

CHAPTER 1



FUNDAMENTAL OF THE STORAGE BATTERY.

Definition and Chemistry of The Storage Battery.

A storage battery is a chemical device reversible in its action, which storage energy at one time for use at another. The energy stored is chemical, not electrical. Electrical energy in the form of direct current electricity is applied to the battery during the operation termed charging. The electric current produces chemical changes in the battery, and the chemical energy stored in the plates is reconverted to electrical energy when the cell is discharging.

Lead - Acid Storage Cells.

The fundamental parts of a lead - acid storage cell are two dissimilar plates, or electrodes, immersed in an electrolyte in a suitable container, namely:

Positive active material	Lead dioxide (PbO_2)
Negative active material	Spongy lead (Pb)
Electrolyte	Dilute solution of sulphuric acid (H_2SO_4) in water.

In a fully charged healthy cell the positive active material is dark chocolate colour, and the negative active material is slate - grey colour.

Lead plates similar in chemical composition and immersed in dilute sulphuric acid produce no chemical reactions or electric current when connected to an external circuit.

Although the lead - acid battery suffers the handicap of utilizing one of the heaviest of metals - lead - it is still the most widely used of the storage battery devices. Some of the characteristics which have contributed to its success are worth noting:-

a) The lead - acid battery has the lowest initial and operating cost of the various types of storage battery. These include batteries, (Nickel - cadmium and nickel - iron) and silveroxide - zinc.

b) Its voltage on discharge is the highest of all the reversible combinations used.

c) It was comparatively cheap and plentiful materials.

d) The completely reversible chemical reactions produce little physical change in the plates.

e) It can operate satisfactorily over a wide range of temperature from approximately 0° to 110°F (-18° to 43°C .)

Chemical Reactions of Lead - Acid Batteries.

In general, a storage battery must be given a charge before it can function, and this is carried out by connecting a suitable low - voltage d.c. supply across its terminals for a certain number of hours. There are, however, some batteries which can be activated merely by adding acid. These batteries, usually of the automotive type, are fitted with plates which have been specially processed or "Dry charged"

When a battery is fully charged the chemical changes taking place within the cell are complete. The positive active material has been converted to lead dioxide (PbO_2), and the negative to sponge lead (Pb), in contact with the electrolyte of dilute sulphuric acid (H_2SO_4)

Discharging. When the battery is discharged by connecting a conductor across its terminals, a current will flow in the external circuit from the positive to negative terminal. Current also flows inside the battery between plates of opposite polarity by way of the conducting sulphuric acid solution.

It is in the dilute sulphuric acid (the electrolyte) that very important chemical changes take place when a current passes between the battery plates. This is very different from the flow of current (electrons) in the conductor across the terminals of the battery, which leaves the conductor completely unchanged.

Electrolyte are substances which, in the liquid state or in solution, are largely dissociated into positive and negative ions, or charged particles. Thus in solution a molecule of sulphuric acid (H_2SO_4), which is electrically neutral, is dissociated into one sulphate ion (SO_4^{--}), carrying two electronic charges, and two hydrogen ion (H) each carrying a positive charge which is numerically equal to the charge of an electron (1.602×10^{-19} coulomb)

1 Coulomb = 1 ampere - second, 60×60 coulomb = 1 amperehour.

It is the migration of these ions to the electrodes (plates) immersed in the sulphuric acid which causes electricity to flow within the cell. Most of the chemical changes take place at the surface of the plates in contact with the electrolyte, for it is here that the ions produce chemical changes within the active material.

Cell on Open - Circuit. With no external circuit connected to the terminals of the cell, the two sets of ions within the electrolyte are in equilibrium and prevented from moving to the respective plates.

Cell on Discharge. When an external circuit is connected across the cell terminals the sulphate ions move to negative plate and part with their negative charges. This produce an excess of negative charge on the plate, which is relieved by a flow of electrons into the conductor from the negative terminal to the positive terminal, that is, (from)

from a point of low potential to one of higher potential. (This is opposite to the conventional direction of electric current, which is that in which positive charges would move - if they could - in the external circuit.) The passage of surplus electrons from the negative plate to the conductor allows more sulphate ions from the electrolyte to combine with the lead to form lead sulphate ($PbSO_4$).

