REPORT

ENERGY STORAGE SYSTEM CODE COMPLIANCE REPORT

Aligned Data Centers, Inc.
Coal City, Illinois

PREPARED FOR

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Project #: 1VAB26014
Date: June 3, 2026

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Revision Record Summary

Revision	Revision Summary	Date
0	Draft Issue	June, 2026

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Executive Summary

Jensen Hughes (Consultant) has been contracted by Aligned Data Centers, Inc. (Client) to prepare a code analysis and large-scale fire testing (LSFT) and explosion control analysis on uninteruptible power supply (UPS) solutions which utilize lithium-ion battery energy storage system (BESS) installations. It is assumed that the Eaton 9395XC UPS will be utilized with up to 10 Samsung SDI 136S lithium-ion BESS supporting each UPS. The analysis reviews applicable code requirements for installations within Coal City, Illinois and interprets large scale fire testing data, gathered in accordance with UL 9540A, for a basis of code allowances regarding BESS group size, spacing, sprinkler density, and explosion control requirements. A Hazardous Mitigation Analysis is also provided for the basis of code allowances regarding BESS maximum allowable quantities.

1.0 Introduction

Jensen Hughes (Consultant) has been contracted by Aligned Data Centers, Inc. (Client) to prepare an energy storage system (ESS) code analysis for a new data center within Coal City, Illinois. The building is in the early stages of design and plans to install uninterruptible power supply (UPS) systems that utilize lithium-ion ESS cabinets. As such, ESS installation requirements applicable to the the Village of Coal City will be reviewed against the current design to determine if code compliance is met.

Note, the information and analyses documented within this report is subject to the information provided by the Client. Information provided is assumed to be up to date and accurate, and will serve as the basis of analyses herein.

1.1 PURPOSE + SCOPE

The purpose of this report is to evaluate installation requirements of lithium-ion ESS UPS configurations at a new data center with respect to the Village of Coal City's applicable codes. The scope of the report is limited to the ESS installations serving as the building's UPS.

1.2 APPLICABLE CODES AND STANDARDS

At the time of this report, the building is being designed under the following codes and standards:

+ 2021 International Building Code (IBC) [1].
+ 2021 International Fire Code (IFC) [2].
+ 2019 Edition NFPA 13, *Standard for the Installation of Sprinkler Systems* [3].
+ 2019 Edition NFPA 69, *Standard on Explosion Prevention Systems* [4].
+ 2019 Edition NFPA 72, *National Fire Alarm and Signaling Code* [5].
+ 2020 Edition NFPA 855, *Standard for the Installation of Stationary Energy Storage Systems* [6].

Additionally, the following standards and guidelines were relied upon for assessing the hazards from the proposed batteries and protection methods to mitigate the hazards:

+ UL 9540, *Standard for Energy Storage Systems and Equipment*, 2023 [7].
+ UL 9540A, *Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems*, 2019 [8].

1.3 ANALYSIS INPUTS

Project documentation utilized to form a foundation of this report includes:

+ Eaton. Aligned 2000 kW V4 Submittal. Dated March 13, 2025 [9].
+ IE Corp. Aligned Data Centers LBB01 UPS Container. Dated March 19, 2026 [10].
+ Aligned. Apex 24 MW Module Concept Design. Dated May 8, 2026 [11].
+ Underwriters Laboratory. UL 9540A Test Report for Eaton Corporation on Samsung Gen-3 136S. Issued February 26, 2024 and revised June 3, 2024 [12].

2.0 General Information

This section contains general information on the building's proposed UPS and supporting test data of the lithium-ion battery. The information presented below is based on the references in Section 6.0 provided for review.

2.1 PROJECT OVERVIEW

The data center will be newly built within Coal City, Illinois. It is assumed that the building will be fully sprinklered throughout and provided with a fire detection and notification system.

The building will utilize 14 lithium-ion ESS and UPS skids for the data center which are proposed to be installed and evenly split between two electrical rooms. The electrical rooms are approximately 25.25-feet at the highest point in the room. Each proposed container package will include one (1) Eaton 9395XC 2000 kW UPS along with ten (10) Samsung Gen-3 136S lithium-ion battery cabinets. The intent is for the UPS to draw energy from the connected ESS for building use in case of primary power failure. As a UPS, the battery cabinets will not undergo continuous charge and discharge cycles. For the purposes of this report, it is assumed that each battery cabinet will be at maximum battery cell and module capacity.

General project information is provided in Table 2-1. A plan view of the UPS skid is shown in Figure 2-2.

Table 2-1: Project Information

Project Name	Aligned Coal City, IL Data Center
Project Address	Unknown
UPS Manufacturer	Eaton
UPS Model	9395XC
UPS Capacity	2000 kW (2000 kVa)
BESS Manufacturer	Samsung
BESS Model	Samsung Gen-3 136S
BESS Capacity	34.6 kWh per cabinet
Function	Uninterruptible power supply (UPS) for data center server racks
Installation Type	Indoor, Non-Dedicated Use Building. Refer to Section 3.0 for details.

