

UN Battery Classification Test Method Development and Testing

Presented to: UN Lithium Battery Classification informal
working group

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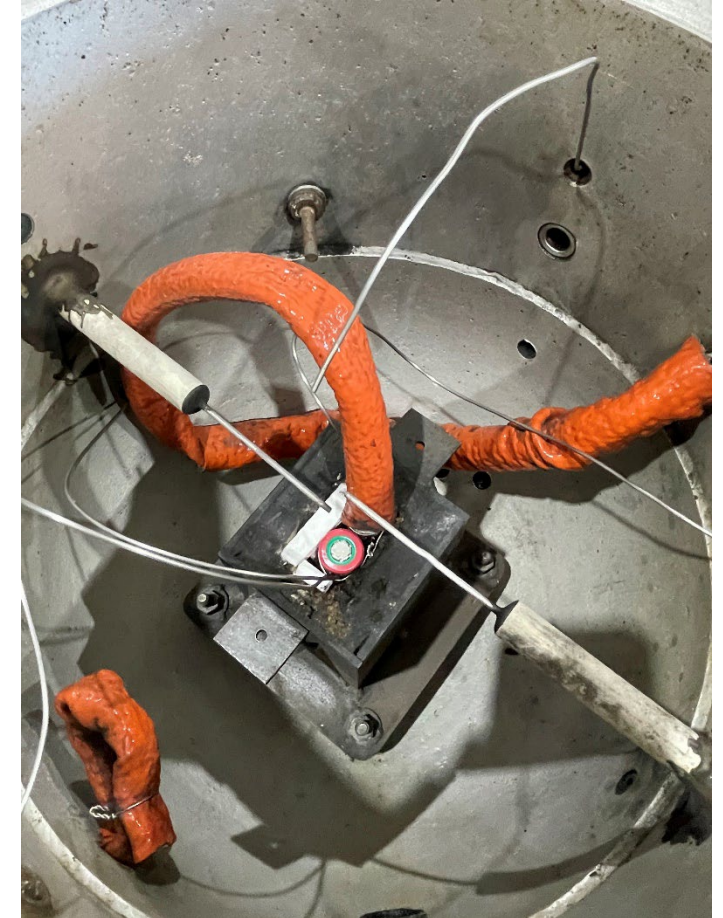
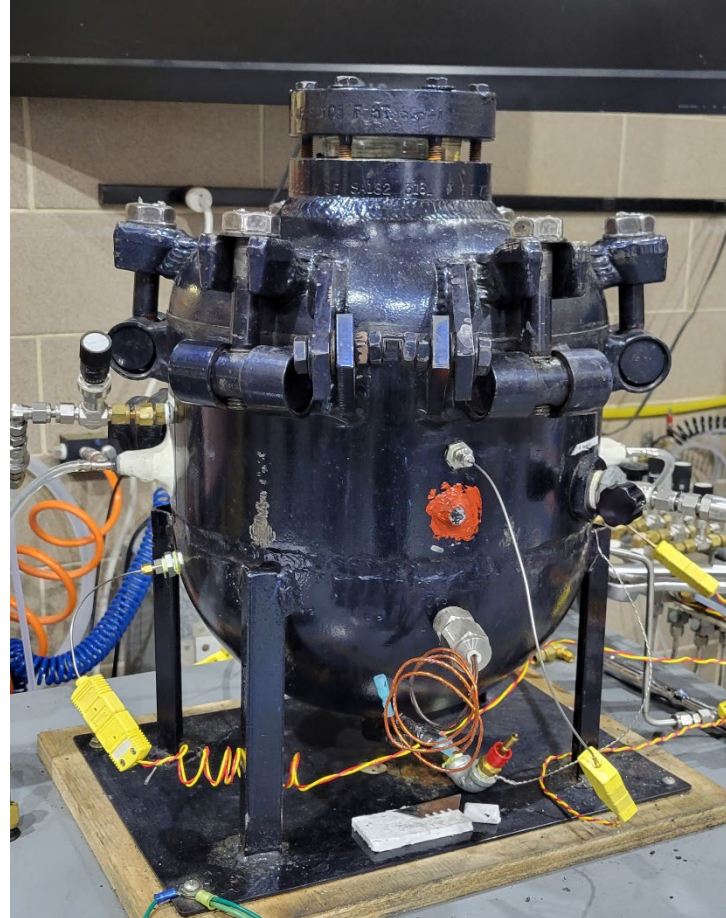


