CERTIFICATE OF COMPLIANCE

Certificate Number: **SGSNA/23/SZ/00039**

Contract Number: 801898
Certificate Project Number: SZ-CERT230300445

Certified Product: Rechargeable lithium-ion battery pack
Trademarks: Deye
Model(s): SE-G5.1 Pro, SE-G5.1 Pro-B
Technical Data: 51.2 V, 100 Ah; Max. charging current: 100 A; Max. charging voltage: 57.6 V; Max. discharging current: 100 A; End of discharging voltage: 43.2 V; Charging temperature range: 0~55 ºC; Discharging temperature range: -20~55 ºC

Certificate Holder: NINGBO DEYE ESS TECHNOLOGY CO., LTD
No.18, Zhenglong 2 Road, Binhai Economic Development Zone, Cixi, Ningbo, Zhejiang, China

This certificate supercedes previous certificates issued with the same certificate number. Certification is valid when products are indicated on the SGS directory of certified products at www.sgs.com or using the QR code below. The product is certified according to ISO/IEC Guide 17067, Conformity assessment - Fundamentals of product certification, System 3, and in accordance with:

ANSI/UL 1973-2018, Second Edition, Dated February 7, 2018
CAN/UL 1973-2018, Second Edition, Dated February 7, 2018

Authorized by:

Jason Wei
Certifier

Effective date: 23 February 2024

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CERTIFICATE OF COMPLIANCE

Certificate Number: **SGSNA/24/SH/00299**

Contract Number: 801898
Certificate Project Number: SH-CERT240603601

Certified Product: Low Voltage ESS
Trademarks: Deye
Model(s): SE-GX-15K-US (X=1,2,3,4,5,.....,32, which means the number of batteries in parallel)
Technical Data: See page 2

Certificate Holder: NINGBO DEYE ESS TECHNOLOGY CO., LTD.
No.18, Zhenlong 2 Road, Binhai Economic Development Zone, Cixi, Ningbo, Zhejiang, China

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ANSI/CAN/UL 9540:2023,Third Edition, Dated June 28, 2023

Authorized by:

Mark Lohmann
Certifier

Effective date: 19 August 2024

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CERTIFICATE OF COMPLIANCE

Certificate Number: **SGSNA/24/SH/00299**

Contract Number: 801898
Certificate Project Number: SH-CERT240603601

Additional Information:

Technical Data:

SE-GX-15K-US series can be matched with different numbers of battery modules (the maximum number is 32). And it is simply connected in parallel to increase the system capacity, the models and ratings of battery module and PCS have not changed, so the ratings of PCS and battery module are written in the report.

For SE-GX-15K-US type series

PCS part

Limitless 15K-LV

PV side: 175-425V(500Vmax), 26A+26A+26A, 44A+44A+44A;

Battery side: 43-63V, 275A max

AC grid side: 208Vac/240Vac(120Vac), Split phase, 60Hz, 15KW, 62.5A, -0.9~+0.9

Battery Part

SE-G5.1 Pro-B

51.2 V, 100 Ah; Max. charging current: 100 A; Max. charging voltage: 57.6 V; Max. discharging current: 100 A; End of discharging voltage: 43.2 V; Charging temperature range: 0~55 ºC; Discharging temperature range: -20~55 ºC.

Other Ratings:

IP65 for PCS and IP20 for Battery

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CERTIFICATE OF COMPLIANCE

Certificate Number: **SGSNA/24/SH/00297**

Contract Number: 801898
Certificate Project Number: SH-CERT240603600

Certified Product: Low Voltage ESS
Trademarks: Deye

Model(s): SE-GX-5K-US, SE-GX-8K-US, SE-GX-12K-US
(X=1,2,3,4,5,.....,32, which means the number of batteries in parallel)

Technical Data: See page 2-3

Certificate Holder: NINGBO DEYE ESS TECHNOLOGY CO., LTD.
No.18, Zhenlong 2 Road, Binhai Economic Development Zone, Cixi, Ningbo, Zhejiang, China

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Authorized by:

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CERTIFICATE OF COMPLIANCE

Certificate Number: **SGSNA/24/SH/00297**

Contract Number: 801898
Certificate Project Number: SH-CERT240603600

Additional Information:

Technical Data:

SE-GX-12K-US, SE-GX-8K-US and SE-GX-5K-US series can be matched with different numbers of battery modules (the maximum number is 32). And it is simply connected in parallel to increase the system capacity, the models and ratings of battery module and PCS have not changed, so the ratings of PCS and battery module are written in the report.

For SE-GX-12K-US type series

PCS part

Sol-Ark-12k-P

AC side:

AC Voltage@120/240V: 240V(211V-264V), 37.5A, 9000W(L-L) / 4500W(L-N), 60Hz,

AC Voltage@120/208V: 208V(183V-229V), 37.5A, 7800W(L-L) / 4500W(L-N), 60Hz

PV side: 150dc-500Vdc (MPPT range:175Vdc-425Vdc), 20A/20A

Battery side: 48Vdc(43Vdc-63Vdc), 185A

Battery Part

SE-G5.1 Pro-B

51.2 V, 100 Ah; Max. charging current: 100 A; Max. charging voltage: 57.6 V; Max. discharging current: 100 A; End of discharging voltage: 43.2 V; Charging temperature range: 0~55 ºC; Discharging temperature range: -20~55 ºC.

For SE-GX-8K-US type series

PCS part

Sol-Ark-8K-48-ST

AC side:

AC Voltage@120/240V: 240V(211V-264V), 33.0A, 8000W(L-L) / 4000W(L-N), 60Hz,

AC Voltage@120/208V: 208V(183V-229V), 33.3A, 6900W(L-L) / 4000W(L-N), 60Hz

PV side: 150dc-500Vdc (MPPT range:175Vdc-425Vdc), 18A/18A

Battery side: 48Vdc(43Vdc-63Vdc), 185A

Battery Part

SE-G5.1 Pro-B

51.2 V, 100 Ah; Max. charging current: 100 A; Max. charging voltage: 57.6 V; Max. discharging current: 100 A; End of discharging voltage: 43.2 V; Charging temperature range: 0~55 ºC; Discharging temperature range: -20~55 ºC.

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CERTIFICATE OF COMPLIANCE

Certificate Number: **SGSNA/24/SH/00297**

Contract Number: 801898
Certificate Project Number: SH-CERT240603600

Additional Information:

Technical Data:

For SE-GX-5K-US type series

PCS Part

Sol-Ark-5K-48-ST

AC side:

AC Voltage@120/240V: 240V(211V-264V), 20.8A, 5000W(L-L) / 2500W(L-N), 60Hz,

AC Voltage@120/208V: 208V(183V-229V), 29.1A, 5000W(L-L) / 2500W(L-N), 60Hz

PV side: 150dc-500Vdc (MPPT range:175Vdc-425Vdc), 10A/10A

Battery side: 48Vdc(43Vdc-63Vdc), 120A

Battery Part

SE-G5.1 Pro-B

51.2 V, 100 Ah; Max. charging current: 100 A; Max. charging voltage: 57.6 V; Max. discharging current: 100 A; End of discharging voltage: 43.2 V; Charging temperature range: 0~55 ºC; Discharging temperature range: -20~55 ºC.

