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Attachment 2

Draft Hazard Mitigation Analysis

Tesla Megapack 2 XL

Hazard Mitigation Analysis:
Compass Battery Energy Storage System
San Juan Capistrano, CA

Draft Report | Rev.C | November 25th 2024

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Warning, this document is draft material.
Significant changes can occur after final review.

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EXECUTIVE SUMMARY

Fire and Risk Alliance, LLC. (FRA) was contracted by Engie North America (Client) to conduct a Hazard Mitigation Analysis (HMA) in accordance with the requirements of the 2022 California building Code (CBC) and the California Fire Code (CFC). The HMA is being used to evaluate the Tesla Megapack 2 XL (MP2XL) lithium-ion Battery Energy Storage System (BESS), intended for installation at the Compass BESS site, located at 29251 Camino Capistrano, San Juan Capistrano, CA 92675. The Compass BESS is anticipated to initially include 316 MP2XL cabinets with an approximate capacity of 309.4 megawatts (MW) / 1,238 megawatt hours (MWh). It will store energy from grid-based electrical generation systems and discharge that energy at a later time. This narrative also includes a review of the proposed MP2XL installation at the Compass BESS site for installation-level compliance with the 2022 CFC based on a review of the drawing set.

This analysis also includes a review of the proposed MP2XL installation at the Compass BESS Site for installation level compliance with the 2022 CFC. Based on a review of the MP2XL product and the Site Plan, the Compass BESS can meet the CFC requirements for a remote when it is installed in accordance with the MP2XL DIM, its listing, the approved drawings, and the CFC.

UL 9540A testing was performed on the MP2XL cells, modules, and cabinet. The UL 9540A unit-level testing demonstrated that the MP2XL contains the incident to the cabinet of origin. The fire did not spread to adjacent MP2XL cabinets, and no observations of explosion hazards were observed. In addition, no observations of chemical or liquid runoff (such as from glycol or electrolyte solution) were observed during the test or afterward during cleanup. Based on these test results, an HMA was performed for the Compass BESS. CFC §1207.1.4.2 lists the criteria that must be met to gain approval of the HMA. The MP2XL installation at the Compass BESS meets all five criteria for approval, as follows:

- *Fires will be contained within unoccupied ESS rooms or areas for the minimum duration of the fire-resistance-rated separations identified in Section 1207.7.4:*

  The Compass BESS meets this requirement. The MP2XL cabinet is installed outdoors, not within an unoccupied BESS room or area. However, it should be noted, the MP2XL design includes a series of passive fire protection schemes (barriers) to protect it from spreading a fire from one MP2XL cabinet to another. As demonstrated in UL 9540A unit level fire testing, a nearly simultaneous failure of up to seven cells did not result in thermal runaway propagating throughout the battery module or to adjacent MP2XL cabinets. Although this requirement applies to BESS rooms or areas (and not an outdoor installation), the Compass BESS still meets the intent of the requirement by containing a fire event to a single MP2XL cabinet. (CFC §1207.1.4.2 #1)

- *Fires and explosions in battery cabinets in occupied work centers will be detected in time to allow occupants within the room to evacuate safely:*

  The Compass BESS meets this requirement. The MP2XL is installed outdoors, not within an occupied work center (or any other room). However, it should be noted, the Compass BESS will have an external flame detection system capable of detecting a fire event within the MP2XL cabinet. This external flame detection system will be monitored separately (not monitored through the MP2XL) by a fire alarm monitoring company that operates 24/7, as required by the CFC. In addition, the MP2XL has a number of internal sensors within it that can detect an off-normal overheating event, such as a fire. Although this requirement applies to occupied work centers (and not an outdoor installation), the Compass BESS still meets the intent of the requirement through the external flame detection system provided at the site and internal sensors provided within the MP2XL. (CFC §1207.1.4.2 #2)

- *Toxic and highly toxic gases released during fires and other fault conditions shall not reach concentrations in excess of Immediately Dangerous to Life or Health (IDLH) levels in the building or adjacent means of egress routes during the time deemed necessary to evacuate from that area:*

  The Compass BESS meets this requirement. The MP2XL is installed outdoors, not within a building. However, it will be installed adjacent to a means of egress from the maintenance office, which has a door located over 20 feet away from the closest MP2XL cabinet. Preliminary results indicate no toxic gas exposures extend to this location or beyond the site property lines. As such, based on the detailed plume model, no toxic or highly toxic gases released during fires and other fault conditions will not reach concentrations in excess of IDLH levels in adjacent means of egress routes during the time deemed necessary to evacuate from that area.

- *Flammable gases released from batteries during charging, discharging and normal operation shall not exceed 25 percent of their lower flammability limit (LFL):*

  The Compass BESS meets this requirement. The MP2XL utilizes listed lithium-ion cells that are hermetically sealed and do not vent during charging, discharging or normal operation. Unlike other battery types, no flammable gases are released during normal operation of the lithium-ion batteries. As such, no flammable gases exceeding 25% of their LFL will be released from the Compass BESS during charging, discharging and normal operation. (CFC §1207.1.4.2 #4)

- *Flammable gases released from ESS during fire, overcharging and other abnormal conditions will be controlled through the use of ventilation of the gases, preventing accumulation, or by deflagration venting:*

  The Compass BESS meets this requirement. The MP2XL has an integral explosion control system installed inside cabinet that includes a sparker system and overpressure vents designed to ignite flammable gases very early in a thermal runaway event before they accumulate within the enclosure and become an explosion hazard. The effectiveness of the explosion control system of the MP2XL was demonstrated through UL 9540A unit level fire testing. During that test, the failure of six cells within the same battery module did not create an explosion hazard. There were no observations of deflagration, projectiles, flying debris, detonation, or other explosive discharge of gases. (CFC §1207.1.4.2 #5)

In summary, based on the UL 9540A testing, the proposed MP2XL installation at the Compass BESS location meets the Hazard Mitigation Analysis approval criteria presented in the CFC, as described above.

1.0 INTRODUCTION

Fire and Risk Alliance, LLC, (FRA) performed a Hazard Mitigation Analysis (HMA) in accordance with the requirements of the California Fire Code (CFC). This HMA is being used to evaluate the Tesla Megapack 2 XL (MP2XL) lithium-ion Battery Energy Storage Systems (BESS), intended for installation at the Compass BESS facility. The Compass BESS is anticipated to include 316 MP2XL cabinets, each with a capacity of 3,916.8 kilowatt hours (kWh). In total, the Compass BESS will have a capacity of 1,238 megawatt hours (MWh).

This report has been prepared by FRA and summarizes our analysis. It is intended to be used as a tool for a fire code official (FCO) or an authority having jurisdiction (AHJ) to assist in their review of the Compass BESS. The HMA includes a review of the MP2XL, its construction, design, fire safety features, listings, certifications, and UL 9540A fire test data. In addition, this report includes a review of the proposed MP2XL installation at the Compass BESS for installation level compliance with the 2022 CFC based on a review of the permit drawings.

1.1 APPLICABLE CODES AND STANDARDS

The HMA was performed based on the 2022 CFC which adopts the 2021 IFC with modifications, the following codes and standards were also considered during this evaluation:

- NFPA 68, Standard on Explosion Protection by Deflagration Venting, 2013 Edition (NFPA 68).
- NFPA 69, Standard on Explosion Prevention Systems, 2019 Edition (NFPA 69).
- NFPA 855, Standard for the Installation of Stationary Energy Storage Systems, 2023 Edition (NFPA 855).
- IEC 60529, Degrees of Protection Provided by Enclosures, 2.2 Edition, January 2019 (IP Code).
- IEC 62619, Secondary cells and batteries containing alkaline or other non-acid electrolytes – Safety requirements for secondary lithium cells and batteries, for use in industrial applications, Edition 1.0, 2017 (IEC 62619).
- UL 1642, Lithium Batteries, Edition 6, September 29, 2020 (UL1642).
- UL 1973, Standard for Batteries for Use in Stationary, Vehicle Auxiliary Power and Light Electric Rail (LER) Applications, Edition 3, February 25, 2022 (UL1973).
- UL 9540, Standard for Safety of Energy Storage Systems and Equipment, Edition 2, February 27, 2020 (UL 9540).
- UL 9540A, Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems, Edition 4, November 12, 2019 (UL 9540A).

1.2 PURPOSE AND SCOPE

The CFC requires an HMA to evaluate the consequences associated with the following failure modes, and others deemed necessary by the FCO. Note, only single failure modes must be considered in this analysis (CFC §1207.1.4.1):

1. Thermal runaway condition in a single BESS rack, module, or unit.
2. Failure of any battery (energy) management system.

3. Failure of any required ventilation or exhaust system.
4. Voltage surges on the primary electric supply.
5. Short circuits on the load side of the ESS.
6. Failure of the smoke detection, fire detection, fire suppression or gas detection system.
7. Required spill neutralization not being provided or failure of the secondary containment system.

The AHJ or FCO is authorized to approve the HMA provided the analysis demonstrates all of the following (CFC §1207.1.4.2):

1. Fires will be contained within unoccupied ESS rooms or areas for the minimum duration of the fire-resistance rated separations identified in IFC §1207.7.4.
2. Fires in occupied work centers will be detected in time to allow occupants within the room or area to safely evacuate.
3. Toxic and highly toxic gases released during fires will not reach concentrations in excess of the IDLH level in the building or adjacent means of egress routes during the time deemed necessary to evacuate occupants from any affected area.
4. Flammable gases released from ESS during charging, discharging, and normal operation will not exceed 25 percent of their LFL.
5. Flammable gases released from ESS during fire, overcharging, and other abnormal conditions will be controlled through the use of ventilation of the gases, preventing accumulation, or by deflagration venting.

The framework for this analysis is as follows:

- **Review the MP2XL and UL9540A test data**: FRA reviewed the MP2XL, its construction, design, fire safety features, listings, and UL 9540A fire test data (see Section 2.0 and Section 3.0).
- **Review site specifications:** FRA reviewed the proposed Compass BESS site layout and installation including the area surrounding the BESS (see Section 4.0).
- **Prescriptive code compliance review:** The proposed site layout and site response plans / training procedures were reviewed for compliance with the CFC requirements. Where gaps were identified in the BESS installation and response plans / training procedures, recommendations are provided (see Section 5.0 and Section 6.0).
- **Hazard Mitigation Analysis:** The HMA evaluates the BESS failure modes as required by the CFC. The consequence-based analysis considers product level and site level barriers to prevent failure or reduce the consequences of a failure scenario. Based on the provided barriers, the consequences of a failure event are analyzed. The CFC states acceptance criteria for which the FCO or AHJ is authorized to approve the HMA provided the consequences of the analysis meet or exceed the criteria (see Section 7.0).

- **<u>Recommendations</u>:** Recommendations are provided throughout the report where gaps exist between the site design and code requirements and where the consequences of failure modes exceed the approval criteria (see Section 8.0).

1.3 REFERENCE MATERIALS

The following reference materials were reviewed as part of this analysis:

- MP2XL Design and Installation Manual - Rev. 2.2, dated January 30, 2024 (MP2XL DIM).
- MP2XL Operation and Maintenance Manual - Rev. 1.2, dated January 30, 2024 (MP2XL O&MM).
- Industrial Lithium-Ion Battery Emergency Response Guide – Rev. 2.7, dated February 16, 2024 (ERG).
- MP2XL System Specification – Rev. 1.1, dated January 30, 2024
- MP2XL Compliance Packet – Rev. 2.8, dated February 14, 2024.
- MP2XL Fire Protection Engineering and UL 9540A Interpretation Report Rev0, dated April 3, 2024 (MP2XL FPE Report).
- Compass BESS Permit Drawing Package Dated March 27, 2024.

1.4 ACRONYMS AND ABBREVIATIONS

Alternating Current	AC
Authority Having Jurisdiction	AHJ
Battery Energy Storage System	BESS
Battery Management System	BMS
Controller Area Network	CAN
Contemporary Amperex Technology Co., Ltd.	CATL
Customer Interface Bay	CIB
Direct Current	DC
Emergency Response Guide	ERG
Emergency Response Plan	ERP
Energy Storage System	ESS
Fire Alarm Control Panel	FACP
Fire Protection Engineering	FPE
Fire & Risk Alliance, LLC	FRA
Fire Code Official	FCO
Hazard Mitigation Analysis	HMA
Immediately Dangerous to Life or Health	IDLH
International Electrotechnical Commission	IEC
Inspection, Testing, and Maintenance	ITM
Local Operations Center	LOC
Lithium Iron Phosphate	LFP
Lower Explosive Limit	LEL
Lower Flammability Limit	LFL

Megapack 2	MP2
Megapack 2 XL	MP2XL
Minimum Approach Distance	MAD
National Fire Protection Association	NFPA
National Institute for Occupational Safety & Health	NIOSH
Operations and Maintenance	O&M
Personal Protective Equipment	PPE
Supervisory Control and Data Acquisition	SCADA
State of Charge	SOC
Thermal Management System	TMS
Tesla System Controller	TSC
Underwriters Laboratory, LLC	UL

1.5 NOMENCLATURE

Ampere-hour	Ah
Degree Celsius	°C
Degree Fahrenheit	°F
feet	ft
inch	in
kilopascal	kPa
kilowatt-hour	kWh
Megawatt	MW
Megawatt-hour	MWh
Millimeter	mm
Liter	L
Pounds per square inch absolute	psia
Parts per million	ppm
Volt	V

1.6 LIMITATIONS

At the request of Engie North America, FRA performed an HMA in accordance with the requirements of the CFC for the Compass BESS located at 29251 Camino Capistrano, San Juan Capistrano, CA 92675. The scope of services performed during this analysis may not adequately address the needs of other users of this report, and any re-use of this report or its conclusions presented herein are at the sole risk of the user. The opinions and comments formulated during this assessment are based on observations and information available at the time of the analysis, which has been provided to FRA by others. No guarantee or warranty as to future performance of any reviewed condition is expressed or implied.

2.0 MP2XL DESCRIPTION

The MP2XL is a fully integrated BESS consisting of battery modules, power electronics, control systems, a battery management system, a thermal management system, and an explosion control system all pre-assembled within a single, non-occupiable cabinet. The MP2XL has a standardized, modular design that is not customizable or adjustable. MP2XL arrives at the site fully assembled needing just the alternate current (AC) connection and communications cables to be connected on the site. Meaning every installation has the same MP2XL cabinets that are pre-assembled at the factory. It is approximately 28.9 ft in length, 5.4 ft deep, 9.2 ft in height, and can weigh up to 84,000 pounds (8.800 m by 1.650 m by 2.785 m and 38,100 kg). Below is a brief description of the MP2XL, its components, design listing, and fire safety features. For a more detailed discussion of the MP2XL components, their location, functionality, and purpose, refer to the MP2XL DIM.

2.1 CABINET LAYOUT

The MP2XL is intended for outdoor installations, ground-mounted to a foundation or base strong enough to support the weight of the equipment and anchor loads (including concrete pads, grade beams, etc.). The thermal roof (part of the MP2XL's thermal management system) is enclosed within an IP20 enclosure that sits above the battery module bays, as shown in Figure 1.

(1) Battery Module Bays (2) Thermal Bay (3) CIB (4) Thermal Roof Enclosure (5) IP66 Enclosure

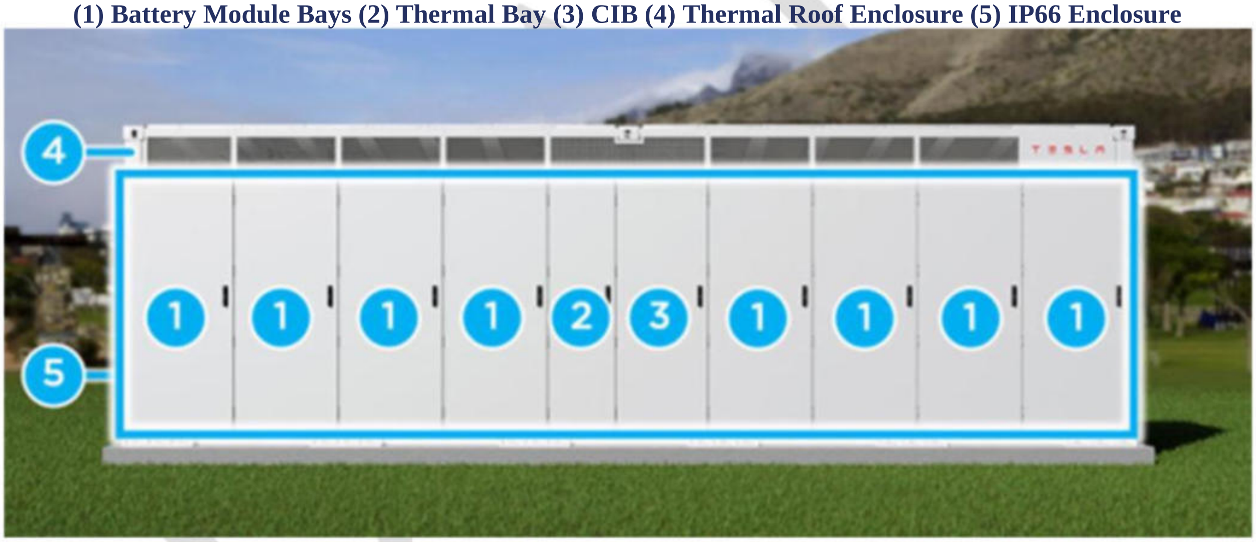


Figure 1. MP2XL Internal Components

The lithium-ion batteries are housed inside an IP66 steel enclosure (battery module bay) that provides protection against particle and water ingress coming into contact with the battery modules and power electronics. The IP66 enclosure is one continuous unit, meaning each of the eight bays is open to one another. However, when the MP2XL cabinet is populated with battery modules, it cannot be entered. This modular, cabinet-style approach allows for the system to be easily maintained and serviced from outside the cabinets (i.e., the battery modules, thermal management system, and power electronics are serviced through doors located on the front of the cabinets or from the top through the thermal roof), thus eliminating the need for personnel to enter an enclosure, structure, building or container to perform those activities. Since the BESS cabinets do not permit walk-in access, it is a non-walk-in style (NWI) BESS, they are not defined as occupied buildings or structures per the CFC.

