# 1

# Introduction & Proposed Development

Appendix 1.1: Letter of Intention to Submit an Environmental Statement;

Appendix 1.2: Department for Infrastructure (DFI) response to Intention to Submit an Environmental Statement.

Appendix 1.3: BESS - UL9540A.

## Appendix 1.1: Letter of Intention to Submit an Environmental Statement;

RES UK & Ireland Limited
Willowbank Business Park, Willowbank Road, Millbrook, Larne
County Antrim, Northern Ireland BT40 2SF, United Kingdom
T +44 (0)28 2844 0580 F +44 (0)1923 299 299
E info@res-group.com www.res-group.com

Jane Curley
DFI Planning,
Clarence Court,
10-18 Adelaide Street,
Belfast,
Bt2 8GB

Our Ref: 04291-2883672

13th September 2021

Dear Janey,

**Re: Intention to Submit an Environmental Statement for the proposed Unshinagh Wind Farm**

Pursuant with the Planning (Environmental Impact Assessment) Regulations (Northern Ireland) 2017 (Part III: Preparation of Environmental Statements), Regulation 9 (1), RES Ltd duly gives notice of its intention to submit an Environmental Statement in support of a planning application for a wind energy project referred to as Unshinagh Wind Farm, in the townlands Drumourne, Unshinagh Mountain, Unshinagh South, Ticloy, Slane, Cregcattan (part of Galdanagh) and Aughareamlag, approximately approximately 4 km south west of the village of Carnlough village Co. Antrim (see enclosed Survey Boundary Drawing which includes Site Location).

The Environmental Statement will be submitted in support of a planning application for a wind farm comprising up to 14 three bladed wind turbines, each up to a maximum of 180m tip height associated external electricity transformers; underground cabling; a newly created site entrance; access tracks; turning heads; crane hardstandings; control building and substation compound, energy storage containers, off-site areas of widening to the public road and all ancillary works. During construction and commissioning there would be a number of temporary works including a construction compound with car parking; temporary parts of crane hardstandings; welfare facilities and temporary guyed meteorological masts.
The purpose of the development is for the generation of electricity.

Under Part III, Regulation 9 (2), we identify the major issues which will be addressed in this Environmental Statement as:

- the implications of siting the wind turbines on the landscape quality and the visual character of the site;
- the impact on local population (traffic generation, noise, shadow flicker, employment);
- the impact on local flora and fauna;
- the impact on the historic and archaeological interest of the site and surrounding area.

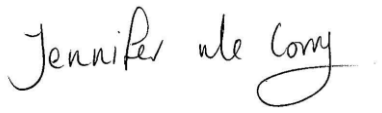
We note that on receipt of the developer's notice of intention to submit, the Department for Infrastructure (DFI) will notify the relevant authorities likely to be concerned by the proposed development under Part III, Regulation 9, Paragraph 3 (b) (i &ii). The developer would like to be informed of the names and addresses of the bodies as detailed under Part III, Regulation 9, Paragraph 3 (b) (iii).

We also request that DFI communicates our intention to enter into consultation, with anybody identified by DFI in order to ascertain whether the body has information in its possession that they consider relevant to the preparation of the environmental statement and that such information should be made available to the developer, under Part III Regulation 8.

Further to this, RES and the various consultants that are carrying out survey work for the Unshinagh site, have notified some authorities regarding the proposed development in order to ascertain whether the body has information which they consider to be relevant to the preparation of the environmental statement.

We trust the information provided is satisfactory, however if you have any queries please do not hesitate to contact us.

Yours sincerely,



Jennifer McCorry
Senior Development Project Manager
E Jennifer.McCorry@res-group.com
T +44 282 844 0595

# Appendix 1.2: Department for Infrastructure (DFI) response to Intention to Submit an Environmental Statement

**Strategic Planning Directorate**

Department for Infrastructure
An Roinn Bonneagair
www.infrastructure-ni.gov.uk

Ms J McCorry
RES UK & Ireland Limited
Willowbank Business Park
Willowbank Road
Millbrook Industrial Estate
Larne
County Antrim
BT40 2SF

Clarence Court
10-18 Adelaide Street
BELFAST
BT2 8GB
Tel: 0300 200 7830

Our Reference:
LA02/2021/0939/DETEIA

13 October 2021

Dear Ms McCorry

**Location:** **Drumourne, Unshinagh Mountain, Unshinagh South, Ticloy, Slane, Cregcattan (part of Galdanagh) and Aughareamlag, approximately approximately 4 km south west of the village of Carnlough village Co. Antrim.,**

**Proposal:** **Intention to submit Environmental Statement for Proposed Unshinagh Wind Farm comprising 14 three-bladed horizontal axis wind turbines, each up to a maximum of 180m tip height associated external electricity transformers; underground cabling; a newly created site entrance; access tracks; turning heads; crane hardstandings; control building and substation compound, energy storage containers, off-site areas of widening to the public road and all ancillary works. During construction and commissioning there would be a number of temporary works including a construction compound with car parking; temporary parts of crane hardstandings; welfare facilities and temporary guyed meteorological masts.**

I refer to the above and your letter dated 13 September 2021 indicating that you intend to submit an Environmental Statement for the above proposal.

As required by Regulation 9(4) of the Planning (Environmental Impact Assessment) Regulations (NI) 2017, I enclose a list of the District Council and other authorities likely to be concerned by the proposal by reason of their specific environmental responsibilities or local or regional competences. These bodies have been advised of your name and address and of their duty under Regulation 10(1) of the Regulations to make available to you information in their possession which they or you consider relevant to the preparation of the Environmental

Statement.  You are strongly advised to consult these bodies.

Schedule 4 to the Regulations sets out matters to be included in any Environmental Statement.  You should note that the onus is on the developer to demonstrate the environmental acceptability of his proposal and to deal with issues raised through the Statement.  If the Statement proves to contain insufficient information, the Department may be obliged to seek additional information necessary to enable it to properly assess your proposal.

If you wish to discuss the above or seek further guidance, please contact Louise Leighton on telephone number 028 9054 0528.

Yours faithfully

Nola Jamieson

for Strategic Planning Directorate
Enc

**List of names and addresses of bodies notified under Regulation 9(4)(b)(ii) of the Planning (Environmental Impact Assessments) Regulations (Northern Ireland) 2017 – Proposed Unshinagh Wind Farm (LA02/2021/0939/DETEIA)**

| NAME | ADDRESS |
|---|---|
| Adelphi Net1 Limited | Andrew McKeever, Adelphi Net1 Limited, Tullyallen Village Centre, Tullyallen, Co. Louth. |
| Arqiva Services Limited | Mr Peter Hayne, Crawley Court, Winchester, Hampshire SO21 2QA |
| Belfast City Airport | Fiona McCurdy Safety And Compliance Manager Belfast City Airport, Sydenham Bypass, Belfast, Co. Antrim, BT3 9JH |
| Belfast International Airport | Mr Joe McGuigan, Belfast International Airport, Aldergrove, Belfast, Co. Antrim, BT29 4AB |
| British Telecom Radio Network Connection - Windfarms | Mr Dale Aitkenhead, Postpoint, 5 CTE, Carlisle Square, Newcastle-Upon-Tyne, NE1 1BB |
| CAA - Directorate of Airspace Policy | Mr Mark Smailes, Directorate Of Airspace Policy, Civil Aviation Authority, CAA House, 45-59 Kingsway, London WC2B 6TE |
| Cable And Wireless Worldwide PLC | Mr Martin Kendall, Cable And Wireless Worldwide, Berkeley Square, 99 Berkeley Street, Glasgow, G3 7HR |
| Chief Exec Mid And East Antrim | The Braid, 1-29 Bridge Street Ballymena Co Antrim BT43 5EJ N Ireland |
| DAERA - Countryside Management Branch | John Courtney Inishkeen House Enniskillen County Fermanagh BT74 4EJ |
| DAERA - Fisheries Division | John O'Hare Fisheries Division Dundonald House, Room 426, Upper Newtownards Road Belfast BT4 3SU |
| DAERA - Forestry Division | Room37 Dundonald House, Upper Newtownards Road, Ballymiscaw, Belfast, Co. Down, BT4 3SU |

| | |
|---|---|
| DAERA - NIEA | Klondyke Building Cromac Avenue Gasworks Business Park Belfast BT7 2JA N Ireland |
| DAERA - Veterinary Service | Room 716 Dundonald House Upper Newtownards Road Belfast BT4 3SU |
| DfE- Geological Survey (NI) | Colby House, Stranmillis Court, Malone Lower, Belfast BT9 5BF |
| DfE Energy Division | Netherleigh, Massey Avenue, Belfast, BT4 2JP |
| DfI Roads - Ballymena Office | Stephen Fullerton County Hall, 182 Galgorm Road, Ballymena, Co. Antrim, BT42 1QG |
| DfI - Economics Branch | Clarence Court 10-18 Adelaide Street Belfast BT2 8GB |
| DfI Rivers | John Moore Planning Advisory Unit DfI Rivers 44 Seagoe Industrial Estate Craigavon BT63 4 QE |
| Eircom UK Limited | Mr Mark Nixon, Forsythe House, Cromac Square, Belfast, BT2 8LA |
| Environmental Health Department Mid And East Antrim | The Braid, 1-29 Bridge Street Ballymena Co Antrim BT43 5EJ N Ireland |
| Everything Everywhere Limited | RAZ SANGHAR Transmission Deployment Engineer NRO & FS UK D&I Ericsson Ashbrook Court, Central Boulevard, Prologis Park Coventry, CV7 8PE |
| Foyle Carlingford & Irish Lights Commission | Mr Declan Lawlor, Loughs Agency, Headquarters, 22 Victoria Road, Londonderry. BT47 2AB |
| Fire Service NI | Group Commander William Boyd, Resilience Department, Northern Ireland Fire & Rescue Service 1 Seymour Street Lisburn BT27 4SX |
| Historic Environment Division (HED) | Dept For Communities Causeway Exchange 1-7 Bedford Street Belfast BT2 7EG |
| Hutchison 3G UK Ltd | Mr Robin Haddon, Ericsson Limited, Ashbrook Court, Central Boulevard, Prologis Park, Coventry, CV7 8PE. |
| HSENI | Health & Safety Executive for NI, Notifications Team, Room 118, 83 Ladas Drive, Belfast, Co. Antrim, BT6 9FR |

| | |
|---|---|
| Mll Telecom Ltd - Windfarms | Mr Martin French Jubilee House Third Avenue Marlow Buckinghamshire SL7 1EY |
| Mobile Broadband Network Ltd | Ms Amanda Baker, Mobile Broadband Network Ltd, 6 Anglo Office Park, 67 White Lion Road, Amersham, Buckinghamshire, HP7 9FB. |
| MP & E Trading Company & EMR Integrated Solutions | Mr Derek Glynn, Unit 11, Dunboyne Business Park, Dunboyne, Co. Meath. |
| N.I Water - Windfarms | Mr Willie Wickens, Bretland House, 115 Duncrue Street, Belfast, BT3 9JS |
| National Air Traffic Services | NATS Safeguarding Office, 4000, Solent Business Park, Whiteley, Hampshire, PO15 7FL |
| Network Repeater Service Limited | Mr Mike Foster, Network Repeater Service Limited, 313 Belmont Road, Belfast, BT4 2NE |
| NI Water - Strategic Applications | NI Water Strategic Applications, Westland House, Old Westland Road, Belfast, BT14 6TE |
| NIE - Windfarm Developments | Fortwilliam House, Edgewater Road, Belfast, Co. Antrim, BT3 9JQ |
| North West Electronics - Windfarms | Mr Scott McClelland, Unit 16, Skeoge Industrial Estate, Beraghmore Road, Derry, BT48 8SE |
| Northern Ireland Tourist Board | Policy And Insights Unit Floors 10-12, Linum Chambers Bedford Square Bedford Street Belfast BT2 7ES |
| P.S.N.I. Information And Communications Services | P.S.N.I, Radio Development, Information And Communications Services, Police Service Of Northern Ireland, 18 Lislea Drive, Lisburn Road, Belfast, BT9 7JG |
| Royal Society for the Protection of Birds - Headquarters | Ms Michelle Hill Belvoir Forest Park, Belfast, Co. Antrim, BT8 7QT |
| SONI | Castlereagh House 12 Manse Road Belfast BT6 9RT |
| The Joint Radio Company | The Joint Radio Company, 6th Floor, Dean Bradley House, 52 Horseferry Road, Lonson, London, SW1P 2AF |

| | |
|---|---|
| UK Crown Bodies - D.I.O. LMS | Building 153, Thiepval Barracks, British Forces Post Office 825, Lisburn, Co. Antrim, BT28 3NP |
| UK Crown Bodies - D.I.O. Safeguarding | Room B4/3, Ministry Of Defence, Leatherhead Road, Chessington, Surrey KT9 2LU |
| Vodafone (Cable And Wireless) | Mrs Stephanie Robinson Vodafone, Quarry Corner, Dundonald, Belfast BT16 1UD |
| The National Association of Areas of Natural Beauty | National Association for AONBs, Belmont House, Shrewsbury Business Park, Shrewsbury, Shropshire SY2 6LG<br>Email: office@landscapesforlife.org.uk |
| Causeway Coast & Glens Heritage Trust | The Old Bank, 27 Main Street, Armoy, Ballymoney, County Antrim, BT53 8SL<br>info@ccght.org |
| Ulster Hang Gliding and Paragliding Club | 24 Upper Road, Carrickfergus, Co Antrim, BT38 8RL |
| The Honourable The Irish Society | 54 Castleroe Road, Coleraine, BT51 3RL |
| Mountaineering Ireland | Irish Sport HQ, National Sports Campus Park, Blanchardstown, Dublin 15,Ireland<br>info@mountaineering.ie |
| Ulster Wildlife Trust | McClelland House, 10 Heron Road, Belfast, BT3 9LE<br>info@ulsterwildlife.org |

