

TEST REPORT

ANSI/CAN/UL 9540A:2026

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

Report Reference No. : 2604B0501SHA-001

Tested by (name + signature)

..... : Eric Yu

Eric Yu

Approved by (name + signature)

..... : Sofm Shen

Sofm Shen

Total number of pages : 68

Date of issue : 2026-07-08

Testing Laboratory : Intertek Testing Services (Shanghai FTZ) Co., Ltd.

Address : Building No.86, 1198 Qinzhou Road (North), Shanghai 200233, China

Testing location/ procedure : Witness testing

Testing location/ address : Building 3, No. 1065, Beihe Road, Jiading District, Shanghai

Applicant's name : Weiheng Intelligent Technology Co., Ltd.

Address : Sheng Xiang, Yaxi Community, Luoshe Town, Huishan District, 214000
Wuxi, Jiangsu Province, P. R. China.

Test specification:

Standard : ANSI/CAN/UL 9540A:2026

Test procedure : Module level test (clause 8.1-8.6)

Non-standard test method : N/A

Test Report Form No. : ANSI/CAN/UL 9540A_Module

Test Report Form(s) Originator : Intertek

Master TRF : Dated 2026-03

This publication may be reproduced in whole or in part for non-commercial purpose as long as Intertek is acknowledged as copyright owner and source of the material. Intertek takes no responsibility and will not assume liability for damages resulting from the reader's interpretation of the reproduced material due to its placement and context.

Test item description : Rechargeable Li-ion Battery Module

Trade Mark :



Manufacturer : Weiheng Intelligent Technology Co., Ltd.

Address : No.99 Luoqi Road, Huishan District, Wuxi City, Jiangsu Province, China

Model/Type reference : BM52S314E-BF10

Ratings : 314Ah, 166.4V, 52.24kWh

General disclaimer:

This report is for the exclusive use of Intertek's Client and is provided pursuant to the agreement between Intertek and its Client. Intertek's responsibility and liability are limited to the terms and conditions of the agreement. Intertek assumes no liability to any party, other than to the Client in accordance with the agreement, for any loss, expense or damage occasioned by the use of this report. Only the Client is authorized to permit copying or distribution of this report and then only in its entirety. Any use of the Intertek name or one of its marks for the sale or advertisement of the tested material, product or service must first be approved in writing by Intertek. The observations and test results in this report are relevant only to the sample tested. This report by itself does not imply that the material, product, or service is or has ever been under an Intertek certification program.

List of attachments:

Attachment 1 – Photos

Attachment 2 – Module conditioning (charge/discharge) profiles

Attachment 3 – Module thermal runaway record

Attachment 4 – Temperature and voltage profile during thermal runaway

Attachment 5 – Chemical heat release rate measurement

Attachment 6 – Gas generation measurement

Attachment 7 – Smoke release rate measurement

Attachment 8 – Equipment list

Test video 2604B0501SHA-001-1~2.mp4 are provided in addition to this test report.

Summary of testing:

Method exhibited thermal runaway	External heating with flexible film heaters
Heating ramp rate	4.5°C /min (4°C/min -7°C/min)
Thermal runaway Propagation	1 cell went to thermal runaway due to external heating. 1 cell vented and went to thermal runaway due to thermal runaway propagation and 1 cell vented without thermal runaway.
Flame spread outside of the module	Not observed
Peak chemical heat release rate HRR (kW)	2.32 kW (No flaming occurred)
Peak smoke release rate SRR (m ² /s)	0.0027 m ² /s
Total smoke release TSR (m ²)	0.3 m ²
Total Hydrocarbons (equivalent to CH ₄ , measured by FID)	164.2 L
Module weight loss	0.7 kg

Conclusion:

Thermal runaway and propagation from cell to cell happened and no flame spread outside of the module during thermal runaway propagation test.

Thermal runaway is contained by module design, and the module exterior surface temperature does not exceed the cell venting temperature, but cell vent gas is flammable as determined by the cell level test.

According to the standard, a unit level testing in accordance with UL 9540A needs to be conducted on a unit employing this module.

Possible test case verdicts:

- test case does not apply to the test object.....: N/A
- test object was not evaluated for the requirement.....: N/E
- test object does meet the requirement.....: Pass (P)
- test object does not meet the requirement: Fail (F)

Testing:

Date of receipt of test items: 2026-04-08

Date(s) of test performed: 2026-06-03 to 2026-06-17

General remarks:

"(see Attachment #)" refers to additional information appended to the report.

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

The tests 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.

List of test equipment must be kept on file and available for review.

Additional test data and/or information is provided in the attachments to this report.

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

Determination of the test results includes consideration of measurement uncertainty from the test equipment and methods.

For products manufactured from more than one location, the sample submitted for evaluation is representative of the products from each factory.

Product information:

Cell information

Manufacturer	REPT BATTERO Energy Co., Ltd.
Address	No.205, Binhai 6th Road, Konggang New District, Longwan District, Wenzhou 325000 Zhejiang, P.R.China
Model name	CB75
Chemistry	LiFePO ₄
Physical configuration	Prismatic
Dimension	(206.8±2) mm* (174±2) mm* (71.7±2) mm See cell diagram with overall dimension
Weight	(5.78±0.3) kg
Nominal voltage	3.2 V
Rated capacity	314 Ah
If the cell compliance with UL 1973	Refer to TUV Rheinland Certificate No. CU 72303136 01-02

Standard charge method

Charge current	157A
End of charge voltage	3.65 Vdc
Cut off current	--
Charge temperature range	0°C to 60°C

Standard discharge method

Discharge current	157A
End of discharge voltage	2.5 V
Discharge temperature range	-30°C to 60°C
Interval between charge and discharge (min)	30min

Test result from ANSI/CAN/UL 9540A:2019 cell level test report

Cell level test report ¹⁾:	Refer to TUV Rheinland test report No.: CN234568 001
Method exhibited thermal runaway	External heating with flexible film heaters
Heating ramp rate	4°C/min -7°C/min
Average cell venting temperature	127.9°C
Average cell thermal runaway onset temperature	179.8°C
Gas Volume	188 L (25°C, 101.3kPa)
Gas composition	CO: 10.095%, CO ₂ : 24.614%, H ₂ : 54.373 %, Hydrocarbon:10.918%
LFL at ambient temperature	7.7% at 24±2°C and 101±3kPa
LFL at cell venting temperature	7.1% at 127.9±2°C and 101±3kPa
Burning velocity	68.8 cm/s at room temperature and atmosphere pressure
P _{max}	0.798MPa at 24±2°C and 101±3kPa

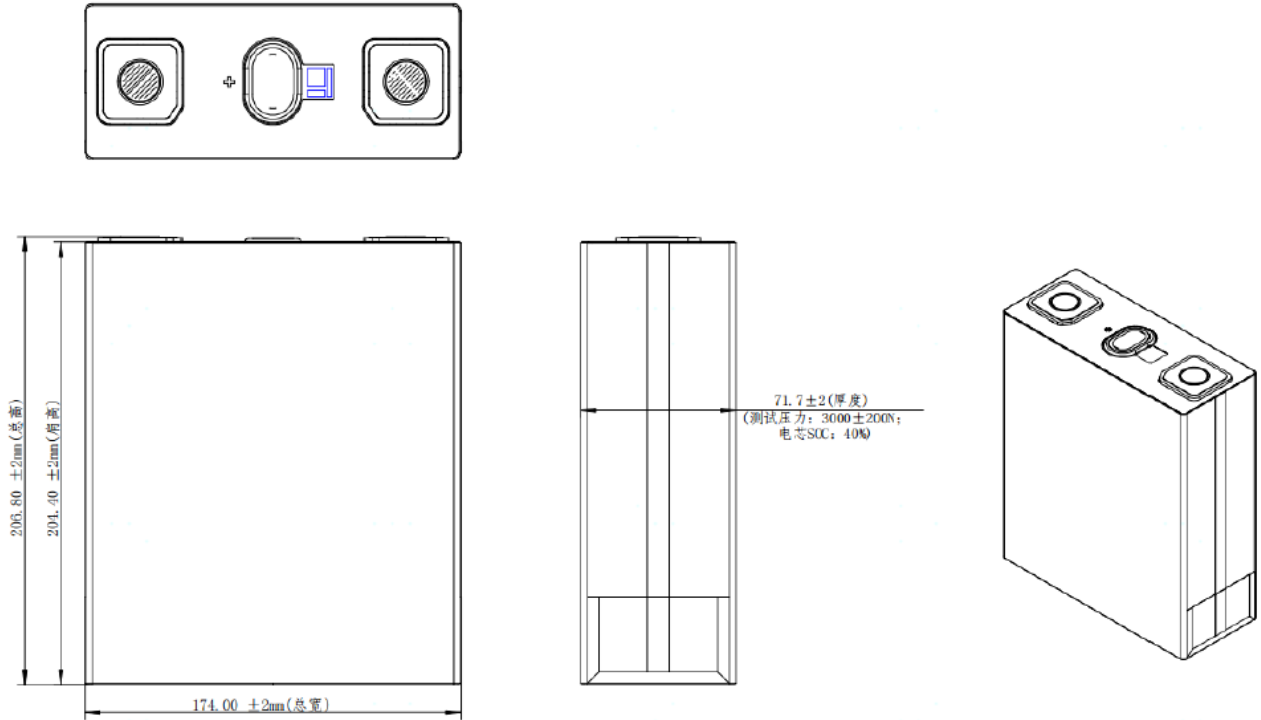
Conclusion:

The performance criteria of the cell level test as indicated in 7.8 of UL 9540A 4th edition has not been met, therefore module level testing in accordance with UL 9540A needs to be conducted on a module employing this cell.

Remark:

¹⁾ Cell level test was performed by TUV Rheinland lab according to ANSI/CAN/UL 9540A:2019.

Diagram of cell with overall dimension (unit: mm)

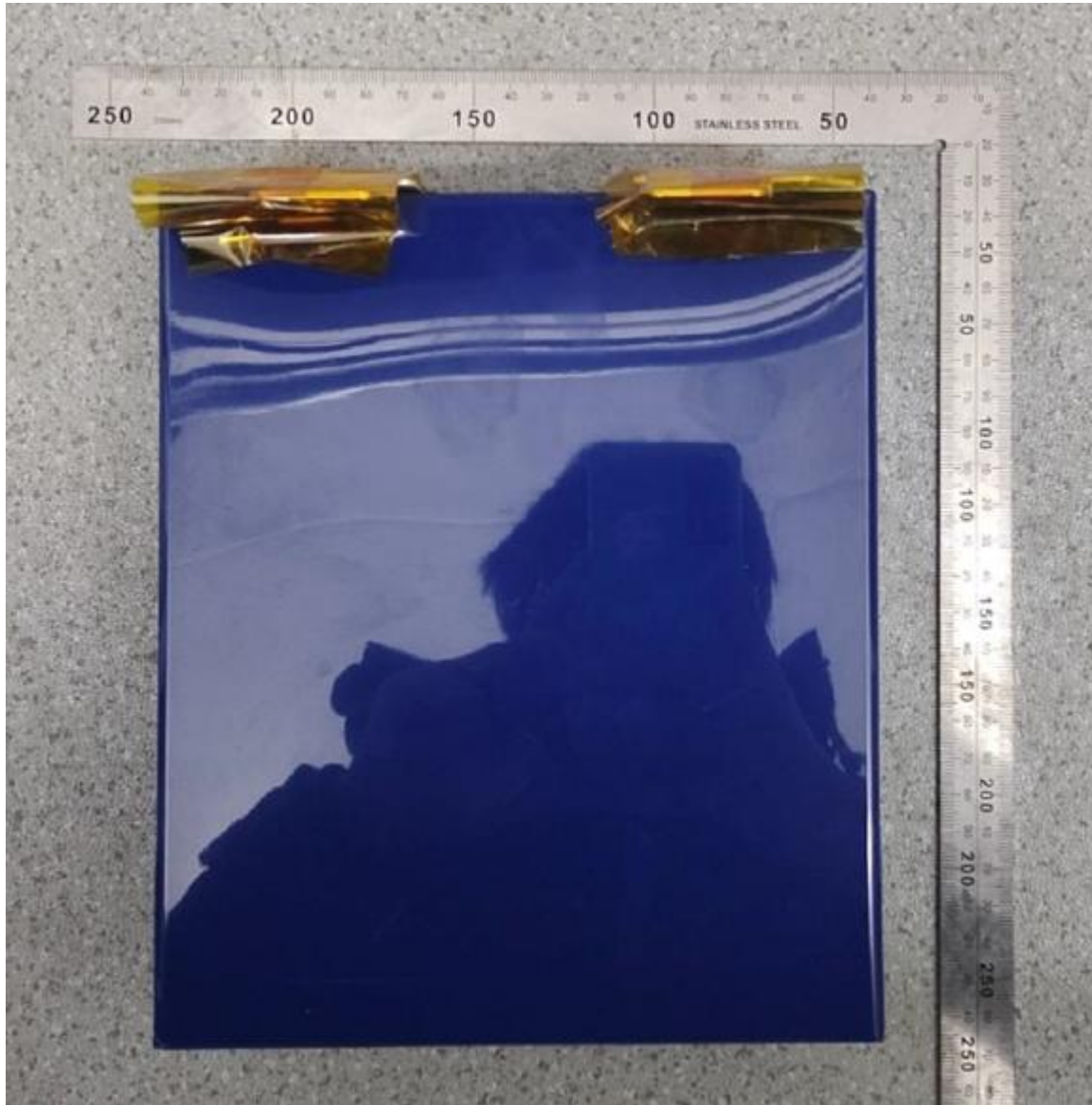


$(206.8 \pm 2) \text{ mm} * (174 \pm 2) \text{ mm} * (71.7 \pm 2) \text{ mm}$

Construction of the cell

/
Not provided

Overall view of the cell



Module information

Manufacturer: Weiheng Intelligent Technology Co., Ltd.
Address: No.99 Luoqi Road, Huishan District, Wuxi City, Jiangsu Province, China
Model name: BM52S314E-BF10

Physical configuration

Enclosure material: Metal (min. thickness: 1.2mm)
Dimension: (1145±5) mm* (790±3) mm* (245±3) mm
Weight: (345±5) kg
Cells in series/parallel:: 1P52S
Total number of cells:: 52 cells
Cooling method: Liquid cooling
Separation between cells: Ceramicized foamed silicone foam (Thickness:1.5 mm)

