TEST REPORT

ANSI/CAN/UL 9540A:2019

TÜV SÜD Test Report for Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems on Module Level

Report No.:	5061924025705
Date of issue:	2024-03-19
Project handler:	You, Duo
Testing laboratory:	Chuweineng Testing Technology (Shanghai) Co., Ltd.
Address:	Building 3, No. 1065, Beihe Road, Jiading District, Shanghai
Testing location:	as above
Client:	Shanghai PYTES Energy Co., Ltd.
Client number:	003364
Address:	No. 3492 Jinqian Road, Qingcun Town, Fengxian District, Shanghai, China
Contact person:	Yang, Lijuan
Standard:	ANSI/CAN/UL 9540A:2019 Fourth Edition (4Ed)
TRF number and revision:	TRF ANSI/CAN/UL 9540A:2019 Rev 0
TRF originated by:	TÜV SÜD Product Service
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Scheme:	☐ TUV Mark ☐ cTUV Mark (SCC) ☐ TUVus Mark (NRTL) ☐ GS Mark ☒ without certification ☒ other:TÜV SÜD Test Report from witness test ☐ AoC/CoC for EU-Directive / EU-Regulation:
Non-standard test method:	☒ No ☐ Yes, see details under *Summary of testing*
National deviations:	N/A
Number of pages *(Report)*:	36
Number of pages *(Attachments)*:	9

Compiled by: (Project Handler)	You, Duo You Duo 2024.03.19	Approved by: (Designated Reviewer)	Frank, Marco 2024.03.19

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TÜV SÜD Group
No.15 Factory Building A, Jintong International Industrial Park,
No.8 Xihu Road, Changzhou, Jiangsu, 213164 P. R. China

Test sample:	Rechargeable Li-ion Battery
Type of test object:	Protype Sample
Trademark:	Pytes
Model and/ or type reference:	HV48100 BMU
Rating(s):	51.2Vd.c., 100Ah

Manufacturer:	Shanghai PYTES Energy Co., Ltd.
Manufacturer number:	003364
Address:	No. 3492 Jinqian Road, Qingcun Town, Fengxian District, Shanghai, China
Name and address of factory(ies)	
Shanghai PYTES Energy Co., Ltd. No. 3492 Jinqian Road, Qingcun Town, Fengxian District, Shanghai, China	

Sub-contractors / tests (clause):	N/A
Name:	N/A
Order description:	☒ Complete test according to TRF
	☐ Partial test according to manufacturer's specifications
	☐ Preliminary test
	☐ Spot check
	☐ Others:
Date of order:	2024-01-10
Date of receipt of test item:	2024-01-26, Storix-ID: ES1000437P00103
Date(s) of performance of test:	2024-01-29 to 2024-01-31

Test item particulars:

According to Module Level of ANSI/CAN/UL 9540A:2019 Fourth Edition.

Purpose of the product (description of intended use):

Rechargeable Li-ion Battery model HV48100 BMU uses in Battery Energy Storage Systems.

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Characteristic data (not shown on the marking plate):	
Product name	HV48100 BMU
Type/model	Module
Nominal voltage	51.2 V
Rated capacity	100 Ah
Charging voltage specified by manufacturer	56.8 V
Upper limit charging voltage	57.6 V
Charging current specified by manufacturer	50 A
Maximum continuous charging current	50 A
Discharging current specified by manufacturer	50 A
Maximum continuous discharging current	50 A
End of discharge voltage	45.5 V
Standard temperature range for charging	0 ~ 57 °C
Standard temperature range for discharging	-18 ~ 57 °C
Standard charging method specified by manufacturer	Charge at constant current 50 A until the voltage reaches 57.6 V
Standard discharging method specified by manufacturer	Discharge at constant current 50A until the voltage reaches 45.5 V
Dimension	424*530*140 mm
Weight	43.6 kg
Number of cells in module and module configuration	16 cells; 1P16S

Attachments:

Attachment 1: Exploding drawing of module & Identification/location of cells within the module
Attachment 2: Pre-conditioning profile
Attachment 3: Photo for sample before test and test setup with thermocouple location
Attachment 4: Photo for sample after test
Attachment 5: Monitored voltage and temperature chart
Attachment 6: Flammable gas generation and composition data chart
Attachment 7: Heat release rate versus time data chart
Attachment 8: Peak smoke release rate and total smoke release data chart
Attachment 9: Summary of Heat release rate & Peak smoke release rate and total smoke release data

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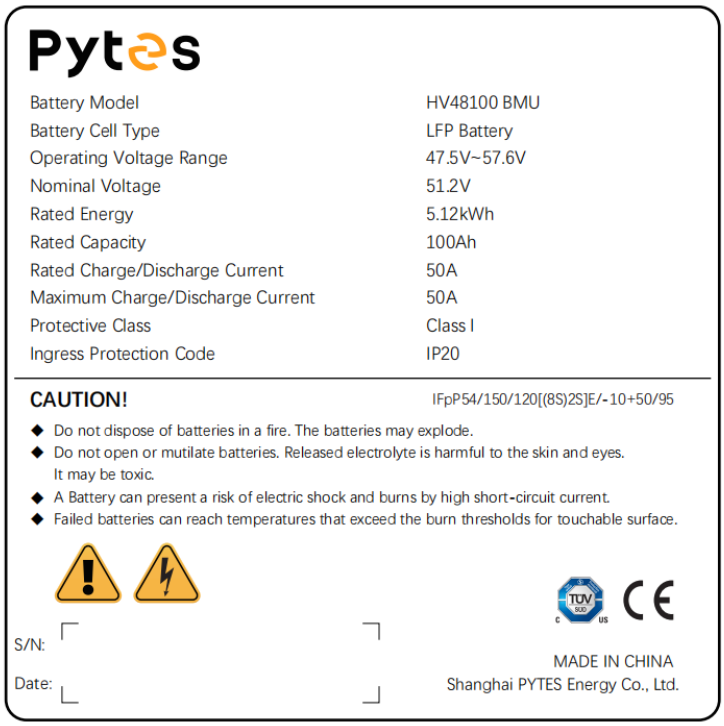
If additional information is necessary, please provide

N/A

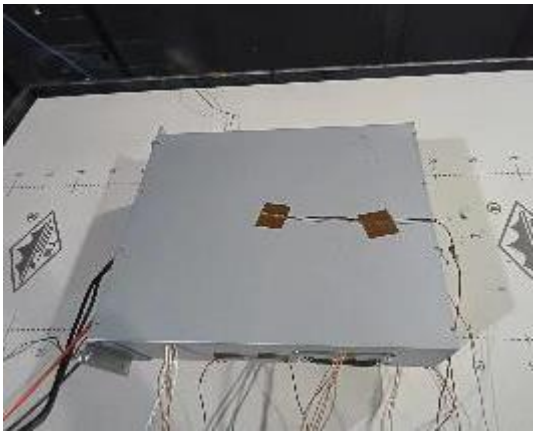
Copy of marking plate:



Pictures of the product:

Rechargeable Li-ion Battery, which ratings is 51.2 Vd.c., 100 Ah, is used in energy storage systems.

Top and internal view of module:



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Summary of testing:	
Module model number	HV48100 BMU
Nominal voltage and rated capacity	51.2 Vd.c., 100 Ah
Number of cells in module and module configuration	1P16S
Whether UL 1973 compliant	Module not compliant with UL 1973
Module voltage corresponding to the tested SOC	53.9 V
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: 101.6 mm × 147 mm (250W/pcs)
Thermal runaway of other cells within module:	Thermal runaway was observed on 8 cells on the same row with the initiating cell. Thermal runway was not observed on 8 cells on the opposite row.
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	N/A
Re-ignitions	No
Performance - module level test:	
a) Thermal runaway is contained by module design; and	Thermal runaway was contained by module design.
b) Cell vent gas is nonflammable as determined by the cell level test.	Cell vent gas is flammable according to cell level test report (external report with project number 4790342745).
Performance - cell level test:	
a) Thermal runaway cannot be induced in the cell; and	Thermal runaway occurred according to cell level test report (external report with project number 4790342745).
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.	Cell vent gas present flammability hazard according to cell level test report (external report with project number 4790342745).

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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.
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MODULE LEVEL			
Clause	Requirement + Test	Result – Remark	Verdict
	INTRODUCTION		
1.	**Scope**		—
2	**Units of Measurement**		—
3	**Normative References**		—
4	**Glossary**		—
	CONSTRUCTION		
5.	**General**		
5.1	**Cell**		
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.		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.	Note: Cell complied with UL 1973; Certificate Number: UL-CA-2236692-0	P
5.1.3	Refer to 7.6.1 for further details to be included in the cell level test report		P
5.2	**Module**		
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 Attachement 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.	Module is not compliant with UL 1973.	N/A
5.2.3	Refer to 8.3 for further details to be included in the module level test report.		P
5.3	**Battery energy storage system unit**		—
5.4	**Flow Batteries**		—

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No.8 Xihu Road, Changzhou, Jiangsu, 213164 P. R. China

MODULE LEVEL			
Clause	Requirement + Test	Result – Remark	Verdict
	PERFORMANCE		
6	**General**		
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
7	**Cell Level**		—
8	**Module Level**		
8.1	**Sample**		
8.1.1	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. During conditioning the ambient temperature and conditions shall be maintained in accordance with 8.2.1.	See Attachment 2: Pre-conditioning profile. Charging method: Charge at constant current 50 A until voltage reaches 57.6 V. Discharge method: Discharge at constant current 50 A till the voltage of battery reaches 45.5 V.	P
8.1.2	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	See Table 1.	P
8.1.3	Electronics and software controls such as the battery management system (BMS) are not relied upon for this testing.		P
8.2	**Test method**		
8.2.1	Ambient indoor laboratory conditions shall be 25 ±5°C (77 ±9°F) and 50 ±25% RH at the initiation of the test.	see Table 1.	P

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MODULE LEVEL			
Clause	Requirement + Test	Result – Remark	Verdict
8.2.2	The test shall be conducted under a smoke collection hood that is sized appropriately to collect the gasses generated from the module.		P
8.2.3	The weight of the module shall be recorded before and after testing is completed to determine weight loss.	See Table 1.	P
8.2.4	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.	Cell to cell propagation occurred within the module.	P
8.2.5	The methodology used for initiating thermal runaway pursuant to 7.2 shall be used to initiate thermal runaway within the module.	Two film heaters were used to initiate thermal runaway. 101.6 mm × 147 mm (220 VDC, 250W) film heater was covered on each large surface of the initiating cell.	P
8.2.6	With reference to 8.2.5, occurrence of thermal runaway shall be verified by sustained temperature above the cell surface temperature at the onset of thermal runaway, as determined in Section 7.		P
8.2.7	The module shall be placed on top of a noncombustible horizontal surface with the module orientation representative of its intended final installation.	See Figure 1 of Attachment 3.	P
8.2.8	The chemical heat release rate of the module in thermal runaway shall be measured with oxygen consumption calorimetry.	See Attachment 7 and 9.	P
8.2.9	The chemical heat release rate shall be measured for the duration of the test. See 8.2.10.	See Attachment 7 and 9.	P
8.2.10	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	See Attachment 7 and 9.	P