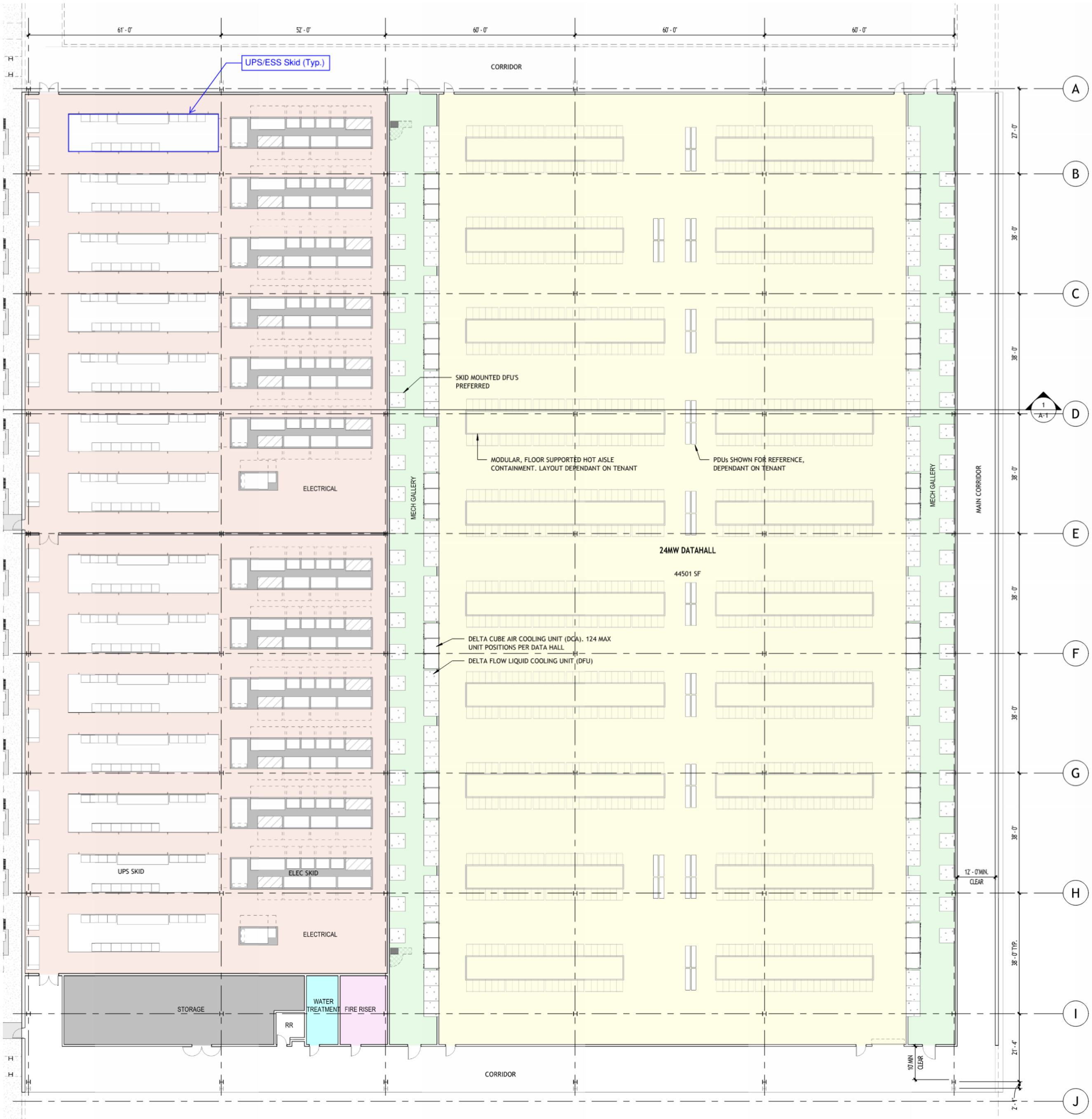

Figure 2-1: Concept Plan Layout of Building

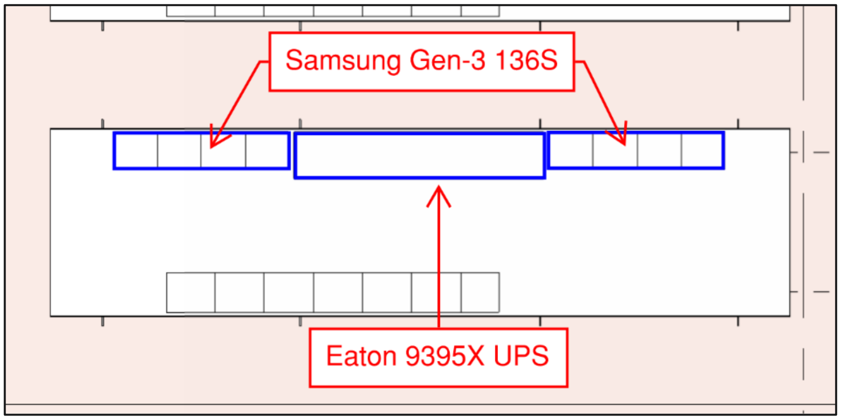

Figure 2-2: Plan Layout of UPS Skid (Typ.)

2.2 DATA CENTER DETAILS

The new building will be one story above-grade and a building height of approximately 30 feet. The building is comprised of one 24 MW network hall, two electrical rooms with seven UPS skids each, storage rooms, and office/administrative areas. The Eaton 9395XC UPS skid will contain various supporting electrical equipment including transformers, panelboards, a switchboard, and the lithium-ion battery cabinets. The skids will be completely open to the electrical room. The electrical room will have a 2-hour fire-resistance rating and fire-rated opening protectives. General information regarding the building is provided in Table 2-2.

Table 2-2: New Building General Information

Occupancy Use Group	Group F-1/S-2
Construction Type	Type IIB
Proposed Stories Above Grade	One (1)
Allowable Stories Above Grade	Three (3)
Proposed Building Height	30’
Allowable Building Height	75’
Proposed Area per Story	Unknown
Allowable Area per Story	Unlimited
Automatic Sprinkler System	Will be provided throughout
Fire Alarm System	Will be provided throughout

2.2.1 Fire Suppression Systems

It is assumed the fire suppression system will utilize water based fire sprinklers throughout the building, a double interlocked preaction sprinkler system will be provided for the electrical rooms.

The site is assumed to have adequate water supply to support the active fire suppression systems along with fire hydrants sited in accordance with the applicable codes to support fire department intervention.

2.2.2 Fire Alarm and Detection Systems

It is assumed a fire alarm system will be installed throughout which will include the following initiating devices for indicating alarm conditions:

+ Air-Aspirating Smoke detection (ASD)
+ Manual pull station
+ Automatic sprinkler waterflow switch

Occupant notification is assumed to be provided throughout the building. If pre-action fire sprinkler systems are to be installed, it is assumed that the simultaneous ASD fire detection and loss of system air pressure will be the means of system activation.

2.3 BESS ARRANGEMENTS

The UPS skid will include two (2) groups of five (5) Samsung Gen-3 136S BESS cabinets for a total of 10 cabinets and each electrical room will include seven (7) skids. Each cabinet is rated for 34.6 kWh, thus, the total battery capacity within each 2-hour fire rated electrical room is 2,422 kWh. This will be the same for both electrical rooms.

2.4 SAMSUNG GEN-3 136S BESS CABINET DETAILS

The Samsung Gen-3 136S lithium-ion BESS cabinet (Gen-3 136S) is constructed of plated steel, has WxDxH dimensions of 2.1 ft. X 1.7 ft. X 6.7 ft, and is rated for 516.8 V and 34.6 kWh. In essence, the BESS battery can be broken down into three basic levels: the unit, the module, and the cell. The cell is the smallest component of the BESS. Cells are combined to comprise a module. Similarly, multiple modules comprise a unit. The unit typically includes integrated monitoring equipment, commonly known as a Battery Management System (BMS), to monitor the “health” and operation by tracking key parameters including state of charge, operating temperature, and any abnormal occurrences. The Gen-3 cabinet (unit) consists of 17 Samsung SDI EM2031AE00XA modules in series, and each module consists of eight (8) Samsung SDI CM0630R0002+ prismatic cells in series.

Photos and additional information on the Gen-3 136S cabinet are provided in Figure 2.3 and Table 2-3.

Figure 2-3: Samsung Gen-3 136S Lithium-Ion BESS Cabinet

Table 2-3: Additional BESS Specifications

Unit	Model	Samsung Gen-3 136S (PHR3462-001A)
	Manufacturer	Samsung SDI
	Configuration	17 modules in series (17S1P)
	Ratings	516.8 Vdc, 34.6 kWh
	Enclosure	Metal enclosure
	Dimensions	25.6 in X 20.6 in X 87.1 in (2.1 ft X 1.7 ft X 7.3 ft)
	Weight	1,160 lbs
	Listing	UL 9540A Tested (Test Report AACD.E519914C6, Test File No. E519914)
Module	Model	EM2031AE00XA
	Manufacturer	Samsung SDI
	Configuration	8 cells in series (8S1P)
	Ratings	30.4 Vdc, 2.04 kWh

	Enclosure	Plastic top cover and metal enclosure
	Dimensions	216 mm X 404.5 mm X 163 mm (8.5 in X 15.9 in X 6.4 in)
	Weight	16.5 kg
	Listing	UL 1973 (File Number: MH49407)
Cell	Model	CM0630R0002+
	Manufacturer	Samsung SDI
	Format	Prismatic
	Chemistry	Lithium Nickel Cobalt Aluminium Oxide + Lithium Nickel Cobalt Manganese Oxide
	Ratings	3.8 Vdc, 67 Ah
	Listing	UL 1642 (File Number: MH49180)

2.5 SAFETY FEATURES

Each Gen-3 136S BESS cabinet includes a BMS, switchgear, power supply, and communication interface. The BMS monitors battery parameters such as temperature, voltage, and current to ensure it is operating as intended. If the BMS detects off-normal conditions, it will automatically trigger a series of protection protocols such as turning the battery breaker off. For example, if the BMS detects a battery cell having an overvoltage condition (greater than 4.28 V) for 5 seconds, it will automatically shunt the breaker. The cabinet cannot be restarted until the cell voltage drops to a normal range and the reset switch is manually pressed. Off-normal conditions will be internally logged and can be transmitted or remotely monitored based on installation configuration.

