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UL 9540A Standard for Safety

Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems

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Introduction:

This white paper highlights key points and summarizes the testing method highlighted in the *Fourth Edition* of the *UL Standard for Safety "Testing Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems", ANSI/CAN/UL 9540A:2019*. Belmont Scientific has the capability to preform accurate safety tests which follow this method at cell and module level. This standard testing method is used to determine the capability of a battery technology to undergo thermal runaway. This test also evaluates the fire and explosion hazard characteristics of those battery energy storage systems that have demonstrated their ability to undergo thermal runaway. Data from this test can be used to guide the development of appropriate fire and explosion protection required for the application of the battery energy storage systems intended for installation, operation, and maintenance in accordance with ICC, IFC, NFPA1, NFPA 70, IEEE C2, CAN/CSA C22.2 No.0, and other codes affecting energy storage systems, and the manufacturer's installation instruction.

UL Testing Methodology:

Cell samples being tested are conditioned prior to testing by discharging and recharging following the specifications provided by the manufacturer. At least two (2) charge cycles are used to verify the samples performance. The cycles consist of charging at a rate specified by the manufacturer to 100% State of Charge (SOC) and discharging to the end of discharge voltage (EODV). Cells are then charged to 100% SOC and are allowed to stabilize for over one hour but no more than eight hours. All tests must be conducted in a laboratory which is maintained at 25°C ± 5°C and 50 ± 25% RH. To determine a cells capacity to exhibit thermal runaway, flexible external heaters are applied to the outer surface of the cell. The heater covers as much of the cell as possible without inhibiting any of the cells built in safety features or terminals. The heaters are turned on and a heating rate of 4°C to 7°C per minute is applied to the cell. The maximum surface temperature endpoint is determined by reviewing the cells chemistry and design.

If the film heater is incapable of causing thermal runaway, then one of the following methods is employed; Mechanical (Nail penetration), Electrical stress (Overcharging, over discharging, short circuit) or an alternate heating source (Such as an oven). The temperature of the cells external surface is monitored using a Type-K thermocouple, connected to the data collector with a wire no greater than 24-gauge in size. The cell vent pressure due to gas generation is documented; and the thermocouple under the center of the film heater is used for this measurement. The thermal runaway onset temperature, defined as the point where the self-heating rate of the cell exceeds the heating rate of the film heater, is recorded. A sample graph taken directly from the UL handbook is shown in *Figure 1*. The results obtained by Belmont Scientific on an 18650 cylindrical cell subjected to 5 °C/min heating rate following the UL9540A test procedure are shown in *Figure 2*.

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This data shows that the cell venting and the onset of thermal runaway occurred at 139.9 °C and 149.8 °C, respectively.

Results:

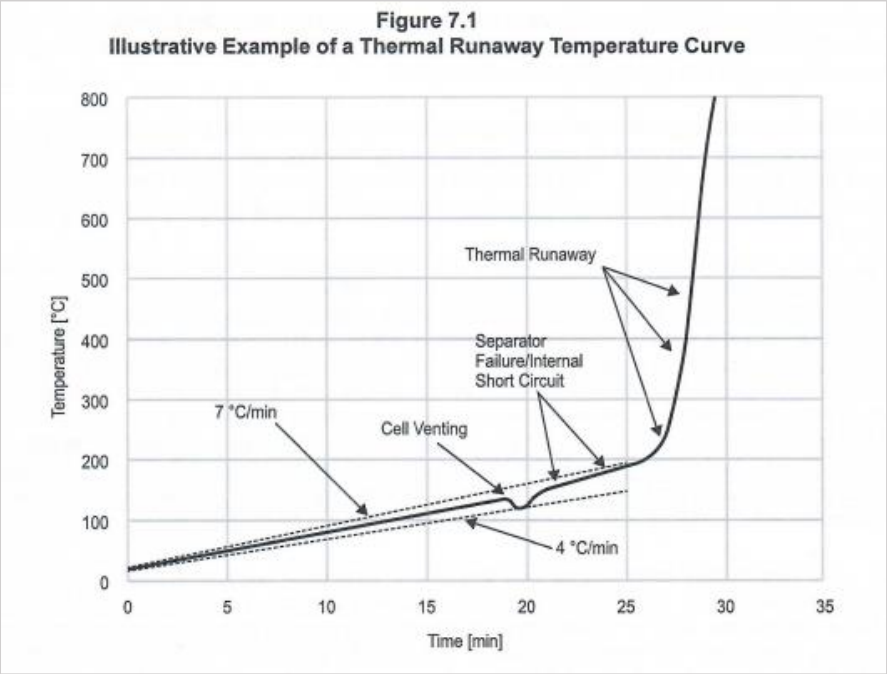

Figure 1. Sample Graph of Expect UL9540A Testing Results.

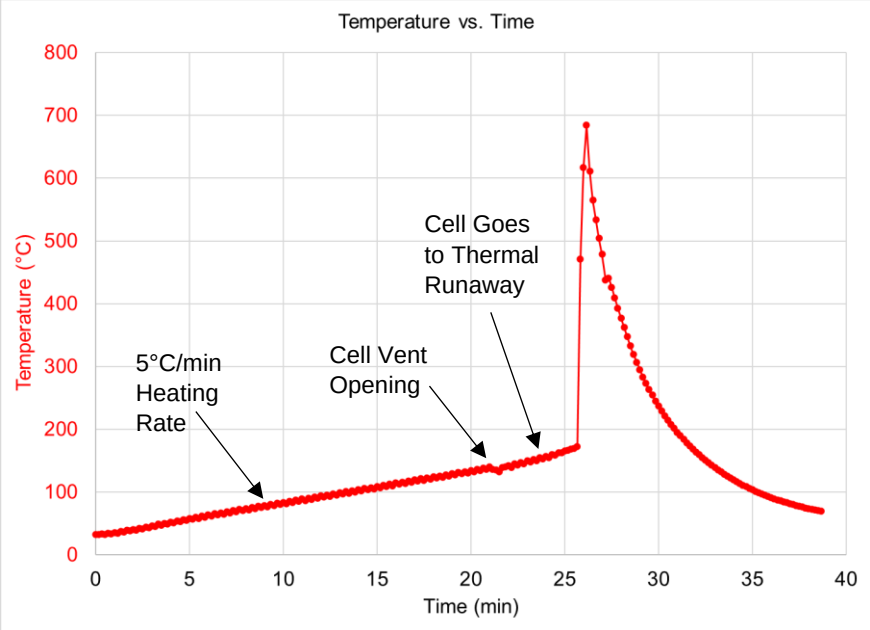

Figure 2. Data Generated by Belmont Scientific following UL9540A Testing Methodology for an 18650 Cylindrical Cell.