Other Ratings:

IP65 for PCS and IP20 for Battery

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Test Report

For

ANSI/CAN/UL9540A

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

[Module Level]

Report Number:	**CQES240400025201**
Date of issue:	**2024-04-12**
Total number of pages:	**26 Pages**
Test object / Model:	**GE-F-PACK5.1-D**
Applicant's name:	**NINGBO DEYE ESS TECHNOLOGY CO., LTD**
Address:	**No.18, Zhenglong 2 Road, Binhai Economic Development Zone, Cixi, Ningbo, Zhejiang, China**

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Report Number:	CQES240400025201
Manufacturer:	NINGBO DEYE ESS TECHNOLOGY CO., LTD
Address:	No.18, Zhenglong 2 Road, Binhai Economic Development Zone, Cixi, Ningbo, Zhejiang, China
Factory：	NINGBO DEYE ESS TECHNOLOGY CO., LTD
Address:	No.18, Zhenglong 2 Road, Binhai Economic Development Zone, Cixi, Ningbo, Zhejiang, China
Test object / Model:	GE-F-PACK5.1-D
Test specifications:	ANSI/CAN/UL9540A:2019 Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems Fourth Edition, Dated November 12, 2019
Date of receipt:	2023-12-06
Sample No.:	M1
Test Period:	2023-12-07 to 2023-12-08
Issuing Laboratory:	SGS-CEC New Energy Technology (Chongqing) Co., Ltd.
Address:	Building 13 & 14, No. 1839, Ranjun Road, Shuangfu Street, Jiangjin District, Chongqing, China
Testing location:	SGS-CEC New Energy Technology (Chongqing) Co., Ltd. Building 13 & 14, No. 1839, Ranjun Road, Shuangfu Street, Jiangjin District, Chongqing, China
Test Result:	Refer to summary of test results page for details.
Remark:	Test results reported relate only to the items being tested.
Confidential level:	☒ Strictly Confidential ☐ Private and Confidential ☐ Public

Tested by / Witness by

Kyle Tian
Project Engineer

Reviewed by

Ryan Hu
Report Reviewer

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[Summary of Test results]

Cell Level Test
Cell model: LF100LA
Report No: 4790509108

Cell Design:	LF100LA
Thermal Runaway Methodology:	External heating
Cell Surface Temperature at Gas venting:	181°C
Cell Surface Temperature at Thermal Runaway:	230°C
Gas Composition:	H_2, CO_2, CO, Hydrocarbon
Lower Flammability Limit:	8.25 Vol% at ambient temperature, 6.73 Vol% at 181°C
Burning Velocity:	97.8 cm/s
Pmax:	0.70533 MPa
Thermal Runaway was Induced in the Cell or not:	Induced
Cell Vent Gas is Flammable or not in Air:	Flammable

Module Level Test
Module model: GE-F-Pack5.1-D
Report No: CQES240400025201

Module Design:	GE-F-Pack5.1-D
Thermal Runaway Methodology:	External heating using film heater
External Flaming:	External flaming observed
Locations of Flame Venting:	External Flame extension observed
Flying Debris:	No flying debris observed
Peak smoke release rate:	0.533 m^2/s
Gas Generation and Composition:	H_2, Hydrocarbon, CO_2
Thermal Runaway are Contained by the Module Design or not:	Flaming propagation outside the enclosure were observed.
Cell Vent Gas is Flammable or not:	Flammable
Other Description:	N/A
Test Video file:	Archived by Applicant

Remark:
1. This report only evaluated module level test which is listed inside the dotted box.
2. This report is issued based on previous SGS report CQES231200062001, dated 2024-01-10, with following changes and/or additions:
   - Revised model of aerosol-generating extinguishing system to 'QRR0.012G/S'.

   After comparison, no further tests were considered necessary. All test data were cited from original test report CQES231200062001.

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[Test object Description]

Table 1: Description of component cell

Model:	LF100LA	
Manufacturer:	EVE Power Co., Ltd.	
Nominal capacity:	100 Ah	
Nominal voltage:	3.2 V	
Chemistry:	Lithium-ion, $LiFePO_4$	
Standard charge current:	50 A	
Standard discharge current:	50 A	
Maximum charge voltage:	3.9 V	
Cut-off Voltage:	1.9 V	
Charge temperature range:	0 to 65 ºC	
Discharge temperature range:	-30 to 65 ºC	
External dimensions:	T×W×H =(50.1±0.5) mm×(160.0±0.8) mm ×(115.7±0.5) mm	
Weight:	(1985±100) g	
UL 1973 compliant:	☒ Yes / ☐ No	Reference: UL file No. MH63503
UL 9540A report provide:	☒ Yes / ☐ No	Reference: UL test report No. 4790509108

Figure 1. View 01 of component cell

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Figure 2. View 02 of component cell

Table 2: Description of battery module

Model:	GE-F-Pack5.1-D	
Manufacturer:	NINGBO DEYE ESS TECHNOLOGY CO., LTD	
Nominal capacity:	100 Ah	
Nominal voltage:	51.2 Vd.c.	
Maximum charge current:	100 A	
Maximum discharge current:	100 A	
Maximum charge voltage:	57.6 V	
Cut-off Voltage:	43.2 V	
Charge temperature range:	0 ºC to 55 ºC	
Discharge temperature range:	-20 ºC to 55 ºC	
Module configuration:	16S	
External dimensions:	570 mm x 495 mm x 135 mm	
Enclosure material:	Metal	
Weight:	Approx. 45.0kg	
UL 1973 compliant:	☒ Yes / ☐ No	Reference: SGS Contract No.: 801898

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Figure 3a. View of battery module