## Appendix 1.3: BESS - UL9540A.

# Test Report

## ANSI/CAN/UL 9540A
## Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems

| | | |
|---|---|---|
| **Report Reference No.** ..... : | 200801760SHA-002 | |
| Tested by (name + signature)…….: | Albert Zhou | Albert Zhou ..... |
| Approved by (name + signature)……: | Will Wang | Will Wang ..... |
| Date of issue ..... : | 2020-10-17 | |
| Total number of pages ..... : | 50 | |
| **Testing Laboratory**..... : | Intertek Testing Services Shanghai | |
| Address ..... : | Building No.86, 1198 Qinzhou Road (North), Shanghai 200233, China | |
| **Applicant's name** ..... : | Zhejiang Narada ESS Integration& Operation Co., Ltd | |
| Address ..... : | Room 503, Building 1, No.223 Yile Road, Hangzhou, Zhejiang, 310000, P. R. China | |
| **Test specification:** | | |
| Standard/or Rule ..... : | ANSI/CAN/UL 9540A:2019, Fourth Edition | |
| Test procedure ..... : | Testing | |
| Non-standard test method……..: | N/A | |
| **Test Report Form No**. ..... : | UL9540AA | |
| TRF Originator ..... : | Intertek Shanghai | |
| Master TRF ..... : | Dated 2019-12 | |

| | |
|---|---|
| **Test item description**.....: | Battery cell, module and unit |
| Trade Mark .....: | NARADA |
| Manufacturer.....: | Hangzhou Narada Motive Power Science&Technology Co., Ltd<br>No.120 Hongda Road, Yuhang Economic Develpment Zone of Yuhang District, Hangzhou, Zhejiang 311100, P.R.China |
| Model/Type reference.....: | Cell: FE105A<br>Module: 76.8NESP200<br>Unit: 76.8NESP200*15pcs |
| Rating.....: | Cell:<br>3.2V, 105Ah<br>Module:<br>76.8V, 200Ah<br>Unit:<br>768V, 200Ah (for 76.8NESP200*15pcs)<br>Up to 1500V, 200Ah, Up to 261kWh (for Unit Configuration) |

**Copy of label**

**Cell:**

Narada 南都®

Polarity: + Polarity: -

Secondary (Rechargeable) Li-ion Cell

IFpP36/130/240 (FE105A)

3.2VDC, 105Ah, 336Wh

Data of Manufacture: 14th August 2020

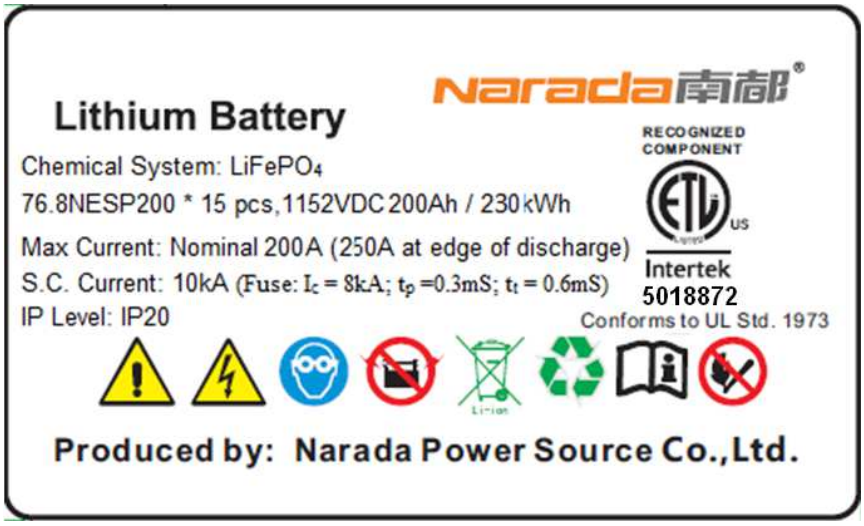
Module:

Narada 南都®

Polarity: + Polarity: -

- Secondary (Rechargeable) Li-ion Battery
- Battery Designation: 76.8NESP200 (24IFpP36/130/240-2)
- Data of Manufacture: dd mm yyyy
- Rated Capacity: 200Ah, 10,240Wh
- Nominal Voltage: 76.8VDC

Unit:



**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 .....: 2020-05-29

Date (s) of performance of tests .....: 2020-05-29 to 2020-09-29

**General remarks:**

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 Issuing testing laboratory.
"(See Enclosure #)" refers to additional information appended to the report.
"(See appended table)" refers to a table appended to the report.
Throughout this report a point is used as the decimal separator.

Determination of the test conclusion is based on IEC Guide 115 in consideration of measurement uncertainty.

“Peak smoke release rate and total smoke release data” is achieved by calculation, since Light transmission signal is not accurate when total smoke volume is small.

For Gas Characteristic Test, it is with accordance of ASTM E681 as per requirement of V3 UL9540A, instead of ASTM E918 according to V4 UL9540A, since when apply UL9540A test, Version 4.0 was just released and ASTM E918 test lab is not available.

For Gas Characteristic Test, the result is refer to report < 200101346SHA-003>

For Cell Level Test, the result is refer to report < 200101346SHA-003>

**Test results:**

Cell Test:

The Cell thermal runaway and test 4 samples；

Module Test:

Initial Cell thermal runaway, and target cell is fine, no thermal propagation;

Not with BMS and Electronics controls

**Unit test:**

Indoor floor mounted non-residential use BESS

Unit Test: Initial Cell thermal runaway, and target cell is fine; No temperature increase for adjoint racks and walls.

See Annex 6 Diagram and dimensions of the test setup, the testing is conducted under two conditions:

Test condition 1: Testing is in room setup

Test condition 2: The testing is conducted in a container

Total inner height is 2.69m and

The surface of wall is a 75mm thickness 90min fire retarded rock wood and steal plate

9.2.13: The adjacent wall layout depends on end use system design

| ANSI/CAN/UL 9540A | | | |
|---|---|---|---|
| Cl. | Requirement + Test | Result – Remark | Verdict |
| **1** | **Scope** | | - |
| 1.1 | The test methodology in this standard determines the capability of a battery technology to undergo thermal runaway and then evaluates the fire and explosion hazard characteristics of those battery energy storage systems that have demonstrated a capability to undergo thermal runaway. | | - |
| **2** | **Units of Measurement** | | - |
| **3** | **Normative References** | | - |
| **4** | **Glossary** | | - |
| **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. | **Cell chemistry:** LFP<br>**Format of the cell:** Prismatic<br>**Cell rating:** 3.2VDC, 105Ah<br>**Dimension:** 36.3*130.2*239.8mm (with terminals)<br>**Weight:** 2.276kg | 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. | See clause 7.6.1 | 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. | **Generic:** metallic<br>**Enclosure material:** galvanized sheet<br>**General layout of module contents:** See Annex 1<br>**Electrical configuration:** 2P24S | 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. | See clause 8.3 | 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. | See clause 9.7.3 | P |

| ANSI/CAN/UL 9540A | | | |
|---|---|---|---|
| Cl. | Requirement + Test | Result – Remark | Verdict |
| 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. | **Number of modules:** 15pcs<br>**Electrical configuration:** 15S1P<br>**Layout of the modules:** See Annex 2<br>**BMS:** 200500576SHA-001 and 200801759SHA-005<br>**Major components:** Refer to report 200801758SHA-001 | NA |
| | It shall be documented as to whether the battery system complies with UL 1973 in addition to the overall BESS compliance to UL 9540. | UL1973 test report: 200601123SHA-001<br>UL9540 test report: 200801758SHA-001 | 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. | Not an integral part | NA |
| 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** | Not flow batteries | NA |
| 5.4.1 | For flow batteries, the report will cover the chemistry, 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. | | NA |
| | 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. | | NA |
| 5.4.2 | The flow battery documentation included in the test report shall indicate if the flow battery system complies with UL 1973. | | NA |
| 5.4.3 | See 7.6.2 for further details to be included in the flow battery thermal runaway determination level test report. | | NA |
| | **PERFORMANCE** | | P |
| **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. All samples shall be disposed of in accordance with local regulations. | | P |
| **7** | **Cell Level** | | P |

| ANSI/CAN/UL 9540A | | | |
|---|---|---|---|
| Cl. | Requirement + Test | Result – Remark | Verdict |
| **7.1** | **General** | | P |
| 7.1.1 | This portion of the test establishes effective methods for forcing a cell into thermal runaway in a repeatable manner. These methods shall be used at the module, unit and installation level of testing. | | P |
| | During this portion of the testing, the vent gas composition shall be gathered and analyzed and cell temperatures shall be monitored to determine the temperature when the cell vents and to verify that thermal runaway as defined in this standard, has occurred. | | P |
| **7.2** | **Sample** | | P |
| 7.2.1 | Cell samples shall be conditioned, prior to testing, through charge and discharge cycles for a minimum of 2 cycles using a manufacturer specified methodology to verify that the cells are functional. | | P |
| | Each cycle shall be defined as a charge to 100% SOC and then to an end of discharge voltage (EODV) specified by the cell manufacturer. | | P |
| | During conditioning a relationship between open circuit voltage and SOC shall be determined through measurement of voltage and SOC. | | P |
| | During conditioning the ambient temperature shall be maintained in accordance with the higher of the temperatures derived from 7.3.1.1 or the operating temperature in the cell manufacturer's specifications. | | P |
| 7.2.2 | The cells to be tested shall be charged to 100% SOC and allowed to stabilize for a minimum of 1 h and a maximum of 8 h before the start of the test. | | P |
| 7.2.3 | Cells with flexible laminate casings shall be constrained during the test in the manner that simulates the constraint in the BESS module to prevent excessive swelling during the test. | | P |
| **7.3** | **Determination of thermal runaway methodology** | | P |
| **7.3.1** | **General** | | P |
| 7.3.1.1 | Ambient indoor laboratory conditions shall be 25 ±5°C (77 ±9°F) and 50 ±25% RH at the initiation of the test. | | P |
| 7.3.1.2 | The propensity of the cell to exhibit thermal runaway shall be demonstrated by heating the cell with externally applied flexible film heaters that cover as much of the cell case as possible without covering safety features or terminals, for consistent heating of the internal cell electrode assembly. A surface heating rate of 4° C (7.2° F) to 7° C (12.6° F) per minute shall be applied to the cell. | Heating cell method used | P |
| | Determination of a maximum surface temperature end point criteria shall be developed based upon a review of cell design and chemistry. | | P |
| | If external heating with a flexible film heater does not cause the cell to exhibit thermal runaway, one of the following methods shall be employed to cause thermal runaway: | Heating cell caused thermal runaway | N/A |
| | a) Mechanical (e.g. nail penetration); | | N/A |

| ANSI/CAN/UL 9540A | | | |
|---|---|---|---|
| Cl. | Requirement + Test | Result – Remark | Verdict |
| | b) Electrical stresses in the form of overcharging, over discharging or external short-circuiting; or | | N/A |
| | c) Use of alternate heating sources (e.g. oven). | | N/A |
| 7.3.1.3 | With reference to 7.3.1.2, when using another cell abuse method to initiate thermal runaway, the details of that method shall be documented. | Heating cell caused thermal runaway | N/A |
| | See the Cell Failure Methods Appendix in UL 1973 for various cell abuse test methods that can be utilized. | | N/A |
| 7.3.1.4 | With reference to 7.3.1.2, in the case of monobloc batteries such as lead acid or nickel cadmium, the monobloc battery can be treated as an individual cell for this testing. | Not monobloc batteries | N/A |
| 7.3.1.5 | Before beginning the test, a surface temperature shall be determined to approximate the temperature at which internal short circuiting within the cell will occur that could lead to a thermal runaway condition. | | P |
| | For Li-ion cells, the surface temperature hold point shall be between 5°C (9°F) and 15°C (27°F) greater than the melting temperature of the cell separator material as determined from differential scanning calorimetry (DSC) data of the separator in accordance with UL 2591 (UL 746A). | | P |
| | Thermal runaway may occur before this hold point temperature range is reached. | | P |
| | However, if thermal runaway is not achieved at this hold point temperature after a period of 4 h, the cell heating rate according to 7.3.1.2 shall be reestablished until thermal runaway occurs or it is demonstrated that thermal runaway is not achievable by heating. | Thermal runaway achieved | N/A |
| 7.3.1.6 | If the cell is susceptible to thermal runaway by external heating, the cell shall be heated until thermal runaway has occurred. | | P |
| | If the cell is not susceptible to thermal runaway by heating with a film heater, another method included in 7.3.1.2 shall be employed. See 7.3.1.7 – 7.3.1.9. | Heating cell caused thermal runaway | N/A |
| | If using another external heating method, the temperature ramp and maximum surface temperature outlined in 7.3.1.2 and 7.3.1.5 shall be used. | | N/A |
| 7.3.1.7 | The cell's exterior surface temperature shall be measured continuously through the cell test with a thermocouple junction formed from 24-gauge or smaller, Type-K thermocouple wire. | | P |
| | The location(s) of thermocouple (s) shall be determined during a construction review. | | P |
| | At least one thermocouple shall be located below the heater film at the center of the cell surface (if the cell is prismatic this would be the center of the wider side of the cell) and one near the positive cell terminals. | | P |
| 7.3.1.8 | The temperature at which the cell case vents due to internal pressure rise shall be documented. | | P |
| | The thermocouple located below the heater film at the center of the cell surface is used for this measurement. | | P |

