



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.:		5061725025703-00			
Date of issue:		2025-07-28			
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Testing laboratory:		TÜV SÜD New Energy Vehicle Testing (Jiangsu) Co., Ltd.			
Address:		Building A, No.15 Factory, Jintong International Industrial Park, No.8, Xihu Road, Wujin National Hi-tech Industrial Development Zone, Changzhou, Jiangsu, China			
Testing location:		Chuweineng Testing Technology (Shanghai) Co., Ltd. Building 3, No. 1065, Beihe Road, Jiading District, Shanghai			
Client:		Shanghai PYTES Energy Co., Ltd.			
Client number:		003364			
Address:		No. 3492 Jinqian Road, Fengxian District, 201406 Shanghai, PEOPLE'S REPUBLIC OF 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 <i>Summary of testing</i>			
National deviations:		N/A			
Compiled by:	Zhu, Jiacheng	Compiled by:	You, Duo	Approved by:	Frank, Marco
(+ signature)	<i>Zhu Jiacheng</i>	(+ signature)	<i>You Duo</i>	(+ signature)	<i>M. Frank</i>



Number of pages (<i>Report</i>):	45
Number of pages (<i>Attachments</i>):	17 (page 29 – 45)
Test sample:	Batteries
Type of test object:	Rechargeable Li-ion Battery
Trademark:	Pytes
Model and/ or type reference:	V10, V10α, V12, V12α
Rating(s):	V10, V10α: 51.2 Vd.c., 200 Ah V12, V12α: 51.2 Vd.c., 230 Ah
Manufacturer:	Shanghai PYTES Energy Co., Ltd.
Manufacturer number:	003364
Address:	No. 3492 Jinqian Road, Fengxian District, 201406 Shanghai, PEOPLE'S REPUBLIC OF CHINA
Name and address of factory(ies)	
Same with Manufacturer above.	
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: Witness test
Date of order:	2024-08-20
Date of receipt of test item:	2025-03-05
Date(s) of performance of test:	2025-03-05 to 2025-03-07
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: V10, V10α, V12, V12α, is used in Battery Energy Storage Systems	
Remark:	
The models V10 and V12, as well as V10α and V12α, are identical in all aspects except for: 1. Rated capacity and rated energy: – V10 / V10α have a rated capacity of 200 Ah and a rated energy of 9.98 kWh, – V12 / V12α feature a rated capacity of 230 Ah and a rated energy of 11.776 kWh. 2. Battery connectors: – V10α / V12α use battery connector model: C10-730189, – V10 / V12 use battery connector model: BPC 250 FTB. Due to the identical product design (except as stated above) and the use of identical critical components, only one model was tested at its maximum state of charge. The results are considered representative of the performance of all models listed. The test results in this report were generated from testing model V12α.	

Characteristic data (not shown on the marking plate):		
Product name	Rechargeable Li-ion Cell	Rechargeable Li-ion Battery
Type/model	230	V10, V10α, V12, V12α
Nominal voltage	3.2 Vd.c.	51.2 Vd.c.
Rated capacity	230 Ah	V10, V10α: 200 Ah V12, V12α: 230 Ah
Charging voltage specified by manufacturer	3.65 V	56.8 V
Upper limit charging voltage	3.65 V	58 V or any cell reaches 3.65 V
Charging current specified by manufacturer	115 A	100 A
Maximum continuous charging current	460 A	150 A
Discharging current specified by manufacturer	115 A	100 A
Maximum continuous discharging current	690 A	150 A
End of discharge voltage	2.5 V ($T > 0^{\circ}\text{C}$); 2.0 V ($T \leq 0^{\circ}\text{C}$)	47.5 V
Operating ambient temperature range	-	0 °C to 25 °C
Standard charging method specified by manufacturer	Charge at constant current 115A until voltage reaches 3.65 V, then charge at constant voltage 3.65 V till charge current is 11.5 A	Charge at constant current 100 A until voltage reaches 56.8 V, then charge at constant voltage 56.8 V till charge current is 9.2 A
Standard discharging method specified by manufacturer	-	Discharge at constant current 100 A until the voltage reaches 47.5 V
Dimension	L×W×H: (173.93 ± 0.5) mm x (53.85 ± 0.5) mm x (207.2 ± 0.5) mm	L×W×H: (671.2 ± 2.0) mm x (260.0 ± 2.0) mm x (520.0 ± 2.0) mm
Weight	(4.140 ± 0.124) kg	(98.6 ± 0.5) kg
Number of cells in module and module configuration	-	16 cells; 16S
Attachments:		
Attachment 1: Exploded-view 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		

If additional information is necessary, please provide

N/A

Copy of marking plate:

For Rechargeable Li-ion Battery, model: V10

Pytes

Product Model	V10
Battery Type	Rechargeable Li-ion Battery
Operating Voltage Range	47.5Vd.c.~56.8Vd.c.
Nominal Voltage	51.2Vd.c.
Rated Energy	9.98kWh
Rated Capacity	200Ah
Rated Charge/Discharge Current	100A
Protection Class	Class I
Ingress Protection Degree	IP66
Short Current/Duration	<2200A/300ms

Modèle de Produit	V10
Type de Batterie	Batterie Li-ion Rechargeable
Plage de Tension de Fonctionnement	47.5Vd.c.~56.8Vd.c.
Tension Nominale	51.2Vd.c.
Énergie Nominale	9.98kWh
Capacité Nominale	200Ah
Courant Nominal de Charge/Décharge	100A
Classe de Protection	Class I
Indice de Protection	IP66
Courant de Court-Circuit/Durée	<2200A/300ms

CAUTION!

IFP55/175/208[16S]E/-10+50/95

- ◆ Do not dispose of batteries in a fire, as they may explode.
- ◆ Do not open or mutilate batteries. The released electrolyte is harmful to the skin and eyes and may be toxic.
- ◆ Batteries can present a risk of electric shock or burns from high short-circuit currents.
- ◆ Failed batteries can reach temperatures exceeding safe touch thresholds for surfaces

ATTENTION!

IFP55/175/208[16S]E/-10+50/95

- ◆ Ne jetez pas les batteries au feu, car elles pourraient exploser.
- ◆ Ne pas ouvrir ni endommager les batteries. L'électrolyte libéré est corrosif pour la peau et les yeux, et peut présenter une toxicité.
- ◆ Les batteries peuvent présenter un risque d'électrocution ou de brûlures dues aux courants intenses de court-circuit.
- ◆ Les batteries défectueuses peuvent atteindre des températures dépassant les seuils de sécurité thermique pour le contact cutané.

S/N:

Date:



2025-Mar-4



MADE IN CHINA (Fabriqué en Chine)
 Shanghai PYTES Energy Co., Ltd.
 No.3492, Jinqian Road, Fengxian District, Shanghai, 201406, China
 (N° 3492, Route Jin Qian, Quartier de Fengxian, Shanghai, 201406, Chine)
www.pytesess.com
ess_support@pytesgroup.com

For Rechargeable Li-ion Battery, model: V10α

Pytes

Product Model	V10α
Battery Type	Rechargeable Li-ion Battery
Operating Voltage Range	47.5Vd.c.~56.8Vd.c.
Nominal Voltage	51.2Vd.c.
Rated Energy	9.98kWh
Rated Capacity	200Ah
Rated Charge/Discharge Current	100A
Protection Class	Class I
Ingress Protection Degree	IP66
Short Current/Duration	<2200A/300ms

Modèle de Batterie	V10α
Type de Batterie	Batterie Li-ion Rechargeable
Plage de Tension de Fonctionnement	47.5Vd.c.~56.8Vd.c.
Tension Nominale	51.2Vd.c.
Énergie Nominale	9.98kWh
Capacité Nominale	200Ah
Courant Nominal de Charge/Décharge	100A
Classe de Protection	Class I
Indice de Protection	IP66
Courant de Court-Circuit/Durée	<2200A/300ms

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S/N:

Date:



2025-Mar-4



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Test Report - ANSI/CAN/UL 9540A:2019 – Module level

For Rechargeable Li-ion Battery, model: V12



Product Model	V12
Battery Type	Rechargeable Li-ion Battery
Operating Voltage Range	47.5Vd.c.~56.8Vd.c.
Nominal Voltage	51.2Vd.c.
Rated Energy	11.776kWh
Rated Capacity	230Ah
Rated Charge/Discharge Current	100A
Protection Class	Class I
Ingress Protection Degree	IP66
Short Current/Duration	<2200A/300ms

Modèle de Produit	V12
Type de Batterie	Batterie Li-ion Rechargeable
Plage de Tension de Fonctionnement	47.5Vd.c.~56.8Vd.c.
Tension Nominale	51.2Vd.c.
Énergie Nominale	11.776kWh
Capacité Nominale	230Ah
Courant Nominal de Charge/Décharge	100A
Classe de Protection	Class I
Indice de Protection	IP66
Courant de Court-Circuit/Durée	<2200A/300ms

CAUTION!

IFpP55/175/208[16S]E/-10+50/95

- ◆ Do not dispose of batteries in a fire, as they may explode.
- ◆ Do not open or mutilate batteries. The released electrolyte is harmful to the skin and eyes and may be toxic.
- ◆ Batteries can present a risk of electric shock or burns from high short-circuit currents.
- ◆ Failed batteries can reach temperatures exceeding safe touch thresholds for surfaces.

ATTENTION!

IFpP55/175/208[16S]E/-10+50/95

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- ◆ Les batteries défectueuses peuvent atteindre des températures dépassant les seuils de sécurité thermique pour le contact cutané.

