



RX Marine International

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Sulphuric (Sulfuric) Acid diluted

Part/Order no: Rxsol-16-1104-025
Packing: 025 Ltr

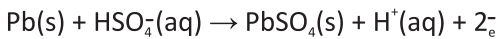


Electrochemistry:-

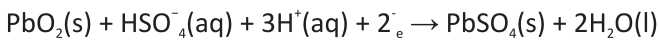
Discharge:-

In the discharged state both the positive and negative plates become lead(II) sulfate (PbSO_4) and the electrolyte loses much of its dissolved sulfuric acid and becomes primarily water. The discharge process is driven by the conduction of electrons from the negative plate back into the cell at the positive plate in the external circuit.

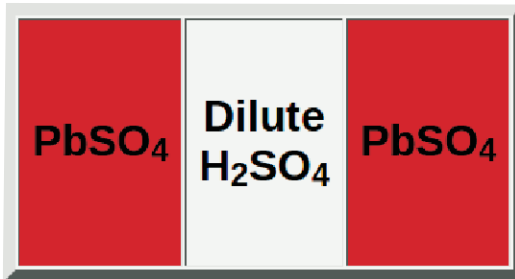
Negative plate reaction(Anode Reaction):



Positive plate reaction(Cathode Reaction):



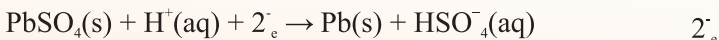
The sum of the molecular weights of the reactants is 642.6, so theoretically a cell can produce two faradays of charge from 642.6 g of reactants, or 83.4 amp-hours per kg (or 13.9 amp-hours per kg for a 12-volt battery). At 2 volts per cell, this comes to 167 watt-hours per kg, but lead-acid batteries in fact give only 30 to 40 watt-hours per kg due to the weight of the water and other factors.



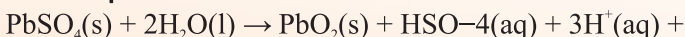
Charging:-

In the charged state, each cell contains negative plates of elemental lead (Pb) and positive plates of lead(IV) oxide (PbO_2) in an electrolyte of approximately 33.5% v/v (4.2 Molar) sulfuric acid (H_2SO_4). The charging process is driven by the forcible removal of electrons from the positive plate and the forcible introduction of them to the negative plate by the charging source.

Negative plate reaction:

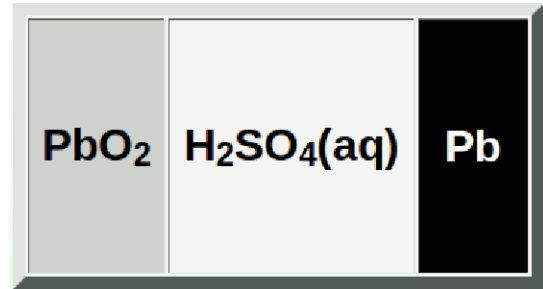


Positive plate reaction:



Overcharging with high charging voltages generates oxygen and hydrogen gas by electrolysis of water, which is lost to the cell. Periodic maintenance of lead acid batteries requires inspection of the electrolyte level and replacement of any water that has been lost.

Due to the freezing-point depression of the electrolyte, as the battery discharges and the concentration of sulfuric acid decreases, the electrolyte is more likely to freeze during winter weather.



Voltages for common usages:-

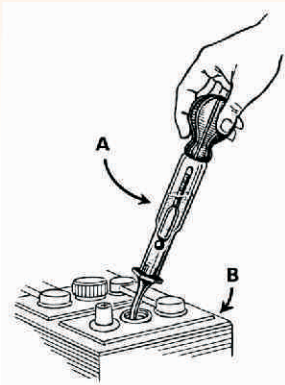
- These are general voltage ranges per cell
- Open-circuit (quiescent) at *full charge*: 2.10V
- Open-circuit at *full discharge*: 1.95V
- Loaded at full discharge: 1.75V
- Typical (daily) charging: 2.37V to 2.4V (depending on temperature and manufacturer's recommendation)
- Equalization charging (for flooded lead acids): 2.5V for no more than 2.205 hours. Battery temperature must be absolutely monitored.
- Gassing threshold: 2.4V

