Compliance challenges for lithium-ion systems with high energy density
Saft container evolution

- No cell-to-cell propagation in earlier designs
  - Single-stage FSS adequate

- Higher energy of latest design presents propagation challenges
  - Two-stage FSS needed

2012 - 0.6 MWh

2015 - 1.0 MWh

2020 - 2.5 MWh

Compliance challenges for high-energy-density systems
SUPPRESSANTS AND RESULTS
Investigated suppressants

Configurations

Stat-X

Novec 1230
NOVEC 1230 block-level results

Minimal Propagation
Potassium carbonate result

Minimal Propagation

Compliance challenges for high-energy-density systems
FULL SCALE RESULTS
System-level NOVEC and Stat X

155 KWh of High Density NMC Lithium Ion Batteries
The aftermath

All Modules Eventually Lost

Compliance challenges for high-energy-density systems
WATER APPROACH - SECONDARY SYSTEM
Ceiling-mounted sprinklers have limited effectiveness

Directed spray at module level much more effective

No module-to-module propagation

Getting water to the source
Comparative temperatures vs. time

Water Provides Much Better Heat Absorption
No module-to-module propagation

Solution at a Price?

Compliance challenges for high-energy-density systems
Other safety measures

- Deflagration panels
  - Mitigating thermal runaway without fire
  - Avoiding propagation between containers
  - The power of hydrogen...

- Gas/electrolyte sensing with remote annunciation
  - Making it safe for first responders
FUTURE WORK
Future work

- Investigate approaches for passive safety at module level
  - Reduce FSS cost
  - Decrease container spacing
  - Must be done while meeting application needs

- Chemistry options
  - Safer chemistries with high energy density (e.g. LMFP)
  - Safer electrolytes
  - Solid-state chemistry
Questions?

Thank you

Merci
Vielen Dank
תודה, תודה!
謝謝
Tack

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