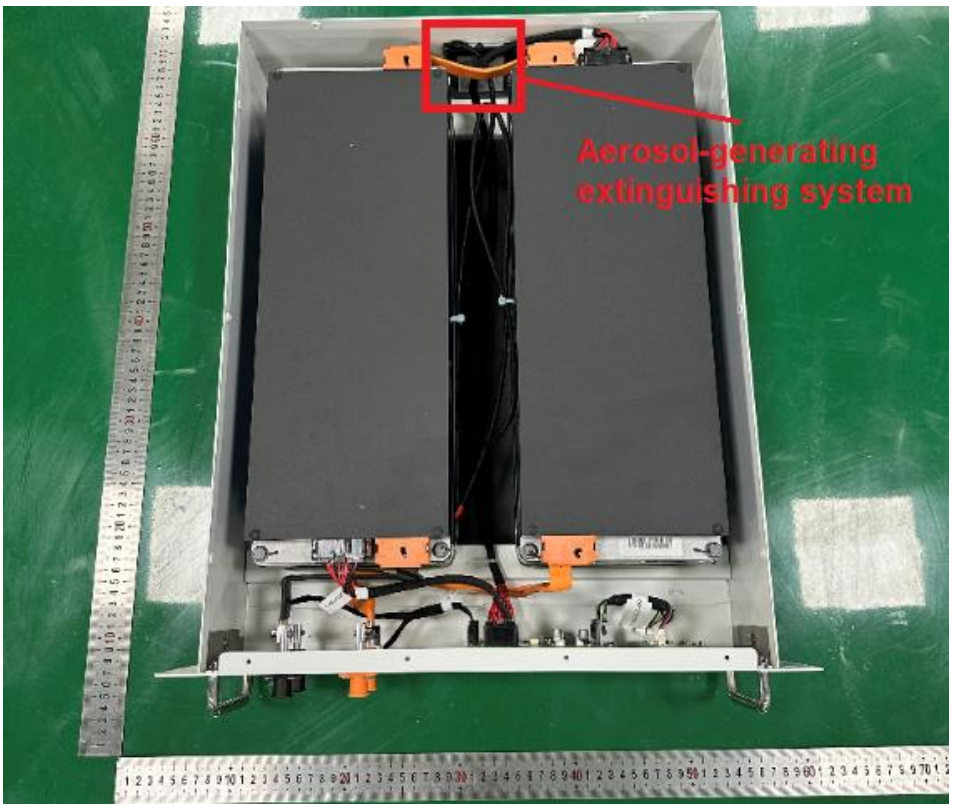

Figure 3b. Internal view of battery module

(Aerosol-generating extinguishing system: Hubei Jiandun Fire Technology Co., Ltd. / Model: QRR0.012G/S)

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Pre-conditioning of test samples

Module samples shall be conditioned, prior to testing, through charge and discharge cycles for a minimum of 2 cycles, using a manufacturer specified methodology to verify that the module is functional. Each cycle shall be defined as a charge to 100% SOC and allowed to rest a maximum of 8 h and then discharged to an end of discharge voltage (EODV) specified by the module manufacturer.

The module to be tested shall be charged to 100% SOC and allowed to rest a maximum of 8 h before the start of the test. The module voltage shall be determined by measuring at the module terminals after charging up to the fully charged condition and before beginning testing. The sample module shall stabilize for a minimum of one hour prior to testing.

Table 3: Charge and discharge parameters (provided by manufacturer)

Charge		Discharge	
Charge current (A)	100	Discharge current (A)	100
Max. charge voltage (V)	57.6	Cut-off voltage (V)	43.2
Cut-off charge current (A)	5.0	--	--

Module level Test method description

Ambient indoor laboratory conditions shall be 25 ±5°C (77 ±9°F) and 50 ±25% RH at the initiation of the test.

The test shall be conducted under a smoke collection hood that is sized appropriately to collect the gasses generated from the module.

The methodology used for initiating thermal runaway pursuant to cell level test shall be used to initiate thermal runaway within the module.

Thermal runaway methodology for module level test: The propensity of the DUT to exhibit thermal runaway be demonstrated by heating the cell with externally applied heaters.

The number of cells within the module that are forced into thermal runaway can be one or multiple cells, and is dependent upon the energy contained within the individual cells. A sufficient number of cells shall be forced into thermal runaway to create a condition of cell to cell propagation within the module. For example, it may be necessary to force nine, 3-Ah cells into thermal runaway as opposed to one, 30-Ah cell in order to get cell to cell propagation. The location of the cell (s) forced into thermal runaway shall be selected to present the greatest thermal exposure to adjacent cells that are not forced into thermal runaway. Factors to be taken into consideration shall include selecting locations within the module where heat transfer is maximized to other cells, cooling by ventilation is restricted or limited, and thermal sensors, detection and suppression discharge points are remote.

The module shall be placed on top of a noncombustible horizontal surface with the module orientation representative of its intended final installation.

The chemical heat release rate of the module in thermal runaway shall be measured with oxygen consumption calorimetry.
The chemical heat release rate shall be measured for the duration of the test.

Occurrence of thermal runaway shall be verified by sustained temperature above the cell surface temperature at the onset of thermal runaway, as determined in cell level test.

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The chemical heat release rate shall be measured by a measurement system consisting of a paramagnetic oxygen analyzer, non-dispersive infrared carbon dioxide and carbon monoxide analyzer, velocity probe, and a Type K thermocouple. The instrumentation shall be located in the exhaust duct of the heat release rate calorimeter at a location that minimizes the influence of bends or exhaust devices.

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

$$HRR_1 = \left[E \times \varphi - (E_{co} - E) \times \frac{1-\varphi}{2} \times \frac{X_{co}}{X_{O_2}}\right] \times \frac{\dot{m}_e}{1+\varphi \times (\alpha - 1)} \times \frac{M_{O_2}}{M_a} \times (1 - X^o_{H_2O}) \times X^o_{O_2}$$

Vent gas composition shall be measured using a Fourier-Transform Infrared Spectrometer with a minimum resolution of 1 cm^{-1} and a path length of at least 2 m (6.6 ft), or equivalent gas analyzer, and velocity and temperature measurements respectively shall be obtained in the exhaust duct of the heat release rate calorimeter using equipment.

The hydrocarbon content of the vent gas shall be measure using flame ionization detection.
Hydrogen gas shall be measured with a palladium-nickel thin-film solid state sensor.

The light transmission in the exhaust duct of the heat release rate calorimeter shall be measured using a white light source and photo detector for the duration of the test, and the smoke release rate shall be calculated.

Smoke release rate shall be calculated as follows:

$$SRR = 2.303\left(\frac{V}{D}\right) Log_{10}\left(\frac{I_o}{I}\right)$$

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Test configuration description

Thermal runaway initiation method used including number and locations of cells for initiating thermal runaway
Initiation method: External heating method was used for initiating thermal runaway. By controlling the input power of the heaters, a surface heating rate of 4°C (9°F) to 7°C (12.6°F) per minute was achieved. Max. power of the film heater was 194 W.
Number of cells for initiating thermal runaway: ☒ Single cell 100 Ah (total capacity) ☐ Multiple cell Ah (total capacity)
Locations of cells for initiating thermal runaway: The battery module consists of 16 cells, which are connected in series. Cell 13 (as shown in Figure 4b & 5) was selected as the initiating cell. Two film heater was placed on large surfaces of cell 13.
Other description : N/A

Figure 4a. Internal view 01 of DUT.

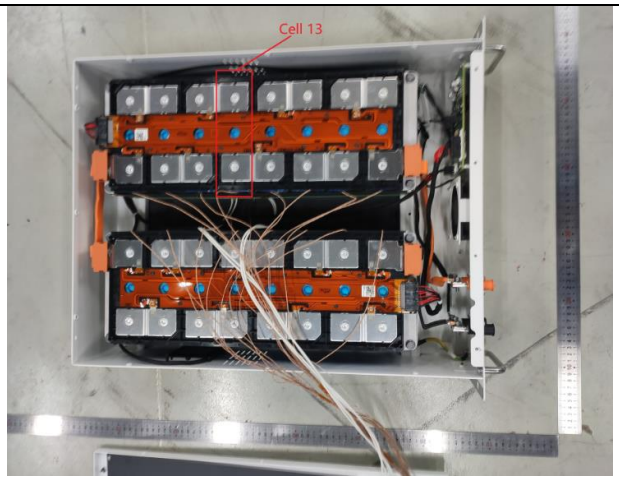

Figure 4b. Internal view 02 of DUT.

