Lead Acid Battery Maintenance and Testing
Moderator

Ron Spataro
AVO Training Institute Marketing Manager
Q&A

- Send us your questions and comments during the presentation
Today’s Presenter: Rod Van Wart
AVO Training Institute, Senior Battery Instructor and Curriculum Advisor
Why Batteries are Needed

- Ensure that critical electrical equipment is available and is backed up
  - Generating stations and substations for protection and utility control
  - Telephone, hospital (for life support), & industry
  - Computer backup, UPS, Power Quality
Why Batteries are Needed

- Prevent unexpected failures
- Electric generating stations and substations for protection and control of switches/breakers and relays
- Telephone companies to support phone service
- Back up of critical power dependant equipment (life support systems, business information systems, data centers)
- Industrial applications for protection and control

Failure is not an Option
Why Batteries are Needed

- To ensure power availability
- Steady state power is available in case of utility anomalies
- To aid in mitigating unexpected sags & surges on the customer service side
Two Reasons

➢ To Protect and Support
  • Critical Equipment & Systems

➢ To Ensure the Safety of Revenue Streams
  • Due to loss of prime power source
Three Questions

- What is the capacity and condition of the battery now?
- 2. When will it need to be replaced?
- 3. What can be done to extend its life?
Battery Types

- Lead Acid – Flooded (wet)
  - Lead Calcium / Lead Antimony
  - Selenium (3% Antimony)

- Valve Regulated
  - Absorbed Glass Matte
  - Gel
Maintenance Philosophies

- Replace batteries if and when they fail
- Replace after a predetermined time
- Engage in a recommended maintenance and testing program
IEEE Standards

- IEEE 450 – Recommended Practice for Maintenance, Testing and Replacement of Vented Lead Acid Batteries for Stationary Applications

- IEEE 1188 - Recommended Practice for Maintenance, Testing, & Replacement of Valve-Regulated Lead Acid Batteries for Stationary Applications
### IEEE Recommended Maintenance Periodicities

<table>
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<tr>
<th></th>
<th>VLA Monthly</th>
<th>VLA Quarterly</th>
<th>VLA Annually</th>
<th>VRLA Monthly</th>
<th>VRLA Quarterly</th>
<th>VRLA Bi-annual</th>
<th>VRLA Annually</th>
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<td>X (other)</td>
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<td>Detailed internal visual inspection</td>
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<td>X</td>
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<td>X (UPS)</td>
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<td>AC ripple current, voltage</td>
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VRLA batteries follow two main designs:

- AGM: liquid electrolyte absorbed in glass mat separators, or
- Gel batteries contain a gelled electrolyte which is "Thixotropic". This Thixotropic gelled electrolyte contains sulfuric acid, fumed silica, pure demineralized and deionized water, and a phosphoric acid. The electrolyte in Gel batteries does not flow like a normal liquid; it has the consistency and look of petroleum jelly.
Monthly Visual Checks - Failures

- Category 1 Failures are considered critical and must be dealt with immediately.

- Category 2 Failures are considered non-critical but will need closer observation and may reach Cat 1 status in a short time.

- See Annex D of IEEE 450 D.5.
VLA Failure Modes

- Plate sulfation
- Positive grid corrosion
- Sediment (plate shedding) build-up
- Top lead corrosion
- Hard shorts (paste lumps)
Plate Sulfation

Plate sulfation
- Sloughing off of active material from the plates
- Causes electrical path problems
- Easily detected by impedance testing
- Visual inspection may find traces

Forms when
- Charger voltage is not set high enough
- Incomplete recharge after an outage
Positive Grid Corrosion

- Lead alloy (plates) that convert to lead oxide over time
  - Lead oxide crystal is larger than the metal, it grows over time
  - Part of design, many data sheet give clearance at bottom of jar over rated life time (20 years)
  - Growth can and does force off tops of battery
Positive Grid Corrosion

- Other effects that cause growth
  - Excessive cycling
  - Excessive temperature
  - Over charging

- Maintenance and environmental conditions can increase or decrease risk of battery failure
Positive Grid Growth
Ohmic Testing

- Impedance, Conductance & Resistance
- IEEE uses term ohmic
- DC based on $V=IR$ : AC based on $V=IZ$
- As a battery ages it may corrode, sulfate, dry-out or suffer a host of other effects based on maintenance, chemistry and usage. All of these effects cause a chemical change in the battery; which in turn causes a change in the batteries internal impedance / resistance.
- Ohmic testing measures the SOH.
Sediment Buildup (shedding)

