GE Hitachi
Nuclear Energy

IEEE Std 535 and Safety-Related Batteries 101

2008 IEEE SC2 COMMITTEE Meeting

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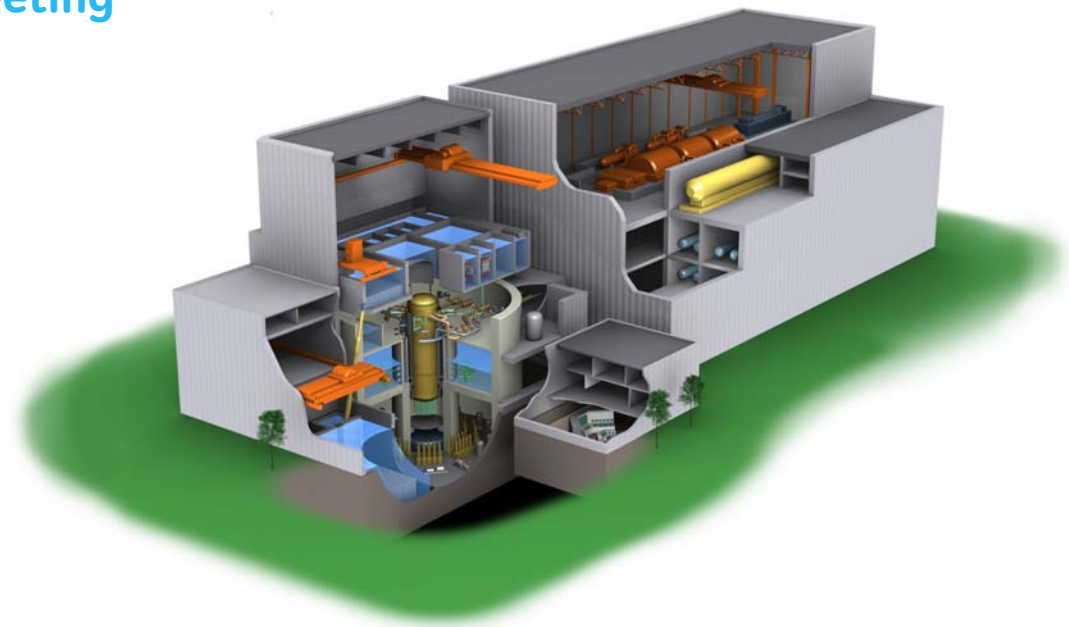
James F. Gleason, PE



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IEEE 323-2003 EQ

- Directly Applicable? YES
- Application
  - Mild Environment
  - Age Sensitivity: Arrhenius Equation
  - Qualified Life and Condition Monitoring

IEEE 344-1987

- Directly Applicable? YES
- Application
  - Seismic Performance
  - C&EUS Seismic Hazard: Seismic High Frequency: Not an Issue for GEH ESBWR or GE BWRs
  - Not Seismic Frequency / Intermittent Sensitive

IEEE-535

- Directly Applicable? YES
- Application
  - Aging
  - Seismic

IEEE-535-1986 (R1994)

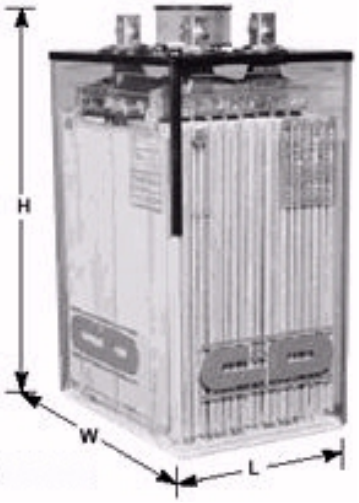
- "Standard for Qualification of Class 1E Lead Storage Batteries for Nuclear Power Generating Stations."
- Applies to Lead Acid Batteries
- Aging based on positive plate growth and grid corrosion

IEEE-535-2006

- "Standard for Qualification of Class 1E Lead Storage Batteries for Nuclear Power Generating Stations."
- 1.1 Scope
  - This standard describes qualification methods for Class 1E vented lead acid batteries and racks to be used in nuclear power generating stations outside primary containment.
- Aging based on positive plate growth and grid corrosion
- Life expectancy of batteries is not affected by two deep discharges per year and is based upon ~50 deep discharges (8 hours) over the life of the cell. Typical 12-15 discharges in plants.

Battery Types

Vented Lead Acid (VLA) – aka Flooded



Valve Regulated Lead Acid (VRLA)

VRLA Batteries History

- Several designs have had issues
  - Infant mortality
  - Short life
  - Thermal runaway
  - Loss of compression with loss of capacity
- Causes
  - Lack of ambient temperature control
  - Internal pressure prior to release
  - Install and forget mentality
  - Designs
  - Applications

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VRLA Battery Standard IEC 60896 –21, -22

Effective March 2007

- Withdrew all other VRLA standards in effect since 1995

- 21 clauses or methods of test are defined for the quantification of properties and characteristics of all types of Valve Regulated Stationary Lead Acid Batteries for float charge application in a static location and incorporated into stationary equipment or installed in battery rooms for use in telecom, uninterruptible power supply (UPS), utility switching, emergency power or similar applications.

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IEC 60896 –21, -22 Effective March 2007

- **Verification Tests**
  - Gas emission
  - Protection against internal ignition from external spark sources
  - Valve operation
  - Flammability rating of materials
  - Intercell connector performance

IEC 60896 –21, -22 Effective March 2007

- **Performance Characteristics**
  - Discharge capacity
  - Charge retention during storage
  - Valve operation
  - Float service with daily discharges
  - Recharge behavior

IEC 60896 –21, -22 Effective March 2007

- **Durability Characteristics**
  - Service life at an operating temperature of 40 °C
  - Impact of a stress temperature of 55 °C or 60 °C
  - Abusive over discharge
  - Thermal runaway sensitivity
  - Low temperature sensitivity
  - Dimensional stability at elevated internal pressure and temperature
  - Stability against mechanical abuse of units during installation

VLA Batteries and Existing Active NPPs

- Nuclear Stationary Batteries
- Typical 20-year life
- Typical Duty Cycle < 8 hours
- Typical Duty Cycle demand
  - Initially high demand for motors and pumps

VLA Batteries and New Passive NPPs

- Nuclear Stationary Batteries
- Typical 20-year life
- Typical Duty Cycle
  - 24 hours (AP-1000)
  - 72 hours (AP-1000 & ESBWR)
- Typical Duty Cycle demand
  - Less AH Demand
    - MOV loads 1000 A initially (24 hours AP-1000)
    - Monitoring and DCIS loads (72 hours AP-1000 & ESBWR)

GEH Research

- VLA Batteries and New Passive NPPs
  - Deep 72 hour Discharge does not appear to change Aging basis
    - Same battery tested for 0.25, 0.5, 1, 3, 5, 11, 26, 93, 266 hour discharges with >80% capacity
  - IEEE 535 20-year aging + IEEE 344 Seismic
  - Additional 22-year aging post seismic (42-year)

GEH Research

- VRLA Batteries and New Passive NPPs
  - Deep 72 hour Discharge does not appear to change Aging basis
    - Same battery tested for 0.4, 0.8, 2, 3, 5, 12, 27, 94, 263 hour discharges with >80% capacity
  - IEEE 535 20-year aging + IEEE 344 Seismic
  - Additional 14-year aging post seismic (34-year)

EPRI and IEEE team
VLA Batteries and New Passive NPPs

- EPRI and IEEE team
- Test plan to verify
  - Aging based on positive plate growth and grid corrosion

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VRLA Batteries and New Passive NPPs

- Assessing manufacturers information