Additionally, the BESS modules include passive fire protection intended to limit or prevent cell-to-cell and module-to-module thermal runaway propagation. Modules are provide an epoxy sheet impregnated with NOVEC 1230 capsules that burst when heated and cells within modules are separated by a mica sheet as an insulating barrier. Note, this passive system is not indicated in the manufacturer's literature and was extracted from UL 9540A test reports; the system would be required as part of the UL 9540 listing and is assumed to be provided in all Samsung Gen-3 136S lithium-ion BESS installations.

2.6 SUPPORTING TEST DATA

The Gen-3 136S lithium-ion BESS cabinet has undergone UL 9540A testing as required to achieve a UL 9540 listing. Eaton has shared the unit level test report which includes key results from the cell and module level testing. Testing was performed in accordance with UL 9540A, 4th Edition (2019) [8].

2.6.1 Test Result Summary – UL 9540A Cell Level Test

The Samsung SDI CM0630R0002+ prismatic cell was induced into thermal runaway via external film heaters. The cell vented gas at a surface temperature of 160 °C and subsequently entered thermal runaway at 167 °C. The cell produced a total of 3.99 ft^3 (113 L) of gas with the composition shown in Table 2-4, below. The mixture had a 6.7% LFL at ambient temperature.

Table 2-4: Cell Level Off-Gas Composition

Gas	Measured %
Carbon Monoxide	16.03
Carbon Dioxide	40.09
Hydrogen	25.72
Methane	5.58
Ethylene	5.29
Ethane	0.94
Propylene	4.70
Propane	0.34
C4 Chemicals	1.20
Pentane	0.11

Due to thermal runaway being successfully induced and presence of combustible off gases, UL 9540A testing escalated to a module level test.

2.6.2 Test Result Summary – UL 9540A Module Level Test

The Samsung SDI EM2031AE00XA includes eight (8) cells connected in series. One cell was induced into thermal runaway where propagation to one adjacent cell was observed. External flaming of the battery vent gas and module enclosure material occurred along with ejection of small internal components. The peak chemical heat release rate was 81 kW.

Vent gases were collected throughout the test with the following results:

Table 2-5: Module Level Vent Gas Volumes

Gas	Pre-Flaming Volume (L)	Flaming Volume (L)
Hydrocarbons (Propane Equivalent)	43	157
Carbon Dioxide	1	259
Carbon Monoxide	1	181
Hydrogen	0	56

Due to thermal runaway not being contained by the module design and the battery cell vent gas being flammable, UL 9540A testing escalated to the unit level.

2.6.3 Test Result Summary – UL 9540A Unit Level Test

The Gen-3 136S lithium-ion BESS cabinet underwent UL 9540A unit level testing. The test configuration included four (4) BESS cabinets – three (3) in a row with side panels removed to replicate installed conditions, and one (1) cabinet back-to-back with the device under test (DUT). The middle cabinet was deemed as the DUT which utilized 17 full modules. Additionally, the DUT incorporated an epoxy sheet impregnated with NOVEC 1230 capsules between modules and a mica sheet between cells as a fire protection feature to mitigate thermal runaway propagation.

Thermal runaway was induced on Cell #6 within Module #7 via external film heaters as depicted below:

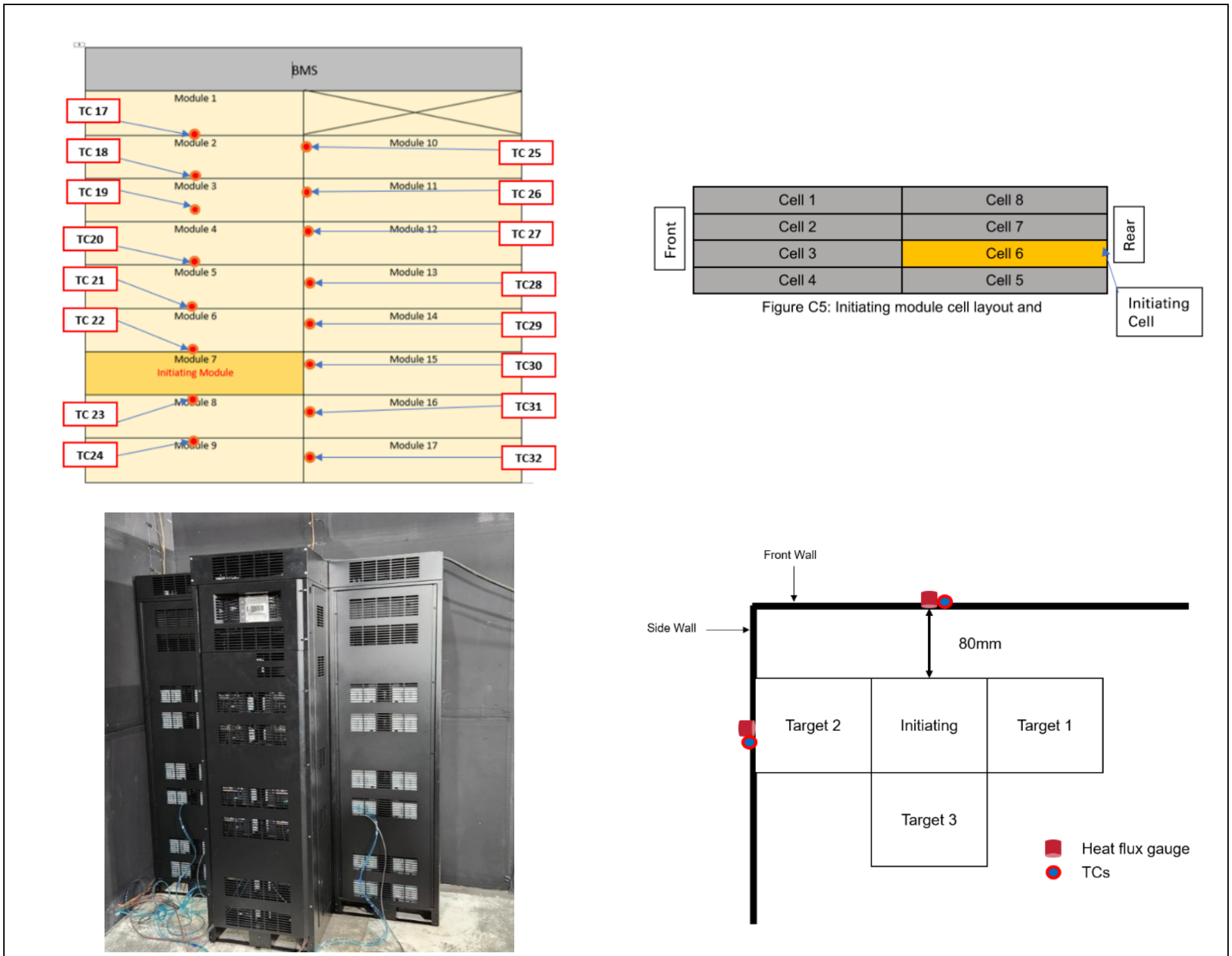

Figure 2-4: Unit Level Test Initiating Module and Test Configuration [12]