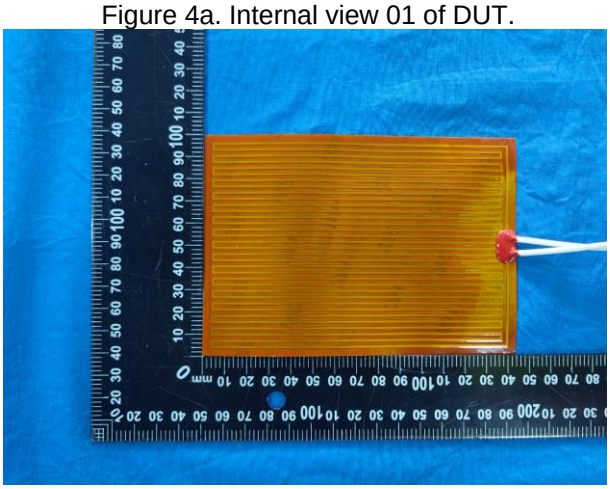

Figure 4c. View of external heater.

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Illustration of external heater and thermocouple location
Description: N/A

Figure 5. Schematic illustration of film heaters and thermocouple locations in initial module (T1 to T18 means thermocouples T1 to T18. H1, H2 means Film heater 1 and 2. View from top.).

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Positioning of module within testing room
Test Start Time: 2023-12-07 10:05:59
Initial Ambient Test Temperature: 27.3 °C
Initial Relative Humidity: 55.7% RH
Description: N/A.

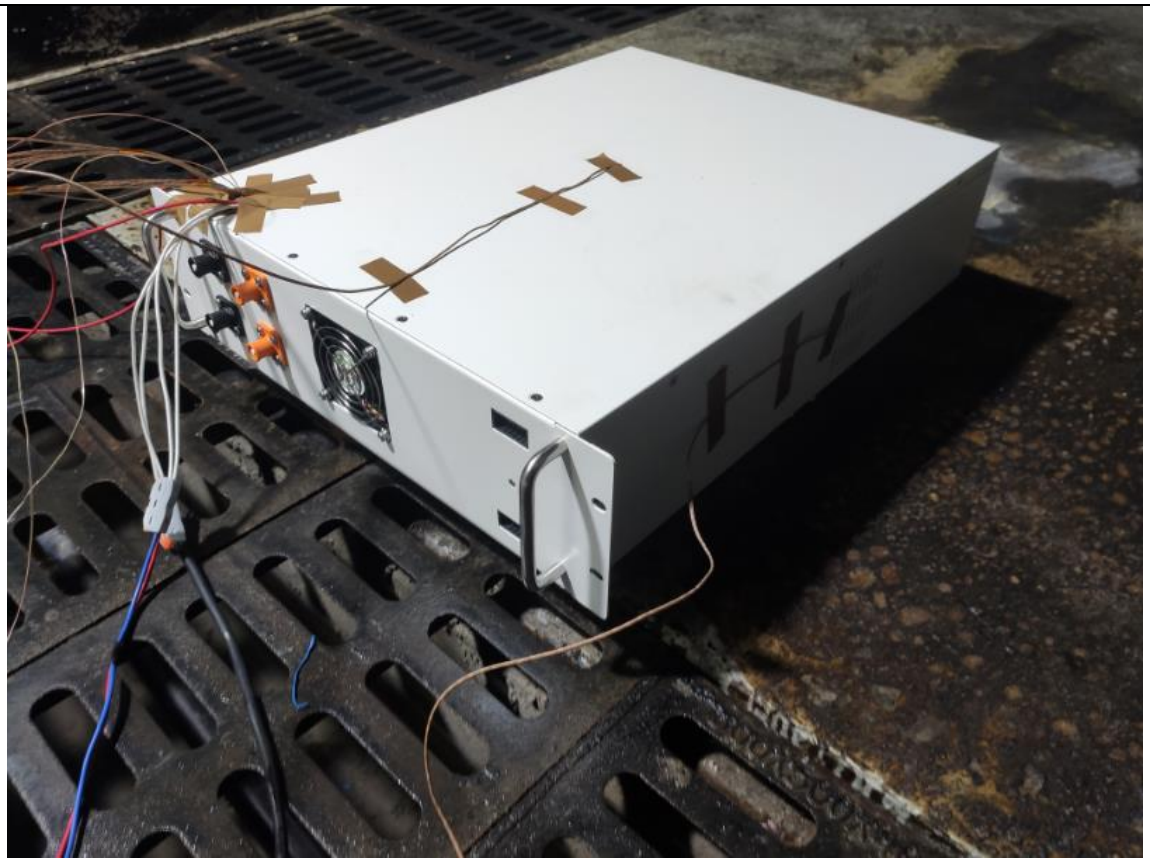

Figure 6. View of positioning of module within testing room.

Table 4: Thermocouple placement

Thermocouple ID	Description of location	Remark
CH3001	Side surface B of Cell 1	T1
CH3002	Side surface B of Cell 2	T2
CH3003	Side surface B of Cell 3	T3
CH3004	Side surface B of Cell 4	T4
CH3005	Side surface B of Cell 5	T5
CH3006	Side surface B of Cell 6	T6
CH3007	Side surface B of Cell 7	T7
CH3008	Side surface B of Cell 8	T8

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CH3009	Side surface A of Cell 9	T9
CH3010	Side surface A of Cell 10	T10
CH3101	Side surface A of Cell 11	T11
CH3102	Side surface A of Cell 12	T12
CH3103	Side surface A of Cell 13	T13
CH3104	Side surface A of Cell 14	T14
CH3105	Side surface A of Cell 15	T15
CH3106	Side surface A of Cell 16	T16
CH3107	Large surface of cell 13, between cell surface and Heater 1	T17
CH3108	Large surface of cell 13, between cell surface and Heater 2	T18
CH3109	Upper surface of the module	--
CH3110	Module side surface	--
CH3201	Ambient temperature	--
Thermocouple information: Type K 24 AWG		

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[Description of test results]

Table 5: Overview of test timeline and key events

Time (HH: MM: SS)	Relative Time (HH: MM: SS)	Event ID	Event	Description	Photo Reference
10:05:59	00:00:00	E1	Test Start	--	Figure 10
10:20:58	00:14:59	E2	Heater 1 and heater 2 Energized	--	--
10:49:28	00:43:29	E3	Initiating cell thermal runaway onset	Smoke release observed. Turn off heater 1 and heater 2. The thermal runaway of No. 13 cell was confirmed from the temperature curve.	Figure 11
10:59:10	00:53:11	E4	External Flaming	Smoke release observed. External flaming observed Internal fire protection device startup.	Figure 12
10:59:20	00:53:21	E5	Flame Extinguished	The flame was extinguished.	Figure 13
11:13:39	01:07:40	E6	Smoke Release	Smoke release observed. The thermal runaway of No. 12 & 14 cell was confirmed from the temperature curve.	Figure 14
12:05:59	02:00:00	E7	Test Termination	--	--
Test Start Time: 2023-12-07 10:05:59					

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Heat release rate versus time
Description: N/A
N/A

