# Performance and Safety Evaluation of High-rate 18650 Lithium IronPhosphate Cells

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**NASA Battery Workshop**
**November, 2009**

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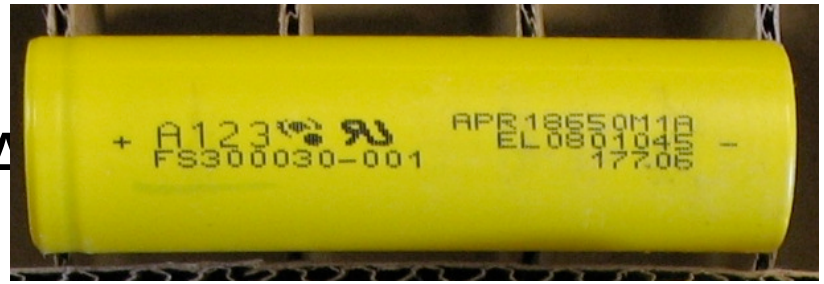
# Introduction

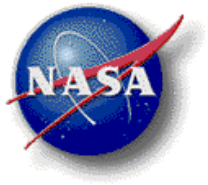
- The A123 cell has the $LiFePO_4$ olivine Li-ion chemistry
- Capacity : 1.1 Ah
- Model # : APR18650M1A
- Mass: 39.26 g

(~92 Wh/kg)




- Voltage range: 3.6 to 2.0 V
- Cells have a more

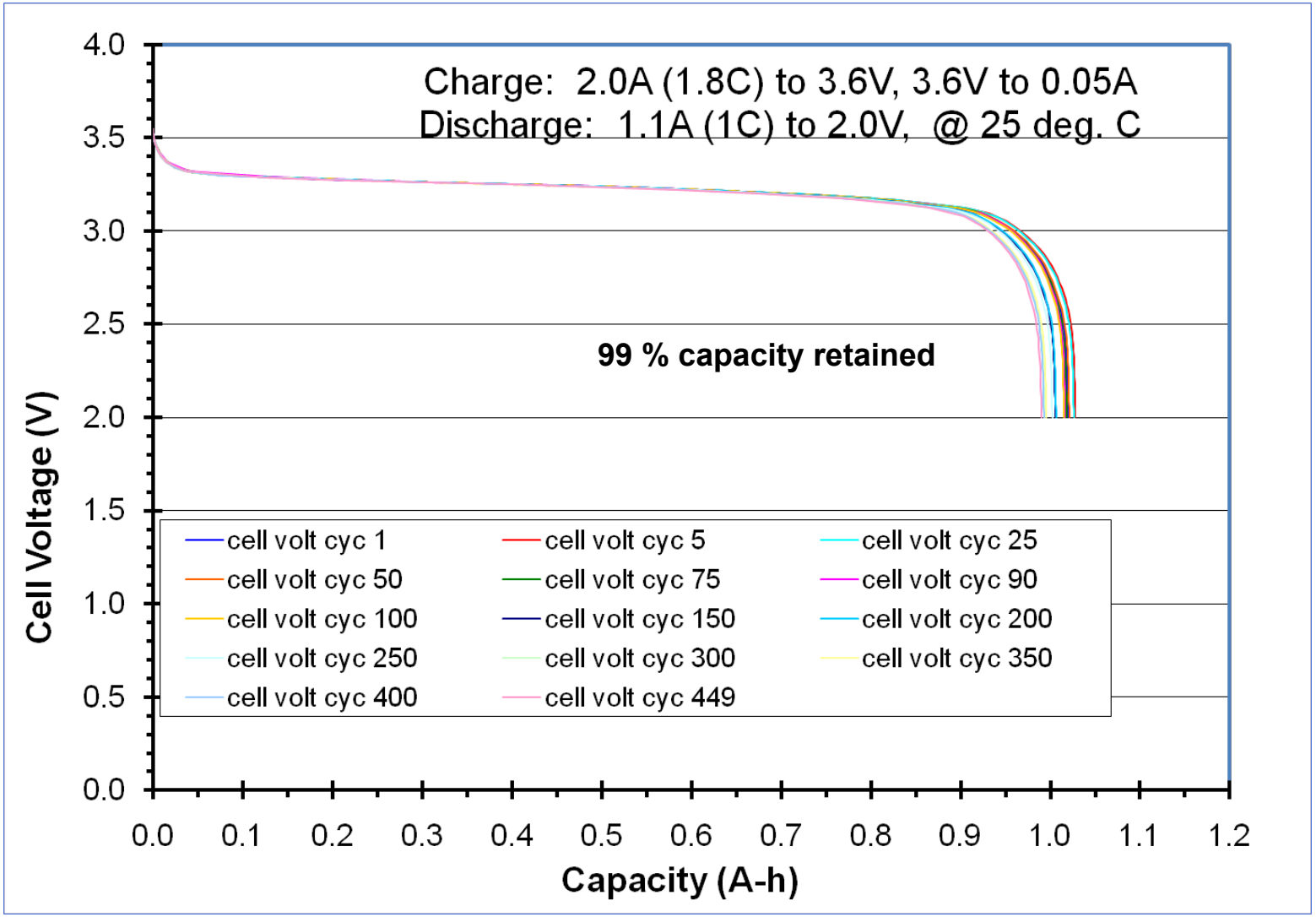
robust cell construction than the 26650 cells tested in 2007



# Tests Performed

- Rate Capability
- Thermal environment capability
- High-power pulse capability
- External short
- Simulated Internal short
- Overdischarge into reversal
- Heat-to-Vent
- Overcharge at single cell and 6-cell string levels

# Rate Capability Test on A123 18650 Li-ion Cells

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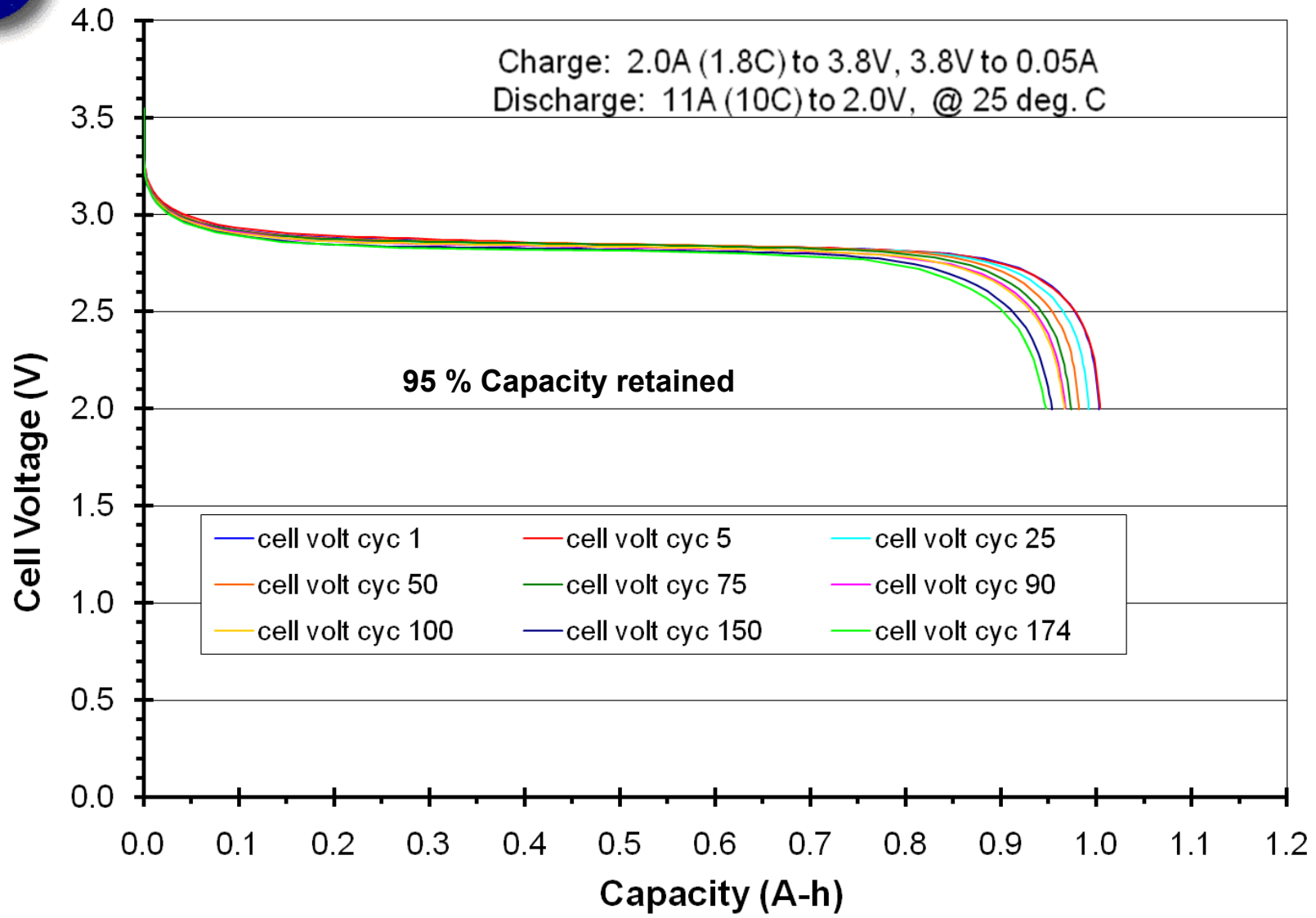


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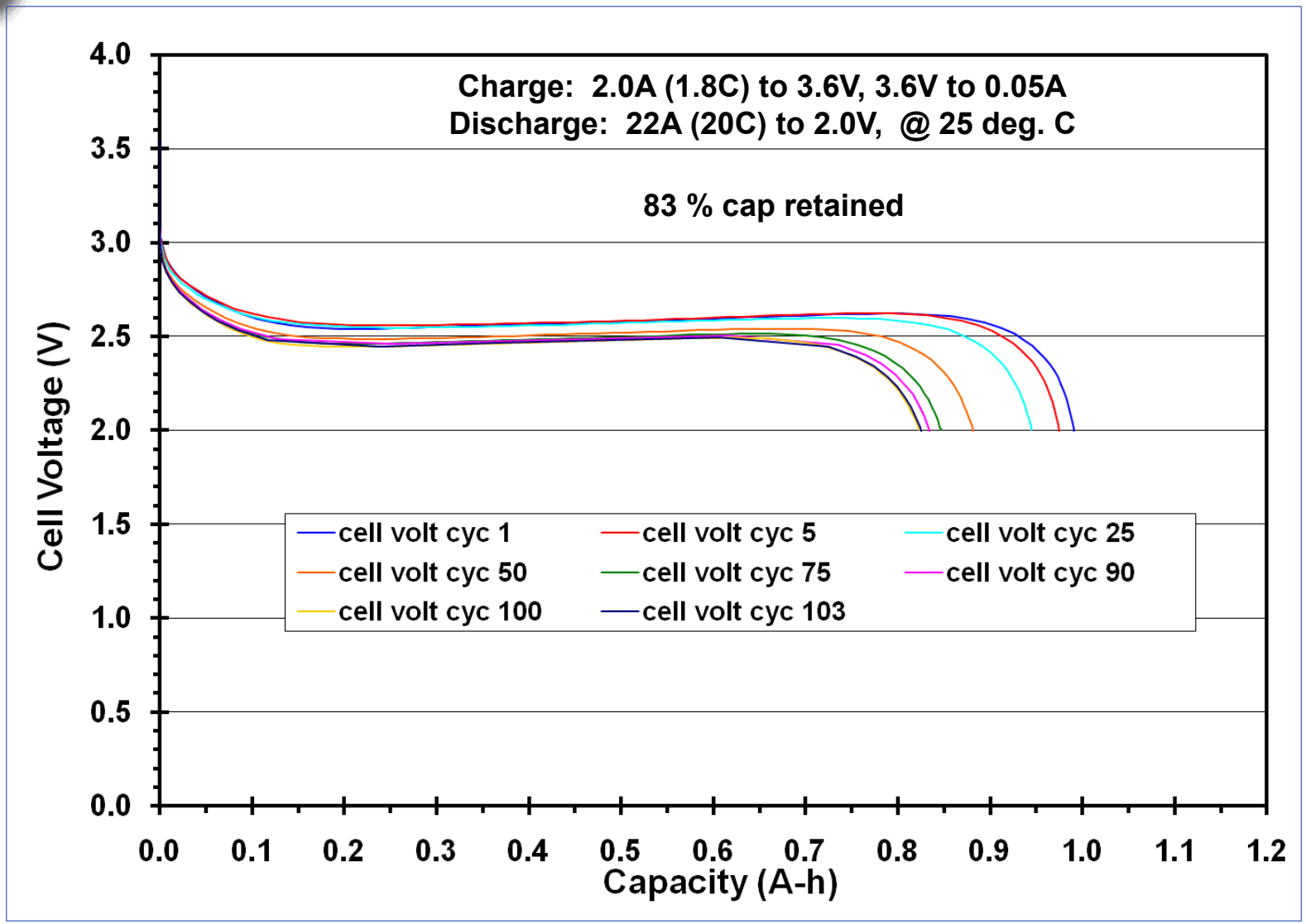