S/N:

Date:



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For Rechargeable Li-ion Battery, model: V12α



Product Model	V12α
Battery Type	Rechargeable Li-ion Battery
Operating Voltage Range	47.5Vd.c.~56.8Vd.c.
Nominal Voltage	51.2Vd.c.
Rated Energy	11.776kWh
Rated Capacity	230Ah
Rated Charge/Discharge Current	100A
Protection Class	Class I
Ingress Protection Degree	IP66
Short Current/Duration	<2200A/300ms

Modèle de Produit	V12α
Type de Batterie	Batterie Li-ion Rechargeable
Plage de Tension de Fonctionnement	47.5Vd.c.~56.8Vd.c.
Tension Nominale	51.2Vd.c.
Énergie Nominale	11.776kWh
Capacité Nominale	230Ah
Courant Nominal de Charge/Décharge	100A
Classe de Protection	Class I
Indice de Protection	IP66
Courant de Court-Circuit/Durée	<2200A/300ms

CAUTION!

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S/N:

Date:



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For S/N and Date

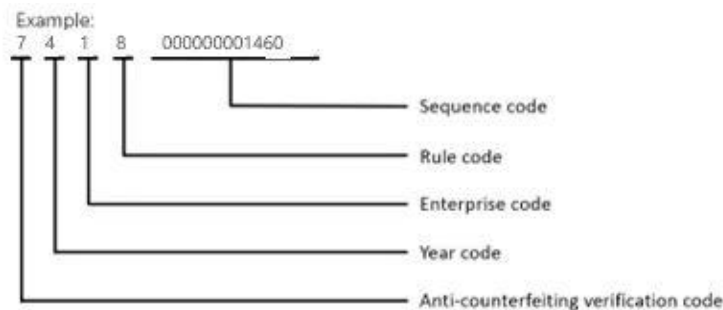
S/N:

Date:



Remark:

1. "+" and "-" are marked near the connector of the battery.
2. The code "741800000001460" can be used to trace the manufacture information of the battery. Its interpretation for Rechargeable Li-ion Battery, which is shown as follows:



"2025-Mar-4" represents the date of manufacture, meaning the battery was produced on Mar 4th, 2025. This is not the manufacture date of actual samples and only for example.

3. The disposal and caution information are in the manual.

Label for warning

DANGER

Danger! Low DC voltage inside
Danger! Arc flash & shock hazard

DANGER ! Basse Tension Continue(DC) interne
DANGER ! Risque d'arc électrique et d'électrocution

Charge the battery every six months to reach 90% SOC, in case of long-term storage.
Recharger la batterie tous les six mois jusqu'à 90% de l'état de charge (SOC) en cas de stockage prolongé.

ATTENTION!

Read the user manual carefully before connecting the wires.
Ensure the grounding connection is properly established before use.
Repairs must be performed by authorized and trained personnel only.
Keep the battery out of reach of children and pets.
Keep the battery away from open flames and flammable materials.
Avoid immersing the battery in or exposing it to water or other liquids.
Avoid exposure to direct sunlight and humid environments.
Do not dismantle the battery unless performed by qualified personnel.
Do not drop, crush, or strike the battery. Do not puncture or cut the battery with sharp objects.
Do not cover or wrap the battery.
Do not place heavy objects on or sit on the battery.
If the battery leaks, catches fire, or is damaged, switch off the breaker on DC side and stay away from the battery.
Contact your supplier immediately within 24 hours of any failure.

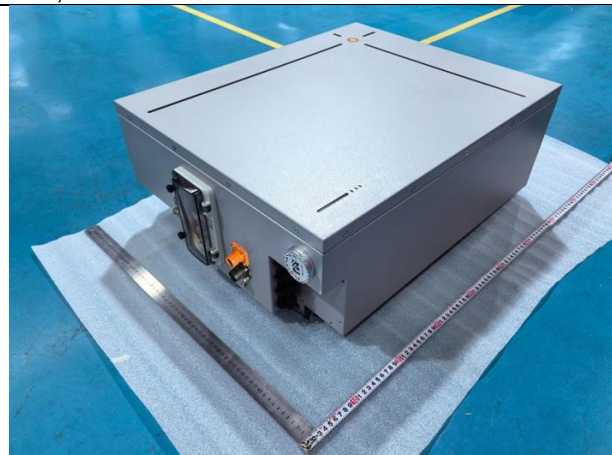
**ATTENTION!**

Lire attentivement le manuel d'utilisation avant de procéder au raccordement des conducteurs des câbles.
S'assurer de la mise à la terre est correctement établie avant toute mise en service.
Toute intervention de maintenance doit impérativement être réalisée par des techniciens certifiés et qualifiés.
Conserver la batterie hors de portée des enfants et des animaux.
Tenir la batterie à l'écart des flammes nues et des matières inflammables.
Éviter toute immersion de la batterie dans l'eau ou tout autre liquide.
Éviter toute exposition directe au soleil et aux environnements humides.
Ne pas démonter la batterie, sauf intervention par un personnel qualifié.
Ne pas laisser tomber, écraser ou heurter la batterie. Éviter tout perçage ou coupure avec des objets tranchants.
Ne pas recouvrir ni envelopper la batterie.
Ne pas placer d'objets lourds sur la batterie ni s'asseoir dessus.
En cas de fuite, d'incendie ou d'endommagement de la batterie: Couper immédiatement le disjoncteur côté continu (DC) et S'éloigner de la batterie.
En cas de dysfonctionnement, veuillez contacter votre fournisseur dans les 24 heures suivant l'incident.

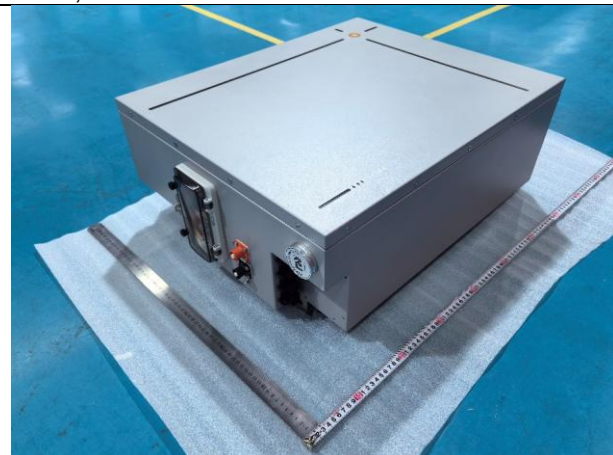
Pictures of the product:

Overview of Rechargeable Li-ion Battery, model:

V10, V12:



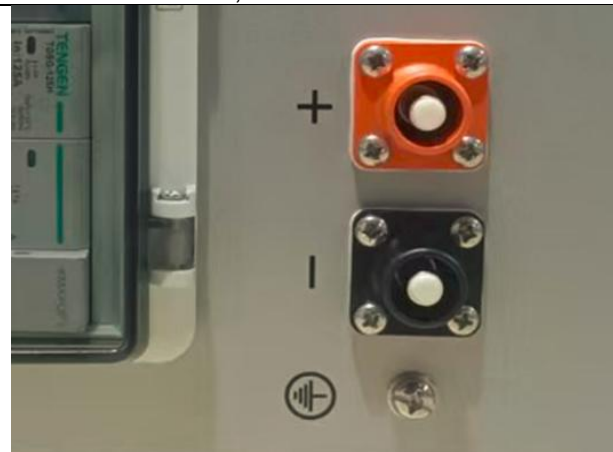
V10α, V12α:



Connector of V10, V12:



Connector of V10α, V12α:

**Summary of testing:**

Module model number	V10, V10α, V12, V12α
Nominal voltage and rated capacity	V10, V10α: 51.2 Vd.c., 200 Ah V12, V12α: 51.2 Vd.c., 230 Ah
Number of cells in module and module configuration	16S
Whether UL 1973 compliant	Module V10, V10α, V12, V12α Compliant with UL 1973. Report No.: 64.280.24.60301.02 Certificate No.: U8 003364 0032 Rev.01
Module voltage corresponding to the tested SOC	56.0 V (100 % SOC)



Method used to initiate thermal runaway	Heating the cell with externally applied 2 pieces flexible film heaters that cover each large surface of the cell. Film heater specifications: 152.4 mm × 203.2 mm (220 V, 480 W/pc)
Thermal runaway of other cells within module:	Thermal runaway was observed on all cells of the module.
Heat release rate versus time data	see Attachment 7 and Attachment 9
Peak smoke release rate and total smoke release data	see Attachment 8 and Attachment 9
Flammable gas generation and composition data	see Table 2 and Attachment 6
Observation(s) of flying debris:	No
Observation(s) of explosive discharge of gas:	No
Observation(s) of sparks, electrical arcs or other electrical events:	No
Locations and visual estimations of flame	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 no flammable as determined by the cell level test.	Cell vent gas is flammable according to cell level test report (external report with project number 4791504604).
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 4791504604).
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 4791504604).



Additional information on non-standard test method(s)

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

Possible test case verdicts:

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

General remarks:

"(see remark #)" refers to a remark appended to the report.

"(see appended table)" refers to a table appended to the report.

*Throughout this report a ☐ **Comma** / ☒ **Point** is used as the decimal separator.*

The test results presented in this report relate only to the object tested.

This report shall not be reproduced except in full without the written approval of the testing laboratory.

