TEST REPORT

ANSI/CAN/UL 9540A:2025

TUV SUD Test Report for Module Level – Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems on Module Level

Report No.: Date of issue: Project handler:	704082527116-00 2025-11-21 Jing Gao
Testing laboratory: Address: Testing location:	TÜV SÜD New Energy Vehicle Testing (Jiangsu) Co., Ltd. Building A, No.15 Factory, Jintong International Industrial Park, No.8,Xihu Road, Wujin National Hi-tech Industrial Development Zone, Changzhou, Jiangsu, China as above
Client: Client number: Address: Contact person:	Shanghai Elecnova Energy Storage Co., Ltd. 125581 Hongqiao Hui No. 990 Shenchang Road, Minhang District, 201100 Shanghai,PEOPLE'S REPUBLIC OF CHINA Pengfei Wang
Standard: TRF number and revision: eDoc_ID: TRF originated by:	This TUV SUD test report form is based on the following requirements: ANSI/CAN/UL 9540A:2025 Fifth Edition (5Ed) TRF ANSI/CAN/UL 9540A:2025 Rev 0 TUV SUD NEW ENERGY TESTING (GUANGDONG) CO., LTD., Mrs. Zoey Liu
Copyright blank test report: General disclaimer:	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. This test report may only be quoted in full. Any use for advertising purposes must be granted in writing. This report is the result of a single examination of the object in question and is not generally applicable evaluation of the quality of other products in regular production.
Scheme:	☐ TUV Mark ☐ cTUV Mark (SCC) ☐ TUVus Mark (NRTL) ☐ GS Mark ☒ without certification ☐ other: ☐ AoC/CoC for EU-Directive / EU-Regulation:
Non-standard test method: National deviations:	☒ No ☐ Yes, see details under *Summary of testing* N/A
Number of pages *(Report)*:	41

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Telefax : +86 519 81239872-123

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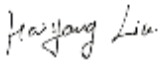
Building A, No.15 Factory, Jintong International Industrial Park, No.8 Xihu Road, Wujin National Hi-tech Industrial Development Zone, Changzhou City, Jiangsu Province, P.R. China

Number of pages *(Attachments)*:	N/A		
Compiled by: (+ signature)	Jing Gao 	Approved by: (+ signature)	Haiyang Liu 

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Test sample:	Batteries
Type of test object:	Rechargeable Li-ion Battery Moudle
Trademark:	Elecnova
Model and/ or type reference:	ECO-P1P52LP
Rating(s):	314Ah, 166.4Vdc

Manufacturer:	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
Name and address of factory(ies)	
Jiangsu Sfere 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	

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:	2025-08-21
Date of receipt of test item:	2025-09-02
Date(s) of performance of test:	2025-09-05 to 2025-09-06

Test item particulars:

Test item particulars:According to Module Level of ANSI/CAN/UL 9540A:2025 Fifth Edition. Decision rule according to IEC Guide 115:2023, clause 4.3 was applied.

Purpose of the product (description of intended use):

Rechargeable Li-ion Battery Module, model: ECO-P1P52LP, used in Battery Energy Storage Systems.

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Characteristic data (not shown on the marking plate):	
Product name	Rechargeable Li-ion Battery Module
Type/model	ECO-P1P52LP
Nominal voltage	DC 166.4 V
Rated capacity	314 Ah
Charging voltage specified by manufacturer	DC 187.2 V or any cell reach 3.6 V
Upper limit charging voltage	DC 187.2 V or any cell reach 3.6 V
Charging power specified by manufacturer	25000 W
Maximum continuous charging current	DC 175 A
Discharging power specified by manufacturer	25000 W
Maximum continuous discharging current	DC 175 A
End of discharge voltage	DC 145.6 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 25000 W until voltage reaches 3.6 V
Dimension	W×D×H: (800±2) mm ×(1135±2) mm ×(248±2) mm
Weight	352±1 kg
Number of cells and configuration	52S

Attachments:

Attachment 1: Exploding drawing of module & Identification/location of cells within the module
Attachment 2: Pre-conditioning profile
Attachment 3: Photo(s) for sample(s) before test and test setup with thermocouple location
Attachment 4: Photo(s) for sample(s) 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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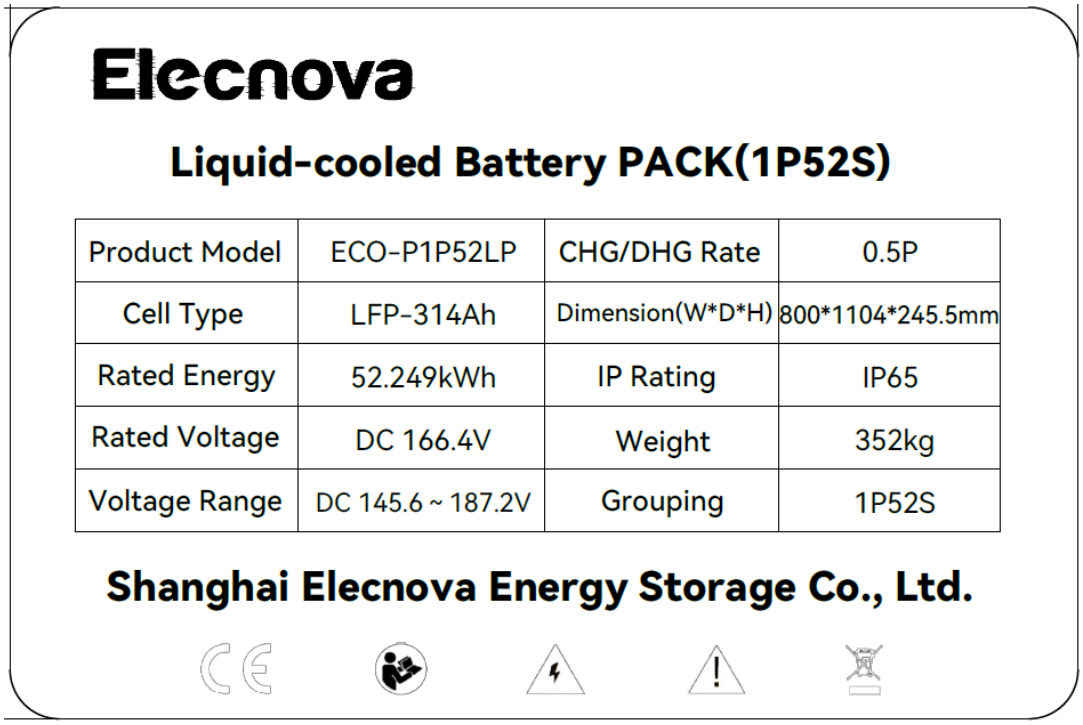
If additional information is necessary, please provide

N/A

Copy of marking plate:



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Pictures of the product:

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Summary of testing: **>>>> module level testing:**	
Module model number	ECO-P1P52LP
Nominal voltage and rated capacity	166.4 Vd.c, 314Ah
Number of cells in module and module configuration	52 cells, 52S
Whether UL 1973 compliant	No related documentation was provided
Module voltage corresponding to the tested SOC	173.7 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: 172mmx204mm (220 V, 900 W/pc)
Thermal runaway of other cells within module:	Thermal runaway was observed on other 2 cells in the module, cell 20 and cell 21.
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
Performance - module level test:	
a) Vent gas is nonflammable as determined by the cell level test;	The cell 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 adlacent to the initiating cell where the greatest thermal exposure is anticipated.	Yes
Performance - cell level test: (tested by: TUV Rheinland , report no.: CN23F118001)	
a) Thermal runaway cannot be induced in the cell; and	No
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.	No

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>>>> 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	No related documentation provided
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_{max} of the cell vent gas	0.78 MPa

Cell vented gas composition:

Composition	Chemical formula	Re-normalized, %
Hydrogen	H2	49.875
Carbon monoxide	CO	16.202
Carbon dioxide	CO2	26.861
Methane	CH4	3.671
Ethane	C2H6	0.548
Ethene	C2H4	1.389
Propene	C3H6	0.745
Propane	C3H8	0.18
Butene	n-C4H8	0.22
Butane	n-C4H10	0.068
Pentane	iso-C5H12	0.112
Pentene	n-C5H10	0.053

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☐ 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.

