Office of Vehicle Technologies

Idaho National Laboratory

Gen 3 Cell Testing

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DOE Vehicle Technologies Annual Merit Review, FY2008
February 26, 2008

This presentation does not contain any proprietary or confidential information

Outline

- Purpose
- Barriers
- Approach
- Previous Reviewer Comments
- FY07 Accomplishments
- Future Activities
- Summary

Purpose, Barriers, and Approach

- **Purpose:**
  - Provide aged Gen3 cells to diagnostic laboratories with precisely known aging histories to elucidate degradation mechanisms.
  - Compare NCA material (Gen2) performance to NMC material (Gen3) performance.
- **Barriers:**
  - *Focus area:* Understand life-limiting mechanisms and enhance life
- **Approach:**
  - Conduct accelerated aging of Gen3 cells built by industrial cell manufacturers:
    - 25 Gen3 prismatic cells (Baseline and Variant A cells) [Vendor D]
    - 20 Gen3 18650 cells (Baseline and Variant A cells) [Vendor B]

Note: **The Variant A cells employ an electrolyte additive**

Previous Reviewer Comments

- **Make more cells to permit statistical significance.**
  - Original plan was to build more cells once a qualified manufacturer was identified. Approach has changed in favor of studying aging mechanisms in multiple cell chemistries.
- **Use statistics more to measure quality control in manufacturing.**
  - This will not be done due to change in approach, which requires fewer cells of each chemistry type.
- **Perform tear down/diagnostic studies to find fault in bad cells.**
  - This will be done at the conclusion of life testing.

FY07 Accomplishments

(25) 400 mAh Gen3 Cells (Prismatic)

- **Matrix:**
  - Calendar-Life at 60% SOC:
    - **45°C** - 2 Baseline cells and 5 Variant A cells
    - **55°C** - 2 Baseline cells and 5 Variant A cells
  - Cycle-Life at 60% SOC:
    - **25°C** - 5 Variant A cells
    - **45°C** - 4 Variant A cells
  - Characterization:
    - 1 Baseline cell and 1 Variant A cell (reference point for diagnostic work)
- **Testing Status:**
  - Characterization completed (C/1, L-HPPC, C/25, EIS)
    - BSF = 1376 (Baseline cells) and 1224 (Variant A Cells)
  - Life testing (32 weeks)
    - Some cells have already reached EOL.

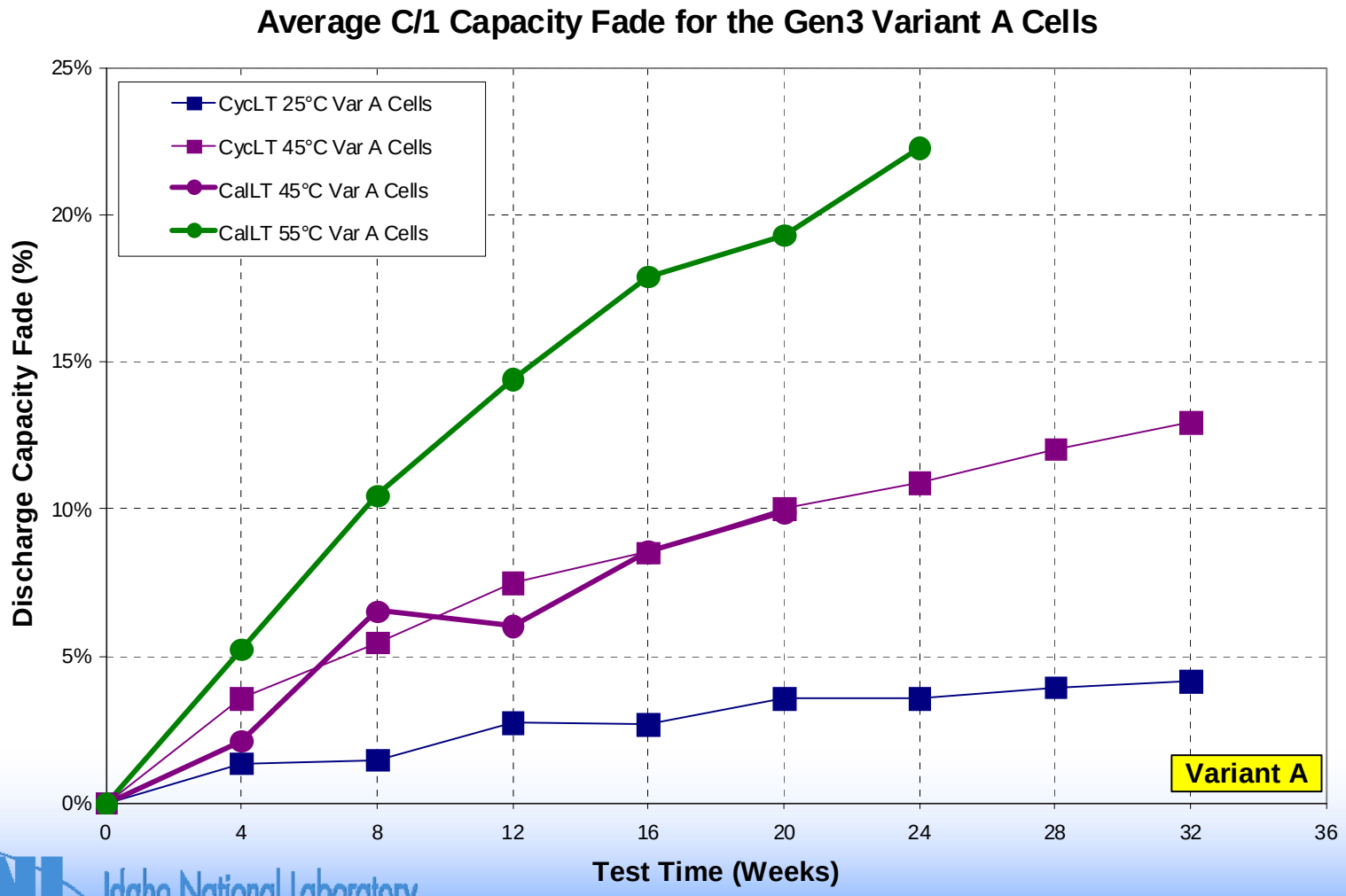
FY07 Accomplishments (cont.)

