



<b>TEST REPORT</b> <b>ANSI/CAN/UL 9540A:2025</b> <b>TUV SUD Test Report for</b> <b>Unit Level – Test Method for Evaluating Thermal Runaway Fire Propagation in</b> <b>Battery Energy Storage Systems</b>	
Report No.:	704082527117-00
Date of issue:	2025-11-21
Project handler:	Jing Gao
Testing laboratory:	TÜV SÜD New Energy Vehicle Testing (Jiangsu) Co., Ltd.
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Testing location:	Chuweineng Testing Technology (Shanghai) Co., Ltd. Building 3, No. 1065, Beihe Road, Jiading District, Shanghai
Client:	Shanghai Elecnova Energy Storage Co., Ltd.
Client number:	125581
Address:	Hongqiao Hui No. 990 Shenchang Road, Minhang District, 201100 Shanghai, PEOPLE'S REPUBLIC OF CHINA
Contact person:	Pengfei Wang
Standard:	This TUV SUD test report form is based on the following requirements: ANSI/CAN/UL 9540A:2025 Fifth Edition (5Ed)
TRF number and revision:	TRF ANSI/CAN/UL 9540A:2025 Rev 0
eDoc_ID:	
TRF originated by:	TUV SUD NEW ENERGY TESTING (GUANGDONG) CO., LTD., Mrs. Zoey Liu
Copyright blank test report:	This test report is based on the content of the standard (see above). The test report considered selected clauses of the a.m. standard(s) and experience gained with product testing. It was prepared by TUV SUD Product Service. TUV SUD Group takes no responsibility for and will not assume liability for damages resulting from the reader's interpretation of the reproduced material due to its placement and context.
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Scheme:	<input type="checkbox"/> TUV Mark <input type="checkbox"/> cTUV Mark (SCC) <input type="checkbox"/> TUVus Mark (NRTL) <input type="checkbox"/> GS Mark <input checked="" type="checkbox"/> without certification <input type="checkbox"/> other: <input type="checkbox"/> AoC/CoC for EU-Directive / EU-Regulation:
Non-standard test method:	<input checked="" type="checkbox"/> No <input type="checkbox"/> Yes, see details under <i>Summary of testing</i>
National deviations:	N/A



Number of pages ( <i>Report</i> ):	71		
Number of pages ( <i>Attachments</i> ):	N/A		
Compiled by:	Jing Gao	Approved by:	Haiyang Liu
(+ signature)	<i>Jing Gao</i>	(+ signature)	<i>Haiyang Liu</i>

<b>Test sample:</b>	Energy Storage System
Type of test object:	Prototype Sample
Trademark:	<b>Elecnova</b>
Model and/ or type reference:	ECO-E261LP-2A
Rating(s):	see label

<b>Manufacturer:</b>	Shanghai Elecnova Energy Storage Co., Ltd.
Manufacturer number:	125581
Address:	Hongqiao Hui No. 990 Shenchang Road, Minhang District, 201100 Shanghai, PEOPLE'S REPUBLIC OF CHINA
<b>Name and address of factory(ies)</b>	
Jiangsu Sfer Electric Co., Ltd.	
Address1: No.1,Dongding Road 214400 Jiangyin,Jiangsu PEOPLE'S REPUBLIC OF CHINA	
Address2: No.59, DongSheng Road, 214400 Jiangyin, Jiangsu, PEOPLE'S REPUBLIC OF CHINA	

<b>Sub-contractors / tests (clause):</b>	N/A
Name:	N/A
Order description:	<input checked="" type="checkbox"/> Complete test according to TRF
	<input type="checkbox"/> Partial test according to manufacturer's specifications
	<input type="checkbox"/> Preliminary test
	<input type="checkbox"/> Spot check
	<input type="checkbox"/> Others:
Date of order:	2025-08-21
Date of receipt of test item:	2025-09-29
Date(s) of performance of test:	2025-10-23 to 2025-10-24

<b>Test item particulars:</b>
According to Unit Level of ANSI/CAN/UL 9540A:2025 Fifth Edition. Decision rule according to IEC Guide 115:2023, clause 9.2 was applied.

<b>Purpose of the product (description of intended use):</b>
The Energy Storage System, ECO-E261LP-2A is used in industrial appliance which consists of rechargeable lithium-ion battery system model ECO-E261LP-2A(DC), Power converter system (PCS), model EPCS125-AM, Liquid cooling system, model EMW50HFNC1A and other subsystems etc..
Rechargeable lithium-ion battery system, ECO-E261LP-2A(DC) consist of one high voltage control box and 5 Rechargeable Li-ion Battery Modules with model ECO-P1P52LP connected in series. The Re-chargeable Li-ion Module ECO-P1P52LP consists of 52 Rechargeable Li-ion Cells with model

LFP71173207/314Ah connected in series.

<b>Characteristic data</b> (not shown on the marking plate): for battery system, others see marking plate for details	
Nominal voltage	DC 832 V
Rated capacity	314 Ah
Charging voltage specified by manufacturer	DC 936 V or any cell reach 3.6 V
Upper limit charging voltage	DC 936 V or any cell reach 3.6 V
Charging power specified by manufacturer	125000 W
Maximum continuous charging power	DC 175 A
Discharging power specified by manufacturer	125000 W
Maximum continuous discharging power	DC 175 A
End of discharge voltage	DC 728 V or any cell less than 2.8 V
Standard temperature range for charging	0 °C to 50 °C
Standard temperature range for discharging	-20 °C to 50 °C
Standard charging method specified by manufacturer	Charge at constant power 125000 W until voltage reaches 3.6 V
Standard discharging method specified by manufacturer	-
Dimension	W×D×H: (1350±5) mm x (1050±5) mm x (2400±5) mm
Weight	2670±5 kg
Number of cells and configuration	(52S)5S

#### Attachments:

Attachment 1: Product description

Attachment 2: Exploding drawing of module & Identification/location of cells within the module

Attachment 3: Pre-conditioning profile

Attachment 4: Photo(s) for sample(s) before test and test setup with thermocouple location

Attachment 5: Photo(s) for sample(s) after test

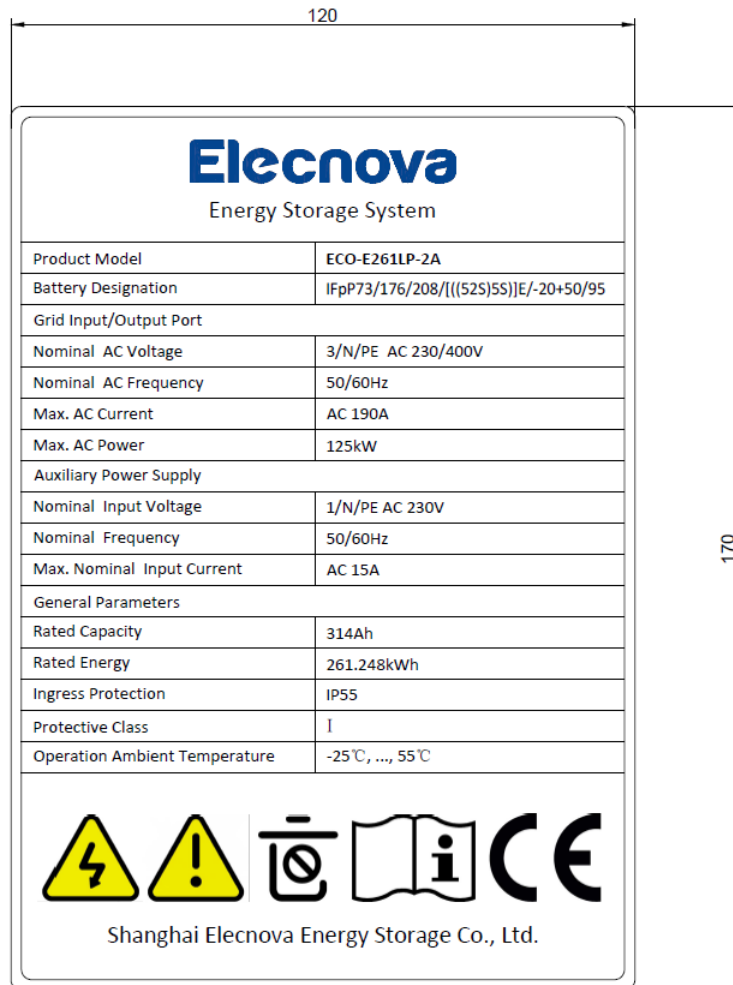
- Attachment 6: Monitored temperature chart
- Attachment 7: Flammable gas generation and composition data chart
- Attachment 8: Heat release rate versus time data chart
- Attachment 9: Peak smoke release rate and total smoke release data chart
- Attachment 10: Summary of Heat release rate & Peak smoke release rate and total smoke release data

**If additional information is necessary, please provide**

N/A

**Copy of marking plate:**

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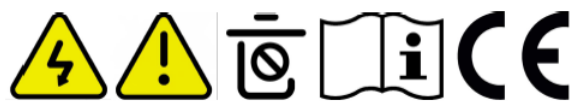


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## Elecnova

Energy Storage System

Product Model	ECO-E261LP-2A
Battery Designation	IFpP73/176/208/[[(52S)5S]]E/-20+50/95
Grid Input/Output Port	
Nominal AC Voltage	3/N/PE AC 230/400V
Nominal AC Frequency	50/60Hz
Max. AC Current	AC 190A
Max. AC Power	125kW
Auxiliary Power Supply	
Nominal Input Voltage	1/N/PE AC 230V
Nominal Frequency	50/60Hz
Max. Nominal Input Current	AC 15A
General Parameters	
Rated Capacity	314Ah
Rated Energy	261.248kWh
Ingress Protection	IP55
Protective Class	I
Operation Ambient Temperature	-25°C, ..., 55°C



Shanghai Elecnova Energy Storage Co., Ltd.

**Pictures of the product:**





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<b>Summary of testing:</b>	
<b>&gt;&gt;&gt;&gt; unit level testing:</b>	
Unit model name	ECO-E261LP-2A
Ratings	AC 230/400Vdc, 261.248 kWh
Whether UL 1973 compliant	No related documentation provided
Number of modules in the initiating BESS unit	5
The construction of the initiating BESS unit per 5.3	See Attachment 1
Fire protection features/detection/suppression systems within unit	Smoke sensor, temperature sensor, aerosol, explosion-proof valve and water hydrant adapter within unit
Module voltage(s) corresponding to the tested SOC	See Table 1
The thermal runaway initiation method used	Heating the cell with externally applied 2 pieces flexible film heaters that cover each large surface of the cell. Film heater specifications: 172mmx204mm (220 V, 900 W/pc)
Location of the initiating module within the BESS unit	See Attachment 4
Diagram and dimensions of the test setup including mounting location of the initiating and target BESS units, and the locations of walls, ceilings, and soffits	See Attachment 4
Observation of any flaming outside the initiating BESS enclosure and the maximum flame extension	No flaming outside the initiating BESS enclosure observed
Chemical and convective heat release rate versus time data	See Attachment 8, 10
Separation distances from the initiating BESS unit to target walls (e. g. distances A and C in Figure 9.1)	See Attachment 4
Separation distances from the initiating BESS unit to target BESS units (e.g. distances D and H in Figure 9.1);	See Attachment 4
The maximum wall surface and target BESS temperatures achieved during the test and the location of the measuring thermocouple	See Table 3 and Attachment 4 and 6
The maximum ceiling or soffit surface temperatures achieved during the indoor or outdoor wall mounted test and the location of the measuring thermocouple	See Attachment 4
The maximum incident heat flux on target wall surfaces and target BESS units	Wall surface: 0 kW/m <sup>2</sup> Target BESS units: 0.01 kW/m <sup>2</sup>

The maximum incident heat flux on target ceiling or soffit surfaces achieved during the indoor or outdoor wall mounted test	Outdoor Ground Mounted& Indoor Floor Mounted non residential
Gas generation and composition data	See Table 2 and Attachment 7
Peak smoke release rate and total smoke release data	See Attachment 9, 10
Indication of the activation of integral fire protection systems and if activated the time into the test at which activation occurred	integral fire protection systems was not activated during whole test
Observation of flying debris or explosive discharge of gases	No flying debris or explosive observed
Observation of re-ignition(s) from thermal runaway events	No re-ignition(s) from thermal runaway events observed
Observation(s) of sparks, electrical arcs, or other electrical events	No sparks, electrical arcs, or other electrical events observed
Observations of the damage to: 1) The initiating BESS unit; 2) Target BESS units; 3) Adjacent walls, ceilings, or soffits;	See Attachment 5
<b>Performance at unit level testing:</b>	
<input checked="" type="checkbox"/> Non-Residential Installations: <input checked="" type="checkbox"/> Indoor Floor Mounted <input checked="" type="checkbox"/> Outdoor Ground Mounted <input type="checkbox"/> Indoor Wall Mounted <input type="checkbox"/> Outdoor Wall Mounted <input type="checkbox"/> Rooftop and Open Parking Garages	
a) Flaming outside the initiating BESS unit is not observed; (for Indoor Floor Mounted & Indoor Wall Mounted)	No Flaming
a) Surface temperatures of modules within the target BESS units adjacent to the initiating BESS unit do not exceed the temperature at which thermally initiated cell venting occurs, as determined in 7.3.1.10; (for Outdoor Ground Mounted & Outdoor Wall Mounted & Rooftop and Open Parking Garages)	Yes, max.temperature of module surface within the target BESS units is 23.3.
b) Surface temperatures of modules within the target BESS units adjacent to the initiating BESS unit do not exceed the temperature at which thermally initiated cell venting occurs, as determined in 7.3.1.10; (for Indoor Floor Mounted & Indoor Wall Mounted)	Yes, see above
b) For BESS units intended for installation near exposures, surface temperature measurements on wall	Yes, max.temperature of wall surface is 22.9.

surfaces do not exceed 97 °C (175 °F) of temperature rise above ambient; (for Outdoor Ground Mounted)	
b) Surface temperature measurements on wall surfaces do not exceed 97 °C (175 °F) of temperature rise above ambient; (for Outdoor Wall Mounted & Rooftop and Open Parking Garages)	N/A
c) Surface temperature measurements on wall surfaces do not exceed 97 °C (175 °F) of temperature rise above ambient; (for Indoor Floor Mounted & Indoor Wall Mounted)	Yes, max.temperature of wall surface is 22.9.
c) Explosion hazards are not observed, including deflagration or detonation; (for Outdoor Ground Mounted & Outdoor Wall Mounted)	No explosion hazard was observed
c) For BESS units intended for installation on combustible roof constructions, surface temperature measurements on roof surfaces do not exceed 97 °C (175 °F) temperature rise above ambient per 9.6.5; (for Rooftop and Open Parking Garages)	N/A
d) Explosion hazards are not observed, including deflagration or detonation. (for Indoor Floor Mounted & Indoor Wall Mounted & Rooftop and Open Parking Garages)	No explosion hazard was observed
d) Heat flux measured at the minimum distance to a means of egress specified by the manufacturer shall not exceed 1.3 kW/m <sup>2</sup> . (for Outdoor Ground Mounted & Outdoor Wall Mounted)	Yes, max. heat flux measured on HF8 is 0.01 kW/m <sup>2</sup>
e) For BESS units intended for installation in open parking garages, heat flux measured at the distance from the BESS to the means of egress shall not exceed 1.3 kW/m <sup>2</sup> . (for Rooftop and Open Parking Garages)	N/A, Outdoor Ground Mounted
<b>Performance - module level test: (tested by: TUV SUD Rheinland , report no.: 704082527116-00 )</b>	
a) Vent gas is nonflammable as determined by the cell level test;	The vent gas presented a flammability hazard
b) There is no spread of flame outside of the module; and	Yes
c) The module exterior surface temperature does not exceed the cell venting temperature as measured adjacent to the initiating cell where the greatest thermal exposure is anticipated.	Yes
<b>&gt;&gt;&gt;&gt; module level test report summary:</b>	
Module model number	ECO-P1P52LP
Nominal voltage and rated capacity	166.4 Vd.c, 314Ah
Number of cells in module and module configuration	1P52S

Whether UL 1973 compliant	No related documentation provided
Module voltage corresponding to the tested SOC	187.2 V (100% SOC)
Method used to initiate thermal runaway	Heating the cell with externally applied 2 pieces flexible film heaters that cover each large surface of the cell. Film heater specifications: 172mmx204mm (220 V, 900 W/pc)
Thermal runaway of other cells within module:	Thermal runaway was observed on 3 cells in the module.
Heat release rate versus time data	see Attachment 7 and Attachment 9
Peak smoke release rate and total smoke release data	see Attachment 8 and Attachment 9
Flammable gas generation and composition data	see Table 2 and Attachment 6
Observation(s) of flying debris:	No
Observation(s) of explosive discharge of gas:	No
Observation(s) of sparks, electrical arcs or other electrical events:	No
Locations and visual estimations of flame and duration from the module	N/A
Re-ignitions	No