2.2 CELLS AND BATTERY MODULES

The MP2XL can be populated with up to twenty-four battery modules with a maximum storage capacity of 3,916.8 kWh for the 4-hour duration system. The Compass BESS will utilize the 24-battery module MP2XL capable of providing a capacity of 3916.8 kWh over a duration of 4 hours. Each battery module contains three battery trays, as shown in Figure 2, which are arrays of prismatic, lithium iron phosphate (LFP) cells. The LFP cells (the cells) utilized in the MP2XL are 157.2-amp hour (Ah) with a nominal voltage of 3.22 volts (V) and are individually hermetically sealed. They are approximately 50.75 millimeters (mm) by 166.0 mm by 169.3 mm and weigh 2,991 grams (g). Each battery tray contains 112 cells; therefore, each battery module has 336 cells. In total, the 24-battery module MP2XL being installed at the Compass BESS will have 8,064 cells.

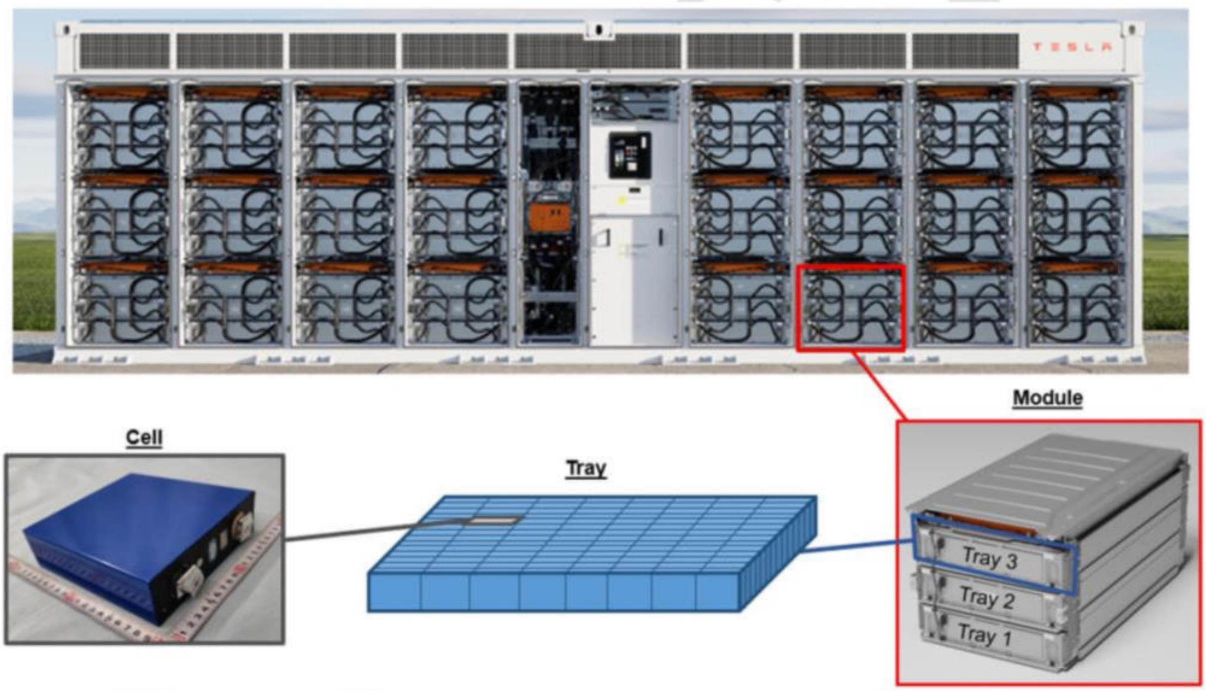


Figure 2. MP2XL Unit, Module, Generalized Tray, and an Individual Cell Layout

2.3 CUSTOMER INTERFACE BAY

The Customer Interface Bay (CIB) is a single bay that includes all the external connections needed for initial MP2XL installation. When the fully assembled MP2XL arrives at the site, the only work necessary inside the cabinet (AC connection and communications cables) is connected inside the CIB. Once installed, the CIB is a user-accessible area designed for operation and servicing. The CIB, as shown in Figure 1, includes the main AC breaker, a status panel and controller area network (CAN) interface for service personnel, customer input/output (I/O) terminals, and the keylock switch (a “Lock Out/Tag Out” switch), which shuts down the AC bus to permit MP2XL maintenance by service personnel.

2.4 THERMAL MANAGEMENT SYSTEM

The thermal management system (TMS) provides a suitable operating temperature for MP2XL. The thermal bay and thermal roof house the components of the TMS. The TMS contains a closed-loop liquid cooling system that circulates a 50/50 mixture of ethylene glycol and water throughout the battery modules and power electronics to maintain an optimum battery operating temperature. The TMS works autonomously and does not require user feedback or controls to turn the system on when needed or to adjust temperature settings. The thermal cabinet includes pumps that circulate the liquid coolant through the MP2XL, an in-line heater that can warm the coolant and a compressor that maintains thermal control for the cabinet. The thermal roof, located above the battery bays within its own IP20 enclosure, provides a ventilation airspace for the MP2XL. It contains fans and radiators that cool the ethylene glycol-water solution. Cool air enters the thermal roof through the grates on the front of the MP2XL. The cool air then passes over the radiators, absorbing heat, and then is exhausted out of the top of the thermal roof via exhaust fans, as shown in Figure 3. The liquid cooling system utilizes approximately 400 liters (106 gallons) of the ethylene glycol-water solution, and the compressor utilizes 1.5 kilograms (3.3 pounds) of R-134a refrigerant for the 4-hour duration MP2XL. The MP2XL cabinet, specifically, the IP66 battery bay enclosure, is designed to hold the volume of the solution should a leak occur in the TMS, either in normal operation or during a failure event.

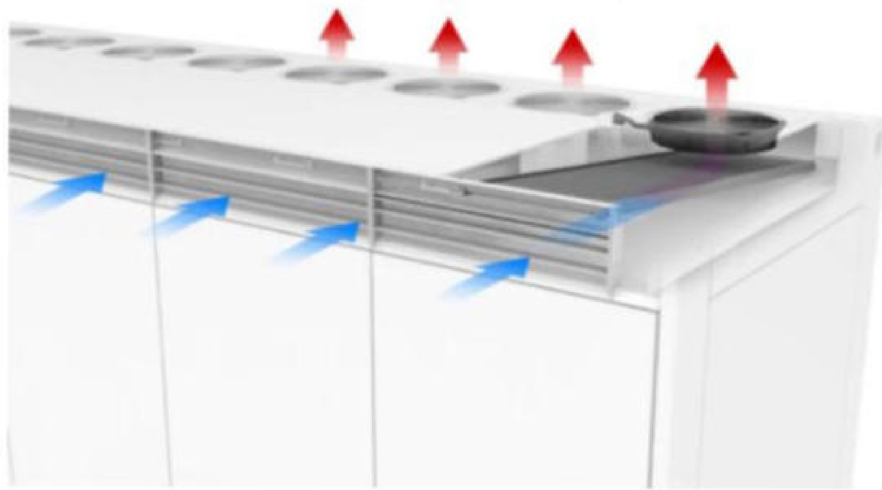


Figure 3. Airflow Through the Thermal Roof

2.5 BATTERY MANAGEMENT SYSTEM

The MP2XL has an integrated battery management system (BMS) that tracks the performance, voltage, current, and state of charge of the cells (among many other datapoints). The BMS is a layered system, where each battery module has its own BMS and the MP2XL itself has a bus controller supervising the output of all the battery modules at the AC bus level. The BMS is engineered to react to fault conditions in an autonomous manner, with safeguards built into the firmware. These fault conditions include, but are not limited to, over-temperature, loss of communication, over-voltage, and isolation. For instance, to prevent a cell over-temperature the TMS is enabled by the BMS to cool the cells/module. This action by the BMS (which is just one example of many ways the BMS can respond to a fault condition) can either prevent thermal runaway from occurring in the cell or prohibit the propagation of thermal runaway to adjacent cells. Depending on the severity of the fault condition, the BMS can automatically isolate the affected battery module temporarily (less severe fault) or it can permanently disconnect the module.

2.6 SYSTEM CONTROLLER AND MONITORING

Beyond the built-in safeguards of the BMS described above, the MP2XL is supported by Tesla's Local Operations Center (LOC), which is designed to support the global fleet of energy storage products. The MP2XL has 24/7 remote monitoring, diagnostics, and troubleshooting capabilities, without needing a Tesla technician on site. Customers and first responders also benefit from immediate hotline support from trained technicians via these LOCs. Additionally, the local energy provider or the facility monitors the MP2XL through a local Supervisory Control and Data Acquisition (SCADA) system. All faults are transmitted to a Tesla LOC, alerting them to off-normal conditions that may require corrective action, either through remote means or an in-person field service visit. This communication link is accomplished via the Tesla Site Controller (TSC). The TSC provides the single point of interface for the utility, network operator, and/or the customer's SCADA systems to control and monitor the entire energy storage site. It dictates the charge and discharge functions of the MP2XL cabinets, aggregating real-time information and using the information to optimize the commands sent to each individual MP2XL cabinet. As such, every MP2XL has a wired Ethernet connection to the TSC, which communicates with a Tesla LOC via a built-in cellular modem. If the cellular network in the installation area is not sufficient, a hardwired internet connection can be provided. Additionally, if the BESS owner or operator wants a network connection for a control interface, the TSC becomes that point of connection to the MP2XL cabinet at the site.

2.7 ELECTRICAL FAULT PROTECTION DEVICES

The MP2XL has several passive and active safety control mechanisms installed within the battery module circuit and distribution circuit that would be available to interrupt a fault current. At a high level, these electrical fault protection features include:

- Battery module overcurrent protection: The battery modules contain DC single-use fusible links mounted directly on the battery modules. These fuses are one-time only use safety devices that can interrupt the flow of an overcurrent in the battery module during an off-normal electrical event.
- Inverter DC protection: The inverter modules, which are installed at each of the battery modules, are equipped with their high-speed pyrotechnic fuse that can isolate the battery module passively or actively during an off-normal event.
- Inverter AC protection: In addition, each inverter module is equipped with its own AC contactor and AC fuses should an off-normal electrical event occur at the inverter module on the AC side of the circuit.

- Ground fault protection: Finally, the MP2XL is also provided with a DC ground fault detection system. It measures insulation resistance prior to operation and looks for excessive leakage current during operation. Additionally, the MP2XL also contains an AC circuit breaker, with ground-fault trip settings, which is installed within the CIB to provide distribution system protection.

2.8 EXPLOSION CONTROL SYSTEM

The MP2XL includes an explosion control system to mitigate the risk of an uncontrolled deflagration. The system includes pressure-sensitive vents (overpressure vents), and sparkers installed throughout the battery module bay. The sparkers are designed to ignite flammable gases very early in a thermal runaway event before they accumulate within the enclosure and become an explosion hazard. They are installed at a variety of locations and heights throughout the battery module bays to ensure the flammable gases released during thermal runaway quickly meet an ignition source. Note, this explosion control system has been extensively validated through installation level testing for previous versions of the Megapack as well as the MP2XL and its performance has been demonstrated in the field during thermal events involving Megapacks.

The overpressure vents are installed in the roof of the sealed battery bay's IP66 enclosure, as shown in Figure 4. When activated, the overpressure vents open up into the enclosed thermal roof, ensuring that the release of the overpressure vents does not create a projectile hazard. In addition, since they are installed in between the battery module bays and the thermal roof, the overpressure vents are not exposed to the environment, which means they are protected from the elements, such as falling tree limbs or snow, which could impact their functionality.

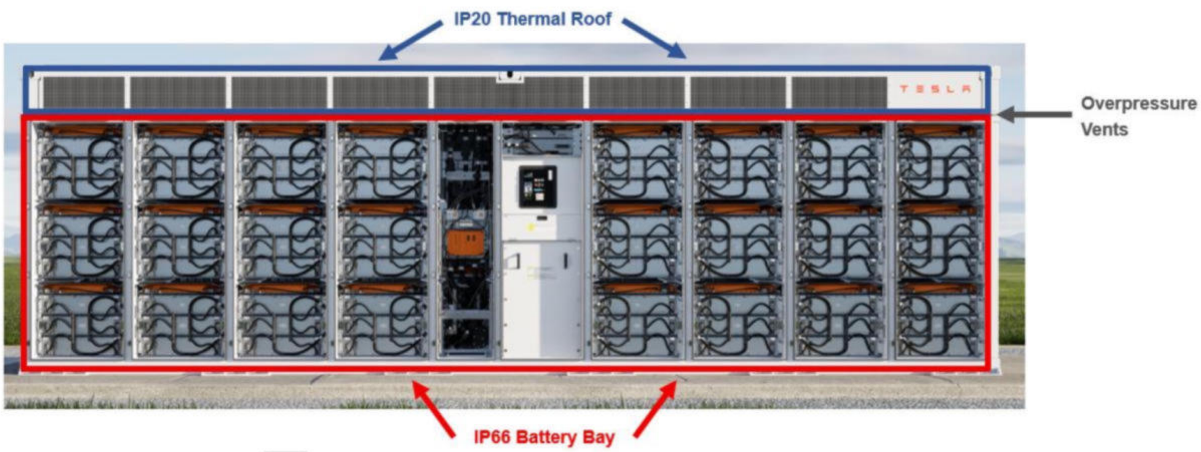


Figure 4. Location of Overpressure Vents In Between the Battery Bay and the Thermal Roof

Once opened, the overpressure vents permit gases, products of combustion, and flames to safely exhaust through the roof of the MP2XL during a thermal event. By designing this natural ventilation flow path, flammable gases are not permitted to accumulate within the MP2XL cabinet, reducing the risk of a deflagration or explosion that could compromise the cabinet's integrity, push open the front doors, or expel projectiles from the cabinet. In addition, the ventilation path creates a controlled fire condition, should one occur, out of the top of the MP2XL cabinet. By maintaining the MP2XL cabinet's integrity, keeping all the doors shut during a fire event, reducing the risk of projectiles, and creating a controlled path for flames to exit the top of the MP2XL cabinet, the likelihood of a thermal event having an impact on life safety, site personnel or first responders, is reduced. In addition, by maintaining these features, the likelihood of a fire propagating to adjacent MP2XL cabinets, electrical equipment, or other exposures is also reduced.

The overpressure vents themselves are passive and are not actuated or controlled by another device. They are designed to release during an overpressure event, such as the rapid ignition of flammable gases by a sparker. The number and total area of overpressure vents were sized following the guidance of NFPA 68 with a safety factor of two times the enclosure's strength, including the front doors. Tesla developed the overpressure vents and sparker system because the direct application of NFPA 68 or NFPA 69 is not suitable for MP2XL cabinets that do not have large volumes of open-air space. This engineered approach is permitted by NFPA 855 §9.6.5.6.4 provided it is validated by installation-level fire and explosion testing and an engineering evaluation, which Tesla has performed.

2.9 FIRE DETECTION AND SUPPRESSION

The MP2XL does not have an internal fire detection or suppression system that is integral to its design/construction. Multi-spectrum IR flame detection will be installed external to the MP2XL to detect flames exiting the cabinets, see Section 4.1.6. Testing performed by Tesla has demonstrated that multi-spectrum IR flame detectors are capable of detecting a fire once flames have exited the cabinet.

2.10 CLEARANCES

The MP2XL is provided with a series of passive fire protection schemes (barriers) to reduce the likelihood of thermal runaway from spreading from module-to-module and reduce the likelihood of a fire from spreading unit-to-unit. The MP2XL can be installed side-to-side with a clearance distance of 6 inches and back-to-back with a clearance distance of 18 inches (or 9 inches with prior Tesla approval). A minimum of 8 feet clearance must be provided in front of adjacent MP2XL cabinets. These clearances are based on UL9540A testing, additional large-scale fire tests and fire modeling results that demonstrate a fire will not propagate from one MP2XL to adjacent MP2XL cabinets under the tested conditions.

2.11 EMERGENCY RESPONSE

Tesla developed a MP2XL commissioning protocol, design and installation manual (DIM), an operations and maintenance manual (O&MM), and a lithium-ion battery emergency response guide (ERG) to provide guidance to anyone designing, installing, commissioning, operating, maintaining, servicing, decommissioning, or responding to an emergency involving an MP2XL. These manuals and guides can be utilized by site owners/operators to develop their own site-specific documents, such as commissioning plans, decommissioning plans, emergency operations plans (EOP), or emergency response plans (ERP).

2.12 MP2XL PRODUCT LISTINGS

The MP2XL and its subcomponents are certified or listed to multiple national and international product design standards. These certifications and listings apply to the cells, battery modules, inverters, power electronics, control systems, integration between the BESS and the grid, as well as the BESS as a whole. The standards highlighted below pertain to the lithium-ion cells, the battery modules and the MP2XL at the unit level. For a full listing of all certifications and listings for all the MP2XL components, please refer to the MP2XL Compliance Packet.