At the positive plate, the highly oxidised lead dioxide (PbO_2) is short of negative charge, so that it readily accepts the electrons arriving from the conductor. Hydrogen ions move into the positive plate from the electrolyte and combine with oxygen to form water (H_2O). This leaves some lead free to combine with the sulphuric acid to form lead sulphate and more water.

As the discharge proceeds and current continues to flow, more lead sulphate is formed, in both plates, by combination of the acid from the electrolyte. Water also is manufactured, which helps to dilute the electrolyte, and it is this progressive weakening of the electrolyte by formation of water which provides a convenient way of measuring the amount of discharge taking place. The cell is discharged when its voltage falls rapidly, and at this stage most of the active material has been converted to lead sulphate and the plates are most identical in chemical composition.

Cell on Charge. To reverse the chemical changes taking place in the cell during discharge, it is necessary to pass a current into the cell in the opposite direction to that of discharge.

The charging source must therefore have a voltage greater than that of the cell or battery to be charged. The charging source connected across the cell supply an excess of negatively charged electron to the negative plate and create a shortage at the positive plate. The result is that hydrogen ions (positively charged) attracted to the negative plate, where the hydrogen combines with the lead sulphate to form lead (Pb) and acid (H_2SO_4).

The shortage of charge produced at the positive plate results in sulphate ions being attracted, and combining with hydrogen of the water to form sulphuric acid. Some of the oxygen of the water combines with the lead of the positive plate to form lead dioxide. At the negative plate the process of recombination of the hydrogen and sulphate continues as long as there is sulphate present. When the process of conversion of lead sulphate to lead is almost complete, hydrogen bubbles form at the negative plate and rise through the electrolyte.

Similarly sulphate ions react with water at the positive plate, forming sulphuric acid and leaving oxygen to react with lead to form lead dioxide. When most of the lead is converted, the oxygen appears as gas at the positive plate. The formation of hydrogen and oxygen gas at the plates is a sign that the cell is reaching the fully charged condition.

As the charging proceeds, acid is released from the plates passes into the electrolyte and the specific gravity slowly increases. Measurement of the specific gravity of the electrolyte during the course of a charge does not give a true indication of the charged condition of the cell or battery. It is not until gassing commences that the stronger acid, liberated from the plates, is mixed with the weaker acid at the top of the cell. Specific gravity reading can therefore be of value only toward the end of the charge, when constancy of readings indicates that all the strong acid has been liberated from the plates and the cell is fully charged.

Although some gassing is necessary to bring into circulation the strong acid released during charge, excessive and prolonged gassing does no good, and can in time shorten the life of a battery by scouring the active materials at the surface of the plates.

Hydrolysis of the electrolyte results in loss of water which must be replaced by adding pure water from time to time, this is termed "Topping - Up." 100 Ah of gassing will drive off about 1.2 oz. of water; and the demands of a battery as regards the amount of topping - up water required, when working a known duty, are a good guide to correct charging.