## Module vented gas composition:

Composition	Chemical formula	Measurement peak (L/s)	Measurement (L)	Analysis Method
Carbon monoxide	CO	0.129	-	NDIR
Carbon dioxide	CO <sub>2</sub>	0.975	-	NDIR
Hydrogen	H <sub>2</sub>	0.0285	-	Palladium nickel thin film solid state sensor
Total Hydrocarbons	(CH <sub>4</sub> Equivalent)	0.867	-	FID

**Performance - cell level test:** (tested by: TUV Rheinland , report no.: CN23F118001 )

a) Thermal runaway cannot be induced in the cell; and	Thermal runaway was induced in the cell
b) The cell vent gas does 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.	The cell vent gas presented a flammability hazard

## &gt;&gt;&gt;&gt; cell level test report summary:

Cell manufacturer name	Xiamen Hithium Energy Storage Technology Co., Ltd.
Cell model number	LFP71173207/314Ah
Nominal voltage and rated capacity	3.2 Vd.c, 314Ah
Cell chemistry (e.g. NMC, or LFP)	LFP
Physical format (i.e. prismatic, cylindrical, pouch)	Prismatic
Whether UL 1973 compliant	Yes, TUV Rheinland report No.: CN23RGEH 001
Method used to initiate thermal runaway	Heating the cell with externally applied 2 pieces flexible film heaters that cover each large surface of the cell.
Average vent temperature of the samples tested excluding the gas collection sample	203.7 °C
Average thermal runaway temperature of the samples tested excluding the gas collection sample	295.7 °C
The lower flammability limit of the cell vent gas at ambient temperature	8.1%
The lower flammability limit of the cell vent gas at vent temperature	6.5%
Burning velocity of the cell vent gas	0.779 m/s
P <sub>max</sub> of the cell vent gas	0.78 MPa

## Cell vented gas composition(normalized):

Composition	Chemical formula	Re-normalized, %
Hydrogen	H <sub>2</sub>	49.875
Carbon monoxide	CO	16.202
Carbon dioxide	CO <sub>2</sub>	26.861
Methane	CH <sub>4</sub>	3.671
Ethane	C <sub>2</sub> H <sub>6</sub>	0.548
Ethene	C <sub>2</sub> H <sub>4</sub>	1.389
Propene	C <sub>3</sub> H <sub>6</sub>	0.745
Propane	C <sub>3</sub> H <sub>8</sub>	0.18
Butene	n-C <sub>4</sub> H <sub>8</sub>	0.22
Butane	n-C <sub>4</sub> H <sub>10</sub>	0.068
Pentane	iso-C <sub>5</sub> H <sub>12</sub>	0.112
Pentene	n-C <sub>5</sub> H <sub>10</sub>	0.053



- deviation(s) found
- no deviations found

The product fulfils the requirements of:  UL 9540A (as indicated on page 1)  
 CAN/UL 9540A (as indicated on page 1)

**Additional information on non-standard test method(s)**

Sub clause: N/A  
Page: N/A  
Rational: N/A

**Possible test case verdicts:**

test case does not apply to the test object: N/A (not applicable / not included in the order)  
test object does meet the requirement: P (Pass)  
test object does not meet the requirement: F (Fail)

**General remarks:**

*"(see remark #)" refers to a remark appended to the report.*  
*"(see appended table)" refers to a table appended to the report.*  
*Throughout this report a  Comma /  Point is used as the decimal separator.*  
*The test results presented in this report relate only to the object tested.*  
*This report shall not be reproduced except in full without the written approval of the testing laboratory.*

<b>UNIT LEVEL</b>			
Clause	Requirement + Test	Result – Remark	Verdict
<b>INTRODUCTION</b>			
1.	<b>Scope</b>		
2	<b>Units of Measurement</b>		
3	<b>Normative References</b>		
4	<b>Glossary</b>		

**CONSTRUCTION**

<b>5.</b>	<b>General</b>		
<b>5.1</b>	<b>Cell</b>		
5.1.1	The cells associated with the BESS that were tested shall be documented in the test report, including cell chemistry (e.g. NMC, LFP), the physical format of the cell (i.e. prismatic, cylindrical, pouch), cell electrical rating in capacity and nominal voltage, the overall dimensions of the cell, and weight.	Cell chemistry: LFP Physical cell format: Prismatic	P
5.1.2	The cell documentation included in the test report shall indicate if the cells associated with the BESS comply with UL 1973.		P
5.1.3	Refer to 7.7.1 for further details to be included in the cell level test report		P
<b>5.2</b>	<b>Module</b>		
5.2.1	The modules associated with the BESS that were tested shall be documented in the test report, including the generic (e. g., metallic or nonmetallic) enclosure material, the general layout of the module contents and the electrical configuration of the cells in the modules and the modules in the BESS.	Module consists of a metallic enclosure material. Further details of the layout and module contents see Attachment 1.	P
5.2.2	The module documentation included in the test report shall indicate if the modules associated with the BESS comply with UL 1973.	No related documentation provided	N/A
5.2.3	Refer to 8.4 for further details to be included in the module level test report.		P
<b>5.3</b>	<b>Battery energy storage system unit</b>		
5.3.1	The BESS unit documentation included in the test report shall indicate the units that comply with UL	No related documentation provided	N/A

<b>UNIT LEVEL</b>			
Clause	Requirement + Test	Result – Remark	Verdict
	9540 and include the manufacturer, model, electrical ratings, and energy capacity of all BESS.		
5.3.2	For BESS units for which UL 9540 compliance cannot be determined, the documentation included in the test report shall include the number of modules in the BESS, electrical configuration of the module, and physical layout of the modules in the BESS, battery management system (BMS) and other major components of the BESS. The BESS enclosure overall dimensions and generic (e.g., metallic or nonmetallic) material used for the enclosure shall be documented. Depending upon the configuration of the BESS (e.g. the power conditioning system is external to the BESS enclosure), a battery system(s) can be tested as representative of the BESS. It shall be documented as to whether the battery system complies with UL 1973 in addition to the overall BESS compliance to UL 9540.	No related documentation provided	N/A
5.3.3	If applicable, the details of any fire detection and suppression systems that are an integral part of the BESS shall be noted in the test report.	Integral part of DUT, test conducted without fire suppression system actived.	P
5.3.4	Refer to 9.7, 10.4 and 10.7 for further details to be included in the unit level and if applicable, installation level test reports.		P
<b>5.4</b>	<b>Flow Batteries</b>		
5.4.1	For flow batteries, the report will cover the chemistry (e.g. vanadium redox, zinc bromine, etc.), a generic description of the electrolyte (s), the overall dimensions of the individual stack as well as the electrical rating in capacity and nominal voltage of the cell stack. The report will also include information on the complete flow battery system including the manufacturer's name and model number of the system, the electrical rating in volts and rated storage capacity in Ah or Wh, the number of cells and stacks in the system, and the maximum volume of electrolyte(s) for the system.		N/A
5.4.2	The flow battery documentation included in the test report shall indicate if the flow battery system complies with UL 1973.		N/A
5.4.3	See 7.7.2 for further details to be included in the flow battery cell level test report and 9.10 for further details to be included in the flow battery unit level test report.		N/A

### UNIT LEVEL

Clause	Requirement + Test	Result – Remark	Verdict
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### PERFORMANCE

<b>6.</b>	<b>General</b>		P
6.1	The tests in this standard are extreme abuse conditions conducted on electrochemical energy storage devices that can result in fires, explosions, smoke, off gassing of flammable and toxic materials, exposure to toxic and corrosive liquids, and potential exposure to hazardous voltages and electrical energy. See Annex B for recommended testing practices.		P
6.2	At the conclusion of testing, samples shall be discharged in accordance with the manufacturer's specifications. All samples shall be disposed of in accordance with local regulations.		P
6.3	Temperatures on parts and surfaces shall be measured continuously, taking the average over every 60 seconds through the test with a thermocouple junction formed from 24-gauge or smaller, Type-K thermocouple wire unless noted otherwise in the specific test. The maximum of these averages shall be documented for each thermocouple location. Cell surface temperatures shall be measured continuously, but not averaged over every 60 seconds as the other temperature measurements are.		P
6.4	When heat flux measurements are taken, they shall be measured continuously, taking the average over every 60-second interval. The maximum of these averages shall be documented for each gauge location.		P
<b>7</b>	<b>Cell Level</b>		—
<b>8</b>	<b>Module Level</b>		—
<b>9</b>	<b>Unit Level</b>		
<b>9.1</b>	<b>Sample and test configuration</b>		
9.1.1	The unit level test shall be conducted with BESS units installed as described in the manufacturer's instructions and this section. Test configurations may include the following:		P
	a) Indoor floor mounted non-residential use BESS;		P

<b>UNIT LEVEL</b>			
Clause	Requirement + Test	Result – Remark	Verdict
	b) Indoor floor mounted residential use BESS;		N/A
	c) Outdoor ground mounted non-residential use BESS;		N/A
	d) Outdoor ground mounted residential use BESS;		P
	e) Indoor wall mounted non-residential use BESS;		N/A
	f) Indoor wall mounted residential use BESS;		N/A
	g) Outdoor wall mounted non-residential use BESS;		N/A
	h) Outdoor wall mounted residential use BESS;		N/A
	i) Rooftop non-residential use BESS;		N/A
	j) Rooftop residential use BESS; and		N/A
	k) Open parking garage non-residential use BESS installations.		N/A
9.1.2	The unit level test requires one initiating BESS unit, in which a thermal runaway condition resulting in cell to cell thermal runaway propagation in accordance with the module level test in 8.2.4 is initiated, and adjacent target BESS units representative of an installation. Tests conducted for indoor floor mounted installations for residential BESS may 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 for residential BESS may be considered to also represent an outdoor installation. Examples of potential test configurations are shown in Figure 9.1, Figure 9.2 and Figure 9.3.		P
	<p><b>Exception:</b> Testing can be conducted outdoors for outdoor only installations if there are the following controls and environmental conditions in place:</p> <ul style="list-style-type: none"> <li>a) Wind screens are utilized with a maximum wind speed maintained at <math>\leq 12</math> mph;</li> <li>b) The temperature range is within <math>10^{\circ}\text{C}</math> to <math>40^{\circ}\text{C}</math> (<math>50^{\circ}\text{F}</math> to <math>104^{\circ}\text{F}</math>);</li> <li>c) The humidity is <math>&lt; 90\%</math> RH;</li> <li>d) There is sufficient light to observe the testing;</li> <li>e) There is no precipitation during the testing;</li> <li>f) There is control of vegetation and combustibles in the test area to prevent any impact on the testing and to prevent inadvertent fire spread from the test area; and</li> <li>g) There are protection mechanisms in place to prevent inadvertent access by unauthorized persons in the test area and to prevent exposure of persons to any hazards as a result of testing.</li> </ul>		N/A

UNIT LEVEL			
Clause	Requirement + Test	Result – Remark	Verdict
9.1.3	For outdoor non-residential use High Temperature Batteries installed in a container, the unit level test is waived as there is no additional information to be collected at the unit level for this technology when it is utilized for outdoor use only. Instead, the installation level test shall be conducted in accordance with 10.9.		N/A
9.1.4	9.1.4 For installations, where the high temperature battery modules are not installed on racks but rather within separate compartments within the container, the module is considered the test unit for the test of 10.9. See 10.2.3 and 10.2.4.		N/A
9.1.5	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.	Test conducted at cabinet ESS	N/A
9.1.6	Where the manufacturer's instructions indicate that the BESS can be installed outdoors and in open parking garages less than 3 m (10 feet) from the means of egress or other exposures, testing shall be conducted as described in this Section.		P
9.1.7	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.		P
9.1.8	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 units may also include one live, populated module at the location of the highest anticipated temperature in the enclosure. The remaining target BESS unit module enclosures do not need to contain cells.		P
9.1.9	The initiating BESS unit shall be brought to the maximum operating state of charge (MOSOC), in accordance with the manufacturer's specifications and allowed to rest for a minimum of 1 hour at room ambient before the start of the test.		P
9.1.10	Prior to initiating the test, the voltage of the initiating module shall be measured and recorded. If the voltage drop is greater than 0.1 % of the fully charged voltage of the module, then the initiating BESS shall		P

<b>UNIT LEVEL</b>			
Clause	Requirement + Test	Result – Remark	Verdict
	be charged again as noted in 9.1.9 and the voltage of the initiating BESS shall be recorded.		
9.1.11	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.	fire suppression system not actived during whole test	N/A
9.1.12	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 864 that is external to the BESS, but provided as part of an integral fire suppression system per 9.1.11.		P
<b>9.2</b>	<b>Test method – Indoor floor mounted BESS units</b>		
9.2.1	During an indoor 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).	See table1 for details	P
9.2.2	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.		P
9.2.3	The initiating BESS unit shall be positioned adjacent to two instrumented wall sections.		P
9.2.4	Instrumented wall sections shall extend not less than 0.49 m (1.6 feet) horizontally beyond the exterior of the target BESS units.		P
9.2.5	Instrumented wall sections shall be at least 0.61-m (2-feet) taller than the BESS unit height, and not less than 2.13 m (7 feet) in height above the floor.		P
9.2.6	The surface of the instrumented wall sections shall be covered with gypsum wall board and painted flat black. An incremental visual reference shall be provided on the instrumented wall sections for scale so that flame extension can be accurately measured if applicable. The gypsum wall board shall be 13-mm (1/2-inch) thick at minimum.		P
9.2.7	The initiating BESS unit shall be centered underneath an appropriately sized smoke collection hood of an oxygen consumption calorimeter.		P
9.2.8	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	Outdoor installation, only for reference.	P

<b>UNIT LEVEL</b>			
Clause	Requirement + Test	Result – Remark	Verdict
	smoke release rate shall be calculated as described in 8.2.17.		
9.2.9	The chemical and convective heat release rates shall be measured for the duration of the test, using the methodologies specified in 8.2.13 and 9.2.12, respectively.	Outdoor installation, only for reference.	P
9.2.10	With reference to 9.2.9, 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.		P
9.2.11	With reference to 9.2.9, 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. See 9.2.12.		P
9.2.12	With reference to 9.2.9, the convective heat release rate shall be calculated using the following equation: $HRR_c = V_e A \frac{353.22}{T_e} \int_{T_o}^T C_p dT$		P
9.2.13	The physical spacing between BESS units (both initiating and target) and adjacent walls shall be representative of the intended installation as noted in 9.1.	See attachment 1 for details	P
9.2.14	Separation distances shall be specified by the manufacturer for distance between:	See attachment 1 for details	P
	a) The BESS units and the instrumented wall sections; and		P
	b) Adjacent BESS units.		P
9.2.15	Wall surface temperatures shall be measured in vertical array(s) at 152-mm (6-inch) 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. Temperatures shall be measured continuously, averaging over every 60-second interval per 6.3. The maximum of these averages shall be documented for each thermocouple location.		P
9.2.16	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		P

<b>UNIT LEVEL</b>			
Clause	Requirement + Test	Result – Remark	Verdict
	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.		
9.2.17	Heat flux shall be measured with the sensing element of at least two water-cooled Schmidt-Boelter or Gardon gauges at the surface of each instrumented wall as follows in (a) – (c). Heat flux shall be measured continuously, averaging over every 60-second interval per 6.4. The maximum of these averages shall be documented for each gauge location. 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.	See attachment 1 for details	P
	<b>Exception:</b> <i>If (b) and (c) are deemed to be at the same location based on a construction review, only one gauge is required.</i>		P
9.2.18	Heat flux shall be measured with the sensing element of at least two water-cooled Schmidt-Boelter or Gardon gauges at the surface of each adjacent target BESS unit that faces the initiating BESS unit as follows in (a) and (b). Heat flux shall be measured continuously, averaging over every 60-second interval per 6.4. The maximum of these averages shall be documented for each gauge location. 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.	See attachment 1 for details	P
	<b>Exception:</b> <i>If (a) and (b) are deemed to be at the same location based on a construction review, only one gauge may be installed on the target unit for the measurement.</i>		N/A
9.2.19	For BESS intended for installation outdoors or in open parking garages covered by 9.1.6, heat flux shall be measured with the sensing element of at least one water-cooled Schmidt-Boelter or Gardon gauge positioned at the mid height of the initiating unit at the minimum horizontal distance from the BESS specified by the manufacturer or the point where the majority of	See attachment 1 for details, HF8 was setted on the back of initiating unit at the minimum horizontal distance from point where the majority of off-gas venting is expected from the initiating unit.	P