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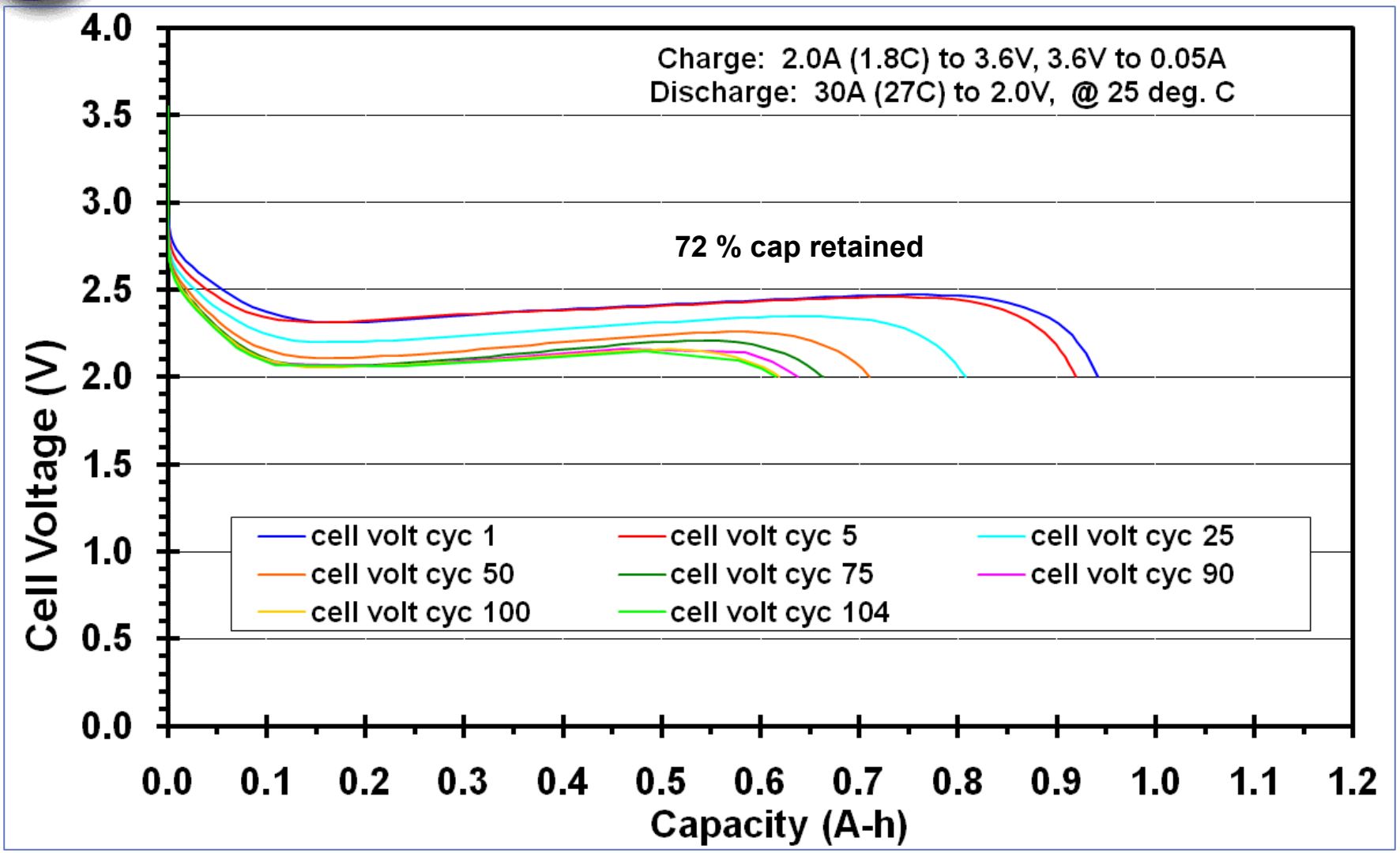


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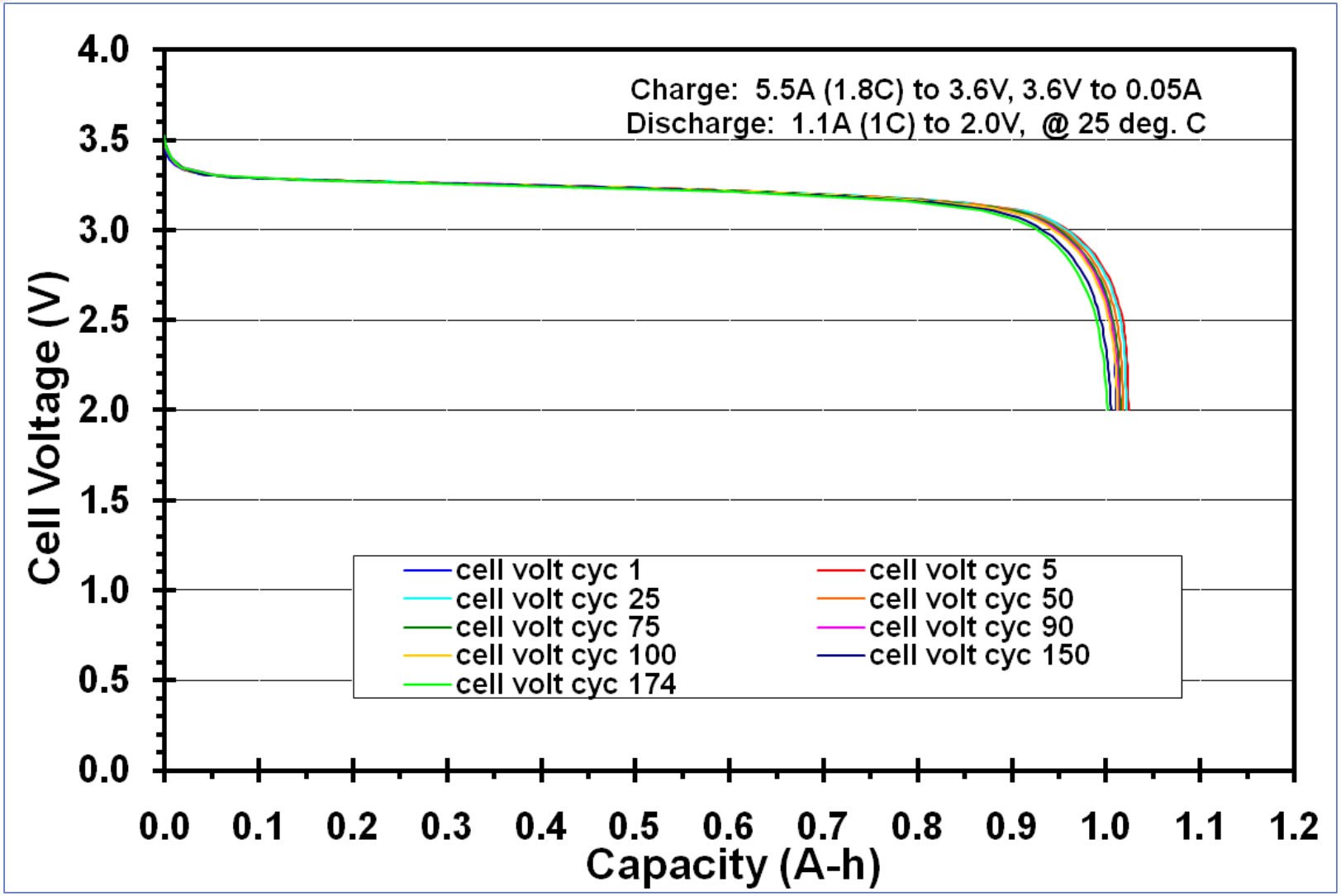
# Rate Capability Test on A123 18650 Cells

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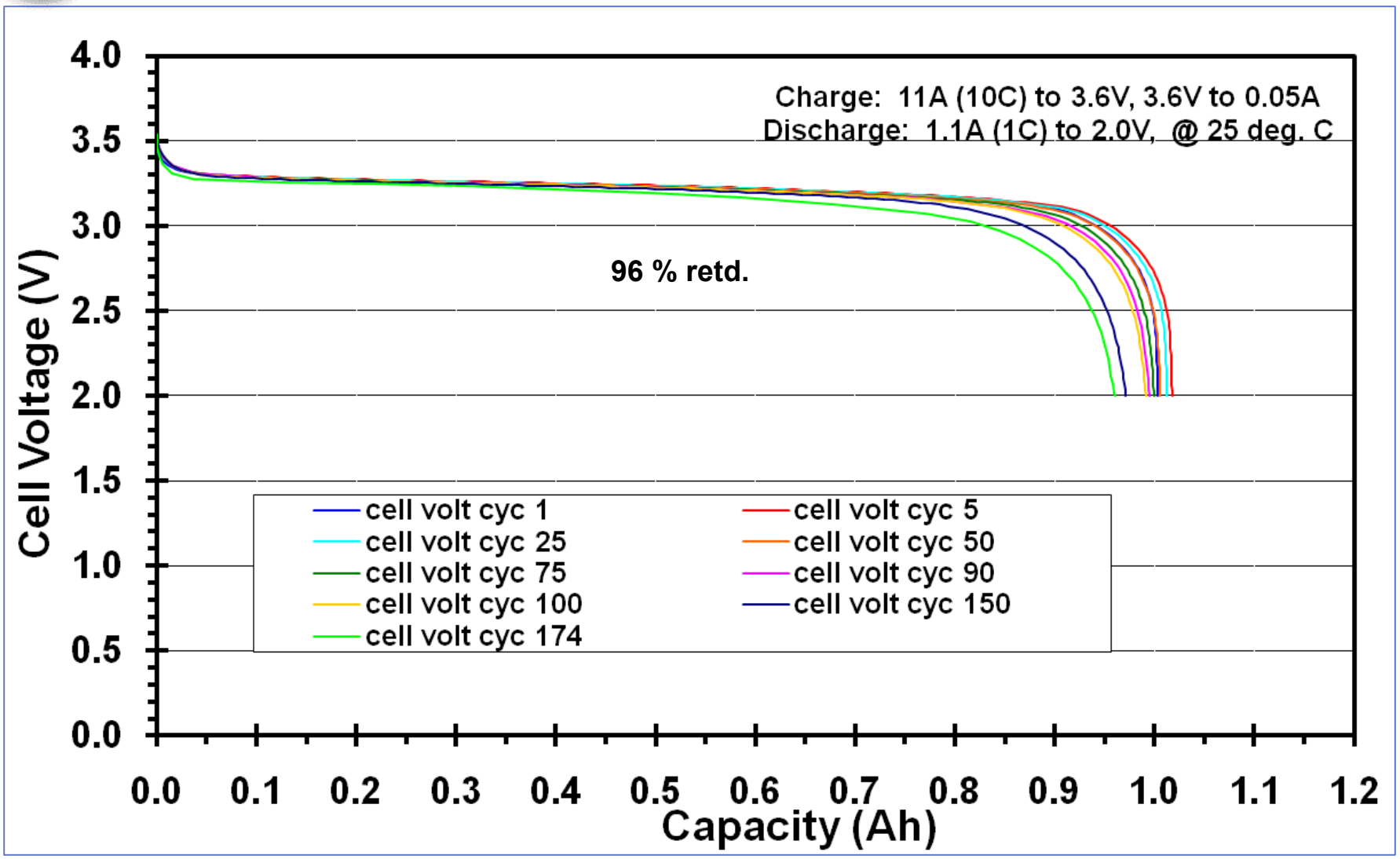
# Rate Capability Test on A123 18650 Cells

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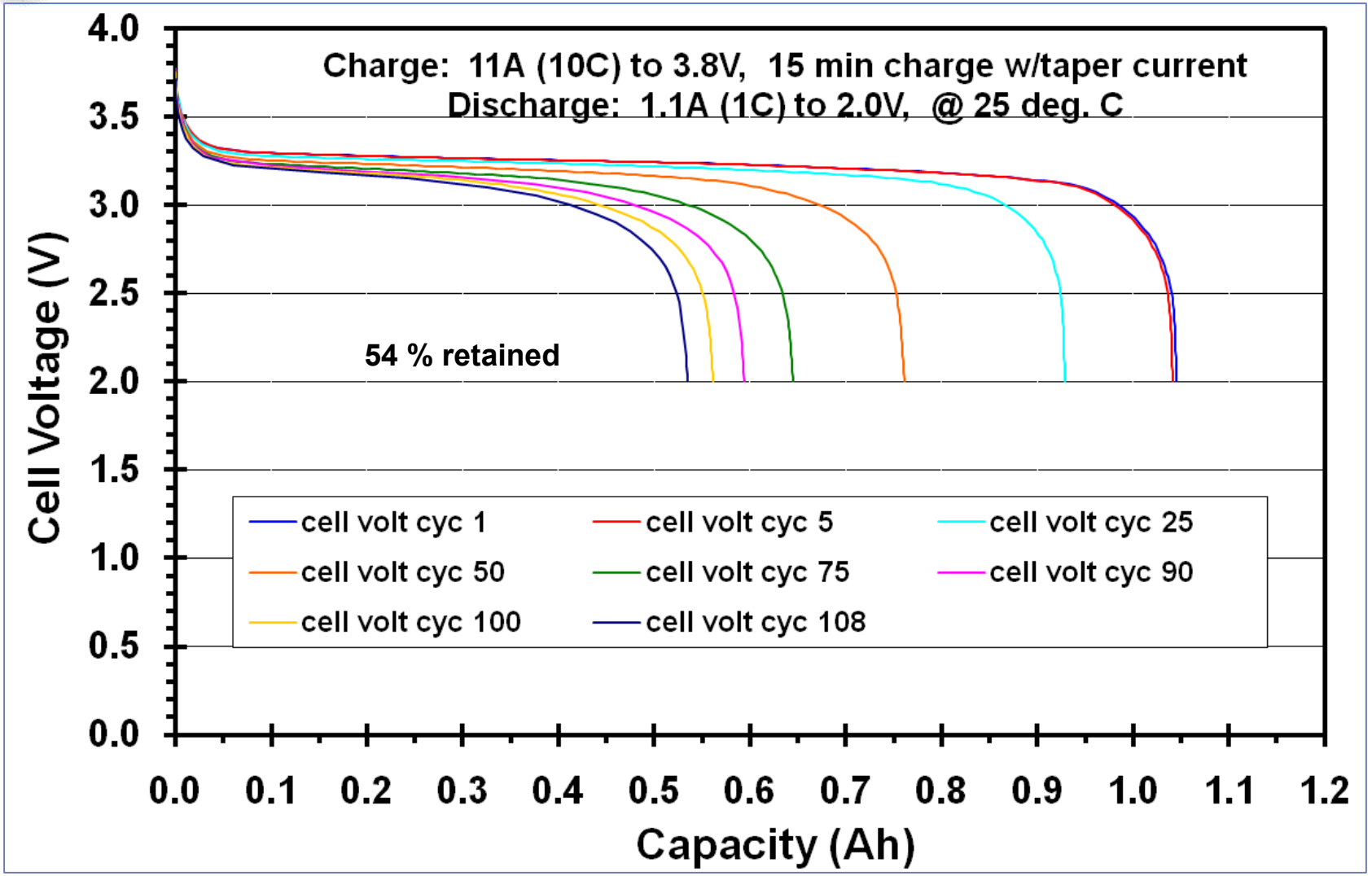
# Fast Charge Test on the A123 18650 Cells