It was observed that Cell #6 (initiating cell) vented and immediately entered thermal runaway at the 54 minute and 12 second mark at a surface temperature of 166 °C. Voltage drops were observed at the 1 hour, 6 minute, and 3 second and the 1 hour, 20 minute, and 5 second marks, but no venting or thermal runaway events were visually observed.

Vent gases were collected throughout the test with the following results:

Table 2-6: Unit Level Vent Gas Volumes

Gas	Volume (L)
Hydrocarbons (Propane Equivalent)	62.31
Carbon Dioxide	Below detectable limit
Carbon Monoxide	Below detectable limit
Hydrogen	Below detectable limit

Hydrocarbons, constituted the majority of vent volume while carbon dioxide, carbon monoxide, and hydrogen had no accumulation detected. This is contrary to expectations based on the cell level off-gas results where Carbon Dioxide had the largest percent volume, followed by hydrogen, then hydrocarbons (40.07% vs. 25.65% vs. 18.05%, respectively) though this may be attributed to sensitivity of data collection equipment at large scale.

Figure 2-5: Vent Gases From Cabinet During Thermal Runaway

During the unit level test, no thermal runaway propagation was observed to adjacent cells, no internal or external flaming was observed, and no flying debris was observed. The maximum heat flux recorded on target modules was 0.76 kW/m^2 and no heat flux was recorded on the instrumented wall (80 mm or 3.15 inches in front of the DUT). The instrumented wall recorded a maximum surface temperature of 18.3 °C while the ambient temperature at test start was recorded as 15.1 °C. Additionally, surface temperatures of target BESS unit modules were recorded to be up to 28.4 °C which is below the temperature necessary to vent (160 °C based on cell level testing). The results of the test satisfy UL 9540A's unit level performance criteria and show that thermal runaway within an initiating cell does not propagate to adjacent cells or modules.

Note, based on the module level testing, thermal runaway propagation was anticipated to occur; however, the introduction of the NOVEC 1230 epoxy sheet between modules and mica sheet between cells appears to have mitigated propagation as no other cells entered thermal runaway.

3.0 Prescriptive Code Analysis

This section aims to outline prescriptive building and fire code requirements with respect to the Eaton UPS and lithium-ion BESS skids. Codes applicable to the building are outlined in Section 1.2 of this report.

The applicable requirements for ESS installations are dependant upon the installation classification (outdoor vs. indoor, dedicated use vs. non-dedicated use) and the technology used (lithium-ion, lead acid, etc.). ESS requirements are additional to those specific for the building occupancy type.

3.1 BUILDING OCCUPANCY CLASSIFICATION

The occupancy classification of a building is determined by its primary use. The building is primarily a data center with office spaces and is assumed to be permitted under the 2021 IBC as a Group F-1, S-2, and Group B occupancy. The building will be mixed-use with a non-separated approach.

Note, per IBC §307.1.1, areas with stationary storage battery systems are exempted from a Group H occupancy classification if storage, use, and handling complies with the applicable provisions of the International Fire Code. As such, areas with lithium-ion ESS will be designated as Group F-1 per IBC §306.2.

3.2 BESS INSTALLATION CLASSIFICATION

Chapter 12 of the IFC covers Energy Systems with §1207 specifically covering Electrical Energy Storage Systems. Note, areas where the State Fire Marshal's Office has jurisdiction, the 2020 Edition of NFPA 855 is applicable. NFPA 855 will be referenced as applicable for this report.

The building qualifies as an indoor, non-dedicated-use ESS installation per IFC §1207.7.2 and NFPA 855 §4.4.2.2. Specifically, the building is not used solely for energy generation, storage, and supply and will include other occupancies Figure 3-1 below visually demonstrates this classification process.