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MODULE LEVEL			
Clause	Requirement + Test	Result – Remark	Verdict
	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. See 8.2.11.		
8.2.11	With reference to 8.2.10, calculate the chemical heat release rate at each of the flows as follows: $HRR_i = \left\| E \times \varphi \cdot (K_{m} - E) \times \frac{1-\eta}{2} \times \frac{X_{m}}{X_{O_2}} \right\| \times \frac{\dot{m}_e}{1+\varphi \times (\alpha - 1)} \times \frac{M_{O_2}}{M_a} \times (1 - X^{w}_{H_2O}) \times X^{w}_{O_2}$		P
8.2.12	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 specified in 8.2.10.	See Table 2 and Attachment 6.	P
8.2.13	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.	See Table 2 and Attachment 6.	P
8.2.14	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. See 8.2.15.	See Attachment 7 and 8.	P
8.2.15	Smoke release rate shall be calculated as follows: $SRR = 2.303\left(\frac{V}{D}\right) Log_{10}\left(\frac{I_o}{I}\right)$		P
8.3	**Module level test report**		
8.3.1	The report on module level testing shall include the following:	(See appended table)	P
	a) Module manufacturer name and model number (and whether UL 1973 compliant)	Name of the manufacturer: Shanghai PYTES Energy Co., Ltd. Model no.: HV48100 BMU Module is not compliant with UL 1973.	P
	b) Number of cells in module;	16 cells in module.	P
	c) Module configuration with cells in series and parallel;	1P16S	P
	d) Module construction features per 5.2;	See Attachment 1.	P
	e) Module voltage corresponding to the tested SOC;	See Table 1.	P

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MODULE LEVEL			
Clause	Requirement + Test	Result – Remark	Verdict
	f) Thermal runaway initiation method used including number and locations of cells for initiating thermal runaway;	See Table 1 and Attachment 1.	P
	g) Heat release rate versus time data;	See Attachment 7 and 9.	P
	h) Flammable gas generation and composition data;	See Table 2 and Attachment 6.	P
	i) Peak smoke release rate and total smoke release data.	See Attahment 8 and 9.	P
	j) Observation(s) of flying debris or explosive discharge of gases;	See Table 1.	P
	k) Observation(s) of sparks, electrical arcs, or other electrical events;	See Table 1.	P
	l) Identification/location of cells(s) that exhibited thermal runaway within the module;	See Table 1.	P
	m) Locations and visual estimations of flame extension and duration from the module shall be documented;	See Table 1.	P
	n) Module weight loss based on measurements per 8.2.3; and	See Table 1	P
	o) Video of the test.		P
8.4	**Performance at module level testing**		
8.4.1	Unit level testing in Section 9 is not required if the following performance conditions are met during the module level test:		F
	a) Thermal runaway is contained by module design; and		P
	b) Cell vent gas is nonflammable as determined by the cell level test.	Cell vent gas is flammable according to cell level test report (external report with project number 4790342745).	F
9	**Unit Level**		—
10	**Instalaton Level**		—
ANNEX A	**Test Concepts And Application Of Test Results To Installations** (informative)		—
A1	Introduction		N/A
A2	Test Methodology and Purpose		N/A
A3	Evaluating the Results		N/A

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MODULE LEVEL			
Clause	Requirement + Test	Result – Remark	Verdict
ANNEX B	**Safety Recommendations for Testing** (informative)		—
B1	General		P

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MODULE LEVEL

	TABLE: Critical components information				
Object/part no.	**Manufacturer/ trademark**	**Type/model**	**Technical data**	**Standard**	**Mark(s) of conformity**
Rechargeable Lithium-ion Cell			3.2Vd.c., 100Ah	ANSI/CAN/UL 1973: 2022	UL MH64238
Supplementary information: N/A					

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MODULE LEVEL

MODULE LEVEL TEST RESULT:

Table 1: Thermal runaway test result	
Initial ambient temperature:	24.9 °C
Initial relative humidity:	52% RH
Pre-conditioning time	From 2024-01-29 16:17:46 to 2024-01-30 10:37:34
Thermal runwaway test start time	2024-01-30 13:33:14
Module voltage (OCV) before test:	53.9 V
Methods used to initiate thermal runaway	Heating the cell with externally applied flexible film heater
Average heating rate:	T12: 4.85 K/min, T13: 4.85 K/min
Surface temperature at which gases were first vented:	T12: 195.4 °C, T13: 195.4 °C, T5: 131.5 °C
Time when gases were first vented:	Cell 5: 2024-01-30 14:08:02
Surface temperature prior to thermal runaway:	T12: 126.7 °C, T13: 263.7 °C, T5: 145.4 °C
Time when thermal runaway:	Cell 5: 2024-01-30 14:30:30
Module voltage (OCV) after test:	26.56 V
Location of cell(s) for intiating thermal runaway	Cell 5 (see Attachment 1)
Thermal runaway of other cells within module:	Thermal runaway was observed on 8 cells on the same row with the initiating cell. Thermal runway was not observed on 8 cells on the opposite row.
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 flames observed.
Module weight before test:	43.4 kg
Module weight after test:	40.6 kg
Module weight loss:	2.8 kg

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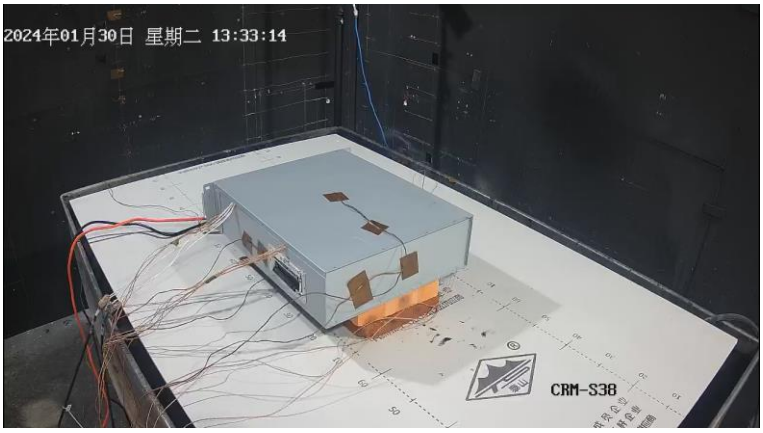
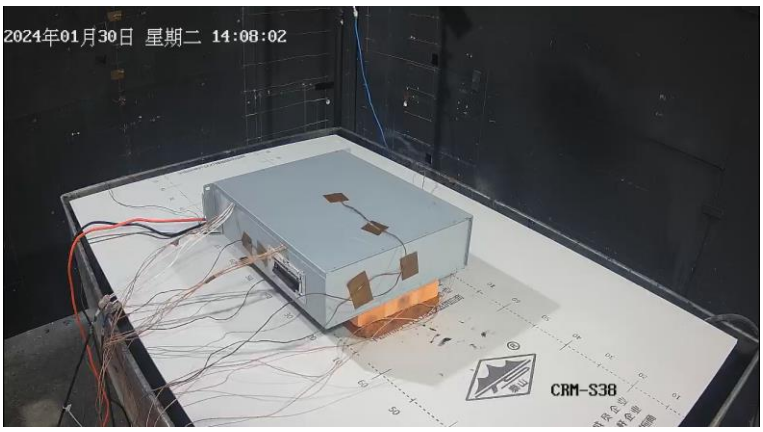
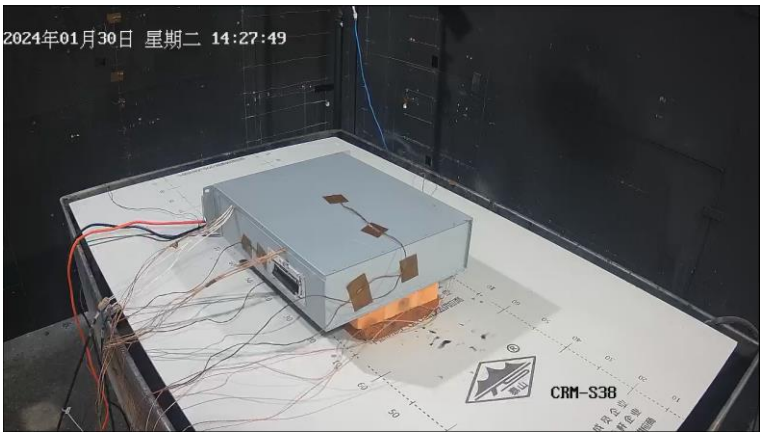
MODULE LEVEL

Timeline of thermal runaway		
Time (hh:mm:ss)	Event	Description
2024-01-30 13:33:14	Start testing.	
2024-01-30 14:08:02	The initiating cell 5 first vented at 14:08:02. Meanwhile, one film heater got damaged / stopped working, the value of T12 had decreased from 193.2 °C to 179.4 °C.	
2024-01-30 14:27:49	The cell 4 vented at 14:27:49.	

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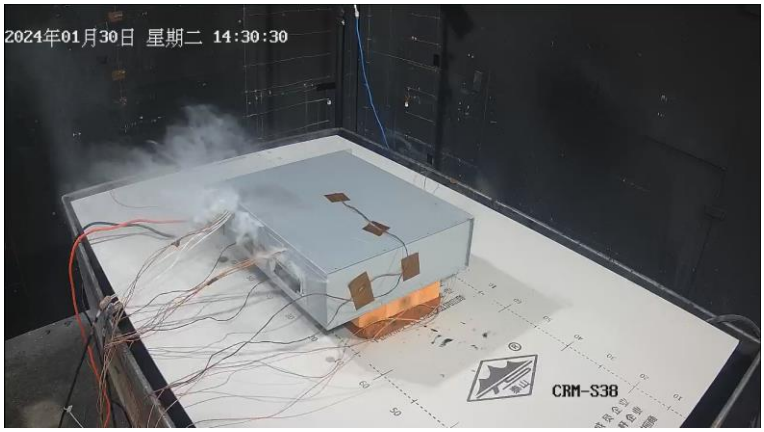
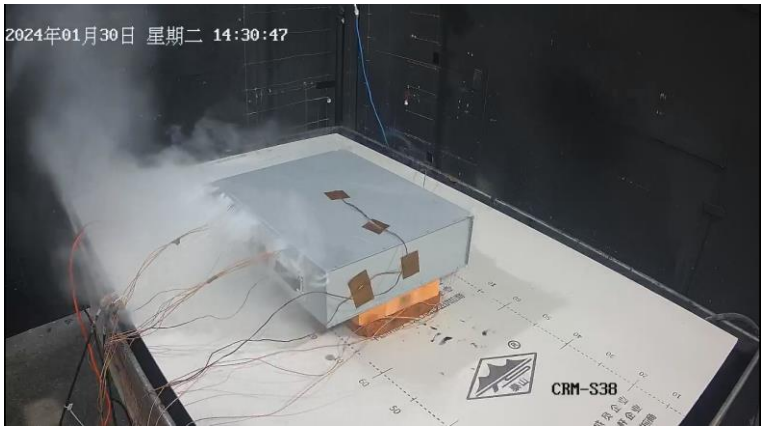
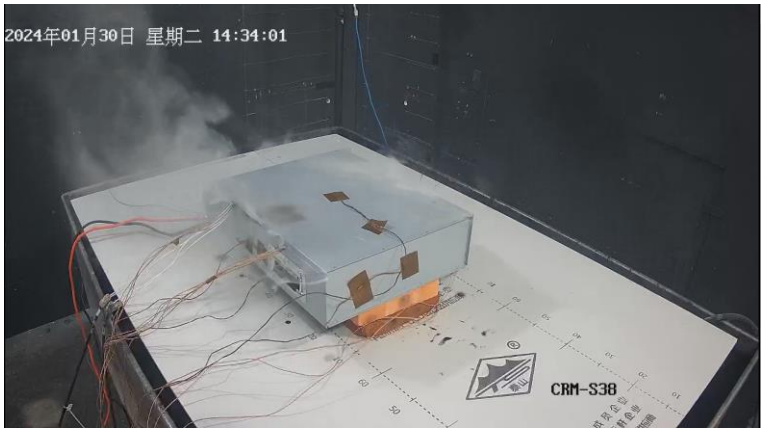
MODULE LEVEL		
2024-01-30 14:30:30	The temperature of initiating cell 5 started to rise sharply, thermal runaway occurred.	
2024-01-30 14:30:47	The temperature of cell 4 started to rise sharply, thermal runaway occurred.	
2024-01-30 14:34:01	The cell 6 vented at 14:34:01.	