Flammable gas generation and composition
Flammable gas generation: ☒ YES ☐ NO
Description : N/A

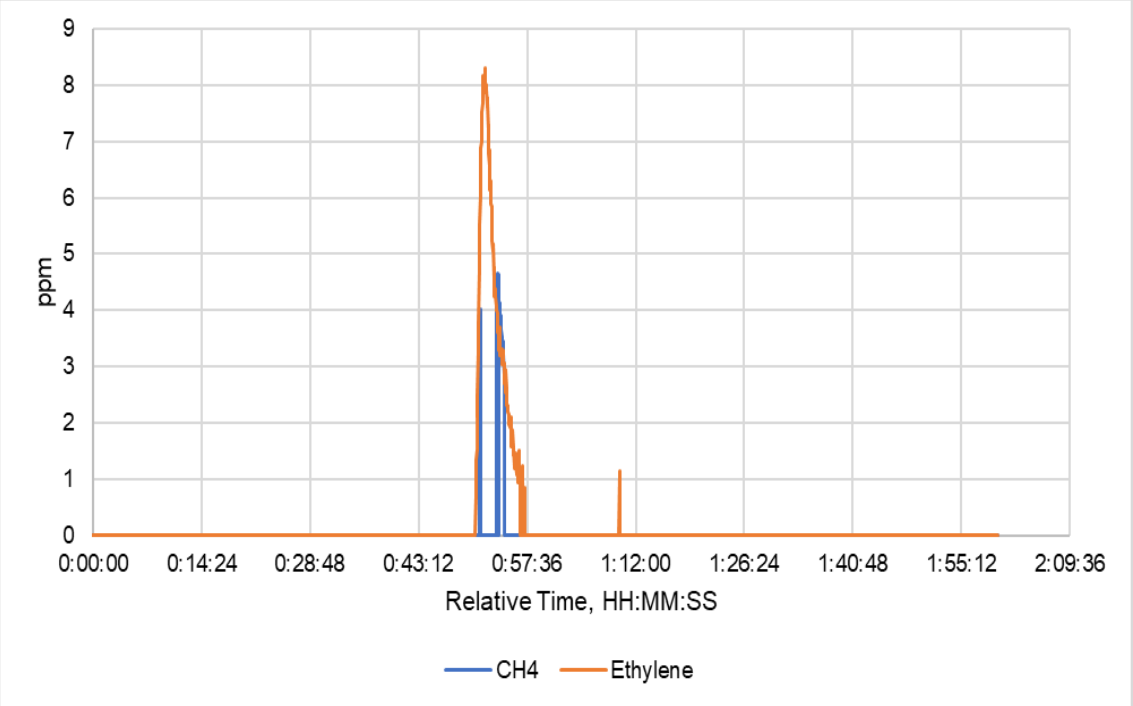

Figure 7a. Online flammable gas content measurements during test. (Remark: The content of other hydrocarbons is below the detection limit of the test equipment.)

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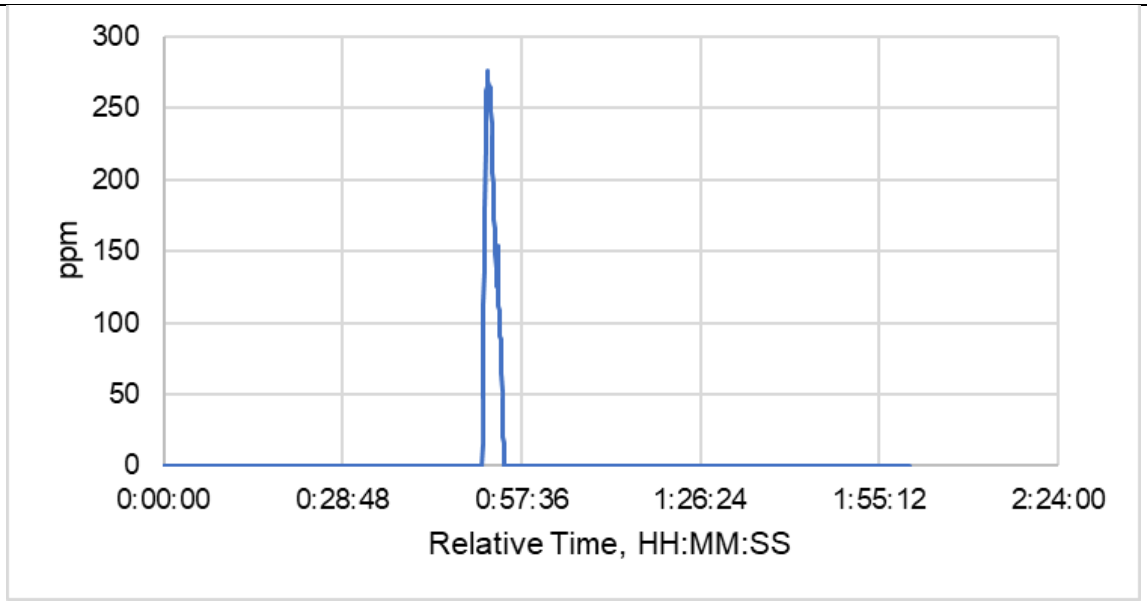

Figure 7b. Online Hydrogen content measurements during test.

Peak smoke release rate and total smoke release
Description : Peak smoke release rate is 0.533 m^2/s during test.

