

**Evaluation of Lead-Carbon Devices**  
**DOE Energy Storage Program**  
**Contract # 407411**

**Benjamin J Craft**  
Specialty Chemicals Division  
MeadWestvaco Corporation  
843-746-8312  
[bjc11@meadwestvaco.com](mailto:bjc11@meadwestvaco.com)

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# Participants

- MeadWestvaco
  - ◆ Developing carbons for energy storage
  - ◆ Lab scale and battery testing
- DOE Energy Storage Program and Sandia National Labs
  - ◆ Verification and battery testing
  - ◆ Analytic Support
- NorthStar Battery Company
  - ◆ Manufacturing and Battery Testing
  - ◆ Battery Expertise
- ETA
  - ◆ Testing
  - ◆ System Estimates
- WPS Energy
  - ◆ Valuation

# Program Overview

## Phase 1

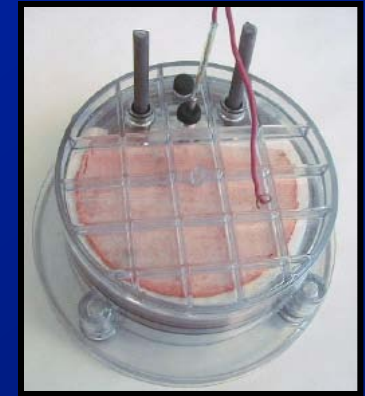
- Evaluate lead based energy storage technologies
- Develop carbon for lead based technologies
  - ◆ Increase cycle life for some applications
  - ◆ Improve charging characteristics

## Phase II

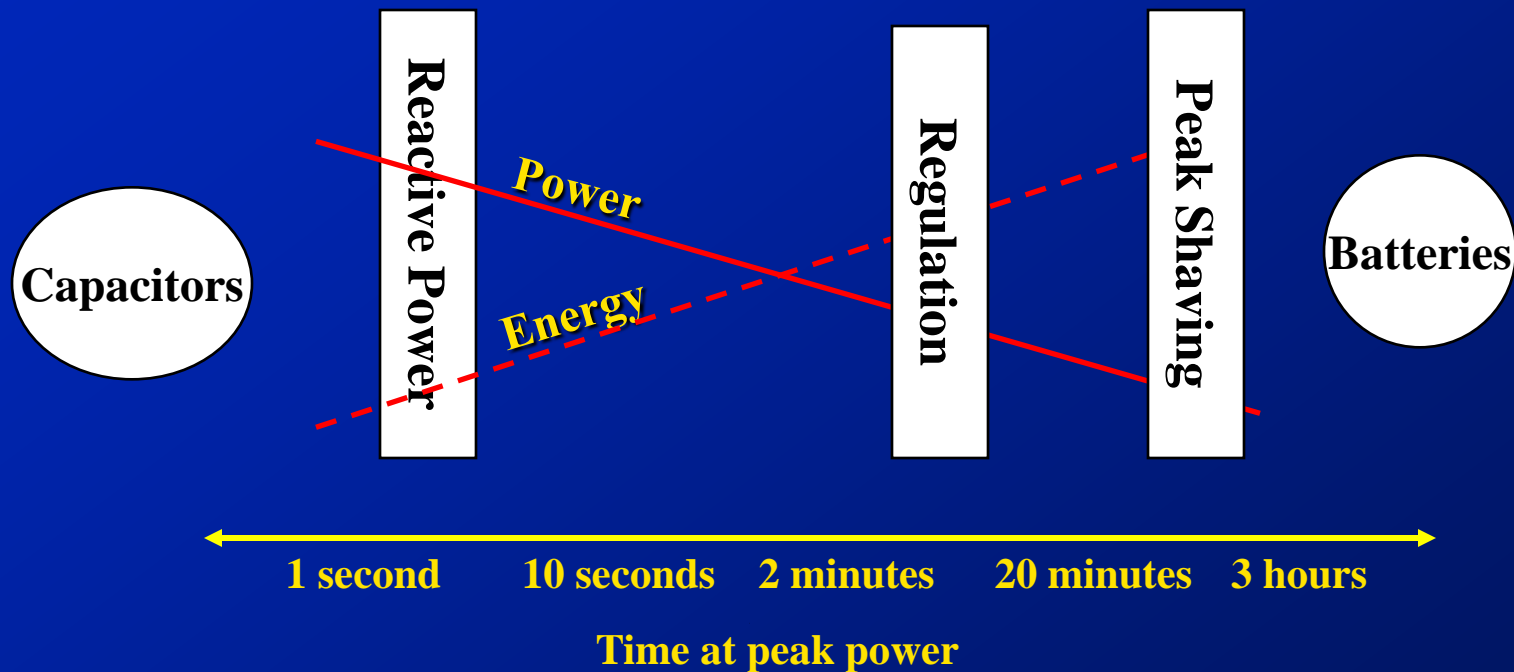
- Select best technology for 1MW utility demonstration