Table 1. MP2XL Product Listings

Listing Standard		Description
Cell/ Module Level	UL 1642	This certification standard is applicable to secondary (rechargeable) lithium-ion cells and batteries used as a power source (such as BESS). The standard's requirements are intended to reduce the risk of fire or explosion when the battery is used in a product. For example, the standard subject's lithium-ion batteries to severe abuse conditions and evaluates if they can safely withstand them.
	UL 1973	This certification standard is applicable to batteries and battery systems utilized for energy storage. The standard evaluates the battery system's ability to safely withstand simulated abuse conditions. For example, the standard subjects module-level stationary batteries to an internal fire exposure test to force a thermal runaway in one cell to ensure it does not explode, propagate fire to neighboring cells, or propagate to the rest of the modular battery system. UL 1973 applies to stationary BESS applications, such as photovoltaic installations and wind turbine energy storage systems (ESS), as well as other specialized ESS, such as light electric rail (LER) operations.
	IEC 62619	This safety standard specifies requirements and tests to ensure the safe operation of secondary (rechargeable) lithium-ion cells and batteries used in ESS and in other industrial applications. Electrical safety is covered under Clause 8 of the standard, which requires the completion of a risk analysis to determine specific electrical safety issues associated with the intended use of a given battery system or device.
MP2XL Level	IEC 92933-5-2	This safety standard addresses various aspects of BESS, including the requirements for grid-integrated BESS.
	UL 9540	This standard covers ESS (including lithium-ion BESS) for stationary indoor and outdoor installations and establishes the system-level certification for ESS and their associated equipment
	UL 9540A	The test methodology evaluates the fire characteristics and thermal runaway fire propagation of a BESS (including lithium-ion BESS). The test method provides a means to evaluate thermal runaway and fire propagation at the cell level, module level, and unit level. The data generated from the test method can be used to determine the fire and explosion protection required for a BESS installation based on fire test data. This test is specifically referenced by the CFC and NFPA 855 to demonstrate the functionality of the BESS fire protection features during large-scale fire testing.

3.0 MP2XL UL 9540A TESTING

The UL 9540A test method provides a method to evaluate thermal runaway and fire propagation of a lithium-ion BESS at the cell level, module level, unit level, and installation level. The data generated from the test method can be used to determine the fire and explosion protection systems/features required for a BESS installation. This includes, but is not limited to, thermal runaway characteristics of the cell; cell thermal runaway gas composition; the fire propagation potential from cell to cell, module to module, and unit to unit; products of combustion; heat release rate; smoke release rate; and performance of fire protection systems.

Initially, cells are tested to determine if further testing is required. Module level testing is required if the following observations are recorded during cell level testing:

- Thermal runaway is induced in the cell; and,
- The cell vent gas is flammable in air when tested in accordance with ASTM E918.

Module level testing examines the module design, heat release rate, gas generation, external debris, and flying debris hazards. Unit level testing is required if the following observations are recorded during module level testing:

- Module design is unable to contain thermal runaway; and,
- Cell vent gas is flammable.

Unit level testing assesses the BESS design of the unit, heat release rate, gas generation and composition, deflagration and flying debris hazards, BESS and wall surface temperatures, heat flux at the target walls, and reignition. Installation level testing is required if the following observations are recorded during unit level testing:

- Flaming is observed outside the initiating BESS unit;
- Surface temperature of the modules in the adjacent BESS unit exceeds the temperature at which cell level gas venting occurred;
- Surface temperatures of wall surfaces increase more than 175 ºF (79.4 ºC) from ambient; and,
- Explosion hazards are observed.

Installation level testing assesses the effectiveness of fire protection systems installed as mitigation methods for the BESS in its intended installation configuration.

A summary of the cell, module, and unit-level test results for the MP2XL are provided below.

3.1 UL 9540A CELL LEVEL SUMMARY

Cell-level testing was conducted at UL in December 2021. UL is an OSHA-approved Nationally Recognized Testing Laboratory (NRTL) and offers the UL mark for products. Testing was performed on five model CB5T0, 3.22 V, 157.2 Ah, LFP cells manufactured by Contemporary Amperex Technology Co., Ltd. (CATL) for use in the MP2XL. Each cell was charged to 100% state of charge (SOC) prior to testing. Thermal runaway was initiated via film strip heaters installed on both of the wide side surfaces of each cell, as shown in Figure 5. Meaning two heaters were installed on each cell. The heaters were programmed to increase the temperature of the cell's surface by approximately 4.5°C per minute until the cell vented and went into thermal runaway. The cell was placed within an enclosed enclosure and the products released during testing were collected and analyzed.

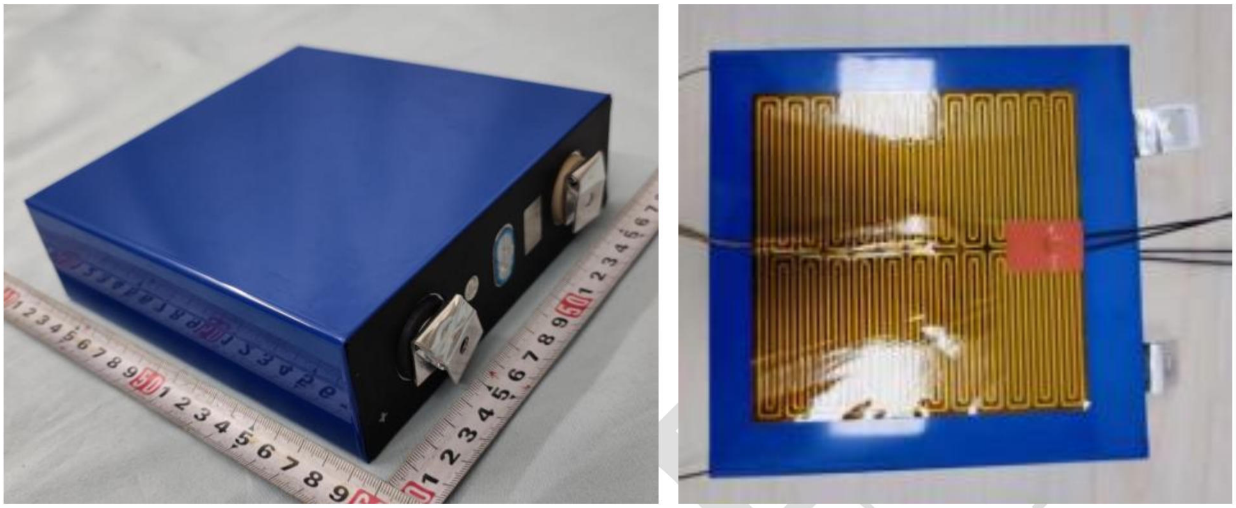


Figure 5. Individual Cell Tested to UL 9540A (Left) And Installed Film Strip Heater (Right)

3.1.1 Key takeaways & Results

Key takeaways from the tests include:

- The average cell vent and thermal runaway temperature was determined to be 174°C (345°F) and 239°C (462°F), respectively, as listed Table 2.
- 93.3 liters of cell vent gases were released.
- The cell vent gas mixture is flammable and has an LFL of 7.15% at ambient temperature.
- The cell vent gases were predominantly (approximately 95%) Carbon Monoxide (CO), Carbon Dioxide (CO2), Hydrogen (H2), and Methane (CH4), as listed in Table 3.
- Toxic gases sometimes associated with lithium-ion batteries, such as Hydrogen Fluoride (HF), Hydrogen Chloride (HCL), and Hydrogen Cyanide (HCN) were not vented from the cell.

Table 2. UL 9540A Cell Level Testing: Key Flammability Characteristics

Flammability Property	Value
Average cell surface temperature at gas venting	174°C
Average cell surface temperature at thermal runaway	239°C
Cell vent gas volume released	93.3 L
LFL, % volume in air at the ambient temperature	7.15%
LFL, % volume in air at the venting temperature	6.05%
Burning Velocity (Su)	90.0 cm/s
Maximum pressure (Pmax)	98.46 psig

Table 3. UL 9540A Cell Level Testing: Cell Vent Gas Composition (Excluding O_2 and N_2)

Gas Name	Chemical Structure	% Measured	Component LFL
Carbon Monoxide	CO	10.881	10.9
Carbon Dioxide	CO2	27.107	N/A
Hydrogen	H2	50.148	4.0
Methane	CH4	6.428	4.4
Acetylene	C2H2	0.264	2.3
Ethylene	C2H4	3.283	2.4
Ethane	C2H6	1.100	2.4
Propene	C3H6	0.379	1.8
Propane	C3H8	0.125	1.7
-	C4 (Total)	0.190	N/A
-	C5 (Total)	0.027	N/A
-	C6 (Total)	0.005	N/A
Benzene	C6H6	0.002	1.2
Toluene	C7H8	0.002	1.0
Dimethyl Carbonate	C3H6O3	0.055	N/A
Ethyl Methyl Carbonate	C4H8O3	0.004	N/A
Total	-	100	-

3.1.2 Performance Criteria

UL 9540A, Section 7.7 outlines the performance criteria for the cell level test. If all these conditions are met, further testing (such as module, unit, or installation level tests) are not required. The acceptable performance criteria during the UL 9540A cell level test are as follows:

Thermal runaway cannot be induced in the cell.

The cell vent gas does not present a flammability hazard when mixed with any volume of air, at both ambient and vent temperatures.

Given the cell went into thermal runaway and vented flammable gases, UL 9540A module level testing was required.

3.2 UL 9540A MODULE LEVEL SUMMARY

Module level testing was conducted at a TÜV SÜD (TÜV) laboratory in May 2022. TÜV is an OSHA-approved NRTL and offers the cTÜVus mark, which is equivalent to other NRTL marks such as UL, ETL or CSA. Testing was performed on a 360.64 V, 157.2 Ah, MP2XL tray (model MP2 Module), manufactured by CATL, as shown in Figure 6. Each tray consists of 112, CATL model CB5T0 LFP cells that were charged to 100% SOC prior to testing. During the test, the MP2XL tray is not connected to the BMS or TMS; meaning, they are not actively operating to prevent thermal runaway in a cell or to prohibit the propagation of thermal runaway from cell to cell. Thermal runaway was initiated via film strip heaters installed on both of the wide side surfaces of two cells, similar to the cell level test (see Figure 5). This resulted in the simultaneous heating of six cells forcing multiple cells into thermal runaway at approximately the same time. The heaters were programmed to increase the temperature of the cell's surface by approximately 4.17 - 4.52°C per minute until the cells vented and went into thermal runaway. The tray was placed under an instrumented hood and the products released during combustion were collected for analysis.

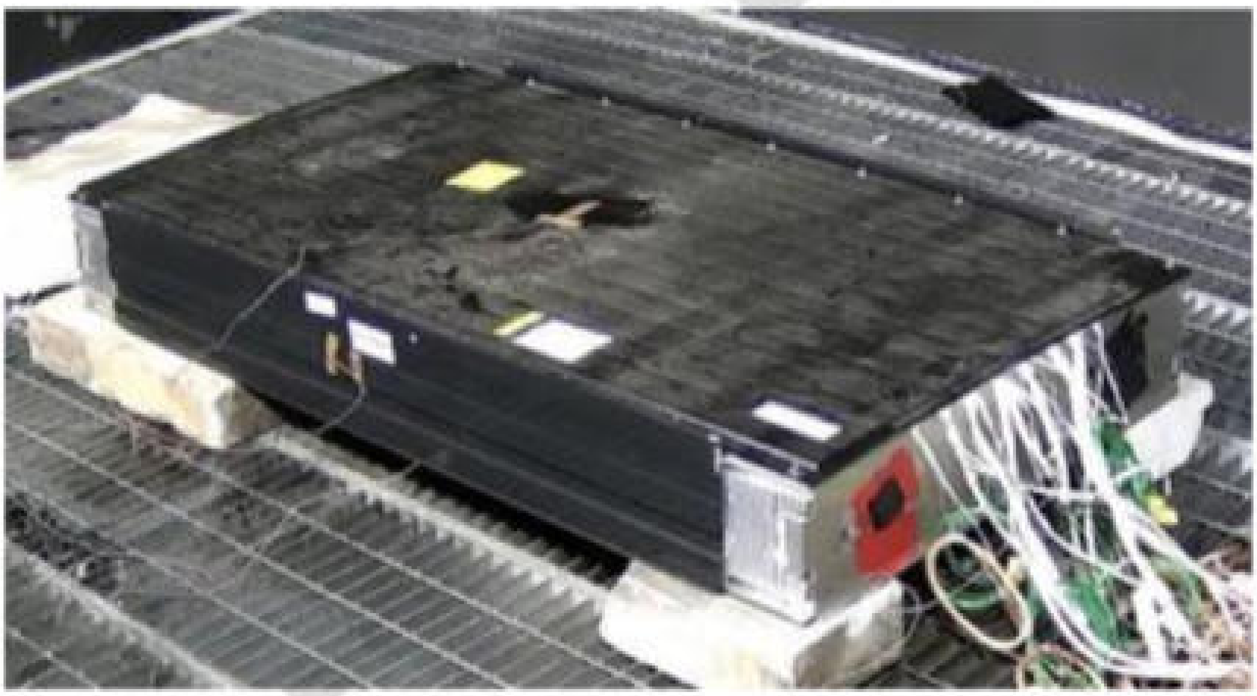


Figure 6. Tray Tested to UL 9540A Module Level Testing

3.2.1 Key Takeaways and Results

This simultaneous heating of six cells forced multiple cells to go into thermal runaway that propagated from the initiating cells to all the cells in the MP2XL tray. Once ignited, the MP2XL tray fire appears to be a slow-progressing thermal event that took approximately 30-35 minutes to burn itself out. Sparks and flying debris were observed during the test; however, there were no explosive discharges of gases. Products of combustion were collected in the hood and flammable gases were identified. Key takeaways from the UL 9540A module level test include:

- Thermal runaway propagated from the initiating cells to all the cells in the MP2XL tray.
- The MP2XL tray fire appears to be a slow-progressing thermal event requiring over 30 minutes to burn itself out.
- Sparks and flying debris were observed, however, there were no explosive discharges of gases.
- Products of combustion were collected, as listed in Table 4.
- Toxic gases sometimes associated with lithium-ion batteries, such as HF, HCL, and HCN, were not detected during the combustion of the MP2XL tray.

Table 4. UL 9540A Module Level Testing: Products of Combustion

Gas Name	Chemical Structure	Measurement Peak (ppm)	Detection Method
Carbon Monoxide	CO	205	FTIR
Carbon Dioxide	CO_2	6721	FTIR
Methane	CH_4	68.8	FTIR
Acetylene	C_2H_2	17.1	FTIR
Ethene	C_2H_4	Not Detected	FTIR
Ethane	C_2H_6	Not Detected	FTIR
Propane	C_3H_8	Not Detected	FTIR
Butane	C_3H_4	Not Detected	FTIR
Pentane	C_3H_6	Not Detected	FTIR
Benzene	C_6H_6	9.0	FTIR
Hexane	C_7H_{14}	Not Detected	FTIR
Hydrofluoric Acid	HF	Not Detected	FTIR
Hydrogen Chloride	HCL	Not Detected	FTIR
Hydrogen Cyanide	HCN	Not Detected	FTIR
Hydrogen	H_2	446	Hydrogen Sensor
Total Hydrocarbons	(Propane Equivalent)	247	FID

3.2.2 Performance Criteria

UL 9540A, Section 8.4 outlines the performance criteria for the module level test. If all these conditions are met, further testing (such as unit or installation level tests) are not required. The acceptable performance criteria during the UL 9540A module level test are as follows:

Thermal runaway is contained by module design.

Cell vent gas is nonflammable as determined by the cell level test.

Given the cell vent gases are flammable (as summarized previously) and thermal runaway was not contained by the module design, UL 9540A unit level testing was required.

3.3 UL 9540A UNIT LEVEL SUMMARY

The unit level fire test was conducted at the Northern Nevada Research Center (NNRC) on March 9, 2022, and was witnessed by TÜV. TÜV is an OSHA-approved NRTL and offers the cTÜVus mark, which is equivalent to other NRTL marks such as UL, ETL or CSA. Below is a summary of the UL 9540A unit level fire test results as well as a description of the performance of key fire safety features and systems during the test. This discussion is a summary of the test setup, test data and results. For a full description of the test, please refer to TÜV's UL 9540A unit level test report.

3.3.1 Test Setup and Initiation

The test was performed on a fully populated Megapack 2 (MP2). Note, the MP2XL is the larger version of the MP2. The MP2XL is equipped with 24 battery modules as opposed to the 19 battery modules found in the MP2. Its design, however, is almost identical to the MP2 other than being greater in length to accommodate the additional battery modules. Meaning, the MP2XL uses the exact same cells, battery modules, and power electronics (i.e., all the same internal components) that the MP2 utilizes in its design. In addition, the construction of cabinet itself, enclosure strength, and fire safety features, such as the explosion control system, are nearly identical for the two products. Given these similarities, TÜV witnessed and reported on one UL 9540A unit level fire test for the MP2 and MP2XL (i.e., the test and report apply to both models). Given all these similarities and that TÜV has determined one test can be applied to both models, it is also appropriate for this analysis to review the UL 9540A unit level fire test for the MP2 and apply those results to the MP2XL.

The MP2 test unit consisted of 19 battery modules, with a capacity of 3,100.8 kWh, tested at 100% SOC. Of all the MP2 variations, the unit tested during UL 9540A unit level testing is the largest capacity variant Tesla manufactures. In addition, during the test, the BMS and TMS are disabled; meaning, they are not actively operating to prevent thermal runaway in a cell or to prohibit the propagation of thermal runaway from cell-to-cell, or module-to-module. As such, the UL 9540A unit level fire test can be considered a worst-case scenario fire scenario, where: (1) the unit tested was the largest variation in terms of energy capacity; (2) the unit tested was at the highest energy density possible (100% SOC); and (3) the BMS and TMS were disabled and, therefore, unable to actively respond to the thermal runaway condition. It should be noted, the explosion protection sparker system was active during the test.

