




TEST REPORT ANSI/CAN/UL 9540A:2019 Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems on Unit Level	
Report Number.....:	64.280.20.60401.01
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Name of Testing Laboratory preparing the Report.....:	TÜV SÜD New Energy Testing (Guangdong) Co., Ltd.
Applicant's name.....:	Huawei Technologies Co., Ltd.
Address	Administration Building, Headquarters of Huawei Technologies Co., Ltd., Bantian, Longgang District, 518129 Shenzhen, PEOPLE'S REPUBLIC OF CHINA
Test specification:	
Standard	ANSI/CAN/UL 9540A:2019
Test procedure	Test report
Non-standard test method	N/A
Test Report Form No.....:	ANSI/CAN/UL 9540A:2019 Rev 0
Test Report Form(s) Originator	TUV SUD Product Service
Master TRF	Dated 2021-01-01
<p>This test report is based on the content of the standard (see above). The test report considered selected clauses of the a.m. standard(s) and experience gained with product testing. It was prepared by TUV SUD Product Service.</p> <p>TUV SUD Group takes no responsibility for and will not assume liability for damages resulting from the reader's interpretation of the reproduced material due to its placement and context.</p>	
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Test item description	Rechargeable Lithium Ion Battery (Energy Storage Battery Rack)
Trade Mark.....	 HUAWEI
Manufacturer	Same as the applicant
Model/Type reference.....	LUNA2000
Ratings.....	1075.2Vd.c., 320Ah

Responsible Testing Laboratory (as applicable), testing procedure and testing location(s):

Testing Laboratory.....	TÜV SÜD New Energy Testing (Guangdong) Co., Ltd.
Testing location/ address	North-1/F, 2/F & Unit 301-3/F, TÜV SÜD Testing Center, D1, No. 63 Chuangqi Road, Shilou Town, Panyu District, Guangzhou 511447, China
Tested by (name, function, signature).....	<div> Ryan Jin (Project Handler)  </div>
Approved by (name, function, signature)....	<div> Harry Zhang (Designated Reviewer)  </div>

Summary of testing:


Summary of unit level testing:	
Unit model name	LUNA2000
Ratings	1075.2Vd.c., 320Ah
Whether UL 1973 compliant	No
Number of modules in the initiating BESS unit	See Attachment 1
The construction of the initiating BESS unit per 5.3	See Attachment 1
Fire protection features/detection/suppression systems within unit	No
Module voltage(s) corresponding to the tested SOC	See Table 1
The thermal runaway initiation method used	Heating the cell with externally applied flexible film heaters that cover two wider side surfaces of the cell
Location of the initiating module within the BESS unit	See Attachment 4
Diagram and dimensions of the test setup including mounting location of the initiating and target BESS units, and the locations of walls, ceilings, and soffits	See Attachment 4
Observation of any flaming outside the initiating BESS enclosure and the maximum flame extension	No flaming outside the initiating BESS enclosure
Chemical and convective heat release rate versus time data	See Attachment 8, 10

Separation distances from the initiating BESS unit to target walls (e. g. distances A and C in Figure 9.1)	See Attachment 4
Separation distances from the initiating BESS unit to target BESS units (e.g. distances D and H in Figure 9.1);	Attachment 4
The maximum wall surface and target BESS temperatures achieved during the test and the location of the measuring thermocouple	See Table 3 and Attachment 4 and 6
The maximum ceiling or soffit surface temperatures achieved during the indoor or outdoor wall mounted test and the location of the measuring thermocouple	N/A
The maximum incident heat flux on target wall surfaces and target BESS units	0 kW/m ²
The maximum incident heat flux on target ceiling or soffit surfaces achieved during the indoor or outdoor wall mounted test	N/A
Gas generation and composition data	See Table 2 and Attachment 7
Peak smoke release rate and total smoke release data	See Attachment 9, 10
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 systems
Observation of flying debris or explosive discharge of gases	No
Observation of re-ignition(s) from thermal runaway events	N/A (no fire during test)
Observation(s) of sparks, electrical arcs, or other electrical events	No
Observations of the damage to: 1) The initiating BESS unit; 2) Target BESS units; 3) Adjacent walls, ceilings, or soffits;	1) the initiating cell and another 2 cells thermal runaway in the initiating module; 2) No damage to neighbour modules; 3) No damage to adjacent walls, ceilings, or soffits; see Attachment 5
Performance at unit level testing:	
a) Flaming outside the initiating BESS unit is not observed;	No flaming during test
b) 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 7.3.1.8;	Yes. The maximum temperature of target modules adjacent to the initiating module is 138.5°C
c) 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 per 9.2.15;	The maximum temperature of wall surface is 23.8°C
d) 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; and	Yes



e) Heat flux in the center of the accessible means of egress ²⁾ shall not exceed 1.3 kW/m ² .	0 kW/m ²
Performance - module level test: (please see module level report 64.280.20.60400.01 for more details)	
a) Thermal runaway is contained by module design; and	Yes
b) Cell vent gas is nonflammable as determined by the cell level test.	No
Performance - cell level test: (please see cell level report 64.280.20.60309.01 for more details)	
a) Thermal runaway cannot be induced in the cell; and	No
b) The cell vent gas does not present a flammability hazard when mixed with any volume of air, as determined in accordance with ASTM E918 at both ambient and vent temperatures.	No

Tests performed (name of test and test clause): Clause 9.1, 9.2 was performed.	Testing location: TÜV SÜD New Energy Testing (Guangdong) Co., Ltd. Address: North-1/F, 2/F & Unit 301-3/F, TÜV SÜD Testing Center, D1, No. 63 Chuangqi Road, Shilou Town, Panyu District, Guangzhou 511447, China
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Copy of marking plate:



型号Model: LUNA2000
储能电池簇 Energy Storage Battery Rack
额定电压Nominal Voltage: ~ 1075.2V
充放电电流 Charging/Discharging Current: ~ 320 A Max
额定容量 Rated Capacity: 320Ah
标称能量 Nominal Energy Capacity: 344 kWh
可充式锂离子电池 Rechargeable Lithium Ion Battery
工作温度范围 Operating Temperature Range: - 20 ~ + 55 °C
注意 Caution: 禁止拆卸 Do not Disassemble the Battery
禁止靠近火源 Keep the Battery away from Fire



华为技术有限公司
HUAWEI TECHNOLOGIES CO., LTD.
HQ of Huawei, Bantian, Longgang District, Shenzhen
518129, P.R.C

MADE IN CHINA

Picture of the product:



Test item particulars..... :
Classification of installation and use..... :
Supply Connection..... :
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: 2021-11-16 Date (s) of performance of tests.....: 2021-11-18 to 2021-11-22
General remarks:
<p>"(See Enclosure #)" refers to additional information appended to the report. "(See appended table)" refers to a table appended to the report.</p> <p>Throughout this report a <input type="checkbox"/> comma / <input checked="" type="checkbox"/> point is used as the decimal separator.</p> <p>List of Attachments:</p> <p>Attachment 1: Product description Attachment 2: Exploding drawing of module & Identification/location of cells within the module Attachment 3: Pre-conditioning profile Attachment 4: Photo for sample before test and test setup with thermocouple location Attachment 5: Photo for sample after test Attachment 6: Monitored temperature chart Attachment 7: Flammable gas generation and composition data chart Attachment 8: Heat release rate versus time data chart Attachment 9: Peak smoke release rate and total smoke release data chart Attachment 10: Summary of Heat release rate & Peak smoke release rate and total smoke release data</p>
Name and address of factory (ies).....: 1) Sunwoda Huizhou New Energy Co., Ltd. Sunwoda Industrial Park, Dongpo Avenue, Yuanzhou Town, Boluo County, 516123 Huizhou City, Guangdong Province, PEOPLE'S REPUBLIC OF CHINA 2) Dongguan Yang Tian Electronic Technology Co., Ltd. (i-Brights) No.152, Luyuan Rd., Keyuancheng, Tangxia Town, 523710 Dongguan City, Guangdong Province, PEOPLE'S REPUBLIC OF CHINA

General product information:

Product name	Rechargeable Lithium Ion Battery (Energy Storage Battery Rack)
Type/model	LUNA2000
Nominal voltage	1075.2Vd.c.
Rated capacity	320Ah (rated energy: 344kWh)
Charging voltage specified by manufacturer	1226.4V
Upper limit charging voltage	1226.4V
Charging current specified by manufacturer	160A
Maximum continuous charging current	320A
Discharging current specified by manufacturer	160A
Maximum continuous discharging current	320A
End of discharge voltage	840V or any cell reaches 2.5V
Standard temperature range for charging	0°C to 55°C
Standard temperature range for discharging	-20°C to 55°C
Standard charging method specified by manufacturer	Charge at constant current 160A until voltage reaches 1209.6V then charge at constant current 10A till charge voltage reaches 1209.6V, or any cell reaches 3.6V.
Standard discharging method specified by manufacturer	Discharge at constant current 160A until voltage reaches 840V or any cell reaches 2.5V
Dimension	WxDxH: 1625mmx787.5mmx2475mm
Weight	3195kg
Configuration	(16S)21S



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Clause	Requirement + Test	Result - Remark	Verdict
CONSTRUCTION			
5.	General		P
5.1	Cell		P
5.1.1	The cells associated with the BESS that were tested shall be documented in the test report, including cell chemistry (e.g. NMC, LFP), the physical format of the cell (i.e. prismatic, cylindrical, pouch), cell electrical rating in capacity and nominal voltage, the overall dimensions of the cell, and weight.		P
5.1.2	The cell documentation included in the test report shall indicate if the cells associated with the BESS comply with UL 1973.	Not UL 1973 compliant	P
5.1.3	Refer to 7.6.1 for further details to be included in the cell level test report		P
5.2	Module		P
5.2.1	The modules associated with the BESS that were tested shall be documented in the test report, including the generic (e. g., metallic or nonmetallic) enclosure material, the general layout of the module contents and the electrical configuration of the cells in the modules and the modules in the BESS.	Metallic enclosure	P
5.2.2	The module documentation included in the test report shall indicate if the modules associated with the BESS comply with UL 1973.	Not UL 1973 compliant	P
5.2.3	Refer to 8.3 for further details to be included in the module level test report.		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 and include the manufacturer, model, electrical ratings, and energy capacity of all BESS.		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. The BESS enclosure overall dimensions and generic (e. g., metallic or nonmetallic) material used for	Not UL 1973 compliant for the battery system	P



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Clause	Requirement + Test	Result - Remark	Verdict
	the enclosure shall be documented. Depending upon the configuration of the BESS (e.g. the power conditioning system is external to the BESS enclosure), a battery system(s) can be tested as representative 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.		
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.	No fire detection and suppression systems in the battery systems	N/A
5.3.4	Refer to 9.7, 10.4 and 10.7 for further details to be included in the unit level and if applicable, installation level test reports.		P
5.4	Flow Batteries		N/A
5.4.1	For flow batteries, the report will cover the chemistry (e.g. vanadium redox, zinc bromine, etc.), a generic description of the electrolyte (s), the overall dimensions of the individual stack as well as the electrical rating in capacity and nominal voltage of the cell stack. The report will also include information on the complete flow battery system including the manufacturer's name and model number of the system, the electrical rating in volts and rated storage capacity in Ah or Wh, the number of cells and stacks in the system, and the maximum volume of electrolyte(s) for the system.		N/A
5.4.2	The flow battery documentation included in the test report shall indicate if the flow battery system complies with UL 1973.		N/A
5.4.3	See 7.6.2 for further details to be included in the flow battery thermal runaway determination level test report.		N/A
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. See Annex B for recommended testing practices.		P



