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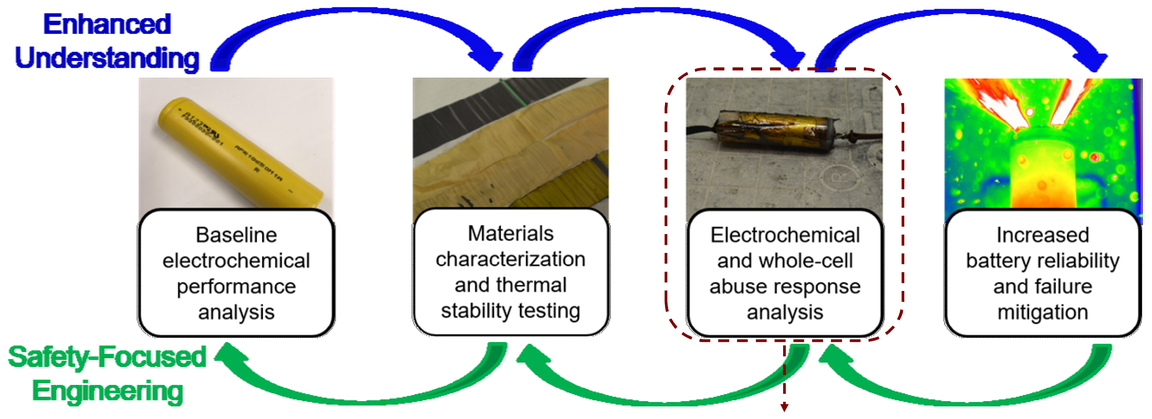
SNL Energy Storage Technology and Systems – Energy Storage Safety
Funded by Dr. Imre Gyuk
U.S. Department of Energy; Office of Electricity; Energy Storage Systems Program

Estimating Lithium-ion Battery Fire Behavior from ARC Data Using CFAST Fire Model

Heather Barkholtz, Alice Muna, Ethan Sena, Chris LaFleur, John Hewson, Josh Lamb, Jill Langendorf, Babu Chalamala, and Summer Ferreira

Introduction

- Stationary energy storage systems (ESS) are increasingly deployed to maintain a robust and resilient grid
- As system size increases, financial and safety issues become important topics
- Holistic approach: electrochemistry, materials, and whole-cell abuse will fill knowledge gaps
- A key issue in lithium-ion battery safety is quantifying effectiveness of water suppression techniques
- Tools must be explored to estimate sprinkler response to rack fires of various chemistry, SOC, and number of cells involved

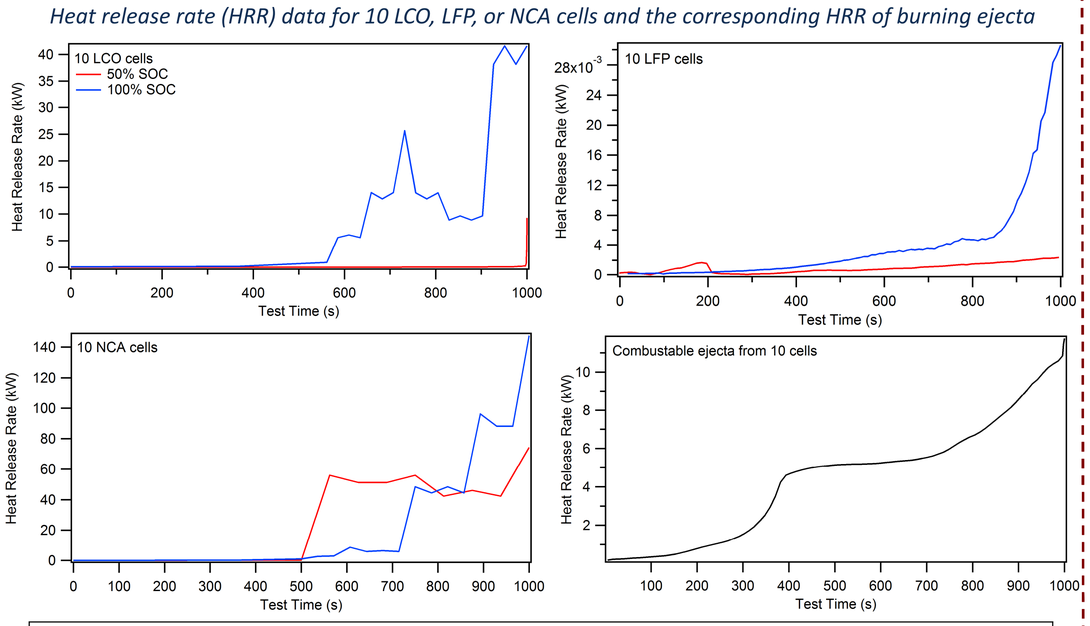


Input Data

Easily obtainable ARC data was used to estimate the heat release rate (HRR) of rack fires with various cell chemistry, SOC, and amount of cells involved