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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**		P
5.1	**Cell**		P
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.	No related documentation provided	N/A
5.1.3	Refer to 7.7.1 for further details to be included in the cell level test report.		P
5.2	**Module**		P
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.	No related documentation was provided	N/A
5.2.3	Refer to 8.4 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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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
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.		N/A
7	**Cell Level**		—
8	**Module Level**		P
8.1	**Sample**		P
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 hours and then discharged to an end of discharge voltage	See Attachment 2: Preconditioning profile. Charge method: Charge at constant power	P

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MODULE LEVEL			
Clause	Requirement + Test	Result – Remark	Verdict
	(EODV) specified by the module manufacturer. During conditioning the ambient temperature and conditions shall be maintained in accordance with 8.2.1.	25.000kW until voltage reaches 172.8V Discharge method: Discharge at constant Power 25.000kW until the voltage reaches 134.4 V. charge stopped when single cell voltage exceeds 3.6V; discharge stopped when single cell voltage less than 2.8V	
8.1.2	The module to be tested shall be charged to 100% SOC or to the manufacturer's specification for a fully charged voltage and allowed to rest for a minimum of 1 hour before the start of the test.	See Table 1.	P
8.1.3	Prior to initiating the test, the module voltage shall be measured at the module terminals and recorded. If the module is not in a fully charged condition, the module shall be charged again as noted in 8.1.2 and this value shall be recorded.		P
8.1.4	Electronics and software controls such as the battery management system (BMS) are not relied upon for this testing.		P
8.2	**Test method**		P
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
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 unless the module is consumed by fire, which shall be indicated in the report.	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 and the design of the module. The results of the cell test and the design of the module shall inform the approach taken with the goal to achieve cell to cell thermal runaway propagation within the module. 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	One cell was forced into thermal runaway. Cell to cell propagation occurred within the module.	P

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MODULE LEVEL			
Clause	Requirement + Test	Result – Remark	Verdict
	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.		
8.2.5	With reference to 8.2.4, a sufficient number of cells shall be forced into thermal runaway to create a condition of cell to cell thermal runaway propagation within the module. Cell to cell thermal runaway propagation occurs when at least one additional non-initiating cell goes into thermal runaway during the test. If non-initiating cells only vent during the test, this is not considered a thermal runaway propagation. If thermal runaway propagation is not achieved, the test shall be repeated with additional cells forced into thermal runaway. For example, module designs with a cell capacity larger than 10 Ah may need no more than 3 cells forced into thermal runaway, and module designs with a cell capacity less than 10 Ah may need no more than the equivalent of 30 Ah of cells forced into thermal runaway. Temperatures shall be measured on the initiating cells and nearby non-initiating cells to determine cell to cell thermal runaway propagation. If cell to cell thermal runaway propagation is not achieved with additional initiating cells, then it can be determined that thermal runaway propagation is not possible.	Two film heaters were used to initiate thermal runaway. 220Vac, 429W/pc film heater were covered on each large surface of the initiating cell. The cell was heated with the externally applied flexible film heater at a heating rate of 5℃/min until thermal runaway occurred.	P
	NOTE: To establish a cell to cell thermal runaway propagation event within a module, it may be necessary to remove any thermal insulator or electrical insulation between the heater and the initiating cell(s) to allow for placement of the heater without significantly altering the design of the module.		P
8.2.6	With reference to 8.2.5, temperatures shall be measured on the initiating cells and nearby non-initiating cells to determine thermal runaway propagation. Temperatures shall also be measured on the exterior surface of the module enclosure in the area closest to the initiating cell location(s).		P
8.2.7	The methodology used for initiating thermal runaway in accordance with 7.3 shall be used to initiate thermal runaway within the module.	See Figure 1 of Attachment 3.	P
8.2.8	With reference to 8.2.7, 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 7.3.1.11.	See Attachment 7 and 9.	P
8.2.9	The module shall be placed on top of a noncombustible horizontal surface with the module	See Attachment 7 and 9.	P

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MODULE LEVEL			
Clause	Requirement + Test	Result – Remark	Verdict
	orientation representative of its intended final installation.		
8.2.10	The chemical heat release rate of the module in thermal runaway shall be measured with oxygen consumption calorimetry.		P
8.2.11	The chemical heat release rate shall be measured for the duration of the test. See 8.2.12.		P
8.2.12	The chemical heat release rate shall be measured by a measurement system consisting of a paramagnetic oxygen analyzer, non-dispersive infrared carbon dioxide and carbon monoxide analyzer, velocity probe, and a Type K thermocouple. The instrumentation shall be located in the exhaust duct of the heat release rate calorimeter at a location that minimizes the influence of bends or exhaust devices. See 8.2.13.	See Table 2 and Attachment 6.	P
8.2.13	With reference to 8.2.12, calculate the chemical heat release rate at each of the flows as follows: $HRR_1 = \left[\dot{F} \times \varphi \cdot (E_{ox} - E) \times \frac{1-\eta}{2} \times \frac{X_{ox}}{X_{O_2}} \right] \times \frac{\dot{m}_e}{1+\varphi \times (\alpha - 1)} \times \frac{M_{O_2}}{M_e} \times (1 - X^{H_2O}_{ox}) \times X^{ox}_{O_2}$		P
8.2.14	The hydrocarbon content of the vent gas shall be measure using flame ionization detection. Hydrogen gas shall be measured with an appropriate sensor for the anticipated range of gas as well as for exposure to anticipated contaminants, such as a palladium-nickel thin-film solid state sensor. This may require multiple sensors to cover a wider range of concentrations depending on the anticipated cell off gas.	See Table 2 and Attachment 6.	P
8.2.15	At the request of the BESS manufacturer, the hydrocarbon components of the vent gas composition may additionally 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 feet), or an equivalent gas analyzer. Velocity and temperature measurements respectively shall be obtained in the exhaust duct of the heat release rate calorimeter using equipment specified in 8.2.12.	See Table 2 and Attachment 6.	P
8.2.16	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 8.2.17.		P
8.2.17	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

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MODULE LEVEL			
Clause	Requirement + Test	Result – Remark	Verdict
8.3	**Module test method for high temperature batteries**		N/A
8.3.1	The module test procedure as outlined in 8.2 shall be modified as noted in 8.3.2 – 8.3.5. During the test, the module shall be placed on top of a noncombustible horizontal surface with the module orientation representative of its intended final installation.		N/A
8.3.2	The module shall be fully charged prior to testing and heated to the manufacturer's specified operating temperatures. The module shall be provided with electrical connections to the cell(s) to be failed in order to overcharge the cell(s).		N/A
8.3.3	The cell failure test method as outlined in 7.3.4 shall be conducted on at least one cell within the module. During the test, the voltage of the cell(s) being failed as well as temperatures on the failed cell(s) and surrounding cells shall be monitored and documented. The voltage of the module shall be monitored during the test.		N/A
8.3.4	Thermocouples shall be placed on the external casing of the module to monitor any breakdown of thermal insulation in the module case. The chemical heat release rate, smoke release rate and gas measurements are not conducted.		N/A
8.3.5	The results of the cell(s) failure shall be observed and documented.		N/A
8.4	**Module level test report**		P
8.4.1	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)	No related documentation was provided	P
	b) Number of cells in module;		P
	c) Module configuration with cells in series and parallel;		P
	d) Module construction features per 5.2;		P
	e) Module voltage corresponding to the tested SOC;		P
	f) Thermal runaway initiation method used including number and locations of cells for initiating thermal runaway;		P
	g) Heat release rate versus time data;		P
	h) Flammable gas generation and composition data;		P
	i) Peak smoke release rate and total smoke release data.		P

