Powerwall 3

ANSI/CAN/UL 9540A:2019 Fourth Edition
Test Report Supplemental Guide

2023

Introduction

Tesla Powerwall 3 was tested by Intertek Testing Services NA, Inc., an ISO 17025 accredited laboratory and Nationally Recognized Testing Laboratory (NRTL). The testing laboratory was provided by ESRG (Energy Service Response Group), also ISO 17025 accredited. Testing was conducted in November 2022 in accordance with ANSI/CAN/UL 9540A:2019 Fourth Edition, Dated November 12, 2019 - *Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems*.

This supplemental guide is intended to aid Authorities Having Jurisdiction (AHJs) in the application of the test results to determine compliance with applicable codes. Specifically, it is intended for use where building and/or fire codes require large-scale fire test data to support deviations from the minimum requirements set forth in those codes.

The Tesla Powerwall 3 has met the unit level performance criteria outlined in ANSI/CAN/UL 9540A when installed as follows:

- The Powerwall must be installed in accordance with the manufacturer's installation instructions
- No additional non-combustible substrate is required
- Where applicable, a minimum clearance of 1" on the side(s) of the unit is required to mitigate the risk of side-to-side propagation to adjacent Powerwall 3 units and walls
    - The Powerwall 3 manufacturer installation instructions require a minimum lateral separation of 4" between units

*Page and Section numbers referenced from the test report are presented in **bold type**. For example, verification that the Tesla Powerwall 3 has met the performance criteria outlined in ANSI/CAN/UL 9540A can be found on **pages 17 through 20** of the report.*

For ease of use, this guide is arranged to follow the sequence used in the report issued by Intertek titled *Test Report ANSI/CAN/UL 9540A:2019*. The scope of the report includes the performance criteria outlined in Section 9 – Unit Level Testing of ANSI/CAN/UL 9540A: 2019 Fourth Edition. The report also includes a summary of data acquired at the cell and module levels during prior testing.

All Section numbers in the report are references to ANSI/CAN/UL 9540A:2019 Fourth Edition, Dated November 12, 2019.

Product Details

The device under test (DUT) in the attached report is the Tesla Powerwall 3, model 1707000-XX-Y, which integrates Energy Storage System (ESS) into an all-in-one Solar PV and Storage solution with a storage capacity of 13.5 kWh. Full product specifications and certifications are available on request from all Tesla authorized installers.

Unit Label

TESLA POWERWALL ENERGY STORAGE SYSTEM GRID SUPPORT UTILITY INTERACTIVE & STANDALONE INVERTER

TESLA PART NO. 1707000-XX-Y

SERIAL NO DATAMATRIX (15mm x 15 mm)

SN:XXXXXXXXXX

BATTERY ENERGY STORAGE SYSTEM (BESS) & PHOTOVOLTAIC (PV) POWER CONVERSION EQUIPMENT

NOMINAL BATTERY ENERGY	13.5 KW-HR
BATTERY TYPE	LI-ION
PROTECTIVE CLASS	CLASS I
ENCLOSURE TYPE	NEMA 3R
OPERATING TEMPERATURE RANGE	-20°C TO 50°C
DE-RATED TEMPERATURE RANGE	40°C TO 50°C
PV INVERTER TOPOLOGY	NON-ISOLATED
BESS INVERTER TOPOLOGY	ISOLATED
MASS	130 KG

