Battling Lithium-Ion Battery Fires: Uniting for a Safer Future

Seizing the Opportunity to Confront a Global Challenge

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Questions Presented

1. What do we see going on in the market currently for our respective standpoints (the problem)?

2. How may we move towards finding solutions to the issue(s)?

3. Are there opportunities for global collaboration to implement solutions?

4. What are the obstacles to these solutions?
Increasing use of and reliance on lithium-ion batteries in all aspects of our lives.
# Battery Breakdown

- Scale and consequences
- Causes – why and how Lithium-ion batteries fail
- Recommendations for tackling the issue.
Consequences
Causes of Thermal Runaway

Three main external conditions can contribute to battery failure:

I. **Electrical:**
   - ever charge or over-discharge – incompatibility between battery and charger, faulty/sub-standard battery management system (BMS)
   - external or internal short-circuit e.g. water ingress

II. **Mechanical:**
   - triggered by crushing or penetration with an external object
   - caused by extreme or repeated impact, such as striking a kerbstone

III. **Thermal:**
   - extreme high and low temperature environments
Other causal factors

- Universal and substandard chargers
- Conversion kits with 1000W motors
- DIY and modification videos
Lithium-ion Battery Fires

James Frake, PhD, CPhys

Managing Scientist
Common Causes of Battery Failure (Field Failure Experience)

- Common causes of thermal runaway failure in e-mobility battery packs include:
  - Mechanical damage or abuse
  - Poor quality / counterfeit or aftermarket batteries and chargers
  - Moisture Ingress
  - Cell, battery and electrical faults
  - All, or combinations, of the above
Battery Failure Causes

- Thermal
- Software / Firmware
- Usability / Human Factors
- Cell Engineering
- Electrical
- Mechanical

Photograph: National Transportation Safety Board

https://commons.wikimedia.org/wiki/File:Li-ion_battery_explosion.jpg

https://www.wellpcb.com/wp-content/uploads/2022/03/324.jpg
Case Study – Poor Quality Battery Issues on E-Bike

- Poor quality finishes
- Damaged / poor quality wiring
- Damaged / poorly assembled or faulty protection electronics
- Uncontrolled processes
- Insufficiently rated / generic connectors
- Lack of / insufficient waterproofing
- Limited protection against propagating faults
Battery Thermal Failures

https://www.bbc.co.uk/news/uk-england-london-63036417
Case Study: Swollen Cell Gas Analysis

<table>
<thead>
<tr>
<th>Gas</th>
<th>Aged at 60 °C for 18 Days at 4.35 V</th>
<th>Field Returned Swollen Cell</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon Dioxide</td>
<td>90.0</td>
<td>76.0</td>
</tr>
<tr>
<td>Carbon Monoxide</td>
<td>0.1</td>
<td>0.5</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>N/D</td>
<td>2.4</td>
</tr>
<tr>
<td>Methane</td>
<td>3.6</td>
<td>7.5</td>
</tr>
<tr>
<td>Ethylene</td>
<td>2.7</td>
<td>1.5</td>
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<tr>
<td>Ethane</td>
<td>2.6</td>
<td>11.2</td>
</tr>
<tr>
<td>Total other VOCs</td>
<td>0.8</td>
<td>1.0</td>
</tr>
</tbody>
</table>
Case Study – Picking a Cell from a Manufacturer

5 different commercial battery cells (18650 format).

Same internal construction, similar specification and same cycling conditions.
Current sources of short-term relief:
- Regional / State / Province
- City / Town
- University
- Building
- Insurer
- Employer
- Individuals / Associations
CONCLUSION

Questions?

Martyn Allen | Technical Director | Electrical Safety First

James Frake | Managing Scientist | Exponent

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