| ANSI/CAN/UL 9540A | | | |
|---|---|---|---|
| Cl. | Requirement + Test | Result – Remark | Verdict |
| | If using the other cell abuse methods, the thermocouples would be located at the same locations on the cells as noted in 7.3.1.7. | | P |
| 7.3.1.9 | The temperature at the onset of thermal runaway shall be documented. | | P |
| | Onset of thermal runaway shall be determined by the point at which the rate of change of the surface temperature of the cell exceeds that of the externally applied heat input if utilizing the external heater method. As defined in 4.17, thermal runaway is a condition where there is heating of the cell in an uncontrolled manner and should not be confused with overheating leading to venting only. | | P |
| | Cell venting may occur first, but it is necessary to continue heating when using the heater method until thermal runaway occurs. | | P |
| | With other stress methods, it will be necessary to continue applying the stress such as mechanical or electrical stress until onset of thermal runaway occurs. | | P |
| | If there is a transitory temperature dip during the cell venting, the heat input may need to be increased to bring it back to the heating rate range. | | P |
| 7.3.1.10 | When using methods other than the heater method, the stresses shall be applied to the cell until thermal runaway occurs. | | P |
| | Thermal runaway as defined in 4.17, is considered to have occurred, regardless of the method of stress chosen, when there is a rapid increase in temperature as shown in Figure 7.1 and should not be confused with simple overheating leading to venting. | | P |
| 7.3.1.11 | If the cell exhibits thermal runaway behavior (using any method), 3 additional samples shall be tested using the same method and exhibit thermal runaway to demonstrate repeatability. | | P |
| | The vent temperature and thermal runaway onset temperatures shall be averaged over the tested samples (excluding the gas vent capture sample). | | P |
| | This average temperature shall be used to establish the temperature limits for the other test levels of this standard. | | P |
| **7.3.2** | **Flow battery thermal runaway determination tests** | Not Flow battery | NA |
| 7.3.2.1 | For flow battery technology, the propensity for thermal runaway shall be demonstrated by testing the energy reservoir according to the test methods of 7.3.2.2 through 7.3.2.6 as applicable to the flow battery technology. | | NA |
| 7.3.2.2 | The flammability of the electrolytes shall be determined based upon a suitable test method to determine flammability. | | NA |
| 7.3.2.3 | For flow battery systems with two electrolytes, the flammability of the liquid electrolytes shall be demonstrated by subjecting each electrolyte to the appropriate test method outlined in 7.3.2.2. | | NA |

| ANSI/CAN/UL 9540A | | | |
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| Cl. | Requirement + Test | Result – Remark | Verdict |
| 7.3.2.4 | The temperature increase possible due to a flow battery failure where there are two electrolytes shall be demonstrated by charging the energy reservoir in a test flow battery assembly to 100% SOC, and then directly mixing the two electrolyte materials in a closed container within approximately 1 min. | | NA |
| 7.3.2.5 | For flow battery technologies with one active electrolyte containing solid metal particles the appropriate test method of 7.3.2.2 is conducted to determine the flash point temperature. | | NA |
| 7.3.2.6 | If a flash point has been observed for a flow battery technology with one active electrolyte containing solid metal particles, a test battery representative of the flow battery system shall be subjected to an overcharge test and short circuit test in accordance with UL 1973 while monitoring the temperature of the energy reservoir. | | NA |
| **7.4** | **Cell vent gas composition test** | | P |
| 7.4.1 | Cell vent gas shall be generated and captured by forcing a cell into thermal runaway with the methodology developed in 7.3, inside a pressure vessel, which is large enough to accommodate cells, but not so large as to influence measurement of the gas composition. | | P |
| | An 82-L (21.7-gal) pressure vessel is recommended for this purpose for most sizes of commercially available cells. | | P |
| | The test shall be initiated with an initial condition of atmospheric pressure and less than 1% oxygen by volume. The initial atmospheric conditions prior to testing shall be noted. | | P |
| 7.4.2 | Cell vent gas composition shall be determined using Gas Chromatography (GC) with detection techniques for quantifying component gases or equivalent gas analysis techniques, to identify hydrocarbon gases that represent an ignition or explosion hazard as well as other additional gases requested to be measured. | | P |
| | Hydrogen gas shall be measured with a sensor capable of measuring in excess of 30% by volume. The initial atmospheric conditions prior to testing shall be noted. | | P |
| 7.4.3 | Upon determination of the cell vent gas composition per 7.4.2, the lower flammability limit of the cell vent gas shall be determined on samples of the synthetically replicated gas mixture in accordance with ASTM E918, testing at both ambient and cell vent temperatures | | P |
| 7.4.4 | The synthetically replicated gas mixture shall be used to determine gas burning velocity in accordance with the Method of Test for Burning Velocity Measurement of Flammable Gases Annex in ISO 817. | | P |
| 7.4.5 | The synthetically replicated gas mixture shall be used to determine Pmax in accordance with EN15967. | | P |
| **7.5** | **Off gas composition for flow battery systems** | Not flow battery systems | NA |

| ANSI/CAN/UL 9540A | | | |
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| Cl. | Requirement + Test | Result – Remark | Verdict |
| 7.5.1 | The off gas composition from the flow battery testing of 7.3.2 shall be determined by conducting the test method of 7.3.2.2 in a closed container and capturing the off gasses generated, and by collecting the off gasses generated at vent openings and vent ducts during the overcharge and short circuit testing of 7.3.2.4 and 7.3.2.6 as applicable to the flow battery technology. Composition of these captured gases and their flammability limit shall be determined through the methods outlined in 7.4.2 and 7.4.3 at both ambient temperature and the maximum temperature measured. | | NA |
| 7.5.2 | The volume of flammable gases measured during the testing shall be scaled to the maximum energy reservoir for the intended flow battery system in order to determine the potential total flammable gas that can be produced by the system under a fault condition that leads to off gassing. This information shall be provided in the report. | | NA |
| **7.6** | **Cell level test report** | | P |
| 7.6.1 | The report on cell level testing shall include the following: | | P |
| | a) Cell manufacturer name and cell model number | Narada Power Source Co., Ltd.<br>Cell Model: FE105A | P |
| | b) Cell details | | P |
| | cell chemistry (e.g. NMC, LFP), | LFP | P |
| | physical format of the cell (i.e. prismatic, cylindrical, pouch | Prismatic | P |
| | cell electrical rating in capacity and nominal voltage | 3.2V, 105AH | P |
| | overall dimensions of the cell, and weight | 2.276kg<br>36.3*130.2*239.8mm(with terminals) | P |
| | If comply with UL 1973. | Yes<br>200601123SHA-001 | P |
| | c) Energy storage technology (and whether UL 9540 compliant); | Yes<br>200801758SHA-001 | P |
| | d) The rated energy storage capacity of the cell (e.g. Ampere-hours); | 3.2V ,105AH | P |
| | e) Voltage and current obtained during conditioning of the cell; | Charging:3.65V, 105A,<br>Discharging :2.5V, 105A | P |
| | f) Open-circuit voltage of the cell at initiation of test; | 3.385V | P |
| | G Methods attempted and used to initiate thermal runaway; | Heat | P |

| ANSI/CAN/UL 9540A | | | |
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| Cl. | Requirement + Test | Result – Remark | Verdict |
| | h) Surface temperature at which gases are first vented and the average temperature of the samples tested excluding the gas collection sample; | 1# 135.5 ℃<br>2# 133.2℃<br>3#130.9℃<br>4#124.4℃<br>average temperature：131.0℃ | P |
| | I Surface temperature (and location of maximum temperature) prior to thermal runaway and average temperature of the samples tested excluding the gas collection sample; | 1# 185.7℃<br>2# 161.5℃<br>3#192.2℃<br>4#145.9℃<br>average temperature：171.3℃ | P |
| | j) Flammable gas generation and composition measurements | 1.55m3<br>Appended Tables 7.4 | P |
| | k) The lower flammability limit of the cell vent gas; | 3.45% (LEL) | P |
| | l) Burning velocity of the cell vent gas; and | 142.216MPa/s (Maximum explosive pressure rising speed) | P |
| | m) Pmax of the cell vent gas. | Venting Pressure<br>1# 0.11725 MPa<br>2# 0.11725 MPa<br>3# 0.11575 MPa<br>4# 0.11225MPa<br>Average Pmax：0.11563Mpa<br>Explosion Pressure<br>Pmax：0.733MPa | P |
| **7.7** | **Performance – cell level test** | | NA |
| 7.7.1 | Module level testing in Section 8 is not required if the following performance conditions are met: | | NA |
| | a) Thermal runaway cannot be induced in the cell; and | | P |
| | 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. | Vent gas is flammable | N/A |
| 7.7.2 | BESS that contain cells that all comply with the criteria in 7.7.1 shall be suitable for installation in residential dwelling units. | | NA |
| **7.8** | **Performance – flow battery thermal runaway determination tests** | Not flow battery | NA |
| 7.8.1 | For flow batteries, no further testing is required if the following performance conditions are met during the flow battery thermal runaway determination test: | | NA |
| | a) The electrolyte(s) subjected to the test method in accordance with 7.3.2.2 does not ignite; or | | NA |
| | b) The flash point temperature(s) measured in the test of 7.3.2.2 exceed the maximum temperature measured on the energy reservoir during the overcharge and short circuit tests of 7.3.2.4 or 7.3.2.6 by at least 5°C (9°F); and | | NA |

| ANSI/CAN/UL 9540A | | | |
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| Cl. | Requirement + Test | Result – Remark | Verdict |
| | c) The flash point temperature(s) measured in the test of 7.3.2.2 exceed the maximum temperature of the mixed solution measured in accordance with 7.3.2.4 by at least 5°C (9°F) for systems with two active electrolytes. | | NA |
| 7.8.2 | Flammable off gassing during the abnormal tests are addressed as outlined in 7.5.2 by scaling the results in accordance with the largest anticipated flow battery energy reservoir. | | NA |
| **8** | **Module Level** | | P |
| **8.1** | **Sample** | | P |
| 8.1.1 | Module samples shall be conditioned, prior to testing, through charge and discharge cycles for a minimum of 2 cycles, to verify that the module is functional. | | P |
| | Each cycle shall be defined as a charge to 100% SOC and allowed to rest a maximum of 8 h and then discharged to an end of discharge voltage (EODV) specified by the module manufacturer. | | P |
| | During conditioning the ambient temperature and conditions shall be maintained in accordance with 8.2.1. | | P |
| 8.1.2 | The module to be tested shall be charged to 100% SOC and allowed to rest a maximum of 8 h before the start of the test. | | P |
| | The module voltage shall be determined by measuring at the module terminals after charging up to the fully charged condition and before beginning testing. | | P |
| | The sample module shall stabilize for a minimum of one hour prior to testing. | | P |
| 8.1.3 | Electronics and software controls such as the battery management system (BMS) are not relied upon for this testing. | Not with BMS and Electronics controls | P |
| **8.2** | **Test method** | | P |
| 8.2.1 | Ambient indoor laboratory conditions shall be 25 ±5°C (77 ±9°F) and 50 ±25% RH at the initiation of the test. | 25 ±5°C , 50 ±25% RH | P |
| 8.2.2 | The test shall be conducted under a smoke collection hood that is sized appropriately to collect the gasses generated from the module. | | P |
| 8.2.3 | The weight of the module shall be recorded before and after testing is completed to determine weight loss. | | P |
| 8.2.4 | The number of cells within the module that are forced into thermal runaway can be one or multiple cells, and is dependent upon the energy contained within the individual cells. A sufficient number of cells shall be forced into thermal runaway to create a condition of cell to cell propagation within the module. | | P |
| | For example, it may be necessary to force nine, 3-Ah cells into thermal runaway as opposed to one, 30-Ah cell in order to get cell to cell propagation. | Energy is big enough for one cell | P |

