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Appendix C

Enterprise BESS Hazard Mitigation Analysis

COFFMAN ENGINEERS

ENTERPRISE BATTERY ENERGY STORAGE SYSTEM PROJECT

Hazard Mitigation Analysis

COFFMAN PROJECT NO. 253107

IFR SUBMITTAL

December 26, 2025

Prepared for: Enterprise BESS LLC

www.coffman.com

HAZARD MITIGATION ANALYSIS

FOR

ENTERPRISE BESS

Escondido, California

Project Number: 253107

Revision	Date	Description
A	10/15/2025	Issued for Review
B	12/05/2025	Issued for Permit
C	12/17/2025	Change to 2025 Code Cycle
D	12/25/2025	IFP Revision

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APPENDICES

ABBREVIATIONS

AHJ	Authorities Having Jurisdiction
BESS	Battery Energy Storage System
BMS	Battery Management System
BOL	Beginning of Life
CATL	Contemporary Amperex Technology Co., Limited
CFC	California Fire Code
DC	Direct Current
EMS	Energy Management System
EOL	End of Life
ESS	Energy Storage System
FACP	Fire Alarm Control Panel
FCC	Fire Command Center
FHSZ	Fire Hazard Severity Zone
IFC	International Fire Code
HMA	Hazard Mitigation Analysis
HVAC	Heating, Ventilation, and Air Conditioning
IDLH	Immediately Dangerous to Life and Health
kV	Kilovolt
LFL	Lower Flammability Limit
LPC	Local Plant Controller
LRA	Local Responsibility Area
MW	Megawatt
MWh	Megawatt-hour
MV	Medium Voltage
NEC	National Electric Code
NESC	National Electric Safety Code
PCS	Power Conversion System
PEL	Permissible Exposure Limits
SCADA	Supervisory Control and Data Acquisition
SDG&E	San Diego Gas & Electric
UPS	Uninterruptible Power Supply

1 PROJECT BACKGROUND

1.1 Introduction

Coffman Engineers, Inc. provides this Hazard Mitigation Analysis (HMA) in accordance with the 2025 California Fire Code (CFC), as amended and adopted by City of Escondido, for the Enterprise (Battery Energy Storage System) project. The site utilizes 19 SYL (model #SU3794U3794KC) enclosures containing Prismatic Lithium Iron Phosphate (LFP) batteries totaling 52 Megawatts (MW) of battery energy storage.

This HMA is being submitted to the California Energy Commission (CEC) for review and approval. The CEC is the entity responsible for licensing the BESS project including review (in consultation with the Escondido Fire Department) and approval of fire-related plans and design related to the BESS facility. The Escondido Fire Department is the Fire Marshal and is considered the AHJ for the purposes of Fire and Life Safety matters (e.g., emergency response planning and incident response). The life safety of personnel shall be the highest priority during any event.

The project has plans to expand the number of battery enclosures to a total of 24 enclosures in future phases. As the facility expands the number of enclosures provided at the site, the Hazard Mitigation Analysis Report will need to be updated accordingly to accurately convey the site.

1.2 Site Location

The Enterprise Battery Energy Storage System project is located at 2361 Auto Park Way, Escondido, CA 92029 with coordinates 33°07'23.3"N 117°07'01.4"W. See Figure 1.2.1 and 1.2.2 below for site location and layout.

Project Summary	
Engineering, Procurement and Construction	RavenVolt
Owner	Enterprise BESS LLC
Utility	San Diego Gas & Electric (SDG&E)
ESS Enclosure Type	Enclosure Type IP-55 SYL SU3794U3794KC
Number of ESS Enclosures	19 BOL (24 EOL)
Total Site Footprint	0.83 acres
Capacity	52 MW / 52 MWh

The project will utilize SYL SU3794U3794KC energy storage system (ESS) enclosures, an on-site project substation, and associated on-site support facilities including inverters, collection lines, fencing, access roads, SCADA, and other ancillary equipment.

The typical equipment arrangement is a block of one SYL ESS enclosures connected to a single power conversion system (PCS) which is then connected to the site substation via buried medium voltage (MV) circuits.

Figure 1.2.1 – Enterprise BESS Vicinity Map (North ↑)

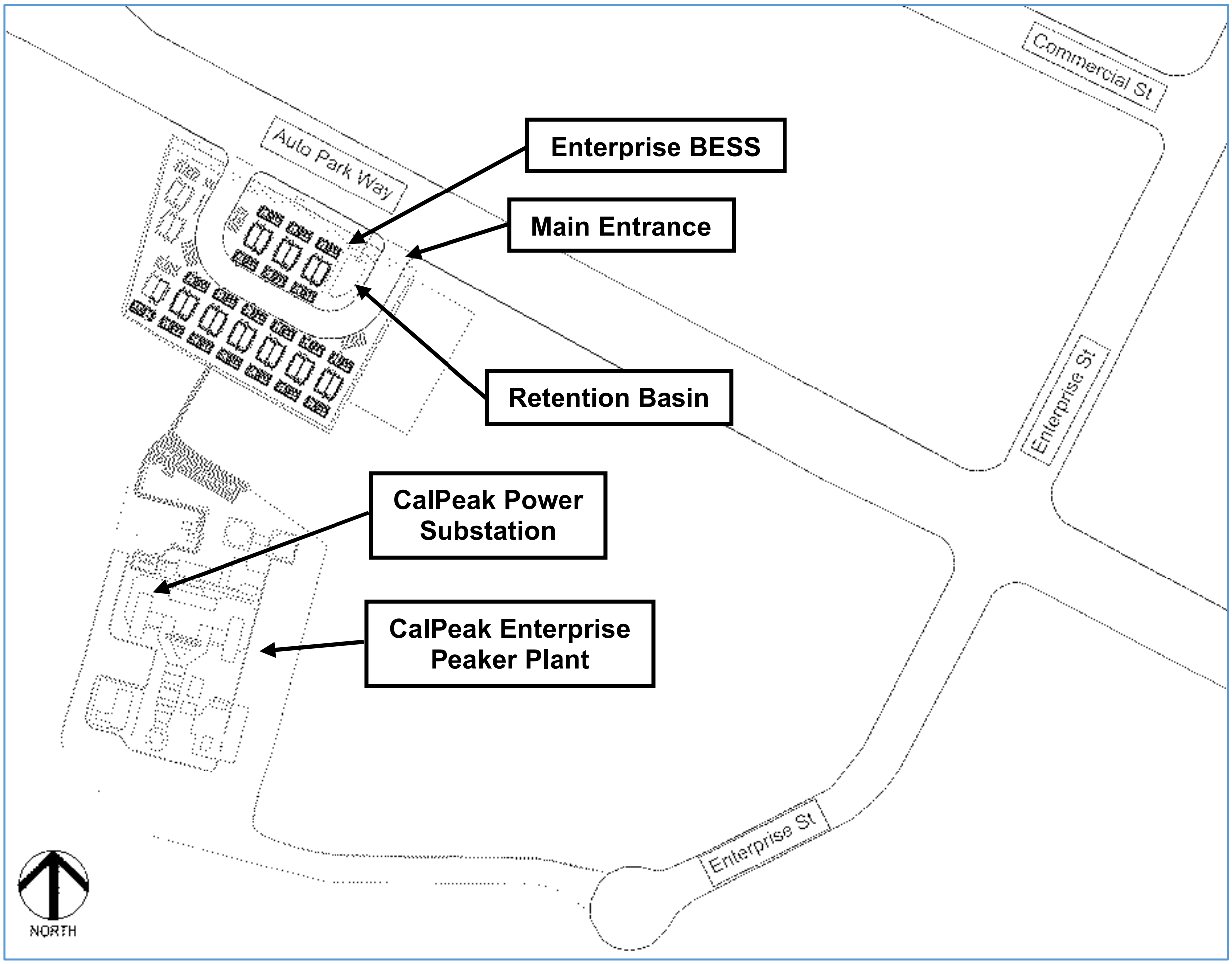

Figure 2.3.2 – Enterprise BESS Site Layout. (North ↑)

1.3 Project and Code Summary

1.3.1 Enclosure and Battery Requirements

ESS REQUIREMENTS		
Code	Requirement	Compliance Status
Equipment Listing: *CFC §1207.3.2*	ESS shall be listed in accordance with UL 9540.	**Compliant.** SYL SU3794U3794KC ESS Enclosure, SGS-CSTC certified to UL 9540. Certificate #: SGSNA/24/SH/00469. *Additional details: HMA Appendix A*
ESS Type: *CFC §202 CFC 2025 Edition Definition)*	An enclosure containing an energy storage system and meeting the applicable requirements of the listing for the system. Personnel are not able to enter the enclosure other than reaching in to access components for maintenance purposes.	**Compliant.** Classification: Energy Storage System Cabinet Note: "ESS enclosure", and "non-walk-in" are used synonymously with "Energy Storage System Cabinet" in this report. All terms refer to the SYL enclosure. *Additional details: HMA Section 1.6*
Technology: *CFC §1207.6*	Requires lithium-ion ESS to comply with provisions relating to thermal runaway and explosion control.	**Compliant.** ESS Enclosures are provided with an Energy Management System and explosion prevention system.
Size and Separation: *CFC §1207.5.1, 1207.5.2*	Allows groups to exceed 50 kWh with less than 3-ft spacing based upon large-scale testing. The ESS's Maximum allowable stored energy (600 kWh) to be exceeded where an HMA and large-scale testing justify an increase.	**Compliant.** 3,794 kWh total per enclosure. Large-scale testing (UL 9540A) has been conducted to justify reduced spacing.
Hazard mitigation analysis: *CFC §1207.1.6*	The ESS's Maximum allowable stored energy (600 kWh) to be exceeded where an HMA and large-scale testing justify an increase.	**Compliant.** Hazard Mitigation Analysis will be submitted to the AHJ for final Approval.
Thermal Runaway: *CFC §1207.6.5*	Listed device or approved method required to preclude, detect, and minimize the impact of thermal runaway.	**Compliant.** Thermal runaway mitigation provided via UL9540A tested design and UL1973 listed Battery Management System (BMS) which actively monitors the voltage and temperature of all cells. *Additional details: HMA Section 3.3*
Explosion Control: *CFC §1207.6.3*	Explosion prevention or deflagration venting measures required.	**Compliant.** NFPA 69 Explosion Protection by Mechanical Ventilation system has been included. *Additional details: HMA Section 3.4*
Fire Detection: *CFC §1207.5.4*	Requires a smoke fire detection system be installed in all rooms containing ESS	**Compliant.** The SYL enclosure is equipped with an automatic fire detection system (smoke and heat detectors) and a gas detection system. *Additional details: HMA Section 3.1*

1.3.2 ESS Site Requirements

SITE REQUIREMENTS		
Code	**Requirement**	**Compliance Status**
Outdoor ESS Installation Type: *CFC §1207.8*	Outdoor ESS installations less than 100 feet from adjacent to site exposures, buildings, lot lines, or public ways shall be classified as "Near Exposures." Installations greater than 100 feet are "Remote locations.	**Compliant.** Classification: Outdoor ESS installations, location near exposures.
Clearance to Exposures: *CFC §1207.8.3*	A 10-foot clearance from ESS to lot lines, public ways, buildings, combustible materials, and other potential exposure hazards is required to prevent fire spread. Clearances to exposures other than buildings may be reduced to 3 ft where approved and supported by large-scale fire testing of the ESS.	**Compliant.** The installation complies with the clearance to exposure requirement based on the results from UL 9540A Test. A minimum of 10 feet is provided in all directions within the BESS Yard to the nearest lot line. *Additional details: HMA Figure 1.6.1*
Site Fire Water Source: *CFC §507.1 (inferred)*	Requires adequate on-site fire water source.	**Compliant**. UL 9540A testing was completed without water suppression. Water availability for site non-ESS fire events will be provided via existing public fire hydrants located near the site. *Additional details: HMA Section 3.2*
Vegetation Control: *CFC §1207.5.7*	Areas within 10 ft on each side of outdoor ESS shall be cleared of combustible vegetation and other combustible growth.	**Compliant.** Decomposed granite or paved areas are provided at least 10ft on all sides of the ESS enclosures.
Fire Department Access: *CFC Chapter 5*	Ensures adequate site access for emergency events and would require proper features including road widths, turnarounds, grade/surface and signage/markings.	**Compliant.** The site will incorporate all requirements within these access provisions established by CFC Chapter 5 subject to AHJ requirements and approval.
Impact Protection: *CFC §1207.4.5*	ESS shall be located or protected to prevent physical damage from impact where such risks are identified.	**Compliant.** There is limited risk to vehicle impact without individual bollards based upon the following: 1) Completely fenced off area with no public access. 2) Only technicians familiar with the site will access the site. 3) Enclosures are located at least 5-ft from the edge of the access roads 4) Vehicle traffic speeds will be limited to 10-mph. At a minimum there will be bollards placed at the corners of the road for turning protection.
Security of installation *CFC §1207.4.9*	ESS shall be secured against unauthorized entry and safeguarded in an approved manner.	**Compliant.** A 7-foot fence is provided around the entire site with no public access. The entrance gates are manually operated, and pad locked closed.

1.3.3 ESS Provisions not Applicable to this Project

REQUIREMENTS NOT APPLICABLE TO THIS PROJECT		
Code	Requirement	Compliance Status
Fire Area Separation: *CFC §1207.7.4*	Rooms or spaces containing ESS shall be separated from other areas of the building by 2-hour fire barriers.	**Not Applicable.** Enclosures have no fire rating requirement as they are not installed in a building.
Exhaust Ventilation: *CFC §1207.6.1*	N/A for Lithium-Ion technology.	**Not Applicable.** Not required/applicable as it does not off-gas during normal charging operations.
Fire Suppression Systems: *CFC §1207.5.5*	Requires rooms containing ESS systems shall be equipped with an automatic sprinkler system installed.	**Not Applicable.** No suppression is required per the UL 9540 listing of the enclosure. (9540A testing shows limited propagation with no suppression). Enclosures are also non-walk type. Additional details: HMA Section 3.2
Spill Control: *CFC §1207.6.2*	N/A for lithium-ion technology.	**Not Applicable.** Not required/applicable as the electrolyte is sealed.
Safety Caps: *CFC §1207.6.4*	N/A for Lithium-Ion technology.	**Not Applicable.** Not required/applicable.
Means of Egress Separation: *CFC §1207.5.8*	A 10-foot separation between ESS enclosures and egress paths is required to ensure safe escape routes in case of fire.	**Not Applicable.** The ESS enclosures are not installed in a building, occupied areas, or adjacent to an egress path. No egress path separation provisions apply.

1.4 Code Requirements

1.4.1 Applicable Codes and Standards

The applicable codes with regards to fire protection and life safety, with local amendments, are listed below.

- CFC, California Fire Code, (2025 Edition), as adopted by the City of Escondido
    - Including adoption of Fire Hazard Severity Zones (FHSZ)
- NFPA 72, National Fire Alarm and Signaling Code (2025 Edition)
- NFPA 70, National Electrical Code (NEC) (2023 Edition)
- NFPA 69, Standard on Explosion Prevention Systems (2024 Edition)
- NFPA 855, Standard for the Installation of Stationary Energy Storage Systems (2023 Edition)
- UL 9540, Standard for Energy Storage Systems and Equipment (2023 Edition)
- UL 9540A, Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems (2019 Edition)

The following standards, not adopted by the CFC, are used as guidance:

- NFPA 855, Standard for the Installation of Stationary Energy Storage Systems (2026 Edition)
- Pre-incident planning per NFPA 1620, Standard for Pre-incident Planning (2020 Edition)

The referenced editions exceed the requirements of the existing guides and standards referenced in the 2025 CFC.

1.5 Hazard Mitigation Analysis

1.5.1 Purpose

This HMA report is required by CFC § 1207.1.6 to support the approval of maximum energy storage quantities greater than 600 kWh for lithium-ion battery installations.

1.5.2 Basis of Analysis

This HMA report is a technical assessment conducted by a qualified professional fire protection engineer (compliant with CFC §104.2.2) to evaluate the consequences of single failure modes as required by CFC §1207.1.6.1.

The site is also located within a Moderate Fire Hazard Severity Zone (FHSZ) within a Local Responsibility Area (LRA) per California Department of Forestry and Fire Protection (CAL FIRE). However, this FHSZ designation does not trigger additional design requirements beyond the requirements of the adopted Fire Code. See Figure 1.5.2.

Figure 1.5.2 – FHSZ Designation – Moderate FHSZ in LRA (North ↑)

The fire protection and life safety strategies incorporated into the HMA are informed by manufacturer documentation, results of full-scale fire testing (UL 9540A), and site planning for the Enterprise BESS. Manufacturer documentation is included in the appendix.

The HMA should be kept in a safe location and reviewed annually by the site operator and owner. As part of the management of change process, any modifications or changes to equipment type could trigger a permit by the AHJ. As the Engineer of Record for this project, revisions to this document must be completed by Coffman Engineers.

1.5.3 AHJ Evaluation Criteria

The AHJ may approve increased maximum energy storage quantities. An approved HMA must support this approval. The HMA should evaluate the consequences of the following hazard and incorporate large-scale fire testing evidence and analysis.

CFC	Hazard Consequences Evaluated	Compliance Assessment
§ 1207.1.6.2 (1)	Fires will be contained within unoccupied ESS rooms or areas for the minimum duration of the fire-resistance-rated walls identified in Section 1207.7.4.	This minimum duration of the fire-resistance-rated walls provision is not applicable to this project as the ESS is an outdoor installation and is not a room within a building. There is no requirement for fire-resistance-rated separations.
§ 1207.1.6.2 (2)	Fires involving the ESS will allow occupants or the general public to evacuate to a safe location.	This project is classified as an outdoor unoccupied ESS installation and is not open to the public.
		While toxic gases will be released in the event that a fire occurs involving an ESS, there are no buildings on site and the site is considered to be unoccupied, and the toxic gases will not reach a concentration level in excess of the IDLH where occupants or the general public will be located.
		The batteries are hermetically sealed and do not vent under normal charging or discharging operating conditions. Flammable gases are not released during normal operations.
		There is potential that the battery cells will vent flammable gases in the event of an internal short within a battery cell, overcharging, in the event of a BMS or EMS failure, or other abnormal conditions. Fires or explosion hazards will be mitigated with an explosion prevention system designed to maintain flammable gas concentrations below 25% of the lower flammability limit (LFL), to prevent development of an explosion hazard with the potential to injure service personnel and emergency responders.

Table 1.5.3 - AHJ Evaluation Criteria

1.6 System Overview

The SYL ESS enclosure is designed as an outdoor installation complying with CFC Section 1207. The site layout allows for potential expansion, and any future installations will necessitate an updated HMA to maintain code compliance. See Appendix for additional information.

1.6.1 ESS System Description

The SYL enclosures are non-walk-in outdoor steel ESS Cabinets. They are not intended for occupancy and will be accessed externally for maintenance only. See the configuration in the table below for a high level of each component.

				
Component	**Cell**	**Module**	**Rack/Unit**	**SYL Enclosure**
Manufacturer	CATL	SYL	SYL	SYL
Model	CBDC0	SM94K8FM2	SR94K8FM24	SU3794U3794KC
Nominal Voltage (V)	3.2	332.8	n/a	n/a
Nominal Capacity (kWh)	n/a	n/a	208	3,794
Weight (lbs.)	12	1,433	n/a	70,000
Dimensions (in)	6.86 x 8.16 x 2.82	31.10 x 85.43 x 9.57	n/a	19.9 ft x 9.5 ft x 8 ft
Configuration / Chemistry	Prismatic Lithium Iron Phosphate (LiFePO4)	104 Cells (1P104S)	4 Modules	416S*10P
Thermal Management	n/a	n/a	Liquid Cooling System	Liquid Cooling System
Listing / Certification	UL 1973	UL 1973	n/a	UL 9540

Table 1.6.1 - SYL Configuration

Figure 1.6.1 – ESS Separation Requirements per SYL (Manufacturer)

2 FIRE TEST ANALYSIS

Test Standard: UL 9540A, Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems, 4th Edition, November 12, 2019.

2.1 Cell Test

2.1.1 Setup and Conditions

A lithium iron phosphate (LiFePO4, LFP) battery cell (Model CBDC0), certified to UL 1973, was tested according to UL 9540A. Thermal runaway was induced using an external heater. Vent gas was captured in a 100L pressure vessel for analysis. Gas flammability was assessed using the ASTM E918 method at both ambient and cell vent temperatures.

The cell level test document that was references for this report was published by UL (Changzhou) Quality Technical Service Co., LTD. Dated 9/7/2023, Project No. 4790838636.1. The UL9540A Cell Level Test can be found in Appendix B.

2.1.2 Cell Test Results

The cell's average venting temperature was 156 °C (312.8 °F) with an average thermal runaway temperature of 232 °C (449.6 °F). Vent gas analysis confirmed flammability when mixed with air. The LFL was 7.45% (vol in air) at 25°C, decreasing to 6.545% at vent temperature. The vent gas contained significant amounts of hydrogen, carbon dioxide, carbon monoxide, and various hydrocarbons.

2.2 Module Test

2.2.1 Setup and Conditions

This test evaluates fire hazards within a battery module as part of an ESS installation. Measurements include chemical heat release rate, maximum temperature, vent gas composition, enclosure integrity, and the presence of explosions, hazardous ejections, and external flaming. Thermal runaway was induced using external heaters at a rate of 4-7°C per minute.

The module level test document that was references for this report was published by SGS-CEC New Energy Technology (Chongqing) Co., Ltd. Dated 7/30/2024, Report No. CQES240700055301. The UL9540A Module Level Test can be found in Appendix B.

2.2.2 Module Test Results

The module level test was performed by heating two cells using film heaters. Each module contains 104 cells. The report does not confirm the number of cells that went into thermal runaway, but the results look similar to what was observed during the unit level test. Gas and smoke venting was observed. No external flaming or sparking and no explosion or flying debris was observed.

2.3 Unit Test

2.3.1 Setup and Conditions

This test evaluated fire behavior and propagation within a SYL ESS unit with a focus on containment and preventing flying debris or explosive gas discharge. Thermal runaway was induced using external heaters at a rate of 4-7°C per minute. No BMS or fire suppression systems were utilized.

The unit level test document that was references for this report was published by SGS-CEC New Energy Technology (Chongqing) Co., Ltd. Dated 08/29/2024, Report No. CQES240800069201. The UL9540A Unit Level Test can be found in Appendix B.

2.3.2 Unit Test Results

The unit level test was performed by heating two cells using film heaters. The enclosure level test results demonstrate that thermal runaway propagation was limited to three cells. Module-to-module propagation of thermal runway was not observed along with no external flaming or sparking and no explosion or flying debris. Gas and smoke venting was observed.

3 ESS SAFETY SYSTEMS

Battery storage ESS enclosures at the Enterprise BESS site will incorporate the following safety features:

3.1 Fire Detection and Alarm

Each ESS enclosure is provided with an internal fire detection and alarm system, consisting of an internal Fire Alarm Control Panel (FACP) with two smoke detectors and two heat detectors within the main ESS container, as well as one smoke detector within the enclosure's integration cabinet. A site fire alarm control panel, referred to as a “Fire Command Center” (FCC), located in an approved location monitors all fire alarm signals from each ESS enclosure. ESS Status indicators will be visible at the FCC and the ESS container's associated FACP.

3.1.1 Code Requirements

CFC §1207.5.4 requires all fire areas containing ESS systems located within buildings or structures to be provided with a smoke detection system in accordance with NFPA 72. The SYL enclosures comply with this requirement.

3.1.2 System Description

The fire alarm system incorporates multiple detection technologies, integrated actions, and redundant monitoring:

- Detection: Each SYL ESS container will contain smoke detectors, heat detectors, and combustible gas detectors. These detectors, compliant with NFPA 72 standards, were not active during the UL 9540A unit (rack) level test.
- Integration: Detection systems also transmit signals to the BMS system. Upon gas detection, the system automatically shuts down the HVAC, halts charge/discharge processes, and activates off-gas ventilation.

- Monitoring: The stand-alone site level fire alarm panels are monitored at the Fire Command Center (FCC) featuring an annunciator display. All alarms, supervisory, and trouble signals are transmitted to the FCCs and off-site monitoring service. FACPs include an uninterruptible power supply (UPS) for 24 hours of standby plus 2 hours of alarm.

3.1.3 Safety Assessment

The fire alarm system's design aligns with relevant sections of CFC and NFPA 72 standards to provide the following benefits:

- Fire Detection: Detection enables reliable identification of thermal runaway hazards with overlapping coverage.

- Redundancy: Networked FACPs and off-site monitoring ensure continuous oversight and minimize response delays.

- Proactive Mitigation: Automatic ventilation triggered by gas detection reduces the risk of flammable gas buildup.

3.2 Fire Suppression System

3.2.1 Code Requirements

The SYL ESS enclosures are classified as outdoor, non-occupiable installations. CFC § 1207.5.5 requires “rooms” containing stationary storage battery systems to be equipped with an automatic sprinkler system and designed in accordance with NFPA 13. As they are not considered "rooms" within buildings, CFC § 1207.5.5 does not require in-unit fire suppression systems.

3.2.2 System Description

While the SYL ESS enclosures have the infrastructure to support a water spray system, they were tested without an automatic water supply in accordance with UL 9540A unit (unit) testing procedures. It should also be noted that the ESS containers will come preinstalled with a manual dry sprinkler system with a fire department connection but will not be connected or used.

3.2.3 Safety Assessment

UL 9540A tests demonstrated that the SYL ESS design successfully prevents thermal runaway propagation between modules without an internal suppression system. This indicates that the ESS enclosure design effectively contains fire hazards. The decision to rely on the fire department for water supply aligns with CFC provisions for outdoor, non-occupiable installations while still offering a level of fire protection.

Fire water may either be brought to the site via tankers or accessed from the existing public fire hydrants located in close proximity to the site. The Emergency Response Plan (ERP) should be further referenced for recommendations.

3.3 Thermal Runaway Protection

3.3.1 Code Requirements

The design of the SYL ESS system aligns with the fire safety provisions outlined in the CFC regarding thermal runaway prevention in lithium-ion ESS:

- CFC § 1207.6.5: This paragraph mandates the use of listed devices or other approved methods to prevent, detect, and minimize the impact of thermal runaway events.
- CFC § Table 1207.6: Table emphasizes the necessity of specific protection against potential fire and explosion hazards associated with thermal runaway in lithium-ion batteries.
    - Footnote E, Table 1207.6: This footnote clarifies that thermal runaway mitigation strategies can be incorporated into the BMS, provided the BMS has been evaluated in conjunction with the battery using UL 1973 standards.

3.3.2 System Description

The SYL ESS module employs a thermal runaway design prevention based on thermal management and is comprised of the following elements:

- Battery Management System (BMS): The BMS plays a central role in monitoring and safeguarding the health of the batteries. It continuously tracks critical parameters, including voltage, temperature, and state of charge. See Appendix F for additional information. Essential BMS functions include:
    - Fault Detection: The BMS monitors for over-temperature, over-charge, over-discharge, over-current conditions, and overall system health. Upon detection of faults or parameters exceeding safe tolerances, the BMS will isolate affected battery strings and transmit alarm signals to the Emergency Management System (EMS).
    - Thermal Management: The BMS actively oversees temperature monitoring and control, ensuring optimal operating conditions to prevent thermal events.
- Liquid Cooling System: Cooling liquid powered by an internal pump will circulate inside battery modules and take the heat from the batteries and will circle back to a heat exchanging tank. This design feature actively cooling the batteries to reduce the potential of thermal runaway, reducing the risk of cascading failures.
- LFP Chemistry: Lithium Iron Phosphate (LFP) batteries are inherently more stable and resistant to thermal runaway when compared to other lithium-ion chemistries, offering a foundational layer of fire safety.

3.3.3 Safety Assessment

The effectiveness of the SYL ESS design in containing and mitigating thermal runaway events has been validated through UL 9540A unit (rack) level testing. Key findings from these tests include:

- Containment: In tests initiating thermal runaway, the event was successfully confined to a small number of cells resulting in no sparks, flaming, electrical arcs, or other electrical events during test.

- Minimal Hazards: The tests observed no deflagration, external flaming, projectiles, explosive events, or other hazards that could pose a risk to personnel or surrounding property.

3.4 Explosion Control Systems

3.4.1 Code Requirements

The SYL ESS installation incorporates an explosion control system to mitigate the risks associated with flammable gas release during potential fire events. This system aligns with the following code requirements (reference Appendix E for NFPA 69 report):

- CFC § 1207.6.3: Mandates explosion control measures for ESS installations.
- CFC § 911: Permits the use of NFPA 69 or NFPA 68 compliant systems.
- NFPA 69 Section 8.3.1: Requires the maintenance of flammable gas concentration below 25% of the Lower Flammability Limit (LFL).

3.4.2 System Description

The explosion control system within the SYL ESS enclosure employs a proactive approach that integrates gas detection devices, ventilation system, and operational safeguards:

- Gas Detection: Each ESS container houses two gas detectors specifically designed to detect Hydrogen (factory calibrated) typically released during lithium-ion battery thermal runaway.
- Exhaust Ventilation (NFPA 69): Upon gas detection, exhaust fans activate to remove flammable gases from the ESS container. Reference Appendix E for the full report.
- Operational Controls: Detection triggers several actions: alarms are sent, charging/discharging processes halt, off-gassing valves open, and exhaust ventilation activates.

3.4.3 Safety Assessment

An analysis of UL 9540A testing supports the design and effectiveness of the explosion control system. Gas release data obtained during these tests provides a reliable prediction of the expected gas concentration, composition, and LFL release from a thermal runaway event to validate the ventilation system design.

Even with the explosion control system in place, strict safety protocols are essential. During fire or thermal runaway events, personnel must not approach ESS containers until the ventilation system has effectively cleared flammable gases, and all alarm conditions have been reset.

The explosion control system implemented in the SYL ESS design is based on testing and validated analysis and aligns with relevant fire codes. These proactive measures, in conjunction with safety procedures, significantly reduce the risk of explosion hazards.

FAULT CONSEQUENCE ANALYSIS

Failure	Safety Compliance Level	System Response	Failure Consequence	Severity Risk Analysis
Thermal Runaway §1207.1.6.1 (1)	Containment of fire/gas within the originating module or ESS unit, preventing spread to adjacent units.	Thermal runaway contained to the originating module. Detection of combustible gas, smoke, or heat triggers a fire alarm. The ventilation system activates, purging gases. BMS monitors parameters and disconnects power if necessary.	A thermal runaway event remains confined to the affected module, or unit (rack). Potential smoke/gas release is likely. A fire alarm signal is transmitted.	While a thermal runaway event is disruptive, the demonstrated containment capability limits the potential damage. The fire alarm signal alerts personnel and triggers further mitigation measures.
BMS Failure §1207.1.6.1 (3)	System design and safeguards prevent thermal runaway, even without the BMS.	Affected battery modules cease charging/discharging.	Failure of the BMS (not caused by thermal runaway) results in halted charging/discharging. However, isolated batteries still store electrochemical energy. Other fire and gas detection remains active.	A BMS failure removes an active layer of protection but does not eliminate the inherent energy storage risk of electrochemical batteries. The continued function of other detection systems provides a crucial safety net.
Voltage Surge §1207.1.6.1 (3)	Surge protection prevents widespread equipment damage or immediate fire risks. No unsafe conditions or thermal events were created.	Protective relays/breakers shut down affected ESS portions. Surge arresters divert excess voltage. BMS monitors and shuts down affected segments if anomalies are detected.	Electrical code compliance, surge arresters, and the BMS minimize the potential for severe damage to SYL ESS components from voltage surges.	The system incorporates multiple layers of protection against voltage surges, significantly reducing the likelihood and severity of potential damage.
Short Circuit (Load Side) §1207.1.6.1 (3)	Overcurrent protection prevents widespread damage within the ESS. No unsafe conditions or thermal events were created.	Overcurrent protection devices activate, isolating the fault.	Adherence to electrical codes and the UL 9540 certification of the SYL ESS significantly reduce the likelihood and potential severity of load-side short circuit events.	Code compliance and UL 9540 certification provide a high degree of confidence in the system's ability to withstand and manage short-circuit events safely.
Exhaust Ventilation System Failure §1207.1.4.1 (3)	A transmitted trouble signal to initiate an investigation or shutdown reduces the risk of thermal runaway. No unsafe conditions or thermal events were created.	Batteries remain in a normal, non-off-gassing state. Combustible gas and smoke detectors trigger a fire alarm signal.	An exhaust ventilation system failure in isolation has minimal immediate impact. In a dual-fault scenario with thermal runaway, redundant detection systems, alarms, and procedures alert personnel and prevent unsafe approaches.	While an exhaust ventilation failure alone poses minimal risk, its consequences become more severe if coupled with thermal runaway. The presence of redundant safety systems and emergency procedures significantly reduces the likelihood and potential severity of this dual-fault scenario.
Fire Detection Equipment Failure §1207.1.6.1 (3)	Immediate trouble signals provide impairment notification. Detection redundancies ensure monitoring continues. No unsafe conditions or thermal events were created.	Redundant detection (smoke, heat, gas) remains operational. Smoke detector failure transmits a trouble signal. EMS triggers ESS container shutdown upon smoke/heat detector failure. The tiered alarm system activates. NFPA 72 maintenance minimizes failure likelihood.	Delayed detection of smoke or heat is possible. However, redundancy, trouble signaling, automated EMS shutdown, and proactive maintenance significantly reduce the risk and potential severity posed by a single detector failure.	While complete detection system failure is a remote possibility, the multiple safeguards and maintenance protocols in place significantly mitigate the likelihood and adverse consequences of such an event.

FAULT CONSEQUENCE ANALYSIS

Failure	Safety Compliance Level	System Response	Failure Consequence	Severity Risk Analysis
FACP Failure §1207.1.6.1 (4)	Immediate trouble signals provide impairment notification. Redundant FACPs or signaling pathways ensure continued alarm functionality or notification of impairment.	Trouble signals were sent to FCC, EMS, and LPC. EMS initiates shutdown of the affected ESS container group. Redundant fiber-optic pathways ensure signaling for other ESS container groups.	An FACP failure primarily affects only the directly connected ESS container group. Trouble signals, shutdown procedures, and redundant pathways mitigate the potential consequences.	The localized impact, automated response, and redundant signaling design limit the severity of an FACP failure. While disruption to the affected ESS container group is likely, the overall ESS installation maintains a high level of protection.

4 FAULT CONSEQUENCE ANALYSIS

4.1 Thermal Runaway in a Single ESS Module or Rack/Unit

This analysis assesses the potential for a thermal runaway event within a single SYL ESS module, or rack/unit.

4.1.1 Mitigation and System Response

- **Containment:** UL9540A test results confirm that thermal runaway will not propagate to adjacent modules, racks/units. This containment feature significantly reduces the potential impact of the event.
- **Early Detection:** Initial signs of thermal runaway are likely to include the detection of combustible gas released from off-gassing battery cells or the presence of smoke. Detection triggers a fire alarm signal transmitted to the fire alarm panel and a monitored location.
- **Ventilation:** Upon detection, the ventilation system activates to purge combustible gases, maintaining concentrations below 25% of the LFL.
- **Battery Management System (BMS):** The BMS continuously monitors battery voltage, temperature, and other operational parameters. In the event of irregularities, the BMS will proactively disconnect power to help prevent the escalation of an abnormal condition into a thermal runaway event.

4.1.2 Consequence and Severity

The UL 9540A testing demonstrates successful containment of a thermal runaway event within the originating module. Additional measures of protection beyond the test configuration include integrated fire detection and gas detection system, exhaust ventilation, and proactive BMS intervention, which significantly reduce the potential severity of a single module thermal runaway event within the SYL ESS system. These integrated safety measures are designed to prevent a localized module failure from cascading into a catastrophic event.

4.2 Failure of Battery or Energy Management System

This analysis assesses the impact of a failure within the SYL ESS battery system or its associated BMS.

4.2.1 Mitigation and System Response

- **BMS Functionality:** The SYL ESS incorporates a BMS designed to protect battery modules from common triggers for off gassing or thermal runaway, including over/under voltage, excessive temperatures, and short circuits.
- **BMS Failure Response:** Upon BMS failure, the affected battery modules immediately cease charging and discharging. This mitigates electrical conditions that could exacerbate a hazardous situation.

4.2.2 Consequence and Severity

While a BMS failure removes active charging and discharging, it does not eliminate the inherent energy storage risk of electrochemical batteries. Even in isolation, batteries can still pose a hazard. Fire safety and emergency response plans, compliant with relevant IFC guidelines, address the potential consequences of this residual risk.

4.3 Failure of the Emergency Ventilation System

This analysis assesses the impact of a ventilation system failure within a SYL ESS installation.

4.3.1 Mitigation and System Response

- **Normal Operation:** Under normal operating conditions, SYL ESS batteries do not off-gas. This minimizes the immediate impact of a ventilation failure.
- **Dual-Fault Scenario:** In the unlikely event of a ventilation failure coinciding with a thermal runaway event, several safeguards remain in place: Combustible gas, smoke, and heat detectors continue to function. Alarms are transmitted to remote fire alarm panels, the ESS yard entrance annunciator, and a constantly monitored location. Emergency procedures mandate that personnel maintain a safe distance until safety checks are complete and alarms are silenced.

4.3.2 Consequence and Severity

A ventilation system failure in isolation carries minimal immediate risk due to the lack of off-gassing during normal battery operation. In the unlikely dual-fault scenario involving thermal runaway, redundant detection systems and emergency procedures alert personnel and prevent unsafe approaches. While a complete ventilation failure coupled with a thermal runaway could have severe consequences, the layered safety measures in place significantly reduce the likelihood and potential severity of such an event.

4.4 Voltage Surges on the Primary Electric Supply

This analysis assesses the impact of voltage surges on the primary electrical supply to SYL ESS.

4.4.1 Mitigation and System Response

- **Electrical Code Compliance**: System design adheres to electrical code standards, including protective relays and breakers that trigger ESS shutdown in response to voltage fluctuations outside operational limits.
- **Surge Arresters**: Substation switches for each MV feeder are equipped with 35kV surge (lightning) arresters. These limit the severity of surges by diverting excess current to ground.
- **Battery Management System (BMS)**: The BMS continuously monitors battery voltage (individual cells and total). If excessive charge or discharge voltage is detected, the BMS immediately shuts down the affected ESS portion.

4.4.2 Consequence and Severity

The combination of code-compliant design, surge arresters, and the BMS significantly minimizes the potential for damage to the ESS from voltage surges. While surges present an inherent risk, these layered mitigation strategies reduce the likelihood of a severe incident.

4.5 Short Circuits on the Load Side of the ESS

This analysis assesses the potential impact of short circuits occurring on the load side of the SYL ESS installation. Short circuits pose a risk of electrical arcing, which could lead to fires or damage to ESS components.

4.5.1 Mitigation and System Response

The system incorporates several safeguards to address load-side short circuits:

- **Electrical Code Compliance:** The entire system design adheres to all relevant electrical codes, including specific provisions for short circuit protection. This ensures the use of appropriate overcurrent protection devices and system design practices to minimize the risk and severity of short-circuit events.
- **UL 9540 Certification:** The SYL ESS has achieved UL 9540 certification. This assessment includes short circuit studies, verifying the system's ability to withstand and manage potential short circuit faults.

4.5.2 Consequence and Severity

The combined effect of code compliance and UL 9540 certification reduces the likelihood and potential severity of load-side short circuit events in the SYL ESS.

4.6 Failure of the Fire Detection Equipment System

This analysis assesses the impact of a smoke or heat detector failure within a SYL ESS container. While detector failure poses a risk, the system incorporates multiple safeguards to mitigate potential consequences.

4.6.1 Mitigation and System Response

- **Redundancy:** The system employs overlapping detection capabilities with smoke, heat, and combustible gas detectors. Failure of a single detector is unlikely to disable fire detection fully.
- **Trouble Signaling:** Smoke detector failures automatically transmit a trouble signal to the site fire alarm panel and a monitored location, alerting personnel to the need for system maintenance.
- **EMS Response:** Failure of either smoke or heat detection triggers an automatic shutdown of the affected ESS container via the Energy Management System (EMS). This puts the batteries into an idle state, reducing the risk of thermal runaway. The ESS container remains offline pending manual inspection and restoration.
- **Alarm Tiers:** A tiered alarm system (Level 1, Level 2) ensures a graduated response. A single smoke or heat detector activation (Level 1) initiates alarm bell while a second

smoke or heat detector activation (Level 2) initiates HVAC shutdown, EMS alert, external notification, cessation of charge/discharge operations, and clean agent system releasing.

- **Inspection & Maintenance:** A formal documented inspection, testing, and maintenance program compliant with NFPA 72 standards proactively minimizes the likelihood of fire detection system failures.

4.6.2 Consequence and Severity

The combination of redundant detection systems, trouble signaling, automated EMS shutdown, tiered alarms, and strict maintenance protocols significantly reduces the risk and potential severity posed by a single smoke or heat detector failure. While complete system failure remains a remote possibility, these integrated safeguards mitigate the impact of such an event.

4.7 Failure of the Local FACP

This analysis addresses the impact of an FACP failure within a SYL ESS enclosure.

4.7.1 Mitigation and System Response

- **Localized Impact:** An FACP failure primarily affects the SYL ESS enclosure in which the compromised FACP is located in. Other ESS enclosures, served by separate FACPs, maintain operational status.
- **Trouble Signaling:** An FACP failure automatically transmits trouble signals to the monitoring Fire Command Center (FCC), the site Energy Management System (EMS), and the Local Plant Controller (LPC). This alerts personnel and triggers corrective actions.
- **EMS Shutdown:** Upon receiving a trouble signal, the EMS initiates a shutdown of the affected ESS enclosure. Batteries enter an idle state, significantly reducing the risk of thermal runaway. The ESS enclosure remains offline until FACP functionality is restored.

4.7.2 Consequence and Severity

The combination of localized impact, proactive trouble signaling, automated EMS shutdown, and redundant signaling pathways significantly minimizes the potential consequences of an FACP failure. At the same time, the affected ESS enclosure will experience temporary disruption.

5 CONCLUSIONS

Coffman Engineers, Inc. has prepared this HMA report to satisfy the requirements of CFC 1207.1.6 to permit the installation of the ESS with lithium-ion batteries which exceeds the limit of 600 kWh from CFC Table 1207.5. The HMA has summarized the fire protection features of the proposed ESS outdoor installation and addressed the single failure modes addressed by CFC § 1207.1.6.1.

The analysis is supported by UL 9540A full scale fire testing results (Appendix B) and aligns with the Emergency Response Plan, prepared by Coffman Engineers, to aid emergency responders and AHJs with regards to safety surrounding SYL products.

The Emergency Response Plan can be used as guidance to first responders and development of emergency response fire-fighting procedures. Additional supporting documentation for this HMA can be found in the appendices.

Your consideration of the information presented in this report is appreciated. If there are any questions regarding the content of this report, please contact our office.

APPENDICES

Appendix A

UL 9540 CERTIFICATE

CERTIFICATE OF COMPLIANCE

Certificate Number: **SGSNA/24/SH/00469**

Contract Number: 801768
Certificate Project Number: SH-CERT240905570

Certified Product: DC Energy Storage System
Trademarks: risen | SYL
Model(s): SU3794U3794KC, SU3414U3414KC, SU3035U3035KC, SU2655U2655KC, SU2276U2276KC, SU1897U1897KC
Technical Data: See page 2~3

Certificate Holder: SYL (NINGBO) BATTERY CO., LTD.
No.23, Xingke Middle Road, Meilin Street, Ninghai County, Ningbo City, Zhejiang Province, China

This certificate supercedes previous certificates issued with the same certificate number. Certification is valid when products are indicated on the SGS directory of certified products at www.sgs.com or using the QR code below. The product is certified according to ISO/IEC Guide 17067, Conformity assessment - Fundamentals of product certification, System 3, and in accordance with:

ANSI/CAN/UL 9540:2023,Third Edition, Dated June 28, 2023

Authorized by:

Mark Lohmann
Certifier

Effective date: 25 November 2024

Certification Body

Connectivity & Products, a division of SGS North America Inc.
620 Old Peachtree Road, Ste. 100, Suwanee, GA 30024, USA
t +1 770 570 1800 f +1 770 277 1240 www.sgs.com

CERTIFICATE OF COMPLIANCE

Certificate Number: **SGSNA/24/SH/00469**

Contract Number: 801768
Certificate Project Number: SH-CERT240905570

Additional Information:

Technical Data:

SU3794U3794KC

Rated Voltage: 1331.2Vdc

Battery Voltage Range: 1164.8~1497.6Vdc

Max. DC Input/Output Power: 3794kW

Rated Energy: 3794kWh

Operating temperature range: -30~50 ºC

SU3414U3414KC

Rated Voltage: 1331.2Vdc

Battery Voltage Range: 1164.8~1497.6Vdc

Max. DC Input/Output Power: 3414kW

Rated Energy: 3414kWh

Operating temperature range: -30~50 ºC

SU3035U3035KC

Rated Voltage: 1331.2Vdc

Battery Voltage Range: 1164.8~1497.6Vdc

Max. DC Input/Output Power: 3035kW

Rated Energy: 3035kWh

Operating temperature range: -30~50 ºC

SU2655U2655KC

Rated Voltage: 1331.2Vdc

Battery Voltage Range: 1164.8~1497.6Vdc

Max. DC Input/Output Power: 2655kW

Rated Energy: 2655kWh

Operating temperature range: -30~50 ºC

Certification Body

Connectivity & Products, a division of SGS North America Inc.
620 Old Peachtree Road, Ste. 100, Suwanee, GA 30024, USA
t +1 770 570 1800 f +1 770 277 1240 www.sgs.com

CERTIFICATE OF COMPLIANCE

Certificate Number: **SGSNA/24/SH/00469**

Contract Number: 801768
Certificate Project Number: SH-CERT240905570

Additional Information:

Technical Data:

SU2276U2276KC

Rated Voltage: 1331.2Vdc

Battery Voltage Range: 1164.8~1497.6Vdc

Max. DC Input/Output Power: 2276kW

Rated Energy: 2276kWh

Operating temperature range: -30~50 ºC

SU1897U1897KC

Rated Voltage: 1331.2Vdc

Battery Voltage Range: 1164.8~1497.6Vdc

Max. DC Input/Output Power: 1897kW

Rated Energy: 1897kWh

Operating temperature range: -30~50 ºC

Other Ratings: IP55

Certification Body

Connectivity & Products, a division of SGS North America Inc.
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Appendix B

UL 9540A TEST REPORTS

CELL TEST REPORT
UL 9540A
Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems (AACD)

Project Number..............................:	**4790838636.1**
Date of issue ....:	**2023.09.07 Amendment No.1: 2023.12.11**
Total number of pages...................:	**51**
UL Report Office ....:	**UL(Changzhou) Quality Technical Service Co., LTD**
Applicant's name...........................:	**Contemporary Amperex Technology Co., Limited**
Address ....:	No 2 Xingang Road Zhangwan Town Jiaocheng District NingdeFujian 352100 China
Test specification:	4th Edition, Section 7, November 12, 2019
Standard ....:	UL 9540A, Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems
Test procedure ....:	7.1, 7.2, 7.3.1, 7.4, 7.6.1, 7.7
Non-standard test method ....:	N/A

General disclaimer:

The test results presented in this report relate only to the sample tested in the test configuration noted on the list of the attachments.

UL LLC did not select the sample(s), determine whether the sample(s) was 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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Cell level information	
Model No ....:	CBDC0
Ratings (Vdc, Ah) ....:	3.2V, 285Ah
Chemistry of test item………………:	Lithium Iron Phosphate
Original Equipment Manufacturer (OEM):	Contemporary Amperex Technology Co., Limited
Branding Manufacturer (if not OEM):	N/A
Was the cell certified? ………………………….:	Yes
Standard test item certified to …………..:	UL 1973
Organization that certified test item …….:	MH62898
Average cell surface temperature at gas venting, °C:	156
Average surface temperature at thermal runaway, °C:	232
Gas Volume-:	211.7L
Lower flammability limit (LFL), % volume in air at the ambient temperature	7.45
Lower flammability limit (LFL), % volume in air at the venting temperature	6.545
Burning velocity (S_u) cm/s:	62.44
Maximum pressure (P_{max}) psig:	96.79

Cell Gas composition

Gas		Measured %
Carbon Monoxide	CO	13.453
Carbon Dioxide	CO_2	27.205
Hydrogen	H_2	41.313
Methane	CH_4	7.403
Acetylene	C_2H_2	0.101
Ethylene	C_2H_4	4.408
Ethane	C_2H_6	1.235
Propylene	C_3H_6	1.297
Propane	C_3H_8	0.734
-	C4 (Total)	1.296
-	C5 (Total)	0.335
-	C6 (Total)	0.147
1-Heptene	C7H14	0.025
Styrene	C8H8	0.013
Benzene	C_6H_6	0.049
Toluene	C_7H_8	0.013
Dimethyl Carbonate	$C_3H_6O_3$	0.917
Ethyl Methyl Carbonate	$C_4H_8O_3$	0.055
Total	-	100

Cell failure test method performed (summary of method and test clause):

☒ External heating using thin film with 4°C to 7°C thermal ramp.
☐ Nail Penetration
☐ Overcharge
☐ External short circuit (***X*** Ω *external resistance*)
☐ Flow Battery with 2 active electrolyte methods
☐ Flow Battery with 1 active electrolyte methods
☐ Others

Description of method used to fail cells if other than external thin film heater with thermal ramp, : N/A

Summary of testing:

Performance Criteria in accordance with Clause 7.7 and Figure 1.1:

[ ] Thermal runaway was not induced in the cell; and

[ ] The cell vent gas did not present a flammability hazard when mixed with any volume of air, as determined in accordance with ASTM E918 at both ambient and vent temperatures.

Necessity for a module level test

[X] The performance criteria of the cell level test as indicated in 7.7 of UL 9540A 4th edition has not been met, therefore a module level testing in accordance with UL 9540A will need to be conducted on a complete module employing this cell.

[ ] The performance criteria of the module level tests as indicated in 7.7 of UL 9540A 4th edition has been met, therefore a module level testing in accordance with UL 9540A need not be conducted.

Testing Laboratory information

Testing Laboratory and testing location(s):

Testing Laboratory:	UL(Changzhou) Quality Technical Service Co., LTD	
Testing location/ address .... :	21 Longmen Rd, National High-Tech Industrial Development District, Wujin, Changzhou, Jiangsu, China	
Tested by (name, signature)........................ :	Zhang Wei /Vic Zhang	
Witnessed by (for 3rd Party Lab Test Location) (name, signature) .... :	N/A	N/A
Project Handler (name, signature).............. :	Arui Zhou	Arui Zhou
Reviewer (name, signature) …………….:	Benjamin Liu	Benjamin Liu
Amendment 1 Project Handler (name, signature) .... :	Arui Zhou	Arui Zhou
Amendment 1 Reviewer (name, signature) …………….:	Benjamin Liu	Benjamin Liu

Gas Analysis Testing Laboratory :	UL(Changzhou) Quality Technical Service Co., LTD
Testing location/ address .... :	21 Longmen Rd, National High-Tech Industrial Development District, Wujin, Changzhou, Jiangsu, China
Project Handler (name, signature).............. :	Arui Zhou
Reviewer (name, signature) …………….:	Albert He

List of Attachments (including a total number of pages in each attachment):

Attachment A: Cell Conditioning (Charge/discharge) Profiles - (*Pages **18** through **20***)

Attachment B: Cell Instrumentation Photos - (*Pages **21** through **21***)

Attachment C: Cell Temperature Profiles during testing - (*Pages **22** through **24***)

Attachment D: Cell Testing Photos - (*Pages **25** through **34***)

Attachment E: Cell vent gas test chamber photo and profile of chamber gas analysis (O_2 and Pressure) – (*Pages **35** through **35***)

Attachment F: Cell Gas Analysis Report - (*Pages **36** through **36***)

Attachment G-1~G4 for Amendment 1 report

Attachment G-1: Cell Conditioning (Charge/discharge) Profiles - (*Pages **39** through **40***)

Attachment G-2: Cell Instrumentation Photos - (*Pages **41** through **41***)

Attachment G-3: Cell Temperature Profiles during testing - (*Pages **42** through **43***)

Attachment G-4: Cell Testing Photos - (*Pages **44** through **51***)

Photo of cell/Stack:	
	
Figure 0-1	**Figure 0-2**
Test Item Charge/Discharge Specifications:	
• **Charge current, A:**	285
• **Charge Power, W**	912
• **Standard full charge voltage, Vdc:**	3.65
• **Charge temperature range, °C:**	0~60
• **End of charge voltage, V:**	3.65
• **Discharge current, A:**	285
• **Discharge Power, W**	912
• **End of discharge voltage, Vdc:**	2.5
• **Discharge temperature range, °C:**	-20~60

Test item particulars:	
Possible test case verdicts:	
- test case does not apply to the test object...........:	N/A
- test object does meet the requirement ....:	P (Pass)
- test object does not meet the requirement...........:	F (Fail)
- test object was completed per the requirement...:	C(Complete)
- test object was completed with modification……:	M(Modification)
Testing..:	CBDC0
Date of receipt of test item ....:	2023-04-28, 2023-10-10
Date (s) of performance of tests ....:	2023-05-10~2023-05-13, 2023-10-20~2023-10-29

General remarks:

"(See Enclosure #)" refers to additional information appended to the report.
"(See appended table)" refers to a table appended to the report.

Throughout this report a point is used as the decimal separator.

Manufacturer's Declaration of samples submitted for test:	
The applicant for this report includes samples from more than one factory location and a declaration from the Manufacturer stating that the sample(s) submitted for evaluation is (are) representative of the products from each factory has been provided ....:	☒ **Yes** ☐ **Not applicable**
Name and address of factory (ies) ....:	Factory_1: Guangdong Ruiqing Contemporary Amperex Technology Limited Factory_1 address: No.1 Shidai Street,High-tech Industrial Development Zone, Zhaoqing City， Guangdong Province Factory_2: Jiangxi Yichun Contemporary Amperex Technology Limited Factory_2 address: No. 1, Chunfeng Road, Yichun Economic and Technological Development Zone, Jiangxi Province Factory_3: Fuding Contemporary Amperex Technology Limited Factory_3 address: No. 1, Shidai Road, Xueqiao Village, Qianqi Town, Fuding City, 355200 Ningde City, Fujian Province, PEOPLE'S REPUBLIC OF CHINA

General product information and other remarks:

The tested cell is a Lithium-ion battery cell, Model CBDC0. Each cell has a capacity of 285 Ah and nominal voltage 3.2 Vdc.

The weight of cell is 5400g±300g.

The test samples were produced in Factory 1.

The test samples are figure 0-1 and figure 0-2.

Amendment 1 report:

The overall dimensions of cell were corrected from 71.6±0.8mm(Width) by 174.7±0.8mm(Length) by 207.3±0.8mm(Height) to the 71.55±0.8mm (depth) by 174.3±0.8 mm(width) by 207.3±0.8 mm(height).

The customer has changed the design of the top cover of the cell, figures 0-1 and 0-2 are the original design of the cell, 0-3 and 0-4 are the new designs.

Attachment G-1~G-4 is the supplementary test after the design change of the cell.

According to customer analysis, the above differences do not affect the test results.

UL 9540A, Edition 4,			
Clause	Requirement + Test	Result - Remark	Verdict

5.0	**CONSTRUCTION**		**Verdict**
5.1. 5.4	**Cell/Stack Construction**		—
5.1.1, 5.4.1	Generic Chemistry:	Lithium iron phosphate	—
	Electrolyte Chemistry:	LiPF6 with additives	—
	Flow Battery Electrolyte No. 1 Chemistry:	Not flow battery	—
	Max volume of system electrolyte No. 1, L:	Not flow battery	—
	Flow Battery Electrolyte No. 2 Chemistry:	Not flow battery	—
	Max volume of system electrolyte No. 2, L:	Not flow battery	—
	Separator Melt Temperature, °C:	Not used during test	—
	Format: Cylindrical /Prismatic /Pouch Flow Battery Stack	Prismatic	—
	Overall Dimensions, mm	174.3±0.8mm (depth) by 71.55±0.8mm (width) by 207.3±0.8mm (height)	—
	Cell Weight, g	5400±300g	—
5.1.2	Cell Certification:	Yes	—
	Standard Used for Cell Certification:	UL 1973	—
	Organization that Certified Cell:	MH62898	—
5.1.1, 5.4.1	Cell/Stack Ratings: • Nominal Voltage, Vdc •Nominal Capacity, Ah	3.2 285	— —
5.4.1	Flow Battery: No. of Cells per Stack:	Not flow battery	—
	Flow battery system manufacturer:	Not flow battery	—
	Flow battery system model:	Not flow battery	—
	Flow battery system ratings, Vdc, Ah:	Not flow battery	—
5.4.2	Flow battery system certified to UL 1973:	Not flow battery	—
	Organization that certified flow battery system:	Not flow battery	—
6.0	**PERFORMANCE**		**Verdict**
6.1	**General**		C
7.2	**Samples**		C

UL 9540A, Edition 4,			
Clause	Requirement + Test	Result - Remark	Verdict

7.2.1	Samples conditioned through charge discharge cycling a minimum of 2 cycles.	See Attachment A and Attachment G1 for profiles See Table 1 and Table G0-1 for specifications See also Table 2 and Table G0-2	C
7.2.2	100% SOC and stabilize from 1h to 8 h before testing		
7.2.3	Pouch Cells constrained per end use during testing.		N/A
7.3	**Determination of thermal runaway methodology**		C
7.3.1	**General**		C
7.3.1.1	Ambient indoor laboratory conditions: 25 ±5°C (77 ±9°F) ≤50 ±25% RH at the initiation of the test.	See Attachment C and Attachment G3 See Table 3 and Table G0-3	C
7.3.1.2	Heat the cell to thermal runaway by externally applied flexible film heaters	See Attachment B and Attachment G2	C
	Heater Dimension	Two heaters 152.4mm by 203.2 mm in size for each sample. Each side of the cells was instrumented with the heater	
	A surface heating rate of 4° C (7.2° F) to 7° C (12.6° F) per minute was applied to the cell.	See Attachment C, D, G1, G4 See Table 4 and Table G0-4	C
	Maximum surface end point temperature, °C	Not used, the cells are heated until the thermal runaway achieved According to the Certification Requirement Decision: Test Method for Evaluating Thermal Runaway Fire Propagation in Battery. Holding temperature was not utilized during the test and the cell was continuously heated until thermal runaway occurred	

UL 9540A, Edition 4,			
Clause	Requirement + Test	Result - Remark	Verdict

	The following method(s) was employed to cause thermal runaway: ☐ Mechanical (e.g. nail penetration); ☐ Electrical stress in the form of overcharging, ☐ Electrical stress in the form of over discharging ☐ Electrical stress in the form of external short-circuiting ☐ Use of alternate heating sources (e.g. oven). ☐ Other (explain)	Only external heating in the form of using flexible thin film heaters to cause thermal runaway	N/A
7.3.1.3	Detail of test method when using another cell abuse method to initiate thermal runaway	See Attachment E	N/A
7.3.1.4	Monobloc batteries such as a lead acid battery		N/A
7.3.1.5	Estimated surface temperature at which internal short circuiting within the cell will occur that could lead to a thermal runaway condition.	Not used, the cells are heated until the thermal runaway achieved According to the Certification Requirement Decision: Test Method for Evaluating Thermal Runaway Fire Propagation in Battery. Holding temperature was not utilized during the test and the cell was continuously heated until thermal runaway occurred	N/A
7.3.1.6	The cell was heated until thermal runaway has occurred.	Refer to Attachment C and Attachment G3	C
	Another external heating method was used to cause cell thermal runaway		N/A
7.3.1.7	The cell's exterior surface temperature was measured	See Attachment B and Attachment G2	C
7.3.1.8	The temperature at which the cell case vents due to internal pressure rise was documented.	See Table 4 and Table G0-4 See Attachment C, D, G3,G4	C
7.3.1.9	The temperature at the onset of thermal runaway was documented.	See Table 4 and Table G0-4 See Attachment C, D, G3, G4	C
	If cell venting occurs first, the cell was heated continuously until thermal runaway occurs.	See Attachment C and Attachment G3	C

UL 9540A, Edition 4,			
Clause	Requirement + Test	Result - Remark	Verdict
7.3.1.10	When using methods other than the heater method, the stresses were applied to the cell until thermal runaway occurs.		N/A
7.3.1.11	3 additional samples were tested using the same method and exhibited thermal runaway	See Table 3, 4 5, G0-3, G0-4 and G0-5 See Attachment C, D, G3, G4	C
7.4	**Cell vent gas composition test**		C
7.4.1	Cell vent gas was generated and captured by forcing a cell into thermal runaway with the methodology developed in 7.3, inside a pressure vessel	Size of pressure vessel used: 100L Refer to Attachment E	C
	The test was initiated with an initial condition of atmospheric pressure and less than 1% oxygen by volume.	Refer to Attachment E Atmospheric pressure (psig):0.17	C
		Oxygen concentration measured (% volume):0.17	
		Inert gas used: Nitrogen	
7.4.2	Cell vent gas composition was determined using Gas Chromatography (GC)	Refer to Table 8 Refer to Attachment F	C
	Hydrogen gas was measured	Refer to Table 8	C
	The initial atmospheric conditions prior to testing were noted.	Refer to Table 3 Refer to attachment C and F	C
7.4.3	The lower flammability limit of the cell vent gas was determined on samples of the synthetically replicated gas mixture in accordance with ASTM E918, testing at both ambient and cell vent temperatures.	Refer to Table 9 and 10	C
7.4.4	The gas burning velocity of the synthetically replicated cell vent gas was determined in accordance with the Method of Test for Burning Velocity Measurement of Flammable Gases Annex in ISO 817.	Refer to Table 9 and 10	C
7.4.5	P_{max} of the synthetically replicated cell vent gas was determined in accordance with EN 15967.	Refer to Table 9 and 10	C
7.6	**Cell Level Test Report Information**		C

UL 9540A, Edition 4,			
Clause	Requirement + Test	Result - Remark	Verdict
7.6.1	Minimum information provided in the report for items a) through m)		C
7.6.2	Minimum information of items a) through k) was provided in the report for flow battery		N/A
7.7	**Performance – cell level test**		C
7.7.1	a) Thermal runaway cannot be induced in the cell; and	Thermal runaway can be induced in the cell with external heater during the test	F
	b) The cell vent gas does not present a flammability hazard when mixed with any volume of air, at both ambient and vent temperatures.	As a result of gas analysis, the gas generated from the cell were identified flammable	F

Note: Table G0-1~G0-5 and Attachment G-1~G4 for amendment 1, Table 1~5 and Attachment A~F for original report.

UL 9540A, Edition 4,			
Clause	Requirement + Test	Result - Remark	Verdict

Table 1 – Specified conditioning parameters			
Charging:		Discharging	
Current, A	285	Current, A	285
Power (CP), W	912	Power (CP), W	912
Standard full charge voltage, Vdc	3.65	Voltage at start of discharge, Vdc	3.65
End of charge voltage, Vdc	3.65	End of discharge voltage, Vdc	2.5
Charging Test Ambient, °C	0~60	Discharging Test Ambient, °C	-20~60
Refer to Attachment A for charge/discharge profiles for each cell.			

Note: The charge and discharge cycle of the cell is carried out in accordance with 912W constant power.

