CellBlock®
Fire Containment Systems

Certificate of Test

Project:	Demonstration of LIBIK products for use in Aviation	**Date:**	March 14, 2023
		Document No.:	CBDLT0023-01
		Project Manager:	Dylan Vandemark
		Date of Testing:	February 28, 2023

Purpose: To show thermal runaway in typical li-ion powered consumer products and demonstrate effective methods of mitigation and extinguishing.

Description: A demonstration consisting of five thermal runaway scenarios:

1. Baseline thermal runaway demonstration of typical batteries found in consumer power bank. PED-Pad pillow and LIBIK fire blanket applied to extinguish.
2. Thermal runaway demonstration in overhead bin. Three polymer pouch cells were used to replicate those found in typical consumer devices. PED-Pad pillow and LIBIK fire blanket applied to extinguish.
3. Thermal runaway demonstration of a power bank on the tray table. PED-Pad pillow and LIBIK fire blanket applied to extinguish.
4. Thermal runaway presentation demonstrating the placement of a suspect power bank in a LIBIK.
5. Demonstration of thermal runaway in a consumer laptop on a tray table. PED-Pad pillow applied to extinguish. LIBIK fire blanket used to bundle laptop and place in a LIBIK (Lithium-Ion Battery Incident Kit).

Description: Baseline thermal runaway demonstration of typical batteries found in consumer power bank. PED-Pad pillow and LIBIK fire blanket applied to extinguish.

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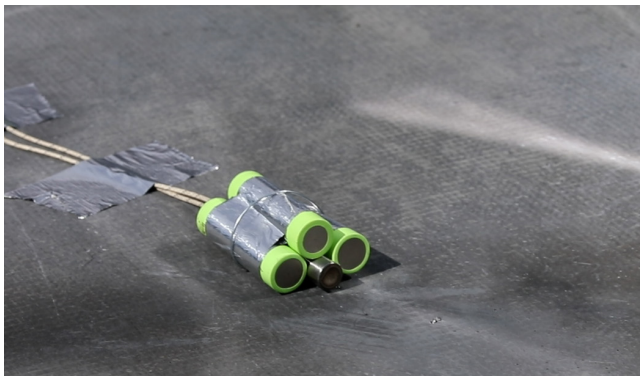

Test sample pre-test - three 18650 batteries.

Test sample in thermal runaway.

Application of PED-Pad fire suppression pillow and LIBIK fire blanket.

Test Sample
The test sample consisted of three bundled 9.6 Wh 18650 lithium-ion batteries with an aggregate energy of 28.8 Wh at 100% SOC. Thermal runaway was induced using a Watlow Firerod heater cartridge.

Test Equipment:
Watlow Firerod heater cartridge, 110 DC Power Supply

Procedure: Cell ignition was achieved by heating at a rate of 1.2°C/sec to vent and thermal runaway.

Results: The cells were heated until rapid disassembly (thermal event). The cells discharged and smoke and flames were observed. A PED-pad fire suppression pillow and blanket were applied to mitigate the event. Upon allowing the test sample to cool, it was visually inspected. It was observed that all cells had fully propagated.

Temperature was not recorded, as the purpose of this presentation was to demonstrate the behavior of lithium-ion batteries in thermal runaway.

Description: Thermal runaway demonstration in overhead bin. Three polymer pouch cells were used to replicate those found in typical consumer devices. PED-Pad pillow and LIBIK fire blanket applied to extinguish.

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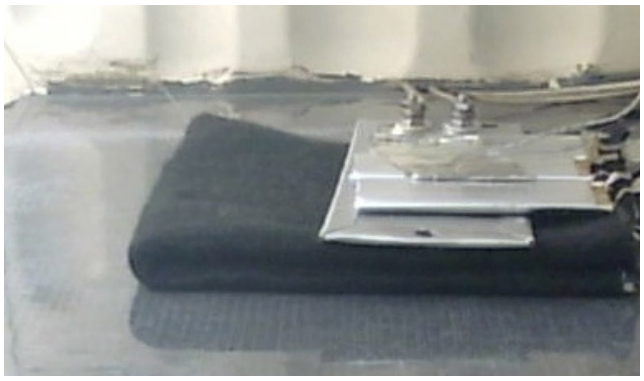


Test sample pre-test - polymer pouch cells in overhead bin.

Test sample in thermal runaway.

