Product Service

TEST REPORT

ANSI/CAN/UL 9540A:2019

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

Report Number. ..... :	64.280.23.60019.01
Date of issue ..... :	2023-06-05
Total number of pages ..... :	32 pages
Name of Testing Laboratory preparing the Report ..... :	TÜV SÜD New Energy Testing (Guangdong) Co., Ltd.
Applicant's name ..... :	Sunwoda Energy Technology Co., Ltd.
Address ..... :	Room 201, Building C, Sunwoda Electronic Factory, Tangjia Community, Fenghuang Street, Guangming District, 518100 Shenzhen City, PEOPLE'S REPUBLIC OF CHINA
Test specification:	
Standard ..... :	ANSI/CAN/UL 9540A:2019
Test procedure ..... :	Test report
Non-standard test method ..... :	N/A
Test Report Form No. ..... :	ANSI/CAN/UL 9540A:2019 Rev 0
Test Report Form(s) Originator .... :	TÜV SÜD Product Service
Master TRF ..... :	Dated 2021-01-01

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.

General disclaimer:

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.

TÜV®

Test item description ..... :	Rechargeable Lithium Iron Phosphate Battery Module
Trade Mark ..... :	SUNWODA ENERGY
Manufacturer ..... :	Same as the applicant
Model/Type reference ..... :	B051100P03
Ratings ..... :	51.2Vd.c., 100Ah

Responsible Testing Laboratory (as applicable), testing procedure and testing location(s):

Testing Laboratory.....:	TÜV SÜD New Energy Testing (Guangdong) Co., Ltd.	
Testing location/ address.....:	North-1/F, 2/F & Unit 301-3/F, TÜV SÜD Testing Center, D1, No. 63 Chuangqi Road, Shilou Town, Panyu District, Guangzhou 511447, China	
Tested by (name, function, signature) .....:	Zoey Liu (Project Handler)	
Approved by (name, function, signature)...:	Harry Zhang (Designated Reviewer)	

Summary of testing:

Summary of module level testing:	
Module model number	B051100P03
Nominal voltage and rated capacity	51.2Vd.c., 100Ah
Number of cells in module and module configuration	16S
Whether UL 1973 compliant	UL 1973 compliant
Module voltage corresponding to the tested SOC	53.69V
Method used to initiate thermal runaway	Heating the cell with externally applied flexible film heaters that cover two widest side surfaces of the cell, film heater dimension: 160mm × 118mm (500W/pcs)
Thermal runaway of other cells within module:	Cell 9, Cell 10, Cell 11, Cell 13, Cell 14, Cell 15, Cell 16
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 of flying debris
Observation(s) of explosive discharge of gas:	No explosive discharge of gas observed
Observation(s) of sparks, electrical arcs or other electrical events:	No observation of sparks, electrical arcs or other electrical events
Locations and visual estimations of flame	No observation of flame
Re-ignitions	N/A (No flame during test)
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.	The cell vent gas presented a flammability hazard
Performance - cell level test: (please see cell level report CQES220800015401 for more details)	
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

Tests performed (name of test and test clause):	**Testing location:**
Clause 8.1, 8.2 was performed on Rechargeable Lithium Iron Phosphate Battery System, model: B051100P03.	TÜV SÜD New Energy Testing (Guangdong) Co., Ltd. Address: North-1/F, 2/F & Unit 301-3/F, TÜV SÜD Testing Center, D1, No. 63 Chuangqi Road, Shilou Town, Panyu District, Guangzhou 511447, China

Copy of marking plate:

SUNWODA ENERGY Rechargeable Lithium Iron Phosphate Battery Module	
Model:B051100P03	Rated Capacity:100Ah
Nominal Voltage:51.2Vd.c.	Rated Energy:5kWh
Max. Charge Current:100A	Max. Discharge Current:100A
Charge Temperature:-10~50℃	Discharge Temperature:-20~50℃
Battery Type:IFpP51/161/119[16S]E/-20+50/90	Enclosure Type:IP65
Maximum short circuit current and duration time:3000A/1ms	
	CE UN38.3 SP US 300254

Picture of the product:

Test item particulars..... :	Rechargeable Lithium Iron Phosphate Battery Module
Classification of installation and use..... :	Use in industrial applications
Supply Connection..... :	Supply by terminals
Possible test case verdicts:	
- test case does not apply to the test object.....:	N/A
- test object does meet the requirement.....:	P (Pass)
- test object does not meet the requirement.....:	F (Fail)
Testing.....:	
Date of receipt of test item .....:	2023-04-21
Date (s) of performance of tests.....:	2023-04-21 to 2023-06-02

General remarks:

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

Throughout this report a ☐ comma / ☒ point is used as the decimal separator.

List of Attachments:

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

Attachment 2: Pre-conditioning profile(s)

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 temperature chart

Attachment 6: Flammable gas generation and composition data chart

Attachment 7: Heat release rate versus time data chart

Attachment 8: Summary of Heat release data and total smoke release data chart

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

Name and address of factory (ies).....:	Huizhou Sunwoda Energy Technology Co., Ltd. "Jiweidu" (local name) section of Zhenxing Avenue, Lixi Economic Union, Yuanzhou Town, Boluo County, 516000 Huizhou City, Guangdong, PEOPLE'S REPUBLIC OF CHINA

General product information:

Product name	Rechargeable Lithium Iron Phosphate Battery Module
Type/model	B051100P03
Nominal voltage	51.2Vd.c.
Rated capacity	100Ah
Charging voltage specified by manufacturer	55.2V
Charging current specified by manufacturer	50A
Maximum continuous charging current	100A
Discharging current specified by manufacturer	100A
Maximum continuous discharging current	100A
End of discharge voltage	44.8V or any cell reaches 2.8V
Standard temperature range for charging	-10°C to 50°C
Standard temperature range for discharging	-20°C to 50°C
Standard charging method specified by manufacturer	Charge at constant current 50A until voltage of battery reaches 55.2V, then constant voltage 55.2V until charging current reduces to 5A, wait 30min
Standard discharging method specified by manufacturer	Discharge at constant current 100A until voltage of battery reaches 44.8V or any cell reaches 2.8V, wait 30min
Dimension	W*H*D: 573mm*347mm*189mm
Weight	Approx. 47kg
Number of cells in module and module configuration	16S