Measuring the charge level:-

Because the electrolyte takes part in the charge-discharge reaction, this battery has one major advantage over other chemistries. It is relatively simple to determine the state of charge by merely measuring the specific gravity (S.G.) of the electrolyte, the S.G. falling as the battery discharges. Some battery designs include a simple hydrometer using colored floating balls of differing density. When used in diesel-electric submarines, the S.G. was regularly measured and written on a blackboard in the control room to indicate how much longer the boat could remain submerged.

The battery's open circuit voltage can also be used to gauge the state of charge.[4] If the connections to the individual cells are accessible, then the state of charge of each cell can be

determined which can provide a guide as to the state of health of the battery as a whole.



Construction:-

Plates:The lead–acid cell can be demonstrated using sheet lead plates for the two electrodes. However such a construction produces only around one ampere for roughly postcard sized plates, and for only a few minutes.

Gaston Planté found a way to provide a much larger effective surface area. In Planté's design, the positive and negative plates were formed of two spirals of lead foil, separated with a sheet of cloth and coiled up. The cells initially had low capacity, so a slow process of "forming" was required to corrode the lead foils, creating lead dioxide on the plates and roughening them to increase surface area. Initially this process used electricity from primary batteries; when generators became available determined which can provide a guide as to the state of health of the battery as a whole. after 1870, the cost of production of batteries greatly declined. Planté plates are still used in some stationary applications, where the plates are mechanically grooved to increase their surface area.

Faure pasted-plate construction is typical of automotive batteries. Each plate consists of a rectangular lead grid alloyed with antimony or calcium to improve the mechanical characteristics. The holes of the grid are filled with a paste of red lead and 33% dilute sulfuric acid. (Different manufacturers vary the mixture). The paste is pressed into the holes in the grid which are slightly tapered on both sides to better retain the paste. This porous paste allows the acid to react with the lead inside the plate, increasing the surface area many fold. Once dry, the plates are stacked with suitable separators and inserted in the battery container. An odd number of plates is usually used, with one more negative plate than positive. Each alternate plate is connected.

The positive plates are the chocolate brown color of lead dioxide, and the negative are the slate gray of "spongy" lead at the time of manufacture. In this charged state the plates are called 'formed'.

One of the problems with the plates is that the plates increase in size as the active material absorbs sulfate from the acid during discharge, and decrease as they give up the sulfate during charging. This causes the plates to gradually shed the paste. It is important that there is room underneath the plates to catch this shed material. If it reaches the plates, the cell short-circuits.

The paste contains carbon black, *blanc fixe* (barium sulfate) and lignosulfonate. The blanc fixe acts as a seed crystal for the lead–to–lead sulfate reaction. The blanc fixe must be fully dispersed in the paste in order for it to be effective. The lignosulfonate prevents the negative plate from forming a solid mass during the discharge cycle, instead enabling the formation of long needle–like crystals. The long crystals have more surface area and are easily converted back to the original state on charging. Carbon black counteracts the effect of inhibiting formation caused by the lignosulfonates. Sulfonated naphthalene condensate dispersant is a more effective expander than lignosulfonate and speeds up formation. This dispersant improves dispersion of barium sulfate in the paste, reduces hydroset time, produces a more breakage-resistant plate, reduces fine lead particles and thereby improves handling and pasting characteristics. It extends battery life by increasing end–of–charge voltage. Sulfonated naphthalene requires about one-third to one-half the amount of lignosulfonate and is stable to higher temperatures.



Separators:Separators between the positive and negative plates prevent short-circuit through physical contact, mostly through dendrites ('treeing'), but also through shedding of the active material. Separators obstruct the flow of ions between the plates and increase the internal resistance of the cell. Wood, rubber, glass fiber mat, cellulose, and PVC or polyethylene plastic have been used to make separators. Wood was the original choice, but deteriorated in the acid electrolyte. Rubber separators were stable in the battery acid.

