire safety study (FSS) for the proposed BESS Bellambi Heights located at 696 Castlereagh Highway, Beryl, NSW 2852.

1.1.2 The battery energy storage system (BESS) compound is divided into two subdivisions, designated BB1 and BB2. Each subdivision has an electrical capacity of 204 MW, the energy discharge / generation capacity is 408MWh which is on average approximately 2 hrs during the integrated resources systems life. The total compound (BB1 & BB2) comprises a total of 256 BESS units, 128 power conversion system modules (PCSMs), and eight medium voltage (MV) transformers. Each subdivision (BB1 and BB2) includes a switch room, emergency diesel generator, two auxiliary transformers, and a dedicated fire water tank and pumping system. In addition, BB1 accommodates the Operations and Maintenance (O&M) Building, which houses both a site office and a warehouse. Samsung C&T has selected the Hithium BESS product as the battery technology for the Project.

1.1.3 The following hazard sources have been identified at the BESS site, as displayed in Table 4 and have been named as hazard locations (HL#s).

1.1.4 Bushfire has not been listed as a hazard source for this FSS as it has been addressed separately by a Bushfire Hazard Report (BHR), the Bushfire hazard management plan (BHMP) and the construction bushfire management plan (CBMP).

Table 4: Hazard locations

HL#	LOCATION NAME
HL1	BESS Units
HL2	Cables
HL3	Electrical systems – MV Transformer
HL4	Electrical systems - PCSM
HL5	Electrical systems – Diesel Generators
HL6	Electrical systems – Miscellaneous (Aux Transformer)
HL7	Site buildings – O&M Building
HL8	Site buildings – Warehouse
HL8	Switch room
HL9	Vehicles
HL10	Transgrid transformer

1.2 Report Applicability

1.2.1 This report reviews the potential fire hazards associated with the facility described in Section 1.1. It provides recommendations to manage fire safety risk appropriately and aligning with relevant safety legalisation. The strategy behind the management of fire and life safety is to limit the number and size of fires at

this site, with a focus of not having a fire spread off the site. The actions taken to achieve this management may also support property & asset protection and business continuity, but have not been explicitly designed to achieve these outcomes.

1.2.2 The findings and opinions expressed within this report are based on the input information provided by Samsung C&T and are applicable only to the detailed circumstances envisaged herein. We have not investigated the validity of the information provided by Samsung C&T as this is outside the scope of RED's engagement. The recommendations consider compliance with relevant legal and regulatory requirements and their applicability in the current operational and legislative context.

1.2.3 This report, which is intended to meet condition B27 of the development consent, is intended for use by Samsung C&T to understand how fire risks at this site can be managed in line with safety legalisation and associated code of practice plus relevant standards. The report must be updated if any changes to the site arrangement affect the information relied upon in the preparation of this report. This is to ensure that the recommendations remain consistent with current regulations and operational conditions.

1.3 Applicable Legislation

1.3.1 Condition B27 of the development consent (as per Section 4.38 of the Environmental Planning & Assessment Act 1979 (NSW Legislation, 1979) has requested that prior to commencing construction, a fire safety study (FSS) for the development must be prepared and meet the requirements of FRNSW.

1.3.2 This FSS has been conducted in line with the NSW Hazardous Industry Planning Advisory Paper No.2 – Fire Safety Study Guidelines (NSW Department of Planning, 2011). The principal NSW legislation associated with this FSS is:

a) Environment Protection Act, 2017,
b) Protection of the Environment Operations (General) Regulation 2022,
c) Dangerous Goods Act (Environmentally Hazardous Chemicals Act), 1985,
d) Work Health and Safety Act, 2011,
e) Work Health and Safety Regulations, 2017,
f) Environmental Planning and Assessment Act 1979 (EP&A Act)

1.4 Process of the Fire Safety Study

General

1.4.1 The FSS focuses on analysing specific fire risks and designing safety measures to address them. The level of detail required depends on the type and size of the project, in order to tailor the fire safety measures to the facility's needs.

1.4.2 HIPAP 2 was last updated before Work Health and Safety (WHS) regulations adopted the So Far As Is Reasonably Practicable (SFAIRP) risk principle. Therefore, the study focuses more on fire consequences rather than specific risk

levels. Instead of using risk contours, the results are presented in a risk matrix as called for in the Occupational Health and Safety legalisation, where likelihood and consequences are determined using available data or expert consultation.

1.4.3 Fire protection requirements are determined based on worst-case scenarios associated with credible incidents. This will be referred to as credible worst case. While Codes and Standards provide a structured framework, they are only appropriate if support by engineering due diligence, i.e., an evaluation of the credible incident is necessary to assess whether the Standards sufficiently address the specific scenarios in this case.

1.4.4 A summary of the fire risk assessment process is shown in Figure 1. This process is reflective of that in HIPAP 2 and the overall HIPAP series, whilst partly incorporating the operators needs to consider likelihood of events under WHS regulations.

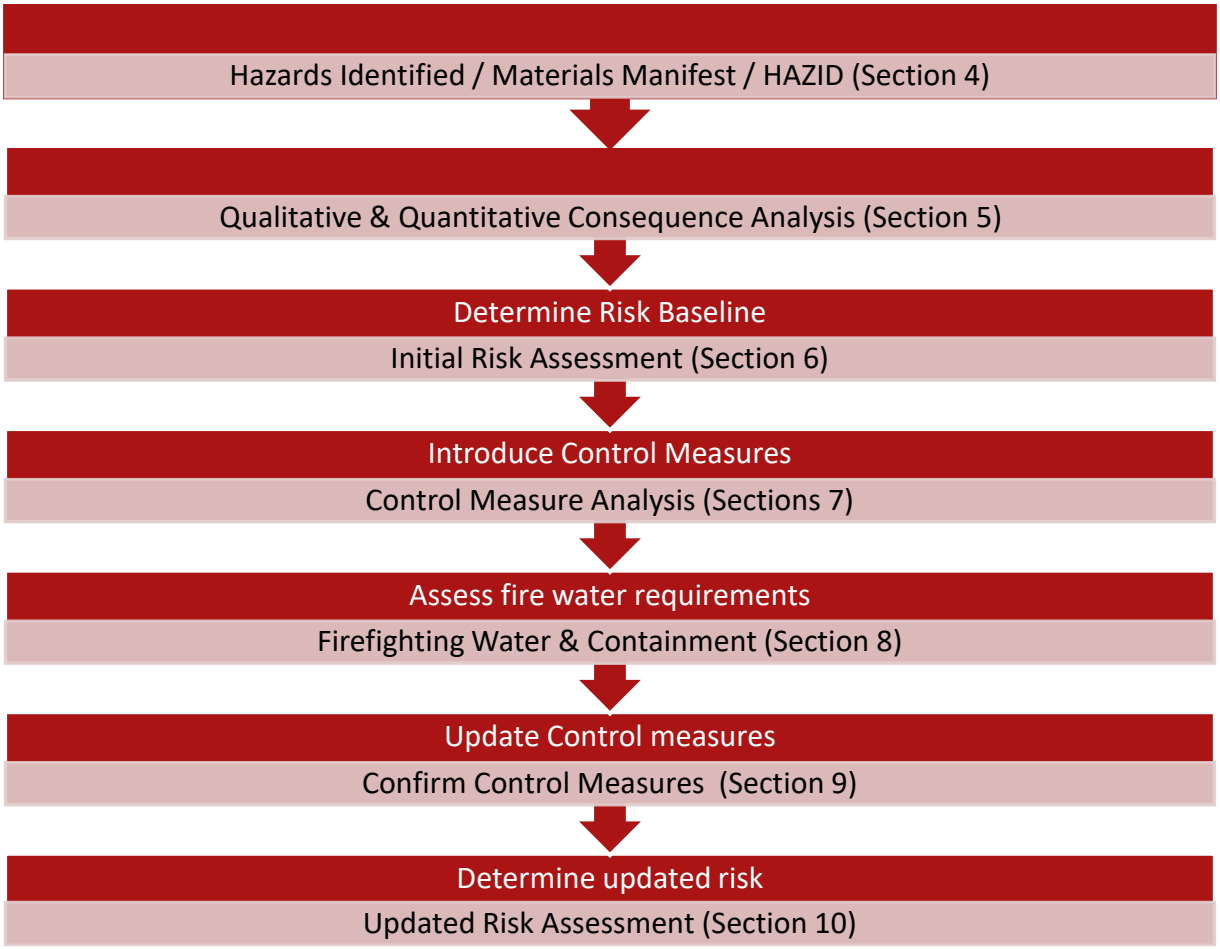


Figure 1: Fire Risk Assessment process

Identifying hazards

1.4.5 The first step in the fire risk assessment process is to identify potential hazards associated with fire, explosion, and toxic releases. This step is conducted in Section 3.13.1 of this report.

1.4.6 Typical fire hazards for this type of facility include:

a) Flammable materials – Liquids, gases etc.
b) Ignition sources – Sparks, electrical faults, hot surfaces, and open flames.
c) Storage risks – inadequate containment or inappropriate placement in high-risk areas.
d) Fire spread potential – the rate and extend to which a fire could escalate.

Consequence analysis

1.4.7 The next step involves conducting a consequence analysis to evaluate the potential outcomes of identified hazards in the absence of any control measures. This establishes a baseline risk profile for the site or specific hazard area and is detailed in Section 5. The consequence analysis includes:

a) Fire scenario modelling – predicting the development and behaviour of a fire event.
b) Impact analysis – evaluating potential effects on people, property, and the environment.
c) Fire type assessment – determining whether the event would constitute a pool fire, jet fire, flash fire, or explosion.

1.4.8 Following identification of the consequence type and magnitude, the associated risk is evaluated based on both consequence severity and likelihood of occurrence under uncontrolled conditions.

1.4.9 Subsequently, appropriate control measures are identified and assessed to reduce risks based on so far as is reasonably practicable (SFAIRP) principle. The effectiveness of these measures is examined in terms of their ability to reduce both consequence severity and event likelihood. The revised risk profile, incorporating these control measures, is then re-evaluated.

Prevention and protection measures

1.4.10 The recommended control measures, presented in Section 5, are categorised as passive or active systems, and as preventative or protective measures. Further detail on the implementation and effectiveness of these controls is provided in Section 6 and in the relevant Appendices to this report.

1.5 Stakeholders and Documentation

1.5.1 The stakeholders associated with this project are listed in Table 5.

Table 5: Project stakeholders

Organisation	Role	Representative
Samsung	Project Manager	Pablo Ha Mohamed Elnakib
RED Fire Engineers Pty Ltd	Fire Safety Engineer	Ian Raymond Nate Lobel Paul Laughlin-Hyde MC Hui

Organisation	Role	Representative
FRNSW	Statutory referral authority	Richard Jay Jun Hey
Department of Planning, Housing and Infrastructure (DPHI)	Consent authority	-

1.5.2 The relevant documents and drawings on which this report is based are listed in Table 6.

Table 6: Relevant documentation

Organisation	Title	Project number/ ref	Date	Revision
Hithium	Product Identification, Packings, Transportation, and Storage	-	-	-
	Fire Protection System	ESS_5016kWh_Fire protection System (AU)_V1.1	-	V1.1
	ESS Container 5.016 MWh	-	-	-
	Liquid Cooling 2.0 ESS Container Technical Specification (AU-6 Racks-A)	-	May 2025	A/0
Underwriters Laboratory	Hithium ∞Block 5 MWh product liquid-cooled battery energy storage system – Large Scale Fire Test	-	10/07/25	-
Samsung C&T	Electrical Equipment List – Bellambi BESS Generation Unit 1 & 2	BLB BESS-00GEN001_E01-0001	18/07/2025	-
	Bellambi Heights BESS – Stage 1 & 2 – General Arrangement Plan	DWG-BHB-GA0101	08/07/25	A
	Bellambi Heights BESS – Stage 1 & 2 – Bulk Earthworks Cut Fill Plan	DWG-BHB-BE0101	08/07/25	A
	Bellambi Heights BESS – Stage 1 & 2 – Bulk Earthworks Site Section – P1	DWG-BHB-BE0501		

Organisation	Title	Project number/ ref	Date	Revision
	Bellambi Heights BESS – Stage 1 & 2 – Bulk Earthworks Site Section – P2	DWG-BHB-BE0502		
	Bellambi Heights BESS – Stage 1 & 2 – Pavement Plan & Details	DWG-BHB-PV0101		
	Bellambi Heights BESS – Stage 1 & 2 – Foundation Plan	DWG-BHB-FD0101		
	Bellambi Heights BESS – Stage 1 & 2 – Road Alignment Plan	DWG-BHB-RD0101		
	Bellambi Heights BESS – Stage 1 & 2 – Road Alignment Long Section – P1	DWG-BHB-RD0501		
	Bellambi Heights BESS – Stage 1 & 2 – Road Alignment Long Section – P2	DWG-BHB-RD0502		
	Bellambi Heights BESS – Stage 1 & 2 – Road Alignment Long Section – P3	DWG-BHB-RD0503		
	Bellambi Heights BESS – Stage 1 & 2 – Storm Water Pit & Pipe Long Section – P2	DWG-BHB-SW0502		
	Bellambi Heights BESS – Stage 1 & 2 – Storm Water Pit & Pipe Long Section – P3	DWG-BHB-SW0503		
	Bellambi Heights BESS – Stage 1 & 2 – Storm Water Pit & Pipe Long Section – P1	DWG-BHB-SW0501		
Vena Energy	Appendix A SEARs compliance table	E220170	-	3
	Appendix D Mitigation measures summary		-	
	Appendix N Preliminary hazards analysis	21689-RP-001	24/05/23	0

Organisation	Title	Project number/ ref	Date	Revision
	Appendix O Bushfire assessment	-	10/05/23	1.2
	Bellambi Heights Renewable Project – Overall Layout	BLB BESS-00GEN00_E29-0001	-	D
	Bellambi Heights Renewable Project – Fire water ring main layout	BLB BESS-00GEN00_XXX-0001	01/07/25	A
	Bellambi Heights Renewable Project – Scoping Report	E211048 RP#1	31/03/22	3
Yurika	Bellambi Heights Renewable Project, 33 kV BESS, General Arrangement, Overall Site Layout	VEBE-SCT-ELE-LAY-001	18/07/25	D
	Bellambi Heights Renewable Project, 33 kV BESS, General Arrangement, BESS Section View, Elevations	VEBE-SCT-ELE-LAY-003		B
	Bellambi Heights Renewable Project, 33 kV BESS, Earthing and Lightning Plan	VEBE-SCT-ELE-LAY-005		B
	Bellambi Heights Renewable Project, 33 kV BESS, General Arrangement, BESS Plot Plan	VEBE-SCT-ELE-LAY-002		D
	Bellambi Heights Renewable Project, 33 kV BESS, Cable Route Plan	VEBE-SCT-ELE-LAY-004		B
Dept of Planning, Housing, and Infrastructure	Bellambi Heights Battery Energy Storage System	SSD 33344237	May 2024	-
	Development Consent		02/05/24	-
	Notice of decision		02/05/24	-

Organisation	Title	Project number/ ref	Date	Revision
Fire and Rescue New South Wales	Re: Advice on Environmental Impact Statement (EIS) – Bellambi Heights Battery Energy Storage System, 696 Castlereagh Highway, 79 Puggoon Road, Beryl	FRN23/2931 BFS23/4915 8000030507	06/09/23	-
New South Wales Rural Fire Service	Development Application State Significant – Pre-EIS Consultation – Hazardous Storage Establishment 696 Castlereagh Highway & Puggoon Road, Beryl	DA20220413007058_Pre_EIS	12/09/23	-
Mid-Western Regional Council	Advice on Environmental Impact Statement; Bellambi Heights Battery Energy Storage System	LAN900140	25/09/23	-
Guangzhou MCM Certification and Testing Co Ltd	Material Safety Data Sheet – Hithium BESS unit	CCBA2FX805SDS01	18/02/25	-
	Material Safety Data Sheet – Hithium BESS unit	CCBA2F6602SDS01	31/07/25	-
RED Fire Engineers	Fire Protection Design Basis	251103_JN25-00265_BESS_BH_FPDB	03/11/2025	V1
	Bushfire Hazard Report	251120_JN25-00265_BESS Bellambi Heights_BHR	22/10/2025	V1
	Bushfire Construction Management Plan	251120_JN25-00265_BESS Bellambi_BCMP	20/11/2025	DRAFT
Vena Energy Services	Bellambi Heights BESS EPC Works Specification – Schedule 2	BH - EPC Sch.2 - Works Spec SCT - Rev 0 - VE 20250708	02/12/2024	Rev 0
Aurecon	Bellambi Heights BESS RAM Report	P529361-001	28/11/2025	Rev 2

1.5.3 Citations and references used throughout this report are listed in Section 12.

1.6 Assumptions and Limitations

1.6.1 Table 7 presents assumptions underpinning this fire safety study (FSS). It is noted that deviations from these assumptions may introduce additional risks that have not been assessed within this report.

Table 7: Assumptions and Deviation Consequences

Assumption	Deviation consequence
All equipment on site is maintained for safety and efficient operations.	Failure to maintain equipment may lead to increased risk of equipment failure, compromising fire safety systems and potentially escalating fire scenarios.
All items / substances, especially dangerous good, are correctly packed and stored in their appropriate location(s).	Incorrect storage or packing of substances can increase the likelihood of fire, toxic, or explosive incidents, or hinder emergency response efforts.
All equipment on the site operates as designed.	Malfunctioning equipment may reduce the effectiveness of fire suppression or detection systems as well as increase the potential likelihood and / or severity of an incident.
All fire safety measures on site have been and will continue to be maintained to the relevant Australian Standards and the local regulations.	Non-compliance with standards or regulations of essential safety measures may lead to undetected incidents and reduced system performance to respond to an incident.

1.6.2 The outcomes of this fire safety study (FSS) are subject to the limitations presented in Table 8. Where these limitations are not respected or additional changes occur, the conclusions of this report may no longer be valid, and a review may be necessary.

Table 8: Limitations and Deviation Consequences

Assumption	Deviation consequence
The outcome of this assessment is based on the information referenced in this report.	If the information provided is incomplete, inaccurate, or changes significantly, the risk analysis and fire safety recommendations may be insufficient or ineffective.
This report excludes the analysis of premeditated fires including incendiary fires involving accelerants, explosives and/or multiple ignition sources, or acts of terrorism.	Should these events occur, the outcomes are likely to exceed the scenarios considered in this report, and additional measures or contingency plans would be required.
No significant additional fuel loads, outside that noted in this report, are to be stored at this facility.	If unaccounted-for fuel loads are introduced, they may increase the intensity and spread of fire scenarios beyond the assumptions of this study.
If a technical standard is superseded during the course of reporting, the report will continue to reference and comply with the version current at the time of project commencement.	This ensures consistency, accuracy, and alignment with the design basis established at the outset of the assessment or engineering work.

1.6.3 Whilst RED Fire Engineers has used reasonable care and judgement in performing the FSS, a fire with a severity exceeding the design inputs may still occur. It is impossible to have a 'zero risk' or be 'risk free'. Regardless of what measures are applied, this does not and cannot eliminate all possibilities of a fire starting, and nothing in this report lays claim to achieving a zero risk, making the site risk free, or eliminating all fire and life risks from the project.

1.6.4 Health and Safety legislation, supported by Health and Safety Regulations, is the principal legislation concerned with work health and safety in Australia, pertaining to risk to persons at a place of work. Generally, under Health and

Safety regulations, employees and non-employees legally entitled to be in a workplace must be provided with an acceptable level of safety in the workplace at all times.

1.6.5 Any substitution of fire safety measures, fire protection equipment and/or products nominated in this report without prior approval of RED Fire Engineers Pty Ltd may render this report invalid, and RED fire Engineers Pty Ltd should be contacted to assess the potential impact of the proposed substitution.

1.7 Glossary and Abbreviations

Table 9: Glossary and Abbreviations

Abbreviation	Meaning	Definition
AC	Alternating Current	Electric current which periodically reverses direction.
BESS	Battery Energy Storage Systems	Systems used to store energy in batteries for later use.
BMS	Battery Management System	A system that monitors and manages battery performance and safety.
DC	Direct Current	Electric current that flows in a single direction.
DPS	Distributed Power Station	A power station that distributes energy over a specific area.
EWS	Emergency Warning System	A system designed to alert people to emergencies and provide instructions for safety.
FIP	Fire Indicator Panel	A panel displaying the status of fire alarms and related systems.
FRL	Fire Resistance Level	A measure of a material or structure's ability to resist fire, expressed in time duration.
FRNSW	Fire Rescue NSW	The agency responsible for fire safety, rescue, and emergency response in NSW, Australia.
FSS	Fire Safety Study	An analysis aimed at assessing and enhancing fire safety measures within a facility.
HIPAP 2	Hazardous Industry Planning Advisory Paper No.2	Guidelines for risk assessment and land use planning around hazardous industrial sites.
HRR	Heat Release Rate	Rate at which energy is generated by a burning material, expressed in kilowatts (kW) or megawatts (MW).
IRA	Initial Risk Assessment	The first evaluation of potential risks in a given context, often as part of safety planning.
LFP	Lithium Iron Phosphate	A type of lithium-ion battery known for safety and durability.
Li-ion	Lithium Ion	A rechargeable battery type used in portable electronics and electric vehicles.
NSW RFS	NSW Rural Fire Service	Primary agency responsible for bushfire prevention, preparedness, response, and recovery across rural and regional NSW.
O&M	Operation and Maintenance	Activities involved in operating and maintaining a system or facility.
RMS	Remote Monitoring Site	A facility used to monitor systems from a distance.
RMU	Ring Main Unit	Equipment used to protect and switch a distribution transformer within an electrical power grid
SARET	Safety of Alternative and Renewable Energy Technologies	FRNSW collaborative research program on the Safety of Alternative and Renewable Energy Technologies
SFAIRP	So Far As Is Reasonably Practicable	Doing what is achievable and reasonable under the circumstances to address a risk or requirement.

Abbreviation	Meaning	Definition
SQEP	Suitably Qualified and Experienced Person	A person with appropriate qualifications and experience for a specific task or responsibility.
URA	Updated Risk Assessment	A revised evaluation of risks, taking into account new information or changes in context.

2 Scope of Report

2.1 Scope

2.1.1 The scope of this fire safety study (FSS) is limited to the potential fire hazards associated with the facility described in Section 1.1. Specifically, this report considers fire and life safety risk to this facility and adjacent properties that may originate within or outside of the site. This assessment evaluates these risks and proposed treatments. The actions taken to achieve this may also support property & asset protection and business continuity but have not been explicitly designed to achieve these outcomes.

2.1.2 The Belambi Heights BESS compound is broken into two subdivisions, BB1 and BB2. Each BESS subdivision, i.e., BB1 and BB2, has an electrical capability of 204 MW / 408 MWh. Each BESS unit has a capacity of 5016 kWh. Across the BESS compounds there are 256 BESS units, 128 PCSM, and 8 MV transformers.

2.1.3 The following hazard locations have been identified at this BESS site:

Table 10: Hazard locations

HL#	LOCATION NAME
HL1	BESS Units
HL2	Cables
HL3	Electrical systems – MV Transformer
HL4	Electrical systems - PCSM
HL5	Electrical systems – Diesel Generators
HL6	Electrical systems – Miscellaneous (Aux Transformer)
HL7	Site buildings – O&M Building
HL8	Site buildings – Warehouse
HL8	Switch room
HL9	Vehicles
HL10	Transgrid transformer

2.1.4 This project comes under SSD-33344237 [and SSD-33344237-Mod-1]. On 2 May 2024, the Executive Director, Energy Assessments, granted consent to the development application for the Bellambi Heights Battery Energy Storage System. A modified and consolidated consent was issued for the submitted modifications on 20 October 2025.

2.1.5 Fire and Rescue New South Wales (FRNSW) has issued correspondences as part of the (Planning) Secretary's Environmental Assessment Requirements (SEAR) phase (FRN23/2931 BFS25/5682 8000044561) and Environmental Impact Statement (EIS) phase and during the consent modification process, providing comments on 21 August 2025. In both of these correspondences FRNSW calls for a fire safety study (FSS) to be developed in accordance with Hazardous Industry Planning Advisory Paper (HIPAP) No. 2. FRNSW states that this 'FSS is to be used to inform the design and as such it is FRNSW Position that the FSS be developed to the satisfaction of FRNSW prior to any further submissions be made to FRNSW'. In addition, 'FSS should be prepared consistent with the FRNSW Fire

Safety Guidelines Technical Information – Large scale external lithium-ion battery energy storage system – fire safety study considerations'.

2.1.6 As this is an FSS, it is not intended to analyse the environmental consequences due to the loss of containment of contaminants from the site in depth, but just to inform of this risk. In this respect, this FSS addresses the containment of fire water.

2.2 Input from associated Safety Studies

2.2.1 As noted in Table 6 of this report Vena Energy developed a preliminary hazard analysis (PHA) for this site. The following are the main finding and recommendations from the PHA for this Bellambi BESS site.

2.2.2 The findings are:

a) The project is not considered "potentially hazardous" under SEPP (Resilience and Hazards) 2021; hazardous materials storage and transport thresholds are well below screening limits.
b) 13 hazardous events were identified (fire, explosion, electrical fault, EMF exposure, etc.).
c) No significant off-site impacts are expected from any event due to:
   i. Large separation distance (nearest sensitive receptor 1,210 m away).
   ii. Rural location with low surrounding population density.
   iii. Built-in design controls and standards compliance.

2.2.3 The recommendations are:

a) Confirm with BESS supplier that system design and controls have addressed all lessons learned (e.g., coolant leak detection, redundancy, shutdown logic).
b) Ensure manufacturer requirements for installation, commissioning, operations, maintenance, and emergency response are fully implemented.
c) Engage FRNSW during detailed design to verify fire protection measures, including:
d) Fire-fighting or control media type (e.g. water, inert gas).
e) Demand, storage, and containment systems for that medium.
f) Outcomes to inform the subsequent fire safety study (this document) required under development consent.
g) Maintain BESS clearances per manufacturer / NFPA 855.
h) Implement Fire Management Plan, Emergency Response Plan, and Asset Protection Zone (APZ).
i) Incorporate security fencing, cameras, and signage to deter unauthorised access.
j) Ensure training and maintenance procedures per AS/NZS 5139 and TransGrid requirements.

3 Description of Facility

3.1 Site Layout and Location

General

3.1.1 The project BESS Belambi Height that is to be located at 696 Castlereagh Highway, Beryl, NSW. The nearest town centre is Gulgong, located approximately 6.5 km south-east of the project.



Figure 2: BESS Belambi Heights (Google Maps © 2025) – North at top of image

BESS Site Arrangement

3.1.2 The BESS compound is divided into two subdivisions, designated BB1 and BB2. Across the compound, there are 256 BESS units, 128 power conversion system modules (PCSMs), and eight medium-voltage (MV) transformers. Each half of the compound (BB1 and BB2) is equipped with a switch room, an emergency diesel generator, two auxiliary transformers, and dedicated fire water tanks and pumping systems. The BB1 subdivision also includes the Operations and Maintenance (O&M) Building, which comprises administrative offices and a warehouse to support site operations and equipment maintenance. To the south of the site is the Transgrid substation which is positioned approximately 200 m away.

3.1.3 A.5 to this report provides a detailed proposed arrangement of this BESS site.

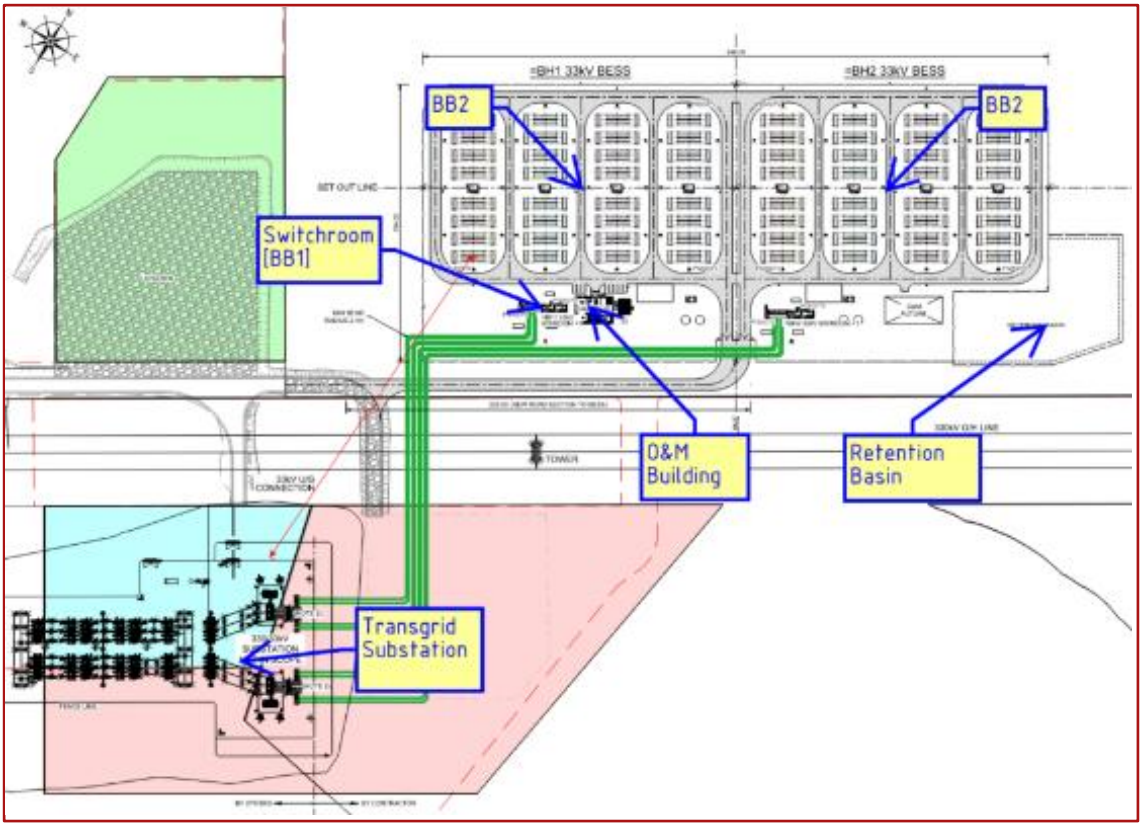


Figure 3: BESS site arrangement

3.1.4 Table 11 provides a summary of the BESS site / compound.

Table 11: BESS site / compound parameters

Aspect	Description
Development footprint	5.4 hectares (54,000 m^2)
Access route	Heavy vehicles would travel via the Golden Highway and Castlereagh Highway from the north and Castlereagh Highway from the south. Heavy vehicles required escort would travel from the Port of Newcastle on State roads.
Site access	A new site access would be constructed off Castlereagh Highway, comprising basic left turn and basic right turn treatments.
Operation	The expected operational life of the project is approximately 25 years, subject to component replacement and life extension as stated within the EIS Appendix N.
Hours of operation	The BESS would operate 24 hours per day, seven days per week and be able to be operated remotely. When operated remotely, the staff response time to site is approximately 90 minutes.
Employment	Up to 100 construction jobs and 6-10 operational jobs. The project's operational workforce would complete routine operations and maintenance one week out of every month the project is operational.

Boundary and Adjacent land use

3.1.5 The preliminary hazard analysis (PHA) report (Vena Energy, 2023) lists 72 sensitive receptors (non-associated residential dwellings within approximately 4

km of the project area). A further two dwellings are associated with the project (R70, R71). Sensitive receptors are primarily located in loose clusters to the south, east and north-west of the project area, with most lying between 1 and 4 km from the nearest boundary of the project area (either BESS compound or switching station components). The surrounding residential dwellings are visually presented in Figure 4.

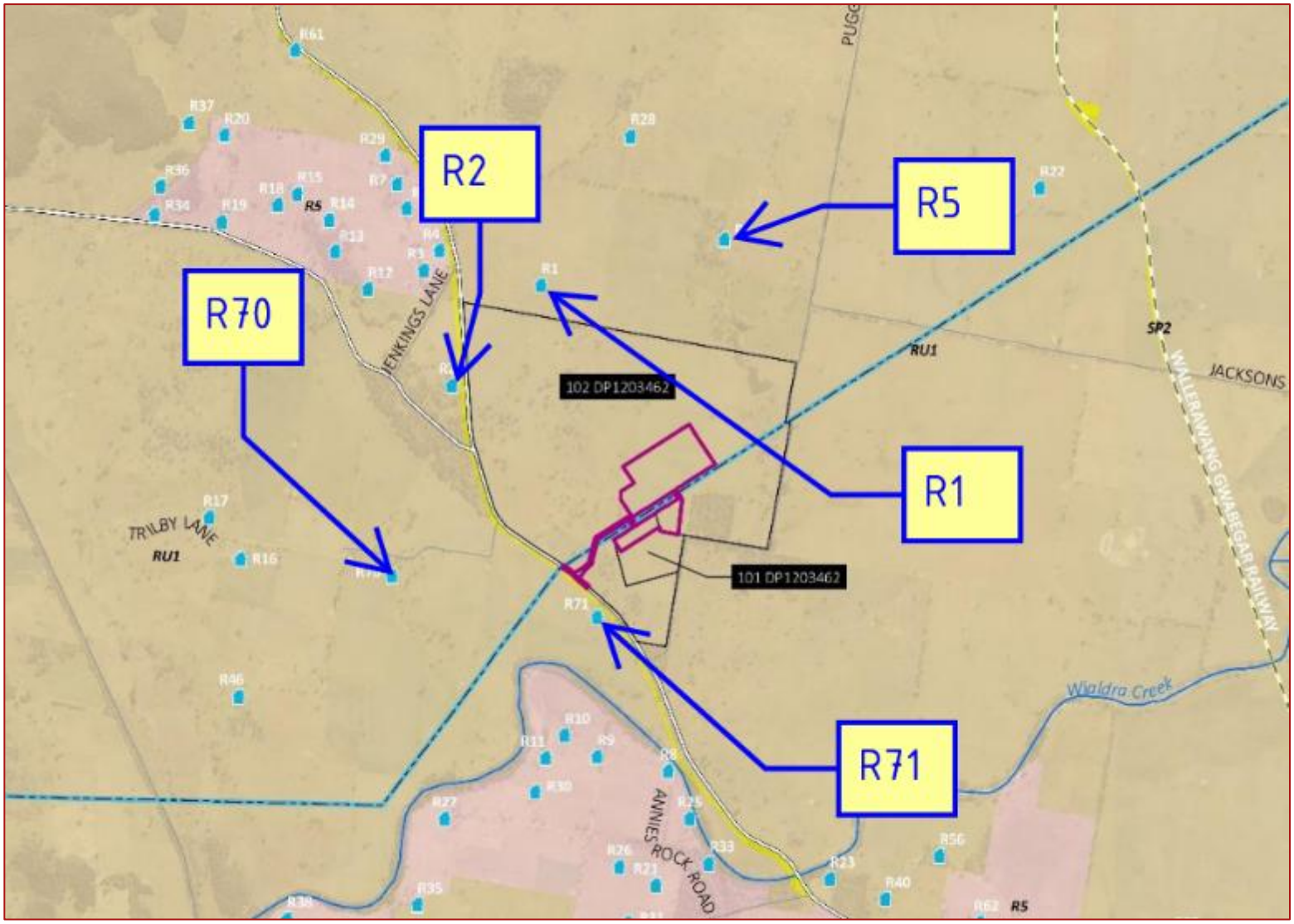


Figure 4: Proximity of BESS area to external receptors

Table 12: External Receptors

Ref	Description	Approximate Distance (m)
R1	Dwelling (sensitive receptor)	1,280
R2	Dwelling (sensitive receptor)	1,330
R5	Dwelling (sensitive receptor)	1,470
R70	Dwelling (sensitive receptor)	1,750
R71	Dwelling (sensitive receptor)	767

3.1.6 The site is surrounded by farmland and trees to the south-east mainly around Wyaldra Creek. The land zoning within this area is classed as RU1 Primary Production under the Mid-Western Regional LEP 2012.

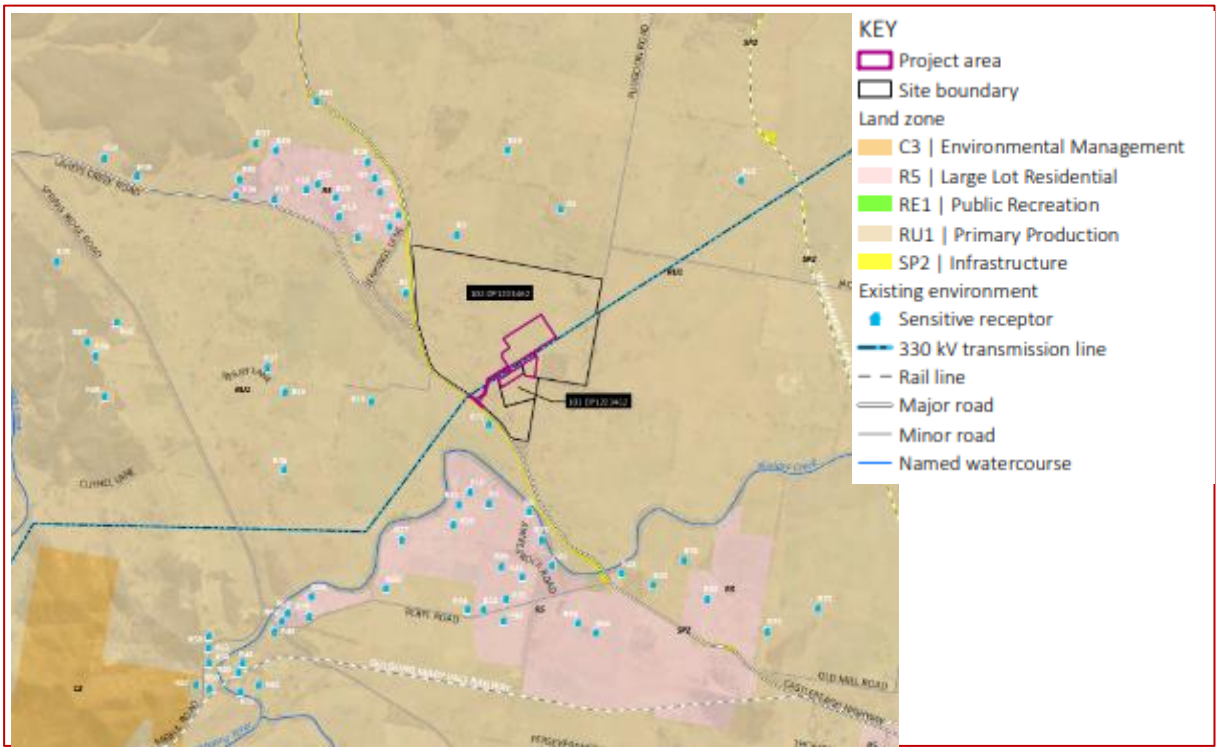


Figure 5: Land zoning

Access and Roads

3.1.7 The site is currently serviced by a single vehicle access point from the Castlereagh Highway, as shown in Figure 6, which is dedicated to the BESS site.

3.1.8 Figure 6 shows the proposed pavement arrangement across the site and main access road. The road into the site is an unsealed road, whilst the BESS compound will be paved roads.

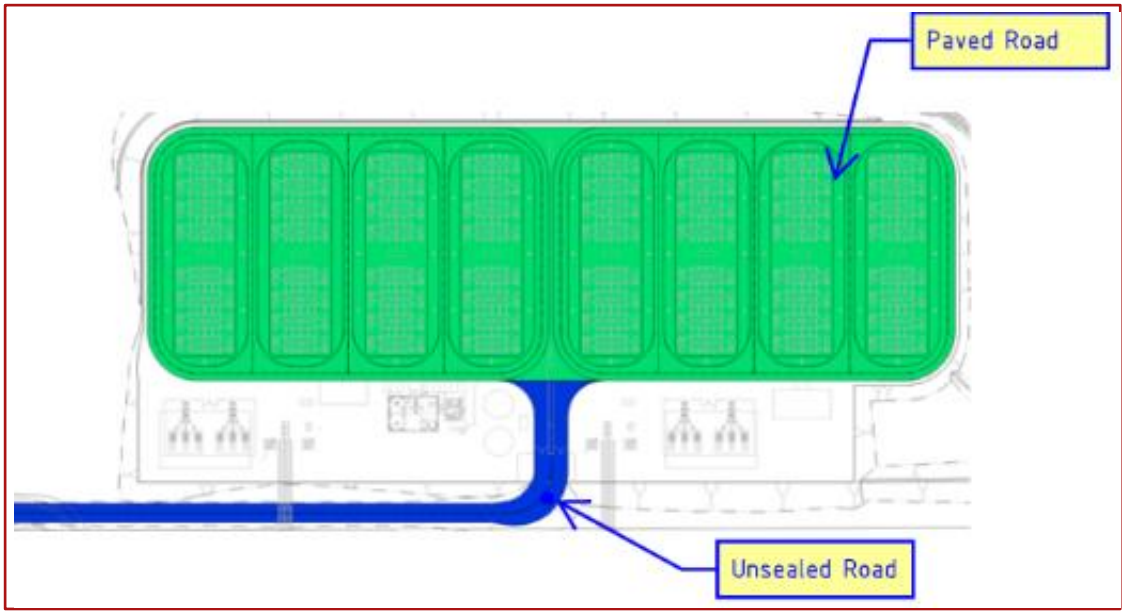


Figure 6: BESS site arrangement, with proposed different pavement types

3.2 Electrical Plant

3.2.1 All electrical plant, including BESS units and Transformers, are to be protected from floods, i.e., set above ground level by at least 200 mm.

3.2.2 Section 7.3.1 of the Bellambi Heights BESS EPC Works Specification (Rev. 0 dated Dec 2024) specifies that all electrical plant and equipment (including BESS and transformers) shall be adequately protected from flooding and must include a minimum freeboard of 200mm above the 100-year ARI flood level.

3.3 BESS Units

3.3.1 Appendix B to this report provides a summary of the Hithium BESS units to be used within the BESS compound. These BESS units will be located on plinths so that the top of the BESS units will be approx. 2.9 m above the finished ground level.

3.3.2 The Hithium BESS unit comprises 48 lithium-iron-phosphate (LFP) modules with 104 cells in each module, therefore, there are 4,992 cells in each BESS unit. The system has integrated liquid cooling, fire protection, and battery management systems. Across the site there are 256 BESS unit, thus, there would be 1,277,952 cells.

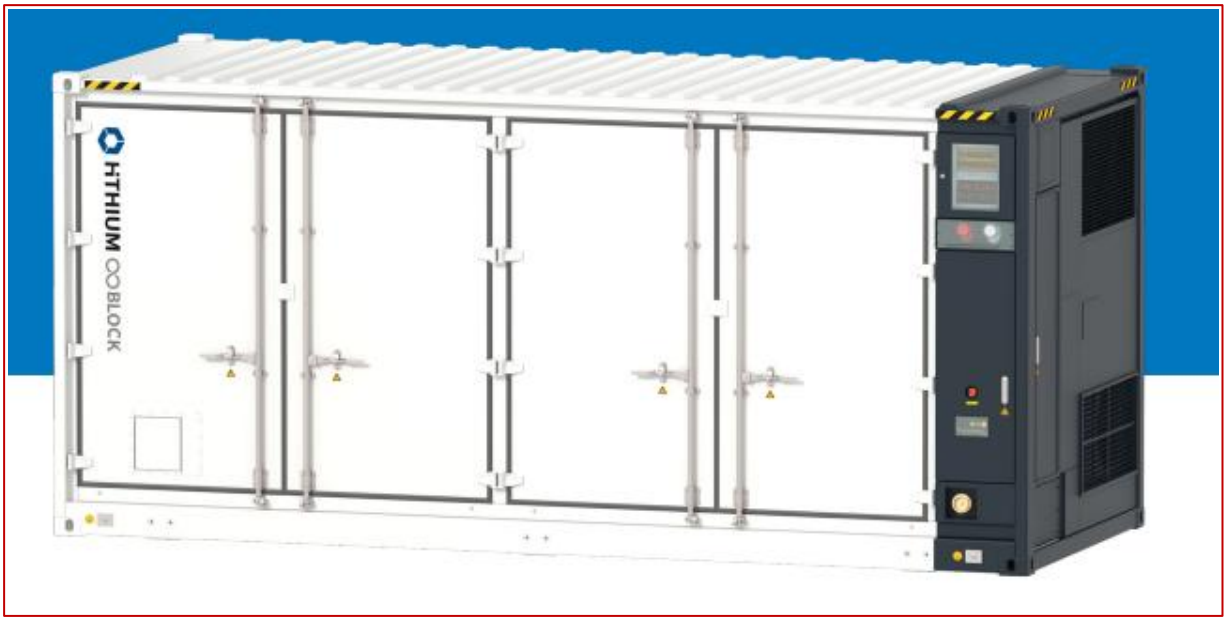


Figure 7: Hithium battery enclosure

Table 13 Racks, Modules, & Cells

Item	Value	Per BESS Container
Battery Racks	6 racks per BESS in parallel	6
Modules	8 modules per rack in series	48
Cells	104 per module in series [2 parallel, 52 in series]	4,992
Site Total		
BESS Containers	256	
Racks	1,536	
Modules	12,288	
Cells	1,277,952	

3.3.3 The fire protection systems for the Hithium BESS unit have been developed based on NFPA 855. This system consists of a fire alarm control panel (FACP), automatic alarm system, gas detection system, fire detection system ventilation system, aerosol extinguishing system (12x 300g), and a dry pipe suppression system.

3.3.4 The BESS is provided with a 2 stage fire alarm scheme, as described in B.3. There are 2 smoke detectors and 2 heat detectors in each BESS unit. Stage 1 alarm is triggered by any single detector, and Stage 2 is triggered by any two detectors activating, i..e, double knock. At Stage 2, the fire brigade are automatically called out.

3.3.5 The gas detection system is responsible for activating the ventilation system which is an NFPA 69 explosion mitigation system. A copy of the NFPA 69 system report is provided in Appendix B. The ventilation system is also linked to the fire detection system, and is to continue to operate regardless of the fire alarm

status / aerosol system. It is not permissible for the fire alarm system to override the NFPA 69 system.

3.3.6 The enclosure composes of three layers which are an inner and outer steel plate with a core of fireproof rock wall. This provides a nominal fire resistance of 1 hour. This complies with key standards including UL 9540A, UL 1973, IEC 62619, and AS 3000.

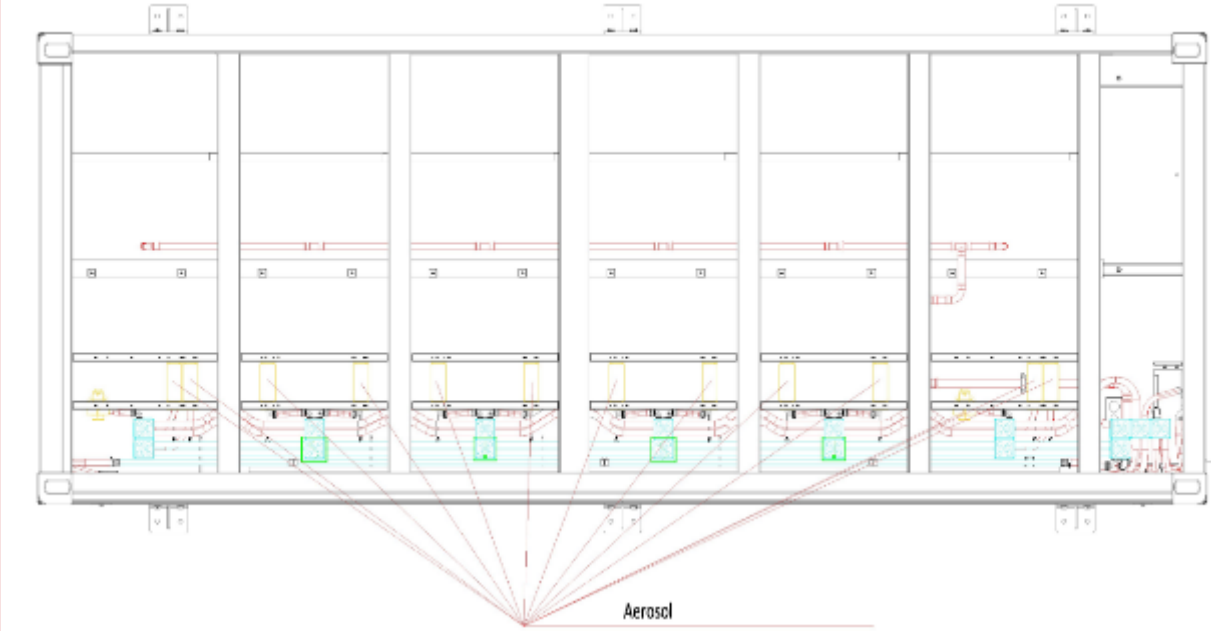


Figure 8: BESS Aerosol system top view

3.3.7 UL 9540A testing showed thermal runaway at around 251°C, releasing approx. 171 L of gas primarily containing hydrogen (45%), carbon dioxide (23%), and carbon monoxide (14%).

3.3.8 In a large-scale fire test (LSFT), ignition of one container produced a peak heat-release rate of ~14 MW but no fire propagation to adjacent units, confirming that the containerised construction and spacing effectively limited external fire spread. This LSFT was carried with multiple containers arranged similar to CSA C800. The LSFT report is provided in Appendix A to this report.

3.3.9 The LSFT test is based off 3 Standards, UL 9540 Installation Level, large scale fire tests (UL Solutions, 2016), NFPA 855 (NFPA, 2023) and CSA/ANSI C800 (CSA/ANSI, 2025). The testing has incorporated all three Standards, but it is not specific to any one of them.

3.4 Cables

3.4.1 Most of the cabling is planned to be buried and located within conduits, although some of the cabling on site will be above ground and in conduits / trays. The cables are to be manufactured and installed to the appropriate Australian Standards.

3.5 Electrical systems – MV Transformer

3.5.1 The MV transformers are oil-immersed KNAN-type transformers utilising FR3 natural ester insulating fluid. Each transformer contains approximately 1,556 L of insulating oil **(TBC)**. FR3 is an ester-based dielectric fluid with a high flash point exceeding 310°C and an auto-ignition temperature of approximately 401°C.

3.5.2 Oil-filled transformers using FR3 natural ester fluid offer significantly improved fire safety performance relative to typical mineral oil, with a reduced likelihood of ignition under electrical fault or thermal stress conditions. In the event of an internal transformer fault, the ester fluid exhibits a lower heat release rate and a strong tendency to self-extinguish once the ignition source is removed. As a result, the probability of a sustained pool fire or fire escalation beyond the transformer kiosk enclosure is considered low.

3.5.3 The transformers are not pressurised systems and are not expected to present an explosion hazard under normal operating conditions. However, a rapid internal fault, e.g. electrical arc, may result in sudden vaporisation of FR3 fluid. In the unlikely event that pressure relief mechanisms fail or are overwhelmed, a mechanical rupture of the transformer enclosure may occur. This scenario represents a low-likelihood event and would constitute a pressure-driven rupture rather than a true explosion. While localised burning of insulating fluid may occur following such a failure, significant projectile generation or off-site impacts are not anticipated.

3.6 Electrical systems – PCSM

3.6.1 The power conversion system modularity (PCSM) consists of power conversion system (PCS) inverter and PCS Transformer. The transformers that are part of the PCS are dry type.

3.7 Electrical systems – Diesel Generator

3.7.1 The diesel generators, one located near each switch room, are confirmed to support 24 hours of operations. It is assumed that the diesel tank is no larger than 1.5 kL**.**

3.8 Electrical systems - Auxiliary Transformers

3.8.1 There are two auxiliary transformers associated within each switch room, i.e., a total of four auxiliary transformers on site. These transformers are of dry type.

3.9 Site buildings

O&M building

3.9.1 The O&M building is separated into two distinct areas. Area 1 consists of the following to consist of storage areas (storage 1 & 2), warehouse, hot works area

and an air conditioned storage room. Area 2 consists of an office area, meeting room, kitchen and wash facilities. This building is located within BESS BB1 area.

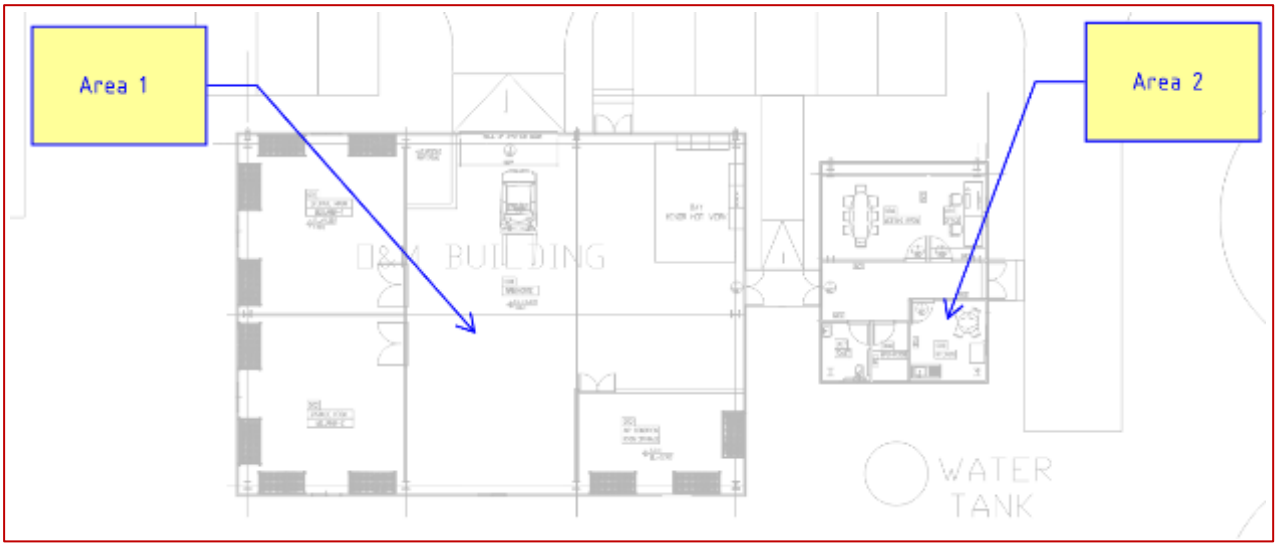


Figure 9: O&M building

3.10 Switch room

3.10.1 There is a switch room in each subdivision of the BESS compound, i.e., one switch room in BB1 and one in BB2.

3.11 Vehicles

3.11.1 Within the BESS compound, in BB1 subdivision, there are eight car parking spots next to the site building.

3.12 Remote monitoring

3.12.1 Remote monitoring and control shall be provided via the SCADA system. Operators will have access to SCADA from within the control room, O&M compound or remotely via a dedicated (cyber secure) internet access.

3.12.2 It is understood that the site will initially operate staffed 24/7, however it is designed and intended to be operated remotely in the long term. When unoccupied, the expected response time for staff to site in an emergency is approximately 2 hours.

3.13 Fire Fighting Systems

3.13.1 Both subdivisions (BB1 & BB2) are to be provided with an AS 2419.1:2021, (Standards Australia, 2021), fire hydrant system design for open yard protection shown in Figure 10 & Figure 11. The location of the fire brigade booster, pumps and tanks are shown in Figure 11.

3.13.2 Additional requirements for the system are detailed in the recommendations section. Updated fire protection design details are provided in Appendix D. For any difference between these figures and those in the appendix, the appendix provides the most up to date and detailed arrangements.

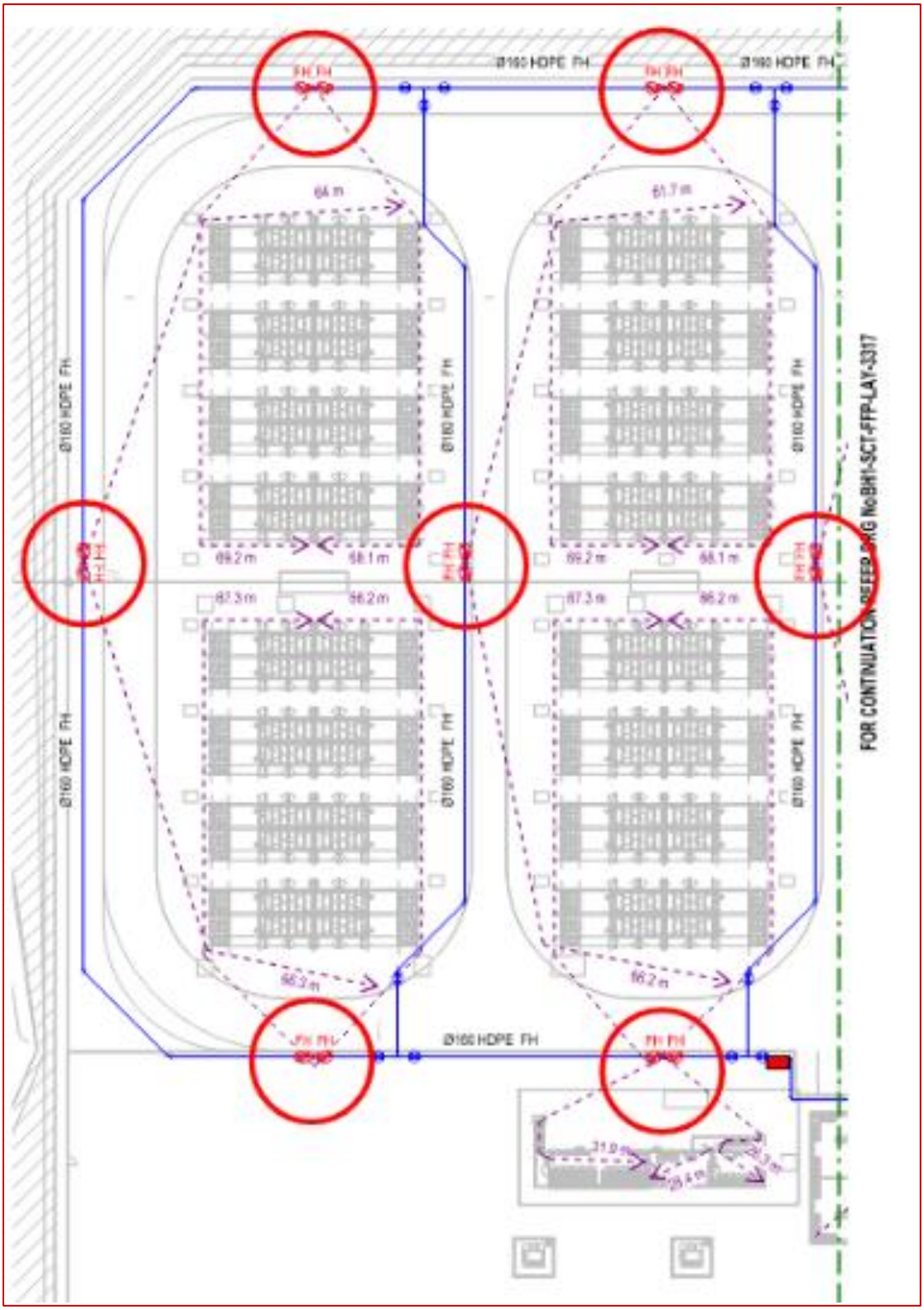


Figure 10: Fire Hydrant Layout BB1

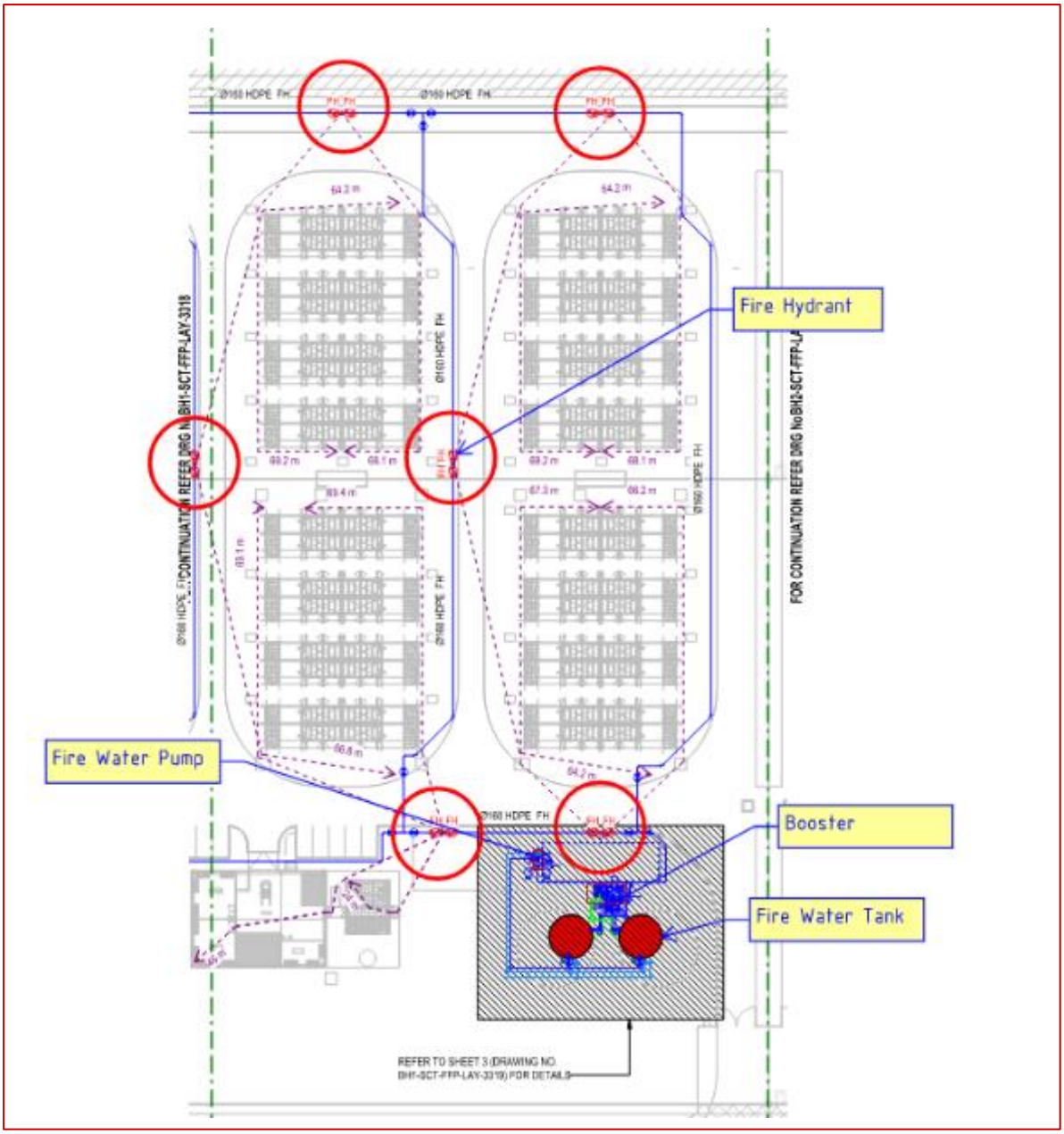


Figure 11: Fire Hydrant Layout BB2

4 Hazards Identified

4.1 Approach to Hazard Identification

4.1.1 The process of defining the hazard potential of a plant and/or its operations involves identifying hazards and estimating the potential consequences of credible incidents. In accordance with HIPAP 2 (NSW Planning, 2011), several additional factors must also be considered in selecting an appropriate system, including:

a) **Land use safety considerations:** the impact of incidents on the surrounding land uses, and the sensitivity of these land uses,
b) **Infrastructure availability:** such as water mains supply, area emergency planning, fire brigade response times and access,
c) **External factors:** effects from surrounding and land use (for example, other hazardous industries, bush fires, weather, etc), and
d) **Regulations:** requirements of statutory bodies.

4.1.2 These identified hazards are used to develop control measures for the associated credible worst case scenarios, as set out in HIPAP 2 (NSW Planning, 2011). The preventive and mitigative controls for these hazards are explained in detail in Chapters 7 & 9.

4.1.3 For the purposes of identifying the hazards at the site two key processes have been undertaken. Firstly, a review of a manifest of expected chemical stored at the site, and secondly a Hazard Log has been developed based on review of the site, experience on similar sites, and through collaboration with the project team to obtain a well-rounded view of the potential fire safety hazards at the site.

4.1.4 For this specific site, the quantities of dangerous goods stored are minimal, with most dangerous goods being part of the active process or equipment (e.g. integrated into the BESS or transformers). The only expected stored dangerous goods are spares and minor storage of substances in the O&M buildings. The exact quantities cannot be confirmed at this stage; therefore a list of goods and estimated quantities has been agreed and is detailed in Section 4.3.

4.1.5 The Hazard Log has been developed by systematically reviewing each area of the facility to identify equipment and materials that may present a fire hazard. It incorporates hazards associated with the storage of materials outlined in Section 4.3 as well as additional potential sources of ignition or escalation, including hazards arising from materials in use, operational activities, and external factors such as bushfire exposure.

4.1.6 A manifest of the chemicals expected to be stored on site has been provided and agreed with the client, and a corresponding hazard log has been developed in the form of a word diagram. The hazard log has been prepared following a detailed review of the manifest, the site layout, and the operational use of materials, ensuring all relevant fire and hazardous events are appropriately captured.

4.2 Materials Manifest

4.2.1 All dangerous goods (DGs) and hazardous materials associated with the site have been identified and documented in accordance with the NSW Work Health and Safety Regulation 2017 and relevant requirements under the Dangerous Goods (Road and Rail Transport) Regulation 2022 (NSW).

4.2.2 A Dangerous Goods Manifest and Hazardous Materials Register has been developed to record the type, classification, quantity, and storage location of all DGs stored or used on site. These records are to be maintained in the Operations and Maintenance (O&M) Building and made available to responding emergency services in accordance with FRNSW guidance.

4.2.3 Dangerous goods stored on site are primarily limited to materials located within the O&M Building, where a controlled storage area has been designated. Approximately 37 spare battery modules will be stored on site for maintenance and replacement purposes. A dedicated battery energy storage system (BESS) enclosure will be provided on site for the storage of spare battery modules only. The enclosure will not be electrically connected or operational but will function solely as a passive storage unit. The spare modules will be stored inside the enclosure, and the enclosure will be located external to the main buildings (location TBC). The system may be connected electrically for only monitoring and maintenance, not for use as part of BESS site operations.

4.2.4 The presence of coolant (typically ethylene glycol or a similar formulation) within each BESS unit has also been reviewed. While this coolant is recognised as a combustible liquid, it is contained within a sealed circuit and, under normal operating and maintenance conditions, does not pose a significant standalone fire or explosion hazard. This may come into effect in a large fire, refer to the large scale fire test.

4.3 Materials Manifest

4.3.1 Table 14 presents the materials manifest, identifying the proposed on-site stored materials that are classified as dangerous goods. At the issue of this report, the client has informed us that these are present, but this is subject to change.

Table 14: Materials Manifest

Material	DG Class	UN Number	Quantity	Storage Location	Storage Type	Comments
Lithium-ion Battery Modules (spares)	9 (Miscellaneous Dangerous Goods)	UN 3480	37 modules / 1 BESS unit	Location TBC	BESS Enclosure	A dedicated battery energy storage system (BESS) enclosure will be provided on site for the storage of spare battery modules only. The enclosure will not be electrically connected or operational but will function solely as a passive storage unit. The spare modules will be stored internally within the enclosure, which will be located externally to the main buildings (location TBC). The system must be connected electrically for monitoring, and if necessary, may be connected for maintenance charging, not for use as part of BESS site operations.
Lithium-ion Batteries (within operational BESS units)	9	UN 3481	Operational systems (refer to Table 13	BESS compound – containerised units	Sealed system modules	Considered in overall BESS fire risk assessment. Enclosed units with integrated detection.

Material	DG Class	UN Number	Quantity	Storage Location	Storage Type	Comments
Ethylene Glycol	C1 Combustible Liquid (non-DG under ADG Code)	N/A	320 L per unit (estimated)	Within BESS units (cooling circuit)	Closed loop system	Low volatility; contained in sealed system. Not a significant standalone fire hazard.
BESS refrigerant gas [R134A]	2.2 (Non-flammable, Non-toxic)	3159	16 kg	Within BESS units (cooling circuit)	Closed loop system	Does pose a health risk when exposed to personnel in sufficient quantity.
FR3 transformer oil	C2 Combustible Liquid (non-DG under ADG Code)	N/A	TBC as spares. Assumed <1,000 L	Within the MV Transformers	Closed loop system	Contained in sealed system. Not a significant standalone fire hazard.
Cleaning and Maintenance Chemicals (e.g. detergents, lubricants)	3 (Flammable Liquid) / 8 (Corrosive)	Various	<50 L combined	O&M Building – DG Cabinet	Bunded metal cabinet	Stored in accordance with AS 1940 and SDS requirements.
Diesel Fuel (for standby generator)	C1 Combustible Liquid (non-DG under ADG Code)	UN 1202	≤ 2,000 L	Generator area – double-walled tank	Above-ground tank with bund	Complies with AS 1940 and EPA bunding requirements.

4.4 Hazard identification

4.4.1 A general summary of the potential Loss of Control (LoC) events and associated hazards considered within this study is presented in Table 15. The hazards listed in this table are intentionally broad and generic, providing context and description of the typical types of LoC events relevant to hazardous industries and energy storage facilities.

4.4.2 The purpose of this table is to provide background information and facilitate understanding of the range of LoC events that may occur under abnormal or failure conditions. For simplicity and relevance to this project, LoC events that are not applicable to the site, such as boiling liquid expanding vapour explosion (BLEVE) or large-scale liquid spills, have been excluded from this summary. Following this general overview, a second table is provided which identifies the specific hazard locations, equipment, and relevant LoC scenarios applicable to this project site.

Table 15: Generalised Hazard Types

Hazard Type	General Description	Typical Causes
Small Fire (SF)	Small fire typically localised to the original fuel package. Generally, of no consequence to offsite areas, but pose an onsite hazard.	- AC / DC cable fire - Kitchen fires within the building. - Physical impact / damage, i.e., trespassers - Transformer or vehicle fire from a small leak
Large Fire (LF)	Large fire from a significant fuel source or spreading beyond the initiating source. Potential for offsite hazard from heat if fuel sources are close to the boundary.	- Small fire progressing to a large fire as a result of fire spread. - Vehicle fire spreading to adjacent infrastructure. - Gas pipeline fire. - Collection and Switching substations fires - Physical impact / damage, i.e., Vehicle impact - Lightning strike
Explosion (EX)	Blast initiated by any of several mechanisms such as vapour cloud explosion (VCE), boiling liquid expanding vapour explosion, pressurised vessels, deflagration/detonation of explosions.	- Release and ignition of gases reaching the Lower Explosive Limit (LEL) - Fire heating pressure vessels, typically where relief valves fail - Pressurised release of flammable liquids - Dust explosion due to static or other ignition sources

Hazard Type	General Description	Typical Causes
Small Leak (SL)	Small leak from a storage or process container such as an IBC in warehouses, oil reservoir from a transformer, pipeline, or vehicle fuel tank.	Transformer damage, vehicle collision, misuse/impact of equipment, poor maintenance
Large Leak (LL)	Significant failure of containment for materials	Physical impact, poor maintenance/upkeep of vessels, inadequate design, incompatibility between chemicals and storage vessels, overfilling of vessels, damage from explosion
Gas Release (GR)	Release of toxic gasses from a storage container, or as a result of another event such as toxic gasses produced from a chemical fire	Physical impact, poor maintenance/upkeep of vessels, inadequate design, incompatibility between chemicals and storage vessels, overfilling of vessels, fire, damage from explosion

4.4.3 A summary of the potential internal and external hazards relevant to the site is provided in Table 16. These hazards have been identified with reference to the nature and quantities of hazardous materials present, the characteristics of potential hazardous events (e.g. loss of containment, electrical fault, or thermal runaway), potential initiating mechanisms, ignition sources, and other contributing factors.

4.4.4 Rows in light blue represent hazards that were considered but determined not to be applicable to that specific hazard location or source. These are provided for completeness only.

Table 16: Hazard Identification

ID	Context	Location / Source	Type	Site Specific Potential Causes / Comments	Potential Results / Consequences	Potential Protective & Preventative Concepts
L1-SF	Localised BESS fire such as from a single or multiple cell thermal runaway	BESS (L1)	Small Fire (SF)	Localised puncture / impact, overheating (failure of cooling system), electrical stress (overcharging / discharging), isolated manufacturing defect	Damage to the affected module / unit. Unlikely to have any offsite consequences.	Impact protection devices Battery Management System (BMS). Regular maintenance UL 9540 testing to be confident this does not escalate significantly.
L1-LF	Major failure of multiple systems leading to burnout of a full BESS unit	BESS (L1)	Large Fire (LF)	Requires complete failure of the BMS and/or a significant event to overcome the cooling and protection measures in-built to the BESS unit	Loss of entire BESS container. Significant fire, and smoke produced. Potential for fire spread between BESS units over a long period and/or to nearby infrastructure. Significant thermal effects are likely. The potential for toxic gas emissions is considered separately under L1-GR	Equipment separation. Regular maintenance. Adequate design and commissioning of systems UL9540A testing, large scale testing to analysis to limit fire spread.
L1-GR	Major failure of multiple systems leading to venting of a full BESS unit. This could be thermal runaway with or without a fire. This scenario considers only the toxic effects.	BESS (L1)	Gas Release (GR)	A gas release can occur without fire, if a sufficient number of cells enter thermal runaway and vent simultaneously, or as part of a fire	Potential for a significant release of hydrogen fluoride (HF) or other gases which pose a significant toxic risk. Gases can spread easily and could pose an offsite risk and risk to onsite personnel	Testing regime, maintaining, safe operation, don't abuse batteries, BMS to avoid initiating events.
L1-EX	Significant failure leading to multiple cells venting to produce a vapour cloud explosion / release of battery electrolyte	BESS (L1)	Explosion (EX)	Multiple cell failures likely due to cascading thermal runaway & finding an ignition source	Loss of entire BESS, potential damage to adjacent equipment and personnel if present. Depending on severity of the blast there is potential for an offsite hazard.	Hydrogen and other off-gassing detection. Deflagration and / or hydrogen management systems. NFPA 855 / NFPA 69 compliant active ventilation. Regular inspections and maintenance of systems. Hazardous area compliance.

ID	Context	Location / Source	Type	Site Specific Potential Causes / Comments	Potential Results / Consequences	Potential Protective & Preventative Concepts
L2-SF	Localised cable fire within BESS enclosure or within a cable tray in switch room.	Cables (L2)	Small Fire (SF)	Localised heating of cables may lead to smouldering and thermal degradation of the cable insulation, potentially resulting in a small fire. The presence of cable trays may provide additional fuel, allowing limited fire propagation within the bundle.	Cable fire due to arc flash with the potential to impact BESS, transformers or other infrastructure. Small fire but has the potential to spread if undetected.	Equipment separation. Regular maintenance. Correct / appropriate insulation material used.
L2-LF	Cable fire - large	Cables (L2)	Large Fire (LF)	A cable fire does not involve sufficient combustible material to justify consideration of a large-scale fire scenario.	N/A	N/A
L2-EX	Cable fire - explosion	Cables (L2)	Explosion (EX)	A cable fire is not expected to generate sufficient gaseous emissions to result in an explosive atmosphere.	N/A	N/A
L2-GR	Cable fire - gas release	Cables (L2)	Gas Release (GR)	A cable fire is not expected to generate a significant toxic gas dispersion due to the limited scale of the fire event.	N/A	N/A
L3-SF	MV transformer small fire - Localised small fire from small source or spillage.	MV Transformer (L3)	Small Fire (SF)	Degradation of equipment over time, or mechanical damage, resulting in an ignition within the equipment. For ignition to occur, an external event must occur e.g. arc flash.	Damage to the affected module / unit. Potential for radiant heat between equipment. Potential for fire spread over a long period.	Equipment separation. Regular maintenance. Fault isolation. Ventilation and dispersion Hazardous area compliance.
L3-LF	MV transformer large fire - major fire assuming full contents of transformer released	MV Transformer (L3)	Large Fire (LF)	Degradation of equipment over time, or mechanical damage, resulting in an ignition within the equipment. For ignition to occur, an external event must occur e.g. arc flash.	Damage to the affected module / unit. Potential for fire spread between equipment due to size of fire.	Equipment separation. Regular maintenance. Fault isolation. Ventilation and dispersion Hazardous area compliance.
L3-EX	MV Transformer explosion - potential VCE from transformer oil being heated and released in a mist.	MV Transformer (L3)	Explosion (EX)	In general, FR3 type transformers are less likely to cause an explosion than typical oil filled transformers but can do under certain conditions.	Potential for a significant damage to equipment, adjoining assets and people. Potential for offsite consequences	Equipment separation. Regular maintenance. Fault isolation. Ventilation and dispersion.

ID	Context	Location / Source	Type	Site Specific Potential Causes / Comments	Potential Results / Consequences	Potential Protective & Preventative Concepts
				These can be caused by either short circuits or overheating due to internal faults.		Hazardous area compliance.
L3-GR	MV Transformer - gas release	MV Transformer (L3)	Gas Release (GR)	It is not considered plausible that the oil used within the transformer could support a toxic dispersion	N/A	N/A
L4-SF	PCSM - Localised small fire.	PCSM (L4)	Small Fire (SF)	Degradation of equipment over time, or mechanical damage, resulting in an ignition within the equipment. For ignition to occur, an external event must occur e.g. arc flash.	Damage to the affected module / unit. Potential for radiant heat between equipment. Potential for fire spread over a long period.	Equipment separation. Regular maintenance. Fault isolation. Ventilation and dispersion. Hazardous area compliance.
L4-LF	PCSM - major fire	PCSM (L4)	Large Fire (LF)	Degradation of equipment over time, or mechanical damage, resulting in an ignition within the equipment. For ignition to occur, an external event must occur e.g. arc flash.	Damage to the affected module / unit. Potential for fire spread between equipment due to size of fire.	Equipment separation. Regular maintenance. Fault isolation. Ventilation and dispersion. Hazardous area compliance.
L4-EX	PCSM - explosion	PCSM (L4)	Explosion (EX)	In general, dry type transformers are less likely to cause an explosion than oil filled transformers but can do under certain conditions. These can be caused by either short circuits or overheating. This is mainly a maintenance issue; there will not be modelled. These 'explosions' are also due to a pressure build up rather than a combustion reaction.	Potential for a significant damage to equipment, adjoining assets and people. Potential for offsite consequences	Equipment separation. Regular maintenance. Fault isolation. Ventilation and dispersion. Hazardous area compliance.
L4-GR	PCSM - gas release	PCSM (L4)	Gas Release (GR)	It is not considered plausible that a dry type of transformer could support a toxic dispersion	N/A	N/A
L5-SF	Diesel generator small fire - Localised small fire from small source or spillage.	Diesel Generators (L5)	Small Fire (SF)	Degradation of gaskets or similar components over time, or mechanical damage, which results in the partial release of	Damage to the affected module / unit. Potential for radiant heat between	Double bunding of transformer oil tanks. Equipment separation. Regular maintenance.

ID	Context	Location / Source	Type	Site Specific Potential Causes / Comments	Potential Results / Consequences	Potential Protective & Preventative Concepts
				diesel. For ignition to occur, released oil must come into contact with an appropriate ignition source.	equipment. Potential for fire spread over a long period.	Impact protection around equipment.
L5-LF	Diesel generator large fire - major fire assuming full contents of diesel tank released	Diesel Generators (L5)	Large Fire (LF)	Mechanical impact of tank or corrosion. For ignition to occur, released oil must come into contact with an appropriate ignition source.	Damage to the affected module / unit. Potential for fire spread between equipment due to size of fire.	Bunding around tanks. Equipment separation. Regular maintenance. Impact protection around equipment.
L5-EX	Diesel generator - explosion	Diesel Generators (L5)	Explosion (EX)	A diesel generator failure is not expected to generate sufficient gaseous emissions to result in an explosive atmosphere.	N/A	N/A
L5-GR	Diesel generator - toxic	Diesel Generators (L5)	Gas Release (GR)	A diesel generator failure is not expected to generate sufficient gaseous emissions to result in a significant toxic atmosphere.	N/A	N/A
L6-SF	AUX transformer small fire - Localised small fire from small source or spillage.	Aux Transformer (L6)	Small Fire (SF)	Degradation of equipment over time, or mechanical damage, resulting in an ignition within the equipment. For ignition to occur, an external event must occur e.g. arc flash.	Damage to the affected module / unit. Potential for radiant heat between equipment. Potential for fire spread over a long period.	Equipment separation. Regular maintenance. Fault isolation. Ventilation and dispersion. Hazardous area compliance.
L6-LF	AUX transformer large fire - major fire assuming full contents of transformer released	Aux Transformer (L6)	Large Fire (LF)	Degradation of equipment over time, or mechanical damage, resulting in an ignition within the equipment. For ignition to occur, an external event must occur e.g. arc flash.	Damage to the affected module / unit. Potential for fire spread between equipment due to size of fire.	Equipment separation. Regular maintenance. Fault isolation. Ventilation and dispersion. Hazardous area compliance.
L6-EX	AUX Transformer explosion - potential VCE from transformer oil being heated and released in a mist.	Aux Transformer (L6)	Explosion (EX)	In general, transformer explosions are rare but possible and could be due to VCE or BLEVE mechanisms. These can be caused by either short circuits or overheating. This is mainly a maintenance issue, these will not be	Potential for a significant damage to equipment, adjoining assets and people. Potential for offsite consequences	Equipment separation. Regular maintenance. Fault isolation. Ventilation and dispersion. Hazardous area compliance.

ID	Context	Location / Source	Type	Site Specific Potential Causes / Comments	Potential Results / Consequences	Potential Protective & Preventative Concepts
				modelled, instead referring to appropriate design standards.		
L6-GR	AUX Transformer - gas release	Aux Transformer (L6)	Gas Release (GR)	It is not considered plausible that the oil used within the transformer could support a toxic dispersion	N/A	N/A
L7-SF	O&M small fire - localised small fire due to storage of combustibles.	O&M Building (L7)	Small Fire (SF)	Small fire due to stored combustibles within the building which can be contained.	Fire likely contained within the same room. Possibility for smoke damage and some equipment damage.	Detection. Fire extinguishers. Suppression systems. Good housekeeping.
L7-LF	O&M large fire - major fire assuming fire spread within the building.	O&M Building (L7)	Large Fire (LF)	Small fire escalating to a large fire due to no detection resulting in fire spread.	Combustible materials can contribute to rapid fire growth and increased heat release rates potentially endangering any staff present or any neighbouring buildings / equipment or Members of the Public (MOP).	Detection. Fire extinguishers. Suppression systems. Good housekeeping.
L8-SF	Switch room small fire - localised small fire due to storage of combustibles.	Switch room (L8)	Small Fire (SF)	Failure of an auxiliary component within the building leading to fire spread / escalation within the building.	Fire likely contained within the same room. Possibility for smoke damage and some equipment damage.	Detection. Fire extinguishers. Suppression systems. Maintenance of electrical systems.
L8-LF	Switch room large fire - major fire assuming fire spread within the building.	Switch room (L8)	Large Fire (LF)	Failure of multiple auxiliary components within the building leading to fire spread / escalation within the building.	Fire likely to spread throughout the building	Detection. Fire extinguishers. Suppression systems. Maintenance of electrical systems.
L9-SF	Vehicle fire - localised fire which may impact the car.	Vehicles (L9)	Small Fire (SF)	Small leak source from the vehicle finding an ignition source. Site vehicle may be involved in the fire (may also occur adjacent resulting in minor damage to car)	Site vehicle unsuitable for use.	Regular maintenance. Speed restrictions on site. Drug and alcohol policy Impact protection.
L9-LF	Vehicle large fire - complete loss of fuel from car resulting in	Vehicles (L9)	Large Fire (LF)	Complete loss of fuel from the car finding an ignition source. Assume that the car would be engulfed in flames.	Site vehicle unsuitable for use. Has the potential to spread to adjacent equipment.	Regular maintenance. Speed restrictions on site. Drug and alcohol policy. Impact protection.

ID	Context	Location / Source	Type	Site Specific Potential Causes / Comments	Potential Results / Consequences	Potential Protective & Preventative Concepts
L9-EX	Vehicle - explosion	Vehicles (L9)	Explosion (EX)	It is not considered plausible that a petrol / diesel used within vehicles could result in an explosion. Any blast from an EV would be smaller than a BESS blast and not a credible scenario.	N/A	N/A
L9-GR	Vehicle - toxic release	Vehicles (L9)	Gas Release (GR)	Neither diesel nor petrol are relevant chemicals in relation to toxic dispersion hazards. EVs may release some gas from cells but any such hazard would be outweighed by the BESS assessment.	N/A	N/A
L10-LF	Transgrid transformer large fire - major fire assuming full contents of transformer released	Transgrid Substation (L10)	Large Fire (LF)	This would be a catastrophic event assuming the full contents of the transformer released e.g. significant impact strike, lightning strike, arc flash, or malicious damage/ destruction	Potential for a significant damage to equipment, adjoining assets and people. Potential for offsite consequences due to loss of grid infrastructure.	This is a third party entity which prevents measures from being directly prescribed. Nonetheless effective and regular maintenance, sufficient security measures and monitoring should be considered by the operator.

4.4.5 Rows indicated in light blue in the preceding table are LoC events that were initially considered but have been deemed not applicable, typically because the type of hazardous event is not applicable to that hazard source/location. Therefore, rows in light blue are not considered any further.

5 Analysis of Consequences of Incidents

5.1 General

5.1.1 This section progresses the hazards identified in the preceding chapter into a consequence analysis to assess the potential impacts of fire-related incidents at the site, including fire, explosion, and toxic release scenarios. Consequences are evaluated either qualitatively within this section or incorporated directly into the updated risk assessment presented in Section 8. Consistent with the requirements of HIPAP 2, this section addresses the intent of analysing the potential consequences of fire safety incidents relevant to the facility.

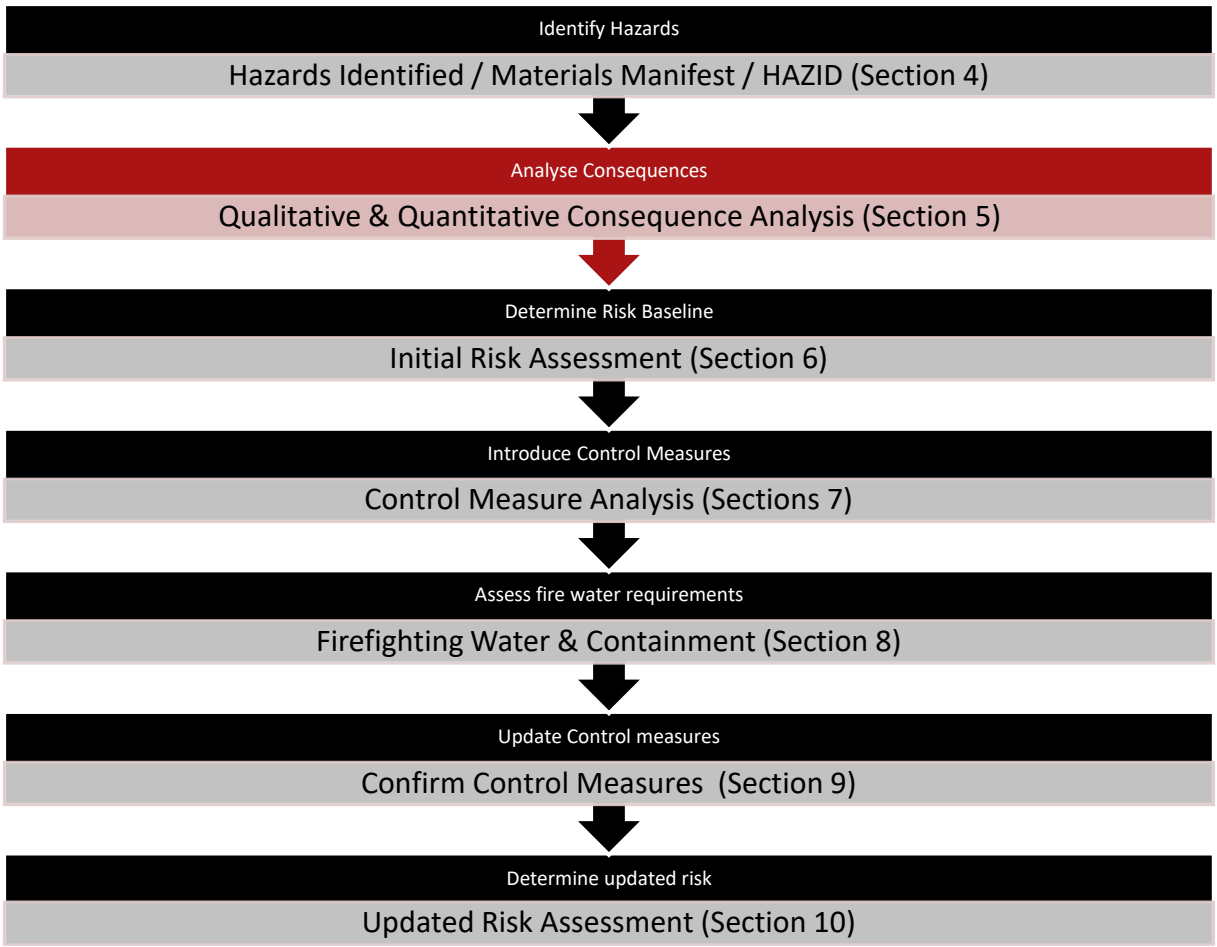


Figure 12: Section 5 - Fire Risk Assessment

The methodology links the risks identified in Section 3.13.1 to the specific activities and hazards present within each area of the site. Each hazard location and associated loss-of-containment (LoC) event is assessed independently, taking into account the localised hazards and applicable risk-management measures. This section also addresses areas not included in the location-specific assessments, such as office and administration spaces, and considers potential interactions between different parts of the site, including site-wide security measures. The final sub-section outlines the control measures adopted within this FSS.

5.1.2 Building on the HAZID word diagram, Table 17 resents the hazards identified across the site together with a summary of the corresponding consequence analyses undertaken. Rows indicated as N/A were screened out at the HAZID stage and are only repeated here for consistency. Modelling techniques referenced in the table are described in further detail following the table.

Table 17: Consequence Analysis approach overview

ID	Context	Location / Source	Type	Potential Results / Consequences	Applicable Consequence Analysis
L1-SF	Localised BESS fire such as from a single or multiple cell thermal runaway	BESS (L1)	Small Fire (SF)	Damage to the affected module / unit. Unlikely to have any offsite consequences.	No further consequence analysis is required, on the basis that the cells have been tested to UL9540A, and the results demonstrated that a single cell in thermal runaway should not cascade to adjacent cells. The test report shall be provided as an Appendix in the final FSS.
L1-LF	Major failure of multiple systems leading to burnout of a full BESS unit	BESS (L1)	Large Fire (LF)	Loss of entire BESS container. Significant fire, and smoke produced. Potential for fire spread between BESS units over a long period and/or to nearby infrastructure. Significant thermal effects are likely. The potential for toxic gas emissions is considered separately under L1-GR	Hithium have provided a LSFT report which is used to determine the risk of fire spread between BESS units.
L1-GR	Major failure of multiple systems leading to venting of a full BESS unit. This could be thermal runaway with or without a fire. This scenario considers only the toxic effects.	BESS (L1)	Gas Release (GR)	Potential for a significant release of Hydrogen Fluoride (HF) which poses a significant toxic risk. HF spreads easily and could pose an offsite risk and risk to onsite personnel	HF is a toxic and lighter than air gas which may spread significantly beyond the site boundary. The AEGL-3 (1800) for HF will be modelled in EFFECTs [no wind / avg / 95th%].
L1-EX	Significant failure leading to multiple cells venting to produce a vapour cloud explosion	BESS (L1)	Explosion (EX)	Loss of entire BESS, potential damage to adjacent equipment and personnel if present. Depending on severity of the blast there is potential for an offsite hazard.	EFFECTS modelling Hydrogen build up inside the container and subsequent vapour cloud explosion. We will assume the volume of 1 BESS container has reached LEL with hydrogen gas. Overpressure contours at 7/21/35/70 kPa determined measured.
L2-SF	Localised cable fire within BESS enclosure or within a cable tray in switch room.	Cables (L2)	Small Fire (SF)	Cable fire due to arc flash with the potential to impact BESS, transformers or other infrastructure. Small fire but has the potential to spread if undetected.	For cable fires, we will apply NRC spreadsheets (7) to estimate the HRR. We shall assume the cable is polyethylene, 1m in length and 0.2m in width.
L3-SF	MV transformer small fire - Localised small fire from small source or spillage.	MV Transformer (L3)	Small Fire (SF)	Damage to the affected module / unit. Potential for radiant heat between equipment. Potential for fire spread over a long period.	We will perform a radiation calculation for an ester based oil release (200 L) to determine if this results in the potential for fire spread within the context of the surrounding equipment.
L3-LF	MV transformer large fire - major fire assuming full contents of transformer released	MV Transformer (L3)	Large Fire (LF)	Damage to the affected module / unit. Potential for fire spread between equipment due to size of fire.	We will perform a GEXCON radiation calculation for a complete release of oil from the MV transformer (1,556 L) into the bund. to determine if this results in the potential of fire spread within the context of the surrounding equipment.
L3-EX	MV Transformer explosion - potential VCE from transformer oil being heated and released in a mist.	MV Transformer (L3)	Explosion (EX)	Potential for a significant damage to equipment, adjoining assets and people. Potential for offsite consequences	EFFECTS modelling vaporisation of the ester oil within the MV kiosk area and subsequent vapour cloud explosion.
L4-SF	PCSM - Localised small fire from small source or spillage.	PCSM (L4)	Small Fire (SF)	Damage to the affected module / unit. Potential for radiant heat between equipment. Potential for fire spread over a long period.	Heat release rate parameters for dry type transformers (NUREG 2020), show that for >750kVA transformers, the 98th percentile HRR is 130kW. We will perform a fire model to show if there is any potential for fire spread within the context of the surrounding equipment.
L4-LF	PCSM - major fire assuming full contents of transformer released	PCSM (L4)	Large Fire (LF)	Damage to the affected module / unit. Potential for fire spread between equipment due to size of fire.	For a dry type transformer to be fully engulfed, it would only be a contribution of a fire and not be the only source of a fire. This has not been included in the consequence modelling. As above, the peak fire size for such a transformer is expected to be on the order of 130 kW, which is comparable to a domestic rubbish bin on fire.

ID	Context	Location / Source	Type	Potential Results / Consequences	Applicable Consequence Analysis
L4-EX	PCSM - explosion	PCSM (L4)	Explosion (EX)	Potential for a significant damage to equipment, adjoining assets and people. Potential for offsite consequences	An explosion event is not considered a likely credible event within the context of this project.
L5-SF	Diesel generator small fire - Localised small fire from small source or spillage.	Diesel Generators (L5)	Small Fire (SF)	Damage to the affected module / unit. Potential for radiant heat between equipment. Potential for fire spread over a long period.	As the diesel generator will be bunded, only the large fire scenario will be considered. That scenario is more onerous.
L5-LF	Diesel generator large fire - major fire assuming full contents of transformer released	Diesel Generators (L5)	Large Fire (LF)	Damage to the affected module / unit. Potential for fire spread between equipment due to size of fire.	The diesel generator is assumed to be no larger than 1,500L. A pool fire of 10 m² will be modelled in GEXCON based on the drawings. The material to be modelled will be diesel.
L6-SF	AUX transformer small fire - Localised small fire from small source or spillage.	Aux Transformer (L6)	Small Fire (SF)	Damage to the affected module / unit. Potential for radiant heat between equipment. Potential for fire spread over a long period.	Not modelled on the basis that the large fire below captures a more onerous consequence.
L6-LF	AUX transformer large fire - major fire assuming full contents of transformer released	Aux Transformer (L6)	Large Fire (LF)	Damage to the affected module / unit. Potential for fire spread between equipment due to size of fire.	EFFECTS model considering full release of the oil into the bund and ignition.
L6-EX	AUX Transformer explosion - potential VCE from transformer oil being heated and released in a mist.	Aux Transformer (L6)	Explosion (EX)	Potential for a significant damage to equipment, adjoining assets and people. Potential for offsite consequences	An explosion event is not modelled on the basis of the design being required to comply with AS 2067 which includes offsets for explosion protection distances to buildings.
L7-SF	O&M small fire - localised small fire due to storage of combustibles.	O&M Building (L7)	Small Fire (SF)	Fire likely contained within the same room. Possibility for smoke damage and some equipment damage.	A FiRE model of the building will be undertaken to measure the radiation to the surrounding infrastructure.
L7-LF	O&M large fire - major fire assuming fire spread within the building.	O&M Building (L7)	Large Fire (LF)	Combustible materials can contribute to rapid fire growth and increased heat release rates potentially endangering any staff present or neighbouring buildings / equipment.	A FiRE model of the building will be undertaken to measure the radiation to the surrounding infrastructure.
L8-SF	Switch room small fire - localised small fire due to storage of combustibles.	Switch room (L8)	Small Fire (SF)	Fire likely contained within the same room. Possibility for smoke damage and some equipment damage.	A FiRE model of the building will be undertaken to measure the radiation to the surrounding infrastructure.
L8-LF	Switch room large fire - major fire assuming fire spread within the building.	Switch room (L8)	Large Fire (LF)	Fire likely to spread throughout the building	A FiRE model of the building will be undertaken to measure the radiation to the surrounding infrastructure.
L9-SF	Vehicle fire - localised fire which may impact the car.	Vehicles (L9)	Small Fire (SF)	Site vehicle unsuitable for use.	A release this small is not expected to have significant impact, therefore only the large fire scenario will be considered.
L9-LF	Vehicle large fire - complete loss of fuel from car resulting in	Vehicles (L9)	Large Fire (LF)	Site vehicle unsuitable for use. Has the potential to spread to adjacent equipment.	A diesel release will be modelled within GEXCON. As a diesel pool fire.
L10-LF	Transgrid substation large fire	Transgrid Substation (L10)	Large Fire (LF)	Potential for a significant damage to equipment, adjoining assets and people.	A complete loss of the Substation oil as a contained pool fire. Radiation modelling will be conducted to assess the impact upon

ID	Context	Location / Source	Type	Potential Results / Consequences	Applicable Consequence Analysis
				Potential for offsite consequences due to loss of grid infrastructure.	the BESS areas. A GEXCON EFFECT pool fire of 75kL will be modelling in a bunded area of 14.5m x 22.5m. Refer to Appendix G for calculations.

5.2 Quantitative Assessment Methods

5.2.1 This section sets out a summary of the tools used for consequence analysis in the following subsections, their general inputs, limitations, and assumptions. Hazard specific inputs are within the relevant subsections, and further information on software tools are in the referenced appendix.

5.2.2 The following modelling software and calculation techniques have been used as part of this study:

a) GEXCON EFFECTS
b) FiRE
c) The Nuclear Regulatory Commission (NRC) Fire Dynamics Tools

5.2.3 The majority of the consequence modelling has been undertaken using GEXCON EFFECTS, which applies methodologies from the TNO [1] "Yellow, Green, and Purple Books" to provide validated frameworks for fire, explosion, and toxic dispersion analysis. The following key assumptions have been applied to the consequence modelling:

a) Source term characteristics (release rate, duration, inventory, phase, temperature, and pressure) must be defined by the user and significantly influence results.
b) Terrain is simplified and generally treated as flat or homogeneous, with complex topographical features not explicitly represented.
c) Meteorological inputs (wind speed, atmospheric stability class, ambient temperature, humidity) are assumed to be steady-state throughout the simulation.
d) A true zero-wind condition cannot be modelled; dispersion requires a minimum non-zero wind speed (typically ~0.2 m/s) to maintain atmospheric turbulence and numerical stability within the software.
e) Gas dispersion assumes ideal mixing behaviour and may not capture complex reactions, degradation, or particulate formation unless supported by the model.
f) Pool formation and evaporation rates rely on flat surface conditions and do not reflect irregular containment or drainage.
g) Obstructions and barriers are not fully modelled within the models
h) Explosion modelling uses representative multi-energy assumptions and simplifies real-world confinement conditions.
i) Secondary hazards (projectiles, shrapnel, overpressure from enclosure rupture) are not inherently captured.
j) Toxic dose calculations depend on the selected probit or concentration–time relationship and assume uniform exposure conditions.

5.2.4 GEXCON EFFECTS includes the model "Li-ion battery storage thermal runaway" to estimate the release of toxic substances during a BESS thermal runaway. This

1 https://www.gexcon.com/ebooks/

empirical model relies on data from combustion experiments compiled by (Peter J. Bugryniec 2024).

a) Thermal-runaway is treated as a gas release, not a chemically reactive or evolving multiphase system.
b) A BESS enclosure fire cannot be modelled within the software, thermal radiation and fireball outputs are based on general combustion models, not battery-specific flame behaviour.
c) HF is modelled as a pure toxic gas, with dispersion governed by standard atmospheric dispersion algorithms (e.g., dry plume, dense gas), without secondary reaction products.
d) Battery module geometry is simplified, with the release represented as an orifice, vent, or area source, not a detailed cell-level failure mechanism.
e) Constant release conditions are typically assumed, even though real thermal runaway may vary significantly over time.
f) No internal propagation modelling is included; EFFECTS does not simulate cascading cell failures or escalating heat output.

5.2.5 FiRE is a Quantified Fire Risk Assessment tool used to simulate fire behaviour and evaluate its potential impacts on building occupants and structural elements. The software applies two-dimensional finite element analysis (FEA) with dynamic mesh generation to model complex heat-transfer processes with improved accuracy. FiRE provides advanced thermal-radiation assessment functionality, allowing direct interaction with building elevations and 3D panel selection to facilitate dose-based egress and tenability calculations.

5.2.6 The Nuclear Regulatory Commission (NRC) Fire Dynamics Tools (FDTs) are a set of Excel-based calculation methods for first principles fire hazard assessment. The tools use established fire-dynamics correlations from sources such as the SFPE Handbook and NFPA to estimate parameters including heat release rates, smoke layer formation, hot gas temperatures, and cable tray fire behaviour. Although developed for nuclear facilities, the methodology can be used for a high level screening analysis

5.2.7 The assumptions with these NRC sheets are:

a) Calculations rely on empirical fire-dynamics correlations, providing simplified representations rather than detailed modelling.
b) Analysis generally assumes steady or quasi-steady fire behaviour, without capturing rapid transients or suppression effects.
c) Heat-release rates are user-defined and conservatively selected.
d) Smoke and temperature predictions assume uniform mixing within the hot-gas layer.

5.3 Acceptance Criteria & Damage Thresholds

5.3.1 Two types of quantitative analysis are carried out, these are toxic dispersion assessing exposure to hydrogen fluoride (HF) gas, and blast analysis which

assesses the extent of the explosive pressure wave, or overpressure. This section sets out the type of criteria relevant to each.

5.3.2 HF exposure in EFFECTS is to be reported as different sets of contours, each with their own meaning and use for analysis. These contours are summarised in Table 18. All HF contours have been applied assuming occupants are outdoors. Indoor exposures are generally less, but these can be complicated to calculate and therefore in the initial assessment all contours are based on people being outdoors.

Table 18 Summary of Toxic Exposure Contours

Toxicity Contour	Meaning / Intent
1% Lethality Dose	In this area, the dose of a toxic substance is to cause death in 1% of the population who are exposed to the toxic substance. The dose is determined both on concentration and duration of exposure.
1% Lethality Concentration	In this area, the concentration of a toxic substance is lethal to 1% of the population when being exposed for the full exposure duration.
AEGL-3	AEGL-3 concentrations represent a level at which harmful health effects are expected and people exposed are likely to need to seek medical assistance. This is to be reported for three different durations of exposure, being 600 s, 1800 s, and 3600 s.

5.3.3 For blast modelling, the results are also to be reported in 1% various sets of contours, each with their own meaning and use for analysis, these are as described in Table 19, which is partly replicated from HIPAP 6.

Table 19 Summary of Overpressure Contours

Overpressure Contour	Meaning / Intent
7 kPa	Probability of injury of 10%, no fatality. This may cause repairable damage to internal partitions and joinery.
21 kPa	Reinforced structures distorted, failure of storage tanks. 20% chance of fatality to a person in a building. Often cause by debris, hence a significantly lower chance for occupants outdoors.
35 kPa	Houses damaged beyond repair, wagons and plant items overturned. This is the threshold for eardrum damage. 50% chance of fatality for a person in a building and 15% chance for a person in the open.
70 kPa	Threshold of lung damage. 100% chance of fatality for a person in a building or in the open. Complete demolition of houses.

5.3.4 For modelling focused on radiative heat fluxes, the key values for assessment are shown in Table 20.

Table 20 Heat Flux Criteria

Heat Flux Contour	Meaning/Intent
35 kW/m²	Equipment failure, cellulosic material will ignite (piloted) within one minute exposure, significant change of instant fatality for people
20 kW/m²	Inferred NCC acceptance criteria for fire spread between buildings based on Table C1V2 of NCC 2022 Volume One
12.5 to 13 kW/m²	Piloted ignition of timber or fabric after long exposure. Significant chance of fatality for extended exposure and high chance of injury. Thin insulation backed steel may achieve thermal stress failure. Damage may occur requiring replacement of porcelain bushings/insulators
3 kW/m²	Hazardous conditions for firefighter operations (10 minutes operations)
1 to 1.2 kW/m²	Received from sun in summer at noon

5.3.5 Further information on the software uses, assumptions, and limitations can be found in **Error! Reference source not found.** to this report.

5.4 BESS (L1) – LF, GR, & EX

5.4.1 Based on the initial screening, the hazards for the BESS requiring further analysis from the HAZID table include a large fire (loss of entire BESS container), gas release (HF), and explosion scenarios (L1-LF, GR, and EX). A small fire was not considered for consequence analysis on the basis that the cells have been tested to UL9540A, and the results demonstrated that a single cell in thermal runaway should not cascade to adjacent cells.

5.4.2 A general overview of the safety and hazards of lithium-ion batteries can be found in several resources, with detailed background on the chemistry and failure mechanisms not repeated here. Such sources are readily available and include:

a) Management of lithium-ion battery safety risks: a literature review of current knowledge and best practices published by FRNSW under their SARET research programme in August 2025.
b) Lithium-ion battery safety – A report for the Australian Competition and Consumer Commission published by CSIRO in May 2023.

c) Hazard Assessment of Lithium Ion Battery Energy Storage Systems (Final Report) published by the Fire Protection Research Foundation in February 2016.
d) Lithium-Ion Batteries Hazard and Use Assessment (Final Report) published by the Fire Protection Research Foundation in 2013.

5.4.3 The BESS units for the site are Hithium Block as described briefly in Section 3.3 and detailed further in Appendix B this report.

5.4.4 These units have been subjected to several tests, are required to comply with several design standards, and contain several in-built safety systems which mitigate the risk of failure. Such measures are described in Appendix B and the control measures section of this report (Section 7). The consequence analysis conducted is based off the results obtained in the UL9540A fire test report.

L1-GR: Gas Release

5.4.5 *As of Version 3 of this FSS, additional hydrogen fluoride modelling and discussion can be found in H.2. Such work does not change the risk outcomes indicated in this section.*

5.4.6 Whilst lithium ion batteries (LIBs) produce many gases when undergoing thermal runaway or combustion, the primary gas of concern for this consequence analysis is hydrogen fluoride (HF) which is a highly toxic, corrosive, and lighter than air gas which is well studied and spreads easily. HF is produced in both fire and thermal runaway however all scenarios consider a thermal runaway-only event. This is a conservative approach as given HF is already lighter than air, a fire would result in even lighter more buoyant HF gases which would more rapidly disperse resulting in dilution, and any concentrations of HF being at higher elevations, above occupied areas.

5.4.7 The determination of how much HF is provided from a cell is complex, as HF is the result of multiple chemical reactions dependent on water, and can be difficult to test for due to its high reactivity/corrosiveness. For the purposes of modelling in EFFECTS, the HF must be input in a quantity of mg/kWh of storage, and the energy per cell must also be input.

5.4.8 For this project, the amount of HF generated has been determined from the UL 9540A module fire test data.

5.4.9 Based on EFFECTS default values, considering a Low input, as shown in Figure 13. This figure is from the GEXCON Technical Background document title Li-ion Battery Storage Thermal Runaway. This reference describes how GEXCON has established these values based on several research papers which assess the amount of HF produced from cells.

Chemical = HF	NMC				LFP			
	Low (average)	Moderate (68% percentile)	High (95% percentile)	Very high (99% percentile)	Low (average)	Moderate (68% percentile)	High (95% percentile)	Very high (99% percentile)
α (mg/Wh)	7.10	17.22	36.19	41.50	52.47	167.89	223.34	284.82

Figure 13: Extract from GEXCON Technical Background information

5.4.10 Based on the results of the UL 9540A module fire testing, a total HF yield of approximately 0.872 L of HF was produced from 2 cells going into thermal runaway. Whilst this gas was heated, it has been converted to mg based on ambient conditions (a conservative approach), and by applying the energy capacity of a cell, the result is that a value of 0.5 mg/Wh for this specific cell. Comparing this to the GEXCON Low (average) default of 52.47mg/Wh, the model will use this value for dispersion modelling which is 100 times larger than the tested values.

5.4.11 This release rate has been used as the source term for atmospheric dispersion modelling to determine potential off-site concentrations and associated hazard distances under representative meteorological conditions.

5.4.12 The scenarios wind speeds are based on data from (WillyWeather, 2025) with consideration of no wind, average wind, and 95th percentile wind conditions. A summary of extreme conditions is provided in Appendix F to this report.

5.4.13 The contours show the extent of area expected to be exposed to AEGL-3 [2] concentrations based on duration of exposure at intervals of 600s (10 min), 1800s (30 min), and 3600s (60 min).

5.4.14 As per Table 21, two scenarios have been considered. Firstly, the failure of a single rack over the course of an hour, and secondly the failure of the entire BESS unit over 6 hours, which aligns with the LSFT. Wind is considered for each, however the 95th percentile was not replicated for the full BESS failure as the earlier results demonstrated that wind leads to more favourable outcomes as it assists with the passion of HF.

Table 21 Table of Scenarios

Scenario	Number of Racks/Cells	Duration	Wind
Gas Release – 1 Rack	1 Rack containing 832 cells	1 hour	No wind Average wind 95th percentile wind
Gas Release – Full BESS	6 Racks containing 4,992 cells	6 hours	No wind Average wind

[2] AEGL-3 represents the airborne concentration of a substance above which the general population, including potentially vulnerable individuals, could experience life-threatening health effects or death.

Atmospheric dispersion – 1 rack over 1 hour

5.4.15 For the no wind case 1-rack case, the AEGL-3 (3600) dispersion is approximately 115 m from Puggoon Rd. This is shown in Figure 14.

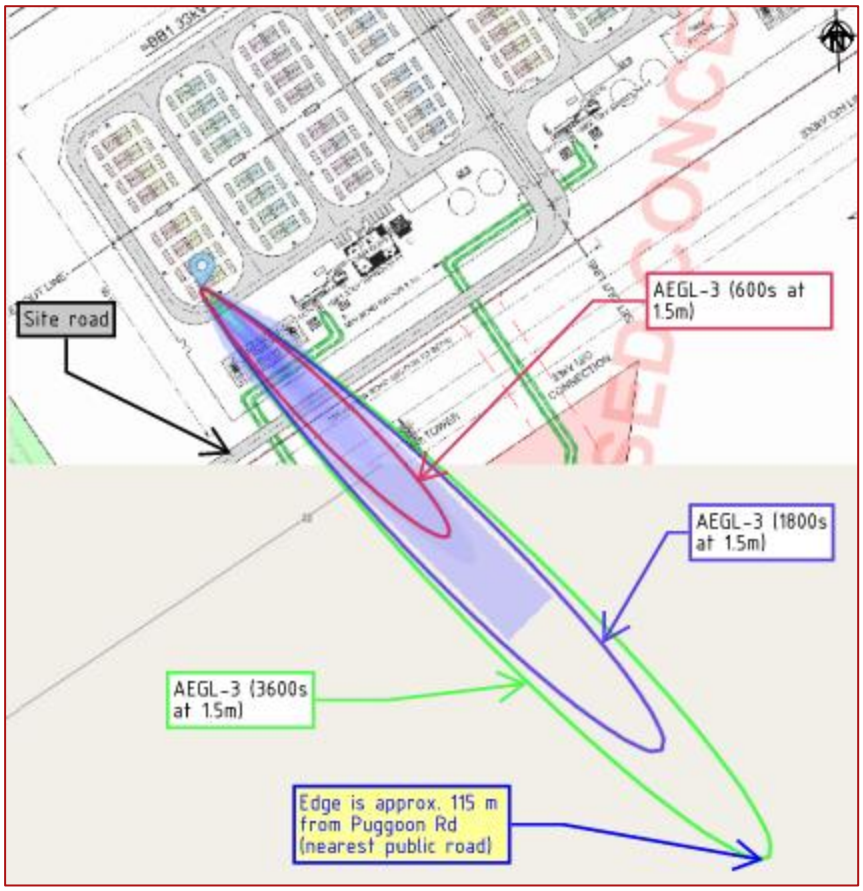


Figure 14: Atmospheric dispersion from 1 rack over 1 hour – no wind

5.4.16 For the same LoC event, but with an average wind speed, the area impacted is significantly reduced, with the AEGL-3 (3600) dispersion being approximately 340 m from Puggoon Rd. This can be seen in Figure 15.

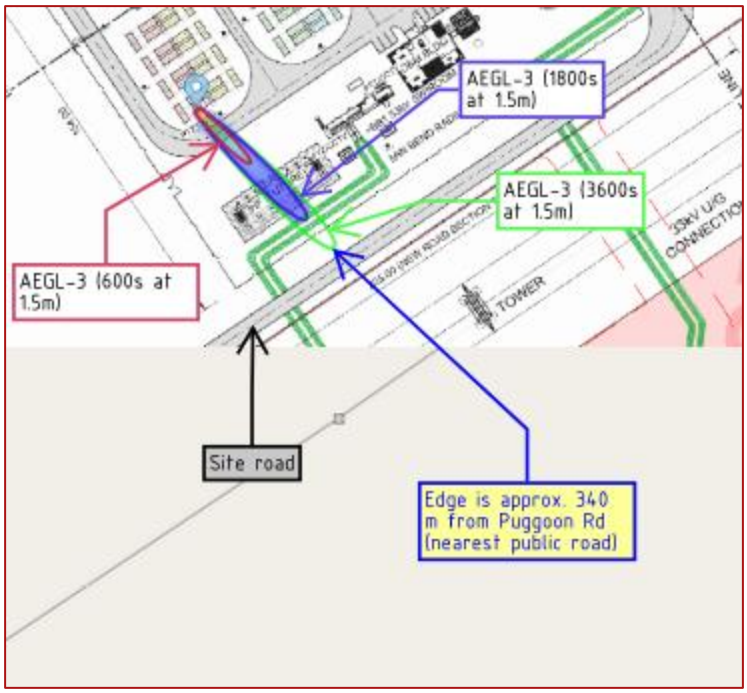


Figure 15: Atmospheric dispersion from 1 rack over 1 hour – average wind

5.4.17 Finally, for the same LoC event, but with the 95th percentile wind speed, the area impacted by the release is even further reduced as shown in Figure 16 fand Figure 17From the results of the average and 95th percentile wind speed scenarios, it can be readily determined that a higher wind speed results in a more favourable result.

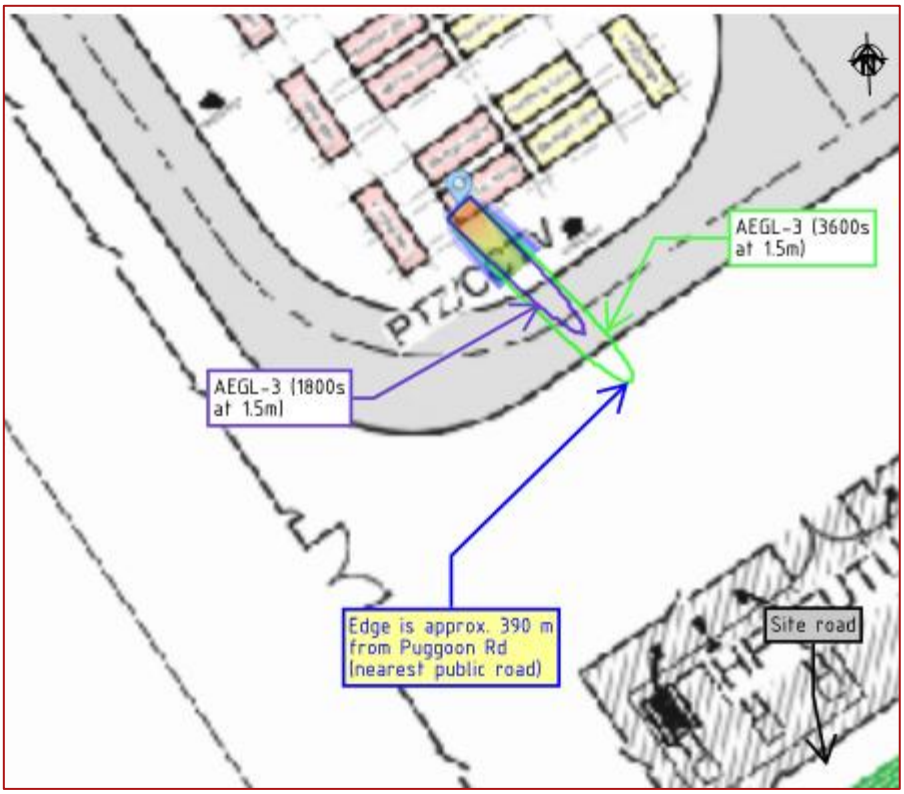


Figure 16: Atmospheric dispersion from 1 rack over 1 hour – 95th percentile wind

Atmospheric dispersion – 1 BESS Unit over 6 hours

5.4.18 For the no wind 1 BESS Unit case, the AEGL-3 (3600) AEGL-3 (3600) dispersion is approximately 120 m from Puggoon Rd. This is shown in Figure 17.

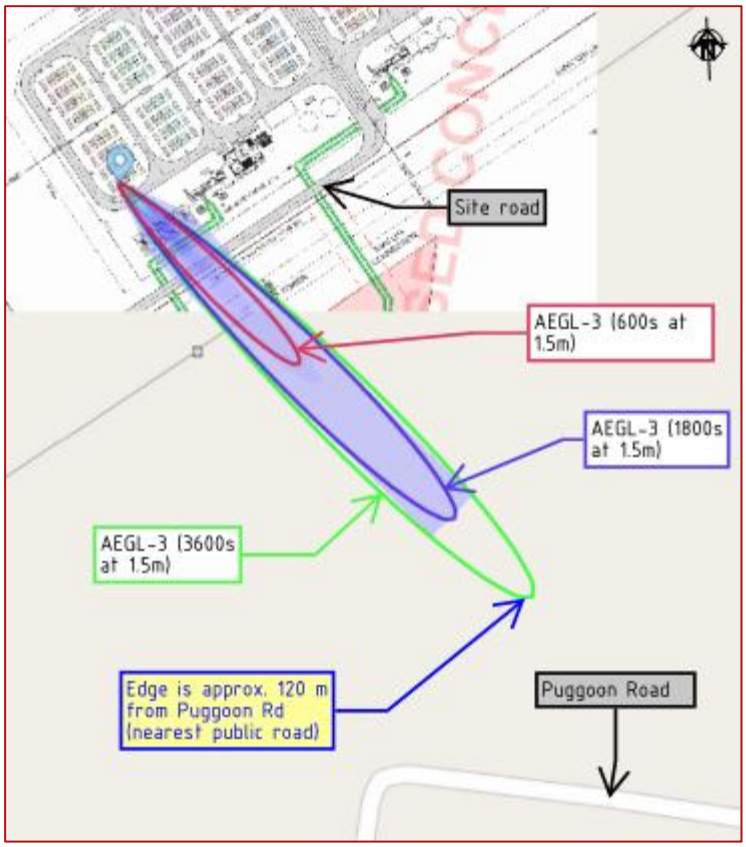


Figure 17: Atmospheric dispersion from 1 BESS Unit over 6 hours – no wind

5.4.19 For the same LoC event, but with an average wind speed, the area impacted is significantly reduced, with the AEGL-3 (3600) dispersion being approximately 340 m from Puggoon Rd. This can be seen in Figure 18.

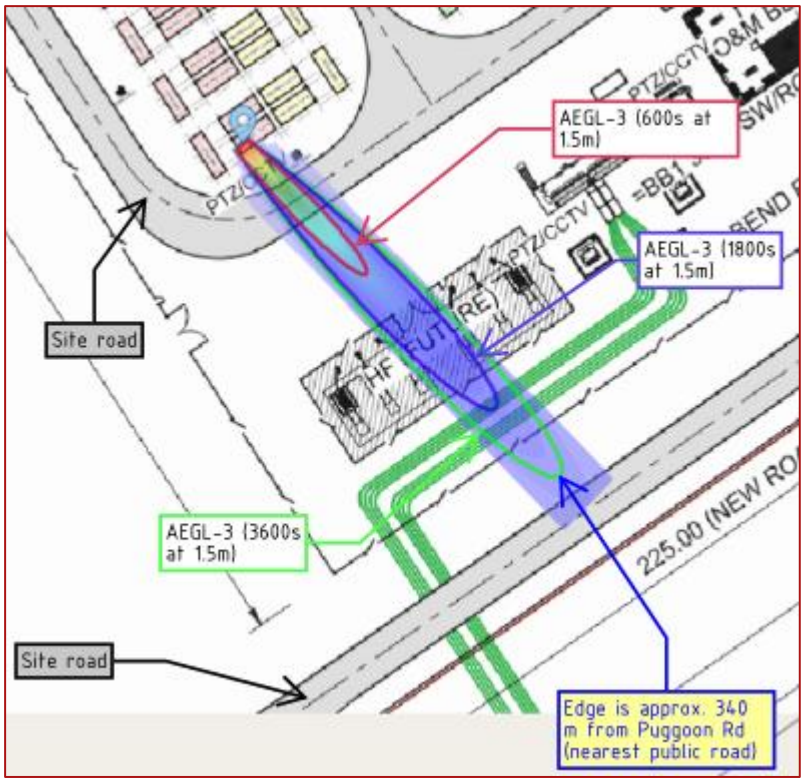


Figure 18: Atmospheric dispersion from 1 BESS Unit over 6 hours – average wind

L1-GR Consequence Summary

5.4.20 Based on the HF gas dispersion modelling (Scenario L1-GR), a loss-of-containment event has the potential to disperse HF over distances exceeding 100 m, but the actual life-safety risk remains low. The site's remote location means that only people working on site (24/7 occupation) would likely be within the affected area, or occasionally any farmers within this area. HF concentrations approaching AEGL-3 thresholds are unlikely to result in significantly harmful effects to individuals due to the short exposure duration and the expectation that people would not remain in place. Such an event is expected to result in injuries or illness requiring non-emergency medical attention, or multiple minor health outcomes, rather than permanent disability or fatality. Property impacts are similarly limited, with only minimal damage anticipated to surrounding equipment or facility assets.

L1-EX: Explosion

5.4.21 The potential for an explosion to occur in a BESS unit has been studied on the basis of a vapour cloud explosion. This is considered the most relevant as the cells themselves are not solid explosives, instead there is the potential for combustible gases to be released if cells failed, which could result in an explosive atmosphere occurring within a BESS unit. This has been analysed in GEXCON EFFECTS.

5.4.22 In this analysis it has been assumed that the entire volume of the BESS unit has been filled with hydrogen, i.e., gross volume, to its lower explosive limit. Then,

the overpressure is determined with no consideration of the BESS unit structural strength. Therefore, this analysis is conservative as the structural strength of the BESS unit would reduce the maximum overpressure due to an explosion.

5.4.23 This analysis is carried out disregarding the provision of the NFPA 69 explosion mitigation system. Importantly the NFPA 69 system is only required to consider the results of UL9540A test which for these cells results in consideration of only 2 cells in thermal runaway. Nonetheless the actual NFPA 69 system has been sized based on 3 cells, resulting in 430 L of off gassing.

5.4.24 For simplicity only hydrogen has been considered in the model, the inputs into the model assumed 0.1 kg of hydrogen involved in the explosion. At STP the density of hydrogen gas is approximately 0.00008988 kg/L, therefore this represents approximately 1,100 L of hydrogen gas which is more than 2 x that assumed in the NFPA 69 analysis.

5.4.25 Figure 19 present the overpressure range associated with the explosion. The over pressure contour values have been selected based on the acceptance criteria in **Error! Reference source not found.** to this report. Specifically:

a) 7 kPa related to 10% probability of injury but no fatality and damage to internal partitions and joinery but can be repaired,
b) 21 kPa related to 20% chance of fatality to a person in a building and distorting of reinforced structures,
c) 35 kPa related to 15% chance of fatality for a person out in the open and equipment failure,
d) 70 kPa related to 100% lethality for a person in a building or in the open and complete demolition of a house.

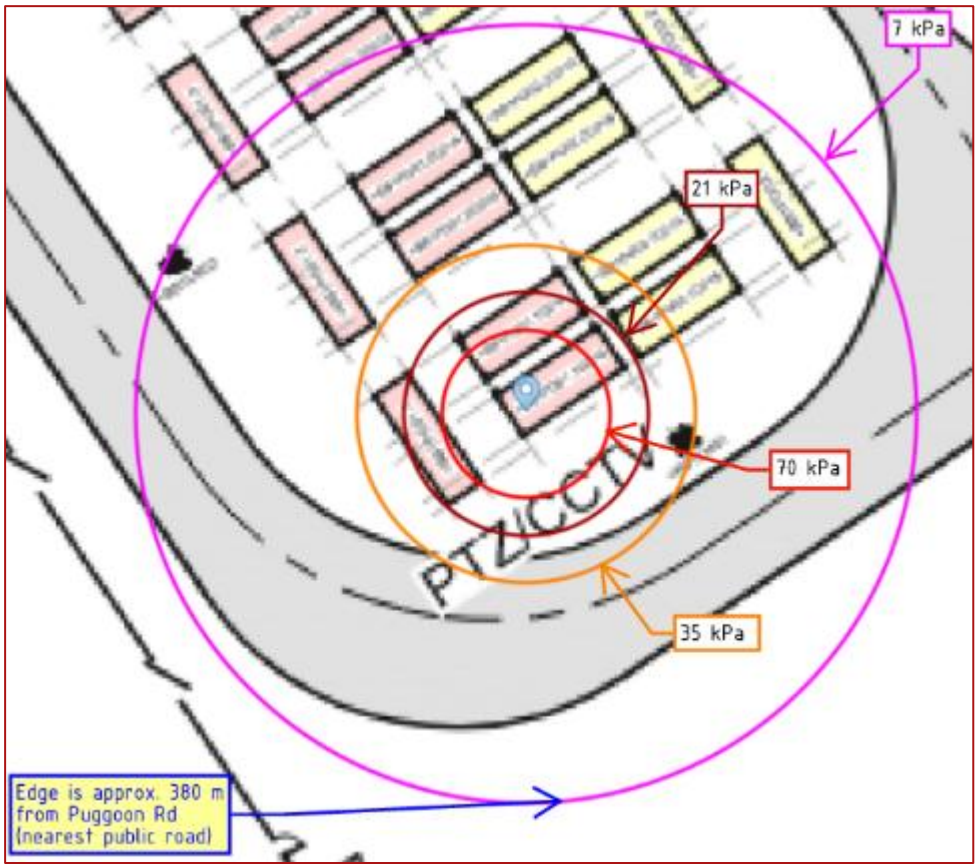


Figure 19: LFP BESS – VCE Overpressure Contours

5.4.26 As shown in Figure 19, the overpressure contours do not reach the nearest public road (Puggoon Rd). Therefore, this scenario does not have a significant offsite hazard.

5.4.27 Whilst there is not a significant offsite hazard associated with this event, as shown in Figure 19, the overpressure generated is sufficient at close range to result in a fatality, and may cause damage to nearby equipment.

L1-LF: Large Fire

5.4.28 The large scale fire test (LSFT) report has been conducted on Hithium BESS. This test was conducted in accordance with UL 9540 Task Group 3 Proposed Revision to UL 9540A Installation Level – LSFT, NFPA 855 Annex G11, and CSA C800 Standard.

5.4.29 One enclosure of origin was set up with a complete installation, three target containers and one instrumented wall were positioned around it according to specifications provided. The yellow box in Figure 20 is the electrical cabinet, the green box is the battery rack, the red is the trigger module, and the grey indicates that the rack is left blank.

5.4.30 Figure 24 presents the test set up:

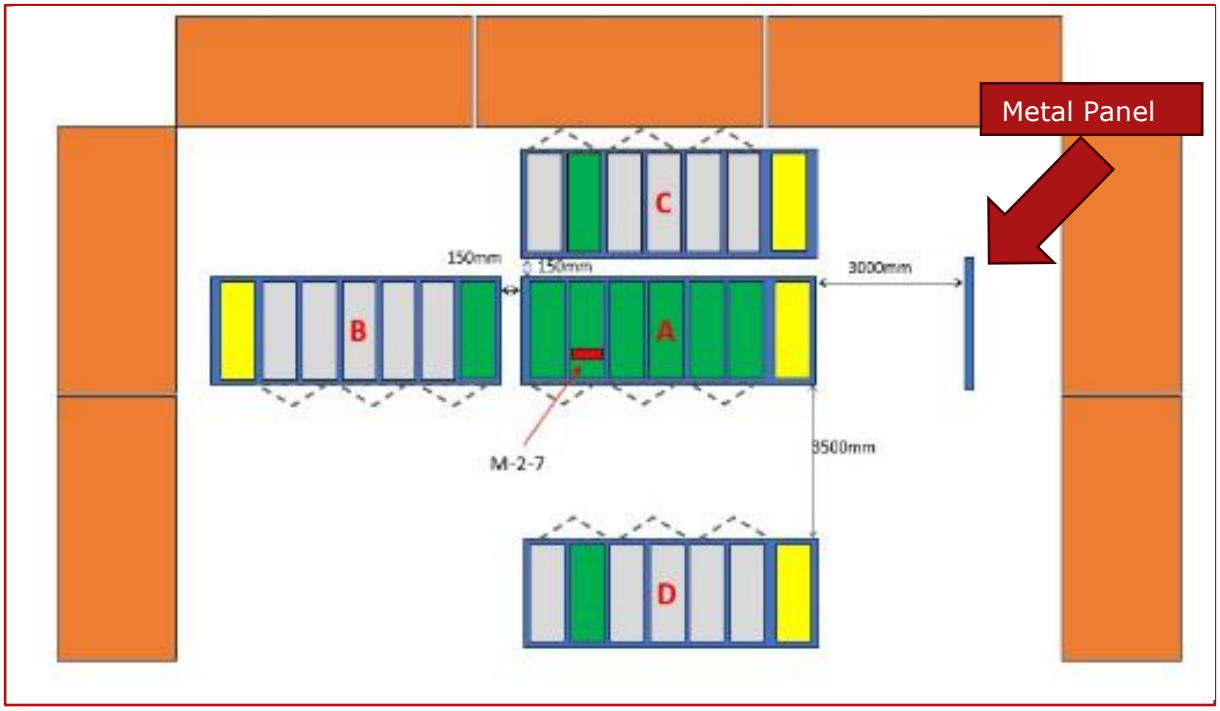


Figure 20: LSFT configuration

5.4.31 The outcome of this LSFT was that no fire spread occurred from Unit A to any of the surrounding units. This was the case even with the doors to Unit A being open, allowing for more heat to reach Unit D, and being 150 mm from Unit C and B. Based on this full-scale test, a BESS fire is not expected to spread to other nearby BESS units.

5.4.32 At the Belambi site, the closest adjacent equipment to the group of BESS units is located approximately 3.47 m from the enclosure, as illustrated in in Figure 21. Results from the LSFT indicate that the maximum incident radiant heat flux measured at a metal panel positioned 3 m from Unit A was 8.7 kW/m² (refer Figure 20). In accordance with the acceptance criteria outlined in **Error! Reference source not found.**, this level of radiant heat flux is below the threshold typically associated with fire spread. Accordingly, escalation to neighbouring equipment is not expected based solely on radiant heat exposure at this separation distance.

5.4.33 However, a radiant heat flux of 8.7 kW/m² exceeds occupational tenability limits for personnel exposure and would be unsafe for any staff member remaining within this proximity for an extended duration without appropriate shielding or firefighting PPE.

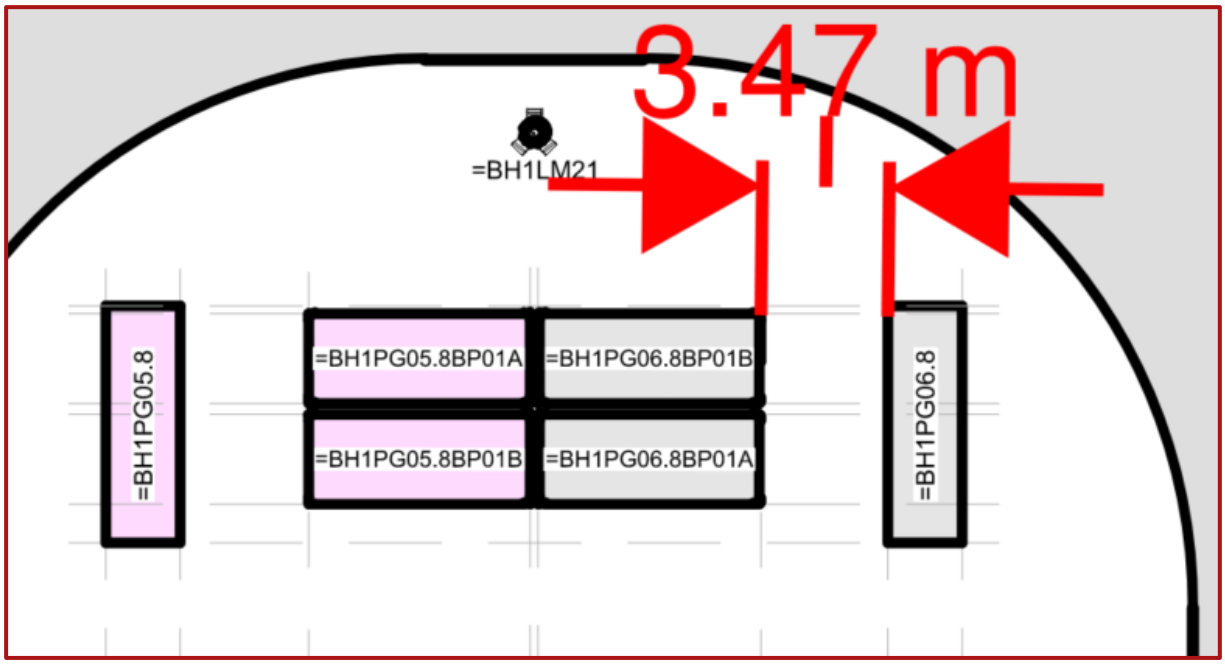


Figure 21: Neighbouring equipment

5.4.34 Radiant heat flux measurements were recorded at multiple locations and averaged over 60-second intervals. The maximum measured heat flux was 37.4 kW/m² at a distance of 1,750 mm from the initiating enclosure (HF-4), with corresponding values of 32.7 kW/m² and 21.9 kW/m² recorded at adjacent positions.

5.4.35 At a separation distance of 3 m (instrumented wall location), measured heat flux values were 8.3 kW/m² and 7.3 kW/m², which are below the 12.5 kW/m² radiative exposure criteria referenced in Section 10.1K.1.9 of UL 9540A. No thermal runaway, cell venting, or flame penetration occurred within the adjacent target containers, and the performance criteria of Section 10.1K were satisfied.

5.4.36 On the basis of the test outcomes, the large-scale fire event was contained to the initiating enclosure, and the measured radiant heat flux at 3 m separation remained below 12.5 kW/m². These results demonstrate that, under the tested configuration and separation distances, the system exhibited no fire propagation to adjacent BESS units occurred. The detailed results of this test are shown in Appendix B.

5.4.37 Further to the above, wind has been considered Appendix I with flame tilt included in additional models. These models show that fire spread is not expected to occur even with wind effects.

5.5 Cables (L2) - SF

L2-SF: Localised cable fire

5.5.1 Based on the initial screening, the hazards for cables requiring further analysis from the HAZID table include a localised fire (within BESS enclosure or within a cable tray in switch room). A large cables fire, explosion (due to cable fire) or a

gas release due to cable fire was not considered for consequence analysis on the basis that a cable fire does not involve sufficient combustible material and the limited scale of the fire event cannot justify consideration of a large-scale fire explosions or toxic gas scenario.

5.5.2 The common causes of fire or electrocution due to electrical equipment items are:

a) Electrical faults, such as short circuits, overcurrent, and arc flash which are often associated with faulty connections.
b) Mechanical damage to the insulation material, cables, and the connection. These can often occur due to construction activities or extreme environmental events.
c) Cable aging and insulation breakdown due to UV radiation, extreme temperatures, and physical wear.
d) Overheating of the cable due to improper installation or insufficient cooling.
e) Humidity and moisture related to water ingression can accelerate the breakdown of cable insulation.
f) Manufacturing defects such as inferior insulation and poor sealing can lead to cable breakdown and failure.
g) Arc flashes, which have the potential to ignition a fire in combustible material nearby.

Consequence Quantification

5.5.3 DC cables used on the BESS units consist of a copper core and typically a cross-linked polyethylene (XLPE) or thermoplastic rubber (TPR) external covering. They present a low fire risk and most of the related fires would be as a result of installation, damage and overheating. The localised fire / heating of cables may lead to smouldering and thermal degradation of the cable insulation. The presence of cable trays may provide additional fuel, allowing limited fire propagation within the bundle.

5.5.4 Small Fire: A small cable fire has been assessed using FDT Spreadsheet 7. An assumed length of 1 m and 0.2 m in width has been used for the calculation. The result of this analysis is a potential fire size of 16 kW.

5.5.5 We have used spreadsheet 7 in Fire Dynamics Tools:2004 (US Nuclear Regulatory Comission, 2004) and assumed that the cable insulation is crosslinked polyethylene (XPE). From this spreadsheet the bench-scale heat release rate per area of cables is 178 kW/m^2. The failure of the cable would be localised. It is therefore assumed to be limited to over a length of 1 m and width of several cables of 0.2 m. Therefore, the potential heat release rate of this cable fire would be 16.02 kW.

5.5.6 Small Fire Consequence: This fire size is unlikely to cause radiation which would lead to fire spread, however poorly selected cabling materials, insulating materials, and other design or maintenance issues could lead to fire spreading

along cables. As such, for the worst scenario, with no reasonable controls applied, is that fire spreads along cables to connected equipment.

5.5.7 Limitations and assumptions of this spreadsheet are:

a) The analysis is based on data obtained from flaming fire of cable samples,
b) Complex cable tray configurations may result in less accurate approximation of the HRR, and
c) Spreadsheet can be used to determine the heat release rate for any type of cable.

5.6 Electrical Systems – MV Transformers (L3 – SF, LF & EX)

5.6.1 Based on the initial screening, the hazards for the MV Kiosk transformers requiring further analysis from the HAZID table include a small fire (leak from transformer) large fire (complete loss of FR3), and explosion scenarios (L3-SF, LF and EX).

L3: Small Fires in MV Transformer

5.6.2 A realistic small leak of 200 L (or 180 kg) has been estimated for the MV transformer. This represents a small leak which would be largely caused by corrosion, mechanical damage or by thermal cycling causing an FR3 oil to leak.

Consequence Quantification

5.6.3 As FR3 fluid is an ester based fluid, this is represented by ethyl linoleate within GEXCON EFFECTS. The pool size is the surface area of the 20 m^2 [3] ,and the radiative fraction of the heat release rate has been assumed to be of 35%. Figure 22 to Figure 24 present the radiation top down view pattern for this incident. These patterns include 1, 3, 12.5, 13, 20 and 35 kW/m^2. These values have been chosen based on the acceptance criteria set out in **Error! Reference source not found.**.

[3] Worst case pool size of 1 cm thick has been used, as any thinner and the fire would not last sufficiently long to be relevant.

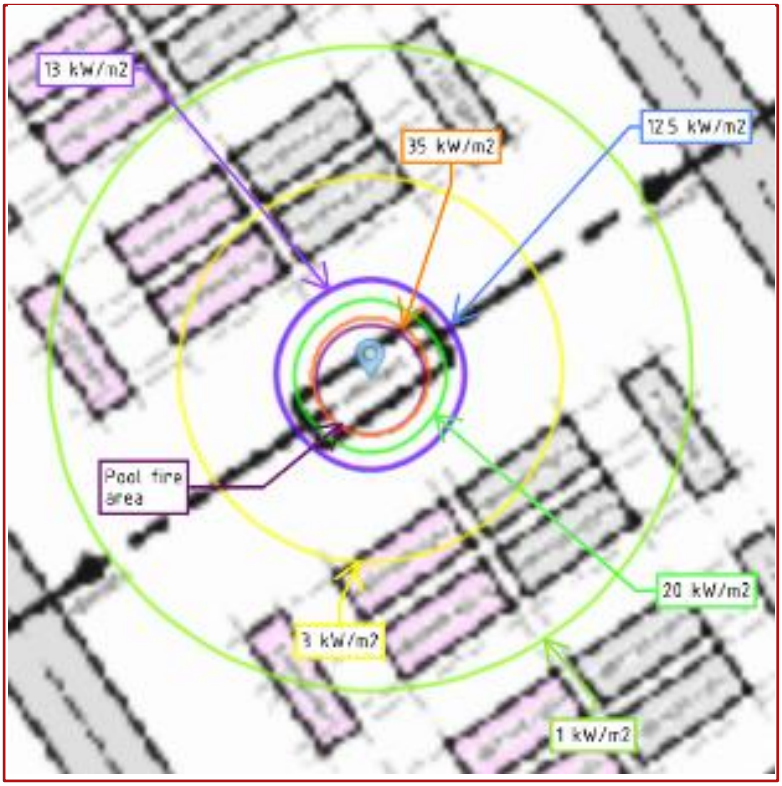


Figure 22: MV Transformer – (L3 – SF) – No wind

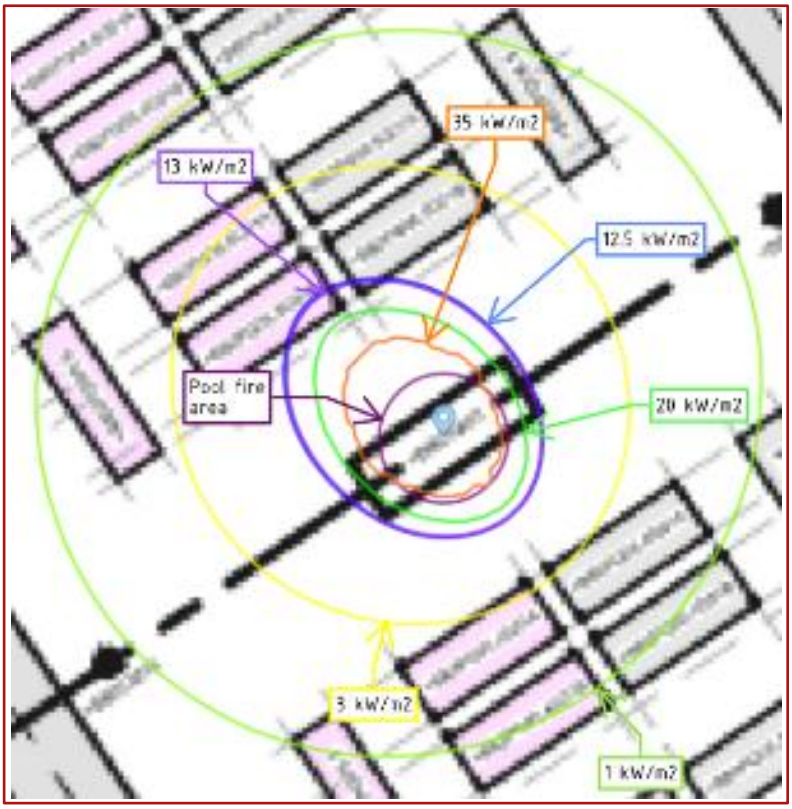


Figure 23: MV Transformer (L3 – SF) – Average wind

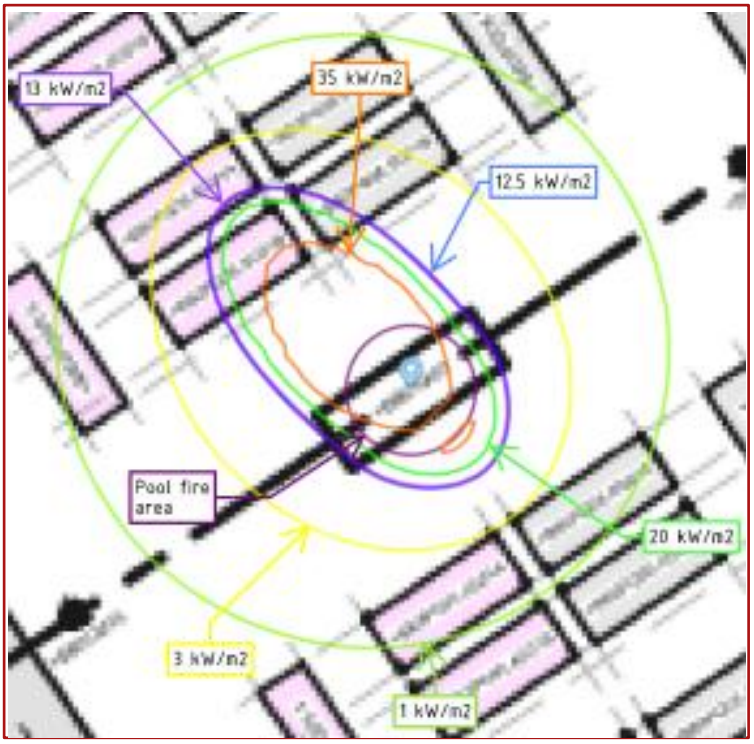


Figure 24: MV Transformer - (L3 – SF) – 95th percentile wind

5.6.4 Based on the above, a fire involving an MV Transformer has the potential to impact the adjacent BESS units and equipment under wind conditions, as the 12.5, 13, 20 and 35 kW/m² radiation contours intersect these areas. This level of thermal radiation has the potential to cause damage to equipment or even equipment failure after a prolonged exposure period.

L3: Large Fires in MV Transformer

5.6.5 A complete release from the transformer of 1,556 L (or 1,363.1 kg) has been estimated for the MV transformer. This represents a large leak which would be largely caused by mechanical damage, switching surge or corrosion due to lack of maintenance.

Consequence Quantification

5.6.6 As FR3 fluid is an ester based fluid, this is represented by ethyl linoleate within GEXCON EFFECTS. The pool size is the surface area of the 156 m^2 [4], and the radiative fraction of the heat release rate has been assumed to be of 35%.

5.6.7 Figure 25 to Figure 27 present the radiation top view pattern for this incident. These patterns include 1, 3, 12.5, 13, 20 and 35 kW/m^2.

[4] Worst case pool size of 1 cm thick has been used, as any thinner and the fire would not last sufficiently long to be relevant.



Figure 25: MV Transformer – (L3 – LF) – No wind

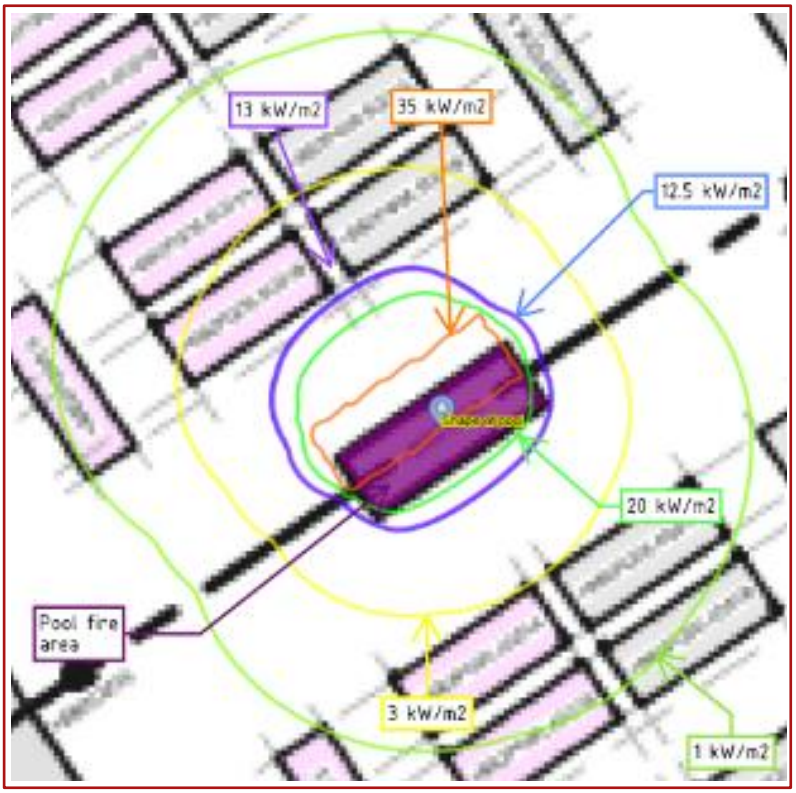


Figure 26: MV Transformer (L3 – LF) – Average wind

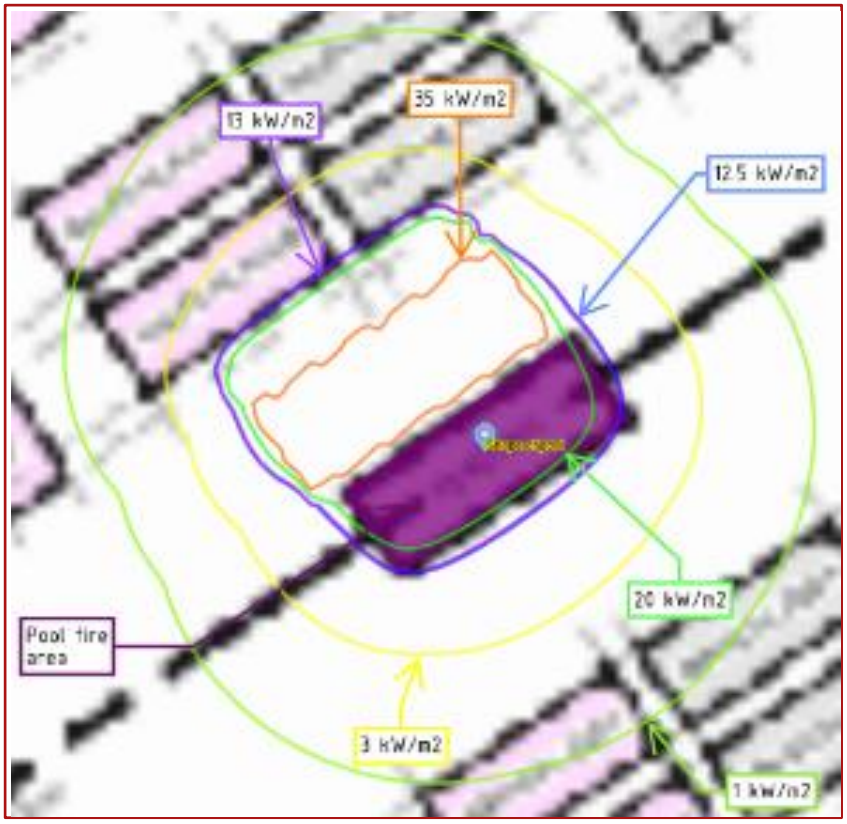


Figure 27: MV Transformer - (L3 – LF) – 95th percentile wind

5.6.8 Based on the above, a fire involving an MV Transformer has the potential to impact the adjacent BESS units and equipment under both no wind and wind conditions, as the 12.5, 13, 20 and 35 kW/m² radiation contours intersects these areas. This level of thermal radiation has the potential to cause damage to equipment or even equipment failure after a prolonged exposure period.

5.7 Electrical Systems – PCSM (L4 - SF)

L4, & L6: Small Fires in PCSM, or Aux Transformers

5.7.1 Based on the initial screening, the hazards for the PCSM requiring further analysis from the HAZID table are confined to small, localised fires with low potential for escalation or explosive behaviour.

5.7.2 Dry-type transformers present only a limited fire hazard because they contain no flammable oil and therefore cannot produce a pool fire or explosion. Any fault is typically restricted to localised arcing or insulation breakdown, which may ignite small amounts of combustible insulation or surface dust (as secondary fuel) but there is not sufficient fuel to sustain a large fire. As a result, a large (major) fire, explosion or toxic gas scenario is not considered a credible scenario.

Consequence Quantification

5.7.3 Fire parameters for dry type transformer have been obtained from NUREG 2020 (U.S. Nuclear Regulatory Commission and Electric Power Research Institute, 2020), as presented in Figure 28 provides heat-release-rate parameters for dry type coil transformers. For large units rated above 750 kVA, the study identifies

a 98th-percentile heat release rate of approximately 130 kW, based on updated statistical distributions for the transformer group labelled "Group C."

Transformer Classification Group	Transformer Power (kVA)	α	β	75th Percentile (kW)	98th Percentile (kW)
A	>45–75	0.38	12.84	6	30
B	>75–750	0.41	28.57	15	70
C	>750	0.46	50.26	30	130

Figure 28: Heat release rate parameters for dry type transformers, NUREG 2020 (U.S. Nuclear Regulatory Commission and Electric Power Research Institute, 2020)

5.7.4 From NUREG 2020, (U.S. Nuclear Regulatory Commission and Electric Power Research Institute, 2020) it is noted that the expected fire duration would be:

a) Growth: 0 minutes
b) Steady burning: 10-13 minutes, and
c) Decay: 10-13 minutes, linear decay.

5.7.5 This short duration and low heat release rate fire event is not expected to be able to heat the compartment up significantly.

5.7.6 This initial fire spread analysis is undertaken for no control measures in place. This consequence analysis is conducted for no wind as the dry type transformers are located inside of buildings.

Fire Spread Analysis - Initial

5.7.7 Table 22 provide properties of the fire in the initial analysis. It is worth noting that this value of 130 kW is based on statistical modelling of limited data for dry-type transformers not direct large-scale fire tests for every transformer size.

Table 22: Fire properties from NUREG 2020

Fire properties	Initial fire analysis
Heat release rate (kW)	130

5.7.8 Enclosure Fire Dynamics provides one of two approximate methods to calculate the radiation from flame to target (Karlsson B, 2000). Modak's simple method considers that radiation to the surroundings can be approximated as isotropic, or as emanating from a point source. Modak's study allows a very simple formula to be applied for computing radiant heat to a remote target (normal to the source), as shown in Figure 29.

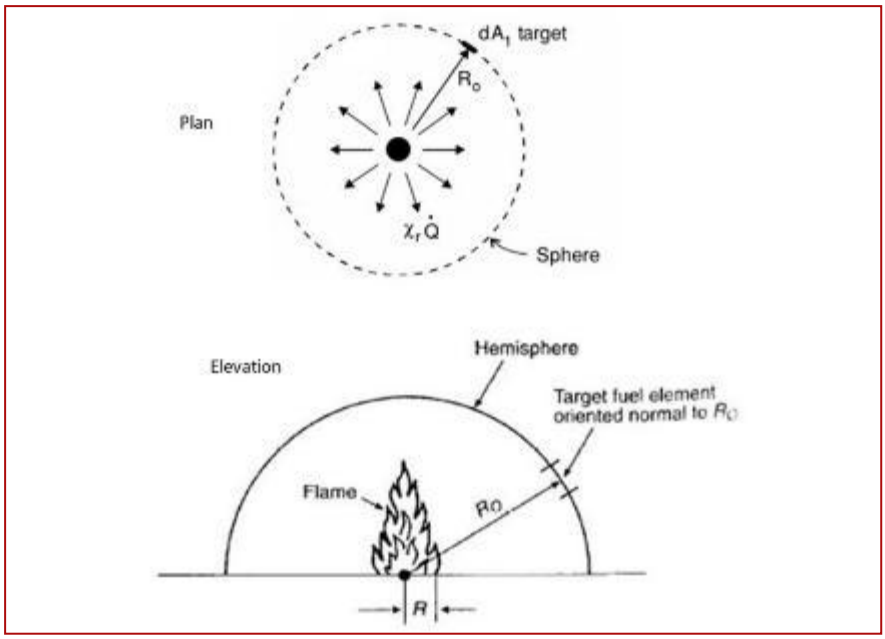


Figure 29: Radiant Heat Transfer to a Target (Isotropic Radiative Source)

5.7.9 Modak's simple method for determining radiation is expressed as—

$$\dot{q}" = \frac{\chi_r \dot{Q}}{4\pi R_0^2}$$ **Equation 1**

where

$\dot{q}"$	radiant heat flux received by the target (kW/m^2)
χ_r	fraction of total energy radiated, 0.15 for low sooting and 0.6 for high sooting fuels
$\dot{Q}$	total heat release rate of the fire (kW)
R_0	distance of the target to the centre of the fire (m)

$$\dot{q}" = \frac{0.6\ x\ 130}{4\pi\ 3.5\text{^}2}$$

Equation 2

5.7.10 Hand calculations have been conducted to determine the radiant heat flux from a dry type transformer to nearby equipment located at a distance of 3.5 m away. For a heat release rate of 130 kW, the radiant heat flux expected to be received by the adjacent dry type transformer during a fire is 0.6 kW/m^2. Ignition of the dry type transformer is not expected at this level of radiation, refer to the acceptance criteria contained within **Error! Reference source not found.** to this report.

5.7.11 The acceptance criteria for thermal radiation exposure of general occupants are outlined within **Error! Reference source not found.**. However, as dry type transformers can generate debris, a separate hazard, there remains the potential consequence of injury to staff if present.

5.8 Electrical Systems – Aux TX

L6 Auxiliary Transformers in BB1 and BB2

5.8.1 Based on the hazard screening, the hazard for analysis for the Aux TX is a large fire scenario. This captures the large fire impacts as well as the small fire impacts. An explosion has not been assessed as the Aux TX are to be located in accordance with AS 2067 which includes offset distances for nearby structures.

5.8.2 Based on the information provided these have been modelled as a fire occurring in the entire bund footprint of the transformer (ignoring the space occupied by the transformer) for a full release of the 1 kL of oil contained within the transformers.

5.8.3 The models have been undertaken using the no wind, average wind, and 95th percentile wind as set out in earlier analysis. The fires have been considered as a pool fire in Gexcon EFFECTS with both an Aux TX in BB1 and an Aux TX in BB2 modelled as they have different distances to adjacent structures. Since the Aux TX in each are identical, the table of results for both are identical, and only the figure of contours is different based on their locations.

5.8.4 Table 23 shows the fire properties of the transformer fire based on the model.

Table 23 Fire properties of transformer fire

Fire properties	Pool fire
Heat release rate (MW)	19 MW
Burning Duration (s)	1715
Length of Flame (m)	5.7

5.8.5 Table 24 to Table 26 show the maximum contour distances for the no wind, average wind, and 95th percentile wind scenarios.

Table 24 Heat radiation contour distances - no wind

Heat radiation (kW/m2)	Distance (m)	Max Width (m)
35	3	6
20	4	8
13	5	9
12.5	5	10
3	10	18
1	16	30

Table 25 Heat radiation contour distances - average wind

Heat radiation (kW/m2)	Distance (m)	Max Width (m)
35	4	6
20	6	7
13	7	9

Heat radiation (kW/m2)	Distance (m)	Max Width (m)
12.5	7	9
3	11	16
1	16	26

Table 26 Heat radiation contour distances - 95th percentile wind

Heat radiation (kW/m2)	Distance (m)	Max Width (m)
35	6	6
20	8	6
13	8	7
12.5	8	7
3	10	13
1	13	20

5.8.6 Based on the tables above, whilst the 1 kW/m² contour reaches furthest for the no wind condition, the more onerous contours reach furthest for the 95th percentile wind conditions. Therefore, those contours are reported in figures below. Furthermore the 1 kW/m² is only shown for information, not as a risk, with that value being approximately equal to strong sunshine.

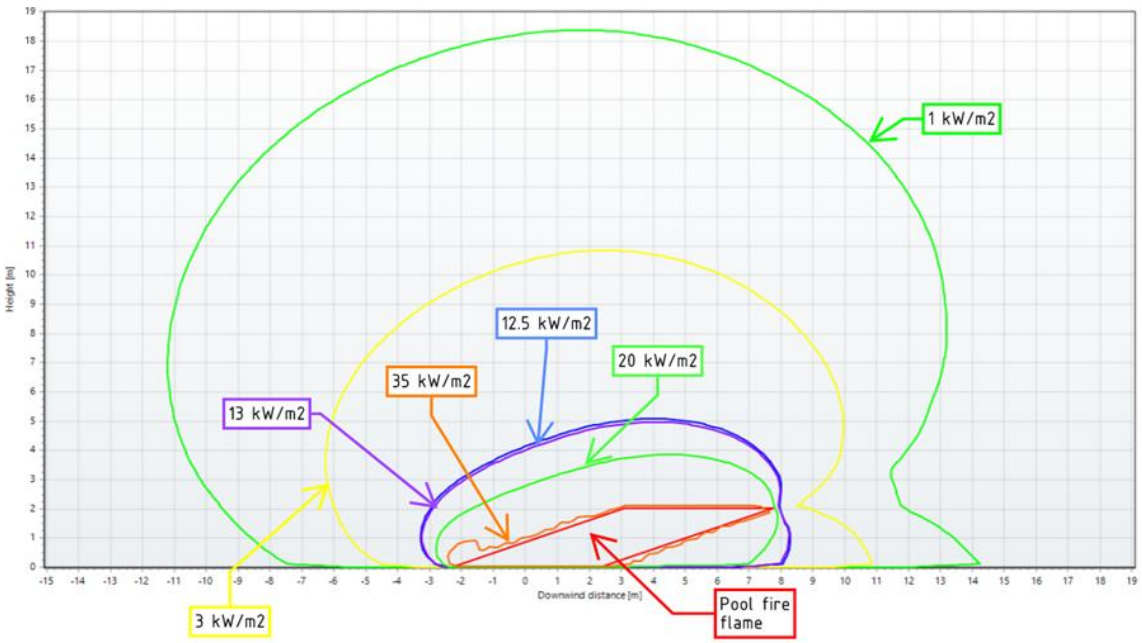


Figure 30 BH 1 heat radiation side view (95th percentile wind)

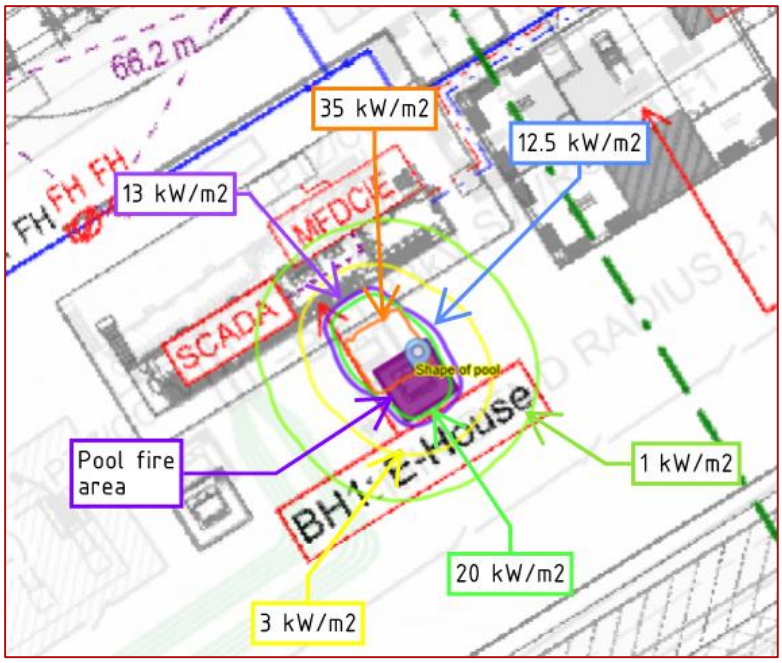


Figure 31 BH 1 Heat Radiation Map – 95th percentile wind

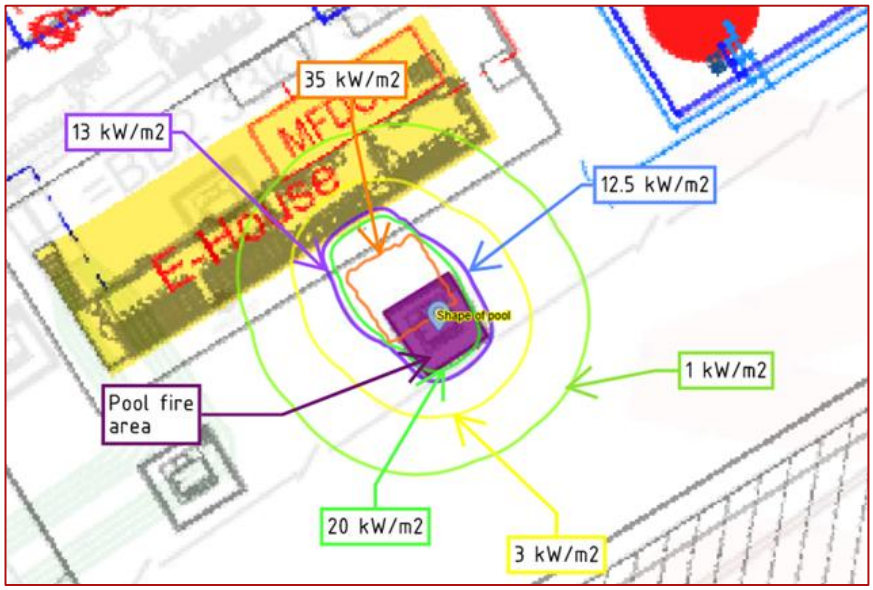


Figure 32 BH 2 Heat Radiation Map – 95th percentile wind

5.8.7 Based on the consequence modelling the worst case outcome is the 13 kW/m² contour just touching on the outside of the nearest building in the 95th percentile wind. In the average wind this would be reduced. Based on this exposure damage could occur to the e-house, however it would require sustained wind and worst case scenarios.

5.8.8 In terms of life safety, people in close proximity could be exposed to life threatening thermal radiation, however this area is not normally occupied, and the contours do not include the roadway or O&M building.

5.9 Electrical Systems – Diesel Generator

L5 SF & LF: Diesel Generator small and large fires

5.9.1 Based on the initial screening, the hazards for diesel generators requiring further analysis from the HAZID table include a localised small fire and a large fire as a result of loss of containment of the fuel. Explosion and toxic-release scenarios have not been carried forward in this study because they are not considered credible. Diesel fuel has a high flash point (typically > 60 °C) and produces insufficient vapour at ambient temperatures to form a flammable vapour cloud. Similarly, diesel combustion products do not generate toxic gases in quantities relevant for off-site or life-safety impact.

Consequence Quantification

5.9.2 The diesel generators are assumed to contain up to 1.5 kL of diesel fuel. For both the small and large fire scenarios, it is assumed that any loss of containment remains fully retained within the bund, preventing fuel migration. Based on site drawings, a pool surface area of 10 m² has been adopted for both diesel generators in areas BB1 and BB2. The consequence analysis has been undertaken using EFFECTS (GEXCON), with the model inputs summarised in Table 27. Conservatively, consequence assessments have only been carried out for the large fire scenarios.

Table 27: Fire input properties of Diesel Generator fire

Area	Scenario	Pool area (m2)	Fuel volume (L)
BB1	Small fire	10	150
	Large fire	10	1,500
BB2	Small fire	10	150
	Large fire	10	1,500

5.9.3 Table 28 provides the principal fire properties of this analysis.

Table 28: Fire properties of diesel generator fire

Fire properties	Pool fire
Heat release rate (MW)	23.8
Burning Duration (s)	2361.1
Length of flame (m)	7.46

5.9.4 Figures Figure 33 to Figure 36 present the top down view pattern for this incident. These patterns include 3, 12.5, 13, 20 and 35 kW/m².