Table 2 – Charge completion and cell test initiation times		
Cell Test Number	**Charge Completion Date and Time**	**Cell test Date and Time**
1	2023-05-18 08:43	2023-05-18 11:10
2	2023-05-18 12:14	2023-05-18 19:35
3	2023-05-19 06:04	2023-05-19 10:39
4	2023-05-20 12:00	2023-05-20 16:02
5	2023-05-25 10:38	2023-05-25 18:08

Table 3 - Test Initiation Details					
	Cell Test 1	**Cell Test 2**	**Cell Test 3**	**Cell Test 4**	**Cell Test 5**
Test Date	2023-05-18	2023-05-18	2023-05-19	2023-05-20	2023-05-25
Test Start Time	11:10	19:35	10:39	16:02	18:08
Initial Lab Temperature	25.9°C	25.9°C	24.4°C	25.0°C	24.6°C
Initial Relative Humidity	70.9%RH	70.9%RH	71.5%RH	61.9%RH	56.3%RH

Table 4 - Thermal Runaway Results					
	Cell Test 1	**Cell Test 2**	**Cell Test 3**	**Cell Test 4**	**Cell Test 5**
OCV at start of test, Vdc	3.355	3.349	3.351	3.340	3.340
Average Heating Rate, °C/min	4.5	4.5	4.6	4.5	4.5
Venting Time after the test start (hh:mm:ss)	0:34:44	0:35:14	0:35:00	0:35:46	0:35:54
Venting Temperature, °C	157	156	154	158	163
Thermal Runaway Time after the test start (hh:mm:ss)	0:54:20	0:54:06	0:54:22	0:55:04	0:53:11
Thermal Runaway Temperature, °C	231	227	233	237	229
Refer to Attachment C for surface temperature profiles during testing					

Table 5 – Average Vent and Thermal Runaway Temperatures	
Average of Cell Vent Temperatures, °C	156
Average of Cell Thermal Runaway Temperatures, °C	232
#Averages of cell tests other than the gas analysis test	

Table 6 – Parameters Flow Battery
N/A

Table 7 – Results of Flammability Testing of Flow Battery Electrolyte
N/A

Table 8 – Results of Gas Analysis (Excluding O_2 and N_2)			
Gas		Measured %	Component LFL[1]
Carbon Monoxide	CO	13.453	10.9
Carbon Dioxide	CO_2	27.205	N/A
Hydrogen	H_2	41.313	4.0
Methane	CH_4	7.403	4.4
Acetylene	C_2H_2	0.101	2.3
Ethylene	C_2H_4	4.408	2.4
Ethane	C_2H_6	1.235	2.4
Propylene	C_3H_6	1.297	1.8
Propane	C_3H_8	0.734	1.7
-	C4 (Total)	1.296	N/A
-	C5 (Total)	0.335	N/A
-	C6 (Total)	0.147	N/A
1-Heptene	C7H14	0.025	N/A
Styrene	C8H8	0.013	1.1
Benzene	C_6H_6	0.049	1.2
Toluene	C_7H_8	0.013	1.0
Dimethyl Carbonate	$C_3H_6O_3$	0.917	N/A
Ethyl Methyl Carbonate	$C_4H_8O_3$	0.055	N/A
Total	-	100	-

[1] Extracted LFL values from ISO 10156-2017

Table 9 – Gas composition excluding the constituents with boiling points higher than 60°C[2]			
Gas		**Measured %**	**Component LFL**
Carbon Monoxide	CO	13.619	10.9
Carbon Dioxide	CO_2	27.541	N/A
Hydrogen	H_2	41.823	4.0
Methane	CH_4	7.494	4.4
Acetylene	C_2H_2	0.102	2.3
Ethylene	C_2H_4	4.463	2.4
Ethane	C_2H_6	1.251	2.4
Propylene	C_3H_6	1.313	1.8
Propane	C_3H_8	0.743	1.7
Propadiene	C_3H_4	0.000	1.9
-	C_4 (Total)	1.312	N/A
-	C_5 (Total)	0.339	N/A
Total	-	100	-

[2] The constituents with a higher boiling point were excluded for the flammability characteristic analysis as these components will turn into a liquid state at room temperature and will not release from the gas bottle as a homogenous mixture.

UL 9540A, Edition 4,			
Clause	Requirement + Test	Result - Remark	Verdict

Table 10 – Properties of Vent Gas Analysis	
Lower Flammability limit at Ambient Temperature, 25°C (% vol in air)	7.45
Lower Flammability limit at Vent Temperature, [156°C] (% vol in air)	6.545
Burning Velocity Measurement, S_u cm/sec	62.44
Maximum Pressure P_{max}, psig	96.79

UL 9540A, Edition 4,			
Clause	Requirement + Test	Result - Remark	Verdict

	TABLE: Critical components information				
Object / part No.	**Manufacturer/ trademark**	**Type / model**	**Technical data**	**Standard**	**Mark(s) of conformity**
Cell Model	Contemporary Amperex Technology Co.,Limited	CBDC0	Nominal voltage：3.2V Rated capacity：285Ah	UL 1973	MH62898
Separator	Contemporary Amperex Technology Co.,Limited	SBM	Material: PE Size: LxWxT;(30542-36690mm) * (176-214mm) * (0.008-0.018mm) Separator melting temperature: 140±5°C	—	—
Electrolyte	Contemporary Amperex Technology Co.,Limited	ESN	Composition: $LiPF_6$, DMC, EMC, EC, PC, DEC;	—	—
Case	Contemporary Amperex Technology Co.,Limited	PPA	Material: Al 3003 Minimum thickness: 0.6-0.7mm	—	—
Insulators/ location in cell	Contemporary Amperex Technology Co.,Limited	PTA PAP	Up-Plate Material: PP Down-Plate Material: PP	—	—
Vent	Contemporary Amperex Technology Co.,Limited	PTA	Size: (25.3-30.3) mm *(13.7-16.7) mm Pressure: 0.4Mpa~1.2Mpa	—	—

Attachment A: Cell Conditioning (Charge/discharge) Profiles - (*Pages **18** through **19***)
Note: The charge and discharge cycle of the cell is carried out in accordance with 912W constant power.

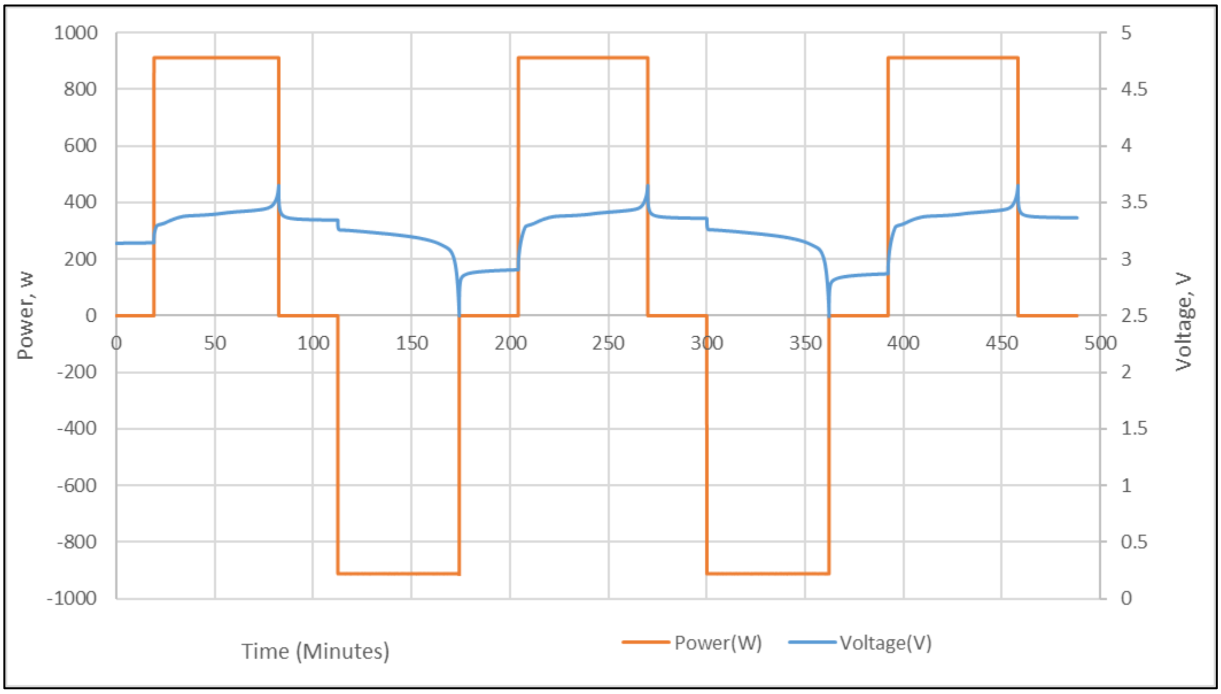


Figure 1: Cell 1 Conditioning (Charge/discharge) Profiles

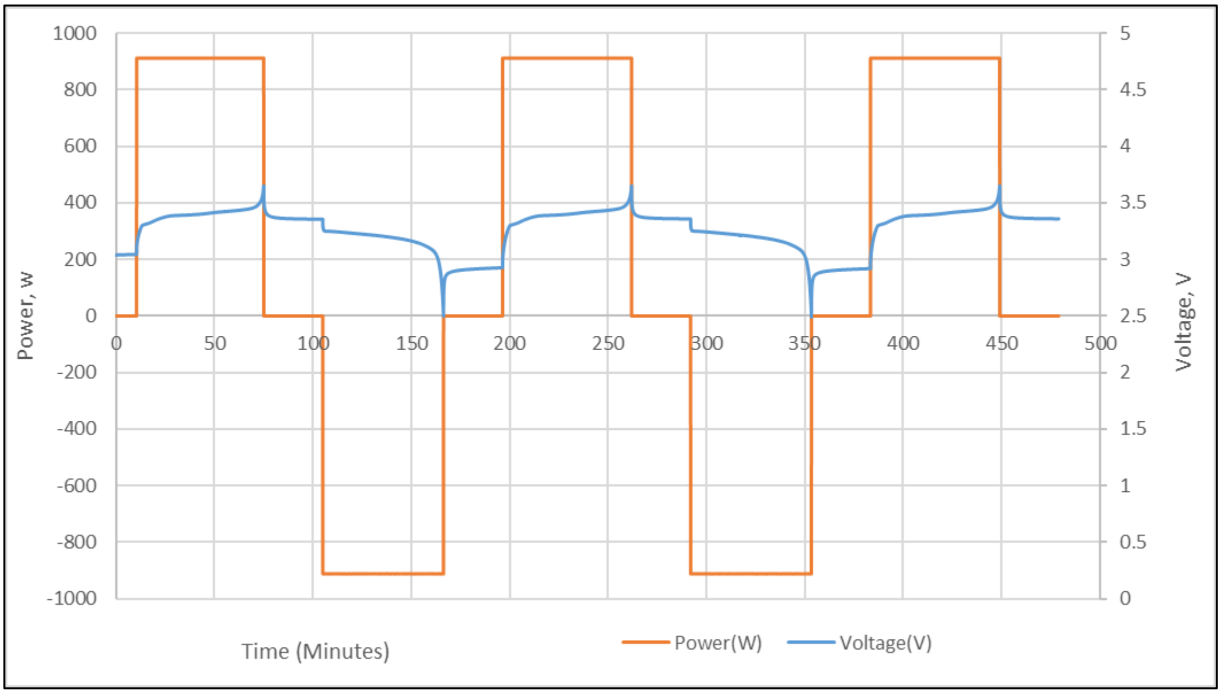


Figure 2: Cell 2 Conditioning (Charge/discharge) Profiles

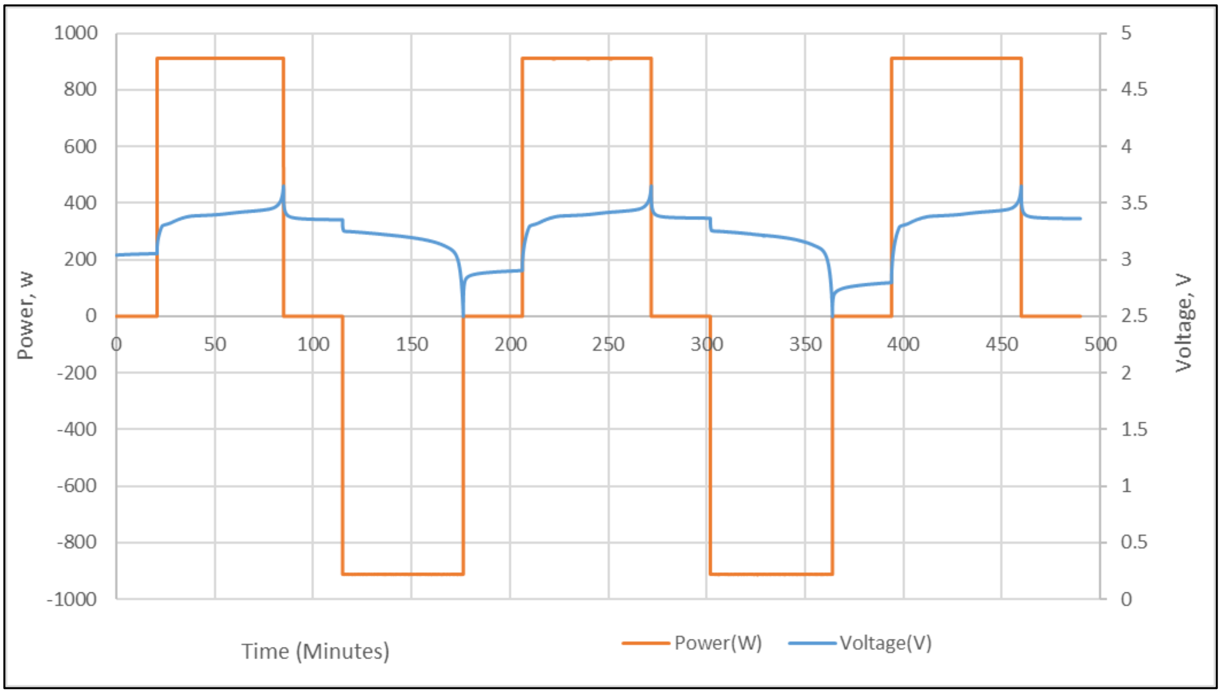


Figure 3: Cell 3 Conditioning (Charge/discharge) Profiles

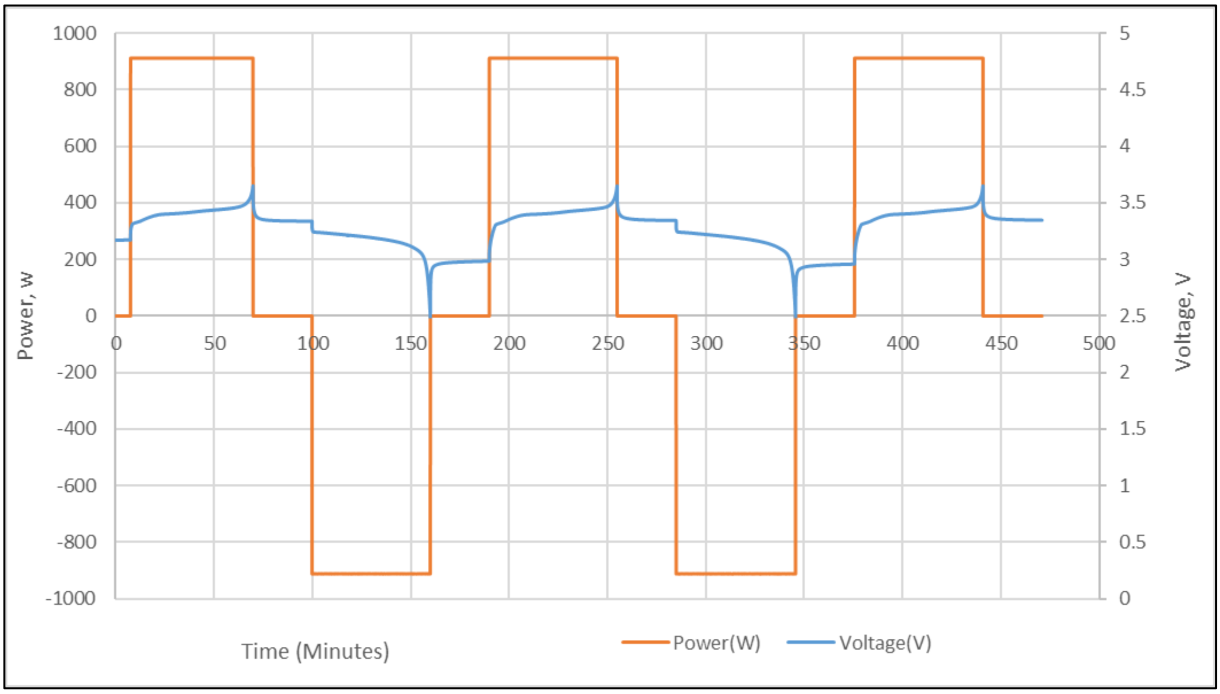


Figure 4: Cell 4 Conditioning (Charge/discharge) Profiles

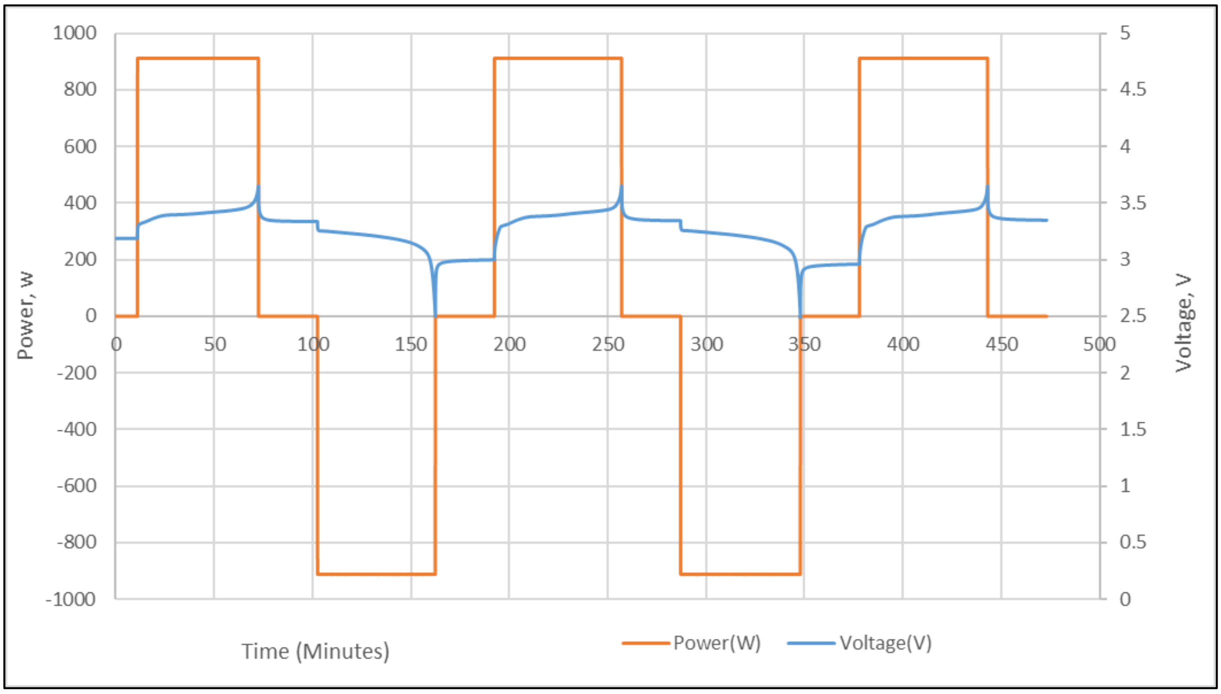
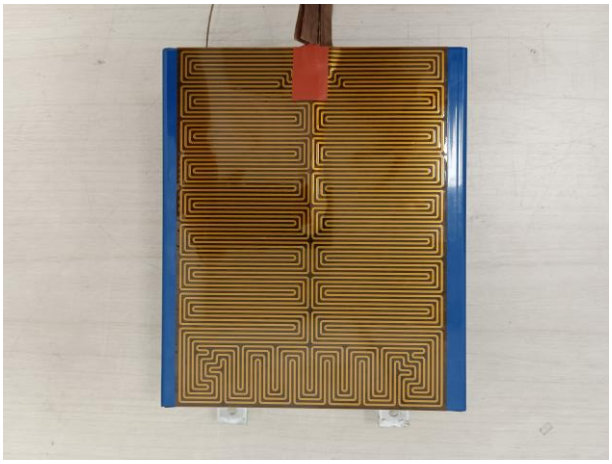
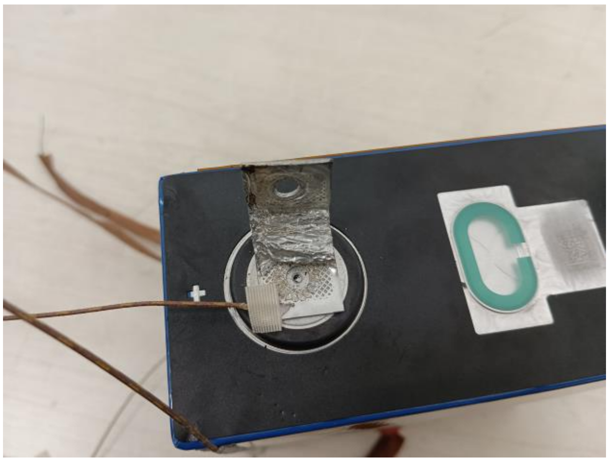
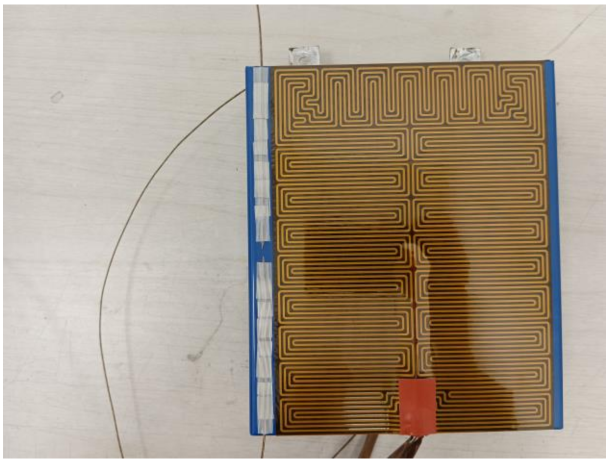


Figure 5: Cell 5 Conditioning (Charge/discharge) Profiles

Attachment B: Cell Instrumentation Photos - (*Pages **21** through **21***)







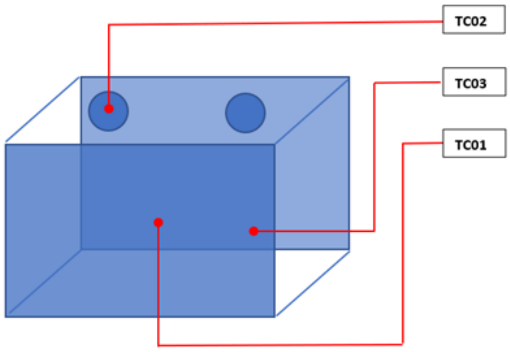


Figure 6: Sample Instrumentation Prior to Test

Note: heaters were placed on two sides of the cell after thermocouples were instrumented.

Note: TC01 between cell body and heater; TC02 on the cell positive; TC03 on the cell body not covered by heater; TC04 Ambient temperature; V1 cell voltage.

Attachment C: Cell Temperature Profiles during testing - (*Pages **22** through **24***)

Note: TC01 between cell body and heater; TC02 on the cell positive; TC03 on the cell body not covered by heater; TC04 Ambient temperature; V1 cell voltage.
TC01 was used to control the temperature at 4 to 7°C/min and TC03 temperatures were reported herein for the surface temperature at the onset of vent and thermal runaway.

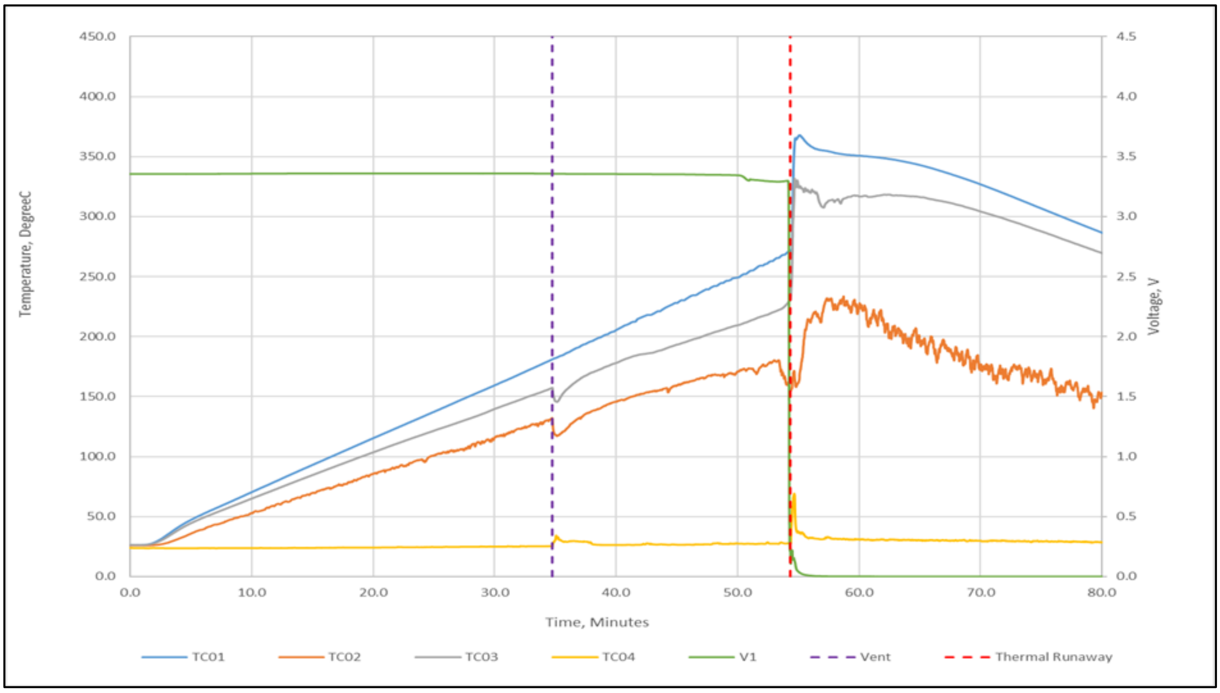


Figure 7: Cell 1 – External Heating 4.5°C per minute

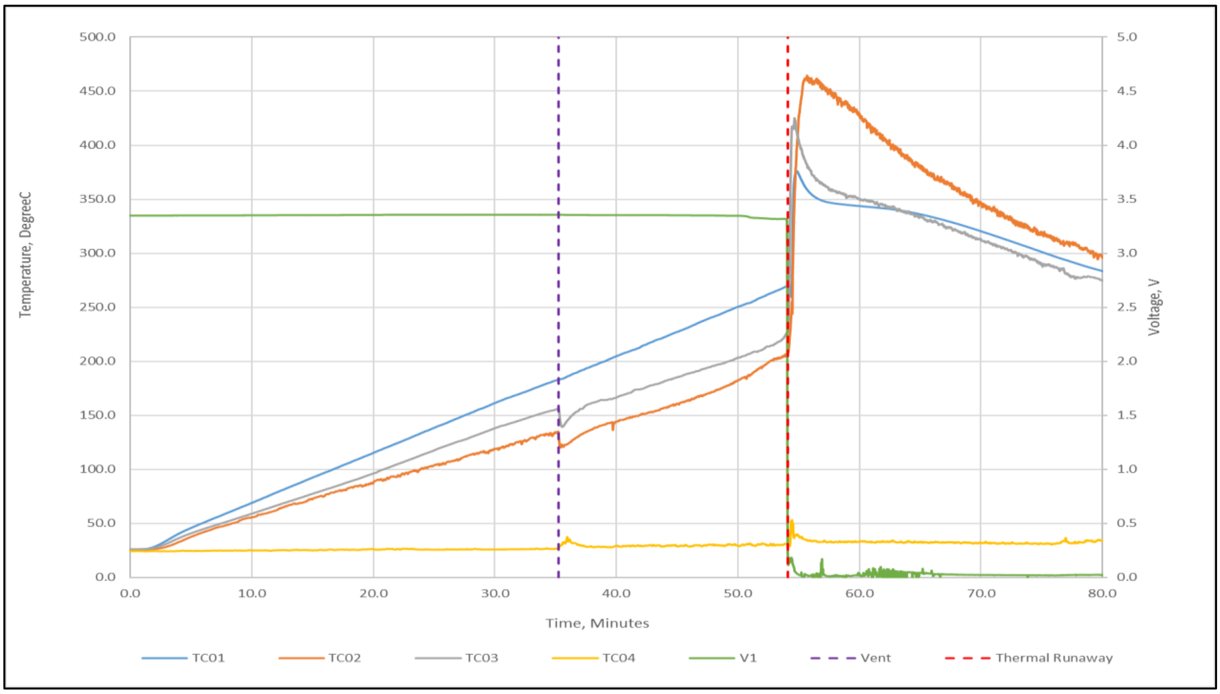


Figure 8: Cell 2 – External Heating 4.5°C per minute

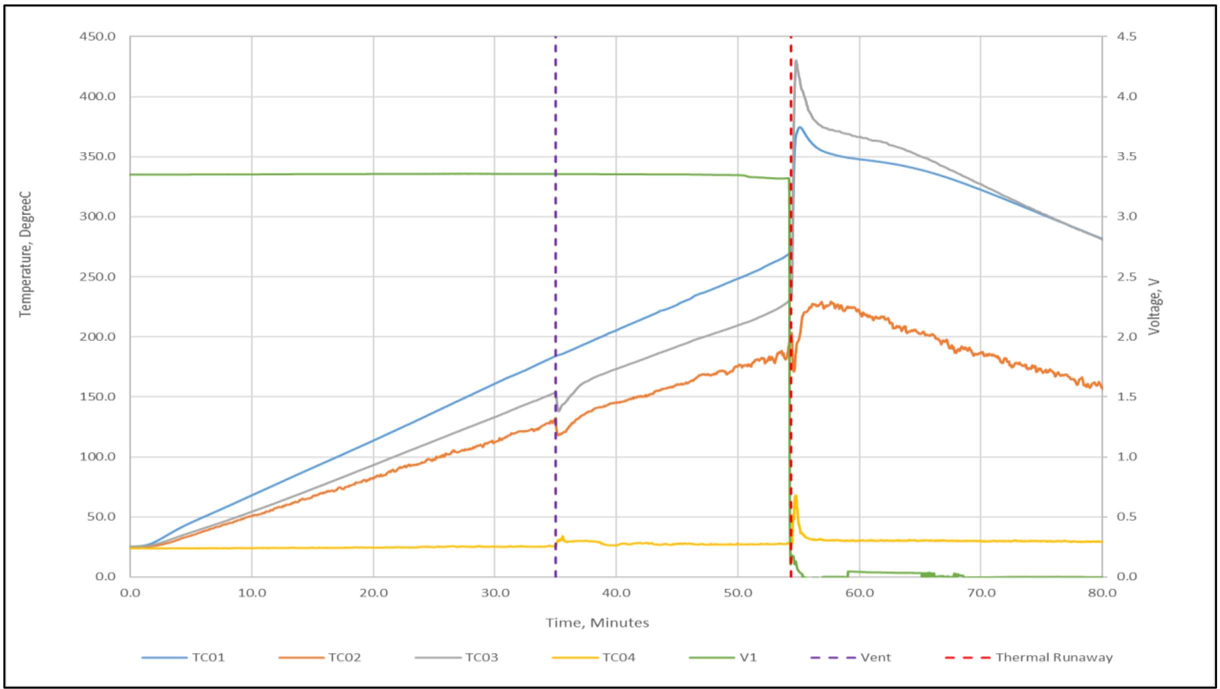


Figure 9: Cell 3 – External Heating 4.5°C per minute

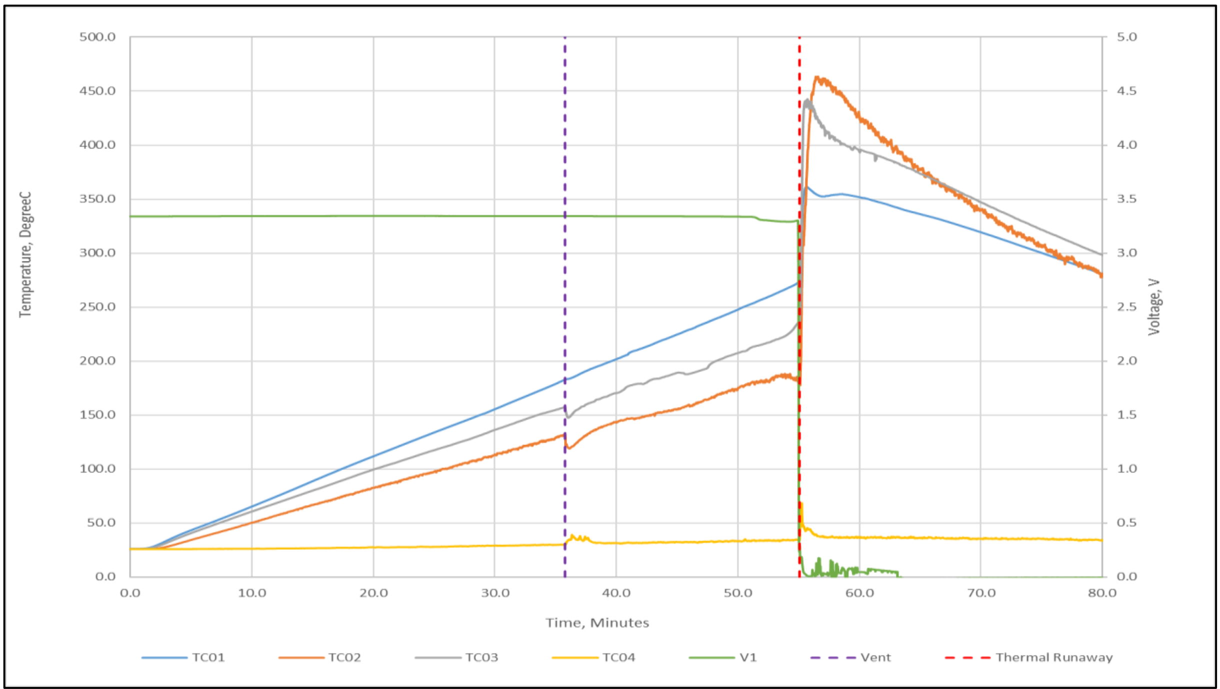


Figure 10: Cell 4 – External Heating 4.5°C per minute

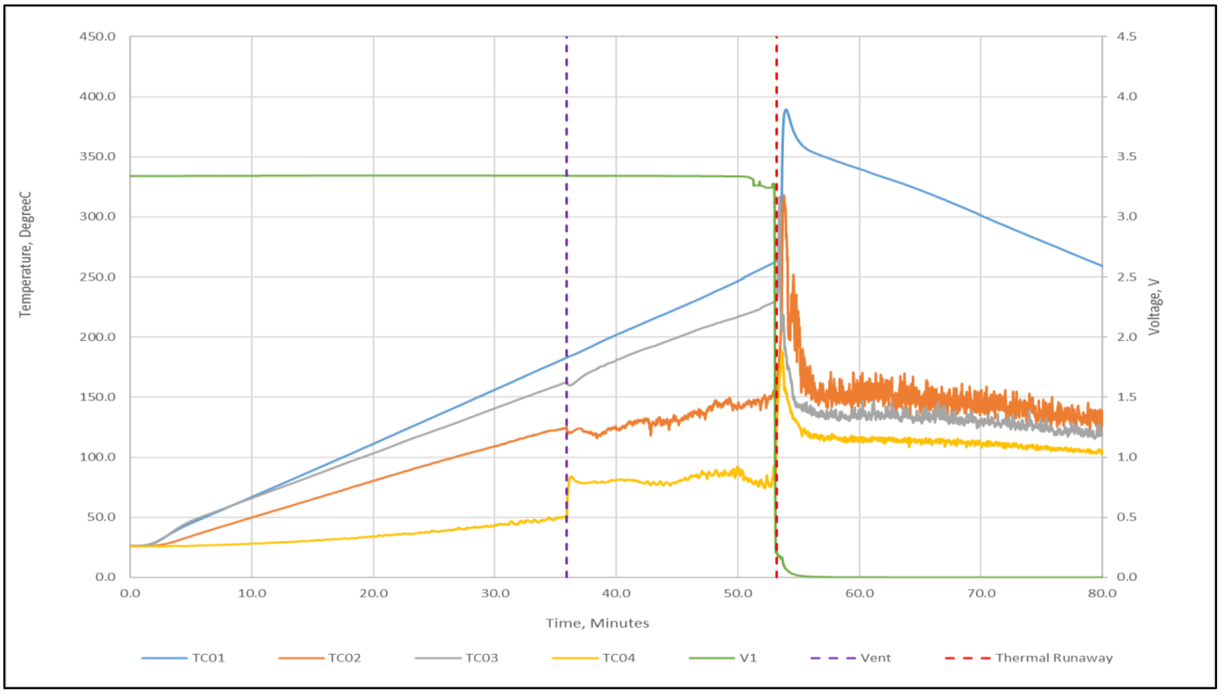


Figure 11: Cell 5 – External Heating 4.5°C per minute

Attachment D: Cell Testing Photos - (*Pages **25** through **34***)

Cell Sample 1 – below figure shows highlights of cell testing. Cell venting and thermal runaway were observed, however no evidence of fire. Figure on next page shows photos of cell after testing.

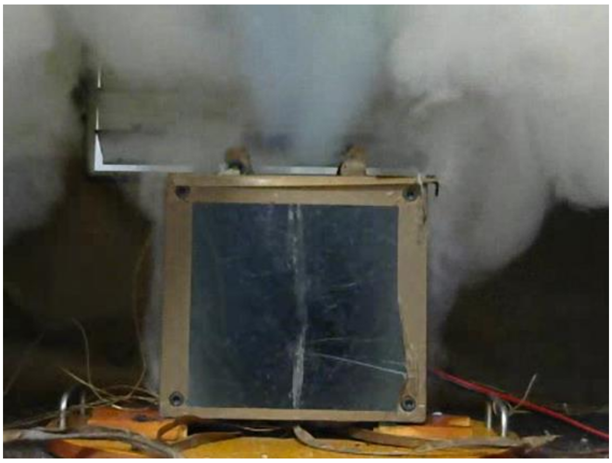
	
(a) Test Start [00:00]	(b) Cell Venting [34:44]
	
(c) Thermal runaway behavior [54:20]	
Figure 12: Highlights of Cell 1 Testing	

Figure 13: Sample 1 Post Test Photos

Cell Sample 2 – below figure shows highlights of cell testing. Cell venting and thermal runaway were observed, however no evidence of fire. Figure on next page shows photos of cell after testing.

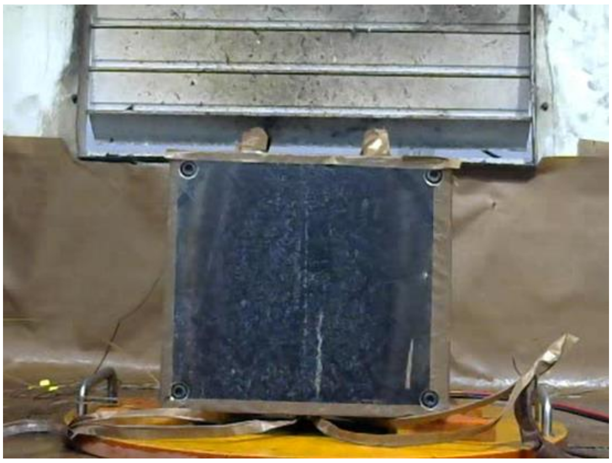
	
(a) Test Start [00:00]	(b) Cell Venting [35:14]
	
(c) Thermal runaway behavior [54:06]	

Figure 14: Highlights of Cell 2 Testing

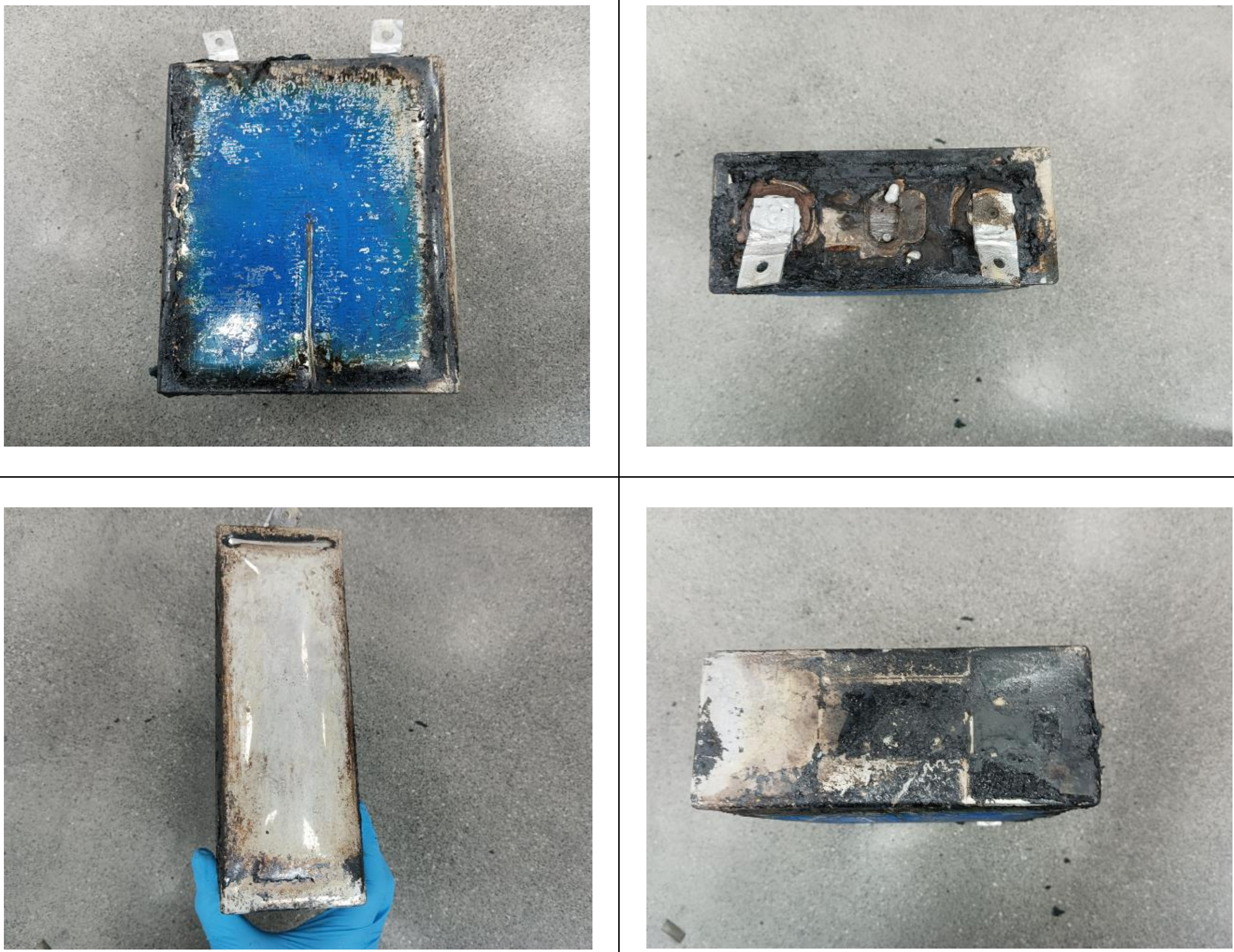


Figure 15: Sample 2 Post Test Photos

Cell Sample 3 – below figure shows highlights of cell testing. Cell venting and thermal runaway were observed, however no evidence of fire. Figure on next page shows photos of cell after testing.

	
(a) Test Start [00:00]	(b) Cell Venting [35:00]
	
(c) Thermal runaway behavior [54:22]	

Figure 16: Highlights of Cell 3 Testing

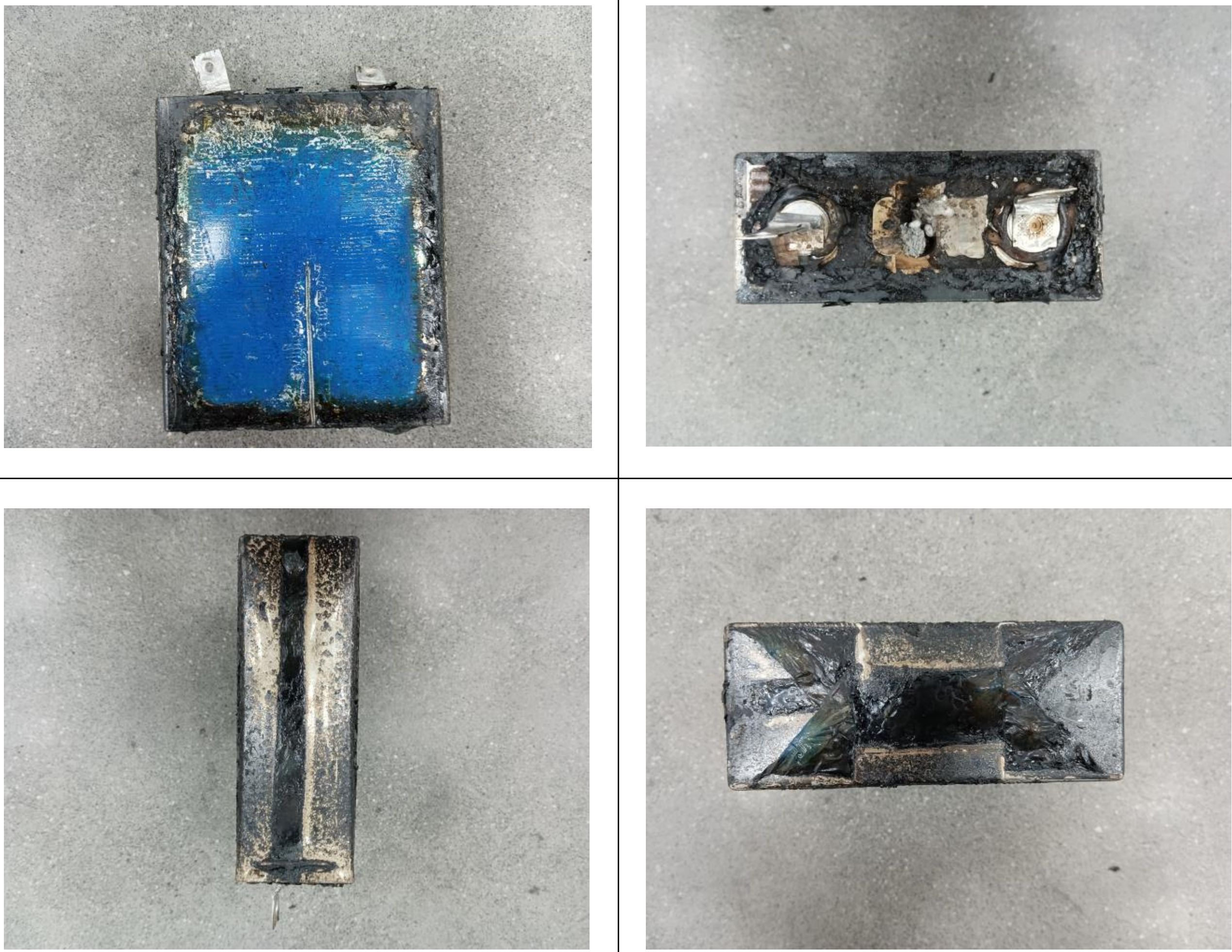


Figure 17: Sample 3 Post Test Photos

Cell Sample 4 – below figure shows highlights of cell testing. Cell venting and thermal runaway were observed, however no evidence of fire. Figure on next page shows photos of cell after testing.

	
(a) Test Start [00:00]	(b) Cell Venting [35:46]
	
(c) Thermal runaway behavior [55:04]	

Figure 18: Highlights of Cell 4 Testing

Figure 19 Sample 4 Post Test Photos

Cell Sample 5 – below figure shows highlights of cell testing. Cell venting and thermal runaway were observed, however no evidence of fire. Figure on next page shows photos of cell after testing.

<table>
<tr><td></td><td></td></tr>
<tr><td>(a) Test Start
[00:00]</td><td>(b) Cell Venting
[35:54]</td></tr>
<tr><td></td><td></td></tr>
<tr><td>(c) Thermal runaway behavior
[53:11]</td><td></td></tr>
<tr><td colspan="2">Figure 20: Highlights of Cell 5 Testing</td></tr>
</table>

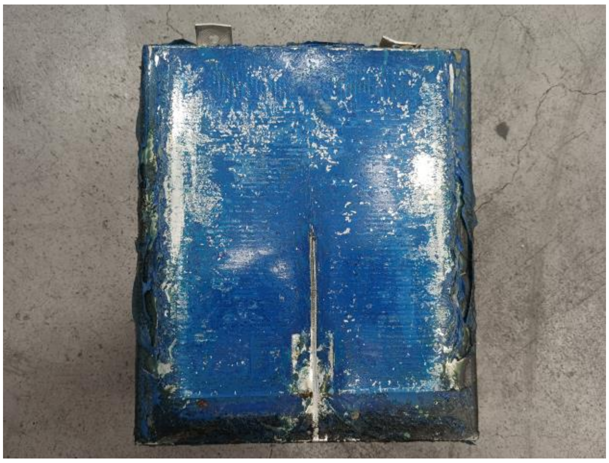
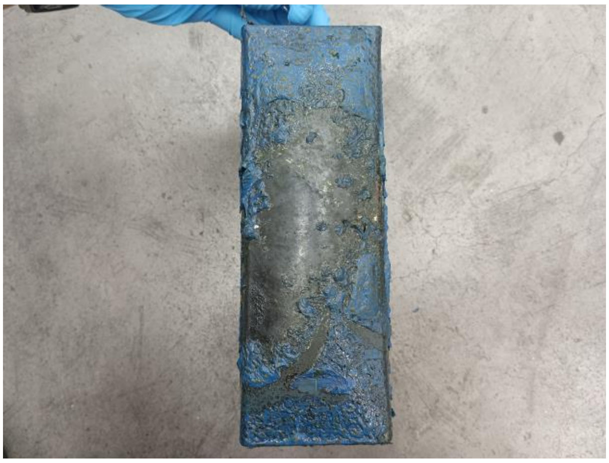
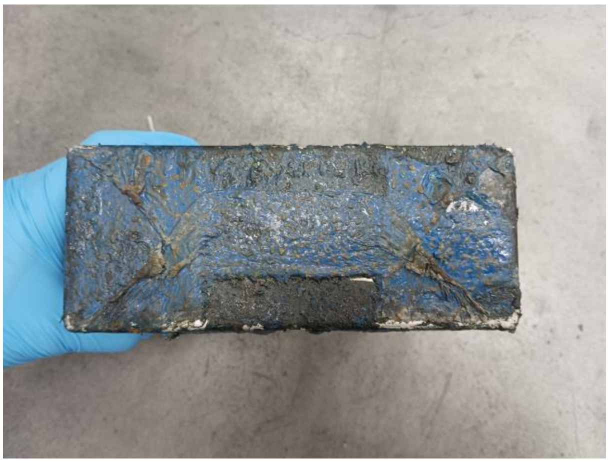
	
	

Figure 21: Sample 5 Post Test Photos

Attachment E: Cell vent gas test chamber photo and profile of chamber gas analysis (O2 and Pressure) - (Pages ***35*** through ***35***)

The gas composition test was conducted with the battery inserted into the battery gas composition test chamber and the chamber was sealed. The battery gas composition test chamber is a 100 L pressure vessel and is shown in figure below.

Prior to initiating thermal runaway, the chamber's atmosphere was purged until a condition of less than 1% oxygen by volume (actual 0.17%, with initial pressure 0.17psig).

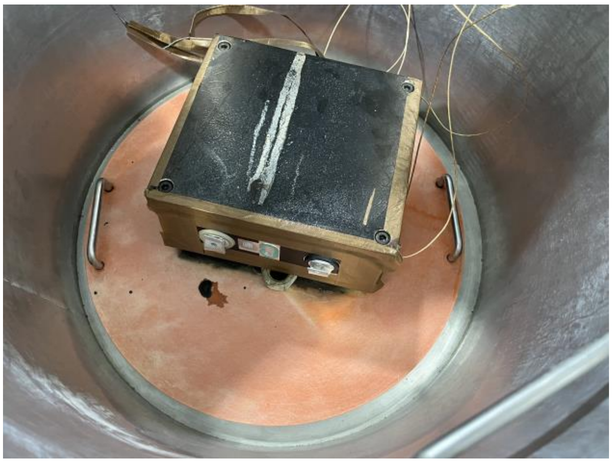


Figure 22: Sample 5 instrumented and inside gas test chamber

$\phi_{O2,\ chamber}$=	0.17	%		Pinitial,chamber=	0.17	psig

Figure 23: Profile of gas test chamber (O2 and Pressure)

Attachment F: Cell Gas Analysis Report - (Pages ***36*** through ***36***)

Table Re-normalized Gas Quantification, excluding N_2 and O_2, and unknown compounds.

Item	Measure	Chemical formula	Conc.(%)
1	Carbon Monoxide	CO	13.453
2	Carbon Dioxide	CO_2	27.205
3	Hydrogen	H_2	41.313
4	Methane	CH_4	7.403
5	Ethylene	C_2H_4	4.408
6	Acetylene	C_2H_2	0.101
7	Ethane	C_2H_6	1.235
8	Propane	$CH_3CH_2CH_3$	0.734
9	Propylene	C_3H_6	1.297
10	Propadiene (Allene)	C_3H_4	0.000
11	Isobutane	$CH_3CH(CH_3)CH_3$	0.017
12	Butane	C_4H_{10}	0.193
13	Isobutylene	C_4H_8	0.522
14	1-Butene	C_4H_8	0.221
15	trans-2-Butene	C_4H_8	0.143
16	cis-2-Butene	C_4H_8	0.199
17	Pentane	C_5H_{12}	0.198
18	trans-2-Pentene	C_5H_{10}	0.061
19	cis-2-Pentene	C_5H_{10}	0.053
20	1,4-Pentadiene	C_5H_8	0.023
21	Hexane	C_6H_{14}	0.024
22	1-Hexene	C_6H_{12}	0.123
23	Benzene	C_6H_6	0.049
24	1-Heptene	C_7H_{14}	0.025
25	Toluene	C_7H_8	0.013
26	Styrene	C_8H_8	0.013
27	Dimethyl Carbonate	$C_3H_6O_3$	0.917
28	Ethyl Methyl Carbonate	$C_4H_8O_3$	0.055
29	Diethyl Carbonate	$C_5H_{10}O_3$	0.000
	Total	Measurement result	100.000

Amendment 1 report:

Photo of cell/Stack:	

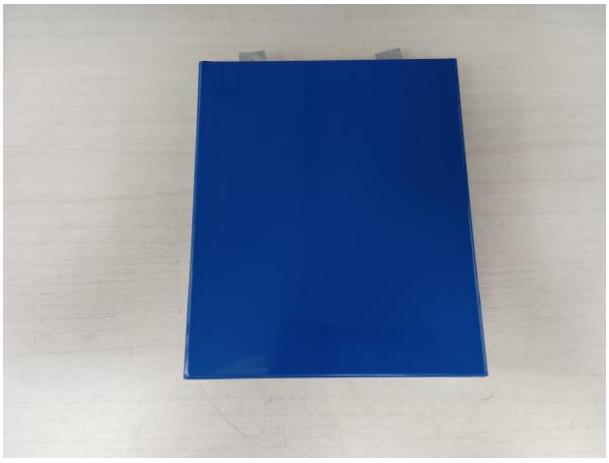



Figure 0-3	**Figure 0-4**
Test Item Charge/Discharge Specifications:	
• **Charge Power, W**	912
• **Standard full charge voltage, Vdc:**	3.65
• **Charge temperature range, °C:**	0~60
• **End of charge voltage, V:**	3.65
• **Discharge Power, W**	912
• **End of discharge voltage, Vdc:**	2.5
• **Discharge temperature range, °C:**	-20~60

Table G0-1 – Specified conditioning parameters			
Charging:		Discharging	
Power (CP), W	912	Power (CP), W	912
Standard full charge voltage, Vdc	3.65	Voltage at start of discharge, Vdc	3.65
End of charge voltage, Vdc	3.65	End of discharge voltage, Vdc	2.5
Charging Test Ambient, °C	0~60	Discharging Test Ambient, °C	-20~60
Refer to Attachment A-1 for charge/discharge profiles for each cell.			

