POWERWALL 2: BATTERY SAFETY AND CODE OVERVIEW

This document provides an overview of the battery system safety and the codes and standards applicable to Powerwall, Tesla's home battery solution. Tesla Powerwall is a state-of-the-art battery system intended for residential and light commercial applications. A Frequently Asked Questions (FAQ) section at the end of the document addresses common questions from permitting and fire service authorities.

TECHNOLOGY OVERVIEW

Each battery in Tesla Energy Products is composed of multiple small format, cylindrical lithium-ion cells. The cells are connected in series and parallel to form modules. One or more modules are combined within an IP67-rated steel enclosure. Each product contains independent protection hardware and an electrically-isolating controlled power electronics stage. In addition, each product has an integrated battery thermal management system.

In its assembled state, Powerwall is a fully-integrated energy storage system that contains some of the most advanced battery technology in the industry.

SAFETY OVERVIEW

Powerwall is designed and manufactured to meet or exceed the most stringent industry safety standards. Units are manufactured in the United States with repeatable and highly precise processes. This enables a high level of quality control and the ability to mass produce a safe and reliable product.

Powerwall is listed by Nationally Recognized Testing Laboratories to the following safety standards:

- UL 1642: *Standard for Lithium Batteries*. This tests for safety incorporated into each individual cell. Each Tesla lithium-ion cell is listed to this standard.

- UL 1973: *Standard for Batteries for Use in Light Electric Rail (LER) Applications and Stationary Applications*. This is a product-level certification that tests the integrity of the battery assembly. To achieve compliance with UL 1973, Tesla Energy Products must meet the following requirements:
    - Products must be robust to internal fire exposure: they must demonstrate that a single cell failure will not cascade to cause a fire external to the product, or an explosion.
    - Products must be robust to mechanical stresses: they must withstand drop and impact tests as well as other mechanical stresses.
    - Products must be robust to environmental stresses: they must withstand high heat and humidity tests, as well as salt fog exposure and other environmental stresses.
    - Products must be robust to electrical abuse: they must withstand overcharge and short circuit tests, as well as other abuse conditions.

- UL 9540: *Standard for Energy Storage Systems and Equipment.* This standard ensures the Powerwall is safety tested as a fully-integrated battery system.

- UL 1741: *Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources.* This standard ensures all equipment can safely interact with, and in some cases even support, the utility grid. The Powerwall, Powerpack, and Powerpack Inverter are all listed to this standard.

Additional compliance information can be found in Powerwall 2 datasheets. Beyond the requirements found in industry standards for stationary systems, Tesla leverages 15 years of battery experience gained

from the automotive environment. Tesla designs and tests all batteries to ensure that they survive harsh vibration, shock, corrosion, thermal, and abnormal electrical conditions.

CODE OVERVIEW

Tesla Energy Products are subject to local building and fire codes. In the United States, most installations must meet the requirements set forth in the International Fire Code (IFC) or the International Residential Code (IRC), which are considered the most stringent model codes available. In other countries, fire and building code requirements can vary widely. Please consult with the Authority Having Jurisdiction (AHJ) or local fire service to understand what requirements apply in your jurisdiction.

Historically, fire codes have provided little or no guidance for energy storage systems, especially those with lithium-ion batteries. The most recent versions (2018) of the IFC and IRC contain specific references to stationary storage battery systems and/or lithium-ion batteries, and Tesla recommends that all Tesla Energy Products be installed in a manner that meets the requirements stated in the latest versions of these codes.

Powerwall is regulated by the 2018 IRC, Section R327 *Stationary Storage Battery Systems* for installations in or on detached one- and two-family dwellings and townhouses not more than three stories above grade plane in height. Within Section R327, the Powerwall meets the requirements of or is subject to subsections R327.1/2/3/4/6.

When Powerwall is installed in locations that do not fall under the scope of the IRC, the IFC may be triggered. The 2018 IFC only applies if a 20 kWh total system capacity threshold is exceeded, which only occurs if two (2) or more Powerwalls are installed at the same project site. Please consult with the AHJ to ensure the appropriate code is followed.

FAQ

How are Tesla Energy Products classified under Hazardous Material Inventory?

Powerwall is classified as UN 3480 “lithium-ion batteries.” It is classified per the United States Code of Federal Regulations 49CFR172.101 as a Class 9 Hazardous Material (Miscellaneous).

Per the Code of Federal Regulations, lithium-ion batteries are **NOT** classified as any of the following: Explosive (Class 1), Gas (Class 2), Flammable liquid (Class 3), Flammable solid (Class 4), Spontaneously combustible material (Class 4), Materials dangerous when wet (Class 4), Oxidizer (Class 5), Organic peroxide (Class 5), Poison (Class 6), Toxic (Class 6), Infectious (Class 6), Radioactive (Class 8), or Corrosive (Class 8).