# History

1. Lead Carbon Asymmetric
  - Research Cells
2. Evaluation of carbon modified lead acid batteries
  - Research Cells
  - 2 battery trials (250 Batteries)
3. Testing of Batteries and cells under several tests



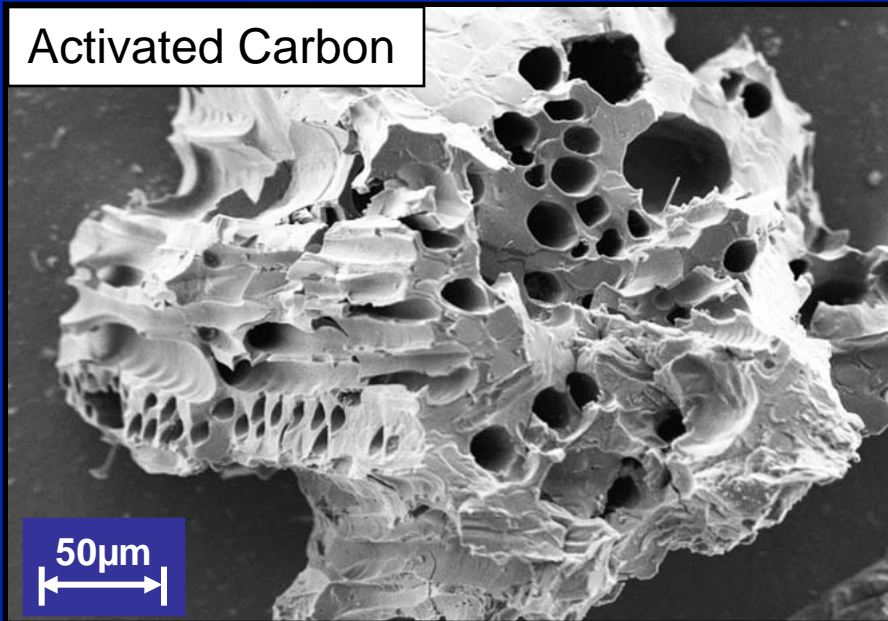
# Utility Market Opportunity



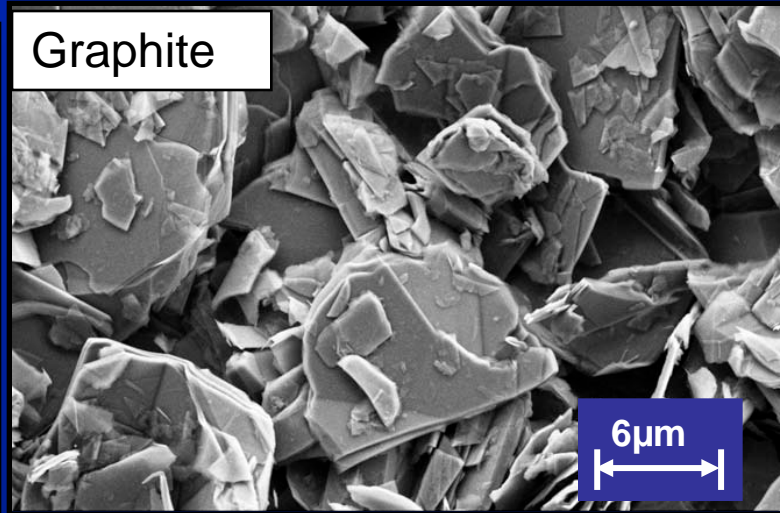
*10 seconds to 20 minutes charge/discharge requires device that has capacitor and battery properties.*