Federal Aviation
Administration



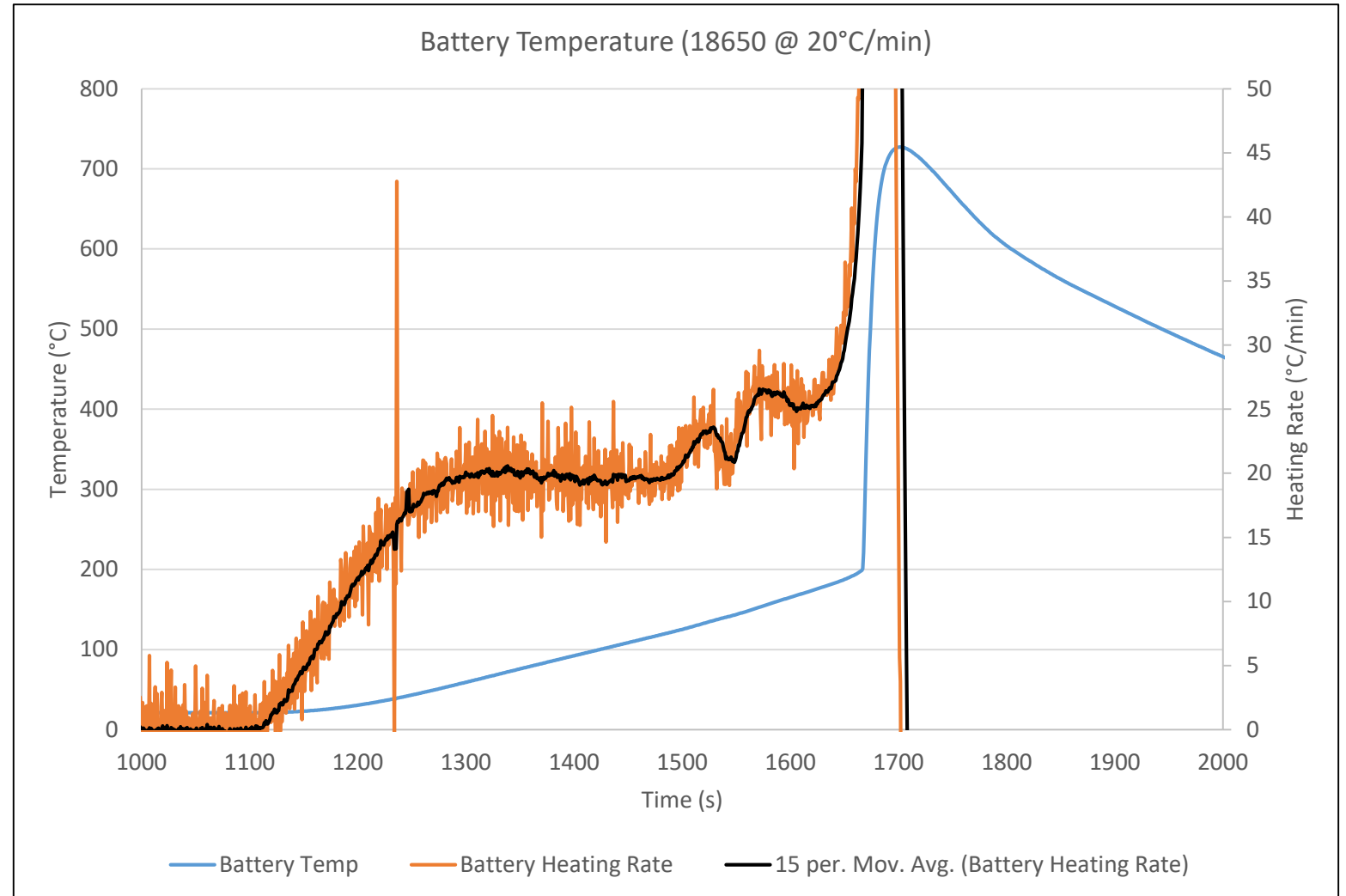
Battery Gas Volume Measurements

- Single cell placed in 21.7L pressure vessel and heated until thermal runaway
- Instrumented with pressure transducers and thermocouples for heater, battery, and ambient air
- Chamber is evacuated with vacuum pump, then filled with nitrogen at atmospheric pressure
- Battery gas volume is calculated from temperature and pressure measurements
- All cells at 100% SOC