Where Powerwall must be classified into sub-categories for the purposes of hazardous material reporting, the smallest applicable unit is the lithium-ion battery cell. It is most appropriate to classify the lithium-ion cells as “Miscellaneous Hazardous Materials – Solid (MISC-S)”.

What is the system’s liquid capacity?

This is a common question for battery-based systems, but it does not apply to Powerwall. Tesla lithium-ion batteries do not contain free liquid electrolyte and do not pose a liquid release hazard. Electrolyte added to cells during production is not merely absorbed by cell materials, but reacts with those materials and is consumed during normal operation of the batteries, making it impractical to report the volume of electrolyte within Tesla lithium-ion cells or battery packs. For these reasons, Tesla recommends that electrolyte volume content be reported as “N/A” on permit hazard forms.

The issue of electrolyte capacity has been addressed in the 2018 IFC by classifying energy storage systems based on their energy capacity (kWh) rather than electrolyte volume. The IFC does not require spill control and neutralization for lithium-ion battery systems.

It is very difficult to mechanically damage cells in such a way as to cause leakage of any liquid content. For example, Figure 1 shows a Tesla lithium-ion cylindrical cell subjected to an axial crush between two flat plates. Even though the cell is crushed to approximately half of its initial height, it does not leak any contents.

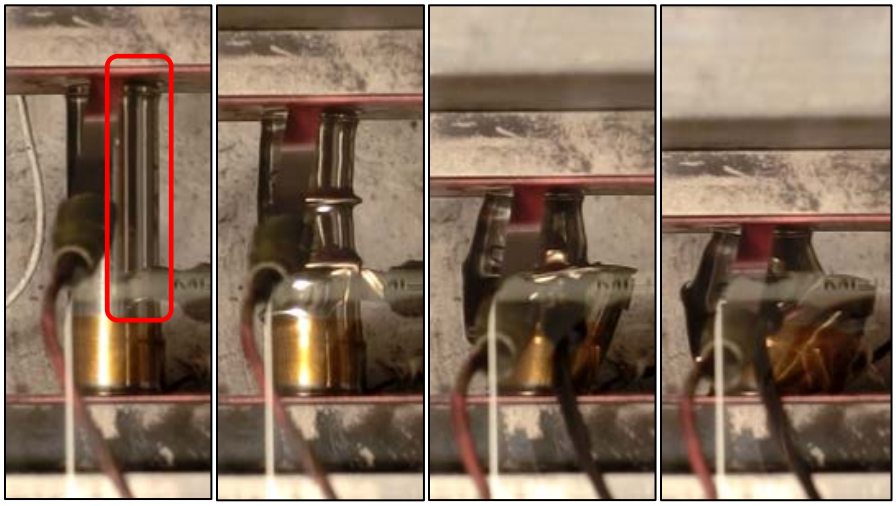

Figure 1: Cylindrical lithium-ion cell undergoing axial crush between two flat plates

Does Powerwall have a Safety Data Sheet (SDS)?

Tesla Energy Products are classified by OSHA as articles rather than materials and therefore do not require SDS sheets per OSHA's Hazard Communication Standard requirements. The coolant within Powerwall has an SDS sheet.

Refer to Tesla's *Lithium-Ion Battery Emergency Response Guide* (ERG) for detailed information about SDS requirements.

Are any site precautions or systems needed in the event of a fire?

In Tesla's experience, city and county regulations do not require sprinklers or explicit fire suppression measures for outdoor lithium-ion battery installations. Requirements for indoor installations are outlined in the 2018 IFC and IRC.

Powerwall is not capable of detecting fire or flames internally, neither through software nor through detection hardware. For large outdoor projects requiring flame detection, an independent, external fire detection system can be installed by the customer. These systems do not connect or communicate with Powerwall, but can be connected to an on-site fire alarm panel for monitoring.

Fire detection systems Tesla customers have used in the past are infrared flame detectors, and thermal security cameras (such as DET-TRONICS detectors and FLIR cameras).

What is an appropriate response in the event of a fire?

Water is the recommended suppressant in case of a fire involving Powerwall. Some people are confused by the recommendation to mix water with batteries, especially lithium-ion batteries, because solid metallic

lithium is water-reactive; however, lithium-ion batteries do **NOT** contain any solid metallic lithium. Thus, the use of water is appropriate, and will not exacerbate a fire involving lithium-ion cells.

Refer to the recommendations in Tesla's *Lithium-Ion Battery Emergency Response Guide* for further details.

Can emergency personnel gain access to the inside of the Powerwall in the event of an emergency or fire?

No, emergency personnel cannot gain access to the inside of the Powerwall as it is a fully enclosed unit. When responding to a smoke or fire event involving Powerwall, all incident response shall be performed from a safe distance without physically interacting with the equipment.

Refer to the recommendations in Tesla's *Lithium-Ion Battery Emergency Response Guide* for further details.