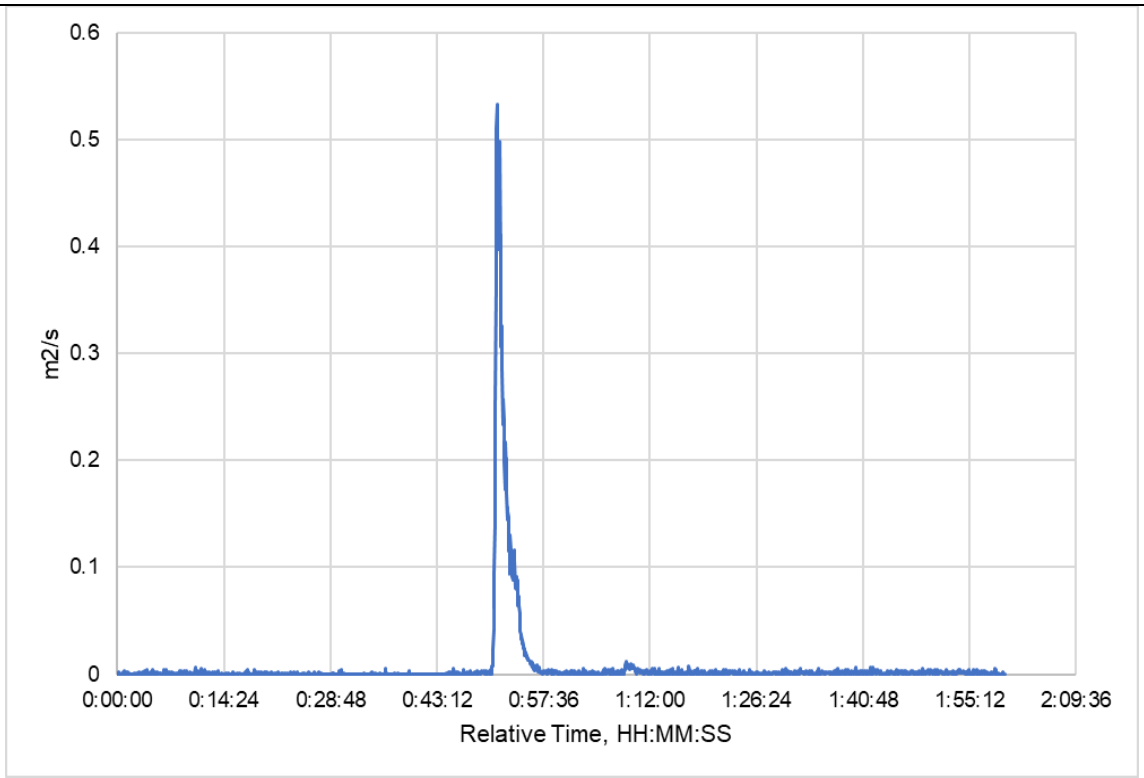

Figure 8. Smoke release rate versus time

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Identification/location of cell(s) that exhibited thermal runaway within the module
Cells(s) that exhibited thermal runaway: ☒ YES ☐ NO
Description : N/A

Figure 9. View of cell that exhibited thermal runaway after test.

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Figure 9a. View of cell that exhibited thermal runaway after test.

Locations and visual estimations of flame extension and duration from the module
Flame extension: ☒ YES ☐ NO
Description : Flaming propagation outside the enclosure were observed.
N/A

Other observations during test
Description : N/A
N/A

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Table 6: Data during test

Model	SOC of Battery Module Before Test, (%)	OCV of Battery Module Before Test, (V dc)	Weight of Battery Module Before Test, (Kg)	Weight of Battery Module After Test, (Kg)	Battery Module Weight Loss Rate, (%)
GE-F-PACK5.1-D	100%	53.395	45.92	45.52	0.87
Peak Smoke Release Rate, (m^2/s)	**Observation Results**				
0.533	Gas and smoke release observed from module enclosure. Flaming propagation outside the enclosure were observed.				
Supplementary information: No additional thermal runaway events or re-ignition occurred during post-test observations of the test module.					

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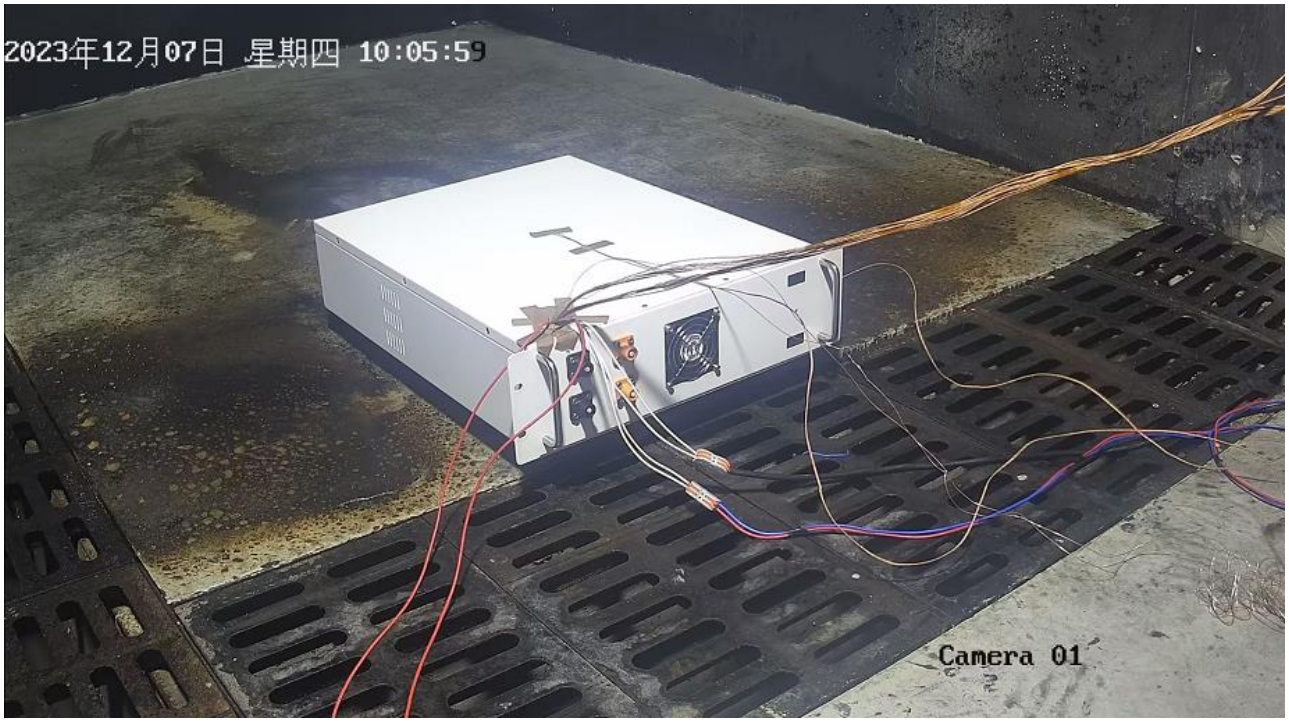

