PURE Pb+

The Benefits and Differences of the New Pure Lead UPS batteries

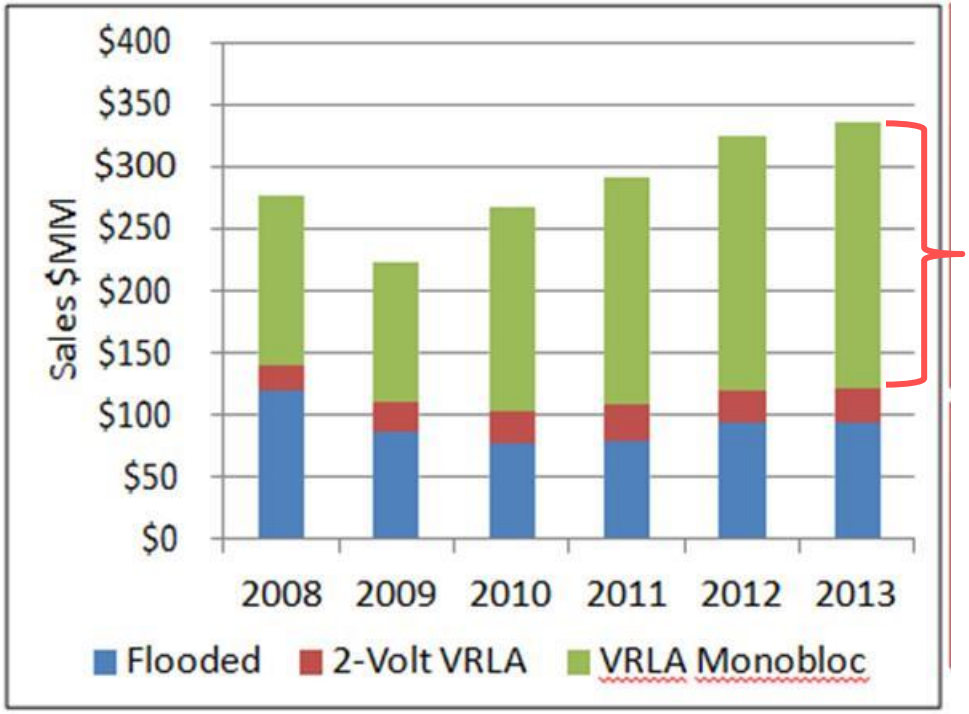
C&D TECHNOLOGIES

Power Solutions

2014

UPS Market Summary-Historical Growth

North American UPS Battery Sales



Valve-Regulated Lead-Acid (VRLA)

1.Largest segment (>$200M)

2.Fastest growing UPS segment

What's New? **Pure Lead is new growing portion of UPS VRLA**

Latest Generation of VRLA Batteries

‘Pure Lead’ VRLA

The promise of ‘Pure Lead’

- **Longer life – promises of 20-100% longer life vs non pure-lead VRLA**
- **Higher temperature tolerance – normal VRLA degradation 50% for every 10 degrees C**
- **Longer shelf life – up to 4X non pure-lead VRLA**

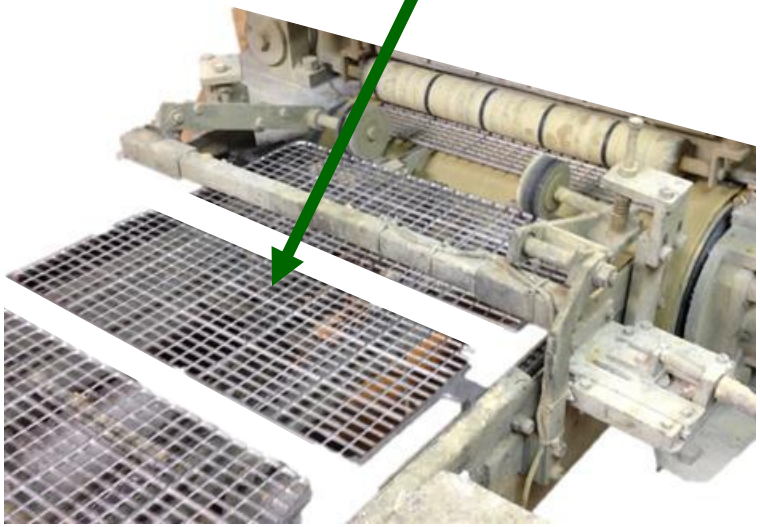
BUT…Not all Pure Lead Batteries are made the same