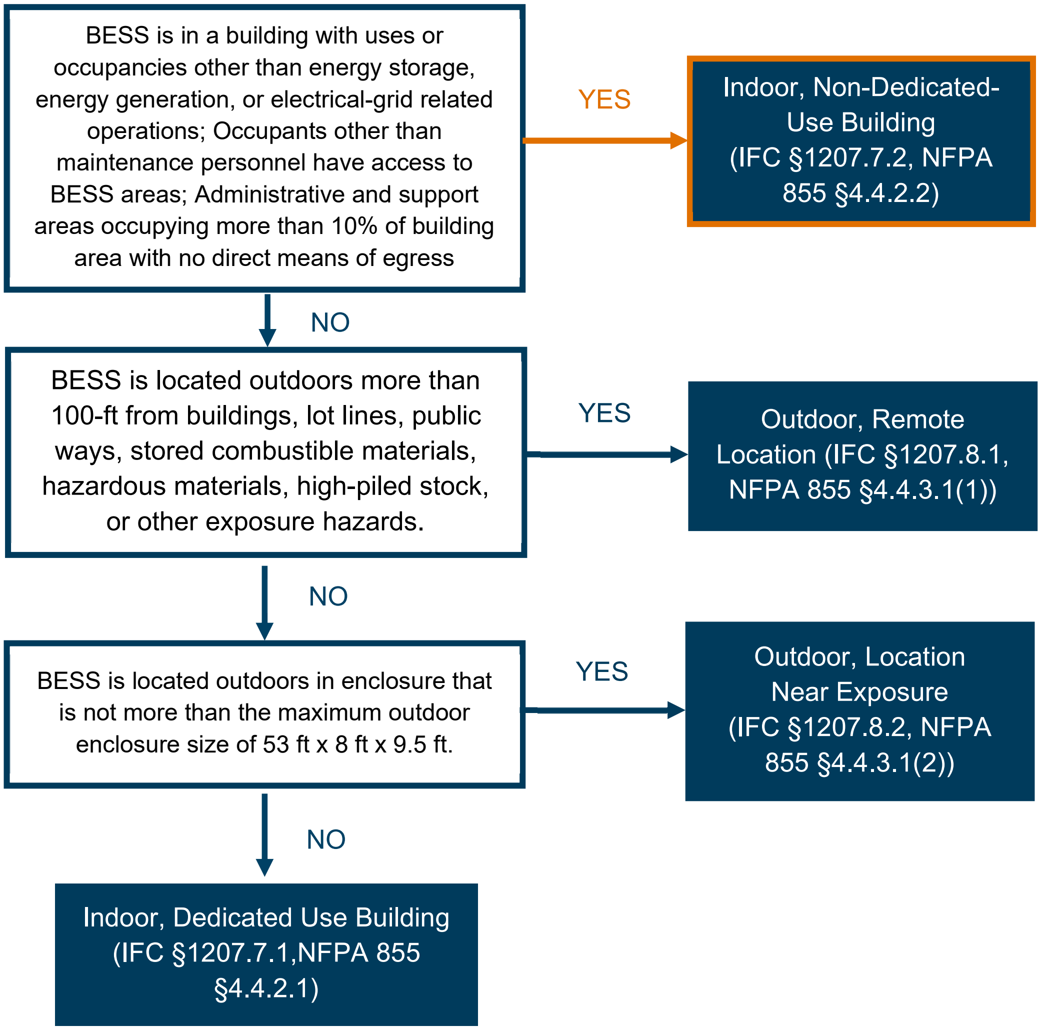

Figure 3-1: BESS Installation Classification Flowchart

3.3 IFC AND NFPA 855 REQUIREMENTS

A comprehensive analysis of installation and documentation requirements pertaining to the Coal City, Illinois data center UPS installations was performed and documented within Appendix A of this report. For brevity, Table 3-1 identifies all applicable code requirements from the IFC and NFPA 855 for lithium-ion ESS installations located in dedicated use buildings.

Table 3-1: IFC and NFPA 855 Evaluation

IFC/NPFA 855 Section	*Description*	*Compliance (Y/N)*
IFC §1201 NFPA 855 §1.3	Establishment of scope for Chapter 12 of the IFC. Energy storage systems regulated by Section 1207 shall comply with Chapter 12 of the IFC and NFPA 855.	Y
IFC §1207.1 NFPA 855 §1.3	Establishment of scope for IFC Section 1207 and NFPA 855. Both texts are applicable to stationary electrical ESS utilizing lithium-ion technology with over 20 kWh within a fire area.	Y
IFC §1207.1.2, 1207.1.3 NFPA 855 §4.5.3, 4.5.4, 6.3 Permits & Construction Documents	Includes requirements for construction and operational permits and supporting construction documents.	TBD
NFPA 855 §4.1.3 Emergency Planning & Training	Includes requirements for emergency planning and training. The owner of the ESS or authorized representative of the ESS facility operations is to be responsible for establishing, maintaining and conducting the emergency operations plan and training. The owner will provide Emergency Planning and Training documents to the AHJ.	TBD

IFC/NFPA 855 Section	*Description*	*Compliance (Y/N)*
IFC §1207.1.4 NFPA 855 §4.1.4 Hazard Mitigation Analysis (HMA)	Requires hazard mitigation analysis (HMA) if any of the following conditions are met: + The battery technology is not specifically addressed within the code + More than one ESS technology is provided in a single fire area where the potential for adverse interaction exists. + Where allowed as a basis for increasing maximum stored energy + Where required by the AHJ to address a potential hazard with an ESS installation that is not addressed by existing requirements.	Y
IFC §1207.4.6 NFPA 855 §4.1.6 Combustible Storage	Prohibits the storage of combustible materials in BESS rooms, areas or cabinets. Requires combustible materials in occupied work centers covered by IFC §1207.4.10 and NPFA 855 to be stored at least 3-ft away from BESS cabinets.	Y
IFC §1207.3.1 NFPA 855 §4.2.1 Listings	Requires BESS to be listed in accordance with UL 9540.	Y
IFC §1207.3.4 NFPA 855 §4.2.9 Energy Storage Management System (ESMS)	Areas containing ESS shall be provided with an ESMS or BMS. The system should monitor and automatically balance cell voltage, currents, and temperatures within the manufacturer's specifications. The system shall be capable of disconnecting the ESS from electrical connections if hazardous conditions are detected.	Y

IFC/NPFA 855 Section	*Description*	*Compliance (Y/N)*
IFC §1207.4 NFPA 855 §4.3 Installation	The BESS must be installed to fulfill requirements of the IFC and NFPA 855 including, but not limited to: + Working space clearances + Seismic protection + Signage + Fire resistant separation + Security + Means of egress	TBD
IFC §1207.5.4 NFPA 855 §4.10 Smoke and Fire Detection	Requires an automatic smoke detection or radiant energy-sensing fire detection system in rooms, areas and walk-in units containing BESS. Alarm signals must be transmitted to a central station or constantly attended location.	Y
IFC §1207.5.5 NFPA 855 §4.11 Fire Control and Suppression	Requires an automatic suppression system in rooms containing BESS and within walk-in BESS units: + For BESS groups of up to 50 kWh and separated by at least 3 ft. from other groups and walls, provide an automatic sprinkler system per NFPA 13 with a minimum density of 0.3 gpm/sqft over 2,500 sqft or the area of the room, whichever is smaller. + For BESS groups exceeding 50 kWh an automatic sprinkler system using a density based on large-scale fire testing per IFC §1207.5.5(2) and NFPA 855 §4.1.5. + An alternative fire-extinguishing system per IFC §1207.5.5(3) and NFPA 855 §4.1.5 and approved based on large-scale fire testing.	Y, See Section 4.3

IFC/NPFA 855 Section	*Description*	*Compliance (Y/N)*
IFC §1207.5.2 and Table 1207.5 NFPA 855 §4.8 Maximum Stored Energy	Fire areas within indoor non-dedicated use buildings shall not have an aggregate stored energy exceeding 600 kWh for lithium-ion technology. This limit may be exceeded where approved by the AHJ based on an HMA and large scale fire testing.	Y, See Section 4.1 & Appendix B
IFC §1207.5.1 NFPA 855 §4.6 Size and Separation	Limits the size and separation of BESS groups to 50 kWh (180 MJ), separated by a minimum of 3 feet (914 mm) from each other and from walls. Groups with larger sizes or smaller separations need AHJ approval based on large-scale fire testing per IFC §1207.1.5 and NFPA 855 §4.1.5.	Yes, See Section 4.1
IFC §1207.6 NFPA 855 §9.2 Electrochemical ESS Technology-Specific Requirements	Protection requirements for specific battery technologies is listed in IFC Table 1207.6 and NFPA 855 Table 9.2. Specifically, lithium-ion technology requires thermal runaway protection and explosion control.	Y
IFC §1207.6.5 NFPA 855 §4.1, 9.2 Thermal Runaway Protection (TRP)	Where required, ESS shall be provided with a listed device or other approved method to prevent, detect, and minimize the impact of thermal runaway. TRP is permitted to be provided by the battery management system that has been evaluated as part of the UL 1973 or UL 9540 listing.	Y

IFC/NPFA 855 Section	*Description*	*Compliance (Y/N)*
IFC §1207.6.3 NFPA 855 §4.12 Explosion Control	Where required, rooms, areas, ESS cabinets, or walk-in units shall be provided an explosion control system complying with NFPA 68, NFPA 69, or both; where an NFPA 69 system is provided, additional requirements regarding standby power and fire alarm supervision apply. Specfically, if gas detection is used to activate the explosion control system, it shall be provided with a minimum of 24 hours of standby power and 2 hours in alarm, and the ventilation system shall be provided with a minimum of 2 hours of standby power. Where approved, ESS cabinets designed to ensure no debris, shrapnel, or enclosure pieces are ejected, as validated by large scale fire testing complying with Section 1207.1.5 shall be permitted in lieu of provided NFPA 68 or NFPA 69 explosion control. Additionally, explosion control is permitted to be waived by the AHJ based on large-scale fire testing demonstrating the BESS does not have the potential to release combustible concentrations in excess of 25% of the LFL within the fire area.	Yes, See Section 4.3

4.0 Large-Scale Fire Testing and Explosion Control Anlaysis

As described in Section 3.0 and Appendix A of this report, several code requirement deviations are permitted to be approved by an AHJ based on results of large-scale fire testing performed in accordance with IFC §1207.1.5 and NFPA 855 §4.1.5. Specifically, deviations for ESS maximum stored energy, group size and separations, sprinkler density, and omission of an explosion control system may be substantiated for and approved by the AHJ.