ANSI/CAN/UL 9540A:2019			
Clause	Requirement + Test	Result – Remark	Verdict
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.		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.	UL 1973 compliant: UL MH65547	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		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.	Metallic enclosure	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.	UL 1973 compliant: CSA Cert. No.: 80117111 CSA Report No.: 80117111	P
5.2.3	Refer to 8.3 for further details to be included in the module level test report.		P
PERFORMANCE			
6.	General		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		P

ANSI/CAN/UL 9540A:2019			
Clause	Requirement + Test	Result – Remark	Verdict
	shall be disposed of in accordance with local regulations.		
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 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 50A until voltage of battery reaches 55.2V, then constant voltage 55.2V until charging current reduces to 5A, wait 30min Discharge method: Discharge at constant current 100A until voltage of battery reaches 44.8V or any cell reaches 2.8V, wait 30min	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		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		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.		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.		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	Cell to cell propagation occurred within the module	P

ANSI/CAN/UL 9540A:2019			
Clause	Requirement + Test	Result – Remark	Verdict
	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.		
8.2.5	The methodology used for initiating thermal runaway pursuant to 7.2 shall be used to initiate thermal runaway within the module.	Used flexible film heaters for initiating thermal runaway. Two pieces of 160mm x 118 mm (500W/pcs) film heaters was covered on the two widest side surfaces of the 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.		P
8.2.8	The chemical heat release rate of the module in thermal runaway shall be measured with oxygen consumption calorimetry.		P
8.2.9	The chemical heat release rate shall be measured for the duration of the test. See 8.2.10.		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 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		P

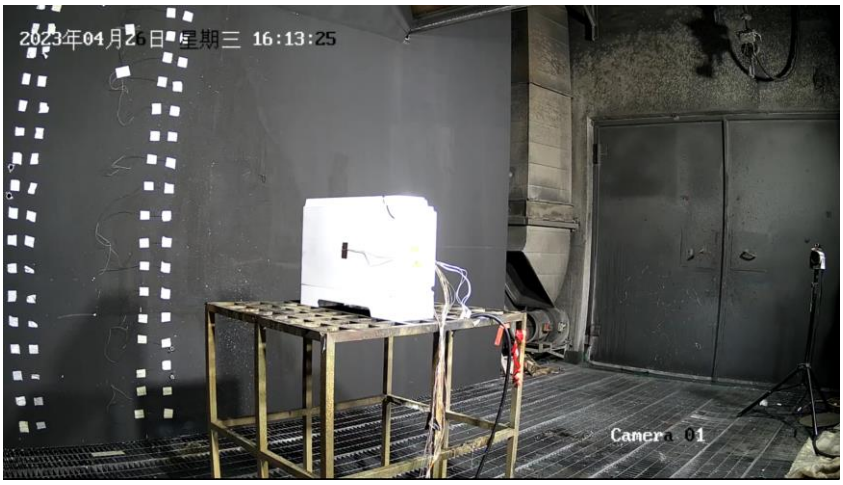
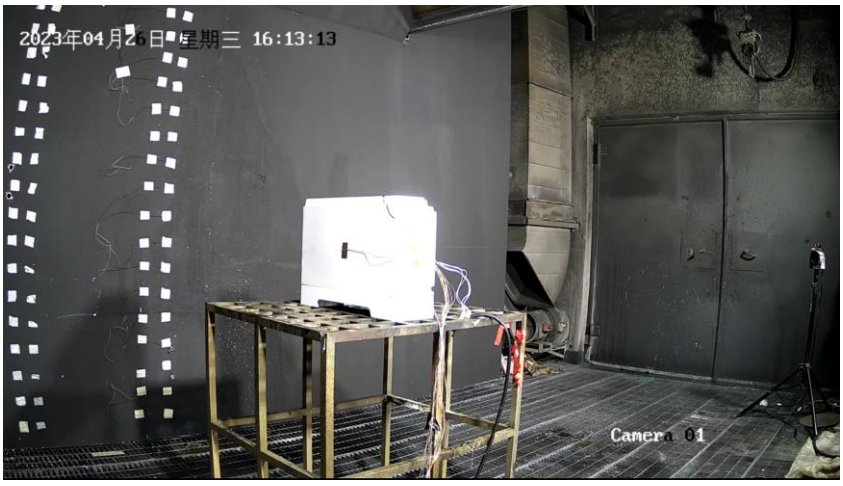
ANSI/CAN/UL 9540A:2019			
Clause	Requirement + Test	Result – Remark	Verdict
	influence of bends or exhaust devices. See 8.2.11.		
8.2.11	With reference to 8.2.10, calculate the chemical heat release rate at each of the flows as follows: $HRR_1 = \left[E \times \varphi - (E_{co} - E) \times \frac{1-\varphi}{2} \times \frac{X_{co}}{X_{O_2}}\right] \times \frac{\dot{m}_e}{1+\varphi \times (\alpha - 1)} \times \frac{M_{O_2}}{M_a} \times (1 - X^o_{H_2O}) \times X^o_{O_2}$		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.		P
8.2.13	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 sensor.		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.		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	(See appended table)	P
8.3.1	The report on module level testing shall include the following:		P
	a) Module manufacturer name and model number (and whether UL 1973 compliant)	Module manufacturer name: Sunwoda Energy Technology Co., Ltd. Model number: B051100P03 UL 1973 compliant	P
	b) Number of cells in module;	16 cells in module	P
	c) Module configuration with cells in series and parallel;	16 cells in series	P
	d) Module construction features per 5.2;	See Attachment 1	P
	e) Module voltage corresponding to the tested SOC;	See Table 1	P