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Clause	Requirement + Test	Result - Remark	Verdict
6.2	At the conclusion of testing, samples shall be discharged in accordance with the manufacturer's specifications. All samples shall be disposed of in accordance with local regulations.		P
9	Unit Level		P
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 include the following:		P
	a) Indoor floor mounted non-residential use BESS;	The battery system is regarded as indoor floor mounted non-residential use	P
	b) Indoor floor mounted residential use BESS;		N/A
	c) Outdoor ground mounted non-residential use BESS;		N/A
	d) Outdoor ground mounted residential use BESS;		N/A
	e) Indoor wall mounted non-residential use BESS;		N/A
	f) Indoor wall mounted residential use BESS;		N/A
	g) Outdoor wall mounted non-residential use BESS;		N/A
	h) Outdoor wall mounted residential use BESS; and		N/A
	i) Rooftop and open garage non-residential use BESS installations.		N/A
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. Tests conducted for indoor floor mounted installations shall be considered representative of both indoor floor mounted and outdoor ground mounted installations with fire propagation hazards and separation distances between initiating and target units representative of the installation. Tests shall be conducted indoors with fire propagation hazards and separation distances between initiating and target units representative of the installation. The results of such tests shall be considered to also represent an outdoor installation. Examples of potential test configurations are shown in	See Attachment 4	P



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Clause	Requirement + Test	Result - Remark	Verdict
	Figure 9.1, Figure 9.2, Figure 9.3, and Figure 9.4.		
	<p><i>Exception: Testing can be conducted outdoors for outdoor only installations if there are the following controls and environmental conditions in place:</i></p> <p><i>a) Wind screens are utilized with a maximum wind speed maintained at ≤ 12 mph;</i></p> <p><i>b) The temperature range is within 10°C to 40°C (50°F to 104°F);</i></p> <p><i>c) The humidity is < 90% RH;</i></p> <p><i>d) There is sufficient light to observe the testing;</i></p> <p><i>e) There is no precipitation during the testing;</i></p> <p><i>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</i></p> <p><i>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.</i></p>		N/A
9.1.3	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. 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
9.1.4	The initiating BESS unit shall contain components representative of a BESS unit in a complete installation. Combustible components that interconnect the initiating and target BESS units shall be included.		P
9.1.5	Target BESS units shall include the outer cabinet (if part of the design), racking, module enclosures, and components that retain cells components. The target BESS unit module enclosures do not need to contain cells.		P
9.1.6	The initiating BESS unit shall be at the maximum operating state of charge (MOSOC), in accordance with the manufacturer's specifications, for conducting the tests in this standard. After charging and prior to testing, the initiating BESS shall rest for a maximum period of 8 h at room ambient.	For initiating module (module 7): Charging method: Charge at constant current 160A until voltage reaches 56.4V, then charge at constant voltage 56.4V till charge current is 6.4A;	P



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Clause	Requirement + Test	Result - Remark	Verdict
		<p>Discharge method: Discharge at constant current 160A until voltage reaches 43.2V.</p> <p>For target modules (module 2, 6, 8, 12)</p> <p>Charging method: Charge at constant current 160A until voltage reaches 56V, then charge at constant voltage 56V till charge current is 64A or charged capacity reaches 310Ah;</p> <p>Discharge method: Discharge at constant current 160A until voltage reaches 43.2V.</p>	
9.1.7	If a BESS unit includes an integral fire suppression system, there is an option of providing this with the DUT. If the BESS unit is provided with an optional integral fire suppression system, the system shall not be provided on the DUT.	No fire detection and suppression systems in the battery systems	N/A
9.1.8	Electronics and software controls such as the battery management system (BMS) in the BESS are not relied upon for this testing. This does not include a fire suppression control in accordance with UL 840 that is external to the BESS, but provided as part of an integral fire suppression system per 9.1.7.		N/A
9.2	Test method – Indoor floor mounted BESS units		P
9.2.1	Samples and test configurations are in accordance with 9.1. During the test, the test room environment shall be controlled to prevent drafts that may affect test results. 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).		P
9.2.2	Any access door(s) or panels on the initiating BESS unit and adjacent target BESS units shall be closed, latched and locked at the beginning and duration of the test.		N/A
9.2.3	The initiating BESS unit shall be positioned adjacent to two instrumented wall sections.		P
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-ft) taller than the BESS unit height,		P



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	but not less than 3.66 m (12 ft) in height above the bottom surface of the unit.		
9.2.6	The surface of the instrumented wall sections shall be covered with 16-mm (5/8-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
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, and the smoke release rate shall be calculated as described in 8.2.15.		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 using an atomized heptane diffusion burner. The calibration shall be performed using flows of 3.8, 7.6, 11.4 and 15.2 L/min (1, 2, 3 and 4 gpm) of heptane.		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. See 9.2.12.		P
9.2.12	With reference to 9.2.9, the convective heat release rate shall be calculated using the following equation: $HRR_c = V_e A \frac{353.22}{T_e} \int_{T_o}^T C_p dT$		P
9.2.13	The physical spacing between BESS units (both initiating and target) and adjacent walls shall be representative of the intended installation as noted in 9.1.	See Attachment 4	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		P
	b) Adjacent BESS units.		P
9.2.15	Wall surface temperature measurements shall be collected for BESS intended for installation in locations with combustible construction. If the intended installation is composed completely of noncombustible construction in		P



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Clause	Requirement + Test	Result - Remark	Verdict
	which wall assemblies, cables, wiring and any other combustible materials are not to be present in the BESS installation, then the report should note that the installation shall contain no combustible construction and that surface temperature rises can be deemed not applicable.		
9.2.16	Wall surface temperatures shall be 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. 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
9.2.17	Thermocouples shall be secured to gypsum surfaces by the use of staples placed over the insulated portion of the wires. The thermocouple tip shall be 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
9.2.18	Heat flux shall be measured with the sensing element of at least two water-cooled Schmidt-Boelter gauges at the surface of each instrumented wall: 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.		P
9.2.19	Heat flux shall be measured with the sensing element of at least two water-cooled Schmidt-Boelter gauges at the surface of each adjacent target BESS unit that faces the initiating BESS unit: 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		P



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Clause	Requirement + Test	Result - Remark	Verdict
	flux due to the thermal runaway of the initiating BESS.		
9.2.20	For non-residential use BESS, heat flux shall be measured with the sensing element of at least one water-cooled Schmidt-Boelter gauge positioned at the mid height of the initiating unit in the center of the accessible means of egress.		P
9.2.21	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. 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. Additional thermocouples shall be placed to account for convoluted enclosure interior geometries.		P
9.2.22	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.		N/A
9.2.23	An internal fire condition in accordance with the module level test shall be created 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
9.2.24	The composition, velocity and temperature of the initiating BESS unit vent gases shall be measured within the calorimeter's exhaust duct. 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 2.0 m (6.6 ft), or equivalent gas analyzer. Composition, velocity and temperature instrumentation shall be collocated with heat release rate calorimetry instrumentation.		P



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9.2.25	The hydrocarbon content of the vent gas shall be measured using flame ionization detection.		P
9.2.26	The test shall be terminated if:		P
	a) Temperatures measured inside each module within the initiating BESS unit return to ambient temperature;		P
	b) The fire propagates to adjacent units or to adjacent walls; or		N/A
	c) A condition hazardous to test staff or the test facility requires mitigation.		N/A
9.2.27	For residential use systems, the gas collection data gathered 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.		N/A
9.3	Test method – Outdoor ground mounted units		N/A
9.3.1	Outdoor ground mounted non-residential use BESS being evaluated for installation in close proximity to buildings and structures shall use the test method described in Section 9.2. 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
9.3.2	Outdoor ground mounted residential use BESS being evaluated for installation in close proximity to buildings and structures shall use the test method described in Section 9.2 except as noted in 9.3.3 and 9.3.4. Heat flux measurements for the accessible means of egress shall be measured in accordance with 9.2.20. 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-ft) tall with a 0.3-m (1-ft) wide horizontal soffit (undersurface of the eave shown in Figure 9.2). 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. The wall and soffit shall be constructed with 19.05-mm (3/4-in)		N/A



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	plywood installed on wood studs and painted flat black. The instrumented wall shall extend not less than 0.49-m (1.6-ft) 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 9.2.16 shall extend to the surface of the soffit as shown in Figure 9.2.		
	<i>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.</i>		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		N/A
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.		N/A
9.4.2	The test shall be conducted in a standard NFPA 286 fire test room, 3.66 × 2.44 × 2.44-m (12 × 8 × 8-ft) high, with a 0.76 × 2.13-m (2-1/2 × 7-ft) high opening. The room shall be constructed with 16-mm (5/8-in) gypsum wall board installed on wood studs and painted flat black.		N/A
9.4.3	The initiating BESS unit shall be positioned on the wall opposite of the door opening, with the center located 1.22-m (4-ft) above the floor, and halfway between adjacent walls.		N/A
9.4.4	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.		N/A
9.4.5	The wall on which the initiating and target BESS units are mounted shall be instrumented in accordance with Section 9.2.		N/A
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		N/A



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Clause	Requirement + Test	Result - Remark	Verdict
	determine if the flammable gas collected exceeds 25% LFL in air.		
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 m2/kg with a count of 28 – 32 threads in either direction within a 6.45 cm2 (1 in2) area.		N/A
9.5	Test Method – Outdoor wall mounted units		N/A
9.5.1	Testing of outdoor wall mounted BESS shall be in accordance with Section 9.2, except as modified in this section. See Figure 9.4. 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.		N/A
9.5.2	Test samples shall be mounted on an instrumented wall section that is 3.66-m (12-ft) tall with a 0.3-m (1-ft) wide horizontal soffit (undersurface of the eave shown in Figure 9.4). The wall and soffit shall be constructed with 19.05-mm (3/4-in) plywood installed on wood studs and painted flat black. The instrumented wall shall extend not less than 0.49-m (1.6-ft) 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 9.2.16 shall extend to the surface of the soffit as shown in Figure 9.4.		N/A
9.5.3	The initiating BESS unit shall be positioned on the instrumented wall, with its center located 1.22-m (4-ft) above the floor, and halfway between wall edges.		N/A
9.5.4	Target BESS 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.		N/A
9.5.5	The wall on which the initiating and target BESS units are mounted shall be instrumented in accordance with Section 9.2.		N/A
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 m2/kg		N/A



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Clause	Requirement + Test	Result - Remark	Verdict
	with a count of 28 – 32 threads in either direction within a 6.45 cm ² (1 in ²) area .		
9.6	Rooftop and open garage installations		N/A
9.6.1	Testing of BESS intended for non-residential use rooftop or open garage installations shall be in accordance with 9.2.		N/A
9.6.2	If intended for rooftop and open 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
9.7	Unit level test report		P
9.7.1	The report on the unit level testing shall identify the type of installation being tested, as follows:		P
	a) Indoor floor mounted non-residential use BESS;		P
	b) Indoor floor mounted residential use BESS;		N/A
	c) Outdoor ground mounted non-residential use BESS;		N/A
	d) Outdoor ground mounted residential use BESS;		N/A
	e) Indoor wall mounted non-residential use BESS;		N/A
	f) Indoor wall mounted residential use BESS;		N/A
	g) Outdoor wall mounted non-residential use BESS;		N/A
	h) Outdoor wall mounted residential use BESS;		N/A
	i) Rooftop installed non-residential use BESS; or		N/A
	j) Open garage installed non-residential use BESS.		N/A
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);	Unit manufacturer name: Huawei Technologies Co., Ltd. Model number: LUNA2000 Not UL 1973 compliant	P
	b) Number of modules in the initiating BESS unit;	21 modules	P
	c) The construction of the initiating BESS unit per 5.3;	See Attachment 1	P