<b>UNIT LEVEL</b>			
Clause	Requirement + Test	Result – Remark	Verdict
	off-gas venting is expected from the initiating unit. Heat flux shall be measured continuously, averaging over every 60-second interval per 6.4.		
9.2.20	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. Temperatures shall be measured continuously, averaging over every 60-second interval per 6.3. The maximum of these averages shall be documented for each thermocouple location.	24AWG, Type-K thermocouple used	P
9.2.21	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 <sup>2</sup> /kg with a count of 28 – 32 threads in either direction within a 6.45 cm <sup>2</sup> (1 in <sup>2</sup> ) area.	Non- residential use BESS	N/A
9.2.22	Cell to cell thermal runaway propagation in accordance with the module level test in 8.2.4 shall be established 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 (Section 8).	See attachment 1 for details	P
9.2.23	The composition, velocity and temperature of the initiating BESS unit vent gases shall be measured within the calorimeter's exhaust duct as outlined in 8.2.12. The hydrocarbon content of the vent gas shall be measured using flame ionization detection. Hydrogen gas shall be measured with a palladium-nickel thin-film solid state analyzer. Composition, velocity and temperature instrumentation shall be collocated with heat release rate calorimetry instrumentation.		P
9.2.24	At the request of the BESS manufacturer, the hydrocarbon content of the vent gas may additionally		P

<b>UNIT LEVEL</b>			
Clause	Requirement + Test	Result – Remark	Verdict
	be measured using a Fourier-Transform Infrared Spectrometer with a minimum resolution of 1 cm <sup>-1</sup> and a path length of at least 2.0 m (6.6 feet), or equivalent gas analyzer.		
9.2.25	The test shall be terminated if:	See below	P
	a) There are three consecutive temperature readings measured inside each module within the initiating BESS unit that are determined to be falling over 15-minute intervals;		P
	b) The modules return to a temperature less than 60 °C (140 °F);	Test terminated with temperature measured return to ambient.	P
	c) The fire propagates to adjacent units or to adjacent walls;	No propagates between units	N/A
	d) A condition hazardous to test staff or the test facility requires mitigation; or	Not observed	N/A
	e) Flaming outside the test room is observed.	No fire observed.	N/A
9.2.26	For residential use systems, the gas collection data gathered in 9.2 shall be compared to the smallest room installation specified by the manufacturer to determine if the flammable gas collected exceeds 25% LFL in air.	Non-residential BESS	N/A
<b>9.3</b>	<b>Test method – Outdoor ground mounted units</b>		P
9.3.1	Outdoor ground mounted non-residential use BESS being evaluated for installation in close proximity to buildings and structures shall use the test method described in 9.2. If intended for outdoor use only installations, including rooftop installations, the smoke release rate, the convective and chemical heat release rate and content, velocity and temperature of the released vent gases need not be measured.	Clause 9.2 method used	P
9.3.2	Outdoor ground mounted residential use BESS being evaluated for installation in close proximity to buildings and structures shall use the test method described in Section 9.2 except as noted in 9.3.3 and 9.3.4. If intended for outdoor use only installations, the smoke release rate, the convective and chemical heat release rate and content, velocity, and temperature of the released vent gases need not be measured.	Non-residential use BESS	N/A
9.3.3	Test samples shall be installed as shown in Figure 9.2 in proximity to an instrumented wall section that is 3.66-m (12-feet) tall with a 0.3-m (1-foot) wide horizontal soffit (undersurface of the eave shown in Figure 9.2). The sample shall be mounted on a		P

<b>UNIT LEVEL</b>			
Clause	Requirement + Test	Result – Remark	Verdict
	support substrate and spaced from the wall in accordance with the minimum separation distances specified by the manufacturer. The wall and soffit shall be constructed with 19.05-mm (3/4-inch) plywood installed on wood studs and painted flat black. The instrumented wall shall extend not less than 0.49-m (1.6-feet) horizontally beyond the exterior of the target BESS units. The No. 24-gauge or smaller, Type-K exposed junction thermocouple array on the walls as noted in 9.2.15 shall extend to the surface of the soffit as shown in Figure 9.2.		
	<i><b>Exception:</b> If the manufacturer requires installation against non-flammable material, the test setup may include manufacturer recommended backing material between the unit and plywood wall.</i>		N/A
9.3.4	Target BESS shall be installed on each side of the initiating BESS in accordance with the manufacturer's installation specifications. The physical spacing between BESS units (both initiating and target) shall be the minimum separation distances specified by the manufacturer.		P
<b>9.7</b>	<b>Unit level test report</b>		P
9.7.1	The report on the unit level testing shall identify the type of installation being tested, as follows:		P
	a) Indoor floor mounted non-residential use BESS;		P
	b) Indoor floor mounted residential use BESS;		N/A
	c) Outdoor ground mounted non-residential use BESS;		P
	d) Outdoor ground mounted residential use BESS;		N/A
	e) Indoor wall mounted non-residential use BESS;		N/A
	f) Indoor wall mounted residential use BESS;		N/A
	g) Outdoor wall mounted non-residential use BESS;		N/A
	h) Outdoor wall mounted residential use BESS;		N/A
	i) Rooftop installed non-residential use BESS; or		N/A
	j) Open parking garage installed non-residential use BESS.		N/A
9.7.2	With reference to 9.7.1, if testing is intended to represent more than one installation type, this shall be noted in the report.	Indoor floor mounted non-residential use BESS & Outdoor ground mounted non-residential use BESS	P
9.7.3	The report shall include the following, as applicable:	See summary of testing in this report	P

UNIT LEVEL			
Clause	Requirement + Test	Result – Remark	Verdict
	a) Unit manufacturer name and model number (and whether UL 9540 compliant);		P
	b) Number of modules in the initiating BESS unit;		P
	c) The construction of the initiating BESS unit per 5.3;	<p>The BESS unit consists of 5 battery modules, 1 High voltage box, 1 PCS, 1 Liquid-cooled system and fire protection system.</p> <p>Battery modules were connected in series, each battery module was designed with a cell configuration 52S, total 260 battery cells.</p> <p>-Physical layout of the modules in BESS: see attachment 1.</p> <p>Refer to component list label for details.</p> <p>Unit level test was conducted with the setup indicated in attachment 2.</p> <p>1 battery system unit(cabinet) fully populated with battery modules for initiating BESS unit, target unit 2 cabinet without battery cell.</p>	P
	d) Fire protection features / detection / suppression systems within unit;	Smoke sensor, temperature sensor, aerosol, explosion-proof valve and water hydrant adapter within unit, not activated during test.	P
	e) Module voltage(s) corresponding to the tested SOC;		P
	f) The thermal runaway initiation method used;		P
	g) Location of the initiating module within the BESS unit;		P
	h) Diagram and dimensions of the test setup including mounting location of the initiating and target BESS units, and the locations of walls, ceilings, soffits as applicable, and thermocouples;		P

<b>UNIT LEVEL</b>			
Clause	Requirement + Test	Result – Remark	Verdict
	i) Observation of any flaming outside the initiating BESS enclosure and the maximum flame extension;		P
	j) Chemical and convective heat release rate versus time data;		P
	k) Separation distances from the initiating BESS unit to target walls (e. g. distances A and C in Figure 9.1) and target heat flux gauges;		P
	l) Separation distances from the initiating BESS unit to target BESS units (e.g. distances D and H in Figure 9.1);		P
	m) The maximum wall surface and target BESS temperatures achieved during the test and the location of the measuring thermocouple; NOTE: The maximum target BESS temperature is averaged over 60 seconds.		P
	n) The maximum ceiling or soffit surface temperatures achieved during the indoor or outdoor wall mounted test and the location of the measuring thermocouple;	Indoor floor mounted non-residential use BESS & Outdoor ground mounted non-residential use BESS	N/A
	o) The maximum incident heat flux on target wall surfaces and target BESS units;		P
	p) The maximum incident heat flux on target ceiling or soffit surfaces achieved during the indoor or outdoor wall mounted test;	Indoor floor mounted non-residential use BESS & Outdoor ground mounted non-residential use BESS	N/A
	q) Gas generation and composition data if conducted indoors;	Outdoor ground mounted non-residential use BESS, test data for reference.	P
	r) Peak smoke release rate and total smoke release data if conducted indoors;	Outdoor ground mounted non-residential use BESS, test data for reference.	P
	s) Indication of the activation of integral fire protection systems and if activated the time into the test at which activation occurred;	Smoke sensor, temperature sensor, aerosol, explosion-proof valve and water hydrant adapter within unit, not activated during test.	P
	t) Observation of flying debris or explosive discharge of gases unless mitigated by an engineered deflagration protection system;	See summary of testing in this report for details	P
	u) Observation of re-ignition(s) from thermal runaway events;	See above	P

<b>UNIT LEVEL</b>			
Clause	Requirement + Test	Result – Remark	Verdict
	v) Observation(s) of sparks, electrical arcs, or other electrical events;	See above	P
	w) Observations of the damage to: 1) The initiating BESS unit; 2) Target BESS units; 3) Adjacent walls, ceilings, or soffits;	See above	P
	x) Photos and video of the test;	Vidieo Provided to client	P
	y) If the test is terminated in accordance with 9.2.25, the circumstances of the termination; and	See summary of testing in this report for details	P
	z) Module level test report summary and cell level test report summary.	See summary of testing in this report for details	P
<b>9.8</b>	<b>Performance at unit level testing</b>		P
9.8.1	Installation level testing in Section 10 is not required if the following performance conditions outlined in Table 9.1 are met during the unit level test.	See below	P
<b>Table 9.1 Unit Level Performance Criteria</b>			P
<b>Non-Residential Installations:</b>			P
<b>Indoor Floor Mounted</b>	a) Flaming outside the initiating BESS unit is not observed;  b) Surface temperatures of modules within the target BESS units adjacent to the initiating BESS unit do not exceed the temperature at which thermally initiated cell venting occurs, as determined in 7.3.1.10;  c) Surface temperature measurements on wall surfaces do not exceed 97 °C (175 °F) of temperature rise above ambient;  d) Explosion hazards are not observed, including deflagration or detonation.	Cconfirmed	P
<b>Outdoor Ground Mounted</b>	a) Surface temperatures of modules within the target BESS units adjacent to the initiating BESS unit do not exceed the temperature at which thermally initiated cell venting occurs, as determined in 7.3.1.10;  b) For BESS units intended for installation near exposures, surface temperature measurements on wall surfaces do not exceed 97 °C (175 °F) of temperature rise above ambient;	Cconfirmed	P

<b>UNIT LEVEL</b>			
Clause	Requirement + Test	Result – Remark	Verdict
	<p>c) Explosion hazards are not observed, including deflagration or detonation; and</p> <p>d) Heat flux measured at the minimum distance to a means of egress specified by the manufacturer shall not exceed 1.3 kW/m<sup>2</sup>.</p>		
<b>Indoor Wall Mounted</b>	<p>a) Flaming outside the initiating BESS unit is not observed;</p> <p>b) Surface temperatures of modules within the target BESS units adjacent to the initiating BESS unit do not exceed the temperature at which thermally initiated cell venting occurs, as determined in 7.3.1.10;</p> <p>c) Surface temperature measurements on wall surfaces do not exceed 97 °C (175 °F) of temperature rise above ambient; and</p> <p>d) Explosion hazards are not observed, including deflagration or detonation.</p>	Indoor floor mounted non-residential use BESS & Outdoor ground mounted non-residential use BESS	N/A
<b>Outdoor Wall Mounted</b>	<p>a) Surface temperatures of modules within the target BESS units adjacent to the initiating BESS unit do not exceed the temperature at which thermally initiated cell venting occurs, as determined in 7.3.1.10;</p> <p>b) Surface temperature measurements on wall surfaces do not exceed 97 °C (175 °F) of temperature rise above ambient;</p> <p>c) Explosion hazards are not observed, including deflagration or detonation; and</p> <p>d) Heat flux measured at the minimum distance to a means of egress specified by the manufacturer shall not exceed 1.3 kW/m<sup>2</sup>.</p>	Indoor floor mounted non-residential use BESS & Outdoor ground mounted non-residential use BESS	N/A
<b>Rooftop and Open Parking Garages</b>	<p>a) Surface temperatures of modules within the target BESS units adjacent to the initiating BESS unit do not exceed the temperature at which thermally initiated cell venting occurs, as determined in 7.3.1.10;</p>	Indoor floor mounted non-residential use BESS & Outdoor ground mounted non-residential use BESS	

<b>UNIT LEVEL</b>			
Clause	Requirement + Test	Result – Remark	Verdict
	b) Surface temperature measurements on wall surfaces do not exceed 97 °C (175 °F) of temperature rise above ambient; c) For BESS units intended for installation on combustible roof constructions, surface temperature measurements on roof surfaces do not exceed 97 °C (175 °F) temperature rise above ambient per 9.6.5; d) Explosion hazards are not observed, including deflagration or detonation; and e) For BESS units intended for installation in open parking garages, heat flux measured at the distance from the BESS to the means of egress shall not exceed 1.3 kW/m <sup>2</sup> .		N/A
<b>Residential Installations:</b>			N/A
<b>Indoor Floor Mounted</b>	a) Charring or ignition of the cheesecloth indicator is not observed; b) Surface temperatures of modules within the target BESS units adjacent to the initiating BESS unit do not exceed the temperature at which thermally initiated cell venting occurs, as determined in 7.3.1.10; c) Surface temperature measurements on wall surfaces do not exceed 97 °C (175 °F) of temperature rise above ambient; d) Explosion hazards are not observed, including deflagration or detonation; and e) The concentration of flammable gas does not exceed 25% LFL in air for the smallest specified room installation size.	Indoor floor mounted non-residential use BESS & Outdoor ground mounted non-residential use BESS	N/A
<b>Outdoor Ground Mounted</b>	a) Flaming outside the initiating BESS unit is not observed. b) Surface temperatures of modules within the target BESS units adjacent to the initiating BESS unit do not exceed the temperature at which thermally initiated cell venting occurs, as determined in 7.3.1.10;	Indoor floor mounted non-residential use BESS & Outdoor ground mounted non-residential use BESS	N/A

<b>UNIT LEVEL</b>			
Clause	Requirement + Test	Result – Remark	Verdict
	<p>c) For BESS units intended for near exposures, surface temperature measurements on wall surfaces do not exceed 97 °C (175 °F) of temperature rise above ambient;</p> <p>d) Explosion hazards are not observed, including deflagration or detonation; and</p> <p>e) Heat flux measured at the minimum distance to a means of egress shall not exceed 1.3 kW/m<sup>2</sup>.</p>		
<b>Indoor Wall Mounted</b>	<p>a) Flaming outside the initiating BESS unit is not observed as demonstrated by no flaming or charring of the cheesecloth indicator;</p> <p>b) Surface temperatures of modules within the target BESS units adjacent to the initiating BESS unit do not exceed the temperature at which thermally initiated cell venting occurs, as determined in 7.3.1.10;</p> <p>c) Surface temperature measurements on wall surfaces do not exceed 97 °C (175 °F) of temperature rise above ambient;</p> <p>d) Explosion hazards are not observed, including deflagration or detonation; and</p> <p>e) The concentration of flammable gas does not exceed 25% LFL for the smallest intended room installation size.</p>	Indoor floor mounted non-residential use BESS & Outdoor ground mounted non-residential use BESS	N/A
<b>Outdoor Wall Mounted</b>	<p>a) Charring or ignition of the cheesecloth indicator is not observed;</p> <p>b) Surface temperatures of modules within the target BESS units adjacent to the initiating BESS unit do not exceed the temperature at which thermally initiated cell venting occurs, as determined in 7.3.1.10;</p> <p>c) Surface temperature measurements on wall surfaces do not exceed 97 °C (175 °F) of temperature rise above ambient;</p> <p>d) Explosion hazards are not observed, including deflagration or detonation; and</p> <p>e) Heat flux measured at the minimum distance to a means of egress shall not exceed 1.3 kW/m<sup>2</sup>.</p>	Indoor floor mounted non-residential use BESS & Outdoor ground mounted non-residential use BESS	N/A