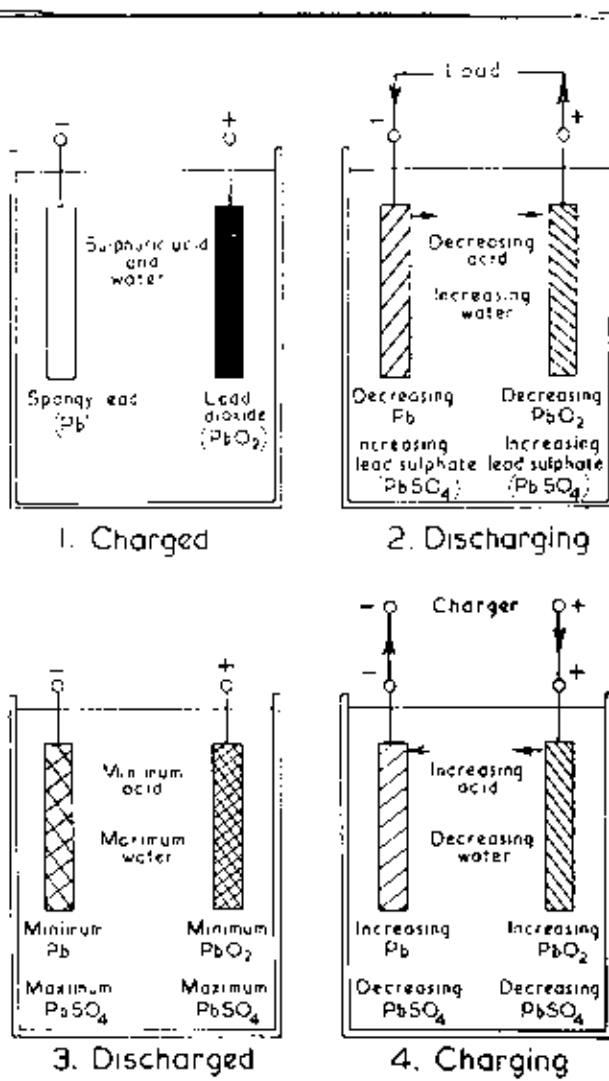
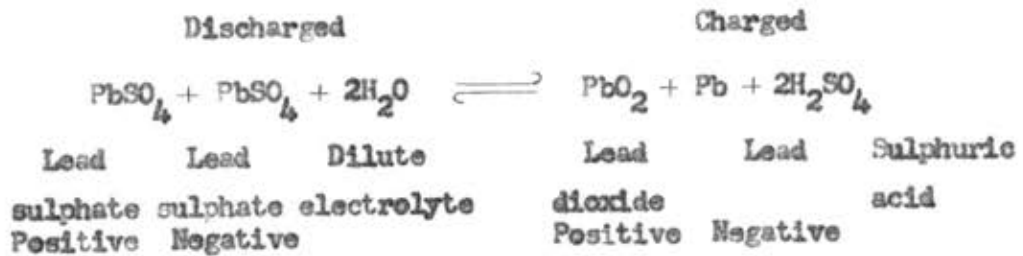


Fig 1 Chemical Reactions within the Lead - Acid Cell during Discharge and Charge.

Excessive water usually means overcharging, whilst too little means undercharging.

The chemical reaction can be expressed as follows -



The arrow are used instead of an equal sign (=) to indicate that the reaction is reversible.

It will be appreciated that the normal working of a battery produces lead sulphate at both positive and negative, which are reconnected to their original condition by charging. Sulphated is the term usually applied to a battery which has been abused by under charging, or leaving in a discharged condition for long periods, when the plates become excessively sulphated, lose porosity and develop a high resistance. In this abnormal condition the sulphated plates will not usually accept a charge, but some of the less severe cases can be recovered by special treatment.

Fig.1 is a diagrammatic illustration of the various stages in the complete cycle of discharge and charge of a lead - acid storage battery.

Classification of Storage Batteries.

There are many types of battery designed to give optimum performance under different operating conditions. Battery performance can be a measure of one or more characteristics whose relative importance will vary according to the nature of the duty. For some duties, life or portability, for some maximum output per unit weight or volume, and for others, low operating costs may be all important characteristics.

Battery may be divided roughly into two classes in relation to the type of duty they have to satisfy. Battery which are to be operated at various locations, or carried about in the course of operation either by hand or in the vehicle of which they form a component part, are called

portable batteries. Batteries which are to be static, or located in a fixed place during their life, are called stationary Batteries.

Portable batteries include.

- Automotive batteries (car and motor vehicles).
- Traction batteries (vehicles industrial trucks, etc.)
- Submarine, and marine batteries.
- Miners hand - and cap - lamp batteries.
- Diesel locomotive starting batteries.
- Train batteries.
- Motorcycle and scooter batteries.
- Radio and small laboratory batteries.
- Aircraft batteries.

Stationary batteries include.

- Power station batteries.
- Telephone exchange batteries.
- Emergency lighting batteries.
- Engine starting batteries.
- Fire and alarm batteries.
- Clock batteries.
- Laboratory batteries.