Exhibit AS-1 (BCC hearing)

June 13, 2024 CSA Group test report on AES detection/suppression system

CSA GROUP

Laboratory Test Data – Custom Test (Installation Level)

ORIGINAL TEST DATA

The results relate only to the items tested.
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Master Contract:	N/A	Model:	AES Spec CEN-E5S Enclosure	Page number 1 of 36
Project / Network:	80202692	Description:	Energy Storage Installation	

Standard(s):	ANSI/CAN/UL 9540A:2019 Fourth Edition, Dated November 12, 2019 - Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems
Decision(s):	UL 9540A CRD Fourth Edition, Dated May 19, 2022 - Section / Paragraph Reference: Revised: 9.91, 10.1.2, 10.3.1, 10.4.1, 10.7.1. New: 4.4.1, 9.1.2.1, 10.1.1, 10.2.3, 10.3.16, 10.5.9, 10.6.2, 10.8.2 Subject: Test Approach for Multi-Battery Rack Container BESS
Deviations from Standard:	This is a custom test based on the methodology outlined in UL 9540A:2019, Section 10. An installation level test for container systems was already conducted (4790648557) with satisfactory results. This test was conducted for additional information to evaluate the performance of the fire protection system in the PHR3843-001A container energy storage system. - Temperature measurements were made in limited locations on container walls (§ 10.6.2.4) - No flame-indictor cable tray was located above the BESS (§10.2.2) - Module initiation utilized single insulated heater on one face of Cell 1, not consistent with module level test (§10.3.12).

Testing Laboratory Name: CSA Group

Address: 8801 E Pleasant Valley Rd, Independence, OH 44131

Testing Program: **Custom Test:** Cover Letter [ ] Testing Only [X]

Note: Mark " X " in applicable test program block

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

Testing Laboratory Name: SAFE Laboratories and Engineering Corp.

Address: 5901 Elwin Buchanan Dr, Sanford, NC 27330

As above / or describe otherwise

Customer: AES Clean Energy

Address: 282 Century Place Louisville, CO 80027, USA

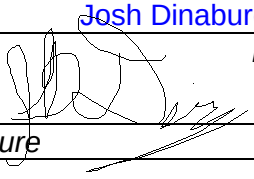
☒ **Tested By:** SAFE Laboratories and Engineering Corp.
Name, Title

Signature On File — ---
Signature — *Date (YYYY-MM-DD)*

☒ **Witnessed By:** Sara Bowen, Product Safety Engineer
Name, Title

Sara Bowen — 2024-08-29
Signature — *Date (YYYY-MM-DD)*

☒ **Written By:** Josh Dinaburg, Fire Testing Specialist
Name, Title



2024-08-29
Signature — *Date (YYYY-MM-DD)*

Master Contract:	N/A	Model:	AES Spec CEN-E5S Enclosure	Page number 2 of 36
Project / Network:	80202692	Description:	Energy Storage Installation	

Test Summary – Container System BESS Installation Level

On June 13, 2024 a custom test was conducted in accordance with the general procedures of a UL9540A Container System Installation Level test based on the Certification Requirement Decision dated May 19, 2022. This test was conducted to obtain engineering information about the performance of the detection/suppression system in the AES Spec CEN-E5S BESS Enclosure energy storage container prior to conduct of a large scale fire test. A previous installation level test was conducted by Underwriters' Laboratories on March 22, 2023 on this unit that demonstrated compliance with the criteria of UL9540A. This test was similar in setup and outcome but is not intended for application to certification due to several non-compliances in the setup and instrumentation scheme.

Thermal runaway was initiated in a single cell at the end of a module in a populated container using a thin film heater. This cell was selected because of access at the end of the module to install the heater and was not the same heater/cell setup as used in the previous module level testing. Smoke produced by thermal runaway of the cell activated the integral detection systems and initiated the release of the 50 kg / 25 bar NOVEC 1230 FK-5-1-12 clean agent suppression system in the container. The fire was extinguished in 37 seconds after activation and the NOVEC discharged for a total of 47 seconds. Thermal damage was limited to the initiating cell and propagation did not occur to adjacent cells or modules. No deflagration or explosion was observed and no temperatures in excess of the cell venting temperatures (166 °C) were measured on target modules in the initiating BESS unit. No temperatures on the container walls or target walls exceeded a temperature rise of 97 °C above the ambient condition. Heat fluxes in egress paths were measured below 1.3 kW/m². All temperatures returned to ambient within 6 hours of initiation. No re-ignition was observed after 6 hours and the test was terminated and the initiating module removed. The requirements of UL9540A dictate a 24 hour observation period that did not occur.

Product Details	
Test Request:	☐ Cell Level Testing ☐ Module Level Testing ☐ Unit Level Testing ☒ Installation Level Testing
Manufacturer	Cell: Samsung SDI CO LTD Module: Samsung SDI CO LTD Unit: Samsung SDI CO LTD
Brand name / Trademark	Cell: N/A Module: N/A Unit: N/A
Model Number	Cell: CP1495L101+ Module: E5S (MS3204L101A) Unit: PHR3843-001A (E5S)
Date of receipt of test sample(s)	2024/05
Cell/Battery Type	Prismatic (NCA Li-ion)
Approximate Dimension (mm)	Cell: 175.4 x 125.1 x 50.2 Module: 388.2 x 1751.8 x 155.0 (w/o bracket) Unit: 960.5 x 1752 x 2352
Mass (g)	Cell: 2,500 Module: 173,000 Unit: 2,524,000
DUT Sample/Serial Number	Cell: N/A Module: N/A Unit: N/A
DUT Nominal Voltage Rating (Vdc)	Cell: 3.68 Module: 110.4 Unit: 1324.8
DUT Nominal Charge Capacity Rating (Ah)	Cell: 145 Module: 290 Unit: 290
Fire Mitigation Strategies: (For installation level testing)	☐ Water: ☒ Other (Specify): NOVEC 1230 FK5-1-12 ☐ N/A
Additional Information	50 kg of NOVEC discharged from a cylinder at 25 bar

Cell Level Test Summary	
Name of test laboratory perform cell level testing:	UL Solutions
Unique identification of test report:	4790746849
Standard and its edition used for testing:	UL 9540A, 4th Edition
Manufacturer:	Samsung SDI CO LTD
Brand name / Trademark:	N/A
Model number:	CP1495L101+
Nominal cell voltage, (V)	3.68
Cell capacity, (Ah)	145
Cell chemistry:	Li-ion ($LiNiCoAlO_2$)
Physical format of cell:	Prismatic
Approximate dimension, (mm)	175.4 x 125.1 x 50.2
Mass, (g)	2,500
Method used to initiate thermal runaway:	Film Heater
Average temperature at which cell first vented excluding gas collection sample, (°C)	166
Average temperature prior to thermal runaway excluding gas collection sample, (°C)	178
Flammable gas generation, (Liter)	74.456
Total gas generation, (Liter)	82
Lower flammability limit (LFL) at ambient temperature (25 ± 5°C), (%)	8.04
Lower flammability limit (LFL) at average gas vent temperature, (%)	6.74
Burning velocity, (Cm/Sec)	86.40
Maximum pressure P_{max}, (psig)	726.02

Gas composition:

Gas	Measured %
Hydrogen	32.7 %
Carbon monoxide	40.9 %
Methane	15.43 %
Ethylene	0.56 %
Ethane	1.06 %
Carbon dioxide	9.2 %
Propene (Propylene)	0.04 %
Propane	0.03 %
C4 Total	0.05 %
C5 Total	0.01 %
Benzene	0.06 %
Total	**100 %**

Module Level Test Summary	
Name of test laboratory perform module level testing:	UL Solutions
Unique identification of test report:	4790351859
Standard and its edition used for testing:	UL 9540A, 4th Edition
Manufacturer:	Samsung SDI CO LTD
Brand name / Trademark:	N/A
Model number:	E5S (MS3204L101A)
Nominal voltage rating, (V)	110.4
Nominal capacity rating, (Ah)	290
Approximate dimension, (mm)	388.2 x 1751.8 x 155.0 (w/o bracket)
Method used to initiate thermal runaway:	Film Heater
Number of cells used for initiating thermal runaway:	1
Cell to cell propagation condition:	Occurred (All 60 cells)
Peak chemical heat release rate, (kW)	3,935
Flammable gas generation, (Liter)	2,104.87
Total gas generation, (Liter)	41,647.37
Peak Smoke Release Rate (m^2/s)	7.06
Total Smoke Released (m^2)	3,516
Weight loss, (%)	90.3

Gas composition:

Table 8– Summary of battery gas volumes for deflagration hazard calculations

Gas Component	Gas Type	During Pre-flaming (L)	During Flaming (L)	Minimum detectable flow rate(LPM)
Total Hydrocarbons (Propane Equivalent)	Hydrocarbons	6.61	677.14	0.04
Carbon Dioxide	Carbon Containing	Below detectable limit	39542.50	3.11
Carbon Monoxide	Carbon Containing	Below detectable limit	1421.12	0.44
Hydrogen	Hydrogen	*	*	*

*The hydrogen measurement system malfunctioned during the test, however, the same module design was tested with different charging specifications and the hydrogen quantity was below detectable limits Please refer to the report under UL project 4790648531.

Additional Information:	---

Master Contract:	N/A	Model:	AES Spec CEN-E5S Enclosure	Page number 6 of 36
Project / Network:	80202692	Description:	Energy Storage Installation	

Unit Level Test Summary	
Manufacturer:	Samsung SDI CO LTD
Brand name / Trademark:	N/A
Model number:	PHR3843-001A (E5S)
Nominal voltage rating, (V)	1324.8
Nominal capacity rating, (Ah)	290
Approximate dimension, (mm)	960.5 x 1752 x 2352
BESS test configuration/intended installation:	Non-residential indoor floor mounted
Unit certification available?, (Yes/No)	Yes
Standard(s) used to certify product:	UL 9540A, 4th Edition
Certification organization name and its certificate number:	UL Solutions, MH49407
Electrical configuration of module in BESS:	30S/2P
Number of modules in BESS:	24
Fire detection and suppression system integral part of BESS:	Yes
Test conducted with fire detection and suppression system:	Yes
Method used to initiate thermal runaway:	Film Heater
Number of cells used for initiating thermal runaway:	1
Number of cells exhibited thermal runaway within initiating module:	1
Number of modules exhibited thermal runaway within initiating BESS:	1
Cell to cell propagation condition:	No propagation
Peak chemical heat release rate, (kW)	426.1
Peak convective heat release Rate, (kw)	191.4
Flammable gas generation, (Liter)	343.97 Hydrocarbons reported as “Inconclusive” A separate Installation Level Report (4790648557) summarizes this test and reports the hydrocarbon production as an additional 3,340.26 Liters of flammable gas Hydrogen was below detectable limits
Total gas generation, (Liter)	1,132.97

Gas composition:

Summary of Unit level test Gas Analysis Data:

Unit level Gas Composition & Volume for Each Compound (Pre-flaming and After flame):

Gas Compound	Gas Type	Pre-Flaming (L)	Flaming (L)	Minimum detectable flow rate(LPM)
Total Hydrocarbons (Propane Equivalent)	Hydrocarbons[3]	Inconclusive	Inconclusive	2.21
Carbon Dioxide	Carbon Containing	Below detectable limit	343.97	11.24
Carbon Monoxide	Carbon Containing	Below detectable limit	789	8.91
Hydrogen	Hydrogen	Below detectable limit	Below detectable limit	20.67

