SBS
The Thin Plate Pure Lead (TPPL) Advantage
What do you know about EnerSys?

- World’s largest *industrial* battery company
- Headquarters in Reading, Pennsylvania USA
- Annual revenue in excess of $2.0 Billion; over 8000 Employees worldwide
- Manufactures and distributes industrial batteries in three markets
  - Reserve Power
  - Motive Power
  - Aerospace & Defense
- Broadest product portfolio in industry
- Nationwide Service Group
Product Applications Reserve Power

- Telecom – Wireline
- Extended Run time
- UPS
- Telecom - Wireless
- Wind & Solar
- Railroad Crossing Backup
# EnerSys Product Matrix

<table>
<thead>
<tr>
<th>Single Cell Sizes</th>
<th>Central Office and MTSO’s</th>
<th>Hub Sites</th>
<th>Indoor Cell Sites</th>
<th>Outdoor Cell Sites OSP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flooded</td>
<td>GU</td>
<td>FTC</td>
<td>GU</td>
<td>FTC</td>
</tr>
<tr>
<td>Up to 3900 Ah</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tubular Gel</td>
<td>GU</td>
<td>FTC</td>
<td>OPzV</td>
<td></td>
</tr>
<tr>
<td>Up to 3000 Ah</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2V AGM</td>
<td></td>
<td></td>
<td>DDm</td>
<td></td>
</tr>
<tr>
<td>Up to 2000 Ah</td>
<td></td>
<td></td>
<td>m Series (NEBS)</td>
<td></td>
</tr>
<tr>
<td>12V Blocks</td>
<td></td>
<td></td>
<td>NCR Racks: Up to 2280 Ah (24V)</td>
<td></td>
</tr>
<tr>
<td>Up to 190 Ah</td>
<td></td>
<td></td>
<td>Tyco List 15: 1160 Ah (24V)</td>
<td>SBS, V, VE</td>
</tr>
</tbody>
</table>
Thin Plate, Pure Lead VRLA Batteries
VRLA characteristics

- AGM technology
- Non-spillable design
- Generates hydrogen and oxygen gas when on charge
- Valve Regulated design – recombines H₂ and O₂
- Recombination rate of 98 to 99%
- Compact design – Space savings
VRLA metallurgy

• **Pure lead**
  – Grid metallurgy used when VRLA technology was introduced in the 1970s in a cylindrical format

• **Lead calcium**
  – Introduced mainly to overcome manufacturing issues with pure lead

• **Thin-Plate Pure-Lead Technology**
  – Combines strengths of pure lead and lead calcium technologies while minimizing their weaknesses
EnerSys 12 Volt Product Offering

V Series Lead Calcium

Conventional Valve Regulated Lead Acid (VRLA) Batteries Can Provide Lowest Initial Purchase Price

• SBS (Pure Lead)

Thin Plate Pure Lead Technology Can Increase Battery Life And Reduce Total Life Cost of Ownership
Conventional Lead Calcium Battery Grids

Use of a hardening alloy:

- Provides stiffness and strength for handling and manufacturing
- Grid is Cast
- Costs less to manufacture
- Accelerates grid corrosion
- Accelerates self-discharge
- Requires thicker plates for longevity
Primary failure of a lead acid battery is due to Grid Corrosion
Lead Acid Battery Failure Mode

Corrosion
the oxidation of the battery grid

Oxidation of the lead grid causes plate growth and eventually destroys the grid
What Makes SBS Pure Lead different?