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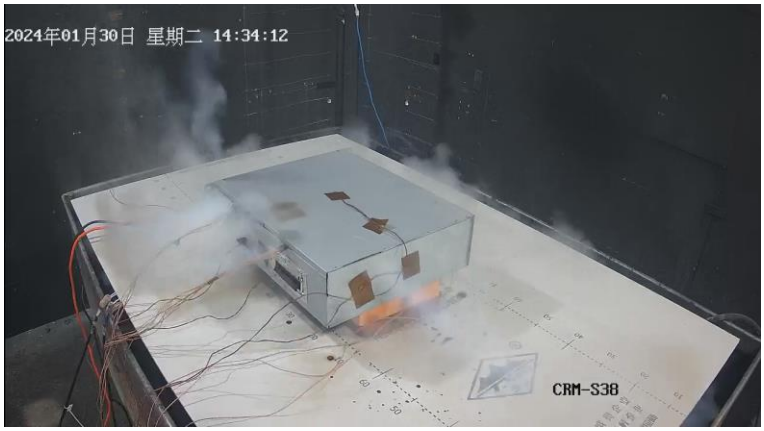
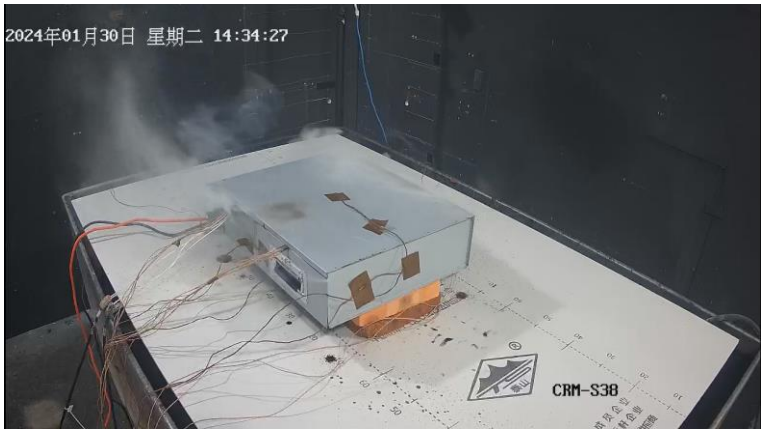
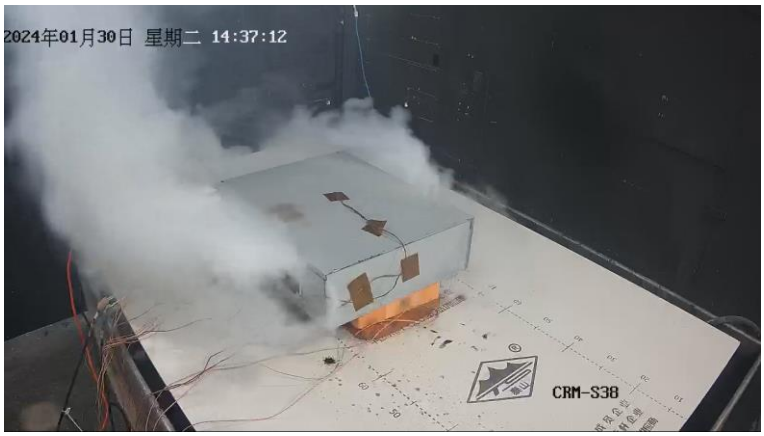
MODULE LEVEL		
2024-01-30 14:34:12	The cell 3 vented at 14:34:12.	
2024-01-30 14:34:27	The temperature of cell 6 started to rise sharply, thermal runaway occurred.	
2024-01-30 14:37:12	The temperature of cell 3 started to rise sharply, thermal runaway occurred.	

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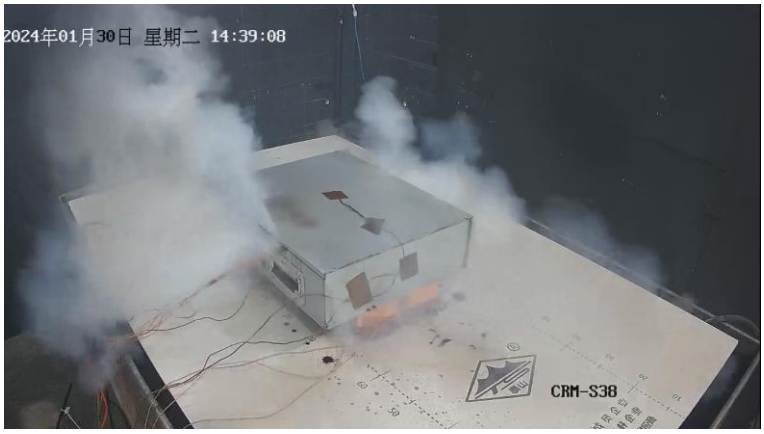
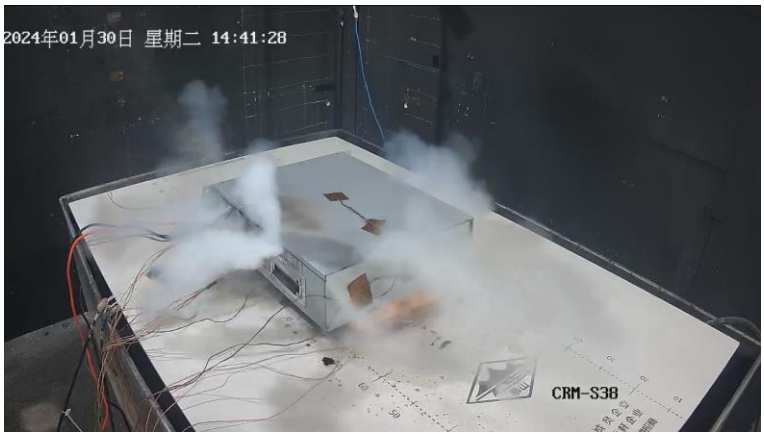
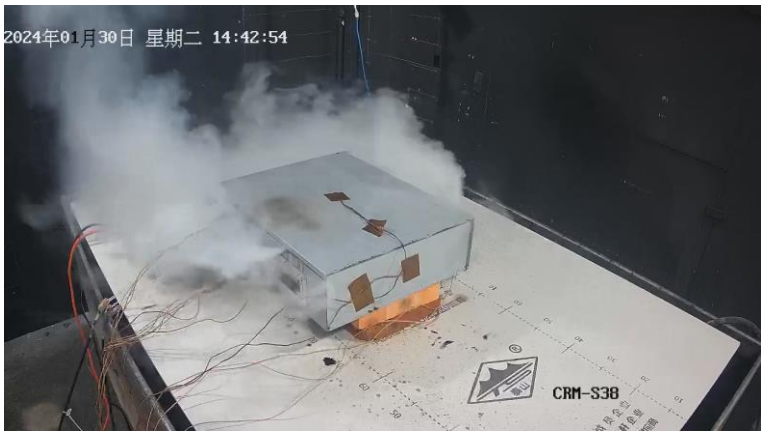
MODULE LEVEL		
2024-01-30 14:39:08	The cell 2 vented at 14:39:08.	
2024-01-30 14:41:28	The cell 7 vented at 14:41:28.	
2024-01-30 14:42:54	The temperature of cell 2 started to rise sharply, thermal runaway occurred.	

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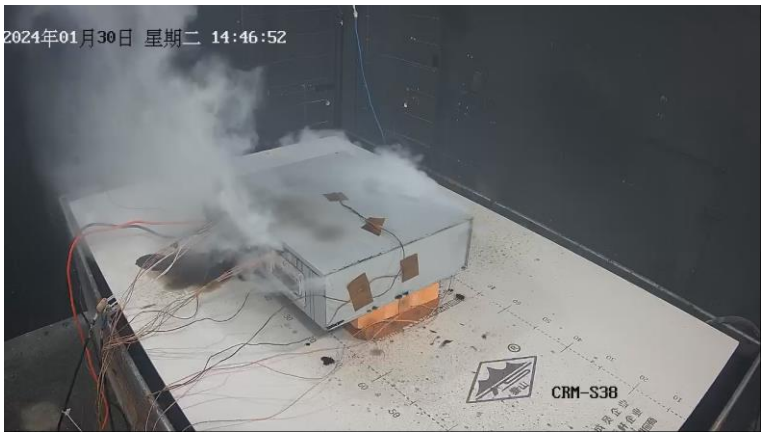
MODULE LEVEL		
2024-01-30 14:43:41	The temperature of cell 7 started to rise sharply, thermal runaway occurred.	
2024-01-30 14:46:27	The cell 8 vented at 14:46:27.	
2024-01-30 14:46:52	The temperature of cell 8 started to rise sharply, thermal runaway occurred.	