BATTERY ENERGY STORAGE SYSTEM (BESS) & PHOTOVOLTAIC (PV) SPECIFICATIONS

NOMINAL GRID VOLTAGE INPUT & OUTPUT	240 V (AC)
GRID VOLTAGE RANGE	211 V - 264 V (AC)
PHASE	2W+N+PE
FREQUENCY	60 Hz
MAX SUPPLY FAULT CURRENT	10 kA (AC)
MAX CONTINUOUS OUTPUT CURRENT (POWER AT 240V)	☐ 24A (AC) (5.8 KVA) ☐ 32A (AC) (7.7 KVA) ☐ 40A (AC) (9.6 KVA) ☐ 48A (AC) (11.5 KVA)
BESS MAX CONTINUOUS INPUT CURRENT	20.8 A (AC)
BESS MAX CONTINUOUS INPUT POWER	5 kVA
POWER FACTOR	-1 TO +1
PV OPERATING DC INPUT VOLTAGE RANGE	60 - 550 V (DC)
PV OPERATING DC MPPT VOLTAGE RANGE	150 - 480 V (DC)
PV MAX SYSTEM VOLTAGE	600 V (DC)
PV MAX INPUT CURRENT	13 A (DC)
PV DC ARC FAULT PROTECTION	TYPE 1
CONFORMS TO UL STD 9540, UL STD 1741, UL STD 1973, UL STD 1699B	
CONTAINS FCC ID: 2AEIM-WL18DBMOD, XMR2020BG95M2	
CONTAINS IC: 20098-WL18DBMOD, 10224A-2020BG95M2	

THE MAXIMUM OPERATING CURRENT OF THIS SYSTEM MAY BE CONTROLLED ELECTRONICALLY. REFER TO THE MANUFACTURER'S INSTRUCTIONS FOR MORE INFORMATION.

Summary of Results

A comprehensive summary of the required information that must be included in the unit level test report is provided beginning on **page 13** of the test report. This section provides important information needed to determine residential and fire code compliance where reduced minimum separation distances are permitted, and where the unit is intended to be installed on a combustible substrate.

Final verification that the Tesla Powerwall 3 has met the performance criteria outlined in ANSI/CAN/UL 9540A can be found on **pages 17 through 20** of the report. This portion of the report can be used as a checklist to aid in the verification of the *unit's conformance to the performance criteria for the intended installation configurations*. **Table 9.1** from the test report is divided into two parts, residential and non-residential installations. It is important to note that Tesla Powerwall 3 was only evaluated for residential installations under the scope of this testing.

In the unit level test, it was demonstrated that:

- The Powerwall 3 enclosure provides adequate thermal protection from the wall surface on which it is mounted. Wall surface temperatures did not exceed 97°C (175°F) of temperature rise above ambient per **9.2.15** of the test standard; as such, additional substrate is not required
- Thermal runaway did not propagate past (1) target cell
- Large scale fire testing was conducted with 1" lateral unit spacing to represent worst-case scenario conditions. Testing showed the risk of unit-to-unit propagation to adjacent units is mitigated with 1" unit spacing
    - Manufacturer installation instructions dictate 4" minimum lateral spacing between units to maintain proper airflow during normal operation.

Figure 1: **Photo 2** from Test Report Displaying Test Set Up

Cell Level Construction and Tests

General product details, including cell and module level construction information, are outlined on **pages 5 and 6** of the test report. **Pages 5 and 37** of the report provide background information and data collected during cell and module-level testing previously conducted. This data does not directly correlate to residential or fire code requirements; rather, it is used to document and compare the characteristics of different cell chemistries and module designs. One important value recorded is the temperature at which thermal runaway occurs. This value is determined in accordance with **7.3.1.9** of the test standard. This temperature of **188°C** is used to verify that an internal fire condition has been established during the Unit Level test.

Construction Details: Cell Level

Powerwall 3 utilizes Lithium Iron Phosphate/Graphite chemistry based prismatic cells. Cell dimensions, weight and electrical characteristics are noted on **page 5** of the test report.

Figure 2: **Photo 1** from Test Report Displaying an Individual Cell

Performance Criteria: Cell Level

Application of heat using film heater methodology did result in a thermal runaway condition; therefore, module level testing was required (**page 37** of the test report)

- Cell surface temperature at venting: **174°C**
- Cell surface temperature at runaway: **188°C**

Module Level Construction and Tests

Construction Details: Module Level

Powerwall 3 consists of a single module with cells positioned within a metallic semi-open enclosure. The Powerwall 3 module is designed without a fully encapsulated metallic enclosure to allow vent gases to be routed in such a way that increases the overall propagation resistance of the module; this prevents a dangerous buildup of gases that could lead to an explosion or deflagration hazard.