Maximum wall surface temperature, (°C)	169
Maximum target BESS temperature, (°C)	31
Maximum ceiling or soffit surface temperatures, (°C)	N/A
Maximum incident heat flux on target wall surfaces, (kw/m^2)	6.74
Maximum incident heat flux on target BESS, (kw/m^2)	0.70
Maximum incident heat flux of egress path, (kw/m^2)	6.60
Maximum incident heat flux on target ceiling or soffit surfaces, (kw/m^2)	N/A
Total smoke release, (m^2)	269.37
Peak smoke release rate, (m^2/s)	1.1
Additional Information:	NOVEC Firefighting system utilized activated by alarm of two smoke detectors 50 kg at 25 bar

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)

Section	Requirement	Comments
10	Installation Level Testing	
10.1	The installation level test method assesses the effectiveness of the fire and explosion mitigation methods for the BESS in its intended installation.	
	Test Method	☐ Test Method 1: Effectiveness of sprinklers ☐ Test method 2: Effectiveness of fire protection plan ☒ Test Method: Container System BESS Installation Level Test
	See Attachment 5 for Installation Manual	
	BESS is not intended for outdoor installation only or residential use.	☐ Conformed ☒ N/A Per Section 10.1.2
10.1.2	Container system BESS for outdoor use installations are included in the installation level test as the container. This may include integral fire detection and suppression and integral explosion protection.	BESS is evaluated for installation level testing per the CRD Dated May 2022: Test Approach for Multi-Battery Rack Container BESS. Unit Level test was conducted in accordance with the CRD for non-residential indoor floor mount condition.
10.2	Sample	
	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.	☒ Conformed
	A flame indicator consisting of a cable tray	☐ Used during testing as it complies with UL 1685 and representative of installation per manufacturer's specification used at XX m above BESS ☐ Not used; cabling to be installed below the BESS ☒ Other (Specify): No cable tray included in test
10.3	Test method 1 – Effectiveness of sprinklers	Not Applicable
	No. 24-gauge or smaller, Type-K exposed junction thermocouples installed to measure the temperature of the surface proximate to the	☒ Conformed

Section	Requirement	Comments
	cells and between the cells and exposed face of the initiating module. Each non-initiating module enclosure within the initiating BESS unit instrumented with at least one No. 24-gauge or smaller Type-K thermocouple(s) to provide data to monitor the thermal conditions within non-initiating modules. Additional thermocouples placed to account for convoluted enclosure interior geometries.	Surrounding units of initiating units/modules were monitored, as well as units in target unit closest to initiating module position.
	An internal fire condition in accordance with the module level test created within a single module in the initiating BESS unit:	☒ Conformed
	a) The position of the module 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	☒ Conformed Module 6 the mid height of Unit 8 was selected. See Figure 2.2.
	b) The setup (i.e. type, quantity and positioning) of equipment for initiating thermal runaway in the module is same as that used to initiate and propagate thermal runaway within the module level test (Section 8).	☐ Conformed Alternative initiation method used compared to module level level test. 480 Watt heater placed on a single surface of Cell 1 and insulated to the cover. See Figure 2.1. Cell heating ramp of 6.79 °C/min achieved.
	a) Temperatures measured inside each module within the initiating BESS unit return to below cell vent temperature	☒ Conformed Initiating cell temperature returned to ambient
	b) The fire propagates to adjacent units or to adjacent walls; or	No propagation to adjacent units or walls.
	c) A condition hazardous to test staff or the test facility requires mitigation.	No hazardous condition developed.
	The initiating unit shall be under observation for 24 h after conclusion of the installation test to determine that re-ignition does not occur.	☒ Conformed

10.4	Installation level test report – Test method 1 – Effectiveness of sprinklers Installation level test report	Not Applicable BESS Installation Test method 2 used.
10.5	Performance – Test method 1 – Effectiveness of sprinklers	
10.5.1	BESS installation location	☒ Not applicable for container system BESS
10.5.2	Surface temperature of module within BESS unit adjacent to initiating unit.	☒ Does not exceed cell venting temperature of 166 °C ☐ Exceed cell venting temperature
10.5.3	Fire spread on the cables in the flame indicator	☐ Yes ☐ No ☒ Flame Indicator cable tray not used
10.5.4	Flaming outside the test room	☐ Yes ☒ No
10.5.5	Observation of detonation or deflagration unless mitigated by an engineered deflagration protection system	☐ Yes ☒ No
10.5.6	Heat flux in the center of the accessible means of egress	☒ Does not exceed 1.3 kW/m^2. ☐ Exceed 1.3 kW/m^2.
10.5.7	Observation of re-ignition within the initiating unit after the installation test had been concluded and the sprinkler operation was discontinued	☐ Yes ☒ No
10.5.8	Non-compliant results indicate the need for installation system revision and retest	☐ Yes ☒ No
10.5.9	Test Method - Container System BESS Installation Level (Test Method 1) - Performance	
10.5.9.1	Performance of container system BESS comply with 10.5.2 through 10.5.8 except:	
	a) Temperatures on any combustible construction within the container including target components shall not exceed a temperature rise of 97°C above ambient.	☐ Yes ☒ No
	b) There shall be no flaming outside of the container if intended for indoor installation.	Not Intended for indoor installation. No flaming was observed outside the container.
10.6	Test method 2 – Effectiveness of fire protection plan	
10.6.1	Fire protection and explosion mitigation equipment were representative of a planned installation.	The BESS Unit includes a smoke detection and NOVEC system as a fire suppression system. Once smoke is detected by two smoke detectors a signal is sent to the fire control panel, which will open the solenoid valve on the NOVEC cylinder for NOVEC to be released into the integral suppression system pipes.

Master Contract:	N/A	Model:	AES Spec CEN-E5S Enclosure	Page number 11 of 36
Project / Network:	80202692	Description:	Energy Storage Installation	

		See Attachment 12 for Installation Manual
10.6.2	Test Method - Container System BESS Installation Level (Test Method 2)	
10.6.2.1	Container with alternative fire suppression system was tested in accordance with 10.6 except as noted in 10.6.2.2 through 10.6.2.5	☒ Conformed
10.6.2.2	The actual container was used as the test room.	☒ Conformed
10.6.2.3	Installation included targets for major components in the container and temperatures shall be measured on the targets.	☒ Conformed No major combustible targets were included in the container. Temperatures were measured on modules.
10.6.2.4	Container wall surface temperatures were measured in vertical arrays with 304 mm (12 in) intervals for the full height of test walls with 24 gauge or smaller, type K, exposed thermocouples placed horizontally to receive the greatest thermal exposure from the initiating BESS.	☐ Conformed Container wall surface temperatures were not measured. An External wall was placed at a distance of 3.048 m (10 ft) from the front side of the initiating container. Walls were constructed with 16-mm (5/8-in) gypsum wall board, painted flat black. Wall surface temperatures were measured in vertical array(s) at 152-mm (6-in) intervals for the full height using No. 24-gauge, Type-K exposed junction thermocouples secured to the gypsum. An additional narrow column of gypsum board was located to the left side of the initiating container. Temperatures were measured at heights of 3,6,9, and 12 feet.
10.6.2.5	Heat flux was measured with the sensing element of at least two water-cooled Schmidt-Boelter or Gardon gauges at the surface of each instrumented wall.	☒ Conformed
	a) Both were collinear with the vertical thermocouple array.	☒ Conformed
	b) One was positioned at the elevation estimated to receive the greatest heat flux due to the thermal runaway of the initiating module	☒ Conformed
	c) One was positioned at the elevation estimated to receive the greatest heat flux during potential propagation of thermal runaway within the initiating BESS unit.	☒ Conformed
	Heat flux was measured continuously, averaging over every 60 second interval.	☒ Conformed

	The maximum of these averages was documented for each gauge location.	☒ Conformed
10.7	Installation level test report – Test method 2 – Effectiveness of fire protection plan Includes (a) – (x) from section 10.4.1 and (y) and (z) if applicable	
	a) Unit manufacturer name and model number (and whether compliant with UL 9540 or UL 1973) and the container system BESS manufacturer name and model number (and whether compliant with UL 9540);	Samsung SDI PHR3843-001A (E5S) UL 1973 (MH49407)
	b) Number of modules in the initiating BESS unit;	12
	c) The construction of the initiating BESS unit per 5.3, and the number of battery system racks and overall construction within the container for a container system BESS;	See Attachment 2 and Critical Components List – Attachment 6.
	d) Module voltage(s) of initiating BESS corresponding to the tested SOC;	123.3 VDC
	e) The thermal runaway initiation method used;	Thin film heater placed on the end surface of the rear right cell (Cell 1) in the module and insulated between the heater and the end casing. See Figure 2.1 A single thin film Kapton heater, 10 W/in^2 was applied. 480 W, 120 Volt.
	f) Diagram and dimensions of the test setup including location of the initiating and target BESS units, and the locations of walls and ceilings, and location of included internal target components in the container system BESS (e.g. target integral power conditioning system or integral switch gear enclosure, etc.);	See Attachment 2.
	g) Location of initiating module within the BESS unit;	See Figure 2.2 in Attachment 2.
	h) Separation distances from the initiating BESS unit to target walls	See Figure 2.5 in Attachment 2.
	i) Separation distances from the initiating BESS unit to target BESS units (e.g. distances D and E inFigure 10.1);	Spacing dictated by internal rack. No spacing between Units. See Figure 2.3 in Attachment 2.
	j) Distances of the flame indicator (if used) with respect to the BESS (e. g. distances A and B in Figure 10.2);	No Flame Indicator used.
	k) Maximum temperature at the ceiling or, for a container BESS, maximum temperature of the container ceiling;	Container ceiling temperatures were not measured.

	l) Distance of fire spread within the flame indicator or indication of fire spread through wiring in a container system BESS;	See Figure 2.10.
	m) The maximum wall surface and target BESS unit temperatures achieved during the test and the location of the measuring thermocouple;	See Attachment 3.
	n) The maximum incident heat flux on target wall surfaces and target BESS units;	See Attachment 4.
	o) Voltages of initiating BESS;	1484 Volts. See Attachment 3.
	p) Total number of sprinklers that operated and length of time the sprinklers operated during the test;	Not Applicable
	q) Gas generation and composition data, if measured;	Not Applicable
	r) Observation of flaming outsde of the test room or container and the length and location of the external flaming;	No flaming outside of the container. See Attachment 5.
	s) Observation of installed explosion /deflagration protection operation and maximum pressures measured at deflagration vents;	No actuation of deflagation protection vents.
	t) Observation of flying debris or explosive discharge of gases;	No flying debris or explosive discharge of gases.
	u) Observation of re-ignition(s) from thermal runaway events;	No reignition. Only monitored for 6 hours when all temperatures returned to ambient and not 24 hours.
	v) Observations of the damage to: 1) The initiating BESS unit 2) Target BESS units; and 3) Adjacent walls;	See Attachment 1.
	w) Photos and video of the test;	See Attachment 1.
	x) Fire protection features / detection /suppression systems within unit; and	50 kg – 25 bar NOVEC 1230 system actuated when two smoke detectors enter alarm.
	y) Explosion and deflagration protection; and	See Figure 2.5 in Attachment 1.
	z) Sprinkler K-factor, RTI, manufacturer and model, number of sprinklers and layout.	Not Applicable
10.8	Performance – Test method 2 – Effectiveness of fire protection plan	
10.8.1	See 10.5 for performance criteria	
10.8.2	10.8.2 Test Method - Container System BESS Installation Level (Test Method 2) - Performance	
10.8.2.1	See 10.5.9 for performance criteria for container system.	☐ Conformed ☒ All measured criteria conformed with requirements; not all required data points collected for custom test