**Adders = Contaminants = Corrosion**

**SBS - High Purity Materials**

- 99.99% Pure Lead Grid

  Virgin Lead Oxide
  Medical Grade Acid

**Typical Lead Calcium Product**

- Grid is made from recycled lead and calcium is added for manufacturing

  Recycled Lead Oxide
  Standard Grade Acid
Manufacturing Difference for SBS

SBS - Grid is Cold Rolled and Punched

Typical Lead Calcium – Grid is Cast
Conventional Pb-Ca-Sn “Book Mold” Cast Grid
Prone to growth and corrosion at grain boundaries
Must be 3 to 4 times thicker than Pb-Sn or Pb grids for same life. High internal losses = short storage life

Cold Rolled Pb Strip
High purity lead (no hardening agents or tin) Cold rolling process produces finest grain structure. Highest resistance to anodic corrosion.
High purity grids and electrolyte for long storage life
Lead Calcium Positive vs Pure Lead Grain Structures

Typical Cast Lead Grid

Cold-Rolled TPPL Grid
The SBS Benefit - A Longer Life Battery

Corrosion Behavior: Pure Lead vs. PbCaSn

Plate growth

Grid corrosion

... Same battery – Different alloy – 7 years @ 2.27Vpc - 20°C ...
SBS - A Longer Life Battery

Lead-Tin-Calcium (PbSnCa) vs. Pure Lead (Pb):
Capacity during accelerated float life testing
(Float: 13.65V float @ 50°C/122°F)
(Room temperature capacity tests performed at ~60 day intervals)
(Discharge: 8-hr rate)

<table>
<thead>
<tr>
<th>Capacity (hours to 10.0V cutoff)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SBS Product</td>
</tr>
<tr>
<td>Competitor</td>
</tr>
</tbody>
</table>

Days at 50°C @ 13.65V (1 day @ 50°C / 122°F = 6.6 days @ 25°C/77°F)

6.4 hrs = 80% of rated capacity (pass/fail limit)
5.6 hrs = 70% of rated capacity (test end for that battery)
Higher Energy Density

Automation of plate manufacture allows processing of thin Pb\(^0\) grid

Result: 1mm Thin

Bookmold casting requires inherent grid strength - thick with added hardeners

Result: 2 - 4 mm Thick

Means the difference between a 155AH lead calcium to a 170Ah Pure Lead

Thin = Greater Surface Area = More Power
3X Increased Shelf Life

SBS Self Discharge Characteristics

Up to 18 months of storage vs. 6 months for lead calcium.

Stop installing dead batteries when deployments take longer than expected.
### SBS Versus PbCa at Cold Temperature

<table>
<thead>
<tr>
<th>Rate</th>
<th>PbCaSn</th>
<th>SBS</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 Hour Discharge @ 0ºF</td>
<td>Approx. 50% of nominal</td>
<td>Approx. 70% of Nominal</td>
</tr>
<tr>
<td>1 Hour Discharge @ 0ºF</td>
<td>Approx. 40% of nominal</td>
<td>Approx. 70% of nominal</td>
</tr>
</tbody>
</table>

At 0ºF SBS has approximately 40% higher capacity versus PbCaSn for an eight hour discharge. For a one hour discharge SBS has a 75% higher capacity at 0ºF.
Lead Calcium vs. SBS
Cost of Ownership

V Series Lead Calcium

• Cost of Ownership
• Warranty
• Network Reliability

• SBS (Pure Lead)
The SBS Pure Lead Advantage

- Longer life high temperature battery
  - 5 year vs. 3 year in uncontrolled cabinet
- Lower cost of ownership
  - 32% less cost over 10 years
- Longer Storage time
  - 18 months vs. 6 months
- Better cold temperature operation
  - 75% more capacity at 0 degrees Fahrenheit
- Higher power density
  - Up to 190 Ah
- Highest Quality
  - Translates into improved network reliability
Warrensburg, Missouri Facility

- 360,000 sq. ft.
- 33 acres
- 330+ employees
- ~30,000 Batts./day

- First battery plant in the world to be certified as ISO 14001 Environmental Management System
- ISO 9001 Certified Quality Management System
- 1995-1997 Gold Pretreatment Award Missouri Water Environmental Association
- 1997 Industrial Water Quality Achievement Award
- FAA Certified Production Approval Holder (PAH/PMA)
- Approved Supplier to the Military