Internal Conductance Testing

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Abstract:

In recent years, the results of a series of studies have been presented at conferences world wide [1,2,3,4,5]. Those results demonstrate the capability of conductance measurements to identify VRLA Valve Regulated Lead Acid battery capacity failures. While some debate still exists on the degree of correlation with capacity discharge results the industry has generally accepted the technology for identification of gross failures.

The results of this work has clearly demonstrated the need to maintain VRLA batteries while demonstrating the capability of alternative test methods (Conductance, Impedance, Admittance and Resistance) to assess failed batteries (less than 80% of rated capacity). The purpose of this presentation is to help improve the understanding of battery problems and how the conductance measurement technique can be a useful tool in a maintenance practice. This talk will also provide an overview of basic battery installation, data collection and evaluation methods, which are currently used by many battery users. Finally, this talk will provide an overview of a process for managing the testing of existing battery systems already in service and new battery installations.

Acknowledgment:

I would like to acknowledge the significant contributions of Dr. David Feder in his continuing effort to educate the battery user community.

References:

1: D.O. Feder; T.G. Croda; K.S. Champlin; S.J. McShane; M.J. Hlavac: "Conductance Testing Compared to Traditional Methods of Evaluating Capacity of Valve Regulated Lead Acid Batteries and Predicting State-of- Health" Journal of Power Sources, 40 1992: pp 235-250.

2: D.O. Feder; T.G. Croda; K.S. Champlin; M.J. Hlavac: "Field and Laboratory studies to Assess the State-of-Health of Valve Regulated Lead Acid Batteries: Part 1 of INTELEC Series, Conductance/Capacity Correlation Studies". Proceedings of the 1992 INTELEC Conference:pp 218-233

3. M..J. Hlavac; D.O.Feder: "VRLA Battery Monitoring Using Conductance Technology" Part IV: On-Line State-of-Health Monitoring and Thermal Runaway Detection/Prevention. Proceedings of the 1995 INTELEC Conference, The Hague, The Netherlands: pp 284-291.

4. D.O. Feder: "Performance Measurement and Reliability of VRLA Batteries" Proceedings of the 1995 INTELEC Conference, The Hague, The Netherlands: pp 22-28.

5. M.J.Hlavac; D.O. Feder: " VRLA Battery Conductance Monitoring; Part V. Strategies for VRLA Battery Testing and Monitoring in Telecom Operating Environments" Proceedings 1996 INTELEC Conference, Boston Massachusetts.

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BATTCON97

INTERNAL CONDUCTANCE TESTING

Mark J. Hlavac

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History of Conductance
Work Performed Since 1991

- Studies on conductance and VRLA discharge performance.
- Most extensive quantity of published results in the history of industrial stationary batteries.
- Direct correlation between capacity failure and conductance diagnostic have been demonstrated.

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What is Conductance ?

- The ability of a cell to provide power.
- Small signal current and voltage response of a cell or battery.
- Single frequency measurements are most commonly used.

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What Effects Measured Cell Conductance ?

- Loss of S.O.C "State of Charge".
- Cell Temperature Changes S.O.T "State of Temperature".
- Battery wear-out or performance over time S.O.H "State of Health"

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What's In A Cell ?

- Lead grids.
- Active material both positive and negative.
- Separators.
- Electrolyte.
- Conductance technology measures it all !!!

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Why Measure or Trend Conductance?

- Provides indication of poor cell/battery condition or state of health.
- Demonstrated correlation to timed discharge capacity testing of cells.
- Can be measured quickly.
- Prediction of end of battery life.

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Why Monitor or Trend Conductance ? (Continued)

- Loss of tools to assess VRLA battery conditions.
- Can not perform visual inspection of plates.
- Can no longer use hydrometer or reference electrodes in the field.
- Poor correlation of cell float voltage to capacity has been demonstrated.
- Capacity testing is not always cost effective.