<b>UNIT LEVEL</b>			
Clause	Requirement + Test	Result – Remark	Verdict
<b>9.9</b>	<b>Flow battery unit tests</b>		N/A
9.9.1	For those flow battery systems that do not meet the performance criteria of 7.9, unit level test using a test battery representative of the complete flow battery system but at a scale small enough to fit under the smoke collection hood of the calorimeter.	LFP Battery system	N/A
9.9.2	The test flow battery system shall be subjected to each of the following tests while monitoring the temperature of the electrolyte at a location in the fluid system that is anticipated to be the hottest. Where test data is not already available from UL 1973 testing, the test methods referenced below shall be applied and incorporated into this test Standard:		N/A
	a) The Overcharge Test in accordance with the Performance Electrical Tests of UL 1973;		N/A
	b) The High Rate Charge test in accordance with the Performance Electrical Tests of UL 1973; and		N/A
	c) The Short Circuit Test in accordance with the Performance Electrical Tests of UL 1973.		N/A
	NOTE: The electrolyte from the outlet of the stacks or within the stacks would be an appropriate location for sampling the temperature during these tests.		N/A
9.9.3	If the temperatures of the electrolytes during the tests of 9.9.2 do not exceed the flashpoint temperature determined in 7.3.2.1.2 the testing is concluded at the unit level. If the temperatures of the electrolytes during the tests of 9.9.2 exceed the flashpoint temperature determined during 7.3.2.1.2, the flow battery system is considered noncompliant and would need to be revised and retested.		N/A
9.9.4	The volume of flammable gases measured during the testing shall be scaled to the maximum energy reservoir for the intended flow battery system in order to determine the potential total flammable gas that can be produced by the system under a fault condition that leads to off gassing. This information shall be provided in the report. The gas data collected can be scaled to the largest representative system.		N/A
<b>9.10</b>	<b>Flow battery unit level test report</b>		
9.10.1	The report on flow battery unit testing shall include the following:		N/A
	a) Flow battery system manufacturer name and model number (and whether UL 1973 compliant);		N/A
	b) System Cell stack details per 5.4;		N/A

<b>UNIT LEVEL</b>			
Clause	Requirement + Test	Result – Remark	Verdict
	c) Energy storage technology (and whether UL 9540 compliant);		N/A
	d) The rated energy storage capacity of the flow battery (e.g. Ampere-hours or Watt-hours);		N/A
	e) Electrolyte(s) composition and maximum quantity in the systems;		N/A
	f) Test cell stack details per 5.4;		N/A
	g) Electrolyte quantities in the representative test flow battery system;		N/A
	h) Maximum charge voltage and charge current during the overcharge test;		N/A
	i) External short circuit resistance applied and maximum short-circuit current measured during the short circuit test;		N/A
	j) Flash point temperatures determined for each charged electrolyte (if applicable);		N/A
	k) Maximum electrolyte temperature measured during the overcharge tests;		N/A
	l) Maximum electrolyte temperature measured during the short circuit test;		N/A
	m) Maximum electrolyte temperature measured during the High Rate Charge test;		N/A
	n) Volume of gas measured with representative test flow battery system and scaled volume of gas based on full-size flow battery system;		N/A
	o) Observation(s) of flying debris or explosive discharge of gases;		N/A
	p) Observation(s) of sparks, electrical arcs, or other electrical events; and		N/A
	q) Video of the test.		N/A
<b>9.11</b>	<b>Flow battery unit level performance criteria</b>		
9.11.1	The flow battery performance level criteria is met if:		N/A
	a) The flash point temperature(s) measured in the test of 7.3.2.1.2 exceed the maximum temperature measured on the energy reservoir during each of the tests of 9.9.2 by at least 5 °C (9 °F); and		N/A
	b) For flow battery systems with two electrolytes, the flash point temperature(s) measured in the test of 7.3.2.1.2 exceed the maximum temperature of the mixed solution measured in accordance with 7.3.2.2.2 by at least 5 °C (9 °F).		N/A



### UNIT LEVEL

Clause	Requirement + Test	Result – Remark	Verdict
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<b>10</b>	<b>Instalaton Level</b>		—
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<b>ANNEX A</b>	<b>Test Concepts And Application Of Test Results To Installations</b> (informative)		—
A1	Introduction		
A2	Test Methodology and Purpose		
A3	Evaluating the Results		

<b>ANNEX B</b>	<b>Safety Recommendations for Testing</b> (informative)		—
B1	General		

<b>UNIT LEVEL</b>
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Object/part No.	Manufacturer/ trademark	Type/Model	Technical Data	Standard	Mark(s) of Conformity <sup>1)</sup>
For battery module ECO-P1P52LP					
1.Cell (52 pcs for one battery module)	Xiamen Hithium Energy Storage Technology Co., Ltd	LFP71173207/ 314Ah	DC 3.2V, 314Ah	IEC 62619:2022	TÜV Rheinland Ref. Certif. No.: JPTUV-152897 Report No. : CN23YUR9 001
2.CCS	Shenzhen Topsheng Technology Co., Ltd	TPSNP103F34 35FBL976 A3	Temperature: -40°C to +125°C	IEC62477- 1:2012	Test with unit
-NTC Resistor for cell (20 pcs for one battery module)	SEMITEC	103KT1608T- 1P	R25 =10KΩ±1% B <sub>25/85</sub> =3435K± 1% Temperature: -40°C to +125°C	IEC62477- 1:2012	Test with unit
-FPCA	ALLSTAR TECH(ZHONGSH AN)TO LTD	ASC-FC-H	Flame class: V-0	ANSI/UL 746E ANSI/UL 94 ANSI/UL 746F ANSI/UL 746A ANSI/UL 746B	UL E301444
-Plastic uptake	TEESUN	CL8811	Flame class: V-0 80°C	UL94 UL746	UL E329660
-Connector	POLYPLASTICS CO LTD	13065B	Flame class: V-0 130°C	UL94 UL746	UL E109088
3.Busbar	HUASHEN	T2 0.1*25	Rated current: 276A Thickness: 2.5mm	IEC62477- 1:2012	Test with unit
-Insulating layer	Shanghai Changyuan Electronic Material Co.,Ltd.	CB-HFT(6P)	Temperature: -40°C to +125°C Flammability: VW-1	UL 224	UL E180908
4.MSD PLUG	Shanghai Futronics Electronic	FMSD6102T0 2-A500Z	Rated voltage: 500 V DC Rated current: 250A	UL 4128	TÜV Rheinland Ref. Certif. No.: US 50652259 0001

<b>UNIT LEVEL</b>
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	Technology Co.,Ltd.		Temperature: -40°C to +125°C		
5.MSD Socket	Shanghai Futronics Electronic Technology Co.,Ltd.	FMSD2602T0 1-M61Z	Rated voltage: 1500 V DC Rated current: 350A Temperature: -40°C to +125°C	UL 4128	TÜV Rheinland Ref. Certif. No.: US 50652259 0001
6.Pressure Relief Valve	Voir-Tech	VE-M613-00-122	Pressure: 3±1Kpa Temperature: -40°C to +125°C Flammability: UL94 V0	IEC62477-1:2012	Test with unit
7.Connector Socket (B+, B-)	Phoenix Contact Asia-Pacific (Nanjing) Co., Ltd.	ES-FT-BPC-B/S 35-70 OG ES-FT-BPC-B/S 35-70 BK	Rated voltage: 1500 V DC Rated current: 250A Temperature: -40°C to +125°C Flammability: UL94 V0	PPP 51090A:2018	TÜV SÜD Z2 077026 0023 Rev. 03
8.Connector Plug (B+, B-)	Phoenix Contact Asia-Pacific (Nanjing) Co., Ltd.	ES-BPC-C 50-70 OG ES-BPC-C 50-70 BK	Rated voltage: 1500 V DC Rated current: 250A Temperature: -40°C to +125°C Flammability: UL94 V0	PPP 51090A:2018	TÜV SÜD Z2 077026 0023 Rev. 03
9.Insulating Sheet	MICA ELECTRICAL MATERIAL (LUHE) CO., LTD	Goode Shield T 28	Flammability: V-0 Temperature: +200°C Min Thickness: 0.2mm	ANSI/UL 94 IEC 60695-11- 10 UL 746B	UL E332023
10.Voltage acquisition line	Suzhou Xinchengda Wire & Cable Co Ltd	1332	Voltage Rating: 300V Withstanding Voltage:2000V Temperature: +200°C Flammability: VW-1 30AWG	UL 758	UL E537778

<b>UNIT LEVEL</b>
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11. Temperature acquisition line	Suzhou Xinchengda Wire & Cable Co Ltd	1332	Rated voltage: 300 V Temperature: +200°C Flammability: VW-1 30AWG	UL 758	UL E537778
12. Communication wire	DONG GUAN SHENG PAI ELECTRIC WIRE & CABLE CO LTD	1332	Temperature: +200°C Rated voltage: 300V 30AWG	UL 758	UL E347603
13. Case for battery box	Nantong Chaoda Equipment Co., Ltd	Aluminum	Thickness: 2.5mm W×D×H: (800±2) mm × (1135±2) mm × (248±2) mm	IEC 62619:2022	Test with unit
Module-Slave BMS board model no. ESBMM-6412-F					
14. Slave board in battery box	Gold Electronic	Model: ESBMM-6412-F Hardware version: HV7.1.0 Software version: V1.2	Monitoring the cells' temperature and voltage.	IEC 60730-1:2013	Test with unit
-Plastic enclosure	HENAN SHENMA HUAWEI PLASTIC ENGINEERING CO LTD	27GF(a)	V-0, Min thickness: 1.5mm	UL 94	UL E318518
-Coating material	Guangdong Raise BT Technology Co Ltd	BT51	Coating Flame Class: V-0	IEC 60695-11-10	UL E531378
-PCB material	SHENZHEN KING BROTHER ELECTRONICS TECHNOLOGY CO LTD	KB-04	V-0	UL 796	UL E225430
-AFE chip (U6_1, U6_2, U6_3, U6_4)	BYD	BF8915A	Vin: 0-5V operation temperature: -40°C~125°C	IEC62477-1:2012	Test with unit
-Temperature switching switch (U7_1, U7_2, U7_3, U7_4, U8_1,	TI	CD4051BPWR	Supply voltage: -0.5-20V Temperature range:	IEC62477-1:2012	Test with unit

<b>UNIT LEVEL</b>
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U8_2, U8_3, U8_4)			-55°C+125°C		
-Network isolation transformer (T4)	U&T	UTA06C02	OCL:150uHMin450uHMax, @100KHz/0.1 V Operating temperature range: -40°C to +125°C	UL 62368-1	UL E530055
-MCU(U3)	GD	GD32FCESRB T6	VDD:2.6-3.6V Operating temperature range : -40°C+85°C	IEC62477-1:2012	Test with unit
-Network isolation transformer (T1, T2, T3)	Sichuan Jingweida Technology Group Co., Ltd	S06709BA(R0)	OCL:150uHMin@100KHz/0.1V Operating temperature range: -40°C to +125°C	UL 62368-1	UL E492592
For high voltage control box: contain BCU board, controller and protect devices					
16. Isolating switch	Shanghai Liangxin Electric Appliance Co., Ltd	NDG3VH-315	Rated current: 315A Rated insulation voltage: DC1500V Temp -40-85°C	EN 60947-4-1	TÜV Rheinland Ref. Certif. No.: R 50531200 0001
17.Main Positive & Negative DC Contactor (2pcs)	Join Electric (ShangHai) Co.,Ltd	JEB350A-24B	Max Load Voltage: DC 1500V Contact Rating Current: 350A Temp: -40°C to +85°C	EN IEC 60947-4-1:2019 EN 60947-1:2007/A2:2014 EN 60947-5-1:2017	TÜV SÜD Ref. Certif. No.: N8A 109076 0002 Rev. 00
18.Pre-charge Contactor	Join Electric (ShangHai) Co.,Ltd	EVHC50-24S	Max. contact voltage: DC 1500V Rated current: 50A Temperature: -40°C to +85°C	EN IEC 60947-4-1:2019 EN 60947-1:2007/A2:2014 EN 60947-5-1:2017	TÜV SÜD Ref. Certif. No.: N8A 109076 0001 Rev. 04

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19.Pre-charge Resistor	KRAH ELEKTROTECHNI SCHE FABRIK GMBH + CO. KG	VHPR 200	Temperature: -40°C to +200°C Rated Power: 200W Resistance Range: 0.15~2.5k/ 0.3~666 (UL)	UL 508 UL 61010-1 UL 61010-2- 201 UL 2367	UL E237360
20.DC Fuse for Main Circuit	We, Eaton Bussmann Xi'an Fusegear Co., Ltd.	ESS2H-350	Rated voltage: 1500 V DC Rated current: 350A Breaking capacity 250kA, TC< 4mS	UL 248-1	UL E258171
21.Hall sensor	SINOMAGS TECHNOLOGY CO., LTD.	STB-CAB500	Primary nominal current 500A Primary current measuring range ±500A Supply voltage Min 8V Typical 13.5V Max 16V Temperature: -40°C to +105°C	UL 508 UL 61010 UL 2376	UL E507664
22.Miniature Circuit Breaker	Shanghai Liangxin Electric Appliance Co., Ltd.	NDB2- 63C32/2P +MX+OF2 NDB2- 63C25/2P NDB2- 63C10/2P	Rated current: 32A Temperature: -40°C to +70°C	EN 60898- 1:2003+A1+ A11+A12+A1 3 EN60898- 2:2006	TÜV Rheinland Ref. Certif. No.: R 50436891 0001
23.EMS Industrial Controller	EVOC Intelligent Technology Company Limited	MN50-E	Input Voltage: 9/30VDC Temperature: -20°C to +60°C	IEC62477- 1:2012	Test with unit
24.Ethernet switch	Shenzhen Yutai Technology Co., Ltd	UT-6408SA	Input Voltage: 12/24/48VDC Temperature: -40°C to +85°C	IEC62477- 1:2012	Test with unit

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25.AC/DC	MORNSUN Guangzhou Science & Technology Co., Ltd.	LMF500- 23B24UH	Rated voltage: 85- 305VAC/120- 430VDC Rated insulation voltage: 4000VAC Topr: -40°C - 85°C	GB 17625.1- 2012 GB 4943.1- 2011 GB/T 9254.1- 2021	CQC Ref. Certif. No.: 20220109074939 25
26.DC/DC	MORNSUN Guangzhou Science & Technology Co., Ltd.	PV200- 29B24R3	Rated voltage: 250-1500VDC Rated insulation voltage: 4000VAC Topr: -40°C - 70°C	IEC 62109- 1:2010 EN 62109- 1:2010	CNAS Report Number: ENS2303090094 S00201R
27.Connector Socket(P+P-)	Phoenix Contact Asia-Pacific (Nanjing) Co., Ltd.	ES-FT-BPC- B/S 35-70 OG ES-FT-BPC- B/S 35-70 BK	Rated voltage: 1500 V DC Rated current: 250A Temperature: -40°C to +125°C Flammability: UL94 V0	PPP 51090A:2018	TÜV SÜD Ref. Certif. No.: Z2 077026 0023 Rev. 03
28.Connector Plug(P+P-)	Phoenix Contact Asia-Pacific (Nanjing) Co., Ltd.	ES-BPC-C 50- 70 OG ES-BPC-C 50- 70 BK	Rated voltage: 1500 V DC Rated current: 250A Temperature: -40°C to +125°C Flammability: UL94 V0	PPP 51090A:2018	TÜV SÜD Ref. Certif. No.: Z2 077026 0023 Rev. 03
29.Connector Socket(B+B-)	Phoenix Contact Asia-Pacific (Nanjing) Co., Ltd.	ES-FT-BPC- B/S 35-70 OG ES-FT-BPC- B/S 35-70 BK	Rated voltage: 1500 V DC Rated current: 250A Temperature: -40°C to +125°C Flammability: UL94 V0	PPP 51090A:2018	TÜV SÜD Ref. Certif. No.: Z2 077026 0023 Rev. 03