Figure 10. photo of event (E1) during test

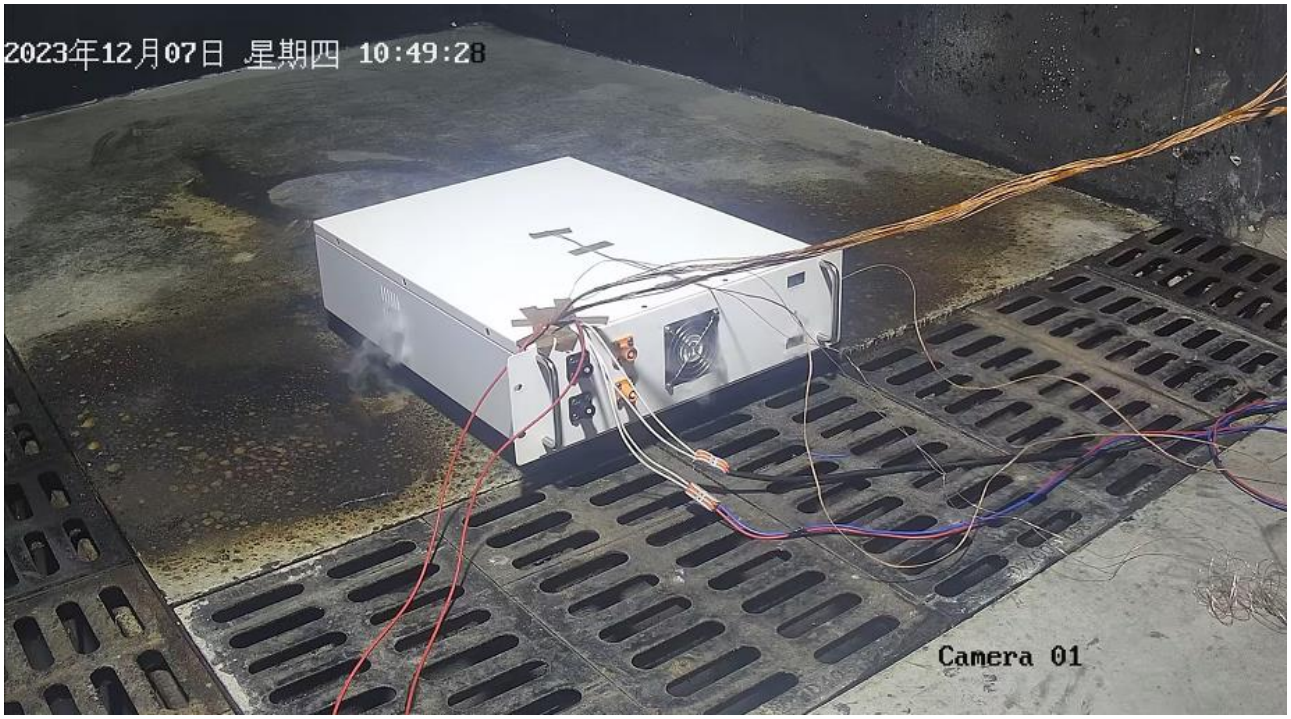

Figure 11. photo of event (E3) during test

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Figure 12. photo of event (E4) during test

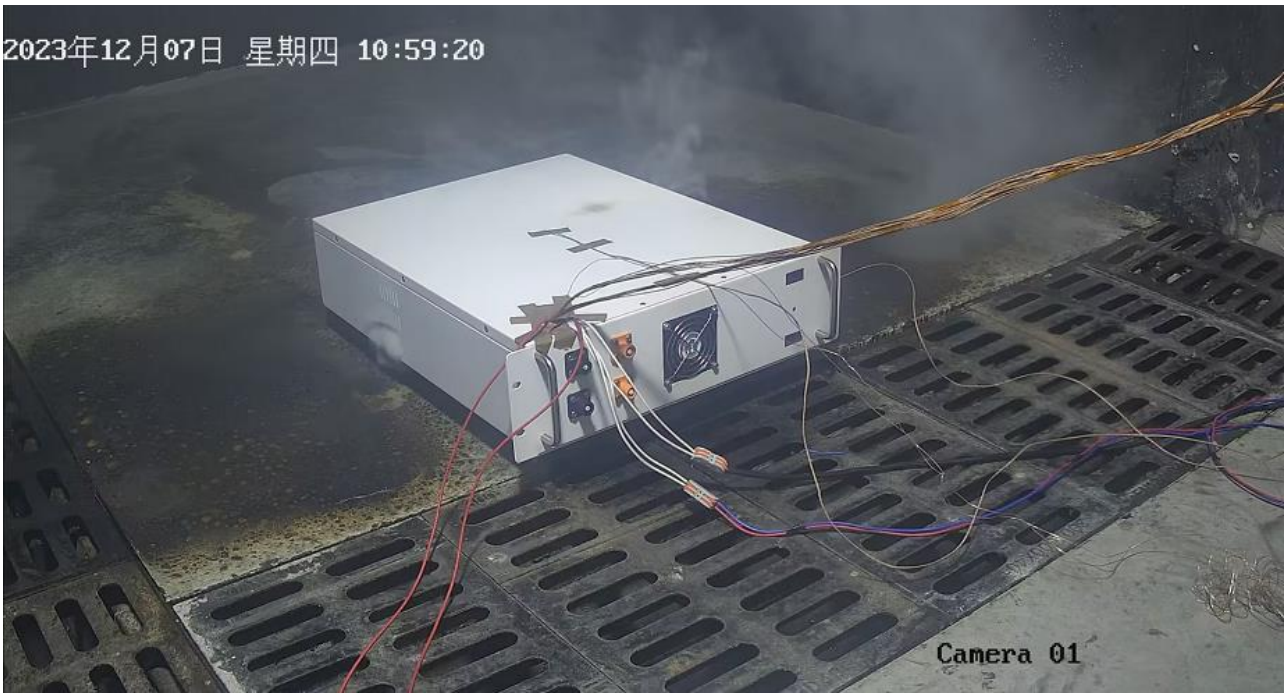

Figure 13. photo of event (E5) during test

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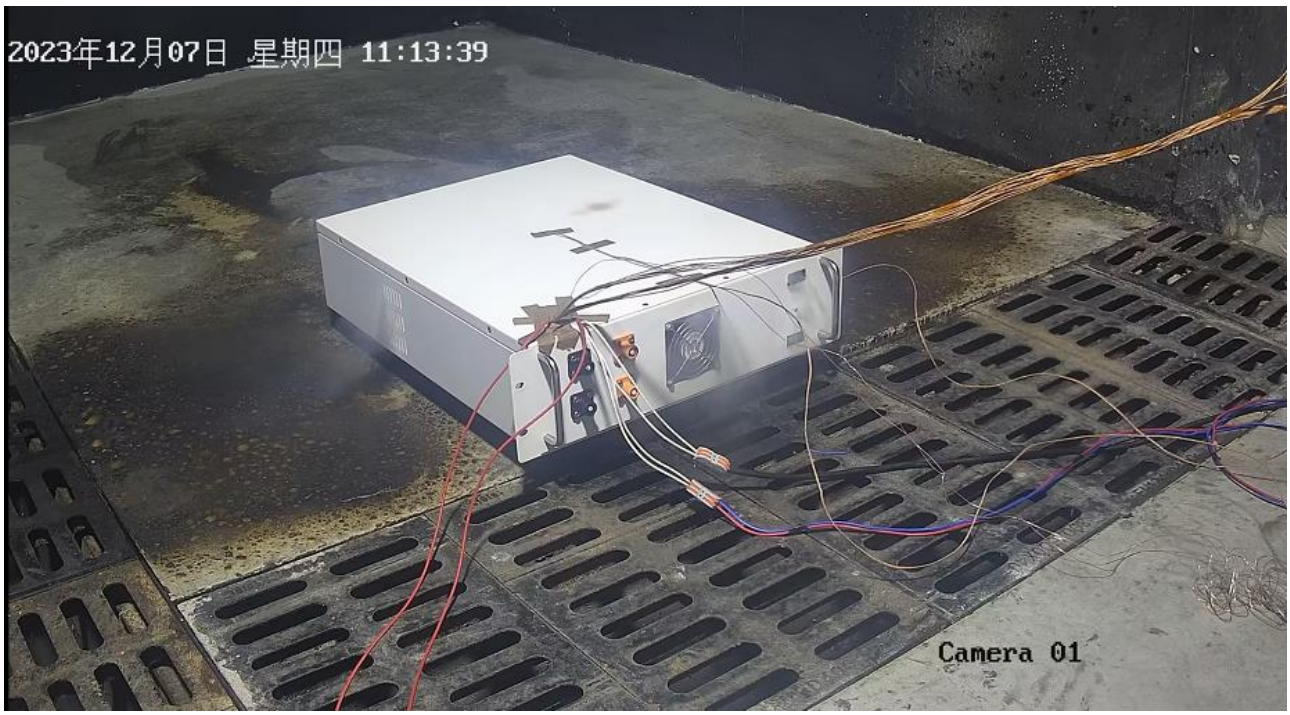

