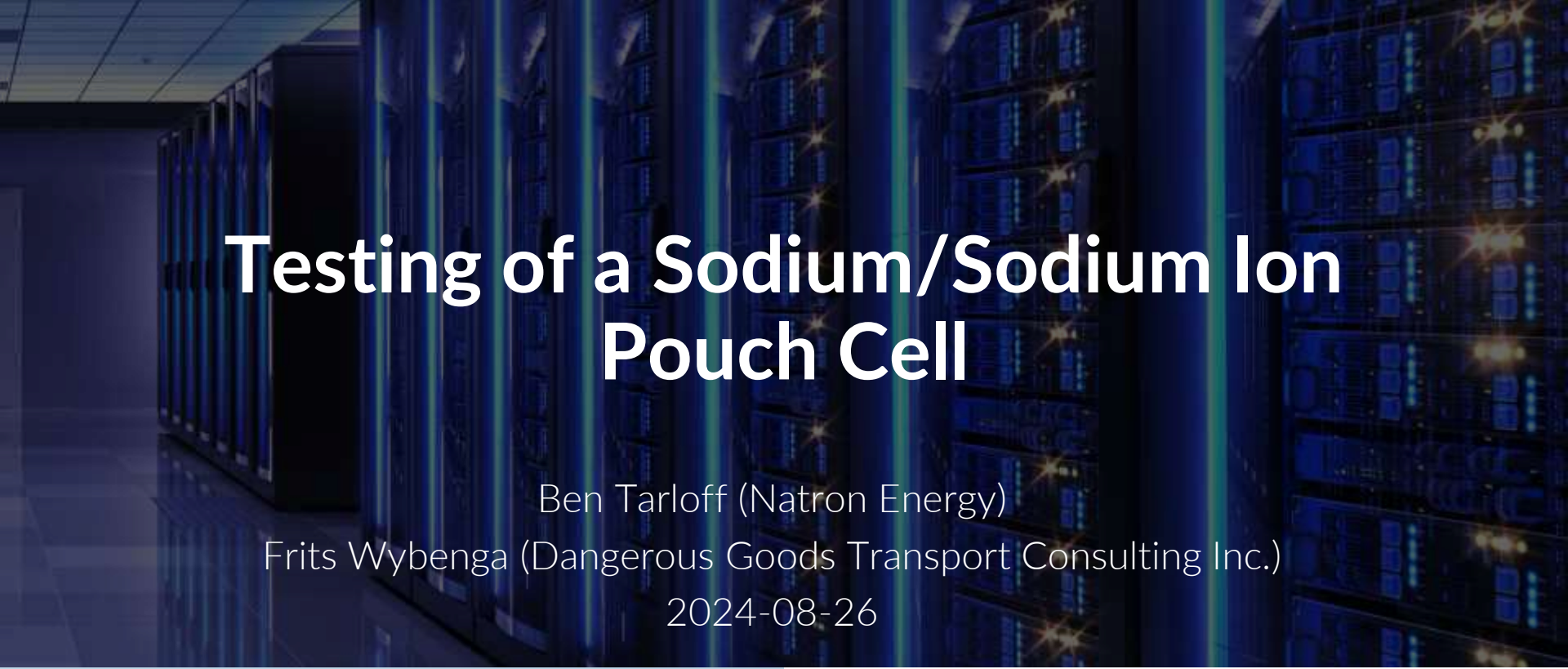


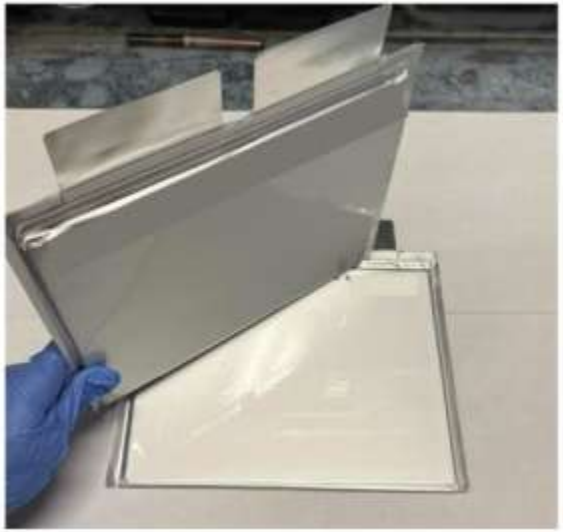
Testing of a Sodium/Sodium Ion Pouch Cell