Attachments

Index of Attachments

Attachment 1 – Photo

General sample photos

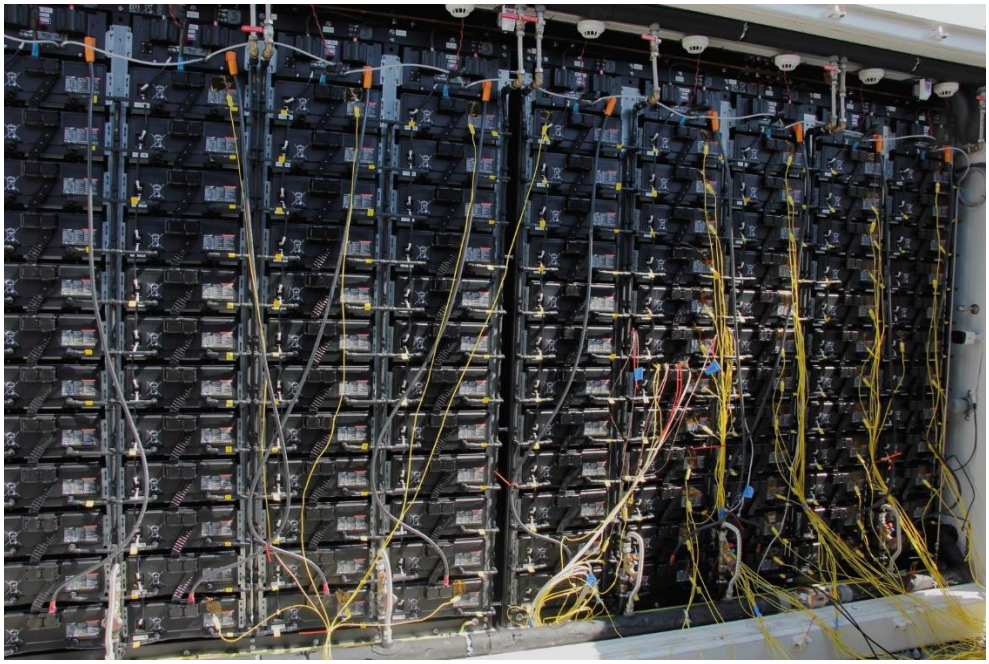


Figure 2.1: Interior of initiating container, Unit Racks 2-10 up to the dividing barrier between Unit 10 and Unit 11

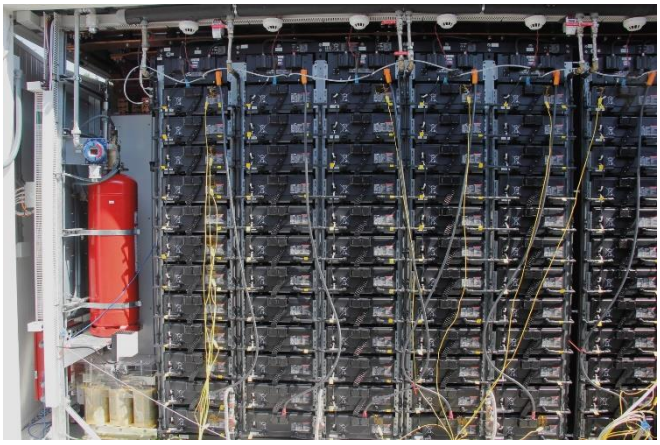


Figure 2.2: Instrumented Units 1-6 and NOVEC cylinder in container

Figure 2.3: Initiating and target containers sealed and in the test area

Attachment 1 – Photo

Figure 2.4: Location of instrumented column near container

Figure 2.5: Location and specification of deflagration panels on top of container

Photos with heater and thermocouple installation

Figure 2.6: Location of primary (left) and secondary (right) film heaters on Cells 1 and 2, respectively

Figure 2.7: Pre-Test conducted on single module to confirm propagation from Cell 1 to Cell 3, post test damage

Attachment 1 – Photo

Photos during test in progress

Figure 2.8: At test start (Time in 13:11)

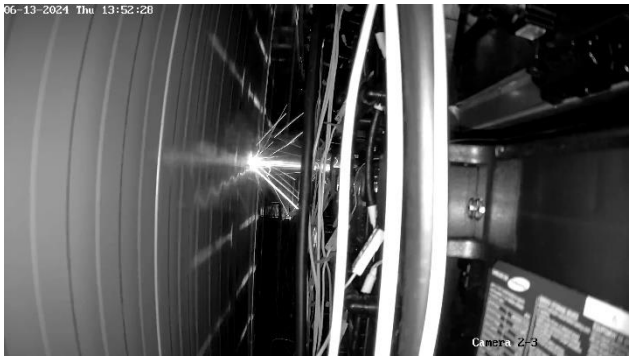


Figure 2.9: During cell venting (Time in 13:52)

Figure 2.10: During thermal runaway (Time in 13:52)

Figure 2.11: During NOVEC realease (Time in 13:52)

Photos after test

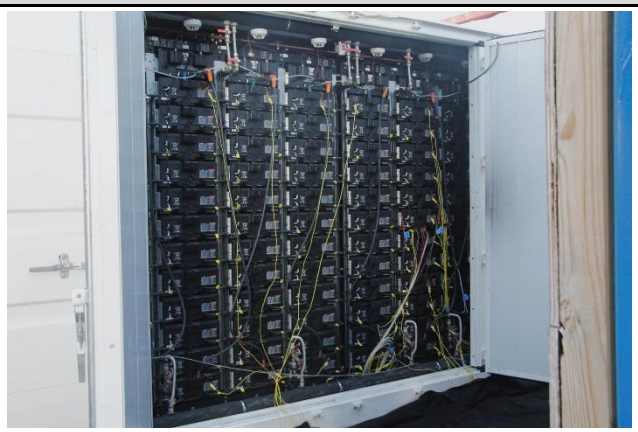


Figure 2.12: After test stopped

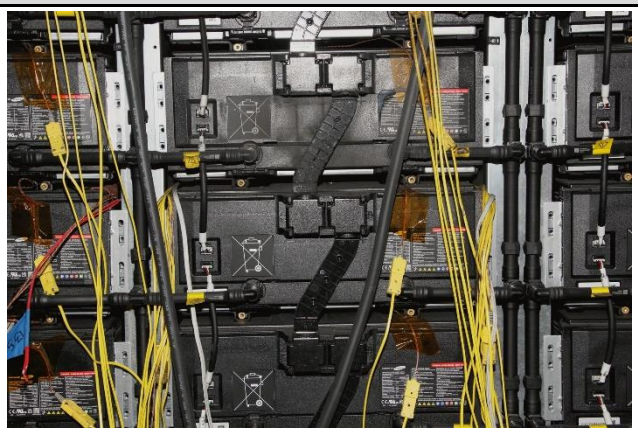


Figure 2.13: After test initiating module

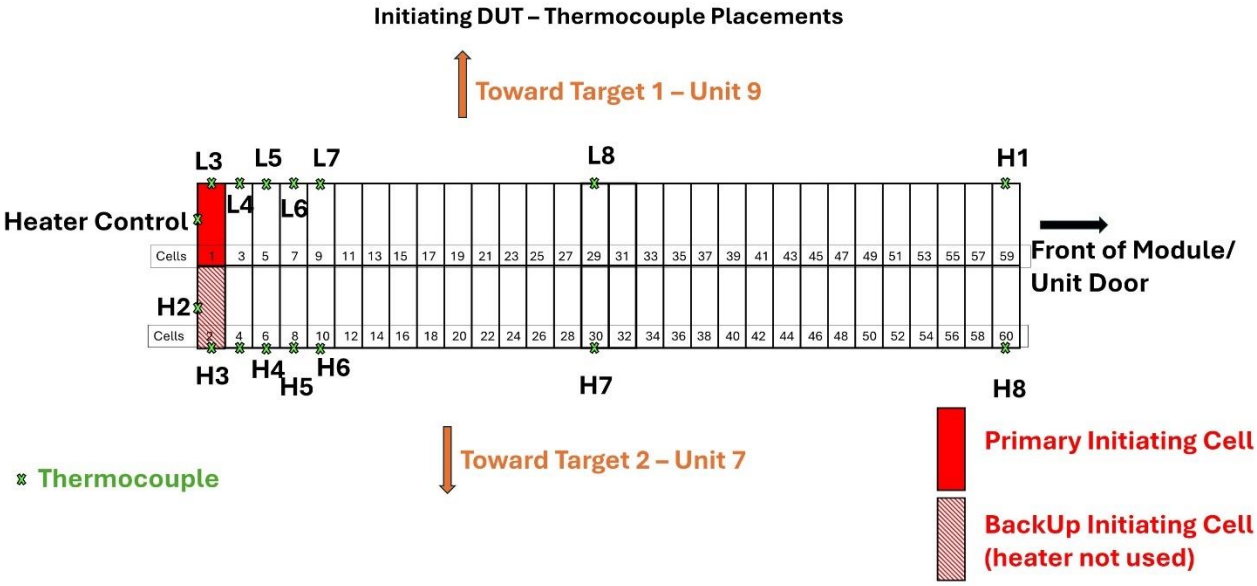
Attachment 1 – Photo

Figure 2.14: After test container

Figure 2.15: After test initiating module soot

Attachment 2 - Diagrams and dimensions of test setup

Location	Lab ID Code
Cell 1	L3
Cell 3	L4
Cell 5	L5
Cell 7	L6
Cell 9	L7
Cell 29	L8
Cell 59	H1
Cell 2	H2
Cell 4	H3
Cell 6	H4
Cell 8	H5
Cell 10	H6
Cell 30	H7
Cell 60	H8



The 200 W, 120 VAC heater was placed on the rear surface of Cell 1 only. A layer of approximately 1 inch of rock wool insulation was then placed between the heater and the module casing to direct heat toward the cell.

