



CSA GROUP
Laboratory Test Data - UL 9540A

Master Contract: 302680
Report: 80112278
Project: 80112278

Nov. 25, 2022

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

Subject: *Li-ion battery system, model ECS4000-H7 (UL 9540A Test Report)*

Dear Mr Xin Chen:

We are pleased to inform you that testing of your product per UL 9540A has been completed. Applicable test(s) was witnessed at CSA partner lab Shanghai Huahui Testing Co.,Ltd . Unit level of test(s) was conducted on the sample you 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,

Joseph Zhou
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 graphs
Att.6 - Gas generation graph
Att.7 - Smoke release graph
Att.8 - Heat flux graph
Att.9 - Notable observation during test
Att.10 – Test Video



ORIGINAL TEST DATA

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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 Letter , Testing Only

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

Testing Laboratory Name: Shanghai Huahui Testing Co., Ltd

Address: No. 158, Changbangcun Road, Fengxian District, Shanghai, China

Facility Qualification Number: 302680

Customer: As above / or describe otherwise
FOXESS CO., LTD

Address: No.939, Jinhai Third Road,
New Airport Industry Area,
Longwan District
Wenzhou, Zhejiang 325025
China

Tested By: Nan Wang (Huahui, Technician)
Name, Title

Nan Wang 2022-08-18
Signature Date (YYYY-MM-DD)

Reviewed by: Joseph Zhou(CSA, Certifier)
Name, Title

Witnessed by: Joseph Zhou 2022-08-18
Signature Date (YYYY-MM-DD)



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Master Contract:	302680	Model:	ECS4000-H7	Page number 2 of 35
Project / Network:	80112278	Description:	Li-ion battery system for stationary application	

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 No. 4789813319
Standard and its edition used for testing:	UL9540A 4 th edition
Manufacturer:	Batterotech Corporation Limited
Brand name / Trademark:	N/A
Model number:	PC-0B1-39148A2-AW
Nominal cell voltage, (V)	3.2
Cell capacity, (Ah)	69
Cell chemistry:	LFP
Physical format of cell:	Prismatic
Approximate dimension, (mm)	39.72±2 mm (depth) by 148.33±2 mm (width) by 105.11±2 mm (height)
Mass, (g)	1330±50 g
Method used to initiate thermal runaway:	Film heater
Average temperature at which cell first vented excluding gas collection sample, (°C)	177
Average temperature prior to thermal runaway excluding gas collection sample, (°C)	221
Flammable gas generation, (Liter)	-
Total gas generation, (Liter)	33.0
Lower flammability limit (LFL) at ambient temperature (25 ± 5°C), (%)	6.95
Lower flammability limit (LFL) at average gas vent temperature, (%)	5.85
Burning velocity, (Cm/Sec)	92.7
Maximum pressure P _{max} , (psig)	99
Gas composition:	See below table

Carbon Monoxide	CO	9.596
Carbon Dioxide Ethane	CO ₂	24.719
Hydrogen	H ₂	54.758



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


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Methane	CH ₄	4.676
Acetylene	C ₂ H ₂	0.090
Ethylene	C ₂ H ₄	2.097
Ethane	C ₂ H ₆	0.670
Propadiene (Allene)	C ₃ H ₄	0.001
Propene	C ₃ H ₆	0.429
Propane	C ₃ H ₈	0.188
-	C ₄ (Total)	0.651
-	C ₅ (Total)	0.099
-	C ₆ (Total)	0.014
i-Heptane	C ₇ H ₁₄	0.007
Benzene	C ₆ H ₆	0.020
Toluene	C ₇ H ₈	0.003
Dimethyl Carbonate	C ₃ H ₆ O ₃	1.520
Ethyl Methyl Carbonate	C ₄ H ₈ O ₃	0.461
Total	---	100

Module Level Test Summary	
Name of test laboratory perform module level testing:	CSA partner lab
Unique identification of test report:	80136755
Standard and its edition used for testing:	UL 9540A 4th edition
Manufacturer:	FOXESS CO., LTD
Brand name / Trademark:	
Model number:	CS4000
Nominal voltage rating, (V)	57.6
Nominal capacity rating, (Ah)	69
Approximate dimension, (mm)	L*W*H: 570*380*155mm
Method used to initiate thermal runaway:	Film heater
Number of cells used for initiating thermal runaway:	1
Number of cells exhibited thermal runaway within module:	13
Cell to cell propagation condition:	Yes




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

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Project / Network: 80112278	Description: Li-ion battery system for stationary application	

Peak chemical heat release rate, (kW)	0.557
Flammable gas generation, (Liter)	257.6
Total gas generation, (Liter)	332.6
Weight loss, (%)	5.71%
Gas composition:	CO: 18.6L; CO ₂ : 75L; THC: 239L
Additional Information:	N/A

Unit Level Test Summary	
Manufacturer:	FOXESS CO., LTD
Brand name / Trademark:	
Model number:	ECS4000-H7
Nominal voltage rating, (V)	57.6*7
Nominal capacity rating, (Ah)	69
Approximate dimension, (mm)	L*W*H: 570*380*950
BESS test configuration/intended installation:	Indoor floor mounted non-residential BESS application
(If residential installation) Smallest room volume specified by manufacturer, (m ³)	6 cubic meter declared with a dimension indicated below: (W*D*H:2m*2m*1.5m)
Unit certification available?, (Yes/No)	Yes, refer to CSA report 80112275
Standard(s) used to certify product:	UL 1973 3 rd edition
Certification organization name and its certificate number:	CSA
Electrical configuration of module in BESS:	7S1P
Number of modules in BESS:	7
Fire detection and suppression system integral part of BESS: (Yes/No)	No, no fire detection and suppression system integral as part of BESS.
Test conducted with fire detection and suppression system: (Yes/No/Not Applicable)	Not Applicable
Method used to initiate thermal runaway:	Film Heater
Number of cells used for initiating thermal runaway:	1
Number of cells exhibited thermal runaway within initiating module:	4



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Unit Level Test Summary	
Number of modules exhibited thermal runaway within initiating BESS:	1
Cell to cell propagation condition:	Cell to cell propagation condition exhibited to at least 4 cells in the initiating module.
Peak chemical heat release rate, (kW)	No flaming occurred
Peak convective heat release Rate, (kw)	No flaming occurred
Flammable gas generation, (Liter)	Before Flaming: 30.8L After Flaming: N/A, no fire ignited during the test
Total gas generation, (Liter)	Before Flaming: 74.5 After Flaming: N/A, no fire ignited during the test
Gas composition:	Before Flaming: (CO:7.0%,CO2: 58.6%,THC:34.4%) After Flaming: N/A, no fire ignited during the test
Maximum wall surface temperature, (°C)	31.7
Maximum target BESS temperature, (°C)	N/A, no target BESS unit specified
Maximum incident heat flux on target wall surfaces, (kw/m ²)	Residential applications, cheesecloth used instead of heat flux gauge
Maximum incident heat flux on target BESS, (kw/m ²)	N/A, no target BESS unit specified
Maximum incident heat flux of egress path, (kw/m ²)	No egress specified for BESS installation
Total smoke release, (m ²)	48.26
Peak smoke release rate, (m ² /s)	0.187
Additional Information:	N/A