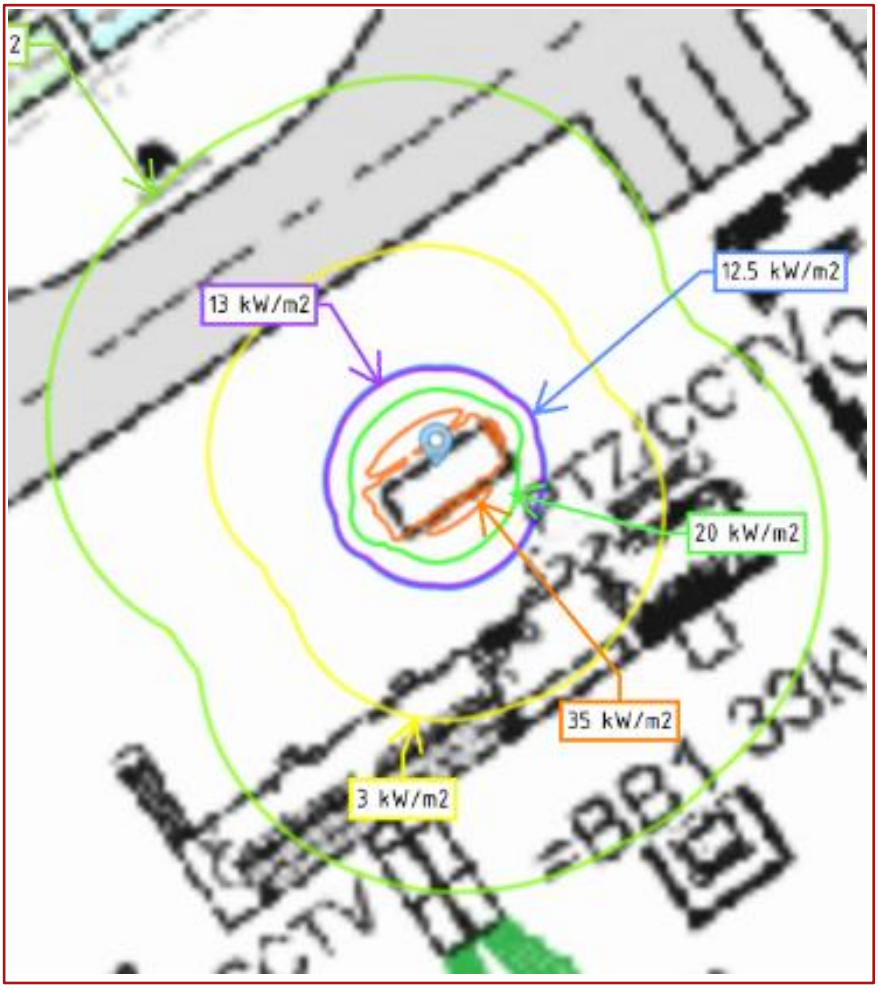


Figure 33: Top down radiation view – BB1 – no wind

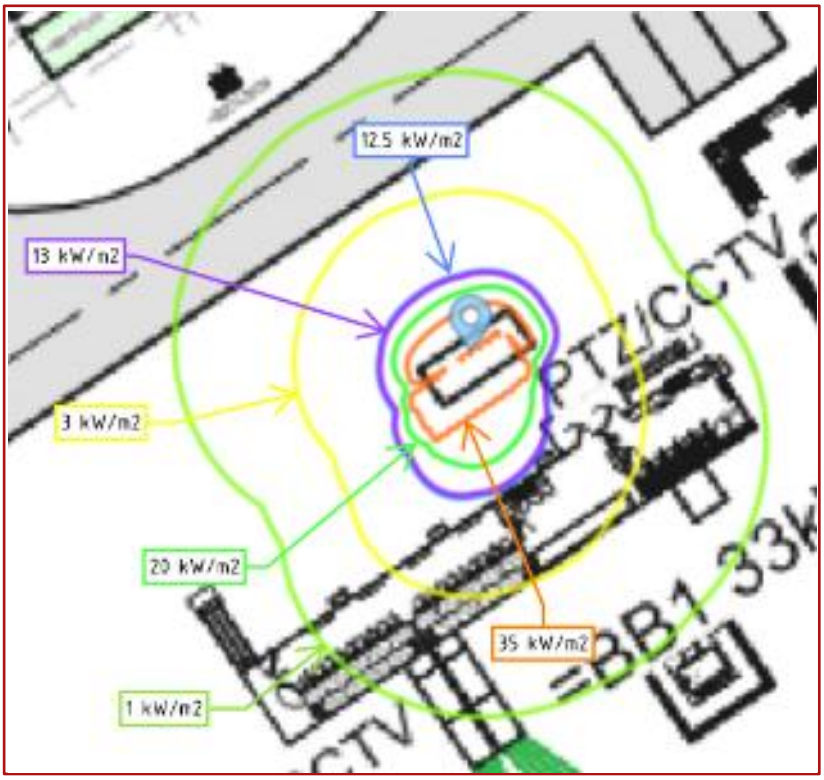


Figure 34: Top down radiation view – BB1 – average wind



Figure 35: Top down radiation view – BB2 – no wind

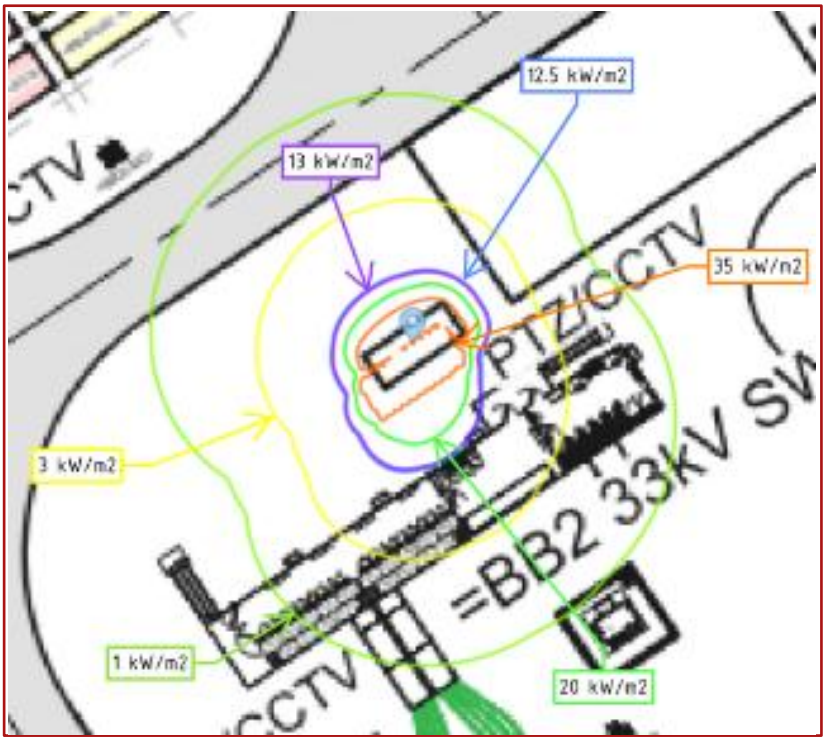


Figure 36: Top down radiation view – BB2 – average wind

5.9.5 Based on the above, a fire involving the diesel generator has the potential to impact the switchrooms in both BB1 and BB2 under wind conditions, as the 13 kW/m² radiation contour intersects these areas. This level of thermal radiation has the potential to cause damage to the building fabric and internal equipment after a prolonged exposure period.

5.9.6 Personnel located within the 12.5 kW/m² radiation contour at the time of a fire would face a significant risk of fatality; however, this outcome is dependent on occupancy levels and the likelihood of staff being present during such an event.

5.10 Site Building: O&M building (L7) – SF & LF

L7-SF: O&M building small fire / L7-LF: O&M building large fire

5.10.1 Based on the initial screening, the hazards for the O&M building requiring further analysis from the HAZID table are confined to small localised and large compartment scale fires.

5.10.2 The O&M building at BB1 is vulnerable to standard fire hazards, such as electrical fault and maintenance incidents, as well as the less common hazards relates to the storage of any chemicals and dangerous goods. The common causes of site building fires are:

a) Inappropriate design and/or construction of the building to be able to safely undertake its role. In this situation fires could occur due to operations, such as refuelling and maintaining site vehicles, being undertaken within a building.
b) Lack of procedures and training related to site building safety, such as the use of unsafe electrical equipment, unattended cooking, and the overuse of extension boards, could lead to fires.
c) Inappropriate storage of chemicals, dangerous goods, and fuels in the site buildings. This situation could rapidly lead to a fire.
d) Poor electrical wiring installation and maintenance could lead to fire ignition.
e) Deterioration of the cable insulation due to ageing or rodent attack.

Consequence Quantification

5.10.3 Hazardous goods stored within a warehouse present elevated fire and safety risks due to their potential to ignite, explode, or release toxic vapours when exposed to heat, incompatible substances, or physical damage.

5.10.4 The site building is approx. 20 m away from the BESS units in BB1 and around 35m away from any adjacent equipment. It is considered plausible (but unlikely) that these areas could be affected by a fire from the site buildings or vice versa. Car parking spots are present outside of the building. A vehicle fire could affect the O&M building.

Table 29: FiRE analysis

Building or Equipment	Emitter or Receiver	Dimensions	Temperature and Emissivity
O&M BB1	Emitter	21 m x 3 m	1200 °C and Emissivity of 0.9
BESS Unit BB1	Receiver	6.1 m x 2.9 m	20 °C and Emissivity of 1
BESS Equipment BB1	Receiver	2.1 m x 2.3 m	20 °C and Emissivity of 1

5.10.5 A FiRE analysis of the O&M building is presented in Figure 37 showing the potential for fire spread within BB1.

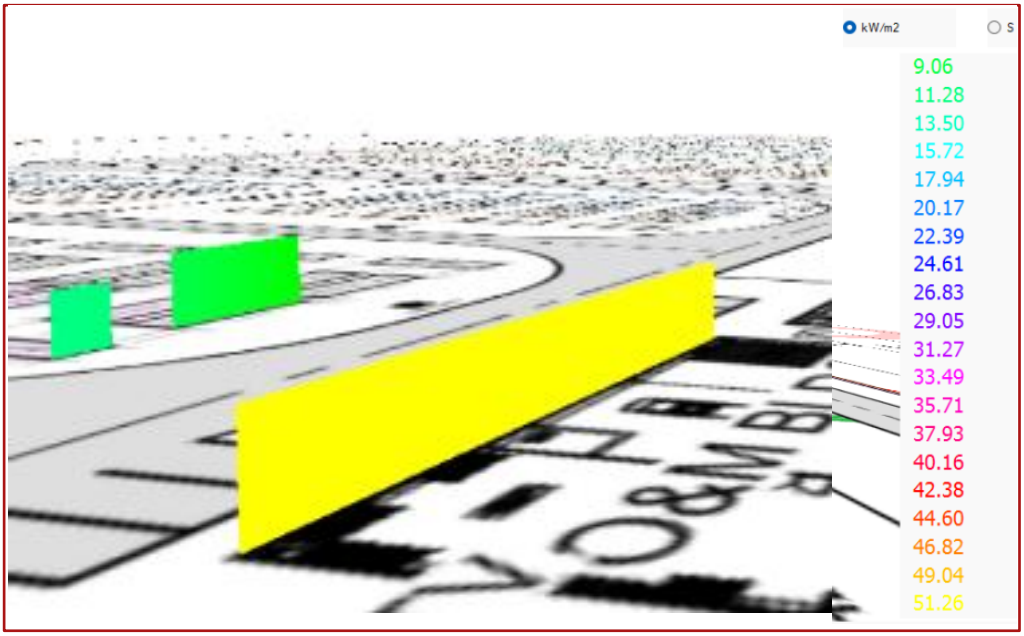


Figure 37: FiRE analysis of an O&M Building fire in BB1

5.10.6 Based on the above, a fire within the O&M building would result in less than 10 kW/m² incident radiation on the neighbouring equipment, including the BESS and transformers.

5.10.7 Using the LSFT, it can be demonstrated that received 10 kW/m2 would not result in thermal runaway.

5.10.8 Based on the large-scale fire test, the incident radiation on the adjacent container (Container D) showed that when a fire in Container A was located 3.5 m away, the heat flux received at Container D reached as high as 32.7 kW/m². The layout of these containers can be found in Figure 45.

5.10.9 The Container D module recorded surface temperatures did not exceed 70°C (refer to Figure 38). Using this logic, a fire occurring at the O&M building, at a separation distance of approximately 20 m, would not be expected to result in an elevated temperature of the adjacent BESS units. This would impose a significantly lower thermal radiation on the nearest BESS container.

Maximum Temperatures on Container D internal cell surface					
TC No.	Maximum Temperature (°C)	TC No.	Maximum Temperature (°C)	TC No.	Maximum Temperature (°C)
T275	68.9	T283	54.3	T291	49.3
T276	64.2	T284	57.0	T292	48.4
T277	64.9	T285	52.5	T293	N/A
T278	61.0	T286	52.2	T294	48.1
T279	56.3	T287	55.6	T295	46.7
T280	56.7	T288	51.1	T296	50.3
T281	58.0	T289	50.2	T297	47.8
T282	54.0	T290	52.8	T298	48.1
Note: Temperatures were measured constantly and then averaged every 60-seconds					

Figure 38: Container D cell surface temperature

5.10.10 Nevertheless, surrounding equipment should be monitored for any signs of increasing temperature during a fire to ensure early detection of adverse thermal effects.

5.11 Site Building – Switch & Control Room

L8-SF: Switch & control room small fire / L8-LF: Switch & control room large fire

5.11.1 Based on the initial screening, the hazards associated with the switch and control rooms (in both BB1 and BB2) that require further analysis from the HAZID assessment are limited to small localised fires and large compartment scale fires. These rooms are also expected to house lead-acid backup power systems, which can generate hydrogen gas during charging. This presents a potential flammability / explosion hazard if ventilation is inadequate. There is no credible atmospheric toxic-dispersion scenario, as hydrogen is non-toxic and disperses rapidly.

5.11.2 The switch and control room has various fire risks and are expected to be provided with at least fire detection systems. The common causes of fires are:

a) Poor quality components and installation within the structure. This could lead to component failure and frequent fires.
b) Mechanical and other damage during transport or whilst in use. This could result in damage resulting in fire conditions.
c) Heat build-up during operations of the various systems. This could lead to system degradation and therefore fire conditions within a system.
d) Fire damage from a bushfire or grassfire.

Consequence Quantification

5.11.3 A FiRE analysis of the switch & control room is presented in Figure 39 shows the potential for fire spread from a fire occurring within BB1 and Figure 40 shows the potential for fire spread from a fire occurring within BB2. PCSM BB1 and PCSM BB2 are located at a distance of 4.9 m from Switchroom BB1 and Switchroom BB2 respectively.

5.11.4 The input used for the FiRE analysis are presented in Table 30.

Table 30: FiRE analysis

Building or Equipment	Emitter or Receiver	Dimensions
Switchroom BB1	Emitter	21 m x 2.4 m
PCSM BB1	Receiver	4.9 mx 2.3 m
Switchroom BB2	Emitter	21 m x 2.4 m
PCSM BB2	Receiver	4.9 mx 2.3 m

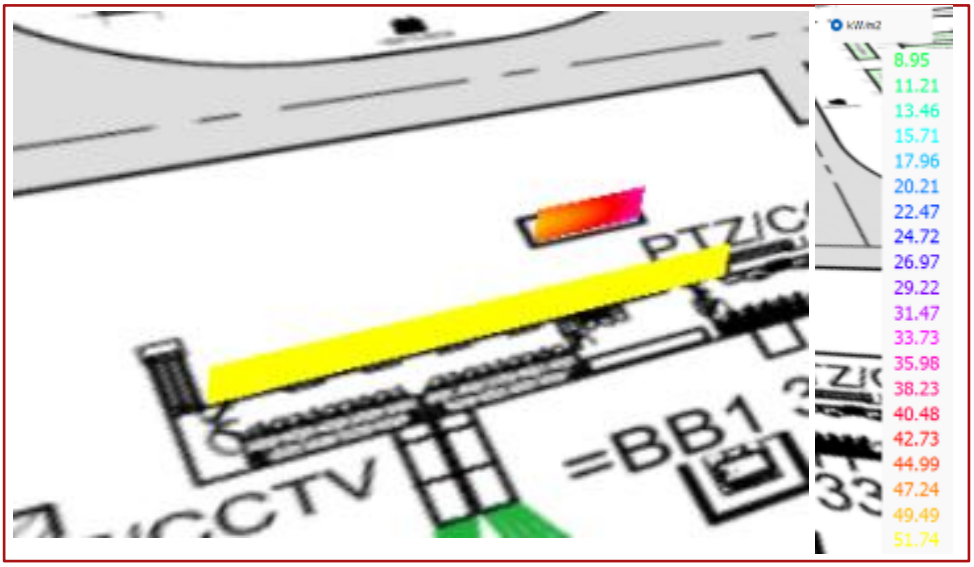


Figure 39: FiRE analysis of a switch & control room in BB1

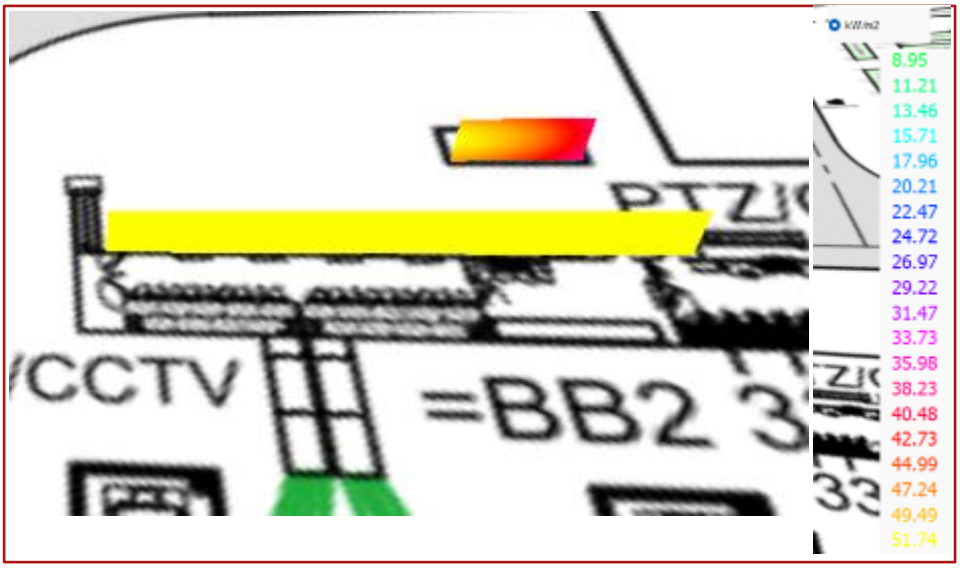


Figure 40: FiRE analysis of a switch & control room in BB2

5.11.5 Based on the above, a fire within the Switchroom BB1 would result in approximately 49.2 kW/m² incident radiation on the neighbouring PCSM, and a fire within the Switchroom BB2 would result in approximately 46.5 kW/m² incident radiation on the neighbouring PCSM.

5.11.6 This level of heat radiation has the potential to cause equipment failure.

5.12 Vehicle

L9-SF: Vehicle small fire / L9-LF: Vehicle large fire

5.12.1 Based on the initial screening, the hazards for vehicles requiring further analysis from the HAZID table are confined to small localised and large compartment scale fires. Vehicles in themselves do not represent a toxic atmospheric dispersion or explosion incident. Therefore, there is no consequence analysis for these incidents will be conducted.

5.12.2 Vehicles will be used on site for the movement of personnel and equipment. We have made the assumption that EVs are not being used on site, therefore have considered internal combustion engines. Vehicles represent a fire threat across the site in the following ways:

a) Inappropriate operations of the vehicle. This could lead to fire due to collision or similar incident.
b) Lack of maintenance of the vehicle.
c) Electric vehicle battery thermal runaway leading to a fire.

Consequence Quantification

5.12.3 For the fire analysis, the credible worst case spill leak from a diesel-powered vehicle would associate with around 120 L of fuel. We are assuming that the pool size is the surface area of 12 m^2. There are limited ignition sources although the collision / incident which cause the leak could result in ignition.

5.12.4 Diesel has been used as the subject fuels within the modelling software using the pool fire model. The outcome of this analysis is presented at Table 31. This modelling was done in GEXCON EFFECTs. To assess the worst case scenario, we have modelled the large fire to show the worst case radiation from a fire.

Table 31: Fire properties of vehicle fire

Fire properties	Credible Worst case leak
Heat release rate (MW)	14.5
Burning Duration (s)	310.2
Flame height (m)	6.27

5.12.5 The result from this analysis is presented in Figure 41 to Figure 47 What can be noted in all situations is that this does not affect any equipment on site due to separation distances.

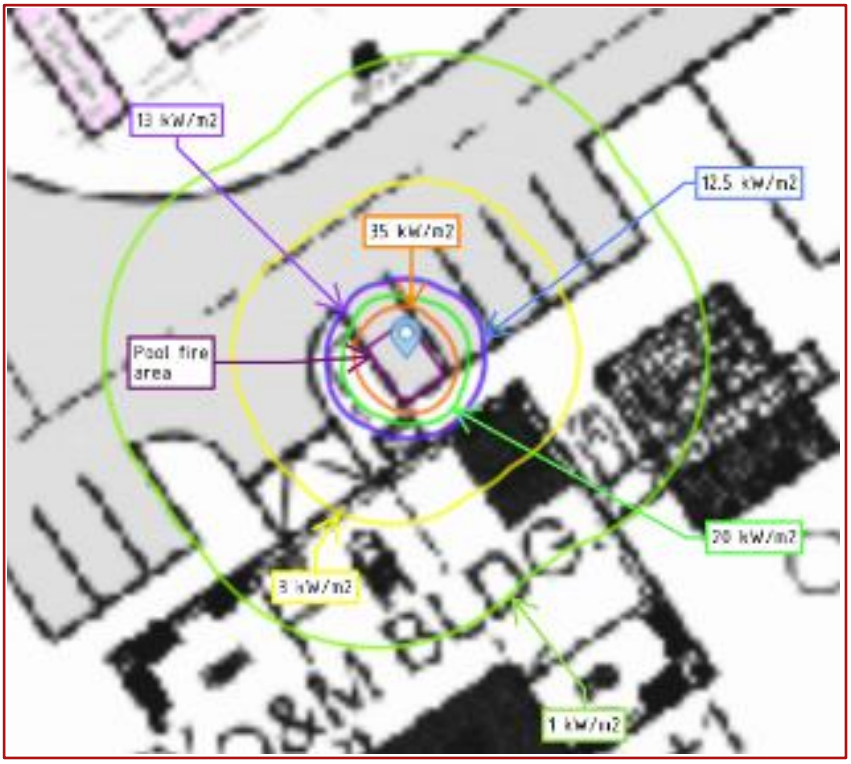


Figure 41: Radiant heat contour plot – no wind



Figure 42: Radiant heat contour plot – no wind side view

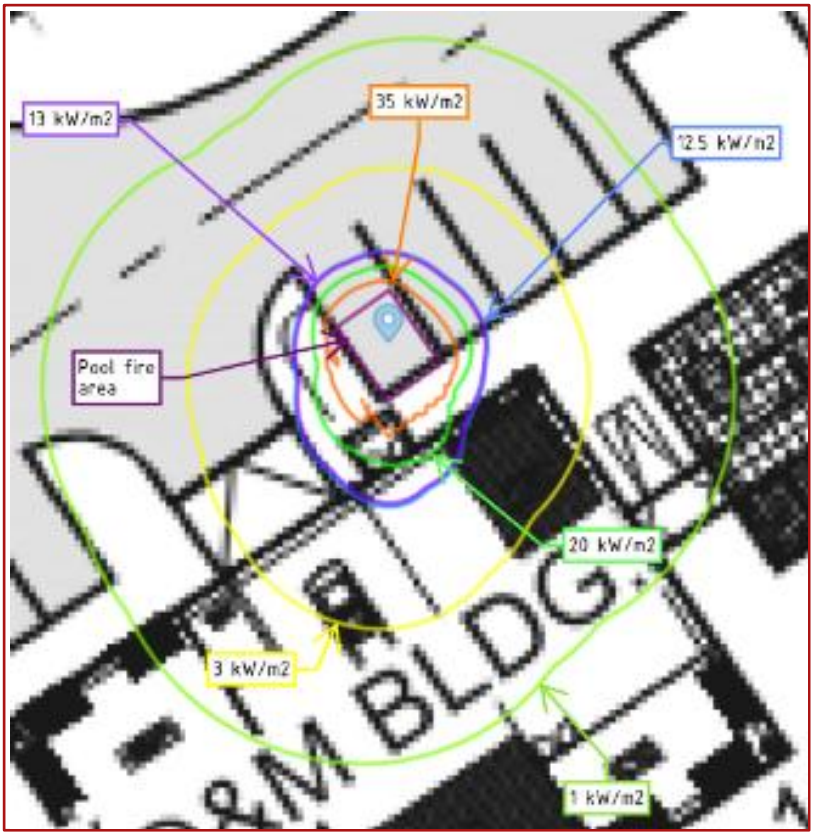


Figure 43: Radiant heat contour plot – average wind

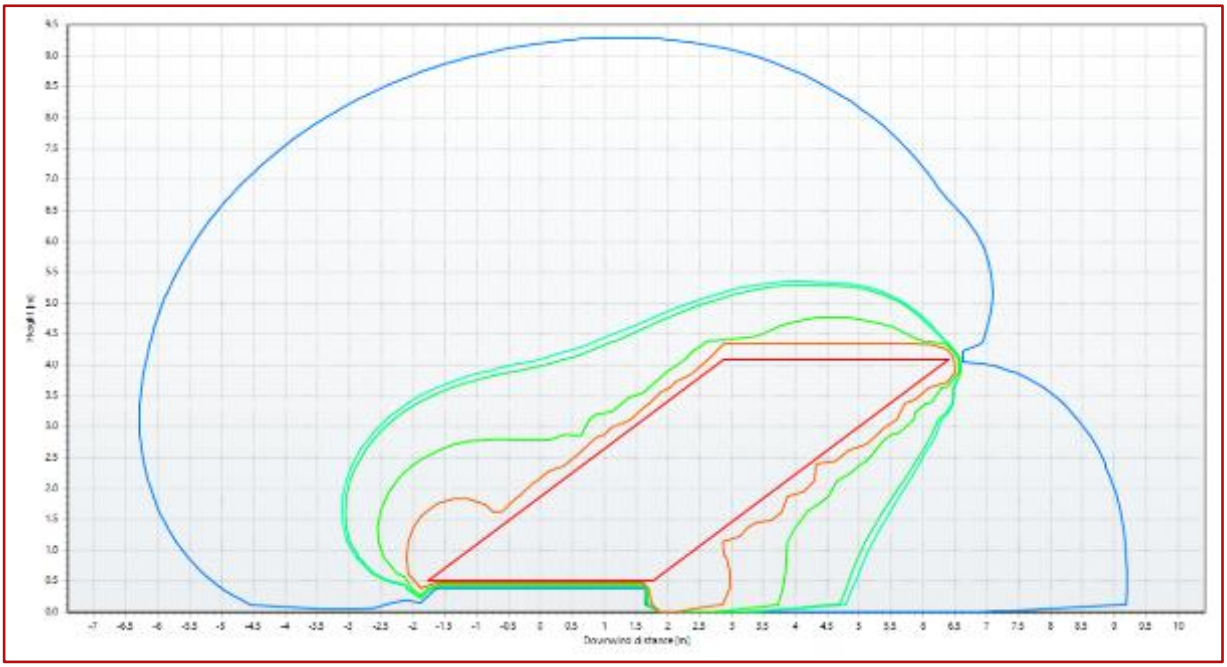


Figure 44: Radiant heat contour plot – average wind side view

5.12.6 A vehicle fire has the potential to cause damage to the neighbouring O&M building due to the close proximity of the parking area. The modelling shows that the vehicle fires has a short duration, and the peak heat release rate reduces rapidly once the plastics and interior materials are consumed.

5.12.7 The calculated incident radiant heat flux at the adjacent building façade is in the order of 12.5–13 kW/m². This level of radiation is consistent with commonly

adopted piloted ignition thresholds for combustible facade materials and therefore presents a credible risk of ignition and fire spread along the building.

5.12.8 A control measure is required to mitigate this risk. It is recommended that the external wall construction of the affected facade be comprised of non-combustible materials in accordance with the NCC requirements, reducing the likelihood of ignition and limiting fire spread potential under the assessed fire scenario.

5.13 Trespassing, vandalism, and animals

Consequence Quantification

5.13.1 This incident relates to unwanted entry to the site by people or animals. There is no inherent atmospheric toxic substances dispersion, fire, or explosion associated with trespassing, vandalism, and animals on site. Although trespassers and vandals may bring unknown fuels for starting a fire.

5.13.2 The potential consequence of this event is undetermined and has not been considered within the HAZID, as it cannot be reliably quantified. Management of this hazard should be addressed through appropriate security measures and operational procedures.

5.14 Boundary fire

Consequence Quantification

5.14.1 The development does not fall within an area identified as bushfire prone under s10.3 of the Environmental Planning and Assessment (EP&A) Act 1979, however, its location relative to a large grassland plain complex places it in a position where it could be impacted by bushfire.

5.14.2 Please refer to the bushfire hazard reports (Section 1.1.4) for the associated outcomes.

6 Initial Risk Assessment

6.1 Introduction

6.1.1 All values are from the level of risk associated with the hazards identified in this report is assessed using the risk matrix presented in Appendix A. This has been developed with reference to relevant legislation and WorkSafe Australia guidance, applying defined likelihood and consequence criteria using descriptors appropriate to the hazard categories considered. Its purpose is to support the evaluation of each hazard and the selection of appropriate control measures to effectively manage the identified risks.

6.1.2 Using the consequence analysis detailed in the preceding section, along with the developed Hazard Log, an initial risk assessment has been developed which shows the risk of each identified hazard.

6.1.3 The initial risk assessment (IRA) has been undertaken considering no control measures have been applied, including where there are inherent control measures that cannot be practically removed. The terminology for likelihood, consequence, and risk level presented in this section are defined in A.5 to this report.

6.1.4 In development of the IRA, data availability for likelihood of events and the reliability of such data varies widely and therefore has required adjustment where described. This is due to the nature of an IRA which requires that no control measures be considered which is opposite to real-world data gathering. In short, it is difficult to obtain failure rate data from any sites/equipment which have had zero control measures including maintenance in place, as such sites either are unlikely to exist or are unlikely to report data.

6.1.5 This section specifically references Appendix A to this report for all values unless otherwise stated.

Table 32: IRA Risk Table

ID	Context	Location & Type	Initial Likelihood Analysis (L)	L	Initial Life Safety Consequence (LSC) Analysis	LSC	Initial LS Risk	Initial Facility Consequence (FC) Analysis	FC	Initial F Risk
L1-SF	Localised BESS fire such as from a single or multiple cell thermal runaway	BESS (L1): Small Fire (SF)	Likelihood of a Li-ion battery fire where the failure rate for Li-ion batteries in a BESS arrangement which could result in a fire. A generic figure of 1 in 40 million per cell years for Li ion batteries from the (Electric Power Research Institute, 2022) has been used.	Probable	Little direct hazard to personnel from single cell events, however without controls this may cascade potentially causing an injury.	Moderate	M	The facility consequence is Minor as the fire would only affect the BESS unit in thermal runaway	Moderate	M
L1-LF	Major failure of multiple systems leading to burnout of a full BESS unit	BESS (L1): Large Fire (LF)	Likelihood of a Li-ion battery fire where the failure rate for Li-ion batteries in a BESS arrangement which could result in a fire. A generic figure of 1 in 40 million per cell years for Li ion batteries from the Electric Power Research Institute, 2022) has been used.	Probable	The consequences are seen to be Major as a fire has the potential for serious injury or illness requiring immediate admission to hospital as an inpatient.	Major	H	The facility consequence is moderate as the fire would affect the surrounding BESS group.	Major	H
L1-GR	Major failure of multiple systems leading to venting of a full BESS unit. This could be thermal runaway with or without a fire. This scenario considers only the toxic effects.	BESS (L1): Gas Release (GR)	Likelihood of a Li-ion battery fire where the failure rate for Li-ion batteries in a BESS arrangement which could result in a fire. A generic figure of 1 in 40 million per cell years for (all) Li ion batteries from the (Electric Power Research Institute, 2022) has been used.	Occasional	The toxic gases produced have the potential at close range that it could kill or result in permanent injuries to a person.	Critical	H	The facility consequence is Minor as the toxicity dispersion not likely to affect systems on site	Minor	L
L1-EX	Significant failure leading to multiple cells venting to produce a vapour cloud explosion	BESS (L1): Explosion (EX)	A thermal runaway event would only result in an explosive atmosphere if sufficient flammable gas were generated, the deflagration panels / venting systems failed, and an ignition source was present.	Improbable	The overpressure generated is sufficient at close range, such that it could kill or result in permanent disability of a person.	Critical	M	The overpressure profile could damage the adjacent BESS units and nearby electrical systems.	Critical	M
L2-SF	Localised cable fire within BESS enclosure or within a cable tray in switch room.	Cables (L2): Small Fire (SF)	Failure rates for underground power cables are approximately 1.3 incidents per 161 km per year, with 0.4 and 0.2 incidents for joints and terminations, respectively (EPRI, 2023). Given the cable network, faults are likely over the facility's life; however, a fire would require a sustained ignition source and sufficient combustible material, making the overall fire likelihood lower therefore it has been reduced by a magnitude of 2.	Occasional	Consequences are seen to be Critical for personnel as it could result in electrocution	Critical	H	Facility consequence is Major as the fire is likely to impact the BESS units, transformers and other infrastructure	Major	M
L3-SF	MV transformer small fire - Localised small fire from small source or spillage.	MV Transformer (L3): Small Fire (SF)	Data for large power transformers indicate failure rates in the order of 0.3 % per annum for major failures in large units (> 100 kV). As the unit under assessment is a dry-type transformer, an adjusted failure rate of 0.1 % per annum is adopted for the purpose of this risk assessment (Tenbohlen, 2023). The failure does not guarantee a fire, so a lower magnitude level has been chosen, i.e. rare.	Rare	Consequences are seen to be Critical for personnel as it could result in significant burns	Critical	L	The facility consequence is Major as the fire is likely to impact the BESS units and / or other infrastructure.	Major	VL
L4-SF	PCSM - Localised small fire from small source or spillage.	PCSM (L4): Small Fire (SF)	Data for large power transformers indicate failure rates in the order of 0.3 % per annum for major failures in large units (> 100 kV). As the unit under assessment is a dry-type transformer, a conservative adjusted failure rate of 0.1 % per annum is adopted for the purpose of this risk assessment (Tenbohlen, 2023). The failure does not guarantee a fire, so a lower magnitude level has been chosen, i.e. rare.	Rare	Consequences are seen to be Critical for personnel as it could result in significant burns	Critical	L	The facility consequence is Major as the fire is likely to impact the BESS units and / or other infrastructure.	Major	VL
L5-SF	Diesel generator small fire - Localised small fire from small source or spillage.	Diesel Generators (L5): Small Fire (SF)	Likelihood of a diesel generator fire comes from (Electric Power Research Institute / US Nuclear Regulatory Commission, 2005), where it notes diesel generators have a fire at a generic rate of 2.1E-2 per year in a well maintained environment. This results in a fire every 47 years.	Occasional	The consequences are seen to be minor for personnel are not expected to have any noticeable injuries	Minor	L	No facility impact is expected as the combustible liquid would be contained.	Minor	L
L5-LF	Diesel generator large fire - major fire assuming full contents of transformer released	Diesel Generators (L5): Large Fire (LF)	Likelihood of a diesel generator fire comes from (Electric Power Research Institute / US Nuclear Regulatory Commission, 2005), where it notes diesel generators have a fire at a generic rate of 2.1E-2 per year in a well maintained environment. This results in a fire every 47 years.	Occasional	The consequences are seen to be moderate for personnel as it could result in injuries that would require hospitalisation.	Moderate	M	The facility consequence is minor as the fire is not expected to spread or effect the BESS units and other infrastructure	Minor	L

ID	Context	Location & Type	Initial Likelihood Analysis (L)	L	Initial Life Safety Consequence (LSC) Analysis	LSC	Initial LS Risk	Initial Facility Consequence (FC) Analysis	FC	Initial F Risk
L6-SF	AUX transformer small fire - Localised small fire from small source or spillage.	Aux Transformer (L6): Small Fire (SF)	Data for large power transformers indicate failure rates in the order of 0.3 % per annum for major failures in large units (> 100 kV). As the unit under assessment is a dry-type transformer, a conservative adjusted failure rate of 0.1 % per annum is adopted for the purpose of this risk assessment. The failure does not guarantee a fire, so a lower magnitude level has been chosen, i.e. rare.	Rare	Consequences are seen to be Critical for personnel as it could result in significant burns	Critical	L	The facility consequence is Major as the fire is likely to impact the BESS units and / or other infrastructure.	Major	VL
L6-LF	AUX transformer small fire - Localised small fire from small source or spillage.	Aux Transformer (L6): Small Fire (SF)		Rare	Consequences are seen to be Critical for personnel as it could result in significant burns	Critical	L	The facility consequence is Major as the fire is likely to impact the BESS units and / or other infrastructure.	Major	VL
L7-SF	O&M small fire - localised small fire due to storage of combustibles.	O&M Building (L7): Small Fire (SF)	The building is vulnerable to the standard fire hazards, such as electrical fault and maintenance incidents, as well as the less common hazards relates to the storage of chemicals and dangerous goods. Likelihood of a site building catching fire if no consideration for the relevant standards and industry practices is Probable	Probable	The consequences are seen to be Critical for personnel as it could result in a death	Critical	VH	The facility consequence is Major as the fire could be expected to spread and have serious impact across the site	Major	H
L7-LF	O&M large fire - major fire assuming fire spread within the building.	O&M Building (L7): Large Fire (LF)	The building is vulnerable to the standard fire hazards, such as electrical fault and maintenance incidents, as well as the less common hazards relates to the storage of chemicals and dangerous goods. Likelihood of a site building catching fire if no consideration for the relevant standards and industry practices is Probable	Probable	The consequences are seen to be Critical for personnel as it could result in a death	Critical	VH	The facility consequence is Major as the fire could be expected to spread and have serious impact across the site	Major	H
L8-SF	Switch room small fire - localised small fire due to storage of combustibles.	Switch room (L8): Small Fire (SF)	Likelihood of a switch and control room fire comes from (Electric Power Research Institute / US Nuclear Regulatory Commission, 2020) where it notes failure rates of main control boards which could result in a fire is 2.05 E-3 per board per year.	Probable	The consequences are seen to be Critical for personnel as it could result in a death	Critical	VH	The facility consequence is Major as the fire could be expected to spread and have serious impact across the site	Major	H
L8-LF	Switch room large fire - major fire assuming fire spread within the building.	Switch room (L8): Large Fire (LF)	Likelihood of a switch and control room fire comes from (Electric Power Research Institute / US Nuclear Regulatory Commission, 2020) where it notes failure rates of main control boards which could result in a fire is 2.05 E-3 per board per year.	Probable	The consequences are seen to be Critical for personnel as it could result in a death	Critical	VH	The facility consequence is Major as the fire could be expected to spread and have serious impact across the site	Major	H
L9-SF	Vehicle fire - localised fire which may impact the car.	Vehicles (L9): Small Fire (SF)	If relevant standards, industry practices, and safe driving procedures are not implemented, the likelihood of a vehicle fire is assessed as Probable. Without such controls, it is reasonable to expect that a vehicle incident could occur more than once within a ten-year period. However, the likelihood of a vehicle crash leading to fire is lower, as ignition requires additional contributing factors such as fuel release and an effective ignition source.	Occasional	The consequences are seen to be Critical for personnel as it could result in serious injuries or possibly death.	Critical	H	The facility consequence is Moderate as the fire would be contained.	Moderate	M
L9-LF	Vehicle large fire - complete loss of fuel from car resulting in	Vehicles (L9): Large Fire (LF)	If relevant standards, industry practices, and safe driving procedures are not implemented, the likelihood of a vehicle fire is assessed as Probable. Without such controls, it is reasonable to expect that a vehicle incident could occur more than once within a ten-year period. However, the likelihood of a vehicle crash leading to fire is lower, as ignition requires additional contributing factors such as fuel release and an effective ignition source.	Occasional	The consequences are seen to be Critical for personnel as it could result in serious injuries or possibly death.	Critical	H	The facility consequence is Major as the fire could be expected to spread if there are no control measures being applied.	Major	M

7 Control Measure Analysis

7.1 Introduction

7.1.1 This section analyses different control measures considered for the project including a description of each control measure, the impact on a hazard or hazards it may have, whether that control measure is recommended or not, and justification as to why a recommendation has been made.

7.1.2 In reference to HIPAP 2, this section fulfills the role of analysing requirements for prevention, mitigation, detection, and protection in relation to fire safety hazards at the site.

7.1.3 In HIPAP-2 terms, prevention encompasses the physical design features and operational or managerial controls that minimise the likelihood of a fire initiating or escalating. Mitigation refers to the design and operational measures that act to limit fire propagation or escalation once a hazardous condition has occurred, thereby reducing the potential consequences of the event. Detection relates to the systems and arrangements, both hardware and procedural, that identify fire precursors (such as flammable atmospheres or overheating) or the early onset of combustion (smoke or flame), enabling prompt response actions and activation of protection systems.

7.1.4 The following sections within HIPAP-2 deal with the following control measures:

a) Section 2.4 defines the key prevention controls for elimination of ignition sources, hazardous-material minimisation, segregation, bunding, housekeeping, security, and safe systems of work.
b) Sections 2.5 and 2.6 outline required detection and protection controls to prevent escalation.
c) Section 2.7 details the firefighting supply and water demand to consider.
d) Section 2.8 addresses additional mitigation and containment controls for fire-water management
e) Section 2.9 deals with first-aid firefighting arrangements and equipment

7.2 Control Measure Analysis

7.2.1 Table 33 sets out all the considered / proposed control measures and notes the measures that are recommended to be applied. This table provides the outcome of the investigation and selection of control measures for this location. The sequence of analysis is as follows:

a) Each type of control measure is provided with an ID and title so it can be tracked going forward.
b) Next the control measure type as either ‘preventative’, i.e., reduces the potential for the incident, ‘detection’, i.e., notification of an incident occurring, and/or ‘responsive’, i.e., a measure that responds to manage an incident control.

c) Then the control measure is described and a system impact of how it relates to the hazards / incident provided.
d) Finally, whether this control measure is recommended or not and a justification for that position is provided.

7.2.2 Where applicable, Australian Standards have been applied directly to the control measures. Where direct application was not practicable, the Standards were adapted to reflect the specific characteristics of the site.

7.2.3 The primary objectives of these control measures are to protect personnel and minimise facility and property damage. While considerations for reducing environmental impact and supporting business continuity are included, these aspects are not the primary focus of this analysis.

Table 33: Proposed control measures for the site

#	Control Measure Title	Type	System Description	System Impact	Status	Justification
CM1	Safe Practices	Prevention, Response	Emergency management plan, operational procedures, and the like to instruct staff how to safely conduct business at the site.	Training and enforcement of safe practices at the site to reduce the potential for an incident or injury during response to an incident.	Y	This is required under law and can have an impact on likelihood of an incident or safety of life.
CM2	Two-way communication	Detection	Two-way communication between the operator and the WCS operator / site manager so that an incident can be rapidly notified, and procedures activated.	Provides an effective means to raise an alarm related to an incident.	Y	Rapid communications
CM3	Portable fire extinguishers	Response	Portable fire extinguishers are to meet AS 2444:2001 (Standards Australia, 2001). Details of the arrangement of portable fire extinguishers are provided in Section 9	Localised small fires can be successfully managed by portable fire extinguishers.	Y	To deal with small fires to ensure escalation doesn't occur.
CM4	Fire hose reel	Response	Fire hose reel that meets AS 2441: 2009 (Amdt 1) (Standards Australia, 2009) discharges water. This system could be used to cool adjacent systems.	The application of water to energised electrical systems may compromise equipment integrity and continuity of operations, potentially resulting in broader functional disruption. The use of a fire hose reel to cool adjacent systems has the potential to place the operator at risk.	N	Fire could involve electrical components (electrocution hazard) or be too large for extinguishment using fire hose reels (direct fire hazard).
CM5	Fire Brigade	Response	A large fire is to be responded to by the fire brigade. Associated with this control measure is a fire hydrant system that provides coverage and water supply for the site as set out in AS 2419:2021 (Standards Australia, 2021). Redundant fire hydrants may be required to deal with thermal radiances and toxic smoke. More information is provided in Section 9	This is the emergency service agency that specialises in these types of incidents. The fire brigade requires a fire hydrant system to undertake their operations.	Y	The fire brigade must be notified if the first aid site response is unsuccessful or inappropriate.
CM6	Selection of systems	Preventative	From BESS unit to site transformer, selection of systems that are appropriate for the operations and the environment it can be located at. This to be shown by compliance with standards and testing certification. Appropriate separate of systems will also be employed. Rodent proof mesh to protect openings within containers, enclosures, external electric system, and the site building.	Appropriately selected and certified systems. Systems are less likely to undergo a fire event or have unplanned downtime.	Y	To maintain system operations and limit fire risk.
CM7	Installation and Maintenance of the system	Preventative	Correctly qualified and experienced personnel are to be used to install and maintain the system.	Using appropriately qualified personnel can reduce the likelihood of a failure during installation or maintenance.	Y	Many systems failure / have an incident due to incorrect installation or poor maintenance.
CM8	Arrangement of the system	Preventative and Response	The arrangement of a system can lower the potential for an incident as well as the escalation of the incident. Site systems surrounded by appropriate ground works and access via paved roads.	These arrangements can protect the systems from fire spread.	Y	This control measure can limit the potential for a fire event to occur or spread
CM9	Vegetation fuel load	Preventative	Appendix 4 to the NSW Planning for Bushfire Protection 2019 to be complied with, especially the two weeks before and during the NSW Bushfire Danger Period.	Limit combustible material across the entire site, especially during the bushfire danger period when there is a greater risk of fire.	Y	Limit the potential for fire initiation and spread across the entire site.

#	Control Measure Title	Type	System Description	System Impact	Status	Justification
			The site will also comply with all the requirements contained within Bushfire Assessment reports (Section 1.1.4).			
CM10	Site Security	Preventative	Resist the movement of unauthorised people and animals onto the entire site by: a. Enclosing the site with a security fence. b. CCTV at strategic locations across the site which will include motion sensing and alarm system to notify staff if present. c. Gates and associated site building within the BESS area are to be covered by IR cameras.	The security fence can resist the movement of trespassers and animals onto the entire site. Monitoring cameras can permit the WCS operator to confirm if trespasser or animals have accessed the BESS area.	**Y**	These measures can limit the risk of damage / fire across the entire site.
CM11	First Aid kit	Responds	The first aid kit is to be appropriate for working in remote areas. This kit shall include a portable eye wash. This kit shall be located in the O&M Building.	Support first aid to workers on site.	**Y**	Provide first aid response to an incident.
CM12	Personal protective equipment (PPE)	Preventative and Responds	All personnel working with high voltage systems shall have approved PPE for this environment.	Protect any staff present from injury relating to high voltage work environment.	**Y**	PPE needs to be used by staff present when working on high voltage systems.
CM13	Site wide incident notification	Responds	Within building this audio notification devices shall comply with the AS 1670.1:2018 building occupant warning system requirements. The outdoor warning system shall consist of a horn / strobe per BESS to ensure sitewide notification of an incident. These will be connected to the main FIP. Normally, the BESS fire alarm control panel supports outdoor type horn/strobe (all-in-one) for notification purpose.	Notification system which can connect into the fire indicator panel.	**Y**	Rapid communication of an incident.
CM14	Fire truck access	Responds	A hardstand area for fire trucks shall be provided at each firewater tank, i.e., in front of any suction-connection outlet as required within AS 2419.1 (Standards Australia, 2021). Road access should be in line with Fire Safety Guideline: Access for fire brigade vehicles and firefighters (FRNSW, 2019).	The fire brigade needs accessible roads across the site and have an alternative exits if required.	**Y**	To allow the fire brigade appropriate access across the site.
CM15	BESS unit door management	Preventative	The BESS units are to be closed and locked on site. A heavy-duty lock of industrial standard will be applied to the enclosures to ensure vandals and trespassers are unable breach the container and leave the door open. Access to these doors will be granted as required by the principal contractor – keys will be kept in a locked box on site.	This would limit the potential for unauthorised access.	**Y**	Limit access, but these BESS units are already in a restricted area.
CM16	Landscaping	Preventative	Any landscape buffer for the site shall be designed such that its highest BAL is 12.5 to electrical systems and site building across the site. These BAL shall be as defined in AS 3959:2018 (Standards Australia, 2018). Structures at the site shall have the control	Limit the heat flux that could be received during a fire off site to infrastructure on site.	**Y**	Limit the fuel load just outside of the site

#	Control Measure Title	Type	System Description	System Impact	Status	Justification
			measures called up in AS 3959:2018 (Standards Australia, 2018) for BAL-12.5.			
CM17	Water drainage and containment	Response	The entire site has distinct water catchment areas is surrounded by a storm water drains that feeds into a catchment pond. The volume of contaminated water is presented at Section 8	This systems would move any potential contaminated water to a holding pond.	Y	Environmental regulation place controls over the emission of contaminated water after a fire
CM18	System monitoring	Preventative and Detection	All system sensor data to be shared, with notification related to potential / actual incidents. Fire indicator panel alarms and fault notification to be shared.	Monitor the site and its associated systems to make sure if an issue occurs notification occurs.	Y	Notification of an issue, fault, or an incident.
CM19	RMS incident support	Responds	The RMS operator will require clear procedures for engaging and support emergency services. This would include when to call them, providing system data to them, and connecting them with system experts.	The RMS operator is the one staff member associated with the site, who can be expected to be available during an incident.	Y	Support the response to an incident
CM20	Impact protection / Speed Limit	Preventative	Protection of systems from vehicle damage is to be achieved by mechanical impact devices such as bollards or bollards with chains near the roads associated with these systems. The onsite speed limit of 20 km/hr and between external electrical system 10 km/hr	Limit speed can reduce the impact force. Mechanical impact devices provide separation between the vehicle and system.	Y	This can remove one of the main mechanisms for an incident on site.
CM21	Lightning protection	Preventative	Electrical systems and their associated cabling arrangements are to have lightning protection as required under AS 1768: 2021, (Standards Australia, 2021).	Lightning can be expected to occur yearly across this site.	Y	So that systems on site are protected from lightning
CM22	Ember attack protection	Preventative	AS 3959: 2018 (Standards Australia, 2018) sets out the required measures to be applied to achieve ember protection.	This is to stop embers entering structures that could result in a fire starting within the structure.	Y	Systems on site are protected from ember attack.
CM23	BESS unit explosion ventilation	Preventative and Responds	Combustible gas detection to be used in conjunction with approved / compliant NFPA 69 explosion ventilation system to be fitted to the BESS units.	This NFPA standard sets out requirements for explosion exhaust ventilation for environments where vapour cloud explosion could occur.	Y	To mitigate the explosion event which could occur.
CM24	Arc flash assessment	Responds	Arc flash report in accordance with industry practices.	Understand the risk of arc flash with respect to frequency and travel distance.	Y	Protection of fire fighters and others during an incident.
CM25	Vibration protection – BESS unit	Preventative	Follow the installation requirements for the BESS unit so that vibration is limited.	BESS unit vibrating can result in thermal runaway.	Y	Limit the potential for vibration.
CM26	Cyber-attack protection	Preventative	Cyber protection to achieve a SIL 3 from attack and to consider the following measures: a. Local laptop access by remote viewer with virtual protection network. b. Computer firewalls, MILS cyber protection specifications. c. No external access to third parties without permission and approved use case. d. Restricted timeframe for third parties accessing for maintenance. e. Control system design to achieve specified security integrity level.	Protect the BESS unit from cyber-attack.	Y	Mitigate the risk of cyber-attack.

#	Control Measure Title	Type	System Description	System Impact	Status	Justification
			f. BESS temperature cutoff values set on-site in firmware and cannot be changed without Hithium base code access.			
CM27	Aerosol fire suppression	Responds	Aerosol fire suppression system that discharges a potassium based substance.	Aerosol systems can be effective in suppressing typical fires within a compartment but can have issues in suppressing BESS fires because the aerosol has relatively low cooling capacity and its interference with the chemical chain reaction is not effective against lithium-ion battery fires because oxygen is generated by the battery during the thermal runaway process.. Data to show the effectiveness of this system for a BESS fire involving lithium-ion batteries is unclear.	**CR***	These suppression systems can be effective in suppressing typical fires within a compartment. However, the testing carried out for it does not show any benefit relative to the outcomes of the UL9540A test without fire suppression.
CM28	Dry pipe fire suppression	Responds	Dry pipe sprinkler system, which would require a water source to be permanently or manually connected.	Internal water sprinkler system can knock down a Li-ion cell / module fire as well as cooling adjacent items within the BESS unit. The sprinkler system could also cause short circuits and similar electrical issues, which could damage additional cells, increase the number of cells involved in thermal runaway and increase the fire and explosive potential. For this reason, a 'let it burn' strategy is generally used across BESS facilities, which focusses on avoiding fire spread to adjacent equipment, vegetation and buildings.	**CR***	The application of water to a BESS enclosure undergoing thermal runaway may influence the generation and behaviour of combustion by-product gases. Contact between water and decomposing electrolyte (particularly lithium hexafluorophosphate, $LiPF_6$) can increase local hydrolysis reactions, potentially increasing the instantaneous formation of hydrogen fluoride (HF). The connection point is at the bottom of the BESS unit and for the fire brigade to use it, it could be dangerous. This system is provided as it is integrated into the unit but is only to be used as the discretion of the responding fire authority. Details of the system are provided in Section D.5.
CM29	Fire Indicator Panel (FIP)	Detection	Fire detection and alarm systems, which meet AS 1670.1:2018 (Standards Australia, 2018) across the site are to connect and use the master FIP located within each control room (BB1 & BB2 each have independent systems). Installation of a local FIP in the O&M building.	Following standard practices for the management, tracking, monitoring, and alarming associate with the fire detection and monitoring system.	**Y**	To make sure that fire alarm system is monitored and alarm received by the remote monitoring site.
CM30	Dangerous goods and chemical cabinets	Preventative	Dangerous goods and chemicals are to be stored in cabinets that align with their dangerous good class or type of chemical.	Although the amount of dangerous goods would relate to minor store or even smaller, cabinet provide a physical control to these substances.	**Y**	Limit the potential for spills and fire.
CM31	Self-bunded tanks	Preventative	The diesel fuel tank is to be self-bunded, with detection of leakage.	Contain any leak and notify the operator of a leak.	**Y**	Limit the risk of a leak and fire.
CM32	Bunding – Diesel generators and tanks	Preventative and Responds	Each diesel generator is to be located within a bund.	Contain any leak of combustible liquid from the diesel generators tanks. The diesel generators themselves are to be bunded to also contain any leaked combustible liquid.	**Y**	Containment and notification of a leak.

#	Control Measure Title	Type	System Description	System Impact	Status	Justification
				This manages the environmental issues and limits the potential for fire / fire spread.		
CM33	Diesel generator enclosure	Preventative and Detection	The diesel generators shall have an enclosure, which can protect it from the environment. There shall also be a thermal (heat) detector located inside of the enclosure approx. in the centre of the enclosure top. This heat detector shall be connected to the fire indicator panel and activate on fire within the enclosure.	Protect the diesel generator and notification of a fire.	Y	Protection of the diesel generator.
CM34	Diesel generator fire isolation	Preventative and Responds	On detection of a fire within the diesel generator enclosure the fuel supply is to be automatically shut off.	Removal of fuel can limit the fire event.	Y	Removal of fuel from a fire.
CM35	Emergency services	Responds	Access and procedures of when to call emergency services.	Application of organisations who can deal with specific issues.	Y	Use of emergency services to protect staff members and facilities.
CM36	Fire and smoke detection and alarm system	Detection	Site structures, not BESS units or electrical system, are to be fitted with an AS 1670.1:2018 (Standards Australia, 2021) fire detection and alarm system. This is required to be generally smoke detectors; but at locations where false alarms are likely then heat detectors are to be used.	Standard fire detection and alarm system used in Australia for structures.	Y	Detection and notification of a fire in a structure.
CM37	Automatic power shutoff to switch & control room	Detection and Responds	The switch and control rooms are to be fitted with an AS 1670.1:2018 (Standards Australia, 2021) fire detection and alarm system.. If the systems activate, i.e., fire detection, then the power to this building is to be isolated automatically.	Reliance on a single detection system could lead to power isolation on false activation.	Y	Remove power from fire generation within the switching room.
CM38	Fitted nitrogen based fire extinguishing system (Switchboard room)	Responds	Fit a nitrogen base gaseous fire extinguishing system to the switchboard room that meets AS 4214:2018 (Standards Australia, 2018).	This system can the potential to limit fire damage in a switchboard room fire.	N	The switchboard room contains primarily metallic electrical equipment with minimal combustible material. The primary control for this space is electrical isolation not suppression. This system is primarily a property protection item and the design team has elected not to apply it for property protection.
CM39	Management Plans	Preventative and Responds	Associated with this Risk Management Plan and fire safety study the following management plans to be developed and issued: a. Emergency Management Plan, b. Evacuation Plan, and c. Emergency Service Information Package.	Meet the objectives of the WHS legalisation for the management and communication of safety at a site.	Y	Appropriate management plans related to fire safety
CM40	Access to meteorological data	Preventative and Detection	Site to have environmental sensors which can inform at least temperature, rainfall, humidity, and wind speed. Additionally, two windsocks are to be located at the site. One windsock at the main	Provide appropriate accuracy data for the management of the site. Show the fire brigade the site's wind direction.	Y	Weather data needed for operations and fire fighting.

#	Control Measure Title	Type	System Description	System Impact	Status	Justification
			entrance and the other near the detention basin.			
CM41	Site housekeeping	Preventative	At least monthly site inspection to remove unnecessary combustible material from site.	Limit the potential for fire spread.	Y	Combustible waste can collect on site and needs to be managed.
CM42	'No Trespassing' signage	Preventative	There shall be signs on the security fence stating, 'NO TRESPASSING'. These signs shall be fade and corrosion resistant, made from metal and mechanically fixed to the fence. The letters shall be at least 50 mm in height and the letter colour black and the background white	To ensure it is clear that the trespassing is not permitted.	Y	Required to make it clear that access is limited.
CM43	Rodent and vermin protection	Preventative	Conduct regular clean up the site of rubbish and food material. Rodent and vermin proofing to be fitted to structures opening. As required, set bait / traps.	Restrict the effect rodent and vermin to impact the site.	Y	Management of rodent and vermin is required across the site.
CM44	Site Access	Responds	The site must meet the requirements set out in the FRNSW Guideline: Access for fire brigade vehicles and firefighters. All access gates, including emergency access gates, to the entire site shall be openable via a 003 key, site-specific key deposited in a locked box outside the site perimeter, or a copy kept at the local fire station, or similar.	To support rapid access for the fire brigade.	Y	Provide the RFS with reliable site access.
CM45	Fire Hydrant System	Responds	Refer to Section 8.3 for additional information	To support fire fighting activities at the site.	Y	Provide the RFS with a reliable water source for firefighting activities. Hydrants will be positions in accordance with the fire water requirements.
CM46	Dangerous Goods Assessment Report (DGAR)	Preventative	Prepare a DGAR within the O&M buildings [BB1 & BB2] to evaluate the risks associated with hazardous substances.	The assessment provides a structured basis for determining appropriate control measures ensuring compliance with WHS legislation, Australian Standards, and insurer expectations.	Y	Enables the facility to operate safely while demonstrating that risks have been reduced so far as reasonably practicable.
CM47	LEL Detection	Responds	To detect a gas leak. These detectors would be located either next to the dangerous goods ventilation system exhaust air vent or located at next to high fire risk items such as handling areas or non-intrinsically safety systems within a hazard zone.	This is to detect the most likely hazard at this location.	N	Support early detection of an LEL issue, which could lead to a fire / explosion.
CM48	Dangerous Goods Ventilation	Responds	A dangerous goods ventilation system which meets the requirements set out in AS 1940 is to be fitted within this area.	Remove volatile and toxic vapours from the warehouse and dilatation of them into the atmosphere.	N	Volatile vapours could lead to a fire and toxic vapours are a risk to the personnel safety.
CM49	External Wall construction [BB1 – O&M building]	Preventative	External wall construction of the O&M building / affected façade be comprised of non-combustible materials in accordance with the NCC requirements	Reduces the likelihood of ignition and limiting fire spread potential under the assessed fire scenario.	Y	Reduces the likelihood of fire spread and the potential life safety to any staff present.

*Client required

8 Firefighting Water & Containment Analysis

8.1 Introduction

8.1.1 This section reviews the need for firefighting water for fire brigade intervention operations at the site, and to the extent necessary, the approach to containment of that water.

8.2 Determination of Fire Fighting Water Requirements

8.2.1 For this project, the BESS equipment is understood to pose the greatest firefighting challenge as batteries can be difficult to suppress due to thermal runaway, release toxic and flammable gases, and are prone to reignition after extinguishment. For these reasons the firewater requirements for the site are based on a major BESS fire.

8.2.2 The above is further supported by the consequence analysis carried out to date, and that all buildings on site are less than 500 m^2, so are not prescribed a dedicated fire hydrant system by the National Construction Code. Nonetheless, the fire hydrant system provided for the BESS is also to be arranged to achieve coverage of site buildings.

8.2.3 Firefighting water is generally used either for suppression/control of a fire, or protection of exposures to prevent a fire from spreading/escalating.

8.2.4 In the case of BESS, direct water application is generally not advised for firefighting operations. Research, such as publications from FRNSW SARET, have clearly indicated that applying water directly to a battery results in increased HF production, potentially increasing the hazard to firefighters. Due to the risk of re-ignition, advice from manufacturers has also largely been to protect the site from escalation and allow the fire affected unit to burnout (Bouldercombe Battery Project in Rockhampton BESS fire).

8.2.5 Based on the above, the primary potential use of firewater on site is for exposure protection, to mitigate the risk of a BESS fire spreading to adjacent BESS or other related equipment. This involves applying cooling water to adjacent equipment during a fire, to prevent fire spread, particularly for adjacent BESS units.

8.2.6 The BESS for this project has been subject to a LSFT in an arrangement based on CSA C800, which includes multiple BESS units in close arrangement and is a fully destructive test. Figure 45 shows the arrangement.

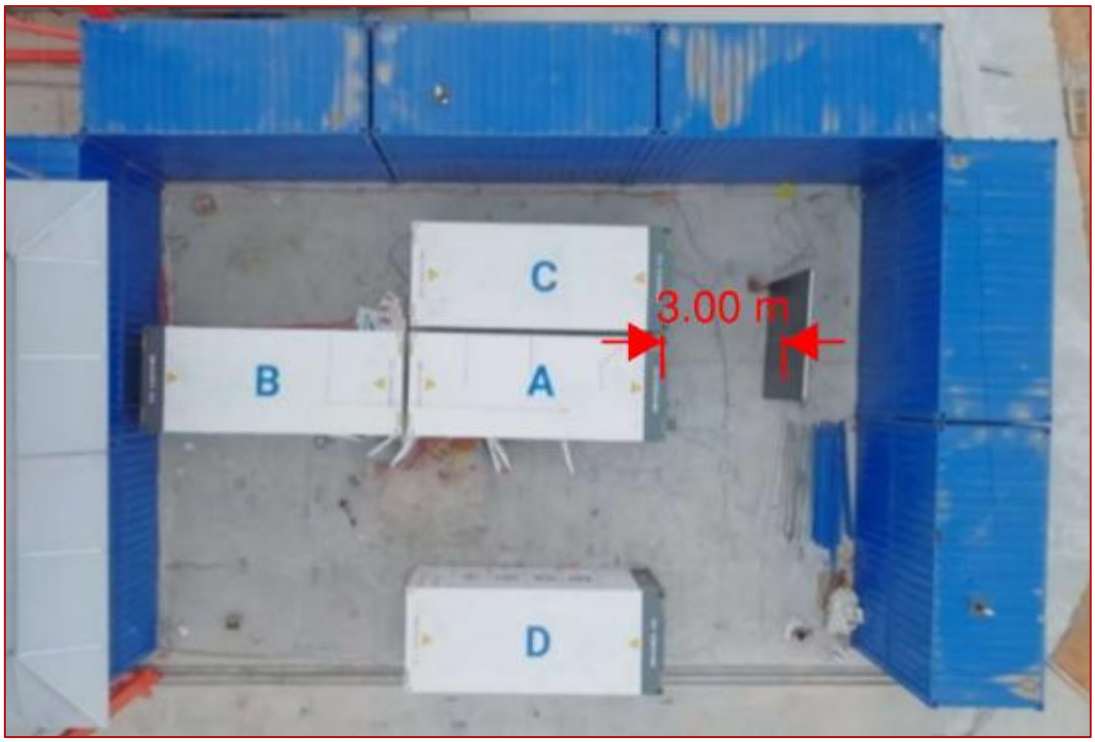


Figure 45: Top view of testing site with enclosure (A) in the middle.

8.2.7 This full-scale test, carried out with all active systems shut off, and the doors to A (fire origin) open and thus exposing BESS D to the most heat, did not result in fire spread. This LSFT demonstrated that the Hithium BESS should not require any cooling water to mitigate fire spread.

8.2.8 Despite the above, the site is to be provided with an AS 2419.1:2021 fire hydrant system, designed for open yard protection. For the project, each area of BESS separated by vehicle circulation can be considered a separate yard, approximately shown in Figure 46. On this basis an individual yard is < 3,000 m² and therefore only requires a single fire hydrant to operate at once.

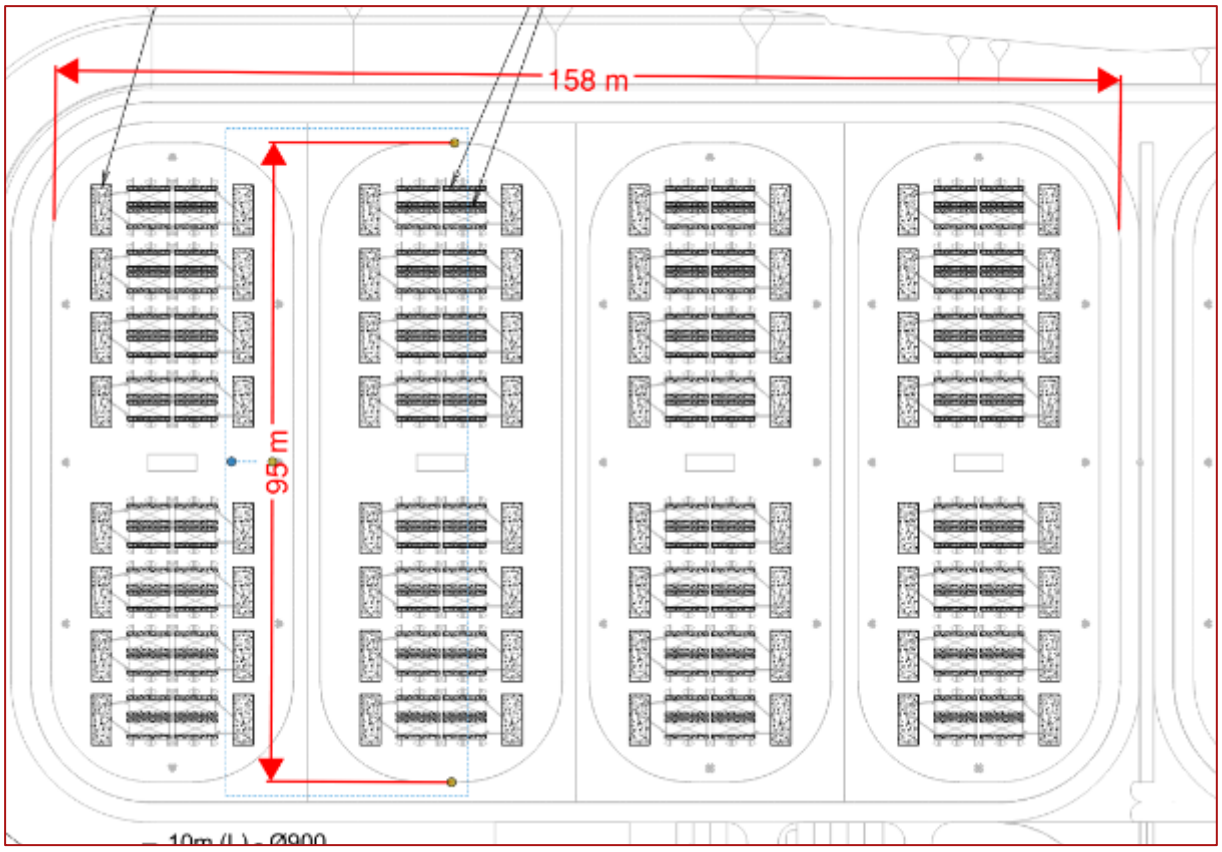


Figure 46: Top view BESS bays.

8.2.9 The site is configured as two independent BESS subdivision (BB1 and BB2), each served by a separate fire ring main and a single fire hydrant. The overall fire water supply for BB1 And BB2 has been designed to allow two hydrants to operate concurrently for a duration of four hours. However, a total fire water storage capacity of for each subdivision of 144 kL is provided. The hydrant systems for BB1 and BB2 are hydraulically independent.

8.3 Fire Hydrant System Arrangement

8.3.1 The fire hydrant system is to comply with AS 2419.1:2021 with fire hydrants located externally. This means that coverage shall be achieved from 2 lengths of hose as per AS 2419.1:2021 from the hydrants.

8.3.2 Fire hydrants are generally to be located > 10 m from electrical systems. Where that is not achievable, then that hydrant shall not be considered for achieving coverage of any systems within 10 m of it, as it should be assumed to be inaccessible if the fire is located nearby.

8.3.3 All BESS are to be reachable from two different hydrants, instead of the minimum of one hydrant under AS 2419.1:2021. The placement of these hydrants shall ensure that a hydrant should be available for use outside of the 3 kW/m2 radiation contour.

8.4 Water Containment for Firefighting

8.4.1 Due to the potential for hazardous chemicals to be absorbed into water on the site during a fire, the runoff from a fire event is proposed to be contained on site. Following a major fire event, it is expected that the fire water will need to be contained on site for testing and analysis before determining if it is safe to release to the water system.

8.4.2 To determine the containment volume, three volumes must be summed. These are:

a) Volume released from a fire affected BESS (minimal relative to fire water and rainfall, so presumed to be 1 kL)
b) Fire water for containment
c) Rainfall during a fire event

Note: A release volume of 1 kL has been assumed for the BESS units. As the large-scale fire test was conducted with the enclosure doors open, an indicative value has been adopted for assessment purposes.

8.4.3 For fire water, whilst the site will be provided with 288 kL, this is over and above the requirements of AS 2419.1 which would only require 144 kL. As such, the fire water volume considered for containment shall be 144 kL.

8.4.4 The NSW EPA does not provide any direct guidance for rainfall considerations from fire affected solid waste or solid dangerous goods sites. The closest available guidance documents provide contrary views. Firstly, FRNSW guidelines for tyre storage does not require consideration of rainfall during a fire event whatsoever, as it only prescribes storage volumes directly in relation to the fire water demand. Secondly, there is a Code of Practice for the storage and handling of dangerous liquids (not solids), which recommends a 1 in 20-year rain event.

8.4.5 Since no available acceptance criteria or guidance is provided in NSW, a reasonable benchmark must be established first to determine a relevant rainfall event frequency. This can be done by benchmarking the combined frequency of a major BESS fire and rainfall event, against that of the 1 in 20 year rain event with a spill from a tank.

8.4.6 Based on *Failure Rate and Event Data for use with Land use Planning Risk Assessment* (UK HSE 2017), the failure rate for atmospheric tanks less than 450 m^3 with flammable contents ranges from 1 x 10E-3 to 1.6 x10E-5 whether the release is small, large, or catastrophic, for non-flammable contents the failure rate is lower. Whilst even a small leak could result in contamination, a large release event with a rate of 1 x 10-4 (1 in 10,000 years) is selected as a more conservative benchmark. When combined with the recommended rainfall frequency of 1 in 20 years for liquid handling, a combined rate of 5 x 10 –6, or 1 in 200,000 years is obtained.

8.4.7 Based on the above, the appropriate rainfall event is the one that results in a combined rainfall x fire frequency of 1 in 200,000.

8.4.8 The Belambi Heights RAM report (Aurecon, 2025) lists the Mean Time to Failure (MTTF) for a BESS unit as 40,299 hours. However, this MTTF incorporates the entire system including the HV box, liquid cooling unit, pipes control panel and other systems associated with the BESS enclosure.

8.4.9 Data on lithium ion batteries has shown that the likelihood of cell failure for a single cell is approximately 1 in 40,000,000. However, using this probability alone is a gross simplification, as it is based on data for all lithium-ion cells produced not only for those used in BESS units. As such it includes systems with fewer control measures such as portable electric devices and those without any testing or certification. Similarly, the UL9540A test for the Hithium cells shows that failure of a single cell does not result in a cascading effect or fire.

8.4.10 On the above basis, for this analysis, the failure rate is reduced, to 1 in 60,000,000. This is considered on the basis of improving technology as referenced in EPRI data, and primarily that cells for the Hithium BESS are constantly monitored by the BMS, actively maintained, and UL9540A tested.

8.4.11 For simplification purposes, a BESS fire requiring intervention and thus potentially resulting in contaminated runoff is assumed to occur if 8 cells were to fail simultaneously. This has been selected as it is the number of cells which were simultaneously heated in the LSFT.

8.4.12 The likelihood of 8 cells individually failing at once based on the probably above would be remote, at 1/(60,000,000^8). However, that assumes that cell failures are independent events. Cell failures may not always be independent events and may be from common cause failures, such as manufacturing defects. However, the statistical data available on cell defects is limited, particularly when trying to only focus on failures resulting fire, and not all cell fails such as performance failures. Similarly not all BESS failures resulting in fire originate in the cell, and data on combined fire failures is difficult to source.

8.4.13 As a conservative approach, the probability of a single cell failing has been multiplied out by 8, which is the number of cells required to fail simultaneously. This has been adjusted for the number of cells in a single BESS, as if the cells fail in separate BESS they would not cascade. There are 4,996 cells in a BESS, failing in fire at a rate of 1/60,000,000 means a failure rate of a single cell event 1 in 12,019 years. This has been multiplied by 8 to result in approximately 1 in 96,000 years. It is recognised that a proper statistical approach would actually multiply the denominators together as separate events, resulting in a rate nearing zero. This is therefore a significant overprediction based on the available data, but nonetheless is used due to insufficient data on other components and the rapid progression of the technology.

8.4.14 Based on the above, the major fire rate from BESS failure is assumed at 1 in ~96,000 years.

8.4.15 In relating this to a rain event, the 24 hour rain event has been conservatively selected as this aligned with the Participants Manual. To obtain a frequency comparable to 1 in 200,000, the 50% Annual Exceedance Probability rainfall event is taken (1 in 2 years).

8.4.16 By applying this rainfall event to the probability of fire, a resulting probability of approximately 1 in ~192,000 is obtained, which is comparable to the 1 in 200,000 benchmark set above. On this basis, the 24 hours, 50% AEP rainfall event shall be the basis of design for the containment water volumes, unless the Civil Engineer determines a more onerous requirement.

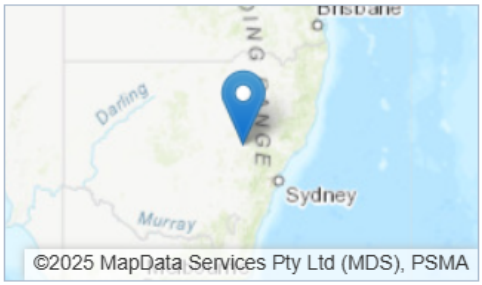
8.4.17 Based on Figure 47, the '24 hour', 2 yearly rain event results in 62.6 mm of rain. Using the size of the catchment area on site as approximately 19,000 m^2 (BB1 and BB2 are separate catchments) this gives a total rainwater value of 1.19 million litres. However, the civil engineer is to confirm the required volume based on their catchment design.

Location

Label: Not provided

Latitude: -32.323 [Nearest grid cell: 32.3125 (S)]

Longitude: 149.4658 [Nearest grid cell: 149.4625 (E)]



IFD Design Rainfall Depth (mm)

Issued: 21 November 2025

Rainfall depth for Durations, Exceedance per Year (EY), and Annual Exceedance Probabilities (AEP).
FAQ for New ARR probability terminology

Table | Chart

Unit: mm

	Annual Exceedance Probability (AEP)						
Duration	**63.2%**	**50%#**	**20%***	**10%**	**5%**	**2%**	**1%**
1 hour	20.7	23.0	30.7	36.0	41.5	48.8	54.6
1.5 hour	23.4	26.1	34.7	40.7	46.8	54.9	61.3
2 hour	25.5	28.5	37.8	44.4	50.9	59.6	66.5
3 hour	28.9	32.2	42.8	50.2	57.4	67.2	74.8
4.5 hour	32.9	36.6	48.7	57.0	65.2	76.2	84.8
6 hour	36.1	40.2	53.4	62.5	71.5	83.8	93.3
9 hour	41.2	46.0	61.2	71.6	82.0	96.3	108
12 hour	45.3	50.6	67.3	79.0	90.5	107	120
18 hour	51.6	57.6	76.9	90.5	104	124	139

Note:
The 50% AEP IFD **does not** correspond to the 2 year Average Recurrence Interval (ARI) IFD. Rather it corresponds to the 1.44 ARI.
* The 20% AEP IFD **does not** correspond to the 5 year Average Recurrence Interval (ARI) IFD. Rather it corresponds to the 4.48 ARI.

Figure 47: IFD Design rainfall depth for the site [5]

8.4.18 Based on the analysis above, the fire water containment must allow for the following in each catchment area:

a) 144kL of fire water, plus
b) 1 kl of debris
c) 62.8 mm of rain to the catchment area (approximately 19,000 m² resulting in 1.2 ML)

8.4.19 This gives a total fire water of approximately 1.4 ML of water.

5 https://www.bom.gov.au/water/designRainfalls/revised-ifd/?design=ifds&sdhr=true&nsd%5B%5D=&nsdunit%5B%5D=m&coordinate_type=dd&latitude=-32.323026358402984&longitude=149.46578328671222&user_label=&values=depths&update=

8.4.20 The Civil Engineer is to undertake the detailed analysis based on the actual catchment area.

8.5 Detailed Hydraulic Calculation for Fire Fighting Water

8.5.1 Direct firefighting of any BESS unit on fire is not to be undertaken as water will make the fire and its emissions worse. Fire water is to only be used to cool adjacent systems, as deemed required by NSW RFS.

9 Recommended Control Measures

9.1 Introduction

9.1.1 Based on the analysis presented in this report, this section outlines the recommended control measures for the site, encompassing prevention, detection, and response strategies.

9.1.2 Preventative strategies represent the overarching approaches used to reduce fire risk, such as facility design measures that minimise inherent hazards. Fire Prevention Measures refer to the practical actions taken to implement these strategies, including intruder alarms, segregation of combustible materials, and management controls. Together, these measures reduce the likelihood of credible worst-case incidents and limit their potential severity or extent.

9.1.3 The strategies for detection and response include a mixture of systems used to detect adverse events, communicate them to appropriate systems or personnel, and where appropriate provide a means to respond to an event. The means of response in some cases may be directly suppressive, and other cases may be focused on monitoring and defensive approaches to limit escalation of events.

9.2 Recommended Control Measures

9.2.1 Based on this report, the control measures recommended to be adopted at the site in respect to the fire hazard are detailed in Table 34 with further detail in subsequent subsections and appendices where required.

9.2.2 The primary objectives of these control measures are to protect personnel and minimise facility and property damage. While considerations for reducing environmental impact and supporting business continuity are included, these aspects are not the primary focus of this analysis.

9.2.3 Some items in the table are detailed further in subsections following the table. These subsections are titled with the corresponding Control Measure number (CM#).

Table 34: Proposed control measures for the site

#	CM Title	Category	System Description	Further Details / Responsibility
CM1	Safe Practices	Operational Procedures	Sets out safe work procedures and policies which would limit the potential for an incident to occur, as well as the safe response to an incident. Emergency response plan, operational procedures, and the like to instruct any staff present on how to safely conduct business at the site.	To be developed by operator. The following types of plans are expected to be required at minimum: - ESIP - Standard Operating Procedures - Emergency Plan
CM2	Two-way communication	Detection	Two-way communication between the operator and the remote operator / site manager so that an incident can be rapidly notified, and procedures activated.	Procedure for use to be developed by the operator.
CM3	Portable fire extinguishers	First Aid Fire Protection	Dry powder, ABE, portable fire extinguishers shall be provided across the site. These portable fire extinguishers are to meet AS 2444:2001 (Standards Australia, 2017). Where portable fire extinguishers are stored outside, they shall be within weather-proof cabinets.	Fire extinguishers to be marked up emergency plan and documented within the ESIP.
CM5	Fire Brigade	Active protection	Arrangements for fire brigade notification, access and intervention at the site.	To be finalised within the ESIP for firefighting arrangements. Fire fighting hardstand details to be prepared by Fire Protection Engineer
CM6	Selection of systems	Arrangements	Selection of: - appropriate equipment suitable for purpose - equipment to be suitable for operating conditions	To be designed / selected and approved.
CM7	Installation and Maintenance of the system	Operational Procedures	Installation and ongoing maintenance of equipment and fire protection systems in accordance with relevant Australian Standards.	Installation and maintenance responsibilities to be defined in the site inspection, Testing and maintenance schedules to be determined by operator based on manufacturing guidelines / standards.
CM8	Arrangement of the system	Arrangements	Physical layout and arrangement of any fire protection systems and equipment across the site.	Final arrangement to be coordinated with design team, building layout to be confirmed, access paths and equipment clearances.
CM9	Vegetation fuel load	Operational procedures	Management of vegetation and other combustible fuel loads to reduce the potential for fire spread.	Vegetation management to be incorporated into the site maintenance plan and bushfire mitigation strategy.
CM10	Site Security	Arrangements	Measures to maintain site security and control unauthorised access.	Security measures to be coordinated with the site security management plan and access control system. Details of security fence to be finalised. Details of CCTV to be finalised. Details of remote monitoring to be finalised
CM11	First Aid kit	First Aid Fire Protection	Provision and maintenance of first aid kits to support initial treatment of injuries.	Responsibility for inspection and replenishment to be assigned within the site HSE or operations team (once operational). Documented within the emergency plan.
CM12	Personal protective equipment (PPE)	First Aid Fire Protection	Provision and use of appropriate personal protective equipment (PPE) by site personnel.	PPE requirements to be documented in task-specific risk assessments and induction training. Responsibility for inspection and replenishment to be assigned within the site HSE or operations team (once operational).
CM13	Site wide incident notification	Active Protection	Processes for site-wide incident notification, escalation and communication.	Automatic sitewide and fire brigade notification is to be provided. Fire services to develop design at minimum as per detailed provided in the relevant subsection. This is to include on-site audible notification, and automatic fire brigade callout at certain detection thresholds.
CM14	Fire truck access	Active protection	Provision and maintenance of suitable fire truck access routes and hardstand areas.	Access design to comply with local fire authority guidelines for appliance access and turning circles. Refer to FRNSW guidelines Access for fire brigade vehicles and firefighters
CM15	BESS unit door management	Preventative	This would limit the potential for unauthorised access.	Limit access, but these BESS units are already in a restricted area.

#	CM Title	Category	System Description	Further Details / Responsibility
CM16	Landscaping	Arrangements	Landscaping design and maintenance to minimise fire and ember attack risk. Design to ensure water / storm water drainage can flow into the collection pond.	Landscaping plan to maintain appropriate separation distances and low-fuel zones around key assets. Final design to be approved by civil engineer.
CM17	Water drainage and containment	Water Management	Water drainage and containment systems to manage contaminated firewater and runoff.	Drainage and containment design to consider contaminated firewater retention and controlled discharge. Final design to be approved by civil engineer.
CM18	System monitoring	Arrangements	Monitoring of key systems and alarms to identify abnormal conditions at an early stage. System sensors data to be shared with the RMS operator, with notification related to potential / actual incidents.	System monitoring to be integrated with the site control system and, where appropriate, remote monitoring. Site to have environmental sensors which can inform the RMS operator of at least temperature, rainfall, humidity, and wind speed.
CM19	RMS incident support	Arrangements	Arrangements for coordination and support from RMS during incidents.	Protocols for liaison with RMS to be included in the Emergency Response Plan. Development of clear procedures for engaging and support emergency services Training of RMS operators.
CM20	Impact protection / Speed Limit	Arrangements	Impact protection measures and speed controls on access tracks to reduce BESS collision risk.	Define speed limits for site – to be determined by operator. Impact barriers to be designed and installed on site in appropriate areas. This is to be specified in site traffic management procedures.
CM21	Lightning protection	Arrangements	Lightning protection systems to minimise the risk of ignition from lightning strikes.	Lightning protection design to be in accordance with relevant Australian Standards. Appropriate testing and maintenance of lightning systems.
CM22	Ember attack protection	Arrangements	Protection measures against ember attack, including shielding and exclusion zones. Refer to landscaping.	Ember protection measures to be aligned with bushfire design requirements and guidelines. Landscaping plan to maintain appropriate separation distances and low-fuel zones around key assets.
CM23	BESS unit explosion ventilation	Arrangements	Explosion relief and ventilation provisions for BESS units to limit overpressure effects. Provisions to be in accordance with NFPA 69.	Explosion ventilation to be designed by a qualified engineer based on Hithium equipment vendor guidance.
CM24	Arc flash assessment	Arrangements	Assessment of arc flash hazards and implementation of appropriate controls.	Arc flash assessment outcomes to be documented and used to define PPE and exclusion zones. Arc flash assessment to be shared with the fire brigade.
CM25	Vibration protection – BESS unit	Arrangements	Measures to limit vibration impacts on BESS units and associated equipment.	Vibration limits and monitoring to be defined in consultation with equipment suppliers.
CM26	Cyber-attack protection	Arrangements	Cyber security controls to protect critical systems from malicious attacks.	Cyber security measures to be aligned with the operator's information security policies. On going maintenance and upgrading to software to ensure attacks do not occur.
CM29	Fire Indicator Panel (FIP)	Detection	Fire indicator panel (FIP) to receive, display and transmit fire and fault signals.	Fire detection and alarm systems, which meet AS 1670.1:2018 (Standards Australia, 2018) across the site are to connect and use the master FIP located within each control room (BB1 & BB2 each have independent systems). Installation of a local FIP in the O&M building.
CM30	Dangerous goods and chemical cabinets	Active protection	Use of dangerous goods and chemical storage cabinets compliant with relevant Standards.	Cabinets to be installed and labelled in accordance with dangerous goods requirements. Fire Safety Engineer to complete a Dangerous Goods Assessment Report. Li-ion modules are to be stored in UL 1487 approved containers on the ground. These cabinets are to be at least 1 m apart as well as separated from any combustible material or other dangerous goods.
CM31	Self-bunded tanks	Passive Protection	Use of self-bunded tanks to provide integral spill containment for stored liquids.	Bund capacity and inspection requirements to be documented in the maintenance plan. All tanks to meet AS 1940 and/or AS 2067 as applicable.
CM32	Bunding – Diesel generators and tanks	Passive Protection	Bunding arrangements for diesel generators and tanks to contain leaks and spills.	Bunding to be designed for the largest tank volume plus freeboard, with controlled drainage. All tanks to meet AS 1940 and/or AS 2067 as applicable.
CM33	Diesel generator enclosure	Passive Protection	Enclosure of diesel generators to limit fire spread and protect adjacent equipment.	Enclosure must be generally non-combustible, e.g. external walls to be sheet metal or similar rather than timber framed. The enclosure must be sufficiently sound to allow for the installation of the heat alarm to the roof.

#	CM Title	Category	System Description	Further Details / Responsibility
CM34	Diesel generator fire isolation	Passive Protection	Fire isolation measures for diesel generators to separate them from other plant and structures.	Isolation arrangements to allow emergency shut-down and separation during a fire. The heat detector in the diesel generator enclosure must automatically shutdown the diesel generator electrically and by isolating the fuel supply. The ESIP must include the location of the manual isolation valve for the responding fire brigade.
CM35	Emergency services	Responds	Access and procedures of when to call emergency services.	Application of organisations who can deal with specific issues.
CM36	Fire and smoke detection and alarm system	Detection	Fire and smoke detection and alarm system covering relevant plant and building areas.	Detection zones and alarm set-points to be defined by the Fire Protection Engineer.
CM37	Automatic power shutoff to switch & control room	Active Protection	Automatic power shut-off to switch and control rooms under defined emergency conditions.	Control logic for automatic power shut-off to be documented and tested regularly. Design to be confirmed by electrical engineer.
CM39	Management Plans	Operational procedures	Preparation and implementation of management plans covering safety and emergency response.	Plans to cover normal operations, construction and emergency phases as applicable.
CM40	Access to meteorological data	Operational procedures	Access to meteorological data to support emergency planning and response decisions.	Meteorological data to be accessible to the incident controller during an emergency.
CM41	Site housekeeping	Operational procedures	Site housekeeping measures to control combustible waste and maintain clear access.	Housekeeping responsibilities to be allocated and documented in site procedures.
CM42	'No Trespassing' signage	Operational procedures	Control of site access through signage and defined entry points.	Signage to comply with relevant safety signage standards and be maintained in good condition. Location of signage to be determined.
CM43	Rodent and vermin protection	Operational procedures	Measures to manage rodent and vermin activity that may affect equipment and cabling.	Pest management program to be implemented and periodically reviewed.
CM44	Site Access	Operational procedures	Provision and control of site access for personnel, contractors and visitors.	Access controls to be aligned with security and safety requirements for the site.
CM45	Fire Hydrant System	Water Management	Provision of a fire hydrant system to supply firefighting water for the site.	Hydrant locations, coverage and flow requirements to be determined by the Fire Protection Engineer.
CM46	DGAR	Operational procedures	The assessment provides a structured basis for determining appropriate control measures ensuring compliance with WHS legislation, Australian Standards, and insurer expectations.	Enables the facility to operate safely while demonstrating that risks have been reduced so far as reasonably practicable. To be completed by a suitably qualified Fire Safety Engineer.
CM47	LEL Detection	Active Protection	These detectors would be located either next to the dangerous goods ventilation system exhaust air vent or located at next to high fire risk items	The LEL detection system should meet the requirements as set out in AS/NZS IEC 60079
CM48	Dangerous Goods Ventilation	Active Protection	A dangerous goods ventilation system is to be fitted within the BESS modules storage area.	The ventilation system should meet the requirements set out in AS 1940
CM49	External Wall construction [BB1 – O&M building]	Preventative	External wall construction of the O&M building / affected façade be comprised of non-combustible materials	The façade requirements should be in accordance with the NCC requirements

9.3 CM1 - Safe Practices

9.3.1 Emergency Planning and ESIP for the site must consider the findings of the Consultant Advice Note (CAN) in regard to deflagration hazards. This is provided in Appendix J.

Emergency Plan

9.3.2 To meet the requirements of clause 361 of the NSW WHS Regulation 2017, an emergency plan is to be developed in accordance with clause 43 of the NSW WHS Regulation 2017 and submitted to FRNSW. An ESIP is to also be developed and issued to FRNSW.

9.3.3 The Emergency Plan shall be developed for the site in accordance with Hazardous Industry Planning Advisory Paper No 1 (HIPAP No. 1) Emergency Planning. The findings of the FSS should inform the development and content of the Emergency Plan. This should include, but not be limited to:

a. Details on how the owner / operator is alerted to abnormal operation, fault or hazard in a BESS.
b. Details on how fire services are notified of an incident. This should be described as part of the fire safety strategy. Upon detection of a fire in a BESS or on the site via an automatic detection system, notification of the fire services should be automatic.
c. Detail effective communication strategy with remote operator representative for incident duration.
d. Suitable arrangements for attendance on site by an appropriately qualified representative during any incident.
e. Details on how battery status and information is relayed to emergency services, including items such as deployment of deflagration panels, etc.

9.3.4 The Emergency Plan must also satisfy the specific requirements of Consent Condition B30 as specified in the planning approval.

9.3.5 Both the Emergency Plan and future Emergency Services Information Package (ESIP) are to clearly indicate that the dry pipe sprinkler system integrated into the BESS units are not to be used for fire suppression. Connecting would potentially expose someone to a fire or blast hazard.

Basic Training / Induction

9.3.6 All personnel associated with the site shall receive basic training that covers:

a) Site and operational risk and hazards,
b) Emergency management roles, responsibilities, and procedures that includes the how to understand what incident is occurring,
c) How to operate systems associated with emergency response, including the fitting of personnel protective equipment, and
d) Location and use of first aid kits and other emergency response equipment on site.

9.3.7 All personnel are to annually demonstrate the above knowledge as well as the site undergo a full emergency response exercise. This exercise is expected to involve the local fire brigade.

Maintenance

9.3.8 Appropriate management and maintenance of systems is an essential part of safe practices and must occur in line with AS 1851 and manufacturer recommendations.

9.3.9 Whilst the dry pipe sprinkler system and aerosol systems are not required to meet the intent of this FSS, since they are integrated into the BESS they must be maintained. In other words, unless these are fully removed, they must be managed and maintained as essential fire safety systems. Degradation of these systems could have adverse effects.

9.4 CM2 - Two way communication

9.4.1 Two-way communication with the RMS operator is to be continuously available. This shall be the first method of communication from someone on site if they are in trouble or see an incident. Equally, it is expected that the RMS operator would inform anyone of site of an incident via this method and via the BOWS and horn / strobe warning systems, i.e., site wide notification system.

9.5 CM3 – Portable fire extinguishers

9.5.1 Portable fire extinguishers shall be fitted across the control rooms, switchboard room, and the battery rooms in accordance with AS 2444:2001, (Standards Australia, 2001).

9.5.2 The location for portable fire extinguishers around the site are shown in **[TBC]**

9.6 CM11 - First Aid Kit

9.6.1 First aid kit, which includes an eye wash, shall be located near the FIP within the O&M building. This first aid kit shall at least meet Type B as defined by International Safety Equipment Association (ISEA).

9.6.2 Each site vehicle shall also have a first aid kit, which includes an eye wash. This may be a Type A as defined by International Safety Equipment Association (ISEA).

9.7 CM13 – Site wide notification

9.7.1 Within building this audio notification devices shall comply with the AS 1670.1:2018 building occupant warning system requirements.

9.7.2 The outdoor warning system shall consist of horns or speakers to provide site wide notification. Due to the challenges of achieving high sound pressure levels (SPLs) outdoors, and that AS 1670.1 is not directly applicable to the site, the

outdoor notification level is to achieve 5 dB(A) above background, instead of the typical 10 dB(A) required by AS 1670.1. These will be connected to the main FIP.

9.7.3 Mobile phone number of staff onsite must be provided to the remote monitoring station for direct contact in an emergency, this includes any visitors/visiting contractors.

9.7.4 Each BESS is provided with 2 smoke detectors (SD) and 2 heat detectors (HD) with a two-stage fire alarm. At Stage 1, any single detector activating, the site wide notification system shall activate. At Stage 2, any two detectors activating, automatic fire brigade callout is to occur.

9.8 CM14 – Fire Truck Access

9.8.1 All access gates, including emergency access gates, to the entire site shall be openable via a 003 key, site-specific key deposited in a locked box outside the site perimeter, or a copy kept at the local fire station, or similar.

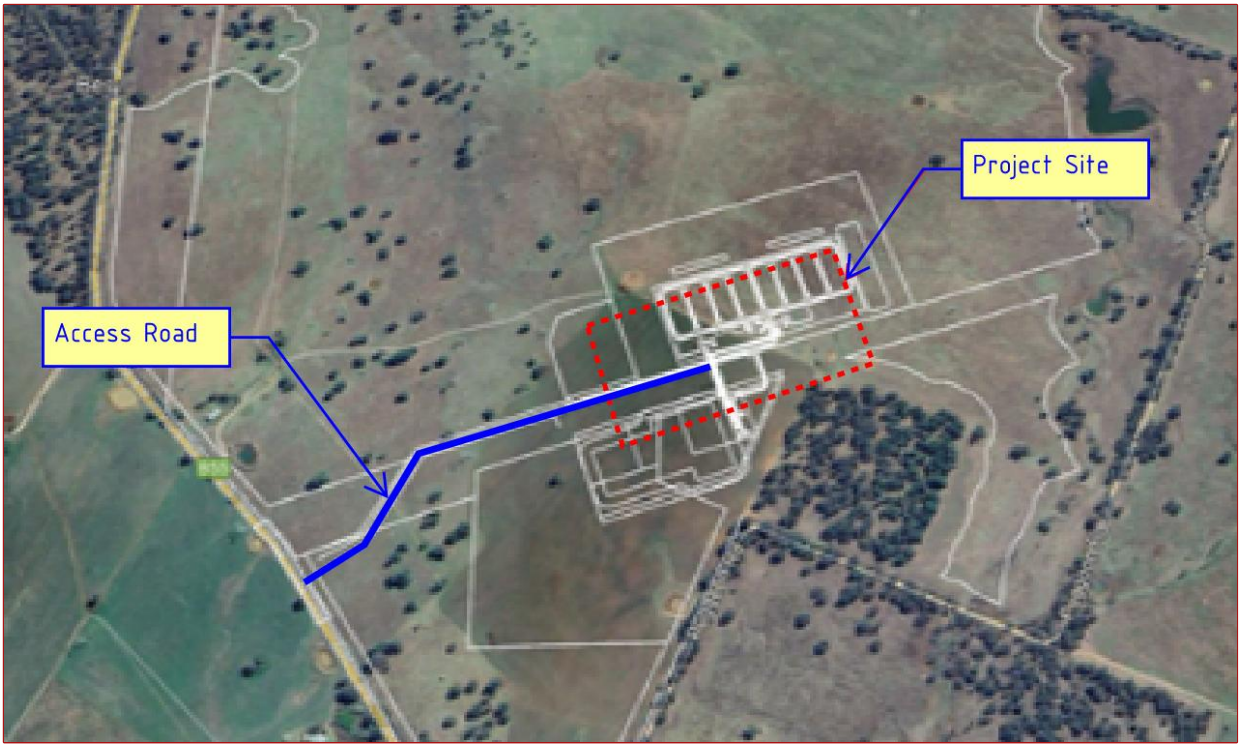


Figure 48: Access Road

9.8.2 Figure 49 below shows the typical access road detail arrangement. It shows the 200 mm subbase, 170 mm gravel base course and the 100 mm thick crushed rock.

9.8.3 All roads indicated to be paved must be paved to support the heaviest expected vehicles, which include fire brigade response vehicles. Based on the civil engineer inputs the road paving is to be as per Figure 49 or similar.

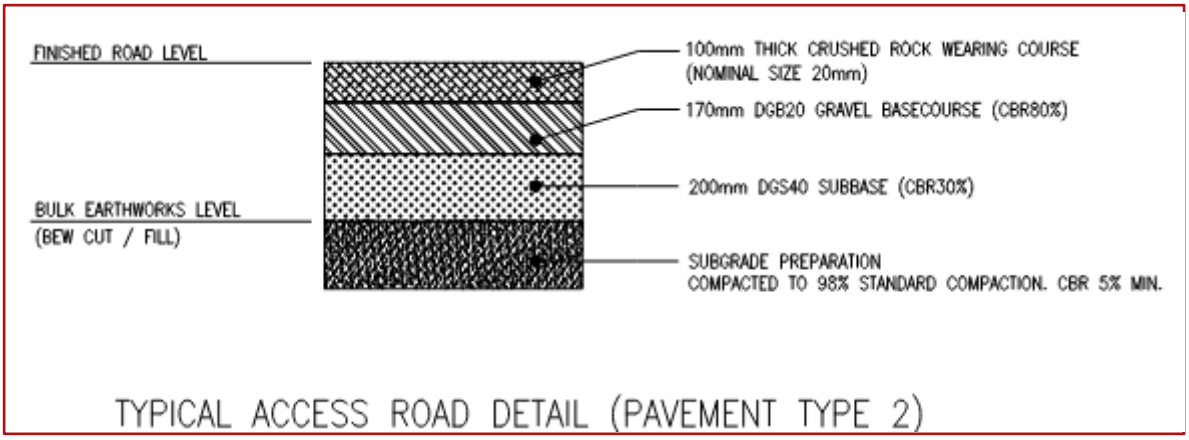


Figure 49: Access road structure

9.8.4 Table 35 summarises the high level requirements of the FRNSW fire safety guidelines for access for fire brigade vehicles and firefighters.

Table 35: High level requirements access for fire brigade vehicles

Category	High-Level Requirement	Key Details / Performance Criteria	Source (FRNSW Guideline)
Carriageway Width	Provide sufficient width for fire appliances	4.5 m min width (general appliances) 6 m min width (specialist/aerial)	Page 10, Fig. 3
Turning & Swept Path	Allow for large vehicle turning radii	6.5 m inner / 11.5 m outer (general) 7.5 m inner / 14.6 m outer (aerial) Consideration for body swing	Page 10–11, Fig. 4–5
Dead Ends & Turnarounds	Avoid reversing; provide turnarounds	Dead ends > 120 m require a compliant turnaround Must accommodate body swing	Page 11, Fig. 6–7
Pinch Points	Prevent narrow access restrictions	No pinch points < 3.2 m wide No constrictions > 50 m long	Page 12, Fig. 8
Overhead Clearance	Ensure overhead clearance for tall appliances	4.0 m (general) / 4.5 m (specialist) No obstacles (pipes, beams, lights)	Page 14, Fig. 10
Underbody Clearance / Kerbs	Prevent damage or grounding of appliances	Kerbs ≤200 mm high Centre islands ≤ 500 mm wide and mountable	Page 13, Fig. 9
Gradients & Ramps	Ensure safe travel on slopes	Max grade 1:6 / Preferred ≤ 1:8 Curved ramps max 1:8 Transition slope 1:16 over 7 m	Page 14–15, Fig. 11–12
Gates & Security Barriers	Must not delay emergency entry	Gates to be unlockable, removable, retractable Fail-safe open mode preferred	Page 15–16
Hardstand Areas	Provide safe working zones for firefighters	Within 20 m of hydrants Within 8 m of booster Level, all-weather surface 3.5 m clearance around appliance	Page 16–17, Fig. 13–15
Structural Capacity (Road/Bridges)	Roads must support heavy fire appliances	15 t (general) / 28 t (specialist) Consider dynamic loads of stabilisers	Page 18–20, Table 3
Wayfinding & Signage	Enable quick navigation for firefighters	Clear signage at site entry + building entry	Page 25–26, Fig. 23

Category	High-Level Requirement	Key Details / Performance Criteria	Source (FRNSW Guideline)
		Labelling of exits, floors, control rooms	
LATM / Traffic Devices	Do not restrict access with traffic calming	Avoid devices that reduce speed/width excessively Prefer mountable/negotiable devices	Page 28–29, Table 4

9.8.5 Further details on the emergency vehicular access to the site is provided in Appendix E to this report.

9.9 CM19 – RMS incident support

9.9.1 The RMS shall be provided with all available detector, sensor, and camera information. Notification of fire, system fault / failure, environmental issues, and the like shall have appropriate procedures.

9.9.2 Procedures shall be regularly exercised, at least three times a year. Each emergency response exercise shall consider a different potential fire scenario (e.g. bushfire, BESS fire, transformer fire, generator fire, building fire and so on) so that a minimum of three different scenarios is considered each year. The hazards considered in the body of this report outline potential fire scenarios.

9.10 CM29 – FIP

9.10.1 Both BB1 and BB2 shall have FIPs located within their respective control room (BB1 & BB2). Both FIPs operate independently for their own respective subdivision but will communicate between each other as required. Each O&M building will also have a local FIP installed.

9.10.2 The FIP shall be connected to the control panels on each BESS which are provided by Hithium as controllers for the in-built fire detection, alarm, and suppression systems.

9.10.3 Each BESS enclosures has a fire alarm control panel (FACP) which receives input from the BESS heat and smoke detection system, this also provides feedback to the internal BMS. The FACP is effectively an AS1670.1 FIP/FDCIE, with a different terminology applied.

9.10.4 The individual BESS FACPs are to be connected to the respective BESS BMS. Each BMS is then connected to the site wide FIP via SCADA in lieu of an AS 1670.1 connection. This is due to the SCADA already being available, having the capability of carrying the signal, and being treated as an essential system. For site operations the SCADA is required to have an extremely high reliability as the whole site cannot operate without it. Nonetheless, if the SCADA were to fail to the FIP, the fire affected BESS unit would still sound the in-built alarm and signal with in-built strobes.

9.10.5 The individual BESS FACPs do not have their own automatically call out to fire brigade (alarm signalling equipment, ASE). However, the main FIP at both BB1 and BB2 are each to have their own ASE to automatically callout the fire brigade in the event of fire.

9.11 CM36 – Fire and smoke detection and alarm system

9.11.1 Table 36 provides a list of the systems with detailed drawings provided and the relevant Appendices

9.12 CM42 – No Trespassing Signage

9.12.1 There shall be signs on the security fence stating, 'NO TRESPASSING'. These signs shall be fade and corrosion resistant, made from metal and mechanically fixed to the fence. The letters shall be at least 50 mm in height and the letter colour black and the background white as per the requirements of AS 1319:1994.

9.13 CM45 - Fire Hydrant System

9.13.1 The site is configured as two independent BESS subdivisions (BB1 and BB2), each served by a separate fire ring main and a single fire hydrant. The overall fire water supply for BB1 And BB2 has been designed to allow two hydrants to operate concurrently for a duration of four hours. However, a total fire water storage capacity of for each subdivision of 144 kL is provided. The hydrant systems for BB1 and BB2 are hydraulically independent.

9.13.2 Based on compliance with AS2419.1:2021, it is understood that only 144 kL of water storage is required per subdivision, and such storage meets the intent of this FSS. Nonetheless, the current design includes 288 kL of storage is 144kL for BB1 and BB2 until such time that consultation for this FSS takes place.

9.13.3 Though it is permitted for BB1 and BB2 to share a single fire hydrant system, it is understood that for operational reasons it is preferable to have separate hydrant systems, therefore the system shall be fully replicated for BB1 and BB2 (separate pumps, tanks, boosters, etc).

9.13.4 A hardstand area for fire trucks shall be provided for the hydrant system, i.e. in front of any suction-connection outlet as required within AS 2419.1: 2021 (Standards Australia, 2021) & Fire Safety Guideline: Access for fire brigade vehicles and firefighters (FRNSW, 2019).

9.13.5 Any fire water tanks used for fire water storage must be installed at the site entrance to aid NSW RFS operations. We propose to have additional fire water tank placed at an emergency access gate to support local fire brigade operations.

9.13.6 The connection point for the fire water tank must be adjacent to the road.

9.13.7 Drawings of the fire main layout and hydrants are provided in Appendix D to this report.

9.13.8 All fittings are to comply with the FRNSW Technical Information bulletin for compatible fittings.

9.14 Detailed Drawings

9.14.1 Table 36 provides a list of the systems with detailed drawings provided and the relevant Appendices.

Table 36: Detailed Drawings

System	Drawing Location
Fire Hydrant System	Drawings of the fire main system and fire hydrants are provided in Appendix D to this report.
BESS Fire Protection systems	Appendix D to this report provides information on the fire, smoke, temperature, and leak detection systems across the site.
Portable Fire Extinguishers	Portable fire extinguishers are to be applied across the site, and their locations are provided in section D.2 of this report.
Fire Truck Access	Appendix E to this report presents movement of a fire truck around the site.

10 Updated Risk Assessment

10.1 Introduction

10.1.1 Following the initial risk assessment and control measure analysis, an updated risk assessment (URA) has been conducted with respect to the recommended control measures having been applied. This follows on from the IRA which considered no control measures being applied (including statutory measures). The terminology for likelihood, consequence, and risk level presented in this section are as defined in Appendix A.

10.2 Updated Risk Assessment

Table 37: Updated risk assessment

ID	Context	Location & Type	Relevant CMs	Updated Likelihood Analysis (L)	U-L	Update Life Safety Consequence Analysis (U-LSC)	U-LSC	Updated LS Risk (Initial Risk)	Updated Facility Consequence Analysis (U-FC)	U-FC	Updated F Risk (Initial Risk)
L1-SF	Localised BESS fire such as from a single or multiple cell thermal runaway	BESS (L1): Small Fire (SF)	CM1, CM2, CM5, CM6, CM7, CM13, CM15, CM17, CM19, CM25, CM26	Likelihood of a Li-ion fire comes from (Electric Power Research Institute, 2022) where it notes failure rated for Li-ion batteries which could result in a fire is 1 in 40 million per cell manufactured. However, BESS unit cells are likely to be more robust, more controlled, and feature more safety and monitoring systems than a typical cell which reduces this rate. Each BESS unit holds 4992 cells and therefore across the site with 256 BESS units the total number of cells is 1,277,952 cells. The frequency would be 1 in 62 years.	Occasional	Little direct hazard to personnel from single cell events, with control this is unlikely to cascade and cause injuries.	Minor	L (M)	Little direct hazard to the facility from a single cell event, with control this is unlikely to cause issues beyond the module level.	Moderate	M (M)
L1-LF	Major failure of multiple systems leading to burnout of a full BESS unit	BESS (L1): Large Fire (LF)	CM1, CM2, CM5, CM6, CM7, CM13, CM14, CM15, CM17, CM18, CM19, CM20, CM22, CM25, CM26	Likelihood of a Li-ion fire comes from (Electric Power Research Institute, 2022) where it notes failure rated for Li-ion batteries which could result in a fire is 1 in 40 million per cell manufactured. However, BESS unit cells are likely to be more robust, more controlled, and feature more safety and monitoring systems than a typical cell which reduces this rate. Each BESS unit holds 4992 cells and therefore across the site with 256 BESS units the total number of cells is 1,277,952 cells. The frequency would be 1 in 62 years.	Occasional	The consequences are seen to be Moderate for personnel as it could result in injuries not requiring hospitalisation.	Moderate	M (M)	The consequences are seen to be Major for the facility as the damage could involve several BESS Groups.	Moderate	M (M)
L1-GR	Major failure of multiple systems leading to venting of a full BESS unit. This could be thermal runaway with or without a fire. This scenario considers only the toxic effects.	BESS (L1): Gas Release (GR)	CM1, CM2, CM5, CM6, CM7, CM13, CM14, CM15, CM17, CM18, CM19, CM20, CM22, CM25, CM26	Likelihood of a Li-ion fire comes from (Electric Power Research Institute, 2022) where it notes failure rated for Li-ion batteries which could result in a fire is 1 in 40 million per cell manufactured. However, BESS unit cells are likely to be more robust, more controlled, and feature more safety and monitoring systems than a typical cell which reduces this rate. Each BESS unit holds 4992 cells and therefore across the site with 256 BESS units the total number of cells is 1,277,952 cells. The frequency would be 1 in 62 years.	Occasional	The consequences are seen to be Moderate for personnel as it could result in injuries not requiring hospitalisation.	Moderate	M (H)	The consequences are seen to be Minor for the facility as they may be not further damage than what happened to the BESS unit with the explosion.	Minor	L (H)
L1-EX	Significant failure leading to multiple cells venting to produce a vapour cloud explosion	BESS (L1): Explosion (EX)	CM1, CM2, CM5, CM6, CM7, CM13, CM14, CM15, CM17, CM18, CM19, CM20, CM22, CM23, CM25, CM26	Likelihood of a Li-ion fire comes from (Electric Power Research Institute, 2022) where it notes failure rated for Li-ion batteries which could result in a fire is 1 in 40 million per cell manufactured. However, BESS unit cells are likely to be more robust, more controlled, and feature more safety and monitoring systems than a typical cell which reduces this rate. Each BESS unit holds 4992 cells and therefore across the site with 256 BESS units the total number of cells is 1,277,952 cells. The frequency would be 1 in 62 years.	Occasional	The consequences are seen to be Moderate for personnel as it could result in injuries not requiring hospitalisation.	Moderate	M (M)	The consequences are seen to be Minor for the facility as they may be not further damage than what happened to the BESS unit with the explosion.	Minor	L (M)
L2-SF	Localised cable fire within BESS enclosure or within a cable tray in switch room.	Cables (L2): Small Fire (SF)	CM1, CM2, CM3, CM6, CM7, CM8, CM18, CM24, CM43	The small, localised fire can be expected to self-extinguish or not spread, unless human error is involved, similar for facility impact. From (Alber, et al., 1995), it is noted that human error is 1 E-3. This would result in a frequency of 1 in 11,500 years for a significant threat to personnel and facilities.	Rare	Hospitalisation is not expected due to the control measures, such as detection system, personnel protective equipment, spill kits, and safety procedures, but	Major	VL (H)	Due to cables buried underground fire is not likely to spread, although at least one cable run would be lost	Minor	VL (H)

ID	Context	Location & Type	Relevant CMs	Updated Likelihood Analysis (L)	U-L	Update Life Safety Consequence Analysis (U-LSC)	U-LSC	Updated LS Risk (Initial Risk)	Updated Facility Consequence Analysis (U-FC)	U-FC	Updated F Risk (Initial Risk)
						some injuries could occur.					
L3-SF	MV transformer small fire - Localised small fire from small source or spillage.	MV Transformer (L3): Small Fire (SF)	CM1, CM2, CM3, CM6, CM7, CM8, CM18, CM19, CM24, CM24, CM39, CM43	Data for large power transformers indicate failure rates in the order of 0.3 % per annum for major failures in large units (> 100 kV). As the unit under assessment is a dry-type transformer, a conservative adjusted failure rate of 0.1 % per annum is adopted for the purpose of this risk assessment. The possibility of a fire would be expected to lower the magnitude of possibility; however this would still remain as rare.	Rare	The consequences are seen to be major for personnel as it could result in injuries that would require hospitalisation.	Moderate	VL (L)	The facility consequence is Major as the fire would result in the loss of function of one of the sites transformers.	Major	VL (L)
L4-SF	PCSM - Localised small fire from small source or spillage.	PCSM (L4): Small Fire (SF)	CM1, CM2, CM3, CM6, CM7, CM8, CM18, CM19, CM24, CM24, CM39, CM43	Data for large power transformers indicate failure rates in the order of 0.3 % per annum for major failures in large units (> 100 kV). As the unit under assessment is a dry-type transformer, a conservative adjusted failure rate of 0.1 % per annum is adopted for the purpose of this risk assessment. The possibility of a fire would be expected to lower the magnitude of possibility; however this would still remain as rare.	Rare	The consequences are seen to be major for personnel as it could result in injuries that would require hospitalisation.	Moderate	VL (L)	The facility consequence is Major as the fire would result in the loss of function of one of the sites transformers.	Major	VL (L)
L5-SF	Diesel generator small fire - Localised small fire from small source or spillage.	Diesel Generators (L5): Small Fire (SF)	CM1, CM2, CM3, CM6, CM7, CM8, CM18, CM19 CM31, CM32, CM33, CM34, CM39	Likelihood of a diesel generator fuel leak is based on fire data from (Electric Power Research Institute / US Nuclear Regulatory Commission, 2005), where it notes diesel generators have a fire at a generic rate of 2.1E-2 per year in a well maintained environment. This results in a fire every 47 years. As not all leaks' results in a fire, it is assumed that only one in ten leaks would results in a fire, or in other words once each 4.7 years	Probable	The consequences are seen to be minor for personnel who are not expected to have any noticeable injuries	Minor	L (L)	No facility impact is expected as the combustible liquid would be contained.	Minor	L (L)
L5-LF	Diesel generator large fire - major fire assuming full contents of transformer released	Diesel Generators (L5): Large Fire (LF)	CM1, CM2, CM3, CM6, CM7, CM8, CM13, CM14, CM18, CM19, CM31, CM32, CM33, CM34, CM39	Likelihood of a diesel generator fuel leak is based on fire data from (Electric Power Research Institute / US Nuclear Regulatory Commission, 2005), where it notes diesel generators have a fire at a generic rate of 2.1E-2 per year in a well maintained environment. This results in a fire every 47 years. As not all leaks' results in a fire, it is assumed that only one leak would in ten results in a fire, or in other words once each 4.7 years	Occasional	The consequences are seen to be major for personnel as it could result in injuries that would require hospitalisation	Major	M (M)	The facility consequence is minor as the fire is not expected to spread or effect the BESS units and other infrastructure.	Minor	L (M)
L6-SF	AUX transformer small fire - Localised small fire from small source or spillage.	Aux Transformer (L6): Small Fire (SF)	CM1, CM2, CM3, CM6, CM7, CM8, CM18, CM19, CM24, CM24, CM39, CM43	Data for large power transformers indicate failure rates in the order of 0.3 % per annum for major failures in large units (> 100 kV). As the unit under assessment is a dry-type transformer, a conservative adjusted failure rate of 0.1 % per annum is adopted for the purpose of this risk assessment. The possibility of a fire would be expected to lower the magnitude of possibility; however, this would still remain on rare.	Rare	The consequences are seen to be major for personnel as it could result in injuries that would require hospitalisation.	Moderate	VL (L)	The facility consequence is Major as the fire would result in the loss of function of one of the sites transformers.	Major	VL (L)
L6-LF	AUX transformer small fire - Localised small fire from small source or spillage.	Aux Transformer (L6): Large Fire (LF)	CM1, CM2, CM3, CM6, CM7, CM8, CM18, CM19, CM24, CM24, CM39, CM43	Data for large power transformers indicate failure rates in the order of 0.3 % per annum for major failures in large units (> 100 kV). As the unit under assessment is a dry-type transformer, a conservative adjusted failure rate of 0.1 % per annum is adopted for the purpose of this risk assessment. The possibility of a fire would be expected to lower the magnitude of possibility; however, this would still remain on rare.	Rare	The consequences are seen to be major for personnel as it could result in injuries that would require hospitalisation.	Moderate	VL (L)	The facility consequence is Major as the fire would result in the loss of function of one of the sites transformers.	Major	VL (L)
L7-SF	O&M small fire - localised small fire due to storage of combustibles.	O&M Building (L7): Small Fire (SF)	CM1, CM2, CM3, CM6, CM7, CM8, CM14, CM18, CM19, CM22, CM29, CM30, CM35, CM36,	The building is vulnerable to the standard fire hazards, such as electrical fault and maintenance incidents, as well as the less common hazards relates to the storage of chemicals and dangerous goods. The likelihood of a site building catching fire is considered reduced by a magnitude of 10 if the control measures are implemented therefore the likelihood is considered occasional.	Occasional	The consequences are seen to be Major for personnel as it could result in injuries requiring hospitalisation.	Major	M (VH)	The facility consequence is Moderate as the fire is not expected to spread other infrastructure.	Moderate	M (VH)

ID	Context	Location & Type	Relevant CMs	Updated Likelihood Analysis (L)	U-L	Update Life Safety Consequence Analysis (U-LSC)	U-LSC	Updated LS Risk (Initial Risk)	Updated Facility Consequence Analysis (U-FC)	U-FC	Updated F Risk (Initial Risk)
			CM41, CM39, CM43, CM45								
L7-LF	O&M large fire - major fire assuming fire spread within the building.	O&M Building (L7): Large Fire (LF)	CM1, CM2, CM3, CM6, CM7, CM8, CM14, CM18, CM19, CM22, CM29, CM30, CM35, CM36, CM41, CM39, CM43, CM45	The building is vulnerable to the standard fire hazards, such as electrical fault and maintenance incidents, as well as the less common hazards relates to the storage of chemicals and dangerous goods. The likelihood of a site building catching fire is considered reduced by a magnitude of 10 if the control measures are implemented therefore the likelihood is considered occasional.	Occasional	The consequences are seen to be Major for personnel as it could result in injuries requiring hospitalisation.	Major	M (VH)	The facility consequence is Moderate as the fire is not expected to spread other infrastructure.	Moderate	M (VH)
L7-GR	O&M - failure leading to venting of a full module. This could be thermal runaway with or without a fire. This scenario considers only the toxic effects.	O&M Building (L7): Gas Release (GR)	CM1, CM2, CM3, CM6, CM7, CM8, CM14, CM18, CM19, CM22, CM29, CM30, CM35, CM36, CM41, CM39, CM43, CM45, CM46	Storage of the additional BESS modules within the storage area has the potential for a gas release if the integrity of the modules is compromised.	Occasional	The consequences are seen to be Major for personnel as it could result in injuries requiring hospitalisation.	Major	M (VH)	The facility consequence is Moderate as the consequences are not expected to spread other infrastructure.	Moderate	M (VH)
L7-EX	O&M - significant failure for spare Hithium Module leading to multiple cells venting to produce a vapour cloud explosion	O&M Building (L7): Explosion (EX)	CM1, CM2, CM3, CM6, CM7, CM8, CM14, CM18, CM19, CM22, CM29, CM30, CM35, CM36, CM41, CM39, CM43, CM45, CM46	Storage of the additional BESS modules within the storage area has the potential for a gas release if the integrity of the modules is compromised. This could lead to an explosion scenario as the release is indoors.	Occasional	The consequences are seen to be Major for personnel as it could result in injuries requiring hospitalisation.	Major	M (VH)	The facility consequence is Moderate as the consequences are not expected to spread other infrastructure.	Moderate	M (VH)
L8-SF	Switch room small fire - localised small fire due to storage of combustibles.	Switch room (L8): Small Fire (SF)	CM1, CM2, CM3, CM6, CM7, CM8, CM14, CM18, CM19, CM22, CM29, CM35, CM36, CM37, CM41, CM39, CM43, CM45	Likelihood of a switch and control room fire comes from (Electric Power Research Institute / US Nuclear Regulatory Commission, 2020) where it notes failure rates of main control boards which could result in a fire is 2.05 E-3 per board per year. The likelihood of a site building catching fire is considered reduced by a magnitude of 10 if the control measures are implemented therefore the likelihood is considered occasional.	Occasional	The consequences are seen to be Major for personnel as it could result in injuries requiring hospitalisation.	Major	M (VH)	The facility consequence is Moderate as the fire is not expected to spread other infrastructure.	Moderate	M (VH)
L8-LF	Switch room large fire - major fire assuming fire spread within the building.	Switch room (L8): Large Fire (LF)	CM1, CM2, CM3, CM6, CM7, CM8, CM14, CM18, CM19, CM22, CM29, CM35, CM36, CM37, CM41, CM39, CM43, CM45	Likelihood of a switch and control room fire comes from (Electric Power Research Institute / US Nuclear Regulatory Commission, 2020) where it notes failure rates of main control boards which could result in a fire is 2.05 E-3 per board per year. The likelihood of a site building catching fire is considered reduced by a magnitude of 10 if the control measures are implemented therefore the likelihood is considered occasional.	Occasional	The consequences are seen to be Major for personnel as it could result in injuries requiring hospitalisation.	Major	M (VH)	The facility consequence is Moderate as the fire is not expected to spread other infrastructure.	Moderate	M (VH)
L9-SF	Vehicle fire - localised fire which may impact the car.	Vehicles (L9): Small Fire (SF)	CM1, CM2, CM3, CM6, CM7, CM8, CM17, CM20, CM49	Only a small portion of vehicle accidents led to fires or would be considered a major accident. With the control measures applied, which include these vehicles generally on all-weather roads. From the International Road Safety Comparison, 2022, (Bureau of Infrastructure and Transport Research Economics, 2023), it is noted that fatality crashes occur 0.49 per 100 million kilometres	Rare	The consequences are seen to be major for personnel as it could result in injuries that would	Major	VL (H)	There may be limited impact to the facility, therefore the consequence is moderate.	Moderate	VL (H)

ID	Context	Location & Type	Relevant CMs	Updated Likelihood Analysis (L)	U-L	Update Life Safety Consequence Analysis (U-LSC)	U-LSC	Updated LS Risk (Initial Risk)	Updated Facility Consequence Analysis (U-FC)	U-FC	Updated F Risk (Initial Risk)
				travelled, which can be considered the point of a fire occurring as well. If we consider 300 km driven in a year, then the likelihood is once in over 600,000 years. Therefore, the likelihood would be rare.		require hospitalisation					
L9-LF	Vehicle large fire - complete loss of fuel from car resulting in	Vehicles (L9): Large Fire (LF)	CM1, CM2, CM3, CM6, CM7, CM8, CM17, CM20	Only a small portion of vehicle accidents led to fires or would be considered a major accident. With the control measures applied, which include these vehicles generally on all-weather roads. From the International Road Safety Comparison, 2022, (Bureau of Infrastructure and Transport Research Economics, 2023), it is noted that fatality crashes occur 0.49 per 100 million kilometres travelled, which can be considered the point of a fire occurring as well. If we consider 300 km driven in a year, then the likelihood is once in over 600,000 years. Therefore, the likelihood would be rare.	Rare	The consequences are seen to be major for personnel as it could result in injuries that would require hospitalisation	Major	VL (H)	There may be limited impact to the facility, therefore the consequence is moderate.	Moderate	VL (H)

11 Conclusions

11.1.1 RED Fire Engineers Pty Ltd has been appointed by Samsung C&T to develop a fire safety study (FSS) for the proposed BESS Belambi Heights located at 696 Castlereagh Highway, Beryl, NSW 2852.

11.1.2 The following hazard locations have been identified at the BESS site as listed in Table 38

Table 38: Hazard locations

HL#	LOCATION NAME
HL1	BESS Units
HL2	Cables
HL3	Electrical systems – MV Transformer
HL4	Electrical systems - PCSM
HL5	Electrical systems – Diesel Generators
HL6	Electrical systems – Miscellaneous (Aux Transformer)
HL7	Site buildings – O&M Building
HL8	Site buildings – Warehouse
HL8	Switch room
HL9	Vehicles
HL10	Transgrid transformer

11.1.3 Various control measures have been noted in Section 7 of this report and these have been reviewed within Sections 9. Water requirement and containment of containment water have been covered in Section 8.

11.1.4 After the endorsement of this fire safety study by FRNSW, it will be used to develop site specific emergency plan and emergency service information pack.

11.1.5 On the basis that the recommendations in this study are implemented, commissioned, and undergo routine maintenance in accordance with manufacturer's recommendations and AS 1851:2012 (Standards Australia, 2012), and all fire safety measures on site are maintained to AS 1851:2012, (Standards Australia, 2012), and NSW Design and Building Practitioners Reg, 2021, it is our professional opinion that the likelihood and consequences associated with a fire associated with the site can be reduced so far is reasonably practicable.

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Appendix A. Risk Management Framework

A.1. Introduction

A.1.1. The level of risk which the hazards identified in this report present is determined using the risk matrix detailed in this appendix.

A.1.2. This risk matrix has been developed from relevant legislation and WorkSafe Australia guidance as set out within this appendix. The risk matrix assesses the identified hazards and determines the risk rating based on different likelihood and consequence criteria. It includes likelihood and consequence descriptors for the risk category analysed, relevant to the hazards identified within this report.

A.1.3. The application of this appendix and its risk matrix are for assessing appropriate measures to control the risk.

A.2. Legislation

A.2.1. Across Australia safety at work is governed by the Work Health and Safety (WHS) Acts and Regulations [6]. These are all based off the Commonwealth legislation:

a) Work Health and Safety Act, 2011, (Australia Government, 2018)
b) Work Health and Safety Regulations, 2011, (Australian Government, 2024)

A.2.2. Within New South Wales the legislation is:

a) Work Health and Safety Act 2011, (New South Wales Government, 2024a)
b) Work Health and Safety Regulations, 2017, (New South Wales Government, 2024)

A.2.3. The WHS legislation across Australia is similar, but not identical. Therefore, there are differences between the Commonwealth and other jurisdiction[7].

A.2.4. All of these Acts and Regulations require risk to be undertaken with respect to 'So Far As Is Reasonably Practicable' (SFAIRP). Associated with the WHS Regulations are Codes of Practice (CoPs). A CoP is a practical guide to achieve the standard of health and safety required under the WHS Act and Regulations of their jurisdiction. The application of a specific CoP may limit the need for a risk assessment or provide criteria for the risk assessment. Additionally, standards, guides and codes, although not legally binding, are provided to assist with risk assessment undertaken and their criteria. Some examples of CoP that are relevant are:

[7] The differences between WHS legislation across Australian can be found here: https://www.safeworkaustralia.gov.au/doc/model-whs-act-cross-comparison-table.

a) National:

- Code of Practice, How to Manage Work Health and Safety Risks, 2018, (Safe Work Australia, 2018)
- Code of Practice, Managing the Risk of Plant in the Workplace, 2023, (Safe Work Australia, 2023)
- Code of Practice, Managing Risks of Hazardous Chemicals in the Workplace, 2023, (Safe Work Australia, 2023a)
- Guide for Major Hazard Facilities: Safety Assessment, 2012, (Safe Work Australia, 2012)

b) New South Wales:

- Code of Practice, How to Manage Work Health and Safety Risks, 2019, (SafeWork NSW, 2019)
- Code of Practice, Managing Risks of Hazardous Chemicals in the Workplace, 2022, (SafeWork NSW, 2022)
- Code of Practice, Managing the Risks of Plant in the Workplace, 2022, (SafeWork NSW, 2022)
- Code of Practice, Managing the Work Environment and Facilities, 2019, (SafeWork NSW, 2019)
- Code of Practice, Safe Design of Structures, 2019, (SafeWork NSW, 2019)

A.2.5. Of these CoP, the CoP for the 'How to Manage Work Health and Safety Risks' sets out a framework of how risk is to be assessed / managed and therefore is the most relevant.

A.3. Implementation

A.3.1. The WHS legalisation calls up, Code of Practice, How to Manage Work Health and Safety Risks (Safe Work Australia, 2018). Under this CoP, the risk management process involves four steps, (Figure 50):

a) Identify hazards, i.e., what will cause a consequence at a specific location / system,
b) Assess risks, specify the nature of the hazard that could occur, how serious the consequence could be, and then the likelihood of the incident occurring,
c) Control risks, propose and implement control measures to eliminate or limit the harm with respect to SFAIRP, and
d) Review control measures, ongoing review of the hazard, harm, and their associated control measures.



Figure 50: Risk management process (Figure 1 from Safe Work Australia, 2018, (Safe Work Australia, 2018))

A.3.2. The risk assessment, provided within this document, by its very nature can only progress to the proposal of control measures. It is the responsibility of the business owner to implement and maintain all of these required control measures as well as conduct ongoing regular risk reviews. The control measures proposed in this report are only applicable to the situation and arrangement noted within this report. If the situation and arrangement change, then this report and its associated risk assessment are not valid.

A.3.3. The hazard assessment, i.e., steps 01 and 02 from Figure 50, will be undertaken with consideration to AS ISO 31000:2018, (Standards Australia, 2018) risk management framework, see Figure 51. In the context of developing this document a modified risk management process presented at Figure 52 is used. Specifically, the following are noted:

a) The potential magnitude of the consequence and the quality of the available information related to the hazard will influence the levels determined for likelihood and consequence.
b) The risk analysis may be undertaken either solely or in combination of qualitative, semi-quantitative, or quantitative.

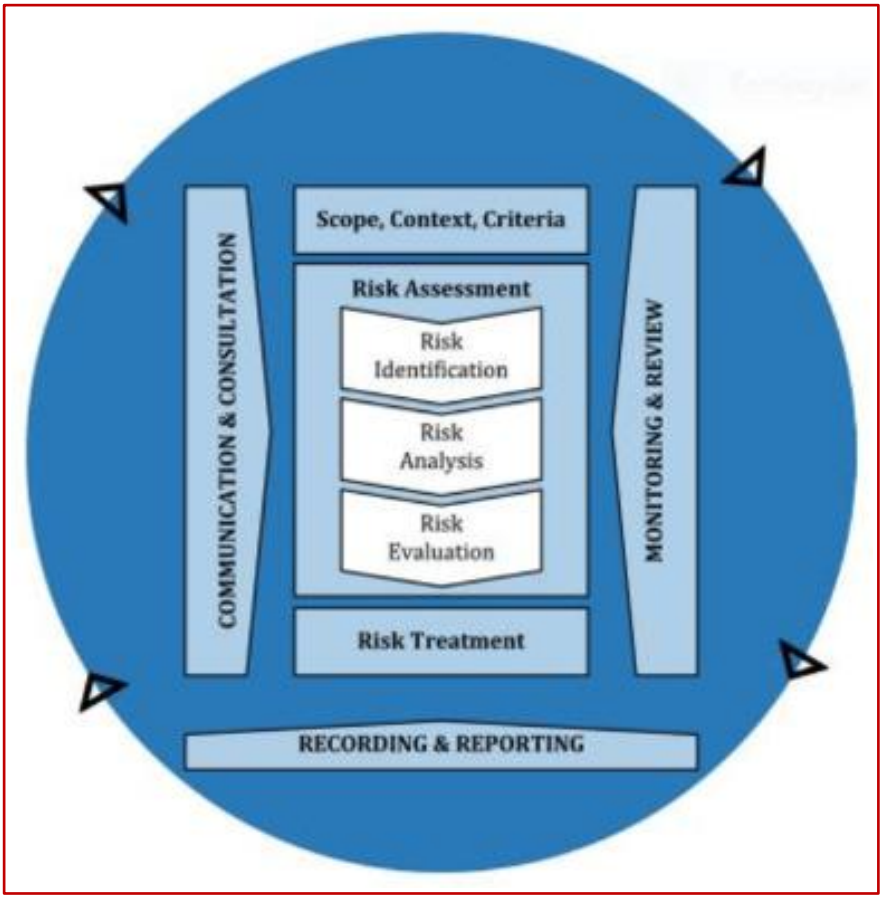


Figure 51: Default AS ISO 31000:2018, (Standards Australia, 2018), risk management process

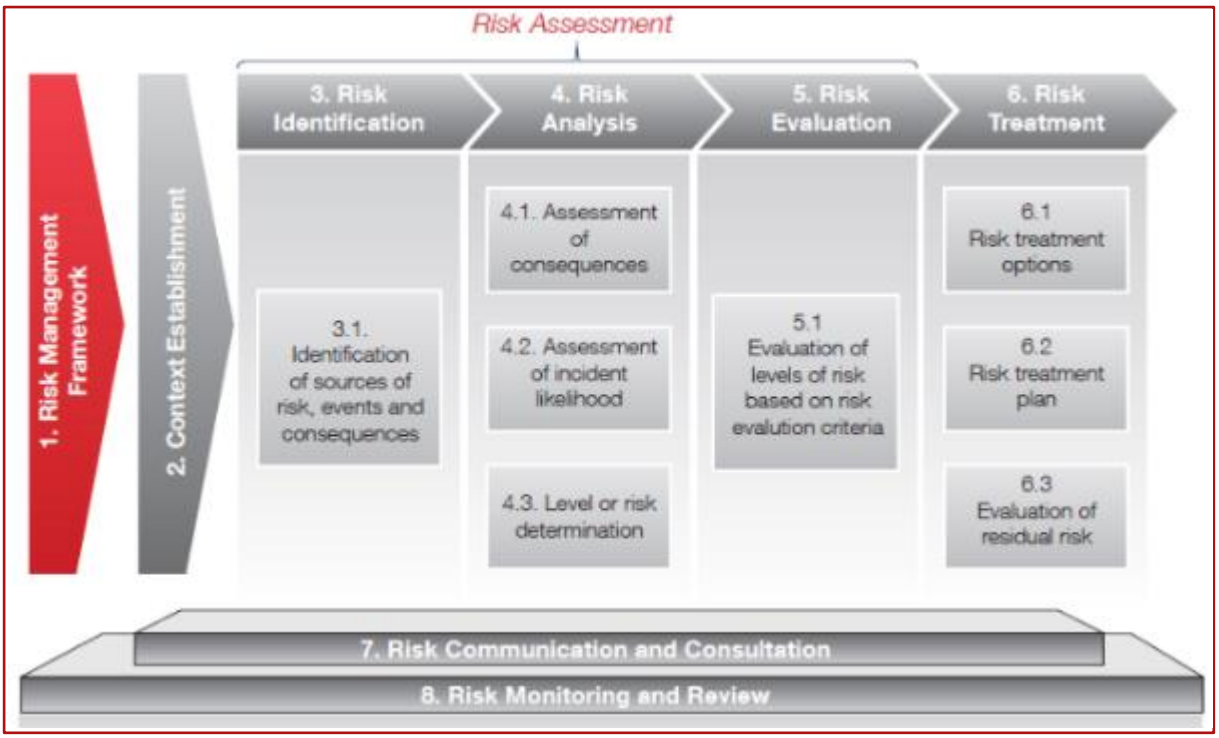


Figure 52: Modified Risk Management process

A.3.4. Control measures will be developed with respect to the hierarchy of control measures, Figure 53. As Elimination is unlikely, the focus will generally initially

be on isolation and engineering control, followed by administrative and personnel protective equipment.

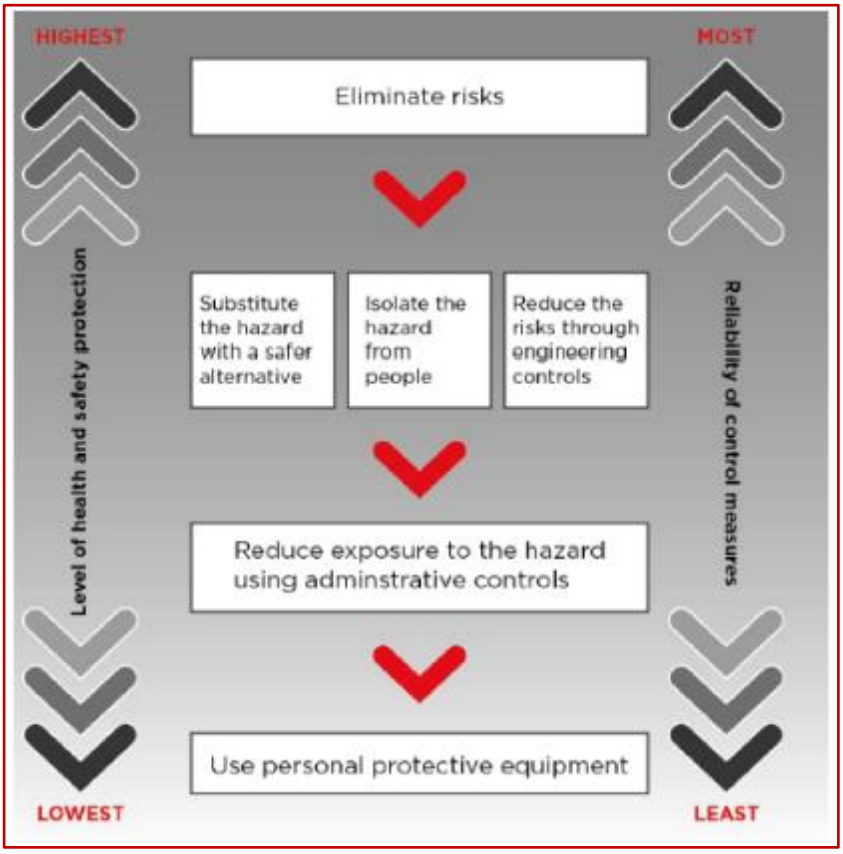


Figure 53: Hierarchy of control measures (Figure 2 from Safe Work Australia, 2018, (Safe Work Australia, 2018))

A.3.5. Control measures will be considered and recommended until SFAIRP is considered to have been achieved, or in other words a reasonably practicable level of safety is met for the risk event under investigation via the required range of control measures. As set out in Code of Practice, How to Manage Work Health and Safety Risks (Safe Work Australia, 2018), reasonably practicable means that which is, or was at a particular time, reasonably able to be done to ensure health and safety, taking into account and weighing up all relevant matters including:

a) the likelihood of the hazard or the risk concerned occurring,
b) the degree of harm that might result from the hazard or the risk,
c) what the person concerned knows, or ought reasonably to know, about the hazard or risk, and ways of eliminating or minimising the risk,
d) the availability and suitability of ways to eliminate or minimise the risk, and
e) after assessing the extent of the risk and the available ways of eliminating or minimising the risk, the cost associated with available ways of eliminating or minimising the risk, including whether the cost is grossly disproportionate to the risk.

A.3.6. Control measures will be developed in consultation with the client and other relevant consultants, such as fire protection engineer. In determining what is reasonably practicable the following must be considered:

a) All potential control measures are to be considered,
b) Then consider if it is reasonable to apply all of these proposed control measures. In other words, all control measures that can be applied should be implemented unless it is reasonable for some control measures not to be applied. An example of this could be a control measure which has the same influence on the hazard as another existing / proposed control measure, and
c) Where cost-benefit cannot support the implementation of a proposed control measure. It is the client's responsibility to demonstrate the excessive cost.

A.3.7. Demonstrating reasonably practicable in this fashion is in line with the objectives of the WHS legislation.

A.3.8. The risk matrix provided in Section A.4 and its associated consequence table will be used to determine the risk ranking for each identified scenario throughout this report. Code of Practice, How to Manage Work Health and Safety Risks (Safe Work Australia, 2018), does not specify a format or process that risk assessment is to be undertaken.

A.3.9. The implementation of the Risk Matrix presented at Table 41, will be influenced by the type of documentation being developed.

a) For a fire safety study (FSS), this document will have been developed with consideration to HIPAP 2, (NSW Planning, 2011). Where preliminary / final hazard assessment [8] (PHA / FHA) has been developed for this project, the outcomes from these PHA / FHA will be included within this FSS, in the same format as used in the original PHA / FHA. In other words, where risk curves and the like have been developed and issued for this project, these risk tools will be used for the hazards that they refer to within this document. New fire specific risk not covered by these previous assessment(s) will be assessed against the fire matrix noted within this appendix.
b) For Fire Risk Assessment (FRA) and other risk reports, related to fire safety, relevant legalisation, codes, and guides will be considered. If the relevant legalisation or codes require a specific risk management process, then this would be applied instead of this risk matrix.

A.3.10. The risk assessment begins with an initial risk assessment (IRA) of the scenario under consideration, developed using the risk matrix presented at Table 41. In an IRA it is assumed that there are no control measures in place. Where manual

8 From Hazard Industry Planning Advisory Paper No. 3, Preliminary Hazard Assessment is to identify all potential hazards, analyse these hazards effects on people and the environment, determine the probability of occurrence, and via the application of multi-level risk assessment quantify risk levels to surrounding land uses and the environment. Final Hazard Assessment is the same as a Preliminary Hazard Assessment, outside of the fact it is done later in the design / development of the site.

procedures could lead to the incident the likelihood is to be considered 'Almost Certain'.

A.3.11. An IRA will generally include two analyses, these being:

a) The incident at the location of origin, and
b) An IRA which relates to the spread of the incident to another location site after the original incident has occurred.

A.3.12. An updated risk assessment (URA) is conducted for the scenario under consideration after recommended control measures have been reviewed and selected. As with the IRA, two URAs will be conducted these being for the incident at the location of origin and for the incident to spread.

A.3.13. As control measures may affect likelihood, consequence or both, therefore additional URA's that focus on a reduced likelihood and then a reduced consequence scenario may be undertaken. In accordance with the WHS focus on consequence the reduce likelihood will be presented in the URA.

A.4. Risk Matrix

A.4.1. To be able to rank the risk, likelihood and consequence levels have been developed considering a number of guidelines as outlined below. These levels are to be reviewed and concurred with all stakeholders.

A.4.2. The likelihood presented in Table 39 has been developed with consideration of:

a) Table 10 from National Emergency Risk Assessment Guidelines, (Australian Institute for Disaster Resilience, 2020),
b) Safe Work Australia, Guide for Major Hazard Facilities, 2012, (Safe Work Australia, 2012), and
c) Tables II and A-II from MIL-STD-882E System Safety (Department of Defense (USA), 2023).

A.4.3. Specifically, the likelihood frequencies used in Table 39 are based on the first five levels presented in Table 10 of National Emergency Risk Assessment Guidelines, (Australian Institute for Disaster Resilience, 2020). Whilst the last level, i.e. Eliminated, presented in Table 39 comes from II and A-II from MIL-STD-882E System Safety (Department of Defense (USA), 2023). This combination has been chosen as intervals up to 1,000 years and then greater is expected to provide an appropriate resolution for the occurrence of fire vulnerability associated with building and infrastructure.

A.4.4. The consequence presented in Table 40, has been developed with consideration of:

a) Table 1 from Risk Management Framework, (Western Parkland City Authority, 2022) for life safety,
b) Table 2 from NSW Health, Enterprise-wide Risk Management 2022, (New South Wales Government, 2022), and

c) Examples 27 and 33 from Safe Work Australia, Guide for Major Hazard Facilities, 2012, (Safe Work Australia, 2012).

A.4.5. These three references all have similar consequences levels for life safety, such as multiple deaths relate to catastrophic. For the facility the consequence levels have been based around the last two referenced documents.

A.4.6. The risk matrix in Table 41, has been developed with consideration of:

a) Table 3 from Risk Management Framework (Western Parkland City Authority, 2022),
b) Figure 2 from Assessing and Controlling Risk for Business, (Environment Protection Authority Victoria, 2018), and
c) Table III, MIL-STD-882E System Safety (Department of Defense (USA), 2023).

A.4.7. The risk matrix supports five levels of risk level, similar to Assessing and Controlling Risk for Business, (Environment Protection Authority Victoria, 2018). In line with the MIL-STD-882E System Safety (Department of Defense (USA), 2023) the 'Very High' risk level relates to a consequence of 'Catastrophic' over a likelihood range of 'Almost Certain' to 'Occasional', plus a likelihood of 'Almost Certain' over a range of consequence 'Major' to 'Catastrophic'. Also inline with the MIL-STD-882E System Safety (Department of Defense (USA), 2023) the risk level for a consequence of 'Catastrophic' and likelihood of 'Rare' is 'Medium'. At the other end of the risk matrix, in line with all three reference documents, the risk level is 'Very Low' for consequence 'Minor' and likelihood 'Rare'. Within this risk matrix the consequence of 'Minor' for a likelihood of 'Almost Certain' has a risk level of 'Medium'. This arrangement aligns with the MIL-STD-882E System Safety (Department of Defense (USA), 2023) and Assessing and Controlling Risk for Business, (Environment Protection Authority Victoria, 2018). The centre of the risk matrix has been developed by stepping from these set edge conditions.

A.4.8. This risk matrix presented at Table 41, is based on the likelihoods defined at Table 39 and the consequences defined at Table 40.

A.4.9. The risk levels presented at Table 41 are defined at Table 42. Table 42 also sets out the actions to be taken at each of these risk levels. These actions are based on Assessing and Controlling Risk for Business, (Environment Protection Authority Victoria, 2018).

Table 39: Likelihood Levels

Name	Description	Average recurrence interval (ARI) / Site historical data	Annual Exceedance Probability (AEP)	Frequency (Indicative)
Almost Certain	Expected to occur several times a year under normal circumstances.	Less than 1 year / Has occurred 3 or more times in the last year or at least each year over the last 5 years.	63% per year or more	Once or more per year
Probable	Expected to occur at least once in a 10 year period or several times over a 100 year period.	1 to < 10 year / Has occurred at least once in the least decade or four or less times over the last 5 years.	10% to < 63% per year	Once per 10 years
Occasional	Expected to occur at least once in a 100 year period or several times over a 100 year period.	10 to < 100 year / Has occurred in the last two decades.	1% to < 10% per year	Once per 100 years
Improbable	Expected to occur at least once in a 1,000 year period or several times over a 1,000 year period.	100 to 1,000 year / An uncommon incident noted within the industry.	0.1% to < 1% per year	Once per 1,000 year
Rare	Not expected to occur any more than several times over a 10,000 year period.	1,000 year or more / May have not been reported across the industry sector.	Less than 0.1% per year	Once per 10,000 years
Eliminated	Incapable of occurrence. This level is only used when potential hazards are identified and later eliminated.	N/A	N/A	N/A

Table 40: Consequence Levels

Rating	Life Safety (Workers and the Public)	Facility
Minor	Minor injury or illness that is treatable in the workplace (first aid) or by a registered health practitioner, with no follow up treatment required.	Minimal damage resulting in negligible business, structural, and system impact.
Moderate	Injury or illness causing no permanent disability, which requires non-emergency medical attention by a registered health practitioner or at least ten minor outcomes.	Limited asset loss across the facility, which may include damage to system but no significant damage to structures.
Major	Serious injury or illness requiring immediate admission to hospital as an inpatient and / or permanent partial disability or at least ten moderate outcomes.	Serious asset loss and damage to the facility, which would include the destruction or significant damage to a single major structure.
Critical	Single fatality and / or permanent total disability or at least ten major outcomes.	Severe asset loss and damage to the facility, which would include the destructed or significantly damaged to multiple major structures.
Catastrophic	Multiple fatalities or at least ten critical outcomes.	Total destruction or damage to the facility, including all or most building and associated systems. Potential for permanent loss of production.

Table 41: Risk Matrix

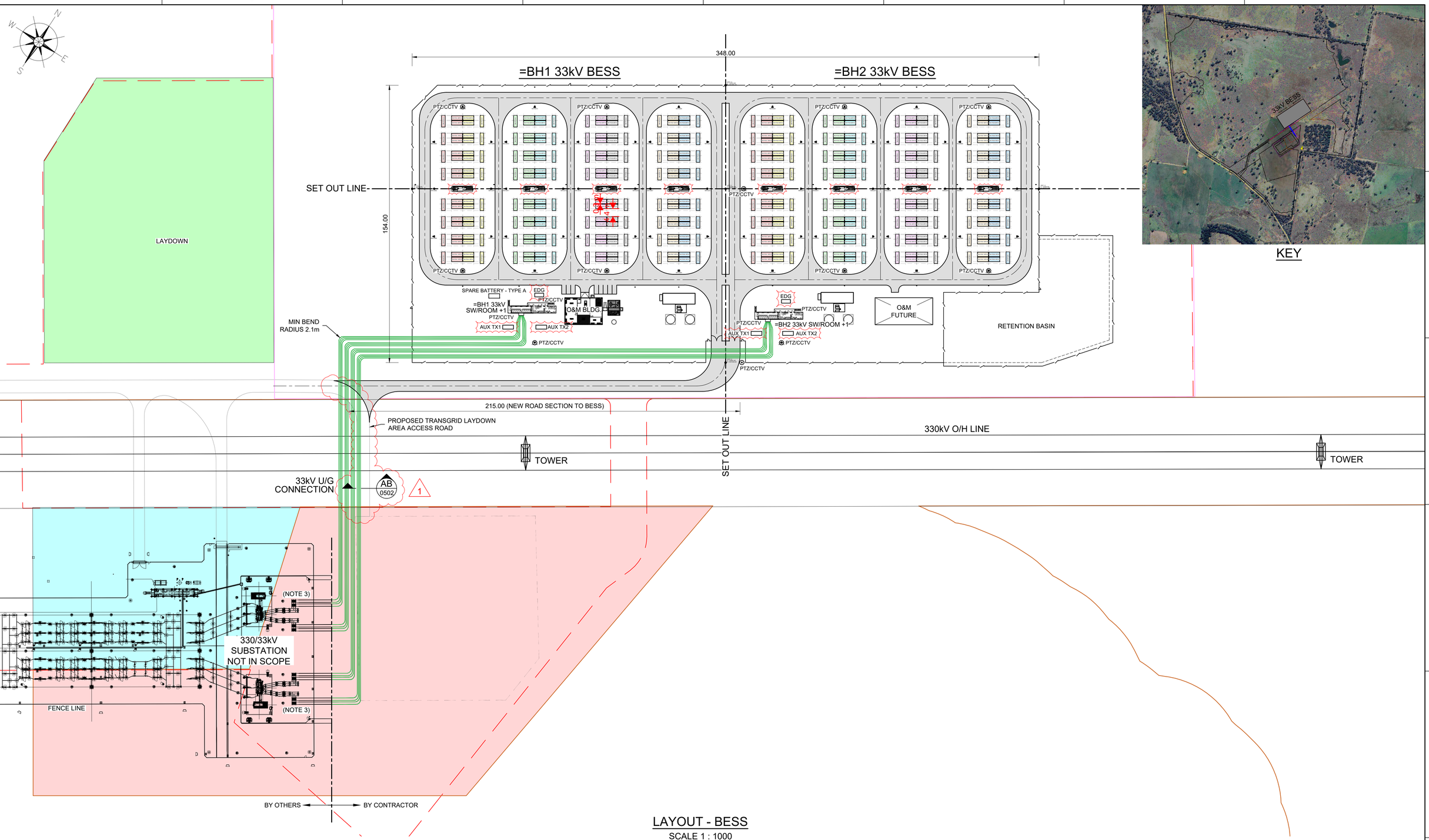
Likelihood	Consequence				
	Minor	Moderate	Major	Critical	Catastrophic
Almost Certain	Medium	High	Very High	Very High	Very High
Probable	Low	Medium	High	Very High	Very High
Occasional	Low	Medium	Medium	High	Very High
Improbable	Very Low	Low	Low	Medium	High
Rare	Very Low	Very Low	Very Low	Low	Medium
Eliminated	Eliminated				

Table 42: Description of Risk Levels

Risk Level	Description	Action
Very High	Totally unacceptable level of risk.	Stop work and undertake action immediately.
High	Unacceptable level of risk.	Action plan immediately required to put controls in place to reduce risk level.
Medium	Could be acceptable if controls have been applied, if not practicable to lower the risk further by additional control measures.	Specific monitoring to be undertaken and additional control measures to be implemented if reasonably practicable. Regular review to be undertaken.
Low	May be considered acceptable level of risk, if not practicable to lower the risk further.	Attempt to lower or eliminate risk but higher risk levels take priority. Periodic reviews are to be undertaken.
Very Low	Generally considered acceptable.	Attempt to lower or eliminate risk but higher risk levels take priority.
Eliminated	Hazard no longer exists.	No action.

A.5. Site Arrangements

A pdf of figures is provided beginning on the next page.



NOTES

1. =BH1 - BELLAMBI HEIGHTS BESS 1
2. =BH2 - BELLAMBI HEIGHTS BESS 2
3. PHYSICAL POINT OF DEMARCATION IS AT 33kV CABLE TERMINATION POINTS WITHIN HV SUBSTATION ON SECONDARY SIDE OF MAIN TX. TRENCHING AND CONDUITS WITHIN SUBSTATION BY OTHERS. DESIGN AND SUPPLY OF CABLE FROM 33kV CABLE TERMINATION POINT WITHIN SUBSTATION TO MV SWITCHGEAR WITHIN SWITCHROOM BY BESS CONTRACTOR. TRENCHING AND CONDUITS FROM 33kV SUBSTATION FENCE TO MV SWITCHGEAR BY BESS CONTRACTOR.
4. SCOPE FOR TERMINATION ON 33KV SIDE OF TRANSFORMER TO BE CONFIRMED

LEGEND

- DEVELOPMENT FOOTPRINT
- BESS BOUNDARY
- APPROVED LAYDOWN FOOTPRINT
- APPROVED SWITCHYARD FOOTPRINT
- TRANSGRID LAND
- CONSTRUCTION BOUNDARY
- SECURITY FENCE
- ROADWAY
- 150mm HD HV CONDUIT IN TREFOIL CONFIG.
- CENTER LINES (ROADS)
- CENTER LINES (BESS SET OUT)

HITHIUM 5.015MWH (128EA PER SITE)

PCSM_FP4203M (64EA PER SITE)

LAYOUT - BESS

SCALE 1 : 1000

(COMPLETE ARRANGEMENT SHOWN)

DRAWING IS COLOUR CODED - PRINT IN COLOUR

0 50 100m

10

UNREDUCED SCALE 1:1000

Rev	DESCRIPTION	DRN	CHK	APPR	DATE
1	RE-ISSUED FOR CONSTRUCTION	A.N	B.M	A.G	16/04/26
0	ISSUED FOR CONSTRUCTION	A.N	B.M	A.G	08/04/26
B	ISSUED FOR 70% DESIGN REVIEW	A.N	C.S	A.G	15/01/26
A	ISSUED FOR 30% DESIGN REVIEW	A.N	B.M	A.G	30/10/25

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REVISION CONTROL	
Drawn	*Date*
A.NEWTON	16/04/26
Checked	*Date*
B.MURUGESAN	16/04/26
Certified RPEQ 23393	*Date*
A.GOKCE	16/04/26

REFERENCES	
OVERALL SITE LAYOUT	BH-SCT-GEN-LAY-0401
BESS PLOT PLAN	BH-SCT-GEN-LAY-0402
BESS UNIT SECT/ELEVATION	BH-SCT-GEN-LAY-0403
CABLE ROUTE PLAN	BH-SCT-ELE-LAY-0404
EARTHING & LIGHTNING PLAN	BH-SCT-ELE-LAY-0405
OVERALL SLD	BH-SCT-ELE-SLD-0301

Project Number WR2017993

Design Approval (optional) - *Date* -

SAMSUNG C&T

BELLAMBI HEIGHTS RENEWABLE PROJECT

33kV BESS
=BH1 & =BH2 OVERALL
SITE LAYOUT
GENERAL ARRANGEMENT

Client	*Drawing Number*	*Revision*	*Drawing Status*	*Scale*
SAMSUNG C&T	BH-SCT-GEN-LAY-0401	1	**Released For Construction**	1:1000

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NOTES

1. ALL DIMENSIONS IN METERS UNLESS STATED OTHERWISE.

LEGEND

- SECURITY FENCE
- ROADWAY
- 150mm HD HV CONDUIT IN TREFOIL CONFIG.
- CENTER LINES (ROADS)
- CENTER LINES (BESS SET OUT)
- CONSTRUCTION BOUNDARY
- GPO REACH (SINGLE PHASE) - 20m RAD
- CRANE REACH - 30m Rad
- 10m FIRE BREAK
- PTZ/CCTV — LIGHTNING MAST W/LIGHT, GPO, PAN/TILT/ZOOM CCTV CAMERA
- FH — FIRE HYDRANT
- LIGHTNING MAST W/ LIGHT & GPO

LAYOUT - BESS

SCALE 1 : 500
(COMPLETE ARRANGEMENT SHOWN)

DRAWING IS COLOUR CODED - PRINT IN COLOUR

0 10 20 30 40 50m
5
UNREDUCED SCALE 1:500

REVISION CONTROL		REFERENCES	
Drawn	*Date*	OVERALL SITE LAYOUT	BH-SCT-GEN-LAY-0401
A.NEWTON	08/04/26	BESS PLOT PLAN	BH-SCT-GEN-LAY-0402
Checked	*Date*	BESS UNIT SECT/ELEVATION	BH-SCT-GEN-LAY-0403
B.MURUGESAN	08/04/26	CABLE ROUTE PLAN	BH-SCT-ELE-LAY-0404
Certified RPEQ 23393	*Date*	EARTHING & LIGHTNING PLAN	BH-SCT-ELE-LAY-0405
A.GOKCE	08/04/26	BUILDING +1 LAYOUT	BH-SCT-ELE-LAY-0406
Design Approval (optional)	*Date*	OVERALL SLD	BH-SCT-ELE-SLD-0301
-	-		

Rev	DESCRIPTION	DRN	CHK	APPR	DATE
0	ISSUED FOR CONSTRUCTION	A.N	B.M	A.G	08/04/26
B	ISSUED FOR 70% DESIGN REVIEW	A.N	C.S	A.G	15/01/26
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Project Number WR2017993

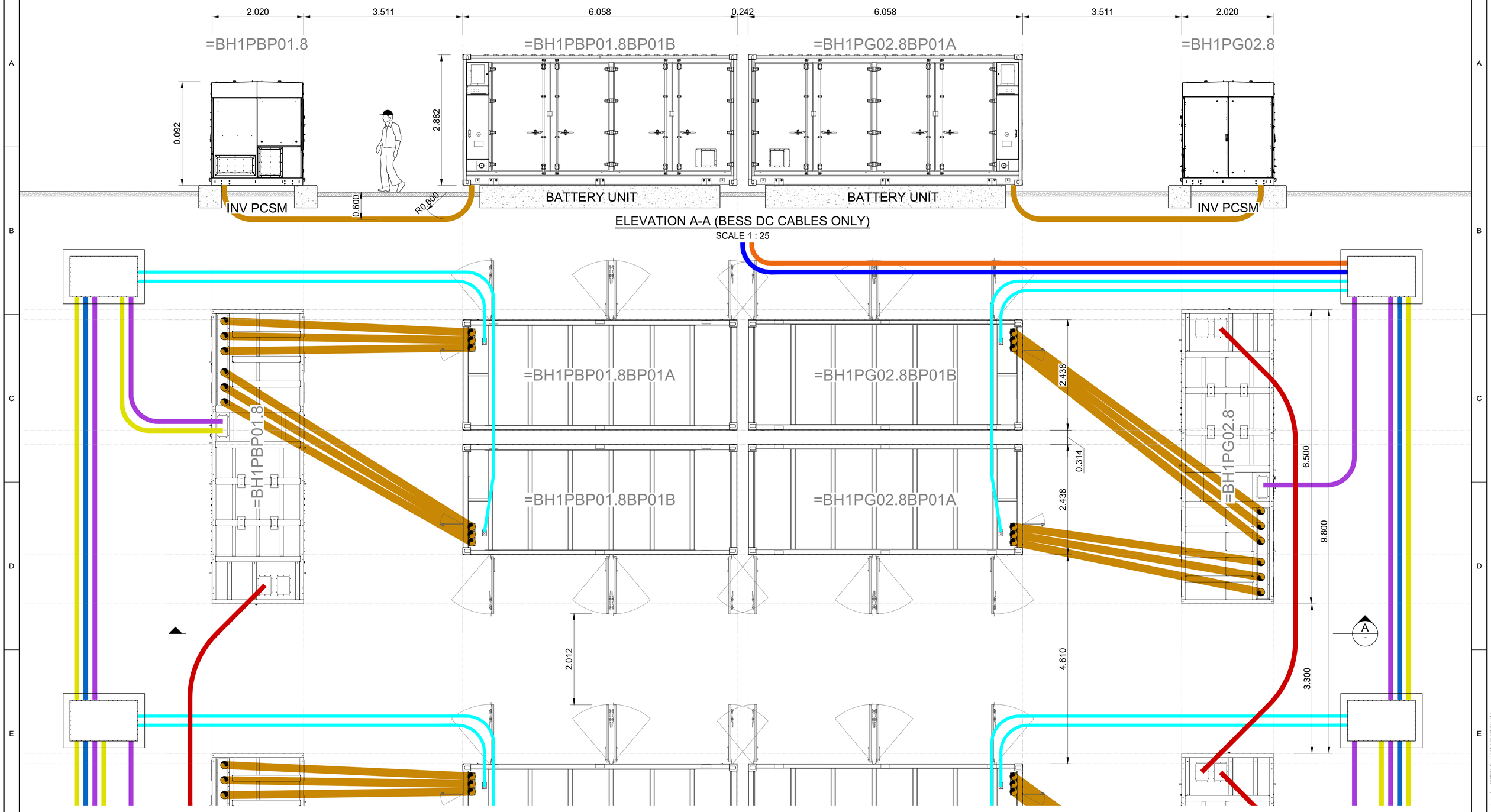
SAMSUNG C&T

BELLAMBI HEIGHTS RENEWABLE PROJECT

33kV BESS
=BH1 & =BH2 OVERALL
BESS PLOT PLAN
GENERAL ARRANGEMENT

Client	*Drawing Number*	*Revision*	*Drawing Status*	*Scale*
SAMSUNG C&T	BH-SCT-GEN-LAY-0402	0	**Released For Construction**	1:500

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ELEVATION A-A (BESS DC CABLES ONLY)

SCALE 1 : 25

LAYOUT - BESS STAGE 1 (TYP)

SCALE 1 : 25

NOTES

1. ALL DIMENSIONS IN METERS.

LEGEND

SIZE	TYPE	DESCRIPTION
150mm	ORANGE HEAVY DUTY (HD) CONDUIT	BESS DC CABLES
100mm	ORANGE HEAVY DUTY (HD) CONDUIT IN TREFOIL CONFIGURATION	BESS 33kV POWER CABLES
100mm	ORANGE HEAVY DUTY (HD) CONDUIT	LV/CONTROL CABLES
100mm	WHITE HEAVY DUTY (HD) COMMS CONDUIT	COMMUNICATIONS CABLES
63mm	ORANGE HEAVY DUTY (HD) CONDUIT & COMMS WHITE CONDUIT (VERTICALLY STACKED)	BATTERY LV & COMMS
63mm	WHITE HEAVY DUTY (HD) COMMS CONDUIT	CCTV
100mm	ORANGE HEAVY DUTY (HD) CONDUIT	LIGHTING CABLES

DRAWING IS COLOUR CODED - PRINT IN COLOUR

0 1000 2000mm

200

UNREDUCED SCALE 1:25

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REVISION CONTROL		
Drawn	A.NEWTON	*Date* 02/04/26
Checked	B.MURUGESAN	*Date* 08/04/26
Certified RPEQ 23393	A.GOKCE	*Date* 08/04/26
Design Approval (optional)	-	*Date* -

REFERENCES	
OVERALL SITE LAYOUT	BH-SCT-GEN-LAY-0401
BESS PLOT PLAN	BH-SCT-GEN-LAY-0402
BESS UNIT SECT/ELEVATION	BH-SCT-GEN-LAY-0403
CABLE ROUTE PLAN	BH-SCT-ELE-LAY-0404
EARTHING & LIGHTNING PLAN	BH-SCT-ELE-LAY-0405
OVERALL SLD	BH-SCT-ELE-SLD-0301

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BELLAMBI HEIGHTS RENEWABLE PROJECT

33kV BESS

TYPICAL

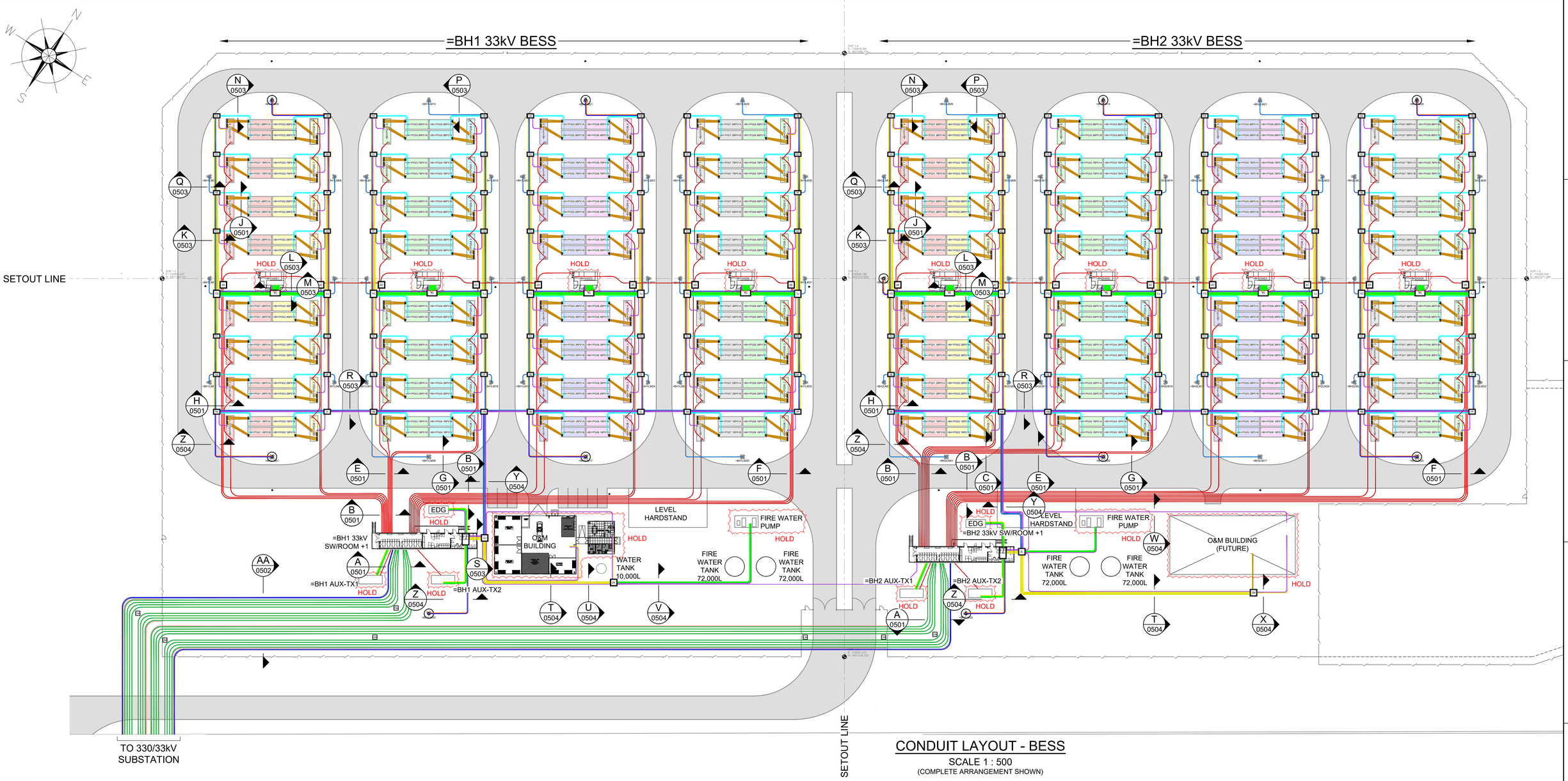
BESS SECTION VIEW, ELEVATIONS

GENERAL ARRANGEMENT

Client	*Drawing Number*	*Revision*	*Drawing Status*	*Scale*
SAMSUNG C&T	BH-SCT-GEN-LAY-0403	0	Released For Construction	1:25

Project Number
WR2017993

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CONDUIT LAYOUT - BESS

SCALE 1 : 500
(COMPLETE ARRANGEMENT SHOWN)

NOTES:

1. ALL CONDUITS TO PROTRUDE AT LEAST 500mm PAST FINISHED GROUND LEVEL (FGL)
2. ALL CONDUITS TO BE FITTED WITH DRAW ROPES
3. SECURELY CAP UNDERGROUND CONDUITS AS REQUIRED
4. ALL PIT ENTRIES TO UTILISE BELLMOUTHS
5. LV & CONTROL CONDUITS MUST ALL BE ORANGE HEAVY DUTY (HD) (UNLESS NOTE OTHERWISE ALL CONDUITS ARE LV)
   MINIMUM DEPTH 600mm
   MINIMUM BENDING RADIUS 600mm
   BESS AUX POWER SUPPLY CONDUIT BENDING RADIUS TO BE 1000mm
6. HV FEEDER CONDUITS
   MUST ALL BE ORANGE HEAVY DUTY (HD)
   MINIMUM DEPTH 750mm
   MINIMUM BEND RADIUS FOR 300mm² = 1300mm
   MINIMUM BEND RADIUS FOR 630mm² = 1600mm
   MINIMUM BEND RADIUS FOR 1000mm² = 1800mm
7. COMMUNICATION CONDUITS TO BE WHITE & LABELLED 'COMMUNICATIONS'
   MINIMUM DEPTH 600mm
   MINIMUM BENDING RADIUS 600mm
8. 6% STABILISED SAND BACKFILL TO BE USED WHERE CONDUITS PASS UNDER DESIGNATED ROADWAYS.
9. PIT 3 SET OUT IS TO BE COORDINATED WITH THE BUILDING FOOTING DESIGN.
10. 400mm² DC CABLES BENDING RADIUS:
    680mm PULL
    450mm SET IN POSITION
11. 33kV FEEDER CABLE TRANSITION TO OCCUR IN PIT UNDER SWITCHGEAR ROOMS.