Table G0-2 – Charge completion and cell test initiation times		
Cell Test Number	**Charge Completion Date and Time**	**Cell test Date and Time**
6	2023-10-20 07:49	2023-10-20 10:42
7	2023-10-20 09:49	2023-10-20 14:40
8	2023-10-28 10:23	2023-10-28 15:41
9	2023-10-29 11:30	2023-10-29 15:00

Table G0-3 - Test Initiation Details				
	Cell Test 6	**Cell Test 7**	**Cell Test 8**	**Cell Test 9**
Test Date	2023-10-20	2023-10-20	2023-10-28	2023-10-29
Test Start Time	10:42	14:40	15:41	15:00
Initial Lab Temperature	25.7°C	25.7°C	25.3°C	26.0
Initial Relative Humidity	61.2%RH	61.2%RH	53.4%RH	51.5%RH

Table G0-4 - Thermal Runaway Results				
	Cell Test 6	**Cell Test 7**	**Cell Test 8**	**Cell Test 9**
OCV at start of test, Vdc	3.354	3.338	3.344	3.347
Average Heating Rate, °C/min	4.5	4.5	4.5	4.5
Venting Time after the test start (hh:mm:ss)	0:34:41	0:34:16	0:33:40	0:33:40
Venting Temperature, °C	161	150	156	152
Thermal Runaway Time after the test start (hh:mm:ss)	0:54:48	0:54:51	0:54:22	0:54:53
Thermal Runaway Temperature, °C	240	232	240	237

Table G0-5 – Average Vent and Thermal Runaway Temperatures	
Average of Cell Vent Temperatures, °C	155
Average of Cell Thermal Runaway Temperatures, °C	237
#Averages of cell tests other than the gas analysis test	

Attachment G-1: Cell Conditioning (Charge/discharge) Profiles - (*Pages**39** through **40***)

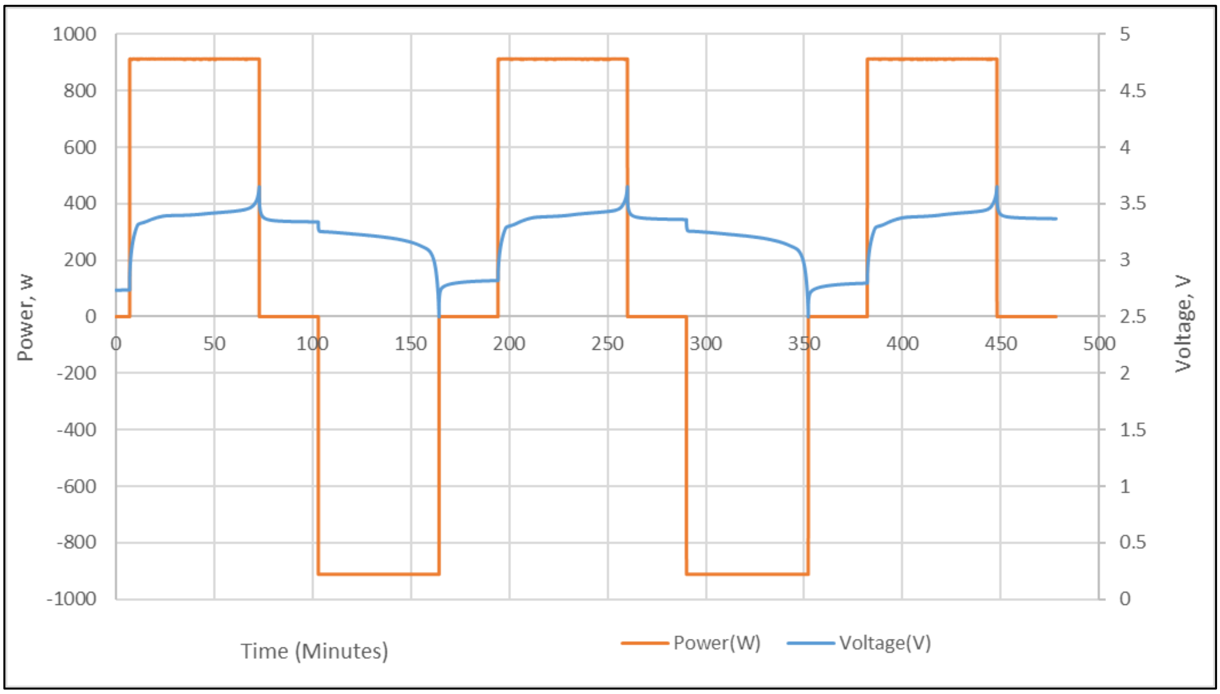


Figure 24: Cell 6 Conditioning (Charge/discharge) Profiles

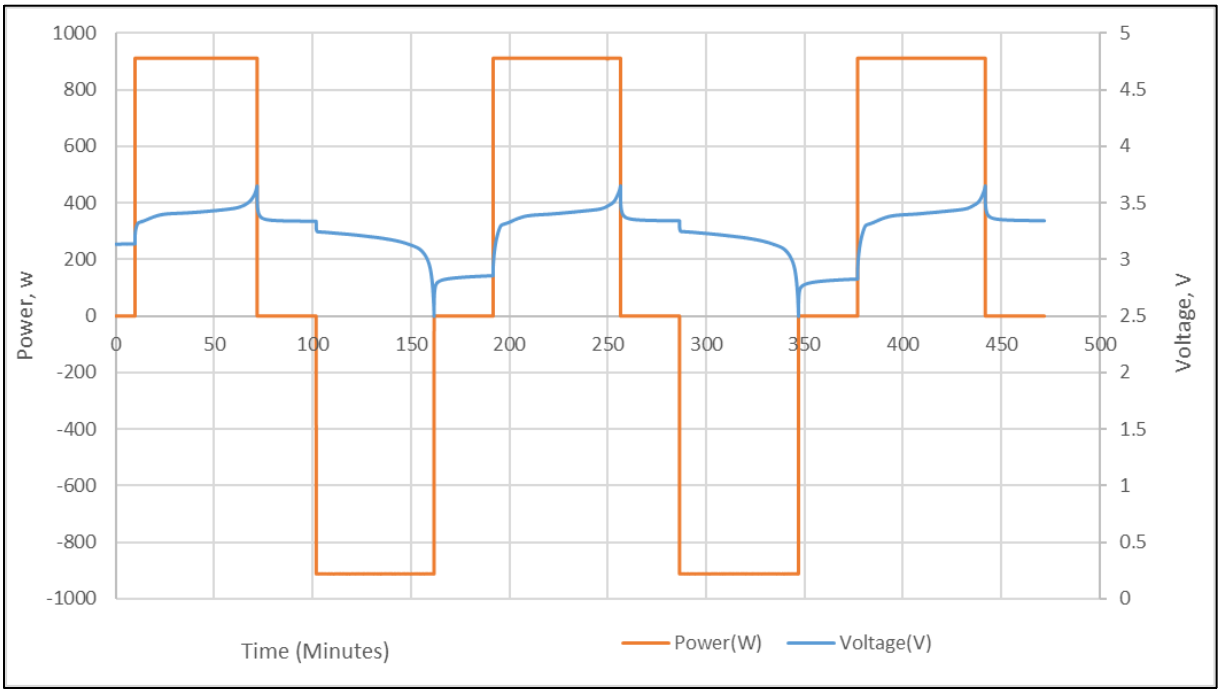


Figure 25: Cell 7 Conditioning (Charge/discharge) Profiles

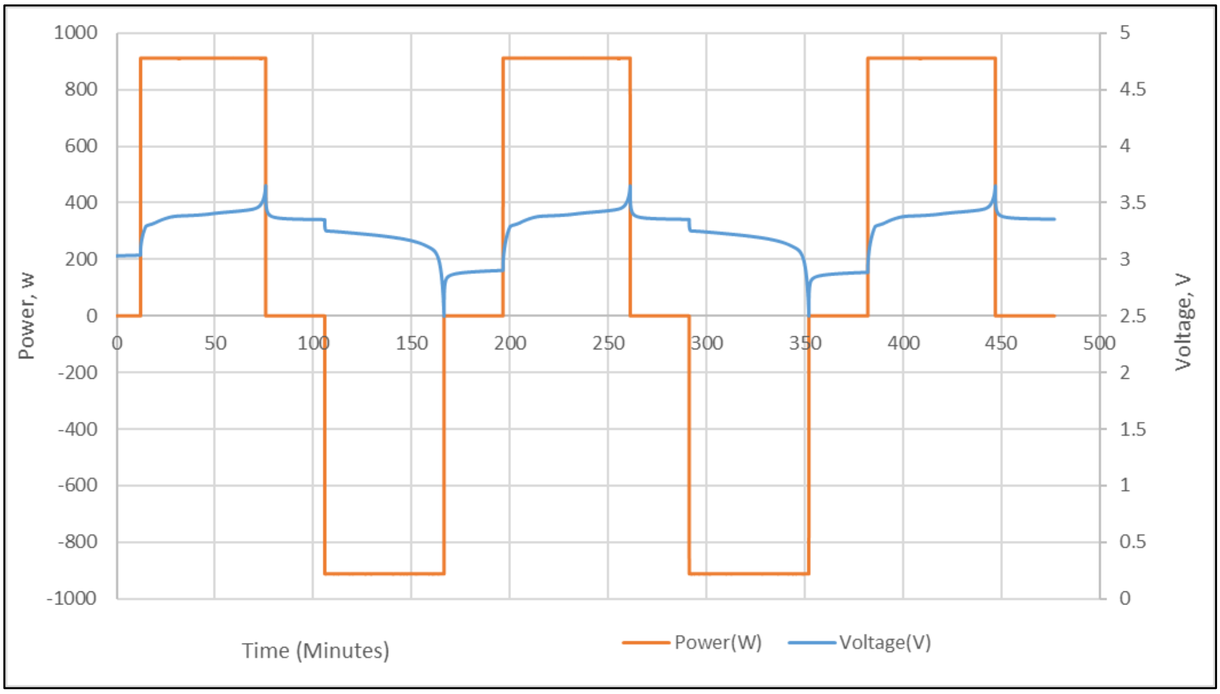


Figure 26: Cell 8 Conditioning (Charge/discharge) Profiles

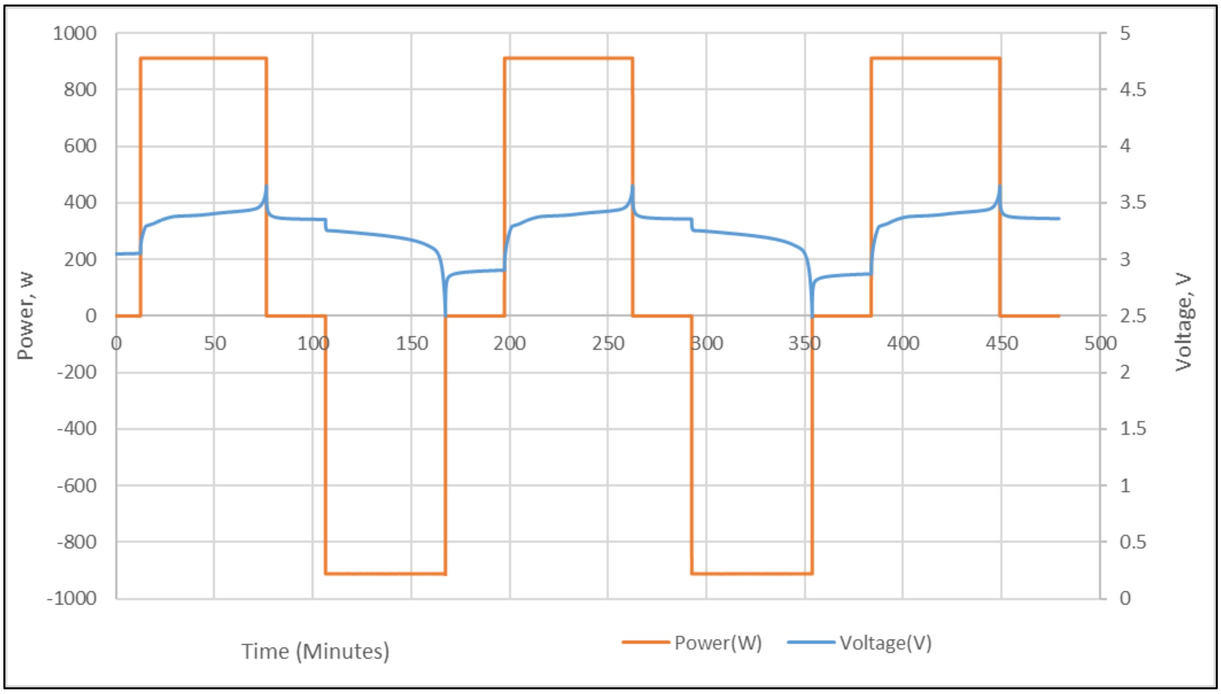


Figure 27: Cell 9 Conditioning (Charge/discharge) Profiles

Attachment G-2: Cell Instrumentation Photos - (*Pages **41** through **41***)

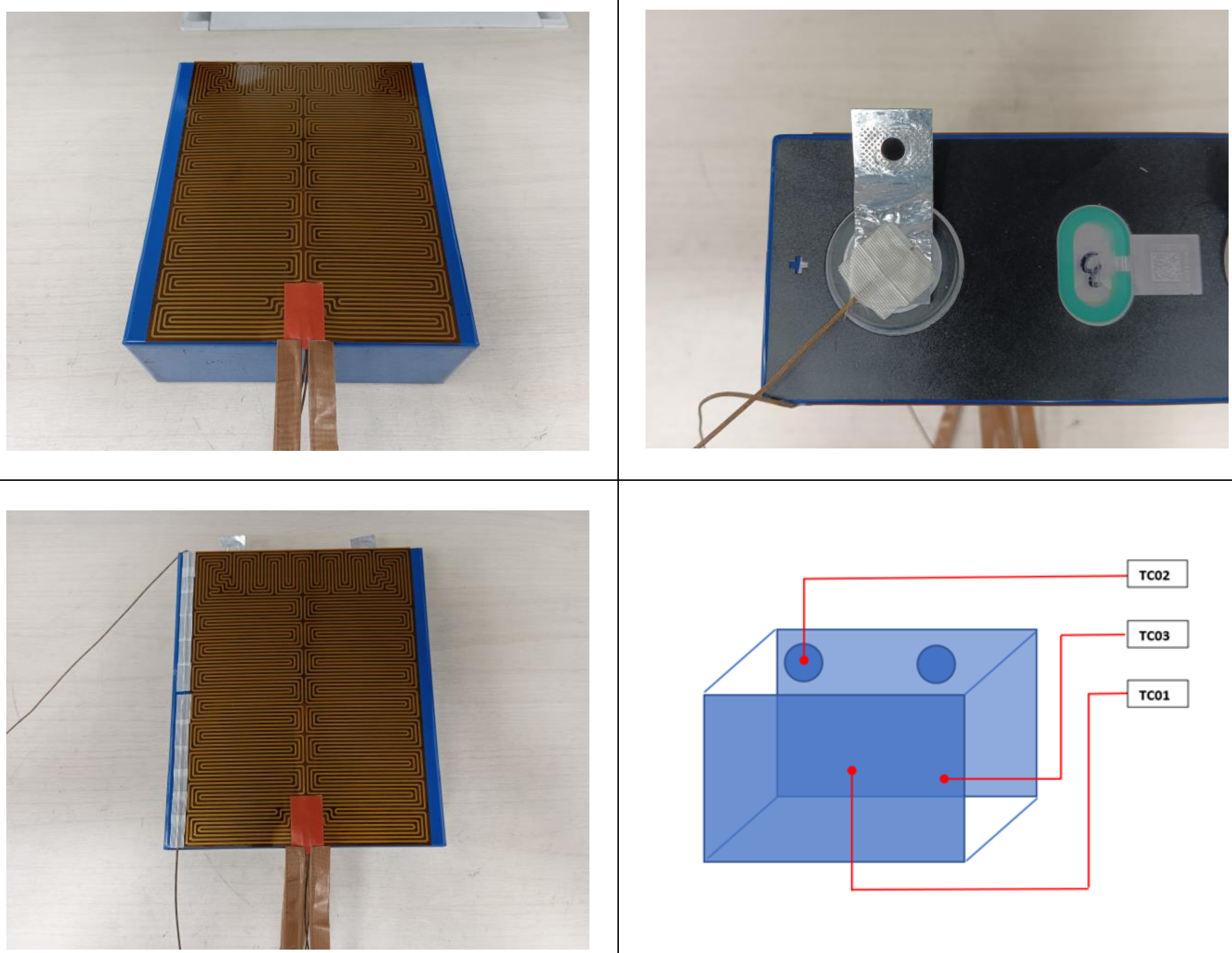


Figure 28: Sample Instrumentation Prior to Test

Note: heaters were placed on two sides of the cell after thermocouples were instrumented.

Note: TC01 between cell body and heater; TC02 on the cell positive; TC03 on the cell body not covered by heater; TC04 Ambient temperature; V1 cell voltage.

Attachment G-3: Cell Temperature Profiles during testing - (*Pages **42** through **43***)

Note: TC01 between cell body and heater; TC02 on the cell positive; TC03 on the cell body not covered by heater; TC04 Ambient temperature; V1 cell voltage.
TC01 was used to control the temperature at 4 to 7°C/min and TC03 temperatures were reported herein for the surface temperature at the onset of vent and thermal runaway.

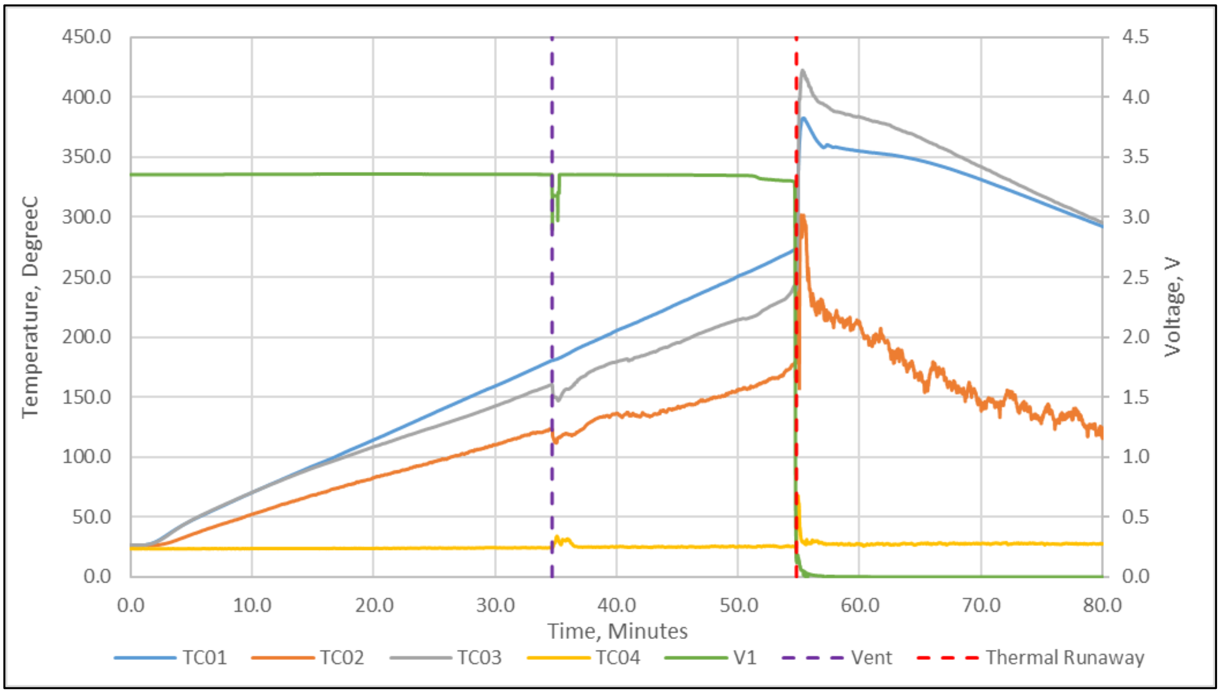


Figure 29: Cell 6 – External Heating 4.5°C per minute

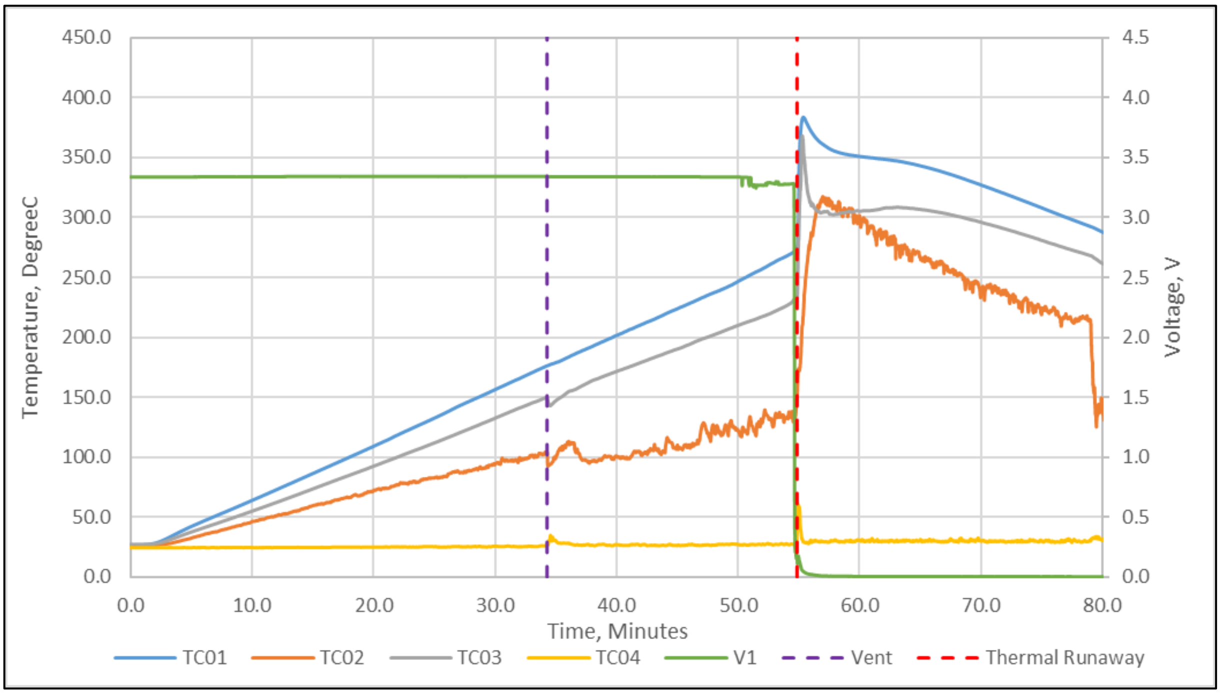


Figure 30: Cell 7 – External Heating 4.5°C per minute

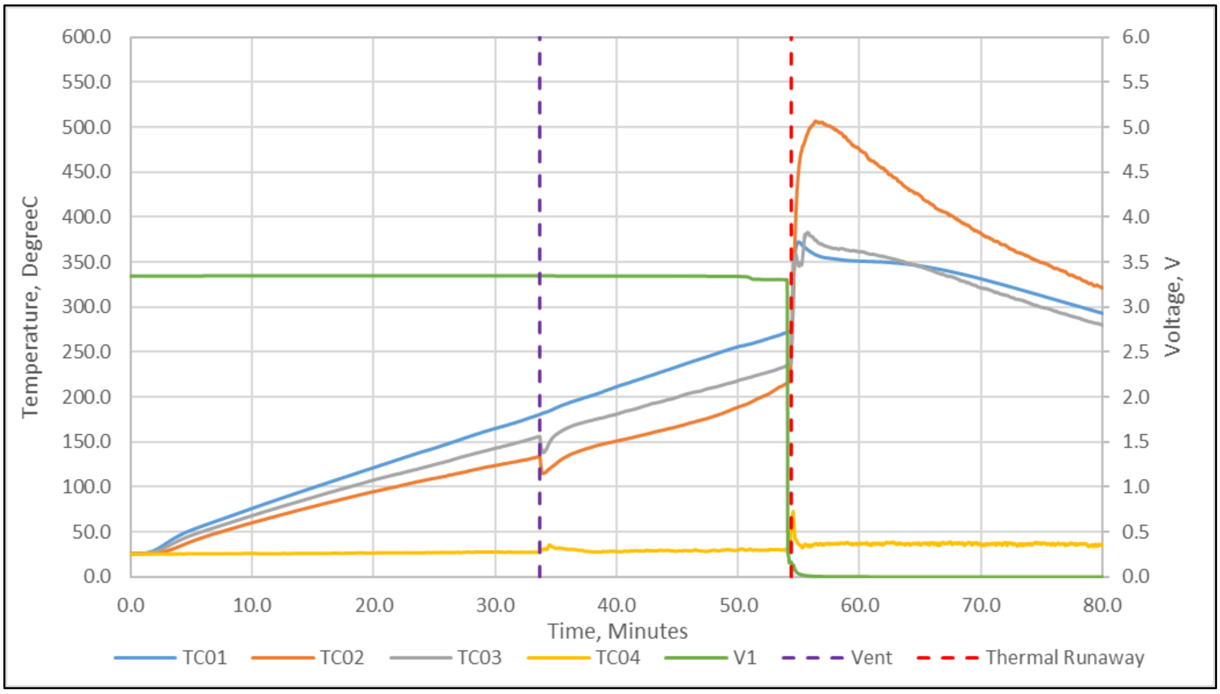


Figure 31: Cell 8 – External Heating 4.5°C per minute

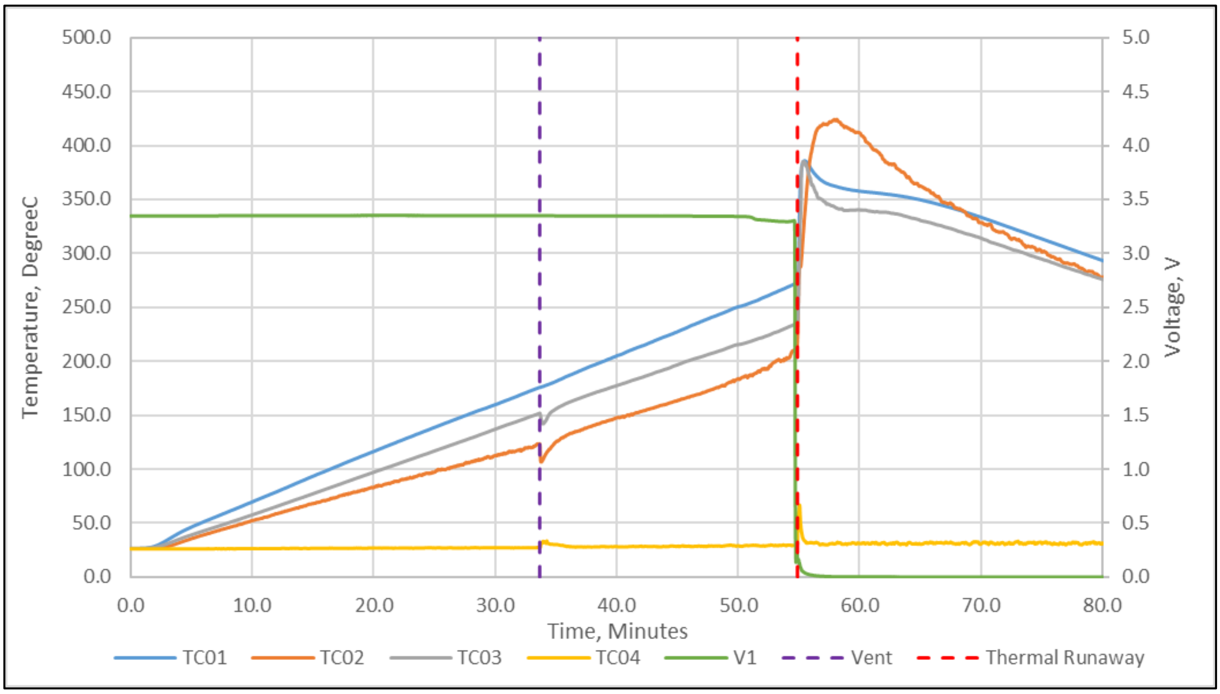


Figure 32: Cell 9 – External Heating 4.5°C per minute

Attachment G-4 Cell Testing Photos - (*Pages **44** through **51***)

Cell Sample 6 – below figure shows highlights of cell testing. Cell venting and thermal runaway were observed, however no evidence of fire. Figure on next page shows photos of cell after testing.

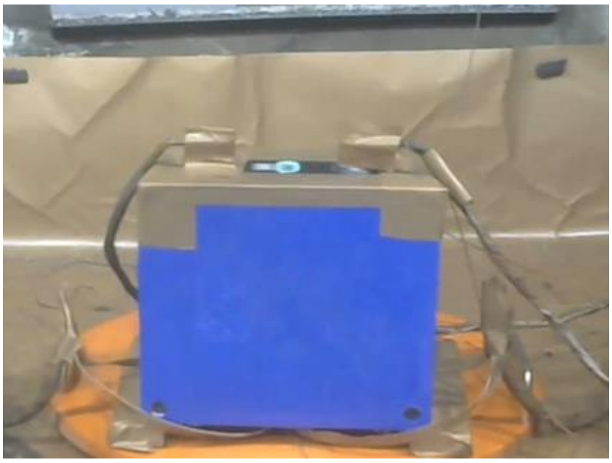
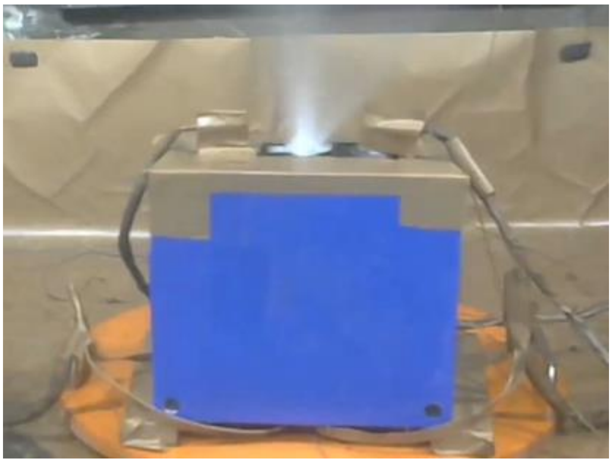
	
(a) Test Start [00:00]	(b) Cell Venting [34:41]
	
(c) Thermal runaway behavior [54:48]	

Figure 33: Highlights of Cell 6 Testing

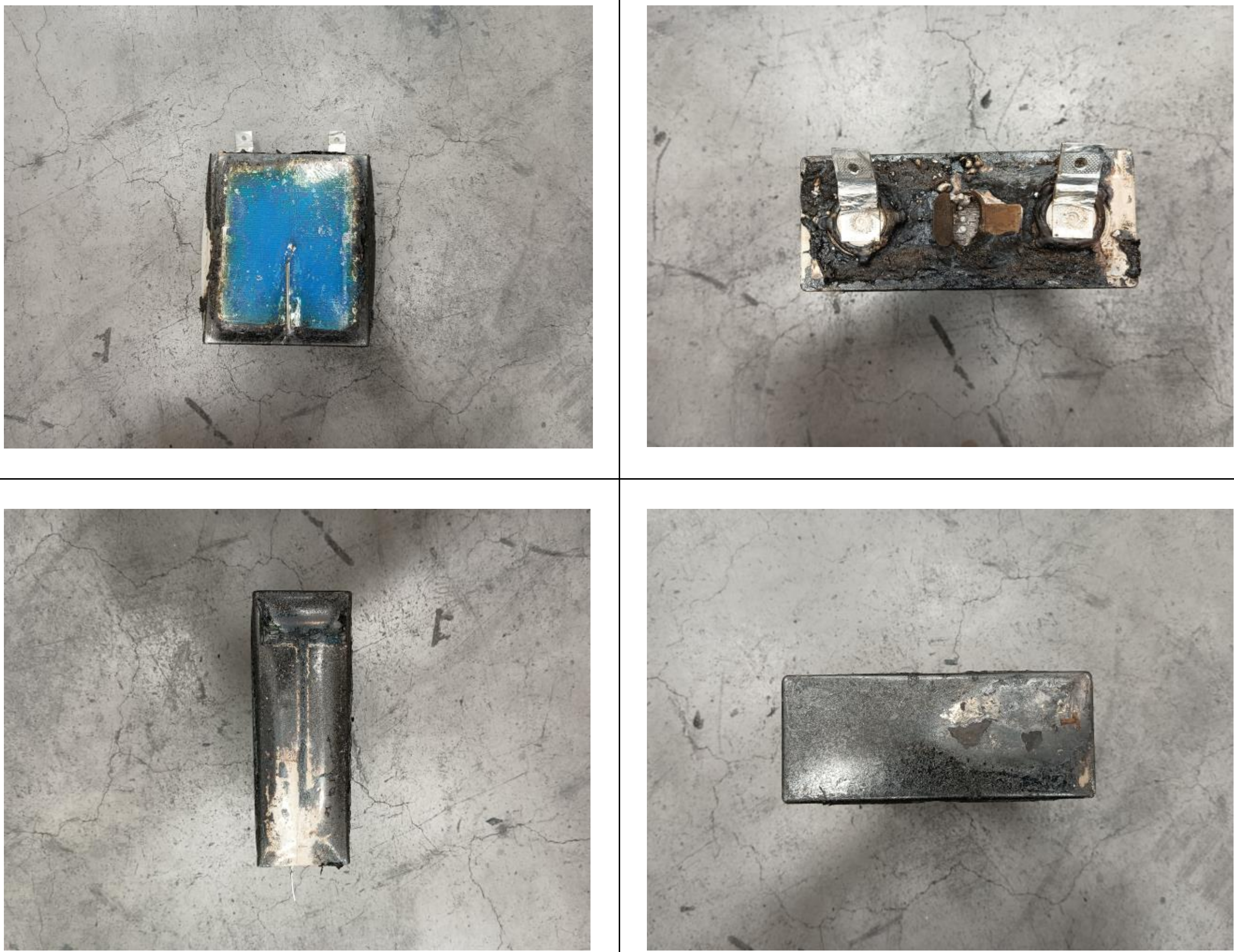


Figure 34: Sample Post Test Photos

Cell Sample 7 – below figure shows highlights of cell testing. Cell venting and thermal runaway were observed, however no evidence of fire. Figure on next page shows photos of cell after testing.

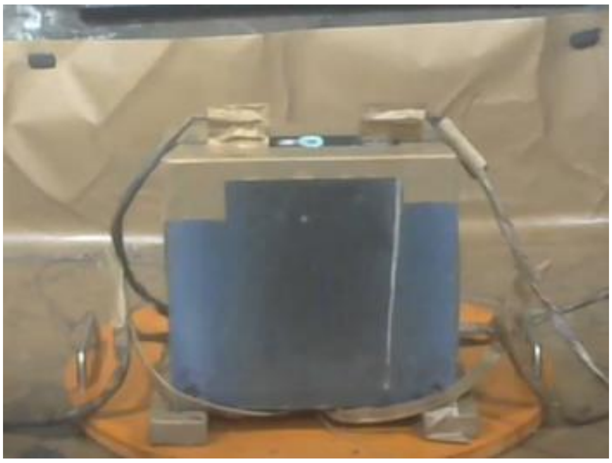
	
(a) Test Start [00:00]	(b) Cell Venting [34:16]
	
(c) Thermal runaway behavior [54:51]	
Figure 35: Highlights of Cell 6 Testing	

Figure 36: Sample Post Test Photos

Cell Sample 8 – below figure shows highlights of cell testing. Cell venting and thermal runaway were observed, however no evidence of fire. Figure on next page shows photos of cell after testing.

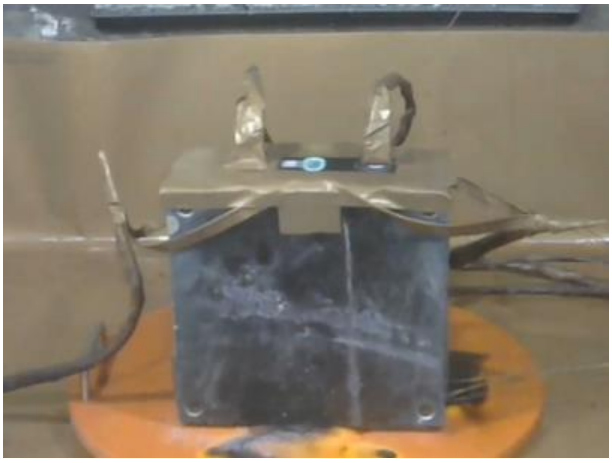
	
(a) Test Start [00:00]	(b) Cell Venting [33:40]
	
(c) Thermal runaway behavior [54:22]	
Figure 37: Highlights of Cell 6 Testing	

Figure 38: Sample Post Test Photos

Cell Sample 9 – below figure shows highlights of cell testing. Cell venting and thermal runaway were observed, however no evidence of fire. Figure on next page shows photos of cell after testing.

	
(a) Test Start [00:00]	(b) Cell Venting [33:40]
	
(c) Thermal runaway behavior [54:53]	

Figure 39: Highlights of Cell 6 Testing

Figure 40: Sample Post Test Photos

Test Report

For

ANSI/CAN/UL9540A

Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems

[Module Level]

Report Number:	**CQES240700055301**
Date of issue:	**2024-07-30**
Total number of pages:	**22**
Test object / Model:	**SM94K8FM2**
Applicant's name:	**SYL(Ningbo) Battery Co., Ltd.**
Address:	**3F, Building 1, No. 23, Xingke Middle Road, Meilin Street, Ninghai County, Ningbo, Zhejiang, China**

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检验检测专用章
Inspection & Testing Services
SGS-CEC New Energy Technology (Chongqing) Co., Ltd.

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Report Number:	CQES240700055301
Manufacturer:	Same as applicant
Address:	Same as applicant
Factory:	Same as applicant
Address:	Same as applicant
Test object / Model:	SM94K8FM2
Test specifications:	ANSI/CAN/UL9540A:2019 Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems Fourth Edition, Dated November 12, 2019
Date of receipt:	2024-07-01
Sample No.:	M1
Test Period:	2024-07-19 to 2024-07-24
Issuing Laboratory:	SGS-CEC New Energy Technology (Chongqing) Co., Ltd.
Address:	Building 13 & 14, No. 1839, Ranjun Road, Shuangfu Street, Jiangjin District, Chongqing, China
Testing location:	SGS-CEC New Energy Technology (Chongqing) Co., Ltd. Building 13 & 14, No. 1839, Ranjun Road, Shuangfu Street, Jiangjin District, Chongqing, China
Test Result:	Refer to summary of test results page for details.
Remark:	Test results reported relate only to the items being tested.
Confidential level:	☒ Strictly Confidential ☐ Private and Confidential ☐ Public

Tested by / Witness by

Kyle Tian

Kyle Tian
Project Engineer

Reviewed by

Ryan Hu
Technical Manager

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[Summary of Test results]

Cell Level Test
Cell model: CBDC0
Report No: 4790838636.1

Cell Design:	CBDC0
Thermal Runaway Methodology:	External heating
Cell Surface Temperature at Gas venting:	156 °C
Cell Surface Temperature at Thermal Runaway:	232 °C
Gas Composition:	Mainly Hydrocarbon, H_2, CO_2, CO
Lower Flammability Limit:	7.45 Vol% at the ambient temperature 6.545 Vol% at 156 °C
Burning Velocity:	62.44 cm/s
Pmax:	96.79 psig
Thermal Runaway was Induced in the Cell or not:	Induced
Cell Vent Gas is Flammable or not in Air:	Flammable

Module Level Test
Module model:
SM94K8FM2
Report No:
CQES240700055301

Module Design:	SM94K8FM2
Thermal Runaway Methodology:	External heating
External Flaming:	No external flaming observed
Locations of Flame Venting:	No flame extension observed
Flying Debris:	No flying debris observed
Explosion or not:	No explosion observed
Gas Generation and Composition:	Mainly Hydrocarbon, H_2, CO_2, CO
Thermal Runaway are Contained by the Module Design or not:	Contained by the Module Design
Cell Vent Gas is Flammable or not:	Flammable
Other Description:	N/A
Test Video file:	Archived by Applicant

Remark: This report only evaluated module level test which is listed inside the dotted box.

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[Test object Description]

Table 1: Description of component cell

Model:	CBDC0	
Manufacturer:	Contemporary Amperex Technology Co., Limited	
Nominal capacity:	285 Ah	
Nominal voltage:	3.2 V	
Charge current:	285 A	
Discharge current:	285 A	
Standard full charge voltage:	3.65 V	
End of discharge voltage:	2.5 V	
Charge temperature range:	0 °C to 60 °C	
Discharge temperature range:	-20 °C to 60 °C	
UL 1973 compliant:	☒ Yes / ☐ No	Reference: File No. MH62898 issued by UL
UL 9540A report provided:	☒ Yes / ☐ No	Reference: Report No. 4790838636.1, issued by UL

Figure 1a. View 01 of component cell

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Figure 1b. View 02 of component cell

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Table 2: Description of battery module

Model:	SM94K8FM2	
Manufacturer:	SYL(Ningbo) Battery Co., Ltd.	
Nominal capacity:	285 Ah	
Nominal voltage:	332.8 V	
Standard charge current:	285 A	
Standard discharge current:	285 A	
Maximum charge voltage:	374.4 V	
Cut-off Voltage:	291.2 V	
Charge temperature range:	5°C to 55 °C	
Discharge temperature range:	-10°C to 55 °C	
Module configuration:	1P104S	
External dimensions:	(243±1.5) mm * (790±1.5) mm * (2170±4) mm	
Enclosure material:	Thermoplastic materials (Min. thickness: 2.5mm)	
Weight:	Approx 650 kg	
UL 1973 compliant:	☐ Yes / ☐ No	Reference: N/A

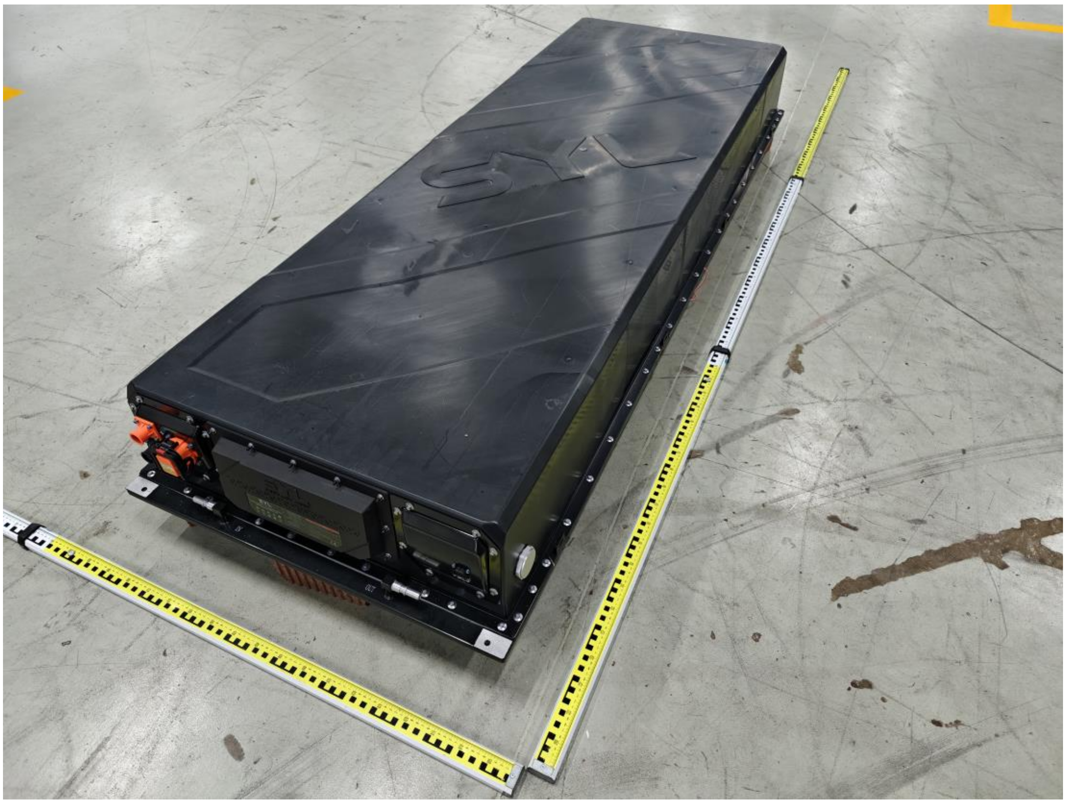

Figure 2. View of battery module

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[Description of thermal runaway methodology]

Pre-condition of test sample

Module samples shall be conditioned, prior to testing, through charge and discharge cycles for a minimum of 2 cycles, using a manufacturer specified methodology to verify that the module is functional. Each cycle shall be defined as a charge to 100% SOC and allowed to rest a maximum of 8 h and then discharged to an end of discharge voltage (EODV) specified by the module manufacturer.

The module to be tested shall be charged to 100% SOC and allowed to rest a maximum of 8 h before the start of the test. The module voltage shall be determined by measuring at the module terminals after charging up to the fully charged condition and before beginning testing. The sample module shall stabilize for a minimum of one hour prior to testing.

Table 3: Charge and discharge parameters (provided by manufacturer)

Charge		Discharge	
Charge current (A)	285	Discharge current (A)	285
Max. charge voltage (V)	374.4 or the maximum cell voltage reaches 3.60V	Cut-off voltage (V)	291.2 or the minimum cell voltage reaches 2.7V
Cut-off charge current (A)	--	--	--

Module level Test method description

Ambient indoor laboratory conditions shall be 25 ±5°C (77 ±9°F) and 50 ±25% RH at the initiation of the test.

The test shall be conducted under a smoke collection hood that is sized appropriately to collect the gasses generated from the module.

The methodology used for initiating thermal runaway pursuant to cell level test shall be used to initiate thermal runaway within the module.

Thermal runaway methodology for module level test: The propensity of the module to exhibit thermal runaway was demonstrated by heating the cell with externally applied heaters. With a surface heating rate of 4°C (7.2°F) to 7°C (12.6°F) per minute until cell thermal runaway occurs within the test module.

The number of cells within the module that are forced into thermal runaway can be one or multiple cells, and is dependent upon the energy contained within the individual cells. A sufficient number of cells shall be forced into thermal runaway to create a condition of cell to cell propagation within the module. For example, it may be necessary to force nine, 3-Ah cells into thermal runaway as opposed to one, 30-Ah cell in order to get cell to cell propagation. The location of the cell (s) forced into thermal runaway shall be selected to present the greatest thermal exposure to adjacent cells that are not forced into thermal runaway. Factors to be taken into consideration shall include selecting locations within the module where heat transfer is maximized to other cells, cooling by ventilation is restricted or limited, and thermal sensors, detection and suppression discharge points are remote.

The module shall be placed on top of a noncombustible horizontal surface with the module orientation representative of its intended final installation.

The chemical heat release rate of the module in thermal runaway shall be measured with oxygen consumption calorimetry.
The chemical heat release rate shall be measured for the duration of the test.

Occurrence of thermal runaway shall be verified by sustained temperature above the cell surface temperature at the onset of thermal runaway, as determined in cell level test.

The chemical heat release rate shall be measured by a 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 instrumentation shall be located in the exhaust duct of the heat release rate calorimeter at a location that minimizes the influence of bends or exhaust devices.

Calculate the chemical heat release rate at each of the flows as follows:

$$HRR_1 = \left[E \times \varphi - (E_{co} - E) \times \frac{1-\varphi}{2} \times \frac{X_{co}}{X_{O_2}}\right] \times \frac{\dot{m}_e}{1+\varphi \times (\alpha - 1)} \times \frac{M_{O_2}}{M_a} \times (1 - X^o_{H_2O}) \times X^o_{O_2}$$

Vent gas composition shall be measured using a Fourier-Transform Infrared Spectrometer with a minimum resolution of 1 cm^{-1} and a path length of at least 2 m (6.6 ft), or equivalent gas analyzer, and velocity and temperature measurements respectively shall be obtained in the exhaust duct of the heat release rate calorimeter using equipment.

The hydrocarbon content of the vent gas shall be measure using flame ionization detection.
Hydrogen gas shall be measured with a palladium-nickel thin-film solid state sensor.

The light transmission in the exhaust duct of the heat release rate calorimeter shall be measured using a white light source and photo detector for the duration of the test, and the smoke release rate shall be calculated.

Smoke release rate shall be calculated as follows:

$$SRR = 2.303\left(\frac{V}{D}\right) Log_{10}\left(\frac{I_o}{I}\right)$$

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Test configuration description

Thermal runaway initiation method used including number and locations of cells for initiating thermal runaway
Initiation method: External heating method was used to initiate thermal runaway. By controlling the input power of the heater, a surface heating rate of 4°C (9°F) to 7°C (12.6°F) per minute was achieved. Max. power of the heater was 900W.
Number of cells for initiating thermal runaway: ☐ Single cell Ah (total capacity) ☒ Multiple cell 570 Ah (total capacity)
Locations of cells for initiating thermal runaway: The battery module, referred to as DUT (device under test) in the following context, consists of 8 submodules. Each submodule consists of 13 serial cells (1P13S). Eight submodules are connected in series. One 1P13S submodule was selected as the initiating submodule. The heater was placed on the large surface of Cell No. 45. Cell No. 45 was selected as the initiating cell (as shown in Figure 3c).
Other description : N/A.

Figure 3a. Internal view 01 of DUT.

Figure 3b. Internal view 02 of DUT.

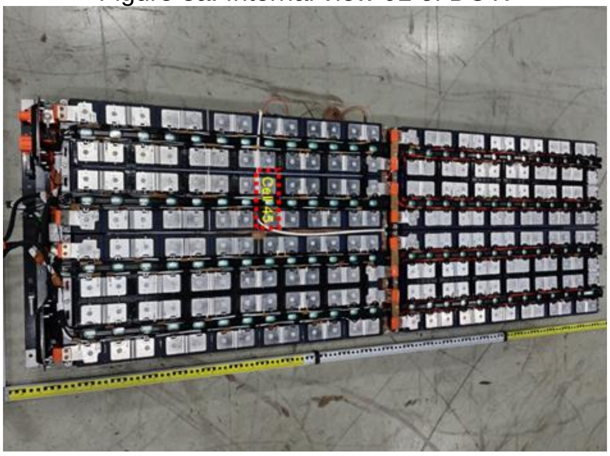

Figure 3c. location of initiating cell.

Figure 3d. View of external heater.

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Illustration of external heater and thermocouple location
Description: N/A

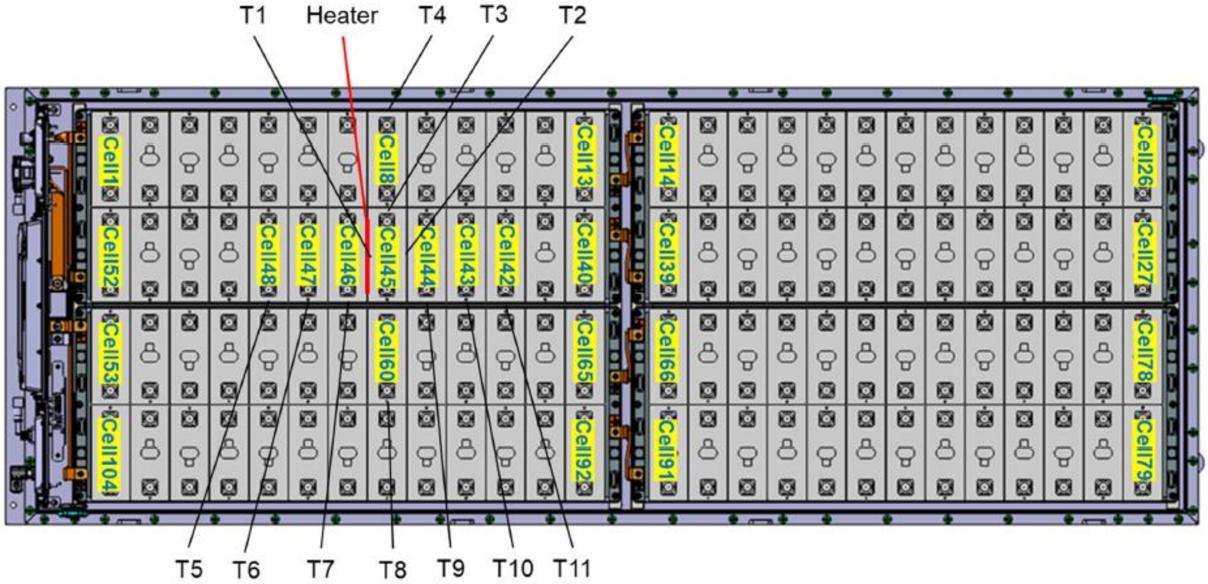

Figure 4. Schematic illustration of heater and thermocouple locations in the initiating module.

Positioning of module within testing room
Test Start Time: 2024-07-22 13:55:40
Initial Ambient Test Temperature: 29.3 °C
Initial Relative Humidity: 60.5% RH
Description: N/A

Figure 5. View of positioning of module within testing room.

Table 4: Thermocouple placement

Thermocouple ID	Description of location	Remark
CH2004	Center of surface between Cell 45 and Heater 1	T1
CH2005	Center of surface of Cell 45 near to Cell 44	T2
CH2006	Center of side surface of Cell 45 near to Cell 8	T3
CH2007	Center of side surface of Cell 8	T4
CH2008	Center of side surface of Cell 48	T5
CH2009	Center of side surface of Cell 47	T6
CH2010	Center of side surface of Cell 46	T7
CH2101	Center of side surface of Cell 60	T8
CH2102	Center of side surface of Cell 44	T9

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CH2103	Center of side surface of Cell 43	T10
CH2104	Center of side surface of Cell 42	T11
CH2105	Surface of battery top enclosure	T12
CH2106	Surface of battery side enclosure	T13
CH2107	Ambient temperature	--
Thermocouple information: Type K, 24 AWG.		

[Description of test results]

Table 5: Overview of test timeline and key events

Time (HH: MM: SS)	Relative Time (HH: MM: SS)	Event ID	Event	Description	Photo Reference
13:55:40	00:00:00	E1	Test Start	--	--
13:58:47	00:03:07	E2	Heater Energized	--	Figure 9
15:04:57	01:09:17	E3	Initiating Cell Venting (First Release)	Module enclosure bulging.	Figure 10
15:05:21	01:09:41	E4	Thermal Runaway onset	Smoke venting observed from module enclosure. Heater de-energized.	Figure 11
15:05:49	01:10:09	E5	Module enclosure rupture	Smoke venting observed from the rupture	Figure 12
23:55:39	09:59:59	E6	Test Termination	--	--

Heat release rate versus time
Description: No flaming combustion observed outside test module.
N/A

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Flammable gas generation and composition		
Flammable gas generation:	☒ YES	☐ NO
Description : N/A		

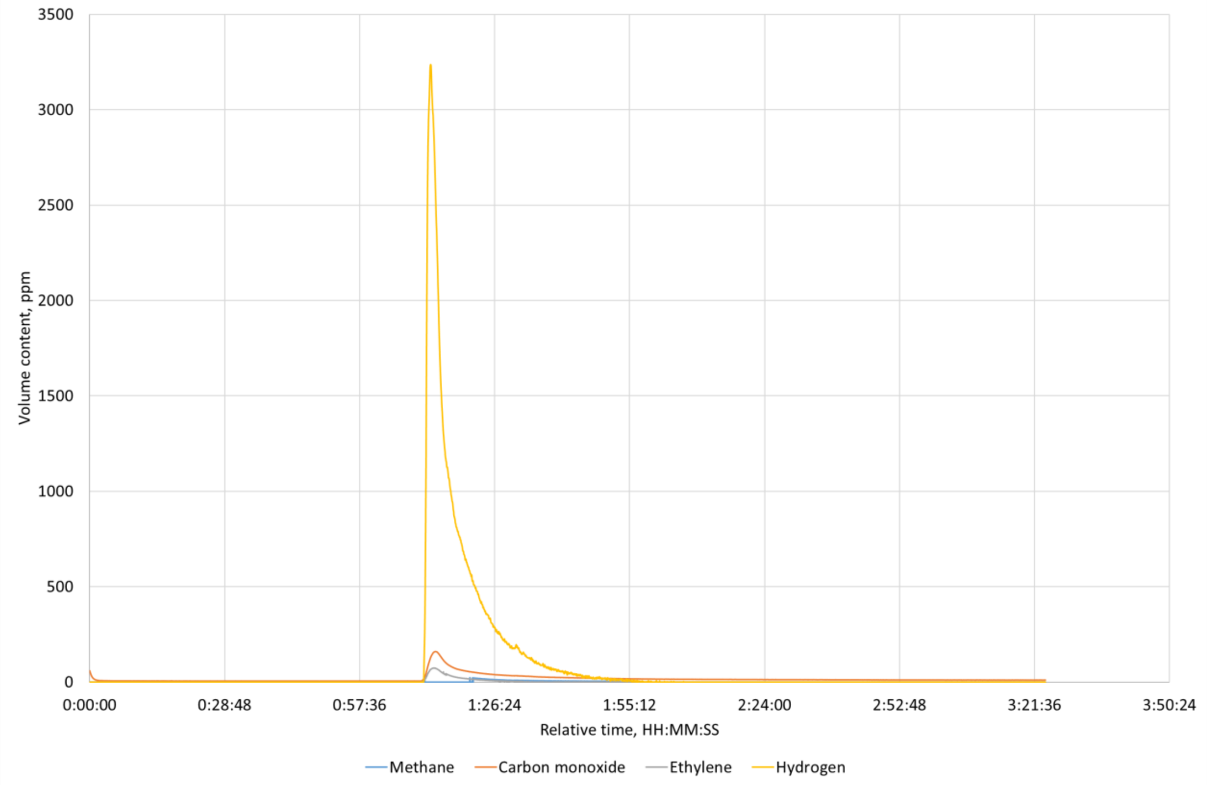

Figure 6. Online flammable gas content measurements during test. (Remark: The content of other hydrocarbons is below the detection limit of the test equipment.)

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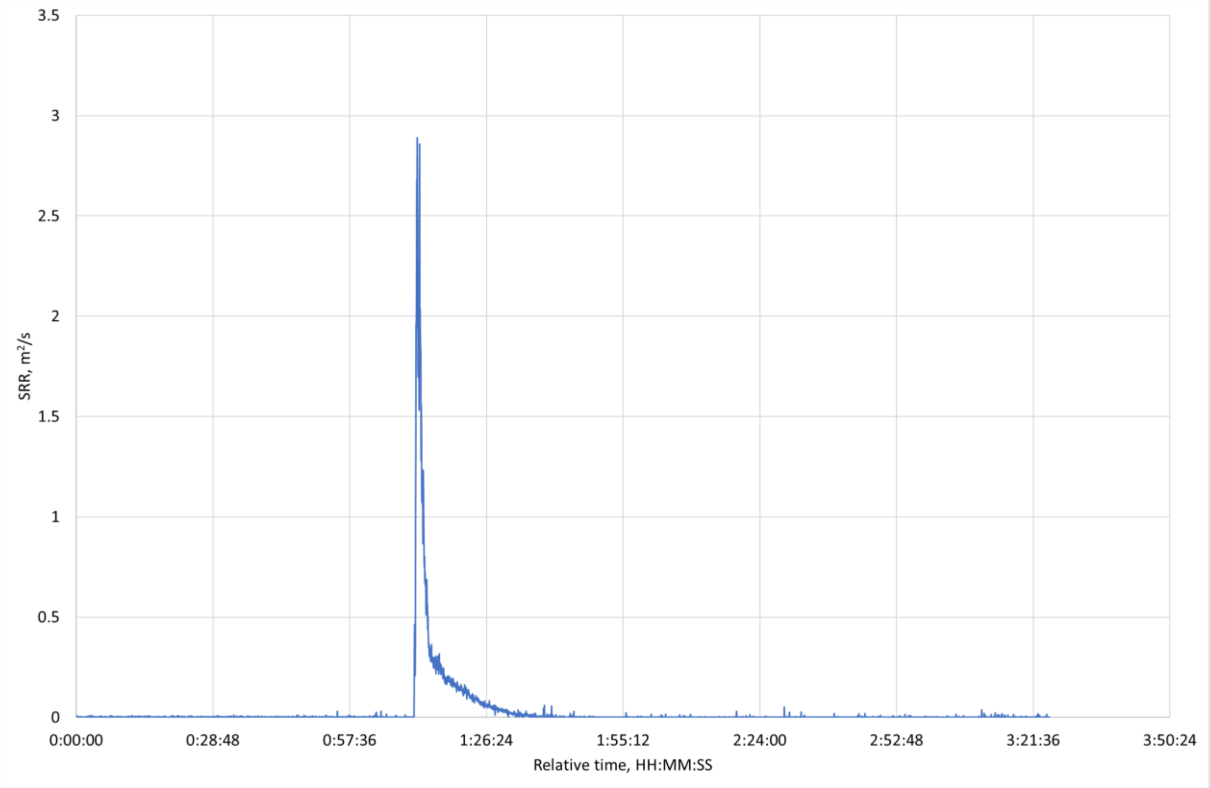
Peak smoke release rate and total smoke release
Description : 1. Peak smoke release rate is 2.890 m^2/s during test. 2. Total somke release is 369.706 m^2 during test.
 Figure 7. SRR measurement during test.

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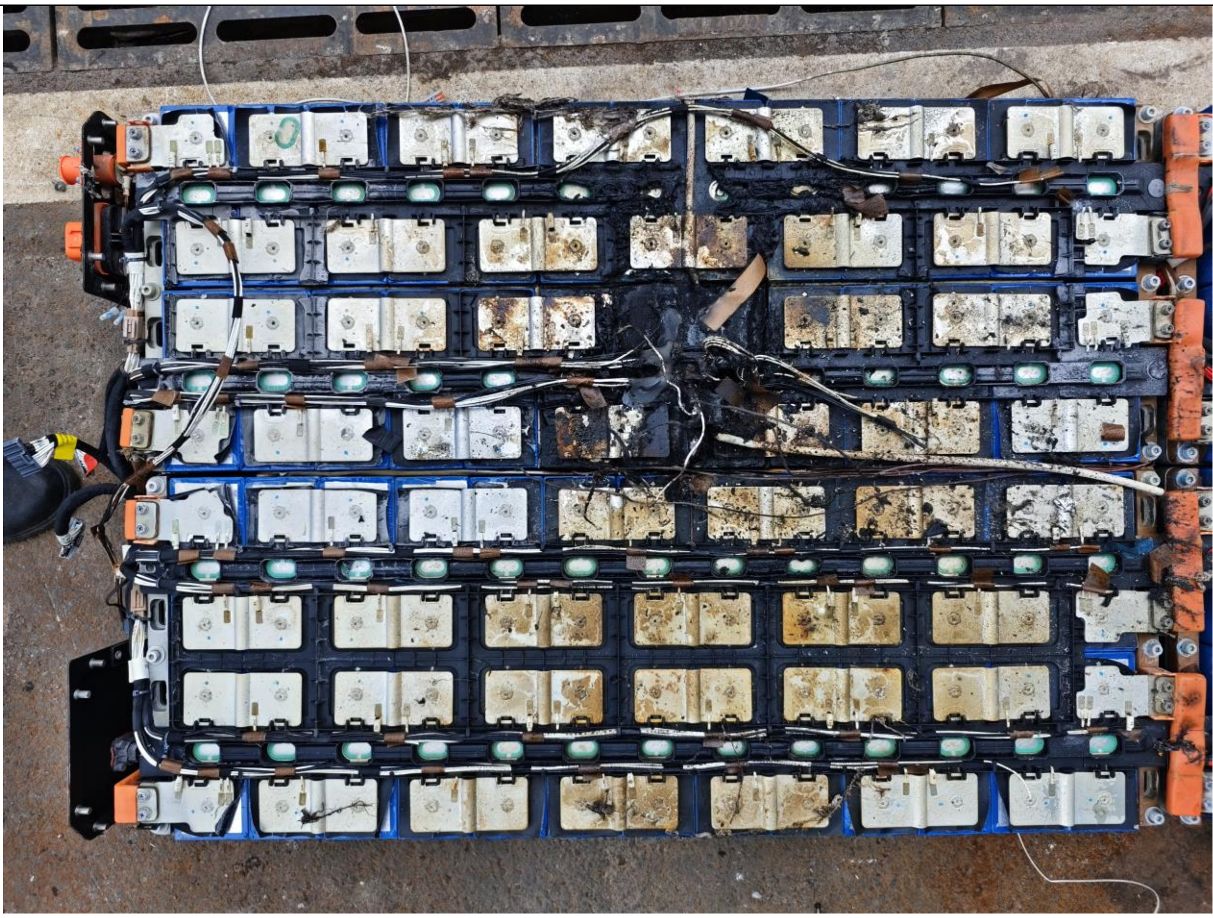
Identification/location of cell(s) that exhibited thermal runaway within the module
Cells(s) that exhibited thermal runaway: ☒ YES ☐ NO
Description : N/A
 Figure 8. View of cells that exhibited thermal runaway after test.

Locations and visual estimations of flame extension and duration from the module
Flame extension: ☐ YES ☒ NO
Description : No external flaming observed. No explosion observed. No flying debris observed.
N/A

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Table 6: Data during test

Model	SOC of Battery Module Before Test, (%)	OCV of Battery Module Before Test, (V dc)	Weight of Battery Module Before Test, (Kg)	Weight of Battery Module After Test, (Kg)	Battery Module Weight Loss Rate, (%)
SM94K8FM2	100	347.1	647.8	646.7	0.02
Peak Smoke Release Rate, (m^2/s)	**Total Smoke Release**	**Observation Results**			
2.890	369.706 m^2	Gas and smoke release observed from module enclosure. No external flaming observed. No explosion observed.			
Supplementary information: No additional thermal runaway events or re-ignition occurred during post-test observations of the test module.					

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Figure 9. Photo of event (E2) during test.

Figure 10. Photo of event (E3) during test.

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Figure 11. Photo of event (E4) during test.

Figure 12. Photo of event (E5) during test.

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Figure 13. Photo 01 of DUT after test.

Figure 14. Photo 02 of DUT after test.

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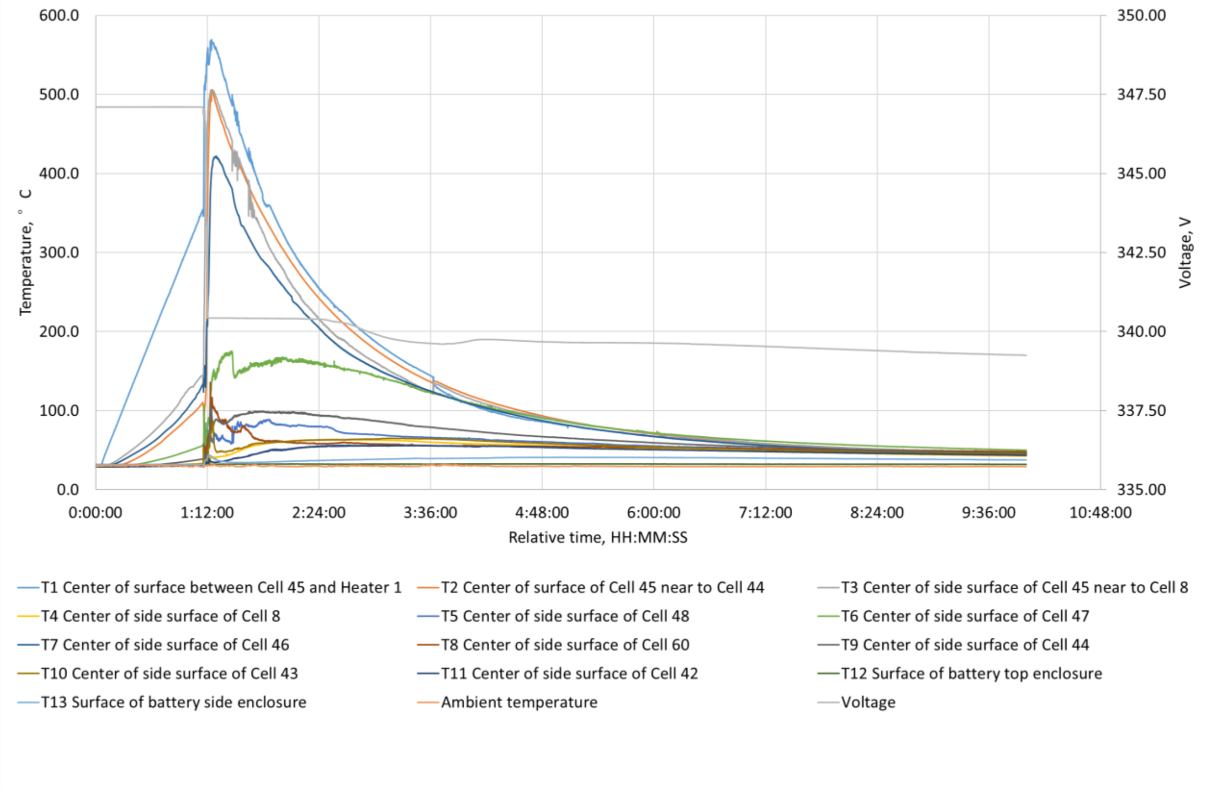

Figure 15. Temperature and voltage measurements during test.

NOTES TO THIS TEST REPORT

1.

2. According to the standard, instruction sheets and other texts required by the standard should be written in the official language(s) of the country in which the product is to be sold. The applicant should ensure that the product in future production fulfils the receptive standard requirements.

3. The components performed satisfactorily during testing and are considered to be suitable for use in the sample tested.

- - - End of Report - - -

Test Report

For

ANSI/CAN/UL9540A

Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems

[Unit Level]

Report Number:	**CQES240800069201**
Date of issue:	**2024-08-29**
Total number of pages:	**46**
Test object / Model:	**SR94K8FM24**
Applicant's name:	**SYL(Ningbo) Battery Co., Ltd.**
Address:	**3F, Building 1, No. 23, Xingke Middle Road, Meilin Street, Ninghai County, Ningbo, Zhejiang, China**

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Report Number:	CQES240800069201
Manufacturer:	Same as applicant
Address:	Same as applicant
Factory:	Same as applicant
Address:	Same as applicant
Test object / Model:	SR94K8FM24
Test specifications:	ANSI/CAN/UL9540A:2019 Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems Fourth Edition, Dated November 12, 2019
Date of receipt:	2024-07-30
Sample No.:	M1 to M4
Test Period:	2024-08-06 to 2024-08-09
Issuing Laboratory:	SGS-CEC New Energy Technology (Chongqing) Co., Ltd.
Address:	Building 13 & 14, No. 1839, Ranjun Road, Shuangfu Street, Jiangjin District, Chongqing, China
Testing location:	SGS-CEC New Energy Technology (Chongqing) Co., Ltd. Building 13 & 14, No. 1839, Ranjun Road, Shuangfu Street, Jiangjin District, Chongqing, China
Test Result:	Refer to summary of test results page for details.
Remark:	Test results reported relate only to the items being tested.
Confidential level:	☒ Strictly Confidential ☐ Private and Confidential ☐ Public

Tested by / Witness by	**Reviewed by**
Hanson Wei	Ryan Hu
Hanson Wei Project Engineer	Ryan Hu Report Reviewer

标瑞新能源技术（重庆）有限公司
检验检测专用章
Inspection & Testing Services
SGS-CEC New Energy Technology (Chongqing) Co., Ltd.