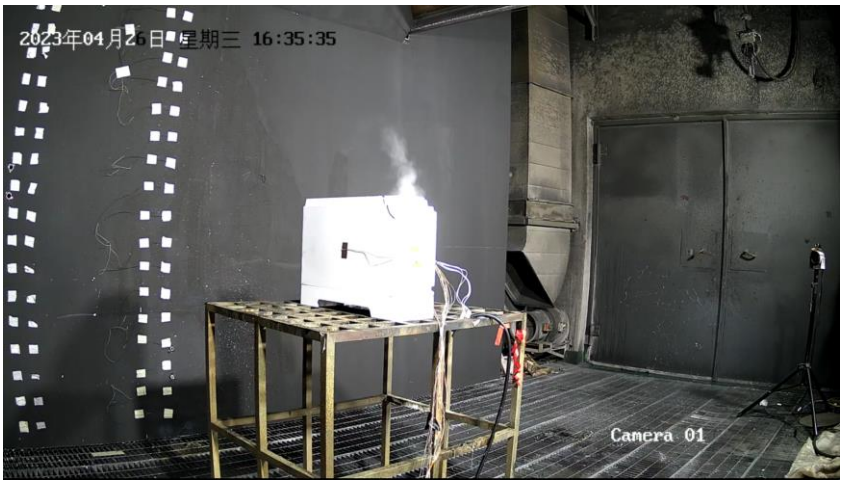
ANSI/CAN/UL 9540A:2019			
Clause	Requirement + Test	Result – Remark	Verdict
	f) Thermal runaway initiation method used including number and locations of cells for initiating thermal runaway;	See Table 1 and Attachment 1	P
	g) Heat release rate versus time data;	See Attachment 7 and 9	P
	h) Flammable 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		F
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.	The cell vent gas presented a flammability hazard	F
ANNEX A	**(INFORMATIVE) Test Concepts And Application Of Test Results To Installations**		N/A
A1	Introduction		N/A
A2	Test Methodology and Purpose		N/A
A3	Evaluating the Results		N/A
ANNEX B	**(INFORMATIVE) Safety Recommendations for Testing**		P
B1	General		P

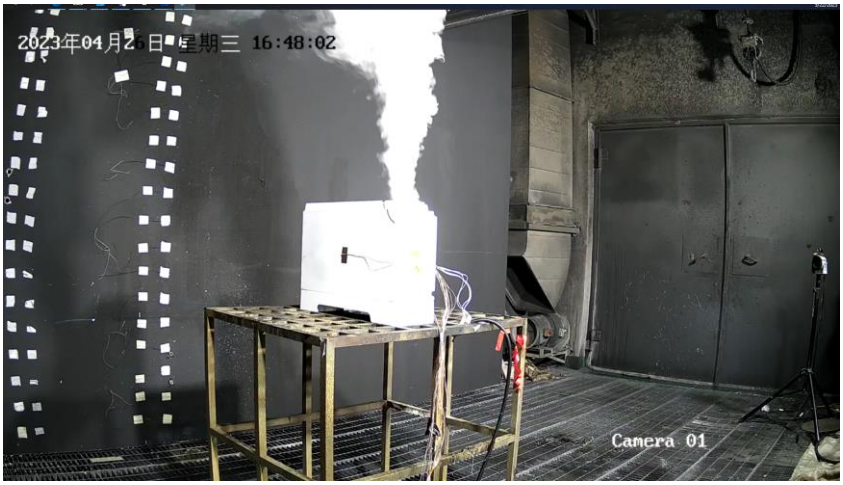
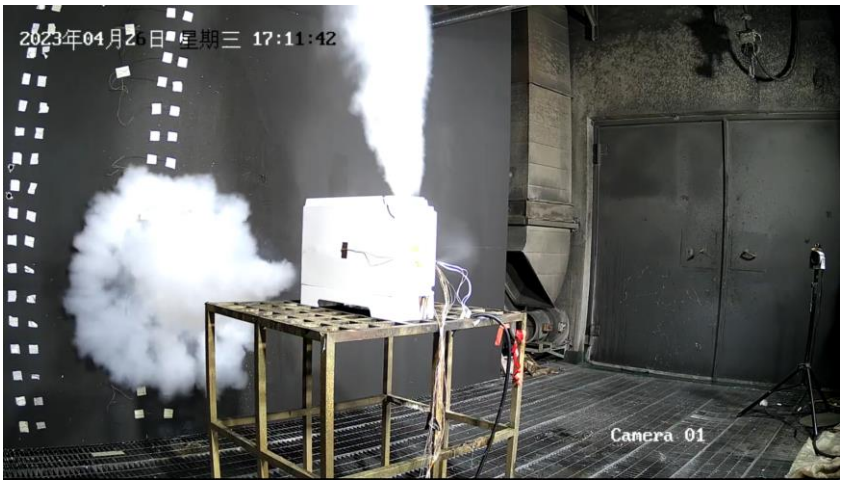
	TABLE: Critical components information				
Object/part no.	**Manufacturer/ trademark**	**Type/model**	**Technical data**	**Standard**	**Mark(s) of conformity**
Rechargeable Lithium-ion Cell	Sunwoda Electric Vehicle Battery Co., Ltd.	SBP-01-1000	3.2Vd.c., 102Ah	-	-
Supplementary information: N/A					

Module Level Test result:

Table 1: Thermal runaway test result		
Initial ambient temperature:		22.9°C
Initial relative humidity:		56%RH
Pre-conditioning time		From 2023-04-25 16:22:25 to 2023-04-26 12:26:41
Thermal runwaway test start time		2023-04-26 15:26:45
Module voltage (OCV) before test:		53.69V
Methods used to initiate thermal runaway		Heating the cell with externally applied flexible film heaters that cover two widest side surfaces of the cell 12
Average heating rate:		5.2K/min
Surface temperature at which gases were first vented:		271.8°C
Time when gases were first vented:		2023-04-26 16:13:25
Surface temperature prior to thermal runaway:		275.6°C
Time when thermal runaway:		2023-04-26 16:13:33
Module voltage (OCV) after test:		26.56V
Location of cell(s) for intiating thermal runaway		Cell 12
Thermal runaway of other cells within module:		Cell 9, Cell 10, Cell 11, Cell 13, Cell 14, Cell 15, Cell 16
Observation(s) of flying debris:		No observation of flying debris
Observation(s) of explosive discharge of gas:		No explosive discharge of gas observed
Observation(s) of sparks, electrical arcs or other electrical events:		No observation of sparks, electrical arcs or other electrical events
Locations and visual estimations of flame		N/A (No flame during test)
Module weight before test:		47.6kg
Module weight after test:		44.4kg
Module weight loss:		3.2kg
Timeline of thermal runaway		
Time (hh:mm:ss)	Event	Description

2023-04-26 15:26:45	Start testing	
2023-04-26 16:13:25	The initiating cell 12 first vented at 16:13:25	
2023-04-26 16:13:33	The temperature of initiating cell 12 started to rise sharply, thermal runaway occurred	

2023-04-26 16:13:48	After the initiating cell 12 thermal runaway, smoke generated continuously	
2023-04-26 16:28:47	First propagation occurred, smoke generated continuously	
2023-04-26 16:35:35	Second propagation occurred, smoke generated continuously	

2023-04-26 16:48:02	Smoke generated more and more	
2023-04-26 17:11:42	Last propagation occurred, smoke generated continuously	
2023-04-26 17:13:01	Smoke generated more and more	