| ANSI/CAN/UL 9540A | | | |
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| Cl. | Requirement + Test | Result – Remark | Verdict |
| | The location of the cell (s) forced into thermal runaway shall be selected to present the greatest thermal exposure to adjacent cells that are not forced into thermal runaway. | | P |
| | Factors to be taken into consideration shall include selecting locations within the module where heat transfer is maximized to other cells, cooling by ventilation is restricted or limited, and thermal sensors, detection and suppression discharge points are remote. | | P |
| 8.2.5 | The methodology used for initiating thermal runaway pursuant to 7.2 shall be used to initiate thermal runaway within the module. | | P |
| 8.2.6 | With reference to 8.2.5, occurrence of thermal runaway shall be verified by sustained temperature above the cell surface temperature at the onset of thermal runaway, as determined in Section 7. | | P |
| 8.2.7 | The module shall be placed on top of a noncombustible horizontal surface with the module orientation representative of its intended final installation. | | P |
| 8.2.8 | The chemical heat release rate of the module in thermal runaway shall be measured with oxygen consumption calorimetry. | | P |
| 8.2.9 | The chemical heat release rate shall be measured for the duration of the test. See 8.2.10. | | P |
| 8.2.10 | The chemical heat release rate shall be measured by a measurement system consisting of a paramagnetic oxygen analyzer, non-dispersive infrared carbon dioxide and carbon monoxide analyzer, velocity probe, and a Type K thermocouple. | | P |
| | The instrumentation shall be located in the exhaust duct of the heat release rate calorimeter at a location that minimizes the influence of bends or exhaust devices. See 8.2.11. | | P |
| 8.2.11 | With reference to 8.2.10, calculate the chemical heat release rate at each of the flows as follows: | | P |
| | $HRR_1 = \left[E \times \varphi - (E_{co} - E) \times \frac{1-\varphi}{2} \times \frac{X_{co}}{X_{O_2}}\right] \times \frac{\dot{m}_e}{1+\varphi \times (\alpha - 1)} \times \frac{M_{O_2}}{M_a} \times (1 - X^o_{H_2O}) \times X^o_{O_2}$ | | P |
| 8.2.12 | Vent gas composition shall be measured using a Fourier-Transform Infrared Spectrometer with a minimum resolution of 1 cm-1 and a path length of at least 2 m (6.6 ft), or equivalent gas analyzer, and velocity and temperature measurements respectively shall be obtained in the exhaust duct of the heat release rate calorimeter using equipment specified in 8.2.10. | | P |
| 8.2.13 | The hydrocarbon content of the vent gas shall be measure using flame ionization detection. Hydrogen gas shall be measured with a palladium-nickel thin-film solid state sensor. | | P |
| 8.2.14 | The light transmission in the exhaust duct of the heat release rate calorimeter shall be measured using a white light source and photo detector for the duration of the test, and the smoke release rate shall be calculated. See 8.2.15. | | P |

| ANSI/CAN/UL 9540A | | | |
|---|---|---|---|
| Cl. | Requirement + Test | Result – Remark | Verdict |
| 8.2.15 | Smoke release rate shall be calculated as follows: | | P |
| | $SRR = 2.303\left(\frac{V}{D}\right) Log_{10}\left(\frac{I_o}{I}\right)$ | | P |
| **8.3** | **Module level test report** | | P |
| | a) Module manufacturer name and model number (and whether UL 1973 compliant); | Narada, 76.8NESP200<br>200601123SHA-001 | P |
| | b) Number of cells in module; | 48 pcs | P |
| | c) Module configuration with cells in series and parallel | 2 parallel 24 series | P |
| | d) Module construction features per 5.2; | | |
| | e) Module voltage corresponding to the tested SOC | 100%SOC 86.4V | P |
| | f) Thermal runaway initiation method used including number and locations of cells for initiating thermal runaway; | Heating;<br>1 Cell;<br>Detail in Annex 3 | P |
| | g) Heat release rate versus time data; | Appended Curve 8.3 | P |
| | h) Flammable gas generation and composition data | Appended Tables 8.3 | P |
| | i) Peak smoke release rate and total smoke release data. | 0.018$m^2$/s based on 1m* 2m;<br>1.768$m^3$ (flammable gas according to 8.3 h)) | P |
| | j) Observation(s) of flying debris or explosive discharge of gases | No flying debris or explosive discharge of gases | P |
| | k) Observation(s) of sparks, electrical arcs, or other electrical events; | No sparks, electrical arcs, or other electrical events; | P |
| | l) Identification/location of cells(s) that exhibited thermal runaway within the module | | P |
| | m) Locations and visual estimations of flame extension and duration from the module shall be documented | No Flame extension | P |
| | n) Module weight loss based on measurements per 8.2.3; and | 0.836kg | P |
| | o) Video of the test | | P |
| **8.4** | **Performance at module level testing** | | NA |
| | Unit level testing in Section 9 is not required if the following performance conditions are met during the module level test: | | NA |
| | a) Thermal runaway is contained by module design; and | No thermal propagation, but vented gas spill out of module enclosure | NA |
| | b) Cell vent gas is nonflammable as determined by the cell level test. | | NA |
| **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. | | P |

| ANSI/CAN/UL 9540A | | | |
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| Cl. | Requirement + Test | Result – Remark | Verdict |
| | Test configurations include the following: | | P |
| | a) Indoor floor mounted non-residential use BESS; | | P |
| | b) Indoor floor mounted residential use BESS; | | NA |
| | c) Outdoor ground mounted non-residential use BESS; | | NA |
| | d) Outdoor ground mounted residential use BESS; | | NA |
| | e) Indoor wall mounted non-residential use BESS; | | NA |
| | f) Indoor wall mounted residential use BESS; | | NA |
| | g) Outdoor wall mounted non-residential use BESS; | | NA |
| | h) Outdoor wall mounted residential use BESS; and | | NA |
| | i) Rooftop and open garage non-residential use BESS installations. | | NA |
| 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. | | P |
| | 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. | Test condition 1 | P |
| | Tests shall be conducted indoors with fire propagation hazards and separation distances between initiating and target units representative of the installation. | Test condition 1 | P |
| | The results of such tests shall be considered to also represent an outdoor installation. Examples of potential test configurations. | Test condition 1 | P |
| | Exception: Testing can be conducted outdoors for outdoor only installations if there are the following controls and environmental conditions in place: | Test condition 1 | P |
| | a) Wind screens are utilized with a maximum wind speed maintained at ≤ 12 mph; | Test condition 1 | P |
| | b) The temperature range is within 10°C to 40°C (50°F to 104°F); | Test condition 1 | P |
| | c) The humidity is < 90% RH; | Test condition 1 | P |
| | d) There is sufficient light to observe the testing; | Test condition 1 | P |
| | e) There is no precipitation during the testing; | Test condition 1 | P |
| | 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 | Test condition 1 | P |
| | 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. | Test condition 1 | P |
| 9.1.3 | Depending upon the configuration and design of the BESS, this testing to determine fire characterization can be done at the battery system level. | | P |

| ANSI/CAN/UL 9540A | | | |
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| Cl. | Requirement + Test | Result – Remark | Verdict |
| | 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. | | P |
| | 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. | | P |
| | 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. | | P |
| | After charging and prior to testing, the initiating BESS shall rest for a maximum period of 8 h at room ambient. | | P |
| 9.1.7 | If a BESS unit includes an integral fire suppression system, there is an option of providing this with the DUT. | No fire suppression | NA |
| | If the BESS unit is provided with an optional integral fire suppression system, the system shall not be provided on the DUT. | | NA |
| 9.1.8 | Electronics and software controls such as the battery management system (BMS) in the BESS are not relied upon for this testing. | No such BMS | NA |
| | 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. | | NA |
| **9.2** | **Test method – Indoor floor mounted BESS units** | | P |
| 9.2.1 | Samples and test configurations are in accordance with 9.1. | | P |
| | 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. | | P |
| 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, but not less than 3.66 m (12 ft) in height above the bottom surface of the unit. | Test condition 1 | P |

| ANSI/CAN/UL 9540A | | | |
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| Cl. | Requirement + Test | Result – Remark | Verdict |
| 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. | Test condition 1 | 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. | Test condition 1 | 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 | Test condition 1 | P |
| | b) Adjacent BESS units. | Test condition 1 | P |
| 9.2.15 | Wall surface temperature measurements shall be collected for BESS intended for installation in locations with combustible construction. | | P |
| | If the intended installation is composed completely of noncombustible construction in 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. | | P |
| 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. | | P |

| ANSI/CAN/UL 9540A | | | |
|---|---|---|---|
| Cl. | Requirement + Test | Result – Remark | Verdict |
| | 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. | | P |
| | 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: | | P |
| | a) Both are collinear with the vertical thermocouple array; | | P |
| | b) One is positioned at the elevation estimated to receive the greatest heat flux due to the thermal runaway of the initiating module; and | | P |
| | 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: | | P |
| | 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 | | P |
| | b) One is positioned at the elevation estimated to receive the greatest surface heat flux due to the thermal runaway of the initiating BESS. | | P |
| 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. | | 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. | | P |
| 9.2.22 | For residential use BESS, the DUT shall be covered with a single layer of cheese cloth ignition indicator. | | NA |

| ANSI/CAN/UL 9540A | | | |
|---|---|---|---|
| Cl. | Requirement + Test | Result – Remark | Verdict |
| | 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 $cm^2$ (1 $in^2$) area. | | NA |
| 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: | | P |
| | 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 | | P |
| | 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. | | P |
| | 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 |
| 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 | | P |
| | c) A condition hazardous to test staff or the test facility requires mitigation. | | P |
| 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. | | NA |
| **9.3** | **Test method – Outdoor ground mounted units** | | NA |
| 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. | | NA |
| | 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. | | NA |
| 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. | | NA |

| ANSI/CAN/UL 9540A | | | |
|---|---|---|---|
| Cl. | Requirement + Test | Result – Remark | Verdict |
| | 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. | | NA |
| 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). | | NA |
| | 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. | | NA |
| | The wall and soffit shall be constructed with 19.05-mm (3/4-in) plywood installed on wood studs and painted flat black. | | NA |
| | The instrumented wall shall extend not less than 0.49-m (1.6-ft) horizontally beyond the exterior of the target BESS units. | | NA |
| | 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. | | NA |
| 9.3.4 | Target BESS shall be installed on each side of the initiating BESS in accordance with the manufacturer's installation specifications. | | NA |
| | The physical spacing between BESS units (both initiating and target) shall be the minimum separation distances specified by the manufacturer. | | NA |
| **9.4** | **Test Method – Indoor wall mounted units** | | NA |
| 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. | | NA |
| 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. | | NA |
| 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. | | NA |
| 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. | | NA |
| | The physical spacing between BESS units (both initiating and target) shall be the minimum separation distances specified by the manufacturer. | | NA |
| 9.4.5 | The wall on which the initiating and target BESS units are mounted shall be instrumented in accordance with Section 9.2. | | NA |

| ANSI/CAN/UL 9540A | | | |
|---|---|---|---|
| Cl. | Requirement + Test | Result – Remark | Verdict |
| 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. | | NA |
| 9.4.7 | For residential use BESS, the DUT shall be covered with a single layer of cheese cloth ignition indicator. | | NA |
| | 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. | | NA |
| **9.5** | **Test Method – Outdoor wall mounted units** | | NA |
| 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. | | NA |
| | 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. | | NA |
| 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. | | NA |
| | 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. | | NA |
| 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. | | NA |
| 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. | | NA |
| | The physical spacing between BESS units (both initiating and target) shall be the minimum separation distances specified by the manufacturer. | | NA |
| 9.5.5 | The wall on which the initiating and target BESS units are mounted shall be instrumented in accordance with Section 9.2. | | NA |
| 9.5.6 | For residential use BESS, the DUT shall be covered with a single layer of cheese cloth ignition indicator. | | NA |
| | 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. | | NA |
| **9.6** | **Rooftop and open garage installations** | | NA |
| 9.6.1 | Testing of BESS intended for non-residential use rooftop or open garage installations shall be in accordance with 9.2. | | NA |

| ANSI/CAN/UL 9540A | | | |
|---|---|---|---|
| Cl. | Requirement + Test | Result – Remark | Verdict |
| 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. | | NA |
| **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; | Indoor floor mounted non-residential | P |
| | b) Indoor floor mounted residential use BESS; | | NA |
| | c) Outdoor ground mounted non-residential use BESS; | | NA |
| | d) Outdoor ground mounted residential use BESS; | | NA |
| | e) Indoor wall mounted non-residential use BESS; | | NA |
| | f) Indoor wall mounted residential use BESS; | | NA |
| | g) Outdoor wall mounted non-residential use BESS; | | NA |
| | h) Outdoor wall mounted residential use BESS; | | NA |
| | i) Rooftop installed non-residential use BESS; or | | NA |
| | j) Open garage installed non-residential use BESS. | | NA |
| 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. | Indoor ground mounted | P |
| 9.7.3 | The report shall include the following, as applicable: | | P |
| | a) Unit manufacturer name and model number (and whether UL 9540 compliant); | Manufacturer: Narada<br>Model number: 76.8NESP200*15pcs<br>Refer to 5002817-200801758SHA-001 | P |
| | b) Number of modules in the initiating BESS unit; | 15 pcs modules | P |
| | c) The construction of the initiating BESS unit per 5.3; | See Annex 4 | P |
| | d) Fire protection features/detection/suppression systems within unit; | No such systems | NA |
| | e) Module voltage(s) corresponding to the tested SOC; | 100%SOC 86.4V | P |
| | f) The thermal runaway initiation method used; | Heating | P |
| | g) Location of the initiating module within the BESS unit; | Middle of battery rack, between two units. See Annex 5. | 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 Annex 6 | P |
| | i) Observation of any flaming outside the initiating BESS enclosure and the maximum flame extension; | No flaming outside the initiating BESS enclosure | P |
| | j) Chemical and convective heat release rate versus time data; | Same as Appended Curve 8.3 g) | P |

