WHITE PAPER

Selecting the Proper Lead-Acid Technology

Introduction

With so many different battery technologies on the market today, it can be difficult to make sure you're selecting the right battery for your application. This document will describe the basic types of lead-acid batteries available, and help you understand which one will provide the best performance and value for your needs.

Basic Battery Types

Flooded (Wet)

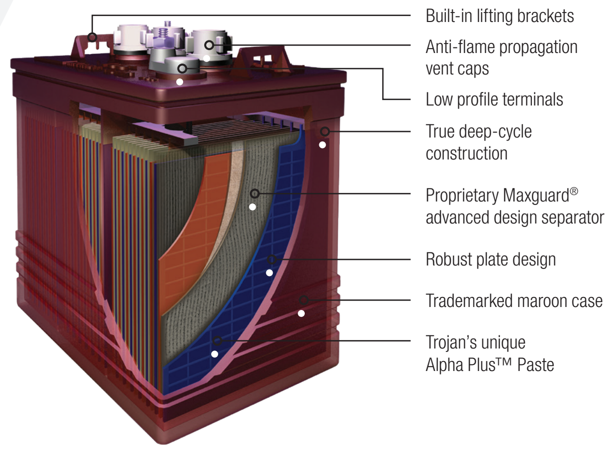
The flooded lead-acid (FLA) battery, invented in 1859, was the first rechargeable battery. After decades of refinement, it remains the primary choice for many applications. The battery plates are immersed in an electrolyte of dilute sulfuric acid, and removable caps in the lid allow replacement of lost water. FLA batteries are cost effective, rugged, and provide reliable performance when properly maintained.

Because FLA batteries are not sealed, they must be kept in the proper orientation (upright) to avoid spilling of electrolyte. Due to the risk of spills, they cannot be shipped by air.

During the charging process, FLA batteries consume water and release hydrogen gas, which must be properly vented to avoid potential fire hazards. The water consumed during charging must periodically be replaced at a frequency that varies with the usage profile.

Although the introduction of single-point watering systems has reduced the overall effort to water FLA batteries, this periodic requirement means that these batteries are appropriate only in situations where regular maintenance can be assured. With proper maintenance and charging, flooded batteries can provide years of reliable service in many applications.

Figure 1: Construction of a Flooded Battery



Absorbed Glass Mat (AGM)

The AGM battery is a sealed battery that fits into the category of Valve-Regulated Lead Acid (VRLA) batteries. These batteries are designed so that hydrogen and oxygen are recombined within the battery, rather than being vented. A built-in valve will release excess gas in case of a severe overcharge.

An AGM battery is constructed by compressing a glass fiber mat between each plate. The glass mat holds electrolyte in place much like a sponge, and helps support the plates. This gives AGM batteries good resistance to shock and vibration.

Since AGM batteries are sealed, they can be mounted on their sides if desired and ventilation requirements are much less demanding than with flooded batteries. They can be shipped by air if needed. They have the ability to charge and discharge at high rates and perform well at low temperatures.

It is very important that AGM batteries not be severely overcharged, as this will cause the battery to rapidly dry out. The selected charger must specifically have an AGM setting to avoid damaging the battery.

Figure 2: Construction of an AGM Battery

Gel

A Gel battery is another type of VRLA battery, and like the AGM, is sealed. Although the basic internal construction of a Gel battery is similar to that of the flooded battery, the electrolyte has been immobilized by the addition of a thickening agent, taking on the look and consistency of petroleum jelly. Like the AGM, it can be mounted on its side and doesn't release hydrogen during normal operation.

Gel batteries have a higher initial cost, and typically don't work as well in higher power applications. In deep-cycle applications, they will generally outlast an AGM battery, unless the AGM has been designed for deep cycling. Like the AGM, the selected charger must have a specific Gel setting to avoid overcharge damage. Additionally, the charger and charge algorithm should support temperature-compensated charging. Since Gel batteries are resistant to spills and leakage, they can also be shipped by air.