Electrical rating

Rated capacity: 314 Ah
Rated energy: 52249.6 Wh
Nominal voltage: 166.4 V

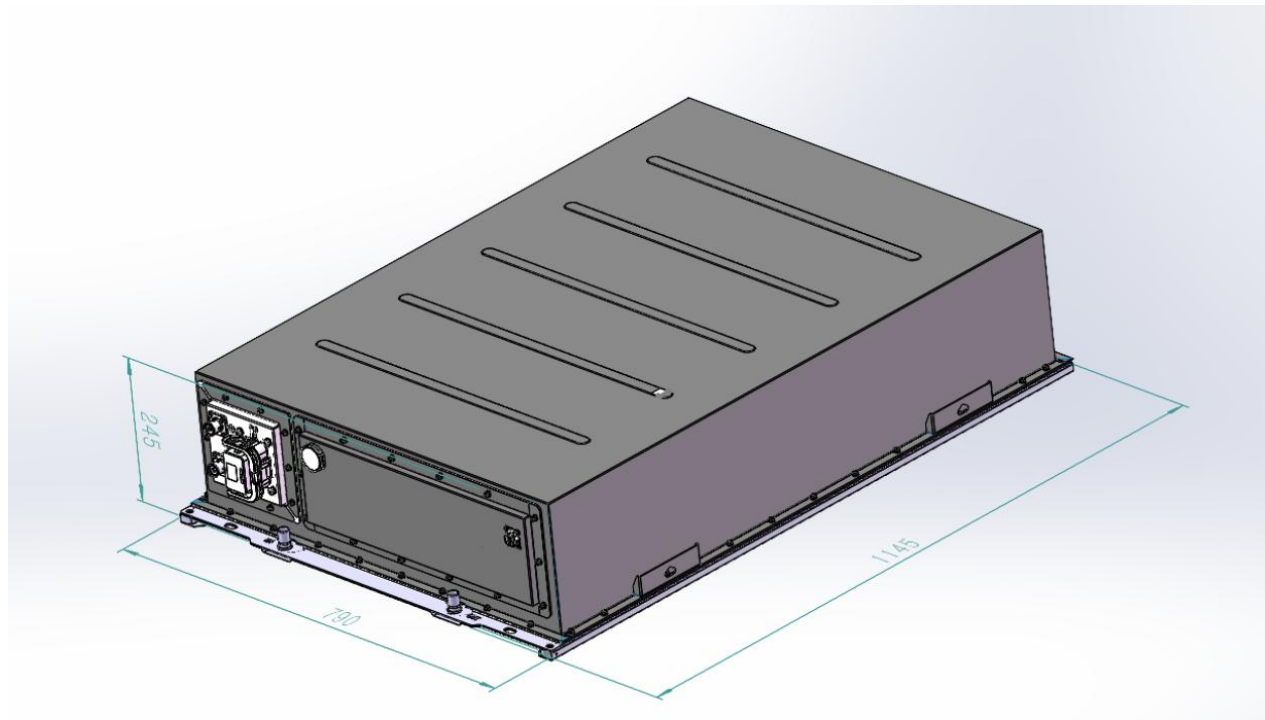
Standard charge method

Charge power: 26 kW
End of charge voltage: 187.2 V (3.6V/cell)
Charging temperature range: 5~55 °C

Standard discharge method

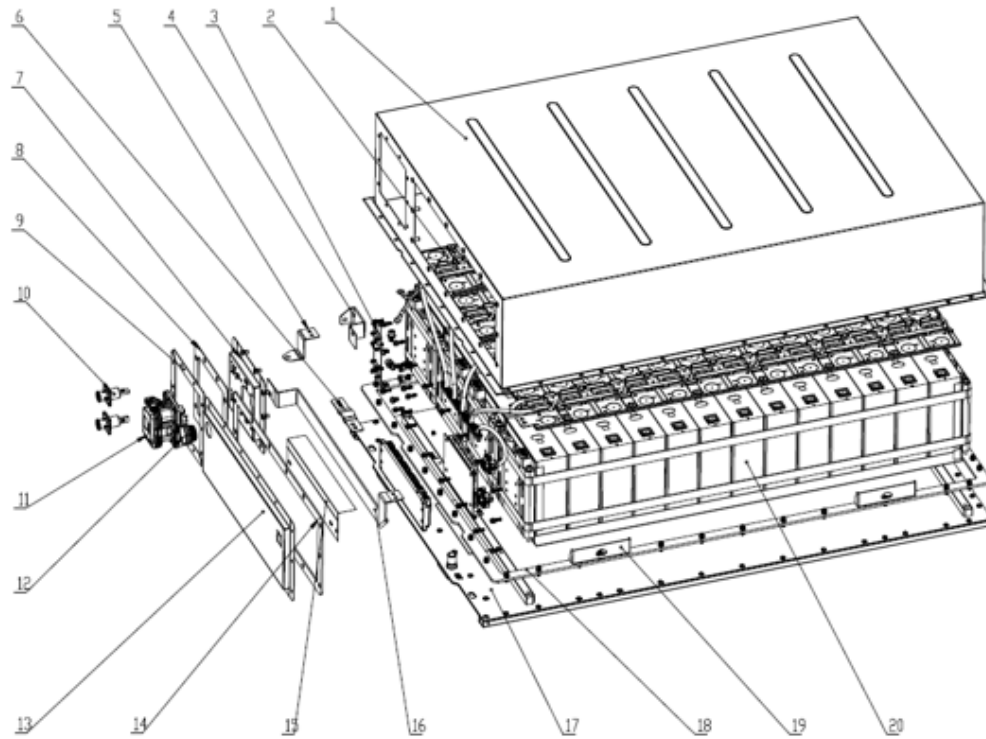
Discharge power: 26 kW
End of discharge voltage: 140.4 V (2.7V/cell)
Discharging temperature range: -15~55 °C
Cycling interval: Rest time between charge and discharge: 30 min
If the module compliance with UL 1973: Consider in unit level
Technical identical declaration: The construction of the module matches the construction of the module subjected to the testing of this standard.

Diagram of module with overall dimension (unit: mm)



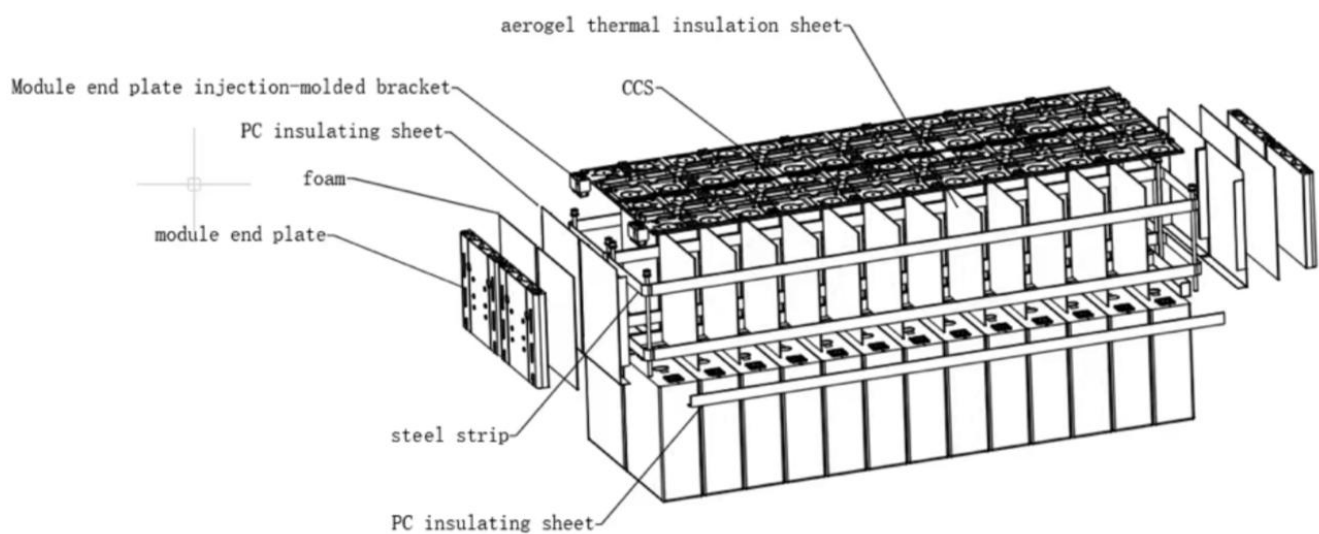
(1145±5) mm* (790±3) mm* (245±3) mm

Exploded view of the module contents

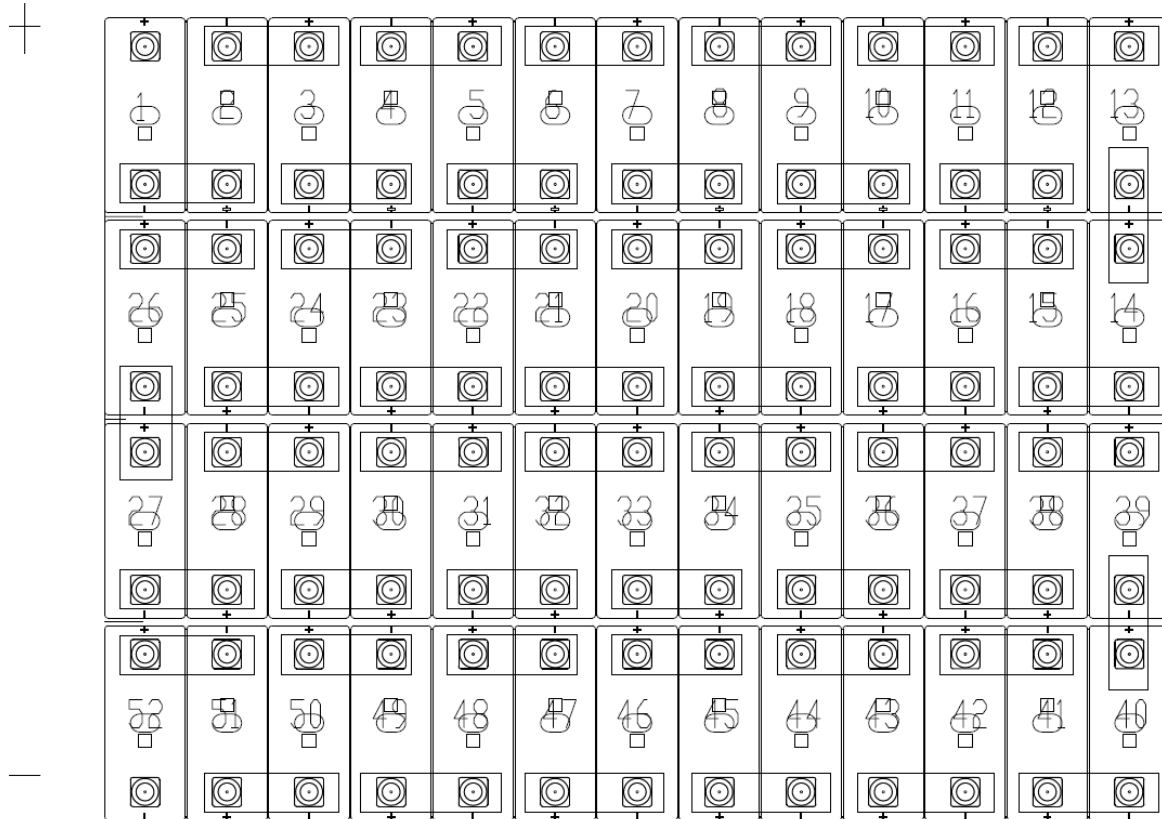


1.Top enclosure 2.CCS 3.PC 4. Copper Busbar 5. Copper Busbar 6. Copper Busbar 7. Front Panel 8. silicone foam 9. pressing strip 10. Socket 11.MSD 12. explosion-proof valve 13. Service panel 14. silicone foam 15.PC 16. Copper Busbar 17. liquid cooling plate 18. silicone foam 19. hook 20. battery module

Exploded view of the cell block contents



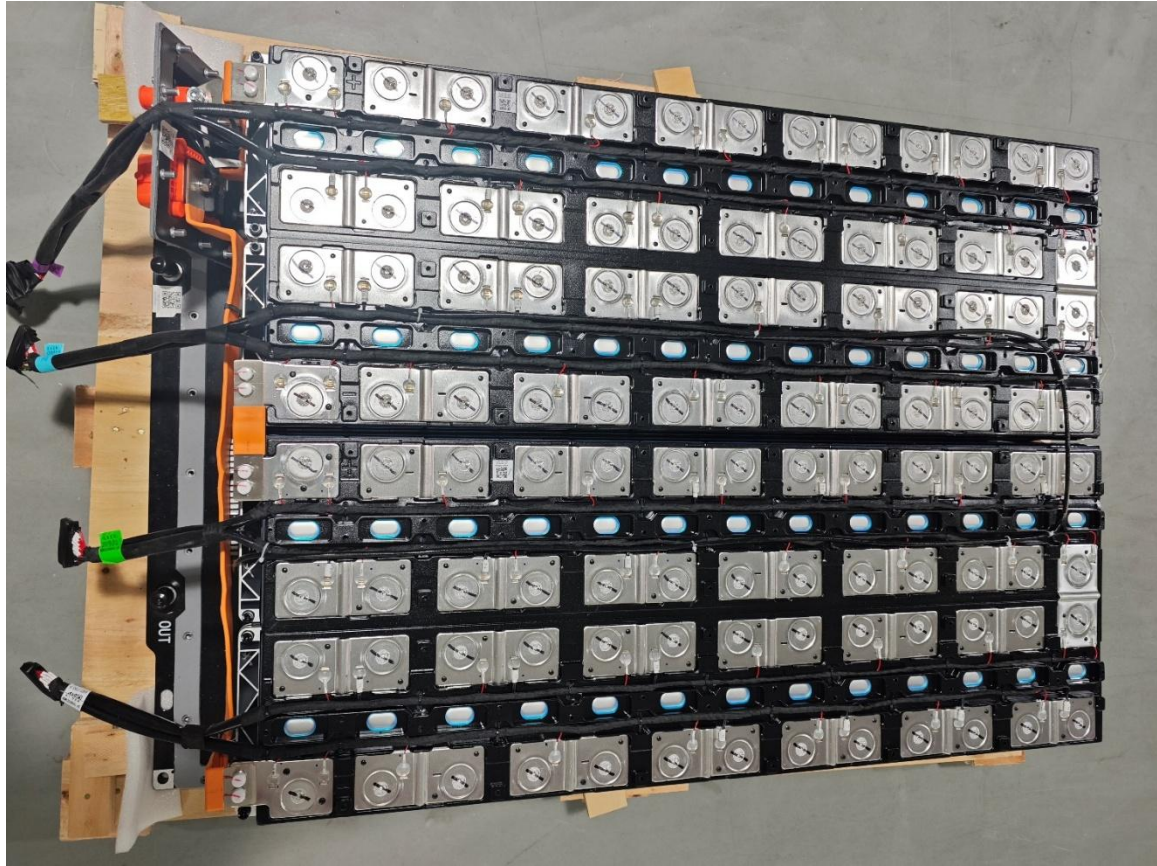
Module structure diagram and cell series and/or parallel configuration (1P104S)



Overall view of the module



Internal view of the module





ANSI/CAN/UL 9540A			
Clause	Requirement – Test	Result - Remark	Verdict
5	Construction – General		
5.1	Cell		--
5.1.1	The cell info associated with the BESS includes:		Pass
	cell chemistry (e.g. NMC, LFP);	See cell information	Pass
	the physical format of the cell (i.e. prismatic, cylindrical, pouch);	See cell information	Pass
	the cell electrical rating in capacity and nominal voltage;	See cell information	Pass
	the overall dimensions of the cell, and weight.	See cell information	Pass
5.1.2	The cells associated with the BESS comply with ANSI/CAN/UL 1973 or not.	See cell information	Pass
5.1.3	Further details are included in the cell level test report.	See cell information	Pass
5.2	Module		--
5.2.1	The modules info associated with the BESS includes:		Pass
	the generic enclosure material (e.g., metallic or non-metallic);	See module information	Pass
	the general layout of the module contents;	See module information	Pass
	the electrical configuration of the cells in the modules.	See module information	Pass
5.2.2	The module documentation included in the test report shall indicate if the modules associated with the BESS comply with UL 1973.		N/A
5.2.3	Further details are included in the module level test report.	Refer to 8.4	Pass
5.4	Flow Batteries		--
5.4.1	For flow batteries, to include the following information:	Not flow battery	N/A
	the chemistry (e.g. vanadium redox, zinc bromine, etc.);		N/A
	a generic description of the electrolyte (s);		N/A
	the overall dimensions of the individual stack;		N/A
	the electrical rating in capacity and nominal voltage of the cell stack.		N/A
5.4.3	Further details are included in the flow battery cell level test report.	Not flow battery	N/A
6	Performance – General		

ANSI/CAN/UL 9540A			
Clause	Requirement – Test	Result - Remark	Verdict
6.1	The tests 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.	Considered	Pass
6.2	At the conclusion of testing, samples discharged in accordance with the manufacturer' specifications.	Complied	Pass
	All samples disposed of in accordance with local regulations.	Complied	Pass
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.	Complied	Pass
	The maximum of these averages shall be documented for each thermocouple location.	Complied	Pass
	Cell surface temperatures shall be measured continuously, but not averaged over every 60 seconds as the other temperature measurements are.	Complied	Pass
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.	See attachment 2	Pass
	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 (EODV) specified by the module manufacturer.	See attachment 2	Pass
	During conditioning the ambient temperature and conditions shall be maintained in accordance 25 ±5 °C and 50 ±25 % RH.	See attachment 2	Pass
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 attachment 2	Pass
8.1.3	Prior to initiating the test, the module voltage shall be measured at the module terminals and recorded.	See attachment 3	Pass