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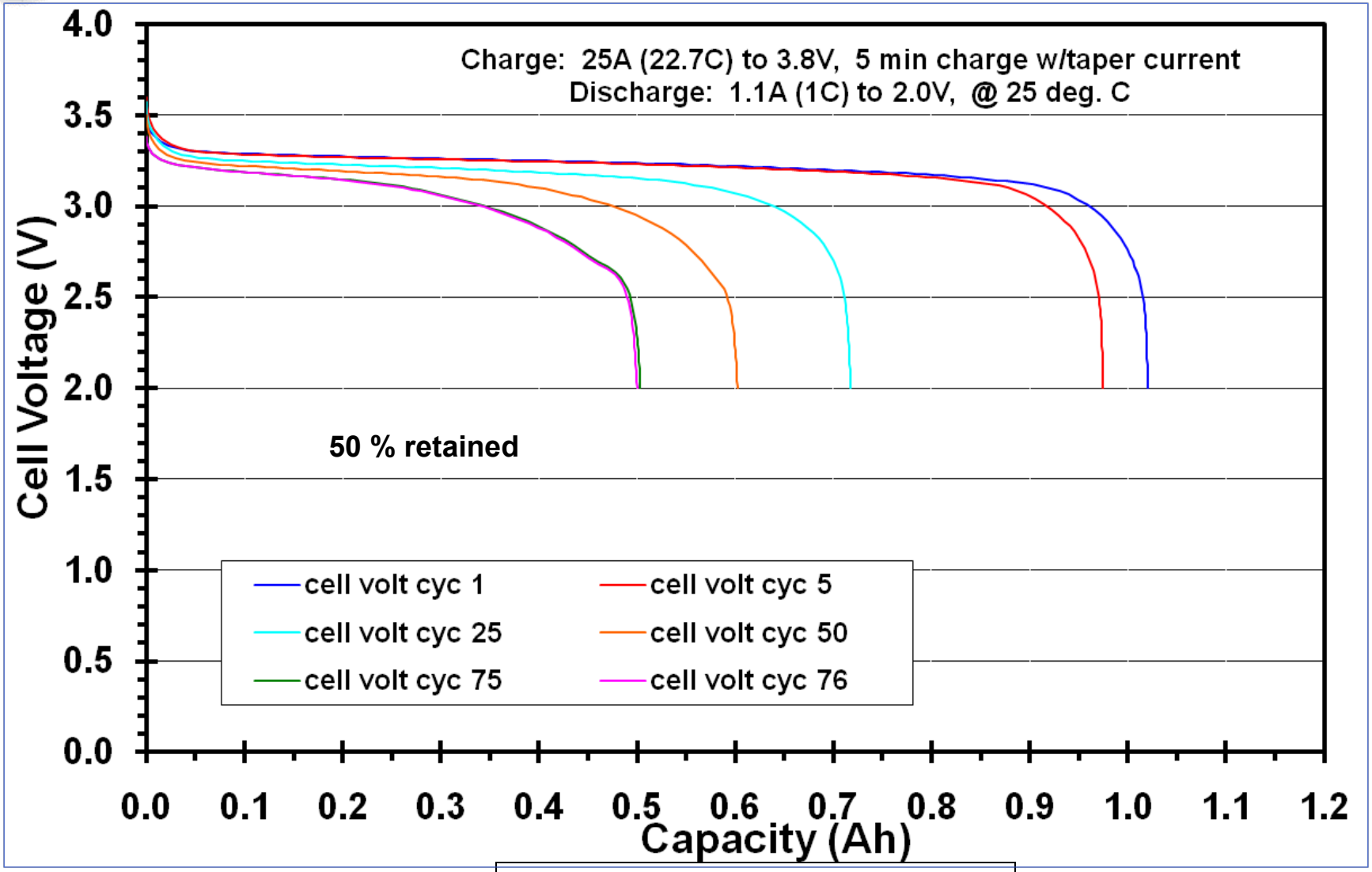
# Fast Charge Test on A123 18650 Cells

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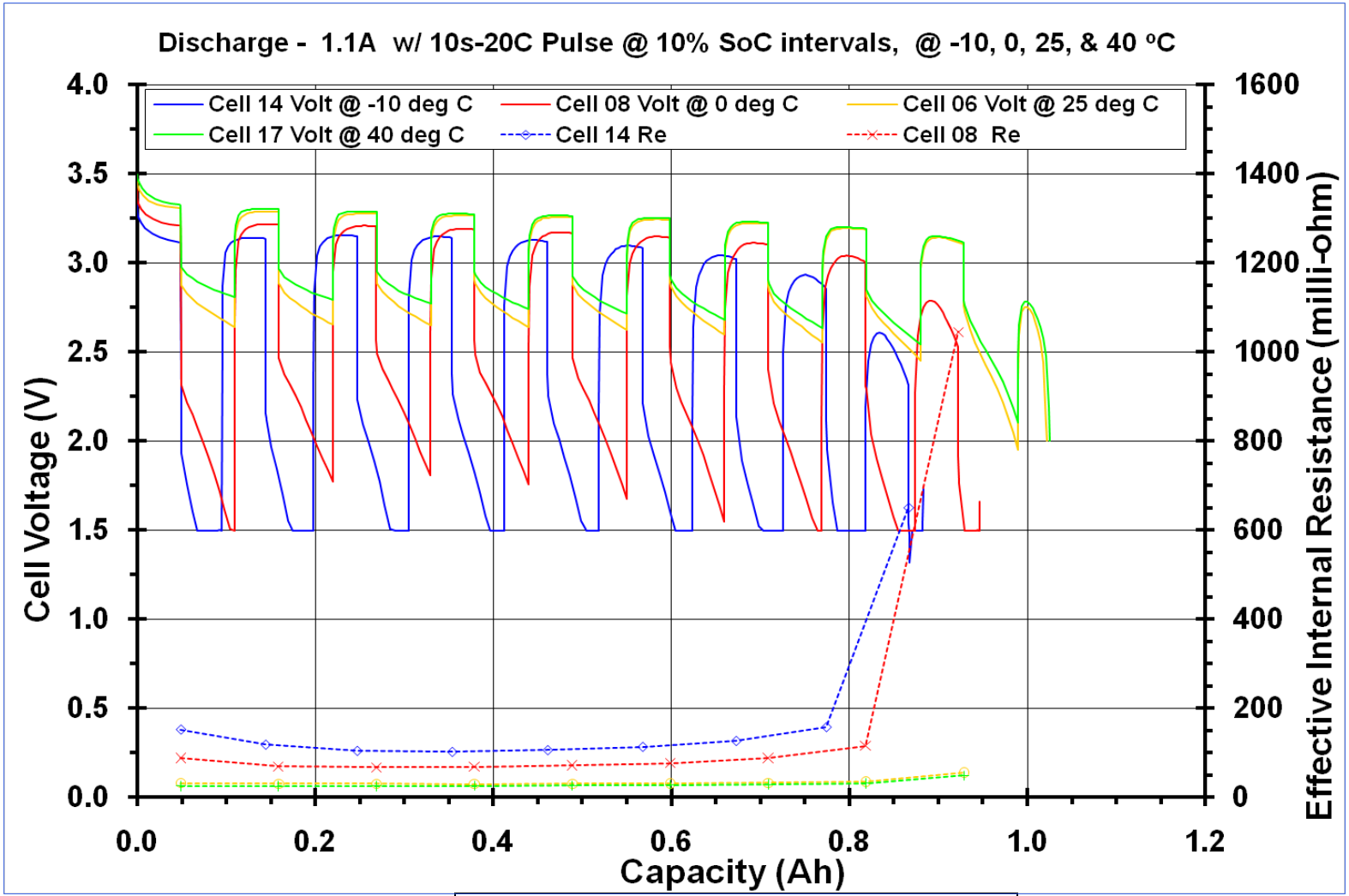
# Performance of A123 18650 Cells at Different Temperatures

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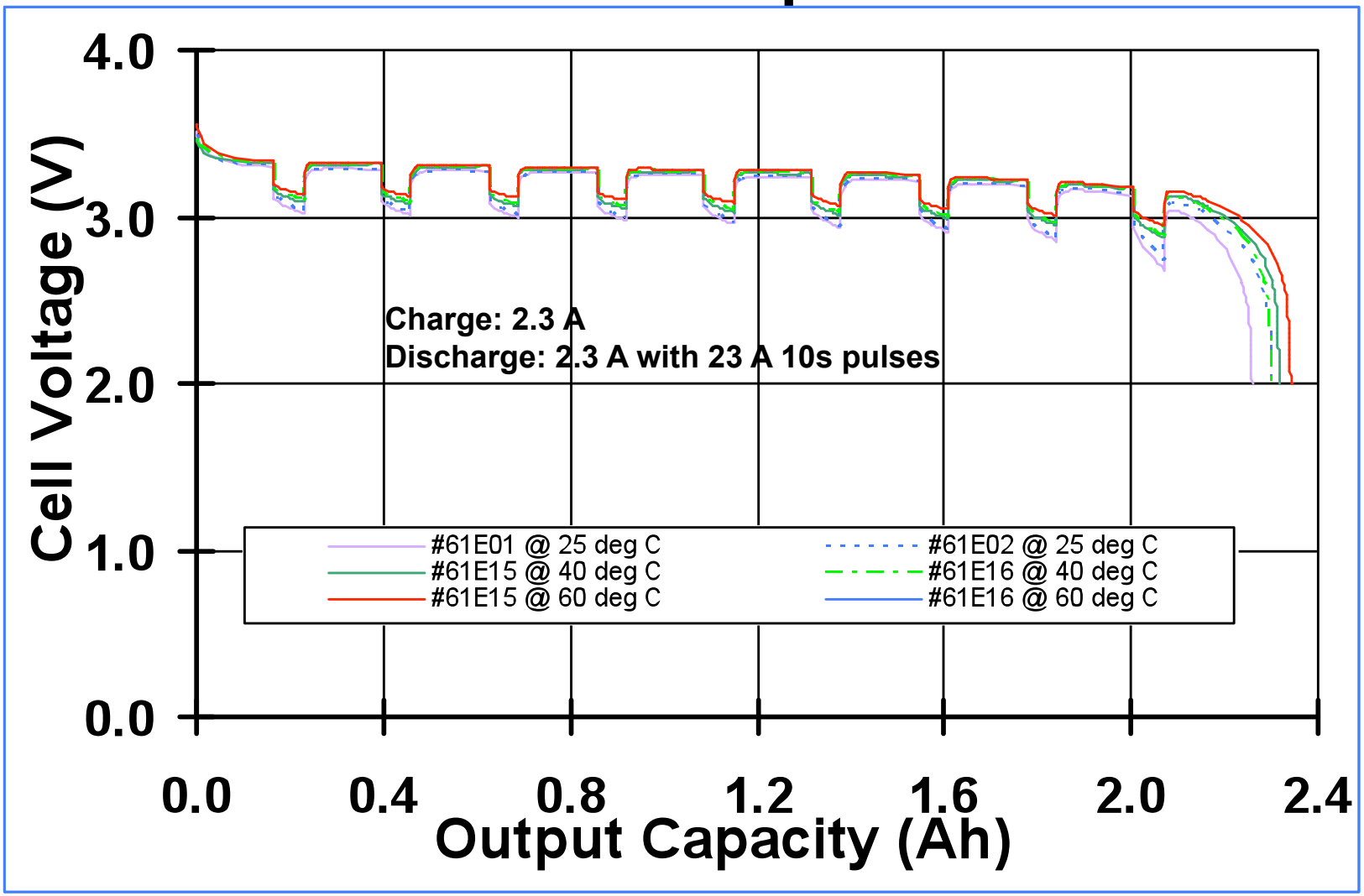
# Pulse Performance of A123 26650 Cells at Different Temperatures

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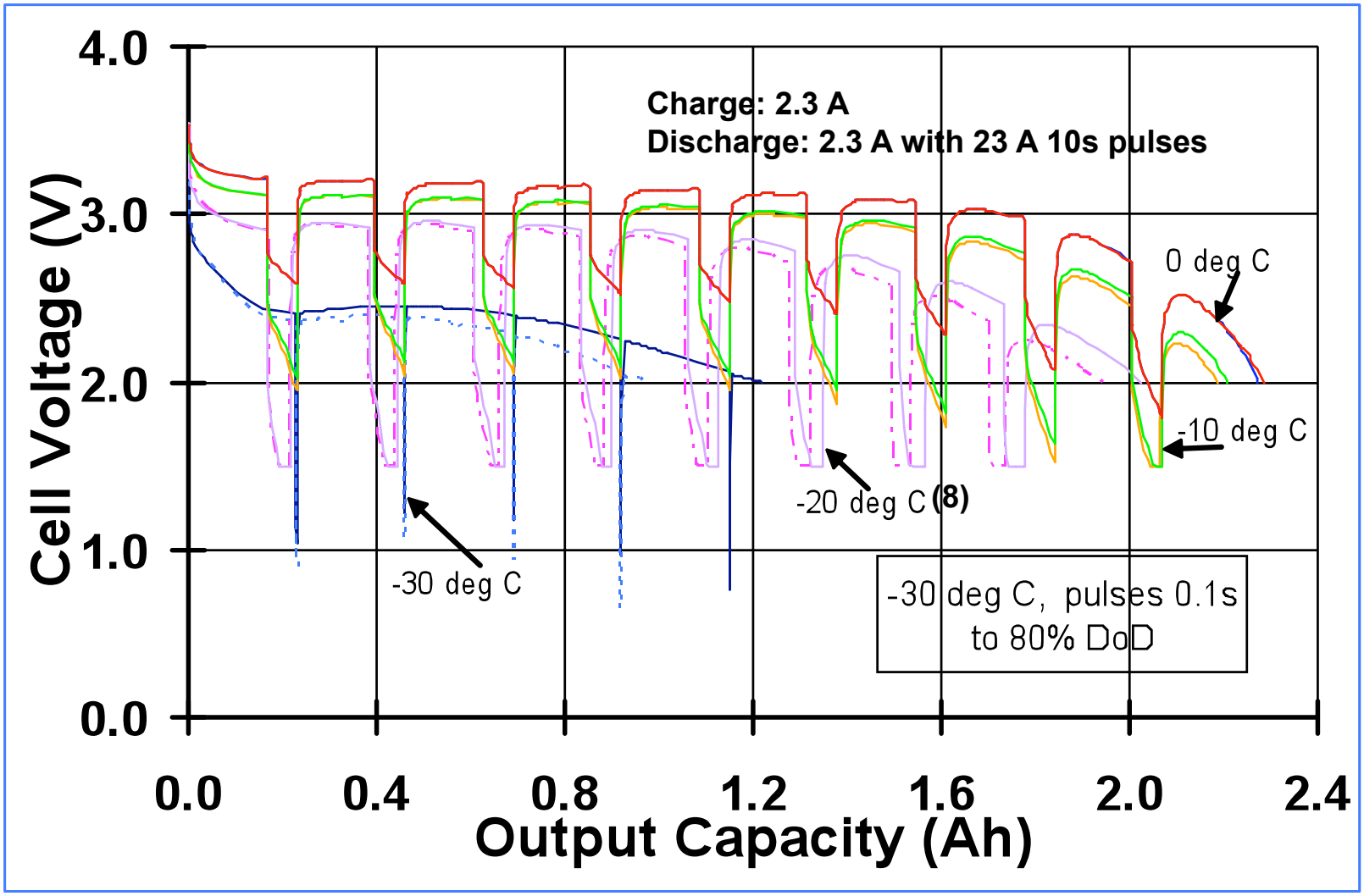
# Low Temperature Pulse Performance for the A123 26650 Cells