4.1 MAXIMUM STORED ENERGY

Fire areas with lithium-ion battery technology are limited to a maximum of 600 kWh per IFC §1207.5.2 and NFPA 855 §4.8. As stated in Section 2.3 of this report, the Coal City, Illinois data center electrical rooms will have up to 2,422 kWh each.

Based on the unit level large-scale fire testing performed in accordance with UL 9540A, summarized in Section 2.6.3 of this report, thermal runaway within one fully charged unit at the cell level did not cause venting or thermal runaway in adjacent cells or modules within the same unit. Additionally, modules within adjacent BESS cabinets did not reach cell venting or thermal runaway surface temperatures while exposed to the device under test. Thus, introduction of additional ESS cabinets past the maximum allowable quantity would not cause an increased frequency of thermal runaway initiation or propagation from cell-to-cell or beyond.

Note, AHJ allowance for exceeding the maximum stored energy threshold is also subject to evaluation within an Hazard Mitigation Analysis (HMA) (See Appendix B).

4.2 GROUP SIZE AND SEPARATION

Per IFC §1207.5.1 and NFPA 855 §4.6, ESS shall be comprised of groups with a maximum stored energy of 50 kWh each and shall be spaced at least 3 ft. from other groups and from walls.

As stated in Section 2.3 of this report, each UPS container will have two (2) groups of five (5) interconnected cabinets on either side of the Eaton 9395X UPS. It is assumed the UPS and the BESS cabinets will be installed with minimal space between. The total energy capacity of each group would be 173 kWh.

Large-scale fire testing data at the unit level shows that thermal runaway is not expected to propagate to any adjacent cells, thus limiting flammable/toxic gas generation and the emitted heat release rate. As such, the resulting heat flux on adjacent cabinets (with no separation between cabinets) was minimal and adjacent cabinet surface temperatures did not reach critical thresholds for cell venting or thermal runaway. Additionally, minimal heat flux was applied to the instrumented wall located 3 inches from the initiating BESS cabinet resulting in a maximum wall temperature of 18.3°C. Based on these test results, the proposed 2-hour fire-resistance rated battery room compartments are expected to contain a thermal runaway event.

In summary, BESS cabinet/unit performance during UL 9540A large-scale fire testing supports providing BESS groups with capacities greater than 50 kWh. The testing results also indicate that groups can be separated from each other and adjacent walls by less than 3 feet. Specifically, groups can be installed directly adjacent to each other with a minimum of 3 inches of separation to adjacent walls.

Therefore, installation of ESS groups in excess of 50 kWh and with separations less than the 3 ft. from adjacent BESS groups and walls will not constitute a greater fire hazard than what would be prescriptively provided.

4.3 BESS SPRINKLER SYSTEM

Per IFC §1207.5.5 and NFPA 855 §4.11, sprinkler systems protecting ESS groups with a maximum stored energy of 50 kWh shall be designed with a density of 0.3 gpm/ft^2 / 2500 ft^2. Sprinkler systems protecting ESS of larger groups shall use a density based on large-scale fire and explosion testing in accordance with UL 9540A.

It is understood that the Apex data center Electrical Rooms containing ESS will be protected by automatic sprinkler systems designed with a density of 0.3 gpm/ft^2 / 2500 ft^2 in line with NFPA 13 Extra Hazard Group 1. However, the BESS installations within the Electrical Rooms exceed the 50 kWh group limits and include testing per UL 9540A showing that thermal runaway in one ESS will not propagate to an adjacent ESS or throughout the initiating cabinet.

Based on the UL 9540A unit level testing, external flaming and unit-to-unit thermal runaway propagation is not anticiapted along with internal thermal runaway propagation being mitigated by passive integral systems. An Extra Hazard Group 1 sprinkler density is sufficient to prevent the spread of a BESS cabinet fire within the Electrical Room.

4.4 EXPLOSION CONTROL ANALYSIS

Per IFC §1207.6.3 and NFPA 855 §4.12, fire areas with lithium-ion technology are required to provide explosion control in accordance with NFPA 68, NFPA 69, or a combination of the two. Commonly, fire areas within buildings will incorporate a mechanical exhaust system in accordance with NFPA 69 Chapter 8 with the intent of preventing deflagration by actively removing combustible gas concentrations until tenable conditions are stabilized. However, IFC §1207.6.3(2) and NFPA 855 §4.12.1.1 states explosion control is permitted to be waived by the fire code official based on large-scale fire testing demonstrating the BESS does not have the potential to release combustible gas concentrations in excess of 25% of the LFL within the fire area.

4.4.1 Hazard Scenario & Assumptions

The hazard under assessment will be thermal runaway within a Samsung Gen-3 136S lithium-ion BESS cabinet. The scenario assessed will be:

+ Thermal runaway per UL 9540A unit level testing. It is assumed one (1) Samsung SDI EM2031AE00XA cell will vent.

Assumptions used within this analysis include:

+ Cell venting and thermal runaway will initate in one (1) BESS cabinet as a single failure.
+ One (1) cell will vent to completion with the gas concentration mixture reflecting results of the UL 9540A cell level test.
+ Normal HVAC and air cycling will not be credited to allow off-gas concentrations to accumulate freely. Under normal conditions, the HVAC system would constantly cycle contaminated air to the outside and fresh air to the inside, thus slowing the accumulation of off-gas concentrations.
+ The electrical room has an area of approximately 16,030 square feet and an average ceiling height of 24 feet.

- All fire areas with lithium-ion BESS installations are assumed to have up to 90% volume available, with 10% dedcuted to account for fixed structures and equipment.

Table 4-1: Fire Area Volume

Fire Area Name	90% Volume (ft^3)	100% Volume (ft^3)
Electrical Room	346,248	384,720

4.4.2 System Objective

Per NFPA 69 §8.3.1, the combustible concentration reduction method will maintain a combustible concentration within the fire area to below 25 percent of the mixture LFL. Exhausted air will be directed to the outside away from any air intakes to prevent recirculation of combustible concentration. Air intakes will provide the afflicated fire area with fresh air and be located so that combustible concentration cannot re-enter the system per NFPA 69 §8.3.3.2(1).

4.4.3 Explosion Control Necessity Per Fire Area

Per IFC §1207.6.3(2) and NFPA 855 §4.12, explosion control is permitted to be waived by the AHJ based on large-scale fire testing demonstrating the BESS does not have the potential to release combustible concentrations in excess of 25% of the LFL within the fire area. Thus, the necessity of explosion control is dictated by the relationship between BESS combustible concentration production during venting and the volume of the fire area.