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Clause	Requirement + Test	Result - Remark	Verdict
	d) Fire protection features / detection / suppression systems within unit;		N/A
	e) Module voltage(s) corresponding to the tested SOC;	See Table 1	P
	f) The thermal runaway initiation method used;	See Table 1	P
	g) Location of the initiating module within the BESS unit;	See Attachment 4	P
	h) Diagram and dimensions of the test setup including mounting location of the initiating and target BESS units, and the locations of walls, ceilings, and soffits;	See Attachment 4	P
	i) Observation of any flaming outside the initiating BESS enclosure and the maximum flame extension;	No flaming during the test	P
	j) Chemical and convective heat release rate versus time data;	See Attachment 8, 10	P
	k) Separation distances from the initiating BESS unit to target walls (e. g. distances A and C in Figure 9.1);	See Attachment 4	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 4	P
	m) The maximum wall surface and target BESS temperatures achieved during the test and the location of the measuring thermocouple;	See Table 3 and Attachment 4 and 6	P
	n) The maximum ceiling or soffit surface temperatures achieved during the indoor or outdoor wall mounted test and the location of the measuring thermocouple;		N/A
	o) The maximum incident heat flux on target wall surfaces and target BESS units;	0 kW/m ²	P
	p) The maximum incident heat flux on target ceiling or soffit surfaces achieved during the indoor or outdoor wall mounted test;		N/A
	q) Gas generation and composition data;	See Table 2 and Attachment 7	P
	r) Peak smoke release rate and total smoke release data;	See Attachment 9, 10	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 systems	N/A
	t) Observation of flying debris or explosive discharge of gases;	No	P
	u) Observation of re-ignition(s) from thermal runaway events;	N/A (no fire during test)	P
	v) Observation(s) of sparks, electrical arcs, or other electrical events;	No	P
	w) Observations of the damage to: 1) The initiating BESS unit;		P



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Clause	Requirement + Test	Result - Remark	Verdict
	2) Target BESS units; 3) Adjacent walls, ceilings, or soffits; and		
	x) Photos and video of the test.		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.		P
Table 9.1	Unit Level Performance Criteria		P
	Non-Residential Installations: Indoor Floor Mounted		P
	a) Flaming outside the initiating BESS unit is not observed;	No flaming during test	P
	b) 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 7.3.1.8;	Yes. The maximum temperature of target modules adjacent to the initiating module is 138.5°C	P
	c) 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 per 9.2.15;	The maximum temperature of wall surface is 23.8 °C	P
	d) 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; and	Yes	P
	e) Heat flux in the center of the accessible means of egress ²⁾ shall not exceed 1.3 kW/m ² .	0 kW/m ²	P
	Non-Residential Installations: Outdoor Ground Mounted		N/A
	a) If flaming outside of the unit is observed, separation distances to exposures shall be determined by greatest flame extension observed during test.		N/A
	b) 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 7.3.1.8;		N/A
	c) 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 per 9.2.15;		N/A
	d) Explosion hazards are not observed, including deflagration, detonation or		N/A



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Clause	Requirement + Test	Result - Remark	Verdict
	accumulation (to within the flammability limits in an amount that can cause a deflagration) of battery vent gases; and		
	e) Heat flux in the center of the accessible means of egress ²⁾ shall not exceed 1.3 kW/m ² .		N/A
	Non-Residential Installations: Indoor Wall Mounted		N/A
	a) Flaming outside the initiating BESS unit is not observed;		N/A
	b) 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 7.3.1.8;		N/A
	c) For BESS units intended for installation in locations with combustible construction, surface temperature measurements on wall surfaces do not exceed 97°C (175°F) of temperature rise above ambient per 9.2.15;		N/A
	d) 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; and		N/A
	e) Heat flux in the center of the accessible means of egress ²⁾ shall not exceed 1.3 kW/m ² .		N/A
	Non-Residential Installations: Outdoor Wall Mounted		N/A
	a) Flaming outside the initiating BESS unit is not observed;		N/A
	b) 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 7.3.1.8;		N/A
	c) For BESS units intended for installation on walls with combustible construction, surface temperature measurements on wall surfaces do not exceed 97°C (175°F) of temperature rise above ambient per 9.2.15;		N/A
	d) 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; and		N/A
	e) Heat flux in the center of the accessible means of egress ²⁾ shall not exceed 1.3 kW/m ² .		N/A
	Non-Residential Installations:		N/A



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Clause	Requirement + Test	Result - Remark	Verdict
	Rooftop and Open Garages		
	a) If flaming outside the unit is observed, separation distances to exposures shall be determined by greatest flame extension observed during test;		N/A
	b) 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 7.3.1.8;		N/A
	c) For BESS units intended for installation in locations with combustible construction, surface temperature measurements on wall surfaces do not exceed 97°C (175°F) of temperature rise above ambient per 9.2.15;		N/A
	d) 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; and		N/A
	e) Heat flux in the center of the accessible means of egress ²⁾ shall not exceed 1.3 kW/m ² .		N/A
	Residential Installations: Indoor Floor Mounted		N/A
	a) Flaming outside the initiating BESS unit is not observed as demonstrated by no flaming or charring of the cheesecloth indicator;		N/A
	b) 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 7.3.1.8;		N/A
	c) For BESS units intended for installation in locations with combustible construction, surface temperature measurements on wall surfaces do not exceed 97°C (175°F) of temperature rise above ambient per 9.2.15;		N/A
	d) 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; and		N/A
	e) The concentration of flammable gas does not exceed 25% LFL in air for the smallest specified room installation size.		N/A
	Residential Installations: Outdoor Ground Mounted		N/A
	a) If flaming outside the unit is observed, separation distances to exposures shall be		N/A



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Clause	Requirement + Test	Result - Remark	Verdict
	determined by greatest flame extension observed during test.		
	b) 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 7.3.1.8;		N/A
	c) For BESS units intended for near exposures, surface temperature measurements on wall surfaces do not exceed 97°C (175°F) of temperature rise above ambient per 9.2.15;		N/A
	d) 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; and		N/A
	e) Heat flux in the center of the accessible means of egress ²⁾ shall not exceed 1.3 kW/m ² .		N/A
	Residential Installations: Indoor Wall Mounted		N/A
	a) Flaming outside the initiating BESS unit is not observed as demonstrated by no flaming or charring of the cheesecloth indicator;		N/A
	b) 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 7.3.1.8;		N/A
	c) For BESS units intended for installation in locations with combustible construction, surface temperature measurements on wall surfaces do not exceed 97°C (175°F) of temperature rise above ambient per 9.2.15;		N/A
	d) 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; and		N/A
	e) The concentration of flammable gas does not exceed 25% LFL for the smallest intended room installation size.		N/A
	Residential Installations: Outdoor Wall Mounted		N/A
	a) Flaming outside the initiating BESS unit is not observed as demonstrated by no flaming or charring of the cheesecloth indicator;		N/A
	b) Surface temperatures of modules within the target BESS units adjacent to the initiating BESS unit do not exceed the temperature at		N/A

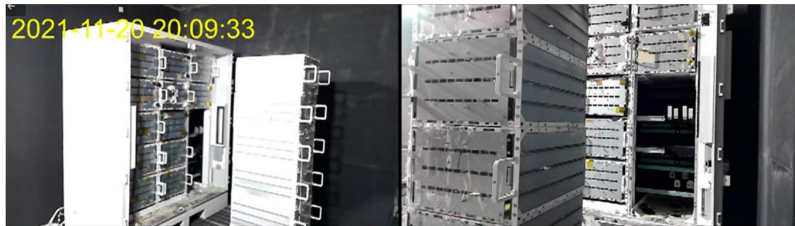
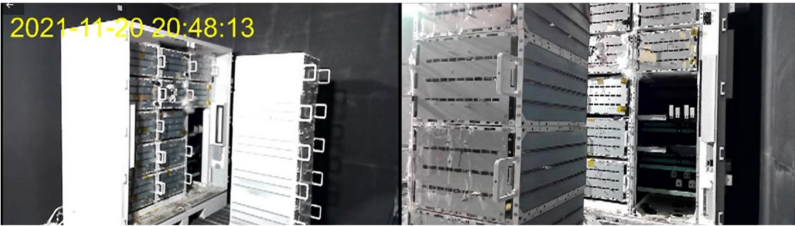

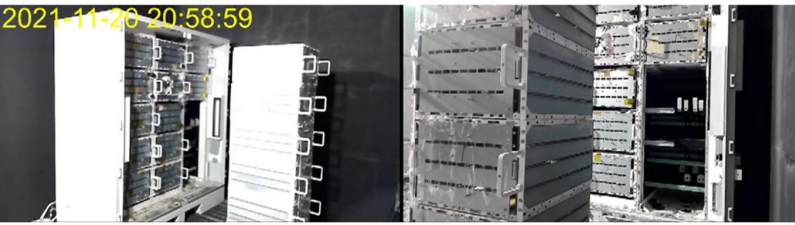


ANSI/CAN/UL 9540A:2019			
Clause	Requirement + Test	Result - Remark	Verdict
	which thermally initiated cell venting occurs, as determined in 7.3.1.8;		
	c) For BESS units intended for installation in locations with combustible construction, surface temperature measurements on wall surfaces do not exceed 97°C (175°F) of temperature rise above ambient per 9.2.15; and		N/A
	d) 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.		N/A
ANNEX A	(INFORMATIVE) Test Concepts And Application Of Test Results To Installations		P
A1	Introduction		P
A2	Test Methodology and Purpose		P
A3	Evaluating the Results		P
ANNEX B	(INFORMATIVE) Safety Recommendations for Testing		P
B1	General		P

Test Report ANSI/CAN/UL 9540A:2019

Unit Level Test result:

Table 1: Thermal runaway test result	
Summary of initiating module	
Initial ambient temperature:	22.9 °C
Initial relative humidity:	65%RH
Pre-conditioning time	From 2021-11-19 18:22 to 2021-11-20 12:42
Thermal runaway test start time	2021-11-20 20:09:33
Module voltage before test::	55.16V
Methods used to initiate thermal runaway	Heating the cell with externally applied flexible film heaters that cover two wider side surfaces of the cell
Average heating rate:	5.5 °C/min
Surface temperature at which gases were first vented:	218.5 °C
Time when gases were first vented:	2021-11-20 20:48:13
Surface temperature prior to thermal runaway:	303.2 °C
Time when thermal runaway:	2021-11-20 20:58:59
Module voltage after test:	43.99V
Location of cell(s) for initiating thermal runaway	Cell 7 (see Attachment 2)
Thermal runaway of other cells within module:	Yes (cell 3 and cell 11, see Attachment 2)
Observation(s) of flying debris:	No
Observation(s) of explosive discharge of gas:	No
Observation(s) of sparks, electrical arcs or other electrical events:	No
Locations and visual estimations of flame	No
Module weight before test:	135.10kg
Module weight after test:	130.25kg
Module weight loss:	4.85kg
Summary of other modules	

Status of other modules		Thermal runaway did not propagate to adjacent modules; Module 2, 6, 8, 12 were not affected, and the open-circuit voltages were not changed.
Supplementary information:		N/A
Timeline of thermal runaway		
Time (hh:mm:ss)	Event	Description
2021-11-20 20:09:33	Start testing	
2021-11-20 20:48:13	The initiating cell first vented, smoke was out of module	 
2021-11-20 20:58:59	The initiating cell's temperature started to rise sharply, thermal runaway occurred.	