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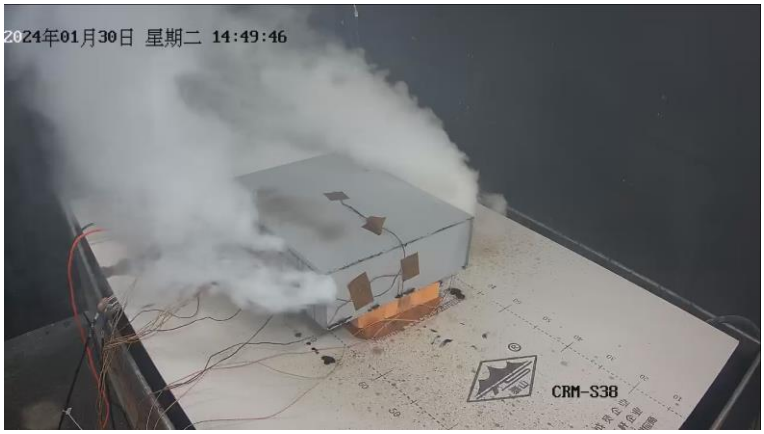
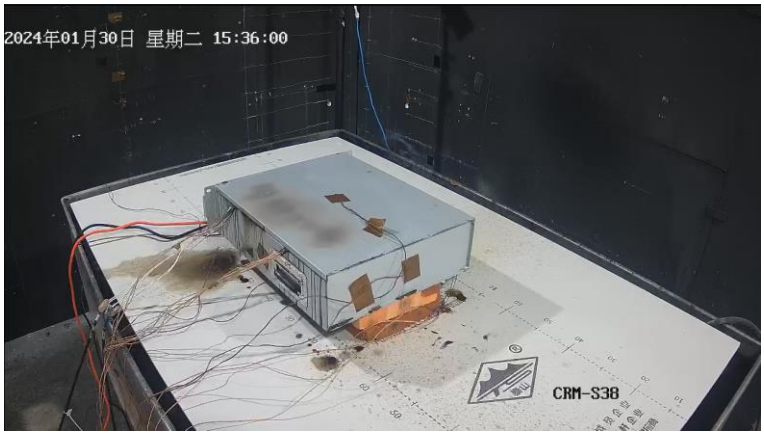
MODULE LEVEL		
2024-01-30 14:47:46	The cell 1 vented at 14:47:46.	
2024-01-30 14:49:46	The temperature of cell 1 started to rise sharply, thermal runaway occurred.	
2024-01-30 15:36:00	No smoke was observed	
Remark: Refer to attachment 3 for details of sample before test and test setup with thermocouple location.		

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MODULE LEVEL

Table 2: Vent gas composition			
Composition	Chemical formula	Measurement peak (ppm)	Analysis Method
Carbon monoxide	CO	55.8	FTIR
Carbon dioxide	CO2	552.8	FTIR
Methane	CH4	22.4	FTIR
Acetylene	C2H2	1.5	FTIR
Ethene	C2H4	25.3	FTIR
Ethane	C2H6	6.1	FTIR
Propane	C3H8	11.2	FTIR
Butane	C4H10	/	FTIR
Pentane	C5H12	/	FTIR
Benzene	C6H6	/	FTIR
Hexane	C6H14	/	FTIR
Hydrofluoric acid	HF	27.1	FTIR
Hydrogen chloride	HCl	0	FTIR
Hydrogen	H2	0	Hydrogen sensor
Total Hydrocarbons	(Methane Equivalent)	635.3	FID
Flow rate in exhaust duct (m^3/s)		1.5	

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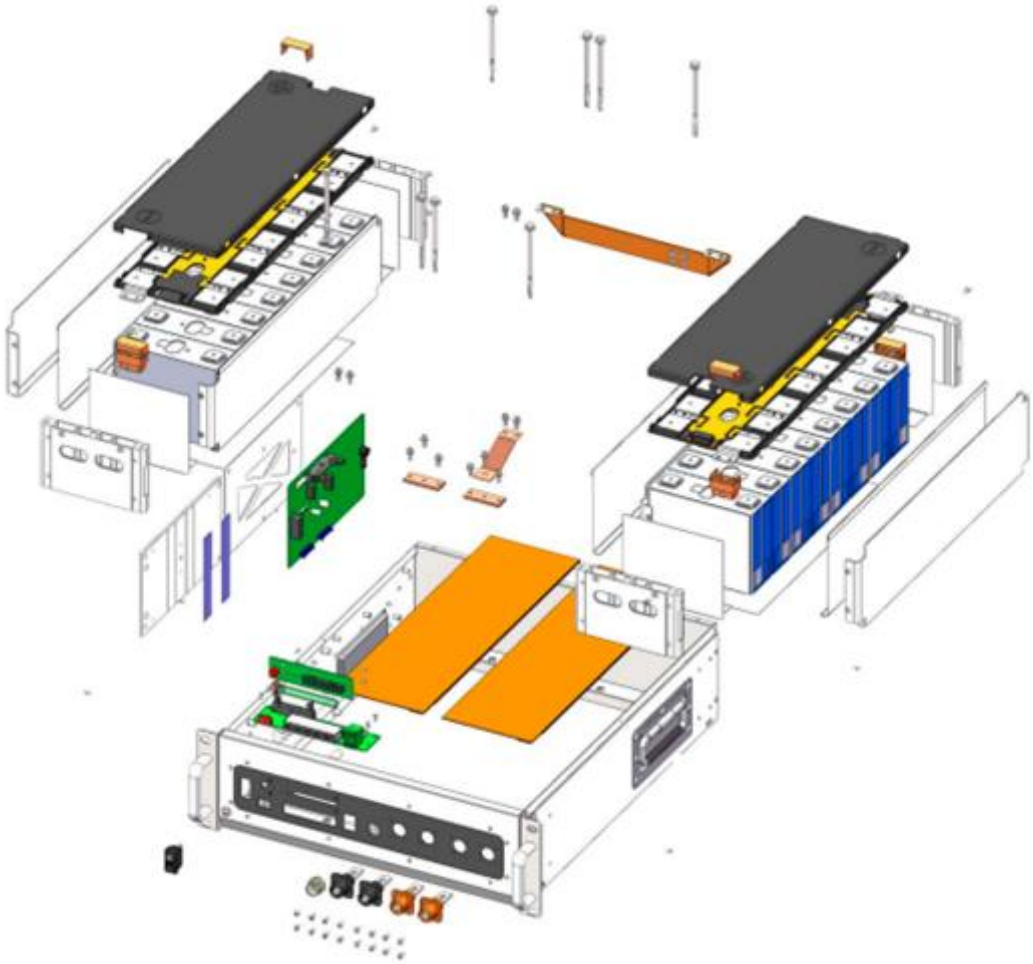
MODULE LEVEL

Attachment 1: Exploding drawing of module & Identification/location of cells within the module

Exploding drawing of module as below:



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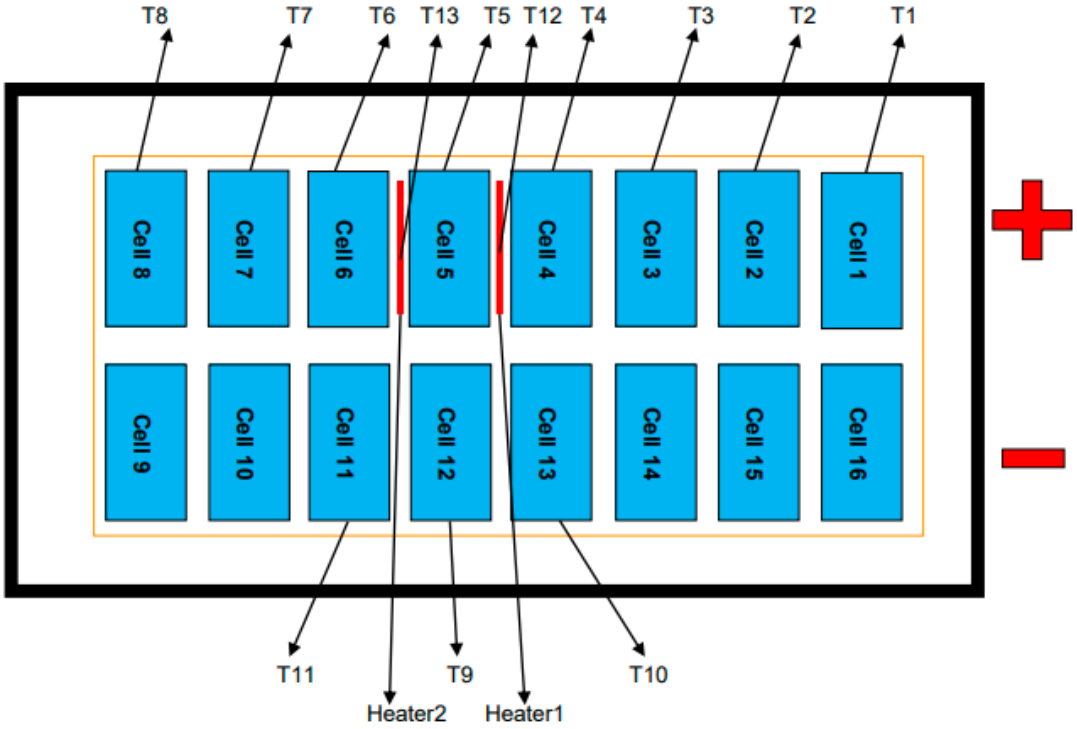
MODULE LEVEL

Identification/location of cells within the module as below (Cell 5 as inititating cell):



Attachment 2: Pre-conditioning profile

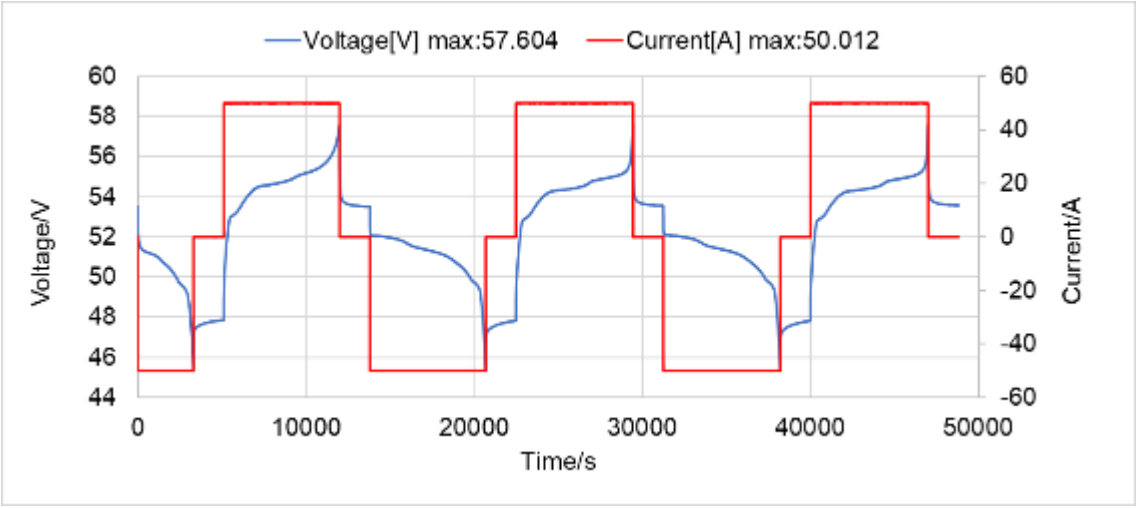


Figure 1 of Attachment 2: Charge and discharge cycles chart for module.

