CSA GROUP
Laboratory Test Data – UL 9540A

Master Contract:*302680*
Report*: 80182817*
Project: *80182817*

Apr.3, 2024

Mr.YongZhou
Project manager
FOXESS CO., LTD.
No.939,Jinhai Third Road,
New Airport Industry Area
Longwan District
Wenzhou,Zhejiang 325025
China

Subject: *Lithium-ion Rechargeable battery unit, model US1H-11.4-EQL7 (UL 9540A Test Report)*

Dear *Mr.YongZhou*

We are pleased to inform you that testing of your product per UL 9540A has been completed. Applicable test(s) was witnessed at ChuWeiNeng Testing Technology (Shanghai) Co.Ltd, and witnessed by CSA Group – Kunshan. Unit level of test was conducted on the sample provided and the results are enclosed in the test report.

> Note: This Test Report is not an Authorization to apply the CSA Mark to the product. The results contained in the report(s) provided are contingent upon the characteristics of the actual sample(s) used in the investigation. In the absence of a continuing inspection service, CSA provides no assurance, expressed or implied, that the contents of the report are applicable to reproductions of the sample(s). Use or reproduction of the CSA name, logo, or trademark is not permitted without the prior written consent of CSA. No references can be made to this report when using the results of this investigation for the purposes of advertising, promotion or litigation, without the prior written consent of CSA.

Please examine the enclosed documents and contact me if you have any questions or would like us to make any changes.

On behalf of CSA, I would like to thank you for your business and offer our services for your future needs.

Yours truly,

Evan Zhang
CSA –*CCIC-CSA International Certification Co., Ltd. Kunshan Branch*
Building 8, Tsinghua Science Park, No. 1666 Zu chongzhi Rd (S), Kunshan, Jiangsu (215347)

Encl. [*UL 9540A Test Report*]
Att.1 - Unit charge/discharge conditioning graphs
Att.2 - Photos
Att.3 - Diagram and dimension of test setup
Att.4 - Temperature/voltage graph during testing
Att.5 - Heat release rate graph
Att.6 - Gas generation graph
Att.7 - Smoke release graph
Att.8 - Heat flux graph
Att.9 - Notable observation during test
Att.10 - Video (separated file)

CSA GROUP

Laboratory Test Data - UL 9540A Checklist and Test Result (Unit Level)

ORIGINAL TEST DATA

The results relate only to the items tested.
This report shall not be reproduced, except in full, without the approval of CSA Group Testing & Certification Inc.

Master Contract:	302680	Model:	US1H-11.4-EQL7	Page number 1 of 44
Project / Network:	80182817	Description:	Rechargeable lithium-ion battery unit	

Standard(s): ANSI/CAN/UL 9540A:2019 Fourth Edition, Dated November 12, 2019 - Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems

Testing Laboratory Name:	CCIC-CSA International Certification Co.,Ltd. Kunshan Branch
Address:	Building 8, Tsinghua Science Park, No. 1666 Zu chongzhi Rd(S), Kunshan, Jiangsu(215347)
Testing Program:	**Custom Test** : Cover Latter ☒, Testing Only ☐

If tests were performed at another facility, then described below:

Testing Laboratory Name:	ChuWeiNeng Testing Technology (Shanghai) Co.Ltd
Address:	Building 3, No.1065 Beihe Road, Jiading District, Shanghai
Facility Qualification Number:	N/A

	As above / or describe otherwise
Customer:	FOXESS CO., LTD.
Address:	No.939,Jinhai Third Road,New Airport Industry Area,Longwan District, Wenzhou,Zhejiang 325025,China

Tested By: Hao Zhang, Technician
Name, Title

Hao Zhang — 2024-03-04
Signature — *Date (YYYY-MM-DD)*

☒ **Reviewed by:** Jarvis Shen, Certifier
☒ **Witnessed by:**
Name, Title

Evan Zhang/Jarvis Shen — 2024-03-04
Signature — *Date (YYYY-MM-DD)*

Version6 : 2022-08-02

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Cell Level Test Summary	
Name of test laboratory perform cell level testing:	UL(Changzhou) Quality Technical Service Co.,LTD
Unique identification of test report:	UL, Project Number:4790517961
Standard and its edition used for testing:	UL 9540A, 4th edition
Manufacturer:	REPT BATTERO Energy Co.,Ltd
Brand name / Trademark:	N/A
Model number:	CB59
Nominal cell voltage, (V)	3.2
Cell capacity, (Ah)	72
Cell chemistry:	LFP
Physical format of cell:	Prismatic
Approximate dimension, (mm)	Depth:39.72±1;Width:148.66±1;Height:110.01±1
Mass, (g)	1380±150
Method used to initiate thermal runaway:	External heating
Average temperature at which cell first vented excluding gas collection sample, (°C)	154
Average temperature prior to thermal runaway excluding gas collection sample, (°C)	211
Flammable gas generation, (Liter)	---
Total gas generation, (Liter)	41.8
Lower flammability limit (LFL) at ambient temperature (25 ± 5°C), (%)	7.95
Lower flammability limit (LFL) at average gas vent temperature, (%)	6.95
Burning velocity, (Cm/Sec)	125.8
Maximum pressure P_{max}, (psig)	94.8
Gas composition:	See below

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Cell Level Test Summary

Gas		Measured %
Carbon Monoxide	CO	8.949
Carbon Dioxide	CO2	31.946
Hydrogen	H2	51.599
Methane	CH4	4.029
Acetylene	C2H2	0.149
Ethylene	C2H4	2.120
Ethane	C2H6	0.693
Propadiene (Allene)	C3H4	N.D
Propylene	C3H6	0.232
Propane	C3H8	0.074
-	C4 (Total)	0.140
-	C5 (Total)	0.017
-	C6 (Total)	0.006
1-Heptene	C7H14	N.D
Styrene	C8H8	N.D
Benzene	C6H6	0.002
Toluene	C7H8	N.D
Dimethyl Carbonate	C3H6O3	0.035
Ethyl Methyl Carbonate	C4H8O3	0.007
Diethyl Carbonate	C5H10O3	N.D
Total	-	100

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Module Level Test Summary	
Name of test laboratory perform module level testing:	ChuWeiNeng Testing Technology (Shanghai) Co.Ltd
Unique identification of test report:	CSA Report number:80204927
Standard and its edition used for testing:	UL9540A 4th Edition
Manufacturer:	FOXESS CO., LTD.
Brand name / Trademark:	FOX ESS
Model number:	EQ4000
Nominal voltage rating, (V)	57.6
Nominal capacity rating, (kWh)	3.97
Approximate dimension, (mm)	W×H×D:570mm×138 mm×380mm
Method used to initiate thermal runaway:	External heating
Number of cells used for initiating thermal runaway:	1
Number of cells exhibited thermal runaway within module:	3
Cell to cell propagation condition:	Yes
Peak chemical heat release rate, (kW)	No flame observed
Flammable gas generation, (Liter)	97.6
Total gas generation, (Liter)	124.1
Weight loss, (%)	1.1
Gas composition:	CO_2 (21.35%); THC (70.99%);CO(7.65%); H_2(below detectable limit)
Additional Information:	The sample to be tested is provided by the customer.

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Unit Level Test Summary	
Manufacturer:	FOXESS CO., LTD.
Brand name / Trademark:	FOX ESS
Model number:	US1H-11.4-EQL7
Nominal voltage rating, (V)	240Vac
Nominal capacity rating, (kWh)	27.79
Approximate dimension, (mm)	W×H×D:570mm×1538mm×380 mm
BESS test configuration/intended installation:	Indoor floor mounted residential use BESS/ Outdoor ground mounted residential use BESS
(If residential installation) Smallest room volume specified by manufacturer, (m^3)	2.5
Unit certification available?, (Yes/No)	Yes
Standard(s) used to certify product:	UL 9540, 3rd Edition
Certification organization name and its certificate number:	CSA, Report number:80182818
Electrical configuration of module in BESS:	1p-7s
Number of modules in BESS:	7
Fire detection and suppression system integral part of BESS: (Yes/No)	No
Test conducted with fire detection and suppression system: (Yes/No/Not Applicable)	Not Applicable
Method used to initiate thermal runaway:	External heating
Number of cells used for initiating thermal runaway:	1
Number of cells exhibited thermal runaway within initiating module:	1
Number of modules exhibited thermal runaway within initiating BESS:	1
Cell to cell propagation condition:	No
Peak chemical heat release rate, (kW)	No flame observed
Peak convective heat release Rate, (kw)	0
Flammable gas generation, (Liter)	Before Flaming: 10.1 After Flaming: ---
Total gas generation, (Liter)	Before Flaming: 14.3 After Flaming: ---

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Unit Level Test Summary	
Gas composition:	Before Flaming: CO(14.7%),CO_2(29.4%),THC(55.9%),H_2(Below detectable limit) After Flaming: ---
Maximum wall surface temperature, (°C)	24
Maximum target BESS temperature, (°C)	23
Maximum incident heat flux on target wall surfaces, (kw/m^2)	N/A
Maximum incident heat flux on target BESS, (kw/m^2)	N/A
Maximum incident heat flux of egress path, (kw/m^2)	N/A
Total smoke release, (m^2)	0.68
Peak smoke release rate, (m^2/s)	0.0086
Additional Information:	The sample to be tested is provided by the customer and there was no cell-to-cell propagation observed during test

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Performance Unit Level Test (Residential Indoor Floor Mounted)		
Requirement	**Comments**	**Verdict**
Flaming outside the initiating BESS unit is not observed as demonstrated by no flaming or charring of the cheesecloth indicator;	No flaming outside the initiating BESS and the cheesecloth was not charring	P
Surface temperatures of modules within the target BESS units adjacent to the initiating BESS unit do not exceed the temperature at which thermally initiated cell venting occurs	Maximum surface temperatures of modules within the target BESS units are 23°C and it's less than cell venting temperature.	P
For BESS units intended for installation in locations with combustible constructions, surface temperature measurements on wall surfaces do not exceed 97°C (175°F) of temperature rise above ambient	Maximum wall surface temperature is 24°C and it's less than 97°C (175°F) of temperature rise above ambient	P
Explosion hazards are not observed, including deflagration, detonation or accumulation (to within the flammability limits in an amount that can cause a deflagration) of battery vent gases	Explosion hazards were not observed during testing	P
The concentration of flammable gas does not exceed 25% LFL in air for the smallest specified room installation size.	The concentration of flammable gas was not exceed 25% LFL in air for the smallest specified room installation size	P
Summary of Result: A unit level test meets the applicable performance criteria noted above from section 9.8 of UL 9540A 4th Edition is considered compliant.		