Test Sample
The test sample consisted of three exposed 12.5 Wh polymer pouch cells for an aggregate energy of 37.5 Wh at 100% SOC. The cells were placed in a closed overhead bin and thermal runaway was induced using a heat plate and a spark igniter. Cells were equipped with a Type-K thermocouple to measure temperature.

Test Equipment:
Heat plate, spark igniter, 110 DC Power Supply, Type-K Thermocouple

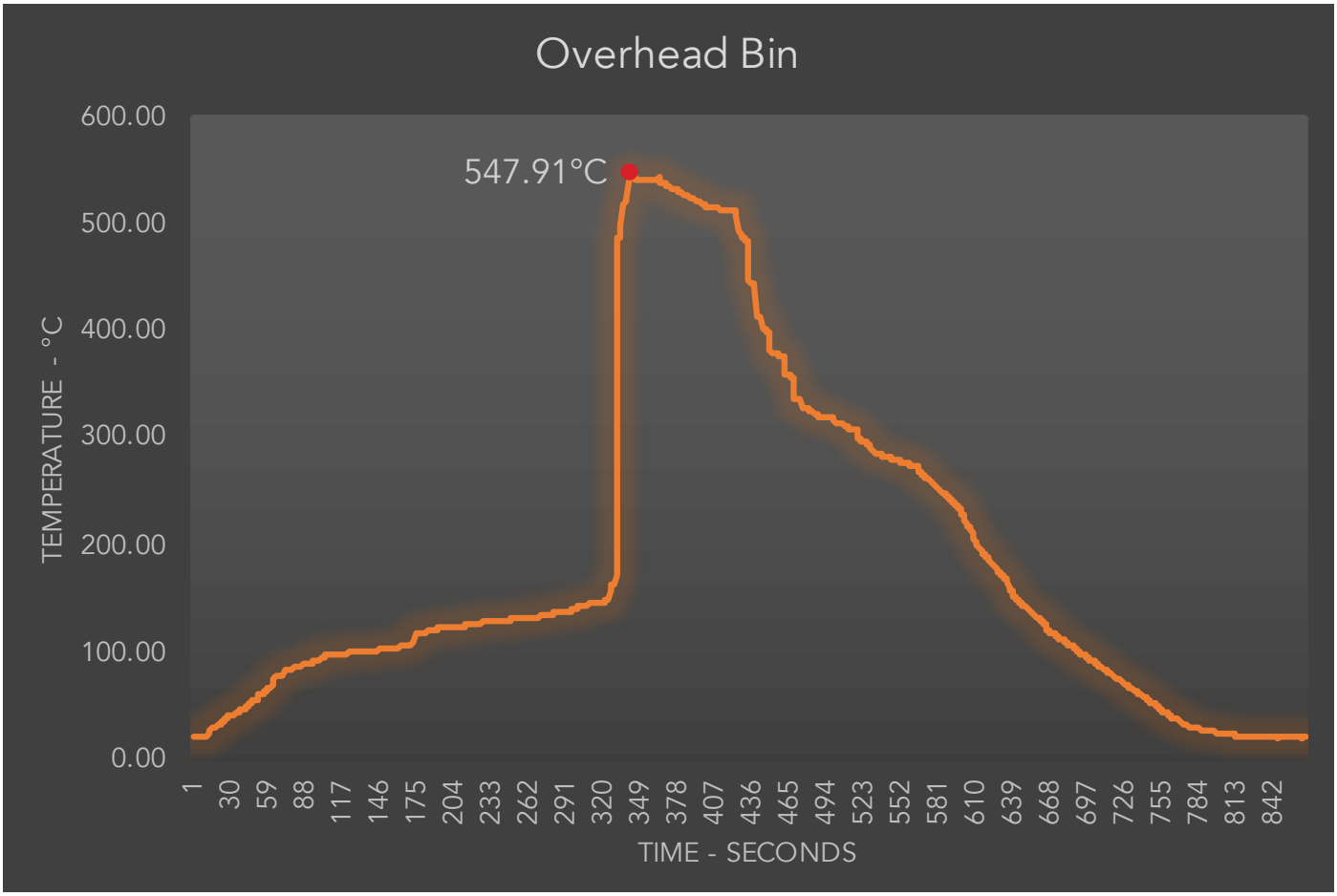
Procedure: Cell ignition was achieved by heating at a rate of 0.6°C/sec to vent and thermal runaway. Temperature was recorded every 1 second using a Type-K thermocouple

Results: The cells were heated until rapid disassembly (thermal event). The cells discharged at approximately 340 seconds and smoke and flames were observed. At approximately 370 seconds the overhead bin was opened and a PED-pad fire suppression pillow and blanket were applied to mitigate the event. Rapid cooling was documented at 436 seconds.

