STORAGE BATTERY SYSTEMS, LLC

White Paper

Lead-Acid Batteries

Comparison Between Flat and Tubular Positive Plates

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Introduction

Lead-acid batteries have been around for more than 150 years. While flat plate models with a lattice grid represented a technological leap forward in 1881, tubular construction is a more robust technology with many advantages. With advancements such as the use of non-woven gauntlets encasing the positive spine plate, to more advanced manufacturing techniques, tubular batteries provide enhanced performance and improved reliability as compared to flat plate technology.

Origin / Timeline

Innovations in manufacturing improved storage density as well as battery life.

1859 French physicist Gaston Planté invents the first practical model of a lead-acid battery by corroding foils of lead to form positive active material. It is the first battery that can be recharged by passing a reverse current through it.

1881 Camille Alphonse Faure develops a significantly improved version of Planté's flat model that consists of a lead grid lattice — which resembles the cross section of a honeycomb — into which a sponge-like lead oxide paste is pressed, forming a plate with a greater surface area. Faure's design is more efficient and easier to mass-produce.

1910 Industrialized cells with tubular construction — with positive active material held in rubber tubes — enter the market. Originally developed in the U.S., European markets successfully adopt the tubular designs, which become the primary technology offering throughout Europe.

1960s A continuous evolution of the tubular plate brings single tubes made of fiberglass surrounded by perforated PVC.

1973 Tubular construction evolves again to become woven multi-tube bags made of glass-polyester yarn called gauntlets, followed some years later by non-woven gauntlets and woven polyester gauntlets fixed by acrylic resin.

Description of Positive Plate Construction Types

A clear understanding of the different types of construction is required to adequately compare and contrast the differing technologies employed by lead-acid battery manufacturers.

Explanation of lead-acid positive plate technologies:

***Reminder**: the negative plates in all lead-acid cells are the flat, pasted type*

- **Planté plates** are positive plates made with pure lead versus a lead alloy. The active mass is formed by a corrosion process out of the grid. The demand for Planté plate is declining. Costly and challenging production techniques, and the requirement to use more lead in construction, do not deliver significant benefits as compared to alloyed tubular or flat plate batteries. ***Figure 1*** shows Planté plate
- **Pasted plates** are flat, positive plates made by pasting the lead oxide active mass on a mesh grid. ***Figure 2*** shows classic pasted plate
- **Tubular plates** use a frame structure consisting of a series of vertical spines connected to a common bus bar. The tubular design keeps the active material mechanically together and presses it onto the grid. The paste is held in micro-porous, non-conductive tubes (gauntlets), which are placed over the individual spines. Assembling the spines, gauntlets, lead oxide, and bottom bar together makes a positive plate. Volume changes during discharge and charge are mostly compensated by a high mass porosity, and gas bubbles help to distribute remaining free particles in the cell. Pressing the PbO_2 corrosion layer onto the grid surface also helps to protect the lead grid against further corrosion. ***Figure 3*** shows classic tubular plate