| ANSI/CAN/UL 9540A | | | |
|---|---|---|---|
| Cl. | Requirement + Test | Result – Remark | Verdict |
| | k) Separation distances from the initiating BESS unit to target walls (e. g. distances A and C in Figure 9.1); | See Annex 6 | P |
| | l) Separation distances from the initiating BESS unit to target BESS units (e.g. distances D and H in Figure 9.1); | See Annex 6 | P |
| | m) The maximum wall surface and target BESS temperatures achieved during the test and the location of the measuring thermocouple; | 22 ℃ | 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; | 22 ℃ | P |
| | o) The maximum incident heat flux on target wall surfaces and target BESS units; | 0kW/m$^2$ | P |
| | p) The maximum incident heat flux on target ceiling or soffit surfaces achieved during the indoor or outdoor wall mounted test; | 0kW/m$^2$ | P |
| | q) Gas generation and composition data; | Same as Appended Table 8.3 | P |
| | r) Peak smoke release rate and total smoke release data; | 0.018m$^2$/s based on 1m* 2m; 1.768m$^3$ (flammable gas according to 8.3 h)) | P |
| | s) Indication of the activation of integral fire protection systems and if activated the time into the test at which activation occurred; | | NA |
| | t) Observation of flying debris or explosive discharge of gases; | No flying debris or explosive discharge of gases; | P |
| | u) Observation of re-ignition(s) from thermal runaway events; | No re-ignition(s) from thermal runaway events; | P |
| | v) Observation(s) of sparks, electrical arcs, or other electrical events; | No sparks, electrical arcs, or other electrical events; | P |
| | w) Observations of the damage to: | | P |
| | 1) The initiating BESS unit; | No | P |
| | 2) Target BESS units; | No | P |
| | 3) Adjacent walls, ceilings, or soffits; and | No | P |
| | x) Photos and video of the test. | See Annex 9 | 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 |
| | **Non-Residential Installations:** | | P |
| | Indoor Floor Mounted: | | P |
| | a) Flaming outside the initiating BESS unit is not observed; | No flaming outside the initiating BESS unit | 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; | No temperature increase of target BESS unit | P |

| ANSI/CAN/UL 9540A | | | |
|---|---|---|---|
| Cl. | Requirement + Test | Result – Remark | Verdict |
| | 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; | No temperature increase of the wall surface, remain same as room environment temperature | 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 | No explosion hazards are observed | P |
| | e) Heat flux in the center of the accessible means of egress shall not exceed 1.3 kW/m$^2$. | Not exceed 1.3 kW/m$^2$ | P |
| | Outdoor Ground Mounted: | | NA |
| | a) If flaming outside of the unit is observed, separation distances to exposures shall be determined by greatest flame extension observed during test. | | NA |
| | 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; | | NA |
| | 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; | | NA |
| | 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 | | NA |
| | e) Heat flux in the center of the accessible means of egress shall not exceed 1.3 kW/m$^2$. | | NA |
| | Indoor Wall Mounted: | | NA |
| | a) Flaming outside the initiating BESS unit is not observed; | | NA |
| | 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; | | NA |
| | 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; | | NA |
| | 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 | | NA |
| | e) Heat flux in the center of the accessible means of egress shall not exceed 1.3 kW/m$^2$. | | NA |
| | Outdoor Wall Mounted: | | NA |
| | a) Flaming outside the initiating BESS unit is not observed; | | NA |
| | 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; | | NA |

| ANSI/CAN/UL 9540A | | | |
|---|---|---|---|
| Cl. | Requirement + Test | Result – Remark | Verdict |
| | 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; | | NA |
| | 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 | | NA |
| | e) Heat flux in the center of the accessible means of egress shall not exceed 1.3 kW/m$^2$. | | NA |
| | Rooftop and Open Garages: | | NA |
| | a) If flaming outside the unit is observed, separation distances to exposures shall be determined by greatest flame extension observed during test; | | NA |
| | 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; | | NA |
| | 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; | | NA |
| | 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 | | NA |
| | e) Heat flux in the center of the accessible means of egress shall not exceed 1.3 kW/m$^2$. | | NA |
| | **Residential Installations** | | NA |
| | Indoor Floor Mounted: | | NA |
| | a) Flaming outside the initiating BESS unit is not observed as demonstrated by no flaming or charring of the cheesecloth indicator; | | NA |
| | 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; | | NA |
| | 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; | | NA |
| | 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 | | NA |
| | e) The concentration of flammable gas does not exceed 25% LFL in air for the smallest specified room installation size. | | NA |
| | Outdoor Ground Mounted: | | NA |
| | a) If flaming outside the unit is observed, separation distances to exposures shall be determined by greatest flame extension observed during test. | | NA |

| ANSI/CAN/UL 9540A | | | |
|---|---|---|---|
| Cl. | Requirement + Test | Result – Remark | Verdict |
| | 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; | | NA |
| | 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; | | NA |
| | 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 | | NA |
| | e) Heat flux in the center of the accessible means of egress shall not exceed 1.3 kW/m$^2$. | | NA |
| | Indoor Wall Mounted: | | NA |
| | a) Flaming outside the initiating BESS unit is not observed as demonstrated by no flaming or charring of the cheesecloth indicator; | | NA |
| | 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; | | NA |
| | 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; | | NA |
| | 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 | | NA |
| | e) The concentration of flammable gas does not exceed 25% LFL for the smallest intended room installation size. | | NA |
| | Outdoor Wall Mounted: | | NA |
| | a) Flaming outside the initiating BESS unit is not observed as demonstrated by no flaming or charring of the cheesecloth indicator; | | NA |
| | 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; | | NA |
| | 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 | | NA |
| | 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. | | NA |
| **10** | **Installation Level** | Not required see clause 9.8 | NA |
| **10.1** | **General** | | NA |

| ANSI/CAN/UL 9540A | | | |
|---|---|---|---|
| Cl. | Requirement + Test | Result – Remark | Verdict |
| 10.1.1 | The installation level test method assesses the effectiveness of the fire and explosion mitigation methods for the BESS in its intended installation. The installation level testing does not apply to residential use BESS. | | NA |
| | a) Test Method 1 – "Effectiveness of sprinklers" is used to evaluate the effectiveness of sprinkler fire protection and explosion mitigation methods installed in accordance with code requirements. | | NA |
| | b) Test Method 2 – "Effectiveness of fire protection plan" is used to evaluate the effectiveness of other fire and explosion mitigation methods. | | NA |
| 10.1.2 | Installation level testing is not appropriate for units only intended for outdoor use or residential use. | | NA |
| **10.2** | **Sample** | | NA |
| 10.2.1 | The samples (initiating BESS and target BESS) and their preparation for testing, including separation distances from walls, shall be identical to that used for the unit level test in Section 9. | | NA |
| 10.2.2 | A flame indicator consisting of a cable tray with fire rated cables that complies with UL 1685 and representative of the installation per the manufacturer's specifications shall be deployed above the BESS at a distance specified by end-use installation. | | NA |
| | If the installation requires that cabling be installed below the BESS, then the flame indicator is not needed. | | NA |
| **10.3** | **Test method 1 – Effectiveness of sprinklers** | | NA |
| 10.3.1~10.3.11 | Prepared according standard | | NA |
| 10.3.12 | An internal fire condition in accordance with the module level test shall be created within a single module in the initiating BESS unit: | | NA |
| 10.3.13 | The composition of BESS unit vent gases 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), total hydrocarbon analyzer, and hydrogen analyzer. The gas composition sampling port shall be located in the ceiling jet, 25-mm (1-in) below the ceiling. | | NA |
| 10.3.14 | The test shall be terminated if: | | NA |
| | a) Temperatures measured inside each module of the initiating BESS return to below the cell vent temperature; | | NA |
| | b) The fire propagates to adjacent units or to adjacent walls; or | | NA |
| | c) A condition hazardous to test staff or the test facility requires mitigation. | | NA |
| 10.3.15 | The initiating unit shall be under observation for 24 h after conclusion of the installation test to determine that re-ignition does not occur. | | NA |

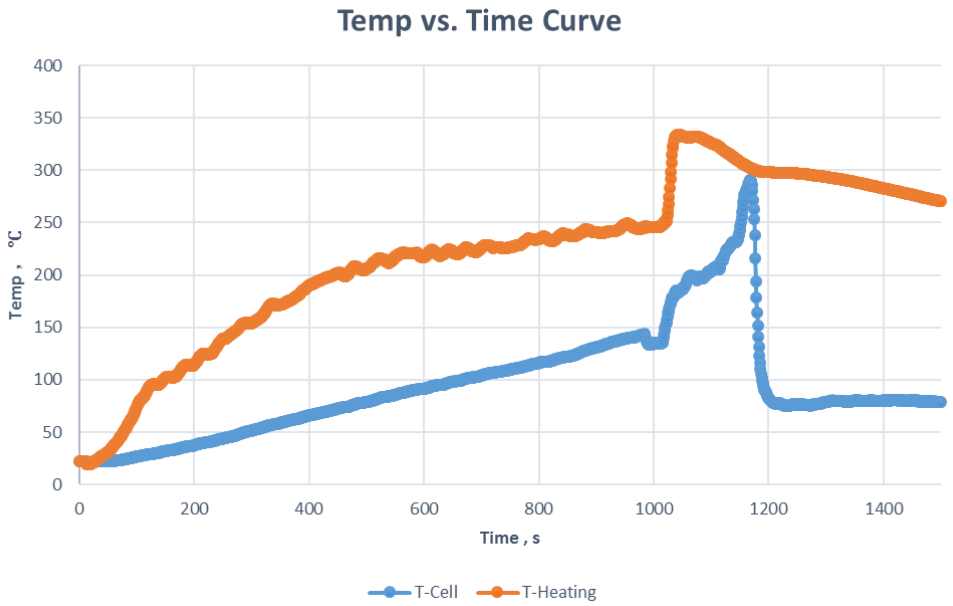
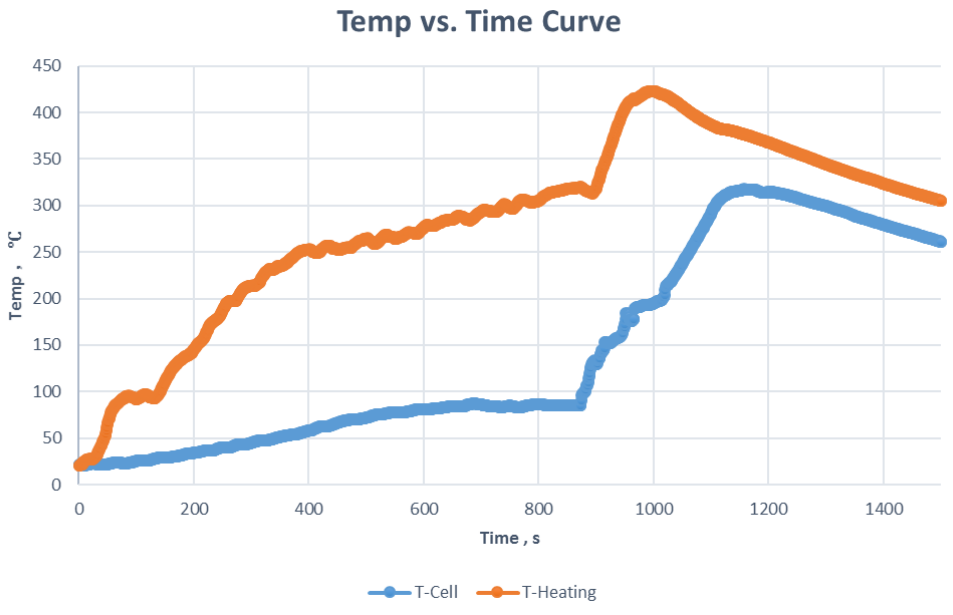
| ANSI/CAN/UL 9540A | | | |
|---|---|---|---|
| Cl. | Requirement + Test | Result – Remark | Verdict |
| **10.4** | **Installation level test report – Test method 1 – Effectiveness of sprinklers** | | NA |
| 10.4.1 | The report on installation level testing shall include the following: | | NA |
| | a) Unit manufacturer name and model number (and whether compliant with UL 9540); | | NA |
| | b) Number of modules in the initiating BESS unit; | | NA |
| | c) The construction of the initiating BESS unit per 5.3; | | NA |
| | d) Module voltage(s) of initiating BESS corresponding to the tested SOC; | | NA |
| | e) The thermal runaway initiation method used; | | NA |
| | f) Diagram and dimensions of the test setup including location of the initiating and target BESS units, and the locations of walls and ceilings; | | NA |
| | g) Location of initiating module within the BESS unit; | | NA |
| | h) Separation distances from the initiating BESS unit to; | | NA |
| | i) Separation distances from the initiating BESS unit to target BESS units; | | NA |
| | j) Distances of the flame indicator (if used) with respect to the BESS; | | NA |
| | k) Maximum temperature at the ceiling; | | NA |
| | l) Distance of fire spread within the flame indicator; | | NA |
| | m) The maximum wall surface and target BESS unit temperatures achieved during the test and the location of the measuring thermocouple; | | NA |
| | n) The maximum incident heat flux on target wall surfaces and target BESS units; | | NA |
| | o) Voltages of initiating BESS; | | NA |
| | p) Total number of sprinklers that operated and length of time the sprinklers operated during the test; | | NA |
| | q) Gas generation and composition data, if measured; | | NA |
| | r) Observation of flaming outside of the test room; | | NA |
| | s) Observation of flying debris or explosive discharge of gases; | | NA |
| | t) Observation of re-ignition(s) from thermal runaway events; | | NA |
| | u) Observations of the damage to: | | NA |
| | 1) The initiating BESS unit; | | NA |
| | 2) Target BESS units; and | | NA |
| | 3) Adjacent walls; | | NA |
| | v) Photos and video of the test; | | NA |
| | w) Fire protection features/detection/suppression systems within unit; and | | NA |
| | x) Sprinkler K-factor, RTI, manufacturer and model, number of sprinklers and layout. | | NA |

