

Prüfbericht-Nr.: <i>Test report no.:</i>	CN2540H0 002	Auftrags-Nr.: <i>Order no.:</i>	168562530	Seite 1 von 25 Page 1 of 25
Kunden-Referenz-Nr.: <i>Client reference no.:</i>	2544823	Auftragsdatum: <i>Order date:</i>	2025-07-02	
Auftraggeber: <i>Client:</i>	Discover Energy Systems corp. 320 - 13711 International Place, Richmond, B.C., V6V 2Z8, Canada			
Prüfgegenstand: <i>Test item:</i>	Rechargeable Li-ion battery			
Bezeichnung / Typ-Nr.: <i>Identification / Type no.:</i>	52-48-16000_3			
Auftrags-Inhalt: <i>Order content:</i>	Test report			
Prüfgrundlage: <i>Test specification:</i>	ANSI/CAN/UL 9540A: 2025(Fifth Edition)			
Wareneingangsdatum: <i>Date of sample receipt:</i>	2025-09-23			
Prüfmuster-Nr.: <i>Test sample no.:</i>	25W39A135-001~003			
Prüfzeitraum: <i>Testing period:</i>	2025-09-25 to 2025-09-27			
Ort der Prüfung: <i>Place of testing:</i>	See page 4			
Prüflaboratorium: <i>Testing laboratory:</i>	TÜV Rheinland (Shenzhen) Co., Ltd.			
Prüfergebnis*: <i>Test result*:</i>	See main report.			
erstellt von: <i>created by:</i>	genehmigt von: <i>authorized by:</i>			
Datum: <i>Date:</i>	2025-09-30		2025-09-30	
 Lemon Diao		 Stephen Huang		
Stellung / Position:	Sachverständige(r)/Expert	Stellung / Position:	Sachverständige(r)/Expert	
Sonstiges / Other:	This report does not evidence compliance of the provided sample with the relevant standards but only with the referred tests. This test report documents the findings of examination conducted on the delivered product mentioned above only. This report does not entitle the applicant to carry any safety mark on this or similar products. Further for sales or other application purposes of the tested product, any reference to TÜV Rheinland or a test through TÜV Rheinland is only permissible with prior written consent of TÜV Rheinland.			
Zustand des Prüfgegenstandes bei Anlieferung: <i>Condition of the test item at delivery:</i>	Prüfmuster vollständig und unbeschädigt <i>Test item complete and undamaged</i>			
* Legende:	P(ass) = entspricht o.g. Prüfgrundlage(n)	F(ail) = entspricht nicht o.g. Prüfgrundlage(n)	N/A = nicht anwendbar	N/T = nicht getestet
* Legend:	P(ass) = passed a.m. test specification(s)	F(ail) = failed a.m. test specification(s)	N/A = not applicable	N/T = not tested
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Prüfbericht-Nr.: CN2540H0 002
Test report no.:

Seite 2 von 25
Page 2 of 25

Anmerkungen Remarks

1	Alle eingesetzten Prüfmittel waren zum angegebenen Prüfzeitraum gemäß eines festgelegten Kalibrierungsprogramms unseres Prüfhauses kalibriert. Sie entsprechen den in den Prüfprogrammen hinterlegten Anforderungen. Die Rückverfolgbarkeit der eingesetzten Prüfmittel ist durch die Einhaltung der Regelungen unseres Managementsystems gegeben. Detaillierte Informationen bezüglich Prüfkonditionen, Prüfequipment und Messunsicherheiten sind im Prüflabor vorhanden und können auf Wunsch bereitgestellt werden. <i>The equipment used during the specified testing period was calibrated according to our test laboratory calibration program. The equipment fulfils the requirements included in the relevant standards. The traceability of the test equipment used is ensured by compliance with the regulations of our management system. Detailed information regarding test conditions, equipment and measurement uncertainty is available in the test laboratory and could be provided on request.</i>
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3	Prüfklausel mit der Note * wurden an qualifizierte Unterauftragnehmer vergeben und sind unter der jeweiligen Prüfklausel des Berichts beschrieben. Abweichungen von Prüfspezifikation(en) oder Kundenanforderungen sind in der jeweiligen Prüfklausel im Bericht aufgeführt. <i>Test clauses with remark of * are subcontracted to qualified subcontractors and described under the respective test clause in the report.</i> <i>Deviations of testing specification(s) or customer requirements are listed in specific test clause in the report.</i>
4	Die Entscheidungsregel für Konformitätserklärungen basierend auf numerischen Messergebnissen in diesem Prüfbericht basiert auf der "Null-Grenzwert-Regel" und der "Einfachen Akzeptanz" gemäß ILAC G8:2019 und IEC Guide 115:2021, es sei denn, in der auf Seite 1 dieses Berichts genannten angewandten Norm ist etwas anderes festgelegt oder vom Kunden gewünscht. Dies bedeutet, dass die Messunsicherheit nicht berücksichtigt wird und daher auch nicht im Prüfbericht angegeben wird. Zu weiteren Informationen bezüglich des Risikos durch diese Entscheidungsregel siehe ILAC G8:2019. <i>The decision rule for statements of conformity, based on numerical measurement results, in this test report is based on the "Zero Guard Band Rule" and "Simple Acceptance" in accordance with ILAC G8:2019 and IEC Guide 115:2021, unless otherwise specified in the applied standard mentioned on Page 1 of this report or requested by the customer. This means that measurement uncertainty is not taken in account and hence also not declared in the test report. For additional information to the resulting risk based of this decision rule please refer to ILAC G8:2019.</i>

TEST REPORT ANSI/CAN/UL 9540A:2025 Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems	
Report Number	CN2540H0 002
Date of issue	See cover page
Total number of pages.....	25 pages
Name of Testing Laboratory preparing the Report.....	TÜV Rheinland (Shenzhen) Co., Ltd.
Manufacturer's name	Discover Energy Systems corp.
Address	320 - 13711 International Place, Richmond, B.C., V6V 2Z8, Canada
Test specification:	
Standard.....	ANSI/CAN/UL 9540A:2025
Test procedure	Test report
Non-standard test method	N/A
Test Report Form No.	UL9540A_1E_U01
Test Report Form(s) Originator	TÜV Rheinland (Shenzhen) Co., Ltd.
Master TRF.....	Dated 2025-04-21
General disclaimer: The test report is invalid if scribbled or altered. The test report is invalid without the signatures of authorized persons. The test results presented in this report relate only to the object tested. This report shall not be reproduced, except in full, without the written approval of the TÜV Rheinland. The authenticity of this Test Report and its contents can be verified by contacting the TÜV Rheinland (Shenzhen) Co., Ltd., responsible for this Test Report.	
Other / Scope: This report presents the result of module level tests of ANSI/CAN/UL 9540A:2025. All tests were conducted at TÜV Rheinland's partner labs that were under supervision of TÜV Rheinland's engineer.	

List of Attachments:

Attachment A: Diagrams of setup for unit level testing (Total 2 pages)
Attachment B: Module Conditioning (Charge/discharge) Profiles (Total 1 pages)
Attachment C: Observations and records (Total 1 pages)
Attachment D: Temperature Profiles During Testing (Total 4 pages)
Attachment E: Heat Release and Smoke Release (Total 3 pages)
Attachment F: Flammable gas generation and composition data (Total 3 pages)
Attachment G: Sample Photos and Test Photos (Total 8 pages)

Summary of testing:
Tests performed (name of test and test clause):

cl 9. Unit Level

The performance criteria of the unit level tests as indicated in Table 9.1 of UL 9540A 4th edition has been met, therefore installation level testing in accordance with UL 9540A need not be conducted.

Testing location:

This test was conducted at TÜV Rheinland's partner labs that were under supervision of TÜV Rheinland's engineer.

Possible test case verdicts:

- test case 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)

Testing:

Date of receipt of test item : See cover page

Date (s) of performance of tests : See cover page

General remarks:

"(See Attachment #)" refers to additional information attached to the report.
 "(See appended table)" refers to a table appended to the report.

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

Name and address of factory (ies) :

Other:

N/A

General product information:
Product Specification

Cell level information		
Manufacturer:	[REDACTED]	
Model number:	GSP71173204F	
Chemistry:	LiFePO ₄	
Overall dimensions (mm):	Height: 207.3mm ± 0.5mm; Thickness: 71.7mm ± 0.8mm; Width: 173.9mm ± 0.5mm;	
Physical configuration:	Prismatic	
	Weight:	Max. 5.9 kg
Electrical rating:	Rated capacity:	314 Ah
	Nominal voltage:	3.2 V
Charging current, A	157	
Discharging current, A	157	
Average cell surface temperature at gas venting, °C	166.0	
Average cell surface temperature at thermal runaway, °C	185.0	
Gas Volume, L	177.8	
Lower flammability limit (LFL), % volume in air at the ambient temperature:	7.54	
Lower flammability limit (LFL), % volume in air at the venting temperature:	6.44	
Burning velocity (Su) cm/s:	74.18	
Max pressure (Pmax) psig:	99.97	
Compliance with UL1973	☒ Yes, UL Report No.: MH64562 ☐ No	
Compliance with UL9540A.....	☒ Yes, UL Report No.: 4790919769 ☐ No	

Gas		Measured %
Carbon Monoxide	CO	9.576
Carbon Dioxide	CO ₂	24.949
Hydrogen	H ₂	49.706
Methane	CH ₄	6.631
Acetylene	C ₂ H ₂	0.230
Ethylene	C ₂ H ₄	5.046
Ethane	C ₂ H ₆	1.331
Propene	C ₃ H ₆	0.562
Propane	C ₃ H ₈	0.220
-	C4 (Total)	0.709
-	C5 (Total)	0.277
-	C6 (Total)	0.149
1-Heptene	C ₇ H ₁₄	0.024
Benzene	C ₆ H ₆	0.051
Toluene	C ₇ H ₈	0.007
Dimethyl Carbonate	C ₃ H ₆ O ₃	0.011
Ethyl Methyl Carbonate	C ₄ H ₈ O ₃	0.521
Total	-	100