Figure 2.1: Placement and Test Lab ID Code of thermocouples and heaters in the initiating module

Master Contract:	N/A	Model:	AES Spec CEN-E5S Enclosure	Page number 20 of 36
Project / Network:	80202692	Description:	Energy Storage Installation	

Attachment 2 - Diagrams and dimensions of test setup

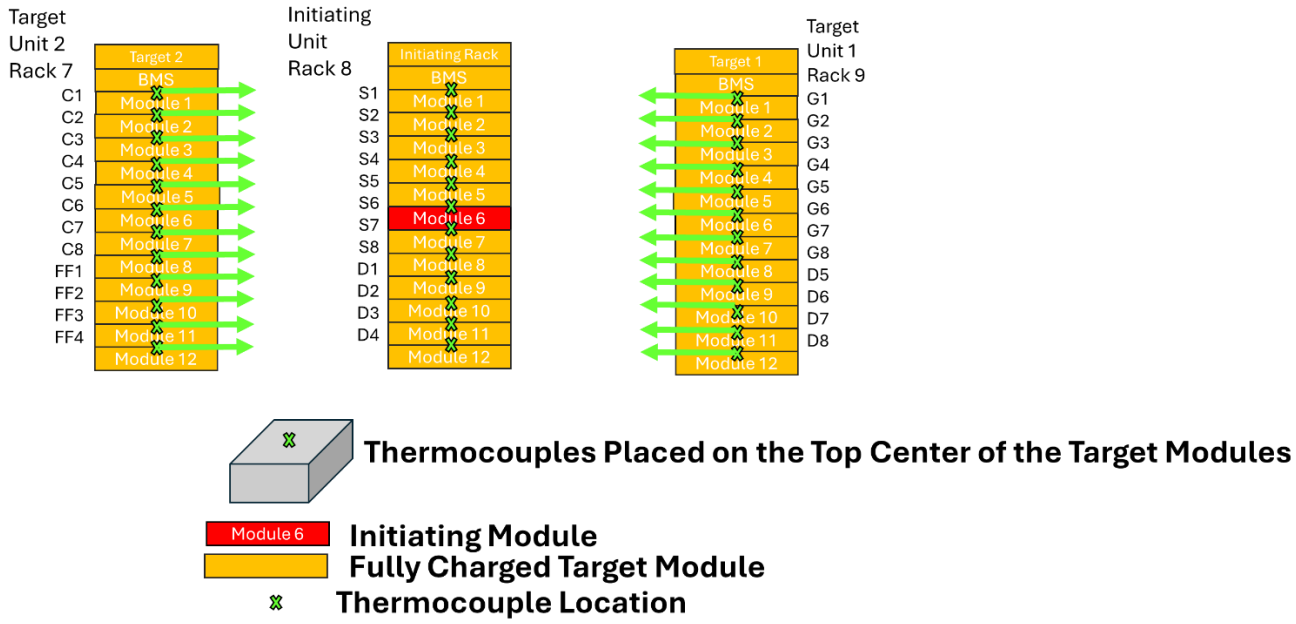


Figure 2.2 Placement of thermocouples on modules in the initiating and target BESS Units

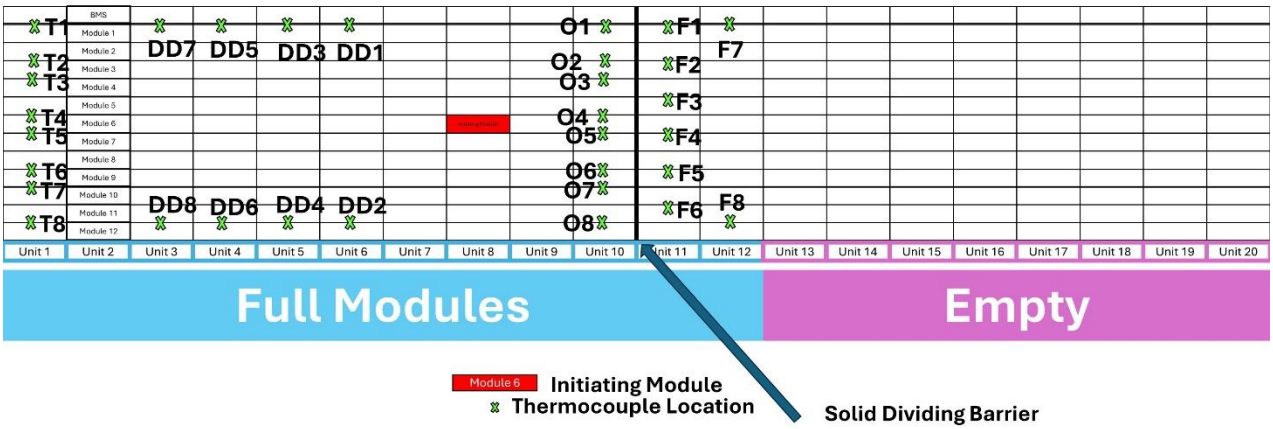


Figure 2.3 Placement and of thermocouples on modules in the container and the location of modules populating the Unit Racks in the Container

Attachment 2 - Diagrams and dimensions of test setup

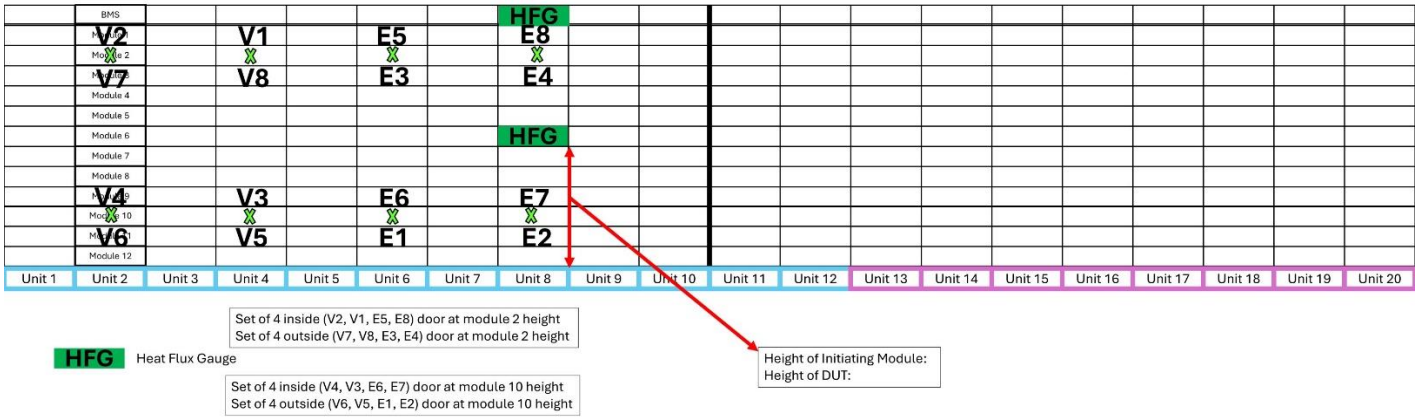


Figure 2.4 Placement of thermocouples on the surface of the container door and location of heat flux gauges inside the container

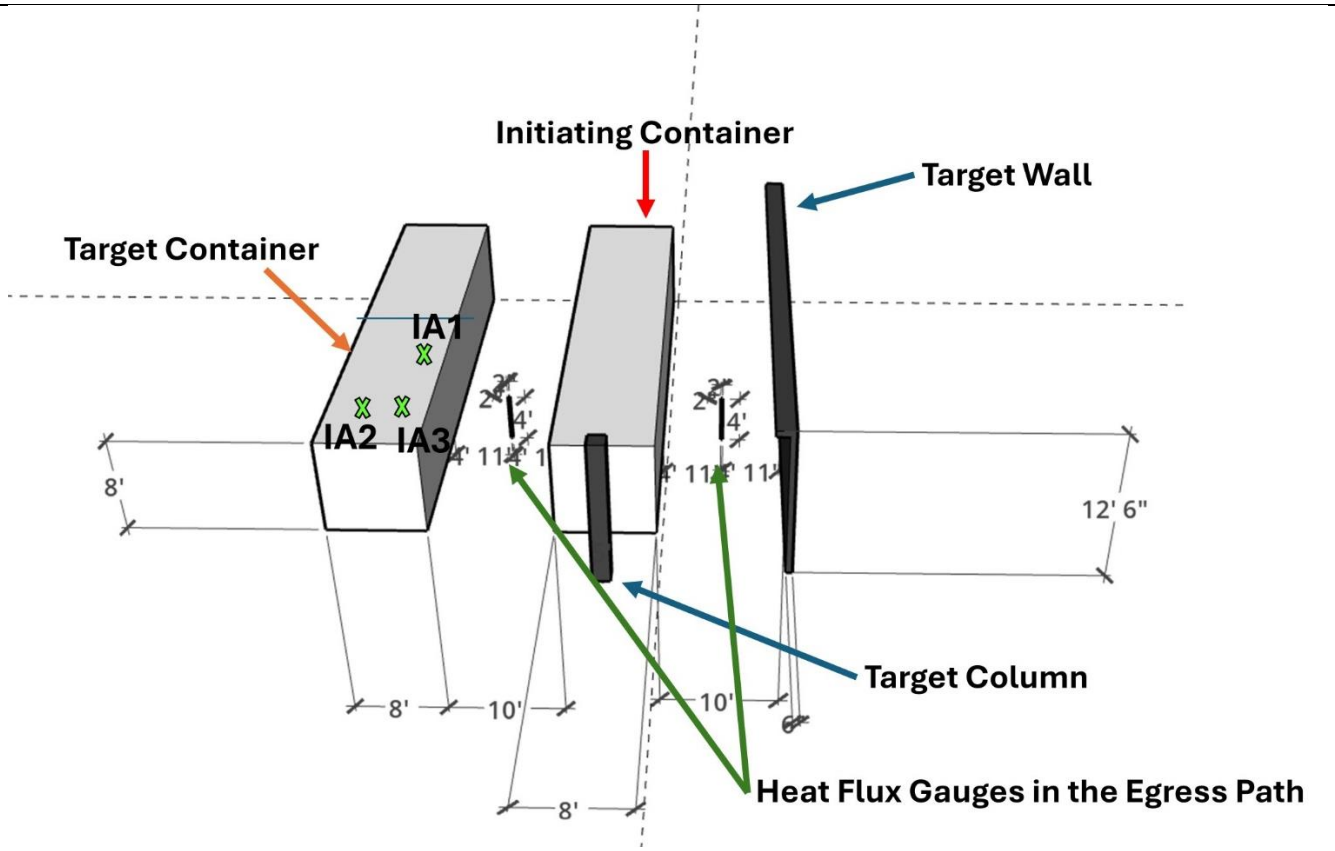


Figure 2.5 Overall Arrangement of the test area

Master Contract:	N/A	Model:	AES Spec CEN-E5S Enclosure	Page number 22 of 36
Project / Network:	80202692	Description:	Energy Storage Installation	

Attachment 2 - Diagrams and dimensions of test setup

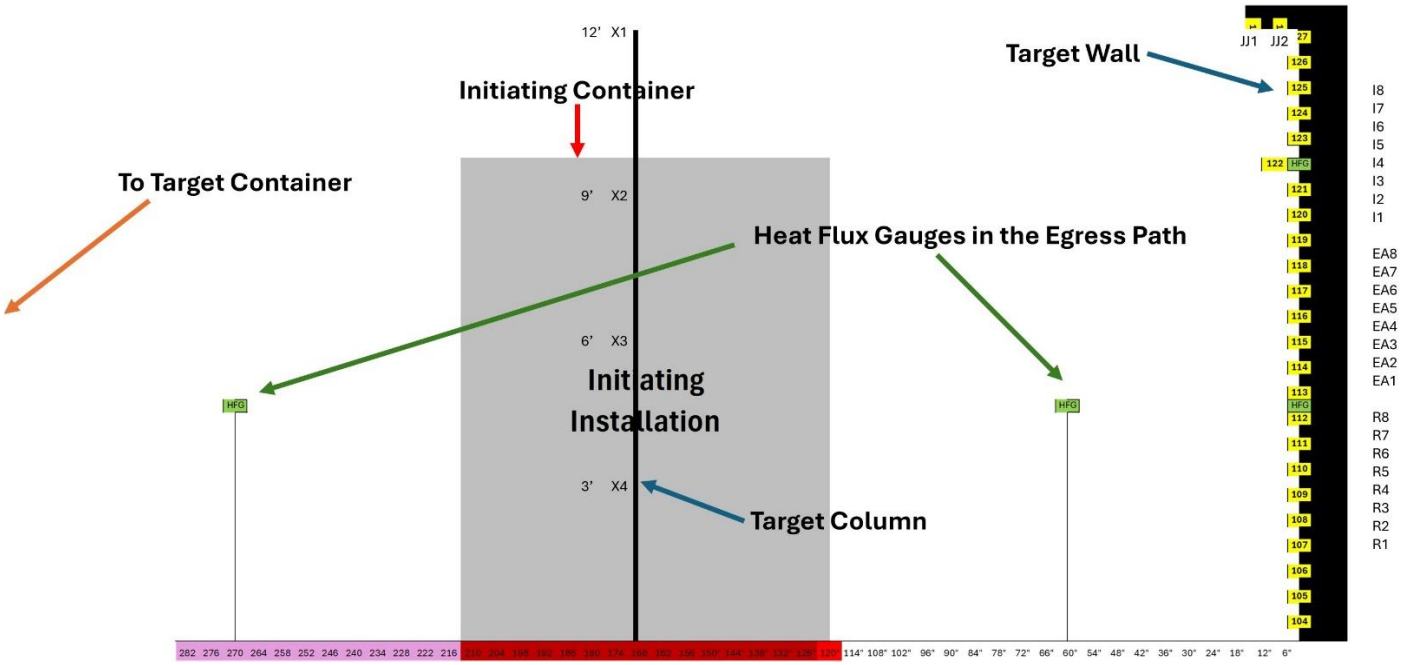


Figure 2.6 Thermocouples and heat flux gauge targets surrounding the initiating container

