Unique Risks to Large-Format Lithium Batteries

Research and Development Forum

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PHMSA

Research on Large Format Lithium Batteries

Purpose

- Enhance risk reduction during transportation of cells and batteries.
- Investigate Manufacturer's Compliance Concerns so that Compliance can be ensured.

- IAA with Navy Surface Warfare Center

Current Expected Program Outcomes

1. Develop criteria and methods for conducting tests on large format battery designs.
2. Improve conditions to manage the hazard associated with the air transport of large format batteries.
3. Develop a standardized method for conducting a forensic analysis on a failed lithium battery or lithium battery powered equipment.
4. Improve criteria and safety provisions specific to the transport of large format lithium batteries, including prototype lithium batteries.
5. Identify risks and determine effective, safe and practical methods of transporting pallet loads of batteries.

Applications of Large Lithium Batteries

1. Automotive Batteries
2. Commercial Aviation
3. Military Applications
4. Continuous Power Supply Systems

Ongoing Research Initiatives at NSWC

- Define objectives of research – approach & time frame
- Tests of Large Format Cells and Batteries
- Appropriateness of weight limits on aircraft – BMS, construction, State of Charge, Packaging
- Battery Forensic Analysis- New Lithium Battery; Failed Lithium Battery
- Develop standard criteria & safety provisions specific to prototype large format batteries.
- Examine alternate packaging methods, configurations, conditions to prevent thermal runaway and mitigate fires.
- Conduct a capability case study for fire forensics & casualties.
- Develop ways to mitigate Internal Short Circuiting (not funded at present)

Tests of Large Format Cells and Batteries

Goal: Generate test conditions indicative of transport or reasonable abuse conditions.

Achievements and products to date:

- Study revealed that the present shock test parameters may not be representative of abuse conditions during transportation.
- Experiments showed that the critical factors in the shock test is the weight of the battery, its height of drop and , the type of surface on which the battery is dropped.
- Study revealed that the most severe shocks occur during mishandling scenarios such as accidental drops.

Expected outcomes:

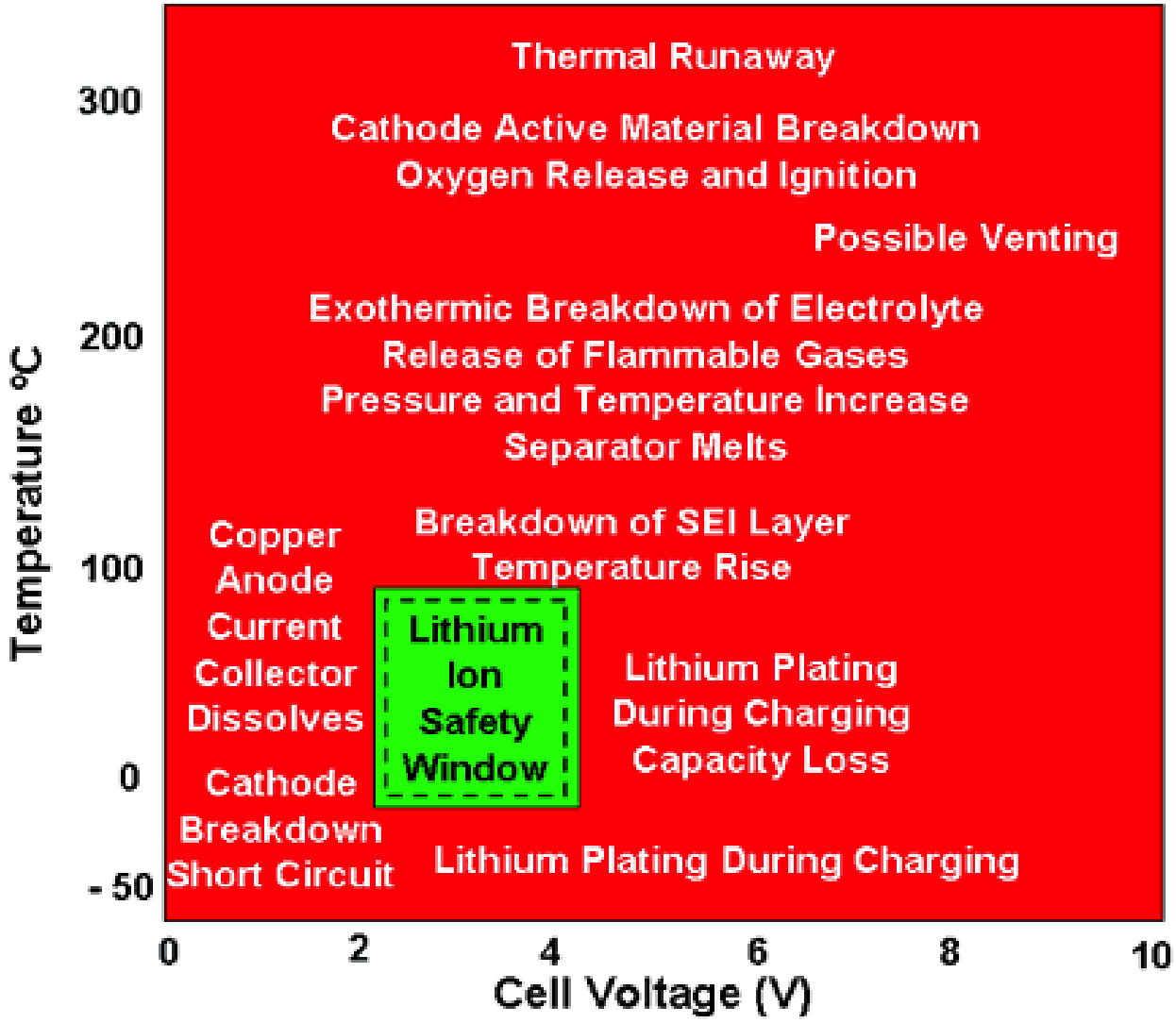
- Identify findings of a shock test on large format batteries.
- Identify the comparative risk at 50 g_n versus lower or higher acceleration.
- Identify additional actions for future investigation.