# Carbons Under Review

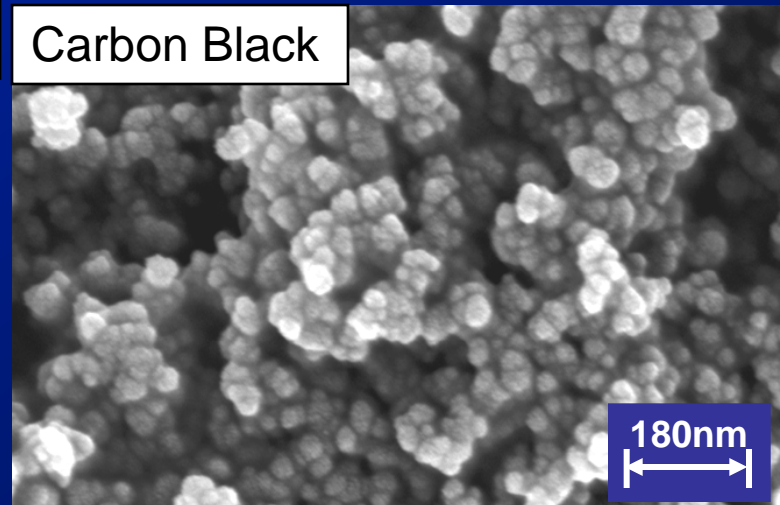
Activated Carbon



Graphite



Carbon Black



# Current Theories

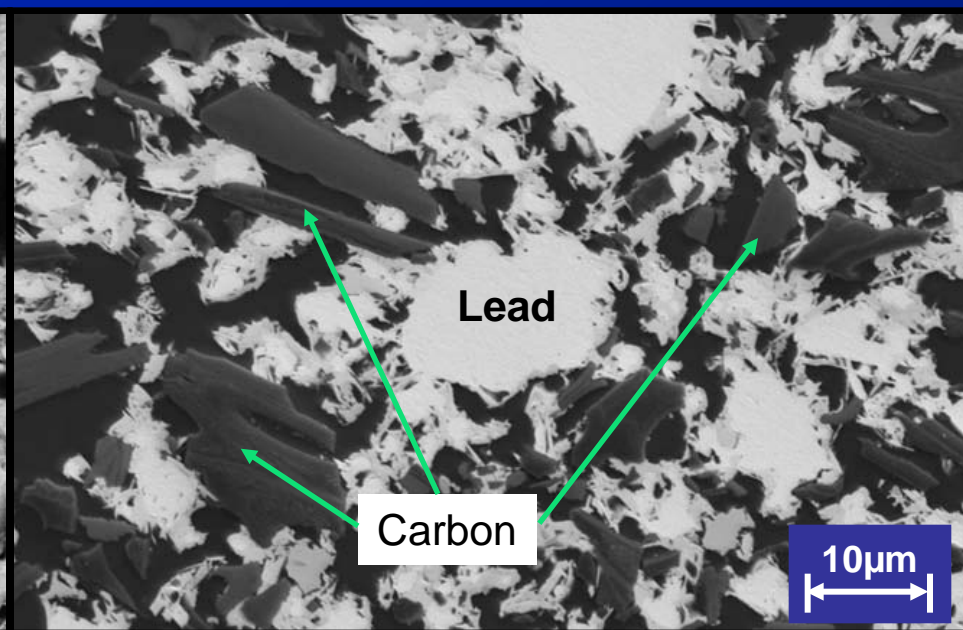
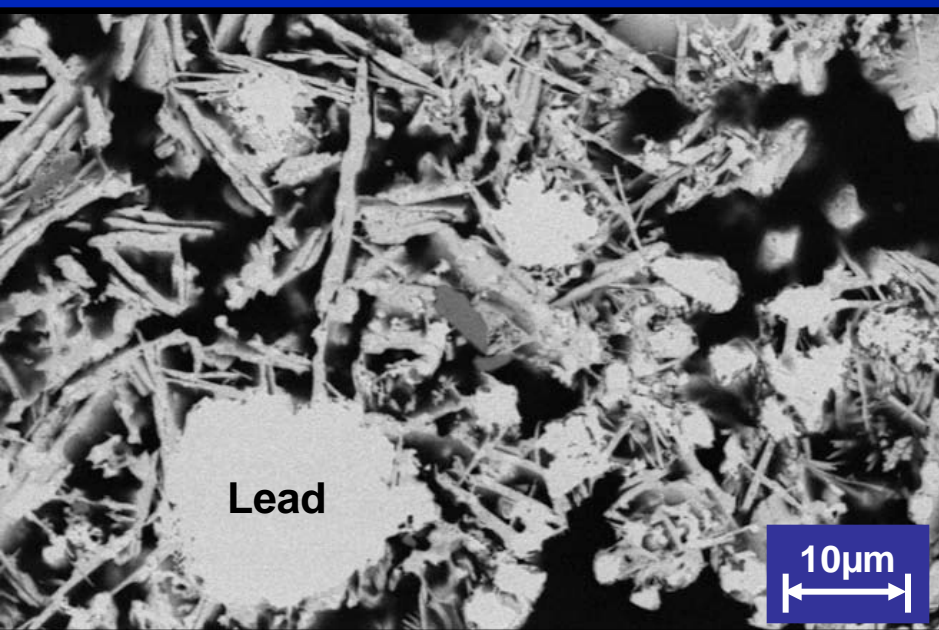
- Activated Carbon
  - ◆ Pore Former (Acid Reservoir)
  - ◆ Increase Capacitance
- Graphite
  - ◆ Conductivity
- Carbon Black
  - ◆ Conductivity