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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 fire ignited, no flaming or charring of the cheesecloth observed	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	Single battery system was installed, no target battery system provided for testing	N/A
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	Surface temperature measured on wall surface (31.7°C) were within the temperature limits	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 or hazards or deflagration of vented gas was not observed	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 within 25% LFL in air based on the smallest specified room installation size	P

Summary of Result:

A unit level test meet 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/Battery system certification available? (Yes/No)	Yes, CSA project No.80112275	---
	Standard(s) used to certify product:	UL 1973 3 rd edition	---
5.3.2	BESS/Battery system component documentation	<input checked="" type="checkbox"/> BESS/Battery system certification was available – Component detail not documented. <input type="checkbox"/> BESS/Battery system certification was not available – See list of critical components in attachment section. <input type="checkbox"/> Other(explain):	---
	BESS/Battery system enclosure approximate dimension, (mm)	L*W*H: 570*380*950	---
	BESS/Battery system enclosure material:	Metallic	---
	Based on configuration of BESS, test conducted on:	<input type="checkbox"/> BESS <input checked="" type="checkbox"/> Battery system	---
5.3.3	Fire detection system	<input type="checkbox"/> Integral part of DUT, test conducted with fire detection system. <input type="checkbox"/> Integral part of DUT, test conducted without fire detection system. <input checked="" type="checkbox"/> Not integral part of DUT	---
	Fire suppression system	<input type="checkbox"/> Integral part of DUT, test conducted with fire suppression system. <input type="checkbox"/> Integral part of DUT, test conducted without fire suppression system. <input checked="" type="checkbox"/> 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 application	---
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.	Single battery system installation, no target BESS unit provided for testing	N/A
	Additional representative test configuration based on test configuration.	Outdoor ground mounted residential application	---
	Separation distances between initiating and target units were representative of the installation.	Single battery system installation, no target BESS unit provided for testing	N/A
	Testing conducted outdoor for BESS intended for outdoor installation only. Following controls and environmental conditions were in place.	Test conducted per indoor floor mounted residential application	N/A
	a) Wind screens were utilized with a maximum wind speed maintained at ≤ 12 mph	-	N/A
	b) Temperature range was within 10°C to 40°C	-	N/A
	c) The humidity was < 90% RH	-	N/A
	d) There was sufficient light to observe the testing;	-	N/A
	e) There was no precipitation during the testing;	-	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	-	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.	-	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.	Not a container BESS	N/A
9.1.3	Based on configuration and design of BESS, test conducted on:	<input type="checkbox"/> BESS <input checked="" type="checkbox"/> 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.	Confirmed	P
9.1.5	Target BESS units include the outer cabinet (if part of the design), racking, module enclosures, and components that retain cells components.	Single system installation, no target BESS unit provided for testing	N/A
	The target BESS unit module enclosures did not contain cells.	See above	N/A
9.1.6	Initiating BESS unit was at the maximum operating state of charge (MOSOC).	BESS fully charged condition was considered achieved following the charging procedure of the DUT	P
	After charging and prior to testing, the initiating BESS was rested for a maximum period of 8 h at room ambient.	See table 2 for details.	P
9.1.7	BESS unit test conducted as per following condition.	See below	P
	a) Integral fire suppression system provided with the DUT.	See below	N/A
	b) Without Integral fire suppression system.	No fire suppression system designed for the BESS	P
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.	No integral fire suppression system provided for the BESS	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).	See table 2 for details	P
	Ambient temperature range during test, °C	See table 2 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.	No access door or panels designed for the BESS	N/A
9.2.3	The initiating BESS unit was positioned adjacent to two instrumented wall sections.	See figure 22 for details	P

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Clause	Requirement + Test	Result - Remark	Verdict
9.2.4	Instrumented wall sections were extended not less than 0.49 m (1.6 ft) horizontally beyond the exterior of the target BESS units.	Confirmed	P
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.	Confirmed	P
	Chemical heat release rate was calculated as per following formula. $HRR_1 = \left[E \times \varphi - (E_{CO} - E) \times \frac{1 - \varphi}{2} \times \frac{X_{CO}}{X_{O_2}} \right] \times \frac{m_e}{1 + \varphi \times (\alpha - 1)} \times \frac{M_{O_2}}{M_a} \times (1 - X_{H_2O}) \times X_{O_2}^2$	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.	Confirmed	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



CSA GROUP
Laboratory Test Data - UL 9540A Checklist and Test Result (Unit Level)
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Clause	Requirement + Test	Result - Remark	Verdict
9.2.12	Convective heat release rate was calculated as per following formula. $HRR_c = V_c A_c \frac{353.22}{T_c} \int_{T_c}^T C_p dT$	Confirmed	P
9.2.13	Physical spacing between BESS units (both initiating and target) and adjacent walls were representative of the intended installation.	See figure 22 for details	P
9.2.14	Separation distances was specified by the manufacturer for distance between:	See below	P
	a) The BESS units and the instrumented wall sections.	See figure 22 for details	P
	b) Adjacent BESS units.	Single BESS installation, no adjacent BESS specified	N/A
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	Confirmed	P



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Clause	Requirement + Test	Result - Remark	Verdict
	with the surface at that point by the use of pressure-sensitive paper tape.		
9.2.18	Heat flux was measured with the sensing element of at least two water-cooled Schmidt- Boelter or Gardon gauges at the surface of each instrumented wall.	Cheesecloth was used as indicator to instead of heat flux gauge following UL 9540A Certification Requirement Decision dated on Mar 21, 2021 for residential BESS units.	N/A
	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, cheesecloth was used as redundant indicator	N/A
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.	See above	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:	Residential BESS application, no target BESS unit specified. Cheesecloth was used as indicator to instead of heat flux gauge following UL 9540A Certification Requirement Decision dated on Mar 21, 2021 for residential BESS units.	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



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Clause	Requirement + Test	Result - Remark	Verdict
	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
9.2.19.1	Heat flux measurements on target units were waived for residential units that are tested with the cheesecloth indicator.	Cheesecloth indicator was used to instead of the heat flux gauge	N/A
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.	See above	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.	Residential applications	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