ANSI/CAN/UL 9540A			
Clause	Requirement – Test	Result - Remark	Verdict
	If the module is not in a fully charged condition, the module shall be charged again and this value shall be recorded.	Complied	Pass
8.1.4	Electronics and software controls such as the battery management system (BMS) are not relied upon for this testing.	BMS protections disabled during the testing	Pass
8.2	Test method		--
8.2.1	Ambient indoor laboratory conditions shall be $25 \pm 5^{\circ}\text{C}$ ($77 \pm 9^{\circ}\text{F}$) and $50 \pm 25\%$ RH at the initiation of the test.	See attachment 1	Pass
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.	See attachment 1	Pass
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 attachment 3	Pass
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.	x1 cell forced into thermal runaway	Pass
	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.	Complied	Pass
	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.	Complied	Pass
	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.	Complied	Pass
8.2.5	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.	Refer to 8.2.4	Pass
	Cell to cell thermal runaway propagation occurs when at least one additional non-initiating cell goes into thermal runaway during the test.	One additional non-initiating cell went into thermal runaway, see attachment 4	Pass
	If non-initiating cells only vent during the test, this is not considered a thermal runaway propagation.	Complied	Pass

ANSI/CAN/UL 9540A			
Clause	Requirement – Test	Result - Remark	Verdict
	If thermal runaway propagation is not achieved, the test shall be repeated with additional cells forced into thermal runaway.	Complied	Pass
	Temperatures shall be measured on the initiating cells and nearby non-initiating cells to determine cell to cell thermal runaway propagation.	Complied	Pass
	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.	Propagation achieved with x1 cell forced into thermal runaway	Pass
	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.	Complied	Pass
8.2.6	Temperatures shall be measured on the initiating cells and nearby non-initiating cells to determine thermal runaway propagation.	See attachment 3	Pass
	Temperatures shall also be measured on the exterior surface of the module enclosure in the area closest to the initiating cell location(s).	See attachment 3	Pass
8.2.7	The methodology used for initiating thermal runaway in cell level shall be used to initiate thermal runaway within the module.	Complied	Pass
8.2.8	Occurrence of thermal runaway shall be verified by sustained temperature above the cell surface temperature at the onset of thermal runaway.	See attachment 4	Pass
8.2.9	The module shall be placed on top of a noncombustible horizontal surface with the module orientation representative of its intended final installation.	See attachment 1	Pass
8.2.10	The chemical heat release rate of the module in thermal runaway shall be measured with oxygen consumption calorimetry.	See attachment 5	Pass
8.2.11	The chemical heat release rate shall be measured for the duration of the test.	See attachment 5	Pass
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.	Complied	Pass
	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.	Complied	Pass

ANSI/CAN/UL 9540A			
Clause	Requirement – Test	Result - Remark	Verdict
8.2.13	Calculate the chemical heat release rate at each of the flows as follows:		Pass
	$HRR_t = \left[E \times \phi - (E_{CO} - E) \times \frac{1 - \phi}{2} \times \frac{X_{CO}}{X_{O_2}} \right] \times \frac{\dot{m}_e}{1 + \phi \times (\alpha - 1)} \times \frac{M_{O_2}}{M_a} \times (1 - X_{H_2O}^0) \times X_{O_2}^0$		Pass
8.2.14	The hydrocarbon content of the vent gas shall be measured using flame ionization detection.	See attachment 6	Pass
	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.	The hydrogen content was measured with a palladium-nickel thin-film solid state sensor.	Pass
	This may require multiple sensors to cover a wider range of concentrations depending on the anticipated cell off gas.	Complied	Pass
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.	A resolution of 0.5 cm ⁻¹ and a path length of 5.11 m See attachment 6	Pass
	Velocity and temperature measurements respectively shall be obtained in the exhaust duct of the heat release rate calorimeter using equipment.	See attachment 6	Pass
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.	Light transmission is integrated into the testing system	Pass
8.2.17	Smoke release rate shall be calculated as follows: $SSR = 2.303 \left(\frac{V}{D} \right) \log_{10} \left(\frac{I_0}{I} \right)$	See attachment 7	Pass
8.3	Module test method for high temperature batteries		--
8.3.1	The module test procedure shall be modified as below.	Not high temperature batteries	N/A
	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.		N/A
	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 shall be conducted on at least one cell within the module.	Refer to 7.3.4	N/A

ANSI/CAN/UL 9540A			
Clause	Requirement – Test	Result - Remark	Verdict
	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.		N/A
	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.		N/A
	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		--
8.4.1	The report on module level testing shall include the following:		Pass
	a) Module manufacturer name and model number (and whether UL 1973 compliant);	See module information.	Pass
	b) Number of cells in module;	See module information	Pass
	c) Module configuration with cells in series and parallel;	See module information	Pass
	d) Module construction features per 5.2;	See module information	Pass
	e) Module voltage corresponding to the tested SOC	See Attachment 2 and 3	Pass
	f) Thermal runaway initiation method was used including number and locations of cells for initiating thermal runaway;	See Attachment 3	Pass
	g) Heat release rate versus time data;	See Attachment 5	Pass
	h) Flammable gas generation and composition data;	See Attachment 6	Pass
	i) Peak smoke release rate and total smoke release data.	See Attachment 7	Pass
	j) Observation(s) of flying debris or explosive discharge of gases;	See Attachment 3	Pass
	k) Observation(s) of sparks, electrical arcs, or other electrical events;	See Attachment 3	Pass
	l) Identification/location of cell(s) that exhibited thermal runaway within the module;	See Attachment 4	Pass
	m) Locations and visual estimations of flame extension and duration from the module shall be documented;	See Attachment 3	Pass
	n) Module weight loss based on measurements per 8.2.3;	0.7 kg	Pass
	o) Video of the test;	2604B0501SHA-001-1~2.mp4 are provided in addition to this test report.	Pass

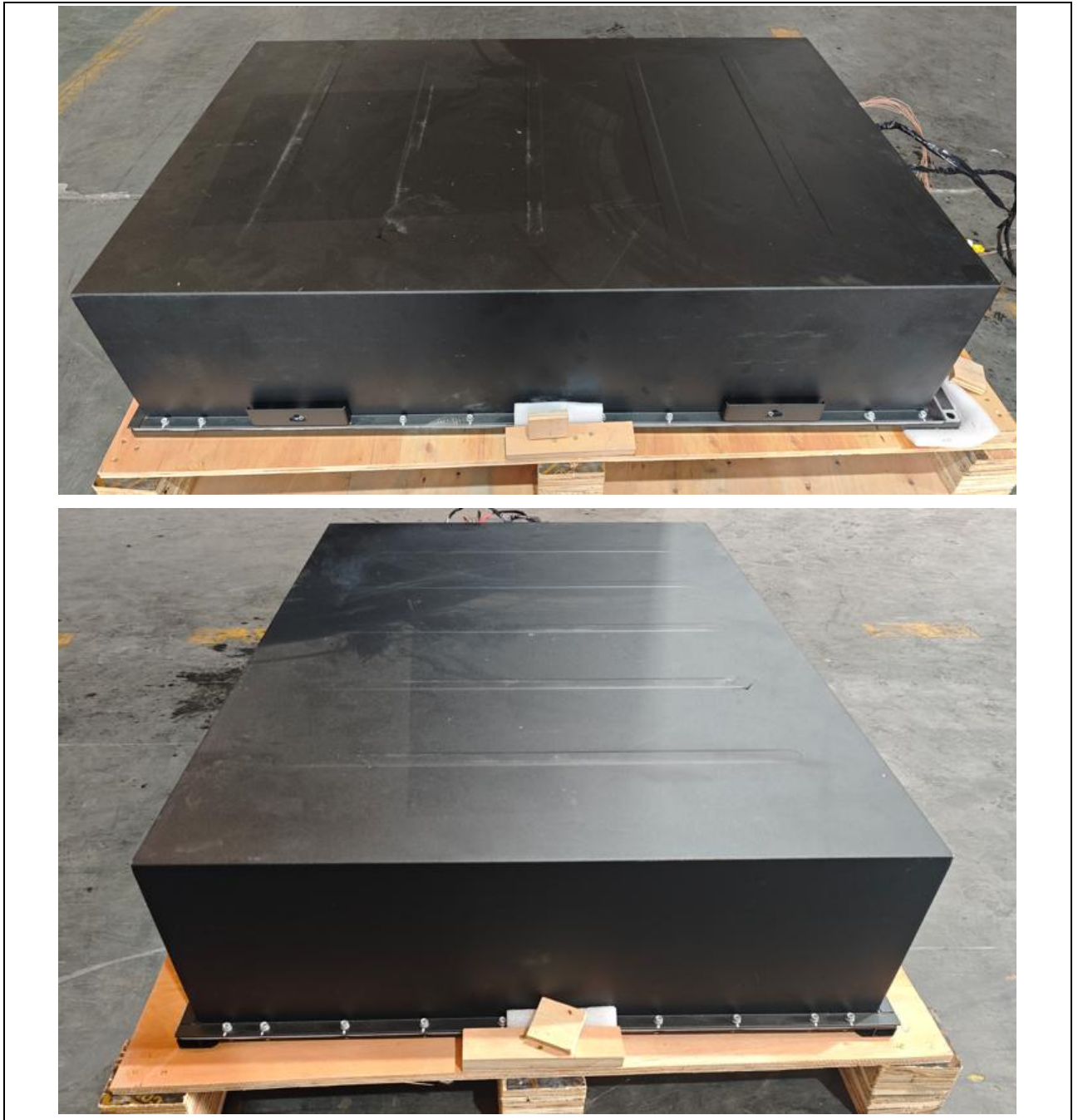
ANSI/CAN/UL 9540A			
Clause	Requirement – Test	Result - Remark	Verdict
	p) Cell level test report summary	See cell information	Pass
8.4.2	The report on the high temperature battery module level testing of 8.3 shall include the following:		N/A
	a) Module manufacturer name and model number (and whether UL 1973 compliant);	Not high temperature battery module	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;		N/A
	l) Video of the test.		N/A
8.5	Performance at module level testing		-- ¹⁾
8.5.1	Unit level testing is not required if all of the following performance conditions are met during the module level test:		Fail
	a) Vent gas is nonflammable as determined by the cell level test;	Vent gas is flammable as determined by the cell level test	Fail
	b) There is no spread of flame outside of the module; and	No spread of flame outside of the module	Pass
	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.	The module exterior surface temperature does not exceed the cell venting temperature	Pass
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

ANSI/CAN/UL 9540A			
Clause	Requirement – Test	Result - Remark	Verdict
	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
Remark: ¹⁾ Thermal runaway and propagation from cell to cell happened during test and no flame spread outside. Thermal runaway is contained by module design, and the module exterior surface temperature does not exceed the cell venting temperature, but cell vent gas is flammable as determined by the cell level test. According to the standard, a unit level testing in accordance with UL 9540A need to be conducted on a unit employing this module.			

Attachment 1 Photos

Overall view of the initiating module before test







Internal view of the initiating module before test





Voltage and weight of the initiating module before test



Module voltage after 1h rest [172.9 V]



Module voltage before test [172.9 V]

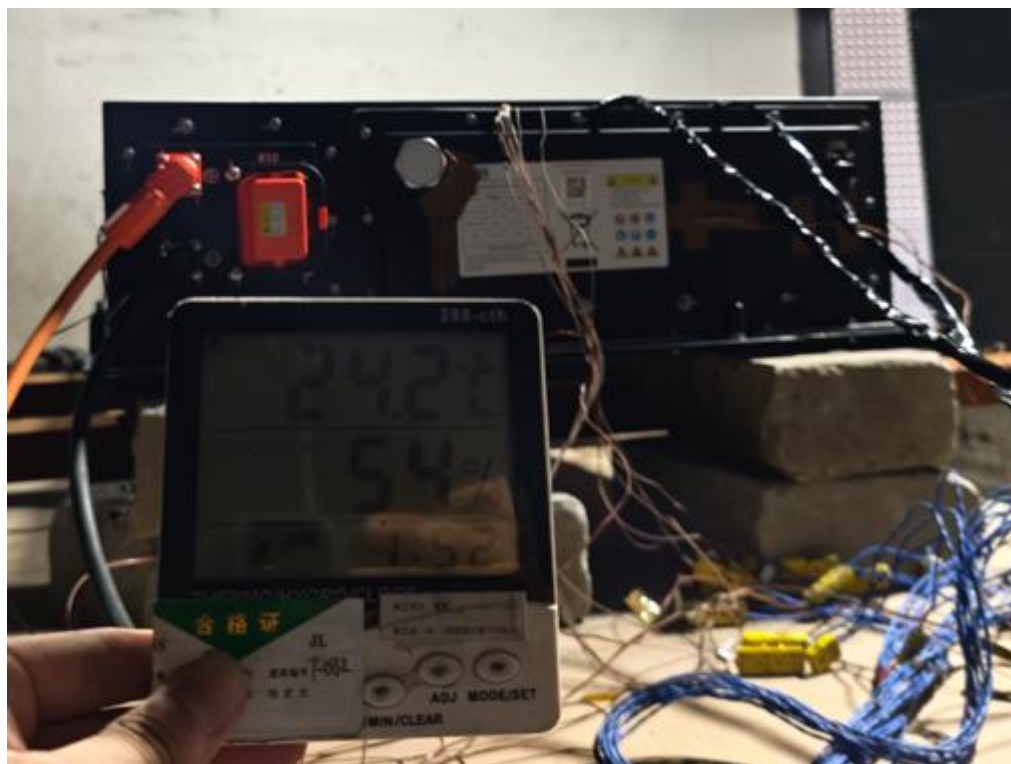


Module weight [353.3 kg]

Sample centered under smoke collection hood



Initial temperature and humidity



24.2°C and 54%RH

Thermal runaway propagation test



Test initiating [12:06]

Thermal runaway propagation test



1st cell vented [12:52]

Thermal runaway propagation test



1st cell thermal runaway induced [13:04].