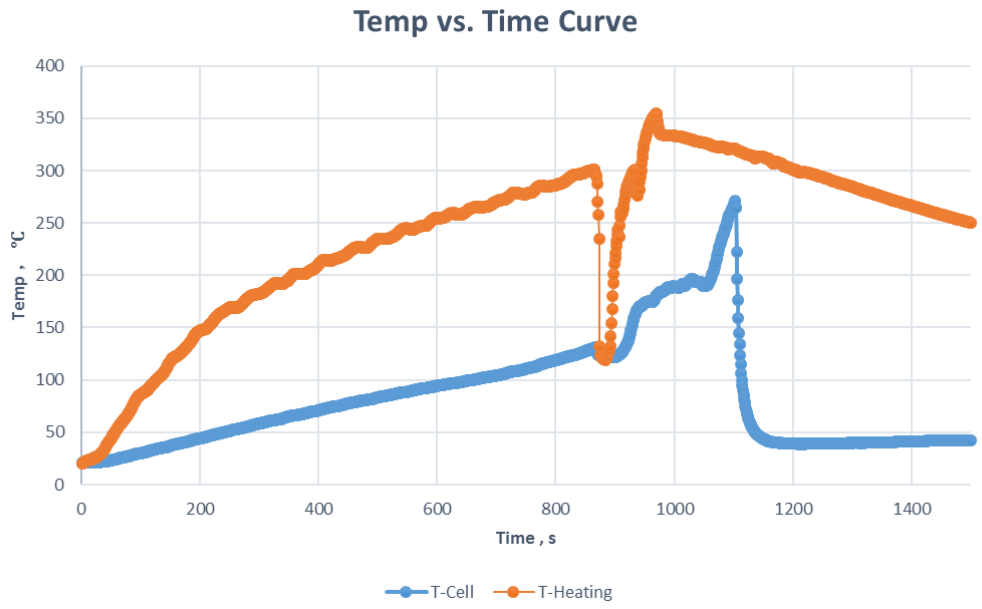
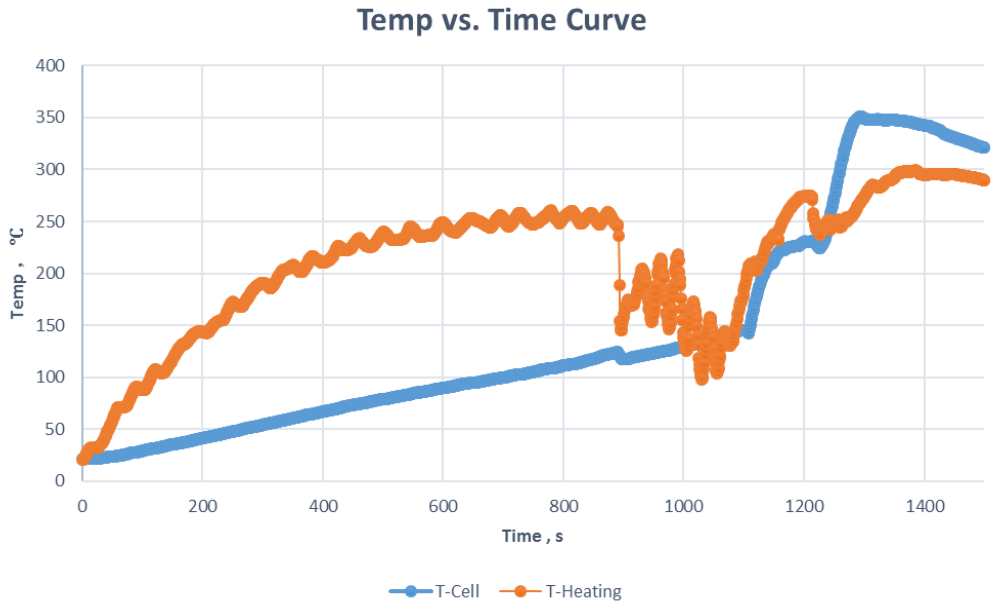
| ANSI/CAN/UL 9540A | | | |
|---|---|---|---|
| Cl. | Requirement + Test | Result – Remark | Verdict |
| **10.5** | **Performance – Test method 1 – Effectiveness of sprinklers** | | NA |
| 10.5.1 | For BESS units intended for installation in locations with combustible construction, surface temperature measurements along instrumented wall surfaces shall not exceed a temperature rise of 97°C (175°F) above ambient. Surface temperature rise is not applicable if the intended installation is composed completely of noncombustible materials in which wall assemblies, cables, wiring and any other combustible materials are not to be present in the BESS installation. In this case, the report shall note that the installation shall contain no combustible materials. | | NA |
| 10.5.1~10.5.8 | Prepared according standard | | NA |
| **10.6** | **Test method 2 – Effectiveness of fire protection plan** | | NA |
| 10.6.1 | The test method 2 test set-up and test procedures are identical to that in 10.3, except instead of the sprinkler system set up of 10.3.2, the room shall be fitted with the specified fire protection and explosion mitigation equipment representative of a planned installation for the tested BESS system. | | NA |
| **10.7** | **Installation level test report – Test method 2 – Effectiveness of fire protection plan** | | NA |
| 10.7.1 | The report on installation level testing shall include the following: | | NA |
| | a) The report information in 10.4.1 items (a) – (u), and (v) if applicable; | | NA |
| | b) Fire protection features/detection/suppression systems within installation; and | | NA |
| | c) Length of time of operation of the clean agent, or other suppression system in addition to any sprinklers used. | | NA |
| **10.8** | **Performance – Test method 2 – Effectiveness of fire protection plan** | | NA |
| 10.8.1 | See 10.5 for performance criteria. | | NA |
| **ANNEX A (INFORMATIVE)** | **Test Concepts And Application Of Test Results To Installations** | | - |
| **ANNEX B (INFORMATIVE)** | **Safety Recommendations for Testing** | | - |

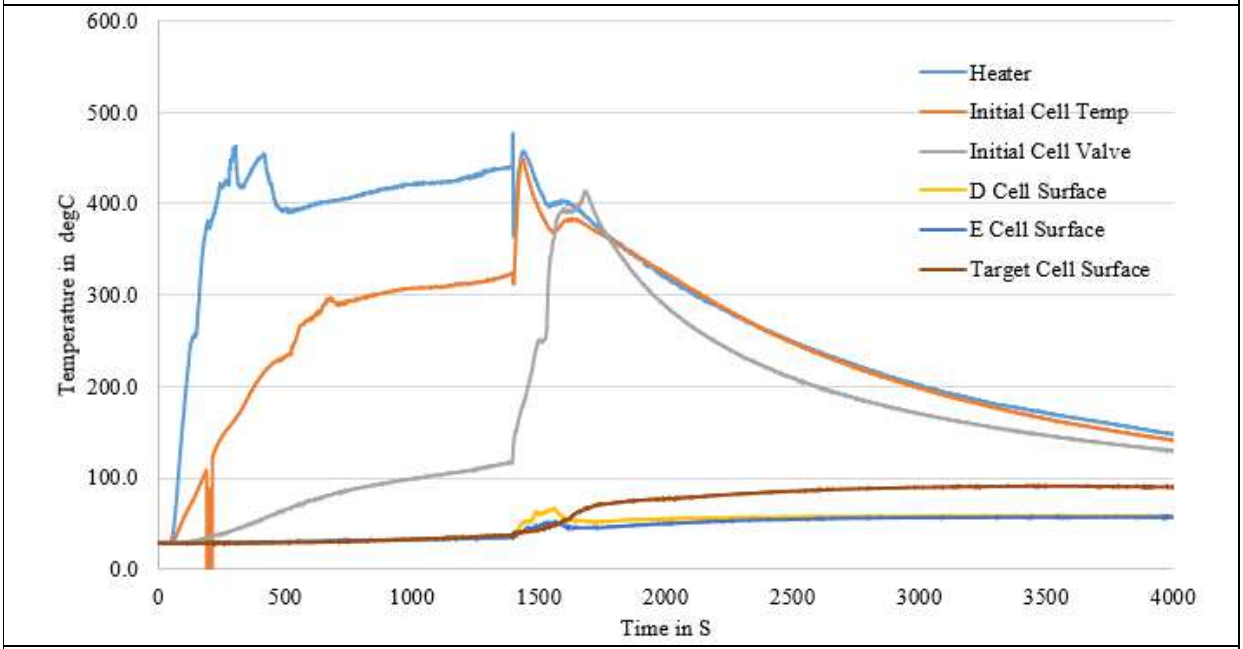
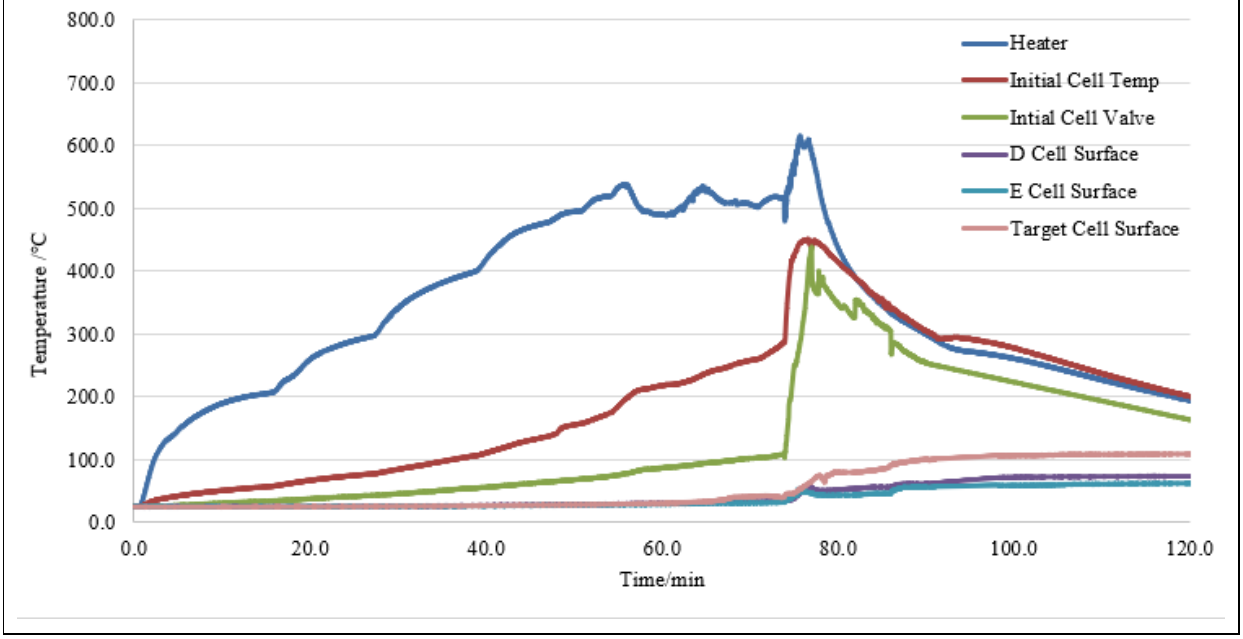
**Appended Tables:**

| **Table 7.4 Cell vent gas composition** -Gas Components | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| CO2 | CO | H2 | CH4 | C2H2 | C2H4 | C2H6 | C3H6 | C3H8 |
| 22.84 | 6.65 | 45.33 | 5.55 | 0.24 | 10.51 | 2.15 | 3.56 | 0.59 |

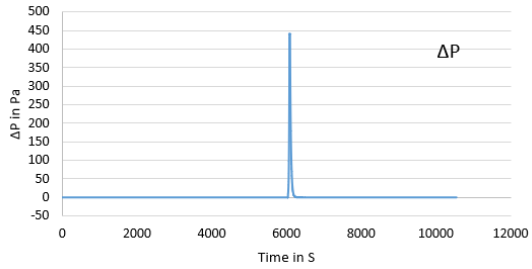
Temperature measure curve Cell

| Curve of Temperature |
| --- |
| Sample1 |
|  |
| Sample 2 |
|  |

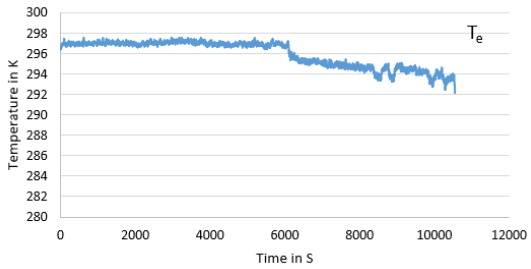
| Curve of Temperature |
| --- |
| Sample3 |
|  |
| Sample 4 |
|  |

| Curve of Temperature |
| --- |
| Module |
|  |
| Unit |
|  |

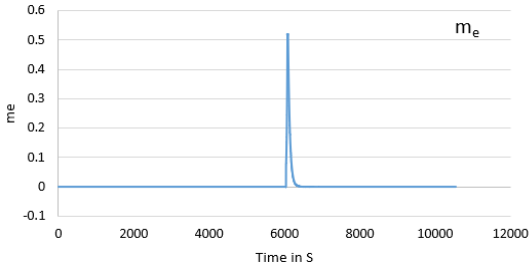
**Appended Curve: 8.3 g) Heat release rate versus time data**



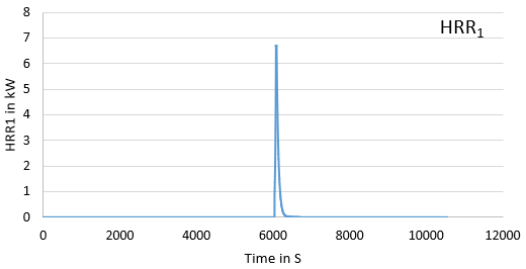

ΔP is adjusted to 0, before cell venting and after smoke is cleared




Orifice plate is 3m higher than test sample, so, its temperature is same as room temperature




$m_e$ is a caculated result according to ΔP and $T_e$

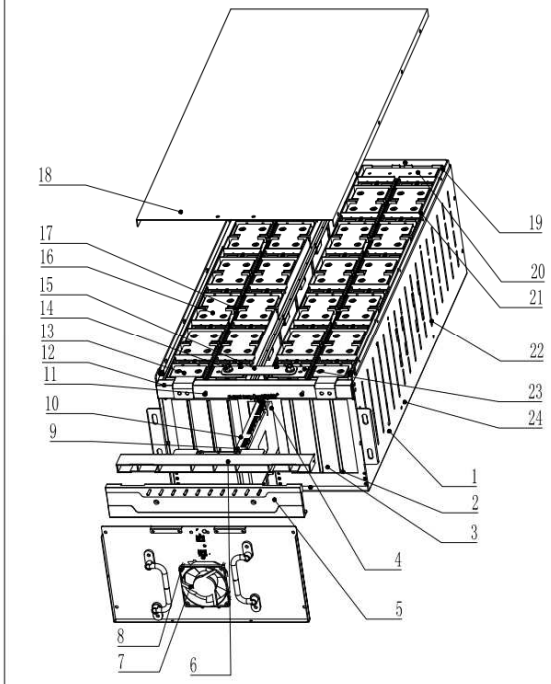



$HRR_1$ is a calculated result.
Test sample has no flame, so $HRR_1$ is small.