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MODULE LEVEL			
Clause	Requirement + Test	Result – Remark	Verdict
	j) Observation(s) of flying debris or explosive discharge of gases;		P
	k) Observation(s) of sparks, electrical arcs, or other electrical events;		P
	l) Identification/location of cells(s) that exhibited thermal runaway within the module;		P
	m) Locations and visual estimations of flame extension and duration from the module shall be documented;		P
	n) Module weight loss based on measurements per 8.2.3;		P
	o) Video of the test; and		P
	p) Cell level test report summary.		P
8.4.2	The report on the high temperature battery module level testing of 8.3 shall include the following:		N/A
	a) Module manufacturer name and model number (and whether UL 1973 compliant):		N/A
	b) Number of cells in module;		N/A
	c) Module configuration with cells in series and parallel;		N/A
	d) Module construction features per 5.2;		N/A
	e) Module voltage corresponding to the tested SOC at start and end of test;		N/A
	f) Overvoltage charge parameters used to initiate thermal runaway or details of other failure method(s) per exception of 7.3.4.2 used to initiate thermal runaway, including number and locations of cells for initiating thermal runaway;		N/A
	g) Observation(s) of flying debris, module enclosure rupture or explosive discharge of gases;		N/A
	h) Observation(s) of sparks, electrical arcs, or other electrical events;		N/A
	i) Identification/location of cells(s) that exhibited thermal runaway within the module;		N/A
	j) Locations and visual estimations of flame extension and duration from the module shall be documented;		N/A
	k) Maximum temperature measured on module case; and		N/A
	l) Video of the test.		N/A
8.5	**Performance at module level testing**		

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MODULE LEVEL			
Clause	Requirement + Test	Result – Remark	Verdict
8.5.1	Unit level testing in Section 9 is not required if all of the following performance conditions are met during the module level test:		F
	a) Vent gas is nonflammable as determined by the cell level test;	Cell vent gas is flammable according to cell level test report	F
	b) There is no spread of flame outside of the module; and		P
	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.		P
8.6	**Performance at high temperature module level testing**		
8.6.1	Unit level testing in Section 9 is not required if the following performance conditions are met during the module level test:		N/A
	a) Thermal runaway is contained by module design; and		N/A
	b) There was no leakage of hazardous materials, rupture of the module casing or explosion with flying debris.		N/A
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 Li-ion Battery	Shanghai Elecnova Energy Storage Co., Ltd.	ECO-261LP-2A	DC 832 V, 314 Ah	IEC 63056:2022	TÜV SÜD SUD Cert. No. B 125581 0022 Rev.01 Report no. 704082527103-01
				IEC 62619:2022	TÜV SÜD SUD Cert. No. B 125581 0021 Rev.01 Report no. 704082527102-01
For battery module ECO-P1P52LP					
1.Cell (52 pcs for one battery module)	Xiamen Hithium Energy Storage Technology Co., Ltd	LFP711732 07/314Ah	DC 3.2V, 314Ah	IEC 62619:2022	TÜV Rheinland Ref. Certif. No.: JPTUV-152897 Report No. : CN23YUR9001
2.CCS	Shenzhen Topsheng Technology Co., Ltd	TPSNP103 F3435FBL9 76 A3	Temperature: -40°C to +125°C	IEC62477-1:2012	Test with unit
-NTC Resistor for cell (20 pcs for one battery module)	SEMITEC	103KT1608 T-1P	R25 =10KΩ±1% $B_{25/85}$=3435K±1% Temperature: -40°C to +125°C	IEC62477-1:2012	Test with unit
-FPCA	ALLSTAR TECH(ZHONGSHAN)TO LTD	ASC-FC-H	Flame class: V-0	ANSI/UL 746E	UL E301444

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MODULE LEVEL

				ANSI/UL 94 ANSI/UL 746F ANSI/UL 746A ANSI/UL 746B	
-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 Technology Co.,Ltd.	FMSD6102 T02-A500Z	Rated voltage: 500 V DC Rated current: 250A Temperature: -40°C to +125°C	UL 4128	TÜV Rheinland Ref. Certif. No.: US 50652259 0001
5.MSD Socket	Shanghai Futronics Electronic Technology Co.,Ltd.	FMSD2602 T01-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

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MODULE LEVEL

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
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	KB-04	V-0	UL 796	UL E225430

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MODULE LEVEL

	TECHNOLOGY CO LTD				
-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, U8_2, U8_3, U8_4)	TI	CD4051BPWR	Supply voltage: -0.5-20V Temperature range：-55°C-+125°C	IEC62477-1:2012	Test with unit
-Network isolation transformer (T4)	U&T	UTA06C02	OCL:150uHMin450uHMax,@100KHz/0.1V Operating temperature range: -40°C to +125°C	UL 62368-1	UL E530055
-MCU(U3)	GD	GD32FCESRBT6	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

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MODULE LEVEL

MODULE LEVEL TEST RESULT:

Table 1: Thermal runaway test result	
Initial ambient temperature:	24.6°C
Initial relative humidity:	61.8%RH
Pre-conditioning time	2 cycle From 2025-09-04 17:14:04 to 2025-09-05 04:03:39
Thermal runwaway test start time (heating start time)	2025/9/5 16:48:00 s
Module voltage (OCV) before test:	173.7 Vdc
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: 109.8 °C, T8: 133.1°C (Thermocouple location see Attachment 1)
Time when gases were first vented:	Cell 19 2025-09-5 17:12:46
Surface temperature prior to thermal runaway:	T7: 181.7 °C, T8: 203.5°C (Thermocouple location see Attachment 1)
Time when thermal runaway:	Cell 19 2025-09-05 17:31:10
Module voltage (OCV) after test:	163.5 Vdc
Location of cell(s) for intiating thermal runaway	Cell 19 (see Attachment 1)
Thermal runaway of other cells within module:	Thermal runaway was observed on 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 flames observed.
Module weight before test:	351.0 kg
Module weight after test:	350.5 kg
Module weight loss:	0.5 kg

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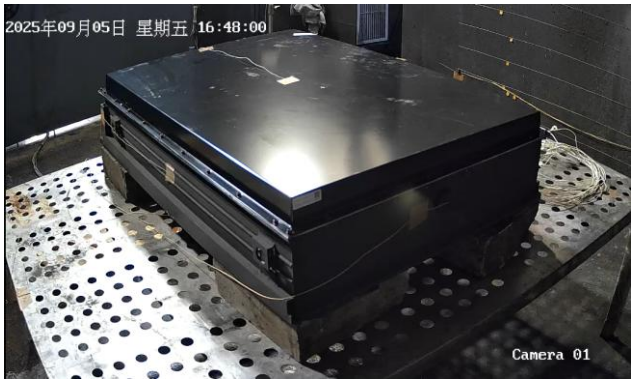
MODULE LEVEL

Timeline of thermal runaway		
Time (hh:mm:ss)	Event	Description
2025-09-05 16:48:00	Start testing.	
2025-09-05 17:12:46	The initiating cell 20 first vented.	
2025-09-05 17:31:10	The temperature of initiating cell 20 started to rise sharply,thermal runaway occurred.	