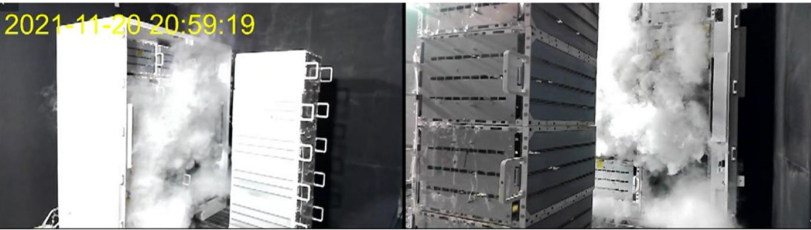
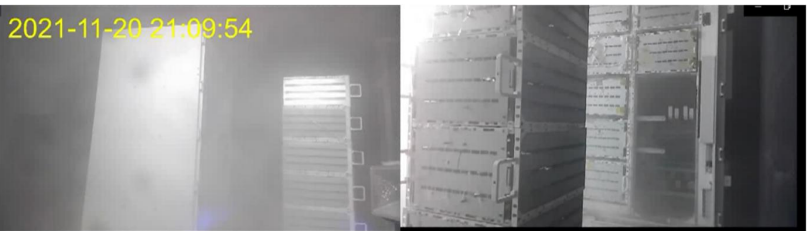

2021-11-20 20:59:19	After the initiating cell thermal runaway, smoke generated continuously	
2021-11-20 21:09:54	Smoke released slowly	
2021-11-20 22:25:23	No smoke released	
Remark: Refer to attachment 4 for details of sample before test and test setup with thermocouple location		



Table 2: Vented gas composition result			
Composition	Chemical formula	Measurement peak (ppm)	Analysis Method
Carbon monoxide	CO	124.0184	FTIR
Carbon dioxide	CO ₂	703.8814	FTIR
Methane	CH ₄	81.1959	FTIR
Acetylene	C ₂ H ₂	5.2179	FTIR
Ethene	C ₂ H ₄	109.8332	FTIR
Ethane	C ₂ H ₆	27.1401	FTIR
Butane	C ₄ H ₁₀	98.2952	FTIR
Pentane	C ₅ H ₁₂	489.3667	FTIR
Benzene	C ₆ H ₆	4.4152	FTIR
Methanal	HCHO	4.1323	FTIR
Hydrofluoric acid	HF	14.4807	FTIR
Hydrogen chloride	HCl	1.0223	FTIR
Hydrogen	H ₂	227.0	Hydrogen sensor
Total Hydrocarbons	(Propane Equivalent)	369.3193	FID
Flow rate in exhaust duct (m ³ /s)		1.6	



Table 3: Monitored temperature result		
Thermocouple location	Measured maximum temperature, °C	Limit, °C
Cell 1	79.8	-
Cell 2	154.6	-
Cell 3	540.1	-
Cell 4	159.7	-
Cell 5	79.6	-
Cell 6	156.5	-
Cell 7_case 1	545.6	-
Cell 7_case 2	536.2	-
Cell 7 positive	299.6	-
Cell 7 vent	430.6	-
Cell 8	166.5	-
Cell 9	73.5	-
Cell 10	132.3	-
Cell 11	550.6	-
Cell 12	153.9	-
Cell 13	64.8	-
Cell 14	82.8	-
Cell 15	216.7	-
Cell 16	94.1	-
Module 1_inside right case	37.1	231.3
Module 2_inside right case	138.5	231.3
Module 2_cell surface	76.0	231.3
Module 2_outer top surface	36.3	231.3
Module 2_outer bottom surface	29.7	231.3
Module 3_inside right case	29.2	231.3
Module 4_inside right case	26.7	231.3
Module 5_inside right case	32.3	231.3
Inside surface of ceiling	36.5	-
Module 6_outer bottom case	52.4	231.3
Module 7_outer top case	64.9	-
Module 7_outer bottom case	143.6	-
Module 8_outer top case	74.1	231.3

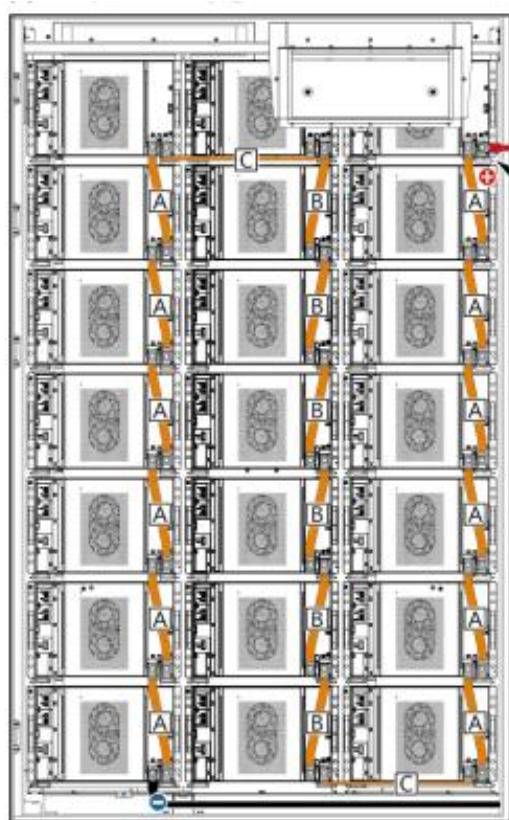


Module 9_ outer top case	25.4	231.3
Module 10_ outer top case	26.5	231.3
Module 11_ inside left case	34.3	231.3
Module 12_ cell surface	55.5	231.3
Module 12_ inside left case	108.9	231.3
Module 12_ outer top case	34.2	231.3
Module 12_ outer bottom case	28.4	231.3
Inside left case near module 8	27.3	231.3
Inside left case near module 9	25.0	231.3
Inside left case near module 10	27.8	231.3
Wall surface 1	23.5	121.0
Wall surface 2	23.5	121.0
Wall surface 3	23.5	121.0
Wall surface 4	23.6	121.0
Wall surface 5	23.6	121.0
Wall surface 6	23.7	121.0
Wall surface 7	23.8	121.0
Wall surface 8	23.7	121.0
Wall surface 9	23.4	121.0
Wall surface 10	23.2	121.0
Wall surface 11	22.8	121.0
Wall surface 12	23.0	121.0
Wall surface 13	22.8	121.0
Wall surface 14	22.9	121.0
Wall surface 15	22.8	121.0
Wall surface 16	23.2	121.0
Wall surface 17	22.8	121.0
Wall surface 18	22.8	121.0
Ambient	24.0	-
Remark: please see Attachment 4 for thermocouple locations and Attachment 6 for monitored temperature charts.		

Attachment 1: Product description

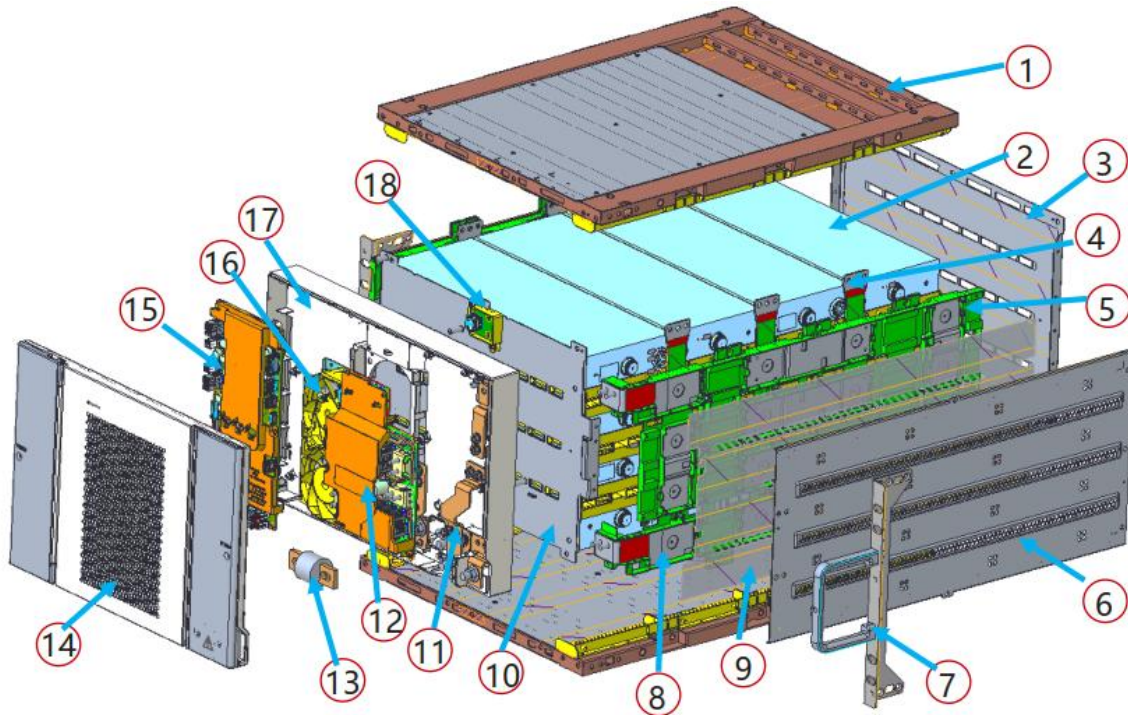
The Rechargeable Lithium Ion Battery (Energy Storage Battery Rack), model No.: LUNA2000 is used in industrial applications, which consists by one DCDC control box and 21pcs battery module with model no. ESM51320AS1.

Below is the view of battery rack, model: LUNA2000, it contains 21 pcs battery modules connected in series. There are 3 columns and each column has 7 pcs modules.