Attachment 3 – Temperature Measurements
Cool Down Period after 2 hours omitted from charts
Gaps in the data occurred due to noise from selected TC channels, as the offending channels were identified and disconnected some batch data just before and after thermal runaway has been omitted.
Data peaks resulting from noise have been omitted from the chart scaling

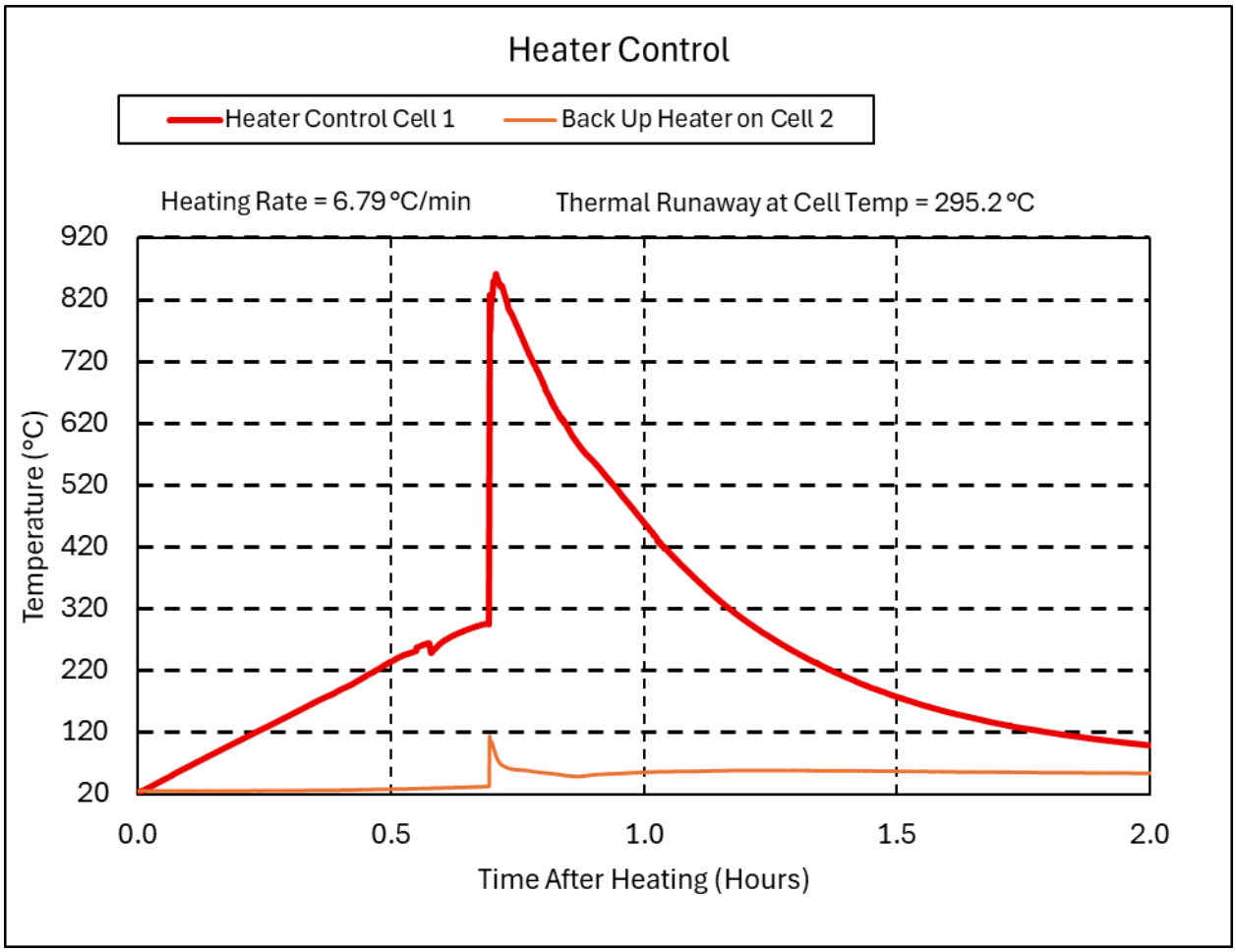
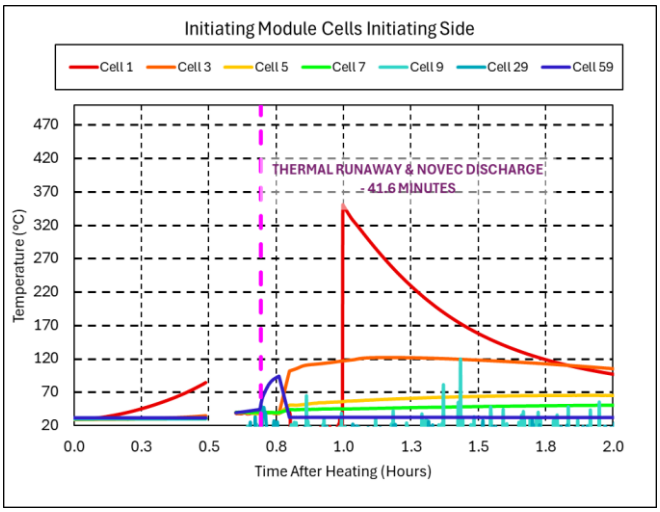


Figure 3.1: Heater temperature on Cell 1 and Cell 2 (not heated, only backup)

Master Contract:	N/A	Model:	AES Spec CEN-E5S Enclosure	Page number 24 of 36
Project / Network:	80202692	Description:	Energy Storage Installation	

Attachment 3 – Temperature Measurements
Cool Down Period after 2 hours omitted from charts
Gaps in the data occurred due to noise from selected TC channels, as the offending channels were identified and disconnected some batch data just before and after thermal runaway has been omitted.
Data peaks resulting from noise have been omitted from the chart scaling



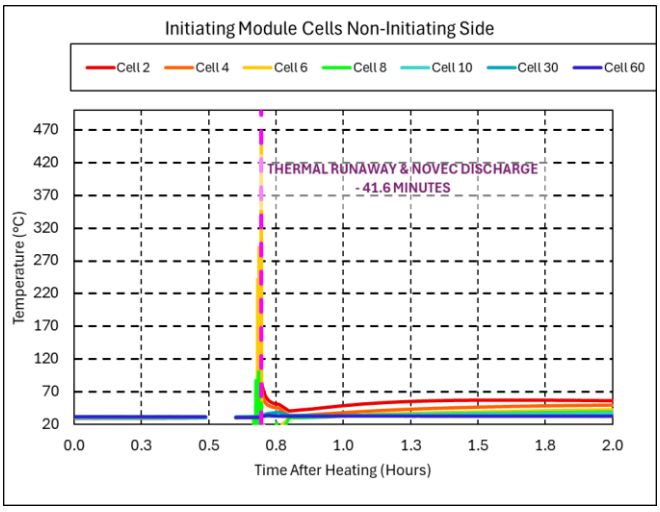
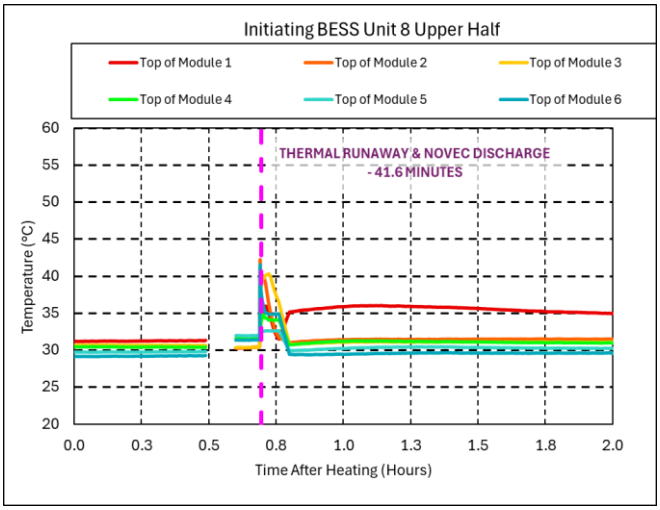


Figure 3.2 Temperatures of Cells in the Initiating Module



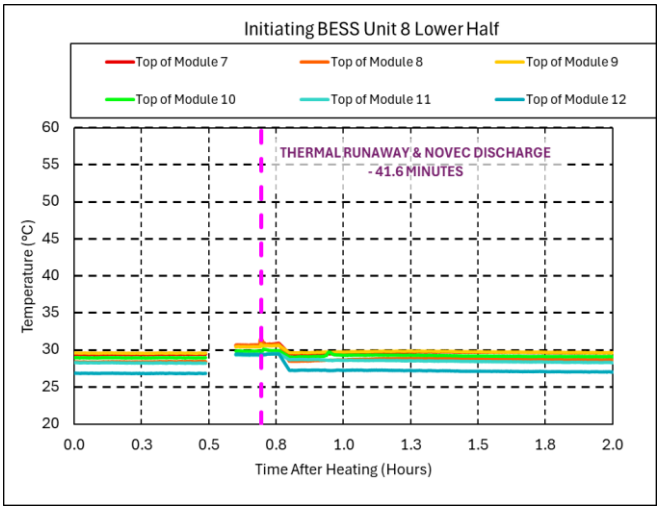
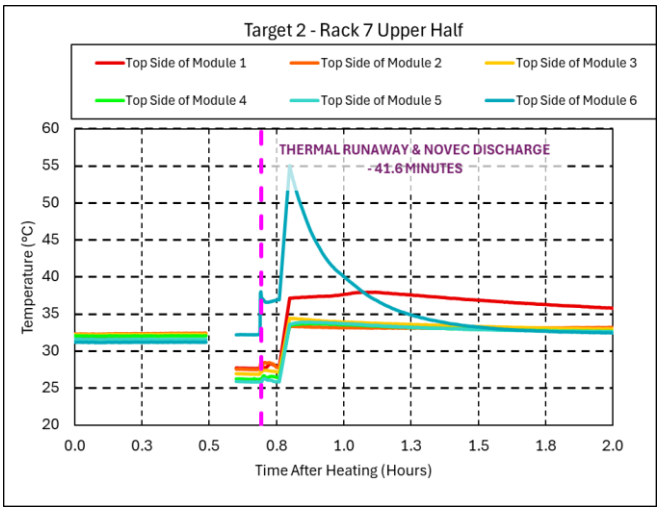
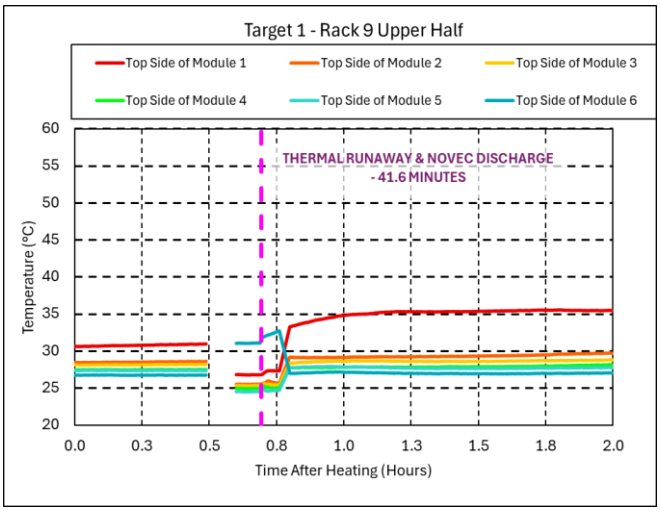