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Clause	Requirement + Test	Result - Remark	Verdict
9.2.22	For residential use BESS, the DUT was covered with a single layer of cheese cloth ignition indicator.	Confirmed	P
	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.	See figure 5~7 in attachment 2 for details	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;	2 nd module from the bottom was selected for thermal runaway initiating	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.	HFID was used to measure the total hydrocarbons	P
	Hydrogen gas was measured with a palladium-nickel thin-film solid state sensor.	Pd-Ni thin film solid state sensor was used for hydrogen measurement	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 was additionally used for reference	P
9.2.26	The test was terminated at:	See below	P
	a) Temperatures measured inside each module within the initiating BESS unit return to ambient temperature;	Confirmed	P



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Clause	Requirement + Test	Result - Remark	Verdict
	b) The fire propagates to adjacent units or to adjacent walls; or	See above	N/A
	c) A condition hazardous to test staff or the test facility requires mitigation.	See above	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.	No detectable flammable gas collected exceeds 25% based on the smallest room installation specified by the manufacturer.	P
9.3	Test method – Outdoor ground mounted units	Test conducted followed the requirements of indoor floor mounted residential application.	N/A
9.4	Test Method – Indoor wall mounted units	Test conducted followed the requirements of indoor floor mounted residential application.	N/A
9.5	Test Method – Outdoor wall mounted units	Test conducted followed the requirements of indoor floor mounted residential application.	N/A
9.6	Rooftop and open garage installations	Test conducted followed the requirements of indoor floor mounted residential application.	N/A
9.7	Unit level test report	See below	P
9.7.1	Type of installation considered during unit level testing:	Indoor floor mounted residential application	P
9.7.2	Additional installation represented by type of installation considered during unit level testing:	Outdoor ground mounted residential application	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);	FOXESS CO., LTD, Model No. ECS4000-H7	P
	b) Number of modules in the initiating BESS unit;	7	P
	c) The construction of the initiating BESS unit per 5.3;	Confirmed	P
	d) Fire protection features / detection / suppression systems within unit;	No fire suppression system within the unit	N/A
	e) Module voltage(s) corresponding to the tested SOC;	Confirmed, see table 3 for details.	P
	f) The thermal runaway initiation method used;	Film Heater	P
	g) Location of the initiating module within the BESS unit;	The 2 nd module from the bottom	P



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Clause	Requirement + Test	Result - Remark	Verdict
	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;	No target BESS units were defined, see figure 22 in attachment 2 for the test setup diagram and dimensions.	P
	i) Observation of any flaming outside the initiating BESS enclosure and the maximum flame extension;	No flaming outside the initiating BESS enclosure was 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 figure 22 in attachment 2 for details.	P
	l) Separation distances from the initiating BESS unit to target BESS units;	No target BESS unit defined	N/A
	m) The maximum wall surface and target BESS temperatures achieved during the test and the location of the measuring thermocouple;	Max wall surface temperature measured, see attachment 4 for details.	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;	Indoor floor mounted residential applications, no ceiling or soffit surface considered when testing	N/A
	o) The maximum incident heat flux on target wall surfaces and target BESS units;	Heat flux not measured for residential BESS application, cheesecloth used as instead based on UL9540A Certification Requirement Decision dated on 2021-03-21	N/A
	p) The maximum incident heat flux on target ceiling or soffit surfaces achieved during the indoor or outdoor wall mounted test;	Indoor floor mounted residential application	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;	Not observed	P
	u) Observation of re-ignition(s) from thermal runaway events;	Not observed	P
	v) Observation(s) of sparks, electrical arcs, or other electrical events;	Not observed	P
	w) Observations of the damage to:	Not observed	P



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Clause	Requirement + Test	Result - Remark	Verdict
	1) The initiating BESS unit; 2) Target BESS units; 3) Adjacent walls, ceilings, or soffits x) Photos and video of the test.	Confirmed	P

Table 1 – Unit charge/discharge specification			
Charging method	CC	Discharging method	CC
Charge current, (Adc)	50	Discharge current, (Adc)	35
Charge voltage, (Vdc)	64.8	---	---
Charge end current, (Adc)	-	Discharge end voltage, (Vdc)	48.6
Manufacturer recommended charge temperature, (°C)	N/A	Manufacturer recommended discharge temperature, (°C)	N/A

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)
DUT1	2022-08-18	13:21	2022-08-18	15:18PM
Ambient temperature during unit conditioning				
Ambient Lab Temperature, (°C)		Relative Humidity, (%RH)		
24.1 to 25.6		65 to 72		

Table 3 – Unit level test	
Sample Number:	DUT1
Ambient temperature at start of test, (°C)	25.4
Ambient temperature range during test, (°C)	24.1 to 25.6
Relative humidity, (%RH)	67
Number of cells used for initiating thermal runaway:	1
Open circuit voltage before test, (Vdc)	61.2
External film heater ramp rate, (°C/min)	5.4
Other method used to initiate thermal runaway:	N/A
Location of cell and module for initiating thermal runaway:	See figure 5 and figure 8 in attachment 2 for details
Number of cells exhibited thermal runaway within initiating module:	4



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Table 3 – Unit level test	
Number of modules exhibited thermal runaway within initiating BESS:	1
Location of cell and module exhibited thermal runaway within initiating BESS:	See attachment for details
Cell to cell propagation condition:	Yes, cell to cell propagation initiated to 4 cells within the initiating module.
Peak chemical heat release rate, (kW)	0, no fire ignited during the test
Peak convective heat release rate, (kW)	No flaming occurred
Flammable gas generation, (Liter)	Before Flaming: 30.8 After Flaming: -
Total gas generation, (Liter)	Before Flaming: 74.5 After Flaming: -
Peak smoke release rate, (m ² /sec)	0.1873
Total smoke release rate, (m ²)	48.26

Table 4 – Gas composition			
Gas Component		Volume Released (Before Flaming) (Liter)	Volume Released (After Flaming) (Liter)
Carbon Monoxide	CO	5.2	-
Carbon Dioxide	CO ₂	43.7	-
Total Hydrocarbons equivalent to	THC	25.6	-
Hydrogen	H ₂	0	-
Methane ⁽¹⁾	CH ₄	5.2	-
Ethylene ⁽¹⁾	C ₂ H ₄	2.6	-
Ethane ⁽¹⁾	C ₂ H ₆	0.8	-
Propylene ⁽¹⁾	C ₃ H ₆	4.8	-
Propane ⁽¹⁾	C ₃ H ₈	1.6	-
Hydrogen Fluoride ⁽¹⁾	HF	0.8	-
Methanol ⁽¹⁾	CH ₄ O	1.7	-
Diethyl carbonate ⁽¹⁾	C ₅ H ₁₀ O ₃	0.1	-
Ethylmethyl carbonate ⁽¹⁾	C ₄ H ₈ O	22.3	-
Dimethyl carbonate ⁽¹⁾	C ₃ H ₆ O ₃	28.6	-

⁽¹⁾Note: Gases measured for reference using FTIR equipment.

