

AkroFire

# Shipment of Lithium Batteries: Threat Mitigation at the Package Level

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The statements contained herein are presented in good faith for general information only.

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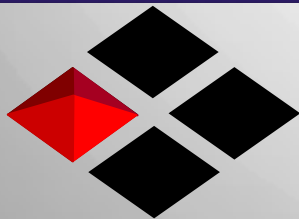
- AkroFire is a solutions-oriented engineering company specializing in fire and thermal management for the Aerospace Industry.
- Products and services cover OEM, Aftermarket and Defense.
- This expertise has led to the development of a wide range of products and services including repair products for aircraft maintenance, interior products, high temperature insulation systems, firewall and fire hard composites, and hazardous material packaging solutions.

# Background

PHSMA Rule HM224B defined performance parameters for the packaging of Oxygen Cylinders and Oxygen Generators:

- **Prevent Flame Penetration**  
(1700°F / 5min – pt.III.AppF.par(a)(3)/(f)(5) 14CFRpt25)
- **Prevent Ox cylinder/generator from reaching critical temperature in an environment of 400°F for 3 hours**  
(Critical temperature being the auto vent or ignition temperature)

In response to this Akro developed a range of 'Fire/Thermal Pack' technologies and together with Americase developed a complete range of HM224B packaging solutions.



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# Current HazMat Packing Challenge: Lithium Batteries

How can the 'HM224B' experience and technology developments be used to Mitigate the threat at the Package Level?

Existing concepts:

- Bespoke rigid containers
- Fire resisting over pack containers

DOT/FAA/AR-10/31

Air Traffic Organization  
NextGen & Operations Planning  
Office of Research and  
Technology Development  
Washington, DC 20591

**Fire Protection for the Shipment  
of Lithium Batteries in Aircraft  
Cargo Compartments**

Challenge is creating a packaging method that covers a broad spectrum of battery equipment and technologies and meets a global need including:

- Small applications (Small Quantity Shipments)
- Urgent Response Medical Equipment
- Prototype Equipment
- Damaged/ Defective Equipment
- Analytical Equipment



# Concept

Develop an 'overpack' method that utilizes a free-flowing, loose fill "Packing Nut" that following exposure to significant heat / fire forms a contiguous rigid protective barrier.

Key properties:

- Heat absorption
- Heat resistance
- High temperature stability
- Gap filling
- Versatility

allow the use of 'common' packaging that is in regular industry use

**i.e. standard HazMat boxes**



The testing parameters used for the development have been:

1. Protect batteries from external fire:

*Prevent the shipment from contributing to a fire*

2. Protect batteries from heat:

*Prevent the latent heat of a surrounding fire from initiating a thermal runaway*

3. Containment:

*Prevent a thermal runaway from adversely affecting adjacent shipments*

Various batteries have been used in the research however most frequently CR123 3v 1550mA.hr Primary Cells are used as they represent a conservative threat level:

Highly energetic

- Render more conservative testing when compared to Li-ion Secondary (rechargeable) cells
- *One C123 has a similar power capacity as a 'smart phone'*

The aim of the testing is to provide a threat level that is comparable to what industry needs to ship.



## Packaging Configuration

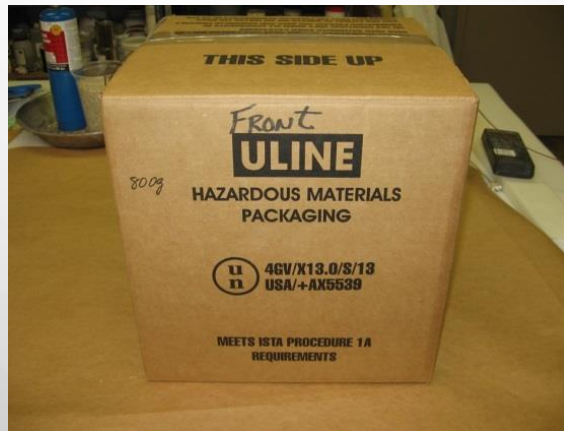
In all testing, a standardized packaging method has been used which utilizes an inner battery containing carton packed in an outer HazMat box. The inner space filled with the loose fill packing:



inner carton  
'OEM packaging'



Inner carton  
surrounded  
by loose fill packing.



Double-wall outer box  
taped shut.