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30.Connector Plug(B+B-)	Phoenix Contact Asia-Pacific (Nanjing) Co., Ltd.	ES-BPC-C 50-70 OG ES-BPC-C 50-70 BK	Rated voltage: 1500 V DC Rated current: 250A Temperature: -40°C to +125°C Flammability: UL94 V0	PPP 51090A:2018	TÜV SÜD Ref. Certif. No.: Z2 077026 0023 Rev. 03
31.Fuse	SHANGHAI HUGONG ELECTRICAL FACTORY	RT18-32X/6A	Rated voltage: DC 250V Breaking capacity: DC 25KA	EN 60947-1:2007+A1:2011+A2:2014 EN 60947-3:2009+A1:2012+A2:2015	ECM No. 0P210423.SHEU Q43
32.Diode (Preventing Reverse Connection)	Liujing Rectifier Co., Ltd.	LJ-MD25A	Voltage: AC1500V Current:25A Temperature: -40°C to +160°C	IEC 60747-2:2016	TÜV Rheinland Ref. Certif. No.: R 50606763 0001
33.Medium Power Relay	Xiamen Hongfa Electroacoustic Co., Ltd.	HF41F/24-ZS HF115F/024-2ZS4AF	Insulation Resistance 1000MΩ (500VDC) Temperature: -40°C to +85°C	IEC 60079-15: 2010	TÜV Rheinland Ref. Certif. No.: AK 50435463 0002
-Medium Power Relay Base	Jiangyin Changjiang Electric Appliance CO.,LTD	41F-1Z-C2-1 14FF-2Z-C2	Rated voltage: AC 250V Temperature: -40°C to +70°C	IEC62477-1:2012	Test with unit
34.Busbar for Main Circuit	Cangzhou Lianchuang Hardware Manufacturing Co., Ltd	T2 Cu, 20*5mm,	Cross-section: 20mm*5mm 1500VDC, 1mm	IEC62477-1:2012	Test with unit
-Insulating layer	Nanjing Sunyoung Insulation Material Co Ltd	CZ1531-2	Thicknesses: 1.2mm 105°C V-0	UL 94 UL746	UL E540086
35.Auxiliary power terminal	Shanghai Elinker Electric Co., Ltd.	LC1-5.08	300V, Cu	IEC62477-1:2012	Test with unit

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36. Insulation supporter	HAITAN	SM51	1500V GWIT 960°C 125°C	IEC62477-1:2012	Test with unit
37. Case for high voltage box	Wuxi Huineng Automation Equipment Co, Ltd.	SPCC	Material: SPCC T=2.0mm	IEC62477-1:2012	Test with unit
BMS main board in voltage control box, model: ESBCM-F133-L, HV5.0.1					
38. BMS (Main board)	GOLD ELECTRONIC	Model: ESBCM-F133-L Hardware version: HV5.0.0.2 Software version: V1.2	Over-charge detection voltage for each cell: 3.65, 1007.4V for battery system. Over-discharge detection voltage for each cell: 2.5V 690V for battery system. Charge overcurrent detection current: 200A Discharge overcurrent detection current: 200A Charge high temperature protection: 53 °C Charge low temperature protection: 0 °C Discharge high temperature protection: 53 °C	IEC 62619:2022 IEC 60664-3	Test with unit TÜV SÜD Report No. 70.409.22.690 .01-00

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			Discharge low temperature protection:0° C		
-PCB	SHENZHEN KING BROTHER ELECTRONICS TECHNOLOGY CO LTD	KB-04	UL 94V-0	UL 796	UL E225430
-MCU(U16)	Beijing Zhixin Microelectronics Technology Co., Ltd	SCM620L144 MJA0	3.0V-3.6V, -40°C- +105°C	IEC 62477- 1:2012	Test with unit
-IC for DC/DC POWER (U1)	SCT	SCT2430	Voltage range: 0.8V~40V Topr: -40°C to 125°C	IEC 62477- 1:2012	Test with unit
-IC for digital isolator (U31 U33 U26)	Suzhou Novosense Microelectronics Co., Ltd	NSi8221N1	3750 Vrms 2.5V-5V -40°C- +125°C	IEC 62477- 1:2012	Test with unit
-IC for EEPROM(U20)	Shanghai beiling Company Limited	BL24C512A	Supply voltage: 1.7V-5.5V Topr: -40°C to 125°C	IEC 62477- 1:2012	Test with unit
-IC for WDT (U18)	IMP	IMP706SESA	1.2V-5.5V -40°C -+85°C	IEC 62477- 1:2012	Test with unit
-Alternative	SGMICRO	SGM706B- SXS8G/TR	-0.6V-6V -40°C - +125°C	IEC 62477- 1:2012	Test with unit
-IC for Flash (U22,U23)	WINBOND	W25Q128FV	2.7V-3.6V -40-+85°C	IEC 62477- 1:2012	Test with unit
-Connector (CN1)	CZT	11110205D0 01	-55 -+105 °C	UL 94	UL E28476
-IC for CAN (U24 U32 U33)	SIT	SIT1051T	4.5V-5.5V -40°C- +150°C	IEC 62477- 1:2012	Test with unit
-IC for RS485 (U27)	SIT	SIT65176B	4.5V~5.5V -40°C - +105 °C	IEC 62477- 1:2012	Test with unit
-Transformer (T2 T3 T4 T5 T7 T8)	Hanrun Electronics Company Limited	HR600781	Isolation voltage:3750 Vac -40°C- +125°C	IEC 62477- 1:2012	Test with unit

<b>UNIT LEVEL</b>
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-Case	WAH HONG INDUSTRIAL CORP	WH-9100	V-0, 130°C, CTI I	UL 94	UL E150608
-Cover	POLYPLASTICS CO LTD	E130i	V-0, 130°C	UL 746C	UL E106764
-Wire	HUIZHOU CITY DENGGAODA ELECTROTECH CO LTD	FIW F	155°C 0.094- 0.039mm	UL 60950-1	UL E501004
-Transformer (T6 T10)	Mianyang Dunyuan Electronics Technology Co.,Ltd	ST06709A0	Isolation voltage: 4300VDC 1mA 60s or 2600VAC Topr:-40°C to 125°C	IEC 62477-1:2012	Test with unit
-IC for HV sampling (U43, U45)	Suzhou Novosense Microelectronics Co., Ltd	NSI1311-DSWVR	Supply voltage: 0.3V-6.5V, Isolation voltage: 5000 Vrms Topr: -40-+125°C	UL 1577	UL E500602
-Optocoupler (U35, U37, U39, U41, U42)	Everlight Electronics., Ltd.	EL1019	Supply voltage: 1.45V, Isolation voltage: 5000 Vrms Topr: -55-+110°C	UL 1577	UL E214129
-Relay(K1)	XIAMen Hongfa Electroacoustic Co.Ltd	HF D3-VI/5	VDC:5V Operation temperature: -40°C -+85°C	IEC 62776-1:2012	UL E134481
-Resettable fuse (F2 F3 F5 F6 F7 F8 F9 F10 F11 F12)	POLYTRONICS TECHNOLOGY CORP	SMD1206P03 5TF	33V, Ih: 0,35A, It: 0,75A, Imax: 100A	UL 1434	UL E201431
For system: controller and protect devices					
39.PCS	Shenzhen Enjoy Technology Co., Ltd.	EPCS125-AM	DC 615-950V AC400V,3P+P E(+N) Temperature: -30°C to +55°C	EN 62477-1:2012+A1:2017	TÜV Rheinland Certification test report No.: CN25FXA8 0001

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40.5kW Chiller	Shenzhen Envicool Technology Co., Ltd.	EMW50HFN C1A	Rated voltage: 220V~50/60 Hz Temperature: -30°C to +55°C	CE-24-6002	TÜV Rheinland Registration No.: AM 50632900 0001
41.E-Stop	Schneider	ZB2BS54C	Rated Voltage: 24V IP65 Temperature: -25°C to +70°C	IEC 62477-1:2012	Test with unit
42.Fan	TINGXIANG ELECTRIC (SHANGHAI) CO LTD	TX17250H24 B	Rated voltage: 24V Rated Current: 2.2A Temperature: -25°C to +70°C	UL 507	UL E526072
43.Smoke detector	Hubei He'andun Fire Protection Technology Co., Ltd	55000-316	Supply voltage: 9 V to 33 Vdc Temperature: -20°C to +60°C	EN 54-7:2018	LPCB Certificate Number: 010q Issue: 48
44.Temperature detector	Hubei He'andun Fire Protection Technology Co., Ltd	55000-121	Supply voltage: 9 V to 33 V dc Temperature: -30°C to +80°C	EN 54-5:2000+A1:2002	LPCB Certificate Number: 010p Issue: 42
45.Enclosure for Integrated cabinet (Max. dimension for frame structure)	Nantong Chaoda Equipment Co., Ltd	Aluminum	Aluminum Thickness: 2.5mm Length: 824±4mm Width: 821±4mm	IEC 62477-1:2012	Test with unit
46.Indicator light	YUEQING DAHE ELECIRIC CO., LTD,	HBD16-22DS	Rated voltage: 12V; 110V; 220V Temperature: -25°C to +65°C IP40	IEC 62477-1:2012	Test with unit
47.Warn Lamp	VIMPEX	Banshee Excel Lite	Topr: -20°C - 70°C 9V-30V	EN54-3:2011	LPCB No.539c/03

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48.Signal Lamp	Schneider	XB2BVB1LC XB2BVB3LC XB2BVB4LC	Rated voltage:24V Topr: -25°C - 70°C IP65	IEC 60947-1	DocuSign Envelope ID:999E92FC- 0099-4E53- B0ED- 38A24C3348DE
49.magnetic ring	Cergen Technology (Suzhou) Co.,LTD	ES5169-01	55.0μH ≤ AL @ 10KHz, 0.3V 17.0μH ≤ AL @ 100KHz, 0.3V	IEC61000-6- 2 IEC61000-6- 4	Test with unit
50.DC Wire	Qunxing	ES-H15Z-H	1500VDC 125°C 70mm <sup>2</sup>	PPP 58049A:2019	TÜV SÜD No.B123941 0001 Rev.00
51.AC Wire	Qunxing	ES-H15Z-H	1500VDC 125°C 70mm <sup>2</sup>	PPP 58049A:2019	TÜV SÜD No.B123941 0001 Rev.00
52.Aerosol	Hubei Jiandun	QRR0.15G/S -PEK, QRR0.05/S- PFK, QRR0.1G/S- PFK	-	EN60204- 1:2018 ENISO12100 :2010	ICR ICR/VC/HU24010 8
53. explosion- proof valve	BRIM	BR-J04009- 000R	Mechanical, 174mmx140m mx46.7mm for main body, with SUS 304 spring,1.2mm* 8mm*35mm	-	-

Supplementary information:

<sup>1)</sup> Provided evidence ensures the agreed level of compliance. See OD-CB2039.

<b>UNIT LEVEL</b>
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**UNIT LEVEL TEST RESULT:**

<b>Table 1: Thermal runaway test result</b>	
<b>Summary of initiating module</b>	
Initial ambient temperature:	21.2 °C
Initial relative humidity:	47%RH
Pre-conditioning time	One cycle (discharge to charge) For 4 target module in initiating unit, From 2025-10-21 11:57 to 2025-10-21 22:37 One cycle (discharge to charge) For initiating module in initiating unit, From 2025-10-22 18:41 to 2025-10-22 23:32
Thermal runaway test start time (heating start time)	2025-10-23 15:29:00
Module voltage before test:	176.0
Methods used to initiate thermal runaway	Heating the cell with two externally applied flexible film heaters with 5°C /min heating rate until thermal runaway occurs.
Average heating rate:	5°C /min
Surface temperature at which gases were first vented:	T7: 137.3 °C, T8: 151.7 °C (Thermocouple location see Attachment 1)
Time when gases were first vented:	Cell 20 2025-10-23 16:09:42
Surface temperature prior to thermal runaway:	T7: 187.2 °C, T8: 286.3 °C (Thermocouple location see Attachment 1)
Time when thermal runaway:	Cell 20 2025-10-23 16:25:59
Module voltage after test:	165.3 Vdc
Location of cell(s) for initiating thermal runaway	Cell 20 (see Attachment 1)
Thermal runaway of other cells within module:	Thermal runaway was observed on cell 20, cell 21, cell 22 in the module
Observation(s) of flying debris:	No
Observation(s) of explosive discharge of gas:	No
Observation(s) of sparks, electrical arcs or other electrical events:	No
Locations and visual estimations of flame	N/A, No flame observed
Module weight before test:	350.0 kg
Module weight after test:	348.8 kg
Module weight loss:	1.2 kg



**UNIT LEVEL**

**Summary of other modules**




Status of other modules	<p>The max. surface temperatures of modules within the target BESS units adjacent to the initiating BESS unit is 83.5 °C which do not exceed the temperature at which thermally initiated cell venting occurs.</p> <p>Voltage of other modules in initiating unit,</p> <p>module 1:176.3 Vdc                  module 3:175.5 Vdc                  module 4:176.3 Vdc                  module 5:176.6 Vdc</p>
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Supplementary information:	N/A
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**Timeline of thermal runaway**

Time (hh:mm:ss)	Event	Description
2025-10-23 15:29:00	Start testing.	
2025-10-23 16:09:42	The initiating cell 20 first vented.	

**UNIT LEVEL**

<p>2025-10-23 16:25:45</p>	<p>The temperature of initiating cell 20 started to rise sharply, thermal runaway occurred.</p>	
<p>2025-10-23 16:31:11</p>	<p>The temperature of initiating cell 21 started to rise sharply, thermal runaway occurred.</p>	
<p>2025-10-23 16:47:45</p>	<p>The temperature of initiating cell 22 started to rise sharply, thermal runaway occurred.</p>	

### UNIT LEVEL

2025-10-24 08:00:05	All temperature monitored returned around 40 °C and video stopped	
Remark: Refer to attachment 4 for details of sample before test and test setup with thermocouple location		

**Table 2: Vented gas composition result**

Composition	Chemical formula	Measurement peak (L/s)	Measurement (L)	Analysis Method
Carbon Monoxide(NDIR)	CO	0.08	35.7	NDIR
Carbon Dioxide(NDIR)	CO <sub>2</sub>	1.85	127.0	NDIR
Hydrogen(Palladium nickel thin film solid state sensor)	H <sub>2</sub>	0.2	96.6	Palladium nickel thin film solid state sensor
Total Hydrocarbons (equivalent to CH <sub>4</sub> , measured by FID)	THC	0.567	244.5	FID
Flow rate in exhaust duct (m <sup>3</sup> /s)		4.1		
Sampling frequency of FTIR (Hz)		0.1		

**Table 3: Monitored temperature result**

Thermocouple location	Thermocouple location	Measured maximum temperature, °C	Limit, °C
TKK-1	Between left large surface of cell #20 and film heater (TKK-1)	884.2	-
TKK-2	Between right large surface of cell #20 and film heater (TKK-2)	622.3	-
T1	Right large surface center of cell #6 (T1)	80.5	-

<b>UNIT LEVEL</b>
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T2	Right large surface center of cell #7 (T2)	86.9	-
T3	Right large surface center of cell #8 (T3)	83.5	-
T4	Left large surface center of cell #18 (T4)	81.4	-
T5	Left large surface center of cell #19 (T5)	117.1	-
T6	Right large surface center of cell #19 (T6)	769.3	-
T7	Right large surface of cell #20 not covered by film heater (T7)	631.4	-
T8	Near vent device of cell #20 (T8)	461.2	-
T9	Left large surface center of cell #21 (T9)	704.2	-
T10	Right large surface center of cell #21 (T10)	628.9	-
T11	Right large surface center of cell #22 (T11)	292.1	-
T12	Right large surface center of cell #32 (T12)	445.5	-
T13	Right large surface center of cell #33 (T13)	270.7	-
T14	Right large surface center of cell #34 (T14)	120.1	-
T15	Ambient (T15)	20.1	-
T16 (60s average)	Outside of front enclosure (T16)	157.0	-
T17 (60s average)	Outside of back enclosure (T17)	54.8	-
T18 (60s average)	Outside of left enclosure (T18)	42.2	-
T19 (60s average)	Outside of right enclosure (T19)	37.8	-
T20 (60s average)	Outside of top enclosure (T20)	34.7	-
T21 (60s average)	Outside of bottom enclosure (T21)	38.4	-
T1-1 (60s average)	module 5 pack bottom surface in unit 1	23.7	-
T1-2 (60s average)	module 4 pack bottom surface in unit 1	25.4	203.7 °C
T1-3 (60s average)	module 3 pack bottom surface in unit 1	76.9	203.7 °C