The module consists of 26 cells electrically wired in series and arranged in two rows of (13) prismatic cells; this information can be found on **page 5** of the test report.

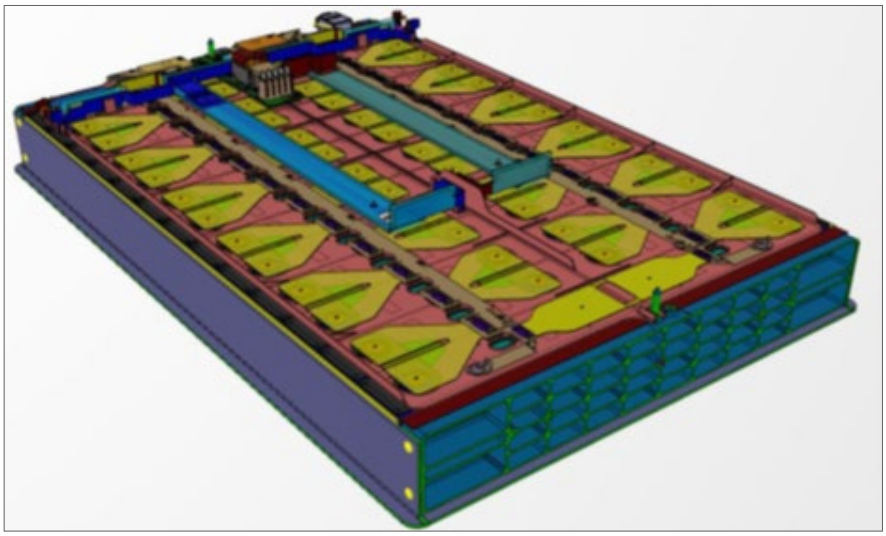


Figure 3: **Illustration 2** from Test Report Depicting the Layout of Cells in the Module

Performance Criteria: Module Level

Application of heat using film heater methodology did result in a thermal runaway condition, and the resulting event was not contained by the module design; therefore, unit level testing was required.

Unit Level Test: General

Section 9: Unit Level Testing information begins on **page 7** of the report. In additional to providing greater detail on the test setup and unit performance, this portion of the report can also be used as a checklist to aid in the verification *of the testing laboratory's conformance to the test procedure*.

Sample and Test Configuration

ANSI/CAN/UL 9540A provides for several configurations:

- Residential and non-residential use cases
- Wall and floor mounting
- Indoor and outdoor locations

Tested Configuration

Testing was conducted using a single indoor wall-mounted test configuration that was determined to be representative of all intended installation configurations. Tesla Powerwall 3 is intended to be installed in any of the configurations noted below (**Section 9.1.1** of the test report):

- Indoor floor-mounted residential use BESS
- Outdoor ground-mounted residential use BESS
- Outdoor wall-mounted residential use BESS
- Indoor wall-mounted residential use BESS

The testing configuration was adapted to include the characteristics necessary to be an accurate representative test case for the above listed scenarios. This determination was made by the testing laboratory based on allowable installation scenarios for Powerwall 3 in conjunction with rigorous pre-test planning, component level review of the BESS unit construction, integral thermal runaway mitigating factors, and cell level chemistry.

- In accordance with **Section 9.1.2** of the test standard, the indoor floor-mounted test is considered representative of the outdoor ground-mounted test with the incorporation of a 1-ft soffit.
- **Section 9.1.2** of the test standard dictates all testing is to be done indoors with distances between initiating and target units being representative of the intended installation scenario.
    - Tesla Powerwall 3 unit to unit spacing is agnostic of the installation configuration.
- Worst case representative testing conducted with 1" unit to unit spacing; manufacturer installation instructions dictate 4" minimum unit to unit spacing.

Tested Configuration: Unit Level Test

Testing was conducted in a standard NFPA 286 fire test room, with the test room being 12 x 8 x 8-ft high with a 2.5 x 7.5-ft high opening. Walls were covered with standard 5/8" gypsum board which was painted black in accordance with **Section 9.2.6** of the test standard.