Possible test case verdicts:

- Test object does not apply to the test object: N/A
- Test object does meet the requirement: P (Pass)
- Test object does not meet the requirement: F (Fail)
- Test object waived based construction detail: W (Waived)

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Clause	Requirement + Test	Result - Remark	Verdict
Construction			
5	**General**	**---**	**---**
5.3	**Battery energy storage system unit**	**---**	**---**
5.3.1	BESS certification available? (Yes/No)	Yes	---
	Standard(s) used to certify product:	UL 9540, 3rd Edition	---
5.3.2	BESS component documentation	☒ BESS certification was available – Component detail not documented. ☐ BESS certification was not available – See list of critical components in attachment section. ☐ Other(explain):	---
	BESS enclosure approximate dimension, (mm)	W×H×D: 570mm×1538mm×380mm	---
	BESS enclosure material:	Metallic	---
	Based on configuration of BESS, test conducted on:	☒ BESS ☐ Battery system	---
5.3.3	Fire detection system	☐ Integral part of DUT, test conducted with fire detection system. ☐ Integral part of DUT, test conducted without fire detection system. ☒ Not integral part of DUT	---
	Fire suppression system	☐ Integral part of DUT, test conducted with fire suppression system. ☐ Integral part of DUT, test conducted without fire suppression system. ☒ Not integral part of DUT	---
5.3.4	Unit level test report	See below	---
Performance			
9	**Unit level**	**---**	**---**
9.1	**Sample and test configuration**	**---**	**---**
9.1.1	The unit level test was conducted with BESS units installed as described in the manufacturer's instructions and this section.	Confirmed	P
	BESS test configuration:	Indoor floor mounted residential use BESS	---
9.1.2	Unit level test was conducted in which internal fire condition created as per module level test.	Confirmed	P

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Clause	Requirement + Test	Result - Remark	Verdict
	Test setup include initiating BESS unit and target BESS unit representative of an installation.	See attachment 3 for details	P
	Additional representative test configuration based on test configuration.	Outdoor ground mounted residential use BESS	---
	Separation distances between initiating and target units were representative of the installation.	Confirmed	P
	Testing conducted outdoor for BESS intended for outdoor installation only. Following controls and environmental conditions were in place.	Testing was conducted indoor	N/A
	a) Wind screens were utilized with a maximum wind speed maintained at ≤ 12 mph	See above	N/A
	b) Temperature range was within 10°C to 40°C	See above	N/A
	c) The humidity was < 90% RH	See above	N/A
	d) There was sufficient light to observe the testing;	See above	N/A
	e) There was no precipitation during the testing;	See above	N/A
	f) There was control of vegetation and combustibles in the test area to prevent any impact on the testing and to prevent inadvertent fire spread from the test area; and	See above	N/A
	g) There were protection mechanisms in place to prevent inadvertent access by unauthorized persons in the test area and to prevent exposure of persons to any hazards as a result of testing.	See above	N/A
9.1.2.1	For a container system BESS including those intended for outdoor installation only, the unit level test performed in accordance with the indoor floor mounted unit level test using the battery system racks as the test units and with the test installation set up in accordance with the installation layout within the container.	---	N/A
9.1.3	Based on configuration and design of BESS, test conducted on:	☒ BESS ☐ Battery system	---

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Clause	Requirement + Test	Result - Remark	Verdict
9.1.4	Initiating BESS unit contain components representative of a BESS unit in a complete installation.	Confirmed	P
	Combustible components that interconnect the initiating and target BESS units were included.	No combustible components interconnect the initiating and target BESS units	N/A
9.1.5	Target BESS units include the outer cabinet (if part of the design), racking, module enclosures, and components that retain cells components.	Confirmed	P
	The target BESS unit module enclosures did not contain cells.	Confirmed	P
9.1.6	Initiating BESS unit was at the maximum operating state of charge (MOSOC).	Confirmed	P
	After charging and prior to testing, the initiating BESS was rested for a maximum period of 8 h at room ambient.	Confirmed	P
9.1.7	BESS unit test conducted as per following condition.	No fire suppression system designed for the BESS unit	N/A
	a) Integral fire suppression system provided with the DUT.	See above	N/A
	b) Without Integral fire suppression system.	See above	N/A
9.1.8	Electronic and software control were not relied upon for this testing.	Confirmed	P
	BESS unit test conducted with Integral fire suppression system meet UL 840 and considered reliable for this testing.	---	N/A
9.2	**Test method – Indoor floor mounted BESS units**	**---**	**---**
9.2.1	Test room environment was controlled to prevent drafts that may affect test results.	Confirmed	P
	At the start of the test, the room ambient temperature was not less than 10°C (50°F) nor more than 32°C (90°F).	Confirmed	P
	Ambient temperature range during test, °C	See table 3 for details	P
9.2.2	Any access door(s) or panels were closed, latched and locked at the beginning and duration of the test.	Confirmed	P
9.2.3	The initiating BESS unit was positioned adjacent to two instrumented wall sections.	See attachment 3 for details	N/A
9.2.4	Instrumented wall sections were extended not less than 0.49 m (1.6 ft) horizontally	Confirmed	P

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Clause	Requirement + Test	Result - Remark	Verdict
	beyond the exterior of the target BESS units.		
9.2.5	Instrumented wall sections were at least 0.61-m (2-ft) taller than the BESS unit height, but not less than 3.66 m (12 ft) in height above the bottom surface of the unit.	Confirmed	P
9.2.6	The surface of the instrumented wall sections was covered with 16-mm (5/8-in) gypsum wall board and painted flat black.	Confirmed	P
9.2.7	The initiating BESS unit was centered underneath an appropriately sized smoke collection hood of an oxygen consumption calorimeter.	Confirmed	P
9.2.8	The light transmission in the calorimeter's exhaust duct was measured.	Confirmed	P
	White light source and photo detector was used for the duration of the test.	Confirmed	P
	Smoke release rate was calculated as per following formula. $SRR = 2.303\left(\frac{V}{D}\right) Log_{10}\left(\frac{I_o}{I}\right)$	Confirmed	P
9.2.9	The chemical and convective heat release rates were measured for the duration of the test.	See attachment 5 for details	P
	Chemical heat release rate was calculated as per following formula. $HRR_1 = \left[E \times \varphi - (E_\infty - E) \times \frac{1-\varphi}{2} \times \frac{X_{\infty}}{X_{O_2}}\right] \times \frac{\dot{m}_e}{1+\varphi \times (\alpha - 1)} \times \frac{M_{O_2}}{M_a} \times (1 - X^o_{H_2O}) \times X^o_{O_2}$	Confirmed	P
9.2.10	The heat release rate measurement system shall be calibrated using an atomized heptane diffusion burner.	Confirmed	P
9.2.11	The convective heat release rate was measured during test.	See attachment 5 for details	P
	Thermopile, a velocity probe, and a Type K thermocouple, located in the exhaust system of the exhaust duct were used for measurement.	Confirmed	P
9.2.12	Convective heat release rate was calculated as per following formula.	Confirmed	P

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Clause	Requirement + Test	Result - Remark	Verdict
	$HRR_c = V_e A \frac{353.22}{T_e} \int_{T_o}^{T} C_p dT$		
9.2.13	Physical spacing between BESS units (both initiating and target) and adjacent walls were representative of the intended installation.	See attachment 3 for details	P
9.2.14	Separation distances was specified by the manufacturer for distance between:	See attachment 3 for details	P
	a) The BESS units and the instrumented wall sections.	See attachment 3 for details	P
	b) Adjacent BESS units.	See attachment 3 for details	P
9.2.15	Wall surface temperature measurements was collected for BESS intended for installation in locations with combustible construction.	Confirmed	P
9.2.16	Wall surface temperatures was measured in vertical array(s) at 152-mm (6-in) intervals for the full height of the instrumented wall sections.	Confirmed	P
	No. 24-gauge or smaller, Type-K exposed junction thermocouples were used for measurement.	Confirmed	P
	The thermocouples were placed horizontally positioned in the wall locations anticipated to receive the greatest thermal exposure.	Confirmed	P
	Temperatures was measured continuously, averaging over every 60 second interval.	Confirmed	P
	The maximum of these averages was documented for each thermocouple location.	Confirmed	P
9.2.17	Thermocouples were secured to gypsum surfaces by the use of staples placed over the insulated portion of the wires.	Confirmed	P
	The thermocouple tip was depressed into the gypsum so as to be flush with the gypsum surface at the point of measurement and held in thermal contact with the surface at that point by the use of pressure-sensitive paper tape.	Confirmed	P
9.2.18	Heat flux was measured with the sensing element of at least two water-cooled	Heat flux was used only for reference in accordance with the Certification	N/A

Clause	Requirement + Test	Result - Remark	Verdict
	Schmidt- Boelter or Gardon gauges at the surface of each instrumented wall.	Requirement Decision: Measuring Heat Flux for Residential and Non-residential Unit Testing. Heat flux measurements on walls may be waived for residential units that are tested with the cheesecloth indicator	
	a) Both were collinear with the vertical thermocouple array.	See above	N/A
	b) One was positioned at the elevation estimated to receive the greatest heat flux due to the thermal runaway of the initiating module	See above	N/A
	c) One was positioned at the elevation estimated to receive the greatest heat flux during potential propagation of thermal runaway within the initiating BESS unit.	See above	N/A
	Heat flux was measured continuously, averaging over every 60 second interval.	See above	N/A
	The maximum of these averages was documented for each gauge location.	See above	N/A
9.2.18.1	Heat flux measurements on walls were waived for residential units that are tested with the cheesecloth indicator.	Confirmed	P
9.2.18.2	With reference to 9.2.18, if b) and c) were deemed to be at the same location, only one gauge was installed on the wall for the measurement.	---	N/A
9.2.19	Heat flux was measured with the sensing element of at least two water-cooled Schmidt- Boelter or Gardon gauges at the surface of each adjacent target BESS unit that faces the initiating BESS unit:	Heat flux was not used in accordance with the Certification Requirement Decision: Measuring Heat Flux for Residential and Non-residential Unit Testing. Heat flux measurements on target units may be waived for residential units that are tested with the cheesecloth indicator	N/A
	a) One was positioned at the elevation estimated to receive the greatest heat flux due to the thermal runaway of the initiating module within the initiating BESS	See above	N/A
	b) One was positioned at the elevation estimated to receive the greatest surface heat flux due to the thermal runaway of the initiating BESS.	See above	N/A
	Heat flux was measured continuously, averaging over every 60 second interval.	See above	N/A