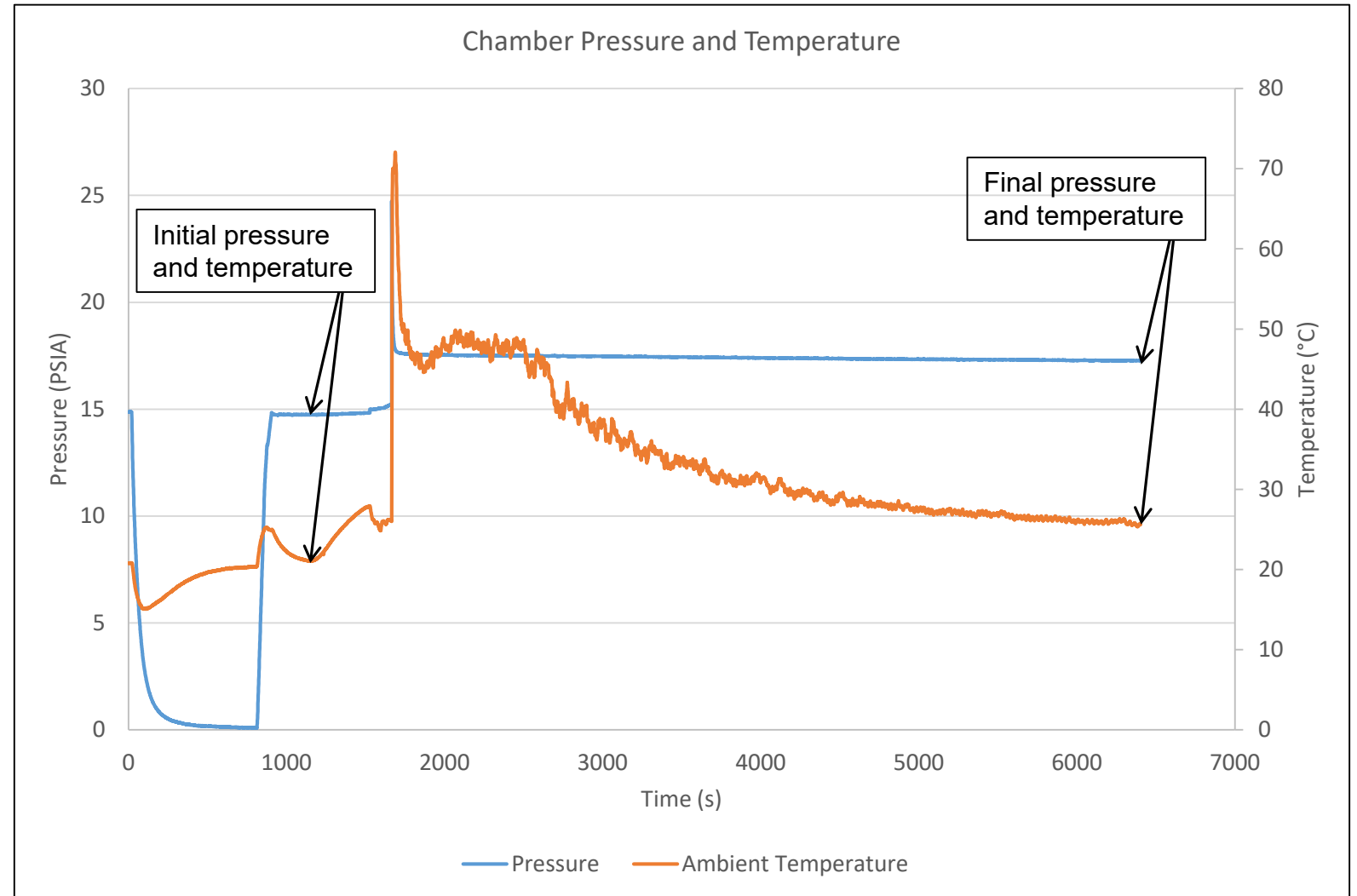
Battery Gas Volume Measurements

- Heating rate controlled with temperature controller
- Cells heated at rates of 5°C, 10°C, and 20°C per minute
- Example shows an 18650 cell heated at 20°C/min



Battery Gas Volume Measurements

- Chamber pressure and temperature data from same test
- Calculated amount of gas (in moles) using ideal gas law
- Converted to liters of gas at NIST normal temperature and pressure (NTP – 20°C and 1 atm)
- This test produced 3.39L of gas



Battery Gas Volume Measurements

- **Tested 20 lithium-ion cells**
 - Size from AAA to large pouches
 - LCO, NMC, LFP, LTO, LMN chemistries
- **Tested 9 lithium metal cells**
 - Size AAA, CR2, to 17500
 - LiFeS_2 , LiMnO_2 , LiSOCl_2 chemistries