The initiating battery module was chosen to be the bottom battery module from Bay 7, in the middle battery tray, as shown in Figure 7. This location was deemed to be the worst-case, given there are battery trays directly above it and below it. In addition, by initiating in the bottom battery module, there are two additional battery modules installed directly above the initiation location. Within the battery tray itself, six interior cells were simultaneously heated via four film heaters (as shown previously in Figure 5). The heaters were programed to provide a heating rate of 5°C (9°F) per minute, as specified by UL 9540A. The number of cells and the location were selected to provide the greatest thermal exposure to adjacent cells to ensure cell to cell propagation during the test. The objective of this initiation method is to simulate a mass failure of multiple cells in a localized area within the same battery module.

Figure 7. MP2 Initiation Location: Bay 7, Bottom Battery Module Within Tray 2

Three additional target MP2 cabinets were installed: (1) 6 in (150 mm) behind; (2) 6 in (150 mm) to the side; and (3) 8 ft (2.44 m) in front the initiating MP2, as shown in Figure 8. The two target MP2 cabinets behind and to the side were populated with 100% SOC battery modules to simulate a multiple MP2 installation and to determine if thermal runaway and/or fire will propagate from one MP2 cabinet to adjacent cabinets at separation distances of 6 in (150 mm). Additionally, a combustible, instrumented wall (wood framing with plywood facing, painted black) was installed 5 ft (1.52 m) on the opposite side of the initiating MP2 to demonstrate if fire could spread to a combustible surface (plywood wall) during the test.

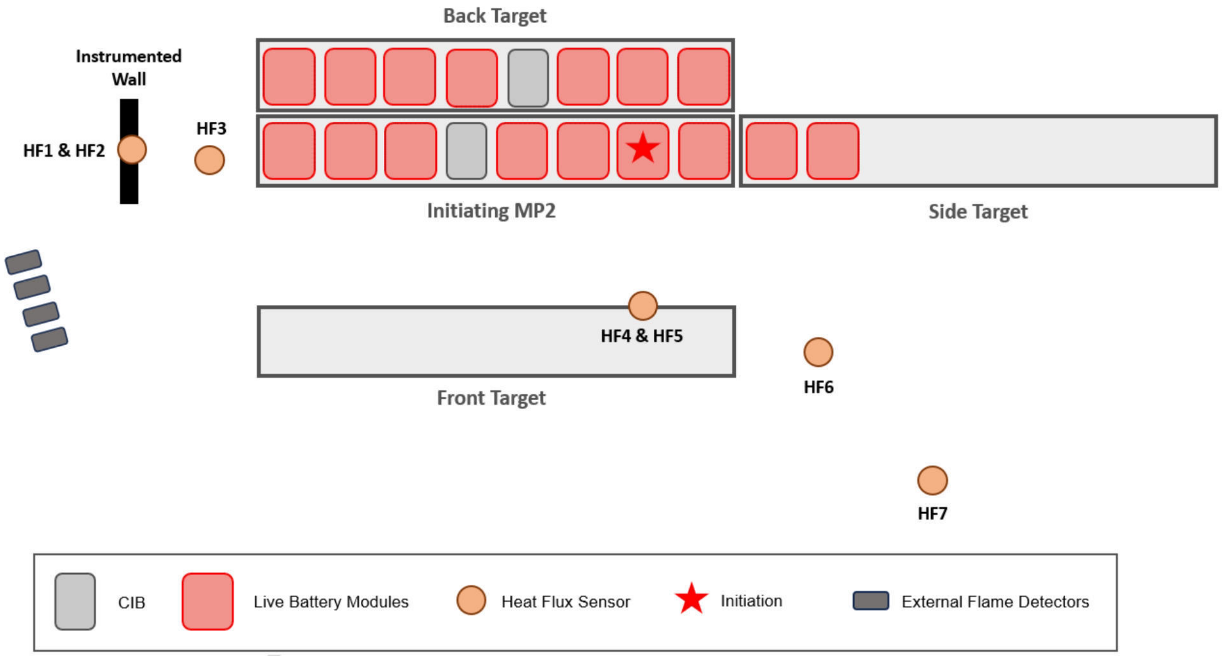


Figure 8. Instrumentation and Target MP2 Cabinet Setup (Top View)

3.3.2 Test Results

The cameras and instrumentation were turned on at or around time 0:00:00 (hours: minutes: seconds) and the heaters within the initiating MP2 were turned on at time 0:09:25. They heated six cells simultaneously for over 1-hour and 18 minutes until the first initiation cell reached its thermal runaway temperature of 239°C (462°F). Fifteen minutes later, the second group of initiating cells reached their thermal runaway temperature. Around 6 minutes later (approximately 1-hour 39 minutes into the test), light smoking/off-gassing was observed exiting the MP2 cabinet in the location where instrumentation was routed into the cabinet (i.e., where thermocouple wiring and power wiring for the film heaters were in contact with the gasket that forms a tight seal for Bay 7's front door). Cell-to-cell propagation (thermal runaway spreading beyond the initial six cells being forcibly heated) was confirmed at approximately 1 hour 45 minutes when a seventh cell reached a temperature of 239°C (462°F). The heaters continued to run for an additional 5 minutes after this observation and then were shut off (at approximately 1 hour and 51 minutes into the test). Thermocouple temperatures inside the initiating MP2 subsided and no additional off-gassing, smoking or thermal runaways were observed. By 2 hours and 30 minutes, the test ended. However, a period of observation and data collection continued for hours afterwards to ensure the MP2 did not demonstrate any signs of distress. Table 5 provides a summary of key events from the UL 9540A unit level fire test of the MP2.

Table 5. UL 9540A Unit Level Testing: Timeline of Key Events

Elapsed Time hr:min:sec	Event
00:00:00	**Start of Test.** Cameras and Data acquisition system (DAQ) turned on.
0:09:25	Heaters ON.
1:18:18	First group of initiating cells reach thermal runaway temperature of 239°C (462°F).
1:33:38	Second group of initiating cells reach thermal runaway temperature of 239°C (462°F).
1:39:28	Smoke observed exiting out the bottom of the initiating MP2 cabinet's bay door where instrumentation was routed into the cabinet.
1:45:48	Confirmation of cell propagation to a 7^{th} cell via internal thermocouple measurements.
1:51:09	Heaters turned OFF.
2:00:00	No additional smoke was observed from the initiating MP2 cabinet. Internal temperatures subside.
2:30:00	**End of Test.**
Post Test Overhaul	The initiating MP2 cabinet was observed for several hours afterwards and allowed to cool. No additional off-gassing, smoking, elevated temperatures, fire, thermal runaways, or signs of abnormal conditions were observed.

After 24 hours, the initiating MP2 had not shown any signs of abnormal conditions or distress since the test had concluded (no additional off-gassing, smoking, smells, thermal runaway, or flare ups) and it was opened for inspection. Prior to opening the initiating MP2, handheld gas detection devices were utilized around the cabinets and did not detect the presence of flammable gases nor were flammable gases detected internally after the Bay 7 door was opened.

3.3.3 Key Takeaways

After the test, analysis of the data and a visual inspection of the initiating MP2 yielded the following observations:

- Over the duration of the test, seven cells went into thermal runaway: the six that were forcibly heated and one additional cell. This demonstrated that cell to cell propagation had occurred during the test, as is required by UL 9540A.
- No other signs of distress were observed in the initiating battery module. Thermal runaway did not propagate beyond the seven cells within Tray 2, nor did it spread to the tray above or below it within the battery module.
- Visible clues of fire damage were not observed to components (plastics, electronics, etc.) adjacent to the seven failed cells. Based on this observation, it is likely that a sustained fire did not occur around the initiating battery module, even with the failure of seven cells occurring.
- The battery modules within the target MP2 cabinets installed 6 in behind and to the sides were unaffected.
- Heat flux measurements were recorded throughout the UL 9540A unit level fire test at distances of 3, 5, 8, 20 and 30 ft. Since flames did not occur outside the initiating MP2 cabinet, predictably, these measurements were 0.00 kW/m2 throughout the entire test.
- The MP2XL does not have an internal fire suppression system or one that is integral to its design/construction. The UL 9540A unit level fire test results demonstrate that a suppression system is not required to prevent thermal runaway propagation from cell-to-cell, module-to-module or cabinet-to-cabinet when a near simultaneous failure of up to six cells occurs within the same battery module.
- Explosion hazards, including but not limited to, observations of a deflagration, projectiles, flying debris, detonation, or other explosive discharge of gases were not observed during the test when a near simultaneous failure of up to six cells occurs within the same battery module.
- Internal cell components were observed inside the initiating MP2 cabinet in the area of the initiating battery module and around Bay 7's front door; however, no free-flowing liquid or runoff was observed.
- The overpressure vents in Bay 7 had not opened, indicating that the internal pressure within Bay 7 did not see a significant rise during the failure of the seven cells.
- 24 hours after the conclusion of the test, flammable/toxic gases were not present in the vicinity of the cabinet.

These test results meet all five of UL 9540A's performance criteria for outdoor ground mounted BESS units. The unit level test demonstrated that the near simultaneous failure of six cells within the same battery tray did not lead to flaming combustion nor to a propagating thermal runaway event throughout the MP2 cabinet.

4.0 COMPASS BESS

The Compass BESS is being proposed for installation in San Juan Capistrano, CA. The Compass BESS Site is bounded by Camino Capistrano to the east and open land to north, west and south, as shown in Figure 9. For a more detailed view of the surrounding area, see Appendix A, Aerial Maps. As such, the Compass BESS will be located in a developed area in San Juan Capistrano surrounded by residential neighborhoods and commercial properties.

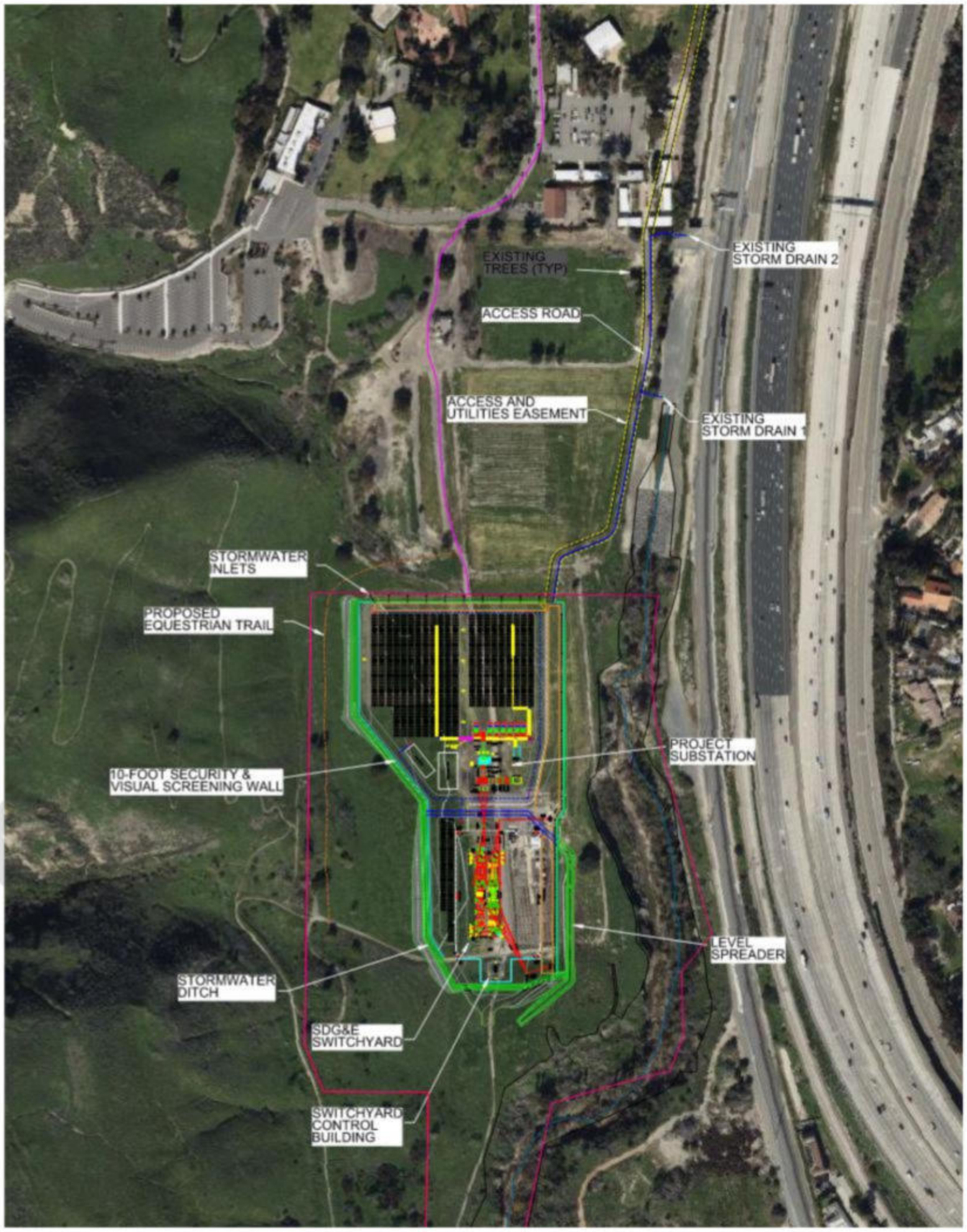


Figure 9. Aerial Map

4.1 SITE LEVEL FIRE SAFETY

Based on a review of the Compass BESS Permit Drawing Package (the drawing set), the Compass BESS includes 316 MP2XL cabinets with an approximate capacity of 1,238 MWh, as shown in Figure 10. It will also include 79 medium voltage transformers, a new BESS substation, and a new SDG&E switchyard to support the MP2XL cabinets. For a more detailed view of the site layout and associated equipment, see Appendix B – Site Plans.

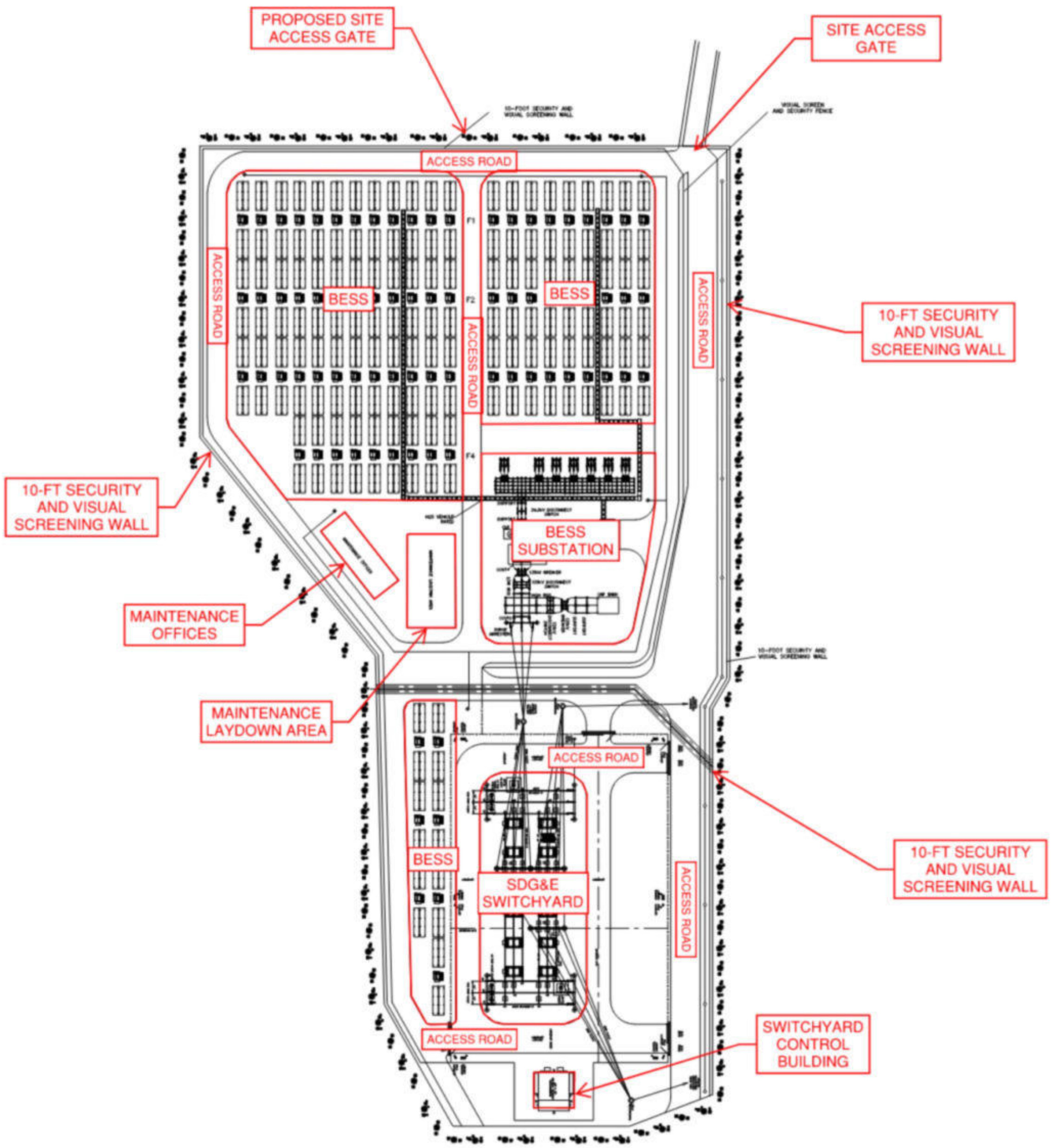


Figure 10. Site Plan

Note: The Site Plan will be updated at a later time to include additional items requested by Orange County Fire Authority (OCFA) and CEC.