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Different Types of Batteries

Flooded

Wet Cell

VLRA

Maintenance Free

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VRLA Cells are Designed to Fail by Positive Grid Growth

But

- They rarely live that long
- Other failures occur sooner

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Factors Which Affect VRLA Performance and Capacity

(Differences from Vented Cells)

- Dry-out.
- Glass mat characteristics and element compression.
- Negative group bar corrosion.
- Grid corrosion consumes water (leads to dry-out)
- Higher S.G. electrolyte
- Higher float currents
- New grid alloys

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Recombination is More Complicated in Reality Than in Theory

- Negative plate reactions are complex
- Delicate balance between:
  - Oxygen reduction
  - Hydrogen evolution
  - Negative plate sulfation
- As cells age/dryout does this balance change?
- Is this balance "location sensitive"

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VRLA Cell Dryout

- How much dryout before capacity falls below 80%
- Published data says > 10% water loss = < 80% capacity
  - How design specific is this?
  - Is dryout uniform throughout the stack?
  - Is dryout location sensitive?
- Are quantitative techniques available to measure dryout for teardown diagnostics?

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Positive Grid Corrosion

- Oxygen lost to form PbO_2
  - Is part of the water loss equation
  - An equivalent amount of hydrogen gas is evolved
- This can be a major source of dryout and capacity failure
- How much grid corrosion =
  % Water Loss =
  % Capacity Loss?

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We Have More Questions Than Answers !

- VRLA Failure mechanisms are not yet fully understood.
- No industry standards for teardown methodology and analysis are available.
- VRLA application environments vary significantly.
- Can VRLA accelerated life testing methods be used to verify possible improvements ?

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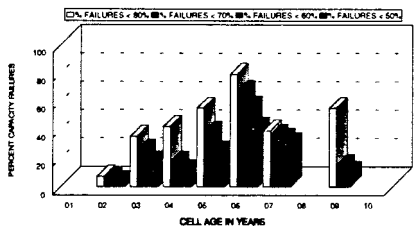
VRLA Cell Failures
% Failures vs. Age



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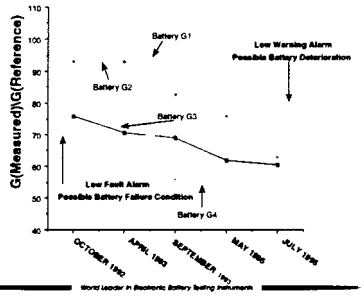
Three Year Relative Conductance Trend



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Trending of Conductance

- The data shows relative conductance decrease of 16 to 30 percent.
- This corresponds to a 25 to 30 percent decrease of rated discharge capacity.

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Reference Values

- Known (typical)
- Unknown

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Data Evaluation

- Test Batteries to Compare with (known typical values)
- Find cell/battery which varies from the norm within a string
- Monitor (trend) data over time.
- Re-confirm (suspect) measurements
- Document test point locations
- Document site conditions (i.e. temperature etc.)
- Consider centralized database
- Be consistent

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Steps to Battery Management (Existing Installations)

- Battery plant test audit.
- Risk assessment.
- Priority replacement of poor cells/batteries or strings.
- Utilize data for future budgetary process.
- Continue testing and trend data.

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Steps to Battery Management "New Installations"

- Incoming inspection of cells using conductance.
- Measure before installing into field.
- After installation.
- After 6 month burn-in.
- Identify problems or defects immediately (post seal, jar to cover leakage, conductance, charging etc...)

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Installation of Batteries

- **Before install, test battery's conductance & visual inspection.**
- **Measure string voltage after monobloc/cells are connected.**
- **Test continuity in the entire system, cell intercell measurements, using conductance equipment.**
- **Adjust charger float/equalize to manufacturer's recommended values. For the specific battery type ie (1.215 sg Flooded vs. 1.300 sg VRLA)**

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Industry Approvals & Recommendations

- IEEE 1188 Recommended practice for testing and replacing VRLA batteries.
- T1E1 ANSI (American National Standards Institute) Approval in process.
- EPRI (Electrical Power Research Institute) Guide for testing stationary batteries.

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Summary

- Batteries do require maintenance.
- Conductance technology is a valuable maintenance tool.
- For battery plant audits and trending.
- Continuing to gain experience in helping to establish and enhance battery maintenance programs.