# Properties

Carbon	Surface Area (m <sup>2</sup> /g)	Capacitance (F/g)	Conductivity (ohm-cm)	Pore Volume (cc/g)
Graphite	1-20	1-5	0.001-0.1	0-0.1
Activate Carbon	500-2000	50-200	0.5-2.0	0.5-1.3
Carbon Black	50-1700	5-100	0.1	0.1-0.3



# Standard Negative Electrode

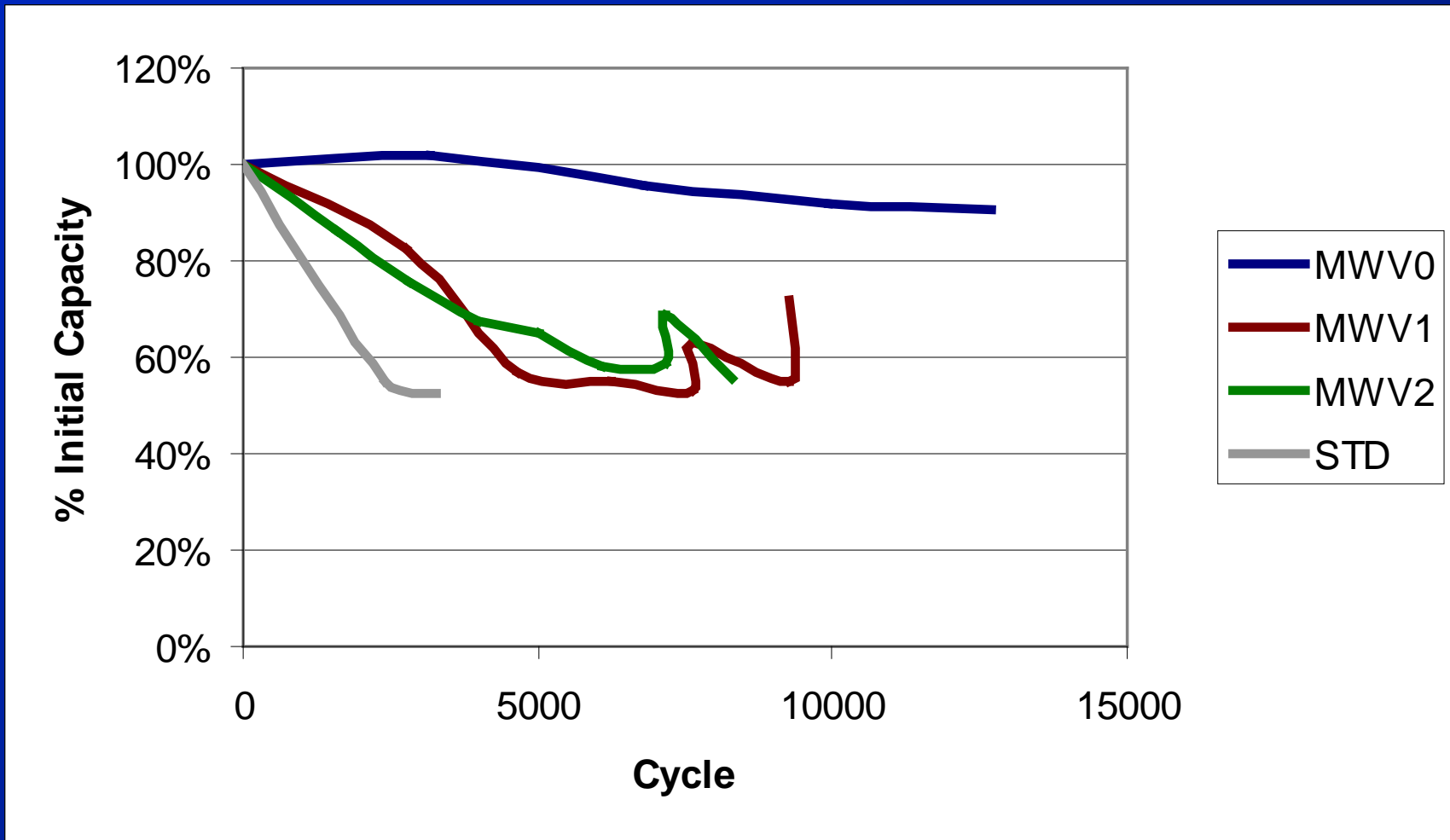


Secondary Electron Image (SEI) in SEM