4.1.1 BESS Monitoring and Emergency Notification

The Compass BESS will be remotely monitored by a Tesla LOC. If an abnormal signal is received at the Tesla LOC, they will contact the operation and maintenance (O&M) management organization and the responsible service personnel (O&M service personnel). If necessary, such as the abnormal condition leading to a thermal event, the O&M service personnel responding to the signal will then notify first responders.

4.1.2 Periodic Maintenance

The Compass BESS will be periodically inspected and serviced by trained O&M service personnel from the O&M management organization, as required by Tesla's MP2XL O&MM.

4.1.3 BESS Security

A 10-ft tall security and visual screening wall will be installed around the perimeter of the Compass BESS to prohibit access to the MP2XL cabinets. The secured area around the Compass BESS will include two gates provided on the north side of the perimeter wall for vehicle/equipment access. A Knox Box for the fire department (and other authorized personnel) will be provided at the site access gates.

Additionally, the Compass BESS site operates a 24/7 monitoring system that includes video surveillance, and infrared monitoring connected to its remote operations center with links to local emergency responders.

4.1.4 Fire Department Access

Orange County Fire Authority Station 9 is the closest fire department to the Compass BESS and is approximately 1.5 miles away to the north. The closest access road to the Compass BESS is provided off Camino Capistrano which leads to the site access gate on the north side. The fire apparatus access road will meet CFC and OCFA requirements and has the following design features:

- Extends to within 50 feet of the Compass BESS.
- Have a minimum unobstructed width of 20 feet with suitable turning radius/angles of approach/departure and an unobstructed vertical clearance.
- Constructed of a terrain capable of providing all-weather driving capabilities.
- No dead-ends. Dead-end fire apparatus access roads are provided with areas for turning around.
- The grade of the fire apparatus access road does not exceed 16%.

4.1.5 Emergency Water

The Compass BESS site will be provided with fire hydrants throughout, in compliance with CFC §507 and OCFA requirements. The quantity and location of the fire hydrants at the Compass BESS site will be coordinated in collaboration with OCFA. The fire hydrants will provide emergency response water supply for fire department use during a fire event, if needed. Note, per Tesla's

ERG, manual fire suppression (hose lines) is not required to suppress an MP2XL fire. However, if manual firefighting tactics are used, water is considered the preferred agent for managing lithium-ion battery fires, suppressing nearby combustibles, cooling nearby exposures, and controlling smoke. Other fire suppression methods, such as gaseous agents (CO_2, Halon), dry chemical suppressants, or foams, are unlikely to be effective, as stated by Tesla's ERG.

4.1.6 Fire Alarm and Notification System

The MP2XL does not come equipped with an integral smoke, gas, or fire detection system inside the cabinet. To provide early detection and notification of a thermal event, the Compass BESS will have an external flame detection system installed outside of the MP2XL cabinets. The flame detectors will be mounted and are capable of detecting fires or other thermal events emanating from the MP2XL cabinets once hot gases or flames exit the cabinet. The fire detection will be installed in accordance with NFPA 72 and monitored locally by a fire alarm control panel (FACP). The FACP will be monitored 24/7 by a remote monitoring station, as required by the CFC. Should a fire or other thermal event occur at the Compass BESS Site that triggers an alarm at the FACP, the remote monitoring station will receive that alarm signal and can then notify the site contact (O&M management organization) and the fire department.

4.2 PERMANENT BESS OR ELECTRICAL GRID EXPOSURES

(For purposes of this Section, the term "exposure" refers to a structure or other infrastructure that can potentially be subjected to the BESS.)

The Compass BESS, and its associated equipment mentioned below, are intended to operate year-round, 24 hours a day, 365 days a year. Installed within the secured Compass BESS Site will be at least 316 MP2XL cabinets, 1 main voltage transformer, 79 medium voltage transformers, and other auxiliary equipment. Installed at the new substation will be the switchgear, high-voltage lines, and substation control building. The new SDG&E switchyard will be the point of interconnection (POI) between the grid and the Compass BESS. As described in the Permit Drawing Package, the clearance distances to these permanent electrical exposures associated with the Compass BESS and or electrical grid are summarized in Table 6.

Table 6. Distance to Permanent Exposures Associated with the Compass BESS or Grid

Exposure	Distance	Comment
Transformers	4.5 ft	In the BESS yard
SDG&E Switchgear	43 ft	In the new SDG&E switchyard east of the closest MP2XL
Substation Switchgear	46 ft	In the new BESS substation east of the closest MP2XL
Substation Control Building	108 ft	In the new BESS substation south of the closest MP2XL
Switchyard Control Building	110 ft	Southeast of the closest MP2XL

4.3 PERMANENT PUBLIC EXPOSURES

(For purposes of this Section, the term “exposure” refers to a structure or other infrastructure that can potentially be subjected to the BESS.)

The proposed location for the Compass BESS is a developed area in San Juan Capistrano surrounded by residential neighborhoods and commercial properties. All permanently installed public exposures (lot lines, public ways, buildings, stored combustible materials, hazardous materials, high-piled stock, and exposures not associated with electrical grid infrastructure) are greater than 10 ft from the MP2XL cabinets, as required by CFC §1207.8.3. Clearance distances to these public exposures are summarized in Table 7.

Table 7. Distance to Permanent Public Exposures

Exposure	Distance	Comment
Maintenance Offices	20 ft	North of the closest MP2XL
Security and Visual Screening Wall	34 ft	North of the closest MP2XL
Maintenance Laydown Area	43 ft	North of the closest MP2XL
Property Line	53 ft	North of the closest MP2XL
Metrolink Railroad	440 ft	East of the closest MP2XL
Camino Capistrano	520 ft	East of the closest MP2XL
Interstate Highway 5	580 ft	East of the closest MP2XL
Saddleback Church Parking Lot	780 ft	Northeast of the closest MP2XL
Nearest Residence	960 ft	East of the closest MP2XL
Saddleback Church Building	1,050 ft	North of the closest MP2XL

5.0 BESS SITE DESIGN CODE ANALYSIS

BESS projects within the state of California are required to meet the requirements of the CFC §1207. The Compass BESS is an outdoor installation and thus falls under CFC §1207.8, *"Outdoor installations shall be in accordance with Sections 1207.8.1 through 1207.8.3. Exterior wall installations for individual ESS units not exceeding 20 kWh shall be in accordance with Section 1207.8.4."* The requirements for outdoor BESS installations are found in CFC Table 1207.8.

5.1 BESS INSTALLATION CLASSIFICATIONS

The Compass BESS includes 316 MP2XL cabinets, installed outdoors. The MP2XL is a NWI style BESS that is unoccupiable, with all internal components accessible via exterior doors. For outdoor BESS installations, the CFC provides code requirements based on the proximity and location of the BESS equipment from adjacent exposures [CFC §1207.8]. The two outdoor installation classifications are as follows:

- **Remote locations** – BESS located more than 100 ft from buildings, lot lines that can be built upon, public ways, stored combustible materials, hazardous materials, high-piled stock, and other exposure hazards not associated with electrical grid infrastructure.
- **Installations near exposures** – BESS locations that do not comply with remote outdoor location requirements.

Based on the Permit Drawing Package, there is a 100 ft separation distance between the MP2XL cabinets, and the nearest exposures not associated with the electrical grid infrastructure. As such, the Compass BESS is classified as a remote, outdoor BESS for this analysis. CFC Table 1207.8 and 1207.6 list the code requirements pertaining to a remote, outdoor lithium-ion BESS installation. These requirements are summarized below in Table 8 and discussed in detail within the following sections. Other CFC requirements that apply to all facilities regulated by the CFC, BESS or otherwise, include fire apparatus access roads (CFC §503), key boxes (CFC §506), and fire protection water supplies (CFC §507).

Table 8. CFC Remote Location BESS Installation Requirements

Requirement	Compliance Required	CFC Code Reference
All ESS installations	Yes	§1207.4
Size and separation	No	§1207.5.1
Maximum allowable quantities	No	§1207.5.2
Smoke and automatic fire detection	Yes	§1207.5.4
Fire suppression systems	Yes	§1207.5.5
Maximum enclosure size	Yes	§1207.5.6
Vegetation control	Yes	§1207.5.7
Means of egress separation	Yes	§1207.5.8
Clearance to exposures	Yes	§1207.8.3
Technology Specific Protection – Lithium-Ion Batteries		

Requirement	Compliance Required	CFC Code Reference
Explosion control	Yes	§1207.6.3
Thermal runaway	Yes	§1207.6.5
Other CFC Requirements – All Facilities		
Fire apparatus access roads	Yes	§503
Key boxes	Yes	§506
Fire protection water supply	Yes	§507

5.2 ALL ESS INSTALLATIONS

CFC §1207.4 applies to all ESS installations: indoors, outdoors, stationary, or mobile. Only the fire and life safety general installation requirements applicable to the site design of a remote, outdoor, NWI style BESS installation are summarized in the following sections. Requirements unrelated to fire and life safety or pertaining to other types of BESS installations, such as indoor installs, are not discussed. These include fire-resistance rated separations [CFC §1207.4.3], seismic and structural design [CFC §1207.4.4], occupied work centers [CFC §1207.4.10], open rack installation [CFC §1207.4.11], walk-in units [CFC §1207.4.12].

5.2.1 Electrical Disconnects

CFC §1207.4.1 states, "*Where the ESS disconnecting means is not within sight of the main electrical service disconnecting means, placards or directories shall be installed at the location of the main electrical service disconnecting means indicating the location of stationary storage battery system disconnecting means in accordance with the California Electrical Code.*

Exception: *Electrical disconnects for lead-acid and nickel-cadmium battery systems at facilities under the exclusive control of communications utilities and operating at less than 50 VAC and 60 VDC shall be permitted to have electrical disconnects signage in accordance with NFPA 76."*

The MP2XL installation at the Compass BESS meets this requirement. The BESS utility AC disconnect will be installed at the new substation, adjacent to the main electrical service disconnecting means. In addition, placards and signage will be provided, if necessary, depicting the locations of all electrical disconnects, as required by CFC §1207.4.1.

5.2.2 Working Clearances

CFC §1207.4.2 states, *"Access and working space shall be provided and maintained about all electrical equipment to permit ready and safe operation and maintenance of such equipment in accordance with the California Electrical Code and the manufacturer's instructions."*

The MP2XL installation at the Compass BESS meets this requirement. Based on a review of the MP2XL DIM, working clearances of 8 ft in front of the MP2XL are provided at the Compass BESS, which is what Tesla specifies in the MP2XL DIM.

5.2.3 Vehicle Impact Protection

CFC §1207.4.5 states, "*Where stationary storage battery systems are subject to impact by a motor vehicle, including fork lifts, vehicle impact protection shall be provided in accordance with Section 312.*"

The MP2XL installation at the Compass BESS meets this requirement. The MP2XL installation at the Compass BESS is not located in an area subject to vehicle impact. The Compass BESS area is secured from the public and does not permit public vehicular traffic.

5.2.4 Combustible storage

CFC $1207.4.6. states, *"Combustible materials shall not be stored in ESS rooms, areas or walk-in units. Combustible materials in occupied work centers covered by Section 1207.4.10 shall be stored at least 3 feet (914 mm) from ESS cabinets."*

The MP2XL installation at the Compass BESS meets this requirement. Combustible storage will not be present within the Compass BESS site.

5.2.5 Toxic and Highly Toxic Gases

CFC §1207.4.7 states, *"ESS that have the potential to release toxic and highly toxic gas during charging, discharging and normal use conditions shall be provided with a hazardous exhaust system in accordance with Chapter 5 of the California Mechanical Code."*

The MP2XL installation at the Compass BESS meets this requirement. The MP2XL utilizes hermetically sealed cells that do not release toxic and highly toxic gas during charging, discharging, and normal use conditions.

5.2.6 Signage

CFC §1207.4.8 states, *"Approved signs shall be provided on or adjacent to all entry doors for ESS rooms or areas and on enclosures of ESS cabinets and walk-in units located outdoors, on rooftops or in open parking garages. Signs designed to meet both the requirements of this section and the California Electrical Code shall be permitted. The signage shall include the following or equivalent:*

1. *"ENERGY STORAGE SYSTEM," "BATTERY STORAGE SYSTEM," "CAPACITOR ENERGY STORAGE SYSTEM" or the equivalent.*
2. *The identification of the electrochemical ESS technology present.*
3. *"ENERGIZED ELECTRICAL CIRCUITS."*
4. *Where water-reactive electrochemical ESS are present, the signage shall include "APPLY NO WATER."*
5. *Current contact information, including phone number, for personnel authorized to service the equipment and for fire mitigation personnel required by Section 1207.1.6.1.*

Exception: *Existing electrochemical ESS shall be permitted to include the signage required at the time they were installed."*

The MP2XL installation at the Compass BESS will meet this requirement. The permitted electrical drawings will include all signage required by the CFC.

5.2.7 Security of Installations

CFC §1207.4.9 states, "*Rooms, areas and walk-in units in which electrochemical ESS are located shall be secured against unauthorized entry and safe-guarded in an approved manner. Security barriers, fences, landscaping and other enclosures shall not inhibit the required air flow to or exhaust from the electrochemical ESS and its components.*"

The MP2XL installation at the Compass BESS meets this requirement. A 10-foot-tall security and visual screening wall will be installed around the perimeter of the Compass BESS to prohibit access to the MP2XL. Additionally, the Compass BESS site operates a 24/7 monitoring system that includes video surveillance, and infrared monitoring connected to its remote operations center with links to local emergency responders.

5.3 REMOTE OUTDOOR ESS INSTALLATIONS

5.3.1 Size and Separation

CFC §1207.5.1 states, *"Electrochemical ESS shall be segregated into groups not exceeding 50 kWh (180 megajoules). Each group shall be separated a minimum of 3 feet (914 mm) from other groups and from walls in the storage room or area. The storage arrangements shall comply with Chapter 10.*

1. *Lead-acid and nickel-cadmium battery systems in facilities under the exclusive control of communications utilities and operating at less than 50 VAC and 60 VDC in accordance with NFPA 76.*
2. *The fire code official is authorized to approve larger capacities or smaller separation distances based on large-scale fire testing complying with Section 1207.1.5."*

The MP2XL is a remote outdoor installation; therefore, the size and separation requirement does not apply. Nonetheless, the MP2XL installation at the Compass BESS meets this requirement. The Compass BESS will have larger capacities and smaller separation distances than what is specified in CFC §1207.5.1. However, the CFC permits the size and separation utilized at the Compass BESS based on the UL 9540A large-scale fire testing results (CFC §1207.5.1 Exception 2). Large-scale fire testing performed on the MP2XL in accordance with UL 9540A (see Section 3.3) demonstrated that a fire will not propagate from module-to-module within the MP2XL or to adjacent MP2XL cabinets.

5.3.2 Maximum Allowable Quantities

CFC §1207.5.2 states, *"Fire areas within rooms, areas and walk-in units containing electrochemical ESS shall not exceed the maximum allowable quantities in Table 1207.5.*

1. *Where approved by the fire code official, rooms, areas and walk-in units containing electrochemical ESS that exceed the amounts in Table 1207.5 shall be permitted based on a hazardous mitigation analysis in accordance with Section 1207.1.4 and large-scale fire testing complying with Section 1207.1.5.*
2. *Lead-acid and nickel-cadmium battery systems installed in facilities under the exclusive control of communications utilities, and operating at less than 50 VAC and 60 VDC in accordance with NFPA 76.*

3. *Dedicated-use buildings in compliance with Section 1207.7.1."*

The MP2XL is a remote outdoor installation; therefore, the maximum allowable quantity requirement does not apply. Nonetheless, the MP2XL installation at the Compass BESS meets this requirement. The Compass BESS will have a capacity of 1,238 MWh, which is greater than the 600-kWh threshold specified in CFC Table 1207.5. However, the CFC permits the maximum allowable quantity utilized at the Compass BESS based on the development of an HMA and performing UL 9540A large-scale fire testing (CFC §1207.5.2 Exception 1). Large-scale fire testing performed on the MP2XL in accordance with UL 9540A (see Section 3.3) demonstrated that a fire will not propagate from module-to-module within the MP2XL or to adjacent MP2XL cabinets. In addition, this HMA has been developed for the Compass BESS and demonstrates that the 600-kWh limitation can be exceeded (CFC §1207.5.2 Exception 1).

5.3.3 Fire Detection

CFC §1207.5.4 states, *"An approved automatic smoke detection system or radiant energy-sensing fire detection system complying with Section 907.2 shall be installed in rooms, indoor areas and walk-in units containing electrochemical ESS. An approved radiant energy-sensing fire detection system shall be installed to protect open parking garage and rooftop installations. Alarm signals from detection systems shall be transmitted to a central station, proprietary or remote station service in accordance with NFPA 72, or where approved to a constantly attended location.*

The MP2XL installation at the Compass BESS meets this requirement. The Compass BESS will have an external flame detection system capable of detecting a fire event should flames exit the MP2XL cabinet. The fire detection system will be connected to a FACP and will be monitored by a remote monitoring station, which, in the event of a fire, will call the fire department.