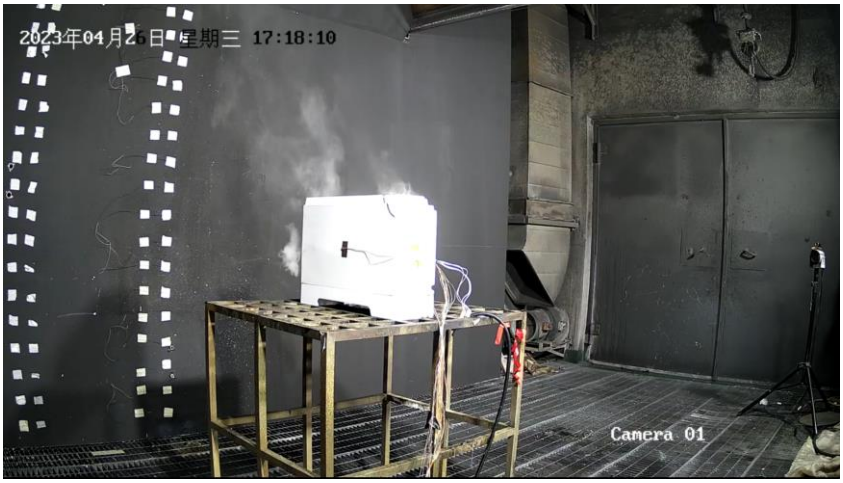
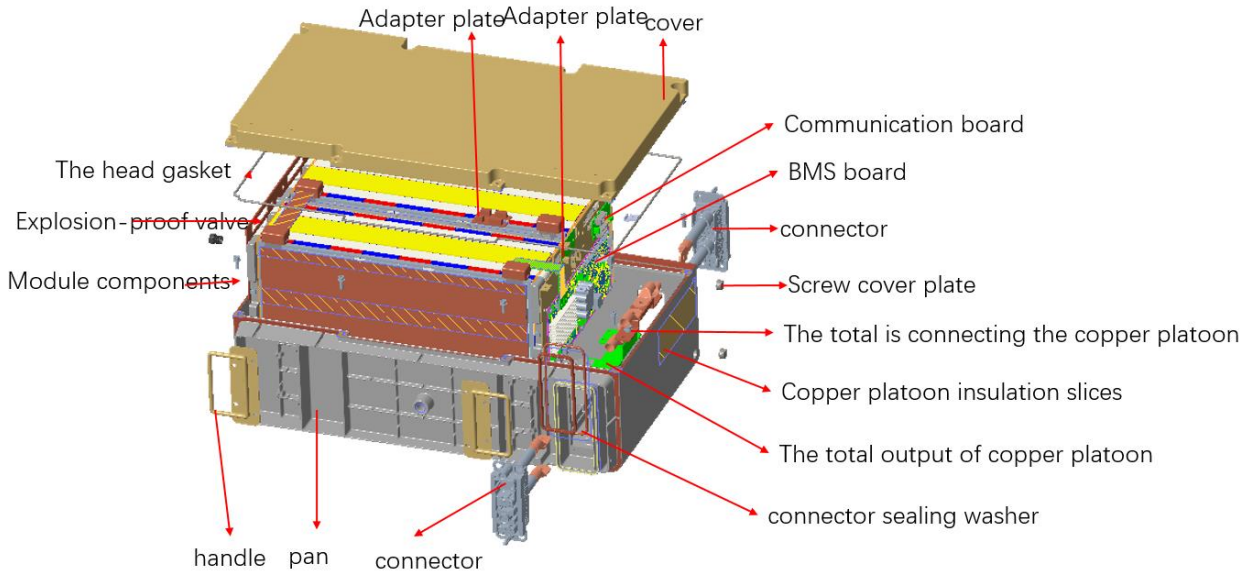
2023-04-26 17:18:10	Smoke generated less	
2023-04-26 18:55:10	No more gas released	
Remark: Refer to attachment 3 for details of sample before test and test setup with thermocouple location		

Table 2: Vented gas composition result			
Composition	Chemical formula	Measurement peak (L/s)	Analysis Method
Carbon monoxide	CO	1.190	FTIR
Carbon dioxide	CO2	10.920	FTIR
Methane	CH4	0.494	FTIR
Acetylene	C2H2	Not detected	FTIR
Ethene	C2H4	0.357	FTIR
Ethane	C2H6	Not detected	FTIR
Propane	C3H8	Not detected	FTIR
Butane	C4H10	Not detected	FTIR
Pentane	C5H12	Not detected	FTIR
Benzene	C6H6	Not detected	FTIR
Hexane	C6H14	Not detected	FTIR
Hydrofluoric acid	HF	Not detected	FTIR
Hydrogen chloride	HCl	Not detected	FTIR
Hydrogen cyanide	HCN	Not detected	FTIR
Methanol	CH4O	Not detected	FTIR
Ethylene carbonate	C3H4O3	Not detected	FTIR
Ethyl methyl carbonate	C4H8O3	0.812	FTIR
Propylene carbonate	C4H6O3	Not detected	FTIR
Phosphoric trifluoride	POF3	Not detected	FTIR
Diethyl carbonate	C5H10O3	Not detected	FTIR
Dimethyl carbonate	C3H6O3	1.963	FTIR
Hydrogen	H2	Not detected	Hydrogen sensor
Total Hydrocarbons	(Propane Equivalent)	0.073	FID
Flow rate in exhaust duct (m^3/s)		2.0	