Table 5 – Critical observation	
Condition	Comment



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Table 5 – Critical observation	
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;	N/A, no target BESS unit defined
Damage to adjacent walls	Not observed
Damage to ceilings	Indoor floor mounted residential application, N/A
Damage to soffits	Indoor floor mounted residential application, N/A

Attachments

Index of Attachments		
No.	Name	Page
1	Unit charge/discharge conditioning graphs	20
2	Photos	21-25
3	Diagram and dimension of test setup	26~27
4	Temperature/voltage graph during testing	28~30
5	Heat release rate graph	31
6	Gas generation graph	32
7	Smoke release graph	33
8	Heat flux graph	34
9	Notable observation during test	35
10	Test Video (Separate file)	MP4

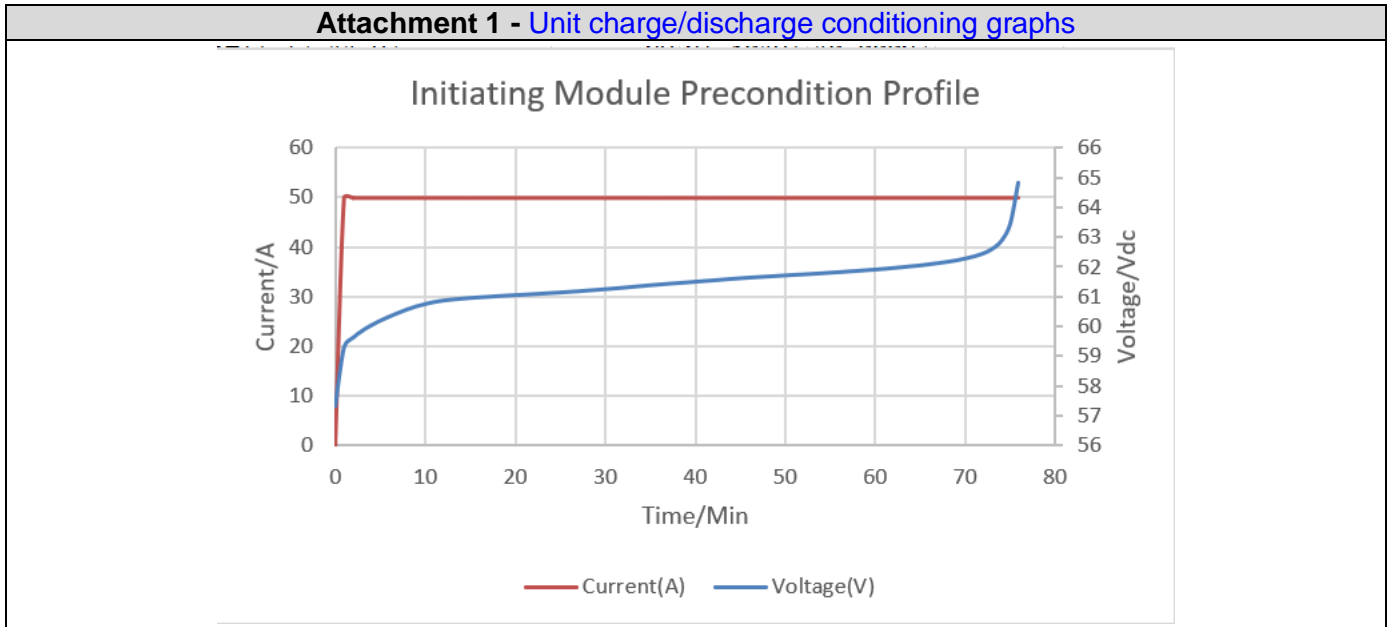
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Attachment 1 - Unit charge/discharge conditioning graphs



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Attachment 2 – Photos

General sample photos



Figure 1: Front View of BESS unit



Figure 2: Back View of BESS unit

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Attachment 2 – Photos



Figure 3: Side View of BESS unit



Figure 4: Side View of BESS unit

Photos with heater and thermocouple installation

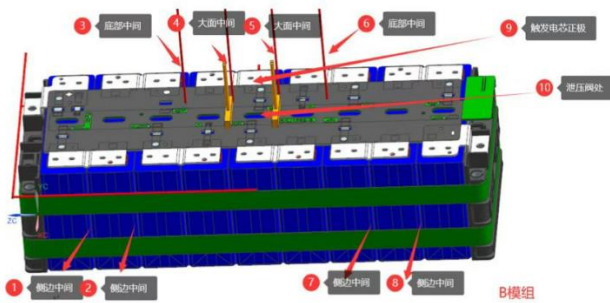


Figure 5: Heater and TC map in initiating module(sub-module B)

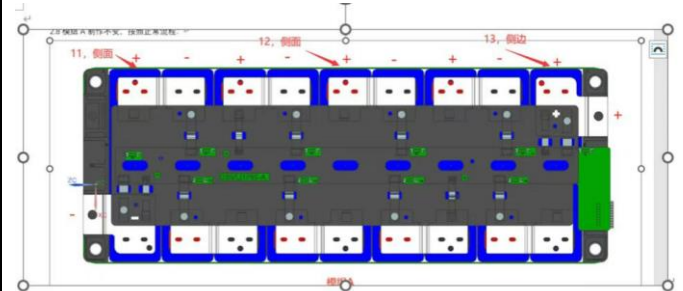


Figure 6: TC map in initiating module(sub-module A)

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Attachment 2 – Photos

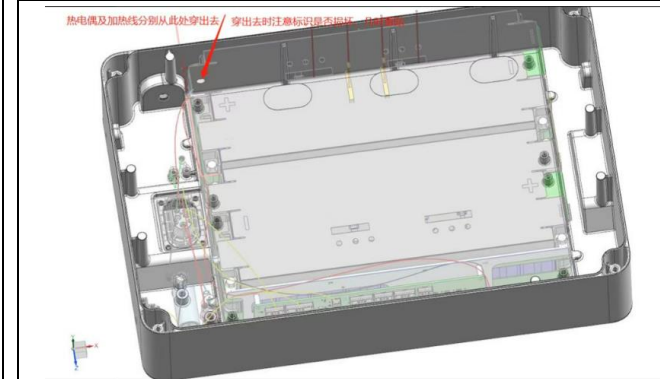


Figure 7: Output for TC wire



Figure 8: Unit Level Test Setup

Photos during test in progress



Figure 9: At test start (Time in 15:18)