An effective separator must possess a number of mechanical properties; such as permeability, porosity, pore size distribution, specific surface area, mechanical design and strength, electrical resistance, ionic conductivity, and chemical compatibility with the electrolyte. In service, the separator must have good resistance to acid and oxidation. The area of the separator must be a little larger than the area of the plates to prevent material shorting between the plates. The separators must remain stable over the battery's operating temperature range.

Applications:-

Most of the world's lead–acid batteries are automobile starting, lighting and ignition (SLI) batteries, with an estimated 320 million units shipped in 1999. In 1992 about 3 million tons of lead were used in the manufacture of batteries.

Wet cell stand-by (stationary) batteries designed for deep discharge are commonly used in large backup power supplies for telephone and computer centers, grid energy storage, and off-grid household electric power systems. Lead–acid batteries are used in emergency lighting and to power sump pumps in case of power failure.

Traction (propulsion) batteries are used in golf carts and other battery electric vehicles. Large lead–acid batteries are also used to power the electric motors in diesel-electric (conventional) submarines and are used on nuclear submarines as well. Valve-regulated lead acid batteries cannot spill their electrolyte. They are used in back-up power supplies for alarm and smaller computer systems (particularly in uninterruptible power supplies ("UPS")) and for electric scooters, electric wheelchairs, electrified bicycles, marine applications, battery electric vehicles or micro hybrid vehicles, and motorcycles.

Lead–acid batteries were used to supply the filament (heater) voltage, with 2 V common in early vacuum tube (valve) radio

Cycles:-

Starting batteries:

Lead acid batteries designed for starting automotive engines are not designed for deep discharge. They have a large number of thin plates designed for maximum surface area, and therefore maximum current output, but which can easily be damaged by deep discharge. Repeated deep discharges will result in capacity loss and ultimately in premature failure, as the electrodes disintegrate due to mechanical stresses that arise from cycling. Starting batteries kept on continuous float charge will have corrosion in the electrodes which will result in premature failure. Starting batteries should be kept open circuit but charged regularly (at least once every two weeks) to prevent sulfation.

Starting batteries are lighter weight than deep cycle batteries of the same battery dimensions, because the cell plates do not extend all the way to the bottom of the battery case. This allows loose disintegrated lead to fall off the plates and collect under the cells, to prolong the service life of the battery. If this loose debris rises high enough it can touch the plates and lead to failure of a cell, resulting in loss of battery voltage and capacity.

Deep cycle batteries:

Specially designed deep-cycle cells are much less susceptible to degradation due to cycling, and are required for applications where the batteries are regularly discharged, such as photovoltaic systems, electric vehicles (forklift, golf cart, electric cars and other) and uninterruptible power supplies. These batteries have thicker plates that can deliver less *peak current*, but can withstand frequent discharging.

Some batteries are designed as a compromise between starter (high-current) and deep cycle batteries. They are able to be discharged to a greater degree than automotive batteries, but less so than deep cycle batteries. They may be referred to as "Marine/Motorhome" batteries, or "leisure batteries".

Fast and slow charge and discharge:

The capacity of a lead–acid battery is not a fixed quantity but varies according to how quickly it is discharged. An empirical relationship exists between discharge rate and capacity, known as Peukert's law. When a battery is charged or discharged, this initially affects only the reacting chemicals, which are at the interface between the electrodes and the

With time, the charge stored in the chemicals at the interface, often called "interface charge", spreads by diffusion of these chemicals throughout the volume of the active material.

If a battery has been completely discharged (such as by leaving the car lights on overnight) and then is given a fast charge for only a few minutes, the battery plates charge only near the interface between plate and electrolyte. The battery voltage may rise to be close to the charger voltage so that the charging current decreases significantly. After a few hours this interface charge will spread to the volume of the electrode and electrolyte, leading to an interface charge so low that it may be insufficient to start the car.