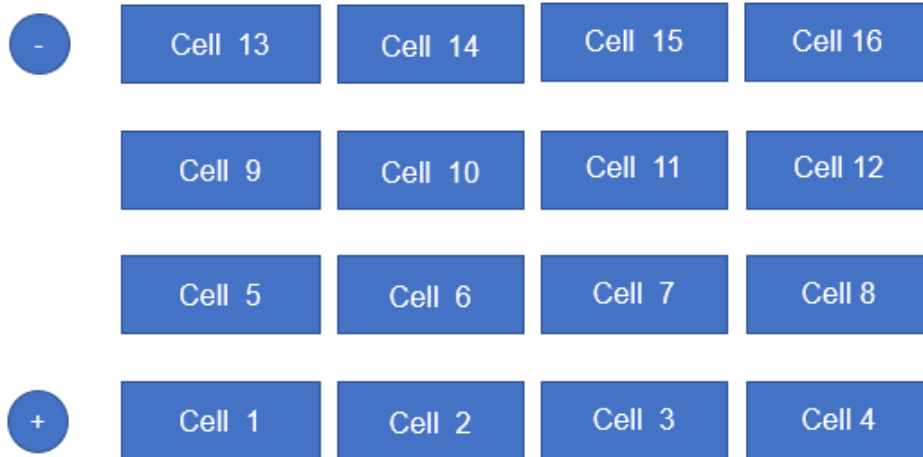
Attachment 2: Exploding drawing of module & Identification/location of cells within the module

Exploding drawing of module, model: ESM51320AS1 as below:



No.	Component	No.	Component
(1)	Top cover	(2)	Battery
(3)	Back cover	(4)	Pull beam
(5)	Plastic bracket	(6)	Side cover
(7)	hanger	(8)	Aluminium busbar
(9)	Epoxy resin	(10)	Front cover
(11)	Copper busbar	(12)	S1S2
(13)	Fuse	(14)	Panel
(15)	BMU	(16)	Fan
(17)	PCB case	(18)	Electroinc label

Identification/location of cells within the module as below:



Attachment 3: Pre-conditioning profile

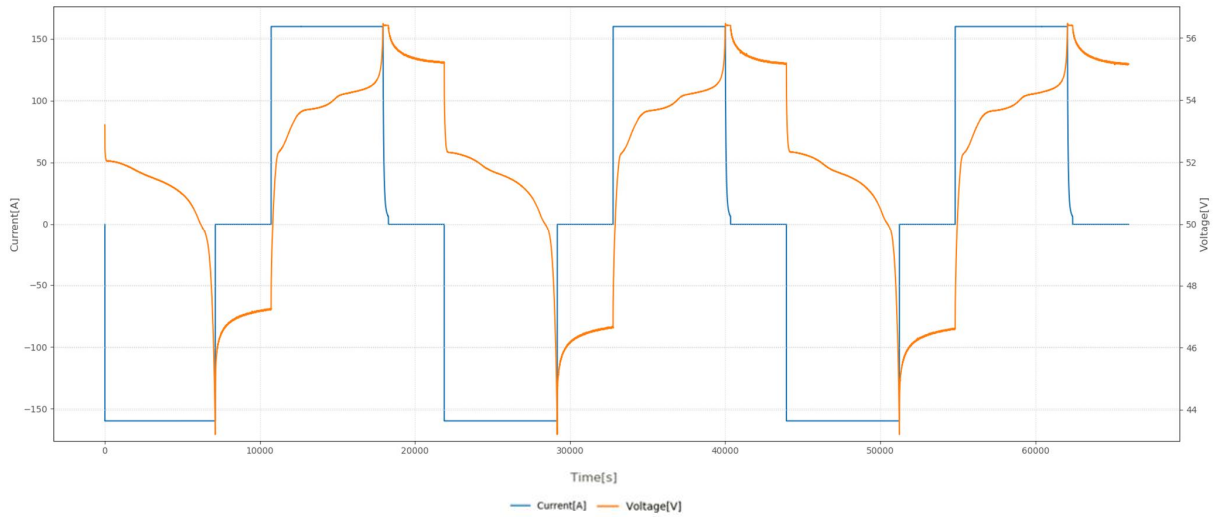

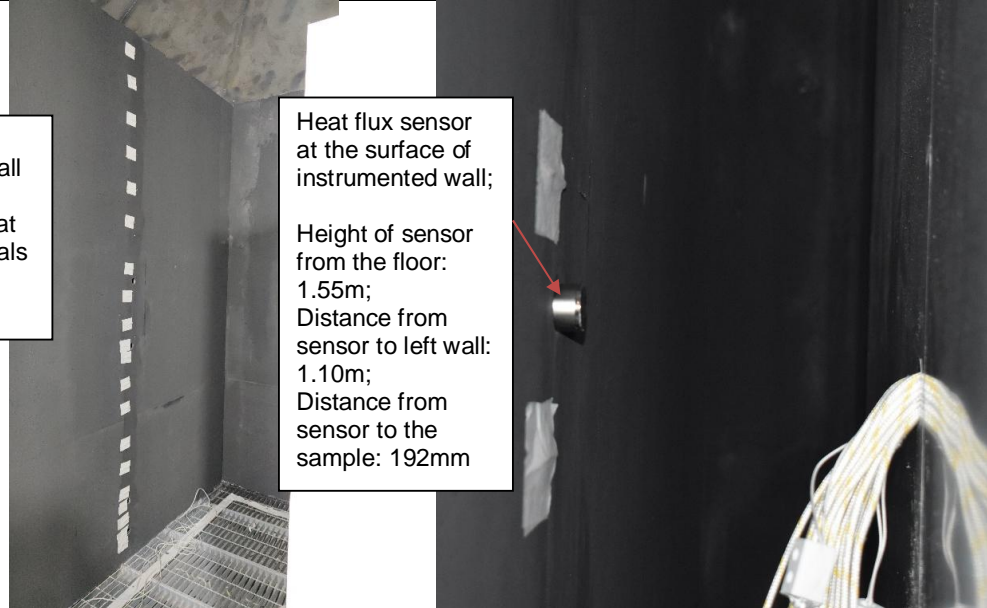
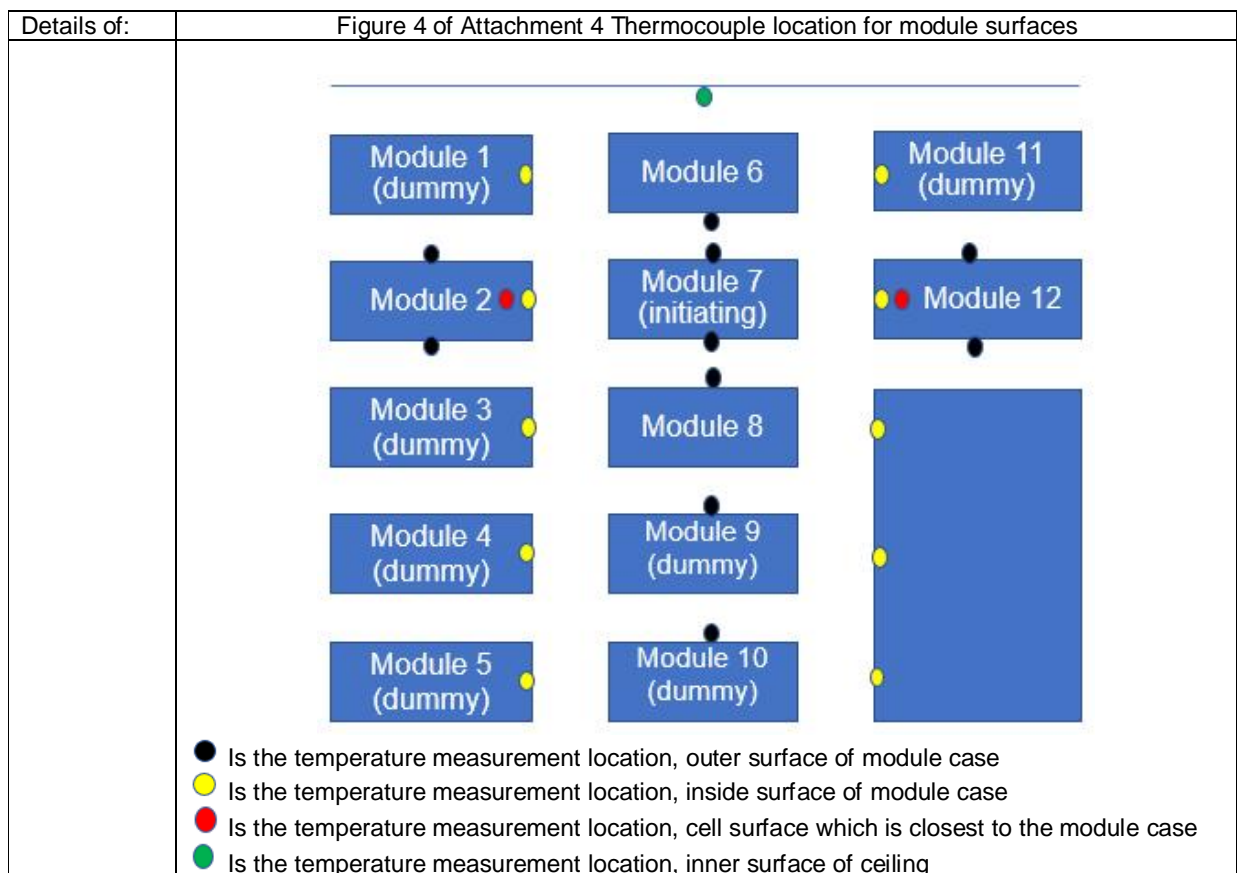
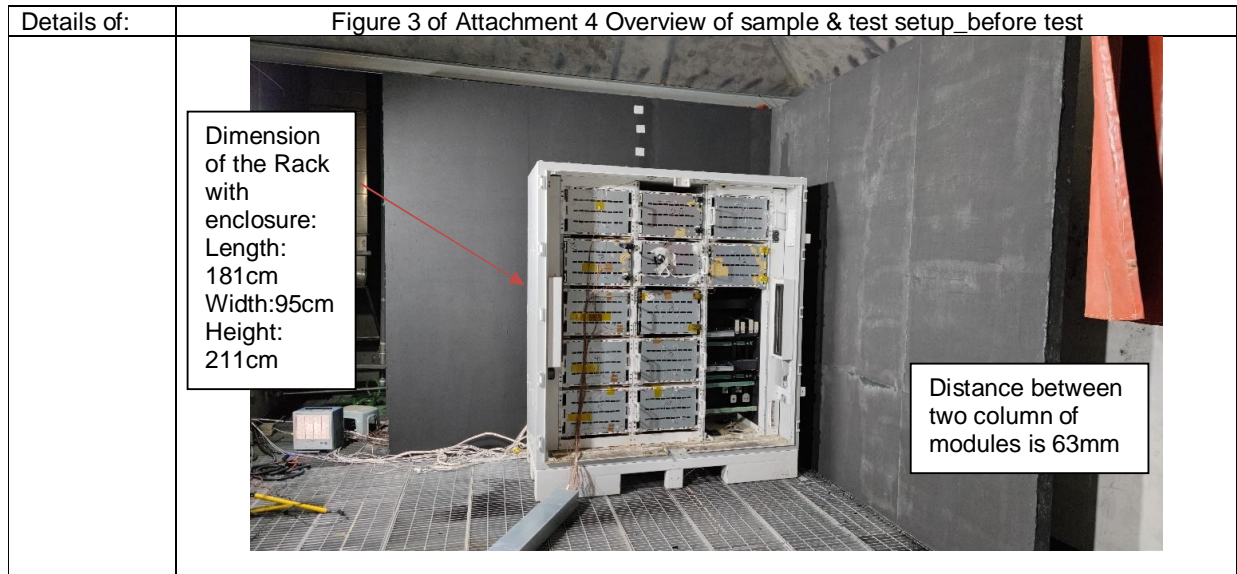


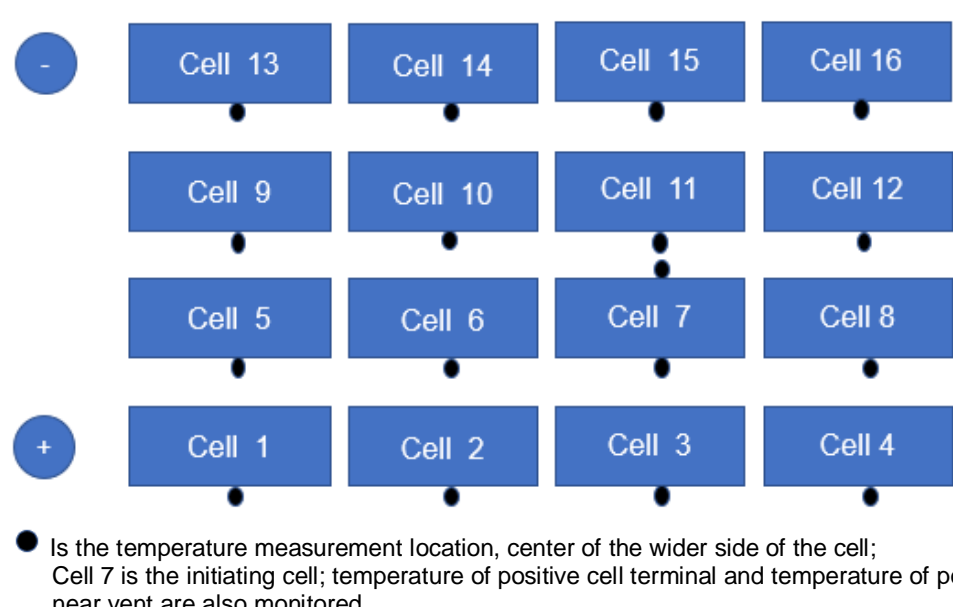
Figure 1 of Attachment 3: charge and discharge cycles chart for initiating module