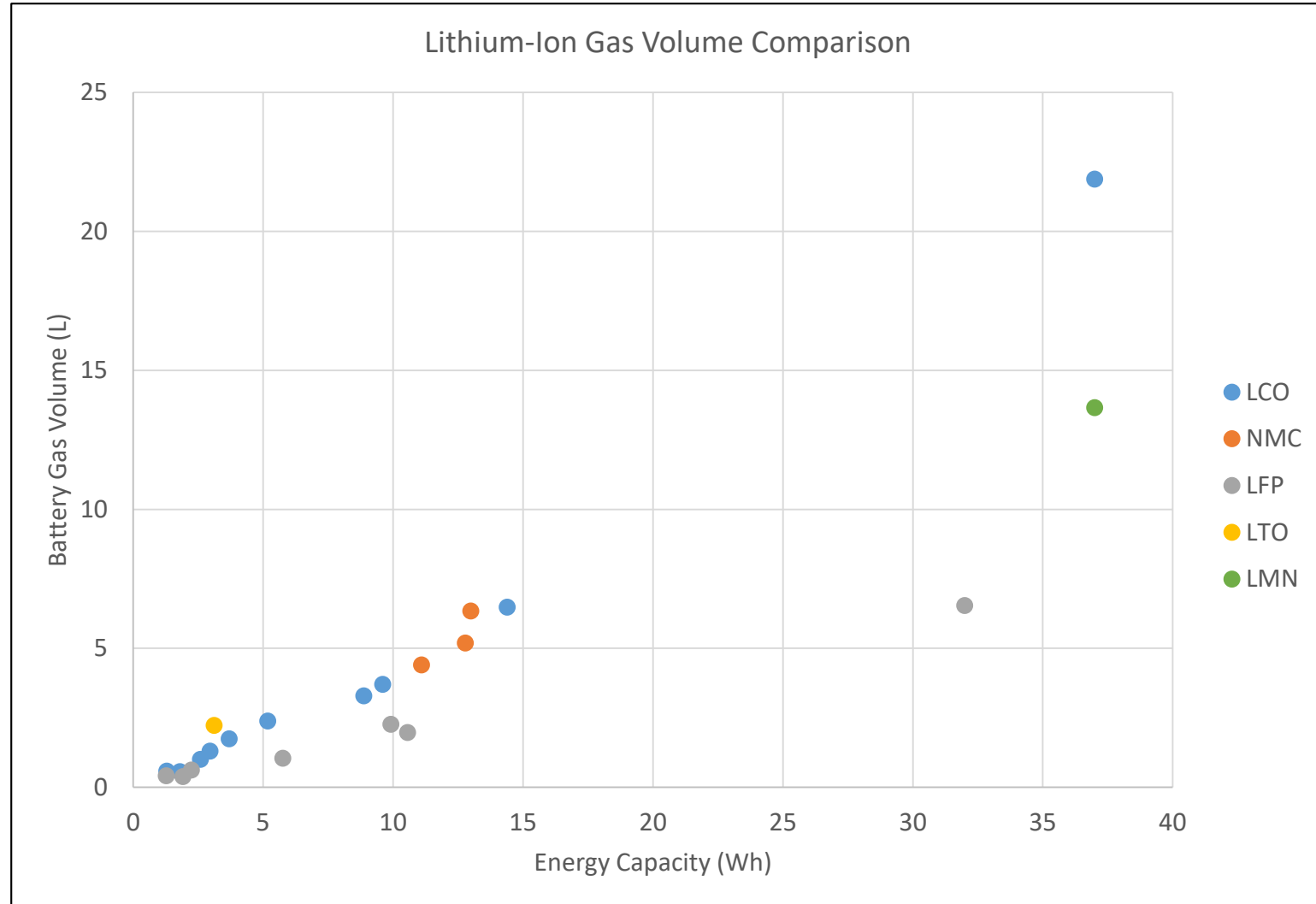
Lithium-ion batteries tested



Lithium metal batteries tested

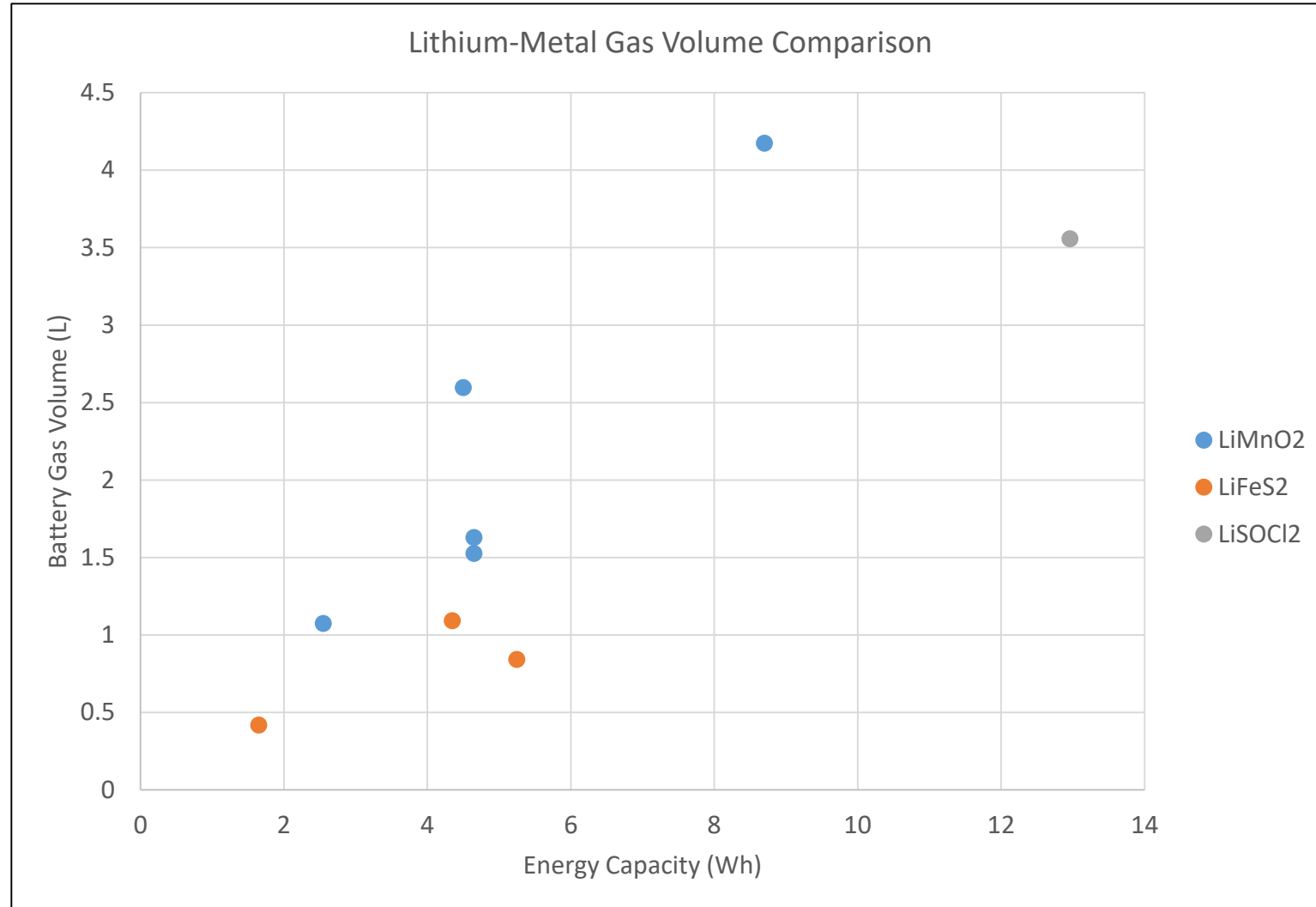
Battery Gas Volume Measurements