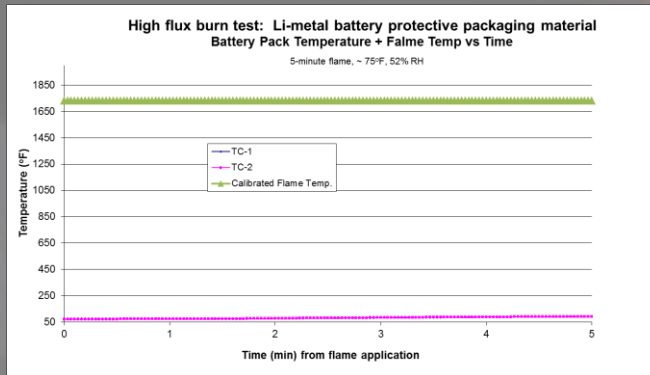


# Direct flame impingement

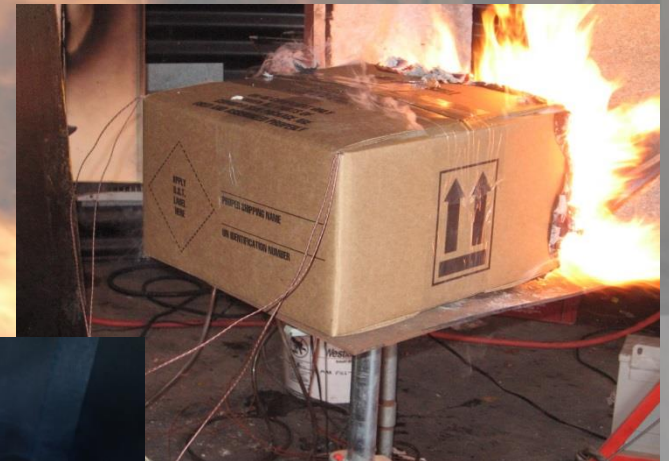
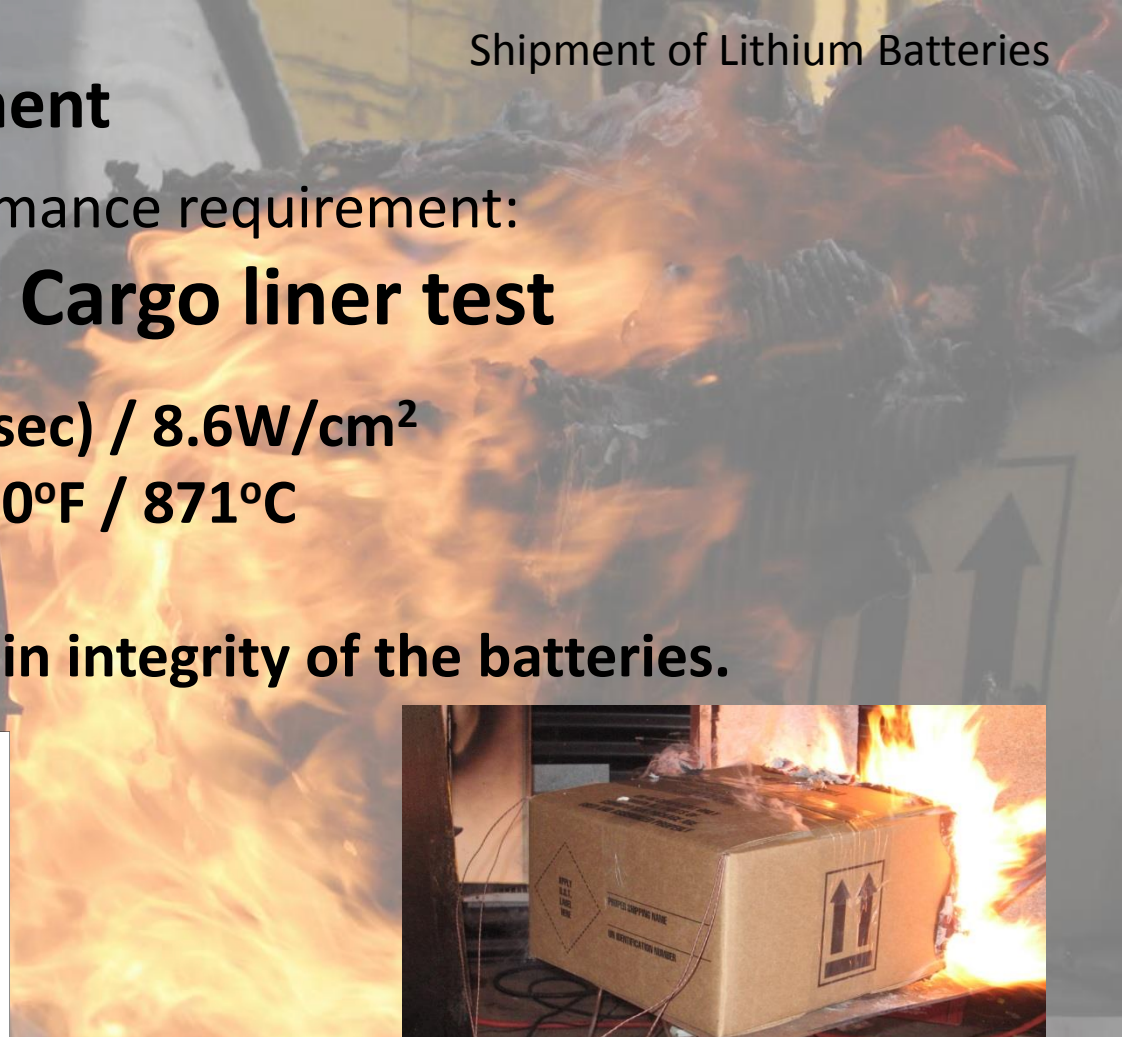
Industry recognized performance requirement:

## FAR 25.855 25 Cargo liner test

- Heat Flux:  $7.5 \text{ BTU}(\text{ft}^2\text{sec}) / 8.6 \text{ W}/\text{cm}^2$
- Flame Temp: min  $1600^\circ\text{F} / 871^\circ\text{C}$
- 5 min duration
- Pass criteria = maintain integrity of the batteries.



Maximum 'battery'  
temperature after 5  
min =  $92^\circ\text{F} / 33^\circ\text{C}$





# Direct Flame Impingement



# Suppressed Cargo Fire – Thermal Resistance Test

General parameters as per PHSMA Rule HM224B:

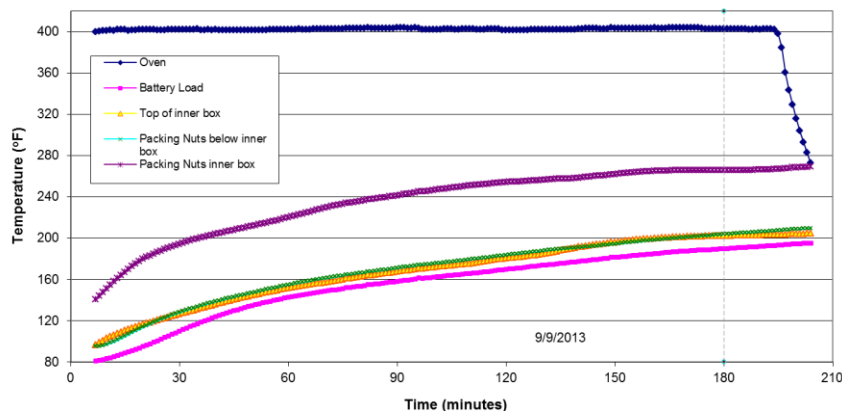
400°F / 204°C Environment for 3 hours (cargo compartment temp during a halon suppressed fire + aircraft diversion).

Pass criteria: prevent the batteries from reaching a thermal runaway initiation temperature.

- Lithium Metal: ~350°F
- Lithium-ion: ~ 450°F
- Lithium –polymer: ~ 330°F



400°F heat soak of simulated 100 CR123A cells protected in 14x14x7.6" box



8# CR123 cells  
open runaway





# Thermal Runaway

Testing:

Thermal runaway initiated with a 75watt cartridge heater inserted into the test group.

All cells are consumed- cascading thermal runaway

Stage 1:

**Volatile components vent from cell.** Resulting smoke or mist will ignite if there is air (oxygen) and a source of ignition.

Stage 2:

**Internal cell components mix to produce a violent exotherm**

High heat release in the cell, resulting in cell temperatures up to 2000°F and beyond; also sparks and flame jets.

Stage 3:

**Propagation to adjacent cells, resulting in increasing conflagration**

## Review: Performance evaluation of existing materials

Standard 'Packing' grade Vermiculite

100 cell screening test to determine comparative performance.