Lead Acid Battery Basics

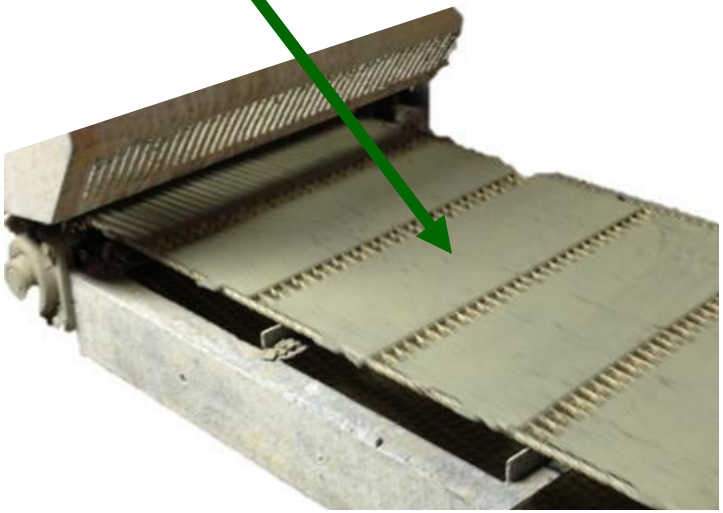
There are many variations of lead acid batteries

Lead Acid Plates

- **Almost all have a solid metallic grid to carry the current …**



...filled with a lead oxide paste to create the current



Significance of Pure Lead Raw Materials

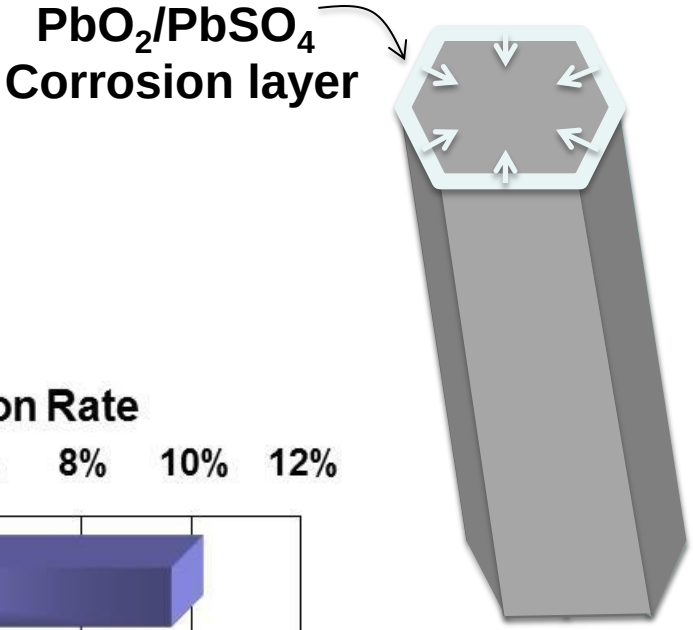
- **‘Pure-Lead’ means using virgin, or freshly mined lead as the raw material for internal components**
- **Both positive and negative plates are essentially all lead**
  - **Grids**
  - **Active material plate paste**
- **Making the plates out of pure lead changes how they age**