**Appended Table: 8.3 h) Flammable gas generation and composition data**

| Table 8.3 Flammable gas generation and composition data | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| CO2 | CO | H2 | CH4 | C2H2 | C2H4 | C2H6 | C3H6 | C3H8 |
| 17.15 | 4.90 | 58.38 | 4.37 | 0.23 | 7.80 | 1.64 | 3.20 | 0.48 |

## Annex 1: Drawing

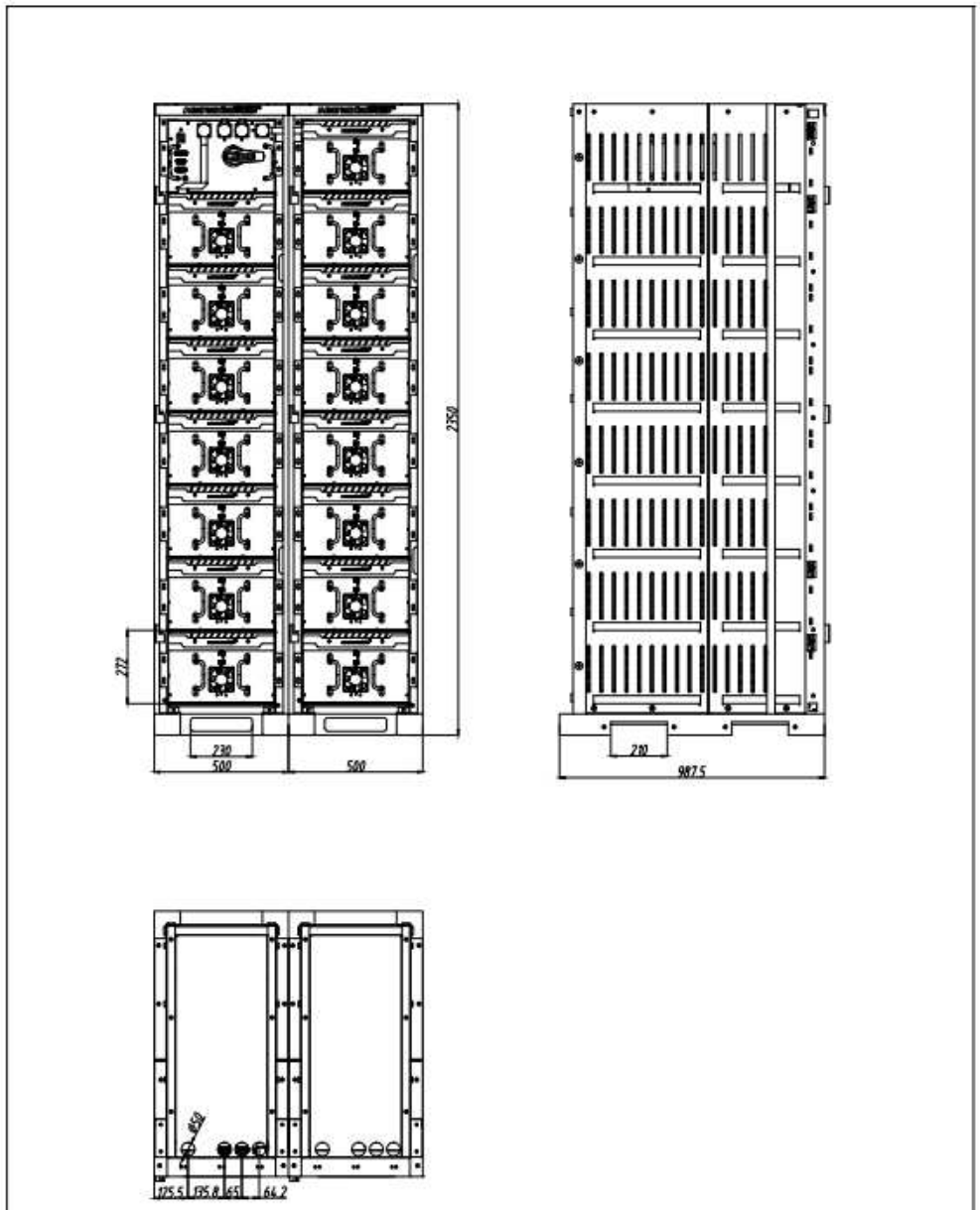



| NO. | Name | Description | quantity | Materials | SUM Weight | Mark |
|---|---|---|---|---|---|---|
| 24 | PFES250X24A.00-02 | Bottom epoxy | 1 | ERB t=0.5mm | | |
| 23 | PFES250X16.00-03 | Transfer LvPai | 2 | AL1060 | | |
| 22 | PFES250X24A.00-01 | Side epoxy | 2 | ERB t=0.5mm | | |
| 21 | PFES250X16.00-08 | upper bracket | 6 | PP+20%GF | | |
| 20 | PFES250X16.00-01 | Connection LvPai | 2 | AL1060 H24 | | |
| 19 | PFES210X16A1.00-08 | Front | 4 | Epoxy t=0.5mm | | L=60mm |
| 18 | PFES250X24A.00-03 | Top epoxy plate | 1 | ERB t=0.5mm | | |
| 17 | PFES250X16.00-12 | Low voltage acquisition | 1 | | | |
| 16 | PFES250X16.00-02 | Connection LvPai | 20 | AL1060 H24 | | |
| 15 | PFES250X16.00-05 | connected copper bar | 1 | red copperT2 | | |
| 14 | Nuts /M8 | Nuts/M8 | 2 | | | |
| 13 | PFES250X16.00-04 | Terminal bracket | 2 | AL1060 H24 | | |
| 12 | PFES250X16.00-06 | Terminal support | 1 | PP+20%GF | | |
| 11 | Bolt/M4×16 | Bolt/M4×16 | 2 | 304 | | |
| 10 | PFES210X16A1.00-05 | Bracket insulating board | 2 | ERB t=0.5mm | | |
| 9 | BMU,PCB,WH | BMU,PCB,WH | 1 | | | |
| 8 | Nuts/M3 | Nuts/M3 | 4 | 304 | | |
| 7 | fan/3414NHH | fan/3414NHH | 1 | | | |
| 6 | PFES250X16.00-07 | mound layer | 1 | PP+20%GF | | |
| 5 | PFES250X16.00-11 | shield | 1 | PP+20%GF | | |
| 4 | Nuts /M4 | Nuts /M4 | 4 | 304 | | |
| 3 | FE125A batteries | FE125A batteries | 48 | | | |
| 2 | PFES250X16.00-09 | lower bracket | 6 | PP+20%GF | | |
| 1 | PFES250X24A.01 | PFES250X24A | 1 | SGCC | | |

NARADA

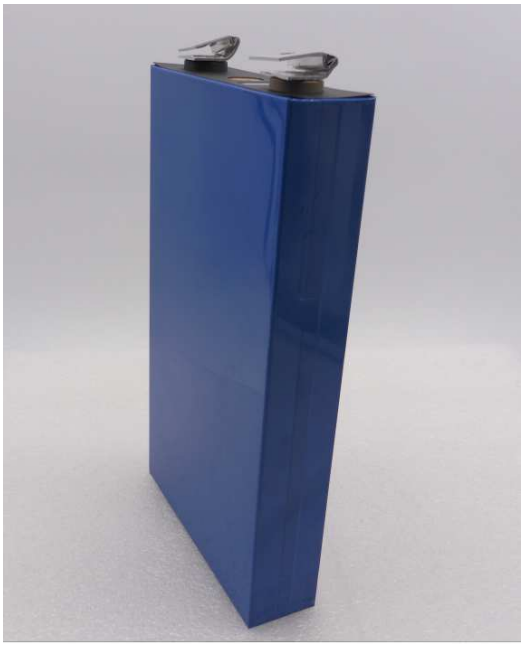
Mark | Place | Rev. document NO. | Signature | Date
Design | Standard check up | Drawing mark | Weight (kg) | Proportion
Proof
Technology check
Approve
Total:1 page | First page

## Annex 2: Drawings




| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | | | NARADA |
| Mark | Place | Rev. document NO. | | Signature | Date | | |
| Design | | | Standard check up | | | Drawing mark / Weight (kg) / Proportion | 76.8V NESP Rack drawing |
| Proof | | | | | | | |
| Technology check | | | | | | | ZNG |
| | | | Approve | | | Total:1 page First page | |

## Annex3: Photos

| Overview-cell |
| --- |
|  |
| Overview-cell |
|  |

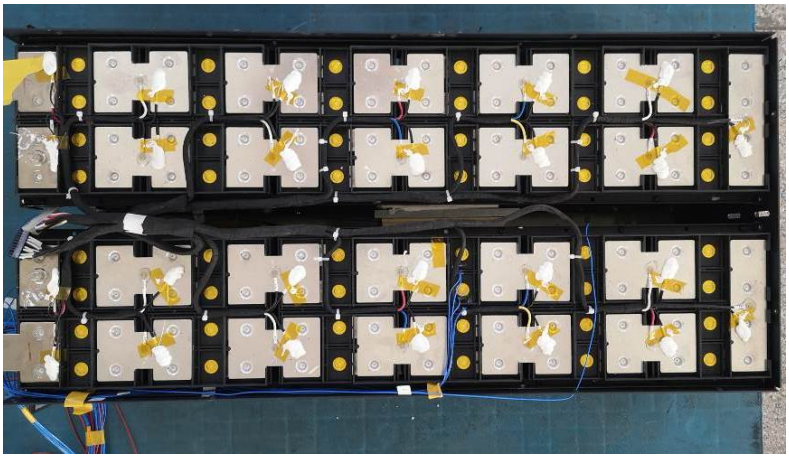
## Annex1: Photos

| Overview -after testing |
| --- |
|  |
| Overview -after testing |
|  |

## Annex 4-Photos

| Overview - module |
| --- |
|   |
| Overview - module |
|  |

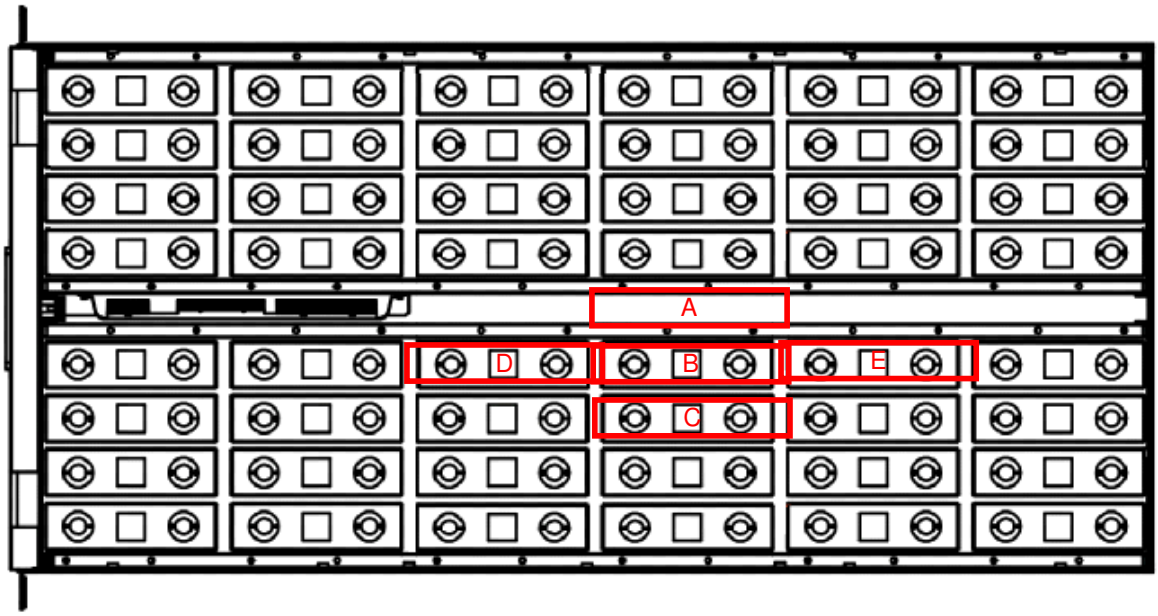
## Annex4x-Photos

| Overview – module before test |
| --- |
|  |
| Overview – module at test |
|  |