LEGEND

- SECURITY FENCE
- ROADWAY
- CCTV CAMERA
- HYDRANT

PIT SCHEDULE

TYPE	SIZE (W x L x D)	DESCRIPTION	QTY
1	900 x 1500 x 900 (A,B,C,D,E,F)	PRE-CAST CONCRETE CABLE PIT CLASS 'D'	96 off
	1500 x 1700 x 1000 (G&J)	PRE-CAST CONCRETE CABLE PIT CLASS 'D'	16 off
	1300 x 2400 x 1000 (H)	PRE-CAST CONCRETE CABLE PIT CLASS 'D'	8 off
	1100 x 1500 x 900 (K,L,M,N,P)	PRE-CAST CONCRETE CABLE PIT CLASS 'D'	16 off
2	1500 x 1500 x 1400	PRE-CAST CONCRETE CABLE PIT CLASS 'D'	20 off
3	1600 x 2800 x 1000	PRE-CAST CONCRETE CABLE PIT CLASS 'D'	2 off
CM		33kV CABLE ROUTE MARKER TO HV SUBSTATION, LOCATED AT: ROAD CROSSINGS, CHANGE IN DIRECTION, EVERY 200m MIN.	AS REQ'D

CONDUIT SCHEDULE

SIZE	TYPE	DESCRIPTION	QTY
150mm	ORANGE HEAVY DUTY (HD) CONDUIT IN TREFOIL CONFIGURATION	33kV SWITCHYARD FEEDER	18,500m
150mm	ORANGE HEAVY DUTY (HD) CONDUIT	LV/CONTROL CABLES	1,300m
150mm	ORANGE HEAVY DUTY (HD) CONDUIT	BESS DC CABLES	5,000m
100mm	ORANGE HEAVY DUTY (HD) CONDUIT IN TREFOIL CONFIGURATION	BESS 33kV POWER CABLES	17,500m
100mm	ORANGE HEAVY DUTY (HD) CONDUIT	LV/CONTROL CABLES	5,500m
100mm	WHITE HEAVY DUTY (HD) COMMS CONDUIT	COMMUNICATIONS CABLES	3,600m
50mm	WHITE HEAVY DUTY (HD) COMMS CONDUIT	COMMUNICATIONS CABLES	1,700m
63mm	ORANGE HEAVY DUTY (HD) CONDUIT & COMMS WHITE CONDUIT (VERTICALLY STACKED)	BATTERY LV & COMMS	3,500m (EACH)
63mm	WHITE HEAVY DUTY (HD) COMMS CONDUIT	CCTV	350m
100mm	ORANGE HEAVY DUTY (HD) CONDUIT	LIGHTING CABLES	2,400m
50mm	ORANGE HEAVY DUTY (HD) CONDUIT	EARTHING CONDUITS	1,500m

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REVISION CONTROL		REFERENCES	
Drawn	*Date*	OVERALL SITE LAYOUT	BH-SCT-GEN-LAY-0401
A.GRAHAM	20/02/26	BESS PLOT PLAN	BH-SCT-GEN-LAY-0402
Checked	*Date*	BESS UNIT SECT/ELEVATION	BH-SCT-GEN-LAY-0403
B.MURUGESAN	20/02/26	CABLE ROUTE PLAN	BH-SCT-ELE-LAY-0404
Certified RPEQ 23393	*Date*	EARTHING & LIGHTNING PLAN	BH-SCT-ELE-LAY-0405
A.GOKCE	20/02/26	OVERALL SLD	BH-SCT-ELE-SLD-0301
Project Number	*Design Approval (optional)*	*Date*	
WR2017993	-	-	

Rev	DESCRIPTION	DRN	CHK	APPR	DATE
0	ISSUED FOR CONSTRUCTION	A.G	B.M	A.G	20/02/26
B	ISSUED FOR 70% DESIGN REVIEW	A.N	C.S	A.G	15/01/26
A	ISSUED FOR 30% DESIGN REVIEW	A.N	B.M	A.G	30/10/25

0 10 20 30 40 50m
5
UNREDUCED SCALE 1:500

SAMSUNG C&T

BELLAMBI HEIGHTS RENEWABLE PROJECT

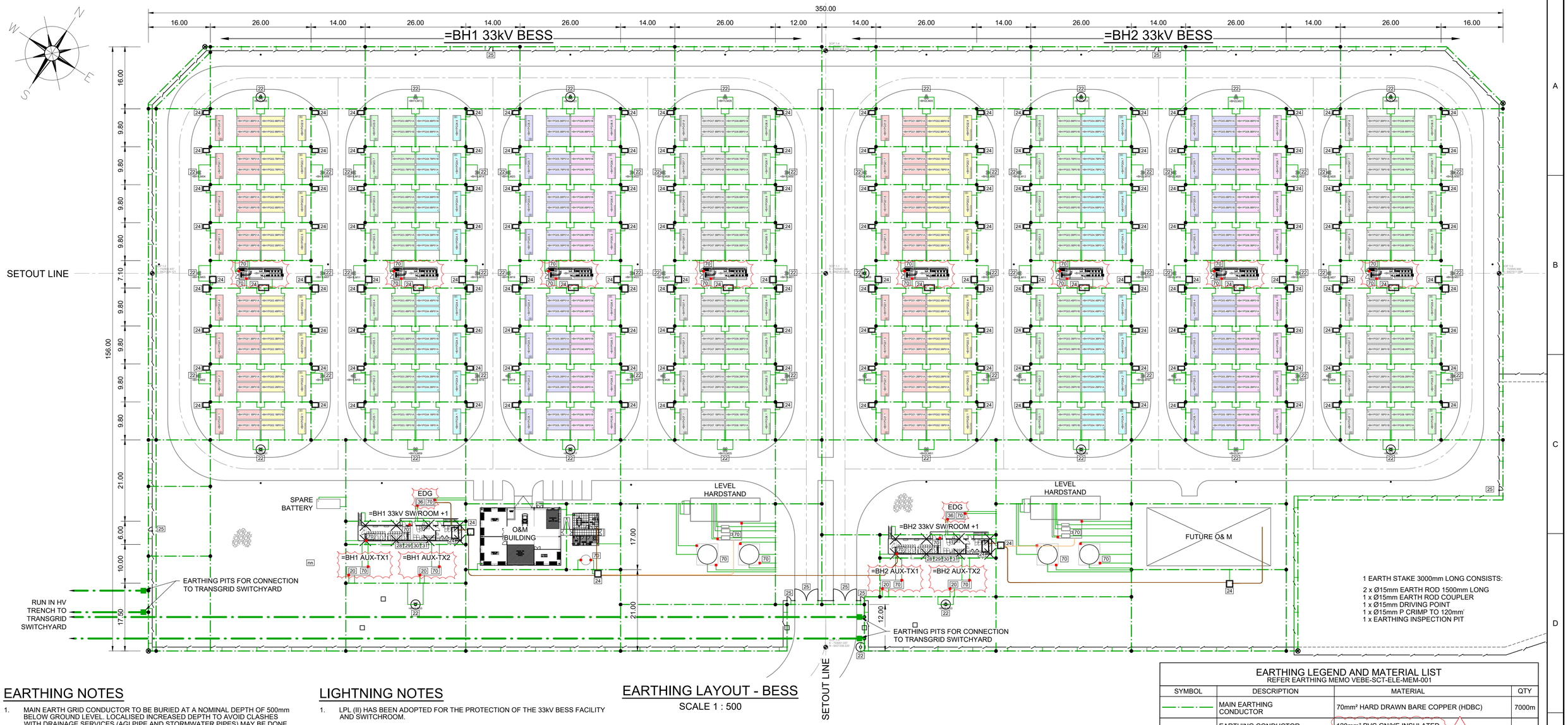
33kV BESS
=BH1 & =BH2 OVERALL
CABLE ROUTE
PLAN

Client	*Drawing Number*	*Revision*	*Drawing Status*	*Scale*
SAMSUNG C&T	BH-SCT-ELE-LAY-0404	0	**Released For Construction**	1:500

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EARTHING LAYOUT - BESS

SCALE 1 : 500

0 10 20 30 40 50m
5

UNREDUCED SCALE 1:500

EARTHING NOTES

1. MAIN EARTH GRID CONDUCTOR TO BE BURIED AT A NOMINAL DEPTH OF 500mm BELOW GROUND LEVEL. LOCALISED INCREASED DEPTH TO AVOID CLASHES WITH DRAINAGE SERVICES (AGI PIPE AND STORMWATER PIPES) MAY BE DONE AS REQUIRED.
2. EVERY THIRD FENCE POST TO BE EARTHED.
3. MATERIALS LIST DOES NOT INCLUDE THE EARTHING EQUIPMENT REQUIRED DURING CIVIL WORKS TO ALLOW CONNECTION TO STRUCTURES OR EXTRA EQUIPMENT REQUIRED FOR INDIVIDUAL STRUCTURE ASSEMBLIES.
4. TWO BUILDING EQUIPMENT EARTH TAILS TO ENTER BUILDING VIA CABLE LADDER.
5. ELECTRICAL AND DRAINAGE PIT LIDS TO BE EARTHED IF CONDUCTIVE.
6. 33kV CABLE SCREENS SHALL BE BONDED BOTH ENDS AT THE RMU KIOSK, BESS TRANSFORMER AND SWITCHGEAR.

LIGHTNING NOTES

1. LPL (II) HAS BEEN ADOPTED FOR THE PROTECTION OF THE 33kV BESS FACILITY AND SWITCHROOM.
2. ROLLING SPHERE RADIUS OF 20m UTILISED IN DESIGN.

LEGEND

- SECURITY FENCE
- CENTER LINES
- BASE POINT MARKER (GDA20-56 IN mm)
- nn EARTHING DETAIL REFERENCE - REFER TO RELEVANT SHEET OF YURIKA EARTHING GUIDELINES BH-SCT-CIV-DWG-0540 DRAWING

DRAWING IS COLOUR CODED - PRINT IN COLOUR

EARTHING LEGEND AND MATERIAL LIST

REFER EARTHING MEMO VEBE-SCT-ELE-MEM-001

SYMBOL	DESCRIPTION	MATERIAL	QTY
	MAIN EARTHING CONDUCTOR	70mm² HARD DRAWN BARE COPPER (HDBC)	7000m
	EARTHING CONDUCTOR TO TRANSGRID SUB	120mm² PVC GN/YE INSULATED ANNEALED COPPER CABLE (1)	1350m
	EARTHING TAIL	1x70mm² PVC GN/YE INSULATED ANNEALED COPPER CABLE	4100m
●	EARTH GRID-GRID CONNECTOR	DOUBLE C-CRIMP 70mm² - 70mm² DOUBLE C-CRIMP 120mm² - 70mm²	250 4
○	EARTH GRID-TAIL CONNECTOR	DOUBLE C-CRIMP OR THERMAL FUSION (EXOTHERMIC) TYPE CADWELD 70mm² - 70mm²	1000
■	EARTHING PIT	1 x EARTHING INSPECTION PIT 1 x EARTHING BUSBAR FOR ISOLATION	4
■	EARTH STUD CONNECTION TO FOUNDATION REINFORCEMENT	ERRICO DB12, PLP D-C70 OR EQUIVALENT	46
	COPPER EARTH GRID COMPRESSION LUG	1 x M12 LUG TO SUIT (70mm²)	AS REQ.
	COPPER EARTH GRID COMPRESSION LUG	2 x M12 LUG TO SUIT (70mm²)	AS REQ.
⊗	EARTH STAKE WITH INSPECTION PIT	1 EARTH STAKE 3000mm LONG CONSISTS: 2 x Ø15mm EARTH ROD 1500mm LONG 1 x Ø15mm EARTH ROD COUPLER 1 x Ø15mm DRIVING POINT 1 x Ø15mm P CRIMP TO 70mm² 1 x EARTHING INSPECTION PIT	4 8 4 4 4 4
	CRUSHED ROCK	100mm THK 3000Ωm, 20-30mm NOMINAL, NO FINES TO BE APPLIED TO ENTIRE YARD & 1.5m AROUND PERIMETER FENCE	~54m²

LIGHTNING LEGEND AND MATERIAL LIST

REFER LIGHTNING MEMO VEBE-SCT-ELE-MEM-002

SYMBOL	DESCRIPTION	MATERIAL	QTY
×	LIGHTNING AIR TERMINAL	2.7m AIR TERMINAL POSITIONED ON A 0.5m BRACKET ABOVE THE BUILDING ROOF LEVEL.	16
⊠	LIGHTNING MAST	15.5m LIGHTNING MAST FITTED WITH A LIGHTNING ROD THAT EXTENDS APPROX 16.6m ABOVE FSL	66

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Project Number WR2017993

REVISION CONTROL		REFERENCES	
Drawn A.NEWTON	*Date* 16/04/26	OVERALL SITE LAYOUT	BH-SCT-GEN-LAY-0401
Checked B.MURUGESAN	*Date* 16/04/26	BESS PLOT PLAN	BH-SCT-GEN-LAY-0402
Certified RPEQ 23393 A.GOKCE	*Date* 16/04/26	BESS UNIT SECT/ELEVATION	BH-SCT-GEN-LAY-0403
Design Approval (optional) -	*Date* -	CABLE ROUTE PLAN	BH-SCT-ELE-LAY-0404
		EARTHING & LIGHTNING PLAN	BH-SCT-ELE-LAY-0405
		OVERALL SLD	BH-SCT-ELE-SLD-0301

Rev	DESCRIPTION	DRN	CHK	APPR	DATE
1	RE-ISSUED FOR CONSTRUCTION	A.N	B.M	A.G	16/04/26
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A	ISSUED FOR 30% DESIGN REVIEW	A.N	B.M	A.G	30/10/25

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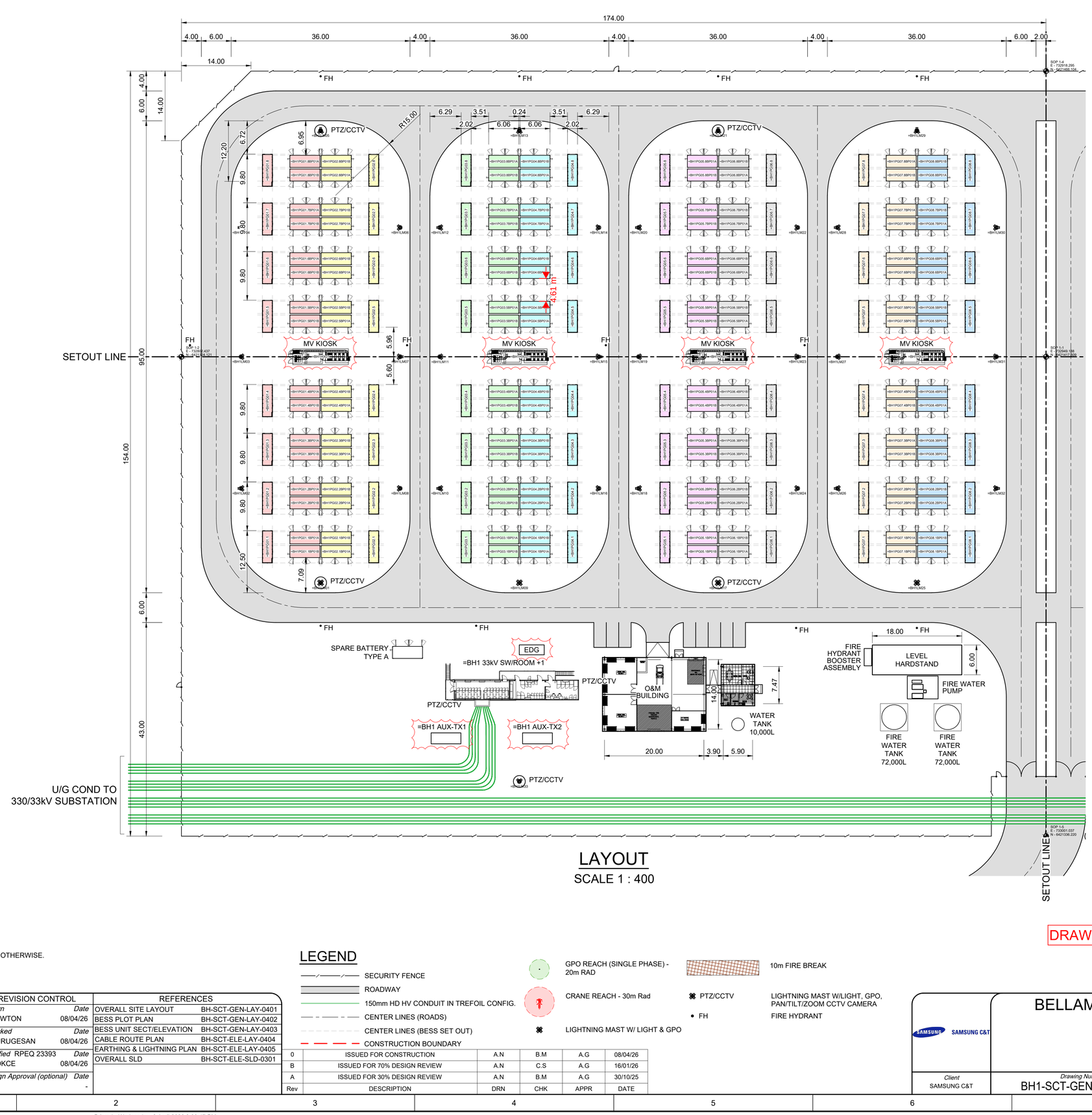
33kV BESS
=BH1 & =BH2 OVERALL EARTHING & LIGHTNING PLAN

Client	*Drawing Number*	*Revision*	*Drawing Status*	*Scale*
SAMSUNG C&T	BH-SCT-ELE-LAY-0405	1	Released For Construction	1:500

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LAYOUT

SCALE 1 : 400

NOTES

1. ALL DIMENSIONS IN METERS UNLESS STATED OTHERWISE.

LEGEND

- SECURITY FENCE
- ROADWAY
- 150mm HD HV CONDUIT IN TREFOIL CONFIG.
- CENTER LINES (ROADS)
- CENTER LINES (BESS SET OUT)
- CONSTRUCTION BOUNDARY
- GPO REACH (SINGLE PHASE) - 20m RAD
- CRANE REACH - 30m Rad
- LIGHTNING MAST W/ LIGHT & GPO
- 10m FIRE BREAK
- PTZ/CCTV — LIGHTNING MAST W/LIGHT, GPO, PAN/TILT/ZOOM CCTV CAMERA
- FH — FIRE HYDRANT

DRAWING IS COLOUR CODED - PRINT IN COLOUR

0 10 20 30 40m
5
UNREDUCED SCALE 1:400

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REVISION CONTROL	
Drawn	*Date*
A.NEWTON	08/04/26
Checked	*Date*
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Certified RPEQ 23393	*Date*
A.GOKCE	08/04/26
Design Approval (optional)	*Date*
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EARTHING & LIGHTNING PLAN	BH-SCT-ELE-LAY-0405
OVERALL SLD	BH-SCT-ELE-SLD-0301

Project Number WR2017993

SAMSUNG C&T

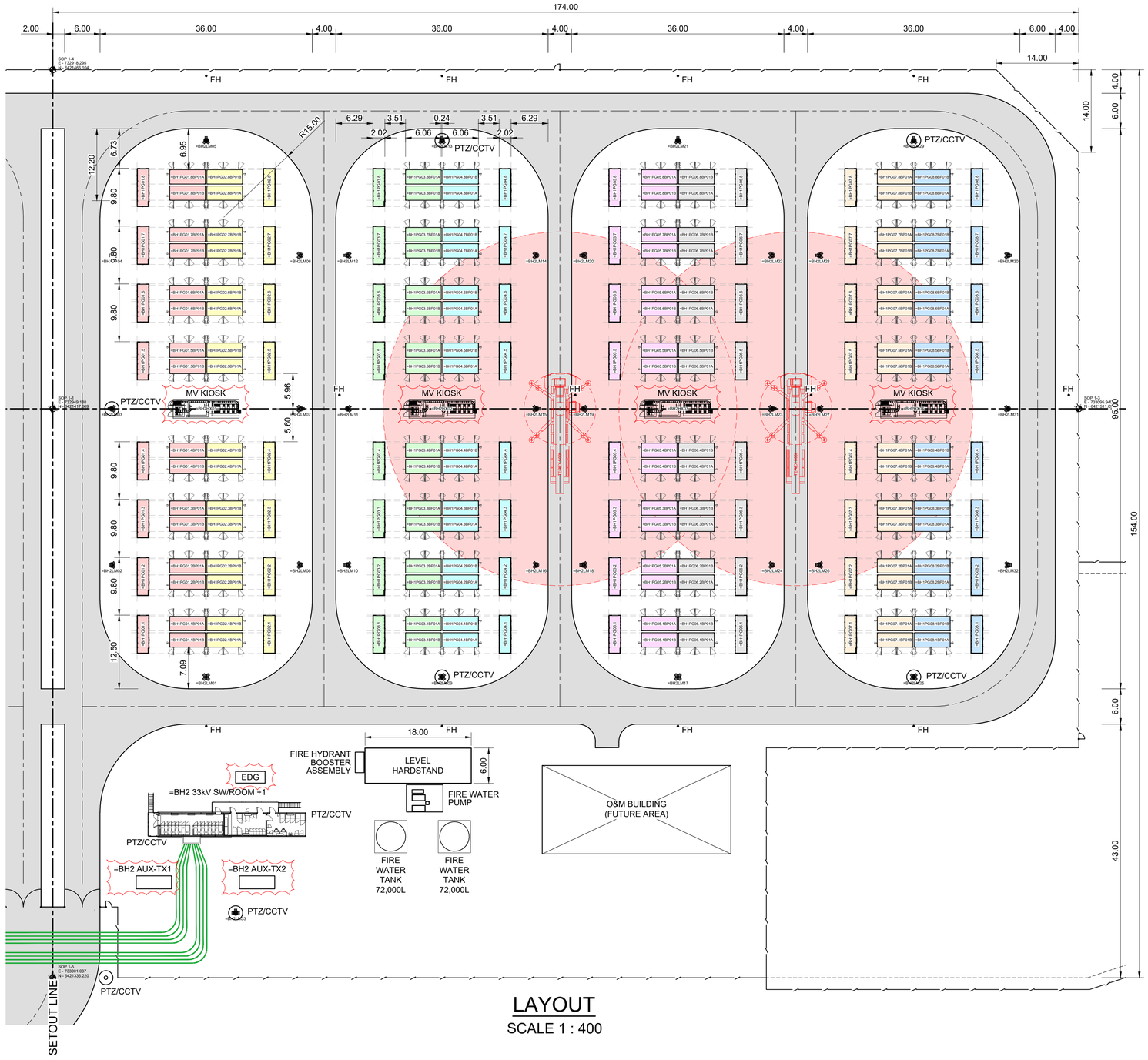
BELLAMBI HEIGHTS RENEWABLE PROJECT
33kV BESS
=BH1
SITE LAYOUT
GENERAL ARRANGEMENT

Client	*Drawing Number*	*Revision*	*Drawing Status*	*Scale*
SAMSUNG C&T	BH1-SCT-GEN-LAY-0407	0	**Released For Construction**	1:500

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LAYOUT

SCALE 1 : 400

NOTES

1. ALL DIMENSIONS IN METERS UNLESS STATED OTHERWISE.

LEGEND

- SECURITY FENCE
- ROADWAY
- CENTER LINES (ROADS) 150mm HD HV CONDUIT IN TREFOIL CONFIG. CENTER LINES (BESS SET OUT)
- CONSTRUCTION BOUNDARY
- GPO REACH (SINGLE PHASE) - 20m RAD
- CRANE REACH - 30m Rad
- LIGHTNING MAST W/ LIGHT & GPO
- 10m FIRE BREAK
- PTZ/CCTV — LIGHTNING MAST W/LIGHT, GPO, PAN/TILT/ZOOM CCTV CAMERA
- FH — FIRE HYDRANT

DRAWING IS COLOUR CODED - PRINT IN COLOUR

0 5 10 20 30 40m

UNREDUCED SCALE 1:400

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REVISION CONTROL		REFERENCES	
Drawn A.NEWTON	*Date* 08/04/26	OVERALL SITE LAYOUT	BH-SCT-GEN-LAY-0401
Checked B.MURUGESAN	*Date* 08/04/26	BESS PLOT PLAN	BH-SCT-GEN-LAY-0402
Certified RPEQ 23393 A.GOKCE	*Date* 08/04/26	BESS UNIT SECT/ELEVATION	BH-SCT-GEN-LAY-0403
		CABLE ROUTE PLAN	BH-SCT-ELE-LAY-0404
		EARTHING & LIGHTNING PLAN	BH-SCT-ELE-LAY-0405
Design Approval (optional) -	*Date* -	OVERALL SLD	BH-SCT-ELE-SLD-0301

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Project Number WR2017993

SAMSUNG C&T

BELLAMBI HEIGHTS RENEWABLE PROJECT

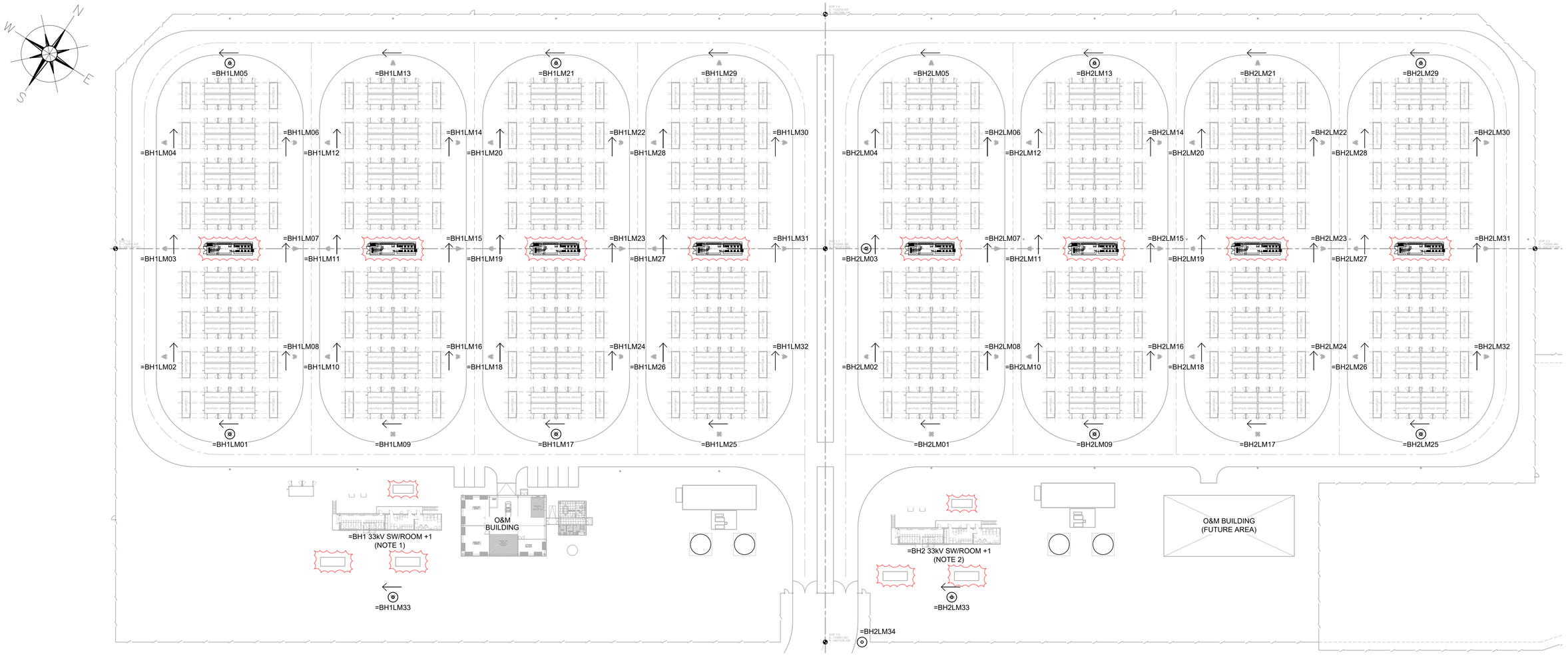
33kV BESS
=BH2
SITE LAYOUT
GENERAL ARRANGEMENT

Client	*Drawing Number*	*Revision*	*Drawing Status*	*Scale*
SAMSUNG C&T	BH2-SCT-GEN-LAY-0408	0	**Released For Construction**	1:500

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File Name: BH2-SCT-GEN-LAY-0408.dwg *Printed:* Wednesday, 8 April 2026 3:39:28 PM

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LIGHTING & CCTV LAYOUT

SCALE 1 : 500

=BH1 FLOOD LIGHTING

LIGHTNING MAST	QTY	HEIGHT (m)	ORIENTATION (°)	TILT (°)
=BH1LM01	4	15	45/135/225/315	0
=BH1LM02	3	15	45/180/315	0
=BH1LM03	2	15	45/315	0
=BH1LM04	3	15	45/180/315	0
=BH1LM05	3	15	90/225/315	0
=BH1LM06	2	15	135/225	0
=BH1LM07	3	15	0/135/225	0
=BH1LM08	2	15	135/225	0
=BH1LM09	4	15	45/135/225/315	0
=BH1LM10	3	15	45/180/315	0
=BH1LM11	2	15	45/315	0
=BH1LM12	3	15	45/180/315	0
=BH1LM13	3	15	90/225/315	0
=BH1LM14	2	15	135/225	0
=BH1LM15	3	15	0/135/225	0
=BH1LM16	2	15	135/225	0
=BH1LM17	4	15	45/135/225/315	0
=BH1LM18	3	15	45/180/315	0
=BH1LM19	2	15	45/315	0
=BH1LM20	3	15	45/180/315	0
=BH1LM21	3	15	90/225/315	0
=BH1LM22	2	15	135/225	0
=BH1LM23	3	15	0/135/225	0
=BH1LM24	2	15	135/225	0
=BH1LM25	4	15	45/135/225/315	0
=BH1LM26	3	15	45/180/315	0
=BH1LM27	2	15	45/315	0
=BH1LM28	3	15	45/180/315	0
=BH1LM29	3	15	90/225/315	0
=BH1LM30	2	15	135/225	0
=BH1LM31	3	15	0/135/225	0
=BH1LM32	2	15	135/225	0
=BH1LM33	2	15	45/135	0

=BH2 FLOOD LIGHTING

LIGHTNING MAST	QTY	HEIGHT (m)	ORIENTATION (°)	TILT (°)
=BH2LM01	4	15	45/135/225/315	0
=BH2LM02	3	15	45/180/315	0
=BH2LM03	2	15	45/315	0
=BH2LM04	3	15	45/180/315	0
=BH2LM05	3	15	90/225/315	0
=BH2LM06	2	15	135/225	0
=BH2LM07	3	15	0/135/225	0
=BH2LM08	2	15	135/225	0
=BH2LM09	4	15	45/135/225/315	0
=BH2LM10	3	15	45/180/315	0
=BH2LM11	2	15	45/315	0
=BH2LM12	3	15	45/180/315	0
=BH2LM13	3	15	90/225/315	0
=BH2LM14	2	15	135/225	0
=BH2LM15	3	15	0/135/225	0
=BH2LM16	2	15	135/225	0
=BH2LM17	4	15	45/135/225/315	0
=BH2LM18	3	15	45/180/315	0
=BH2LM19	2	15	45/315	0
=BH2LM20	3	15	45/180/315	0
=BH2LM21	3	15	90/225/315	0
=BH2LM22	2	15	135/225	0
=BH2LM23	3	15	0/135/225	0
=BH2LM24	2	15	135/225	0
=BH2LM25	4	15	45/135/225/315	0
=BH2LM26	3	15	45/180/315	0
=BH2LM27	2	15	45/315	0
=BH2LM28	3	15	45/180/315	0
=BH2LM29	3	15	90/225/315	0
=BH2LM30	2	15	135/225	0
=BH2LM31	3	15	0/135/225	0
=BH2LM32	2	15	135/225	0
=BH2LM33	3	15	0/90/180	0

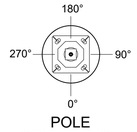
LEGEND

CCTV CAMERA

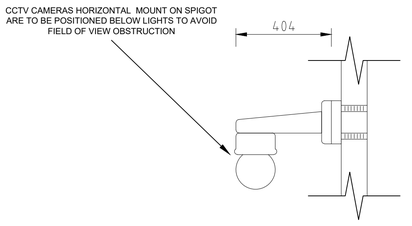
TILT DIRECTION

CCTV CAMERAS

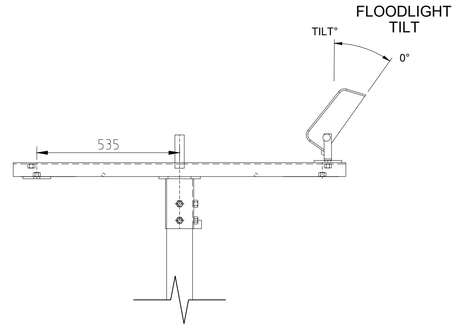
LIGHTNING MAST	QUANTITY	HEIGHT (m)
=BH1LM01	1	15
=BH1LM05	1	15
=BH1LM17	1	15
=BH1LM21	1	15
=BH1LM33	1	15
=BH2LM03	1	15
=BH2LM09	1	15
=BH2LM13	1	15
=BH2LM25	1	15
=BH2LM29	1	15
=BH2LM33	1	15
=BH2LM34	1	15



POLE ORIENTATION
(RELATIVE TO PLAN VIEW)



CCTV INSTALLATION



LIGHTING MAST MOUNTING CROSS ARM

NOTES

1. FOR =BH1 BUILDING LIGHTING & CCTV LAYOUT REFER DRAWING BH1-SCT-ELE-DWG-09xx.
2. FOR =BH2 BUILDING LIGHTING & CCTV LAYOUT REFER DRAWING BH2-SCT-ELE-DWG-10xx.

0 10 20 30 40 50m
5

UNREDUCED SCALE 1:500

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Project Number WR2017993

REVISION CONTROL		REFERENCES	
Drawn A.NEWTON	*Date* 08/04/26	OVERALL SITE LAYOUT	BH-SCT-GEN-LAY-0401
Checked B.MURUGESAN	*Date* 08/04/26	BESS PLOT PLAN	BH-SCT-GEN-LAY-0402
Certified RPEQ 23393 A.GOKCE	*Date* 08/04/26		
Design Approval (optional) -	*Date* -		

Rev	DESCRIPTION	DRN	CHK	APPR	DATE
0	ISSUED FOR CONSTRUCTION	A.N	B.M	A.G	08/04/26
A	ISSUED FOR 70% DESIGN REVIEW	A.N	C.S	A.G	15/01/26

SAMSUNG C&T

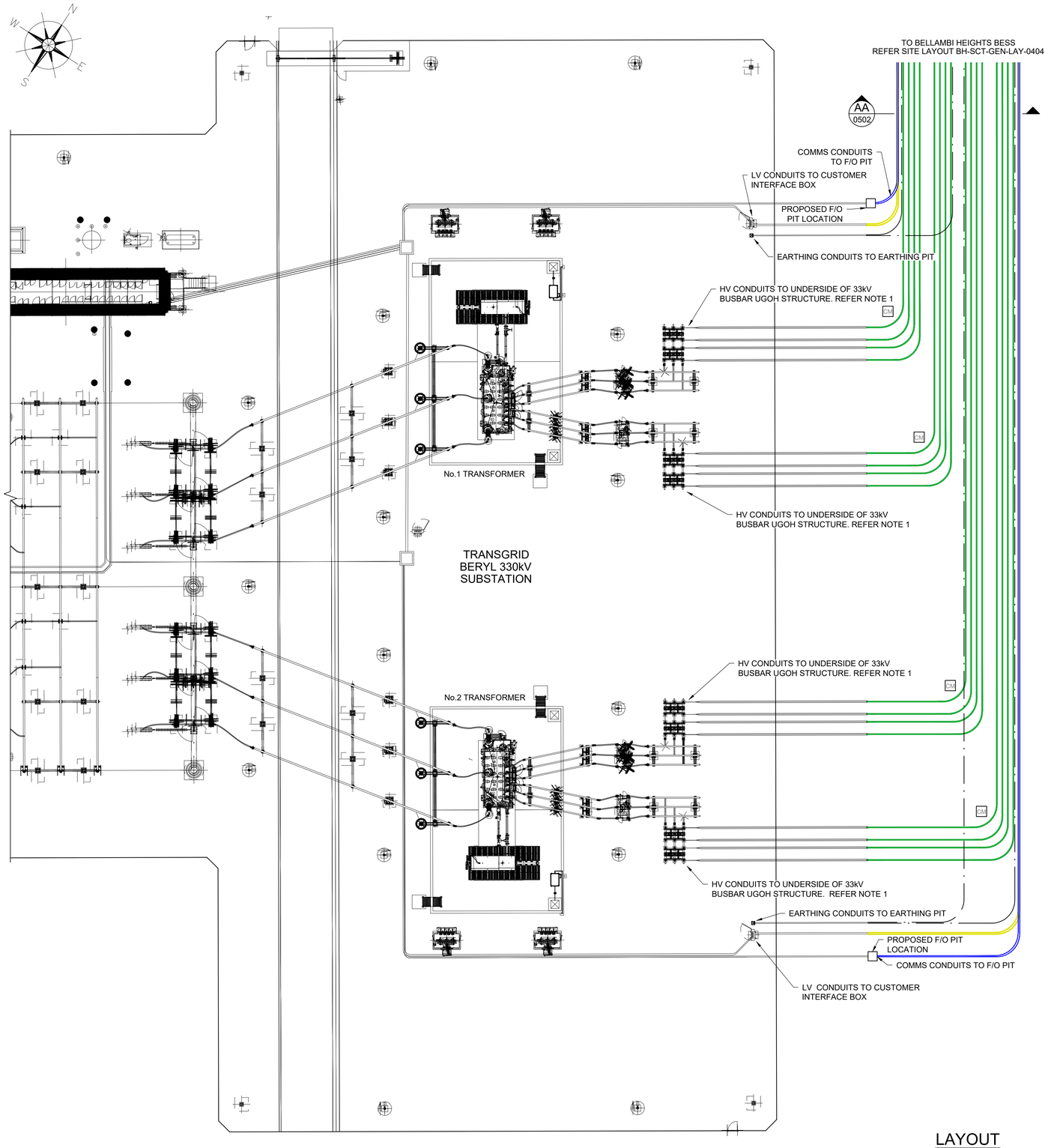
BELLAMBI HEIGHTS RENEWABLE PROJECT

33kV BESS
=BH1 & =BH2 OVERALL
LIGHTING & CCTV LAYOUT
GENERAL ARRANGEMENT

Client	*Drawing Number*	*Revision*	*Drawing Status*	*Scale*
SAMSUNG C&T	BH-SCT-GEN-LAY-0409	0	Released For Construction	1:500

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LAYOUT
SCALE 1 : 250

NOTES

1. CONTRACTOR TO PULL THE CABLE TO 33kV SIDE OF TRANSFORMER AND TERMINATE IT ONTO THE TRANSFORMER BUSBARS AND CABLE SUPPORT STRUCTURES PROVIDED BY TRANSGRID

LEGEND	
TYPE	DESCRIPTION
	150mm ORANGE HEAVY DUTY (HD) CONDUIT IN TREFOIL CONFIGURATION
	100mm ORANGE HEAVY DUTY (HD) CONDUIT
	50mm COMMS WHITE CONDUIT
	50mm ORANGE HEAVY DUTY (HD) CONDUIT FOR EARTHING
CM	33kV CABLE ROUTE MARKER

DRAWING IS COLOUR CODED - PRINT IN COLOUR

0 10 20m
2
UNREDUCED SCALE 1:250

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Project Number
WR2017993

REVISION CONTROL	
Drawn	*Date*
A.NEWTON	02/04/26
Checked	*Date*
B.MURUGESAN	08/04/26
Certified RPEQ 23393	*Date*
A.GOKCE	08/04/26
Design Approval (optional)	*Date*
-	-

REFERENCES	
OVERALL SITE LAYOUT	BH-SCT-GEN-LAY-0401
BESS PLOT PLAN	BH-SCT-GEN-LAY-0402
CABLE ROUTE PLAN	BH-SCT-ELE-LAY-0404
EARTHING & LIGHTNING PLAN	BH-SCT-ELE-LAY-0405

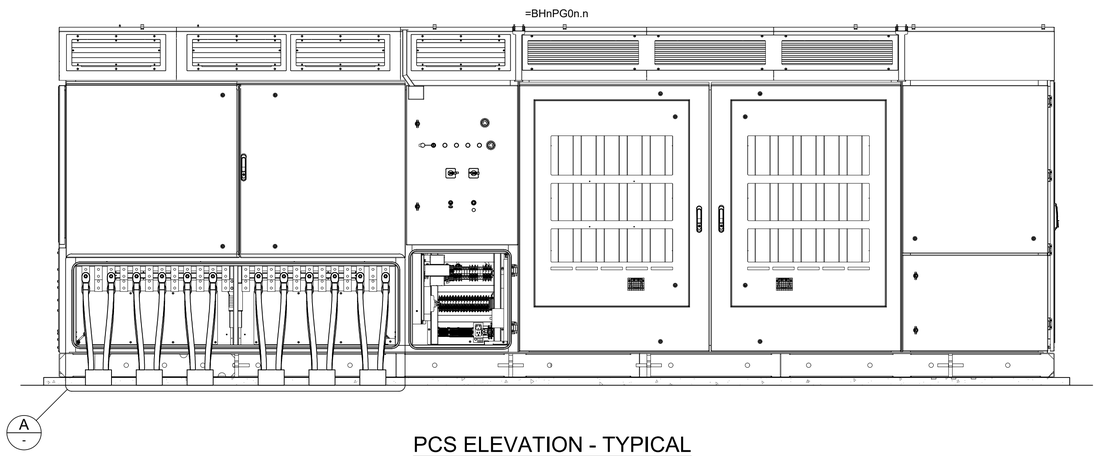
Rev	DESCRIPTION	DRN	CHK	APPR	DATE
0	ISSUED FOR CONSTRUCTION	A.N	B.M	A.G	08/04/26
A	ISSUED FOR 70% DESIGN REVIEW	A.N	C.S	A.G	15/01/26

SAMSUNG C&T

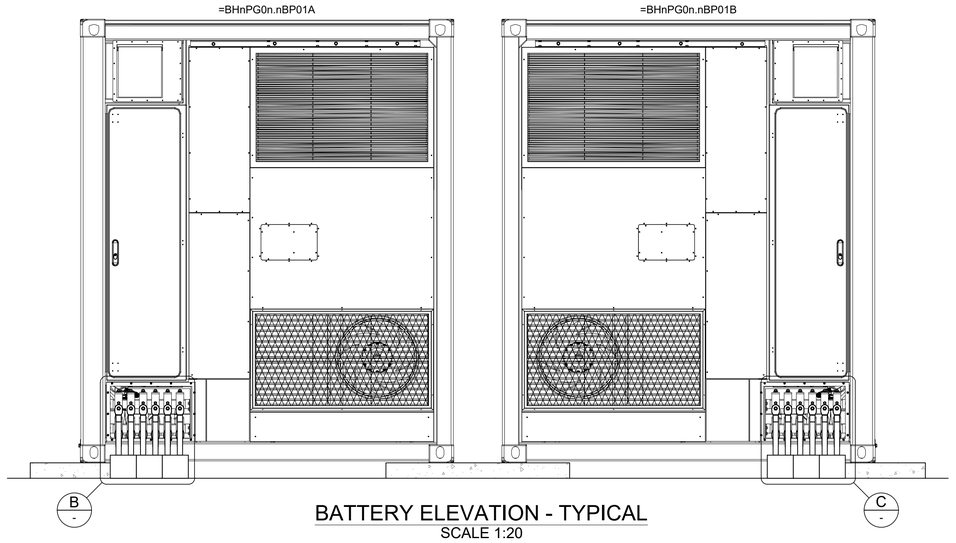
BELLAMBI HEIGHTS RENEWABLE PROJECT
33kV BESS
=BH1 & =BH2 OVERALL
CABLE INTERFACE WITH LUMEA 330/33kV SWITCHYARD LAYOUT
GENERAL ARRANGEMENT

Client	Drawing Number	Revision	Drawing Status	Scale
SAMSUNG C&T	BH-SCT-GEN-LAY-0410	0	Released For Construction	1:1000

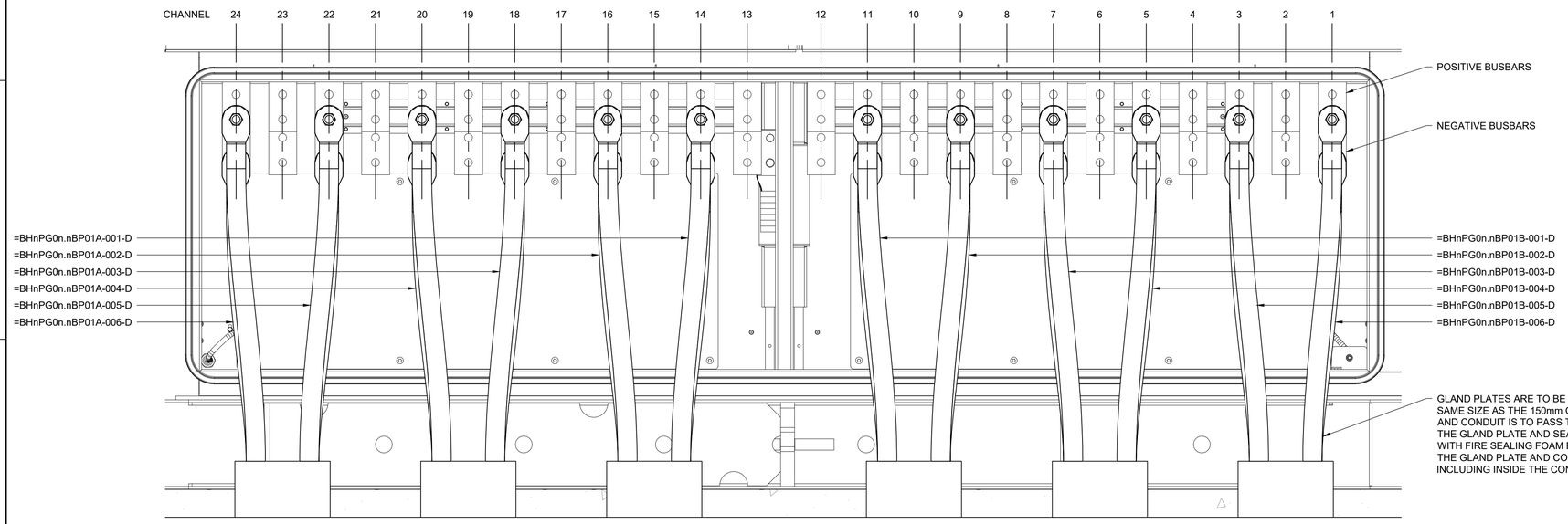
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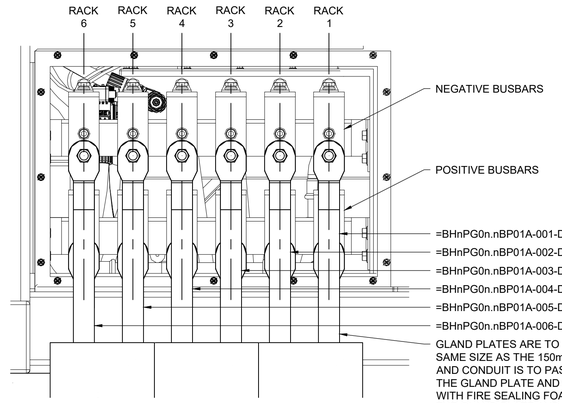
PCS ELEVATION - TYPICAL
SCALE 1:20



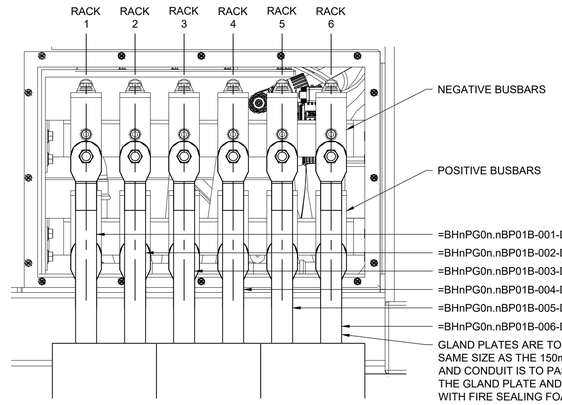
BATTERY ELEVATION - TYPICAL
SCALE 1:20



DETAIL A
SCALE 1:5



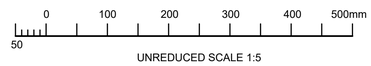
DETAIL B
SCALE 1:5



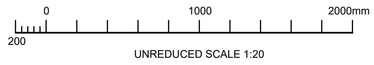
DETAIL C
SCALE 1:5

NOTES

1. DETAILS SHOWN ARE FOR TYPICAL DC CABLE CONNECTION BETWEEN PCS AND BATTERY UNITS. FOR ACTUAL CABLE NUMBERS REFER SLDS BH1-SCT-ELE-SLD-0309 TO BH2-SCT-ELE-SLD-0343.



UNREDUCED SCALE 1:5



UNREDUCED SCALE 1:20

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Project Number: WR2017993

REVISION CONTROL		REFERENCES	
Drawn	Date	BESS PLOT PLAN	BH-SCT-GEN-LAY-0402
A.NEWTON	02/04/26	BESS UNIT SECT/ELEVATION	BH-SCT-GEN-LAY-0403
Checked	Date	CABLE ROUTE PLAN	BH-SCT-ELE-LAY-0404
B.MURUGESAN	08/04/26		
Certified RPEQ 23393	Date		
A.GOKCE	08/04/26		
Design Approval (optional)	Date		
-	-		

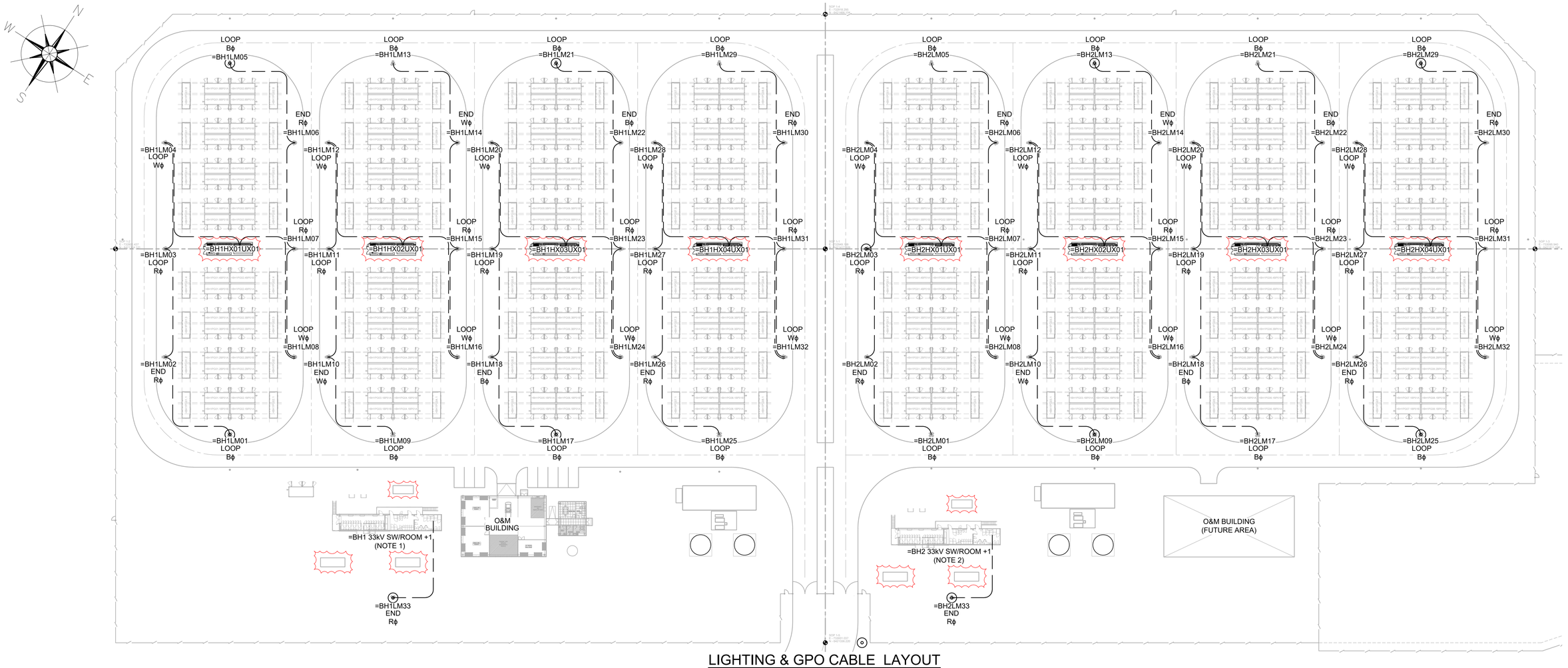
Rev	DESCRIPTION	DRN	CHK	APPR	DATE
0	ISSUED FOR CONSTRUCTION	A.N	B.M	A.G	08/04/26
A	ISSUED FOR 70% DESIGN REVIEW	A.N	C.S	A.G	15/01/26

SAMSUNG C&T

BELLAMBI HEIGHTS RENEWABLE PROJECT
33kV BESS
TYPICAL
PCS & BATTERY DC CABLE CONNECTION DETAIL

Client	Drawing Number	Revision	Drawing Status	Scale
SAMSUNG C&T	BH-SCT-GEN-LAY-0411	0	Released For Construction	1:25

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LIGHTING & GPO CABLE LAYOUT

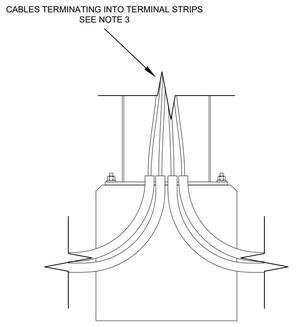
SCALE 1 : 500

=BH1 FLOOD LIGHTING & GPOs

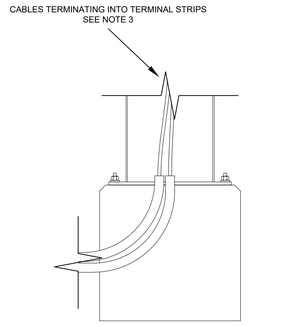
LIGHTNING MAST	SUPPLY PHASE	LIGHTING CABLE IN	LIGHTING CABLE OUT	GPO CABLE IN	GPO CABLE OUT
=BH1LM01	BLUE	BH1LM01-001-L	-	BH1LM01-002-L	-
=BH1LM02	RED	BH1LM02-001-L	BH1LM01-001-L	BH1LM02-002-L	BH1LM01-002-L
=BH1LM03	RED	BH1LM03-001-L	BH1LM02-001-L	BH1LM03-002-L	BH1LM02-002-L
=BH1LM04	WHITE	BH1LM04-001-L	BH1LM03-001-L	BH1LM04-002-L	BH1LM03-002-L
=BH1LM05	BLUE	BH1LM05-001-L	-	BH1LM05-002-L	-
=BH1LM06	RED	BH1LM06-001-L	BH1LM05-001-L	BH1LM06-002-L	BH1LM05-002-L
=BH1LM07	RED	BH1LM07-001-L	BH1LM06-001-L	BH1LM07-002-L	BH1LM06-002-L
=BH1LM08	WHITE	BH1LM08-001-L	BH1LM07-001-L	BH1LM08-002-L	BH1LM07-002-L
=BH1LM09	BLUE	BH1LM09-001-L	-	BH1LM09-002-L	-
=BH1LM10	WHITE	BH1LM10-001-L	BH1LM09-001-L	BH1LM10-002-L	BH1LM09-002-L
=BH1LM11	RED	BH1LM11-001-L	BH1LM10-001-L	BH1LM11-002-L	BH1LM10-002-L
=BH1LM12	WHITE	BH1LM12-001-L	BH1LM11-001-L	BH1LM12-002-L	BH1LM11-002-L
=BH1LM13	BLUE	BH1LM13-001-L	-	BH1LM13-002-L	-
=BH1LM14	WHITE	BH1LM14-001-L	BH1LM13-001-L	BH1LM14-002-L	BH1LM13-002-L
=BH1LM15	RED	BH1LM15-001-L	BH1LM14-001-L	BH1LM15-002-L	BH1LM14-002-L
=BH1LM16	WHITE	BH1LM16-001-L	BH1LM15-001-L	BH1LM16-002-L	BH1LM15-002-L
=BH1LM17	BLUE	BH1LM17-001-L	-	BH1LM17-002-L	-
=BH1LM18	BLUE	BH1LM18-001-L	BH1LM17-001-L	BH1LM18-002-L	BH1LM17-002-L
=BH1LM19	RED	BH1LM19-001-L	BH1LM18-001-L	BH1LM19-002-L	BH1LM18-002-L
=BH1LM20	WHITE	BH1LM20-001-L	BH1LM19-001-L	BH1LM20-002-L	BH1LM19-002-L
=BH1LM21	BLUE	BH1LM21-001-L	-	BH1LM21-002-L	-
=BH1LM22	BLUE	BH1LM22-001-L	BH1LM21-001-L	BH1LM22-002-L	BH1LM21-002-L
=BH1LM23	RED	BH1LM23-001-L	BH1LM22-001-L	BH1LM23-002-L	BH1LM22-002-L
=BH1LM24	WHITE	BH1LM24-001-L	BH1LM23-001-L	BH1LM24-002-L	BH1LM23-002-L
=BH1LM25	BLUE	BH1LM25-001-L	-	BH1LM25-002-L	-
=BH1LM26	RED	BH1LM26-001-L	BH1LM25-001-L	BH1LM26-002-L	BH1LM25-002-L
=BH1LM27	RED	BH1LM27-001-L	BH1LM26-001-L	BH1LM27-002-L	BH1LM26-002-L
=BH1LM28	WHITE	BH1LM28-001-L	BH1LM27-001-L	BH1LM28-002-L	BH1LM27-002-L
=BH1LM29	BLUE	BH1LM29-001-L	-	BH1LM29-002-L	-
=BH1LM30	RED	BH1LM30-001-L	BH1LM29-001-L	BH1LM30-002-L	BH1LM29-002-L
=BH1LM31	RED	BH1LM31-001-L	BH1LM30-001-L	BH1LM31-002-L	BH1LM30-002-L
=BH1LM32	WHITE	BH1LM32-001-L	BH1LM31-001-L	BH1LM32-002-L	BH1LM31-002-L
=BH1LM33	RED	BH1LM33-001-L	-	BH1LM33-002-L	-

=BH2 FLOOD LIGHTING & GPOs

LIGHTNING MAST	SUPPLY PHASE	CABLE IN	CABLE OUT	GPO CABLE IN	GPO CABLE OUT
=BH2LM01	BLUE	Wxx15	Wxx17	Wxx16	Wxx18
=BH2LM02	RED	Wxx17	-	Wxx18	-
=BH2LM03	RED	Wxx01	Wxx03	Wxx02	Wxx04
=BH2LM04	WHITE	Wxx03	Wxx05	Wxx04	Wxx06
=BH2LM05	BLUE	Wxx05	Wxx07	Wxx06	Wxx08
=BH2LM06	RED	Wxx07	-	Wxx08	-
=BH2LM07	RED	Wxx11	Wxx13	Wxx12	Wxx14
=BH2LM08	WHITE	Wxx13	Wxx15	Wxx14	Wxx16
=BH2LM09	BLUE	Wxx35	Wxx37	Wxx36	Wxx38
=BH2LM10	WHITE	Wxx37	-	Wxx38	-
=BH2LM11	RED	Wxx21	Wxx23	Wxx22	Wxx24
=BH2LM12	WHITE	Wxx23	Wxx25	Wxx24	Wxx26
=BH2LM13	BLUE	Wxx25	Wxx27	Wxx26	Wxx28
=BH2LM14	WHITE	Wxx27	-	Wxx28	-
=BH2LM15	RED	Wxx31	Wxx33	Wxx32	Wxx34
=BH2LM16	WHITE	Wxx33	Wxx35	Wxx34	Wxx36
=BH2LM17	BLUE	Wxx55	Wxx57	Wxx56	Wxx58
=BH2LM18	BLUE	Wxx57	-	Wxx58	-
=BH2LM19	RED	Wxx41	Wxx43	Wxx42	Wxx44
=BH2LM20	WHITE	Wxx43	Wxx45	Wxx44	Wxx46
=BH2LM21	BLUE	Wxx45	Wxx47	Wxx46	Wxx48
=BH2LM22	BLUE	Wxx47	-	Wxx48	-
=BH2LM23	RED	Wxx51	Wxx53	Wxx52	Wxx54
=BH2LM24	WHITE	Wxx53	Wxx55	Wxx54	Wxx56
=BH2LM25	BLUE	Wxx75	Wxx77	Wxx76	Wxx78
=BH2LM26	RED	Wxx77	-	Wxx78	-
=BH2LM27	RED	Wxx61	Wxx63	Wxx62	Wxx64
=BH2LM28	WHITE	Wxx63	Wxx65	Wxx64	Wxx66
=BH2LM29	BLUE	Wxx65	Wxx67	Wxx66	Wxx68
=BH2LM30	RED	Wxx67	-	Wxx68	-
=BH2LM31	RED	Wxx71	Wxx73	Wxx72	Wxx74
=BH2LM32	WHITE	Wxx73	Wxx75	Wxx74	Wxx76
=BH2LM33	RED	Wxx81	-	Wxx82	-



LOOP EXAMPLE
FLOODLIGHT AND GPO CABLES
LOOPING INTO AND OUT OF POLE



END EXAMPLE
FLOODLIGHT AND GPO CABLES
LOOPING INTO POLE

LEGEND

— —— — INDICATIVE CABLE ROUTE

xxϕ ELECTRICAL PHASE SUPPLYING LIGHTING & GPO

NOTES

1. FOR =BH1 BUILDING LIGHTING & CCTV LAYOUT REFER DRAWING BH1-SCT-ELE-DWG-09xx.
2. FOR =BH2 BUILDING LIGHTING & CCTV LAYOUT REFER DRAWING BH2-SCT-ELE-DWG-10xx.
3. FOR FLOODLIGHTING AND GPO MARSHALING BOX INTERNAL TERMINAL ARRANGEMENT REFER TO BH1-SCT-ELE-DWG-1107

0 10 20 30 40 50m
5

UNREDUCED SCALE 1:500

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REVISION CONTROL	
Drawn	*Date*
A.NEWTON	08/04/26
Checked	*Date*
B.MURUGESAN	08/04/26
Certified RPEQ 23393	*Date*
A.GOKCE	08/04/26
Design Approval (optional)	*Date*
-	-

REFERENCES	
OVERALL SITE LAYOUT	BH-SCT-GEN-LAY-0401
BESS PLOT PLAN	BH-SCT-GEN-LAY-0402
FLOODLIGHT DETAILS	BH1-SCT-ELE-DWG-1107

Project Number WR2017993

Rev	DESCRIPTION	DRN	CHK	APPR	DATE
0	ISSUED FOR CONSTRUCTION	A.N	B.M	A.G	08/04/26
A		J.M	C.S	A.G	15/01/26

SAMSUNG C&T

BELLAMBI HEIGHTS RENEWABLE PROJECT

33kV BESS
=BH1 & =BH2 OVERALL
LIGHTING & GPO CABLE LOOPING LAYOUT
GENERAL ARRANGEMENT

Client	*Drawing Number*	*Revision*	*Drawing Status*	*Scale*
SAMSUNG C&T	BH-SCT-GEN-LAY-0412	0	**Released For Construction**	1:500

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File Name: BH-SCT-GEN-LAY-0412.dwg *Printed:* Wednesday, 8 April 2026 3:38:05 PM

UNLESS OTHERWISE STATED ALL DIMENSIONS, NOTES AND CALLOUTS ARE IN MILLIMETRES. CAD ACAD A1 841 x 594

A.6. Acceptance criteria

A.6.1. The following table presented in **Error! Reference source not found.** has been used within the report to set the standards for acceptance criteria throughout the report. This covers acceptable levels of radiation for firefighters to non-piloted ignition for equipment failure and fire spread.

Table 43: Acceptance criteria related to radiant heat

Phenomena	Radiant heat (kW/m^2)	Source
Non-piloted ignition of timber in 10 s	55	Table A.3 from AS 1530.4:2014
Non-piloted ignition of timber in 20 s	45	Table A.3 from AS 1530.4:2014
Non-piloted ignition of cotton fabric after 5 s	42	Table A.3 from AS 1530.4:2014
Non-piloted ignition of black drill fabric after a long time	38	Table A.3 from AS 1530.4:2014
Sufficient to cause damage to process equipment	37.5	Table B.3 from IEEE Std 979:2012
Equipment failure	35	Table B.3 from IEEE Std 979:2012
Damage to unprotected metal	30	Table B.3 from IEEE Std 979:2012
Non-piloted ignition of gaberdine fabric after a long time	27	Table A.3 from AS 1530.4:2014
Spontaneous ignition of wood	25	Table B.3 from IEEE Std 979:2012
Non-piloted ignition time after a long time	25	Table A.3 from AS 1530.4:2014
Non-piloted ignition cotton fabric after a long time	25	Table A.3 from AS 1530.4:2014
Cable insulation degrades	20	Table B.3 from IEEE Std 979:2012
Piloted ignition of timber after a long time	13	Table A.3 from AS 1530.4:2014
Piloted ignition of cotton fabric after a long time	13	Table A.3 from AS 1530.4:2014
Pilot ignition of wood	12.5	Table B.3 from IEEE Std 979:2012
Plastic melts	12.5	Table B.3 from IEEE Std 979:2012
Damage may occur requiring replacement or in extreme cases catastrophic failure of porcelain bushing / insulators	12.5	Ausgrid Network Standard NS187
Pain after 3 s	10	Table A.3 from AS 1530.4:2014
Pain threshold reached after 8 s / Second-degree burns after 20 s	9.5	Table B.3 from IEEE Std 979:2012
Possible failure of ceramic bushings	5	Table B.3 from IEEE Std 979:2012

Phenomena	Radiant heat (kW/m^2)	Source
Skin burns	5	Table B.3 from IEEE Std 979:2012
Pain after 10 s to 20 s	4	Table A.3 from AS 1530.4:2014
Acceptable levels for firefighter operations	3	-

Appendix B. Hithium Block 5 MWh

B.1. Introduction

B.1.1. This appendix relates to Hithium BESS unit with a model number of IF5015P050AAU.

B.1.2. This appendix provides two key things, firstly it provides a high-level description of the BESS system using information provided by Hithium. Then also provided are copies the fire test reports which have been made available.

B.1.3. Table 44 provides a summary of the test reports which are provided in this Appendix.

Table 44 Summary of Test Reports

Test	Summary	Result Summary
UL9540A:2019 – Cell Level	Cell level test returning the cell vent temperature, thermal runaway temperature, and hydrocarbon off gasses for flammability.	Average vent temperature was 203.7°C, with average thermal runaway onset temperature being 295.7°C. The off-gas mixture was flammable with a LFL of 8.1% as ambient and 6.5% at 205°C. No mention is made of HF gas.
UL9540A:2019 – Module Level	Module testing for failure and fire propagation between cells	No external flaming observed. Peak HRR of 22.7 kW. One cell heated and propagated to a second cell. No further cells went into thermal runaway. Off-gas mixture was flammable, and HF was tested for and detected. 0.872 L of HF was detected along with a mixture of hydrocarbon gasses.
UL9540A:2019 – Unit Level	A unit consisting of 8 modules is tested along with a receiving unit in close proximity.	Only the heated cell and one further cell went into thermal runaway. However, based on the temperatures other cells likely vented or were close to venting and thermal runaway. Off-gas mixture was flammable, no mention is made of HF gas.

Test	Summary	Result Summary
Large Scale Fire Test	Full scale test method developed based on UL 9540 Task Group 3 and CSA C800:25. This test consists of 1 complete BESS container, with three additional BESS containers which are filled with battery modules in the closest areas.	Full container permitted to burnout to self-extinguishment. No fire spread between BESS Units, with initiating unit destroyed. Peak heat release rate of ~14 MW was reached. This test report contains measures for surface, internal, and cell temperatures for exposed units, as well as received heat fluxes at various points which can be used to understand the potential for fire spread.

Table 45: Parameters of the Hithium BESS unit

Item		Parameter
Nominal energy (kWh)		5016
Nominal Voltage (V)		1331.2
Nominal Power (kW)		2508
Operating environment requirements	Humidity	100% non-condensing
	Temperature (°C)	-30 – 55
	Elevation (m)	≤ 4000
Dimensions (mm) (W x D x H)		6058 x 2438 x 2896
Maximum weight (kg)		40,000
IP rating		IP55
Cooling method		Liquid cooling
Coolant		Glycol-Water
Refrigerant		R410A – 50/50 of difluoromethane and pentafluoroethane
Cooling capacity		≥ 60 kW @ 45°C
GHS classification		Flammable liquid – Category 1 Acute Toxicity – Oral – Category 3 Skin Corrosion / Irritation – Category 1A Serious eye damage – Category 1 Specific Target Organ Toxicity (Repeated Exposure) – Category 1
Ingredient	Graphite	10-25%
	Lithium Iron Phosphate	35-50%
	Acetylene Black	0-5%
	Lithium Hexafluorophosphate	0-5%

	4-Fluoro-1, 3-Dioxolan-2-One	0-5%
	Ethyl Methyl Carbonate	0-20%
	Ethylene Carbonate	0-20%
	Dimethyl Carbonate	0-20%
Conditions to Avoid		Fire source, heating source, disassemble, external short circuit, crushes, deformation, high temperature above 100°C, direct sunlight and high humidity, immerse in water or overcharge.
Hazardous Decomposition Products		Metal oxides, carboxyl compound such as CO, CO_2, etc.
Dangerous goods class		9
Packing group		II
UN number		3536

B.1.4. outlines the standards with which the Hithium BESS unit complies.

Table 46: Standards for Hithium BESS unit

Component	Standard
Cell	UN38.3
	UL1973
	UL9540A
	IEC 62620
	IEC 62619
Unit	AS 1170
	AS 3000 (3008)
	IEC 61000-6-2/4
	IEC 62477-1:2012+A1:2016
	IEC 62619:2022
	NFPA70E
	AS 4100
	AS/NZS 4600
	AS 4991
	UL1973
	UL9540A
	AS/NZS 5131
	UN 38.3

B.2. Operating Features and Certifications

B.2.1. The following pages provided by Hithium summarise the system certification, dimensions, and operating conditions.

B.2.2. One key feature of the Hithium BESS separate from other systems is that the container it is installed in is insulated. The wall construction is a sandwich of steel, non-combustible rock wool, and steel.

HiTHIUM ∞ BLOCK

HiTHIUM

ESS **Container** 5.016 MWh

Liquid-cooled energy storage system



Liquid-cooled energy storage system based on HiTHIUM prismatic LFP ESS Cells 314 Ah with very high cyclic lifetime.

Improved safety characteristics and specially optimised for the highest requirements on safety, reliability and performance. Suitable e.g. for industrial, utility, and grid serving applications.

- Product certification and compliance:
  IEC 62619, IEC 62477, IEC 61000, AS 61000, AS 3000, AS 3008, UL1973, UL 9540A, UN38.3, NFPA 855
- Company certifications:
  ISO 9001, ISO 14001, ISO 45001, SA 8000
- Environmental Compliance:
  RoHS, REACH, Cobalt free
- Flexible solution:
  String or central PCS compliance.

High safety

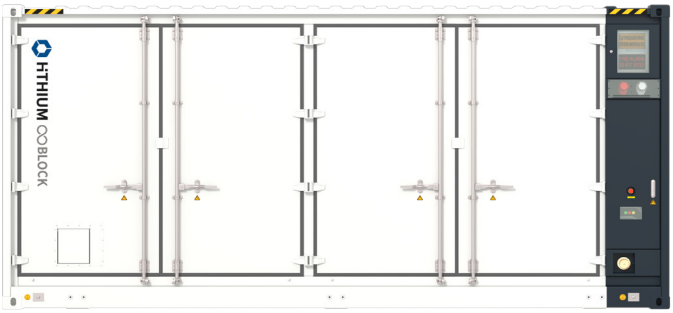
- High thermal stability thanks to liquid cooling
- Multi-stage, active fire protection system, compliance to NFPA 855
- Use of highly safe prismatic HiTHIUM LFP cells
- Dedicated cell monitoring and protection system

Low LCOS (Levelised Cost of Storage)

- Excellent thermal management improves energy throughput by ensuring optimal operating temperature
- Highly integrated: including thermal management system, fire protection system, BMS, etc.
- Supports back to back and side by side installations

ESS **Container**
5.016 MWh

Liquid-cooled energy storage system based on prismatic LFP cells with very high cyclic lifetime



GENERAL	
Configuration	6*2P416S
Cooling Method	Liquid Cooling
BMS Communication	CAN, RS485, Ethernet
Gravimetric ED	≥ 125 Wh/kg
Volumetric ED	≥ 117 Wh/L
Application Altitude	≤ 4,000 m

ELECTRICAL	
Nominal Voltage	1,331.2 V
Operating Voltage	1,040 V … 1,500 V
Nominal Energy	5,016 kWh [1, 2]
Nominal SOC at Delivery	27 % [2]
Nominal Charge/Discharge Rate	0.5 P / 0.5 P
Round Trip Efficiency	≥ 94 % [1, 2]

[1] *0.5 P / 0.5 P*
[2] *25 °C +/- 2 °C*
[3] *ambient temperature*

MECHANICAL	
Dimensions (L x W x H)	6,058 x 2,438 x 2,896 mm
Maximum Weight	40,000 kg
Protection Level	IP 55

TEMPERATURE RANGE	
Operating	-30 °C … 55 °C [3]
Storing (Recommended)	-20 °C … 35 °C [3]

PRODUCT CERTIFICATIONS AND COMPLIANCE	
Certificates, Report and Compliance	IEC 62619, IEC 62477, IEC 61000, AS 61000, AS 3000, AS 3008, UL1973, UL 9540A, NFPA 855
Safe Transportation	UN 38.3

ENVIRONMENTAL	
Compliance	RoHS, REACH, Cobalt free
Battery Regulation (EU)	2023/1542

COMPANY CERTIFICATIONS	
	ISO 9001, ISO 14001, ISO 45001, SA 8000

Xiamen HiTHIUM Energy Storage Technology Co., Ltd.
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LinkedIn Website

Document is subject to regular updates, corrections, and improvements.
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B.3. Fire Protection System

B.3.1. The BESS unit has an in-built aerosol fire suppression system composed of 12 x 300g aerosols, as well as a dry pipe sprinkler system which fire brigade could connect to from the outside. It also has in-built smoke and heat detection to control the suppression system, as well as warning signs and horns/strobes to alert any staff present to activation of systems.

B.3.2. The following pages have been provided by Hithium as background on the in-built fire protection system for the BESS unit.

液冷 2.0 预制舱技术规格书（澳版-6 簇-A）

Liquid Cooling 2.0 ESS Container Technical Specification (AU-6 Racks-A)

1331.2V/3768Ah 磷酸铁锂储能型液冷 2.0 预制舱

1331.2V/3768Ah Lithium Iron Phosphate Liquid Cooling 2.0 ESS Container

型号 Model No：IF5015P050AAU

版本 Version：A/0

客户名称： Customer Name:
客户确认（盖章）：对本规格书内容无异议。 Customer confirms (seal): No objection to the contents of this specification.
客户确认日期： Customer confirmation date:

厦门海辰储能科技股份有限公司

Xiamen Hithium Energy Storage Technology Co., Ltd.

2025 年 5 月

May 2025

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1. 术语定义 Definition of Terms

海辰 Hithium	厦门海辰储能科技股份有限公司 Xiamen Hithium Energy Storage Technology Co., Ltd.
客户 Customer	液冷 2.0 预制舱的采购方 Purchasers of liquid cooling 2.0 ESS container
产品 Product	若无特别说明，产品指客户向海辰采购的 1331.2V/3768Ah 液冷储能预制舱，型号：IF5015P050AAU。 If not otherwise specified, the product refers to the 1331.2V/3768Ah liquid cooling ESS container purchased by the customer from Hithium, model number: IF5015P050AAU.
电池单体 Battery cell	实现化学能和电能相互转换的基本单元，由正极、负极、隔膜、电解质、壳体和端子等组成。 The fundamental unit that facilitates the mutual conversion of chemical energy and electrical energy, comprising a positive electrode, negative electrode, separator, electrolyte, casing, terminals, etc.
电池模组 Battery module	由电池单体通过串联、并联或串并联连接方式，且只有一对正负极输出端子的电池组合体，还宜包括外壳、管理和保护等部件。 Battery assemblies consisting of Battery cells connected in series, parallel or series-parallel and having only one pair of positive and negative output terminals, also including housing, management and protection components.
电池簇 Battery rack	由电池模组通过串联、并联或串并联连接方式，且与储能变流器及附属设施连接后实现独立运行的电池组合体，还宜包括电池管理系统、监测和保护电路、电气和通讯接口等部件。 A battery rack consisting of battery modules connected in series, parallel or series-parallel, and connected to an energy storage converter and ancillary facilities to achieve independent operation, which may also include a battery management system, monitoring and protection circuits, electrical and communication interfaces and other components.
高压盒 HV box	用于电池簇充放电过程中的保护和控制，由簇级电池管理单元、继电器、熔断器和隔离开关等组成。 Used for protection and control during the charging and discharging process of the racks, it consists of CBMU, relay, Fuses, and disconnector.
中控柜 Control panel	主要包含电池控制系统、系统供电功能，放置在液冷 2.0 预制舱。 Mainly includes the battery control system and system power supply functions, placed inside the liquid cooling 2.0 ESS container.
液冷储能预制舱 Liquid cooling ESS container	由电池簇、BMS 系统、液冷机组、消防及中控柜组成。采用标准 20 英尺高柜预制舱一体化集成装置，整体防护等级 IP55。 It consists of the racks, BMS system, liquid cooling unit, fire protection system and control panel. It adopts a standard 20-foot high container as an integrated device, with an overall protection level of IP55.
新产品状态 New Product Status	指客户收货 15 天以内且循环充放次数少于 5 次的产品状态。 Referring to the product condition within 15 days of customer receipt and with fewer than 5 charge and discharge cycles.
电池管理系统 Battery Management System	检测电池的电压、电流、温度等参数信息，并对电池的状态进行管理和控制的装置。 A device that detects voltage, current, temperature, and other parameters of the battery, managing and controlling the battery's state.
MBMU	电池管理系统内的从控模块，负责模组内单体电池的电压和温度采集及电池均衡管理。 A subordinate control module within the Battery Management System, responsible for collecting voltage and temperature data from cells within a module and managing battery balancing.
CBMU	电池管理系统内的主控模块，提供对电池簇参数进行实时监控、故障诊断、SOC/SOH 估算、绝缘检测、显示报警、远程监控，并与 MBMU 通信，与 SMBU 通讯上传电池实时数据。 The main control module within the Battery Management System, offering real-time monitoring of rack parameters, fault diagnosis, SOC/SOH estimation, insulation detection, alarm display, remote monitoring, communication with MBMU, and communication with SMBU to upload real-time

	battery data.
SBMU	电池管理系统内的总控模块，对 CBMU 上传的电池实时数据进行数值计算、性能分析、报警处理及记录存储，此外，可实现与 PCS 主机、储能调度监控系统等进行联动控制。 The total control module within the Battery Management System performs numerical calculations, performance analysis, alarm processing, and record storage based on real-time battery data uploaded by CBMU. Additionally, it can establish linkage control with the PCS, energy storage dispatch monitoring system, and more.
标称电压 Nominal voltage	标志或识别一种电池或一种电化学体系的适当的电压近似值。 The approximate voltage that serves as a marker or identifier for a specific battery or electrochemical system.
充电倍率 Charge rate	充电功率与电池管理系统多次测量的产品的能量值的比率。 例如:产品能量为 1004.8Wh，充电功率 502.4W 时,则充电倍率为 0.5P；当产品能量衰减为 703.36Wh，充电功率为 351.68W 时，则充电倍率为 0.5P。 The rate of the charging power to the energy value of a product measured multiple times by the Battery Management System. For example: If the product energy is 1004.8Wh and the charging power is 502.4W, then the charging rate is 0.5P. When the product energy decreases to 703.36Wh and the charging power is 351.68W, the charging rate is 0.5P.
放电倍率 Discharge rate	放电功率与电池管理系统多次测量的产品的能量值的比率。 例如:产品能量为 1004.8Wh，放电功率为 502.4W 时,放充电倍率为 0.5P；当产品能量衰减为 703.36Wh，放电功率为 351.68W 时，则放电倍率为 0.5P。 The rate of the discharging power to the energy value of a product measured multiple times by the Battery Management System. For example: If the product energy is 1004.8Wh and the discharging power is 502.4W, then the discharging ratio is 0.5P. When the product energy decreases to 703.36Wh and the discharging power is 351.68W, the discharging rate is 0.5P.
标准充电 Standard charge	在室温下(25±2) °C，以 0.5P 恒功率充电至模组内任一电池单体电压 3.6V，停止充电，静置 30min。 At room temperature (25±2) °C, charge at a constant power rate of 0.5P until the voltage of any cell within the module reaches 3.6V. Stop charging and let it stand for 30 minutes.
标准放电 Standard discharge	在室温下(25±2) °C，以 0.5P 恒功率放电至模组内任一电池单体电压 2.5V，停止放电，静置 30min。 At room temperature (25±2) °C, discharge at a constant power rate of 0.5P until the voltage of any cell within the module reaches 2.5V. Stop discharging and let it stand for 30 minutes.
循环 Cycle	电池或模组按照规定的标准充放电充放一次为一个循环。 A cycle is defined as one charge and discharge of the cell or module according to the specified standard.
测量单位 Unit of measure	电压单位 Voltage unit："V"(Volt)伏特（V） 电流单位 Current unit："A"(Ampere)安培（A） 功率单位 Power unit："W"(Watt)瓦特（W） 容量单位 Capacity unit："Ah"(Ampere-Hour)安培-小时（Ah） 能量单位 Energy unit："Wh"(Watt-Hour)瓦特-小时（Wh） 内阻单位 Internal resistance unit："mΩ"(milliOhm)毫欧姆（mΩ） 温度单位 Temperature unit："°C "(degree Celsius)摄氏度（°C） 长度单位 Length unit："mm"(millimeter)毫米（mm） 时间单位 Time unit："s"(second)秒（s） 频率单位 Frequency unit："Hz"(Hertz)赫兹（Hz） 质量单位 Quality unit："kg"(kilogram)千克（kg） 力单位 Force unit："N"(Newton)牛顿（N）

2. 适用范围 Scope of Application

本技术规格书规定了 IF5015P050AAU 型 1331.2V/3768A 磷酸铁锂储能型液冷 2.0 预制舱系统的技术方案详细介绍、运输、包装、储存要求和注意事项等。

本技术规格书的产品规格、性能及参数等内容仅供客户作初步参考，海辰有权对技术规格书内容进行修改，具体以双方后续实际签订的合同、文件为准。

This document outlines the detailed technical specifications, transportation, packaging, storage requirements, and precautions for the IF5015P050AAU 1331.2V/3768A lithium iron phosphate liquid cooling 2.0 ESS container product.

The product specifications, performance, and parameters outlined in this document are provided for the customer's preliminary reference only. Hithium reserves the right to modify the content of the technical specification document, and the specifics are subject to the contract and documents signed by both parties in the future.

3. 规范性引用文件 Normative References

下列文件对于本文件的应用是必不可少的，凡是注日期的引用文件，仅注日期的版本适用于本文件。凡是不注日期的引用文件，其最新版本（包括所有的修改单）适用于本文件。

The following documents are indispensable for the application of this document. Any referenced document with a specified date is applicable only to the version annotated with that date in this document. Any referenced document without a specified date is applicable to the latest version (including all amendments) of this document.

AS 1170 结构设计动作

AS 1170 Structural design actions

AS 2312 用保护涂层保护结构钢抗大气腐蚀的指南

AS 2312 Guidelines for Protecting Structural Steel Against Atmospheric Corrosion with Protective Coatings

AS 3000-2018 电气安装

AS 3000-2018 Electrical Installation

AS 3008 电气设施-电缆的选择 0.6/1 kV 及以下交流电压电缆典型的澳大利亚安装条件

AS 3008 Electrical Installations - Cable Selection Typical Australian Installation Article for AC Voltage Cables 0.6/1 kV and Below

AS 4312-2008 澳大利亚的大气腐蚀区

AS 4312-2008 Atmospheric corrosion zones in Australia

AS 60529-2004 外壳提供的保护等级(IP Code)

AS 60529-2004 Protection class provided by the housing (IP Code)

AS 61000 电磁兼容性(EMC)

AS 61000 Electromagnetic Compatibility (EMC)

AS 614 低压开关设备和控制设备。额定电压不超过交流 600V 和直流 250V 的模塑外壳断路器

AS 614 Low voltage switchgear and control equipment. Molded case circuit breakers with rated voltage not exceeding 600V AC and 250V DC

IEC 60999 连接设备-电铜导体-螺钉式和无螺钉式夹紧装置的安全要求

IEC 60999 Connection equipment - Electrical copper conductors - Safety requirements for screw and screwless clamping devices

IEC 61000 电磁兼容性(EMC)

IEC 61000 Electromagnetic Compatibility (EMC)

IEC 62477 电力装置用电子设备

IEC 62477 Electronic equipment for electrical installations

UL 1973 用于固定和动力辅助电源应用的电池安全标准

UL 1973 Standard for Safety Batteries for Use in Light Electric Rail (LER) Applications and Stationary Applications

UL 9540 储能系统与设备研究大纲

UL 9540 Energy Storage Systems and Equipment Research Outline

UL 9540A 评价电池储能系统中热失控火焰传播的安全试验方法标准

UL 9540A Standard for Safety Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems

IEC 62619 含碱性或其他非酸性电解质的二次电池和电池 工业用二次锂电池和电池的安全要求

IEC 62619 Secondary cells and batteries containing alkaline or other non-acidic electrolytes Safety requirements for secondary lithium cells and batteries for industrial use

NFPA 855 固定式储能系统的安装标准

NFPA 855 Installation Standards for Fixed Energy Storage Systems

NFPA 69 防爆系统标准

NFPA 69 Standard on Explosion Prevention Systems

NFPA 70E 工作场所的电气安全标准

NFPA 70E Standard for Electrical Safety in the Workplace

AS 4214:2018 气体灭火系统

AS 4214:2018 Gas Extinguishing System

AS 4487-2013 冷凝气溶胶灭火系统、系统设计、安装、调试要求和部件试验方法

AS 4487-2013 Condensing aerosol fire extinguishing systems, system design, installation, commissioning requirements and component test methods

UN 38.3 联合国危险品运输试验和标准手册第 3 部分 38.3 款-锂电池的要求

UN 38.3 Requirements for Lithium Batteries, Section 38.3 of the United Nations Manual of Tests and Criteria for the Transport of Dangerous Goods

4. 测试条件 Test Condition

若无特别说明，产品的参数均为新产品状态下的参数，测试对象为新产品状态的液冷储能预制舱（除自放电测试外）。除非有其他说明，实验和测量需在室温(25±2)°C、标准湿度(55±20)%条件下进行。

Unless otherwise specified, the parameters of the product are based on the new product state, and the test object is the liquid cooling ESS container in a new product state (excluding self-discharge tests). Unless otherwise stated, experiments and measurements should be conducted at room temperature (25±2) °C and standard humidity (55±20) %.

4.1. 测量设备及精度 Measuring Equipment and Accuracy

1) 电流测量精度：≥0.5 级。

Current measurement accuracy: ≥0.5 grade.

2) 电压测量精度：≥0.5 级。

Voltage measurement accuracy: ≥0.5 grade.

3) 温度测量精度：±0.5°C。

Temperature measurement accuracy: ±0.5°C.

4) 尺寸测量精度：±0.1%。

Dimensional measurement accuracy: ±0.1%.

5) 重量测量精度：±0.1%。

Weight measurement accuracy: ±0.1%.

4.2. 充放电模式 Charge and Discharge Mode

若无特别说明，充放电模式均应为标准充电/放电模式。

If not otherwise specified, the charging and discharging modes should be in standard charging/discharging mode.

5. 产品介绍 Product Introduction

本产品是由 48 个 166.4V/628Ah 磷酸铁锂液冷模组、电池管理系统以及相关的温控、消防等辅助系统组成。电池管理系统包含 MBMU 、CBMU 和 SBMU，可对电池实时数据进行数值计算、性能分析、报警处理及记录存储，此外可实现与 PCS、EMS 等进行联动控制，保证所有电池系统稳定运行；具备能量密度高、温度使用范围宽、寿命长、安全可靠性高等特点。

This product is composed of 48 166.4V/628Ah lithium iron phosphate liquid cooling modules, BMS and related auxiliary systems such as temperature control system and fire protection system. The BMS includes MBMU, CBMU, and SBMU. It performs real-time data calculations, performance analysis, alarm processing, and record storage for the batteries. Additionally, it can achieve linkage control with PCS and EMS, ensuring the stable operation of all battery systems. The system is characterized by high energy density, a wide temperature range, a long service life, and high safety and reliability.

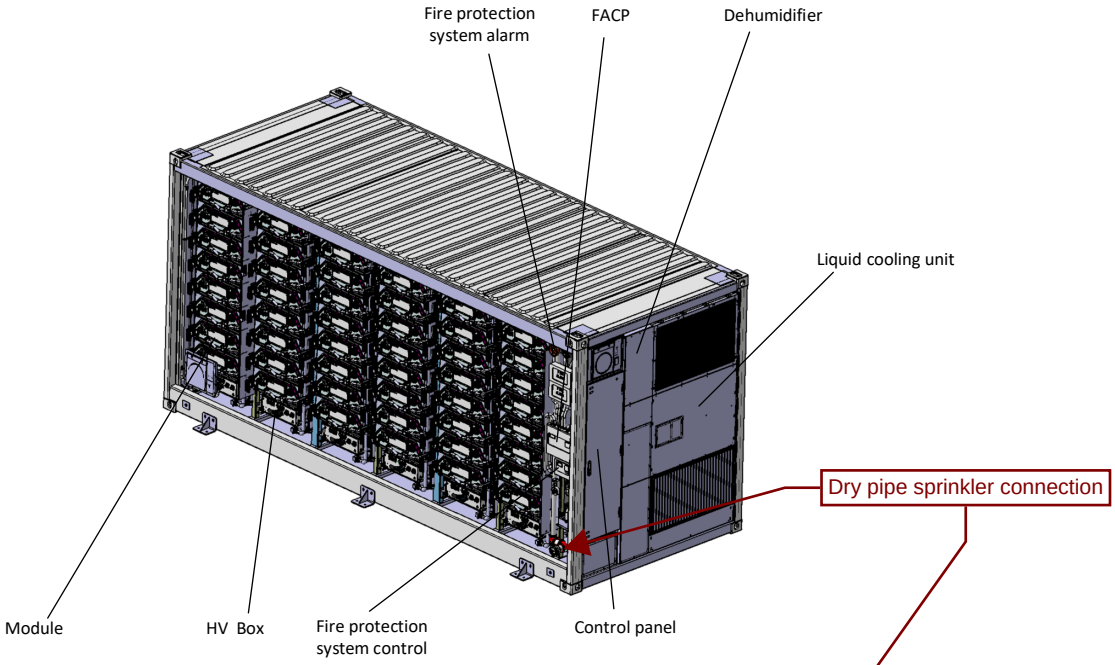
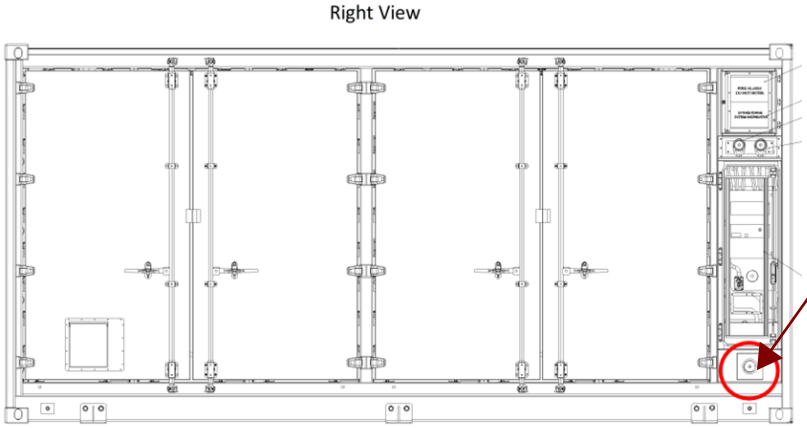


图 5-1 液冷 2.0 预制舱

Fig. 5-1 Liquid Cooling 2.0 ESS Container





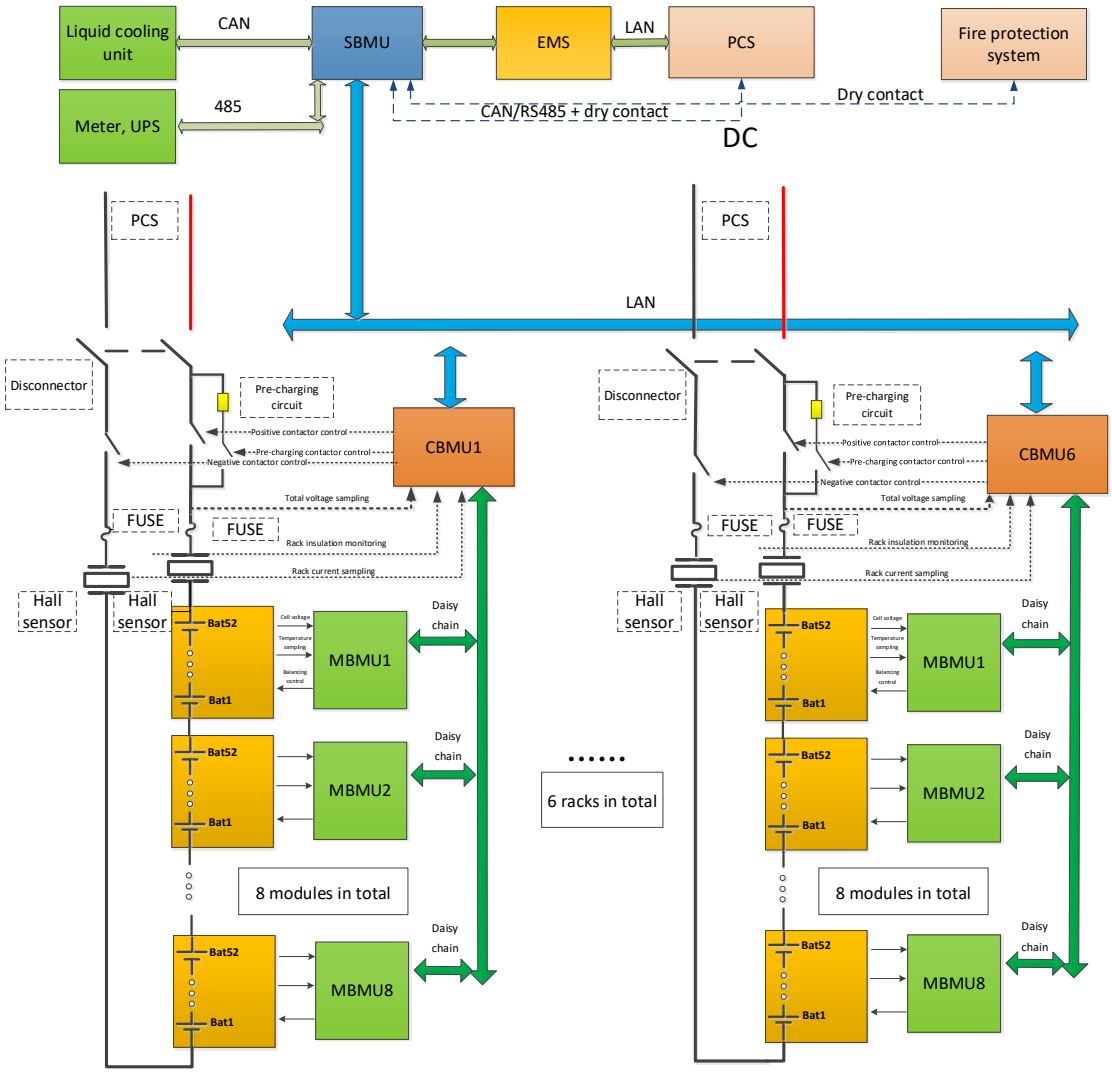


图 5-2 电气原理图

Fig. 5-2 Electrical Schematic Diagram

5.1. 技术参数表 Technical Parameters

储能系统技术参数是基于新产品状态，室温(25±2)°C、湿度(55±20)%条件下的测量结果。

The technical parameters of the energy storage system are determined under new product conditions, with measurements conducted at a room temperature of (25±2) °C and humidity of (55±20) %.

产品主要技术参数表

Product main technical parameters table

序号 No.	项目 Item		规格 Standard	备注 Remark
1	成组方式 Grouping method		2P416S*6	
2	额定能量 Nominal energy (kWh)		5016	
3	标称电压 Nominal voltage (V)		1331.2	
4	电压范围 Voltage range (V)		1040-1500	
5	额定功率 Nominal power (kW)		2508	
6	最大功率 Max power (kW)		0.6P	持续 1min Continuous 1minute, (SOC:30%-80%)
7	辅助电源 Auxiliary power	电压 Voltage (V)	400 (AU)	
8		功率 Power (kVA)	41.5	
9	运行环境要求 Operating environment requirements	湿度 Humidity	100% non-condensing	
10		温度 Temperature (°C)	-30~55	环境温度 Ambient temperature
11		海拔 Elevation (m)	≤4000	
12	其他参数 Other parameters	尺寸 Dimension (mm) (WxD×H)	6058*2438*2896	
13		最大重量 Maximum weight (kg)	40000	
14		防护等级 IP level	IP55	模组 Module: IP67 高压盒 HV box: IP65 液冷机组 Liquid cooling unit: IP 55
15		冷却方式 Cooling method	液冷 Liquid cooling	

16		通讯方式 Communication method	CAN, RS485, Modbus TCP/IP	
17		动力线缆连接方式 Power cable connection method	铜排 Copper Bar	
18		通讯线缆连接方式 Communication cable connection method	快插 Quick plug	
19		辅助电源连接方式 Auxiliary power supply connection method	端子排 Terminal strip	
20		冷却液 Coolant	乙二醇水溶液 Glycol-Water Coolant Solution	
21		消防 Fire protection	干管系统+通风系统 Dry pipe system+ ventilation system	
22	认证标准 Certification Standard	电芯 Cell	UN38.3	
23			UL1973	
24			UL9540A	
25			IEC 62620	
26			IEC62619	
27		系统 System	AS 1170	
28			AS 3000 (3008)	
29			IEC61000-6-2/4	
30			IEC 62477-1:2012+A1:2016	
31			IEC 62477-1:2012+A1:2016	
32			IEC 62619:2022	
34			NFPA70E	
35			AS 4100	
36			AS/NZS 4600	
37			AS 4991	
38			UL 1973	
39			UL 9540	
40			UL 9540A	
41			AS/NZS 5131	
42			UN 38.3	

5.2. 功能介绍 Function Introduction

5.2.1. 高压盒 HV box

高压盒配置在各电池簇底部，前面板如下图所示。配置高压电接口、低压电接口、开关和指示灯。

The HV box is configured at the bottom of each rack. The front panel is as shown below. It includes HV electrical interfaces, LV electrical interfaces, disconnector, and indicators.

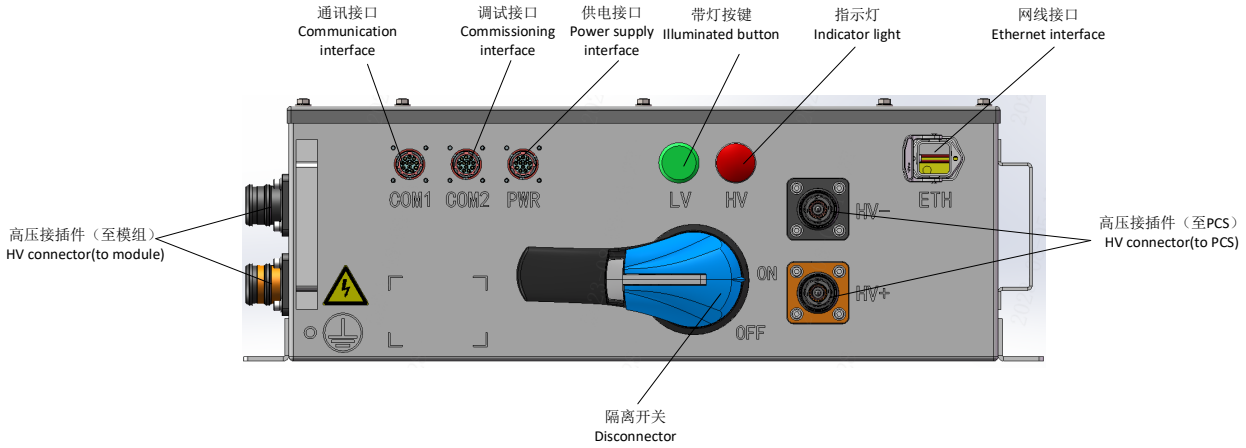


图 5-3 高压盒前面板

Fig. 5-3 HV Box Front Panel

1) 外部接口定义 External Interface Definition

COM1 为高压盒与电池包（BMS 主从）通讯接口

COM1 is the communication interface between the HV box and the module (CBMU and MBMU).

COM2 为高压盒调试预留接口

COM2 is the reserved commissioning interface for the HV box.

PWR 为高压盒 220V 供电进线接口

PWR is the 220V power supply input interface for the HV box.

ETH 为高压盒与中控柜(BMS 总主)通讯接口

ETH is the communication interface between the HV box and the control panel (SBMU and CBMU).

注意：接口定义的细节请参照高压盒电气图。

Note: Details of the Interface Definition are referred to the *HV Box Electrical* Drawings.

2) 开关定义 Switch Definition

高压盒上的开关为隔离开关(QS)，功能定义如下表。

The switch on the HV box is a disconnector (QS), and the function is as defined below.

序号 No.	名称 Name	定义 Definition	功能 Function	备注 Remark
1	QS	隔离开关 Disconnector	切断和闭合电池系统主回路 Cutting and closing the main circuit of the battery system	不可带载操作 Do not operate under load

3) 指示灯定义 Indicator Definition

高压盒前面板配置 2 个指示灯，功能定义如下表。

The front panel of HV box is equipped with two indicator lights, and the function is as defined below.

序号 No.	名称 Name	定义 Definition	功能 Function	备注 Remark
1	LV	绿灯 Green light	辅助电源带电 Auxiliary power supply is lived.	按下接通 Press to turn on
2	HV	红灯 Red light	一次回路带电 DC circuit is energized.	

5.2.2. 中控柜 Control Panel

中控柜如下图所示。中控柜柜面板配置 BMS 总控、指示灯及急停按钮，内部配置辅助供电断路器、UPS、开关电源、插座、柜内环控、通讯设备及端子排等，对外接线端子排均排布于中控柜下部出口处。

The control panel is as shown below. The control panel is configured with SBMU, indicator lights, and emergency stop button. It internally includes auxiliary power circuit breaker, auxiliary power transformer (applicable only for the UL version), UPS, switch mode power supply, socket, environmental control, communication equipment, terminal strip and etc. External connection terminal strips are arranged at the lower exit of the control panel.

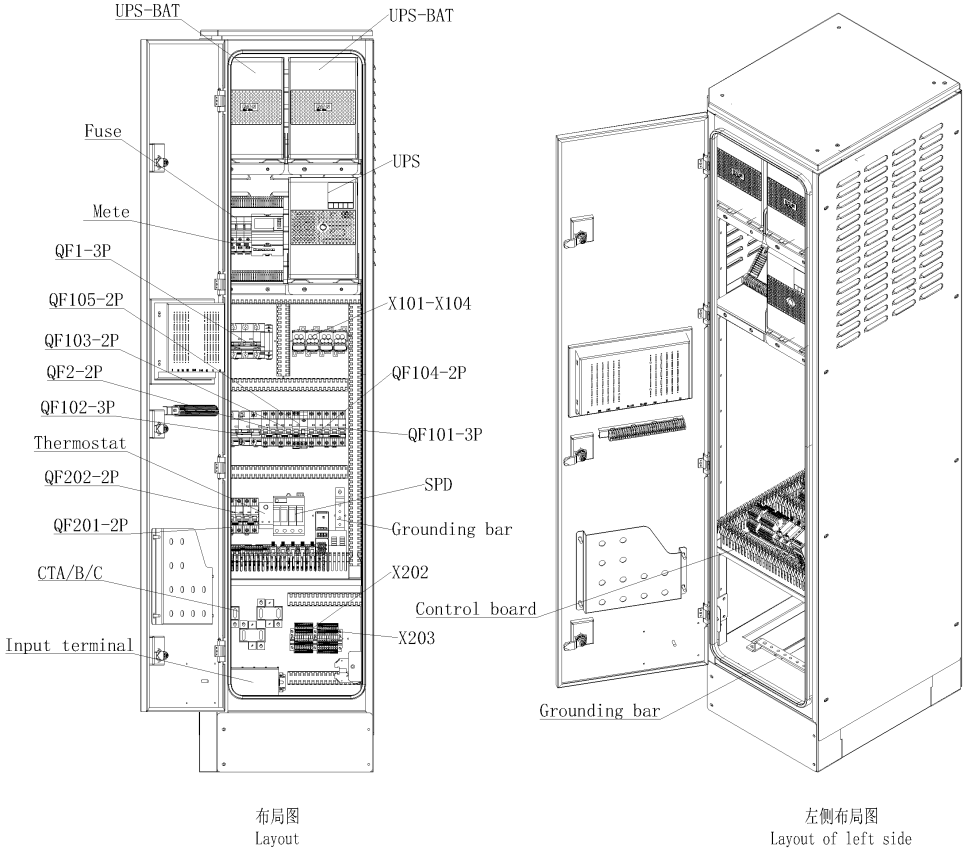


图 5-4 中控柜（澳版）

Fig. 5-4 Control Panel (AU Version)

1）辅助供电断路器定义 Auxiliary Power Supply Circuit Breaker Definition

辅助供电断路器为系统辅助控制电源，功能定义如下：

The auxiliary power supply circuit breaker is the auxiliary control power supply of the system, and the function is as defined below.

序号 No.	名称 Name	定义 Definition	功能 Function	备注 Remark
1	QF1	辅助供电电源断路器 Auxiliary power supply circuit breaker	系统辅助电源总进电 System auxiliary power supply input	
2	QF101	SPD 后备保护断路器 SPD backup protection circuit breaker	SPD 后备保护 SPD backup protection	
3	QF102	液冷机组电源断路器 Liquid cooling unit power supply circuit breaker	液冷机组供电 Liquid cooling unit power supply	
4	QF103	消防电源断路器 Fire protection power supply circuit breaker	消防和中控柜环控系统供电 Fire protection and control panel environmental control system power supply	
5	QF104	UPS 输入电源断路器 UPS input power supply circuit breaker	UPS 输入电源 UPS input power supply	
6	QF2	UPS 电源输出断路器 UPS power output circuit breaker	UPS 电源输出 UPS power output	
7	QF201	CBMU 电源供电断路器 CBMU power supply circuit breaker	各电池簇 BMS 主控电源 CBMU power supply for each rack	UPS 供电 UPS power supply
8	QF202	开关电源供电断路器 Control power circuit breaker	SBMU 及各传感器等控制模块电源 Power supply for control modules such as various sensors and SBMU	UPS 供电 UPS power supply

2)对外端子排/以太网口定义 External Terminal Strip/Ethernet Port Definition

对外端子排/以太网口为辅助电源进电、控制通讯端子以及 BMS 总控对外通讯接口

The external terminal strip/ Ethernet port is the external communication interface for the auxiliary power input, the control communication terminals, and the SBMU.

3)预制舱内部接口定义 Container Internal Interface Definition

对内端子排为液冷机组供电、液冷机组通讯、消防及防爆风机供电通讯端子

The internal terminal strips are designed for power supply and communication for the liquid cooling unit, as well as power supply and communication for the fire protection and explosion-proof fan.

COM1 为中控柜 UPS 对各电池簇高压盒供电接口

COM1 is the power supply interface from the control panel UPS to the HV boxes of each rack.

COM2 为中控柜对预制舱门禁及急停按钮信号接口

COM2 is the signal interface between the control panel and the access control and emergency stop button of the container.

注意：接口定义的细节请参照中控柜电气图。

Note: Details of the Interface Definition are referred to the *Control Panel Electrical* Drawings.

5.2.3. 冷却系统 Liquid Cooling system

冷却系统主要包含液冷机组、冷却液和冷却管路两部分组成，机组参数如下表：

The liquid cooling system mainly consists of liquid cooling unit, coolant and cooling pipeline, and the parameters of the unit are as listed below.

序号 No.	规格 Standard	参数 Parameters	备注 Remark
1	工作环境温度 Operating temperature	-30°C~55°C	大于 45°C 降额运行 Derated operation above 45°C
2	工作海拔 Operating altitude	0-4000m	大于 2000m 降额运行 Derated operation above 2000m
3	冷却液 Coolant	乙二醇/水溶液 Glycol-Water Coolant Solution	不同品牌冷却液禁止混用 Mixing of coolants from different brands is strictly prohibited.
4	冷却管路 Cooling pipe	一级管 PE/二级管 PA12-PP/三级管 PA12-PP Primary Pipe PE/Secondary Pipe PA12-PP/Tertiary Pipe PA12-PP	
5	制冷剂类型 Type of refrigerant	R410A	
6	供电电压 Supply voltage	400VAC±10%, 50±2%Hz	
7	制冷量 Cooling capacity	额定值≥60kW@45°C 环境温度 Rated value ≥ 60kW@45°C ambient temperature	
8	制热量 Calorimetric	额定值≥12kW Rated value ≥ 12kW	
9	最大功率 Max power	40kW	
10	最大电流 Max current	64A	AC
11	防护等级 IP level	IP55	电控部分 Electronic control section
12	防腐等级 Corrosion protection	C5-M	
13	重量 Weight	485±5kg	不含冷却液 Excluding coolant
14	机组外形尺寸 Liquid cooling unit dimension	1600×510×2580mm	
15	机组颜色 Liquid cooling unit color	RAL7016（磨砂哑光） RAL7016 (satin matte)	

5.2.4. 消防系统 Fire Protection System

液冷 2.0 预制舱消防系统包括灭火系统、主动排爆系统。消防布置如图下图所示。

The liquid cooling 2.0 container fire protection system includes a fire extinguishing system and active explosion suppression system.

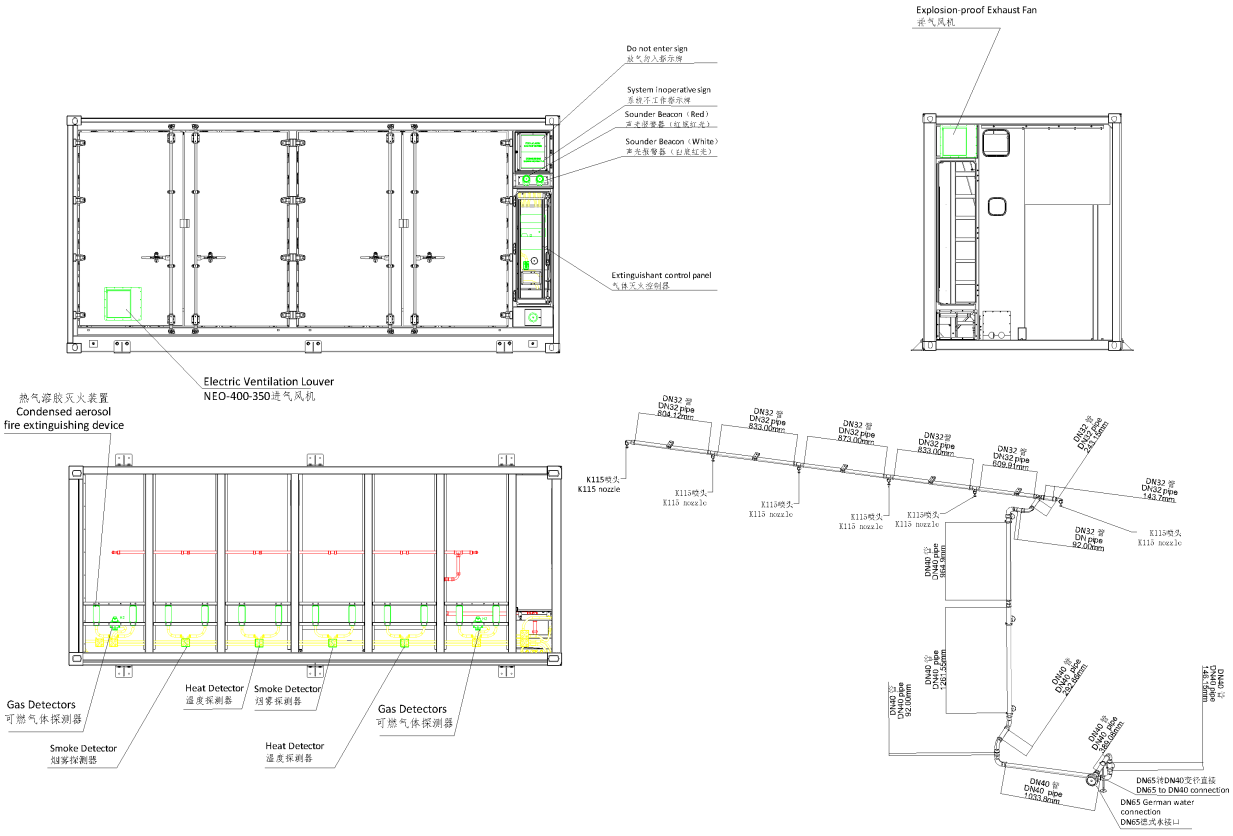


图 5-5 消防布置图

Fig. 5-5 Fire Protection System Layout Diagram

5.2.5. 安装界面 Installation Interface

液冷 2.0 预制舱吊装及箱体接地位置示意，如下图所示。箱体顶部配置 4 个端部吊装孔，用于产品吊装。当吊点为预制舱顶部四个角件处，推荐吊绳竖直起吊；箱体侧面底部共计 2 个接地点可供现场实际布置使用。（以上吊装方式仅适用厂内吊装，具体吊装方式由吊装公司根据现场实际情况和相关法律法规确定）。

Liquid cooling 2.0 ESS container lifting and enclosure grounding position are as shown below. The top of the container is equipped with 4 lifting holes for product hoisting. When the lifting points are at the four corners of the container top, it is recommended to hoist the rope vertically. There are 2 grounding points on the bottom of the enclosure, which can be used for actual on-site arrangement. (The above lifting method is only applicable to in-factory lifting, The specific lifting method shall be determined by the lifting company based on actual on-site conditions and relevant laws and regulations).

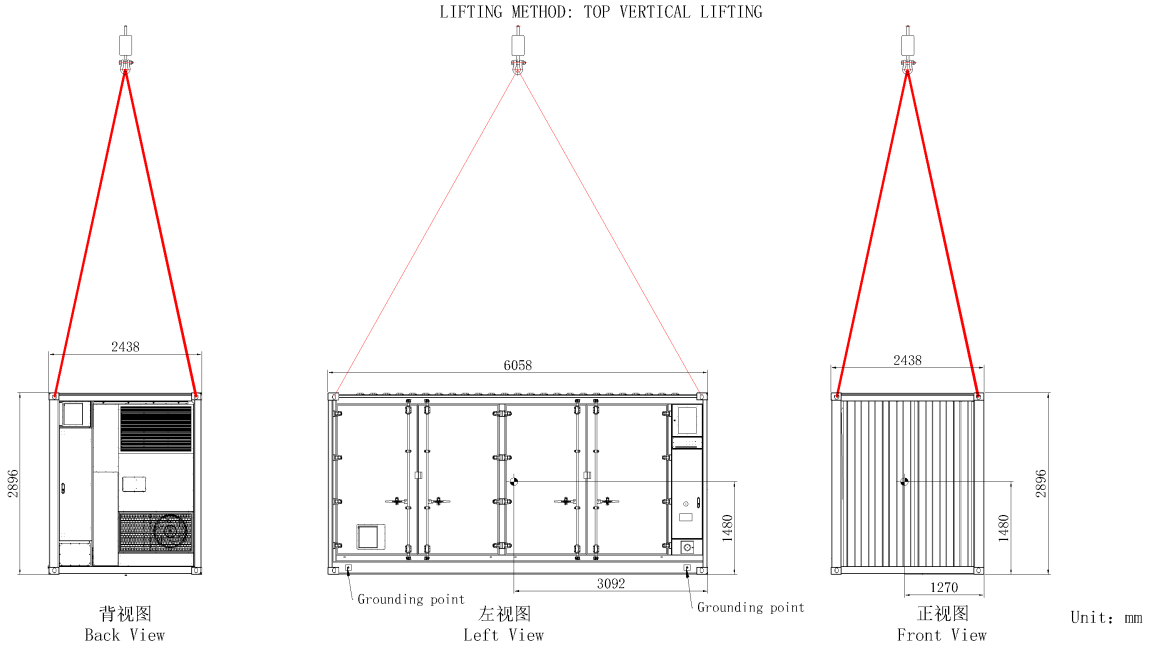


图 5-6 安装界面示意

Fig. 5-6 Installation Interface Schematic Diagram

6. 产品标识、包装、运输与储存要求 Product Identification, Packaging, Transportation, and Storage Requirements

1) 产品标识按照客户和海辰双方约定标准执行，若双方未约定，按海辰的标准执行。

Product identification is carried out according to the standards agreed upon by the customer and Hithium. In the absence of a mutual agreement, it will be executed according to Hithium's standards.

2) 产品出货报告包含预制舱内各电池簇的容量、尺寸及电池簇内的模组数据。

The product shipping report includes the capacity, dimensions, and module data of each rack inside the container.

3) 产品存储时，应放在空气流通、相对湿度不大于 95%，温度在-20~35°C 范围内，可防水、防腐及防尘的仓库中，SOC 保持为 20%~50%。

When storing the product, it should be placed in a warehouse with good air circulation, a relative humidity not exceeding 95% and a temperature within the range of -20 to 35°C. The warehouse should be waterproof, corrosion-resistant, and dustproof. The SOC should be maintained between 20% and 50%.

4) 产品在运输过程中应小心轻放，避免碰撞和敲击，严禁与酸碱等腐蚀物品放在一起。

The product should be carefully and gently placed during transportation to avoid collision and knocking, and it is strictly prohibited to be placed together with corrosive items such as acids and alkalis.

5) 产品在正常托运或放置时，不允许出现倾斜、塌陷等不良。

The product should not be tilted or collapsed during normal handling or storage.

7. 应用条件 Application Conditions

客户应当确保严格遵守以下与产品相关的应用条件:

The customer should ensure strict compliance with the application conditions relevant to the product.

1) 客户必须按产品批次配对使用，不同批次不可混用。

Customers must use products from the same batch in pairs, and different batches should not be mixed.

2) 客户端收到到货产品后，应在 15 天内完成入库检验，具体参考双方协商的检验规范。

Upon receiving the delivered products, the customer should complete the incoming inspection within 15 days, referring to the inspection specifications mutually agreed upon by both parties.

3) 工作环境温度范围： -30～55°C。

Operating temperature range: -30~55°C.

4) 储存温度范围：-20～35°C。

Storage temperature range: -20~35°C.

5) 海拔：≤ 4000m。

Altitude: ≤ 4000m.

6) 相对湿度：≤ 100%RH 无凝露。

Relative humidity: ≤ 100%RH noncondensing

7) 系统必须配置电池管理系统，严密监控、管理与保护每个电芯。

The system must be equipped with the BMS, ensuring close monitoring, management, and protection of each cell.

8) 为避免影响产品的使用性能，客户不可擅自修改电池管理系统的设计和框架，否则发生直接因果关系质量问题或质量事故，应免除海辰责任。

To avoid affecting the performance of the product, the customer is not allowed to modify the design and framework of the battery management system without authorization. In the event of a direct causal relationship with quality issues or incidents, Hithium shall be exempt from responsibility.

9) 客户应保存完整的产品内电芯运转的监测数据，用作产品质量责任划分参考，否则海辰不承担产品质量保证责任。

The customer should keep complete monitoring data of the operation of the cells within the product as a reference for the division of product quality responsibility. Otherwise, Hithium does not assume responsibility for product quality assurance.

10) 客户及第三方应避免产品到达过放状态。储能预制舱系统内任一电芯电压低于 2.0V 时，产品内部可能会遭到永久性的损坏，此时海辰的产品质量保证责任失效。当产品内任一电芯放电截止电压低于 2.5V 时，客户需要培训使用者在最短的时间内重新充电，防止产品进入过放状态。

The customer and third parties should avoid the product arriving in an over-discharged state. When the voltage of any cell inside the ESS container system falls below 2.0V, permanent damage to the internal components may occur, and Hithium's product quality assurance responsibility becomes void. When the discharge cut-off voltage of any cell inside the product is below 2.5V, the customer needs to train users to recharge the product in the shortest time possible to prevent it from entering an over-discharged state.

11) 如果产品存储超过 6 个月，建议客户进行 1 次充放电维护，将 SOC 调整为 20%～50%，以降低存储对产品造成的容量损失。

If the Product is stored for more than 6 months, it is recommended for the customer to perform one charge and discharge maintenance to adjust the SOC to 20% to 50% in order to reduce the capacity loss caused by storage on the Product.

8. 注意事项 Notes

1) 禁止将产品浸入水中。

It is prohibited to immerse the product in water.

2) 产品非正确使用和存放，存在火灾、爆炸和烧伤的风险，勿将产品拆解、压碎、焚化和加热。

The product may pose risks of fire, explosion, and burns if not used and stored correctly. Do not disassemble, crush, incinerate, or heat the product.

3) 禁止将产品投入火中或长时间暴露在超过本规格书规定的温度条件的高温环境中，否则可能会导致火灾。在任何正常的使用情况下，系统内的电芯温度不能超过 60°C，如果温度超过 60°C，需关闭产品，停止运行。

It is prohibited to throw the product into fire or expose it to high-temperature environments exceeding the conditions specified in this manual for an extended period, as it may result in a fire hazard. Under normal usage, the internal temperature of the system must not exceed 60°C. If the temperature exceeds 60°C, shut down the product and cease operation.

4) 将产品置于儿童能接触的范围之外，使用之前不得将产品原包装移除，应根据当地的回收或废弃物法规及时处理废旧产品。

Keep the product out of reach of children. Do not remove the original packaging before use. Dispose of obsolete products promptly in accordance with local recycling or waste disposal regulations

5) 勿擅自以任何方式拆解、拆卸或修整产品。

Do not dismantle, disassemble, or modify the product in any unauthorized way.

6) 勿将不同规格、不同品牌及不同批次的产品混合使用。

Do not mix and use products of different specifications, brands, and batches.

7) 如果产品发出异味、发热、变形、变色或出现其它任何异常现象时，不得使用并将其转移到安全的位置。

"If the product emits an unusual odor, heats up, deforms, changes color, or exhibits any other abnormal phenomena, it must not be used, and should be moved to a safe location.

8) 禁止产品正负极短路，否则强电流和高温可能导致人身伤害或者火灾。在电池系统组装和连接时，应有足够的安全保护，以避免短路。

It is prohibited to short-circuit the positive and negative terminals of the product, as this may result in high current and high temperature, leading to personal injury or fire. Sufficient safety precautions should be taken during the assembly and connection of the battery system to prevent short circuits.

9) 严格按照标示和说明连接产品的正负极，禁止反向或串线充电。

Strictly follow the markings and instructions to connect the positive and negative terminals of the product. Reverse or series charging is prohibited.

10) 禁止产品过充/过放，否则，可能引起电池簇内的电芯过热和火灾事故的发生。在产品安装和使用中，需实行硬件和软件的多重过充过放失效安全保护。

It is prohibited to overcharge/discharge the product, as it may lead to overheating of the cells and the occurrence of fire accidents. Multiple hardware and software overcharge/discharge failure safety protections must be implemented during the installation and use of the product.

11) 产品充电过程中可能发生不适当的终止充电现象。如超出允许的充电时间，充电电压过高而终止充电或充电电流过强而终止充电。上述现象被定义为“不适当的终止充电”。当发生以上现象时，可能意味着电池系统出现漏电或某些部件出现故障。在没有找到根本原因并彻底解决之前继续对该产品充电可能会引起电池簇内的电芯过热或发生火灾。

During the charging process, the product may experience inappropriate termination of charging, such as exceeding the allowed charging time, termination due to high charging voltage, or termination due to excessive charging current. The above phenomena are defined as inappropriate termination of charging. When such events occur, it may indicate a leakage in the battery system or a malfunction in certain components. Continuing to charge the product without identifying the root cause and resolving it thoroughly may lead to overheating of the cells or a fire in the rack.

12) 客户应将产品安全地固定在固体平面上，并将电源线安全地束缚在合适的位置、以避免摩擦而引起电弧和火花。

The customer should securely fasten the product on a solid surface and safely restrain the power cord in an appropriate position to prevent friction that may cause arcs and sparks.

13) 严禁用塑料进行电气连接。不正确的电气连接方式可能会造成产品在使用过程中发生过热现象。

It is prohibited to use plastic for electrical connections. Improper electrical connections may lead to overheating of the product during use.

14) 当电解液泄露时，应避免皮肤和眼睛接触电解液。如有接触，应使用大量的清水清洗接触到的区域并向医生寻求帮助。禁止任何人或动物吞食产品的任何部件。

When electrolyte leakage occurs, avoid skin and eye contact with the electrolyte. In case of contact, rinse the affected area with plenty of water and seek medical help. Prohibit anyone, including animals, from ingesting any parts of the product.

15) 产品在使用过程应有保护措施，使其免受机械震动、碰撞及压力冲击，否则产品的内部可能短路，产生高温和火灾。产品存在潜在的危险，在操作和维护时必须采取适当的防护措施；在安全性能测试实验中如操作不当可能会引起产品内的电芯起火或者爆炸，安全性能测试实验只能由配备适当的防护装备的专业人员在专业的实验室进行。否则，可能会导致严重的人身伤害和财产损失。不遵守上述警告可能造成多种灾难。

The product should have protective measures during use to prevent it from mechanical vibration, impact, and pressure shock, as internal short circuits may occur, leading to high temperatures and fires. The product poses potential dangers, and appropriate protective measures must be taken during operation and maintenance. Improper handling during safety performance testing experiments may cause the product's internal cells to catch fire or explode. Safety performance testing experiments should only be conducted by professionals equipped with appropriate protective gear in specialized laboratories. Otherwise, it may result in serious personal injury and property damage. Failure to comply with the above warnings may lead to various disasters.

16) 客户知悉在产品使用和操作过程中存在以下潜在的危险:操作者在操作时可能会受到化学品、电击或者电弧的伤害；尽管人体对遭受直流电与交流电的反应不同，但是高于 50V 的直流电压与交流电对人体的伤害是同样严重的，因此客户必须在操作中采取保守的姿势以避免电流的伤害。在操作产品和选择个人防护装备时，客户及其雇员必须考虑到以上潜在的风险防止发生意外短路，造成电弧、爆炸或热失控。

The customer is aware of the following potential dangers during the use and operation of the product: Operators may be exposed to hazards such as chemicals, electric shock, or arcs during operation. Although the human body reacts differently to direct current and alternating current, voltages above 50V for both DC and AC pose equally serious risks to the human body. Therefore, customers must adopt a conservative posture during operation to avoid injury from electrical currents. When operating the product and selecting personal protective equipment, customers and their employees must consider the above potential risks to prevent accidents such as short circuits, arcs, explosions, or thermal runaway.

17) 当使用中的产品容量小于等于标称容量 65%，客户应停止使用产品，否则发生的参数不符、质量问题、电芯故障及任何损失，海辰均不承担责任。

When the capacity is less than or equal to 65% of the nominal capacity, the customer should stop using the product. Otherwise, Hithium is not responsible for any parameter non-compliance, quality issues, cell failures, or any losses incurred.

9. 其他约定 Other Agreements

1) 产品安装、使用过程中需要海辰技术支持时，海辰可提供服务和技术支持。若是未按照本规格书当中的内容使用造成的产品问题，海辰可提供技术指导意见，不承诺免费更换服务。

When technical support is needed during the installation and use of the product, HIthium can provide services and technical assistance. If product issues arise due to non-compliance with the content of this specification, Hithium can offer technical guidance but does not commit to providing free replacement services.

2) 客户应严格按照本规格书当中的内容使用产品，客户并应确保产品的使用者按本规格书的内容使用产品，否则发生的产品参数不符、质量问题、故障及任何损失，海辰均不承担责任。

The customer should strictly follow the content of this specification when using the product. The customer should also ensure that the users of the product follow the content of this specification. Otherwise, Hithium will not be responsible for any non-compliance of product parameters, quality issues, faults, or any losses incurred.

3) 客户对本规格书的内容负有保密义务，客户不得擅自向任何第三方泄露，具体约定见双方签订的保密协议。

The customer has a confidentiality obligation regarding the content of this specification and may not disclose it to any third party without authorization. Specific arrangements are outlined in the confidentiality agreement signed by both parties.

4) 未经海辰的书面同意，客户、产品使用者及任何相关方在任何情况下不得综合、分离及修改产品的技术方案，不得对产品进行刺探、做反向工程等。

Without the written consent of Hithium, customers, product users, and any relevant parties are not allowed to integrate, separate, or modify the technical specifications of the product in any way. Unauthorized probing, reverse engineering, or similar activities on the product are strictly prohibited.

5) 海辰保留对产品的规格及性能参数修改的权利。客户在订购海辰的产品前，需要与海辰提前确认产品的最新规格及性能参数。

HIthium reserves the right to modify the specifications and performance parameters of the product. Before placing an order for Hithium's products, customers need to confirm the latest specifications and performance parameters of the product with Hithium in advance.

6) 产品样品处于开发阶段的，仅供测试使用，具体测试项目客户需与海辰协商确定，禁止擅自出售至任何第三方。

Samples of products in the development stage are for testing purposes only. The specific testing parameters need to be negotiated and confirmed between the customer and Hithium. Unauthorized sale to any third party is strictly prohibited.

7) 如果由于客户、产品使用者及任何相关方不当使用产品造成社会性影响，并对海辰的声誉造成影响的，客户、产品使用者及任何相关方应赔偿海辰的一切损失。

If improper use of the product by the customer, product users, or any related parties results in a negative societal impact and adversely affects the reputation of Hithium, the customer, product users, and any related parties shall be liable for compensating Hithium for all resulting losses.

8) 验收、质保售后及技术服务等内容均以双方约定为准。

Acceptance, warranty, after-sales service, and technical support are all subject to the agreements made between both parties.

9) 若本技术规格书与其他海辰提供给客户的相关文件内容存在不一致的，海辰对此享有最终解释权。

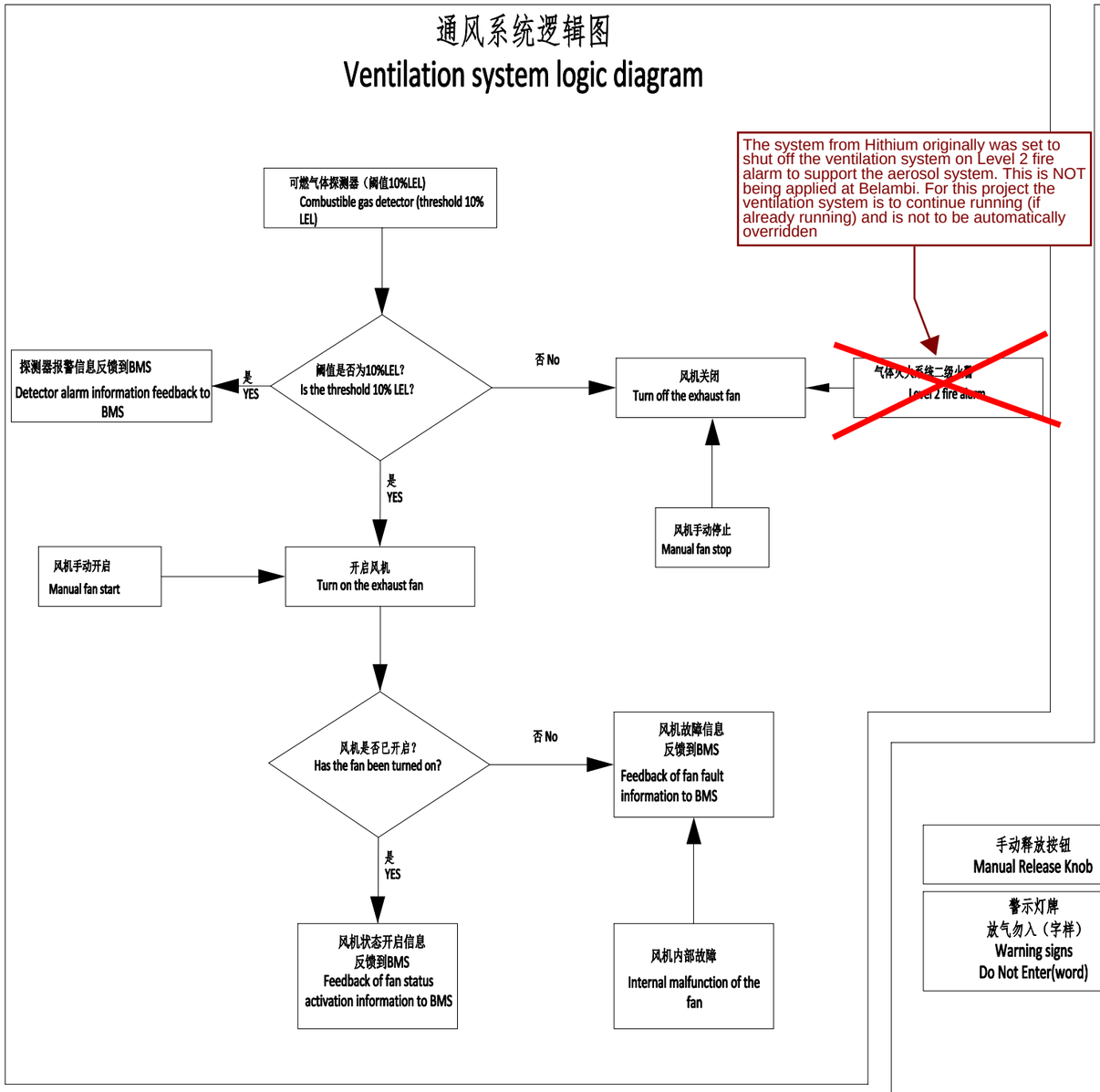
If there is any inconsistency between this technical specification document and other relevant documents provided by Hithium to the customer, Hithium reserves the right to make the final interpretation.

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通风系统逻辑图
Ventilation system logic diagram



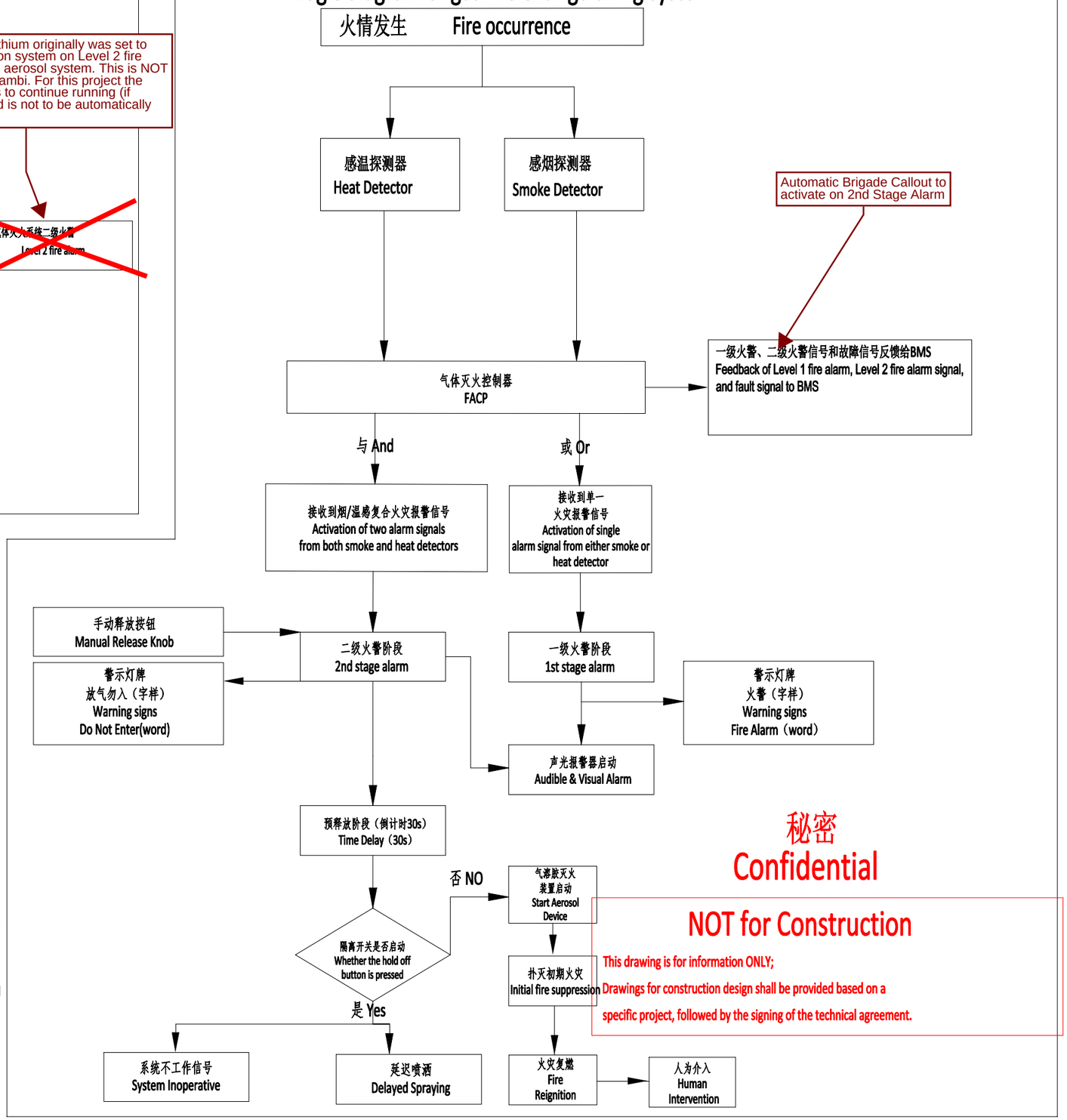
当感烟/感温探测器中任意一种探测到火情发生，气体灭火控制器会触发一级报警，启动声光报警器，灯牌火警字样亮起提醒现场人员撤离。此时人为判定是否发生火情，如发生误报现象，则处理该故障；如确认发生火情，则按下紧急启动按钮。

当控制器接收到人为按下的紧急启动按钮或者烟温感同时探测到火情时，触发二级火警，进入释放倒计时，灯牌放气勿入字样亮起，启动声光报警器提醒现场人员撤离，此时如发现是误报现象，还可以通过按下隔离开关来停止预释放操作，同时故障灯牌亮起。当倒计时结束后，气溶胶灭火装置启动，喷放气溶胶进行灭火。

When either the smoke detector or the heat detector detects a fire, the FACP will trigger level 1 fire alarm, activate the Horn/Strobe, and the "Fire Alarm" sign on the lamp panel will light up to remind on-site personnel to evacuate. At this point, people need to determine whether a fire has actually occurred. If it is a false alarm, the fault should be dealt with; if a fire is confirmed, press the emergency start button.

When the FACP receives a signal from the manually pressed emergency start button or when both the smoke and heat detectors detect a fire simultaneously, a level 2 fire alarm is triggered, and the countdown to release begins. The "No Entry - Gas Discharge in Progress" sign on the lamp panel will light up, and the audible and visual alarm will be activated to remind on-site personnel to evacuate. If it is found to be a false alarm at this time, the pre - release operation can still be stopped by pressing the hold off button, and the fault sign on the lamp panel will light up. After the countdown ends, the aerosol will be activated, and aerosol will be discharged to extinguish the fire.

气体灭火系统逻辑图
Logic diagram of gas fire extinguishing system



秘密
Confidential

NOT for Construction

This drawing is for information ONLY;
Drawings for construction design shall be provided based on a specific project, followed by the signing of the technical agreement.

设计 DESIGN	Jian Hanxi	日期 DATE	2025.10.20	项目名称 PROJECT	液冷2.0 (AU-A) ESS 2.0 (AU-A)	卷册名称 VOLUME TITLE	集装箱消防系统图纸 ESS Container Fire Protection System Drawings	物料编码 MATERIAL NO	332800000069	版本 REV	HITHIUM	页码 PAGE
审核 REVIEW	Chen Jiawu	日期 DATE	2025.10.20									
批准 APPROVAL	Zhao Fei	日期 DATE	2025.10.20	图纸名称 DRAWING	Fire extinguishing flow chart 灭火流程图			文件编码 DRAWING NO	HC-332800000069-DR-0001	A/1		5

Aerosol dosage calculation instructions

（AS）V01

Hubei Jiandun Fire Technology Co., Ltd.

Catalogue

1. Reference Standard 1

2. Terminology 1

3. Calculation formula 1

4. Dosage calculation 2

1. Reference Standard

《Condensed Aerosol Fire Extinguishing Systems》AS4487-2013

2. Terminology

（1）Protected Volume

In calculating the dose of total flooding extinguishing agent, the protective volume shall be reduced by the volume of material permanently present in the protective zone that is not penetrable by the extinguishing medium.

（2）Total Flooding Extinguishing System

A system for discharging a fire extinguishing agent into an enclosed space so that the agent is uniformly distributed throughout the enclosed space at or above the design application density.

3. Calculation formula

（1）The effective mass of aerosols in the system should be at least sufficient to simultaneously protect against the largest single hazard or group of hazards.

（2）The minimum design application density for Class B fires shall be the extinguishing density multiplied by a safety factor of 1.3.

（3）The minimum design application density for Class E fires shall be the highest extinguishing density determined from the results of the test scenario, multiplied by a safety factor of 1.3.

（4）The formula for the mass of extinguishing agent required to achieve the design application density is as follows：

$$M=C \cdot V$$

Where

M=Designed quantity for fire extinguishing（g）

C=Design Application Density（g/m^3）：The minimum mass of the specified aerosol generating agent per unit volume of confined space required for the design of the total flooding system, including a safety factor of 1.3 times.

V=Protected volume [m^3](may contain adjacent hazardous or work areas)

K_1 ——a compensation factor between the inhomogeneity of the aerosol distribution and the height of the protected area.

When the height of the protection zone is ≤2.4 m，K_1 = 1.00；

When the height of the protective zone is 2.41m～3.0m，K_1 = 1.10；

When the height of the protection zone is 3.01m～5.0m，K_1 =1.20；

Consult the manufacturer when the height of the protection zone is greater than 5m.

Calculated according to the formula

4. Dosage calculation

$W=K_1 \cdot C \cdot V=1.1\times105.3\times30.7=3555.981$

Each JAD300-U01 fire extinguishing device has a dose of 300g.

Based on this formula, the minimum dosage configuration is as follows (if the exhaust system is not shut down during spraying, a larger amount of agent may be selected to achieve the appropriate design application density, depending on the actual situation):

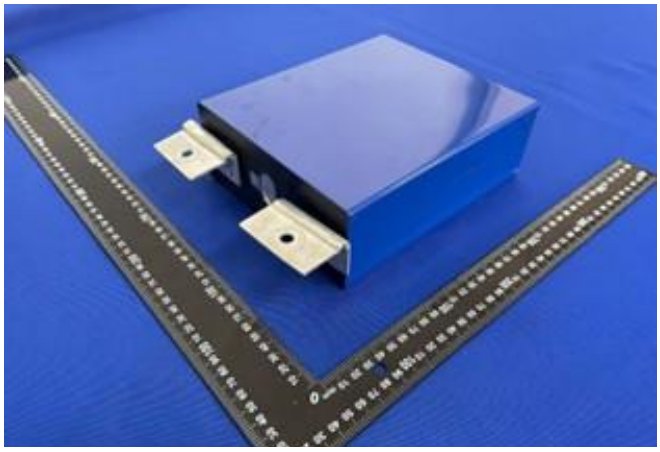
Protective area	Equipment name	Number of equipment	Note
Installation level protection	Rapid Condensed Aerosol Fire Extinguishers	12	Determined on a case-by-case basis

B.4. UL9540A:2019 – Cell Level Test Report

Test report provided on subsequent pages.

Prüfbericht-Nr.: *Test report no.*:	CN23F118 001	**Auftrags-Nr.:** *Order no.*:	168441619	
Kunden-Referenz-Nr.: *Client reference no.*:	2347845	**Auftragsdatum:** *Order date:*	2023-08-29	
Auftraggeber: *Client*:	Xiamen Hithium Energy Storage Technology Co., Ltd. 201-1, Comprehensive Building 5, No.11, Butang Middle Road, Industrial Base Of Xiamen Torch High Tech Zone (Tongxiang), Xiamen, Fujian, P.R. China			
Prüfgegenstand: *Test item*:	Iron Phosphate-Lithium Cell			
Bezeichnung / Typ-Nr.: *Identification / Type no.*:	LFP71173207/314Ah			
Auftrags-Inhalt: *Order content*:	Test report			
Prüfgrundlage: *Test specification*:	UL 9540A:2019 (Forth Edition)			

Wareneingangsdatum: *Date of sample receipt*:	2023-08-30
Prüfmuster-Nr.: *Test sample no:*	Engineering sample
Prüfzeitraum: *Testing period*:	2023-09-04 - 2023-11-21
Ort der Prüfung: *Place of testing*:	See to clause 1.1 of main report
Prüflaboratorium: *Testing laboratory:*	TÜV Rheinland (Shenzhen) Co., Ltd.
Prüfergebnis*: *Test result**:	See main report



erstellt von: *created by:*		**genehmigt von:** *authorized by*:	
Datum: *Date:* 2023-12-06	Jason Zhu	**Ausstellungsdatum:** *Issue date:* 2023-12-06	Xun Yu
Stellung / Position:	Project Engineer	**Stellung** / Position:	Reviewer

Sonstiges / *Other*:

This report does not evidence compliance of the provided sample with the relevant standards but only with the referred tests. This test report documents the findings of examination conducted on the delivered product mentioned above only. This report does not entitle the applicant to carry any safety mark on this or similar products. Further for sales or other application purposes of the tested product, any reference to TÜV Rheinland or a test through TÜV Rheinland is only permissible with prior written consent of TÜV Rheinland.

Zustand des Prüfgegenstandes bei Anlieferung: Prüfmuster vollständig und unbeschädigt
Condition of the test item at delivery: *Test item complete and undamaged*

* Legende:	P(ass) = entspricht o.g. Prüfgrundlage(n)	F(ail) = entspricht nicht o.g. Prüfgrundlage(n)	N/A = nicht anwendbar	N/T = nicht getestet
** Legend:*	*P(ass) = passed a.m. test specification(s)*	*F(ail) = failed a.m. test specification(s)*	*N/A = not applicable*	*N/T = not tested*

Dieser Prüfbericht bezieht sich nur auf das o.g. Prüfmuster und darf ohne Genehmigung der Prüfstelle nicht auszugsweise vervielfältigt werden. Dieser Bericht berechtigt nicht zur Verwendung eines Prüfzeichens.
This test report only relates to the above mentioned test sample. Without permission of the test center this test report is not permitted to be duplicated in extracts. This test report does not entitle to carry any test mark.

Anmerkungen
Remarks

1	Alle eingesetzten Prüfmittel waren zum angegebenen Prüfzeitraum gemäß eines festgelegten Kalibrierungsprogramms unseres Prüfhauses kalibriert. Sie entsprechen den in den Prüfprogrammen hinterlegten Anforderungen. Die Rückverfolgbarkeit der eingesetzten Prüfmittel ist durch die Einhaltung der Regelungen unseres Managementsystems gegeben. Detaillierte Informationen bezüglich Prüfkonditionen, Prüfequipment und Messunsicherheiten sind im Prüflabor vorhanden und können auf Wunsch bereitgestellt werden. *The equipment used during the specified testing period was calibrated according to our test laboratory calibration program. The equipment fulfils the requirements included in the relevant standards. The traceability of the test equipment used is ensured by compliance with the regulations of our management system.* *Detailed information regarding test conditions, equipment and measurement uncertainty is available in the test laboratory and could be provided on request.*
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3	Prüfklausel mit der Note * wurden an qualifizierte Unterauftragnehmer vergeben und sind unter der jeweiligen Prüfklausel des Berichts beschrieben. Abweichungen von Prüfspezifikation(en) oder Kundenanforderungen sind in der jeweiligen Prüfklausel im Bericht aufgeführt. *Test clauses with remark of * are subcontracted to qualified subcontractors and descripted under the respective test clause in the report.* *Deviations of testing specification(s) or customer requirements are listed in specific test clause in the report.*
4	Die Entscheidungsregel für Konformitätserklärungen basierend auf numerischen Messergebnisen in diesem Prüfbericht basiert auf der "Null-Grenzwert-Regel" und der "Einfachen Akzeptanz" gemäß ILAC G8:2019 und IEC Guide 115:2021, es sei denn, in der auf Seite 1 dieses Berichts genannten angewandten Norm ist etwas anderes festgelegt oder vom Kunden gewünscht. Dies bedeutet, dass die Messunsicherheit nicht berücksichtigt wird und daher auch nicht im Prüfbericht angegeben wird. Zu weiteren Informationen bezueglich des Risikos durch diese Entscheidungsregel siehe ILAC G8:2019. *The decision rule for statements of conformity, based on numerical measurement results, in this test report is based on the "Zero Guard Band Rule" and "Simple Acceptance" in accordance with ILAC G8:2019 and IEC Guide 115:2021, unless otherwise specified in the applied standard mentioned on Page 1 of this report or requested by the customer. This means that measurement uncertainty is not taken in account and hence also not declared in the test report. For additional information to the resulting risk based of this decision rule please refer to ILAC G8:2019.*

Introduction

Model fire codes and energy storage system standards require energy storage systems to comply with UL 9540, which in turn requires battery cells and modules to comply with UL 1973. Compliance with these standards reduces the risk of batteries and battery energy storage systems (BESS) creating fire, shock or personal injury hazards. However, they don't evaluate the ability of the BESS installed as intended and with fire suppression mechanisms in place if necessary, from contributing to a fire or explosion in the end use installations.

To address these fire and explosion hazards associated with the installation of a BESS, the fire and other codes require energy storage systems to meet certain location, separation, fire suppression and other criteria. Those codes also provide a means to provide an equivalent level of safety based on large scale fire testing of anticipated BESS installations.

UL 9540A is intended to provide a test method that can be used as a basis for validating the safety of a BESS installation in lieu of meeting the specific criteria provided in those codes. The data generated can be used to determine the fire and explosion protection required for installation of a BESS.

The test method is initiated through the establishment of a thermal runaway condition that leads to combustion within the BESS. The test method outlined in UL 9540A consists of several steps – cell level testing, module level testing, unit level testing and installation level testing. The cell and module level testing steps are information gathering steps to inform the unit and installation level testing.

The following outlines the information that may gathered as part of the testing:

a) Cell level – An individual cell fails in a manner that leads to thermal runaway and fire through a suitable method such as external heating. Data such as off-gassing contents, temperatures at venting and temperatures at thermal runaway are recorded.

b) Module level – One or more cells within a BESS module fail in the manner determined during the cell level testing. Data such as fire propagation in the module, temperatures on the failed cells and surrounding cells, off-gassing contents and heat release data are gathered.

c) Unit level – A complete BESS is installed surrounded by target (e.g. dummy) BESS and walls separated at a distance as intended in its installation. The module level test is repeated on a module located in the BESS in the most unfavorable location. Data such as temperature within the BESS, on surrounding walls and target BESS; incident heat flux on walls and target BESS; observation of fire propagation from BESS to target units and walls as well as observance of explosions or evidence of re-ignition within the BESS; and heat release and off-gassing contents are gathered.

d) Installation level – This test is a repeat of the unit level test with the test conducted within a test room and with the intended fire suppression system installed as well as any overhead cables (that can lead to fire propagation) installed. This test is intended to validate the fire suppression system for the BESS installation. Data such as temperature within the BESS, on surrounding walls and target BESS; incident heat flux on walls and target BESS; fire propagation from the BESS to target units, walls or overhead cables and any observable explosion incidents or re-ignition within the BESS; and off-gassing contents (if needed) and heat release are gathered.

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APPENDIXC: CELL VENT GAS MAXIMUM PRESSURE (P_{MAX}) TEST 34

1 General information

1.1 Test specification

Standard: ANSI/CAN/UL 9540A:2019 (Fourth Edition)

Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems

This report presents the result of cell level tests of UL 9540A: 2019.

All tests were conducted at TUV Rheinland (Shenzhen) Co., Ltd. and TUV Rheinland's partner labs that were under supervision of TÜV Rheinland's engineer.

Testing period: 2023-09-04 to 2023-11-17

Refer to Clause 4 for test and measurement instruments.

1.2 General remarks

This report is descriptive and provide the test data only.

The test results presented in this report relate only to the object tested.

This report shall not be reproduced, except in full, without the written approval of the testing laboratory.

Throughout this report a ☐ comma / ☒ point is used as the decimal separator.

1.3 List of attachments

The following attachments resulting from the tests, provided with separate page number, are included in this report.

Appendix A: Cell vent gas lower flammability limit (LFL) test

Appendix B: Cell vent gas burning velocity (S_u) test

Appendix C: Cell vent gas maximum pressure (P_{max}) test

1.4 Revision information

New report, not applicable

1.5 Definitions

CELL – The basic functional electrochemical unit containing an assembly of electrodes, electrolyte, separators, container, and terminals. It is a source of electrical energy by direct conversion of chemical energy.

MODULE – A subassembly that is a component of a BESS that consists of a group of cells or electrochemical capacitors connected together either in a series and/or parallel configuration (sometimes referred to as a block) with or without protective devices and monitoring circuitry.

UNIT – A frame, rack or enclosure that consists of a functional BESS which includes components and subassemblies such a cells, modules, battery management systems, ventilation devices and other ancillary equipment.

BATTERY SYSTEM (BS) – Is a component of a BESS and consists of one or more modules typically in a rack configuration, controls such as the BMS and components that make up the system such as cooling systems, disconnects and protection devices.

BATTERY ENERGY STORAGE SYSTEM (BESS) – Stationary equipment that receives electrical energy and then utilizes batteries to store that energy to supply electrical energy at some future time. The BESS, at a minimum consists of one or more modules, a power conditioning system (PCS), battery management system (BMS) and balance of plant components.

a) INITIATING BATTERY ENERGY STORAGE SYSTEM UNIT (INITIATING BESS) – A BESS unit which has been equipped with resistance heaters in order to create the internal fire condition necessary for the installation level test (Section 9).

b) TARGET BATTERY ENERGY STORAGE SYSTEM UNIT (TARGET BESS) – The enclosure and/or rack hardware that physically supports and/or contains the components that comprise a BESS. The target BESS unit does not contain energy storage components, but serves to enable instrumentation to measure the thermal exposure from the initiating BESS.

Note: Depending upon the configuration and design of the BESS (e.g. the BESS is composed of multiple separate parts within separate enclosures), the unit level test can be done at battery system level. In such case, the BESS is be read as BS throughout this report.

NON-RESIDENTIAL USE – Intended for use in commercial, industrial or utility owned locations.

RESIDENTIAL USE – In accordance with this standard, intended for use in one or two family homes and town homes and individual dwelling units of multi-family dwellings.

THERMAL RUNAWAY- The incident when an electrochemical cell increases its temperature through self-heating in an uncontrollable fashion. The thermal runaway progresses when the cell's generation of heat is at a higher rate than the heat it can dissipate. This may lead to fire, explosion and gas evolution.

STATE OF CHARGE (SOC) – The available capacity in a BESS, pack, module or cell expressed as a percentage of rated capacity.

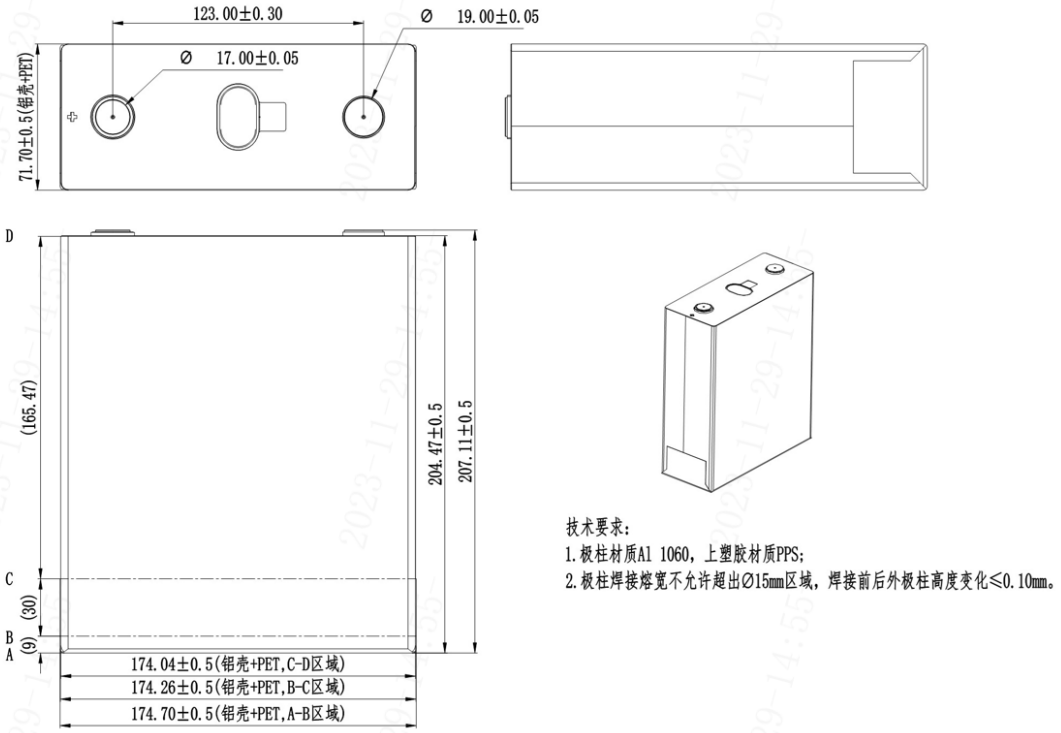
2 General Product Information

2.1 Product information and parameters

The product information and parameters are provided by the client as below.

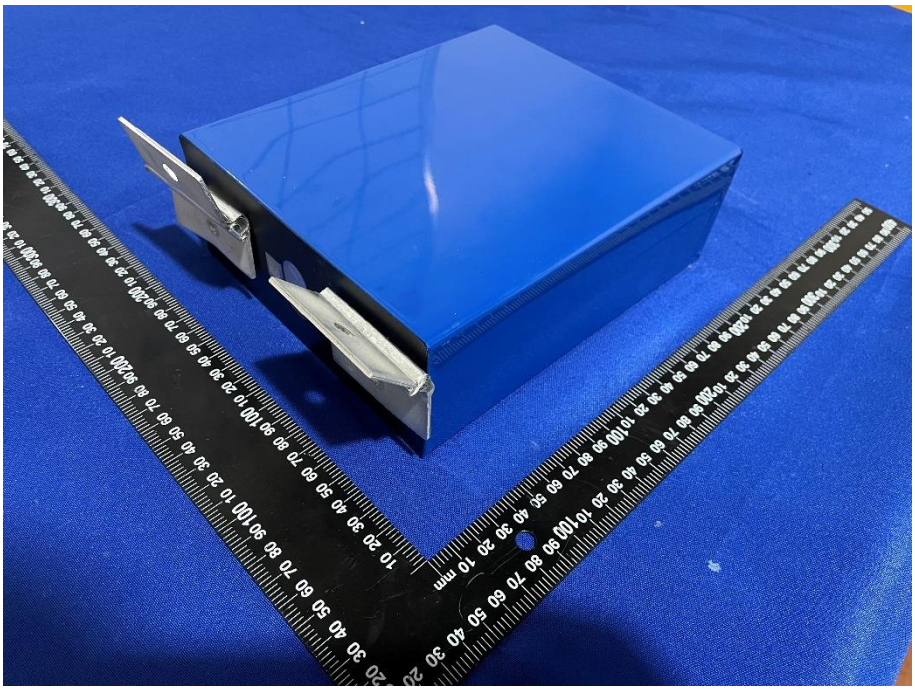
Manufacturer .....:	Xiamen Hithium Energy Storage Technology Co., Ltd. 201-1, Comprehensive Building 5, No.11, Butang Middle Road, Industrial Base Of Xiamen Torch High Tech Zone (Tongxiang), Xiamen, Fujian, P.R. China	
Model number.....:	LFP71173207/314Ah	
Chemistry .....:	☒ $LiFePO_4$ ☐ NMC ☐ NCA ☐ LTO ☐ Other:	
Physical configuration.....:	☒ Prismatic ☐ Cylindrical ☐ Pouch	
	Weight(kg):	5.6±0.2
Electrical rating .....:	Rated capacity(Ah):	314 (25°C±2°C)
	Nominal voltage(V):	3.2
Standard charge method .....:	Charge current(A):	157 (25°C±2°C)
	Standard Charge Voltage(V):	3.65
	Cut off current(A):	/
Standard discharge method.....:	Discharge current(A):	157 (25°C±2°C)
	End of discharge voltage(V):	2.5V (T>0°C) 2.0V (T≤0°C)
Maximum continuous charge current:	314A	
Maximum continuous discharge current .....:	314A	
Compliance with UL 1973.....:	☒ Yes, TUV Report No.: CN23RGEH 001 ☐ No	
Note:		

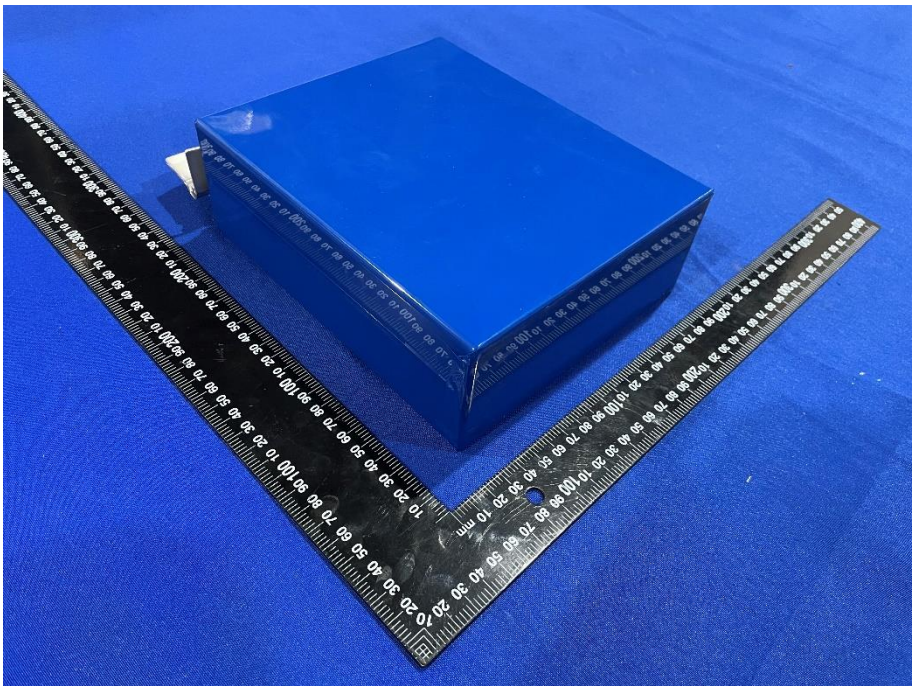
2.2 Diagram with overall dimension

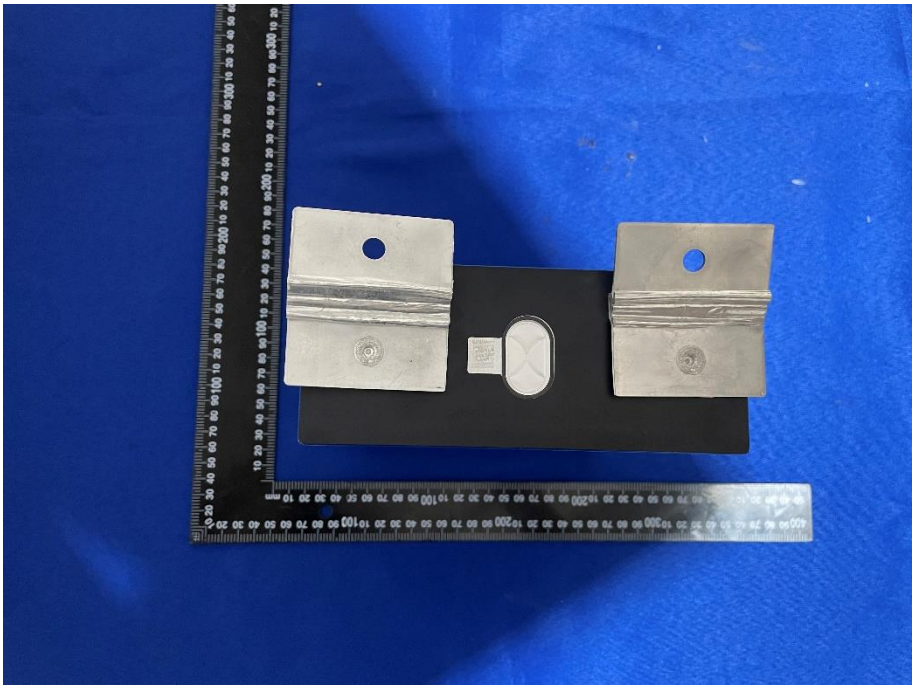


Unit: mm

Photos







3 Cell level test (section 7 of UL 9540A)

3.1 General

This testing is conducted on individual cells and uses various stress conditions such as external heating to force the cells into thermal runaway.