5.3.4 Fire Suppression Systems

CFC §1207.5.5 states, *"Rooms and areas within buildings and walk-in units containing electrochemical ESS shall be protected by an automatic fire suppression system designed and installed in accordance with one of the following:*

1. *An automatic sprinkler system designed and installed in accordance with Section 903.3.1.1 with a minimum density of 0.3 gpm/ft2 (1.14 L/min) based on the fire area or 2,500 square-foot (232 m2) design area, whichever is smaller.*
2. *Where approved, an automatic sprinkler system designed and installed in accordance with Section 903.3.1.1 with a sprinkler hazard classification based on large-scale fire testing complying with Section 1207.1.5.*
3. *The following alternative automatic fire-extinguishing systems designed and installed in accordance with Section 904, provided that the installation is approved by the fire code official based on largescale fire testing complying with Section 1207.1.5:*
    - 3.1. *NFPA 12, Standard on Carbon Dioxide Extinguishing Systems.*
    - 3.2. *NFPA 15, Standard for Water Spray Fixed Systems for Fire Protection.*
    - 3.3. *NFPA 750, Standard on Water Mist Fire Protection Systems.*
    - 3.4. *NFPA 2001, Standard on Clean Agent Fire Extinguishing Systems.*

3.5. NFPA 2010, Standard for Fixed Aerosol Fire-Extinguishing Systems.

Exception: Fire suppression systems for lead-acid and nickel-cadmium battery systems at facilities under the exclusive control of communications utilities that operate at less than 50 VAC and 60 VDC shall be provided where required by NFPA 76."

The MP2XL is listed for outdoor installations and will not be installed in a room, areas within buildings, nor within a walk-in unit at the Compass BESS. Therefore, the fire suppression system requirement does not apply. Nonetheless, the MP2XL meets the intent of this requirement through a series of passive fire protection features (barriers), which prevents a fire in one MP2XL cabinet from spreading to adjacent cabinets without an integral fire suppression system installed inside the MP2XL, as demonstrated in UL 9540A unit level fire testing.

5.3.5 Maximum Enclosure Size

CFC §1207.5.6 states, *"Outdoor walk-in units housing ESS shall not exceed 53 feet by 8 feet by 9.5 feet high (16154 mm × 2438 mm × 2896 mm), not including bolt-on HVAC and related equipment, as approved. Outdoor walk-in units exceeding these limitations shall be considered indoor installations and comply with the requirements in Section 1207.7."*

The maximum enclosure size requirement does not apply to the MP2XL installation at the Compass BESS. The MP2XL is not a walk-in unit. Therefore, the maximum enclosure size requirement does not apply. Nonetheless, the MP2XL meets the intent of this requirement, as described in Section 2, its dimensions are 28.9 ft in length, 5.4 ft deep, and 9.2 ft in height. These dimensions are below the maximum length, width, and height requirements specified in §1207.5.6.

5.3.6 Vegetation Control

CFC §1207.5.7 states, *"Areas within 10 feet (3048 mm) on each side of outdoor ESS shall be cleared of combustible vegetation and other combustible growth. Single specimens of trees, shrubbery or cultivated ground cover such as green grass, ivy, succulents or similar plants used as ground cover shall be permitted to be exempt provided that they do not form a means of readily transmitting fire."*

The MP2XL installation at the Compass BESS meets this requirement. Combustible vegetation and other combustible growth will be cleared around the MP2XL cabinets such that none are within 10 feet. Additionally, a 10-foot-tall security and visual screening wall will be provided around the site and act as a barrier against external vegetation.

The Compass BESS site is located with a fuel modification zone and the landscaping plan will meet the requirements of the CFC and OCFA.

5.3.7 Means of Egress Separation

CFC §1207.5.8 states, "*Stationary storage battery systems located outdoors shall be separated from any means of egress as required by the fire code official to ensure safe egress under fire conditions, but not less than 10 feet (3048 mm).*

Exception: *The fire code official is authorized to approve a reduced separation distance if large-scale fire testing complying with Section 1207.1.5 is provided that shows that a fire involving the ESS will not adversely impact occupant egress."*

The MP2XL installation at the Compass BESS meets this requirement. Based on a review of the Permit Drawing Package, the closest building to a MP2XL cabinet will be the maintenance offices, which are greater than 10 ft away from the nearest MP2XL cabinet.

5.3.8 Clearance to Exposures

CFC §1207.8.3 states, "*ESS located outdoors shall be separated by a minimum of 10 feet (3048 mm) from the following exposures*: *1. Lot lines, 2. Public Ways, 3. Buildings, 4. Stored combustible materials, 5. Hazardous materials, 6. High-piled stock, 7. Other exposure hazards.*

Exceptions:

1. *Clearances are permitted to be reduced to 3 feet (914 mm) where a 1-hour free-standing fire barrier suitable for exterior use and extending 5 feet (1524 mm) above and 5 feet (1524 mm) beyond the physical boundary of the ESS installation is provided to protect the exposure.*
2. *Clearances to buildings are permitted to be reduced to 3 feet (914 mm) where noncombustible exterior walls with no openings or combustible overhangs are provided on the wall adjacent to the ESS and the fire-resistance rating of the exterior wall is a minimum of 2 hours.*
3. *Clearances to buildings are permitted to be reduced to 3 feet (914 mm) where a weatherproof enclosure constructed of noncombustible materials is provided over the ESS, and it has been demonstrated that a fire within the enclosure will not ignite combustible materials outside the enclosure based on large-scale fire testing complying with Section 1207.1.5.*

The MP2XL installation at the Compass BESS meets this requirement. Based on a review of the Permit Drawing Package, the closest exposure to the MP2XL cabinet will be the maintenance offices, which is greater than 10 ft away from the nearest MP2XL cabinet.

5.4 TECHNOLOGY SPECIFIC PROTECTION – LITHIUM-ION

CFC §1207.6 requires electrochemical ESS to comply with the requirements as outlined in CFC Table 1207.6. For lithium-ion batteries, it requires compliance with the explosion control requirements of §1207.6.3 and the thermal runaway requirements of §1207.6.5. Note, lithium-ion batteries do not need to meet the exhaust ventilation requirements of §1207.6.1, the spill control and neutralization requirements of §1207.6.2, or the safety cap requirements of §1207.6.4.

5.4.1 Explosion Control

CFC §1207.6.3 states, *"Where required by Table 1207.6 or elsewhere in this code, explosion control complying with Section 911 shall be provided for rooms, areas or walk-in units containing electrochemical ESS technologies.*

Exceptions:

1. *Where approved, explosion control is permitted to be waived by the fire code official based on large-scale fire testing complying with Section 1207.1.5 that demonstrates that*

flammable gases are not liberated from electrochemical ESS cells or modules where tested in accordance with UL 9540A.

2. *Where approved, explosion control is permitted to be waived by the fire code official based on documentation provided in accordance with Section 104.7 that demonstrates that the electrochemical ESS technology to be used does not have the potential to release flammable gas concentrations in excess of 25 percent of the LFL anywhere in the room, area, walk-in unit or structure under thermal runaway or other fault conditions."*

The MP2XL includes an explosion control system to mitigate the risk of uncontrolled deflagration. The system includes pressure-sensitive vents (overpressure vents), and sparkers installed throughout the battery module bay designed to ignite flammable gases very early in a thermal runaway event before they accumulate within the enclosure and become an explosion hazard. The sparkers are installed at a variety of locations and heights throughout the battery module bay to ensure the flammable gases released during thermal runaway quickly meet an ignition source. The overpressure vents are installed in the roof of the sealed battery module bay's IP66 enclosure and permit gases, products of combustion and flames to safely exhaust through the roof during a thermal event. By designing this natural ventilation flow path, flammable gases are not permitted to accumulate within the MP2XL cabinet, reducing the risk of an explosion that could compromise the cabinet's integrity, push open the front doors, or expel projectiles from the cabinet. In addition, the ventilation path creates a controlled fire condition, should one occur, out the front and top of the MP2XL cabinet. By maintaining the cabinet's integrity, keeping all the doors shut during a fire event, reducing the risk of projectiles, and creating a controlled path for flames that exit the top of. Tesla developed the overpressure vents and sparker system because the application of NFPA 68 or NFPA 69 was not suitable for the MP2XL cabinet given it does not have large volumes of open space, as is typical of BESS cabinets. This engineered approach is permitted by NFPA 855, §9.6.5.6.4 provided it is validated through large-scale, unit level fire testing, which Tesla has performed (described in Section 7.3).

As demonstrated through UL 9540A unit level and destructive unit level fire testing, the explosion control system is effective in mitigating the risk of deflagrations and overpressure events. The overpressure vents and sparker system work in combination with each other to mitigate the risk of deflagration and overpressure events by combusting flammable off-gases (using the sparkers as an ignition source) very early in a thermal runaway event before there is time for the gases to accumulate inside the cabinet. The UL 9540A testing and destructive unit level testing did not result in any observations of explosion hazards, including but not limited to, observations of deflagration, projectiles, flying debris, detonation, or other explosive discharge of gases.

5.4.2 Thermal Runaway

CFC §1207.6.5 states, *"Where required by Table 1207.6 or elsewhere in this code, batteries and other ESS shall be provided with a listed device or other approved method to prevent, detect and minimize the impact of thermal runaway."*

The MP2XL installation at the Compass BESS meets this requirement. Thermal runaway protection can be provided with a listed device or other approved method to prevent, detect, and minimize the impact of thermal runaway. As previously described, the BMS is engineered to react to fault conditions in an autonomous manner, with safeguards built into the firmware. These fault conditions include, but are not limited to, over-temperature, loss of communication, over-voltage, and isolation. The BMS can direct the thermal management system to provide cooling to a cell/module and if that proves insufficient the BMS can automatically isolate the affected battery module temporarily (less severe fault) or it can permanently disconnect the module. Thermal runaway protection is permitted to be part of a BMS that has been evaluated to UL 1973 (CFC Table 1207.6, Exception e). A BMS tested and verified during the UL 9540 certification process is provided for the MP2XL.

5.5 ALL FACILITIES

CFC §501.1 requires facilities regulated by the CFC to comply with Chapter 5, Fire Service Features. For remote, outdoor BESS, that requires, or could require, compliance with the fire apparatus access road requirements of §503, the key box requirements of §506, and the fire protection water supply requirements of §507. Other sections of Chapter 5 would not be applicable to a remote, outdoor BESS facility.

5.5.1 Fire Department Access

The MP2XL installation at the Compass BESS meets this requirement. As previously described in Section 4.1.4, Orange County Fire Authority Station 9 is the closest fire department to the Compass BESS and is approximately 1.5 miles away to the north. The BESS site will have two points of access from the north. The roads around the Compass BESS are a minimum of 20-ft wide, satisfying the requirements of CFC §503.

5.5.2 Key Boxes

The MP2XL installation at the Compass BESS meets this requirement. As previously described in Section 4.1.3, a Knox Box for the fire department (and other authorized personnel) will be provided at the gate entrances, satisfying the requirements of CFC §506.

5.5.3 Fire Protection Water Supplies

The MP2XL installation at the Compass BESS meets this requirement. As previously described in Section 4.1.5, the Compass BESS site is provided with fire hydrants throughout, in compliance with CFC §507. These fire hydrants provide water for fire department use during a fire event, if needed, as required by CFC §507.

5.6 BESS SITE DESIGN CODE ANALYSIS SUMMARY

The Compass BESS site is classified as a remote outdoor installation and meets all the requirements of CFC §1207.8. Additionally, the general installation, technology specific requirements of §1207.4 and §1207.6 are satisfied, and the facility is provided with fire department access, key boxes, and fire protection water supplies meeting the requirements of CFC Chapter 5.

6.0 BESS PLANS AND TRAINING

The CFC and California Senate Bill 38 (CA SB38) requires a number of plans to be developed for a BESS facility. Often, these documents are developed during the design and construction phase of the project and finalized after substantial completion of the BESS. Below is a description of the plans required for the Compass BESS.

6.1 COMMISSIONING, OPERATION, DECOMMISSIONING, AND ITM

The CFC requires commissioning, decommissioning, and inspection, testing, and maintenance (ITM) requirements for all BESS installations. A commissioning plan must be developed for the integration of the new BESS equipment into the electrical utility grid. The commissioning documentation must capture the commissioning roles and responsibilities, list of equipment, conditions, BESS operation compliance, fire protection feature compliance, and operability. [CFC §1207.2.1]. An operation and maintenance manual will be developed and provided to both the Owner, or their authorized agent, and the BESS operator before the BESS is put into operation [CFC §1207.2.2]. A decommissioning plan is developed to provide the organization, documentation requirements, contingencies, and methods and tools necessary to indicate how the safety systems, ESS, and components will be decommissioned and removed from the site [CFC §1207.2.3]. In addition, all fire protection systems installed at the Compass BESS must be periodically inspected, tested, and maintained as required by the CFC and their respective NFPA standard [CFC Chapter 9].

It is anticipated that commissioning, operation and maintenance, and decommissioning plans are being developed for the Compass BESS facility. A commissioning guide, operations and maintenance, and a decommissioning guide have been prepared by Tesla for the MP2XL. These documents can be used as a guide for the development of site-specific plans. FRA recommends that prior to energizing the Compass BESS, finalize all commissioning, operations and maintenance, and decommissioning for the Compass BESS, as required by the CFC.

6.2 EMERGENCY RESPONSE PLAN

CA SB38 requires every BESS facility in California to have an emergency response and emergency action plan. The MP2XL ERG covers general emergency response procedures related to the equipment and can be used as a guide for the site-specific ERP.

A Compass BESS Emergency Response Plan (ERP) is being developed by FRA to address general site organization and management, fire/thermal runaway incidents, and subsequent appropriate efforts to meet CA SB38 requirements. FRA recommends that prior to energizing the Compass BESS, finalize the ERP for the Compass BESS, as required by CA SB38.

6.3 EMERGENCY RESPONSE TRAINING

CA SB38 requires the owner of the BESS or their authorized representative to engage in emergency planning and training emergency responders such that any foreseeable hazards associated with the BESS can be effectively addressed.

FRA recommends that all site personnel and emergency response personnel, who could be responsible for responding to a Compass BESS emergency, be trained on the ERP prior to energizing the Compass BESS. Refresher training should be provided as appropriate, typically annually, as required by the AHJ.

7.0 HAZARD MITIGATION ANALYSIS

This HMA is being prepared following the guidance by CFC §1207.1.4. The HMA evaluates the fire safety features of the MP2XL, the findings of the UL 9540A cell, module, and unit level tests as summarized in the MP2XL FPE report, and the site level fire safety features of the Compass BESS.

Based on the product level and site level safety features, the fire and life safety consequences associated with typical BESS failure modes can be evaluated to determine the impact to site personnel, the general public, and adjacent exposures.

Per CFC §1207.1.4.1 the consequences of the following failure modes must be evaluated in an HMA:

1. Thermal runaway condition in a single ESS rack, module, or unit.
2. Failure of any battery (energy) management system.
3. Failure of any required ventilation or exhaust system.
4. Voltage surges on the primary electric supply.
5. Short circuits on the load side of the BESS.
6. Failure of the smoke detection, fire detection, fire suppression or gas detection system.
7. Required spill neutralization not being provided or failure of the secondary containment system.

Only single failure-modes must be evaluated. The consequences of each failure mode are evaluated in Sections 7.1 through 7.7 of this report.

7.1 THERMAL RUNAWAY CONDITION

7.1.1 Description

Thermal runaway is a condition in which a self-heating chemical reaction occurs within a battery cell. This occurs when the battery cell generates heat faster than the battery cell is able to dissipate heat. Thermal runaway can be caused by physical damage (e.g. puncture, crushing), electrical malfunctions (e.g. overcharging), exposure to elevated ambient temperatures (e.g. adjacent cells in thermal runaway with elevated temperatures), manufacturing defects, and other internal conditions which may develop inside of aging battery cells (e.g. dendrites).

Thermal runaway typically results in an overpressure event within the battery cell due to internal heat generation inside the casing causing battery gases to be ejected from the cell through the pressure relief valve. Depending on the conditions, thermal runaway may be limited to the initiating cell(s) or thermal runaway may propagate to adjacent cells. Thermal runaway propagation typically occurs through conductive and convective heating or physical damage of adjacent cells due to swelling of the initiating cell. Conductive heating is the primary mode of heat transfer to adjacent cells for a non-flaming event and convective heating is the primary mode of heat transfer to adjacent cells for a flaming event.

Based on the cell level and module level testing, the MP2XL cells generate toxic and flammable gases. Depending on the conditions of release, flammable gases released during a thermal runaway event may present an explosion or fire hazard. An explosion hazard exists when sufficient flammable gases are released in the absence of an ignition source and build-up within the container. A fire hazard exists when the flammable gases are released in the presence of an ignition source or self-ignite. It should be noted, the fire hazard and explosion hazard are not mutually exclusive, and both may exist at different time periods throughout a propagating thermal runaway event. In addition, toxic gases present a health exposure hazard to site personnel and first responders located in the vicinity of a BESS failure.

7.1.2 Barriers

Passive and active mitigation strategies are provided to prevent batteries from entering thermal runaway and cool adjacent batteries to prevent thermal runaway propagation. The following barriers are provided in the MP2XL:

- The cells and modules utilized in the MP2XL are certified to UL 1973, as described in Section 2.12. The standard evaluates the battery system's ability to safely withstand simulated abuse conditions. For example, the standard subjects module-level stationary batteries to an internal fire exposure test to force a thermal runaway in one cell to ensure it does not explode, propagate fire to neighboring cells, or propagate to the rest of the modular battery system.
- The MP2XL is equipped with a BMS which monitors cell health and shuts down power to modules/cabinets with cells operating outside of their operating conditions, as described in Section 2.5.
- The MP2XL is equipped with a TMS which automatically activates to provide cooling and prevent batteries from overheating and escalating to a thermal runaway event, as described in Section 2.4. Additionally, the TMS cools adjacent batteries in a thermal runaway scenario to prevent thermal runaway propagation.
- The MP2XL modules are equipped with passive barriers to minimize the likelihood of thermal runaway of spreading from module to module. In addition, the MP2XL itself is provided with passive barriers, such as the thermal bay and customer interface bay, to minimize the chance of a thermal runaway event from propagating throughout the entire container.
- The MP2XL is equipped with a series of electrical fault protection devices, as described in Section 2.7.
- The MP2XL will be regularly maintained to ensure it is operating within its specific parameters and to verify the batteries are in good working condition, as described in Section 4.1.2.