- **Pouch Cell Performance Summary**

	Temp (ºC)	Life Test	C/1 Capacity Fade (%)	C/25 Capacity Fade (%)	ASI Growth (%)	Power Fade (%)	Weeks on Test
Baseline	45	Calendar	12.94%	17.12%	62.18%	40.03%	20
	55	Calendar	39.94%	28.91%	218.48%	74.01%	12
Variant A	25	Cycle	4.15%	6.26%	9.63%	9.66%	32
	45	Cycle	12.96%	14.89%	35.39%	29.70%	32
	45	Calendar	9.91%	12.38%	39.43%	30.24%	20
	55	Calendar	22.27%	21.51%	119.52%	58.76%	24

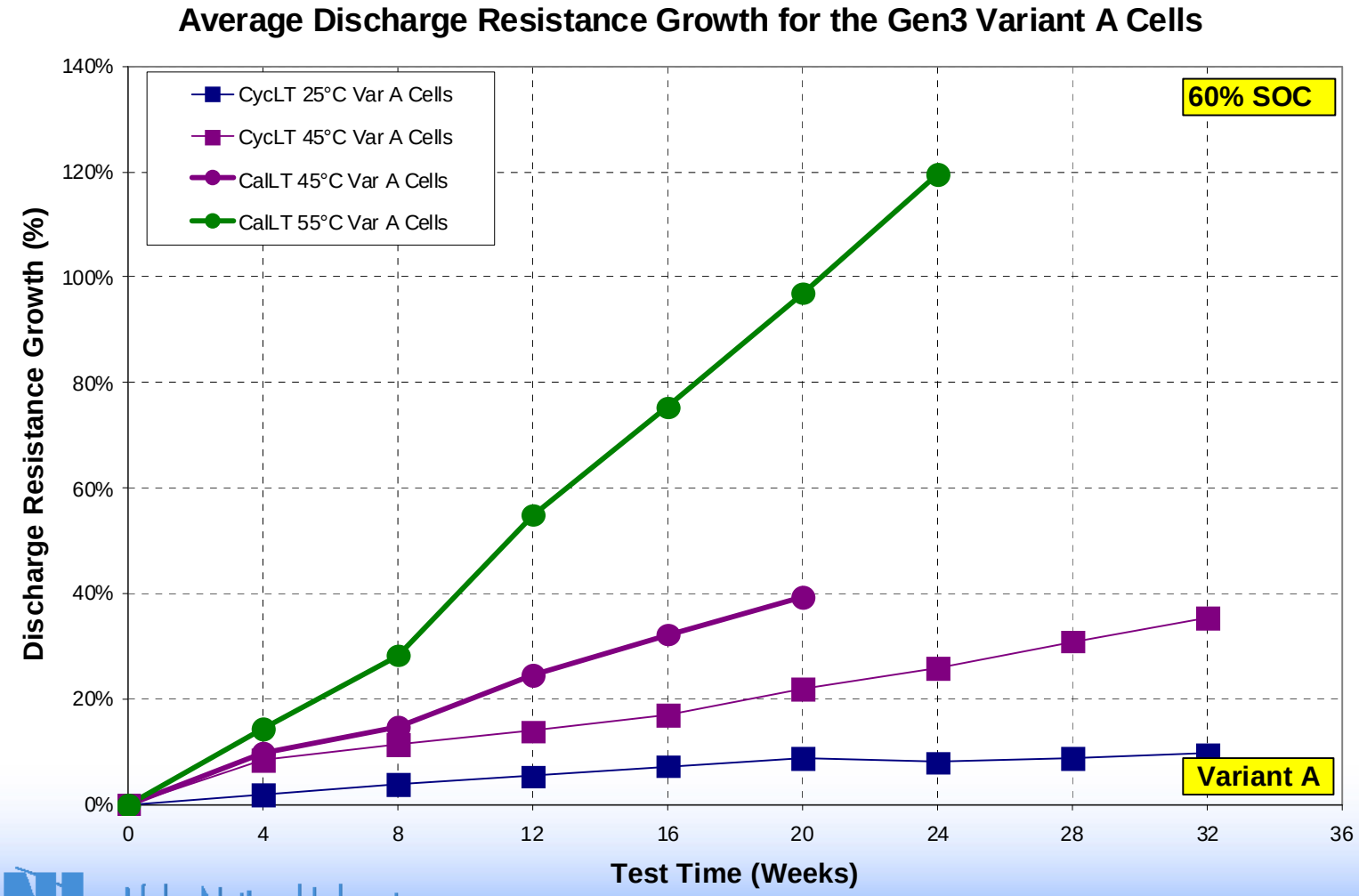
FY07 Accomplishments (cont.)

- The average discharge C/1 capacity fade increases with increasing test temperature.
- At 45°C, the Variant A cell rate of degradation appears to be independent of life testing.



FY07 Accomplishments (cont.)

- Unlike the Gen2 cells, the Gen3 Variant A calendar-life cells show a faster degradation rate through 20 weeks of aging compared to the cycle-life cells.