Once the stress mechanism is induced, the test measures the temperature at which the cell vents and then the temperature at which thermal runaway occurs.

The test also measures the volume and pressure of the vent gases that are released from the cells, and the composition of the vent gases.

Cell vent gas with flammable components in its composition should have the following parameters characterized in order to enable deflagration venting design:

a) Measurement of fundamental burning velocity by the vertical tube method described in the Method of Test for Burning Velocity Measurement of Flammable Gases Annex in ISO 817; and

b) Maximum pressure developed in a contained deflagration of an optimum mixture per EN 15967.

Cell level testing performed on the cells used within a BESS module establishes a base line fire test performance that can be evaluated against the fire performance of other battery cells the BESS manufacturer may choose to use within the unit's modules.

If none of the cell samples can be forced into thermal runaway and none of the cell samples vent flammable gases as determined by the ASTM E918 test, during any of the cell level tests, it is not necessary to conduct additional module or unit level testing on BESS that utilize these cells.

3.2 Sample preparation

3.2.1 Test method and description

The cells were conditioned, prior to testing, through charge and discharge cycles for 2 cycles using a manufacturer specified methodology (refer to 2.1.1).

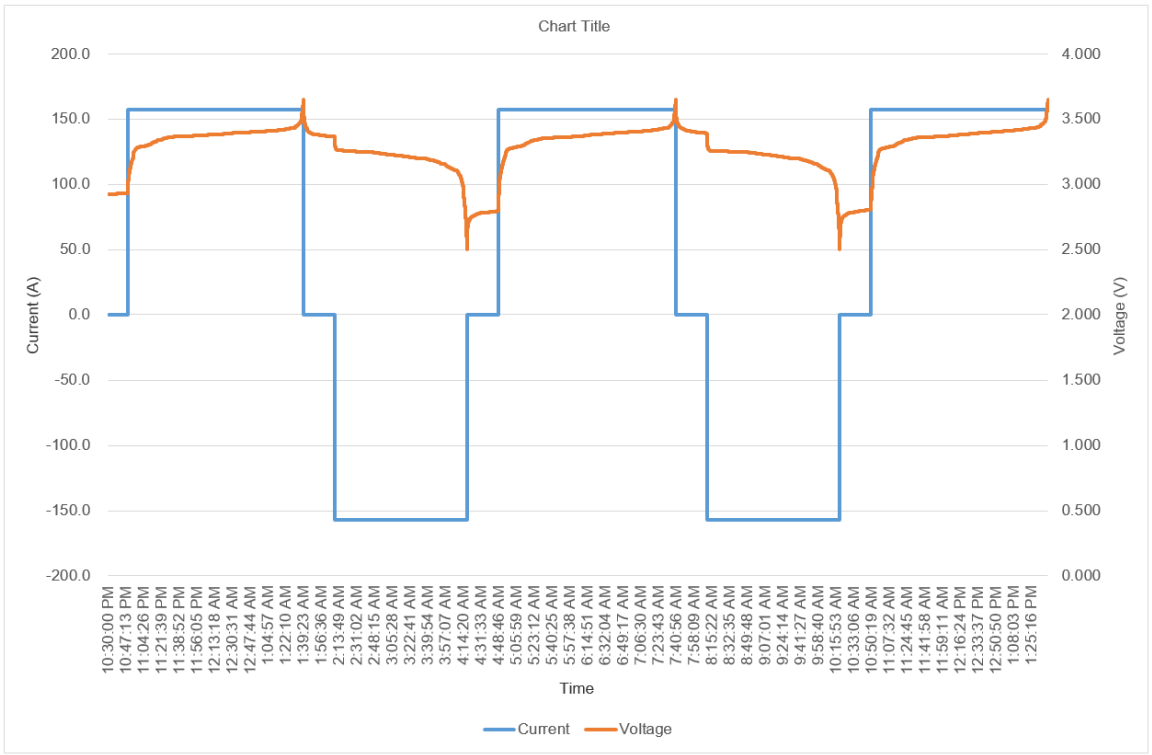
During the cycling, ambient condition is maintained within 25°C±2°C and R.H. 50±25 %.

3.2.2 Cell cycling curves

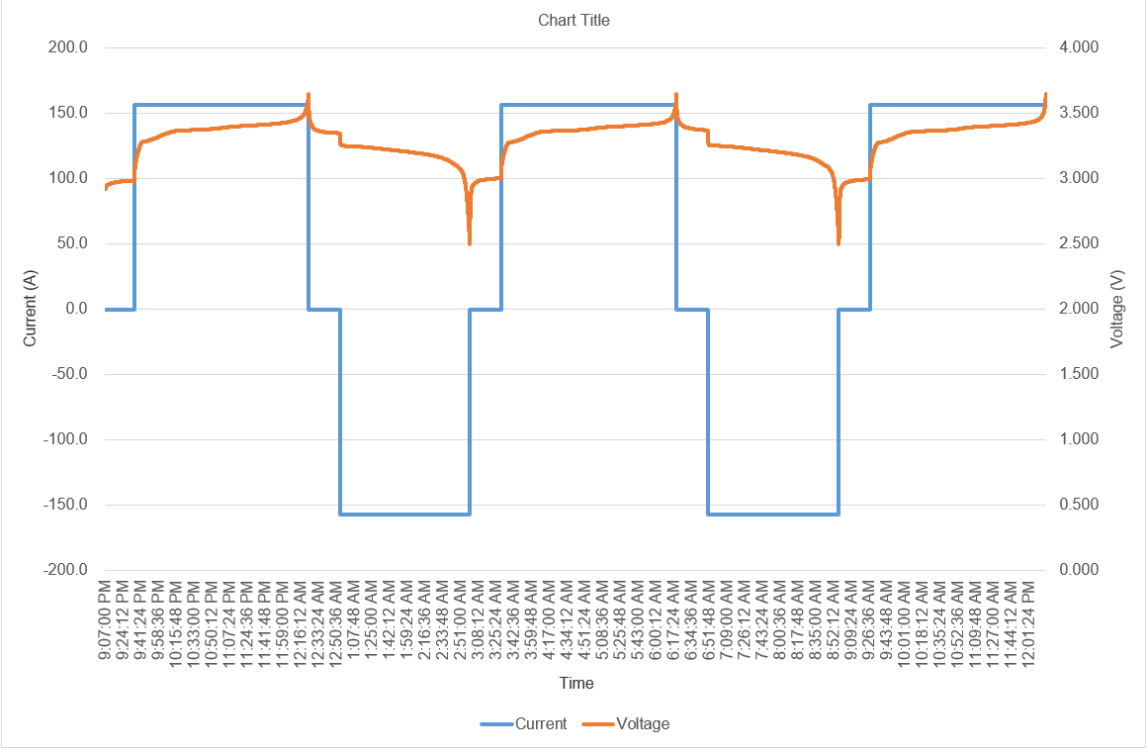
#1



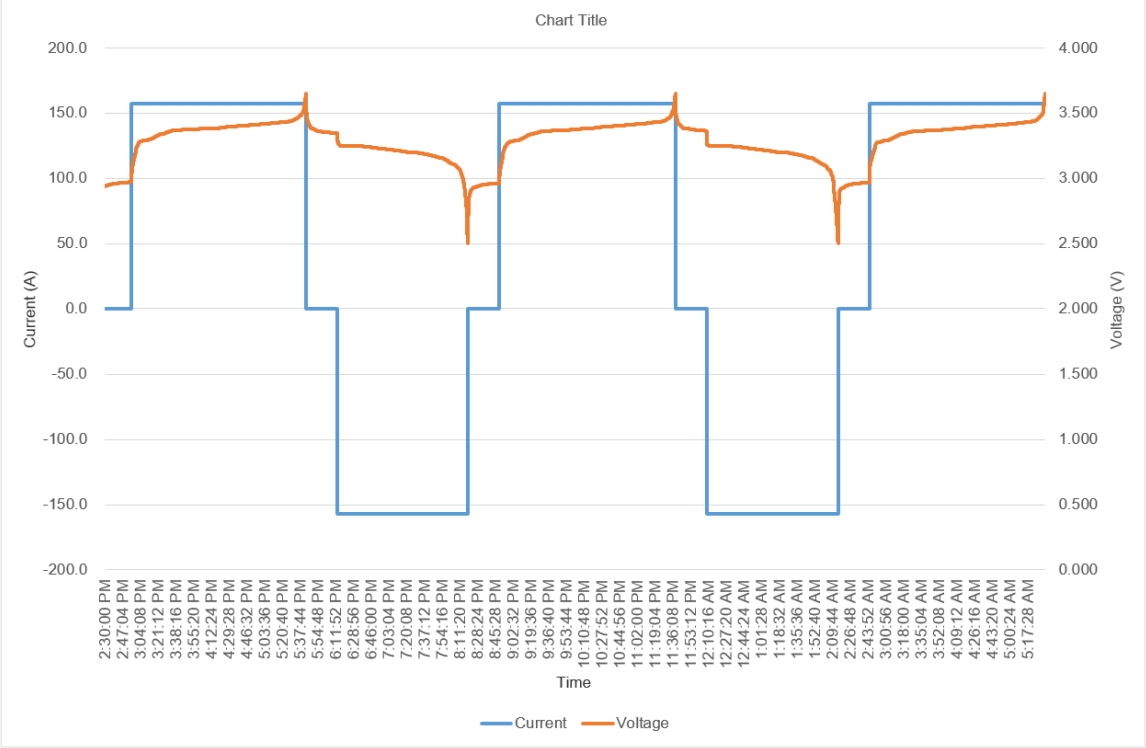
#2



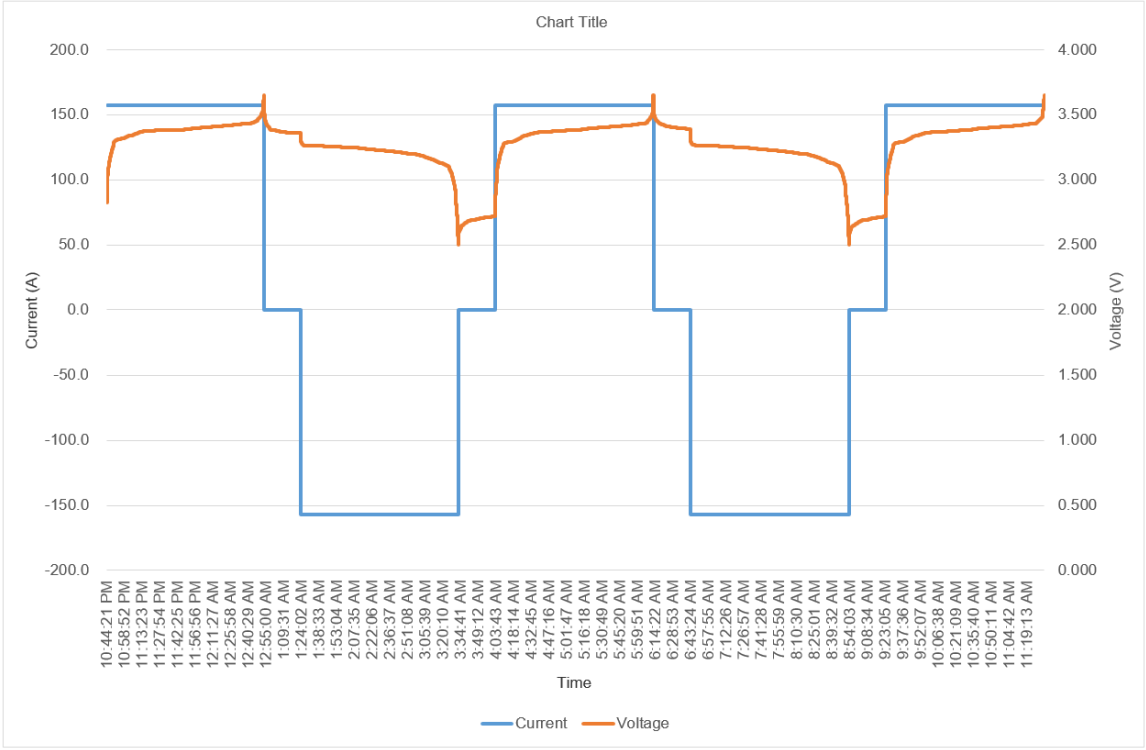
#3


Chart Title
Current (A)
Voltage (V)
Time
Current
Voltage

#4


Chart Title
Current (A)
Voltage (V)
Time
Current
Voltage

#5


Chart Title
200.0
150.0
100.0
50.0
0.0
-50.0
-100.0
-150.0
-200.0
Current (A)
4.000
3.500
3.000
2.500
2.000
1.500
1.000
0.500
0.000
Voltage (V)
10:44:21 PM
10:58:52 PM
11:13:23 PM
11:27:54 PM
11:42:25 PM
11:56:56 PM
12:11:27 AM
12:25:58 AM
12:40:29 AM
12:55:00 AM
1:09:31 AM
1:24:02 AM
1:38:33 AM
1:53:04 AM
2:07:35 AM
2:22:06 AM
2:36:37 AM
2:51:08 AM
3:05:39 AM
3:20:10 AM
3:34:41 AM
3:49:12 AM
4:03:43 AM
4:18:14 AM
4:32:45 AM
4:47:16 AM
5:01:47 AM
5:16:18 AM
5:30:49 AM
5:45:20 AM
5:59:51 AM
6:14:22 AM
6:28:53 AM
6:43:24 AM
6:57:55 AM
7:12:26 AM
7:26:57 AM
7:41:28 AM
7:55:59 AM
8:10:30 AM
8:25:01 AM
8:39:32 AM
8:54:03 AM
9:08:34 AM
9:23:05 AM
9:37:36 AM
9:52:07 AM
10:06:38 AM
10:21:09 AM
10:35:40 AM
10:50:11 AM
11:04:42 AM
11:19:13 AM
Time
Current
Voltage

3.3 Determination of cell thermal runaway methodology

3.3.1 Test method and description

The cells to be tested were charged to 100% SOC and allowed to stabilize for a minimum of 1 h and a maximum of 8 h before the start of the test.

External film heater rated 220Vac/429W was put below the cell to induce the cell thermal runaway.

The cell sample and heater were clamped by two steel plate together using four bolts during test to simulate the constraint in the BESS module to prevent excessive swelling during the test.

The thermocouple (type K, 24AWG) was located below the heater that used to measure vent and thermal runaway onset temperature.

An AC power supply controller was used to control the voltage supply to the heater and maintain a 4°C/min to 7°C/min heating rate. Once thermal runaway was observed, the heaters were immediately de-energized.

The cell exhibits thermal runaway after establishing the heating rate. 3 additional samples were repeated to demonstrate repeatability.

The vent temperature and thermal runaway onset temperatures were averaged over the tested samples.

3.3.2 Test result

Ambient conditions at the initiation of the test.....:	26.1°C, 51%R.H.	27.9°C, 51%R.H.	26.1°C, 52%R.H.	27.9°C, 50%R.H.	26.1°C, 51%R.H.
Sample number .....:	#1[1)]	#2	#3	#4	#5
Open circuit voltage before test (V) :	3.35	3.37	3.36	3.35	3.35
Cell vent temperature (°C) .....:	231.4	201.8	200.7	208.5	203.6
Thermal runaway onset temperature (°C) .....:	328.8	306.3	283.5	291.4	301.6
Average cell vent temperature (°C)[2)] .....:	--	203.7			
Average thermal runaway onset temperature (°C) [2)] .....:	--	295.7			

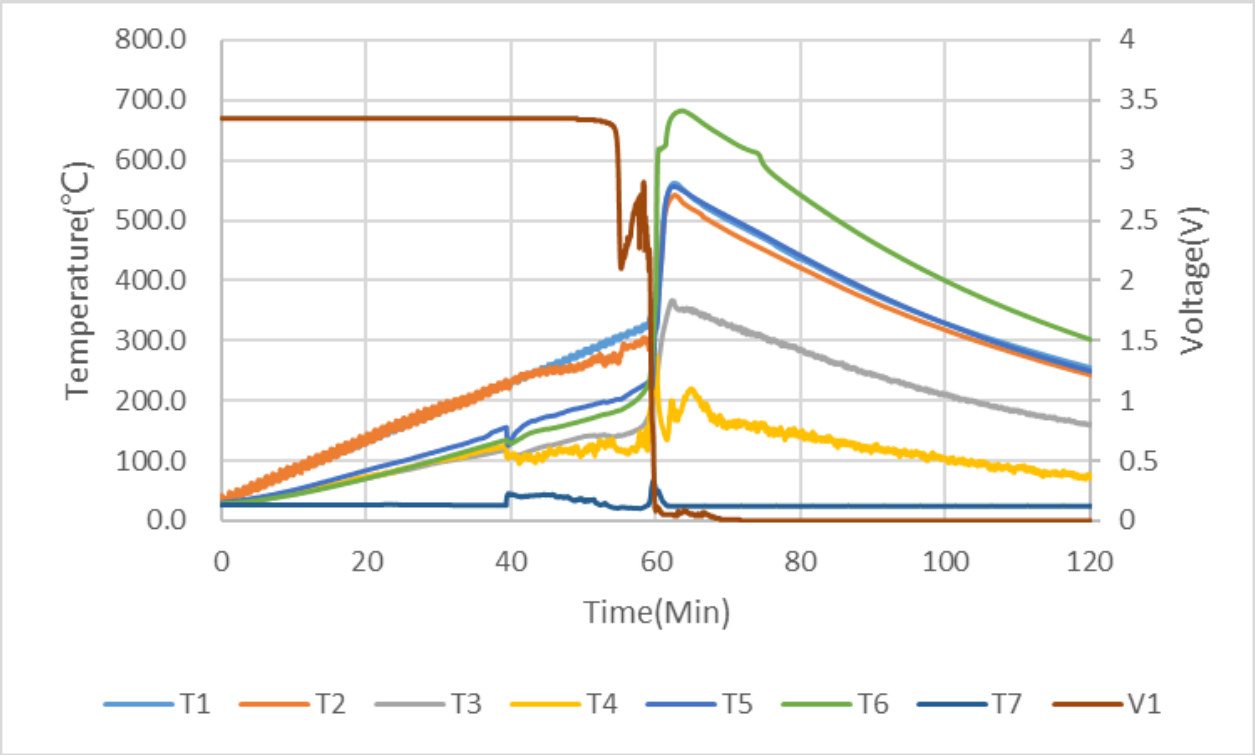
Note:

1) The sample (#1) is for gas vent capture.

2) The temperatures were averaged over the tested samples (#1, #2, #3, #4, #5) excluding the gas vent capture sample (#1).

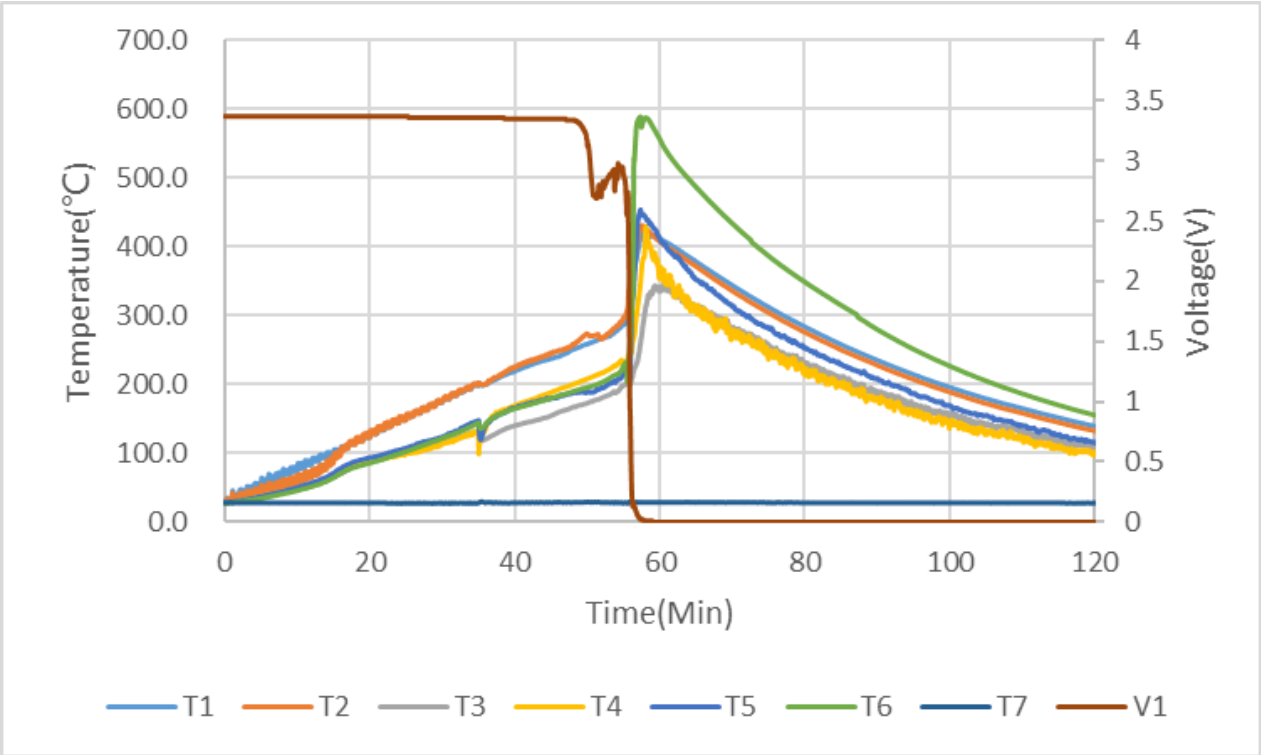
3.3.3 Temperature/voltage vs time curve

#1



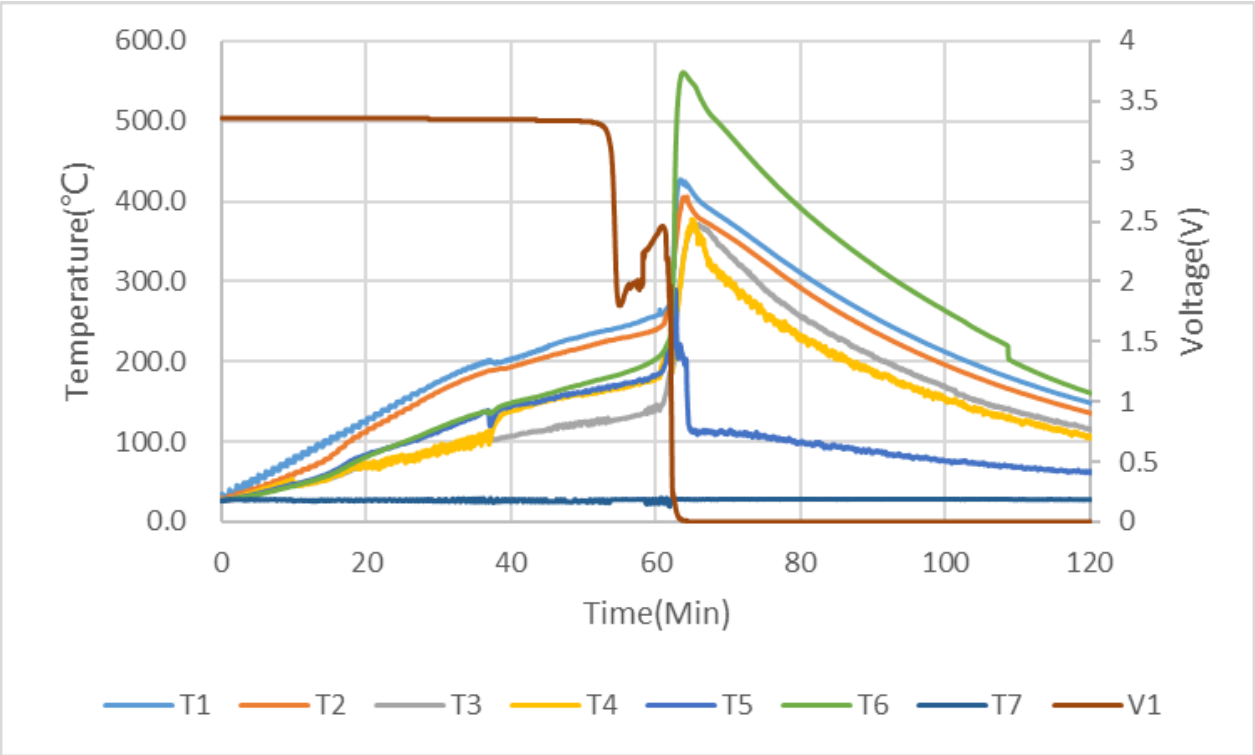
Thermalcouple No.	Location
T1	Cell center below the heater(A side)
T2	Cell center below the heater(B side)
T3	Positive eletrode tap
T4	Near pressure relief valve
T5	Cell narrow side
T6	Cell bottom
T7	Ambient temperature (Inside of pressure vessel)
V1	Cell Voltage

#2



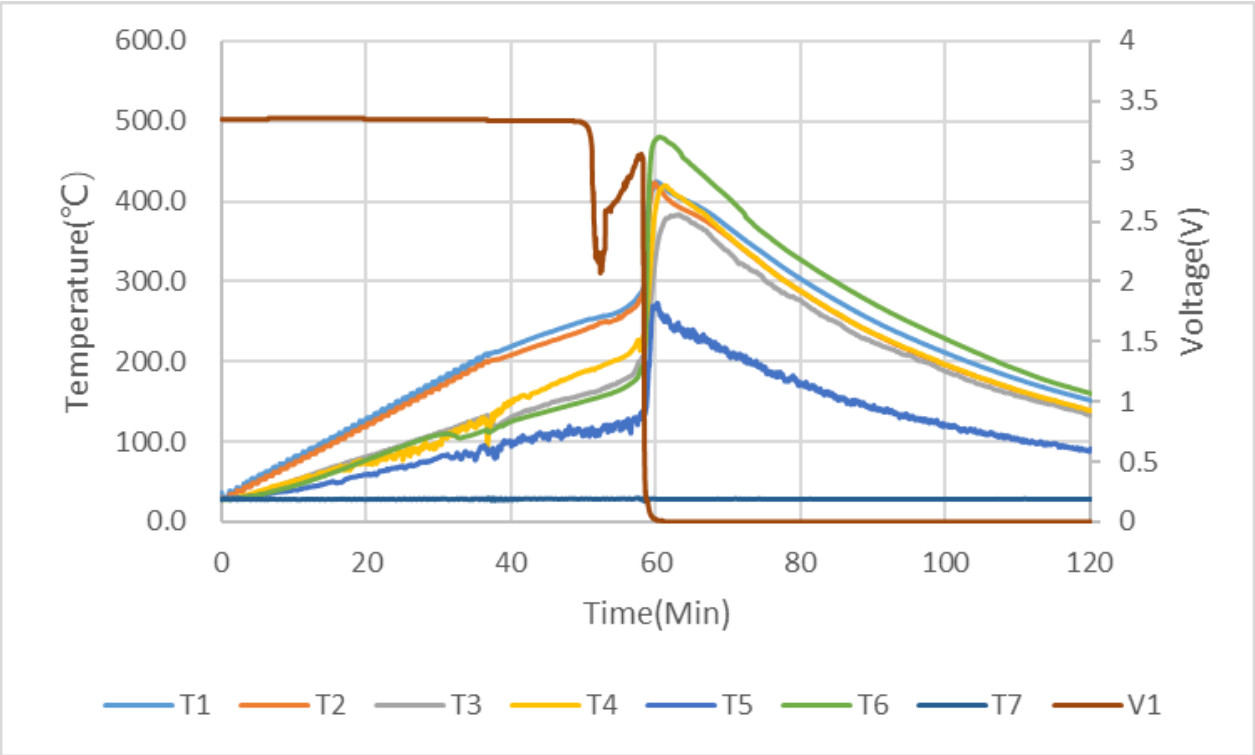
Thermalcouple No.	Location
T1	Cell center below the heater(A side)
T2	Cell center below the heater(B side)
T3	Positive eletrode tap
T4	Near pressure relief valve
T5	Cell narrow side
T6	Cell bottom
T7	Ambient temperature
V1	Cell Voltage

#3



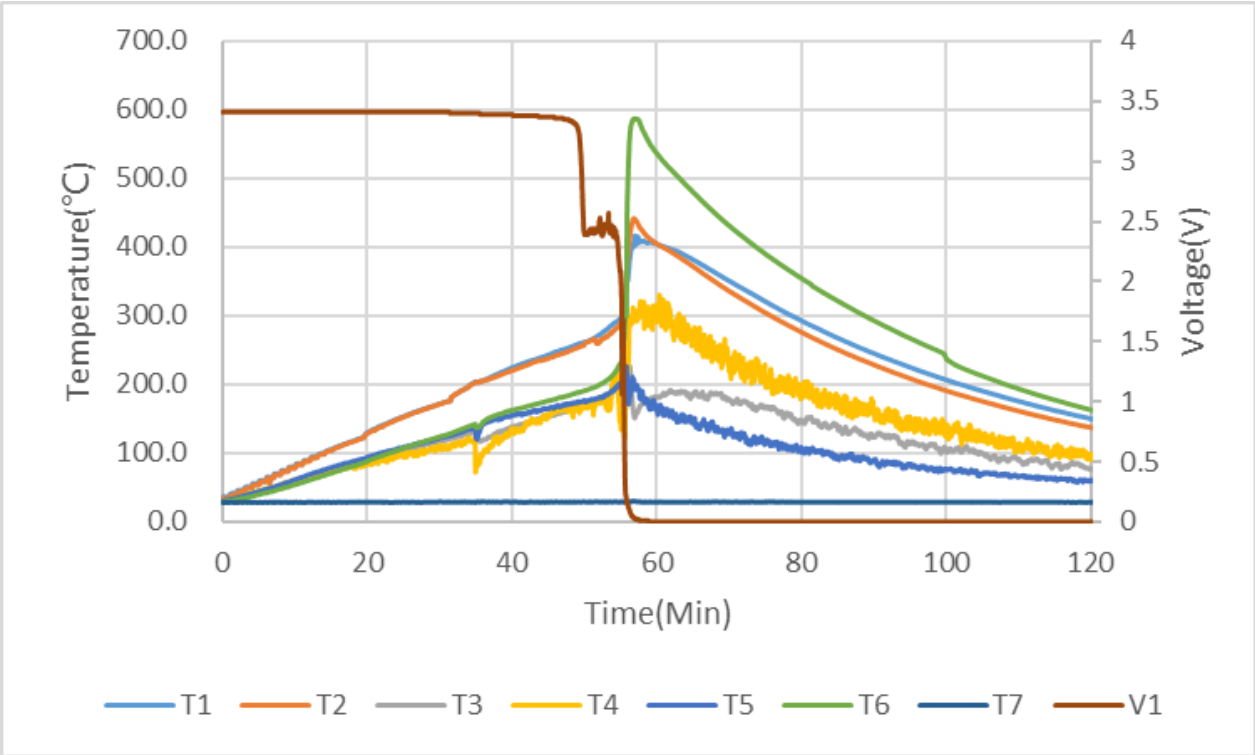
Thermalcouple No.	Location
T1	Cell center below the heater(A side)
T2	Cell center below the heater(B side)
T3	Positive eletrode tap
T4	Near pressure relief valve
T5	Cell narrow side
T6	Cell bottom
T7	Ambient temperature
V1	Cell Voltage

#4



Thermalcouple No.	Location
T1	Cell center below the heater(A side)
T2	Cell center below the heater(B side)
T3	Positive eletrode tap
T4	Near pressure relief valve
T5	Cell narrow side
T6	Cell bottom
T7	Ambient temperature
V1	Cell Voltage

#5



Thermalcouple No.	Location
T1	Cell center below the heater(A side)
T2	Cell center below the heater(B side)
T3	Positive eletrode tap
T4	Near pressure relief valve
T5	Cell narrow side
T6	Cell bottom
T7	Ambient temperature
V1	Cell Voltage

3.4 Cell vent gas generation and capturing

3.4.1 Test method and description

The cells to be tested were charged to 100% SOC and allowed to stabilize for a minimum of 1 h and a maximum of 8 h before the start of the test.

A cell was forced into thermal runaway by the external heating as determined in cell thermal runaway methodology test inside an 280L pressure vessel.

Before testing, the vessel was purged with N_2 to reduce the oxygen content below 1% by volume.

Gas mixtures were collected before and after thermal runaway testing. 0.3L gas collection bag with two valve were used for the gas collection.

Two bags after thermal runaway were used to determine the vent gas composition.

Cell weight was measured before and after test for reference.

Pressure was measured before and after thermal runaway to calculate the total gas produced for reference.

3.4.2 Test result

Ambient conditions ..... :	26.1 °C, 51 % R.H
Sample number ..... :	#1
Open circuit voltage before test (V) .... :	3.35
Pressure vessel size..... :	280L
Initial oxygen content by volume (%) .. :	< 0.1%
Cell weight before test (g)..... :	5626.0
Cell weight after test (g)..... :	4474.1
Total vent gas produced (L).....	130

3.5 Determination of cell vent gas composition

3.5.1 Test method

Cell vent gas composition was determined using Gas Chromatography (GC) with detection techniques for quantifying component gases.

The gases make up in table 1 is the gas composition after cell thermal runaway.

Table 2 contains normalized volumetric gas compositions by removing the N_2 contributions. This information was used to synthetically replicated gas mixture for further flammability character parameter tests.

3.5.2 Test result

Table 1: Vent gas components

Gas component	Concentration (v, %)
CH_4	1.1092
C_2H_6	0.1655
C_2H_4	0.4196
C_3H_8	0.0545
C_3H_6	0.2250
n-C_4H_{10}	0.0207
n-C_4H_8	0.0666
n-C_5H_{12}	0.0230
iso- C_5H_{12}	0.0339
n-C_5H_{10}	0.0160
CO	4.8960
CO_2	8.1173
H_2	15.0719
N_2	69.7808

Table 2: Vent gas components (normalized)
The gas components N_2 was removed.

Gas component	Concentration (v, %)
CH_4	3.671
C_2H_6	0.548
C_2H_4	1.389
C_3H_8	0.18
C_3H_6	0.745
n-C_4H_{10}	0.068
n-C_4H_8	0.22
n-C_5H_{12}	0.076
iso-C_5H_{12}	0.112
n-C_5H_{10}	0.053
CO	16.202
CO_2	26.861
H_2	49.875

3.6 Flammability character parameters of the cell vent gas

3.6.1 Test method

Upon determination of the cell vent gas composition, the flammability character parameters were determined on sample of the synthetically replicated gas mixture with maximum uncertainty 2%.

Lower flammability limit (LFL) of the cell vent gas was determined in accordance with ASTM E918, testing at both ambient and cell vent temperatures.

The gas burning velocity was determined in accordance with the Method of Test for Burning Velocity Measurement of Flammable Gases Annex in ISO 817.

The maximum explosion pressure P_{lax} was determined on samples of the synthetically replicated gas mixture in accordance with EN 15967.

Below table show the test result only. Detailed test report refer to Appendix A, Appendix B and Appendix C.

References:

ASTM E 918-19 – Standard Practice for Determining Limits of Flammability of Chemicals at Elevated Temperature and Pressure

ISO 817: 2014/Amd 1: 2017 – Refrigerants- Designation and safety classification

EN 15967: 2011 – Determination of maximum explosion pressure and the maximum rate of pressure rise of gases and vapours

3.6.2 Test result

LFL at 25°C±5°C and 101±5kPa ..... :	8.1%	(see Appendix A for details)
LFL at 205°C±5°C and 101±5kPa ..... :	6.5%	(see Appendix A for details)
Burning Velocity S_u(m/s) at room temperature ..... :	0.779	(see Appendix B for details)
P_{max} (MPa) at room temperature ..... :	0.78	(see Appendix C for details)

3.7 Photos

Sample #1: Gas generation and capturing setup



Sample #1: After thermal runaway test



Sample #2: Thermal runaway test setup



Sample #2: After thermal runaway test



4 List of Test and Measurement Instruments

No.	Equipment	Model	Rating	Last Cal. date
1	Gas Chromatography	8890	--	2023.09.06
2	Hybrid Recorder	TWC-2A	-50~700°C	2023.03.17
3	Data Acquisition	34970A	10mA-1000mA 0.1-300V	2023.07.06
4	Battery Testing System	CT-4004-5V200A-ATL	5V/200A	2023.07.10
5.	Digital multi-meter	15B+	400mVdc~100Vdc	2023.07.10
6.	Electronic Weight	CHS-D	0-10kg	2023.03.17
7.	Gas acquisition system	WRNK-191 HM90-H3-2-BD-801KZ DTM	0-1200°C -0.1~1.5 MPa 0-1000°C	2023.09.07 2023.09.07 2023.09.07
8.	Oxygen analyzer	HG-BX-O2	0-30%	2023.09.07
9.	Gas lower flammability limit test system			
	Temperature measurement	TJ120-CAXL-116U-10-SPW-M	0-300°C	2023.09.07
	Pressure transducer	PTX50G2-TC-A3-CA-H0-PB	-100~150KPa	2023.09.07
10.	Gas explosion test system			
	Temperature measurement	TJ120-CAXL-116U-10-SPW-M	0-300°C	2023.09.07
	Pressure transducer	Kistler 603CAA	0~100MPa	2023.09.07
	Pressure sensor	HM90-H3-2-V2-F1-W2	-0.1~2.0 MPa -0.1~0.15 MPa	2023.09.07
11.	High speed camera	MV-XG1205GC/M-T MV-XG280GC-T	90fps 409fps	--
12.	Combustible gas combustion rate device			
	Temperature measurement	TJ120-CAXL-116U-10-SPW-M	0-300°C	2023.09.07
	straight steel ruler	dawn 1m	1000mm	2023.09.07

Appendix A: Cell vent gas lower flammability limit (LFL) test

Test Method	ASTM E918-19 Standard Practice for Determining Limits of Flammability of Chemicals at Elevated Temperature and Pressure
Test Item	The lower flammability of gas mixture
Test Apparatus	Test Vessel: 5L closed sphere Ignition system: Fusing Wire
Preparation of Test Mixture	Partial pressure method used inside the vessel; Accuracy: within 0.2% absolute
Symbol and definition	The symbols used in this report are defined as below except otherwise defined: c_s —— Concentration of sample; T_i —— Initial temperature in each trial; p_i —— Initial pressure in each trial; p_{ex} —— Overpressure in each trial; It is considered flame occurred, if pex / pi ≥ 1.07. L_1 —— The minimum sample concentration that gives flame propagation; L_2 —— The maximum sample concentration that does not give flame propagation; LFL —— Lower flammable limit; LFL is expressed as: LFL = (L1+ L2)/2 Concentration defined in this report means volume percentage.
Remark	This report is effective under the specific condition; please seek for the advice of expert for risk assessment in producing, processing, transportation and storage.

LFL test data at room temperature (part)						
Test Condition	Initial Temperature: 25(±5)°C Initial Pressure: 101(±5)kPa					
No.	cs [%]	Ti [°C]	p_i [kPa]	p_{ex} [kPa]	p_{ex} / p_i	Ignition?
1	7.8	22	101.98	108.35	1.062	N
2	8.0	22	101.73	107.67	1.058	N
3	8.0	23	101.88	108.50	1.065	N
4	8.0	23	101.92	108.31	1.063	N
5	8.2	23	102.04	109.65	1.075	Y
6	8.2	23	101.88	109.98	1.080	Y
7	8.2	23	101.54	109.06	1.074	Y
Test result	L1=8.2 %, L2=8.0%, LFL=8.1 % at 25(±5)°C and 101(±5)kPa					

LFL test data at cell vent temperature (part)						
Test Condition	Initial Temperature: 205(±5)°C Initial Pressure: 101(±5)kPa					
No.	cs [%]	Ti [°C]	p_i [kPa]	p_{ex} [kPa]	p_{ex} / p_i	Ignition?
1	6.2	205	101.00	105.12	1.041	N
2	6.4	206	101.46	107.17	1.056	N
3	6.4	207	100.83	107.69	1.068	N
4	6.4	206	101.60	106.46	1.048	N
5	6.6	206	101.21	108.56	1.073	Y
6	6.6	207	101.33	110.73	1.093	Y
7	6.6	203	100.98	109.44	1.084	Y
Test result	L1=6.6%, L2=6.4%, LFL=6.5% at 205(±5)°C and 101(±5)kPa					

Appendix B: Cell vent gas burning velocity (S_u) test

Same synthetically replicated gas mixture as LFL test was used for the test.

Test Method	ISO 817: 2014 / Amd 1: 2017 Refrigerants - Designation and safety classification
Test Item	Burning velocity of flammable gases
Test Apparatus	Test vessel: Glass tube; length 1500 mm; inner diameter 40 mm Ignition system: Electric spark Recorder: High speed camera
Preparation of Test Mixture	Partial pressure method used inside the vessel; Accuracy: within 0.2% absolute
Symbol and definition	The symbols used in this report are defined as below except otherwise defined: c_s —— Concentration of sample; S_S —— Flame propagation speed； a_f —— Cross-sectional area of flame bottom； A_f —— Flame surface area； S_u is calculated as： $$S_u = S_S \times \frac{a_f}{A_f}$$
Remark	This report is effective under the specific condition; please seek for the advice of expert for risk assessment in producing, processing, transportation and storage.

Burning velocity test data (part)				
Test Condition	Initial temperature: room temperature Initial pressure: atmospheric pressure The oxidant used: synthetic air Smallest flammable substance content increment: 1.0% volume			
No	c_s [%]	S_S [m/s]	a_f/ A_f [m^2]	S_u [m/s]
1	21%	1.032	0.492	0.508
2	22%	1.267	0.510	0.646
3	23%	1.366	0.511	0.698
4	24%	1.426	0.506	0.722
5	25%	1.483	0.509	0.755
6	26%	1.524	0.511	0.779
7	27%	1.467	0.506	0.742
8	28%	1.432	0.504	0.722
9	29%	1.393	0.501	0.698
Test result	Su= 0.779m/s at room temperature and atmosphere pressure.			

Appendix C: Cell vent gas maximum pressure (P_{max}) test

Same synthetically replicated gas mixture as LFL test was used for the test.

Test Method	EN 15967:2011 Determination of maximum explosion pressure and the maximum rate of pressure rise of gases and vapours
Test Item	Maximum explosion pressure of the gas mixture
Test Apparatus	Test Vessel: 5L closed sphere Ignition system: Fusing Wire
Preparation of Test Mixture	Partial pressure method used inside the vessel; Accuracy: within 0.2% absolute
Symbol and definition	The symbols used in this report are defined as below except otherwise defined: c_s—— Content of flammable substance by volume; p_{exn} —— Explosive overpressure in the n^{th} ignition test at a certain concentration; p_{ex} —— Highest pressure occurring in a closed vessel during the explosion of a specific mixture of flammable substances with air or air and inert gases determined under specified test conditions; P_{Mean}——The average value of the explosion overpressure at a certain concentration; P_{max} —— Maximum explosion pressure; $p_{max}$is expressed as the maximum value of p_{ex}.
Remark	This report is effective under the specific condition; please seek for the advice of expert for risk assessment in producing, processing, transportation and storage.

P_{max} test data (part)						
Test Condition	Initial Temperature: 25(±2)°C Initial Pressure: 101(±5)kPa					
Part of Test Data						
No.	c_s [%]	p_{ex1} [MPa]	p_{ex2} [MPa]	p_{ex3} [MPa]	p_{ex4} [MPa]	p_{ex5} [MPa]
1	19	0.6106	0.6213	0.6119	--	--
2	21	0.6593	0.6599	0.6587	--	--
3	23	0.7070	0.6801	0.6942	--	--
4	25	0.7319	0.7286	0.7308	--	--
5	27	0.7571	0.7565	0.7562	--	--
6	29	0.7550	0.7691	0.7644	--	--
7	29.8	0.7667	0.7693	0.7713	0.7702	0.7688
8	31	0.7796	0.7805	0.7784	0.7815	0.7820
9	31.2	0.7764	0.7782	0.7758	0.7773	0.7672
10	31.4	0.7745	0.7675	0.7583	0.7726	0.7747
11	33	0.7562	0.7517	0.7537	--	--
12	35	0.7350	0.7351	0.7355	--	--

Determination of the explosion pressure			
No.	c_s [%]	P_{Mean} [MPa]	P_{max} [MPa]
1	19	0.6146	0.6213
2	21	0.6593	0.6599
3	23	0.6938	0.7070
4	25	0.7304	0.7319
5	27	0.7566	0.7571
6	29	0.7628	0.7691
7	29.8	0.7693	0.7713
8	31	0.7804	0.7820
9	31.2	0.7750	0.7782
10	31.4	0.7695	0.7747
11	33	0.7539	0.7562
12	35	0.7352	0.7355

Test result	
Content of flammable substance	31 % volume
Smallest flammable substance content increment	0.2% absolute
Maximum explosion pressure (P_{max})	0.78 MPa

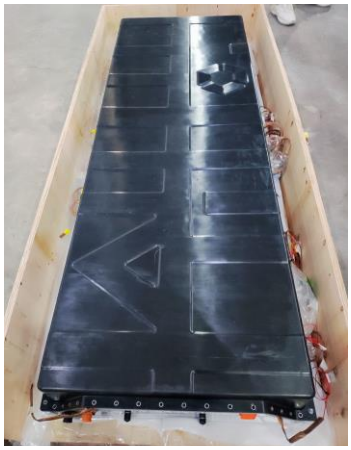
End of Test Report

B.5. UL9540A:2019 – Module Level Test Report

Test report provided on subsequent pages.

Prüfbericht-Nr.: *Test report no.*:	**CN23XXY9 003**	**Auftrags-Nr.:** *Order no.*:	168449171	Seite 1 von 37 *Page 1 of 37*
Kunden-Referenz-Nr.: *Client reference no.:*	2347845	**Auftragsdatum:** *Order date:*	2023-12-16	
Auftraggeber: *Client:*	**Xiamen Hithium Energy Storage Technology Co., Ltd.** No.1 Benyuan Road, Tongxiang High - Tech Zone, Xiamen, Fujian, China			
Prüfgegenstand: *Test item:*	Lithium iron phosphate battery module			
Bezeichnung / Typ-Nr.: *Identification / Type no.:*	LM010401-A			
Auftrags-Inhalt: *Order content*:	Test Report			
Prüfgrundlage: *Test specification:*	UL 9540A: 2019 (Fourth Edition)			

Wareneingangsdatum: *Date of sample receipt:*	2023-12-16
Prüfmuster-Nr.: *Test sample no:*	A003672973-001
Prüfzeitraum: *Testing period:*	2024-01-08 - 2024-01-10
Ort der Prüfung: *Place of testing:*	See to clause 1.1 of main report
Prüflaboratorium: *Testing laboratory:*	See to clause 1.1 of main report
Prüfergebnis*: *Test result*:*	See main report



erstellt von: *created by:*		**genehmigt von:** *authorized by*:	
Datum: *Date:* 2024-05-11	Jason Zhu	**Ausstellungsdatum:** *Issue date:* 2024-05-11	Xun Yu
Stellung / *Position:*	Project Engineer	**Stellung** / *Position:*	Reviewer

Sonstiges / *Other:*

This report does not evidence compliance of the provided sample with the relevant standards but only with the referred tests. This test report documents the findings of examination conducted on the delivered product mentioned above only. This report does not entitle the applicant to carry any safety mark on this or similar products. Further for sales or other application purposes of the tested product, any reference to TÜV Rheinland or a test through TÜV Rheinland is only permissible with prior written consent of TÜV Rheinland.

Zustand des Prüfgegenstandes bei Anlieferung: **Prüfmuster vollständig und unbeschädigt**
Condition of the test item at delivery: ***Test item complete and undamaged***

* Legende:	P(ass) = entspricht o.g. Prüfgrundlage(n)	F(ail) = entspricht nicht o.g. Prüfgrundlage(n)	N/A = nicht anwendbar	N/T = nicht getestet
* *Legend:*	*P(ass) = passed a.m. test specification(s)*	*F(ail) = failed a.m. test specification(s)*	*N/A = not applicable*	*N/T = not tested*

Dieser Prüfbericht bezieht sich nur auf das o.g. Prüfmuster und darf ohne Genehmigung der Prüfstelle nicht auszugsweise vervielfältigt werden. Dieser Bericht berechtigt nicht zur Verwendung eines Prüfzeichens.
This test report only relates to the a. m. test sample. Without permission of the test center this test report is not permitted to be duplicated in extracts. This test report does not entitle to carry any test mark.

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Remarks

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4	Die Entscheidungsregel für Konformitätserklärungen basierend auf numerischen Messergebnisen in diesem Prüfbericht basiert auf der "Null-Grenzwert-Regel" und der "Einfachen Akzeptanz" gemäß ILAC G8:2019 und IEC Guide 115:2021, es sei denn, in der auf Seite 1 dieses Berichts genannten angewandten Norm ist etwas anderes festgelegt oder vom Kunden gewünscht. Dies bedeutet, dass die Messunsicherheit nicht berücksichtigt wird und daher auch nicht im Prüfbericht angegeben wird. Zu weiteren Informationen bezueglich des Risikos durch diese Entscheidungsregel siehe ILAC G8:2019. *The decision rule for statements of conformity, based on numerical measurement results, in this test report is based on the "Zero Guard Band Rule" and "Simple Acceptance" in accordance with ILAC G8:2019 and IEC Guide 115:2021, unless otherwise specified in the applied standard mentioned on Page 1 of this report or requested by the customer. This means that measurement uncertainty is not taken in account and hence also not declared in the test report. For additional information to the resulting risk based of this decision rule please refer to ILAC G8:2019.*

INTRODUCTION

Model fire codes and energy storage system standards require energy storage systems to comply with UL 9540, which in turn requires battery cells and modules to comply with UL 1973. Compliance with these standards reduces the risk of batteries and battery energy storage systems (BESS) creating fire, shock or personal injury hazards. However, they don't evaluate the ability of the BESS installed as intended and with fire suppression mechanisms in place if necessary, from contributing to a fire or explosion in the end use installations.

To address these fire and explosion hazards associated with the installation of a BESS, the fire and other codes require energy storage systems to meet certain location, separation, fire suppression and other criteria. Those codes also provide a means to provide an equivalent level of safety based on large scale fire testing of anticipated BESS installations.

UL 9540A is intended to provide a test method that can be used as a basis for validating the safety of a BESS installation in lieu of meeting the specific criteria provided in those codes. The data generated can be used to determine the fire and explosion protection required for installation of a BESS.

The test method is initiated through the establishment of a thermal runaway condition that leads to combustion within the BESS. The test method outlined in UL 9540A consists of several steps – cell level testing, module level testing, unit level testing and installation level testing. The cell and module level testing steps are information gathering steps to inform the unit and installation level testing.

The following outlines the information that may gathered as part of the testing:

a) Cell level – An individual cell fails in a manner that leads to thermal runaway and fire through a suitable method such as external heating. Data such as off-gassing contents, temperatures at venting and temperatures at thermal runaway are recorded.

b) Module level – One or more cells within a BESS module fail in the manner determined during the cell level testing. Data such as fire propagation in the module, temperatures on the failed cells and surrounding cells, off-gassing contents and heat release data are gathered.

c) Unit level – A complete BESS is installed surrounded by target (e.g. dummy) BESS and walls separated at a distance as intended in its installation. The module level test is repeated on a module located in the BESS in the most unfavorable location. Data such as temperature within the BESS, on surrounding walls and target BESS; incident heat flux on walls and target BESS; observation of fire propagation from BESS to target units and walls as well as observance of explosions or evidence of re-ignition within the BESS; and heat release and off-gassing contents are gathered.

d) Installation level – This test is a repeat of the unit level test with the test conducted within a test room and with the intended fire suppression system installed as well as any overhead cables (that can lead to fire propagation) installed. This test is intended to validate the fire suppression system for the BESS installation. Data such as temperature within the BESS, on surrounding walls and target BESS; incident heat flux on walls and target BESS; fire propagation from the BESS to target units, walls or overhead cables and any observable explosion incidents or re-ignition within the BESS; and off-gassing contents (if needed) and heat release are gathered.

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1 General information

1.1 Test specification

Standard: ANSI/CAN/UL 9540A: 2019 (Fourth Edition)

Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems

This report presents the result of module level tests of UL 9540A: 2019.

All tests were conducted at TUV Rheinland (Shenzhen) Co., Ltd. and TUV Rheinland's partner labs that were under supervision of TÜV Rheinland's engineer.

Testing period: 2024.01.09 to 2024.01.10

Refer to Clause 3 for test and measurement instruments.

1.2 General remarks

This report is descriptive and provide the test data only.

The test results presented in this report relate only to the object tested.

This report shall not be reproduced, except in full, without the written approval of the testing laboratory.

Throughout this report a ☐ comma / ☒ point is used as the decimal separator.

1.3 Revision information

Description of changes:

1. Updated the Figures 12 to 16, detail see page 23 to 31.

Change	Testing	Comment
1	N/A	No additional test necessary.

History of amendments and modifications:

Ref. No. CN23XXY9 001, dated 2024-03-11(original test report)

Ref. No. CN23XXY9 002, dated 2024-04-24(1st amendment)

Ref. No. CN23XXY9 003, dated 2024-05-11(2st amendment)

1.4 Summary of the test

Video records of the test from 2 directions were provided in .mp4 format.

One external heater was place in the module to initiating the thermal runaway inside module. The initiating cells were heated at a rate of 4°C to 7°C per minute until the cell thermal runaway.

White smoke was observed during test. No flying debris or explosive discharge of gases during test. No sparks, electrical arcs, or other electrical events during test. No external flaming observed.

The battery pack weight measured was 675.0kg (before test) and 674.5kg (after test).

Measured peak chemical heat release rate HRR was 22.70kW.

Measured total heat release through the test THR was 97.90MJ.

Measured peak smoke release rate SRR was 0.821m^2/s.

Total smoke release TSR was 118.0m^2

Total hydrocarbons gas was 101.04L.

Detail information see relevant clause of this report.

1.5 Definitions

CELL – The basic functional electrochemical unit containing an assembly of electrodes, electrolyte, separators, container, and terminals. It is a source of electrical energy by direct conversion of chemical energy.

MODULE – A subassembly that is a component of a BESS that consists of a group of cells or electrochemical capacitors connected together either in a series and/or parallel configuration (sometimes referred to as a block) with or without protective devices and monitoring circuitry.

UNIT – A frame, rack or enclosure that consists of a functional BESS which includes components and subassemblies such a cells, modules, battery management systems, ventilation devices and other ancillary equipment.

BATTERY SYSTEM (BS) – Is a component of a BESS and consists of one or more modules typically in a rack configuration, controls such as the BMS and components that make up the system such as cooling systems, disconnects and protection devices.

BATTERY ENERGY STORAGE SYSTEM (BESS) – Stationary equipment that receives electrical energy and then utilizes batteries to store that energy to supply electrical energy at some future time. The BESS, at a minimum consists of one or more modules, a power conditioning system (PCS), battery management system (BMS) and balance of plant components.

a) INITIATING BATTERY ENERGY STORAGE SYSTEM UNIT (INITIATING BESS) – A BESS unit which has been equipped with resistance heaters in order to create the internal fire condition necessary for the installation level test.

b) TARGET BATTERY ENERGY STORAGE SYSTEM UNIT (TARGET BESS) – The enclosure and/or rack hardware that physically supports and/or contains the components that comprise a BESS. The target BESS unit does not contain energy storage components, but serves to enable instrumentation to measure the thermal exposure from the initiating BESS.

Note: Depending upon the configuration and design of the BESS (e.g. the BESS is composed of multiple separate parts within separate enclosures), the unit level test can be done at battery system level. In such case, the BESS is be read as BS throughout this report.

NON-RESIDENTIAL USE – Intended for use in commercial, industrial or utility owned locations.

RESIDENTIAL USE – In accordance with this standard, intended for use in one or two family homes and town homes and individual dwelling units of multi-family dwellings.

THERMAL RUNAWAY- The incident when an electrochemical cell increases its temperature through self-heating in an uncontrollable fashion. The thermal runaway progresses when the cell's generation of heat is at a higher rate than the heat it can dissipate. This may lead to fire, explosion and gas evolution.

STATE OF CHARGE (SOC) – The available capacity in a BESS, pack, module or cell expressed as a percentage of rated capacity.

2 General Product Information

2.1 Cell

2.2.1 Product information and parameters

The product information and parameters are provided by the client as below.

Manufacturer:	**Xiamen Hithium Energy Storage Technology Co., Ltd.** 201-1, Comprehensive Building 5, No. 11, Butang Middle Road, Industrial Base Of Xiamen Torch High Tech Zone (Tongxiang), Xiamen, Fujian P.R. China	
Model number:	LFP71173207/314Ah	
Chemistry:	☒ $LiFePO_4$ ☐ NMC ☐ NCA ☐ LTO ☐ Other:	
Physical configuration:	☒ Prismatic ☐ Cylindrical ☐ Pouch	
	Weight(kg):	5.60±0.20
Electrical rating :	Rated capacity (Ah):	314 (25°C±2°C)
	Nominal voltage (V):	3.2
Standard charge method:	Charge current (A):	157(25°C±2°C)
	Standard Charge Voltage (V):	3.65
	Cut off current (A):	/
Standard discharge method:	Discharge current (A):	157(25°C±2°C)
	End of discharge voltage (V):	2.5(T>0°C) 2.0(T≤0°C)
Maximum continuous charge current (A):	314(25°C±2°C)	
Maximum continuous discharge current (A):	314(25°C±2°C)	
Compliance with UL 1973:	☒ Yes TUV Report No.: CN23RGEH 001 ☐ No	

2.2.2 Cell level test information

Cell level thermal runaway test information is copy from TUV Rheinland UL 9540A cell level test report No.: CN23F118 001

Thermal Runaway Methodology:	External heater applied on one side of the cell with surface heating rate at about of 5°C per minute until thermal runaway triggered.
Average Cell Surface Temperature at Gas Venting:	203.7°C
Average Cell Surface Temperature Start Thermal Runaway:	295.7°C

2.2 Module

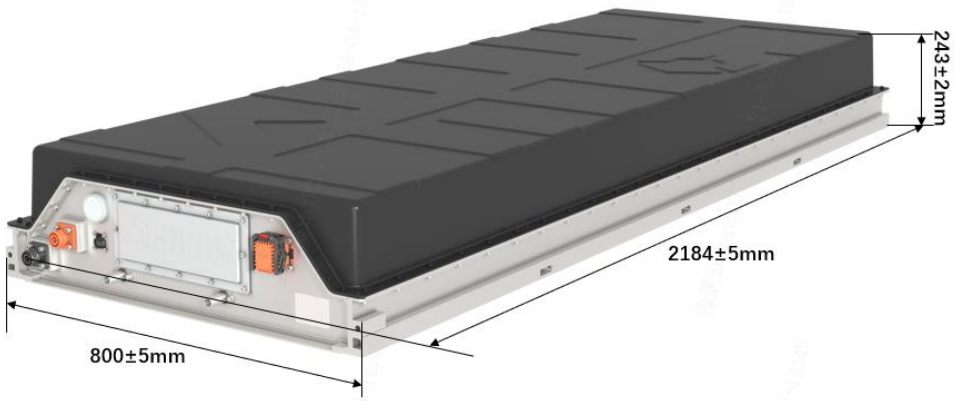
2.2.1 Product information and parameters

The product information and parameters are provided by the client as below.

Manufacturer:	**Xiamen Hithium Energy Storage Technology Co., Ltd.** 201-1, Comprehensive Building 5, No. 11, Butang Middle Road, Industrial Base Of Xiamen Torch High Tech Zone (Tongxiang), Xiamen, Fujian, P.R. China	
Model number:	LM010401-A	
Physical configuration:	Metal base, the other sides are non-metallic material. A mica plate is installed under the top enclosure.	
	Weight:	667 ±10 kg
	Cells in series/parallel:	2P52S
Cooling method:	Liquid cooling	
Separation between cells:	Thermal insulation sheet: Aerogel Heat insulation pad and Polyurethane foam, see Figure 4 for install location details.	
Electrical rating:	Rated capacity:	628 Ah
	Nominal voltage:	166.4Vdc
Standard charge method:	Charge power:	52.25KW
	End of charge:	The highest cell voltage reaches 3.65 V
Standard discharge method:	Discharge power:	52.25KW
	End of discharge:	The lowest cell voltage reaches 2.5 V
Compliance with UL 1973:	☐ Yes	☒ No

2.2.2 Diagram with overall dimension

Figure 1 Diagram with overall dimension



(Unit : mm)

3 Module level test (section 8 of UL 9540A)

3.1 General

This testing is conducted on battery modules, which are in turn installed in an enclosure or in an open rack system to form a BESS unit.

This test uses applied stresses determined during the cell level test to force a selected number of battery cells within the module into thermal runaway. If there is fire that results from the cell being driven into thermal runaway, the fire is allowed to progress within the module.

The test measures the chemical heat release rate, smoke release rate, maximum temperature, and vent gas composition; and documents the module enclosure integrity after the test, any explosions or hazardous ejection of parts outside of the module enclosure, and the extent and duration of any flame propagation outside of the module.

The module level testing establishes a base line fire test performance that can be evaluated against the fire performance of other battery modules the BESS manufacturer may choose to use within the system. Testing can be discontinued after the module level testing if the effects of thermal runaway (fire and explosion) are contained by the module design and the cell vent gas (as determined by the cell level testing) is non-flammable.

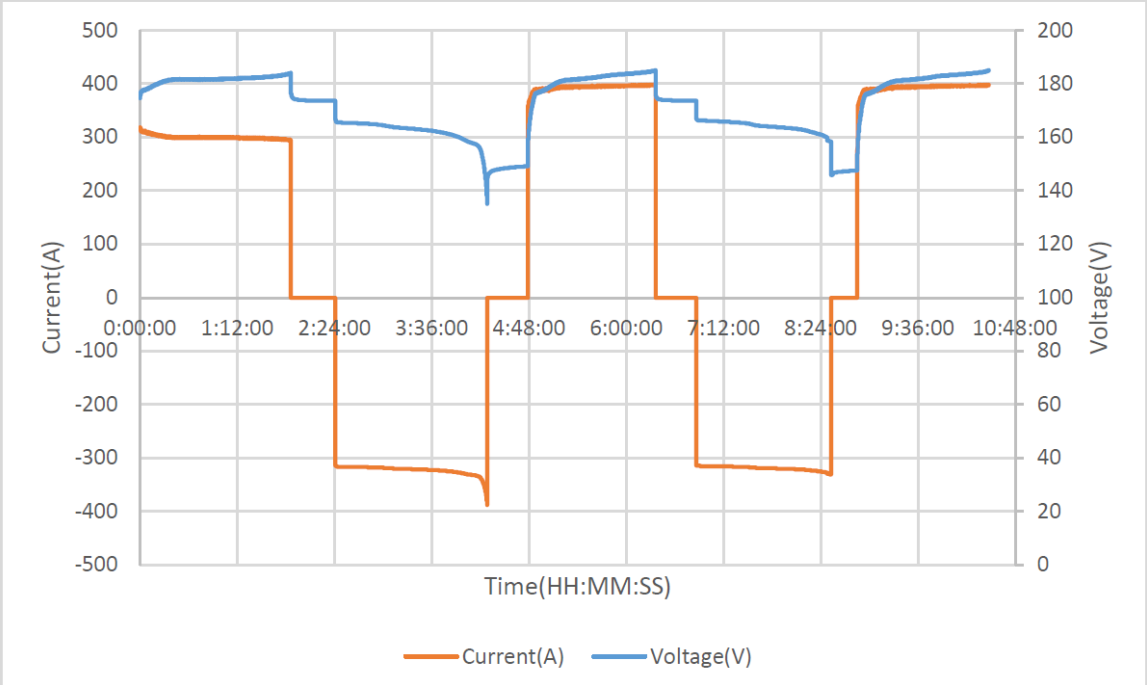
3.2 Sample preparation

Module sample was conditioned, prior to testing, through charge and discharge cycles of 2 cycles to verify that the module was functional.

Each cycle was defined as a charge to 100% SOC and allowed to rest several minutes and then discharged to an end of discharge voltage (EODV) determined by the manufacturer. Refer to 2.2.1 for charge and discharge profile.

The module sample was put in a climate chamber during charge and discharge. The ambient is kept at 25°C±2°C and 50%±5% R.H.

Figure 2 Sample cycling curve



3.3 Module level thermal runaway test

3.3.1 Thermal runaway test method description

The module to be tested was charged to 100% SOC and allow stabilizing for a minimum of 1 h and a maximum of 8 h before the start of the test.

The module consisted of 104 cells 2P52S. All cells in the pack were numbered from #1-1 to #1-26, #2-1 to #2-26, #3-1 to #3-26, #4-1 to #4-26 as below.

External heating method was used to initiate thermal runaway in the module. One metal heater was fitted on cell (rated 220V ac/1000 W, size 190*160).

Total 11 thermocouples (type K, 24AWG) were attached at the center of the wider side surface of cell and below the hater film in the module. See Figure 3 and Figure 4 for the detail locations.

Voltage of the module was monitored during test.

Figure 3 Internal view of module

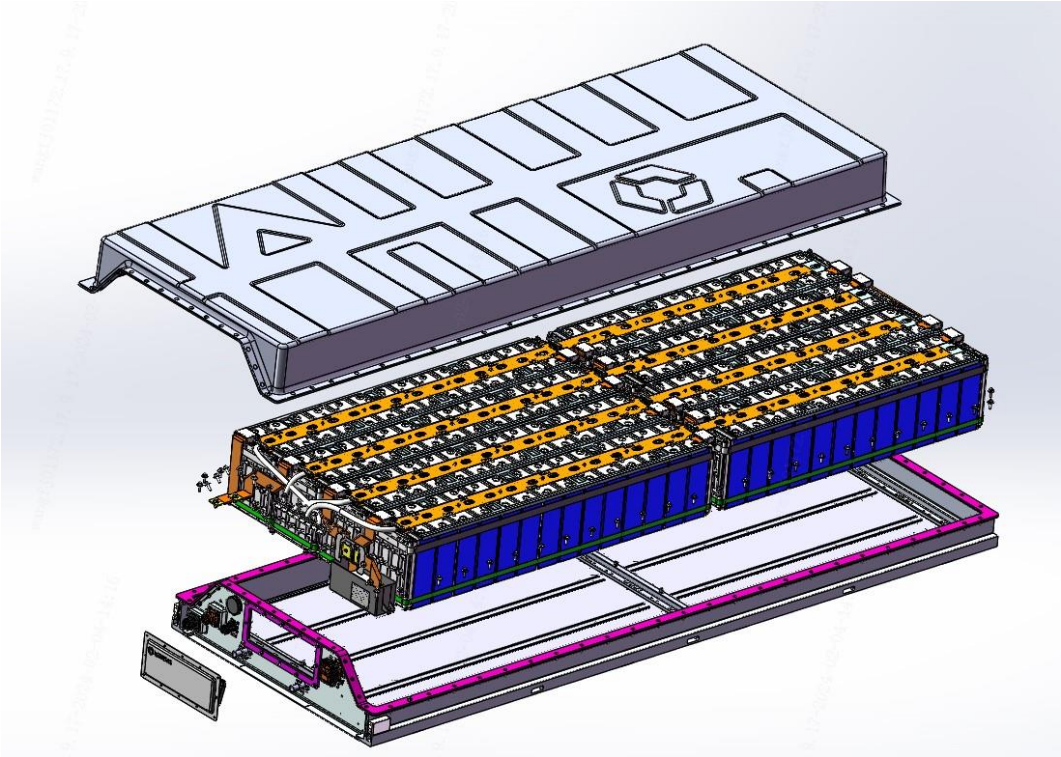


Figure 4 Cell number, location of heater, thermal insulation sheet (Aerogel Heat insulation pad and Polyurethane foam) and thermocouple



A PID controller was used to control the voltage supply to the heater and maintain a 4°C/min to 7°C/min heating rate. Additional one thermocouple on the center of initiating cell surface below heater was used to feedback the cell surface temperature to the controller.

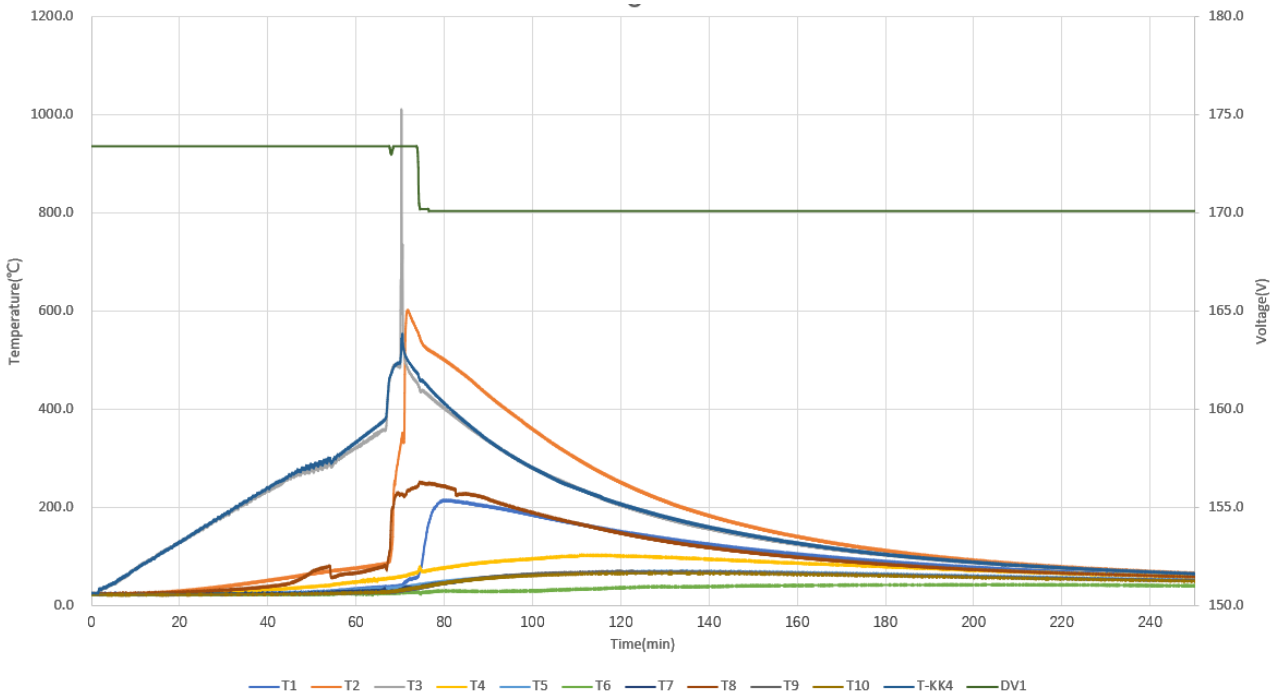
The initiating cells were heated at a rate of 4°C to 7°C per minute until the cell thermal runaway. Once the measured temperature exceed the set heating rate, the heaters were immediately de-energized.

3.3.2 Observations and records

Ambient conditions at the initiation of the test	:	21.2°C, 62% R.H.
Sample number	:	A003672973-001
Open circuit voltage before test (V)	:	173.4
Weight before test (kg)	:	675.0
Time initiating the test	:	2024.01.09 11:30:56
Observations during test	:	The first thermal runaway cell (#1-10) and smoke release at 12:38. The second thermal runaway cell (#1-9) at 12:41. No flying debris or explosive discharge of gases during test. No sparks, electrical arcs, or other electrical events during test. No external flaming observe.
Posttest evaluation	:	Two cells (#1-9 to #1-10) went into thermal runaway during test. one cell (#1-9) went into thermal runaway by cell to cell propagation.
Open circuit voltage after test (V)	:	170.1
Weight after test (kg)	:	674.5
Weight loss (kg)	:	0.5

3.3.3 Temperature measurements

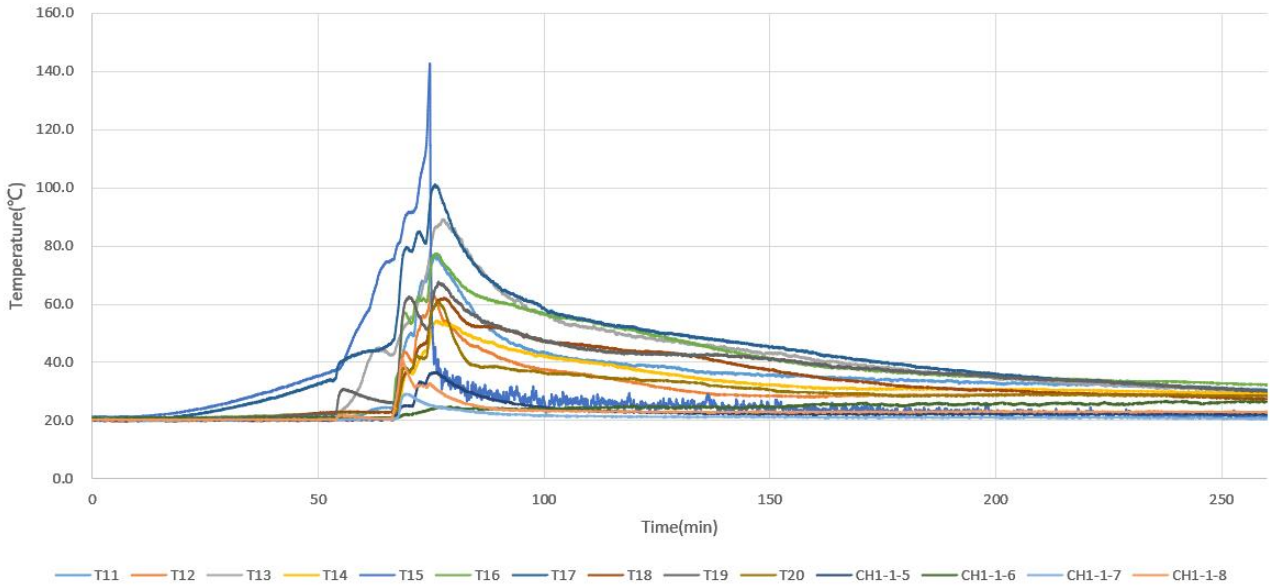
Figure 5 The cells temperature and module voltage VS time curve



Thermocouple no.	Location	Maximum temp. °C
T1	Surface of cell #1-8	214.0
T2	Surface of cell #1-9	601.7
T3	Surface of cell #1-10	1010.4
T4	Surface of cell #1-11	102.3
T5	Surface of cell #1-12	70.4
T6	Surface of cell #1-13	42.3
T7	Surface of cell #2-9	67.4
T8	Surface of cell #2-10	251.3
T9	Surface of cell #3-9	69.1
T10	Surface of cell #3-10	65.5
T-KK4	Heater	553.3

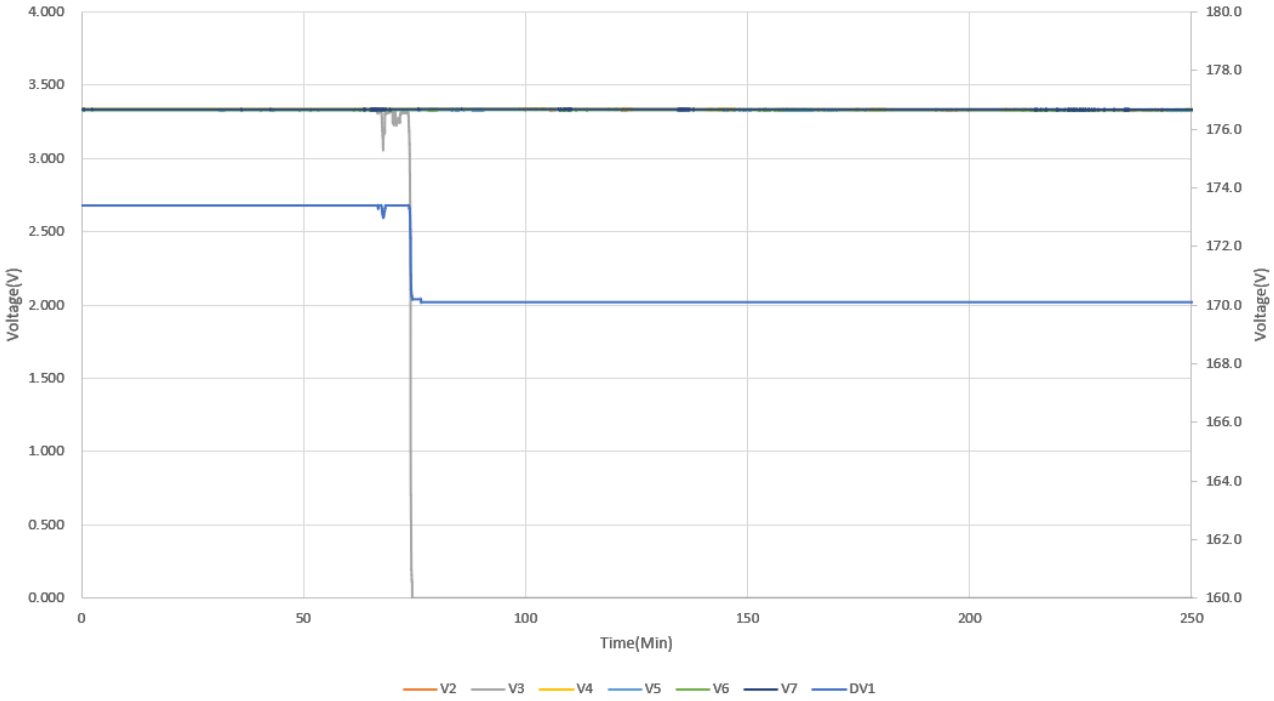
Voltage no.	Name	Voltage(V)
V-Module	Voltage of Module	173.4 V to 170.1 V

Figure 6 The enclosure temperature VS time curve



Thermocouple no.	Location	Maximum temp. °C
T11	Top surface of the Enclosure	76.6
T12	Top surface of the Enclosure	64.4
T13	Top surface of the Enclosure	89.2
T14	Top surface of the Enclosure	54.3
T15	Top surface of the Enclosure	142.7
T16	Top surface of the Enclosure	77.3
T17	Top surface of the Enclosure	101.1
T18	Top surface of the Enclosure	62.1
T19	Top surface of the Enclosure	67.7
T20	Top surface of the Enclosure	60.8
CH1-1	Right surface of the Enclosure	36.6
CH1-2	Left surface of the Enclosure	26.9
CH1-3	Back surface of the Enclosure	29.2
CH1-4	Front surface of the Enclosure	41.1

Figure 7 The cells and module voltage VS time curve



Name	V2 #1-7 & #1-8	V3 #1-9& #1-10	V4 #1-11& #1-12	V5 #1-13& #1-14	V6 #2-9& #2-10	V7 #3-9& #3-10	DV1
Begin of the test	3.334	3.335	3.338	3.331	3.332	3.336	173.4
End of the test	3.330	0.000	3.334	3.331	3.331	3.335	170.1

3.4 Chemical heat release rate measurement

3.4.1 Test method

The chemical heat release rates were measured by an oxygen consumption calorimeter measurement system consisting of a paramagnetic oxygen analyzer, non-dispersive infrared carbon dioxide and carbon monoxide analyzer, velocity probe, and a Type K thermocouple.

The instrumentations are located in the exhaust duct of the heat release rate calorimeter.

The chemical heat release rate was calculated at each of the flows as follows:

$$HRR_1 = \left[E \times \varphi - (E_{co} - E) \times \frac{1-\varphi}{2} \times \frac{X_{co}}{X_{O_2}}\right] \times \frac{\dot{m}_e}{1+\varphi \times (\alpha - 1)} \times \frac{M_{O_2}}{M_a} \times (1 - X^o_{H_2O}) \times X^o_{O_2}$$

In which:

HRR_t = total heat release rate, as a function of time (kW)

E = Net heat released for complete combustion per unit of oxygen consumed (adjusted for oxygen contained within cell chemistry, 13,100 kJ/kg)

E_{CO} = Net heat released for complete combustion per unit of oxygen consumed, for CO (adjusted for oxygen contained within cell chemistry, 17,600 kJ/kg)

φ = Oxygen depletion factor (non-dimensional), where:

$$\varphi = \frac{X^o_{O_2} \times [1 - X_{CO_2} - X_{CO}] - X_{O_2} \times [1 - X^o_{CO_2}]}{X^o_{O_2} \times [1 - X_{O_2} - X_{CO_2} - X_{CO}]}$$

X_{CO} = Measured mole fraction of CO in exhaust flow (non-dimensional)

X_{CO_2} Measured mole fraction of CO_2 in exhaust flow (non-dimensional)

$X°_{CO_2}$ = Measured mole fraction of CO_2 in incoming air (non-dimensional)

$X°_{H_2O}$ = Measured mole fraction of H_2O in incoming air (non-dimensional)

X_{O_2} = Measured mole fraction of O_2 in exhaust flow (non-dimensional)

$X°_{O_2}$ = Measured mole fraction of O_2 in incoming air (non-dimensional)

α = Combustion expansion factor (non-dimensional; normally a value of 1.105)

M_a = Molecular weight of incoming and exhaust air (29 kg/kmol)

M_{O_2} = Molecular weight of oxygen (32 kg/kmol)

$\dot{m}_e$ = Mass flow rate in exhaust duct (kg/s), in which:

$$\dot{m}_e = C \times \sqrt{\frac{\Delta p}{T_e}}$$

or

$$\dot{m}_e = 26.54 \times \frac{A \times k_c}{f(\mathrm{Re})} \times \sqrt{\frac{\Delta p}{T_e}}$$

C = Orifice plate coefficient (in $kg^{1/2}m^{1/2}K^{1/2}$)

Δp = Pressure drop across orifice plate or bidirectional probe (Pa)

T_e = Combustion gas temperature at orifice plate or bidirectional probe (K)

A = Cross sectional area of the duct (m^2)

k_c = Velocity profile shape factor (non-dimensional)

$f(Re)$ = Reynolds number correction (non-dimensional)

3.4.2 Test result

Peak chemical heat release rate HRR: 22.70kW

Total heat release through the test THR: 97.90MJ

Figure 8 HRR curve

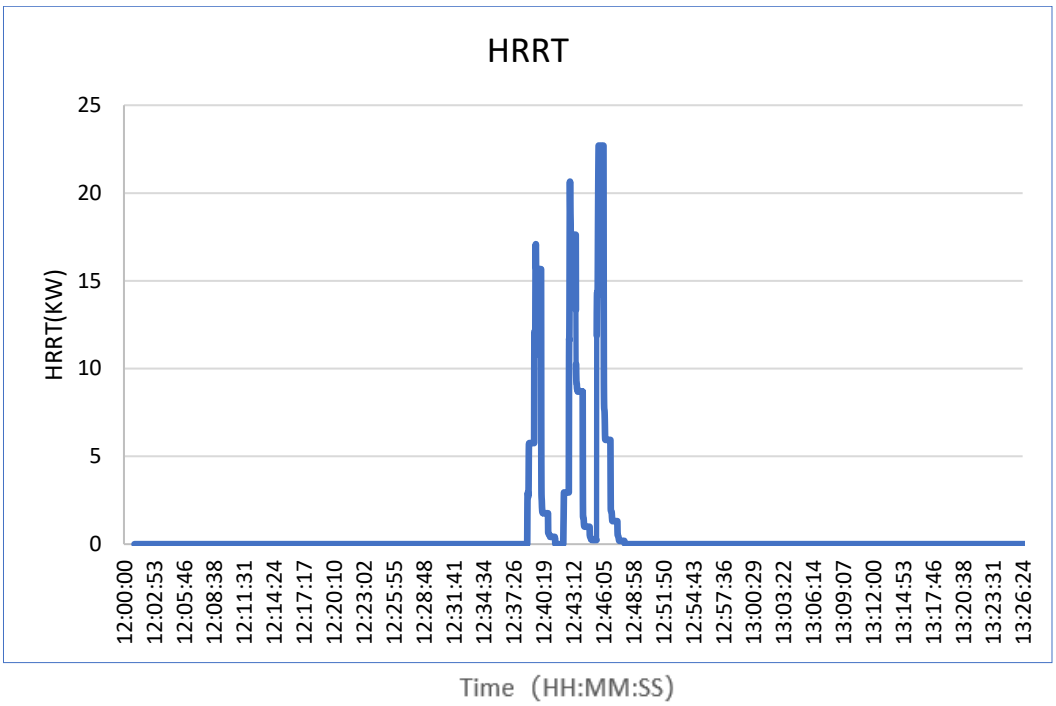
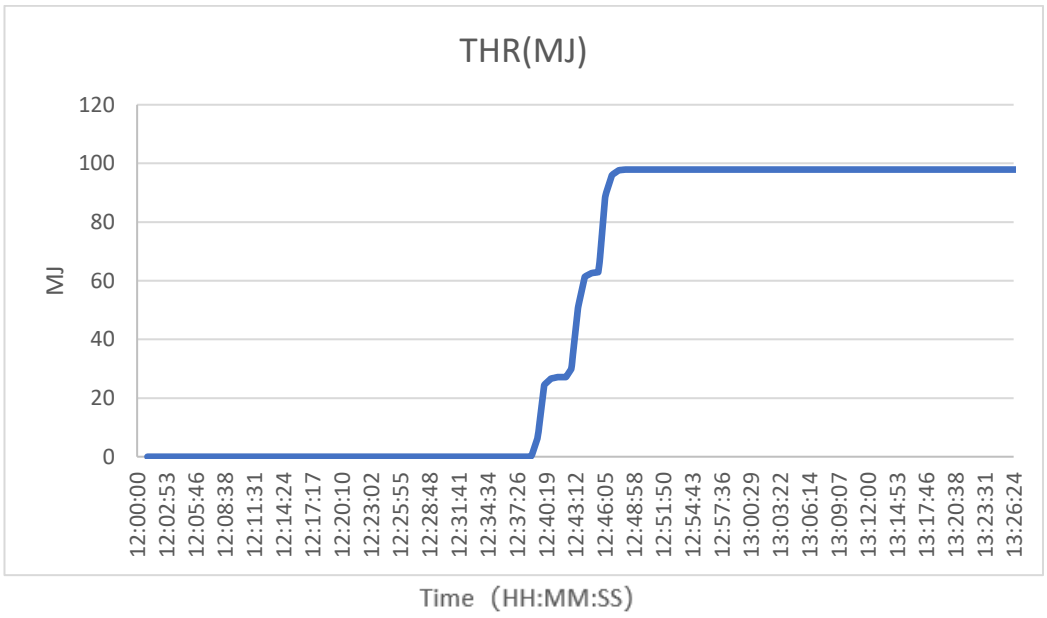


Figure 9 THR curve



3.5 Smoke release rate measurement

3.5.1 Test method

The light transmission in the calorimeter's exhaust duct was measured using a white light source and photo detector for the duration of the test.

The smoke release rate was calculated as follows:

$$SRR = 2.303\left(\frac{V}{D}\right) Log_{10}\left(\frac{I_o}{I}\right)$$

Where:

SRR = Smoke release rate (m^2/s)

V = Volumetric exhaust duct flow rate (m^3/s)

D = duct diameter (m)

I_o = Light transmission signal of clear (pre-test) beam (V)

I = Light transmission signal during test (V)

The whole smoke release rate measurement system were self-checked using calibrated light filter before test.

3.5.2 Test result

Peak smoke release rate SRR: 0.821m²/s

Total smoke release TSR: 118.0m²

Figure 10 SRR curve

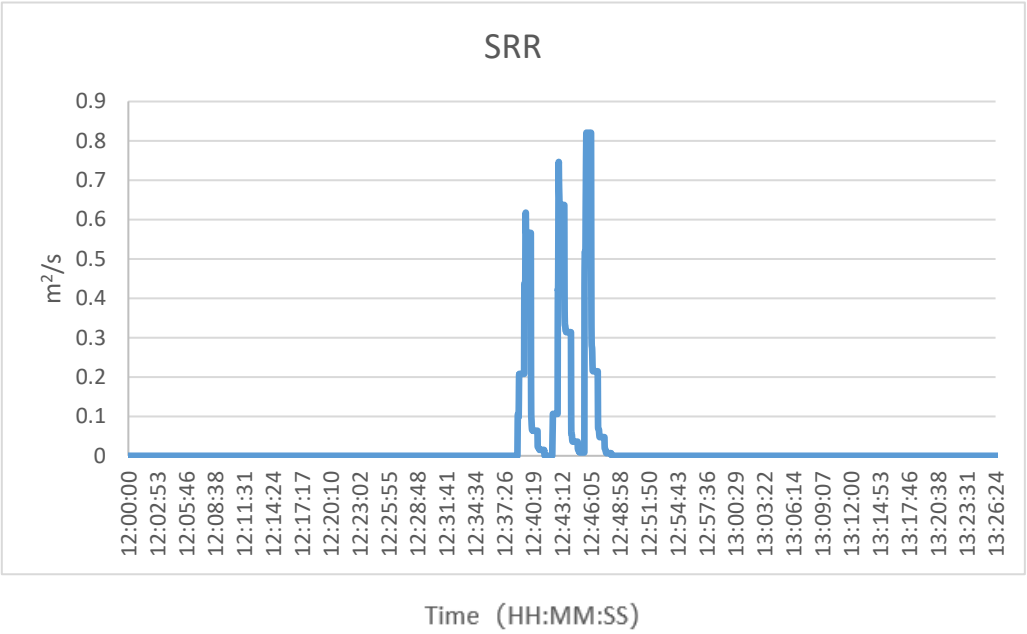
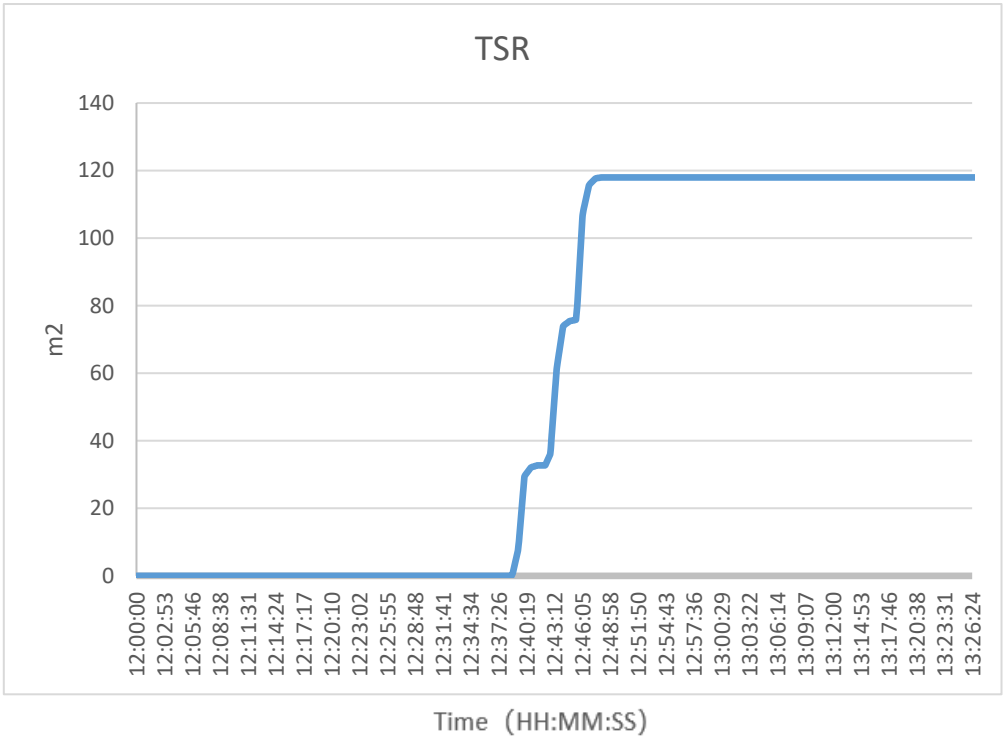


Figure 11 TSR curve



3.6 Gas generation measurement

3.6.1 Test method

The composition, velocity and temperature of the vent gases were measured within the calorimeter's exhaust duct.

Gas composition were measured using a Fourier-Transform Infrared Spectrometer with a resolution of 0.5 cm^{-1} and a path length of 5.1 m within the calorimeter's exhaust duct.

The hydrocarbon content of the vent gas was measured using flame ionization detection.

Hydrogen gas was measured with a palladium-nickel thin-film solid state sensor.

Composition, velocity and temperature instrumentation were collocated with heat release rate calorimetry instrumentation

3.6.2 Total gas release

The flow rates of various gases were integrated over the test duration and the total cumulative volume of gas calculated for the total test duration were presented in below table.

Gas type	Gas components		Total volume of gas (L)
Hydrocarbon species	Methane	CH_4	20.570
	Ethylene	C_2H_4	13.594
	Ethane	C_2H_6	1.787
	Propylene	C_3H_6	2.581
	Propane	C_3H_8	0.824
Hydrogen halide species	Hydrogen Fluoride	HF	0.872
Others	Carbon Monoxide	CO	33.852
	Carbon Dioxide	CO_2	77.634
	Hydrogen (Electrochemical) For reference only	H_2	160.97**
	Hydrogen (Palladium nickel thin film solid state sensor)	H_2	Below detectable limit*

	Carbonyl Sulfide	COS	0.464
	Oil as octane	/	1.362
	Dimethyl carbonate	$C_3H_6O_3$	36.830
	Ethyl methyl carbonate	$C_4H_8O_3$	16.244
	Methanol	CH_3OH	/
Total Hydrocarbons (equivalent to C_3H_8, measured by FID)			101.04

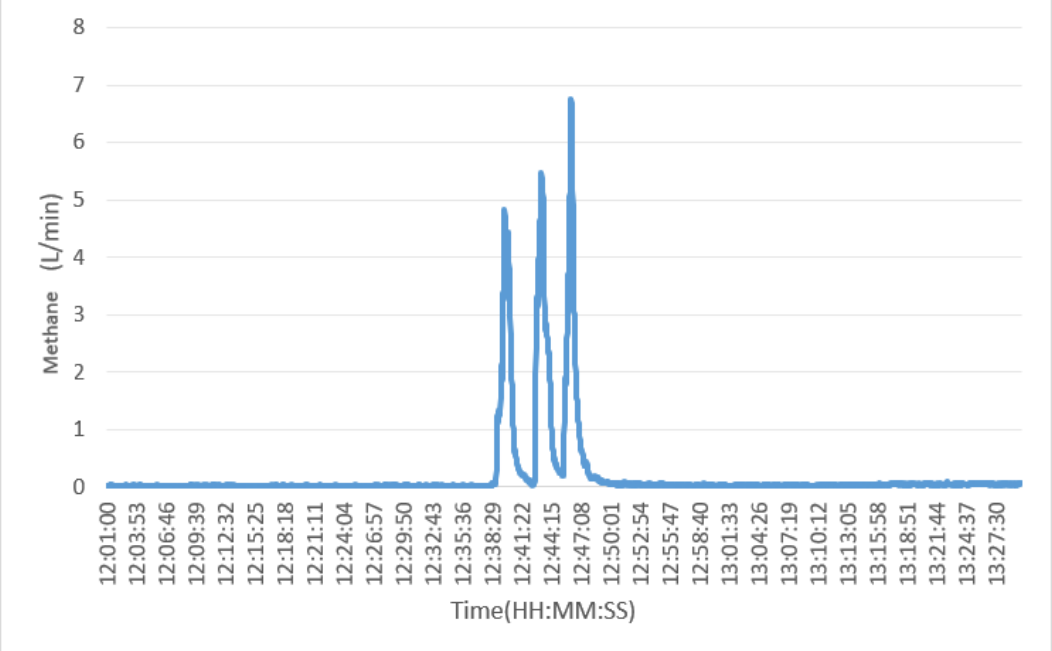
* = The volume of hydrogen released by a single cell after thermal runaway referred to the cell UL 9540A report is about 64.8L. However, it should be noted that the gas production of a single cell in the current test environment is not exactly equivalent to the gas production of the cell level test, because the test environment is not the same.

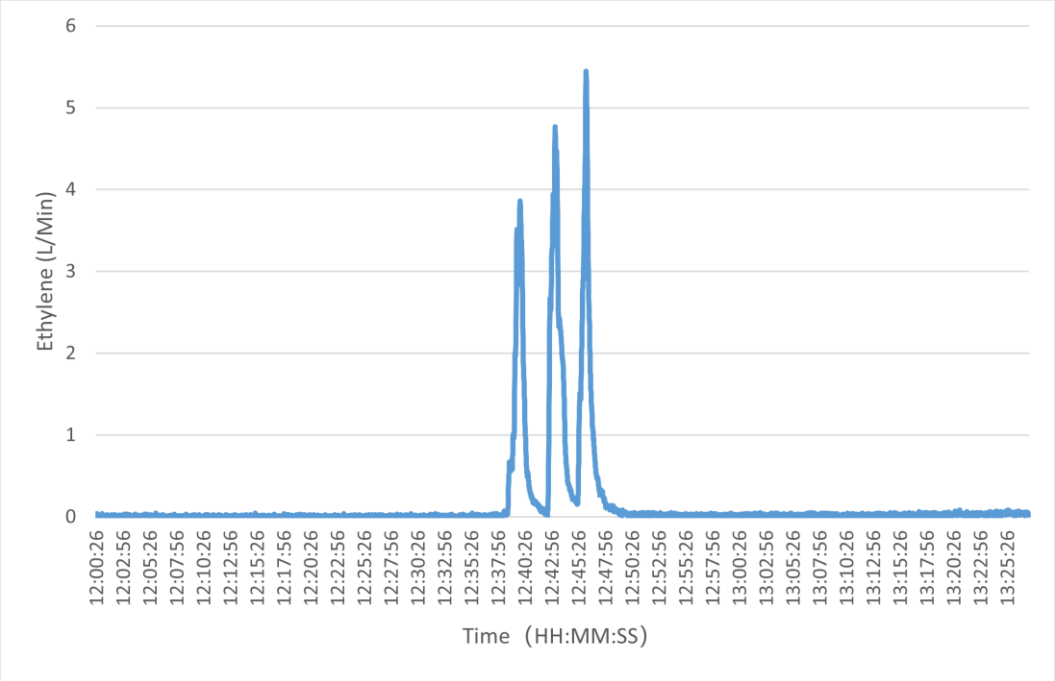
** = As there are some factor sensors which can affect the accuracy of hydrogen gas measurements, such as the accuracy for gas voltage signal, airflow rates, and environmental variables, the 160.97L in only for reference.

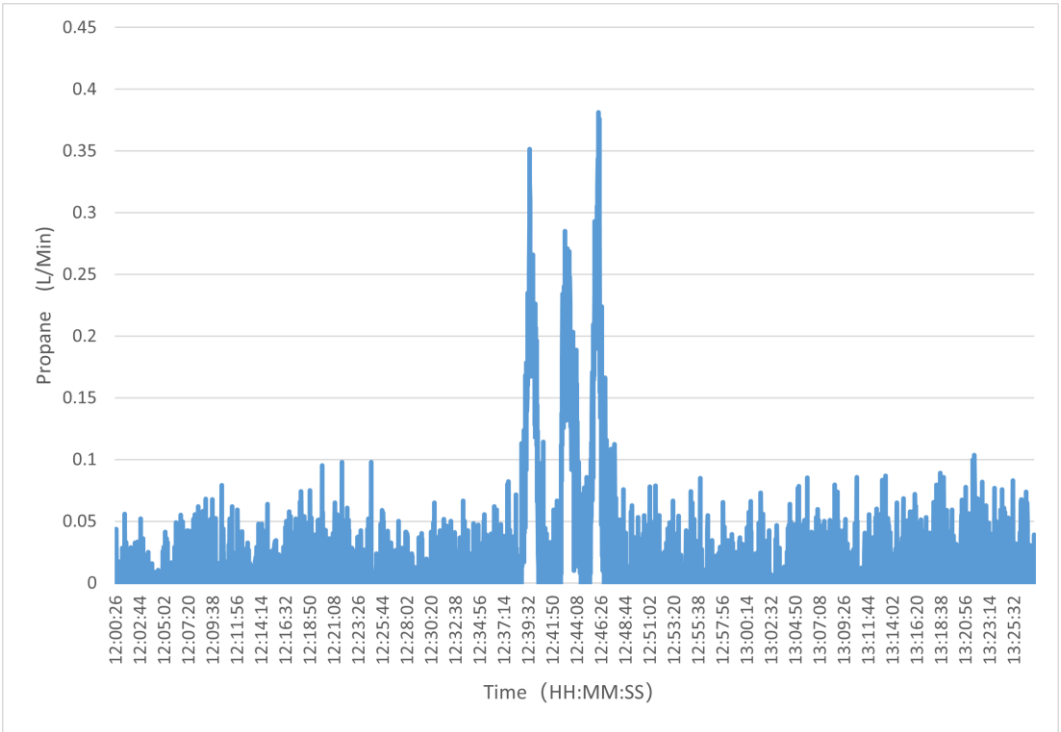
3.6.3 Gas components

Concentration of different gas components were present according to gas species classification in Figures 12 to 16. Average flow rate was 2.09 m^3/s during test.

Figure 12 Hydrocarbon species:




Ethylene (L/Min)
0
1
2
3
4
5
6
12:00:26
12:02:56
12:05:26
12:07:56
12:10:26
12:12:56
12:15:26
12:17:56
12:20:26
12:22:56
12:25:26
12:27:56
12:30:26
12:32:56
12:35:26
12:37:56
12:40:26
12:42:56
12:45:26
12:47:56
12:50:26
12:52:56
12:55:26
12:57:56
13:00:26
13:02:56
13:05:26
13:07:56
13:10:26
13:12:56
13:15:26
13:17:56
13:20:26
13:22:56
13:25:26
Time (HH:MM:SS)


Propane (L/Min)
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
12:00:26
12:02:44
12:05:02
12:07:20
12:09:38
12:11:56
12:14:14
12:16:32
12:18:50
12:21:08
12:23:26
12:25:44
12:28:02
12:30:20
12:32:38
12:34:56
12:37:14
12:39:32
12:41:50
12:44:08
12:46:26
12:48:44
12:51:02
12:53:20
12:55:38
12:57:56
13:00:14
13:02:32
13:04:50
13:07:08
13:09:26
13:11:44
13:14:02
13:16:20
13:18:38
13:20:56
13:23:14
13:25:32
Time (HH:MM:SS)

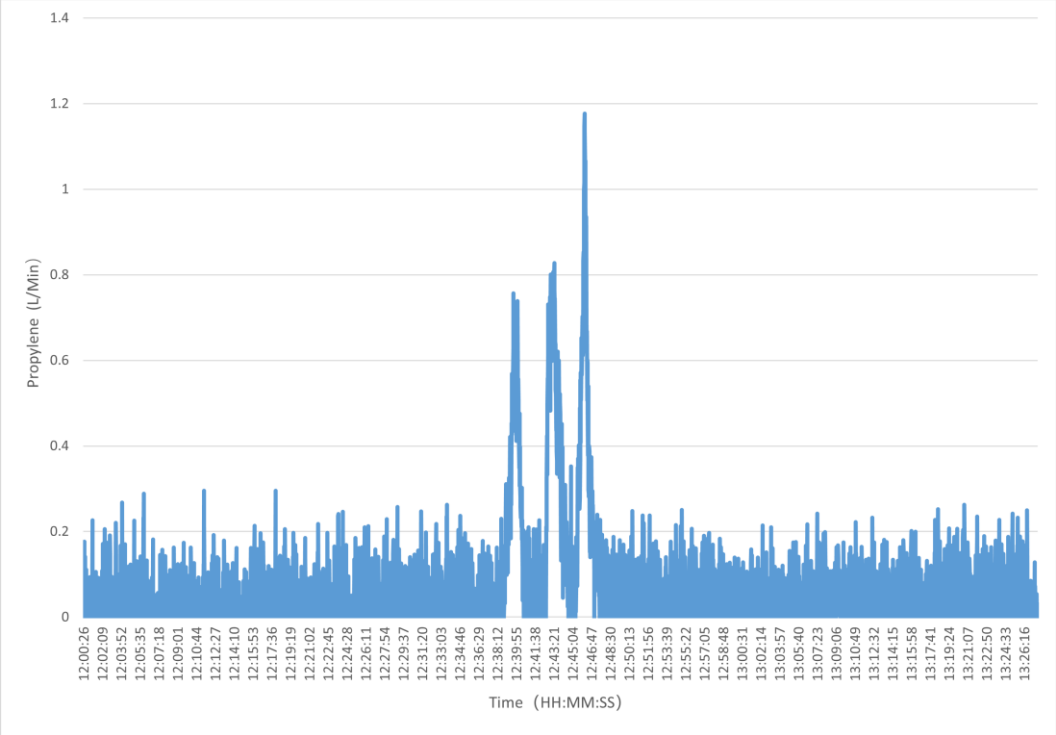


Figure 13 Hydrogen halide species:

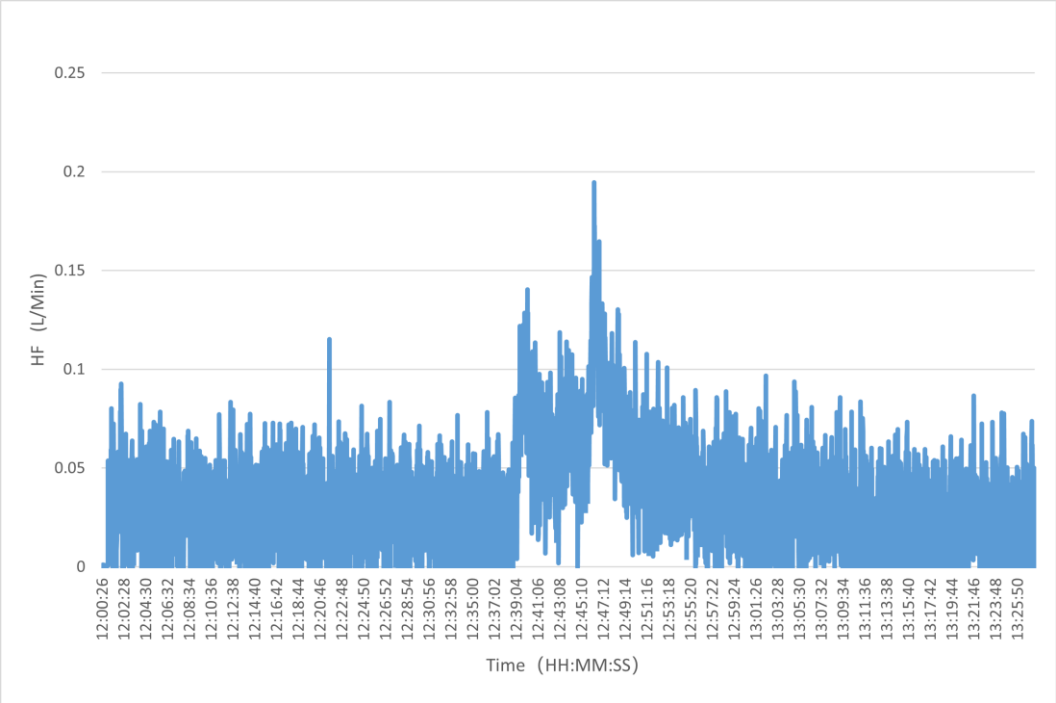
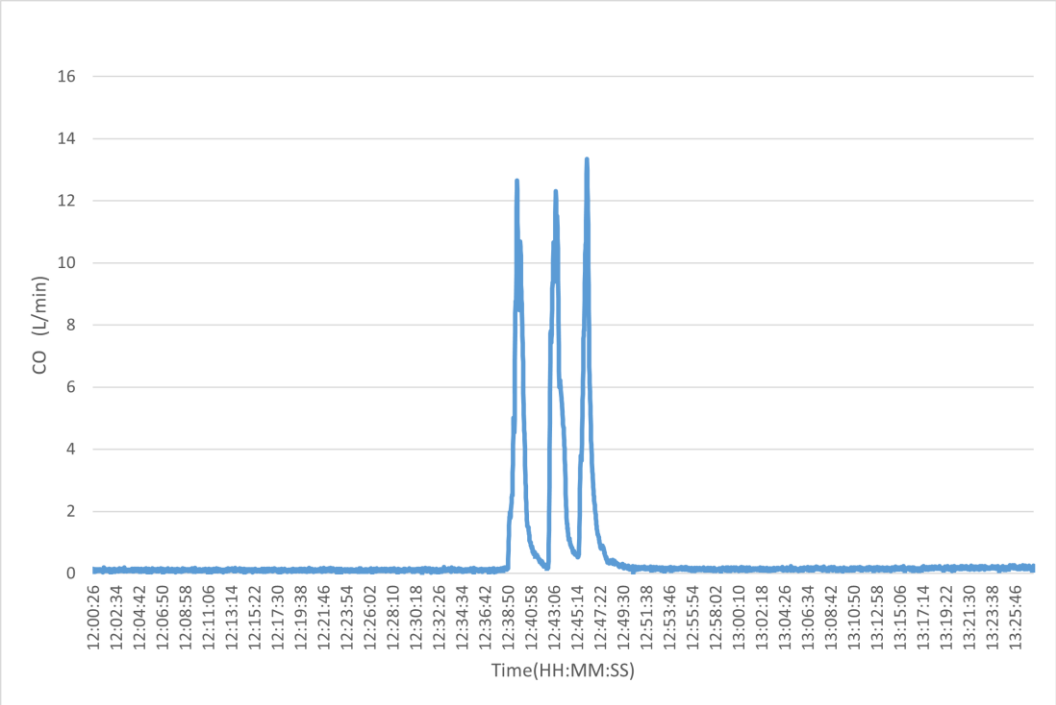


Figure 14 CO, CO2 concentration:



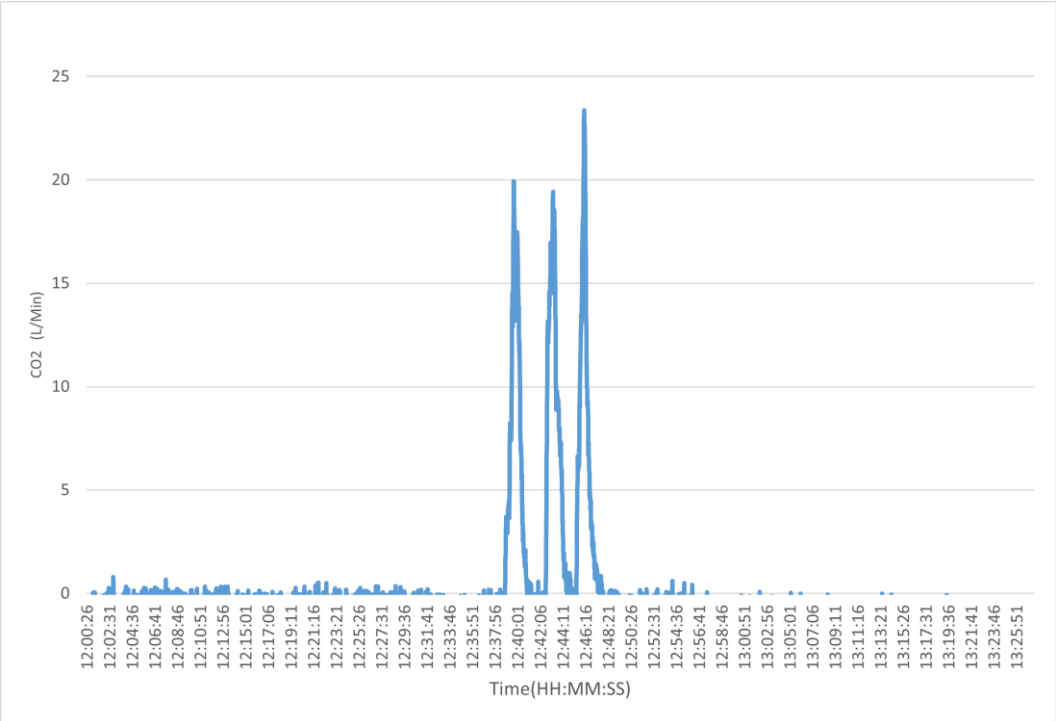


Figure 15 Total Hydrocarbons (equivalent to C3H8, measured by FID):

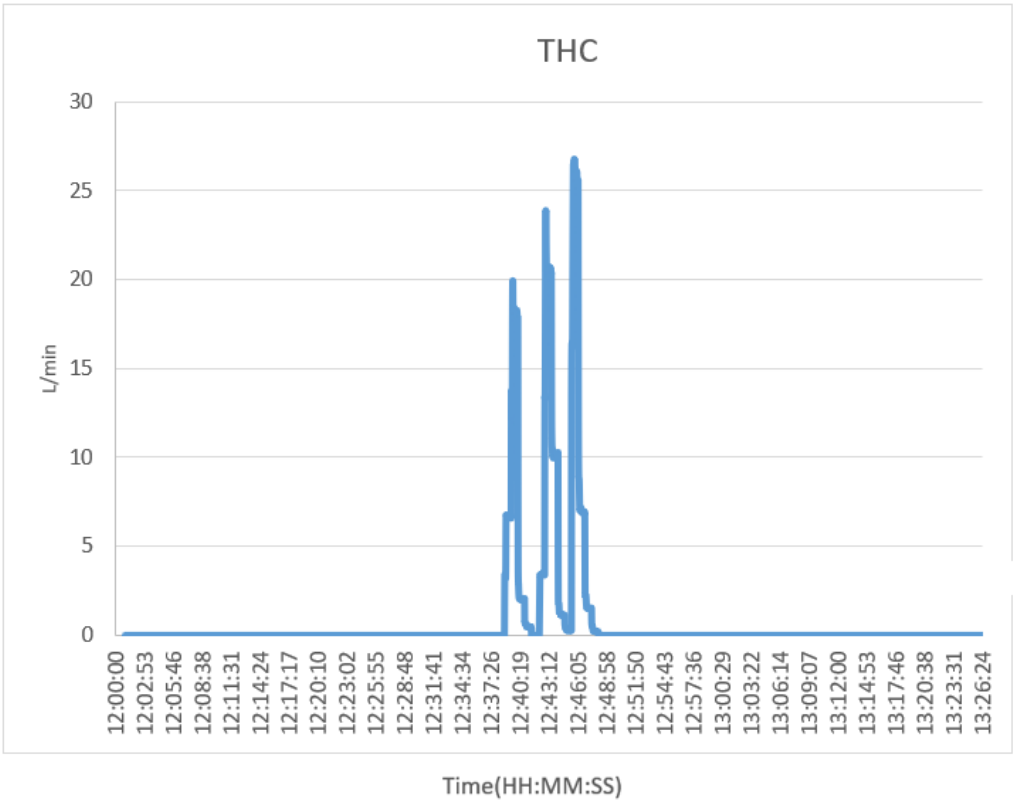
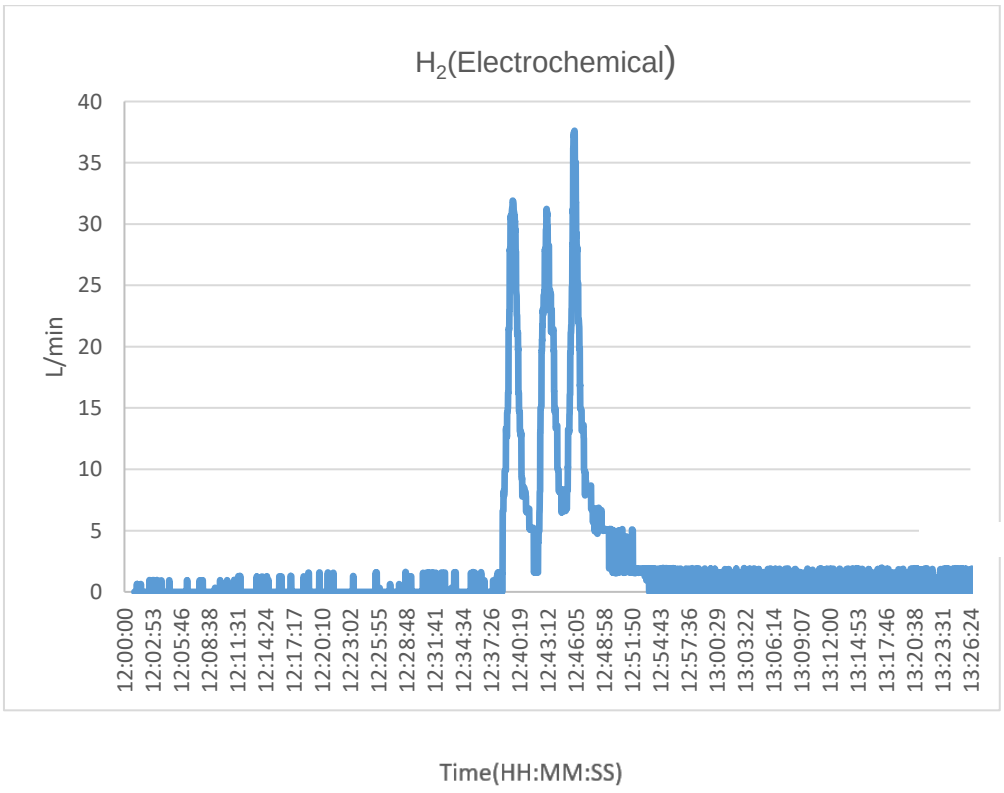
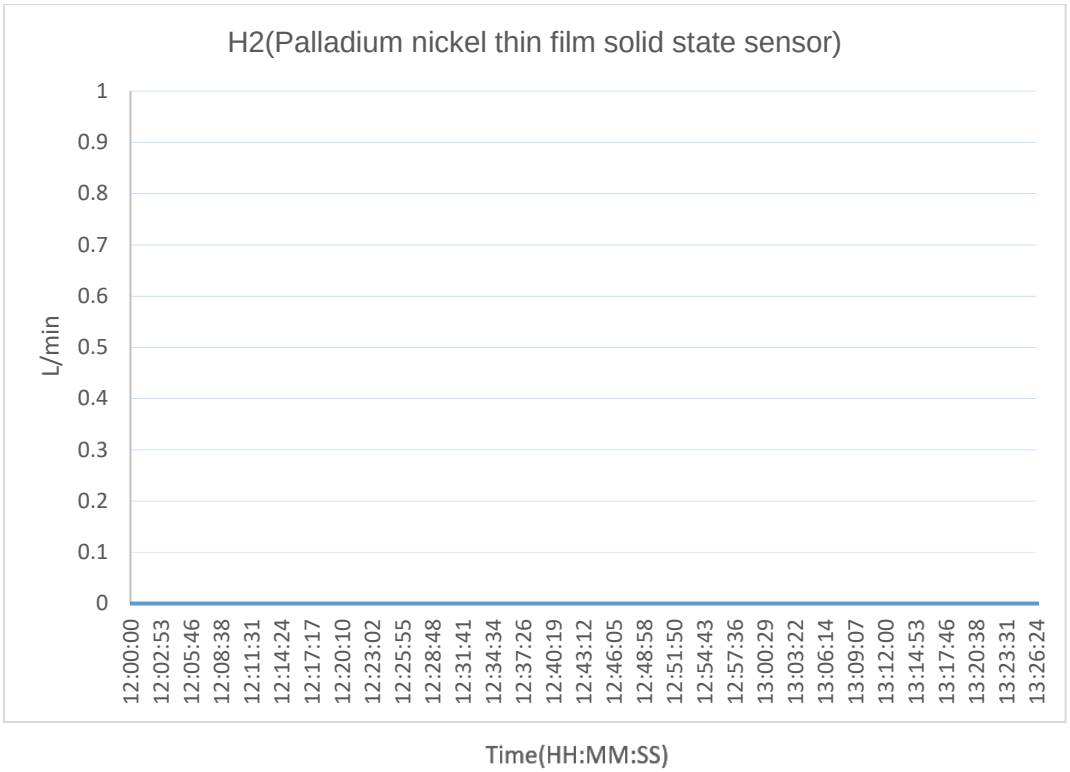
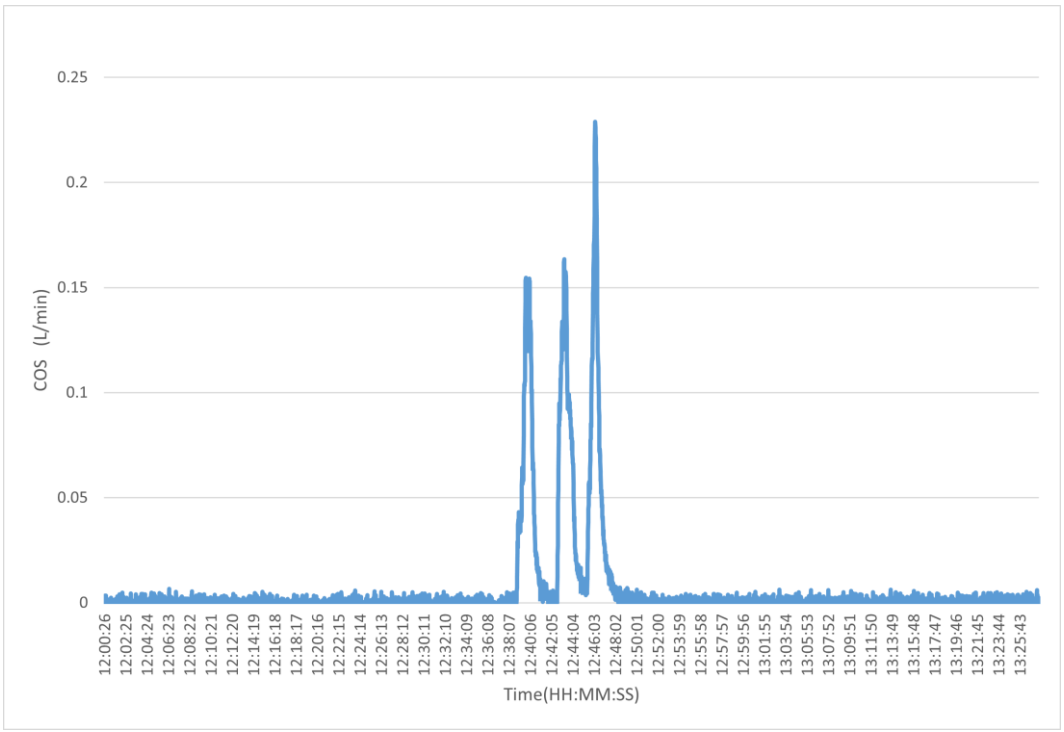
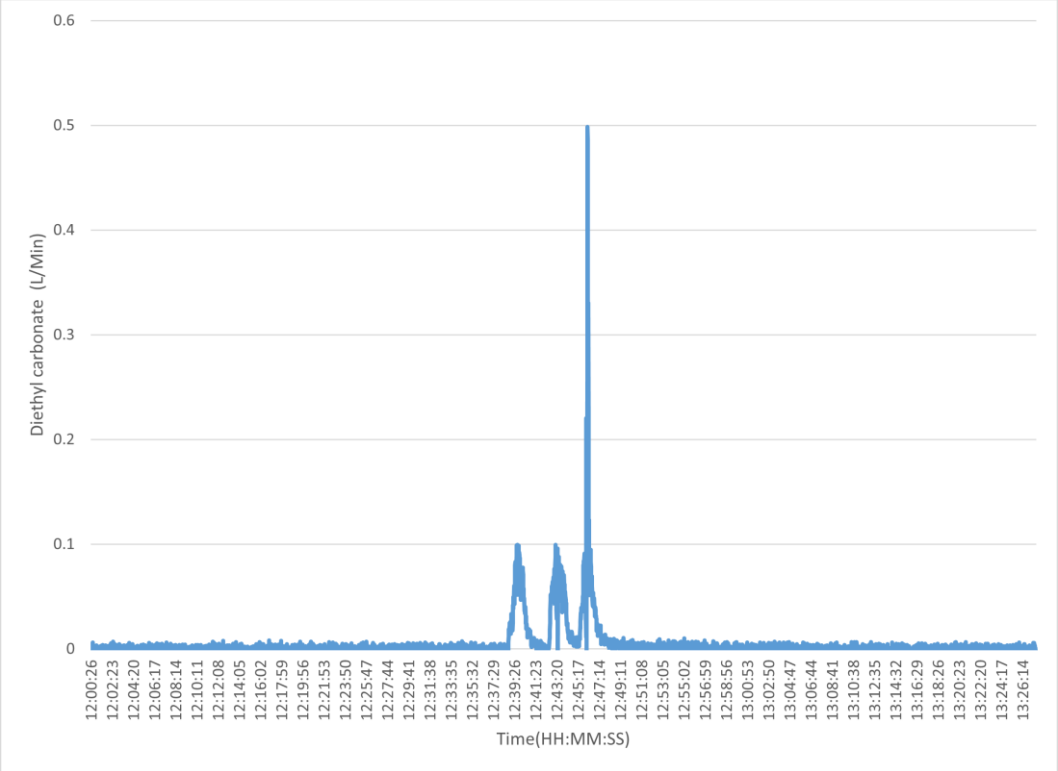


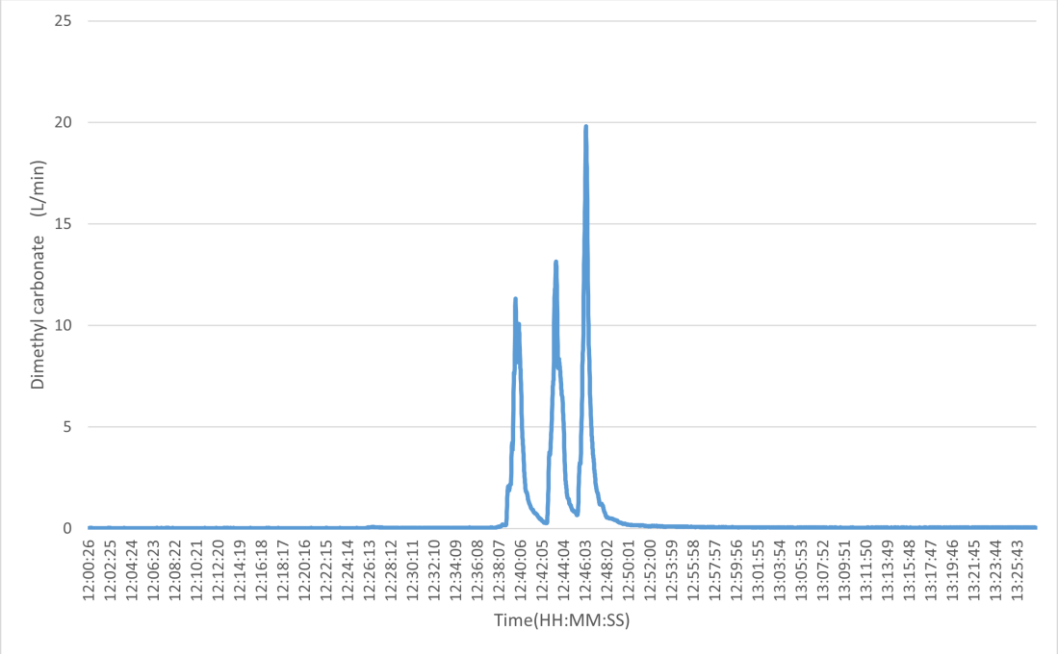
Figure 16 Others:

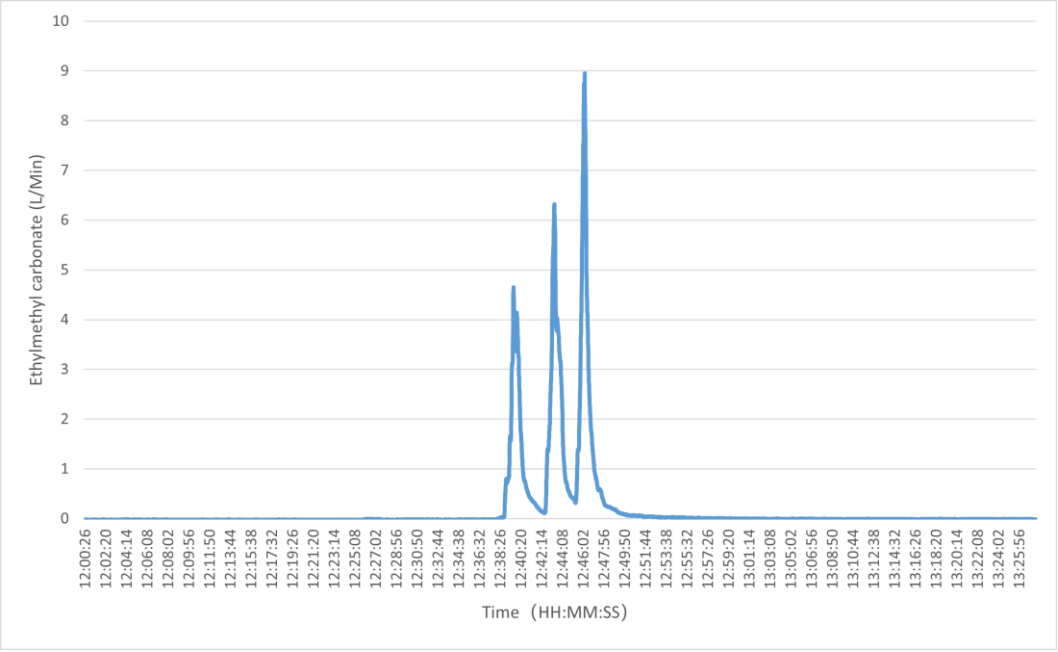


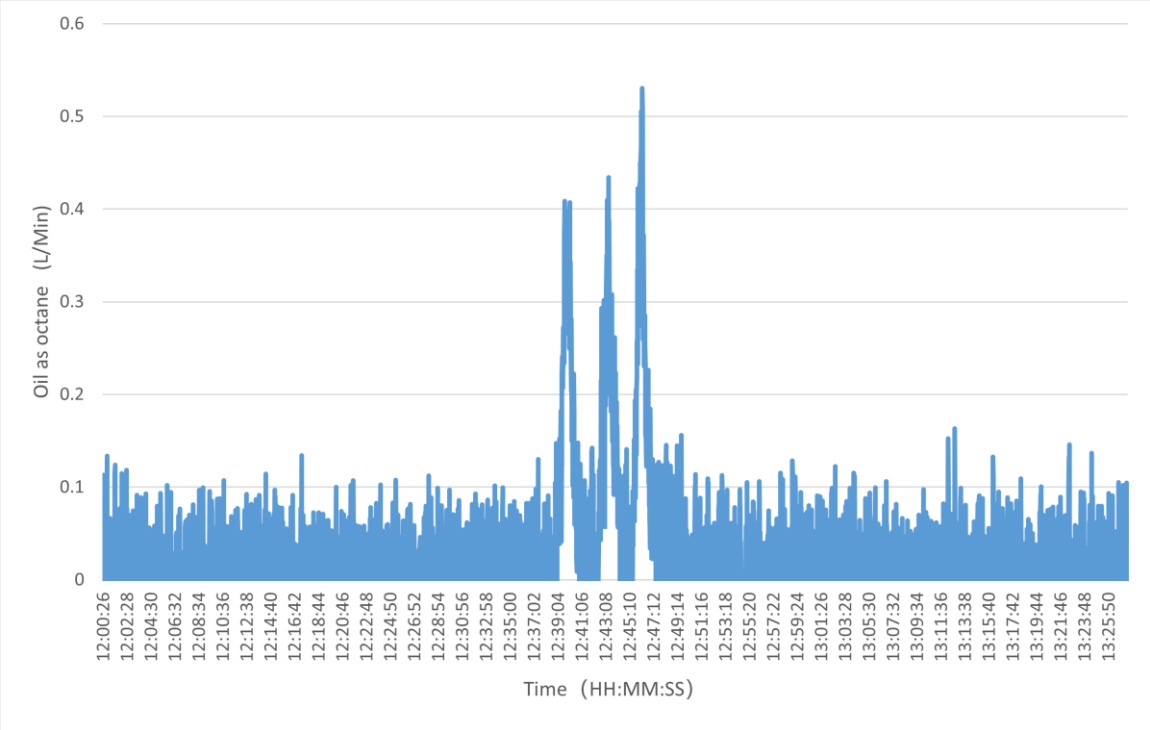

H2(Palladium nickel thin film solid state sensor)
L/min
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
12:00:00
12:02:53
12:05:46
12:08:38
12:11:31
12:14:24
12:17:17
12:20:10
12:23:02
12:25:55
12:28:48
12:31:41
12:34:34
12:37:26
12:40:19
12:43:12
12:46:05
12:48:58
12:51:50
12:54:43
12:57:36
13:00:29
13:03:22
13:06:14
13:09:07
13:12:00
13:14:53
13:17:46
13:20:38
13:23:31
13:26:24
Time(HH:MM:SS)


COS (L/min)
0.25
0.2
0.15
0.1
0.05
0
12:00:26
12:02:25
12:04:24
12:06:23
12:08:22
12:10:21
12:12:20
12:14:19
12:16:18
12:18:17
12:20:16
12:22:15
12:24:14
12:26:13
12:28:12
12:30:11
12:32:10
12:34:09
12:36:08
12:38:07
12:40:06
12:42:05
12:44:04
12:46:03
12:48:02
12:50:01
12:52:00
12:53:59
12:55:58
12:57:57
12:59:56
13:01:55
13:03:54
13:05:53
13:07:52
13:09:51
13:11:50
13:13:49
13:15:48
13:17:47
13:19:46
13:21:45
13:23:44
13:25:43
Time(HH:MM:SS)


0.6
0.5
0.4
0.3
0.2
0.1
0
Diethyl carbonate (L/Min)
12:00:26
12:02:23
12:04:20
12:06:17
12:08:14
12:10:11
12:12:08
12:14:05
12:16:02
12:17:59
12:19:56
12:21:53
12:23:50
12:25:47
12:27:44
12:29:41
12:31:38
12:33:35
12:35:32
12:37:29
12:39:26
12:41:23
12:43:20
12:45:17
12:47:14
12:49:11
12:51:08
12:53:05
12:55:02
12:56:59
12:58:56
13:00:53
13:02:50
13:04:47
13:06:44
13:08:41
13:10:38
13:12:35
13:14:32
13:16:29
13:18:26
13:20:23
13:22:20
13:24:17
13:26:14
Time(HH:MM:SS)

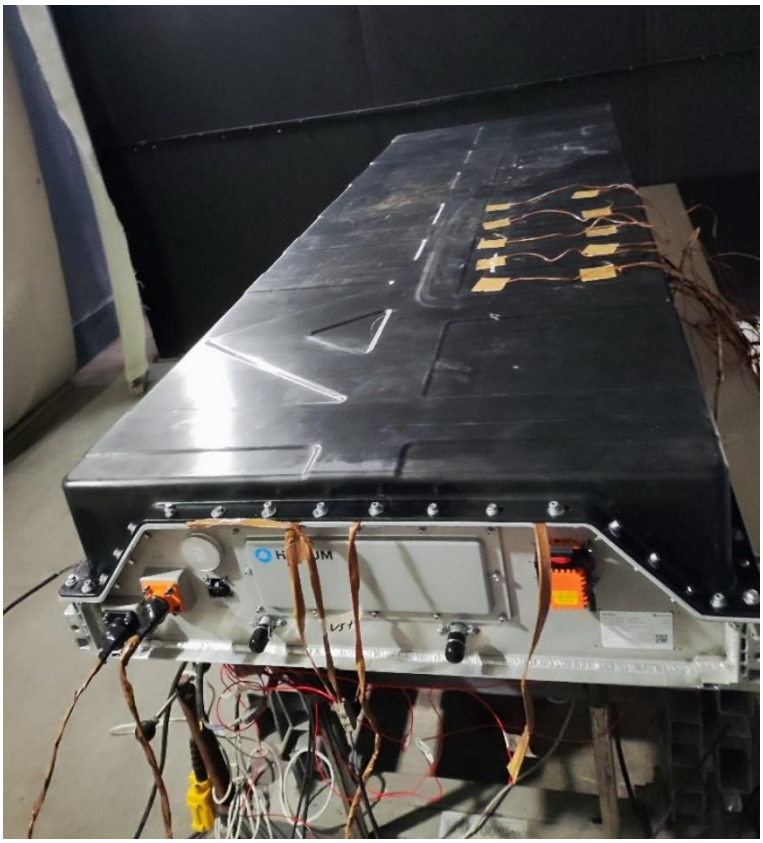

Dimethyl carbonate (L/min)
25
20
15
10
5
0
12:00:26
12:02:25
12:04:24
12:06:23
12:08:22
12:10:21
12:12:20
12:14:19
12:16:18
12:18:17
12:20:16
12:22:15
12:24:14
12:26:13
12:28:12
12:30:11
12:32:10
12:34:09
12:36:08
12:38:07
12:40:06
12:42:05
12:44:04
12:46:03
12:48:02
12:50:01
12:52:00
12:53:59
12:55:58
12:57:57
12:59:56
13:01:55
13:03:54
13:05:53
13:07:52
13:09:51
13:11:50
13:13:49
13:15:48
13:17:47
13:19:46
13:21:45
13:23:44
13:25:43
Time(HH:MM:SS)


Ethylmethyl carbonate (L/Min)
10
9
8
7
6
5
4
3
2
1
0
12:00:26
12:02:20
12:04:14
12:06:08
12:08:02
12:09:56
12:11:50
12:13:44
12:15:38
12:17:32
12:19:26
12:21:20
12:23:14
12:25:08
12:27:02
12:28:56
12:30:50
12:32:44
12:34:38
12:36:32
12:38:26
12:40:20
12:42:14
12:44:08
12:46:02
12:47:56
12:49:50
12:51:44
12:53:38
12:55:32
12:57:26
12:59:20
13:01:14
13:03:08
13:05:02
13:06:56
13:08:50
13:10:44
13:12:38
13:14:32
13:16:26
13:18:20
13:20:14
13:22:08
13:24:02
13:25:56
Time (HH:MM:SS)


0.6
0.5
0.4
0.3
0.2
0.1
0
Oil as octane (L/Min)
12:00:26
12:02:28
12:04:30
12:06:32
12:08:34
12:10:36
12:12:38
12:14:40
12:16:42
12:18:44
12:20:46
12:22:48
12:24:50
12:26:52
12:28:54
12:30:56
12:32:58
12:35:00
12:37:02
12:39:04
12:41:06
12:43:08
12:45:10
12:47:12
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12:53:18
12:55:20
12:57:22
12:59:24
13:01:26
13:03:28
13:05:30
13:07:32
13:09:34
13:11:36
13:13:38
13:15:40
13:17:42
13:19:44
13:21:46
13:23:48
13:25:50
Time (HH:MM:SS)

3.7 Photos

Module before test





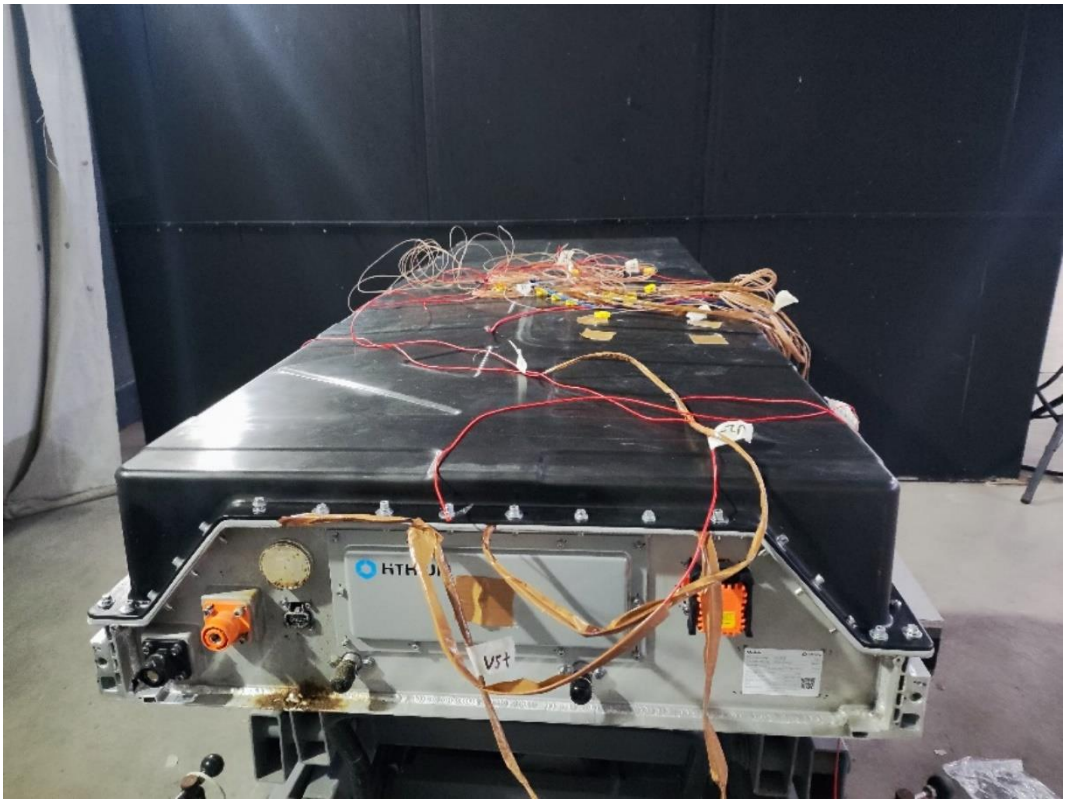


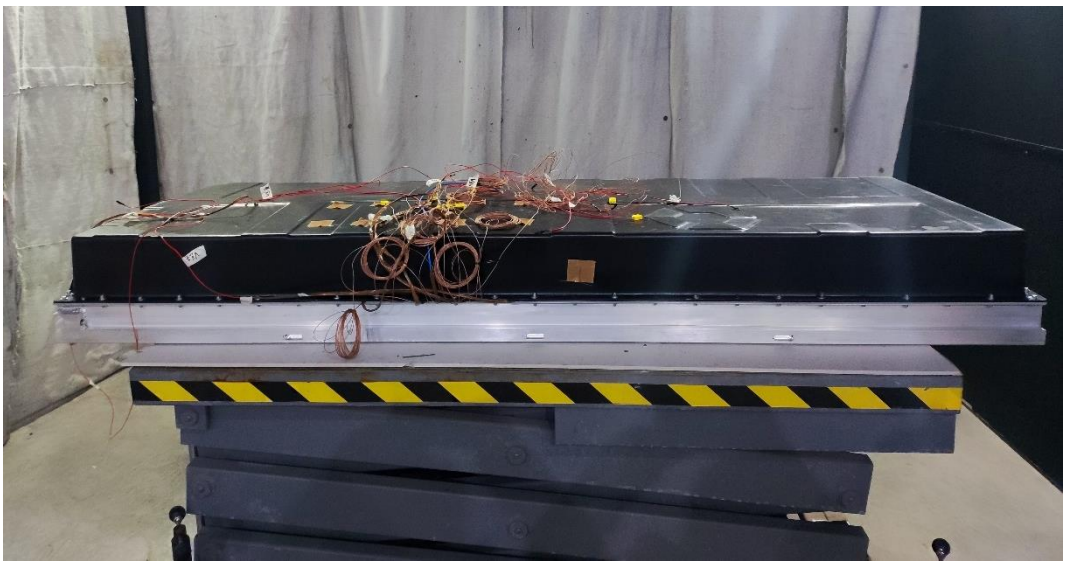

HTHIUM

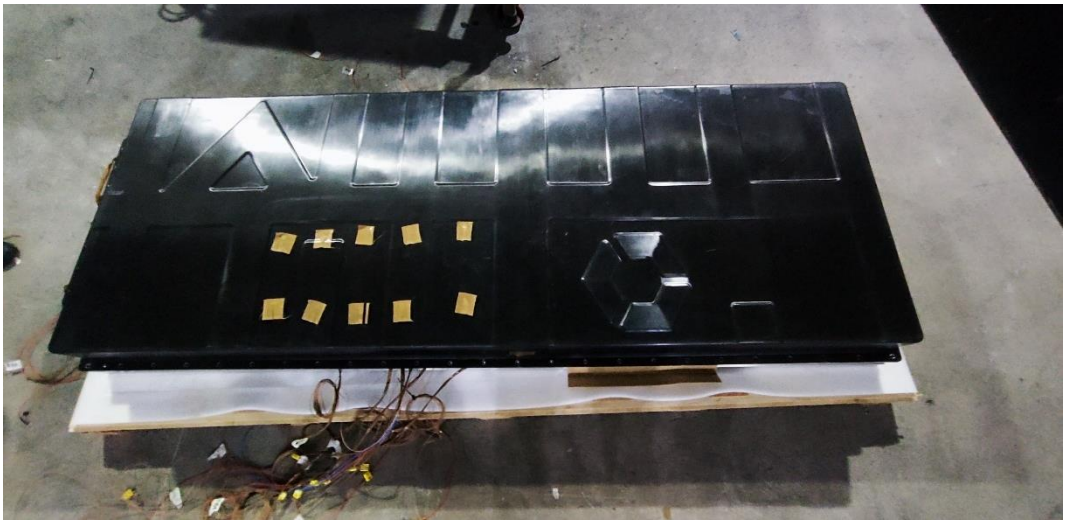
Smoke release during test



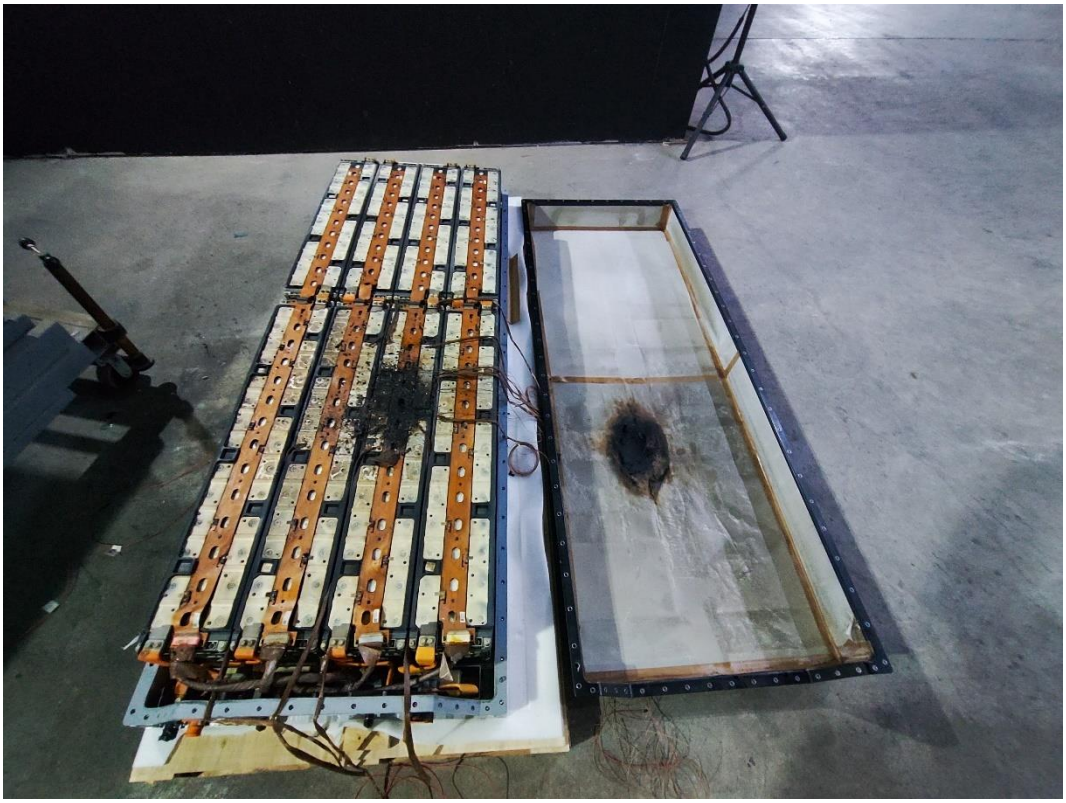
Sample after test







Damage of the internal components





3.8 List of test and measurements instruments:

No.	Equipment	Model	Rating	Inventory no.	Last Cal. date
1	Ambient temperature and humidity	COS-03	0°C ~50°C, 30%RH~95%RH	D-ZNDW23052402	2023.05.24
2	Data acquisition equipment	LR8450-01	0~1100°C	0221-0704-06	2023.10.19
3	Electronic scale	OCS-2t/1kg	1kg~2000kg	0221-0704-10	2023.11.19
4	Paramagnetic oxygen analyser	AO2020	Oxygen measurement: 6.02%vol~24%vol; Hydrogen concentration: 1%~3%; Carbon monoxide: 0.2%~0.8%; Carbon dioxide concentration: 2%~8%	0221-0704-03	2023.03.06
5	Velocity probe	DYM3	800~1060hPa	D-ZNDW23032210	2023.03.10
7	Fourier-Transform Infrared Spectrometer	MULTIGAS 6030	Methane, propane, acetylene concentration: 100μmol/mol~1000μmol/mol; Carbon monoxide concentration: 0.2%~0.8%	0221-0704-08	2023.03.06
9	Palladium-nickel thin-film solid state sensor	HY-OPTIMA-2720	Range: 0.4%~5.0%	0221-0704-01	2023.03.20
10	Flame ionization detector	AO2040	Methane concentration: 100μmol/mol~500μmol/mol	0221-0704-04	2023.03.06
11	Thermopile	TJ120-CAXL-116U-80	0~300°C	0221-0704-31	2023.10.22

Remark: Calibration of equipment is valid for 1 year.

End of Test Report

B.6. UL9540A:2019 - Unit Level Test Report

Test report provided on subsequent pages.

Prüfbericht-Nr.: *Test report no.*:	**CN244DBX 001**	**Auftrags-Nr.:** *Order no.*:	**168460578**	
Kunden-Referenz-Nr.: *Client reference no.:*	2347845	**Auftragsdatum:** *Order date:*	2023-12-28	
Auftraggeber: *Client:*	**Xiamen Hithium Energy Storage Technology Co., Ltd.** No.1 Benyuan Road, Tongxiang High - Tech Zone, Xiamen, Fujian, China			
Prüfgegenstand: *Test item:*	Battery cluster			
Bezeichnung / Typ-Nr.: *Identification / Type no.:*	LC083502			
Auftrags-Inhalt: *Order content*:	Test report			
Prüfgrundlage: *Test specification:*	UL 9540A: 2019 (Fourth Edition)			

Wareneingangsdatum: *Date of sample receipt:*	2024-03-01
Prüfmuster-Nr.: *Test sample no:*	Engineering samples
Prüfzeitraum: *Testing period:*	2024-03-02 to 2024-03-07
Ort der Prüfung: *Place of testing:*	See page 5
Prüflaboratorium: *Testing laboratory:*	TÜV Rheinland (Shenzhen) Co., Ltd.
Prüfergebnis*: *Test result*:*	See main report.



erstellt von: *created by:*		**genehmigt von:** *authorized by*:	
Datum: *Date:* 2024-04-26	Stephen Huang	**Ausstellungsdatum:** *Issue date:* 2024-04-26	Xun Yu
Stellung / *Position:*	Project Engineer	**Stellung** / *Position:*	Reviewer

Sonstiges / *Other:* This report does not evidence compliance of the provided sample with the relevant standards but only with the referred tests. This test report documents the findings of examination conducted on the delivered product mentioned above only. This report does not entitle the applicant to carry any safety mark on this or similar products. Further for sales or other application purposes of the tested product, any reference to TÜV Rheinland or a test through TÜV Rheinland is only permissible with prior written consent of TÜV Rheinland.

Zustand des Prüfgegenstandes bei Anlieferung: Prüfmuster vollständig und unbeschädigt
Condition of the test item at delivery: *Test item complete and undamaged*

* Legende:	P(ass) = entspricht o.g. Prüfgrundlage(n)	F(ail) = entspricht nicht o.g. Prüfgrundlage(n)	N/A = nicht anwendbar	N/T = nicht getestet
* *Legend:*	*P(ass) = passed a.m. test specification(s)*	*F(ail) = failed a.m. test specification(s)*	*N/A = not applicable*	*N/T = not tested*

Dieser Prüfbericht bezieht sich nur auf das o.g. Prüfmuster und darf ohne Genehmigung der Prüfstelle nicht auszugsweise vervielfältigt werden. Dieser Bericht berechtigt nicht zur Verwendung eines Prüfzeichens.
This test report only relates to the a. m. test sample. Without permission of the test center this test report is not permitted to be duplicated in extracts. This test report does not entitle to carry any test mark.

Anmerkungen
Remarks

1	Alle eingesetzten Prüfmittel waren zum angegebenen Prüfzeitraum gemäß eines festgelegten Kalibrierungsprogramms unseres Prüfhauses kalibriert. Sie entsprechen den in den Prüfprogrammen hinterlegten Anforderungen. Die Rückverfolgbarkeit der eingesetzten Prüfmittel ist durch die Einhaltung der Regelungen unseres Managementsystems gegeben. Detaillierte Informationen bezüglich Prüfkonditionen, Prüfequipment und Messunsicherheiten sind im Prüflabor vorhanden und können auf Wunsch bereitgestellt werden. *The equipment used during the specified testing period was calibrated according to our test laboratory calibration program. The equipment fulfils the requirements included in the relevant standards. The traceability of the test equipment used is ensured by compliance with the regulations of our management system.* *Detailed information regarding test conditions, equipment and measurement uncertainty is available in the test laboratory and could be provided on request.*
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3	Prüfklausel mit der Note * wurden an qualifizierte Unterauftragnehmer vergeben und sind unter der jeweiligen Prüfklausel des Berichts beschrieben. Abweichungen von Prüfspezifikation(en) oder Kundenanforderungen sind in der jeweiligen Prüfklausel im Bericht aufgeführt. *Test clauses with remark of * are subcontracted to qualified subcontractors and descripted under the respective test clause in the report.* *Deviations of testing specification(s) or customer requirements are listed in specific test clause in the report.*
4	Die Entscheidungsregel für Konformitätserklärungen basierend auf numerischen Messergebnisen in diesem Prüfbericht basiert auf der "Null-Grenzwert-Regel" und der "Einfachen Akzeptanz" gemäß ILAC G8:2019 und IEC Guide 115:2021, es sei denn, in der auf Seite 1 dieses Berichts genannten angewandten Norm ist etwas anderes festgelegt oder vom Kunden gewünscht. Dies bedeutet, dass die Messunsicherheit nicht berücksichtigt wird und daher auch nicht im Prüfbericht angegeben wird. Zu weiteren Informationen bezueglich des Risikos durch diese Entscheidungsregel siehe ILAC G8:2019. *The decision rule for statements of conformity, based on numerical measurement results, in this test report is based on the "Zero Guard Band Rule" and "Simple Acceptance" in accordance with ILAC G8:2019 and IEC Guide 115:2021, unless otherwise specified in the applied standard mentioned on Page 1 of this report or requested by the customer. This means that measurement uncertainty is not taken in account and hence also not declared in the test report. For additional information to the resulting risk based of this decision rule please refer to ILAC G8:2019.*

INTRODUCTION

Model fire codes and energy storage system standards require energy storage systems to comply with UL 9540, which in turn requires battery cells and modules to comply with UL 1973. Compliance with these standards reduces the risk of batteries and battery energy storage systems (BESS) creating fire, shock or personal injury hazards. However, they don't evaluate the ability of the BESS installed as intended and with fire suppression mechanisms in place if necessary, from contributing to a fire or explosion in the end use installations.

To address these fire and explosion hazards associated with the installation of a BESS, the fire and other codes require energy storage systems to meet certain location, separation, fire suppression and other criteria. Those codes also provide a means to provide an equivalent level of safety based on large scale fire testing of anticipated BESS installations.

UL 9540A is intended to provide a test method that can be used as a basis for validating the safety of a BESS installation in lieu of meeting the specific criteria provided in those codes. The data generated can be used to determine the fire and explosion protection required for installation of a BESS.

The test method is initiated through the establishment of a thermal runaway condition that leads to combustion within the BESS. The test method outlined in UL 9540A consists of several steps – cell level testing, module level testing, unit level testing and installation level testing. The cell and module level testing steps are information gathering steps to inform the unit and installation level testing.

The following outlines the information that may be gathered as part of the testing:

a) Cell level – An individual cell fails in a manner that leads to thermal runaway and fire through a suitable method such as external heating. Data such as off-gassing contents, temperatures at venting and temperatures at thermal runaway are recorded.

b) Module level – One or more cells within a BESS module fail in the manner determined during the cell level testing. Data such as fire propagation in the module, temperatures on the failed cells and surrounding cells, off-gassing contents and heat release data are gathered.

c) Unit level – A complete BESS is installed surrounded by target (e.g. dummy) BESS and walls separated at a distance as intended in its installation. The module level test is repeated on a module located in the BESS in the most unfavorable location. Data such as temperature within the BESS, on surrounding walls and target BESS; incident heat flux on walls and target BESS; observation of fire propagation from BESS to target units and walls as well as observance of explosions or evidence of re-ignition within the BESS; and heat release and off-gassing contents are gathered.

d) Installation level – This test is a repeat of the unit level test with the test conducted within a test room and with the intended fire suppression system installed as well as any overhead cables (that can lead to fire propagation) installed. This test is intended to validate the fire suppression system for the BESS installation. Data such as temperature within the BESS, on surrounding walls and target BESS; incident heat flux on walls and target BESS; fire propagation from the BESS to target units, walls or overhead cables and any observable explosion incidents or re-ignition within the BESS; and off-gassing contents (if needed) and heat release are gathered.

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1 General information

1.1 Test specification

Standard: ANSI/CAN/UL 9540A: 2019 (Fourth Edition)

Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems

This report presents the result of unit level tests of UL 9540A: 2019.

All tests were conducted at TUV Rheinland (Shenzhen) Co., Ltd. and TUV Rheinland's partner labs that were under supervision of TÜV Rheinland's engineer.

Testing period: 2024-03-02 to 2024-03-07

Refer to Clause 4 for test and measurement instruments.

1.2 General remarks

This report is descriptive and provide the test data only.

The test results presented in this report relate only to the object tested.

This report shall not be reproduced, except in full, without the written approval of the testing laboratory.

Throughout this report a ☐ comma / ☒ point is used as the decimal separator.

1.3 Revision information

New report, not applicable.

1.4 Definitions

CELL – The basic functional electrochemical unit containing an assembly of electrodes, electrolyte, separators, container, and terminals. It is a source of electrical energy by direct conversion of chemical energy.

MODULE – A subassembly that is a component of a BESS that consists of a group of cells or electrochemical capacitors connected together either in a series and/or parallel configuration (sometimes referred to as a block) with or without protective devices and monitoring circuitry.

UNIT – A frame, rack or enclosure that consists of a functional BESS which includes components and subassemblies such as cells, modules, battery management systems, ventilation devices and other ancillary equipment.

BATTERY SYSTEM (BS) – Is a component of a BESS and consists of one or more modules typically in a rack configuration, controls such as the BMS and components that make up the system such as cooling systems, disconnects and protection devices.

BATTERY ENERGY STORAGE SYSTEM (BESS) – Stationary equipment that receives electrical energy and then utilizes batteries to store that energy to supply electrical energy at future time. The BESS, at a minimum consists of one or more modules, a power conditioning system (PCS), battery management system (BMS) and balance of plant components.

a) INITIATING BATTERY ENERGY STORAGE SYSTEM UNIT (INITIATING BESS) – A BESS unit which has been equipped with resistance heaters in order to create the internal fire condition necessary for the installation level test.

b) TARGET BATTERY ENERGY STORAGE SYSTEM UNIT (TARGET BESS) – The enclosure and/or rack hardware that physically supports and/or contains the components that comprise a BESS. The target BESS unit does not contain energy storage components, but serves to enable instrumentation to measure the thermal exposure from the initiating BESS.

Note: Depending upon the configuration and design of the BESS (e.g. the BESS is composed of multiple separate parts within separate enclosures), the unit level test can be done at battery system level. In such case, the BESS is be read as BS throughout this report.

NON-RESIDENTIAL USE – Intended for use in commercial, industrial or utility owned locations.

RESIDENTIAL USE – In accordance with this standard, intended for use in one or two family homes and town homes and individual dwelling units of multi-family dwellings.

THERMAL RUNAWAY- The incident when an electrochemical cell increases its temperature through self-heating in an uncontrollable fashion. The thermal runaway progresses when the cell's generation of heat is at a higher rate than the heat it can dissipate. This may lead to fire, explosion and gas evolution.

STATE OF CHARGE (SOC) – The available capacity in a BESS, pack, module or cell expressed as a percentage of rated capacity.

2 General Product Information

The product information and parameters were provided by the client as below.

2.1 Cell

Manufacturer:	**Xiamen Hithium Energy Storage Technology Co., Ltd.** 201-1, Comprehensive Building 5, No. 11, Butang Middle Road, Industrial Base Of Xiamen Torch High Tech Zone (Tongxiang), Xiamen, Fujian P.R. China	
Model number:	LFP71173207/314Ah	
Chemistry:	☒ $LiFePO_4$ ☐ NMC ☐ NCA ☐ LTO ☐ Other:	
Physical configuration:	☒ Prismatic ☐ Cylindrical ☐ Pouch	
	Weight(kg):	5.60±0.20
Electrical rating :	Rated capacity (Ah):	314 (25°C±2°C)
	Nominal voltage (V):	3.2
Standard charge method:	Charge current (A):	157(25°C±2°C)
	Standard Charge Voltage (V):	3.65
	Cut off current (A):	/
Standard discharge method:	Discharge current (A):	157(25°C±2°C)
	End of discharge voltage (V):	2.5(T>0°C) 2.0(T≤0°C)
Maximum continuous charge current (A):	314(25°C±2°C)	
Maximum continuous discharge current (A):	314(25°C±2°C)	
Compliance with UL 1973:	☒ Yes TUV Report No.: CN23RGEH 001 ☐ No	

Cell level test information

Cell level thermal runaway test information is copy from TUV Rheinland UL 9540A cell level test report No.: CN23F118 001

Thermal Runaway Methodology:	External heater applied on one side of the cell with surface heating rate at about of 5°C per minute until thermal runaway triggered.
Average Cell Surface Temperature at Gas Venting:	203.7°C
Average Cell Surface Temperature Start Thermal Runaway:	295.7°C

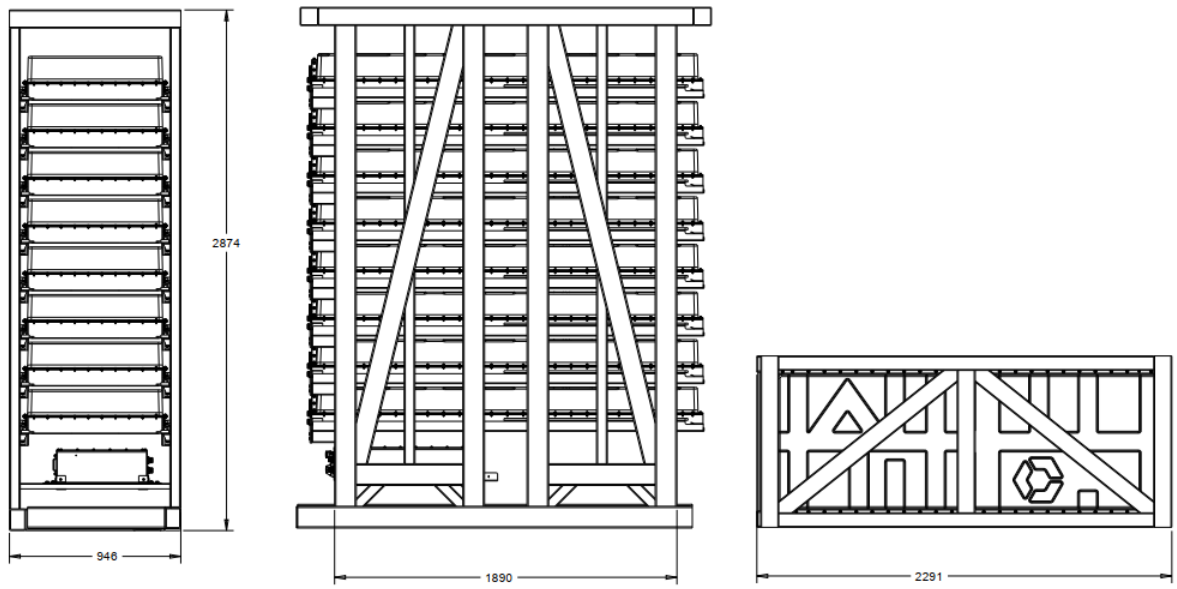
2.2 Module

Manufacturer:	**Xiamen Hithium Energy Storage Technology Co., Ltd.** 201-1, Comprehensive Building 5, No. 11, Butang Middle Road, Industrial Base Of Xiamen Torch High Tech Zone (Tongxiang), Xiamen, Fujian, P.R. China	
Model number:	LM010401-A	
Physical configuration:	Metal base, the other sides are non-metallic material. A mica plate is installed under the top enclosure.	
	Weight:	680 ±10 kg
	Cells in series/parallel:	2P52S
Cooling method:	Liquid cooling	
Separation between cells:	Thermal insulation sheet: Aerogel Heat insulation pad and Polyurethane foam, see Figure 4 for install location details.	
Electrical rating:	Rated capacity:	628 Ah
	Nominal voltage:	166.4Vdc
Standard charge method:	Charge power:	52.25KW
	End of charge:	The highest cell voltage reaches 3.65 V
Standard discharge method:	Discharge power:	52.25KW
	End of discharge:	The lowest cell voltage reaches 2.5 V
Compliance with UL 1973:	☐ Yes	☒ No

2.3 Unit

Product name	Battery cluster
Model	LC083502
Voltage range	1040 VDC – 1500 VDC
Nominal voltage	1331.2VDC
Rated capacity	628Ah
Operating Temperature	0-55°C(Cell)(Charge), -30-55°C(Cell)(Discharge)
Recommend charging method declared by the manufacturer	Charged with constant power 417.996kW till cell voltage reaches 3.65V, at 25±2°C.
Recommend discharging method declared by the manufacturer	Discharged with constant power 417.996kW till cell voltage reaches 2.5V, at 25±2°C.
Nominal mass	6500±500kg
External dimensions (mm)	L*W*H: 946*2291*2874

Unit diagram with overall dimension, Unit: mm:



2.4 Photo



Unit

3 Unit level test (section 9 of UL 9540A)

3.1 General

Unit level testing corresponds with the testing anticipated by fire codes and other codes impacting energy storage system installations to evaluate the large scale fire performance of BESS units installed in, on or adjacent to buildings or in other areas and their resultant performance to qualify for exceptions to limits in the codes imposed on these installations. The limitations where exceptions may be sought are limitations on the size of the individual BESS units, the total number of BESS units installed within a room, and the separation distances between BESS units and between BESS units and walls of the building.

In this test the initiating BESS unit is placed a set distance from target BESS units simulating BESS units identical to the initiating BESS unit, and from simulated walls representative on the installation. A thermal runaway is induced in cells, using the same approach as used in the module level testing within one of the modules in the initiating BESS, and a variety of measurements are taken. The results are intended to be used to verify that a fire within a single BESS unit will not spread to other units, nor breach the walls or the BESS enclosure (if provided), and there shall be no flying debris or explosive discharge of gases.