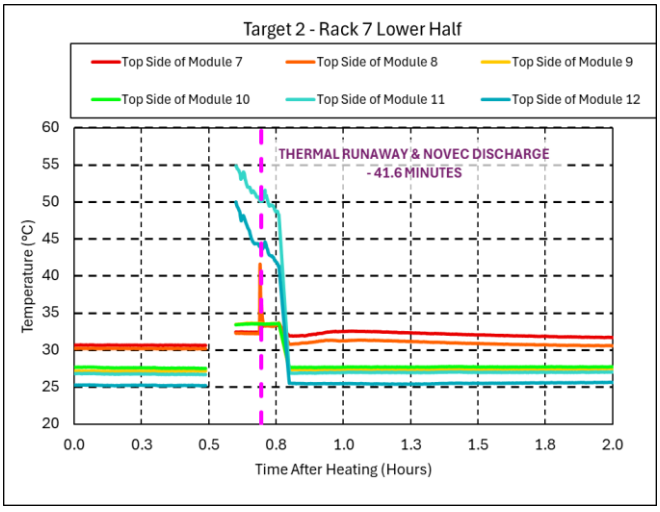
Figure 3.3 Temperatures of Modules in the Initiating Rack (Unit 8)

Master Contract:	N/A	Model:	AES Spec CEN-E5S Enclosure	Page number 25 of 36
Project / Network:	80202692	Description:	Energy Storage Installation	

Attachment 3 – Temperature Measurements
Cool Down Period after 2 hours omitted from charts
Gaps in the data occurred due to noise from selected TC channels, as the offending channels were identified and disconnected some batch data just before and after thermal runaway has been omitted.
Data peaks resulting from noise have been omitted from the chart scaling







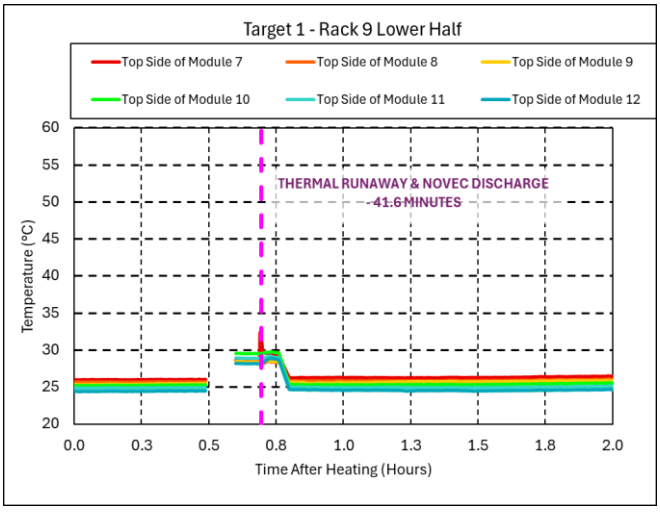


Figure 3.4 Temperatures of Modules in the Target Racks Units 7 and 9

Master Contract:	N/A	Model:	AES Spec CEN-E5S Enclosure	Page number 26 of 36
Project / Network:	80202692	Description:	Energy Storage Installation	

Attachment 3 – Temperature Measurements
Cool Down Period after 2 hours omitted from charts
Gaps in the data occurred due to noise from selected TC channels, as the offending channels were identified and disconnected some batch data just before and after thermal runaway has been omitted.
Data peaks resulting from noise have been omitted from the chart scaling

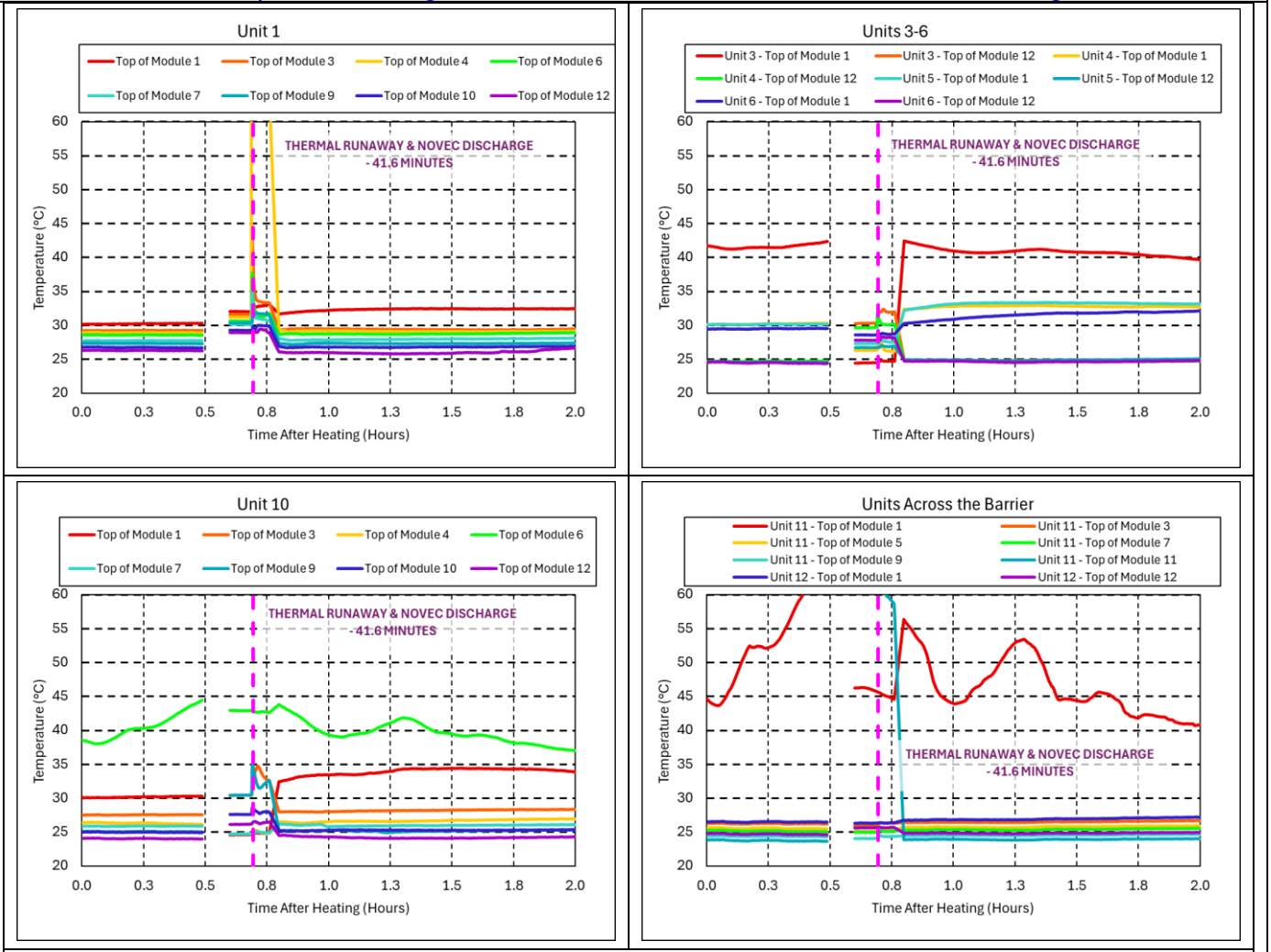
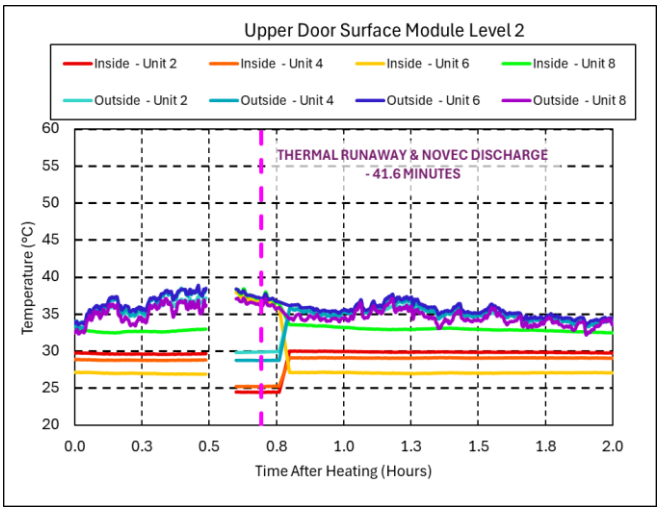


Figure 3.5 Temperatures of Modules Remote from the Initiating Unit

Master Contract:	N/A	Model:	AES Spec CEN-E5S Enclosure	Page number 27 of 36
Project / Network:	80202692	Description:	Energy Storage Installation	

Attachment 3 – Temperature Measurements
Cool Down Period after 2 hours omitted from charts
Gaps in the data occurred due to noise from selected TC channels, as the offending channels were identified and disconnected some batch data just before and after thermal runaway has been omitted.
Data peaks resulting from noise have been omitted from the chart scaling



