Welcome

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Battery Monitoring and Management

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Topics for today

- Introduction and my background.
- Current Nickel-Zinc Installations and uses.
- Growth in the UPS specific industry going forward.
- Long term benefits and expectations

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My Background

Michael Smith - 35 years Working with Generators through distribution in Critical Power Environments

Specializing in commissioning and testing of all chemistries and sizes of Battery systems

1184 - IEEE Guide for Batteries for Uninterruptible Power Supply Systems

Millions of data points on VRLA and Nicad batteries as director of monitoring services

Involved with Nickel Zinc companies for the last 5 years

(–) electrode: $Zn + 4\ OH^- \rightleftharpoons Zn(OH)_4^{2-} + 2e^-$ ($E^0 = -1.2$ V/SHE)

Electrolyte: KOH

$Zn(OH)_4^{2-} \rightleftharpoons Zn(OH)_2 + 2OH^-$

$Zn(OH)_2 \rightleftharpoons ZnO + H_2O$

(+) electrode: $2\ NiO(OH) + 2\ H_2O + 2\ e^- \rightleftharpoons 2\ Ni(OH)_2 + 2\ OH^-$ ($E^0 = +0.50$ V/SHE)

Overall reaction: $Zn + 2\ NiO(OH) + H_2O \rightleftharpoons ZnO + 2\ Ni(OH)_2$

Parasitic reaction: $Zn + 2\ H_2O \rightarrow Zn(OH)_2 + H_2$

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Current Nickel Zinc Installations

Telco

Military

Marine and Air use

Automotive and Trucking

UPS Applications and Stand-by Applications

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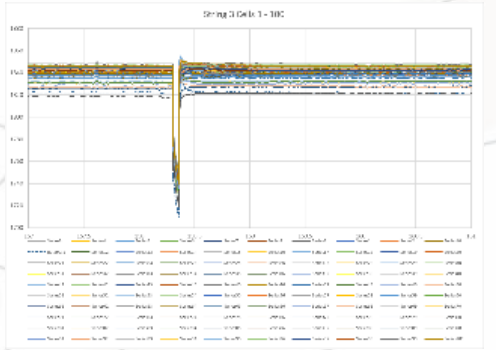
Current Nickel Zinc UPS Installations

- Large Scale Ni-Zn Battery in Data Center
  - Rated at 675 kW for 10 minutes
  - Battery on float at 553V
    - Minimum voltage 380V
  - 300s3p configuration
    - 300 G31 cells in series in each cabinet
      - 30 ten-cell battery blocks
    - 3 parallel cabinets
    - Total of 900 G31 cells
  - Management system developed that includes single cell monitoring and balancing
    - Monitoring of individual cell voltage and temperature
      - Data recorded every 1 minute and for a specific ΔV to capture pulses
      - Data downloaded every night and sent to ZAF's facility in Joplin
    - Balancing features
      - Balancing is based on bypass current at certain voltage levels