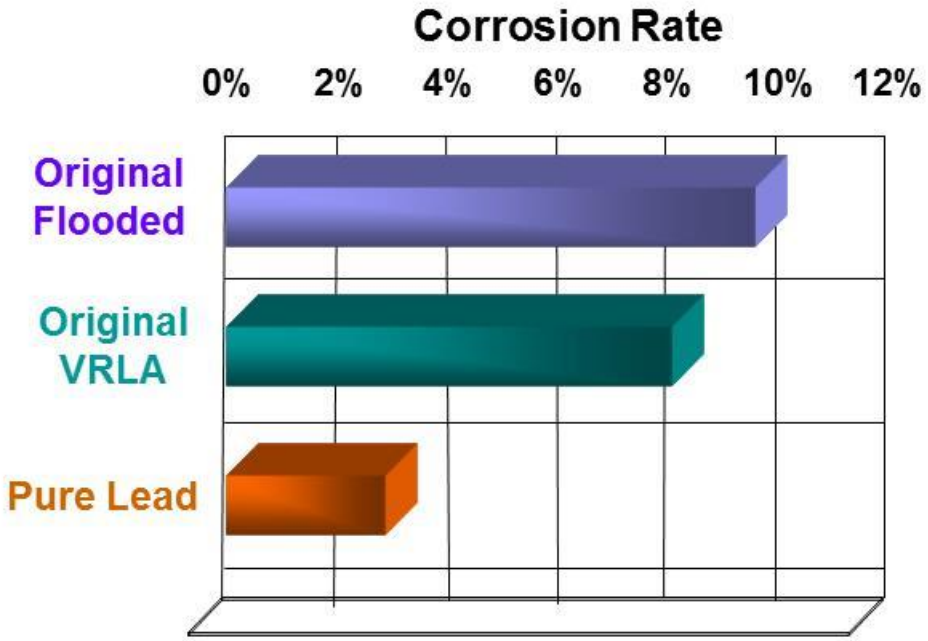
How Lead Acid Batteries Fail

- **Positive Grid Corrosion - Grid corrosion is well understood, easy to control and predictable**
- **Is mainly a function of:**
  - **Grid alloy**
  - **Specific gravity of electrolyte**
  - **Temperature**
  - **Float voltage**

Pure Lead Grid Advantages

- **Pure lead reduces grid corrosion**
  - **Grain boundaries**
  - **Corrosion rate**





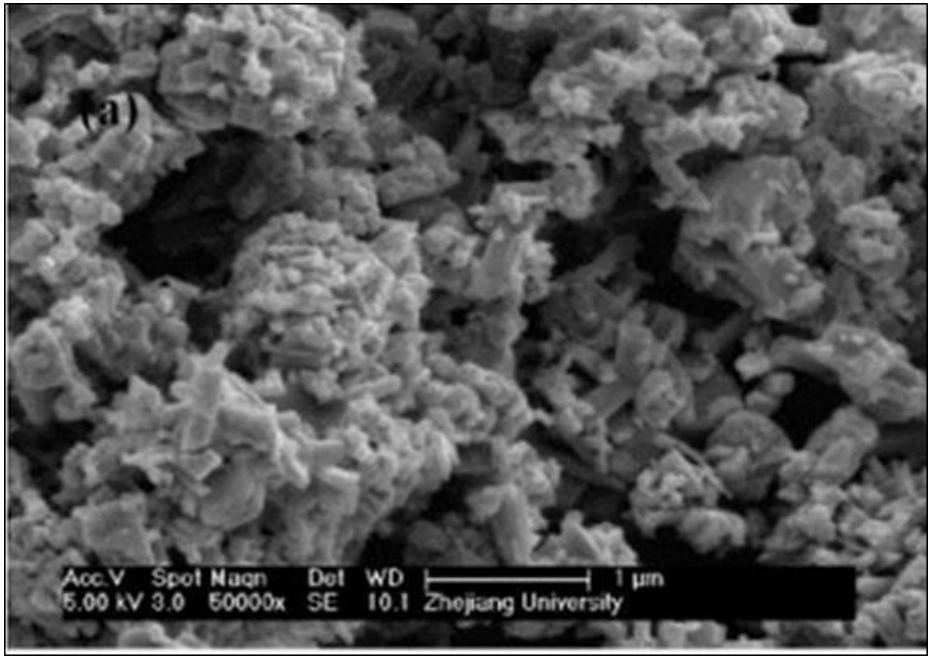
Active Material Paste

BUT… This Grid Corrosion is only ½ the Story:

Improvement in the grid will not improve how the active material paste ages

- **For full benefits, the entire plate must be made from pure lead**
  - **The oxide used in the paste must be made from pure (virgin) lead**
  - **The oxide manufacturing step must be tightly controlled**
    - **Particle size distribution is critical**
    - **Oxide density is key metric**