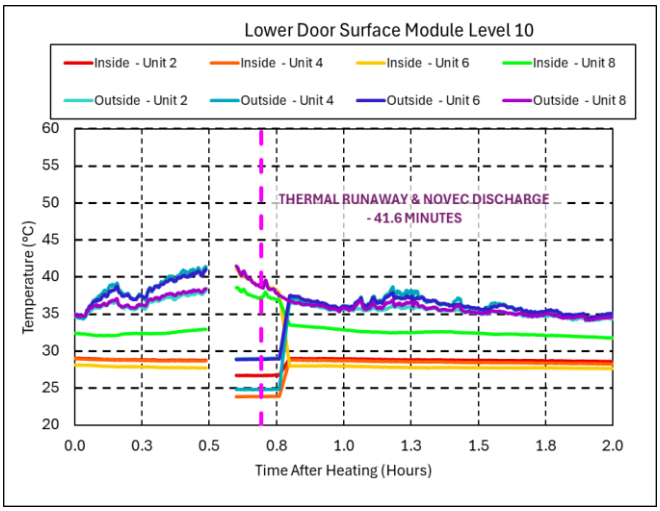
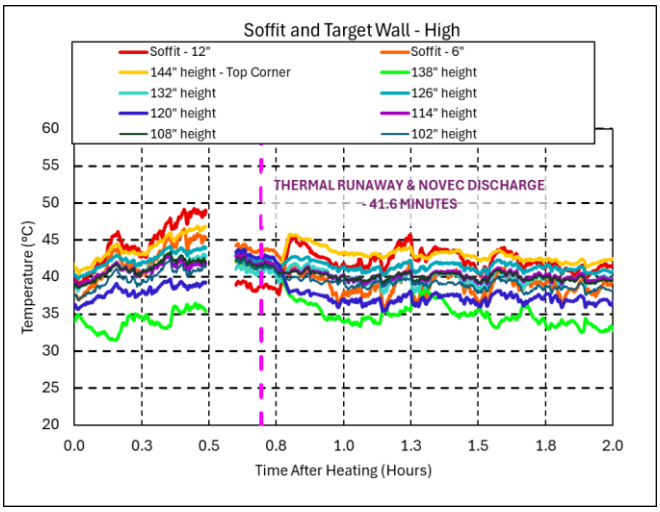
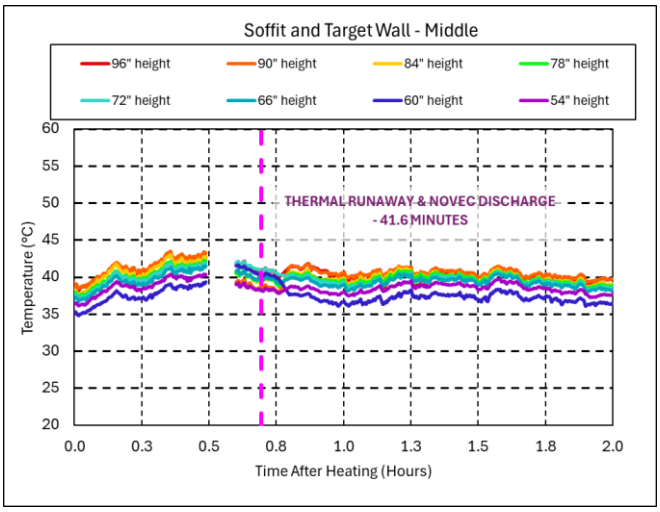


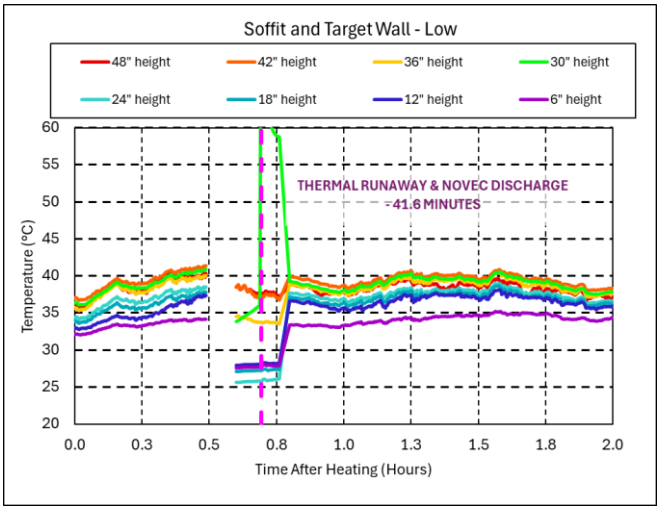
Figure 3.6 Temperatures of The Inner and Outer Surface of the Door

Master Contract:	N/A	Model:	AES Spec CEN-E5S Enclosure	Page number 28 of 36
Project / Network:	80202692	Description:	Energy Storage Installation	

Attachment 3 – Temperature Measurements
Cool Down Period after 2 hours omitted from charts
Gaps in the data occurred due to noise from selected TC channels, as the offending channels were identified and disconnected some batch data just before and after thermal runaway has been omitted.
Data peaks resulting from noise have been omitted from the chart scaling







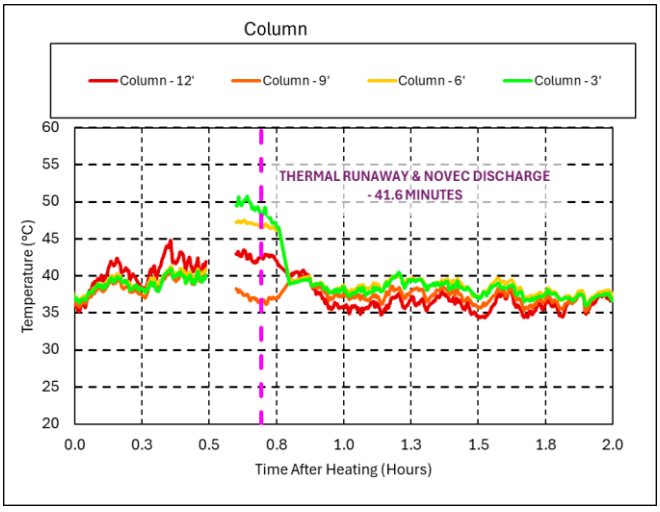


Figure 3.7 Temperatures of Target Wall and Soffit and Instrumented Column

Attachment 3 – Temperature Measurements
Cool Down Period after 2 hours omitted from charts
Gaps in the data occurred due to noise from selected TC channels, as the offending channels were identified and disconnected some batch data just before and after thermal runaway has been omitted.
Data peaks resulting from noise have been omitted from the chart scaling

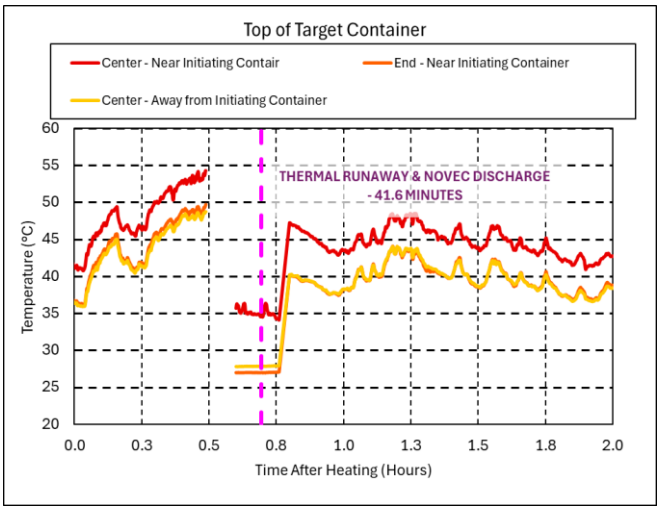


Figure 3.8 Temperatures on the top surface of the target container

Master Contract:	N/A	Model:	AES Spec CEN-E5S Enclosure	Page number 30 of 36
Project / Network:	80202692	Description:	Energy Storage Installation	

Location		Lab ID Code	Temperature limit (°C)	Measured maximum temperature (°C)
Control Heater	Cell 1	N/A	N/A	862.0
Initiating Module	Cell 1	L3	N/A	351.1
Initiating Module	Cell 3	L4	N/A	122.2
Initiating Module	Cell 5	L5	N/A	65.5
Initiating Module	Cell 7	L6	N/A	51.5
Initiating Module	Cell 9	L7	N/A	144.7
Initiating Module	Cell 29	L8	N/A	50.6
Initiating Module	Cell 59	H1	N/A	94.3
Initiating Module	Cell 2	H2	N/A	171.3
Initiating Module	Cell 4	H3	N/A	117.1
Initiating Module	Cell 6	H4	N/A	448.9
Initiating Module	Cell 8	H5	N/A	100.7
Initiating Module	Cell 10	H6	N/A	40.1
Initiating Module	Cell 30	H7	N/A	39.0
Initiating Module	Cell 60	H8	N/A	34.0
Initiating Unit 8	Top of Module 1	S1	N/A	36.1
Initiating Unit 8	Top of Module 2	S2	N/A	42.1
Initiating Unit 8	Top of Module 3	S3	N/A	40.3
Initiating Unit 8	Top of Module 4	S4	N/A	34.9
Initiating Unit 8	Top of Module 5	S5	N/A	32.7
Initiating Unit 8	Top of Module 6	S6	N/A	41.3
Initiating Unit 8	Top of Module 7	S7	N/A	31.1
Initiating Unit 8	Top of Module 8	S8	N/A	31.6
Initiating Unit 8	Top of Module 9	D1	N/A	30.8
Initiating Unit 8	Top of Module 10	D2	N/A	30.1
Initiating Unit 8	Top of Module 11	D3	N/A	29.5
Initiating Unit 8	Top of Module 12	D4	N/A	29.5
Target 1 (Unit 9)	Top of Module 1	G1	166	35.6
Target 1 (Unit 9)	Top of Module 2	G2	166	31.3
Target 1 (Unit 9)	Top of Module 3	G3	166	29.8
Target 1 (Unit 9)	Top of Module 4	G4	166	29.4
Target 1 (Unit 9)	Top of Module 5	G5	166	28.7
Target 1 (Unit 9)	Top of Module 6	G6	166	32.7
Target 1 (Unit 9)	Top of Module 7	G7	166	32.4
Target 1 (Unit 9)	Top of Module 8	G8	166	28.6
Target 1 (Unit 9)	Top of Module 9	D5	166	28.7
Target 1 (Unit 9)	Top of Module 10	D6	166	29.8
Target 1 (Unit 9)	Top of Module 11	D7	166	29.2
Target 1 (Unit 9)	Top of Module 12	D8	166	28.9
Target 2 (Unit 7)	Top of Module 1	C1	166	38.0
Target 2 (Unit 7)	Top of Module 2	C2	166	33.8

Target 2 (Unit 7)	Top of Module 3	C3	166	34.4
Target 2 (Unit 7)	Top of Module 4	C4	166	33.7
Target 2 (Unit 7)	Top of Module 5	C5	166	33.9
Target 2 (Unit 7)	Top of Module 6	C6	166	55.0
Target 2 (Unit 7)	Top of Module 7	C7	166	34.3
Target 2 (Unit 7)	Top of Module 8	C8	166	41.5
Target 2 (Unit 7)	Top of Module 9	FF1	166	33.7
Target 2 (Unit 7)	Top of Module 10	FF2	166	33.6
Target 2 (Unit 7)	Top of Module 11	FF3	166	54.9
Target 2 (Unit 7)	Top of Module 12	FF4	166	50.0
Unit 1	Top of Module 1	T1	166	34.9
Unit 1	Top of Module 3	T2	166	42.7
Unit 1	Top of Module 4	T3	166	Inconclusive - Noise
Unit 1	Top of Module 6	T4	166	37.6
Unit 1	Top of Module 7	T5	166	34.9
Unit 1	Top of Module 9	T6	166	31.8
Unit 1	Top of Module 10	T7	166	30.0
Unit 1	Top of Module 12	T8	166	29.5
Unit 3	Top of Module 1	DD7	166	42.9
Unit 3	Top of Module 12	DD8	166	32.4
Unit 4	Top of Module 1	DD5	166	33.0
Unit 4	Top of Module 12	DD6	166	31.8
Unit 5	Top of Module 1	DD3	166	33.4
Unit 5	Top of Module 12	DD4	166	27.0
Unit 6	Top of Module 1	DD1	166	33.2
Unit 6	Top of Module 12	DD2	166	28.3
Unit 10	Top of Module 1	O1	166	34.5
Unit 10	Top of Module 3	O2	166	34.8
Unit 10	Top of Module 4	O3	166	28.3
Unit 10	Top of Module 6	O4	166	44.5
Unit 10	Top of Module 7	O5	166	27.0
Unit 10	Top of Module 9	O6	166	35.1
Unit 10	Top of Module 10	O7	166	28.7
Unit 10	Top of Module 12	O8	166	26.6
Unit 11	Top of Module 1	F1	166	64.0
Unit 11	Top of Module 3	F2	166	28.0
Unit 11	Top of Module 5	F3	166	27.0
Unit 11	Top of Module 7	F4	166	26.4
Unit 11	Top of Module 9	F5	166	25.5
Unit 11	Top of Module 11	F6	166	65.8
Unit 12	Top of Module 1	F7	166	28.8
Unit 12	Top of Module 12	F8	166	25.8
Door Surface High	Inside - Unit 2	V2	126.8	30.2
Door Surface High	Inside - Unit 4	V1	125.9	29.7