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.	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.	Note: Cell complies with UL 1973; Certificate Number: UL-US-2441492-0	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 non-metallic) enclosure material, the general layout of the module contents and the electrical configuration of the cells in the modules and the modules in the BESS.	Module consists of a metallic enclosure material. Further details of the layout and module contents see Attachment 1.	P
5.2.2	The module documentation included in the test report shall indicate if the modules associated with the BESS comply with UL 1973.	Comply with UL 1973. Report No.: 64.280.24.60301.02 Certificate No.: U8 003364 0032 Rev.01	P
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		—



MODULE LEVEL			
Clause	Requirement + Test	Result – Remark	Verdict
5.4	Flow Batteries		—

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. Charge method: Charge at constant current 100 A until voltage reaches 56.8 V, then charge at constant voltage 56.8 V till charge current drops to 9.2A. Discharge method: Discharge at constant current 100 A until the voltage reaches 47.5 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

MODULE LEVEL			
Clause	Requirement + Test	Result – Remark	Verdict
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 $\pm$ 5°C (77 $\pm$ 9°F) and 50 $\pm$ 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.	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.	One cell was forced into thermal runaway. 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. 152.4 mm $\times$ 203.2 mm (220 V, 480 W/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 4.5 K/min until thermal runaway occurred.	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

MODULE LEVEL			
Clause	Requirement + Test	Result – Remark	Verdict
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 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.	See Attachment 7 and 9.	P
8.2.11	With reference to 8.2.10, calculate the chemical heat release rate at each of the flows as follows: $HRR_1 = \left[E \times \varphi - (E_{co} - E) \times \frac{1 - \varphi}{2} \times \frac{X_{co}}{X_{O_2}} \right] \times \frac{\dot{m}_e}{1 + \varphi \times (\alpha - 1)} \times \frac{M_{O_2}}{M_a} \times (1 - X_{H_2O}^a) \times X_{O_2}^a$		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



MODULE LEVEL			
Clause	Requirement + Test	Result – Remark	Verdict
	a) Module manufacturer name and model number (and whether UL 1973 compliant)	Name of the manufacturer: Shanghai PYTES Energy Co., Ltd. Model no.: V10, V10α, V12, V12α The module complies with UL 1973. Report No.: 64.280.24.60301.02 Certificate No.: U8 003364 0032 Rev.01	P
	b) Number of cells in module;	16 cells in module.	P
	c) Module configuration with cells in series and parallel;	16S	P
	d) Module construction features per 5.2;	See Attachment 1.	P
	e) Module voltage corresponding to the tested SOC;	See Table 1.	P
	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 Attachment 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



MODULE LEVEL			
Clause	Requirement + Test	Result – Remark	Verdict
	b) Cell vent gas is non-flammable as determined by the cell level test.	Cell vent gas is flammable according to cell level test report (external report with project number 4791504604).	F
9	Unit Level		—
10	Installation 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
ANNEX B	Safety Recommendations for Testing	(informative)	—
B1	General		P



MODULE LEVEL

TABLE: Critical components information					
Object/part no.	Manufacturer/ trademark	Type/model	Technical data	Standard	Mark(s) of conformity
Lithium-ion Cell	EVE Power Co., Ltd.	230	3.2 Vd.c., 230 Ah	ANSI/CAN/UL 1973: 2022	UL MH63503-20241022
Lithium-ion Cell	EVE Power Co., Ltd.	230	3.2 Vd.c., 230 Ah	ANSI/CAN/UL 9540A: 2019	External report with project number 4791504604
Rechargeable Li-ion Battery	Shanghai PYTES Energy Co., Ltd.	V10, V10α V12, V12α	51.2 Vd.c., 200 Ah 51.2 Vd.c., 230 Ah	ANSI/CAN/UL 1973: 2022	Report No.: 64.280.24.6 0301.02 Certificate No.: U8 003364 0032 Rev.01
Supplementary information: N/A					

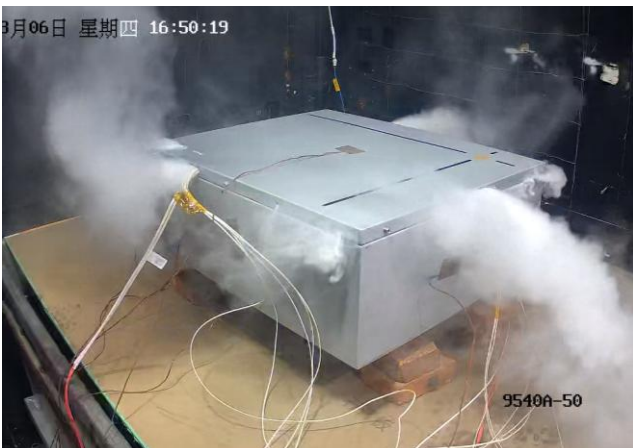
MODULE LEVEL

MODULE LEVEL TEST RESULT:

Table 1: Thermal runaway test result	
Initial ambient temperature:	22.8 °C
Initial relative humidity:	56 % RH
Pre-conditioning time	From 2025-03-05 19:48:36 to 2025-03-06 08:06:46
Thermal runaway test start time	2025-03-06 15:52:00
Module voltage (OCV) before test:	56.0 V
Methods used to initiate thermal runaway	Heating the cell with two externally applied flexible film heaters with 4.5 K/min heating rate until thermal runaway occurs.
Average heating rate:	T12: 4.5 K/min, T13: 4.5 K/min
Surface temperature at which gases were first vented:	T4: 141.4 °C, T12: 239.7°C, T13: 240.0 °C (Thermocouple location see Attachment 1)
Time when gases were first vented:	Cell 4: 2025-03-06 16:40:34
Surface temperature when thermal runaway:	T4: 161.5 °C, T12: 288.1°C, T13: 262.0 °C
Time when thermal runaway:	Cell 4: 2025-03-06 16:50:19
Module voltage (OCV) after test:	0 V
Location of cell(s) for initiating thermal runaway	Cell 4 (see Attachment 1)
Thermal runaway of other cells within module:	Thermal runaway was observed on all 16 cells of 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:	98.8 kg
Module weight after test:	86.0 kg
Module weight loss:	12.8 kg

MODULE LEVEL

Timeline of thermal runaway test

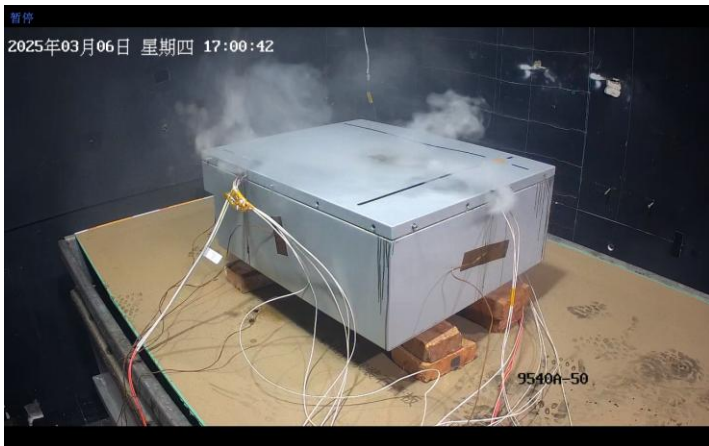
Time (hh:mm:ss)	Event	Description
2025-03-06 15:52:01	Start testing.	
2025-03-06 16:40:34	The initiating cell 4 first vented.	
2025-03-06 16:50:19	The temperature of initiating cell 4 started to rise sharply, thermal runaway occurred.	

MODULE LEVEL		
2025-03-06 16:50:23	The cell 3 vented.	
2025-03-06 16:51:10	The cell 3 went into thermal runaway based on the temperature measurement data.	
2025-03-06 16:55:13	The cell 5 vented.	

MODULE LEVEL

2025-03-06 16:55:21	The cell 2 vented.	
2025-03-06 16:55:51	The cell 5 went into thermal runaway based on the temperature measurement data.	
2025-03-06 16:56:26	The cell 2 went into thermal runaway based on the temperature measurement data.	

MODULE LEVEL

2025-03-06 17:00:42	The cell 1 vented.	
2025-03-06 17:01:25	The cell 6 vented and the cell 1 went into thermal runaway based on the temperature measurement data.	
2025-03-06 17:02:07	The cell 6 went into thermal runaway based on the temperature measurement data.	

MODULE LEVEL

2025-03-06 17:07:31	The cell 7 vented.	
2025-03-06 17:12:17	The cell 7 went into thermal runaway based on the temperature measurement data.	
2025-03-06 17:15:06	The cell 8 vented.	

MODULE LEVEL		
2025-03-06 17:17:55	The cell 8 went into thermal runaway based on the temperature measurement data.	
2025-03-06 17:20:38	The cell 9 vented.	
2025-03-06 17:30:45	The cell 10 vented.	

MODULE LEVEL		
2025-03-06 17:30:47	The cell 11 vented.	
2025-03-06 17:32:26	The cell 9 went into thermal runaway based on the temperature measurement data.	
2025-03-06 17:33:23	The cell 12 vented.	

MODULE LEVEL		
2025-03-06 17:33:44	The cell 13 vented.	
2025-03-06 17:34:44	The cell 10 went into thermal runaway based on the temperature measurement data.	
2025-03-06 17:34:54	The cell 14 vented.	

MODULE LEVEL		
2025-03-06 17:35:12	The cell 15 vented.	
2025-03-06 17:35:42	The cell 16 vented.	
2025-03-06 17:37:06	The cell 11 went into thermal runaway based on the temperature measurement data.	

MODULE LEVEL		
2025-03-06 19:46:37	No smoke was observed	
Remark: Refer to Attachment 3 for details of sample before test and test setup with thermocouple location.		

MODULE LEVEL

Table 2: Vent gas composition

Composition	Chemical formula	Measurement peak (L/min)	Analysis Method
Carbon monoxide	CO	16.20	NDIR
Carbon dioxide	CO ₂	66.60	NDIR
Methane	CH ₄	7.31	FTIR
Acetylene	C ₂ H ₂	0.33	FTIR
Ethene	C ₂ H ₄	8.39	FTIR
Ethane	C ₂ H ₆	1.55	FTIR
Propane	C ₃ H ₈	1.40	FTIR
Butane	C ₄ H ₁₀	/	FTIR
Pentane	C ₅ H ₁₂	/	FTIR
Benzene	C ₆ H ₆	/	FTIR
Hexane	C ₆ H ₁₄	/	FTIR
Hydrofluoric acid	HF	7.07	FTIR
Hydrogen chloride	HCl	0.13	FTIR
Hydrogen	H ₂	29.52	Hydrogen sensor
Total Hydrocarbons	(Methane Equivalent)	198.35	FID
Flow rate in exhaust duct (m ³ /s)		1.5	

MODULE LEVEL

Attachment 1: Exploded-view drawing of module & Identification/location of cells within the module

Exploded-view drawing of module V12α as below:

Remark:

The models V10 and V12, as well as V10α and V12α, are identical in all aspects except for:

1. Rated capacity and rated energy:

- V10 / V10α have a rated capacity of 200 Ah and a rated energy of 9.98 kWh,
- V12 / V12α feature a rated capacity of 230 Ah and a rated energy of 11.776 kWh.

