Lithium Battery Update

The Effect of State of Charge On Flammability and Propagation of Thermal Runaway

Presented to: Systems Working Group
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The Effect of State of Charge On Flammability

• Groups of rechargeable lithium-ion 18650 cells were tested in two modes.
  - Heated using an external alcohol flame
    • 7 cells wired together
  - Cone calorimeter
    • 5 separate tests with 1 cell at each charge, 20%, 30%, 50%, 70%, 100%
      - heat flux of 50 kw/m²
The Effect of State of Charge On Flammability
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• Results: Heated Using External Flame
  – 100% Charge: produced flammable electrolyte, large pressure pulse, strong torching fire, sparks, vent 4:00 minutes, ignition of electrolyte 4:28
  – 50% Charge: produced flammable electrolyte, large pressure pulse, vent 3:46 minutes, ignition of electrolyte 4:56 minutes
  – 30% Charged: produced flammable electrolyte, small pressure pulse, vent 3:39 minutes, ignition of electrolyte 5:07 minutes
Peak Heat Release Rates For Different Charges

![Bar Chart](chart.png)
Cone-Calorimeter 100% charged Test
Cone-Calorimeter 30% Charged Test

![Image of burnt cylindrical objects on aluminum foil background]
Effect of State of Charge On Flammability – 100%
The Effect of State of Charge On The Propagation of Thermal Runaway

• Tests were designed to measure the effect of state of charge on the propagation of thermal runaway
  - 4 cells were wired together in line
  - A 100 Watt Cartridge Heater was secured to the first battery as the heat source
The Effect of State of Charge On The Propagation of Thermal Runaway

- A series of 5 tests were conducted; 100%, 50%, 40%, 30%, 20% charge

- 5 thermocouples (one for the heater and one for each corresponding battery) recorded the temperatures
Propagation Test Configuration
Propagation Test Data

Graphs showing test data for 1860 Prop at 100% on two different dates: 3/19/2012 and 3/30/2012.
Propagation Test Data

[Graphs showing propagation test data for different charge levels]
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• Results
  – 100% Battery exploded in both tests, rapid cooling was observed. Peak temperature: 1030°F
  – 50% test consumed all cells. Peak temperature: 1044°F
  – 40% 2 cells were consumed, peak temperature 760°F decreased after thermal runaway in cell 2.
  – 30% venting occurred in battery 1 with no thermal runaway. Peak temperature: 560°F
  – 20% venting occurred with a peak temperature 502°F
The Effect of State of Charge On The Propagation of Thermal Runaway

• Conclusions
  – 50% charge produces the greatest possibility of thermal runaway propagation
  – 30% or less charge halts the propagation of thermal runaway
  – Heat release values decrease with reduced states of charge
  – Shipping cells at less than 50% state of charge may reduce the severity of a fire event
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