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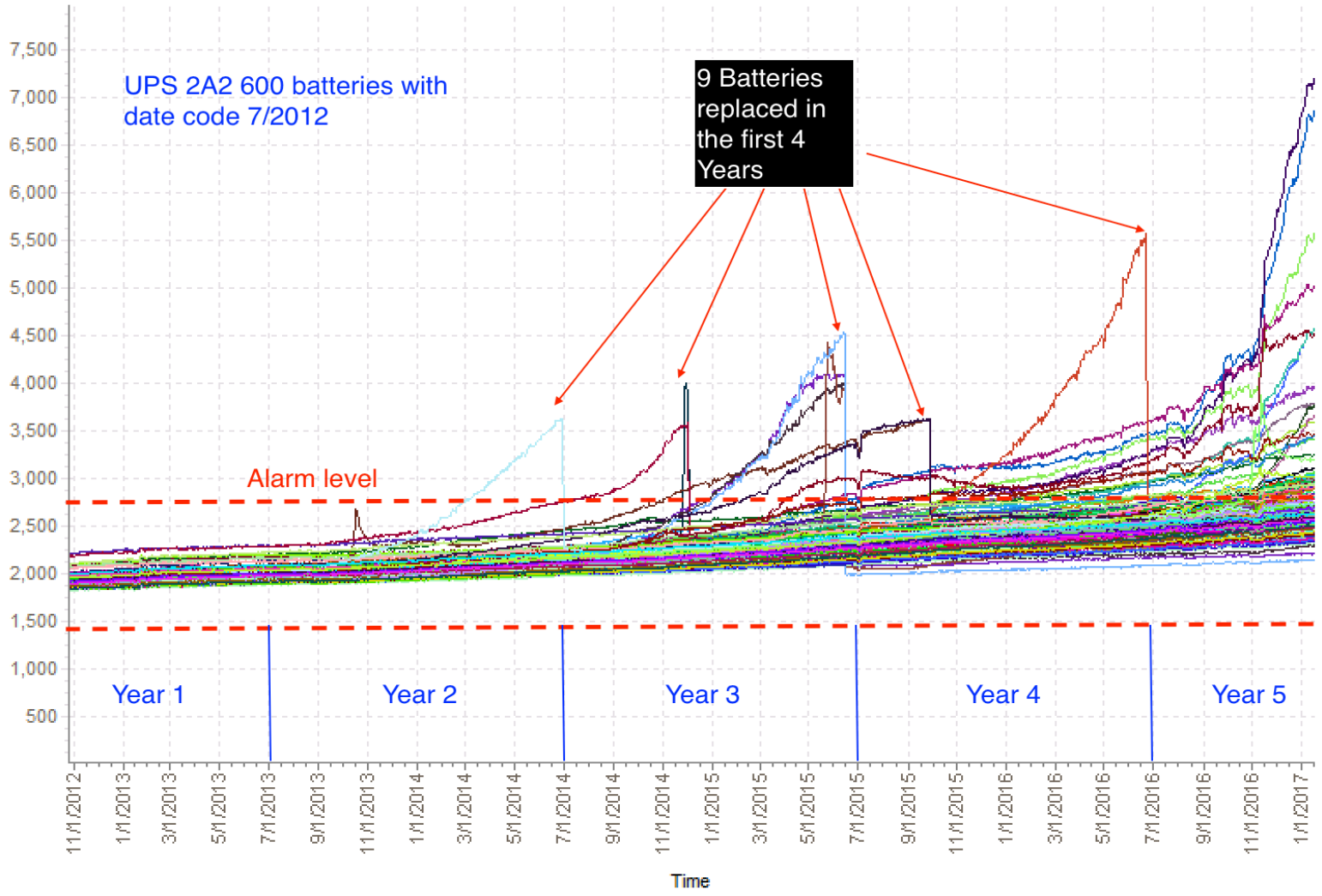
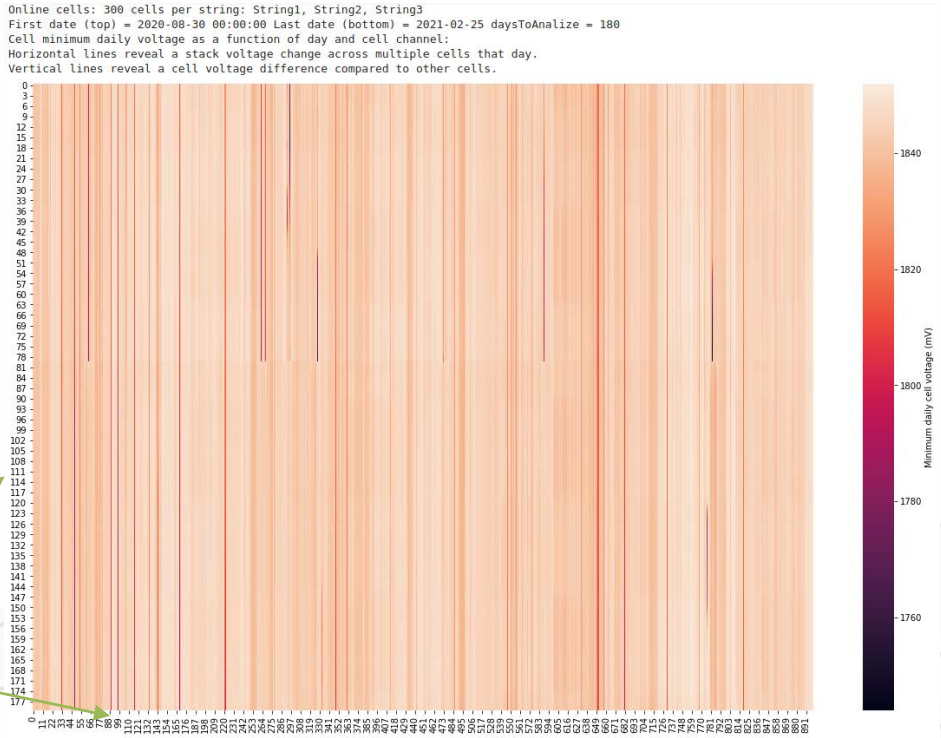
Looking at VRLA failures first for comparison



Overview of Cell Voltage Data in Application

- **Heat Map of Cell Voltages:**
- History of all 900 cell voltages over the last 180 days
  - Overview from 8/30/20 to 2/25/21
  - Darker color indicate lower voltage
  - Last data set at day 180 is shown below in a voltage vs cell number plot