[Summary of Test results]

Cell Level Test
Cell model: CBDC0
Report No: 4790838636.1

Cell Design:	CBDC0
Thermal Runaway Methodology:	External heating
Cell Surface Temperature at Gas venting:	156 °C
Cell Surface Temperature at Thermal Runaway:	232 °C
Gas Composition:	Mainly Hydrocarbon, H_2, CO_2, CO
Lower Flammability Limit:	7.45 Vol% at the ambient temperature 6.545 Vol% at 156 °C
Burning Velocity:	62.44 cm/s
Pmax:	96.79 psig
Thermal Runaway was Induced in the Cell or not:	Induced
Cell Vent Gas is Flammable or not in Air:	Flammable

Module Level Test
Module model:
SM94K8FM2
Report No:
CQES240700055301

Module Design:	SM94K8FM2
Thermal Runaway Methodology:	External heating
External Flaming:	No external flaming observed
Locations of Flame Venting:	No flame extension observed
Flying Debris:	No flying debris observed
Peak Smoke Release Rate:	2.890 m^2/s
Gas Generation and Composition:	Mainly Hydrocarbon, H_2, CO_2, CO
Thermal Runaway are Contained by the Module Design or not:	Contained by the Module Design
Cell Vent Gas is Flammable or not:	Flammable
Other Description:	N/A
Test Video file:	Archived by Applicant

Unit Level Test
Unit model:
SR94K8FM24
Report No:
CQES240800069201

Unit Design:	SR94K8FM24
Thermal Runaway Methodology:	External heating using thin film
External Flaming:	No external flaming observed
Locations of Flame Venting:	No flame extension observed
Flying Debris:	No flying debris observed
Explosion or not:	No explosion observed
Max. Surface Temperature of Module in Target BESS Unit:	41.1 °C
Max. Temperature Rise on Wall Surfaces:	11.9 °C
Thermal Runaway are Contained by the Unit Design or not:	Contained by the Unit Design
Cell Vent Gas is Flammable or not:	Flammable
Heat Flux in the Center of Egress:	N/A
Cheesecloth Indicator Flaming or not:	N/A
Test Video File:	Archived by Applicant

Remark:
This report only evaluated unit level test which is listed inside the dotted box.

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[Test object Description]

Table 1: Description of component cell

Model:	CBDC0	
Manufacturer:	Contemporary Amperex Technology Co., Limited	
Nominal capacity:	285 Ah	
Nominal voltage:	3.2 V	
Charge current:	285 A	
Discharge current:	285 A	
Standard full charge voltage:	3.65 V	
End of discharge voltage:	2.5 V	
Charge temperature range:	0 °C to 60 °C	
Discharge temperature range:	-20 °C to 60 °C	
UL 1973 compliant:	☒ Yes / ☐ No	Reference: File No. MH62898 issued by UL
UL 9540A report provided:	☒ Yes / ☐ No	Reference: Report No. 4790838636.1, issued by UL

Figure 1. View 01 of component cell

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Figure 2. View 02 of component cell

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Table 2: Description of battery module

Model:	SM94K8FM2	
Manufacturer:	SYL(Ningbo) Battery Co., Ltd.	
Nominal capacity:	285 Ah	
Nominal voltage:	332.8 V	
Standard charge current:	285 A	
Standard discharge current:	285 A	
Maximum charge voltage:	374.4 V	
Cut-off Voltage:	291.2 V	
Charge temperature range:	5°C to 55 °C	
Discharge temperature range:	-10°C to 55 °C	
Module configuration:	1P104S	
External dimensions:	(243±1.5) mm * (790±1.5) mm * (2170±4) mm	
Enclosure material:	Thermoplastic materials (Min. thickness: 2.5mm)	
Weight:	Approx 650 kg	
UL 1973 compliant:	☐ Yes / ☐ No	Reference: N/A

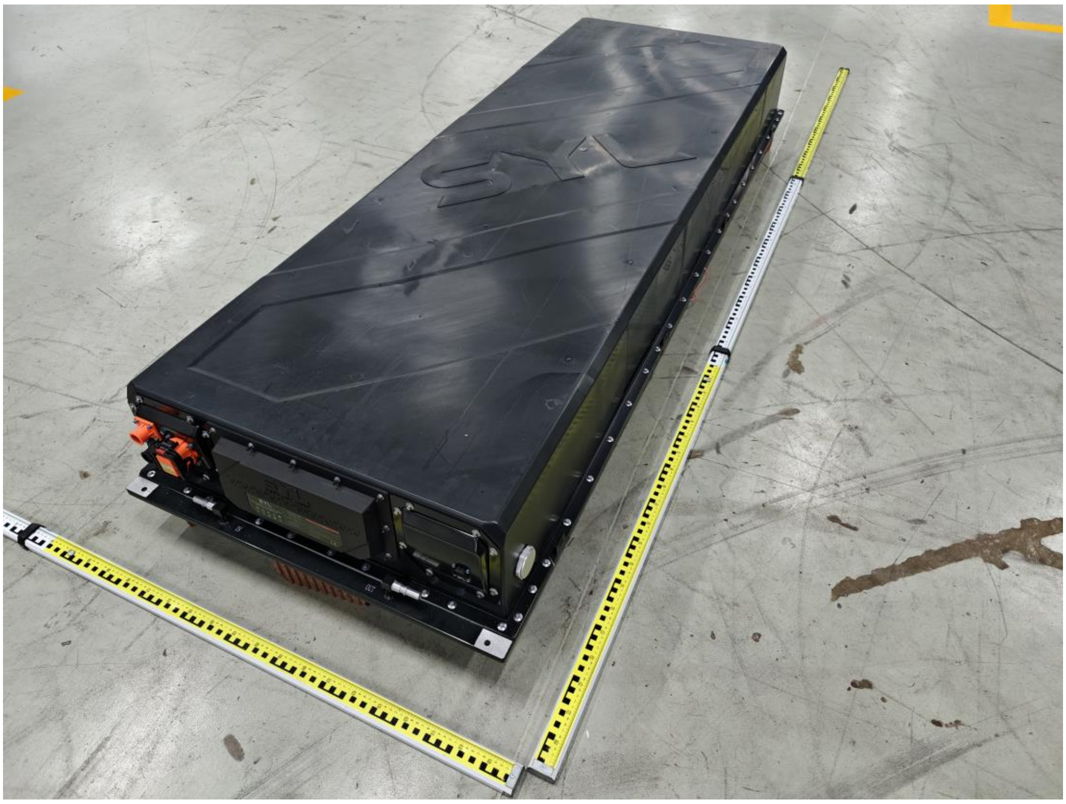

Figure 3. View of battery module

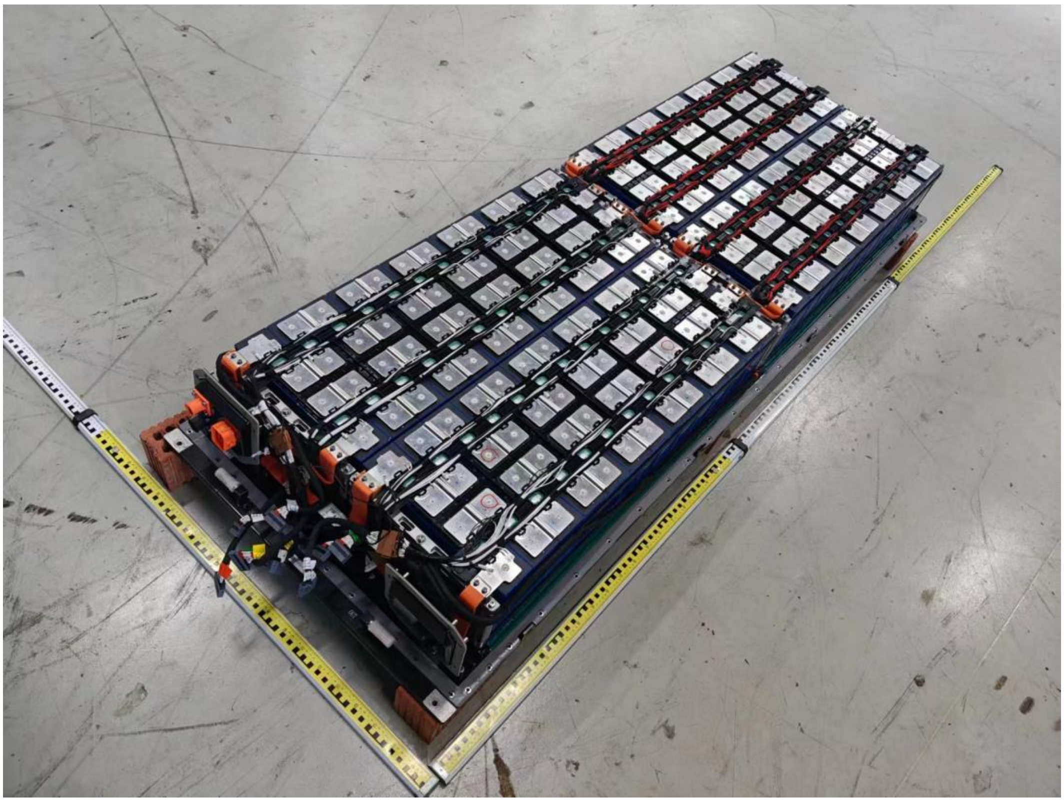

Figure 4. Internal view of battery module

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Table 3: Description of battery system

Model:	SR94K8FM24	
Manufacturer:	SYL(Ningbo) Battery Co., Ltd.	
Rated capacity:	285 Ah	
Rated Voltage:	1331.2 V	
Charge power:	379.39 kW	
Discharge power:	379.39 kW	
Maximum charge voltage:	1497.6V	
Cut-off Voltage:	1123.2V	
Charge operating temperature:	5 to 55 °C	
Discharge operating temperature:	-10 to 55 °C	
Number of battery modules	4	
Dimensions of one test BESS unit	(2630±5)*(950±2)*(2175±5) mm	
Weight	(2642±5) kg	
Fire suppression system contain	☐ Yes / ☒ No	Reference: N/A
UL 1973 compliant:	☐ Yes / ☐ No	Reference: N/A
UL 9540 compliant:	☐ Yes / ☐ No	Reference: N/A

Supplementary information:

A Rechargeable Li-ion Battery System consists of 4 battery modules (model No.: SM94K8FM2) and one high voltage control box. Two parallel battery systems (a total of 8 battery modules and one high-voltage box that can support two parallel systems simultaneously) are assembled in one rack. Battery modules are connected in series in each battery system. Each battery module consists of 104 Lithium-ion cells in 1P104S. Two battery systems were selected as one test BESS unit.

	
Figure 5. View 01 of battery systems	Figure 6. View 02 of battery systems

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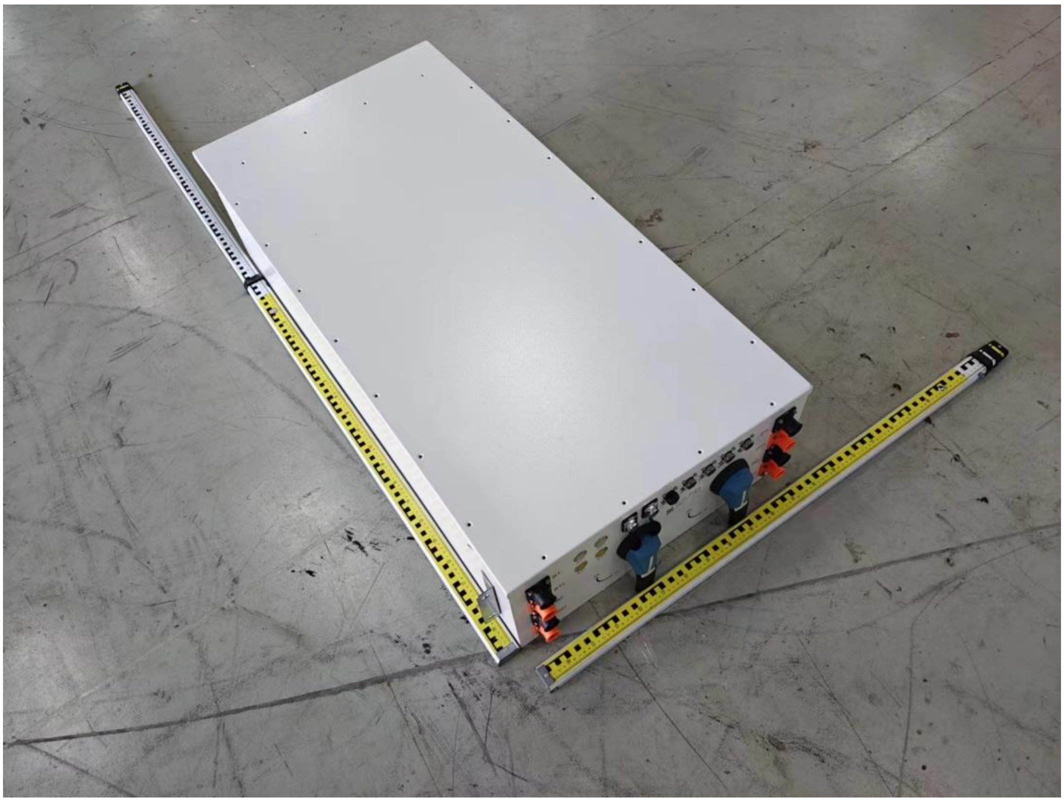

Figure 7. View 01 of high voltage box

Figure 8. View 02 of high voltage box

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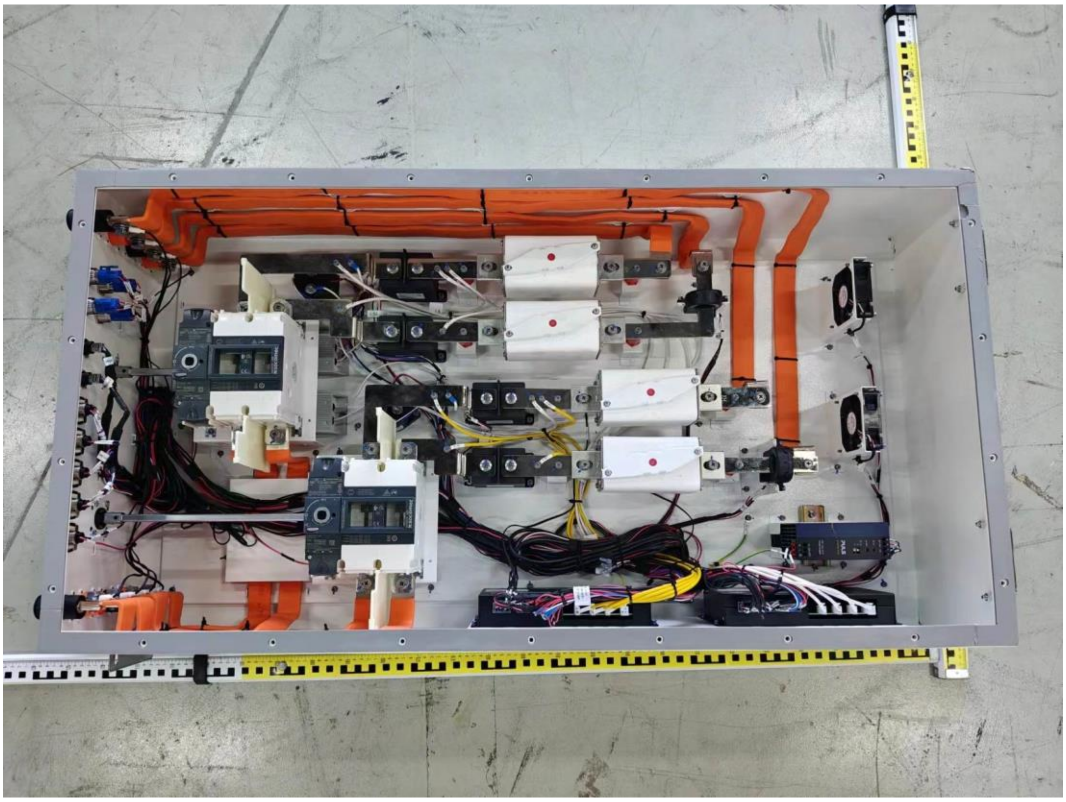

Figure 9. Internal view of high voltage box

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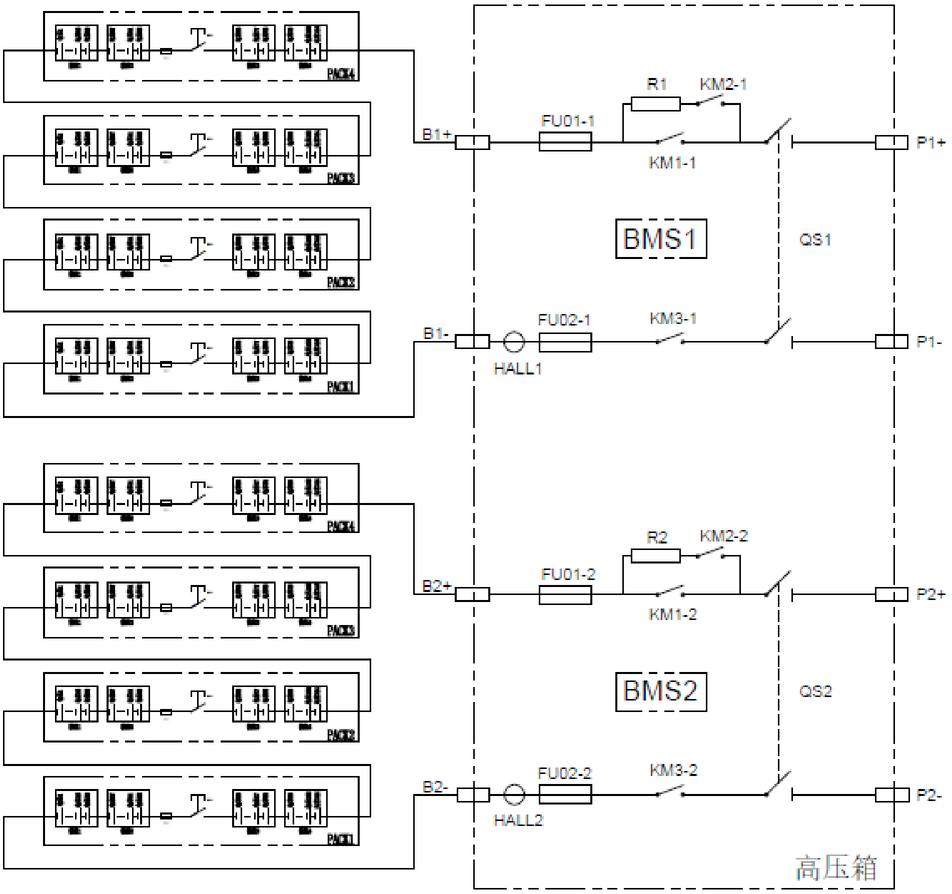

Figure 10. Electrical configuration of battery system

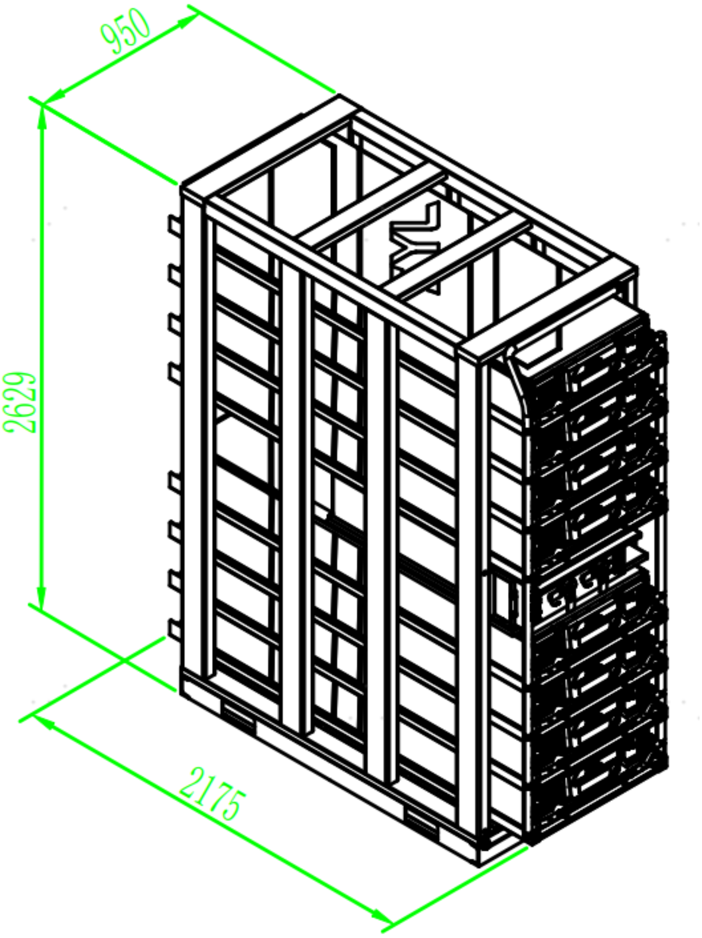

Figure 11. Illustrations of battery systems

[Description of thermal runaway methodology]

Sample and test configuration

The unit level test shall be conducted with BESS (Battery Energy Storage System) units installed as described in the manufacturer's instructions and this section.

The unit level test requires one initiating BESS unit in which an internal fire condition in accordance with the module level test is initiated and target adjacent BESS units representative of an installation. Tests conducted for indoor floor mounted installations shall be considered representative of both indoor floor mounted and outdoor ground mounted installations with fire propagation hazards and separation distances between initiating and target units representative of the installation. Tests shall be conducted indoors with fire propagation hazards and separation distances between initiating and target units representative of the installation. The results of such tests shall be considered to also represent an outdoor installation.

Depending upon the configuration and design of the BESS (e.g. the BESS is composed of multiple separate parts within separate enclosures), this testing to determine fire characterization can be done at the battery system level. The suitability of this approach shall be determined based upon the overall design of the BESS and an analysis of the battery system as representative of the overall BESS for fire characterization concerns.

The initiating BESS unit shall contain components representative of a BESS unit in a complete installation. Combustible components that interconnect the initiating and target BESS units shall be included.

Target BESS units shall include the outer cabinet (if part of the design), racking, module enclosures, and components that retain cells components. The target BESS unit module enclosures do not need to contain cells.

The initiating BESS unit shall be at the maximum operating state of charge (MOSOC), in accordance with the manufacturer's specifications, for conducting the tests in this standard. After charging and prior to testing, the initiating BESS shall rest for a maximum period of 8 h at room ambient.

If a BESS unit includes an integral fire suppression system, there is an option of providing this with the DUT. If the BESS unit is provided with an optional integral fire suppression system, the system shall not be provided on the DUT.

Electronics and software controls such as the battery management system (BMS) in the BESS are not relied upon for this testing. This does not include a fire suppression control in accordance with UL 840 that is external to the BESS, but provided as part of an integral fire suppression system.

Table 4: Integral fire suppression system information

Integral fire suppression system information	N/A
Standard or optional	☐ Standard / ☐ optional / ☒ N/A
Test with fire suppression or not	☐ Yes / ☒ No

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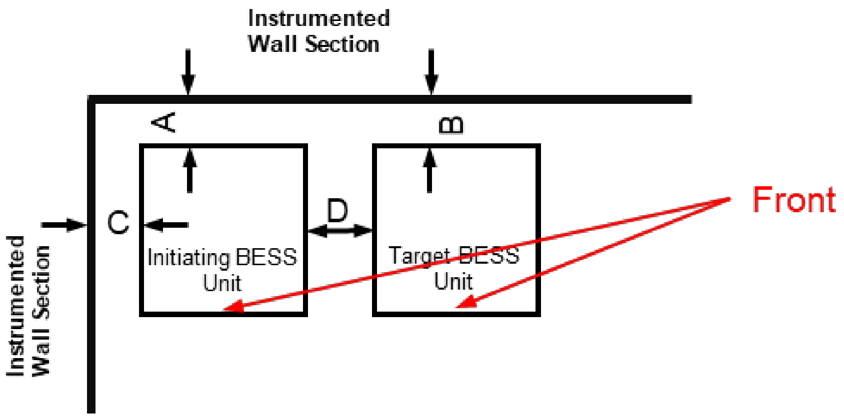
Table 5: BESS installations/ Test configurations

Description :N/A		
☒ a) Indoor floor mounted non-residential use BESS		
☐ b) Indoor floor mounted residential use BESS		
☒ c) Outdoor ground mounted non-residential use BESS		
☐ d) Outdoor ground mounted residential use BESS		
☐ e) Indoor wall mounted non-residential use BESS		
☐ f) Indoor wall mounted residential use BESS		
☐ g) Outdoor wall mounted non-residential use BESS		
☐ h) Outdoor wall mounted residential use BESS		
☐ i) Rooftop garage non-residential use BESS		
☒ j) Open garage non-residential use BESS		
Test configurations for Indoor floor mounted non-residential use BESS		
	A	100 mm
	B	100 mm
	C	150 mm
	D	120 mm
	--	

Unit level Test method description

☒ **Test method – Indoor floor mounted BESS units**

Samples and test configurations are in accordance with Table 5. During the test, the test room environment shall be controlled to prevent drafts that may affect test results. At the start of the test, the room ambient temperature shall not be less than 10°C (50°F) nor more than 32°C (90°F).

Any access door(s) or panels on the initiating BESS unit and adjacent target BESS units shall be closed, latched and locked at the beginning and duration of the test.

The initiating BESS unit shall be positioned adjacent to two instrumented wall sections.

Instrumented wall sections shall extend not less than 1.6 ft (0.49 m) horizontally beyond the exterior of the target BESS units.

The surface of the instrumented wall sections shall be covered with 16-mm (5/8-in) gypsum wall board and painted flat black. The initiating BESS unit shall be centered underneath an appropriately sized smoke collection hood of an oxygen consumption calorimeter.

The light transmission in the calorimeter's exhaust duct shall be measured using a white light source and photo detector for the duration of the test, and the smoke release rate shall be calculated.

The chemical and convective heat release rates shall be measured for the duration of the test.
The heat release rate measurement system shall be calibrated using an atomized heptane diffusion burner. The calibration shall be performed using flows of 3.8, 7.6, 11.4 and 15.2 L/min (1, 2, 3 and 4 gpm) of heptane.

The convective heat release rate shall be 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 shall be calculated using the following equation:

$$HRR_c = V_e A \frac{353.22}{T_e} \int_{T_o}^{T} C_p dT$$

The physical spacing between BESS units (both initiating and target) and adjacent walls shall be representative of the intended installation.

Separation distances shall be specified by the manufacturer for distance between:
a) The BESS units and the instrumented wall sections; and
b) Adjacent BESS units.

Wall surface temperature measurements shall be collected for BESS intended for installation in locations with combustible construction. If the intended installation is composed completely of noncombustible construction in which wall assemblies, cables, wiring and any other combustible materials are not to be present in the BESS installation, then the report should note that the installation shall contain no combustible construction and that surface temperature rises can be deemed not applicable.

Wall surface temperatures shall be measured in vertical array(s) at 152-mm (6-in) intervals for the full height of the instrumented wall sections using No. 24-gauge or smaller, Type-K exposed junction thermocouples. The thermocouples for measuring the temperature on wall surfaces shall be horizontally positioned in the wall locations anticipated to receive the greatest thermal exposure from the initiating BESS unit.

Thermocouples shall be secured to gypsum surfaces by the use of staples placed over the insulated portion of the wires. The thermocouple tip shall be depressed into the gypsum so as to be flush with the gypsum surface at the point of measurement and held in thermal contact with the surface at that point by the use of pressure-sensitive paper tape.

Heat flux shall be measured with the sensing element of at least two water-cooled Schmidt-Boelter gauges at the surface of each instrumented wall:
a) Both are collinear with the vertical thermocouple array;
b) One is positioned at the elevation estimated to receive the greatest heat flux due to the thermal runaway of the initiating module; and
c) One is positioned at the elevation estimated to receive the greatest heat flux during potential propagation of thermal runaway within the initiating BESS unit.

Heat flux shall be measured with the sensing element of at least two water-cooled Schmidt- Boelter gauges at the surface of each adjacent target BESS unit that faces the initiating BESS unit:
a) One is positioned at the elevation estimated to receive the greatest heat flux due to the thermal runaway of the initiating module within the initiating BESS; and
b) One is positioned at the elevation estimated to receive the greatest surface heat flux due to the thermal runaway of the initiating BESS.

For non-residential use BESS, heat flux shall be measured with the sensing element of at least one water-cooled Schmidt-Boelter gauge positioned at the mid height of the initiating unit in the center of the accessible means of egress.

No. 24-gauge or smaller, Type-K exposed junction thermocouples shall be installed to measure the temperature of the surface proximate to the cells and between the cells and exposed face of the initiating module. Each non-initiating module enclosure within the initiating BESS unit shall be instrumented with at least one No. 24-gauge or smaller Type-K thermocouple(s) to provide data to monitor the thermal conditions within non-initiating modules. Additional thermocouples shall be placed to account for convoluted enclosure interior geometries.

For residential use BESS, the DUT shall be covered with a single layer of cheese cloth ignition indicator. The cheesecloth shall be untreated cotton cloth running 26 – 28 m^2/kg with a count of 28 – 32 threads in either direction within a 6.45 cm^2 (1 in^2) area.

An internal fire condition in accordance with the module level test shall be created within a single module in the initiating BESS unit:
a) The position of the module shall be selected to present the greatest thermal exposure to adjacent modules (e.g. above, below, laterally), based on the results from the module level test; and
b) The setup (i.e. type, quantity and positioning) of equipment for initiating thermal runaway in the module shall be the same as that used to initiate and propagate thermal runaway within the module level test.

Thermal runaway methodology for module level test: The propensity of the module to exhibit thermal runaway shall be demonstrated by heating the initiating cell with externally applied heaters. With a surface heating rate of 4°C (7.2°F) to 7°C (12.6°F) per minute heating until cell thermal runaway occurs.

The composition, velocity and temperature of the initiating BESS unit vent gases shall be measured within the calorimeter's exhaust duct. Gas composition shall be measured using a Fourier-Transform Infrared Spectrometer with a minimum resolution of 1 cm^{-1} and a path length of at least 2.0 m(6.6 ft), or equivalent gas analyzer. Composition, velocity and temperature instrumentation shall be collocated with heat release rate calorimetry instrumentation.

The hydrocarbon content of the vent gas shall be measured using flame ionization detection.
The test shall be terminated if:

a) Temperatures measured inside each module within the initiating BESS unit return to ambient temperature;
b) The fire propagates to adjacent units or to adjacent walls; or
c) A condition hazardous to test staff or the test facility requires mitigation.

For residential use systems, the gas collection data gathered shall be compared to the smallest room installation specified by the manufacturer to determine if the flammable gas collected exceeds 25% LFL in air.

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Test configuration description

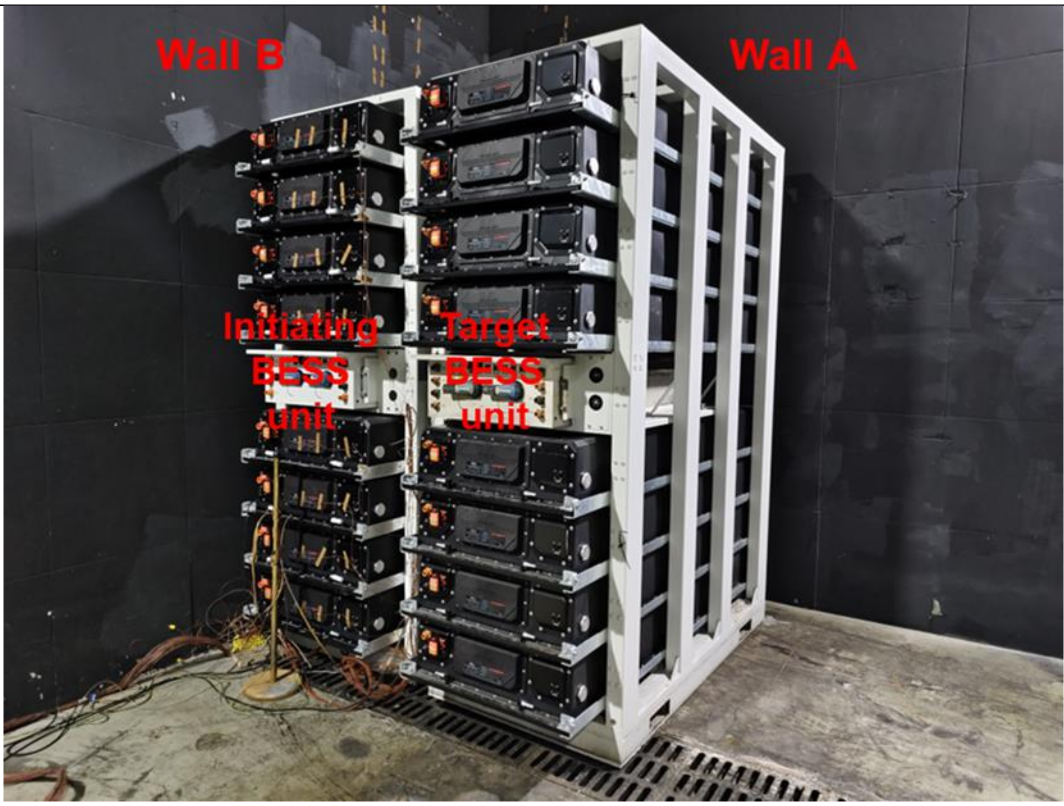
Illustration of initial BESS unit
Description: N/A
 Figure 12. View of initiating BESS unit and target BESS Unit in testing room

Illustration of initial module in BESS
Description: Module 6 located in the lower middle of rack was selected as initial module in initiating BESS unit.

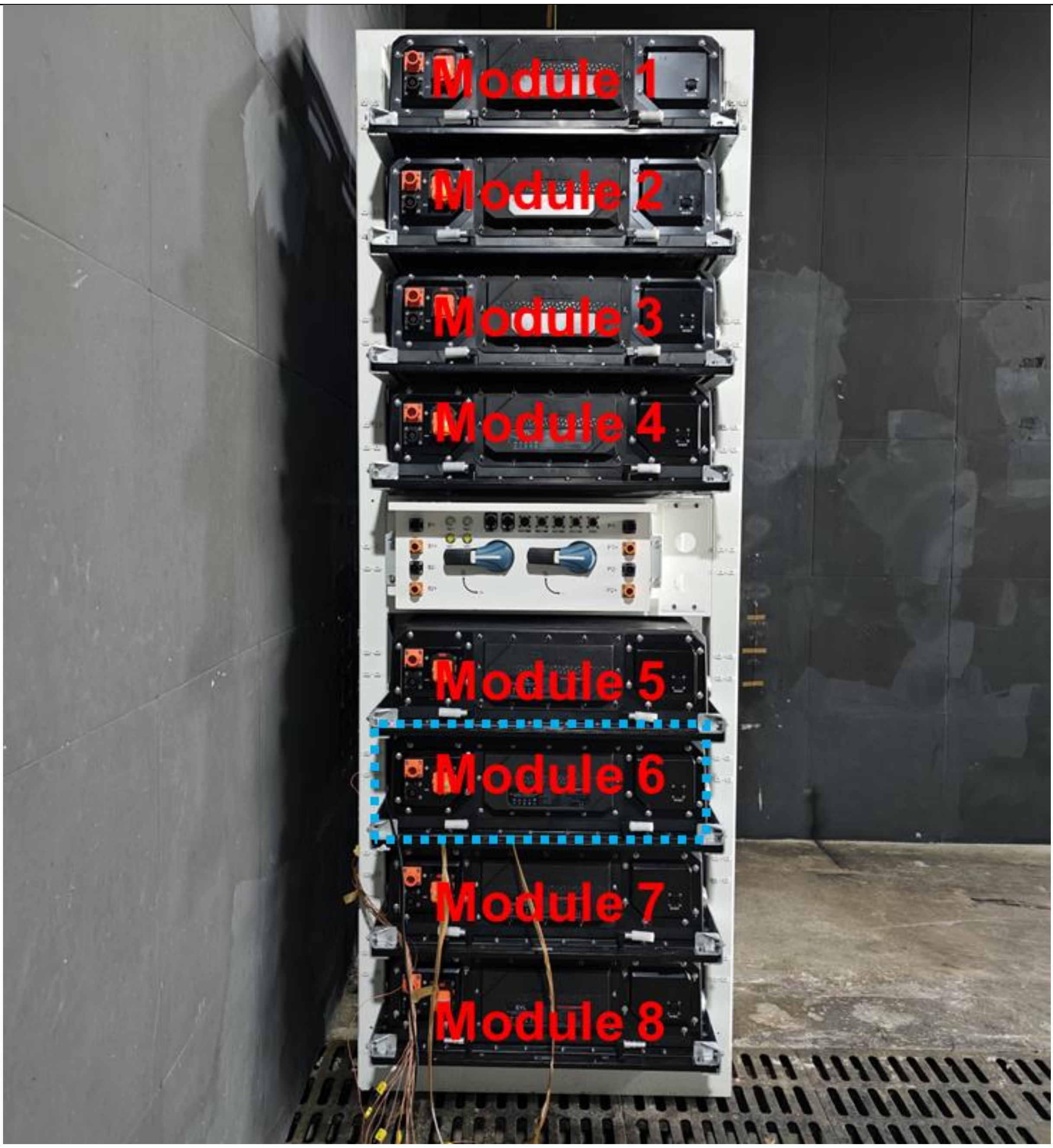



Figure 13. View of initiating module in BESS unit

Thermal runaway initiation method used including number and locations of cells for initiating thermal runaway
Initiation method: External heating method was used for initiating thermal runaway. By controlling the input power of the heater, a surface heating rate of 4°C (9°F) to 7°C (12.6°F) per minute was achieved. Max. power of the heater was 900W.
Number of cells for initiating thermal runaway: ☐ Single cell Ah (total capacity) ☒ Multiple cell 570 Ah (total capacity)
Locations of cells for initiating thermal runaway: Locations of cells for initiating thermal runaway: The battery module, referred to as DUT (device under test) in the following context, consists of 8 submodules. Each submodule consists of 13 serial cells (1P13S). Eight submodules are connected in series. One 1P13S submodule was selected as the initiating submodule. The heater was placed between Cell No. 45 and No.46. Cell No. 45 and No. 46 were selected as the initiating cells (as shown in Figure 14c).
Other description: N/A

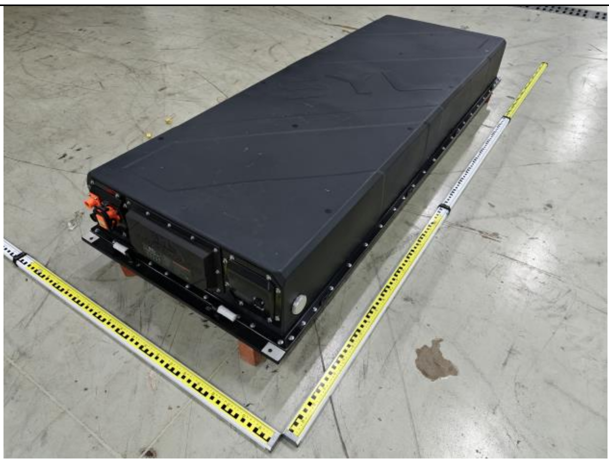


Figure 14a. External view of initiating module.

Figure 14b. Internal view of initiating module.

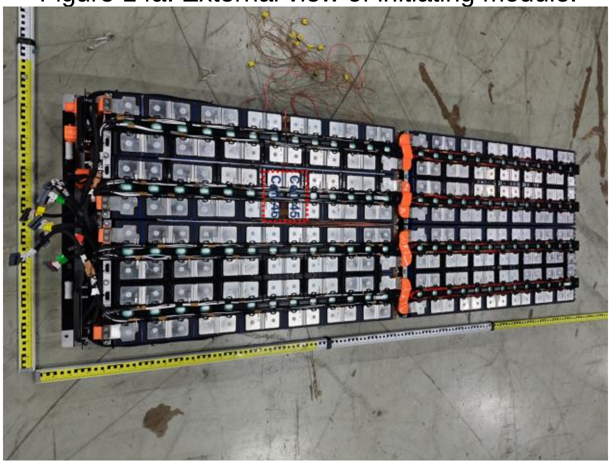


Figure 14c. Location of initiating cell.

Figure 14d. View of external heater.

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Illustration of external heater and thermocouple location in initial module
Description : N/A

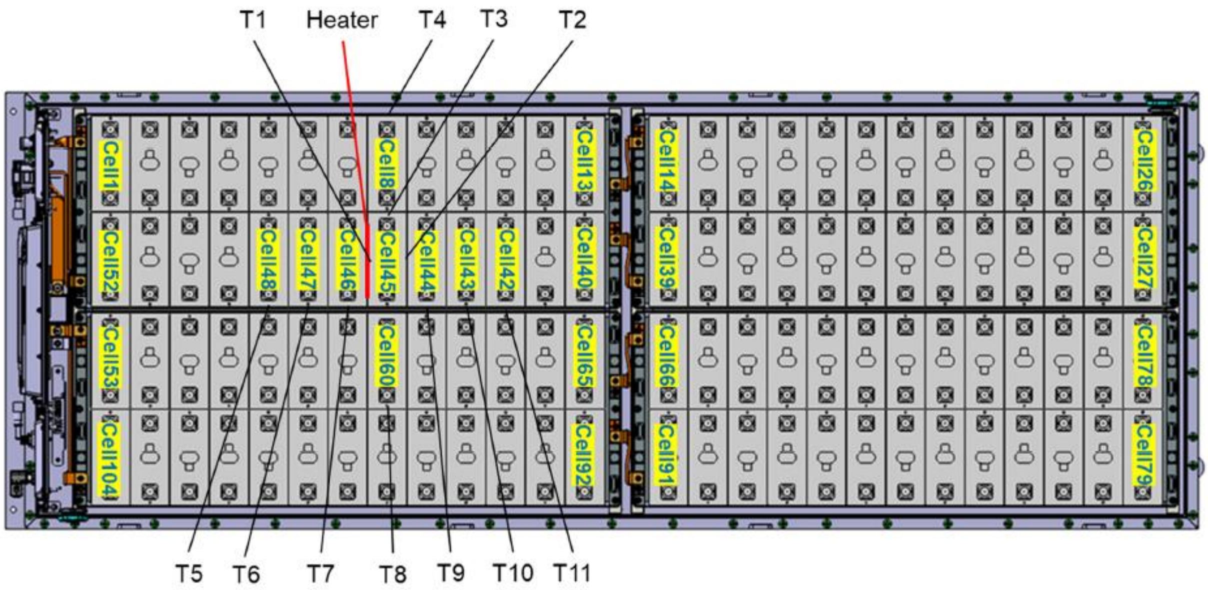

Figure 15. Schematic illustration of heater and thermocouple locations in the initiating module. (T1 to T1 means thermocouples T1 to T11. View from top.)

Positioning of units within testing room
Test Start Time: 2024-08-07 14:49:10
Initial Ambient Test Temperature: 28.9 °C
Initial Relative Humidity : 61.0%
Description: N/A

Figure 16. View of positioning of BESS units in testing room.

Table 6: Thermocouple placement

Thermocouple ID	Description of location	Remark
CH2302	Ambient temperature	--
CH0001	No. 1 of Instrumented Wall A	WA 1
CH0002	No. 2 of Instrumented Wall A	WA 2
CH0003	No. 3 of Instrumented Wall A	WA 3
CH0004	No. 4 of Instrumented Wall A	WA 4
CH0005	No. 5 of Instrumented Wall A	WA 5
CH0006	No. 6 of Instrumented Wall A	WA 6
CH0007	No. 7 of Instrumented Wall A	WA 7
CH0008	No. 8 of Instrumented Wall A	WA 8
CH0009	No. 9 of Instrumented Wall A	WA 9
CH0010	No. 10 of Instrumented Wall A	WA 10
CH0101	No. 11 of Instrumented Wall A	WA 11
CH0102	No. 12 of Instrumented Wall A	WA 12
CH0103	No. 13 of Instrumented Wall A	WA 13
CH0104	No. 14 of Instrumented Wall A	WA 14
CH0105	No. 15 of Instrumented Wall A	WA 15
CH0106	No. 16 of Instrumented Wall A	WA 16
CH0107	No. 17 of Instrumented Wall A	WA 17
CH0108	No. 18 of Instrumented Wall A	WA 18
CH0109	No. 19 of Instrumented Wall A	WA 19
CH0110	No. 20 of Instrumented Wall A	WA 20
CH0201	No. 21 of Instrumented Wall A	WA 21
CH0202	No. 22 of Instrumented Wall A	WA 22
CH0203	No. 23 of Instrumented Wall A	WA 23
CH0204	No. 24 of Instrumented Wall A	WA 24
CH0205	No. 25 of Instrumented Wall A	WA 25
CH0206	No. 26 of Instrumented Wall A	WA 26
CH0207	No. 27 of Instrumented Wall A	WA 27
CH0208	No. 28 of Instrumented Wall A	WA 28
CH0209	No. 29 of Instrumented Wall A	WA 29

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CH0210	No. 30 of Instrumented Wall A	WA 30
CH0301	No. 31 of Instrumented Wall A	WA 31
CH0302	No. 32 of Instrumented Wall A	WA 32
CH0303	No. 33 of Instrumented Wall A	WA 33
CH0304	No. 34 of Instrumented Wall A	WA 34
CH0305	No. 35 of Instrumented Wall A	WA 35
CH0306	No. 36 of Instrumented Wall A	WA 36
CH0307	No. 37 of Instrumented Wall A	WA 37
CH0308	No. 38 of Instrumented Wall A	WA 38
CH0309	No. 39 of Instrumented Wall A	WA 39
CH0310	No. 40 of Instrumented Wall A	WA 40
CH0401	No. 41 of Instrumented Wall A	WA 41
CH0402	No. 42 of Instrumented Wall A	WA 42
CH0403	No. 43 of Instrumented Wall A	WA 43
CH0404	No. 44 of Instrumented Wall A	WA 44
CH0405	No. 45 of Instrumented Wall A	WA 45
CH0406	No. 46 of Instrumented Wall A	WA 46
CH0407	No. 47 of Instrumented Wall A	WA 47
CH0408	No. 48 of Instrumented Wall A	WA 48
CH0409	No. 49 of Instrumented Wall A	WA 49
CH0410	No. 50 of Instrumented Wall A	WA 50
CH0501	No. 51 of Instrumented Wall A	WA 51
CH0502	No. 52 of Instrumented Wall A	WA 52
CH0503	No. 53 of Instrumented Wall A	WA 53
CH0504	No. 54 of Instrumented Wall A	WA 54
CH0505	No. 55 of Instrumented Wall A	WA 55
CH0506	No. 56 of Instrumented Wall A	WA 56
CH0507	No. 57 of Instrumented Wall A	WA 57
CH0508	No. 58 of Instrumented Wall A	WA 58
CH0509	No. 59 of Instrumented Wall A	WA 59
CH0510	No. 60 of Instrumented Wall A	WA 60
CH1001	No. 61 of Instrumented Wall A	WA 61

CH1002	No. 62 of Instrumented Wall A	WA 62
CH1003	No. 63 of Instrumented Wall A	WA 63
CH1004	No. 1 of Instrumented Wall B	WB 1
CH1005	No. 2 of Instrumented Wall B	WB 2
CH1006	No. 3 of Instrumented Wall B	WB 3
CH1007	No. 4 of Instrumented Wall B	WB 4
CH1008	No. 5 of Instrumented Wall B	WB 5
CH1009	No. 6 of Instrumented Wall B	WB 6
CH1010	No. 7 of Instrumented Wall B	WB 7
CH1101	No. 8 of Instrumented Wall B	WB 8
CH1102	No. 9 of Instrumented Wall B	WB 9
CH1103	No. 10 of Instrumented Wall B	WB 10
CH1104	No. 11 of Instrumented Wall B	WB 11
CH1105	No. 12 of Instrumented Wall B	WB 12
CH1106	No. 13 of Instrumented Wall B	WB 13
CH1107	No. 14 of Instrumented Wall B	WB 14
CH1108	No. 15 of Instrumented Wall B	WB 15
CH1109	No. 16 of Instrumented Wall B	WB 16
CH1110	No. 17 of Instrumented Wall B	WB 17
CH1201	No. 18 of Instrumented Wall B	WB 18
CH1202	No. 19 of Instrumented Wall B	WB 19
CH1203	No. 20 of Instrumented Wall B	WB 20
CH1204	No. 21 of Instrumented Wall B	WB 21
CH1205	No. 22 of Instrumented Wall B	WB 22
CH1206	No. 23 of Instrumented Wall B	WB 23
CH1207	No. 24 of Instrumented Wall B	WB 24
CH1208	No. 25 of Instrumented Wall B	WB 25
CH1209	No. 26 of Instrumented Wall B	WB 26
CH1210	No. 27 of Instrumented Wall B	WB 27
CH1301	No. 28 of Instrumented Wall B	WB 28
CH1302	No. 29 of Instrumented Wall B	WB 29
CH1303	No. 30 of Instrumented Wall B	WB 30

CH1304	No. 31 of Instrumented Wall B	WB 31
CH1305	No. 32 of Instrumented Wall B	WB 32
CH1306	No. 33 of Instrumented Wall B	WB 33
CH1307	No. 34 of Instrumented Wall B	WB 34
CH1308	No. 35 of Instrumented Wall B	WB 35
CH1309	No. 36 of Instrumented Wall B	WB 36
CH1310	No. 37 of Instrumented Wall B	WB 37
CH1401	No. 38 of Instrumented Wall B	WB 38
CH1402	No. 39 of Instrumented Wall B	WB 39
CH1403	No. 40 of Instrumented Wall B	WB 40
CH1404	No. 41 of Instrumented Wall B	WB 41
CH1405	No. 42 of Instrumented Wall B	WB 42
CH1406	No. 43 of Instrumented Wall B	WB 43
CH1407	No. 44 of Instrumented Wall B	WB 44
CH1408	No. 45 of Instrumented Wall B	WB 45
CH1409	No. 46 of Instrumented Wall B	WB 46
CH1410	No. 47 of Instrumented Wall B	WB 47
CH1501	No. 48 of Instrumented Wall B	WB 48
CH1502	No. 49 of Instrumented Wall B	WB 49
CH1503	No. 50 of Instrumented Wall B	WB 50
CH1504	No. 51 of Instrumented Wall B	WB 51
CH1505	No. 52 of Instrumented Wall B	WB 52
CH1506	No. 53 of Instrumented Wall B	WB 53
CH1507	No. 54 of Instrumented Wall B	WB 54
CH1508	No. 55 of Instrumented Wall B	WB 55
CH1509	No. 56 of Instrumented Wall B	WB 56
CH1510	No. 57 of Instrumented Wall B	WB 57
CH2001	No. 58 of Instrumented Wall B	WB 58
CH2002	No. 59 of Instrumented Wall B	WB 59
CH2003	No. 60 of Instrumented Wall B	WB 60
CH2004	Center of surface between Cell 45 and Heater 1	T1 In initiating module
CH2005	Center of surface of Cell 45 near to Cell 44	T2 In initiating module

CH2006	Center of side surface of Cell 45 near to Cell 8	T3 In initiating module
CH2007	Center of side surface of Cell 8	T4 In initiating module
CH2008	Center of side surface of Cell 48	T5 In initiating module
CH2009	Center of side surface of Cell 47	T6 In initiating module
CH2010	Center of side surface of Cell 46	T7 In initiating module
CH2101	Center of side surface of Cell 60	T8 In initiating module
CH2102	Center of side surface of Cell 44	T9 In initiating module
CH2103	Center of side surface of Cell 43	T10 In initiating module
CH2104	Center of side surface of Cell 42	T11 In initiating module
CH2106	Front surface of module 1 in initiating unit	In initiating unit
CH2107	Front surface of module 2 in initiating unit	In initiating unit
CH2108	Front surface of module 3 in initiating unit	In initiating unit
CH2109	Front surface of module 4 in initiating unit	In initiating unit
CH2110	Front surface of module 5 in initiating unit	In initiating unit
CH2201	Front surface of module 6 in initiating unit	In initiating unit
CH2202	Front surface of module 7 in initiating unit	In initiating unit
CH2203	Front surface of module 8 in initiating unit	In initiating unit
CH2204	Left surface of module 1 in target unit	In target unit
CH2205	Left surface of module 2 in target unit	In target unit
CH2206	Left surface of module 3 in target unit	In target unit
CH2207	Left surface of module 4 in target unit	In target unit
CH2208	Left surface of module 5 in target unit	In target unit
CH2209	Left surface of module 6 in target unit	In target unit
CH2210	Left surface of module 7 in target unit	In target unit
CH2301	Left surface of module 8 in target unit	In target unit
Thermocouple information: Type K, 24AWG		

[Description of test results]

Table 7: Overview of test timeline and key events

Time (HH: MM: SS)	Relative Time (HH: MM: SS)	Event ID	Event	Description	Photo Reference
14:49:10	00:00:00	E1	Test Start	--	--
14:51:04	00:01:54	E2	Heaters Energized	--	Figure 22
16:02:46	01:13:36	E3	Initiating Cell Venting	Smoke venting observed from DUT enclosure.	Figure 23
16:04:31	01:15:21	E4	Thermal Runaway onset	Smoke venting observed from DUT enclosure. All Heaters de-energized.	Figure 24
23:55:00	07:05:50	E5	Test Termination	--	--
Test Start Time: 2024-08-07 14:49:10					

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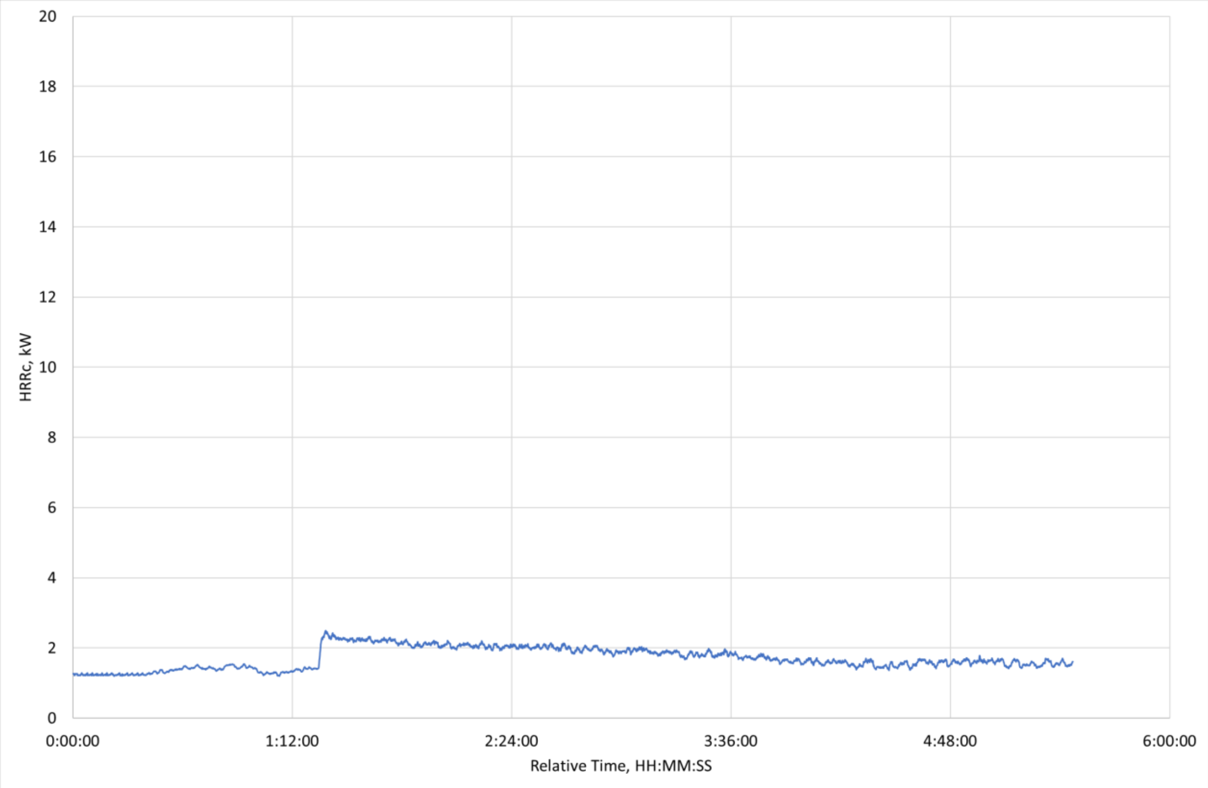
Chemical heat release rate versus time
Description: No flaming combustion observed outside initiating BESS unit.
N/A

Convective heat release rate versus time
Description: N/A
 Figure 17. Convective heat release rate versus time

Maximum incident heat flux on instrumented wall surfaces and target unit
Description :N/A

Heat Flux ID	Description of location
CH3407	Surface of instrumented wall A, facing the rear of module 5 in initiating unit
CH3408	Surface of instrumented wall A, facing the rear of module 6 (initiating module) in initiating unit
CH3409	Surface of instrumented wall B, facing the left of module 5 in initiating unit
CH3410	Surface of instrumented wall B, facing the left of module 6 (initiating module) in initiating unit
CH3501	100 mm away from the front of module 6 in initiating unit, facing the front of module 6 in initiating unit
CH3502	Left surface of module 6 in target unit, facing the right of module 6 in initiating unit

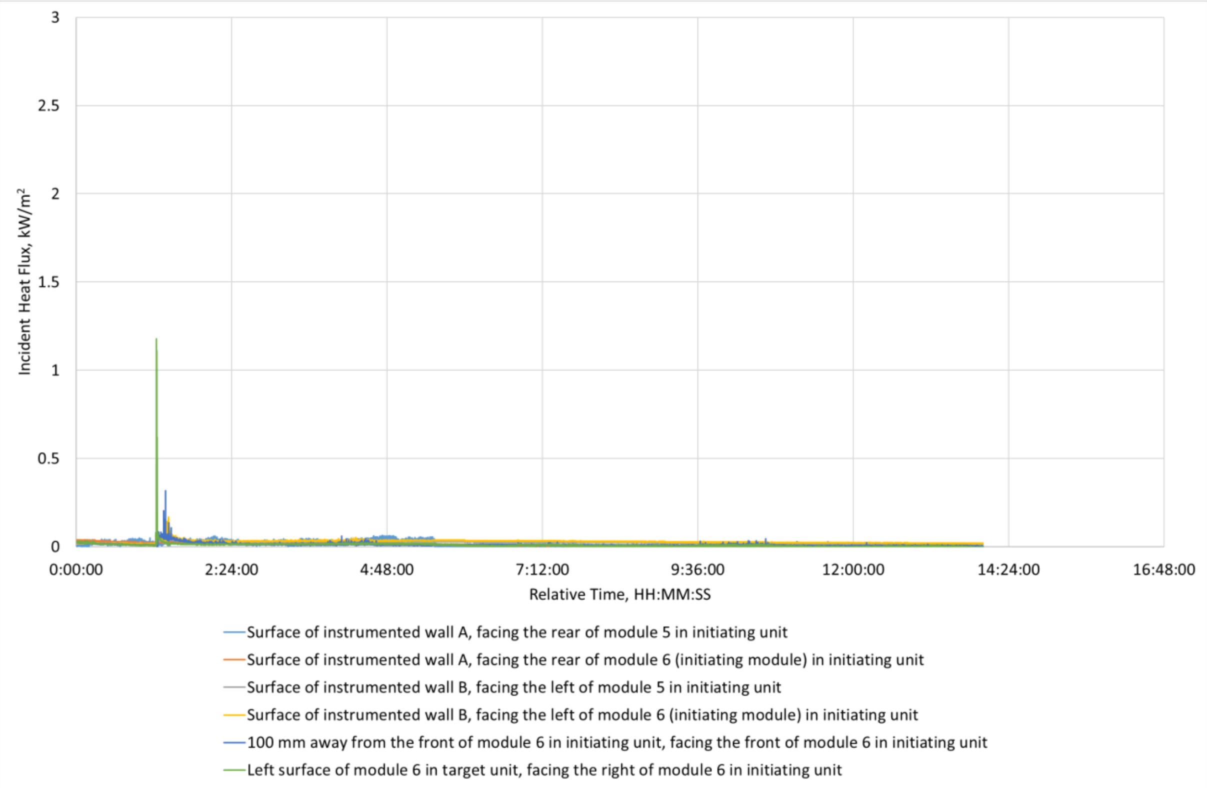


Figure 18. Incident heat flux on instrumented wall surfaces and target unit

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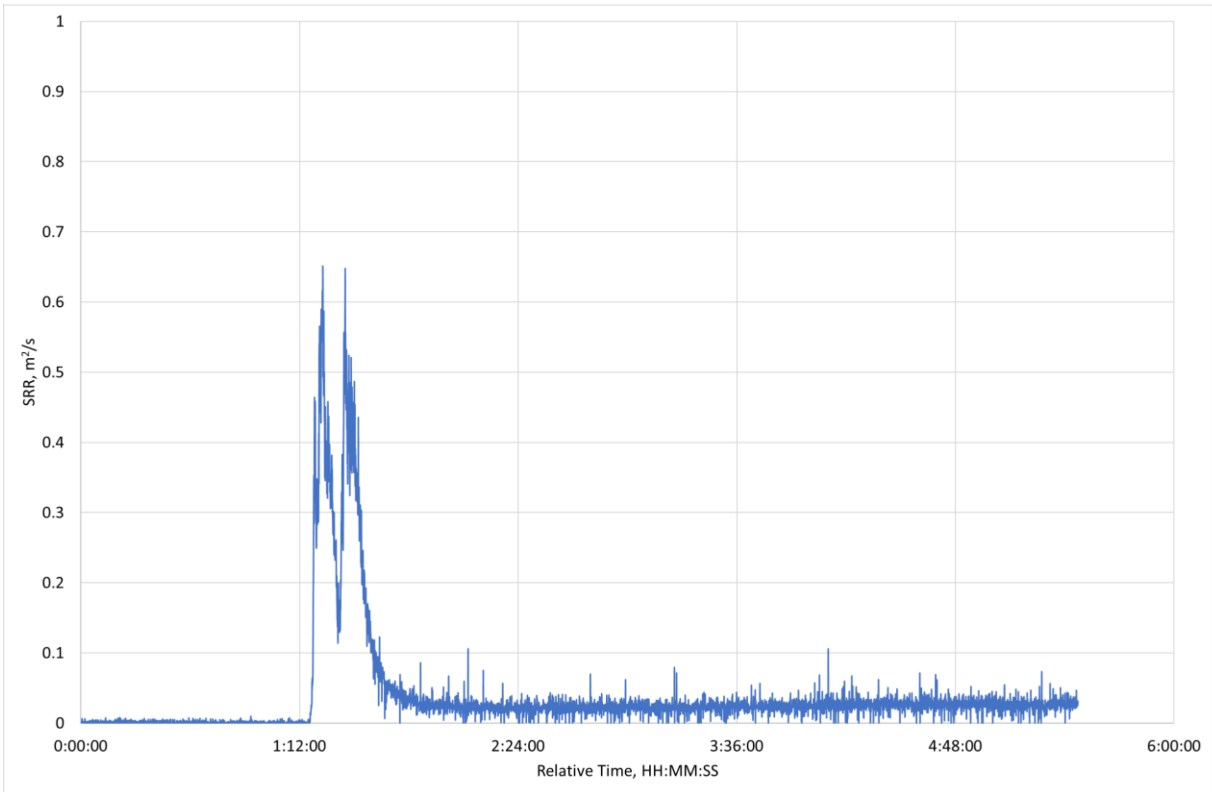
Peak smoke release rate and total smoke release data
Description: Peak smoke release rate is 0.651 m^2/s during test. Total smoke release 768.794 m^2
 Figure 19. Smoke release rate versus time.

