White Paper

Advanced AGM Batteries

Windsor is pleased to offer an array of Advanced AGM batteries for our equipment. For years, cleaning equipment has been powered by traditional, flooded lead-acid batteries, however advances in battery technology and environmental and safety concerns have brought this technology to the forefront of our industry.

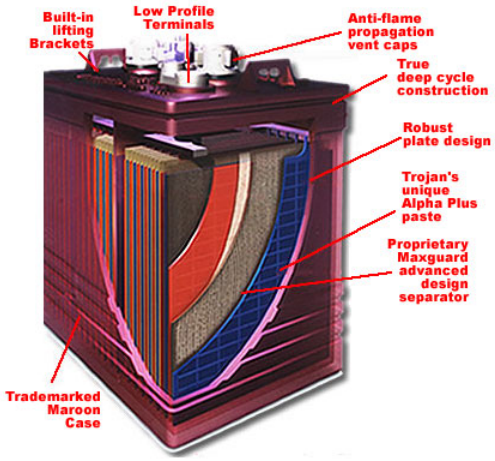
This paper is designed to cover the basics of battery operation and explain in simple-to-understand terms their inner workings. The goal is that sales people and end users will be able to understand how the batteries work and make an informed decision on which battery is right for their particular application.

Table of Contents

- **Page 2: How a Flooded, Lead Acid Battery works**
- **Page 4: How a Gel Battery works**
- **Page 5: How an Advanced AGM Battery works**
- **Page 6: Advantages of the AGM Battery**
- **Page 6: Differences between "AGM" and "Advanced AGM" batteries**

A member of KÄRCHER Floor Care

How a Flooded Lead-Acid Battery Works



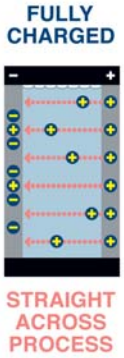
A flooded, lead acid battery is composed of lead plates in the shape of a grid that are immersed in an acid-based water solution referred to as “electrolyte”. There are a number of cells, each with 2 plates, a positive and a negative, with the positive plate containing and holding the electrons that are in the battery.

In simplest terms, once a circuit has been created between the terminals on the top of the battery, the discharge process begins. This is where the positively charged electrons, which had been residing on the positive plate migrate or travel through the water to the negative plate based on their polarity (a positive attracting to a negative). The energy created in this tiny process, replicated hundreds of millions of times, generates the power that comes from the battery.

The Discharging Process

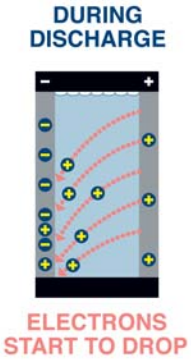
When a battery has been fully charged and the circuit is closed, the electrons move rapidly from the positive plate to the negative plate. As electrons move between plates, generating power, the polarities of the plates begin to become more similar. With more and more positively charged electrons residing on the negative plate the attraction weakens.

As this occurs the process of the electron moving from the positive to the negative plate becomes less of a “straight across” process. At that point it becomes more like a bomb that is dropped from a plane onto a target. The bomb falls on a curve once it is released. Because of this action, much of the material ends up towards the bottom of the plates. Once all the electrons have migrated from the positive plate to the negative plate, the energy is expended and the battery needs charging.

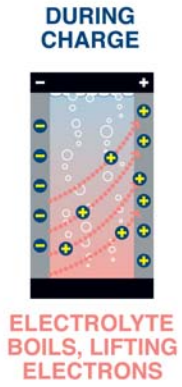


The Recharging Process

At this point many of the electrons that are residing on the negative plate are lower then where they first started on the positive plate because of the “falling action” during their travel between the plates. Additionally, they need to transfer back to the positive plate in order for the discharge process to begin again. When the battery is hooked to a charger to begin the charging process the effect is essentially that of reversing the discharging process. Electrons now travel from the negative plate to the positive plate. But how do we correct for the “falling effect”, so that the tops of the plates get covered with electrons as well, and the electrons do not fall even further in the trip back to the positive plate?



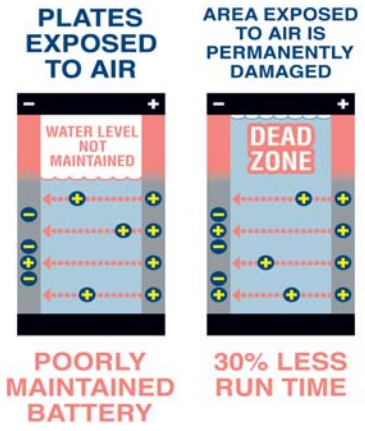
When the battery is charged the electrolyte inside begins to boil. The boiling of the electrolyte essentially bubbles all the electrons to the top where they distribute themselves evenly on the positive plate. Reversing the discharge process (getting the positive and negative electrons back to their original plate) typically takes longer, thus accounting for the rule of thumb that charging time is twice the discharge time of the battery.