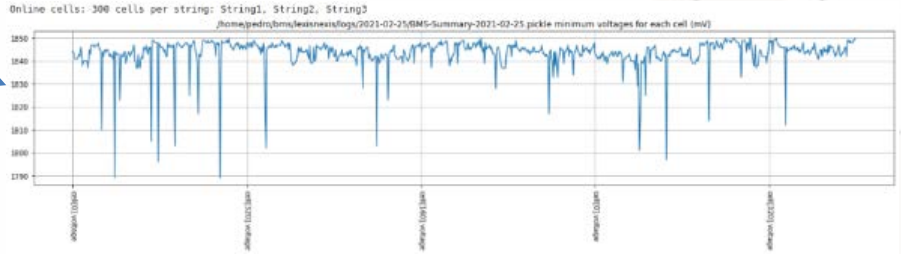


Darker color indicates lower voltage

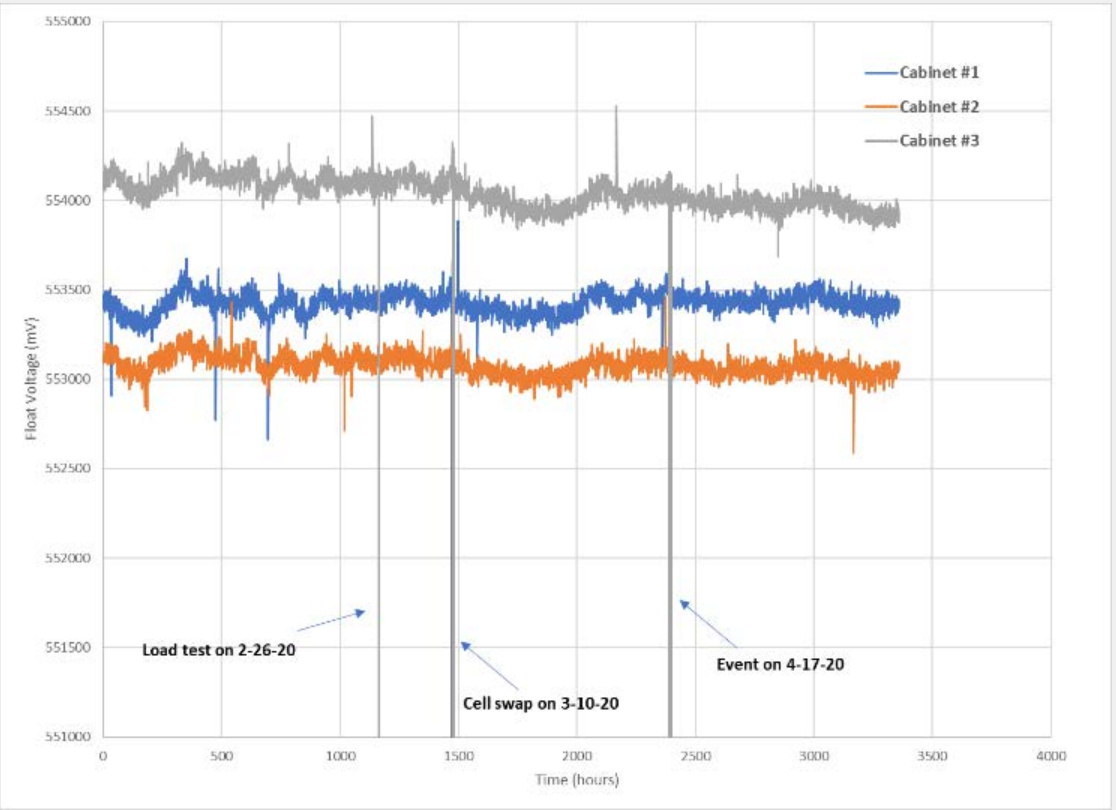
Days from 8/30/20

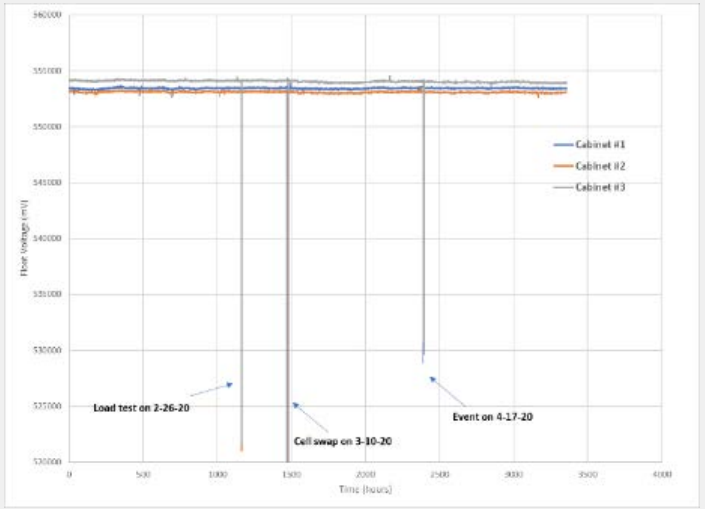
Cell numbers

- **Voltage vs. Cell Number:**
- Cell voltage vs cell number at moment in time
  - 900 cell voltages recorded on 2/25/21
    - All 3 strings
  - Data is same as the bottom data set on heat map above