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Flammable gas generation and composition		
Flammable gas generation:	☒ YES	☐ NO
Flammable gas content ⩾ 25% of LFL or not: N/A.		
Description: N/A		

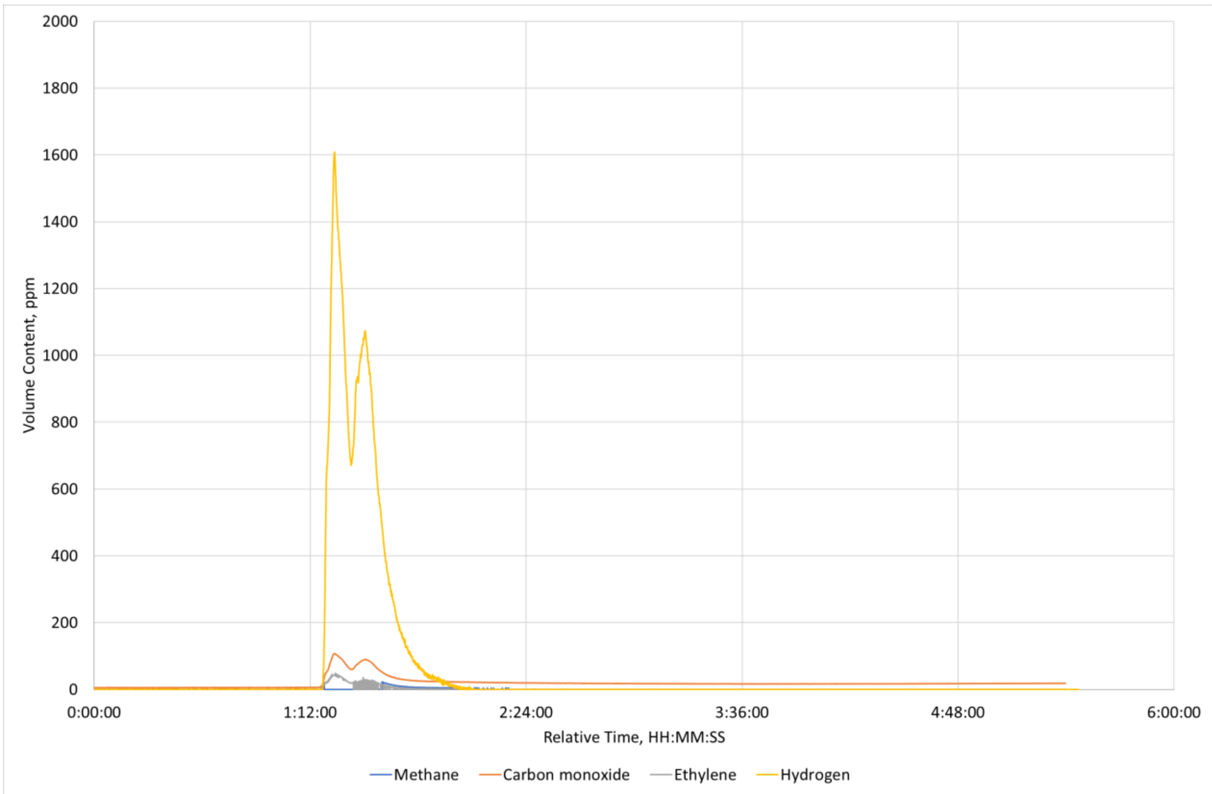

Figure 20. Online flammable gas content measurements during test. (Remark: The content of other hydrocarbons is below the detection limit of the test equipment.)

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Identification/location of module(s) that exhibited thermal runaway within the unit
Module(s) that exhibited thermal runaway: ☒ YES ☐ NO
Description : N/A

Figure 21. View of location of module that exhibited thermal runaway within the initiating unit

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Locations and visual estimations of flame extension and duration from the unit
Flame extension : ☐ YES ☒ NO
Description : No external flaming observed.
N/A

Table 8: Data during test

Module ID	OCV of Battery Module Before Test, (V dc)	OCV of Battery Module After Test, (V dc)	Observation Results
Module 1	346.870	346.870	No gas venting observed. No external flaming observed.
Module 2	346.871	346.870	No gas venting observed. No external flaming observed.
Module 3	346.875	346.875	No gas venting observed. No external flaming observed.
Module 4	346.875	346.873	No gas venting observed. No external flaming observed.
Module 5	346.871	346.870	No gas venting observed. No external flaming observed.
Module 6 (Initiating module)	**346.875**	**336.805**	Gas and smoke venting observed. No external flaming observed. No explosion observed.
Module 7	346.875	346.870	No gas venting observed. No external flaming observed.
Module 8	346.873	346.870	No gas venting observed. No external flaming observed.

Measured Maximum Temperature Rise of Instrumented Wall Surface	
Thermocouple ID	CH2002
Measurements (ºC)	40.8 (temperature rise: 11.9 °C)
Location	Surface of Instrumented Wall B, face the left surface of module 6 (Initiating module) in initiating unit
Limits: △T ≤ 97 ºC	
Measured Maximum Surface Temperature of Modules within the Target BESS Units	
Thermocouple ID	CH2209
Measurements (ºC)	41.1
Location	Left surface of module 6 in target unit
Limits: Tmax. ≤156 °C (Cell surface temperature at gas venting)	
Cheesecloth indicator used or not ☐ Yes ☒ No	
Supplementary information: N/A	

Figure 22. photo of event (E2) during test

Figure 23. photo of event (E3) during test

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Figure 24. photo of event (E4) during test

Figure 25. Photo of initiating and target BESS Unit after test

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Figure 26. Photo 1 of initiating BESS Unit after test

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Figure 27. Photo 2 of initiating BESS Unit after test

Figure 28. Photo 1 of initiating module after test

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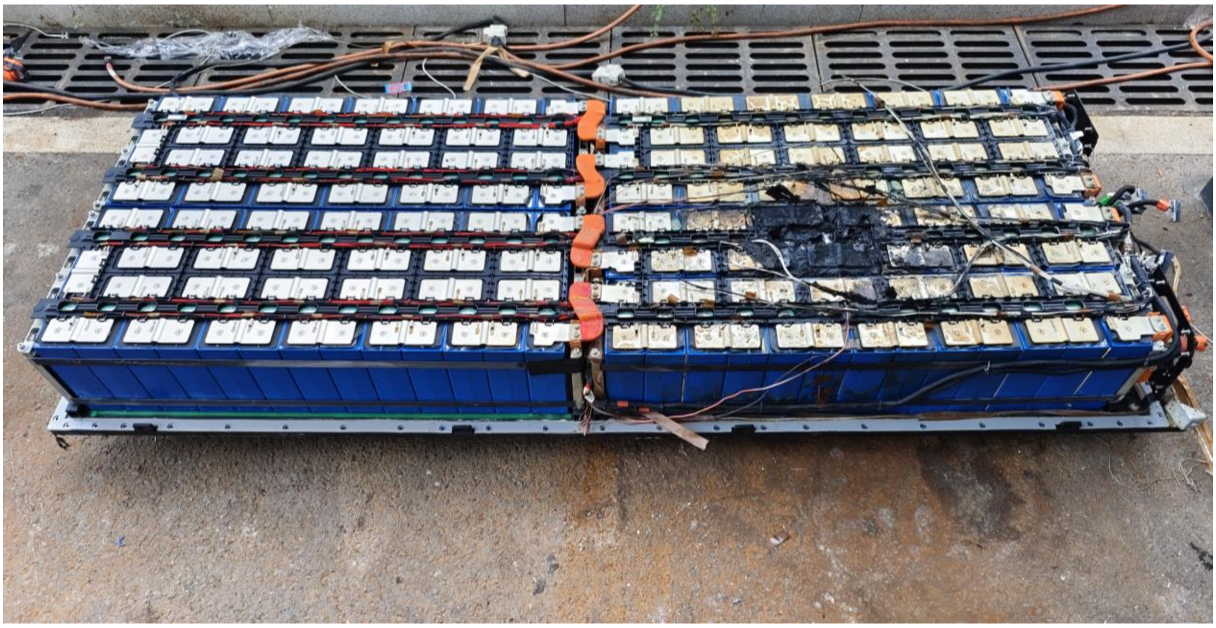

Figure 29. Photo 2 of initiating module after test

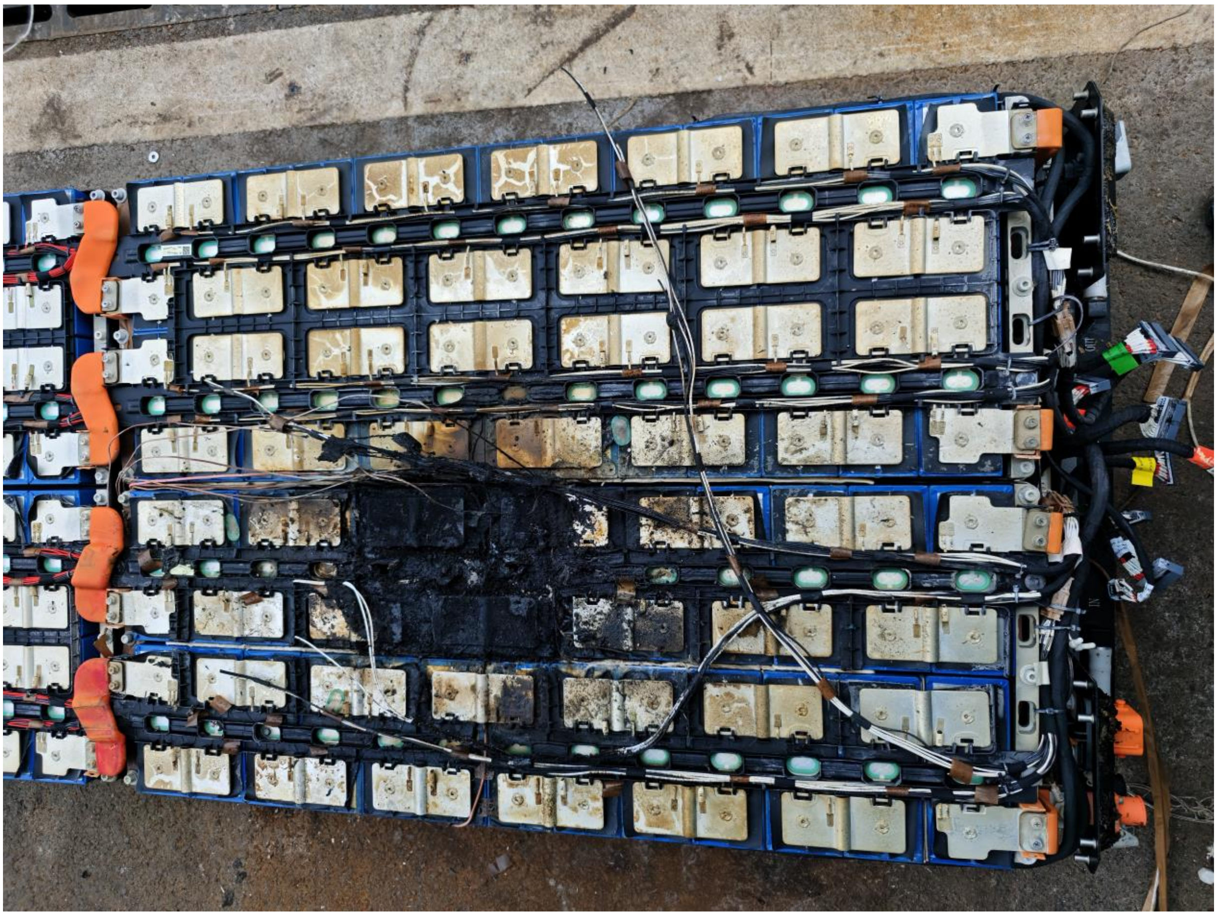

Figure 30. Photo 3 of initiating module after test (3 cells experienced thermal runaway)

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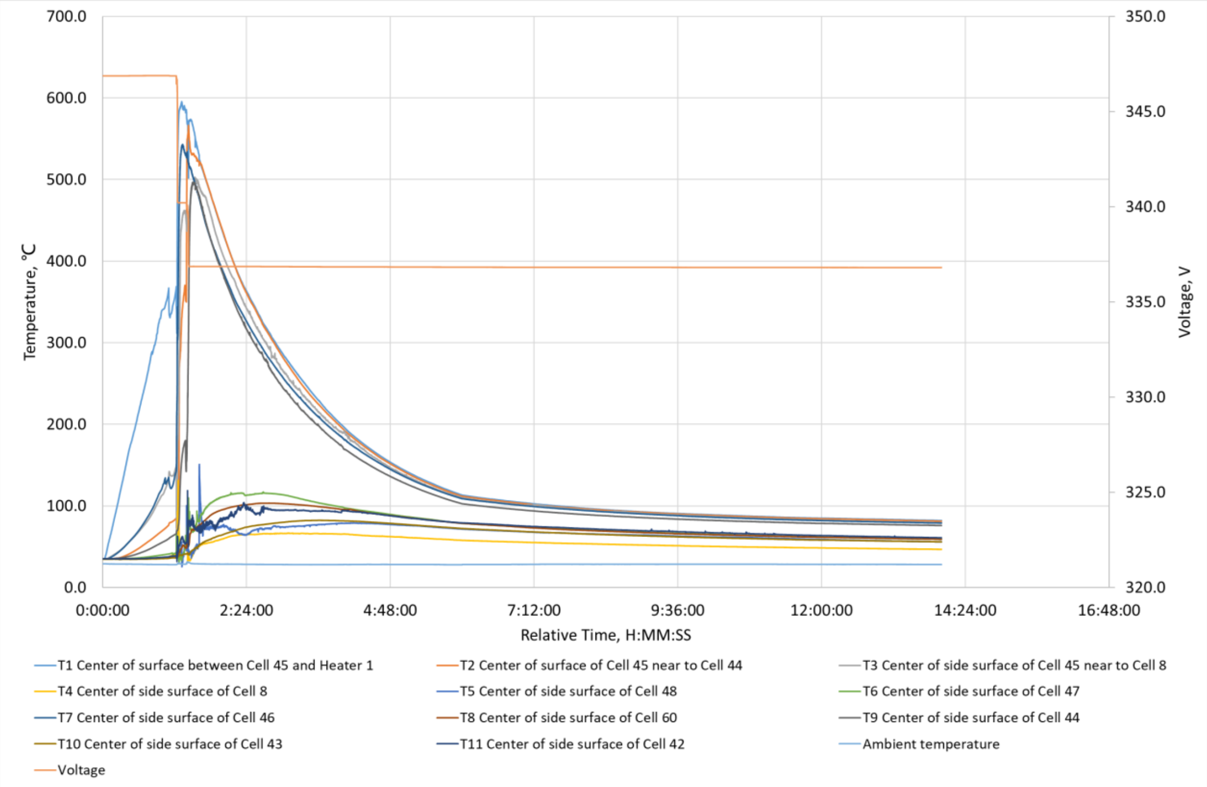

Figure 31. Temperature measurement results on the initiating module

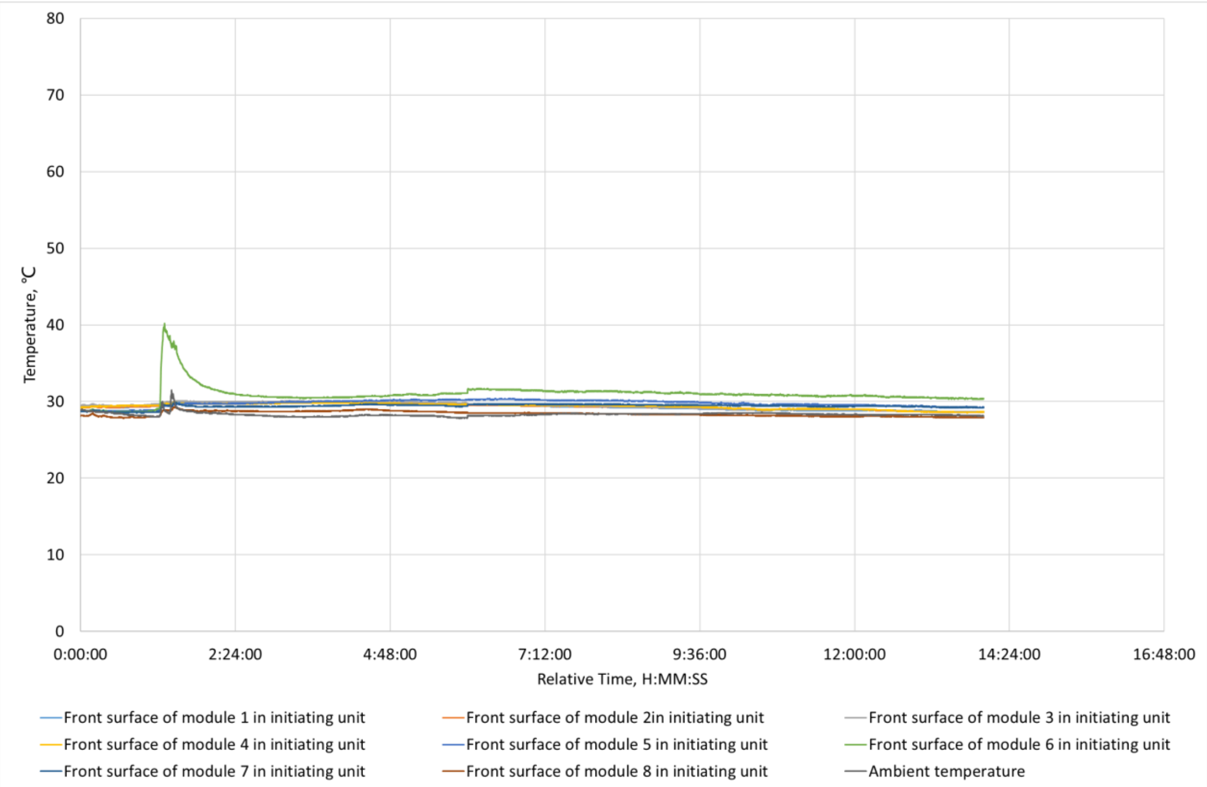

Figure 32. Temperature measurements in initiating BESS unit

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中国・重庆市江津区双福街道冉钧路1839号附13号、14号 邮编：402260 t (86–023) 863676001 sgs.china@sgs.com

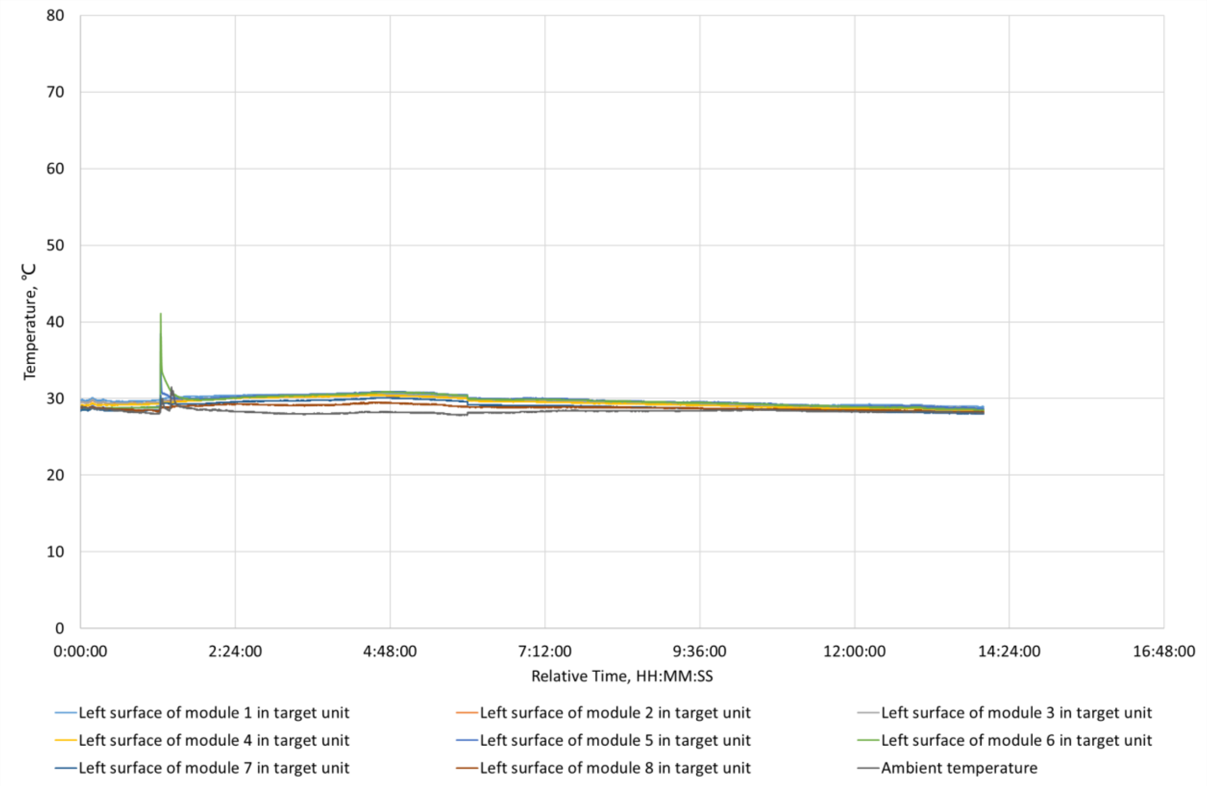

Figure 33. Temperature measurements in target BESS units

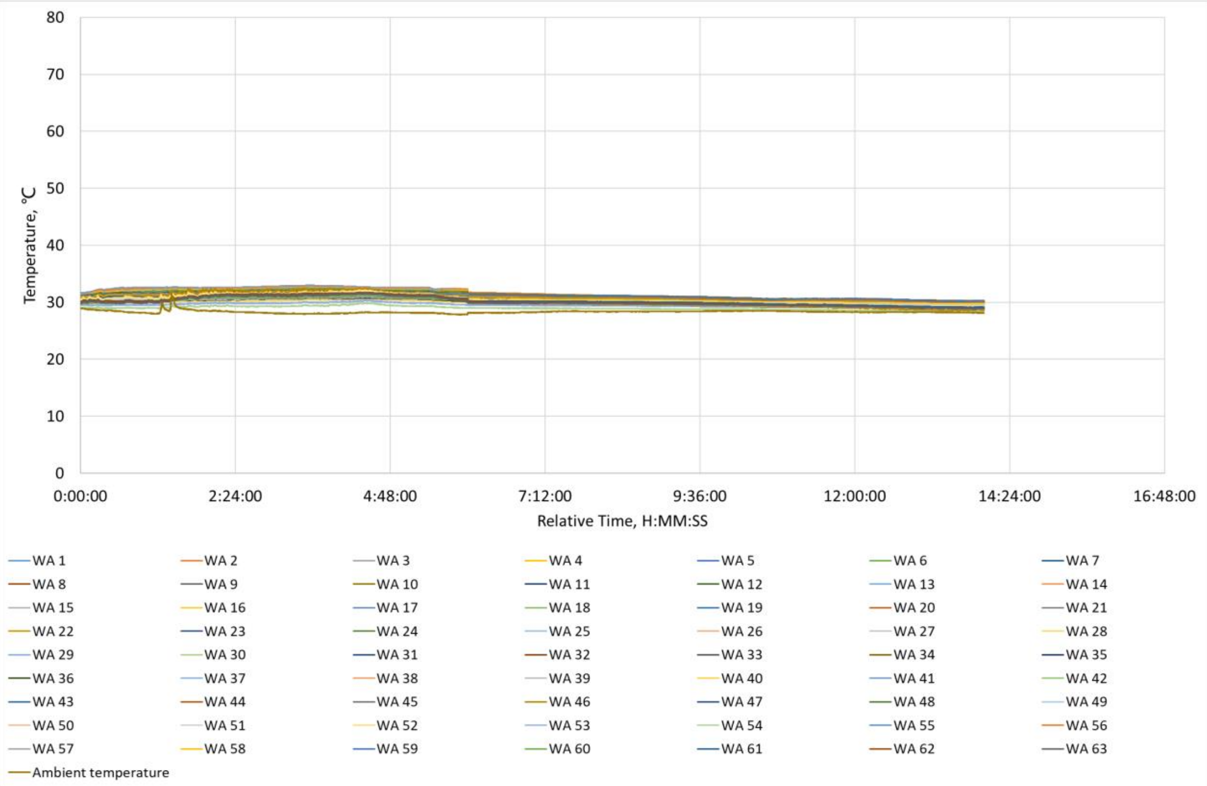

Figure 34. Temperature measurement results on wall A.

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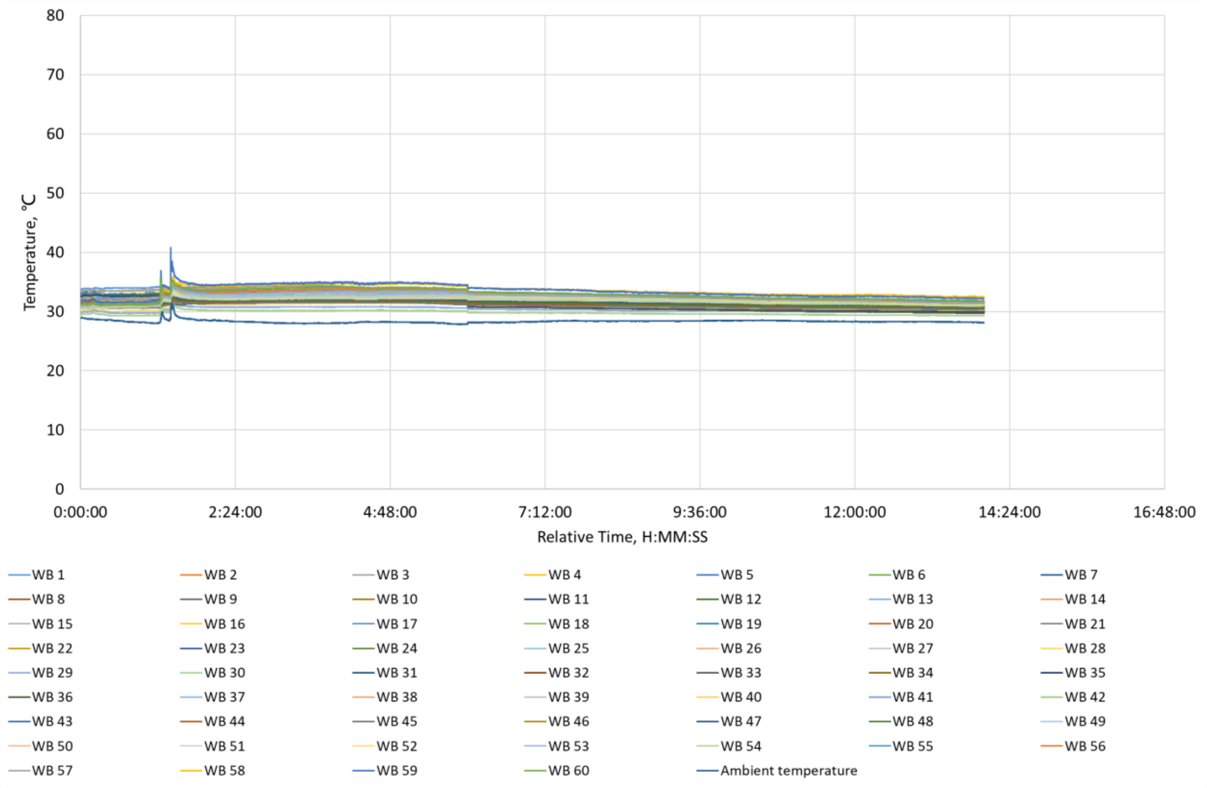

Figure 35. Temperature measurement results on wall B.

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SGS

NOTES TO THIS TEST REPORT

1.

2. According to the standard, instruction sheets and other texts required by the standard should be written in the official language(s) of the country in which the product is to be sold. The applicant should ensure that the product in future production fulfils the receptive standard requirements.

3. The components performed satisfactorily during testing and are considered to be suitable for use in the sample tested.

- - - End of Report - - -

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Appendix C

SYL USER MANUAL

SYL

A RISEN GROUP COMPANY

USER MANUAL

SU3794U3794KC

Document version: 01

Release date:.09/24/2024

GREEN NEW ENERGY CREATES NEW HUMAN LIFE

REVISION HISTORY

REV.	DESCRIPTION	DATE	BY	REVIEW
V01	Issued for review	09/24/2024	Yantao Zhu	Lei Zhang

IMPORTANT NOTICE

CAUTION

READ THIS MANUAL BEFORE PERFORMING ANY INSTALLATION ACTION!

IF YOU HAVE ANY UNCERTAINTY REGARDING THE CONTENT OF THIS MANUAL, PLEASE CONTACT SYL FOR ADVICE OR CLARIFICATION.

IMPORTANT

KEEP THIS MANUAL IN A SECURE PLACE FOR FUTURE REFERENCES!

CAUTION

THIS DOCUMENTATION ALONG WITH INFORMATION INSIDE IS THE PROPERTY OF SYL (NINGBO) BATTERY CO., LTD.

IMPORTANT

ALTHOUGH SYL HAS MADE ITS BEST EFFORT TO ENSURE THE ACCURACY OF THIS DOCUMENTATION, SYL (NINGBO) BATTERY CO., LTD., TAKES NO RESPONSIBILITY FOR THE ERRORS/TYPOS THAT MAY APPEAR HEREIN.

THIS DOCUMENTATION IS SUBJECT TO CHANGES WITHOUT PRIOR NOTICE.

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LIST OF FIGURES

LIST OF TABLES

1 ACRONYMS AND DEFINITIONS

1	AC	Alternating Current
2	Ah	Amp-hour
3	BCP	Battery Connection Panel
4	BESS	Battery Energy Storage System
5	BMS	Battery Management System
6	BMU	Battery Management Unit
7	BOL	Beginning of Life
8	BOP	Balance of Plant
9	BOS	Balance of System
10	BSPU	Battery Safety and Protection Unit
11	EMS	Energy Management System
12	EOL	End of Life
13	ESS	Energy Storage System
14	DC	Direct Current
15	FSS	Fire Suppression System
16	GSC	Golden Shield Controller
17	HMI	Human Machine Interface
18	HV	High Voltage
19	HVAC	Heating & Ventilation and HVAC
20	IP	Ingress Protection
21	kV	Kilovolt
22	kW	Kilowatt
23	MV	Medium Voltage
24	MW	Megawatt
25	MWh	Megawatt-hour
26	MVA	Mega Volt-Amps
27	MVAr	Mega Volt Amps (reactive)
28	NMC	NiMnCo

29	OSD	Overcharge Safety Device
30	O&M	Operation and Maintenance
31	PCS	Power Conversion System
32	PPA	Power Purchase Agreement
33	PPE	Personal Protective Equipment
34	RMU	Ring Main Unit
35	RTU	Remote Terminal Unit
36	SCADA	Supervisory Control and Data Acquisition
37	SOC	State of Charge
38	SOH	State of Health
39	SPDs	Surge Protection Devices
40	SYL	SYL (Ningbo) Battery Co., Ltd
41	TCP	Transmission Control Protocol
42	UPS	Uninterruptable Power Supply

2 ABOUT THIS MANUAL

2.1 APPLICABLE PRODUCT

This document mainly describes the installation, electrical connection, debugging, maintenance and troubleshooting methods of the following models of battery containers ("Product").

- SU3794U3794KC

Before installing or using the product, read this document carefully to obtain the safety information and be familiar with the functions and features of the product. If you have any questions about the contents of this manual, please contact SYL for advice or clarification.

2.2 TARGET GROUP

This manual is intended for:

- Installation and maintenance personnel
- Users

2.3 LEVELS OF SAFETY INSTRUCTIONS

To ensure personal and property safety in using the system or to use the system efficiently, this manual provides relevant instructions that are highlighted by corresponding symbols. Read the following symbols carefully, as they indicate levels of safety warnings and are used everywhere in this manual.

To ensure the safety of personnel and property, please carefully read all safety instructions in this document before the installation.

	DANGER

FAIL TO FOLLOW THE INSTRUCTION WITH THIS SYMBOL MAY RESULT IN A FATAL ACCIDENT, SEVERE INJURY, EVEN DEATH!

WARNING

INDICATES A HAZARDOUS SITUATION THAT, IF NOT AVOIDED, COULD RESULT IN INJURY OR DEATH.

CAUTION

INDICATES A HAZARDOUS SITUATION THAT, IF NOT AVOIDED, COULD RESULT IN MINOR INJURY OR DAMAGE TO THE EQUIPMENT.

IMPORTANT

INFORMATION WHICH CONSIDERED IMPORTANT BUT NOT HAZARD-RELATED. FAIL TO FOLLOW THE INSTRUCTION WITH THIS SYMBOL MAY RESULT IN EQUIPMENT DAMAGE!

IMPORTANT

INDICATES AN IMPORTANT STEP OR TIP THAT LEADS TO BEST RESULTS, BUT IS NOT SAFETY OR DAMAGE RELATED.

2.4 SYMBOLS ON THE PRODUCT

HAZARDOUS VOLTAGE, RISK OF ELECTRIC SHOCK OR BURN. AUTHORIZED PERSONNEL ONLY.

OPEN THE DOOR.

CLOSE THE DOOR.

GROUNDING.

DANGER, BE CAREFUL WHEN HANDLING THE BATTERIES.

RECHARGEABLE BATTERIES, CANNOT DISPOSE OF IN THE HOUSEHOLD WASTE.

DO NOT DAMAGE THE BATTERIES IN SUCH A WAY AS DROP, DEFORM, IMPACT, CUT, OR SPEARING OBJECT.

NO SMOKING, NO OPEN FLAME, EMBERS, OR SPARKS NEARBY THE BATTERY, TO AVOID RISK OF FIRE OR EXPLOSION.

KEEP OUT OF REACH OF YOUNG CHILDREN PETS, OR ANIMALS.

HEAVYWEIGHT, SINGLE-PERSON LIFT COULD CAUSE INJURY. USE ASSISTANCE WHEN MOVING OR LIFTING.

ELECTROLYTE IS HIGHLY CORROSIVE.

METAL PARTS OF THE BATTERY CELL ARE ALWAYS LIVE. NEVER PLACE FOREIGN OBJECTS OR TOOLS ON THE BATTERY.

OBSERVE INSTALLATION AND OPERATION INSTRUCTIONS IN THE MANUALS BEFORE WORKING ON THE BATTERIES.

WEAR EYE PROTECTION AND PROTECTIVE CLOTHING WHEN WORKING WITH BATTERIES. OBSERVER ACCIDENT-PREVENTION REGULATIONS.

WEAR PROTECTIVE GLOVES AND CLOTHING WHEN WORKING WITH BATTERIES.

PREPARE FIRST-AID BEFORE WORKING WITH BATTERIES.

WHEN ELECTROLYTES LEAK OUT, AVOID CONTACTING WITH EYES, SKIN, OR CLOTHES. IN EVENTS OF ACCIDENTS, FLUSH WITH WATER AND GET MEDICAL HELP IMMEDIATELY.

RECYCLABLE.

3 SAFETY GUIDELINES

WARNING
SAFETY FIRST! ALWAYS OBSERVE AND FOLLOW SAFETY INSTRUCTIONS!

3.1 GENERAL PRECAUTIONS

When installing, operating, and maintaining the equipment, read this manual and follow the labels on the equipment and all safety precautions in this manual.

The "Danger", "Warning", "Caution" and "Important" in this manual do not represent all the safety precautions to be followed, but only serve as a supplement to the safety precautions. SYL is not responsible for any breach of safe operation requirements or safety standards for design, manufacture, and use of the equipment.

The product should be used in an environment that meets the design requirements. Otherwise, the equipment may fail, and the resulting equipment function abnormalities, component damage, personal safety accidents, and property losses are not covered by the quality guarantee.

Comply with local laws and regulations when installing, operating, and maintaining the equipment. The safety precautions in this manual only serve as a supplement to local laws and regulations.

SYL is not responsible for any of the following circumstances:

- Do not operate under the operating conditions described in this manual.
- The installation and operating environment dose not conform to international, state or regional standards.
- Disassemble or modify the product or modify the software code without authorization.
- Do not follow the operation instructions and safety warnings written on the product and in the manual.

- Equipment damage caused by abnormal natural environment (earthquake, fire, storm, flood, debris flow, etc.)
- Damage caused by storage conditions that do not meet product documentation requirements.
- Hardware or data damage caused by negligence, improper operation or intentional destruction of customers.

DANGER

DO NOT INSTALL, USE, OR OPERATE OUTDOOR DEVICES AND CABLES (INCLUDING BUT NOT LIMITED TO HANDLING DEVICES, OPERATING DEVICES AND CABLES, PLUGGING AND UNPLUGGING SIGNAL PORTS CONNECTED TO THE OUTDOORS, WORKING AT HEIGHTS, AND OUTDOOR INSTALLATION) IN SEVERE WEATHER SUCH AS LIGHTNING, RAIN, SNOW, STRONG BREEZE OR WIND OF HIGHER FORCE ON BEAUFORT WIND SCALE.

DANGER

OBSERVE THE REQUIREMENTS OF THIS MANUAL, USE THE CORRECT TOOLS, AND MASTER THE CORRECT METHODS OF USING THE TOOLS.

DANGER

MEASURE THE VOLTAGE AT THE CONTACT POINT BEFORE TOUCHING ANY CONDUCTOR SURFACE OR TERMINAL TO ENSURE THAT THERE IS NO DANGER OF ELECTRIC SHOCK.

DANGER

PAINT SCRATCH IN THE PROCESS OF EQUIPMENT TRANSPORTATION AND INSTALLATION MUST BE REPAIRED IN TIME, AND IT IS STRICTLY FORBIDDEN TO EXPOSE THE SCRATCHED PART TO THE OUTDOOR ENVIRONMENT FOR A LONG TIME.

DANGER

DO NOT CHANGE THE STRUCTURE, INSTALLATION ORDER, ETC. OF THE EQUIPMENT WITHOUT AUTHORIZATION AND PERMISSION UNDER ANY CIRCUMSTANCES

DANGER

IN CASE OF FIRE, EVACUATE THE BUILDING OR EQUIPMENT AREA AND PRESS THE FIRE BELL OR CALL THE FIRE ALARM. UNDER NO CIRCUMSTANCES SHOULD YOU RE-ENTER THE BURNING BUILDING.

DANGER

PLEASE BE AWARE THAT THE BATTERIES PRESENT A RISK OF ELECTRICAL SHOCK INCLUDING A HUGE SHORT-CIRCUIT CURRENT.

DANGER

ARC FLASH HAZARD IS ASSOCIATED WITH BATTERIES. THERE IS A SERIOUS RISK OF ARC FLASH RELATING TO ANY EQUIPMENT MODIFICATION. SERIOUS INJURIES CAN OCCUR IN ARC FLASH INCIDENTS.

WARNING

FIRE MAY OCCUR UNDER CERTAIN FAULT CONDITIONS.

WARNING

REMOVE WATCHES, RINGS, OR OTHER METAL OBJECTS.

WEAR PROPER PPE IN ACCORDANCE WITH LOCAL CODES AND REGULATIONS.

WARNING

USE TOOLS WITH INSULATED HANDLES TO AVOID ACCIDENTAL SHORT-CIRCUIT.

DO NOT PUT TOOLS OR ANY METAL PARTS ON THE TOP OF THE BATTERIES.

WARNING

DO NOT OPEN OR VANDALIZE THE BATTERIES.

WARNING

BATTERIES SHALL BE DISPOSED OF ACCORDING TO THE SYL RECYCLING POLICY, DISPOSE OF THE BATTERIES IN A FIRE COULD CAUSE AN EXPLOSION.

WARNING

SHARP POINTS AND PINCH POINTS ARE PRESENT ON MOST SYSTEM COMPONENTS. BE AWARE OF THE SERIOUS RISK OF INJURY WHILE WORKING AROUND EQUIPMENT BATTERIES.

CAUTION

COMPONENTS IN THE BATTERY SYSTEM CAN BE DAMAGED BY ELECTROSTATIC DISCHARGE. BE SURE TO WEAR A GROUNDED ANTI-STATIC WRIST STRAP AND TO DISCHARGE STATIC ELECTRICITY BY TOUCHING A GROUNDED SURFACE NEAR THE EQUIPMENT BEFORE YOU TOUCH ANY SYSTEM COMPONENTS.

CAUTION

DAMAGE, MISHANDLING, OR EXPOSURE TO CONDITIONS BEYOND THOSE RECOMMENDED BY SYL COULD RESULT IN LEAKAGE OF FLAMMABLE GAS, WITH CONSEQUENT HAZARDOUS SITUATIONS ARISING.

CAUTION

WHEN CARRYING OUT TRANSPORTATION, TURNOVER, INSTALLATION, WIRING AND MAINTENANCE AND OTHER OPERATIONS, IT MUST MEET THE LAWS AND REGULATIONS AND RELEVANT STANDARDS OF THE COUNTRY OR REGION WHERE IT IS LOCATED.

CAUTION

IT IS NECESSARY TO OBTAIN THE PERMISSION OF THE POWER DEPARTMENT OF THE COUNTRY OR REGION WHERE IT IS LOCATED TO WORK ON THE GRID.

CAUTION

BE FAMILIAR WITH THE COMPOSITION OF THE ENTIRE ENERGY STORAGE SYSTEM, WORKING PRINCIPLE, AND THE RELEVANT STANDARDS OF THE COUNTRY/REGION WHERE THE PROJECT IS LOCATED.

IMPORTANT

REVERSE ENGINEERING, DECOMPILING, DISASSEMBLING, ADAPTING, IMPLANTING OR OTHER DERIVATIVE OPERATIONS ON THE DEVICE SOFTWARE ARE PROHIBITED. RESEARCH ON THE INTERNAL IMPLEMENTATION OF THE DEVICE, OBTAINING THE SOURCE CODE OF THE DEVICE SOFTWARE, STEALING INTELLECTUAL PROPERTY, ETC., AND DISCLOSURE OF THE PERFORMANCE TEST RESULTS OF ANY DEVICE SOFTWARE ARE PROHIBITED.

3.2 PERSONNEL REQUIREMENTS

- Personnel responsible for the installation and maintenance of SYL equipment must be trained to understand safety precautions and correct operation methods.
- Only qualified professionals or trained personnel are allowed to install, operate, and maintain the equipment.
- Only qualified professionals are allowed to remove safety facilities and repair equipment.
- Personnel who operate the equipment, including operators, trained personnel, and professionals, must have local and state-required special operation qualifications, such as high voltage operation, height climbing, and special equipment operation qualifications.
- Replace equipment or components (including software) only by professionals or authorized personnel.

CAUTION

PROFESSIONAL PERSONNEL: PERSONNEL WITH TRAINING OR EXPERIENCE IN OPERATING DEVICES AND KNOW THE POTENTIAL SOURCES AND LEVELS OF HAZARDS DURING DEVICE INSTALLATION, OPERATION, AND MAINTENANCE.

TRAINED PERSONNEL: PERSONNEL WITH APPROPRIATE TECHNICAL TRAINING AND NECESSARY EXPERIENCE. BEING AWARE OF THE DANGER THAT MAY BE POSED TO HIM WHILE PERFORMING AN OPERATION AND MINIMIZE THE RISK TO HIMSELF OR OTHER PERSONNEL.

OPERATING PERSONNEL: OTHER THAN TRAINED PERSONNEL AND PROFESSIONAL PERSONNEL WHO MAY COME INTO CONTACT WITH THE EQUIPMENT.

3.3 ELECTRICAL SAFETY

3.3.1 GROUNDING REQUIREMENTS

- When installing a device that needs to be grounded, install the protective grounding cable first. When removing a device, remove the protective grounding cable at the end.
- Do not damage the grounding conductor.
- Do not operate the device without a grounding conductor installed.
- The device should be permanently connected to protective ground. Before operating the device, check the electrical connections of the device to ensure that the device is reliably grounded.

3.3.2 GENERAL REQUIREMENTS

WARNING

BEFORE ELECTRICAL CONNECTION, ENSURE THAT THE DEVICE IS NOT DAMAGED; OTHERWISE, ELECTRIC SHOCK OR FIRE MAY OCCUR.

- All electrical connections must meet national/regional electrical standards.
- You must obtain permission from the electricity authority of the country/region to connect to the grid.
- Cables prepared by customers must meet local laws and regulations.
- When performing high voltage operations, use special insulation tools.

3.3.3 DC OPERATION

WARNING

DO NOT INSTALL OR REMOVE POWER CABLES WHEN POWER IS ON. TRANSIENT CONTACT BETWEEN THE CORE OF A POWER CABLE AND THE CONDUCTOR GENERATES ELECTRIC ARCS OR SPARKS, WHICH MAY CAUSE FIRE OR PERSONAL INJURY.

- Before electrical connection of the device, if live parts may be encountered, disconnect the corresponding disconnecting device at the front stage of the device.
- Before connecting a power cable, ensure that the label on the power cable is correct.
- If the device has multiple inputs, disconnect all inputs and perform operations on the device only after the device is completely powered off.

3.3.4 WIRING REQUIREMENTS

- The insulation layer may be aged or damaged if cables are used in a high temperature environment. Keep at least 50mm away from the heating device or heat source area.
- Cables of the same type must be bound together. Cables of different types must be routed at least 30mm apart. Do not intertwine or cross cables.
- Cables must be securely connected, properly insulated, and of appropriate specifications.
- Protect the pipe or cable holes from sharp edges and burrs.

3.3.5 ANTI-STATIC REQUIREMENTS

CAUTION

THE STATIC ELECTRICITY GENERATED BY HUMAN BODIES MAY DAMAGE THE ELECTROSTATIC SENSITIVE COMPONENTS ON BOARDS, SUCH AS THE LARGE-SCALE INTEGRATED CIRCUIT (LSI).

WEAR ESD GLOVES WHEN TOUCHING THE PCB BOARD. DO NOT WEAR CLOTHES PRONE TO STATIC ELECTRICITY.

3.4 FIRST-AID MEASURES

3.4.1 HAZARD AND TOXICITY INSTRUCTIONS

DANGER

HAZARD: CONTACT OF BATTERY MODULE TERMINALS WITH OTHER METALS MAY CAUSE HEAT OR ELECTROLYTE LEAKAGE. ELECTROLYTE IS FLAMMABLE, AND IF THE ELECTROLYTE LEAKS, REMOVE THE BATTERY MODULE FROM THE FIRE IMMEDIATELY.

DANGER

TOXICITY: STEAM FROM BURNING BATTERIES MAY IRRITATE EYES, SKIN AND THROAT.

3.4.2 FIRST-AID MEASURES FOR BATTERY ABNORMALITIES

DANGER

WHEN THERE IS ELECTROLYTE LEAKAGE OR ABNORMAL SMELL, AVOID CONTACT WITH THE LEAKING LIQUID OR GAS. NON- PROFESSIONALS SHOULD KEEP AWAY AND CONTACT PROFESSIONALS IMMEDIATELY. PROFESSIONALS SHOULD WEAR SAFETY GOGGLES, RUBBER GLOVES, GAS MASKS, AND PROTECTIVE CLOTHING TO PROTECT THEMSELVES FROM ELECTROLYTE OVERFLOW.

DANGER

ELECTROLYTE IS CORROSIVE AND CONTACT MAY CAUSE SKIN IRRITATION AND CHEMICAL BURNS. IF YOU COME IN CONTACT WITH BATTERY ELECTROLYTE, TAKE THE FOLLOWING MEASURES:

1. INHALATION: IMMEDIATELY EVACUATE THE CONTAMINATED AREA AND SEEK MEDICAL ATTENTION.

2. EYE CONTACT: IMMEDIATELY RINSE EYES WITH WATER FOR 15 MINUTES AND SEEK MEDICAL ATTENTION.

3.CONTACT WITH SKIN: WASH THE CONTACTED AREA: THOROUGHLY WITH SOAP AND WATER AND SEEK MEDICAL ATTENTION.

4.INGESTION: INDUCE VOMITING AND SEEK MEDICAL ATTENTION.

3.4.3 FIRST-AID MEASURES FOR FIRE

DANGER

IF A FIRE OCCURS DURING THE CHARGING OF THE BATTERIES, ISOLATE THE CHARGER FROM ITS POWER SUPPLY BY TURNING OFF THE POWER SWITCH AT THE INVERTER/PCS OR PUSHING THE E-STOP BUTTON ON THE SYSTEM ENCLOSURE.

PUSH THE MANUAL RELEASING BUTTON ON THE SYSTEM ENCLOSURE IF THE AUTOMATIC FIRE SUPPRESSION SYSTEM IS NOT ACTIVATED BY ITSELF.

DANGER

USE CARBON DIOXIDE, FM-200 OR ABC DRY POWDER FIRE EXTINGUISHERS TO EXTINGUISH THE FIRE.

DANGER

FIREFIGHTERS NEED TO AVOID CONTACT WITH HIGH-VOLTAGE COMPONENTS DURING EXTINGUISHING, OR IT MAY RESULT IN THE RISK OF ELECTRIC SHOCK.

DANGER

WHEN THE BATTERY TEMPERATURE IS TOO HIGH, IT MAY CAUSE BATTERY DEFORMATION, DAMAGE, ELECTROLYTE OVERFLOW, AND TOXIC GAS LEAKAGE. WEAR PROTECTIVE RESPIRATORY EQUIPMENT AND KEEP AWAY FROM THE BATTERY TO AVOID SKIN IRRITATION AND CHEMICAL BURNS.

3.4.4 FIRST-AID MEASURES FOR BATTERY DROP

DANGER

WHEN INSTALLING THE BATTERY, IF THE BATTERY DROPS OR SUFFERS A STRONG IMPACT, IT MAY CAUSE INTERNAL DAMAGE TO THE DEVICE. DO NOT CONTINUE TO USE THE BATTERY, OTHERWISE THERE MAY BE SAFETY RISKS (CELL LEAKAGE, ELECTRIC SHOCK, ETC.).

DANGER

AFTER THE BATTERY DROPS, IF THERE IS OBVIOUS ODOR, DAMAGE, SMOKE, FIRE, ETC., EVACUATE PERSONNEL IMMEDIATELY, CALL THE POLICE IN TIME, AND CONTACT PROFESSIONALS WHO WILL USE FIRE-FIGHTING EQUIPMENT TO EXTINGUISH THE FIRE WHILE ENSURING SAFETY.

DANGER

AFTER THE BATTERY DROPS, IF THERE IS NO OBVIOUS ODOR, DAMAGE, SMOKE OR FIRE CONTACT PROFESSIONALS TO TRANSFER THE BATTERY TO AN OPEN AND SAFE PLACE OR CONTACT A RECYCLING COMPANY FOR SCRAPPING.

3.5 BATTERY RECYCLING TREATMENT

CAUTION

DISPOSE OF USED BATTERY ACCORDING TO LOCAL LAWS AND REGULATIONS. DO NOT DISPOSE OF BATTERY AS HOUSEHOLD GARBAGE. IMPROPER DISPOSAL OF BATTERY MAY LEAD TO ENVIRONMENTAL POLLUTION.

CAUTION

IF THE BATTERY CELL LEAKS OR IS DAMAGED, CONTACT TECHNICAL SUPPORT OR A BATTERY RECYCLING COMPANY FOR DISPOSAL.

CAUTION

WHEN BATTERIES ARE OUT OF SERVICE LIFE, CONTACT A BATTERY RECYCLING COMPANY FOR SCRAPPING.

CAUTION

AVOID EXPOSING USED BATTERIES TO HIGH TEMPERATURES OR DIRECT SUNLIGHT.

CAUTION

AVOID EXPOSING USED BATTERY TO HIGH HUMIDITY OR CORROSIVE ENVIRONMENTS.

3.6 STORAGE REQUIREMENTS

IMPORTANT

DURING THE STORAGE PERIOD, RECORDS SHALL BE MADE ACCORDING TO THE STORAGE REQUIREMENTS OF THE PRODUCT IN THIS MANUAL, SUCH AS TEMPERATURE AND HUMIDITY, STORAGE ENVIRONMENT, ETC.

IMPORTANT

LONG-TERM STORAGE OF BATTERIES IS NOT RECOMMENDED. LONG-TERM STORAGE OF LITHIUM BATTERY WILL CAUSE CAPACITY LOSS. AFTER STORAGE AT THE RECOMMENDED STORAGE TEMPERATURE FOR 12 MONTHS, THE IRREVERSIBLE CAPACITY LOSS OF LITHIUM BATTERIES GENERALLY 3% TO 6%.

IMPORTANT

THE STORAGE ENVIRONMENT MUST MEET THE REQUIREMENTS OF LOCAL LAWS AND STANDARDS.

IMPORTANT

AFTER THE EXPIRATION DATE, THE STORAGE SYSTEM MUST BE INSPECTED AND TESTED BY PROFESSIONAL PERSONNEL BEFORE IT CAN BE PUT INTO USE.

IMPORTANT

WHEN STORING BATTERIES, PLACE THEM CORRECTLY ACCORDING TO THE LABEL ON THE PACKING CASE. DO NOT PUT THEM UPSIDE DOWN OR ON THE SIDE.

IMPORTANT

WHEN STACKING BATTERY PACKING CASES, COMPLY WITH THE PACKING REQUIREMENTS ON THE OUTER PACKAGING.

IMPORTANT

HANDLE THE BATTERIES WITH CARE. DO NOT DAMAGE THE BATTERY.

Storage environment requirements:

- Ambient temperature: -30 °C to 50 °C. Recommended storage temperature: 20° C to 30 °C
- Relative humidity: 0 to 95%RH. Recommended storage humidity <60%RH
- Store in a dry, clean and well-ventilated place, and prevent dust and water vapor from eroding. Do not suffer from rain or ground water erosion.
- Avoid contact with corrosive organic solvents, gases and other substances.
- Avoid direct sunlight.

3.7 HANDLING GUIDELINES

CAUTION

THIS PRODUCT HAS PASSED THE CERTIFICATION OF UN38.3 (UN38.3：SECTION 38.3 OF THE SIXTH REVISED EDITION OF THE RECOMMENDATIONS ON THE TRANSPORT OF DANGEROUS GOODS: MANUAL OF TESTS AND CRITERIA) AND SN/T 0370.2-2009 "RULES FOR INSPECTION OF PACKAGING FOR EXPORT DANGEROUS GOODS-PART 2: PERFORMANCE TEST" AND BELONGS TO CLASS 9-MISCELLANEOUS DANGEROUS GOODS.

HANDLING REQUIREMENTS:

- The energy storage system must be handled according to local laws, regulations, and industry standards. Rough handling may cause short circuit or damage to batteries in the container, which may result in battery leakage, rupture, explosion, or fire.

SHIPMENT CONDITIONS:

- Before shipment, check that the battery should be intact and not appear obvious odor, smoke, fire and other phenomena, otherwise the shipment is prohibited.

IMPORTANT

PRODUCTS WHICH MEET THE REQUIREMENTS OF VEHICLE, SHIP AND OTHER TRANSPORTATION CAN BE DELIVERED DIRECTLY TO THE SITE, TRANSPORTATION PACKING BOXES MUST BE FIRM. HANDLE WITH CARE AND TAKE MOISTURE-PROOF MEASURES. SUBJECT TO EXTERNAL ENVIRONMENT (SUCH AS TEMPERATURE, TRANSPORTATION, STORAGE, ETC.), THE PRODUCT SPECIFICATIONS ARE SUBJECT TO THE MANUFACTURE DATE.

TRANSPORTATION PROCESS REQUIREMENTS:

- Maritime transport in accordance with IMDG CODE.
- Land transport in accordance with ADR or JT T617.
- Meet the regulatory requirements of the transport regulatory authorities in the countries of origin, route and destination.
- Comply with international regulations for the transport of dangerous goods and the regulatory requirements of the corresponding national transport regulatory authorities.

THINGS SHOULD BE PROHIBITED DURING HANDLING OR TRANSPORTATION:

- Direct rain, snow or falling into water.
- Fall or mechanical impact.
- Invert or tilt.

IMPORTANT

IF ANY OF THE PRECEDING EXCEPTIONS OCCURS, HANDLE THEM ACCORDING TO FIRST-AID MEASURES.

3.8 PERSONAL PROTECTIVE EQUIPMENT

Please be aware that a battery can pose a risk of electrical shock including a high short-circuit current. Follow all safety precautions while operating the batteries. During the installation or maintenance of the battery system, a worker shall wear proper PPE such as eye protection, high visibility clothing, protective gloves, and protective footwear. Insulation gloves with over 1500VDC ratings are needed when connecting the busbars and jumpers between modules and racks.

Figure 3-1: Safe gear for installation

- Wear appropriate personal protective equipment when operating the device. If a fault is found that may cause personal injury or device damage, terminate the operation immediately, report the fault to the person in charge, and take effective protective measures.

- Before using the tools, master the proper use of the tools to avoid injury and damage to the device.
- Do not touch the device when it is operating because the case is at a high temperature, which may cause burns.
- To ensure personal safety and normal use, ensure reliable grounding before use.
- Avoid contact with a faulty battery when the temperature may exceed the burn threshold for touchable surfaces.
- Do not open or damage the battery. The electrolyte released is harmful to skin and eyes. Avoid contact with it.
- Do not place irrelevant items on the top of the device or insert them into anywhere of the device.
- Do not place combustible materials around the device.
- Do not place the battery in the fire to avoid explosion which may bring danger in personal safety.
- Do not place the battery module in water or other liquids.
- Do not short-circuit battery terminals. Short-circuited batteries may cause combustion.
- The battery may cause shock and a large short-circuit current hazard. When using batteries, pay attention to the following precautions:

  a）Use tools with insulated handles.

  b）Put on rubber gloves and boots.

  c）Do not place tools or metal parts on the top of the battery.

  d）Disconnect the charging power supply before connecting or disconnecting the battery terminals.

  e）Check whether the battery is accidentally grounded. If so, remove the power supply from the ground.
- Do not use water or detergent to clean electrical components inside or outside the cabinet.
- Do not stand, lean or sit on the device.
- Do not damage any module of the device.

4 SYSTEM OVERVIEW

4.1 SYSTEM DESIGN

4.1.1 PRODUCT SERIES

Table 4-1: Product series

NO.	MODEL	APPLICABLE REGION	NOTE
1	SU3794U3794KC	UL	1C

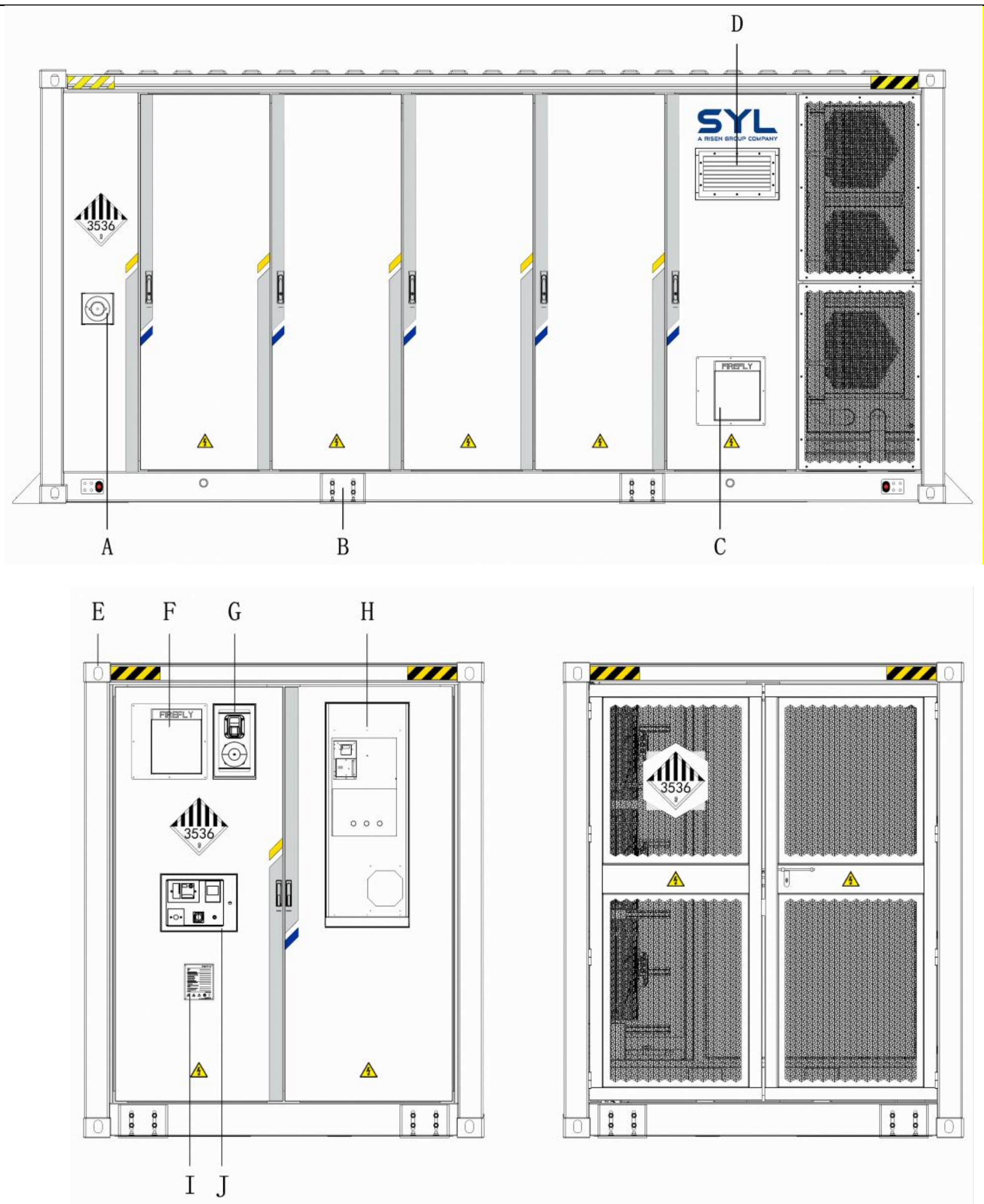


Figure 4-1: Appearance

Table 4-2: Introduction

NO.	ITEM	QTY	DESCRIPTION
A	Water fire suppression pipe coupling	1	Access customer station level water fire suppression pipe network
B	Fastener	6	Used for onsite container anchoring
C	Electric shutter	1	Inlet of fresh air outside the container
D	Pressure relief port	1	Exhaust overpressure gas to maintain cabin pressure balance
E	Top corner fitting	4	Used for container lifting
F	Explosion-proof exhaust fan	1	Outlet of air inside the container
G	Sounder visual indicator, alarm bell	1	Sounder visual indicator is issued when the fire is triggered in the container, and the alarm bell sounds are issued
H	Air-cooled HVAC	1	Distribution bin heat dissipation, dehumidification
I	Nameplate	1	Display container parameters, date of manufacture and other information
J	System emergency stop button, extinguishing abort switch, manual pull stations, isolating switch	1	System emergency stop button: Used for storage system emergency stop Extinguishing abort switch: Used for fire extinguishing system emergency stop Manual pull stations: Used for manually start of the fire extinguishing system Isolating switch: Isolate fire extinguishing system to avoid accidental discharge

4.1.2 SPECIFICATION

Table 4-3: Specification

BATTERY PARAMETERS	
Cell type	3.2V/285Ah
Configuration	416S*10P
Nominal capacity	3793.92 kWh
Voltage range	1164.8~1497.6V
SYSTEM PARAMETERS	
Dimensions(W×D×H)	6058mm×2896mm×2438mm
Weight	35±0.5T
Operating temperature	-30~50 °C(> 45 °C derating)
Charge-discharge rate	1C
Operating humidity	0~95% RH
Anti-corrosion grade	C4-M
Protection grade	IP55
Thermal method	Intelligent liquid cooling
Fire suppression design	Water + Combustible gas detection + Ventilation + Gas extinguishing
Allowable working altitude	≤3000m
Noise	≤80dB@1m
Wind load	66m/s
Snow load	40psf
Seismic zone	Zone 4

5 MAIN SYSTEM EQUIPMENT

5.1 BATTERY SYSTEM

5.1.1 BATTERY CELL

SYL Battery storage systems rely on advanced LFP chemistry to provide a combination of high performance, low cost, and industry-leading safety. Configurable to serve the application at hand, 3.2V 314Ah prismatic cells became SYL’s best pick for a battery storage solution. Cell specifications are as follows.