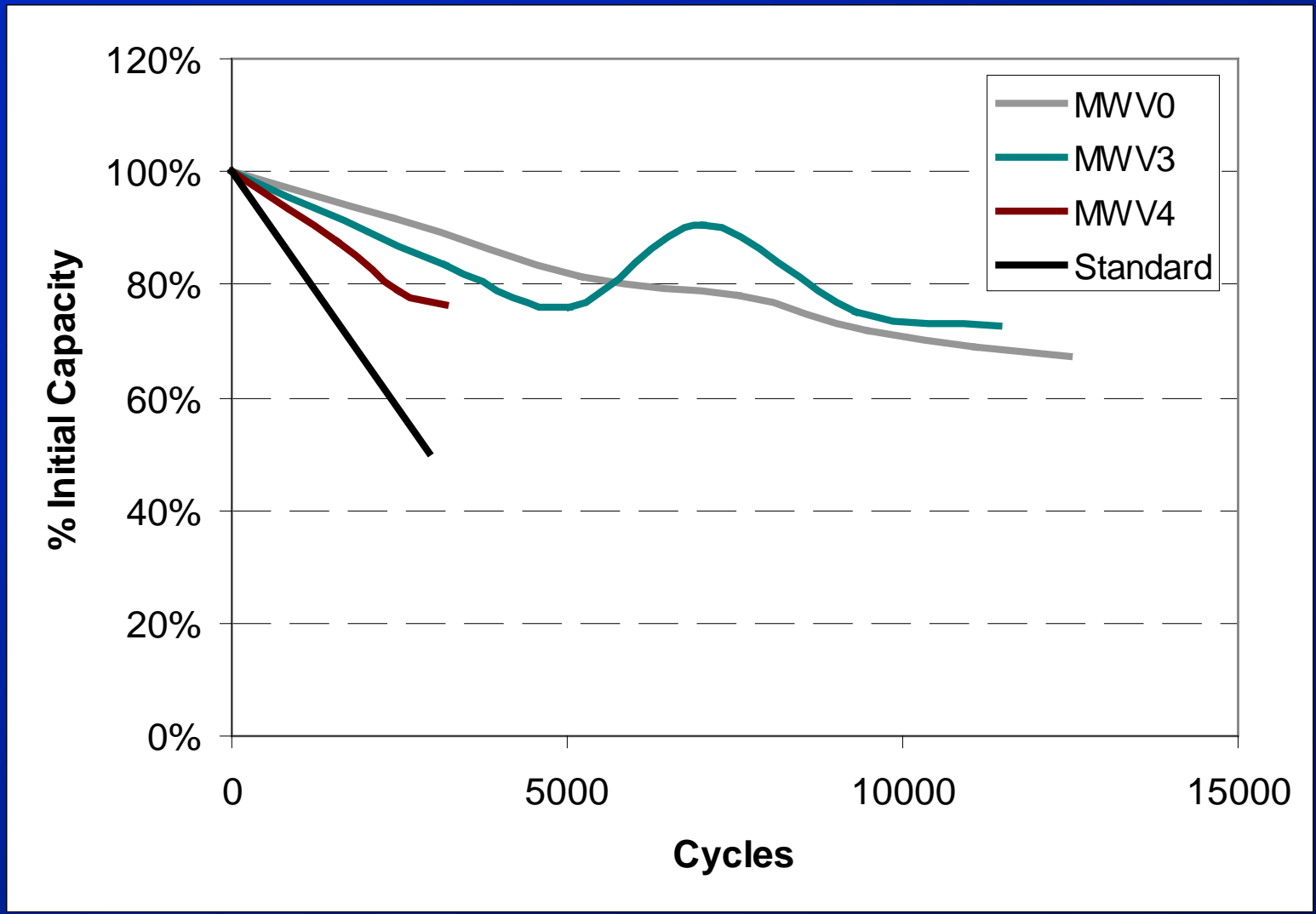
# Battery Build

- **Negative activate material (NAM) modifications**
  - ◆ **Standard**            Standard Battery Formulation
  - ◆ **MWV 0**             2% C-black and 2% graphite (Hammond-ALABC)
  - ◆ **MWV 1**             4% activated carbon
    - A-type Activated Carbon
  - ◆ **MWV 2**             4% activated carbon and 1.5% C-black