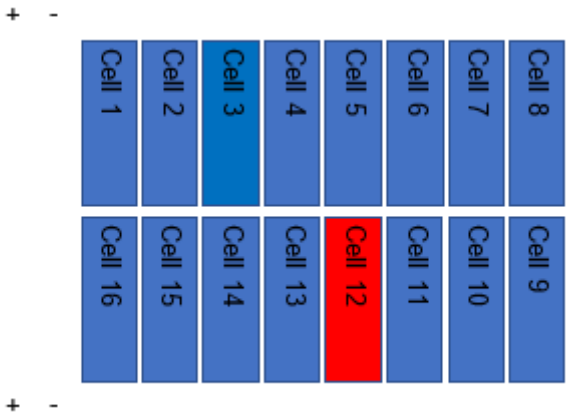
Table 3: Monitored temperature result			
Thermocouple number	Thermocouple location	Measured maximum temperature, °C	Limit, °C
Cell 12-1	Center of the cell 12, the cell surface temperature of widest side 1, near cell 13	569.8	-
Cell 12-3	Center of the cell 12, the cell surface temperature of widest side 2, near cell 11	837.5	-
Cell 12-5	Near the positive terminal of the cell 12	542.7	-
Cell 9-3	Center of the cell 9, the cell surface temperature of widest side 2, near the enclosure	448.3	-
Cell 11-3	Center of the cell 11, the cell surface temperature of widest side 2, near cell 10	1335.8	-
Cell 13-1	Center of the cell 13, the cell surface temperature of widest side 1, near cell 14	478.0	-
Cell 15-1	Center of the cell 15, the cell surface temperature of widest side 1, near cell 16	843.6	-
Cell 1-1	Center of the cell 1, the cell surface temperature of widest side 1, near the enclosure	272.4	-
Cell 3-1	Center of the cell 3, the cell surface temperature of widest side 1, near cell 2	435.6	-
Cell 5-1	Center of the cell 5, the cell surface temperature of widest side 1, near cell 4	240.9	-
Cell 7-1	Center of the cell 7, the cell surface temperature of widest side 1, near cell 6	250.0	-
Top	the center and top of the enclosure	87.4	-
Bottom	the center and bottom of the enclosure	98.4	-
Front	the center and front of the enclosure	87.9	-
Back	the center and back of the enclosure	147.0	-
Right	the center and right of the enclosure	132.2	-
Left	the center and left of the enclosure	147.6	-
Ambient	the temperature of ambient	23.5	-

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:



Attachment 2: Pre-conditioning profile

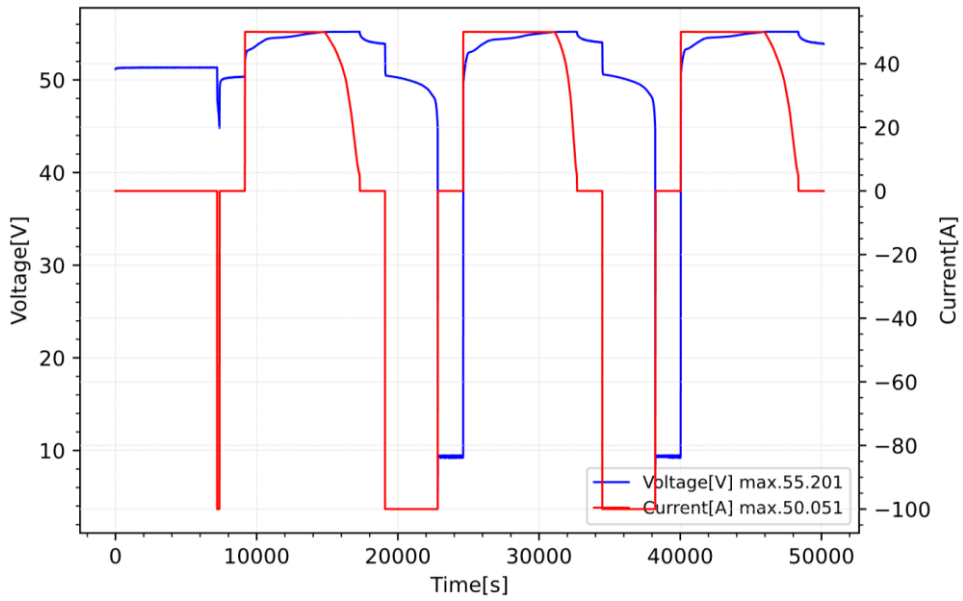
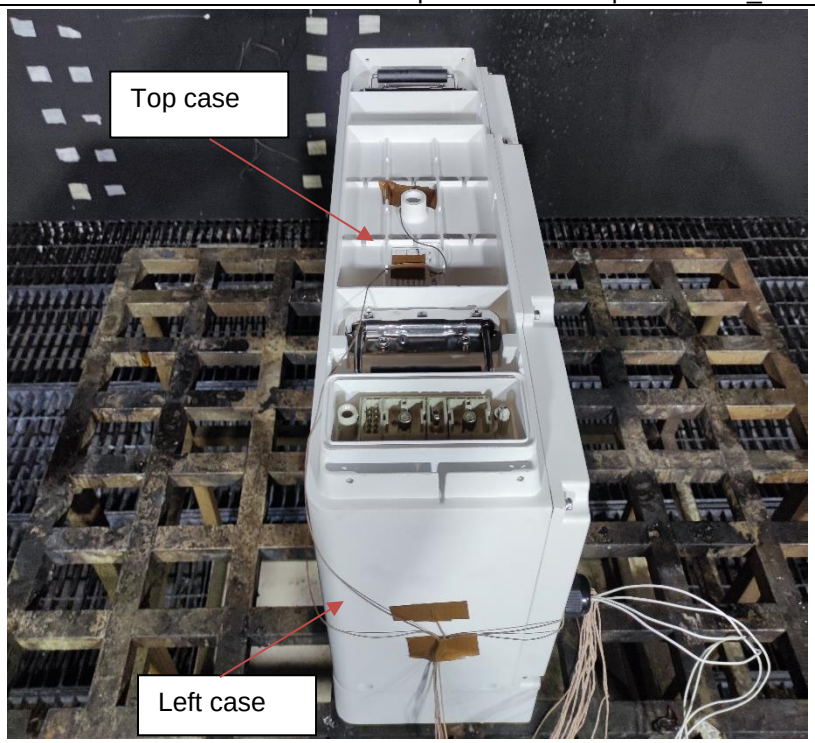


Figure 1 of Attachment 2: charge and discharge cycles chart for module

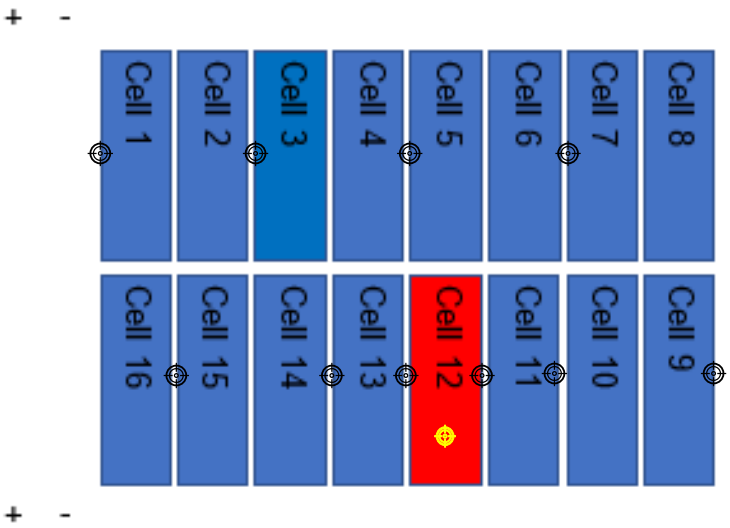
Attachment 3: Photo for sample before test and test setup with thermocouple location

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

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

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

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

Details of:	Figure 5 of Attachment 3 thermocouple location within module
	 is the temperature measurement location at cell surface; is the temperature measurement location near the positive terminal; Cell 12 is the first initiating cell.