Table 5-1: Specification of the Battery cell

ITEM	UNIT	SPECIFICATION	RENDERING
Battery Chemistry	-	LFP	
Shape	-	Prismatic	
Dimension(W×D×H)	mm	(174.7±0.8)×(71.55±0.5)×(207.3±0.8)	
Weight	kg	5.4±0.05	
Nominal Capacity	Ah	285	
Nominal Energy	Wh	912	
Nominal Voltage	Vdc	3.2	
Operating Voltage	Vdc	2.5~3.65V	
Operating Temperature Range	°C	Charge: 0~60. Discharge: -20~60	

5.1.2 BATTERY MODULE

Battery modules are formed by configuring 104 LFP cells in a series connection. Modules are connected to the battery management system (BMS) to form a cluster of module components, and then multiple module components are combined into a container, and each battery cluster contains cluster-level BMS

Table 5-2: Specification of Module

ITEM	UNIT	SPECIFICATION	RENDERING
Configuration	-	1P 104S	
Key Component	-	104 cells, 1 module BMU	
Dimension(W×H×D)	mm	2170×243×790	
Weight	kg	635±10	
Nominal Capacity	Ah	285	
Nominal Energy	kWh	94.848	(For reference only)
Nominal Voltage	Vdc	332.8	
Operating Voltage	Vdc	291.2~374.4	

5.1.3 BATTERY MANAGEMENT SYSTEM

The ESS employs a sophisticated, multilevel battery management system (BMS) for system monitoring and control. Each multilevel battery management system includes:

- Module Battery management unit (BMU)
- Battery Cluster Unit (BCU)
- Battery Array Unit (BAU)

Figure 5-1: BAU diagram

The Battery Module BMS (BMU) is designed to detect voltage and temperature and execute cell balance functions for cells. The Battery Cluster Unit (BCU)can manage all module BMU units and detects total voltage, current, and executes protection functions by switching the DC-contactor. Finally, a Battery Array Unit (BAU) manages rack BCU units and communicates with PCS or EMS. The table below outlines the BMS units of the system.

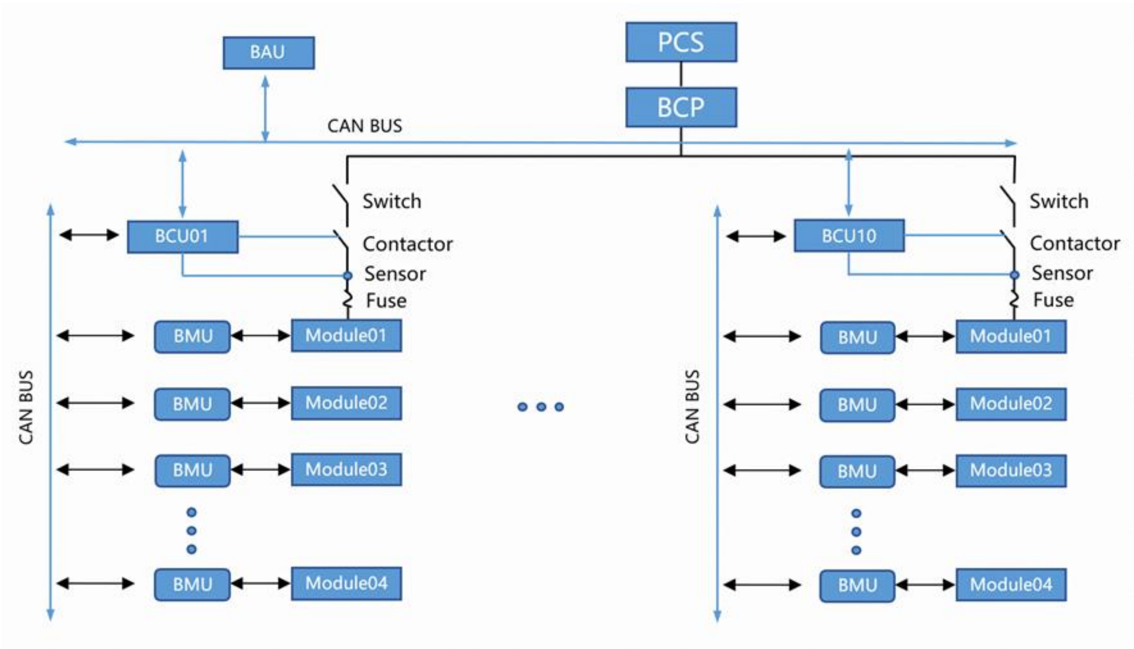


Figure 5-2: Architecture of the BMS

The functionalities of each level of BMS are shown in the following table.

Table 5-3: BMS Functionality

FUNCTIONALITY		BMU	RBMS	SBMS
Measurement	Cell Voltage	√		
	Cell	√		
	Rack Voltage		√	
	Rack Current		√	
Calculation	SOC		√	√
	SOH		√	√
	Power		√	
Control	Contactor		√	
	Cell Balancing	√	√	
Communication	CAN2.0	√	√	
	RS485			√
	Ethernet			√

5.2 GOLDEN SHIELD CONTROLLER

To offer one universal communication interface for battery systems with SCADA or EMS and release EMS from basic system protection, SYL deploys a system controller as part of the BESS integration.

Figure 5-3: Rendering of Golden Shield

5.2.1 FEATURES AND FUNCTIONS

- Control integration of the battery system (include battery BMS, cooling units, BCP etc.).
- Offer a universal interface for communication between battery systems and SCADA or EMS.
- As a communication adapter, converts various communication protocols (RS-485, CAN, dry contact, etc.) of BOS devices such as BMS, PCS, HVAC, and FSS into a communication protocol of the EMS for easy integration.
- Take basic system protection measures to prevent the battery and PCS from being damaged during operation.
- Data logging (short period) for troubleshooting.
- Remote firmware updating (pending).

5.2.2 COMMUNICATION TOPOLOGY

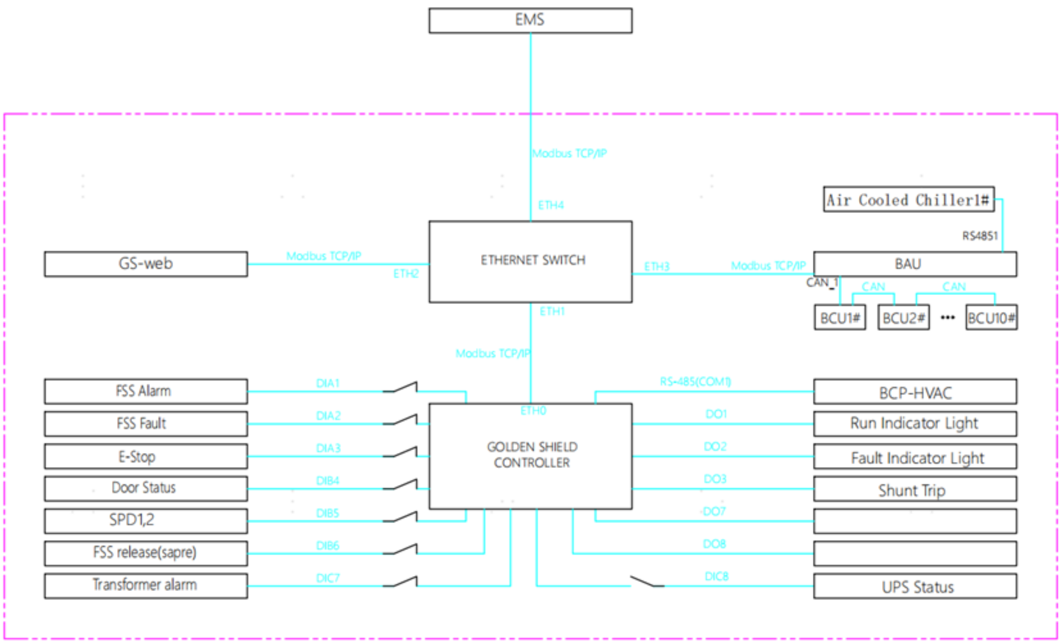


Figure 5-4: Communication topology with Golden Shield

5.3 THERMAL MANAGEMENT SYSTEM

5.3.1 COOLING CONCEPT

The liquid cooling system will be designed and installed inside the battery container.

1.Advantages of Liquid Cooling

- Higher cooling capability: compare to air cooling, liquid cooling is capable of taking more heat away from batteries under the same condition. And liquid cooling is the best choice when thermal density is beyond the capability of air cooling.
- Better temperature uniformity: Cooling liquid has a specific heat capacity which leads to a smaller temperature rise during the cooling process. Therefore, battery cells will have a smaller temperature difference with liquid cooling.
- Lower Noise Emission: Without fans on battery modules for air cooling means no noise emission from battery modules.

2.Working principle of Liquid Cooling

- Battery Cooling: Cooling liquid powered by the pump will circulate inside battery modules and take the heat from batteries. When the liquid gets out of the battery modules, it became hot liquid with the heat from batteries. The hot liquid will circle back to a heat exchanging tank.

- Heat Exchanging: Inside the heat exchange tank, the refrigerant will vaporize from liquid state to gaseous state. During this state/phase change process, the refrigerant will absorb a huge amount of heat from the battery cooling liquid and cool down the cooling liquid.
- AC Cooling: The rest of the system is a standard Air Conditioner which releases the heat to the environment through the phase change of the refrigerant.

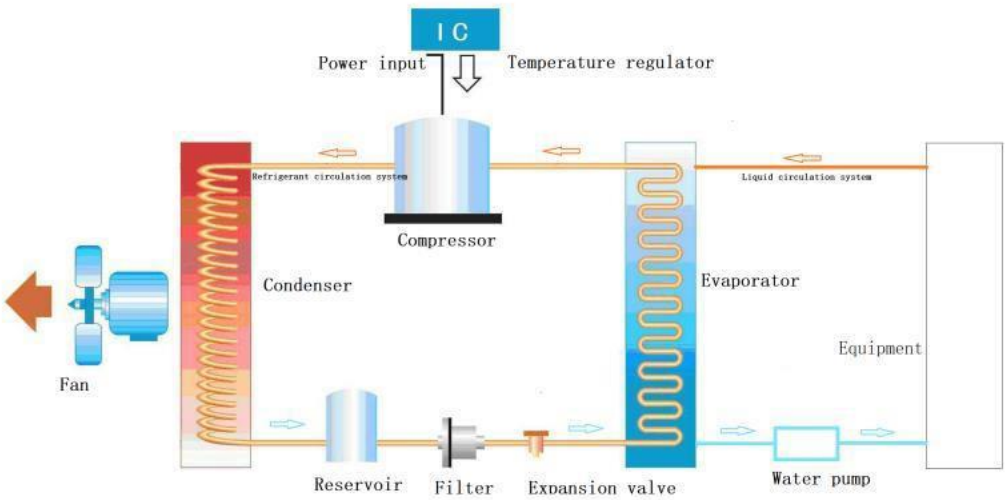
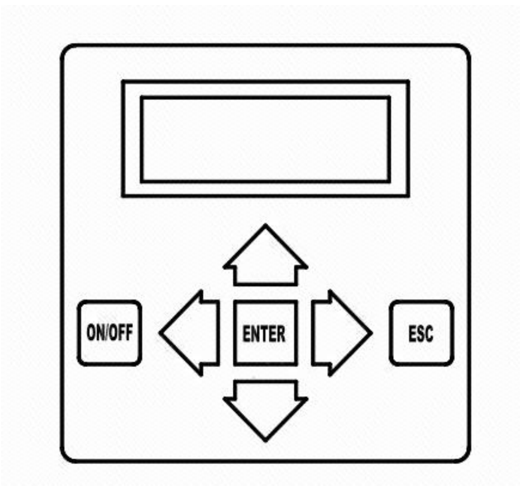


Figure 5-5: Working principle of Liquid Cooling

5.3.2 HVAC INTERFACE

5.3.2.1 AIR-COOLED HVAC



- ON/OFF: ON/OFF button, which can be used to turn on/off the unit:
- ↑: UP button, which is used to select the previous record/menu or increase the setting

value (password only);

- ↓: Down button, which is used to select the next record/menu or decrease the setting value (password only);
- ←: Left button, which is used to increase the setting value or select the previous data while conducting password operation.
- →: Right button, which is used to decrease the setting value or select the next data while conducting password operation.
- ENTER: Return button, which is used to confirm the input.
- ESC: Quit button, which is used to return to the previous page menu.

if there is no keyboard operation for consecutively 60s under any interface after startup.it will automatically return to the normal display interface.

When any button is pressed after the system is powered up, the backlight will turn on. If there is no keyboard operation for consecutively 60s, the backlight will be off.

The operation password of the unit is "0001". On the normal interface, press Enter to enter the password input interface. Press the left button and the right button to select the desired digit, press the up button and the down button to modify the digit, and press Enter to confirm the input. If the password is incorrect, an error message is displayed, and the unit Settings cannot be modified. If the password is correct, enter the main menu, you can edit the unit Settings.

Note: The actual parameters in the menu have been set before the factory as required by the customer.

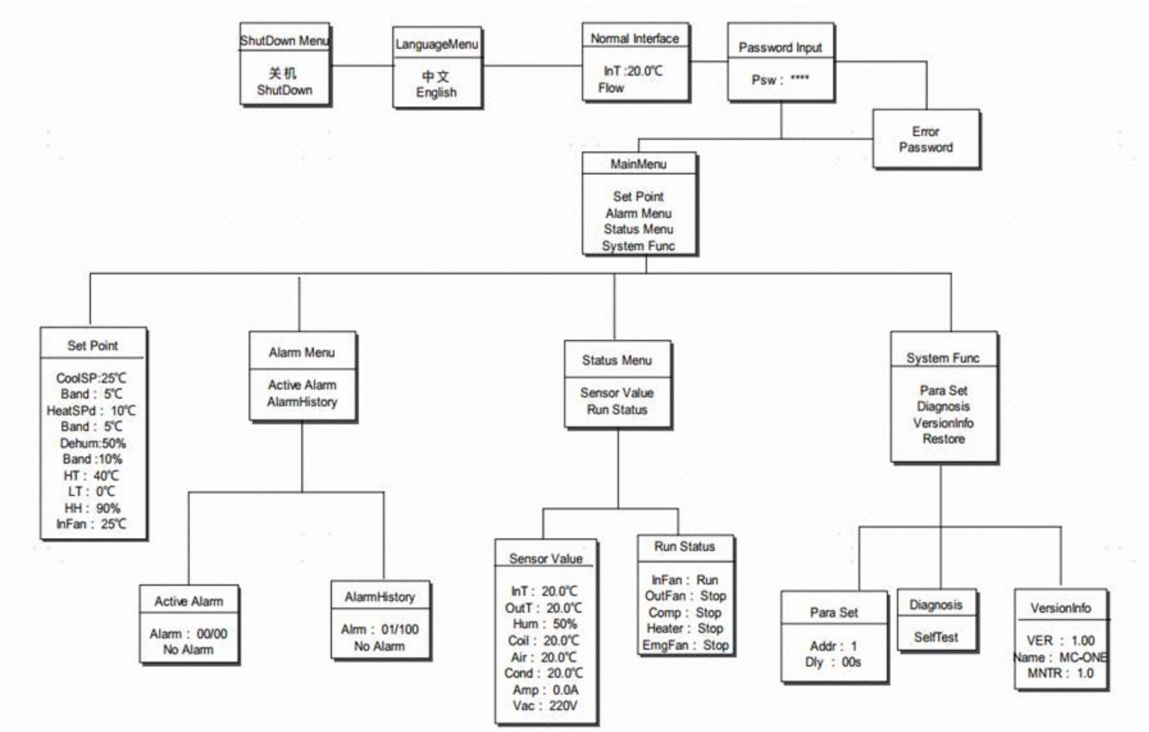


Figure 5-6: Unit menu structure diagram

5.3.2.2 LIQUID COOLING UNIT

➢ Introduction

The controller part of EMW air-cooled liquid cooling unit is equipped with a touch screen display to provide users with a human-computer interaction interface. Users can query, set up and monitor conveniently through the touch screen to ensure the normal operation of the chiller.

➢ Control System Interface

Turn on the power switch to power on the unit, and enter the control system homepage after the system is initialized, as shown in the figure below.

Figure 5-7: Control system homepage interface

On the main interface, you can open/close the coolant supplement function and the air discharge function of the circulation pump. After the system is powered on, press any key and the backlit light will light up. If there is no keyboard operation after a period of time, the backlit light will dim. The meanings of icons in the control interface of the chillers are shown in the figure below.

Icon	Description
ON/OFF	Switch button icon, click it to change the current working state of chiller.
中 文 English	Language icon, click it to switch the language of the current interface to **Chinese** or **English**.
Runing	Working status icon, which displays the current working status of chiller in the form of indicator lights. • Green indicates running status. • Red indicates the shutdown state.
Alarm	Alarm icon, which indicates that the current chiller has generated alarms.
Pump	Circulating pump icon, which indicates that the circulating pump of the chiller is working.
Cool	Cooling icon, which indicates that the chiller is in cooling state, and the compressor is working.
Heat	Heating icon, which indicates that the chiller is in heating state, and the heater is working.
Home	System homepage icon, click it to enter the operation homepage interface of the control system, you can view the current time, operation mode, outlet temperature, outlet pressure and interface language of the chiller.
Status	System status icon, click it to enter the **System Status** interface, you can view the environment status, running status and group control status.
Alarm	System alarm icon, click it to enter the **Alarm** interface, you can view current alarms and historical alarms.
Record	System operation record icon, click it to enter the **Record** interface, you can view the chiller's operation record, operation log and operation curve.
Setting	System setting icon, click it to enter the **Parameter Setting** interface, you can set the temperature and humidity setting, system configuration, account setting and time setting.
Maintain	System maintenance icon, click it to enter the **Maintain** interface, you can manually start the coolant replenishment function, and set the replenishment related time parameters.

Figure 5-8: Control interface icons

➢ System Start-up and Shutdown

After clicking the switch button every time, the system switches the working state of the current unit. The dialog box that pops up when the unit is start up is shown in the figure below.

Figure 5-9: System start-up

After start-up, the status of unit changes from to "Running". On any interface, If there is no keyboard operation for a period of time, the system will automatically return to the homepage interface. The dialog box popped up when shutting down is shown in the figure below.

Figure 5-10: System shutdown

After shutting down, the chiller will be updated from running status to shutdown status. The system supports power-off memory function. If the system is powered on after power off, the system will automatically enter the state before power off (for example, if the system was on before power off, the system will automatically start up and enter the normal display interface after power on).

➢ Status

Click "Status" on the main interface of the control system to view the current environmental status and operation status of the unit, as shown in the figures below.

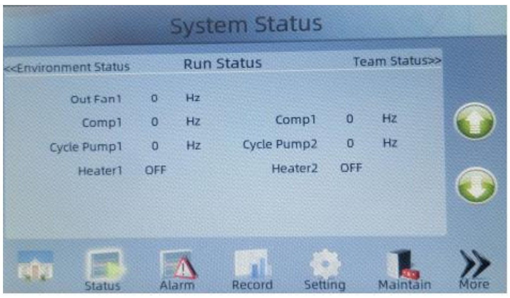


Figure 5-11: Environment Status interface Figure 5-12: Run Status interface

5.4 FIRE SUPPRESSION SYSTEM

DANGER

IF THERE IS AN OBVIOUS FIRE OR EXPLOSION AT THE SCENE, DO NOT BE CLOSE TO THE CONTAINER FOR EMERGENCY START-UP OPERATIONS.

WHEN THE EQUIPMENT AUTOMATICALLY EXTINGUISH THE FIRE, A LARGE AMOUNT OF GAS WILL BE GENERATED. THROUGH CHEMICAL REACTION, THE OXYGEN INSIDE THE CONTAINER WILL BE QUICKLY CONSUMED. AT THIS TIME, THE OPERATOR SHOULD NOT ENTER THE CONTAINER, WHICH MAY CAUSE SUFFOCATION.

WARNING

THE CONTAINER IS EQUIPPED WITH AN AUTOMATIC FIRE EXTINGUISHING SYSTEM. DO NOT TRIGGER THE FIRE EXTINGUISHING SWITCH UNLESS IT IS AN EMERGENCY.

5.4.1 GENERAL RULES

- Please comply with the fire codes and regulations of the country/region where the project is located
- Check and maintain fire extinguishing equipment regularly to ensure that all functions are normal

5.4.2 FIRE EXTINGUISHING SYSTEM COMPOSITION

The container is equipped with water fire extinguishing system, gas fire extinguishing system, automatic fire alarm and linkage control system, combustible gas detection and alarm system and emergency ventilation system. The system is a set of efficient fire extinguishing equipment, through the combustible gas detection equipment, smoke detector, temperature detector and other fire detection devices for detection, when abnormality detected, through the BCP external terminal to send signals to the station alarm host for fire alarm.

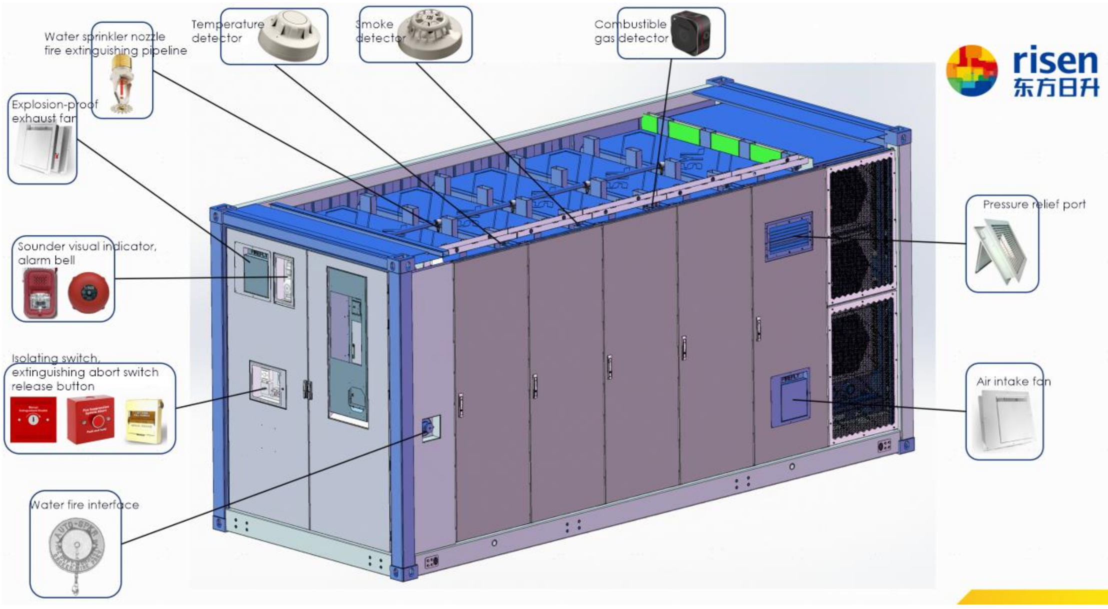


Figure 5-13: Fire extinguishing system main composition diagram

5.4.3 FIRE CONTROL FLOW CHART

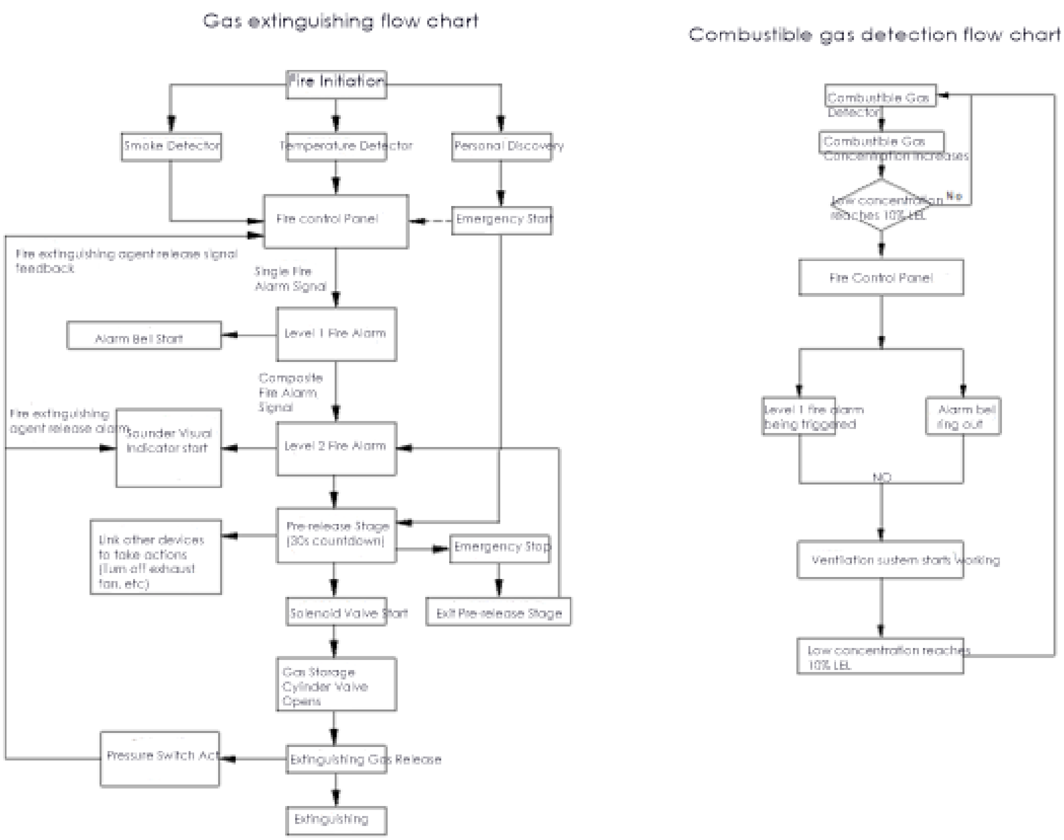


Figure 5-14: Fire control flow chart

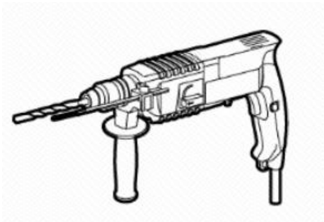
6 INSTALLATION

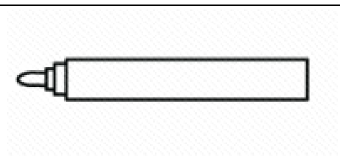
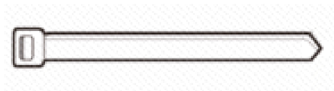
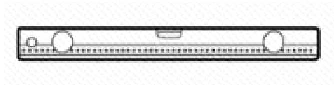
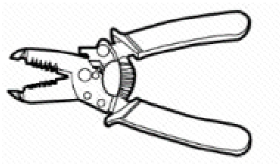
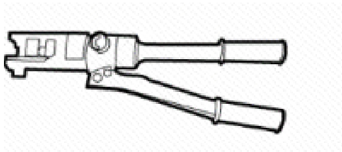
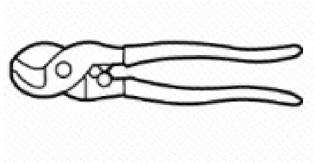
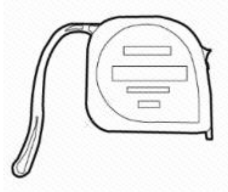
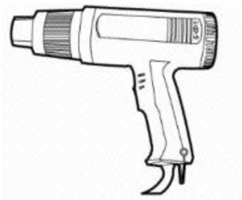
The battery system is a high-voltage energy storage device, which is regarded as dangerous goods. Non-professionals and improper operation and use may cause serious consequences such as electric shock, burning, and explosion. The battery system must be installed and maintained by professional technicians and used in strict accordance with the relevant safety provisions.

6.1 MAIN TOOLS AND COMPONENTS FOR INSTALLATION

Tools needed for the system installation are listed below.

Table 6-1: Tools for system installation

NO.	ITEM	PURPOSE	SAMPLE
1	Drill(Φ16)	Hole the expansion bolts	
2	Expansion bolt(SUS316 stainless steel M16X100)	Connect the foundation to the container fastener	
3	Sleeve assembly + screwdriver assembly	Installation of grounding cable, power cable, rubber channel, forklift hole seal plate	
4	Torque wrench	Fastener torque confirmation	

5	Marking pen	Torque mark	
6	Cable tie	Cable fixation	
7	Gradienter	Container leveling	
8	Multi-meter	Continuity test	
9	Wire stripper	Strip the insulation off the cable header	
10	Hydraulic clamp	Crimp terminals and cables	
11	Wire cutter	Cut cable	
12	Tape Measure	Dimension measurement	
13	Heat gun	Heat shrink tube shrinkage	

14	Heat shrink Sleeve	Wire and terminal connection protection	
15	Cold-press terminal crimping plier	Crimp terminals and cables	
16	Insulation gloves	Insulation protection	
17	Insulation shoes	Insulation protection	
18	Goggles	Arc protection	

6.2 PREPARATION FOR INSTALLATION

6.2.1 INSTALLATION ENVIRONMENT REQUIREMENTS

- The installation and use environment must comply with local laws and regulations and relevant international and regional standards for lithium electric products.
- For areas with frequent natural disasters such as floods, mudslides, earthquakes and typhoons, appropriate preventive measures shall be taken for installation.
- Keep the installation location away from fire and heat sources. Do not place combustible or explosive materials around the device.

- When the device is running, do not block the vent or thermal management system to prevent fire caused by high temperature.
- Do not place the device in an environment with combustible or explosive gas or smoke. Do not perform any operations in such an environment.

IMPORTANT

The operation and service life of the energy storage depends on the operating temperature. Install the storage devices at a temperature equal to or higher than the ambient temperature.

The operating temperature of the SU3794U3794KC series battery container ranges from -30 °C to 50 °C. If the container is stored in a cold environment (such as 0°C) before installation, it will take some time to heat up before it can be recharged.

When the ambient temperature is higher than 45 °C or lower than 0 °C, the battery charging and discharging power decreases.

6.2.2 CHECK BEFORE INSTALLATION

1) Outer packing check

Before opening the outer packaging of the product, please check the outer packing for obvious damage, such as breakage, cracks or other signs of possible internal damage, and check the product model. If there is any abnormal packaging or product type discrepancy, please contact us as soon as possible.

2) Deliverable check

After unpacking the product, please check the deliverables for completeness and for any obvious external damage. If anything is missing or damaged, please contact us.

IMPORTANT

Refer to "Spare Parts" List for details of the spare parts delivered with the case.

3) Installation foundation check

Before product installation, it is necessary to check the prefabricated foundation at the project site and ensure that the foundation is solid and reliable and meets the flatness requirements.

- There must be a concrete foundation with sufficient strength at the bottom of containers to provide adequate support for containers
- Use a gradienter to measure the levelness of the foundation. Ensure that the levelness of the foundation is less than 5mm. In particular, if the levelness of the four corner parts is greater than 5mm, use stainless steel plate to level them. If the levelness is greater than or equal to 5mm, the device frame may be deformed, doors may leak because of improper seal, doors may fail to open and close, and liquid cooling pipes may leak

6.2.3 INSTALLATION SPACE

When installing devices, ensure that there are no combustible or explosive materials around, and reserve enough space to ensure heat dissipation and safety isolation. The installation and maintenance space of a container liquid cooling unit is different according to the highest ambient temperature on site

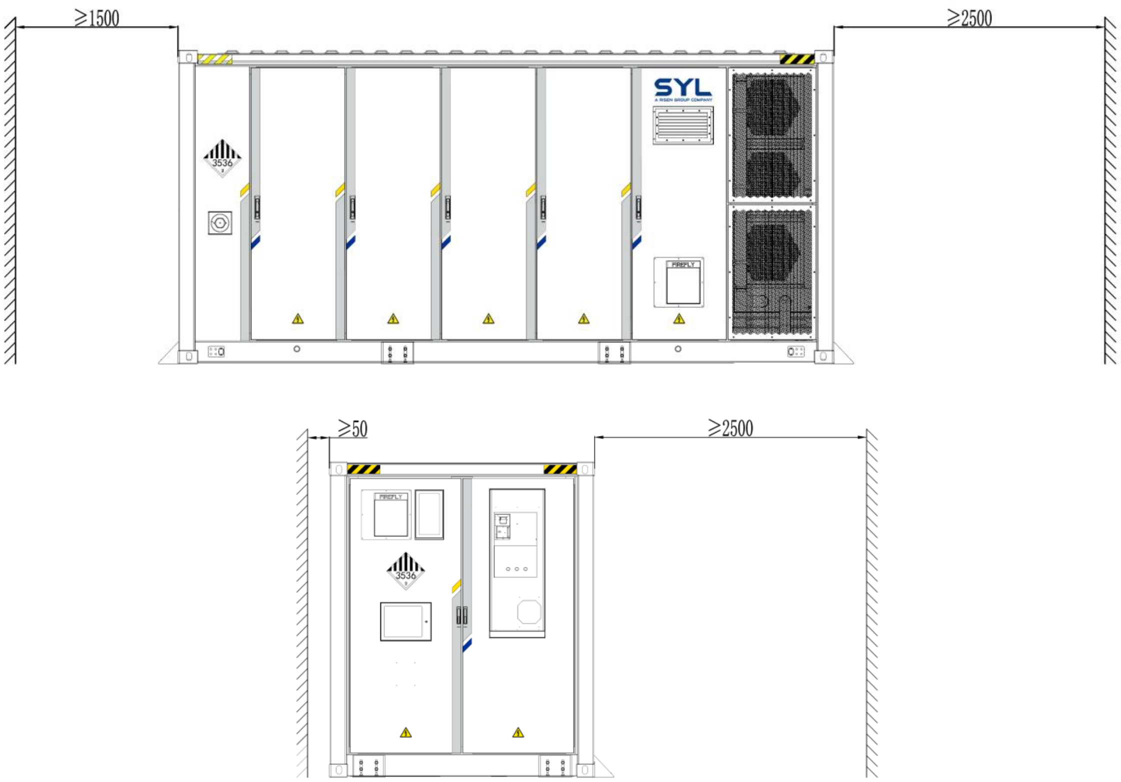


Figure 6-1: Installation space requirements for single container (unit: mm)

Figure 6-2: Installation space requirements for multiple containers (unit: mm)

6.3 PRODUCT HANDLING

When crane lifting, note the following:

- Hoisting according to the site conditions, select the appropriate hoist.
- The lifting equipment is equipped with 4 wire ropes and 4 shackles, according to the dimensions and weight of the product, choose the appropriate length and load bearing.
- Lifting Angle ≥60°. Before lifting, ensure that there are no obstacles around.
- During crane operation, no personnel allowed to stand within 5 m ~ 10 m of the operation area. In particular, it is strictly prohibited to stand under the lifting arm and the lifting or moving machine to avoid casualties
- In case of strong breeze or wind of higher force on Beaufort Wind Scale, heavy

rain, heavy snow, heavy fog, the lifting operation should be suspended.

- The lifting or landing should be at a constant speed. Ensure that the acceleration is less than or equal to 0.1g.
- During the lifting operation, stop the operation immediately if abnormal noises, deformation, or welding cracking occur.

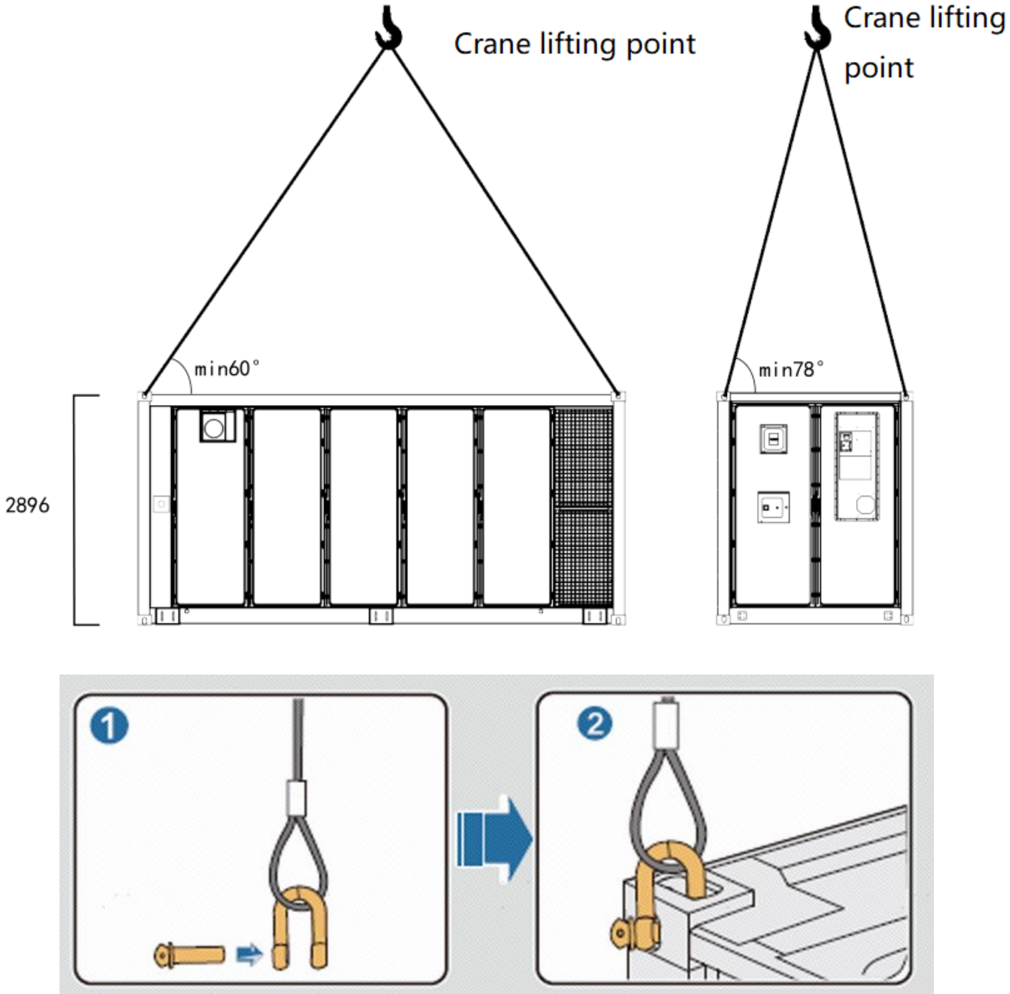


Figure 6-3: Crane lifting

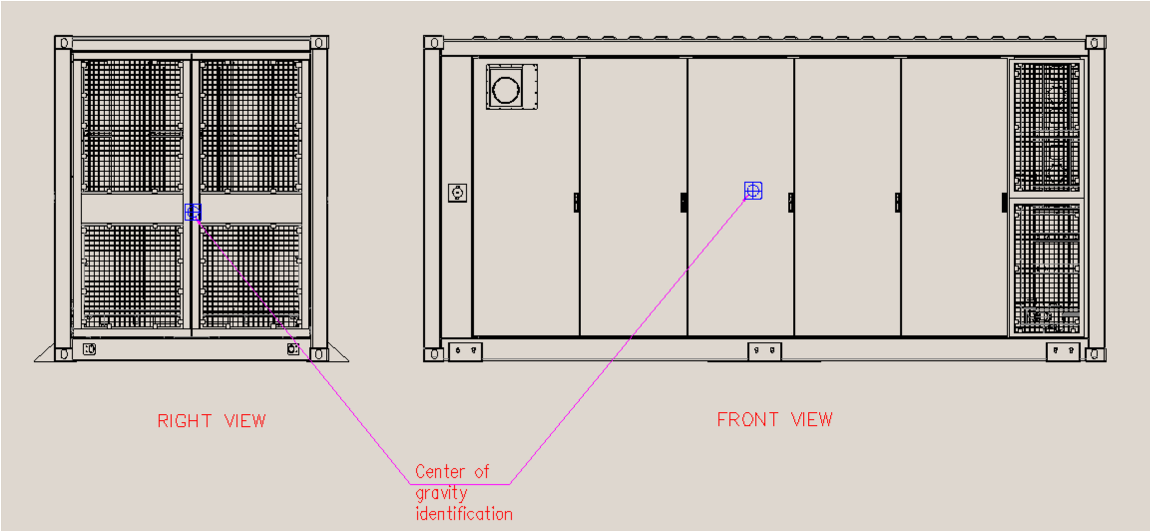


Figure 6-4: Center of gravity (for reference only)

6.4 INSTALLATION STEPS

6.4.1 DEVICE FIXATION

Before hoisting equipment, use a gradienter to measure the levelness of the foundation and ensure that the levelness of the foundation is less than or equal to 5mm, especially in the landing area of the four corner fittings. If the levelness is greater than 5mm, use stainless steel plates for leveling. After the foundation level is adjusted, place the container in the correct position, and then install and secure it. The steps are as follows:

STEP 1: After the container lands, use a gradienter to measure the levelness of the four corner fittings. The levelness must be less than or equal to 5mm. If the levelness is greater than 5mm, use stainless steel gaskets for leveling. After leveling, open and close all the container doors to ensure that they can be opened and closed smoothly. If the door cannot be opened and closed smoothly, adjust the container again to ensure that all doors can be closed and closed properly.

STEP 2: Determine the positions of expansion bolt holes and drill holes to bury M16X100 expansion bolts. Fix the fasteners on the foundation, a single container requires 6 fasteners. Tighten the fasteners to the container with M16X50, A4-70 bolt assembly.

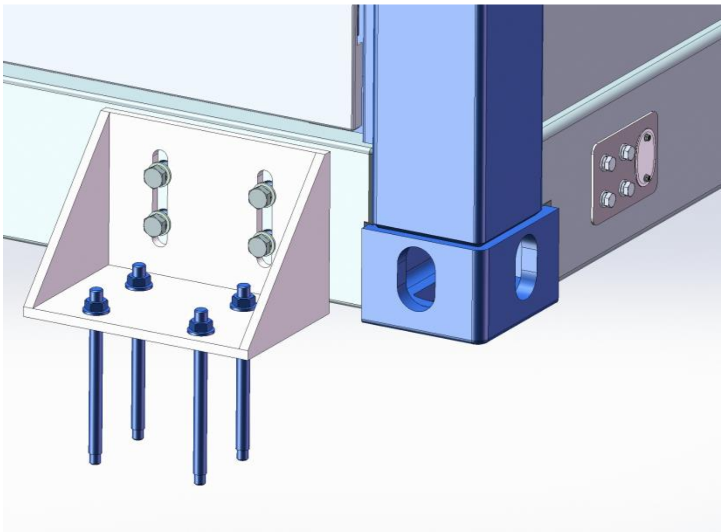
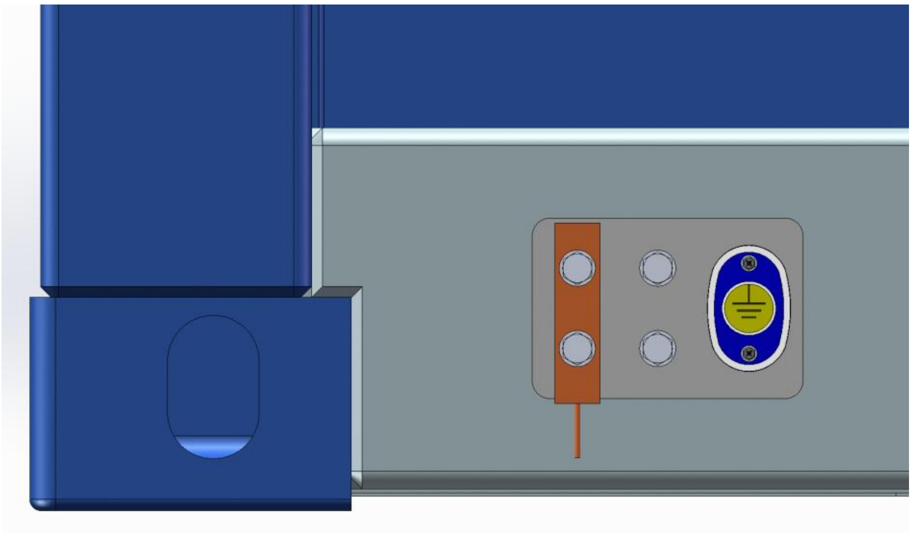


Figure 6-5: Install fasteners

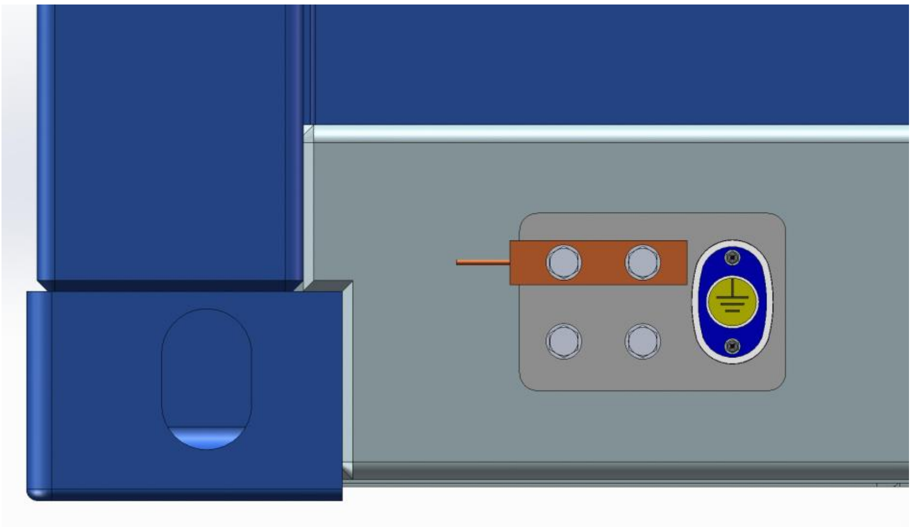
6.4.2 DEVICE GROUNDING

Both the front and rear of the device have 2 grounding points. Select one grounding point based on site requirements. Each grounding point has 4 tightening points in total which are distributed in two rows and two columns. You can flexibly arrange ground cables horizontally or vertically according to the actual situation. The steps are as follows:

STEP 1: Make ground cable: CL250-12-2D double-hole copper nose is recommended. It is recommended to crimp ground cables or ground flat steel with a cross-sectional area of no less than 250mm². Tighten the grounding cable with M10X30, A4-70 bolt assembly.



Vertical connection



Horizontal connection

Figure 6-6: Install grounding cables

6.4.3 WATER FIRE SUPPRESSION PIPE CONNECTION

There is a water fire suppression pipe coupling near the right end of BCP and 1300mm away from the bottom corner fitting. You can determine whether to install a fire hose in advance according to the actual situation. **Note: The water fire suppression pipe is a dry pipe in the normal state, and water can be injected through the external valve only in emergency situations such as fire accidents**

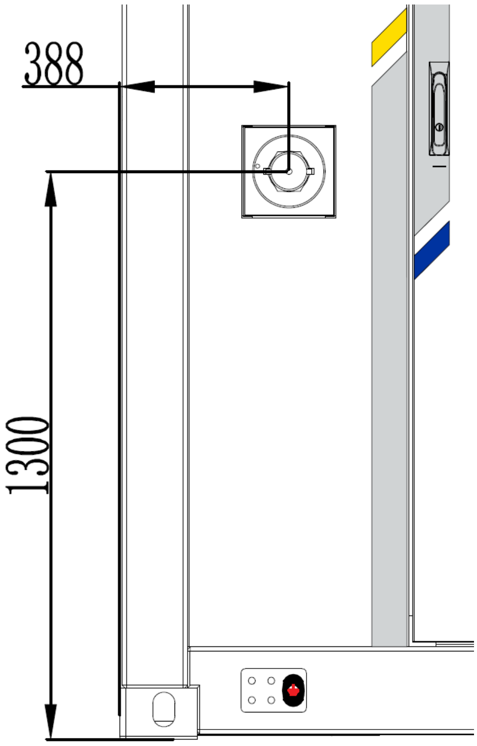


Figure 6-7: Water fire suppression pipe coupling

6.4.4 WIRING AND SEALING

External cable connections can be performed onsite by referring to Section 7.2 System Electrical Connections. Cable holes for the power cable and auxiliary power supply are reserved at the bottom of the BCP, respectively at the bottom of the bus cabinet and the power distribution cabinet, as shown in the following figure. Before delivery, seal plates are installed at the two cable holes. Drill holes to adjust the seal plates as required onsite. After connecting cables, use the fireproof mud delivered with the container to seal the seal plates to ensure sealing inside the BCP.

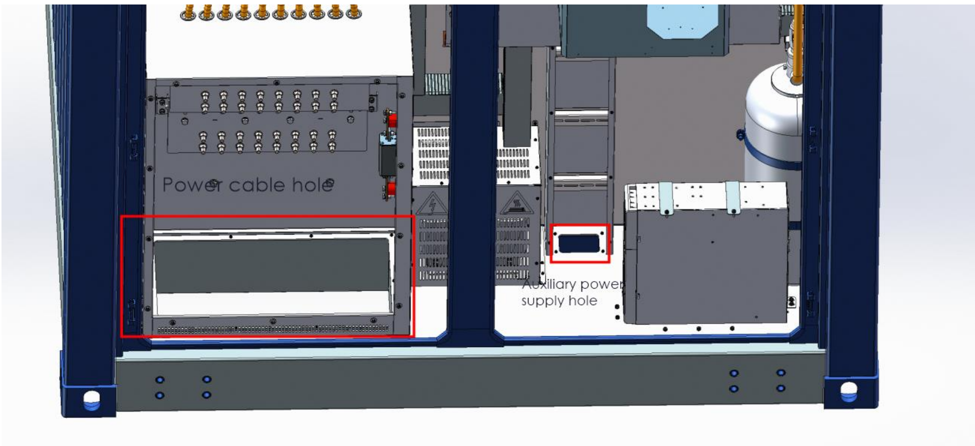


Figure 6-8: External cable holes diagram

6.4.5 REMOVE STICKER

After the equipment is fixed, remove the mesh stickers around the liquid cooling unit.

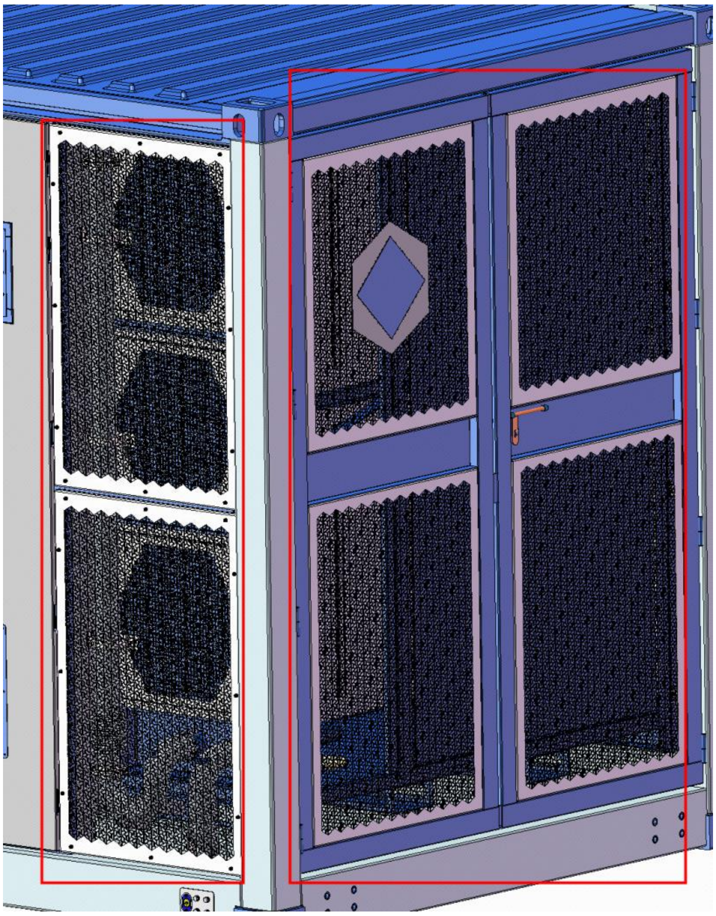


Figure 6-9: Liquid cooling unit mesh position diagram

7 ELECTRICAL CONNECTION

7.1 PREPARATION FOR INSTALLATION

Tools for electrical connections are listed in the table below.

WARNING

THE TOOLS USED FOR BATTERY POWER CONNECTION INSTALLATION SHOULD BE INSULATED OR SHOULD HAVE A MINIMIZED EXPOSED METAL AREA. AT LEAST THE GRIP PART SHOULD BE INSULATED.

IMPORTANT

BECAUSE OF THE STRUCTURAL PARTICULARITY OF THE CABINET TERMINAL BOARD, A SLEEVE SCREWDRIVER TOOL IS USED TO CONNECT.

Table 7-1: Tools for electrical connection

NO.	ITEM	PURPOSE	SAMPLE
1	Cutter	Unpacking	
2	Insulated Torque wrench	Use to install power connection	
3	Insulated driver	Use to install power connection	

4	Multi-meter	Voltage measurement	
5	Insulation gloves	Battery power connection	
6	Wrench set	Busbar connection	

7.2 SYSTEM ELECTRICAL CONNECTION

DANGER

IN THE EVENT OF A GROUND FAULT, COMPONENTS CONSIDERED VOLTAGE-FREE IN THE ENERGY STORAGE SYSTEM MAY CARRY LETHAL HIGH VOLTAGE WHICH IS POTENTIALLY LETHAL. THE DANGER OF ACCIDENTAL TOUCH EXISTS. BEFORE DOING ANY OPERATION, MAKE SURE THAT THE GROUNDING SYSTEM IS NOT FAULTY AND TAKE ADEQUATE PRECAUTIONS.

CAUTION

ELECTRICAL CONNECTIONS ARE MADE ONLY BY PROFESSIONAL ELECTRICIANS AND QUALIFIED PERSONNEL. STRICTLY FOLLOW THE EQUIPMENT INTERNAL WIRING IDENTIFICATION FOR CABLE CONNECTION.

WARNING

ENSURE THAT ALL DC AND AC SWITCHES IN THE PCS ARE DISCONNECTED BEFORE STARTING ELECTRICAL CONNECTIONS.

CAUTION

THE VOLTAGE RATING OF THE SELECTED CABLE SHALL NOT BE LESS THAN THE PCS THREE-PHASE INSTANTANEOUS ALTERNATING VOLTAGE. THE VOLTAGE LEVEL OF THE DC CABLE SHOULD NOT BE LOWER THAN THE MAXIMUM DC VOLTAGE OF A LITHIUM BATTERY.

WARNING

WHEN CONDUCTING ELECTRICAL CONNECTIONS, CHECK THAT ALL CABLES ARE INSULATED AND INTACT. PARTIALLY EXPOSED OR OTHER DAMAGED CABLES OR INSULATED CABLES MAY POSE A SERIOUS SAFETY RISK AND SHOULD BE REPLACED IMMEDIATELY.

CAUTION

FAILURE OF EQUIPMENT OR SYSTEMS RESULTING FROM A VIOLATION OF THE INSTALLATION AND DESIGN REQUIREMENTS SPECIFIED IN THIS MANUAL WILL RENDER THE QUALITY ASSURANCE INEFFECTIVE.

DANGER

HIGH VOLTAGE DANGER! ELECTRIC SHOCK DANGER!

- DO NOT TOUCH LIVE PARTS!
- BEFORE INSTALLATION, ENSURE THAT THE AC AND DC SIDES ARE NOT POWERED ON.

DO NOT PLACE THE DEVICE ON COMBUSTIBLE SURFACES.

WARNING

EQUIPMENT DAMAGE CAUSED BY INCORRECT CABLE CONNECTIONS IS NOT COVERED BY THE EQUIPMENT WARRANTY.

ONLY PROFESSIONAL ELECTRICAL TECHNICIANS PERFORM OPERATIONS RELATED TO ELECTRICAL CONNECTIONS.

OPERATORS MUST WEAR PERSONAL PROTECTIVE EQUIPMENT WHEN MAKING ELECTRICAL CONNECTIONS.

CAUTION

TOOLS FOR BATTERY POWER CONNECTION INSTALLATION SHOULD BE INSULATED OR EXPOSED METAL AREAS SHOULD BE MINIMIZED. AT LEAST THE GRIP PART SHOULD BE INSULATED.

BECAUSE OF THE SPECIAL STRUCTURE OF THE CABINET TERMINAL BOARD, USE A SOCKET SCREWDRIVER TO CONNECT THE TERMINAL BOARD.

7.2.1 AUXILIARY POWER CONNECTION INTERFACE

As shown in the following figure, connect the A, B, and C terminals according to the marks on the copper bars. Cables with a diameter no larger than 4*2AWG and CL38-10-2D double-hole copper nose are recommended.

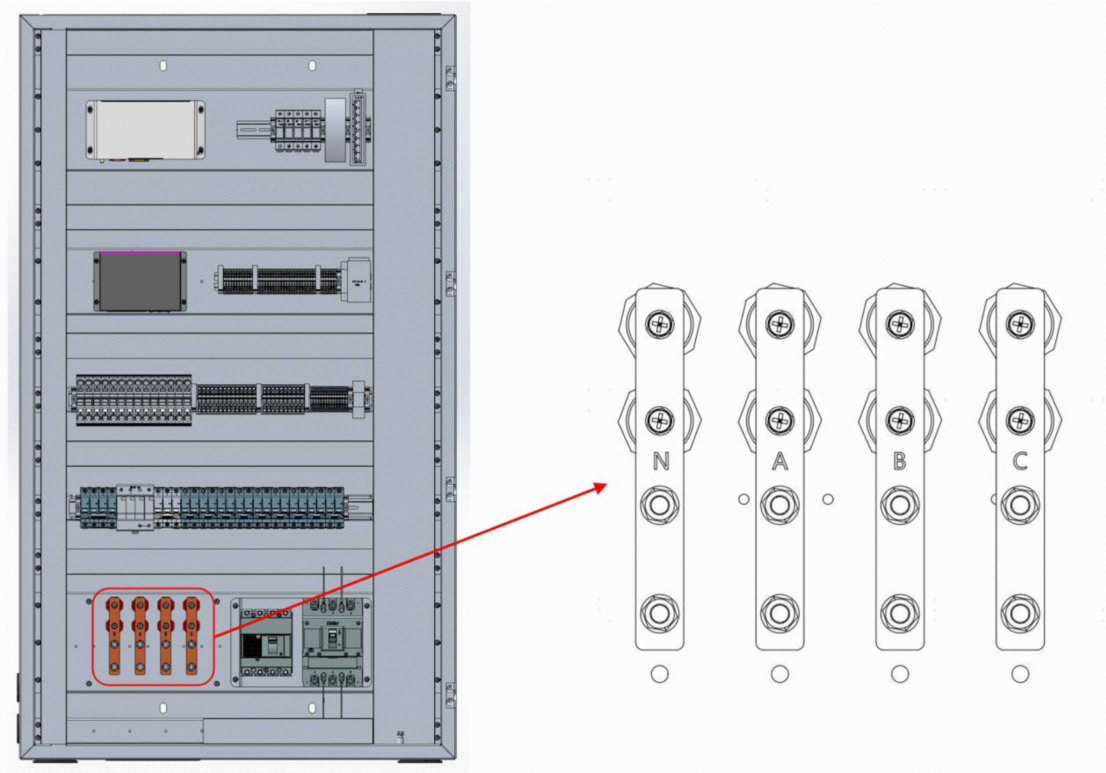
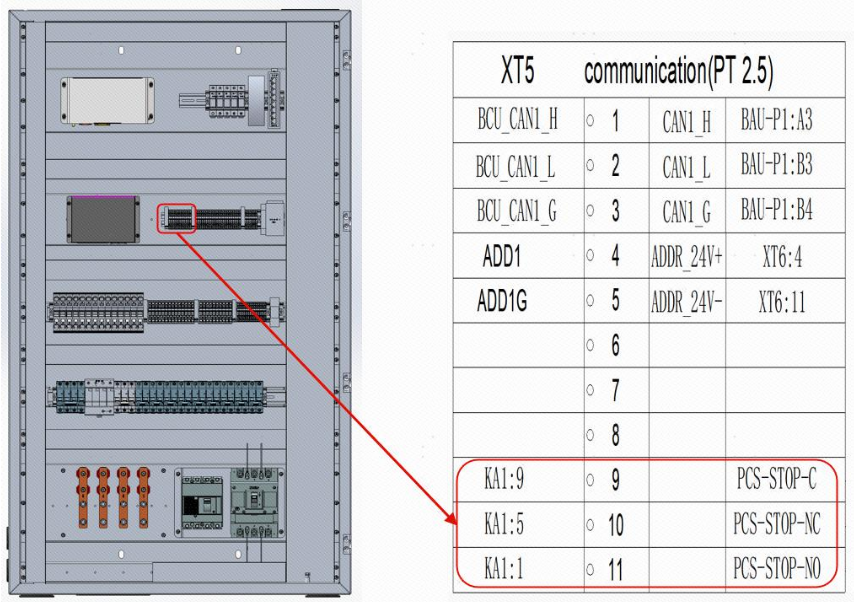


Figure 7-1: BCP auxiliary power supply copper bar(for reference only)

7.2.2 RESERVED PCS DRY CONTACT INTERFACE

As shown in the following figure, XT5-11, XT5-12, XT5-13 are reserved as PCS normally closed and normally open dry contact interface (stop signals). Connect them according to the actual conditions of PCS. 1.0mm² cables and ET1.0-12 terminals are recommended.



XT5	communication(PT 2.5)		
BCU_CAN1_H	1	CAN1_H	BAU-P1:A3
BCU_CAN1_L	2	CAN1_L	BAU-P1:B3
BCU_CAN1_G	3	CAN1_G	BAU-P1:B4
ADD1	4	ADDR_24V+	XT6:4
ADD1G	5	ADDR_24V-	XT6:11
	6		
	7		
	8		
KA1:9	9		PCS-STOP-C
KA1:5	10		PCS-STOP-NC
KA1:1	11		PCS-STOP-NO

Figure 7-2: PCS reserved dry contact for emergency stop(for reference only)

7.2.3 PCS POWER CABLE INTERFACE

As shown in the following figure, connect PCS+ and PCS- respectively. You are advised to use single-stage cables with a diameter larger than 10*4/0AWG. PCS connection points are M12 double-row through holes.