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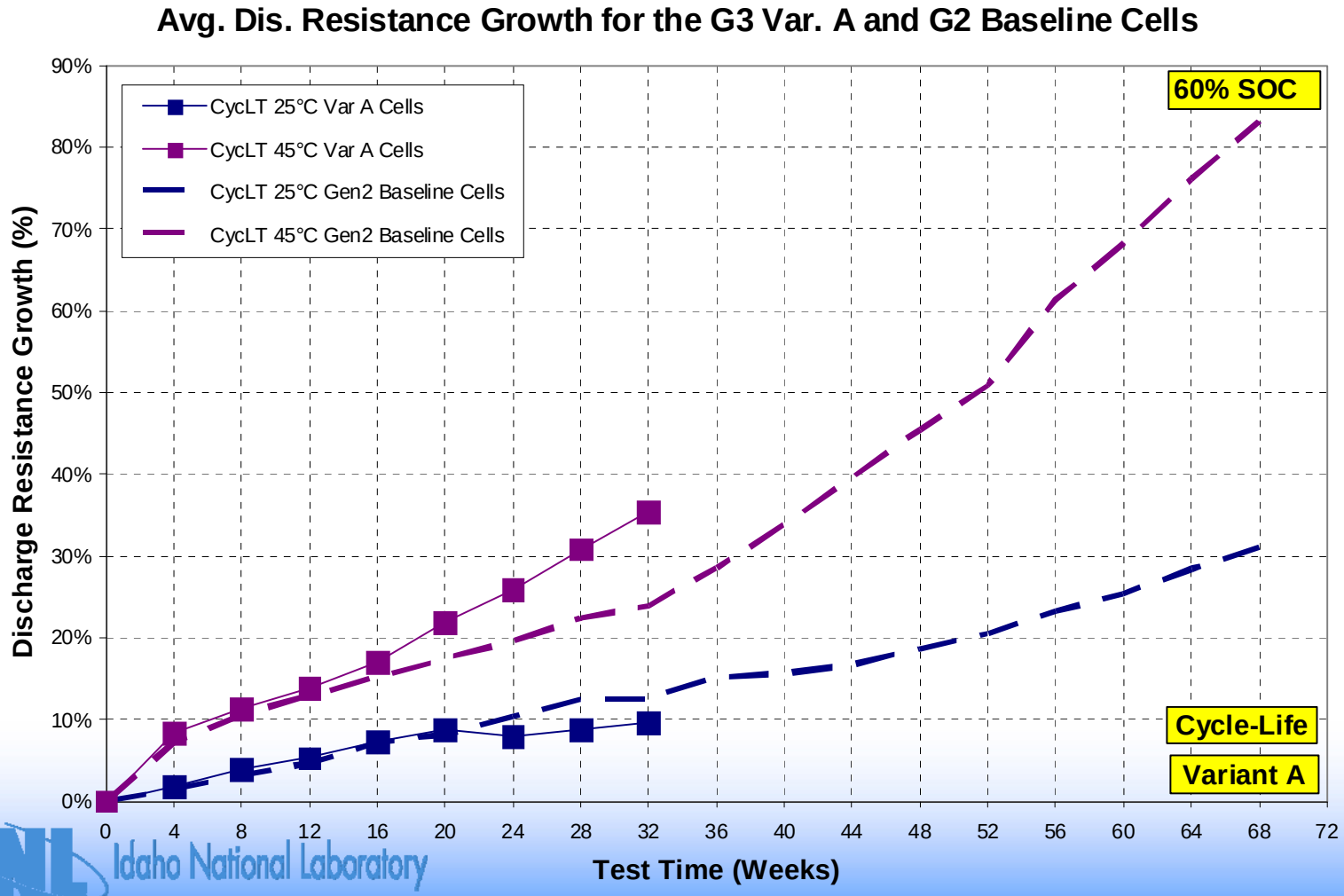
FY07 Accomplishments (cont.)

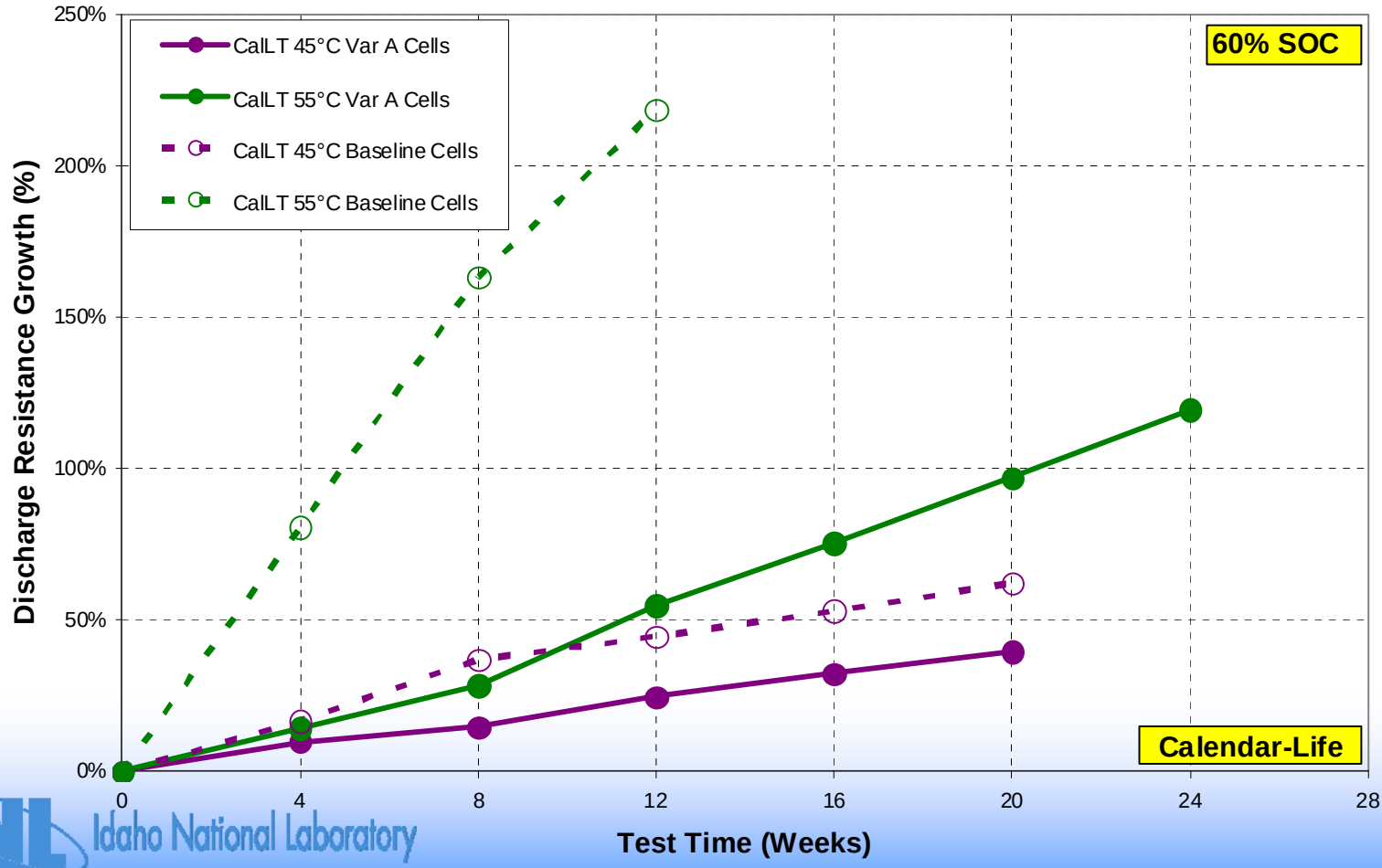
- The average discharge resistance growth at 60% SOC for Gen3 Variant A cycle-life cells is similar to the Gen2 Baseline cells through 16 weeks, but then starts to diverge.
- The change in degradation rates seems to occur earlier for the Gen3 Variant A cells.