Figure 4: **Photo 5** from Test Report Displaying Room Used for Testing

Figure 5: **Photo 3** from Test Report of Test Configuration

Units were installed on an instrumented wall with (16) thermocouples running the length of the wall, with 6" spacing between thermocouples. The south wall of the room was similarly instrumented with (16) thermocouples, and (2) thermocouples were placed in the ceiling.

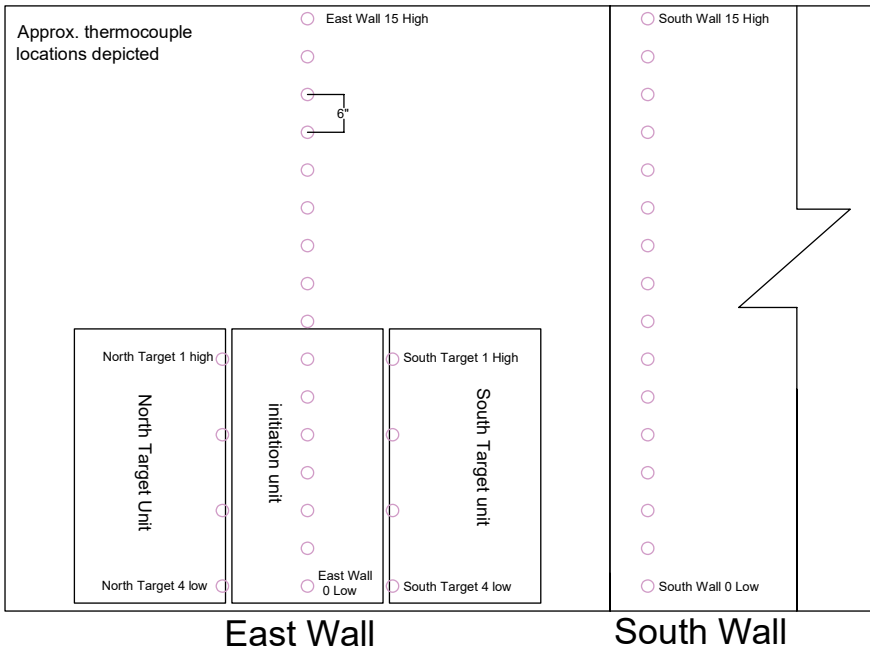


Figure 6: Thermocouple Placement Shown for East Wall, South Wall and Target Units

Tested Configuration: Unit Level Test (cont.)

The initiating unit was placed in the center of the 8’ wall opposite the ventilation opening, with target units installed on both sides with 25 mm (1”) lateral spacing. All units were 32 mm (1.25”) from grade.

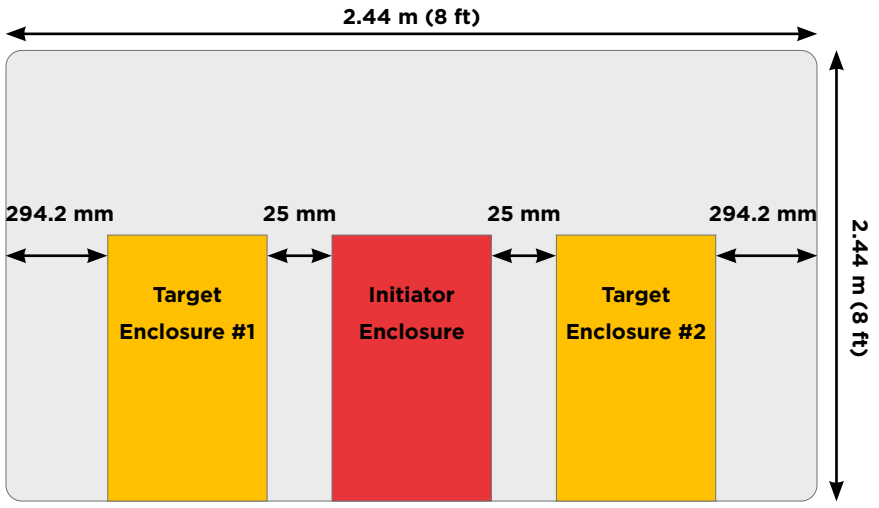
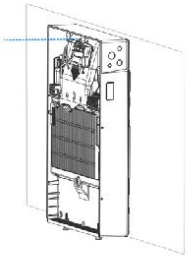
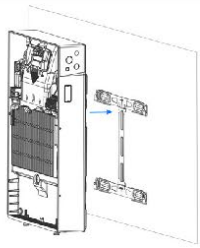
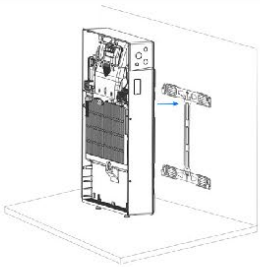
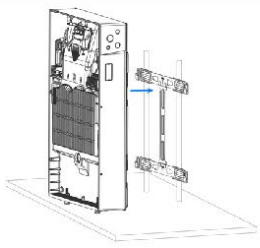


