

## **Fire and Explosion Testing Data (AMC 20.114.100) for Tesla Megapack 2XL**

NFPA 855, Installation Standards for Energy Storage Systems, requires compliance with UL 9540<sup>1</sup>, Safety of Energy Storage Systems and Equipment, and UL 9540A<sup>2</sup>, Test method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems.

In 2023, Fisher Engineering, Inc. (FEI) performed a fire protection engineering (FPE) analysis of Tesla's new suite of battery energy storage systems (BESS), known as the Megapack 2 (MP2) and Megapack 2XL (MP2XL)<sup>3</sup>. The MP2 and MP2XL (MP2/2XL) are lithium-ion BESS with a storage capacity between approximately one and four megawatt hours (MWh). Their design, construction, and operation are substantially similar, and they are meant for outdoor installations, mounted to the ground, in commercial and industrial applications. This FPE analysis included a review of the MP2/2XL, its construction, design, fire safety features, UL 9540A cell, module and unit level test data, additional internal unit level fire tests and fire propagation modeling. This executive summary is an abbreviated list of our analysis and conclusions. Refer to the main report for details of the analysis and a full list of conclusions.

Based on a review of the MP2/2XL, its fire safety features, UL 9540A test results, additional internal MP2/2XL unit level fire testing and fire propagation modeling, FEI offers the following summary of our findings:

1. The design and construction of the MP2 and MP2XL are almost identical other than the MP2XL is greater in length to accommodate additional battery modules. They use the exact same cells, battery modules, and power electronics (i.e., all the same internal components) and the fire safety features of both are nearly identical. Given the similarities between the MP2 and MP2XL, the fire test and fire modeling results that have been summarized in this report can be applied to both the MP2 and MP2XL.
2. The MP2/2XL is listed to all product design standards (such as UL and IEC) required of a BESS and has been tested to UL 9540A at the cell, module, and unit level.
3. Cell and module level UL 9540A testing demonstrated that flammable gases vent from the MP2/2XL cells during thermal runaway; however, they do not release toxic gases sometimes associated with the failure of lithium-ion batteries, such as HCN, HCL and HF.
4. Unit level UL 9540A testing demonstrated that the MP2/2XL meets or exceeds all the performance criteria of UL 9540A, Table 9.1 and UL 9540A installation level testing is not required for a MP2/2XL installation.
  - a. The test was initiated through the simultaneous heating and subsequent failure of six cells within a single battery module of the initiating MP2 cabinet.

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<sup>1</sup> NFPA 855, Section 4.2; 9.2; A.4.2.1

<sup>2</sup> NFPA 855, Section 4.1.5; A.4.1.5.1

<sup>3</sup> Fisher Engineering Fire Protection Engineering Analysis (2023)

- b. This resulted in thermal runaway propagating to a seventh cell within the battery module; however, thermal runaway did not propagate any further than the seventh cell, nor did this failure lead to a fire within the MP2 cabinet.
  - c. The failure did not result in any observations of explosion hazards, including but not limited to, observations of a deflagration, projectiles, flying debris, detonation, or other explosive discharge of gases.
5. Internal unit level products of combustion testing demonstrated that HF was only detected at trace levels (0.10 and 0.12 ppm) in two sampling locations (approximately 20 feet upwind and 5 feet downwind from the MP2/2XL) when six cells within MP2/2XL cabinet were forced into thermal runaway. This trace quantity of HF was detected over the entire 2½ hour test duration (i.e., it was the cumulative quantity detected) and is well below the Immediately Dangerous to Life or Health (IDLH) value of 30 ppm for HF. The testing also found no traces of twenty-seven different metals, including lithium and mercury.
6. Internal destructive unit level testing demonstrated that the MP2/2XL is capable of safely failing in the extreme case of a catastrophic failure of a battery module (the forced thermal runaway of 48 cells simultaneously). This destructive unit level test led to a slow progressing fire that burned for 6 hours and 40 minutes until flaming ceased, only consuming one-half of the battery modules in the cabinet.
7. Fire modeling demonstrated that, in the unlikely event of a fire, it would not propagate from one MP2/2XL cabinet to adjacent cabinets installed 6 inches behind, 6 inches to the side and 8 feet directly in front of the initiating MP2/2XL. This result was analyzed for both no wind and worst-case wind conditions where flames could tilt towards the adjacent MP2/2XL cabinets.
8. In summary, unit level UL 9540A testing, destructive unit level testing and a fire propagation model demonstrated that:
  - a. The MP2/2XL explosion control system can mitigate the deflagration hazard even with an extreme failure scenario of a battery module (the forced thermal runaway of 48 cells simultaneously) resulting in the MP2/2XL safely failing.
  - b. An integral fire suppression system or an external fire suppression system is not required to stop the spread of fire from a MP2/2XL cabinet to adjacent MP2/2XL cabinets when installed at clearances of 8 feet in front, 6 inches behind and 6 inches to the sides.
  - c. Manual fire suppression (hose lines) is not required to stop the spread of fire from a MP2 cabinet to adjacent MP2/2XL cabinets when installed at clearances of 8 feet in front, 6 inches behind and 6 inches to the sides.
9. Based on a review of the MP2/2XL, its fire safety features, UL 9540A test results, additional internal MP2/2XL unit level fire testing and fire propagation modeling, the MP2/2XL can meet or exceed installation level codes and standards, such as the IFC and NFPA 855, required for outdoor, ground mounted BESS installations when installed in accordance with the MP2 and MP2XL Design and Installation Manual.

The entire Fisher report is confidential, however, the full report, including test parameters, findings, and additional technical information is available for review, if needed.