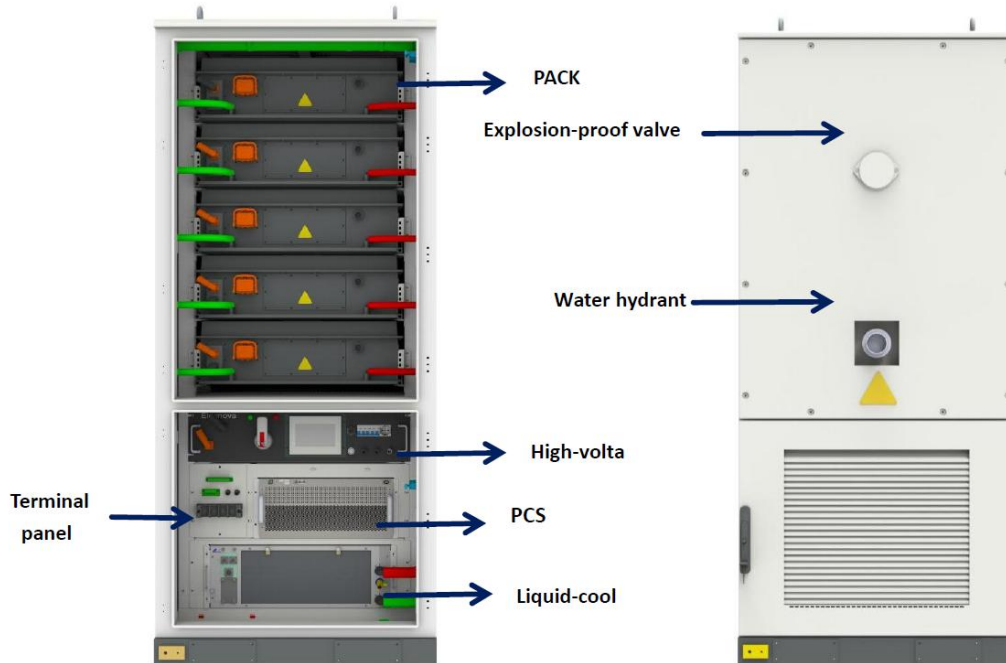


<b>UNIT LEVEL</b>
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T1-4 (60s average)	module 3 front surface in unit 1	26.6	203.7 °C
T1-5 (60s average)	module 1 pack top surface in unit 1	43.8	203.7 °C
T1-6 (60s average)	module 1 pack front surface in unit 1	25.6	203.7 °C
T1-7 to T1-11 (60s average)	Unit 1 cabinet surface	23.9	203.7 °C
T2-1 (60s average)	module 4 pack side surface in unit 2	20.0	203.7 °C
T2-2, T2-3, T2-4 (60s average)	module 3 pack side surface, front surface, back surface in unit 2	22.5	203.7 °C
T2-5, T2-6, T2-7 (60s average)	module 2 pack side surface, front surface, back surface in unit 2	21.7	203.7 °C
T2-8 (60s average)	module 1 pack back surface in unit 2	23.3	203.7 °C
T2-9 to T2-11 (60s average)	Unit 2 cabinet surface	23.3	203.7 °C
WallA1~WallA24	Wall A surface	22.1	118
WallB1~WallB24	Wall B surface	22.4	118
WallC1~WallC24	Wall B surface	22.9	118
Remark: please see Attachment 4 for thermocouple locations and Attachment 6 for monitored temperature charts.			

### Attachment 1: Product description

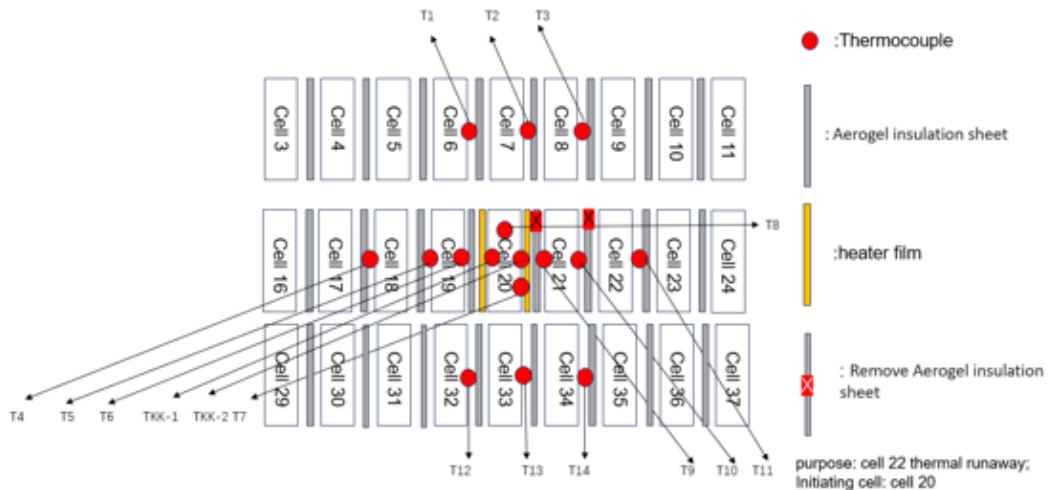
**UNIT LEVEL**



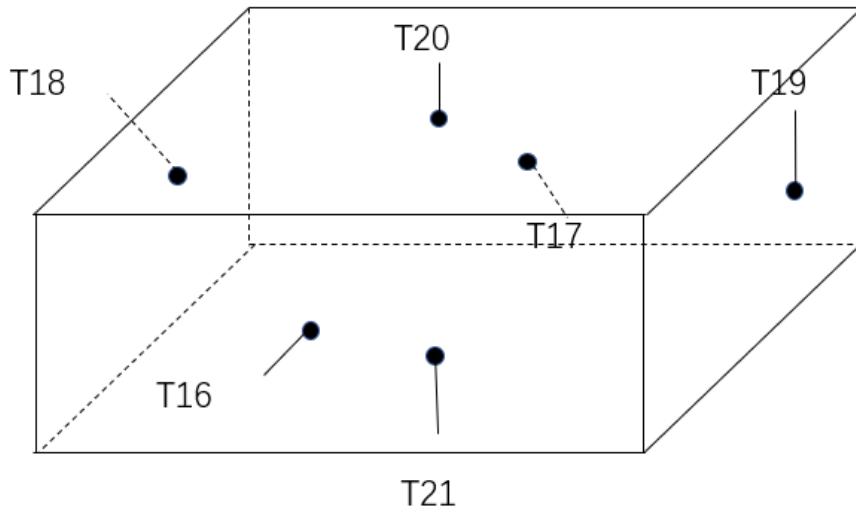
**UNIT LEVEL**

**Attachment 2: Exploding drawing of module & Identification/location of cells within the module**

Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6	Cell 7	Cell 8	Cell 9	Cell 10	Cell 11	Cell 12	Cell 13
Cell 14	Cell 15	Cell 16	Cell 17	Cell 18	Cell 19	Cell 20	Cell 21	Cell 22	Cell 23	Cell 24	Cell 25	Cell 26
Cell 27	Cell 28	Cell 29	Cell 30	Cell 31	Cell 32	Cell 33	Cell 34	Cell 35	Cell 36	Cell 37	Cell 38	Cell 39
Cell 40	Cell 41	Cell 42	Cell 43	Cell 44	Cell 45	Cell 46	Cell 47	Cell 48	Cell 49	Cell 50	Cell 51	Cell 52

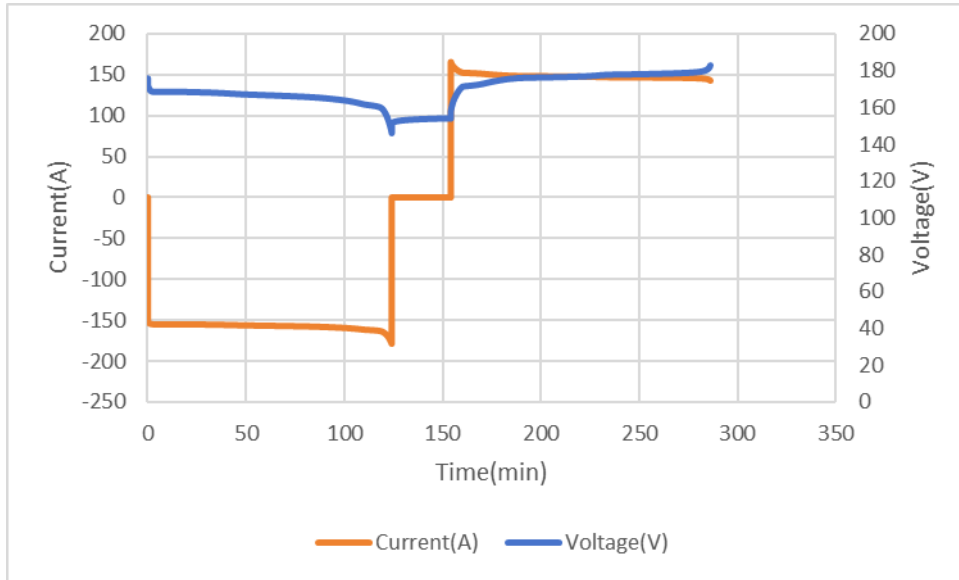


**UNIT LEVEL**

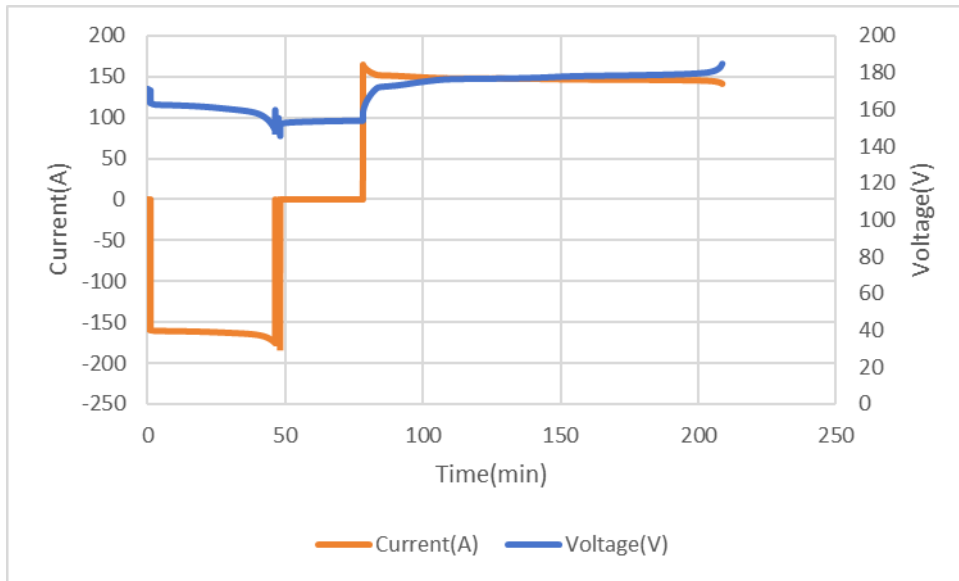


**UNIT LEVEL**

**Attachment 3: Pre-conditioning profile**

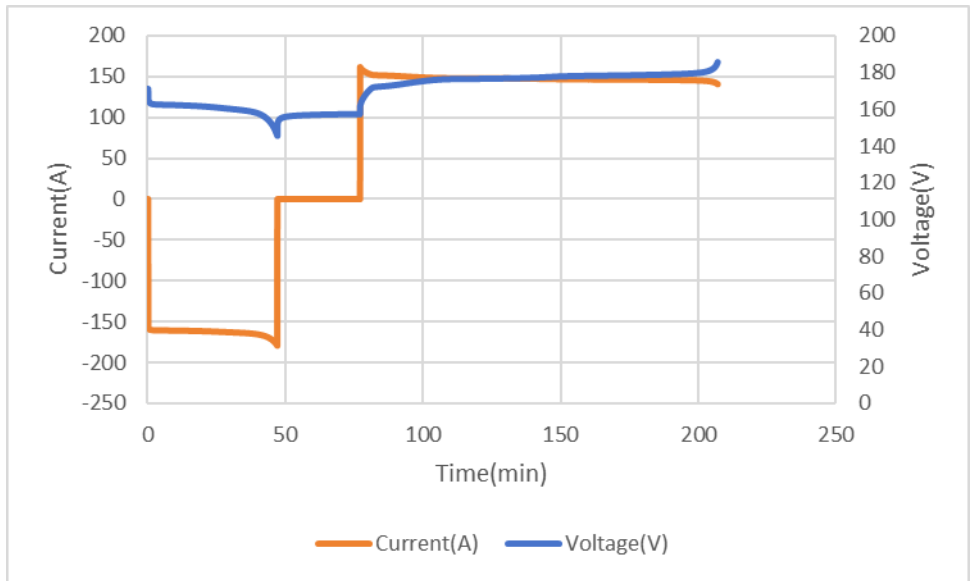


**Figure 1 Initiating module 2 charging/discharging chart**

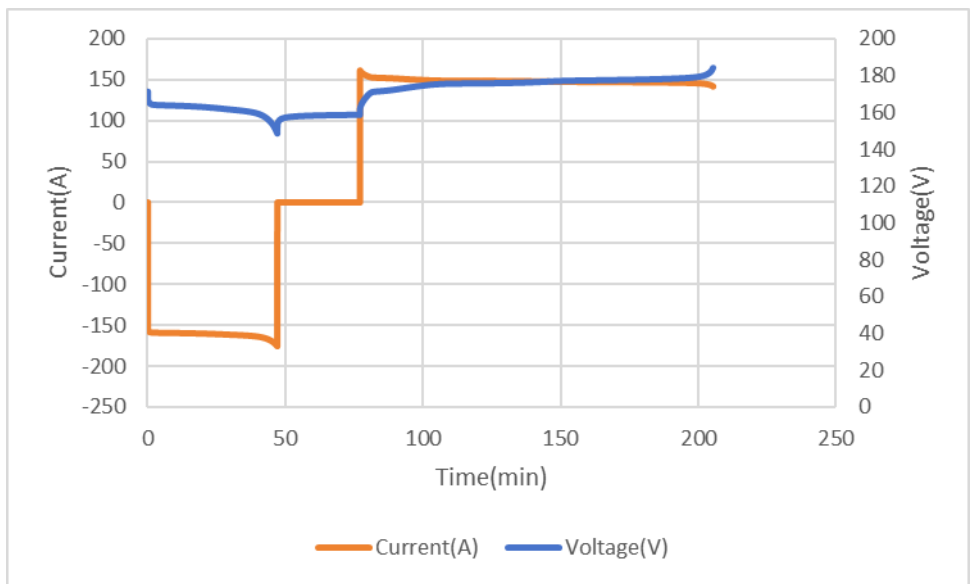


**Figure 2 Module 1 charging/discharging chart**

**UNIT LEVEL**

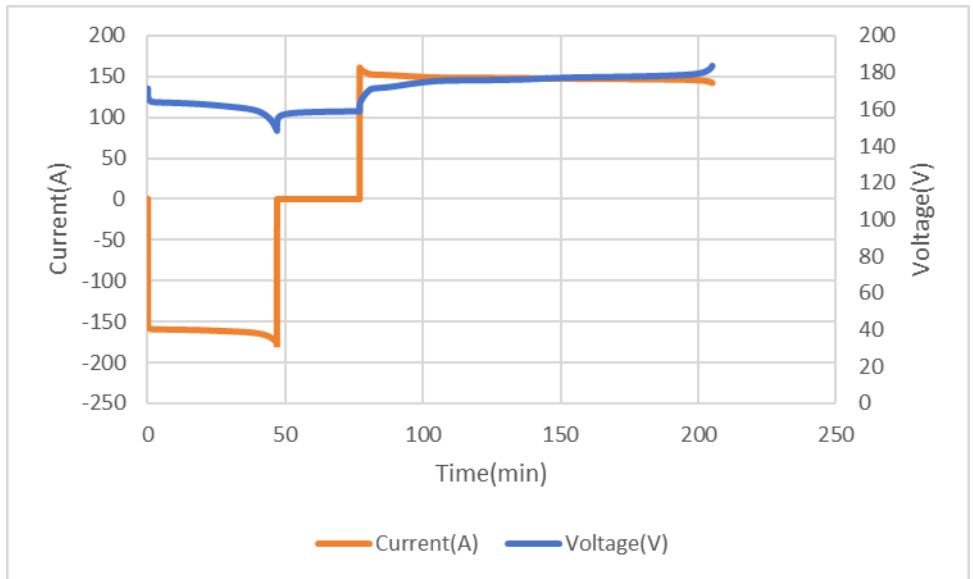


**Figure 3 Module 3 charging/discharging chart**



**Figure 4 Module 4 charging/discharging chart**

**UNIT LEVEL**



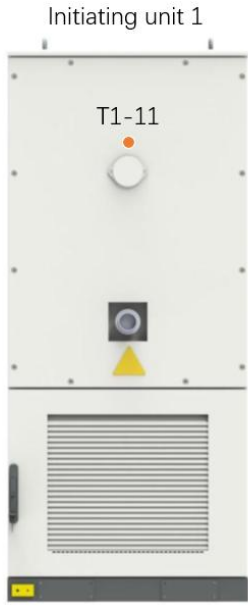
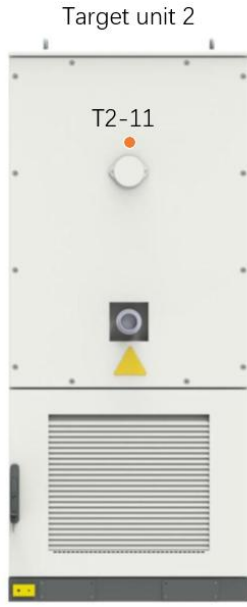