Cell string voltages





Nickel Zinc Specific to UPS Installations

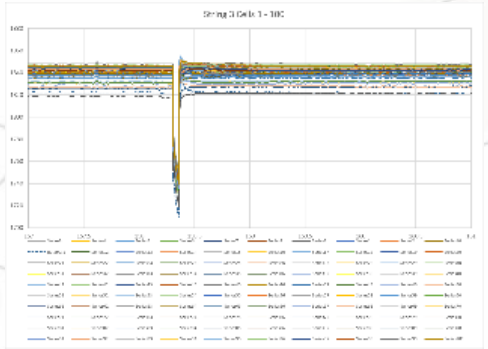
Making them a better fit as the technology expands!

Voltage Matching

- Number of cells/jars
- Float, Equalize, cutoff voltages must match

Physical matching

- Jar counts to size of Jar 38 jars 8 cells/jar



Working with UPS manufacturers to adjust charging characteristics and profiles.

- Re-charging and floating characteristics.

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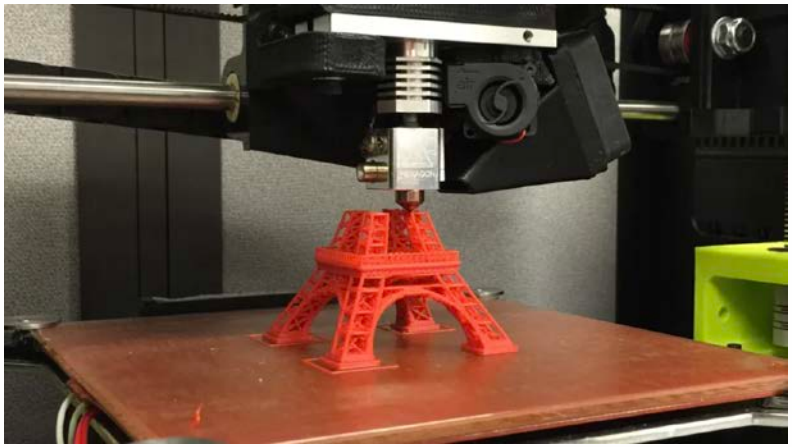
Success in the Market

- Reliable solution that reduces weight.
- Consistent installation logic and operating typical loads
- Voltage matching and charging is done from the ground up with new design.



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To be a Success in the UPS Market

- High flexibility with existing designs
- Consistent installation logic and operating with UPS Breakers, Voltages and charger types
- Efficient, safe, simple, recyclable.

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Advantages and Long-Term Outlook

- NiZn Batteries are a superior replacement for LA batteries in all industrial battery sectors and competes with lithium in many of the emerging markets such as distributed energy and industrial motive and will in the UPS Market
- Light, clean, and easily recycled.
  - Weight reduction (replaces 248 lb. lead acid 16V with 78 lb. NiZn)
  - Environmentally friendly (fully recyclable and lower CO2 emissions that lead acid and lithium)
- Failure modes are better for critical applications.
  - Fails Closed
  - Operates at higher temperature as the facility has reduced HVAC costs by over 20% in the battery room area.
- With cyclic failure rather than age failure the life expectancy is going to get better with time and will long outlast a VRLA application.
- Progress in shape change and dry-out problems through additives will continue and the battery will get stronger just as the VRLA battery did in the early stages.
- UPS Manufacturers will begin to meld the technology with their electronics making a better charging solution and even longer life and capacity.
  - Backwards compatible with existing cabinet and controls
  - Reduced maintenance (yearly visit vs. quarterly)

Advantages and Long Term Outlook

- Weight reduction (replaces 248 lb. lead acid 16V with 78 lb. NiZn)
- Environmentally friendly (fully recyclable and lower CO2 emissions that lead acid and lithium)
- 10 year warranty
- Backwards compatible with existing cabinet and controls
- Reduced maintenance (yearly visit vs. quarterly)
- Light, clean, and easily recycled.
- Failure modes are better for critical applications.
- With cyclic failure rather than age failure the life expectancy is going to get better with time and will long outlast a VRLA application.
- Progress in shape change and dry-out problems through additives will continue and the battery will get stronger just as the VRLA battery did in the early stages.
- UPS Manufacturers will begin to meld the technology with their electronics making a better charging solution and even longer life and capacity.

The future is bright

Thank You!

Michael Smith

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Emergency Power Services Co.