Figure 14. photo of event (E6) during test

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Figure 15. Photo 01 of DUT after test

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Figure 16. Photo 02 of DUT after test

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Figure 17. Photo 03 of DUT after test

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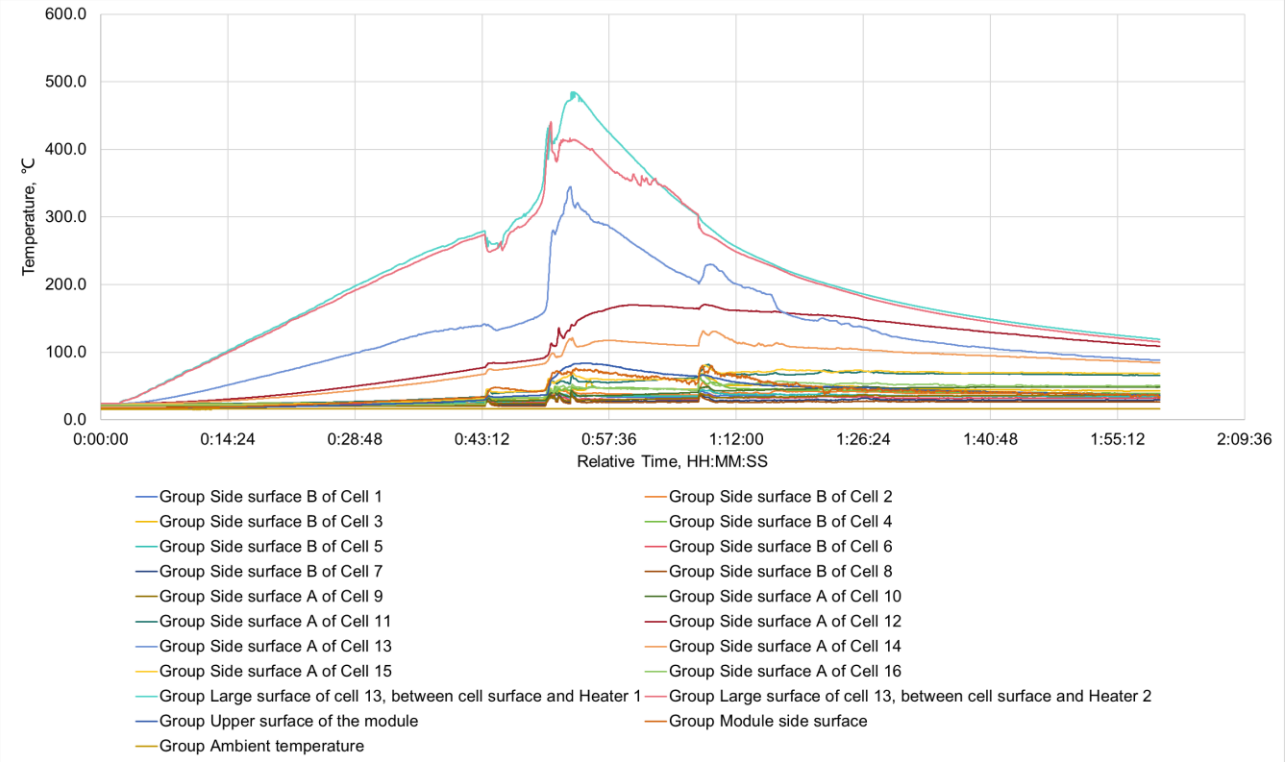

Figure 18. Temperature measurements during test.

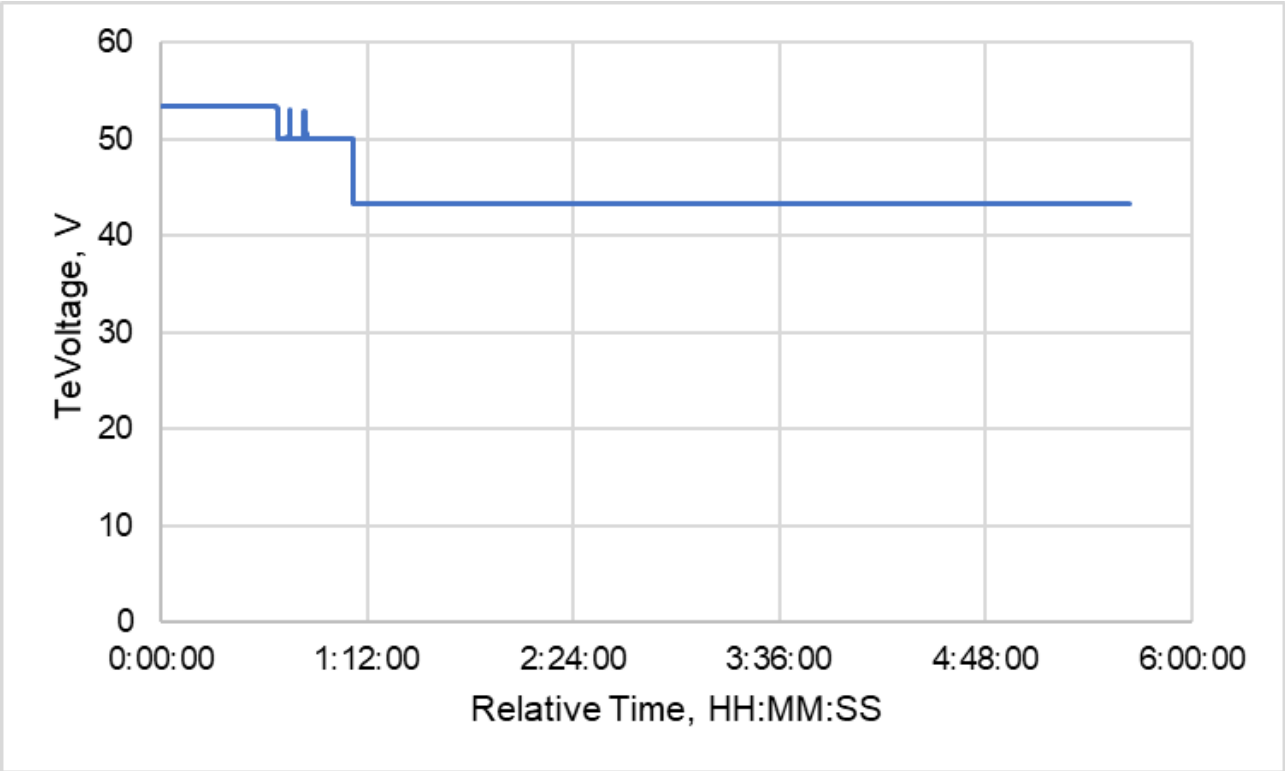

Figure 19. DUT Voltage measurements during test.

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2. According to the standard, instruction sheets and other texts required by the standard should be written in the official language(s) of the country in which the product is to be sold. The applicant should ensure that the product in future production fulfils the receptive standard requirements.

3. The components performed satisfactorily during testing and are considered to be suitable for use in the sample tested.

- - - End of Report - - -

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