Figure 10: During cell venting (Time in 15:56:03)



Figure 11: During thermal runaway (Time in 16:04)



Figure 12: During thermal runaway (Time in 16:08)

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Attachment 2 – Photos



Figure 13: During thermal runaway (Time in 16:20)



Figure 14: Test End

Photos after test



Figure 15: BESS unit after test

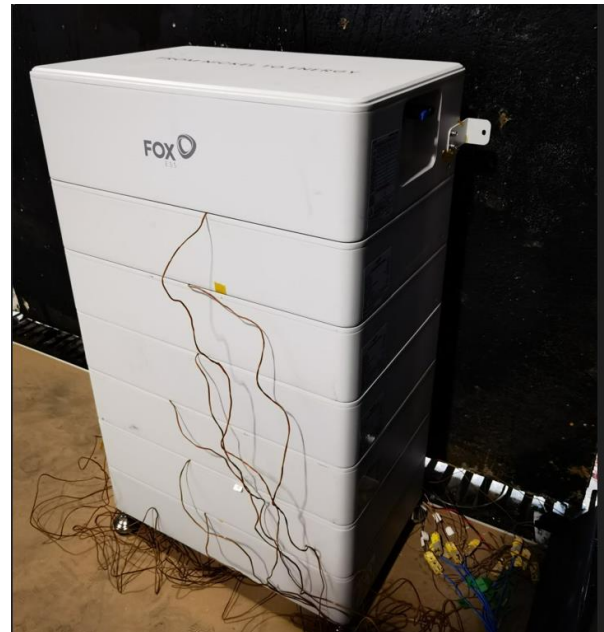


Figure 16: BESS unit after test

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Attachment 2 – Photos



Figure 18: Initiating module voltage after test



Figure 19: Initiating module after test



Figure 20: Internal view of initiating module



Figure 21: Internal view of initiating module

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Attachment 3 - Diagram and dimension of test setup

Unit Level Test Setup and TC wire Instrument on Section Wall

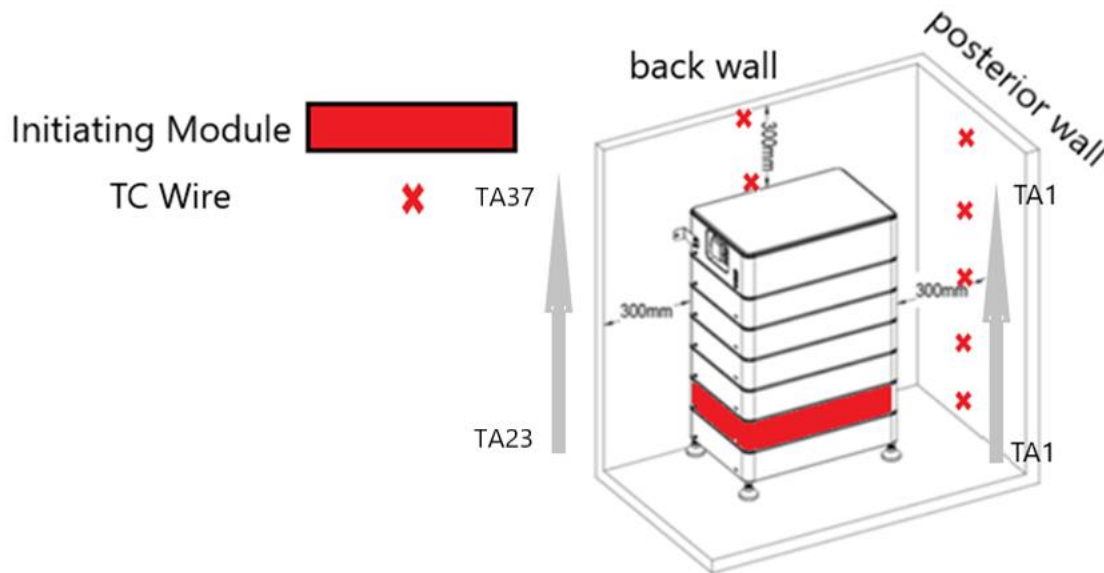


Figure 22a Unit Level Test Setup

Separation Distance between BESS unit and Back Section Wall

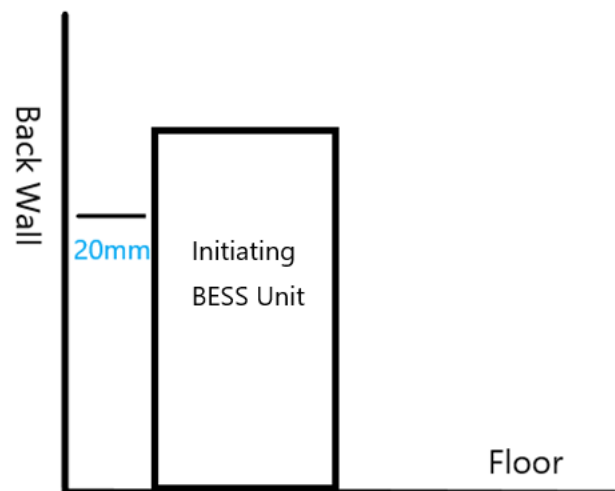


Figure 22b Unit Level Test Setup

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Attachment 3 - Diagram and dimension of test setup

TC Wire on Adjacent Modules of Initiating BESS Unit

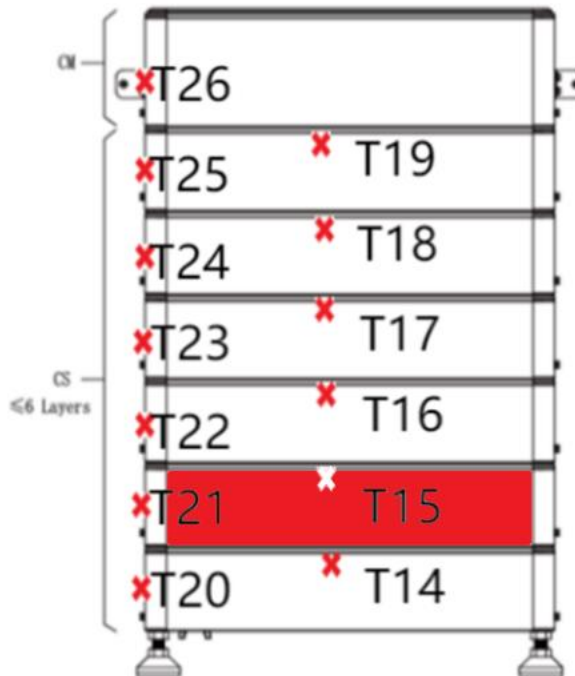


Figure 22c Unit Level Test Setup

Separation distance and other critical dimension detail		
Location	Required by manufacturer (mm)	Measured (mm)
Separation distance between the initiating BESS unit and instrumented wall section behind the initiating BESS unit	20mm	20mm
Separation distance between the initiating BESS unit and instrumented wall section to the side of the initiating BESS unit.	300mm	300mm