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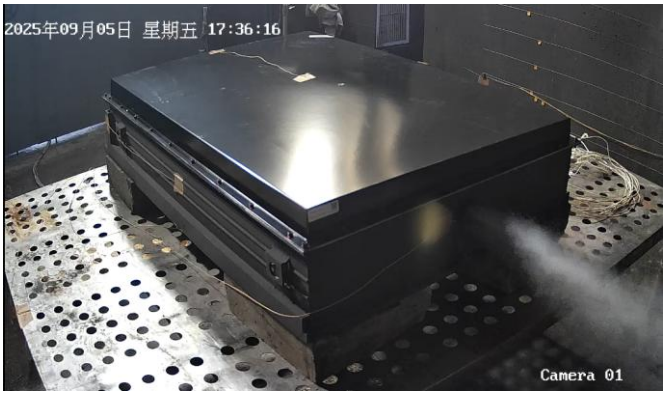
MODULE LEVEL		
2025-09-05 17:34:20	The initiating cell 21 first vented.	
2025-09-05 17:36:16	The temperature of initiating cell 21 started to rise sharply,thermal runaway occurred.	
2025-09-05 17:38:49	The initiating cell 22 first vented.	

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MODULE LEVEL		
2025-09-05 17:42:20	The temperature of initiating cell 22 started to rise sharply, thermal runaway occurred.	
2025-09-06 10:55:10	No smoke was bserved and video stopped	
Remark: Refer to attachment 3 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	CO	0.129	-	NDIR
Carbon dioxide	CO2	0.975	-	NDIR
Hydrogen	H2	0.0316	-	Palladium nickel thin film solid state sensor
Total Hydrocarbons	(CH4 Equivalent)	0.896	-	FID
Flow rate in exhaust duct (m^3/s)		1.6		

Table 3: Thermocouple location		
Thermocouple location	Thermocouple location	Measured maximum temperature, °C
TKK-1	Between left large surface of cell #20 and film heater (TKK-1)	689.2

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MODULE LEVEL		
TKK-2	Between right large surface of cell #20 and film heater (TKK-2)	Broken
T1	Right large surface center of cell #6 (T1)	80.5
T2	Right large surface center of cell #7 (T2)	92.0
T3	Right large surface center of cell #8 (T3)	91.7
T4	Left large surface center of cell #18 (T4)	105.2
T5	Left large surface center of cell #19 (T5)	94.0
T6	Right large surface center of cell #19 (T6)	217.2
T7	Right large surface of cell #20 not covered by film heater（T7）	682.9
T8	Near vent deviceof cell #20 (T8)	420.9
T9	Left large surface center of cell #21 (T9)	697.7
T10	Right large surface center of cell #21 (T10)	593.6
T11	Right large surface center of cell #22 (T11)	141.3
T12	Right large surface center of cell #32 (T12)	121.0
T13	Right large surface center of cell #33 (T13)	174.2
T14	Rright large surface center of cell #34 (T14)	131.3
T15	Ambient (T15)	30.9
T16	Outside of front enclosure (T16)	51.6
T17	Outside of back enclosure (T17)	67.6
T18	Outside of left enclosure (T18)	54.2
T19	Outside of right enclosure (T19)	41.9
T20	Outside of top enclosure (T20)	154.5
T21	Outside of bottom enclosure (T21)	79.3

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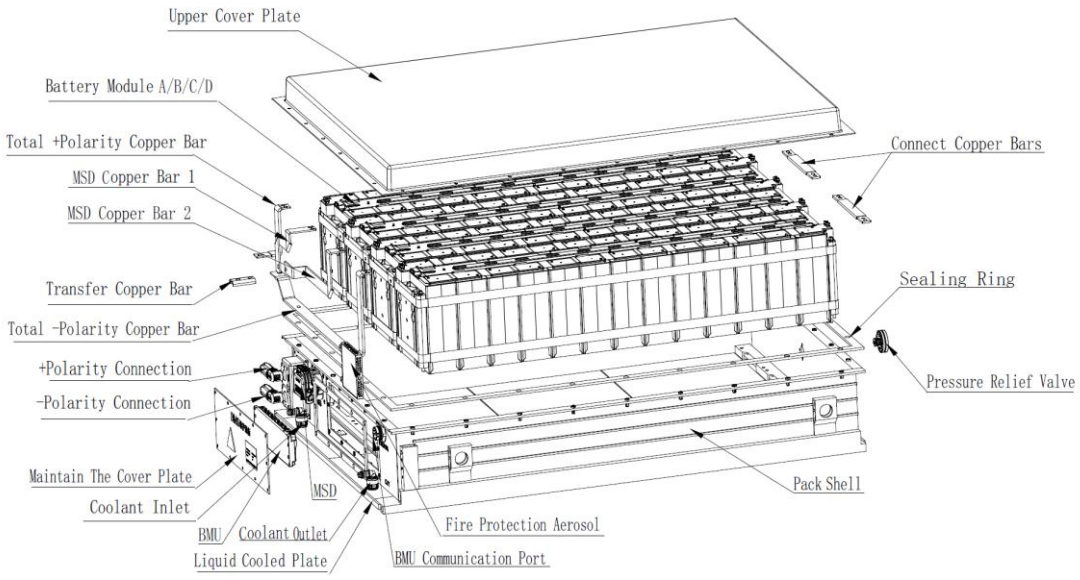
MODULE LEVEL

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

Exploding drawing of module as below:



Identification/location of cells within the module as below:

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

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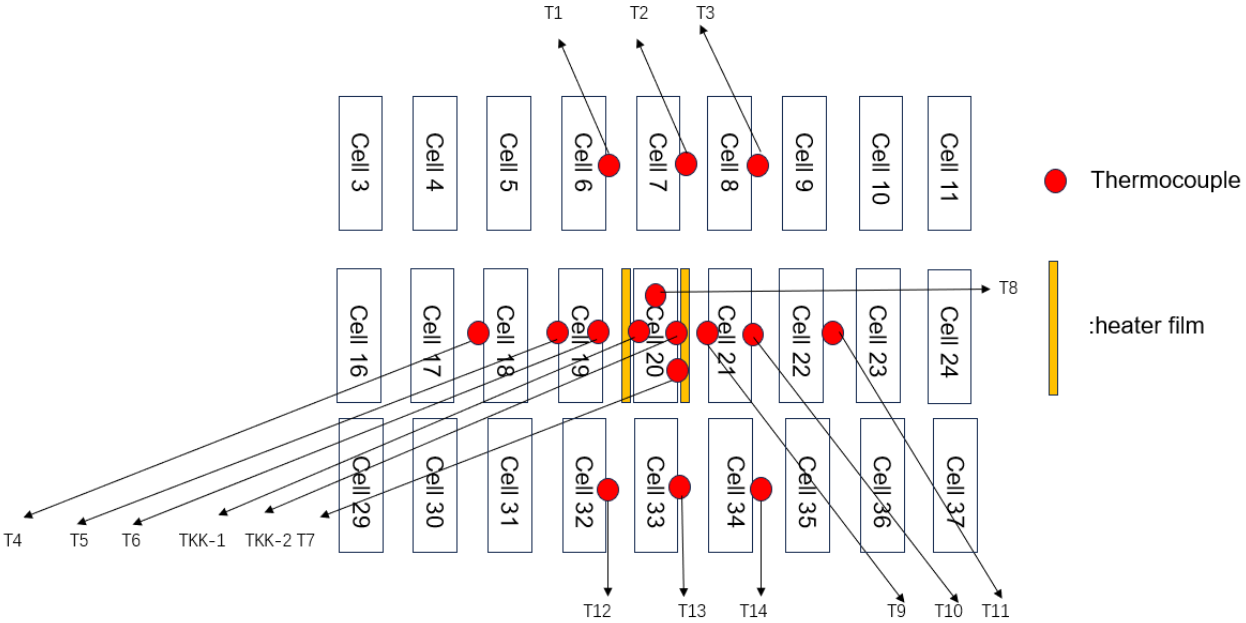
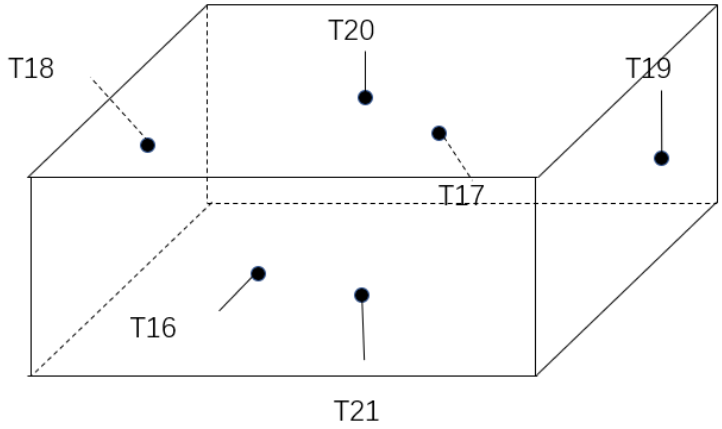
MODULE LEVEL