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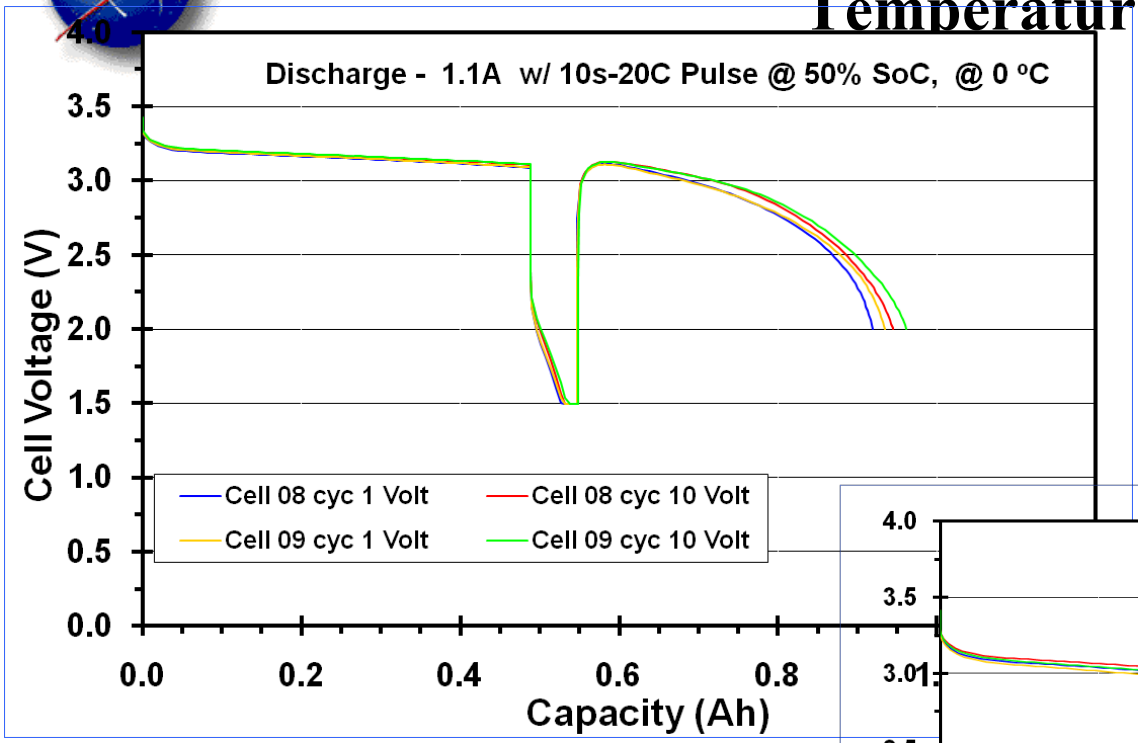
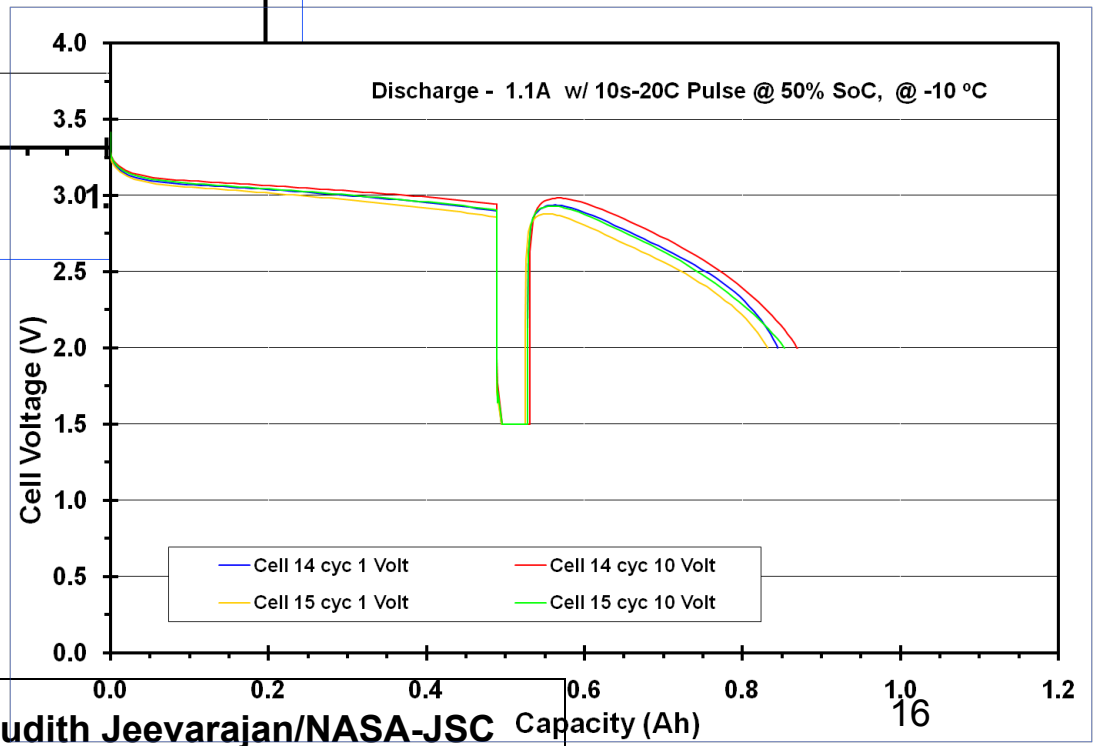
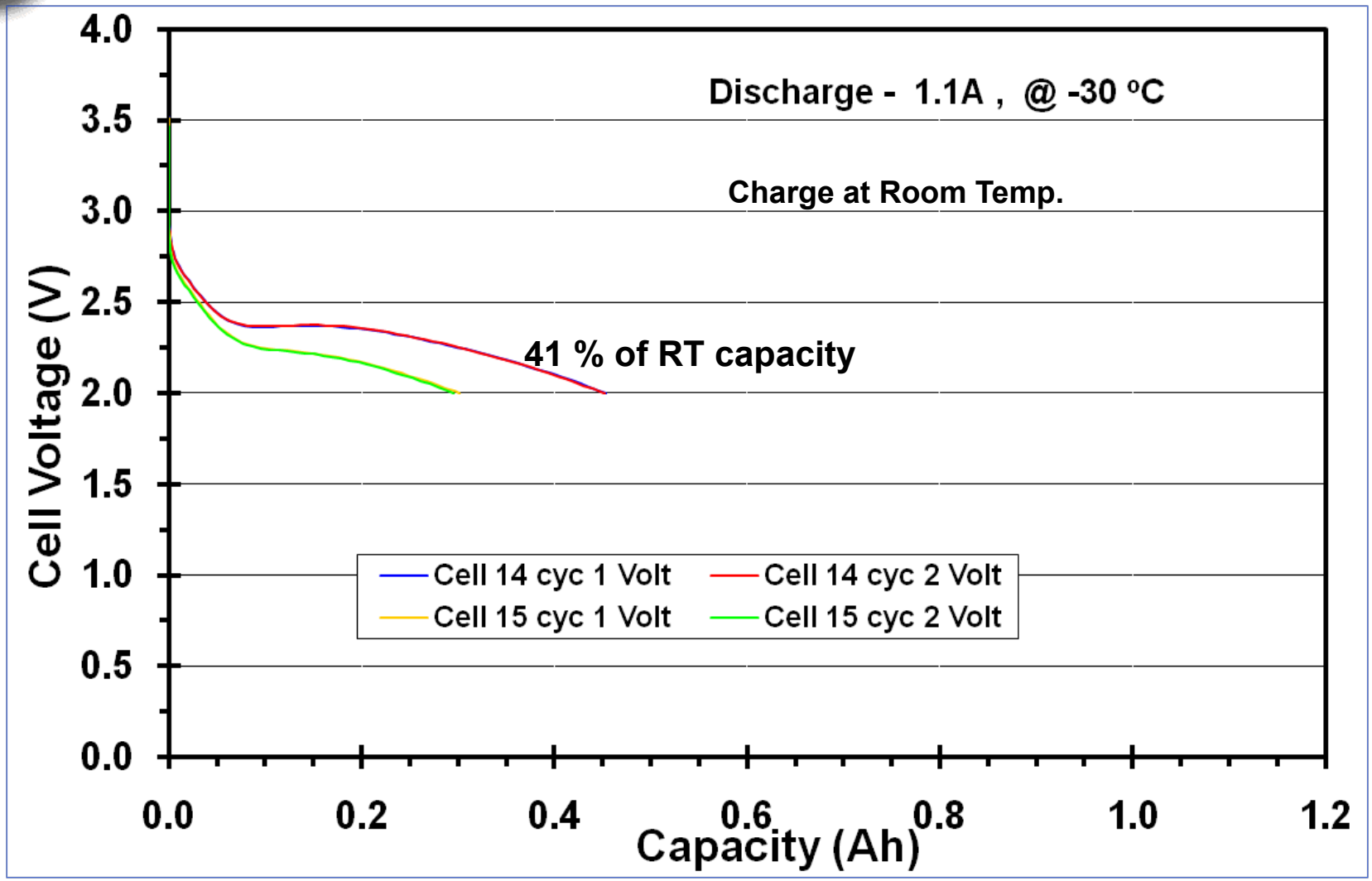
# Performance of A123 18650 Cells at Different Temperatures



# Discharge of A123 18650 Cells at -30 ºC

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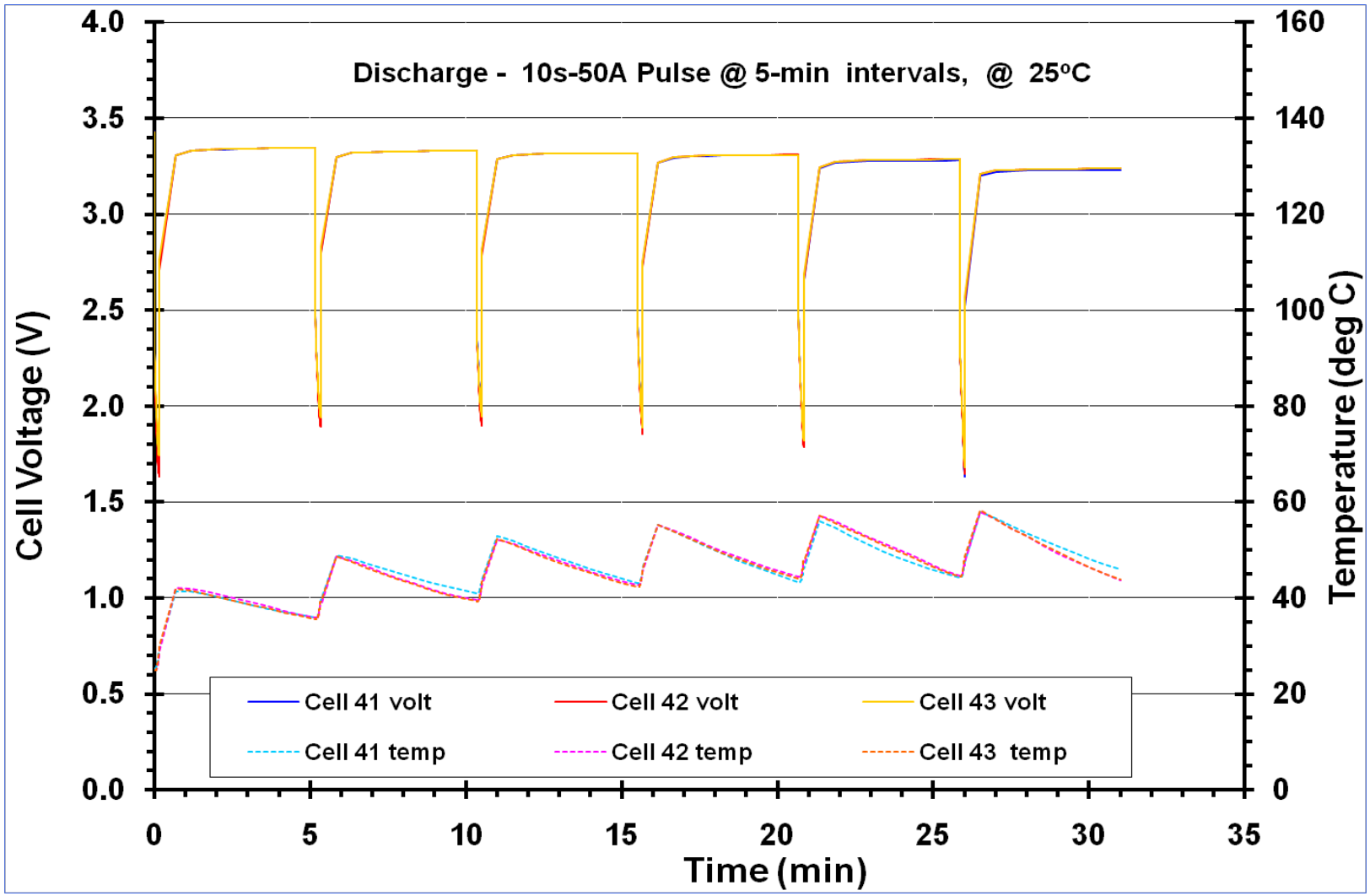
# Maximum Pulse Capability for the A123 18650 Cells

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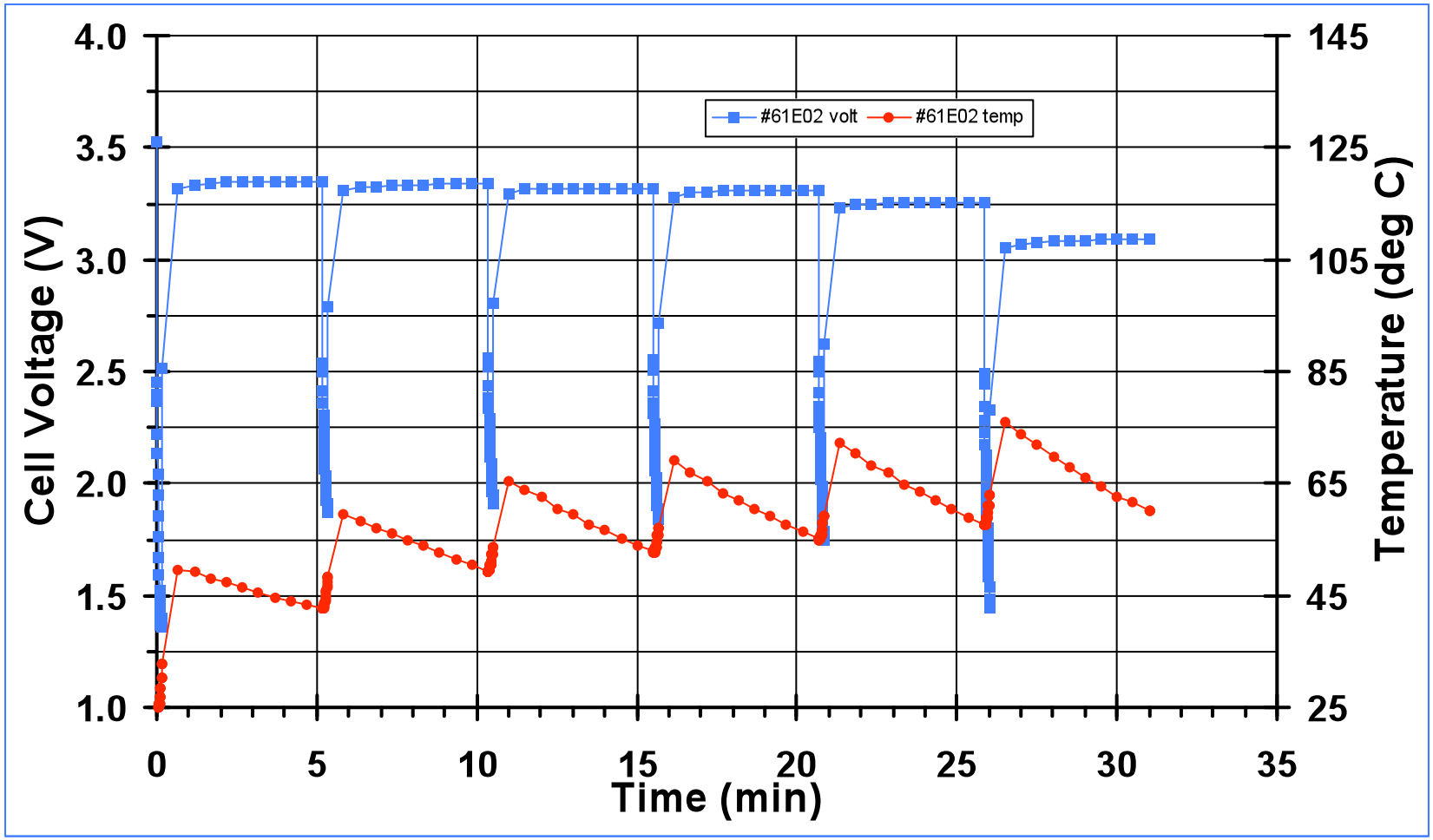
# Maximum Pulse Capability for the A123 26650 Cells