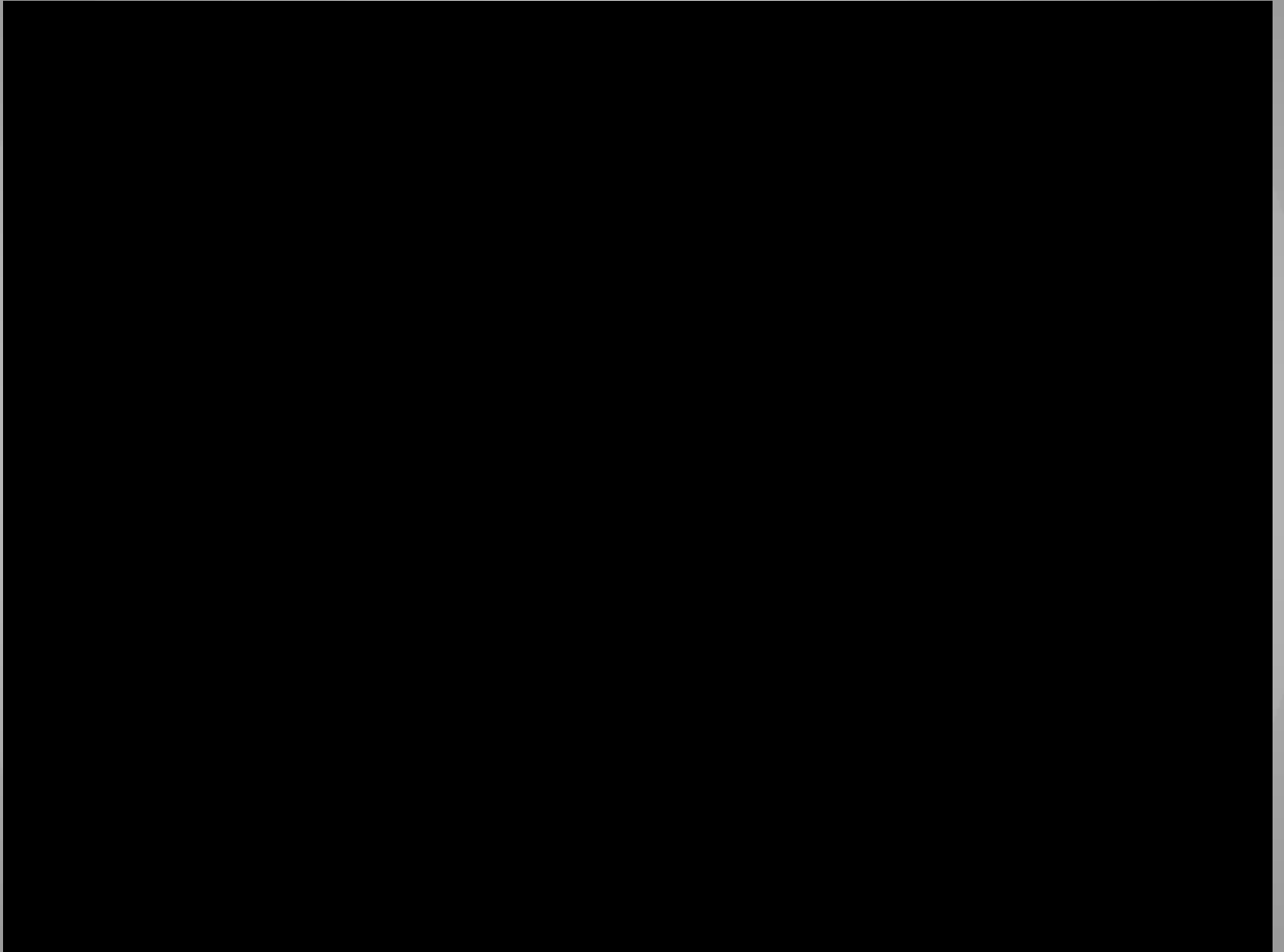
Inner carton  
surrounded by  
Vermiculite



Packing is forcibly  
expelled from the box

Outer packing burnt  
away leaving  
exposed batteries







# Thermal Runaway

Up to 300 Cells have been tested - 100 cells used for ongoing screening.