Ben Tarloff (Natron Energy)
Frits Wybenga (Dangerous Goods Transport Consulting Inc.)
2024-08-26

Natron Energy

US DOT Study: Cell Specifics

- Nominal Voltage: 1.8V
- Nominal Energy Density: 22 Wh/kg
- Anode & Cathode: Prussian Blue
- Cell Mass: 305g
- Cell Format: Pouch
- US DOT Study notes: High safety/low energy



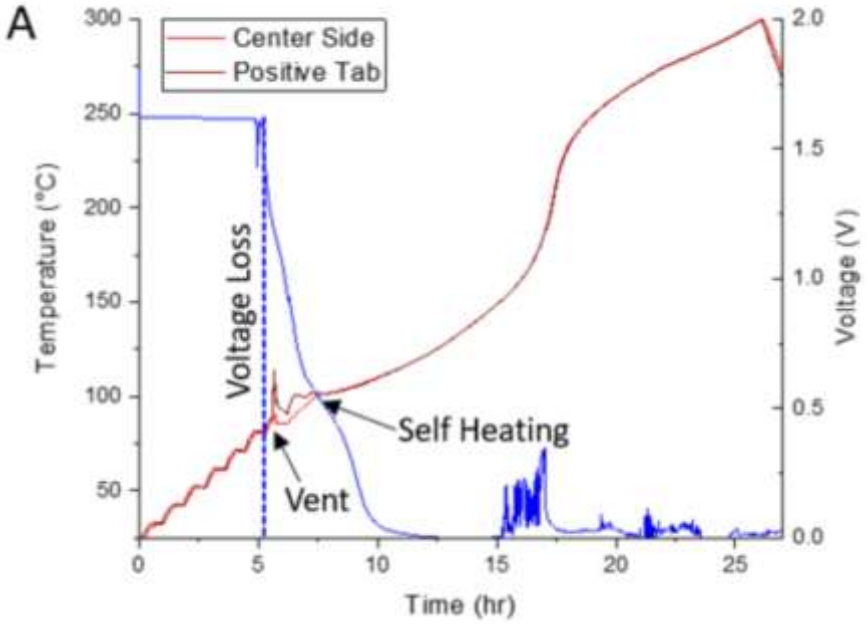
US DOT Study: Heat Test Description

- ARC used
- Heat-wait–seek approach – heating at 5°C increments, 40 min wait
- Chamber maintains adiabatic condition when heating detected
- Cell considered to be in thermal runaway when heat rate surpasses 5°C/min
- US DOT Study link: DOT-SIB-Testing-Report-Web-Version.pdf

US DOT Study: Temperature Profile

Results:

- Voltage loss and venting: ~ 90°C
- Heat rate: <1.2°C/min; 14W. Some acceleration at 200°C but below 20W
- No catastrophic event
- Self heating onset at 175°C
- No thermal runaway of single cell