FY07 Accomplishments (cont.)

- The average resistance growth at 60% SOC for the 45 and 55°C Gen3 Baseline calendar-life cells is larger than the corresponding Variant A cells.
- The electrolyte additive is effective in reducing the rate of impedance rise.

Avg. Resistance Growth at 60% SOC for the Gen3 Calendar-Life Cells



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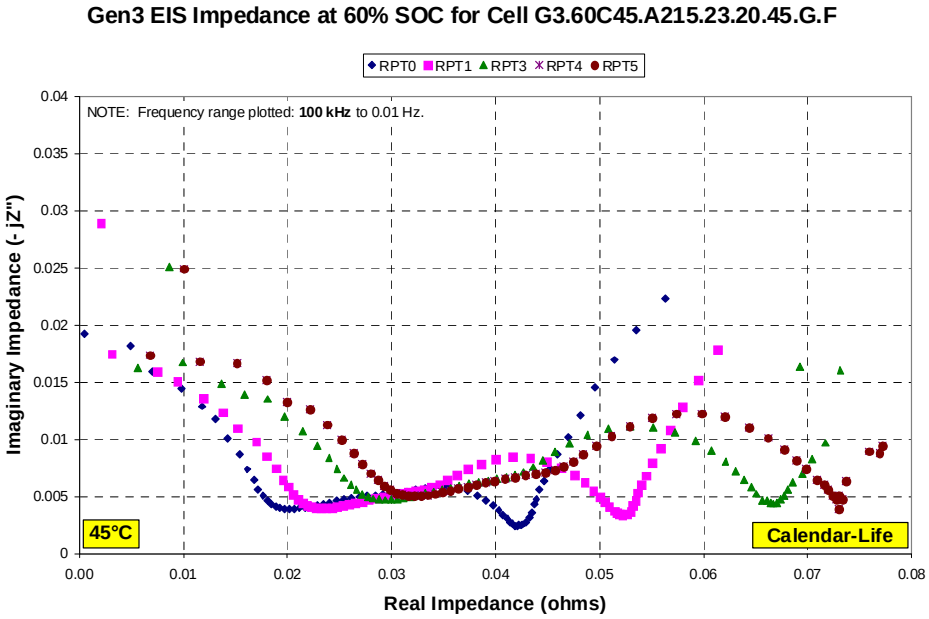
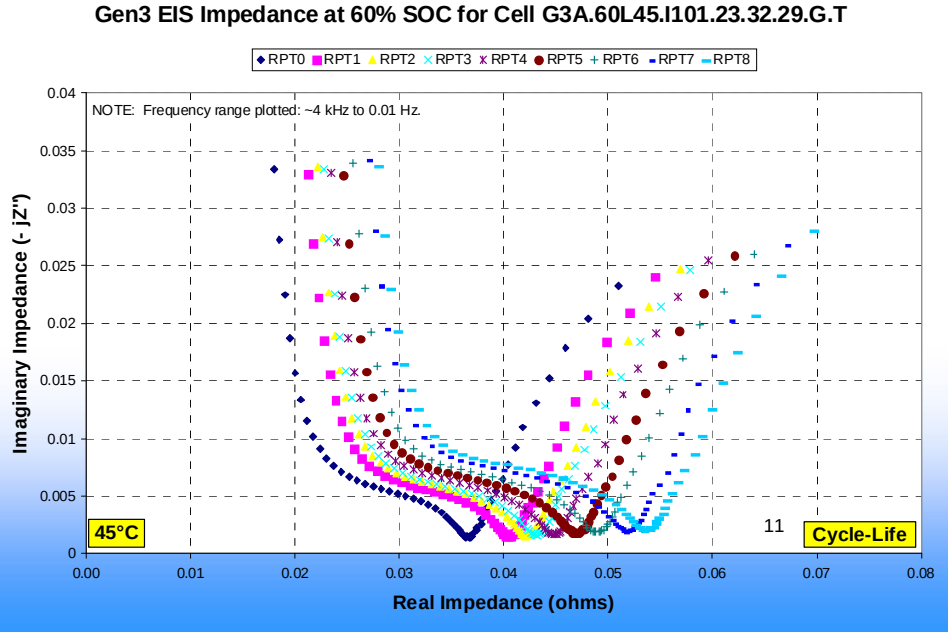
FY07 Accomplishments (cont.)

- The AC impedance data may help shed some light on how the electrolyte additive is effective in reducing the rate of impedance rise.
- The Gen3 Baseline cell AC impedance grows much more rapidly than the Variant A cells, and also shows multiple mid-frequency arcs.





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FY07 Accomplishments (cont.)

(20) 700 mAh Gen3 Cells (18650)

- **Matrix:**
  - Calendar-Life at 60% SOC:
    - **45°C** - 1 Baseline cell and 3 Variant A cells
    - **55°C** - 1 Baseline cell and 3 Variant A cells
  - Cycle-Life at 60% SOC:
    - **45°C** - 3 Variant A cells
  - Characterization:
    - 1 Variant A cell (reference point for diagnostic work)

- **Testing Status:**
  - Several cells showed signs of leaking prior to or during testing.
  - Characterization completed (C/1, L-HPPC, C/25, EIS)
    - BSF = 1509 (Baseline cells) and 1532 (Variant A Cells)
  - Life testing (8 weeks)