Attachment 4: Photo for sample before test and test setup with thermocouple location


Details of:	Figure 1 of Attachment 4 Overview of instrumented walls _before test
	

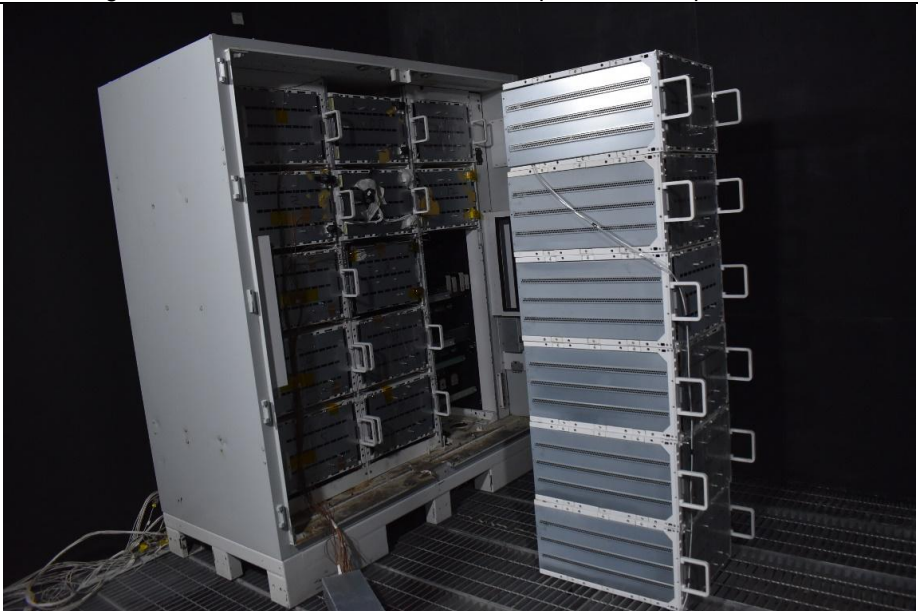
Details of:	Figure 2 of Attachment 4 Overview of thermocouple locations of wall surface & heat flux sensor of instrumented wall _before test
	

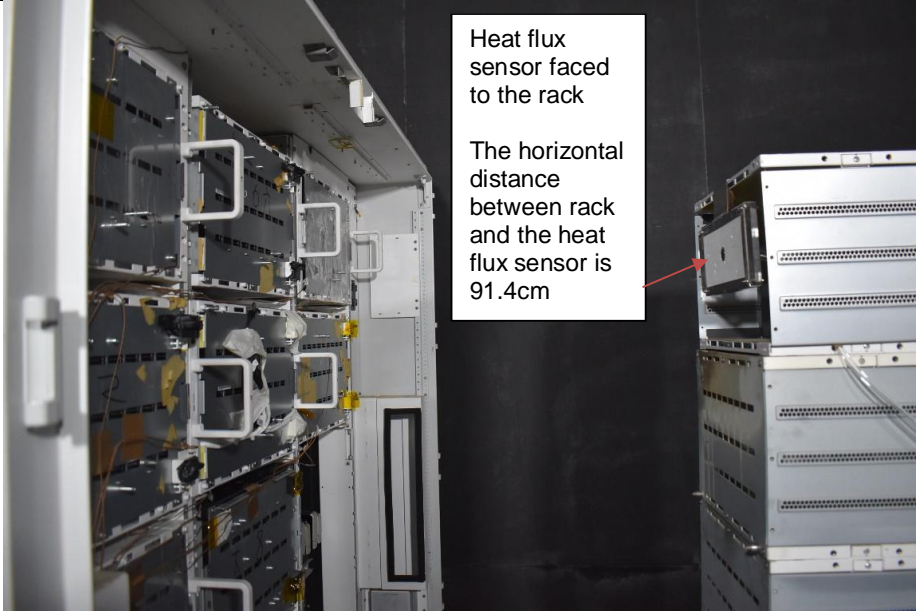


Details of:	Figure 5 of Attachment 4 Thermocouple location within initiating module (module 7)
	 <p>● Is the temperature measurement location, center of the wider side of the cell; Cell 7 is the initiating cell; temperature of positive cell terminal and temperature of position near vent are also monitored</p>


Details of:	Figure 6 of Attachment 4 Overview of sample & test setup_before test
	


Details of:	Figure 7 of Attachment 4 Overview of sample & test setup_before test
	

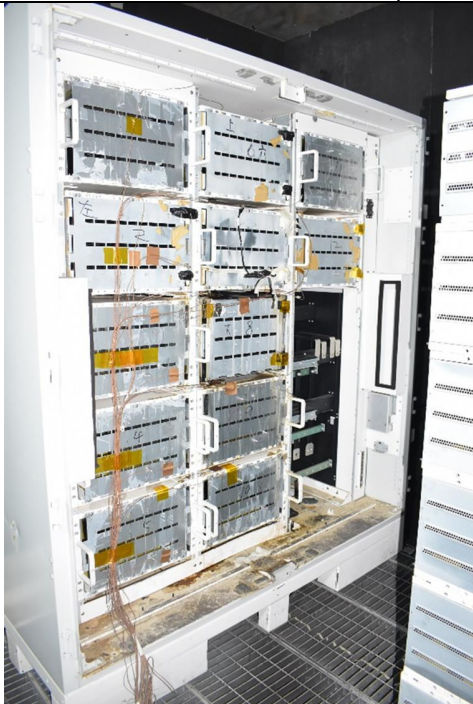
Details of:	Figure 8 of Attachment 4 Overview of sample & test setup_before test
	


Details of:	Figure 9 of Attachment 4 Overview of sample & test setup_before test
	 <p>Heat flux sensor faced to the rack</p> <p>The horizontal distance between rack and the heat flux sensor is 91.4cm</p>

Attachment 5: Photo for sample after test


Details of:	Figure 1 of Attachment 5 Overview of sample_after test
	

Details of:	Figure 2 of Attachment 5 Overview of sample_after test
	

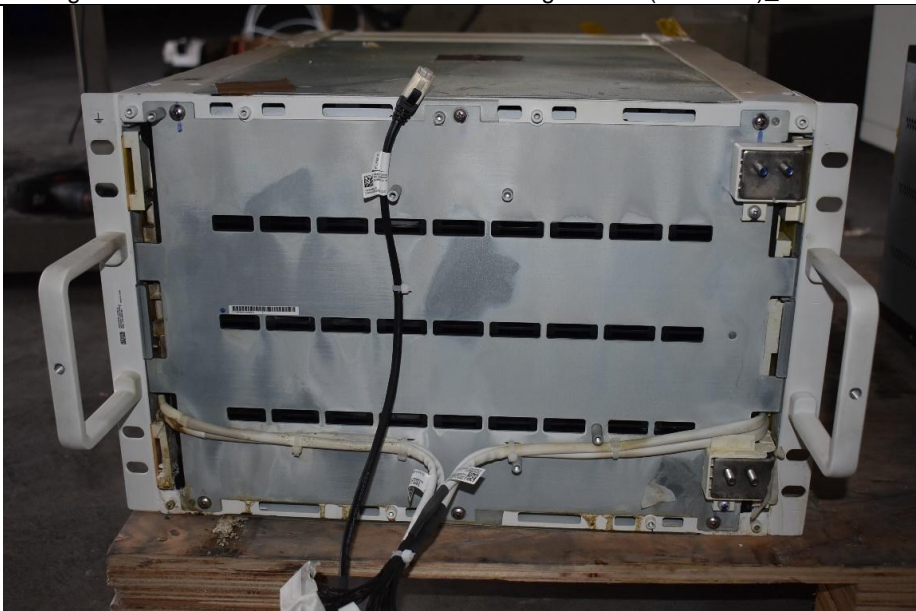
Details of:	Figure 3 of Attachment 5 Overview of sample after test
	


Details of:	Figure 4 of Attachment 5 Overview of sample after test
	

Details of:	Figure 5 of Attachment 5 Overview of sample_after test
	

Details of:	Figure 6 of Attachment 5 Overview of sample_after test
	

Details of:	Figure 7 of Attachment 5 Overview of sample_after test
	

Details of:	Figure 8 of Attachment 5 Front view of initiating module (module 7)_after test
	


Details of:	Figure 9 of Attachment 5 Top view of initiating module (module 7)_after test
	


Details of:	Figure 10 of Attachment 5 Rear view of initiating module (module 7)_after test
	


Details of:	Figure 11 of Attachment 5 Left view of initiating module (module 7)_after test
	 A photograph showing the left side of a metal initiating module. The module is rectangular with a series of horizontal perforated strips across its front face. It shows significant signs of wear, including dark staining, rust, and some physical damage to the metal surface. The module is resting on a wooden pallet.

Details of:	Figure 12 of Attachment 5 Right view of initiating module (module 7)_after test
	 A photograph showing the right side of the same metal initiating module. Similar to the left view, it features horizontal perforated strips and shows extensive staining, rust, and surface degradation. A small piece of yellow tape is visible on the upper right edge. The module is placed on a wooden surface.

Details of:	Figure 13 of Attachment 5 Left view of initiating module (module 7) after test
	


Details of:	Figure 14 of Attachment 5 Left view of initiating module (module 7) after test
	

Details of:	Figure 15 of Attachment 5 Left view of initiating module (module 7) _after test
	 A photograph showing the left side of a rectangular metal module. The module is heavily damaged, with significant charring and debris visible on the front face. The top surface is relatively clean and metallic. The module is resting on a wooden pallet.


Details of:	Figure 16 of Attachment 5 Right view of initiating module (module 7) _after test
	 A photograph showing the right side of the same module. The front face is heavily charred and discolored. A metal plate with a grid of small holes is visible in the foreground, likely a component of the module. A screwdriver and other tools are scattered on the floor next to the module.