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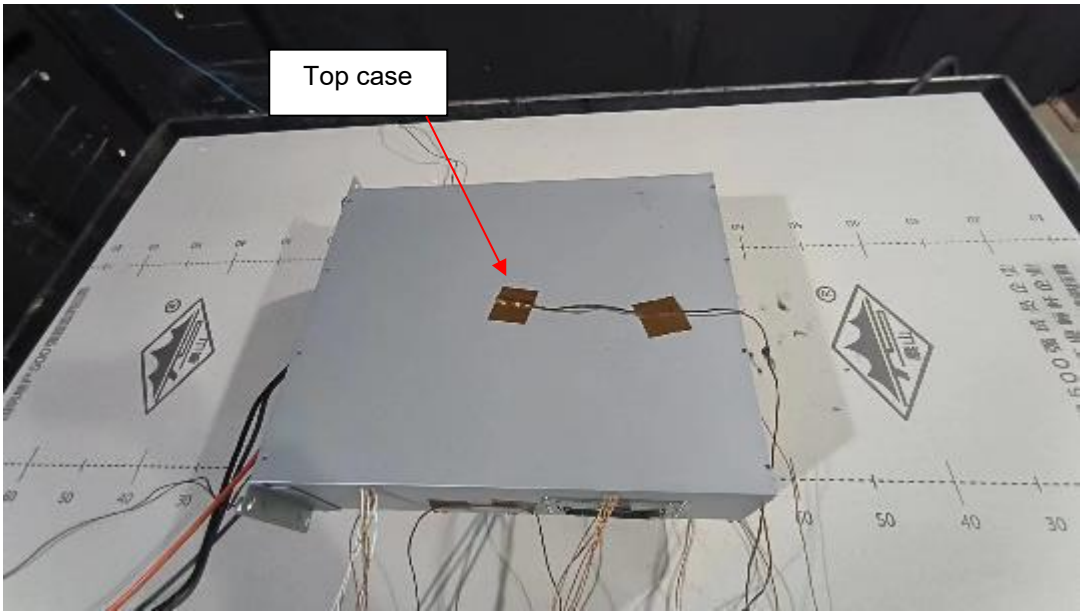
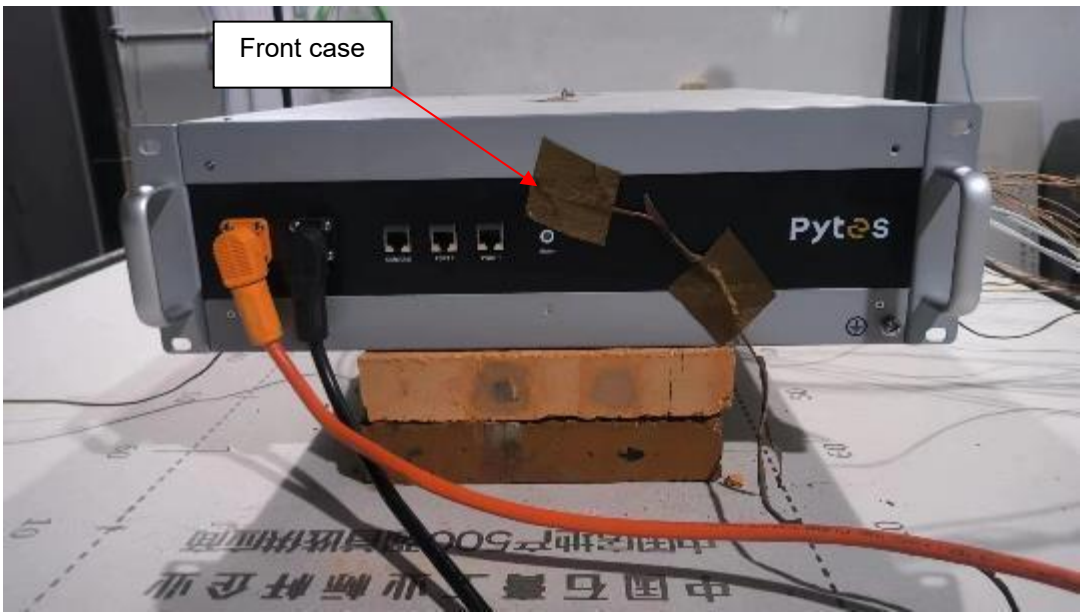
MODULE LEVEL

Attachment 3: Photo for sample before test and test setup with thermocouple location

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

Details of:	Figure 2 of Attachment 3 Overview of sample & thermocouple location_before test
	

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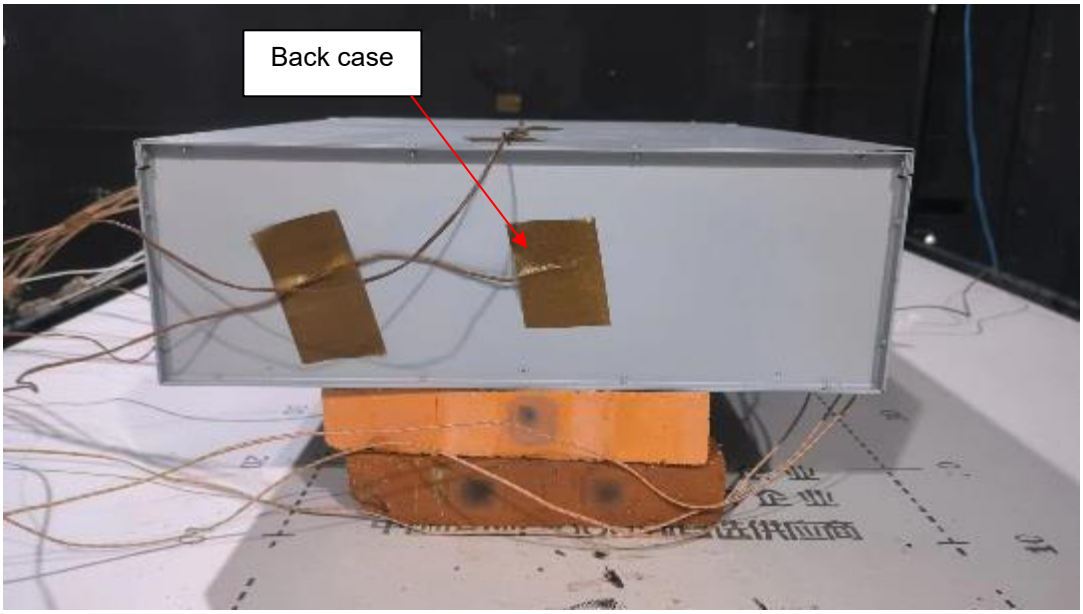
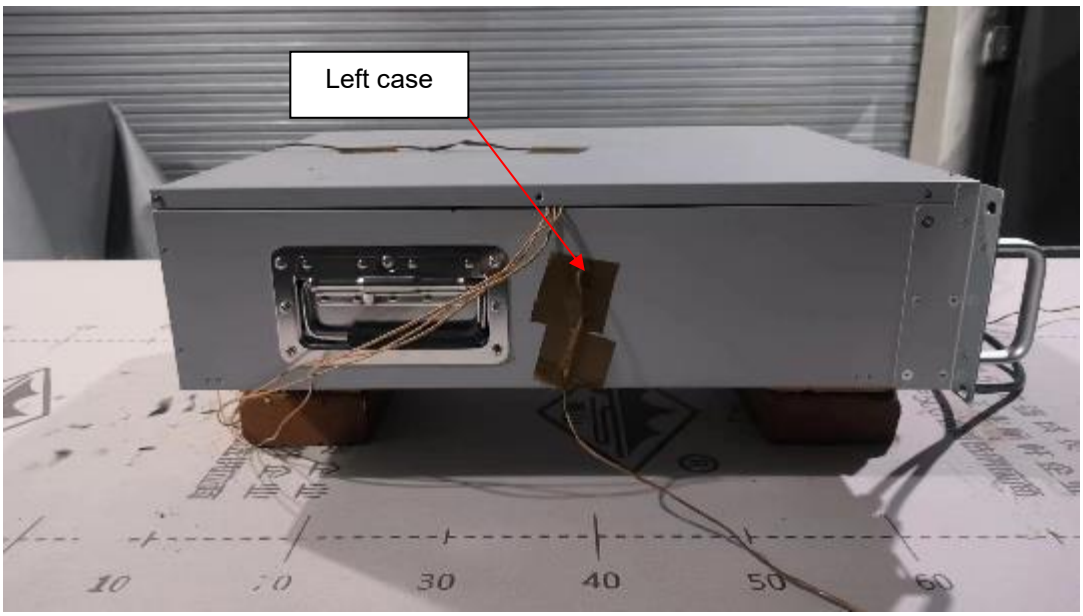
MODULE LEVEL

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



Details of:	Figure 4 of Attachment 3 Overview of sample & thermocouple location_before test



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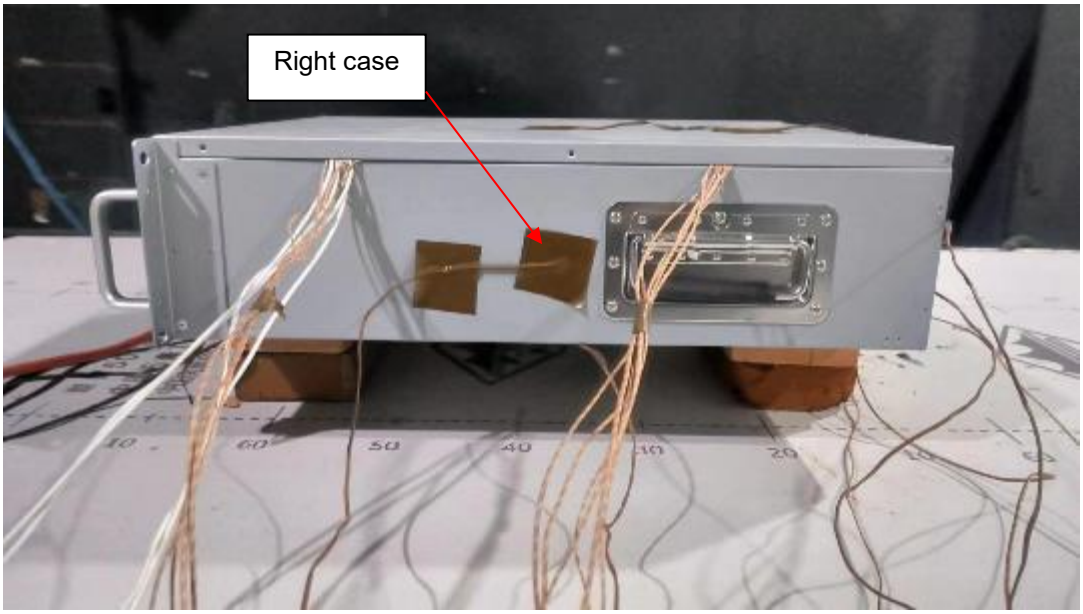
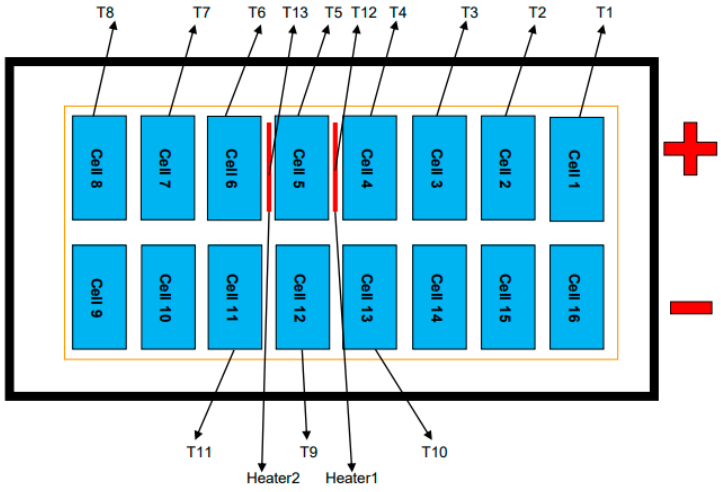
MODULE LEVEL

Details of:	Figure 5 of Attachment 3 Overview of sample & thermocouple location_before test



Details of:	Figure 6 of Attachment 3 Overview of sample & thermocouple location_before test



Schematic Illustration of film heaters and thermocouple locations in DUT.