The test arrangement include the largest (energy) BESS unit for the installation to be represented by the test, and minimum spacing to adjacent walls and BESS units. The BESS may be tested with an internal fire suppression system provided by the manufacturer if that fire suppression system is required to be installed in the BESS. Optional internal fire suppression systems are not included in the unit level testing.

The test monitors the fire behavior of the BESS unit and measures heat release rates (convective and chemical); gas generation and composition; smoke release rate; maximum heat flux on the target BESS units, wall surfaces and within the accessible means of egress; maximum surface temperatures of the walls and modules within the target BESS units; and documents any explosions, deflagrations and flying debris from the BESS under test.

3.2 Unit sample preparation

The battery rack is constructed with 8 modules that was considered as a unit for purposes of the test.

All 8 modules samples through 3 charge/discharge cycles per the manufacturer's instructions to verify that the module was functional. Each cycle was defined as a charge to 100% SOC and allowed to rest 30 minutes and then discharged to an end of discharge voltage (EODV) determined by the module specification. Refer to 2.2 for the end of condition of charge and discharge.

3.3 Setup of the test

3.3.1 Battery system installation information

The installation information was provided by the client as below.

Intended use location.....:	☐ Residential	☒ Non-residential
	☐ Non-residential rooftop	
	☐ Non-residential open garage use	
Type of installation.....:	☒ Indoor	☐ Outdoor
	☒ Floor/ground mounted	☐ Wall mounted
Row(s) of installation	☒ Single	☐ Multiple

3.3.2 Test site setup

Walls were constructed of 16-mm (5/8-in) gypsum wall board and painted flat black.

Two units were used for the purpose of the test.

The initiating unit was positioned adjacent to the three instrumented wall sections.

Minimum separation distance from the unit to wall and between unit were provided by the client, separation distance: A=B=21mm, C=70mm, D=0mm, E=F=134mm,

Unit's layout can be seen in Figure 1.

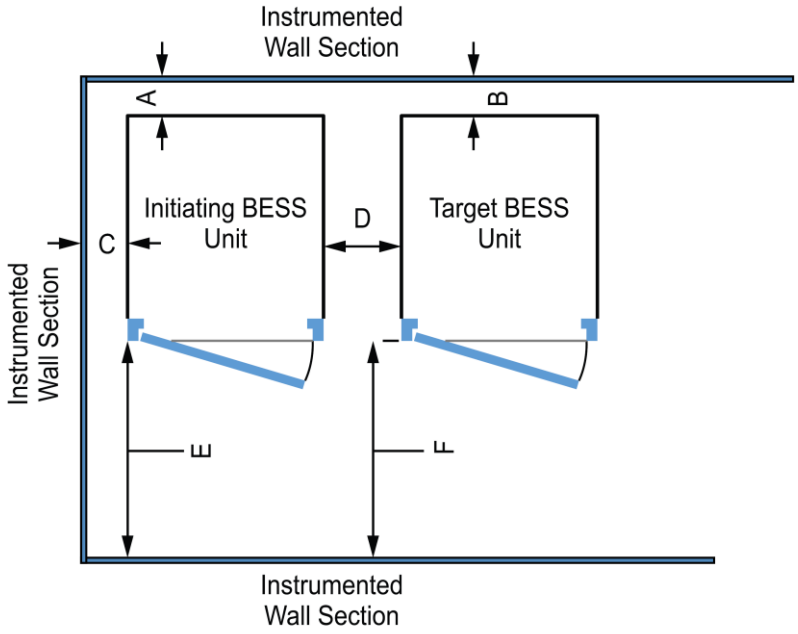


Figure 1 Layout of BESS units

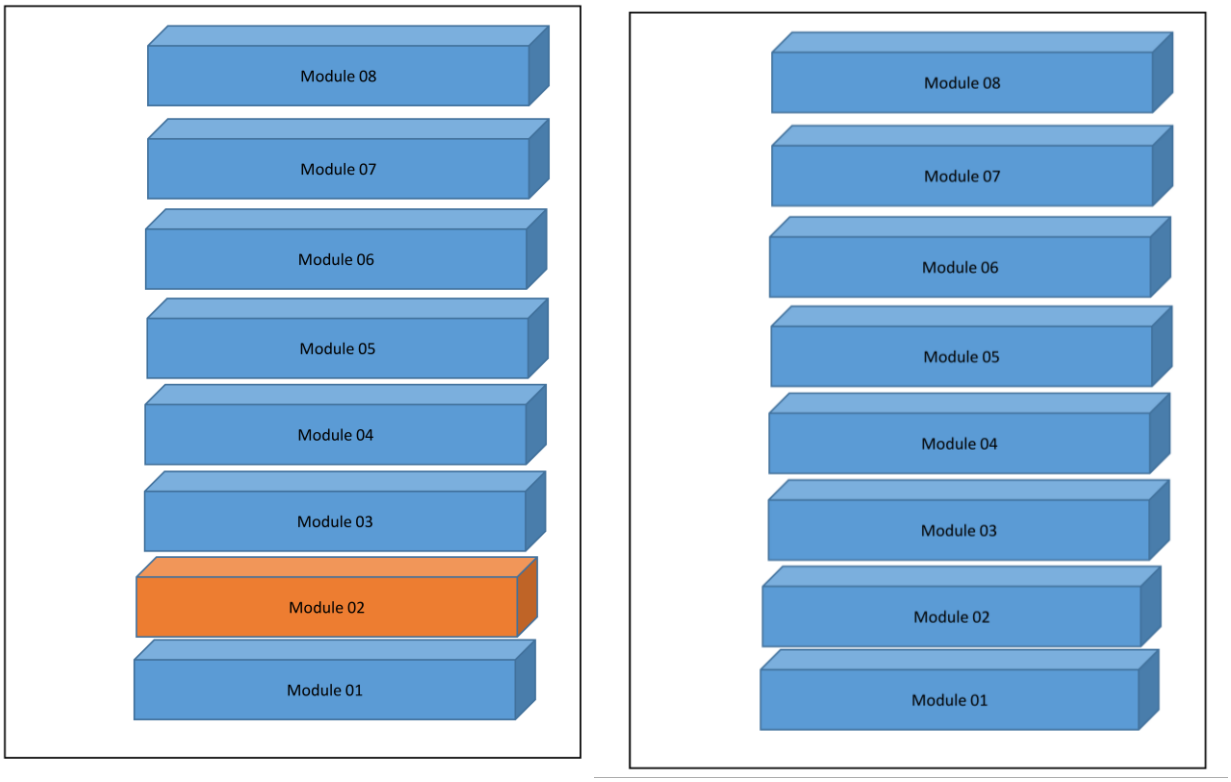
3.3.3 Thermal runaway setup

Setup of Unit:

There were two units were marked as initiating unit and target unit, one was initiating unit, and the other was target unit. Each unit had been installed 8 modules.

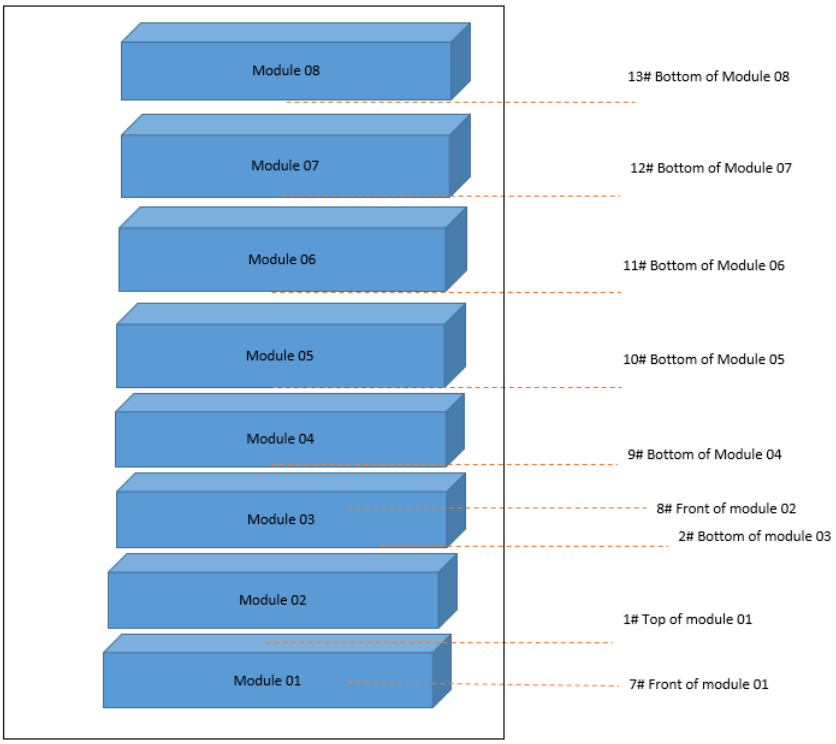
Module 02 in initiating unit was selected as “initiating module” for the test.

Modules 01, 03 in initiating unit and modules in target unit were used to check the possible propagation between modules in initiating unit and target unit. Figure 2 show the details.



Initiating Unit Target Unit

Figure 2 Module numbering in unit



PS: #3 to #6 is on the front, back, left and right surface side of module 02

Figure 3 Thermocouple in initiating unit

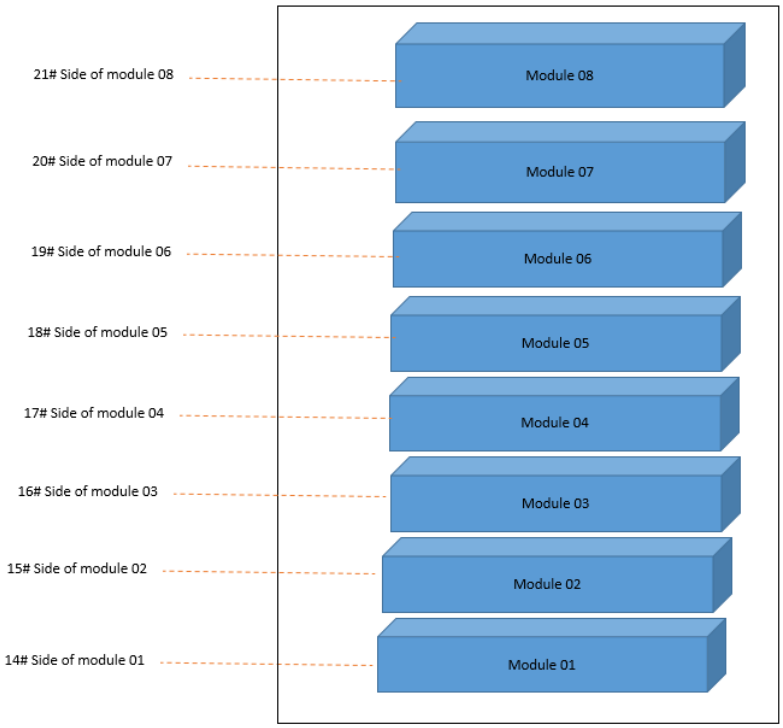


Figure 4 Thermocouple in target unit

Setup of module:

The module consisted of 104 cells 2P52S. All cells in the pack were numbered from #1-1 to #1-26, #2-1 to #2-26, #3-1 to #3-26, #4-1 to #4-26 as below.

External heating method was used to initiate thermal runaway in the module. One metal heater was fitted on cell (rated 220V ac/1000 W, size 190*160).

Total 11 thermocouples (type K, 24AWG) were attached at the center of the wider side surface of cell and below the hater film in the module. See Figure 5 for the detail locations.

Voltage of the module was monitored during test.

See Figure 5 for the detail locations.

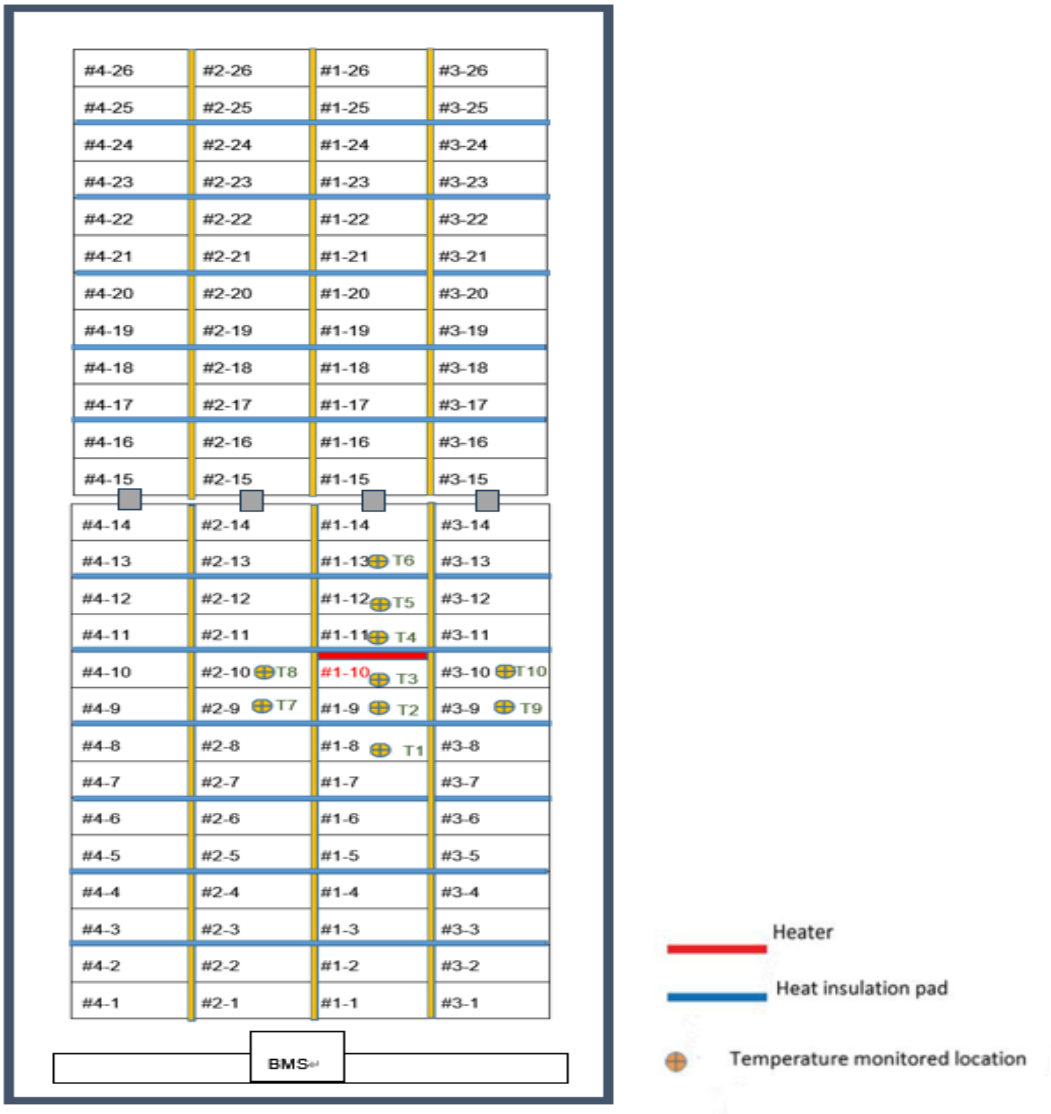


Figure 5 Cell number, location of heater, thermal insulation sheet (Aerogel Heat insulation pad and Polyurethane foam) and thermocouple

3.4 Observations and records

Before test:

The initiating module was charged to 100% SOC and allowed to stabilize for a minimum of 1 h and a maximum of 8 h before the start of the test.

Ambient condition at the initiation of the test was 26.1°C, 62.1% R.H.

Test was performed on 2024-03-07, started at 1:34 PM.

Before the test, The Module 2 in Initiating unit	
OCV (V)	173.5
Weight (kg)	676.5

Observations during test:

Time	1	2
Vent time	14:30:10	14:46:08
Thermal runaway	14:42:58	14:49:49

No flying debris or explosive discharge of gases during test.

No sparks, electrical arcs, or other electrical events during test.

No external flaming was observed.

Observations after test:

No damage on target walls.

No damage on target units.

The initiating cells (#1-10) was damaged (thermal runway) after the test. Cell #1-9 was damaged because of the cell to cell propagation.

After the test, The Module 2 in Initiating unit	
OCV (V)	170.1
Weight (kg)	676.0
Weight loss (kg)	0.5

3.5 Temperature measurement

3.5.1 Temperature measurement of initiating module

Multiple thermocouples, Type K, 24AWG, were attached on all module and unit. See Figure 3 to Figure 5 for the detailed locations.

The thermocouple temperature of the module 2 in initiating unit was shown in the figure 6 as below.

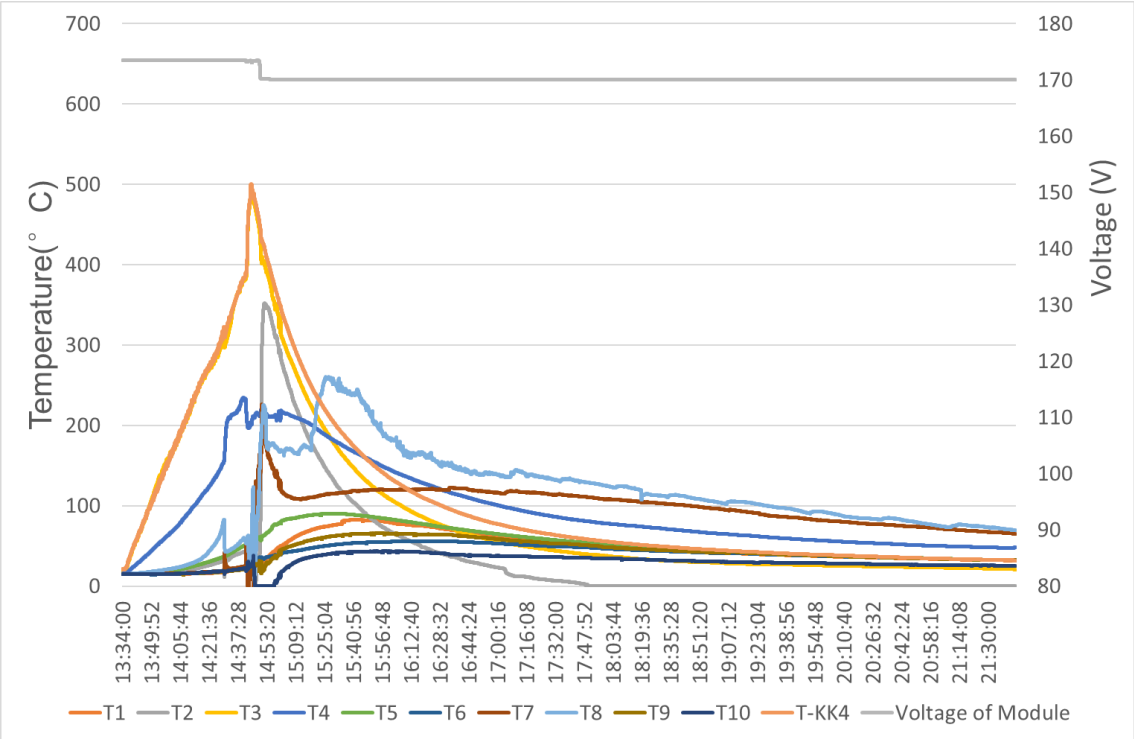


Figure 6 The cells temperature and module voltage in initiating unit

Thermocouple no.	Location	Maximum temp. °C
T1	Surface of cell #1-8	82.7
T2	Surface of cell #1-9	352.6
T3	Surface of cell #1-10	491.1
T4	Surface of cell #1-11	234.8
T5	Surface of cell #1-12	90.2
T6	Surface of cell #1-13	56
T7	Surface of cell #2-9	226.3
T8	Surface of cell #2-10	260.5
T9	Surface of cell #3-9	43.5
T10	Surface of cell #3-10	65.7
T-KK4	Heater	500.6

Voltage no.	Name	Voltage(V)
V-Module	Voltage of Module	173.5 V to 170.1 V

3.5.2 Temperature measurement of module surface in unit

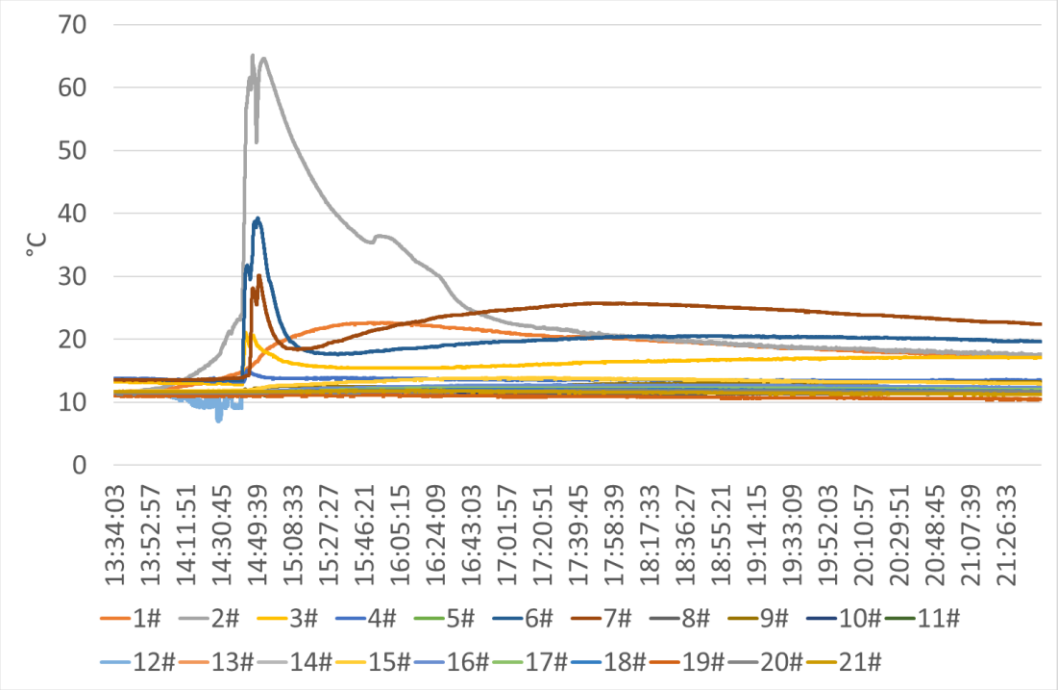


Figure 7 Surface temperatures of module in units

Unit	Channel No.	Location	Max Temp. (°C)
Initiating Unit	1#	Top of module 01 (near the heated cell)	22.60
	2#	Bottom of module 03 (near the heated cell)	65.20
	3#	Front of module 02	21.10
	4#	Back of module 02	15.10
	5#	Left of module 02	12.00
	6#	Right of module 02	39.30
	7#	Front of module 01	30.20
	8#	Front of module 02	12.10
	9#	Bottom of Module 04	13.30
	10#	Bottom of Module 05	11.90
	11#	Bottom of Module 06	12.40
	12#	Bottom of Module 07	12.00
	13#	Bottom of Module 08	12.10
Target unit	14#	Front of module 01	12.50

	15#	Front of module 02	13.90
	16#	Front of module 03	12.80
	17#	Front of module 04	12.30
	18#	Front of module 05	12.00
	19#	Front of module 06	11.10
	20#	Front of module 07	11.90
	21#	Front of module 08	11.90

3.5.3 Temperature measurement of instrumented wall

Wall surface temperatures were measured in vertical array at 152 mm intervals for the full height of the instrumented wall sections using Type K, 24 AWG thermocouple. The thermocouple array were collinear with the center line of initiating unit and target unit.

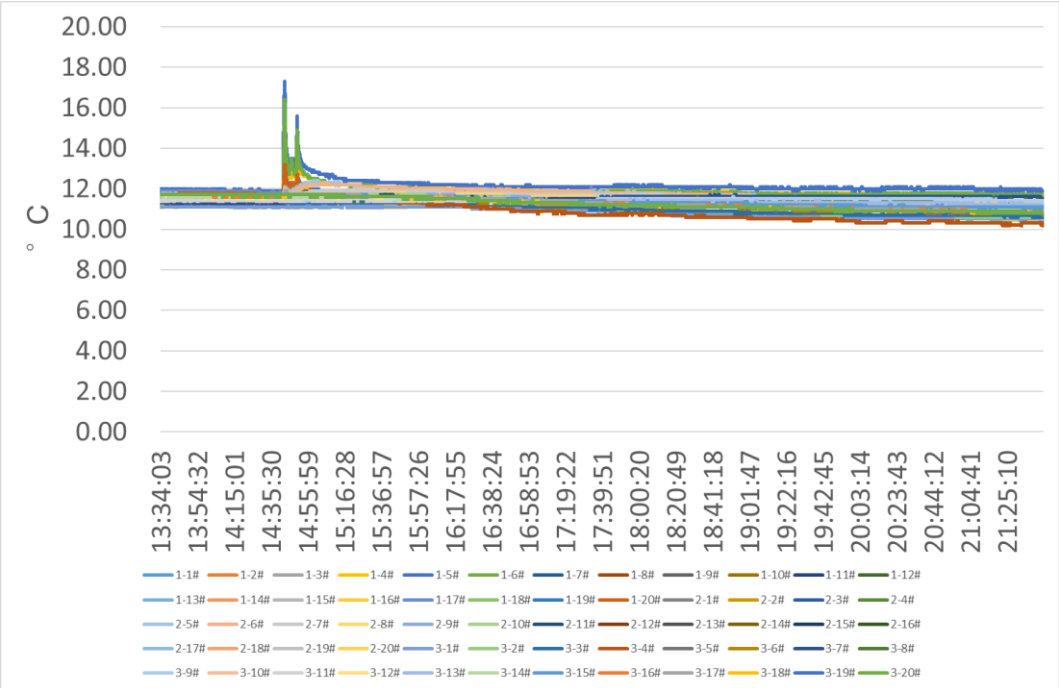


Figure 8 Temperature of instrumented wall A and B

Number	Location	Channel No.	Max Temp. (°C)
1	Wall A.	1-1# to 1-20#	17.3
2	Wall C.	2-1# to 2-20#	
2	Wall E	3-1# to 3-20#	

3.6 Heat flux measurement

Eight sensors were placed on the instrument wall A, wall C, wall E and target units to measure the heat flux, see below table and figure 9 for details.

Channel Number	Location
HF1, HF2	on the surface of instrumented wall C
HF3, HF4	on the surface of instrumented wall A
HF5, HF6	on target unit surface that facing initiating unit
HF7	In the center of the accessible means of egress, at the height of the module 2.
HF8	In the center of the accessible means of egress, at the mid height of the initiating unit

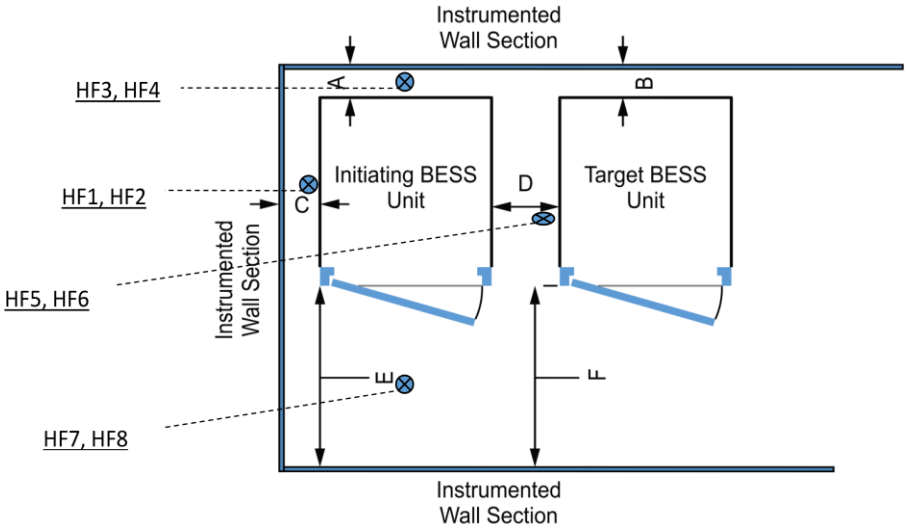


Figure 9 Layout of Heat flux sensor

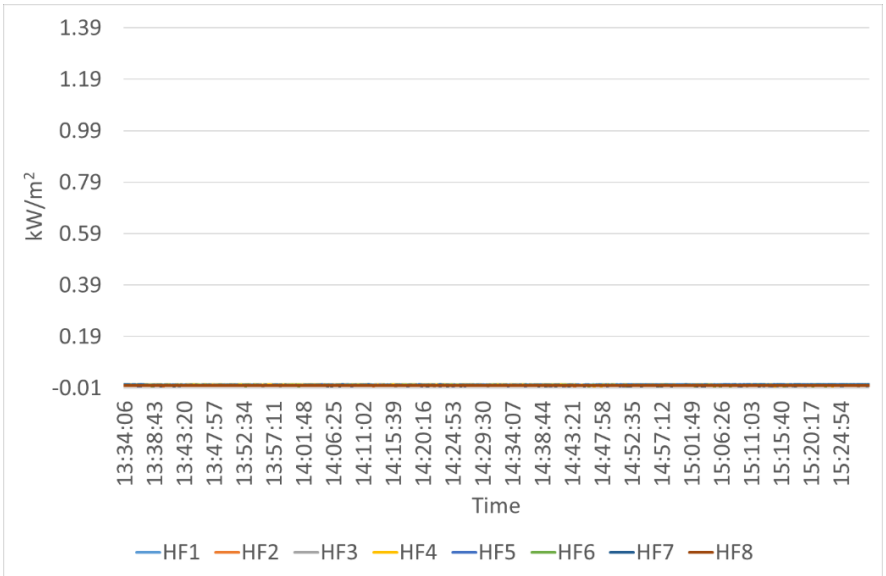


Figure 10 The measured heat flux of target walls and target unit

3.7 Chemical heat release rate measurement

The chemical heat release rates were measured by an oxygen consumption calorimeter measurement system consisting of a paramagnetic oxygen analyzer, non-dispersive infrared carbon dioxide and carbon monoxide analyzer, velocity probe, and a Type K thermocouple.
The instrumentations are located in the exhaust duct of the heat release rate calorimeter.
The chemical heat release rate was calculated at each of the flows as follows:

$$HRR_1 = \left[E \times \varphi - (E_{co} - E) \times \frac{1-\varphi}{2} \times \frac{X_{co}}{X_{O_2}}\right] \times \frac{\dot{m}_e}{1+\varphi \times (\alpha - 1)} \times \frac{M_{O_2}}{M_a} \times (1 - X^o_{H_2O}) \times X^o_{O_2}$$

In which:

HRR_t = total heat release rate, as a function of time (kW)

E = Net heat released for complete combustion per unit of oxygen consumed (adjusted for oxygen contained within cell chemistry, 13,100 kJ/kg)

E_{CO} = Net heat released for complete combustion per unit of oxygen consumed, for CO (adjusted for oxygen contained within cell chemistry, 17,600 kJ/kg)

φ = Oxygen depletion factor (non-dimensional), where:

$$\varphi = \frac{X^o_{O_2} \times [1 - X_{CO_2} - X_{CO}] - X_{O_2} \times [1 - X^o_{CO_2}]}{X^o_{O_2} \times [1 - X_{O_2} - X_{CO_2} - X_{CO}]}$$

X_{CO} = Measured mole fraction of CO in exhaust flow (non-dimensional)

X_{CO_2} Measured mole fraction of CO_2 in exhaust flow (non-dimensional)

$X°_{CO_2}$ = Measured mole fraction of CO_2 in incoming air (non-dimensional)

$X°_{H_2O}$ = Measured mole fraction of H_2O in incoming air (non-dimensional)

X_{O_2} = Measured mole fraction of O_2 in exhaust flow (non-dimensional)

$X°_{O_2}$ = Measured mole fraction of O_2 in incoming air (non-dimensional)

α = Combustion expansion factor (non-dimensional; normally a value of 1.105)

M_a = Molecular weight of incoming and exhaust air (29 kg/kmol)

M_{O_2} = Molecular weight of oxygen (32 kg/kmol)

$\dot{m}_e$ = Mass flow rate in exhaust duct (kg/s), in which:

$$\dot{m}_e = C \times \sqrt{\frac{\Delta p}{T_e}}$$

or

$$\dot{m}_e = 26.54 \times \frac{A \times k_c}{f(\mathrm{Re})} \times \sqrt{\frac{\Delta p}{T_e}}$$

C = *Orifice plate coefficient (in* $kg^{1/2}m^{1/2}K^{1/2}$*)*

Δp = *Pressure drop across orifice plate or bidirectional probe (Pa)*

T_e = *Combustion gas temperature at orifice plate or bidirectional probe (K)*

A = *Cross sectional area of the duct* (m^2)

k_c = *Velocity profile shape factor (non-dimensional)*

$f(Re)$ = *Reynolds number correction (non-dimensional)*

Measured peak chemical heat release rate HRR_t was 19.4 kW.

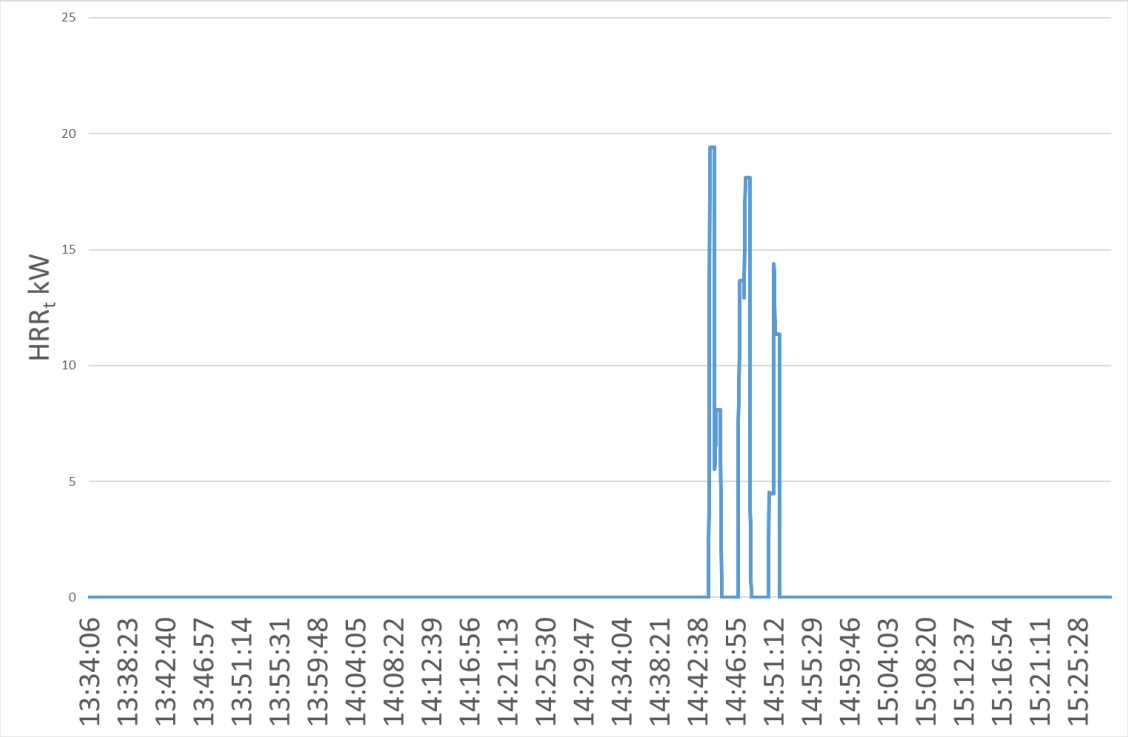


Figure 11 HRR_t curve

Measured total heat release THR through the test was 85.48 MJ

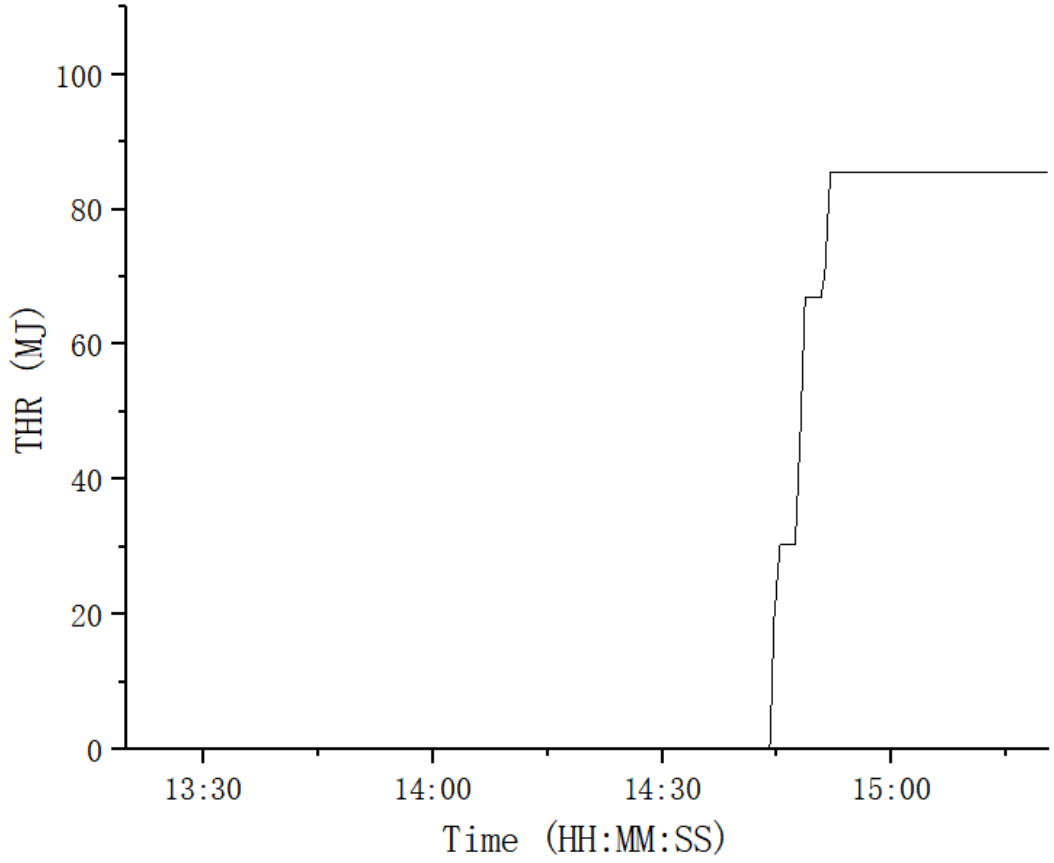


Figure 12 THR curve

3.8 Convective heat release rate measurement

The convective heat release rate were measured using thermopile, a velocity probe, and a Type K thermocouple, located in the exhaust system of the exhaust duct.

The convective heat release rate was calculated at each of the flows as follows:

$$HRR_c = V_e A \frac{353.22}{T_e} \int_{T_o}^{T} C_p dT$$

Where:

HRR_c = *The convective heat release rate (kW)*

V_e = *The exhaust velocity (m/s)*

A = *The exhaust duct cross sectional area (m^2)*

T_e = *The temperature at the location where exhaust velocity is measured (K)*

$353.22/T_e$ = *The density of air at the velocity measurement location (kg/m^3)*

T_o = *The ambient temperature (K) in the test room*

T = *The thermopile temperature (K)*

$$\int_{T_o}^{T} C_p dT = A_0(T - T_o) + A_1/2(T^2 - T_o^2) + A_2/3(T^3 - T_o^3) + A_3/4(T^4 - T_o^4)$$

Cp = Specific heat of air (kJ/kg-K), given as $\boldsymbol{C_p = A_0 + A_1 T + A_2 T^2 + A_3 T^3}$, where:

A_0 = *0.9950*

A_1 = *-5.29933E-05*

A_2 = *3.21022E-07*

A_3 = *-1.22004E-10*

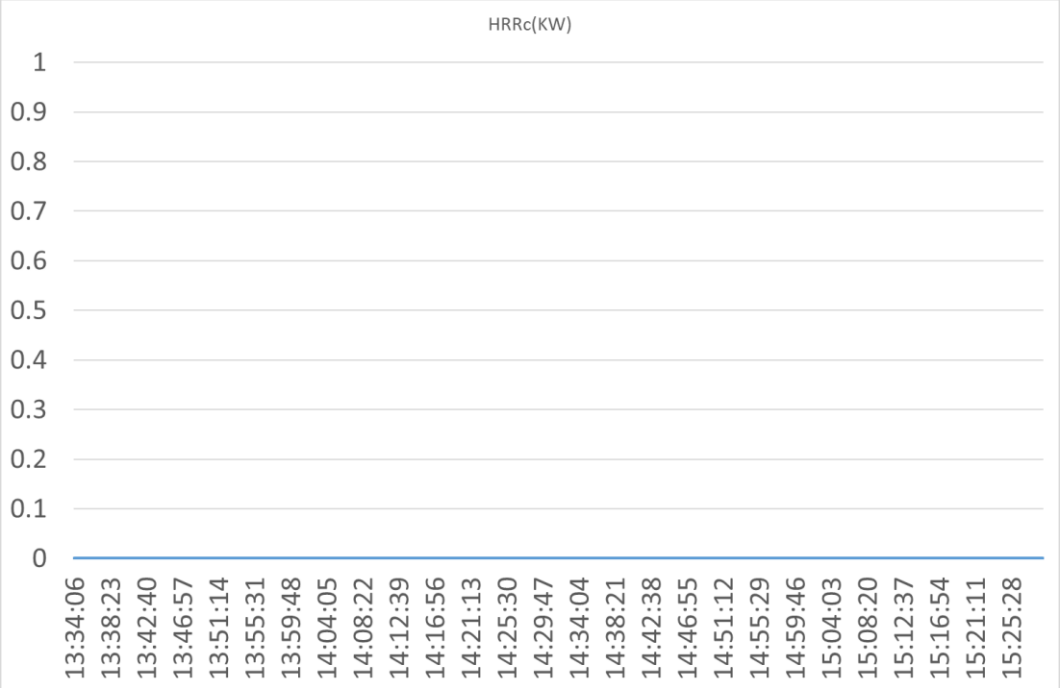


Figure 13 HRRc curve

3.9 Smoke release rate measurement

3.9.1 Test method

The light transmission in the calorimeter's exhaust duct was measured using a white light source and photo detector for the duration of the test.

3.9.2 Test result

Peak smoke release rate SRR: 0.485 m^2/s

Total smoke release TSR: 71.2 m^2

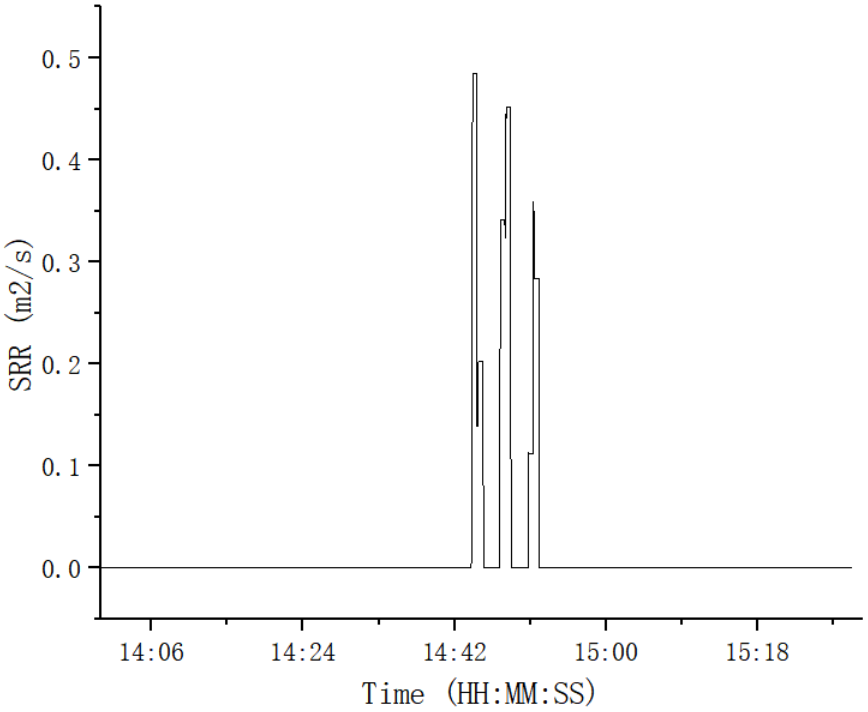


Figure 14 SRR curve

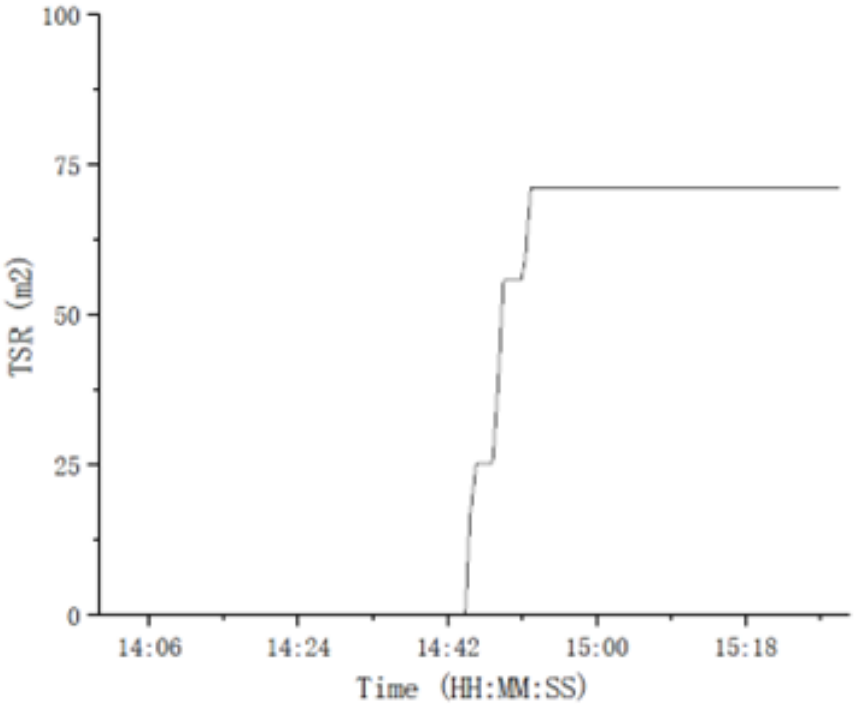


Figure 15 TSR curve

3.10 Gas generation measurement

3.10.1 Test method

The composition, velocity and temperature of the vent gases were measured within the calorimeter's exhaust duct.

Gas composition were measured using a Fourier-Transform Infrared Spectrometer with a resolution of 0.5 cm^{-1} and a path length of 5.1 m within the calorimeter's exhaust duct.

The hydrocarbon content of the vent gas was measured using flame ionization detection.

Hydrogen gas was measured with a palladium-nickel thin-film solid state sensor.

For reference only, the hydrogen gas was measured with a Electrochemical sensor.

Composition, velocity and temperature instrumentation were collocated with heat release rate calorimetry instrumentation.

3.10.2 Total gas release

Gas type	Gas components		Total volume of gas (L)
Hydrocarbon species	Methane	CH_4	24.2
	Ethylene	C_2H_4	18.3
	Ethane	C_2H_6	2.5
Others	Carbon Monoxide	CO	50.4
	Carbon Dioxide	CO_2	97.5
	Hydrogen (Palladium nickel thin film solid state sensor)	H_2	Below detectable limit*
	Hydrogen (Electrochemical sensor, for reference only)	H_2	237**
	Diethyl carbonate	$C_5H_{10}O_3$	3.4
	Ethylmethyl carbonate	$C_4H_8O_3$	10.5
	Dimethyl carbonate	$C_3H_6O_3$	30.6
Total Hydrocarbons (equivalent to C_3H_8, measured by FID)			113
* = The volume of hydrogen released by a single cell after thermal runaway referred to the cell UL 9540A report is about 64.8L. However, it should be noted that the gas			

production of a single cell in the current test environment is not exactly equivalent to the gas production of the cell level test, because the test environment is not the same.

** = As there are some factor sensors which can affect the accuracy of hydrogen gas measurements, such as the accuracy for gas voltage signal, airflow rates, and environmental variables, the 237L in only for reference.

3.10.3 Gas components

Concentration of different gas components were present according to gas species classification in Figures 16 to 25.

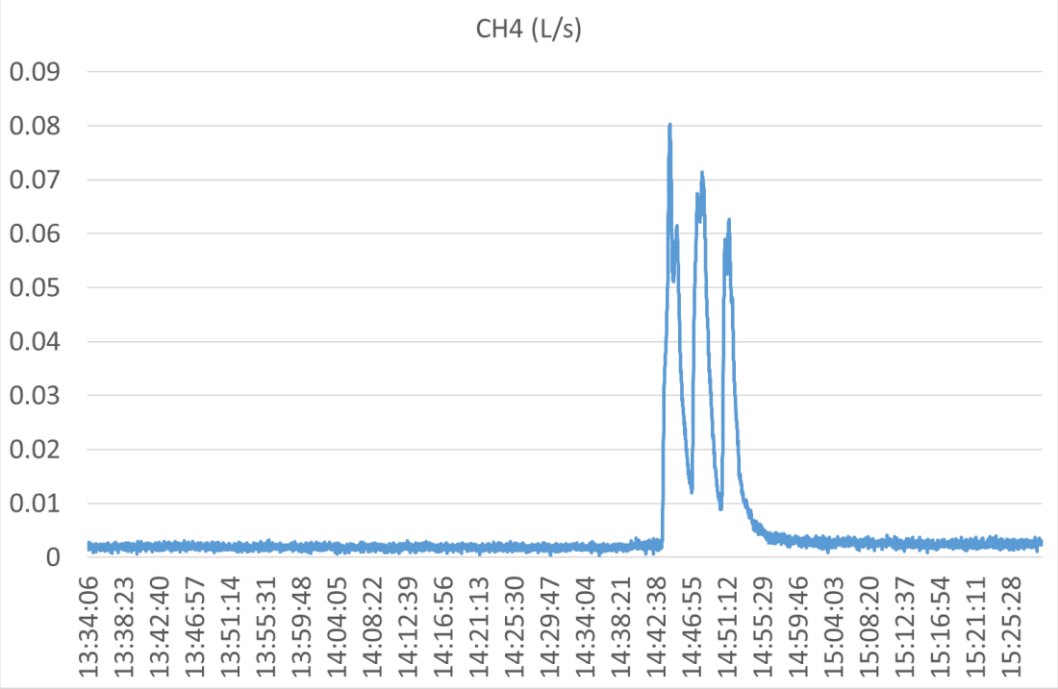


Figure 16 Methane curve

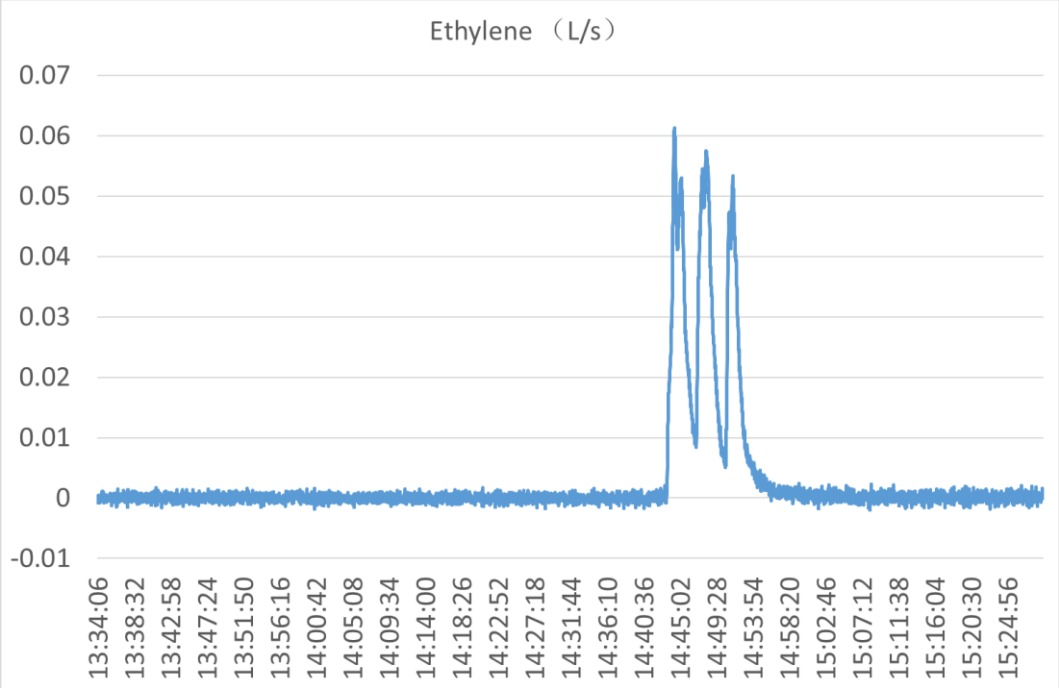


Figure 17 Ethylene curve

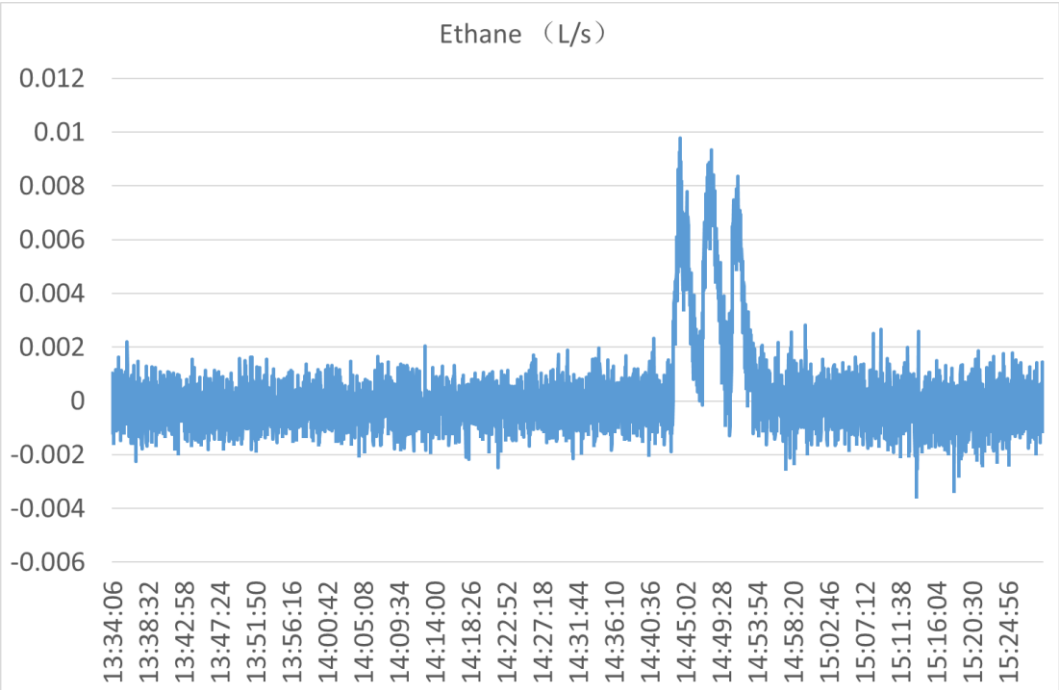


Figure 18 Ethane curve

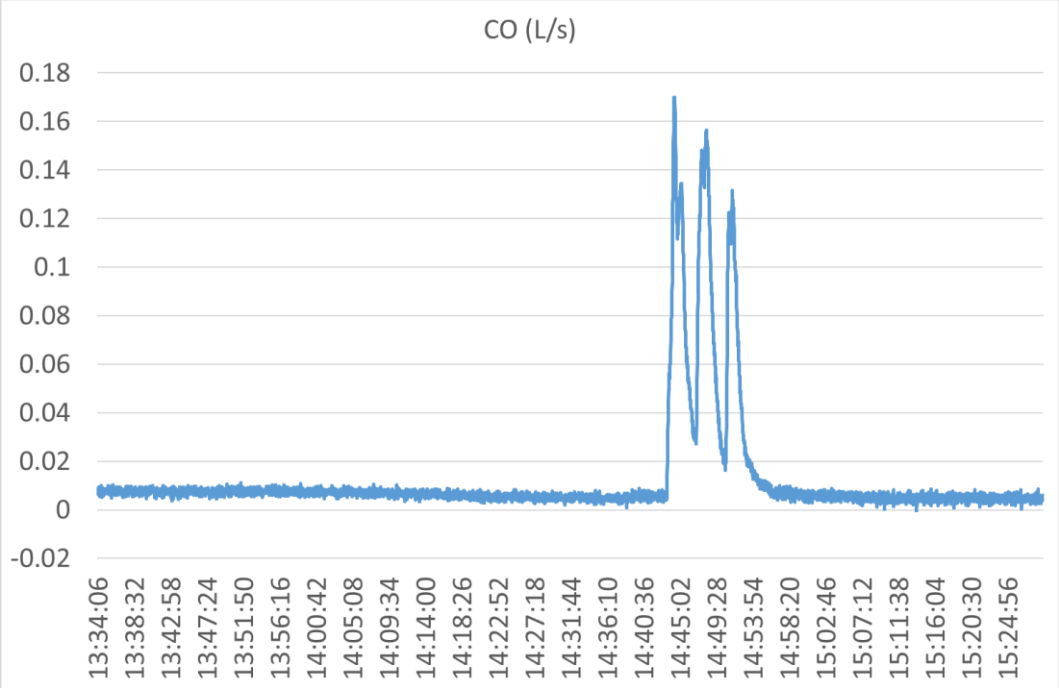


Figure 19 CO curve

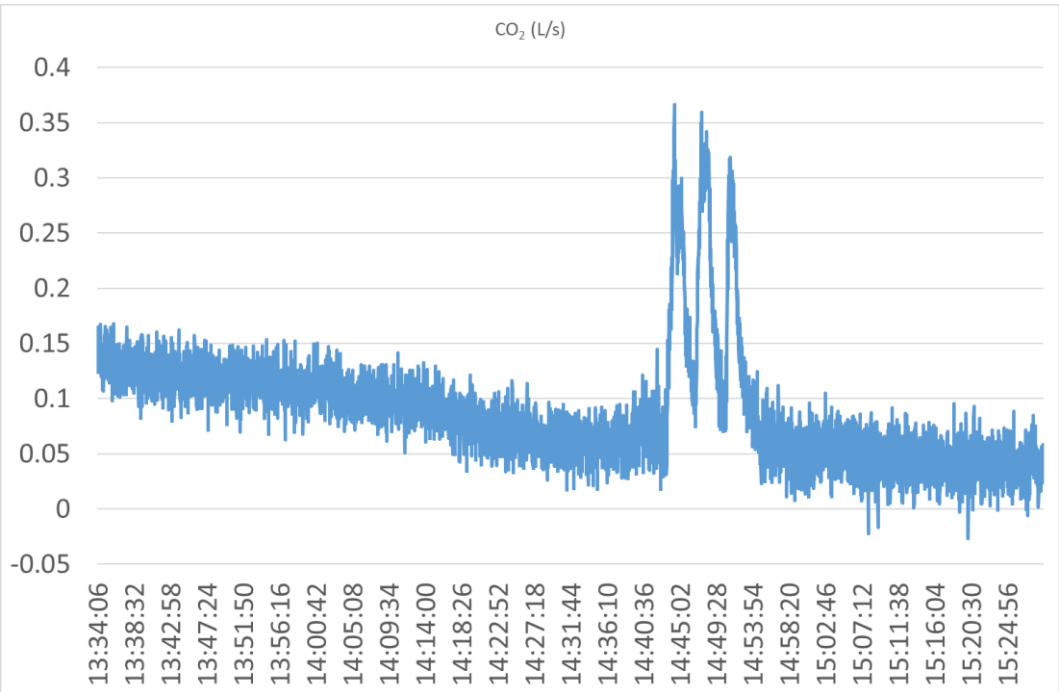


Figure 20 CO2 curve

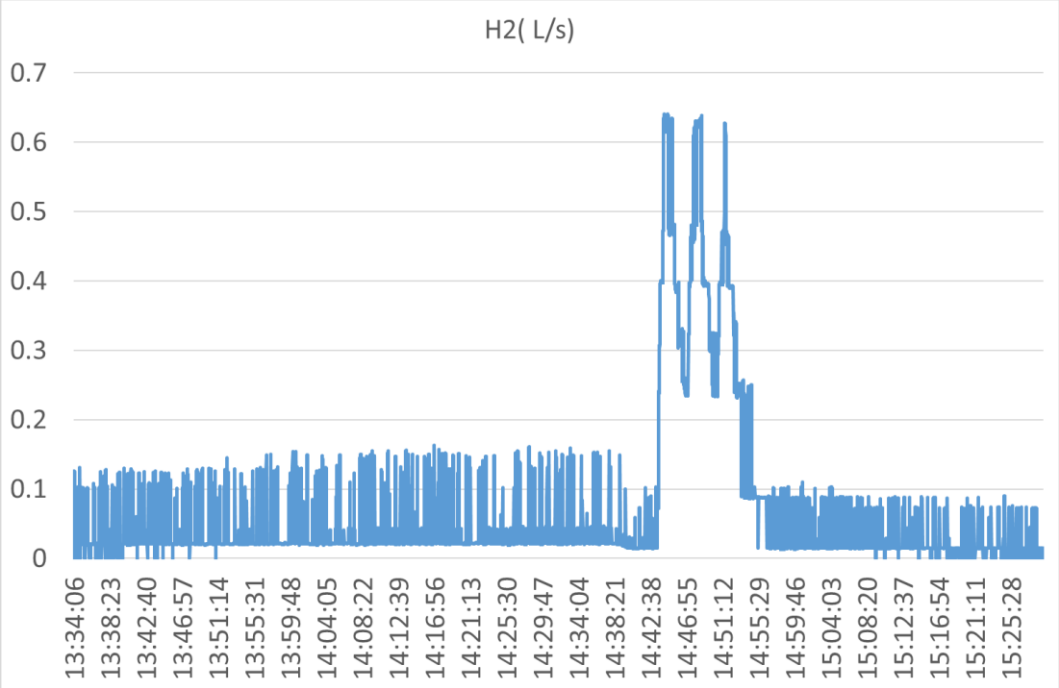


Figure 21 H2 curve (Electrochemical, for reference only)

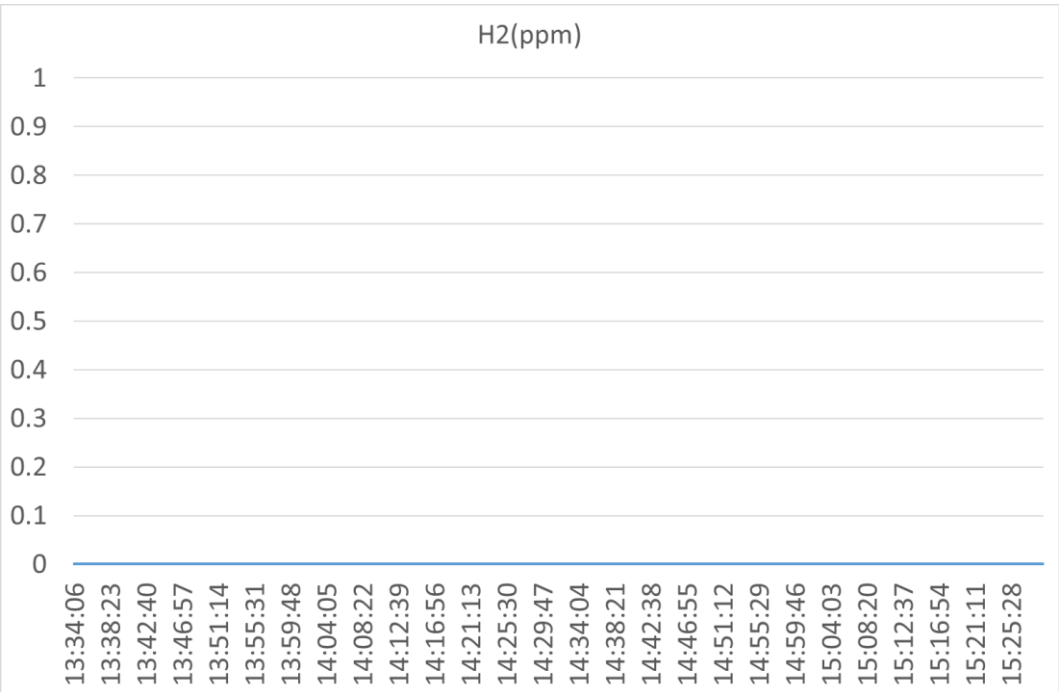


Figure 22 H2 curve (Palladium nickel thin film solid state sensor)

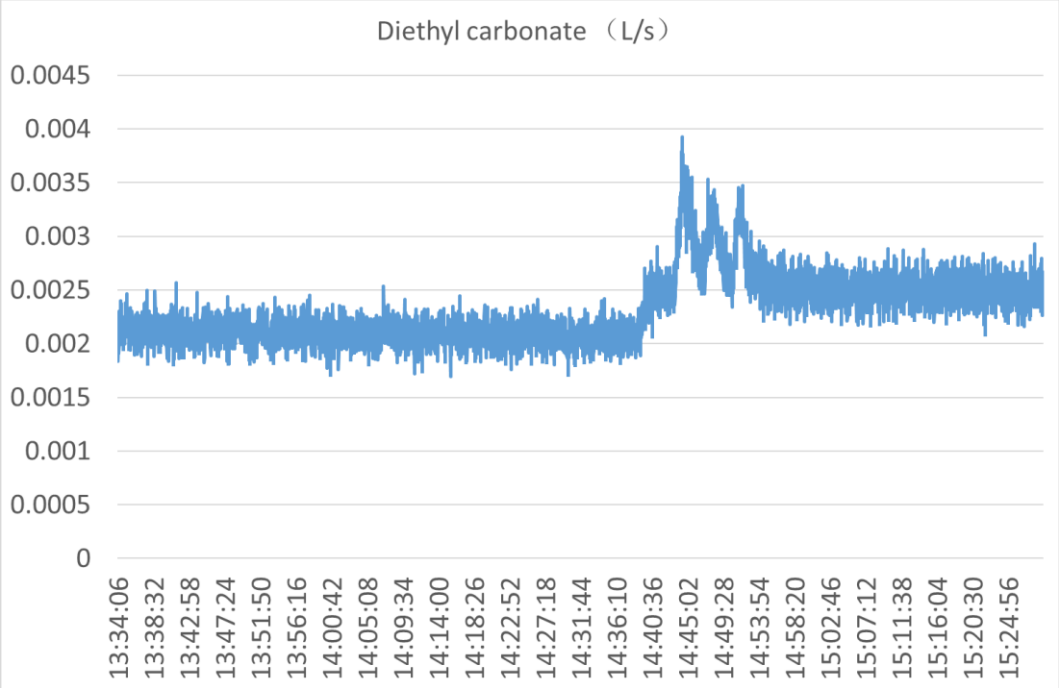


Figure 23 Diethyl carbonate curve

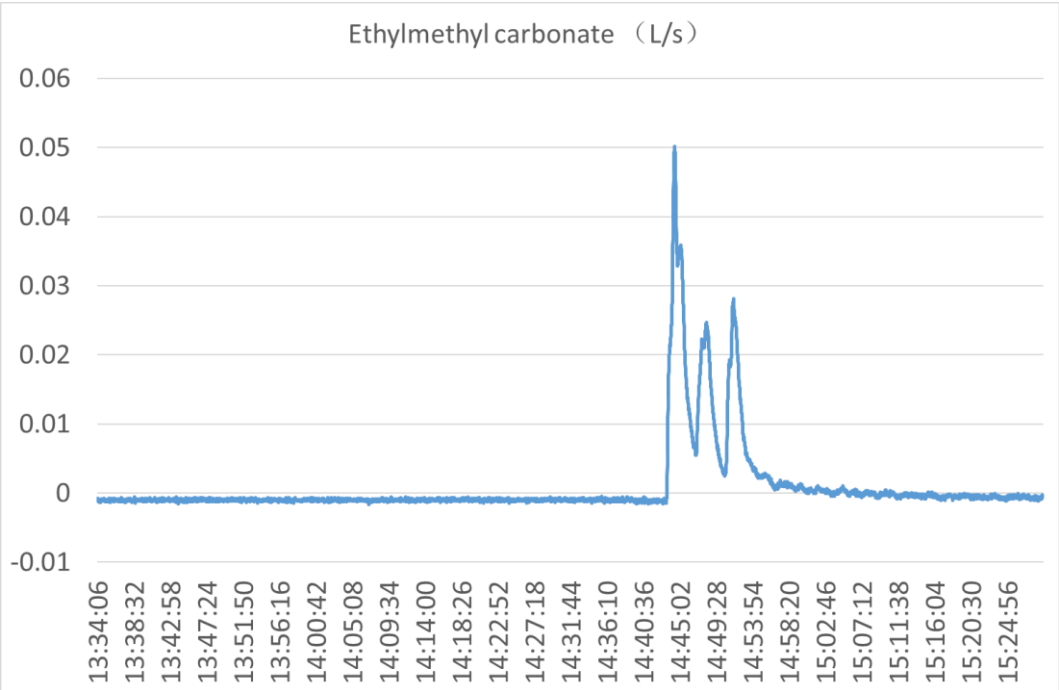


Figure 24 Ethylmethyl carbonate curve

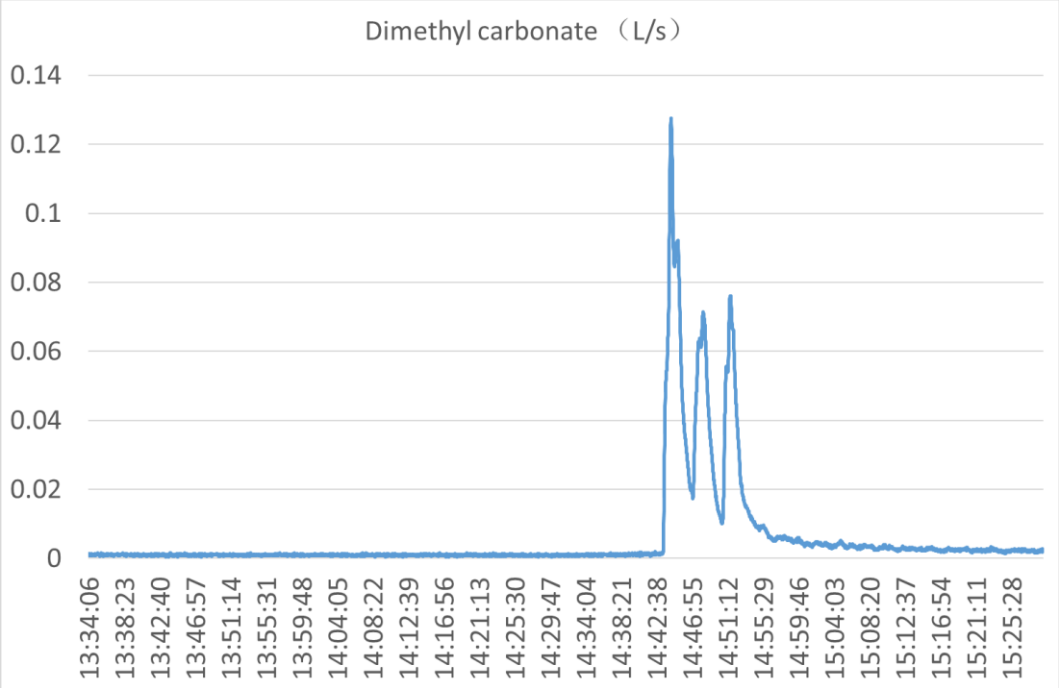


Figure 25 Dimethyl carbonate curve

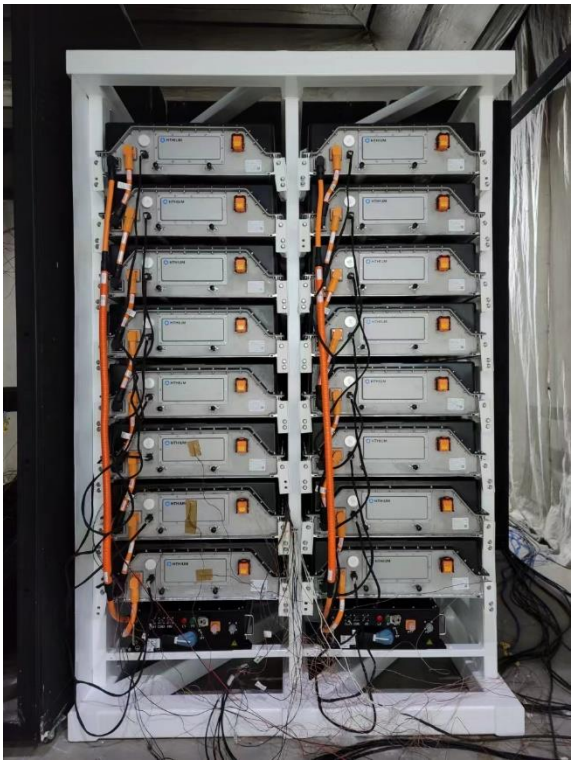
3.11 Performance Summary Remark Against Criteria

Installation level testing was not required as the following performance conditions were met during the unit level test.

Performance conditions	Remark
a) If flaming outside of the unit observed, separation distances to exposures shall be determine by greatest flame extension observed during test. *(No flaming)*	No flaming observed during the test.
b) Surface temperatures of modules within the target units adjacent to the initiating unit do not exceed the temperature at which thermally initiated cell venting occurs.	Surface temperatures of modules within the target units adjacent to the initiating unit was 13.9°C, which is far below the cell venting temperature 203.7°C (From TUV RH cell 9540A report No.: CN23F118 001).
c) For units intended for intended for near exposures, surface temperature measurements on wall surfaces do not exceed 97°C (175°F) of temperature rise above ambient installation.	Surface temperature measurements on wall surfaces was 17.3°C, below the 97°C of temperature rise above ambient.
d) Explosion hazards are not observed, including deflagration, detonation or accumulation of battery vent gases; *(The explosion shall not be observed)*	Explosion hazards were not observed during the test.
e) Heat flux in the center of the accessible means of egress shall not exceed 1.3kW/m^2	Less than 1.3 kW/m^2

3.12 Photos

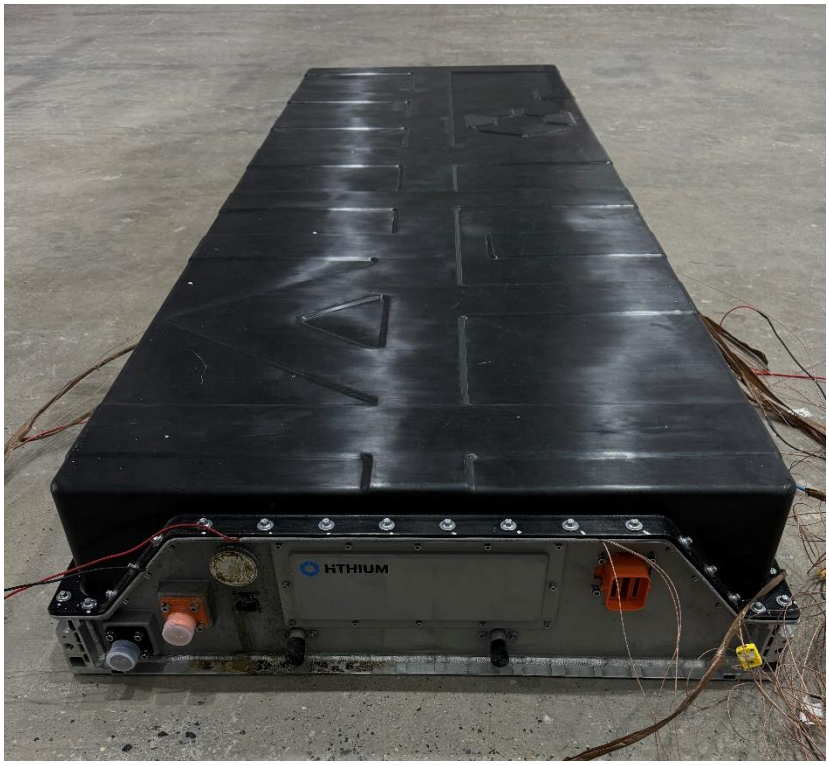
Before the test:



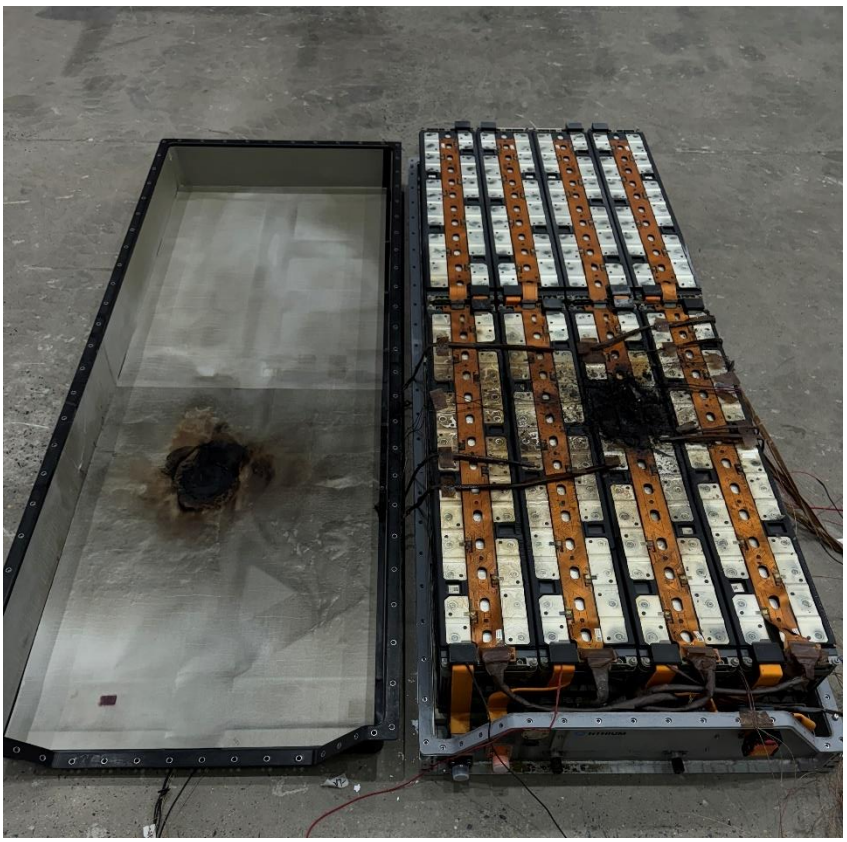
After the test:



Initiating module:









3.13 List of Test and Measurement Instruments

No.	Equipment	Model	Rating	Inventory no.	Last Cal. date
1	Ambient temperature and humidity	COS-03	0°C ~50°C, 30%RH~95%RH	D-ZNDW23052402	2023-05-24
2	Data acquisition equipment	LR8450-01	0~1100°C	0221-0704-06	2023-10-19
3	Electronic scale	OCS-2t/1kg	1kg~2000kg	0221-0704-10	2023-11-19
4	Paramagnetic oxygen analyser	AO2020	Oxygen measurement: 6.02%vol~24%vol; Hydrogen concentration: 1%~3%; Carbon monoxide: 0.2%~0.8%; Carbon dioxide concentration: 2%~8%	0221-0704-03	2023-03-06
5	Velocity probe	DYM3	800~1060hPa	D-ZNDW23032210	2023-03-10
7	Fourier-Transform Infrared Spectrometer	MULTIGAS 6030	Methane, propane, acetylene concentration: 100μmol/mol~1000μmol/mol; Carbon monoxide concentration: 0.2%~0.8%	0221-0704-08	2023-03-06
9	Palladium-nickel thin-film solid state sensor	HY-OPTIMA-2720	Range: 0.4%~5.0%	0221-0704-01	2023-03-20
10	Flame ionization detector	AO2040	Methane concentration: 100μmol/mol~500μmol/mol	0221-0704-04	2023-03-06
11	Thermopile	TJ120-CAXL-116U-80	0~300°C	0221-0704-31	2023-10-22
12	Heat flux measurement equipment	SBG01-050	0-50kW	G-ZNDW23040306 ~12	2023-05-12

End of Test Report

B.7. Large Scale Fire Test Report

Test report provided on subsequent pages.

Hithium ∞Block 5MWh product Liquid-cooled battery energy storage system

Large Scale Fire Test

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Disclaimer

The test results presented in this report relate only to the sample tested in the test configuration noted in this report.

UL LLC did not select the sample(s), determine whether the sample(s) were representative of production samples, witness the production of the test sample(s), nor were we provided with information relative to the formulation or identification of component materials used in the test sample(s).

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The test method was established with reference to several test method documents, including the UL 9540 Task Group 3 Proposed Revisions to UL 9540A Installation Level – Large Scale Fire Test (hereinafter referred to as “9540 Technical Committee Proposal”), Appendix G.11 of NFPA 855: Standard for the Installation of Stationary Energy Storage Systems(hereinafter referred to as “Guidance on Implementing a Large-Scale Fire Test”) and Clause 9.7 of CSA/ANSI C800:25 – A New Standard for ESS Reliability and Quality Assurance(hereinafter referred to as “CSA C800”). Among these, the 9540 Technical Committee Proposal method served as the primary reference, as it is being discussed by a large technical committee that includes many AHJs (Authorities Having Jurisdiction), increasing the likelihood of broad acceptance of the final report. Where specific test method requirements were not clearly defined, HITHIUM consulted with Registered Design Professional (RDP) to ensure that the procedure is sufficiently aligned with the intent of the Large-Scale Fire Test. The procedure outlined in this document reflects the final decisions and discussions from that consultation.

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Executive summary

This report summarizes the results of a large-scale fire test conducted on Hithium ∞Block 5MWh product Liquid-cooled battery energy storage system to evaluate its thermal runaway behavior and fire propagation characteristics in the configuration specified by HITHIUM. The testing was conducted in accordance with procedures derived from UL 9540 Task Group 3 Proposed Revisions to UL 9540A Installation Level – Large Scale Fire Test and NFPA 855 Annex G11, and CSA C800 standards. The test evaluates the fully charged 5016kWh container that represents the complete installation.

One enclosure of origin was set up with a complete installation, three target containers and one Instrumented Wall were positioned around it according to specifications provided by HITHIUM, see Figure 1 for detail. The yellow box in Figure 1 is the electrical cabinet, the green box is the battery Rack, the red is the trigger module, and the gray indicates that the Rack is left blank.

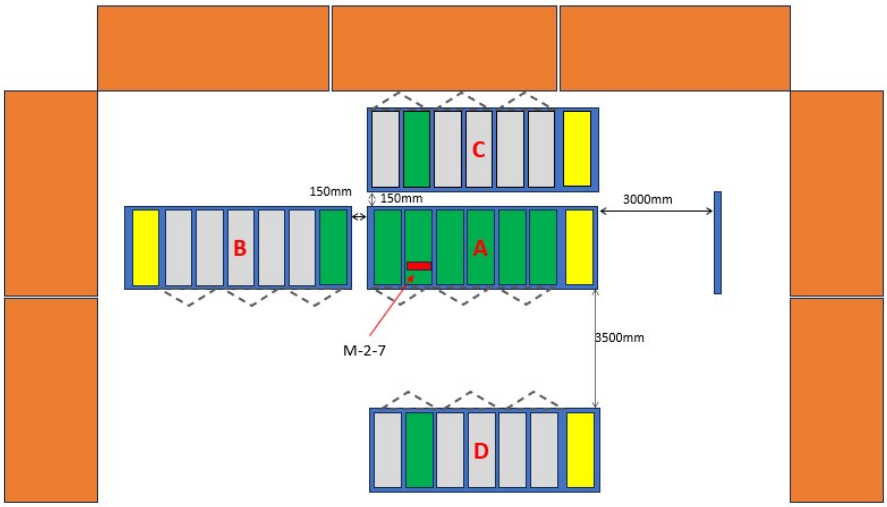


Figure 1 - Layout of Placement Position

Container A: Initiating container, with the red box in Figure 1 above indicating the location of the trigger battery module Rack, positioned in Rack 2 (M-2-7), see Figure 24 for detail.

Container B: Target Container. Located to the right of Container A, arranged side by side with A, with a distance of 150mm between them.

Container C: Target Container. Positioned behind Container A, arranged back-to-back with A, with a distance of 150mm between them.

Container D: Target Container. Located in front of Container A, arranged face-to-face with A, with a distance of 3500mm between them.

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Instrumented Wall: The Instrumented Wall at a distance of 3000mm to the right of Container A (specifications: height 3.7m, width 3m, gypsum board thickness 13mm, and painted light black), add 2 heat flux gauges and temperature line acquisition line array (spacing 152mm) to the Instrumented Wall.

The enclosure of origin was fully populated with 48 modules, while the surrounding target containers were equipped with cells or modules placed in the closest vicinity to the enclosure of origin. All modules were fully charged, with the state of charge confirmed to be 100% prior to the test. The six doors corresponded to the location of the enclosure of origin and the diagonal fan window of enclosure of origin container remained open, the fan did not work during test. The electrical central control cabinet and the fire control cabinet doors were closed. All doors and deflagration vents were closed in the Targets at the beginning of the test.

The enclosure of origin container included an initiating module; the initiating module contained eight initiating cells and eight back up initiating cells. Two sparks plug ignition and one heating element ignition were arranged 5cm apart at the initiating module vent. All target battery enclosures of containers were instrumented with thermocouples to monitor thermal exposure from the fire initiated in the enclosure of origin module. Thermal runaway propagation was successfully triggered by the initiating cells in the initiating module, which led to a fully developed fire and completed thermal runaway propagation in the enclosure of origin container.

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1. Battery Energy Storage System Description

1.1 Cell

The cell test was the LFP71173207/314Ah, manufactured by Xiamen Hithium Energy Storage Technology Co., Ltd. It's a high-capacity lithium-ion cell with a nominal voltage of 3.2 volts and a capacity of 314 ampere-hours (Ah). The cell chemistry is LiFePO4. The cell was certified to the UL 1973 safety standard (UL File No.: MH65937).

In the cell-level test report (UL Project Number 4791072813) the average surface temperature during gas venting was 159°C and the temperature at the onset of thermal runaway was 251°C.

The cell released a gas volume of 171.2 liters, and the composition of the gas was listed in Table 1. The flammability characteristics of the gas were tested. The lower flammability limit (LFL) of the gas mixture was 6.91% by volume in air at ambient temperature and 5.90% at the venting temperature. The burning velocity of these gases was measured at 62.87 cm/s, and the maximum pressure during testing was 101.42 psig. Please refer to Table 1 for detailed information on the cell and the relevant test results.

Table 1 – Information on the cell and the relevant test

Cell Product Information			
Items	**Value**	**Items**	**Value**
Manufacturer	Xiamen Hithium Energy Storage Technology Co., Ltd.	Maximum Charging Current (A)	314
Type/Model	LFP71173207/314Ah	Charging cut-off voltage (V)	3.65
Nominal voltage	3.2	Maximum Discharging Current (A)	314
Rated capacity	314	Disharging cut-off voltage (V)	2.5
Dimensions T*W*H(mm)	71.70 ± 0.5*174.70 ± 0.5*207.11± 0.5	Weight (g)	5600±200
Operating temperature (charge) (℃)	0~60	Operating temperature (discharge) (℃)	-30~60



Figure 2 – Photo of the cell

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Cell level Test information	
UL Project Number	4791072813
Average cell surface temperature at gas venting, °C:	159
Average surface temperature at thermal runaway, °C:	251
Gas Volume, L:	171.2
Lower flammability limit (LFL), % volume in air at the ambient temperature	6.91
Lower flammability limit (LFL), % volume in air at the venting temperature	5.90
Burning velocity (S_u) cm/s:	62.87
Maximum pressure (P_{max}) psig:	101.42

Cell Gas composition

Gas		Measured %
Carbon Monoxide	CO	14.507
Carbon Dioxide	CO_2	23.000
Hydrogen	H_2	45.167
Methane	CH_4	4.868
Acetylene	C_2H_2	0.148
Ethylene	C_2H_4	1.804
Ethane	C_2H_6	0.805
Propadiene (Allene)	C_3H_4	0.006
Propene	C_3H_6	2.256
Propane	C_3H_8	1.379
-	C4 (Total)	2.029
-	C5 (Total)	0.447
-	C6 (Total)	0.021
1-Heptene	C_7H_{14}	0.004
Benzene	C_6H_6	0.018
Toluene	C_7H_8	0.001
Dimethyl Carbonate	$C_3H_6O_3$	3.340
Ethyl Methyl Carbonate	$C_4H_8O_3$	0.198
Total		100

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1.2 Container

This product is composed of 48 lithium iron phosphate liquid cooling modules, BMS and related auxiliary systems such as temperature control system and fire protection system. The BMS includes MBMU, CBMU, and SBMU. It performs real-time data calculations, performance analysis, alarm processing, and record storage for the batteries. Additionally, it can achieve linkage control with PCS and EMS, ensuring the stable operation of all battery systems. The system is characterized by high energy density, a wide temperature range, a long service life, lightweight, and high safety and reliability.



Figure 4 – Hithium Energy Storage Container 2.0 Overview



Figure 5 – Hithium Energy Storage Container 2.0 Overview

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Table 3 - Product main technical parameters

Item	Value/comment	
	LX501501 IF5015P050AAU IF5016P050AAU	**IF5015P050BUS IF5016P050BUS**
Cell Chemistry	Lithium iron Phosphate	
Cell Model	LFP71173207/314Ah	
Cell Capacity	314 Ah	
Cell Voltage, Nominal	3.2 V	
Cell Construction	Prismatic	
Module Model	LM010401-A	ST104P050S104AG
Module Capacity	628 Ah	314 Ah
Module Voltage, Nominal	166.4 Vdc	332.8 Vdc
Unit Model	LC083502	IF0417P050AG
Unit Capacity	628 Ah	314 Ah
System Overall Rated Capacity	5016 kWh	5016 kWh
Unit Voltage, Nominal	1331.2 Vdc	1331.2 Vdc
Container Dimensions	(L x W x H): 6,058 x 2,438 x 2,896 mm (238.5 x 96.0 x 114.0 in)	
UL 9540A Cell Report	UL Project Number 4791072813 cell test report	
UL 9540A Module Report	TUV Rheinland Report CN23XXY9 003	TUV Rheinland Report CN24GMGP 001
UL 9540A Unit Report	TUV Rheinland Report CN244DBX 001	TUV Rheinland Report CN24HUM6 001
Note: The test is executed using LX501501		

The primary difference between the models is that one model has a module configuration of '2P52S' (two parallel, 52 series), and the other model has a module configuration of '1P104S' (one parallel, 104 series). For this large-scale fire test, model LX501501 was the device under test (DUT) and as the difference is in the wiring of the cells. In the Hithium ∞ Block 5 MWh Product, cells are combined into modules and modules are combined into racks. Each rack is comprised of 8 or 4 separate modules (8 for the DUT) and contains a high voltage box which is located beneath the lowest module. 6 or 12 total racks (6 for the DUT) are combined within a singular noncombustible enclosure to create the ESS unit. Bi-folding doors are provided on one side of the plat enclosure (total six individual doors) or corrugated enclosure (total 4 individual doors). The exterior appearance is shown in Figure 4 and 5. The ESS unit is provided with liquid cooling. All control equipment including the battery management system, auxiliary power distribution system, and fire alarm control panel are located in a compartment on one end of the enclosure with exterior access panels.

UL Solutions

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2. Large Scale Fire Test Description

The test method was established with reference to several test method documents, including the UL 9540 Task Group 3 Proposed Revisions to UL 9540A Installation Level – Large Scale Fire Test (hereinafter referred to as “9540 Technical Committee Proposal”) , Appendix G.11 of NFPA 855: Standard for the Installation of Stationary Energy Storage Systems(hereinafter referred to as “Guidance on Implementing a Large-Scale Fire Test”) and Clause 9.7 of CSA/ANSI C800:25 – A New Standard for ESS Reliability and Quality Assurance(hereinafter referred to as “CSA C800”). Among these, the 9540 Technical Committee Proposal method served as the primary reference, as it is being discussed by a large technical committee that includes many AHJs (Authorities Having Jurisdiction), increasing the likelihood of broad acceptance of the final report.

Where specific test method requirements were not clearly defined, HITHIUM consulted with Registered Design Professional (RDP) to ensure that the procedure is sufficiently aligned with the intent of the Large-Scale Fire Test. The procedure outlined in this document reflects the final decisions and discussions from that consultation. These decisions were made based on the prevailing guidance and stakeholder agreement at the time of testing.

2.1 Test setup

The testing on the enclosures was conducted in China on May 26th, 2025. The test samples included one 20ft Initiating container A and three a 20ft target container B, C and D, all submitted by HITHIUM.

The test took place at the Hubei Jiandun Fire Technology Co., Ltd, located at No.55 Shanxiyao Road, Yichang High-tech Zone, Yichang City, Hubei Province, China. Testing was conducted outdoors and the environment conditions measured were as indicated in Table 4.

Table 4 – Environmental conditions measured during the test

Measured items	Measurements
Maximum Wind speed	1.7m/s
Wind direction	See Figure 6
Ambient temperature	22.7°C ~ 31.1°C
Humidity	48.8% R.H ~ 80.7% R.H

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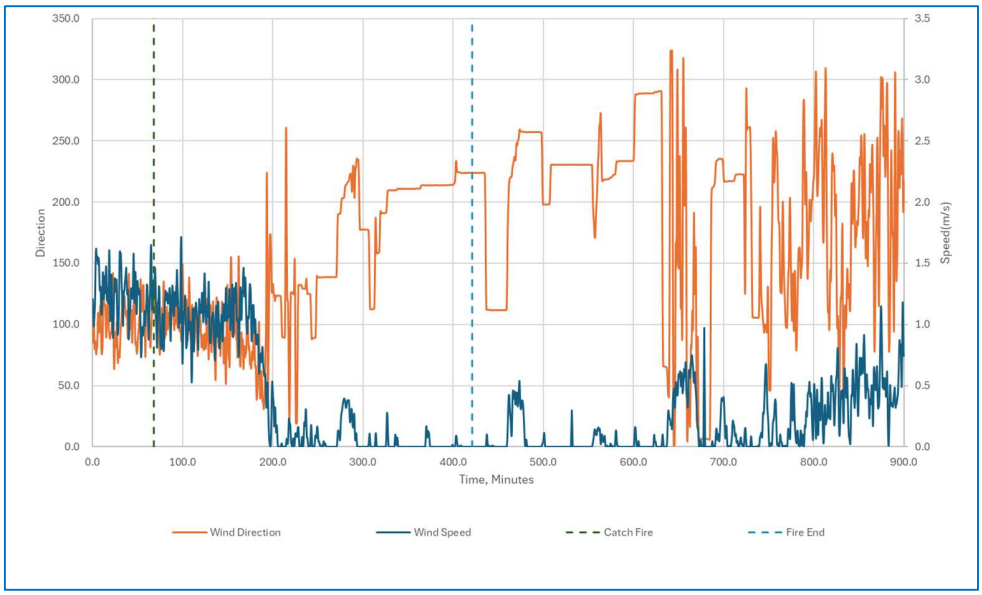


Figure 6 – Profile of the wind direction and speed measured during the test

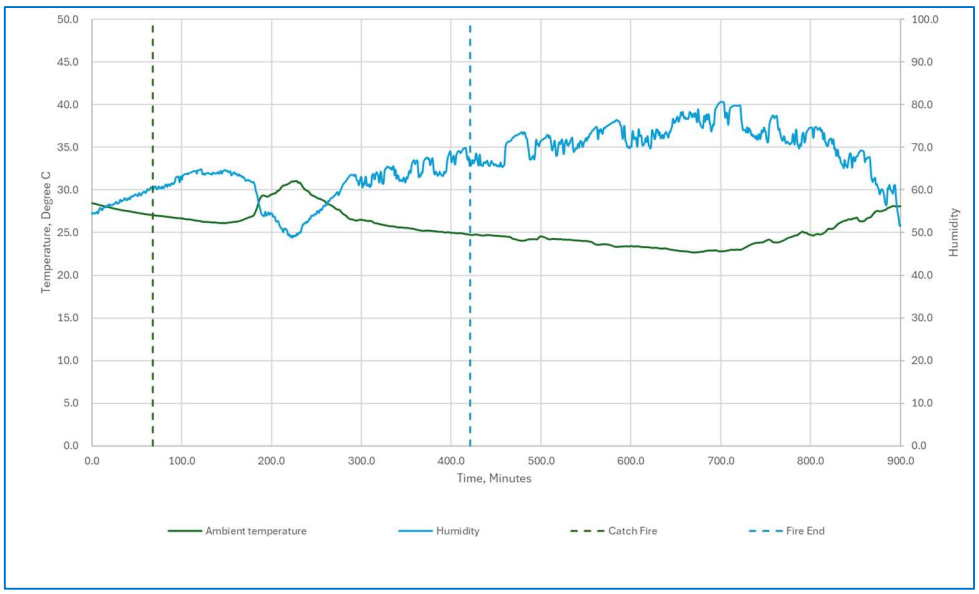


Figure 7 – Profile of the Ambient temperature and Humidity measured during the test

Sufficient lighting was present to allow for clear observation of the test. No precipitation was observed impacting the initiating or target units during the testing period. Vegetation and combustible materials in the test area were adequately controlled to prevent interference with the test and to mitigate the risk of unintended fire spread beyond the designated area. Appropriate protection mechanisms were implemented to restrict unauthorized access to the test site and to ensure that personnel were not exposed to hazards resulting from the testing activities.

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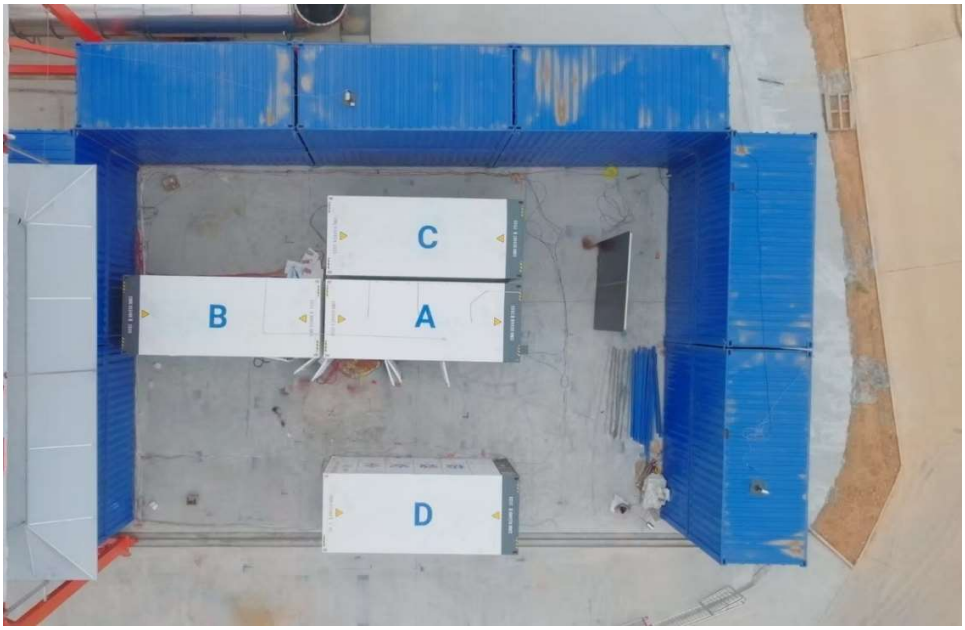


Figure 8 – Top view of the testing site with the enclosure of origin (container A) in the middle

Figure 8 presents a top view of the testing site, with the enclosure of origin at the center. The separation was specified by HITHIUM.

2.2 Configuration

Four enclosures, including the enclosure of origin, were submitted for the test, and they were arranged in a representative installation configuration for the separation distances according to the manufacturer's installation instructions. Spacings between BESS and target containers were provided in Figure 9 and summarized in Table 5.

Container A: Initiating container, with the red box in Figure 9 indicating the location of the trigger battery Rack, positioned in Rack 2.

Container B: Target Container. Located to the right of Container A, arranged side by side with A, with a distance of 150mm between them.

Container C: Target Container. Positioned behind Container A, arranged back-to-back with A, with a distance of 150mm between them.

Container D: Target Container. Located in front of Container A, arranged face-to-face with A, with a distance of 3500mm between them.

Instrumented Wall: the Instrumented wall at a distance of 3000mm to the left of Container A (specifications: height 3700mm, width 3000mm, gypsum board thickness 13mm, and painted light black, add 2 heat flux gauges and temperature line acquisition line array (spacing 152mm) to the Instrumented wall.

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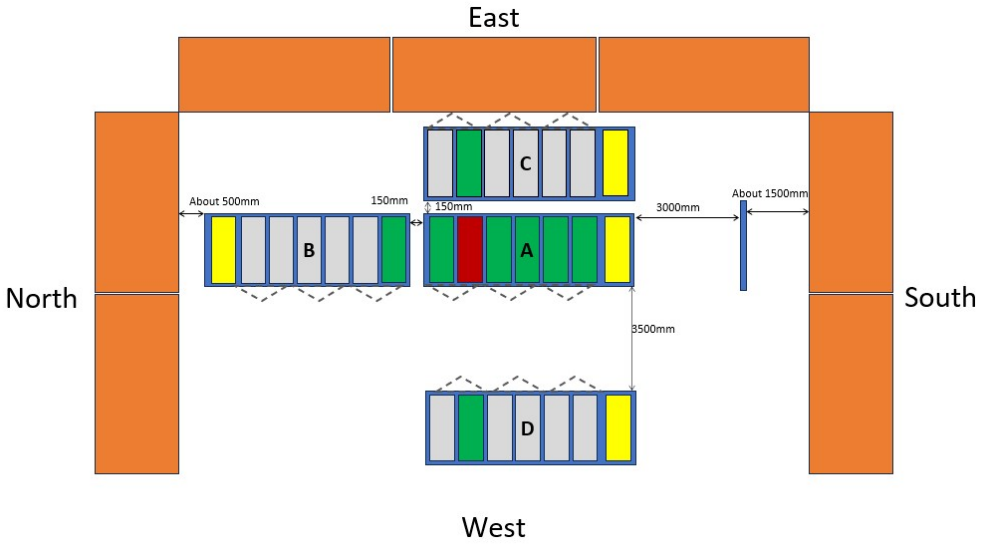
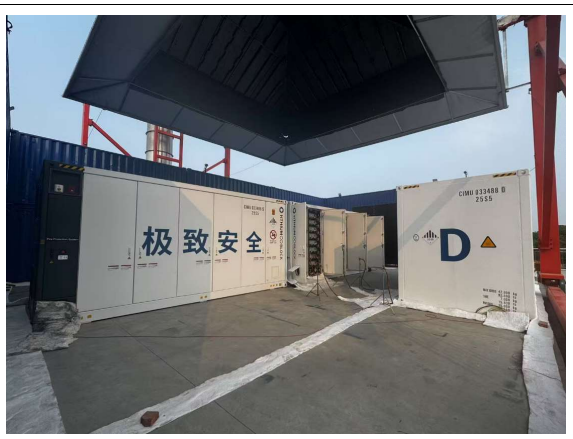


Figure 9 – Overall configuration of the installation for the test



Front left view



Front right view



Back left view



Back right view

Figure 10 – pictures of the Overall configuration

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Table 5 – Separation distance between the enclosure of origin to each target containers

Separation from enclosure of origin to	Distance (mm)
Target B	150
Target C	150
Target D	3500
Instrumented Wall	3000



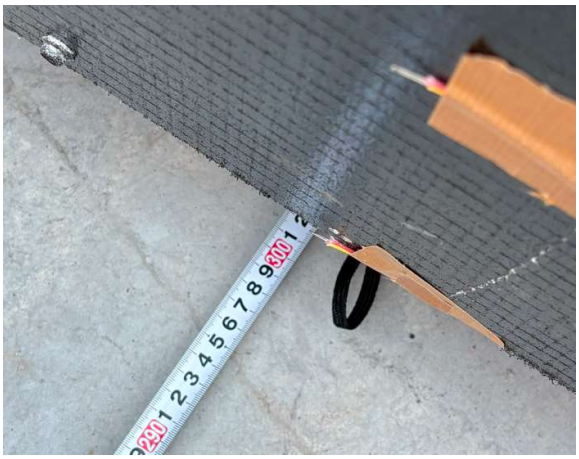
Initiating Container to Target B



Initiating Container to Target C



Initiating Container to Target D



Initiating Container to Instrumented Wall

Figure 11 – pictures of the separation measurements to the target containers from the enclosure of origin

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2.3 Charging

The samples were charged 100% the maximum operating state of charge (MOSOC) in accordance with the manufacturer's specifications.

2.3.1 Enclosure of Origin

The enclosure of origin was fully populated, including the final installed configuration of the battery energy storage system, ancillary equipment, cabling, and outer enclosure. The batteries in the enclosure of origin were brought up to the MOSOC in accordance with the manufacturer's specifications. Prior to initiating the test, the voltage of the Rack(s) used to initiate the developed fire condition were measured and recorded.

The charging information is summarized in Table 6 and Figure 12 -17.

Table 6 – Voltage and Charge information on the enclosure of Origin

Rack No.	Charge Completion Date and Time	OCV Prior to Test (dc V)
M-1	2025-05-24 19:08	1404.2
M-2	2025-05-24 15:00	1403.7
M-3	2025-05-24 10:48	1400.1
M-4	2025-05-23 16:59	1407.2
M-5	2025-05-23 13:03	1408.3
M-6	2025-05-22 18:35	1405.2

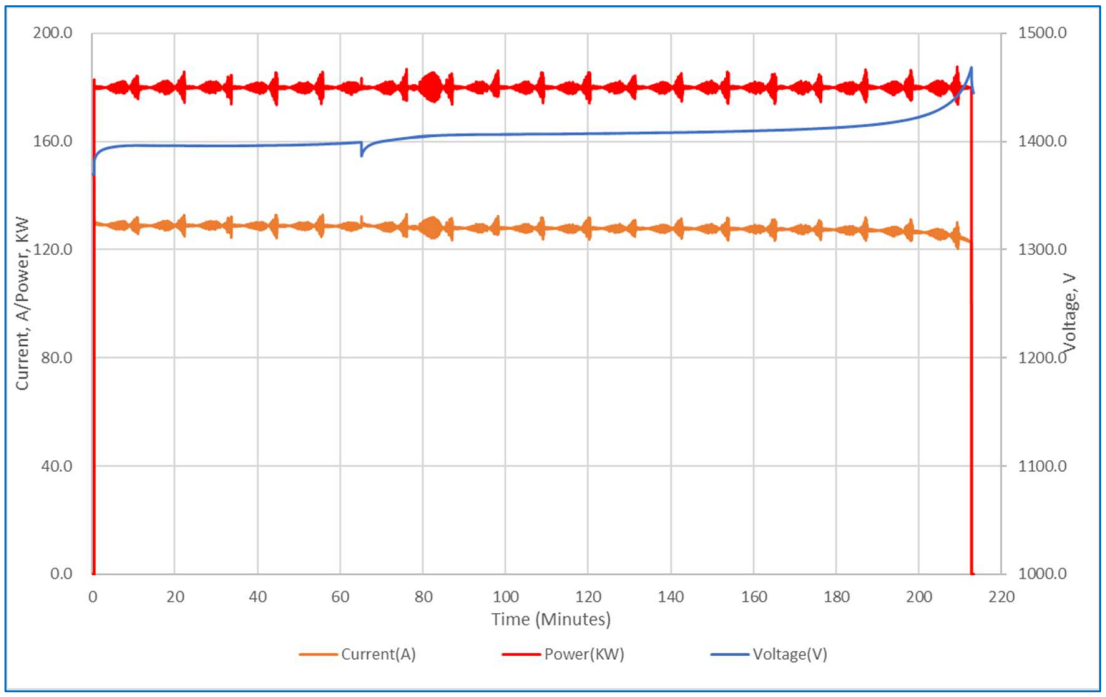


Figure 12 – Rack No. M-1 Charge Full Profiles

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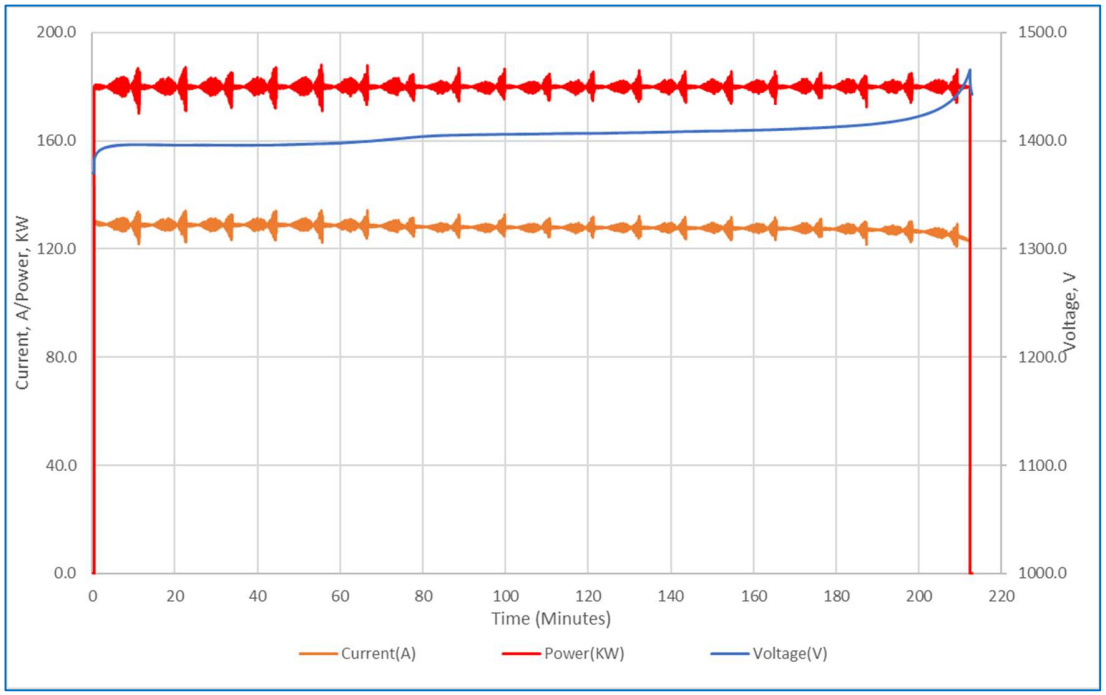


Figure 13 – Rack No. M-2 Charge Full Profiles

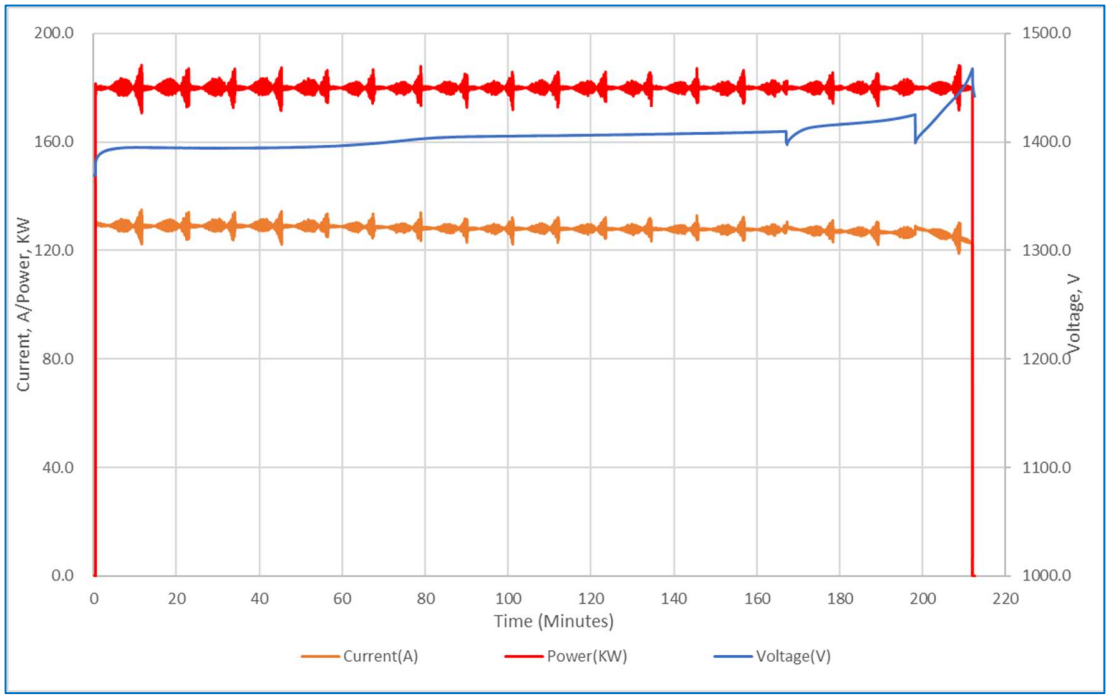


Figure 14 – Rack No. M-3 Charge Full Profiles

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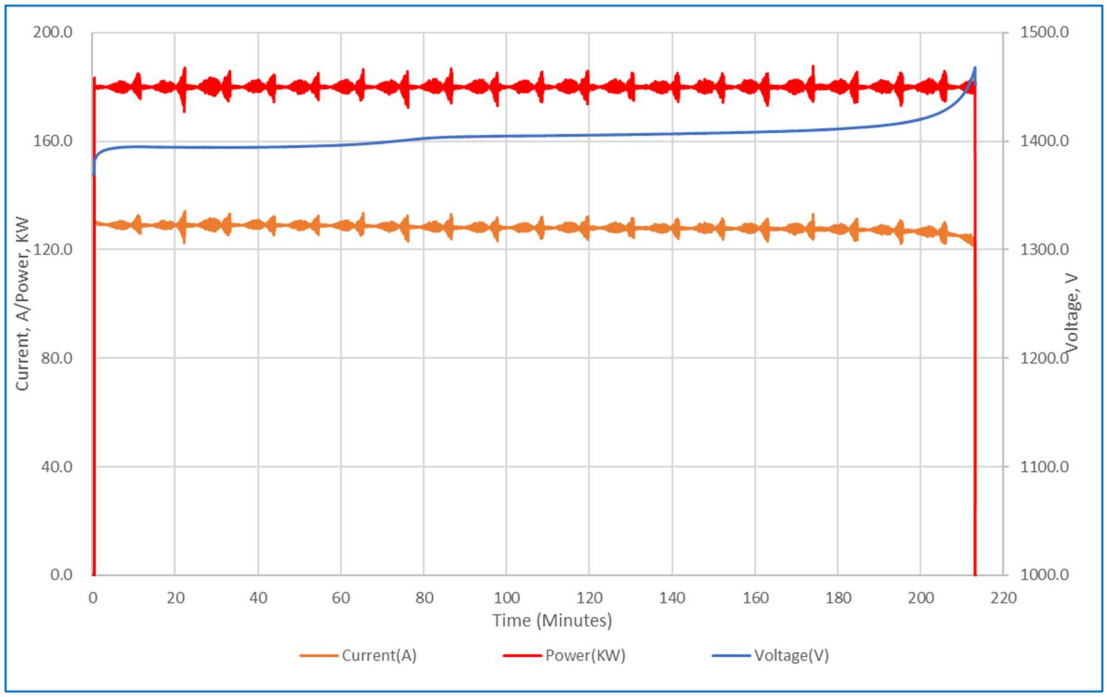


Figure 15 – Rack No. M-4 Charge Full Profiles

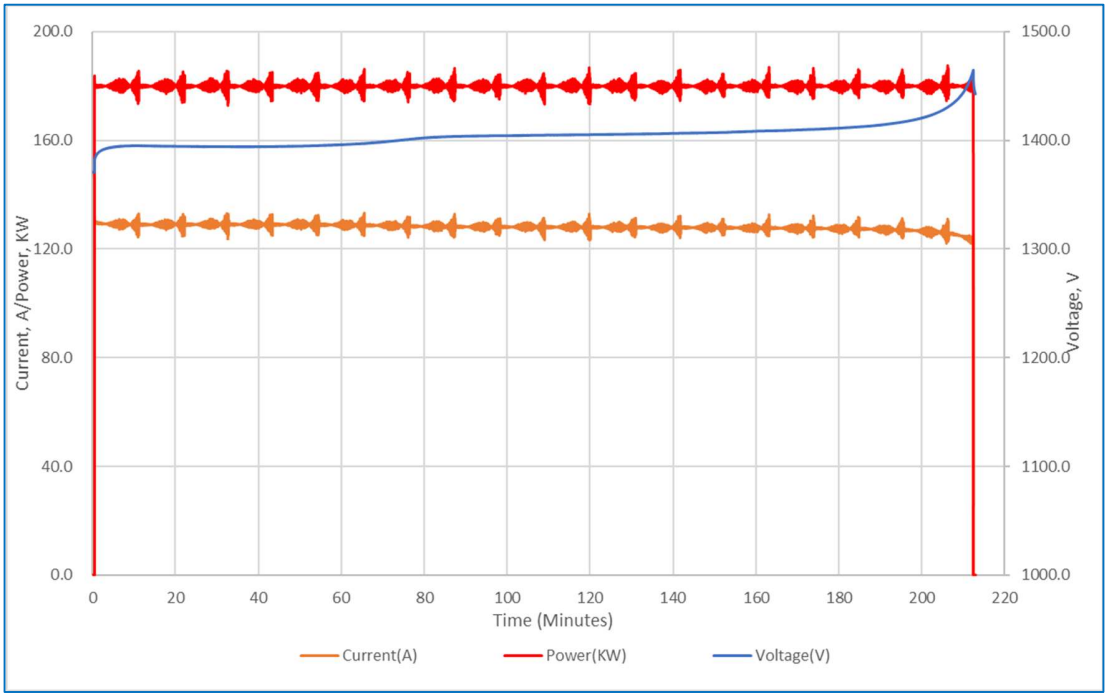


Figure 16 – Rack No. M-5 Charge Full Profiles

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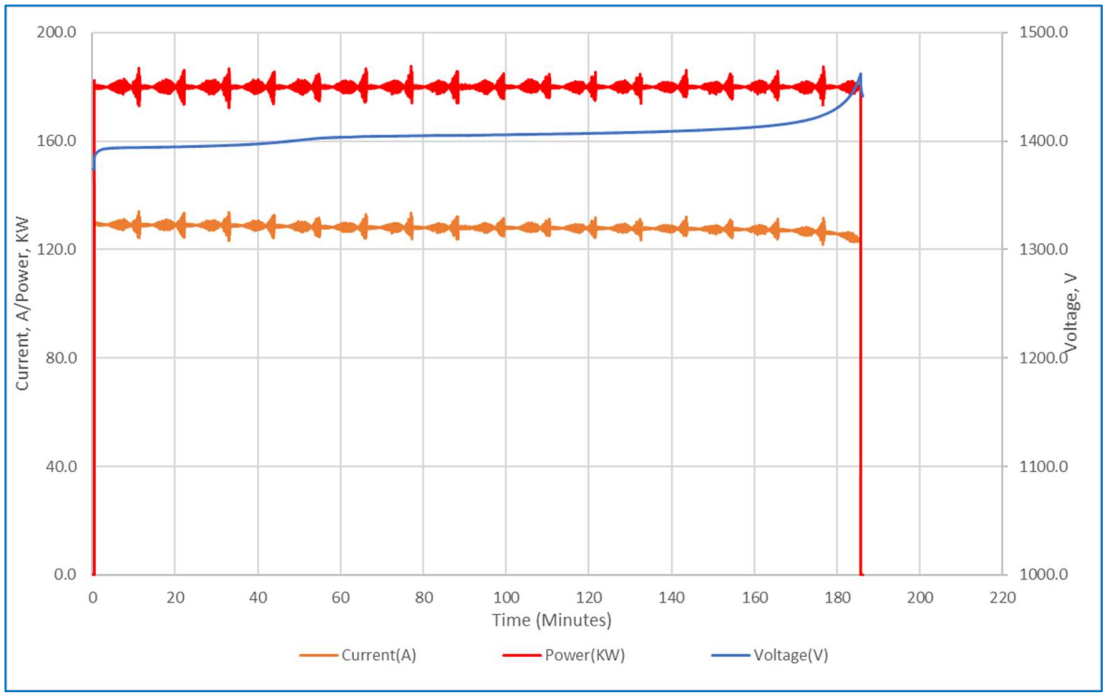


Figure 17 – Rack No. M-6 Charge Full Profiles

Note: The original SOC of Rack M-6 is higher than that of other Racks.

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2.3.2 Target container

All modules included in the targets were charged to 100% SOC Prior to Test.

For Container B located to the right of the enclosure of origin A, arranged side by side with the enclosure of origin A, and near the far-left side of Container A installation one Rack of real battery module in Container B.

For Container C positioned behind the enclosure of origin A, arranged back-to-back with the enclosure of origin A, and installation one Rack of real battery module in second Rack position of Container C.

For Container D located in front of enclosure of origin A, arranged face-to-face with enclosure of origin A, and installation one Rack of real battery module in the second Rack position of Container D.

The charging information is summarized in Table 7 and Figure 18 – 20.

Table 7 – Charging status of the Rack in Target Container B, C and D

Container No.	Charge Completion Date and Time	OCV Prior to Test (dc V)
B	2025-05-24 19:08	1405.3
C	2025-05-19 20:44	1406.0
D	2025-05-25 13:53	1406.0

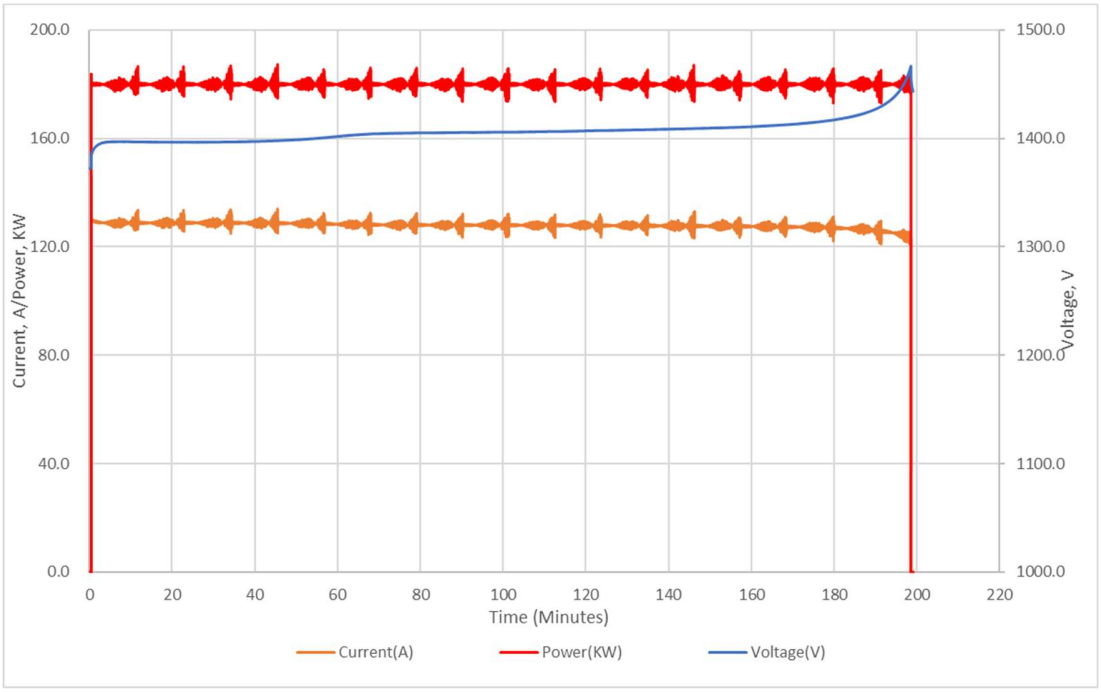


Figure 18 – Container B Rack No. M-1 Charge Full Profiles

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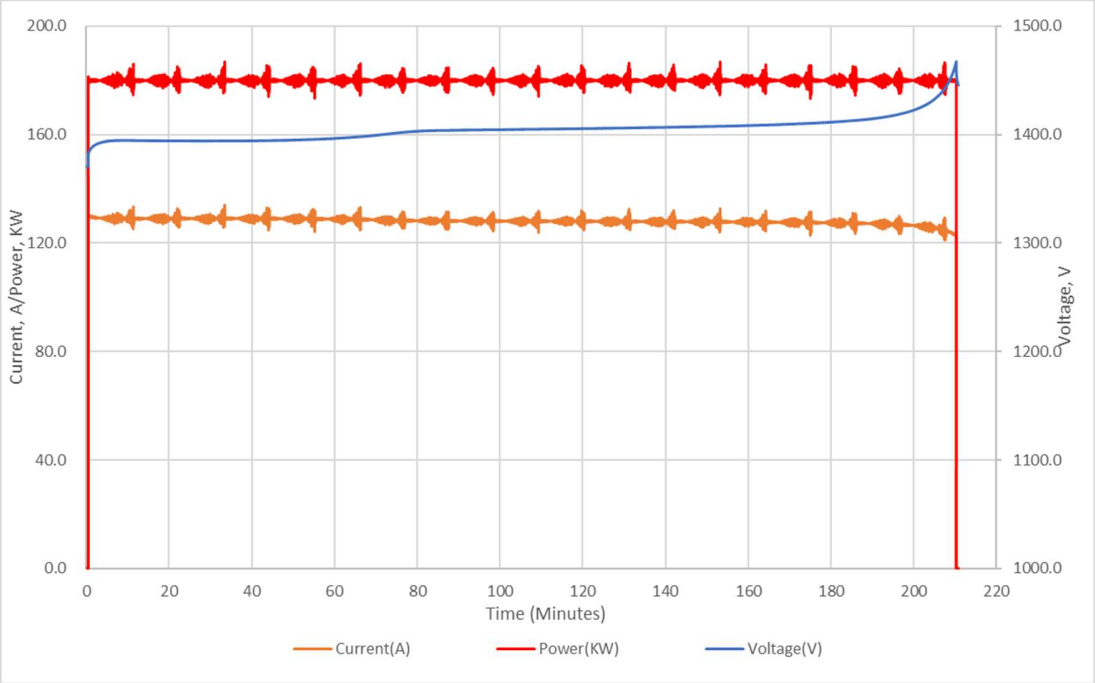


Figure 19 – Container C Rack No. M-2 Charge Full Profiles

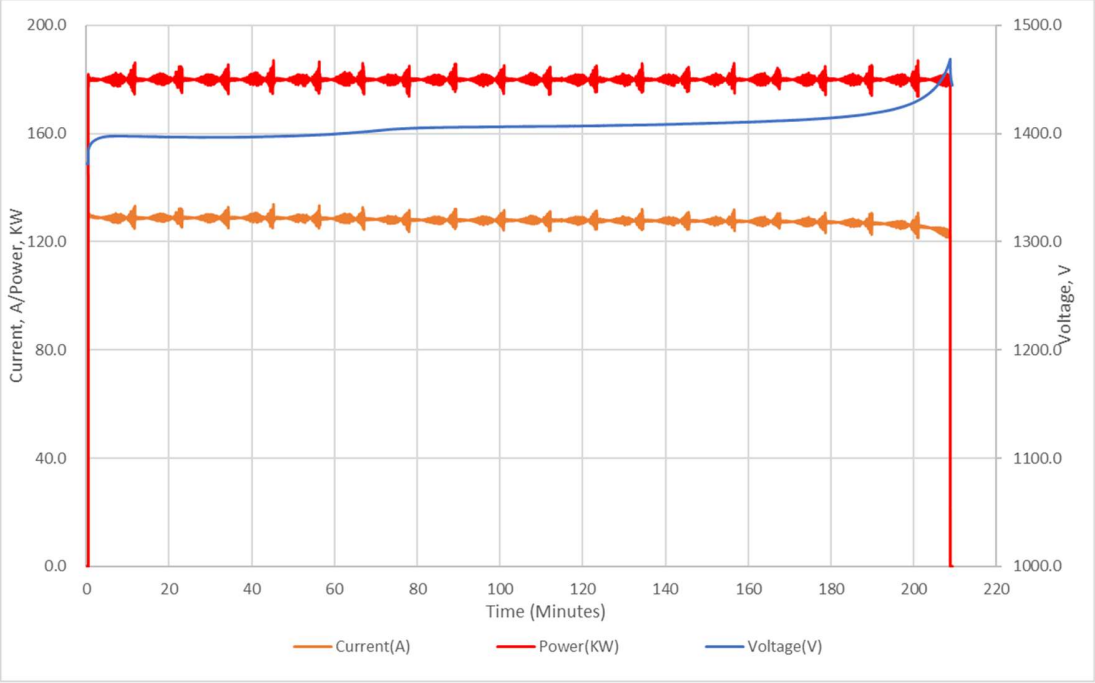


Figure 20 – Container D Rack No. M-2 Charge Full Profiles

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2.4 Enclosure of Origin Installation

2.4.1 Overall Installation

The enclosure of origin was equipped with a total of 48 battery modules.

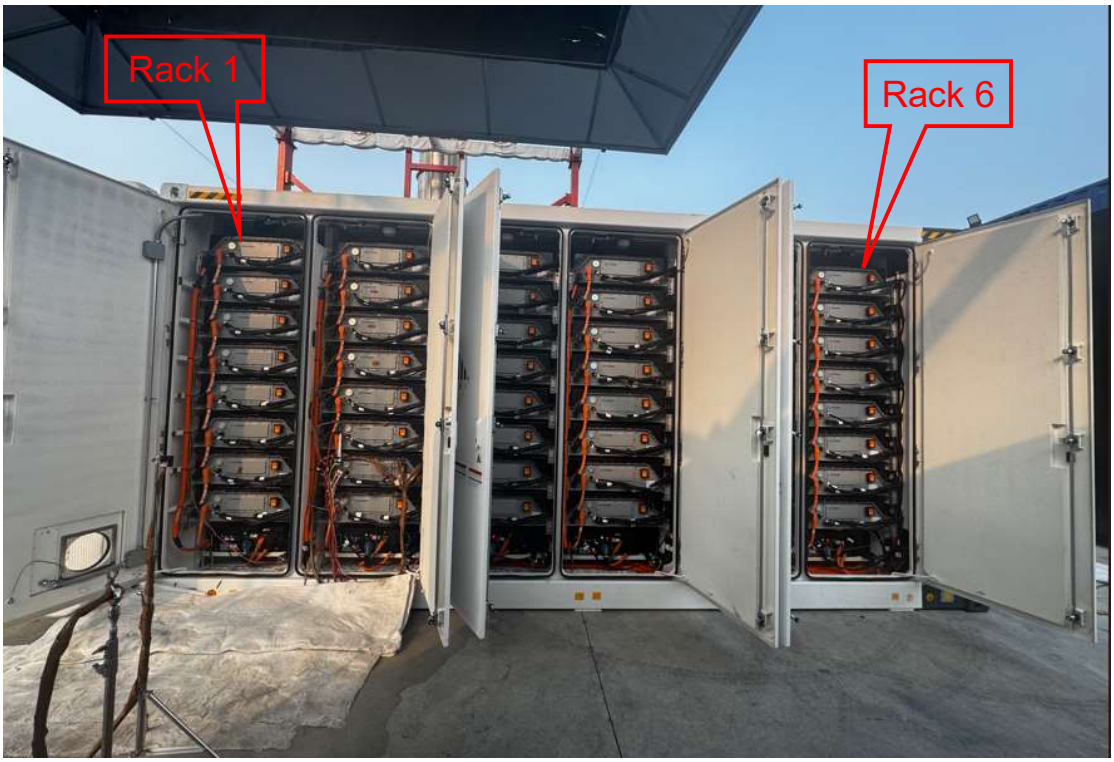


Figure 21 – Picture of fully populated enclosure of origin

2.4.2 Ventilation Systems

The six doors corresponding to the location of the trigger Rack remain open (the doors of Racks 1 & 2 are open and fixed with foot tops, the doors of Racks 3 and 5 are open without foot nails, and the doors of Racks 4 and 6 are open and fixed with foot nails). The diagonal fan window remains open, and the fan does not start. Central control cabinet is closed. The door of the fire control cabinet was closed

2.4.3 Passive Thermal Runaway Mitigation Technologies

The battery modules were equipped with thermal isolation material that were designed to slow down the cell-to-cell propagation of the thermal runaway, that was installed between large surfaces of the two cells. But in order not to affect the heating and thermal runaway propagation for the Initiating cell, the initiating cells thermal isolation material have been removed.

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2.4.4 Active Mitigation Systems

Active fire protection systems were deactivated within the enclosure of origin, such as water firefighting. Retain two temperature detectors, two smoke detectors and two combustible gas detectors of the fire detector system. The explosion control combustible concentration system window remains open, and the system does not start.

2.4.5 Instrumentation

The enclosure of origin was equipped with a total of 48 fully charged battery modules. For clarity in reporting, the sixth Rack M-6 is near the electrical compartment, and the outermost Rack away from the electrical compartment is the first Rack M-1. Within each Rack, modules were numbered sequentially from bottom to top, such as first Rack with the lowest module labeled as M-1-1 and the highest as M-1-8.

To mitigate the risk of malfunction due to power supply failure or heater malfunction, two initiating cell groups were prepared in advance in module M-2-7. The selected locations of these initiating modules, shown in Figure 22, were chosen to allow for analysis of both vertical and horizontal propagation of thermal runaway. Figure 22 provides a visual reference for the initiating modules installed in the enclosure of origin.

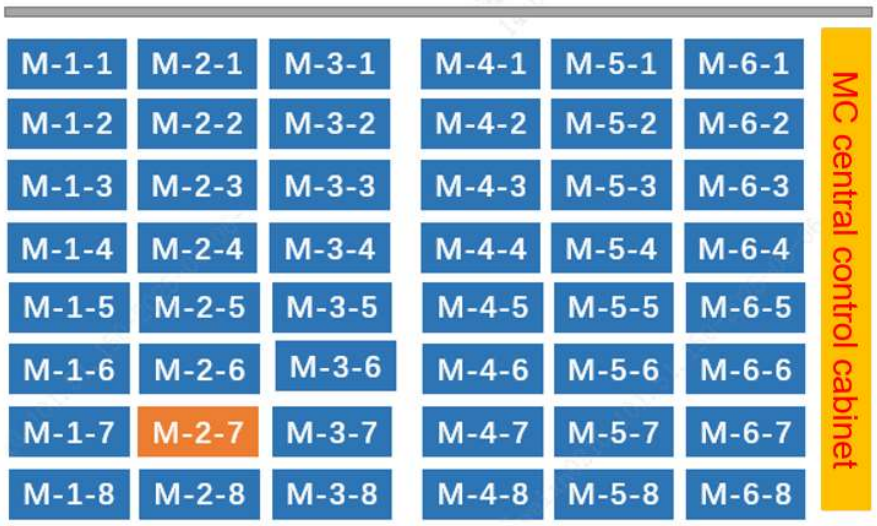


Figure 22 – location of the initiating modules in the enclosure of origin

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Figure 23 – Picture of the initiating module in the enclosure of origin

The flexible film heaters were applied to large faces of two cells, the flexible film heaters rated 220VAC, 800W, size 172mm*202mm. Used for four flexible film heaters to heating eight cells simultaneously. The second half of the module M-2-7 was mainly initiating group cells, the first half of the module M-2-7 as back-up initiating group cells, as illustrated in Figure 24.

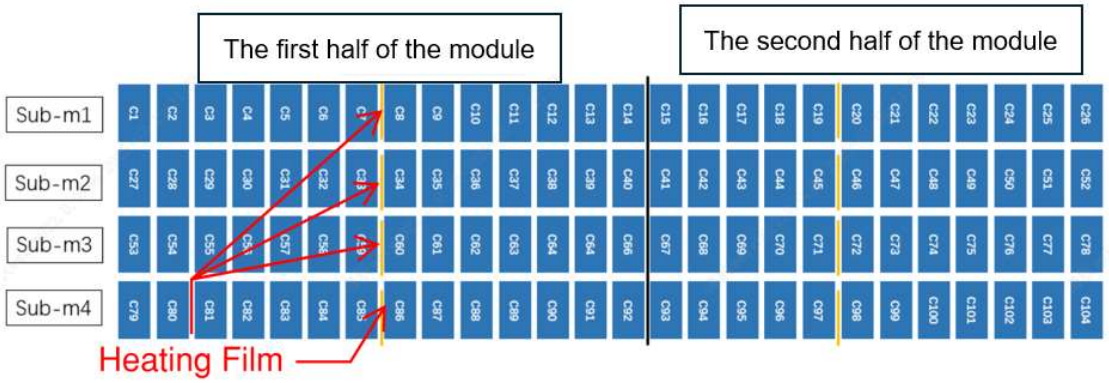


Figure 24 – Position of heating cells of internal Battery Module and orange line is heating film

The initiating cell was instrumented with three Type K thermocouples, one thermocouple as the central surface can be used as control feedback for the heating rate of the cell, other two thermocouples as the cell temperature feedback for the cell thermal runaway, as illustrated in Figure 25.

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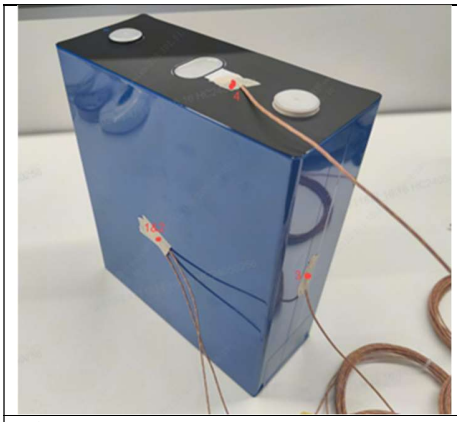
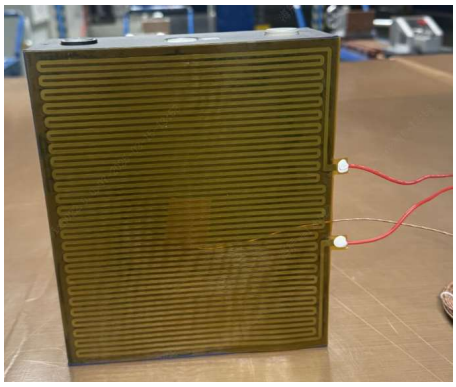
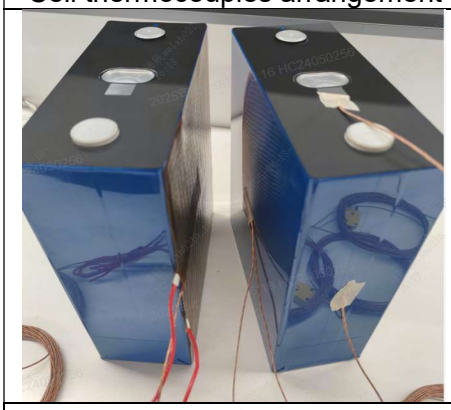
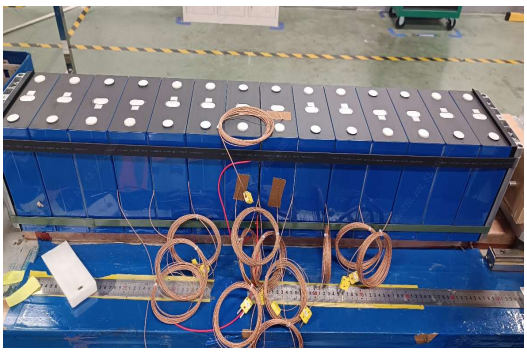
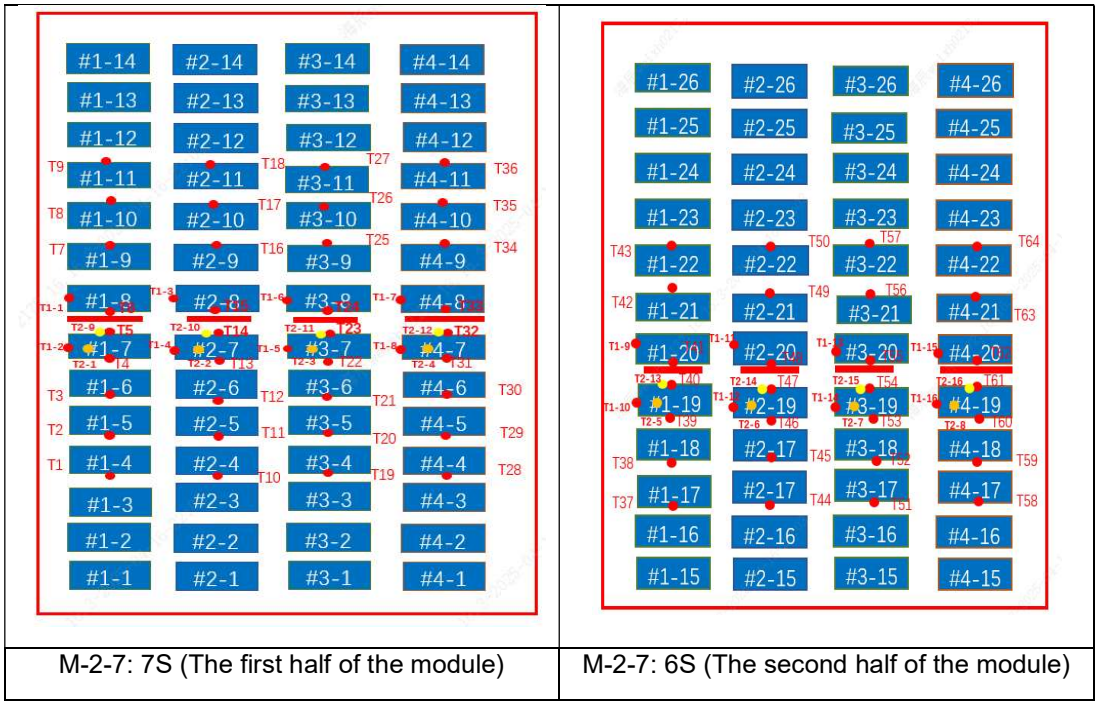
	
Cell thermocouples arrangement	Initiating cell heating film arrangement
	
Two cell heating film arrangement	Sub-cell module assembly

Figure 25 – Thermocouples placement on the initiating cells

Temperature Measurement Points for initiating Battery Module, as illustrated in Figure 26. The yellow temperature sensing wire is an additional monitoring temperature rise rate control (numbered T2-9 to T2-16) to prevent the failure of the heating film temperature sensing wire; the orange one is attached to the battery cell as a thermal runaway temperature reference (numbered T2-1 to T2-8).

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M-2-7: 7S (The first half of the module)	M-2-7: 6S (The second half of the module)

Figure 26 – Thermocouple placement on the initiating Battery Module

Voltage Measurement Points for initiating Battery Module M-2-7, as illustrated in Figure 27.
7S part: Voltage V1 for Cell #1-7 and #1-8, V2 for Cell #2-7 and #2-8, V3 for Cell #3-7 and #3-8, V4 for Cell #4-7 and #4-8;
6S part: Voltage V5 for Cell #1-19 and #1-20, V6 for Cell #2-19 and #2-20, V7 for Cell #3-19 and #1-20, V8 for Cell #4-19 and #4-20.

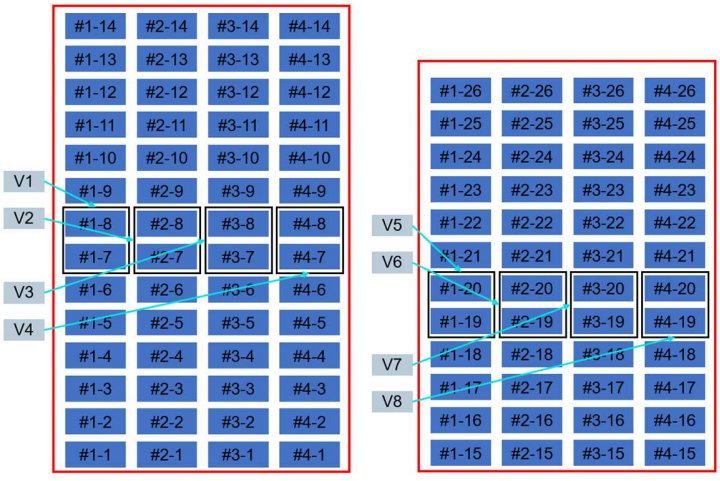
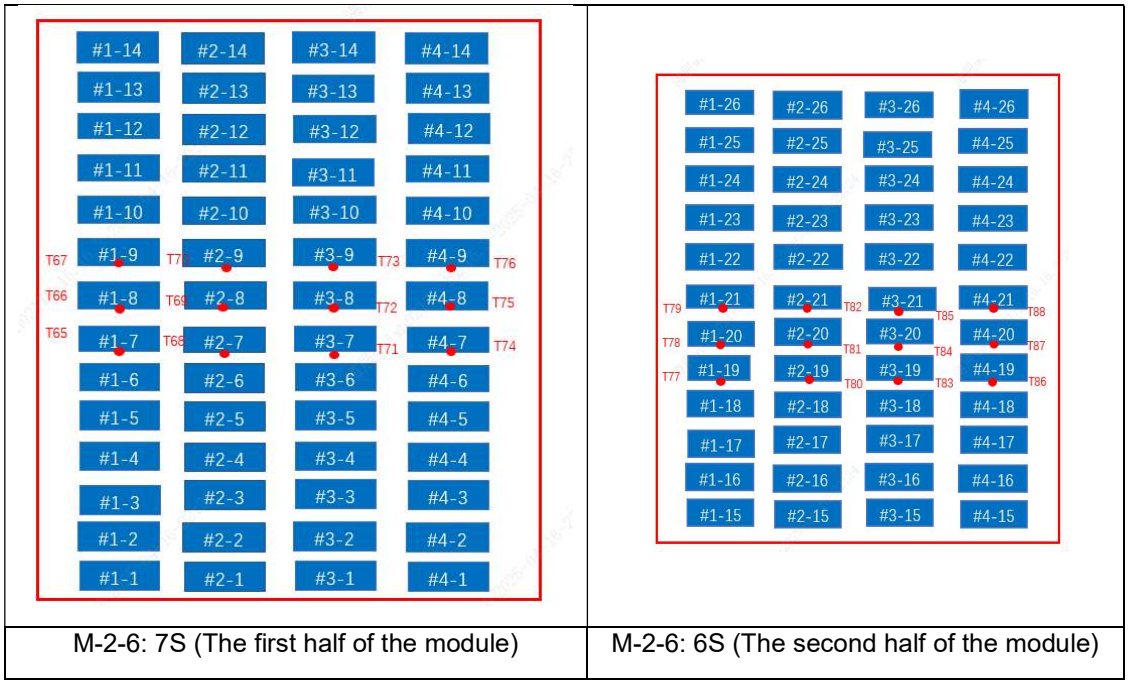


Figure 27 – Voltage Measurement Points for Initiating Battery Module M-2-7

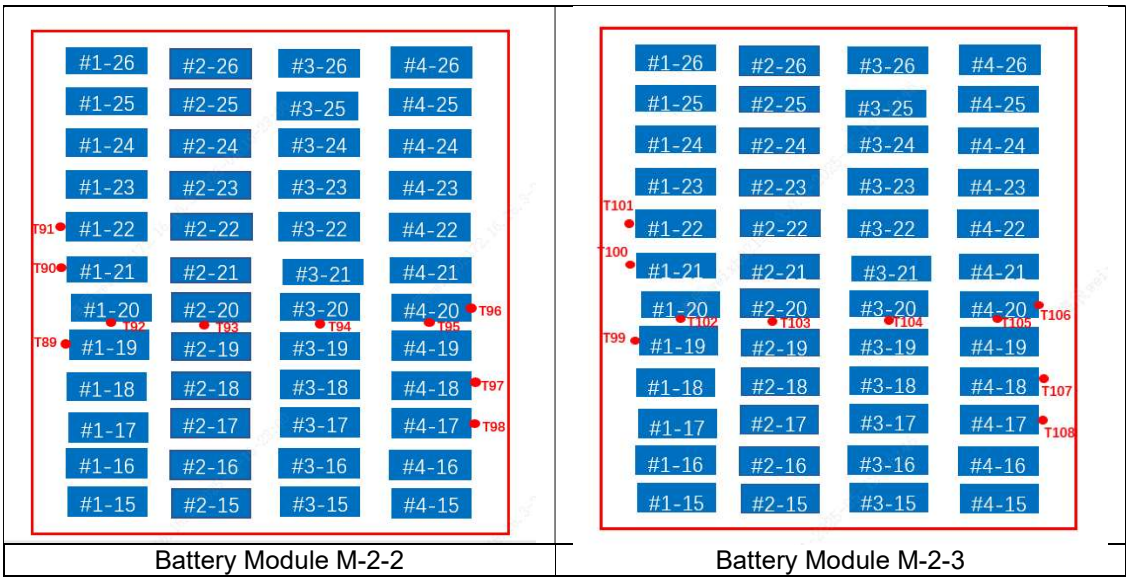
Temperature Measurement Points Around Initiating Battery Module M-2-6 to M-2-2, as illustrated in Figure 28 - 31.

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M-2-6: 7S (The first half of the module)	M-2-6: 6S (The second half of the module)

Figure 28 –Thermocouple placement on a non-initiating module M-2-6



Battery Module M-2-2	Battery Module M-2-3

Figure 29 –Thermocouple placement on a non-initiating module M-2-2 and M-2-3

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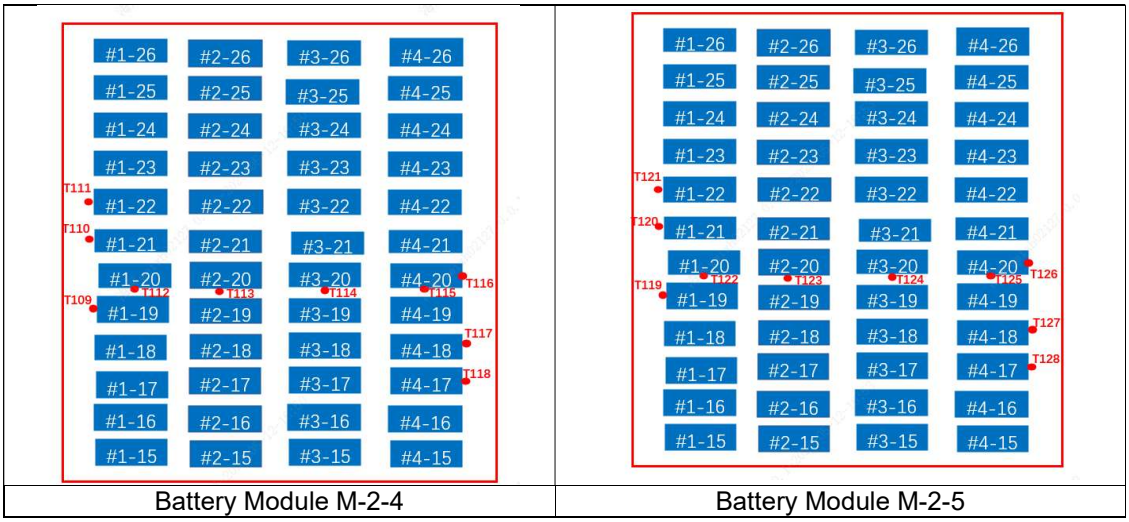


Figure 30 –Thermocouple placement on a non-initiating module M-2-4 and M-2-5

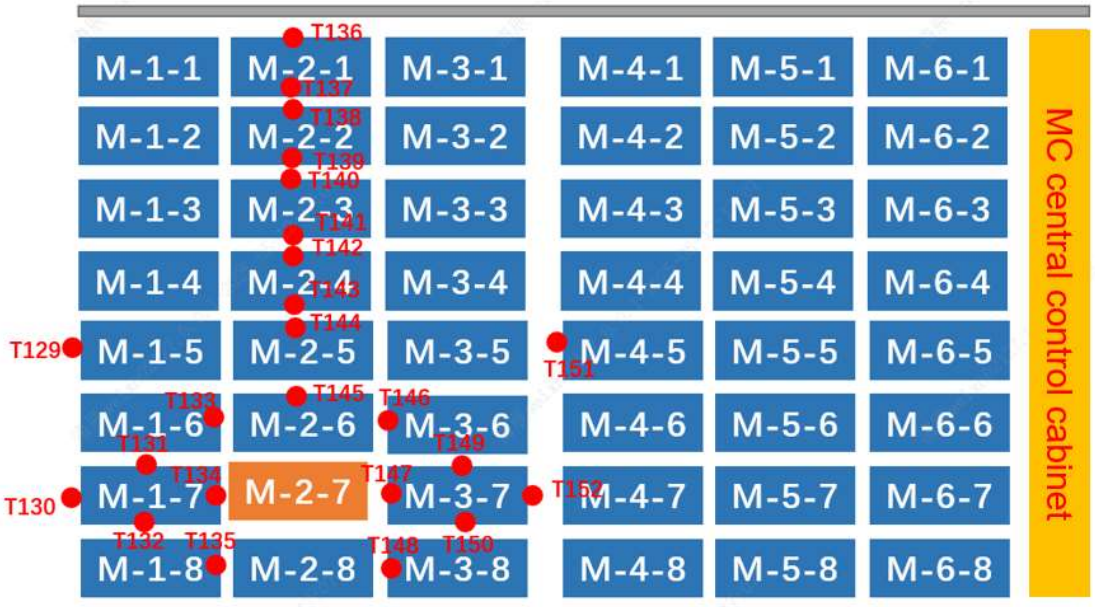


Figure 31 –Thermocouples placement on the outer Enclosure of Surrounding Battery Module

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The four sides of the enclosure of origin were instrumented with thermocouples on the interior and exterior surfaces to monitor. There were 3 equal points inside the left panel, 3 equal points inside the back panel, 3 equal points inside the top panel, and 3 equal points inside the partition of the electrical cabin for adhesive point monitoring, as depicted in Figure 32.

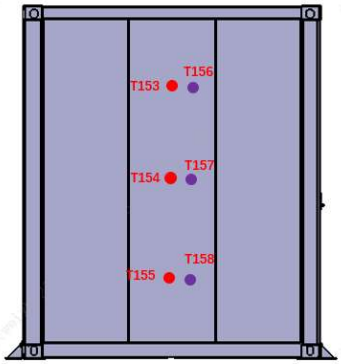
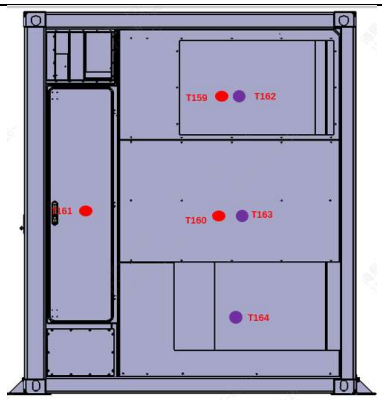
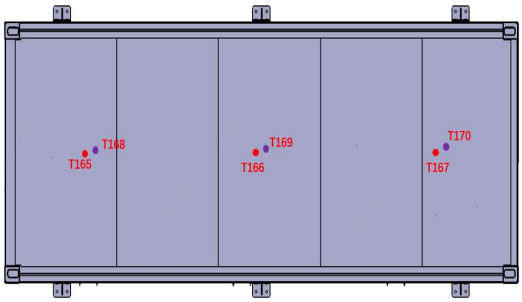
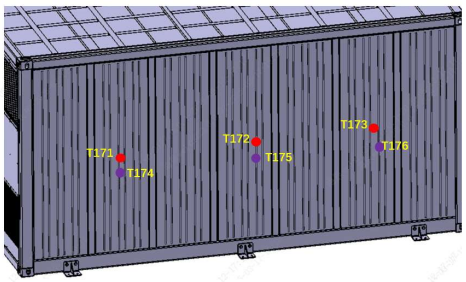
<table>
<tr><td> 
</td><td> 
</td></tr>
<tr><td>Left side door panel internal & external adhesive points</td><td>Right electrical Instrumented internal & external sticky points</td></tr>
<tr><td> 
</td><td> 
</td></tr>
<tr><td>Top Panel Internal & External Sticky Points</td><td>Back panel internal & external adhesive points</td></tr>
<tr><td colspan="2">Note: Internal red, external purple</td></tr>
</table>

Figure 32 – Thermocouples placement on the interior and exterior surfaces of the enclosure of origin

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2.5 Target containers Installation

Three enclosures were positioned around the enclosure of origin at distances specified by HITHIUM based on the minimum separation distances allowed within the manufacturer's installation instructions. Throughout the test, both temperature/heat flux data and visual observations were continuously monitored to assess thermal exposure and to detect any potential thermal runaway events.

2.5.1 Overall Installation

Target B, Target C and Target D Containers were each partially populated with a single Rack containing full modules positioned closest to the enclosure of origin. This configuration was intended to monitor temperature increases due to heat transfer from the enclosure of origin and to evaluate the potential for venting or thermal runaway events in the target containers.

		
Target B Rack No. M-1	Target C Rack No. M-2	Target D Rack No. M-2

Figure 33 – The configuration of Racks within the target container

2.5.2 Ventilation Systems

The doors of the target containers were closed.

2.5.3 Passive Thermal Runaway Mitigation Technologies

The battery modules were equipped with thermal isolation material that were designed to slow down the cell-to-cell propagation of the thermal runaway, that were installed between large surfaces of two cells.

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2.5.4 Active Mitigation Systems

Active fire protection systems were deactivated within the target containers, such as water firefighting. Retain two temperature detectors, two smoke detectors and two combustible gas detectors of the fire detector system. The explosion control combustible concentration system maintains normal working conditions.

2.5.5 Instrumentation

2.5.5.1 Target Container B

Target Container B instrumented with Type K thermocouples mainly located on internal and external surface of container enclosure, battery module enclosure surface and internal cell surface near direction of initiating container A, as shown in Figure 34 - 36.

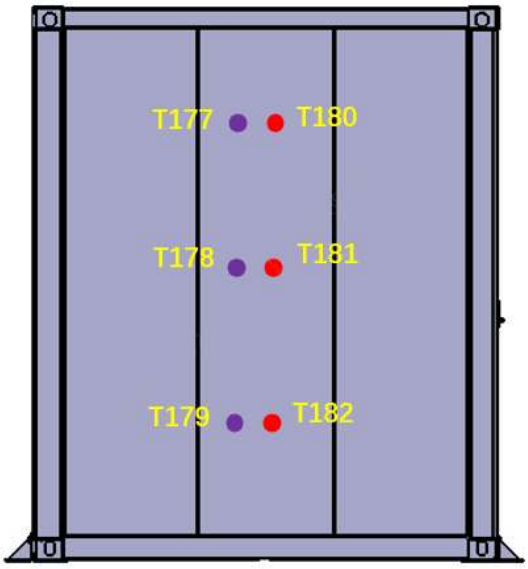


Figure 34 – Thermocouples instrumented on the container B enclosure surface near the direction of Container A, Internal red, external purple

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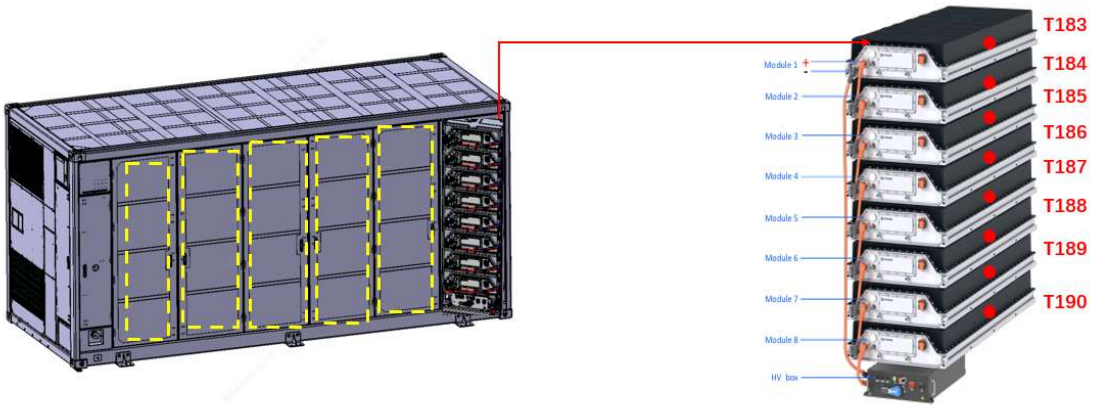


Figure 35 – Thermocouples instrumented on the container B battery module enclosure surface

Note: The yellow dashed box represents the position of the Rack frame, which is empty inside. The red dots indicate the center of the side of the module enclosure.

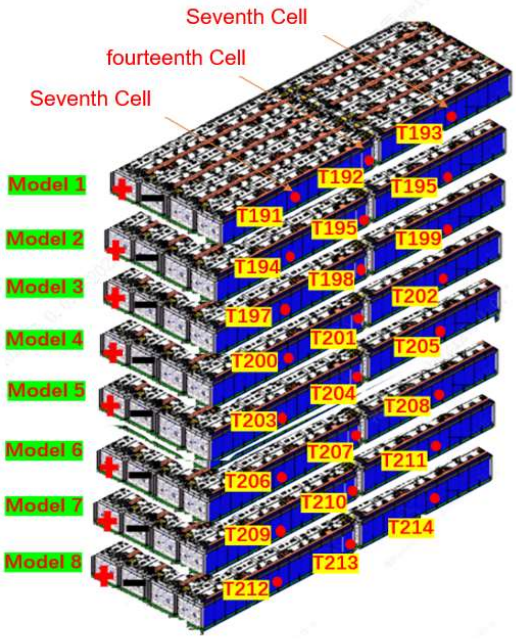


Figure 36 – Thermocouples instrumented on the cell surface of container B battery module

The internal side of the module is divided into three equal parts (selecting the 7th battery cell in the front 7S, the 14th battery cell, and the 7th battery cell in the back 6S). The thermocouples are arranged from top to bottom and numbered in order, monitor cell thermal conditions impact form the initiating Container A.

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2.5.5.2 Target Container C

Target Container C instrumented with Type K thermocouples mainly located on external surface of container enclosure, battery module enclosure surface and internal cell surface near direction of initiating container A, as shown in Figure 37 - 39.

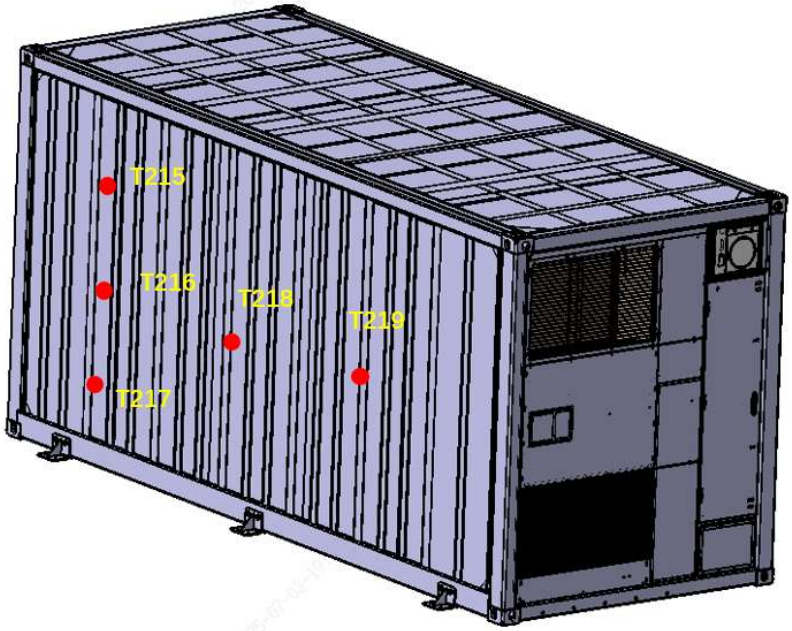


Figure 37 – Thermocouples instrumented on the container C enclosure surface near the direction of Container A.

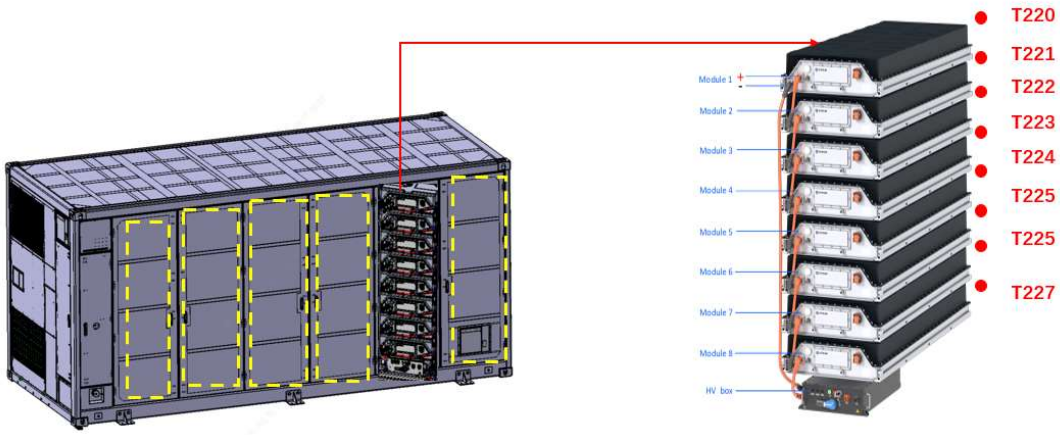


Figure 38 – Thermocouples instrumented on the Container C battery module enclosure surface

Note: The yellow dashed box represents the position of the Rack frame, which is empty inside. The red dots indicate the exact center at the end of the module enclosure.

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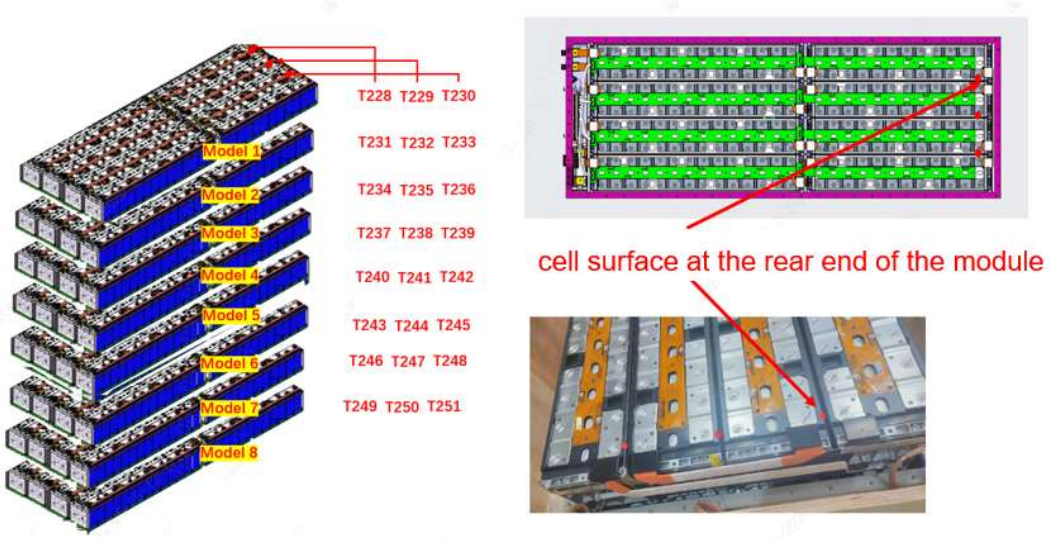


Figure 39 – Thermocouples instrumented on the cell surface of Container C battery module

The thermocouples are arranged on the internal cell surface at the rear end of the module to monitor cell thermal conditions impact from the Initiating container A.

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2.5.5.3 Target Container D

Target Container C instrumented with Type K thermocouples mainly located on external surface of container enclosure, battery module enclosure surface and internal cell surface near direction of initiating container A, as shown in Figure 40 - 42.



Figure 40 – Thermocouples instrumented on the Container D enclosure surface near the direction of Container A.