Time for cell thermal runaway induced

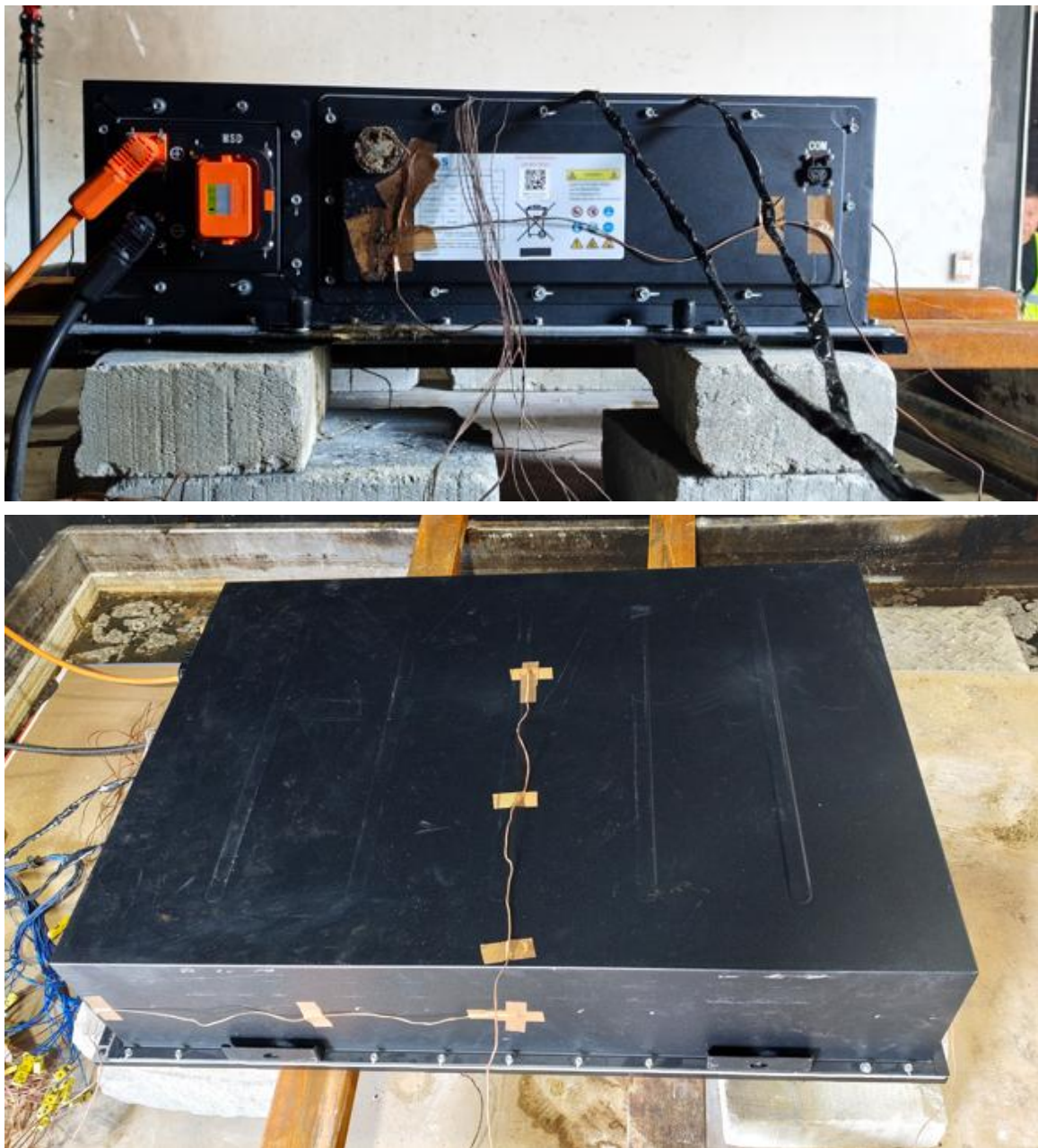


1st cell thermal runaway induced [13:04]



2nd cell thermal runaway induced [13:16]

Overall view of the initiating module after the test





Voltage and weight of the initiating module after test



Module voltage [153.3 V]



Module weight [352.6 kg]

Internal view of the initiating module after the test





3 cells relief valves ruptured (cell 31 to cell 33)
2 cells thermal runaway induced (cell 32 and cell 33)

Attachment 2 Module Conditioning (charge/discharge) profiles

The module was conditioned, prior to testing, through charge and discharge cycles for 2 cycles using a manufacturer specified methodology to verify that the module is functional.

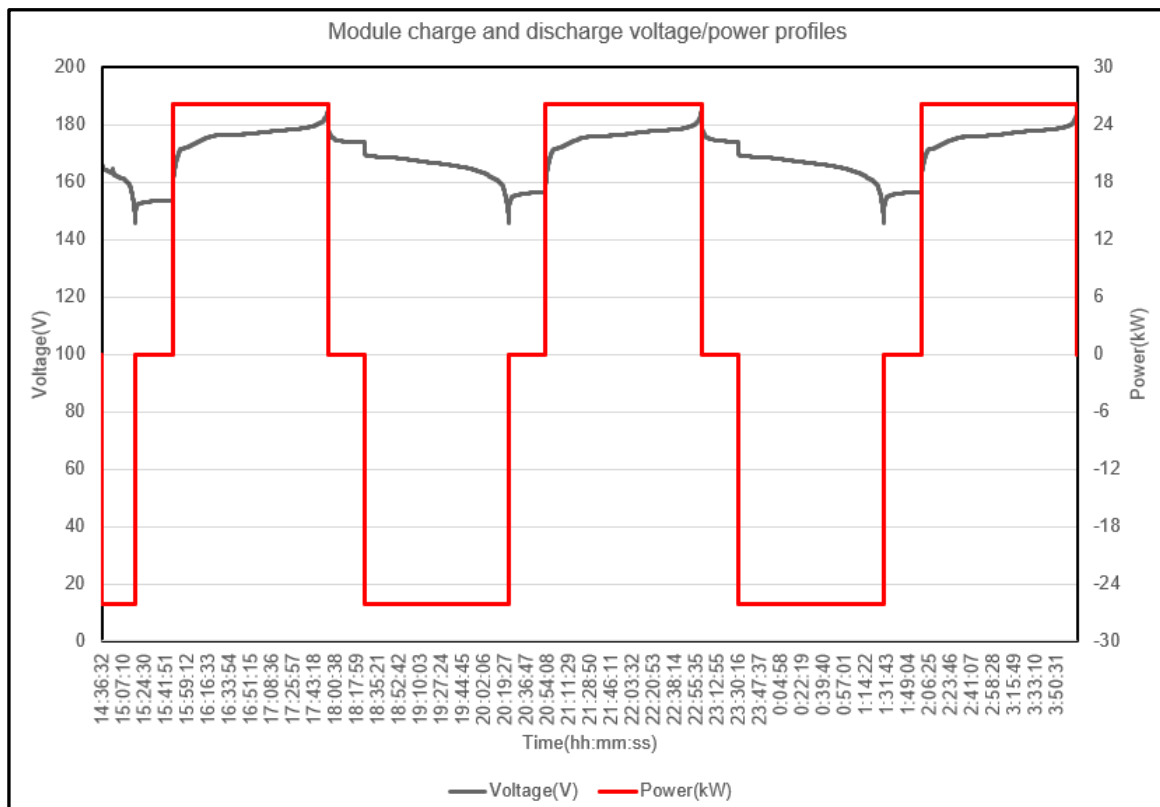
As manufacturer specified, the module was firstly discharged to end of discharge voltage 145.6V with constant power 26.12kW and then rested 30 minutes.

Then the cycles of charging and discharging were stated below and each cycle was charged to 100% SOC.

The module was charged to end of charge voltage 184.6V with constant power 26.12kW and then rested 30 minutes.

Next, the module was discharged to end of discharge voltage 145.6V with constant power 26.12kW and then rested 30 minutes.

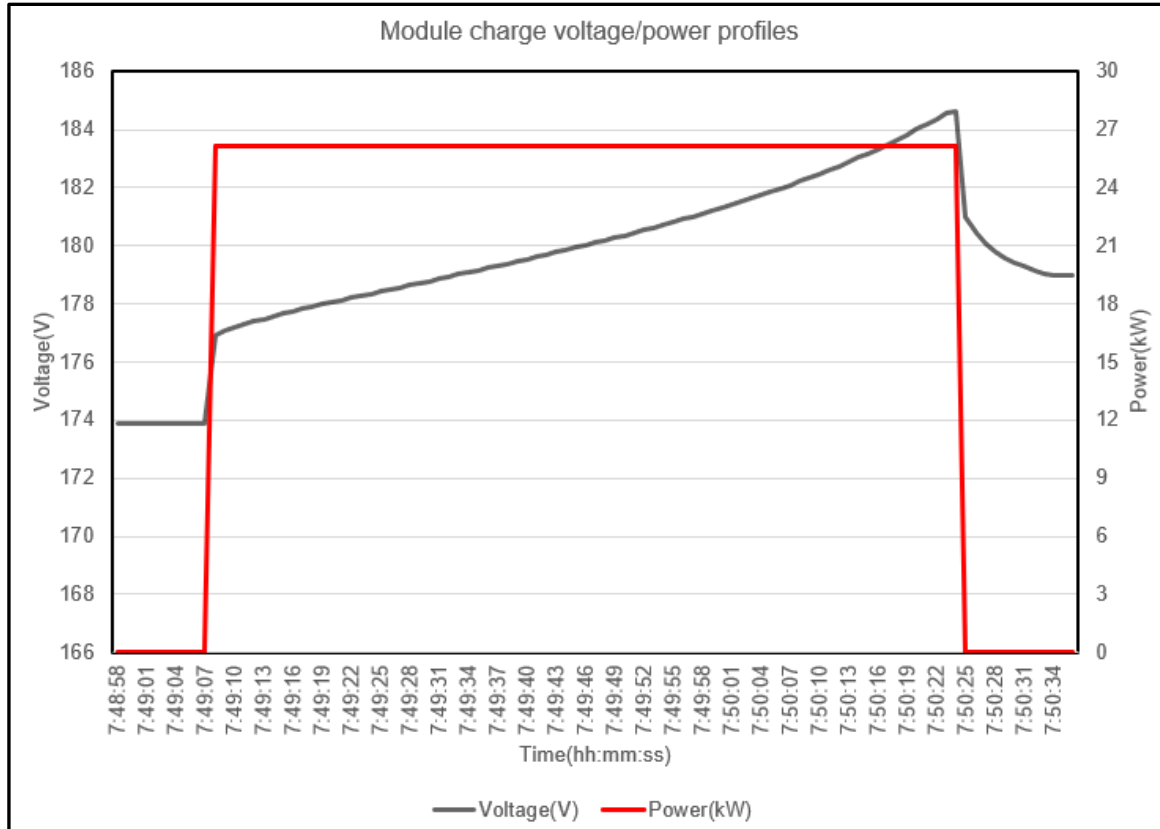
After repeating the cycles of charging and discharging above twice and then module was fully charged to 100% SOC with constant power 26.12kW to module end charge voltage 184.6V.



Module charge and discharge voltage/power profiles

Before testing, the module was stabilized for more than 8 hours.

Then the module was repeatedly charged with constant power 26.12kW to module end charge voltage 184.6V.



Module charge voltage/power profiles

Before testing, the module was stabilized for about 4.3 hours.

During conditioning the ambient temperature and humidity were maintained at $25 \pm 5^{\circ}\text{C}$ and $50 \pm 25\%$ RH.

Rated capacity	Full charge capacity	Tested SOC
314Ah	316Ah	100.6%
Charge complete date and time	Module test date and time	Rest time
2026.06.05 04:07	-	-
2026.06.09 07:50	2026.06.09 12:06	4.3h
Module voltage after 1h rest	Module voltage before test	Voltage drop
172.9V	172.9V	0 %

Tested SOC, charge completion and module test initiation times

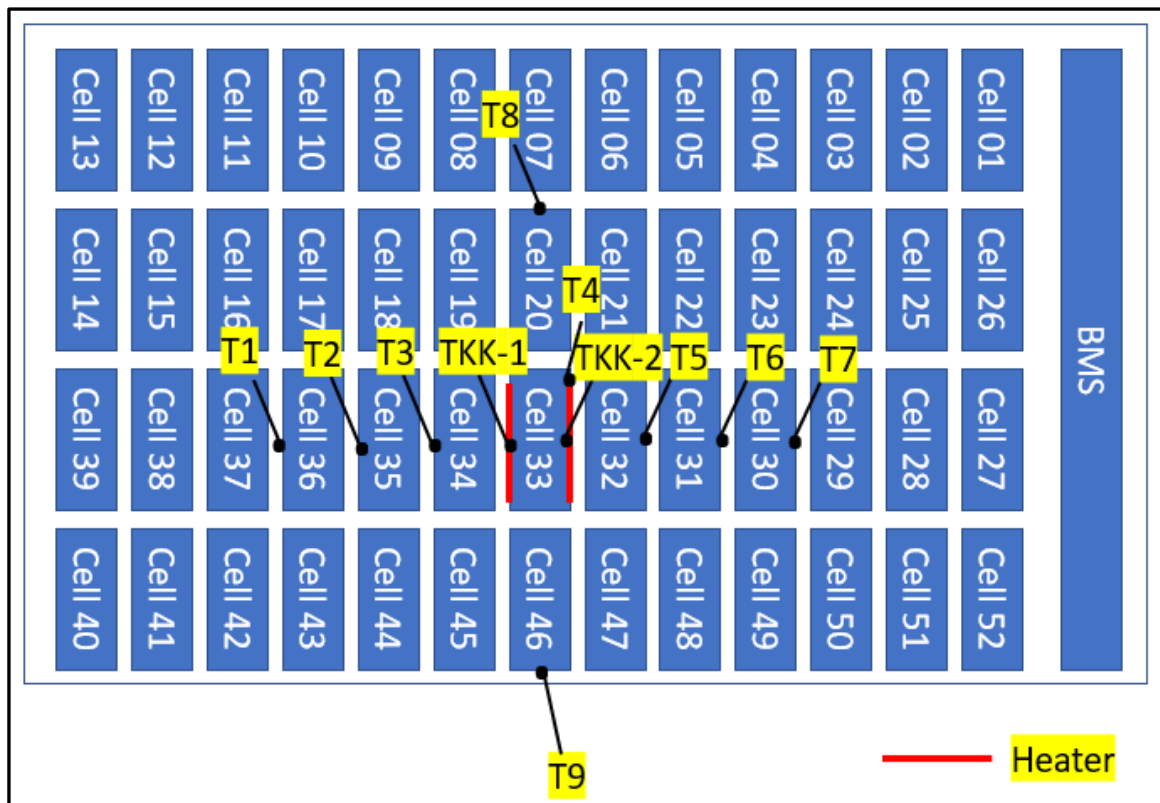
Attachment 3 Module thermal runaway record

The propensity of the cell to exhibit thermal runaway was demonstrated by heating the cell with externally applied flexible film heaters that cover as much of the cell case as possible without covering safety features and terminals, for consistent heating of the internal cell electrode assembly.

So, external heating method was used to initiate thermal runaway in the module.

2 flexible film heaters, rated 220VAC/900W, sized 160*190mm, were pasted on two wide sides of cell 33.

See below figure for detailed location of the flexible film heater.



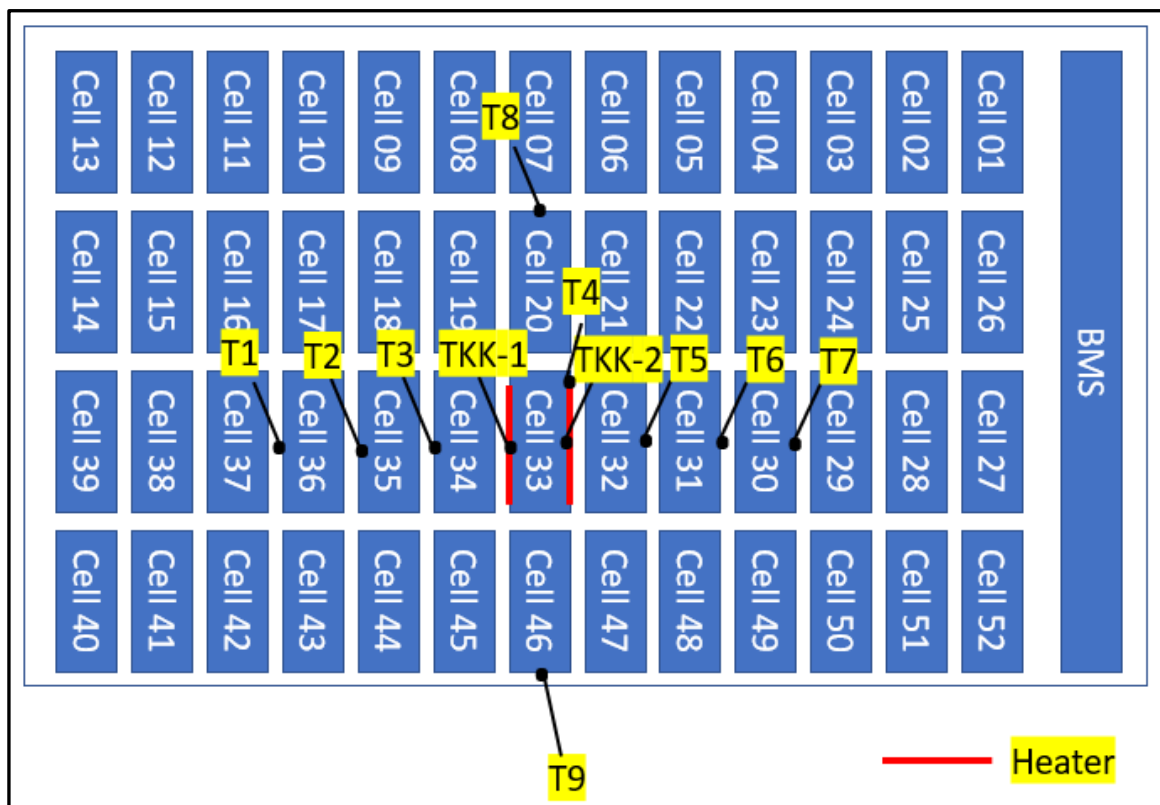
The detailed locations of flexible film heater

To monitor the temperature of cells inside the module, 9 thermocouples (T1 to T9), Type K, were used and thermocouples were attached on the surface of cells.