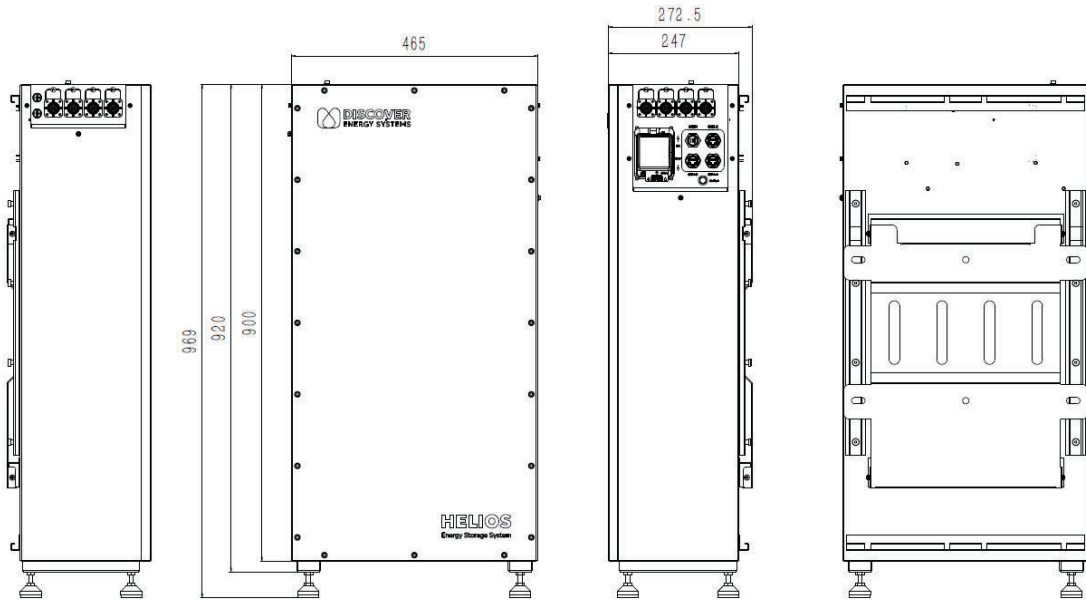
Module level information

Manufacturer name:	[REDACTED]
Model number:	1) 900-0077; 2) 52-48-16000
Physical configuration:	Metal material case
	Weight: Approx. 137.6kg
	Cells in series/parallel: 1P16S
Cooling method:	Air cooling
Rated capacity:	314 Ah
Nominal voltage:	51.2 Vdc
Charge Current:	157A
End of charge:	The highest voltage reaches 55.2V
Discharge Current:	157A
End of discharge:	The lowest voltage reaches 48 V
Compliance with UL1973:	☒ Yes TUV Report No.: CN24RKQO 002 ☐ No
Compliance with UL9540A:	☒ Yes TUV Report No.: CN248DTM 002 ☐ No

Summary of Module level test

Peak the module exterior surface temperature during the test (°C):	100.4		
Maximum Smoke Release Rate (m ² /s):	2.140		
Total Smoke Released (m ²):	251.6		
Peak Chemical Heat Release Rate (kW):	20.278		
External Flaming:	No external flaming observed		
flame extension and duration:	No external flaming observed		
Flying debris or explosive discharge of gases:	No flying debris observed		
Sparks, electrical arcs, or other electrical events:	No such electrical events observed		
Thermal Runaway Propagation:	Cell#11 was the initiating cell. Cells (#12, #10, #09) went into thermal runaway by cell-to-cell thermal propagation.		
Gas composition			
Gas components	Total volume of gas (L)	Gas components	Total volume of gas (L)
Carbon Monoxide (CO)	99.7	Carbon Dioxide (CO ₂)	212.6
Total Hydrocarbons (equivalent to CH ₄)	233.0	Hydrogen (H ₂)	Below detectable limit

Figure 1. Diagram with overall dimension (Unit: mm)



Unit level information		
Manufacturer name		[REDACTED]
Type/Model		52-48-16000_3
Physical configuration.....		Metal enclosure
		Total number of modules: 3
Cooling method		Air cooling
Electrical rating		942 Ah
		51.2 V
Standard charge method.....	Charge current:	400A
	End of charge voltage:	The highest voltage reaches 55.2V
Standard discharge method.....	Discharge current:	400A
	End of discharge voltage:	The lowest voltage reaches 48 V
Compliance with UL1973.....		☐ Yes ☒ No
Compliance with UL9540.....		☒ Yes TUV Report No.: CN2549VH 001 ☐ No
The battery system Model 52-48-16000_3 was used for this report/test.		

The following tables shows differences between the Battery system models:

Module Model	52-48-16000_1	52-48-16000_2	52-48-16000_3
External dimensions (Battery module), Width x Depth x Height:	Approx. LxWxH: 247x465x969mm	Approx. LxWxH: 247x955.4x969mm	Approx. LxWxH: 247x1445.8x969mm
Battery module Mass:	136kg*1	136kg*2	136kg*3
rating	314Ah	628Ah	942Ah
Maximum continuous charging current	200A	380A	400A
Maximum continuous discharging current	200A	380A	400A
Distribution box Mass:	7kg		
External dimensions (Distribution box), Width x Depth x Height:	Approx. LxWxH: 400x350x150mm		

Summary of Unit level test			
Inteded Installation:		Indoor / Outdoor wall mounted non-residential / residential use BESS	
Maximum Target BESS Temperature (°C):		82.2	
Maximum Wall Surface Temperature (°C):		74.9	
Maximum Smoke Release Rate (m²/s):		1.380	
Total Smoke Released (m²):		485.4	
Total Smoke Released Duration:		17:24 to 21:00	
Peak Chemical Heat Release Rate (kW):		No external flaming	
Peak Convective Heat Release Rate (kW):		No external flaming	
Maximum Heat Flux on Target Modules (kW/m²):		7.11	
Maximum Heat Flux on Target Walls (kW/m²):		0.35	
Maximum incident heat flux on target ceiling or soffit surfaces achieved (kW/m²):		0	
Maximum Heat Flux of Egress Path (kW/m²)		0.22	
External Flaming:		No flaming or charring of the cheesecloth indicator	
Flame extension and duration:		No flaming or charring of the cheesecloth indicator	
Flying debris or explosive discharge of gases:		No flying debris observed	
Sparks, electrical arcs, or other electrical events:		No such electrical events observed	
Thermal Runaway Propagation:		Total 4 cells vented. Total 4 cells went into thermal runaway. One initiating cell (cell#11) went into thermal runaway and propagated to 3 adjacent cells (cell#9, cell#10, cell#12).	
Gas composition			
Gas components	Total volume of gas (L)	Gas components	Total volume of gas (L)
Carbon Monoxide (CO)	75.0	Carbon Dioxide (CO₂)	197.2
Total Hydrocarbons (equivalent to CH₄)	273.7	Hydrogen (H₂)	335.1

Figure 2. Diagram of the unit:

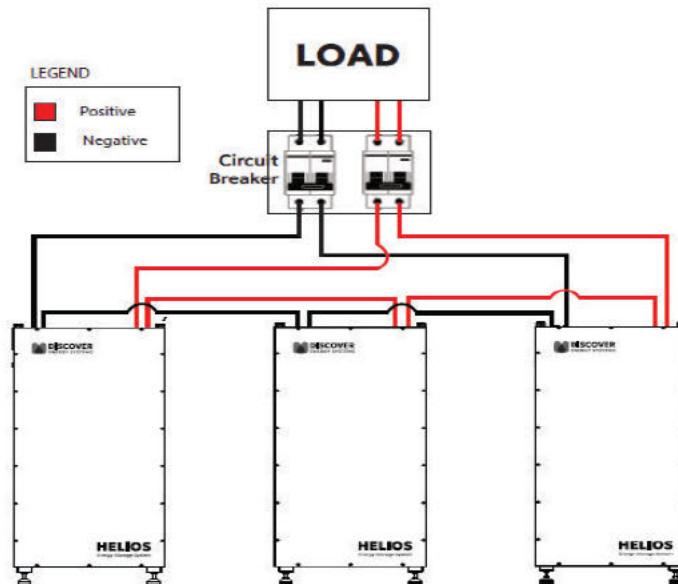
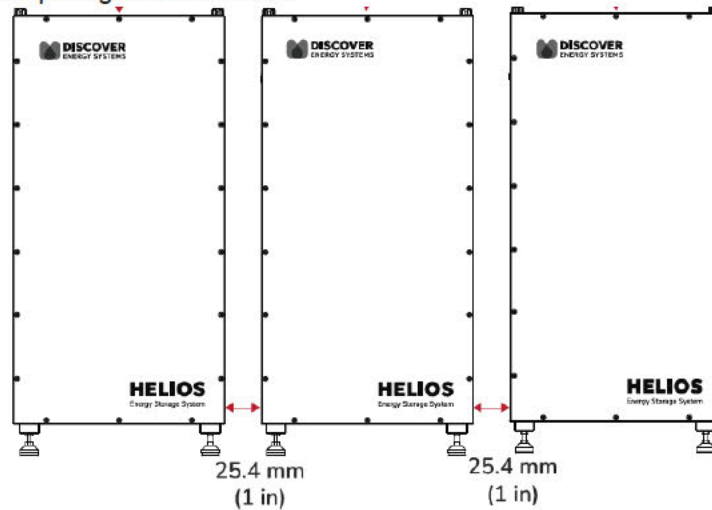


Figure 3. The minimum spacing between BESS:



Description of change(s):

1. The Manufacturer updates the minimum spacing between BESS, details see "Figure 3. The minimum spacing between BESS" on page 11, "Figure A.2. Test site setup diagram with separation distance" on Attachment A.
2. Update a typing error, Type no. from "52-48-16000_1" to "52-48-16000_3", details see page 1.

For the above-described change(s) the following was considered to be necessary:

Change	Testing	Comments	Result
1	CI 9 of UL 9540A	The test is re-verified.	P
2	N/A	No additional test necessary.	--

History of amendments and modifications:

Ref. No. CN2540H0 001, dated 2025-09-30 (original test report)

Ref. No. CN2540H0 002, dated 2025-09-30 (1st modification)

ANSI/CAN/UL 9540A:2025			
Clause	Requirement + Test	Result - Remark	Verdict
CONSTRUCTION			
5	General		P
5.3	Battery energy storage system unit		P
5.3.1	The BESS unit documentation included in the test report shall indicate the units that comply with UL 9540.		P
5.3.2	For BESS units for which UL 9540 compliance cannot be determined, the documentation included in the test report shall include the number of modules in the BESS, electrical configuration of the module, and physical layout of the modules in the BESS, battery management system (BMS) and other major components of the BESS. It shall be documented as to whether the battery system complies with UL 1973 in addition to the overall BESS compliance to UL 9540.		P
5.3.3	If applicable, the details of any fire detection and suppression systems that are an integral part of the BESS shall be noted in the test report		P
5.3.4	Refer to 9.7 for further details		P
PERFORMANCE			
6	General		P
6.1	The tests in this standard are extreme abuse conditions conducted on electrochemical energy storage devices that can result in fires explosions, smoke, off gassing of flammable and toxic materials, exposure to toxic and corrosive liquids, and potential exposure to hazardous voltages and electrical energy.		P
6.2	At the conclusion of testing, samples shall be discharged in accordance with the manufacturer's specifications		P
6.3	Temperatures on parts and surfaces shall be measured continuously, taking the average over every 60 seconds through the test with a thermocouple junction formed from 24-gauge or smaller, Type-K thermocouple wire unless noted otherwise in the specific test. The maximum of these averages shall be documented for each thermocouple location. Cell surface temperatures shall be measured continuously, but not averaged over every 60 seconds as the other temperature measurements are.	Temperatures on parts were measured continuously, taking the average over every 60 seconds.	P
6.4	When heat flux measurements are taken, they shall be measured continuously, taking the average over every 60-second interval. The maximum of these averages shall be documented for each gauge location.	Heat flux measurements are taken and were measured continuously, taking the average over every 60-second interval.	P