Cell 5 is the initiating cell, Heater1 and heater2 mean Film heater1 and film heater2.
T1 to T13 means thermocouples T1 to T13.

View from top.

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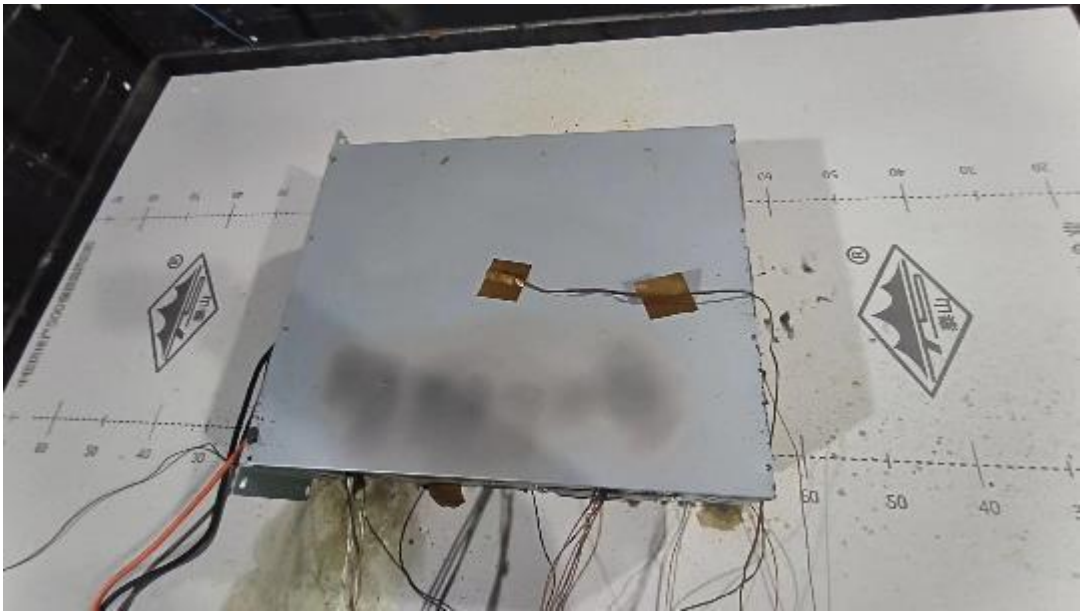
MODULE LEVEL

Attachment 4: Photo for sample after test

Details of:	Figure 1 of Attachment 4 Top view of module_after test
	

Details of:	Figure 2 of Attachment 4 Front view of module_after test
	

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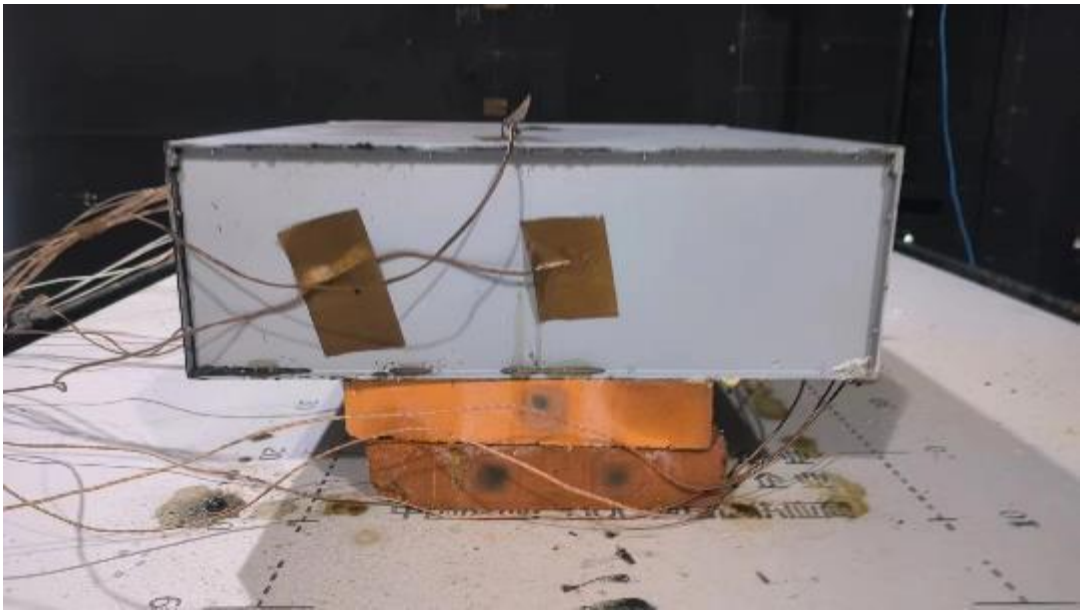
MODULE LEVEL

Details of:	Figure 3 of Attachment 4 Back view of module_after test
	

Details of:	Figure 4 of Attachment 4 Left side view of module_after test
	

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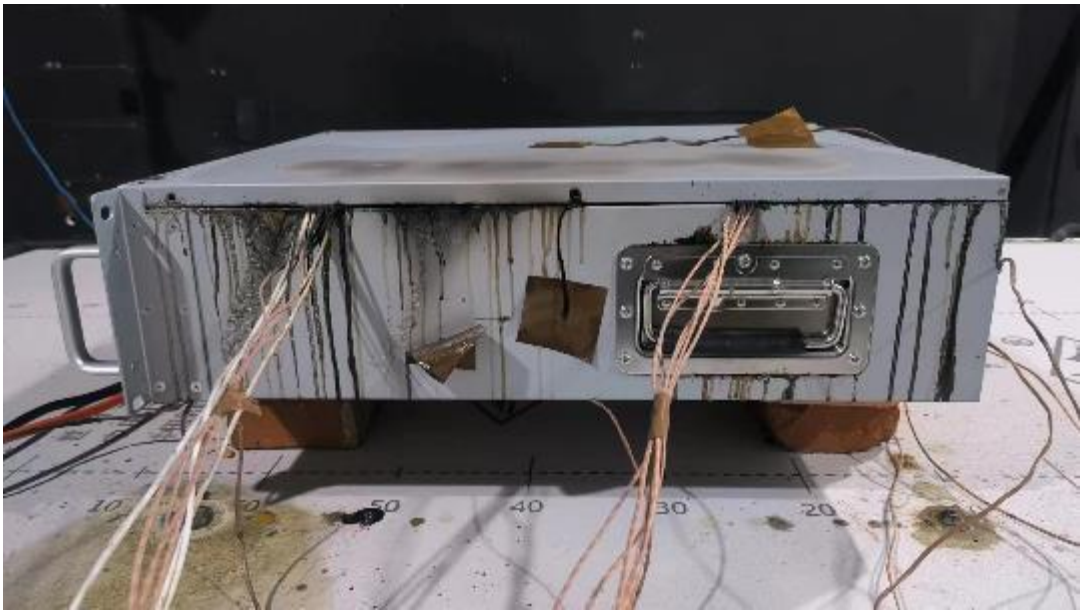
MODULE LEVEL

Details of:	Figure 5 of Attachment 4 Right side view of module_after test
	

Details of:	Figure 6 of Attachment 4 Top view of module_after test, without top cover.
	 Internal view of DUT.

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MODULE LEVEL

Details of:	Figure 7 of Attachment 4 View of module top cover (inner side)_after test
	 Internal view of DUT.

Details of:	Figure 8 of Attachment 4 Top view of module_after test, without top cover.
	 Internal view of DUT. After cleaning of cell row opposite initiating cell.