On the other hand, if the battery is given a slow charge, which takes longer, then the battery will become more fully charged. During a slow charge the interface charge has time to redistribute to the volume of the electrodes and electrolyte, while being replenished by the charger. The battery voltage remains below the charger voltage throughout this process allowing charge to flow into the battery.

Similarly, if a battery is subject to a fast discharge (such as starting a car, a current draw of more than 100 amps) for a few minutes, it will appear to go dead, exhibiting reduced voltage and power. However, it may have only lost its interface charge. If the discharge is halted for a few minutes the battery may resume normal operation at the appropriate voltage and power for its state of discharge. On the other hand, if a battery is subject to a slow, deep discharge (such as leaving the car lights on, a current draw of less than 7 amps) for hours, then any observed reduction in battery performance is likely permanent.



Valve regulated:-

In a valve regulated lead acid battery (VRLA) the hydrogen and oxygen produced in the cells largely recombine into water. Leakage is minimal, although some electrolyte still escapes if the recombination cannot keep up with gas evolution. Since VRLA batteries do not require (and make impossible) regular checking of the electrolyte level, they have been called maintenance free batteries. However, this is somewhat of a misnomer. VRLA cells do require maintenance. As electrolyte is lost, VRLA cells "dry-out" and lose capacity. This can be detected by taking regular internal resistance, conductance or impedance measurements. Regular testing reveals whether more involved testing and maintenance is required. Recent maintenance procedures have been developed allowing "rehydration", often restoring significant amounts of lost capacity.

VRLA types became popular on motorcycles around 1983, because the acid electrolyte is absorbed into the separator, so it cannot spill. The separator also helps them better withstand vibration. They are also popular in stationary applications such as telecommunications sites, due to their small footprint and installation flexibility.

The electrical characteristics of VRLA batteries differ somewhat from wet-cell lead-acid batteries, requiring caution in charging and discharging.

Sulfation and desulfation:-

Lead-acid batteries lose the ability to accept a charge when discharged for too long due to sulfation, the crystallization of lead sulfate. They generate electricity through a double sulfate chemical reaction. Lead and lead dioxide, the active materials on the battery's plates, react with sulfuric acid in the electrolyte to form lead sulfate. The lead sulfate first forms in a finely divided, amorphous state, and easily reverts to lead, lead dioxide and sulfuric acid when the battery recharges. As batteries cycle through numerous discharges and charges, some lead sulfate is not recombined into electrolyte and slowly converts to a stable crystalline form that no longer dissolves on recharging. Thus, not all the lead is returned to the battery plates, and the amount of usable active material necessary for electricity generation declines over time.

Sulfation occurs in all lead-acid batteries during normal operation. It impedes recharging; sulfate deposits ultimately expand, cracking the plates and destroying the battery. Eventually so much of the battery plate area is unable to supply current that the battery capacity is greatly reduced.

Stratification:-

A typical lead–acid battery contains a mixture with varying concentrations of water and acid. There is a slight difference in density between water and acid, and if the battery is allowed to sit idle for long periods of time, the mixture can separate into distinct layers with the water rising to the top and the acid sinking to the bottom. This results in a difference of acid concentration across the surface of the plates, and can lead to greater corrosion of the bottom half of the plates.

Frequent charging and discharging tends to stir up the mixture, since the electrolysis of water during charging forms hydrogen and oxygen bubbles that rise and displace the liquid as the bubbles move upward. Batteries in moving vehicles are also subject to sloshing and splashing in the cells, as the vehicle accelerates, brakes, and turns.

Risk of explosion:-

Excessive charging electrolyzes some of the water, emitting hydrogen and oxygen. This process is known as "gassing". Wet cells have open vents to release any gas produced, and VRLA batteries rely on valves fitted to each cell. Wet cells come with catalytic caps to recombine any emitted hydrogen. A VRLA cell normally recombines any hydrogen and oxygen produced inside the cell, but malfunction or overheating may cause gas to build up. If this happens (for example, on overcharging) the valve vents the gas and normalizes the pressure, producing a characteristic acid smell. Valves can sometimes fail however, if dirt and debris accumulate, allowing pressure to build up.