ANSI/CAN/UL 9540A:2025			
Clause	Requirement + Test	Result - Remark	Verdict
9	Unit Level		--
9.1	Sample and test configuration		P
9.1.1	The unit level test shall be conducted with BESS units installed as described in the manufacturer's instructions and this section. Test configurations may include the following:		P
	a) Indoor floor mounted non-residential use BESS; b) Indoor floor mounted residential use BESS; c) Outdoor ground mounted non-residential use BESS; d) Outdoor ground mounted residential use BESS; e) Indoor wall mounted non-residential use BESS; f) Indoor wall mounted residential use BESS; g) Outdoor wall mounted non-residential use BESS; h) Outdoor wall mounted residential use BESS; i) Rooftop non-residential use BESS; j) Rooftop residential use BESS; and k) Open parking garage non-residential use BESS installations.	e), f), g), h)	P
9.1.2	The unit level test requires one initiating BESS unit in which an internal fire condition in accordance with the module level test is initiated and target adjacent BESS units representative of an installation.	See Attachment A	P
	Tests conducted for indoor floor mounted installations for residential BESS may be considered representative of both indoor floor mounted and outdoor ground mounted installations.		N/A
	Tests shall be conducted indoors with fire propagation hazards and separation distances between initiating and target units representative of the installation.	See Attachment A	P
	The results of such tests for residential BESS may be considered to also represent an outdoor installation.		N/A
	Exception: Testing can be conducted outdoors for outdoor only installations if there are the following controls and environmental conditions in place:		N/A

ANSI/CAN/UL 9540A:2025			
Clause	Requirement + Test	Result - Remark	Verdict
	a) Wind screens are utilized with a maximum wind speed maintained at ≤ 12 mph; b) The temperature range is within 10°C to 40°C (50°F to 104°F); c) The humidity is $< 90\%$ RH; d) There is sufficient light to observe the testing; e) There is no precipitation during the testing; f) There is 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 g) There are 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
9.1.3	For outdoor non-residential use High Temperature Batteries installed in a container, the unit level test is waived as there is no additional information to be collected at the unit level for this technology when it is utilized for outdoor use only. Instead, the installation level test shall be conducted in accordance with Test method – Installation level test for high temperature battery container system BESS for outdoor non-residential use		N/A
9.1.4	For installations, where the high temperature battery modules are not installed on racks but rather within separate compartments within the container, the module is considered the test unit for the test.		N/A
9.1.5	Depending upon the configuration and design of the BESS (e.g. the BESS is composed of multiple separate parts within separate enclosures), this testing to determine fire characterization can be done at the battery system level.		P
	The suitability of this approach shall be determined based upon the overall design of the BESS and an analysis of the battery system as representative of the overall BESS for fire characterization concerns.		P
9.1.6	Where the manufacturer's instructions indicate that the BESS can be installed outdoors and in open parking garages less than 3 m (10 feet) from the means of egress or other exposures, testing shall be conducted as described in this Section.		P
9.1.7	The initiating BESS unit shall contain components representative of a BESS unit in a complete installation.		P
	Combustible components that interconnect the initiating and target BESS units shall be included.		P

ANSI/CAN/UL 9540A:2025			
Clause	Requirement + Test	Result - Remark	Verdict
9.1.8	Target BESS units shall include the outer cabinet (if part of the design), racking, module enclosures, and components that retain cells components.		P
	The target BESS units may also include one live, populated module at the location of the highest anticipated temperature in the enclosure.		P
	The remaining target BESS unit module enclosures do not need to contain cells.		P
9.1.9	The initiating BESS unit shall be brought to the maximum operating state of charge (MOSOC) in accordance with the manufacturer's specifications and allowed to rest for a minimum of 1 hour at room ambient before the start of the test.	100% SOC	P
9.1.10	Prior to initiating the test, the voltage of the initiating module shall be measured and recorded. If the voltage drop is greater than 0.1 % of the fully charged voltage of the module, then the initiating BESS shall be charged again as noted in 9.1.9 and the voltage of the initiating BESS shall be recorded.		P
9.1.11	The BESS unit included an integral fire suppression system.		N/A
9.1.12	Electronics and software controls such as the battery management system (BMS) in the BESS are not relied upon for this testing.		P
	Included a fire suppression control in accordance with UL 864 that is external to the BESS.		N/A
9.2	Test method – Indoor floor mounted BESS units	wall mounted	P
9.2.1	At the start of the test, the room ambient temperature shall not be less than 10 °C (50 °F) nor more than 32 °C (90 °F).	See Attachment C	P
9.2.2	Any access door(s) or panels on the initiating BESS unit and adjacent target BESS units shall be closed,		N/A
9.2.3	The initiating BESS unit shall be positioned adjacent to two instrumented wall sections		N/A
9.2.4	Instrumented wall sections shall extend not less than 0.49 m (1.6 ft) horizontally beyond the exterior of the target BESS units.		P
9.2.5	Instrumented wall sections shall be at least 0.61-m (2-feet) taller than the BESS unit height, and not less than 2.13 m (7 feet) in height above the floor.		P
9.2.6	The surface of the instrumented wall sections shall be covered with 13-mm (1/2-in) gypsum wall board and painted flat black.		P
9.2.7	The initiating BESS unit shall be centered underneath an appropriately sized smoke collection hood of an oxygen consumption calorimeter.		P

ANSI/CAN/UL 9540A:2025			
Clause	Requirement + Test	Result - Remark	Verdict
9.2.8	The light transmission in the calorimeter's exhaust duct shall be measured using a white light source and photo detector for the duration of the test. The smoke release rate was calculated.		P
9.2.9	The chemical and convective heat release rates shall be measured for the duration of the test, using the methodologies specified in 8.2.11 and 9.2.12, respectively.		P
9.2.10	With reference to 9.2.9, the heat release rate measurement system shall be calibrated.		P
9.2.11	With reference to 9.2.9, the convective heat release rate shall be measured using thermopile, a velocity probe, and a Type K thermocouple, located in the exhaust system of the exhaust duct.		P
9.2.12	With reference to 9.2.9, the convective heat release rate shall be calculated using the following equation: $HRR_c = V_e A \frac{353.22}{T_e} \int_{T_e}^T C_p dT$		P
9.2.13	The physical spacing between BESS units (both initiating and target) and adjacent walls shall be representative of the intended installation		P
9.2.14	Separation distances shall be specified by the manufacturer for distance between:		P
	a) The BESS units and the instrumented wall sections; and b) Adjacent BESS units.	See Attachment A	P
9.2.15	Wall surface temperatures were measured in vertical array(s) at 152-mm (6-in) intervals for the full height of the instrumented wall sections using No. 24-gauge or smaller, Type-K exposed junction thermocouples.		P
	The thermocouples for measuring the temperature on wall surfaces shall be horizontally positioned in the wall locations anticipated to receive the greatest thermal exposure from the initiating BESS unit.		P
	Temperatures shall be measured continuously, averaging over every 60-second interval per 6.3. The maximum of these averages shall be documented for each thermocouple location.		P
9.2.16	Thermocouples were secured to gypsum surfaces and 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.		P

ANSI/CAN/UL 9540A:2025			
Clause	Requirement + Test	Result - Remark	Verdict
9.2.17	Heat flux shall be measured with the sensing element of at least two water-cooled Schmidt-Boelter or Gardon gauges at the surface of each instrumented wall as follows in (a) – (c). Heat flux shall be measured continuously, averaging over every 60-second interval per 6.4. The maximum of these averages shall be documented for each gauge location. a) Both are collinear with the vertical thermocouple array; b) One is positioned at the elevation estimated to receive the greatest heat flux due to the thermal runaway of the initiating module; and c) One is positioned at the elevation estimated to receive the greatest heat flux during potential propagation of thermal runaway within the initiating BESS unit. Exception: If (b) and (c) are deemed to be at the same location based on a construction review, only one gauge is required.	See Attachment A	P
9.2.18	Heat flux shall be 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 as follows in (a) and (b). Heat flux shall be measured continuously, averaging over every 60-second interval per 6.4. The maximum of these averages shall be documented for each gauge location. a) One is positioned at the elevation estimated to receive the greatest heat flux due to the thermal runaway of the initiating module within the initiating BESS; and b) One is positioned at the elevation estimated to receive the greatest surface heat flux due to the thermal runaway of the initiating BESS. Exception: If (a) and (b) are deemed to be at the same location based on a construction review, only one gauge may be installed on the target unit for the measurement.	See Attachment A	P
9.2.19	For BESS intended for installation outdoors or in open parking garages covered by 9.1.6, heat flux shall be measured with the sensing element of at least one water-cooled Schmidt-Boelter or Gardon gauge positioned at the mid height of the initiating unit at the minimum horizontal distance from the BESS specified by the manufacturer or the point where the majority of off-gas venting is expected from the initiating unit. Heat flux shall be measured continuously, averaging over every 60-second interval per 6.4.	See Attachment A	P

ANSI/CAN/UL 9540A:2025			
Clause	Requirement + Test	Result - Remark	Verdict
9.2.20	No. 24-gauge or smaller, Type-K exposed junction thermocouples shall be installed to measure the temperature of the surface proximate to the cells and between the cells and exposed face of the initiating module.		P
	Each non-initiating module enclosure within the initiating BESS unit shall be 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.		P
	Additional thermocouples shall be placed to account for convoluted enclosure interior geometries.		
	Temperatures shall be measured continuously, averaging over every 60-second interval per 6.3. The maximum of these averages shall be documented for each thermocouple location.		P
9.2.21	For residential use BESS, the DUT shall be covered with a single layer of cheese cloth ignition indicator. The cheesecloth shall be 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.		P
9.2.22	Cell to cell thermal runaway propagation in accordance with the module level test in 8.2.4 shall be established within a single module in the initiating BESS unit: a) The position of the module shall be selected to present the greatest thermal exposure to adjacent modules (e.g. above, below, laterally), based on the results from the module level test; and b) The setup (i.e. type, quantity and positioning) of equipment for initiating thermal runaway in the module shall be the same as that used to initiate and propagate thermal runaway within the module level test (Section 8).		P
9.2.23	The composition, velocity and temperature of the initiating BESS unit vent gases shall be measured within the calorimeter's exhaust duct.		P
	The hydrocarbon content of the vent gas shall be measured using flame ionization detection.		P
	Hydrogen gas shall be measured with a palladium-nickel thin-film solid state analyzer.		P
	Composition, velocity and temperature instrumentation shall be collocated with heat release rate calorimetry instrumentation.		P