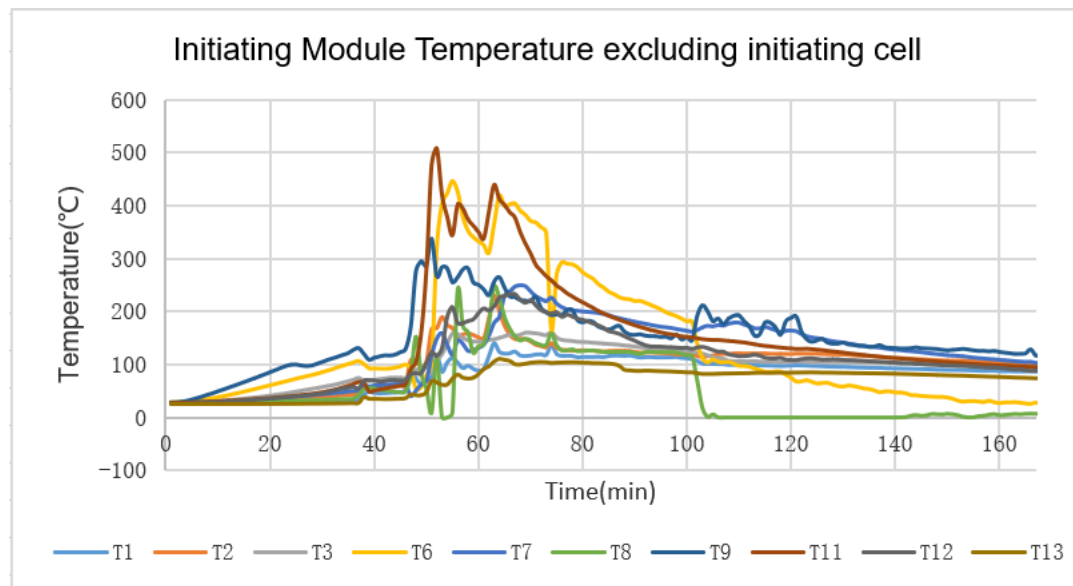
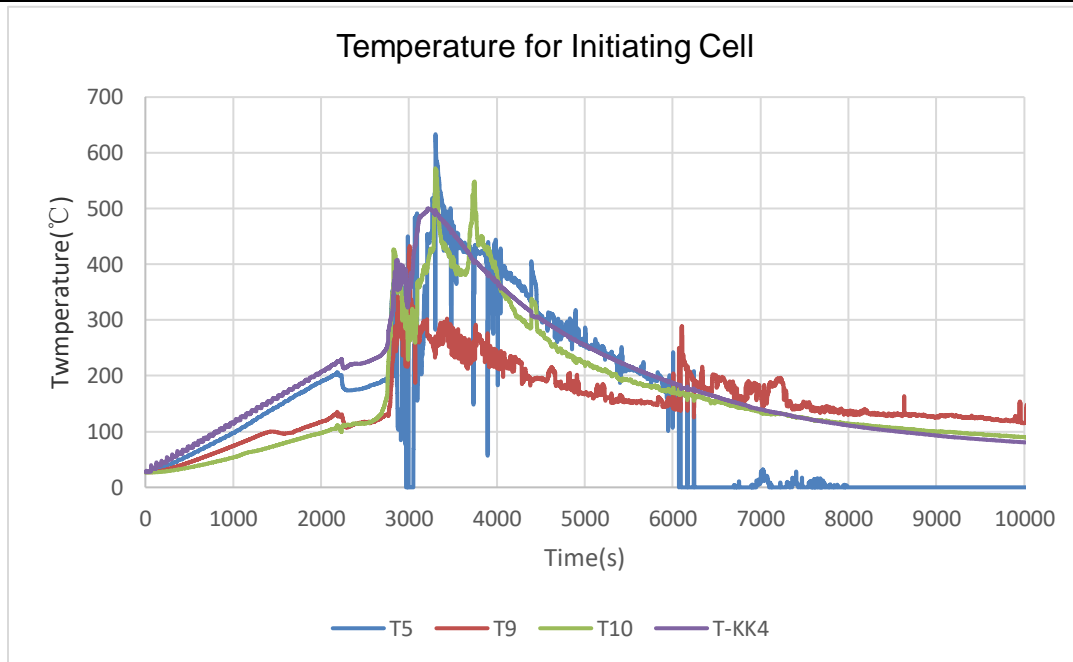
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Attachment 4 - Temperature/voltage graph during testing



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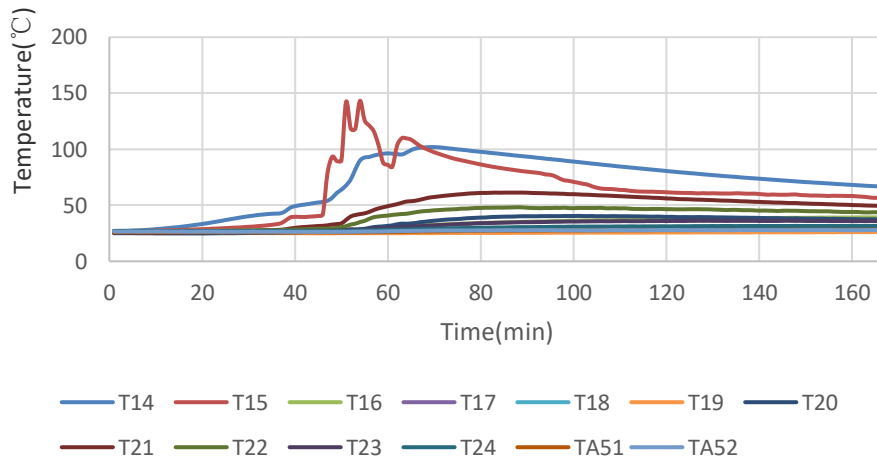
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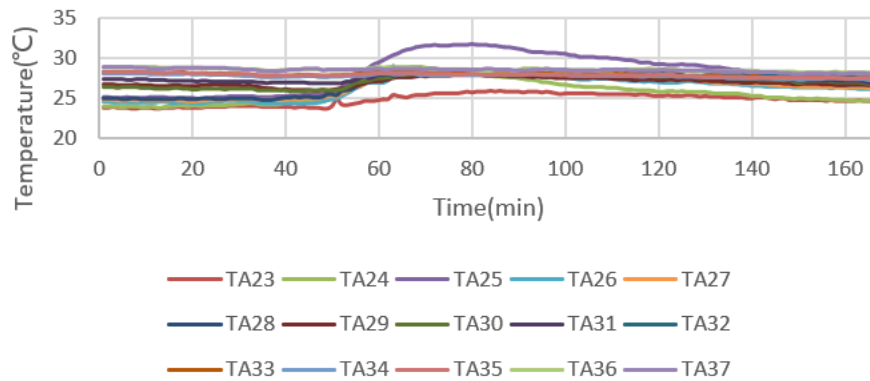
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Attachment 4 - Temperature/voltage graph during testing