For example, if a BESS has been observed to expel large quantities of combustible gas during large-scale fire testing and is installed within a small room, it is expected that the LFL will quickly reach the 25% threshold during cell venting which would require explosion control. Conversly, if a BESS with minimal release of combustible concentrations is installed in a large room it may not reach the 25% LFL threshold prior to cessation of the thermal runaway event.

Establishing the LFL of hydrogen (gas to be detected) as 4% in air, the 25% LFL threshold would be 1% concentration of hydrogen. To determine how much hydrogen would be necessary to reach this threshold within the Elecrical Room, the following calculation is performed for any percent, *x*:

$$Volume\ of\ Gas = \left(x\% \times LFL_{gas}\right) \times (90\%\ \times Room\ Volume)$$

Accordingly, the minimum hydrogen volume to be present within the Electrical Room for the 25% threshold is outlined in the table below:

Table 4-2: Volume of Hydrogen Necessary for 25% LFL

Fire Area Name	Volume for 25% LFL_{H2} (ft^3)
Electrical Room	3,462.48

Based on cell level testing, one cell will release 1.03 ft^3 of hydrogen which is not enough to exceed the required hydrogen volume for the 25% LFL threshold within the Electrical Room. Performing a sensitivity analysis considering the release of 5 battery cabinets worth of hydrogen gas, a total of 680 cells, results in a total of 700.4 ft^3 of hydrogen gas – which is significantly below the 25% LFL_{H2} volume of 3,462.48 ft^3.

A similar analysis was performed on the gas mixture which was stated to have an LFL of 6.7% at ambient temperature per the cell level test results.

Table 4-3: Volume of Gas Mixture Necessary for 25% LFL

Fire Area Name	Volume for 25% LFL_{Mix} (ft^3)
Electrical Room	5,799.65

Based on cell level testing, one cell will release 3.99 ft^3 of gas mixture which is not enough to exceed either the 10% or 25% LFL threshold within the Electrical Room. Performing a sensitivity analysis considering the release of 5 battery cabinets worth of gas, a total of 680 cells, results in a total of 2,713.2 ft^3 of gas mixture – which is significantly below the 25% LFL_{Mix} volume of 5,799.65 ft^3.

Accordingly, the AHJ is permitted to waive requirements of explosion control.

5.0 Conclusions

Stationary lithium-ion BESS units are planned to be installed in electrical rooms to support the new Coal City, Illinois data center for use as uninteruptible power supplies. The 14 UPS skids will be located within two dedicated electrical rooms. The building will be protected by automatic fire detection and water-based fire suppression system designed in accordance with the applicable codes.

The installation requirements for lithium-ion ESS required by the International Fire Code with have been reviewed and provided in Section 3.0 and Appendix A to inform the design of various code requirements.

6.0 References

The following references were used in the development of this report:

1. International Code Council. *2021 International Building Code*. ICC Publications, 4051 Flossmoor Road, Country Club Hills, Illinois 60478.
2. International Code Council. *2021 International Fire Code*. ICC Publications, 4051 Flossmoor Road, Country Club Hills, Illinois 60478.
3. National Fire Protection Association, *NFPA 13: Standard for Installation of Sprinkler Systems*, Quincy, MA: NFPA, 2019.
4. National Fire Protection Association, *NFPA 69: Standard on Explosion Prevention Systems*, Quincy, MA: NFPA, 2019.
5. National Fire Protection Association, *NFPA 72: National Fire Alarm and Signaling Code*, Quincy, MA: NFPA, 2019.
6. National Fire Protection Association, *NFPA 855: Standard for the Installation of Stationary Energy Storage Systems*, Quincy, MA: NFPA, 2020.
7. Underwriters Laboratory. *UL 9540: Energy Storage Systems and Equipment*. UL. Washington, DC, 2023.
8. Underwriters Laboratory. *UL 9540A: Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems*. UL. Washington, DC, 2019.
9. Eaton. Aligned 2000 kW V4 Submittal. Dated March 13, 2025.
10. IE Corp. Aligned Data Centers LBB01 UPS Container. Dated March 19, 2026.
11. Aligned. Apex 24 MW Module Concept Design. Dated May 8, 2026.
12. Underwriters Laboratory. UL 9540A Test Report for Eaton Corporation on Samsung Gen-3 136S. Issued February 26, 2024 and revised June 3, 2024.

7.0 Tables

8.0 Figures

9.0 Appendices

Appendix A – Code Analysis

A comprehensive code analysis of the new Coal City, Illinois data center BESS installations is provided within this appendix. Installation arrangements are described within Section 2.3 of this report. The analysis is subject to documents and information provided by the Client. All code references are to those editions listed in Section 1.2 of this report.

A.1 CONSTRUCTION DOCUMENTS

IFC §1207.1.2, §1207.1.3, and NFPA 855 §4.5.3, §4.5.4, §6.3 requires construction permits to be obtained and construction documents to be provided for AHJ review including:

- Location and layout diagram of the room(s) or area(s) in which the ESS is to be installed
- Details on the hourly fire-resistance ratings of assemblies enclosing the ESS
- The quantities and types of ESS units
- Manufacturer's specifications, ratings, and listings of ESS
- Description of energy storage management systems and their operation
- Location and content of required signage
- Details on fire suppression, smoke or fire detection, gas detection, thermal management, ventilation, exhaust, and deflagration venting systems, if provided
- Support arrangement associated with the installation including any required seismic support/restraint
- A commissioning and decommissioning plan
- A fire safety and evacuation plan
- Location and content of required signage
- Support arrangement associated with the installation including any required seismic support/restraint
- A fire safety and evacuation plans

Several required construction documents such as a signage plan and emergency response plan, and design details for general installation requirements were not provided for review. It is assumed this documentation will be developed and provided to the AHJ.

A.2 EMERGENCY PLANNING AND TRAINING

Facilities with BESS installations shall have ESS emergency planning and training provided by the owner of the ESS or their authorized representative in accordance with NFPA 855 §4.1.3. Required documents may include, but are not limited to, Fire Evacuation Plans, Fire Safety Plans, Lockdown Plans, and Emergency Operation Plans subject to the AHJ.

It is understood emergency planning and response documents will be prepared and submitted by the building owner to the AHJ.

A.3 HAZARD MITIGATION ANALYSIS

Hazard mitigation analyses (HMAs) outline hazards of a system or installation and any mitigation measures and safeguards provided to prevent escalation of consequences. A failure mode and effects analysis (FMEA) is often utilized within the HMA to understand consequences of certain failure modes.

In accordance with IFC §1207.1.4 and NFPA 855 §4.1.4, the HMA for electrochemical ESS is required under any of the following conditions:

+ Where the ESS technology is not specifically identified within Table 1207.1.1 of the IFC or Table 1.3 of NFPA 855.
+ Where more than one ESS technology is provided in a single fire area where there is potential for adverse interaction between technologies.
+ Where allowed as a basis for increasing maximum allowable quantities.
+ Where required by the AHJ to address potential hazard within an ESS installation that is not addressed by existing requirements.