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Clause	Requirement + Test	Result - Remark	Verdict
9.2.24	At the request of the BESS manufacturer, the hydrocarbon content of the vent gas may additionally be measured using a Fourier-Transform Infrared Spectrometer with a minimum resolution of 1 cm ⁻¹ and a path length of at least 2.0 m (6.6 feet), or equivalent gas analyzer.		P
9.2.25	The test shall be terminated if:		P
	a) There are three consecutive temperature readings measured inside each module within the initiating BESS unit that are determined to be falling over 15-minute intervals;		N/A
	b) The modules return to a temperature less than 60 °C (140 °F);		P
	c) The fire propagates to adjacent units or to adjacent walls;		N/A
	d) A condition hazardous to test staff or the test facility requires mitigation; or		N/A
	e) Flaming outside the test room is observed.		N/A
9.2.26	For residential use systems, the gas collection data gathered in 9.2 shall be compared to the smallest room installation specified by the manufacturer to determine if the flammable gas collected exceeds 25 % LFL in air.		P
9.3	Test method – Outdoor ground mounted units		--
9.3.1	Outdoor ground mounted non-residential use BESS being evaluated for installation in close proximity to buildings shall use the test method described in Section 9.2		N/A
	If intended for outdoor use only installations, including rooftop installations, the smoke release rate, the convective and chemical heat release rate and content, velocity and temperature of the released vent gases need not be measured.		N/A
9.3.2	Outdoor ground mounted residential use BESS being evaluated for installation in close proximity to buildings and structures shall use the test method described in 9.2 except as noted in 9.3.3 and 9.3.4.		N/A
	If intended for outdoor use only installations, the smoke release rate, the convective and chemical heat release rate and content, velocity, and temperature of the released vent gases need not be measured.		N/A
9.3.3	Test samples shall be installed as shown in Figure 9.2 in proximity to an instrumented wall section that is 3.66-m (12-feet) tall with a 0.3-m (1-foot) wide horizontal soffit (undersurface of the eave shown in Figure 9.2).		N/A

ANSI/CAN/UL 9540A:2025			
Clause	Requirement + Test	Result - Remark	Verdict
	The sample shall be 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 shall be constructed with 19.05-mm (3/4-inch) plywood installed on wood studs and painted flat black. The instrumented wall shall extend not less than 0.49-m (1.6-feet) 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 as noted in 9.2.15 shall extend to the surface of the soffit as shown in Figure 9.2.		N/A
	Exception: If the manufacturer requires installation against non-flammable material, the test setup may include manufacturer recommended backing material between the unit and plywood wall.		N/A
9.3.4	Target BESS shall be installed on each side of the initiating BESS in accordance with the manufacturer's installation specifications. The physical spacing between BESS units (both initiating and target) shall be the minimum separation distances specified by the manufacturer.		N/A
9.4	Test Method – Indoor wall mounted units		P
9.4.1	Testing of indoor wall mounted BESS shall be in accordance with Section 9.2, except as modified in this section. See Figure 9.3.		P
9.4.2	BESS intended for wall mount installations shall only be tested using instrumented wall sections not less than 2.44 m (8 feet) in height and width, and with a 0.3-m (1-foot) wide horizontal ceiling as shown in Figure 9.3.		P
	The walls and ceiling shall be constructed with gypsum wall board installed on wood studs and painted flat black.		P
	The gypsum wall board shall be 13-mm (1/2-inch) thick at minimum. The instrumented wall shall extend not less than 0.49-m (1.6-feet) horizontally beyond the exterior of the target BESS units.		P
	The No. 24-gauge or smaller, Type-K exposed junction thermocouple array on the walls shall extend to the surface of the ceiling as shown in Figure 9.3.		P
9.4.3	When BESS are tested in accordance with 9.4.2, the initiating BESS unit shall be positioned with the center located 1.22-m (4-feet) above the floor or at a height in accordance with the manufacturer's installation instructions, and halfway between adjacent walls.		P

ANSI/CAN/UL 9540A:2025			
Clause	Requirement + Test	Result - Remark	Verdict
9.4.4	Target BESS shall be installed on the wall on each side of the initiating BESS, at the same height above the floor as the initiating BESS. The physical spacing between BESS units (both initiating and target) shall be the minimum separation distances specified by the manufacturer.		P
9.4.5	The wall on which the initiating and target BESS units are mounted shall be instrumented in accordance with 9.2.		P
9.4.6	The gas collection methods shall be in accordance with 9.2. For residential use systems, the gas collection data gathered in 9.2 shall be compared to the smallest room installation specified by the manufacturer to determine if the flammable gas collected exceeds 25 % LFL in air.		P
9.4.7	For residential use BESS, the DUT shall be covered with a single layer of cheese cloth ignition indicator. The cheesecloth shall be 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.		P
9.5	Test Method – Outdoor wall mounted units		P
9.5.1	Testing of outdoor wall mounted residential and non-residential BESS shall be in accordance with 9.2, except as modified in this section. See Figure 9.3.		P
	If intended for outdoor use only wall mount installations, the smoke release rate, the convective and chemical heat release rate; and the content, velocity and temperature of the released vent gases need not be measured.		P
	Heat flux measurements for the accessible means of egress or in front of the BESS shall be measured in accordance with 9.2.19.		P
9.5.2	Test samples shall be mounted on an instrumented wall section that is a minimum of 3.66-m (12-feet) tall with a 0.3-m (1-foot) wide horizontal soffit (undersurface of the eave shown in Figure 9.3. The wall and soffit shall be constructed with 19.05-mm (3/4-inch) plywood installed on wood studs and painted flat black. An optional substrate of 13-mm (1/2-inch) or 16-mm (5/8-inch) exterior gypsum sheathing shall be permitted to be installed on the plywood. The instrumented wall shall extend not less than 0.49-m (1.6-feet) horizontally beyond the exterior of the target BESS units. The No. 24-gauge or smaller, Type-K exposed junction thermocouple array on the walls as noted in 9.2.15 shall extend to the surface of the soffit as shown in Figure 9.3.		P

ANSI/CAN/UL 9540A:2025			
Clause	Requirement + Test	Result - Remark	Verdict
	Exception: If the manufacturer requires installation against non-flammable material, the test setup may include manufacturer recommended backing material between the unit and plywood wall.	The manufacturer requires installation against non-flammable material; the test setup includes manufacturer recommended backing material between the unit and plywood wall.	P
9.5.3	The initiating BESS unit shall be positioned on the instrumented wall, with its center located 1.22-m (4-feet) above the floor, and halfway between wall edges.		P
9.5.4	Target BESS shall be installed on the wall on each side of the initiating BESS, at the same height above the floor as the initiating BESS. The physical spacing between BESS units (both initiating and target) shall be the minimum separation distances specified by the manufacturer.		P
9.5.5	The wall on which the initiating and target BESS units are mounted, and the soffit in the case of residential use BESS, shall be instrumented in accordance with 9.2.		P
9.5.6	For residential use BESS, the DUT shall be covered with a single layer of cheese cloth ignition indicator. The cheesecloth shall be 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.		P
9.6	Rooftop and open garage installations		N/A
9.6.1	Testing of BESS intended for non-residential use rooftop or open parking garage installations shall be in accordance with 9.2.		N/A
9.6.2	If intended for rooftop and open parking garage use only installations, the smoke release rate, the convective and chemical heat release rate and content, velocity, and temperature of the released vent gases need not be measured.		N/A
9.6.3	BESS intended for installation on combustible roofs shall be mounted on constructed with 13-mm (1/2-inch) gypsum wall board painted flat black, or the mounting surface recommended by the manufacturer, also painted flat black.		N/A
9.6.4	Temperatures on the surface of the combustible roof assembly shall be measured under the center of the BESS and in horizontal array(s) at 152-mm (6-inch) intervals for a minimum 1 m (3.3 feet) from the edge of the initiating BESS unit using No. 24-gauge or smaller, Type-K exposed junction thermocouples.		N/A

ANSI/CAN/UL 9540A:2025			
Clause	Requirement + Test	Result - Remark	Verdict
	The thermocouples for measuring the temperature on roof surfaces shall be positioned in the roof locations anticipated to receive the greatest thermal exposure from the initiating BESS unit.		N/A
9.6.5	If the BESS is intended to be installed on combustible roof assemblies beneath PV panels, combustible materials, or other obstructions, the test shall be conducted with the ESS mounted underneath the obstructions, as specified by the manufacturer.		N/A
	The type of overhead obstruction used in the test shall be that which is anticipated to provide the greatest fire challenge. The vertical distances between the rooftop and the ESS, and between the ESS and the overhead obstruction shall be the minimum specified by the manufacturer.		N/A
	The overhead obstruction shall extend horizontally a minimum 2 m (6.6 feet) in all directions from the edges of the target BESS, unless lesser distances are specified by the manufacturer's installation instructions.		N/A
9.7	Unit level test report		--
9.7.1	a) Indoor floor mounted non-residential use BESS; b) Indoor floor mounted residential use BESS; c) Outdoor ground mounted non-residential use BESS; d) Outdoor ground mounted residential use BESS; e) Indoor wall mounted non-residential use BESS; f) Indoor wall mounted residential use BESS; g) Outdoor wall mounted non-residential use BESS; h) Outdoor wall mounted residential use BESS; i) Rooftop installed non-residential use BESS; or j) Open parking garage installed non-residential use BESS.	e), f), g), h)	P
9.7.2	With reference to 9.7.1, if testing is intended to represent more than one installation type, this shall be noted in the report.		N/A
9.7.3	The report shall include the following, as applicable:		P
	a) Unit manufacturer name and model number (and whether UL 9540 compliant);	See general product information	P
	b) Number of modules in the initiating BESS unit;	See Attachment A	P
	c) The construction of the initiating BESS unit per 5.3;	See Attachment A	P
	d) Fire protection features/detection/suppression systems within unit;		N/A

ANSI/CAN/UL 9540A:2025			
Clause	Requirement + Test	Result - Remark	Verdict
	e) Module voltage(s) corresponding to the tested SOC;	See Attachment C	P
	f) The thermal runaway initiation method used;	External heater	P
	g) Location of the initiating module within the BESS unit;	See Attachment A	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, soffits as applicable, and thermocouples;	See Attachment A	P
	i) Observation of any flaming outside the initiating BESS enclosure and the maximum flame extension;	See Attachment C	P
	j) Chemical and convective heat release rate versus time data;	See Attachment E	P
	k) Separation distances from the initiating BESS unit to target walls (e.g. distances A and C in Figure 9.1) and target heat flux gauges;	See Attachment A	P
	l) Separation distances from the initiating BESS unit to target BESS units (e.g. distances D and H in Figure 9.1);	See Attachment A	P
	m) The maximum wall surface and target BESS temperatures achieved during the test and the location of the measuring thermocouple; NOTE: The maximum target BESS temperature is averaged over 60 seconds.	See Attachment D	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;		P
	o) The maximum incident heat flux on target wall surfaces and target BESS units;	See Attachment E	P
	p) The maximum incident heat flux on target ceiling or soffit surfaces achieved during the indoor or outdoor wall mounted test;		P
	q) Gas generation and composition data if conducted indoors;	See Attachment F	P
	r) Peak smoke release rate and total smoke release data if conducted indoors;	See Attachment E	P
	s) Indication of the activation of integral fire protection systems and if activated the time into the test at which activation occurred;		N/A
	t) Observation of flying debris or explosive discharge of gases unless mitigated by an engineered deflagration protection system;	Not observed	P
	u) Observation of re-ignition(s) from thermal runaway events;	Not observed	P