Clause	Requirement + Test	Result - Remark	Verdict
	The maximum of these averages was documented for each gauge location.	See above	N/A
9.2.19.1	Heat flux measurements on target units were waived for residential units that are tested with the cheesecloth indicator.	Confirmed	P
9.2.19.2	With reference to 9.2.19, if a) and b) were deemed to be at the same location, only one gauge was installed on the target unit for the measurement.	---	N/A
9.2.20	For non-residential use BESS, heat flux was measured with the sensing element of at least one water-cooled Schmidt-Boelter or Gardon gauge positioned at one for the following location.	The BESS is used for residential	N/A
	a. At the mid height of the initiating unit in the center of the accessible means of egress.	See above	N/A
	b. At the point where the majority of off-gas venting was expected from the initiating unit in the center of the accessible means of egress.	See above	N/A
9.2.21	No. 24-gauge or smaller, Type-K exposed junction thermocouples was installed to measure the temperature of the surface proximate to the cells and between the cells and exposed face of the initiating module.	Confirmed	P
	Each non-initiating module enclosure within the initiating BESS unit was instrumented with at least one No. 24-gauge or smaller Type-K thermocouple(s) to provide data to monitor the thermal conditions within non-initiating modules.	Confirmed	P
	Additional thermocouples shall be placed to account for convoluted enclosure interior geometries.	Confirmed	P
	Temperatures was measured continuously, averaging over every 60 second interval.	Confirmed	P
	The maximum of these averages was documented for each thermocouple location.	Confirmed	P
9.2.22	For residential use BESS, the DUT was covered with a single layer of cheese cloth ignition indicator.	Confirmed	P

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Clause	Requirement + Test	Result - Remark	Verdict
	The cheesecloth was untreated cotton cloth running 26 – 28 m^2/kg with a count of 28 – 32 threads in either direction within a 6.45 cm^2 (1 in^2) area.	Confirmed	P
9.2.23	An internal fire condition in accordance with the module level test was created within a single module in the initiating BESS unit.	Confirmed	P
	a) The position of the module was selected to present the greatest thermal exposure to adjacent modules (e.g. above, below, laterally), based on the results from the module level test;	Confirmed	P
	b) The setup (i.e. type, quantity and positioning) of equipment for initiating thermal runaway in the module was same as that used to initiate and propagate thermal runaway within the module level test.	Confirmed	P
9.2.24	The composition, velocity and temperature of the initiating BESS unit vent gases was measured within the calorimeter's exhaust duct.	Confirmed	P
	The hydrocarbon content of the vent gas was measured using flame ionization detection.	Confirmed	P
	Hydrogen gas was measured with a palladium-nickel thin-film solid state sensor.	Confirmed	P
	Composition, velocity and temperature instrumentation were collocated with heat release rate calorimetry instrumentation.	Confirmed	P
9.2.25	The hydrocarbon content of the vent gas was additionally measured a Fourier-Transform Infrared Spectrometer with a minimum resolution of 1 cm^{-1} and a path length of at least 2.0 m (6.6 ft), or equivalent gas analyzer.	FTIR analysis was not used in accordance with the Certification Requirement Decision: Corrections to gas measurement methods to make FTIR as an option for measuring hydrocarbon contents of gas emissions and to include Hydrogen measurements during the Unit Level Test. FTIR was considered redundant to the other gas measurement methods used.	N/A
9.2.26	The test was terminated at:	See below	P

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Clause	Requirement + Test	Result - Remark	Verdict
	a) Temperatures measured inside each module within the initiating BESS unit return to ambient temperature;	Confirmed	P
	b) The fire propagates to adjacent units or to adjacent walls; or	No flame observed	N/A
	c) A condition hazardous to test staff or the test facility requires mitigation.	---	N/A
9.2.27	For residential use systems, the gas collection data gathered was compared to the smallest room installation specified by the manufacturer to determine if the flammable gas collected exceeds 25% LFL in air.	Confirmed	P
9.3	**Test method – Outdoor ground mounted units**	---	N/A
9.3.1	Test method described in Section 9.2 was used for non-residential use BESS testing.	---	N/A
	Smoke release rate, convective and chemical heat release rate and content, velocity and temperature of the released vent gases were not measured for outdoor ground mounted installation only.	---	N/A
9.3.2	Test method described in Section 9.2 except noted in 9.3.3 and 9.3.4 was used for residential use BESS testing.	---	N/A
	Heat flux measurements for the accessible means of egress was measured in accordance with 9.2.20.	---	N/A
	The heat flux measurement for the accessible means of egress was waived for outdoor ground mounted residential use BESS because the BESS was draped with cheesecloth.	---	N/A
	Smoke release rate, convective and chemical heat release rate and content, velocity and temperature of the released vent gases were not measured for outdoor ground mounted installation only.	---	N/A
9.3.3	Test samples was installed in proximity to an instrumented wall section that was 3.66-m (12-ft) tall with a 0.3-m (1-ft) wide horizontal soffit.	---	N/A

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Clause	Requirement + Test	Result - Remark	Verdict
	The sample was mounted on a support substrate and spaced from the wall in accordance with the minimum separation distances specified by the manufacturer.	---	N/A
	The wall and soffit were constructed with 19.05-mm (3/4-in) plywood installed on wood studs and painted flat black.	---	N/A
	The instrumented wall was extended not less than 0.49-m (1.6-ft) horizontally beyond the exterior of the target BESS units.	---	N/A
	The No. 24-gauge or smaller, Type-K exposed junction thermocouple array on the walls were extended to the surface of the soffit	---	N/A
	Manufacturer requires installation against non-flammable material, the test setup included with manufacturer recommended backing material between the unit and plywood wall.	---	N/A
9.3.4	Target BESS were installed on each side of the initiating BESS in accordance with the manufacturer's installation specifications.	---	N/A
	The physical spacing between BESS units (both initiating and target) were the minimum separation distances specified by the manufacturer.	---	N/A
9.4	**Test Method – Indoor wall mounted units**	---	N/A
9.4.1	Test method described in Section 9.2 except as modified in this section was used for indoor wall mounted BESS.	---	N/A
9.4.2	The test was conducted in a standard NFPA 286 fire test room, 3.66 × 2.44 × 2.44-m (12 × 8 × 8-ft) high, with a 0.76 × 2.13-m (2-1/2 × 7-ft) high opening.	---	N/A
	The room was constructed with 16-mm (5/8-in) gypsum wall board installed on wood studs and painted flat black.	---	N/A
9.4.2.1	BESS intended for residential installations only was tested using, instrumented wall sections not less than 2.44 m (8 ft) in height and width instead of the test room of 9.4.2.	---	N/A

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Clause	Requirement + Test	Result - Remark	Verdict
9.4.3	The initiating BESS unit was positioned on the wall opposite of the door opening, with the center located 1.22-m (4-ft) above the floor, and halfway between adjacent walls.	---	N/A
9.4.3.1	When residential BESS was tested in accordance with 9.4.2.1, the initiating BESS unit was positioned with the center located 1.22-m (4-ft) above the floor, and halfway between adjacent walls.	---	N/A
9.4.4	Target BESS was installed on the wall on each side of the initiating BESS, at the same height above the floor as the initiating BESS.	---	N/A
	The physical spacing between BESS units (both initiating and target) was the minimum separation distances specified by the manufacturer.	---	N/A
9.4.5	The wall on which the initiating and target BESS units are mounted were instrumented.	---	N/A
9.4.6	The gas collection methods was in accordance with 9.2	---	N/A
	For residential use systems, the gas collection data gathered were compared to the smallest room installation specified by the manufacturer to determine if the flammable gas collected exceeds 25% LFL in air.	---	N/A
9.4.7	For residential use BESS, the DUT was covered with a single layer of cheese cloth ignition indicator.	---	N/A
	The cheesecloth was untreated cotton cloth running 26 – 28 m^2/kg with a count of 28 – 32 threads in either direction within a 6.45 cm^2 (1 in^2) area.	---	N/A
9.4.8	BESS for residential only installations, the criteria in 9.2.9. 9.2.18 and 9.2.19 were waived.	---	N/A
9.5	**Test Method – Outdoor wall mounted units**	---	N/A
9.5.1	Test method described in Section 9.2 except as modified in this section was used for outdoor wall mounted BESS.	---	N/A

Clause	Requirement + Test	Result - Remark	Verdict
	Smoke release rate, convective and chemical heat release rate and content, velocity and temperature of the released vent gases were not measured for outdoor wall mounted installation only.	---	N/A
9.5.2	Test samples was mounted on an instrumented wall section that is 3.66-m (12-ft) tall with a 0.3-m (1-ft) wide horizontal soffit.	---	N/A
	The wall and soffit were constructed with 19.05-mm (3/4-in) plywood installed on wood studs and painted flat black	---	N/A
	The No. 24-gauge or smaller, Type-K exposed junction thermocouple array on the walls were extended to the surface of the soffit.	---	N/A
9.5.3	The initiating BESS unit was positioned on the instrumented wall, with its center located 1.22-m (4-ft) above the floor, and halfway between wall edges.	---	N/A
9.5.4	Target BESS was installed on the wall on each side of the initiating BESS, at the same height above the floor as the initiating BESS.	---	N/A
	The physical spacing between BESS units (both initiating and target) were the minimum separation distances specified by the manufacturer.	---	N/A
9.5.5	The wall on which the initiating and target BESS units are mounted were instrument.	---	N/A
9.5.6	For residential use BESS, the DUT was covered with a single layer of cheese cloth ignition indicator.	---	N/A
	The cheesecloth was untreated cotton cloth running 26 – 28 m^2/kg with a count of 28 – 32 threads in either direction within a 6.45 cm^2 (1 in^2) area.	---	N/A
9.6	**Rooftop and open garage installations**	---	N/A
9.6.1	Test method described in Section 9.2 was used for non-residential use rooftop or open garage installations.	---	N/A
9.6.2	Smoke release rate, convective and chemical heat release rate and	---	N/A