A heating ramp rate of 4.5°C (4°C to 7°C) per minute was applied to cell 33 surface. The heating ramp rate of the heaters applied to the cell 33 surface were measured with 2 thermocouples (TKK-1 and TKK-2), type K, placed under 2 heaters.

The cell 33 surface temperature was determined by 1 thermocouple (T4), type K, placed in a representative position to ensure measurement of the cell 33 surface which was less influenced by the heater.

See below figures and table for detailed location of the thermocouples.



Location of thermocouples inside the module

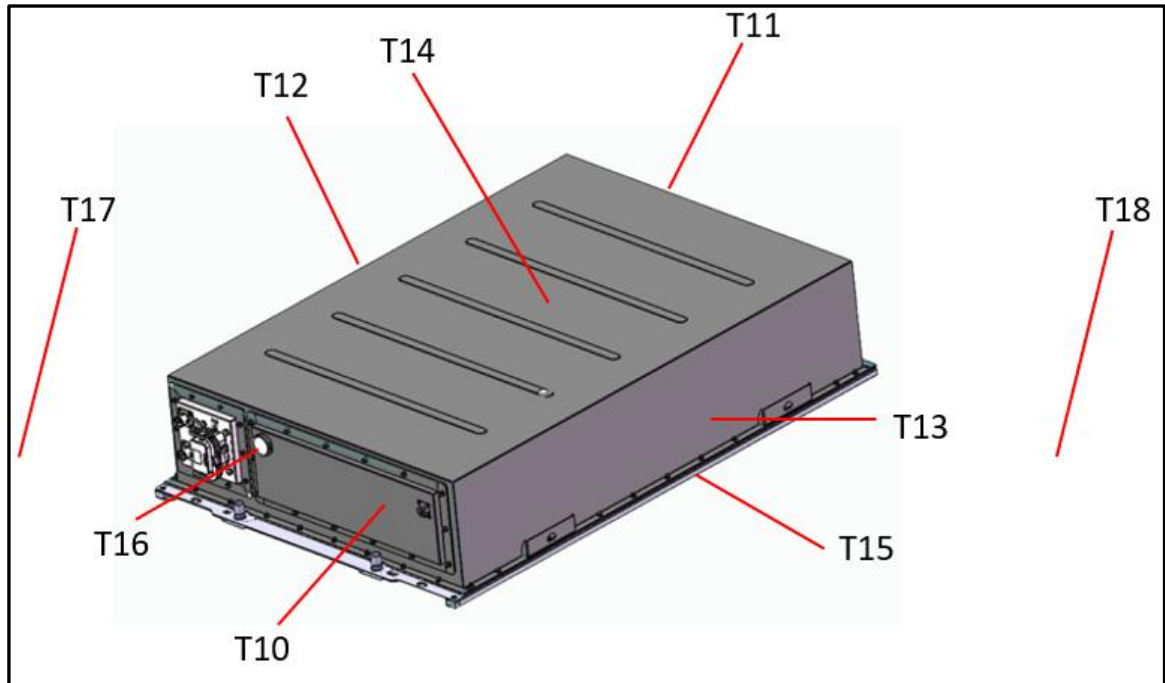
Location of thermocouples inside the module is shown in the table below.

Thermocouple No.	Location of thermocouples inside the module
T1	Center of Cell 36 wide surface, facing Cell 37
T2	Center of Cell 35 wide surface, facing Cell 36
T3	Center of Cell 34 wide surface, facing Cell 35
T4	Edge of Cell 33 wide surface, near flexible film heater
T5	Center of Cell 32 wide surface, facing Cell 31
T6	Center of Cell 31 wide surface, facing Cell 30
T7	Center of Cell 30 wide surface, facing Cell 29
T8	Center of Cell 20 narrow surface, facing Cell 07
T9	Center of Cell 46 narrow surface, facing enclose
TKK-1	Center of Cell 33 wide surface, under flexible film heater, facing Cell 34
TKK-2	Center of Cell 33 wide surface, under flexible film heater, facing Cell 32

Additional 6 thermocouples (T10 to T15), Type K, were located on the surface of module to monitor the module enclosure temperatures during the test.

2 thermocouples (T17 and T18), Type K, were placed near the module to monitor the ambient temperature during the test.

See below figure and table for detailed location of thermocouples. Module orientation as intended for final installation.



Location of external thermocouples of the module

Thermocouple No.	Location
T10	Center of initiating module front surface
T11	Center of initiating module rear surface
T12	Center of initiating module left surface
T13	Center of initiating module right surface
T14	Center of initiating module top surface
T15	Center of initiating module bottom surface
T16	In front of relief valve
T17	Near the module, ambient temperature
T18	Near the module, ambient temperature

Cell 33 was heated as the target cell at a heating ramp rate of 4°C-7°C per minute (4.5°C /min) by TKK-1 and TKK-2 until thermal runaway occurred. Below table summarizes the details:

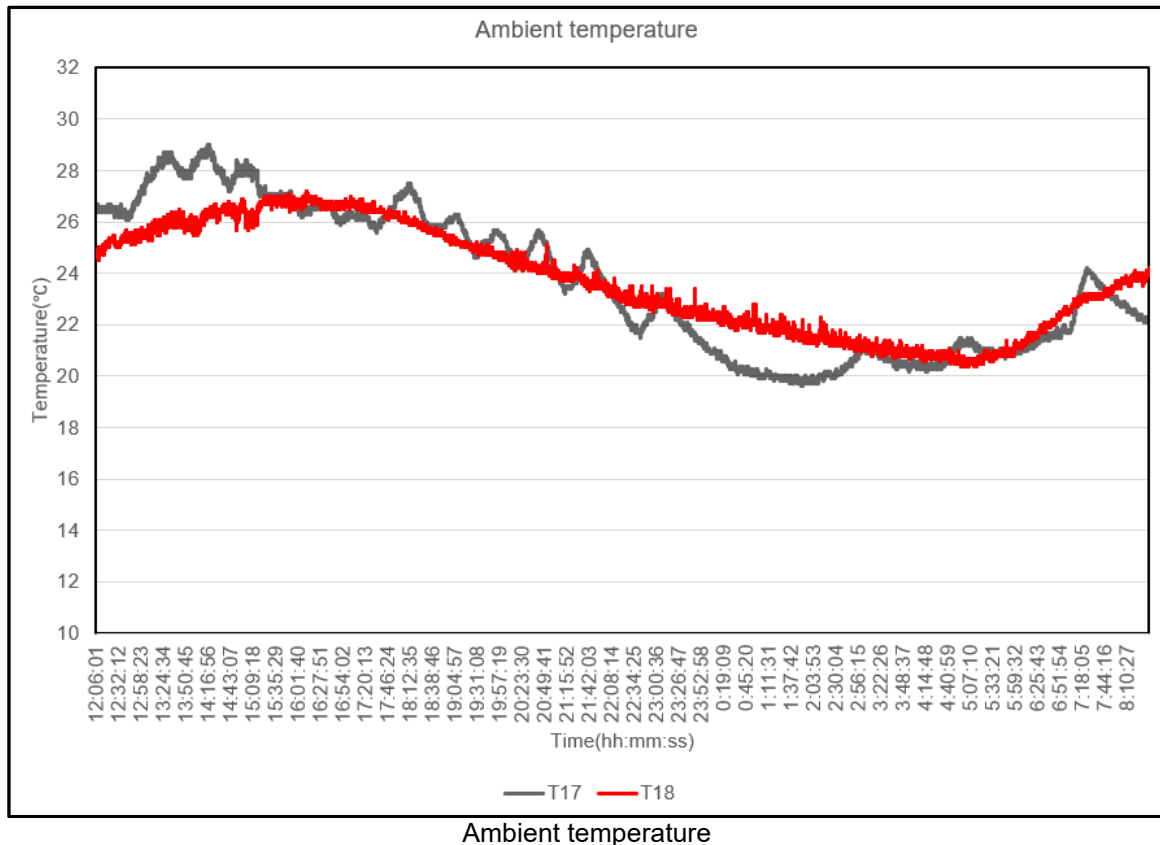
Ambient conditions at the initiation of the test:	24.2°C, 54%RH (measured by ambient monitor)			
Module voltage before test:	172.9 V			
Module weight before test	353.3 kg (with test auxiliary material)			
Time when test was initiated:	2026.06.09 12:06			
Observations during test:	1 st vented	12:52 (Cell 33)	1 st thermal runaway	13:04 (Cell 33)
	2 nd vented	13:07 (Cell 32)	2 nd thermal runaway	13:16 (Cell 32)
	3 rd vented	13:30 (Cell 31)	3 rd thermal runaway	/
	No flying debris or explosive discharge of gases. No sparks, electrical arcs, or other electrical events. No external flaming was observed			
Post-test evaluation:	1 cell went to thermal runaway due to external heating. 1 cell vented and went to thermal runaway due to thermal runaway propagation and 1 cell vented without thermal runaway.			
Time when test was terminated:	2026.06.10 08:00			
Module voltage after test:	153.3 V			
Module voltage loss:	19.6V			
Number of cells vented:	3 cells (cell 31 to cell 33)			
Number of cells went to thermal runaway:	2 cells (cell 32 and cell 33)			
Module weight after test:	352.6 kg (with test auxiliary material)			
Module weight loss:	0.7 kg			

Attachment 4 Temperature and voltage profile during test

At the start of the test, ambient indoor laboratory conditions measured by ambient monitor were $25 \pm 5^{\circ}\text{C}$ (24.2°C) and $50 \pm 25\%$ RH (54% RH) at the initiation of the test.

During the test, the room ambient temperature wasn't less than 10°C nor more than 32°C and the test room environment was controlled to prevent drafts that may affect test results.

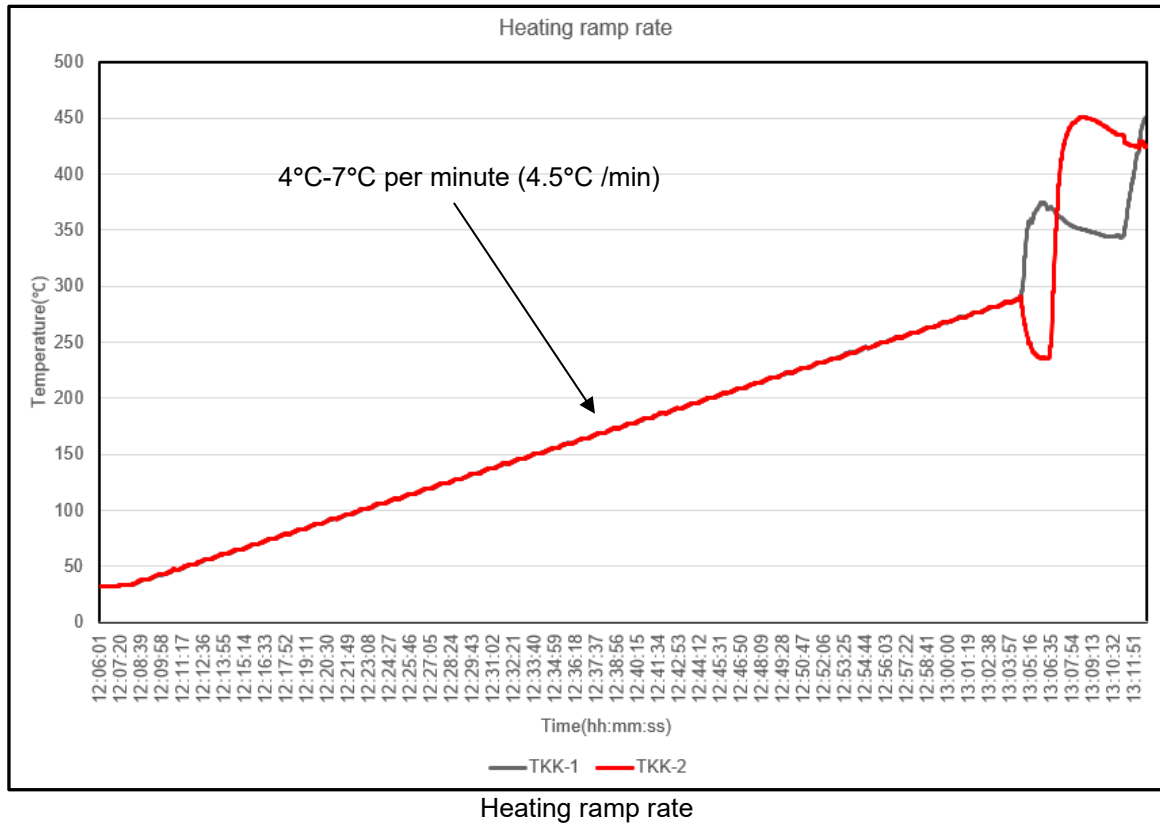
To monitor the ambient temperature, 2 thermocouples (T17 and T18), Type K were used. See below figure for detailed information of the thermocouple's temperature curve during test.



See below table for detailed information of the thermocouple's temperature range during test.

Thermocouple No.	Temperature range ($^{\circ}\text{C}$)
T17	$19.6^{\circ}\text{C} \sim 29.0^{\circ}\text{C}$
T18	$20.4^{\circ}\text{C} \sim 27.2^{\circ}\text{C}$

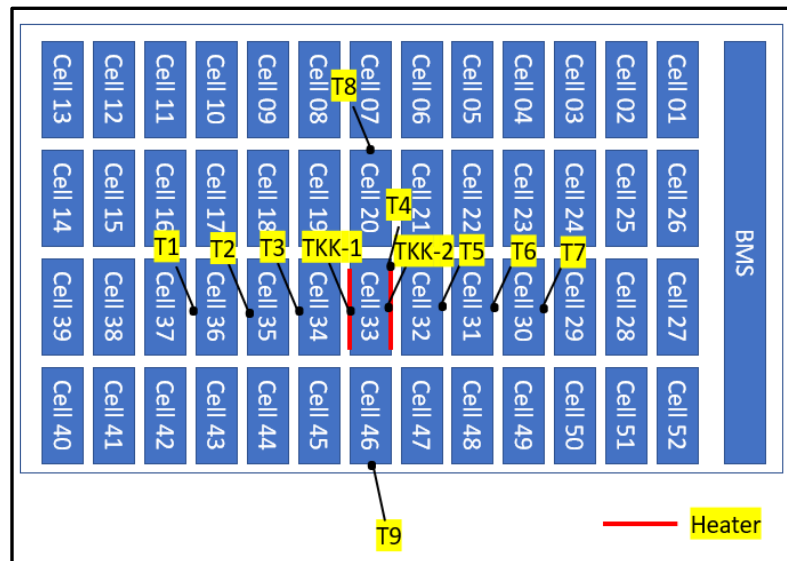
TKK-1 and TKK-2 were used to monitor the heating ramp rate of 4°C-7°C per minute (4.5°C /min). See below figure for detailed information of the heating ramp rate curve during test.