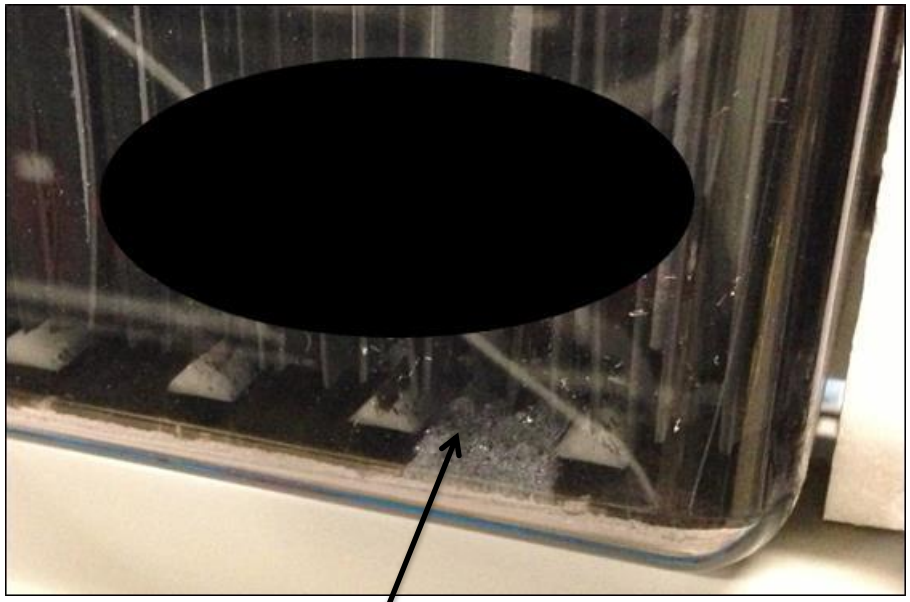
Effect of Pure Lead on paste

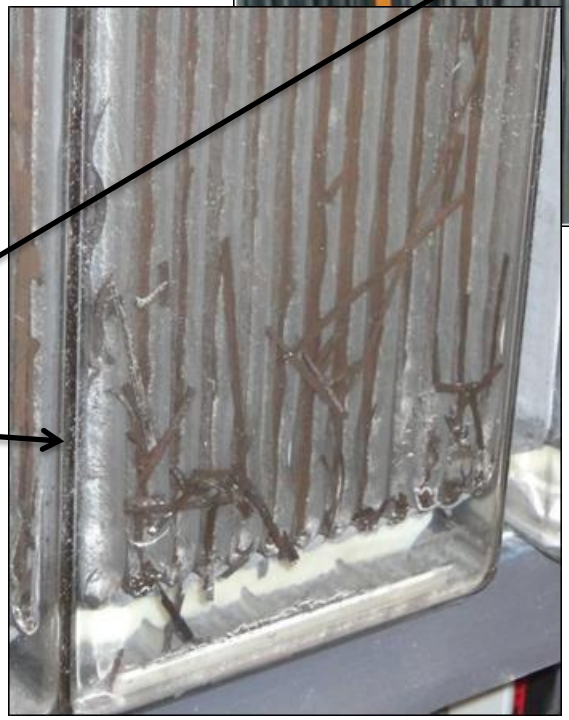


Paste is 40-60% porous – the underlying crystal structure determines the life of the battery