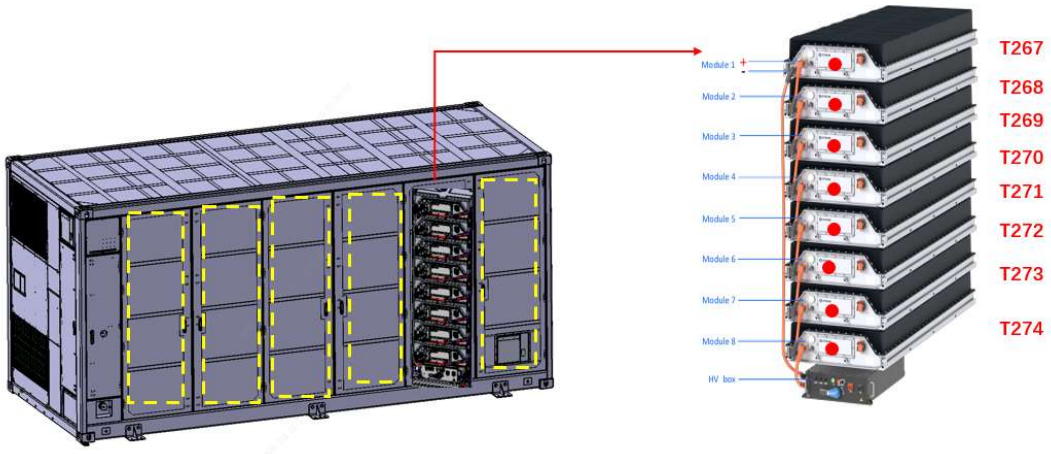


Figure 41 – Thermocouples instrumented on the Container D battery module enclosure surface

Note: The yellow dashed box represents the position of the Rack frame, which is empty inside. The red dots indicate the exact center at the front of the module enclosure.

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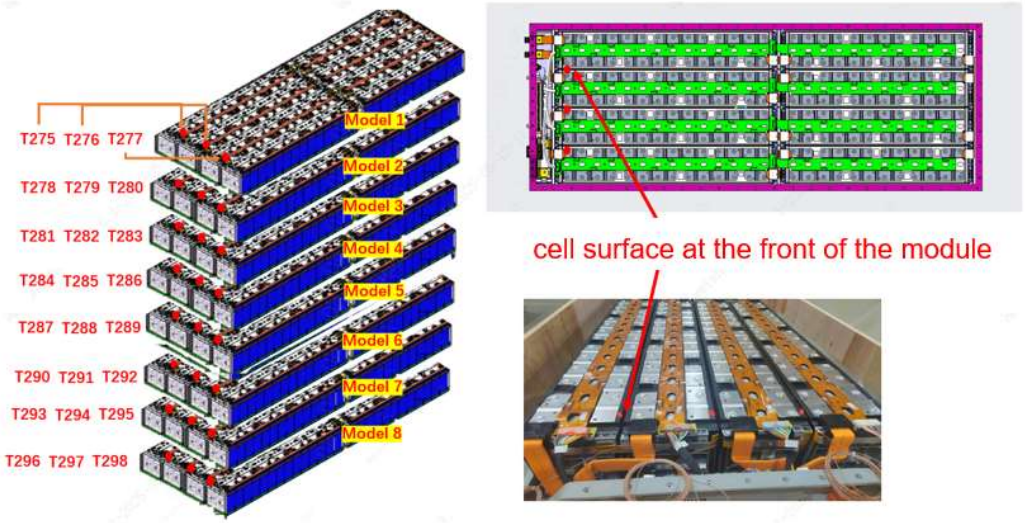


Figure 42 – Thermocouples instrumented on the cell surface of Container D battery module

The thermocouples are arranged internal cell surface at the front of the module to monitor cell thermal conditions impact from the Initiating container A.

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2.6 Instrumented Wall

Request by HITHIUM build an Instrumented wall to represent other equipment placed from the side of Container A, 3m away from container A position. As shown in figure 43 below.

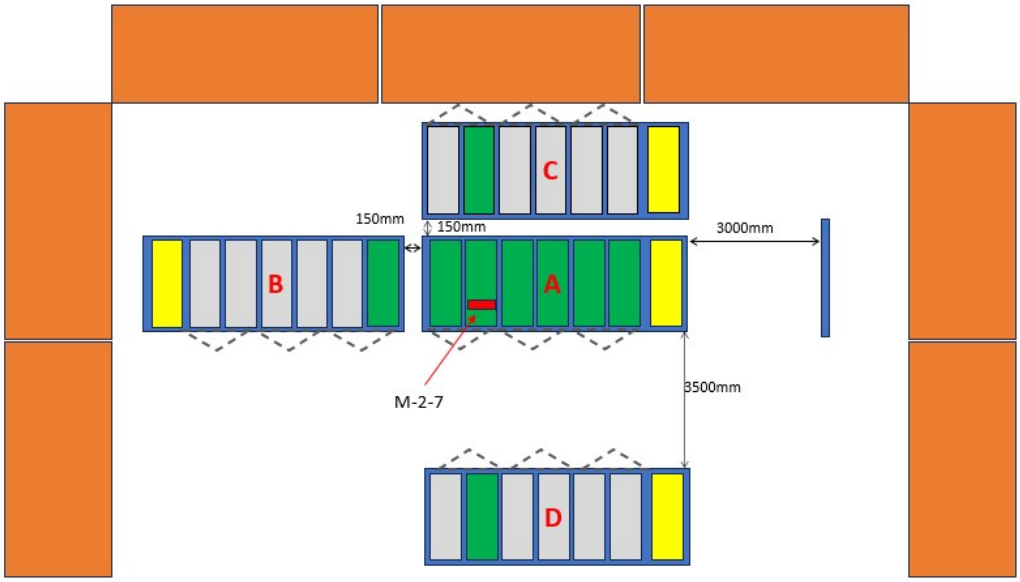


Figure 43 – Instrumented wall view

The temperature sampling of the Instrumented wall should collect the wall temperature measurement value. The wall temperature should be measured using a 24-gauge K-type exposed junction thermocouple arranged vertically at 152mm (6 inches) intervals. The thermocouple used to measure the wall temperature should be placed horizontally at the wall position where the maximum heat exposure is expected to be received from the initiating Container A.

The insulation part of the thermocouple wire should be fixed on the gypsum surface. The thermocouple tip should be pressed into the gypsum so that it flushes with the gypsum surface at the measurement point, and pressure-sensitive paper tape should be used to maintain thermal contact with the gypsum surface at the measurement point.

The Instrumented Wall specifications: 3.7m high, 3m wide and painted flat light black. Two water-cooled Heat flux gauges are arranged on the Wall. The Heat flux gauges were collinear with the vertical thermocouple array. One Heat flux gauges the height position located Initiating module's height used for receiving the maximum thermal flux of the thermal runaway of the Initiating module, one other Heat flux gauges locates on the height of the center of the Battery Module above Initiating module.

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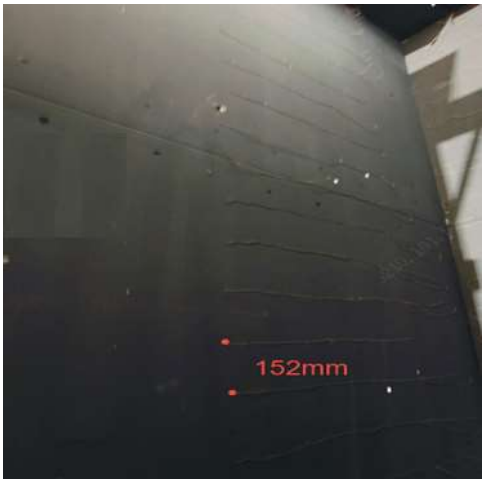


Figure 44 – Thermocouple placement on the Wall

2.7 Ignition Device

Two sparks plug ignition and one heating element ignition were arranged 5cm apart at the initiating module M-2-7 vent of Container A.

Table 8 - Igniter specification

Parameter	Electronic pulse igniter	Electric heating igniter
Size	Length 71mm X Width 35mm X Thickness 25mm	Length 80mm Diameter 10mm
Voltage	DC 12V	AC 220V
Power	12W	50W
Ignition trigger mode	Pulse ignition arc	Heating wire heating

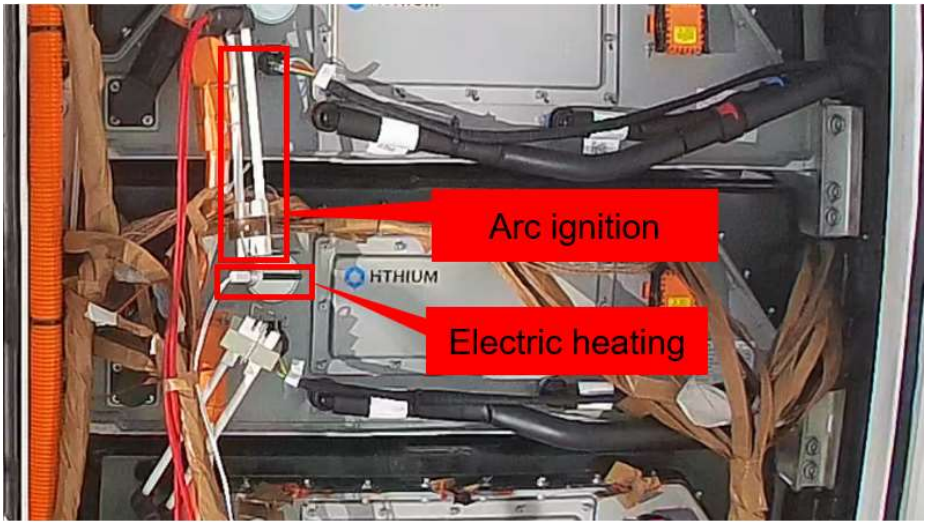


Figure 45 – Ignition Device view

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2.8 Heat Flux gauges

As requested by HITHIUM equipped with heat flux gauges to capture the highest levels of total heat flux. HF1 & HF2 are heat flux gauges on the Instrumented wall. HF3 is 3000mm away from the side of Container D and 2550mm away from the front plane of Container A. HF4 is half the distance (1750mm) between Container A and D. HF6 is 1750mm opposite the first Rack of Container B. HF5 & HF7 are symmetrical mirroring of HF4 & HF6 in front of Container D.

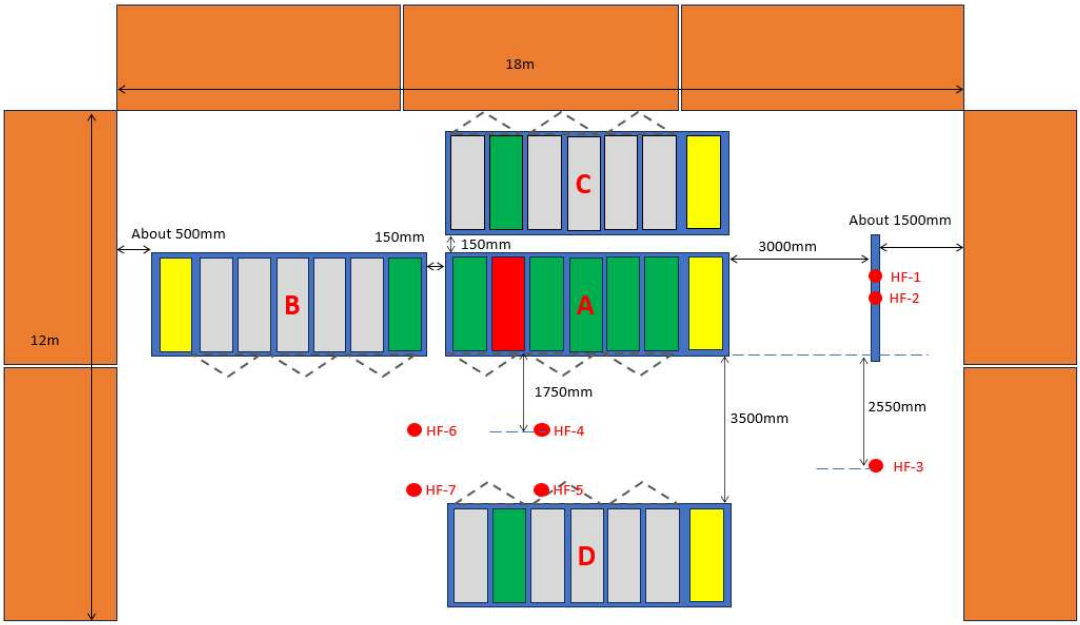


Figure 46 – View of the heat flux gauge placements

Table 9 – The heat flux gauge height

Heat Flux gauge No.	Height (mm)
HF1	923
HF2	1186
HF3	923
HF4	923
HF5	923
HF6	923
HF7	923

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2.9 Surveillance Equipment

The test site arranged eight cameras and two DV cameras to record the states from different angles during the test process.

Camera 1, an ordinary camera is placed between container A and D, facing the initiating module position, monitoring the occurrence of thermal runaway.
Camera 2, an ordinary camera is placed between container A and D, facing overall viewing container A.
Camera 3, shooting from the ground tripod position between Container A and Container C
Position 4, DV camera + thermal imager placed in the same position.
Camera 5, take a panoramic view from the side of the container A electrical warehouse facing the container on the Instrumented wall.
Camera 6, take a panoramic view of container A and C from the Instrumented wall.
Camera 7, facing container B and D from the Instrumented wall.
On position 8, the thermal imager and camera were placed in the same position to shoot the phenomenon of door A facing down.
HD-1 and HD-2, add two High-definition DV camera overall viewing container A.

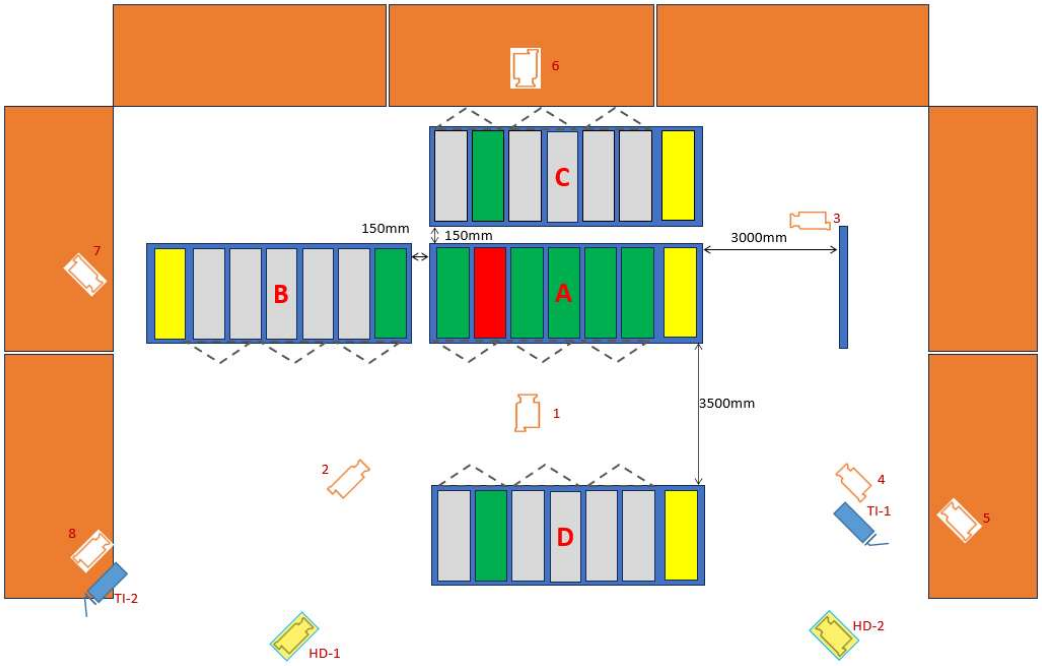


Figure 47 – Position of External Carema

Note :

: Explosion-proof camera/ordinary camera

: Thermal imager

: High-definition camera /DV camera

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3. Test results

3.1 Test Overview Timeline

The test started 18:38:54 on 26th, 2025, mainly event as below table 10 and Figure 48.

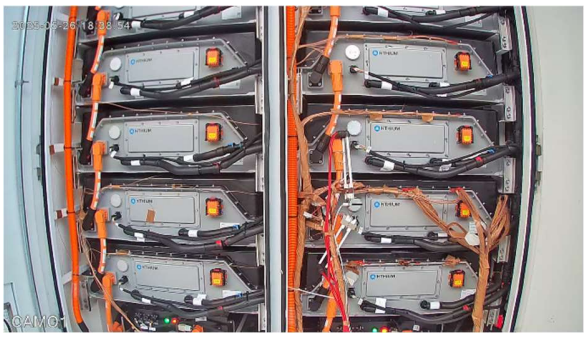
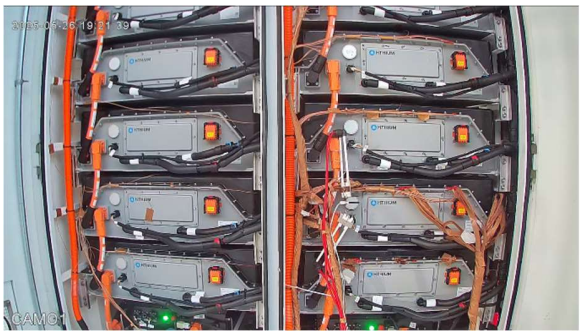
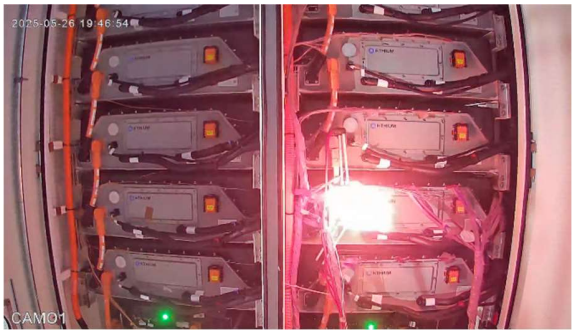
Table 10 - Test Overview Timeline

Time (HH:MM:SS)	Event	Description
00:00:00	Test Start	The test started and the heater was turned on to heat the initiating cells (Cell 1-19, Cell 1-20, Cell 2-19, Cell 2-20, Cell 3-19, Cell 3-20, Cell 4-19 and Cell 4-20) at a ratio of 5.5 °C/min. See Figure (a)
00:42:45	First initiating cell Venting	Initiating cell (Cell 1-20) vented at around 260°C measured through T41 by an indication of sudden dip in cell's temperature curve. See Figure (b)
00:46:11	Initiating cell Thermal runaway	Initiating cell (Cell 1-20) was at around 238°C measured through T41. The temperature of cell 1-20 began to increase in an uncontrollable manner. See Figure (c)
01:07:51	Venting of initiating module	Initiating Module M-2-7 vented and Release flammable gas from venting. See Figure (d)
01:08:00	Catch Fire	Used one Pulse ignition arc successfully ignited the combustible gas and sustained combustion. See Figure (e)
01:08:57	Initiating Container A Fire alarm activation	Initiating Container A Fire sound and light alarm device is activated. See Figure (f)
01:23:20	Flame Propagation	The flame propagation to the out of top enclosure surface of the Initiating Container A, the top battery module M-2-1 of the Initiating Rack begins to burn and gradually propagates to the top modules of the first Rack. See Figure (g) - (h)
01:51:06	Flame Propagation	The flame propagation to the top modules of the sixth Rack. The flame on the outside of the container decreased. See Figure (i) - (j)
02:21:06	Flame Propagation increase	The flame on the outside of the container increased. The first Rack and the second Rack gradually propagate from top to bottom and the combustion intensified. See Figure (k) - (l).
02:25:38	Initiating Container A Fire alarm system failed	The Horn&Strobe was burned out after working continuously about 77 minutes. See Figure (m)

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02:51:06	Flame Propagation increase	The flame on the outside of the container increased. The third Rack and the fourth Rack gradually propagate from top to bottom and the combustion intensified. See Figure (n) - (o).
02:56:55~ 03:03:55	Container D acrylic panel Catch Fire	The acrylic panel of the horn strobes alarm unit melted and combusted and self-extinguished, continuously about 7 minutes. See Figure (p) - (q).
03:06:25	Container D Intake and exhaust fans activation	The Container D Intake and exhaust fans window opened, and the fans activated. See Figure (r).
03:21:06	Flame Propagation Peak	The Heat Release Rate peak reached 13968.59kW, the Container A all battery Rack occurred flame propagation on the outside of the container reached peak. See Figure (s) - (t).
03:52:06	Remove heat release rate calorimeter	The heat release rate calorimeter was removed and stopped collecting data since the calorimeter smoke collection hood was at risk of falling off after being exposed to long-term firing, meanwhile the Flame Propagation decreased, this missing data has no relevant impact on the report. See Figure (u) - (v).
04:30:00	Flame Propagation decrease	The container A battery module keeps burning, the first Rack and second Rack flame decrease, the third to sixth Rack flame increase. See Figure (w) - (x).
05:00:00	Flame Propagation decrease	The container A battery module keeps burning, the first Rack and second Rack flame decrease, the third to sixth Rack flame increase. See Figure (y) - (z).
05:30:00	Flame Propagation decrease	The container A battery module keeps burning, the first Rack and second Rack flame went out, the third to sixth Rack flame decrease. See Figure (aa) - (ab).
06:00:00	Flame Propagation decrease	The container A battery module keeps burning, the first to fourth Rack flame went out, the fifth Rack and sixth Rack flame decrease. See Figure (ac) - (ad).
06:30:00	Flame Propagation decrease	Only visible the sixth Rack top have flame, other part the flame has gone out. See Figure (ae) - (af).
7:01:06	Visiable Fire end	There was no visible burning flame on the enclosure outside of container A. See Figure (ag) - (aj).
17:22:00	Complete Battery Modules combustion	Container A completed Battery Modules combustion about 15-16h, The containers were left in the test site to cool air naturally and the temperature data continually measured, See Figure 77 Overall view of post test

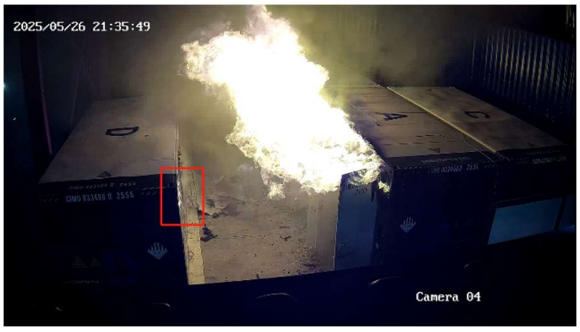
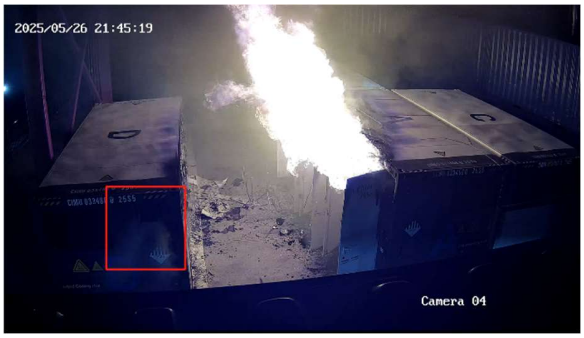
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(a) Test Start [00:00:00]	(b) First initiating cell Venting [00:42:45]
	
(c) Initiating cell Thermal runaway [00:46:11]	(d) Venting of initiating module [01:07:51]
	
(e) Catch Fire [01:08:00]	(f) Initiating Container A Fire alarm activation [01:08:57]

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(g) Flame Propagation [01:23:20]	(h) Flame Propagation [01:23:20]
	
(i) Flame Propagation [01:51:06]	(j) Flame Propagation [01:51:06]
	
(k) Flame Propagation increase [02:21:06]	(l) Flame Propagation increase [02:21:06]

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(m) Container A Fire alarm system failed [02:25:38]	(n) Flame Propagation increase [02:51:06]
	
(o) Flame Propagation increase [02:51:06]	(p) Container D acrylic panel Catch Fire [02:56:55]
	
(q) Container D flame self-extinguished [03:03:55]	(r) Container D fans activation [03:06:25]

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(s) Flame Propagation Peak [03:21:06]	(t) Flame Propagation Peak [03:21:06]
	
(u) Remove heat release rate calorimeter [03:52:06]	(v) Remove heat release rate calorimeter [03:52:06]
	
(w) Flame Propagation decreases [04:30:00]	(x) Flame Propagation decreases [04:30:00]

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(y) Flame Propagation decreases [05:00:00]	(z) Flame Propagation decreases [05:00:00]
	
(aa) Flame Propagation decreases [05:30:00]	(ab) Flame Propagation decreases [05:30:00]
	
(ac) Flame Propagation decreases [06:00:00]	(ad) Flame Propagation decreases [06:00:00]

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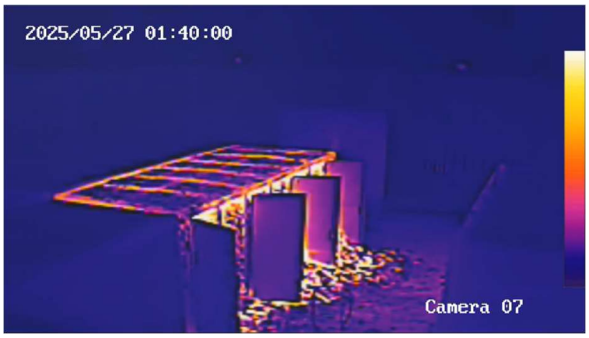
	
(ae) Flame Propagation decreases [06:30:00]	(af) Flame Propagation decreases [06:30:00]
	
(ag) Visiable Fire End [07:01:06]	(ah) Visiable Fire End [07:01:06]
	
(ai) Fire End Thermal imager [07:01:06]	(aj) Fire End Thermal imager [07:01:06]

Figure 48 – Main event view

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3.2 Thermal runaway initiation and propagation

The Initiating Cell 1-20 first occurred venting and thermal runaway, as Figure 49 - 50, the Initiating module thermal runaway as Figure 51 - 52.

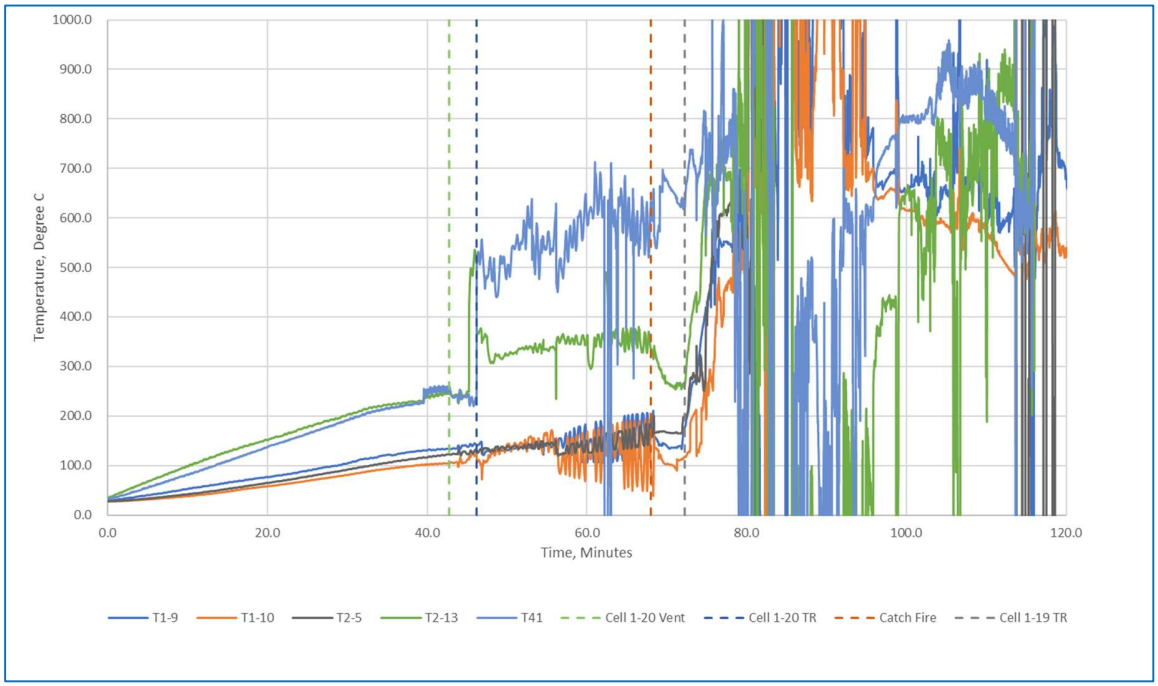


Figure 49 – Initiating Cell 1-20 occurred venting and thermal runaway

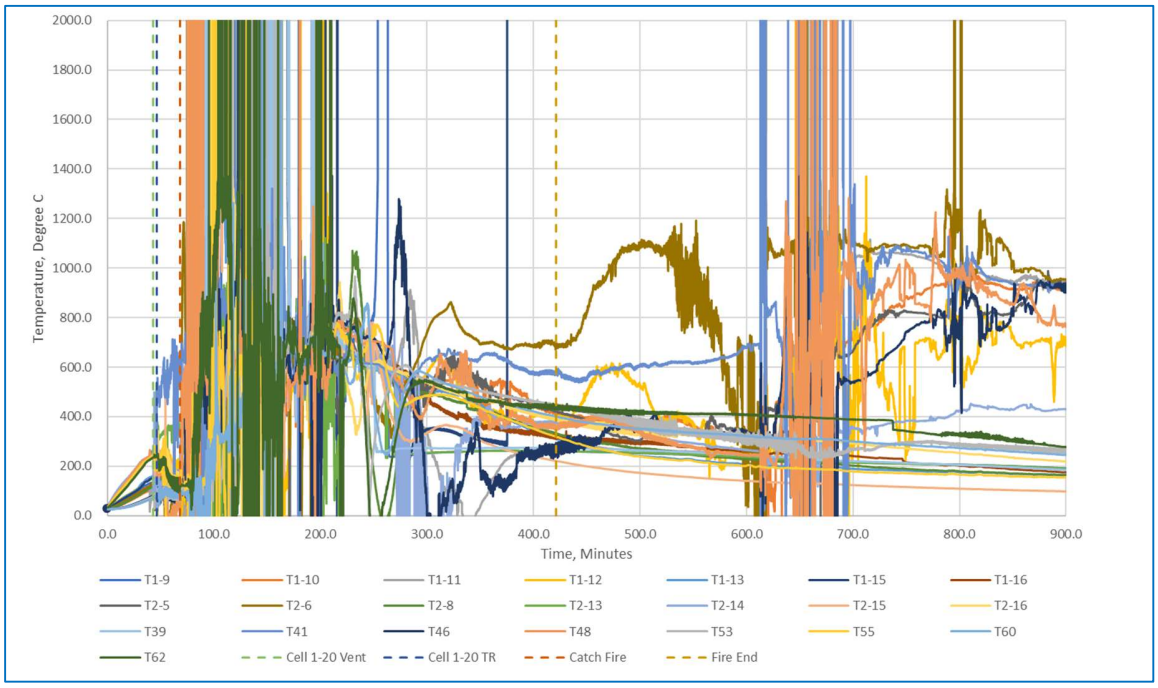


Figure 50 – Overall Initiating Cell temperature

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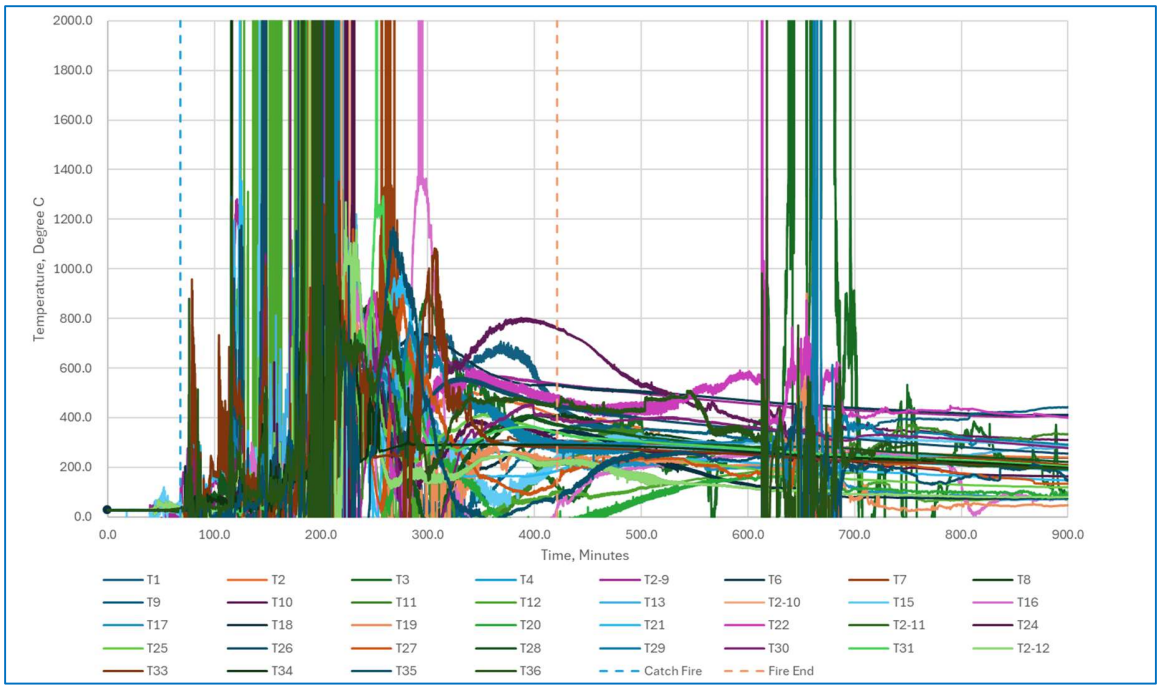


Figure 51 – Container A Initiating Module M-2-7 7S temperature

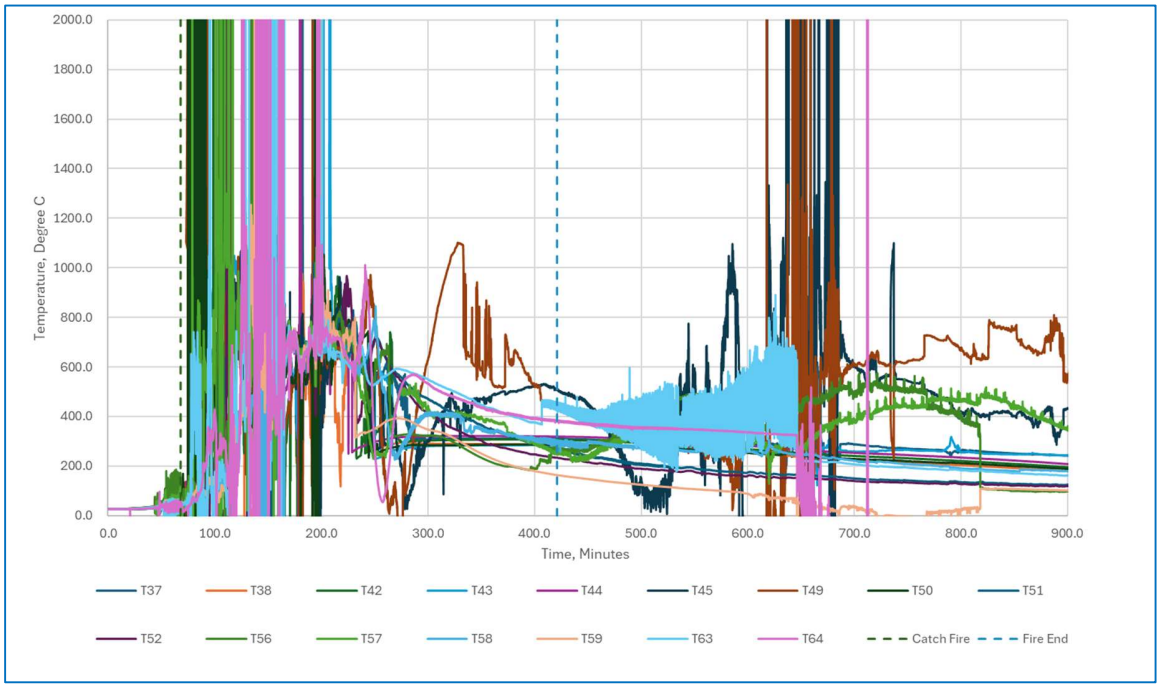


Figure 52 – Container A Initiating Module M-2-7 6S temperature

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3.2.1 Enclosure of Origin

As below Curves Figure 53 - 57 were Enclosure of Origin module enclosure and Container enclosure temperature data that only processed data lasting 900 minutes since the thermocouples have broken after complete combustion, and after 900 minutes dates were just waiting to be returned ambient temperature that were not impact this report.

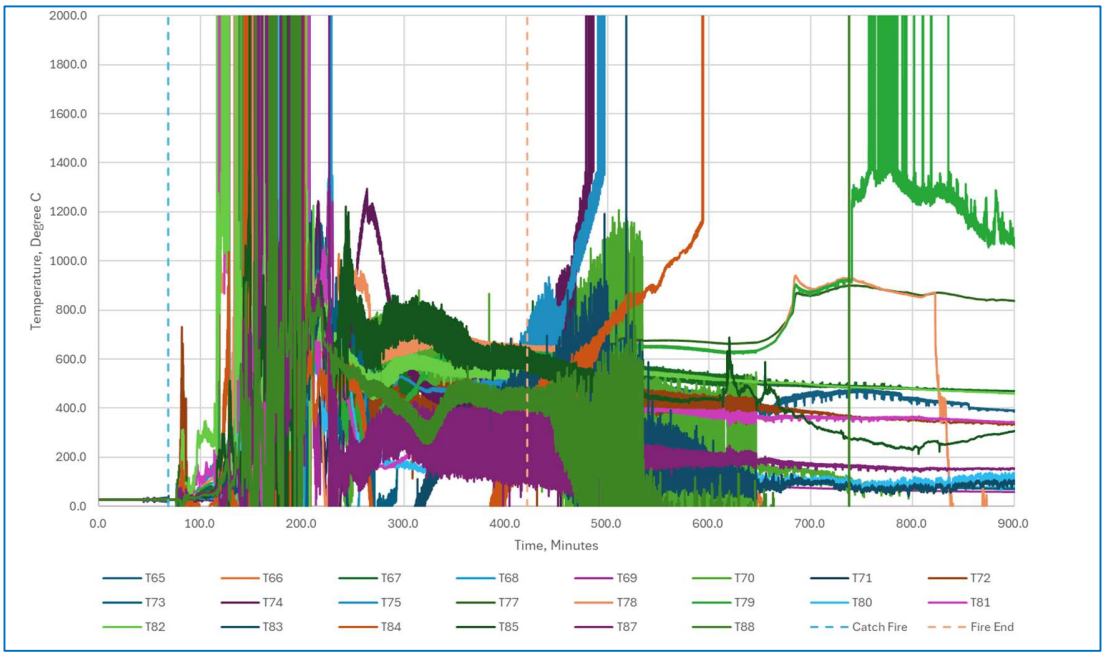


Figure 53 – Container A Module M-2-6 temperature

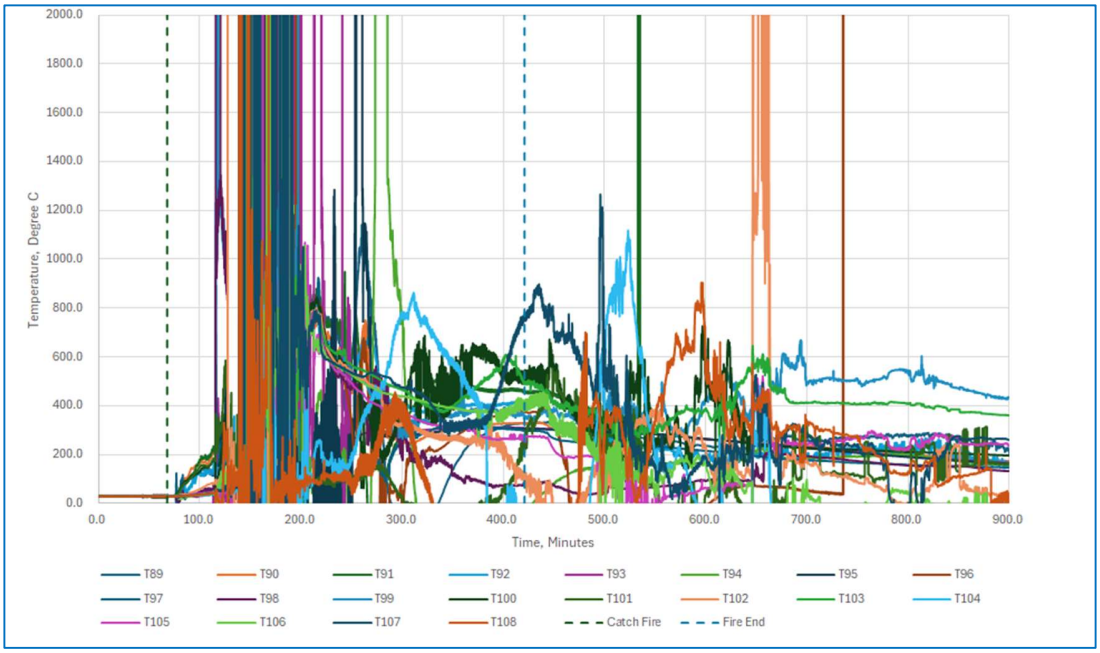


Figure 54 – Container A Module M-2-2 and M-2-3 temperature

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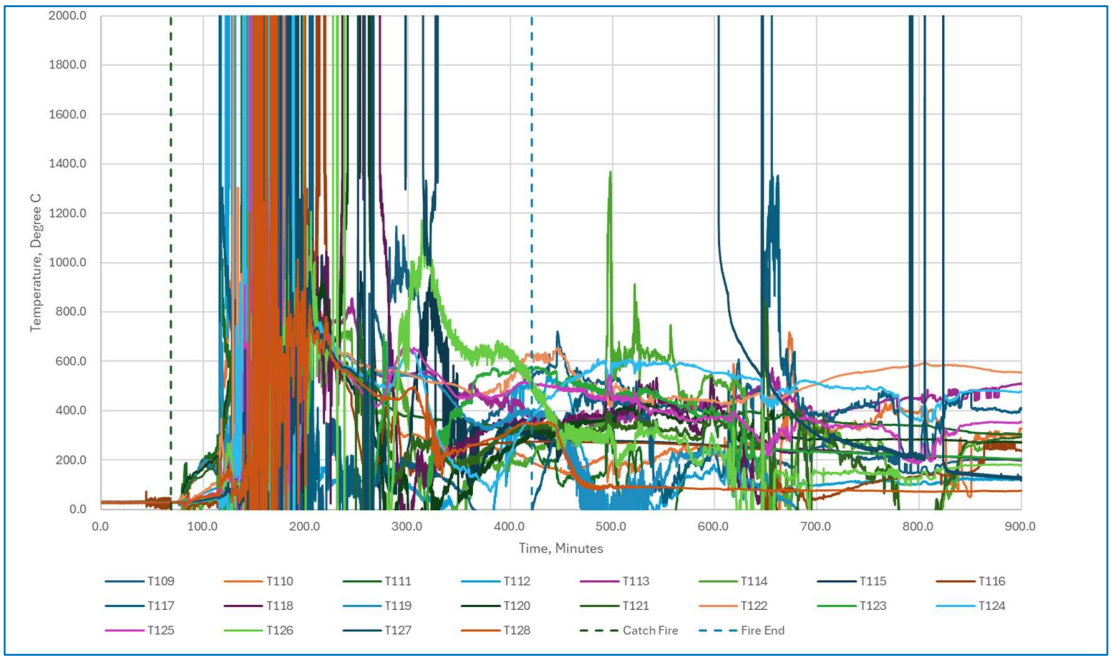


Figure 55 – Container A Module M-2-4 and M-2-5 temperature

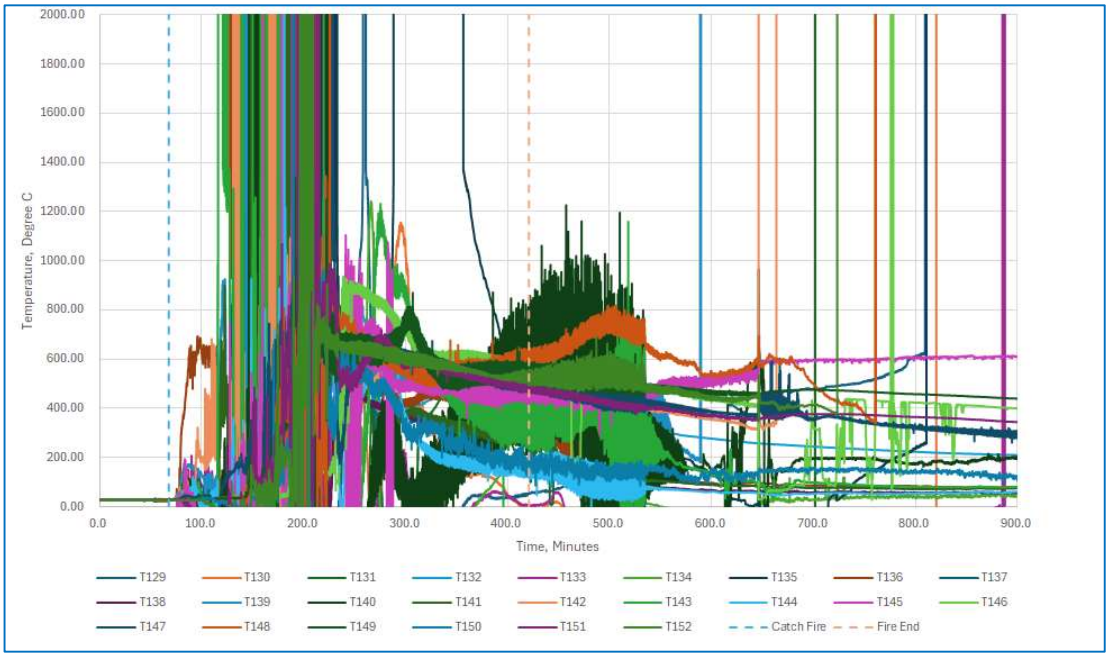


Figure 56 – Container A Module Enclosure temperature

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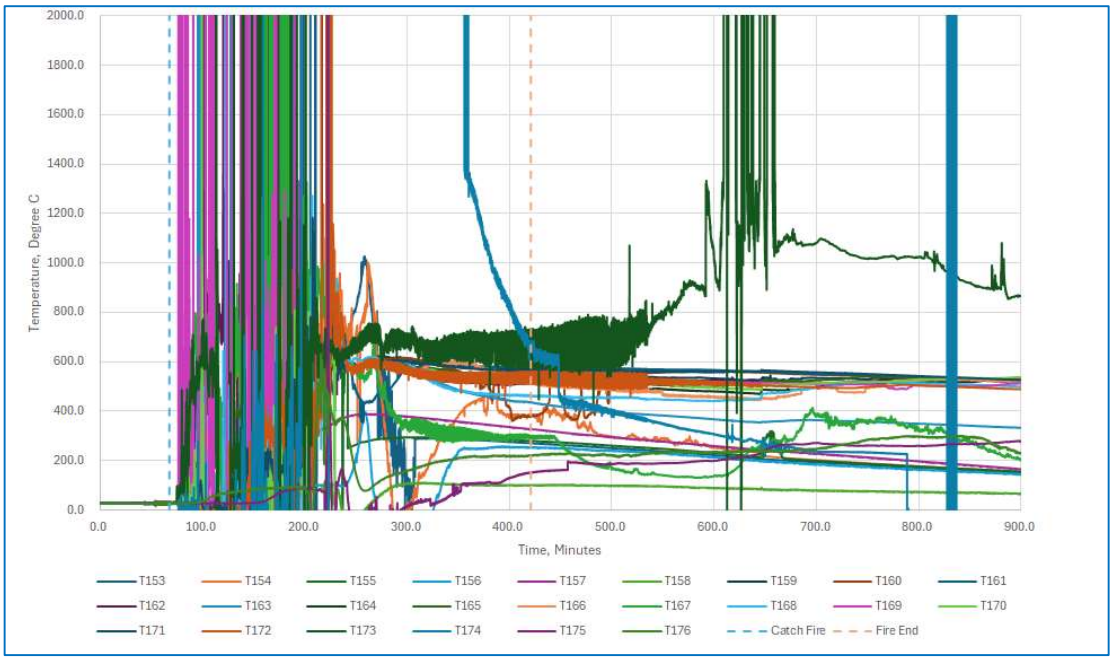


Figure 57 – Container A Enclosure temperature

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3.3 Target container temperature measurements

3.3.1 Target Container B

Maximum Temperatures on Container B enclosure surface			
External TC No.	Maximum Temperature (°C)	Internal TC No.	Maximum Temperature (°C)
T177	87.3	T180	60.6
T178	71.2	T181	46.4
T179	69.6	T182	43.2
Note: Temperatures were measured constantly and then averaged every 60-seconds			

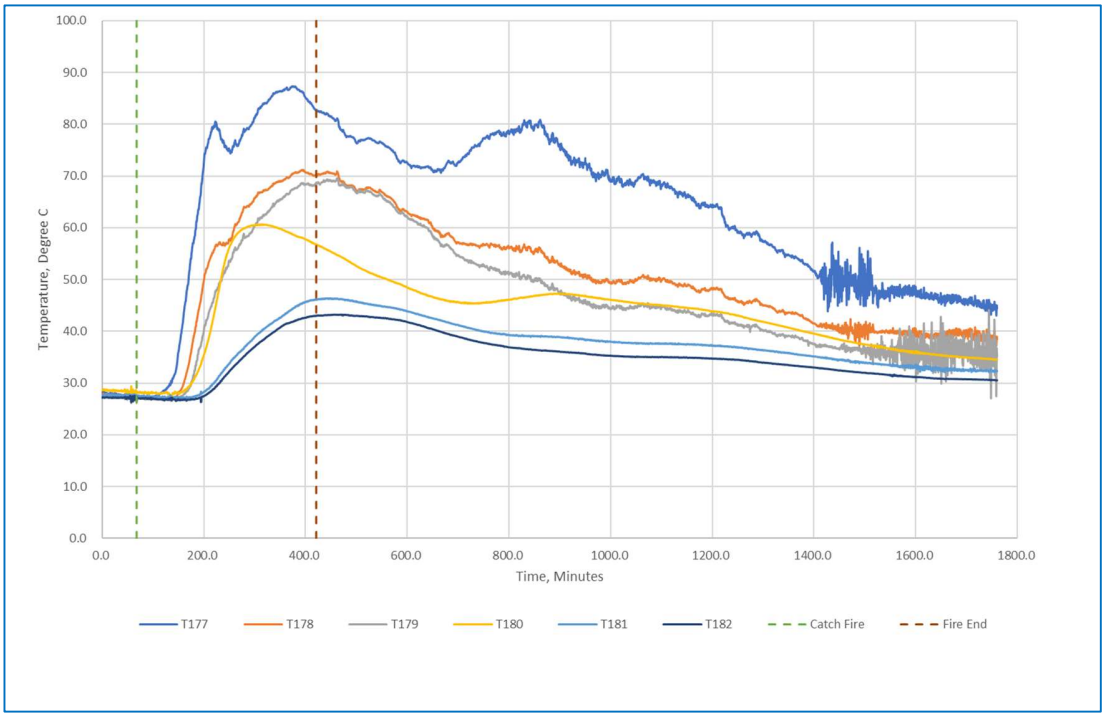


Figure 58 – Container B Enclosure temperature

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Maximum Temperatures on Container B internal module enclosure surface			
TC No.	Maximum Temperature (°C)	TC No.	Maximum Temperature (°C)
T183	76.4	T187	37.4
T184	42.8	T188	35.8
T185	N/A	T189	35.7
T186	37.7	T190	36.5
Note: Temperatures were measured constantly and then averaged every 60-seconds			

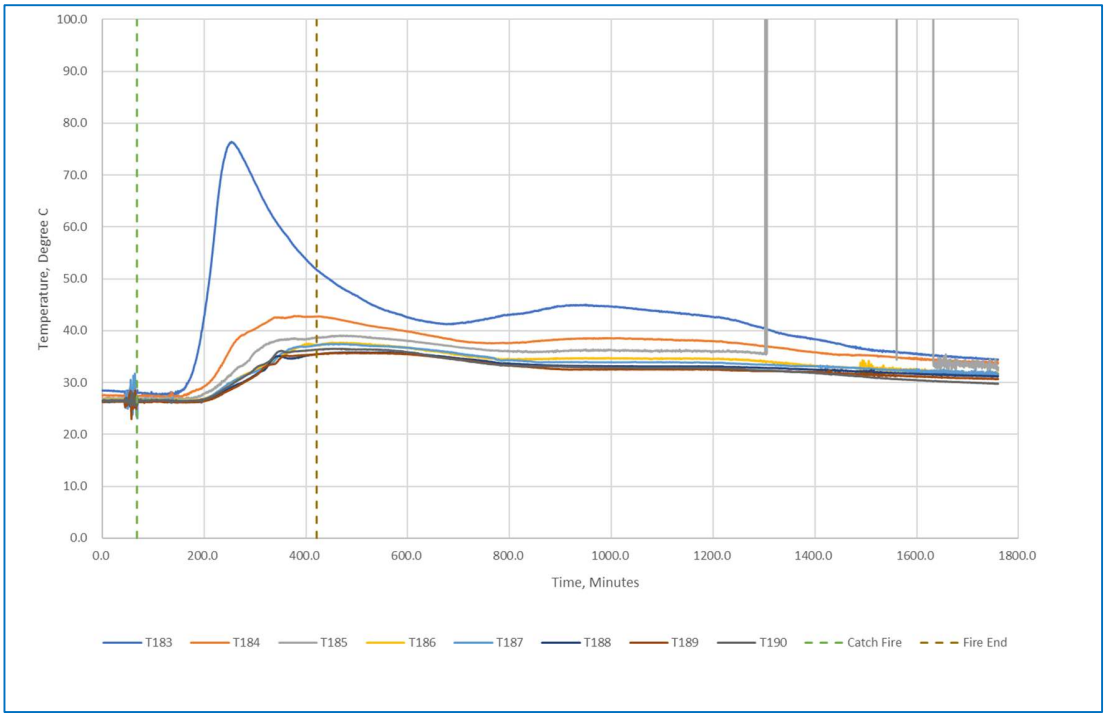


Figure 59 – Container B Module Enclosure temperature

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Maximum Temperatures on Container B internal cell surface					
TC No.	Maximum Temperature (°C)	TC No.	Maximum Temperature (°C)	TC No.	Maximum Temperature (°C)
T191	39.9	T199	35.7	T207	N/A
T192	40.2	T200	31.8	T208	33.1
T193	41.8	T201	32.5	T209	30.5
T194	35.2	T202	34.5	T210	30.9
T195	35.7	T203	31.1	T211	32.6
T196	38.1	T204	32.7	T212	30.9
T197	33.0	T205	33.8	T213	31.4
T198	33.8	T206	30.8	T214	33.0
Note: Temperatures were measured constantly and then averaged every 60-seconds					

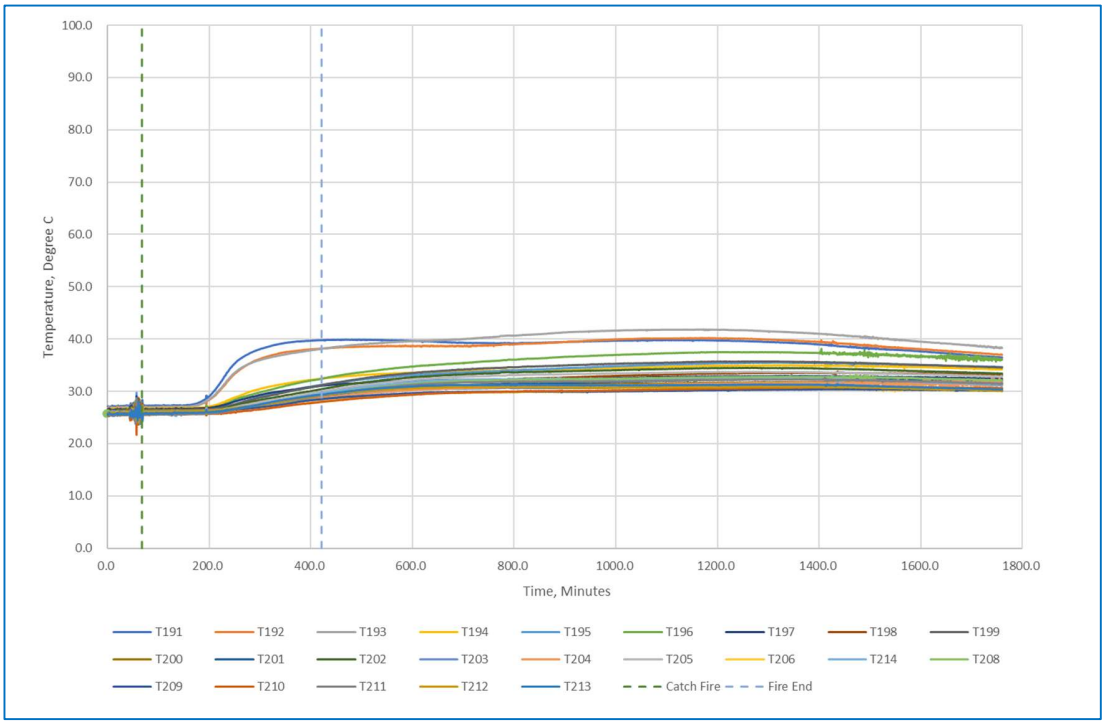


Figure 60 – Container B Module Cell surface temperature

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3.3.2 Target Container C

Maximum Temperatures on Container C enclosure surface			
TC No.	Maximum Temperature (°C)	TC No.	Maximum Temperature (°C)
T215	404.75	T218	537.86
T216	315.70	T219	400.13
T217	234.50	--	--
Note: Temperatures were measured constantly and then averaged every 60-seconds			

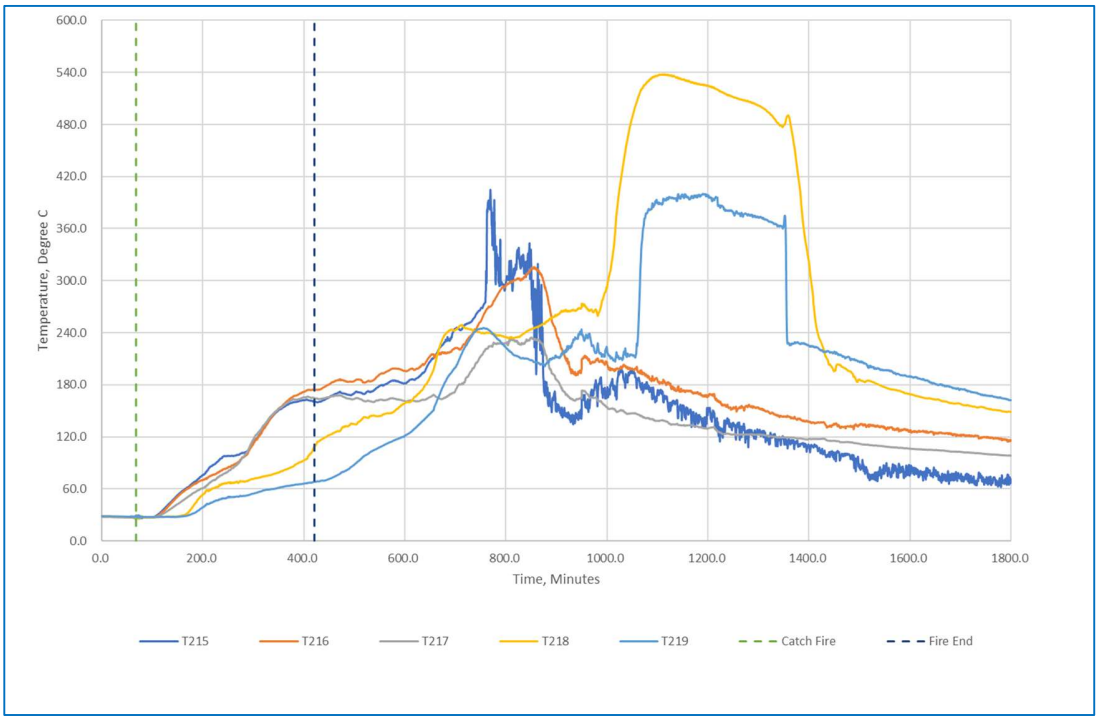


Figure 61 – Container C Enclosure temperature

Note: The Thermocouple No. T218 and T219 rise abnormally after reaching its peak cause by broken, and there wasn't any abnormally observed in the video.

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Maximum Temperatures on Container C internal module enclosure surface			
TC No.	Maximum Temperature (°C)	TC No.	Maximum Temperature (°C)
T220	105.9	T224	82.9
T221	100.2	T225	77.9
T222	97.1	T226	75.9
T223	91.6	T227	73.6
Note: Temperatures were measured constantly and then averaged every 60-seconds			

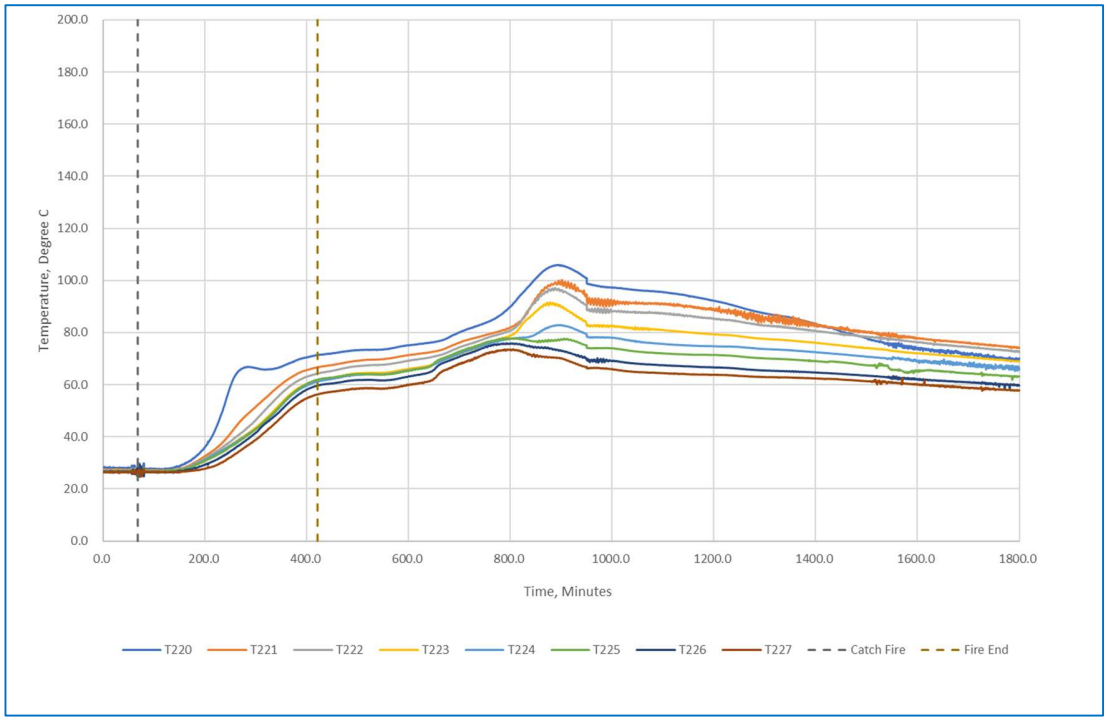


Figure 62 – Container C Module Enclosure temperature

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Maximum Temperatures on Container C internal cell surface					
TC No.	Maximum Temperature (°C)	TC No.	Maximum Temperature (°C)	TC No.	Maximum Temperature (°C)
T228	79.7	T236	72.2	T244	59.1
T229	77.7	T237	66.8	T245	77.8
T230	78.3	T238	66.5	T246	62.9
T231	74.1	T239	67.7	T247	67.4
T232	74.8	T240	63.9	T248	77.1
T233	74.5	T241	62.9	T249	68.5
T234	70.6	T242	62.4	T250	62.7
T235	73.7	T243	59.8	T251	78.0
Note: Temperatures were measured constantly and then averaged every 60-seconds					

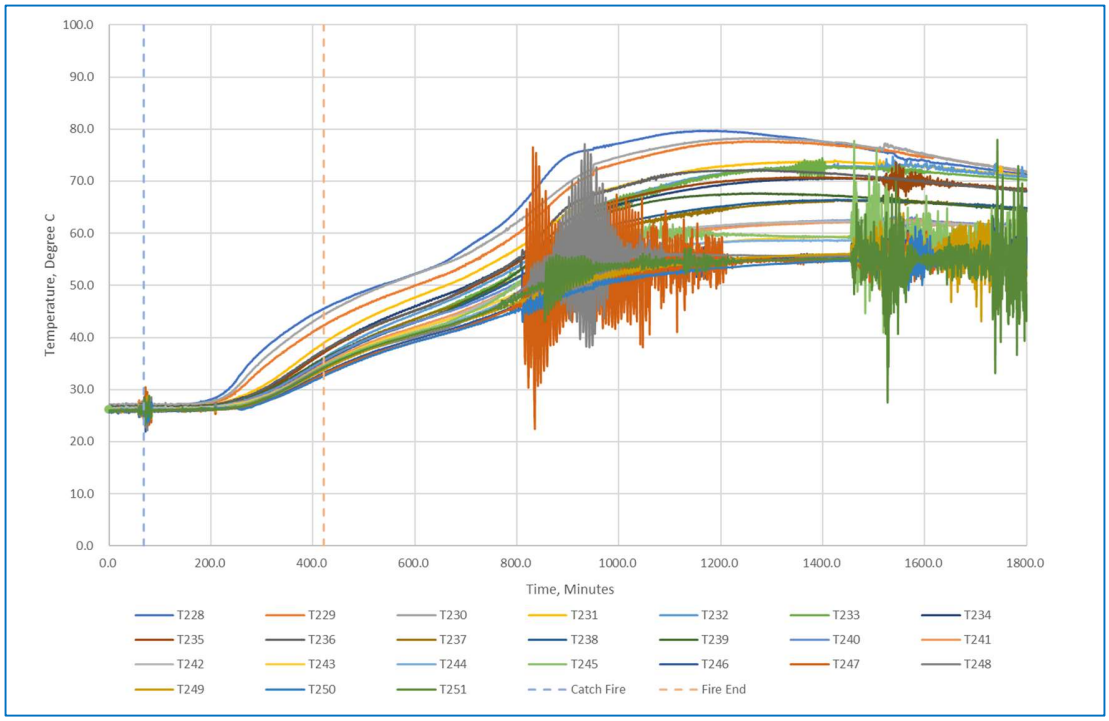


Figure 63 – Container C Module Cell surface temperature

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3.3.3 Target Container D

Maximum Temperatures on Container D enclosure surface			
TC No.	Maximum Temperature (°C)	TC No.	Maximum Temperature (°C)
T252	N/A	T260	426.3
T253	380.9	T261	435.6
T254	488.0	T262	458.3
T255	299.5	T263	371.6
T256	373.7	T264	478.5
T257	448.1	T265	484.4
T258	N/A	T266	420.1
T259	518.3	--	--
Note: Temperatures were measured constantly and then averaged every 60-seconds			

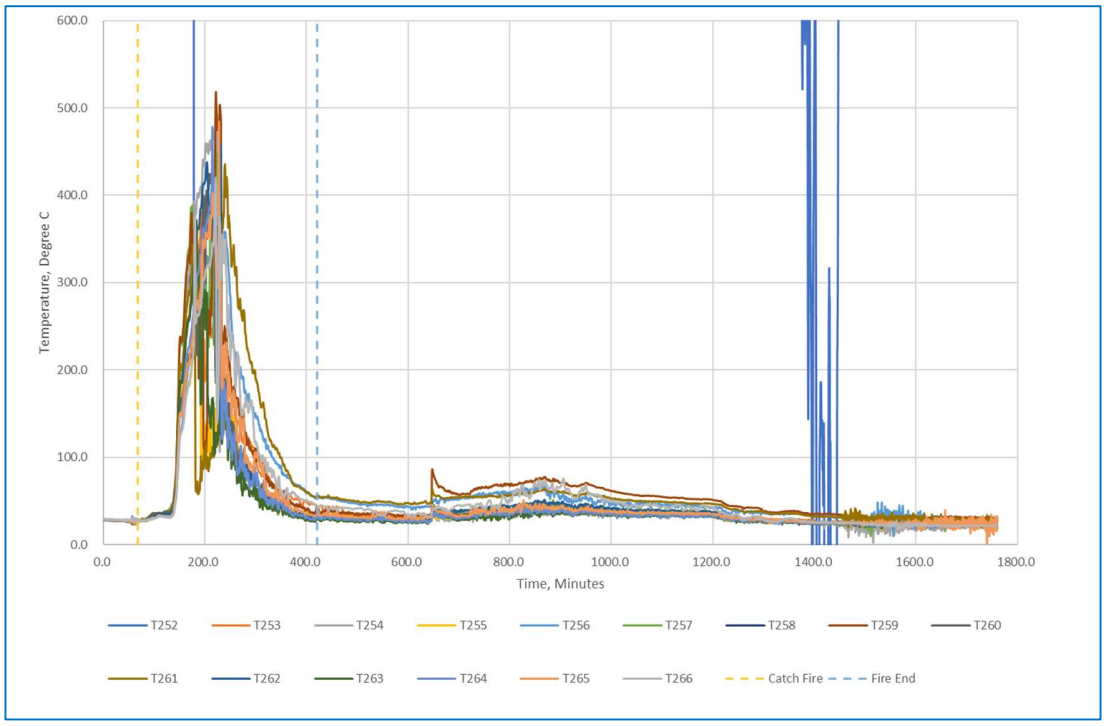


Figure 64 – Container D Enclosure temperature

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Maximum Temperatures on Container D internal module enclosure surface			
TC No.	Maximum Temperature (°C)	TC No.	Maximum Temperature (°C)
T267	128.1	T271	94.9
T268	108.6	T272	83.3
T269	99.3	T273	81.2
T270	91.4	T274	79.0
Note: Temperatures were measured constantly and then averaged every 60-seconds			

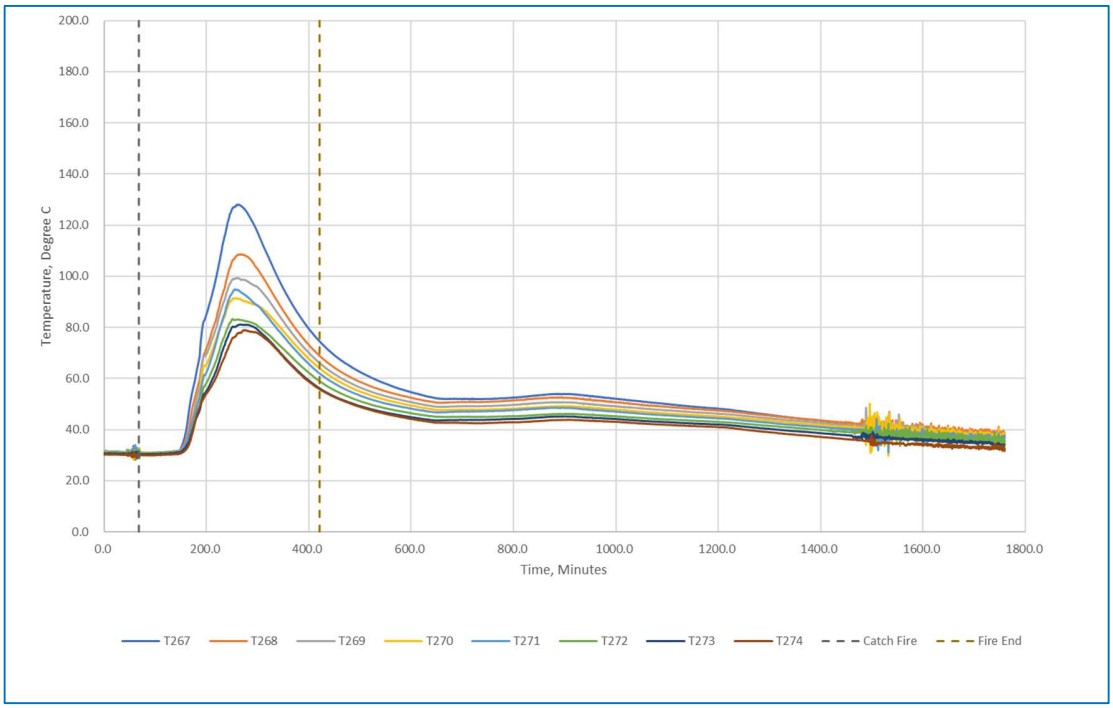


Figure 65 – Container D Module Enclosure temperature

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Maximum Temperatures on Container D internal cell surface					
TC No.	Maximum Temperature (°C)	TC No.	Maximum Temperature (°C)	TC No.	Maximum Temperature (°C)
T275	68.9	T283	54.3	T291	49.3
T276	64.2	T284	57.0	T292	48.4
T277	64.9	T285	52.5	T293	N/A
T278	61.0	T286	52.2	T294	48.1
T279	56.3	T287	55.6	T295	46.7
T280	56.7	T288	51.1	T296	50.3
T281	58.0	T289	50.2	T297	47.8
T282	54.0	T290	52.8	T298	48.1
Note: Temperatures were measured constantly and then averaged every 60-seconds					

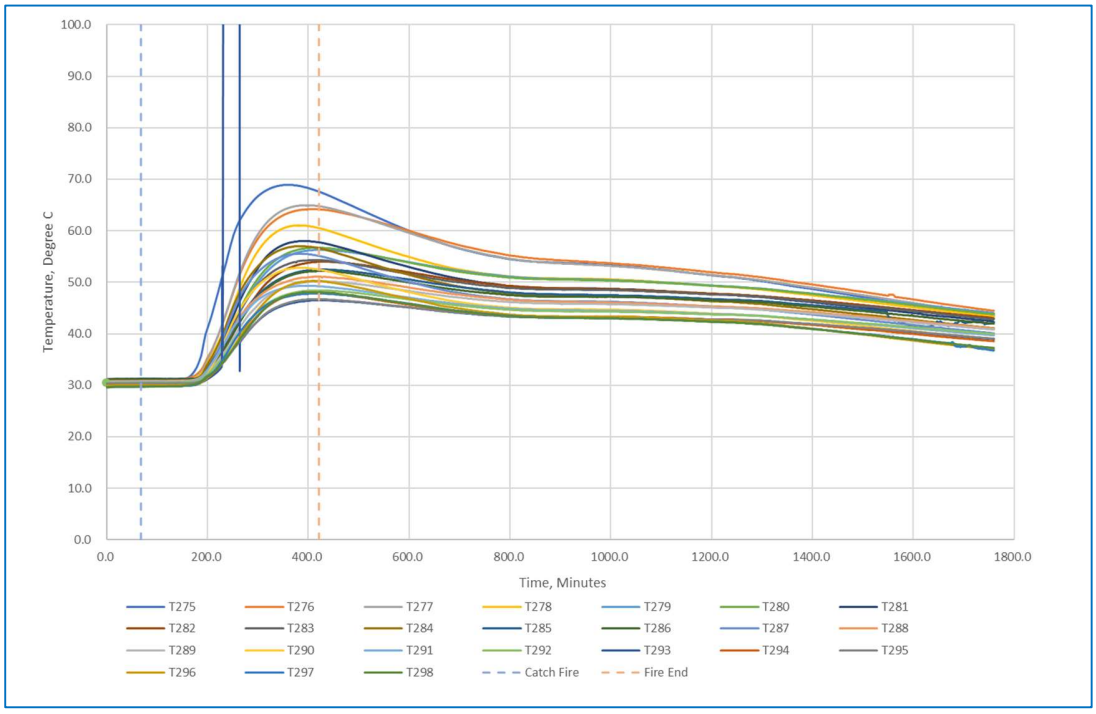


Figure 66 – Container D Module Cell surface temperature

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3.3.4 Instrumented Wall

Maximum Temperatures on Instrumented Wall					
Height, mm	Maximum Temperature (°C)	Height, mm	Maximum Temperature (°C)	Height, mm	Maximum Temperature (°C)
152	101.8	1368	156.6	2584	173.4
304	131.1	1520	174.6	2736	179.5
456	128.4	1672	172.7	2888	204.6
608	161.4	1824	183.7	3040	257.3
760	173.3	1976	158.9	3192	337.7
912	126.2	2128	223.1	3344	186.8
1064	174.7	2280	288.7	3496	168.7
1216	170.5	2432	207.4	3648	291.5
Note: Temperatures were measured constantly and then averaged every 60-seconds					

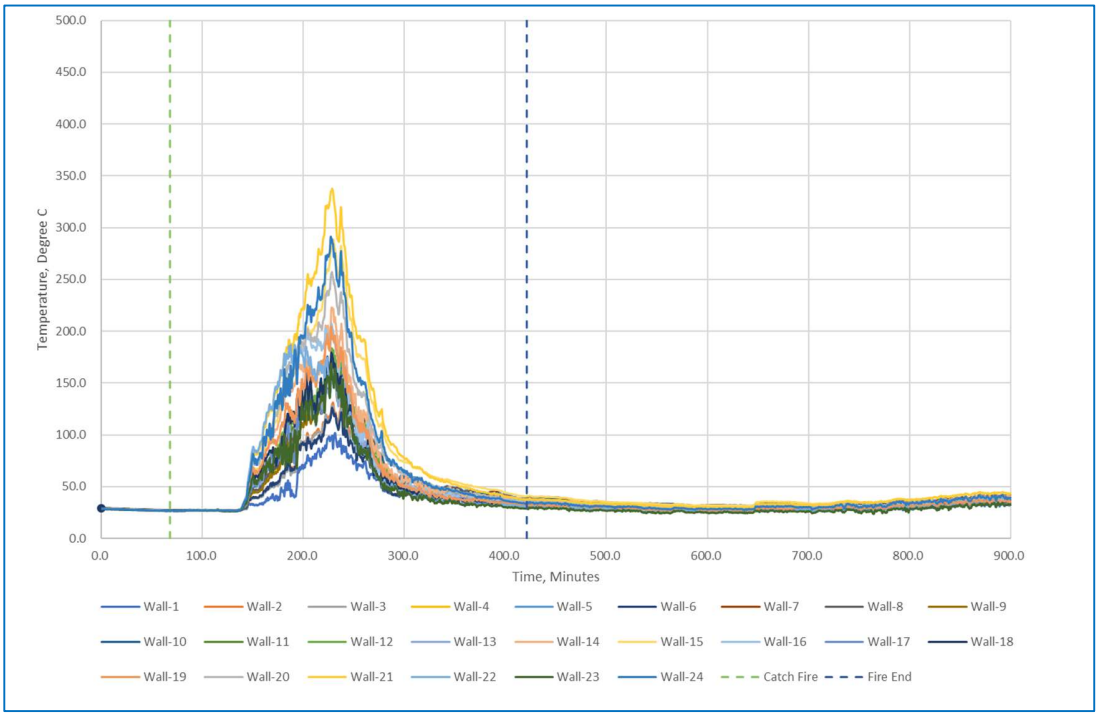


Figure 67 – Instrumented Wall temperature

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3.4 BMS and Fire Detection System Survivability

3.4.1 BMS Survivability

The BMS data was sourced from the upper computer software that communicates with the BMS, and the original data is provided by Hithium, the Container A BMS survivability as below table during the test.

BMS Rack No.	Test start	Failure time
Rack 1	2025-05-26 18:38	2025-05-26 20:33
Rack 2		2025-05-26 20:30
Rack 3		2025-05-26 21:08
Rack 4		2025-05-26 20:30
Rack 5		2025-05-26 21:08
Rack 6		2025-05-26 20:28

3.4.2 Fire Detection System Survivability

The Fire Detection System data was sourced from the Fire control host, and the original data is provided by Hithium, the Container A Fire Detection System Survivability as below table during the test.

Name	Test start	Active time	Status	Status Class	Failure time
1# Smoke Detector	2025-05-26 18:38	2025-05-26 19:44	Fire Alarm	Alarm	2025/5/26 19:57 The communication signal of the fire control host is lost
2# Smoke Detector		2025-05-26 19:44	Fire Alarm	Alarm	
1# Temperature Detector		2025-05-26 19:51	Fire Alarm	Alarm	
2# Temperature Detector		2025-05-26 19:46	Fire Alarm	Alarm	
1# Combustible Gas Detector waring output		2025-05-26 19:51	Supervisory	Supervisory	
2# Combustible Gas Detector waring output		2025-05-26 19:51	Supervisory	Supervisory	
1# Combustible Gas Detector		2025-05-26 19:51	Supervisory	Supervisory	
2# Combustible Gas Detector		2025-05-26 19:51	Supervisory	Supervisory	

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3.5 Heat flux measurements

Summary of maximum heat flux measured	
Heat Flux Gauge No.	kW/m^2
HF-1	8.3
HF-2	7.3
HF-3	12.3
HF-4	37.4
HF-5	32.7
HF-6	14.5
HF-7	21.9
Note: Heat Flux were measured constantly and then average every 60-seconds	

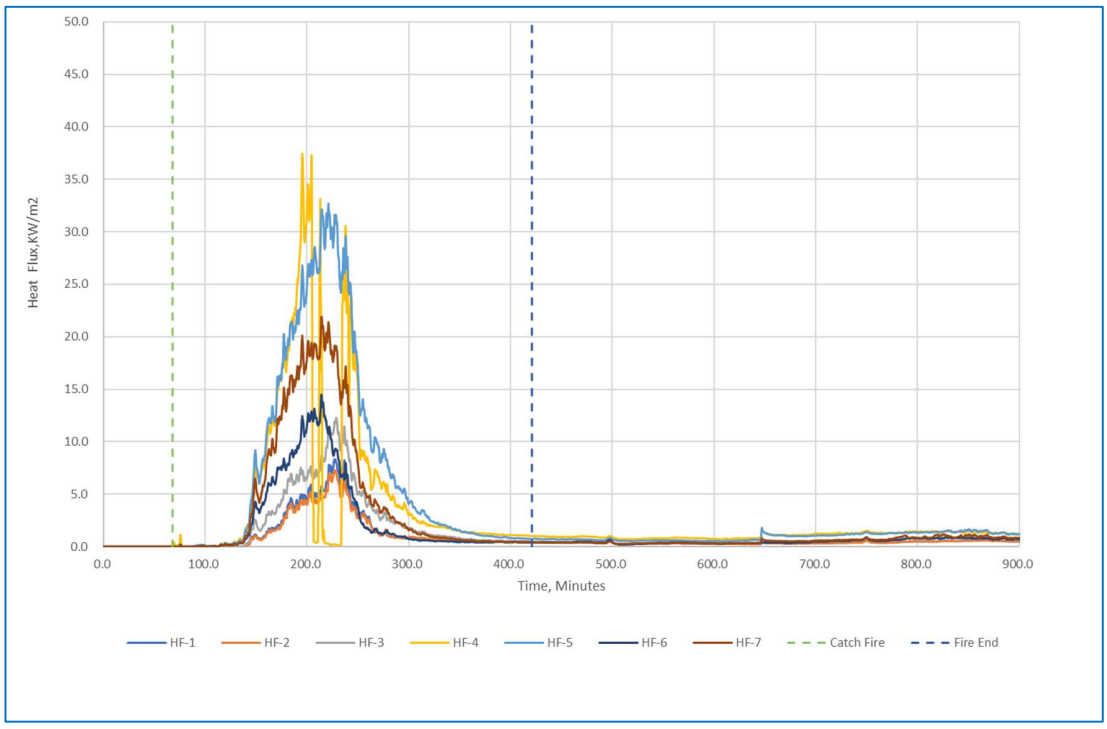


Figure 68 – Heat Flux Measurements

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3.6 Smoke Release Rate

Smoke Release Rate (SRR)	
Maximum SRR (m^2/s)	29.76
Total Smoke Released (m^2)	68375.33

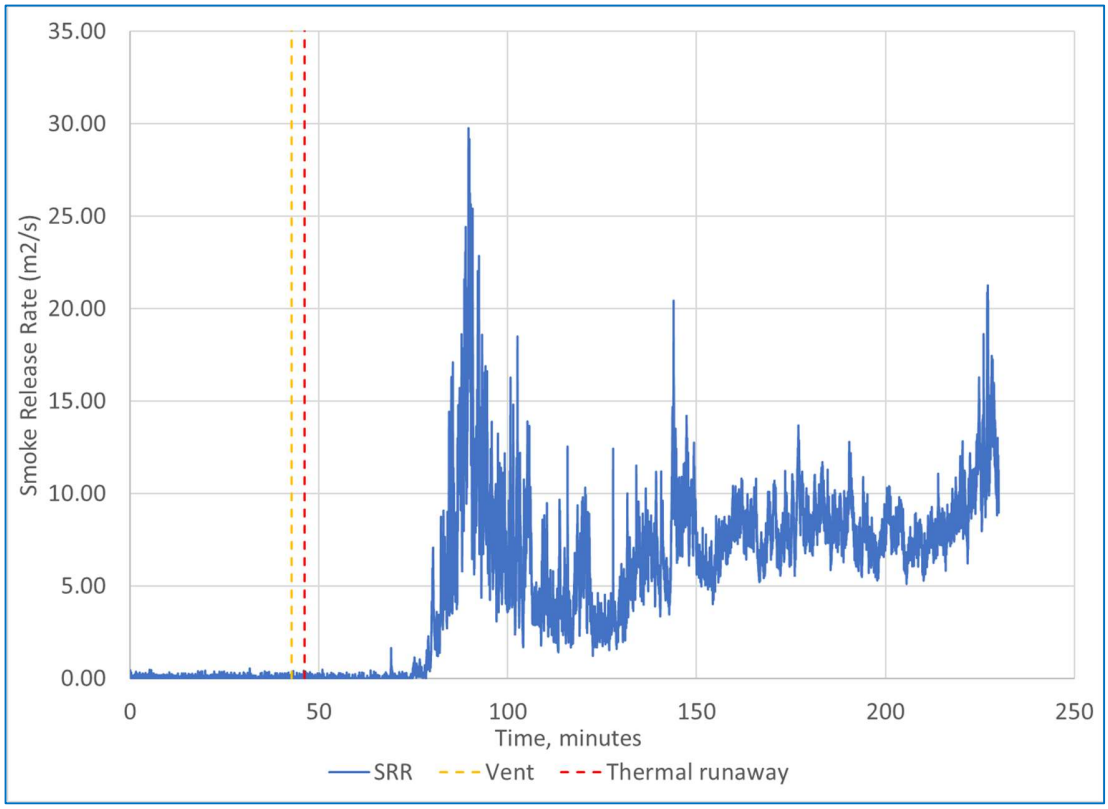


Figure 69 – Smoke Release Rate

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3.7 Heat Release Rate

Heat Release Rate (HRR)	
Peak Chemical HRR (kW)	13968.59
Peak Convective HRR, (kW)	8071.47

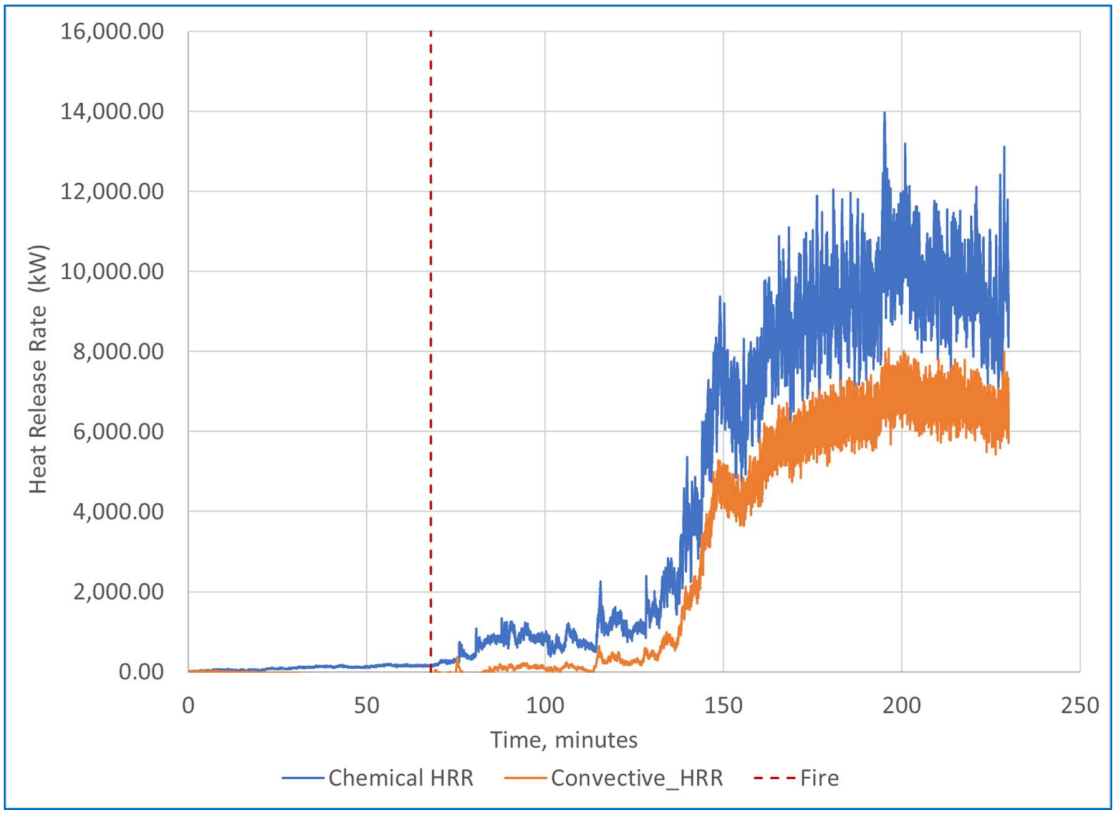


Figure 70 – Heat Release Rate

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4. Performance Criteria

The following are the relevant criteria clauses in 10.1K.1 in 9540 Technical Committee Proposal (Preliminary Review Proposal dated 4-29-2025).

10.1K.1.1 There shall be no venting in any cells in the target containers.

10.1K.1.2 There shall be no thermal runaways in any cells in the target containers.

10.1K.1.3 There shall be no penetration of flames through interconnection paths between the enclosure of origin and target containers.

10.1K.1.4 The temperature criteria in 10.1K.1.5 – 10.1K.1.9 shall not be exceeded, as summarized in Table 10.1. Temperature measurements shall be evaluated with 60-second averaging. The selected criterion shall correspond to the test instrument placement for target BESS. Performance criteria shall be evaluated at the nearest representation to the location to where cells are installed. For example, if the enclosure interior and cell locations are both instrumented, the cell location shall be used to evaluate the performance criteria. Similarly, if the enclosure interior and module surfaces are instrumented, the module surfaces shall be used to evaluate the performance criteria.

NOTE: Temperature criteria is used to assess thermal runaway risk in batteries in adjacent BESS. Superficial damage to paint or enclosure exteriors does not constitute a failure condition.

Table 10.1
Temperature Criteria for Outdoor Installations

Exposures	***Limit***
Cells within the target containers	*90% of the average temperature of venting temperature from the UL9540A cell level test*
Modules within the target containers	*Average temperature of venting temperature from the UL9540A cell level test*
Interior surface of target containers	*Average temperature of venting temperature from the UL9540A cell level test*
Instrumented Wall	*97°C rise above ambient*

10.1K.1.5 With reference to 10.1K.1.4, the temperatures measured by thermocouples placed on cells within the targets per 10.1F.5 shall not exceed 90 % of the average temperature of venting temperature from the Cell Level test, Section 7.

10.1K.1.6 With reference to 10.1K.1.4, the temperatures measured by thermocouples placed on dummy modules within the targets per 10.1F.6 shall not exceed the average temperature at which thermally initiated cell venting occurs according to the Cell Level testing as specified in Section 7.

10.1K.1.7 With reference to 10.1K.1.4, the temperatures measured by thermocouples placed on the interior surface of target containers per 10.1F.7 shall not exceed the average temperature at which thermally initiated cell venting occurs according to the Cell Level testing as specified in Section 7.

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10.1K.1.8 With reference to 10.1K.1.4, surface temperature measurements along instrumented wall surfaces shall not exceed a temperature rise of 97 °C (175 °F) above ambient.

10.1K.1.9 Heat flux measurements shall not exceed 12.5 kW/m^2 where used to determine separation distances to combustible structures. Heat flux measurements shall be evaluated with 60-second averaging.

NOTE: This criterion is applied for clearance to buildings, not BESS enclosures. This criterion is consistent with the threshold established in NFPA 80A for tolerable level of radiation at the face of an exposed building.

10.1K.1.10 For Stacked BESS, the enclosure of origin, stacked target containers, and any target structures, platforms, or supports shall maintain structural integrity.

The test result of this test was compared to the criteria outlined above in Table 10.2.

Table 10.2 – Comparison of the test results to the relevant criteria clauses in 10.1K.1 in 9540 Technical Committee Proposal.

Relevant Clauses	Topic	Results
10.1K.1.1	No venting in any cells in the target containers.	Pass
10.1K.1.2	No thermal runaways in any cells in the target containers.	Pass
10.1K.1.3	No penetration of flames through interconnection paths between the enclosure of origin and target containers	Pass
10.1K.1.4	The temperature criteria in 10.1K.1.5 – 10.1K.1.9 shall not be exceeded, as summarized in Table 10.1.	Pass
10.1K.1.5	Temperatures measured by thermocouples placed on cells within the targets not exceeding the cell level average venting temperature.	Pass
10.1K.1.6	Temperatures measured by thermocouples placed on dummy modules within the targets not exceeding the cell level average venting temperature.	The temperature of modules enclosure and Cells did not exceed the cell level average venting temperature.

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10.1K.1.7	Temperatures measured by thermocouples placed on the interior surface of target containers not exceeding the cell level average venting temperature.	Pass
10.1K.1.8	surface temperature measurements along instrumented wall surfaces shall not exceed a temperature rise of 97 °C (175 °F) above ambient.	Not applicable since the placement position of the instrumented wall was used to simulate non-combustible equipment request by Hithium, and the test result for reference only.
10.1K.1.9	Heat flux measurements shall not exceed 12.5 kW/m^2 where used to determine separation distances to combustible structures.	Not applicable since the placement position of the heat flux gauges were arranged by Hithium where have no combustible material in actual installation, and the test result for reference only.
10.1K.1.10	For Stacked BESS, the enclosure of origin, stacked target containers, and any target structures, platforms, or supports shall maintain structural integrity.	Not Applicable

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5. Post Test Sample Check

5.1 Test sample status after the test

Container A: Complete Battery Modules combustion occurred. Structural integrity maintained with no collapse or critical deformation. Container B, C and D: All maintained structural integrity with no visible deformation, and the voltage check of post test as below table.

Container No.	OCV Prior to Test (V)	OCV Post Test (V)
B	1405.3	1401.3
C	1406.0	1401.0
D	1406.0	1402.1

Container B, C and D BMS communication function verification provide by Hithium, as below Figure 71-76：



Figure 71 Container B BMS display screenshot

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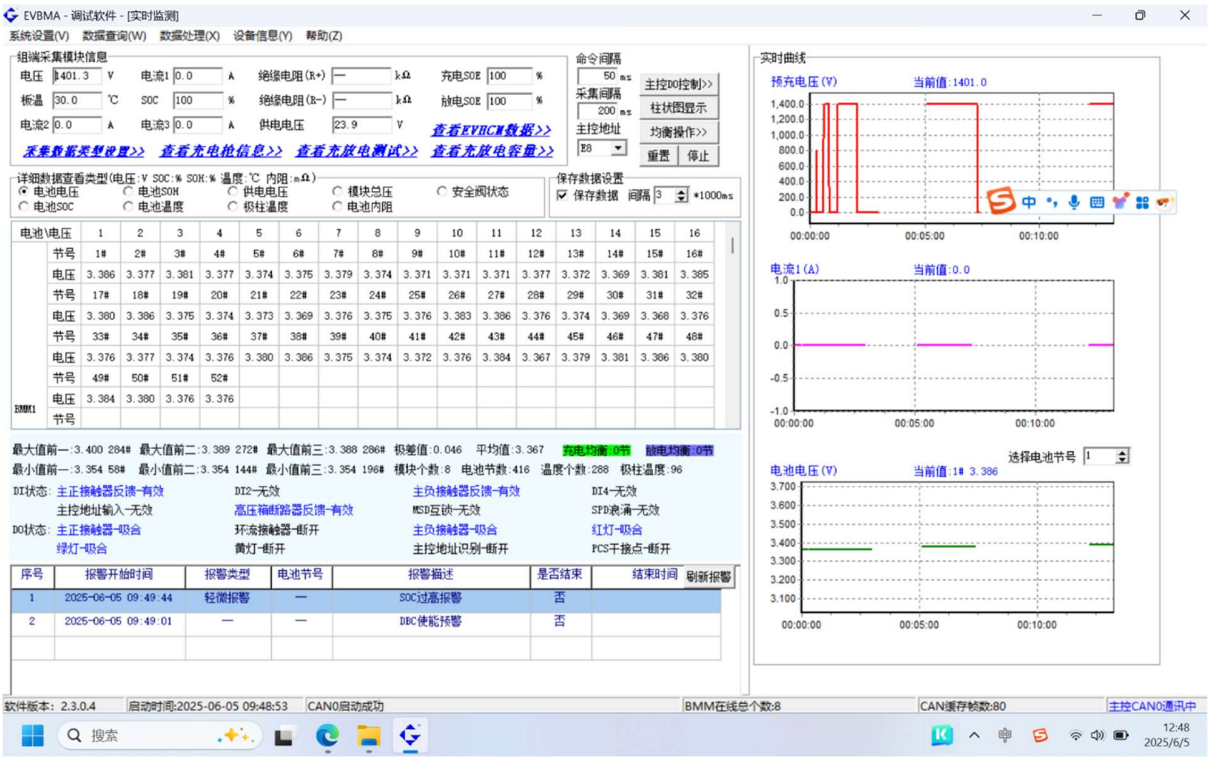


Figure 72 Container B BMS communication function



Figure 73 Container C BMS display screenshot

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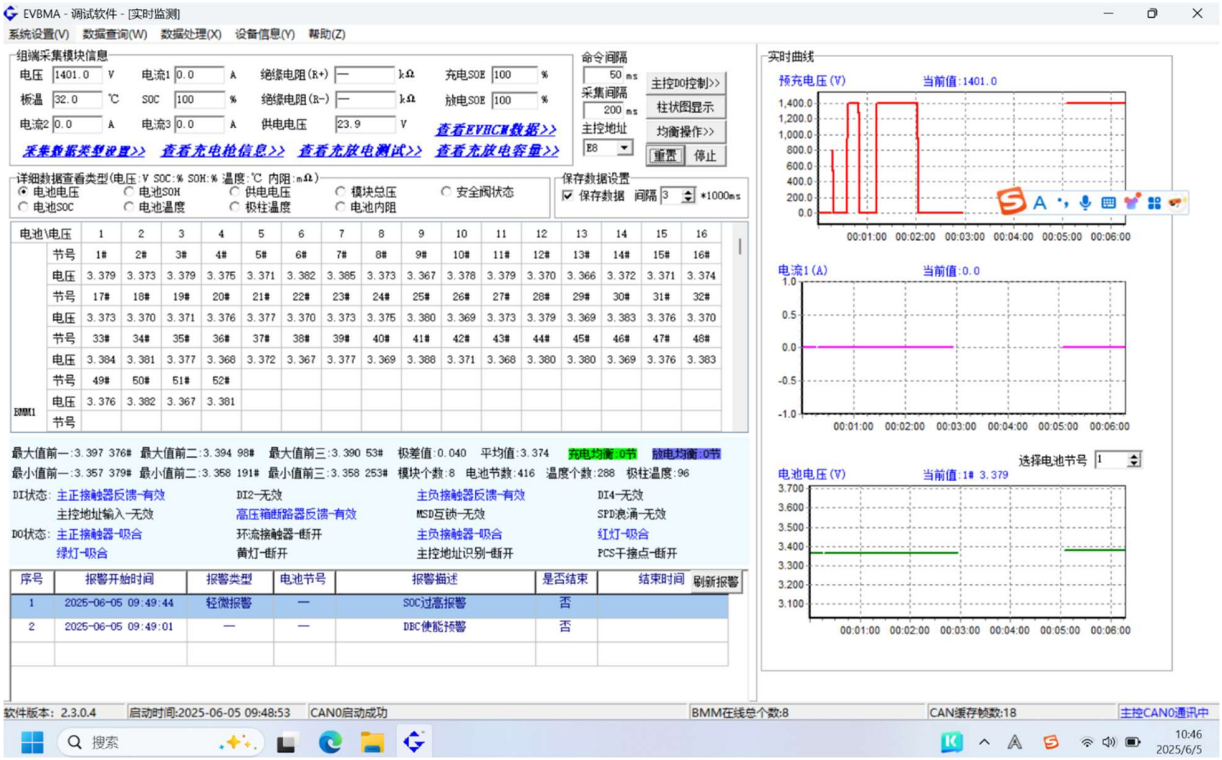


Figure 74 Container C BMS communication function



Figure 75 Container D BMS display screenshot

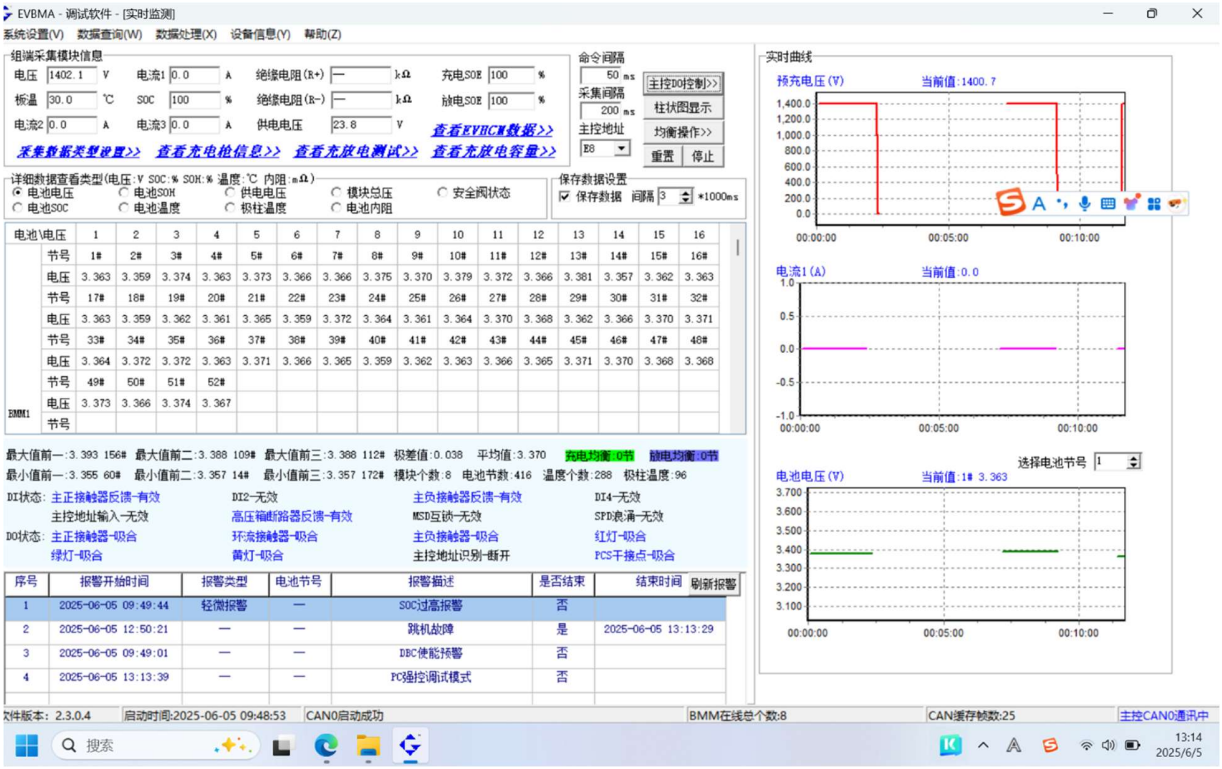


Figure 76 Container D BMS communication function

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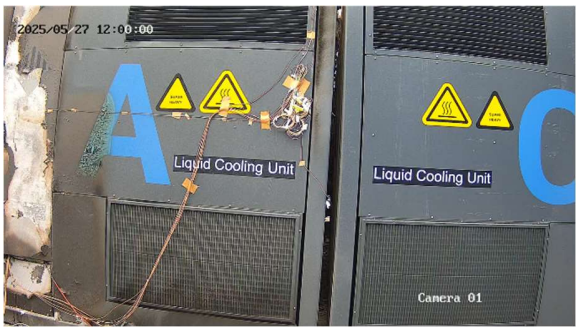
	
8# camera view	7# camera view
	
6# camera view	3# camera view
	
4# camera view	5# camera view

Figure 77 – Overall view of post test

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Figure 78 – Overall internal view of container A post test



Figure 79 – Overall internal view of container A post test

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Figure 80 – Overall back view of container A post test



Figure 81 – Overall Internal Battery and enclosure side view of container B post test

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Figure 82 – Internal view of container C post test



Figure 83 – Overall back view of container C post test

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Figure 84 – Internal view of container D post test



Figure 85 – Overall Front view of container D post test

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6. Test Equipment Information

No.	Equipment Name	Equipment ID	Range/Tolerance	Calibration Due Date
1	Thermometer and hygrometer	SLS106R25011701	15~30℃，±1℃ 40%~80%RH, ±3%	2026-05-19
2	Anemometer	25SR10010200052	0.51~30m/s, ±1.00m/s	2026-05-19
3	Battery Charging/Discharge test system	75F2300015	50~1600V, ±0.8V, 50~400A, ±0.2A	2026-03-31
4	Heat Flux gauges	F0925-08	10~50kW/m^2	2026-05-25
5	Filter	LGP-01	0~100%	2026-04-28
6	Pneumatic Differential Pressure Transducer	11349286	0-500Pa, ±2Pa	2026-04-28
7	Infrared Temperature Sensor	OM018023	0~500℃, ±2.5℃	2026-04-28
8	Thermocouple	K12411294063	200~1000℃ Max tolerance 7.5℃	2026-04-28
9	Data logger	241121668	-50~500℃ Max tolerance 1.5℃	2026-04-28
10	Data logger	241121669	-50~500℃ Max tolerance 1.5℃	2026-04-28
11	Data logger	241121670	-50~500℃ Max tolerance 1.5℃	2026-04-28
12	Gas sensor	HNAG2025021202	10%~60% LFL, ±5%	2026-04-28
13	Gas sensor	HNAG2025021201	10%~60% LFL, ±5%	2026-04-28
14	Gas analyzer	1723-2687	4.0%~10% LFL, ±5%	2026-04-28
15	Total hydrocarbon analyzer	DL70002024	10%~60% LFL, ±5%	2026-04-28
16	Hydrogen sensor	M2502060	10%~60% LFL, ±5%	2026-04-28
17	Methane sensor	M2502065	10%~60% LFL, ±5%	2026-04-28
18	Carbon monoxide sensor	M2502063	200.6~ 808.8μmol/mol, Tolerance ±10.0	2026-04-28
19	Oxygen sensor	M2503117	15%~50%， Max tolerance 1.5%	2026-04-28
20	Steel measuring tape	GJC-01	0-10m, Max tolerance 1.2mm	2026-04-28
21	Clamp meter	H12E-K335606	4~600V DC, 0.1%	2026-04-28

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B.8. NFPA 69 Report

Refer to next page for PDF insertion of the relevant NFPA 69 analysis report for the explosion mitigation ventilation system.

Prüfbericht-Nr.: *Test report no.*:	CN24Q0JQ 002	**Auftrags-Nr.:** *Order no.*:	168542552	
Kunden-Referenz-Nr.: *Client reference no.*:	2347845	**Auftragsdatum:** *Order date:*	2025-03-11	
Auftraggeber: *Client*:	Xiamen Hithium Energy Storage Technology Co., Ltd. No.1 Benyuan Road, Tongxiang High-Tech Zone, Xiamen, Fujian, P.R. China			
Prüfgegenstand: *Test item*:	Energy Storge System			
Bezeichnung / Typ-Nr.: *Identification / Type no.*:	LX501501,LX417901, IF5015P050AAU, IF5016P050AAU, IF4179P050AAU, IF4180P050AAU			
Auftrags-Inhalt: *Order content*:	Test report			
Prüfgrundlage: *Test specification*:	This report provides evaluation and CFD analysis of the ventilation system in energy storage system referring to Chapter 8 in NFPA69:2024.			

Wareneingangsdatum: *Date of sample receipt*:	2024-01-05
Prüfmuster-Nr.: *Test sample no:*	Engineering sample
Prüfzeitraum: *Testing period*:	2024-04-11 - 2024-06-21
Ort der Prüfung: *Place of testing*:	TÜV Rheinland (Shenzhen) Co., Ltd.
Prüflaboratorium: *Testing laboratory:*	TÜV Rheinland (Shenzhen) Co., Ltd.
Prüfergebnis*: *Test result**:	See main report



geprüft von: created by:	Seven Wang	**genehmigt von:** *authorized by*:	Xun Yu
Datum: *Date:* 2025-04-11		**Ausstellungsdatum:** *Issue date:* 2025-04-11	
Stellung / Position:	Sachverständige(r)/Expert	**Stellung** / Position:	Sachverständige(r)/Expert

Sonstiges / *Other*:

1. This report is based on previous report CN24Q0JQ 001.
2. Add one more ripple enclosure style for models LX501501 and LX417901, the differences between ripple style enclosure and original flat style enclosure are in the external structure and appearance, the internal structure of the container has not changed.
3. Add 4 new models (IF5015P050AAU, IF5016P050AAU, IF4179P050AAU, IF4180P050AAU).
--IF5015P050AAU, IF5016P050AAU: identical LX501501 except for variations in sales territories.
--IF4179P050AAU, IF4180P050AAU: identical LX417901 except for variations in sales territories.
4. No further CFD needed.
5. Evaluation period: 2025-04-09 to 2025-04-11.

Zustand des Prüfgegenstandes bei Anlieferung: Prüfmuster vollständig und unbeschädigt
Condition of the test item at delivery: *Test item complete and undamaged*

* Legende:	P(ass) = entspricht o.g. Prüfgrundlage(n)	F(ail) = entspricht nicht o.g. Prüfgrundlage(n)	N/A = nicht anwendbar	N/T = nicht getestet
* *Legend:*	*P(ass) = passed a.m. test specification(s)*	*F(ail) = failed a.m. test specification(s)*	*N/A = not applicable*	*N/T = not tested*

Dieser Prüfbericht bezieht sich nur auf das o.g. Prüfmuster und darf ohne Genehmigung der Prüfstelle nicht auszugsweise vervielfältigt werden. Dieser Bericht berechtigt nicht zur Verwendung eines Prüfzeichens.
This test report only relates to the above mentioned test sample. Without permission of the test center this test report is not permitted to be duplicated in extracts. This test report does not entitle to carry any test mark.

Prüfbericht-Nr.: CN24Q0JQ 002
Test report no.:

Anmerkungen
Remarks

1	Alle eingesetzten Prüfmittel waren zum angegebenen Prüfzeitraum gemäß eines festgelegten Kalibrierungsprogramms unseres Prüfhauses kalibriert. Sie entsprechen den in den Prüfprogrammen hinterlegten Anforderungen. Die Rückverfolgbarkeit der eingesetzten Prüfmittel ist durch die Einhaltung der Regelungen unseres Managementsystems gegeben. Detaillierte Informationen bezüglich Prüfkonditionen, Prüfequipment und Messunsicherheiten sind im Prüflabor vorhanden und können auf Wunsch bereitgestellt werden. *The equipment used during the specified testing period was calibrated according to our test laboratory calibration program. The equipment fulfils the requirements included in the relevant standards. The traceability of the test equipment used is ensured by compliance with the regulations of our management system.* *Detailed information regarding test conditions, equipment and measurement uncertainty is available in the test laboratory and could be provided on request.*
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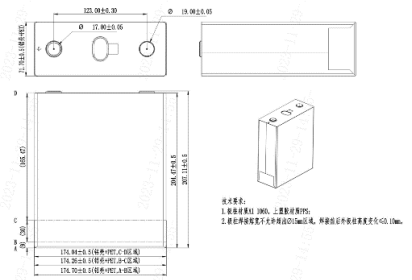
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1. General Production Information:

1.1. Cell

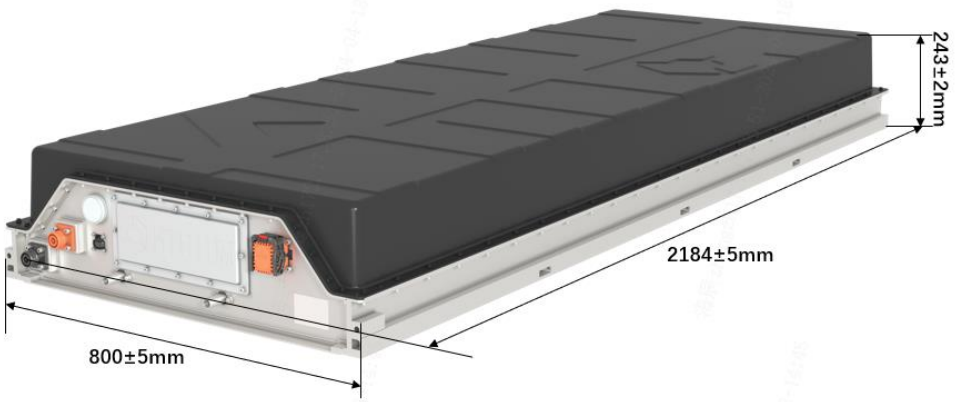
The product information and parameters are provided by the client as below.

Manufacturer .....:	Xiamen Hithium Energy Storage Technology Co., Ltd. No.1 Benyuan Road, Tongxiang High - Tech Zone, Xiamen, Fujian, P.R. China	
Model number.....:	LFP71173207/314Ah	
Chemistry .....:	☒ $LiFePO_4$ ☐ NMC ☐ NCA ☐ LTO ☐ Other:	
Physical configuration.....:	☒ Prismatic ☐ Cylindrical ☐ Pouch	
	Weight(kg):	5.6±0.2
Electrical rating .....:	Rated capacity(Ah):	314 (25°C±2°C)
	Nominal voltage(V):	3.2
Standard charge method .....:	Charge current(A):	157 (25°C±2°C)
	Standard Charge Voltage(V):	3.65
	Cut off current(A):	/
Standard discharge method.....:	Discharge current(A):	157 (25°C±2°C)
	End of discharge voltage(V):	2.5V (T>0°C) 2.0V (T≤0°C)
Maximum continuous charge current :	314A	
Maximum continuous discharge current .....:	314A	
Compliance with UL 1973.....:	☒ Yes, TUV Report No.: CN23RGEH 001 ☐ No	
Diagram:		

1.2. Module

The product information and parameters are provided by the client as below.

Manufacturer:	Xiamen Hithium Energy Storage Technology Co., Ltd. No.1 Benyuan Road, Tongxiang High - Tech Zone, Xiamen, Fujian, P.R. China	
Model number:	LM010401-A	
Physical configuration:	Metal base, the other sides are non-metallic material. A mica plate is installed under the top enclosure.	
	Weight:	667kg
	Cells in series/parallel:	2P52S
Cooling method:	Liquid cooling	
Separation between cells:	Thermal insulation sheet: Aerogel Heat insulation pad and Polyurethane foam, see Figure 4 for install location details.	
Electrical rating:	Rated capacity:	628 Ah
	Nominal voltage:	166.4Vdc
Standard charge method:	Charge power:	52.25KW
	End of charge:	The highest cell voltage reaches 3.65 V
Standard discharge method:	Discharge power:	52.25KW
	End of discharge:	The lowest cell voltage reaches 2.5 V
Compliance with UL 1973:	☒ Yes	☐ No



(Unit : mm)

1.3. Energy Storage System

The product information and parameters are provided by the client as below.

Product name	Battery container	
Model	LX501501	LX417901
Voltage range	1040V-1500Vdc	1040V-1500Vdc
Nominal voltage	1331.2Vdc	1331.2Vdc
Rated charge and discharge power	2508kW	2090kW
Rated capacity	3768Ah	3140Ah
Rated Energy	5016kWh	4180kWh
Max DC Short Circuit Current	16000A*6 (7.7ms)	16000A*5 (7.7ms)
Number of Battery cluster	6	5
AC Input short-circuit current rating (SCCR)	4000A	
Maximum overcurrent protective device rating	100A	
Auxiliary power supply	AC480V, 100A, 3P4L, 60Hz Or AC400V, 100A, 3P4L, 50Hz	
IP Rating	IP55	
Cooling type	Liquid cooling	
Operating Temperature	-30-55°C	
Storage Temperature	-30°C to 60°C	
Nominal mass	Max. 40T	Max. 35T
External dimensions	6058mm*2438mm*2896mm	
Altitude	4000m	
Remark: Model LX417901 have more efficient volume inside. Consider worse result, CFD analysis was performed on model LX501501. All models have two constructions A and B, they are identical to each other with mirror relation.		

2. Product Description:

2.1. General Description

The ESS container mainly consists of Master combiner cabinet, Battery Modules, Battery racks, HV box, Thermal management system, Fire protection system, Auxiliary power supply system.
There are 5 or 6 racks in each ESS container, and each rack consists of 8 (2P52S) modules and one HV box. The 8 modules connect to the HV box in series by DC cables. Here is the standard structure of ESS container in the following chart below.

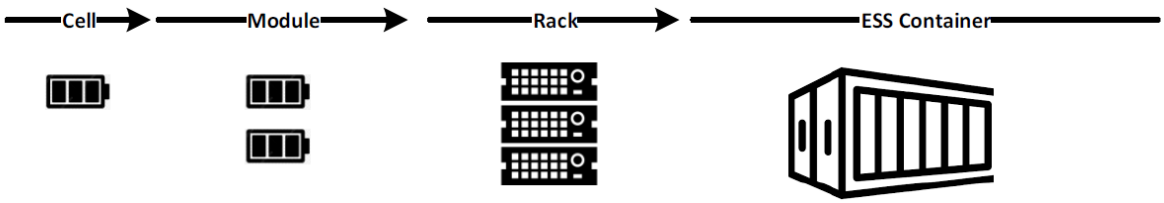


Figure 2-1: Architecture of ESS container

The Block Diagram of the ESS Container is shown in Figure 2-2, and the Venting System Layout is shown in Figure 2-3.

2.2. Energy Storage System Block Diagram

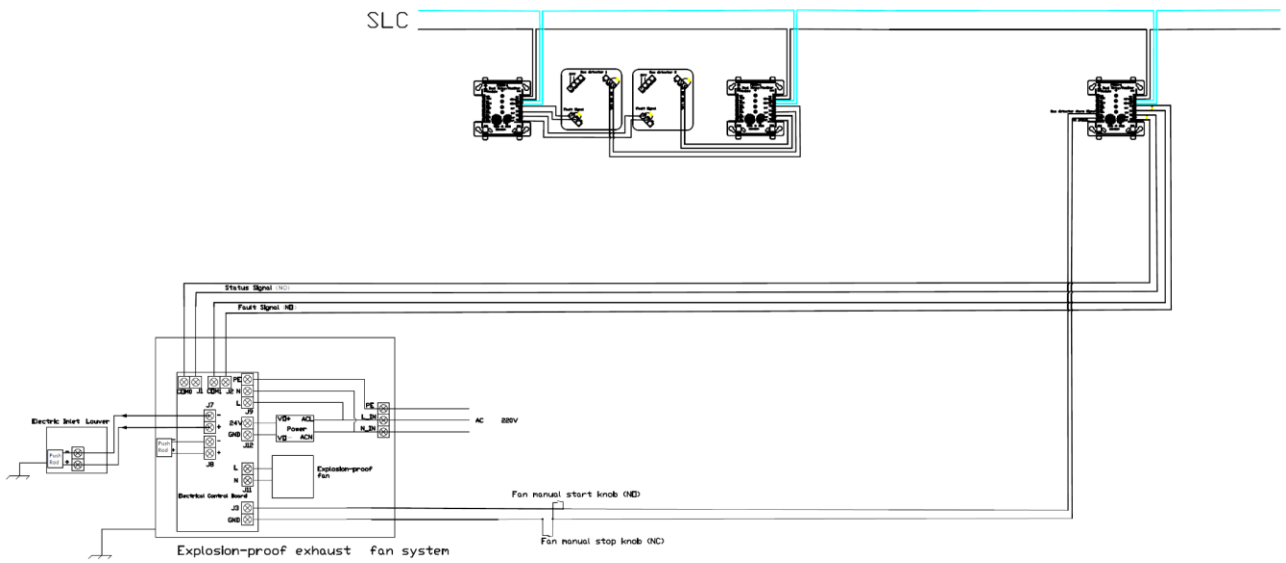


Figure 2-2: Block Diagram of VENTING SYSTEM

2.3. Venting System Layout

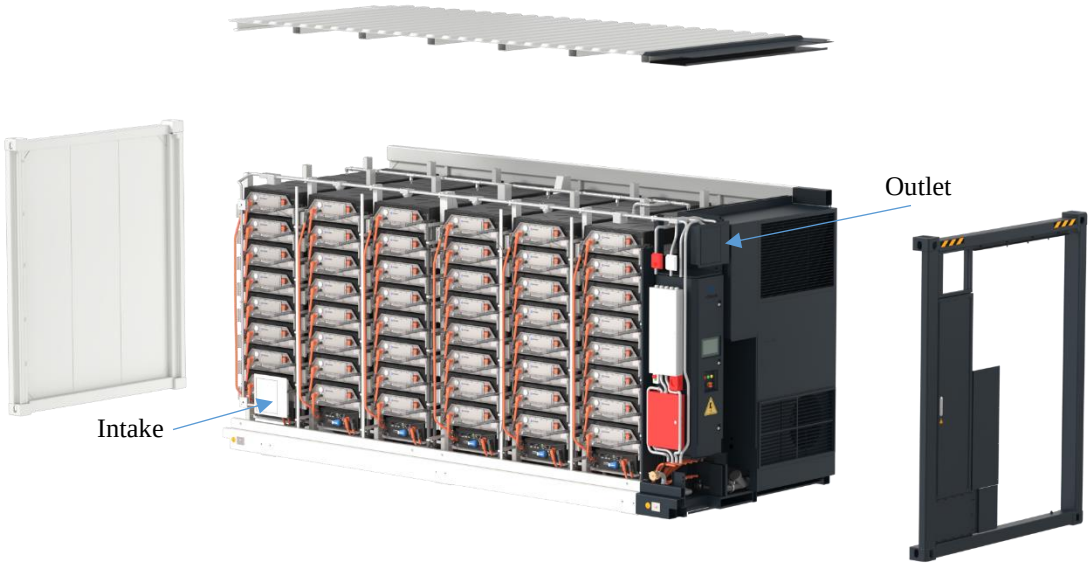


Figure 2-3: Product's Exploded View-FIRE PROTECTION SYSTEM

3. Ventilation system evaluation referring to Chapter 8 in NFPA69:2024

Clause	Requirement – Test	Result – Remark	Verdict
Chapter 8	**Deflagration Prevention by Combustible Concentration Reduction**		--
8.1	**Application.** The technique for combustible concentration reduction shall be permitted to be considered where a mixture of a combustible material and an oxidant is confined to an enclosure and where the concentration of the combustible can be maintained below the lower flammable limit (LFL).	Specified in details in "CFD analysis of the ventilation system"	P
8.2	**Basic Design Considerations**		--
8.2.1	All of the following factors shall be considered in the design of a system intended to reduce the combustible concentration below the LFL:	Specified in details in "CFD analysis of the ventilation system"	P
	1) Required reduction in combustible concentration		P
	2) Variations in the process, process temperature and pressure, and materials being processed		P
	3) Operating controls		P
	4) Maintenance, inspection, and testing		P
	5) Concentration variation with time and location within the protected enclosure		P
8.2.2	The LFLs of the combustible components shall be determined at all operating conditions, including startup and shutdown.		P
8.2.3	**Protection System Design and Operation**		--
8.2.3.1	The owner or operator shall be responsible for a thorough analysis of the process to determine the type and degree of deflagration hazards inherent in the process		P
8.2.3.2	Information required for the monitoring and control of the concentration of combustible components shall be compiled and documented. This information shall include, but not be limited to, the following:		--
	(1) Monitoring and control objectives		P
	(2) Monitored and controlled areas of the process		P
	(3) Dimensioned drawings of the process with the following: (a) Equipment make and model if available, including volumes and diameters and design strengths (b) Plan and elevation views with flows indicated		P

3. Ventilation system evaluation referring to Chapter 8 in NFPA69:2024

Clause	Requirement – Test	Result – Remark	Verdict
	(4) Startup, normal, shutdown, temporary operations, and emergency shutdown process conditions and ranges for the following: (a) Flow (b) Temperature (c) Pressure (d) Oxidant concentration (e) Fuel concentration		P
	(5) Process flow diagram and description		N/A
	(6) Ambient temperature in process area		P
	(7) Process interlocks		N/A
8.2.3.3	The owner or operator shall disclose any and all process information required for the protection system design.		P
8.2.3.4	The protection system design shall be subject to a documented review by a qualified person.		P
8.2.3.5	The owner or operator shall be responsible for the maintenance of the system after installation and acceptance based on procedures provided by the vendor. Maintenance records shall be retained for inspection by the authority having jurisdiction.		P
8.2.3.6	The owner or operator shall be responsible for periodic inspection of the system by personnel trained by the system manufacturer. The inspection frequency shall be in accordance with Section 15.7.		N/A
8.2.3.7	Management of Change. The effect of any process change shall be addressed as specified in Section 15.11.		N/A
8.2.3.8	All documentation relevant to the protection system shall be retained in accordance with Chapter 15.		P
8.3	**Design and Operating Requirements**		--
8.3.1	**Combustible Concentration Limit.** The combustible concentration shall be maintained at or below 25 percent of the LFL for all foreseeable variations in operating conditions and material loadings, unless the following conditions apply:	Specified in details in “CFD analysis of the ventilation system”	P
	(1) Where continuously monitored and controlled with safety interlocks, the combustible concentration shall be permitted to be maintained at or below 60 percent of the LFL.	Specified in details in “CFD analysis of the ventilation system”	N/A

3. Ventilation system evaluation referring to Chapter 8 in NFPA69:2024

Clause	Requirement – Test	Result – Remark	Verdict
	(2) Aluminum powder production systems designed and operated in accordance with NFPA 484 shall be permitted to be maintained at or below 50 percent of the LFL.		N/A
8.3.2	**Catalytic Oxidation.** Where catalytic oxidation is used for combustible concentration reduction, the following shall apply:		N/A
	(1) Isolation systems shall be provided in all inlets to the catalytic oxidation unit.		N/A
	(2) Unless the combustible concentration is monitored continuously, the effectiveness of the catalytic oxidation system shall be verified periodically in accordance with the manufacturer's recommendations.		N/A
8.3.3	**Ventilation or Air Dilution**		P
8.3.3.1	If ventilation is used, the outlets from the protected enclosures shall be located so that hazardous concentrations of the exhausted air cannot enter or be drawn into the fresh air intakes of environmental air‐handling systems.		P
8.3.3.2	Air intakes shall meet one of the following requirements:		P
	(1) They shall be located so that combustible material cannot enter the air-handling system, even in the event of spills or leaks.		P
	(2) They shall be provided with gas detectors that automatically interlock to stop air intake.		P
8.3.3.3	Filters, dryers, or precipitators in the air intakes shall be located such that they are accessible for cleaning and maintenance.		P
8.4	**Instrumentation**		P
8.4.1	Instrumentation shall be provided to monitor and control the process flows.		P
8.4.2	Instrumentation shall be calibrated according to the requirements of Chapter 15.		P
8.4.3	Where the enclosure being protected presents a personnel hazard, alarms shall be provided to indicate abnormal operation of the system.		P

4. CFD analysis of the ventilation system

4.1. Basic Information of the system

The interior and exterior drawings provided by Hithium was verified between TUV and Hithium before running any calculation.

Figure 4-1 shows an external view of the container and the dimensions from a front view. The cube measures 6058*2438*2896 mm including one battery cabinets, liquid coolant unit, BCP and Auxiliary power supply unit. The cabinet contains 48 modules in rack and 104 cells in each module, as shown in Figure 4-1. The overall internal volume is approximately 33.2 m^3. Subtracting the space filled by racks, modules, and the support structure, the actual open internal volume (efficient volume) is 12.8 m^3. The design value of maximum flow rate of exhaust fan is 820 CFM.

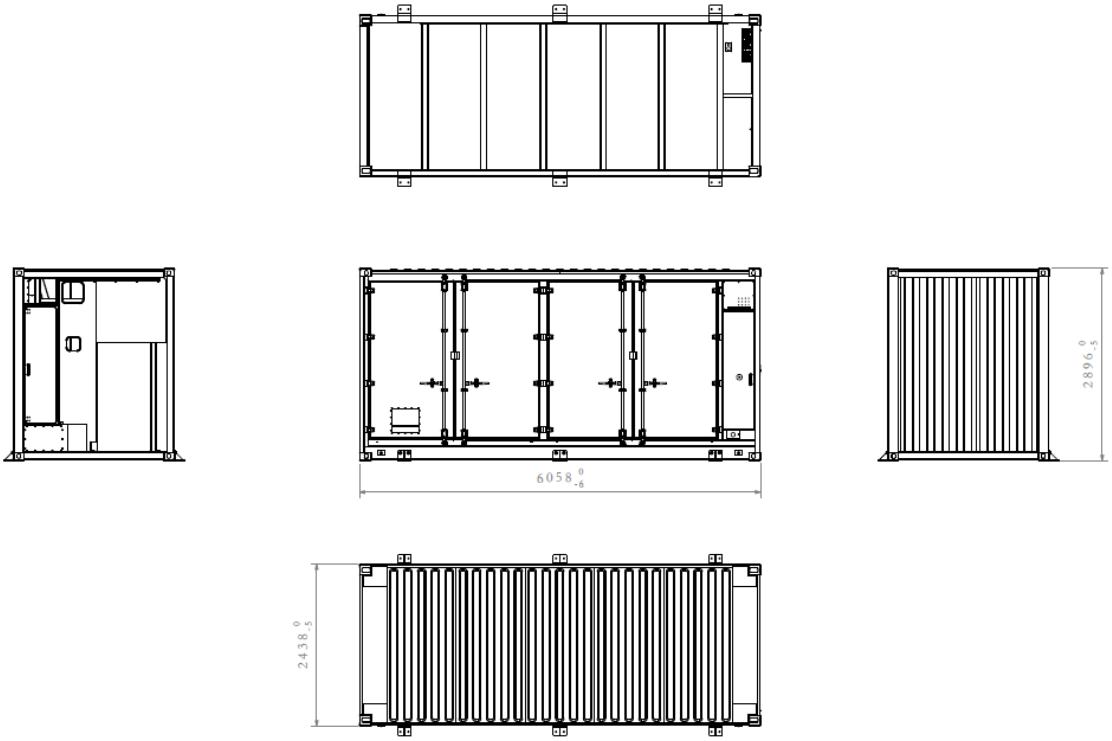


Figure 4-1: Geometry of ESS

4.2. Principles and Assumptions

The following safety systems and CFD analysis have been acknowledged for the basis of the study's assumptions. Note that the scenarios and assumptions are run in unit levels, module levels and cell levels to show progressively worse-case scenarios based on the information available and are considered to be conservative.

Information of References and Assumptions		
No.	**References**	**Assumptions in the study**
1	In UL 9540A test report of module level and unit level, 2 cells go into thermal runaway in the battery module.	Consider worse case, assume 3 cells go into thermal runaway in the battery module.
2	No module-to-module propagation exist in UL 9540A test report of unit level.	No module-to-module propagation.
3	Max rate of CH4 from module level UL 9540A test report. Total volume of gas released in cell level UL 9540A test report.	Total 430L offgas considered. Rate of offgas release=3.086L/s, Release time of gas=140s.
4	Consider the farthest position from to the gas detector and exhausting fan.	Choose the module in the upper left corner, and the module in the bottom right corner as offgas release positions.
5	The construction of ESS container	The position of gas detectors is set as the monitor for measuring the concentration of hydrogen and trigger ventilation fans.
6	Gas composition in cell level UL 9540A test report.	Gas composition is as cell level UL 9540A test report

4.2.1. Thermal runaway and propagation

(1) Propagation between cells:

The UL 9540A test report of module level and unit level indicate that cell to cell propagation could happen within a submodule which contains 104 cells. According to the test report total 2 cells were failed.

For conservative consideration, assume Consider 3 cells thermal runaway as worse condition for CFD analysis.

Assumption 1: There are 3 cells failure within submodule is considered in this study.

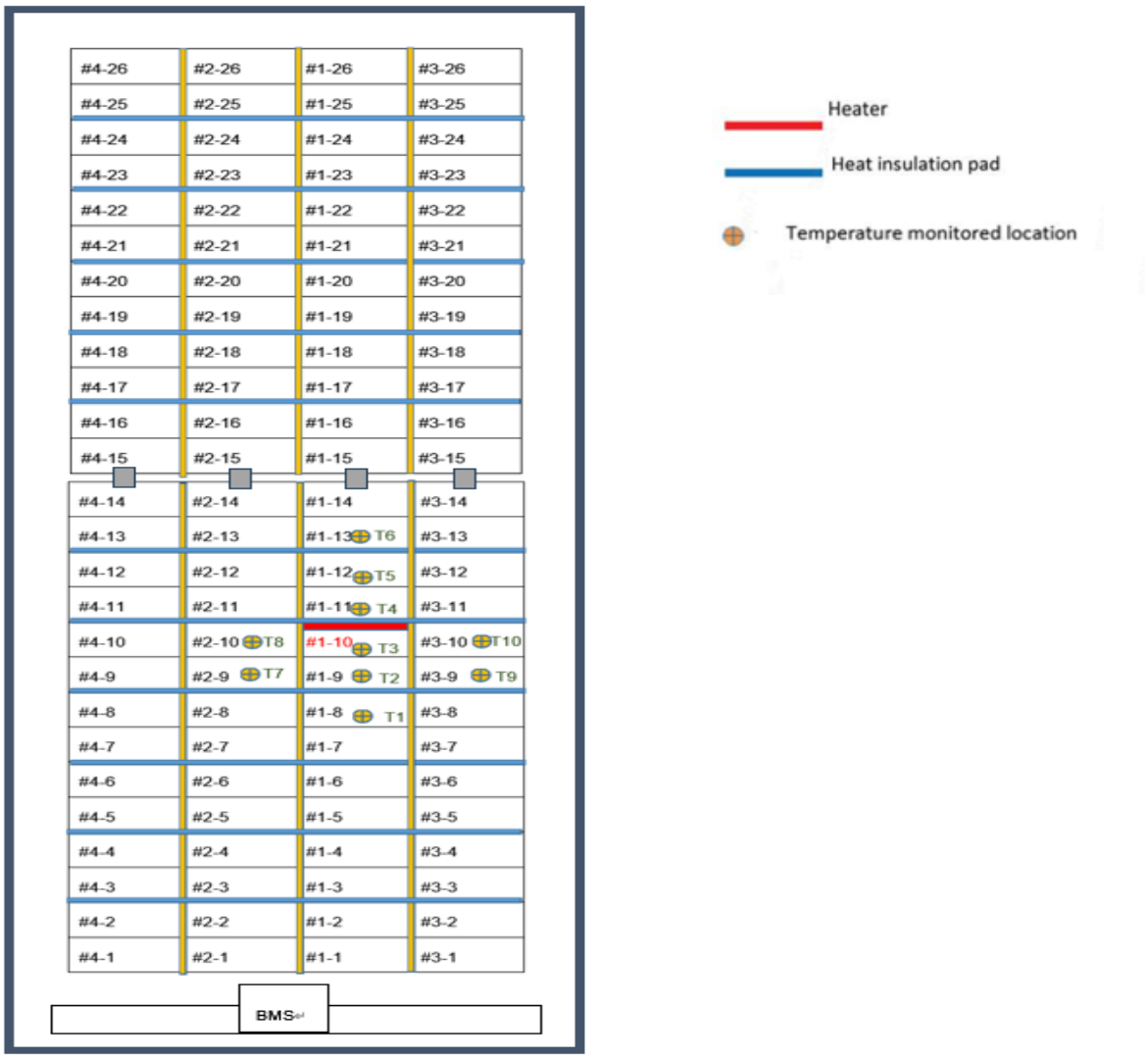


Figure 4-2: Initiating module set up in module level UL9540A test report

(2) Propagation between modules:

The UL 9540A test report of unit level does not indicate that it is possible to have propagation between modules.

Assumption 2: There is no module-to-module propagation.

4.2.2.Leakage profile and gas composition

(1) Leakage profile:

The data and test phenomenon in cell level, module level and unit level UL 9540A test report provide gas release rate and total amount.

For consideration, it is assumed that gas profile release follows the highest rate of CH4 from unit level UL 9540A test. (See Figure 4-3).

The data in cell level UL 9540A test report shows that 130L offgas is released from a single

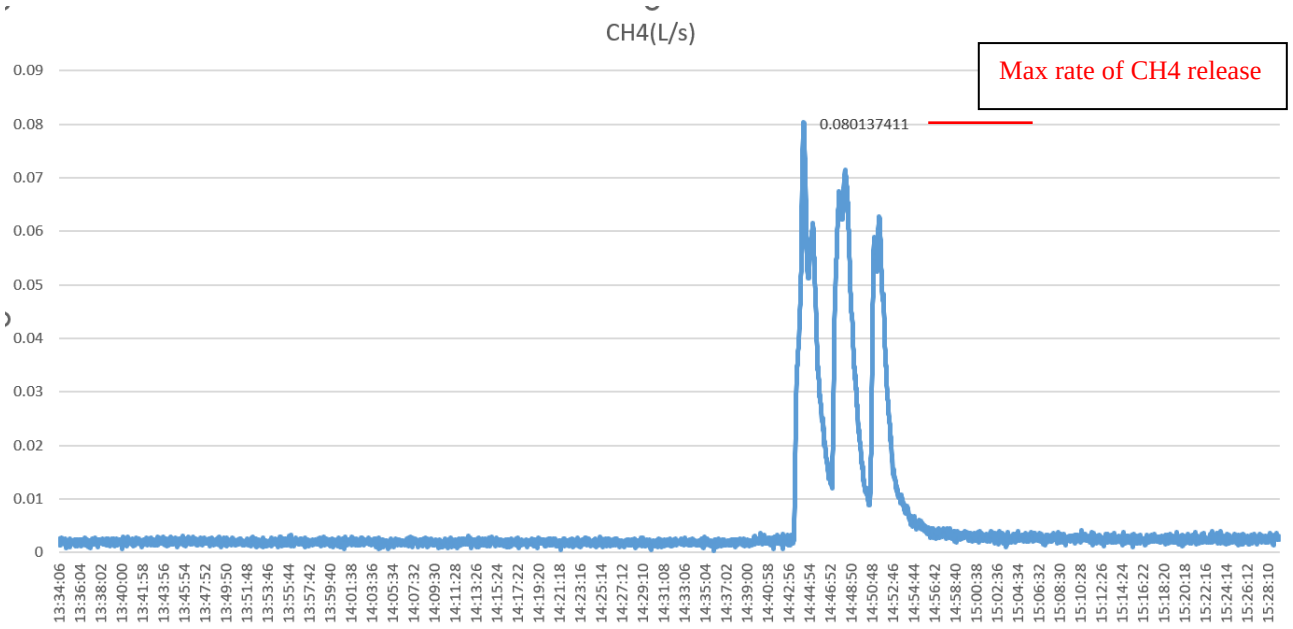


Figure 4-3: Gas(CH4) release rate profile in unit level test report

Assumption 3: The offgas release profile is set as above for each scenario.

The data in cell level UL 9540A test report shows that CH4 accounts for 3.671% of the gas released.

Base above, the rate of offgas released= 0.1133 ÷3.671%=3.086L/s

The data in cell level UL 9540A test report shows that 130L offgas is released from a single cell as the sum of all gas species. From Assumption 1, consider 3 cells thermal runaway as worse condition for CFD analysis.

Total volume of release gas from 3 cells= 130L x3=390L. For rigorous considerations, a 10% increase is used as the total gas generation. 390L x110%≈430L.

A total of 430L of gas is considered to be the volume of offgas from thermal runaway cells.

Total release time= Total volume of gas/ Rate of off released=430/3.086≈140s

Assumption 3: The offgas release profile is set as above for each scenario as following. Rate of offgas release=3.086L/s, release time of gas=140s.

(2) Position of the leak:

According to the travel distance of flammable gas from release position to the gas detector and exhausting fan, 2 scenarios were designed,

a. The module in the upper left corner was chosen to be the initial module (See Figure 4-4).

b. The module in the bottom right corner was chosen to be the initial module (See Figure 4-5)

Assumption 4: Choose Module 1 in the rightmost battery cluster as offgas release positions, which is far from exhaust fan and ventilation louver.

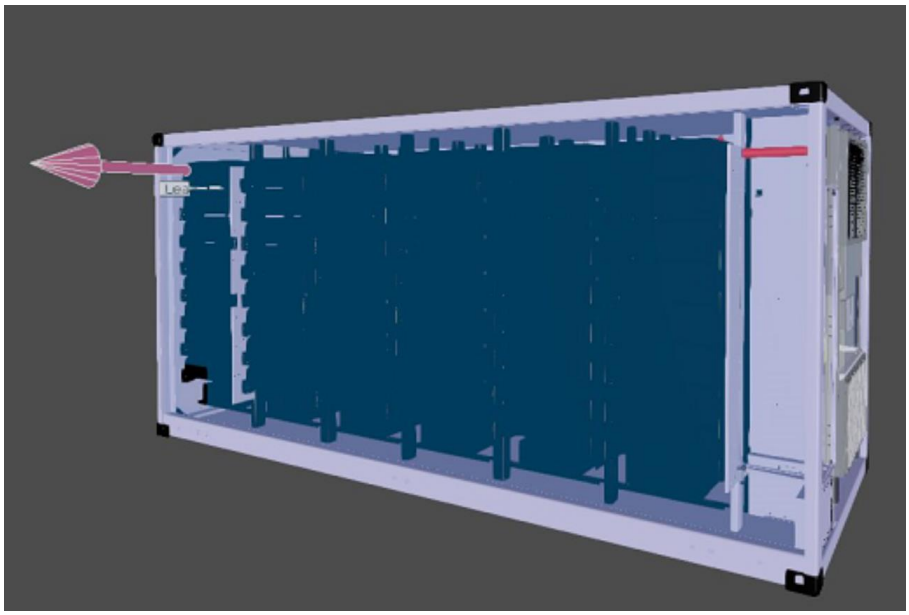


Figure 4-4: Location of gas leakage position (module in the upper left corner)

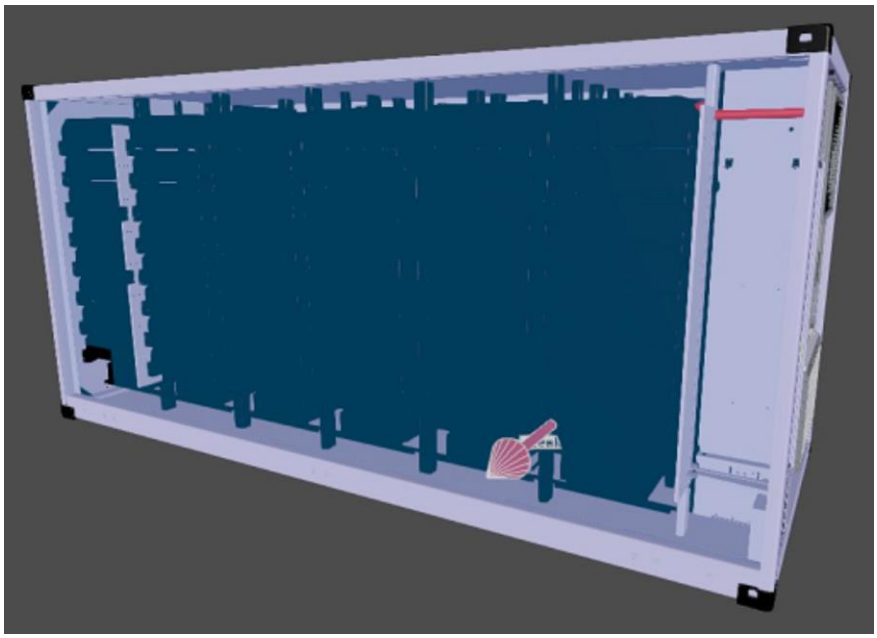


Figure 4-5: Location of gas leakage position (module in the bottom right corner)

(3) Gas detector:

Regarding the construction of the container, there is 2 gas detectors equipped on the edge of roof, the location is shown in figure 4-6.

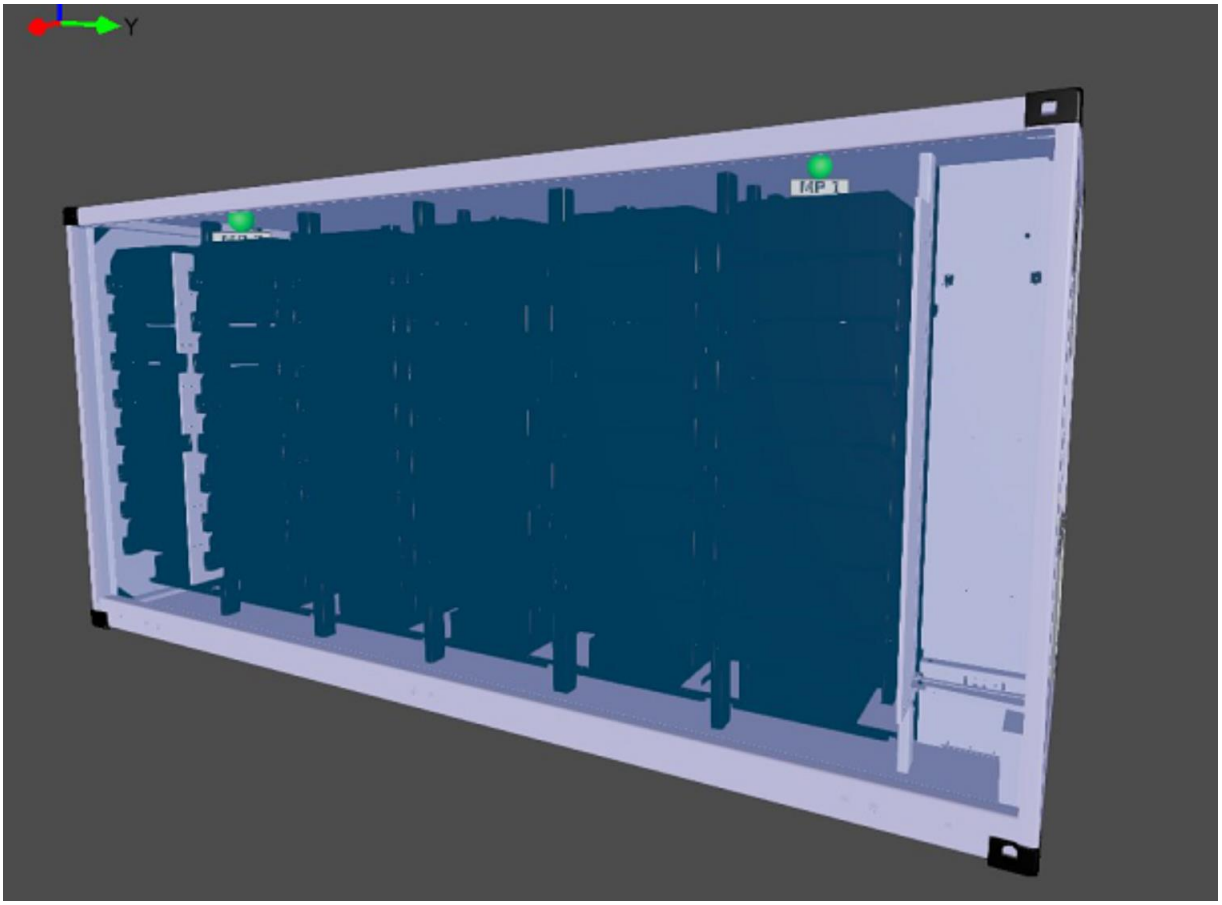


Figure 4-6: Location of gas detectors (front view).

Assumption 5: The position of gas detectors is set as above to monitor the concentration of hydrogen and trigger ventilation fans.

(4) Gas composition and LFL:

Gas composition was provided in the test data of cell level UL 9540A report. Table 4-1 lists the release gas composition by volume.

Table 4-1: Gas composition by volume

Gas component	Concentration (v, %)
CH_4	3.671
C_2H_6	0.548
C_2H_4	1.389
C_3H_8	0.18
C_3H_6	0.745
n-C_4H_{10}	0.068
n-C_4H_8	0.22
n-C_5H_{12}	0.076
iso-C_5H_{12}	0.112
n-C_5H_{10}	0.053

CO	16.202
CO_2	26.861
H_2	49.875

The LFL of offgas is provided as 6.5% vol by cell level UL 9540A test report.

Assumption 6: Gas composition is as above, LFL of gas is set to be 6.5% vol in this study.

4.2.3.System safety

(1) Ventilation system:

The container is fitted with one exhaust fan which activate immediately when 10% LFL H_2 is detected. The rated flow rate of exhaust fan is 1393.3 m^3/h (820 CFM). (See 2.3).

For conservative consideration, the actual flow rate of exhaust fan is always lower than design value due to the internal structure and flow field. Therefore, exhaust fan is considered to operate at a maximum flow rate of 917.6 m^3/h (540CFM). A passive air inlet louver is fitted on the front side of container.

Assumption 7: The dispersion simulations are run with and without the exhaust fans working. The activation time will be calculated from the CFD simulations.

(2) Thermal runaway control:

Assumption 8: Thermal runaway occurs in the module.

(3) Deflagration panels:

Assumption 9: No deflagration panel acts in this report.

4.3. Simulation Results

2 dispersion scenarios were run representing progressively worse-case scenarios based on the assumptions made in the previous sections. The modelling covers 2 leakage position. Each case was run assuming that the extraction fans had not activated and where they have activated.

According to the strategy of ventilation system provided by manufacturer, the fan will be activated when detection reaches 10% LFL of hydrogen. Consider the actual operation of the system, including a 3 second sensor reaction time and fan activation after the gas detector reaches the concentration and it takes 6s for exhausting fan to reach the maximum flowrate.

Table 4-2 shows the activating time of detector and fan for each scenario. Figure 4-7 shows the hydrogen concentration at the location of gas detector in each scenario.

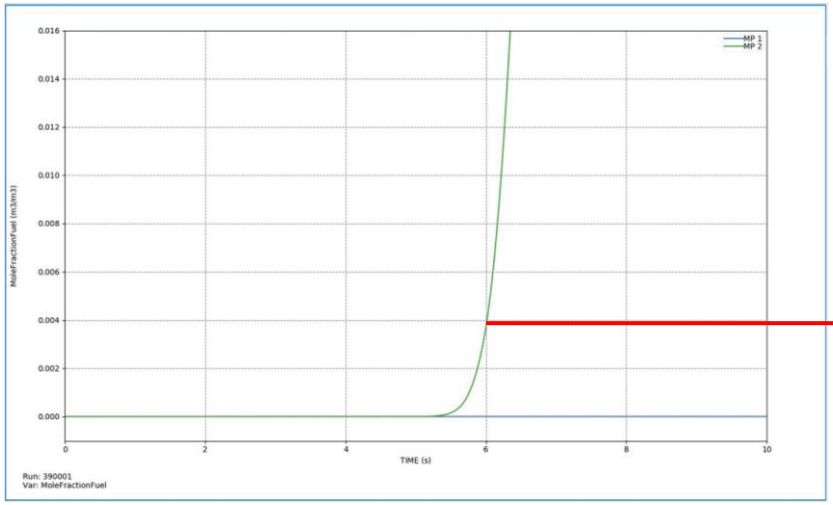


Figure 4-7: Hydrogen concentration at detector1 and 2 (initial module in the bottom right corner)

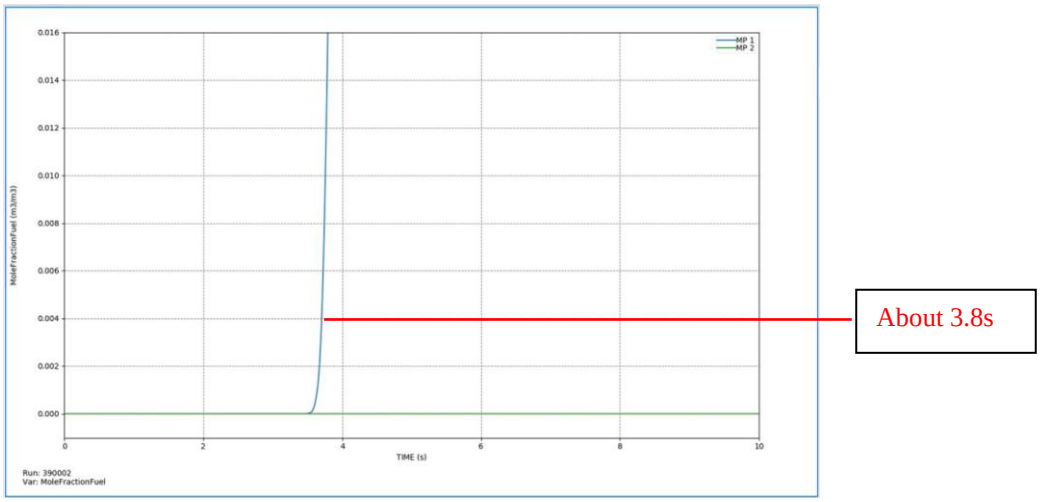


Figure 4-8: Hydrogen concentration at detector1 and 2 (initial module in the upper left corner)

Scenario	Activating time (s, integer)			Remark
	Diffusion	Sensor reaction	Ramp-up time	
1	6	3	6	initial module in the bottom right corner
2	3.8	3	6	initial module in the upper left corner

Table 4-2 Activating time of detector and fan

Table 4-3 presents a summary of the scenarios and the results from the simulation. The maximum average concentration inside enclosure is presented as the combustible concentration limit according to NFPA 69 Chapter 8.

Scenario	Maximum average gas concentration (%vol)	Remark
1	0.148	initial module in the bottom right corner
2	0.868	initial module in the upper left corner

Table 4-3: Average gas concentration

Figure 4-9 and 4-10 shows the average gas concentration for each scenario and with the extraction fans activated.

The relationship between mass and 25% LFL as following,

The density of the gas produced by the runaway cell at 25℃ and 1 bar: 0.768751kg/m^3

The mass limit of ESS=12.8m^3 X 25% X LFL(LFL=6.5%) X 0.768751kg/m^3≈0.16kg.

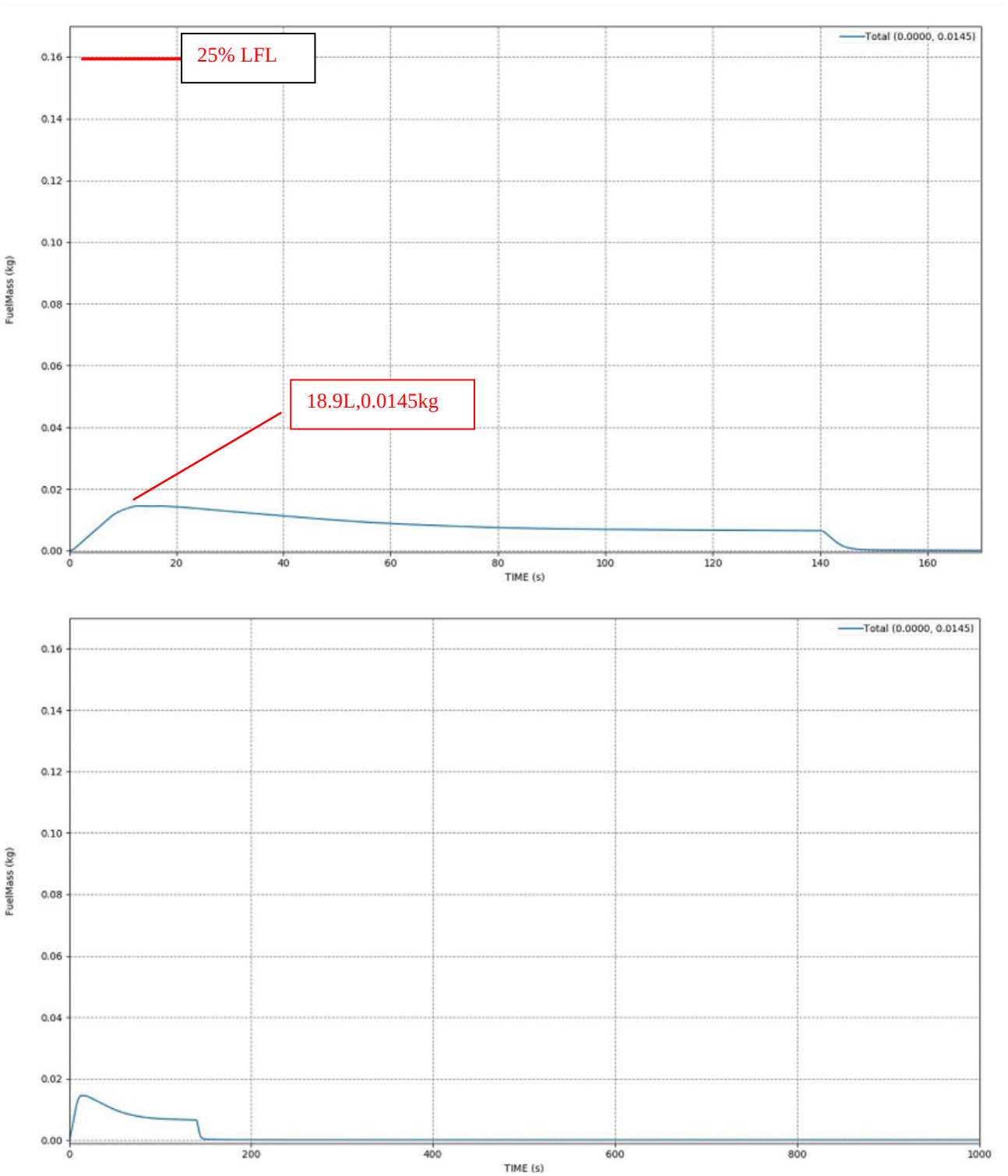
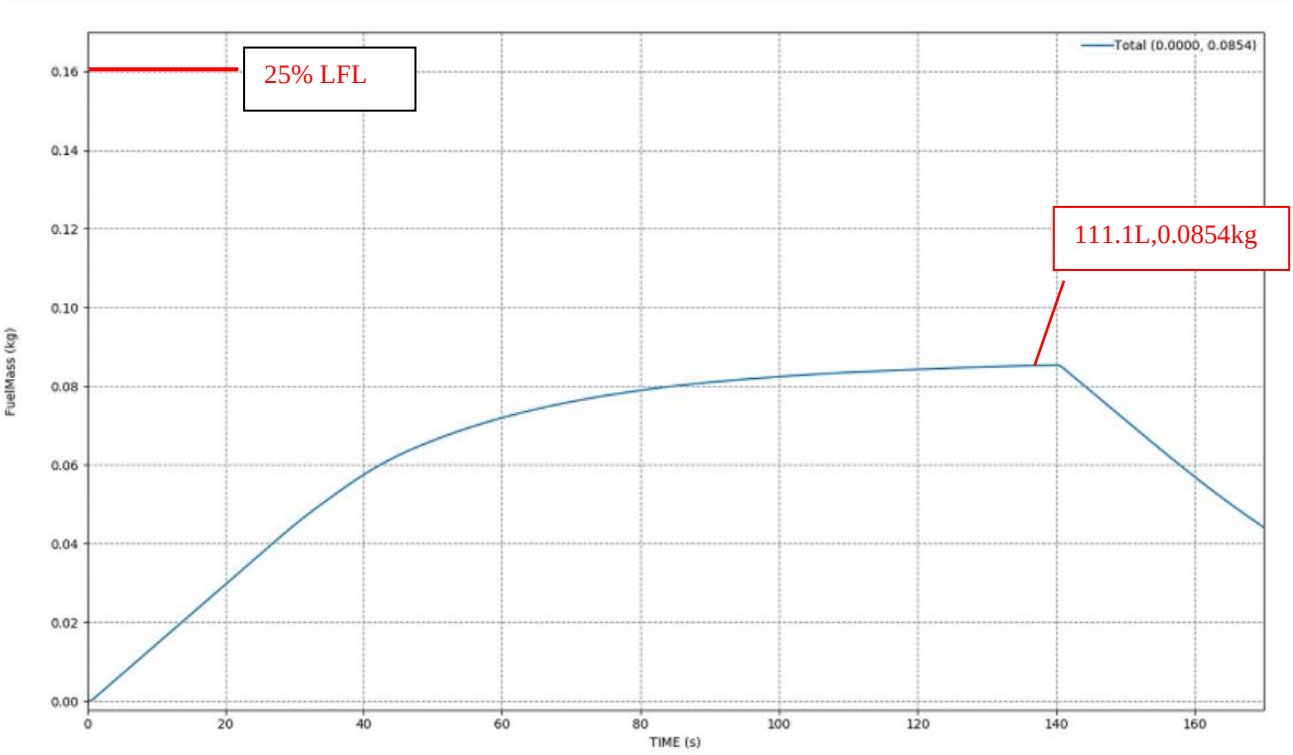


Figure 4-9: Average flammable gas concentration in scenario 1

End time of simulation:160s and 1000s



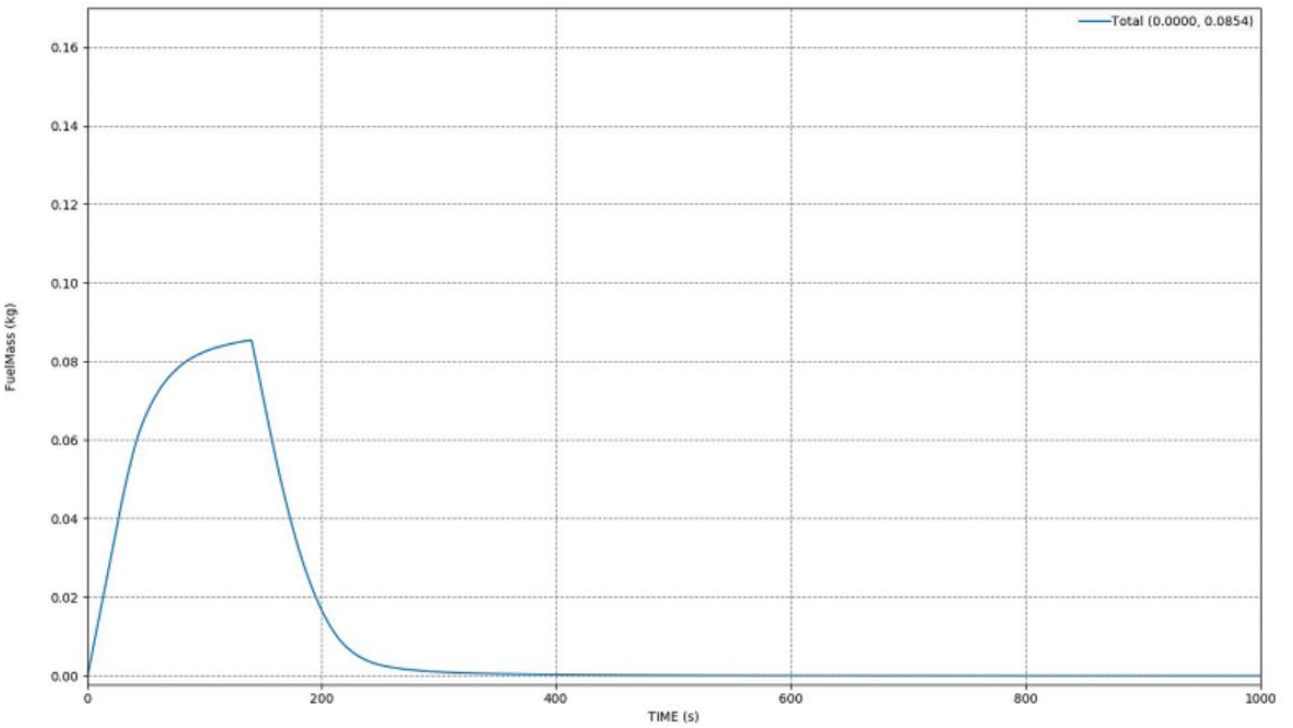
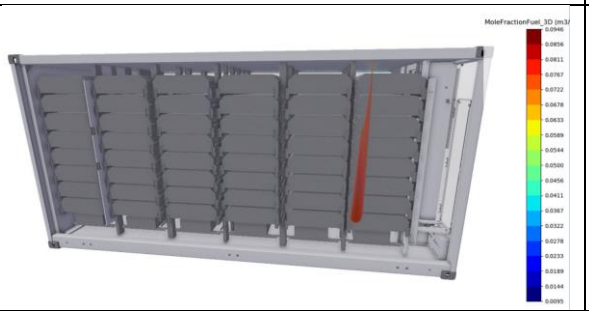
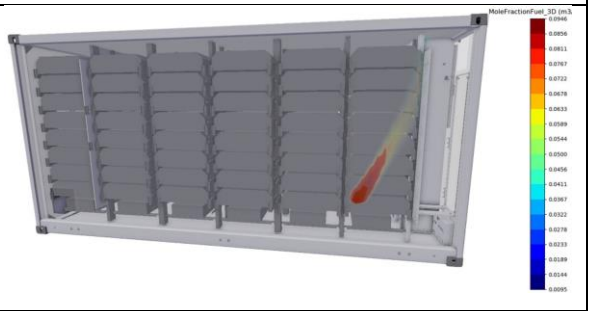
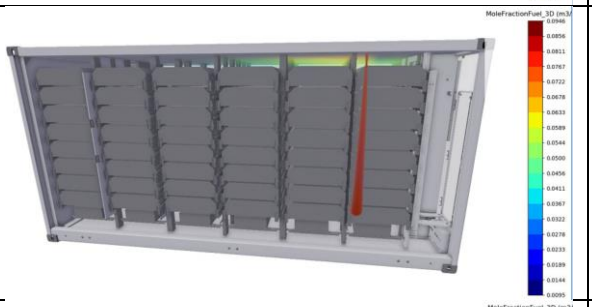
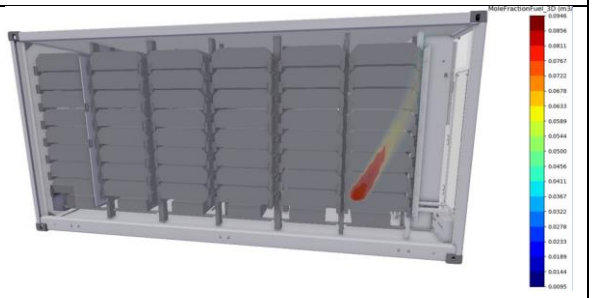
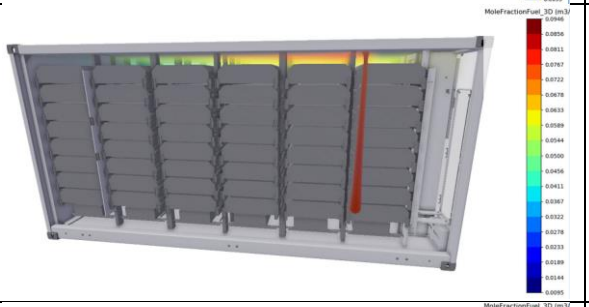
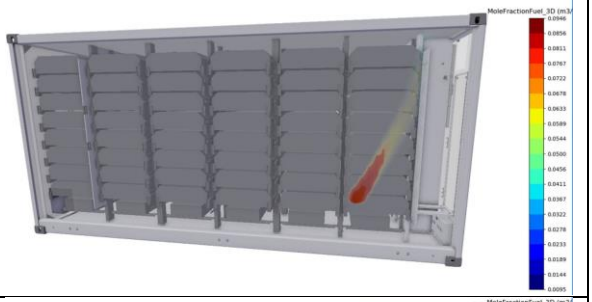
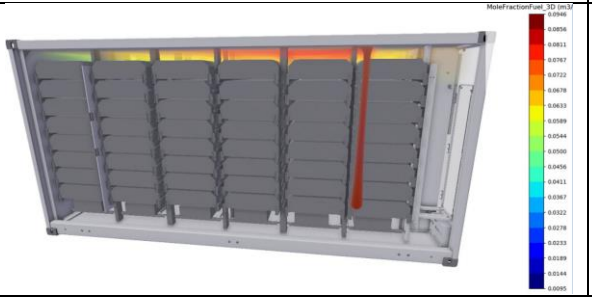
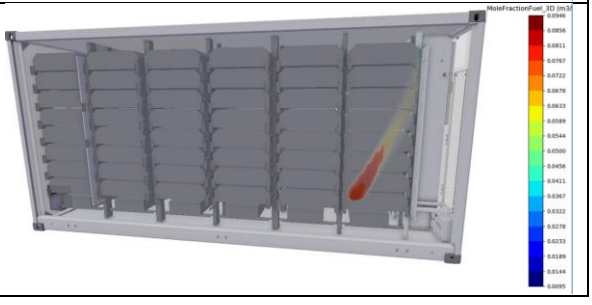


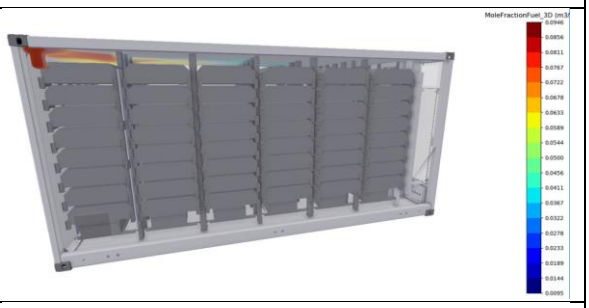
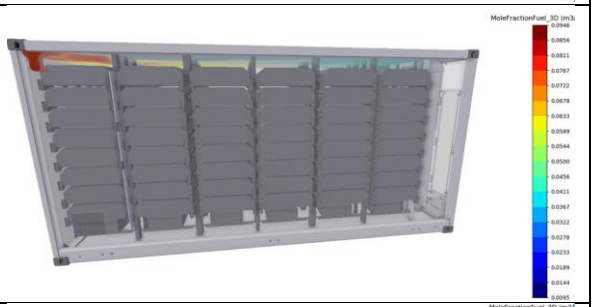
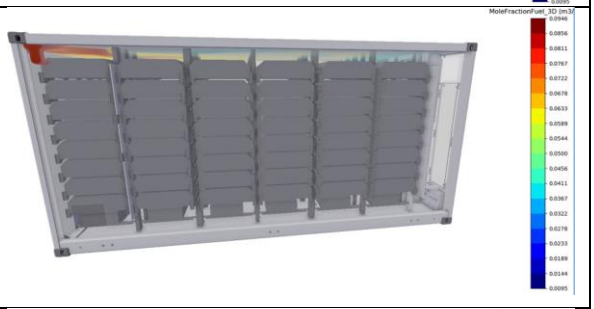
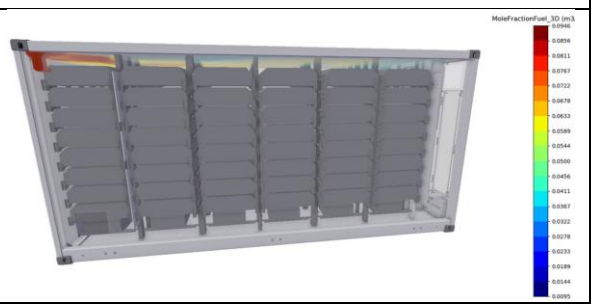
Figure 4-10: Average flammable gas concentration in scenario 2
End time of simulation:160s and 1000s

From the simulations we observe:

a) All scenarios with extraction fans activated can reduce flammable volume of gas;
b) All scenarios without the extraction fans causes gas accumulation above 25% LFL in the container;
c) All scenarios with extraction fans activated can remain gas average concentration below 25% LFL in the container.