Application of PED-Pad fire suppression pillow ...

... and LIBIK fire blanket

Overhead bin, post test. Cells fully extinguished.



Thermocouple data

Thermal runaway was achieved at approximately 340 seconds
Maximum temperature reached 547.91°C
PED-pad and LIBIK fire blanket were applied at approximately 370 seconds, after which rapid cooling was documented

Description: Thermal runaway demonstration of a power bank on the tray table. PED-Pad pillow and LIBIK fire blanket applied to extinguish.

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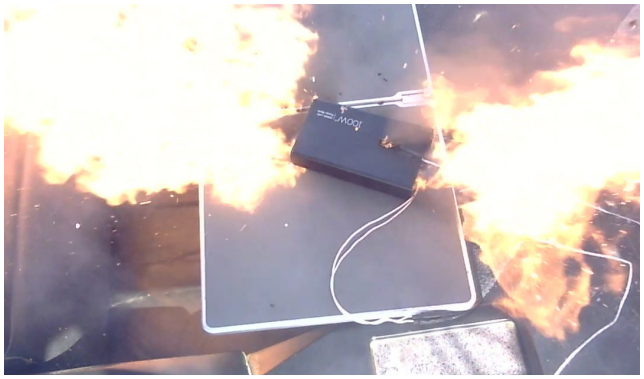
Test sample pre-test - 74 Wh consumer battery pack



Test sample in thermal runaway.

Test Sample
The test sample consisted of a typical consumer battery pack with an aggregate energy of 74 Wh at 100% SOC. Thermal runaway was induced using a heat pad. Battery pack was also equipped with a Type-K thermocouple to track temperature.

Test Equipment:
90 watt heater pad, 110 DC Power Supply, Type-K Thermocouple

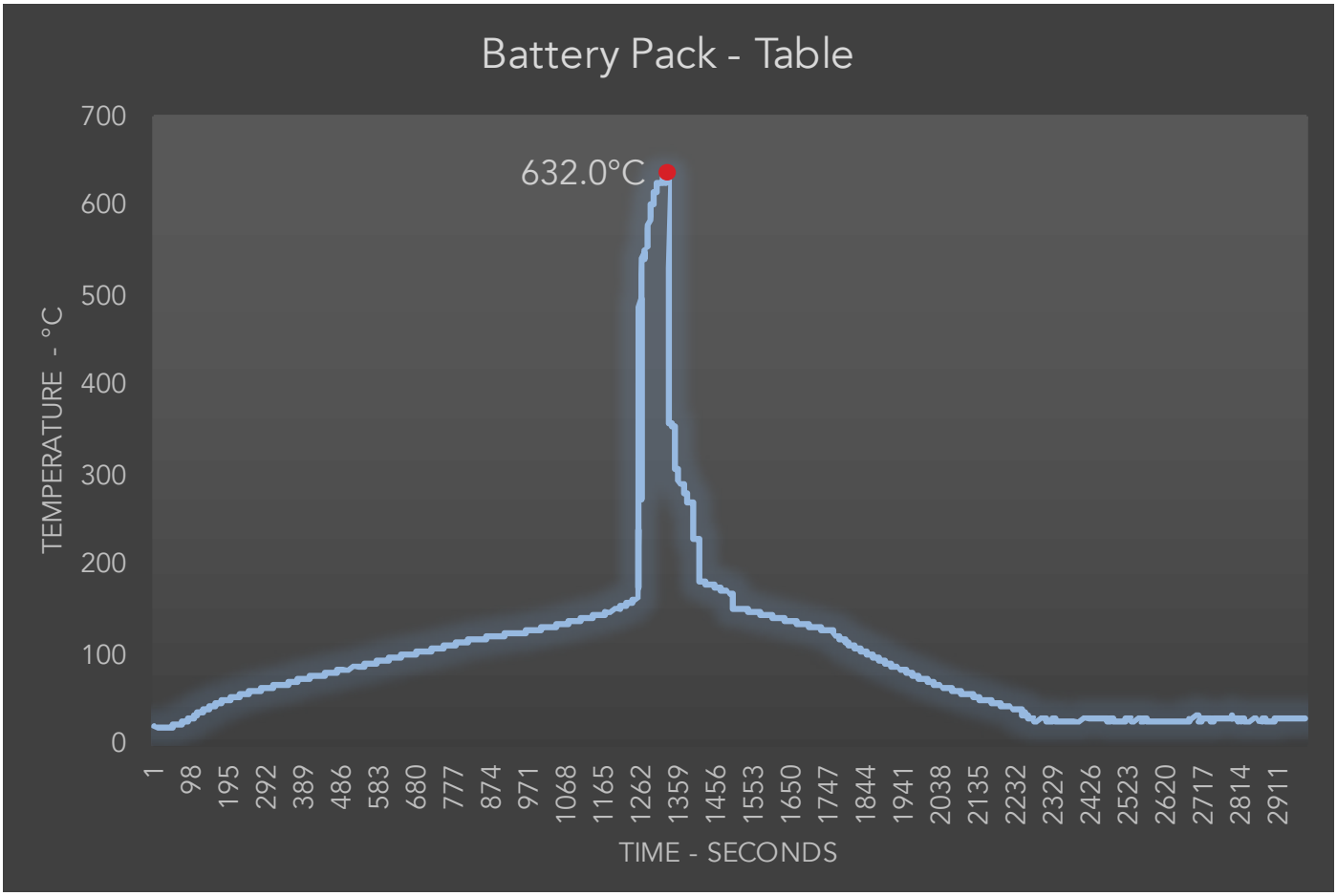
Procedure: Cell ignition was achieved by heating at a rate of 0.2°C/sec to vent and thermal runaway. Temperature was recorded every 1 second using a Type-K thermocouple.

