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Lithium-Ion Battery Fire Hazards: Understanding Thermal Runaway

Office of Nuclear Regulatory Research
(RES)



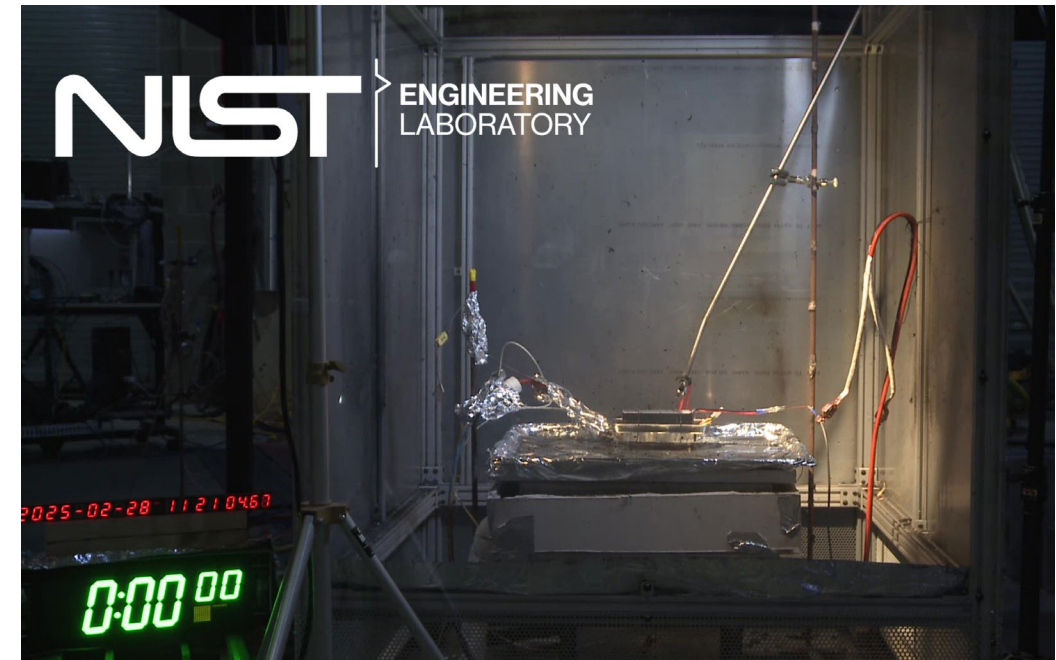
Existing and Future Potential Uses of Lithium-Ion Batteries

- Current uses
 - Emergency lighting (10 CFR 50.48—Appendix R III.J)
 - Digital instrumentation and controls
 - Mobile diagnostic carts (including fire-watch carts)
 - Fork trucks
- Future uses
 - Station batteries
 - Backup emergency power
 - Battery energy storage systems (BESS)



What Is Thermal Runaway?

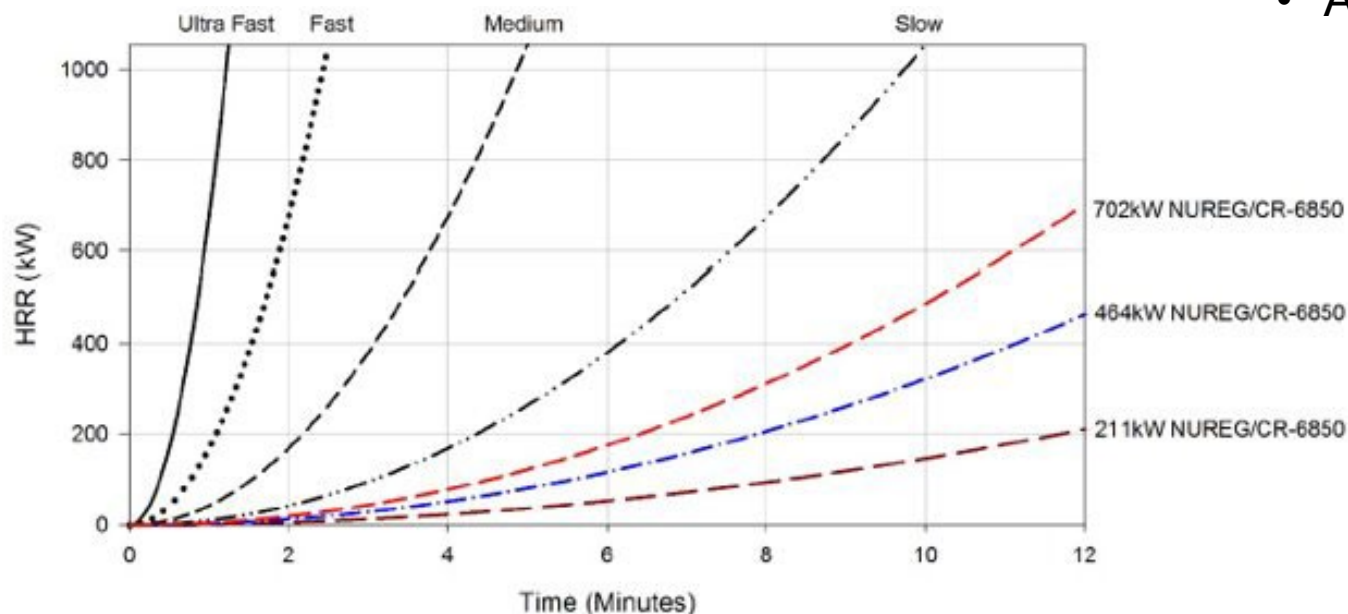
- Self-sustaining chain reaction—typical extinguishing methods (i.e., water) are not effective
- Internal heat can rapidly escalate
- Can result in—
 - The release of flammable gases and lead to a fire and/or explosion
- Trigger mechanisms are often due to—
 - Damage (puncturing)
 - Overcharging
 - Short circuiting
 - External heating