7.1.3 Consequences

The consequences of thermal runaway can vary widely depending on the gas release scenario and level of confinement; however, the primary consequences of thermal runaway can be grouped into the following categories: deflagration and explosion, toxic gas, and fire hazards.

7.1.3.1 Deflagration & Explosion Hazard

The MP2XL has been tested to UL 9540A as required by the CFC. The module level test results shown in Table 9 indicate flammable gases, predominately hydrogen and hydrocarbons, are released during combustion of a battery module. The MP2XL is equipped with an explosion control system that actively ignites flammable gases in conjunction with deflagration panels. Essentially the sparkers ignite flammable gases before the gases can accumulate in significant quantities within the MP2XL cabinet where a full volume explosion hazard could occur. The sparkers ignite partial volumes of flammable gas which then open the deflagration vents and prevent an uncontrolled deflagration and container failure.

The deflagration protection system has been validated through UL 9540A unit level testing. During this test, the failure of six cells nearly simultaneously did not result in an explosion. There were no observations of deflagration, projectiles, flying debris, detonation, or other explosive discharge of gases. In addition, it has been further validated in destructive installation level testing in which forty-eight cells simultaneously failed. During this test, the sparkers ignited the battery vent gases and opened the deflagration vents. After the release of the deflagration events, a controlled fire event ensued. No subsequent deflagration event occurred during the test, the front doors remained closed, and the exterior of the container remained intact.

Table 9. Products of Combustion: UL 9540A Module Level Testing

Gas Name	Chemical Structure	Measurement Peak (ppm)
Carbon Monoxide	CO	205
Carbon Dioxide	CO_2	6721
Methane	CH_4	68.8
Acetylene	C_2H_2	17.1
Benzene	C_6H_6	9
Hydrogen	H_2	446
Total Hydrocarbons	(propane equivalent)	247

7.1.3.2 Toxic Gas Hazard

The MP2XL is not occupiable; therefore, toxic or highly toxic gas exposure is limited to individuals standing outside, in the open ambient air, in proximity to the MP2XL cabinet during a failure/fire event. The non-flammable gases collected during the module level testing are listed in Table 8 and provide guidance on the types of gases individuals and first responders may encounter when evacuating from or responding to an outdoor MP2XL fire. In addition to flammable gases discussed above, typical fire byproducts, such as CO and CO2 were the only non-flammable gases detected during the full combustion of an MP2XL tray of cells. The nonflammable gases detected are similar to gases first responders would encounter in a typical Class A structure fire and do not contain any unique, or atypical, gases beyond what you would find in the combustion of modern combustible materials, such as plastics. Note that toxic gases sometimes associated with lithium-ion batteries, such as HF, HCL, and HCN, were not detected during the combustion of the MP2XL tray during UL 9540A module level testing.

To analyze the potential for a toxic gas hazard off-site, FRA performed a detailed plume model for the Compass BESS. Preliminary results indicate no toxic gas exposures extend beyond the site property lines, as shown in Figure 11.

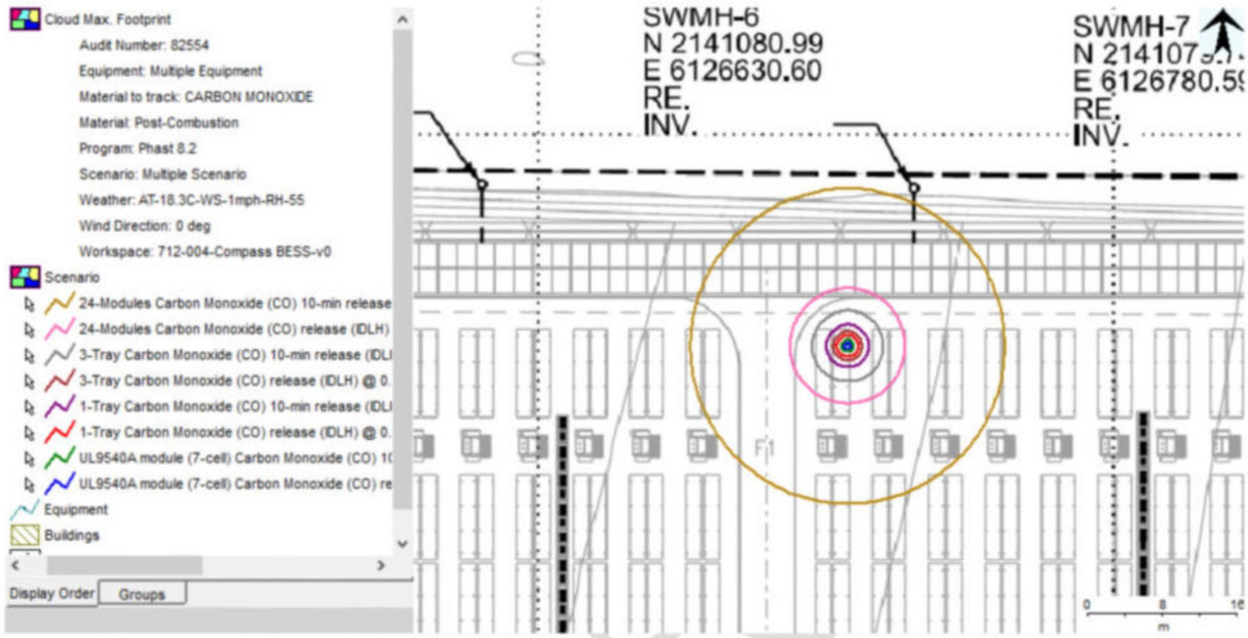


Figure 11. Site Plan with Extent of Toxic Gas Extents

7.1.3.3 Fire & Radiant Heat Exposure Hazard

UL 9540A unit level testing did not result in the creation of a fire. During that test, seven cells went into thermal runaway: the six that were forcibly heated and one additional cell. However, thermal runaway did not propagate beyond that seventh cell and no sustained fire event occurred. To provide additional data to validate clearance/standoff distances for other MP2XL cabinets, site equipment or personnel, Tesla performed a destructive installation level fire test and fire modeling. Note, this destructive test is well beyond what is required for UL product listing and is also in excess of any plausible MP2XL failure scenario contemplated by Tesla. The fire was initiated by simultaneously heating 48 cells within the same battery module tray. This resulted in the ignition of battery vent gases and a controlled fire event. The fire consumed one-half of the MP2XL (Bays 7-10) and did not spread past the CIB and Thermal Bay to Battery Bays 1-4. Flames were observed predominantly coming out the front doors of the cabinet (around the seams), out the front grill of the thermal roof (just above the doors), and out the exhaust vents on the top of the thermal roof.

Fire Propagation

Based on data collected from the destructive installation level fire test, Tesla performed a series of fire models to determine the heat flux imposed on target MP2XL cabinets installed 8 ft in front, 6 inches behind and 6 inches to the side of the initiating MP2XL cabinet and whether this could lead to fire propagation to adjacent MP2XL cabinets. The models were performed looking at typical wind conditions and worst-case wind conditions (where the flames are blown towards adjacent MP2XL cabinets). The fire propagation model predicts maximum temperatures at the battery modules of adjacent MP2XL cabinets are below the threshold for cell thermal runaway (239°C or 462°F). Therefore, based on the fire propagation model, in the unlikely event of an MP2XL fire, and accounting for worst-case wind conditions, thermal runaway would not propagate to an MP2XL installed 8 ft in front, 6 inches behind, or 6 inches to the side of the initiating MP2XL cabinet. Propagation to other equipment on the site can be evaluated once the site design is further refined and finalized. Based on the preliminary site layout, no fire propagation is expected to other site equipment (transformers, BESS substation, maintenance office, etc.).

Minimum Approach Distance

Table 10 provides a summary of the peak heat flux values that were predicted by the fire model at distances up to 100 ft directly in front of a MP2XL fire. Note the heat fluxes presented in Table 10 are only directly in front of the MP2XL cabinet. Given flames exit the MP2XL out the front and top of cabinet, the predicted heat flux values are the greatest directly in front of the MP2XL as opposed to behind or to the side of the cabinet. By assuming the heat flux imposed on surrounding exposures is directly in front of the cabinet, even if the exposure is not in front of the MP2XL, this provides a conservative, worst-case heat flux to exposures scenario.

Table 10. Predicted Peak Heat Flux Values Directly in Front of the MP2XL

Distance	Peak Predicted Heat Flux
8 ft	9.38 kW/m^2
10 ft	7.45 kW/m^2
20 ft	2.87 kW/m^2
50 ft	0.57 kW/m^2
100 ft	0.17 kW/m^2

The values presented in Table 10 can be analyzed to determine the minimum approach distance (MAD) the fire department or other first responders should maintain when responding to a fire event at the Compass BESS. A heat flux of 5 kW/m^2 is considered the limit at which severe skin pain can occur within 10 seconds when exposed to radiant heat. This heat flux threshold is typically identified as the extent at which first responders and fire department personnel should be wearing appropriate personal protective equipment (PPE) when responding to a fire event. By interpolating the data in Table 8, an MP2XL fire would produce a peak predicted heat flux of 5 kW/m^2 at a distance of 12.75 feet away from the MP2XL. As shown in Figure 12, the 12.75-foot 5 kW/m^2 heat flux boundary is contained within the sites 10-foot-tall security and visual screening wall. Therefore, anyone approaching the Compass BESS site would have to enter through the access gates to be exposed to such a heat flux.

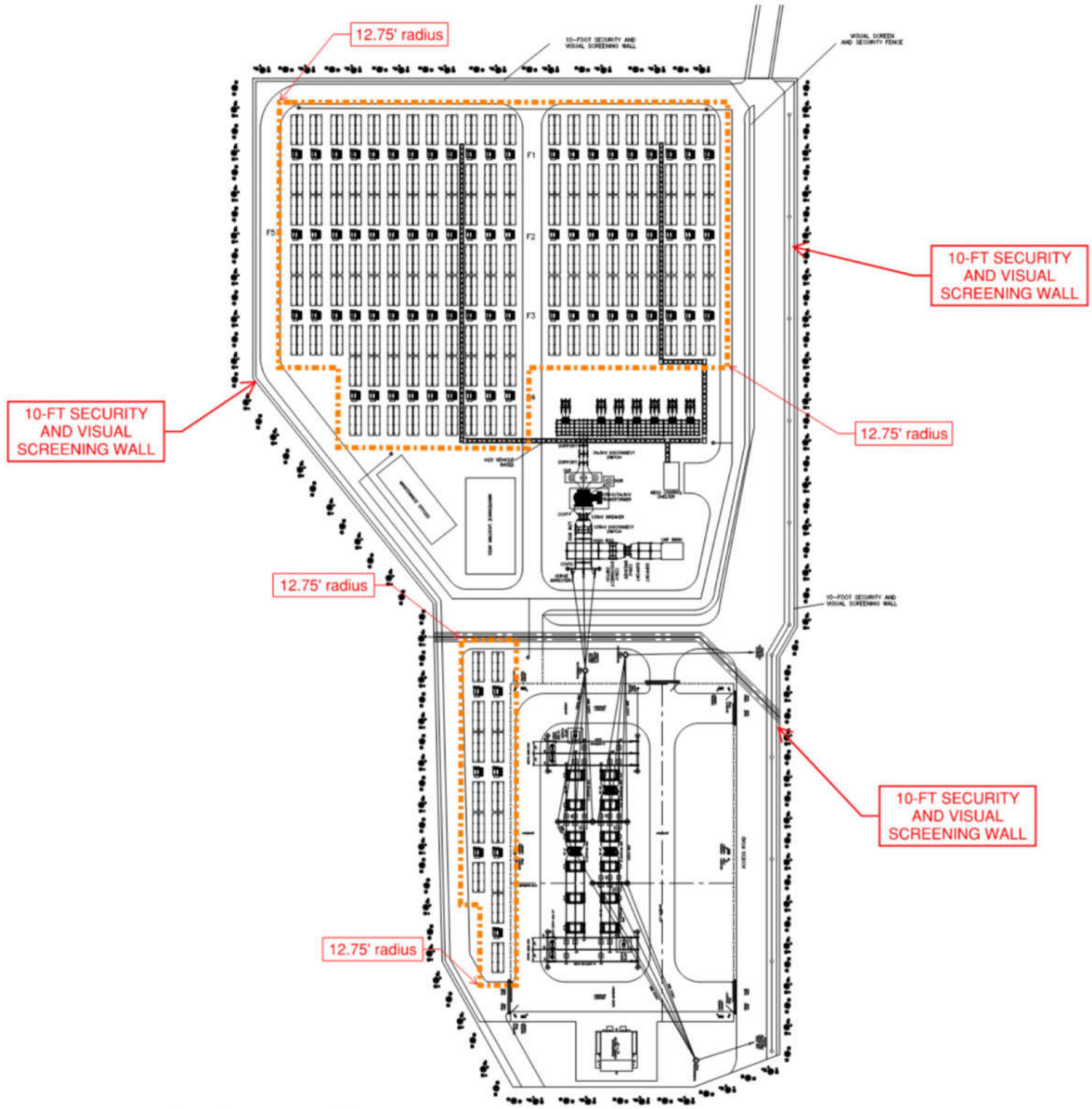


Figure 12. Site Plan with 5 kW/m^2 Heat Flux Radius

7.2 FAILURE OF ANY EMERGENCY MANAGEMENT SYSTEM

7.2.1 Description

The MP2XL is equipped with a BMS. The BMS tracks the performance, voltage, current, and state of charge (SOC) of the cells to ensure they are operating within manufacturer specifications. Per CFC §1207.3.4 the BMS is required to disconnect electrical connections to the ESS if potentially hazardous conditions occur. Additionally, the BMS sends an alarm to the Tesla LOC and can initiate other controls based on the hazard detected as described in Section 2.5. Consequences due to BMS failure are evaluated in this section.

7.2.2 Barriers

The following barriers are provided to prevent BMS failure and minimize the consequences of BMS failure:

- The BMS is certified as part of the battery module to UL 1973, as described in Section 2.12.
- The BMS is monitored by the TSC and the LOC, as described in Section 2.6.
- Electrical fault protection is provided as described in Section 2.7.
- The BMS will be regularly maintained to ensure it is operating within its specific parameters, as described in Section 4.1.2.

7.2.3 Consequences

Failure of the BMS will prevent active monitoring of battery cell conditions. The BMS is monitored by the TSC/LOC such that a failure will be quickly detected and remediated reducing the duration a MP2XL is operating with deficient safety features. Additionally, the LOC has remote capabilities to discharge batteries from affected MP2XL cabinets or shut down modules/entire cabinets, depending on the severity of the issue and the operational capabilities of the system at the time. Discharging the batteries reduces the consequences of a potential thermal event while the BMS is offline because the fire and explosion hazard is a direct correlation to battery SOC. It should be noted, BMS failure alone will not cause battery failure. In a worst-case scenario, a BMS failure in conjunction with a secondary failure condition (such as over voltage, excess temperature, etc.) may result in a thermal runaway event. Barriers and consequences of thermal runaway are provided in Section 7.1.2 and 7.1.3 of this report.

7.3 FAILURE OF ANY REQUIRED VENTILATION SYSTEM

7.3.1 Description

A failure scenario involving any required ventilation or exhaust may expose the batteries to elevated operating temperatures. Depending on the resulting ambient temperature, ventilation failure may cause batteries to be exposed to temperatures outside of the manufacturer recommended operating conditions or temperatures at which the cell fails. The MP2XL is not provided with any required ventilation or exhaust system. However, the MP2XL is provided with a closed loop liquid cooling TMS for the battery modules, as described in Section 2.4. The cooling system performs a similar function to ventilation such that it is provided to cool battery cells and maintain battery operating temperatures within Tesla's recommended range. This failure scenario evaluates the consequences associated with a failure of the liquid cooling system.

7.3.2 Barriers

The MP2XL is equipped with the following barriers to prevent ventilation system failure and reduce the consequences of a failure event:

- The TMS is monitored by the TSC and the LOC, as described in Section 2.6.
- The TMS will be regularly maintained to ensure it is operating within its specific parameters, as described in Section 4.1.2.

7.3.3 Consequences

Failure of the cooling system may expose batteries to ambient temperatures. The average peak ambient temperatures in San Juan Capistrano, CA is 88ºF and occurs in August. The peak temperature is less than the cell venting temperature; therefore, failure of the cooling system is not anticipated to lead to a thermal runaway event. The TMS is monitored by the TSC/LOC such that a failure will be quickly detected and remediated, reducing the duration a MP2XL is operating with deficient safety features. Additionally, the LOC has remote capabilities to discharge batteries from affected MP2XL cabinets or shut down modules/entire cabinets, depending on the severity of the issue and the operational capabilities of the system at the time. Discharging the batteries reduces the consequences of a potential thermal event while the TMS is offline because the fire and explosion hazard is a direct correlation to battery SOC. In a worst-case scenario, batteries operating at elevated temperatures for extended periods of time may degrade and have a higher likelihood of failure over time, possibly leading to thermal runaway. Barriers and consequences of thermal runaway are provided in Section 7.1.2 and 7.1.3 of this report

7.4 VOLTAGE SURGES ON THE PRIMARY ELECTRIC SUPPLY

7.4.1 Description

A voltage surge on the primary electric supply to the BESS may expose batteries to excessive voltage. This failure scenario evaluates the consequences due to a voltage surge on the primary electric supply.