Inner Carton



Loose Fill



Post Test

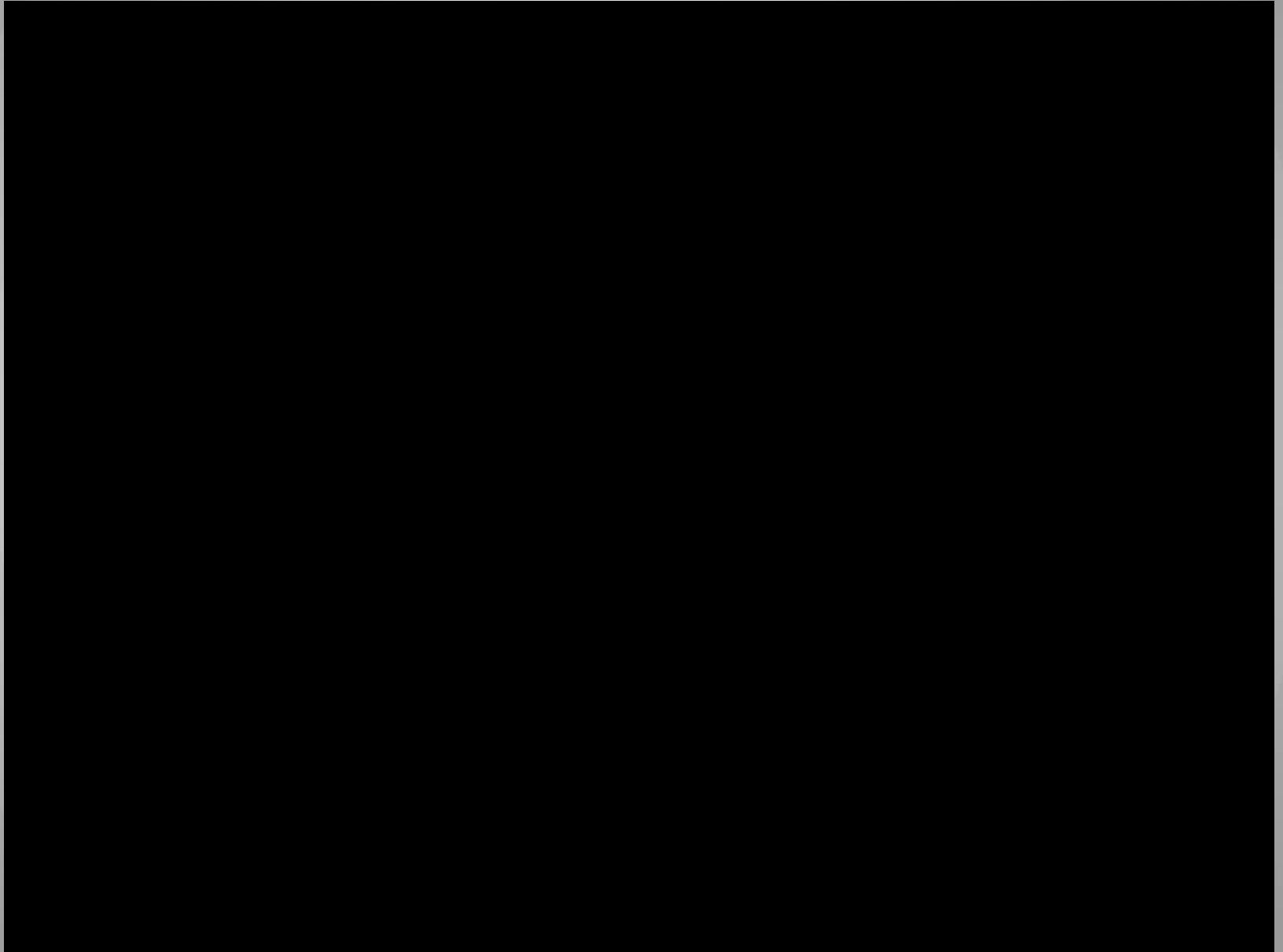


Loose Fill Beneath Lid



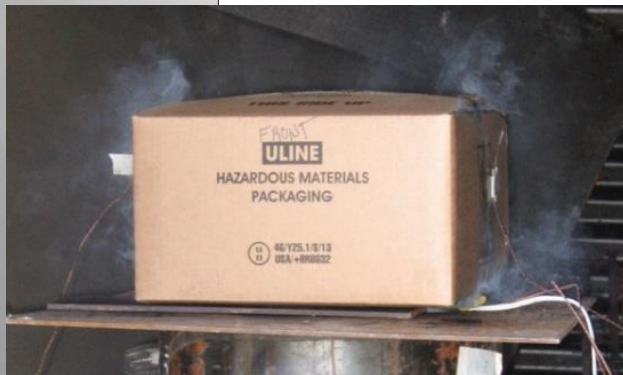
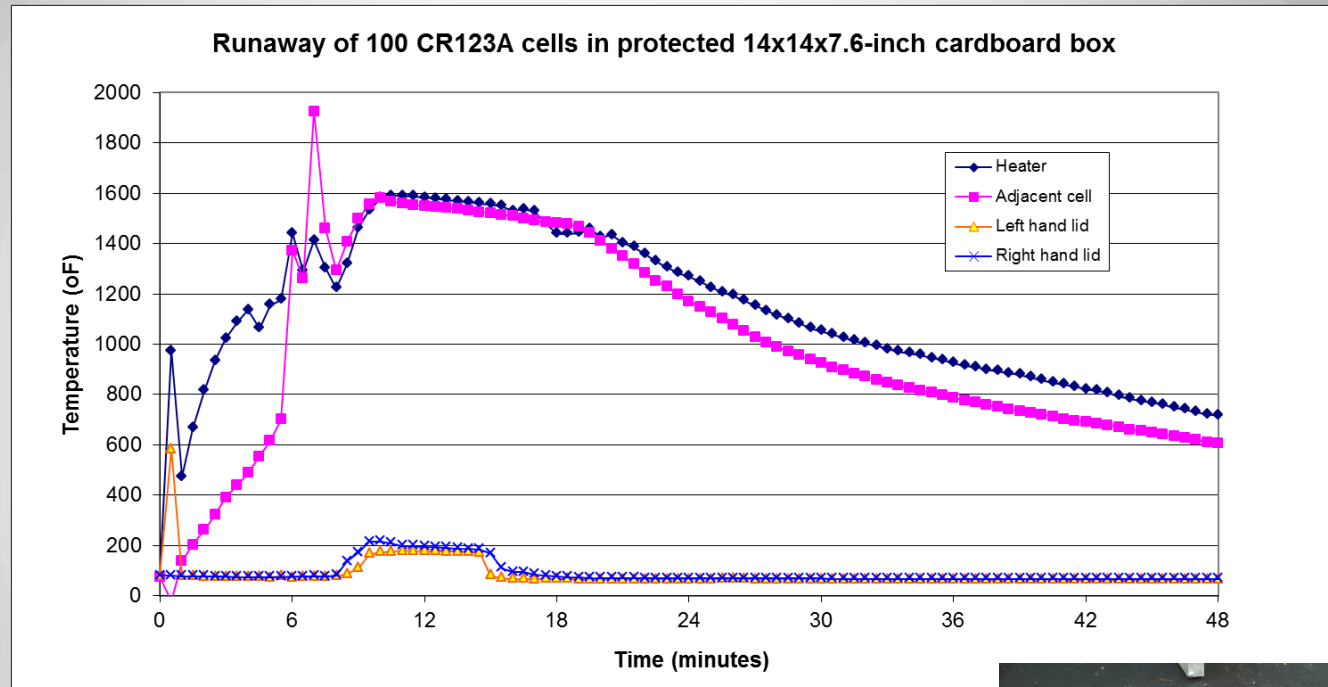
Cell Remains

# Thermal Runaway



# Thermal runaway

All cells are consumed through a cascading thermal runaway





# Summary of Available Options

Proven Lithium Battery Packaging Solutions that provide an appropriate level of safety are available for use in transportation:

From the package level:

- **Aluminum SuperBox, Thermally Insulated, Battery Shipper**
- **Fiberboard Box, Thermally Insulated, Battery Shipper**
- **AkroFire Loose Fill, Thermal “Packing Nut” Media**



# Conclusion

The loose fill concept provides a practical, economical and flexible method of enhancing the safety of lithium battery / equipment shipments.

Broader logistics will likely dictate the type of packaging i.e *re-usable* vs. *single use*.

These packaging methodologies supported by testing provide practical and effective options for the shipment Lithium battery / equipment

**Threat Mitigation at the Package Level is an important element to a multi faceted approach to the safety in shipment issues surrounding lithium batteries.**



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