See below table for detailed information of the heating rate during test.

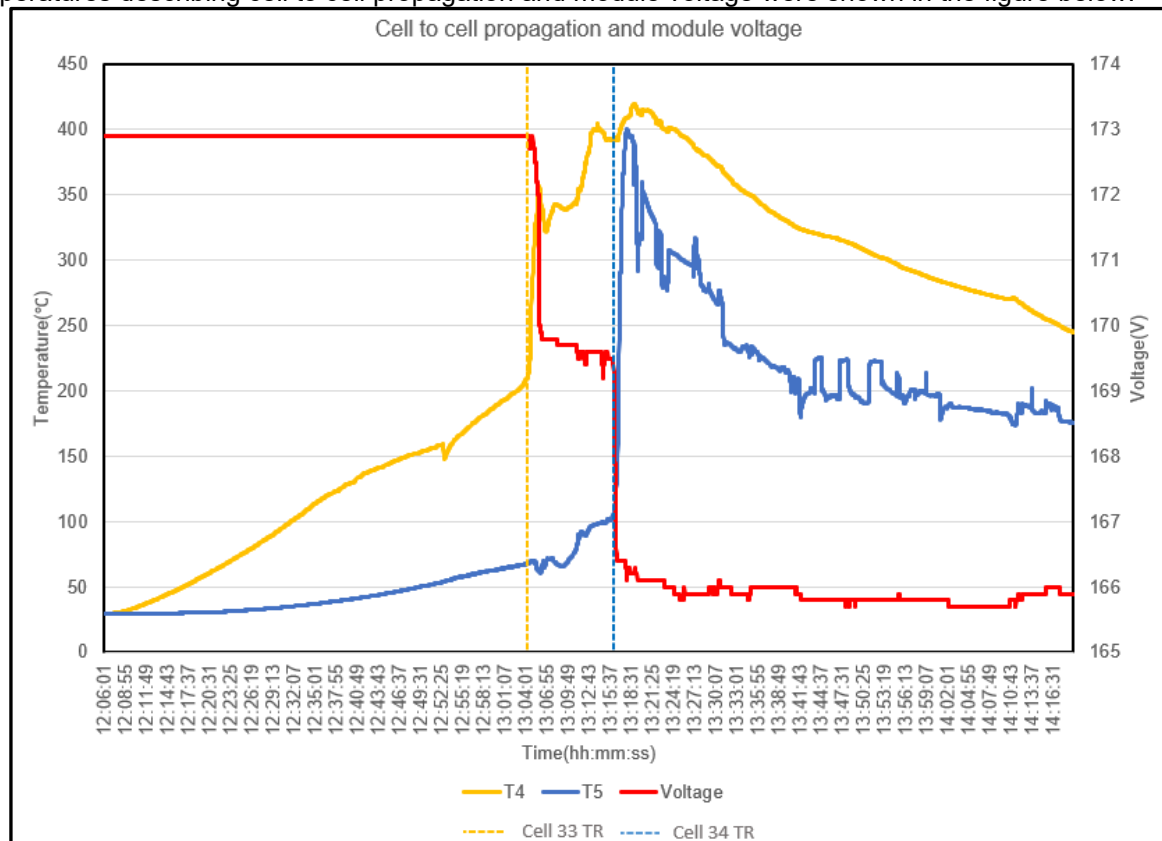
Thermocouple No.	Time and temperature for energizing	Time and temperature for de-energizing	Heating rate
TKK-1	12:07, 29.7°C	13:04, 287.1°C	4.5°C/min
TKK-2	12:07, 29.7°C	13:04, 286.8°C	4.5°C/min

Module structure diagram and cell series configuration with cell numbered is shown in the figure below.



Module structure diagram

Temperatures describing cell to cell propagation and module voltage were shown in the figure below.



Cell to cell propagation and module voltage

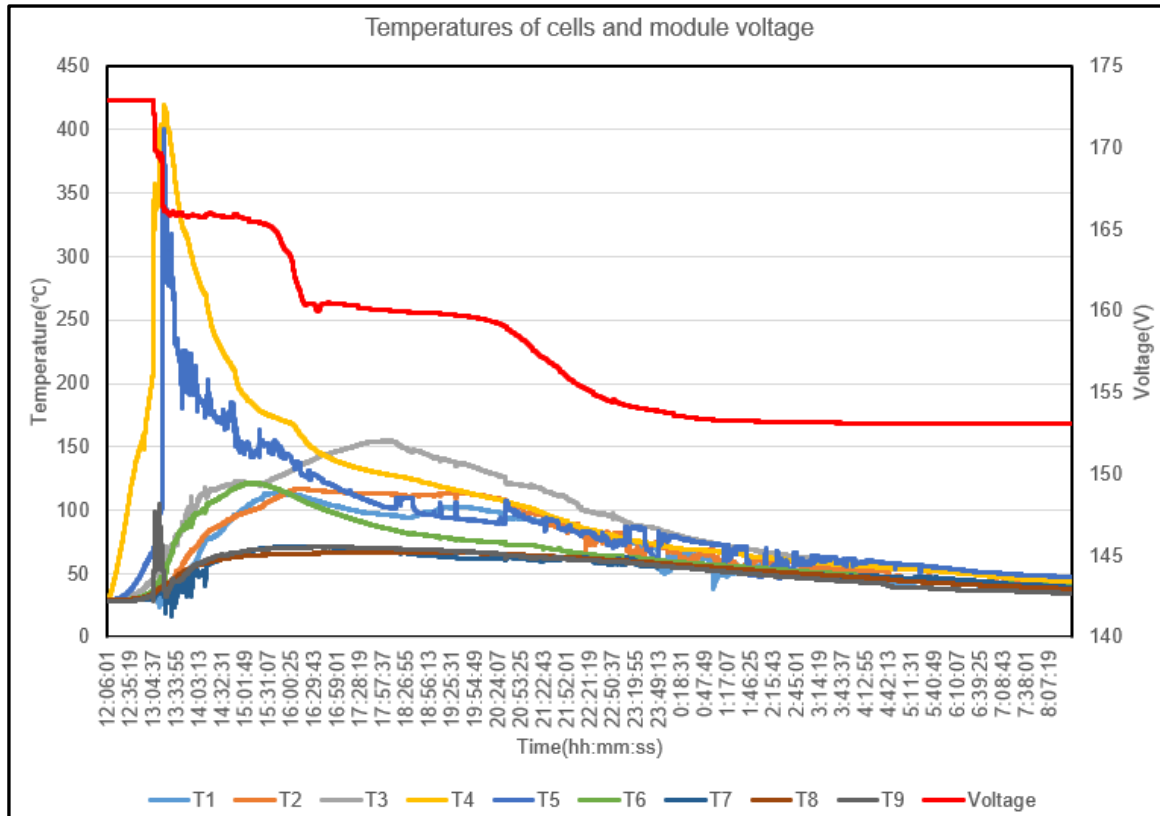
1 cell went to thermal runaway due to external heating.

1 cell vented and went to thermal runaway due to thermal runaway propagation and 1 cell vented without thermal runaway.

To monitor the temperature of cells inside the module, 9 thermocouples (T1 to T9), Type K, were used and thermocouples were attached on the surface of cells.

The cell 33 surface temperature was determined by one thermocouple (T4), type K, placed in a representative position to ensure measurement of the cell 33 surface which was less influenced by the heater.

See below figure for detailed temperatures of the thermocouples.

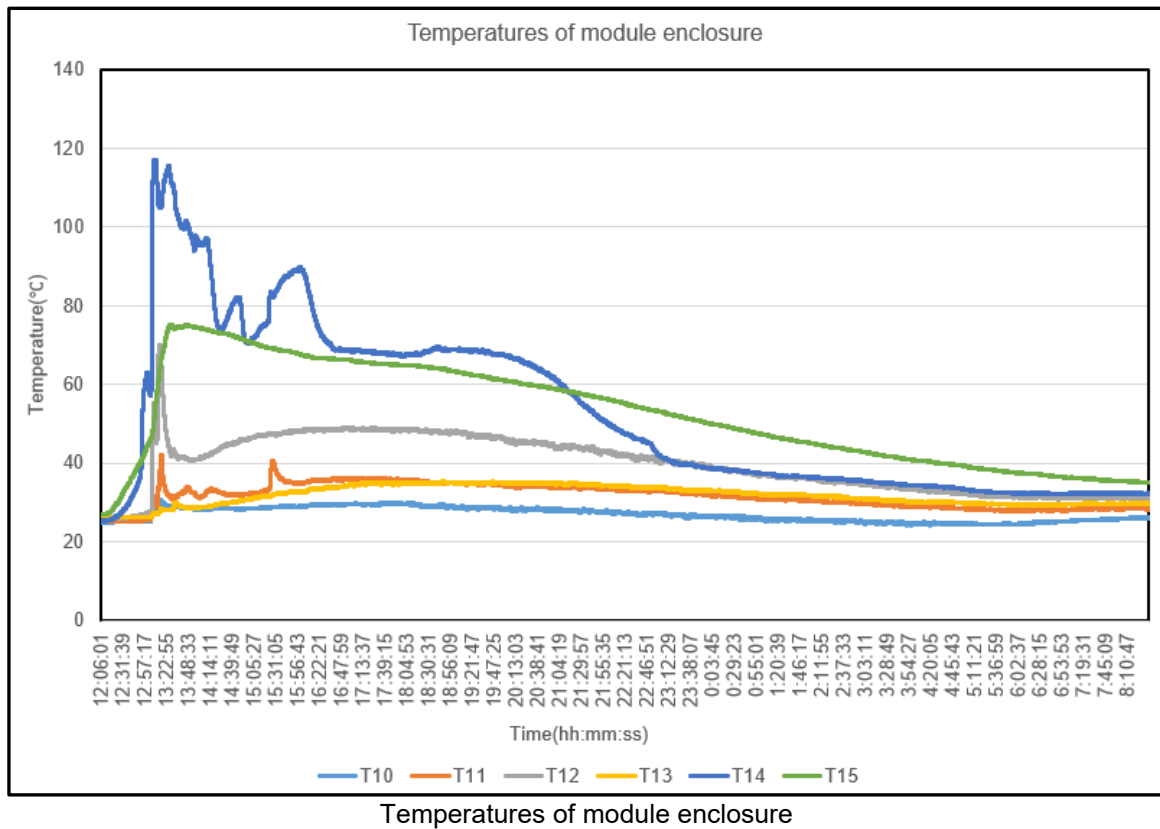


Temperatures of cells and module voltage

The maximum measured temperatures of cells are shown in the table below.

Thermocouple No.	Maximum measured temperature (°C)	Thermocouple No.	Maximum measured temperature (°C)
T1	113.6	T6	121.5
T2	116.9	T7	71.8
T3	154.7	T8	67.2
T4	419.6	T9	105
T5	400.6	/	/

The temperatures of module enclosure during the test are shown in the figure below.



The maximum measured temperatures of each location are shown in the table below.

Thermocouple No.	Maximum measured temperature (°C)
T10	30.8
T11	42.2
T12	69.9
T13	35.6
T14	117.1
T15	75.2

Attachment 5 Chemical heat release rate measurement

The chemical heat release rate was measured by a measurement system consisting of a paramagnetic oxygen analyser, non-dispersive infrared carbon dioxide and carbon monoxide analyser, velocity probe, and a Type K thermocouple.

The instrumentation was located in the exhaust duct of the heat release rate calorimeter at a location that minimizes the influence of bends or exhaust devices.

Calculate the chemical heat release rate at each of the flows as follows

$$HRR_t = \left[E \times \phi - (E_{CO} - E) \times \frac{1 - \phi}{2} \times \frac{X_{CO}}{X_{O_2}} \right] \times \frac{\dot{m}_e}{1 + \phi \times (\alpha - 1)} \times \frac{M_{O_2}}{M_a} \times (1 - X_{H_2O}^0) \times X_{O_2}^0$$

In which: HRR_t = total heat release rate, as a function of time (kW)

E = Net heat released for complete combustion per unit of oxygen consumed (adjusted for oxygen contained within cell chemistry, 13,100 kJ/kg)

E_{CO} = Net heat released for complete combustion per unit of oxygen consumed, for CO (adjusted for oxygen contained within cell chemistry, 17,600 kJ/kg)

ϕ = Oxygen depletion factor (non-dimensional), where:

$$\phi = \frac{X_{O_2}^0 \times [1 - X_{CO_2} - X_{CO}] - X_{O_2} \times [1 - X_{CO_2}^0]}{X_{O_2}^0 \times [1 - X_{O_2} - X_{CO_2} - X_{CO}]}$$

X_{CO} = Measured mole fraction of CO in exhaust flow (non-dimensional)

X_{CO_2} = Measured mole fraction of CO₂ in exhaust flow (non-dimensional)

$X_{CO_2}^0$ = Measured mole fraction of CO₂ in incoming air (non-dimensional)

$X_{H_2O}^0$ = Measured mole fraction of H₂O in incoming air (non-dimensional)

X_{O_2} = Measured mole fraction of O₂ in exhaust flow (non-dimensional)

$X_{O_2}^0$ = Measured mole fraction of O₂ in exhaust flow (non-dimensional)

α = Combustion expansion factor (non-dimensional; normally a value of 1.105)

M_a = Molecular weight of incoming and exhaust air (29 kg/kmol)

M_{O_2} = Molecular weight of oxygen (32 kg/kmol)

$\dot{m}_e$ = Mass flow rate in exhaust duct (kg/s), in which:

$$\dot{m}_e = C \times \sqrt{\frac{\Delta P}{T_e}}$$

or

$$\dot{m}_e = 26.54 \times \frac{A \times k_c}{f(Re)} \sqrt{\frac{\Delta P}{T_e}}$$

C = Orifice plate coefficient (in kg^{1/2}m^{1/2}K^{1/2})

Δp = Pressure drop across orifice plate or bidirectional probe (Pa)

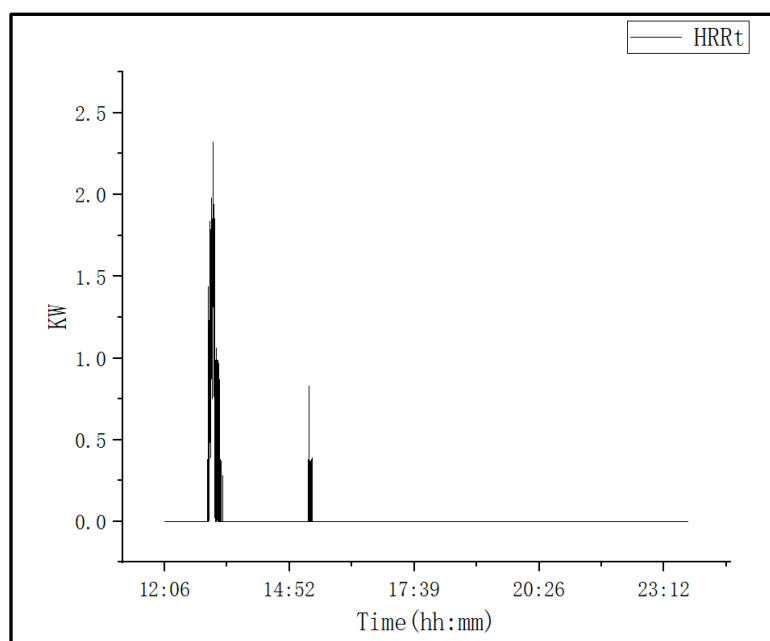
T_e = Combustion gas temperature at orifice plate or bidirectional probe (K)

A = Cross sectional area of the duct (m²)

k_c = Velocity profile shape factor (non-dimensional)

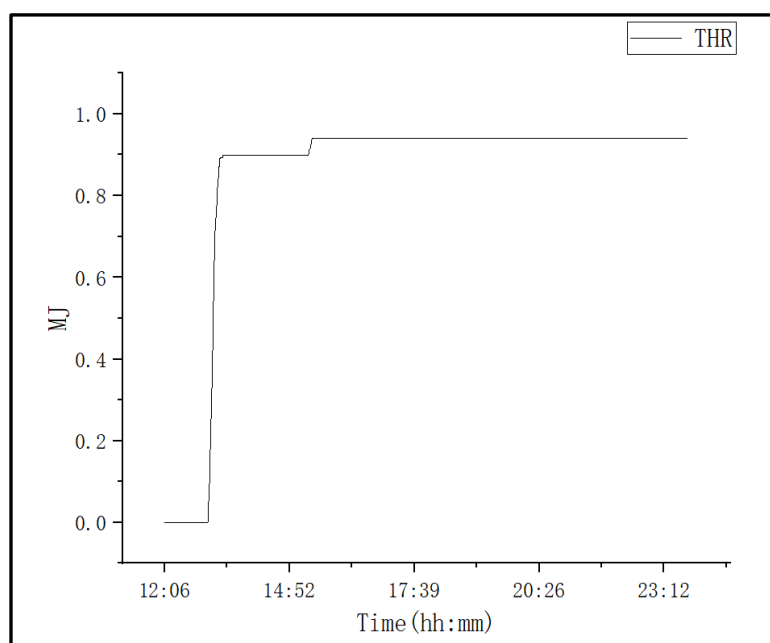
$f(Re)$ = Reynolds number correction (non-dimensional)

Measured peak chemical heat release rate $HRR_t=2.32$ kW (No flaming occurred)



Heat release rate versus time

Measured peak total chemical heat release rate $THR=0.94$ MJ (No flaming occurred)



Total chemical heat release rate versus time

Attachment 6 Gas generation measurement

Vent gas composition was measured using a Fourier-Transform Infrared Spectrometer with a resolution of 0.5 cm^{-1} and a path length of 5.11m within the calorimeter's exhaust duct. And the composition, velocity and temperature of the vent gases were measured within the calorimeter's exhaust duct.