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Clause	Requirement + Test	Result - Remark	Verdict
	v) Observation(s) of sparks, electrical arcs, or other electrical events;	Not observed	P
	w) Observations of the damage to: 1) The initiating BESS unit; 2) Target BESS units; 3) Adjacent walls, ceilings, or soffits;	Not observed	P
	x) Photos and video of the test;	Record	P
	y) If the test is terminated in accordance with 9.2.25, the circumstances of the termination; and	See 9.2.25	P
	z) Module level test report summary and cell level test report summary.	See product information	P
9.8	Performance at unit level testing		P
9.8.1	Installation level testing in Section 10 is not required if the following performance conditions outlined in Table 9.1 are met during the unit level test.	Non-Residential Installations, Outdoor Ground Mounted	P
	a) 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, as determined in 7.3.1.10;	Max. Temperature during the test: 82.2°C Average Cell venting temperature: 166.0 °C	P
	b) For BESS units intended for installation near exposures, surface temperature measurements on wall surfaces do not exceed 97 °C (175 °F) of temperature rise above ambient;	Max. surface temperature during the test: 74.9°C Criteria Temperature: 25.8+97=122.8 °C	P
	c) Explosion hazards are not observed, including deflagration or detonation; and	No explosion observed	P
	d) Heat flux measured at the minimum distance to a means of egress specified by the manufacturer shall not exceed 1.3 kW/m ² .	Measured heat flux 0.22 kW/m ²	P

--End of report--

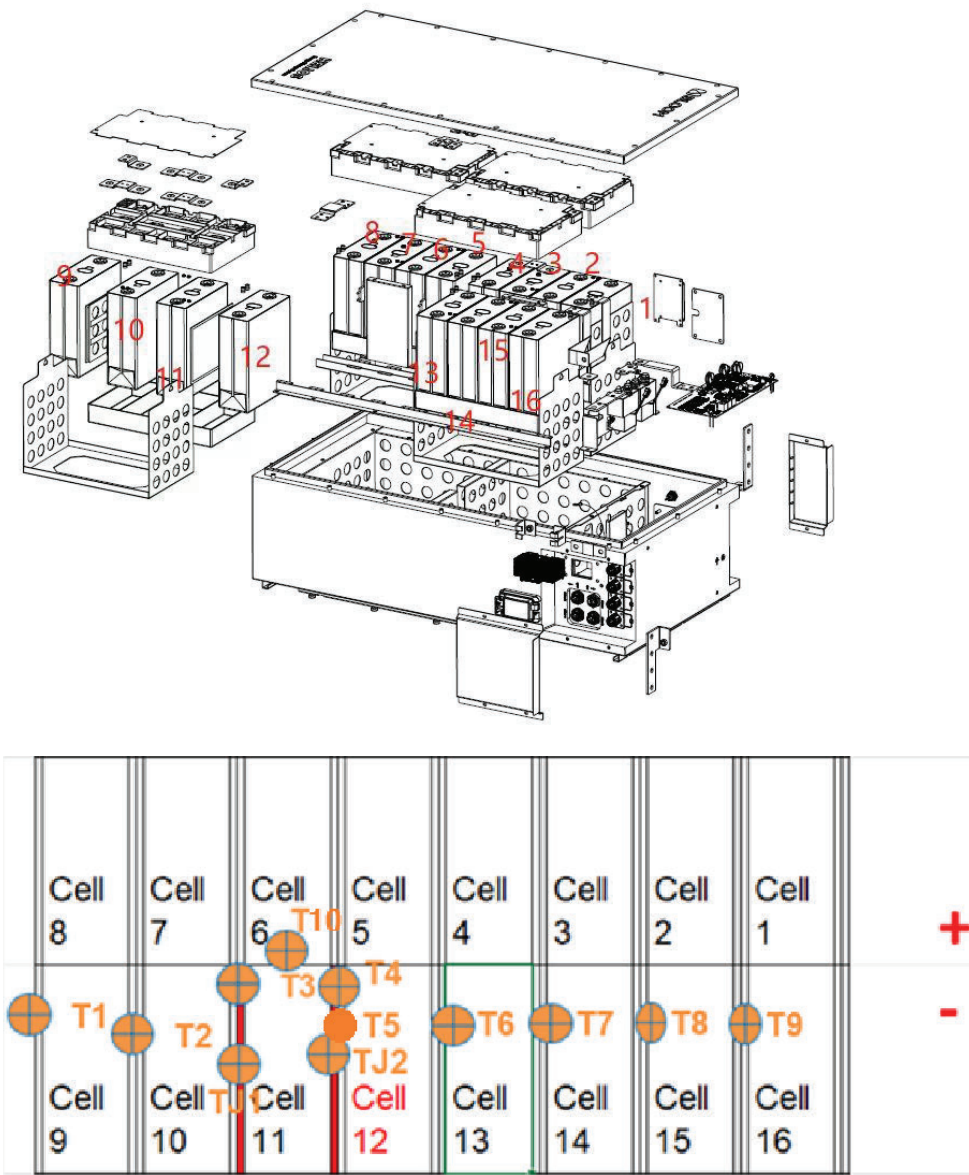
Attachment A Diagrams of setup for unit level testing

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Page 1 of 2

Report No.: CN2540H0 002

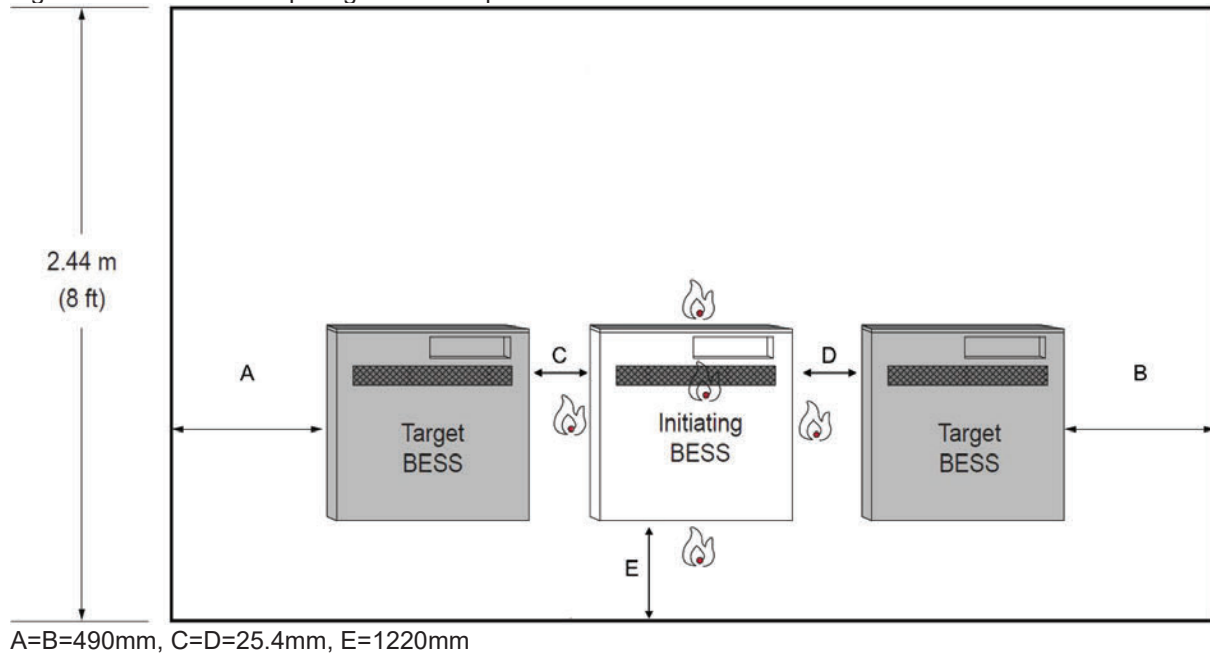
Figure A.1. Thermocouples (no. xx) locations of initiating module



Attachment A Diagrams of setup for unit level testing

Diagrams of setup for unit level testing

Figure A.2. Test site setup diagram with separation distance.



--- End of the attachment ---

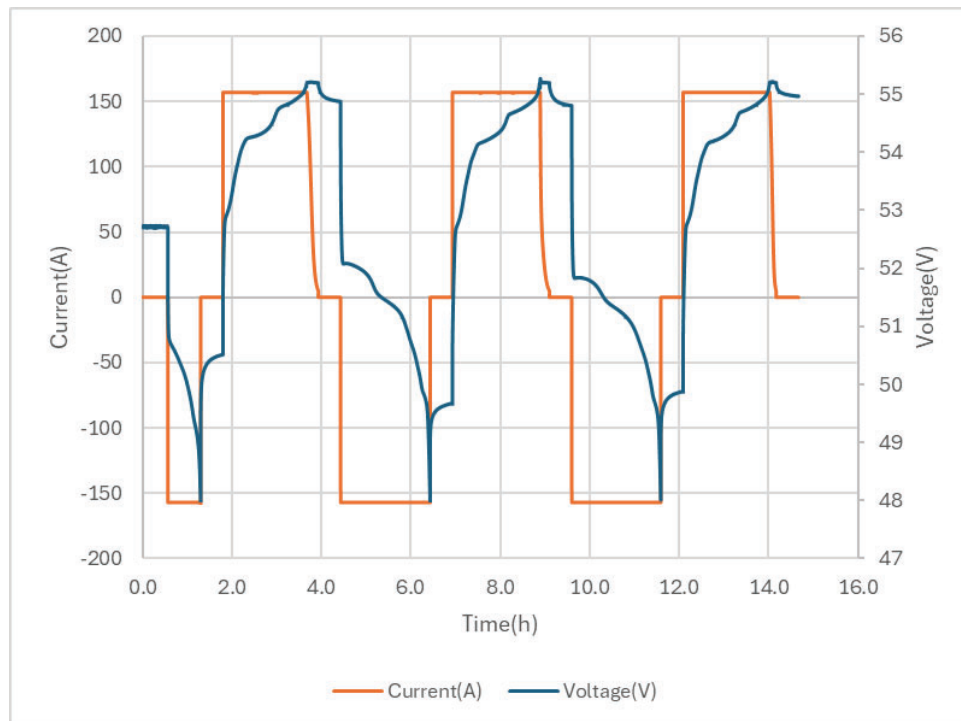
Attachment B Module Conditioning (Charge/discharge) Profiles

Module sample was conditioned, prior to testing, through charge and discharge cycles of 2 cycles to verify that the module was functional.

Each cycle was defined as a charge to 100% SOC and allowed to rest several minutes and then discharged to an end of discharge voltage (EODV) determined by the manufacturer. Refer to general product information in page 7 for charge and discharge profile.

The module sample was put in a climate chamber during charge and discharge. The ambient is kept at $25^{\circ}\text{C} \pm 2^{\circ}\text{C}$ and $50\% \pm 5\%$ R.H.