2. Battery connectors:

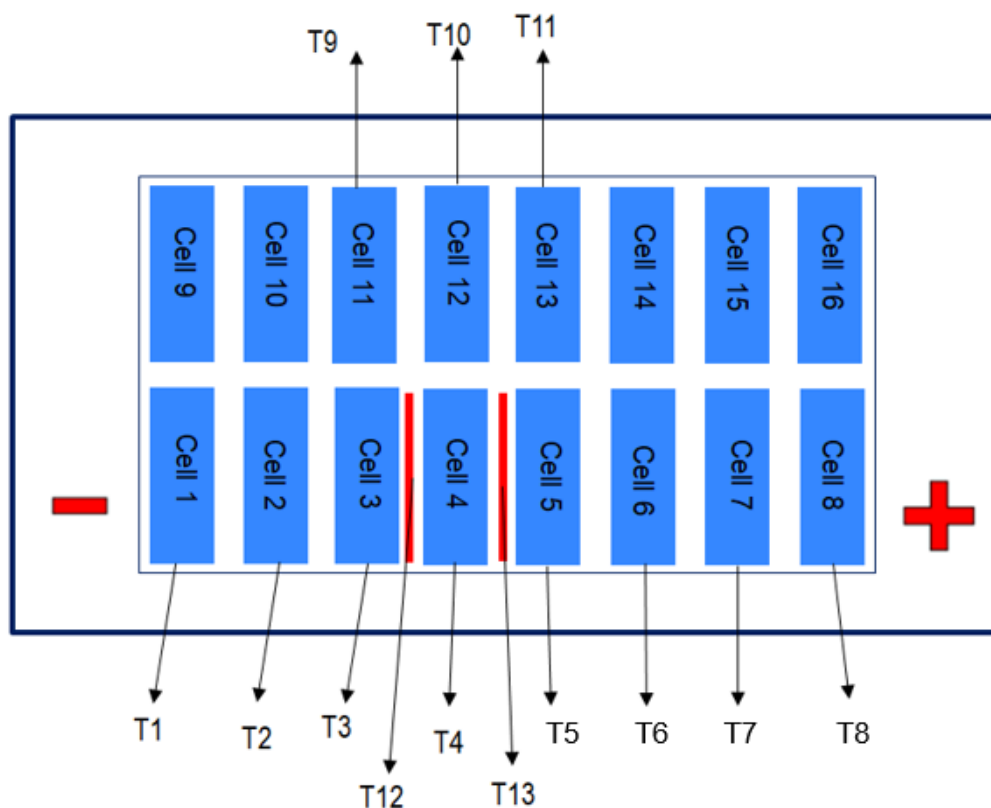
- V10α / V12α use battery connector model: C10-730189,
- V10 / V12 use battery connector model: BPC 250 FTB.

Due to the identical product design (except as stated above) and the use of identical critical components, only one model was tested at its maximum state of charge. The results are considered representative of the performance of all models listed. The test results in this report were generated from testing model V12α.

The differences of battery connectors have been highlighted with red box.

MODULE LEVEL

Identification/location of cells within the module as below (Cell 4 as initiating cell):



Schematic Illustration of film heaters and thermocouple locations in DUT.

Cell 4 is the initiating cell. T1 to T13 means thermocouples T1 to T13.

Thermocouples T12 and T13 are centred under the film heaters

View from top.

For detailed thermocouple locations, refer to Table 3 below:

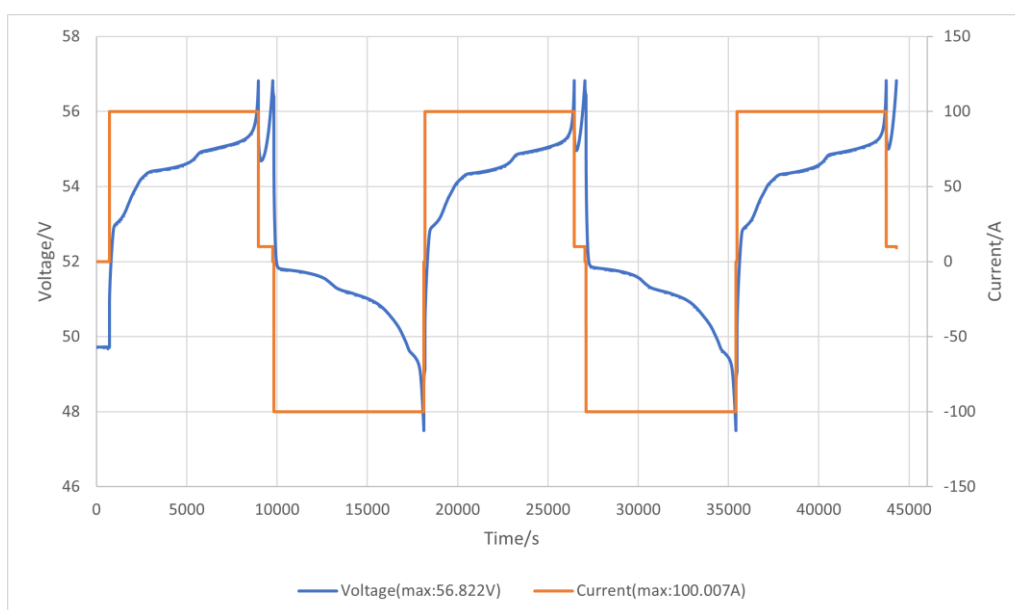
MODULE LEVEL

Table 3: Thermocouple location	
Thermocouple No.	Thermocouple location
T01	Middle of the large surface of Cell 1
T02	Middle of the large surface of Cell 2
T03	Middle of the large surface of Cell 3
T04	Middle of the large surface of Cell 4
T05	Middle of the large surface of Cell 5
T06	Middle of the large surface of Cell 6
T07	Middle of the large surface of Cell 7
T08	Middle of the large surface of Cell 8
T09	Middle of the large surface of Cell 11
T10	Middle of the large surface of Cell 12
T11	Middle of the large surface of Cell 13
T12	Under Film heater 1, between Cell 3 and Cell 4
T13	Under Film heater 2, between Cell 4 and Cell 5
T14	Top cover
T15	Bottom base
T16	Left-side panel
T17	Right-side panel
T18	Front surface
T19	Rear surface
T20	Ambient temperature

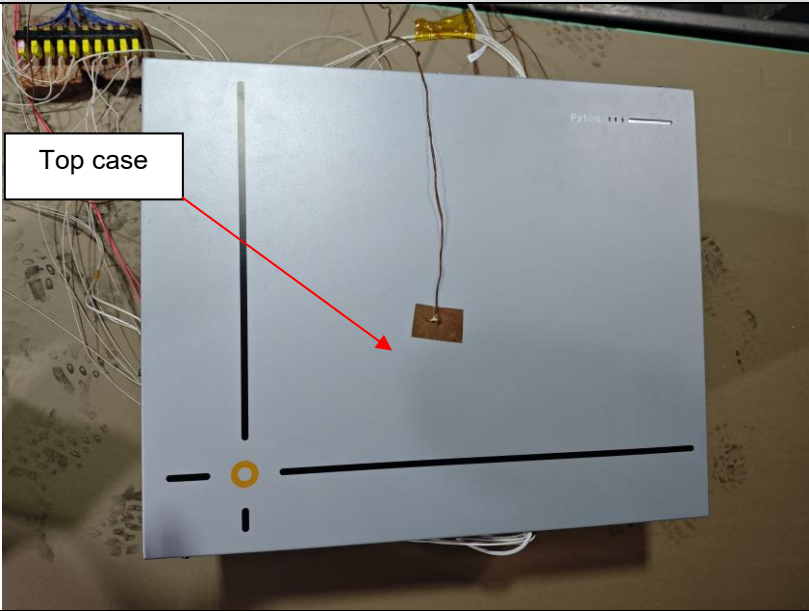
Table 3: Thermocouple location	
Thermocouple No.	Thermocouple location
T01	Middle of the large surface of Cell 1
T02	Middle of the large surface of Cell 2
T03	Middle of the large surface of Cell 3
T04	Middle of the large surface of Cell 4
T05	Middle of the large surface of Cell 5
T06	Middle of the large surface of Cell 6
T07	Middle of the large surface of Cell 7
T08	Middle of the large surface of Cell 8
T09	Middle of the large surface of Cell 11
T10	Middle of the large surface of Cell 12
T11	Middle of the large surface of Cell 13
T12	Under Film heater 1, between Cell 3 and Cell 4
T13	Under Film heater 2, between Cell 4 and Cell 5
T14	Top cover
T15	Bottom base
T16	Left-side panel
T17	Right-side panel
T18	Front surface
T19	Rear surface
T20	Ambient temperature