The hydrocarbon content of the vent gas was measured using flame ionization detection.

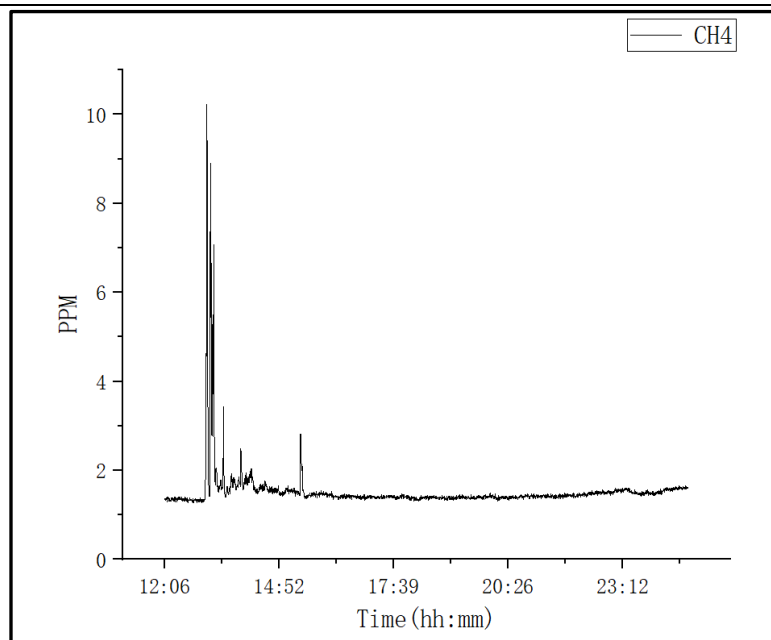
The Hydrogen content was measured with a palladium-nickel thin-film solid state sensor.

The gas composition and volume are shown in below table.

Gas type	Gas components		Volume (L)
Hydrocarbon species	Methane	CH ₄	10.572
	Acetylene	C ₂ H ₂	Not detected
	Ethylene	C ₂ H ₄	5.28
	Ethane	C ₂ H ₆	1.049
	Propylene	C ₃ H ₆	Not detected
	Propane	C ₃ H ₈	0.526
Hydrogen halide species	Hydrogen Cyanide	HCN	Not detected
	Hydrogen Chloride	HCL	Not detected
	Hydrogen Fluoride	HF	Not detected
	Hydrogen bromide	HBr	Not detected
Nitrogen containing species	Nitrogen Monoxide	NO	Not detected
	Nitrogen Dioxide	NO ₂	Not detected
	Nitrous Oxide	N ₂ O	Not detected
Other species	Carbon Monoxide (NDIR)	CO	37.7
	Carbon Dioxide (NDIR)	CO ₂	85.2
	Hydrogen (Palladium nickel thin film solid state sensor)	H ₂	72.2
	Carbonyl Sulfide	COS	0.288
	Oil as octane	/	0.224
	Diethyl carbonate	C ₅ H ₁₀ O ₃	0.137
	Dimethyl carbonate	C ₃ H ₆ O ₃	16.231
	Ethylene oxide	C ₂ H ₄ O	Not detected
	Ethyl methyl carbonate	C ₄ H ₈ O ₃	1.87
	Formaldehyde	CH ₂ O	Not detected
	Methanol	CH ₄ O	Not detected
	Ammonia	NH ₃	Not detected
Total Hydrocarbons (equivalent to CH ₄ , measured by FID)			164.2

Concentration of different gas components according to gas species classification was displayed as following graphs.

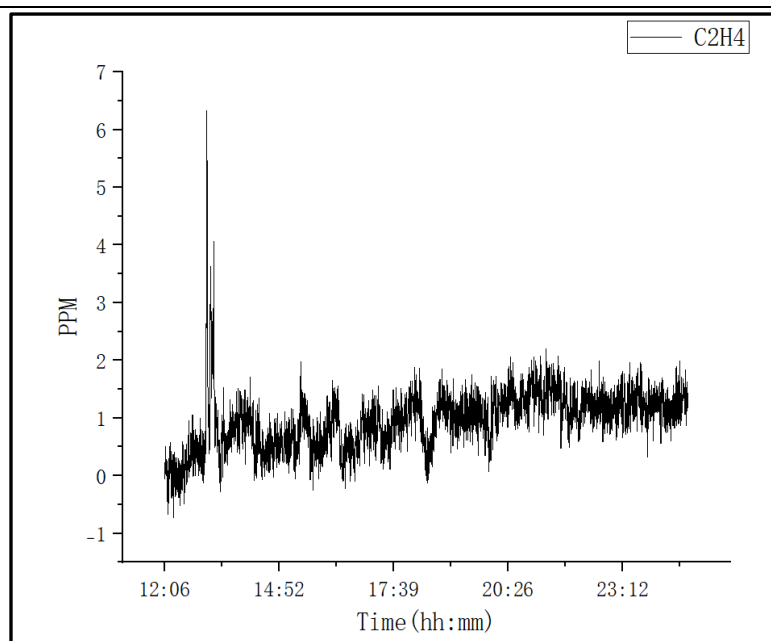
Hydrocarbon species



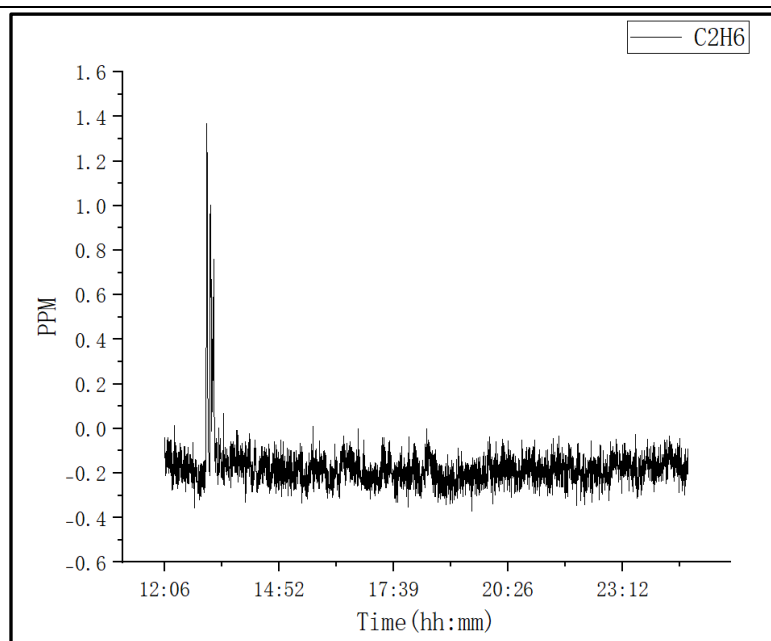
Concentration of Methane (CH_4)

/

Concentration of Acetylene (C_2H_2)



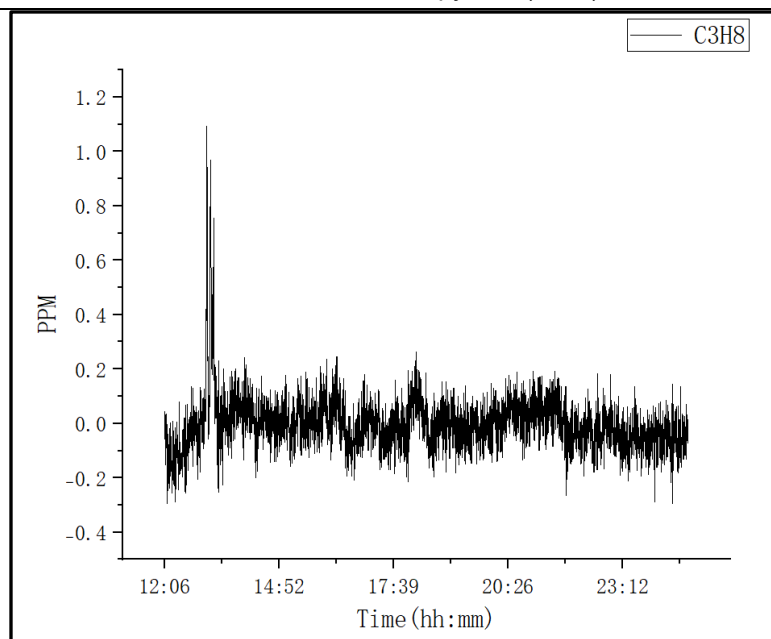
Concentration of Ethylene (C_2H_4)



Concentration of Ethane (C_2H_6)

/

Concentration of Propylene (C_3H_6)

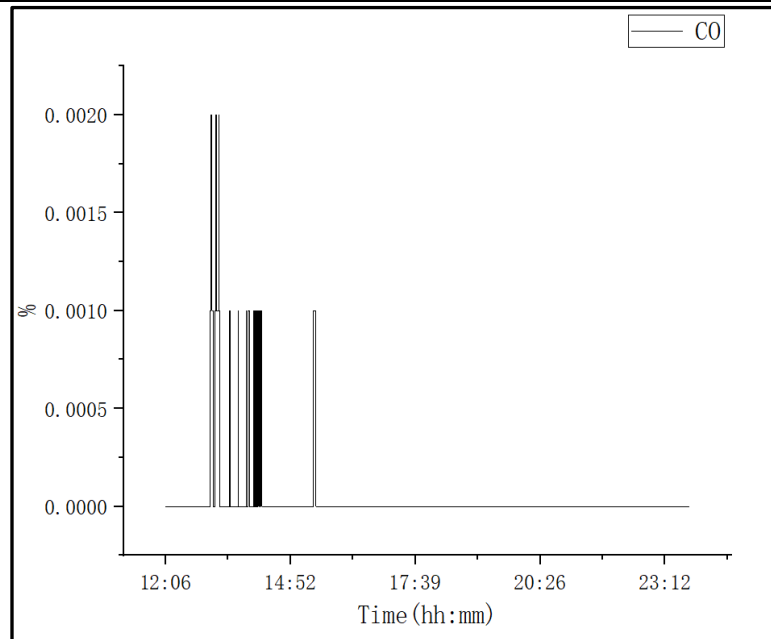


Concentration of Propane (C_3H_8)

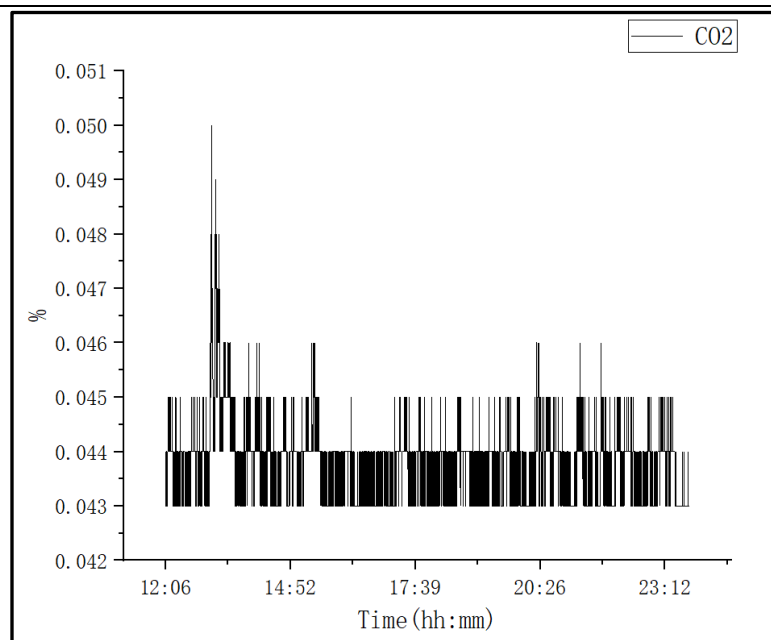
Hydrogen halide species
/
Concentration of Hydrogen Cyanide (HCN)
/
Concentration of Hydrogen Chloride (HCL)
/
Concentration of Hydrogen Fluoride (HF)
/
Concentration of Hydrogen bromide (HBr)

Nitrogen containing species
/
Concentration of Nitrogen Monoxide (NO)
/
Concentration of Nitrogen Dioxide (NO ₂)
/
Concentration of Nitrous Oxide (N ₂ O)

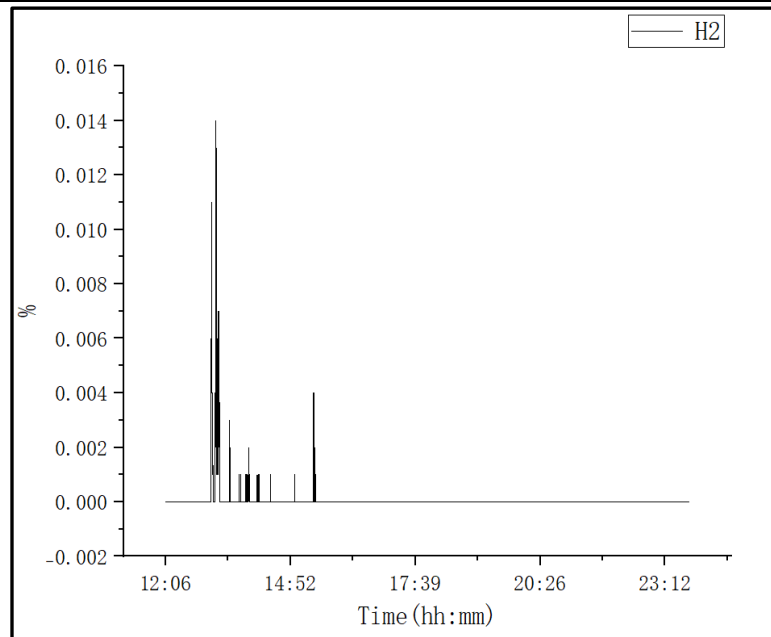
Other species



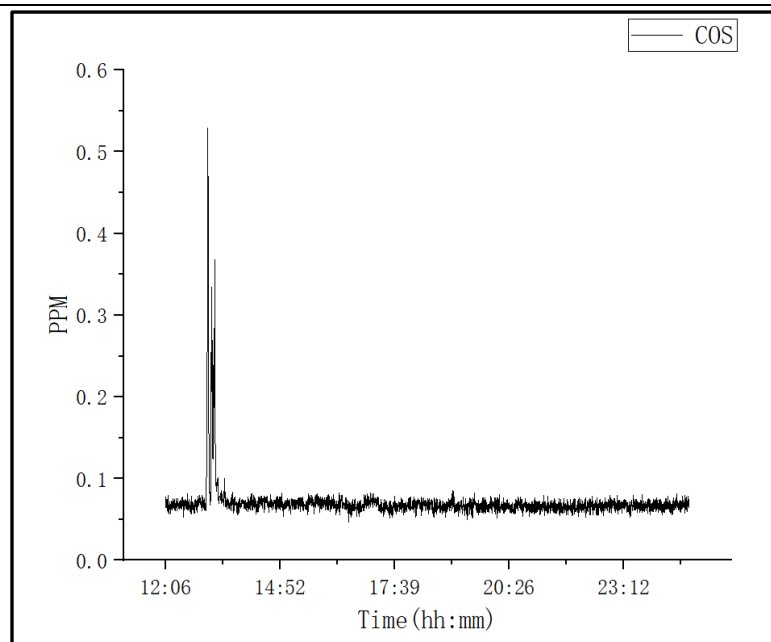
Concentration of Carbon Monoxide (CO) (NDIR)