- **Lithium-ion cells only**
- **Comparing highest volume from each cell**



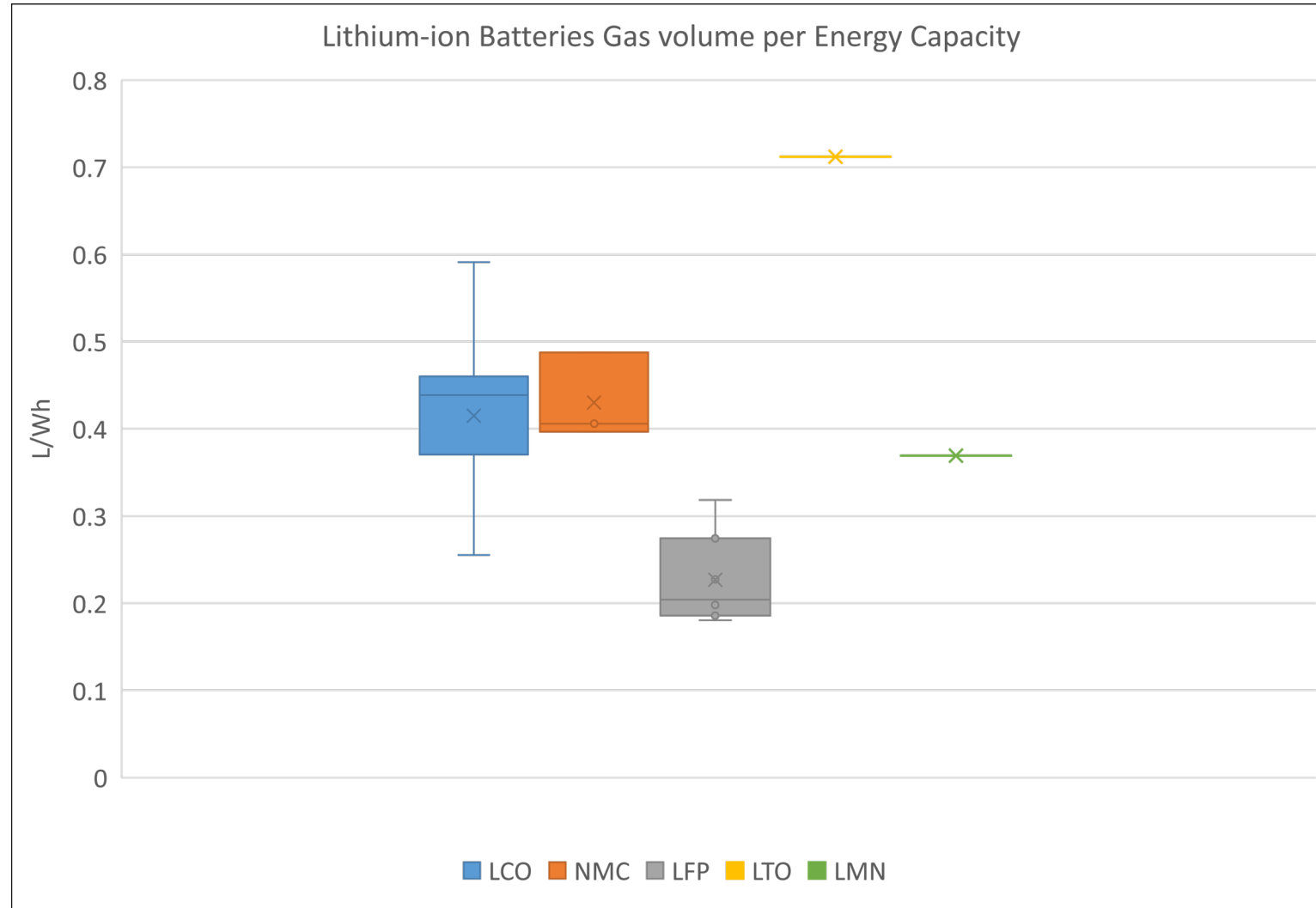
Battery Gas Volume Measurements

- **Lithium metal cells only**