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Clause	Requirement + Test	Result - Remark	Verdict
	content, velocity and temperature of the released vent gases were not measured for rooftop and open garage use only.		
9.7	**Unit level test report**	See below	P
9.7.1	Type of installation considered during unit level testing:	Indoor floor mounted residential use BESS	P
9.7.2	Additional installation represented by type of installation considered during unit level testing:	Outdoor ground mounted residential use BESS	P
9.7.3	Unit level report include following information.	See below	P
	a) Unit manufacturer name and model number (and whether UL 9540 compliant);	Unit manufacturer name: FOXESS CO., LTD. Model number: US1H-11.4-EQL7 UL 9540 compliant, Certification organization name and its certificate number: CSA Group, Report number:80182818	P
	b) Number of modules in the initiating BESS unit;	7	P
	c) The construction of the initiating BESS unit per 5.3;	See attachment 2 for details	P
	d) Fire protection features / detection / suppression systems within unit;	No fire protection and detection system within unit	N/A
	e) Module voltage(s) corresponding to the tested SOC;	See attachment 1 for details	P
	f) The thermal runaway initiation method used;	External heating	P
	g) Location of the initiating module within the BESS unit;	See attachment 3 for details	P
	h) Diagram and dimensions of the test setup including mounting location of the initiating and target BESS units, and the locations of walls, ceilings, and soffits;	See attachment 3 for details	P
	i) Observation of any flaming outside the initiating BESS enclosure and the maximum flame extension;	Not observed	P
	j) Chemical and convective heat release rate versus time data;	See attachment 5 for details	P
	k) Separation distances from the initiating BESS unit to target walls;	See attachment 3 for details	P
	l) Separation distances from the initiating BESS unit to target BESS units;	See attachment 3 for details	P

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Clause	Requirement + Test	Result - Remark	Verdict
	m) The maximum wall surface and target BESS temperatures achieved during the test and the location of the measuring thermocouple;	Confirmed	P
	n) The maximum ceiling or soffit surface temperatures achieved during the indoor or outdoor wall mounted test and the location of the measuring thermocouple;	---	N/A
	o) The maximum incident heat flux on target wall surfaces and target BESS units;	See attachment 8 for details	P
	p) The maximum incident heat flux on target ceiling or soffit surfaces achieved during the indoor or outdoor wall mounted test;	---	N/A
	q) Gas generation and composition data;	See attachment 6 for details	P
	r) Peak smoke release rate and total smoke release data;	See attachment 7 for details	P
	s) Indication of the activation of integral fire protection systems and if activated the time into the test at which activation occurred;	No integral fire protection system provided for the BESS	N/A
	t) Observation of flying debris or explosive discharge of gases;	See table 5 for details	P
	u) Observation of re-ignition(s) from thermal runaway events;	See table 5 for details	P
	v) Observation(s) of sparks, electrical arcs, or other electrical events;	See table 5 for details	P
	w) Observations of the damage to: 1) The initiating BESS unit; 2) Target BESS units; 3) Adjacent walls, ceilings, or soffits	See table 5 for details	P
	x) Photos and video of the test.	See attachment 2 and attachment 10 for details	P

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Table 1 – Unit charge/discharge specification			
Charging method	CC-CV	Discharging method	CC
Charge current, (Adc)	50	Discharge current, (Adc)	50
Charge voltage, (Vdc)	453.6	Discharge voltage, (Vdc)	/
Charge end current, (Adc)	2	Discharge end voltage, (Adc)	365.4
Manufacturer recommended charge temperature, (°C)	0~+55	Manufacturer recommended discharge temperature, (°C)	-10~+55

Table 2 – Unit rest duration				
Sample Number	Final charge end time		Test start time	
	Date (YYYY-MM-DD)	Time (HH:MM AM/PM)	Date (YYYY-MM-DD)	Time (HH:MM AM/PM)
202402001	2024-03-04	11:48 AM	2024-03-04	18:44 PM
Ambient temperature during unit conditioning				
Ambient Lab Temperature, (°C)		Relative Humidity, (%RH)		
23.0 to 24.3		48.0 to 50.1		

Table 3 – Unit level test	
Sample Number:	202402001
Ambient temperature at start of test, (°C)	19.6
Ambient temperature range during test, (°C)	18.4-19.6
Relative humidity, (%RH)	50
Number of cells used for initiating thermal runaway:	1
Open circuit voltage before test, (Vdc)	See attachment 4 for details
External film heater ramp rate, (°C/min)	4.5
Other method used to initiate thermal runaway:	N/A
Location of cell and module for initiating thermal runaway:	See attachment 2 for details
Number of cells exhibited thermal runaway within initiating module:	1
Number of modules exhibited thermal runaway within initiating BESS:	1
Location of cell and module exhibited thermal runaway within initiating BESS:	See attachment 2 for details
Cell to cell propagation condition:	No
Peak chemical heat release rate, (kW)	No flame observed
Peak convective heat release rate, (kW)	0
Flammable gas generation, (Liter)	Before Flaming: 10.1 After Flaming: ---

Table 3 – Unit level test	
Total gas generation, (Liter)	Before Flaming: 14.3 After Flaming: ---
Peak smoke release rate, (m^2/sec)	0.0086
Total smoke release, (m^2)	0.68

Table 4 – Gas composition			
Gas Component		**Volume Released (Before Flaming) (Liter)**	**Volume Released (After Flaming) (Liter)**
Carbon Monoxide	CO	2.1	---
Carbon Dioxide	CO_2	4.2	---
Total Hydrocarbons equivalent to methane	THC	8.0	---
Hydrogen(palladium-nickel thin-film solid state sensor)	H_2	0	---

Table 5 – Critical observation	
Condition	**Comment**
Any flaming outside the initiating BESS enclosure and the maximum flame extension:	Not observed
Flying debris	Not observed
Explosive discharge of gases	Not observed
Re-ignition(s) from thermal runaway events	Not observed
Sparks	Not observed
Electrical arcs	Not observed
Other electrical events	N/A
Damage to the initiating BESS unit	Not observed
Damage to target BESS units;	Not observed
Damage to adjacent walls	Not observed
Damage to ceilings	N/A
Damage to soffits	N/A

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Attachments

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Attachment 1 - Unit charge/discharge conditioning graphs

