Aeroblaze Laboratory Inc.
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FLAMMABILITY TEST REPORT

TEST REPORT #1325.2R, Rev IR

HOT-STOP® 'L'

LITHIUM ION FIRE CONTAINMENT KIT

STORAGE BAG

Prepared for

INDUSTRIAL ENERGY PRODUCTS, INC.

56 Newcomer Rd, Mount Joy, PA 17552

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REVISION HISTORY

REV.	DESCRIPTION	Date	Approval
IR	Initial Release.	May 16, 2018	A. Feghali

The changes made in the most recent release/revision are indicated in the body of the document using a vertical bar in the right margin.

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1.0 INTRODUCTION

Lithium Ion battery powered electronic devices have been identified as in-flight fire hazards due to the potential battery malfunctions that can result in toxic smoke, violent fires, and explosions. These fires are difficult to contain inside an aircraft or in sensitive environments. To make matters worse, many smart phones and laptops are now waterproof – thus preventing water from reaching the cells of the battery.

The HOT-STOP® 'L' Fire Containment Kit is a well-known solution which has safely contained fires, explosions and toxic smoke emissions from Lithium Ion powered devices without the aid of a water supply. HOT-STOP® is a registered trademark of Industrial Energy Products, Inc.

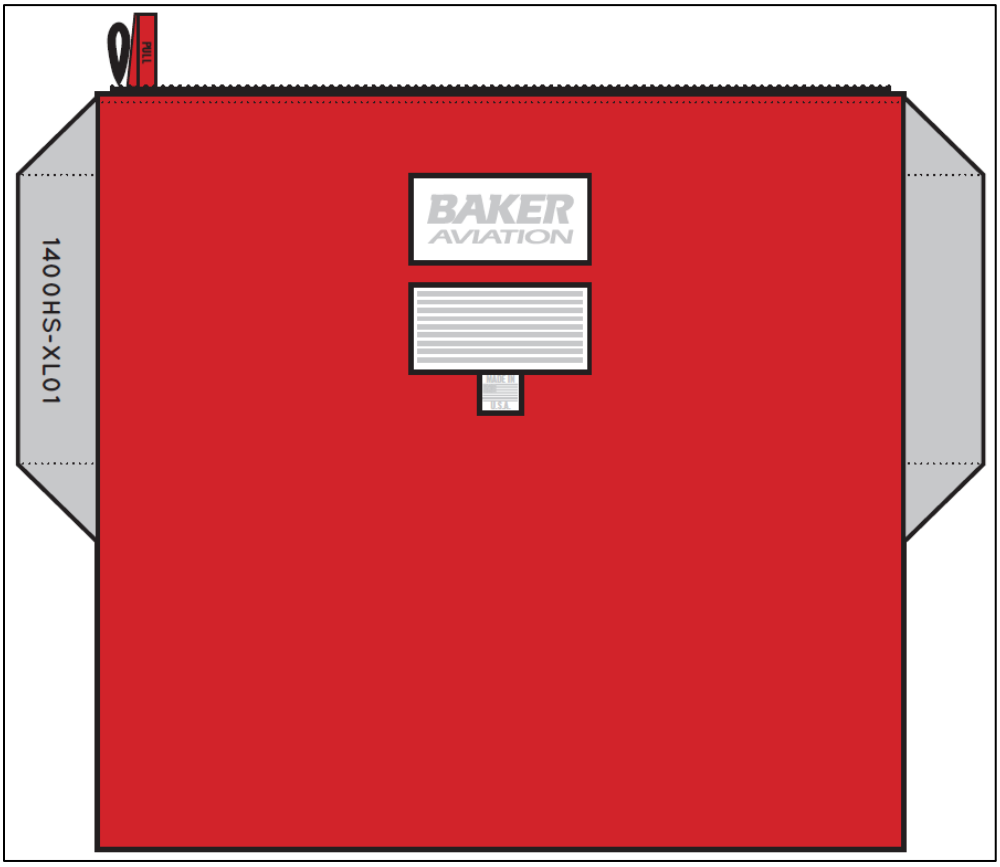

Figure 1 - Example of Containment Kit

To prove the effectiveness of the containment kit against newer, more powerful and waterproof devices, testing must be performed to show that the kit continues to contain battery explosions and subsequent fires.

2.0 SCOPE OF TESTING

Sample ID	Test	Device	Kit Size
01	Explosion & Fire Containment	Laptop (94 Wh)	EVO XL

3.0 TEST FACILITES

All testing was conducted at the following FAA-listed test laboratory:

Aeroblaze Laboratory
12819 Harmon Rd. #575
Fort Worth, TX 76177 USA

4.0 TESTING PROCEDURE

Warning

All testing was performed at an accredited flammability test laboratory. Technicians running theses tests are trained and wearing protective turnout gear. This gear was necessary because the lab was attempting to create the most catastrophic/severe conditions for testing the containment kit to illustrate a worst-case scenario. The manufacturer doesn't recommend anyone handling a device that is in active thermal runaway.