Battery	LCO	LFP	NCA
Nominal capacity (Ah)	2.5	1.1	2.9
Energy Density (Wh L^{-1})	533.3	212.1	569.7
HRR_{max} at 50% SOC (kW)	0.0023	9.3	74.3

Heat release rate (HRR) data for 10 LCO, LFP, or NCA cells and the corresponding HRR of burning ejecta

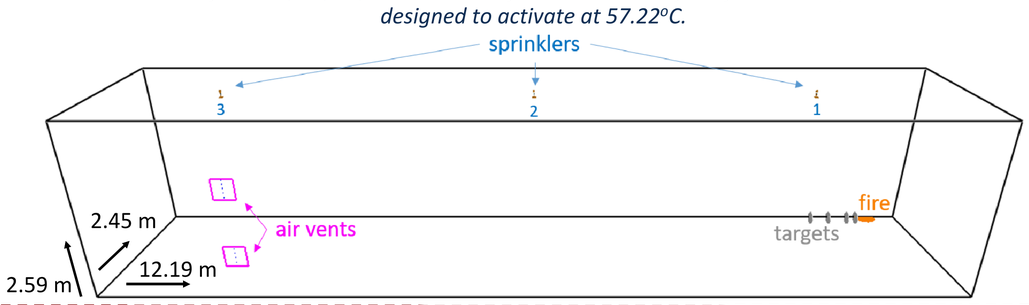


Test Input Conditions

LCO	50%	100%	10	50	100
NCA	50%	100%	10	50	100

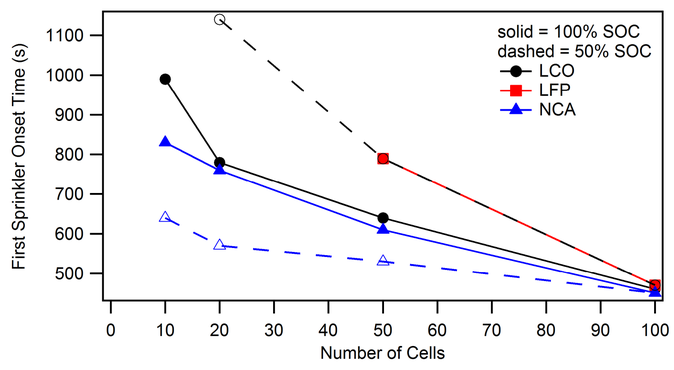
ISO Container

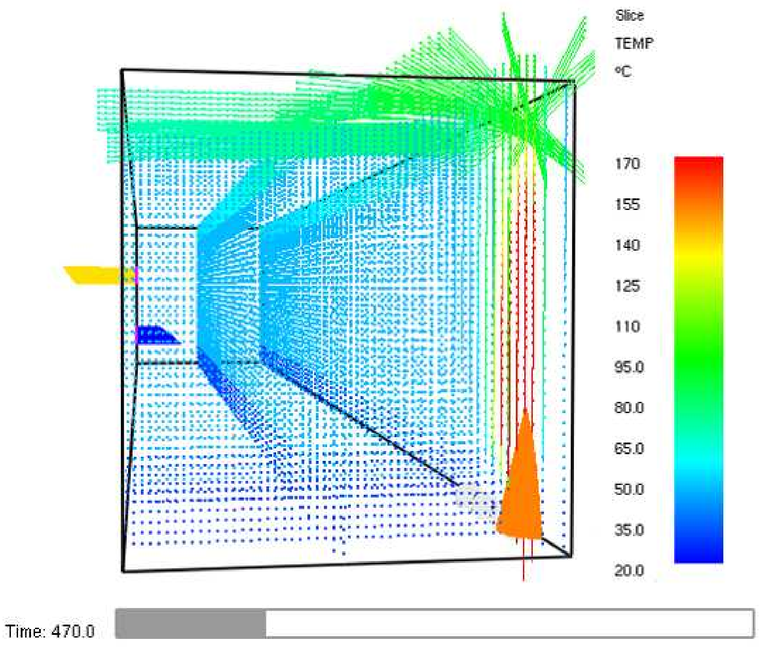
Schematic of the ISO container used in this work. The fire was located in the corner, there are targets to monitor heat flux at 6, 12, 24, and 36 inches from the center of the fire. Three sprinkler heads are designed to activate at 57.22°C.