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MODULE LEVEL

Attachment 2: Pre-conditioning profile

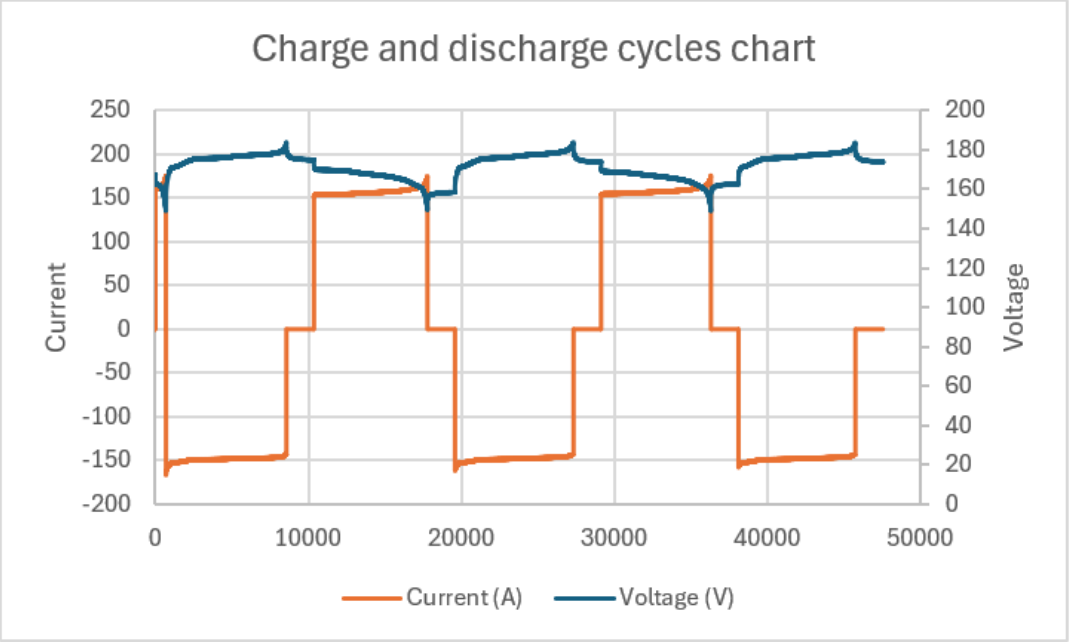

Figure 1 of Attachment 2: Charge and discharge cycles chart for module

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

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

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MODULE LEVEL

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

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

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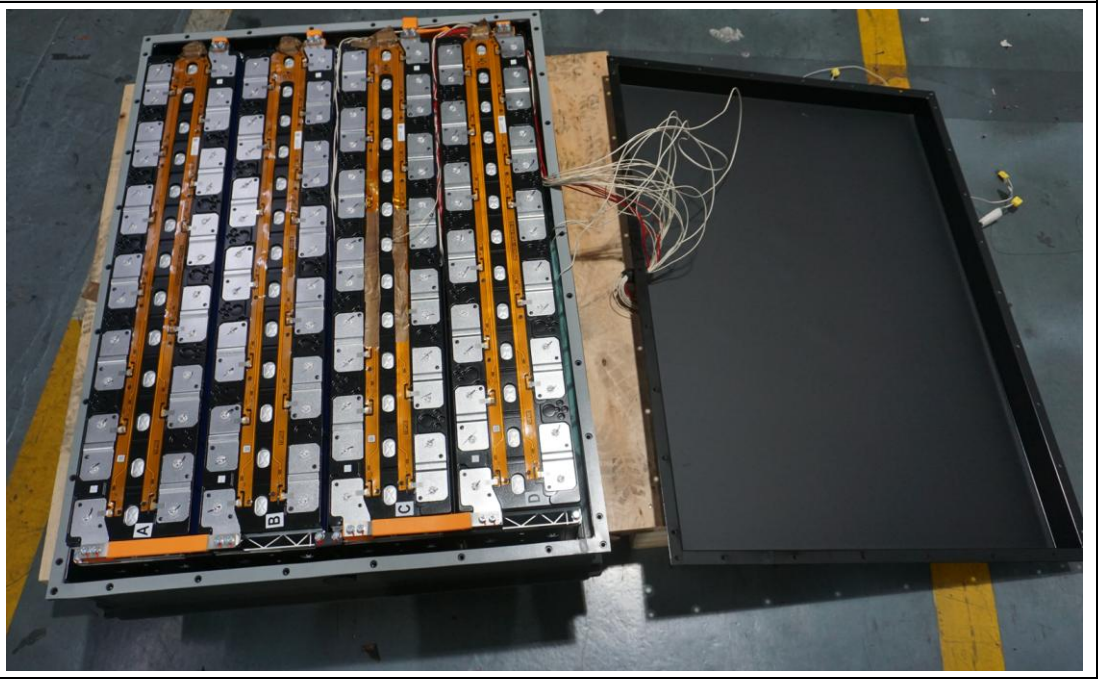
MODULE LEVEL

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

Details of:	Figure 5 of Attachment 3: Top view of module_after test, with top cover opened.
	

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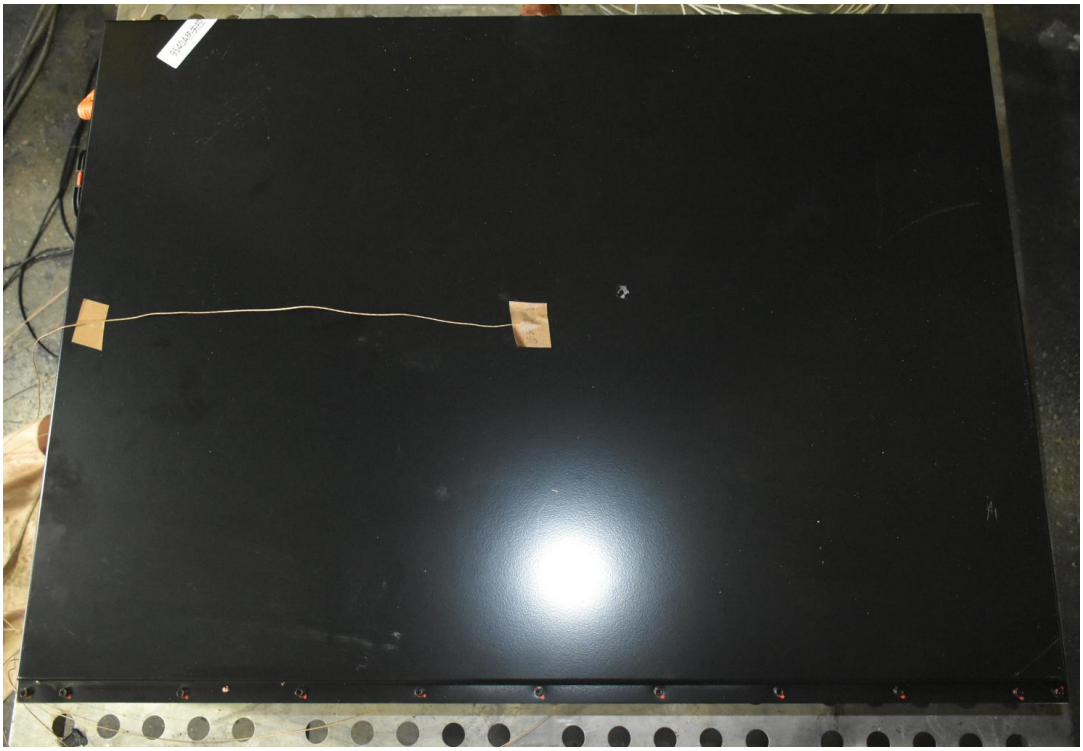
MODULE LEVEL