The device used for testing was a 12.1" laptop with a Li-Ion 94 Wh battery. The battery was comprised of 9 cylindrical cells. The device was charged to 100% battery prior to testing.

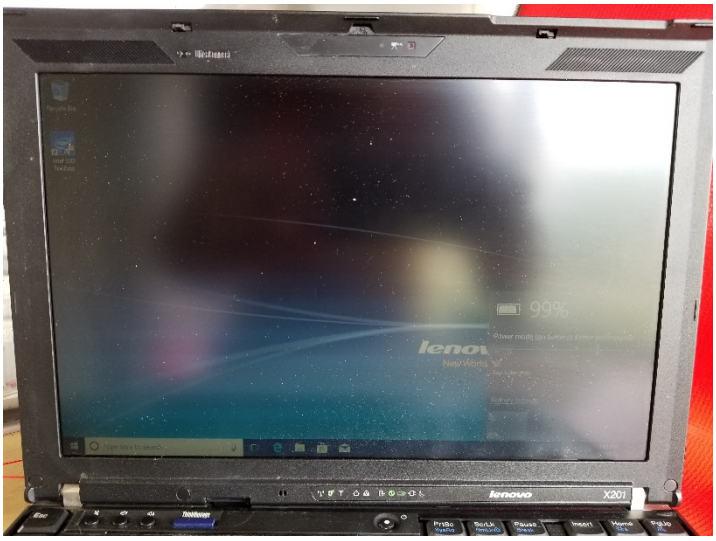

Figure 2. Tablet Device for Testing

The battery casing was opened to reveal the various cells. A film heater was placed on top of two cells and the casing was sealed.

Figure 3. Film Heater on Cells

Figure 4. Battery Closed Up

The battery was placed back into the laptop and the laptop was inserted into the containment kit. A voltage was applied to the heater to increase the temperature of the battery cells.

Figure 5. Laptop Inside Containment Kit

The temperature of the battery continued to increase for about four minutes until thermal runaway was initiated.

Figure 6, Initial Battery Ignition

The battery reached approximately 300 °F before igniting. Immediately after ignition, the recorded peak temperature was 2,932 °F. At this point, the wires to the battery were cut and the bag was sealed.

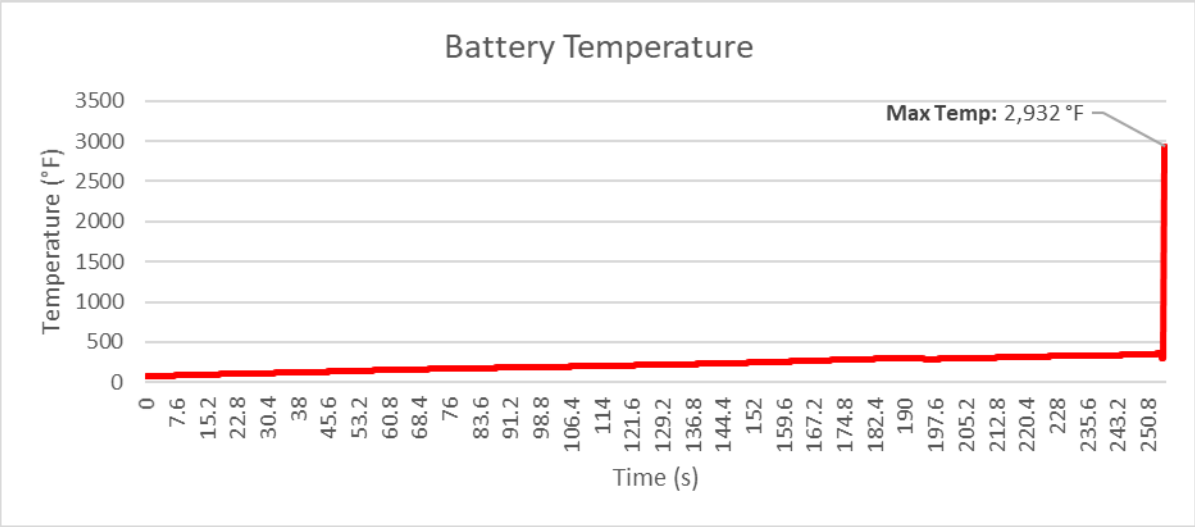

Figure 7. Graph of Battery Temperature

The containment kit consists of three levels of closures: an inner hook & loop seal, an inner zipper, and an outer zipper seal. Once the outer zipper was closed, the kit was left alone for observation for approximately 20 minutes. During that time, no further propagation of thermal runaway occurred, and no smoke was observed exiting the bag.

Figure 8. Kit Under Observation

When the bag was opened, it was determined that only one cell had experienced thermal runaway and no propagation to adjacent cells had occurred.

Figure 9. Battery Post-test

The bag was inspected, and only minor evidence of damage was found. The Storage Bag is comprised of an additional sub-liner material after the primary inner liner for added protection. The sub-liner had experienced minor damage. No damage was found to the primary inner liner.