Attachment 4: Photo for sample after test

Details of:	Figure 1 of Attachment 4 View of module_after test
	

Details of:	Figure 2 of Attachment 4 View of module_after test
	

Details of:	Figure 3 of Attachment 4 View of module_after test
	

Details of:	Figure 4 of Attachment 4 View of module_after test
	

Details of:	Figure 5 of Attachment 4 View of module_after test
	

Details of:	Figure 5 of Attachment 4 View of module_after test
	

Attachment 5: Monitored temperature chart and voltage chart

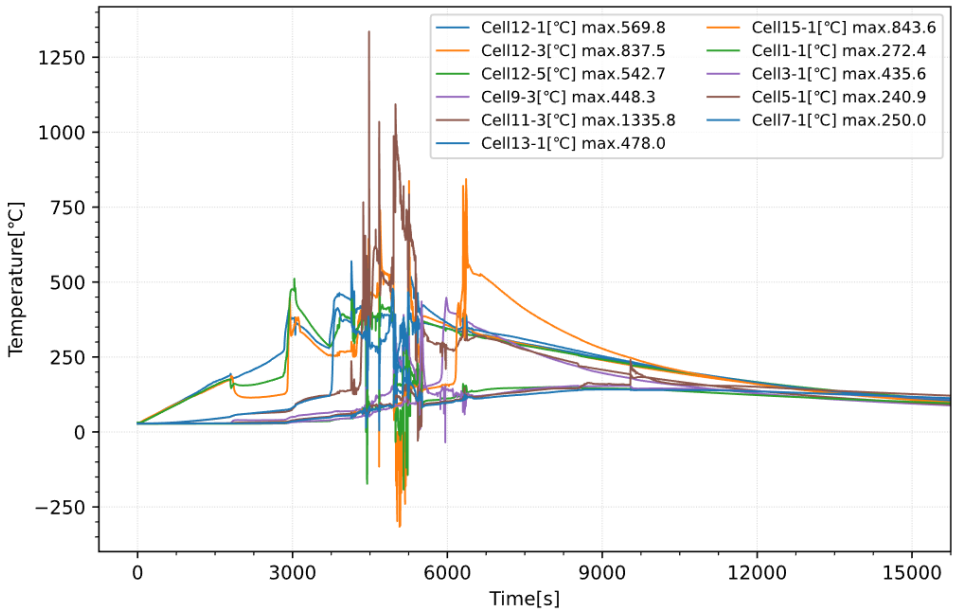


Figure 1 of Attachment 5: temperature of all cells in module

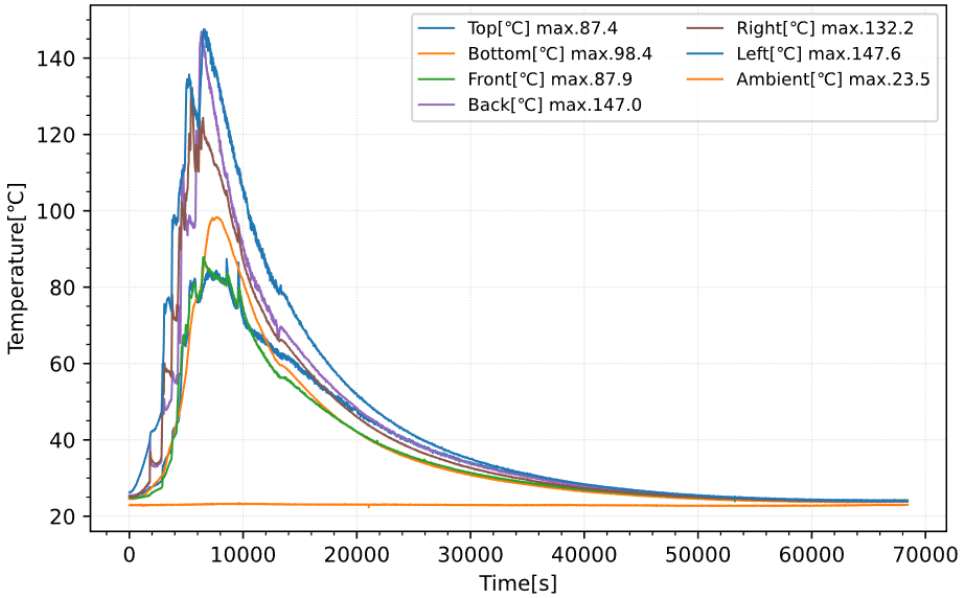


Figure 2 of Attachment 5: temperature of module case

Attachment 6: Flammable gas generation and composition data chart

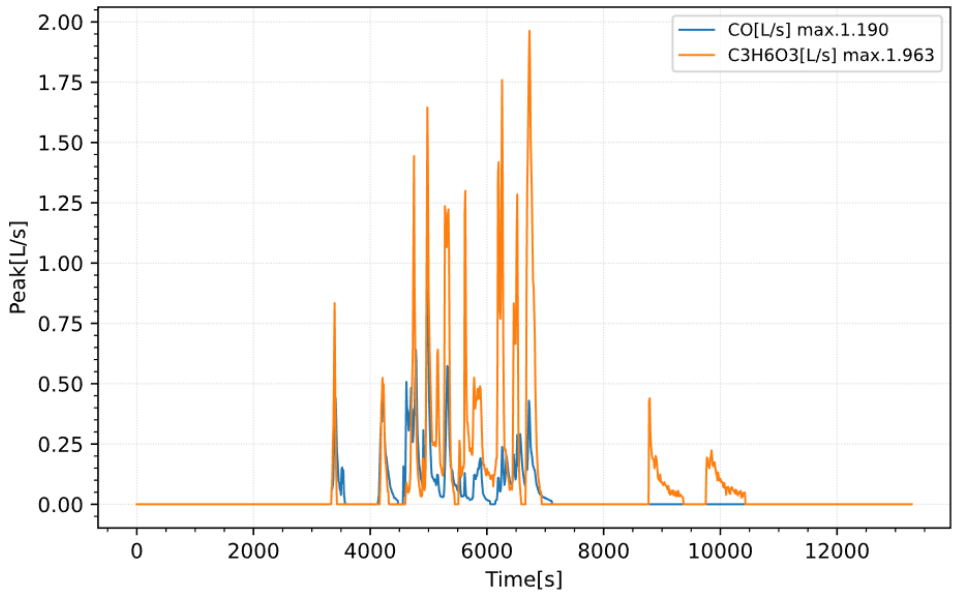


Figure 1 of Attachment 6: Gas generation and composition data chart (Detected by FTIR)