MODULE LEVEL

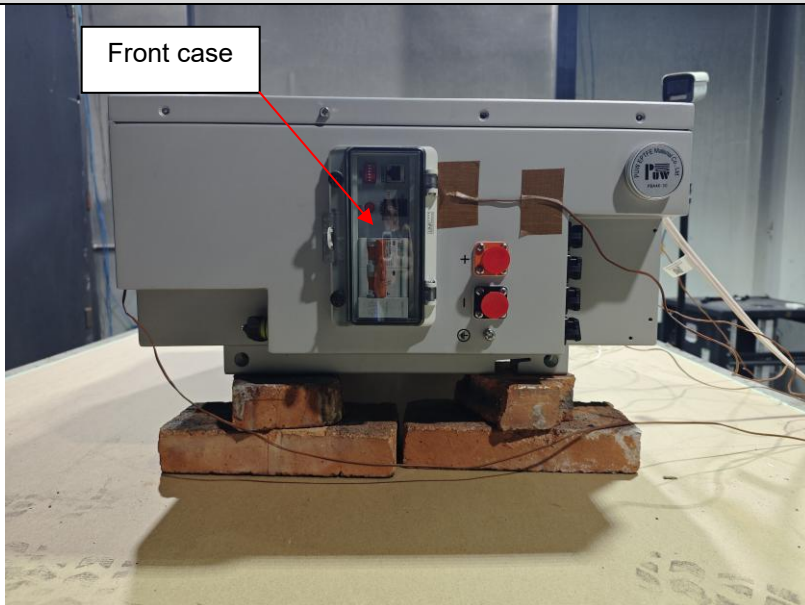
Attachment 2: Pre-conditioning profile

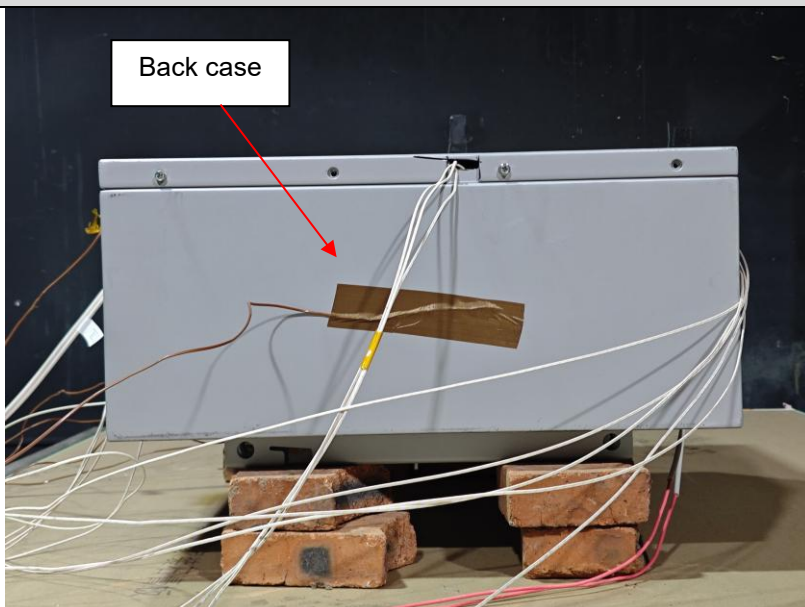


Attachment 3: Photo for sample before test and test setup with thermocouple location

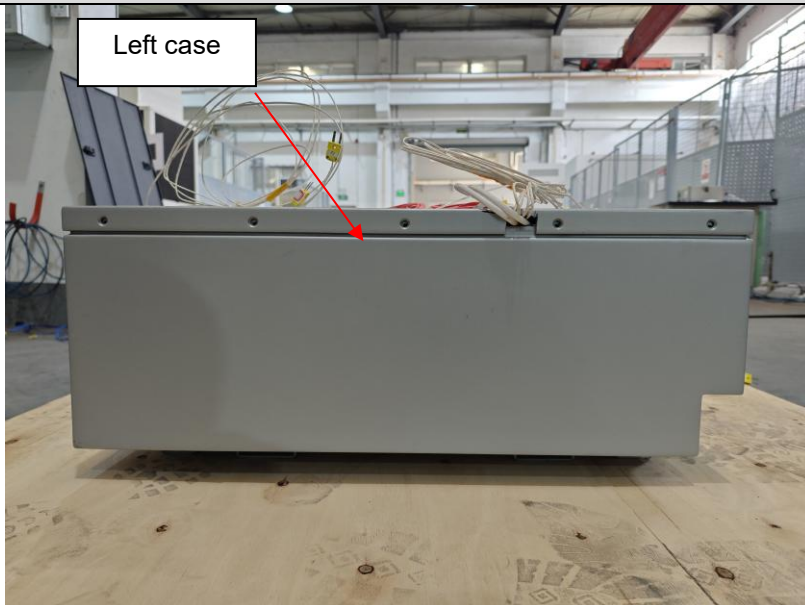
Details of:	Figure 1 of Attachment 3: Overview of sample & thermocouple location_before test
	

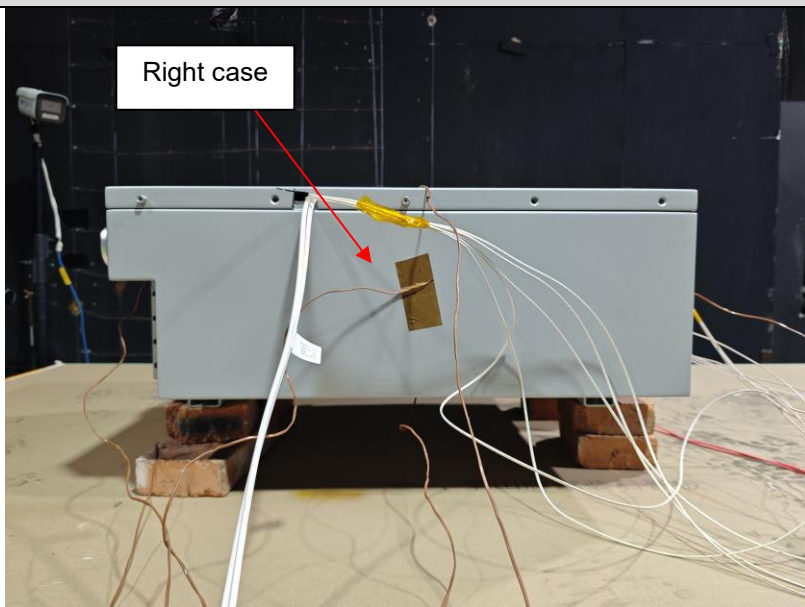
MODULE LEVEL

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

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

MODULE LEVEL

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

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

MODULE LEVEL

Attachment 4: Photos 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
	

MODULE LEVEL

Details of:	Figure 3 of Attachment 4: Back view of module_after test
	 The image shows the back view of a grey rectangular module. The top edge is heavily damaged, with dark, viscous material dripping down the front face. The module is resting on two stacks of red bricks. Several white and yellow cables are connected to the bottom of the module.

Details of:	Figure 4 of Attachment 4: Left side view of module_after test
	 The image shows the left side view of the same grey rectangular module. The top edge is again heavily damaged, with dark, viscous material dripping down the front face. The module is resting on a wooden surface. Several white and yellow cables are connected to the bottom of the module.

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.

MODULE LEVEL

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

MODULE LEVEL

Attachment 5: Monitored voltage and temperature chart

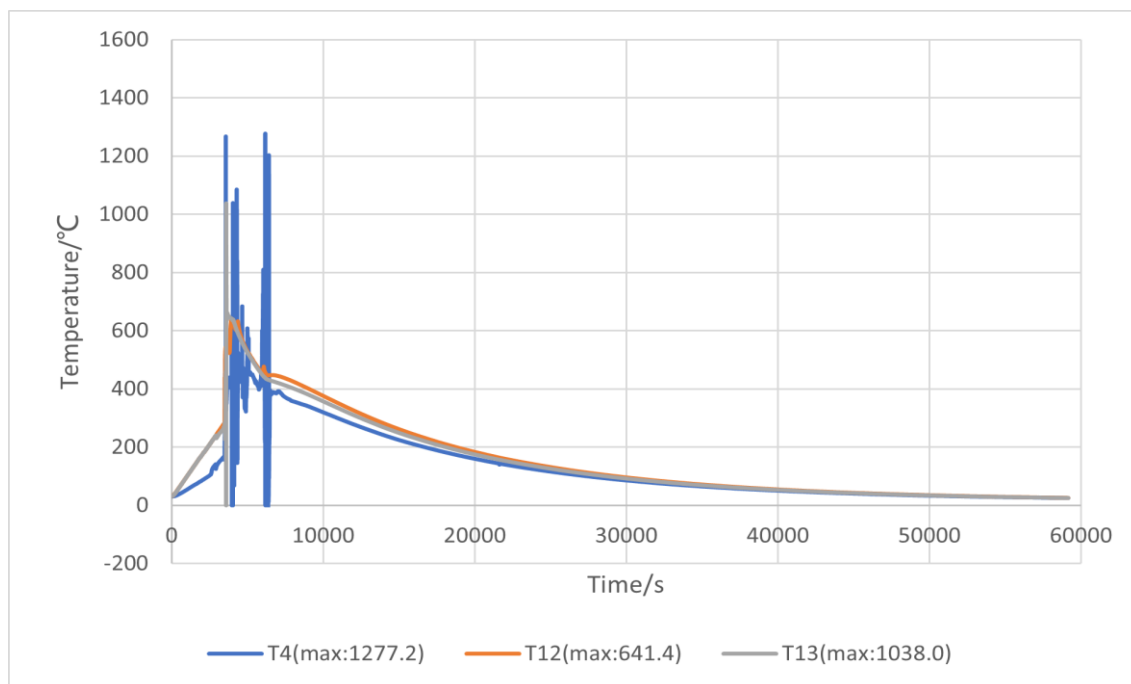


Figure 1 of Attachment 5: Temperatures of initiating cell in module

Remark: Measurement errors observed on T4, probably caused due to electrolyte leakage.