Figure 7: **Illustration 5** from Test Report Displaying Initiating and Target Unit Placement

Initiating and target units were affixed directly to the wall without the utilization of a mounting bracket; this was done to allow testing to be representative of the worst-case allowable installation configuration. In this installation configuration, and in accordance with manufacturer installation instructions, the BESS enclosure is directly secured to the wall with a single fastener. Installation configuration is noted in the manufacturer installation instructions as *ground-mount Powerwall 3 with a Single Fastener*, as shown in the following excerpt from the installation instructions.

	Ground-mount Powerwall 3 with a Single Fastener (Preferred)	Ground- or Wall-mount Powerwall 3 with Wall Bracket	Ground-mount Powerwall 3 on Poured Concrete	Ground-mount Powerwall 3 on Poured Concrete with Steel Posts
				
Wall and Foundation	Existing structural wall and existing approved foundation	Existing structural wall and existing approved foundation	Existing structural wall and poured concrete foundation	Poured concrete with steel posts
Seismic Design Category	A or B	A, B, C, or D	A, B, C, or D	A, B, C, or D

Internal Fire Condition: Unit Level Test

The unit level test begins with the application of heat at a specific site selected to present the greatest amount of thermal exposure to adjacent cells within the module. This application of heat must result in an internal fire condition in accordance with the module level test previously conducted. This was verified by testing staff using temperature data recorded during initiation of the event, compared against the cell surface temperature at thermal runaway during the cell level test. This temperature was determined to be **188°C** in accordance with **7.3.1.9** of the test standard – see **page 37** of the test report.

Thermal Runaway was induced consistent with the methodology determined in the module level test. Internal fire conditions were confirmed using thermocouples placed inside the initiating unit to monitor cell level surface temperatures. Thermal runaway was confirmed in the target and initiation cells with no further propagation to other cells within the module.

Cell 1	Cell 26
Cell 2	Cell 25
Cell 3	Cell 24
Cell 4	Cell 23
Cell 5	Cell 22
Cell 6	Cell 21
Cell 7	Cell 20
Cell 8	Cell 19
Cell 9	Cell 18
Cell 10	Cell 17
Cell 11	Cell 16
Cell 12	Cell 15
Cell 13	Cell 14

Initiator Cell
Target Cell

Note: The heater was placed between Cell 19 and Cell 20

Figure 8: **Illustration 3** from the Test Report Displays Target and Initiator Cell Locations Relative to the Greater Module