**Pulse Load: 130 A**

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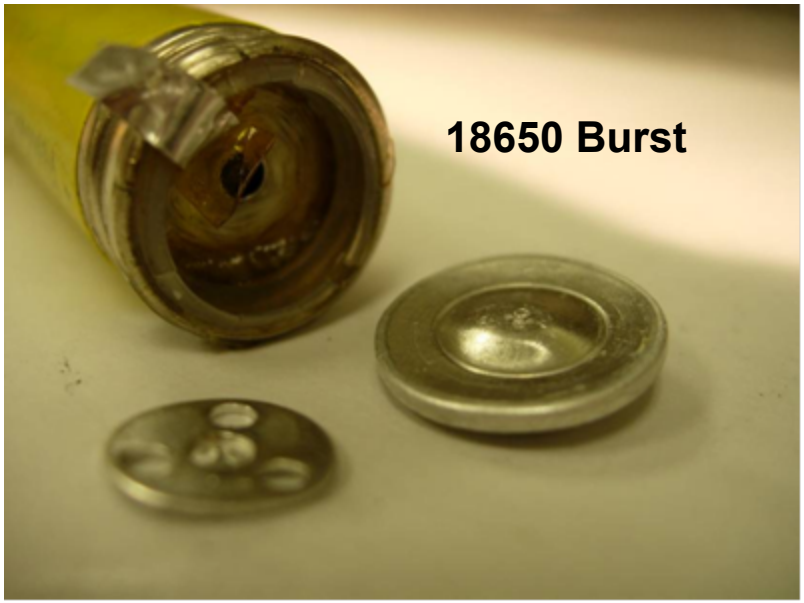
# Vent and Burst Pressure Test for A123 Cells

**18650 Cell:**

**Vent : 539 and 485 psi**

**Burst: 800 to 849 psi**

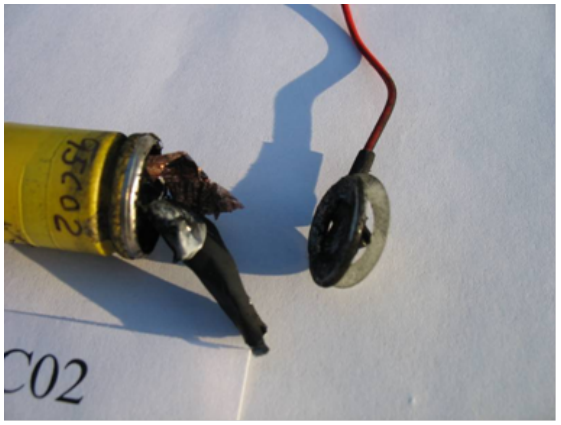



**26650 Cell :**

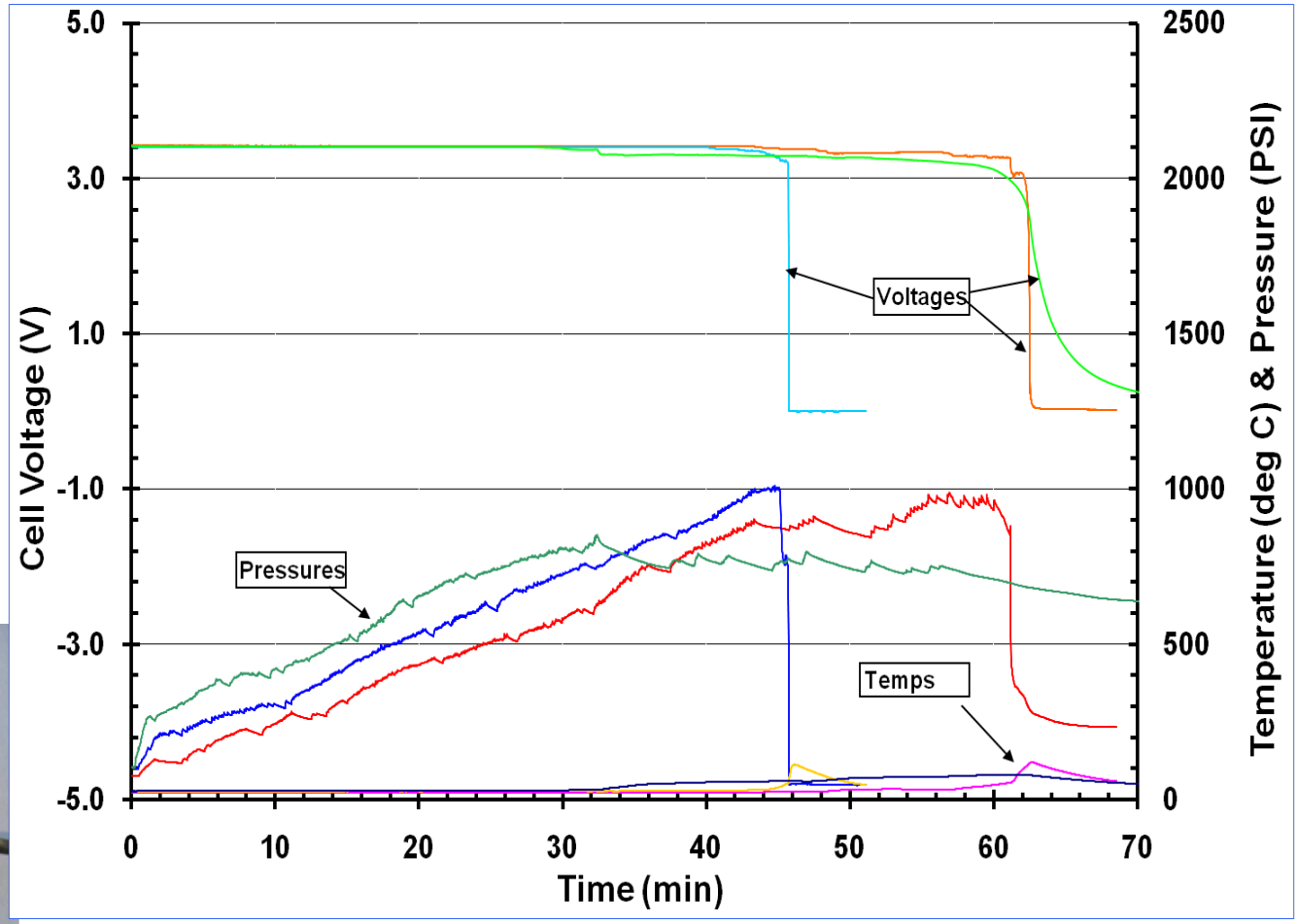
**Vent: approx. 320 to 340 psig**

**Burst: approx. 425 psig**

# Simulated Internal Short (Crush) for A123 18650 Cells





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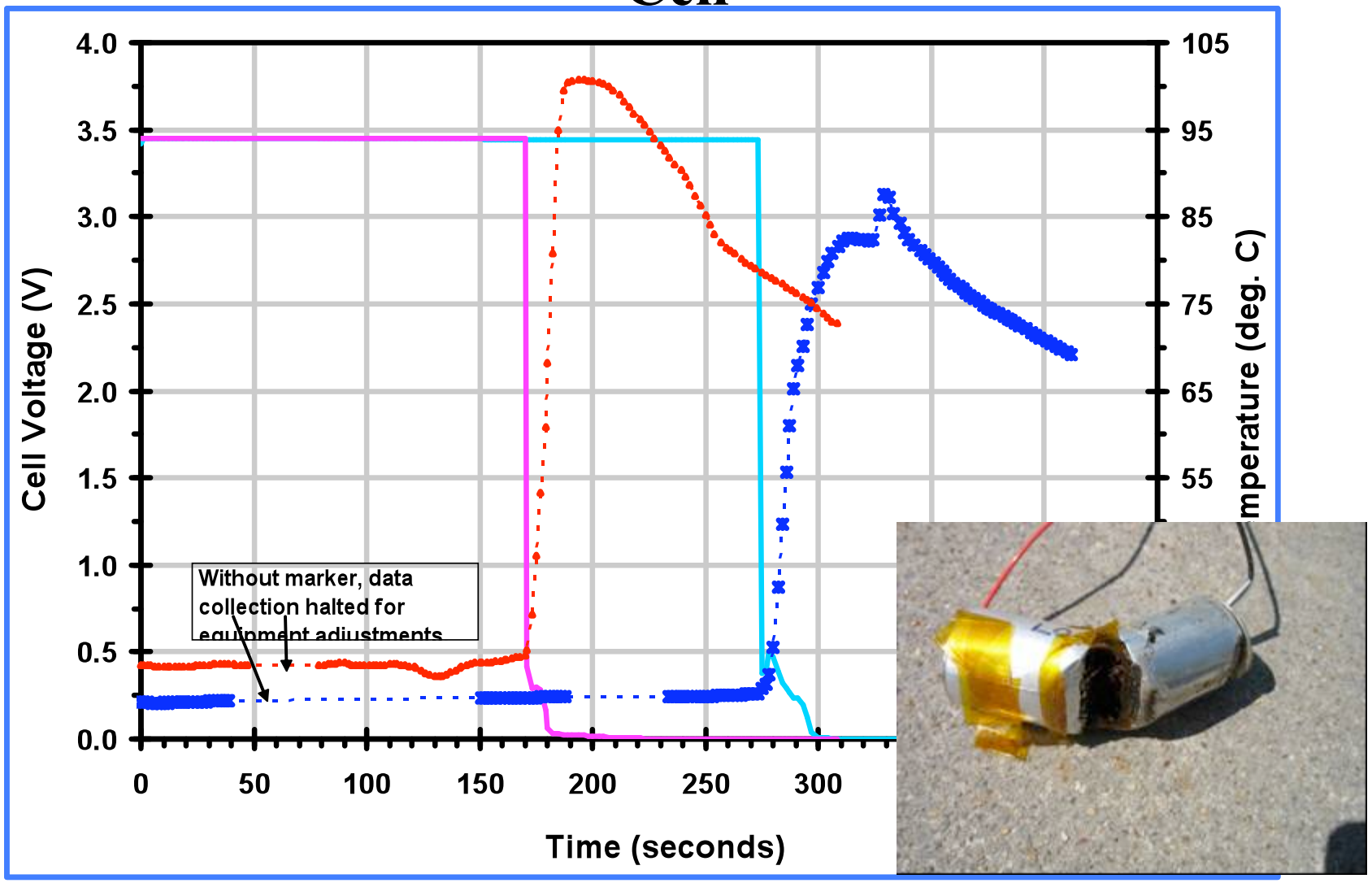
# Simulated Internal Short (Crush) for A123 26650 Cell



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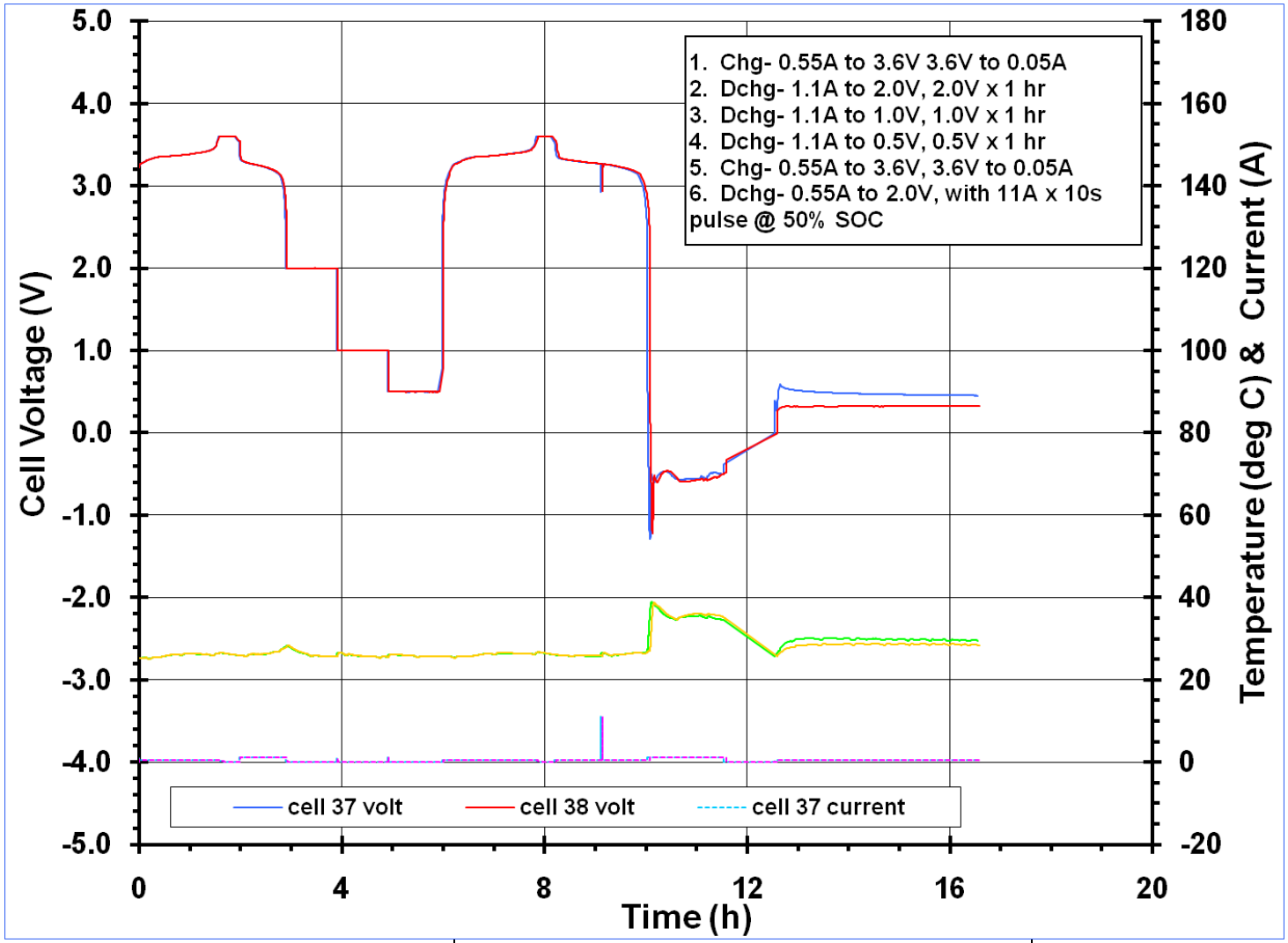
# Overdischarge Into Reversal Test on A123 18650 Cells