The HMA must evaluate the consequences of the following failure modes. Only single failure modes must be considered:

+ A thermal runaway or mechanical failure condition in a single ESS unit.
+ Failure of an energy storage management system or protection system that is not covered by the product listing failure modes and effects analysis (FMEA).
+ Failure of required protection system including, but not limited to, ventilation (HVAC), liquid cooling system, BMS, communication system, or other critical systems that might impact normal operations.
+ Other failure modes required by the AHJ.

The AHJ is permitted to approve the HMA if the consequences of the analysis demonstrate the following (IFC §1207.1.4.2 and NFPA 855 §4.1.4.3):

+ Fires will be contained within unoccupied ESS rooms for the minimum duration of the fire resistance rating specified in IFC §1207.7.4 and NFPA 855 §4.3.6.
+ Fires and products of combustion will not prevent occupants from evacuating to a safe location.
+ Deflagration hazards will be addressed by an explosion control and prevention system.
+ Toxic and highly toxic gases released during fires and other fault conditions will not reach concentrations in excess of immediately dangerous to life or health (IDLH) level in the building or adjacent means of egress routes during the necessary time to evacuate from that area.
+ Flammable gases release during charging, discharging and normal operation will not exceed 25% of the LFL.

Due to exceeding the maximum allowable quantity in a fire area (600 kWh for lithium-ion), an HMA is required, and can be found in Appendix B.

A.4 COMBUSTIBLE STORAGE

Combustible storage is prohibitied within BESS rooms, areas, or cabinets. It is understood that no combustibles will be intentionally stored within areas containing BESS. A robust housekeeping program will be maintained and enforced by building operations personnel to prevent combustible storage.

A.5 EQUIPMENT LISTINGS

In accordance with IFC §1207.3.1 and NFPA 855 §4.2.1, ESSs shall be listed in accordance with UL 9540. Documentation must provided by the Client proving the Samsung Gen-3 136S lithum-ion BESS is listed to UL 9540.

A.6 ENERGY STORAGE MANAGEMENT SYSTEM (ESMS)

Based on documentation provided by the Client and described in Section 2.5 of this report, the Samsung Gen-3 136S lithum-ion BESS is provided with a robust battery management system (BMS). The BMS monitors operating conditions of the BESS and can electrically isolate the ESS or affected components if hazardous conditions are detected. The BMS is compliant as an energy storage management system.

A.7 INSTALLATION REQUIREMENTS

IFC §1207.4 and NFPA 855 §4.3 outlines several requirements pertaining to BESS installation including:

+ Electrical installation in accordance with NFPA 70 including location of electrical disconnects and provision of working clearances
+ Seismic protection and bracing, if necessary
+ Consideration of ESS weight on the building or system foundation
+ Signage location and contents
+ Security of installations via approved methods to prevent unauthorized entry
+ Means of egress
+ Fire-resistace rated separations; rooms or spaces containing ESS shall be separated from other areas with a minimum 2-hour fire resistance rateing and horizontal assemblies with a minimum 2-hour fire restsiance rating

All information listed above must be provided for review.

A.8 SMOKE AND FIRE DETECTION

IFC §1207.5.4 and NFPA 855 §4.10 outlines fire detection requirements for BESS installations including automatic smoke detection or radiant energy-sensing fire detection systems.

Fire detection system design documentation will be provided for review during permitting.

A.9 FIRE CONTROL AND SUPPRESSION

IFC §1207.5.5 and NFPA 855 §4.11 outlines fire control and suppression requirements for BESS installations. Specifically:

- For BESS groups of up to 50 kWh and separated by at least 3 ft. from other groups and walls, provide an automatic sprinkler system per NFPA 13 with a minimum density of 0.3 gpm/sqft over 2,500 sqft or the area of the room, whichever is smaller.
- An automatic sprinkler system using an alternative density based on large-scale fire testing per NFPA 855 §4.1.5.
- An alternative fire-extinguishing system per §4.9.3 and approved based on large-scale fire testing.

Fire suppression system design documentation will be provided for review during permitting.

Based on the analysis documented in Section 4.3 of this report the AHJ is permitted to approved a sprinkler density of 0.3 gpm/sqft over 2,500 sqft for the electrical rooms.

A.10 MAXIMUM STORED ENERGY

IFC §1207.5.2 and NFPA 855 §4.8 states fire areas within indoor non-dedicated use buildings shall not have an aggregate stored energy exceeding 600 kWh for lithium-ion technology.

The AHJ is permitted to approve areas containing electrochemical ESS that exceed the MAQ amounts based on a harzardous mitigation analysis and large-scale fire/explosion testing. The maximum energy to be stored within electrical rooms will exceed the MAQ and therefore must be supported by an HMA.

Based on the analysis documented in Section 4.1 and Appendix B of this report the AHJ is permitted to approve an MAQ amount of 2,422 kWh in each electrical room for lithium-ion technology.

A.11 SIZE AND SEPARATION

IFC §1207.5.1 and NFPA 855 §4.6 requires ESSs to be comprised of groups with a maximum stored energy of 50 kWh each. Each group shall also be spaced a minimum of 3 ft (0.9 m) from other groups and from walls in a storage room or area.

The AHJ is permitted to approve groups with larger energy capacities or smaller group spacing based on performance criteria from fire and explosion testing. The UPS skids exceed the 50 kWh group threshold and have group spacings between adjacent ESS groups and walls of less than 3 ft. Based on the UL 9540A unit level testing, these larger group sizes and lesser group spacings should be acceptable.

Based on the analysis documented in Section 4.1 of this report the AHJ is permitted to approve an energy capacity of 173 kWh per group for lithium-ion technology.

A.12 TECHNOLOGY SPECIFIC REQUIREMENTS

IFC §1207.6 and NFPA 855 §9.2 states technology specific protection requirements for BESS. Lithium-ion BESS are required to be provided thermal runaway protection and explosion control.

A.12.1 Thermal Runaway Protection

Thermal runaway protection is required for lithium-ion BESS which can be provided as a listed device or other approved method to minimize the impact of thermal runaway. Thermal runaway protection is permitted to be part of a BMS that has been evaluated with the battery as part of the evaluation to UL 9540 or UL 1973 certification.

It is understood that the integral BMS of the Samsung Gen-3 136S lithium-ion BESS can automatically detect hazardous conditions (overcharging, high cell voltage, abnormal temperature, etc.) and initate safety protocols to prevent thermal runaway and return the BESS to standard operating conditions. Full proof of the ESS listing to UL 9540 must be provided for review.

A.12.2 Explosion Control and Prevention

Rooms where lithium-ion BESS are installed shall be provided with a reliable explosion control and prevention system designed, installed, operated, maintained, and tested in accordance with NFPA 68, NFPA 69, or both.

Per IFC §1207.6.3(2) and NFPA 855 §4.12, explosion control is permitted to be waived by the AHJ based on large-scale fire testing demonstrating the BESS does not have the potential to release combustible concentrations in excess of 25% of the LFL within the fire area.

Based on the analysis documented in Section 4.3 of this report, the AHJ is permitted to waive explosion control systems for the electrical rooms containing lithium-ion ESS/UPS.

Appendix B – Hazard Mitigation Assessment

This Appendix documents the lithium-ion BESS Hazard Mitigation Assessment as it relates to installations at Aligned Apex data centers.