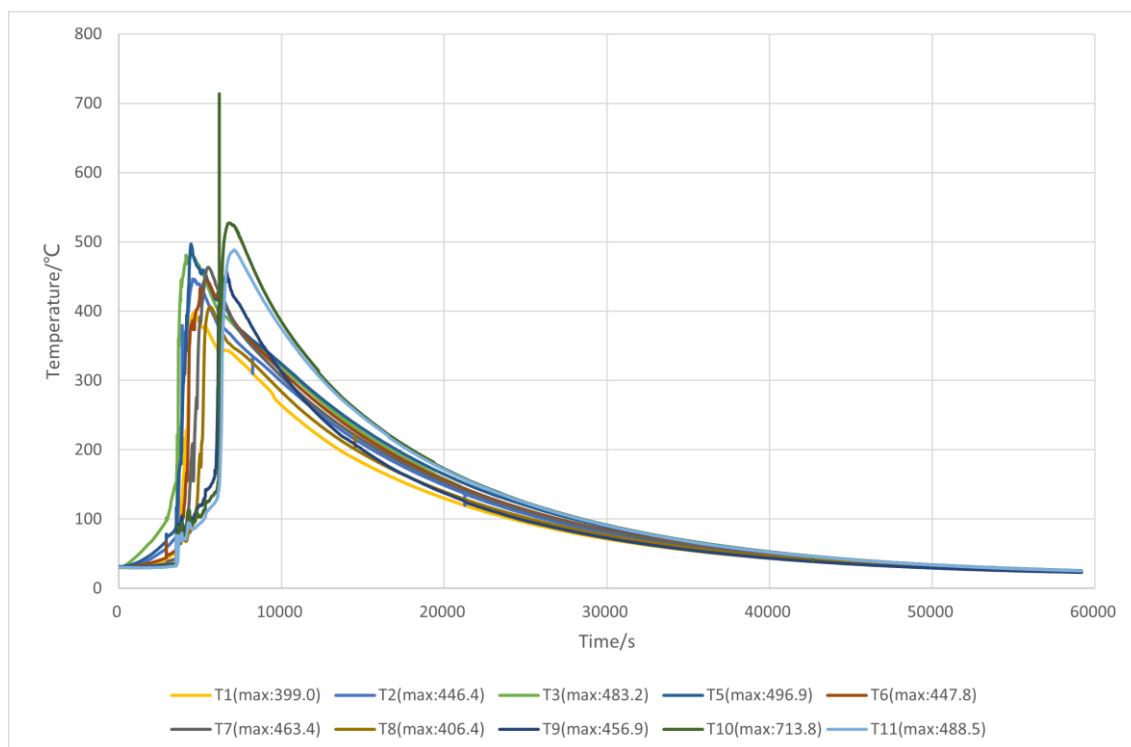


Figure 2 of Attachment 5: Temperatures of other cells in module.

MODULE LEVEL

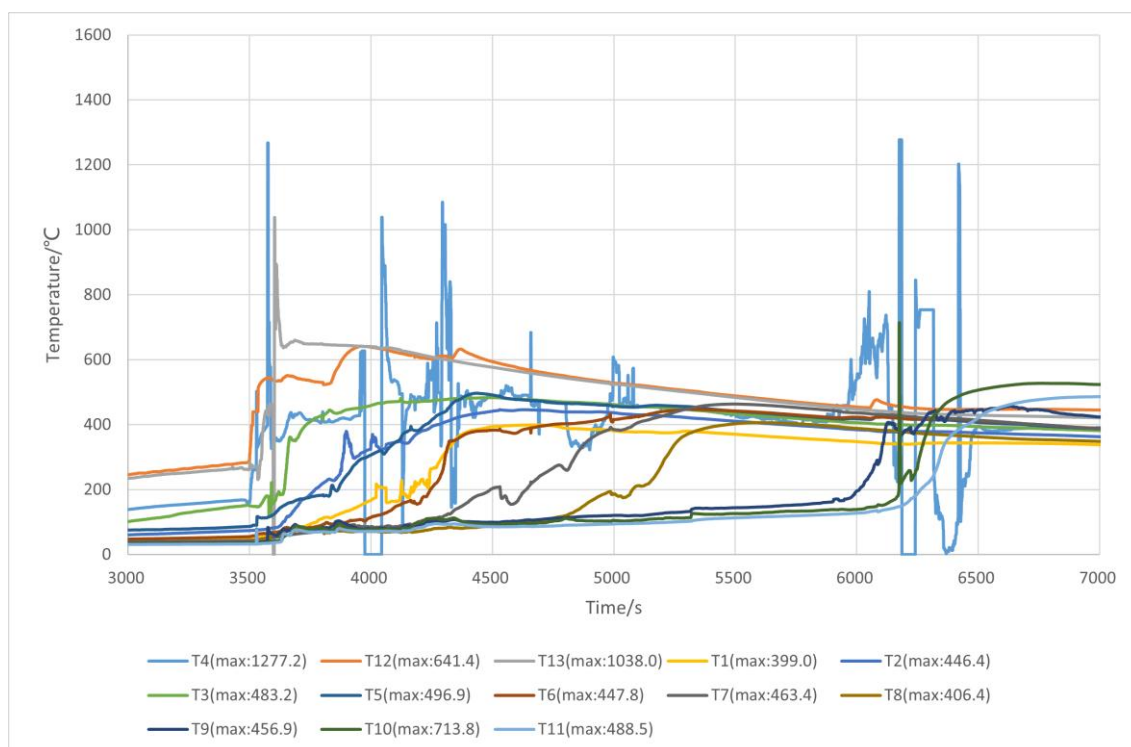


Figure 3 of Attachment 5: Zoomed view of temperatures, including initiating cell and other cells.
Remark: Measurement errors observed on T4, probably caused due to electrolyte leakage.

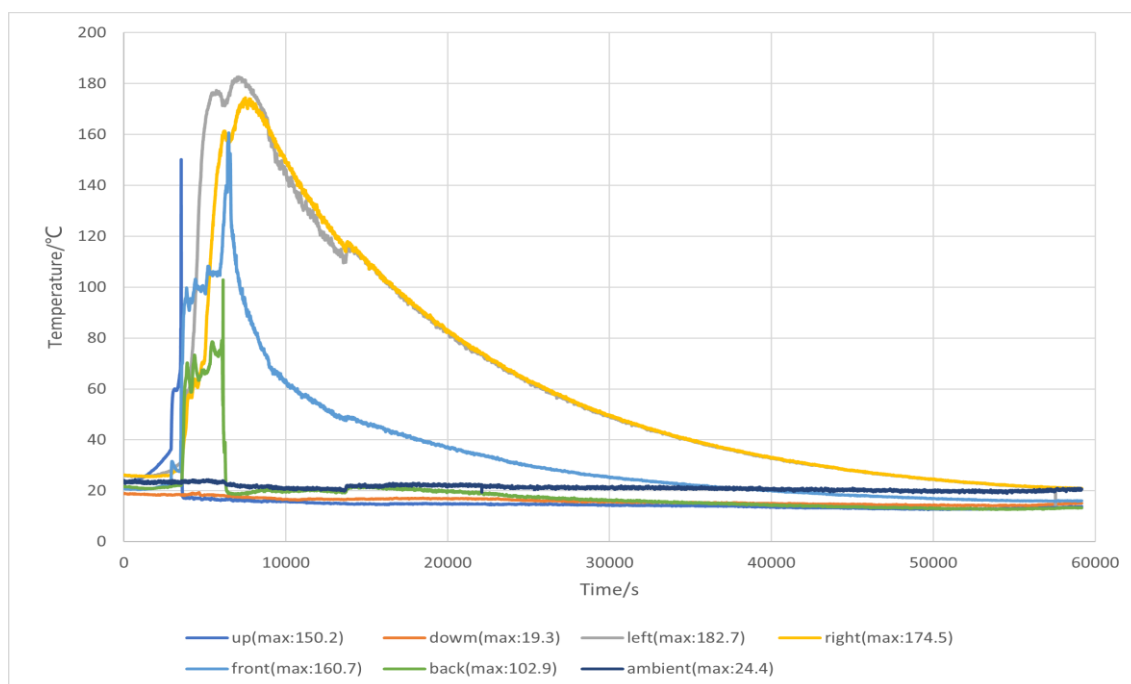


Figure 4 of Attachment 5: Temperatures of module case and ambient.

MODULE LEVEL

Attachment 6: Flammable gas generation and composition data chart

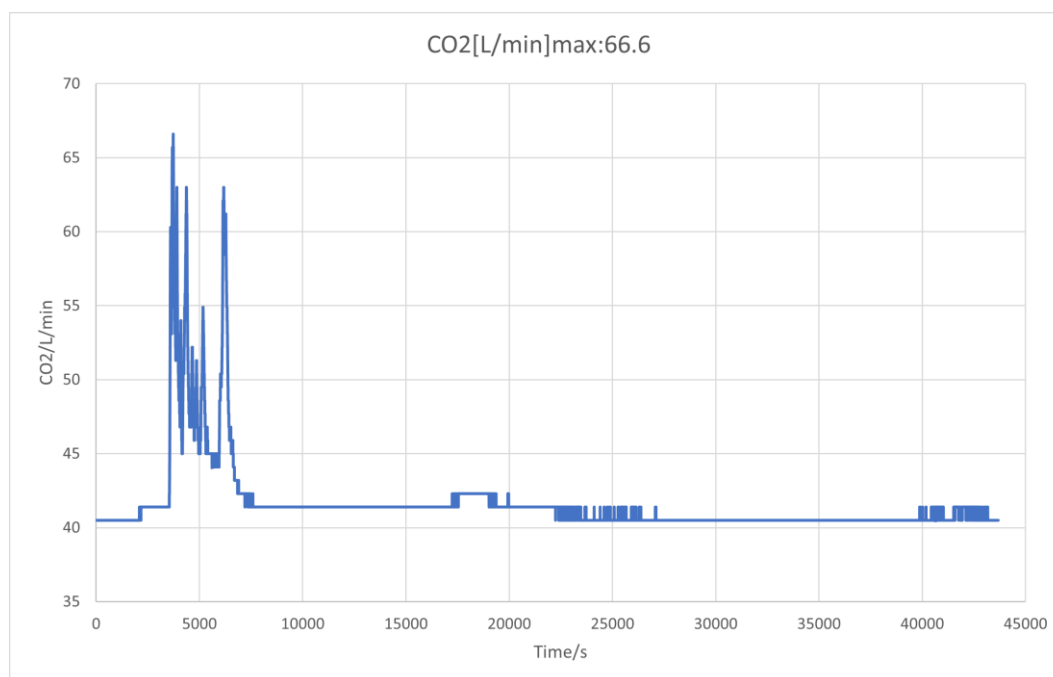


Figure 1 of Attachment 6: Gas generation and composition data chart (Detected by NDIR).