    - A-type Activated Carbon
  - ◆ **MWV 3**             3% activated carbon
    - B-type Activated Carbon
  - ◆ **MWV 4**             3% activated carbon and 1.5% C-black
    - B-Type Activated Carbon

# PSoC Screening test on 30Amphr Batteries

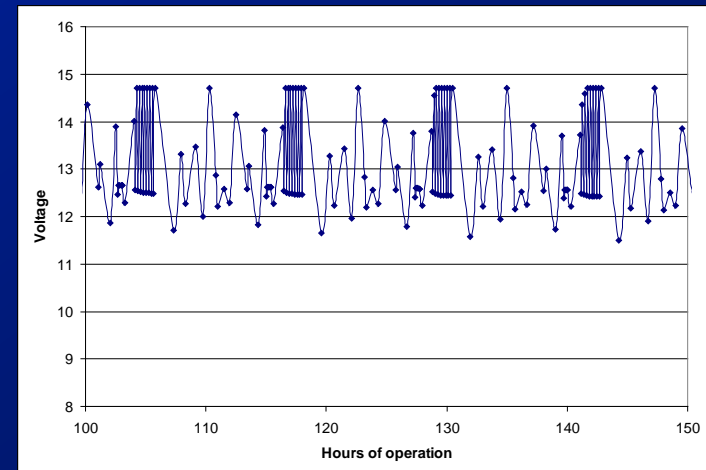
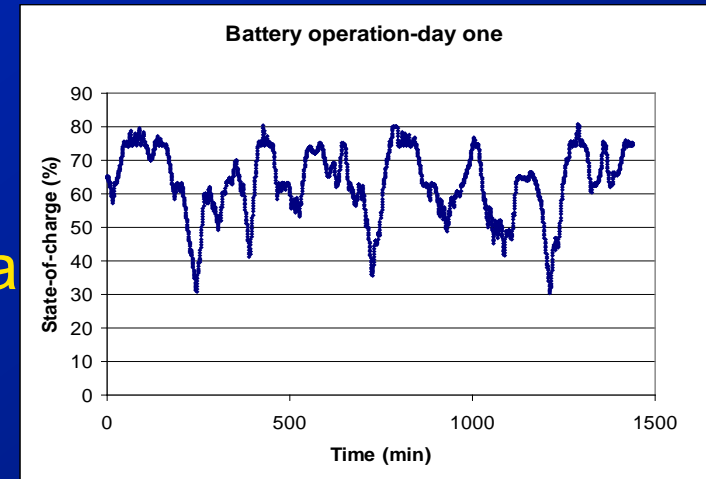