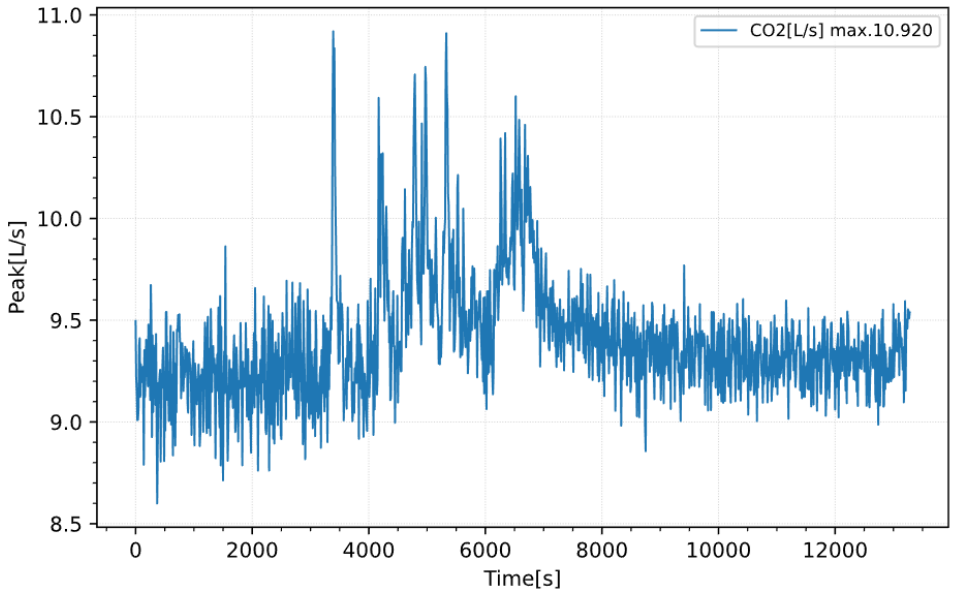


Figure 2 of Attachment 6: Gas generation and composition data chart (Detected by FTIR)

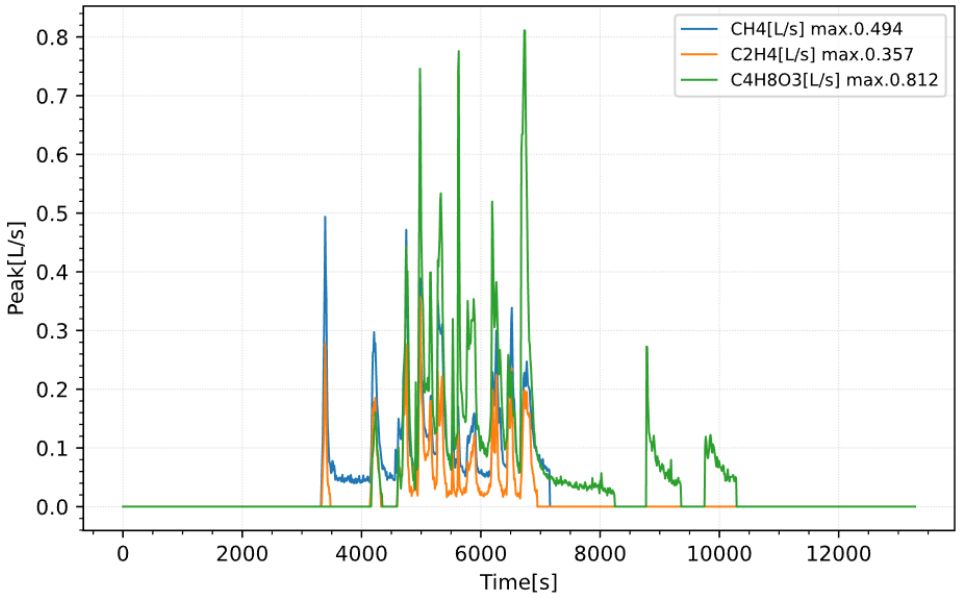


Figure 3 of Attachment 6: Gas generation and composition data chart (Detected by FTIR)