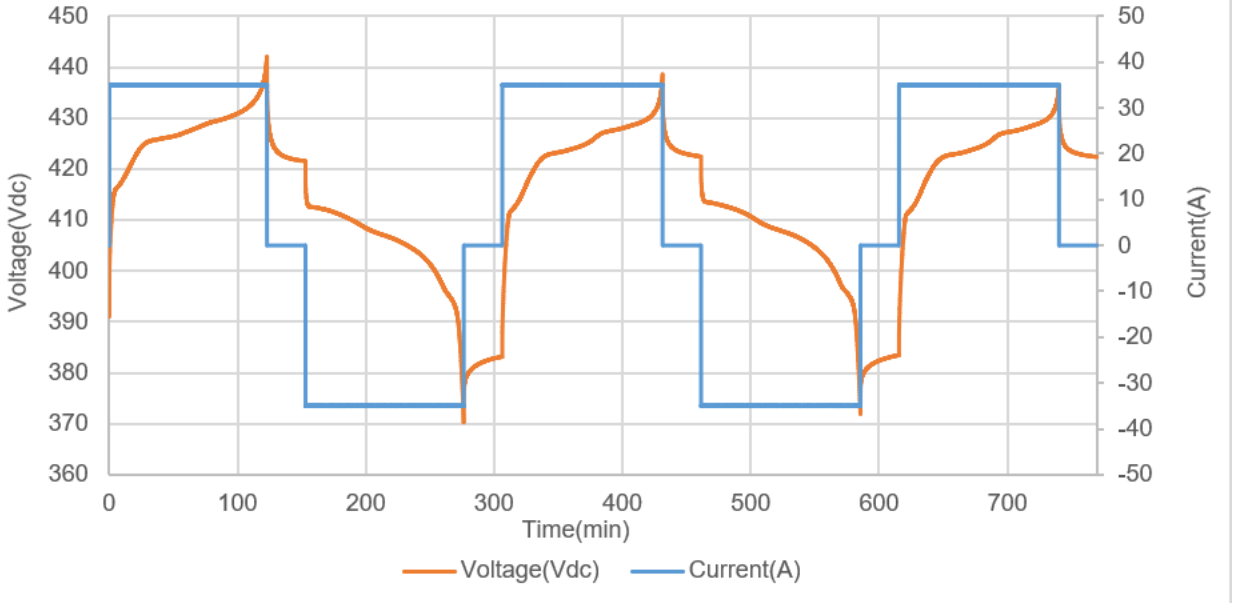

Figure 1: Initiating unit charge/discharge profile

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Attachment 2 – Photos

General sample photos

Attachment 2 – Photos

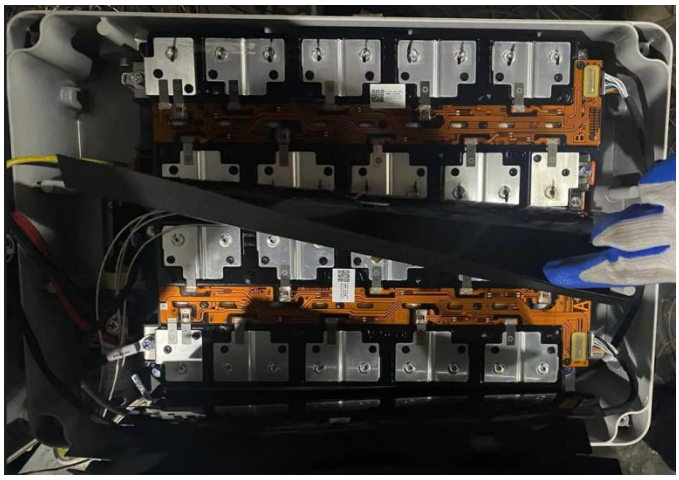

Figure 1: Initiating module overview

Figure 2: BESS overview

Photos with heater and thermocouple installation

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Attachment 2 – Photos

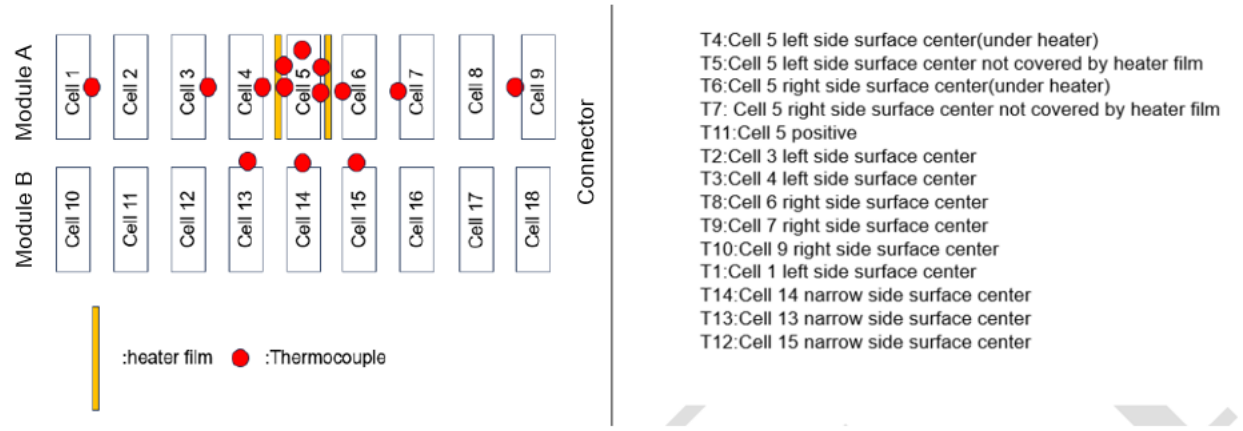

Figure 3: initiating module TC and heater film location

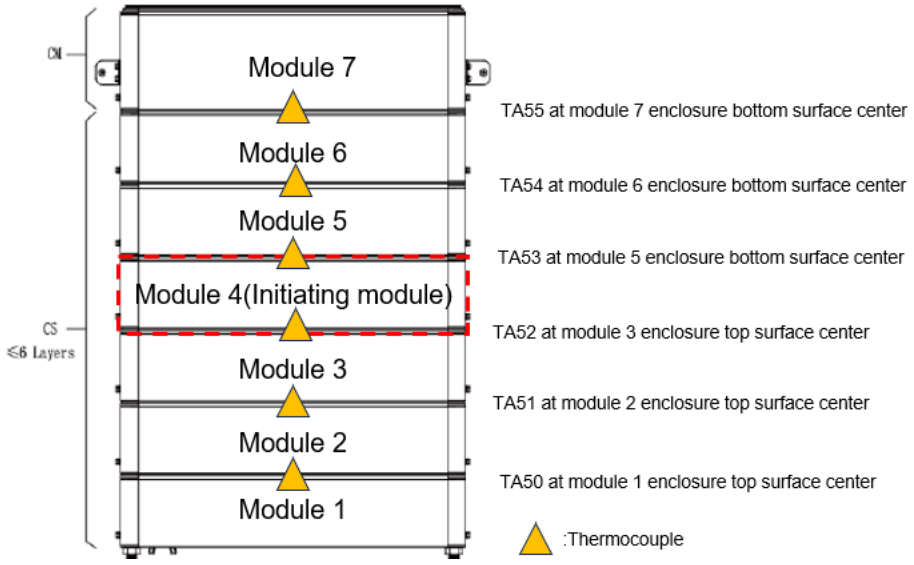

Figure 4: Initiating unit TC location

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Attachment 2 – Photos

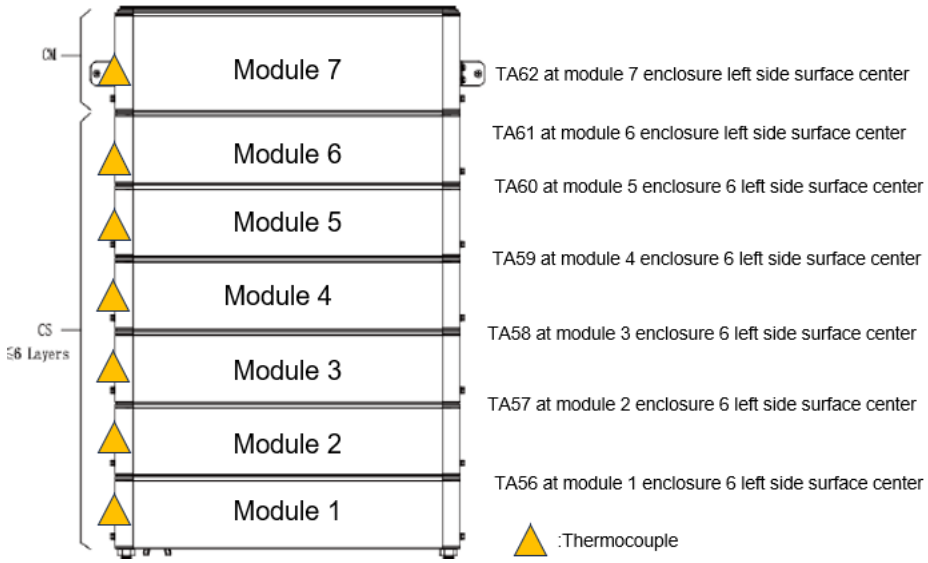

Figure 5: Target unit TC location

Figure 6: Test setup

Photos during test in progress

Attachment 2 – Photos

Figure 7: At test start (Time in 18:44)

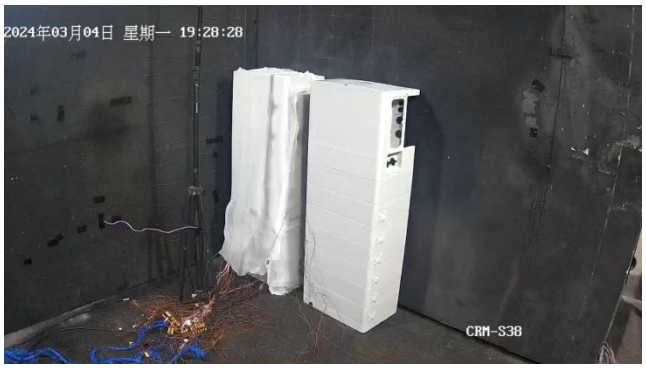

Figure 8: During cell venting (Time in 19:28)

Figure 9: During thermal runaway (Time in 19:39)

No Text on this Box

No Text on this Box

Photos after test

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Attachment 2 – Photos

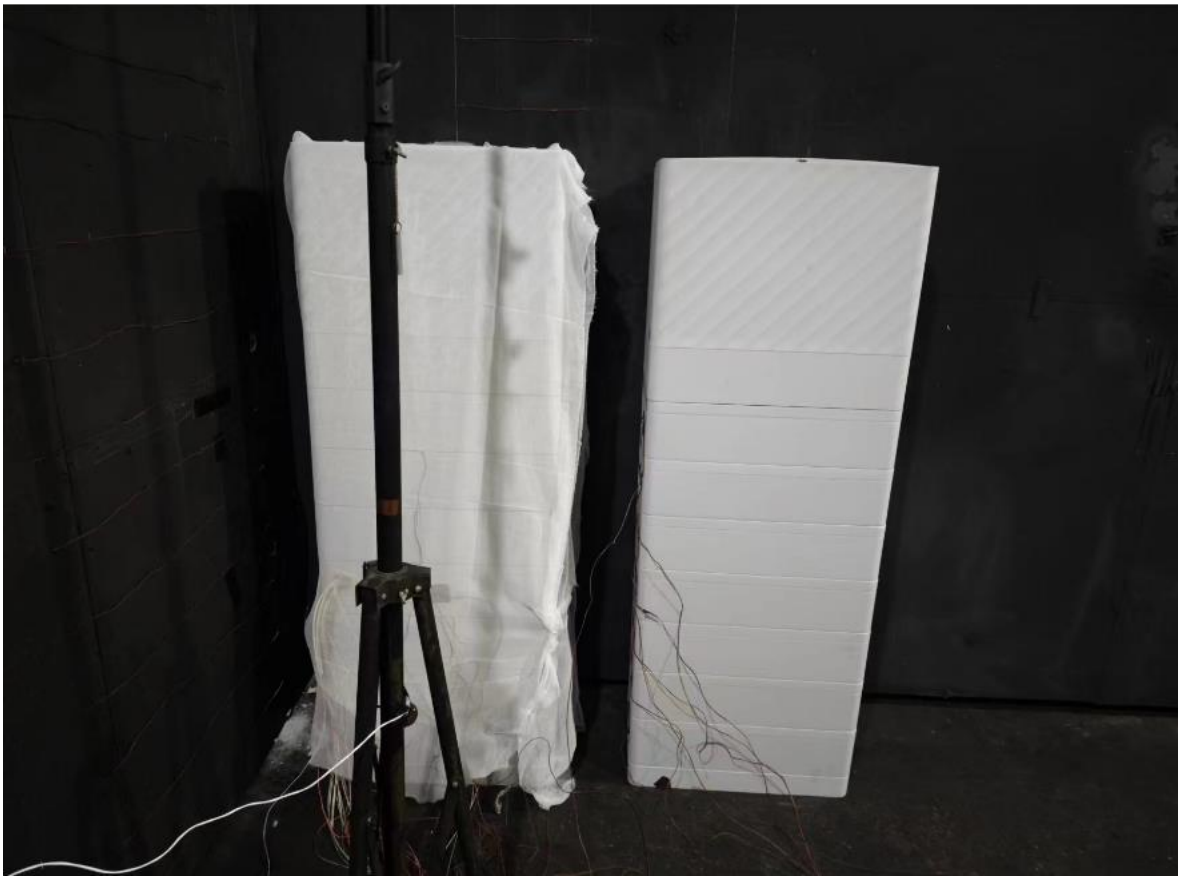

Figure 10: Initiating unit and target unit front view

Attachment 2 – Photos

Figure 11: Initiating unit overview

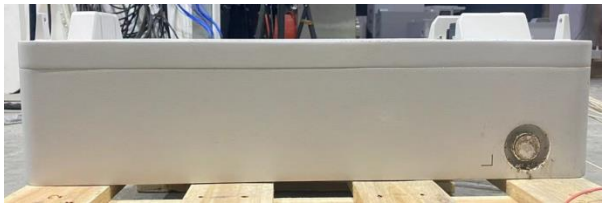

Figure 12: Initiating module rear view

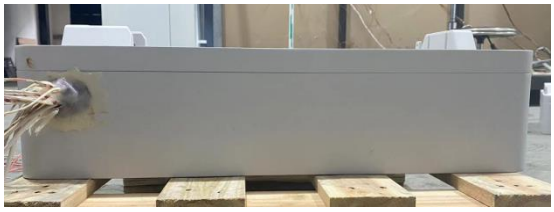

Figure 13: Initiating module front view

Figure 14: Initiating module side view

Attachment 2 – Photos

Figure 15: Initiating module top view

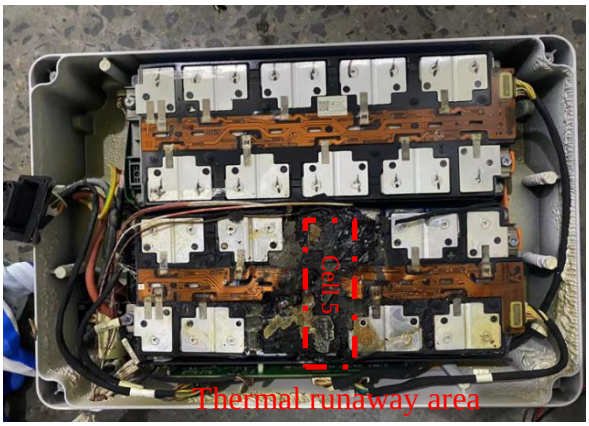

Figure 16: Thermal runaway condition

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Attachment 3 - Diagram and dimension of test setup