US DOT Study: Comments

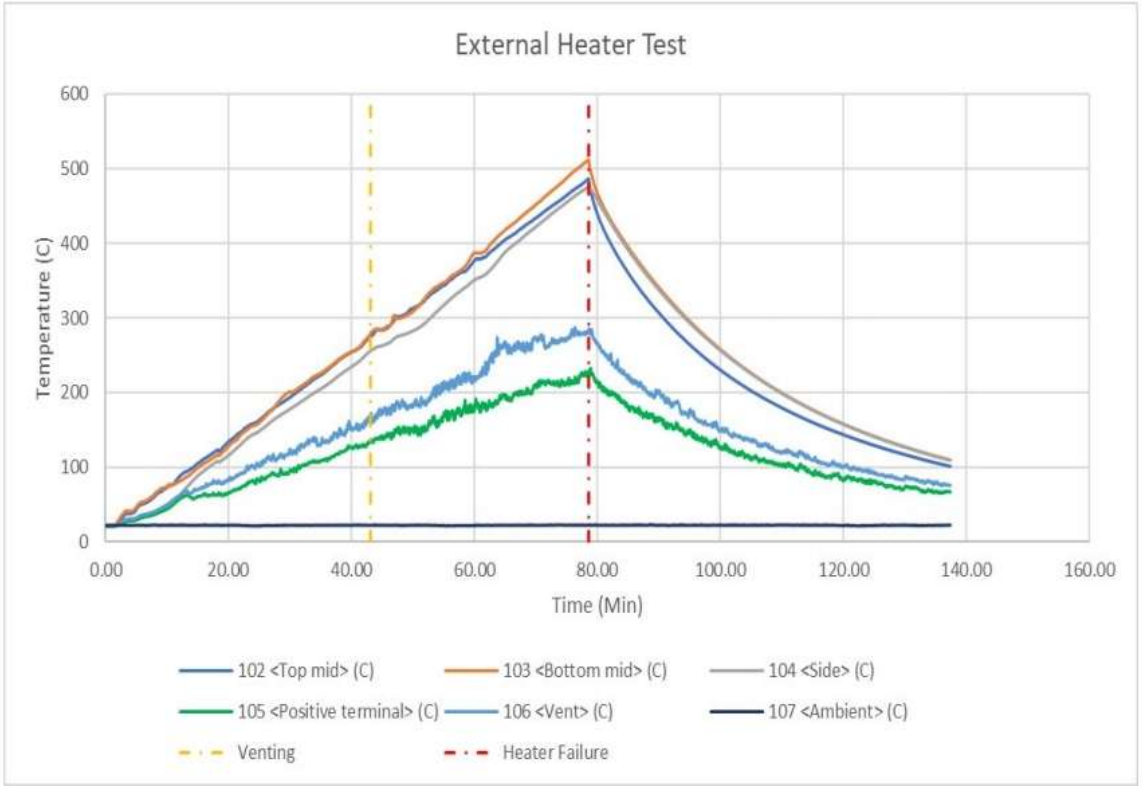
- Study defines threshold for thermal runaway to be 5°C/min
- Low heat flux of no more than 2W indicates an inability to ignite surrounding packaging
- Considers onset temperature, maximum temperature rise, and maximum heat flux are most indicative of transportation risks

ANSI/CAN/UL 9540A:2019 "Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems"

- "THERMAL RUNAWAY – The incident when an electrochemical cell increases its temperature through self-heating in an uncontrollable fashion. The thermal runaway progresses when the cell's generation of heat is at a higher rate than the heat it can dissipate. This may lead to fire, explosion and gas evolution"
- To examine potential cell failure, tests included:
  - External heater test
  - Overcharge
  - Nail penetration
  - Short circuit

Graph of External Heater Test

Attachment C: Cell Temperature Profiles during testing - (*Pages **25** through **30***)



UL Testing: Observations

- The venting was identified from the video at 00:43:10 minutes into the test.
- Cell was heated with two external heaters on each side of the cell
- Ramp up of heater temperature at a rate of 4-7°C per minute.
- Heater fails at ~500°C
- Thermal runaway (single cell) was not observed.

UL Testing: Additional Observations

- UN regulations are intended to provide safety against conditions normal to transport
- 55°C is the acknowledged maximum ambient according to international air regulations; 75°C is the limit for some highly dangerous goods
- Cell testing should likewise relate to behavior at most no higher than 75°C
- Failure to demonstrate thermal runaway at temperatures as high as 375°C demonstrates a high level of safety justifying “not regulated” status
- Even for cells that exhibit thermal runaway at high temperatures, whether regulation is warranted should be based on predicted behavior below 75°C
- New testing at high temperatures should not lead to new requirements (e.g., requiring higher casing integrity to withstand high temperatures)

Thank you