UN Manual of Tests and Criteria

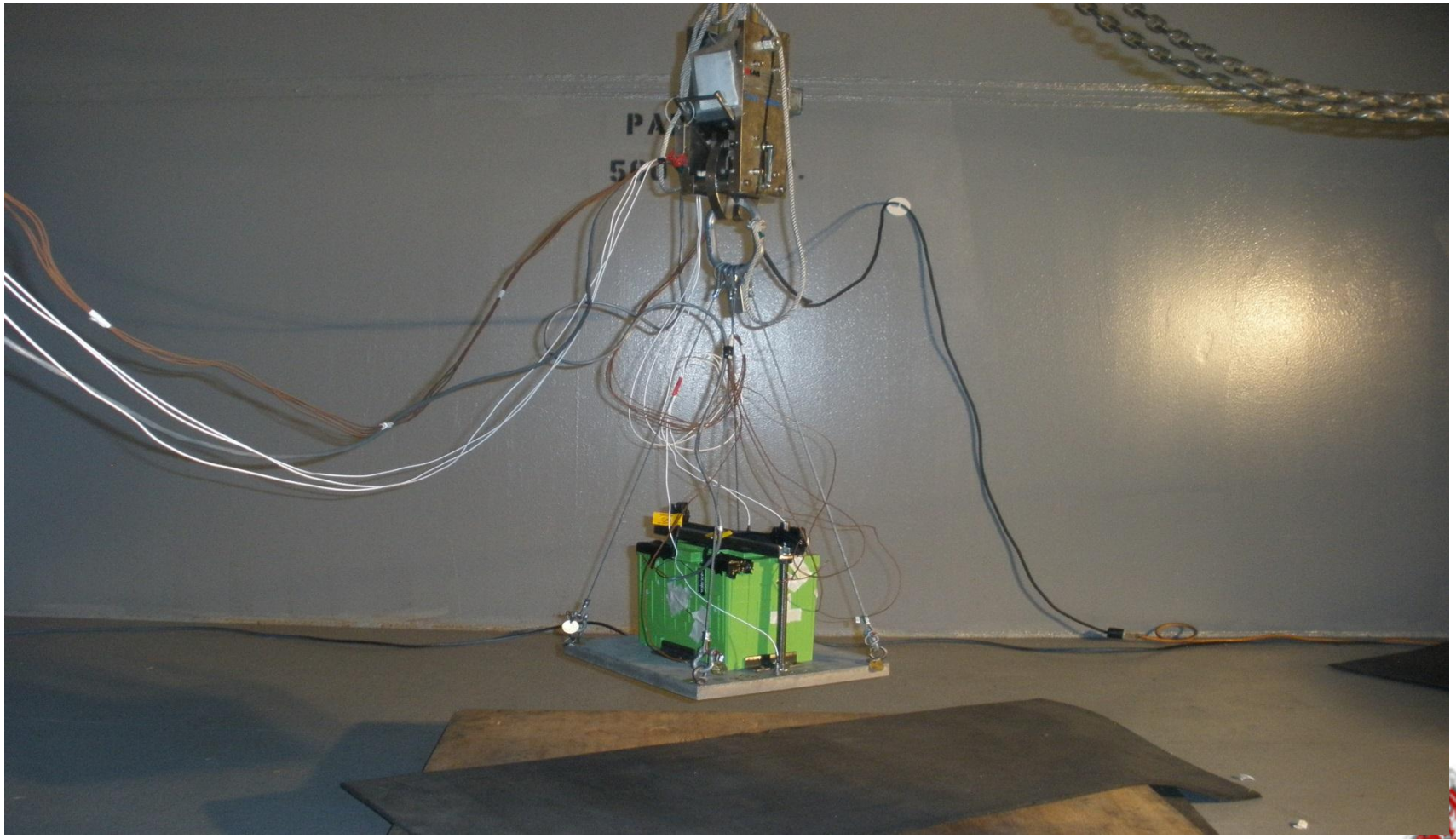
1. Altitude Simulation
2. Thermal test
3. Vibration
4. Shock
5. External short circuit
6. Impact
7. Overcharge
8. Forced discharge