Attachment 4: Photo(s) for sample(s) 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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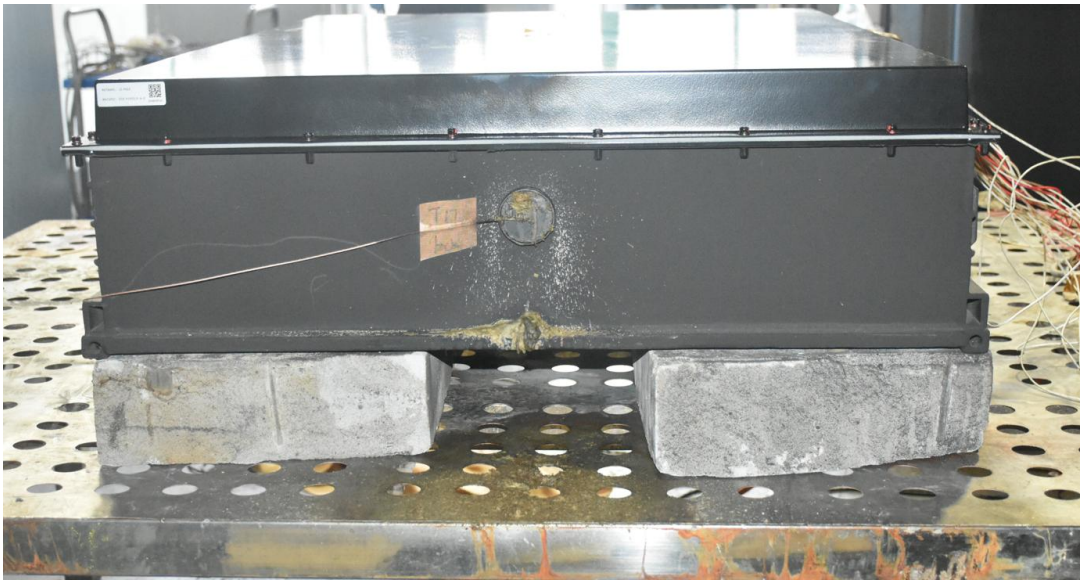
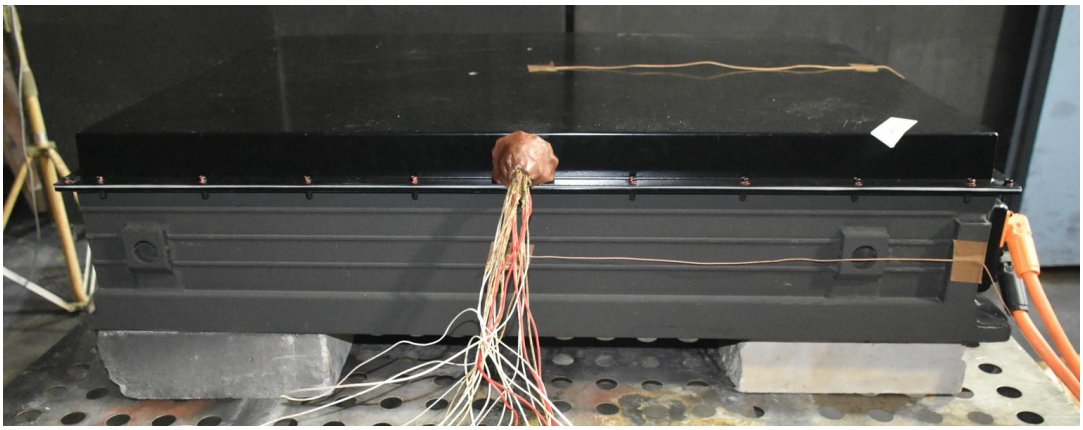
MODULE LEVEL

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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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.
	

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

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Attachment 5: Monitored temperature and voltage chart