Gas Venting

During this boiling process, corrosive hydrogen sulfide gasses are released through the vents on the top of the battery. In confined spaces these gasses can be dangerous. These gasses are also responsible for the corrosion that is found on and around batteries (usually the positive post, since the gas craves electricity) and in machines. All the boiling and releasing of gasses causes the battery to lose water on a regular basis, which is why lead acid batteries must be maintained and filled regularly.

Battery Maintenance



Always fill flooded, lead acid batteries with distilled water after the battery has been fully charged, covering the plates with ¼ inch of water. Not filling the battery on a regular basis will allow portions of the plates to become exposed to the air inside the battery due to the water level dropping. When this occurs, the exposed plate is permanently damaged and cannot be repaired. Since that part of the plate will never attract electrons and hold a charge again the capacity (run time) of the battery will drop accordingly. Lastly, electrons in a lead acid battery can settle off of the positive plate if the battery is not used and charged on a regular basis, so it is a wise idea to charge batteries at least once a month if they are not being used. A lead acid battery that sits unused loses 3% of it's charge per month.

The regular cycle of discharge and charge of a lead acid battery takes its toll over time. The heat created by recharging begins to break down the components, until they literally turn to mush and will not hold a charge. Most lead acid batteries will last for approximately 600 full discharge and charge cycles before needing replacement. However, lack of maintenance can shorten that lifespan dramatically.

"Opportunity Charging"

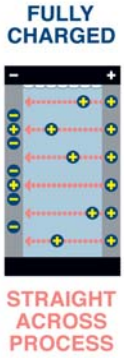
Any charge on a lead acid battery essentially represents one full discharge and charge cycle. For example, if a battery is designed to run for four hours in a certain application, and it is run for the four hours to a complete discharge and then charged again, that represents one cycle. Conversely, if a battery is run for one hour and then charged during a one hour break, which is called "opportunity charging", that also represents one complete cycle (one of the 600 cycles). The best way to extend the life of a lead acid battery is to discharge it completely before charging and to check and maintain the water level on a daily basis. As for discharging and charging, if it is possible to clean the area that requires two hours with a battery that runs for four hours, then charge every other cleaning. However, if the area to be cleaned requires three hours of run time with the same battery then charge the battery every night.

How a Gel Battery Works

As with the flooded lead-acid batteries, the process of generating power through the traveling of the electron from the positive to negative plate is the same in a gel battery, only the medium is different. In a gel battery there is actually gel (though it is more along the lines of a paste) between the positive and negative plates, not acid-based water.

This gel battery offers a number of benefits over a lead acid battery. First and foremost a gel battery is a sealed system, so there is no off-gassing from the batteries during charging, which means no corrosive or potentially harmful fumes. Internally, the process of charging still generates hydrogen sulfide, however a gel battery is what we call a "recombinant battery" which is an industry term that simply means any fumes and accompanying moisture gassed off during charging remain in the battery and are re-combined into its structure to continue being used. The net effect is that the gel battery never needs maintenance to add water, since no moisture escapes during the charging process. Additionally, the gel battery would be considered a "green" battery by today's environmental standards because there is no off-gassing of hydrogen sulfide.

Another benefit of a gel battery, since it contains a gel and not water, is that it can be mounted on it's side and will not leak. This allows for multiple mounting positions in equipment. Additionally, whereas in a flooded lead-acid battery, the electrons would jump from positive to negative and have a "falling effect", the electrons in the gel battery always move straight across through the gel solution. Thus, there is no "falling effect" and no need for the boiling that occurs in a lead acid battery.



Furthermore, because the gel battery is a sealed system, an expected life of 700 charge cycles is very realistic. However, like the flooded lead-acid battery, the gel battery is also susceptible to a reduced life expectancy from opportunity charging and not discharging the battery completely before charging.

The true drawback to a gel battery is run-time during use. Because the electrons move quite easily through the gel, these batteries discharge faster than their lead acid counterparts. Thus, with today's larger equipment, run-times can become dramatically shorter with gel batteries.