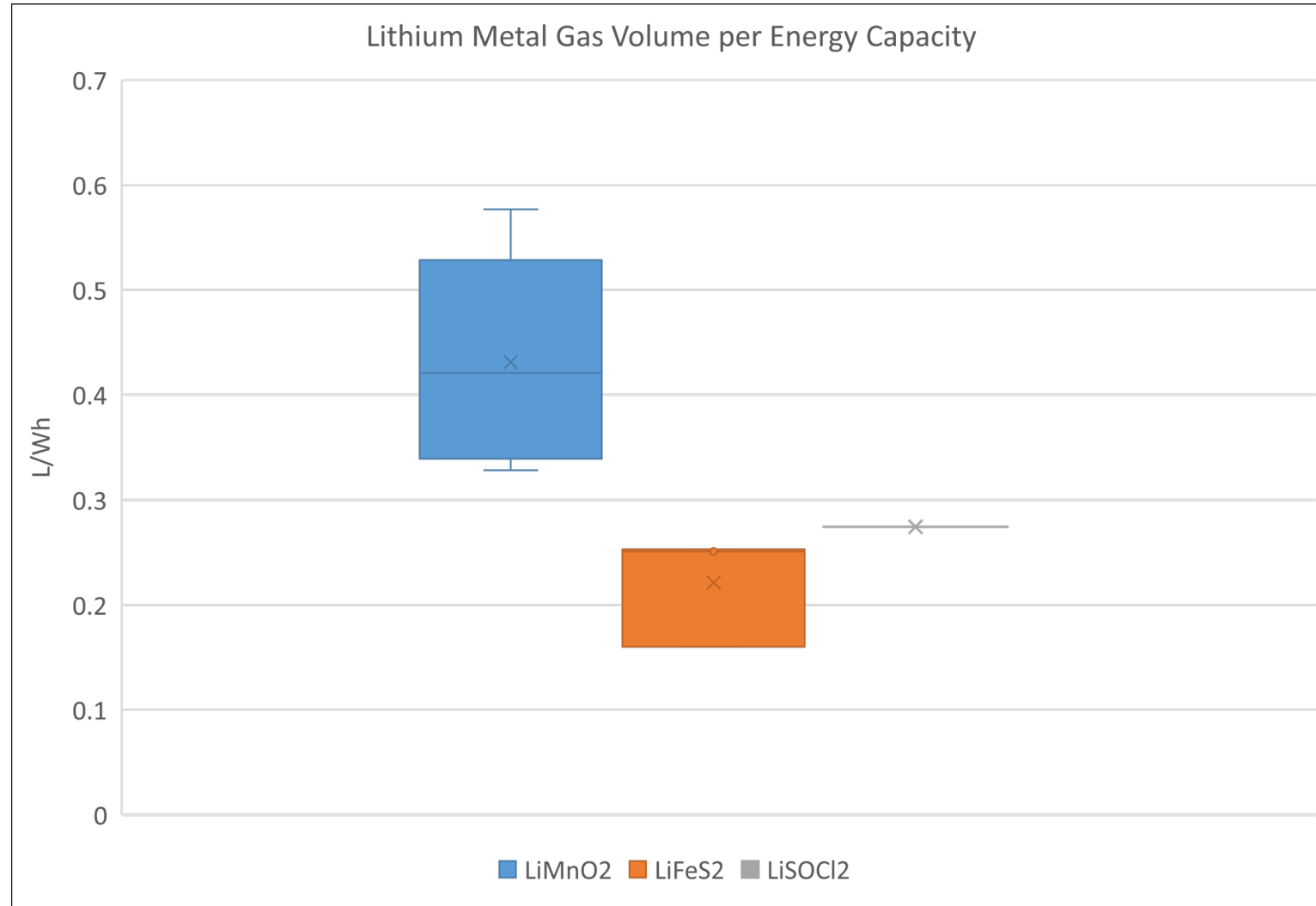
Battery Gas Volume Measurements

- Highest was LTO 18650 at 0.71 L/Wh
- Highest LCO was 10,000 mAh pouch cell at 0.59 L/Wh
- Highest LFP was AA at 0.32 L/Wh