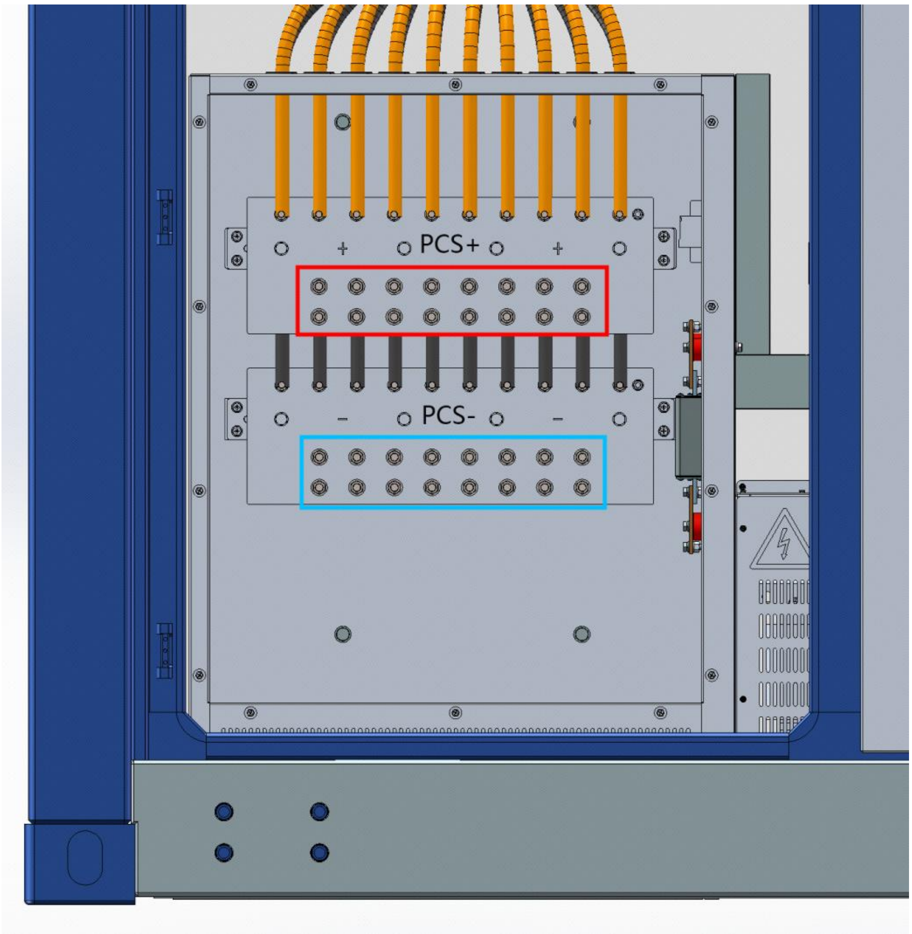


Figure 7-3: BCP copper bar diagram(for reference only)

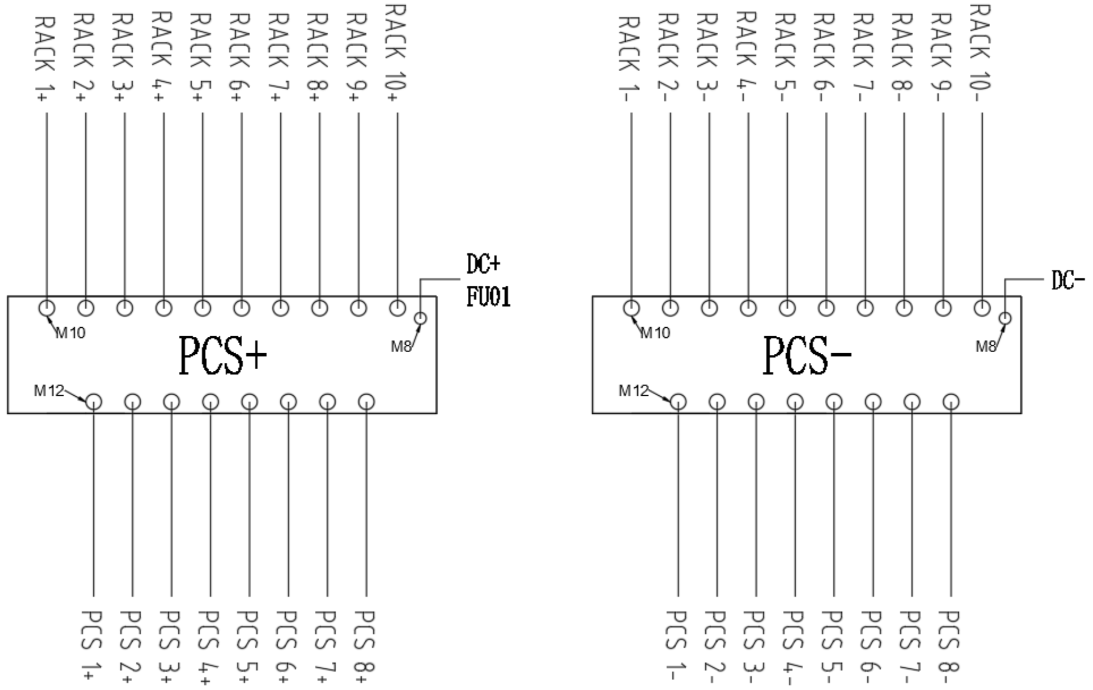


Figure 7-4: BCP wiring diagram(for reference only)

7.3 DC SWITCHGEAR AND PACK DESCRIPTION

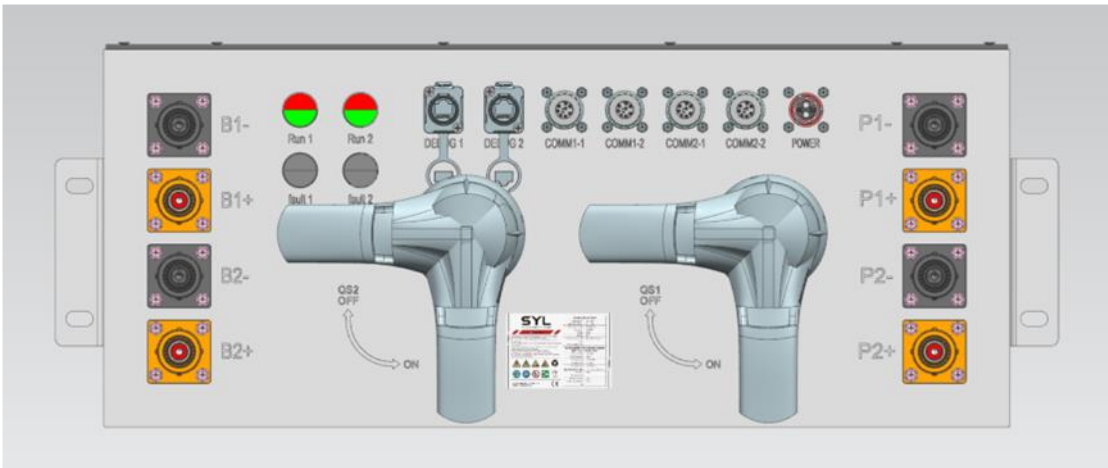


Figure 7-5: DC switchgear interface

Table 7-2: Interface Connectors of DC Switchgear

No.	Item	Function	Description
1	COMM2-2	Communication between RACKs	Connect to next COMM1

2	COMM2-1	Communication between modules	BCU & BMU Communication 2
3	COMM1-2	Communication between modules	BCU & BMU Communication 1
4	Fault 1	Fault indicator	Fault indicator 1
5	Run 1	Power indicator	Power indicator 1
6	Fault 2	Fault indicator	Fault indicator 2
7	Run 2	Power indicator	Power indicator 2
8	POWER	Auxiliary power input	BMS 220V ac auxiliary power input
9	DEBUG1	BCU communication	For debugging only
10	DEBUG2	BCU communication	For debugging only
11	COMM1- 1	Communication between RACKs	Connect to previous COMM2
12	P1-	PCS negative	Connect the negative terminal of the DC bus
13	P1+	PCS positive	Connect the positive terminal of the DC bus
14	PE	Grounding point	Grounding
15	P2-	PCS negative	Connect the negative terminal of the DC bus
16	P2+	PCS positive	Connect the positive terminal of the DC bus
17	QS2	Circuit breaker 2	Connect and disconnect the main circuit 2
18	QS1	Circuit breaker 1	Connect and disconnect the main circuit 1
19	B2+	Battery positive	Connect the highest module positive 2

20	B2-	Battery negative	Connect the highest module negative 2
21	B1+	Battery positive	Connect the highest module positive 1
22	B1-	Battery negative	Connect the highest module negative 2

Figure 7-6: PACK interface

Table 7-3: Interface Connectors of PACK

No.	Item	Function	Description
1	Deflagration vent	Deflagration vent	/
2	BMU COMM	BMU communication power supply	Including 24V power supply, CAN communication
3	Water inlet	Battery module water inlet	/
4	Water outlet	Battery module water outlet	/
5	MSD	Manual maintenance switch	Remove before transportation, install before operation
6	-	Battery Negative	/

7	+	Battery Positive	/

8 COMMISSIONING

After checking all wiring points, make sure the wire harness is not missing or loose. All personnel is forbidden to touch any original device and metal part before power-on operation. Keep a safe distance from the container.

When powering on the device for the first time, professionals must set the parameters correctly. Incorrect Settings may affect the normal operation of the device.

8.1 PRE-COMMISSIONING OF BCP

To ensure the long-term reliable and safe operation of your energy storage system, please read and follow the instructions carefully.
[Note] SYL is not responsible for battery damage and other losses caused by using it not per the specified requirements or using it beyond the specified range. Put into use chapter.

8.1.1 CABLE CONNECTION CONFIRMATION

After checking all wiring points, ensure that the cables are not missing or loose. Do not touch any original equipment or metal parts before powering on. Keep a safe distance, connection terminals are connected tightly and reliably.

Please check the following items carefully before starting.

Table 8-1: Check list

NO.	ITEM
1	All electrical connections must be made in accordance with this manual.
2	The container enclosure is grounded and the protective cover inside the device is securely installed.
3	The system stop button is in the normal state.
4	All AC circuit breakers in the BCP are disconnected, that is, in the "OFF" position.

5	The low-voltage power switches of the DC switchgear of all battery racks are in the ON state.
6	The DC switchgear disconnecting switches of all battery RACKs are in the "ON" position.
7	All PACK MSDs are inserted and locked properly.

8.1.2 MCB

Table 8-2: MCB0~MCB12

MCCB1	MCBB2	MCB0	MCB1	MCB2	MCB3	MCB4	MCB5
Main switch on	HVAC1#	SPD1	380V power	Socket	UPS	UPS bypass(Automatic switchover)	AC/DC

MCB6	MCB7	MCB8	MCB9	MCB10	MCB11
BMS	FSS	Ventilation fan	FSS	HVAC2#	220V Spare

8.2 POWER-ON PROCEDURES

8.2.1 POWERING ON THE AUXILIARY POWER SUPPLY

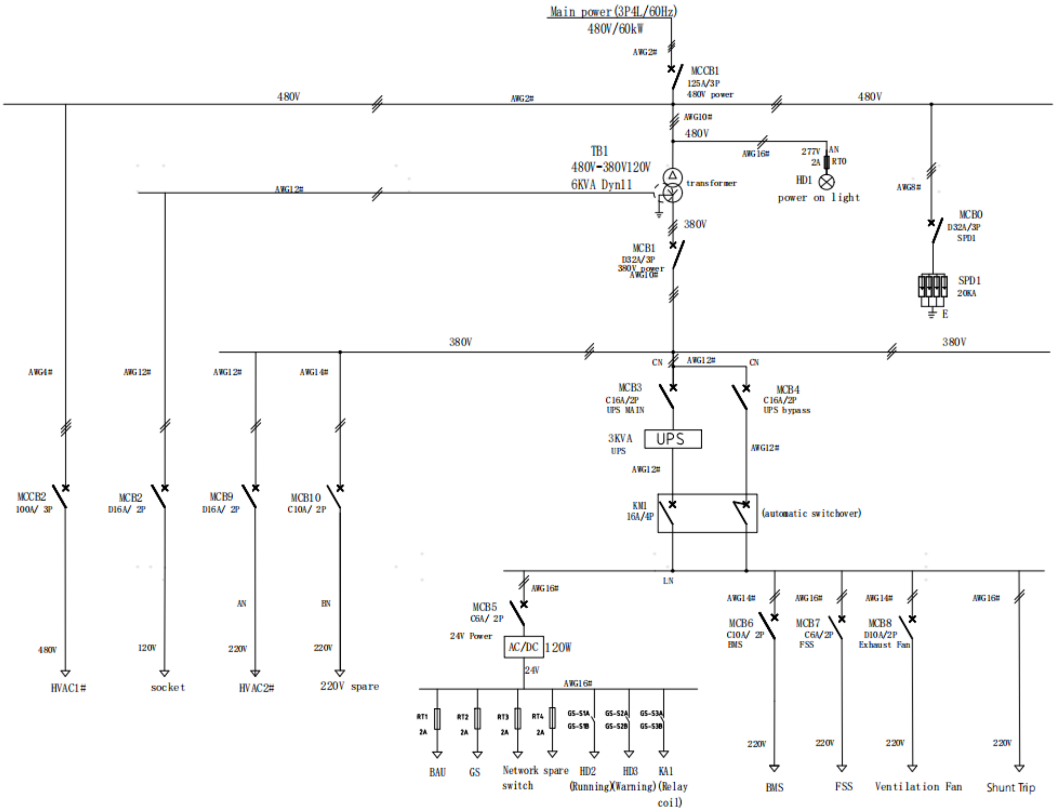


Figure 8-1: Auxiliary connection (for reference only)

Perform the following steps to power on the auxiliary power supply. Keep all the doors closed when the auxiliary power supply and DC battery are not in operation and maintenance mode; otherwise, the auxiliary power supply and DC battery will be forcibly powered off. Use the UPS cold start for the first power-on, enter 192.168.1.136 on the browser to access the GS-web terminal and change the GS operating mode from normal mode to operation and maintenance mode as shown in figure 8-2 (This change is automatically restored to the normal mode after the GS is powered off).

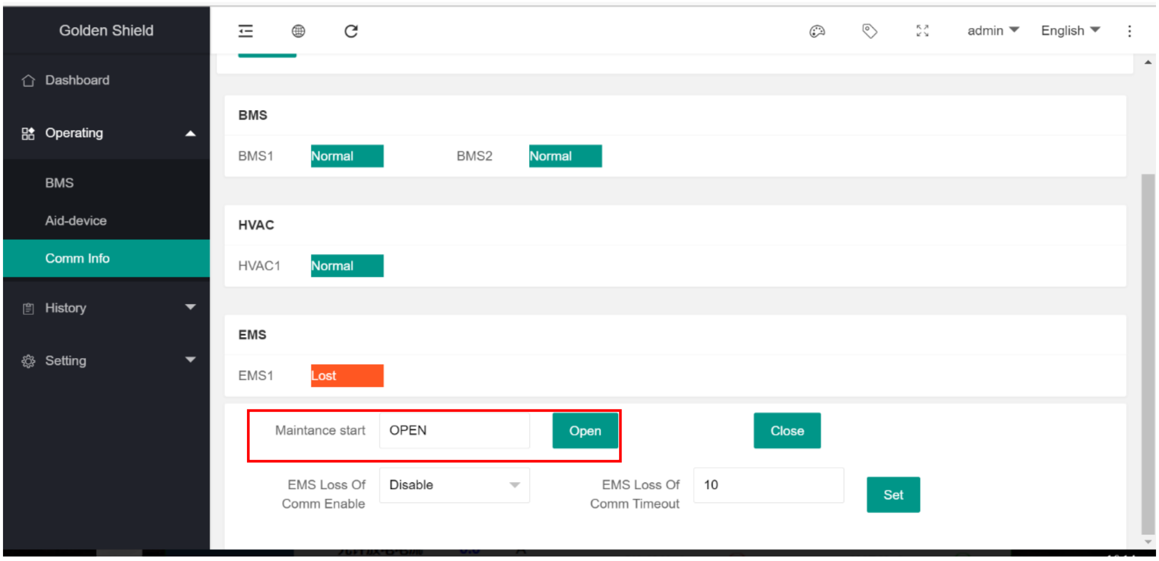


Figure 8-2: GS-web operation and maintenance mode switch

STEP 1: Press the <ON/Mute> button on the front panel of the UPS to start the fan and display the default UPS status screen. Press and hold the <ON/Mute> button for 3 seconds. The UPS buzzer rings for 1 second. Then the UPS is successfully started.

STEP 2: Close MCB5, switch power supply U1 AC/DC power supply, DC24V normal output, GS, switch, BAU and other devices power supply is completed.

STEP 3: Use a network cable to connect the PC to the GS-web port of the container or the switch in the BCP, access the GS-web terminal, and change the GS mode to operation and maintenance mode (exit the operation and maintenance mode after normal operation).

STEP 4: After the 480V 3P4L power supply is connected normally, close the MCCB1 480V power supply switch. At the same time, AC480V is converted to AC380V/AC120V.

STEP 5: Close MCB0 AC surge protector switch to ensure that the AC surge protector works properly.

STEP 6: Close the MCB1 380V power supply switch.

STEP 7: Close MCB3 UPS main power switch. The UPS power supply is normal and the UPS mode is switched to the mains electricity mode.

STEP 8: Close MCB4 UPS bypass switch to automatically switch to the bypass mode through the KM1 contactor when the UPS is abnormal.

STEP 9: Close MCB6 BMS power switch, and the AC power supply to the BMS is normal (the power indicator of the DC switchgear is green).

STEP 10:Open the fire suppression host, connect the 24V backup power, and close MCB7 fire suppression power switch, the fire suppression host power supply is normal.

STEP 11:Close MCB8 fire suppression fan switch, and the fan power supply is normal.

STEP 12:Close MCCB2, the liquid cooling unit runs automatically after power supply.

STEP 13:Close MCB2 maintenance socket power switch the container maintenance socket power supply is normal.

8.2.2 POWERING ON AND OFF THE HVDC

After the auxiliary power supply is normally powered, energy storage system information overview (figure 8-3) and the running status of all RACKs (figure 8-4) and HVACs (figure 8-5) can be normally viewed on the GS-web terminal.

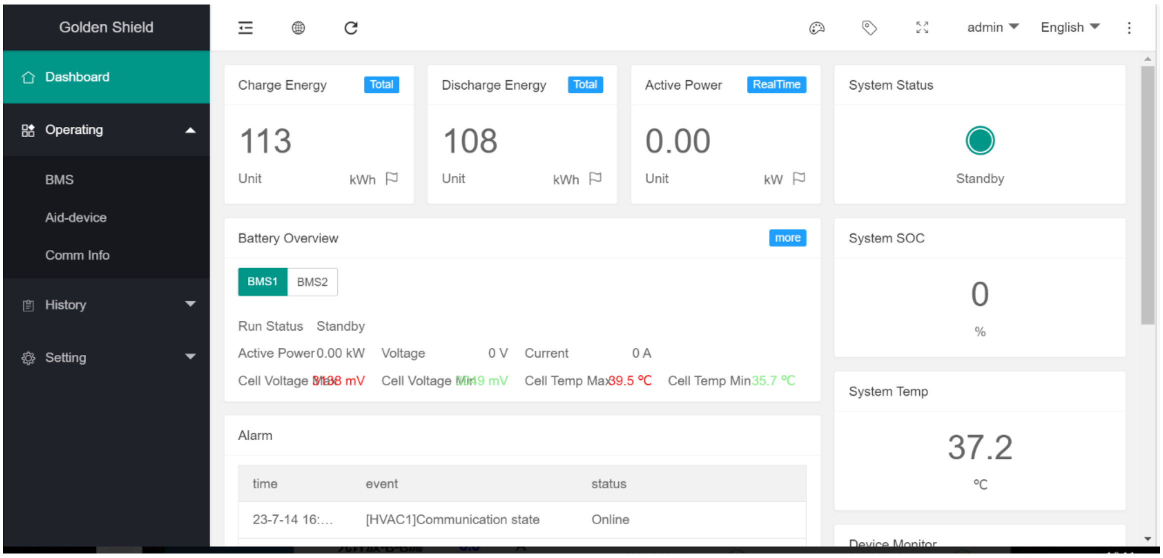


Figure 8-3: Energy storage system information overview

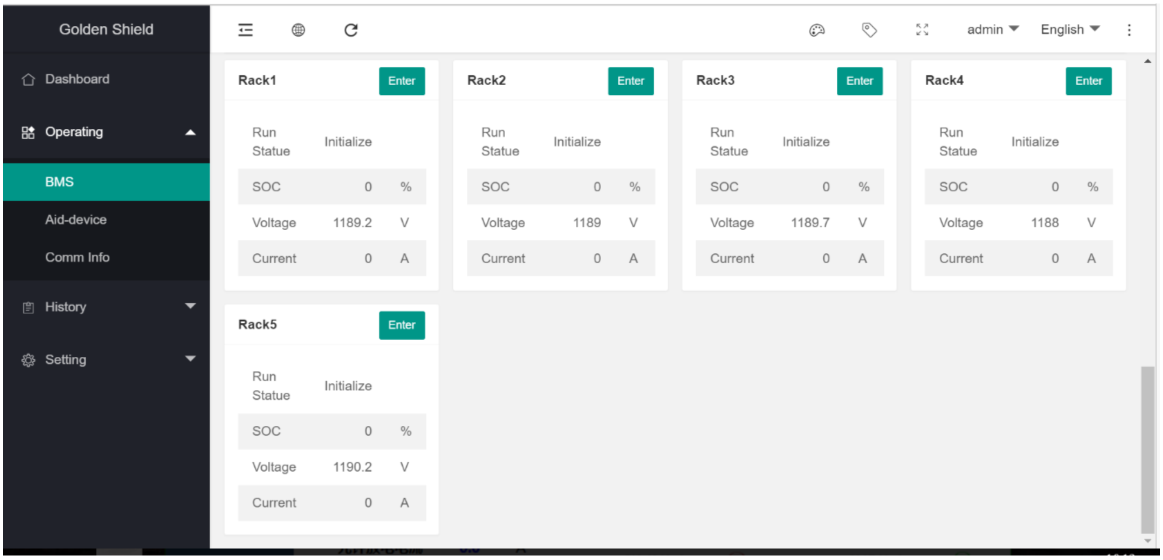


Figure 8-4: RACK information interface

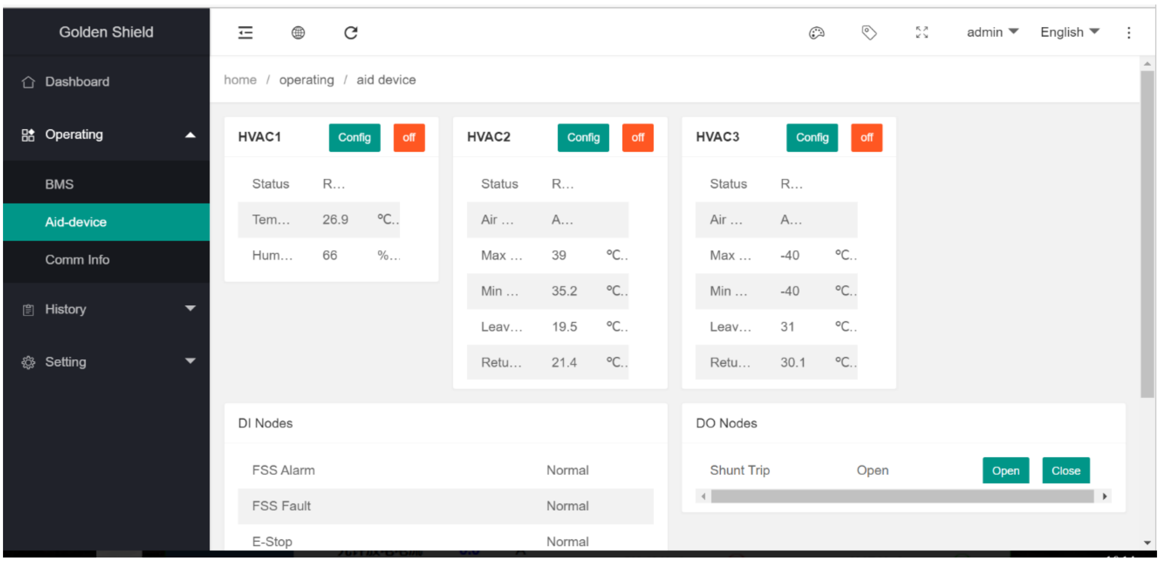


Figure 8-5: HVAC and other auxiliary equipment information

After the communication is normal, you can power on and off HVDC of RACK using the command or the GS-web terminal (as shown in figure 8-6 and figure 8-7). After the contactors of all RACK DC switchgears are closed, the DC side is powered on. Then charge and discharge power of PCS can be delivered as required.

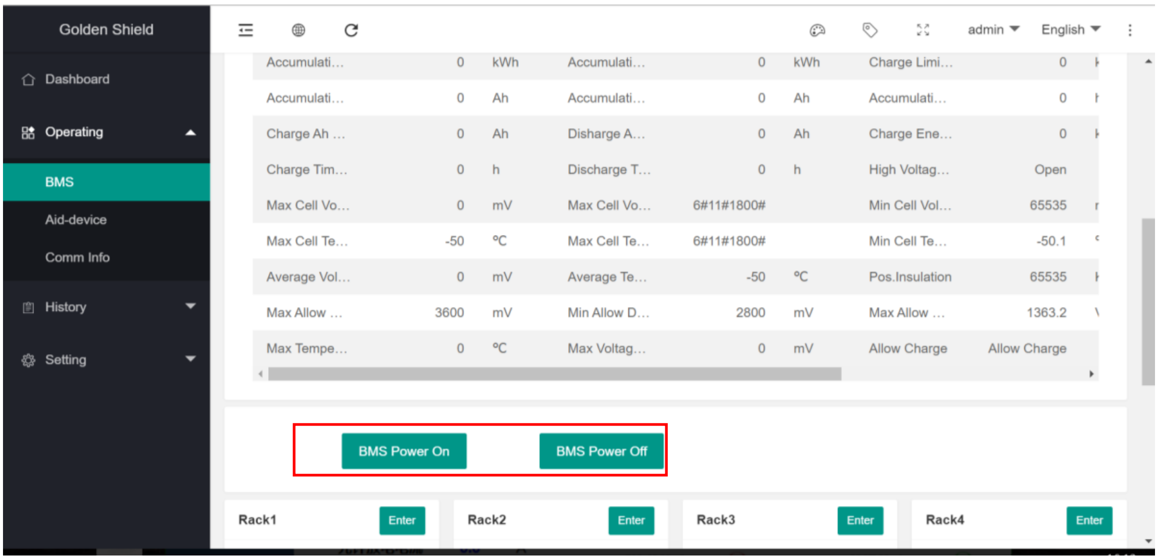


Figure 8-6: BMS real-time running information

8.3 POWER-OFF PROCEDURES

8.3.1 POWERING OFF THE AUXILIARY POWER SUPPLY

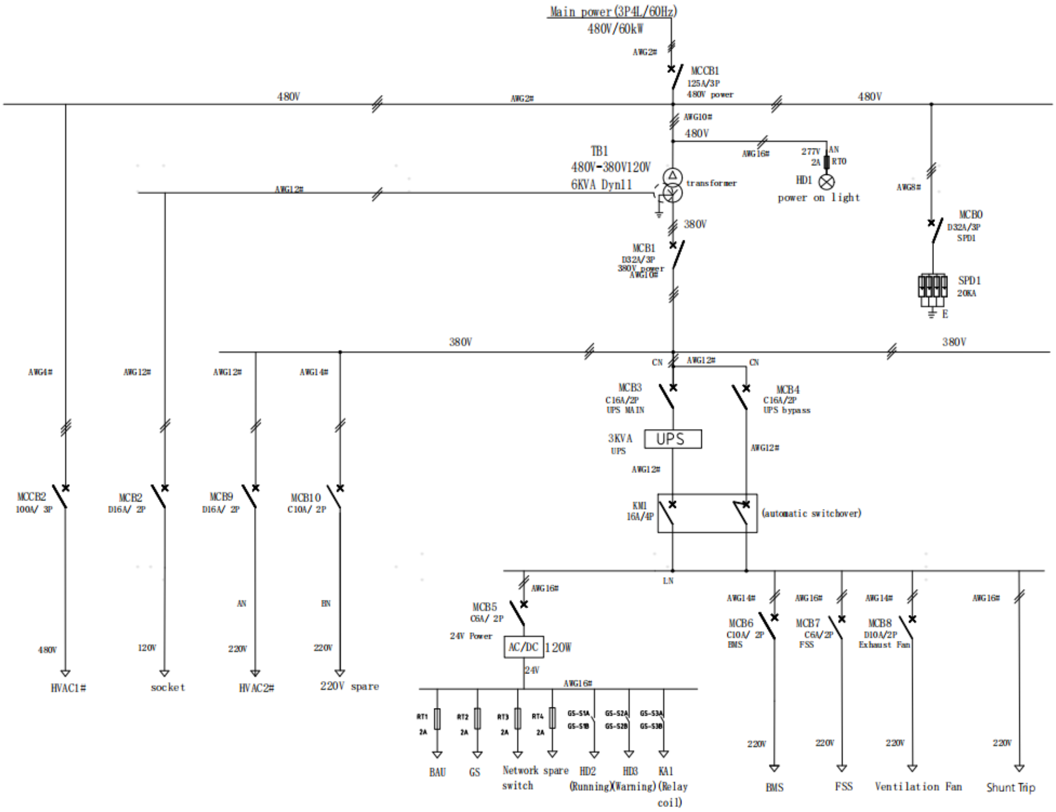


Figure 8-7: Auxiliary connection (for reference only)

STEP 1: Disconnect MCCB2, MCB2, MCB9, MCB10, MCB6, MCB8, MCB5.

STEP 2: Disconnect MCB3, MCB4.

STEP 3: Disconnect MCB1.

STEP 4: Disconnect MCCB1, disconnect 480V 3P4L power supply.

STEP 5: Shutdown UPS.

9 OPERATION

9.1 SYSTEM OPERATION

To ensure the long-term safe and reliable operation of your energy storage system, please read and follow the instructions below:

NOTE

OUR COMPANY WILL NOT BE LIABLE FOR ANY DAMAGE CAUSED BY FAILURE TO USE THE BATTERY SYSTEM IN ACCORDANCE WITH THE SPECIFIED REQUIREMENTS OR BEYOND THE SPECIFIED RANGE AND OTHER LOSSES ARISING OUT OF SUCH DAMAGE.

9.1.1 TEMPERATURE CHARACTERISTICS

- Operating ambient temperature: -30 °C ~50 °C. If stored in a cold environment (e.g. 0 °C) before installation, it will take some time to heat up before it can be recharged.
- Optimum operating ambient temperature: 0 °C ~45 °C. When the ambient temperature is higher than 45 °C or lower than 0 °C, the battery charging and discharging power decreases.
- Safe storage ambient temperature: -30 °C ~50 °C.
- Recommended storage environment temperature: 20°C ~30 °C.

9.1.2 CABLE CONNECTION CONFIRMATION

- Before power on, check the connection cable of the whole system, and make sure that the cable connection is reliable without aging fracture and insulation damage.
- Check whether the positive and negative poles of the DC output power cable in the container are connected correctly.
- Check whether the power connection of the container is correct.

- Check whether all communication wires and cables and sub connections at the connection ends are tight and reliable.

Refer to Section 7.3 for details of DC switchgear.

10 MAINTENANCE

To ensure the safety and the life span of the Battery Energy Storage BESS (BESS), proper maintenance is needed and necessary. SYL provides the Scheduled Maintenance Program (SMP) for up to 10 years for its BESS products, which will bring you trouble-free revenue generation. Cost adder, terms, and conditions apply for SMP.

10.1 PRECAUTIONS

DANGER

WHEN THE DEVICE IS RUNNING, A HIGH VOLTAGE MAY GENERATE ELECTRIC SHOCKS, RESULTING IN DEATH, SERIOUS PERSONAL INJURY, OR PROPERTY DAMAGE. THEREFORE, BEFORE PERFORMING ANY MAINTENANCE, POWER OFF THE DEVICE AND STRICTLY FOLLOW THE SAFETY PRECAUTIONS LISTED IN THIS MANUAL AND OTHER RELATED DOCUMENTS.

- Maintain the device when you are familiar with the contents of this manual and have appropriate tools and test devices.
- Before performing maintenance, power off the device, and then wait for the appropriate time according to the instructions on the delayed discharge label. Ensure that the device is powered off.
- During the maintenance process, avoid irrelevant personnel entering the maintenance site. Temporary warning signs or fences must be erected for isolation.
- If the device fails, please contact our after-sales service in time.
- Power on the device only after the fault is rectified. Otherwise, the fault may expand or the device may be damaged.
- Do not open the device without authorization, otherwise there will be a risk of electric shock, and the resulting failure is not covered by the warranty.

- Operation and maintenance personnel and technical professional should be fully trained in the safe use and maintenance of the device, and operate with adequate precautions and equipped with personal protective equipment.
- When you need to move or reconnect cables, cut off the power input. After the internal energy is completely out and using a multimeter to ensure that there is no dangerous voltage of the DC bus and the parts inside the machine to be repaired, the maintenance can be started.
- Battery maintenance should be performed or supervised by a personnel familiar with the battery and its required precautions.
- When replacing a battery, replace it with the same type of battery or battery pack.
- Check immediately after the maintenance operation to ensure that there is no tool or any other part left inside the device.
- If you do not use the device for a long time, store batteries and recharge them according to this manual

10.2 BATTERY OPERATING TERMS AND OPERATING INSTRUCTIONS

10.2.1 TERMS EXPLANATION

Table 10-1: Terms Explanation

TERM	EXPLANATION
Normal operating	Refers to the system that works every day.
Long-time unused	The battery system has not started working for more than 6 months.
Battery module	The products with power storage and communication function produced by SYL which are sent to customers as spare parts
Discharge energy efficiency	The ratio of discharge energy to charge energy

10.2.2 PERSONNEL REQUIREMENTS

Duties of operation and maintenance engineer:

1) Repair and maintenance of battery system and spare parts, find, report and deal with defects, faults and abnormal operation of products and spare parts.

2) Inspect the operating status of the battery system, monitor instruments and the interface of the upper computer, record data and fill in reports.

10.2.3 GENERAL REQUIREMENTS

- Battery system and spare parts must be maintained by professional personnel.
- Operation and maintenance personnel must receive professional on-the-job training and may not take up their posts until they pass the examination.
- Operation and maintenance personnel must follow the operation process and post specifications.
- Two or more personnel must be present during operation and maintenance and they must take protective measures.

10.2.4 BATTERY SYSTEM STORAGE AND MAINTENANCE PRINCIPLES

10.2.4.1 NORMAL OPERATING STATE CHANGES TO LONG-TIME UNUSED STATE

1) Charge/discharge the battery at 0.25P, adjust the SOC to 30% ~ 40%, record the voltage value of all batteries at this time, and cut off to the system power consumption equipment.

2) Power on the battery system every month, check the cell voltage, SOC and make record, and compare with the data recorded last time. If the SOC value is less than 15%, a charge and discharge activation is required; If the SOC value is less than 30% and more than 15%, the battery system needs to be charged at 0.25P to 40%SOC.

3) Charge and discharge the battery system every 3/6 months, and then charge/discharge at 0.25P to 40%SOC.

10.2.4.2 LONG-TIME UNUSED STATE CHANGES TO NORMAL OPERATING STATE

Activate the battery system with a full charge and discharge at 0.25P power, then maintain the battery system once.

10.2.4.3 CHARGING AND DISCHARGING ACTIVATION METHOD OF BATTERY SYSTEM

1) Discharge the battery system at 0.25P until the system terminates;

2) Standing: the time can be adjusted according to the site situation;

3) Charge the battery system at 0.25P until the system terminates;

4) Standing: the time can be adjusted according to the actual use;

5) Discharge the battery system at 0.25P until the system terminates;

6) Standing: the time can be adjusted according to the actual use;

7) Charge the battery system at 0.25P to 40%SOC.

10.2.4.4 BATTERY CELL MAINTENANCE STANDARD IN BATTERY SYSTEM

Based on the basic performance of the lithium battery to maximize the performance of the battery module, if the following situations occur during the charging and discharging process of the battery module, locate the battery module of the faulty battery cell, remove the battery module from the system, and maintain it:

1) The battery voltage at the discharging end is 400mV lower than the average battery voltage in Rack;

2) The battery voltage at the charging end is 300mV higher than the average battery voltage in Rack;

3) The temperature of the battery cell during charging and discharging is 5℃ higher than the average temperature.

10.2.4.5 CELL MAINTENANCE

- Check before cell maintenance

After removing the battery module from the Rack, check the following:

1) Battery module insulation: Use an insulation meter to measure the insulation value at the positive and negative terminals. If the insulation value is less than 10 MΩ, stop follow-up operations and contact after-sales engineers immediately.

2) Wiring harness check: Visually check whether the high and low voltage wiring harness inside the battery module is aging, falling off, damaged, needle withdrawal, pseudo soldering and other phenomena. If the above phenomena occur, the wiring harness needs to be replaced.

➢ Cell maintenance methods

a. The battery voltage is too low:

1) Discharge the battery module to the minimum voltage of single cell 2.8V;

2) Screen cells with discharging end voltage are less than 3.1V;

3) Recharge the screened cell: recharge the cell to the average voltage +30mV;

4) Continue to discharge the battery module to the minimum voltage of single cell 2.8V after recharge;

5) Screen cells with discharging end voltage are less than 3.0V;

6) Recharge the screened cell: recharge the cell to the average voltage +30mV.

b. The battery voltage is too high:

1) Charge the battery module to the maximum voltage of single cell 3.65V;

2) Screen cells with charging end voltage are greater than 3.4V;

3) Discharge the screened cell: discharge the cell to the average voltage -30mV;

4) Continue to charge the battery module to the maximum voltage of the single cell 3.65V after the discharge balance;

5) Screen cells with charging end voltage greater than 3.45V

6) Discharge the screening cell: discharge the cell to the average voltage +30mV;

c. The battery temperature is abnormal

1) Check whether the temperature sampling line of the battery cell is damaged, broken, pseudo soldering, needle withdrawal, etc. If the sampling line is abnormal, the sampling line needs to be repaired or replaced;

2) Test the AC internal resistance of the battery cell to check whether it is less than 1.8MΩ. If the internal resistance is greater than or equal to 1.8MΩ, replace the battery module where the abnormal battery cell resides.

10.2.5 SPARE PARTS (MODULE/RACK) STORAGE, MAINTENANCE AND PRECAUTIONS

10.2.5.1 BASIC REQUIREMENTS FOR STORING SPARE PARTS

Based on the basic performance of lithium batteries, spare parts must meet the following requirements during storage to maximize battery protection:

1) Storage temperature: -30 ~ 25℃, relative humidity: less than 60%, dry, clean and well-ventilated warehouse, to ensure that there is no short circuit, to avoid water, oil and other liquids into the box resulting in corrosive battery rust.

2) Storage SOC: 20% ~ 50%.

3) Charge and discharge activation should be carried out every 6 months during the storage period. For details, see the chapter of Operation process.

4) Check the main parameters every 3 months: total voltage, single cell voltage, cell temperature, cell voltage difference. If the total voltage is too low or the sampling is abnormal, maintain the battery module in time.

5) Spare parts should be handled lightly during loading and unloading, placed neatly, and strictly prevented from tumbling and heavy pressure.

6) Spare parts should not be stored upside down to avoid mechanical impact or heavy pressure. Battery Eexposure to sun and rain is strictly prohibited.

10.2.5.2 CHECK BEFORE SPARE PARTS MAINTENANCE

Before maintaining spare parts, check the following:

1) Battery module insulation: Use an insulation meter to measure the insulation value at the positive and negative terminals. If the insulation value is less than 10MΩ, stop follow-up operations and contact after-sales engineers immediately.

2) Wiring harness check: Visually check whether the high and low voltage wiring harness inside the battery module is aging, falling off, damaged, needle withdrawal, pseudo

soldering and other phenomena. If the above phenomena occur, the wiring harness needs to be replaced.

3) Voltage check: battery module storage voltage range: 340.81V ~ 343.93V; cell voltage range: 3.277V ~ 3.307V, if the battery module voltage or cell voltage is not within this range need to maintain the battery module or cell.

4) Cell temperature check: Check the internal cell temperature of the battery module through the upper computer. If the cell temperature differs from the average temperature by 5℃ or more, the battery module needs to be maintained.

10.2.5.3 MAINTENANCE METHODS

- The total battery module voltage is too low:

  1) When the total voltage of the battery module is less than 340.81V, recharge the battery module.

  2) At 25℃, the battery module adopts 1/3C constant current discharge to the minimum cell voltage of 2.8V;

  3) Let stand for 1h;

  4) Charge the battery module with 1/3C constant current for 72min at 25℃;

  5) Let stand for 3h;

  6) Measure the open circuit voltage of the battery module to ensure that the battery module voltage reaches 340.81V;

  7) If the open circuit voltage of the battery module does not reach the target voltage value, the SOC state value is calculated according to the SOC-OCV table of the battery module charging in Appendix 1, and 0.1C is continued to charge to 40%SOC.

- The cell voltage is too low

  1) When the voltage of the battery cell in the battery module is less than the average voltage 20mV, it is necessary to recharge the lowest voltage battery cell in the battery module;

2) Charge the battery cell at 0.1C at 25℃ to an average voltage of +30mV;

3) Let stand for 3h;

4) Measure the open circuit voltage of the recharge cell. If it is not reached, continue to recharge the cell according to step 2).

- Temperature anomaly

1) Check whether the temperature sampling line of the battery cell is damaged, broken, pseudo soldering, needle withdrawal, etc. If the sampling line is abnormal, the sampling line needs to be repaired or replaced;

2) Test the AC internal resistance of the battery cell to check whether it is less than 1.8mΩ. If the internal resistance is greater than or equal to 1.8mΩ, replace the battery module where the abnormal battery cell resides.

10.2.5.4 MAINTENANCE METHODS

- Safety precautions

The safety precautions listed below are essential for the safe charging of the battery module:

1) Be careful with the dangerous voltage in the battery module and pay attention to the risk of short circuit.

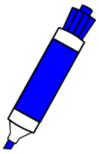
2) Improper operation may result in serious personal injury and property damage.

3) When charging the battery module, do not wear metal jewelry such as necklaces, rings or watches.

- Tools and equipment

I. Tool list

NO.	1	2	3	4	5	6
Name	Charger	Insulated Multimeter	Electric Screw Driver	Marker Pen	Cutter	Grounding Pad

Reference Image						
Measurement Accuracy	±0.5%	0.1mV				

II. Recommended specification of charger

a. Nominal Working Conditions

1) Input voltage: AC220V±10% 50Hz default value; to select the charger model according to the local grid voltage standard;

2) Working Environment: -10℃ ~ +40℃, Relative Humidity < 80%

3) Charging mode: applicable with constant current mode charging

b. Power Output Parameter:

DC Output Voltage Range	DC Output Current Range	Voltage Stability	Current Stability	Load Stability	Ripple and Noise	Measurement accuracy
0～500V	0～200A	≤0.2%	≤0.5%	≤0.5%	≤1%（RMS）	±0.5%

c. Device Function(optional):

1) Storage environment: -20℃ ~ +80℃;

2) Relative humidity < 80%;

3) Equipped with HMI, available to read charging voltage, charging current, charging capacity, charging time and other data from the charging HMI interface.

d. Safety Equipment

NO.	1	2	3	4	5	6
Item	Safety Helmet	Eye Protection	High Visibility Clothing	Protective Gloves	Protective Footwear	Fire Extinguisher

Reference photo		
Specifications	Class 00 or higher-level PPE	The fire extinguisher should be suitable for LPF battery thermal runaway.

- Charge and discharge process

Charge and discharge battery modules according to the following process:

Step	Operation Process	Annotations/Step:	Applied Tools
1	Prepare at least 1 fire extinguisher in the visible area (The fire extinguisher should be suitable for LPF battery thermal runaway.);	Prevent fire caused by short circuit	Fire Extinguisher
2	Wear personal protective equipment, including hard hats, protective glasses, high suits, gloves, and shoes with steel protective parts.	Avoid personal injury caused by any short circuit, arc flash or static electricity.	Personal Protective Equipment
3	Select the battery module needs to be checked and measure its voltage	Mark the package of the selected module with "Checked @date"	Label
4	Open the packaging/carton of the battery module	When unpacking the module, handle it with care to avoid damaging the module and package.	Cutter

5	Remove the battery module from its packaging and place it on a grounding pad or connect the grounding cable to the module shell.	Considering the weight of the battery module, you need to use a forklift lifting tool to remove the battery module from the packaging and move the module.	Grounding pad
6	Set the insulation multimeter to the insulation detection gear, and measure the insulation resistance at the docking point of the "P+/Output+" and "P-/Output-" terminals of the battery module for 30s.	The insulation resistance is greater than 10MΩ If the insulation resistance is less than 10 MΩ, contact after-sales personnel.	Insulated Multimeter
7	Set the insulation multimeter to the voltage gear, measure the voltage between "P+/Output+" and "P-/Output-" terminals of the battery module, and record the voltage V1.	If the voltage V1 measured of the battery module is equal to or greater than 340.81V, the battery module does not need to be charged. Go to Step 12.	Insulated Multimeter
		If the measured voltage V1 of the battery module is in the range of 340.81-343.93V, and it is planned to be installed and operated in the near future, the battery module does not need to be charged; Go to Step 12.	
		If the measured voltage V1 of the battery module is lower than 340.81V, and the installation and operation are not planned in the near future, the battery module needs to be charged. Follow Step 7 to charge all modules.	
		If the measured voltage V1 of the battery module is lower than 208V, the module has been permanently damaged, please contact us in time. And the module need to be fully packed back into the package, do not place with the normal module, need to place the module separately in different areas.	

8	Press the power button to turn on the battery charger.	You are advised to set the CC constant current mode to charge the battery module. The charging voltage is set to the maximum voltage of 374.4V, and the maximum output current is set to not exceed 93.33A. When the setup is complete, turn off the power button.	Charger
9	Connect "P+/Output+" of the battery module to the positive terminal of the battery charger, and "P-/Output-" to the negative terminal.	Check the connection carefully before proceeding to the next step, as a wrong connection may damage the battery charger and battery module. In addition, it may lead to fire accidents. The harness connecting the battery charger to the module must meet a safe current carrying wire diameter of at least 100A or greater.	Charger
10	Turn on the power button to start charging, the battery charger displays the real-time charging voltage and current of the battery, and the upper computer displays the real-time single battery voltage	The charging voltage on the battery charger is the real-time voltage of the battery module, and the current is less than or equal to 93.33A. Charge the battery module until the battery charger shows that the voltage reaches the target voltage and the current is equal to or less than 2A.	Charger
11	Press the power button to turn off the battery charger and disconnect the cable between the battery charger and the battery module.	Make sure the battery charger is powered off before disconnecting. Disconnect the wiring terminals on the battery modules one by one, and cover the first terminal with insulation before removing it to avoid short circuit.	Charger
12	Use a multimeter to measure the voltage of the battery module and record the voltage V2.		Charger

13	Put the battery module back into the package and seal the package.	1. Before packaging, check whether all module accessories are included. 2. Ensure that the module is clean and free from damage. 3. Considering the weight of the battery module, use the forklift lifting tool to install the battery module back into the package	

Charge and discharge the cell according to the following process

Step	Operation Process	Annotations/Step:	Applied Tools
1	Prepare at least 1 fire extinguisher in the visible area (The fire extinguisher should be suitable for LPF battery thermal runaway.);	Prevent fire caused by short circuit	Fire Extinguisher
2	Wear personal protective equipment, including hard hats, protective glasses, high suits, gloves, and shoes with steel protective parts.	Avoid personal injury caused by any short circuit, arc flash or static electricity.	Personal Protective Equipment
3	Select the battery module needs to be checked and measure its voltage	Mark the package of the selected module with "Checked @date"	Label
4	Open the packaging/carton of the battery module	When unpacking the module, handle it with care to avoid damaging the module and package.	Cutter
5	Remove the battery module from its packaging and place it on a grounding pad or connect the grounding cable to the module shell.	Considering the weight of the battery module, you need to use a forklift lifting tool to remove the battery module from the packaging and move the module.	Grounding pad
6	Set the insulation multimeter to the insulation detection gear, and measure the insulation resistance at the docking point of the "P+/Output+" and "P-	The insulation resistance is greater than 10MΩ If the insulation resistance is less than 10 MΩ, contact after-sales personnel.	Insulated Multimeter

	/Output-“ terminals of the battery module for 30s.		
7	Read the voltage value of all cells inside the module and the average voltage of cells inside the module through the upper machine;	If the difference between the voltage value of the battery cell and the average voltage value in the battery module is greater than or equal to 20mV, it is necessary to use a high-precision multimeter (0.1mV) to measure the battery cell again, and then balance the charge and discharge of the battery cell after confirming the voltage value.	Insulated Multimeter
		If the difference between the voltage of the battery cell and the average voltage is less than 20mV, it is not necessary to balance the charge and discharge of the battery cell.	
8	Press the power button to turn on the battery charger.	You are advised to set the CC constant current mode to charge the battery module. The charging voltage is set to the maximum voltage of 3.65V, and the maximum output current is set to not exceed 30A. When the setup is complete, turn off the power button.	Charger
9	Open the upper cover of the battery module and connect “cell+” to the positive terminal of the battery charger and "cell -" to the negative terminal.	Check the connection carefully before proceeding to the next step, as a wrong connection may damage the battery charger and battery module. In addition, it may lead to fire accidents. The harness connecting the battery charger to the cell must	Charger

		meet a safe current carrying wire diameter of at least 30A or greater.	
10	Turn on the power button to start charging, the battery charger displays the real-time charging voltage and current of the battery, and the upper computer displays the real-time single battery voltage	The charging voltage on the battery charger is the real-time voltage of the battery module, and the current is less than or equal to 28A. Charge the battery module until the battery charger shows that the voltage reaches the target voltage.	Charger
11	Press the power button to turn off the battery charger and disconnect the cable between the battery charger and the battery module.	Make sure the battery charger is powered off before disconnecting. Disconnect the wiring terminals on the battery modules one by one, and cover the first terminal with insulation before removing it to avoid short circuit.	Charger
12	Use a multimeter to measure the voltage of the cell and record the voltage V2.	If the battery voltage does not reach the target voltage, perform Step 9 to recharge the battery.	Charger
13	Put the battery module back into the package and seal the package.	1. Before packaging, check whether all module accessories are included. 2. Ensure that the module is clean and free from damage. 3. Considering the weight of the battery module, use the forklift lifting tool to install the battery module back into the package	

Appendix 1

1P104S Battery Module 25℃- static SOC-OCV			
Discharge		Charge	
SOC	OCV	SOC	OCV
100%	365.7108	100%	361.4104
90%	346.5253	90%	347.3472
80%	346.3225	80%	347.3982
70%	346.2270	70%	347.3998
60%	343.4069	60%	344.8454
50%	342.4269	50%	343.9275
40%	342.1816	40%	343.7075
30%	341.3979	30%	343.5105
20%	338.0144	20%	340.8133
10%	333.6138	10%	335.3212
0%	299.9464	0%	299.9404

10.3 FIRE EXTINGUISHING SYSTEM MAINTENANCE

- Inspect the smoke detector every 12 months, open the door of the container, and turn on the power. If the temperature and smoke indicators blink every few seconds, it is considered that the container is in normal working state.
- Inspect water and fire pipes every 6 months for leaks.
- Check intake shutter and exhaust fans every 6 months to see if they can be started or stopped manually.
- Check the batteries in the fire control host every 12 months to check whether the batteries are normally charged and the voltage is within the normal range

10.4 AIR CONDITIONING SYSTEM MAINTENANCE

- Inspect the air conditioning system every 6 months to check for dust collection and foreign matter blockage in the outer circulation vents.
- Check that the air conditioner fan blades are not damaged every 6 months and that the rotating fan is smooth and no noise is detected.
- Check whether the electrical cables and wiring terminals of the air conditioner are loose every 6 months.
- Check the condenser every 6 months for foreign matter blockage and no serious bending deformation of fins.
- Use a brush or cotton cloth every 6 months to clean dirt and dust from the filter, condenser, inlet and outlet air ducts, and fan blades.
- Use a brush or cotton cloth every 6 months to clean the liquid cooling unit dirt and dust.
- Test the coolant every 6 months, use the coolant detector to detect the concentration ≤50%, and visually detect the coolant without dirt, precipitation, algae, etc.

11 COMMON FAULTS AND TROUBLESHOOTING

The common faults and troubleshooting are as follows.

Table 11-1: Common faults and troubleshooting

NO.	Fault category	Fault description	Handing method
1	The voltage display of the cell is inconsistent with the actual voltage (exceeding the requirement of voltage);	1. The collection harness is loose; 2. The cable harness is damaged; 3. The BMU unit is damaged.	1. Use a multimeter to measure the actual voltage. 2. Remove and insert the cable harness connector to check whether the cable harness is connected properly. 3. Replace the BMU with a new one and check whether the BMU is normal. 4. Replace the sampling harness and observe the phenomenon;
2	Cell voltage fluctuation	1. The collection harness is loose; 2. Large on-site interference; 3. The BMU unit is damaged.	1. Remove and insert the cable harness connector to check that the cable harness is normal. 2. Replace the BMU and run it on this PACK.
3	The number of cells collected is abnormal	1. The project configuration is incorrect; 2. The collection harness is abnormal. 3. The BMU unit is damaged.	1. Check whether the item configuration is normal. 2. Remove and insert the collection wire harness to check whether the collection circuit is normal. 3. Replace the slave controller of the BMU and check whether the BMU is normal.

4	Temperature display -40 ℃ /125 ℃	1. NTC damage/harness damage (-40℃ is open circuit, 125℃ is short circuit); 2. The BMU unit is damaged.	1. Reinsert the connector or replace the sampling cable harness to check whether the cable harness is normal. 2. Replace the BMU and check whether the BMU is normal.
5	The temperature collection quantity is abnormal	1. The project configuration is incorrect; 2. The collection harness is abnormal. 3. The BMU unit is damaged.	1. Check whether the item configuration is normal. 2. Remove and insert the collection wire harness to check whether the collection circuit is normal. 3. Replace the slave controller of the BMU and check whether the BMU is normal.

6	The temperature jumps up	1. Received external interference; 2. The BMU unit is damaged.	1. Replace the slave controller of the BMU and check whether the BMU is normal.
7	The temperature jumps down	1. The connector resistance is large;	1. Reinsert the BMU collection harness connector.

8	The battery total voltage collection is abnormal	1. There is a breakpoint in the collection circuit; 2. The fuse is blown; 3. The cable position is abnormal. 4. The BCU main control unit is damaged.	1. Disassemble the DC switchgear and conduct a conduction test on the fuse to determine whether the fuse is normal; 2. Confirm the wiring position of the collection circuit; 3. Measure that the collection circuit is on and confirm that the collection circuit is normal; 4. Replace the BCU and check whether the BCU is normal.
9	The total voltage collection on the load is abnormal	1. There is a breakpoint in the collection circuit; 2. The relay is sticky; 3. The cable position is abnormal. 4. The BCU main control unit is damaged.	1. Measure that the collection circuit is on and confirm that the collection circuit is normal; 2. Measure the relay status to confirm whether it is sticky; 3. Check the wiring position of the collection circuit; 4. Replace the BCU and check whether the BCU is normal.
10	The current is 0	1. The Hall power supply is lost. 2. The Hall baud rate of CAN	1. Check the Hall power supply. 2. Check the CAN Hall Baud rate. 3. Check the communication harness;

		communication is incorrect. 3. The communication harness is abnormal. 4. The solution selected in the configuration is incorrect.	4. Check the Hall scheme.
11	The direction of the current sensor is reversed	1. The direction of the current sensor is incorrectly selected.	1. Check the Hall scheme.
12	The insulation withstand voltage is faulty	1. PCS and BMS are tested for insulation withstand voltage simultaneously;	1. Check whether the insulation voltage withstand of PCS is carried out, and check whether the fault is triggered after disconnecting PCS;

13	The master/slave communication is abnormal	1. The communication harness is abnormal. 2. The matching resistance is not added. 3. The baud rate of the master/slave communication is inconsistent. 4. The slave control address is not assigned;	1. Check the communication harness; 2. Check the baud rate in the configuration. 3. Check the BMU address.
14	The total/master communication is abnormal	1. The CAN line is abnormal. 2. The terminal resistor is not added. 3. The total/master baud rate is inconsistent. 4. The master address is not assigned. 5. The bus is too long;	1. Check the communication harness; 2. Check the terminal resistance; 3. Check the baud rate in the configuration. 4. Check the BCU address. 5. Change the baud rate and check whether the baud rate is abnormal.
15	The BMS-PCS communication is abnormal	1. The point meter is not connected clearly;	1. Confirm the meter of communication points used by both sides;

		2. The communication harness is abnormal. 3. The BMS hardware is faulty. 4. Configuration problems.	2. Check BMS-PCS communication harness; 3. Replace the BMS hardware. 4. Check whether the point meter and dry contact exist in the configuration.
16	The MS-GS/EMS communication is abnormal	1. The point meter is not connected clearly; 2. The communication harness is abnormal. 3. The BMS hardware is faulty. 4. Configuration problems.	1. Confirm the meter of communication points used by both sides; 2. Check MS-GS/EMS communication harness; 3. Replace the BMS hardware. 4. Check whether the point meter and dry contact exist in the configuration.
17	Relay abnormal	1. Relay feedback harness is abnormal; 2. The relay is sticky;	1. Check the relay feedback harness; 2. Test the relay status and replace the relay;
18	Isolation switch abnormal	1. The isolation switch auxiliary contact feedback is abnormal;	1. Check the feedback harness of the isolation switch. 2. Check whether the auxiliary contact of the isolation switch is properly inserted. 3. Check whether the auxiliary contact of the isolation switch is normal;
19	Access control failure	1. The access control display is reversed; 2. The access control does not act;	1. Check whether cable connections to the access control system are normal. 2. Check the item configuration.

		3. The configuration is not written. 4. Access control damaged;	3. Check the configuration. 4. Replace the access control inspection;
20	Air conditioner failure	1. The air conditioner power supply is lost. 2. The air conditioner is damaged. 3. Communication loss;	1. Check whether the power supply to the air conditioner is normal. 2. Check whether the communication is normal; 3. Use the upper computer of the air conditioner to check the fault of the air conditioner.
21	Fire failure	1. The fire control controller displays that the main power supply is faulty. 2. The fire control controller displays that the ZONE circuit is faulty.	1. Check whether the fire power supply is normal. 2. Check the temperature and smoke sensors based on the fire extinguishing wiring diagram. 3. Check the circuit and check whether the corresponding 470Ω and 6.8K resistors are correctly connected.

12 After-sales Service

SLY (Ningbo) Battery Co., Ltd. provides customers with a full range of technical support and after-sales service. Users can gain services by dialing our service number.

Please refer to the contract for the free warranty service information.

The following circumstances are not within the scope of our free warranty service:

- System damage or failure caused by not following the user manual.
- Damage or failure caused by not following the relevant electrical safety specifications for wiring and power supply, or caused by poor site environment.
- System damage or failure caused by users' private modification.
- System damage or failure is caused by irresistible natural factors, such as typhoons, earthquakes, floods, fire, or harsh environments (high temperature, low temperature, high humidity, acid rain, etc.).
- After the failure occurs, the user fails to maintain the initial failure state, fails to timely notify the manufacturer, and handles without authorization, thus causing it to be unable to make a practical fault identification of the failure.

13 contact

If you have technical issues with our products, please contact us. The following data is required to provide you with the necessary assistance:

- Product model number
- Serial number
- Fault information
- A detailed description of the problem

China
SYL (Ningbo) Battery Co., Ltd.

No. 23 Xingke Zhong Road,
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Appendix D

SAFETY DATA SHEETS

Solstice® 513A

10668670

Version 1.3 Revision Date 04/05/2023 Print Date 07/06/2023

SECTION 1. IDENTIFICATION

Product name	:	Solstice® 513A
Number	:	000000022892
Product Use Description	:	Refrigerant
Manufacturer or supplier's details	:	Honeywell International Inc. 115 Tabor Road Morris Plains, NJ 07950-2546
For more information call	:	800-522-8001 +1-973-455-6300(Monday-Friday, 9:00am-5:00pm)
In case of emergency call	:	**Medical: 1-800-498-5701 or +1-303-389-1414**
	:	**Transportation (CHEMTREC): 1-800-424-9300 or +1-703-527-3887**
	:	
	:	(24 hours/day, 7 days/week)

SECTION 2. HAZARDS IDENTIFICATION

Emergency Overview

Form	:	Liquefied gas
Color	:	clear colourless
Odor	:	slight ether-like

Classification of the substance or mixture

Classification of the substance or mixture	:	Gases under pressure, Liquefied gas Simple Asphyxiant

GHS Label elements, including precautionary statements

Symbol(s) :

Signal word : Warning

Hazard statements : Contains gas under pressure; may explode if heated.
May displace oxygen and cause rapid suffocation.

Precautionary statements : **Storage:**
Protect from sunlight. Store in a well-ventilated place.

Hazards not otherwise classified : May cause cardiac arrhythmia.
May cause frostbite.
May cause eye and skin irritation.

Carcinogenicity

No component of this product present at levels greater than or equal to 0.1% is identified as a known or anticipated carcinogen by NTP, IARC, or OSHA.

SECTION 3. COMPOSITION/INFORMATION ON INGREDIENTS

Chemical nature : Mixture

Chemical name	CAS-No.	Concentration
2,3,3,3-Tetrafluoroprop-1-ene	754-12-1	56.00 %
1,1,1,2-Tetrafluoroethane	811-97-2	44.00 %

SECTION 4. FIRST AID MEASURES

Inhalation : Move to fresh air. If breathing is irregular or stopped, administer artificial respiration. Use oxygen as required, provided a qualified operator is present. Call a physician. Do not give drugs from adrenaline-ephedrine group.

Skin contact	:	After contact with skin, wash immediately with plenty of water. If there is evidence of frostbite, bathe (do not rub) with lukewarm (not hot) water. If water is not available, cover with a clean, soft cloth or similar covering. If symptoms persist, call a physician.
Eye contact	:	Rinse immediately with plenty of water, also under the eyelids, for at least 15 minutes. In case of frostbite water should be lukewarm, not hot. If symptoms persist, call a physician.
Ingestion	:	Unlikely route of exposure. As this product is a gas, refer to the inhalation section. Do not induce vomiting without medical advice. Call a physician immediately.

Notes to physician

Indication of immediate medical attention and special treatment needed, if necessary	:	Because of the possible disturbances of cardiac rhythm, catecholamine drugs, such as epinephrine, should be used with special caution and only in situations of emergency life support. Treatment of overexposure should be directed at the control of symptoms and the clinical conditions. Treat frost-bitten areas as needed.

SECTION 5. FIREFIGHTING MEASURES

Suitable extinguishing media	:	The product is not flammable. Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide. Use extinguishing measures that are appropriate to local circumstances and the surrounding environment.
Specific hazards during firefighting	:	Contents under pressure. This product is not flammable at ambient temperatures and atmospheric pressure. However, this material can ignite when mixed with air under pressure and exposed to strong ignition sources. Container may rupture on heating. Cool closed containers exposed to fire with water spray. Do not allow run-off from fire fighting to enter drains or water courses. Vapours are heavier than air and can cause suffocation by

		reducing oxygen available for breathing. In case of fire hazardous decomposition products may be produced such as: Hydrogen halides Hydrogen fluoride Carbon monoxide Carbon dioxide (CO_2) Carbonyl halides
Special protective equipment for firefighters	:	In the event of fire and/or explosion do not breathe fumes. Wear self-contained breathing apparatus and protective suit. No unprotected exposed skin areas.
Further information	:	Use extinguishing measures that are appropriate to local circumstances and the surrounding environment.

SECTION 6. ACCIDENTAL RELEASE MEASURES

Personal precautions, protective equipment and emergency procedures	:	Immediately evacuate personnel to safe areas. Keep people away from and upwind of spill/leak. Wear personal protective equipment. Unprotected persons must be kept away. Remove all sources of ignition. Avoid skin contact with leaking liquid (danger of frostbite). Ventilate the area. After release, disperses into the air. Vapours are heavier than air and can cause suffocation by reducing oxygen available for breathing. Avoid accumulation of vapours in low areas. Unprotected personnel should not return until air has been tested and determined safe. Ensure that the oxygen content is >= 19.5%.
Environmental precautions	:	Prevent further leakage or spillage if safe to do so. The product evaporates readily.
Methods and materials for containment and cleaning up	:	Ventilate the area.

SECTION 7. HANDLING AND STORAGE

Handling

Precautions for safe handling	:	Handle with care. Avoid inhalation of vapour or mist. Do not get in eyes, on skin, or on clothing. Wear personal protective equipment. Use only in well-ventilated areas. Pressurized container. Protect from sunlight and do not expose to temperatures exceeding 50 °C. Follow all standard safety precautions for handling and use of compressed gas cylinders. Use authorized cylinders only. Protect cylinders from physical damage. Do not puncture or drop cylinders, expose them to open flame or excessive heat. Do not pierce or burn, even after use. Do not spray on a naked flame or any incandescent material. Do not remove screw cap until immediately ready for use. Always replace cap after use.
Advice on protection against fire and explosion	:	The product is not flammable. Can form a combustible mixture with air at pressures above atmospheric pressure.