Figure 4-11 and Figure 4-12 shows the gas cloud inside container at the time step that the gas average concentration is the maximum for each scenario.

Time (s)	Figure 4-11: Scenario 1: initial module in the bottom right corner	
	Without exhaust fan	With exhaust fan
35		
70		
105		
140		

Time (s)	Figure 4-12: Scenario 2: initial module in the upper left corner	
	Without exhaust fan	With exhaust fan
35		
70		
105		
140		

4.4. NFPA 69 Analysis

Chapter 8 of NFPA 69 is a section of the standard that discusses deflagration prevention by combustible concentration reduction, which applies to the flammable gas extraction system (via fans and gas detection). Chapter 8 states that the following design and operating requirements must be met to comply with NFPA 69:

The combustible concentration shall be maintained at or below 25 percent of the LFL for all foreseeable variations in operating conditions and material loadings, unless the following conditions apply:

(1) Where continuously monitored and controlled with safety interlocks, the combustible concentration shall be permitted to be maintained at or below 60 percent of the LFL.

(2) Aluminum powder production systems designed and operated in accordance with NFPA 484 shall be permitted to be maintained at or below 50 percent of the LFL.

As shown in Figure 4-9, the extraction fans keep the average concentration of gas in the container below 25% LFL in all scenarios. It is noted that small pockets of gas are seen to exceed 25% LFL during the extraction of the gases.

5. Conclusions

Conclusions for NFPA 69 CFD Analysis are:

a) All scenarios with extraction fans activated can reduce flammable volume of gas;
b) All scenarios without the extraction fans causes gas accumulation above 25% LFL, or even LFL, in the container;
c) All scenarios with extraction fans activated can remain gas average concentration below 25% LFL in the container.
d) The combustible concentration of all scenarios is within the limit of NFPA 69.

The scenarios in this report follow the situation of cells fail and gas release from test observations outlined in the UL 9540A test report and considered conservative by choosing a highest gas release. The exhausting fan activate when gas concentration at detector reaches 10% LFL for hydrogen, consider the actual time lag that takes for exhausting fan to reach maximum flow rate, 6s time lag for fan start was added to each scenario. The result of this study shows the ventilation design could handle the concentration below 25%LFL consistently. Furthermore, the flow rate of exhaust fan, 540 CFM, used in this report is considered conservative according to the effective of structural design of cabinet, the designed flow rate of exhaust fan is 820 CFM.

6. References

(1) NFPA69:2024 Standard on Explosion Prevention Systems

(2) Cell Level UL9540A Report: CN23F118 001

(3) Module Level UL9540A Report: CN23XXY9 003

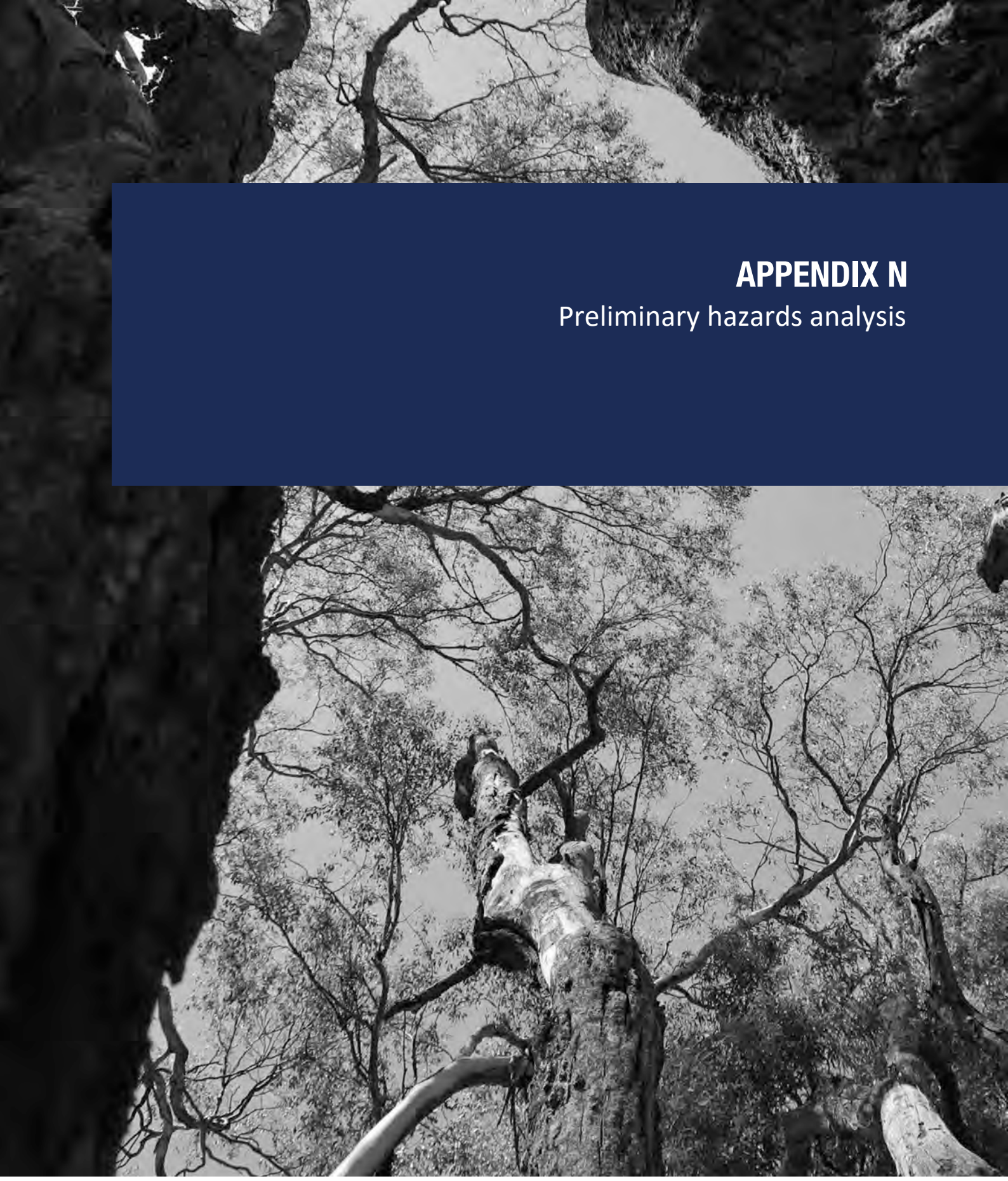
(4) Unit Level UL9540A Report: CN244DBX 001

End of Report

Appendix C. Preliminary Hazard Analysis

C.1. Summary

C.1.1. This project was assessed through the State Significant Development process in NSW. Therefore, a copy of the PHA in full can be found on the NSW Government planning portal website under Application # SSD-33344237. A copy is provided on the following inserted PDF pages.



APPENDIX N

Preliminary hazards analysis

VENA ENERGY AUSTRALIA

EMM creating opportunities

REPORT

PRELIMINARY HAZARD ANALYSIS

BELLAMBI HEIGHTS BATTERY ENERGY STORAGE SYSTEM

SSD-33344237

EMM CONSULTING PTY LTD

DOCUMENT NO:	**21689-RP-001**
REVISION:	**0**
DATE:	**24-May-2023**

Sherpa Consulting Pty Ltd (ABN 40 110 961 898)
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Title: **Report** **Preliminary Hazard Analysis** **Bellambi Heights Battery Energy Storage System** **SSD-33344237**	**QA verified:** G. Peach **Date:** 24-May-2023

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ABBREVIATIONS

AC	Alternating Current
ADGC	Australian Dangerous Goods Code
APZ	Asset Protection Zone
ARPANSA	Australian Radiation Protection and Nuclear Safety Agency
AS/NZS	Australian Standard/New Zealand Standard
BESS	Battery Energy Storage System
BMS	Battery Management System
CCTV	Closed Circuit Television
CSI	Canadian Solar Inc.
CWO	Central-West Orana
DA	Development Application
DC	Direct Current
DG	Dangerous Goods
DoP	Department of Planning
DP	Deposited Plan
DPE	Department of Planning and Environment
DVC	Decisive Voltage Classification
EIS	Environmental Impact Statement
ELF	Extremely Low Frequency
EMF	Electric and Magnetic Fields
EP&A	Environmental Planning and Assessment
FRNSW	Fire and Rescue NSW
G	Gauss
HAZID	Hazard Identification
HIPAP	Hazardous Industry Planning Advisory Paper
HVAC	Heating Ventilation and Air Conditioning
ha	Hectare
Hz	Hertz
ICNIRP	International Commission on Non-Ionizing Radiation Protection
IP	Ingress Protection
km	Kilometres

kV	Kilovolt
kV/m	Kilovolt per metre
kW	Kilowatt
kWh	Kilowatt hours
LEL	Lower Explosive Limit
LEP	Local Environmental Plan
LFP	Lithium Iron Phosphate
LGA	Local Government Area
MW	Megawatt
MWh	Megawatt hours
NEM	National Electricity Market
NFPA	National Fire Protection Association
NSW	New South Wales
O&M	Operations and Maintenance
OH&S	Occupational Health & Safety
PCS	Power Conversion System
PHA	Preliminary Hazard Analysis
PPE	Personal Protective Equipment
REZ	Renewable Energy Zone
RFS	Rural Fire Service
SCADA	Supervisory Control and Data Acquisition
SDS	Safety Data Sheet
SEARs	(Planning) Secretary's Environmental Assessment Requirements
SEPP	State Environmental Planning Policy
SSD	State Significant Development
T	Tesla
UL	Underwriters' Laboratories
V/m	Volt per metre

TERMINOLOGY

Term	Definition
Consequence	Outcome or impact of a hazardous incident, including the potential for escalation.
Project area	The development footprint, comprising the extent of actual surface disturbance required for construction and operation of the project. The development footprint is the outcome of the iterative process outlined in this EIS.
Project area boundary	The perimeter of the project area.
Non-associated residential dwellings (sensitive receptors)	Residence whose owners do not have any part of their property included in a land agreement with the proponent for the project.
Off-site	Areas extending beyond the project area boundary.
Project	Bellambi Heights Battery Energy Storage System.
Proponent	Vena Energy Services (Australia) Pty Ltd.
Risk	The likelihood of a specified undesired event occurring within a specified period or in specified circumstances. It may be either a frequency (the number of specified events occurring in unit time) or a probability (the probability of a specified event following a prior event), depending on the circumstances.
The site	The property known as 'Bellambi Heights', on Lots 101 and 102 of Deposited Plan (DP) 1203462 at 696 Castlereagh Highway and 79 Puggoon Road, Beryl, NSW.

1. INTRODUCTION

1.1. Background

Vena Energy Services (Australia) Pty Ltd (VEA) proposes to develop the Bellambi Heights Battery Energy Storage System (the project), a major grid-scale Battery Energy Storage System (BESS) and associated infrastructure. The project will have a generation capacity of approximately 408 megawatts (MW) comprising two 204 MW BESS generating units, and energy storage capacity of approximately 816 megawatt hours (MWh) (two hours of storage).

The project site is located within the Mid-Western Regional Council Local Government Area (LGA) and the Central-West Orana (CWO) Renewable Energy Zone (REZ). The project site is in the locality of Beryl, approximately 6.5 km north-west of the township of Gulgong, in the Central West of New South Wales (NSW).

The project is a State Significant Development (SSD) under the *State Environmental Planning Policy (Planning Systems) 2021 (Planning Systems SEPP)* and requires an Environmental Impact Statement (EIS) to accompany the Development Application (DA) submission, in accordance with Environmental Planning and Assessment (EP&A) Regulation.

VEA has commissioned EMM Consulting Pty Ltd (EMM) to prepare an EIS for the project. EMM has retained Sherpa Consulting Pty Ltd (Sherpa) to undertake a Preliminary Hazard Analysis (PHA) for the project for input to the 'Hazards' section of the EIS.

1.2. Objectives

The overall study objective was to address the 'Hazards' component of the Planning Secretary's Environmental Assessment Requirements (SEARs), Ref [1], which includes:

1. A preliminary risk screening completed in accordance with the *State Environmental Planning Policy No. 33 – Hazardous and Offensive Development*[1] and *Applying SEPP 33* (DoP, 2011).
2. A PHA must be prepared in accordance with Hazardous Industry Planning Advisory Paper (HIPAP) No. 6 *Hazard Analysis* and *Multi-Level Risk Assessment* (DoP, 2011). The PHA must consider all recent standards and codes and verify separation distances to onsite and off-site receptors to prevent fire propagation and compliance with HIPAP No. 4 *Risk Criteria for Land Use Safety Planning* (DoP, 2011).

[1] SEPP No. 33 *Hazardous and Offensive Development* (SEPP 33) has been revoked and incorporated as Chapter 3 of *SEPP (Resilience and Hazards) 2021*. For the preliminary risk screening, the guidance document *Applying SEPP 33* still applies.

3. An assessment of potential hazards and risks including but not limited to bushfires, land contamination[2] , spontaneous ignition, electromagnetic fields for the proposed grid connection infrastructure against the International Commission on Non-Ionizing Radiation Protection (ICNIRP) *Guidelines for limiting exposure to Time-varying Electric, Magnetic and Electromagnetic Fields*.

1.3. Scope

The project consists of the construction and operation of a major grid-scale battery project immediately adjacent to the Wollar to Wellington 330 kV transmission line. The project will have a discharge capacity of 408 MW and approximately 816 MWh storage capacity. The key project components are:

- BESS compound – comprising battery enclosures/containers (lithium-ion or similar batteries inside battery enclosures/containers), power conversion systems and ancillary infrastructure, operation and maintenance buildings and spare parts warehouses.
- BESS substation – an on-site substation comprising two 330/33 kilovolt (kV) transformer bays including oil retention bunds, indoor medium voltage switchgear units and control rooms housed in buildings, and other ancillary infrastructure.
- Switching station – a switching station that will connect the BESS to the transmission network, and will include overhead transmission lines, high voltage switchgear, current and voltage transformers, a control room and other high voltage electrical equipment.
- Site access intersection – a new site access intersection with the Castlereagh Highway will replace the existing access for the property 696 Castlereagh Highway.

1.4. Exclusions and limitations

The study exclusions and limitations are summarised in Table 1.1.

Table 1.1: Exclusions and limitations

No.	Item	Exclusions and limitations
1	Design elements for the BESS	Design elements for the BESS may be subject to change prior to construction. Sherpa noted that the selection of the BESS supplier and layout of the BESS units will be finalised during detailed design. Detailed design will be conducted upon project approval and following contractor selection to allow sufficient flexibility in the selection of technology.

[2] Sherpa's scope of work excludes assessment of existing and the potential for future land contamination.

No.	Item	Exclusions and limitations
2	Hazards associated with proposed operations	The PHA identified and assessed credible hazards associated with proposed operations of the BESS, and excluded specific hazards relating to construction, commissioning, and decommissioning. This approach is assumed to be appropriate for assessment at the DA stage aimed to obtain approval for the project.
3	Verification that the BESS would be accommodated within the area designated for the BESS compound	Verification of the areas designated for the BESS compound was undertaken to ensure sufficient area for the proposed capacity would be available, taking into account separation distances between BESS sub-units. This was conducted based on the known dimensions from the concept BESS design (make and model) and configuration adopted at the time of the study. An indicative configuration of the battery units, inverters and ring main unit is shown in Figure 7.2.
4	Bushfire hazard assessment	The PHA does not constitute a bushfire hazard assessment (outside of the study scope). Risk events associated with bushfire and the relevant controls (e.g. fire management plan) have been included in the PHA to demonstrate that this event has been considered.
5	Land contamination	The PHA excludes assessment of potential hazards and risks of land contamination for the project. A separate assessment is completed for the EIS.
6	Construction Safety Study	The PHA does not constitute a Construction Safety Study. Requirement for a Construction Safety Study will be subject to the conditions of consent of the project approval. For more information, refer to HIPAP No. 7 *Construction Safety*.
7	Fire Safety Study	The PHA does not constitute a Fire Safety Study. Requirement for a Fire Safety Study will be subject to the conditions of consent of the project approval. For more information, refer to HIPAP No. 2 *Fire Safety Study*.

2. FACILITY DESCRIPTION

2.1. Location and project site

The project will be developed at 79 Puggoon Road and 696 Castlereagh Highway, Beryl NSW 2852 (the site), approximately 6.5 km north-west of Gulgong. The project will be situated on Lots 101 and 102 of Deposited Plan (DP) 1203462 within the Mid-Western Regional LGA and CWO REZ. The site is situated between the Castlereagh Highway, which lies along the western boundary, and Puggoon Road, which lies along its along its eastern boundary.

The project area[3] covers an area of approximately 25 hectares (ha), of which the BESS compound will occupy an area of approximately 15 ha.

The location of the project site and the project area are shown in Figure 2.1 and Figure 2.2, respectively.

2.2. Surrounding land use

The project site is located on land zoned 'RU1 Primary Production' under the Mid-Western Regional Local Environmental Plan (LEP). The surrounding area is primarily cleared land used for grazing or dry land cropping, with scattered rural residences and agricultural buildings and infrastructure.

There are multiple renewable energy generation projects (proposed and approved) in the vicinity of the project site, including the proposed Tallawang Solar Farm and the operational Beryl Solar Farm located approximately 500 m north and 3.5 km south, respectively.

Existing infrastructure within the project area includes the Wollar to Wellington 330 kV transmission line orientated south-west to north-east.

The nearest town centre is Gulgong, located approximately 6.5 km south-east of the project. There are 72 sensitive receptors (non-associated residential dwellings[4]) within approximately 4 km of the project area. A further two dwellings are associated with the project (R70, R71). Sensitive receptors are primarily located in loose clusters to the south, east and north-west of the project area, with most lying between 1 and 4 km from the nearest boundary of the project area (either BESS compound or switching station components). The surrounding residential dwellings are visually presented in Figure 2.3.

[3] The development footprint, comprising the extent of actual surface disturbance required for construction and operation of the project. The development footprint is the outcome of the iterative process outlined in this EIS.

[4] Residence whose owners do not have any part of their property included in a land agreement with the proponent for the project.

Figure 2.1: Project site location

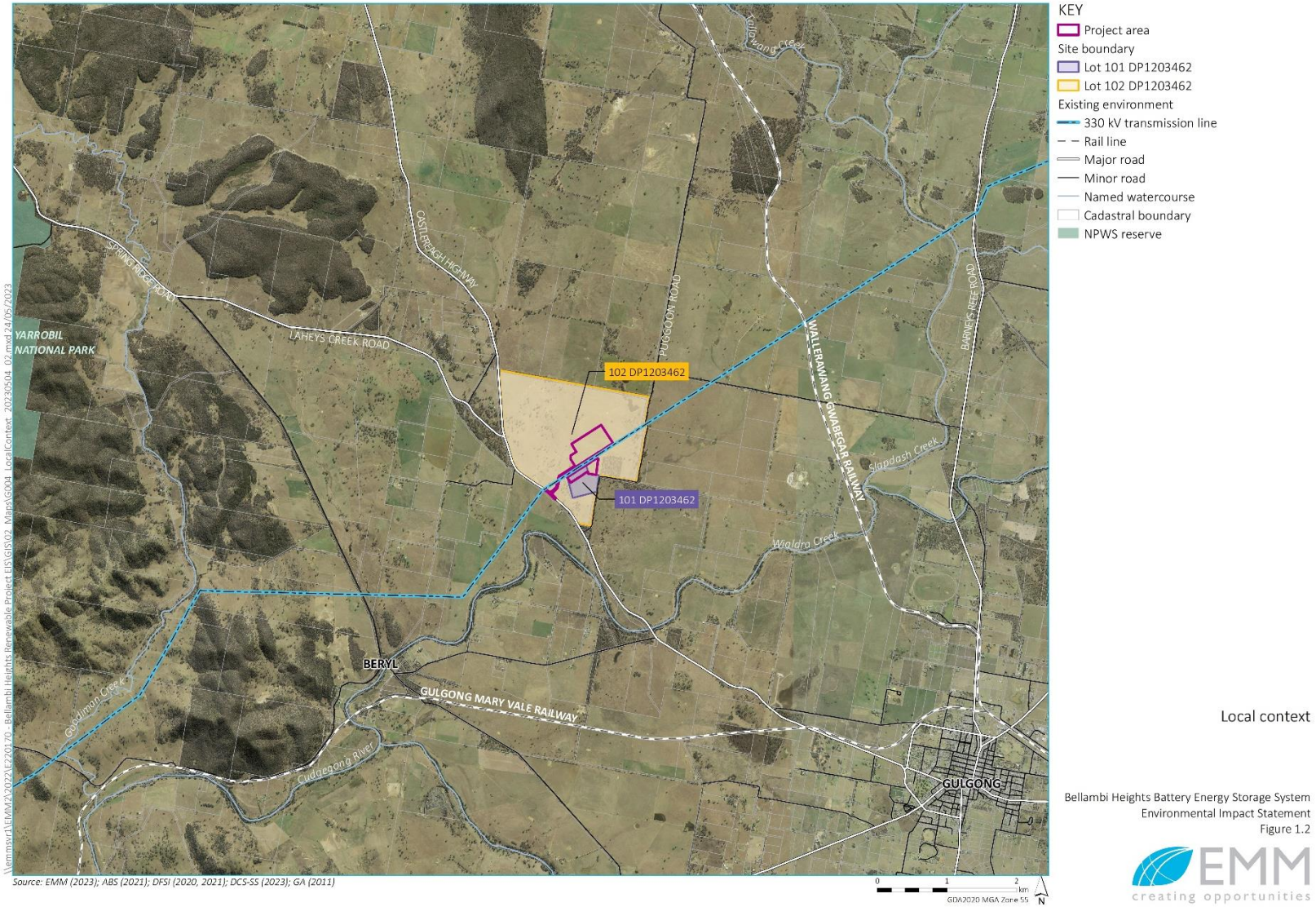


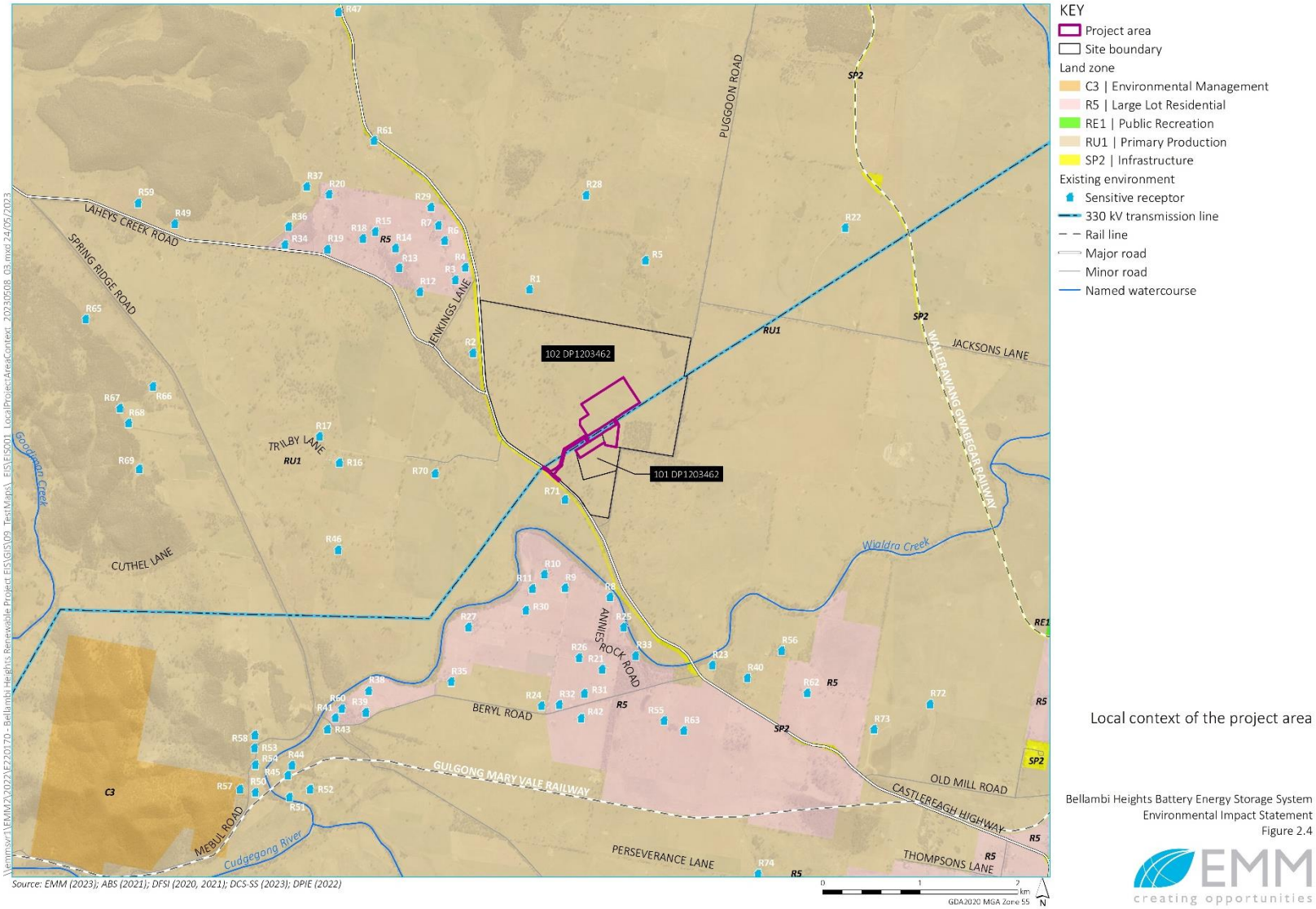
Figure 2.2: Project area



Project layout

Bellambi Heights Battery Energy Storage System
Environmental Impact Statement
Figure 3.1

Figure 2.3: Residential dwellings in the surrounding area



Local context of the project area

Bellambi Heights Battery Energy Storage System
Environmental Impact Statement
Figure 2.4

2.3. Project key infrastructure

2.3.1. Battery Energy Storage System

A BESS is a type of energy storage system that utilises batteries to store and discharge energy in the form of electricity. The energy is stored in Direct Current (DC) and converted to Alternating Current (AC) via a bi-directional inverter to convert the current between the BESS and the grid.

The BESS would store excess energy during peak production periods to later transmit into the grid when required (e.g. peak demand periods), and support stabilising the supply of electricity to the National Electricity Market (NEM). Indicatively for this project, the proposed BESS will have a total capacity of 408 MW/816 MWh (two hours energy storage) and make use of lithium-ion technology.

At the time of this study, VEA has not made a final decision on the BESS supplier. The assessment made in this study was based on the use of the Canadian Solar Inc. (CSI) SolBank battery system, which was used for the project concept design.

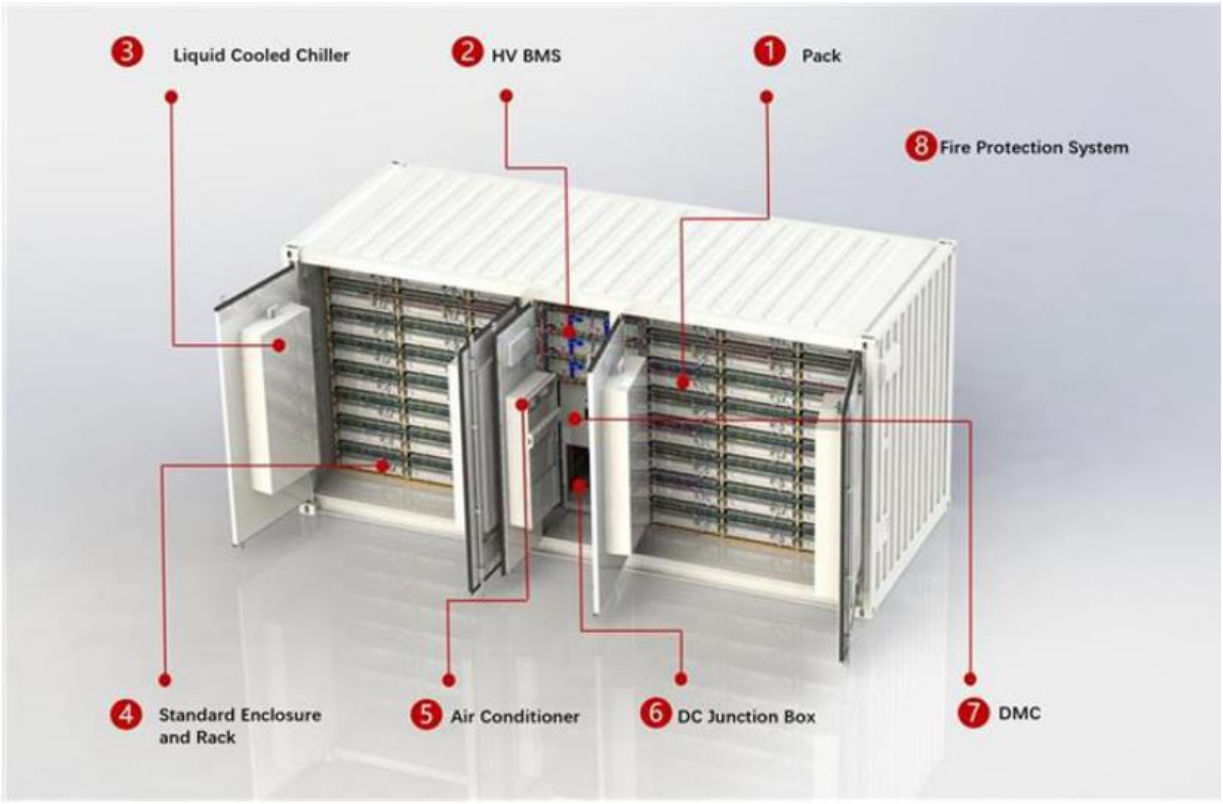
The SolBank battery system, including major equipment and features, is shown in Figure 2.4. Major components and specific features of the battery system are described in Table 2.1, Ref [2]. An indicative configuration of the SolBank batteries, inverters, transformers and ring main unit is provided in Figure 7.2.

The selection of the BESS supplier and layout of the BESS units within the BESS compound will be finalised during detailed design. Detailed design will be conducted upon project approval. The following were assumed for the PHA:

1. The BESS units will be installed in accordance with the manufacturer's instructions provided for best practice for mitigation of fire propagation, including clearance requirements.
2. The BESS units will be installed and meet requirements of the relevant Australian Standards and other codes and standards.
3. The specific BESS (make and model) has been tested to Underwriters' Laboratories (UL) 9540A *Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems* to evaluate the thermal runaway and fire propagation characteristics, informing the required protection for installation and operation of the respective BESS. A UL 9540A test is considered successful if a fire does not propagate from one unit/cabinet to another during the test.

Figure 2.4: The SolBank battery system

(a) Overview of the battery system equipment



(b) Fire and explosion protection system

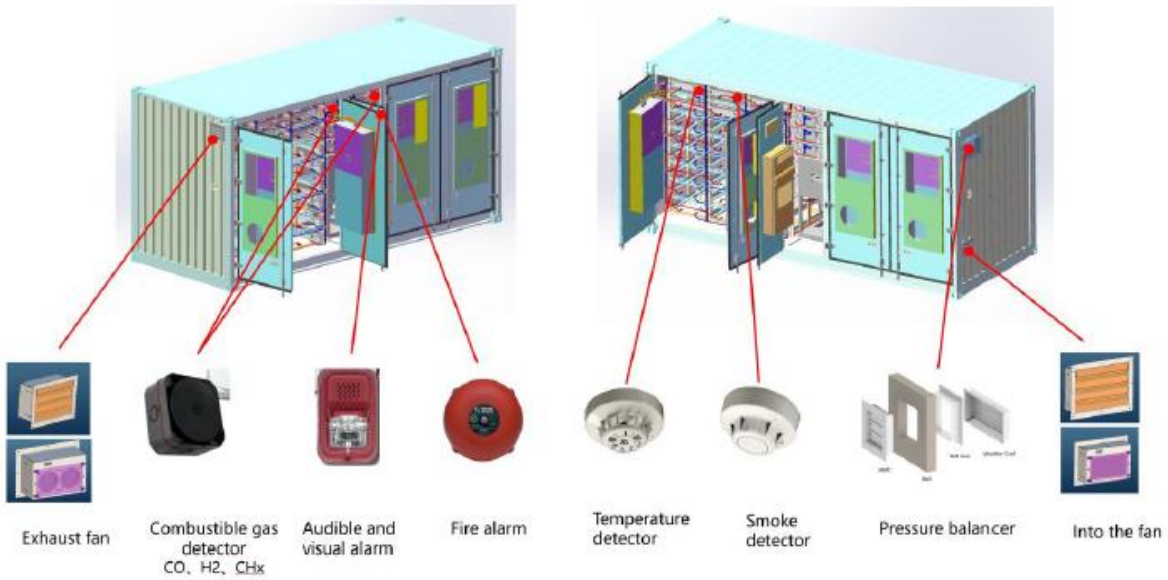


Table 2.1: Typical BESS components

Component	Description
Overview	The SolBank is a modular BESS which integrates batteries, Battery Management System (BMS), power distribution system, controls and safety features. It is a turnkey product solution by CSI Energy Storage Technologies Co., Ltd (a subsidiary of CSI). The assessment made in this study was based on the use of the following configuration: • Battery system: CSI SolBank S1K51K3A01 • Inverter: Power Electronics (1500V 4390 kVA).
Enclosure	The BESS is enclosed in a 6058 mm x 2438 mm x 2896 mm container rated to IP 55, suited for outdoor use.
Battery modules	It is anticipated that 360 SolBanks (2 x 180 units) will be installed to provide the required capacity for the project (2 x 204 MW BESS compounds). The capacity for each SolBank unit is nominally 1375 kW/2750 kWh. Each battery pack consists of 69 Lithium Iron Phosphate (LFP) battery cells. Each battery rack consists of 6 battery packs. The SolBank battery enclosure contains 8 racks connected in parallel.
Power Conversion Systems (PCS) or inverters	Inverters are electrical devices that convert DC to AC or vice versa (i.e. bi-directional). The inverters will function to convert the current between the battery and the grid. It is anticipated that 120 inverters will be installed for the project (i.e. each inverter will connect to 3 SolBank units).
Battery Management System (BMS)	A BMS is the electronic system that monitors and manages the battery system electric and thermal states enabling it to operate within the safe operating region of the battery (e.g. protection against overcurrent, over-charge, over-discharge, overheating, over voltage). The SolBank BMS consists of three units: Battery Management Unit, Battery Controlling Unit and the controller which provide monitoring, protection and control at pack, rack and SolBank level, respectively.
Thermal management system	Thermal management of the SolBank is divided into two systems: 1. Door mounted chiller(s) providing liquid cooling (and heating) directly to battery packs. 2. Door mounted air conditioner circulating air throughout the container to manage internal cooling loads of the rest of the enclosure's electrical components as well as the environmental cooling (and heating) loads from outside the enclosure.
Fire protection system	Each BESS enclosure is equipped with a gas sensor, temperature detector, smoke detector and alarm panel. Confirmed detection will trigger audible and visible alarms and initiate electrical isolation and emergency shutdown of the system to prevent further escalation of the event.
Explosion protection system	Each BESS enclosure is equipped with: • Combustible gas detector (hydrogen, methane, carbon monoxide). • Exhaust fan – to vent flammable/explosive gases upon the detection by the gas detection system. Level 1 triggers at 25% Lower Explosive Limit (LEL) and Level 2 at 50% LEL. • Passive pressure balancer – to balance pressure within the enclosure and automatically activated when pressure difference is greater than the set value (e.g. active air inlet and exhaust systems failure case).

<table>
<tr><th>Component</th><th>Description</th></tr>
<tr><td>Standards, Codes and Testing</td><td>The SolBank and its subcomponents are designed to be compliant with standards that are generally accepted to demonstrate minimum safety considerations in the system’s design for US and Canadian installations. Key standards and tests claimed include:
<table>
<tr><th>Standards and tests</th><th>Title</th><th>Component</th></tr>
<tr><td>UL 1642</td><td>Standard for Lithium Batteries</td><td>Cell</td></tr>
<tr><td>UL 1973</td><td>Standard for Batteries for Use in Stationary, Vehicle Auxiliary Power and Light Electric Rail Applications</td><td>Module/Pack/String</td></tr>
<tr><td>UL 9540</td><td>Standard for Energy Storage Systems and Equipment</td><td>Full system</td></tr>
<tr><td>UL 9540A</td><td>Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems –Cells</td><td>Full system fault and fire testing</td></tr>
<tr><td>UL 9540A</td><td>Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems – Modules/ Packs and Unit/Enclosure</td><td>Full system fault and fire testing</td></tr>
<tr><td>UL 1998</td><td>Standard for Software in Programmable Components</td><td>Electrical and software protection controls</td></tr>
<tr><td>UL 1995</td><td>Heating and Cooling Equipment</td><td>Thermal management system</td></tr>
<tr><td>UN 38.3</td><td>Certification for Lithium Batteries</td><td>Transportation</td></tr>
</table></td></tr>
</table>

2.3.2. BESS substation

A BESS substation will be established within the project area to convert electricity between the medium voltage BESS and the high voltage transmission network. The substation will connect to the BESS infrastructure via underground 33 kV cables. The substation will be separated from the BESS compound by security fencing and an Asset Protection Zone (APZ).

The substation is expected to comprise two 330/33 kV transformer bays. Transformers will be bunded and subject to separation distances in accordance with manufacturer requirements and Australian Standards. The substation will also include:

- Substation buildings to accommodate indoor 33 kV switchgear, secondary protection systems, AC/DC distribution equipment, fire detection systems, a supervisory control and data acquisition (SCADA) system, system dispatch control, Closed Circuit Television (CCTV), and intrusion detection.
- Auxiliary transformers.
- High voltage connections between 330 kV outdoor switchgear.
- Other ancillary components including security fencing, lightning protection masts, lighting poles, security poles and cabling.

2.3.3. Switching station

The project will connect to the adjoining Wollar to Wellington 330 kV transmission line which traverses the project area by way of a new 330 kV switching station, with 330 kV overhead line connections to the adjacent BESS substation.

The required works are subject to detailed design but are expected to require the connection of overhead conductors and 330 kV switchgear and switch bays. The expected work will include:

- Switchyard bench
- Security fencing
- 330 kV gantry columns and beams, busbar supports, disconnectors, circuit breakers, current transformers, voltage transformers, surge arrestors
- Control building
- Overhead or underground cables as required for the new 330 kV switch bay.

2.3.4. Supporting infrastructure

The BESS compound will be supported by ancillary infrastructure including:

1. Operation and Maintenance (O&M) buildings, spare parts warehouses and associated parking
2. Connection to utilities
3. Drainage and stormwater management
4. Security fencing, lighting, CCTV cameras
5. Dedicated fire-fighting water supplies.

Additionally, the following supporting infrastructure will also be developed for the project:

- New site access off the Castlereagh Highway
- Access tracks within the project area
- Temporary construction facilities and laydown area.

2.4. Construction

Subject to approval, construction of the project is expected to commence in 2025. It is considered likely that construction may occur over two stages, with Stage 2 construction commencing approximately 6-12 months following completion of Stage 1 works. Construction for a single stage is expected to occur between 13-20 months.

Temporary infrastructure will be established when the construction work commences. All temporary infrastructure will be strategically placed to minimise potential environmental impacts during the construction phase of the project. The infrastructure

will be dismantled, and its footprint rehabilitated once the project is built and moves into the operational stage.

2.5. Operations

The expected project operational life is approximately 25 years, subject to component replacement and life extension.

The BESS will operate 24 hours per day, seven days per week, 365 days per year and be operated remotely. The BESS is expected to be on standby for the majority of the time and undergo one to two full cycles of charging and discharging per day.

During the operations phase, there will be no permanent staff on site.

2.6. Decommissioning

Once the project reaches the end of its operational life, the project infrastructure will either be replaced, upgraded or decommissioned.

Decommissioning would involve removal of the built infrastructure from site and the project area returned to its pre-development agricultural land use.

3. PRELIMINARY RISK SCREENING

3.1. Overview

The objective of the preliminary risk screening was to determine whether the proposed development is considered as 'potentially hazardous' in the context of *SEPP (Resilience and Hazards) 2021*, Ref [3].

SEPP (Resilience and Hazards) 2021 defines potentially hazardous industry as follows:

> *'Potentially hazardous industry' means a development for the purposes of any industry which, if the development were to operate without employing any measures (including, for example, isolation from existing or likely future development on other land) to reduce or minimise its impact in the locality or on the existing or likely future development on other land, would pose a significant risk in relation to the locality:*
>
> *(a) to human health, life or property, or*
>
> *(b) to the biophysical environment,*
>
> *and includes a hazardous industry and a hazardous storage establishment.*

Development proposals that are classified as 'potentially hazardous' industry must undergo a PHA as per the requirements set in HIPAP No. 6 *Guidelines for Hazard Analysis*, Ref [4], to determine the risk to people, property and the environment. If the residual risk exceeds the acceptability criteria, the development is considered as a 'hazardous industry' and may not be permissible within NSW.

To determine whether a proposed development is potentially hazardous, the NSW Department of Planning and Environment (DPE) *Applying SEPP 33* guideline[5], Ref [5], is used to undertake the risk screening process. The risk screening process considers the type and quantity of hazardous materials to be stored on site, distance of the storage area to the nearest site boundary, as well as the expected number of transport movements.

'Hazardous materials' are defined within the guideline as substances that fall within the classification of the Australian Dangerous Goods Code (ADGC), i.e. have a Dangerous Goods (DG) classification. Detail of the DG classification is typically obtained from the materials' Safety Data Sheet (SDS).

The *Applying SEPP 33* guideline is based on the 7th edition of ADGC, Ref [6], and refers to hazardous chemicals by their DG classification. Risk screening is undertaken by comparing the storage quantity and the number of road movements of the hazardous materials with the screening threshold specified in the guideline. The screening threshold presents the quantities below which it can be assumed that significant off-site risk is unlikely.

[5] SEPP No. 33 *Hazardous and Offensive Development* (SEPP 33) has been revoked and incorporated as Chapter 3 of *SEPP (Resilience and Hazards) 2021*. For the preliminary risk screening, the guidance document *Applying SEPP 33* still applies.

3.2. Risk screening

A summary of the expected hazardous materials to be stored and handled on site for the project, transport movements and the relevant SEPP screening threshold is presented in Table 3.1.

Other materials considered as part of the SEPP risk screening include transformer oil and herbicide/pesticide and BESS coolant (50% ethylene glycol and 50% water solution). Generally, these are not classified as DGs and are excluded from the risk screening. Additionally, these materials will not be stored with other flammable materials and hence not considered to be potentially hazardous under the SEPP.

3.3. Other risk factors

Appendix 2 of *Applying SEPP 33* outlines other risk factors for consideration to identify hazards outside the scope of the risk screening method.

A review of these risk factors was completed, and it was noted that the project would not involve:

- Storage or transport of incompatible materials (i.e. hazardous and non-hazardous). Hazardous materials will be stored in dedicated areas and storage protocols in accordance with standard and guidelines will be followed.
- Generation of hazardous waste.
- Possible generation of dusts within confined areas.
- Type of activities involving the hazardous materials with potential to cause significant off-site impacts.
- Incompatible, reactive or unstable materials and process conditions that could lead to uncontrolled reaction or decomposition.
- Storage or processing operations involving high (or extremely low) temperature and/or pressures.
- Hazardous materials and processes with known past incidents (or near misses) that resulted in significant off-site impacts at similar BESS developments.

3.4. Industries that may fall within the Resilience and Hazards SEPP

Appendix 3 of *Applying SEPP 33* provides a list of industries that may be potentially hazardous. It is noted that this list is illustrative rather than exhaustive. The current edition of the guideline does not include BESS facilities in the example industry listings that may fall within the Resilience and Hazards SEPP or considered as potentially hazardous.

Table 3.1: Preliminary risk screening summary

Material	DG Class	Category	Storage threshold	Transport threshold		Project storage quantities and applicable SEPP screening	Exceed threshold?
				Movements	Quantities		
Diesel	C1	Combustible liquids	N/A	N/A	N/A	No applicable SEPP screening threshold and excluded from risk screening.	No
BESS battery (Lithium ion)	9	Miscellaneous DGs	N/A	> 1000 (annual) > 60 (weekly)	No limit	No applicable SEPP screening threshold and excluded from risk screening. Transport movement threshold will not be exceeded. Movements are expected to occur during construction only and minimal during operation and maintenance (e.g. battery replacement).	No
BESS refrigerant (R134a)	2.2	Non-flammable Non-toxic	N/A	N/A	N/A	No applicable SEPP screening threshold and excluded from risk screening. Class 2.2 are not considered to be potentially hazardous with respect to off-site risk.	No

3.5. Conclusions

The preliminary risk screening found that the project is not considered as 'potentially hazardous' within the meaning of Resilience and Hazards SEPP and does not require a PHA.

The main findings of the preliminary risk screening are summarised as follows:

- The storage and transport of hazardous materials for the project will not exceed the relevant risk screening threshold.
- There are no other risk factors identified that could result in significant off-site impacts.
- The project is not considered as 'potentially hazardous' with respect to DG storage and transportation and does not require a PHA.

4. HAZARDS AND RISK ASSESSMENT

4.1. Overview

Notwithstanding the outcome of the preliminary risk screening, the *Hazards* assessment requirements of the SEARs require (1) a PHA, and (2) an assessment of hazards and risks for the project to be undertaken. The objective of these assessments was to identify the hazards and assess the risks associated with the project at the planning stage of the DA and determine risk acceptability from a land use safety planning perspective.

To address the above requirements, a PHA was completed following the methodology specified in HIPAP No. 6 *Guidelines for Hazard Analysis*, Ref [4], which is focused on off-site impacts.

The HIPAP No. 6 methodology included the following steps:

1. Establishment of the study context.
2. Identification of hazards resulting from the project operations and events with the potential for off-site impact *(Hazard Identification)*.
3. Analysis of the severity of the consequences for the identified events with off-site impact, e.g. fires and explosions *(Consequence Analysis)*.
4. Determination of the level of analysis and risk assessment criteria.
5. Analysis of the risk of the identified events with off-site impact (*Risk Analysis*).
6. Assessment of the estimated risks from identified events against risk criteria to determine acceptability (*Risk Assessment)*.

The PHA assessed the events associated with proposed operation of the BESS (i.e. excluded construction related events). At the DA stage, the PHA is focused on the risk to surrounding land uses (i.e. off-site impacts) and assesses if the development is appropriate for the location.

The project area boundary was used to define and determine off-site impact (i.e. impact extending outside of the project area boundary). Off-site impact was determined based on potential to impact sensitive receptors (i.e. non-associated residential dwellings).

4.2. Level of analysis

The *Multi-Level Risk Assessment* guidelines, Ref [7], sets out three levels of risk analysis that may be appropriate for a land use safety planning assessment, as shown in Table 4.1. This guidance document was consulted to determine the level of analysis required for this study.

The outcomes of the *Hazard Identification* and *Consequence Analysis* were used to determine the level of analysis appropriate for the PHA.

Table 4.1: Level of analysis

Level	Analysis type	Appropriate/can be justified if
1	Qualitative	There are no potential events with significant off-site consequences and societal risk is negligible.
2	Partially quantitative	The frequency of occurrence of risk contributors having off-site consequences is low.
3	Quantitative	There are significant off-site risk contributors, and a Level 2 analysis is unable to demonstrate that the risk criteria will be met.

4.3. Risk assessment criteria

The risk criteria used for assessment followed the guidance provided in HIPAP No. 4 *Risk Criteria for Land Use Safety Planning*, Ref [8], appropriate for the level of analysis determined (based on guidance outlined in Table 4.1).

5. HAZARD IDENTIFICATION

5.1. Overview

Hazard Identification (HAZID) aims to identify all reasonably foreseeable hazards and associated events that may arise due to the operation of the facilities and defining the relevant controls through a systematic and structured approach.

The HAZID process was completed using the following input:

1. Review of the battery system product datasheet, Ref [9], safety manual, Ref [10], installation manual, Ref [2], and UL 9540A test result, Ref [11].
2. Review of AS/NZS 5139:2019 *Electrical installations – Safety of battery systems for use with power conversion equipment*, Ref [12].
3. Literature research of past incidents involving similar BESS systems.
4. Previous risk assessments for similar BESS systems completed by Sherpa.
5. Consultation and feedback from VEA for review and acceptance.

At the time of this study, VEA has not made a final decision on the BESS supplier. The assessment made in this study was based on the use of the CSI SolBank battery system, which was used for the project concept design. Sherpa assumed that the HAZID undertaken for the BESS is representative of other lithium-ion based battery systems from other manufacturers, as the modes of failure and control mechanisms are not dissimilar.

5.2. Identified hazards and events

The following factors were considered to identify the hazards:

- BESS component and type of equipment.
- Hazardous substances/DG present.
- Proposed operation and maintenance activities.
- BESS incident history
- External factors (e.g. unauthorised personal access, lightning storm).

Events with the potential to result in significant impacts to people (i.e. injury and/or fatality) were identified. The study excluded hazards related with Occupational Health & Safety (OH&S), e.g. slips, trips and falls.

The types of hazards and associated events considered were informed from AS/NZS 5139. The identified hazards and events are presented in Table 5.1.

Table 5.1: Identified hazards and events

Hazard	Event
Electrical	Exposure to voltage
Arc flash	Release of energy
Fire	Infrastructure fire
Chemical	Release of hazardous materials
Explosive gas	Generation of explosive gas
Reaction	Battery thermal runaway
EMF	Exposure to Electric and Magnetic Fields (EMF)
External factors	Unauthorised access/trespasser, bushfire, lightning storm, water ingress (rain and flood)

In this study, bushfire was considered as a cause of fire resulting from encroachment of an off-site bushfire impacting the BESS. A bushfire assessment was completed for the project as part of the EIS. Identified controls such as APZ and fire management plan have been referenced in this study, where applicable.

A summary of the hazard present at/applicable to the BESS is provided in Table 5.2.

Table 5.2: Hazards by BESS component

	BESS Components			
Hazard	**Battery modules**	**BMS**	**Thermal management system**	**PCS (inverters)**
Electrical	✓	✓	-	✓
Energy (arc flash)	✓	✓	-	✓
Fire	✓	✓	✓	✓
Chemical	✓	✓	✓	-
Explosive gas	✓	-	✓	-
Reaction	✓	-	-	-
EMF	✓	✓	-	✓
External factors	✓	✓	✓	✓

5.3. Exposure to EMF

The SEARs for '*Hazards*' include a requirement to assess potential hazards and risks associated with exposure to EMF against the ICNIRP guidelines. Details on exposure to EMF and assessment against ICNIRP guideline and reference levels are presented in Section 6.

5.4. Separation distances to off-site receptors

To inform whether the consequence of a hazardous event has the potential to impact off-site receptors, separation distances from the project area boundary to the nearest non-associated residential dwellings were reviewed. This review is provided in Section 7.

5.5. HAZID register

The identified hazards, events, applicable infrastructure and the relationships with causes, consequences and controls are summarised in the HAZID register.

The HAZID register is provided in Table 5.3. The findings are as follows:

- A total of 13 hazardous events were identified.
- As some of the project infrastructure will be located close to the project area boundary, some hazardous events (i.e. fires) may extend beyond this boundary (i.e. off-site impact in the context of HIPAP No. 6). However, the consequences from these events are not expected to result in significant off-site impacts (serious injury and/or fatality to the public or off-site population) as:
  - The BESS will be situated in a rural area.
  - The nearest sensitive receptor/non-associated residential dwelling (R5) is located approximately 1,210 m from the ‘BESS compound’ boundary.

Table 5.3: HAZID register

ID	Hazard	BESS component/ infrastructure	Event	Cause	Consequence	Controls	Other Comments	Significant off-site Impact?
1.	Electrical	Battery modules BMS PCS (inverters, transformers)	Exposure to voltage	<u>Short circuit/electrical connection failure</u> - Faulty equipment - Incorrect installation - Incorrect maintenance - Human error during maintenance - Safety device/circuit compromised - Battery casing/enclosure damage <u>Earth potential rise (exposure to step and touch potentials)</u> - Electrical faults	- Electrocution - Injury and/or fatality to onsite employees - Injury and/or fatality to member of public due to touch and step potential (e.g. transferred through fences). As the BESS will be situated in a rural area and there is a large separation distance to the nearest sensitive receptor, the effects are not expected to have an off-site impact.	- Equipment and systems will be designed and tested to comply with relevant international and/or Australian standards (e.g. AS/NZS 5139) and guidelines - Decisive Voltage Classification (DVC) followed and equipment marked accordingly - Warning signs (electrical hazards, arc flash) - Engagement of reputable contractors - Installation, operations and maintenance will be undertaken by trained personnel in accordance with relevant procedures - Independent owner's engineers' endorsement - Site induction/substation training (i.e. high voltage areas) - Electrical switch-in & switch-out protocol - BESS BMS fault detection and safety shut-off - Earthing study (mitigate touch and step potentials) - Earthing as per manufacturer and standards requirements - Perimeter fence with signage (warning of electrical hazard) - Emergency Response Plan - External firefighting protocol (FRNSW & RFS) - Use of appropriate PPE - Rescue kits (i.e. insulated hooks)	-	No
2.	Energy	Battery modules BMS PCS (inverters, transformers)	Arc flash	- Incorrect procedure (i.e. installation/ maintenance) - Faulty equipment (e.g. corrosion on conductors) - Faulty design - Human error during maintenance - Insufficient isolation/insulation to applied voltage - Mechanical damage - Vibration	- Arc blasts and resulting heat, may result in fires and pressure waves - Burns - Exposure to intense light and noise - Injury and/or fatality to onsite employees Localised effects, the effects are not expected to have an off-site impact.	- Equipment and systems will be designed and tested to comply with relevant international and/or Australian standards (e.g. AS/NZS 5139) and guidelines - Warning signs (arc flash boundary) - Engagement of reputable contractors - Installation, operations and maintenance will be undertaken by trained personnel in accordance with relevant procedures - Independent owner's engineers' endorsement - Site induction and training (i.e. high voltage areas) - Maintenance procedure (e.g. de-energize equipment) - Preventative maintenance (insulation) - Electrical switch-in & switch-out protocol - Emergency Response Plan - External firefighting protocol (FRNSW & RFS) - Use of appropriate PPE for flash hazard within the arc flash boundary. Conductive items not worn while working on or near energised or live conductive parts (e.g. rings, jewellery).	Arc flash is an electrical explosion or discharge, which occurs between electrified conductors during a fault or short circuit condition, Ref [12]. Arc flash occurs when electrical current passes through the air between electrified conductors when there is insufficient isolation or insulation to withstand the applied voltage. Arc flash may result in rapid rise in temperature and pressure in the air between electrical conductors, causing an explosion known as an arc blast.	No

ID	Hazard	BESS component/ infrastructure	Event	Cause	Consequence	Controls	Other Comments	Significant off-site Impact?
3.	Fire	Battery modules BMS PCS (inverters, transformers)	BESS fire	- Faulty equipment - Arc flash - Mechanical damage or failure of battery case (e.g. overload, insulation breakdown, connection failures) - Battery thermal runaway (e.g. short circuit, overheating, overcharge) - External fire (e.g. Substation fire) - Bushfire (e.g. encroachment of off-site bushfire, escalated event due to fire from other project infrastructure)	- Release of toxic and/or explosive combustion products - Escalation to the entire BESS - Injury and/or fatality to onsite employees As the BESS will be situated in a rural area and there is a large separation distance to the nearest sensitive receptor, the effects are not expected to have an off-site impact.	- Equipment and systems will be designed and tested to comply with relevant international and/or Australian standards (e.g. AS/NZS 5139) and guidelines - Equipment will be procured from reputable supplier - Independent owner's engineers' endorsement - Installation, operations and maintenance by trained personnel in accordance with relevant procedures - All relevant TransGrid's requirements for the substation will be met - Circuit breakers provided for the substation - To minimise fire escalation between the BESS sub-units and onto other adjacent infrastructure, the BESS configurations will follow the specified clearances required by the manufacturer and/or applicable standards - Preventative maintenance (e.g. insulation, replacement of faulty equipment) - BESS BMS fault detection and shut-off function - BESS fire and explosion protection system (battery system specific features, refer to Table 2.1) - Activation of emergency shutdown - Fire Management Plan (e.g. establishing defendable fire-fighting boundary) - Emergency Response Plan - Inclusion of APZ buffer to minimise bushfire encroachment - External firefighting protocol (FRNSW & RFS)	-	No
4.	Fire	BESS substation TransGrid switching station (proposed upgrade works only)	Substation fire	- Faulty equipment - Transformer oil leak - Arc flash - Vandalism - External fire (e.g. fire escalation from adjacent BESS) - Bushfire	- Release of toxic combustion products - Escalation to adjacent infrastructure - Injury and/or fatality to onsite employees As the BESS substation and switching station will be situated in a rural area and there is a large separation distance to the nearest sensitive receptor, the effects are not expected to have an off-site impact.	- Equipment and systems will be designed and tested to comply with relevant international and/or Australian standards (e.g. AS/NZS 5139) and guidelines - Equipment will be procured from reputable supplier - Independent owner's engineers' endorsement - All relevant TransGrid requirements will be met - Installation, operations and maintenance by trained personnel in accordance with relevant procedures - To minimise fire escalation between the BESS sub-units and onto other adjacent infrastructure, the BESS configurations will follow the specified clearances required by the manufacturer and/or applicable standards - Preventative maintenance (e.g. insulation, replacement of faulty equipment) - Electrical switch-in & switch-out protocol - BESS fire and explosion protection system (battery system specific features, refer to Table 2.1) - Activation of emergency shutdown - Fire Management Plan - Emergency Response Plan - Inclusion of APZ buffer to minimise bushfire encroachment - External firefighting protocol (FRNSW & RFS)	-	No

ID	Hazard	BESS component/ infrastructure	Event	Cause	Consequence	Controls	Other Comments	Significant off-site Impact?
5.	Fire	BESS BESS substation Switching station	Bushfire	- Encroachment of off-site bushfire - Escalated event due to fire from other project infrastructure	- Escalation to adjacent infrastructure - Injury and/or fatality to onsite employees As the BESS, substation, and switching station will be situated in a rural area and there is a large separation distance to the nearest sensitive receptor, the effects are not expected to have an off-site impact.	- Fire Management Plan - Defendable boundary for firefighting will be established - Emergency Response Plan - External firefighting protocol (FRNSW & RFS) - Inclusion of APZ buffer to minimise bushfire encroachment - Use of appropriate PPE	-	No
6.	Chemical	Battery modules BMS Thermal management system	Release of electrolyte (liquid/vented gas) from the battery cell	<u>Mechanical failure/damage</u> - Dropped impact (e.g. during installation/ maintenance) - Damage (e.g. crush/ penetration/puncture) <u>Abnormal heating/elevated temperature</u> - Thermal runaway - Bushfire - External fire (e.g. Main Substation)	- Release of flammable liquid electrolyte - Vaporisation of liquid electrolyte - Release of vented gas from cells - Fire and/or explosion in battery enclosure - Release of toxic combustion products Injury and/or fatality to onsite employees As the BESS will be situated in a rural area and there is a large separation distance to the nearest sensitive receptor, the effects are not expected to have an off-site impact.	- Equipment and systems will be designed and tested to comply with relevant international and/or Australian standards (e.g. AS/NZS 5139) and guidelines - Equipment will be procured from reputable supplier - Independent owner's engineers' endorsement - Installation, operations and maintenance by trained personnel in accordance with relevant procedures - Each battery pack contains an integrated electrolyte sink, sized to capture all electrolyte contained within the battery pack in the event of substantial damage or pack rupture - To minimise fire escalation between the BESS sub-units and onto other adjacent infrastructure, the BESS configurations will follow the specified clearances required by the manufacturer and/or applicable standards - Venting and containment requirements of the BESS manufacturer and FRNSW to be followed - Battery modules are enclosed with external casing - Spill clean-up using dry absorbent material - BESS BMS fault detection and shut-off function - BESS fire and explosion protection system (battery system specific features, refer to Table 2.1) - Activation of emergency shutdown - Fire Management Plan - Emergency Response Plan - Inclusion of APZ buffer to minimise bushfire encroachment - External firefighting protocol (FRNSW & RFS)	Vented gases are early indicator of a thermal runaway reaction	No

ID	Hazard	BESS component/ infrastructure	Event	Cause	Consequence	Controls	Other Comments	Significant off-site Impact?
7.	Chemical	Battery modules BMS Thermal management system	BESS coolant or refrigerant leak	- Mechanical failure/damage - Incorrect maintenance	- Irritation/injury to onsite employee on exposure to leak (e.g. inhalation and skin contact) - Ingress of coolant or refrigerant to battery or other electrical components (battery enclosure) leading to short circuit, thermal runaway and fire/explosion, resulting in injury and/or fatality to onsite employees. As the BESS will be situated in a rural area and there is a large separation distance to the nearest sensitive receptor, the effects are not expected to have an off-site impact.	- Equipment and systems will be designed and tested to comply with relevant international and/or Australian standards (e.g. AS/NZS 5139) and guidelines - Equipment will be procured from reputable supplier - Independent owner's engineers' endorsement - Installation, operations and maintenance by trained personnel in accordance with relevant procedures - Each pack is designed to be water resistant (IP 65 rated) and will protect a leak inside the enclosure from entering a pack or cascading between packs - To minimise fire escalation between the BESS sub-units and onto other adjacent infrastructure, the BESS configurations will follow the specified clearances required by the manufacturer and/or applicable standards - BESS BMS fault detection and shut-off function - BESS fire and explosion protection system (battery system specific features, refer to Table 2.1) - Activation of emergency shutdown - Fire Management Plan - Emergency Response Plan - Inclusion of APZ buffer - External firefighting protocol (FRNSW & RFS)	The coolant is 50% ethylene glycol aqueous solution. The Heating Ventilation and Air Conditioning (HVAC) system contains 320 L of ethylene glycol coolant and 16 kg of R134a refrigerant. Ethylene glycol is not flammable but does pose a health risk when exposed to personnel in sufficient quantity. R134a can be flammable under certain circumstances and does pose a health risk when exposed to personnel in sufficient quantity.	No[6]
8.	Explosive Gas	Battery modules	Generation of explosive gas (e.g. hydrogen) <u>Note</u>: also refer to Item 6 (release of vented gas)	- Thermal runaway - Bushfire - External fire (e.g. substation fire, fire from adjacent infrastructure)	- Fire and/or explosion in battery enclosure - Release of toxic combustion products - Injury and/or fatality to onsite employees As the BESS will be situated in a rural area and there is a large separation distance to the nearest sensitive receptor, the effects are not expected to have an off-site impact.	- Equipment and systems will be designed and tested to comply with the relevant international and Australian standards (e.g. AS/NZS 5139) and guidelines - Equipment will be procured from reputable supplier - Independent owner's engineers' endorsement - Installation, operations and maintenance will be undertaken by trained personnel in accordance with relevant procedures - To minimise fire escalation between the BESS sub-units and onto other adjacent infrastructure, the BESS configurations will follow the specified clearances required by the manufacturer and/or applicable standards - Ventilation requirements as per manufacturer's instruction - BESS BMS fault detection and shut-off function - BESS fire and explosion protection system (battery system specific features, refer to Table 2.1) - Activation of emergency shutdown - Fire Management Plan - Emergency Response Plan - Inclusion of APZ buffer to minimise bushfire encroachment - External firefighting protocol (FRNSW & RFS)	-	No

[6] The Victorian Big Battery fire (30-Jul-21) was caused by a short circuit (a coolant leak from the cooling system leading to a fire in an electronic component) and subsequent overheating (thermal runaway). The fire involved 2 battery packs and was locally confined to the area. Energy Safe Victoria reported that the battery was offline and the monitoring and protection systems not being available, allowed the initial fault to go undetected. The SolBank safety systems will be equipped with an auxiliary backup power/UPS system that can provide power for up to 2 hours. This will ensure that the safety systems are still operating in the event of an outage.

ID	Hazard	BESS component/ infrastructure	Event	Cause	Consequence	Controls	Other Comments	Significant off-site Impact?
9.	Reaction	Battery modules	Thermal runaway in battery	<u>Elevated temperature</u> - Bushfire - External fire (e.g. Main Substation) <u>Electrical failure</u> - Short circuit - Excessive current/voltage - Imbalance charge across cells <u>Mechanical failure</u> - Internal cell defect - Damage (crush/ penetration/puncture) <u>Systems failure</u> - BMS failure - Thermal management system failure	- Fire and/or explosion in battery enclosure - Escalation to the entire BESS - Injury and/or fatality to onsite employees As the BESS will be situated in a rural area and there is a large separation distance to the nearest sensitive receptor, the effects are not expected to have an off-site impact.	- Equipment and systems will be designed and tested to comply with the relevant international and Australian standards (e.g. AS/NZS 5139) and guidelines - Equipment will be procured from reputable supplier - Independent owner's engineers' endorsement - Installation, operations and maintenance will be undertaken by trained personnel in accordance with relevant procedures - To minimise fire escalation between the BESS sub-units and onto other adjacent infrastructure, the BESS configurations will follow the specified clearances required by the manufacturer and/or applicable standards - BESS BMS temperature monitoring, fault detection and shut-off function - Cell chemistry selection - BESS fire and explosion protection system (battery system specific features, refer to Table 2.1) - Activation of emergency shutdown - Fire Management Plan - Emergency Response Plan - Inclusion of APZ buffer to minimise bushfire encroachment - External firefighting protocol (FRNSW & RFS)	Thermal runaway refers to a cycle in which excessive heat, initiated from inside/outside the battery cell, keeps generating more heat. Chemical reactions inside the cell in turn generate additional heat until there are no reactive agents left in the cell and eventually lead to destruction of the battery. Vented gases are early indicator of a thermal runaway reaction.	No
10.	EMF	BESS BESS substation Transmission line Switching station	Exposure to electric and magnetic fields	Operations of energy storage system and associated equipment	- High level exposure (i.e. exceeding the reference limits) may affect function of the nervous system (i.e. direct stimulation of nerve and muscle tissue and the induction of retinal phosphenes) - Injury to onsite employees EMF created from the BESS will not exceed the ICNIRP reference level for exposure to the general public. Additionally, the strengths of electric and magnetic fields attenuate rapidly away from the source. As the BESS will be situated in a rural area and there is a large separation distance to the nearest residential dwelling, the effects are not expected to have an off-site impact.	- Location siting and selection (i.e. separation distance to sensitive receptors) - Optimising equipment layout and orientation - Reducing conductor spacing - Balancing phases and minimising residual current - Incidental shielding (i.e. BESS enclosure) - Equipment and systems will be designed and tested to comply with international standards and guidelines - Exposure to personnel is short duration in nature (transient) - Warning signs - Studies found that the EMF for commercial power generation facilities comply with ICNIRP occupational exposure limits	Adverse health effects from EMF have not been established based on findings of science reviews conducted by credible authorities, Ref [13]. No established evidence that Extremely Low Frequency (ELF) EMF is associated with long term health effects (ARPANSA) , Ref [14].	No

ID	Hazard	BESS component/ infrastructure	Event	Cause	Consequence	Controls	Other Comments	Significant off-site Impact?
11.	External factors	BESS BESS substation Switching station	Water ingress	- Rain - Flood	- Electrical fault/short circuit - Fire and/or explosion in battery enclosure - Injury and/or fatality to onsite employees As the BESS will be situated in a rural area and there is a large separation distance to the nearest sensitive receptor, the effects are not expected to have an off-site impact.	- Location siting (i.e. outside of flood prone area) - The SolBank battery system enclosure is IP 55 rated suitable for outdoor use - Substation and switchroom will be housed in a dedicated building and constructed in accordance with relevant standards - Drainage system - Preventative maintenance (check for leaks) - To minimise fire escalation between the BESS sub-units and onto other adjacent infrastructure, the BESS configurations will follow the specified clearances required by the manufacturer and/or applicable standards - BESS BMS fault detection and shut-off function - BESS fire and explosion protection system (battery system specific features, refer to Table 2.1) - Activation of emergency shutdown - Fire Management Plan - Emergency Response Plan - Inclusion of APZ buffer - External firefighting protocol (FRNSW & RFS)	-	No
12.	External factors	BESS BESS substation Switching station	Vandalism	- Unauthorised personnel access - Trespassing - Deliberate damage to BESS infrastructure Asset damage	- Asset damage - BESS failure/fire - Potential hazard to unauthorised person (e.g. electrocution) - Injury and/or fatality to trespasser Effects to unauthorised person are expected to be localised and not expected to have an off-site impact. The impact is to a member of public but occurs onsite. For a fire event, the effects are not expected to have an off-site impact as the BESS will be situated in a rural area and there is a large separation distance to the nearest sensitive receptor.	- The BESS will be located in a rural location - The BESS will be located within a secure area and will be fenced - Warning signs (i.e. trespassers and on-site hazards) - Security cameras will be provided at the substation and at the BESS compound.	-	No

ID	Hazard	BESS component/ infrastructure	Event	Cause	Consequence	Controls	Other Comments	Significant off-site Impact?
13.	External factors	BESS BESS substation Switching station	Lightning strike	Lightning storm	- Fire - Injury and/or fatality to onsite employees As the BESS will be situated in a rural area and there is a large separation distance to the nearest sensitive receptor, the effects are not expected to have an off-site impact.	- Lightning protection mast and surge protection devices - Earthing as per manufacturer and standards requirements - Activation of emergency shutdown - To minimise fire escalation between the BESS sub-units and onto other adjacent infrastructure, the BESS configurations will follow the specified clearances required by the manufacturer and/or applicable standards - Fire Management Plan - Emergency Response Plan - Inclusion of APZ buffer - External firefighting protocol (FRNSW & RFS)	-	No

6. ELECTRIC AND MAGNETIC FIELDS

6.1. Overview

EMF are naturally present in the environment. They are present in the earth's atmosphere as electric fields, while static magnetic fields are created by the earth's core. EMF are also produced wherever electricity or electrical equipment is in use (e.g. household appliances, powerlines), Ref [15].

Electric fields are created where there is flow of electricity. Electric fields are related to and directly proportional to voltage (i.e. higher the voltage higher the electric field). Electric fields are often described in terms of their strength and commonly expressed in volts per metre (V/m) or kilovolts per metre (kV/m).

Magnetic fields are created whenever electric current flows. Magnetic fields are directly proportional to the current (i.e. higher the current higher the magnetic field). Magnetic fields are often described in terms of their flux density and commonly measured in either Tesla (T) or Gauss (G).

Electric and magnetic fields are strongest closest to source and their strength attenuates rapidly away from the source. The strength of electric fields is weakened due to shielding effect from common materials (i.e. buildings, walls), whereas magnetic fields are not.

Use of electricity means that people are exposed to EMF as part of daily life. The background electric and magnetic fields in a typical home is around 20 V/m and 0.1 µT, respectively. These may vary depending on the number and type of appliances, configuration and positioning and distances to the other sources (e.g. powerlines). Typical EMF strengths for common household electrical appliances (at distance of 30 cm) are shown in Table 6.1, Ref [16].

EMF associated with the generation, distribution and use of electricity power systems in Australia which have a frequency of 50 Hertz (Hz) are classified by Energy Networks Australia[7] as Extremely Low Frequency[8] (ELF) EMF, Ref [15].

Table 6.1: Typical EMF strengths for household appliances

Electric appliance	Electric field strength (V/m)	Magnetic field density (µT)
Refrigerator	120	0.01 – 0.25
Iron	120	0.12 – 0.3
Hair dryer	80	0.01 – 7
Television	60	0.04 – 2
Vacuum cleaner	50	2 – 20
Electric oven	8	0.15 – 0.5

[7] Energy Networks Association is the peak national body representing gas distribution and electricity transmission and distribution businesses throughout Australia.
[8] ELF EMF occupy the lower part of the electromagnetic spectrum in the frequency range 0-3000 Hz.

6.2. Effects of exposure to EMF

6.2.1. Acute effect

Studies have been conducted to determine the effects of EMF exposure. There have been a number of well-established acute effects on the nervous system due to exposure to high levels of EMF. These include direct stimulation of the nerve and muscle tissue, and induction of retinal phosphene (i.e. sensation of ring or spot of light on eye ball). However, it should be noted that exposure to high levels of EMF is not normally found in everyday environment from electrical sources. There is also indirect scientific evidence that EMF can transiently affect visual processing and motor coordination. For certain occupational instances, the ICNIRP considered that with appropriate training, it is reasonable for workers to voluntarily experience transient effects such as retinal phosphene and minor changes in brain function since these are not believed to result in long term or pathological health effects, Ref [17].

6.2.2. Chronic effect

Numerous studies have been conducted to understand the effects of long-term exposure to EMF. Some studies have linked prolonged exposure to EMF to increased rates of childhood leukemia. Based largely on limited evidence, the International Agency for Research on Cancer has classified ELF magnetic fields as 'possibly carcinogenic to humans'. The ICNIRP views that the current existing scientific evidence is too weak to ascertain a causal relationship that prolonged exposure to ELF magnetic fields is related with increased risk of childhood leukemia, Ref [17].

6.2.3. Advice from public authority

The Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) is a federal government agency assigned with the responsibility for protecting the health and safety of people and the environment from EMF.

ARPANSA advises that:

- *"The scientific evidence does not establish that exposure to ELF EMF found around the home, the office or near powerlines and other electrical sources is a hazard to human health."*, Ref [14].
- *"There is no established evidence that ELF EMF is associated with long term health effects. There is some epidemiological research indicating an association between prolonged exposure to higher-than-normal ELF magnetic fields (which can be associated with residential proximity to transmission lines or other electrical supply infrastructure, or by unusual domestic electrical wiring), and increased rates of childhood leukaemia. However, the epidemiological evidence is weakened by various methodological problems such as potential selection bias and confounding. Furthermore this association is not supported by laboratory or animal studies and no credible theoretical mechanism has been proposed."*, Ref [18].

6.3. Study approach

Although the adverse health impacts have not been established, the possibility of impact due to exposure to EMF cannot be ruled out. As part of a precautionary approach, the study will assess the typical exposure levels to EMF for the proposed project infrastructure.

A task group assembled by the World Health Organisation to assess any potential health risks from exposure to ELF EMF in the frequency range of 0 to 100,000 Hz found that there are no substantive health issues related to ELF electric fields at levels generally encountered by the general public, Ref [19]. Therefore, the information presented in the following sections address predominantly the effects of exposure to ELF magnetic fields.

6.4. Guidelines for limiting EMF exposure

The ICNIRP has produced a publication to establish guidelines for limiting EMF exposure to assist in providing protection against adverse health effects. Separate guidance is given for general public and occupational exposure within the guideline.

The guideline has defined general public and occupational exposures as follows:

- General public – individuals of all ages and of varying health status which might increase the variability of the individual susceptibilities.
- Occupational exposure – adults exposed to time-varying EMF from 1 Hz to 10 MHz at their workplaces, generally under known conditions, and as a result of performing their regular or assigned job.

The ICNIRP reference levels for exposure to EMF at 50 Hz is presented in Table 6.2, Ref [17]. The guideline adopted more stringent exposure restrictions compared to occupational exposures recognising that in many cases the general public are unaware of their exposure to EMF.

Table 6.2: Reference levels for EMF levels at 50 Hz

Exposure	ICNIRP Reference Levels	
	Electric field (V/m)	Magnetic field (μT)
General public	5,000	200
Occupational	10,000	1,000

6.5. BESS and grid connection infrastructure EMF

6.5.1. BESS

The magnetic field associated with a BESS will vary depending on a number of factors including configuration, capacity and type of housing. Due to the limited information on typical measurement of magnetic fields around BESS, the study has assumed the typical magnetic field is not too dissimilar with that of a substation. The study also assumed that

the BESS will be designed in accordance with electrical safety standards and codes which will result in exclusion of general public exposures from these sources.

6.5.2. PCS

A field study was undertaken to characterise the EMF between the frequencies of 0-3 GHz at two large scale solar facilities operated by the Southern California Edison Company in Porterville and San Bernardino, Ref [20].

The field study findings were adopted to estimate the EMF measurements for the project's infrastructures. The findings are as follows:

- The highest DC magnetic fields were measured adjacent to the inverter (277 µT) and transformer (258 µT). These fields were lower than the ICNIRP's occupational exposure limit.
- The highest AC magnetic fields were measured adjacent to the inverter (110 µT) and transformer (177 µT). These fields were lower than the ICNIRP's occupational exposure limit.
- The strength of the magnetic field attenuated rapidly with distance (i.e. within 2-3 m away, the fields drop to background levels).
- Electric fields were negligible to non-detectable. This is mostly likely attributed to the enclosures provided for the electricity generating equipment.

6.5.3. Substation and switching station

The main sources of magnetic fields within a large substation (e.g. transmission substation) include transformer secondary terminations, cable runs to the switch room, capacitors, reactors, bus-bars, and incoming and outgoing feeders. For the majority of cases, the highest magnetic fields at the boundary come from the incoming and outgoing transmission lines.

Generally, the application of electrical safety standards and codes (e.g. fence, enclosure, distance) will result in exclusion of general public exposures from these sources. This is consistent with the measurement of typical magnetic field reported which ranges between 1-8 µT at substation fence, Ref [21].

6.5.4. Transmission lines

The magnetic field from transmission lines will vary with configuration, phasing and load. The typical magnetic fields near overhead transmission lines measured at one metre above ground level range between 1-20 µT (directly underneath) and 0.2-5 µT (at the edge of easement), Ref [21].

6.6. Controls to limit exposure to EMF

The following controls were identified to limit exposure to EMF:

- The design, selection and procurement of electrical equipment for the project will comply with relevant international and Australian standards.
- Location selection for the project infrastructure (i.e. accounts for separation distance to surrounding land uses including neighbouring properties and agricultural operations) and fencing within the project boundary will assist to limit the exposure to EMF for the general public.
- Exposure to EMF (specifically magnetic fields) from electrical equipment will be localised and the strength of the field attenuates rapidly with distance.
- Duration of exposure to EMF for personnel onsite will be transient.

6.7. Conclusion

Based on the review completed in the preceding sections, the study concludes that:

- EMF created from the project will not exceed the ICNIRP occupational exposure reference level.
- As the strengths of EMF attenuate rapidly with distance, the study determined that the ICNIRP reference level for exposure to the general public will not be exceeded and impact to the general public in surrounding land uses will be negligible.
- For the risk assessment, consequence from exposure to EMF was assumed to result in no or minor injury ('Insignificant') in reference to the consequence impact rating shown in Table 9.2.

7. BESS SEPARATION DISTANCES

7.1. Overview

As per the project SEARs, the PHA also includes a requirement to '*consider all recent standards and codes* and *verify separation distances to onsite and off-site receptors to prevent fire propagation'*. Based on clarification with the DPE, this additional requirement (to that of a conventional PHA) is intended to ensure that fire risks from the BESS[9] have been considered in designing the project.

Specifically, the proponent must demonstrate that the proposed BESS capacity would be able to fit within the land area designated for the BESS accounting for separation distances between the:

- BESS sub-units (racks, modules, enclosures, etc.), to ensure that a fire from a sub-unit do not propagate to neighbouring sub-units; and
- The overall BESS and other onsite or off-site receptors.

This section covers the following:

1. Review of separation distances/clearances provided between the BESS sub-units against applicable codes and standards and manufacturer specification.
2. Verification that the required land area for the proposed BESS capacity would fit within the land area designated for the BESS.
3. Review of separation distances between the BESS and onsite and off-site receptors.

7.2. Separation distances between BESS sub-units

7.2.1. NFPA 855

The National Fire Protection Agency (NFPA) 855 *Standard for the Installation of Stationary Energy Storage Systems* is widely viewed as the most comprehensive set of best practice guide in the industry. A review of NFPA 855 was undertaken to determine the required separation distances between the BESS units, Ref [22].

NFPA 855 specifies the default maximum allowable energy storage unit at 50 kWh (and 600 kWh for the overall BESS installation) and minimum separation of 914 mm between units and walls (for indoor installations). However, NFPA 855 also specifies that the BESS may be installed in units with larger energy capacities or smaller separation if they meet the fire and explosion testing in accordance with UL 9540A *Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems*, or equivalent test standard. As such, the results of the UL 9540A test (performed with clearances as specified by the BESS manufacturer) form a key parameter to determine clearances.

[9] Applicable for projects that include a BESS exceeding a peak delivery capacity of 30 MW.

The UL 9540A testing is a destructive test method used for evaluating the thermal runaway impacts in a BESS and gathering data to assist in assessing or developing mitigation measures for the failure event, propagation of the failure, or consequences of an event, such as an explosion or fire. It is currently considered to be the most appropriate published methodology to provide comprehensive, consistent, and reliable data for battery failure testing.

Tests to the 4th edition of UL 9540A have been carried out for the SolBank battery system at the cell, module and unit/enclosure levels. The test reports have been reviewed by DNV as part of its technical due diligence report for the SolBank battery system, Ref [11]. The test results at the unit/enclosure level (SolBank S1K51K3A01) indicate that:

- While cell-to-cell propagation occurred during the test, module-to-module propagation was not observed indicating an adequate thermal barrier between modules.
- The Unit level results show a resiliency of the Unit to thermal runaway propagation and fire hazard in a single failure event.

7.2.2. Manufacturer specified clearances

Sherpa has reviewed the SolBank installation manual, Ref [2], which specifies the minimum equipment clearances and setbacks for maintenance, ventilation, and fire propagation prevention. The manufacturer specified clearances for the battery systems are summarised in Table 7.1, and shown in Figure 7.1.

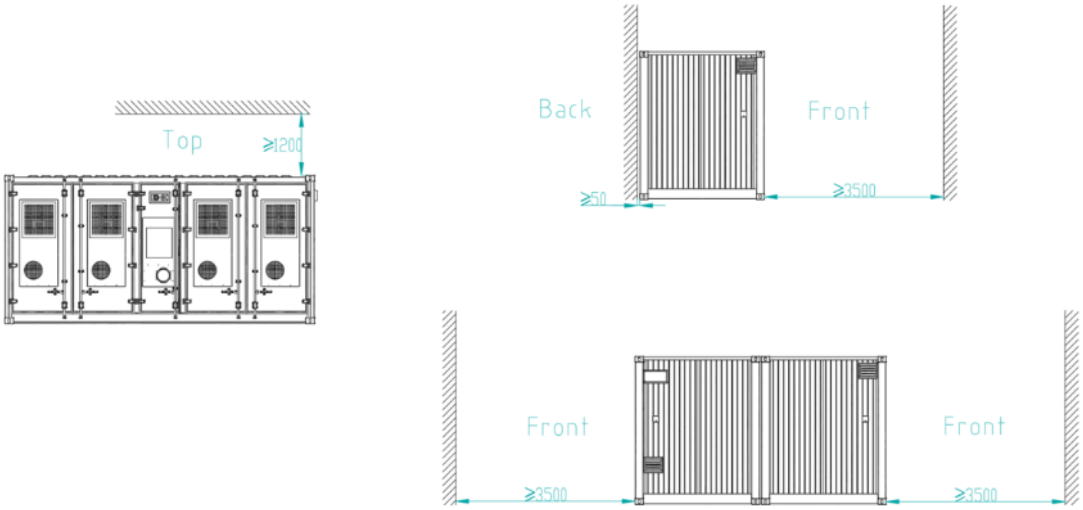
An indicative configuration of the SolBank batteries, inverters, transformers and ring main unit is provided in Figure 7.2. Three SolBank units will connect to an inverter, a transformer, and a ring main unit. Upon review of the clearances between the BESS sub-units, Sherpa found that the indicative configuration meets the specified clearances.

Table 7.1: BESS manufacturer specified clearances

Installation	Clearances
Back-to-back installation	• Recommended gap of 100 mm between SolBanks. • The front of the SolBank housing the access door must always have a clear 3500 mm to ensure sufficient space for door swing, replacement of battery packs and movement of equipment and personnel.
Side-to-side installation	• Minimum clearance of over 1500 mm between SolBanks to accommodate emergency stop buttons and maintenance and operating procedures.
Above the enclosure	• A minimum of 1200 mm is required to ensure sufficient space for lifting and positioning.

Figure 7.1: CSI SolBank specified clearances

(a) Clearances – Top, front, back-to-back installation



(b) Clearances – Front, side to side, back-to-back installations

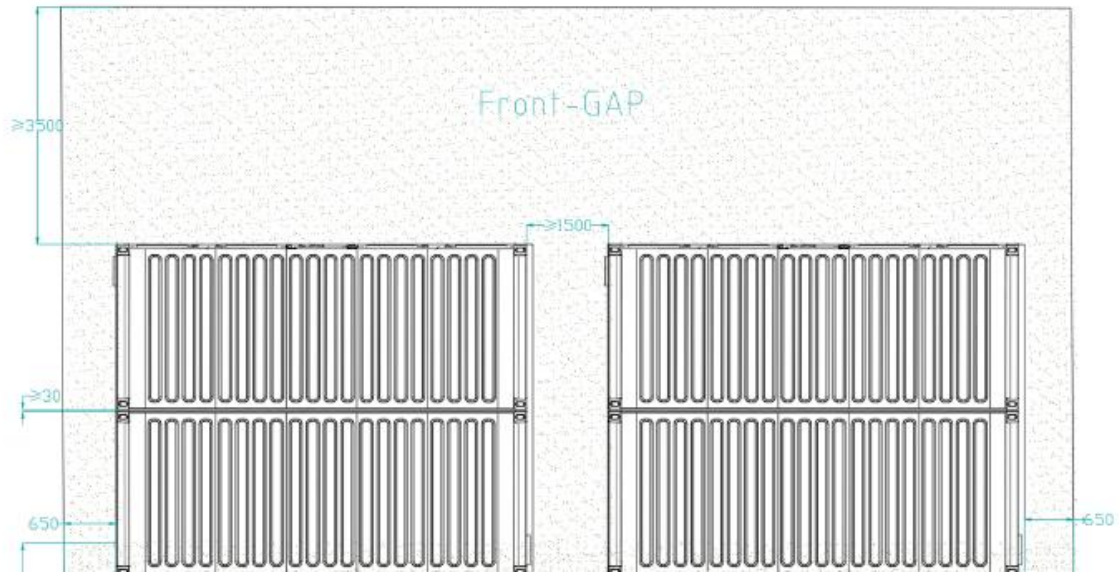
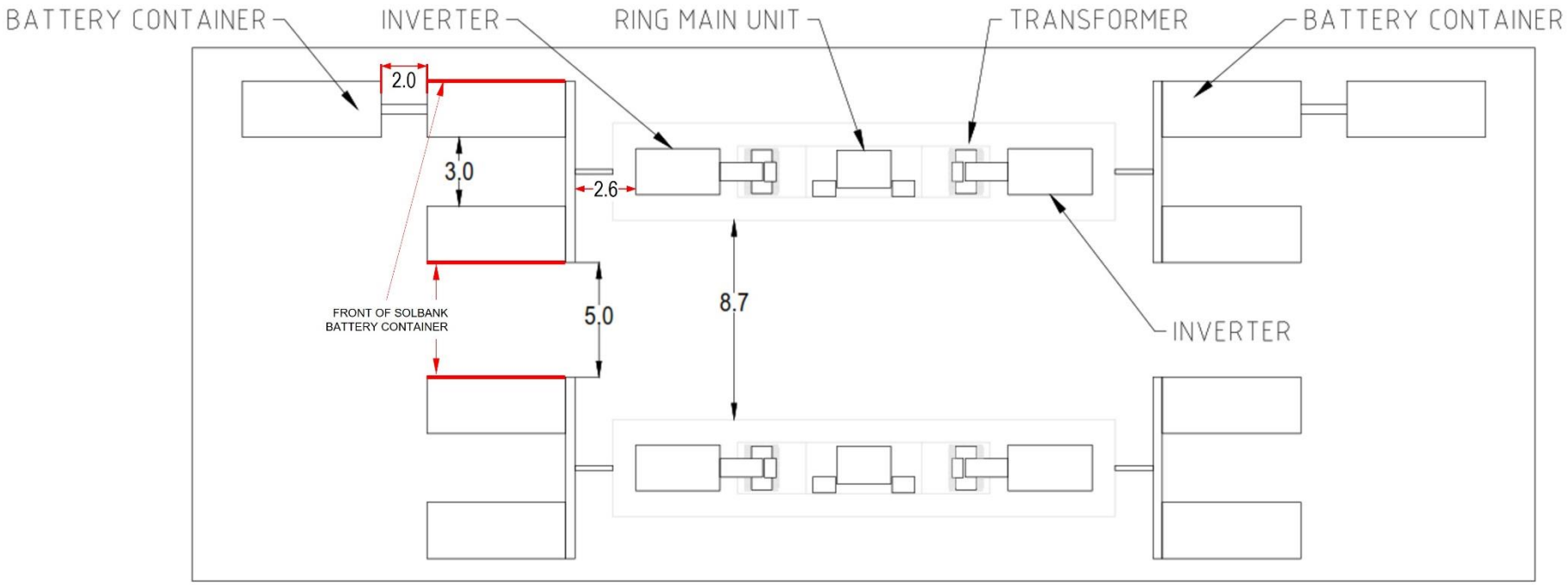


Figure 7.2: Indicative BESS configuration and clearances between units

Note: Measurements based on preliminary drawing 07_BHRP_DEV_ENG_V00_DRW_001 Rev C



7.3. Land area designated for the BESS

Within the 'BESS compound' footprint (shown in Figure 2.2), two BESS operating units will be established (2 x 204 MW/408 MWh) where the battery units, PCS, O&M buildings and fire water tanks will be located. At the time of this study, the layouts of the BESS compounds have not been finalised. Detailed layout configuration will be informed by technical assessments performed during the detailed design stage of the project. In this PHA, verification of whether the required land area for the BESS would fit within the designated land area was performed by comparing the required area against the 'BESS compound' area (expressed in % coverage).

The area allocated for the 'BESS compound' is approximately 15 ha. The area required for a 6-SolBank arrangement (refer to indicative configuration shown in Figure 7.2) is approximately 0.07 ha (700 m^2), inclusive of the separation distances. To provide the required capacity, approximately 360 SolBanks will be installed. This will require an area of 4.2 ha, approximately 28% of the area allowed for the 'BESS compound'.

The designated land area is determined to be sufficient to accommodate the proposed BESS units, including the manufacturer specified clearances shown in Table 7.1 (refer to Section 7.2.2).

7.4. Onsite receptors

The BESS will be located within the 'BESS compound' footprint. The closest onsite receptor to the BESS will be the O&M building which will be located within the BESS compound. At the time of this study, the layouts of the BESS compounds have not been finalised. These will be developed during detailed design which will be conducted post project approval.

Other project infrastructures include the (1) BESS substation and (2) the switching station. The separation distance from the 'BESS compound' boundary to these infrastructures is approximately 60 m, as shown in Figure 7.3.

7.5. Off-site receptors

For the PHA, the non-associated residential dwellings or occupied areas are considered as sensitive receptors for determination of off-site impact. The nearest township to the proposed BESS is Gulgong, located approximately 6.5 km south-east.

For fire events involving the BESS, the separation distances from the 'BESS compound' boundary to the non-associated residential dwellings were used to determine off-site impact. This is conservative as the BESS compounds layouts or configuration have not yet been determined.

A review of the separation distances to off-site receptors is shown in Figure 7.4. The separation distance to the nearest sensitive receptor (R5) is 1,210 m from the proposed BESS.

7.6. Review findings

The review of BESS separation distances found that:

- The indicative configuration (battery units, PCS, ring main unit) included clearances between the sub-units that would meet the minimum or recommended clearances specified by the battery manufacturer. Additionally, the proposed battery system has been tested to UL 9540A and the results indicate that:
  - Module-to-module propagation was not observed, and
  - Unit level results show a resiliency to thermal runaway propagation and fire hazard in a single failure event.
- The designated land area can accommodate the proposed BESS units to meet the proposed capacity.
- The closest sensitive receptor is approximately 1,210 m (R5) from the proposed BESS. No off-site impact is expected as the BESS will be situated in a rural area and there is a large separation distance to the nearest sensitive receptor.

Figure 7.3: Separation distance to onsite receptors

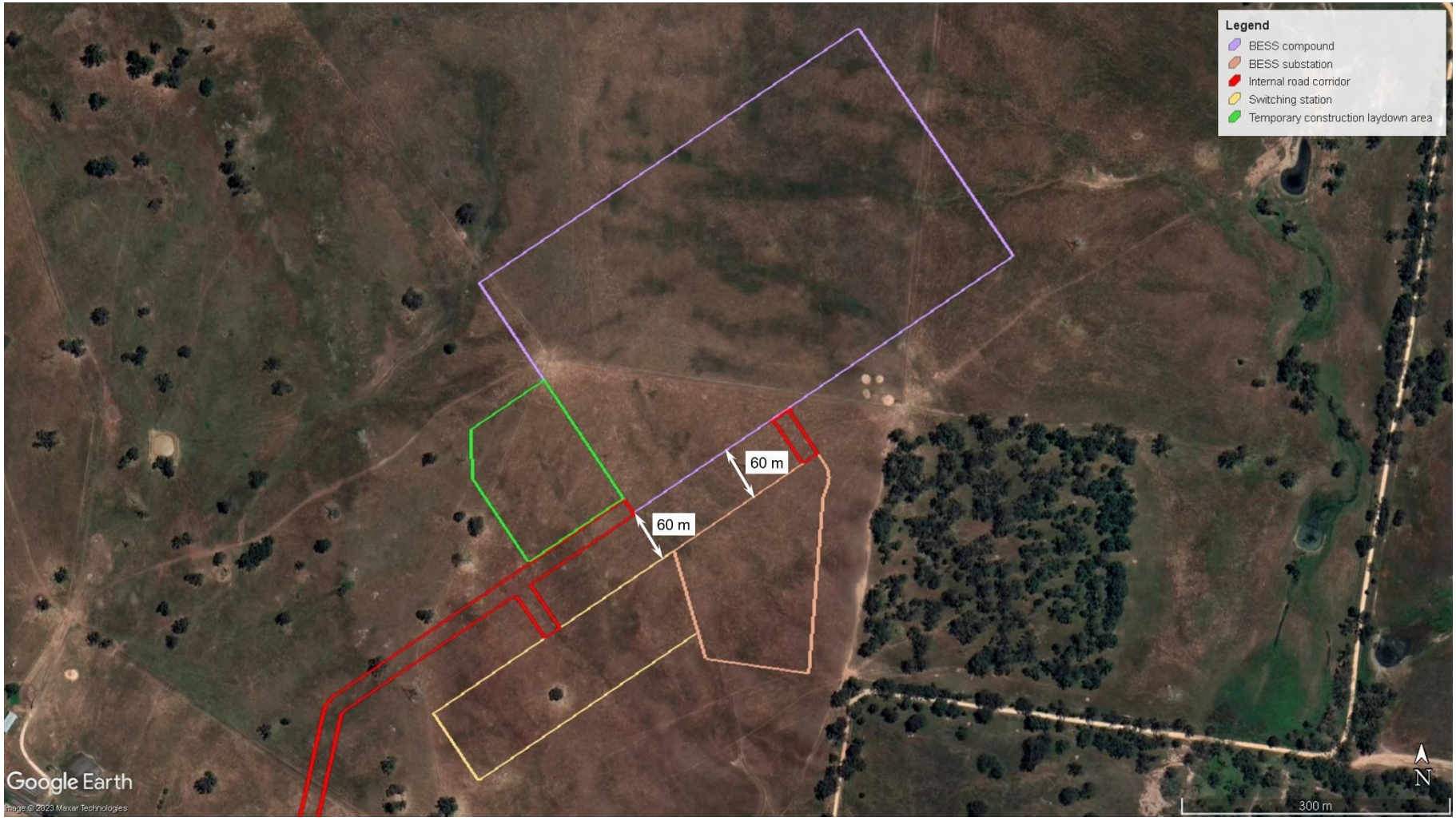


Figure 7.4: Separation distance to off-site receptors



8. LEVEL OF ANALYSIS DETERMINATION

8.1. Level of analysis

The HAZID found that for all identified events the resulting consequences are not expected to have significant off-site impacts (serious injury and/or fatality to the public or off-site population), based on the following considerations:

- The project will be situated in a rural area.
- The nearest non-associated sensitive receptor is located approximately 1,210 m from the 'BESS compound' boundary (R5; refer to Figure 7.4).

Additionally, the identified events are expected to present negligible societal risk impact as:

- The project will be situated in a rural area with the scattered residential dwellings. The nearest non-associated sensitive receptor is approximately 1,210 m from the 'BESS compound' boundary (R5).
- The nearest township is Gulgong, located approximately 6.5 km south-east of the project.

Based on the above findings and the *Multi-Level Risk Assessment* guideline, Ref [7], and guidance to determine the required level of analysis for the PHA (Table 4.1), a fully qualitative approach (i.e. Level 1 analysis) was determined appropriate for this study. The risk analysis is presented in Section 9.

8.2. Qualitative risk criteria

The HIPAP No. 4 *Risk Criteria for Land Use Safety Planning*, Ref [8], recommends a set of qualitative criteria/principles be adopted concerning the land use safety acceptability of a development.

The risk assessment against HIPAP No. 4 criteria is provided in Section 10.

9. RISK ANALYSIS

9.1. Overview

In this study, risk is defined as the likelihood of a specified undesired event occurring within a specified period or in specified circumstances. It may be either a frequency (the number of specified events occurring in a unit of time) or a probability (the probability of a specified event following a prior event) depending on the circumstances.

For each identified event, the risk to off-site population was qualitatively determined from the resulting severity and likelihood rating pair using the risk matrix shown in Table 9.1. In the absence of a suitable company risk matrix, the risk matrix provided in AS/NZS 5139 was used for the study. In line with AS/NZS 5139, events with risks greater than 'Low' should be discussed with the system owner and operator and anyone involved in the installation of the system.

For this study, the acceptance criteria used to assess the risk for off-site population are as follows:

- High and Extreme – Unlikely to be tolerable; review if activity should proceed.
- Medium – Tolerable, if So Far As Reasonably Practicable.
- Very Low and Low – Broadly acceptable.

Table 9.1: Risk matrix

Consequence	Likelihood				
	Rare	Unlikely	Possible	Likely	Almost Certain
Catastrophic	Medium	High	High	Extreme	Extreme
Major	Medium	Medium	High	High	Extreme
Moderate	Low	Medium	Medium	High	High
Minor	Very Low	Low	Medium	Medium	Medium
Insignificant	Very Low	Very Low	Low	Medium	Medium

9.2. Severity rating

For each event, the severity rating was qualitatively assigned based on the consequence description identified in the HAZID register using the category scale shown in Table 9.2 which was reproduced from AS/NZS 5139.

For this study, the severity scale was used to assess impact for off-site population. For example, an event with consequence outcome identified as 'localised effects' or 'effects are not expected to have an off-site impact' was assigned an 'Insignificant' rating to indicate minimal impact to off-site population.

Table 9.2: Consequence rating

Consequence rating	Rating definition
Catastrophic	Any fatality of staff, contractor or public
Major	Non-recoverable occupational illness or permanent injury Injury or illness requiring admission to hospital
Moderate	Injury or illness requiring medical treatment by a doctor Dangerous/reportable electrical incident
Minor	Injury requiring first aid Circumstances that lead to a near miss
Insignificant	No or minor injury

9.3. Likelihood rating

The likelihood of an event was estimated using the category scale shown in Table 9.3 which was reproduced from AS/NZS 5139.

Table 9.3: Likelihood rating

Likelihood rating	Rating definition
Almost certain	Probability of occurrence: greater than 90%
	Expected to occur whenever system is accessed or operated
	The event is expected to occur in most circumstances
Likely	Probability of occurrence: 60% - 89%
	Expected to occur when system is accessed or operated under typical circumstances
	There is a strong possibility the event may occur
Possible	Probability of occurrence: 40% - 59%
	Expected to occur in unusual instances when the system is access or operated
	The event may occur at some time
Unlikely	Probability of occurrence: 20% - 39%
	Expected to occur in unusual instanced for non-standard access or non-standard operation
	Not expected to occur, but there is a slight possibility it may occur at some time
Rare	Probability of occurrence: 1% - 19%
	Highly unlikely to occur in any instance related to coming in contact with the system or associated systems
	Highly unlikely, but it may occur in exceptional circumstances, but probably never will

The likelihood ratings were assigned based on knowledge of historical incidents in the industry and in consultation with VEA. The likelihood ratings were assigned accounting for the initiating causes, resulting consequences with controls (prevention and mitigation) in place.

9.4. Risk results and analysis findings

The qualitative risk results for the identified events are shown in Table 9.4.

The risk analysis findings are as follows:

- **Consequence**: The worst-case consequence for the identified events is a BESS fire and/or explosion event which may result from causes such as battery thermal runaway, encroachment from off-site bushfire or a substation fire. The study found that for all events, the impacts are not expected to have significant off-site impacts. This was assessed based on the location of the proposed BESS (i.e. rural area) and separation distance between the BESS and sensitive receptors (i.e. non-associated residential dwellings).
- **Likelihood**: The highest likelihood rating for the identified events is 'Unlikely' (i.e. not expected to occur, but there is a slight possibility it may occur at some time).
- **Risk analysis**: A total of 13 hazardous events were identified. The breakdown of these events according to their risk ratings are as follows:
  - 'Medium' risk event: 1

    This event relates to unauthorised person access to the proposed BESS footprint resulting in vandalism/asset damage to the infrastructure, with no significant off-site impact expected. Severity rating of 'Major' was assigned to account for the trespasser potentially injuring themselves in the act.

    The PHA noted that the controls for this event are well understood and will be implemented accordingly. In addition to the rural location of the site, it is anticipated that security fencing, cameras and warning signs will be provided. These measures are expected to significantly reduce the likelihood of this event. The likelihood rating for this event was rated as 'Unlikely'.
  - 'Very Low' risk events: 12

    Most of these events relate to fire and/or explosion events, with no significant off-site impact expected (i.e. more likely to affect onsite employees). The study identified proposed prevention controls to reduce the likelihood of these fire events and mitigation controls to contain the fires to minimise potential for escalated events (e.g. fire management plan). Based on the identified controls, the highest likelihood for these events were rated as 'Unlikely'.

Table 9.4: Risk results

Hazard	Event	Consequence	Off-site consequence	Significant off-site impact?	Risk analysis (off-site and public impact)		
					Severity	Likelihood	Risk
Electrical	Exposure to voltage	- Electrocution - Injury and/or fatality to onsite employees - Injury and/or fatality to member of public due to touch and step potential	No off-site impact expected as the BESS will be situated in a rural area and there is a large separation distance to the nearest sensitive receptor.	No	Insignificant	Unlikely	Very Low
Energy	Arc flash	- Arc blasts and resulting heat, may result in fires and pressure waves - Burns - Exposure to intense light and noise - Injury and/or fatality to onsite employees	Localised effects, the effects are not expected to have an off-site impact.	No	Insignificant	Unlikely	Very Low
Fire	BESS compound fire	- Release of toxic and/or explosive combustion products - Escalation to the entire BESS - Escalation to adjacent infrastructure - Injury and/or fatality to onsite employees	No off-site impact expected as the BESS will be situated in a rural area and there is a large separation distance to the nearest sensitive receptor.	No	Insignificant	Unlikely	Very Low
	BESS substation fire						
	Bushfire						
Chemical	Release of battery electrolyte (liquid/vented gas) from the battery cell	- Release of flammable liquid electrolyte - Vaporisation of liquid electrolyte - Release of vented gas from cells - Fire and/or explosion in battery enclosure - Release of toxic combustion products - Injury and/or fatality to onsite employees	No off-site impact expected as the BESS will be situated in a rural area and there is a large separation distance to the nearest sensitive receptor.	No	Insignificant	Unlikely	Very Low
	BESS coolant or refrigerant leak	- Irritation/injury to onsite employee on exposure to leak (e.g. inhalation and skin contact) - Ingress of coolant or refrigerant to battery or other electrical components (battery enclosure) leading to short circuit and fire, resulting in injury and/or fatality to onsite employees	No off-site impact expected as the BESS will be situated in a rural area and there is a large separation distance to the nearest sensitive receptor.	No	Insignificant	Unlikely	Very Low
Explosive gas	Generation of explosive gas	- Fire and/or explosion in battery enclosure - Release of toxic combustion products - Injury and/or fatality to onsite employees	No off-site impact expected as the BESS will be situated in a rural area and there is a large separation distance to the nearest sensitive receptor.	No	Insignificant	Unlikely	Very Low

Hazard	Event	Consequence	Off-site consequence	Significant off-site impact?	Risk analysis (off-site and public impact)		
					Severity	Likelihood	Risk
Reaction	Thermal runaway in battery	- Fire and/or explosion in battery enclosure - Escalation to the entire BESS - Injury and/or fatality to onsite employees	No off-site impact expected as the BESS will be situated in a rural area and there is a large separation distance to the nearest sensitive receptor.	No	Insignificant	Unlikely	Very Low
EMF	Exposure to EMF	- High level exposure (i.e. exceeding the reference limits) may affect function of the nervous system (i.e. direct stimulation of nerve and muscle tissue and the induction of retinal phosphenes) - Injury to onsite employees	EMF created from the project will not exceed the ICNIRP reference level for exposure to the general public. No off-site impact expected as the BESS will be situated in a rural area and there is a large separation distance to the nearest sensitive receptor.	No	Insignificant	Rare	Very Low
External factors	Water ingress (e.g. rain, flood)	- Electrical fault/short circuit - Fire and/or explosion in battery enclosure - Injury and/or fatality to onsite employees	No off-site impact expected as the BESS will be situated in a rural area and there is a large separation distance to the nearest sensitive receptor.	No	Insignificant	Unlikely	Very Low
	Vandalism due to unauthorised personnel access and deliberate damage to the BESS	- Asset damage - BESS failure/fire - Potential hazard to unauthorised person (e.g. electrocution) - Injury and/or fatality to trespasser	Effects to unauthorised person are expected to be localised and not expected to have an off-site impact. The impact is to a member of public but occurs onsite. For a fire event, the effects are not expected to have an off-site impact as the BESS will be situated in a rural area and there is a large separation distance to the nearest sensitive receptor.	No	Major	Unlikely	Medium
	Lightning strike	- Fire - Injury and/or fatality to onsite employees	No off-site impact expected as the BESS will be situated in a rural area and there is a large separation distance to the nearest sensitive receptor.	No	Insignificant	Unlikely	Very Low

10. RISK ASSESSMENT

10.1. Assessment against company risk acceptance criteria

Using the study risk matrix referenced from AS/NZS 5139, the identified hazardous events were qualitatively risk profiled. Of the 13 events identified, all were rated as 'Very Low' risks except for one 'Medium' risk event. This event is related to unauthorised person access to the proposed BESS footprint, resulting in vandalism/asset damage to the infrastructure with the potential for self-injury during the act. The PHA noted that the controls for this event are well understood and will be implemented accordingly. In addition to the rural location of the site, the proposed BESS will be located in a secure area with fencing and warning signs will be provided. These measures are expected to significantly reduce the likelihood of this event. The likelihood rating for this event was rated as 'Unlikely'.

All identified events are not expected to have significant off-site impacts. Based on the study risk acceptance criteria, the risk profile for the proposed BESS is considered to be tolerable.

10.2. Assessment against HIPAP No. 4 criteria

Assessment against the HIPAP No. 4 qualitative land use planning risk criteria is provided in Table 10.1.

Table 10.1: Assessment against HIPAP No. 4 qualitative risk criteria

HIPAP 4 qualitative criteria	Remarks	Complies?
All 'avoidable' risks should be avoided. This necessitates the investigation of alternative locations and alternative technologies, wherever applicable, to ensure that risks are not introduced in an area where feasible alternatives are possible and justified.	The PHA has identified hazardous events and assessed the risks associated with the proposed operations of the BESS. The BESS location is suited for the proposed operation, situated within the CWO REZ in a rural area with considerable separation distance to sensitive receptors to avoid off-site risks. It is not possible to eliminate batteries from a BESS development. Selection of the battery technology is a balance of cost and availability with the most commonly used versions being lithium ion.	Yes
The risk from a major hazard should be reduced wherever practicable, irrespective of the numerical value of the cumulative risk level from the whole installation. In all cases, if the consequences (effects) of an identified hazardous incident are significant to people and the environment, then all feasible measures (including alternative locations) should be adopted so that the likelihood of such an incident occurring is made very low. This necessitates the identification of all contributors to the resultant risk and the consequences of each potentially hazardous incident. The assessment process should address the adequacy and relevancy of safeguards (both technical and locational) as they relate to each risk contributor.	Based on the separation distance to sensitive receptors, consequence impacts from the identified hazardous events are not expected to have significant off-site impacts.	Yes
The consequences (effects) of the more likely hazardous events (i.e. those of high probability of occurrence) should, wherever possible, be contained within the boundaries of the installation.	Events with high probability of occurrence are expected to be contained within the boundaries of the installation. Based on the separation distance to sensitive receptors, consequence impacts from the identified hazardous events (e.g. fire and explosion) are not expected to have significant off-site impacts.	Yes
Where there is an existing high risk from a hazardous installation, additional hazardous developments should not be allowed if they add significantly to that existing risk.	There are no hazardous developments (in the context of the Resilience and Hazards SEPP) in the vicinity of the project site.	Yes

10.3. Conclusion and recommendations

A PHA was completed to identify the hazards and assess the risks associated with the proposed operations of the BESS at the planning stage to determine risk acceptability from land use safety planning perspective.

The PHA was completed following the methodology specified in HIPAP No. 6 Hazard Analysis and the Multi-Level Risk Assessment guidelines for assessment against HIPAP No. 4 criteria. A Level 1 PHA (qualitative) was completed.

The PHA concluded that:

- For all identified events associated with the proposed operation of the BESS, the resulting consequences are not expected to have significant off-site impacts.
- The proposed BESS meets the HIPAP No. 4 qualitative risk criteria.

The following recommendations were identified:

1. VEA to review the investigation reports on the Victorian Big Battery (VBB) Fire (occurred on 31 July 2021) and confirm with the BESS supplier that the BESS systems have been designed and/or improved to address the lessons learnt from the VBB fire incident. Additionally, VEA to ensure that the BESS supplier's requirements on equipment clearances, installation, commissioning, operations and maintenance, and emergency response are met. The publicly available investigation reports include:
   - Energy Safe Victoria: Statement of Technical Findings on fire at the Victorian Big Battery, Ref [23].
   - Fisher Engineering and Energy Safety Response Group: Report of Technical Findings on Victorian Big Battery Fire, Ref [24].
2. VEA to consult with Fire and Rescue NSW (FRNSW) to ensure that the relevant aspects of fire protection measures have been included in the design. These may include: (i) type of firefighting or control medium (ii) demand, storage and containment measures for the medium. The above aspects will form an input to the Fire Safety Study which may be required as part of the development consent conditions, for review and approval by FRNSW.

11. REFERENCES

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[4] NSW Department of Planning, “HIPAP No.6 - Guidelines for Hazard Analysis,” 2011.

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[7] NSW Department of Planning, “Assessment Guideline: Multi-Level Risk Assessment,” 2011.

[8] NSW Department of Planning, “HIPAP No.4 - Risk Criteria for Land Use Planning,” 2011.

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[23] Energy Safe Victoria, “Statement of Technical Findings - Fire at the Victorian Big Battery,” [Online]. Available: https://www.esv.vic.gov.au/sites/default/files/2022-12/VBB_StatementOfFindings_FINAL_28Sep2021.pdf. [Accessed 4 May 2023].

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Appendix D. Proposed Fire Fighting Equipment Specifications, List, and Drawings

D.1. Fire Hydrant System

D.1.1. The battery energy storage system (BESS) site is to be provided with a dedicated fire hydrant system designed to support Fire and Rescue NSW (FRNSW) operations and to provide effective manual firefighting capability across the installation.

D.1.2. The system comprises a static fire water storage supply, fire pumps, a ring main distribution network, external hydrants, and a fire brigade booster assembly. The system is designed generally in accordance with AS 2419.1.

D.1.3. The fire hydrant system fitted to provide fire response to the buildings at the site. As can be seen this fire hydrant system uses a booster cabinet to achieve the required system pressure.

D.2. Portable Fire Extinguisher

D.2.1. This BESS site shall have portable extinguishers that are conform with AS 2444: 2001 (Standards Australia, 2001). The arrangement of portable fire extinguishers across the site shall meet the following:

a) For the areas associated with the BESS units there shall be one ABE dry power portable fire extinguisher (fire rating 4A:60B:E), and one CO_2 portable fire extinguisher (fire rating 5B:E) located within 25 m of a BESS unit.
b) For the diesel generator area there shall be two sets of portable fire extinguishers located approx. 10 m from the bund edge. Each set is to consist of one ABE dry powder portable fire extinguishers (fire rating 4A:60B:E).
c) Each site vehicle is to have small ABE dry powder portable fire extinguisher (fire rating 2A:30B:E) and a small water portable fire extinguisher (fire rating 2A).
d) Within the site building there shall be portable fire extinguishers as required under the NCC (ABCB, 2022).
e) For the switchboard room there shall be four sets of portable fire extinguishers. Each set shall consist of one ABE dry powder portable fire extinguishers (fire rating 4A:60B:E) and one CO_2 portable fire extinguisher (fire rating 5B:E). There shall be one set outside of each entrance, whilst the two other sets equally along the switchboard room.
f) For the site transformer there shall be two sets of portable fire extinguishers. Each set shall consist of one ABE dry power portable fire extinguisher (fire rating 4A:60B:E)and one CO_2 portable fire extinguisher (fire rating 5B:E). These sets of portable fire extinguishers shall be approx. 10 m away from the transformer bund on opposite sides.

D.2.2. Water extinguishers shall never be used against electrical fires, these are only for grass or combustible solid fires.

D.2.3. These portable fire extinguishers, when stored outside, shall be in a weather-proof cabinet.

D.2.4. Additionally, as part of the portable fire extinguisher arrangements, there shall be at least one fire blanket associated with each kitchen / kitchenette across the site.

D.3. Detection and Notification System

D.3.1. Each BESS unit is to be fitted with an automatic alarm system which is composed of a FACP, heat detector, smoke detector, horn / Strobe (red / white) and warning signs. temperature sensors.

D.3.2. The site building is to have fire and smoke detection that is prescribed under the NCC (ABCB, 2022). Smoke detectors may be replaced by heat detectors where false alarms are plausible.

D.3.3. The switchboard room shall be protected with an aspirating smoke detection system, which can provide a location of where the smoke coming from within the room. There shall also be heat detectors, these may be point-type sensor or linear heat detection cables.

D.3.4. Notification at the sites shall be provided by:

a) Within building there shall be a BOWS as prescribed in the NCC (ABCB, 2022), and
b) Across the site there shall be a horn / strobe warning system connected to the main FIP to incident notification.

D.4. Emergency Vehicular Access

D.4.1. This is covered in Appendix E to this report.

D.5. BESS Dry Pipe System

D.5.1. The BESS dry pipe system is mainly composed of 6 sprinklers and pipes located throughout the enclosure.

D.5.2. A DN65 connector shall be reserved for connecting an outdoor fire hydrant or fire truck. The adaption and selection of the DN65 connectors will need to reviewed against the design of the NSW RFS fire appliances to ensure compatibility.

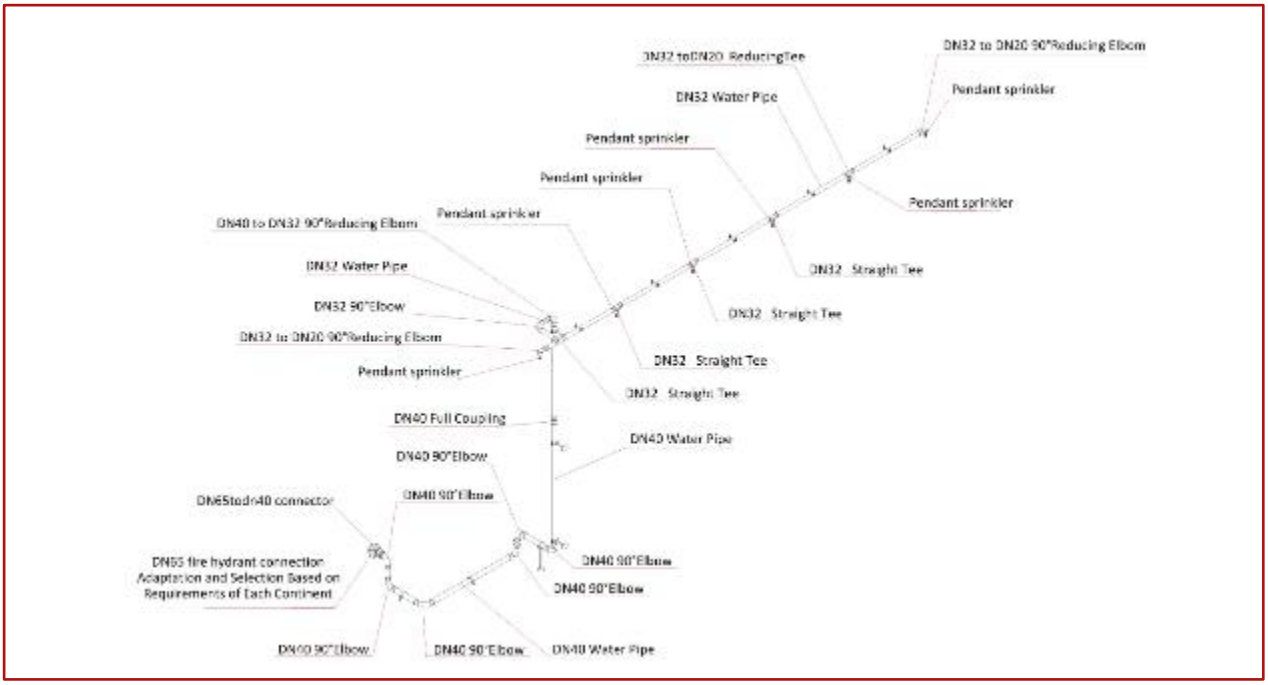


Figure 54: BESS Dry Pipe arrangement

D.6. Fire Protection Drawings

The following pages have been inserted and contain FP drawings for the site.

BELLAMBI HEIGHTS BESS

FIRE SERVICES

BELLAMBI BESS - DRAWING INDEX	
DOCUMENT NUMBER	DOCUMENT NAME
BH-SCT-FFP-DWG-3303	COVER SHEET
BH-SCT-FFP-DWG-3304	LEGENDS AND GENERAL NOTES
BH-SCT-FFP-DWG-3305	FIRE SERVICES TYPICAL DETAILS - SHEET 1
BH-SCT-FFP-DWG-3306	FIRE SERVICES TYPICAL DETAILS - SHEET 2
BH-SCT-FFP-LAY-3307	OVERALL FIRE SERVICES PLAN
BH-SCT-FFP-LAY-3308	O&M BUILDING FIRE DETECTION AND ALARM LAYOUT
BH1-SCT-FFP-SCM-3315	BH1 FIRE HYDRANT SYSTEM SCHEMATIC DIAGRAM
BH1-SCT-FFP-SCM-3316	BH1 FIRE DETECTION & ALARM SCHEMATIC DIAGRAM
BH1-SCT-FFP-LAY-3317	BH1 FIRE HYDRANT LAYOUT - SHEET 1
BH1-SCT-FFP-LAY-3318	BH1 FIRE HYDRANT LAYOUT - SHEET 2
BH1-SCT-FFP-LAY-3319	BH1 FIRE HYDRANT LAYOUT - SHEET 3
BH1-SCT-FFP-LAY-3320	BH1 BESS AREA DRY FIRE LAYOUT
BH1-SCT-FFP-LAY-3321	BH1 E-HOUSE FIRE DETECTION AND ALARM LAYOUT
BH2-SCT-FFP-SCM-3325	BH2 FIRE HYDRANT SYSTEM SCHEMATIC DIAGRAM
BH2-SCT-FFP-SCM-3326	BH2 FIRE DETECTION & ALARM SYSTEM SCHEMATIC DIAGRAM
BH2-SCT-FFP-LAY-3327	BH2 FIRE HYDRANT LAYOUT - SHEET 1
BH2-SCT-FFP-LAY-3328	BH2 FIRE HYDRANT LAYOUT - SHEET 2
BH2-SCT-FFP-LAY-3329	BH2 FIRE HYDRANT LAYOUT - SHEET 3
BH2-SCT-FFP-LAY-3330	BH2 BESS AREA DRY FIRE LAYOUT
BH2-SCT-FFP-LAY-3331	BH2 E-HOUSE FIRE DETECTION AND ALARM LAYOUT
Grand total: 20	

Plot Date: 30/04/2026 2:27:18 PM Office: FFP-DWG-3308 Filename: C:\Users\dominic.winter\Documents\BELLAMBI BESS-F1-AUR-R17-R23_29.04_dominic.winter.rvt

REFERENCE DRAWINGS

REFERENCE MODELS

REV	DATE	REVISION DETAILS	REV	DRAWN	DESIGNED	VERIFIED	APPROVED
A	16.01.26	DRAFT 70% DETAILED DESIGN	A	V.NGUYEN	M.KADER	K.SOLEIMANI	T.JACKSON
B	18.02.26	70% DETAILED DESIGN	B	V.NGUYEN	M.KADER	K.SOLEIMANI	T.JACKSON
0	30.04.26	IFC	0	V.NGUYEN	M.KADER	K.SOLEIMANI	T.JACKSON

All written dimensions take precedence over scaled dimensions.

PREPARED BY

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CERTIFICATION	NO.	CERTIFIER	DATE

CLIENT

yurika
Part of the Energy Queensland Group
ABN 19 100 214 131
☎ 1300 792 611 ✉ hello@yurika.com.au

CLIENT DOCUMENT NUMBER	REV

Coordinate system MGA
Height datum AHD

PRINT ALL COPIES IN COLOUR

CONSTRUCTION STATUS
ISSUED FOR CONSTRUCTION

DRAWN BY
V.NGUYEN

DESIGNED BY
M.KADER

STATUS	CODE
IFC	W1

DOCUMENT STATE
PUBLISHED

PROJECT
BELLAMBI HEIGHTS BESS

TITLE
FIRE SERVICES
COVER SHEET

DOCUMENT CODE
BH-SCT-FFP-DWG-3303

SCALE	SIZE	REFERENCE No.	REV
	A1	FFP-DWG-3303	0

FIRE PROTECTION SERVICES LEGEND

PIPEWORK SYSTEM

NEW PIPEWORK

- FIRE HYDRANT
- FIRE HOSE REEL
- PORTABLE COLD WATER
- FLOW TEST LINE
- PRESSURE RELIEF LINE
- FIRE DRAIN

NEW CABLE

- 2 CORE 1.5 TRANSMISSION CABLE
- SINGLE MODE FIBRE OPTIC FIRE RATED
- 2HR FIRE RATED 2.5mm TWISTED SHIELDED PAIR

FIRE DEVICES

- DIRECTION OF FLOW IN PIPE
- PIPE REDUCER/ENLARGEMENT
- CAPPED END
- CAPPED FLANGE END
- PIPE FLANGED JOINT
- PIPE UNION JOINT
- PIPE ANCHOR POINT
- NON FIXED SUPPORT
- EXPANSION JOINT
- FLEXIBLE PIPE CONNECTION

NOTE:

FOR THE DATA CENTRE PROJECTS, USE RED COLOUR SAMPLING PIPE FOR HOT AISLES AND BLUE FOR COLD AISLES AND ROOM SPACES.

PIPEWORK RISER/DROPPERS

- PIPE DROPPER
- PIPE RISER
- RISER UNIDIRECTIONAL (XX / 100)
- RISER DOWNWARD FLOW (XX / 100)
- RISER UPWARD FLOW (XX / 100)

LINE WORK

- PENETRATION

FIRE TANKS

- TANK RECTANGULAR PANEL
- TANK WITH SUMP
- PRESSURE TANK
- TANK CYLINDRICAL
- TANK CYLINDRICAL

FIRE HYDRANT AND FIRE HOSE REEL

- FHR — FIRE HOSE REEL
- FH — FIRE HYDRANT - LANDING VALVE
- FH FH — FIRE HYDRANT - DOUBLE PILLAR (EXTERNAL)
- SUCTION POINTS
- BOOSTER POINTS
- H — FIRE HYDRANT- STREET HYDRANT
- FH — FIRE HYDRANT- INGROUND
- BOOSTER POINTS
- SUCTION CONNECTION (LARGE BORE AND SMALL BORE FOR FIRE BRIGADE ACCESS)
- EXTERNAL FIRE HYDRANT COVERAGE
- INTERNAL FIRE HYDRANT COVERAGE
- FIRE HOSE REEL COVERAGE

PORTABLE FIRE EXTINGUISHERS

- PORTABLE FIRE EXTINGUISHER - WATER TYPE
- PORTABLE FIRE EXTINGUISHER - FOAM TYPE
- PORTABLE FIRE EXTINGUISHER - WET CHEMICAL TYPE
- PORTABLE FIRE EXTINGUISHER - ABE POWDER TYPE
- PORTABLE FIRE EXTINGUISHER - CARBON DIOXIDE (CO_2)
- FB — FIRE BLANKET
- FIRE POINT CONTAINING EXTINGUISHERS

FIRE PUMPS

- D — FIRE PUMP - CENTRIFUGAL SINGLE STAGE- DIESEL
- E — FIRE PUMP - CENTRIFUGAL SINGLE STAGE- ELECTRIC
- D D — FIRE PUMP - CENTRIFUGAL MULTI STAGE- DIESEL
- E E — FIRE PUMP - CENTRIFUGAL MULTI STAGE- ELECTRIC
- JA — PUMP - JACKING (AUTOMATIC /MANUAL ONLY FOR SPRINKLER SYSTEM)
- JO — PUMP - JOCKEY (AUTOMATIC ONLY- FIRE SERVICES)
- FIRE PUMP - VERTICAL SHAFT PUMP
- FIRE PUMP - SUBMERSIBLE
- FIRE PUMP - HIGH PRESSURE - POSITIVE DISPLACEMENT (WATER MIST)

FIRE DETECTION AND ALARM

- MIMIC — MIMIC PANEL
- DGP — DATA GATHERING PANEL
- FFCP — FIRE FAN CONTROL PANEL
- FBP — FIRE BRIGADE PANEL
- DNE — "DO NOT ENTER" ILLUMINATED SIGN
- FIRE — "FIRE ALARM" ILLUMINATED SIGN
- SIO — "SYSTEM INOPERATIVE" ILLUMINATED SIGN
- EVAC — "EVACUATE AREA" ILLUMINATED SIGN
- LCS — LOCAL CONTROL STATION
- MFDCIE — MAIN FIRE DETECTION CONTROL AND INDICATING EQUIPMENT (MFDCIE)
- FDCIE — FIRE DETECTION CONTROL AND INDICATING EQUIPMENT (FDCIE)
- MEWCIE — MAIN EMERGENCY WARNING CONTROL AND INDICATING EQUIPMENT (MEWCIE)
- EWCIE — EMERGENCY WARNING CONTROL AND INDICATING EQUIPMENT (EWCIE)
- MEICIE — MAIN EMERGENCY INTERCOM CONTROL AND INDICATING EQUIPMENT (EICIE)
- EICIE — EMERGENCY INTERCOM CONTROL AND INDICATING EQUIPMENT (EICIE)
- SHCIE — SPECIAL HAZARD CONTROL AND INDICATING EQUIPMENT
- SHCIEG — SPECIAL HAZARD CONTROL AND INDICATING EQUIPMENT (GAS SUPPRESSION)
- SHCIEW — SPECIAL HAZARD CONTROL AND INDICATING EQUIPMENT (WATER MIST)
- PA SYSTEM — PUBLIC ANNOUNCEMENT SYSTEM (INTERFACE WITH EVACUATION AND WARNING SYSTEM
- MASD — MULTI-POINT ASPIRATING SMOKE DETECTION SYSTEM
- LHDC — LINEAR HEAT DETECTOR CONTROLLER
- JB — JUNCTION BOX
- ELD — END-OF-LINE DEVICE
- MV — MONITORED VALVE
- SOL — SOLENOID VALVE
- LP — LOW PRESSURE INDICATOR
- TLI — TANK LOW WATER LEVEL
- DPCIE — DISTRIBUTED PART OF CIE
- BAT — STANDBY BATTERY
- PSE — EXTERNAL POWER SUPPLY
- SMOKE DETECTOR
- SMOKE DETECTOR (IN CEILING VOID)
- HEAT DETECTOR
- FLAME DETECTOR
- LINEAR HEAT (THERMAL) DETECTOR
- HEAT (THERMAL) DETECTOR IN CEILING VOID
- SMOKE DETECTOR WITH REMOTE INDICATOR
- OPTICAL BEAM SMOKE DETECTOR (TRANSMITTER)
- OPTICAL BEAM SMOKE DETECTOR (RECEIVER)
- SMOKE ALARM
- HEAT ALARM
- MC — MULTI-CRITERIA DETECTOR
- SMOKE DETECTOR WITHIN AIR DUCT
- HEAT (THERMAL) DETECTOR WITHIN AIR DUCT
- DUCT SAMPLING SMOKE DETECTOR (WITH PROBE)
- G — GAS FIRE DETECTOR
- MOTORIZED DAMPER (NORMALLY CLOSED)
- SMOKE DETECTOR SUBFLOOR
- HEAT (THERMAL) DETECTOR SUBFLOOR
- VISUAL ALARM DEVICE (CEILING MOUNTED)
- VISUAL ALARM DEVICE (WALL MOUNTED)
- SOUNDER
- VWD — VISUAL WARNING DEVICE (INDICATE FIXED WORDS DISPLAYED ON VWD)
- BOWS — BUILDING OCCUPANT WARNING SYSTEM
- ASE — ALARM SIGNALING EQUIPMENT
- MSSB — MECHANICAL SERVICES SWITCHBOARD
- LL — LEVEL SWITCH - LOW LEVEL
- I/O — INPUT/OUTPUT DEVICE

FIRE DETECTION AND ALARM (CONT.)

- MR / SG — GAS SUPPRESSION MANUAL RELEASE BREAK GLASS & STOP - GAS ISOLATION SWITCH
- EXTERNAL FIRE ALARM BELL
- ELECTRO MAGNETIC DOOR HOLD DEVICE
- FTR D — FIRE TRIP TO DOOR
- FTR M — FIRE TRIP TO MECH
- MANUAL CALL POINT (RED- FIRE ALARM)
- W — MANUAL CALL POINT (WHITE- EMERGENCY EVACUATION)
- G — MANUAL CALL POINT (GREEN- ELECTRIC LOCK RELEASE)
- WATER MOTOR ALARM GONG
- FIRE GRAPHICAL MONITORING SYSTEM
- REMOTE VISUAL INDICATOR
- WARDEN INTERCOM POINT
- SOUNDER HORN

FIRE DETECTION AND ALARM (CONT.)

- RECESSED SOUNDER SPEAKER
- WALL / CEILING MOUNTED SOUNDER SPEAKER
- EXTERNAL STROBE LIGHT

FIRE VALVE

- VALVE - ANGLE PRESSURE RELIEF/SAFETY
- CHECK VALVE (NON-RETURN VALVE)
- VALVE - DOUBLE CHECK
- VALVE - GAS SOLENOID VALVE
- TANK INFILL/TOP UP FLOAT VALVE
- GATE VALVE, NC= NORMALLY CLOSED, NO=NORMALLY OPEN
- BALL MANUAL VALVE (NORMALLY OPEN)
- BALL MANUAL VALVE (NORMALLY CLOSED)
- BALL/GATE MANUAL VALVE INGROUND
- BACKFLOW PREVENTION
- PRESSURE REDUCING VALVE
- FLOW MEASURING DEVICE- VENTURI
- FLOW MEASURING DEVICE- RESTRICTING ORIFICE
- FLOW MEASURING DEVICE- PILOT TUBE
- FLOW INDICATOR
- INGROUND PIPE (TYPICAL WATER MAIN)
- BUTTERFLY VALVE
- MONITORED BUTTERFLY VALVE
- AUTOMATIC AIR VENT
- VALVE - MONITORED ISOLATION
- VALVE - PRESSURE RELIEF/SAFETY
- SPRINKLER NON-RETURN ALARM VALVE (WET)
- SPRINKLER NON-RETURN ALARM VALVE (DRY)
- VALVE - SOLENOID OPERATED
- STRAINER - COMPLETE WITH DRAIN VALVE
- STRAINER - Y TYPE
- FLOW MEASURING DEVICE - ANNUBAR ELEMENT
- TUNDISH
- NITROGEN GENERATION PLANT AND COMPRESSOR
- FS — FLOW SWITCH
- FS ST — FLOW SWITCH - SELF TEST TYPE
- PS — PRESSURE SWITCH
- PG — PRESSURE GAUGE
- WATER METER

ABBREVIATIONS

GENERAL

AFFL	ABOVE FINISHED FLOOR LEVEL
AG	ABOVE GROUND
C/W	COMPLETE WITH
COS	CHECK ON SITE
F/A	FROM ABOVE
F/B	FROM BELOW
GAL	GALVANISED
H/L	HIGH LEVEL
L/L	LOW LEVEL
NTS	NOT TO SCALE
SM	SITE MEASURE
T/A	TO ABOVE
T/B	TO BELOW
TBA	TO BE ADVISED
UG	UNDER GROUND
U/S	UNDERSIDE
SHCIE	SPECIAL HAZARDS CONTROL & INDICATING EQUIPMENT
FDAS	FIRE DETECTION AND ALARM SYSTEM
DBEP	DESIGNATED BUILDING ENTRY POINT
DSEP	DESIGNATED SITE ENTRY POINT
MSSB	MECHANICAL SERVICES SWITCHBOARD
MCC	MOTOR CONTROL CENTRE
SPL	SOUND PRESSURE LEVEL
VAD	VISUAL ALARM DEVICE
VWD	VISUAL WARNING DEVICE
MCP	MANUAL CALL POINT
BOWS	BUILDING OCCUPANT WARNING SYSTEM
EWIS	EMERGENCY WARNING AND INTERCOM SYSTEM
D	DRY HEAD (FOR SPRINKLER HEAD)
EC	EXTENDED COVERAGE (FOR SPRINKLER HEAD)
HT	HIGH TEMPERATURE (FOR SPRINKLER HEADS)
BMS	BUILDING MANAGEMENT SYSTEM

PIPE SYSTEM

FH	FIRE HYDRANT
FS	FIRE SPRINKLER
FP	FIRE PROTECTION SERVICE (COMBINED WET)
FSA	FIRE SPRINKLER PRE-ACTION
FHR	FIRE HOSE REEL
MASD	MULTI ASPIRATING SMOKE DETECTION
FD	FIRE DRAIN
NG	NITROGEN
SCV	SPRINKLER CONTROL VALVE ASSEMBLY

OTHER

A/P	ACCESS PANEL
MV	VALVE MONITORED AT THE FIP
NC	NORMALLY CLOSED
NO	NORMALLY OPEN

NOTES:
1- FIRE CABLES ARE SHOWN WITH TWO COLOURS. IN ORDER TO DISTINGUISH THE TRANSMISSION AND FIBRE OPTIC NETWORK CABLE, DESIGNER MAY INDICATE THEM WITH TWO DIFFERENT COLOURS.

GENERAL NOTES

1. ALL WORKS TO COMPLY WITH THE FOLLOWING STANDARDS:

•AS 2419.1-2021 - FIRE HYDRANT INSTALLATIONS, PART 1: SYSTEM DESIGN, INSTALLATION AND COMMISSIONING
•AS 2444-2001 - PORTABLE FIRE EXTINGUISHERS AND FIRE BLANKETS
•AS 1670.1-2018 - FIRE DETECTION WARNING CONTROL AND INTERCOM SYSTEMS SYSTEM DESIGN INSTALLATION AND COMMISSIONING
•FSS PREPARED BY RED FIRE ENGINEERS. REPORT NO : JN25-00265, VERSION 1, DATED 20/02/2026

DESIGN, INSTALLATION AND COMMISSIONING, PART 4 EMERGENCY WARNING AND INTERCOM SYSTEMS
•AS 3000 - ELECTRICAL INSTALLATIONS
•AS 3500.1-2021 - PLUMBING AND DRAINAGE, PART 1: WATER SERVICES
•AS 2441 - 2005: INSTALLATION OF FIRE HOSE REELS
•AS 2444 - 2001: PORTABLE FIRE EXTINGUISHERS AND FIRE BLANKETS - SELECTION AND LOCATION
NCC 2022 -NATIONAL CONSTRUCTION CODE
SCOPE OF WORKS INCLUDES THE DESIGN, FABRICATION, PREPARATION OF SHOP DRAWINGS, SUPPLY, DELIVERY, INSTALLATION, SETTING TO WORK, TESTING, COMMISSIONING, DEFECTS LIABILITY, WARRANTY AND MAINTENANCE OF FIRE SPRINKLER. SMOKE DETECTION AND ALARM SYSTEM.

2. THESE DOCUMENTS ARE TO BE READ IN CONJUNCTION WITH THE FIRE SERVICES AND GENERAL REQUIREMENTS SPECIFICATIONS AND CO-ORDINATED WITH ALL OTHER SERVICES INCLUDING ELECTRICAL, MECHANICAL, HYDRAULICS, FUEL, GENERATORS, CSMS, ARCHITECTURE AND STRUCTURE.

3. DO NOT SCALE OFF THESE DRAWINGS. VERIFY ALL DIMENSIONS FROM THE ARCHITECT'S FINAL IFC DRAWINGS AND BY ACTUAL SITE MEASUREMENTS. REFER ALL DIMENSION DISCREPANCIES TO THE PROJECT MANAGER FOR CLARIFICATION PRIOR TO FINALISING SHOP DRAWINGS AND PROCEEDING WITH THE WORK

4. INFORMATION SHOWN ON THESE DRAWINGS IS DIAGRAMMATIC AND REFLECTS DESIGN INTENT. THE DRAWING SHALL NOT BE USED FOR CONSTRUCTION PURPOSES. THE DRAWINGS AND SPECIFICATION DO NOT PURPORT TO SHOW ALL MINOR ITEMS OF EQUIPMENT AND ACCESSORIES WHICH MAY BE NECESSARY. THESE MINOR ITEMS SHALL BE PROVIDED TO FORM COMPLETE AND FULLY OPERATIONAL SYSTEMS.

5. THE FIRE SERVICES CONTRACTOR SHALL FAMILIARIZE THEMSELVES WITH THIS SITE AND THE SURROUNDING AREAS PRIOR TO SUBMITTING THEIR TENDER SUBMISSION.

6. ALL FIRE SERVICES WORK SHALL BE DONE IN A NEAT WORKMAN-LIKE MANNER (TYPICAL THROUGHOUT).

7.THE WORST-CASE SCENARIO HAS BEEN ADOPTED IN THE CALCULATIONS.

8. ONE FIRE EVENT ONLY HAS BEEN CONSIDERED IN EVERY STUDY AND ANALYSIS.

9.FOR THE DETAILS OF THE FIRE PROTECTION SYSTEM REQUIREMENTS AND CALCULATIONS REFER TO FIRE PROTECTION SECTION OF BASIS OF DESIGN REPORT

10. DEFECTS AND LIABILITY: THE CONTRACTOR SHALL BE RESPONSIBLE FOR RECTIFICATION OF ALL DEFECTS IN THE WORK DUE TO FAULTY MATERIALS AND/OR WORKSMANSHIP, FOR A PERIOD OF TWELVE (12) MONTHS AFTER ALL WORK IS COMPLETED AND HANDED OVER.

11. 12-MONTH WARRANTY: ALL PLANT, EQUIPMENT, AND MATERIALS SUPPLIED UNDER THIS CONTRACT SHALL BE COVERED BY TWELVE (12) MONTHS WARRANTY AGAINST FAULTY MANUFACTURE, WORKSMANSHIP, AND/OR MATERIAL QUALITY. THE FIRE CONTRACTOR SHALL BE RESPONSIBLE FOR THE RECTIFICATION AND/OR REPLACEMENT OF ANY PORTION OF THE INSTALLATION WHICH FAILS UNDER WARRANTY.

12. PROVIDE A COPY OF INTENDED ITP BEFORE STARTING ANY WORKS.

DESIGN BASIS

HYDRANT SYSTEM

•BASED ON EXISTING FSS AND IN ACCORDANCE TO AS2419.1 - 2021, ONE HYDRANTS ARE REQUIRED TO WORK SIMULTANEOUSLY TO PROVIDE COVERAGE TO THE ENTIRE BESS AREA AND BUILDINGS.

•TWO FULL PUMPS (DIESEL AND ELECTRIC) HAVE BEEN PROPOSED (TO BE CONFIRMED, SUBJECT TO COORDINATION WITH YURIKA)
• FULL CAPACITY HYDRANT TANKS HAVE BEEN ALLOWED FOR THE HYDRANT SYSTEM ALONG WITH TWO FIRE PUMPS.

DETECTION AND ALARM SYSTEM

• DETECTION AND ALARM SYSTEM HAS BEEN PROPOSED FOR O&M BUILDINGS IN ACCORDANCE WITH AS1670.1 - 2018. MAIN FIRE INDICATOR PANEL TO BE LOCATED IN E-HOUSE, SUB-FIRE INDICATOR PANEL TO BE LOCATED IN O&M BUILDING. SUB-FIRE INDICATOR PANEL TO BE INTERFACED WITH MFDCIE IN BH1 AND BH2.

• FIRE SCOPE WITHIN THE E-HOUSE BUILDING IS INSTALLATION OF A NEW MFDCIE AND INTERFACE CONNECTION WITH SCADA AND FDCIE LOCATED IN THE O&M BUILDING IN BH1.

• FIRE PUMP CONTROL PANELS, TANK LEVEL INDICATORS SIGNALS TO BE INTERFACED WITH SUB-FDCIE LOCATED IN BH1 O&M BUILDING. BH2 FIRE PUMP CONTROL PANELS, TANK LEVEL INDICATORS TO INTERFACE WITH MFDCIE LOCATED IN E-HOUSE.

FIRE EXTINGUISHER AND BLANKET

• FIRE EXTINGUISHER HAS BEEN PROPOSED FOR THE O & M BUILDING IN ACCORDANCE WITH NCC 2022 AND AS2444 - 2001

• FIRE POINTS CONTAINING EXTINGUISHERS HAVE BEEN PROVIDED FOR BESS YARD. EACH FIRE POINT TO CONTAIN 1 OFF OF EACH ABE (4A:60B:E) AND CO2 (5B:E) FIRE EXTINGUISHER.

• FIRE POINTS CONTAINING EXTINGUISHERS HAVE BEEN PROVIDED FOR DIESEL GENERATOR. EACH FIRE POINT TO CONTAIN 2 OFF OF ABE (4A:60B:E) FIRE EXTINGUISHER.

• FIRE POINTS CONTAINING EXTINGUISHERS HAVE BEEN PROVIDED FOR SITE TRANSFORMERS. EACH FIRE POINT TO CONTAIN 1 OFF OF EACH ABE (4A:60B:E) AND CO2 (5B:E) FIRE EXTINGUISHER.

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REFERENCE DRAWINGS

REFERENCE MODELS

REV	DATE	REVISION DETAILS	REV	DRAWN	DESIGNED	VERIFIED	APPROVED
A	16.01.26	DRAFT 70% DETAILED DESIGN	A	V.NGUYEN	M.KADER	K.SOLEIMANI	T.JACKSON
B	18.02.26	70% DETAILED DESIGN	B	V.NGUYEN	M.KADER	K.SOLEIMANI	T.JACKSON
0	30.04.26	IFC	0	V.NGUYEN	M.KADER	K.SOLEIMANI	T.JACKSON

All written dimensions take precedence over scaled dimensions.

PREPARED BY

aurecon
www.aurecongroup.com

CERTIFICATION	NO.	CERTIFIER	DATE

CLIENT

yurika
Part of the Energy Queensland Group
ABN 19 100 214 131
☎ 1300 792 611 ✉ hello@yurika.com.au

CLIENT DOCUMENT NUMBER	REV

Coordinate system MGA
Height datum AHD

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ISSUED FOR CONSTRUCTION

DRAWN BY
V.NGUYEN

DESIGNED BY
M.KADER

STATUS	CODE
IFC	W1

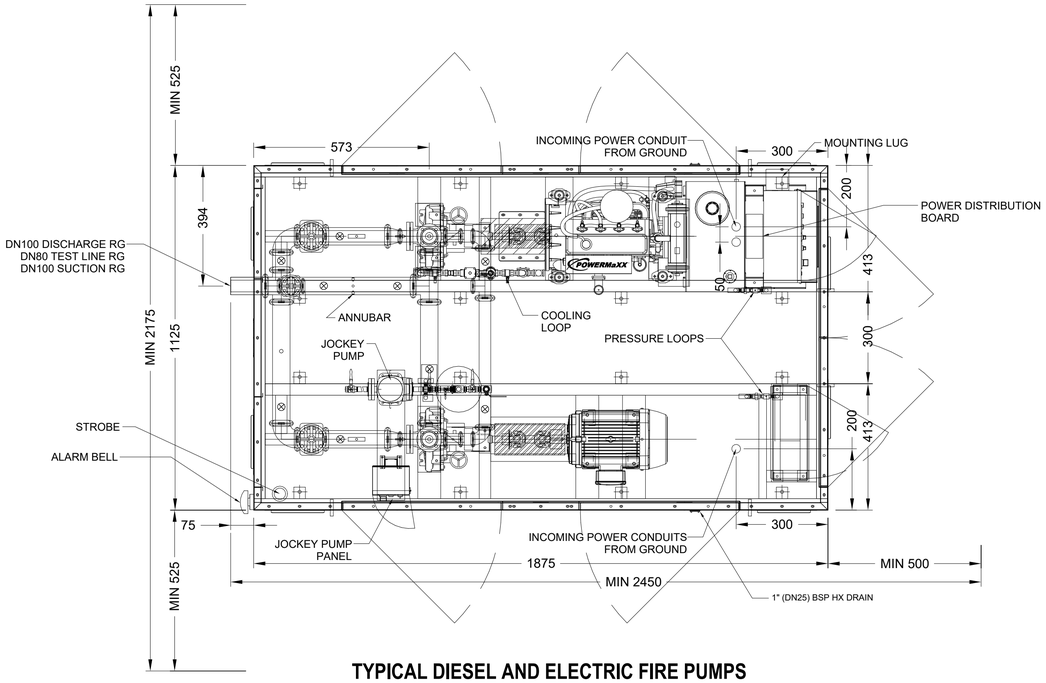
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BELLAMBI HEIGHTS BESS

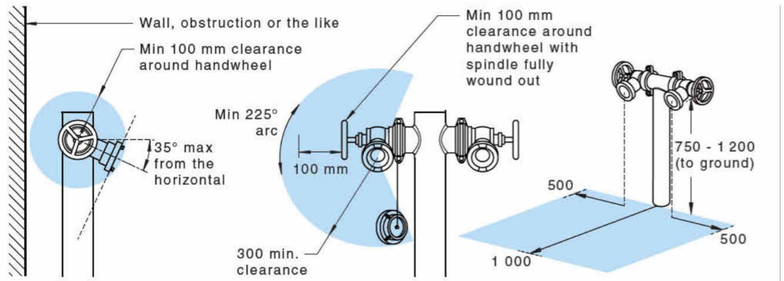
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FIRE SERVICES
LEGENDS AND GENERAL NOTES

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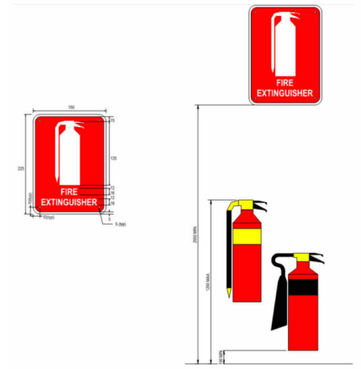
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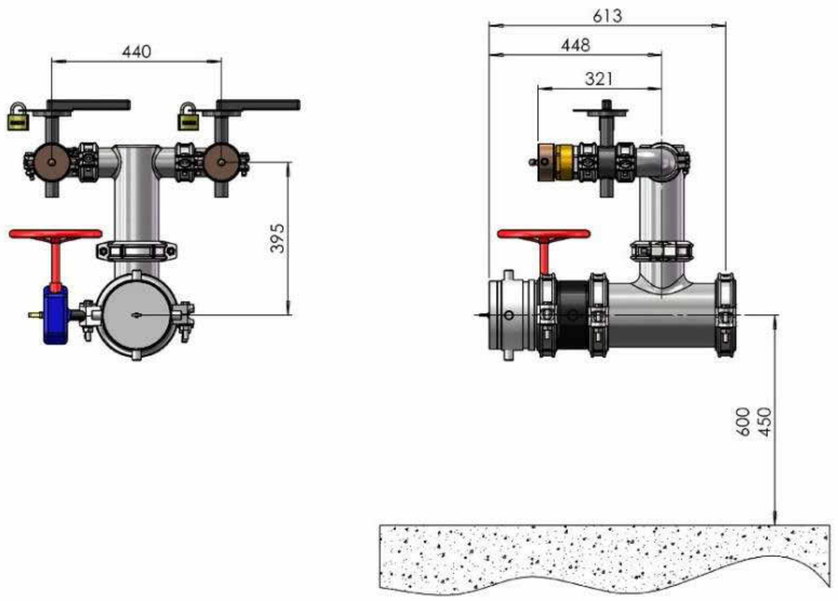
TYPICAL DIESEL AND ELECTRIC FIRE PUMPS TO BKB PUMPS



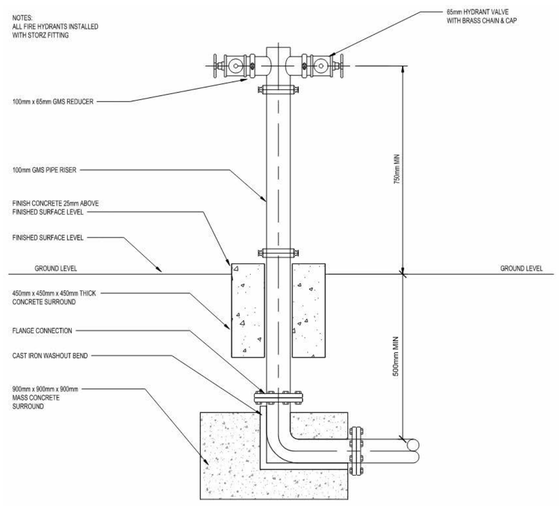
EXTERNAL FIRE HYDRANT CLEARANCES



TYPICAL PORTABLE FIRE EXTINGUISHER INSTALLATION

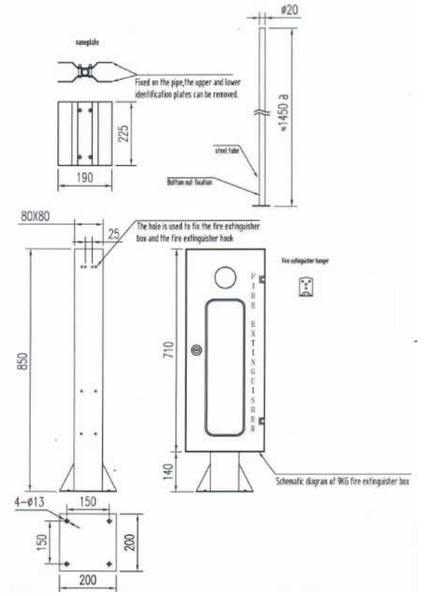


TYPICAL LARGE AND SMALL BORE SUCTION CONNECTION



EXTERNAL DOUBLE PILLAR ATTACK HYDRANT





TYPICAL PORTABLE FIRE EXTINGUISHER CABINET

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REFERENCE DRAWINGS	REFERENCE MODELS

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All written dimensions take precedence over scaled dimensions.

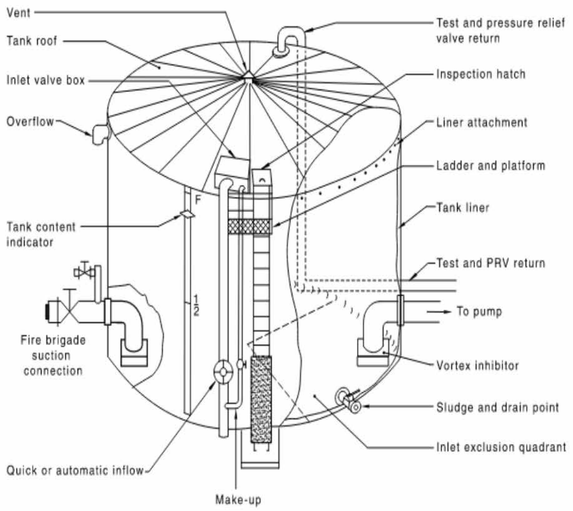
PREPARED BY	CLIENT
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CERTIFICATION	NO.	CERTIFIER	DATE	CLIENT DOCUMENT NUMBER	REV

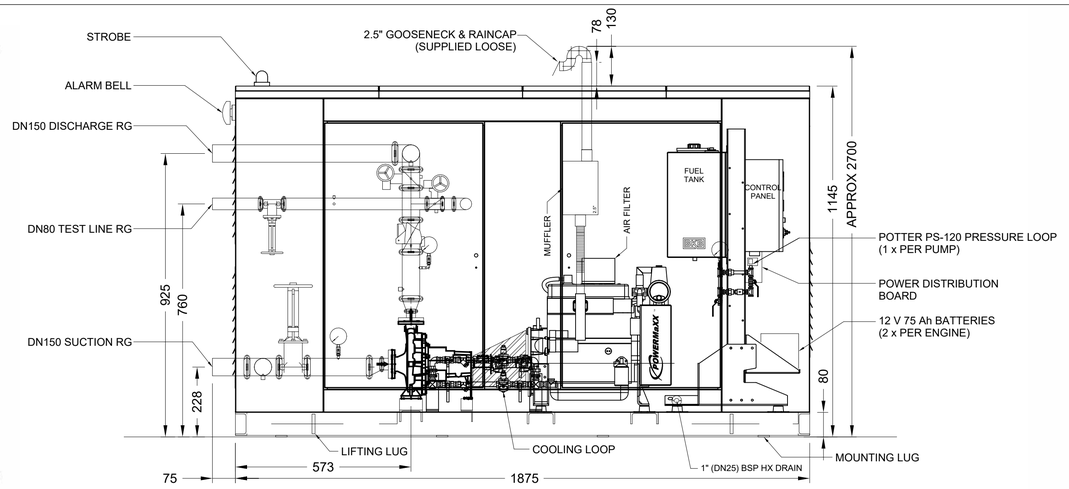
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Height datum AHD

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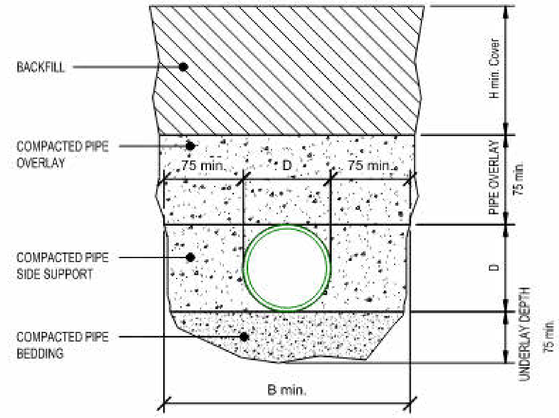
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ISSUED FOR CONSTRUCTION	BELLAMBI HEIGHTS BESS
DRAWN BY V.NGUYEN	**TITLE** FIRE SERVICES FIRE SERVICES TYPICAL DETAILS SHEET 1
DESIGNED BY M.KADER	
STATUS IFC / **CODE** W1	**DOCUMENT CODE** BH-SCT-FFP-DWG-3305
DOCUMENT STATE PUBLISHED	**SCALE** As indicated / **SIZE** A1 / **REFERENCE No.** FFP-DWG-3305 / **REV** 0



FIRE WATER TANK



FIRE PUMP ENCLOSURE (SECTION)



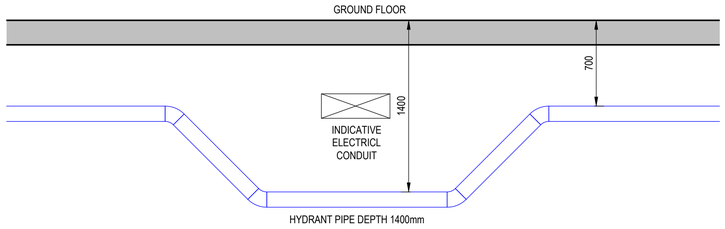
D = PIPE DIAMETER
B = D + 150 mm
H = MINIMUM DEPTH OF COVER

H = MINIMUM DEPTH OF COVER	VEHICLE LOADING		NO VEHICLE LOADING
	ROADS CARRIAGEWAY		LANDSCAPE (FOOTPATH, VEGETATION, ETC)
	SEALED	UNSEALED	
	600 mm	750 mm	600 mm

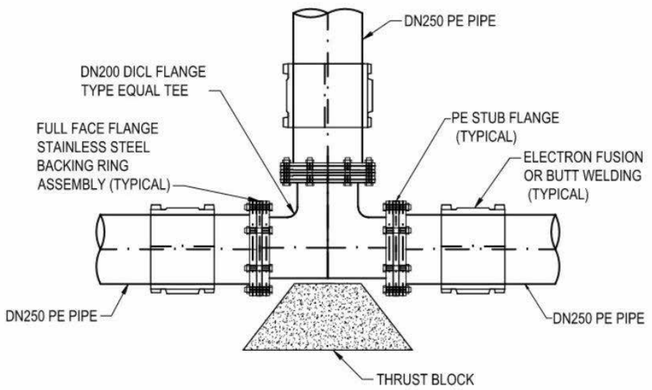
AS PER AS 3500, THE WATER SERVICES SHALL BE SURROUNDED WITH NOT LESS THAN 75 MM OF COMPACTED SAND, OR FINE-GRAINED SOIL, WITH NO HARD-EDGED OBJECT IN CONTACT WITH OR RESTING AGAINST ANY PIPE OR FITTING.

MATERIAL USED FOR FINAL BACKFILL SHALL BE FREE FROM ROCK, HARD MATTER OR ORGANIC MATERIAL AND BE BROKEN UP TO CONTAIN NO SOIL LUMPS LARGER THAN 75 MM.
UNLESS SPECIFIED TO THE CONTRARY, COPPER AND STAINLESS STEEL PIPELINES MAY BE INSTALLED IN SOIL EXCAVATED FROM THE TRENCH IN WHICH THEY ARE TO BE INSTALLED, PROVIDED THE SOIL IS COMPATIBLE WITH COPPER AND STAINLESS STEEL AND FREE FROM ROCK AND RUBBLE.

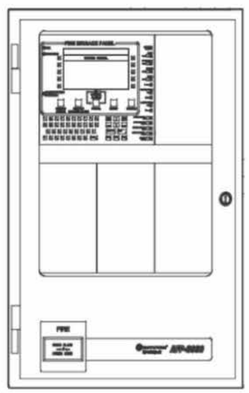
TYPICAL INSTALLATION IN A TRENCH

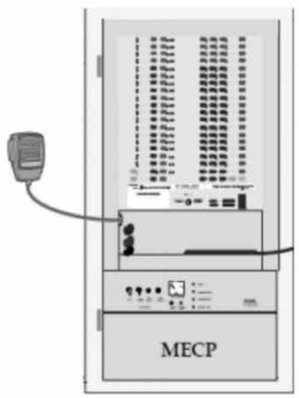


HYDRANT PIPE CROSSING OTHER SERVICES

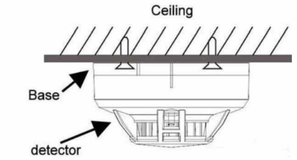


PE PIPE CONNECTION DETAILS

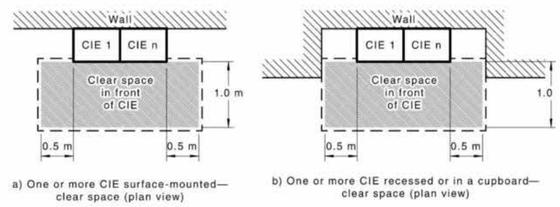


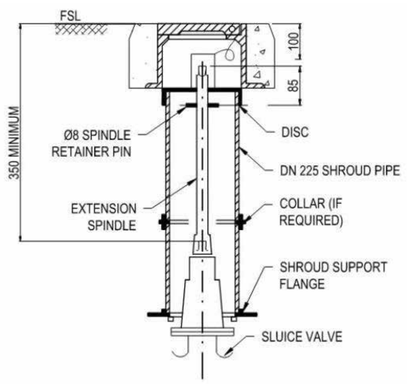


TYPICAL FDCIE AND EICIE

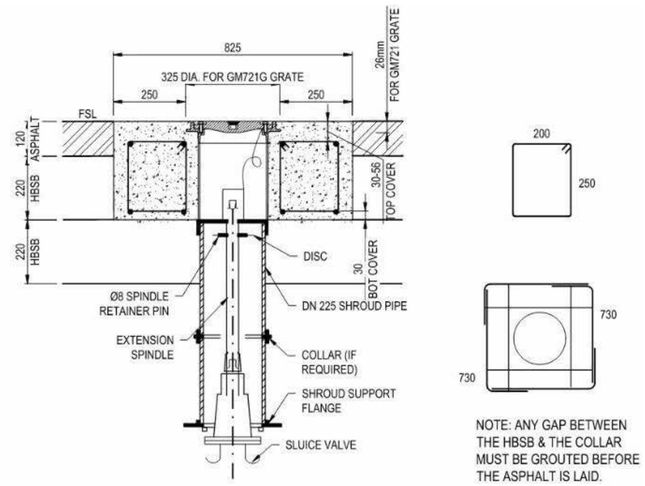


TYPICAL POINT TYPE DETECTOR INSTALLATION





TYPICAL ASSEMBLY FOR SLUICE VALVE LAID DEEPER THAN STANDARD DEPTH (CLASS D)
FIRE CONTRACTOR SHALL COORDINATE WITH CIVIL AND PROCURE



TYPICAL ASSEMBLY FOR SLUICE VALVE LAID DEEPER THAN STANDARD DEPTH (CLASS G)
FIRE CONTRACTOR SHALL COORDINATE WITH CIVIL AND PROCURE

NOTE: ANY GAP BETWEEN THE HBSB & THE COLLAR MUST BE GROUTED BEFORE THE ASPHALT IS LAID.

Plot Date: 30/04/2026 2:37:44 PM Office: FFP-DWG-3306 Filename: C:\Users\dominic.writer\Documents\BELLAMBI BESS-FI-AUR-RVT-R23_29-04_dominic.writer.rvt

REFERENCE DRAWINGS

REFERENCE MODELS

REV	DATE	REVISION DETAILS	REV	DRAWN	DESIGNED	VERIFIED	APPROVED
A	16.01.26	DRAFT 70% DETAILED DESIGN	A	V.NGUYEN	M.KADER	K.SOLEIMANI	T.JACKSON
B	18.02.26	70% DETAILED DESIGN	B	V.NGUYEN	M.KADER	K.SOLEIMANI	T.JACKSON
0	30.04.26	IFC	0	V.NGUYEN	M.KADER	K.SOLEIMANI	T.JACKSON

All written dimensions take precedence over scaled dimensions.

PREPARED BY

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CERTIFICATION	NO.	CERTIFIER	DATE

CLIENT

yurika
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ABN 19 100 214 151
☎ 1300 792 611 ✉ hello@yurika.com.au

CLIENT DOCUMENT NUMBER	REV

Coordinate system MGA
Height datum AHD

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CONSTRUCTION STATUS
ISSUED FOR CONSTRUCTION

DRAWN BY
V.NGUYEN

DESIGNED BY
M.KADER

STATUS	CODE
IFC	W1

DOCUMENT STATE
PUBLISHED

PROJECT
BELLAMBI HEIGHTS BESS

TITLE
FIRE SERVICES
FIRE SERVICES TYPICAL DETAILS SHEET 2

DOCUMENT CODE
BH-SCT-FFP-DWG-3306

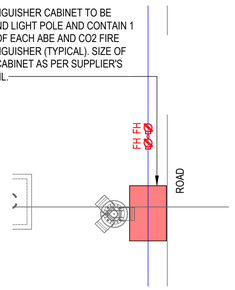
SCALE	SIZE	REFERENCE No.	REV
As indicated	A1	FFP-DWG-3306	0

NOTE:

- EXTERNAL HYDRANTS TO BE 10m AWAY FROM THE BATTERY MODULE THEY ARE COVERING.
- EACH MODULE SHALL BE COVERED VIA TWO EXTERNAL HYDRANTS.
- COVERAGE PLAN HAS BEEN PREPARED AS PER AS2419.1 - 2021 AND FSS.