7.4.2 Barriers

The following barriers are provided to minimize the consequences of a voltage surge on the primary electric supply:

- Electrical fault protection is provided as described in Section 2.7.
- Battery health is monitored by the BMS and automatically shuts down power upon over voltage conditions.
- The electrical components of the MP2XL are monitored by the TSC and the LOC, as described in Section 2.6.

7.4.3 Consequences

In the event of a voltage surge, the electrical fault protection will automatically stop electricity flow in the affected electrical circuit. The BMS provides redundancy and will also cut power to the affected cells and send a signal to the TSC/ LOC such that a failure will be quickly detected and remediated, reducing the duration a MP2XL is operating with a damaged electrical component/equipment. Additionally, the LOC has remote capabilities to discharge batteries from affected MP2XL cabinets or shut down modules/entire cabinets, depending on the severity of the issue and the operational capabilities of the system at the time. Discharging the batteries reduces the consequences of a potential thermal event while the MP2XL is offline because the fire and explosion hazard is a direct correlation to battery SOC. In a worst-case scenario, voltage surges may lead to a thermal runaway event, the barriers and consequences of thermal runaway are provided in Section 7.1.2 and 7.1.3 of this report. It should be noted, if permissible, the Tesla LOC may discharge the batteries in adjacent MP2XL cabinets to reduce the thermal hazard and associated consequences.

7.5 SHORT CIRCUITS ON THE LOAD SIDE OF THE BESS

7.5.1 Description

A short circuit on the load side of the BESS may result in an increased current traveling through the battery circuit. Electrical currents outside of the recommended operating range may damage batteries and lead to a thermal runaway event.

7.5.2 Barriers

The following barriers are provided to minimize the consequences of a short circuit event:

- Electrical fault protection is provided as described in Section 2.7.
- Battery health is monitored by the BMS and automatically shuts down power upon over voltage conditions.
- The electrical components of the MP2XL are monitored by the TSC and the LOC, as described in Section 2.6.

7.5.3 Consequences

In a short circuit condition, the electrical fault protection will automatically stop current in the affected electrical circuit. The BMS provides redundancy and will also cut power to the affected cells and send a signal to the TSC/ LOC such that a failure will be quickly detected and remediated, reducing the duration a MP2XL is operating with a damaged electrical component/equipment. Additionally, the LOC has remote capabilities to discharge batteries from affected MP2XL cabinets or shut down modules/entire cabinets, depending on the severity of the issue and the operational capabilities of the system at the time. Discharging the batteries reduces the consequences of a potential thermal event while the MP2XL is offline because the fire and explosion hazard is a direct correlation to battery SOC. In a worst-case scenario, short circuits may lead to a thermal runaway event, the barriers and consequences of thermal runaway are provided in Section 7.1.2 and 7.1.3 of this report. It should be noted, if permissible, the Tesla LOC may discharge the batteries in adjacent MP2XL cabinets to reduce the thermal hazard and associated consequences.

7.6 FAILURE OF A FIRE PROTECTION SYSTEM

7.6.1 Description

A failure of a fire protection system can include a smoke detection, fire detection, fire suppression, gas detection system or explosion control system. The MP2XL does not have an internal fire detection, gas detection, or suppression system that is integral to its design/construction. It is equipped with an explosion control system (sparker and overpressure vents). Therefore, this failure scenario evaluates the consequences associated with failure of the explosion control system (sparker or overpressure vent).

7.6.2 Barriers

The sparker system is provided with the following features to prevent sparker failure and minimize consequences associated with sparker failure:

- Redundancy in wiring. Failure of one sparker will not cause failure in subsequent sparkers.
- Twelve total sparkers installed throughout the container.
- Automotive grade sparkers designed to operate in extreme temperature and pressure conditions.
- Redundant power supply.
- Monitored by Tesla LOC, if power is lost O&M personnel will be notified to address the issue.
- Sparker interval automatically increases if connection is lost to any of the required inputs (i.e. BMS failure)
- Deflagration vents.
- Regular IT&M performed on sparker system.
- Tesla LOC has remote capabilities to discharge batteries of affected cabinets into adjacent MP2XL cabinets on site.

7.6.3 Consequences

Independent failure of a sparker or the sparker system will have no effect on the battery container and will not induce a thermal runaway event. Sparker power is monitored by Tesla LOC; therefore, sparker failure would be quickly noticed and remediated reducing the duration of the deficiency. Additionally, the Tesla LOC may discharge the batteries in the affected container into an adjacent container to reduce the thermal hazard and associated consequences.

In the unlikely event of sparker failure in conjunction with a thermal runaway event, flammable gases may accumulate locally prior to reaching the next sparker ignition source. The sparker design includes twelve sparkers such that failure of one will not permit an accumulation of gases outside of the deflagration vent design basis. Additionally, the deflagration vents are designed with a safety factor of two which provides an additional level of safety in the event of increased gas accumulation.

7.7 FAILURE TO PROVIDE SPILL NEUTRALIZATION OR SECONDARY CONTAINMENT

7.7.1 Description

Lithium-ion batteries, because of their chemistry and architecture, do not require spill neutralization or secondary containment. Unlike other battery types, such as lead acid, there is no free-flowing liquid inside the cells that requires neutralization or containment. This distinction is also made in CFC Table 1207.6, where lithium-ion BESS is not required to provide spill neutralization and secondary containment.

7.7.2 Barriers

Although the lithium-ion batteries do not require containment, the MP2XL is equipped with a TMS that utilizes 106 gallons of a glycol-water solution. The MP2XL cabinet, specifically, the IP66 battery bay enclosure, is designed to hold the volume of the solution should a leak occur in the TMS, either in normal operation or during a failure event.

7.7.3 Consequences

No consequences - failure mode is not applicable to MP2XL.

7.8 HMA ANALYSIS APPROVAL

Based on the analysis above, the Compass BESS meets all of the HMA approval criteria for FCO or AHJ approval per CFC §1207.1.4.2, as it has demonstrated that:

1. *Fires will be contained within unoccupied ESS rooms or areas for the minimum duration of the fire-resistance-rated separations identified in Section 1207.7.4:*

   The Compass BESS meets this requirement. The MP2XL cabinet is installed outdoors, not within an unoccupied BESS room or area. However, it should be noted, the MP2XL design includes a series of passive fire protection schemes (barriers) to protect it from spreading a fire from one MP2XL cabinet to another. As demonstrated in UL 9540A unit level fire testing, a nearly simultaneous failure of up to seven cells did not result in thermal runaway propagating throughout the battery module or to adjacent MP2XL cabinets. Although this requirement applies to BESS rooms or areas (and not an outdoor installation), the Compass BESS still meets the intent of the requirement by containing a fire event to a single MP2XL cabinet. (CFC §1207.1.4.2 #1)

2. *Fires and explosions in battery cabinets in occupied work centers will be detected in time to allow occupants within the room to evacuate safely:*

   The Compass BESS meets this requirement. The MP2XL cabinet is installed outdoors, not within an occupied work center (or any other room). However, it should be noted, the Compass BESS will have an external flame detection system capable of detecting a fire event within the MP2XL cabinet. This external flame detection system will be monitored separately (not monitored through the MP2XL) by a fire alarm monitoring company that operates 24/7, as required by the CFC. In addition, the MP2XL does have a number of internal sensors within it that can detect an off-normal overheating event, such as a fire. Although this requirement applies to occupied work centers (and not an outdoor installation), the Compass BESS still meets the intent of the requirement through the external flame detection system provided at the Compass BESS Site and internal sensors provided within the MP2XL. (CFC §1207.1.4.2 #2)

3. *Toxic and highly toxic gases released during fires and other fault conditions shall not reach concentrations in excess of Immediately Dangerous to Life or Health (IDLH) levels in the building or adjacent means of egress routes during the time deemed necessary to evacuate from that area:*

The Compass BESS meets this requirement. The MP2XL is installed outdoors, not within a building. However, it will be installed adjacent to a means of egress from the maintenance office, which has a door located over 20 feet away from the closest MP2XL cabinet. Preliminary results indicate no toxic gas exposures extend to this location or beyond the site property lines. As such, based on the detailed plume model, no toxic or highly toxic gases released during fires and other fault conditions will not reach concentrations in excess of IDLH levels in adjacent means of egress routes during the time deemed necessary to evacuate from that area.

4. *Flammable gases released from batteries during charging, discharging and normal operation shall not exceed 25 percent of their lower flammability limit (LFL):*

   The Compass BESS meets this requirement. The MP2XL utilizes listed lithium-ion cells that are hermetically sealed and do not vent during charging, discharging or normal operation. Unlike other battery types, no flammable gases are released during normal operation of the lithium-ion batteries. As such, no flammable gases exceeding 25% of their LFL will be released from the Compass BESS during charging, discharging and normal operation. (CFC §1207.1.4.2 #4)

5. *Flammable gases released from ESS during fire, overcharging and other abnormal conditions will be controlled through the use of ventilation of the gases, preventing accumulation, or by deflagration venting:*

   The Compass BESS meets this requirement. The MP2XL has an integral explosion control system installed inside cabinet that includes a sparker system and overpressure vents designed to ignite flammable gases very early in a thermal runaway event before they accumulate within the enclosure and become an explosion hazard. The effectiveness of the explosion control system of the MP2XL was demonstrated through UL 9540A unit level fire testing. During that test, the failure of six cells within the same battery module did not create an explosion hazard. There were no observations of deflagration, projectiles, flying debris, detonation, or other explosive discharge of gases. (CFC §1207.1.4.2 #5)

7.8.1 Analysis Approval Summary

Based on the above analysis, the Compass BESS meets all CFC requirements for FCO or AHJ approval per CFC §1207.1.4.2 as it has demonstrated that:

1. Fires will be contained to a single MP2XL as demonstrated through UL 9540A unit level testing.
2. Fires will be detected in time to allow personnel to safely evacuate via the external fire detection system (flame detectors) and the internal sensors of the MP2XL.
3. Toxic and highly toxic gases released during fires will not reach concentrations in excess of IDLH levels in the area during the time deemed necessary to evacuate from the Compass BESS area as demonstrated by UL 9540A module level fire testing and the preliminary plume modeling results.
4. Flammable gases released from an MP2XL during charging, discharging and normal operation do not exceed 25% of their LFL given the listed lithium-ion cells utilized in the MP2XL are hermetically sealed and do not vent during charging, discharging or normal operation.

5. Flammable gases released from the MP2XL during a fire, overcharging and other abnormal conditions will be controlled by ventilating the gases preventing accumulation or by deflagration venting via the explosion control system (sparker and overpressure venting system) as demonstrated during the UL 9540A unit level fire test.

8.0 RECOMMENDATIONS

Throughout the report, FRA provided several recommendations related to the Compass BESS installation and emergency response to mitigate the hazards of a fire event. These recommendations are based on our review of the available materials, our background, experience and training, the analyses performed to date described above, Tesla's ERG, common industry best practices for responding to a thermal event involving lithium-ion BESS, as well as from FRA's experience with lithium-ion battery hazards, lithium-ion battery BESS hazards, and previous Tesla BESS fires. These recommendations do not provide opinions or conclusions meant to address specific circumstances or all possible scenarios of an emergency. As with all emergency events, emergency response actions should be evaluated and performed based on real time fire conditions and observations (i.e., wind direction/speed, fire intensity, proximity of flames to adjacent electrical equipment and structures) during the actual emergency. Below is a summarized list of the recommendations provided throughout the report:

1. **Plans:** FRA recommends that prior to energizing the Compass BESS, develop commissioning, operations and maintenance, decommissioning and emergency response plans, as required by the CFC and CA SB38.
2. **Emergency Response Training:** FRA recommends that all site personnel and emergency response personnel, who could be responsible for responding to a Compass BESS emergency, be trained on the ERP prior to energizing the Compass BESS. Refresher training should be provided as appropriate, typically annually as required by the AHJ.
3. **Fire Protection Systems:** FRA recommends that all fire protection systems be designed, installed, commissioned, and periodically inspected, tested, and maintained as required by the CFC and their respective NFPA standards.

9.0 CONCLUSIONS

Based on our review of the available materials, our background, experience and training, and the analysis performed to date described above, the following conclusions are submitted within a reasonable degree of scientific and engineering certainty:

1. The Compass BESS meets the CFC requirements for a remote outdoor BESS installation when it is installed in accordance with the MP2XL DIM, its listing, the Permit Drawing Package, and the CFC.
2. The HMA demonstrates the Compass BESS meets all the HMA performance criteria for approval outlined by the CFC §1207.1.4.2, as follows:
    a. Fires will be contained to a single MP2XL as demonstrated through UL 9540A unit level testing and destructive installation level fire testing and fire modeling.
    b. Fires will be detected in time to allow personnel to safely evacuate via the external flame detection system and internal sensors of the MP2XL.
    c. Toxic and highly toxic gases released during fires will not reach concentrations in excess of IDLH levels in the area during the time deemed necessary to evacuate from the Compass BESS area, as demonstrated by UL 9540A module level fire testing and the preliminary plume modeling results.
    d. Flammable gases released from a MP2XL during charging, discharging and normal operation do not exceed 25% of their LFL given the listed lithium-ion cells utilized in the MP2XL are hermetically sealed and do not vent during charging, discharging or normal operation.
    e. Flammable gases released from the MP2XL during a fire, overcharging and other abnormal conditions will be controlled through the use of ventilation of the gases preventing accumulation or by deflagration venting via the explosion control system (sparker and overpressure venting system) as demonstrated during the UL 9540A unit level and destructive installation level fire testing.
3. Based on this analysis, the Compass BESS may be approved by the FCO or AHJ.

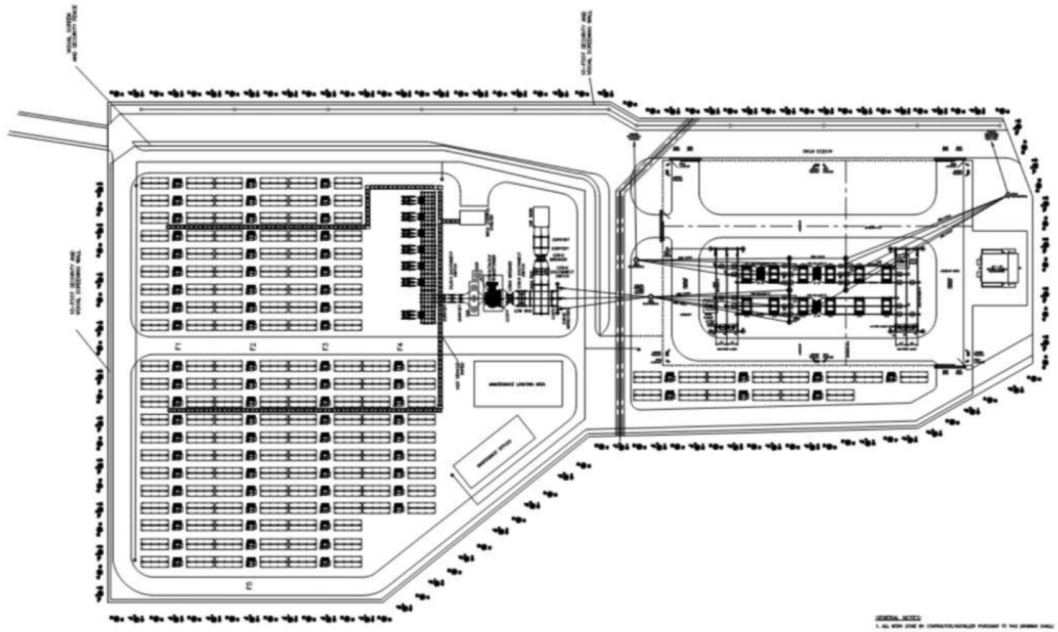
APPENDIX 1 – AERIAL MAPS


CAMINO CAPISTRANO
PROPOSED ACCESS ROAD
US INTERSTATE 5
COMPASS BESS SITE

APPENDIX 2 – SITE PLAN

LEGEND

- BATTERY/INVERTER ENCLOSURE
- TRANSFORMER
- FIRE HYDRANT
- 20-FOOT ACCESS ROAD
- CHAIN LINK FENCE
- 10-FOOT SECURITY AND VISUAL SCREENING WALL
- 138kV UTILITY LINE
- NEW LANDSCAPING
- CONCRETE CABLE TRENCH
- LIGHTING FIXTURE (DARK SKY COMPLIANT)



NORTH

PRELIMINARY

0 125' 250'
GRAPHIC SCALE

HOLD INFORMATION

NO.	DESCRIPTION

CONTRACTOR/INSTALLER SHALL TAKE ALL APPROPRIATE PRECAUTIONS TO ENSURE THE SAFETY OF ALL PEOPLE LOCATED ON THE WORK SITE, INCLUDING CONTRACTOR'S/INSTALLER'S PERSONNEL (OR THAT OF ITS SUB-CONTRACTOR(S)) PERFORMING THE WORK.

RELEASE INFORMATION

REV.	DATE	DESCRIPTION
0I	09/15/2023	30% DESIGN
0J	10/17/2023	30% DESIGN
0K	10/25/2023	30% DESIGN
0L	02/28/2024	ISSUED FOR PERMIT
0M	03/27/2024	ISSUED FOR PERMIT

ISSUE PURPOSE: PERMIT
SPECIFICATION:
PROJECT NO.: 14089.012

CAD FILE NAME: CMP-SE-101_S001.DWG
PREPARED BY: CAV/EM
REVIEWED BY: RDH
APPROVED BY:

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PROJECT

COMPASS
BATTERY ENERGY STORAGE

DRAWING TITLE

GENERAL ARRANGEMENT

DRAWING NUMBER	REVISION
CMP-SE-101	0M

SHEET 1 OF 1