**Figure 5 Module 5 charging/discharging chart**

**Attachment 4: Photo(s) for sample(s) before test and test setup with thermocouple location**

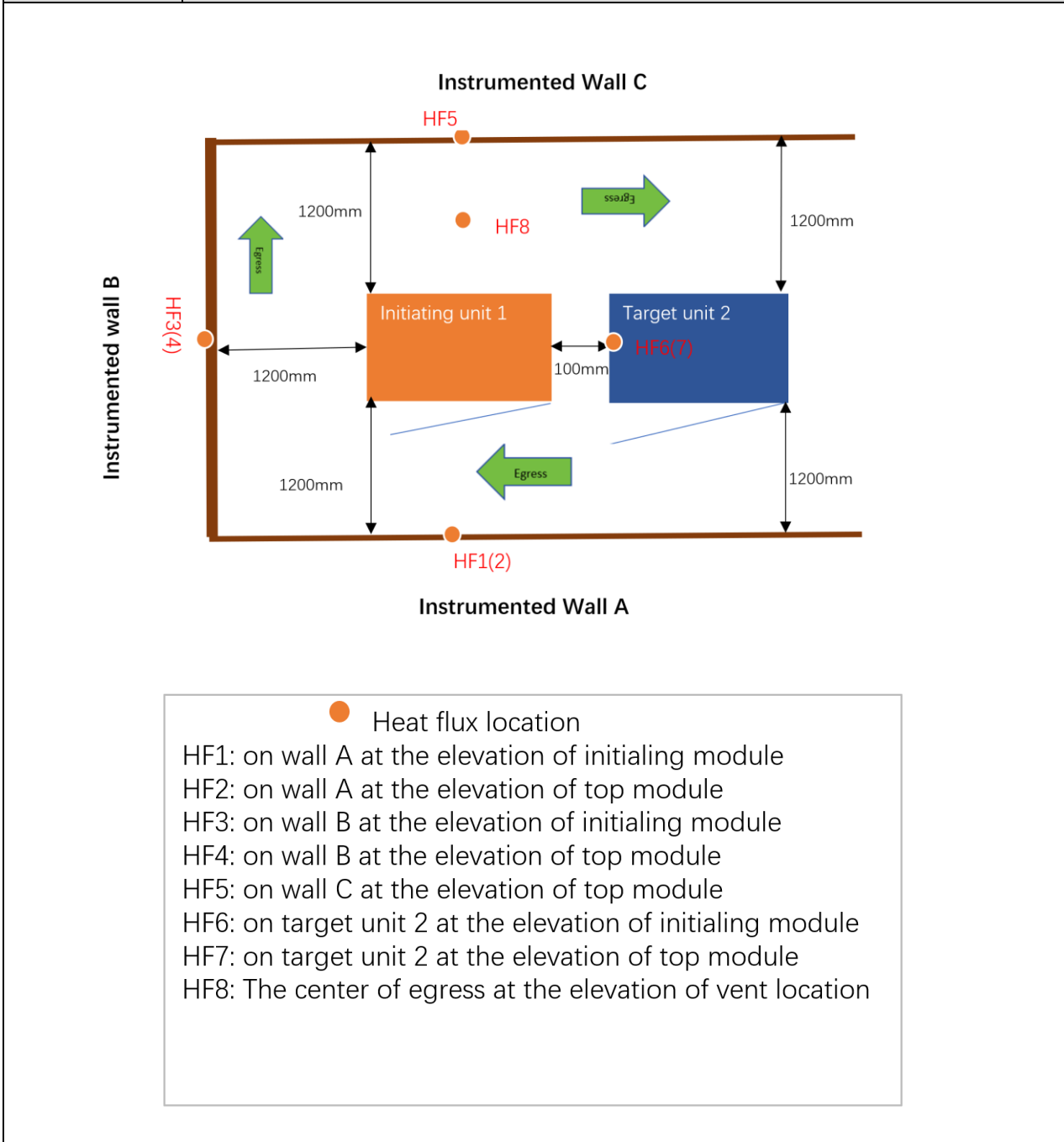
Details of:	Thermocouple location on other modules
<div style="display: flex; justify-content: space-around;"> <div style="text-align: center;"> <p>Initiating unit 1</p> </div> <div style="text-align: center;"> <p>Target unit 2</p> </div> </div>	<div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <p>T1-1: module 5 pack bottom surface</p> <p>T1-2: module 4 pack bottom surface</p> <p>T1-3, T1-4: module 3 pack bottom surface, front surface</p> <p>T1-5, T1-6: module 1 pack top surface, front surface</p> </div> <div style="width: 45%;"> <p>T2-1: module 4 pack side surface</p> <p>T2-2, T2-3, T2-4: module 3 pack side surface, front surface, back surface</p> <p>T2-5, T2-6, T2-7: module 2 pack side surface, front surface, back surface</p> <p>T2-8: module 1 pack back surface</p> </div> </div>

**UNIT LEVEL**


Details of:	Thermocouple location on cabinets enclosure surface
	<div style="display: flex; justify-content: space-around;"> <div style="text-align: center;"> <p>Initiating unit 1</p>  <p>T1-7, T1-8: cabinet front surface, right side surface on elevation of top module 5</p> <p>T1-9, T1-10: cabinet front surface, right side surface on elevation of initiating module 2</p> </div> <div style="text-align: center;"> <p>Target unit 2</p>  <p>T2-9: Cabinet left side surface on elevation of top module 5</p> <p>T2-10: Cabinet left side surface on elevation of initiating module 2</p> </div> </div> <div style="display: flex; justify-content: space-around;"> <div style="text-align: center;"> <p>Initiating unit 1</p>  <p>T1-11</p> </div> <div style="text-align: center;"> <p>Target unit 2</p>  <p>T2-11</p> </div> </div>

**UNIT LEVEL**

Details of:	Units level test set up
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**UNIT LEVEL**

Details of:	Figure 1 of Attachment 3: Overview of sample & thermocouple location_before test
	

**UNIT LEVEL**


Details of:

Figure 2 of Attachment 3: Overview of sample & thermocouple location\_before test



**UNIT LEVEL**

**Attachment 5: Photo(s) for sample(s) after test**

Details of:	Figure 1 of Attachment 5: overview of units_after test
	


**UNIT LEVEL**

Details of:

Figure 2 of Attachment 5: overview of units with door opened\_after test



**UNIT LEVEL**

<p>Details of:</p>	<p>Figure 3 of Attachment 5: overview of units from back view_after test</p>
	

**UNIT LEVEL**

**Attachment 6: Monitored temperature chart**

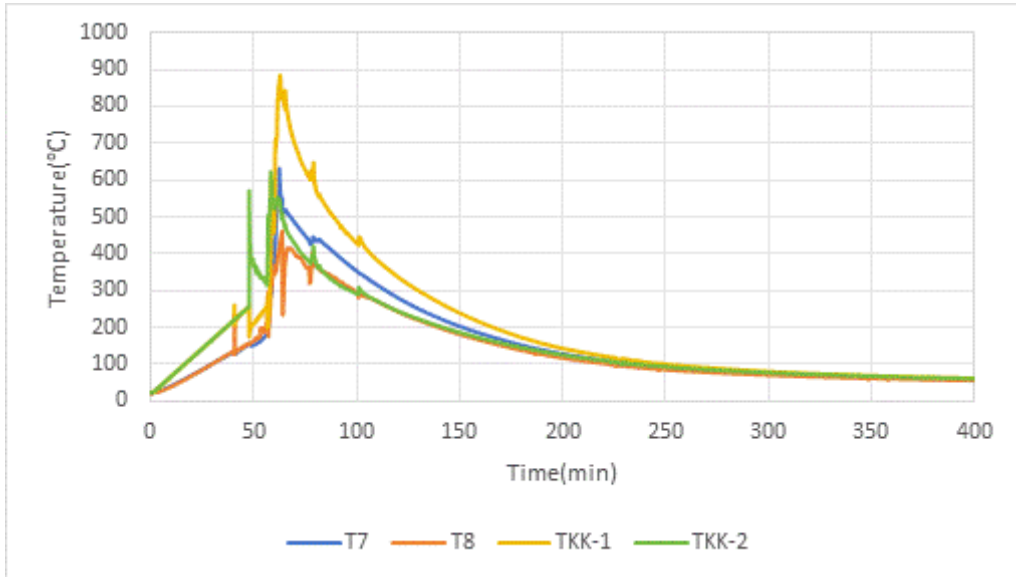


Figure 1 of Attachment 6: Temperatures of initiating cell in module

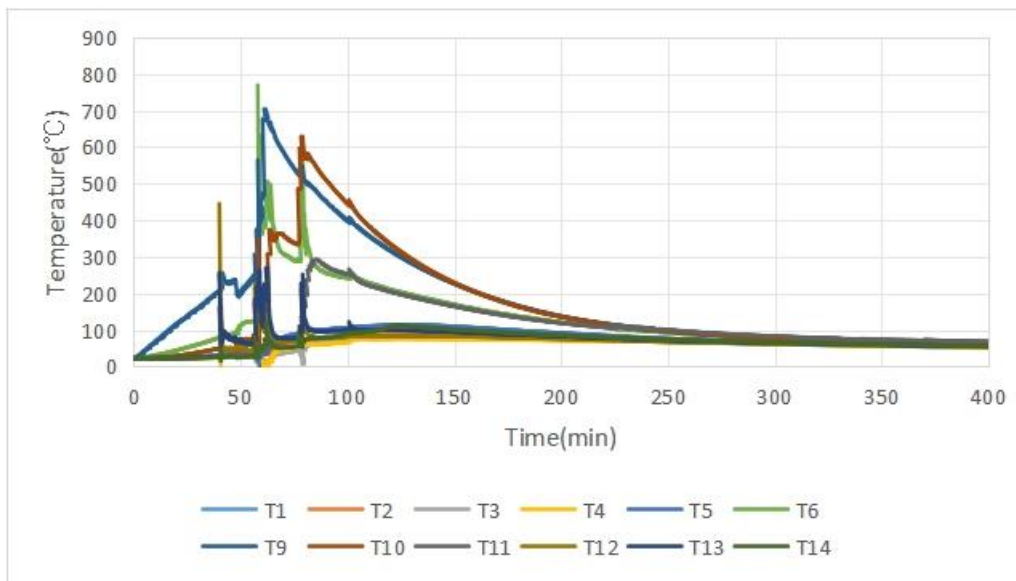


Figure 2 of Attachment 6: Temperatures of initiating cells and other cells in module

