GUIDE BATTERY STORAGE · 8 MIN.

Reading a UL 9540A Report Properly: Which Values Matter for Thermal Barrier Design

UL 9540A reports provide the data basis for thermal compartmentation and fire protection design of battery energy storage systems. This guide shows which parameters from cell, module and unit level testing genuinely belong in the design process.

What UL 9540A Tests — and What It Does Not

UL 9540A is not a product certificate but a test method: it characterises how a battery system behaves during thermal runaway. The outcome is a data report — not a pass/fail verdict. That is precisely where its value for thermal barrier design lies: the report supplies the input parameters needed to dimension fire barriers, wall assemblies and insulation layers, rather than falling back on blanket standard assumptions.

The test programme is structured in four stages: cell level, module level, unit level (rack or cabinet) and installation level. Each stage answers different questions. Anyone evaluating a report should first check up to which stage testing was carried out — and whether the tested configuration matches the installation actually being planned. A module report based on a different cell batch, a different enclosure or a different arrangement offers only limited validity for the specific plant.

Note: Note the 2025 Edition — The current version of UL 9540A (6th edition, 2025) tightens the installation-level test in particular: it assumes a demanding fire scenario following a deflagration and evaluates enclosure construction, separation distances and, for indoor installations, the effectiveness of building-side suppression systems. Older reports based on the 2019 edition are not automatically invalid, but they do not reflect these scenarios.

Cell Level: Gas Data as the Foundation

The cell-level test establishes whether and at what temperature the cell goes into thermal runaway, when the safety vent opens (venting temperature) and which gas mixture is released in the process. FTIR analysis quantifies hydrogen, carbon monoxide, carbon dioxide and hydrocarbons, among others. The safety-related characteristics are then determined from the reconstituted gas mixture.

- Lower and upper flammability limits (LFL/UFL) — at room temperature and at venting temperature
- Maximum explosion pressure Pmax of the vent gas
- Laminar burning velocity of the gas mixture
- Gas volume per cell or relative to capacity
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Venting and thermal runaway temperature of the cell

For compartmentation these values are doubly relevant: they govern the design of explosion venting and ventilation to NFPA 68/69 — and thus the pressure and temperature loads that walls, linings and penetration seals must withstand in the event of an incident.

Module and Unit Level: Thermal Data for the Barrier

At module and unit level, thermal runaway is deliberately initiated and the response of the complete assembly is measured. This is where the values that directly size a fire barrier are found: the heat release rate with its peak value and time profile, the total energy released, the gas release rate, and the question of whether thermal runaway propagates to neighbouring cells and modules.

Particularly valuable for designers of thermal barriers are the measurements taken at the target surfaces: heat flux on instrumented wall segments and adjacent units, plus surface temperatures at defined measuring points. These values show what thermal load a partition wall or protective cladding actually receives at a given distance — and for how long. From this, the choice of insulation material, layer thickness and the permissible temperature on the unexposed side can be derived.

Note: Look at the Time Profile, Not Just the Peaks — A short peak in heat release loads a barrier differently from many cells reacting through over several hours. What counts for the design is the combination of peak value, total energy and duration — the report contains the complete time histories in its appendix.

From the Report to Thermal Barrier Design

The report does not replace fire protection design; it feeds it. In practice, a structured evaluation has proven effective: first check the propagation statement (does the event remain confined to cell, module or unit?), then extract the thermal loads on adjacent surfaces, and finally hand the gas characteristics over to the explosion protection design.

- Propagation behaviour: the basis for separation distances and for whether reduced spacings can be justified under NFPA 855
- Heat flux and wall temperatures: input parameters for fire resistance, insulation build-up and barrier material selection
- Gas volume, LFL, Pmax and burning velocity: the basis for explosion vent areas and ventilation design
- Secondary fire phenomena: flame lengths, sparking and burning particles define protection zones in front of the barrier

If individual values are missing, or testing only went as far as cell level, the design must take a conservative approach — with larger separation distances, higher fire resistance and a more robust lining. A complete report up to unit level therefore also pays off economically: it allows a well-founded, often leaner design instead of blanket safety margins.

Frequently asked questions

Is a UL 9540A report a safety verification for the battery storage system?

No. UL 9540A is a test method that delivers data on thermal runaway behaviour — without any pass-or-fail statement. Whether the installation is safe is only assessed during design, for instance to NFPA 855 or within a German fire protection concept. Product certification itself runs via UL 9540.

Which values in the report matter most for thermal compartmentation?

The heat release rate with its time profile, the heat flux on adjacent surfaces, the measured wall temperatures and the propagation statement. For explosion protection, gas volume, gas composition, LFL, Pmax and burning velocity come on top.

What if the manufacturer only provides a cell- or module-level report?

Then the room-level thermal loads are missing and the compartmentation must be dimensioned conservatively. It is worth requesting the unit-level report — many manufacturers of stationary systems have one, but only release it on request and sometimes under confidentiality.