Temperature Measurement for Modules in Initiating BESS Unit



Temperature Measurement for Back Wall Surface



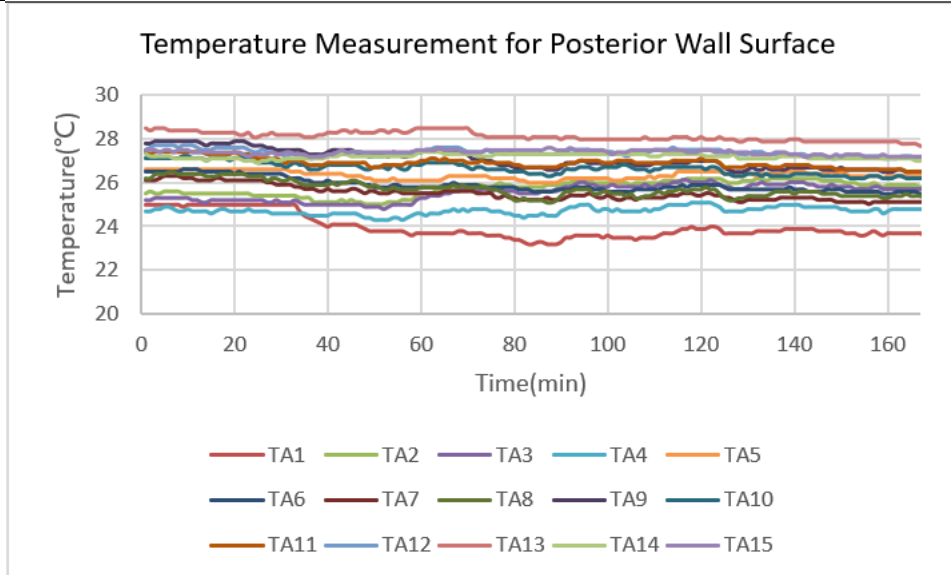
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Attachment 4 - Temperature/voltage graph during testing



Maximum temperature measurement

Location	Temperature limit (°C)	Measured maximum temperature (°C)
Max Wall Surface Temperature (TA26)	122	31.7
Front enclosure of initiating module	-	143.2
Front enclosure of bottom module	-	101.9

Open circuit voltage measurement

Location	Before testing (Vdc)	After testing (Vdc)
Module at bottom(1 st)	61.20	61.10
Initiating Module(2 nd)	61.20	46.19
Module above the initiating module(3 rd)	61.20	61.10
Module above the initiating module(4 th)	61.10	61.10
Module above the initiating module(5 th)	61.20	61.20
Module above the initiating module(6 th)	61.20	61.20
Module above the initiating module(7 th)	61.20	61.20



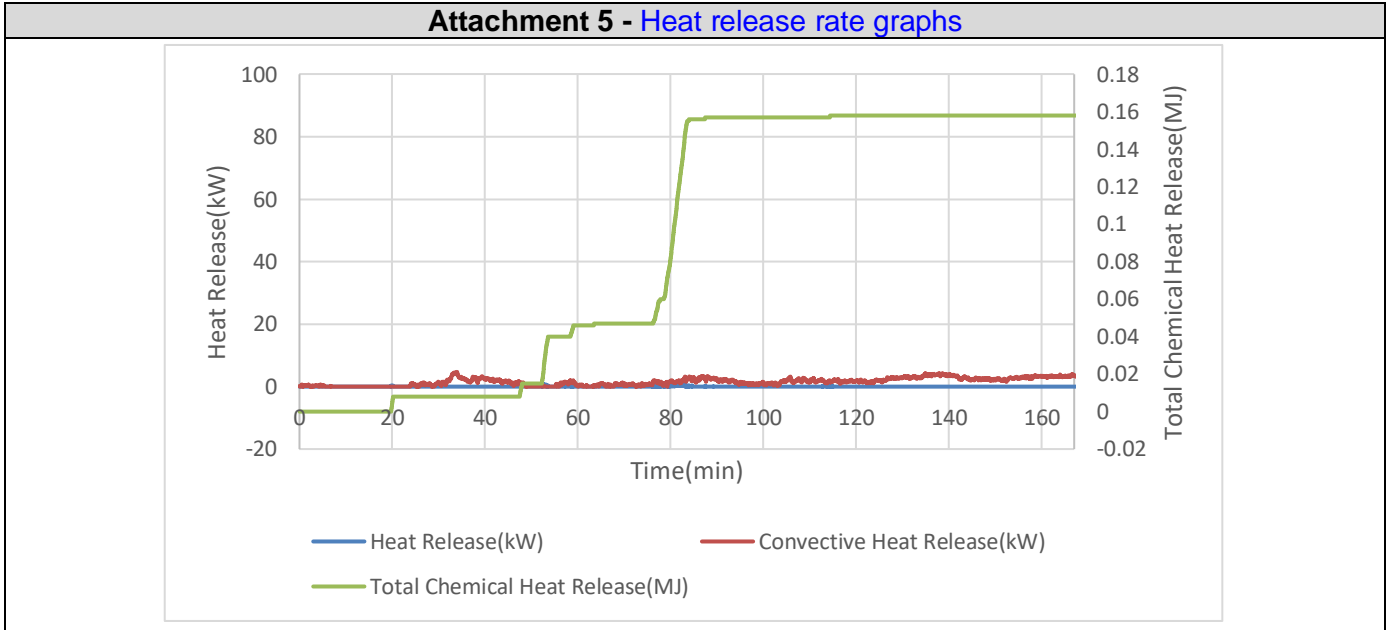
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Attachment 5 - Heat release rate graphs