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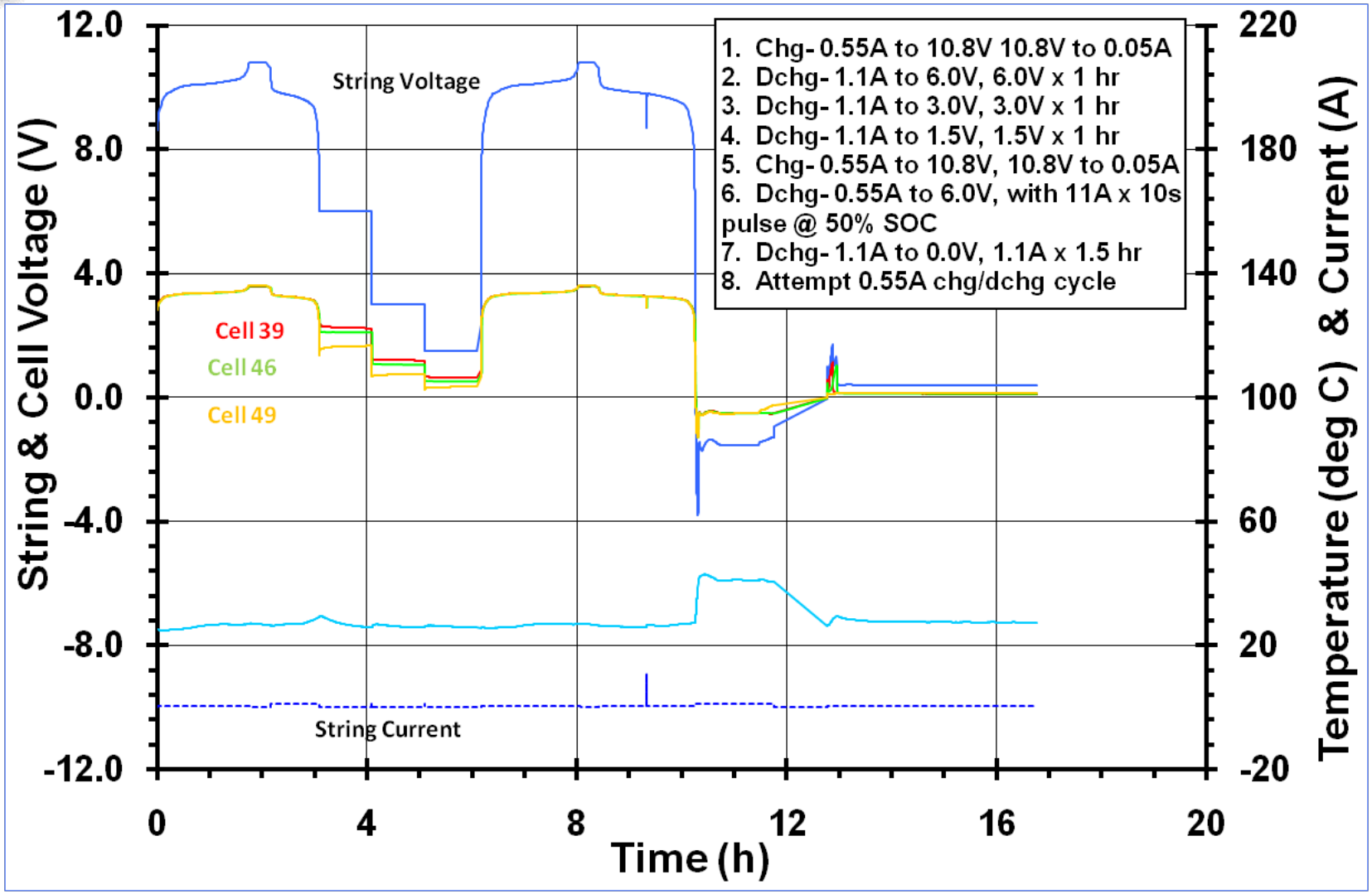
# Overdischarge of String (3S) of A123 18650 Cells

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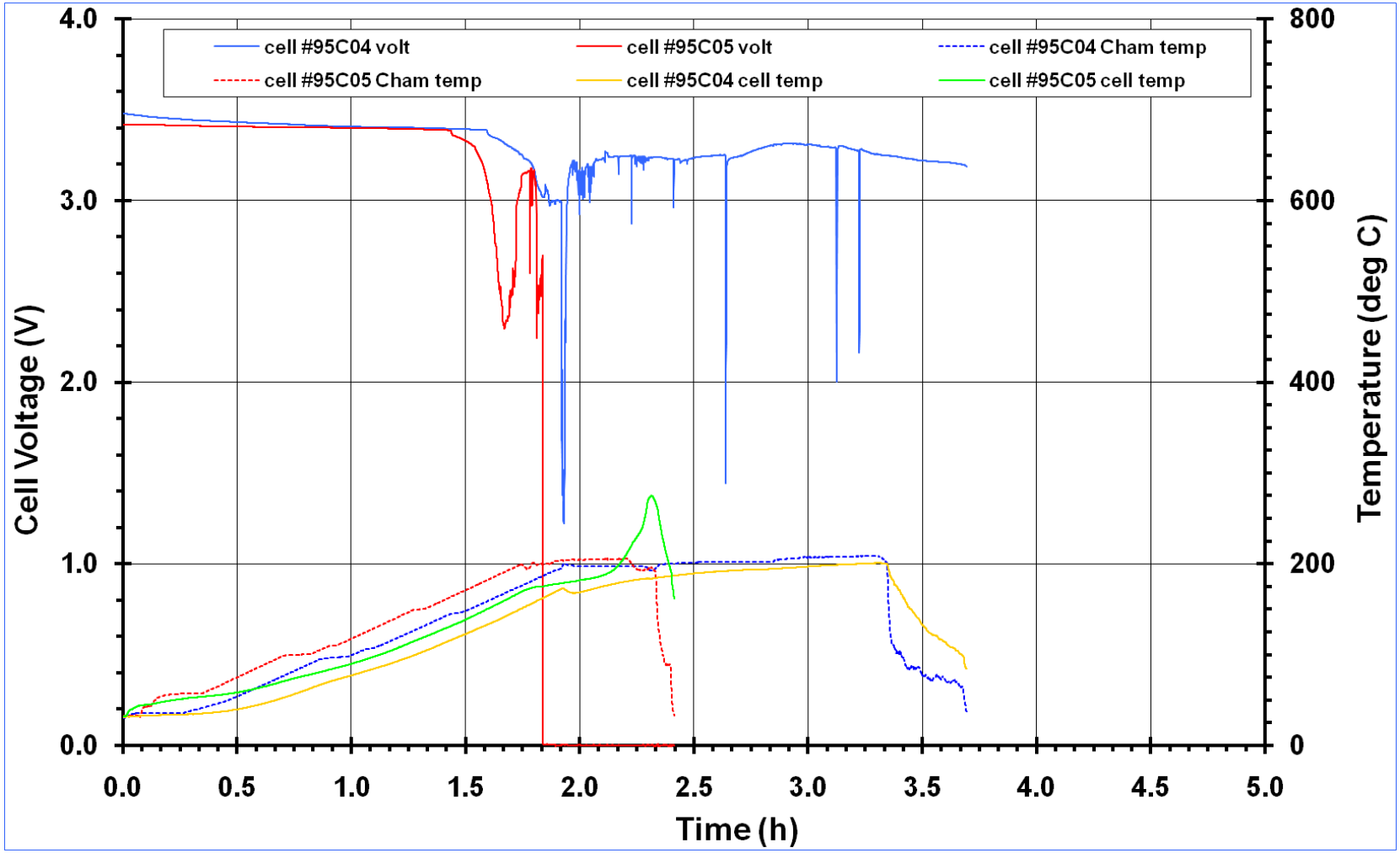
# Heat-to-Vent Test on A123 18650 Cells




**No flame or sparks during venting**

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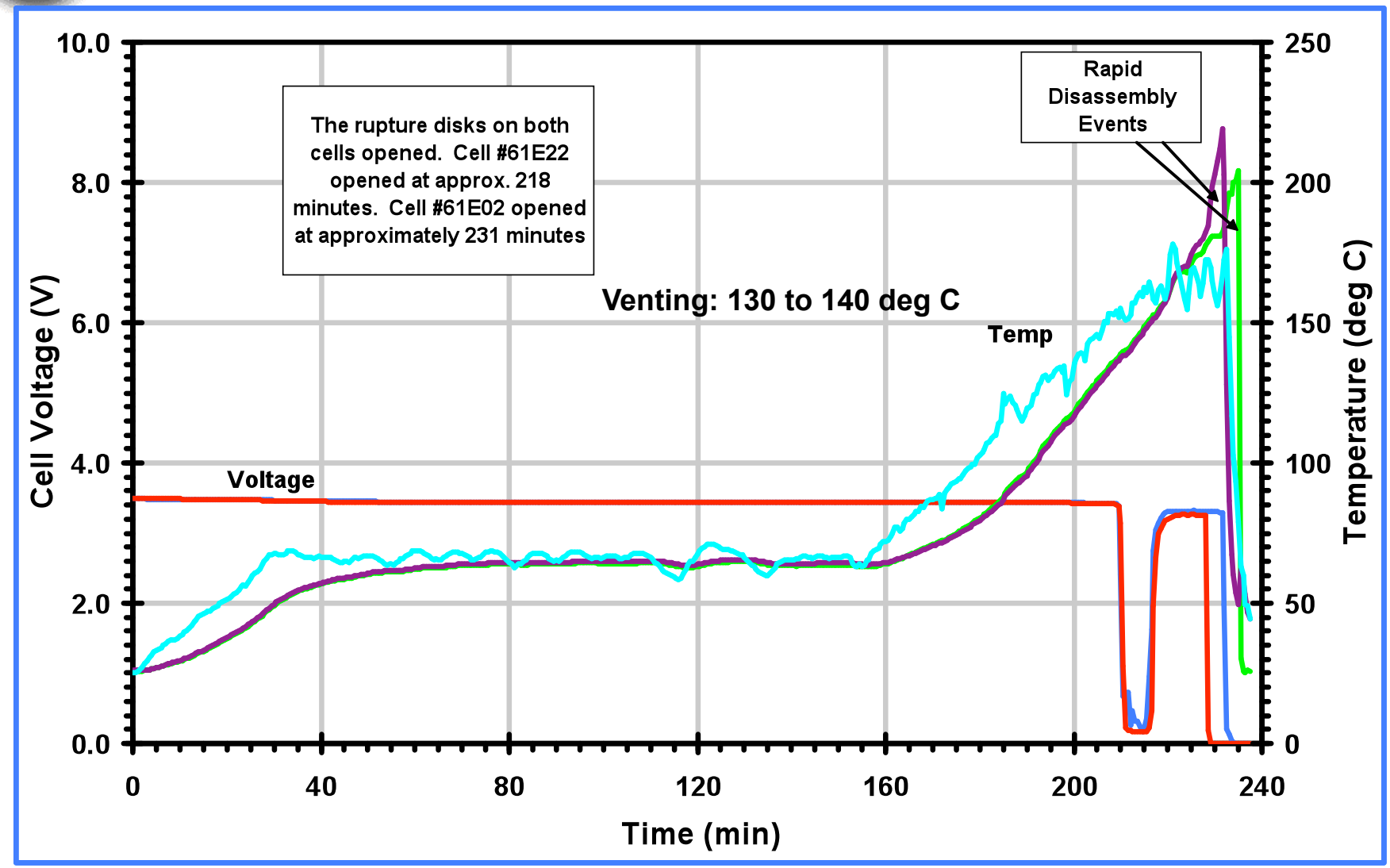
# Heat-to-Vent Test on A123 26650 Cells