Details of:	Figure 17 of Attachment 5 Right view of initiating module (module 7)_after test
	

Details of:	Figure 18 of Attachment 5 Right view of initiating module (module 7)_after test
	


Details of:	Figure 19 of Attachment 5 View of module (module 2)_after test
	

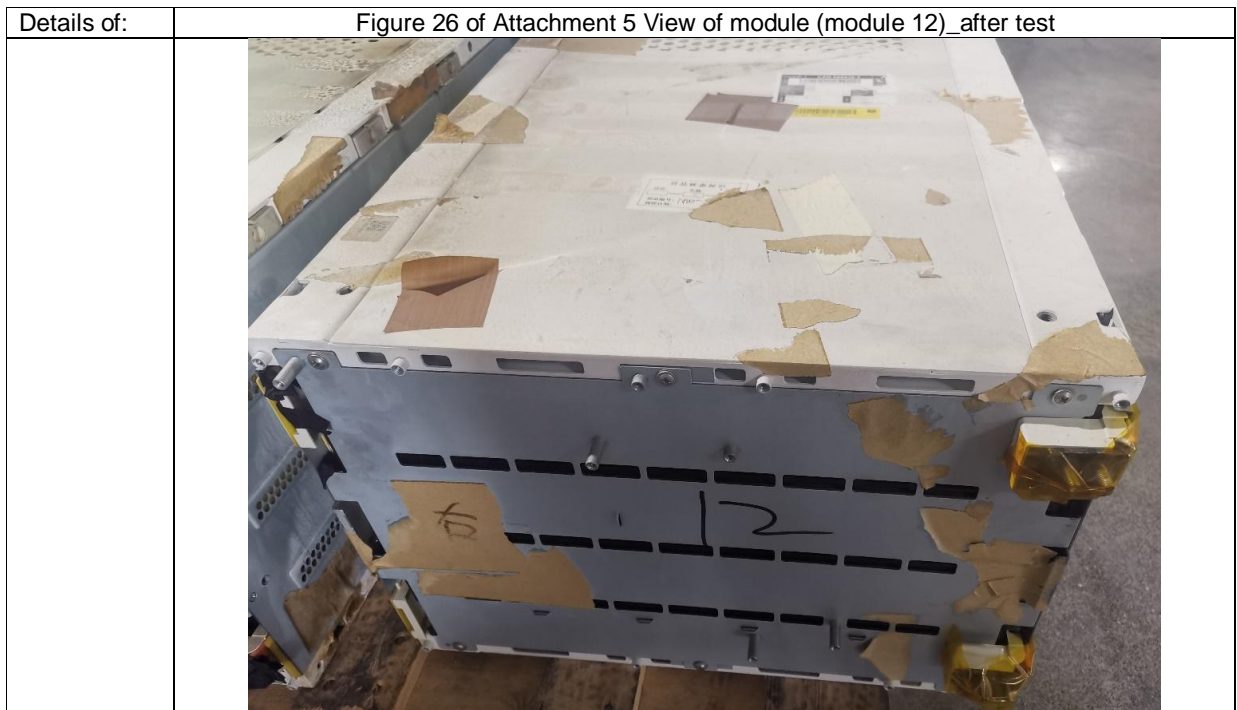
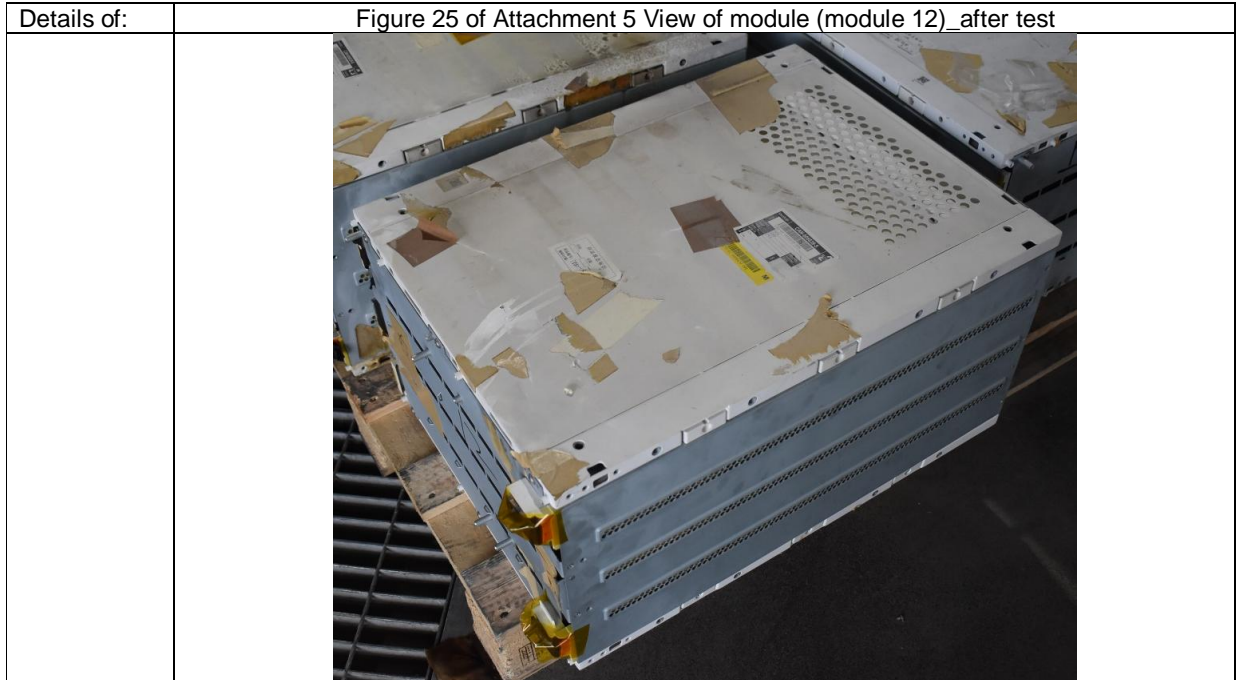
Details of:	Figure 20 of Attachment 5 View of module (module 2)_after test
	

Details of:	Figure 21 of Attachment 5 View of module (module 6)_after test
	

Details of:	Figure 22 of Attachment 5 View of module (module 6)_after test
	

Details of:	Figure 23 of Attachment 5 View of module (module 8)_after test
	

Details of:	Figure 24 of Attachment 5 View of module (module 8)_after test
	



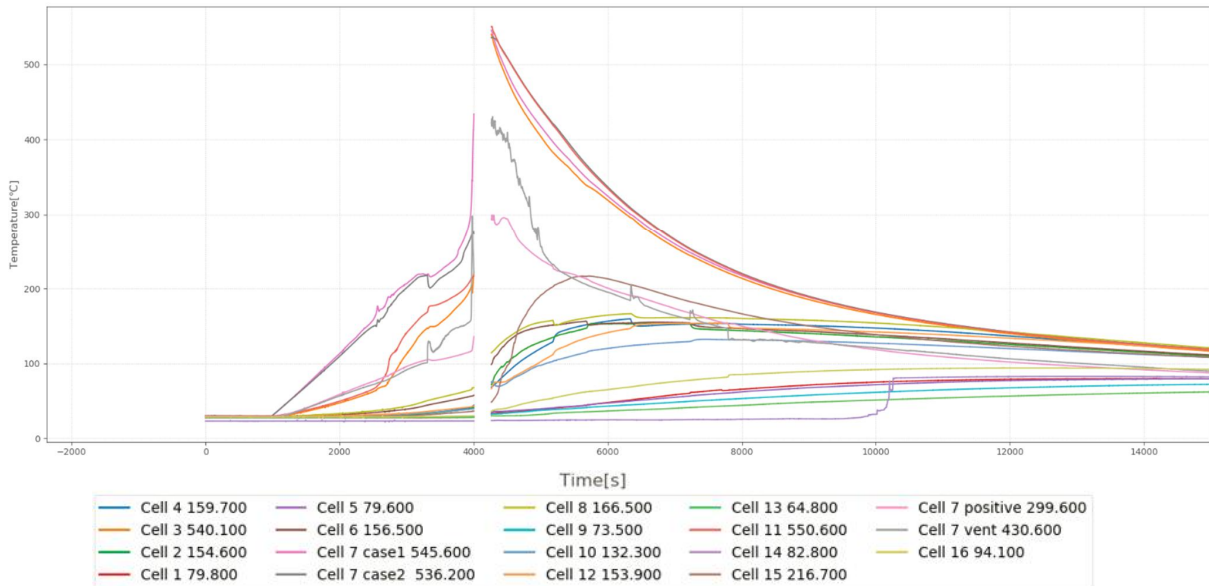
Attachment 6: Monitored temperature chart

Figure 1 of Attachment 6: Temperature of all cells in initiating module (module 7)

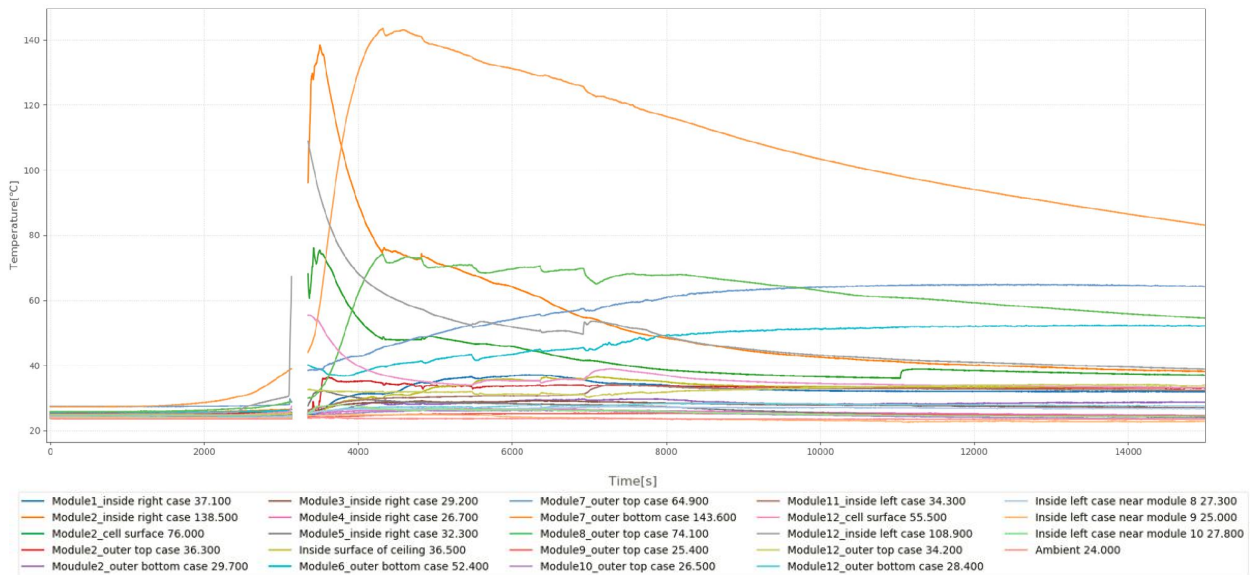


Figure 2 of Attachment 6: Temperature of all module cases

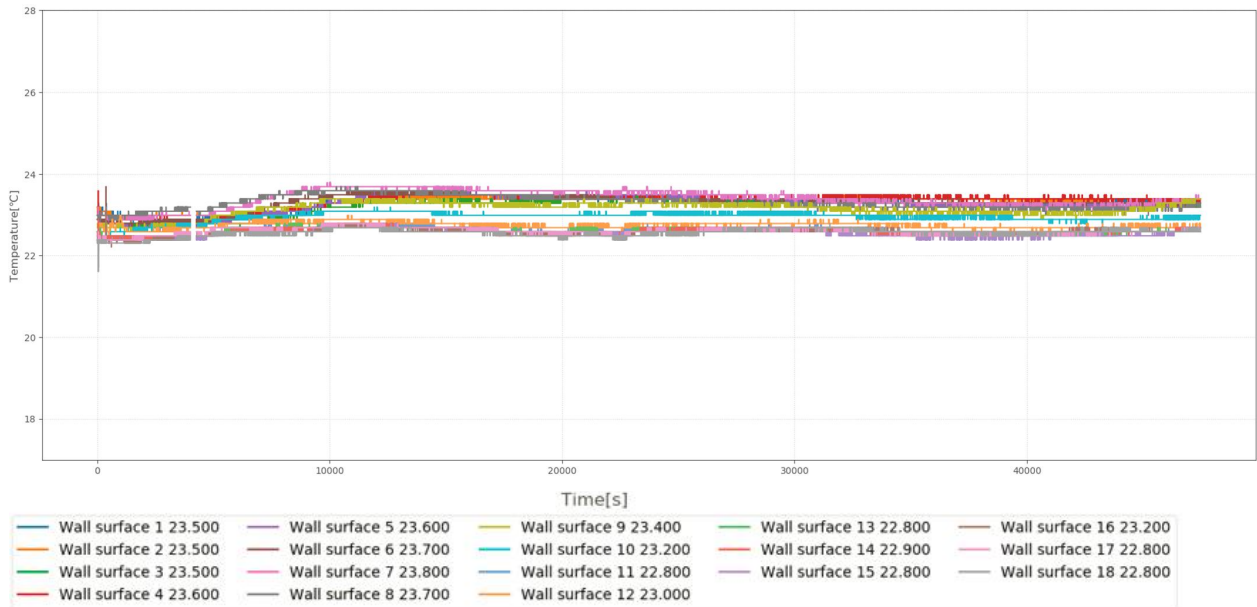


Figure 3 of Attachment 6: Temperature of all module cases

Remark for Figure 3: wall surface 1 to wall surface 18 corresponding to bottom to top of wall

Remark for Figure 1, 2, 3: due to unexpected power outage after the initiating cell thermal runaway, temperature was not recorded for a period of 4min21s.