Remark: Flow rate in exhaust duct was 1.5 m³/s.

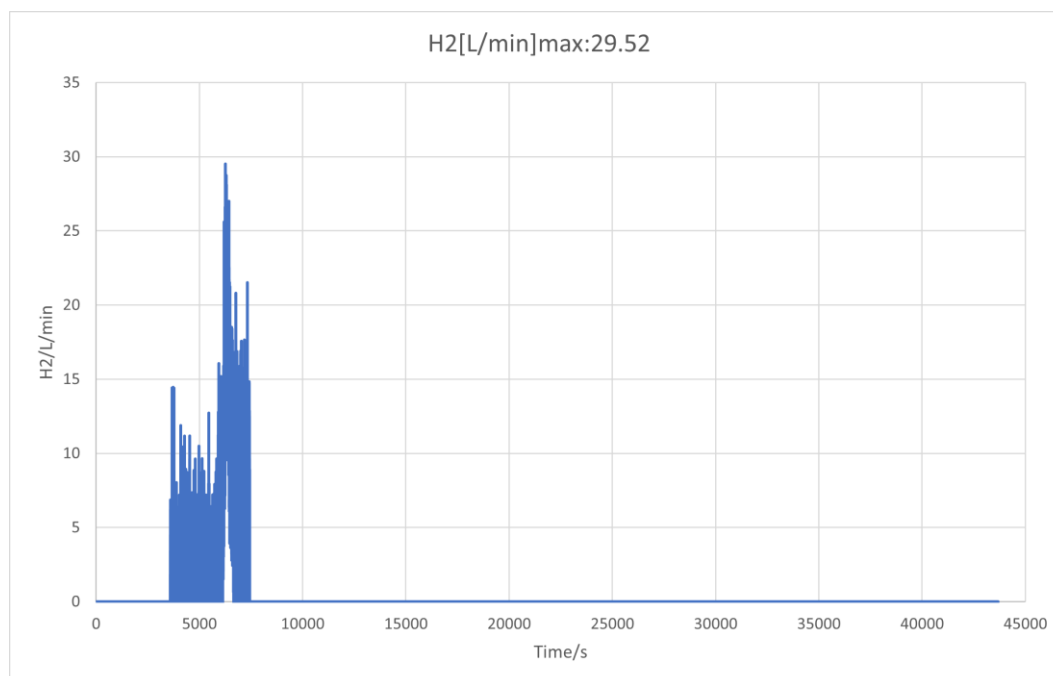


Figure 2 of Attachment 6: Gas generation and composition data chart (Detected by FTIR).

Remark: Flow rate in exhaust duct was 1.5 m³/s.

MODULE LEVEL

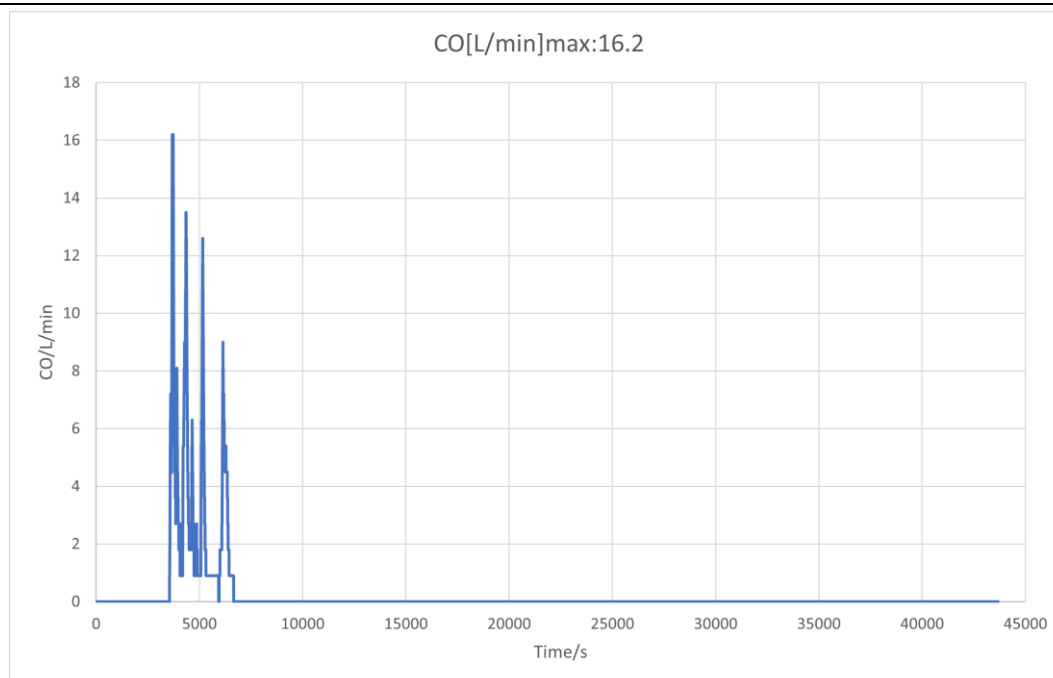


Figure 3 of Attachment 6: Gas generation and composition data chart (Detected by NDIR).
Remark: Flow rate in exhaust duct was 1.5 m³/s.

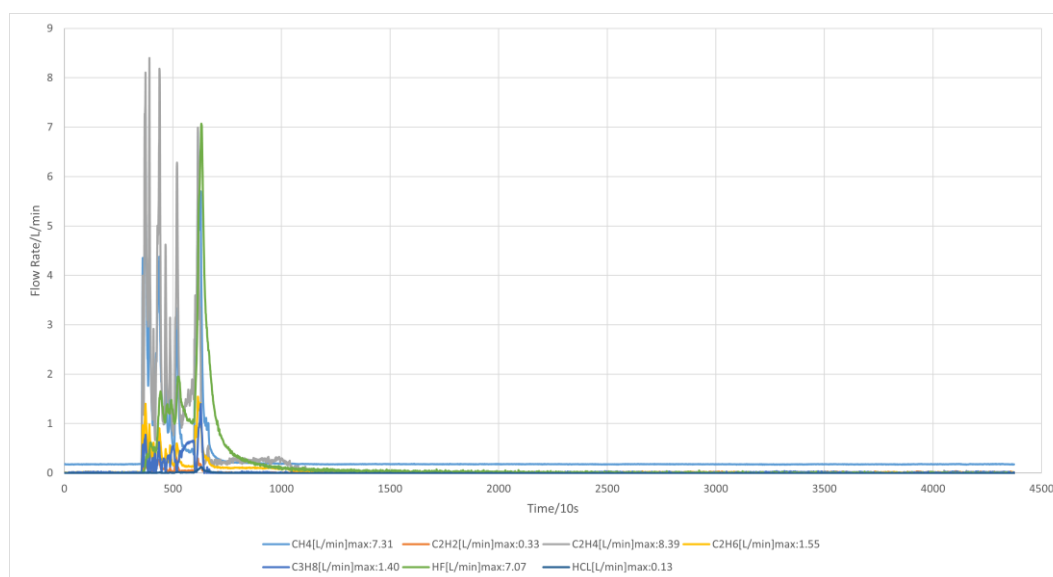


Figure 4 of Attachment 6: Gas generation and composition data chart (Detected by FTIR).
Remark: Flow rate in exhaust duct was 1.5 m³/s.

MODULE LEVEL

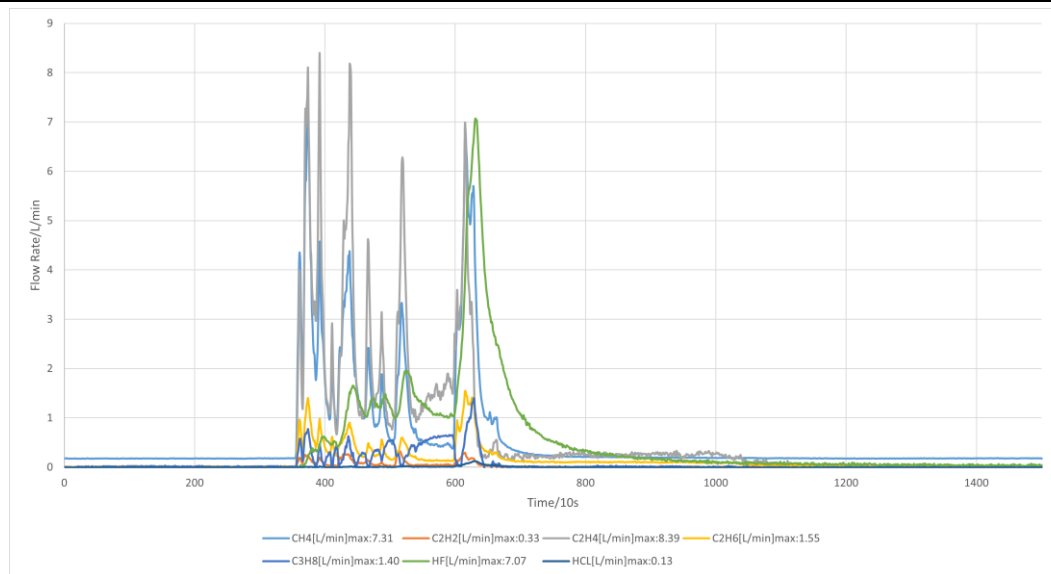


Figure 5 of Attachment 6: Zoomed view of gas generation and composition data chart (Detected by FTIR).
Remark: Flow rate in exhaust duct was 1.5 m³/s.