Future Activities

- **Continue testing Gen3 Material**
  - Anticipate completing the prismatic and 18650 calendar- and cycle-life testing, and shipping cells to diagnostic laboratories.
  - Continue data analysis, life modeling, and comparisons to Gen2 performance.
- **Other ATD Activities:**
  - Near Term: Conduct comparative accelerated aging (HEV vs. PHEV type tests) on one or more chemistries.
  - Longer Term: Conduct accelerated aging on cells of multiple chemistries.

Summary

- **Cell testing and diagnostic analysis of multiple chemistries under the ATD Program helps address the barriers limiting the successful commercialization of lithium-ion batteries.**
- **The Gen3 cells are aged under known conditions, and data are correlated with diagnostic analyses to determine degradation mechanisms.**
- **Gen3 cell testing is on-going:**
  - The use of an electrolyte additive (in the Variant A cells) helps to stabilize the Gen3 cell chemistry.
  - The Gen3 Variant A prismatic cycle-life cells generally show less degradation than the corresponding calendar-life cells, whereas the Gen2 data showed the opposite effect.
  - The Gen3 18650 cells have started life testing, but several have shown signs of leaking.
- **We provide independent cell performance evaluation on chemistries of interest to DOE and FreedomCAR participants.**
- **Anticipate completing Gen3 cell testing in FY08.**