**UNIT LEVEL**

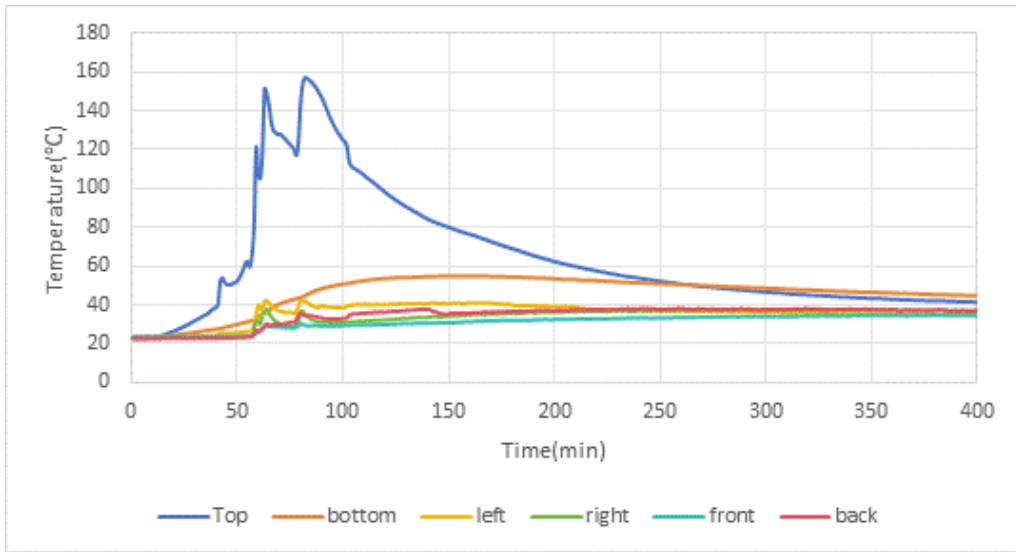


Figure 3 of Attachment 6: Temperatures of module case

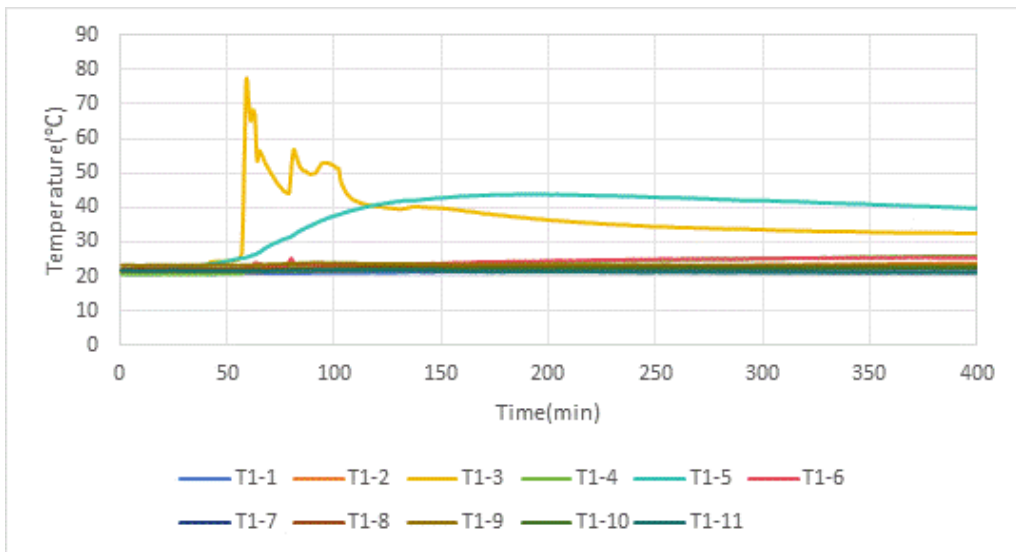


Figure 4 of Attachment 6: Temperatures of initiating unit 1

**UNIT LEVEL**

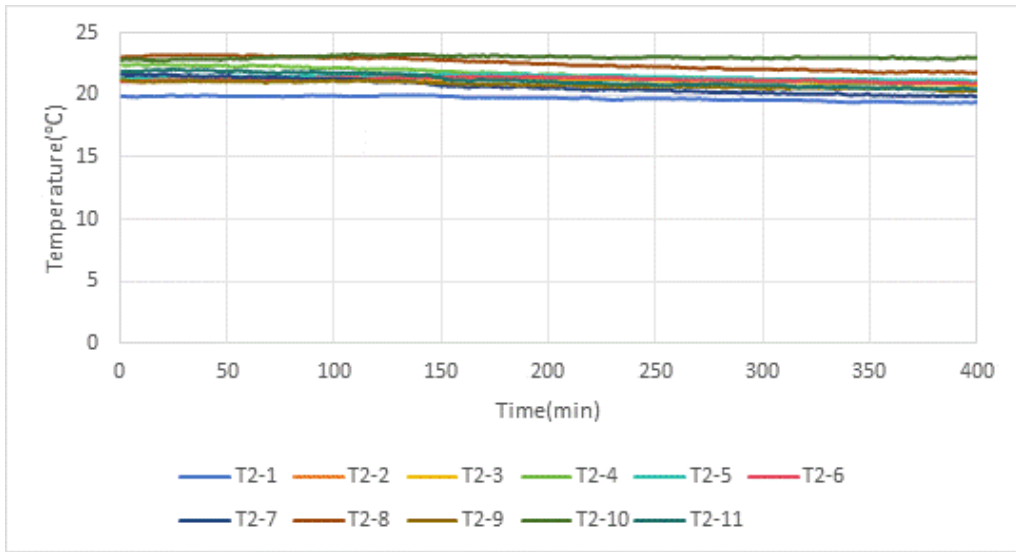


Figure 5 of Attachment 6: Temperatures of target unit 2

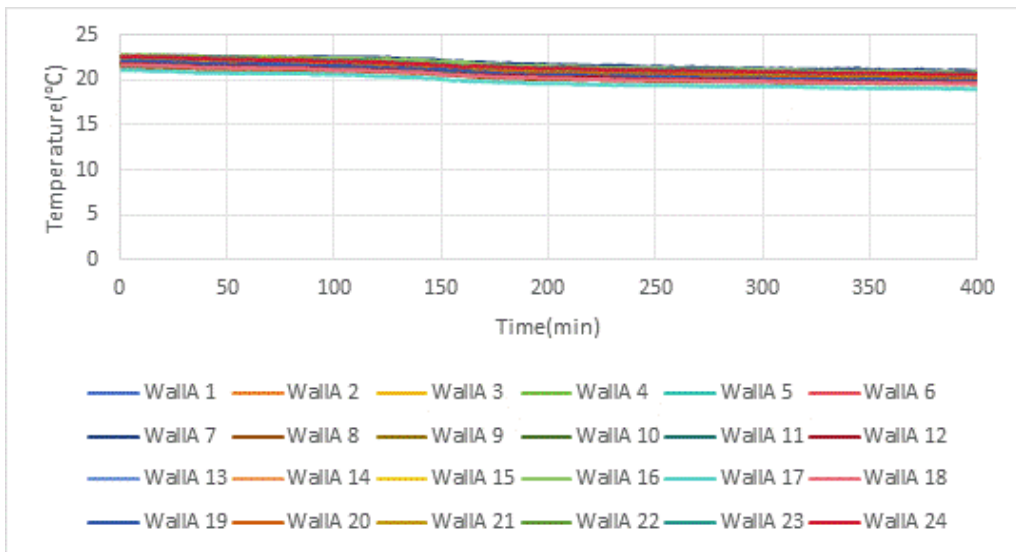


Figure 6 of Attachment 6: Temperatures of wall A

**UNIT LEVEL**

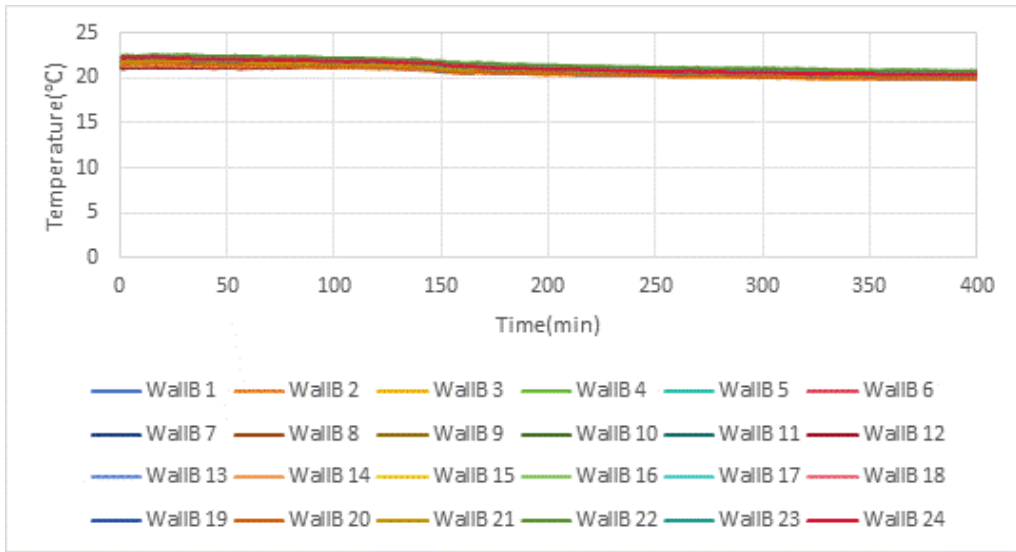


Figure 7 of Attachment 6: Temperatures of wall B

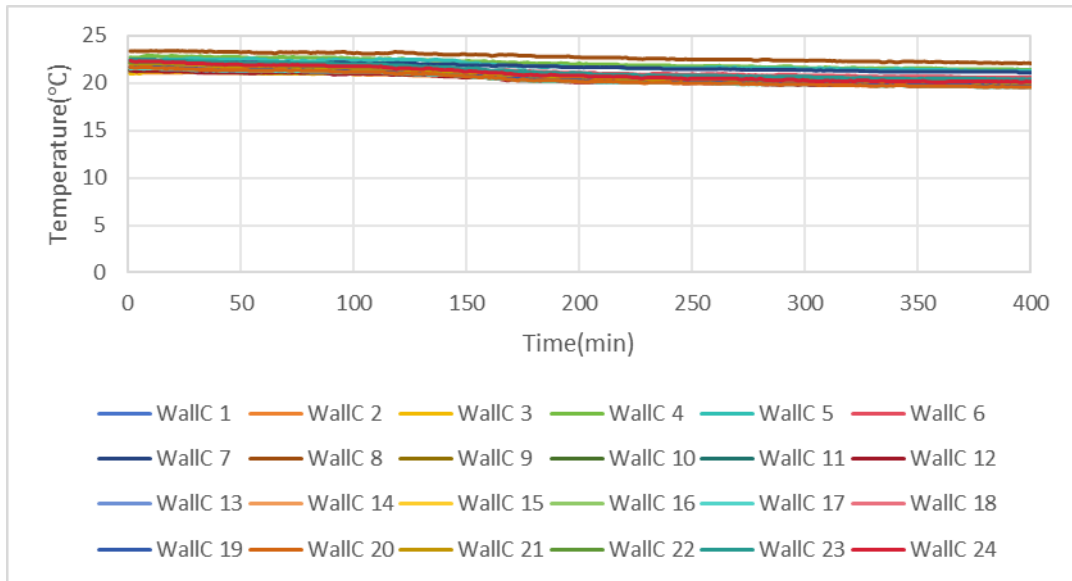


Figure 8 of Attachment 6: Temperatures of wall C

**UNIT LEVEL**

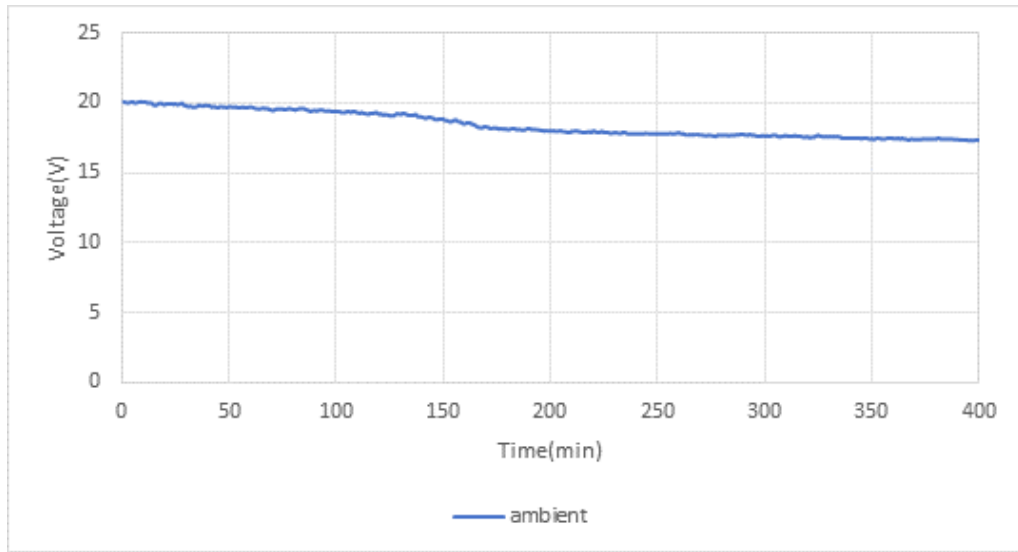


Figure 9 of Attachment 6: Ambient temperature

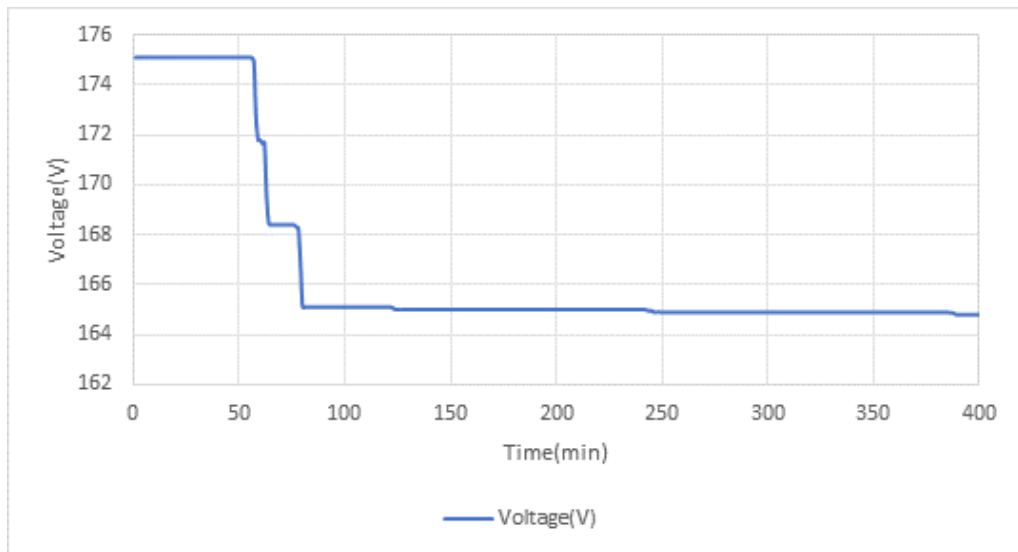
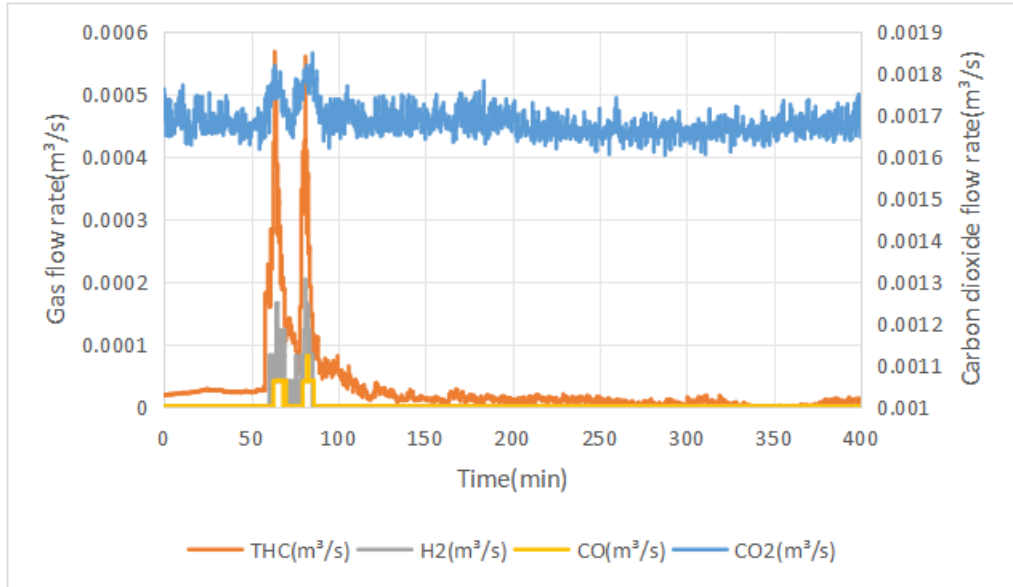


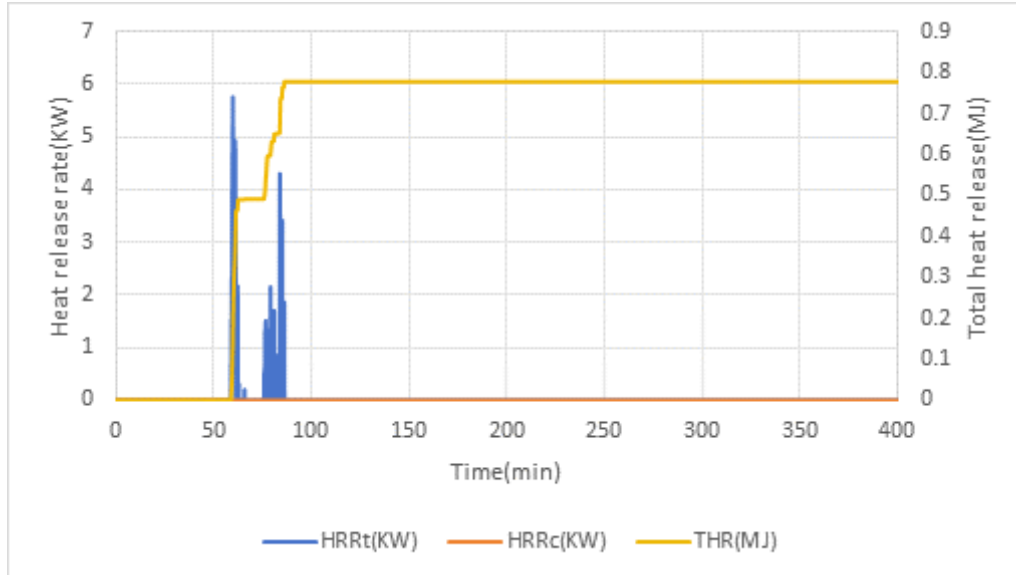
Figure 10 of Attachment 6: Voltage of initiating module 2

**UNIT LEVEL**

**Attachment 7: Flammable gas generation and composition data chart**



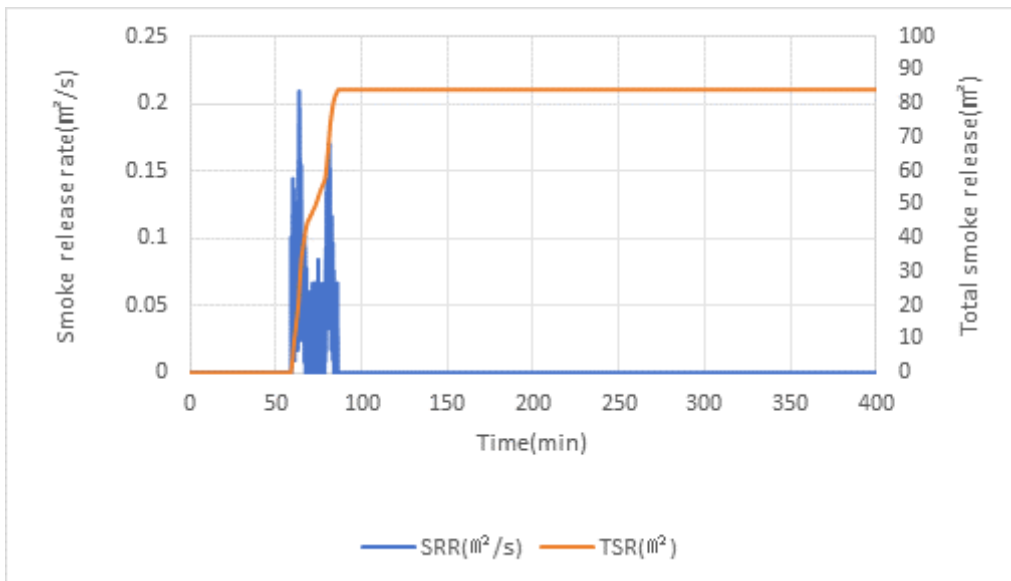
**Attachment 8: Heat release rate versus time data chart**



**UNIT LEVEL**

Number	Max. heat realse rate kW/m <sup>2</sup>	Number	Max. heat realse rate kW/m <sup>2</sup>	Number	Max. heat realse rate kW/m <sup>2</sup>
HF1	0	HF2	0	HF3	0
HF4	0	HF5	0	HF6	0.01
HF7	0.01	HF8	0.01	/	/

**Attachment 9: Peak smoke release rate and total smoke release data chart**



**Attachment 10: Summary of Heat release rate & Peak smoke release rate and total smoke release data**

Peak heat release rate	3.76 kW
Peak convective heat release rate	0 kW
Total smoke release	84.12 m <sup>3</sup>
Peak smoke release rate	0.2093 m <sup>3</sup> /s

----- **END REPORT** -----