A leading engineering & scientific consulting firm dedicated to helping our clients solve their technical problems.
Lithium Ion Batteries: Assessment and Investigation

• Introduction

• Part 1: Developing a company specific product safety evaluation process
  – Presented by Jan Swart

• Part 2: Determining the cause of a battery failure
  – Presented by Celina Mikolajczak, P.E.
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Part 2: Determining the cause of a battery failure
A Scientific Methodology for Investigation of a Lithium Ion Product Failure

- Lithium-ion batteries, on occasion, fail in a manner that includes:
  - Overheating
  - Case rupture
  - Combustion
A Scientific Methodology for Investigation of a Lithium Ion Product Failure

How can the causes of these failures be identified?
Fault Tree

Severe Battery Failure

- External Mechanical Damage
- External Thermal Damage
- Overcharge
- External Short Circuit
- Internal Short Circuit

Most Battery Failures

- Vent
- Flaming Vent
- Uncontrolled Vent
Case Study: Notebook Computer Battery Failure with 18650 Li-Ion Cells
Step 1 – Photograph System
Incident System
Failed Battery Pack

C1
C2
C3
C4
Step 2 – X-Ray Pack and Cells
Likely Fault Propagation Sequence

C1

C2

C3

C4
Cell C3 X-Ray Detail
Step 3 – CT Scan Cells
CT Scan

Scan 0

Scan 900

Scan 866

Scan 387

Scan 191
Cell C3 CT Scan Detail

Scan 936

Scan 957
Step 4 – Examine Production Cells

Now that we know the fault location, we need to find the source.
Particle Contamination on Top of Cell Windings
Possible Source: Burrs on CID
Partially Detached CID Burr

This burr is approximately 330 µm long and is barely attached to the CID.
Particle Contamination on Top of Cell Windings
Step 5 – Statistical Analysis

Now that we know the problem, we need to find out what production time frames are affected
Statistical Analysis

Distribution of Cell Failures by Time

Expected Number of Failures per Million Cells

Time in Service (months)

- □ Pre-April
- △ Post-April
Summary - Internal Cell Fault Investigation

- Determine the initiating cell
  - Visual examination (photography, microscopy)
  - X-rays of cells

- Determine the location of the initiating fault within the cell
  - X-rays and CT scans

- Examine production cells for clues to processes that may have contributed to the fault

- Statistical analysis
  - Estimate rates or counts of incidents over the life of the product
  - Identify production lots potentially susceptible to the fault