Storage

Conditions for safe storage, including any incompatibilities	:	Pressurized container: protect from sunlight and do not expose to temperatures exceeding 50 °C. Do not pierce or burn, even after use. Keep containers tightly closed in a dry, cool and well-ventilated place. Storage rooms must be properly ventilated. Ensure adequate ventilation, especially in confined areas. Protect cylinders from physical damage.

SECTION 8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Protective measures	:	Do not breathe vapour. Avoid contact with skin, eyes and clothing.

		Ensure that eyewash stations and safety showers are close to the workstation location.
Engineering measures	:	General room ventilation is adequate for storage and handling. Perform filling operations only at stations with exhaust ventilation facilities.
Eye protection	:	Wear as appropriate: Safety glasses with side-shields If splashes are likely to occur, wear: Goggles or face shield, giving complete protection to eyes
Hand protection	:	Leather gloves In case of contact through splashing: Protective gloves Neoprene gloves Polyvinyl alcohol or nitrile- butyl-rubber gloves
Skin and body protection	:	Avoid skin contact with leaking liquid (danger of frostbite). Wear cold insulating gloves/ face shield/ eye protection.
Respiratory protection	:	In case of insufficient ventilation, wear suitable respiratory equipment. Wear a positive-pressure supplied-air respirator. Vapours are heavier than air and can cause suffocation by reducing oxygen available for breathing. For rescue and maintenance work in storage tanks use self-contained breathing apparatus.
Hygiene measures	:	Handle in accordance with good industrial hygiene and safety practice. Ensure adequate ventilation, especially in confined areas. Avoid contact with skin, eyes and clothing. Remove and wash contaminated clothing before re-use. Keep working clothes separately.

Exposure Guidelines

Components	CAS-No.	Value	Control parameters	Update	Basis
2,3,3,3-Tetrafluoroprop-1-ene	754-12-1	TWA : Time weighted average	(500 ppm)	2009	WEEL:US. OARS. WEELs Workplace Environmental Exposure Level Guide, as amended

2,3,3,3-Tetrafluoroprop-1-ene	754-12-1	TWA : Time weighted average	(500 ppm)	03 15 2010	Honeywell:Limit established by Honeywell International Inc.

2,3,3,3-Tetrafluoroprop-1-ene	754-12-1	STEL : Short term exposure limit	(1,500 ppm)	03 15 2010	Honeywell:Limit established by Honeywell International Inc.

1,1,1,2-Tetrafluoroethane	811-97-2	TWA : Time weighted average	(1,000 ppm)		Honeywell:Limit established by Honeywell International Inc.

1,1,1,2-Tetrafluoroethane	811-97-2	TWA : Time weighted average	4,240 mg/m3 (1,000 ppm)	2007	WEEL:US. OARS. WEELs Workplace Environmental Exposure Level Guide, as amended

SECTION 9. PHYSICAL AND CHEMICAL PROPERTIES

Physical state	:	Liquefied gas
Color	:	clear colourless
Odor	:	slight ether-like
Odor threshold	:	Note: No data available
pH	:	Note: Not applicable
Melting point/range	:	Note: No data available
Boiling point/boiling range	:	-29.2 °C

Flash point	:	Note: Not applicable
Flammability	:	The product is not flammable.
Lower explosion limit	:	Note: None
Upper explosion limit	:	Note: None
Vapor pressure	:	0.637 MPa at 21.1 °C(70.0 °F)
Vapor density	:	3.83 Note: (Air = 1.0)
Density	:	1.15 g/cm3 at 21.1 °C
Water solubility	:	Note: No data available
Partition coefficient: n-octanol/water	:	Note: No data available
Ignition temperature	:	Note: No data available
Auto-ignition temperature	:	> 750 °C
Decomposition temperature	:	> 250 °C Note: To avoid thermal decomposition, do not overheat.
Viscosity, dynamic	:	Note: No data available
Viscosity, kinematic	:	Note: No data available

SECTION 10. STABILITY AND REACTIVITY

Chemical stability	:	Stable under normal conditions.
Possibility of hazardous reactions	:	Hazardous polymerisation does not occur.
Conditions to avoid	:	Pressurized container. Protect from sunlight and do not expose to temperatures exceeding 50 °C. Decomposes under high temperature. Some risk may be expected of corrosive and toxic decomposition products. Can form a combustible mixture with air at pressures above atmospheric pressure. Do not mix with oxygen or air above atmospheric pressure.
Incompatible materials	:	Potassium Calcium Powdered metals Finely divided aluminium Finely divided magnesium Zinc
Hazardous decomposition products	:	Halogenated compounds Hydrogen fluoride Carbonyl halides Carbon oxides

SECTION 11. TOXICOLOGICAL INFORMATION

Acute inhalation toxicity

2,3,3,3-Tetrafluoroprop-1-ene	:	LC50: > 400000 ppm Exposure time: 4 h Species: Rat Method: OECD Test Guideline 403
1,1,1,2-Tetrafluoroethane	:	LC50: > 500000 ppm Exposure time: 4 h Species: Rat

Skin irritation	:	Note: Not applicable study technically not feasible
Eye irritation	:	Note: Not applicable study technically not feasible
Sensitisation		
2,3,3,3-Tetrafluoroprop-1-ene	:	Dermal Note: Not applicable, as this product is a gas. study technically not feasible
1,1,1,2-Tetrafluoroethane	:	Cardiac sensitization Species: dogs Note: No-observed-effect level 50 000 ppm Lowest observed effect level 75 000 ppm
Repeated dose toxicity		
2,3,3,3-Tetrafluoroprop-1-ene	:	Species: Rat Application Route: Inhalation Exposure time: (2 Weeks) No-observed-effect level: 50000 ppm Method: OECD Test Guideline 412 Species: Rat Application Route: Inhalation Exposure time: (4 Weeks) NOAEL (No observed adverse effect level): 50000 ppm Method: OECD Test Guideline 412 Species: Rat Application Route: Inhalation Exposure time: (13 Weeks) NOAEL (No observed adverse effect level): 50000 ppm Method: OECD Test Guideline 413 Species: Rabbit, male Application Route: Inhalation Exposure time: (28 d) No-observed-effect level: 500 ppm Method: OECD Test Guideline 412 There are no observed toxicological effects, which result in

		classification as a specific target organ toxicant.
		Species: Rabbit, female Application Route: Inhalation Exposure time: (28 d) No-observed-effect level: 1000 ppm Method: OECD Test Guideline 412 There are no observed toxicological effects, which result in classification as a specific target organ toxicant.
		Species: Mini-pig Application Route: Inhalation Exposure time: (28 d) NOAEL (No observed adverse effect level): 10000 ppm highest exposure tested
1,1,1,2-Tetrafluoroethane	:	Species: Rat NOEL: 40000 ppm
Genotoxicity in vitro		
2,3,3,3-Tetrafluoroprop-1-ene	:	Test Method: Ames test Result: 20% and higher, positive in TA 100 and e. coli WP2 uvrA, negative in TA98, TA100, and TA1535. Method: OECD Test Guideline 471
1,1,1,2-Tetrafluoroethane	:	Note: In vitro tests did not show mutagenic effects
	:	Test Method: Chromosome aberration test in vitro Cell type: Human lymphocytes Result: negative Method: OECD Test Guideline 473 Note: Dose 760,000 ppm
Genotoxicity in vivo		
2,3,3,3-Tetrafluoroprop-1-ene	:	Species: Mouse Cell type: Micronucleus Dose: up to 200,000 ppm (4 hour) Method: OECD Test Guideline 474 Result: negative
	:	Test Method: Unscheduled DNA synthesis Dose: up to 50,000 ppm (4 weeks)

Method: OECD Test Guideline 486
Result: negative

: Species: Rat
Cell type: Micronucleus
Dose: up to 50,000 ppm (4 weeks)
Method: OECD Test Guideline 474
Result: negative

Carcinogenicity
2,3,3,3-Tetrafluoroprop-1-ene : Species: Rat
Note: Not classified as a human carcinogen. Substance not expected to be a carcinogen based on available data.

Further information : Note: Rapid evaporation of the liquid may cause frostbite. Vapours are heavier than air and can cause suffocation by reducing oxygen available for breathing. Handle in accordance with good industrial hygiene and safety practice.

SECTION 12. ECOLOGICAL INFORMATION

Toxicity to fish
2,3,3,3-Tetrafluoroprop-1-ene : LC50: > 197 mg/l
Exposure time: 96 h
Species: Cyprinus carpio (Carp)
Method: OECD Test Guideline 203
Note: No demonstrable toxic effect in saturated solution.

Toxicity to daphnia and other aquatic invertebrates
2,3,3,3-Tetrafluoroprop-1-ene : EC50: > 83 mg/l
Exposure time: 48 h
Species: Daphnia magna (Water flea)
Method: OECD Test Guideline 202

Toxicity to algae

2,3,3,3-Tetrafluoroprop-1-ene : EC50: > 100 mg/l
Species: Scenedesmus capricornutum (fresh water algae)
Method: OECD Test Guideline 201

Bioaccumulation
2,3,3,3-Tetrafluoroprop-1-ene : Note: Due to the distribution coefficient n-octanol/water, accumulation in organisms is not expected.

Biodegradability
2,3,3,3-Tetrafluoroprop-1-ene : Result: Not readily biodegradable.
Method: OECD Test Guideline 301F

Further information on ecology

Ecotoxicology Assessment

Results of PBT assessment
This substance is not considered to be persistent, bioaccumulating and toxic (PBT)., This substance is not considered to be very persistent and very bioaccumulating (vPvB).

Additional ecological information : Accumulation in aquatic organisms is unlikely.
This product is subject to U.S. Environmental Protection Agency Clean Air Act Regulations at 40 CFR Part 82.
This product contains greenhouse gases which may contribute to global warming. Do NOT vent to the atmosphere.
To comply with provisions of the U.S. Clean Air Act, any residual must be recovered.

SECTION 13. DISPOSAL CONSIDERATIONS

Disposal methods : Observe all Federal, State, and Local Environmental regulations.

Note : This product is subject to U.S. Environmental Protection Agency Clean Air Act Regulations Section 608 in 40 CFR Part 82 regarding refrigerant recycling.

SECTION 14. TRANSPORT INFORMATION

DOT
UN/ID No. : UN 3163
Proper shipping name : LIQUEFIED GAS, N.O.S.

			(R-1234yf, 1,1,1,2-Tetrafluoroethane)
	Class		2.2
	Packing group		
	Hazard Labels		2.2
IATA	UN/ID No.	:	UN 3163
	Description of the goods	:	LIQUEFIED GAS, N.O.S. (R-1234yf, 1,1,1,2-Tetrafluoroethane)
	Class	:	2.2
	Hazard Labels	:	2.2
	Packing instruction (cargo aircraft)	:	200
	Packing instruction (passenger aircraft)	:	200
IMDG	UN/ID No.	:	UN 3163
	Description of the goods	:	LIQUEFIED GAS, N.O.S. (R-1234yf, 1,1,1,2-TETRAFLUOROETHANE)
	Class	:	2.2
	Hazard Labels	:	2.2
	EmS Number	:	F-C, S-V
	Marine pollutant	:	no

SECTION 15. REGULATORY INFORMATION

Inventories

US. Toxic Substances Control Act : On TSCA Inventory

Australia. Inventory of Industrial Chemicals (AIIC), as amended : On the inventory, or in compliance with the inventory

Canada. Canadian Environmental Protection Act (CEPA). Domestic Substances List (DSL) : All components of this product are on the Canadian DSL

Japan. Kashin-Hou Law List : On the inventory, or in compliance with the inventory

Korea. Existing Chemicals Inventory (KECI)	:	On the inventory, or in compliance with the inventory
Philippines. Inventory of Chemicals and Chemical Substances (PICCS)	:	Not in compliance with the inventory
China. Inventory of Existing Chemical Substances (IECSC)	:	On the inventory, or in compliance with the inventory, or has been registered as new substance
New Zealand. Inventory of Chemicals (NZIoC), as published by ERMA New Zealand	:	Not in compliance with the inventory
Taiwan Chemical Substance Inventory (TCSI)	:	On the inventory, or in compliance with the inventory
TSCA 12B	:	US. Toxic Substances Control Act (TSCA) Section 12(b) Export Notification (40 CFR 707, Subpt D) 2,3,3,3-Tetrafluoroprop-1-ene 754-12-1

National regulatory information

US. Toxic Substances Control Act (TSCA) Section 5(a)(2) Final Significant New Use Rules (SNURs) (40 CFR 721, Subpt E)	:	: Issued.
	:	2,3,3,3-Tetrafluoroprop-1-ene 754-12-1
SARA 302 Components	:	No chemicals in this material are subject to the reporting requirements of SARA Title III, Section 302.
SARA 313 Components	:	This material does not contain any chemical components with known CAS numbers that exceed the threshold (De Minimis) reporting levels established by SARA Title III, Section 313.
SARA 311/312 Hazards	:	Sudden Release of Pressure Hazard Acute Health Hazard

California Prop. 65 : This product does not contain any chemicals known to State of California to cause cancer, birth defects, or any other reproductive harm.

SECTION 16. OTHER INFORMATION

		HMIS III	NFPA
Health hazard	:	1	2
Flammability	:	1	1
Physical Hazard	:	0	
Instability	:		0

Hazard rating and rating systems (e.g. HMIS® III, NFPA): This information is intended solely for the use of individuals trained in the particular system.

Further information

The information provided in this Safety Data Sheet is correct to the best of our knowledge, information and belief at the date of its publication. The information given is designed only as a guidance for safe handling, use, processing, storage, transportation, disposal and release and is not to be considered a warranty or quality specification. The information relates only to the specific material designated and may not be valid for such material used in combination with any other materials or in any process, unless specified in the text. Final determination of suitability of any material is the sole responsibility of the user. This information should not constitute a guarantee for any specific product properties.

Changes since the last version are highlighted in the margin. This version replaces all previous versions.
Previous Issue Date: 05/08/2018
Prepared by Honeywell Performance Materials and Technologies Product Stewardship Group

Design Report of Safety Data Sheet

(SDS)

Sample Name:	FIRE EXTINGUISHERS（WITH COMPRESSED OR LIQUEFIED GAS）
Type/Model:	/
Entrust Unit:	WANZHEN FIRE TECHNOLOGY（GUANGDONG）CO.,LTD

Audited by: DAVE

Edited by: NICOK

（Stamp）

Guangfen Testing Institute (Guangzhou) Quality Inspection Co., Ltd.
Inspection & Testing Services

Unit: Guangfen Testing Institute (Guangzhou) Quality Inspection Co., Ltd.（GFQT）

Add : Room 101, 1st Floor, Building 2, Jinke Industrial Park, No. 1 Xinji Avenue, Nancun Town, Panyu District, Guangzhou

Tel : 020-66624679 Web : www.gflad.com

SAFETY DATA SHEET

FIRE EXTINGUISHERS (WITH COMPRESSED OR LIQUEFIED GAS)

***According to GHS (Tenth Revised Edition)**

SDS

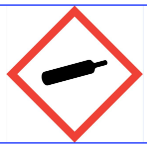
Section 1 Identification of the chemical and supplier

◆ **Product identifier**	
Product Name	FIRE EXTINGUISHERS (WITH COMPRESSED OR LIQUEFIED GAS)
Product Model	-
CAS No.	Not applicable
EC No.	Not applicable
Molecular Formula	Not applicable
◆ **Relevant identified uses of the substance or mixture and uses advised against**	
Relevant identified uses	Fire extinguishing agent
Uses advised against	Please consult the manufacturer.
◆ **Details of the supplier of the Safety Data Sheet**	
Applicant Name	Wanzhen Fire Technology (Guangdong) Co.,Ltd
Applicant Address	Room 116, huichuang space, TCL culture industrial park, no.69, guangpu west road, Huangpu district,Guangzhou, Guangdong, China
Applicant Telephone	+86-20-29866567
Applicant Fax	-
Applicant E-mail	tsd@wanzn.com
Supplier Name	SIEX 2001 S.L.
Supplier Address	C/Merindad de Montija nº6, Burgos, 09001 Burgos (Spain)
Supplier Telephone	-
Supplier Fax	-
Supplier E-mail	-
◆ **Emergency phone number**	
Emergency phone number	+86-20-29866567

Section 2 Hazards identification

Hazard class and label elements of the product according to GHS(the nine revised edition)

◆ **Hazard classification according to GHS**	
Gases under pressure	Compressed gas

Hazardous to the aquatic environment, long-term (Chronic)	Category 3
◆ **GHS Label elements**	
Hazard pictograms	
Signal word	**Warning**
◆ **Hazard statements**	
H280	Contains gas under pressure; may explode if heated
H412	Harmful to aquatic life with long lasting effects.
◆ **Precautionary statements**	
▲ **Prevention**	
P273	Avoid release to the environment.
▲ **Response**	
P301 + P317	IF SWALLOWED: Get medical help.
▲ **Storage**	
P410+P403	Protect from sunlight. Store in a well ventilated place.
▲ **Disposal**	
P501	Dispose of contents/container in accordance with local/regional/national/international regulations.
◆ **Hazard description**	
▲ **Physical and chemical hazards**	
Physical and chemical hazards	It contains high-pressure compressed gas, which may crack and explode in case of heat.
▲ **Health hazards**	
Inhaled	Harmful to health or cause respiratory discomfort.
Ingestion	Abdominal Pain, Vomiting
Skin Contact	Frostbite possible.
Eye	Redness, pain, tears.
▲ **Environmental hazards**	
Environmental hazards	Please refer to 12th chapter of SDS.

Section 3 Composition/information on ingredients

◆ **Substance / mixture**

☐Substance ☑mixture

Component	Cas No.	EC No.	Concentration (weight percent, %)
1,1,1,2,2,4,5,5,5-nonafluoro-4-(trifluoromethyl)-3-pentanone	756-13-8	231-545-4	70-100
Nitrogen	7727-37-9	231-545-4	2.5-10

Section 4 First aid measures

◆ **Description of first aid measures**

General advice	Immediate medical attention is required. Show this safety data sheet (SDS) to the doctor in attendance.
Eye contact	Check and remove any contact lenses, occasionally lifting the upper and lower eyelids, and immediately flush the eyes with water until the residue clears. Provide a convenient eyewash device and a quick and safe shower without rubbing your eyes. If irritation symptoms occur or persist, consult an ophthalmologist.
Skin contact	Remove contaminated clothing and shoes. Wash it off with mild soap and plenty of water. Seek medical attention if irritation symptoms occur or continue to develop. If you have frostbite, seek medical attention.
Ingestion	Rinse mouth with water. If the material has been swallowed and the person is conscious, drink a small amount of water. Water can be dangerous if the person is feeling unwell and vomiting. Do not induce vomiting unless instructed by a medical professional. If vomiting occurs, the head should be kept low so that vomiting cannot enter the lungs. If adverse health effects persist or are severe, seek medical attention and do not orally feed any food to the unconscious person.
Inhalation	Get out of the scene quickly to fresh air, keep the airway open. Rest where you breathe comfortably. If breathing is difficult, oxygen should be given by trained personnel. If symptoms persist or seriously affect health, seek immediate medical attention.
Protecting of first-aiders	Ensure that medical personnel are aware of the substance involved. Take precautions to protect themselves and prevent spread of contamination.

◆ **Most important symptoms/effects, acute and delayed**

1 The most important known symptoms and effects are as described in Parts 2 and/or 11.

◆ **Indication of any immediate medical attention and special treatment needed**

1	Treat symptomatically.
2	Symptoms may be delayed.

Section 5 Firefighting measures

◆	**Extinguishing media**
	Not applicable
◆	**Specific hazards arising from the substance or mixture**
1	May expansion or decompose explosively when heated or involved in fire.
◆	**Special protective equipment and precautions for fire-fighters**
1	As in any fire, wear self-contained breathing apparatus (MSHA/NIOSH approved or equivalent) and full protective gear.
2	Fight fire from a safe distance, with adequate cover.
3	Prevent fire extinguishing water from contaminating surface water or theground water system.

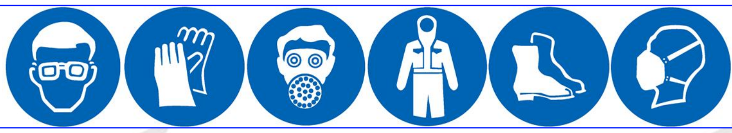
Section 6 Accidental release measures

◆	**Personal precautions, protective equipment and emergency procedures**
1	Do not take any action involving any personal risk or without proper training.
2	Entry of unnecessary and unprotected persons is strictly prohibited.
3	Do not touch or cross spilled material to avoid slipping.
4	Avoid inhalation of vapors/gases.
5	Ensure adequate ventilation. Wear proper breathing apparatus when ventilation is poor.
6	Emergency personnel will be equipped with appropriate personal protective equipment (PPE) (see Section 8).
◆	**Environmental precautions**
1	Prevent further leakage or spillage if safe to do so.
2	Discharge into the environment must be avoided.
◆	**Methods and materials for containment and cleaning up**
1	Small leakage: if there is no danger, stop the leakage and remove the container from the leakage area. If possible, proper ventilation should be used to diffuse and prevent accumulation. Large leakage: if there is no danger, stop the leakage and remove the container from the leakage area. Approaching the leak from upwind, spray the liquid nitrogen to accelerate evaporation, but do not make the water gun to the liquid nitrogen. If possible, the residual or leaked gas will be sent to the washing tower or the fume hood connected to the tower by an exhaust fan. Air leakage containers should be properly handled, repaired, tested before use. Containment and collection of leaking liquids with non-combustible absorbers such as sand, earth, vermiculite, diatomite.
2	Contaminated adsorbents can be just as hazardous as spilled products.
3	Adhered or collected material should be promptly disposed of, in accordance with appropriate laws and regulations.

	Section 7 Handling and storage
◆	**Precautions for safe handling**
1	Wear appropriate personal protective equipment (see Part 8)
2	Eating, drinking and smoking are prohibited where materials are handled, stored and processed.
3	Workers should wash their hands and faces before eating or smoking. Avoid contact with eyes and inhalation of gas.
4	Provide suitable exhaust equipment. Operate in a well-ventilated place.
5	Observe good hygiene procedures and practices.
6	Handling should be light, to prevent damage to the packaging and containers.
7	General fire protection measures. Keep away from heat sources, open flames and hot surfaces.
8	Clean thoroughly after operation.
9	Individuals with a history of skin allergies should not be employed in any work related to this product.
10	Equipped with corresponding varieties and quantities of fire equipment and leakage emergency treatment equipment.
◆	**Conditions for safe storage, including any incompatibilities**
1	Store in accordance with local regulations. Store in a dry, cool and well-ventilated place. Keep container tightly sealed until use.
2	Avoid direct sunlight. Keep away from high temperatures and open flames, from incompatible materials (see Section 10), food and feed.
3	Equipped with corresponding varieties and quantities of fire equipment and leakage emergency treatment equipment.
4	Keep away from children and pets.

	Section 8 Exposure controls/personal protection
◆	**Control parameters**
▲	**Occupational Exposure limit values**
	No information available
▲	**Biological limit values**
	No information available
▲	**Monitoring methods**
1	EN 14042 Workplace atmospheres. Guide for the application and use of procedures for the assessment of exposure to chemical and biological agents.
2	GBZ/T 160.1~GBZ/T 160.81-2004 Determination of toxic substances in workplace air (Series standard)
▲	**Engineering controls**
1	Ensure adequate ventilation, especially in confined areas.

2	Ensure that eyewash stations and safety showers are close to the workstation location.
3	Set up emergency evacuation channels and necessary risk relief areas.
4	Operate in accordance with good industrial hygiene and safety regulations.
▲	**Personal protection equipment**

General requirement	
Eye protection	Wear safety glasses when there is potential eye contact.
Hand protection	Use protective gloves. Check whether the protective gloves are normal before each use Choosing the right glove depends not only on the material, but also on the quality of the material, which varies from manufacturer to manufacturer.
Respiratory protection	If the concentration of vapor/gas exceeds the occupational exposure limit or symptoms such as irritation occur, use a full-cover multifunctional respirator.
Skin and body protection	Wear regular work clothes and boots.

Section 9 Physical and chemical properties

◆ **Physical and chemical properties**

Appearance	Red barrels contain colorless liquids and gases
Odor	Odorless
pH	No information available/Not applicable
Melting point/freezing point(℃)	-108
Initial boiling point and boiling range(℃)	49
Flash point(Closed cup,℃)	No information available/Not applicable
Evaporation rate	No information available/Not applicable
Flammability	Not flammable
Upper/lower explosive limits[%(v/v)]	No information available/Not applicable
Vapor pressure(KPa)	No information available/Not applicable
Vapor density(Air = 1)	No information available/Not applicable
Relative density(Water=1)	No information available/Not applicable
Solubility(mg/L)	not soluble in water
n-octanol/water partition coefficient:	No information available/Not applicable
Auto-ignition temperature(℃)	No information available/Not applicable

Decomposition temperature(℃)	No information available/Not applicable
Viscosity(mm2/s)	No information available/Not applicable
Particle characteristics	No information available/Not applicable
Explosive properties	Not explosive
Oxidizing properties	Not oxidizing

Section 10 Stability and reactivity

◆ **Stability and reactivity**

Reactivity	Stable under proper operation and storage conditions.
Chemical stability	The substance is chemically stable.
Conditions to avoid	Incompatible material, mechanical impact, direct sunlight, high temperature and flame.
Incompatible materials	Strong oxidizing agent.
Hazardous decomposition products	Under normal conditions of storage and use, hazardous decomposition products should not be produced.

Section 11 Toxicological information

◆ **Acute toxicity**

No information Available

◆ **Carcinogenicity**

Component	IARC	NTP
1,1,1,2,2,4,5,5,5-nonafluoro-4-(trifluoro methyl)-3-pentanone	Not Listed	Not Listed
Nitrogen	Not Listed	Not Listed

◆ **Others**

Skin corrosion/irritation	Based on available data, the classification criteria are not met
Serious eye damage/irritation	Based on available data, the classification criteria are not met
Skin sensitization	Based on available data, the classification criteria are not met
Respiratory sensitization	Based on available data, the classification criteria are not met
Reproductive toxicity	Based on available data, the classification criteria are not met
STOT-single exposure	Based on available data, the classification criteria are not met
STOT-repeated exposure	Based on available data, the classification criteria are not met
Aspiration hazard	Based on available data, the classification criteria are not met
Germ cell mutagenicity	Based on available data, the classification criteria are not met

Reproductivetoxicity(additional)	Based on available data, the classification criteria are not met

Section 12 Ecological information

- **Acute aquatic toxicity**

  Based on available data, the classification criteria are not met

- **Chronic aquatic toxicity**

  Harmful to aquatic life with long lasting effects (Category 3)

- **Persistence and degradability**

  No information available

- **Bioaccumulative potential**

  No information available

- **Mobility in soil**

  No information available

- **Results of PBT and vPvB assessment**

Component	Results of PBT and vPvB assessment (according to (EC) No 1907/2006)
1,1,1,2,2,4,5,5,5-nonafluoro-4-(trifluoromethyl)-3-pentanone	not PBT/vPvB
Nitrogen	not PBT/vPvB

Section 13 Disposal considerations

Waste chemicals	Refer to state, local, and national regulations for proper handling. Avoid or reduce waste production whenever possible. It is recommended to transfer to a suitable container and arrange for collection and disposal by a professional waste disposal company.
Contaminated packaging	Containers may still present chemical hazard when empty. Keep away from hot and ignition source of fire. Return to supplier for recycling if possible.
Disposal recommendations	Refer to section waste chemicals and contaminated packaging.

Section 14 Transport information

- **Transport rules**

  According to IATA DGR 64rd Edition for transportation, IMO International Maritime Dangerous Goods Code (Amendment 40-20), European Agreement Concerning the International Carriage of Dangerous Goods by Road. The products are subject to IATA DGR, IMDG and ADR/RID.

- **Label(s) required**

Transporting Label	
◆	**Road transport (UN-ADR)**
UN Number	UN1044
UN Proper shipping Name	Fire extinguisher containing compressed or liquefied gas
Transport hazard class	2.2
Transport subsidiary hazard class	None
Packing group	Not applicable
Special provisions for transportation	225|594
◆	**(ICAO-IATA/DGR)**
UN Number	UN1044
UN Proper shipping Name	Fire extinguisher containing compressed or liquefied gas
Transport hazard class	2.2
Transport subsidiary hazard class	None
Packing group	225|594
Special provisions for transportation	A19
◆	**(IMDG-CODE)**
UN Number	UN1044
UN Proper shipping Name	Fire extinguisher containing compressed or liquefied gas
Transport hazard class	2.2
Transport subsidiary hazard class	None
Packing group	225|594
Special provisions for transportation	A19
Marine pollutant(Yes/No)	No

Section 15 Regulatory information

◆ **International list of chemicals**

CAS No.	EC Inventory	TSCA	DSL	IECSC	NZIoC	PICCS	KECI	AICS	ENCS
756-13-8	×	√	√	√	√	×	√	√	√
7727-37-9	√	√	√	√	√	√	√	√	×

【EC inventory】European Inventory of Existing Commercial Chemical Substances
【TSCA】United States Toxic Substances Control Act Inventory
【DSL】Canadian Domestic Substances List
【IECSC】China Inventory of Existing Chemical Substances
【NZIoC】New Zealand Inventory of Chemicals
【PICCS】Philippines Inventory of Chemicals and Chemical Substances
【KECI】Existing and Evaluated Chemical Substances
【AICS】Australia Inventory of Chemical Substances (AIICS)
【ENCS】Japan Inventory of Existing & New Chemical Substances

Note :
"√" Indicates that the substance included in the regulations
"×" That no data or included in the regulations

Section 16 Additional Information

◆ Information on revision

Creation Date	2024/01/01
Revision Date	2024/01/02 (Explanation: This report is valid until the implementation of the eleventh revised version of the United Nations GHS.)
Reason for revision	-

◆ References

【1】IPCS:The International Chemical Safety Cards (ICSC) ,website: http://www.ilo.org/dyn/icsc/showcard.home.
【2】IARC, website: http://www.iarc.fr/.
【3】OECD: The Global Portal to Information on Chemical Substances, website: http://www.echemportal.org/echemportal/index?pageID=0&request_locale=en。
【4】CAMEO Chemicals, website: http://cameochemicals.noaa.gov/search/simple.
【5】NLM:ChemIDplus, website: http://chem.sis.nlm.nih.gov/chemidplus/chemidlite.jsp.
【6】EPA: Integrated Risk Information System, website: http://cfpub.epa.gov/iris/.
【7】U.S. Department of Transportation:ERG, website: http://www.phmsa.dot.gov/hazmat/library/erg.
【8】Germany GESTIS-database on hazard substance, website: http://gestis-en.itrust.de/.

◆ Abbreviations and acronyms

CAS	Chemical Abstracts Service	UN	The United Nations
PC-STEL	Short term exposure limit	OECD	Organization for Economic Co-operation and Development
PC-TWA	Time Weighted Average	IMDG	International Maritime Dangerous Goods
MAC	Maximum Allowable Concentration	IARC	International Agency for Research on Cancer
DNEL	Derived No Effect Level	ICAO	ICAO-International Civil Aviation Organization
PNEC	Predicted No Effect Concentration	IATA	International Air Transportation Association
NOEC	No Observed Effect Concentration	ACGIH	American Conference of Governmental Industrial Hygienists

LC_{50}	Lethal Concentration 50%	NFPA	National Fire Protection Association
LD_{50}	Lethal Dose 50%	NTP	National Toxicology Program
EC_{50}	Effective Concentration 50%	PBT	Persistent, Bioaccumulative, Toxic
ECX	Effective Concentration X%	vPvB	vPvB -High very Persistent, High very Bioaccumulative
P_{OW}	Partition coefficient Octanol:Water	CMR	Carcinogens, mutagens or substances toxic to reproduction
BCF BCF	Bioconcentration factor (BCF)	RPE	Respiratory Protective Equipment
ED	Endocrine disruptors	-	-

◆ Disclaimer

This Safety Data Sheet (SDS) The data included was derived from international authoritative database and provided by the enterprise. Other information was based on the present state of our knowledge. We try to ensure the correctness of all information. However, due to the diversity of information sources and the limitations of our knowledge, this document is only for user' s reference. Users should make their independent judgment of suitability of this information for their particular purposes. We do not assume responsibility for loss, damage or expense arising out of or in any way connected with the handling, storage, use or disposal of the product, This report may not be published as an advertisement without the approval of the GFQT. Any unauthorized alteration, forgery or falsification of the content or appearance of this document is illegal and the offender may be prosecuted to the fullest extent of the law.In case of any different meanings from the language used in the report, the Chinese version is applicable.

Appendix E

NFPA 69 TEST REPORT

MRP-NA-U-24-01 (284.5 MWh)

MRP Enterprise, Panoche, Midway Project

NFPA 69 Analysis Report

Note: This report provides evaluation and CFD analysis of the ventilation system in energy storage system referring to Chapter 8 in NFPA69:2024.

Risen Energy Co., Ltd.
HQ TEL: 0086-574-59953588
HQ ADD: Tashan Industry Zone, Meilin Street, Ninghai, Ningbo, China

1.General Production Information:

1.1 Cell

The product information and parameters are provided by the client as below.

Manufacturer:	Contemporary Amperex Technology Co., Limited
Model number:	CBDC0/285Ah
Chemistry:	Lithium Iron Phosphate
Physical configuration:	Prismatic
Electrical rating:	Rated capacity: 285Ah
	Nominal voltage: 3.2V
UL 9540A cell test report number:	4790838636.1
Average cell surface temperature at gas venting:	156℃
Average cell surface temperature at thermal runaway:	232℃
Gas volume:	211.7L
Lower flammability limit(LFL), % volume in air at the ambient temperature:	7.45
Lower flammability limit(LFL), % volume in air at the venting temperature:	6.545
Burning velocity(S_u) cm/s:	62.44
Maximum pressure(P_{max}) psig:	96.79

1.2 Module

The product information and parameters are provided by the client as below.

Manufacturer:	SYL(Ningbo) Battery Co., Ltd..
Type/model:	SM94K8FM2
Cell Capacity:	285 Ah
Cell Quantity:	104
Battery structure:	1P104S
Nominal voltage:	332.8 V
Standard charge current:	285 A
Standard discharge current:	285 A
Maximum charge voltage：	374.4 V
Cut-off voltage：	291.2 V

External dimensions：	(243 ± 1.5) × (790 ± 1.5) × (2170 ± 4) mm
Weight：	Approx 650 kg

1.3 Battery System

The product information and parameters are provided as below.

Table 1.1 Specification of Batterry Container

ITEM	UNIT	SPECIFICATION
Make	-	SYL
Container Size	-	20ft
Configuration	-	1P416S10P
Number of Racks	-	10
Cooling System	-	Liquid cooled
Weight	T	40
Nominal Capacity	Ah	285
Nominal Energy	kWh	3793.92
Nominal Voltage	V	1331.2
Operating Voltage	V	1164.8~1497.6V
Operating Temperature Range	℃	-30~45
Recommended Operating Temp	℃	25±3
Storage Temperature	℃	-30~50
Storage Humidity	%	≤95
Degree of Protection	-	IP54
DC Combiner	-	Busbar combiner
AC Aux. Power Supply	-	480VAC 3P3L should be provided by the Client
FSS System	-	Fire suppression and detection system
Cooling System	-	1 set of liquid cooling system with 95kW cooling capacity

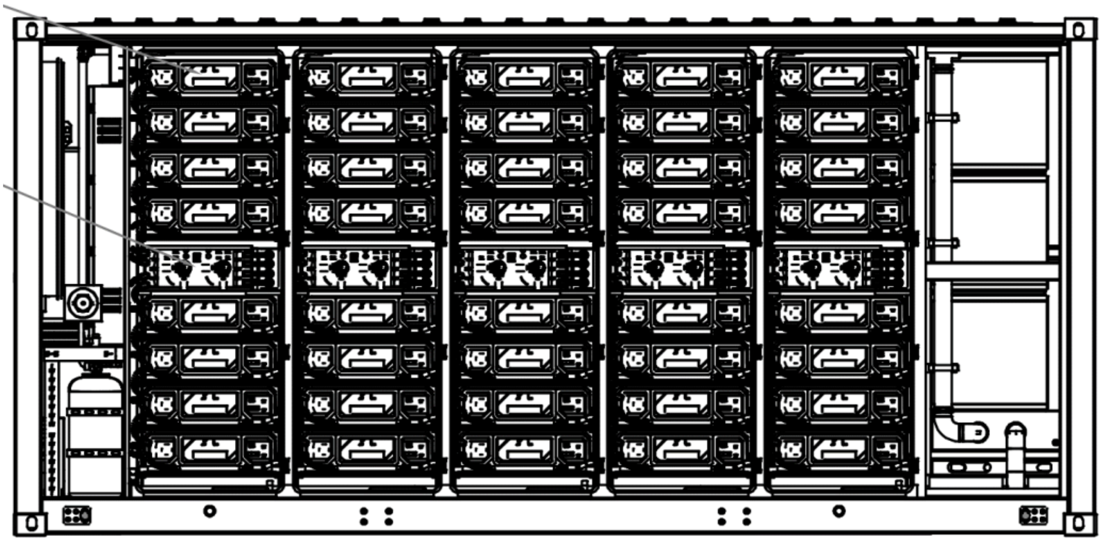


Figure 1.1 Battery Container Overview

2. Product Description

2.1 General Description

1.The EUT covered by this report is a Rechargeable Li-ion Battery System which includes one liquid cooling system, one fire protection system, five master control boxes, achieving 10 clusters in parallel connection. Each cluster consists of 4 battery modules connected in series, and each battery module contains 104 secondary Li-ion cells connected in series.

2.2 Venting System Layout

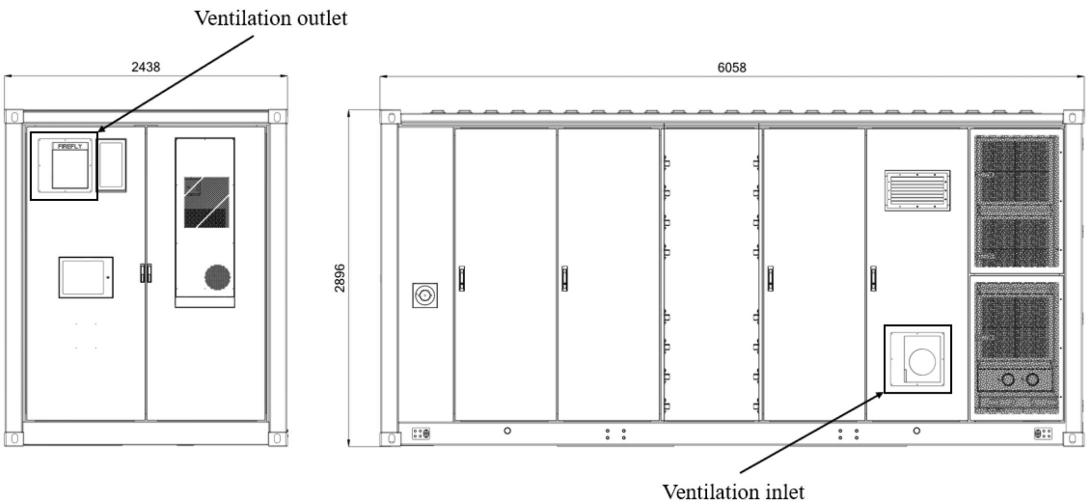


Figure 2.1 Ventilation Layout

3. CFD analysis of the ventilation system

3.1 Basic Information of the system

Figure3.1 shows an external view of the container, the dimensions from a front view, and top view. The cube measures 6058×2438×2896 mm including one battery cabinet, and one electrical cabinet. The battery cabinet contains 10 clusters, each containing 4 modules, and each module contains 104 cells. The overall internal volume is approximately 26.611 m^3.Subtracting the space filled by racks, modules and the support structure, the actual open internal volume(efficient volume) is 9.990 m^3.

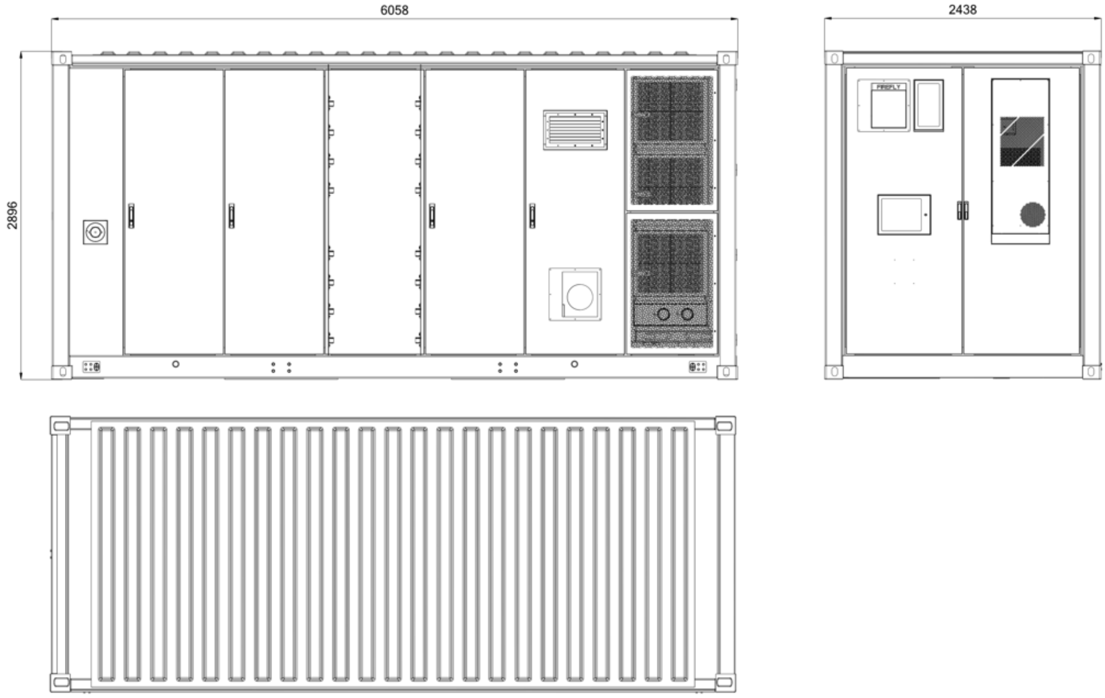


Figure 3.1 Geometry of energy storage system

3.2 Principles and Assumptions

The following safety systems and CFD analysis have been acknowledge for the basis of the study's assumptions. Note that the scenarios and assumptions are run in module levels to show progressively worse-case scenarios based on the information available and are considered to be conservative.

3.2.1 Thermal runaway and propagation

(1) Propagation between cells:

The UL 9540A test report of module level indicate that cell to cell propagation could happen within a submodule which contains 13 cells. According to the test report total 3 cells were failed.

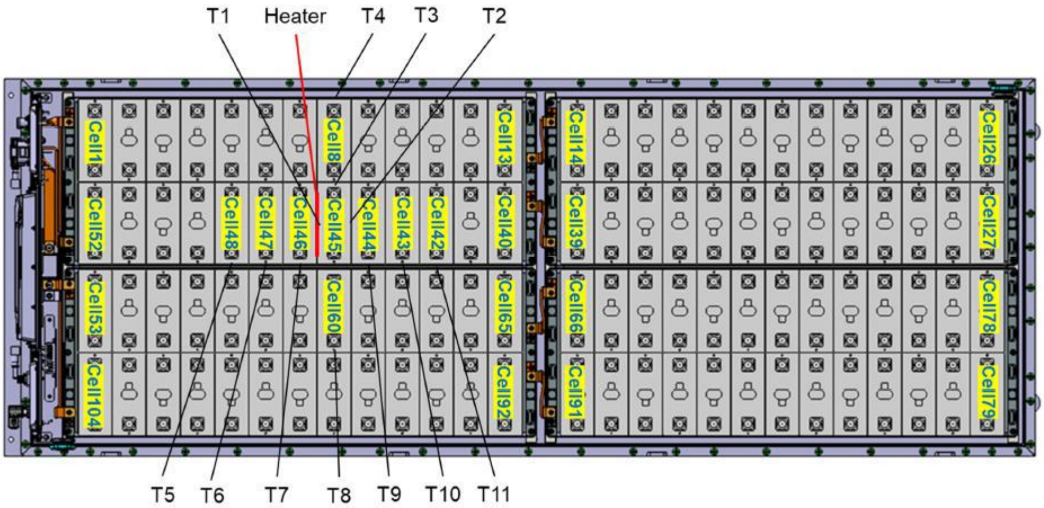


Figure 3.2 Initiating cell set up in module level UL9540Atest report

3.2.2 Leakage profile and gas composition

(1) Leakage profile:

To support the design of an explosion prevention system by means of reduction in flammable concentration, the amount (rate of release into the enclosure over time) of flammable species (battery vent gas) must be estimated. Using UL 9540A test data as the design basis, a gas release rate model was developed.

From cell level UL 9540A report, it was determined that a cell may release 211.7 L of battery gas at normal temperature and pressure. From module level UL 9540A report, the venting duration for a single cell is approximately 19 minutes. Assuming three cells undergo thermal runaway venting simultaneously within this 19-minute period, the total gas release volume for a module would be 635.1 liters. Additionally, based on the gas release rate curve from the module level UL 9540A report, it is estimated that the venting rate of a single cell reaches its maximum approximately 2 minutes after the onset of venting.

Based on all the information above, the gas release rate curve shown in Figure 3.3 was established to evaluate the feasibility of the explosion prevention system.

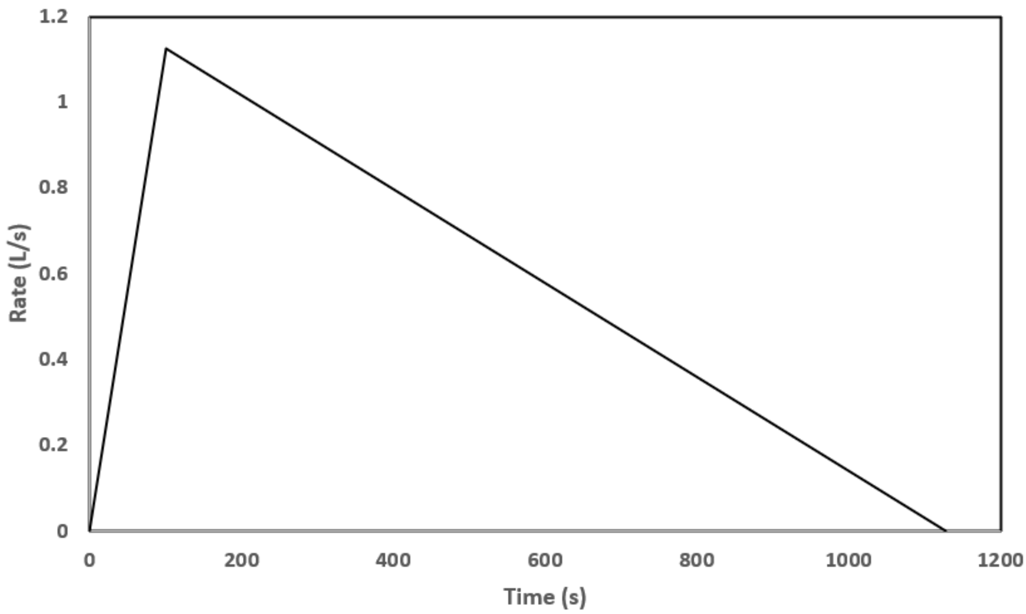


Figure 3.3 Gas release rate profile

(2) Position of the leak:

The gas release from the bottom module of the rack takes more time to reach the detector located at the top of the container. For conservative consideration, the bottom module located farthest from the vent in the battery cabinet was designated as the initiation module and named 001.

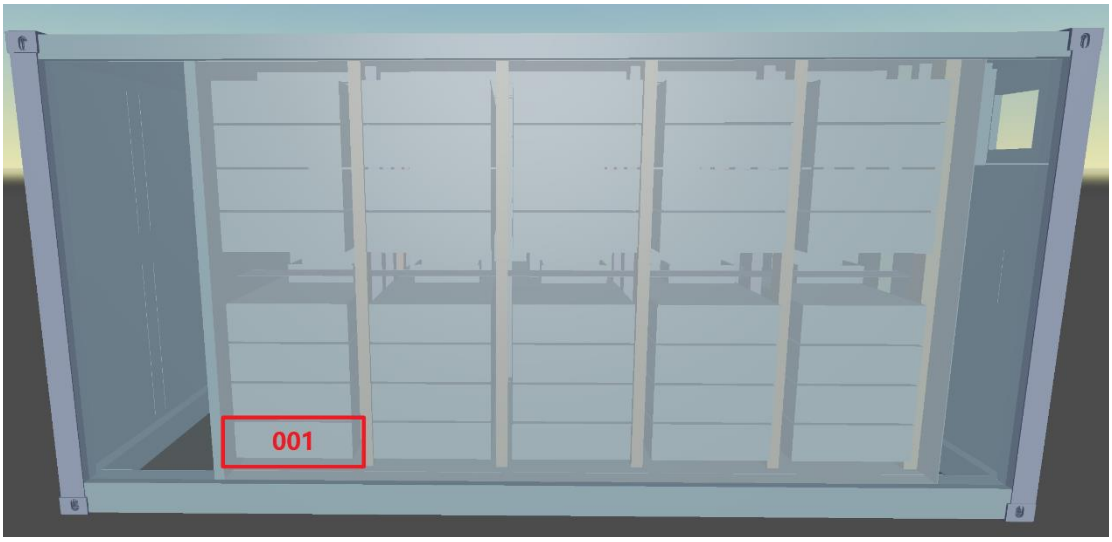


Figure 3.4. Location of gas leakage position (back view)

Assumption: One offgas release position on the rack is considered in this study. (See Figure 3.4)

(3) Gas detector:

Regarding the construction of the container, there is one gas detector equipped on the edge of the roof in battery compartment. Gas detector 1 detects H_2, its location is shown in Figure 3.5

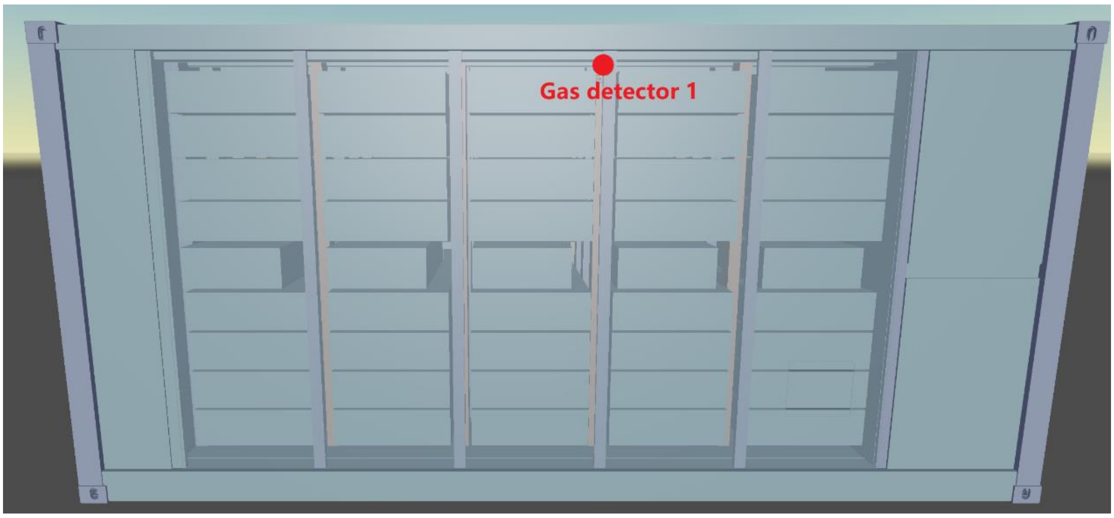


Figure 3.5 Location of gas detector position (front view)

Note: The flammable gas detector, calibrated using hydrogen, is connected to the explosion-proof fan and the fire control panel via dry contacts. Upon detecting a hydrogen concentration at 10% LFL, the detector immediately triggers the fan to start. This activation is accompanied by the opening of the hinge valve.

(4) Gas composition and LFL:

Gas composition was provided in the test data of cell level UL 9540A report. Table 3.1 lists the release gas composition by volume.

Table 3.1 Gas composition by volume

Index	Gas Components	Volume Fraction %
1	CO	13.453
2	CO_2	27.205
3	H_2	41.313
4	CH_4	7.403
5	C_2H_2	0.101
6	C_2H_4	4.408
7	C_2H_6	1.235
8	C_3H_6	1.297
9	C_3H_8	0.734
10	C4(Total)	1.296
11	C5(Total)	0.335
12	C6(Total)	0.147
13	C_7H_{14}	0.025
14	C_8H_8	0.013

15	C_6H_6	0.049
16	C_7H_8	0.013
17	$C_3H_6O_3$	0.917
18	$C_4H_8O_3$	0.055
	LFL (Lower Flammable Limit)	7.45

3.2.3 System safety

Ventilation system:
The container is equipped with one exhaust fan, which activates when 4000ppm H_2 (10%LFL) is detected. According to the exhaust fan specification sheet, the rated airflow of the fan is 820 CFM ±15%. For a conservative analysis, a value of 820 CFM -15% (697 CFM) is adopted for the fan airflow in this assessment.

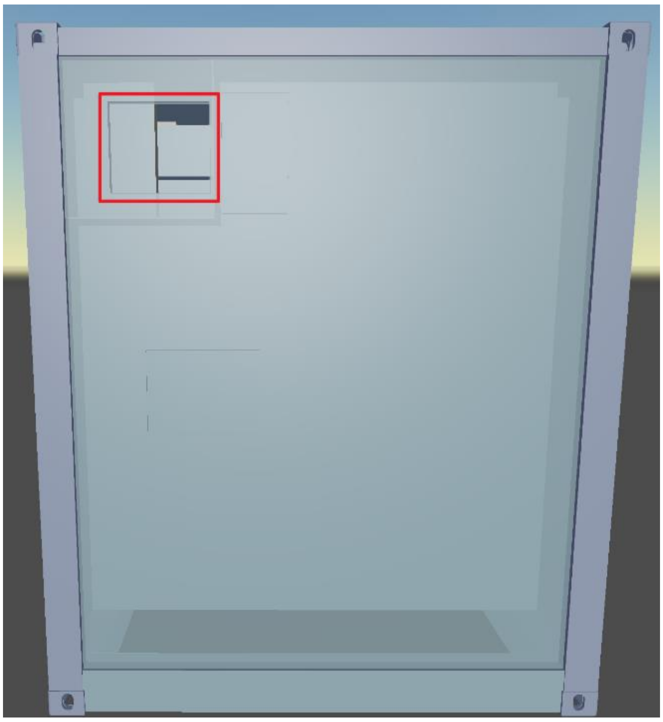


Figure 3.6 Exhaust fans in the container (side view)

Assumption: The dispersion simulations are run with the exhaust fans working. The exhaust fan operates at a flow rate of 697 CFM. The activation time will be calculated from the CFD simulations.

3.3 Simulation Results

This dispersion scenario processed represents progressively worse-case scenarios based on the assumptions made in the previous sections. The model covers 1 leakage position. According to the strategy of the ventilation system, the fan will be activated when the detection reaches 4000 ppm of hydrogen. Considering the time delay of the exhaust fan's hinge from initiation to full opening, we set the hinge's opening angle to gradually increase over 7 seconds, simulating the real-world process where the fan's airflow volume progressively reaches its maximum (697CFM). Table 3.2 shows the activating time for the scenario. Figure 3.7 shows the H_2 concentration at the location of the gas detector in the scenario.

Table 3.2 Fan activating time

Scenario	Leakage Point	Detector activation time (s)	Peak airflow time (s)
001	1	74.7	81.7

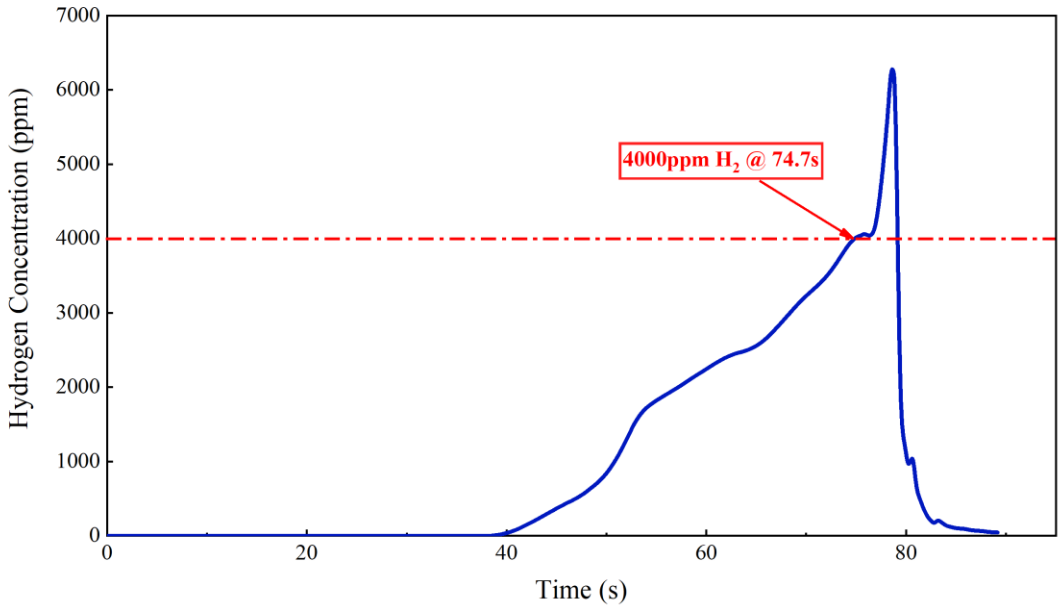


Figure 3.7 Hydrogen concentration at detector

Table 3.3 presents a summary of the scenario and corresponding result from the simulations. The maximum average concentration inside enclosure is presented as the combustible concentration limit according to NFPA 69 Chapter 8.

Table 3.3 Average gas concentration

Scenario	Maximum average gas concentration	
	Vol%	%LFL
001	0.39%	5.23%

Figure 3.8 shows the average gas concentration for the scenario and with the extraction fans activated.

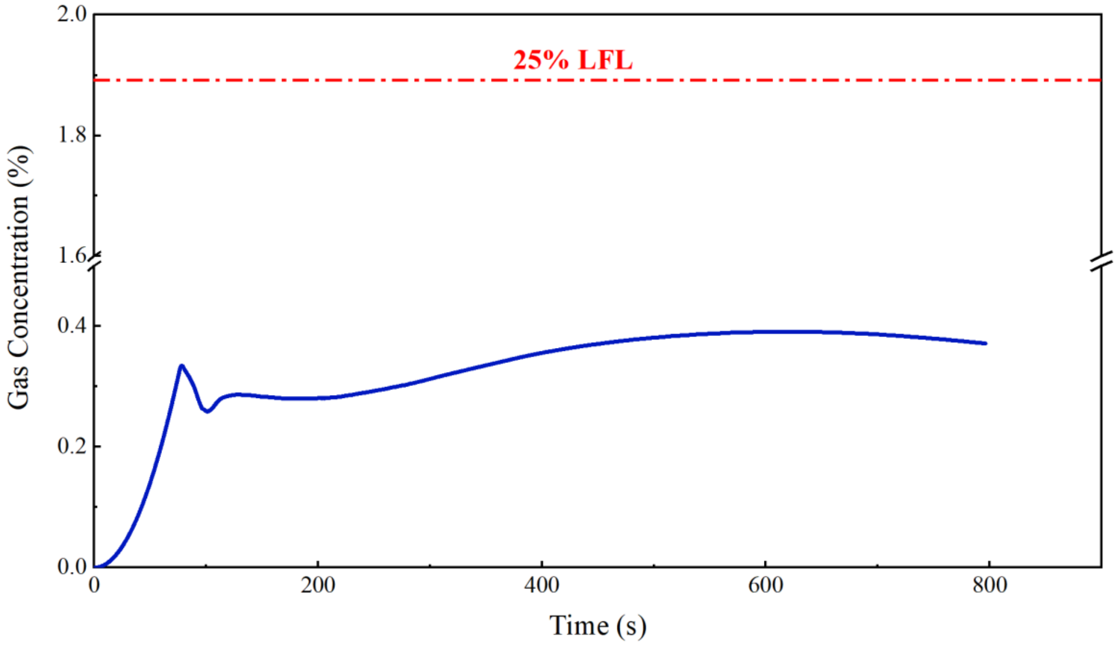


Figure 3.8 Average gas concentration plot

From the simulations we observe:

a) All scenarios with extraction fans activated can reduce flammable volume of gas;

b) All scenarios with extraction fans activated can remain gas average concentration below 25% LFL in the container;

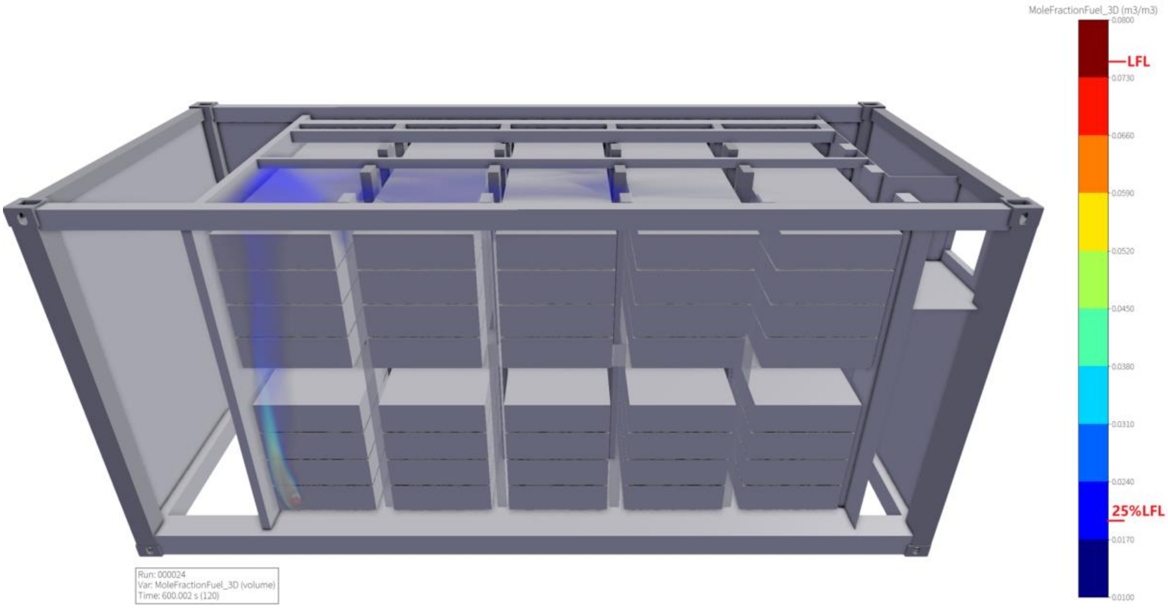


Figure 3.9 The gas cloud inside container at the time step that the gas average concentration is the maximum

4. Conclusions

a) Extraction fans could reduce flammable volume of gas;
b) The average gas concentration could be maintained below 25%LFL for each compartment;
c) The combustible concentration of all compartments are within the limit of NFPA 69.

The scenarios in this report follow the situation of cell failure and gas release from test observations outlined in the UL 9540A test report and are considered conservative by adopting the severe case of simultaneous thermal runaway in three cells as the basis for calculating the gas release rate. The exhaust fan activates when the hydrogen concentration at the detector reaches 4000 ppm. To accurately simulate the actual physical opening process of the explosion-proof hinges on the exhaust duct in the CFD simulation, we set them to gradually open to their maximum angle over a period of 7 seconds. The dynamic airflow changes during this process are calculated in real-time by the solver.

5. References

(1) NFPA 69:2024 Standard on Explosion Prevention Systems
(2) Cell Level UL9540A Report: 4790838636.1
(3) Module Level UL9540A Report: CQES240900092601