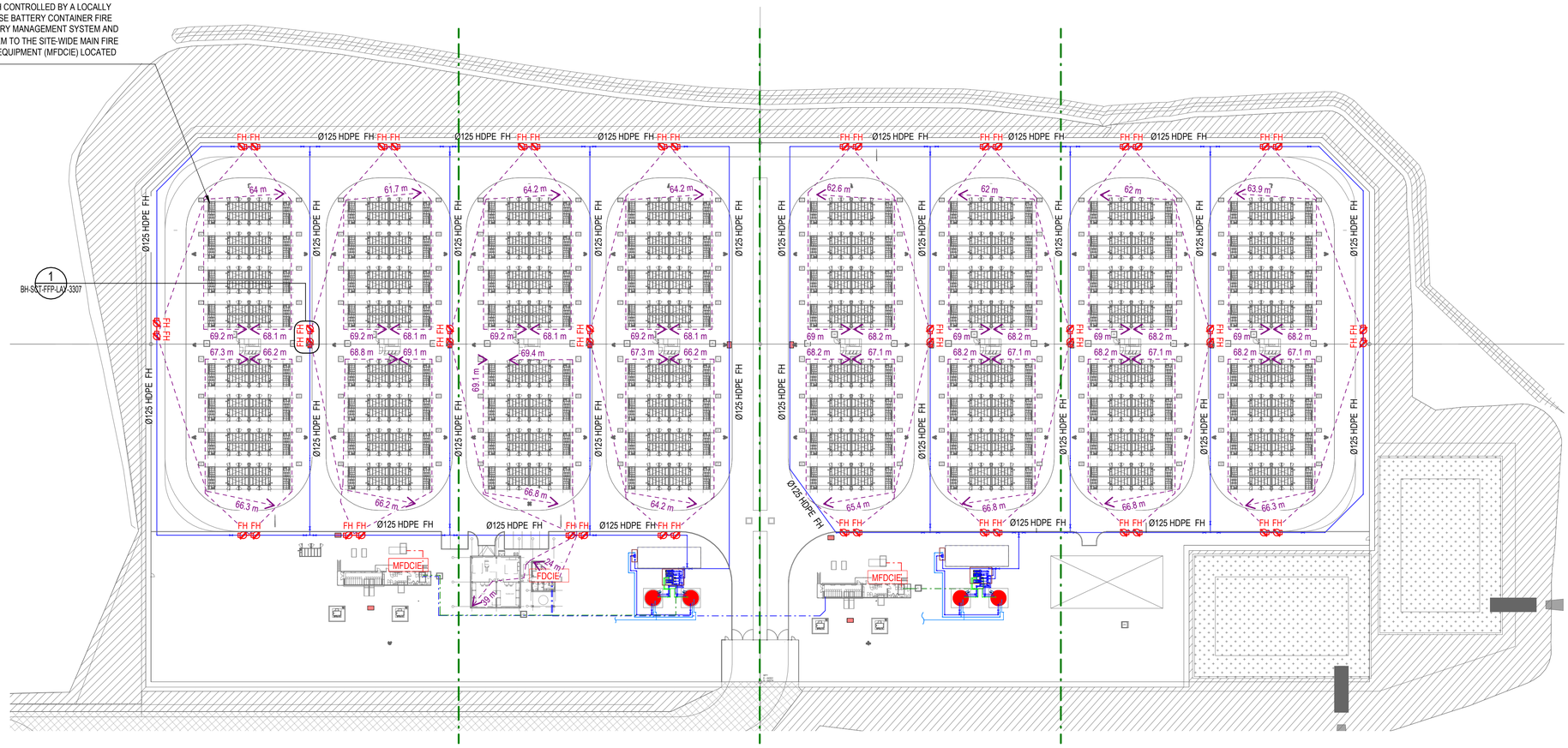
THE BATTERY CONTAINERS ARE PROVIDED WITH INTERNAL FIRE DETECTION AND ALARM SYSTEMS, EACH CONTROLLED BY A LOCALLY INSTALLED FIRE INDICATOR PANEL. THESE BATTERY CONTAINER FIRE PANELS ARE MONITORED BY THE BATTERY MANAGEMENT SYSTEM AND ARE INTERFACED VIA THE SCADA SYSTEM TO THE SITE-WIDE MAIN FIRE DETECTION AND CONTROL INDICATING EQUIPMENT (MFDCIE) LOCATED WITHIN THE E-HOUSE BUILDING.

EXTINGUISHER CABINET TO BE BEHIND LIGHT POLE AND CONTAIN 1 OFF OF EACH ABE AND CO2 FIRE EXTINGUISHER (TYPICAL). SIZE OF THE CABINET AS PER SUPPLIER'S DETAIL.



DETAIL 1 - EXINTINGUISHER CABINET, LIGHT POLE AND HYDRANT LOCATION

1 : 100



OVERALL SITE PLAN

1 : 750

REFERENCE DRAWINGS	REFERENCE MODELS

REV	DATE	REVISION DETAILS	REV	DRAWN	DESIGNED	VERIFIED	APPROVED
A	16.01.26	DRAFT 70% DETAILED DESIGN	A	V.NGUYEN	M.KADER	K.SOLEIMANI	T.JACKSON
B	18.02.26	70% DETAILED DESIGN	B	V.NGUYEN	M.KADER	K.SOLEIMANI	T.JACKSON
0	30.04.26	IFC	0	V.NGUYEN	M.KADER	K.SOLEIMANI	T.JACKSON

0 7.5 15 22.5 30 37.5m

SCALE 1:750 AT A1

All written dimensions take precedence over scaled dimensions.

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CERTIFICATION	NO.	CERTIFIER	DATE

CLIENT

yurika

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ABN 19 100 214 131

☎ 1300 792 611 ✉ hello@yurika.com.au

CLIENT DOCUMENT NUMBER	REV

Coordinate system MGA

Height datum AHD

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CONSTRUCTION STATUS: ISSUED FOR CONSTRUCTION

DRAWN BY: V.NGUYEN

DESIGNED BY: M.KADER

STATUS: IFC

CODE: W1

DOCUMENT STATE: PUBLISHED

PROJECT: BELLAMBI HEIGHTS BESS

TITLE: FIRE SERVICES OVERALL FIRE SERVICES PLAN

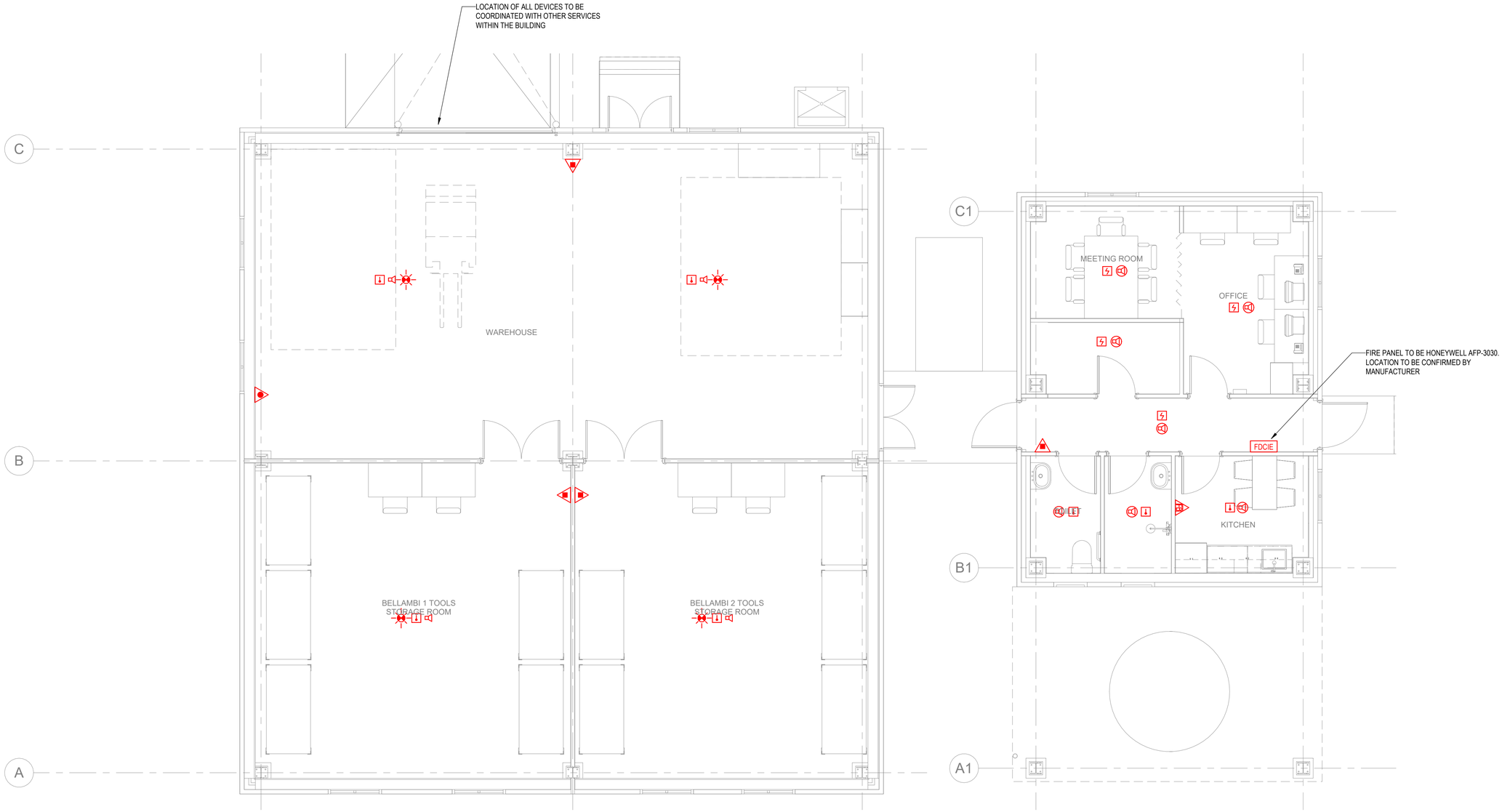
DOCUMENT CODE: BH-SCT-FFP-LAY-3307

SCALE	SIZE	REFERENCE No.	REV
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Plot Date: 30/04/2026 2:41:08 PM Office: FFP-LAY-3307 Filename: C:\Users\dominic.winter\Documents\BELLAMBI BESS F-AUR-RVT-R23_23.04_dominic.winter.rvt

NOTE:

- CONCEALED DETECTION SHALL BE PROVIDED AS PER AS1670.1 2018 (SUBJECT TO CEILING VOID).
- O&M BUILDING WITHIN THE SCOPE OF BUILDING MANUFACTURER. THIS DRAWING SETS THE MINIMUM REQUIREMENT.



BH FIRE DETECTION AND ALARM SYSTEM LAYOUT PLANS - O&M BUILDING

1 : 50

Plot Date: 30/04/2026 2:42:01 PM Office: FFP-LAY-3308 Filename: C:\Users\dominic.winter\Documents\BELLAMBI BESS-F1-AUR-R17-R23_23.0A_dominic.winter.rvt

REFERENCE DRAWINGS

REFERENCE MODELS

REV	DATE	REVISION DETAILS	REV	DRAWN	DESIGNED	VERIFIED	APPROVED
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B	18.02.26	70% DETAILED DESIGN	B	V.NGUYEN	M.KADER	K.SOLEIMANI	T.JACKSON
00	30.04.26	IFI	C	V.NGUYEN	M.KADER	K.SOLEIMANI	T.JACKSON

0 0.5 1 1.5 2 2.5m
SCALE 1:50 AT A1

All written dimensions take precedence over scaled dimensions.

PREPARED BY

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CERTIFICATION	NO.	CERTIFIER	DATE

CLIENT

yurika
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CLIENT DOCUMENT NUMBER	REV

Coordinate system MGA
Height datum AHD

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CONSTRUCTION STATUS
ISSUED FOR INFORMATION

DRAWN BY
V.NGUYEN

DESIGNED BY
M.KADER

STATUS	CODE
IFI	W1

DOCUMENT STATE
PUBLISHED

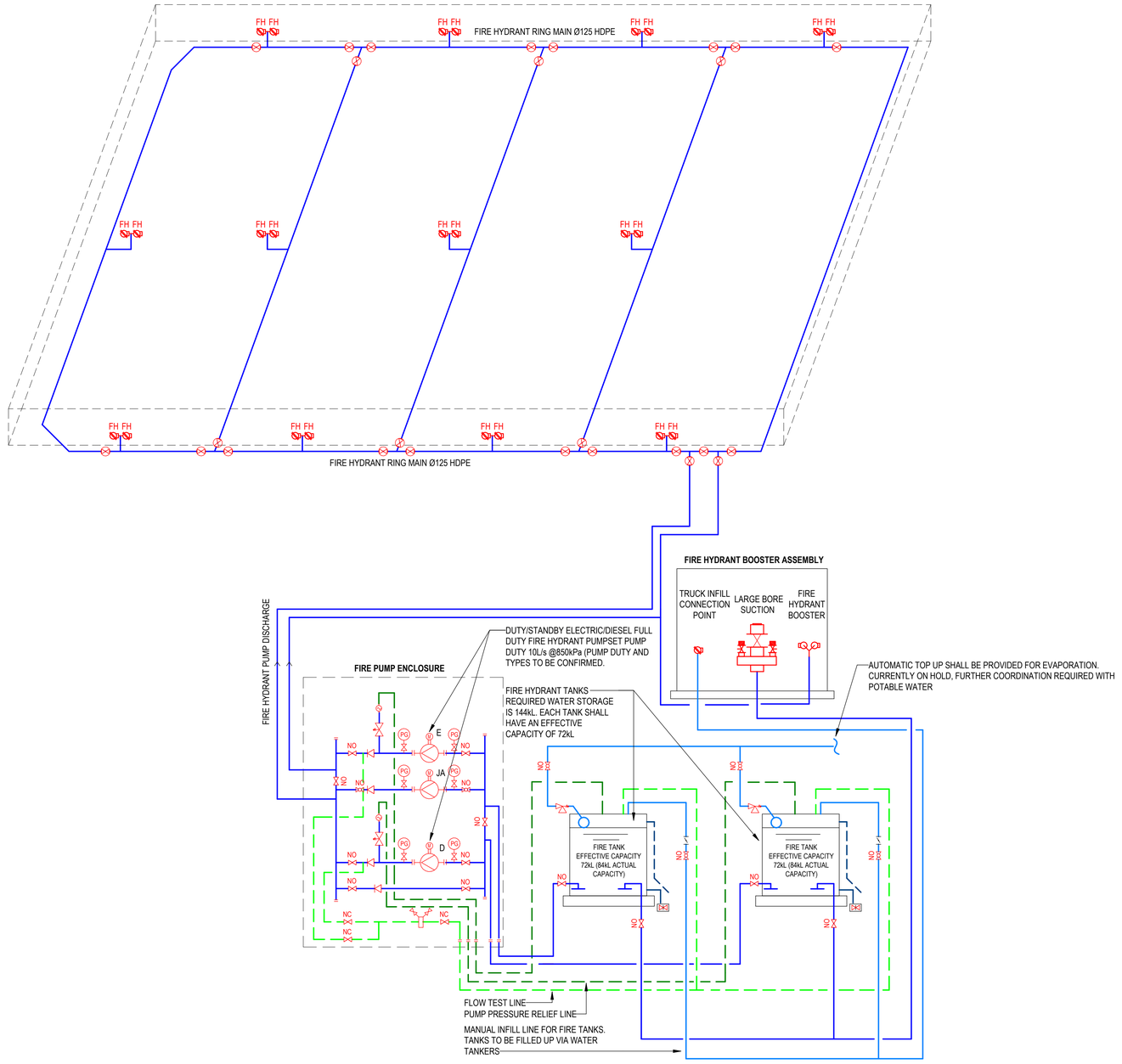
PROJECT
BELLAMBI HEIGHTS BESS

TITLE
FIRE SERVICES
O&M BUILDING
FIRE DETECTION AND ALARM LAYOUT

DOCUMENT CODE
BH-SCT-FFP-LAY-3308

SCALE	SIZE	REFERENCE No.	REV
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BELLAMBI HEIGHTS 1



Plot Date: 30/04/2026 2:28:34 PM Office: FFP-SCM-3315 Filename: C:\Users\dominic.winter\Documents\BELLAMBI BESS\F-FAUR.RVT R23_29.04_dominic.winter.rvt

REFERENCE DRAWINGS	REFERENCE MODELS

REV	DATE	REVISION DETAILS	REV	DRAWN	DESIGNED	VERIFIED	APPROVED
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0	30.04.26	IFC	0	V.NGUYEN	M.KADER	K.SOLEIMANI	T.JACKSON

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CERTIFICATION	NO.	CERTIFIER	DATE

CLIENT

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ABN 19 100 214 131
☎ 1300 792 611 ✉ hello@yurika.com.au

CLIENT DOCUMENT NUMBER	REV

Coordinate system MGA

Height datum AHD

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CONSTRUCTION STATUS
ISSUED FOR CONSTRUCTION

DRAWN BY
V.NGUYEN

DESIGNED BY
M.KADER

STATUS	CODE
IFC	W1

DOCUMENT STATE
PUBLISHED

PROJECT
BELLAMBI HEIGHTS BESS

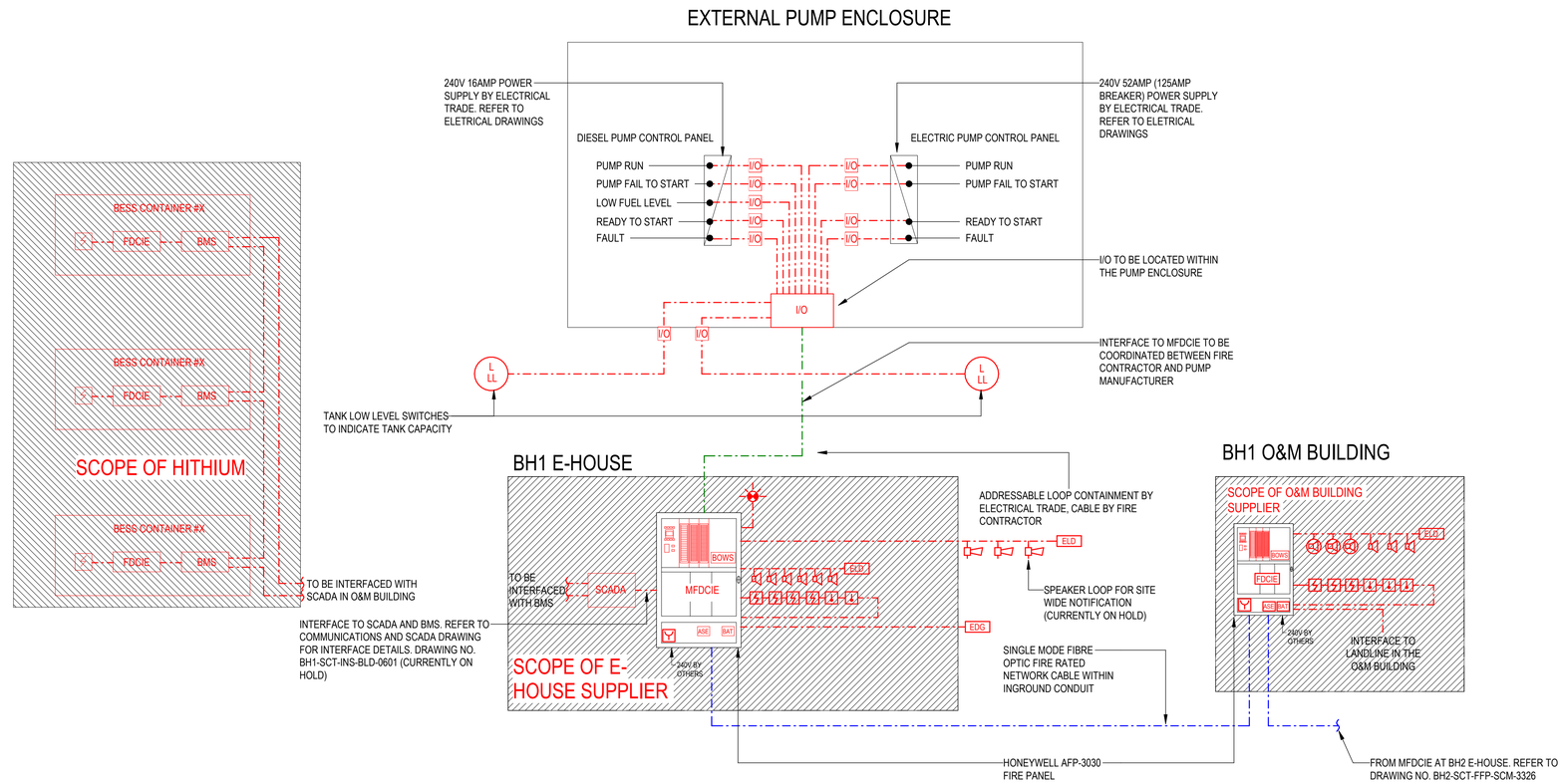
TITLE
FIRE SERVICES
BH1 FIRE HYDRANT SYSTEM
SCHEMATIC DIAGRAM

DOCUMENT CODE
BH1-SCT-FFP-SCM-3315

SCALE	SIZE	REFERENCE No.	REV
NTS	A1	FFP-SCM-3315	0

NOTE:

- IN-GROUND FIRE CABLE SHALL BE AS PER ELECTRICAL DRAWINGS.
REFER TO DRAWING NO. BH-SCT-ELE-LAY-0404.



INTERFACE	PROTOCOL	DIRECTION	SIGNAL NUMBER	SIGNAL DESCRIPTION	SIGNAL TYPE	NOTE
FDCIE-SCADA	MODBUS TCP	FDCIE -> SCADA	FP-01	COMMON FIRE ALARM	DIGITAL	
FDCIE-SCADA	MODBUS TCP	FDCIE -> SCADA	FP-02	COMMON FAULT	DIGITAL	
FDCIE-SCADA	MODBUS TCP	FDCIE -> SCADA	FP-03	COMMON ISOLATE	DIGITAL	
FDCIE-SCADA	MODBUS TCP	FDCIE -> SCADA	FP-04	FIRE PANEL HEALTY	DIGITAL	
FDCIE-SCADA	MODBUS TCP	FDCIE -> SCADA	FP-05	FIRE PUMP RUNNING	DIGITAL	
FDCIE-SCADA	MODBUS TCP	FDCIE -> SCADA	FP-06	FIRE PUMP FAILED	DIGITAL	
FDCIE-SCADA	MODBUS TCP	FDCIE -> SCADA	FP-07	POWER FAILED	DIGITAL	
FDCIE-SCADA	MODBUS TCP	SCADA -> FDCIE	FP-08	BATTERY CONTAINERS - COMMON FIRE ALARM	DIGITAL	

FDCIE - SCADA SIGNAL LIST

Plot Date: 30/04/2026 2:28:42 PM Office: FFP-SCM-331 Filename: C:\Users\dominic.winter\Documents\BELLAMBI BESS-FI-AUR-R\FFP-R23_29.04_dominic.winter.rvt

REFERENCE DRAWINGS

REFERENCE MODELS

REV	DATE	REVISION DETAILS	REV	DRAWN	DESIGNED	VERIFIED	APPROVED
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0	30.04.26	IFC	0	V.NGUYEN	M.KADER	K.SOLEIMANI	T.JACKSON

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CERTIFICATION	NO.	CERTIFIER	DATE

CLIENT

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☎ 1300 792 611 ✉ hello@yurika.com.au

CLIENT DOCUMENT NUMBER	REV

Coordinate system
MGA

Height datum
AHD

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CONSTRUCTION STATUS
ISSUED FOR CONSTRUCTION

DRAWN BY
V.NGUYEN

DESIGNED BY
M.KADER

STATUS IFC | **CODE** W1

DOCUMENT STATE
PUBLISHED

PROJECT
BELLAMBI HEIGHTS BESS

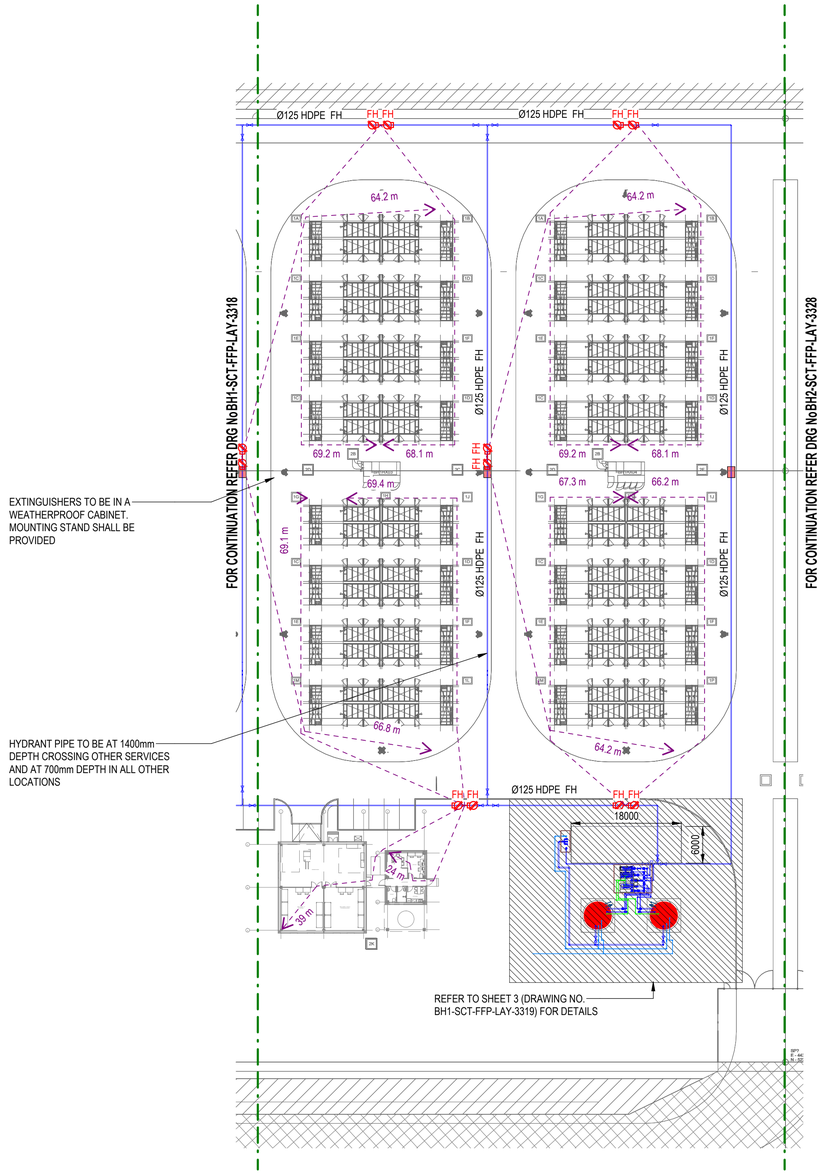
TITLE
FIRE SERVICES
BH1 FIRE DETECTION & ALARM
SCHEMATIC DIAGRAM

DOCUMENT CODE
BH1-SCT-FFP-SCM-3316

SCALE	SIZE	REFERENCE No.	REV
NTS	A1	FFP-SCM-3316	0

NOTE:

- O&M BUILDING IS COVERED VIA EXTERNAL HYDRANT AS PER AS 2419.1 - 2021.



BH1 FIRE HYDRANT LAYOUT - SHEET 1

1 : 500

Plot Date: 30/04/2026 2:25:41 PM Office: FFP-LAY-3317Filename: C:\Users\dominic.writer\Documents\BELLAMBI BESS-FAUR-RVT-R23_29.04_dominic.writer.rvt

REFERENCE DRAWINGS	REFERENCE MODELS

REV	DATE	REVISION DETAILS	REV	DRAWN	DESIGNED	VERIFIED	APPROVED
A	16.01.26	DRAFT 70% DETAILED DESIGN	A	V.NGUYEN	M.KADER	K.SOLEIMANI	T.JACKSON
B	18.02.26	70% DETAILED DESIGN	B	V.NGUYEN	M.KADER	K.SOLEIMANI	T.JACKSON
0	30.04.26	IFC	0	V.NGUYEN	M.KADER	K.SOLEIMANI	T.JACKSON

0 5 10 15 20 25m
SCALE 1:500 AT A1

All written dimensions take precedence over scaled dimensions.

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CERTIFICATION	NO.	CERTIFIER	DATE	CLIENT DOCUMENT NUMBER	REV

Coordinate system MGA
Height datum AHD

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CONSTRUCTION STATUS	PROJECT
ISSUED FOR CONSTRUCTION	BELLAMBI HEIGHTS BESS

DRAWN BY	TITLE
V.NGUYEN	FIRE SERVICES BH1 FIRE HYDRANT LAYOUT SHEET 1

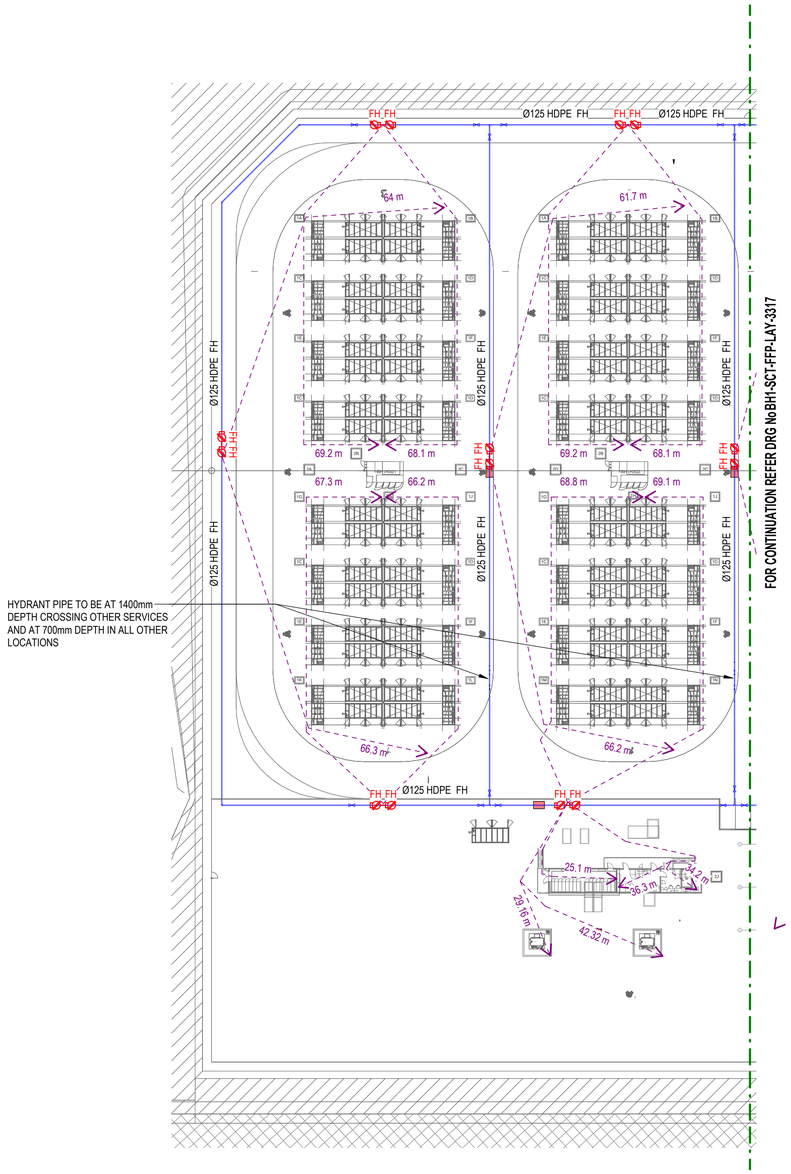
DESIGNED BY		
M.KADER		

STATUS	CODE	DOCUMENT CODE
IFC	W1	BH1-SCT-FFP-LAY-3317

DOCUMENT STATE	SCALE	SIZE	REFERENCE No.	REV
PUBLISHED	1 : 500	A1	FFP-LAY-3317	0

NOTE:

- E-HOUSE IS COVERED VIA EXTERNAL HYDRANT AS PER AS 2419.1 - 2021.



BH1 FIRE HYDRANT LAYOUT - SHEET 2

1 : 500

Plot Date: 30/04/2026 2:26:20 PM Office: FFP-LAY-3318 Filename: C:\Users\dominic.winter\Documents\BELLAMBI BESS\ F-AU\R\RVT-R23_23\04_dominic.winter.rvt

REFERENCE DRAWINGS	REFERENCE MODELS

REV	DATE	REVISION DETAILS	REV	DRAWN	DESIGNED	VERIFIED	APPROVED
A	16.01.26	DRAFT 70% DETAILED DESIGN	A	V.NGUYEN	M.KADER	K.SOLEIMANI	T.JACKSON
B	18.02.26	70% DETAILED DESIGN	B	V.NGUYEN	M.KADER	K.SOLEIMANI	T.JACKSON
0	30.04.26	IFC	0	V.NGUYEN	M.KADER	K.SOLEIMANI	T.JACKSON

0 5 10 15 20 25m
SCALE 1:500 AT A1

All written dimensions take precedence over scaled dimensions.

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CERTIFICATION	NO.	CERTIFIER	DATE

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CLIENT DOCUMENT NUMBER	REV

Coordinate system MGA
Height datum AHD

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CONSTRUCTION STATUS
ISSUED FOR CONSTRUCTION

DRAWN BY
V.NGUYEN

DESIGNED BY
M.KADER

STATUS	CODE
IFC	W1

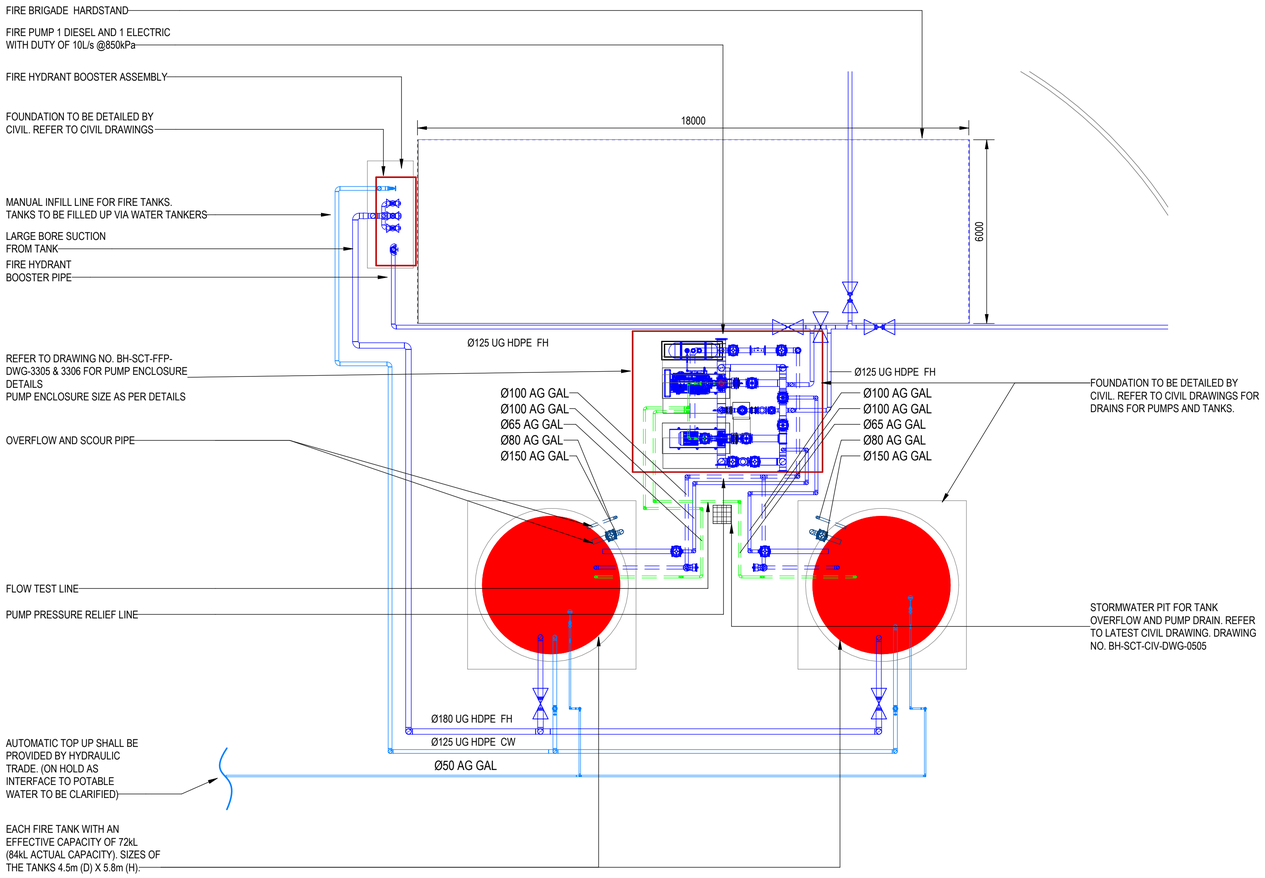
DOCUMENT STATE
PUBLISHED

PROJECT
BELLAMBI HEIGHTS BESS

TITLE
FIRE SERVICES BH1 FIRE HYDRANT LAYOUT SHEET 2

DOCUMENT CODE
BH1-SCT-FFP-LAY-3318

SCALE	SIZE	REFERENCE No.	REV
1 : 500	A1	FFP-LAY-3318	0



BH1 FIRE HYDRANT LAYOUT - SHEET 3

1 : 100

Plot Date: 30/04/2026 2:26:35 PM Office: FFP-LAY-3319Filename: C:\Users\dominic.writer\Documents\BELLAMBI BESS\FFP\AUR\RVT-R23_25\04_dominic.writer.rvt

REFERENCE DRAWINGS	REFERENCE MODELS

REV	DATE	REVISION DETAILS	REV	DRAWN	DESIGNED	VERIFIED	APPROVED
A	16.01.26	DRAFT 70% DETAILED DESIGN	A	V.NGUYEN	M.KADER	K.SOLEIMANI	T.JACKSON
B	18.02.26	70% DETAILED DESIGN	B	V.NGUYEN	M.KADER	K.SOLEIMANI	T.JACKSON
0	30.04.26	IFC	0	V.NGUYEN	M.KADER	K.SOLEIMANI	T.JACKSON

0 1 2 3 4 5m
SCALE 1:100 AT A1

All written dimensions take precedence over scaled dimensions.

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CERTIFICATION	NO.	CERTIFIER	DATE

CLIENT

yurika
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ABN 19 100 214 131
☎ 1300 792 611 ✉ hello@yurika.com.au

CLIENT DOCUMENT NUMBER	REV

Coordinate system MGA
Height datum AHD

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CONSTRUCTION STATUS
ISSUED FOR CONSTRUCTION

DRAWN BY	DESIGNED BY
V.NGUYEN	M.KADER

STATUS	CODE
IFC	W1

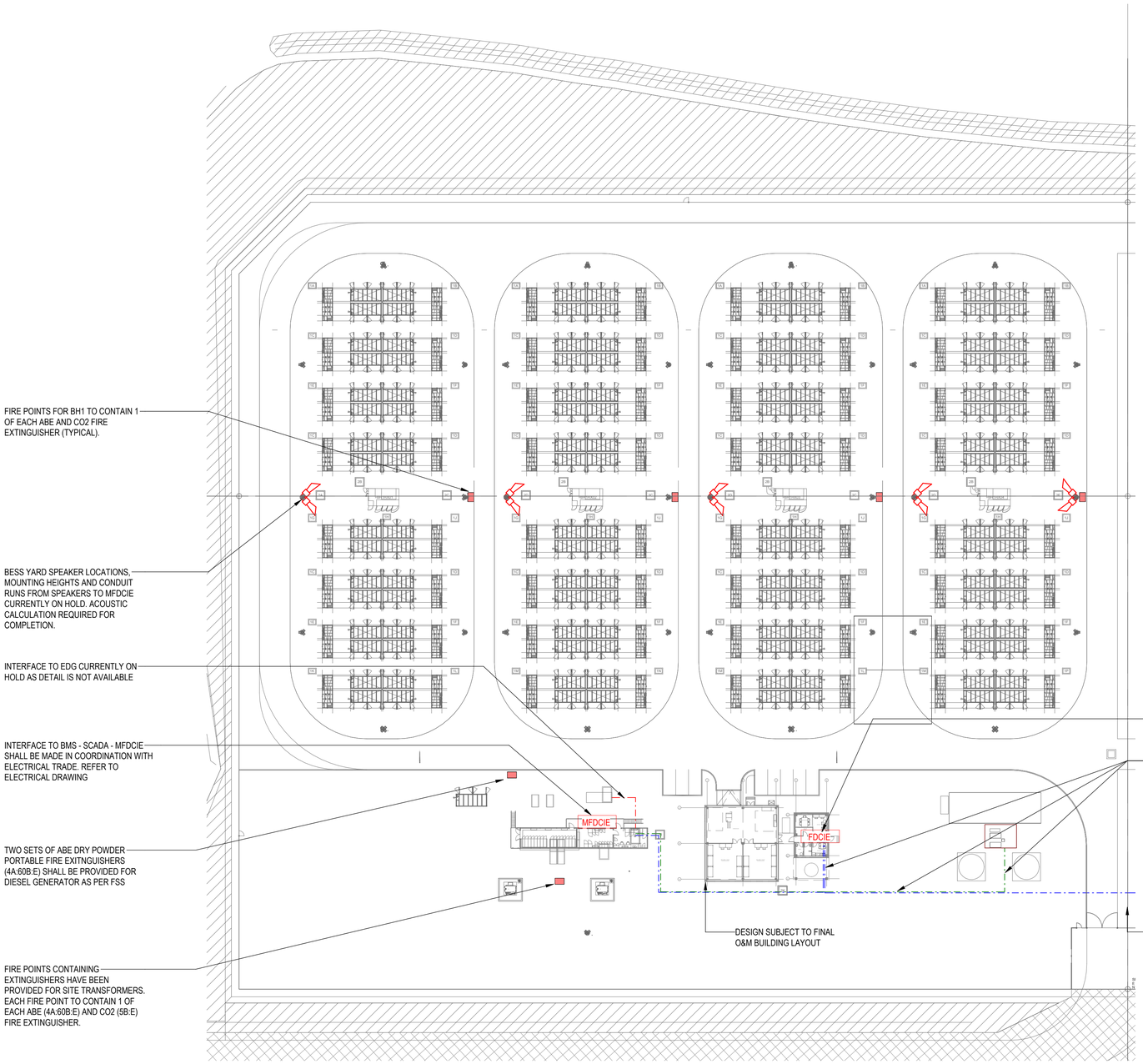
DOCUMENT STATE
PUBLISHED

PROJECT
BELLAMBI HEIGHTS BESS

TITLE
FIRE SERVICES BH1 FIRE HYDRANT LAYOUT SHEET 3

DOCUMENT CODE
BH1-SCT-FFP-LAY-3319

SCALE	SIZE	REFERENCE No.	REV
1 : 100	A1	FFP-LAY-3319	0



BH1 BESS AREA DRY FIRE LAYOUT

1 : 500

Plot Date: 30/04/2026 3:59:24 PM Office: FFPJ-LAY-3320 Filename: C:\Users\dominic.winter\Downloads\BELLAMBI BESS-FFAUR-RVT-R23_30.RA14

REFERENCE DRAWINGS

REFERENCE MODELS

REV	DATE	REVISION DETAILS	REV	DRAWN	DESIGNED	VERIFIED	APPROVED
A	16.01.26	DRAFT 70% DETAILED DESIGN	A	V.NGUYEN	M.KADER	K.SOLEIMANI	T.JACKSON
B	18.02.26	70% DETAILED DESIGN	B	V.NGUYEN	M.KADER	K.SOLEIMANI	T.JACKSON
0	30.04.26	IFC	0	V.NGUYEN	M.KADER	K.SOLEIMANI	T.JACKSON

0 5 10 15 20 25m

SCALE 1:500 AT A1

All written dimensions take precedence over scaled dimensions.

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CERTIFICATION	NO.	CERTIFIER	DATE

CLIENT

yurika

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CLIENT DOCUMENT NUMBER	REV

Coordinate system MGA

Height datum AHD

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CONSTRUCTION STATUS

ISSUED FOR CONSTRUCTION

DRAWN BY V.NGUYEN

DESIGNED BY M.KADER

STATUS	CODE
IFC	W1

DOCUMENT STATE

PUBLISHED

PROJECT

BELLAMBI HEIGHTS BESS

TITLE

FIRE SERVICES
BH1 BESS AREA
DRY FIRE LAYOUT

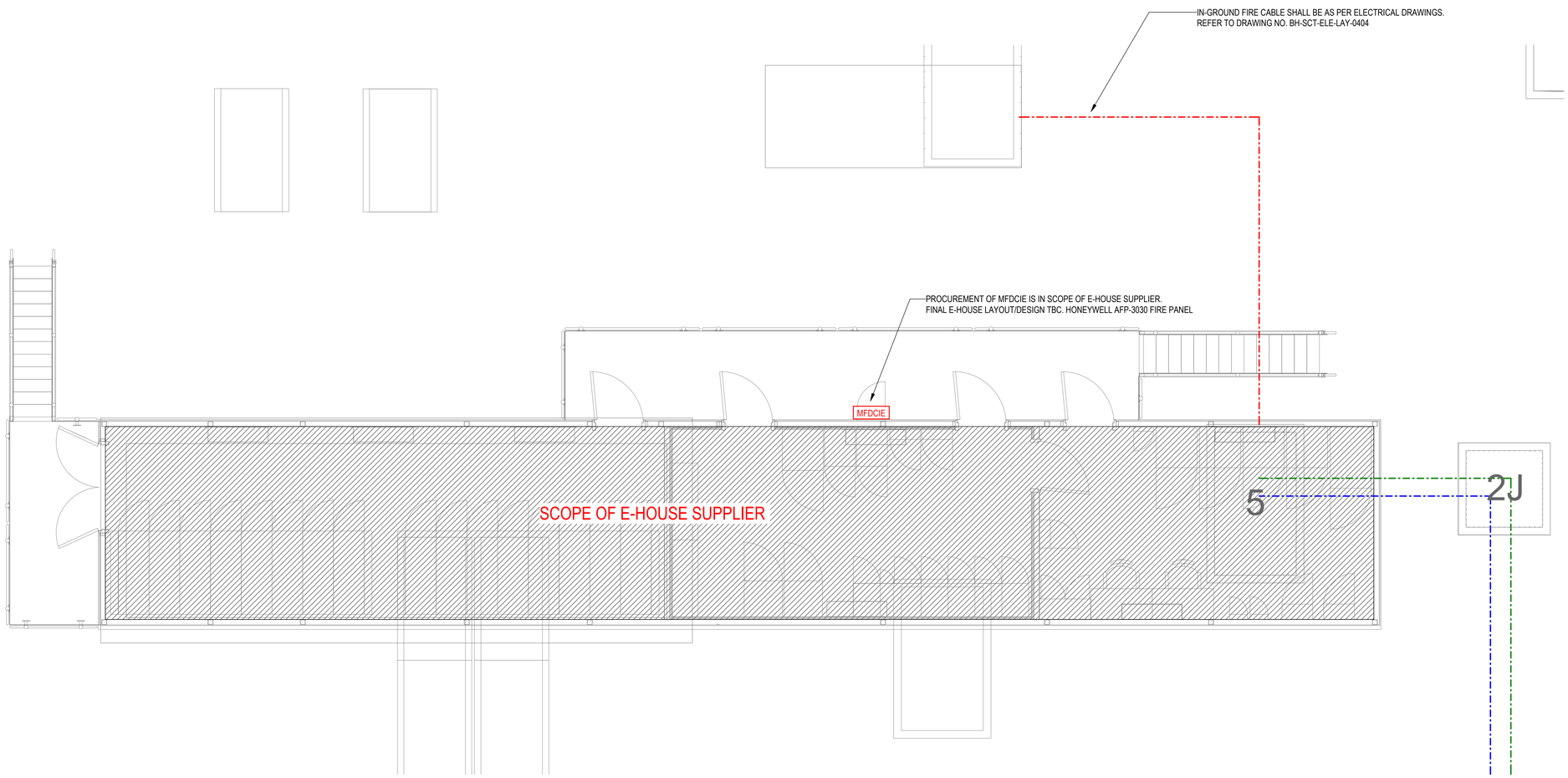
DOCUMENT CODE

BH1-SCT-FFP-LAY-3320

SCALE	SIZE	REFERENCE No.	REV
1 : 500	A1	FFP-LAY-3320	0

NOTE:

- INTERNAL FIRE SERVICES ARE SCOPE OF THE E-HOUSE SUPPLIER.
- MFDCIE OUTSIDE E-HOUSE TO BE INSIDE AN IP66 CABINETS.



BH1 E-HOUSE FIRE DETECTION AND ALARM LAYOUT

1 : 50

Plot Date: 30/04/2026 2:29:28 PM Office: FFP-LAY-3321 Filename: C:\Users\dominic.winter\Documents\BELLAMBI BESS F-AUR-RVT-R23_29.04_dominic.winter.rvt

REFERENCE DRAWINGS

REFERENCE MODELS

REV	DATE	REVISION DETAILS	REV	DRAWN	DESIGNED	VERIFIED	APPROVED
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0	30.04.26	IFC	0	V.NGUYEN	M.KADER	K.SOLEIMANI	T.JACKSON

0 0.5 1 1.5 2 2.5m
SCALE 1:50 AT A1

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PREPARED BY

aurecon
www.aurecongroup.com

CERTIFICATION	NO.	CERTIFIER	DATE

CLIENT

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DESIGNED BY
M.KADER

STATUS	CODE
IFC	W1

DOCUMENT STATE
PUBLISHED

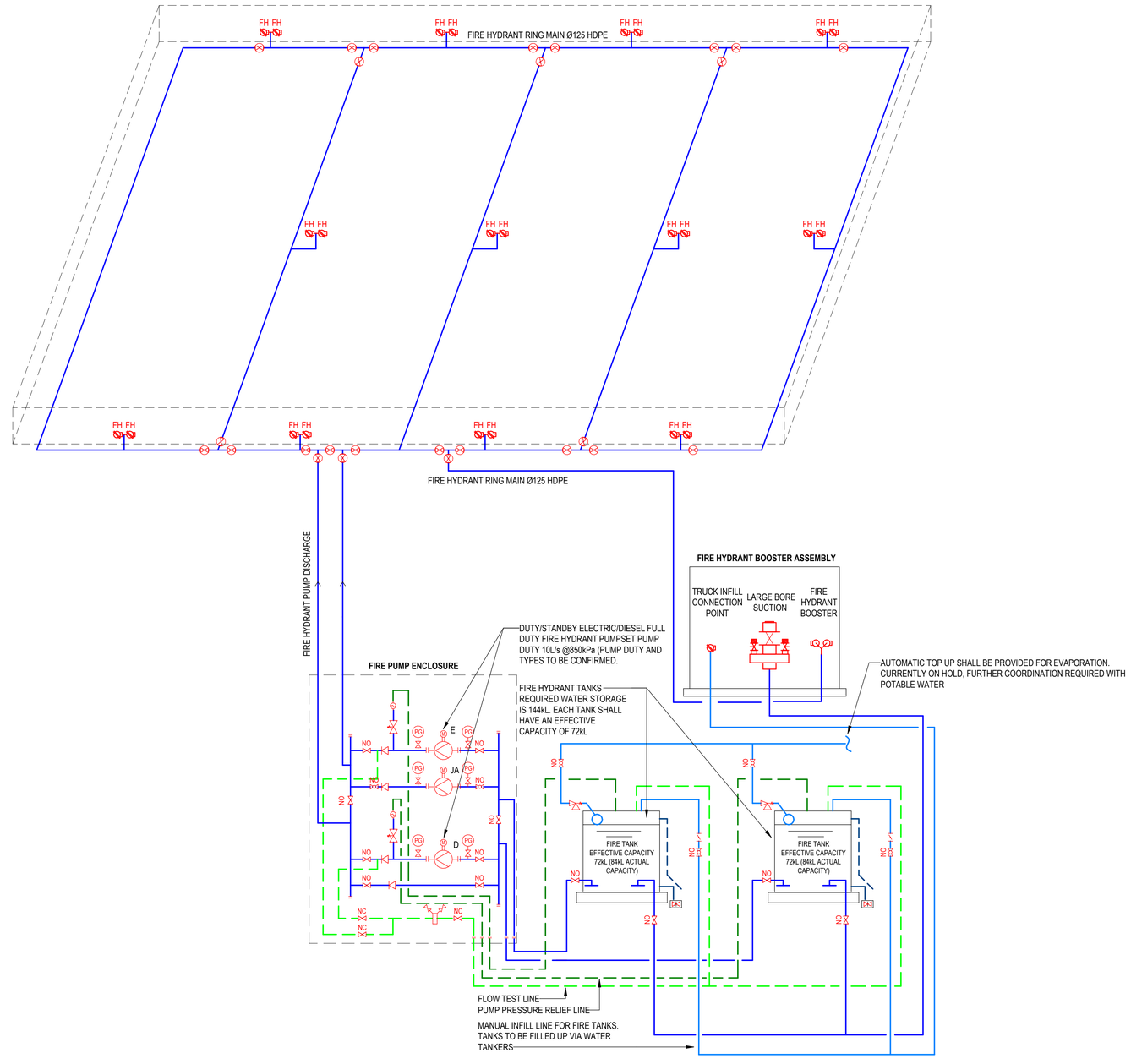
PROJECT
BELLAMBI HEIGHTS BESS

TITLE
FIRE SERVICES
BH1 E-HOUSE
FIRE DETECTION AND ALARM LAYOUT

DOCUMENT CODE
BH1-SCT-FFP-LAY-3321

SCALE	SIZE	REFERENCE No.	REV
1 : 50	A1	FFP-LAY-3321	0

BELLAMBI HEIGHTS 2



Plot Date: 30/04/2026 2:37:07 PM Office: FFP-SCM-3325 Filename: C:\Users\dominic.winter\Documents\BELLAMBI BESS-F1-AUR-RVT-R23_23.0A_dominic.winter.rvt

REFERENCE DRAWINGS

REFERENCE MODELS

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B	18.02.26	70% DETAILED DESIGN	B	V.NGUYEN	M.KADER	K.SOLEIMANI	T.JACKSON
0	30.04.26	IFC	0	V.NGUYEN	M.KADER	K.SOLEIMANI	T.JACKSON

All written dimensions take precedence over scaled dimensions.

PREPARED BY

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CERTIFICATION	NO.	CERTIFIER	DATE

CLIENT

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CLIENT DOCUMENT NUMBER	REV

Coordinate system MGA
Height datum AHD

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CONSTRUCTION STATUS
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DRAWN BY
V.NGUYEN

DESIGNED BY
M.KADER

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DOCUMENT STATE
PUBLISHED

PROJECT
BELLAMBI HEIGHTS BESS

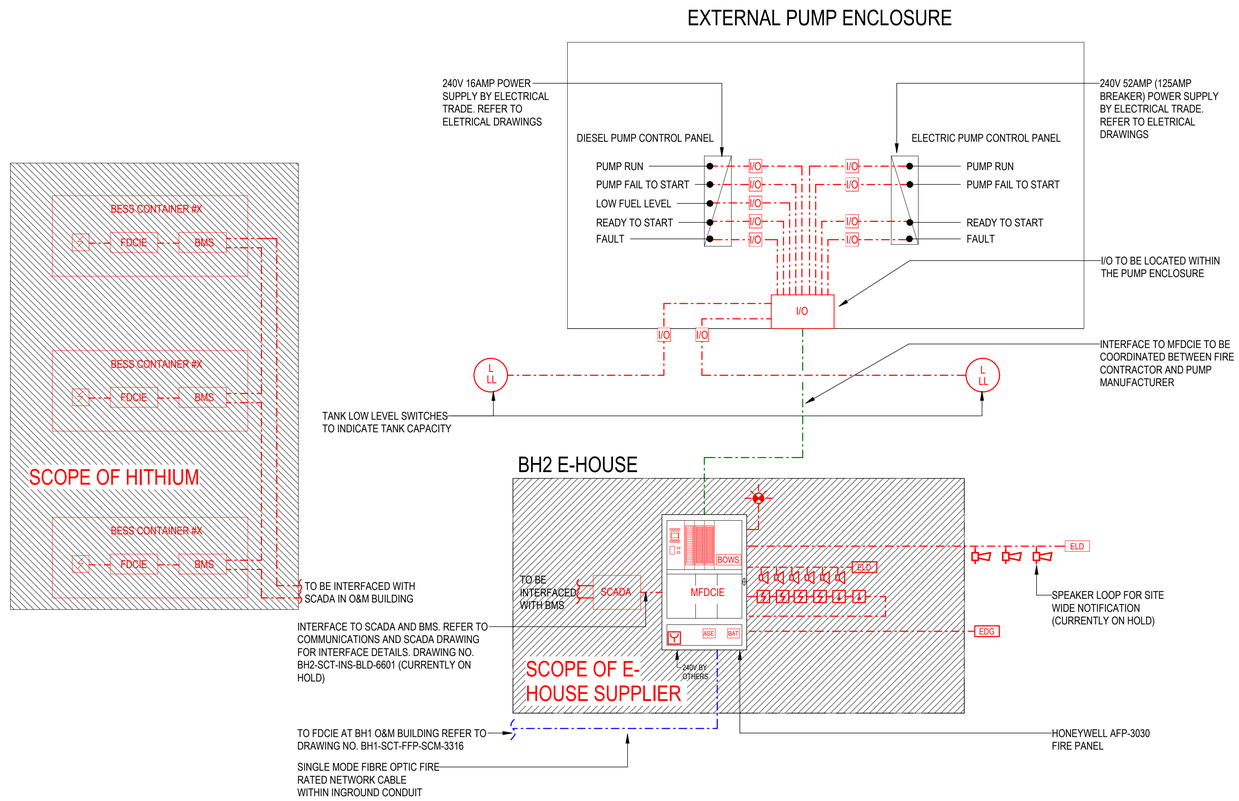
TITLE
FIRE SERVICES
BH2 FIRE HYDRANT SYSTEM
SCHEMATIC DIAGRAM

DOCUMENT CODE
BH2-SCT-FFP-SCM-3325

SCALE	SIZE	REFERENCE No.	REV
NTS	A1	FFP-SCM-3325	0

NOTE:

- IN-GROUND FIRE CABLE SHALL BE AS PER ELECTRICAL DRAWINGS.
REFER TO DRAWING NO. BH-SCT-ELE-LAY-0404.



INTERFACE	PROTOCOL	DIRECTION	SIGNAL NUMBER	SIGNAL DESCRIPTION	SIGNAL TYPE	NOTE
FDCIE-SCADA	MODBUS TCP	FDCIE -> SCADA	FP-01	COMMON FIRE ALARM	DIGITAL	
FDCIE-SCADA	MODBUS TCP	FDCIE -> SCADA	FP-02	COMMON FAULT	DIGITAL	
FDCIE-SCADA	MODBUS TCP	FDCIE -> SCADA	FP-03	COMMON ISOLATE	DIGITAL	
FDCIE-SCADA	MODBUS TCP	FDCIE -> SCADA	FP-04	FIRE PANEL HEALTY	DIGITAL	
FDCIE-SCADA	MODBUS TCP	FDCIE -> SCADA	FP-05	FIRE PUMP RUNNING	DIGITAL	
FDCIE-SCADA	MODBUS TCP	FDCIE -> SCADA	FP-06	FIRE PUMP FAILED	DIGITAL	
FDCIE-SCADA	MODBUS TCP	FDCIE -> SCADA	FP-07	POWER FAILED	DIGITAL	
FDCIE-SCADA	MODBUS TCP	SCADA -> FDCIE	FP-08	BATTERY CONTAINERS - COMMON FIRE ALARM	DIGITAL	

FDCIE - SCADA SIGNAL LIST

Plot Date: 30/04/2026 2:37:15 PM Office: FFP-SCM-3326Filename: C:\Users\dominic.winter\Documents\BELLAMBI BESS-FAUR-RVT-R23_29.04_dominic.winter.rvt

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0	30.04.26	IFC	0	V.NGUYEN	M.KADER	K.SOLEIMANI	T.JACKSON

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Height datum
AHD

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CONSTRUCTION STATUS
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DRAWN BY
V.NGUYEN

DESIGNED BY
M.KADER

STATUS
IFC

CODE
W1

DOCUMENT STATE
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PROJECT
BELLAMBI HEIGHTS BESS

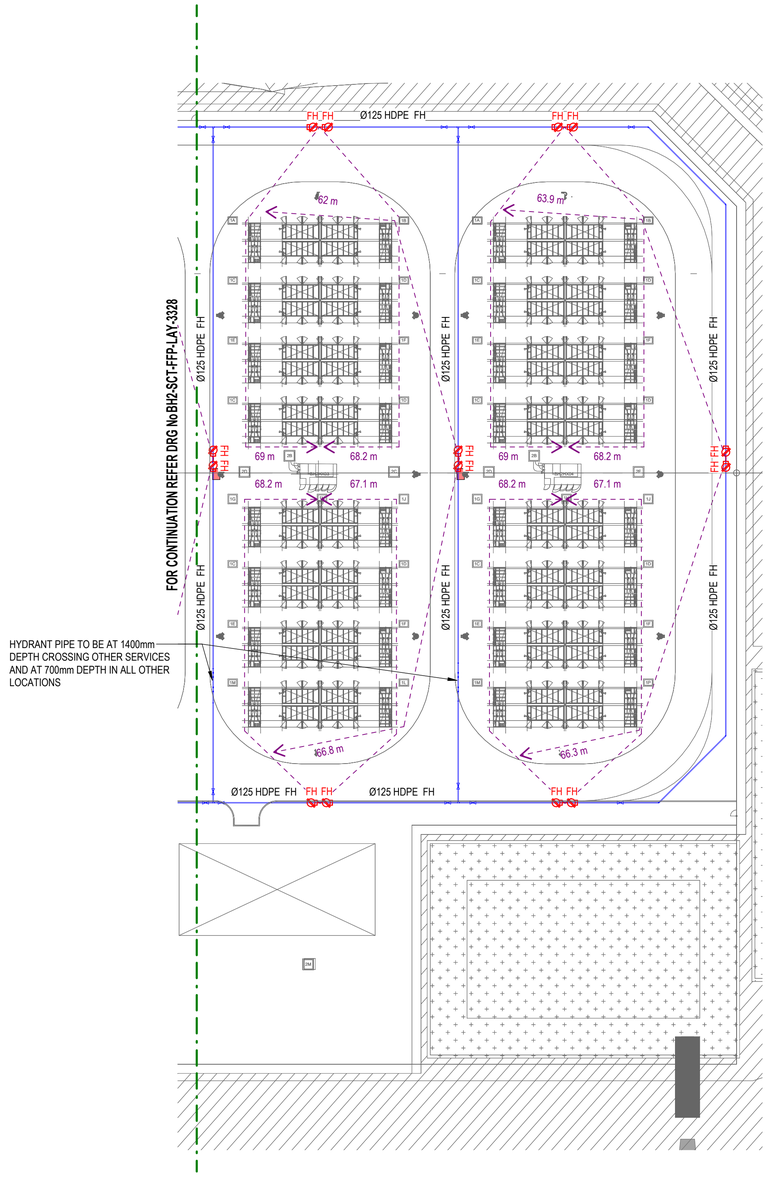
TITLE
FIRE SERVICES
BH2 FIRE DETECTION & ALARM
SCHEMATIC DIAGRAM

DOCUMENT CODE
BH2-SCT-FFP-SCM-3326

SCALE	SIZE	REFERENCE No.	REV
NTS	A1	FFP-SCM-3326	0

NOTE:

- O&M BUILDING IS COVERED VIA EXTERNAL HYDRANT AS PER AS 2419.1 - 2021



BH2 FIRE HYDRANT LAYOUT - SHEET 1

1 : 500

Plot Date: 30/04/2026 2:30:58 PM Office: FFP-LAY-3327 Filename: C:\Users\dominic.winter\Documents\BELLAMBI BESS\FFP-AUR-RVT-R23_29.04_dominic.winter.rvt

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0	30.04.26	IFC	0	V.NGUYEN	M.KADER	K.SOLEIMANI	T.JACKSON

0 5 10 15 20 25m

SCALE 1:500 AT A1

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M.KADER

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IFC	W1

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PROJECT
BELLAMBI HEIGHTS BESS

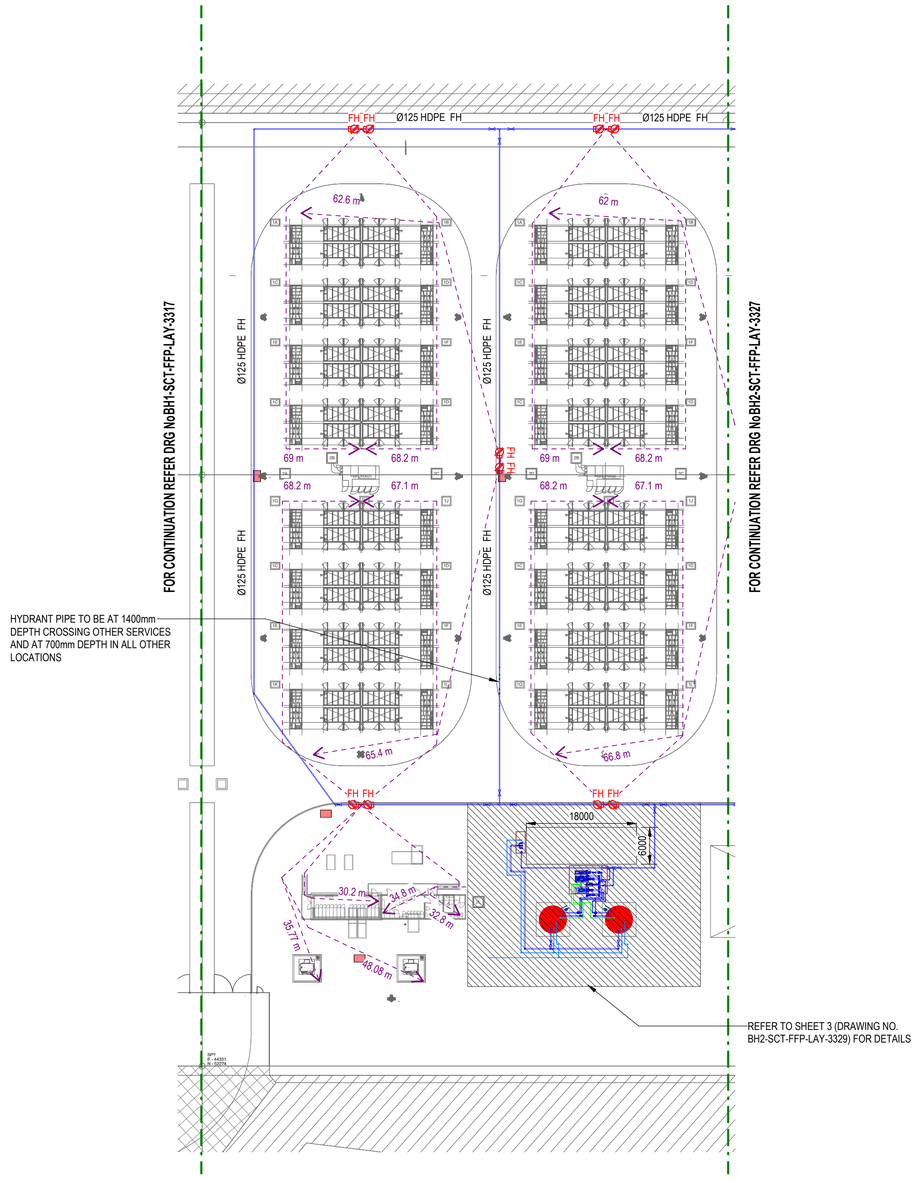
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FIRE SERVICES BH2 FIRE HYDRANT LAYOUT SHEET 1

DOCUMENT CODE
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NOTE:

- E-HOUSE IS COVERED VIA EXTERNAL HYDRANT AS PER AS 2419.1 - 2021
- LAYOUT OF E-HOUSE TO BE FINALISED AS DESIGN PROGRESSES



BH2 FIRE HYDRANT LAYOUT - SHEET 2

1 : 500

Plot Date: 30/04/2026 2:33:37 PM Office: FFP-LAY-3328 Filename: C:\Users\dominic.winter\Documents\BELLAMBI BESS-FI-AUR-R9T-R23_29.f4_dominic.winter.rvt

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0	30.04.26	IFC	0	V.NGUYEN	M.KADER	K.SOLEIMANI	T.JACKSON

0 5 10 15 20 25m
SCALE 1:500 AT A1

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STATUS	CODE
IFC	W1

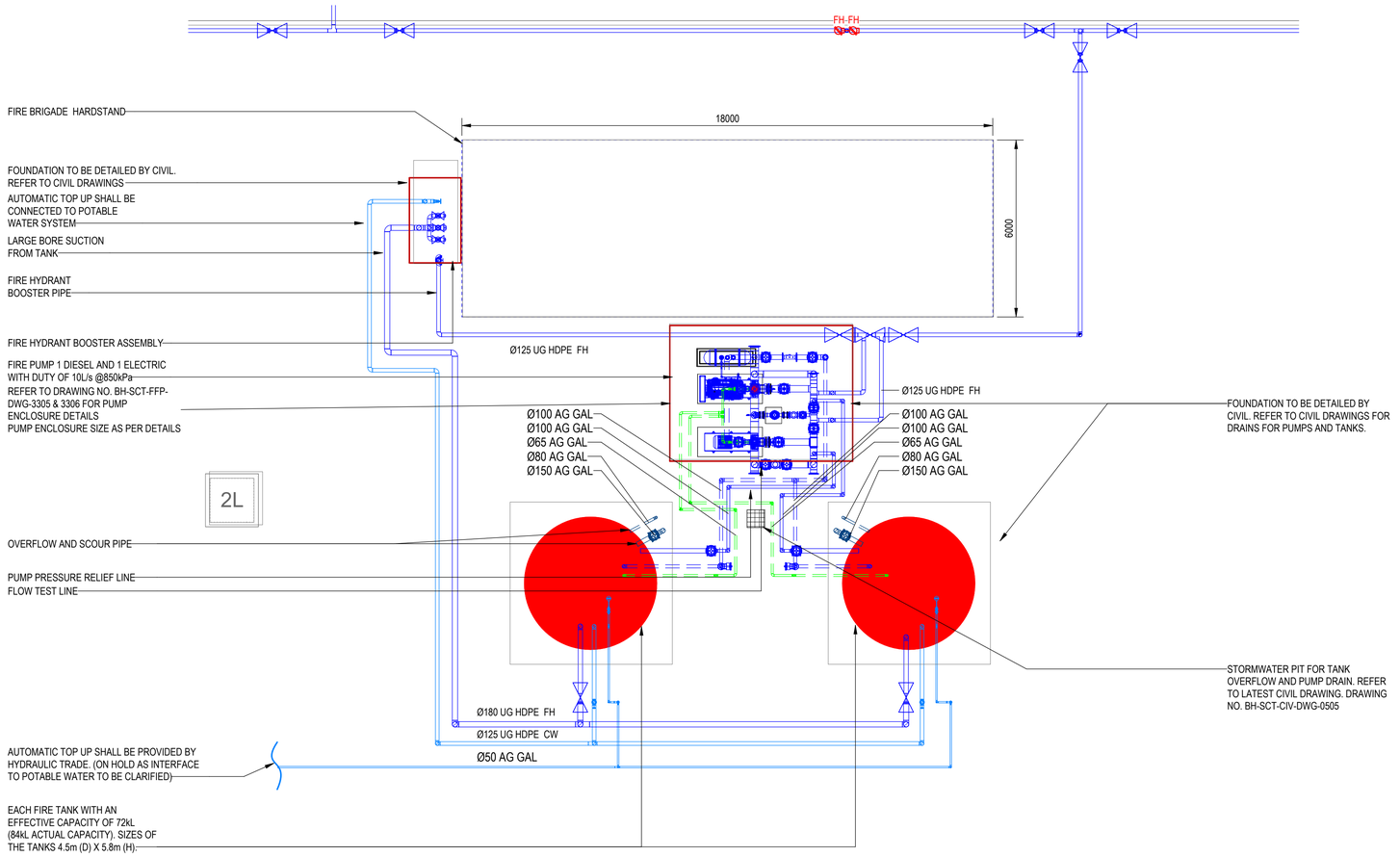
DOCUMENT STATE
PUBLISHED

PROJECT
BELLAMBI HEIGHTS BESS

TITLE
FIRE SERVICES BH2 FIRE HYDRANT LAYOUT SHEET 2

DOCUMENT CODE
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SCALE	SIZE	REFERENCE No.	REV
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BH2 FIRE HYDRANT LAYOUT - SHEET 3

1 : 100

Plot Date: 30/04/2026 2:34:31 PM
Office: FFP-LAY-3329 Filename: C:\Users\dominic.winter\Documents\BELLAMBI BESS-F1-AUR-R17-R23_29.04_dominic.winter.rvt

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0	30.04.26	IFC	0	V.NGUYEN	M.KADER	K.SOLEIMANI	T.JACKSON

0 1 2 3 4 5m
SCALE 1:100 AT A1

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Height datum
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DESIGNED BY
M.KADER

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IFC	W1

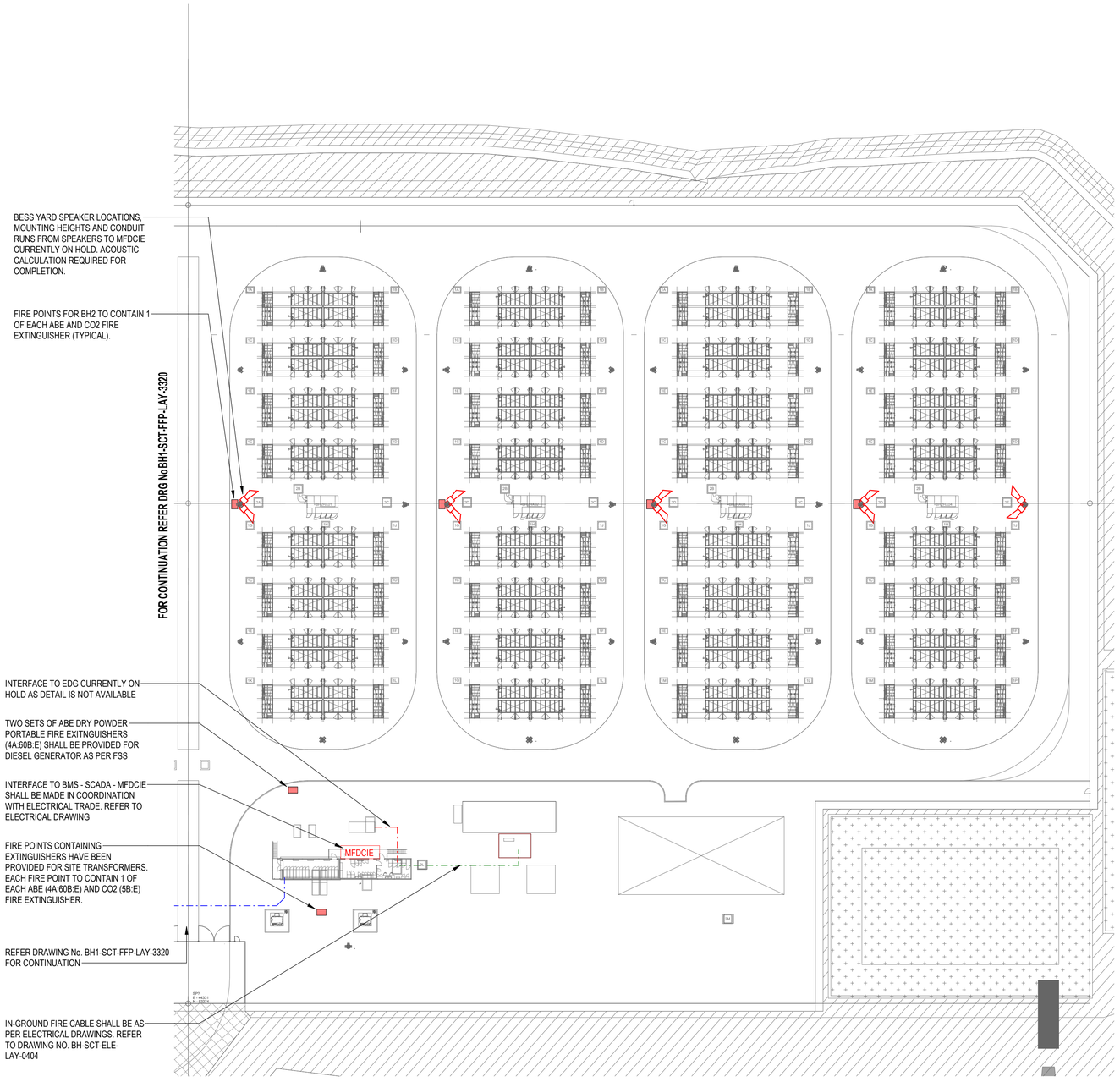
DOCUMENT STATE
PUBLISHED

PROJECT
BELLAMBI HEIGHTS BESS

TITLE
FIRE SERVICES
BH2 FIRE HYDRANT LAYOUT
SHEET 3

DOCUMENT CODE
BH2-SCT-FFP-LAY-3329

SCALE	SIZE	REFERENCE No.	REV
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BH2 BESS AREA DRY FIRE LAYOUT

1 : 500

Plot Date: 30/04/2026 2:26:25 PM Office: FFP-LAY-3330 Filename: C:\Users\dominic.winter\Documents\BELLAMBI BESS F-FAUR-RVT-R23_29.04_dominic.winter.rvt

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0	30.04.26	IFC	0	V.NGUYEN	M.KADER	K.SOLEIMANI	T.JACKSON

0 5 10 15 20 25m

SCALE 1:500 AT A1

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DESIGNED BY

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STATUS	CODE
IFC	W1

DOCUMENT STATE

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PROJECT

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TITLE

FIRE SERVICES
BH2 BESS AREA
DRY FIRE LAYOUT

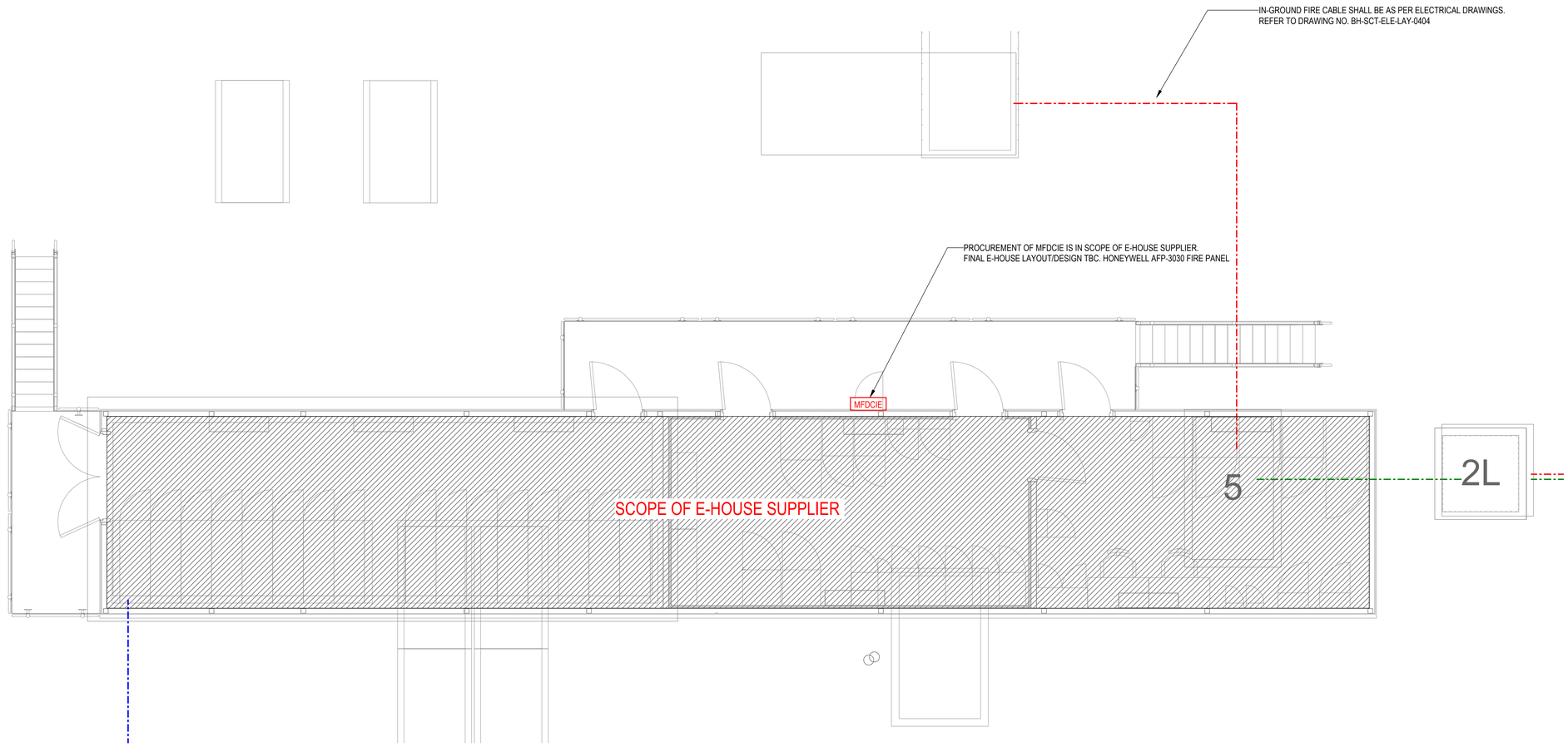
DOCUMENT CODE

BH2-SCT-FFP-LAY-3330

SCALE	SIZE	REFERENCE No.	REV
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NOTE:

- INTERNAL FIRE SERVICES ARE SCOPE OF THE E-HOUSE SUPPLIER.
- MFDCIE OUTSIDE E-HOUSE TO BE INSIDE AN IP66 CABINETS.



BH2 E-HOUSE FIRE DETECTION AND ALARM LAYOUT

1 : 50

Plot Date: 30/04/2026 2:37:01 PM Office: FFP-LAY-3331 Filename: C:\Users\dominic.winter\Documents\BELLAMBI BESS F1-AUR-R1T-R23_2B3A_dominic.winter.rvt

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B	18.02.26	70% DETAILED DESIGN	B	V.NGUYEN	M.KADER	K.SOLEIMANI	T.JACKSON
0	30.04.26	IFC	0	V.NGUYEN	M.KADER	K.SOLEIMANI	T.JACKSON

0 0.5 1 1.5 2 2.5m
SCALE 1:50 AT A1

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STATUS	CODE
IFC	W1

DOCUMENT STATE
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PROJECT
BELLAMBI HEIGHTS BESS

TITLE
FIRE SERVICES BH2 E-HOUSE FIRE DETECTION AND ALARM LAYOUT

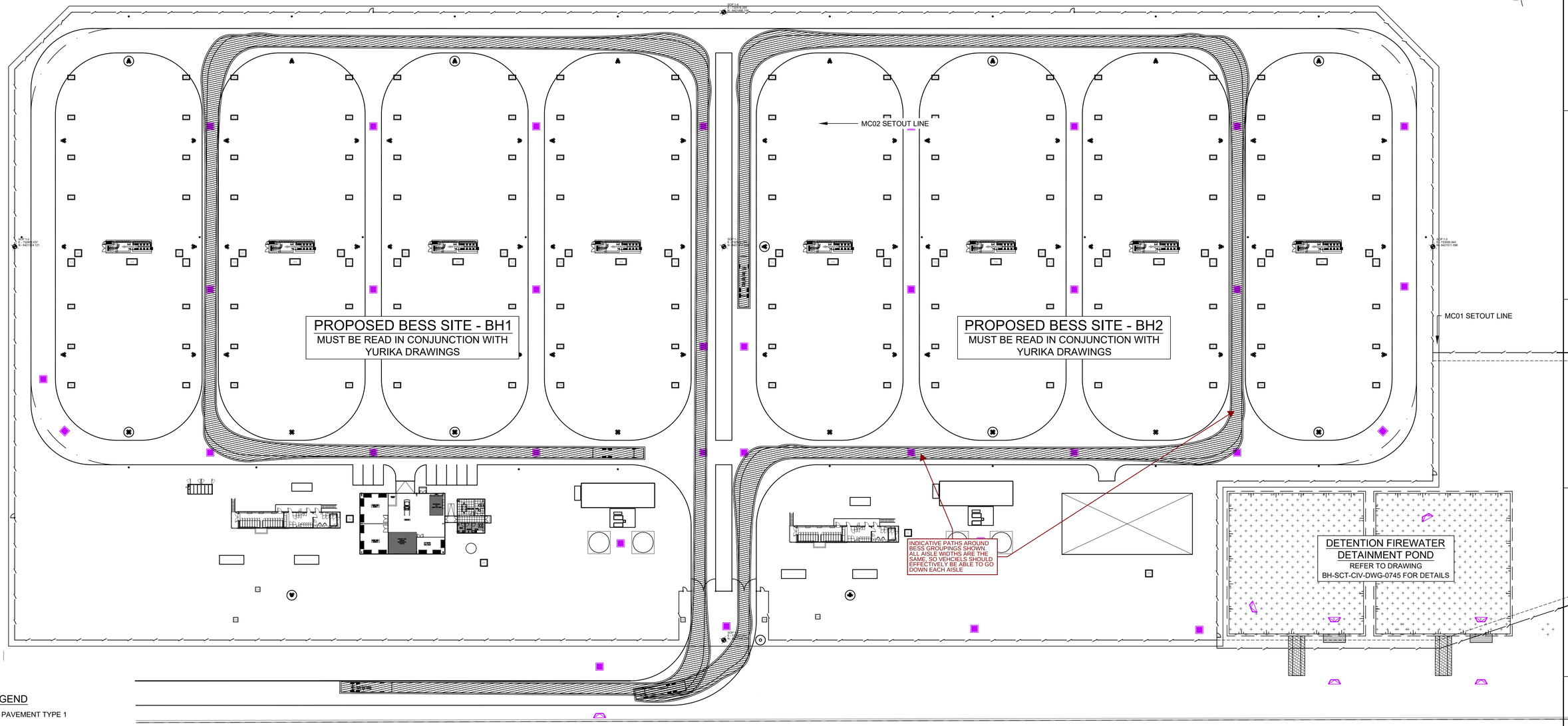
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SCALE	SIZE	REFERENCE No.	REV
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Appendix E. Fire Truck Access

E.1. Swept Path Analysis

E.1.1. Refer to the following inserted pdf pages for the swept path analysis



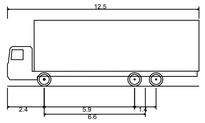
FIRE TRUCK VEHICLE PATH PLAN
1:500 AT A1

PROJECT LEGEND

- PAVEMENT TYPE 1
- PAVEMENT TYPE 2
- PAVEMENT TYPE 3
- LANDSCAPING (BY OTHERS)
- SECURITY FENCE
- STORMWATER PIPE / CULVERT
- STORMWATER FLOW ARROW
- NEW SURFACE CONTOURS
- EXISTING SURFACE CONTOURS
- DEMOLITION AREAS
- DEMOLITION LINES
- EXISTING OVERHEAD ELECTRICAL
- EXISTING UNDERGROUND ELECTRICAL
- EXISTING FENCE
- EXISTING TOE OF BATTER
- EXISTING TOP OF BATTER
- EXISTING GRADE CHANGE

GENERAL NOTES

1. ALL LEVELS ARE IN METRES (m) UNLESS NOTED OTHERWISE
2. ALL DIMENSIONS AND SETOUT SHALL BE VERIFIED BY THE CONTRACTOR ONSITE PRIOR TO COMMENCEMENT OF CONSTRUCTION
3. ALL CLEARING & GRUBBING WORKS TO COMPLY WITH EROSION AND SEDIMENT BEST PRACTICES
4. FINAL AREA OF CLEARING AND GRUBBING TO BE DETERMINED ON SITE WITH YURIKA
5. EXISTING SITE SURVEY IS MGA55 GDA2020 MAPPING SYSTEM



HRV - Heavy Rigid Vehicle	
Overall Length	12.500m
Overall Width	2.500m
Overall Body Height	4.300m
Min Body Ground Clearance	0.417m
Track Width	2.500m
Lock-to-lock time	6.00s
Curb to Curb Turning Radius	12.500m

SMCE REVISION CONTROL	
SMCE Ref. No.:	25330YU
Drawn: SMCE	Date: 31/10/25
Checked: SB	Date: 31/10/25
Approved: RMK	Date: 31/10/25
RPEQ Num.	18480

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REVISION CONTROL		REFERENCES
Drawn: S.BOTTING	Date: 31/10/25	
Checked: S.BOTTING	Date: 31/10/25	
Certified: R. McKENZIE	Date: 31/10/25	
Design Approval (optional): ----	Date: ----	

Project Number: WR2017993

Rev	DESCRIPTION	DRN	CHK	APPR	DATE
00	ISSUED FOR CONSTRUCITON	SB	RJM	RJM	06/05/26

FOR CONSTRUCTION

SAMSUNG C&T

BELLAMBI HEIGHTS RENEWABLE PROJECT
33kV BESS
BH1 & BH2 OVERALL
FIRE TRUCK
VEHICLE PATHS

Client	Drawing Number	Revision	Drawing Status	Scale
SAMSUNG C&T	BH-SCT-CIV-DWG-0751	00	For Construction	1:500

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E.2. Access Road Compliant Statement

E.2.1. The following inserted PDF pages are provided from the road designers and indicate that the access road complaints with Section 9.1.1 of the FRNSW access guidelines. This is in response to Item #5 in the FRNSW file FRN23/2931 BFS26/2052 7000000871.

Maker Consulting Services Pty Ltd
Head Office
101/40 Stewart Street
Wollongong NSW 2500

Phone: 02 4288 4401
Web: www.makercs.com.au
Email: info@makercs.com.au
ABN: 50 628 452 719 ACN: 628 452 719

24 April 2026

Attn: Andrew Brownlow
Vena Energy
Suite 2, Level 10, 200 Mary Street
Brisbane QLD 4000

Dear Andrew,

Bellambi Heights BESS: Site Access Road Compliance Statement

Prepared for Vena Energy Pty Ltd
Prepared by Maker Consulting Services Pty Ltd

SITE LAYOUT AND LOCATION – RESPONSE TO FRNSW COMMENT

Comment

Figure 6 shows the proposed pavement arrangement across the site and main access road. The road into the site is an unsealed road, whilst the BESS compound will be paved roads.

In accordance with Clause 9.1.1 of the FRNSW Guideline – Access for Fire Brigade Vehicles and Firefighters, all carriageways are to be suitably formed and constructed having an all weather sealed surface capable of supporting the fire appliance.

FRNSW recommends confirming that the unsealed road connecting the public road to the BESS compound complies with the relevant FRNSW guidelines.

ASSESSMENT SUMMARY

The site access road has been assessed against Section 9.1.1 of the FRNSW guideline, with consideration of:

- Static fire appliance loading
- Dynamic loading from vehicle operation
- Pavement structural capacity
- All weather access performance

The assessment is based on the detailed civil design, geotechnical investigation, and pavement design prepared for the project.

FRNSW LOADING REQUIREMENTS

Section 9 of the FRNSW guideline defines the governing load cases for carriageways and hardstand areas:

- General fire appliance: 15 t gross vehicle mass
- Specialist fire appliance: 28 t gross vehicle mass

The guideline further requires:

- Carriageways to maintain structural adequacy under load

- Consideration of point loads at tyre contact pressures (~850 kPa)
- Consideration of dynamic loading from aerial appliances, including stabiliser loads up to approximately 200 kN (≈20 t) at a single point

These represent the maximum loading conditions that access roads are required to accommodate for emergency response.

DESIGN BASIS

The access road has been designed in accordance with:

- Transgrid D2013/09395 Standard Design Manual – Civil and Structures
- Austroads pavement design methodology
- Project specific geotechnical recommendations

The design accommodates:

- B double vehicles
- Over Size Over Mass (OSOM) transport for a 155 t transformer
- Heavy haulage axle loads up to approximately **12–14 t per axle**

The adopted pavement comprises:

- 100 mm wearing course (CBR 40%)
- 170 mm base (CBR 50%)
- 200 mm subbase (CBR 30%)
- Prepared subgrade (minimum CBR 4%)

Total pavement thickness is approximately 470 mm engineered granular material.

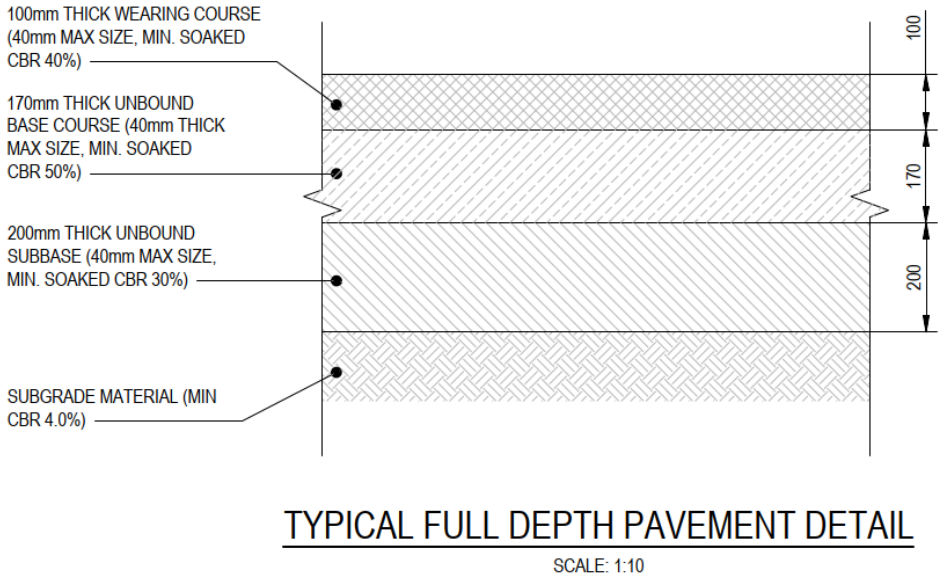


Figure 1 - Pavement Detail

LOAD CAPACITY COMPARISON

Table 1 - Load Capacity Comparison

Item	FRNSW Requirement	Adopted Design	Assessment
Vehicle load	15 t to 28 t	OSOM heavy vehicle loading	Exceeds
Axle loading	Up to 6–9 t per axle	Up to 12–14 t per axle	Exceeds
Point loads	Tyre and stabiliser loads	Designed for heavy haulage loading	Exceeds
Dynamic loads	Aerial appliance stabilisers (~200 kN)	Heavy vehicle braking, turning and repeated loading	Exceeds

ENGINEERING ASSESSMENT

The governing design case for the access road is OSOM and heavy vehicle loading associated with transformer delivery and Transgrid infrastructure access. These loading conditions exceed FRNSW fire appliance requirements in both magnitude and frequency.

The pavement structure provides sufficient capacity through:

- High strength granular materials with specified CBR values
- Adequate pavement thickness for load distribution
- Verified subgrade strength and construction controls

The FRNSW guideline identifies that structural adequacy must consider both distributed vehicle loads and concentrated point loads. The adopted pavement is designed for repeated heavy vehicle trafficking and construction loading, which is more onerous than occasional fire appliance access.

Dynamic loading associated with aerial appliances, including stabiliser forces, is also less critical than the governing heavy vehicle loading case for this development.

Although the access road is unsealed, it is an engineered pavement constructed to controlled material and compaction specifications. This provides a durable all weather trafficable surface suitable for emergency vehicle access.

COMPLIANCE STATEMENT

The access road has been assessed against Clause 9.1.1 and Section 9 of the FRNSW guideline.

Based on the adopted Transgrid and OSOM design criteria:

- The pavement supports loads exceeding the maximum 28 t fire appliance requirement
- Axle and point load effects exceed those defined in the FRNSW guideline
- Dynamic loading conditions are less onerous than the governing design case
- The road provides all weather trafficable access when constructed in accordance with the design

The access road is considered compliant with Section 9.1.1 with respect to load carrying capacity.

Section 9.1.1 references an all weather sealed surface. The access road has been designed as an engineered all weather access road without a sealed surface.

The adopted pavement structure, comprising 470 mm of engineered granular material, together with appropriate subgrade preparation and compaction, provides sufficient structural capacity to support fire appliance loading under both static and dynamic conditions.

In addition, roadside drainage swales have been incorporated to intercept and manage surface runoff, preventing saturation of the pavement and maintaining trafficability during wet conditions.

On this basis, the access road is expected to provide reliable all weather access performance without the requirement for a sealed surface.

CONCLUSION

The site access road has been designed for heavy vehicle and OSOM loading in accordance with Transgrid requirements and Austroads standards.

These design conditions exceed the structural loading requirements defined in the FRNSW guideline.

The unsealed access road is considered structurally suitable to support fire brigade vehicles and satisfies the intent of Section 9.1.1 for load capacity and operational access..

Should you have any queries regarding this memo or require additional information, please do not hesitate to contact the undersigned.

Yours Sincerely,



James Agustin

Director – Maker Consulting Services Pty Ltd

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Appendix F. Extreme Environment Information

F.1.1. The following provided information about the potential hazards associated with extreme environmental events. These three events will also cover the consequence level from other potential extreme environmental events such as hailstorms.

a) Earthquake – (Burbidge, Leonard, Allen, Collins, & Volti, 2012) presents updated earthquake hazard map for Australia. As Homebush is near Dubbo, the earthquake data for Dubbo can be used. This paper highlights that earthquake hazard in Sydney is relatively low. Specifically, Dubbo has a 0.08 AS 1170.4 Z-value and a 0.049 (G) 500-year Peak Ground Acceleration hazard value. The only viable control is to construct site buildings associated with site controls to meet AS 1170.4, with respect to the forementioned values. Where this is not possible manufacturer's instructions for footing / foundations are to be at least followed.

b) Wind speed – Maximum recorded wind speed for Homebush was 141 km/h recorded on 24 Aug 2003 [9]. This is a rare event as the mean daily wind run for the site sites between 340 and 415 depending on the time of year, translating to a typical average wind speed of 17 km/h across an entire day.

c) Flood – As noted at flood risk tracker [10] the flood risk for Bellambi Heights (Beryl) is low for both Storm Surge and River Flood.

9 From https://wind.willyweather.com.au/nsw/sydney/homebush.html accessed on 21 Jul 2025.
10 https://floodrisktracker.steadfast.com.au/ accessed on 21 Jul 2025

Appendix G. Transgrid Substation Fire Modelling

G.1.1. Additional consequence modelling and hazard assessment for fire/explosion emanating from the TransGrid substation. The location and configuration of the bunded area are illustrated in Figure 55.

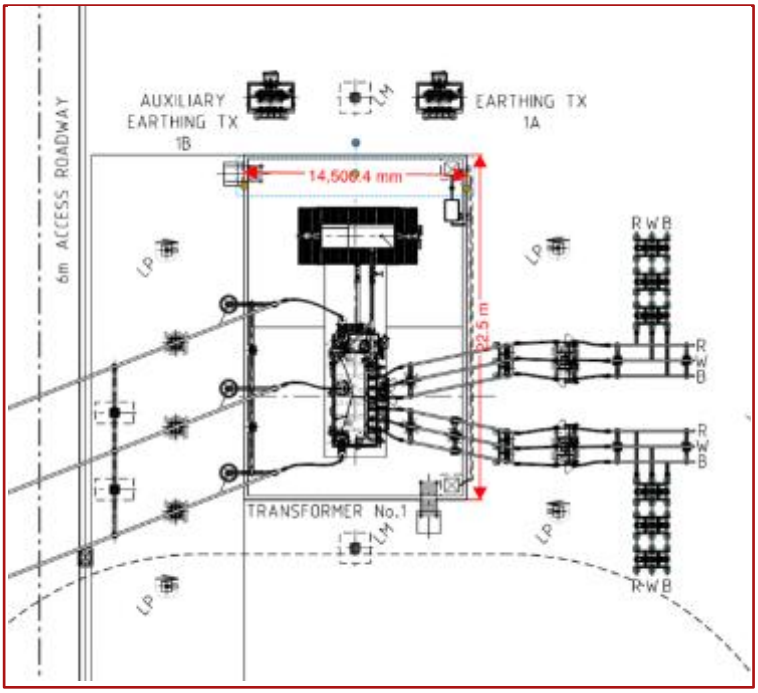


Figure 55: Transgrid Substation bunded area.

G.1.2. A fire modelling scenario for the Transgrid substation has been carried out in GEXCON EFFECTS. A pool fire has been adopted involving 65,860kg (approx. 75,000 L of mineral oil). The scenario assumes a full surface pool fire resulting from a catastrophic loss of containment, with the spilled liquid retained entirely within the designated bunded enclosure measuring 14.5 m × 22.5 m. This assumption provides a worst-case assessment of thermal radiation impacts to adjacent exposures and structures in BB1 & BB2. The results are shown in Figure 56.

G.1.3. The modelling results indicate that the 3 kW/m² and 1 kW/m² radiant heat flux contours extend to distances of 30 m and 52 m and widths of 60 m and 101 m. These predicted radiation distances are substantially less than the measured separation distance of approximately 204 m between the substation and the nearest identified sensitive receptor (Area BB1). On this basis, the separation distance is considered adequate to prevent adverse off-site thermal radiation impacts to the BESS area.

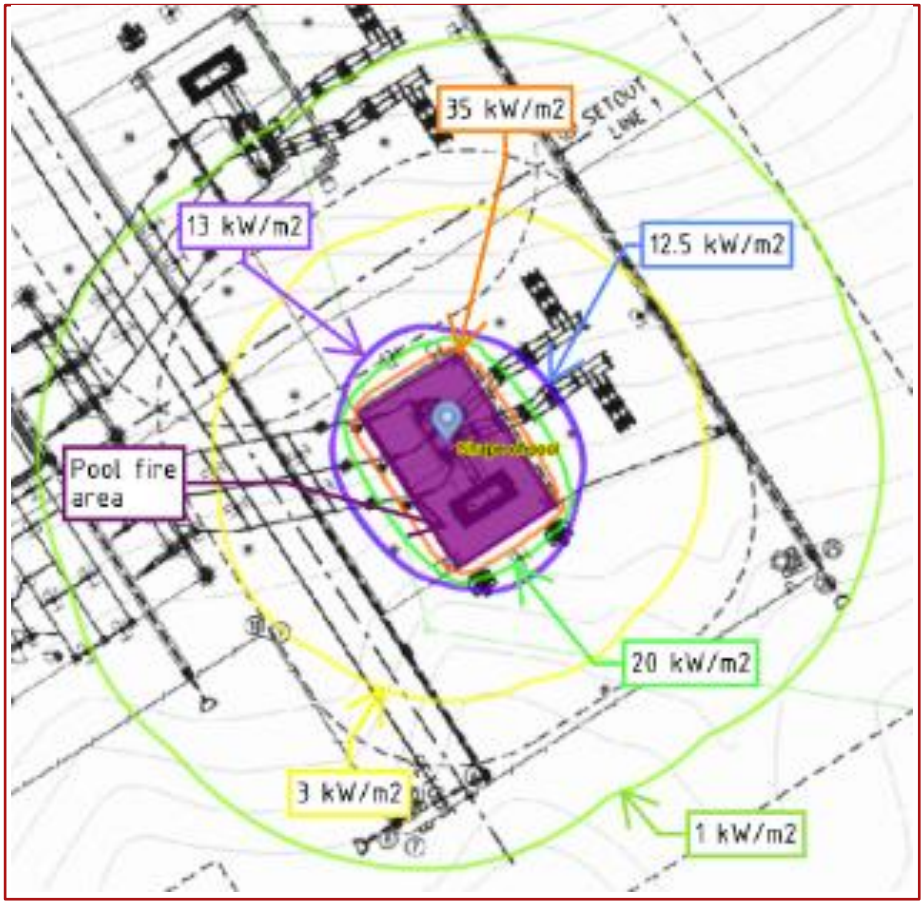


Figure 56: Transgrid Substation bunded pool fire – no wind

G.1.4. Table 6.1 from AS 2067:2016 (Standards Australia AS 2067, 2016) provides guidance for the minimum distances *G1* required for the separation of outdoor transformers without an enclosure and also for the separation of transformers and buildings (in this case the neighbouring BESS units. For a liquid volume of >60kL, the horizontal separation to other transformers or other non combustible surfaces is 23m and to combustible surfaces is 30m. The separation of 204m greatly exceeds these values.

G.1.5. On the above basis, it is not expected that a fire or explosion originating in the Transgrid substation would directly damage the BESS compound or endanger occupants at the BESS site unless there was an electrical failure that cascaded to the site resulting in a short circuit/arc flash type event on site. Such event is not in scope of the FSS, and it is expected that the electrical design would include safety measures to prevent such an incident.

TABLE 6.1

CLEARANCES FOR OUTDOOR TRANSFORMERS

Transformer type	Liquid volume	Clearances to other transformers or equipment	Clearances to buildings		
		Horizontal separation G_1 to other transformers or non-combustible surfaces	Horizontal clearance G_2 to combustible surfaces	Horizontal clearance G_3 to 2 hour fire resistant surfaces of buildings	Vertical extent G_4 for 2 hour fire resistant surfaces of buildings
	L	m	m	m	m
Oil-insulated transformers (O)	100 ≤1000	1	6	1	4.5
	>1000 ≤2000	3	7.5	1.5	7.5
	>2000 ≤20 000	5	10	4.5	15
	>20 000 ≤45 000	10	20	7.5	30
	>45 000 ≤60 000	15	30	7.5	30
	>60 000	23	30	7.5	30

Figure 57: Table 6.1, AS 2067:2016

Appendix H. FRNSW Comments and Responses

H.1. FRNSW Comments and RED Response

H.1.1. The following pages include a copy of the letter from FRNSW in regards to FSS V2, and a table of comments and responses to those comments.

File Ref. No: FRN23/2931 BFS26/3711 7000002136
TRIM Doc. No: D26/91423
Contact: Inspector Luke Loseby

16 June 2026

JADEN PARK
Samsung Vista C&I Australia
Suite 202, 44 Market Street
SYDNEY NSW 2000

Dear Jaden,

Re: Review of Fire Safety Study (FSS) - BELLAMBI HEIGHTS BATTERY ENERGY STORAGE SYSTEM – 696 CASTLEREAGH HIGHWAY, BERYL

Fire and Rescue NSW (FRNSW) acknowledge correspondence received on 21 May 2026 requesting review of the submitted FSS (Report No. JN25-00265 – 3 Dated: 01/05/2026) for BELLAMBI HEIGHTS BATTERY ENERGY STORAGE SYSTEM – 696 CASTLEREAGH HIGHWAY, BERYL. FRNSW note the FSS was to be developed to the satisfaction of FRNSW and in accordance with the Hazardous Industry Planning Advisory Paper (HIPAP) No. 2[1].

FRNSW have reviewed the FSS prepared by RED Fire Engineers Pty Ltd. The current version of the FSS **has not been prepared to the satisfaction of FRNSW**. FRNSW satisfaction is dependent upon the comments in the following table being appropriately addressed.

For further information please contact the Fire Safety Liaison Unit, referencing FRNSW file number BFS26/3711. Please ensure that all correspondence in relation to this matter is submitted electronically to firesafety@fire.nsw.gov.au.

Yours sincerely,

Inspector Chris Naisby
Team Leader
Fire Safety Liaison Unit

Cc: rao.chellaiah@venagroup.com ; m.elnakib@samsung.com ; swassa.ha@samsung.com ; jaden.park1@samsung.com ; nate@redfireengineers.com.au

[1] https://www.planning.nsw.gov.au/-/media/Files/DPE/Guidelines/fire-safety-study-guidelines-2011-01.pdf?la=en

Fire Safety Study – BELLAMBI HEIGHTS BATTERY ENERGY STORAGE SYSTEM – 696 CASTLEREAGH HIGHWAY, BERYL Report No. JN25-00265 – 3 Dated: 01/05/2026					
No.	**Section**	**Fire Safety Study Comment**	**FRNSW Comment**	**RED Response**	**FRNSW Response to V3**
1.	Summary of Main Findings and Recommendations, Table 1	-	This section must include the exact separation distances between BESS units, separation distance between transformers and BESS, PCUs and BESS, and other equipment within the BESS compounds. The separation distances must be maintained throughout the lifetime of the site. Should there be any changes to the site's layout, a revision of the Fire Safety Study should be conducted and resubmitted to FRNSW for review.	This has been added to the FSS. Assumed closed.	Noted.
2.	Summary of Main Findings and Recommendations, Table 1	The current fire hydrant system design will need adjustments to the hydrant locations to allow for safe brigade operations.	FRNSW recommends stating the total volume of static water supply provided on site within Table 1.	This has been added to the FSS. Assumed closed.	Noted.
3.	Summary of Main Findings and Recommendations, Table 1	Fire suppression system -The connection point is at the bottom of the BESS unit and for the fire brigade to use it, would require them to potentially be close to the BESS enclosure in a thermal runaway state.	Confirm provision of the connection point. FRNSW recommends providing further details on the connection point (such as, diameter of the pipe, equipment required and procedures). Specific information regarding the use of the dry pipe suppression system is to be included in the Emergency Plan and Emergency Services Information Package. This should outline when the system is to be activated, any contraindications to its use, and the expected outcomes of activation.	This dry pipe connection point is on the BESS itself. We would NOT expect that FRNSW would want to use it given its location, however it comes as an integrated part of the BESS unit. It is provided as an additional item but not relied upon. The overall FSS control measure analysis that this is an optional item, generally not needed or recommended but is understood to come integrated to the unit and is not removable. Photo/figure of the location is now shown in Appendix B with the fire protection specifications. Despite not relying on it, we have required that it have suitable connections for brigade and the OEM has confirmed it will have Australia specific connections. These will be in line with the FRNSW guideline for connections. The connection is a DN 65mm connection whilst the pipework is DN40 and DN32. To avoid accidental connection/use by first responders including staff, signage is to be provided indicating not to use the dry pipe system, along with wording in the ESIP to avoid its use. This requirement is to be in the EP, ESIP, and supported by signage and has been added to 9.3 We have also updated the report to clearly state that although the dry pipe system and aerosol are not required to meet the intent of	Noted.

				the FSS, since they are provided they must be adequately maintained.	
4.	Summary of Main Findings and Recommendations,	I,_____, from Samsung as a representative of the Development Team and Client, have reviewed and endorsed all of the control measures set out in Table 2 and the further details in Section 9.	Section 3.3 of HIPAP2 requires a summary of the main findings in the report and an implementation program that has been agreed to by the proponent. Confirm implementation of the recommendations by the proponent.	This has been added to the FSS. Assumed closed.	Noted.
5.	2.2 Input from associated Safety Studies	As noted in Table 5 of this report Vena Energy developed a preliminary hazard analysis (PHA) for this site. The following are the main finding and recommendations from the PHA for this Bellambi BESS site.	FRNSW recommends providing a copy of the PHA.	A copy of the PHA is available here: ... In lieu of providing a full copy of the PHA appended to the FSS we have provided a pdf copy alongside the updated FSS.	Noted.
6.	3.1 Site Layout and Location	Figure 6 shows the proposed pavement arrangement across the site and main access road. The road into the site is an unsealed road, whilst the BESS compound will be paved roads.	In accordance with Clause 9.1.1 of FRNSW Guideline (Access for fire brigade vehicles and firefighters), all carriageways are to be suitably formed and constructed having an all-weather sealed surface capable of supporting the fire appliance. FRNSW recommends confirming that the unsealed road connecting the public road to the BESS compound complies with the relevant FRNSW guidelines.	This has been provided in Appendix E.2.	Noted.
7.	3.3.3	The fire protection systems for the Hithium BESS unit have been developed based on NFPA 855. This system consists of a fire alarm control panel (FACP), automatic alarm system, ventilation system, aerosol extinguishing system (12x 300g), and a dry pipe suppression system.	Insufficient assessment documented to demonstrate how aerosol system and the ventilation system is designed. Further assessment demonstrating how the system is designed to comply with the relevant standards needs to be provided for review. For the aerosol extinguishing system, it is understood that the design basis relies on the release of the extinguishing agent within an enclosed space. However, it is also understood that the ventilation system always remains operational, including during fire mode. This appears to be inconsistent with the fundamental design assumption of the aerosol extinguishing system.	The aerosol system is an OEM provided system that is integrated to the unit. It is not a requirement of the FSS and has not been relied upon. The system has been based on a separate test with thermal runaway in a cell in a 20 ft container. For this project it is integrated to the unit and not removable. Whilst not relied upon, it is not expected to pose a danger to staff or the fire brigade. The aerosol sytem activates at stage 2 fire alarm, which is the same time at which automatic call out to the fire brigade occurs. Given a site electrician may be up to 2 hours away and the aerosol system is a once off activation, any impact of the system would be complete prior to the brigade gaining access to the site. In terms of ventilation, the control system for the BESS is being altered to prioritise operation of the NFPA 69 system over that of the aerosol system. As such the ventilation system will continue running if it is already running. The ventilation system activates on H2 gas	Noted.

				detection, not on smoke detection, therefore there is a small subset of fires such as cable fires which could occur and have the aerosol system activate to extinguish within a closed container. The changes to the control system are reflected in Appendix B, and have been directly communication to Hithium.	
8.	3.12.2	It is understood that this site is occupied 24/7 on site where staff may be present, who can also respond to an emergency. The overall design of the site is to operate as a complete unmanned operation	It is understood that the site is manned 24/7 and fenced off from public access. As per Clause 5.4.3 of FRNSW BESS Guideline, FRNSW may not enter the affected BESS compound until an electrical company representative is in attendance on site and has confirmed power is isolated. FRNSW recommends confirming the availability of site personnel during an emergency, including availability of personnel with the technical qualifications to undertake power isolation. Where such personnel are not continuously present on site, FRNSW requires confirmation of the maximum response time for their arrival.	The FSS is to be updated to clarify: - The site is likely to be initially occupied 24/7 for a short period but is desgined for unmanned operation - In the event of an incident when unmanned, the expected response time for staff is 2 hours. - The remote monitoring station is manned 24/7. The site can be isolated remotely and the responding staff can confirm the isolation. The remote monitoring station is understood to be fault-aware. That is they will also be able to provide warning if remote isolation has failed to occur. The person responding after 2 hours is expected to be a trained electrician kept on call for the site.	Noted.
9.	5.2.4	The empirical model relies on data from combustion experiments compiled by (Peter J. Bugryniec 2024).	FRNSW recommends providing a copy of the publications used for the modelling. Further justification is required on appropriateness of the data in relation to the batteries used in the proposed BESS units. It should also be confirmed whether the data is consistent with that obtained from the LSFT, if the LSFT has measured and characterised by-products of BESS fire.	This reference is for the background data which Gexcon used to create the EFFECTS li-ion battery storage thermal runaway software model. The specific inputs used in this project as specified in Section 5.4. This comment is assumed closed, as FRNSW has provided separate comments on those inputs below. Further the Gexcon manual is available for free from Gexcon, and the paper referenced is also free here: …	Noted.
10.	5.4.8	Based on EFFECTS default values, considering a Low input, as shown in Figure 13. This figure is from the GEXCON Technical Background	0.5 mg/kWh equates to 0.0005 mg/Wh, meaning the Gexcon values are 100,000 times larger. This order-of-magnitude difference is unrealistic and could potentially reflect error in	Apologies the report has a typo, the calcualted value is 0.5mg/Wh not kWh. Therefore the	Noted.

		document title Li-ion Battery Storage Thermal Runaway.	data collection, or magnitude of test in UL9540A is not reflective of the worst-case scenario. FRNSW recommends conducting release analysis based on 'very high' release rate for conservative analysis.	Gexcon values are 100x larger as indicated, not 100,000 times. Further FRNSW's comment appears contradictory. FRNSW has indicated that using a value 100,000x larger is unrealsitic and reflects data error, and then recommends using an even higher value. As above, the actual yield used is 100x greater than that measures in the UL9540A module test, not 100,000x. However, following the meeting in which FRNSW indicated that they are not confident that EFFECTS is an appropriate tool or in how HF has been modelled, please refer to Appendix H2 for a separate note and analysis on the potential HF off gas.	
11.	5.4.9	.. by applying the energy capacity of a cell, the result is that a value of 0.5 mg/kWh for this specific cell. Comparing this to the GEXCON Low (average) default of 52.47mg/Wh, the model will use this value for dispersion modelling which is 100 times larger than the tested values.			
12.	5.4.20	In this analysis it has been assumed that the entire volume of the BESS unit has been filled with hydrogen, i.e., gross volume, to its lower explosive limit. Then, the overpressure is determined with no consideration of the BESS unit structural strength.	FRNSW does not support this analysis as this is unrealistic nor supported by observations in a large-scale fire testing (LSFT). FRNSW expectation is that the LSFT includes evaluation of deflagration or explosion mitigation measures. If the LSFT did not include evaluation of deflagration or explosion mitigation measures, FRNSW recommends providing a separate test or assessment to verify the effectiveness of deflagration or explosion mitigation measures.	LSFT by their definition (such as the new UL 9540A 6th edition) do not test for explosions. In some cases they may do a deflagration test as per Appendix C of the new standard, but in doing so it is only requires that the gas volume be greater than that released in the module level test, which for the Hithium system, was 2 cells offgassing. The volume of gas used in the model is significantly greater than that, and represents a larger blast than the minimum test required. The actual system in the NFPA 69 report has been designed to 3 cells instead of the requires 2 cells, plus an additional 10% off gas volume. A copy of the NFPA 69 report has now been provided in Appendix C alongside the Hithium BESS details.	As per Clause 5.3.1 of the FRNSW BESS Guideline, FRNSW expects the large-scale fire test (LSFT) to evaluate the effectiveness of deflagration and explosion mitigation measures. FRNSW notes that the LSFT does not appear to have directly evaluated the proposed deflagration or explosion mitigation measures, as the doors were left open during the test. It is understood that a CFD analysis has been provided to assess the effectiveness of these measures in accordance with NFPA 68. However, the CFD analysis appears to have adopted the gas release rate and gas volume from a module-level test in which only two cells underwent thermal runaway. As per Clause 5.1.2 of the FRNSW BESS Guideline, FRNSW considers a credible incident to include a fire that propagates within a BESS enclosure and involves the full BESS enclosure. On this basis, FRNSW seeks clarification on how the CFD analysis is considered representative of the credible incident scenario expected under the FRNSW BESS Guideline, given that the adopted gas release assumptions appear to be based on a module-level test rather than a full-enclosure fire scenario.

					In particular, FRNSW seeks clarification on the following matters: 1. Under the fire scenario tested in the LSFT, if the fire were to involve the full BESS enclosure, would the quantity of unburnt gases generated from thermal runaway be greater than that assumed in the CFD analysis? 2. If a greater quantity of unburnt gases could be generated, has the ventilation system been demonstrated to extract those gases at a rate sufficient to prevent accumulation to a level that may result in deflagration or explosion? 3. Has the ventilation system been demonstrated to remain operational within the temperature ranges expected during the LSFT scenario or a full-enclosure fire scenario? 4. If the ventilation system were to fail or become ineffective during a fire involving the full BESS enclosure, has it been demonstrated that deflagration or explosion would not occur? Based on the information provided, it is unclear whether the proposed ventilation system and deflagration/explosion mitigation measures have been demonstrated to be effective for the credible incident scenario expected by FRNSW. Further clarification and supporting evidence are therefore requested. This analysis is considered critical, as deflagration and explosion events associated with lithium-ion battery systems have resulted in serious injuries[1] and fatalities[2] to firefighters. Notable incidents include the McMicken BESS explosion in Arizona, where four firefighters were seriously injured, and the Beijing LFP battery installation explosion, where two firefighters were killed and one firefighter was injured.

[1] McKinnon, M., DeCrane, S. and Kerber, S. (2020) *Four Firefighters Injured in Lithium-Ion Battery Energy Storage System Explosion — Arizona*. UL Firefighter Safety Research Institute.
[2] CTIF (2021) *Accident analysis of Beijing lithium battery explosion which killed two firefighters*. International Association of Fire and Rescue Services.

					Accordingly, FRNSW considers it necessary to demonstrate that the proposed ventilation and deflagration/explosion mitigation measures are effective for the credible incident scenario.
13.	L1-LF: Large Fire 5.4.25 to 5.4.31	-	As per section 5.6.5 of the FRNSW BESS Guideline, the impacts of worst-credible environmental conditions (e.g., 95th percentile wind speeds for the area) must also be assessed. This should include assessment of flame tilt, etc. Supplementary modelling may be performed to assess the impacts of environmental conditions, provided that: a) Details of all calculations and analyses are provided in the FSS, containing justification of all inputs and assessment methodology used. b) The results of the modelling being calibrated against the results of LSFT.	Based on the reported data, the maximum internal temperature of any of the adjacent BESS from the LSFT was 80 C for a cell thermocouple in BESS C. The peak cell temperature reached for B was 42 C and for D was 69 C. From the UL9540A cell test, these cells have venting temperatures of 203 C and thermal runaway temperatures of 295 C. Given these are more than twice as high as the maximum temperature reached in the LSFT it is not expected that wind would be a significant factor. Particularly given the LSFT is done without the benefit of additional modules in the receiving BESS units which would have significant thermal mass and act as heat sinks. On this basis, additional wind assessment should not be required. If the internal temperatures reached were much higher then it would be appropriate to require. Nonetheless, section 5.4 and Appendix I has been updated to incorporate a flame tilt due to wind.	Noted.
14.	7.2 Control Measure Analysis, Table 28: Proposed control measures for the site	A hardstand area for fire trucks shall be provided at each firewater tank, i.e., in front of any suction-connection outlet as required within AS 2419.1 (Standards Australia, 2021).	FRNSW recommends submitting drawings clearly indicating the locations of hardstand areas.	Based on the reported data, the maximum internal temperature of any of the adjacent BESS from the LSFT was 80 C for a cell thermocouple in BESS C. The peak cell temperature reached for B was 42 C and for D was 69 C. From the UL9540A cell test, these cells have venting temperatures of 203 C and thermal runaway temperatures of 295 C. Given these are more than twice as high as the maximum temperature reached in the LSFT it is not expected that wind would be a significant factor. Particularly given the LSFT is done without the benefit of additional modules in the receiving BESS units which would have significant thermal mass and act as heat sinks. On this basis, additional wind assessment should not be required. If the internal temperatures reached were much higher then it would be appropriate to require. Nonetheless, section 5.4 and Appendix I has	Noted.

				been updated to incorporate a flame tilt due to wind.	
15.	7.2 Control Measure Analysis, Table 28: Proposed control measures for the site	Combustible gas detection to be used in conjunction with approved / compliant NFPA 69 explosion ventilation system to be fitted to the BESS units. This NFPA standard sets out requirements for explosion exhaust ventilation for environments where vapour cloud explosion could occur.	Further analysis required to demonstrate the effectiveness of the exhaust ventilation in case of a combustible gas detection. It is understood that the ventilation system was turned off, with all doors opened during a LSFT. As such, the LSFT could not demonstrate the effectiveness of the ventilation system in case of the worst-credible fire scenario. FRNSW recommends presenting calculations conducted by the manufacturer/system designer for the design of the explosion exhaust ventilation system.	Though the LSFT was carried out before the formal publishing of the 6th edition UL9540A it was based on the working group documentation and carried out by UL. The new UL edition has now been published and is recognised by NFPA 855 as the key test method. Neither UL9540A nor CS 800, which are the two best known LSFT standards for BESS test for explosions/effectiveness of the ventilation system at full scale. These are fire tests, focusing on fire spread. For instance, UL specifically indicates that deflagration vents are to be open at the beginning of a test. Therefore a test cannot be provided, however the design report for the NFPA 69 explosion system has been provided in Appendix C	Refer to comment provided in Item 12.
16.	7.2 Control Measure Analysis, Table 28: Proposed control measures for the site	Automatic sprinkler system, which would require a water source to be permanently or manually connected.	Insufficient detail provided for review. FRNSW requires clarification as to whether a dedicated water supply is provided for the sprinkler system within the BESS unit, or whether the system relies on water supply from fire brigade appliances. In addition,	The BESS system is a dry pipe system. This will be updated in the FSS.	Noted.
17.	9.2 Recommended Control Measures, Table 29: Proposed control measures for the site	Arrangements for fire brigade notification, access and intervention at the site. To be finalised within the ESIP for firefighting arrangements. Fire fighting hardstand details to be prepared by Fire Protection Engineer	It is noted that the design is not yet finalised. Further detail to be provided for review at the FSS stage.	Hardstanding drawings to be provided. The site wide FIP is to have an AS1670.3 ASE, and the remote monitoring station is also to be able to call out fire brigade. Drawings are provided in E.1.	Noted.
18.	9.2 Recommended Control Measures, Table 29: Proposed control measures for the site	**Arrangement of the system** Physical layout and arrangement of any fire protection systems and equipment across the site. Final arrangement to be coordinated with design team, building layout to be confirmed, access paths and equipment clearances	Design not yet finalised. Further detail to be provided for review.	Drawings provided in appendix D.6.	Noted.

19.	9.2 Recommended Control Measures, Table 29: Proposed control measures for the site	**Personal protective equipment (PPE)** PPE requirements to be documented in task-specific risk assessments and induction training.	Further detail to be provided for review. The proposed PPE on site for the operators must be appropriate for the hazards present on site.	Following the meeting we understand that the intent of this comment is that FRNSW are asking what PPE the emergency electrician may require to protect themselves from HF or the like when responding to the site.e.g. do they need SCBA The site can be remotely isolated. This isoaltion can be confirmed from the O&M building (for either BB1/2) or the BB1 or BB2 switchroom. To provide further robustness, though the switchrooms only directly serve their individual compound (BB1 vs BB2), each switchroom is to provide indication of isolation in the adjacent site. In other words if somehow isolation cannot be confirmed by the remote operator, and both the BB1 switchroom and O&M building are unsafe reach, then isolation of both sites can also be confirmed from the BB2 switchroom which is physically separated from any exposure limiting access to BB1 O&M or BB1 switchrooms. Similarly the site is provided with several emergency pedestrian exits around the perimeter, each of which is accessible with a key, so that access can be achieved from upwind of any incident. Whislt the site can be remotely isolated, and confirmed remotely, the intent of the emergency electrician entering the site is in the unlikely case that remote isolation has failed, and they need to manually isolate. In this case they need protection from arc flash. PPE options to protect from both HF gas and arc flash is limited as the materials are typically opposites. Further it is not considered appropriate to place the electrician at risk when the site has been designed to allow for safe burnout of a BESS without intervention. As such, no additional hazmat PPE is proposed to be provided for the emergency electrician/staff response. The above operational approach is to be incorporated into the future ESIP.	Noted.
20.	9.2 Recommended Control Measures, Table 29: Proposed control measures for the site	**Site wide incident notification** Processes for site-wide incident notification, escalation and communication.	Insufficient detail provided for review. Notification should be automatic and the threshold to be determined and acknowledged during the FSS stage.	The design has been further progressed and shall include horns that achieve 5 dB(A) above background, rather than the 10 dB(A) in AS1670.1. This limitation is due to the large outdoor footprint of the site.	Noted.

		Notification thresholds and contact lists to be defined in the site Emergency Response Plan.		The mobile phone number of staff onsite is also to be provided to the remote monitoring station for direct contact in an emergency. Each BESS is provided with 2 SD and 2 HD across the central 4 bays, alternating HD and SD. The top of the 6 bays allows for smoke/heat circulation in the event of a fire. The units are set with a stage 1 alarm (any single detector), and a stage 2 alarm (any 2 detectors). Automatic brigade call out is to occur at Stage 2 fire alarm. Whilst BESS have temperature sensors these are not connected to fire brigade callout as fire detection is provided.	
21.	9.2 Recommended Control Measures, Table 29: Proposed control measures for the site	**Fire truck access** Access design to comply with local fire authority guidelines for appliance access and turning circles. Refer to FRNSW guidelines Access for fire brigade vehicles and firefighters	Further details to be provided for review. Architectural drawings to assess the fire truck access must be provided for review.	Provided in Appendix E.1	Noted.
22.	9.2 Recommended Control Measures, Table 29: Proposed control measures for the site	**BESS unit explosion ventilation** Explosion relief and ventilation provisions for BESS units to limit overpressure effects. Provisions to be in accordance with NFPA 69**.** Explosion ventilation to be designed by a qualified engineer based on Hithium equipment vendor guidance.	Further detail to be provided for review. The LSFT has been conducted with door opened, and as such, it is unclear whether the effectiveness of deflagration or explosion mitigation measures can be evaluated from the LSFT. If the explosion relief and ventilation provisions for BESS units are designed in accordance with NFPA 69, further assessment is required to be documented within the FSS to demonstrate that the proposed measures are appropriate for the expected explosion scenario, including validation of key design parameters and assumptions.	UL9540A does not evaluate the explosion in the LSFT, it is a fire focused tests as per the latest edition. NFPA 69 report provided in Appendix C	Refer to comment provided in Item 12.
23.	9.2 Recommended Control Measures, Table 29: Proposed control measures for the site	**Self-bunded tanks** Use of self-bunded tanks to provide integral spill containment for stored liquids. Bund capacity and inspection requirements to be documented in the maintenance plan.	Further detail to be provided for the proposed self-bunded tanks to be provided. Assessment against relevant standards must be made for the proposed storage of stored liquids for the justification of the self-bunded tanks.	FSS to be updated, this should clearly reference AS 1940 and AS 2067. The bunding to diesel tanks to meet AS 1940, transformers to comply with AS 2067 which includes bunding.	Noted.
24.	9.2 Recommended Control Measures, Table 29: Proposed	**Bunding – Diesel generators and tanks**	Further detail to be provided for the proposed diesel generators and tanks.	FSS to be updated, this should clearly reference AS 1940 and AS 2067. The bunding to diesel tanks to meet AS 1940, transformers	Noted.

	control measures for the site	Bunding arrangements for diesel generators and tanks to contain leaks and spills. Bunding to be designed for the largest tank volume plus freeboard, with controlled drainage	Assessment against the relevant standards must be undertaken for the proposed bunding design, with the design outcome documented in the FSS.	to comply with AS 2067 which includes bunding.	
25.	9.2 Recommended Control Measures, Table 29: Proposed control measures for the site	**Diesel generator enclosure** Enclosure of diesel generators to limit fire spread and protect adjacent equipment. Enclosure construction and fire resistance to be consistent with the fire engineering strategy.	Further detail to be provided for the diesel generator enclosure. What is the construction bounding the diesel generator enclosure and its fire-resistance level? What standards do they comply with? FRNSW recommends providing justification for the selected construction, including justification that the proposed FRL is appropriate and complies with the NCC or the relevant standards.	FSS to be updated, this should clearly reference AS 1940 and AS 2067. The bunding to diesel tanks to meet AS 1940, transformers to comply with AS 2067 which includes bunding.	Noted.
26.	9.2 Recommended Control Measures, Table 29: Proposed control measures for the site	**Diesel generator fire isolation** Fire isolation measures for diesel generators to separate them from other plant and structures Isolation arrangements to allow emergency shut-down and separation during a fire.	Further detail to be provided for the diesel generator isolation arrangements.	The FSS wording is to be updated. The enclosure does not require an FRL for the FSS and does not require an FRL. The analysis has not relied upon any FRL to the diesel enclosure. The enclosure is to be primarily non-combustible (e.g. sheet metal, not timber)	Noted.
27.	9.8 CM14 – Fire Truck Access	Table 30 summarises the high level requirements of the FRNSW fire safety guidelines for access for fire brigade vehicles and firefighters.	Design is at an early stage and is not sufficiently developed to enable assessment. Drawings demonstrating how the FRNSW Fire Safety Guideline for access by fire brigade vehicles and firefighters is incorporated into the design must be provided.	A heat detector in the diesel generator enclosure is to automatically isolate/shutdown the generator. The ESIP is to include the location of the manual isolation to the generator.	Noted.
28.	9.10.4	Each BESS has an in-built FIP as part of its control systems. These FIPs are to be connected to the site wide FIPs via SCADA in lieu of AS1670.1 connection. This is due to the SCADA already being available, having the capability of carrying the signal, and being treated as an essential system. For site operations the SCADA is required to have an extremely high reliability as the whole site cannot operate without it. Nonetheless, if the SCADA were to fail to the FIP, the fire affected BESS unit would still sound the in-built alarm and signal with in-built strobes.	It is unclear whether the FIPs are not equipped with a fire alarm monitoring system allowing automatic notification of an incident to fire services. As per Clause 5.5.7 of FRNSW BESS Guideline, FRNSW recommends detection systems provided for the BESS units be connected to a fire alarm monitoring systems, connected to the FRNSW dispatch centre in accordance with Australian Standard AS1670.3. This is to ensure automatic notification of the fire services. FRNSW recommends providing further details, including any design documentation, demonstrating how this will be achieved.	The individual FIPs in each BESS do not have ASE. However these FIPs are connected to the individual BESS Battery Management System (BMS). The BMS is then linked to the main FIP via SCADA (not via AS1670.1) and the main FIP is to be provided with an ASE as per AS1670.3, For clarity in full the connection from detector to ASE is: Individual BESS FIP -> BESS BMS -> SCADA -> Sitewide FIP containing ASE. Further BESS fire protection information is provided in Appendix C with fire protection design docs in Appendix D.	Noted.

29.	9.13.2	Based on compliance with AS2419.1:2021, it is understood that only 144 kL of water storage is required per subdivision, and such storage meets the intent of this FSS. Nonetheless, the current design includes 288 kL of storage is 144kL for BB1 and BB2 until such time that consultation for this FSS takes place.	FRNSW supports provision of hydrant system in accordance with the open-yard requirements of AS2419.1:2021. Further details regarding the area of the BESS compounds required for review. In addition, each hydrant outlet should be located at least 10 m from the nearest electrical infrastructure that they are intended to serve. The hydrant outlets must be strategically positioned to provide coverage to all parts of the BESS compounds. The requirements must be stated in the	This requirement is intended to be met in full. Drawings are now provided in Appendix D.	Noted.
30.	D.5 BESS Dry Pipe System	A DN65 connector shall be reserved for connecting an outdoor fire hydrant or fire truck. The adaption and selection of the DN65 connectors will need to reviewed against the design of the NSW RFS fire appliances to ensure compatibility.	FRNSW require all fittings to align with Technical Information - FRNSW compatible Storz hose connections	All fitting to comply with FRNSW technical information. Reconfirmed in 9.13.8.	Noted
31.	E.1. Fire Truck Mobility at the Site	E.1.1. Samsung to provide vehicle tracking around site.	Insufficient information for review at the moment.	Now provided in Appendix E.1	Noted

H.2. Hydrogen Fluoride Modelling

H.2.1. In response to FRNSW comments and discussion with FRNSW at the meeting held 12 May 2026, additional hydrogen fluoride modelling has been carried out and is provided in a Consultant Advice Note beginning on the following page.

Appendix I. FiRE Modelling

Large Scale Fire Test

I.1.1. The LSFT assessed a fully charged 5 MWh Hithium liquid-cooled BESS installation. The test comprised one initiating container, three adjacent target containers, with thermal runaway intentionally initiated within a designated module. The test set up is shown below in Figure 58.

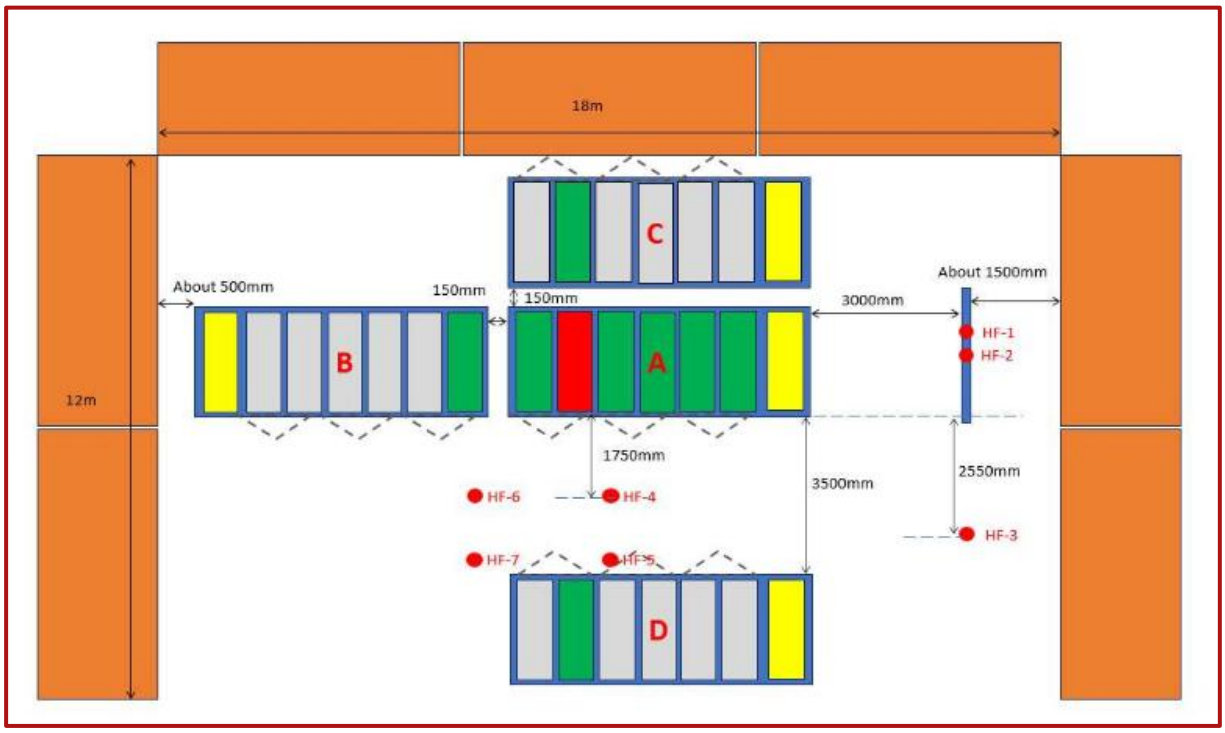


Figure 58: LSFT equipment set up

I.1.2. The following heat fluxes were recorded as part of the LSFT, as shown in Figure 59. HF-5, located external to Container D at an approximate separation distance of 3.5 m from the initiating Container A, recorded a peak incident heat flux of 32.7 kW/m² as per the table and was adopted as the baseline input for calibration of the FiRE model.

Summary of maximum heat flux measured	
Heat Flux Gauge No.	kW/m²
HF-1	8.3
HF-2	7.3
HF-3	12.3
HF-4	37.4
HF-5	32.7
HF-6	14.5
HF-7	21.9
Note: Heat Flux were measured constantly and then average every 60-seconds	

Figure 59: Maximum heat fluxes recorded

I.1.3. The LSFT results were replicated within FiRE to develop a representative model of the credible worst-case external thermal exposure scenario. The model

configuration replicated the LSFT arrangement, including a front-to-front BESS separation distance of 3.5 m, as shown in Figure 60. A representative flame height of 3.5m was also used.

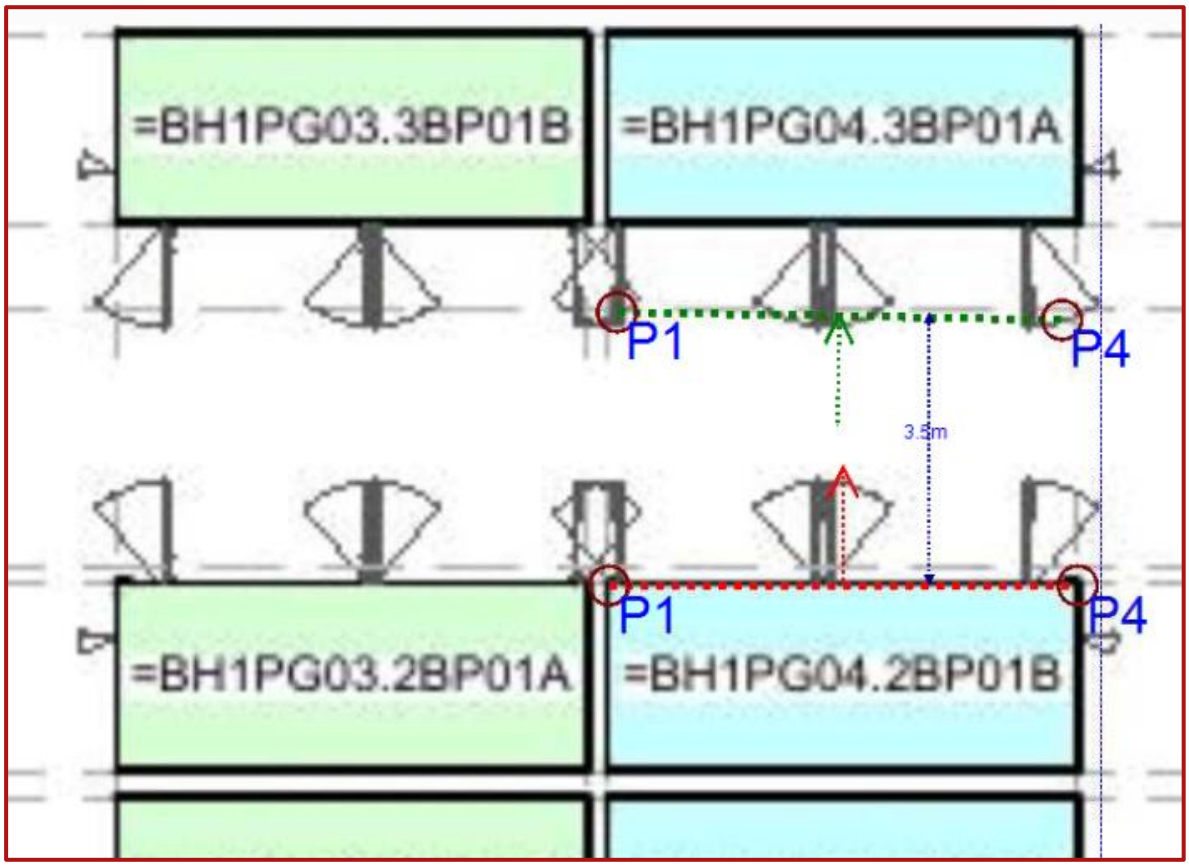


Figure 60: Baseline model set up

I.1.4. For this model, the front face of the BESS was adopted as the emitting surface and represented within FiRE as a radiating flame plane. A representative flame temperature of 1,035 K was applied to both emitting planes, resulting in a predicted incident radiant heat flux of 32.1 kW/m² at the HF-5 receiver location positioned at a separation distance of 3.5 m. This is shown in Figure 61.

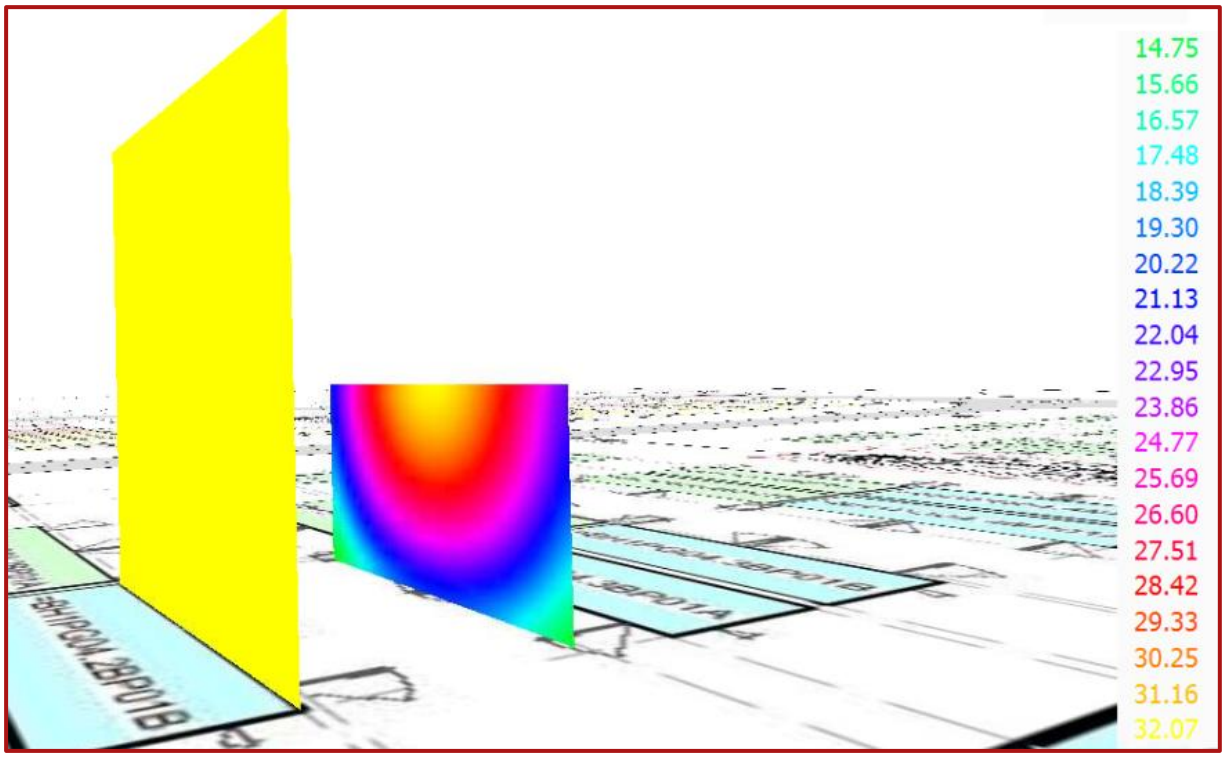


Figure 61: Baseline model output

I.1.5. The actual separation distances of the equipment on site are shown in Table 47.

Table 47: Separation distances

Equipment	Dimension Description	Min spacing value
BESS to BESS	Front to front	>4.3m on site
	Back to back	0.25 m on site
	End to end	0.20m on site

I.1.6. The front to front model has been replicated for the actual separation distance of 4.3m on site. At this distance the model predicts an incident radiant heat flux of 22.5 kW/m². This is shown in Figure 62.

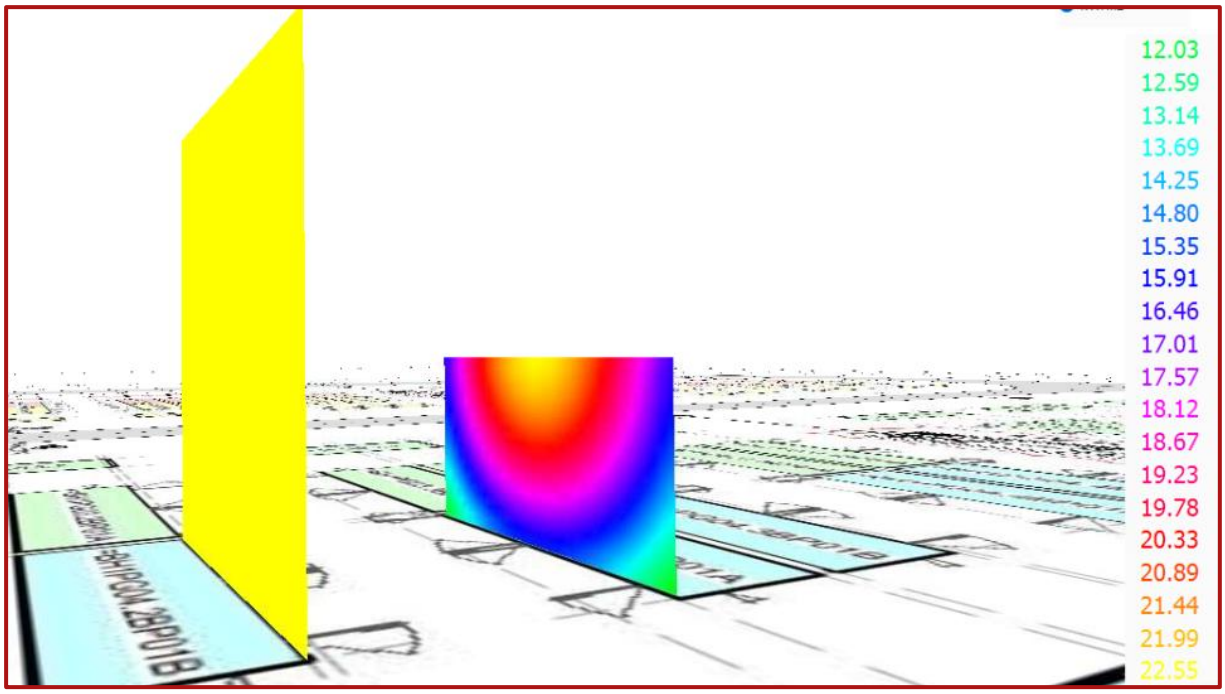


Figure 62: >4.3m front to front separation

I.1.7. An additional FiRE model was undertaken using a 45° flame tilt angle to represent an average wind condition scenario. The model assessed the impact of wind-driven flame deflection on radiant heat exposure. The radiation on the BESS unit is predicted within the model as 29.0kW/m^2. This is shown in Figure 63.

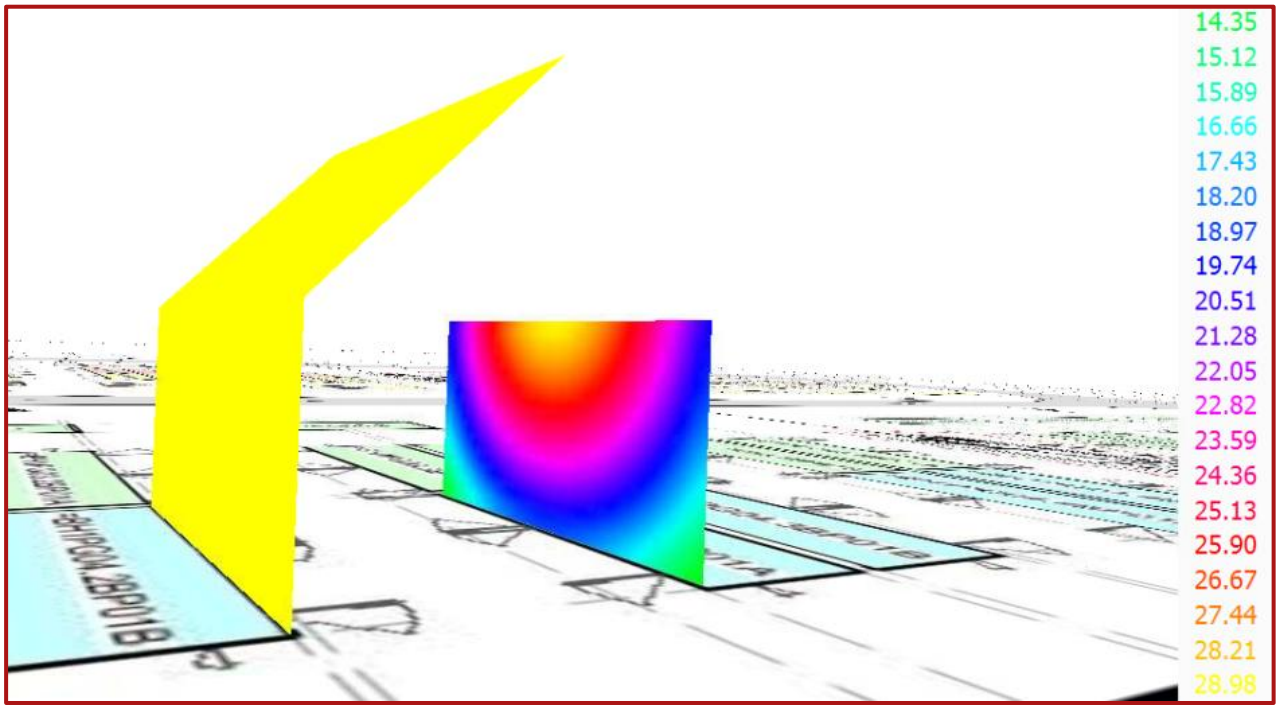


Figure 63: >4.3m front to front separation – flame tilt

I.1.8. Additional modelling inputs were developed for the back-to-back and end-to-end BESS exposure scenarios using representative Li-ion battery fire test data. The modelling considered the protective performance of the BESS enclosure, external

flame projection from door openings, and the thermal insulation characteristics of the system. The following temperatures have been used:

a) Side wall and rear wall of the BESs have an average surface temperature of 500°C
b) The walls associated with the cooling system will have a temperature of 250C.
c) The flame is assumed to be shielded for the back to back scenario due to the close proximity of BESS units.

I.1.9. The Back to back scenario for creates a max radiation of 17 kW/m^2. This is shown in Figure 64.

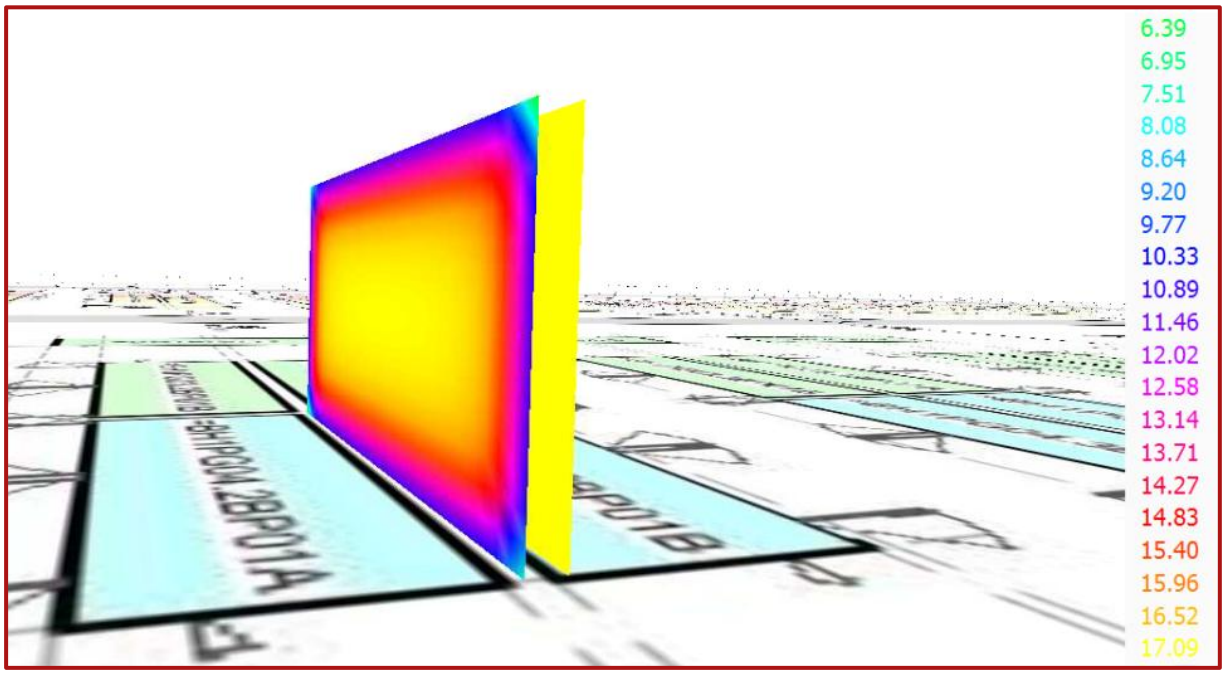


Figure 64: Back to back radiation model

I.1.10. The side to side scenario for creates a max radiation of <1 kW/m^2. This is shown in Figure 65.

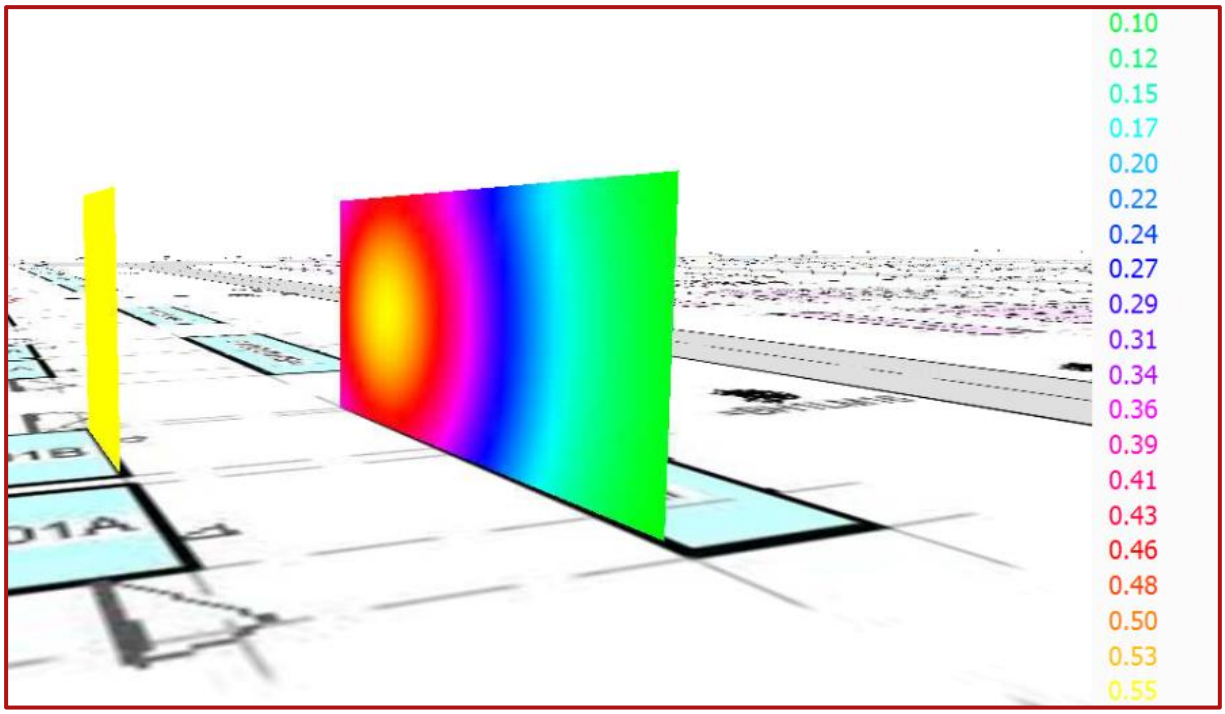


Figure 65: Side to side radiation model

12.1.1 The final results are tabulated in Table 48.

Table 48: FiRE Results

Equipment	Dimension Description	Spacing value (m)	Max Radiation (kW/m2)
BESS to BESS	Front to front (baseline)	3.5	32.1
	Front to front	4.3	22.5
	Front to front – tilted angle	4.3	29.0
	Back to back	0.25	17.0
	Side to side	0.20	N/A
	End to PCSM	3.4	<1

I.1.11. Based on the analysis, the maximum radiation received in all cases is actually lower than that in the LSFT. This is due to the site adopting larger spacing between BESS units than the LSFT minimum. Furthermore, in the LSFT the highest cell temperatures in adjacent units reached was 80°C, given the venting temperature is 205°C, this means significantly more heating would be required to cause failure/fire to spread due to cells.

Appendix J. Deflagration Consultant Advice Note

J.1. Introduction

J.1.1. This section has been added in V4 of the FSS to insert a separate CAN provided in response to FRNSW comments on V3. The CAN is presented beginning on the following page.

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Family • Diversity • Sustainability • Quality

24 June 2026

FRNSW
Via email

Attention: **Richard Jay & Jun Hyeong Lee**

Re: **CONSULTANT ADVICE NOTE 02**
Project No: **JN26-00265** **Version:** **V1**
Project: **Belambi Heights BESS**

1 Background

1.1 This CAN is provided as an addendum to the Belambi Heights BESS Fire Safety Study (FSS) Version 3. The intent of this CAN is as follows:

- Provide qualitative assessment of the deflagration risk of the BESS units with doors open and closed, and
- Set out an additional safety measure to be incorporated into the sites Emergency Plan (EP) and Emergency Services Information Pack (ESIP) in relation to the deflagration risk.

1.2 This CAN has been provided in response to FRNSW comments on FSS V3, specifically FRNSW File Ref # FRN23/2931 BFS26/3711 700000216, TRIM Doc # D26/91423. In that correspondence from FRNSW all comments had been closed out except for those relating to the deflagration hazard.

1.3 This CAN is provided to close out the final comments and has also relied upon phone conversations with FRNSW Staff Luke Loseby (18 June 2026), and Jun Hyeong lee (19 June 2026).

1.4 The intent of this CAN is to close out those comments with this as an addendum to the FSS. The FSS has also been updated to V4 simply to incorporate this CAN as an appendix and requirement.

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2 BESS Large Scale Fire Test (LSFT)

2.1 FRNSW have acknowledged verbally that their concern with this project relates to the deflagration risk, particularly as this is the first project where they have seen a LSFT that takes place with all doors open from the outset. This LSFT was done before the final version of UL9540A 6th Edition was published and therefore was based on draft notes for the 6th edition and on CS-800.

2.2 Whilst an all-doors open LSFT does comply with the latest edition of UL9540A, it does not necessarily provide the most information relative to other options in UL9540A. For instance, one option for units without deflagration vents is to apply Annex C of UL9540A which involves a partial volume deflagration within the unit to then determine which openings fail open.

2.3 The product for this project was tested prior to the 6th edition of UL9540A, and was done so with all doors open, which would generally still be a compliant approach. Nonetheless FRNSW have expressed a desire for greater information in relation to potential deflagration hazards to responding staff. This CAN does so by presenting the following scenarios and information:

- Scenario 1A – Large fire apparent on arrival with BESS doors open,
- Scenario 1B – Significant failure with gases being released but no fire on arrival, with doors open,
- Scenario 2 – Fire or failure with BESS doors closed on arrival, and
- Proposed guidance to be included in the Emergency Services Information Pack (ESIP) on site

3 Large Fire - Doors Open

3.1 This scenario considers the potential deflagration/explosion hazard to the responding brigade in the case that the doors to a BESS unit are open upon their arrival to site.

3.2 The doors could be open due to a fire occurring during maintenance of the unit, or due to an earlier deflagration which damages/opens the doors due to the forces of the blast.

3.3 Scenario 1A: In the case that the BESS unit appears to be burning freely with the doors open, it's generally considered that the risk to brigade of subsequent blasts threats, i.e., overpressure and deflagrations, is reduced, though not eliminated. With the doors open the volume of gases that can build up without having sufficient oxygen to burn is significantly reduced, as the unit burns more freely. This does not mean that a secondary deflagration is impossible, but that the likelihood and intensity of one is reduced relative to the initial blast that would have opened the doors. In this case brigade should be aware of potential for some deflagrations such as partial volume vapour cloud explosion if parts of the unit becomes under ventilated.

3.4 Scenario 1B: In the event that the fire brigade responds to a BESS unit failure but finds the unit is not actively on fire though its doors are open and it is actively off-

gassing, a delayed Vapor Cloud Explosion (VCE) or flash fire hazard remains, if the gases encounter an ignition source. The probability of this scenario occurring is significantly higher for a localized failure involving a limited number of cells rather than a major propagation across multiple modules or racks within the BESS. The latter is highly improbable, as it would require a massive, cascading thermal runaway event to propagate entirely without flaming while simultaneously failing to find an ignition source prior to the brigade's arrival. Given the cell-level results from UL9540A testing and the thermal insulation between cells and modules, a large-scale, spreading thermal runaway event without fire is considered highly unlikely, though it remains technically possible.

3.5 In Scenario 1B, because localised off-gassing can still occur from an isolated module failure despite successful propagation testing, the responding fire brigade must remain highly vigilant regarding toxic vapor accumulation and delayed partial volume VCE risks. The Incident Commander must assess site conditions to determine whether to deploy water for vapor knockdown, carefully weighing the benefits of trying to knockdown the vapour with the known potential for increased overall HF production from the interaction of water with battery off gases. All brigade tactical operations in this scenario must be conducted from a safe defensive standoff distance.

4 Closed Doors

4.1 Scenario 2: In the case of the brigade arriving on site to a clearly identifiable fire or significant thermal runaway gas release failure (without fire) with the doors to the BESS unit closed, it is imperative that the unit be treated as a significant deflagration hazard. In this scenario, the unit is more likely to be under ventilated when burning, and therefore more likely to have flammable gases which leave the unit prior to combustion, potentially posing a significant VCE hazard. Similarly, if a door were to be manually opened, it may introduce air into the unit which could result in a backdraft or a deflagration similar to the McMicken BESS incident in Arizona.

4.2 In this scenario, fire brigade is expected to remain vigilant for the potential deflagration and maintain a safe distance. Temperature monitoring such as using a Thermal Infrared Camera (TIC) is only expected to occur if it can be done from outside the expected danger zone.

4.3 Based on the inputs and assumptions of the Fire Safety Study, this is expected to be a distance of approximately 19 m from the affected BESS unit. In order to assist the fire brigade in understanding the safe distances, the ESIP is to include a map on site, as indicated in the next section.

5 Graphical ESIP Information

5.1 To better inform the responding fire brigade of approximate safe distances on site, the site emergency planning and ESIP are to include figures of distances with site reference points such as equipment. An example is shown below in Figure 1.

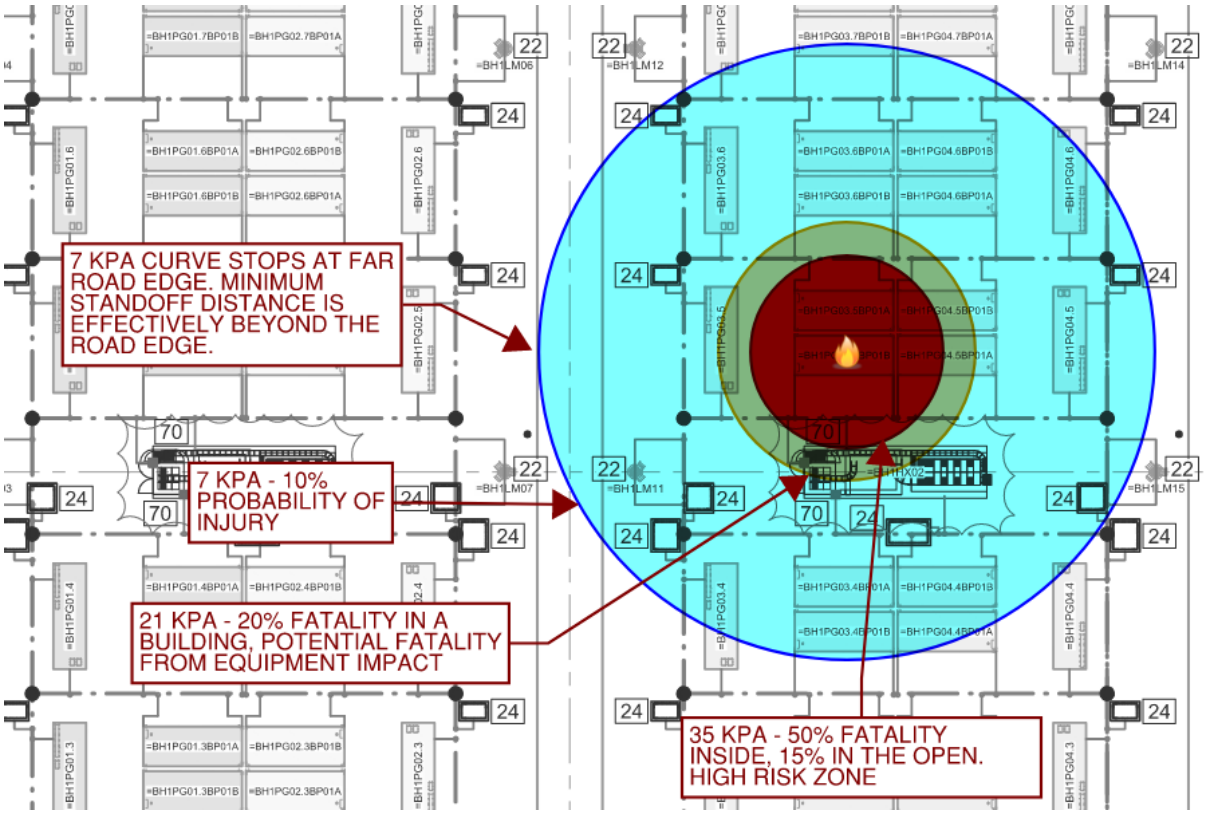


Figure 1 Example EP / ESIP Mark Up

5.2 In this figure, the outer most circles represent the 7 kPa range which is referenced by HIPAP 2 as having a 10% risk of injury. The inner rings represent the 21 kPa and 35 kPa ranges which have an increasing risk of fatality.

5.3 To further assist the brigade in understanding the risk of flammable gases, the site representative who responds is to have access to the SCADA which can be used for live monitoring of the gas detectors within BESS units.

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