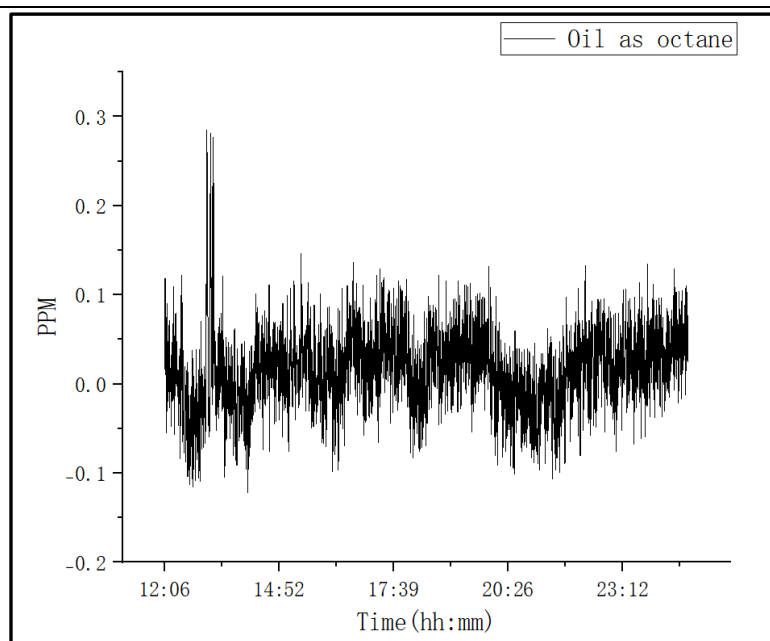
Concentration of Carbon Dioxide (CO₂) (NDIR)



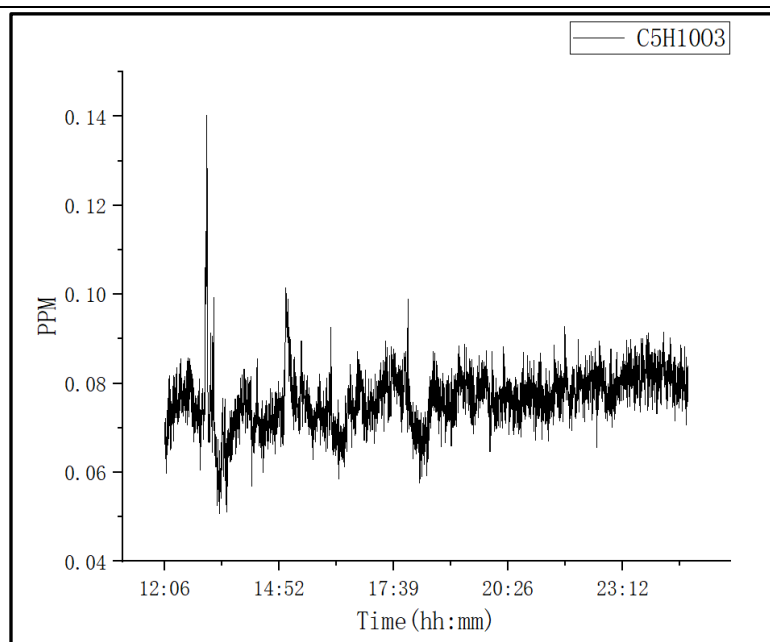
Concentration of Hydrogen (H_2) (Test by Palladium nickel thin film solid state sensor)



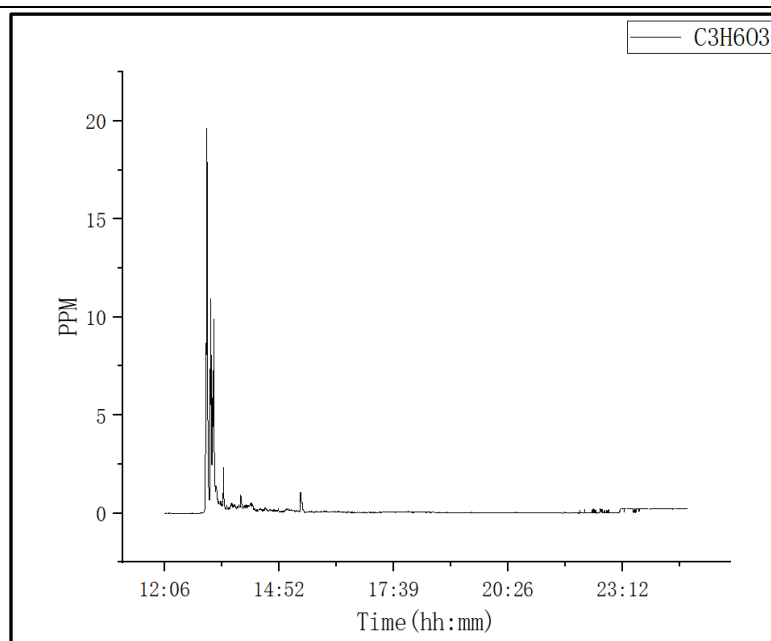
Concentration of Carbonyl Sulfide (COS)



Concentration of oil as octane



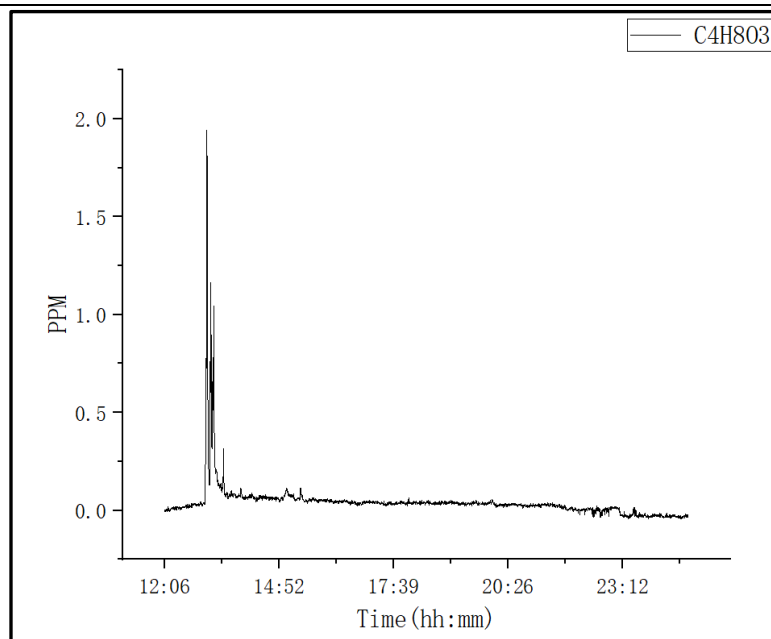
Concentration of Dimethyl carbonate (C₅H₁₀O₃)



Concentration of Dimethyl carbonate ($C_3H_6O_3$)

/

Concentration of Ethylene oxide (C_2H_4O)



Concentration of Ethyl methyl carbonate ($C_4H_8O_3$)

/

Concentration of Formaldehyde (CH_2O)

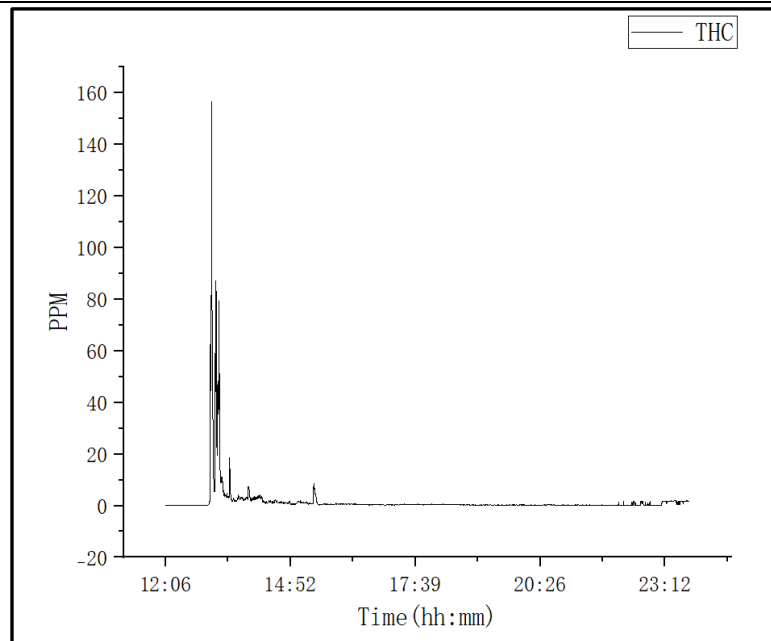
/

Concentration of Methanol (CH_4O)

/

Concentration of Ammonia (NH_3)

Total Hydrocarbons (measured by FID)



Concentration of total hydrocarbons (measured by FID)

Attachment 7 Smoke release rate measurement

Smoke release rate shall be calculated as follows:

$$SSR = 2.303 \left(\frac{V}{D} \right) \log_{10} \left(\frac{I_0}{I} \right)$$

Where:

SRR = Smoke release rate (m²/s)

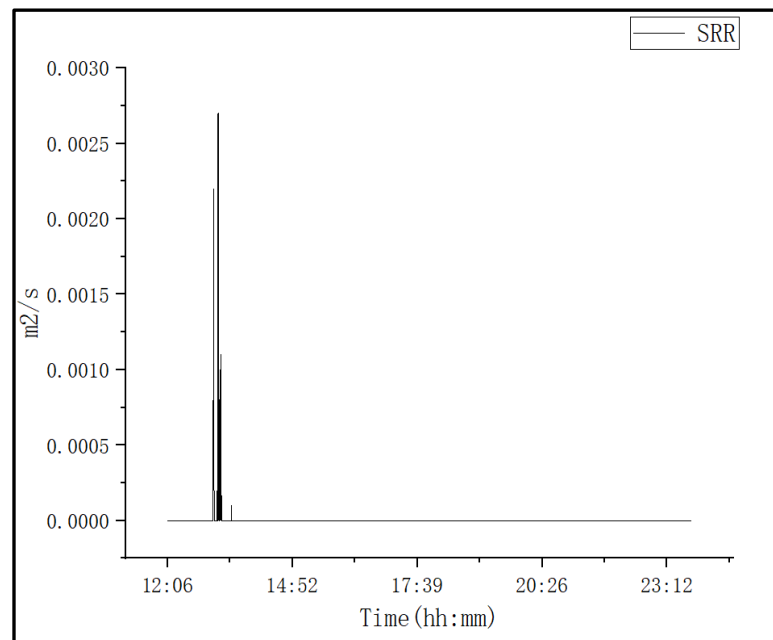
V = Volumetric exhaust duct flow rate (m³/s)

D = duct diameter (m)

I₀ = Light transmission signal of clear (pre-test) beam (V)

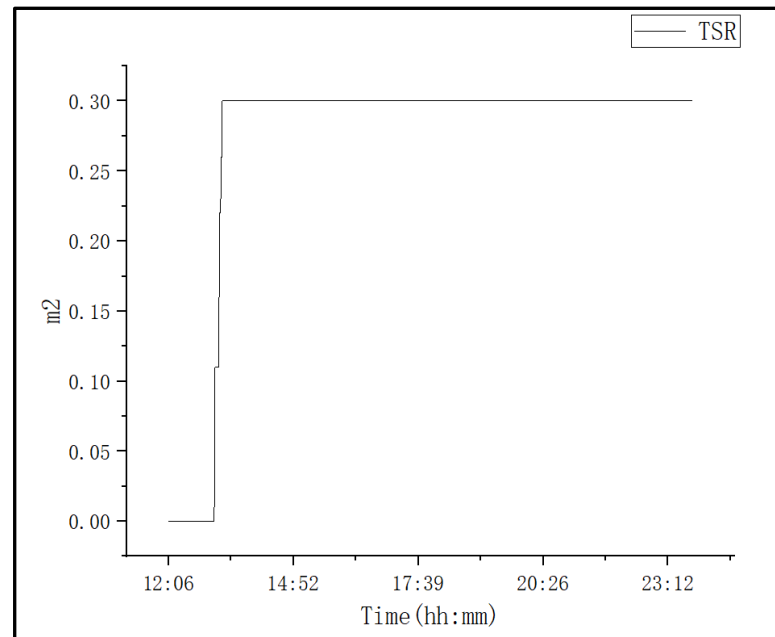
I = Light transmission signal during test (V)

Measured peak smoke release rate SRR: 0.0027m²/s



Smoke release rate versus time

Measured total smoke release rate TSR: 0.3 m²



Total smoke release rate versus time

Attachment 8 Equipment list

No.	Equipment	Model	Rating	Inventory no.	Last Cal. date
1	Ambient monitor	288-cth	-50~+70°C, 10-90%RH	T-038	2027.01.22
2	Temperature chamber	BS-3000DB	-20°C~150°C	T-011	2027.01.21
3	Digital multi-meter V	D05961	100mv~600V	T-126	2026.08.08
4	Digital multi-meter V	ZTW890DS PRO	600mV-2000V	T-288	2026.08.08
5	Tape	5000mm	0-1000mm	T-116	2026.08.19
6	Tape	5000mm	0-1000mm	T-117	2026.08.19
7	Flame ionization detector	EL3020	0~10000ppm	T-089	2026.06.30
8	Electronic scale	XK3150(W)	0kg-800kg	T-234	2026.07.02
9	Charge /Discharge equipment	GBBT-250/300- 4 channels	0~250V, 0~300A	T-073	2026.07.08
10	Palladium-nickel thin-film solid state sensor	710B	0.1%~10%	T-095	2026.06.30
11	Voltage and temperature data acquisition equipment	ICDAM C-4117	0~10V	T-113-1	2026.07.09
		MT4W-DV-48	0~500V	T-113-2	2026.07.09
		DTM/ICDAM	0~1000°C	T-113-3	2026.07.09
		C-4118/DELTA	0~1000°C	T-113-4	2026.07.09
12	Light filter	10%, 25%, 75%	10%, 25%, 75%	T-079	2026.07.01
13	Heating control equipment	DT320VA-0200	0~1000°C	T-113-5	2026.07.09
				T-113-6	2026.07.09
14	Oxygen consumption calorimeter measurement system	OXYMAT 61	O ₂ :0~25%	T-090-1	2026.06.30
		ULTRAMAT 23	CO:0~1% CO ₂ :0~10%	T-090-2	2026.06.30
15	Fourier-Transform Infrared Spectrometer	MG6000	0.01ppm-1%	T-097	/

----- End of test report -----