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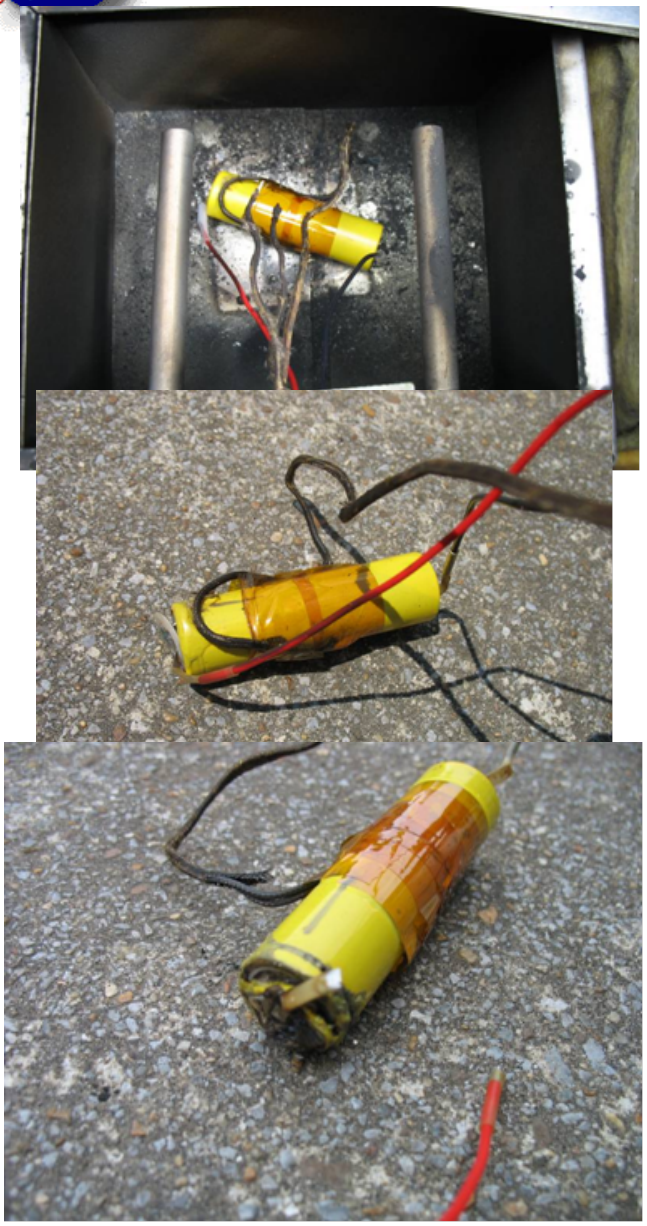
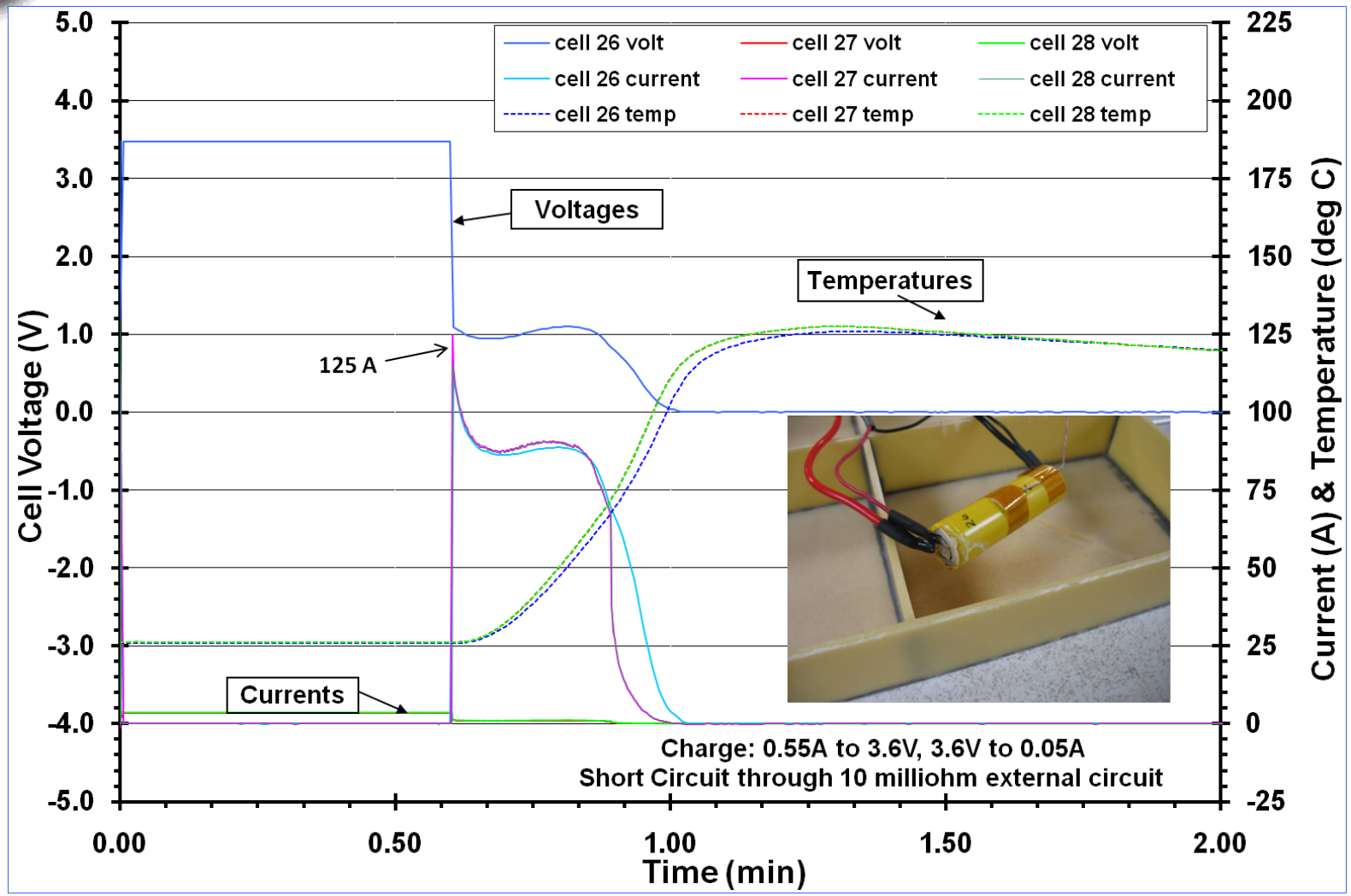
# Heat-to-Vent Test

18650 Cells



26650 Cells

# External Short Circuit Test on A123 18650 Cells

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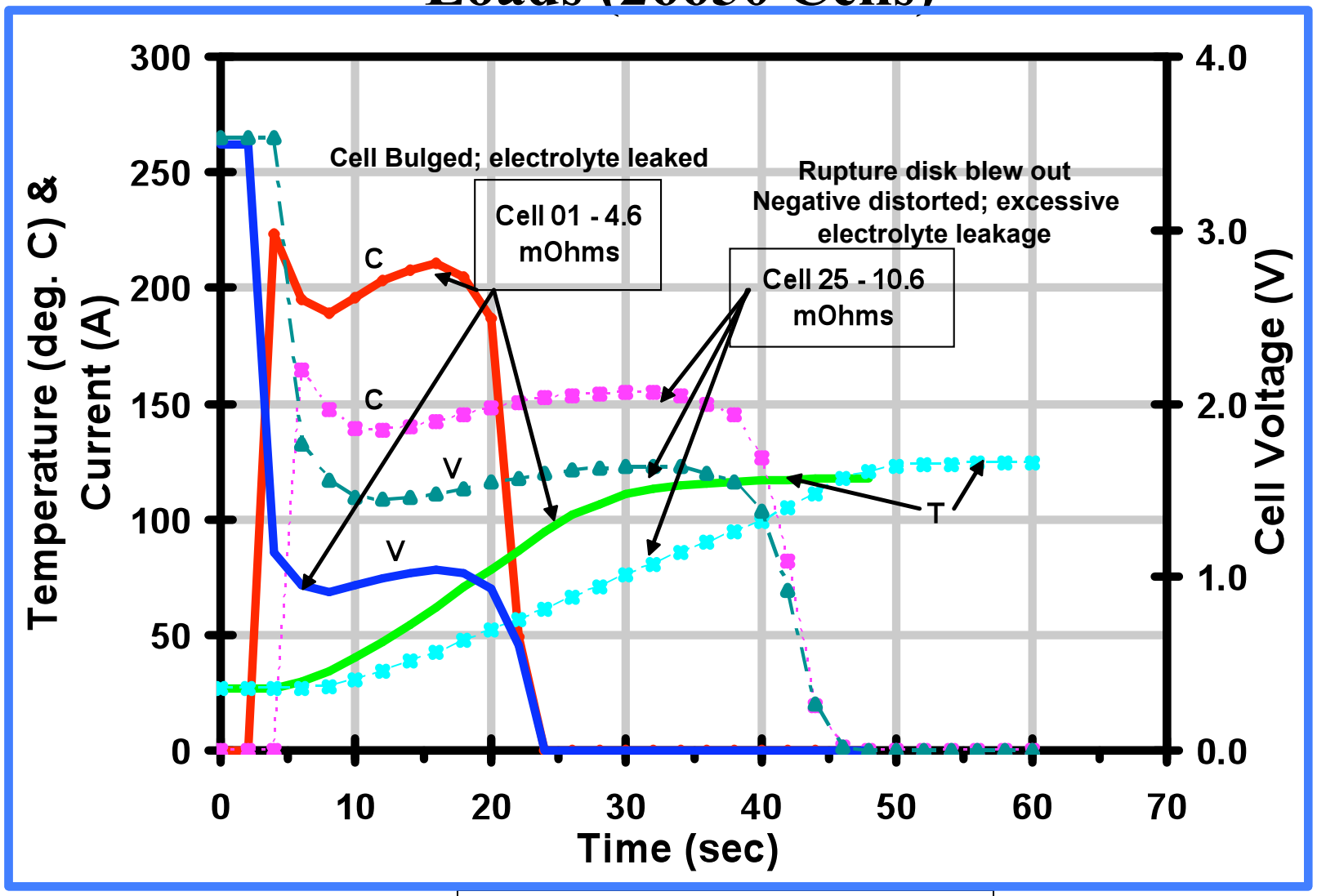
# External Short Circuit Using Two Different Loads (26650 Cells)

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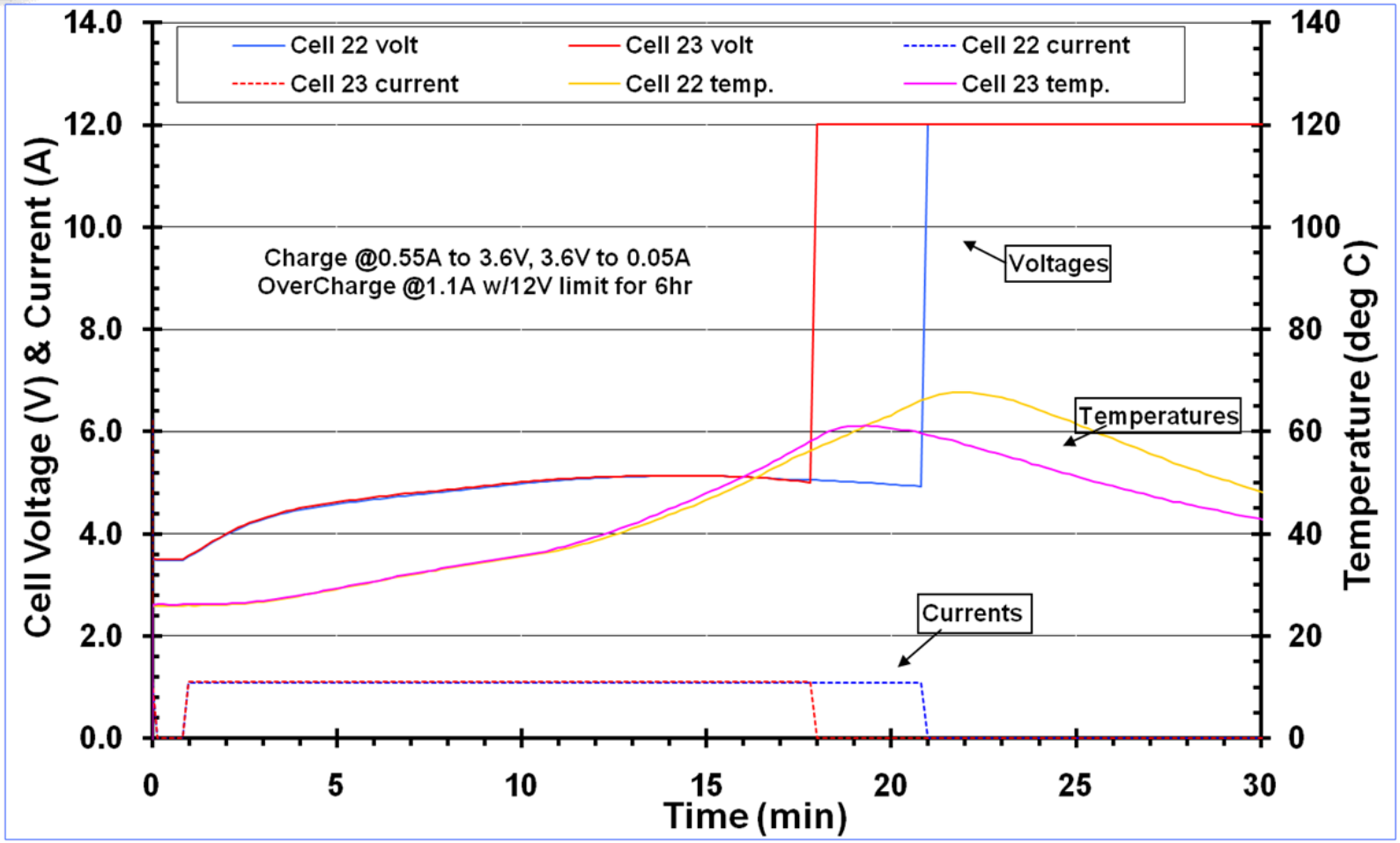
# Overcharge Test on A123 18650 Cells

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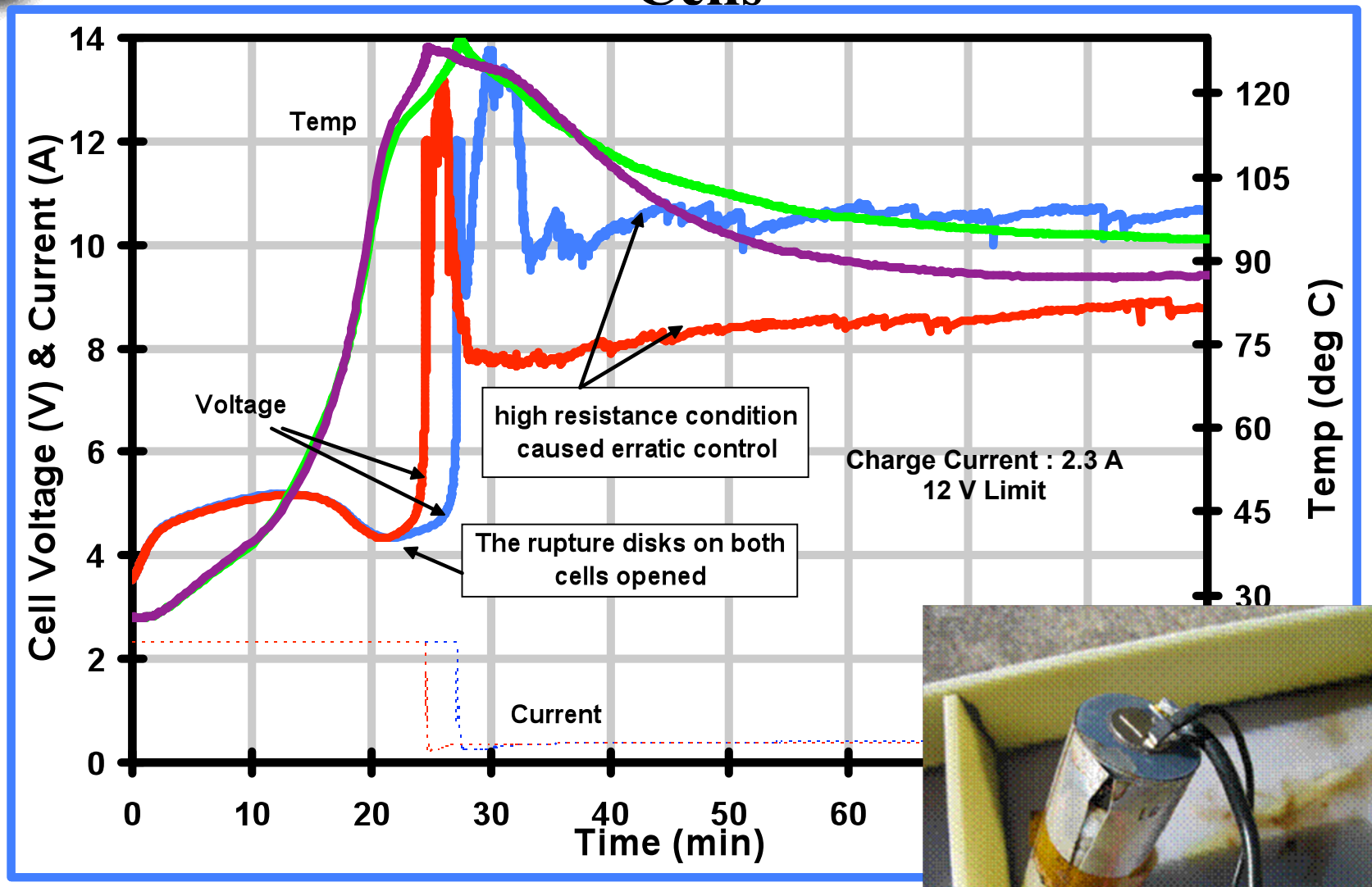
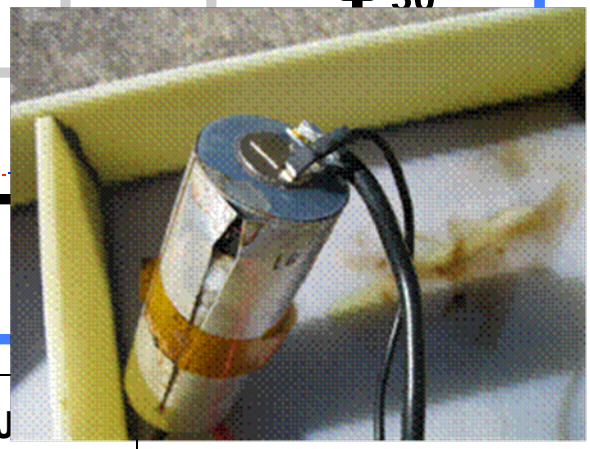
# Overcharge Test at 1C Rate to 12 V on 26650 Cells