Attachment 7: Flammable gas generation and composition data chart

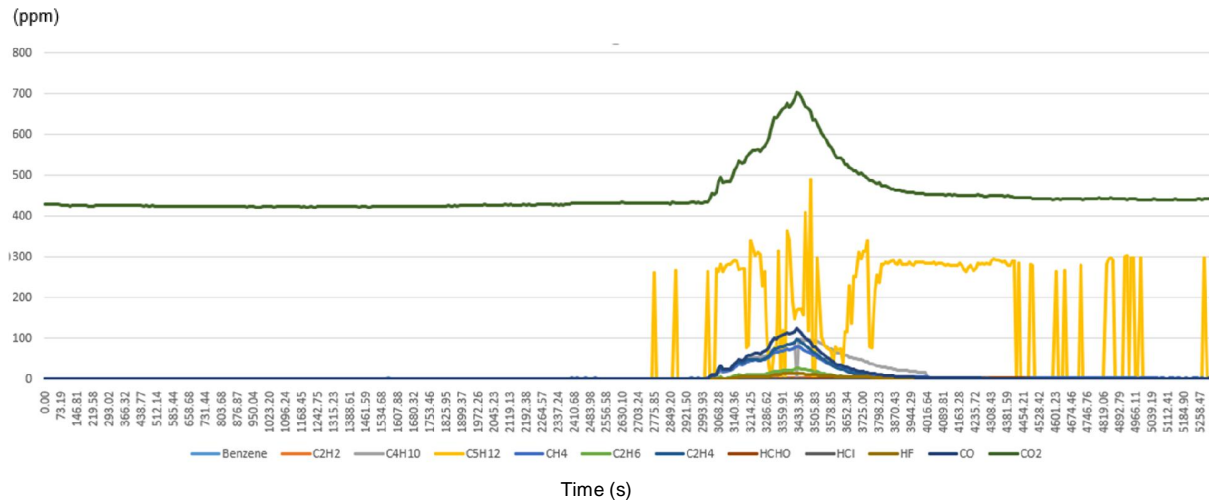


Figure 1 of Attachment 7: Gas generation and composition data chart (Detected by FTIR)

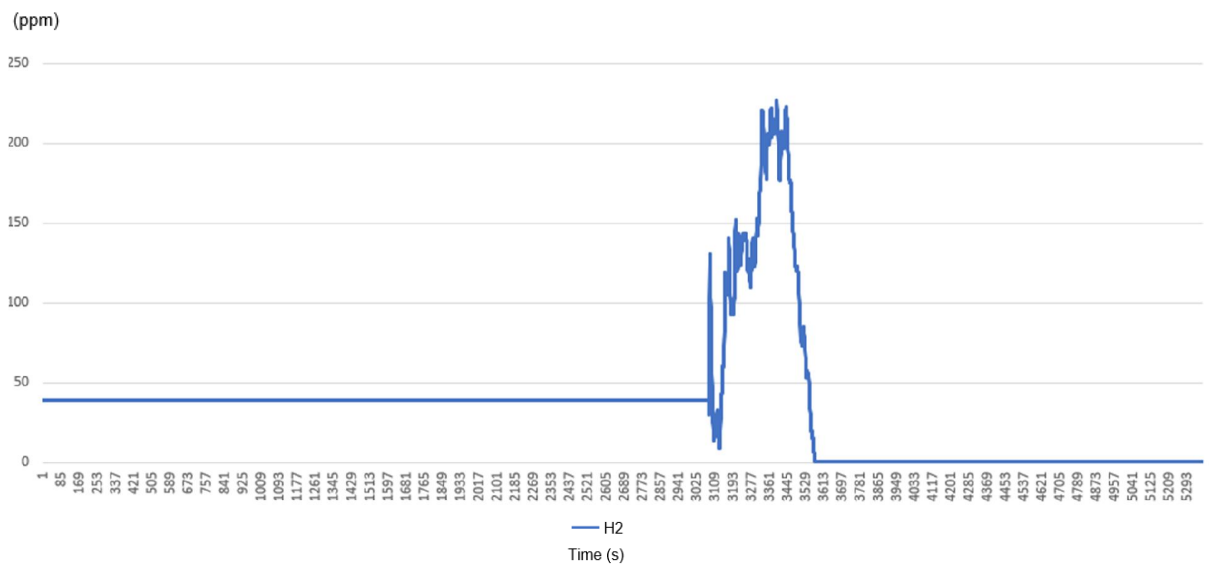


Figure 2 of Attachment 7: H2 chart (Detected by Hydrogen sensor)

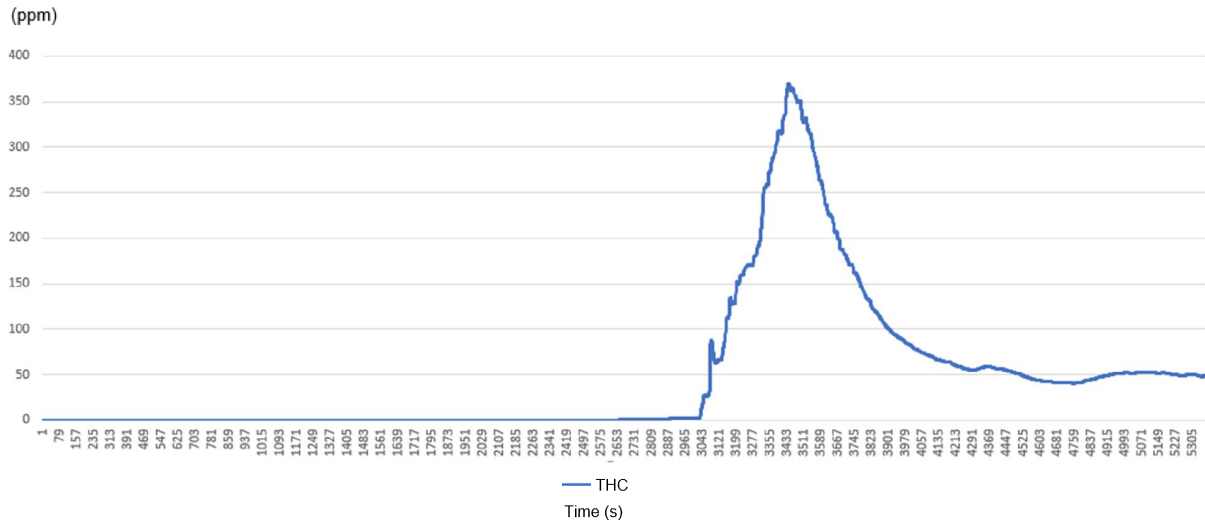
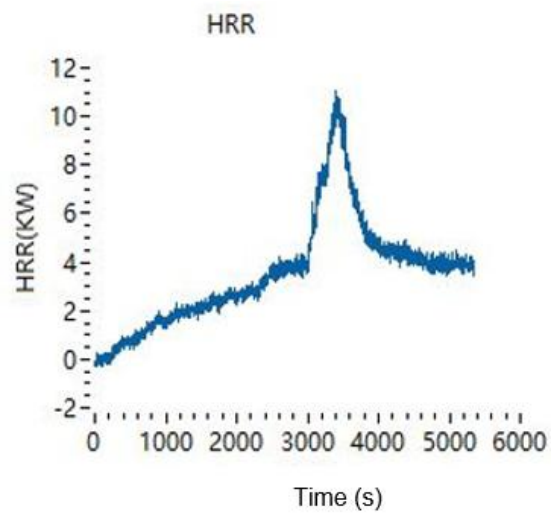


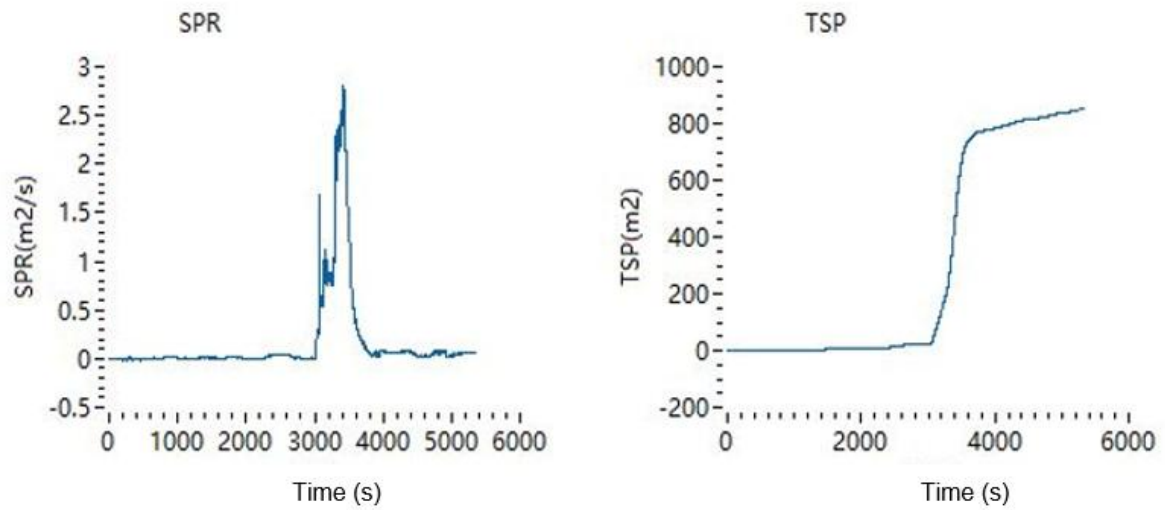
Figure 3 of Attachment 7: THC (Total Hydrocarbons) chart (Detected by FID)

Attachment 8: Heat release rate versus time data chart



Remark: HRR means heat release rate

Attachment 9: Peak smoke release rate and total smoke release data chart



Remark: SPR means smoke production rate, same as SRR which means smoke release rate;
TSP means total smoke production, same as total smoke release

Attachment 10: Summary of Heat release rate & Peak smoke release rate and total smoke release data

Peak heat release rate	11.0kW
Peak convective heat release rate	0.4 kW
Total smoke production	853.2m ²
Peak smoke production rate	2.8m ² /s