## Annex3-Photos of Unit

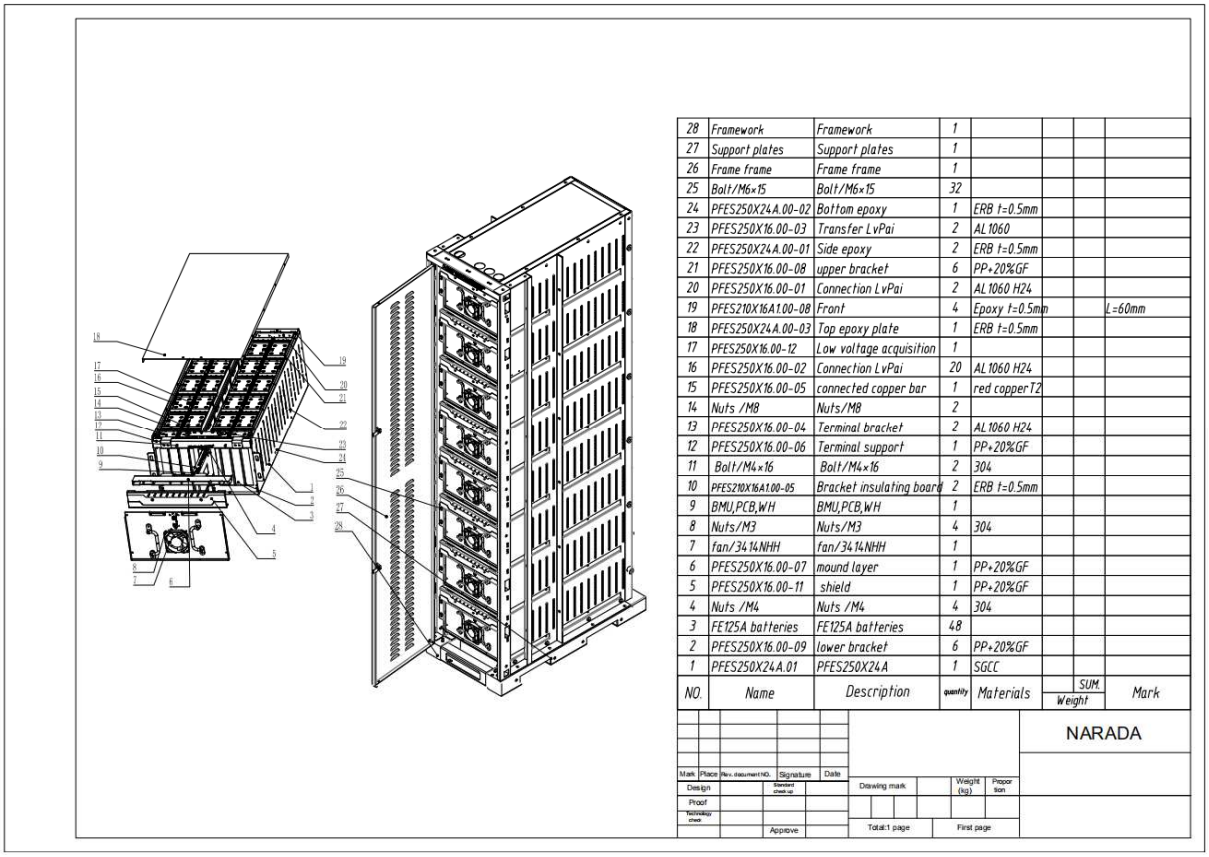
| Overview – Unit |
| --- |
|  |
| Overview – Unit |
|  |

## Annex 5 Description of 8.3

| Thermal runaway initiation method used including number and locations of cells for initiating thermal runaway |
|---|
|  |
| Make initial cell thermal runaway by heating;<br>Heat 1 cell, its position is marked as B.<br>Note:<br>A: Heat Film<br>B: Initial Cell<br>C: Target Cell<br>D: Adjoint Cell 1<br>E: Adjoint Cell 2 |

## Annex 6 The construction of the initiating BESS unit

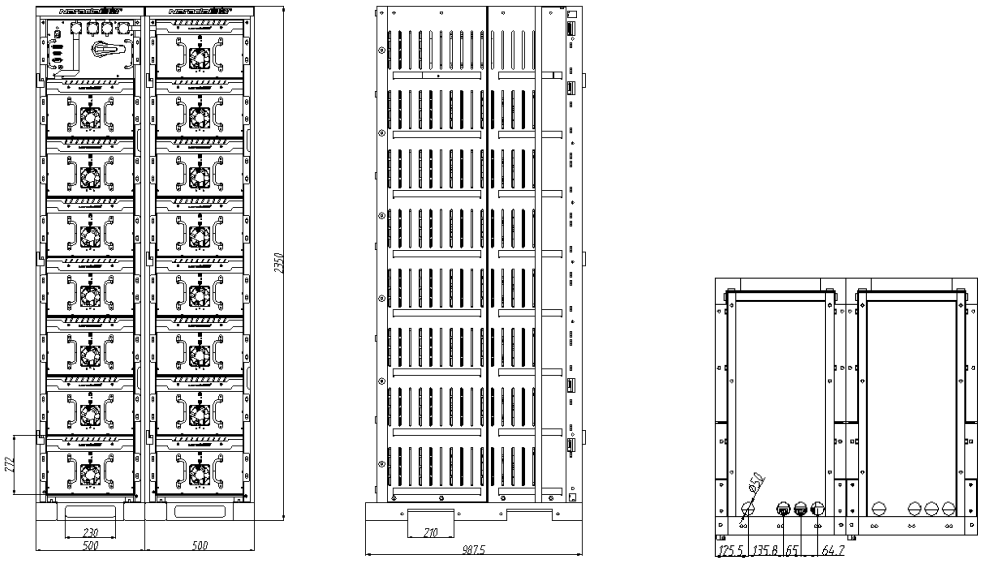
Internal construction for BESS unit



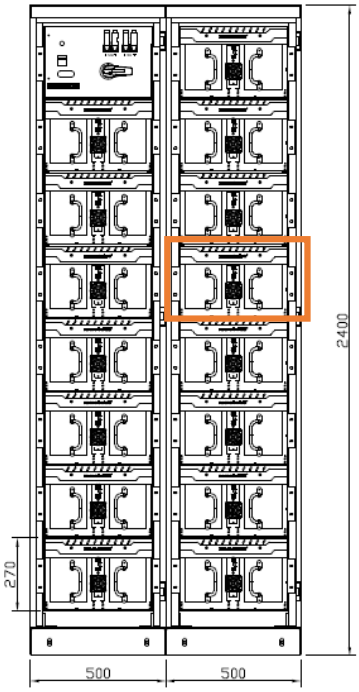
| NO. | Name | Description | quantity | Materials | SUM. Weight | Mark |
|---|---|---|---|---|---|---|
| 28 | Framework | Framework | 1 | | | |
| 27 | Support plates | Support plates | 1 | | | |
| 26 | Frame frame | Frame frame | 1 | | | |
| 25 | Bolt/M6×15 | Bolt/M6×15 | 32 | | | |
| 24 | PFES250X24A.00-02 | Bottom epoxy | 1 | ERB t=0.5mm | | |
| 23 | PFES250X16.00-03 | Transfer LvPai | 2 | AL1060 | | |
| 22 | PFES250X24A.00-01 | Side epoxy | 2 | ERB t=0.5mm | | |
| 21 | PFES250X16.00-08 | upper bracket | 6 | PP+20%GF | | |
| 20 | PFES250X16.00-01 | Connection LvPai | 2 | AL1060 H24 | | |
| 19 | PFES210X16A1.00-08 | Front | 4 | Epoxy t=0.5mm | | L=60mm |
| 18 | PFES250X24A.00-03 | Top epoxy plate | 1 | ERB t=0.5mm | | |
| 17 | PFES250X16.00-12 | Low voltage acquisition | 1 | | | |
| 16 | PFES250X16.00-02 | Connection LvPai | 20 | AL1060 H24 | | |
| 15 | PFES250X16.00-05 | connected copper bar | 1 | red copperT2 | | |
| 14 | Nuts /M8 | Nuts/M8 | 2 | | | |
| 13 | PFES250X16.00-04 | Terminal bracket | 2 | AL1060 H24 | | |
| 12 | PFES250X16.00-06 | Terminal support | 1 | PP+20%GF | | |
| 11 | Bolt/M4×16 | Bolt/M4×16 | 2 | 304 | | |
| 10 | PFES210X16A1.00-05 | Bracket insulating board | 2 | ERB t=0.5mm | | |
| 9 | BMU,PCB,WH | BMU,PCB,WH | 1 | | | |
| 8 | Nuts/M3 | Nuts/M3 | 4 | 304 | | |
| 7 | fan/3414NHH | fan/3414NHH | 1 | | | |
| 6 | PFES250X16.00-07 | mound layer | 1 | PP+20%GF | | |
| 5 | PFES250X16.00-11 | shield | 1 | PP+20%GF | | |
| 4 | Nuts /M4 | Nuts /M4 | 4 | 304 | | |
| 3 | FE125A batteries | FE125A batteries | 48 | | | |
| 2 | PFES250X16.00-09 | lower bracket | 6 | PP+20%GF | | |
| 1 | PFES250X24A.01 | PFES250X24A | 1 | SGCC | | |

NARADA

Dimensions for BESS Unit



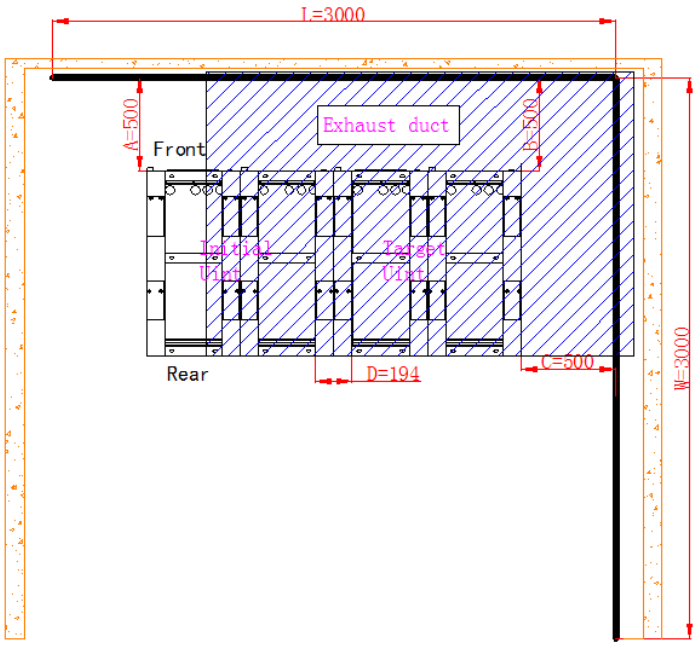
## Annex 7 Location of the initiating module within the BESS unit;



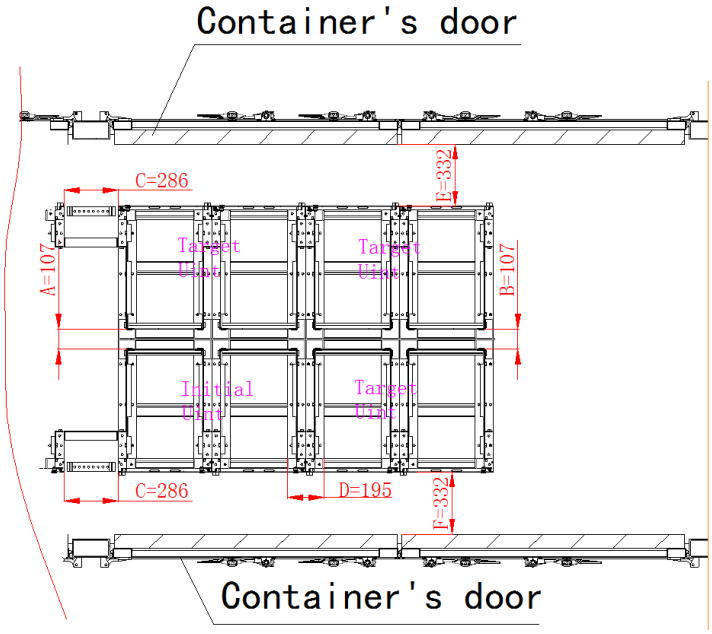

Location of Intial Module is marked as in orange square.

## Annex 8 Diagram and dimensions of the test setup

### Test1: In room setup




### Test 2: In container setup



## Annex 9 Photos of the unit test
## Test 1

| Overview – Unit before test |
| --- |
|  |
| Overview – Unit at test |
|  |

## Annex 9 Photos of the unit test

### Test 1

| Overview – Unit after test |
| --- |
|  |

## Annex 9 Photos of the unit test
## Test 2

| Overview – Unit before test |
| --- |
|  |
| Overview – Unit at test |
|  |

## Annex 9 Photos of the unit test
## Test 2

| Overview – Unit after test |
| --- |
|  |
| Overview – Unit after test |
|  |