Figure 3: Trojan 102 Ah Gel Battery

Key Performance Characteristics

Now that we've described the basic categories of lead-acid batteries, let's take a look at the various performance characteristics that may come into play as you select the proper battery for your application.

Sealing/Gas Release

As previously noted, the process of charging a lead-acid battery generates hydrogen and oxygen. In a flooded battery, these gases are released to the external atmosphere. In a VRLA battery, these gases are internally recombined and stay within the battery.

In some applications, the required ventilation requirements for a flooded battery are not feasible. In others, the possibility of acid leaks during service or due to a broken case are unacceptable. This guides the selection process to one of the VRLA types.

Maintenance

Flooded batteries require regular water replacement to continue to perform effectively. If regular maintenance cycles to add water are impractical, such as in remote, unstaffed installations, then one of the VRLA technologies may be more desirable. Note that even though VRLA batteries don't require watering, periodic cleaning and re-torqueing of connections is still required.

Deep-Cycle Capability

Flooded and VRLA batteries, when designed for deep cycling, have very good cycling capability. While flooded types typically have very good cycling, they require proper maintenance in order to achieve long cycle life. VRLA types do not require maintenance but do require proper charging in order to achieve long cycle life.

Recharge Time

FLA batteries need a higher amount of overcharge than VRLA types to avoid a harmful effect known as stratification, so this can extend FLA charge times. However, charge time is more dependent upon the depth of discharge and the size (power) of the charger being used.

Self-Discharge

Self-discharge is the capacity loss that occurs within a battery even when it is not connected to a load. How quickly a battery self-discharges is related to temperature, where warmer temperatures mean the battery will self-discharge quicker. A result of parasitic chemical reactions within the battery, the self-discharge rate of VRLA batteries is much lower than that of FLA batteries. This can be an important constraint if batteries need to be stored for long periods of time.

Low-Temperature Performance

Some applications require batteries to perform well even at temperatures well below 0°C (32°F). AGM batteries have the best low-temperature performance of the three technologies discussed here.

Energy Density

Within the lead-acid family, FLA batteries have the most capacity for a given size or weight. When you need the most Ah possible in a size-constrained location, then flooded batteries are likely your best choice.

Power Density

AGM batteries are best suited in applications where high discharge currents are needed. Gel batteries are more suited to longer, lower-current cycles. At high rates of discharge, AGM batteries deliver more of their theoretical capacity than do FLA batteries.

Round-Trip Efficiency

Whenever energy is converted and stored, there will always be an efficiency penalty. The round-trip efficiency, or the percentage of energy that a battery delivers compared to the energy that it took to charge it, can be particularly important in certain applications. FLA batteries typically have round-trip efficiencies of 70-80%, while VRLA batteries will be in the range of 80-90%.

Cost

Due to the cost of materials and processing, FLA batteries are generally the least expensive, while Gel batteries are the most expensive. AGM batteries will fall somewhere in between.

Summary

As this paper has described, a wide variety of factors can influence the selection of the proper lead-acid battery technology. In some instances, one particular factor may dominate the decision, while in others a mix of performance attributes may determine which technology will be the best.

The table below summarizes the various factors that have been discussed in the previous sections. For additional information, you may contact Trojan technical support at technical@trojanbattery.com.

SUMMARY TABLE

	Flooded Lead Acid	VRLA - AGM	VRLA - Gel
Sealing/Gas Release	Not sealed – will release H_2 and O_2 during charging	Low to no gassing unless overcharged	Low to no gassing unless overcharged
Spill-proof/Leak-proof	No	Yes	Yes
Mounting Flexibility	Must be upright	Upright or on side	Upright or on side
Maintenance	Requires periodic water replacement	Maintenance-free	Maintenance-free
Deep-Cycle Capability	Best	Better	Better
Recharge Time	Longer	Shorter	Long
Self-Discharge	Up to 15% per month	1-3% per month	1-3% per month
Low-Temperature Performance	Good	Best	Fair
Energy Density	Highest	Lower	Lower
Power Density	Medium	High	Low
Round Trip Efficiency	70-80%	80-90%	80-90%
Cost	Low	Medium	High

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