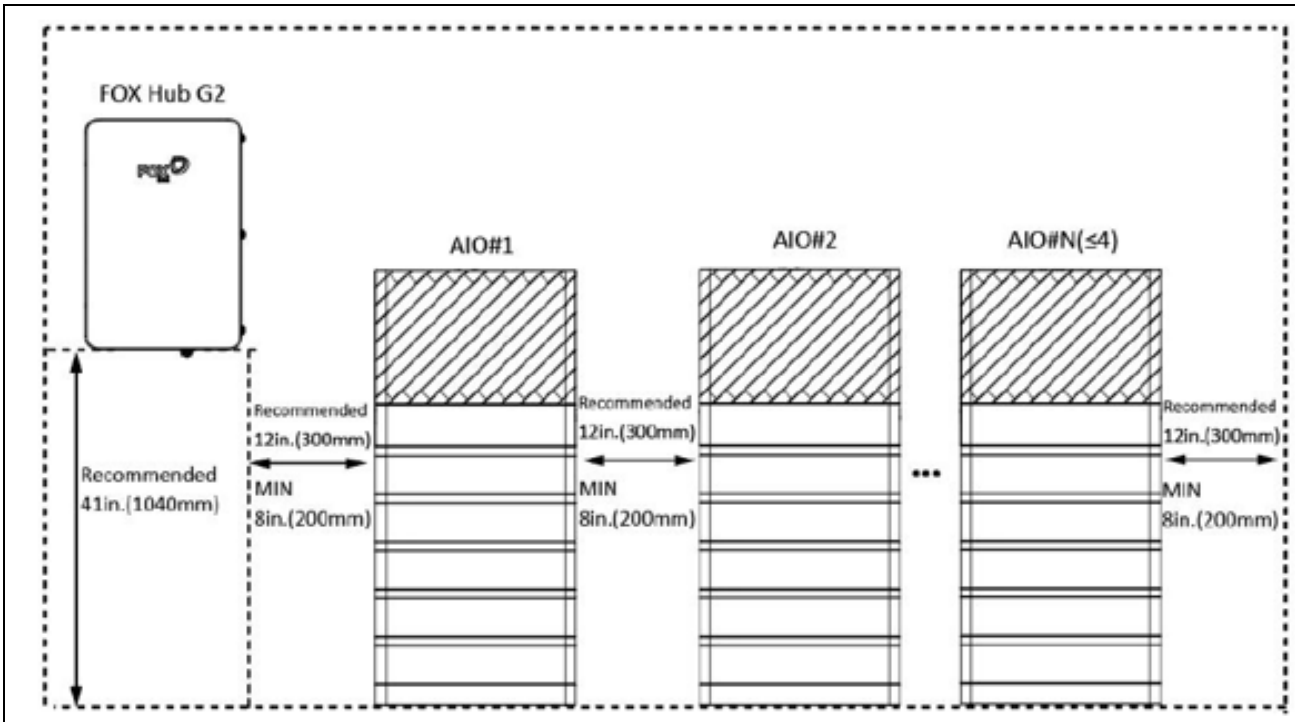

Figure 1: Field ground mounted layout

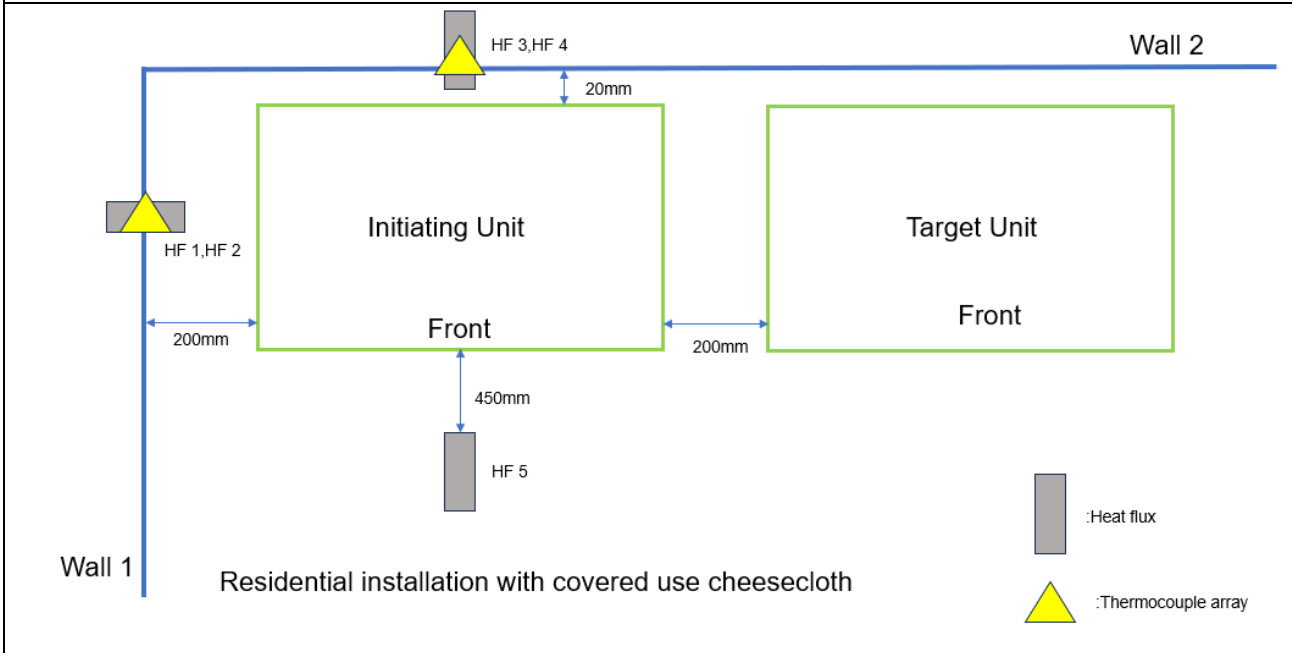

Figure 2: Test setup layout

Attachment 3 - Diagram and dimension of test setup

Separation distance and other critical dimension detail

Location	Required by manufacturer (mm)	Measured (mm)
Distance between initiating unit and wall 1	200	200
Distance between initiating unit and wall 2	20	20
Distance between initiating unit and target unit	200	200

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Attachment 4 - Temperature/voltage graph during testing

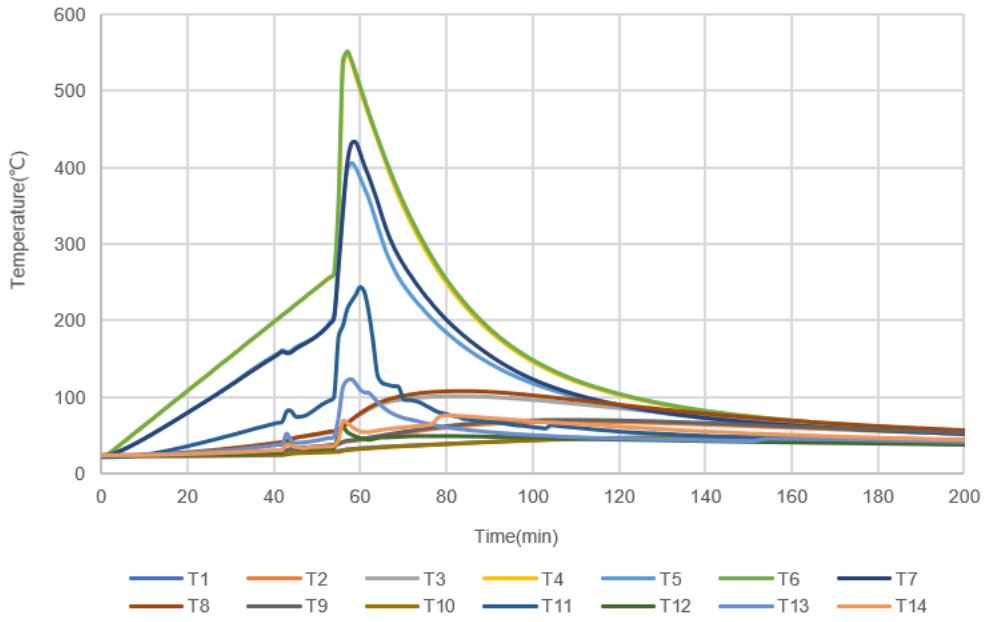

Figure 1: Cells within Initiating module surface temperature

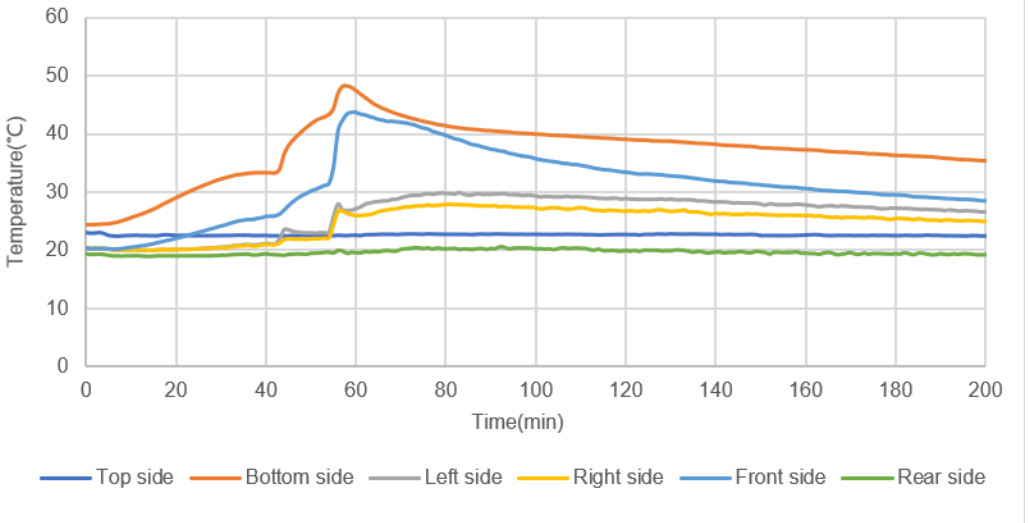

Figure 2: Initiating module enclosure temperature

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Attachment 4 - Temperature/voltage graph during testing

