EAGLE EYE TECHNICAL NOTE

Title	**The Battery Cycle. From Pure Lead to Thin Plate Pure Lead.**
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The Battery Cycle. From Pure Lead to Thin Plate Pure Lead.

Introduction.
Originally, lead-acid batteries consisted of pure lead grids; but lead is very soft, difficult to work with and to transport. Gaston Planté, who is credited with the invention of the lead-acid battery, refined the lead plate. A modern form of pure lead plates, the Planté plate, named after him, although expensive to manufacture, is still being made for some applications, especially in Europe.

Lead Alloy Batteries.
As battery manufacturing progressed, a small amount of antimony (approximately 10 percent) was added to the lead grids to strengthen them and make manufacturing easier. However, antimony had the disadvantage of increasing the gassing rate of batteries as they aged, which resulted in increased watering and maintenance. The telephone companies were the largest users of stationary batteries in the USA, and they requested that Bell Labs come up with a solution. The result was the introduction of the lead-calcium battery in the 1950's, where calcium replaced antimony as the hardening agent. Lead antimony battery cells, usually with much less concentration of antimony, are still being manufactured for certain applications, especially deep cycling. A small amount of antimony, about two percent, is mixed with selenium in the manufacturing of modern lead selenium (low antimony) cells, which are very prevalent outside of North America in Vented Lead-Acid (VLA) batteries and some Valve-Regulated Lead-Acid (VRLA) batteries. Batteries using the lead-acid electrochemistry are often named for the alloy used for their plate grids.

Problems with Lead Calcium.
Calcium introduces a problem into battery aging. It causes the positive plates to grow (expand) through oxidation as the batteries age. This growth is unavoidable and escalated by heat. This growth is also evident on batteries that are overcharged or under constant float charge. The aging factor caused by heat is generally understood to be a decrease of battery life of 50 percent for every 15 – 18 degrees Fahrenheit above the nominal operating temperature of 77°F. Another problem with lead-calcium batteries is that because of self-discharge the shelf life is limited, reducing the period before the battery needs to be given a freshening charge. It is argued that calcium reduces watering and maintenance costs, but battery life is severely reduced. This is especially true with VRLA Absorbed Glass Mat (AGM) batteries, which are now dominating certain battery markets, especially for Uninteruptible Power Supply (UPS) applications.

Lead-Calcium Tin
In order to reduce the effects of the calcium additive, a small amount of tin was added to the positive plate grids to enhance the mechanical properties, reduce the corrosion and increase the short shelf life. Hence, the lead-calcium-tin (PbCaSn) battery was introduced. Unfortunately, tin added cost to the manufacturing of the battery.

Thin Plate Pure Lead and Pure Lead-Tin.

To further counter the shortened life of lead-calcium due to corrosion, various manufacturers started to remove the calcium from the positive grids. Improvements in the manufacturing process made it possible to produce 99.9 percent pure lead positive grid plates; the balance being tin, and hence the Pure Lead-Tin (PLT) name. The plates are made considerably thinner than conventional lead-calcium and pure lead Planté batteries and are referred to as Thin-Plate Pure Lead (TPPL). This allows for greater plate surface area and an increase in power density with more plates in a similar battery container, enhancing the high-rate performance and cycling ability. There is also virtually no grid growth, which means that excess space does not have to be provided in the container for plate growth. The construction, with the exception of the positive grids, is virtually the same as lead-calcium and lead-calcium-tin AGM batteries.

Claimed Advantages of Pure Lead and Pure Lead-Tin.
Manufacturers generally agree with the claimed advantages of TPPL and PLT AGM batteries when compared to lead-calcium AGM batteries. These are:

- High efficiency
- High energy density
- Superior high-rate power density
- Good high-rate performance
- Excellent deep discharge recovery
- Long float life (one manufacturer claims 12-plus years of expected float life)
- Minimal grid corrosion
- High cycle life (one manufacturer claims 200% greater cycle capability over conventional VRLA products)
- Improved shelf life (some manufacturers claim 18 months to 2 years)
- Wide operating temperature range
- Superior performance at lower temperatures in extreme operation (one manufacturer claims twice the performance at temperatures below -20°C with minimal derating at lower temperatures)