Figure B.1. Module charge and discharge voltage/current profiles



--- End of the attachment ---

Attachment C Observations and records

Ambient conditions at the initiation of the test.:	26.2°C, 45% R.H.
Sample number	25W39A135
Open circuit voltage before test (V).....:	54.2
Weight before test (kg)	135.3 (with thermocouples and heater)
Time initiating the test.....:	2025-09-26 17:24 start to heat the cell#11 with 5.5 °C/min
Observations during test.....:	18:02 cell#11 vented 18:03 cell#11 went into thermal runaway 18:04 cell#12 vented 18:04 cell#12 went into thermal runaway 18:04 cell#10 vented 18:06 cell#10 went into thermal runaway 18:07 cell#9 vented 18:07 cell#9 went into thermal runaway No flying debris or explosive discharge of gases during test. No sparks, electrical arcs, or other electrical events during test. No flaming observed.
Posttest evaluation	Total 4 cells vented. Total 4 cells went into thermal runaway. One initiating cell (cell#11) went into thermal runaway and propagated to 3 adjacent cells (cell#9, cell#10, cell#12). 40.0V was measured on the module output terminal.
Weight after test (kg)	131.8 (with thermocouples and heater)
Weight loss (kg).....:	3.5

--- End of the attachment ---

Figure D.1. Temperatures of cell in initial module

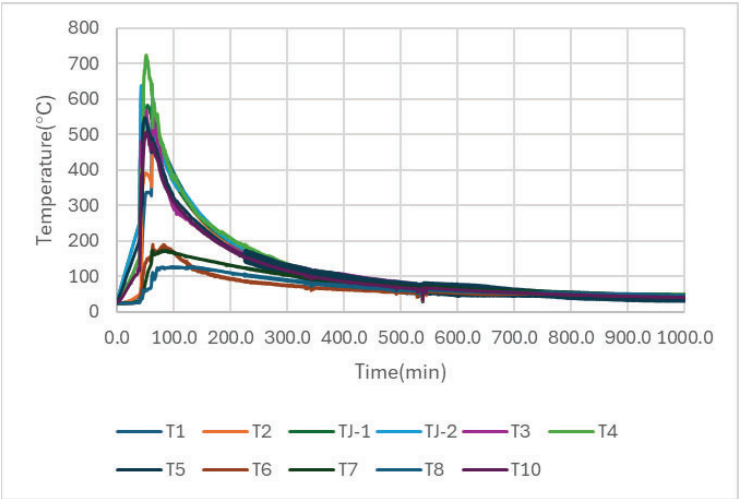


Figure D.2. Temperatures of surface in initial module

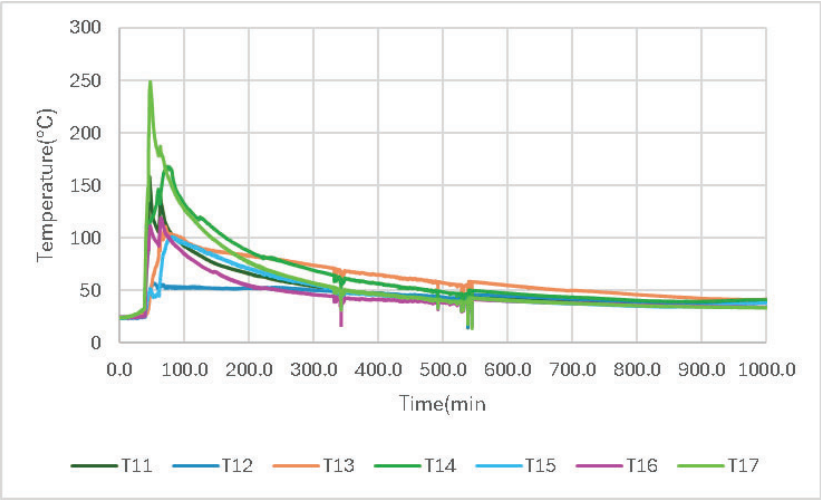
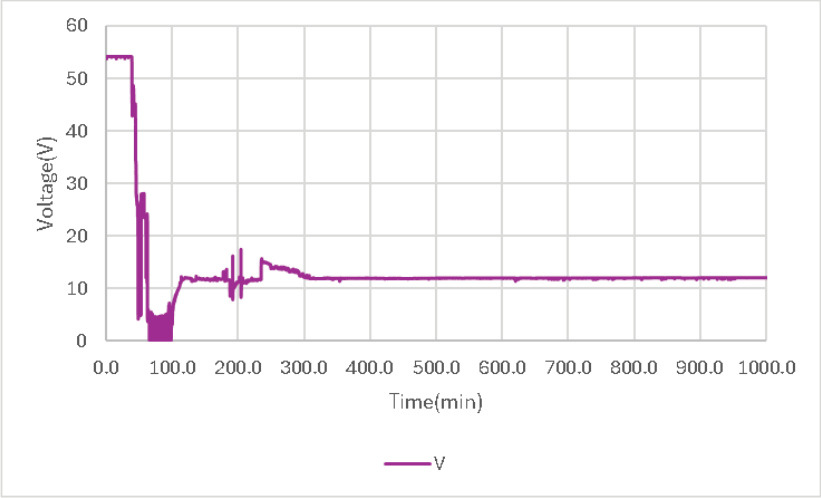
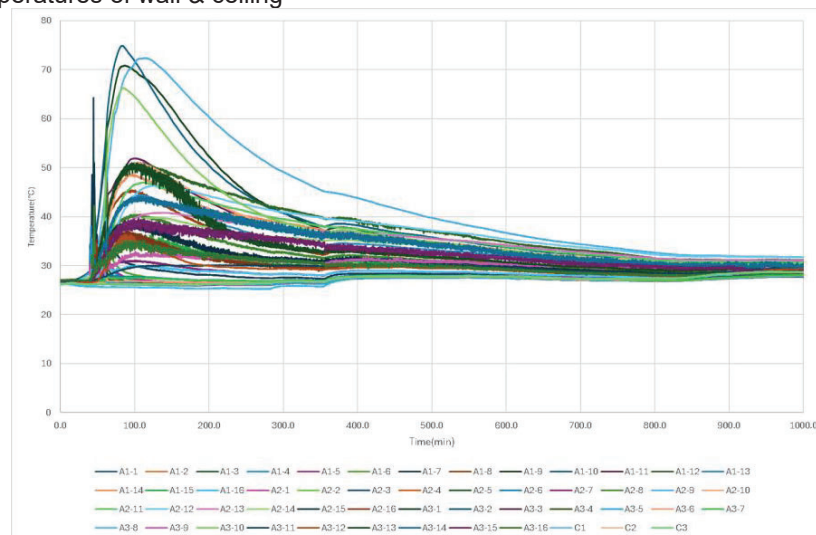


Figure D.3. Voltage of initial module





Attachment D Temperature and Voltage Profiles During Testing

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Page 3 of 4



Report No.: CN2540H0 002

Table D.1 Temperatures of cells in module Record

No.	Location	Max. temperature (°C)
T1	Cell#9, wide side, center (left side)	601.7
T2	Cell#10, wide side, center (left side)	529.1
T3	Cell#11, wide side, center (left side)	582.9
TJ1	Cell#11, wide side, center, under heater, serves to control ramp rate (left side)	639.0
TJ2	Cell#11, wide side, center, under heater, serves to control ramp rate (right side)	568.1
T4	Cell#11, wide side, center (right side)	724.3
T5	Cell#12, wide side, center (left side)	548.0
T6	Cell#13, wide side, center (left side)	190.1
T7	Cell#14, wide side, center (left side)	173.9
T8	Cell#15, wide side, center (left side)	127.7
T10	Cell#6, narrow side, center	506.8

Table D.2 Temperatures of module surface

No.	Location	Max. temperature (°C)
T11	Front side of module surface	158.4
T12	Left side of module surface	56.9
T13	Back side of module surface	111.0
T14	Right side of module surface	168.3
T15	Bottom side of module surface	101.2
T16	Top of module surface	119.2
T17	Top of module internal surface	248.9

Table D.3 Module voltage

No.	Name	Voltage (V dc)
V	Module voltage	54.2 to 40.0

Remark: During the test, an abnormality was detected in voltage monitoring. The multimeter measurements of the total voltage as shown in the photos in Appendix G shall prevail.

Table D.4 Temperatures of target unit

No.	Location	Max. temperature (°C)
T18	Left target BESS, narrow side, center (right side)	35.3
T19	Right target BESS, narrow side, center (left side)	82.2
T20	Ambient temperature (Average)	25.8

Attachment D Temperature and Voltage Profiles During Testing

www.tuv.com

Page 4 of 4

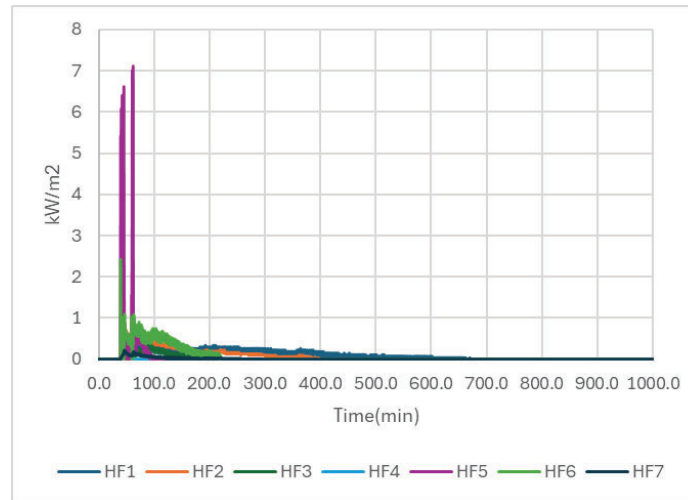


Report No.: CN2540H0 002

Table D.5 Temperatures of Wall, Ceiling		
No.	Location	Max. temperature (°C)
A1-1~A1-16, A2-1~A2-16, A3-1~A3-16, C1~C3 (on the wall)	wall, Ceiling	74.9

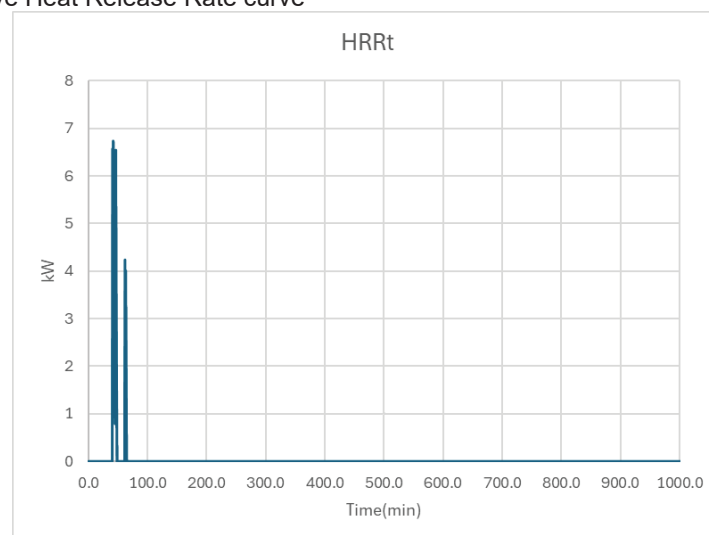
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Figure E.1. Heat Flux curve