Door Surface High	Inside - Unit 6	E5	124.2	38.2
Door Surface High	Inside - Unit 8	E8	130.2	38.5
Door Surface High	Outside - Unit 2	V7	132.2	37.4
Door Surface High	Outside - Unit 4	V8	132.1	38.7
Door Surface High	Outside - Unit 6	E3	132.7	38.9
Door Surface High	Outside - Unit 8	E4	131.4	37.2
Door Surface Low	Inside - Unit 2	V4	126.2	29.4
Door Surface Low	Inside - Unit 4	V3	126.2	29.6
Door Surface Low	Inside - Unit 6	E6	125.3	41.1
Door Surface Low	Inside - Unit 8	E7	129.8	38.6
Door Surface Low	Outside - Unit 2	V6	132.8	38.2
Door Surface Low	Outside - Unit 4	V5	133.6	41.4
Door Surface Low	Outside - Unit 6	E1	133.7	41.1
Door Surface Low	Outside - Unit 8	E2	133.1	41.5
Target Soffit	Soffit - 12 inch	JJ1	139.6	49.3
Target Soffit	Soffit - 6 inch	JJ2	136.3	46.5
Target Wall	144 inch height	I8	139.8	46.9
Target Wall	138 inch height	I7	131.8	42.5
Target Wall	132 inch height	I6	136.6	45.5
Target Wall	126 inch height	I5	137.9	46.1
Target Wall	120 inch height	I4	133.7	43.8
Target Wall	114 inch height	I3	137.2	45.6
Target Wall	108 inch height	I2	137.1	45.1
Target Wall	102 inch height	I1	135.7	43.0
Target Wall	96 inch height	EA8	137.0	45.3
Target Wall	90 inch height	EA7	137.0	45.4
Target Wall	84 inch height	EA6	136.2	45.1
Target Wall	78 inch height	EA5	135.8	44.9
Target Wall	72 inch height	EA4	135.6	45.4
Target Wall	66 inch height	EA3	135.3	45.3
Target Wall	60 inch height	EA2	133.1	43.5
Target Wall	54 inch height	EA1	134.4	46.2
Target Wall	48 inch height	R8	134.3	44.8
Target Wall	42 inch height	R7	135.1	46.7
Target Wall	36 inch height	R6	133.4	47.2
Target Wall	30 inch height	R5	134.3	70.3
Target Wall	24 inch height	R4	132.0	46.1
Target Wall	18 inch height	R3	131.4	46.5
Target Wall	12 inch height	R2	130.3	45.1
Target Wall	6 inch height	R1	129.2	46.2
Target Column	12 ft height	X1	134.3	44.8
Target Column	9 ft height	X2	135.1	41.8
Target Column	6 ft height	X3	136.2	47.5
Target Column	3 ft height	X4	135.7	50.8

Attachment 3 – Temperature Measurements
Cool Down Period after 2 hours omitted from charts
Gaps in the data occurred due to noise from selected TC channels, as the offending channels were identified and disconnected some batch data just before and after thermal runaway has been omitted.
Data peaks resulting from noise have been omitted from the chart scaling

Top of Target Container	Center - Near Initiating Contair	IA1	141.3	54.3
Top of Target Container	End - Near Initiating Container	IA2	136.4	49.7
Top of Target Container	Center - Away from Initiating Container	IA3	136.3	48.8

Attachment 4 - Heat flux graph

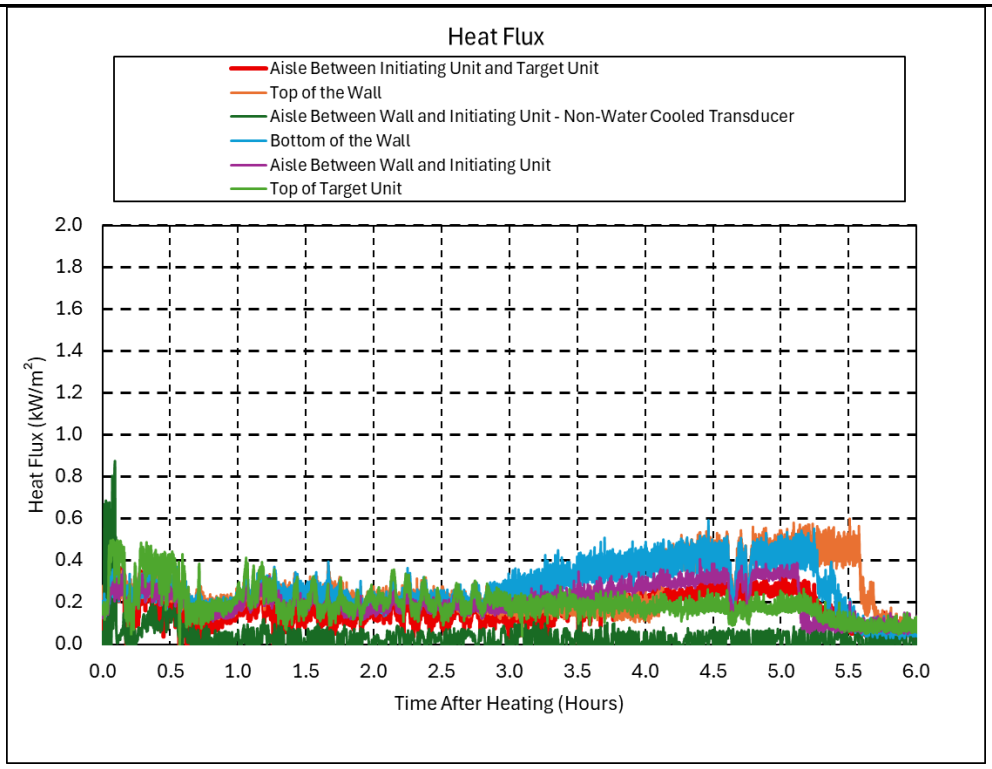


Figure 8.1 Heat Fluxes measured at various locations

Table 6 – Maximum Heatflux measurement

Location	Heatflux limit (kW/m^2)	Measured maximum Heatflux (kW/m^2)
Aisle Between Initiating Unit and Target Unit	1.3	0.4
Top of the Wall	N/A	0.6
Aisle Between Wall and Initiating Unit Non-Water Cooled – Not for Performance Criteria	N/A	0.9
Bottom of the Wall	N/A	0.6
Aisle Between Wall and Initiating Unit	1.3	0.4
Top of Target Unit	N/A	0.5

Attachment 5 - Notable observation during test

Observation	Time from test start (HH:MM:SS)	Comment
Start of Heating	00:00:00	Cell 1, Back side only- 1 heater, insulated with rockwool from the case. Heating at 6.79 °C/min
Loss of data due to high noise	00:29:42	Unplugged various TCs to find the noise source; data not evaluated during this period
Data Restored by removing L2 and L3 thermocouples	00:36:13	Some TCs still read questionable values for a few minutes after most data was restored
Thermal Runaway	00:41:37	Occurred at 295.2 °C heater temperature, high temperature due to single face heating
NOVEC 1230 System Activation	00:41:43	Actuation from smoke detectors; 6 seconds after thermal runaway 50kg of NOVEC 1230 at 25 bar pressure; discharge for 47 seconds
Fire Suppression	00:42:20	Fire appears visually extinguished by the NOVEC system
End of NOVEC 1230 discharge	00:42:30	50kg of NOVEC 1230 at 25 bar pressure; discharge for 47 seconds
All Temperatures Return to Ambient <40°C	06:14:26	No further events or observations; end of test and disassembly occurred without additional 18 hours of observation for re-ignition

No observation of flying debris or explosive discharge of gases

Condition	Comment
Flaming outside the initiating BESS enclosure & the max. extension:	None observed
Flying debris	None observed
Explosive discharge of gases	None observed
Re-ignition(s) from thermal runaway events	None observed
Sparks	None observed
Electrical arcs	None observed
Other electrical events	None observed
Damage to the initiating BESS unit	None observed
Damage to target BESS units;	None observed
Damage to adjacent walls	None observed
Damage to ceilings	None observed
Damage to soffits	None observed

Attachment 6 - Open circuit voltage measurement
Max Cell Voltage on BMS used to Cutoff Charge Per Client Request

Location		Before testing (Vdc)	Max Cell Voltage (Vdc)
Initiating BESS (Unit 8)	Rack 8 - 1484	1484	4.120
Target Unit 1 (Unit 9)	Rack 9 - 1484	1484	4.118
Target Unit 2 (Unit 7):	Rack 7 - 1484	1484	4.120

Attachment 7 - Critical Components List

Object/ Part No.	Manufacturer/ Trademark	Type/Model	Technical Data	Standard	Mark(s) of conformity or certificate
Cell	SAMSUNG SDI CO LTD	CP1495L101+	3.68 Vdc, 145 Ah	UL 1973	MH64496
Smoke Detecting Sensor	MGC System	SD-2WP-LED/SDB-4W	---	UL Listed	---
Fire Agent	3M	FK-5-1-12 (Novec1230)	50 kg, 25 bar	---	---
Cylinder	Zhejiang Winner Fire Fighting Equipment Co., LTD	F1230-CYL-58	66 kg, 25 bar (360 psi)	---	---
Solenoid Actuator	Fiwarec	F1120045	---	---	---
Pressure Guage	Fiwarec	F0580007	---	---	---
Fire Alarm Control Panel	Mircom	FR-320	---	---	---
Fire Alarm Cable	KDC	UL1424	---	---	---
Horn & Strobe	System Sensor	P2RK	---	---	---
Orifice (Pressure Regulator)	HANSUN ENG	SQF2S-1-7/8-12UN	---	---	---
Piping & Fittings	Fittings: S-lok (HANSUN ENG)	SS Tube: ASTM A269 TP316L Tube Fittings: ASTM A182 F316L/ASTM A479 Type316L Threaded Fittings: ASTM A182 F316L	---	---	---
Quick Connectors	Hanjung NCS	D015-00002233 D015-00002237 D015-00002247 D015-00002248	---	SAE J2044	---
Rubber Hose	Hanjung NCS	---	---	---	---
Fire Panel Battery	Aritech	BS127N	12 V, 7.2 Ah	RoHS 2, WEEE	---
ISOFIRE WALL FM	ISOPAN Insulating Design	---	---	---	---

End of Report….