Passing criteria: No fire, no rupture, no disassembly, no venting, no leakage, no mass loss

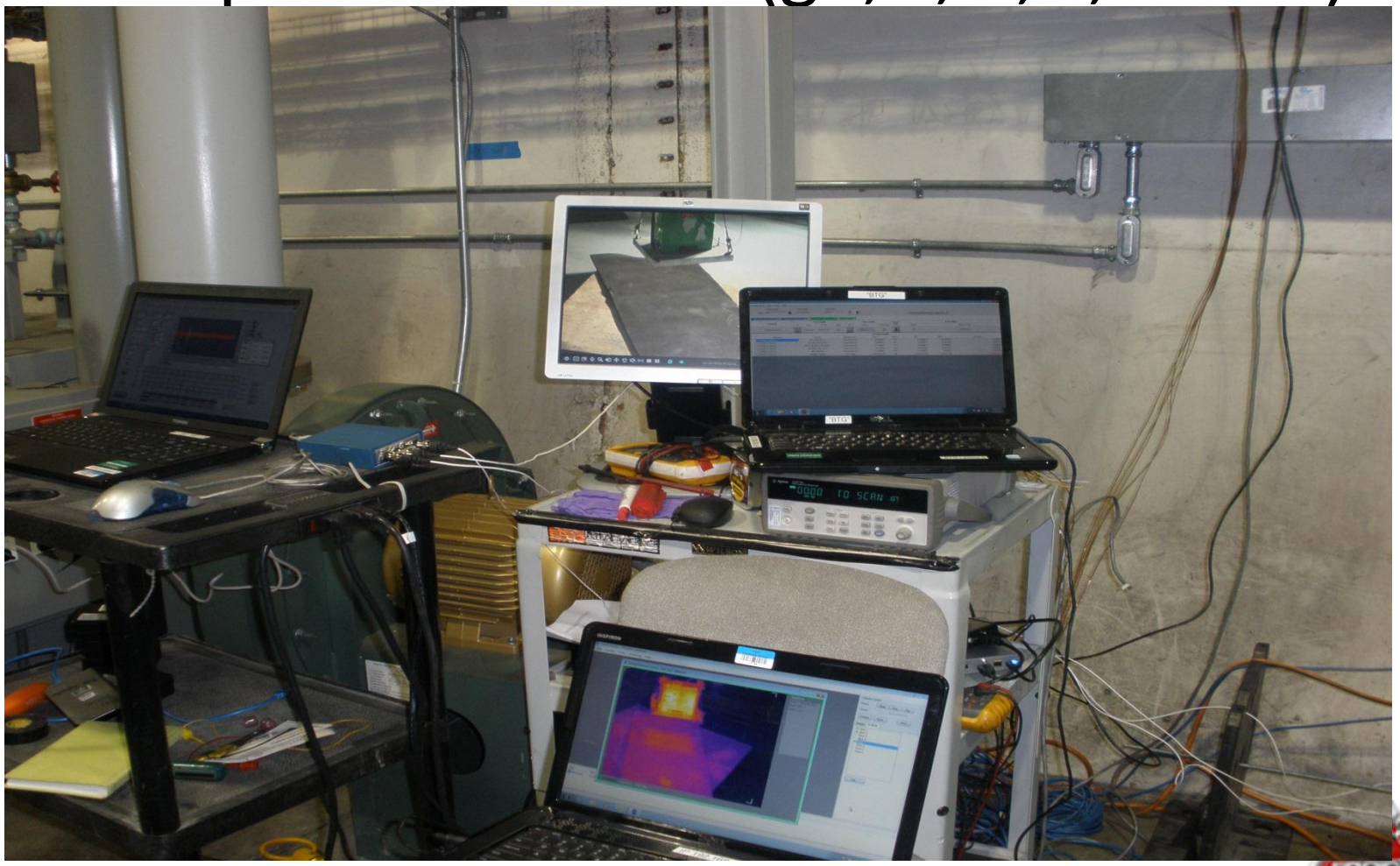
Lithium Ion Cell Operating Window



Experimental Set-up 12/20/2013



Computer Monitors (gn, T, V, T, visual)



Appropriateness of weight limits on aircraft – BMS, construction, State of Charge, Packaging

- Goal: Identify appropriate conditions to manage hazard exceeding 35 kg on aircraft.
- Expected outcomes:
  - Determine the extent to which the mass limitations impede the ability to transport large format batteries.
  - Determine how other factors enhance the overall safety of a large format battery.
  - Recommend appropriate mass limits for lithium batteries.

Battery Forensic Analysis - New Lithium Battery; Failed Lithium Battery

- Goal: Develop a standardized method for conducting a forensic analysis on a failed lithium battery.
- Expected outcomes:
  - Component traceability
  - UN test reports and packaging
  - Events prior to incident
  - Damage pattern
  - Failure Mode & Effect Analysis
  - X-ray

Develop standard criteria & safety provisions specific to prototype large format batteries

- Goal: Evaluate design type testing and transport practices for prototype large format lithium batteries.
- Expected outcomes:

  - Examine existing CA approvals specific to prototypes.

  - Identify specific provisions or alternative testing schemes that achieve an equivalent level of safety.

  - Outline minimum standard criteria and provisions for transportation of large prototype batteries.