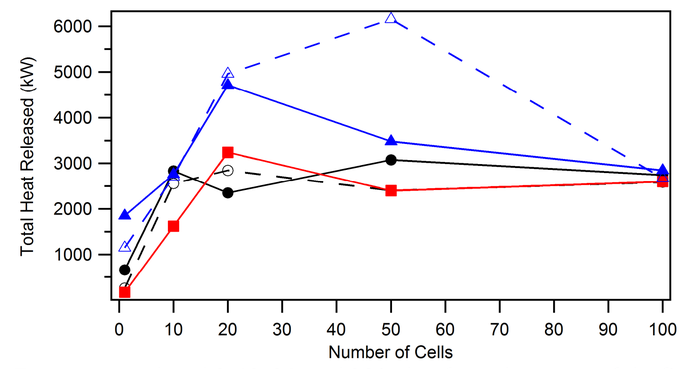


CFAST Fire Model Results

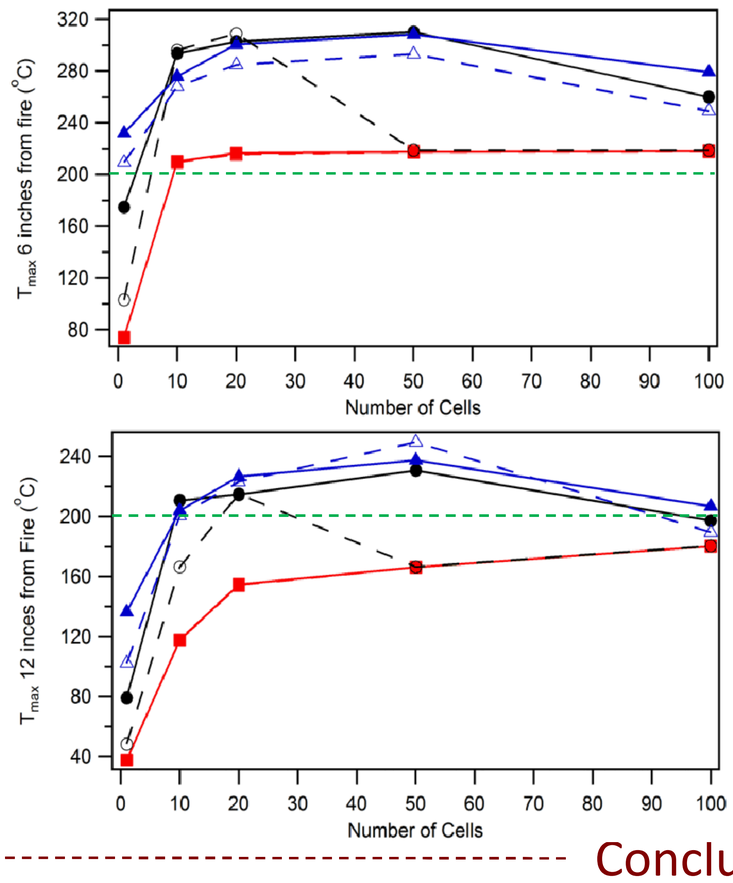
Sprinkler onset time is crucial in determining the total heat release rate and the success of the sprinkler system.

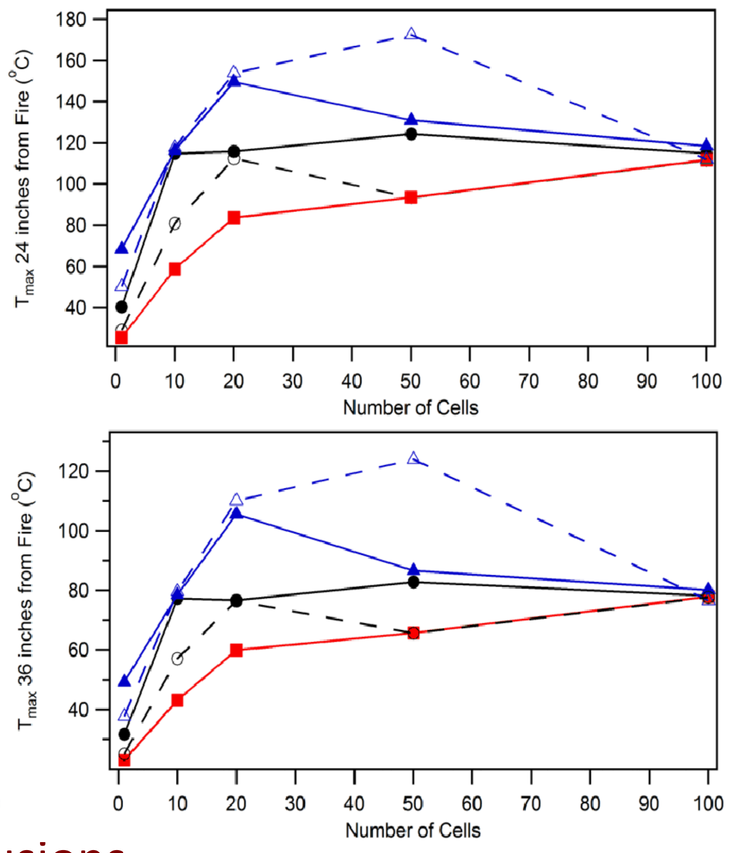






Targets were placed 6, 12, 24, and 26 inches from the center of the fire to measure heat flux and temperature. This was done to estimate the likelihood of fire propagation throughout a module, rack, or the ISO container. Sprinkler activation continued normally as in other tests. If we set the propagation threshold to 200°C (green dashed line below), we can see that in some situations propagation is likely.





Conclusions

- Earlier sprinkler onset time yields lower total heat release rates, less sprinklers activating, and a more controlled fire.
- At 24 and 36 inches from the fire, no fire propagation situations were likely
- Sprinkler response can be screened with CFAST and ARC data prior to more elaborate testing

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