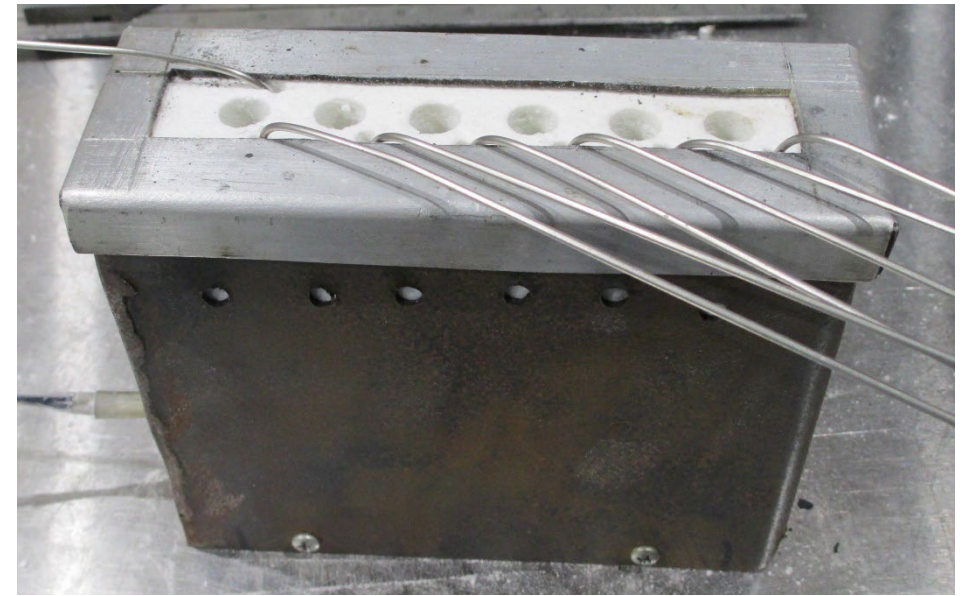
Battery Gas Volume Measurements

- Highest was LiMnO₂ CR123A at 0.58L/Wh



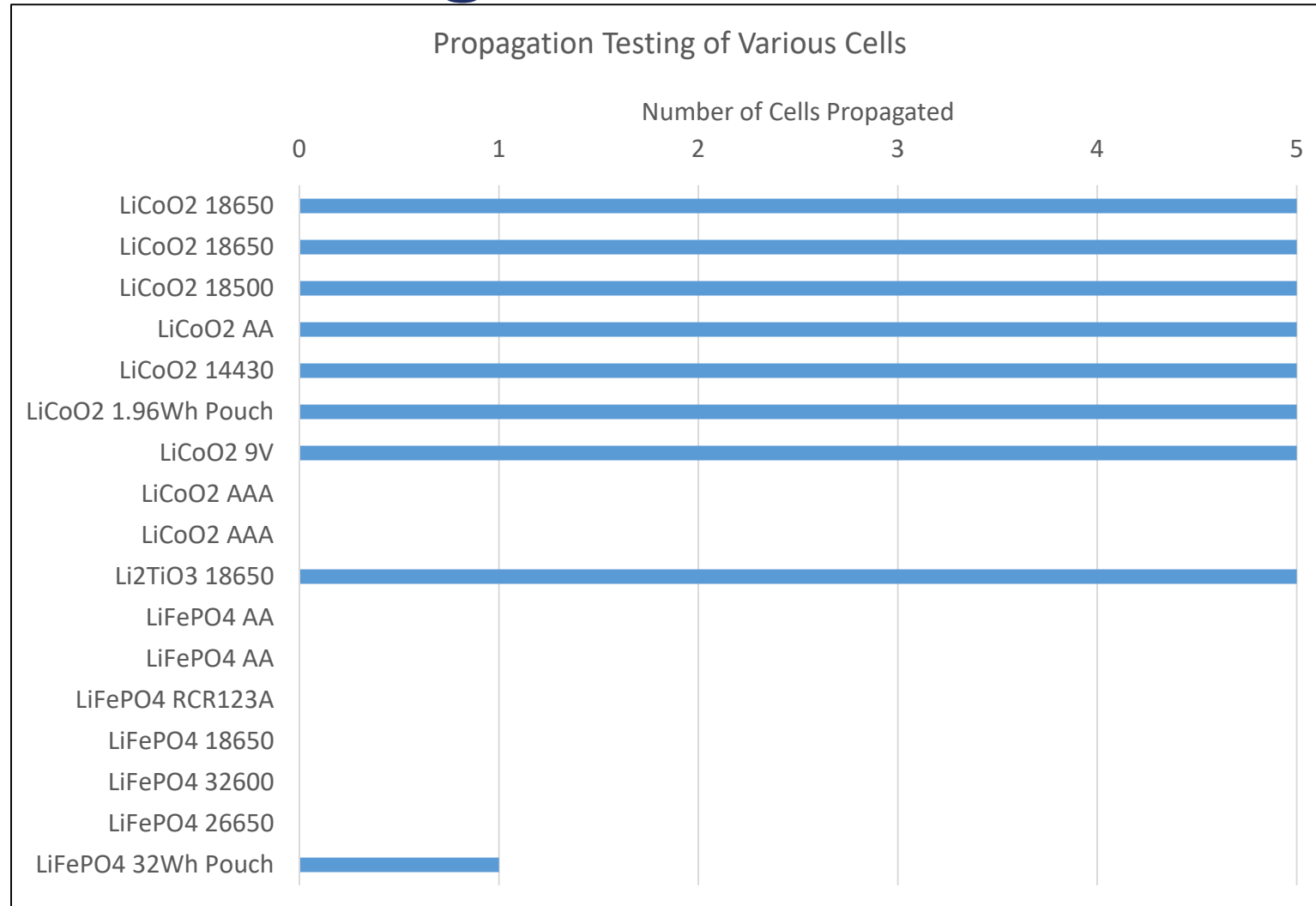
Battery Propagation Testing

- 6 cells placed in a line in an insulated box to determine if thermal runaway will propagate down the line
- Cell #1 heated at 20°C/min until thermal runaway occurs, then heater is turned off
- Thermocouple placed on each cell to measure temperature
- Top of box is vented to allow gas to escape
- Spark ignitor placed 4 inches above the box
 - To determine if gas is flammable
 - Ignitor turned off after first cell goes into thermal runaway
- All cells at 100% SOC
- Tested 17 Li-ions and 14 Li metals so far