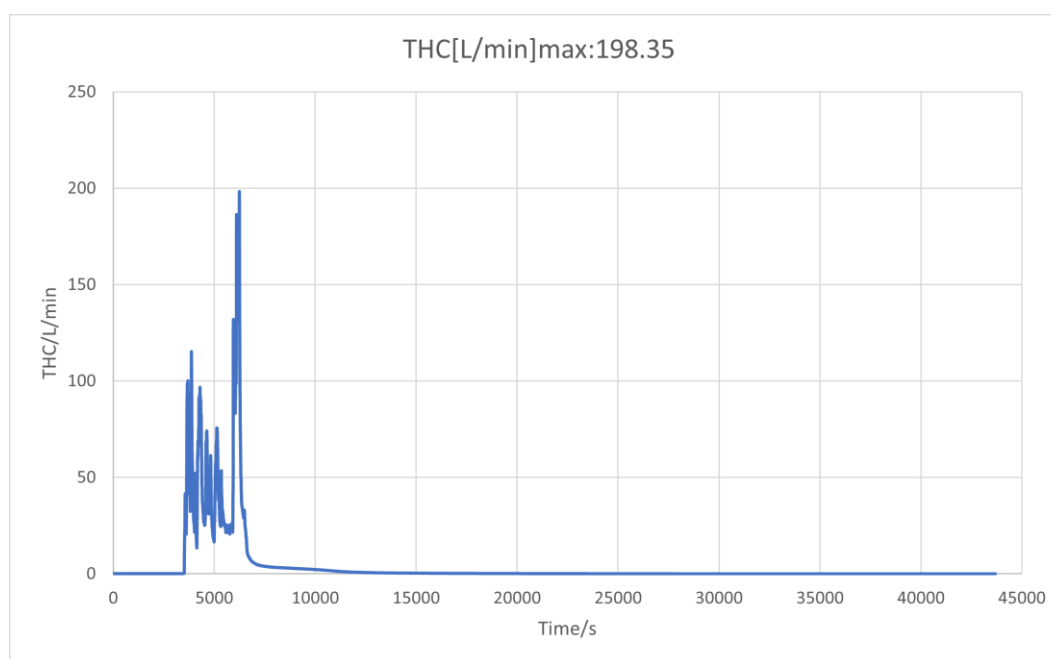
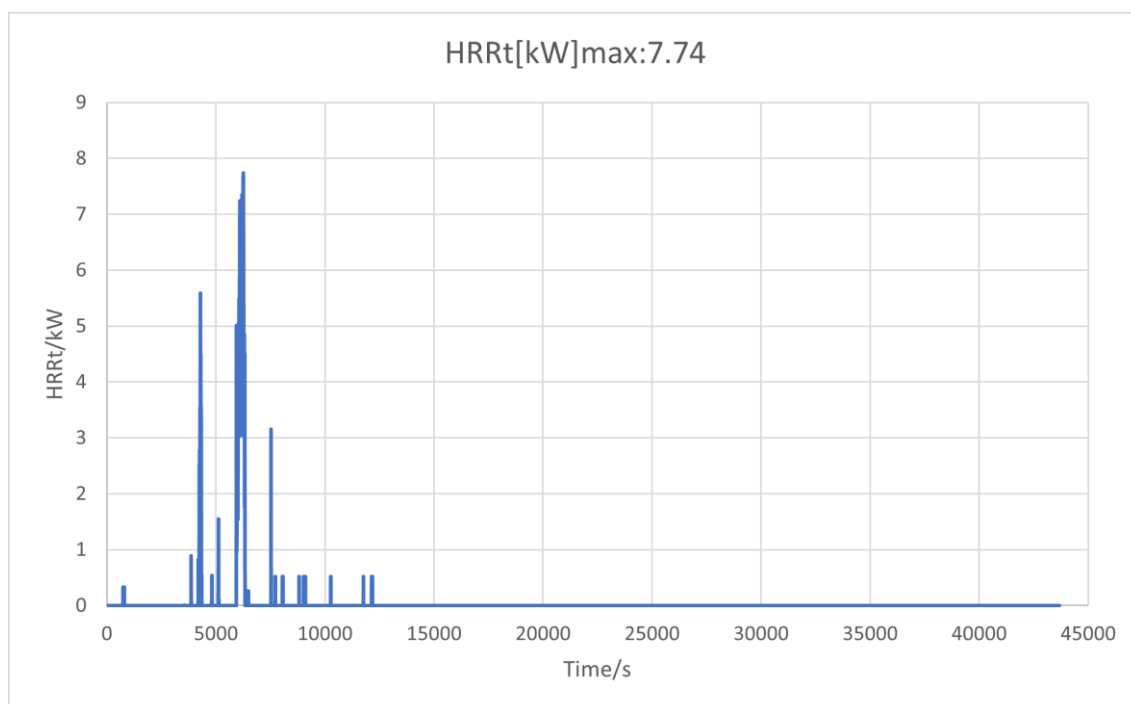


Figure 6 of Attachment 6: THC (Total Hydrocarbons) chart (Detected by FID).
Remark: Flow rate in exhaust duct was 1.5 m³/s.

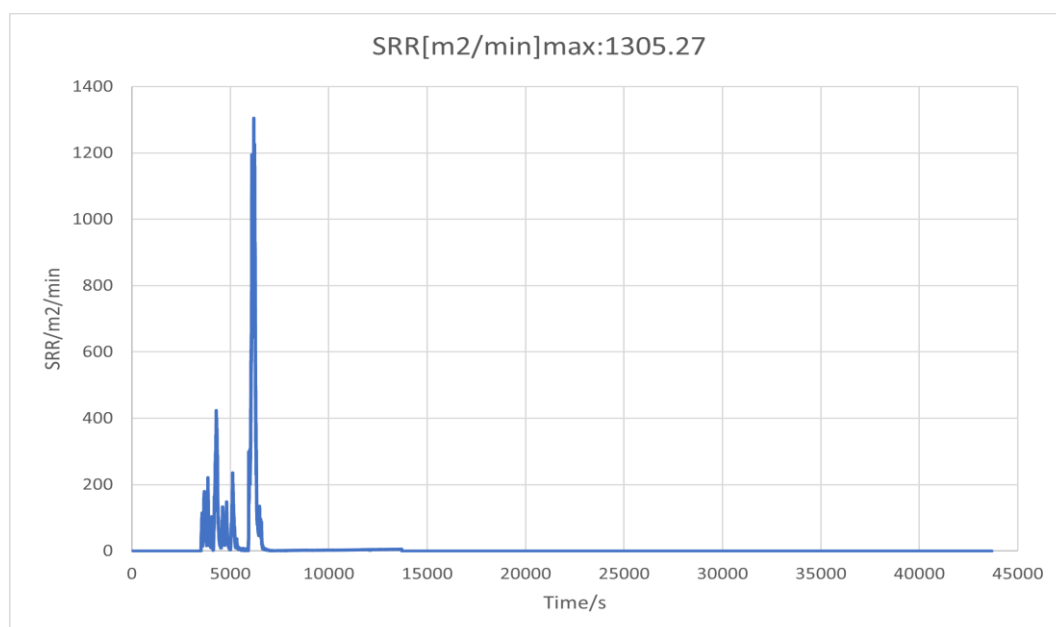
MODULE LEVEL

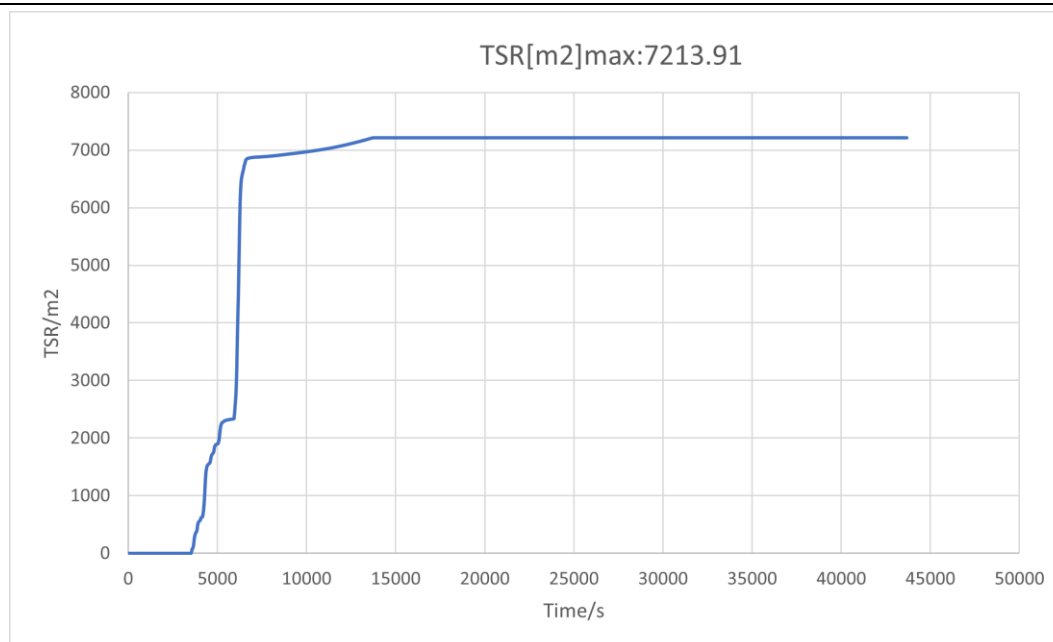
Attachment 7: Heat release rate versus time data chart



Remark: No flames observed during test.

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



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

Peak heat release rate	7.74 kW
Total smoke released	7213.91 m ²
Peak smoke release rate	1305.27 m ² /min

Remark: No flames observed during test

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