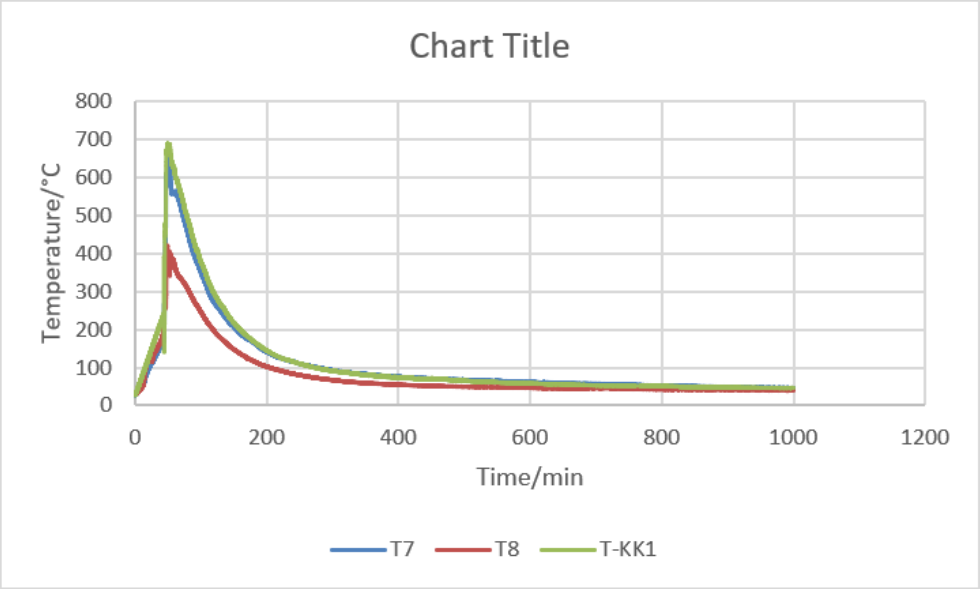

Figure 1 of Attachment 5: Temperatures of initiating cell in module

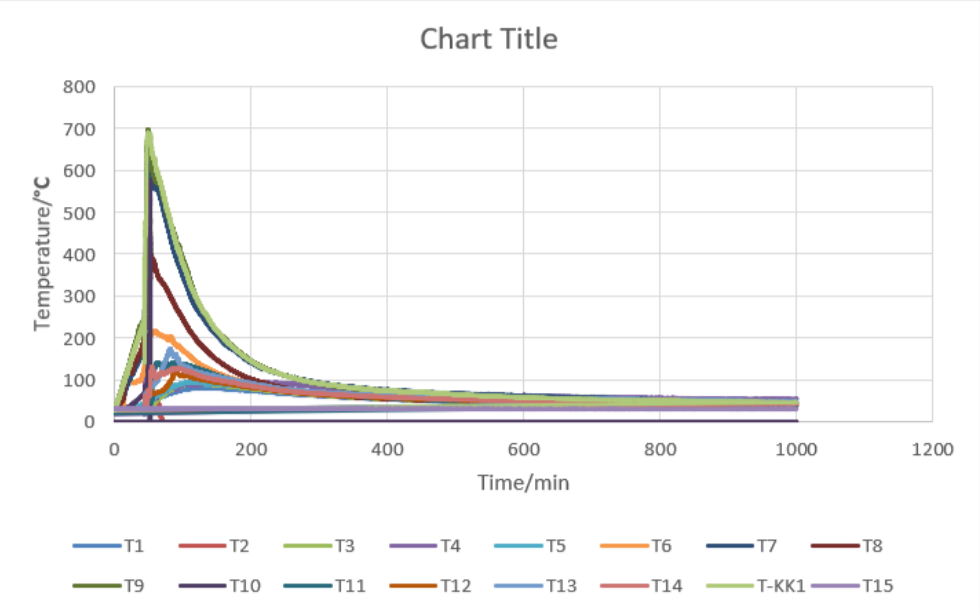

Figure 2 of Attachment 5: Temperatures of initiating cells and other cells in module

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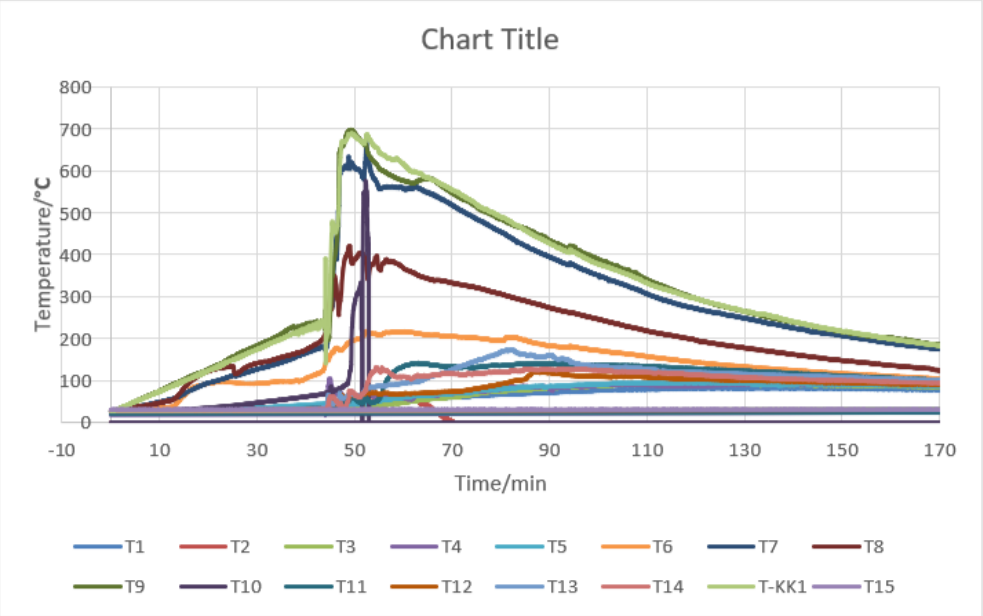

Figure 3 of Attachment 5: Zoomed view of temperatures, including initiating cell and other cells.

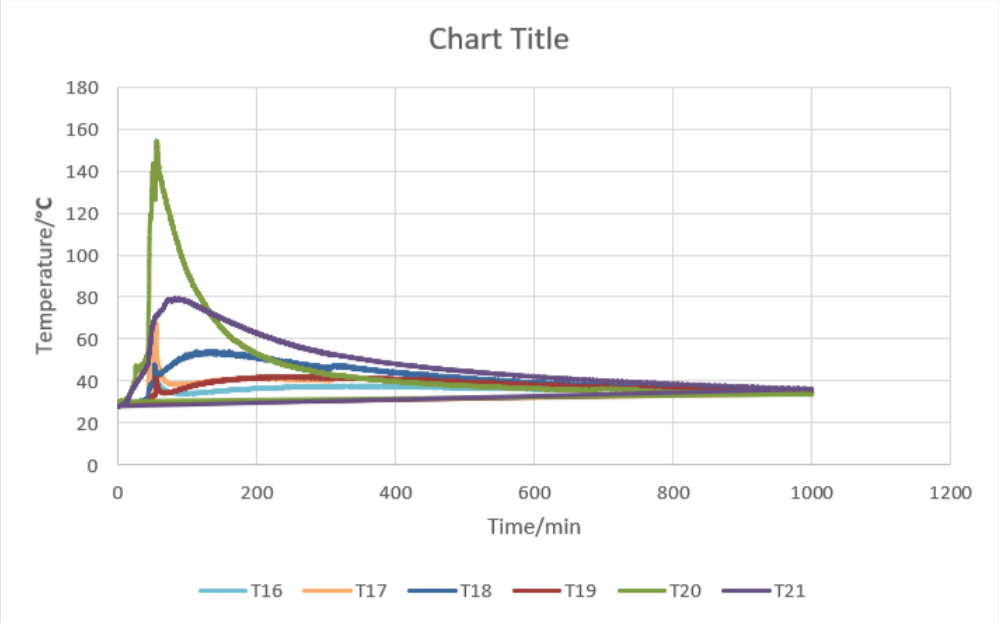

Figure 4 of Attachment 5: Temperatures of module case

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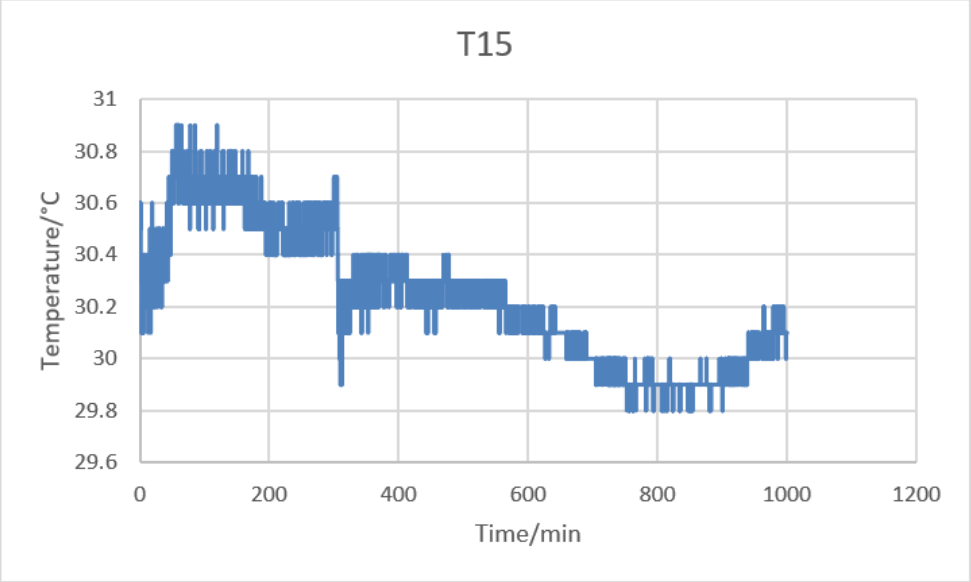