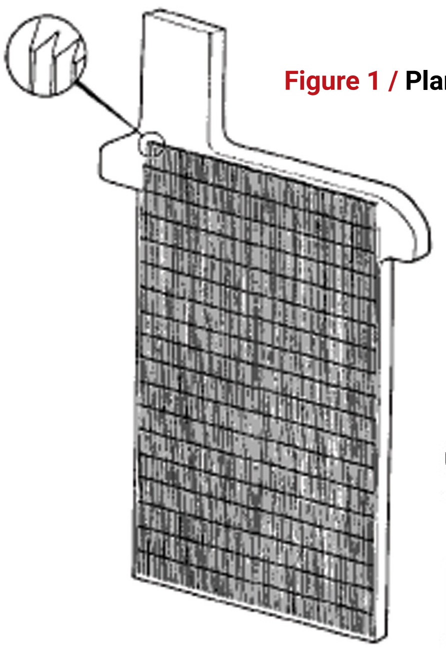

Figure 1 / Planté plate

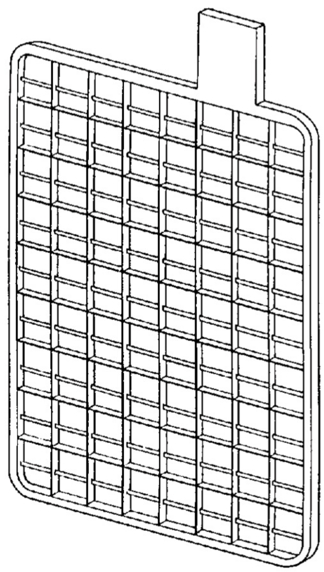

Figure 2 / Pasted plate

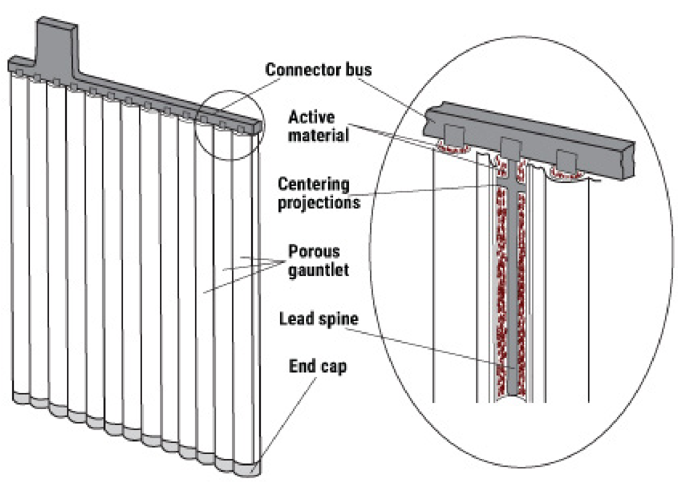

Figure 3 / Tubular plate

	Flat Plate	Tubular	Explanation of tubular advantages
Reliability	Reliable	Most reliable	
Charge cycles (at 80% DOD)	50–1000	1100–1800	
Electrolyte stratification risk	Medium	Low	The external shape of the positive plate allows for easier movement for the electrolyte
Float current	Medium	Low	
Thermal management	Medium	High	Because of the higher relative electrolyte amounts and easier convective heat transport
Interface surface area	Medium	High	
Electrical resistance	Mid-to-Low	Low	Well-defined pore sizes permit easy movement to the electrolyte
Life expectancy	15–18 years	20+ years	
Charge retention	Long	Longest	Because there is no electrolyte pollution from reinforcing agents

Why tubular is better: The secrets are the multi-tube bag gauntlet and increased surface area of the positive plate

Advanced multi-tube bag gauntlets are constructed of 100% polyester high-tenacity, multifilament yarns that are impregnated with an acrylic resin system and fixed crosswise to the tubes, while spun yarn is used lengthwise.

Gauntlet Characteristics

- ***High porosity and low electrical resistance*** – Low electrical resistance can determine a well-defined pore size that permits easy movement to the electrolyte, but at the same time reduces the active material shedding to a negligible amount
- ***Good mechanical resistance and elasticity*** – The gauntlet resists the high pressure that the active material produces during its cyclical expansion. The fabric holds the paste pressed to the conductive lead spines ensuring stable performance. Mechanical resistance to abrasion during cell assembly reduces scraps and pollution
- ***Reduced release speed of antimony*** – The fabric keeping the active material all around the spines acts as a filter for the electrolyte, reducing the release speed of antimony from positive grids. In contrast, for pasted plates there is almost no distance between grid wires and electrolyte
- ***Semi-rigid stability*** – The semi-rigid woven fabric gives the multi-tube bag a stable shape that permits an easy and quick filling procedure with paste, powder or slurry methods
- ***High short-circuit resistance*** – Gauntlets can be supplied with a special solution for the two lateral tubes that result in dramatic increase in plate short-circuit resistance. In particular, the ISM solution (where the external tubes have half of their fabric completely closed) gives the best protection against short circuits between positive and negative plates with only a minor increase in electrical resistance

Due to increased positive plate surface area, tubular batteries have 20% more electrical capacity than flat plate batteries of comparable size and weight. With less positive plate shedding, tubular batteries also provide up to a 30% longer service life than flat plate batteries. In addition, battery engineers in Europe attest that tubular cells are more widely used because they deliver energy at a faster rate.

Other Stationary Tubular Advantages

Doubters of tubular construction might argue that flat plate batteries — due to their simpler construction — are generally less expensive to make and maintain. However, tubular batteries have been shown to have both a longer life and supply more power faster in an equivalent size, while still being produced at a competitive cost.

Tubular plates deliver energy faster due to:

- Compact structure
- Increased mass and surface area of the active material
- Ease with which acid circulates around the tubular plate design

Perhaps most importantly to stationary applications, the tubular positive grid does not require horizontal bars, which virtually eliminates positive plate growth and therefore post seal leaks and jar cracking. As a result, in applications which require a long service life, ***tubular plate batteries provide the best and most reliable power for the money spent.***

Conclusion

The tubular plate design delivers energy faster, has at least 20% more electrical capacity, and up to a 30% longer service life than flat plate. ***The battery world favors tubular positive plate design*** for Flooded, Gel, and even AGM applications. In addition to the superior performance of tubular plate technology, advanced high-tech filling processes and machines have made the tubular design more efficient and reliable to fabricate, allowing tubular batteries to be manufactured at a competitive cost.

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