Gel battery benefits

- **Sealed system**
- **No off-gassing during charging**
- **No maintenance**
- **Multiple mounting positions**
- **"Green"**

Gel battery drawbacks

- **Shorter run-times**
- **May require a special charger**
- **More expensive**

How an Advanced AGM Battery Works

An Advanced AGM (Absorbed Glass Mat) battery works similarly to a gel battery, however the medium is entirely different. In an Advanced AGM battery there is a layer of glass matting between each plate, with each layer of glass matting containing some electrolyte solution to allow the electrons to transfer from the positive plate to the negative plate. The beauty of the glass material is that it allows the electrons to transfer with no "falling effect", while not allowing them to move as freely as the gel battery, resulting in run-times that are generally equal to, or in many cases superior to, lead acid batteries.

The Green Choice

Like a gel battery, the Advanced AGM battery is a recombinant battery, which means that all gases given off during the charging process remain in the battery housing and are re-absorbed into the system. Additionally, maintenance is eliminated as no water needs to be added and there are no corrosive fumes to contend with. As with a gel battery, the sealed system, eliminating potentially harmful off-gassing make this a Green battery. As with all deep cycle, lead-acid batteries, AGM is made of recycled lead and plastic and is 97% recyclable.

The Benefits of an "Acid Starved" Battery

One major difference between the Advanced AGM battery and the gel battery is that the Advanced AGM is an "acid starved" battery. In the other batteries that we have reviewed the medium that transfers the electrons is an electrolyte, whether it is a lead acid, gel or Advanced AGM. In the lead acid and the gel batteries the electrons are used up before the electrolyte in the system is used up. This promotes the deterioration of the plates and eventually destroys the battery, rendering it useless. However, in an Advanced AGM battery the electrolyte that transfers the electrons is used up long before the electrons that are on each plate, thus the term "acid starved". The benefit is that since the plates never fully expend all their electrons they last longer than lead acid or gel batteries.

Minimal Cost to "Opportunity Charge"

An additional benefit is that the Advanced AGM battery, unlike its lead acid and gel counterparts, handles "opportunity charging" quite well. As with gel batteries, the Advanced AGM battery has a full discharge and charge life expectancy of 700 cycles. However, because it is an acid starved battery and the plates deteriorate much slower, an opportunity charge while the operator is on break for an hour will not harm the battery. In fact, when selling the Advanced AGM batteries try not to think of "charge cycles" as much as "hours of use".

Lets say that a set of Advanced AGM batteries will run for 4 hours in a certain machine. With 700 cycles of full discharge and charge, that would equal 2800 hours of run-time from the machine (4 hours run-time x 700 cycles = 2800 hours of run-time). With an Advanced AGM battery, if that machine was run for 2 hours a night the life of the battery would be approximately 1400 cycles or approximately 4 to 6 years of life (2800 hours of runtime / 2 hours = 1400 cycles). Conversely, a 3 hour job with the same batteries would provide about 930 cycles or approximately 3 to 4 years of life, all with no maintenance.

Advantages of the Advanced AGM battery

- **100% Maintenance free**
- **Never need to check electrolyte (water) levels**
- **Green**
- **Made from recycled lead and plastic**
- **Battery is 97% recyclable. Casing and lead can be recycled, electrolyte solution becomes fertilizer**
- **Reduced overall battery maintenance**
- **Comparable or increased run-times compared to lead acid batteries**
- **Increased run-times compared to gel batteries**
- **Sealed recombinant batteries eliminate spills and off-gassing**
- **Self discharge at 1% when sitting unused for extended period, compared to 3% for lead acid batteries**
- **"Acid Starved," keeps plates from fully discharging thus ensuring longer life**
- **Little affected by "opportunity charging"**

Differences between AGM and Advanced AGM

It is quite possible that you may have a situation where an end-user has tried an AGM battery and had extremely poor performance. It is important to remember that the AGM technology has been around for about 25 years and has been used in a wide variety of applications. The rush to bring a product to market with the advantages that are intrinsic in AGM battery technology has resulted in applications where the wrong battery was used to try to achieve the desired end result.

An "AGM" battery is a battery that is designed to be discharged and charged 2 to 3 times per year. These batteries are popular for back-up power and are used in things like exit lights over doors and other similar applications. When a battery like this is subjected to the rigors of the charge and discharge cycles that are common in the cleaning industry, they obviously did not perform anywhere close to their lead acid or gel counterparts.

However, the "Advanced AGM" battery is designed for the deep discharge and charge cycles that are standard in the cleaning industry. The Advanced AGM batteries are designed for approximately 700 discharge and charge cycles, and will perform as well or better than their lead acid or gel counterparts.

AGM batteries

- **Designed for back-up power and other similar applications**
- **Designed for 2-3 discharge and charge cycles per year**

Advanced AGM batteries

- **Designed for deep discharge and charge cycles**
- **Designed for approximately 700 discharge and charge cycles**

Notes

White Paper