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MODULE LEVEL

Attachment 5: Monitored voltage and temperature chart

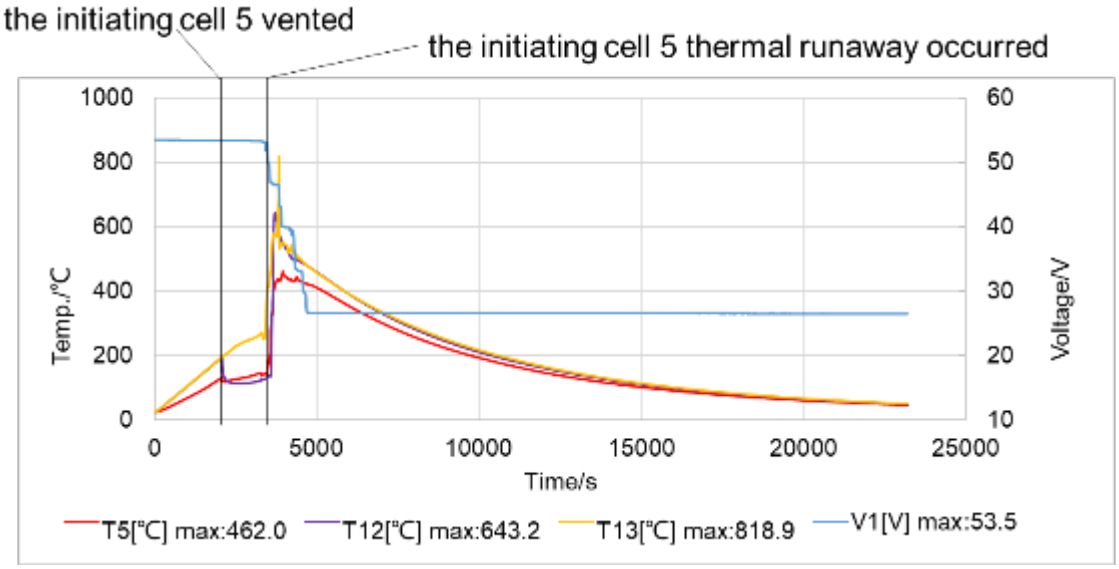

Figure 1 of Attachment 5: temperature of initiating cell in module

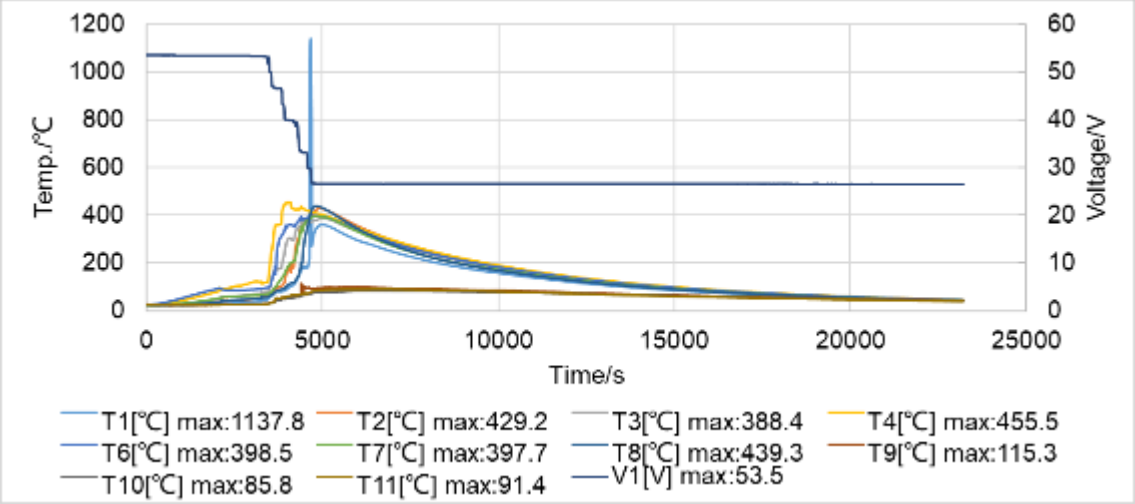

Figure 2 of Attachment 5: temperature of other cells in module.

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MODULE LEVEL

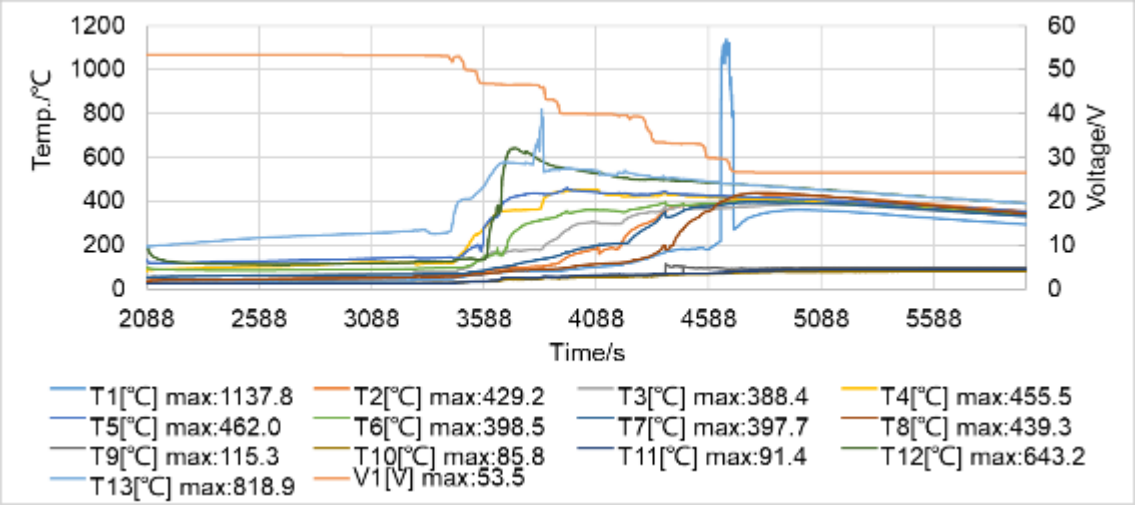

Figure 3 of Attachment 5: Zoomed view of temperature, including initiating cell and other cells.

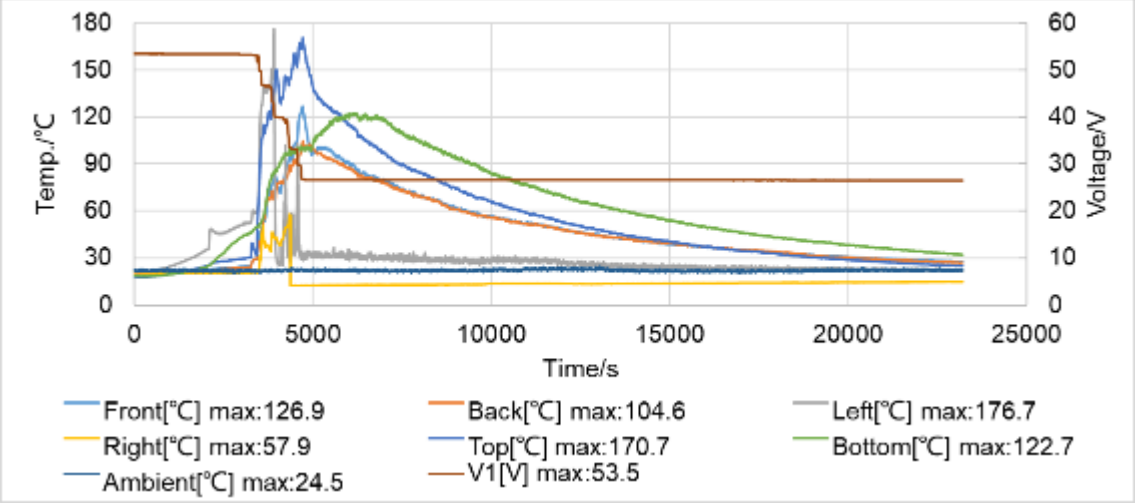

Figure 4 of Attachment 5: temperature of module case.

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MODULE LEVEL

Attachment 6: Flammable gas generation and composition data chart

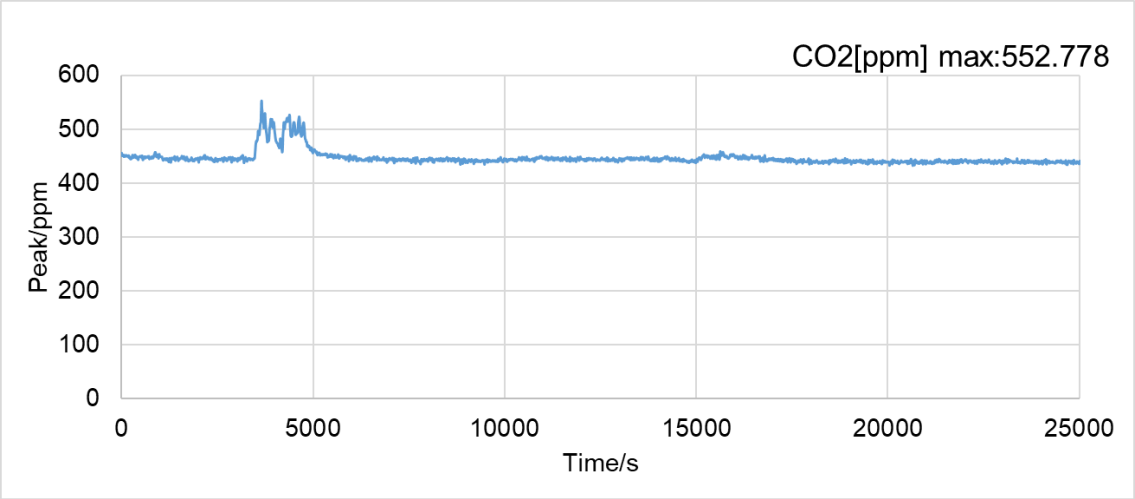

Figure 1 of Attachment 6: Gas generation and composition data chart (Detected by FTIR).

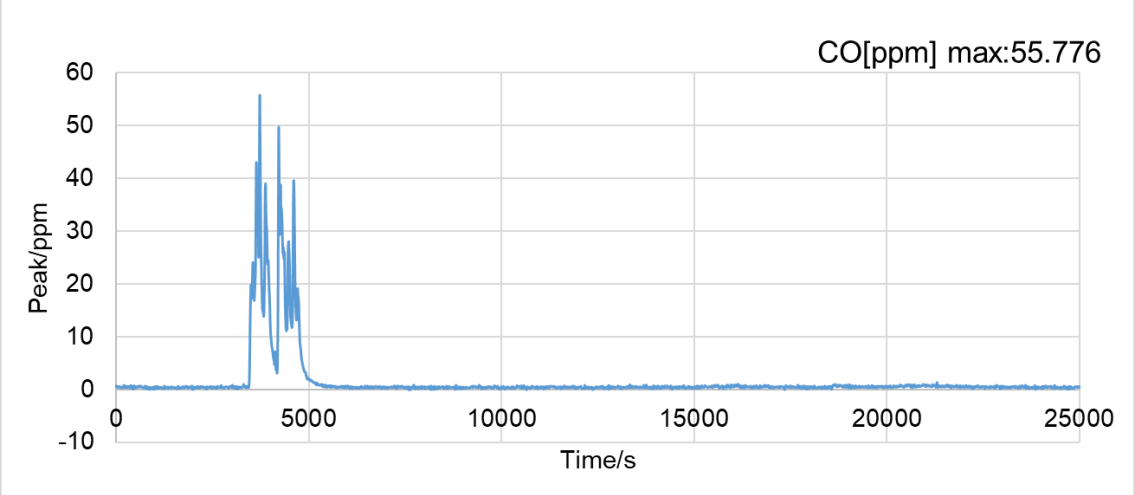

Figure 2 of Attachment 6: Gas generation and composition data chart (Detected by FTIR).