Figure 5 of Attachment 5: Temperatures of ambient

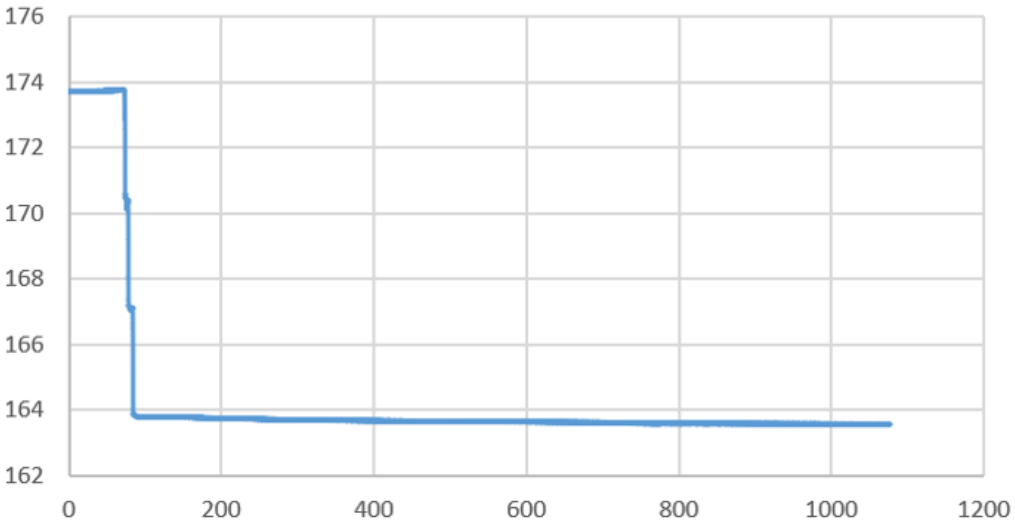

Figure 6 of Attachment 5: Voltage of module

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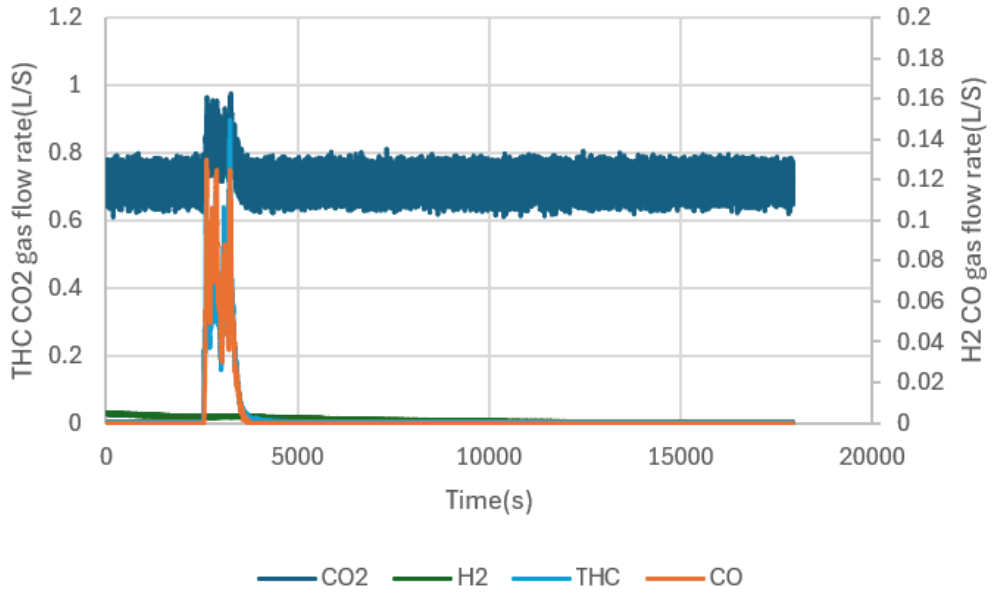
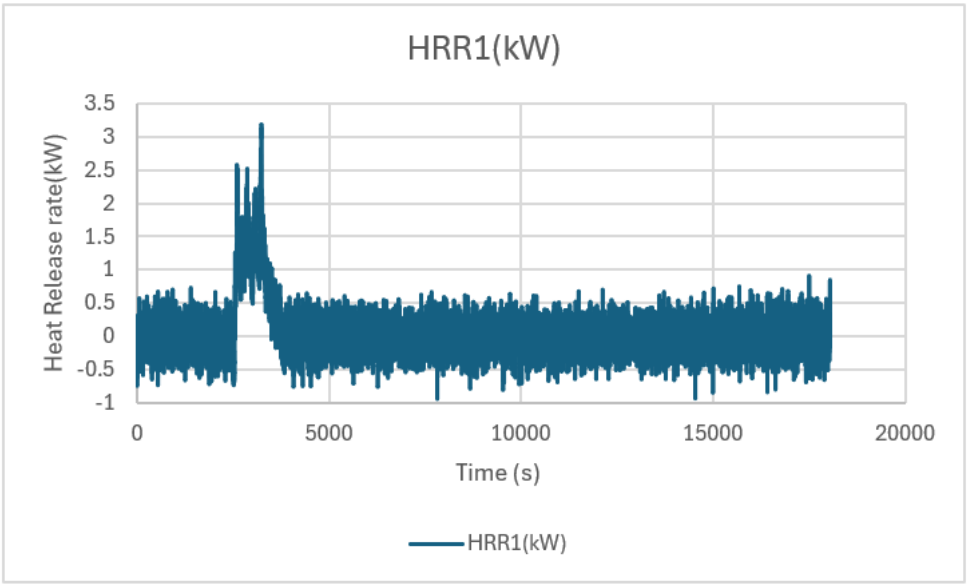
Attachment 6: Flammable gas generation and composition data chart



Attachment 7: Heat release rate versus time data chart



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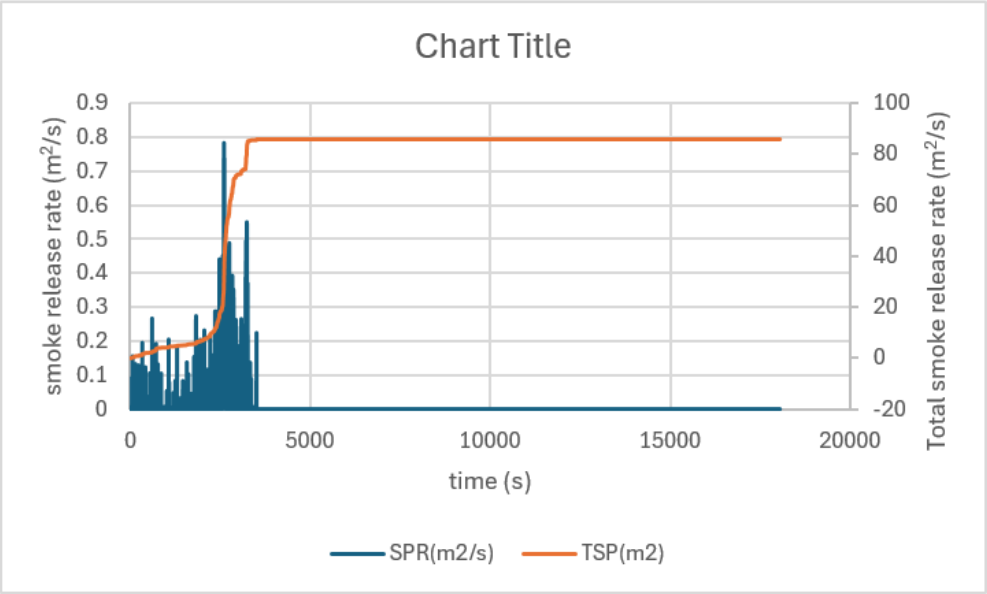
Attachment 8: Peak smoke release rate and total smoke release data chart



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

Peak heat release rate	3.193 kW
Total smoke release	85.9 m^2
Peak smoke release rate	0.783 m^2/s

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

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