- Function of battery cycling
- Sloughing off of active material from the plates, converts it to white lead sulfate (plate sulfation)
- Shedding is normal
- Excessive shedding when added to positive grid growth can cause shorts
  - May cause voltage drop
Top Lead Corrosion

Connection between plates and post

- Difficult to detect, hidden by cover
- Corrosion can lead to heat buildup during high amp discharge
- Melt, crack, causing catastrophic failure when battery string drops off line
VRLA Failure Modes

- Dry out (loss of compression)
- Soft & hard shorts
- Thermal run-away
- Post leakage
- Positive grid corrosion
- Plate sulfation
Dry-Out (Loss of Compression)

- Dry-out is a phenomenon that occurs due to excessive heat, over charging can cause elevated internal temperatures as well as high ambient (room) temperatures.

- At elevated internal temperatures, the sealed cells will vent through the PRV.

- When sufficient electrolyte is vented, the glass matte no longer is in contact with the plates, thereby increasing the internal impedance and reducing battery capacity.
Ohmic Readings Rise
Soft Shorts (VRLA)

- During deep discharge, specific gravity drops with corresponding voltage drop

- When SG gets to low, lead (from the plates) dissolves into the acid which is in the glass matte

- During recharge, lead comes out of solution forming threads of thin lead known as dendrites inside the matte
Hard Shorts

Hard shorts caused by:

- Paste lumps pushing thru the matte and shorting out opposite polarity plate

This condition also reveals itself during ohmic testing with a severe decrease in impedance
Changes in Impedance as a Result of Battery Capacity
Thermal Run-Away

- Battery internal components melt down in a self sustaining reaction
- Two weeks to four months prediction time
- Impedance and float current increases
- Megger recommends quarterly impedance testing of VRLAs
Thermal Run-Away

- To prevent, use temperature compensated chargers and properly vent battery room
  - Charges reduce current as temperature increases
  - Heating is a function of the square of the component ($I^2R$)
No Temperature Compensation
Post Leakage & Corrosion
Determining Available Capacity

Capacity testing or load testing

- cost and time of battery out of service
- recharge time
- detrimental effect on battery life
Capacity Testing Scenarios

- **Acceptance Test:**
  - A capacity test made on a new battery to determine if it meets specifications or manufacturer’s ratings.

- **Capacity Test:**
  - A controlled constant-current or constant-power discharge of a battery to a specified terminal voltage.
Capacity Testing Scenarios

 ➢ Performance Test:
  • A constant-current or constant-power capacity test made on a battery after it has been in service.

 ➢ Modified Performance Test:
  • A test, in the “as found” condition, of battery capacity and the ability of the battery to satisfy the duty cycle.
Battery Replacement Criteria

- Failure to hold a charge, as shown by cell voltage and specific-gravity measurements, is a good indicator for further investigation into the need for battery replacement.

- Conducting a Load test will show what capacity if any is left in the battery.

- After completion of a capacity test, the user should review the sizing criteria to determine if the remaining capacity is sufficient for the battery to perform its intended function.
Battery Replacement Criteria

- The recommended practice is to replace the battery if its capacity as determined is below 80% of the manufacturer’s rating.

- This is typically 1.75 VPC, but may range from 1.67 to 1.82 VPC dependent upon manufacturer.
When Batteries Fail ...
Proper maintenance is critical to battery life
Battery “health” is critical for many safety systems
Regular testing allows you to trend the battery
Decreases chance of battery bank failure
Load testing is critical for measuring capacity
Allows timely replacement
Follow manufacturers recommendations and IEEE Guidelines
Battery Maintenance & Testing Course

Battery Maintenance & Testing
4 Days – 3.2 CEUs
Recommended Equipment

**BITE2/2P**
- Ohmic value
- Voltage of each cell
- Float voltage and current
- Ripple current
- Strap resistances
- Battery continuity verification

**BITE3**
- Ohmic value
- Voltage of each cell
- Float voltage and current
- Ripple current
- Strap resistances

**TORKEL900**
- Performance test
- Modified performance test
- Capacity testing
- Overall battery voltage logger

**PowerDB Software**
- Default & customized test forms
- Database
- Trending
- Asset organization
- Reporting capabilities
- Compliance scheduler
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- Register here:
  - https://attendee.gotowebinar.com/register/879540421804228355
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