Results: The battery pack was heated until rapid disassembly (thermal event). The cells discharged at approximately 1260 seconds and smoke and flames were observed. At approximately 1300 seconds the battery pack was approached using the LIBIK fire blanket for safety. A PED-Pad fire suppression pillow was applied to extinguish and the fire blanket was draped over the tray table to provide further protection.

Test sample in thermal runaway.

PED-Pad pillow and fire blanket applied.

Test sample post-test, extinguished.



Thermocouple data

Thermal runaway was achieved at approximately 1260 seconds

Maximum temperature reached 632.0°C

PED-pad and LIBIK fire blanket was applied at approximately 1360 seconds, after which rapid cooling was documented

Description: Thermal runaway presentation demonstrating the placement of a suspect power bank in a LIBIK.

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Test sample pre-test - power bank placed in LIBIK kit

Test sample in thermal runaway. Explosion evident.

LIBIK contents post test.

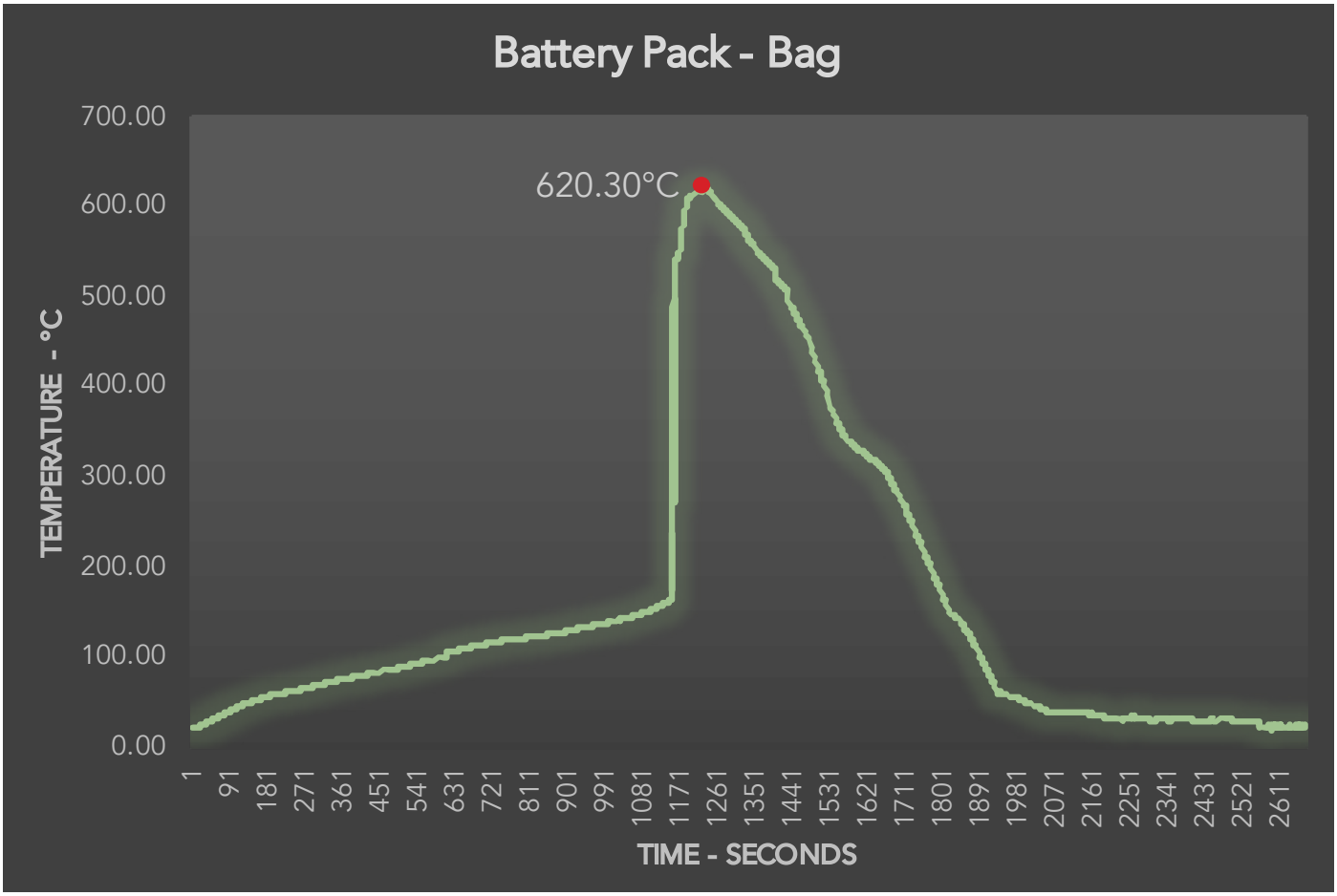
Test Sample
The test sample consisted of a typical consumer battery pack with an aggregate energy of 74 Wh at 100% SOC. Battery pack was placed in a LIBIK which was sealed per product recommendations except for test wire exit point. Thermal runaway was induced using heat tape. Battery pack was equipped with a Type-K thermocouple to measure temperature.

Test Equipment:
90 watt heater pad, 110 DC Power Supply, Type-K Thermocouple