# PSoC Screening test on 50AmpHr Batteries

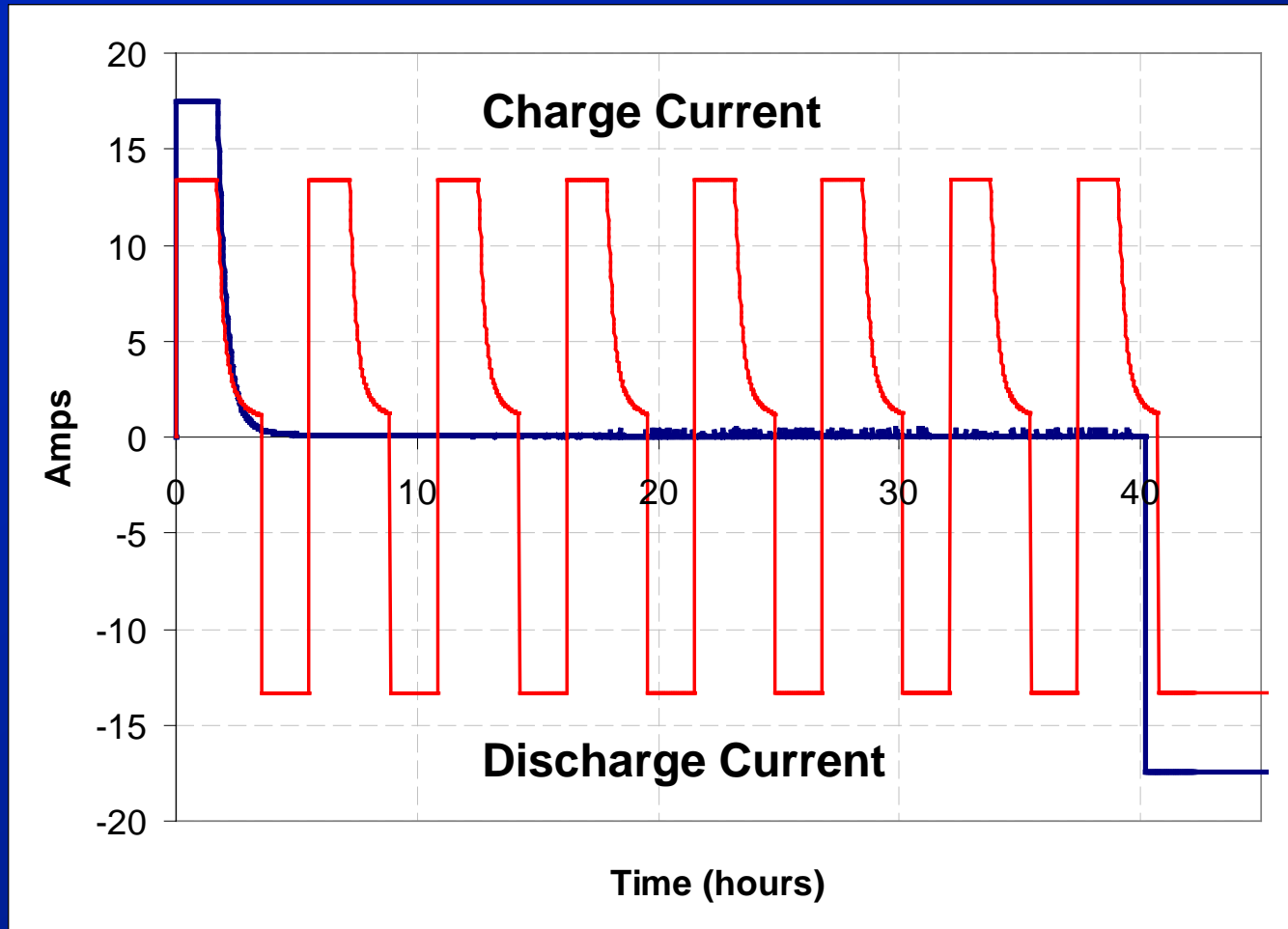


# Simulated Utility algorithm

- Develop algorithm based on real data supplied by WPS Energy
- Profile developed
  - 30-80% SOC operation
  - same Ah balance as actual duty
  - SOC adjustment every 24 h
  - recharge 1-2 times per week
- Laboratory cycling of MWV0 and Standard