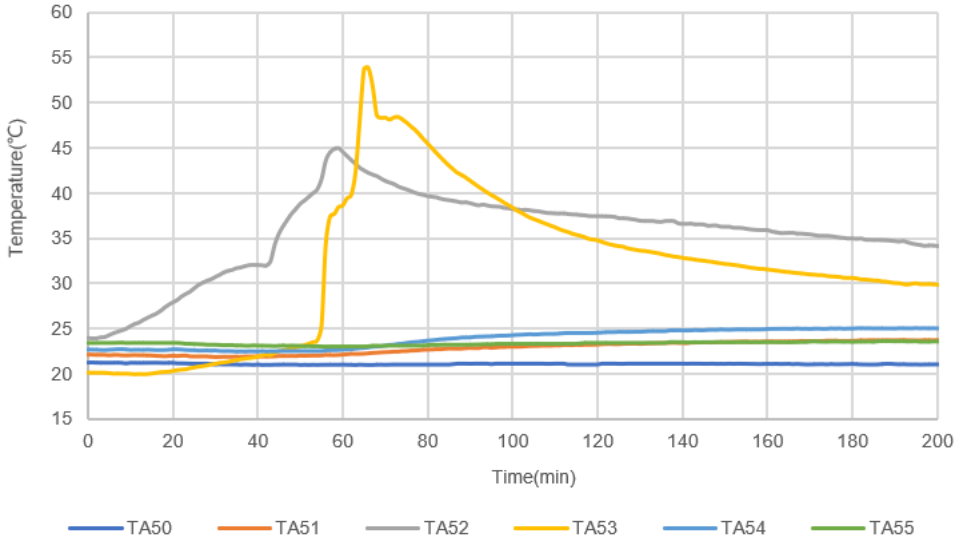

Figure 3: Module enclosure temperature within initiating unit

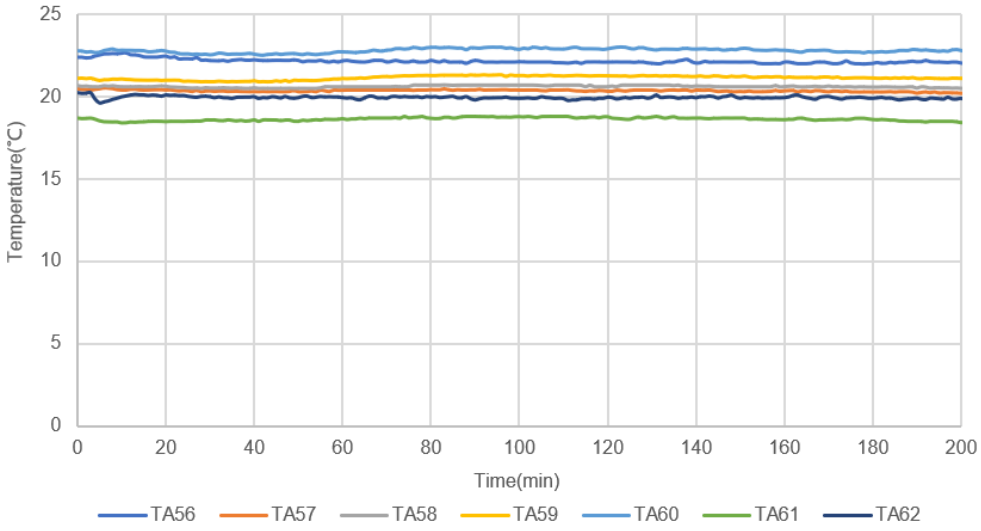

Figure 4: Module enclosure temperature within target unit 1

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Attachment 4 - Temperature/voltage graph during testing

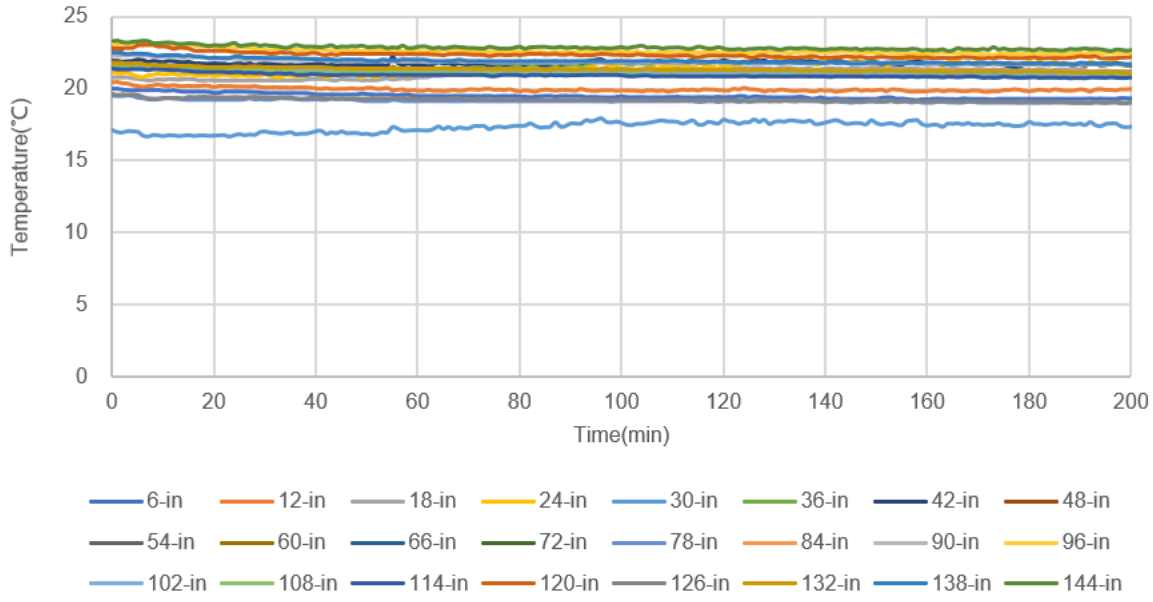

Figure 5: Instrument wall 1 surface temperature

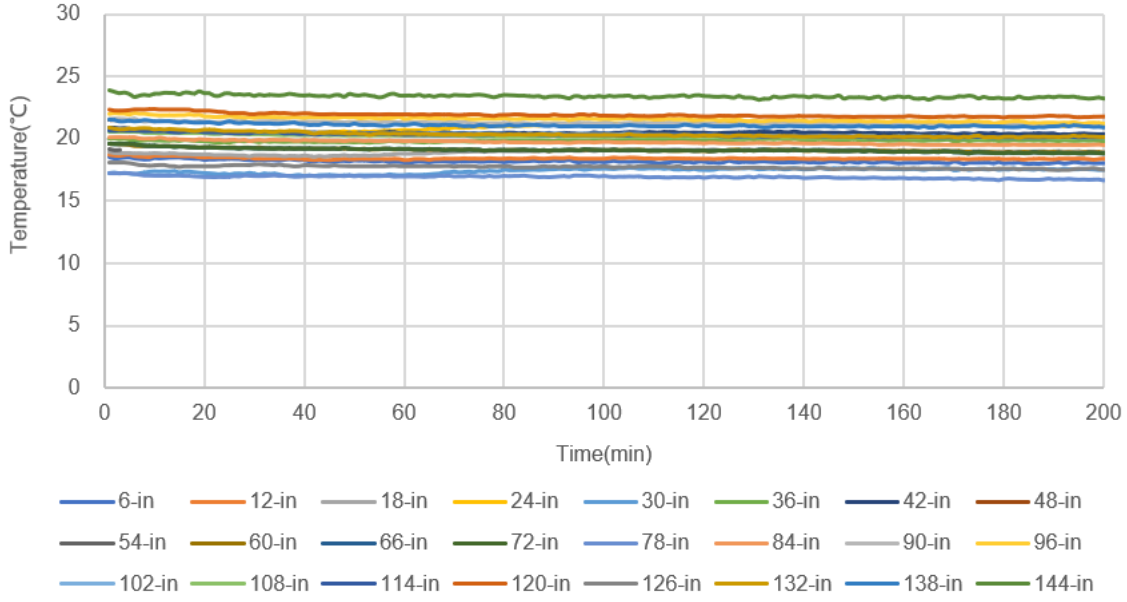

Figure 6: Instrument wall 2 surface temperature

Attachment 4 - Temperature/voltage graph during testing

Maximum temperature measurement

Location	Temperature limit (°C)	Measured maximum temperature (°C)
Initiating module cell surface (the maximum temperature location at right side surface center)	N/A	552
Initiating module enclosure(the maximum temperature location at bottom side)	N/A	48
Initiating unit(the maximum temperature location at TA 53)	N/A	54
Target unit(the maximum temperature location at TA 56)	154	23
Instrument wall 1(the maximum temperature location at the height of 48-in)	116.9	23.0
Instrument wall 2(the maximum temperature location at the height of 144-in)	116.9	24.0

Open circuit voltage measurement

Location	Before testing (Vdc)	After testing (Vdc)
Module 1	60.4	60.0
Module 2	60.4	60.0
Module 3	60.4	60.0
Module 4(Initiating module)	61.0	57.3
Module 5	60.4	60.0
Module 6	60.4	60.0
Module 7	60.4	60.0

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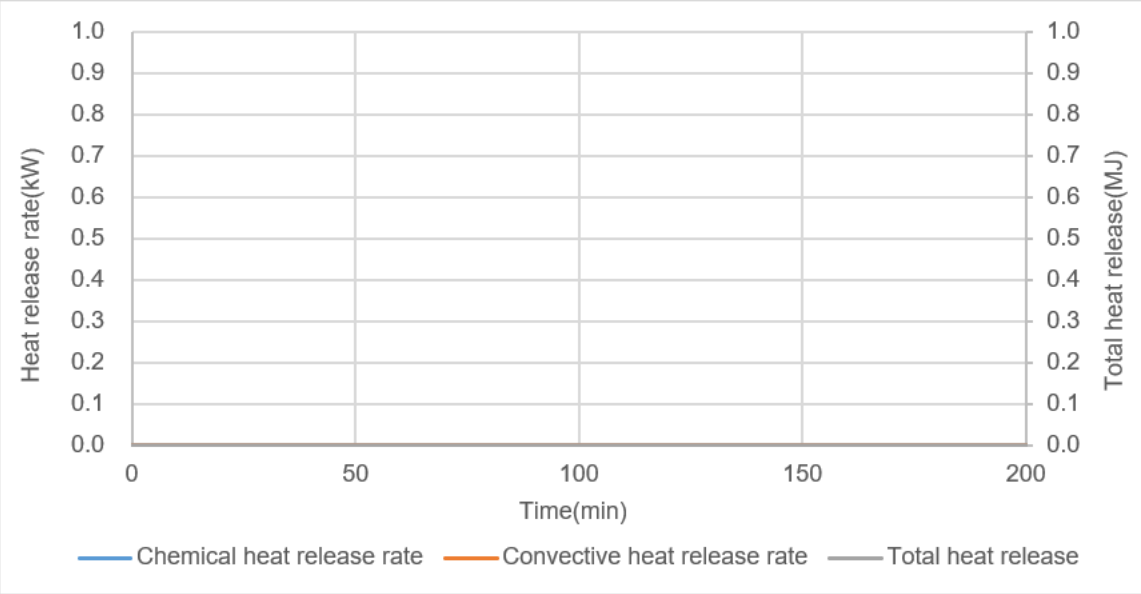
Attachment 5 - Heat release rate graphs



Note: There was no flame occur during test.