Examine alternate packing methods, configurations, conditions to prevent thermal runaway and mitigate fires

- Goal: Evaluate the ability of fire suppression agents capable of suppressing open flames and halt thermal runaway within a shipment.
- Expected outcomes:

  - Address quantity limits to be considered when large quantities of lithium batteries are transported.

  - Evaluate risks associated with large quantities of closely packed lithium batteries such as palletized loads.

  - Recommend alternative methods on mitigating risks with large quantity shipments.

Identify the need for fire forensics & casualty expertise and show a case study example

- Goal: Evaluate the root cause of battery failures and fires if needed.
- Expected outcomes:
  - Provide fire safety and root cause analysis of battery failures and fires.
  - Provide fire forensic activity and analysis.

Future R & D Initiatives on Large Batteries

- Lithium Metal & Ion Cells and Batteries
- UN Manual of Tests and Criteria
- Safety Controls
- Packaging
- Hazard Communication
- Lithium cells and batteries packed with equipment
- Lithium cells and batteries contained in equipment
- Large batteries

Future R & D Initiatives on Large Batteries

- Study the effectiveness of different packaging materials at minimizing propagation
- Investigate the use of hydrofluorinated, low dielectric constant and low boiling point fluids as a suppressant for bulk transport of battery packs
- Investigate failure and forensic analysis of batteries