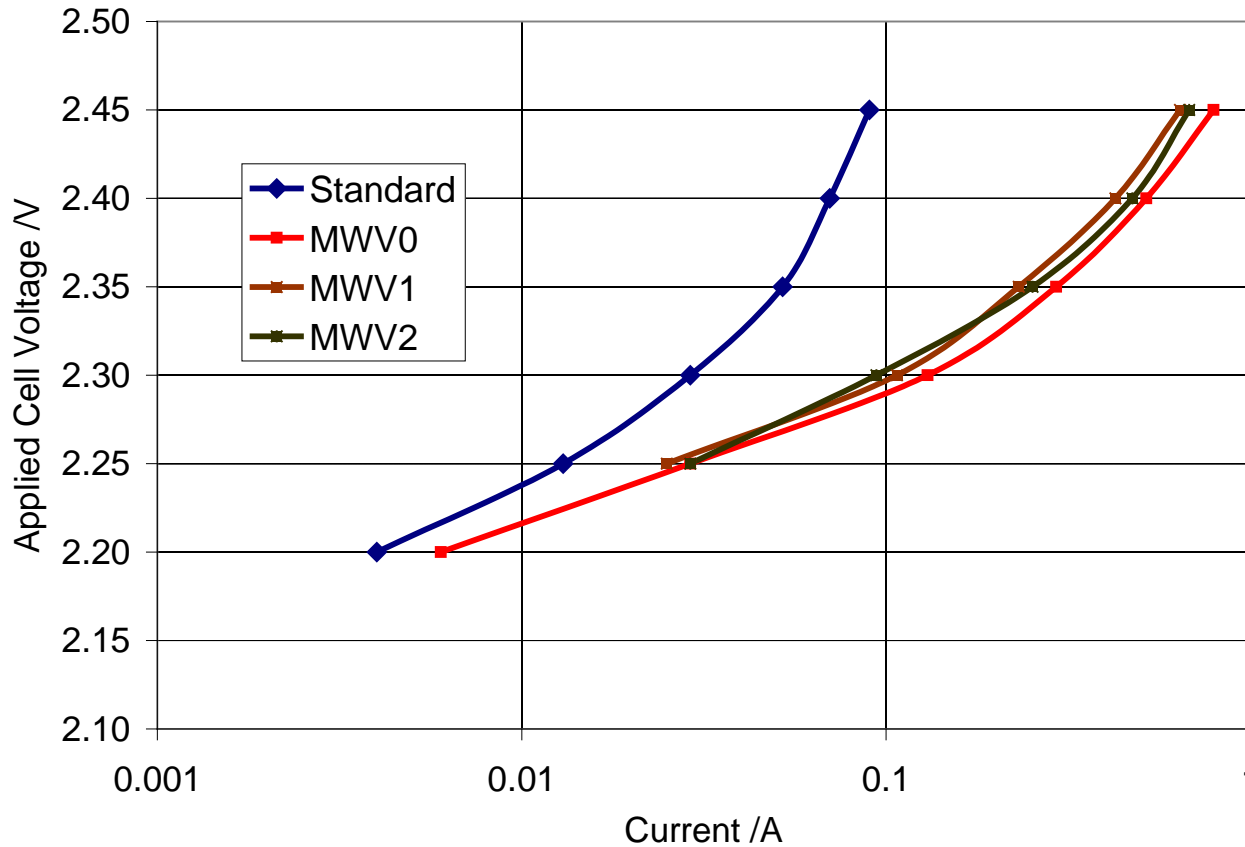


# Fast Charge Cycle 108% Cycling



*Carbon modified batteries has 8 cycles compared to 1 for standard product*

# Tafel Data



*Carbon modified batteries have an increase in current at all voltages*

# Gas lost and float current at 2.45 volts per cell

Battery	Gassing rate to Standard	Float current to Standard	Molar Ratio H <sub>2</sub> :O
Standard	1	1	21
MWV0	22	20	2
MWV1	20	22	2
MWV3	2	10	3



# Conclusion

- Carbon additives increase cycle life under some conditions.
- Carbon improves charging characteristics
- Carbon increases gas evolution and float currents.

# Future Work

- Build new batteries with improved carbons
- Verify mechanisms for carbon effect
  - ◆ Develop new carbons
- Standardizing testing of batteries
- Develop actual system cost for Utility Demonstration

# Thanks to Those Involved



**MeadWestvaco**

Leading with Imagination



*Electric Transportation Applications*

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**WPSenergy.com**

A WPS Resources Company