Cells Ruptured with 10 A overcharge

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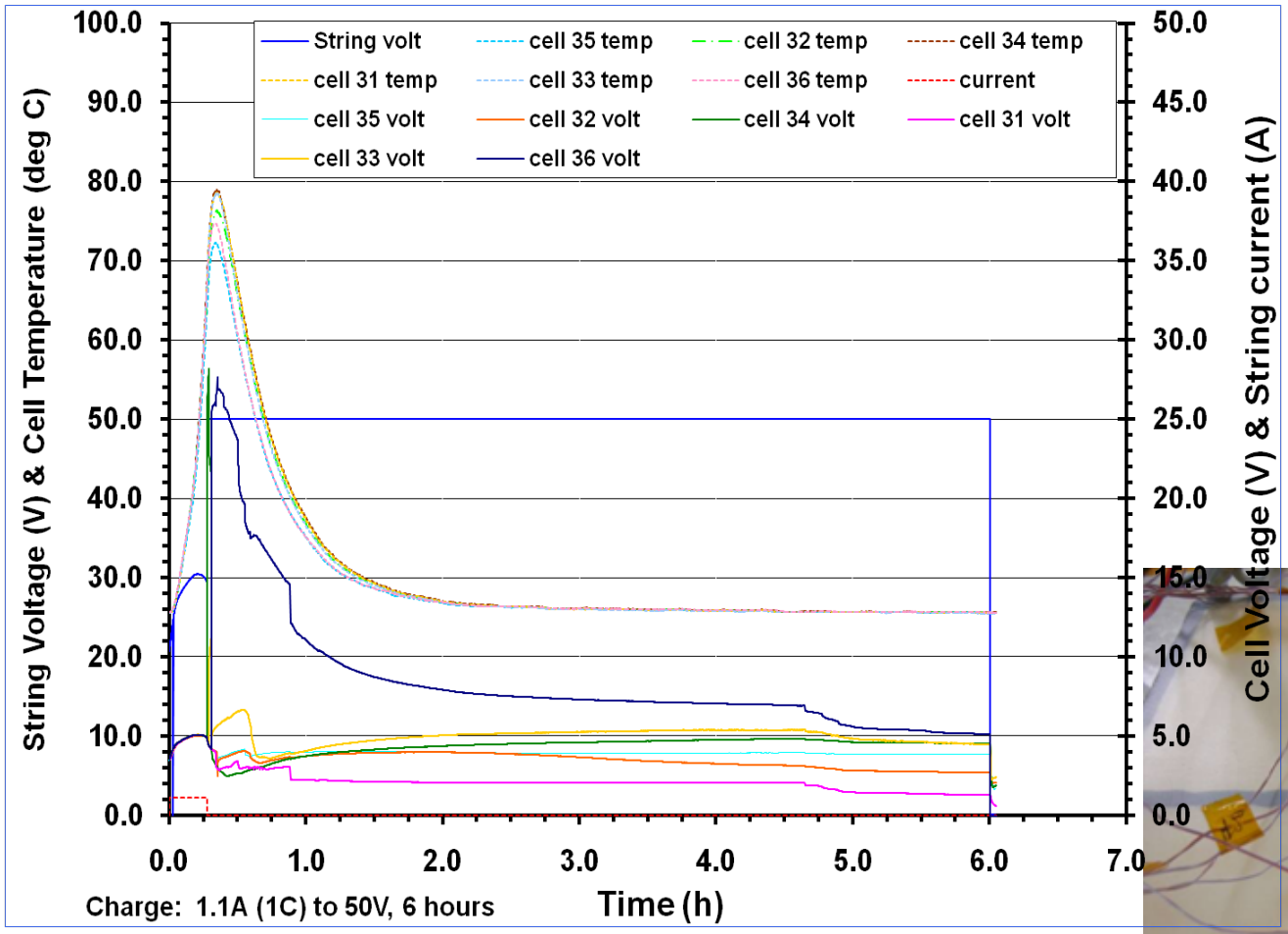
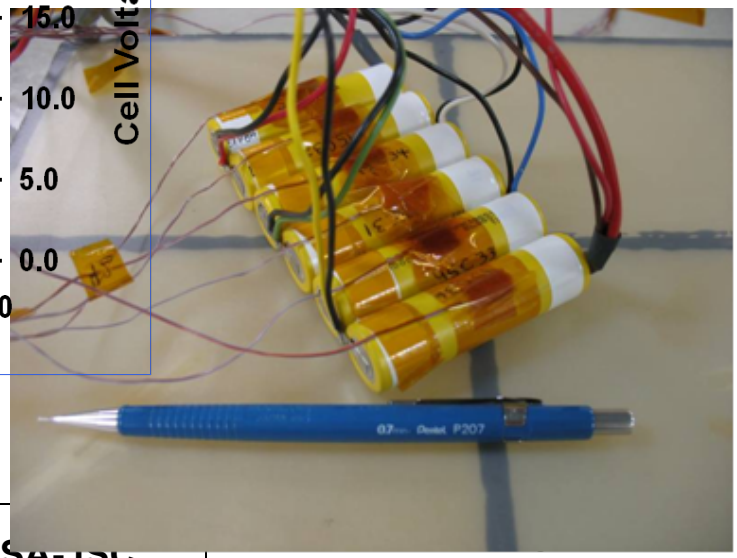
# Overcharge at 1 C Rate on a 6-Cell Series String of A123 18650 Cells



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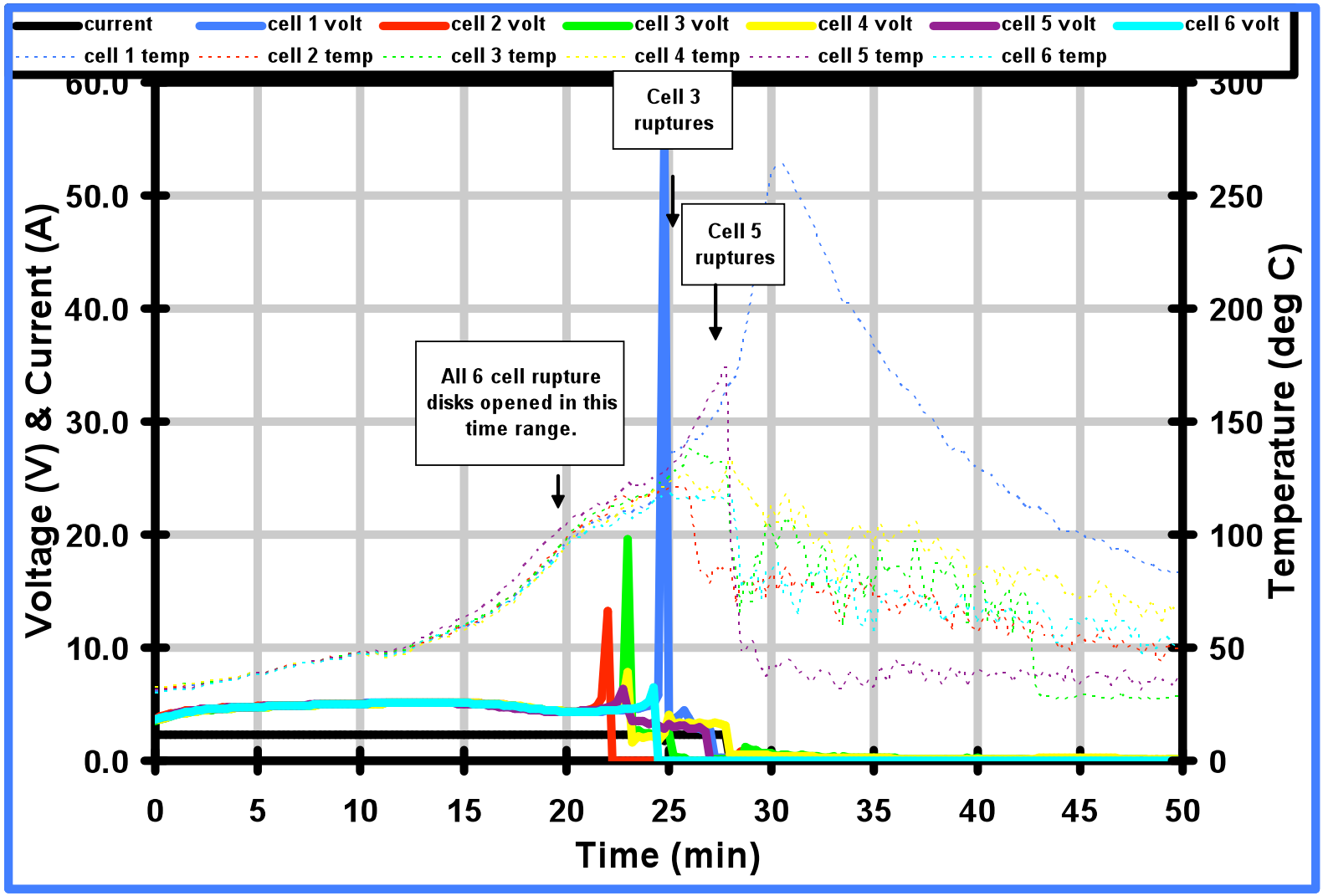
# Overcharge at 1 C Rate on a 6-Cell Series String (26650 Cells)

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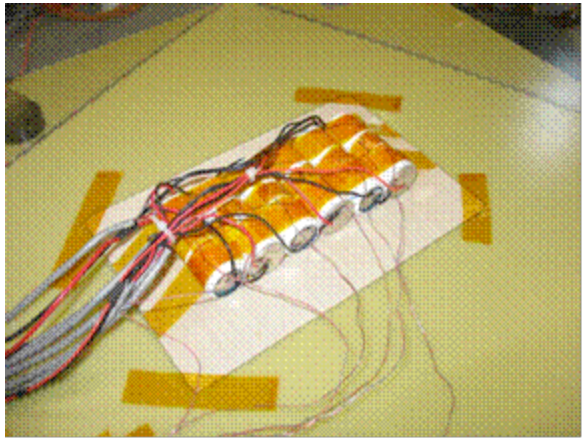
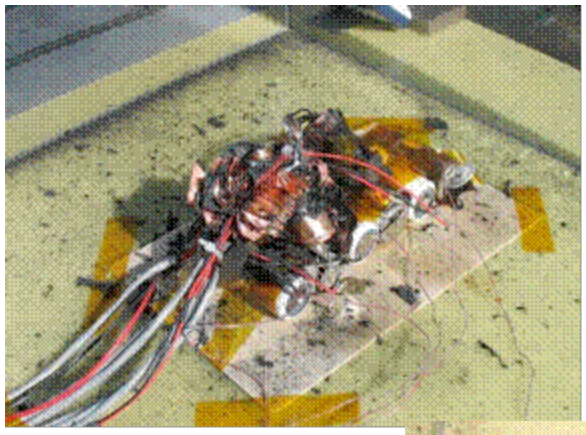
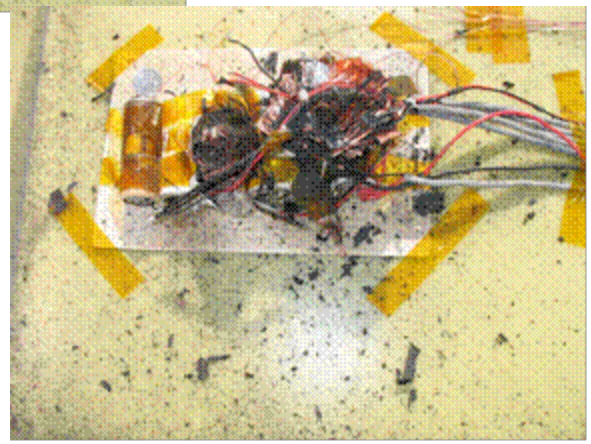
# Six-Cell String Overcharge Test on 26650 Cells







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# Conclusions

- Performance tests of the A123 under different load currents and at different temperatures have been performed
- Cells have shown excellent cycle life performance under the conditions tested except for the -30 °C
- Cells have fast charge and discharge capability as well as high rate pulse capability
- The safety tests indicate that the cells are tolerant to an overdischarge into reversal at the single cell and series string level; the cells vented and sprayed electrolyte under external short circuit conditions and produced a lot of smoke during the hear-to-vent test; CID opening was recorded under overcharge conditions at the single cell and series string level; no cell disassembly under overcharge in a string configuration; cell disassembly observed in one out of 3 simulated internal short tests.
- The burst to vent ratio was approx 1.5.
- The 18650 cells have a more robust design making them more tolerant to off-nominal conditions such as overcharge.

# Acknowledgment

T/J Technologies/A123 : Les Alexander

SRI : Brad Strangways, Tim Nelson