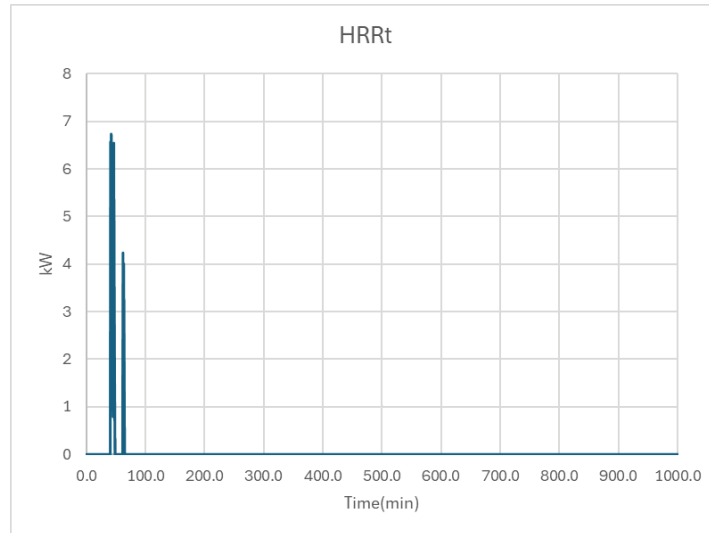
Channel Number	Location	Max. heat flux (kW/m²)
HF1	Left target BESS: narrow side, center (right side)	1.05
HF2	Left target BESS: narrow side, top (right side)	0.88
HF3	Initiating BESS: wide side, center	0.35
HF4	Target ceiling	0.00
HF5	Right target BESS: narrow side, center (left side)	7.11
HF6	Right target BESS: narrow side, top (left side)	2.42
HF7	Emergency exit	0.22

Figure E.2. Connective Heat Release Rate curve



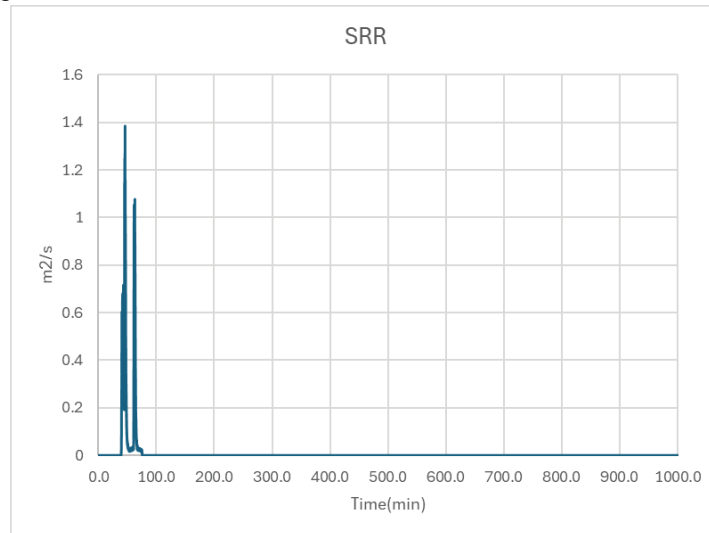
Measured peak connective heat release rate was 0 kW.

Figure E.3. Chemical Heat Release Rate curve



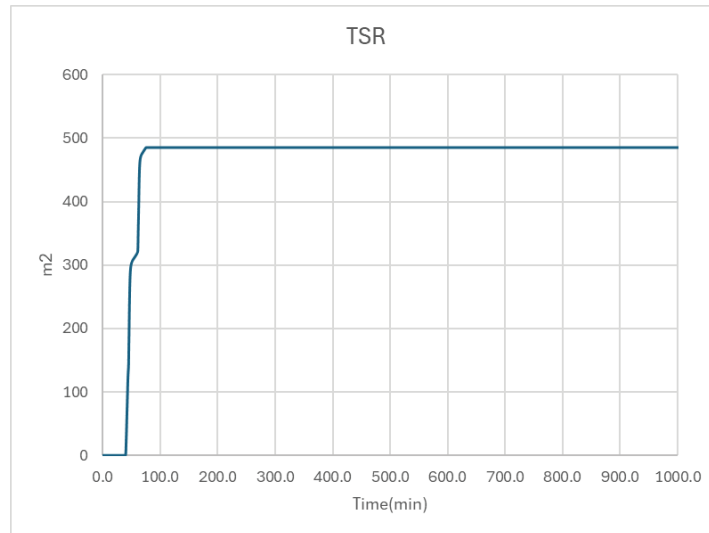
Measured peak chemical heat release rate was 6.72 kW.

Figure E.4. SRR curve



Measured peak smoke release rate was 1.380 m²/s.

Figure E.5. TSR curve



Measured total smoke release was 485.4 m².

--- End of the attachment ---

Attachment F Flammable gas generation and composition data

Gas type	Gas components		Total volume of gas (L)
Hydrocarbon species	Methane	CH ₄	49.6
	Ethylene	C ₂ H ₄	54.2
Others	Carbon Monoxide	CO	75.0
	Carbon Dioxide	CO ₂	197.2
	Hydrogen	H ₂	335.1
Total Hydrocarbons (equivalent to CH ₄ , measured by FID)			273.7
Note:			
1) Hydrogen measured by Palladium nickel thin film solid state sensor.			

Figure F.1. Hydrocarbon species

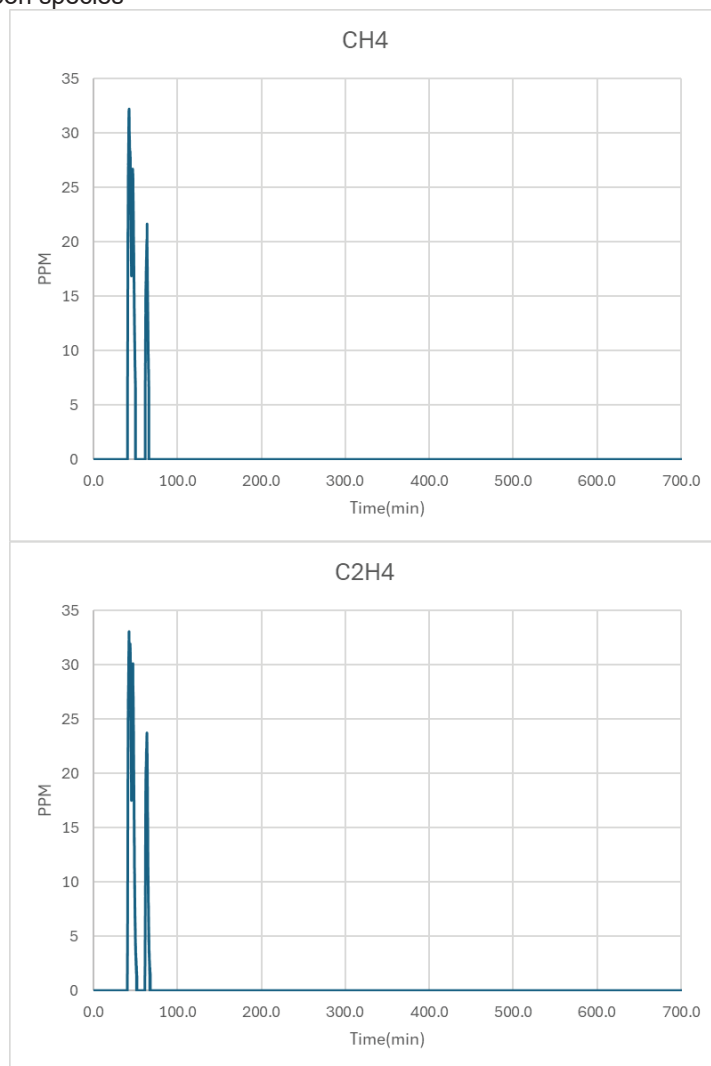


Figure F.2. CO, CO₂ concentration

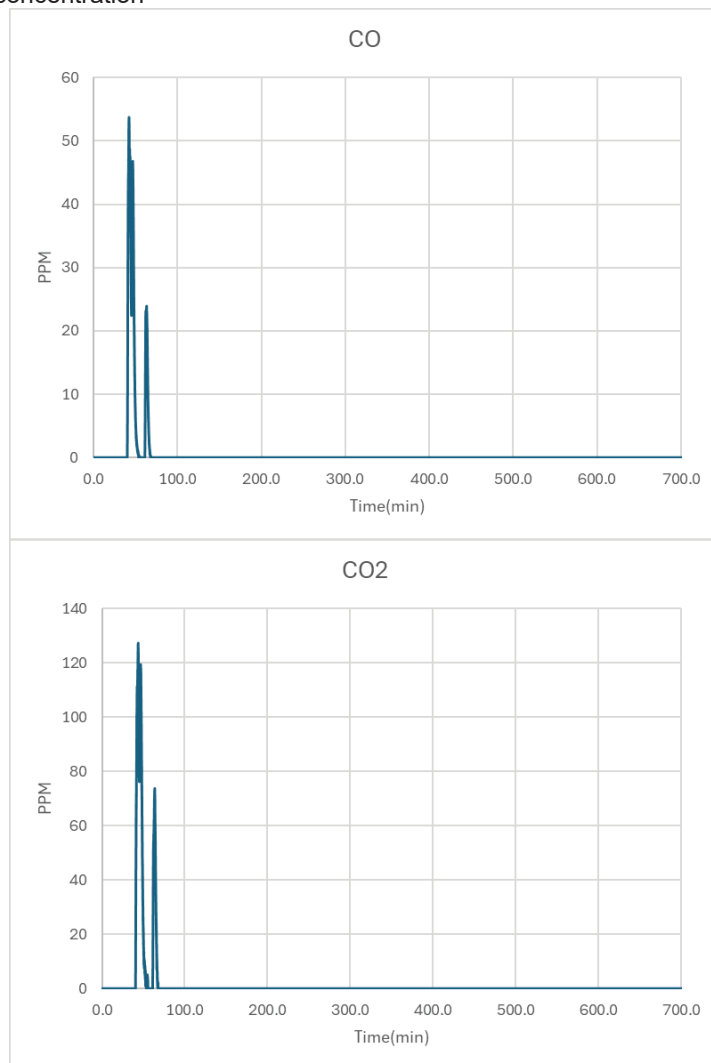
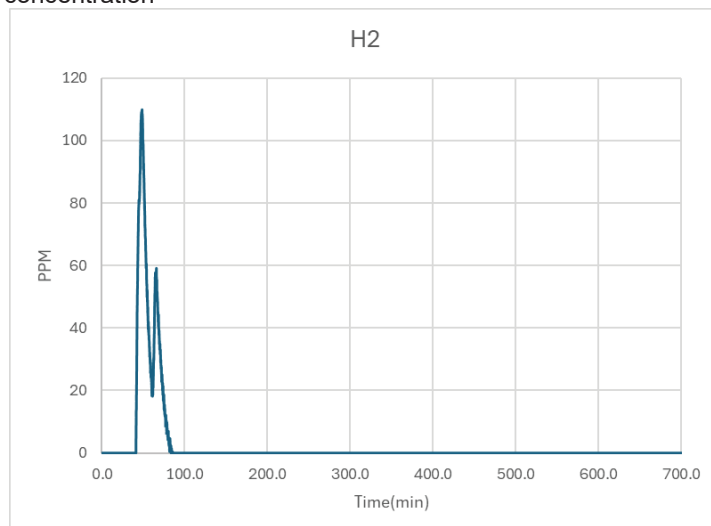