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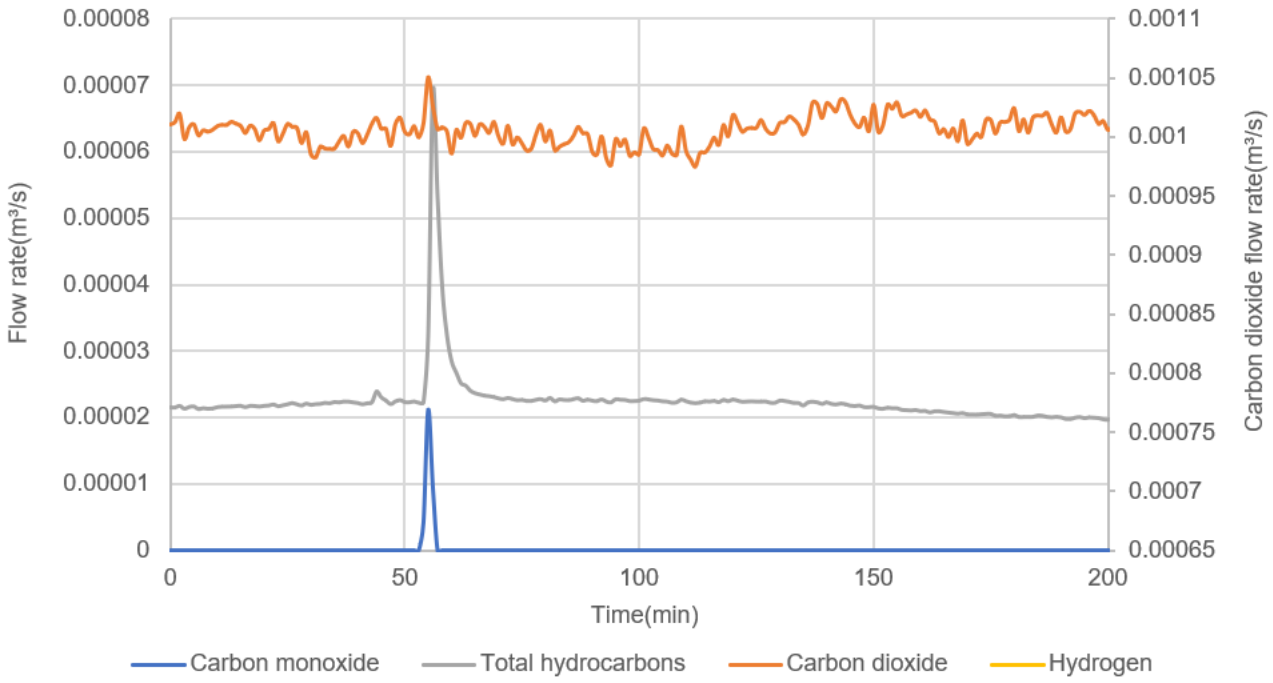
Attachment 6 - Gas generation graphs



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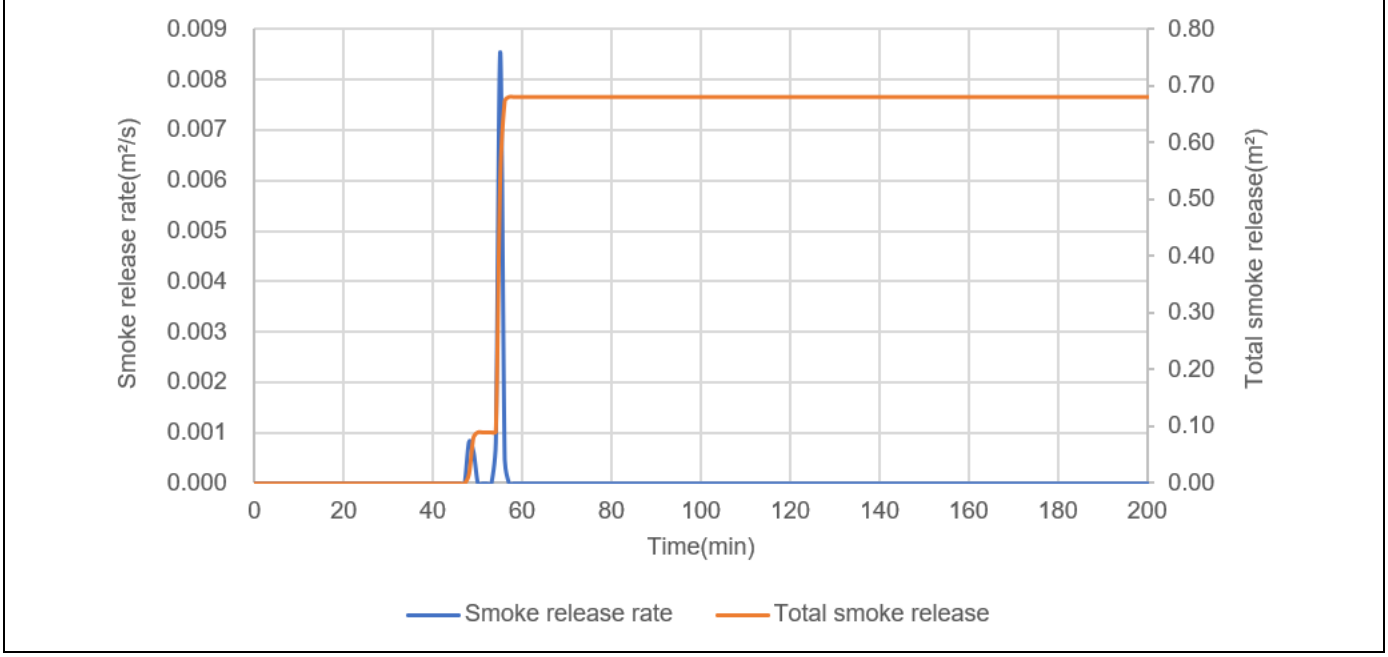
Attachment 7 - Smoke release graph



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Project / Network:	80182817	Description:	Rechargeable lithium-ion battery unit	

Attachment 8 - Heat flux graph

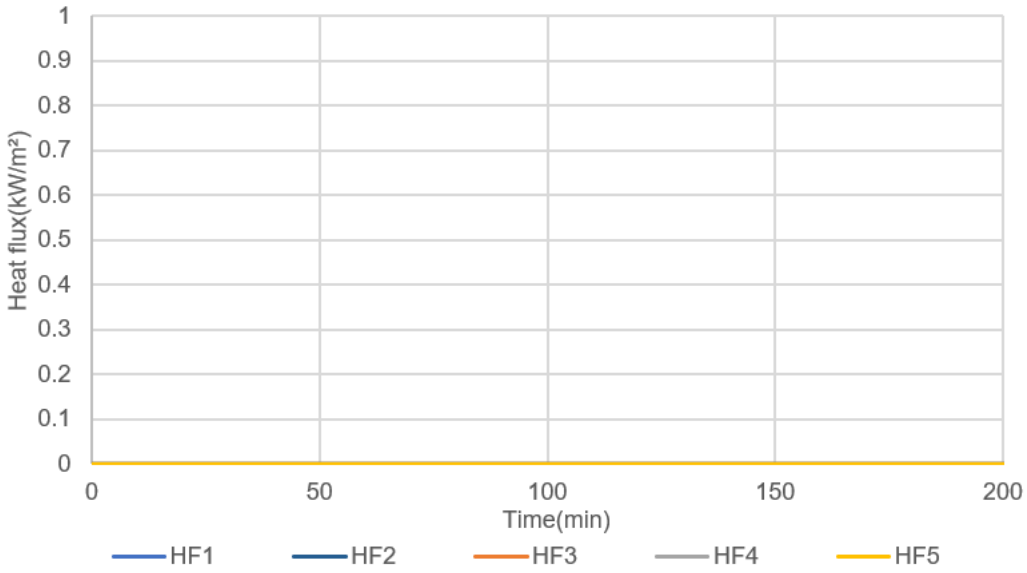

Table 6 – Maximum Heatflux measurement

Location	Heatflux limit (kW/m^2)	Measured maximum Heatflux (kW/m^2)
Heat flux 1: at wall 1, the height of initiating module	N/A	0
Heat flux 2: at wall 1, the height of topper module	N/A	0
Heat flux 3 at wall 2, the height of initiating module	N/A	0
Heat flux 4 at wall 2, the height of topper module	N/A	0
Heat flux 5 at egress path center and the height of initiating module	1.3	0
Note: Because of the cheesecloth may partially occlude heat flux transmission, the value of heat flux only for reference.		

Attachment 9 - Notable observation during test

Observation	Time from test start (mm/dd HH:MM:SS)	Comment
Test start	03/04 18:44:44	Two pieces heater film on cell 5 were energized with thermal ramp 4.5°C /min
Venting/Thermal runaway	03/04 19:28:04	Cell 5 was venting with temperature dropped
Venting/Thermal runaway	03/04 19:39:11	Cell 5 thermal runaway with smoke released and all heater films were deenergized
Test end	03/05 08:00:00	Data acquisition stopped

End of Report….