Procedure: Cell ignition was achieved by heating at a rate of 0.2°C/sec to vent and thermal runaway. Temperature was recorded every 1 second using a Type-K thermocouple.

Results: The battery pack was pre-heated. A LIBIK blanket was then used to safely bundle the pack and place in the LIBIK bag. Heating of the pack continued until rapid disassembly (thermal event) at approximately 1130 seconds. An explosion was evident and smoke was observed exiting the test wires entry point. Rapid cooling of the device was documented after initial explosion. Once device was allowed to cool, the contents were examined. The device was found to have fully propagated and it was observed that the PED-Pad fire suppression pillows had deployed.

LIBIK interior post test.



Thermocouple data

Thermal runaway was achieved at approximately 1130 seconds

Maximum temperature reached 620.30°C

Description: Demonstration of thermal runaway in a typical consumer laptop on a tray table. PED-Pad pillow applied to extinguish. LIBIK fire blanket used to bundle laptop and place in a LIBIK (Lithium-Ion Battery Incident Kit).

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Test sample pre-test - laptop on tray table

Test sample in thermal runaway.

Test Sample
The test sample consisted of a typical consumer laptop with an aggregate energy of 40 Wh at 100% SOC. Laptop was placed on a tray table and thermal runaway was induced using heat tape and a spark igniter. Laptop was equipped with a Type-K thermocouple to measure temperature.