Cell Failures from Poor Plate Processing

Poor paste processing can cause early failures





Sediment and plate deconstruction to cause early cell failure

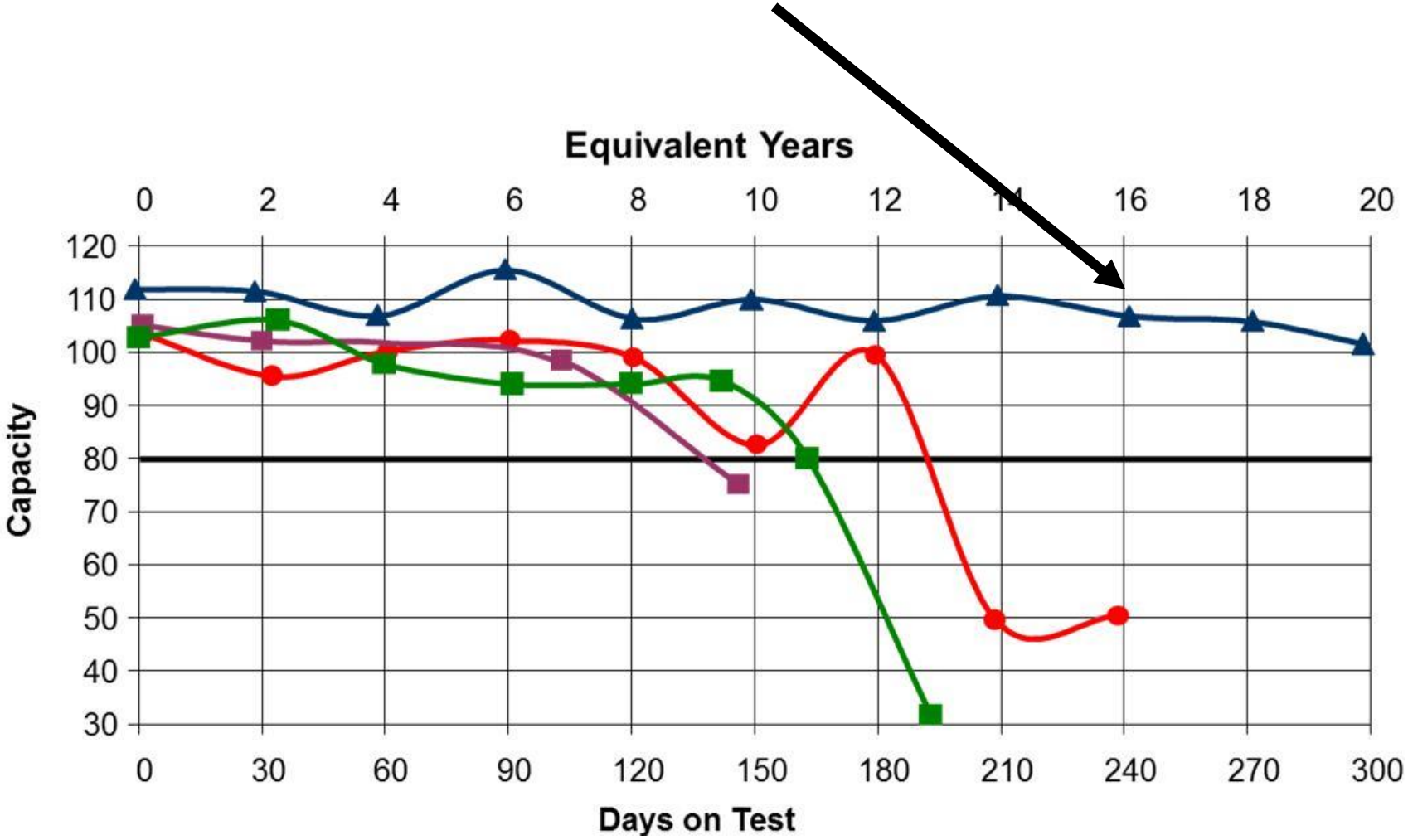
Active Material Paste

Additionally…

- **Factory paste processing methods must be optimized for pure lead raw materials**
  - **Paste mixing time and temperatures**
  - **Plate pasting method**
  - **Plate curing**
    - **Forms the basic crystal structure – defines cycle life and aging characteristics**
  - **Formation process – defines how the batteries perform on a discharge**

Dramatic Pure Lead Improvements

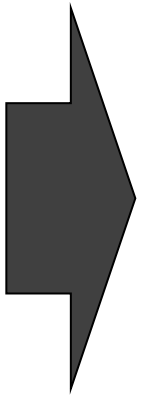
Pure Lead Battery showing 50% greater life in controlled lab tests



Summary of Pure Lead benefits

Desired Benefits

- Reduced grid corrosion
- Reduced side reactions
- Reduced internal heat
- Slower aging mechanisms
- Higher tolerance to heat



- Lasts 2X longer in normal operation
- Lasts longer in high temperature
- 2X longer shelf life

Summary

- **Pure lead can dramatically improve how a lead-acid battery operates and ages**
- **Key: Must improve both components of the plate: the grid and the paste**
  - **Grid: pure lead will lower grid corrosion, grids lasts longer**
  - **Paste: pure lead materials and processing will *lower float voltage*, paste will cycle longer and degrade more slowly**

Pure Lead expected to become the standard in the future

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