TSB G31 Battery Launch

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- Albion, Indiana
- 112,000 Square Foot Campus
- Proven Management Team
- Proven Workforce
- State of the art facility
  - Advanced automation and robotics
  - Product consistency
  - Environmental responsibility
- Composite Bipolar AGM Technology
  - Redefines premium performance in lead acid technology

Current Lead Acid Technology

- Very few fundamental advancements in technology in the last 50 years
- Both flooded and AGM Lead Acid batteries have relatively short life in deep-cycle service for the following:
  - Grid Growth—material shedding
  - Electrolyte Stratification
  - Cell-Cell Connection Failure
  - Excessive water loss
  - Dendrite Growth

Grid Growth

- Conventional cast lead grids utilized in positive plates actually grow dimensionally in cycling service.
- As the grid expands with cycling the active material attached to the grid fractures, disconnecting some of the active material from the positive plate grid resulting in loss of capacity.
- Over time disconnected material can accumulate in the floor of the battery case setting up conditions for a short. Secondary containment of the shed material is required to prevent such shorts from occurring.
- Conventional batteries strengthen and dimensionally stabilize positive grids by alloying lead with a variety of metals.
- This practice lowers grid corrosion life and reduces Hydrogen overvoltage which increases electrolyte water loss.

Electrolyte Stratification

- Stratification occurs under the force of gravity to separate the sulphuric acid solution into water and acid.
- In vertically aligned plates in flooded batteries heavier sulfuric acid migrates toward the cell bottom reducing acid concentration in the upper part of the cell.
- This stratification results in capacity loss and irreversible sulfation in the lower portions of the cell.
- Stratification also occurs in vertical plate AGM designs but in reverse. Acid is moved to the upper part of the cell during cycling leaving an acid deficiency in the lower part of the cell. The result is the same in both cell types.

Cell-Cell Connection Failure

12V Batteries consist of six (6) 2V batteries connected in series.

Conventional batteries provide this connection by connecting the positive plate lugs in one cell to the negative plate lugs in the adjacent cell with a cast-on lead-alloy strap.

Different lead alloys are used in positive and negative plate lugs. A third alloy is used to connect positive and negative lugs with a casting process. Such connections tend to corrode rapidly in service, increasing internal resistance and capacity loss. Poorly executed connections of this type result in fires and explosions.

High internal resistance:

Reduces capacity	Increases operating temperature	Limits cold - cranking amps	Degrades overall battery efficiency

Dendrite Growth

Dendrites in lead acid batteries are formed from non-uniform current distribution over the negative plate surface. The primary cause of non-uniform current distribution is electrolyte stratification and non-uiform potential distribution between plates.

During the charge cycle the strongest current between plates deposits the largest amount of lead on the negative plate. Repeated cycling increases uneven lead deposition and can result in a dendrite which eventually penetrates the separator, contacts the positive plate and shorts the cell.

As conventional AGM battery manufacturers look for ways to control cost they have been using coarser glass fibers in their glass mat separators. Enlargement of separator pores makes it easier for lead dendrites to penetrate the separator and and complete the short circuit.

The TSB Technology Solutions

- Grid Growth
  - TSB replaces conventional cast grids with a screen mesh woven from lead coated fiberglass.
  - This material provides dimensional stability throughout the life of the battery and eliminates grid growth.
  - Dimensional stability precludes active material shedding.
    No capacity loss from material shedding over its lifetime.
  - Eliminating active material shedding removes material shedding as a failure mode and eliminates shed material as a source of shorts.

The TSB Technical Solution

- Electrolyte Stratification
  - TSB replaces vertical plate orientation with horizontal plate orientation which eliminates gravitationally induced electrolyte stratification in its AGM cell designs.
  - TSB design eliminates capacity loss resulting from electrolyte stratification over service life!

The TSB Technical Solution

- Cell – Cell Connection
  - TSB bipolar technology uses a single lead alloy for current collectors in both positive and negative plates and for connecting cells in series.
    - Significantly reduces corrosion as a contributor to internal resistance growth over service life
  - TSB bipolar design has over 1500 internal connections between cells and connected to terminals in a single automated casting procedure which provides the industry's lowest internal resistance and highest reliability.
  - Low internal resistance provides:
    - Capacity maintenance
    - Stable operating temperature
    - Increased Cold Cranking Amps (CCA)
    - Increased overall battery energy efficiency

  - TSB technology precludes cell – cell connection failure associated with fire and explosions

The TSB Technical Solution

- Dendrite Growth
  - TSB horizontal plate orientation eliminates stratification and precludes dendrite growth
  - TSB technology fills internal voids with a proprietary material that precludes shorts that may be caused by negative plate material mossing.

TSB G31 Product Performance