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MODULE LEVEL

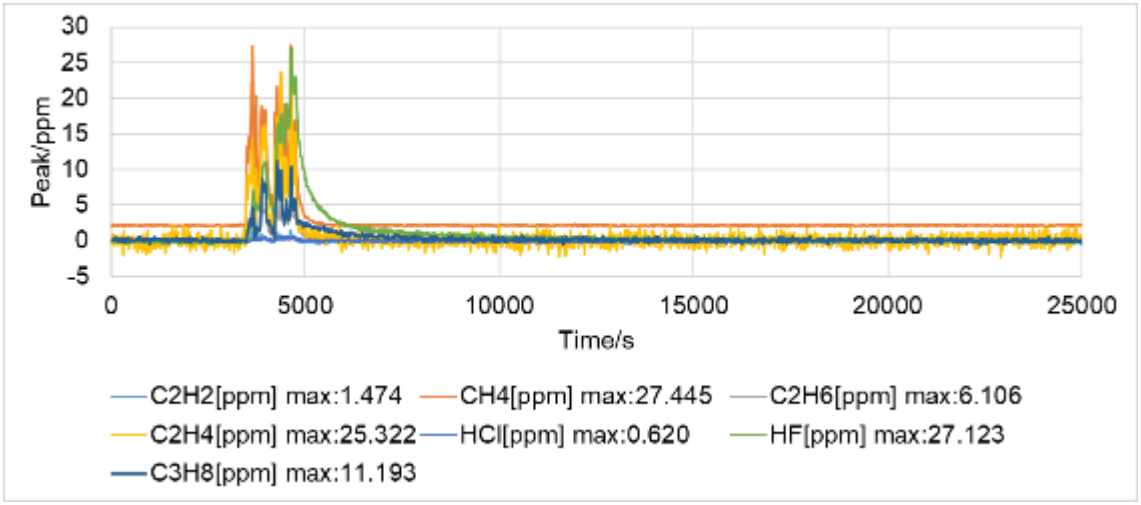

Figure 3 of Attachment 6: Gas generation and composition data chart (Detected by FTIR).

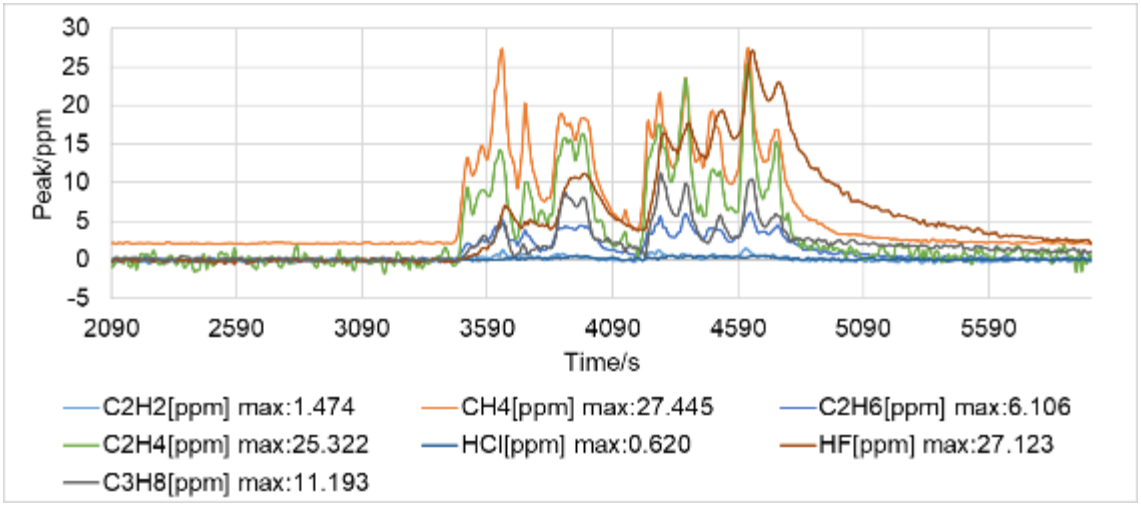

Figure 4 of Attachment 6: Zoomed view of Gas generation and composition data chart (Detected by FTIR).

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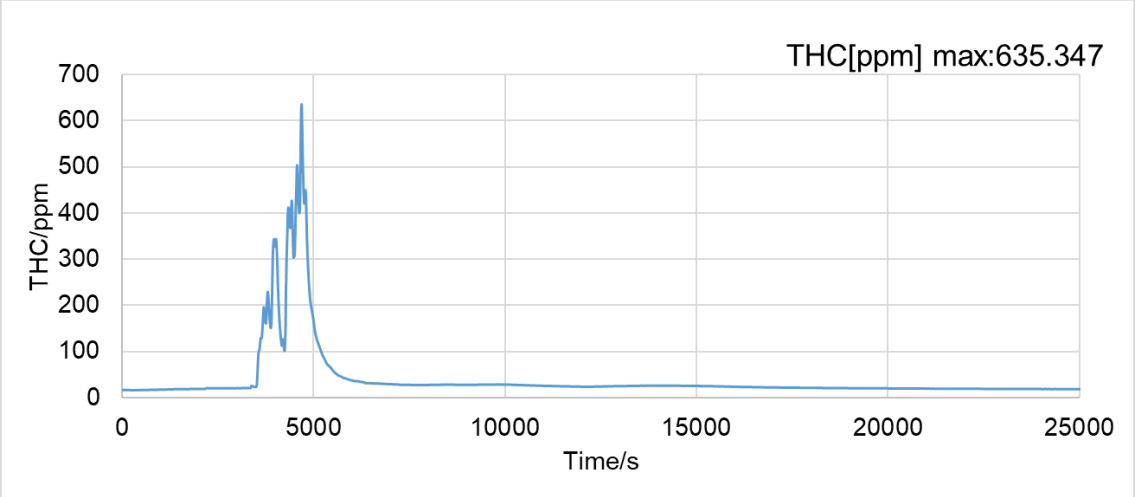
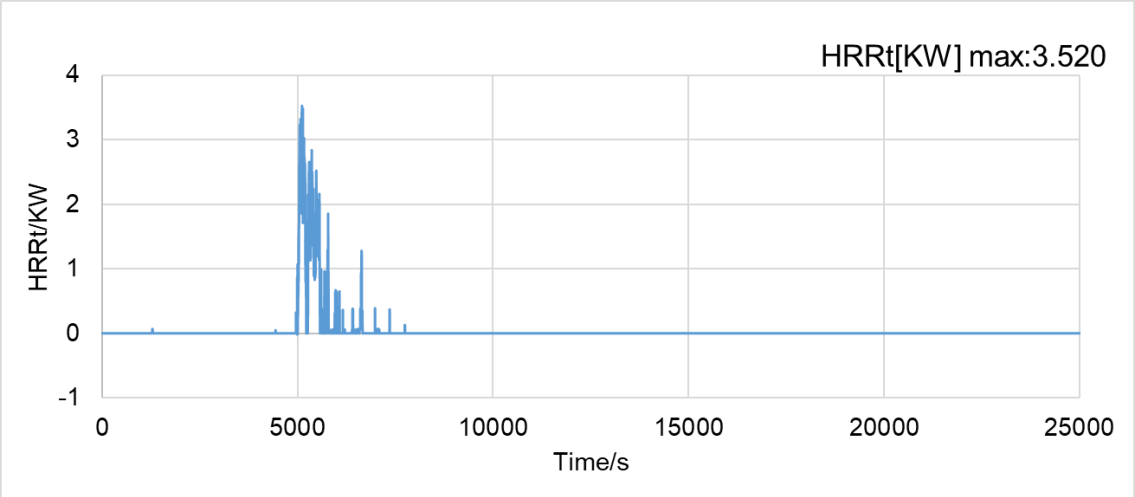


Figure 5 of Attachment 6: THC (Total Hydrocarbons) chart (Detected by FID).

Attachment 7: Heat release rate versus time data chart



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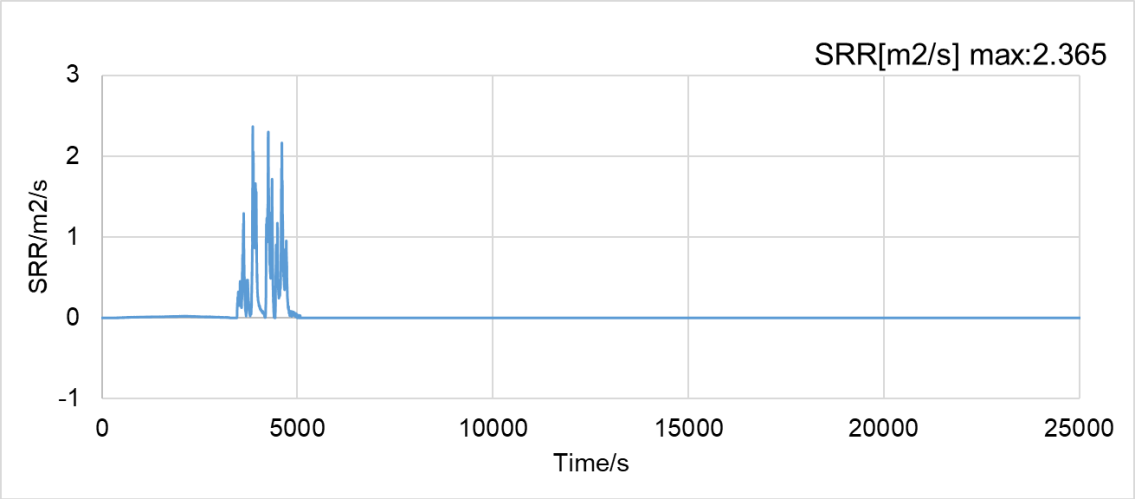
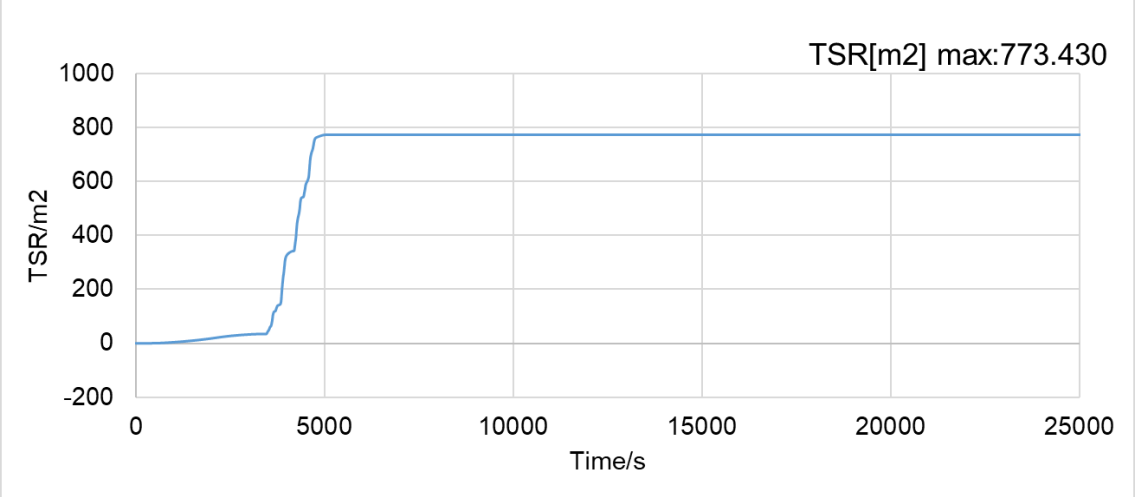
MODULE LEVEL

Attachment 8: Peak smoke release rate and total smoke release data chart





Attachment 9: Summary of Heat release rate & Peak smoke release rate and total smoke release data

Peak heat release rate	3.520 kW
Total smoke production	773.430 m^2
Peak smoke production rate	2.365 m^2/s

---------- END REPORT ----------

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