UL 2596 Test Report for Elven Technologies Battery Enclosure: FireGuard Reinforced

Project Details

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Test Standard: UL 2596
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Scope of Report

The document provides detailed analysis of the Torch and Grit test on FireGuard Light in accordance with the UL 2596 standard *Battery Enclosure Thermal Runaway Barriers*. The objective is to verify the material's ability to maintain structural integrity and limit heat/pressure transmission during extreme thermal-runaway events in lithium-ion cells.

Sample Specification

- **Sample ID: Sample A**
- **Thickness: 5 mm**
- **Density / Basis Weight: 0.31 g cm^{-3}**
- **Flexibility: yes**
- **Colour: Black**

Test Procedure – BETR

.BETR Test Methodology

The BETR test evaluates how battery enclosure materials perform under thermal and mechanical stress caused by thermal runaway in lithium-ion cells. The test apparatus includes a five-sided steel test box with a fuel package of twenty-five 18650 lithium-ion cells, arranged in a 5-by-5 array (Fig. 2), charged to 100% state of charge (SOC). The cells are driven into thermal runaway using flexible film heaters.

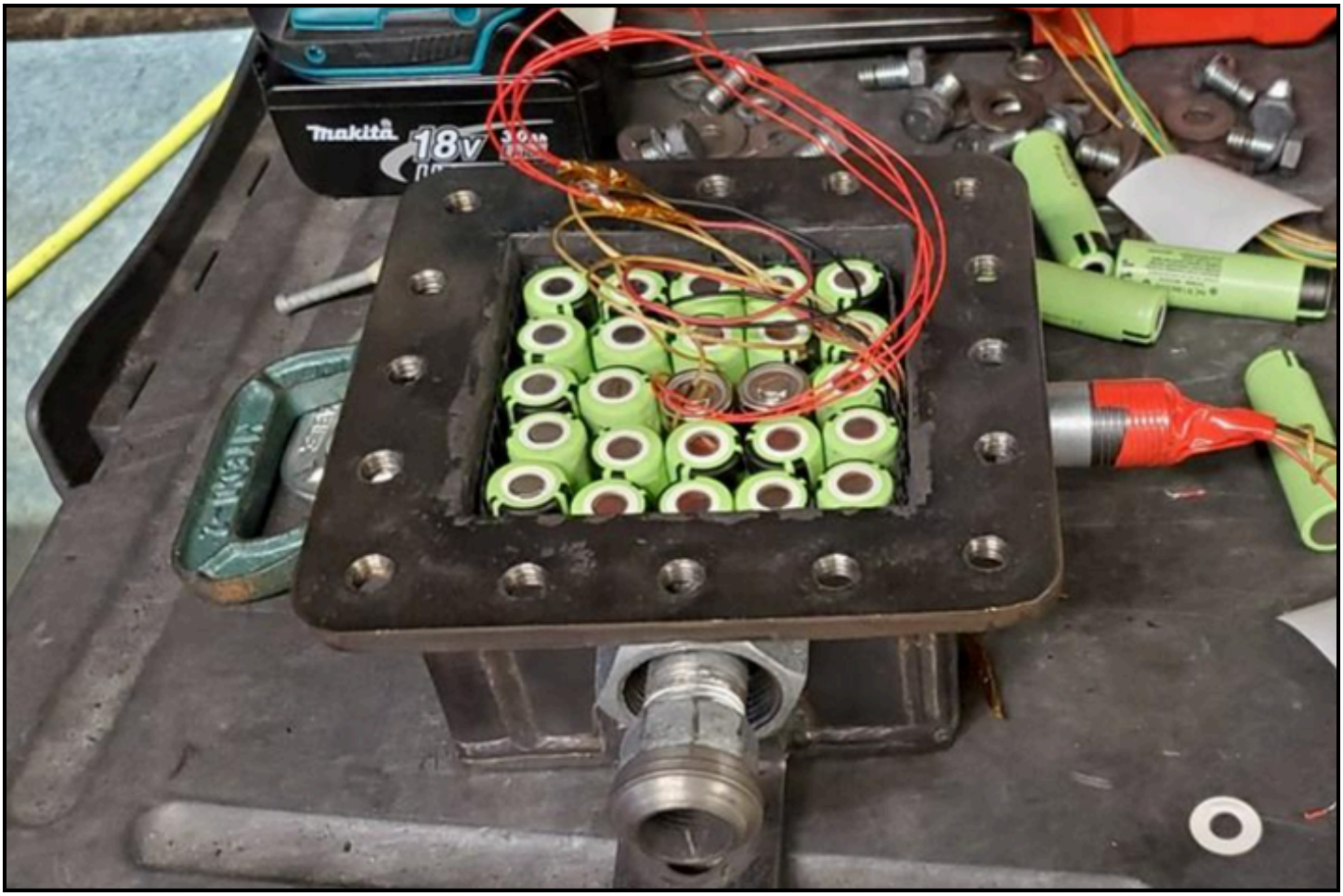

Figure 2:

Arrangement of lithium-ion

cells and test apparatus for

BETR testing.