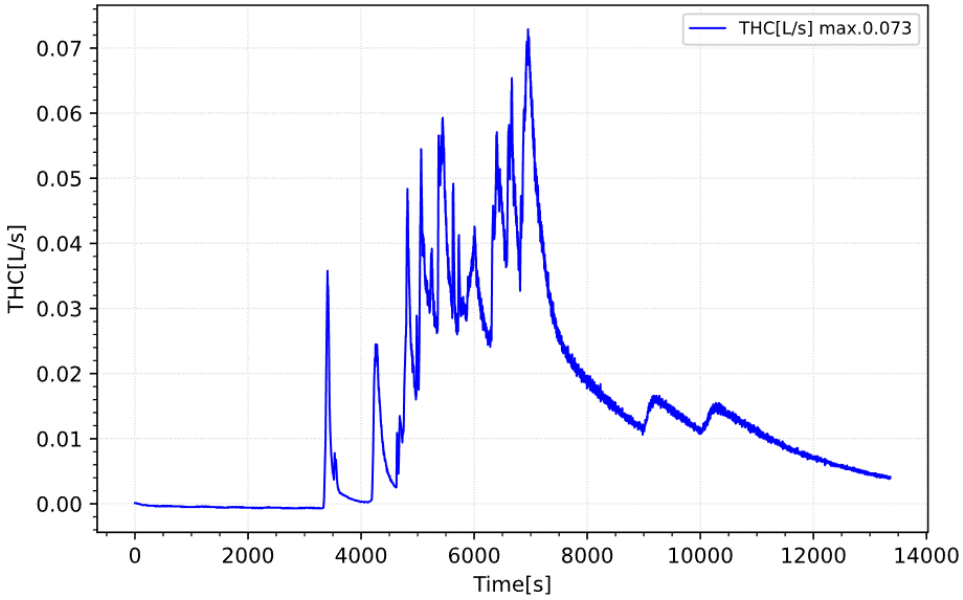
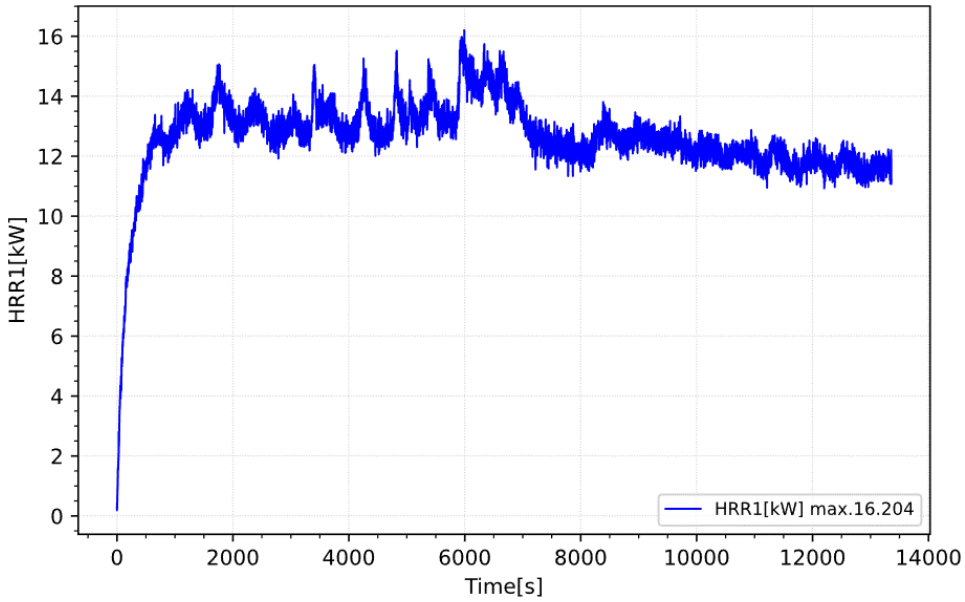
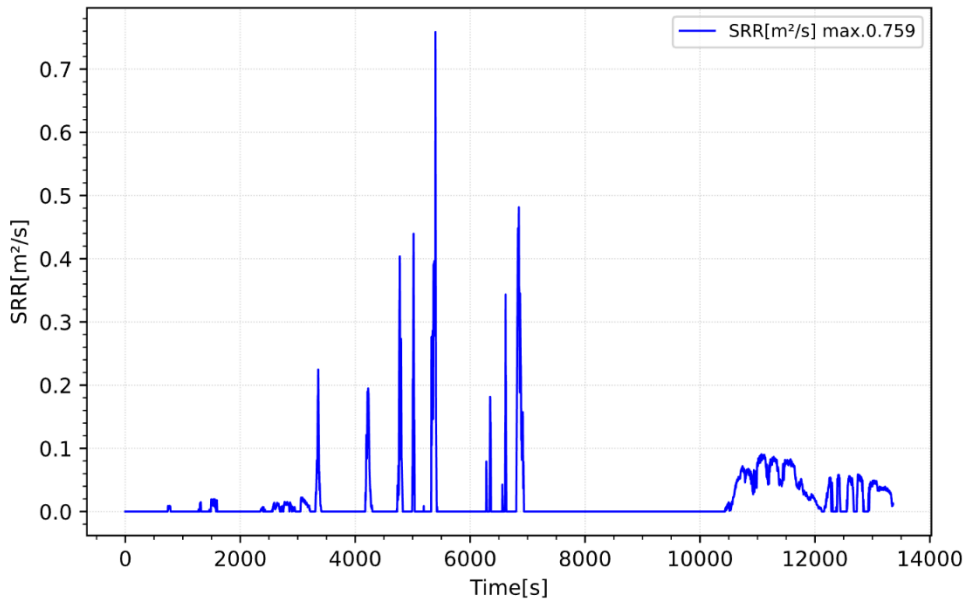


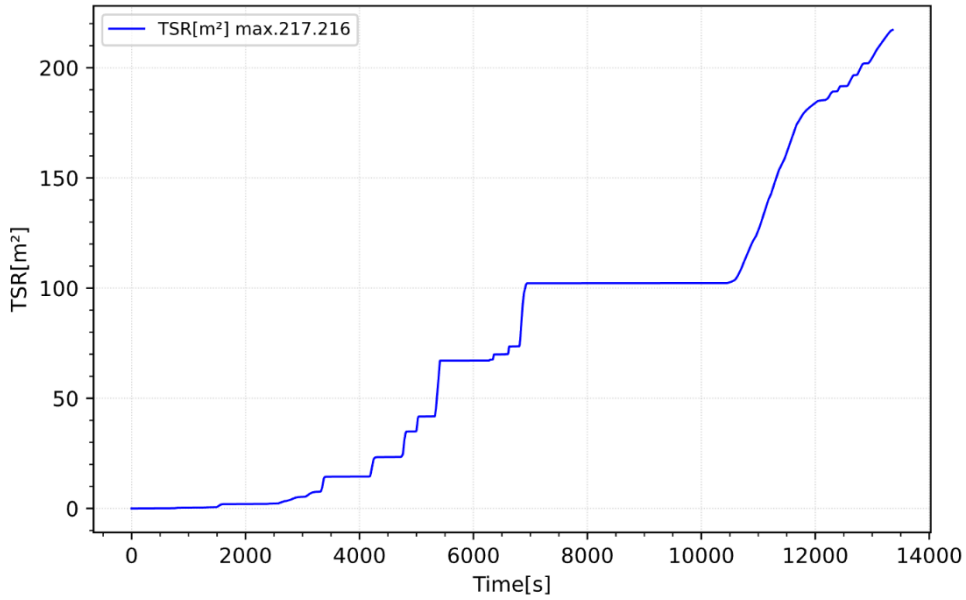
Figure 4 of Attachment 6: THC (Total Hydrocarbons) chart (Detected by FID)

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

Peak heat release rate	16.204kW
Total smoke production	217.216m^2
Peak smoke production rate	0.759m^2/s

---End of report---