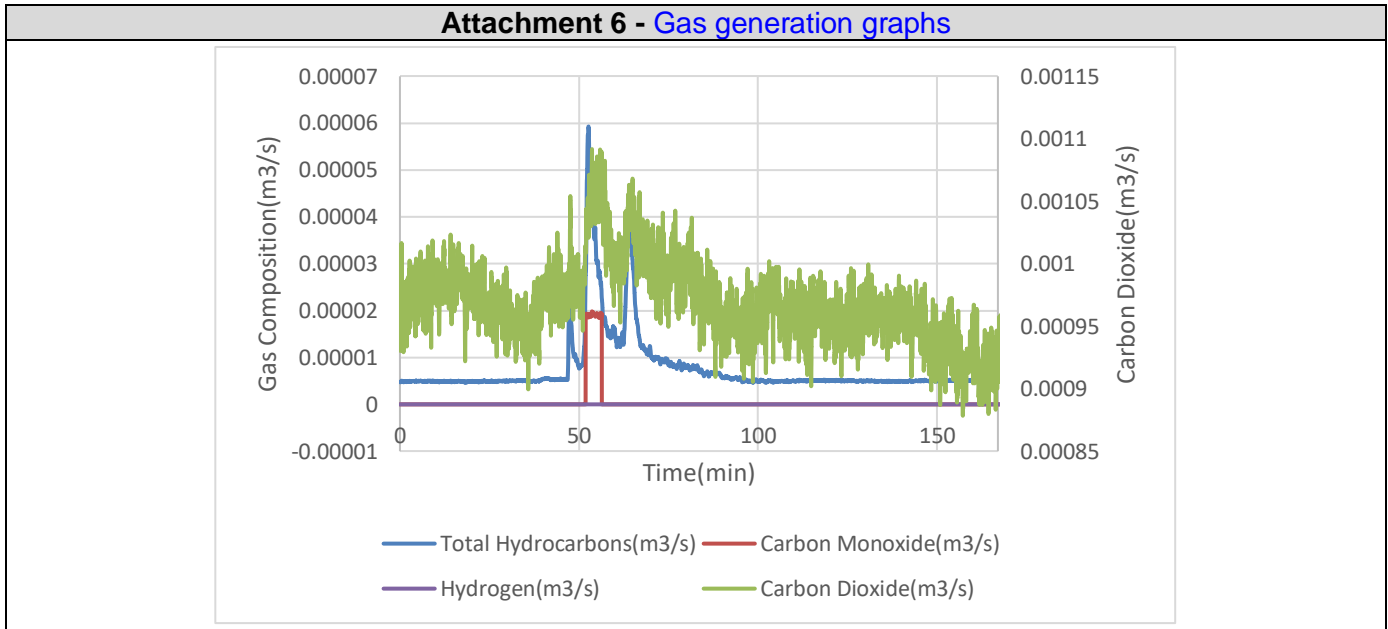
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Attachment 6 - Gas generation graphs





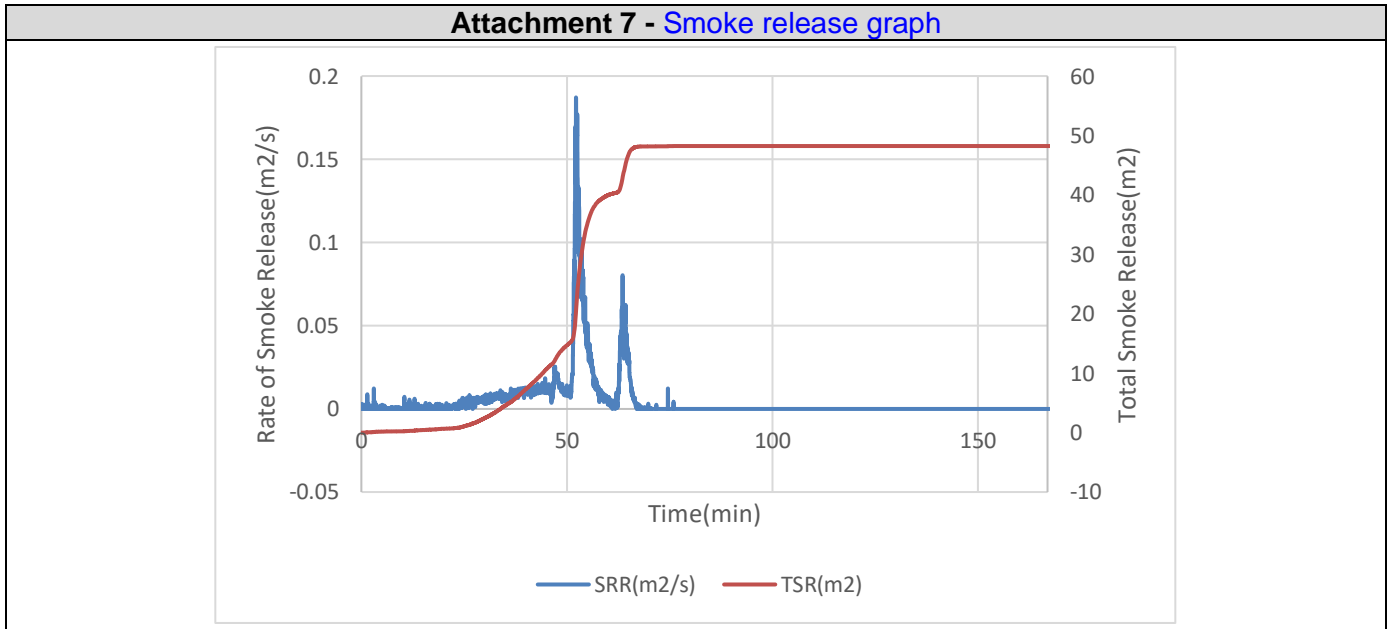
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Attachment 7 - Smoke release graph





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Attachment 8 - Heat flux graph

Heat flux was not measured for residential BESS as cheesecloth was used covering the entire BESS unit for indication.

Table 6 – Maximum Heatflux measurement

Location	Heatflux limit (kW/m ²)	Measured maximum Heatflux (kW/m ²)
N/A	N/A	N/A



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Attachment 9 - Notable observation during test

Observation	Time from test start (HH:MM:SS)	Comment
Test start	15:18:48	Heating started on initiating module (cell 5#: initiating cell) with a heating ramp 4.5 deg.C/minute by adjusting the temperature regulator automatically.
Vent	15:56:03	First venting occurred on initiating cell with pop sounds heard, slight temperature decrease observed on cell surface(T-KK4)
Thermal runaway	16:04:44	Thermal runaway initiated on cell 5#, smoke observed from the side of the BESS unit, heater deenergized immediately.
Thermal runaway	16:08:12	Smoke observed from the side of the BESS unit, 2 nd vent events observed with pop sounds heard
Thermal runaway	16:09	Thermal runaway with heavy smoke and rapid temperature increase observed.
Thermal runaway	16:20	Smoke observed from the side of the BESS unit
Test end	20:35:05	Test terminated with video monitor stopped.

End of Report....