Figure 10. Containment Kit Post-test

Since the kit was found to be in good condition, a second test was then run on the same laptop and bag. The battery casing was re-opened to reveal the remaining eight cells. A film heater was placed on top of two cells and the casing was sealed. The battery was placed back into the laptop.

Figure 11. Film Heater on Cells

Figure 12. Battery Closed Up

The laptop was inserted back into the containment kit. A voltage was applied to the heater to increase the temperature of the battery cells.

Figure 13. Laptop Inside Containment Kit

The temperature of the battery continued to increase for about eight minutes until thermal runaway was initiated.

Figure 14, Initial Battery Ignition

The battery reached approximately 330 °F before igniting. Immediately after ignition, the recorded peak temperature was 1,512 °F. At this point, the wires to the battery were cut and the bag was sealed.

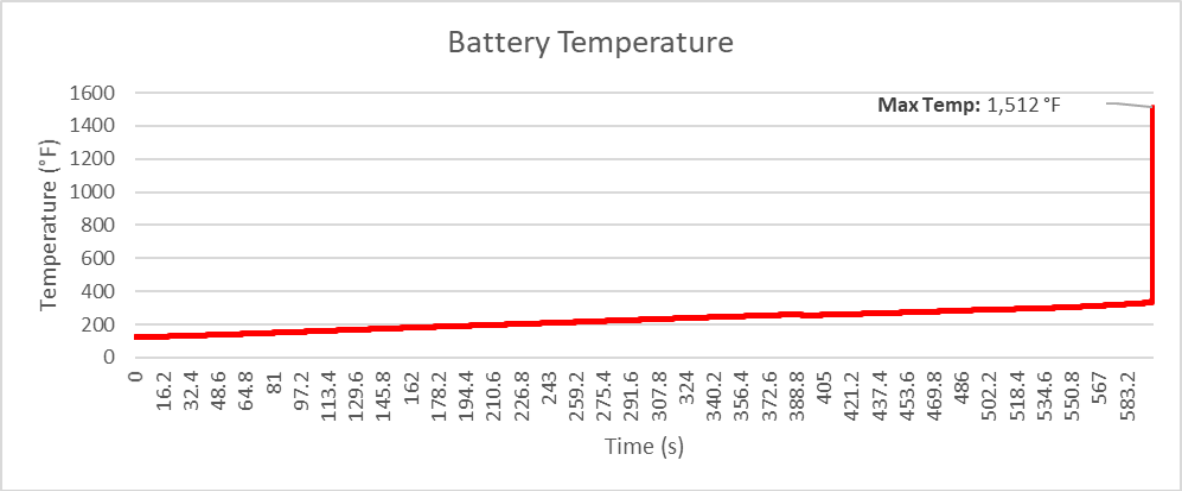

Figure 15. Graph of Battery Temperature

Once the outer zipper was closed, the kit was left alone for observation for approximately 20 minutes. During that time, no further propagation of thermal runaway occurred, and no smoke was observed exiting the bag.

Figure 16. Kit Under Observation

When the bag was opened, it was determined that again, only one cell had experienced thermal runaway and no propagation to adjacent cells had occurred. The bag was inspected, and no further evidence of damage was found.

Figure 17. Battery Post-test

Figure 18. Containment Kit Post-test

5.0 TEST RESULTS

The HOT-STOP® 'L' Fire Containment Kit successfully contained the thermal runaway and the resulting fire of the laptop in both tests.

Previous testing on Lithium Ion batteries resulted in propagation of the thermal runaway to adjacent cells. In both tests performed inside the storage bag, the thermal runaway was limited to the single cell triggered and no propagation occurred, suggesting that the HOT-STOP® 'L' Fire Containment Kit is suppressing the resulting fire and preventing propagation to adjacent cells.

No evidence of smoke was seen coming out of the kit after it was sealed in either test. Only minor damage to the inner-most liner of the bag was found after the first round of testing, and no additional damage after the second round of testing. The damage did not extend to the primary inner liner nor to the exterior of the bag.

Appendix A
Test Data Sheet

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Explosion & Fire Containment	TR# 1325.2

Customer Information	Sample Notes
INDUSTRIAL ENERGY PRODUCTS, INC. 56 NEWCOMER ROAD MOUNT JOY, PA 17552	Hot-Stop® 'L' Lithium Ion Fire Containment Kit Storage Kit

Sample	Kit Type	Burnthrough Observed? (Y/N)	Smoke Emission Observed? (Y/N)
1	Storage	No	No
2	Storage	No	No
3	-	-	-
4	-	-	-
5	-	-	-

Acceptance Criteria:	Result
The thermal runaway and subsequent fire may not burn through the containment kit.	[X] PASS [ ] FAIL

Notes & Observations:

Both tests:
1. Only one cell went into thermal runaway.
2. No damage to kit found at the end of testing.

Tested by: Leslie Gardner 24-Apr-18
Lab Engineer

Approval: Andrew Feghali 24-Apr-18
Andrew Feghali, Lab Manager

TP-01-01, Rev B

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