Figure F.3. Hydrogen concentration



Attachment F Flammable gas generation and composition data

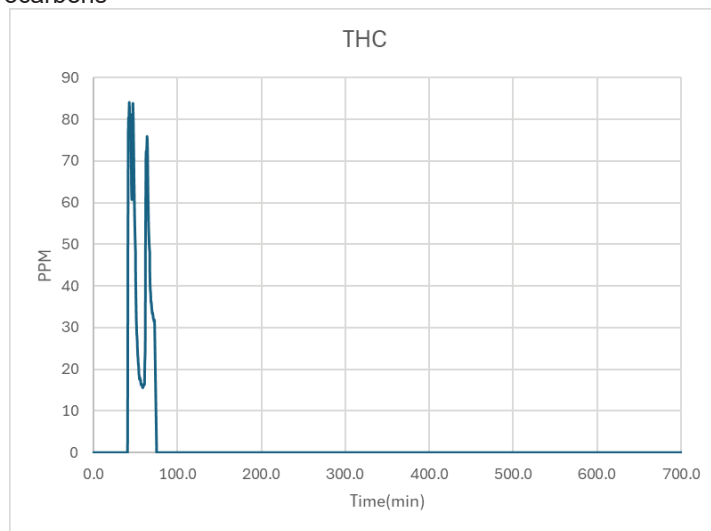
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Page 3 of 3



Report No.: CN2540H0 002

Figure F.4. Total Hydrocarbons



--- End of the attachment ---

Figure G.1. Before the test



Figure G.2. Before the test



Figure G.3. Before the test

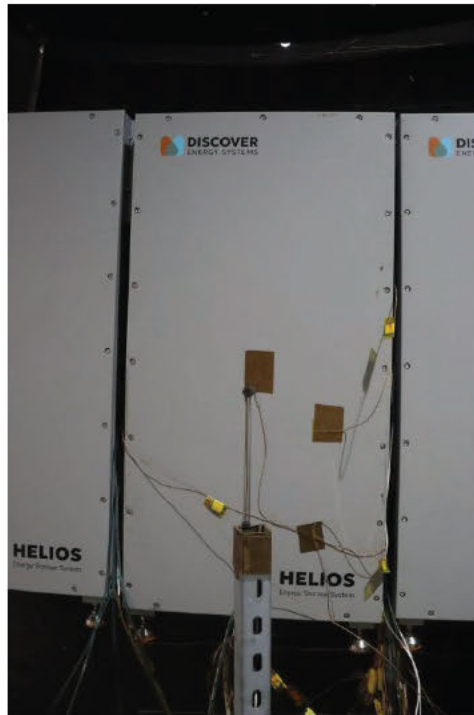


Figure G.4. Before the test



Figure G.5. Before the test



Figure G.6. Before the test

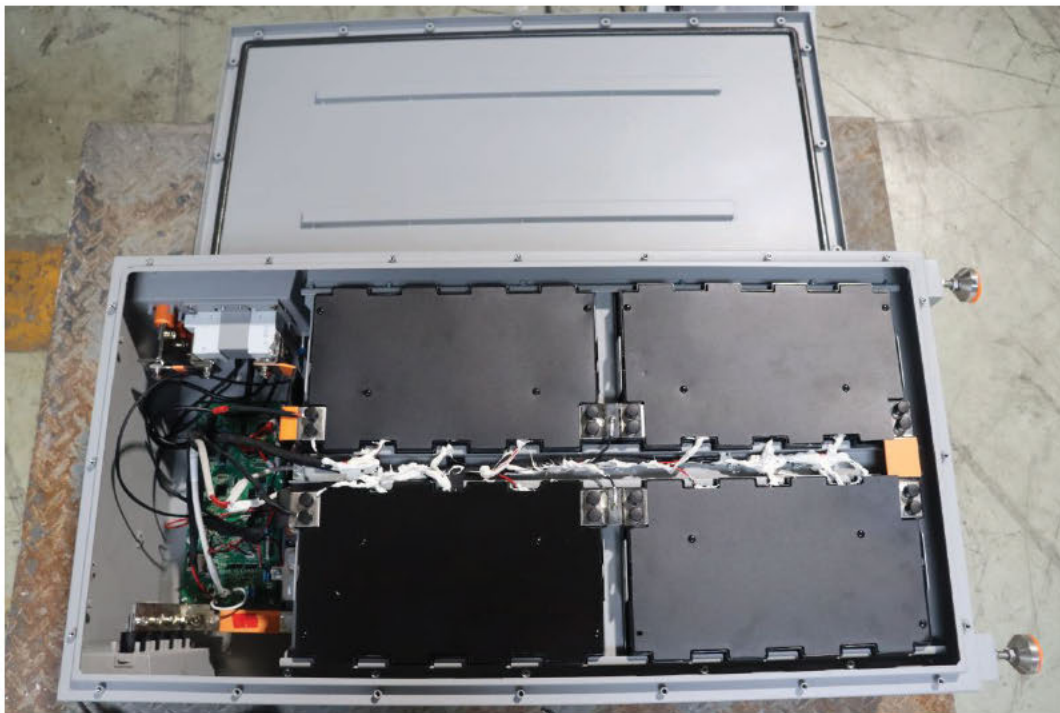


Figure G.7. Before the test



Figure G.8. During the test



Figure G.9. During the test



Figure G.10. After the test

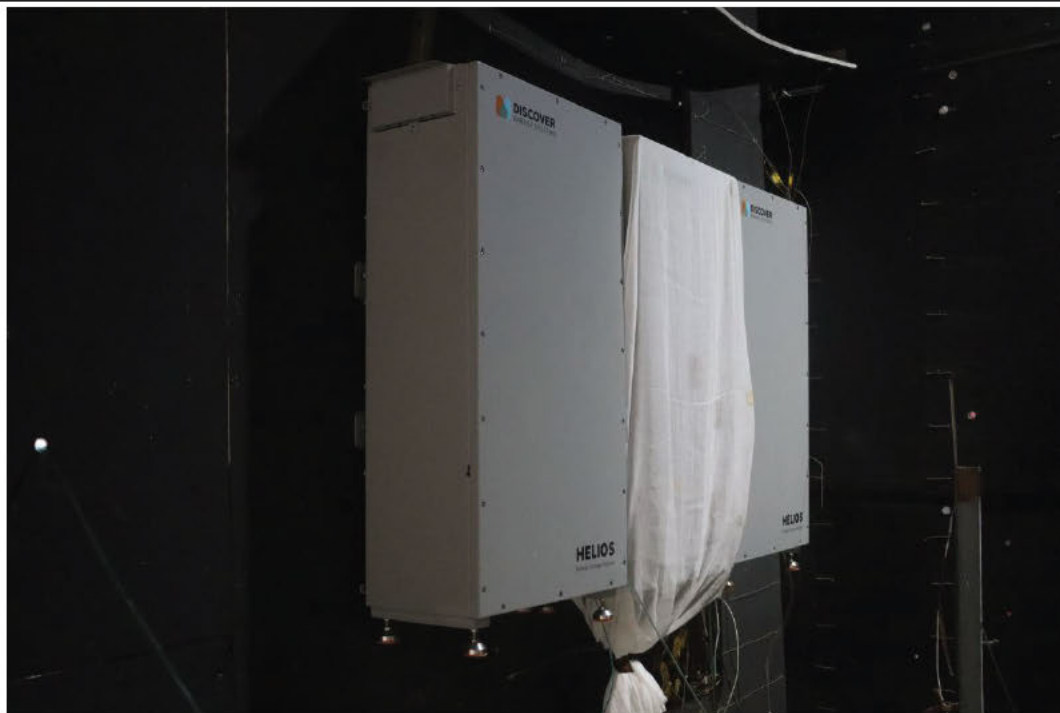


Figure G.11. After the test



Figure G.12. After the test



Figure G.13. After the test



Figure G.14. After the test



Figure G.15. After the test

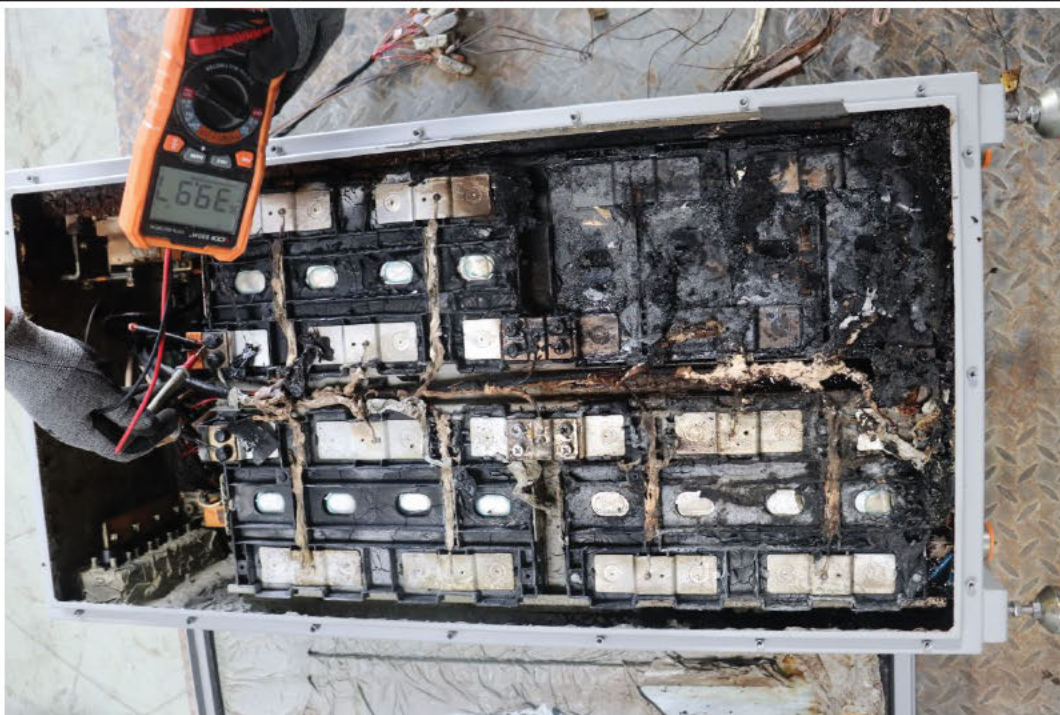


Figure G.16. After the test



--- End of the attachment ---