NIST experimental setup

Understanding the Hazard

- Peak heat release rate (HRR)
- Growth rate
- Fire ignition frequency



Approach

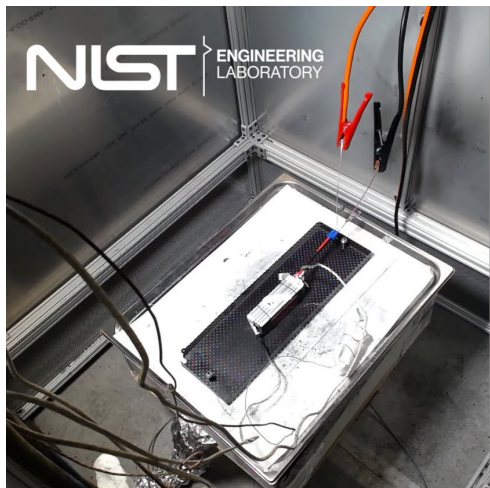
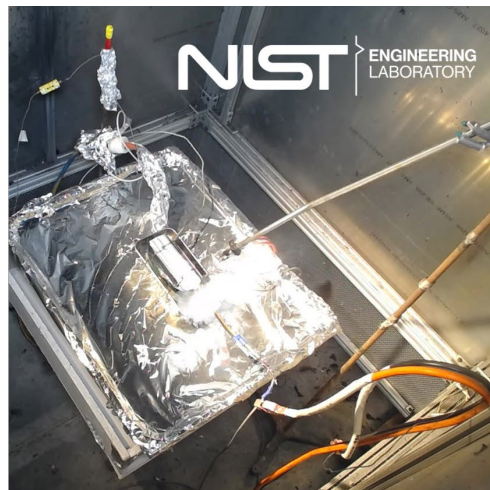
- Literature review
- Operating experience review
- Experiments
- Application of information to characterize hazard
 - HRR profile
 - Development of generic ignition frequency
 - Suppression curves



Form Factors	Chemistries
Cylindrical	Lithium-Nickel-Cobalt Aluminum (NCA)
Prismatic	Lithium-Nickel-Manganese-Cobalt (NMC)
Pouch	Lithium-Iron Phosphate (LPO)

- Lithium-ion battery fires are expected to be different from traditional fires
- Experiments will help determine whether existing fire growth profiles can be used or new curves developed
- Growth, steady-state, and decay stages are important for probabilistic risk assessment (PRA) realism
- Experiments are in collaboration with the Electric Power Research Institute (EPRI) and National Institute of Standards and Technology (NIST)





Overcharging

- Thermal runaway in lithium-ion batteries is a self-sustaining reaction that can lead to a fire and sometimes explosion of the battery
- Current and future uses of lithium-ion battery make this a fire research topic of interest:
 - Mobile diagnostic carts (including fire-watch carts)
 - BESS
- The goal is to characterize the HRR profiles, ignition frequency, and suppression curves for different types of lithium-ion batteries
 - Form factors: cylindrical, prismatic, pouch
 - Chemistries: NCA, NMC, LPO
- Next steps include—
 - Experiments in partnership with EPRI and NIST
 - Enhance PRA realism for lithium-ion battery fires