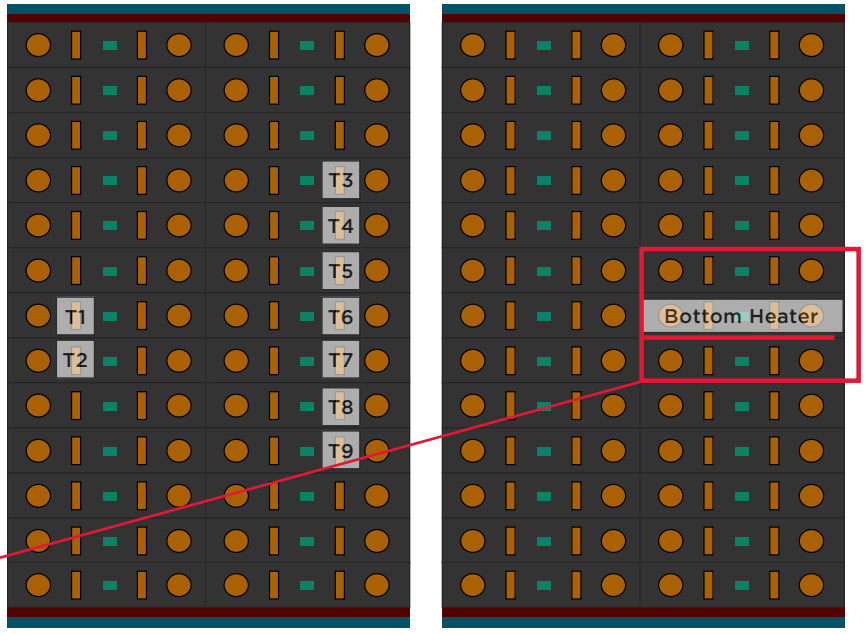


Figure 9: **Illustration 4** from the Test Report Displays Film Heater Placement and Internal Thermocouple Placement that was Utilized to Confirm an Internal Fire Condition

Unit Level Test: Test Results

Beginning on **page 13** of the test report, all required information to be included in the unit level report is provided in long form. The unit level performance criteria table begins on **page 16** of the report, with the applicable performance criteria for residential installations beginning on **page 17.**

Unit level performance criteria indicated in **Table 9.1** of the test report provides a basis for the approval of the test report through satisfactory conformance to all required unit level performance characteristics.

A summary of key sections of the performance criteria are provided below.

Cheesecloth

DUT was wrapped in cheesecloth during entirety of test procedure. No flaming or charring was observed outside of the unit, and the cheesecloth indicator was not burned or charred. The cheesecloth is noted “as is after the test” on **page 23** of the test report. Cheesecloth is frequently used as a fire indicator in regulatory and safety testing to assess fire hazards during abnormal operations; similarly, the cheesecloth is required by the ANSI/CAN/UL 9540A test standard to ensure an internal fire is contained by the unit level enclosure.

Figure 10: **Photo 6** from the Test Report Displaying “Cheesecloth as is After the Test”

Unit Level Test: Test Results (cont.)

Target Units: Maximum Temperature

Target unit module surface temperatures did not exceed the temperature at which cell venting occurs (**174°C** as determined in accordance with **Section 7.3.1.8** of the test standard).

- Maximum instantaneous temperature recorded by thermocouples was **173.4°C** for < 1s
    - Temperature spike remains below cell vent temperatures but is attributed to a momentary thermocouple short as denoted in the relevant sections of **Table 9.1** in the test report
    - Adjacent thermocouples do not experience similar and spontaneous temperature spikes as seen in **Illustration 12** on **page 30** of the test report
- Maximum sustained target unit temperatures were ascertained using a rolling 5 second average. Maximum sustained target unit temperature is **96.3°C** as indicated in test report

Instrumented Walls: Maximum Temperature

- UL 9540A requires BESS intended for installation on combustible substrates to limit surface temperature on wall surfaces, to not exceed 97°C temperature rise above ambient
    - Maximum recorded wall temperature: **54.6°C** (39.1°C rise over ambient)
- Recorded wall surface temperature rise over ambient is well below allowed maxima noted per **Section 9.2.15** of the test standard and does not present a hazard of igniting combustible substrates upon which the BESS is mounted

Deflagration/Explosion Hazards

- No flying debris or explosive discharge of gases were observed during testing
- No sparks, electrical arcing, or other electrical events were observed during testing
- No damage was observed to the initiating BESS unit or target BESS units
- No damage was observed to the adjacent walls or ceiling of the NFPA 286 standard fire test room

For any questions on the test report or this supplemental guide, please email codecompliance@tesla.com.