Test Equipment:
90 watt heater pad, 110 DC Power Supply, Spark Igniter, Type-K Thermocouple

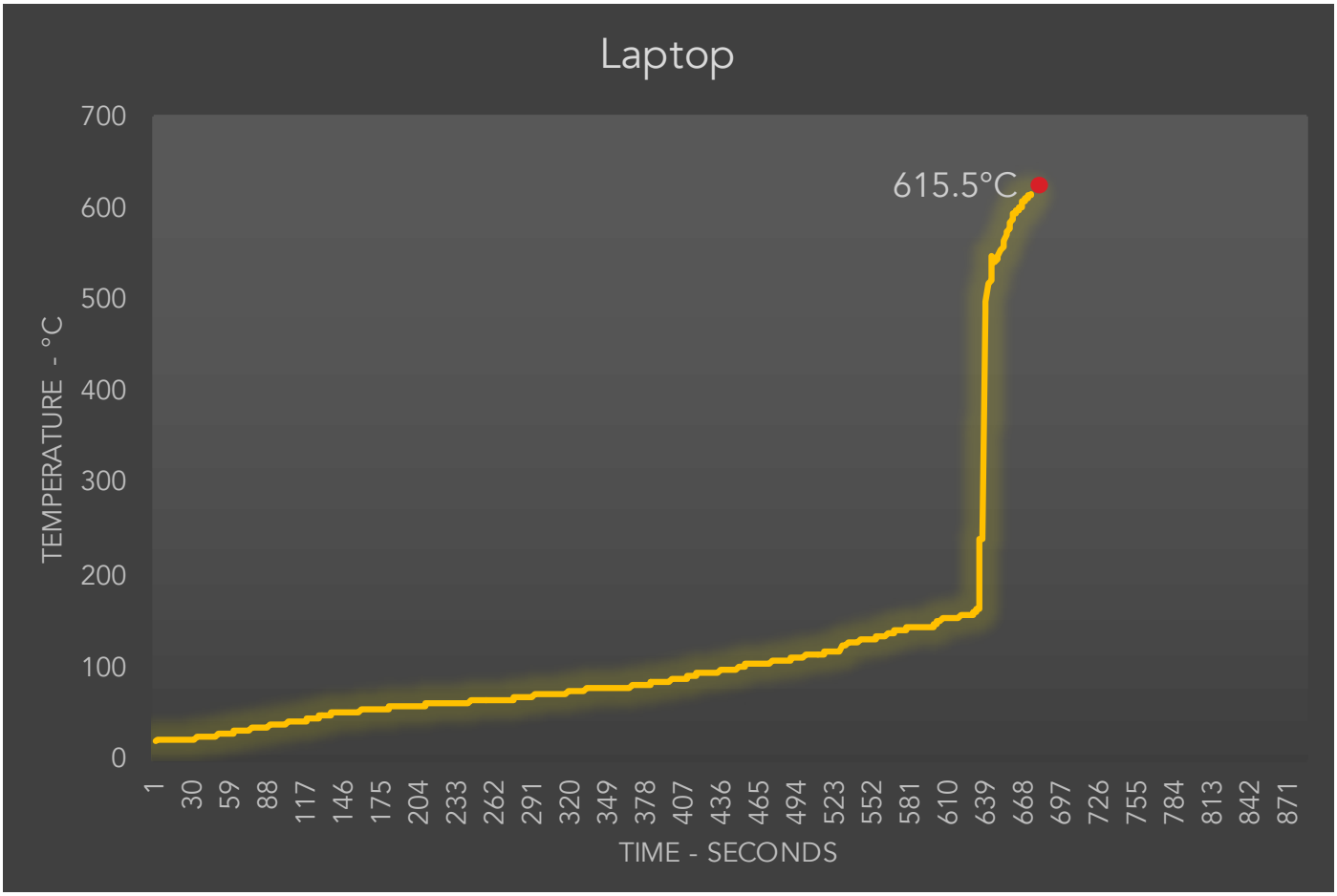
Procedure: Cell ignition was achieved by heating at a rate of 0.2°C/sec to vent and thermal runaway. Temperature was recorded every 1 second using a Type-K thermocouple

Results: The laptop went into thermal runaway at approximately 630 seconds. Smoke and flames were evident.

A PED-Pad fire suppression pillow and LIBIK blanket were applied to the laptop to begin extinguishing. The blanket was then used to bundle the device and device was placed into the LIBIK bag. The LIBIK was sealed per product recommendations.

PED-Pad fire suppression pillow and LIBIK fire blanket application.

Laptop transfer to LIBIK bag.



Thermocouple data

Thermal runaway was achieved at approximately 630 seconds

Maximum temperature reached 615.5°C

Thermocouple was dislodged upon placing the laptop in the LIBIK, at which point temperature data was lost