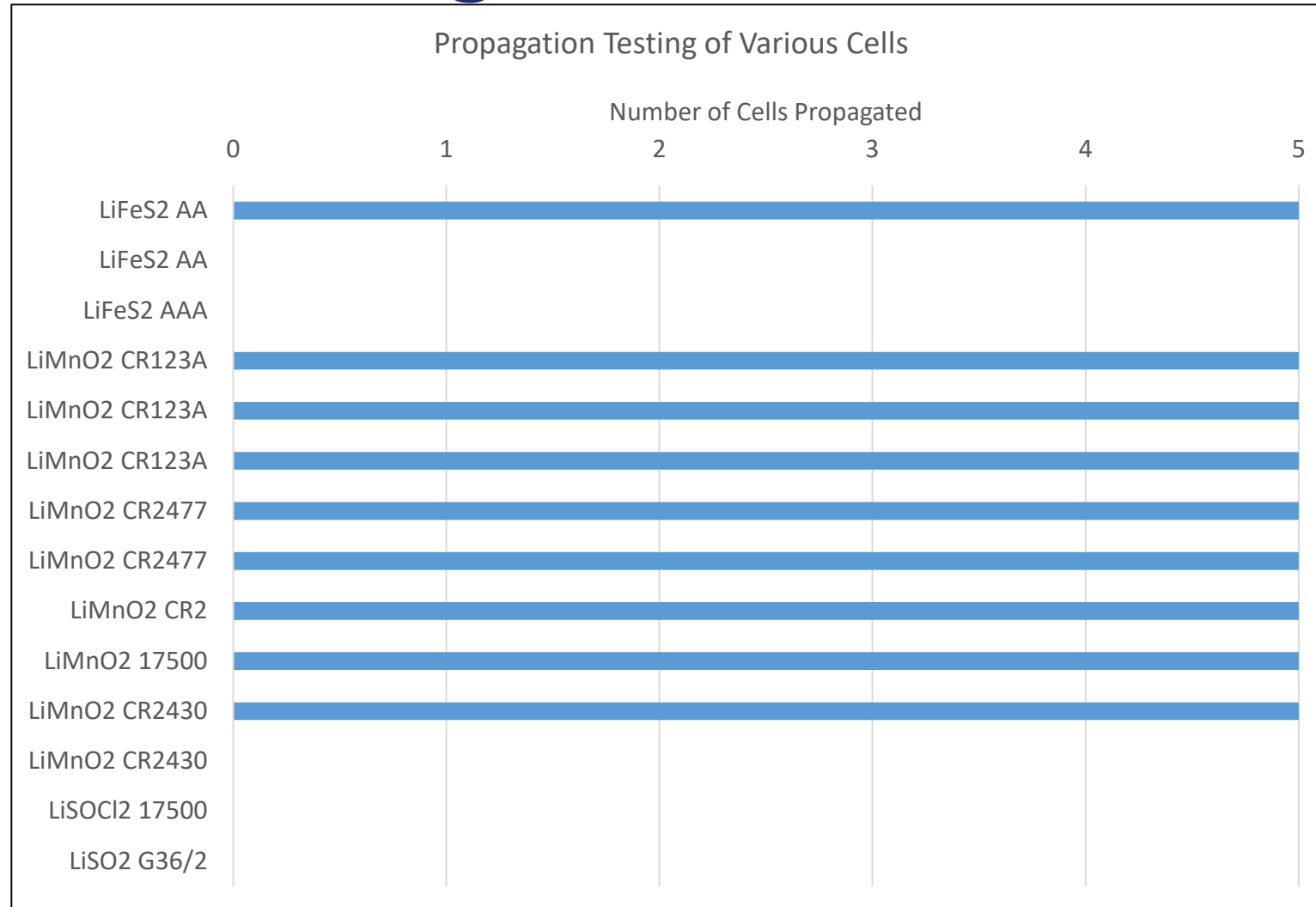
Battery Propagation Testing

- All LCO cells propagated except AAA size
- No LFP cells fully propagated
- All cells produced flammable gas



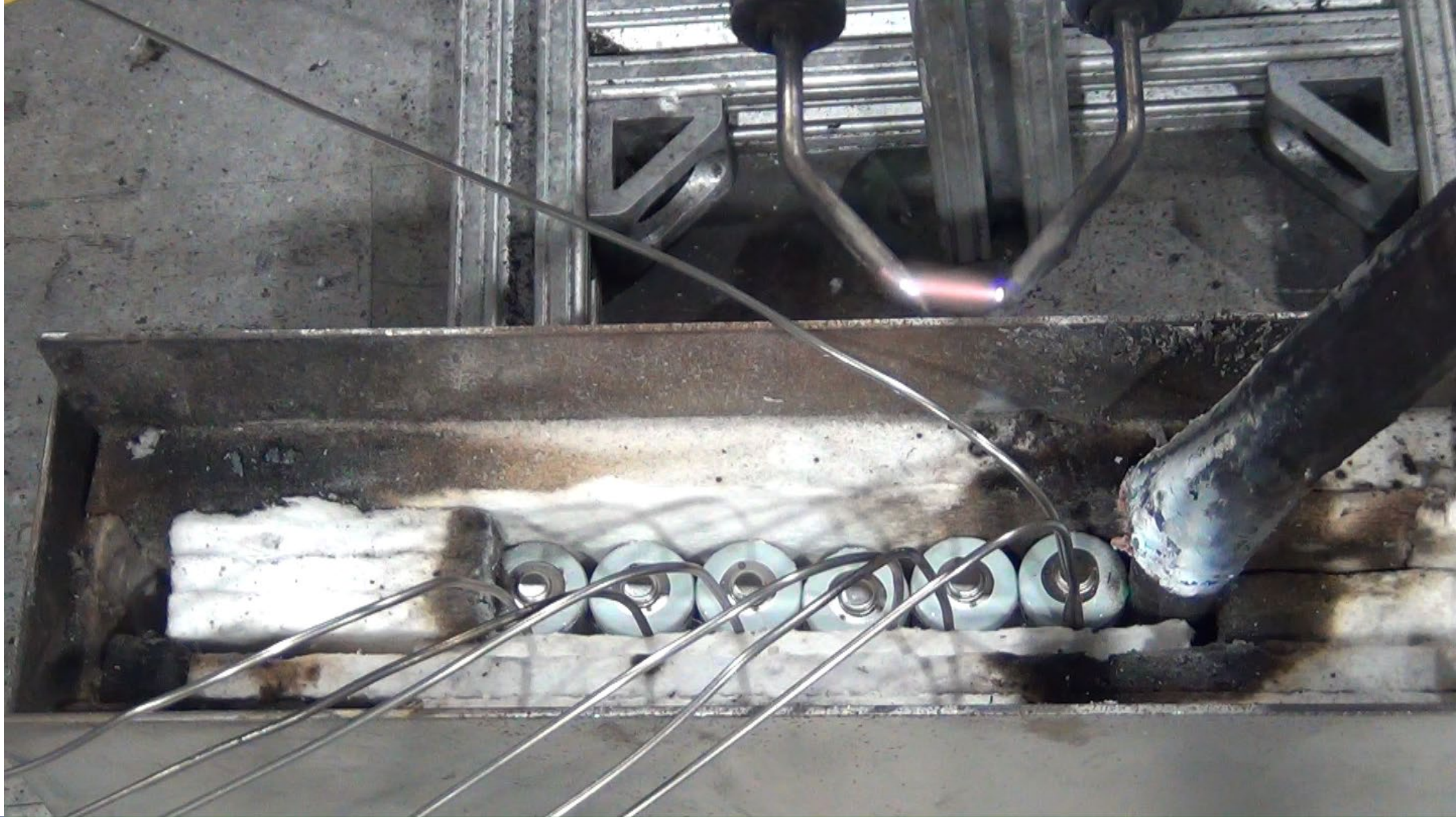
Battery Propagation Testing

- **LiFeS₂ propagated at AA size for one brand, not AAA**
- **All cells produced flammable gas except LiSO₂**
- **Small CR2430 button cell propagated (0.855 Wh)**



LiSOCl₂
17500 Cells

Exploded at
~175°C



Questions?

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