Photo from UL website.

Test Procedure:

- Install the fuel package inside the test box.
- Secure and seal the test sample onto the open side of the test box.
- Attach a thermocouple to the test sample.
- Initiate the test by heating the film heaters at approximately 6 °C/min.
- Record temperature and pressure data during and after thermal runaway.

- Observe and document any visual changes in the test sample.

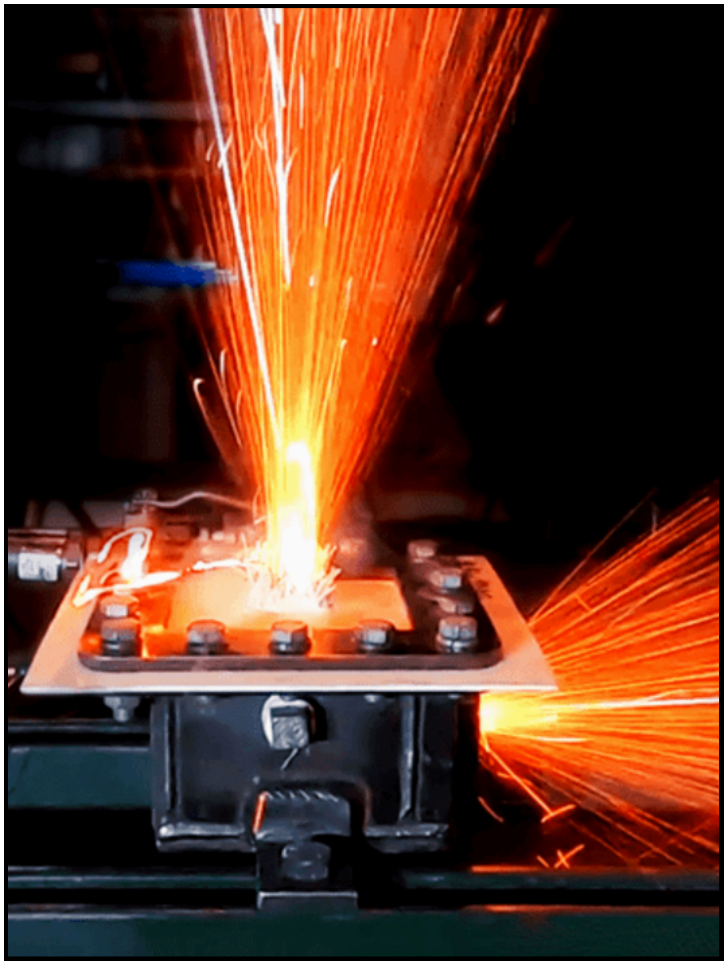

Figure 3: BETR being conducted, heated particles exiting from designated exhaust (side) and damaged test material (top). *Photo from UL website*. *Elven composite is not present in this figure.*

Test Results

The below table summarizes the test results.

Summary of Test Results:

The below table summarizes the test results. A video was used to capture each test and has been provided separately to this test report.

Sample	Run	Vent Orifice Size (Target Pressure)	Max Internal Pressure (kPa)	Max Temperature of Battery Cell (°C)	Max Temperature Inside test Enclosure (°C)	Max Temperature Top of Sample (°C)	Observations (Note: Temperature and Pressure measurements charts and photos are included in Addendum "A")
A	1	16mm (250kPa)	233.5	1499.9*	201.4	317.1	**Did Not Breach**
A	2	16mm (250kPa)	261.9	1398.1	265.0	41.9 (TC disconnected by breach)	**Breached**
A	3	16mm (250kPa)	269.9	1228.3	183.4	648.7	**Breached**

Key observations — Sample A (BETR)

- **Three runs were performed with a 16 mm vent (≈250 kPa target). Run 1 reached 233.5 kPa with no breach; Runs 2–3 breached at 261.9 kPa and 269.9 kPa, respectively.**
- **Recorded peak temperatures: cell 1499.9 °C / 1398.1 °C / 1228.3 °C; enclosure 201.4 °C / 265.0 °C / 183.4 °C across Runs 1–3.**
- **Cold-face (top) maxima: 317.1 °C (Run 1), 41.9 °C just before thermocouple disconnect during breach in Run 2, and 648.7 °C post-breach in Run 3.**
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Conclusion

FireGuard Reinforced (Sample A), BETR

Within this fixture and venting setup, the specimen maintained integrity up to ~**233 kPa** while keeping the protected side below ~**320 °C**; above ~**262–270 kPa** it breached. For designs expecting peaks at or below ~**230 kPa**, the material provides effective thermal attenuation with intact containment; applications anticipating higher peaks should incorporate reinforcement or layering to raise the rupture threshold.