If the accumulated hydrogen and oxygen within either a VRLA or wet cell is ignited, an explosion results. The force can burst the plastic casing or blow the top off the battery, spraying acid and casing shrapnel. An explosion in one cell may ignite the combustible gas mixture in remaining cells.

The cell walls of VRLA batteries typically swell when the internal pressure rises. The deformation varies from cell to cell, and is greater at the ends where the walls are unsupported by other cells. Such over-pressurized batteries should be carefully isolated and discarded.



Environment:-

Environmental concerns: According to a 2003 report entitled, "Getting the Lead Out," by Environmental Defense and the Ecology Center of Ann Arbor, Mich., the batteries of vehicles on the road contained an estimated 2,600,000 metric tons (2,600,000 long tons; 2,900,000 short tons) of lead. Some lead compounds are extremely toxic. Long-term exposure to even tiny amounts of these compounds can cause brain and kidney damage, hearing impairment, and learning problems in children. The auto industry uses over 1,000,000 metric tons (980,000 long tons; 1,100,000 short tons) every year, with 90% going to conventional lead-acid vehicle batteries. While lead recycling is a well-established industry, more than 40,000 metric tons (39,000 long tons; 44,000 short tons) ends up in landfills every year. According to the federal Toxic Release Inventory, another 70,000 metric tons (69,000 long tons; 77,000 short tons) are released in the lead mining and manufacturing process.

Attempts are being made to develop alternatives (particularly for automotive use) because of concerns about the environmental consequences of improper disposal and of lead smelting operations, among other reasons. Alternatives are unlikely to displace them for applications such as engine starting or backup power systems, since the batteries are low-cost although heavy.

Additives:

Since the 1950s chemical additives have been used to reduce lead sulfate build up on plates and improve battery condition when added to the electrolyte of a vented lead–acid battery. Such treatments are rarely, if ever, effective.

Two compounds used for such purposes are Epsom salts and EDTA. Epsom salts reduces the internal resistance in a weak or damaged battery and may allow a small amount of extended life. EDTA can be used to dissolve the sulfate deposits of heavily discharged plates. However, the dissolved material is then no longer available to participate in the normal charge/discharge cycle, so a battery temporarily revived with EDTA will have a reduced life expectancy. Residual EDTA in the lead–acid cell forms organic acids which will accelerate corrosion of the lead plates and internal connectors.

The active materials change physical form during charge/discharge, resulting in growth and distortion of the electrodes, and shedding of electrode into the electrolyte. Once the active material has fallen out of the plates, it cannot be restored into position by any chemical treatment. Similarly, internal physical problems such as cracked plates, corroded connectors, or damaged separators cannot be restored.

Corrosion problems:-

Corrosion of the external metal parts of the lead–acid battery results from a chemical reaction of the battery terminals, lugs and connectors.

Corrosion on the positive terminal is caused by electrolysis, due to a mismatch of metal alloys used in the manufacture of the battery terminal and cable connector. White corrosion is usually lead or zinc sulfate crystals. Aluminum connectors corrode to aluminum sulfate. Copper connectors produce blue and white corrosion crystals. Corrosion of a battery's terminals can be reduced by coating the terminals with petroleum jelly or a commercially available product made for the purpose.

If the battery is over-filled with water and electrolyte, thermal expansion can force some of the liquid out of the battery vents onto the top of the battery. This solution can then react with the lead and other metals in the battery connector and cause corrosion.

The electrolyte can weep from the plastic-to-lead seal where the battery terminals penetrate the plastic case.

Acid fumes that vaporize through the vent caps, often caused by overcharging, and insufficient battery box ventilation can allow the sulfuric acid fumes to build up and react with the exposed metals.