

Introduction

This training course deals with how a lead acid battery works.

It will provide you with information on the electrochemical processes and operational states of the battery.

The lead acid battery operation course consists of the following modules:

- Principle of electricity
- What is a battery
- Generating a voltage
- Electrochemical reaction
- Battery discharge
- Battery recharge

Each module has its own training video, downloadable resources and some will be followed by a short multiple-choice test.

Once you have completed all modules there will be a final test to check your understanding and knowledge.

Once passed you will earn a certificate for the completion of this course.

Module 1 - Principles of Electricity

Electricity is a form of energy that flows along a conductor such as a copper wire in the form of electrons.

The force that pushes the electrons through the conductor is known as a potential difference and is measured in Volts.

The rate of electron flow through the conductor is known as current and is measured in Amps.

Module 2 - What is a Battery?

A battery is a source of electrical energy stored in chemical form that can be released in a controlled way when required. This is known as a voltaic cell.

A voltaic cell is constructed of two different metals or metallic compounds known as positive and negative electrodes which are kept apart by a separator and immersed in an electrolyte.

There are two types of battery, primary which are used until discharged, like the ones in the TV remote and then disposed of and secondary which can be recharged and reused, like the one in your phone.

A lead acid battery is a secondary type battery that uses compounds of lead as its electrodes which take the form of plates and a dilute solution of sulphuric acid as its electrolyte.

Positive plates are made from lead dioxide and negative plates of porous lead.

The positive and negative plates are connected, arranged alternately in a pack, kept apart by a separator and submerged in the electrolyte solution.

Module 3 - Generating a Voltage

When connected to an electrical circuit and an electrical consumer is switched on a load is placed on the battery.

This starts a chemical reaction between the negative plates and the electrolyte creating a potential difference and electron flow between the negative and positive plates.

This release of electrical energy is then used to power the electrical consumer resulting in the battery becoming discharged.

Recharging the battery reverses the chemical reaction between the plates and the electrolyte storing electrical energy in chemical form for reuse when required.

Module 4 - Electrochemical Reaction

An atom is the smallest part of a chemical element that can exist.

Atoms are made up of positively charged protons, neutral neutrons and negatively charged electrons.

Protons and neutrons form the core or nucleus of the atom around which the negatively charged electrons orbit.

Atoms with equal numbers of protons and electrons are neutral in charge

An ion is a charged atom. The atom is charged because the number of protons and electrons are not equal.

An atom becomes positively or negatively charged depending on whether the number of electrons is more or less than the number of protons in the atom.

A negative ion has more electrons than protons and therefore is negatively charged.

A positive ion has less electrons than protons and therefore is positively charged.

A battery uses the chemical reaction between the plates and the electrolyte to produce ions and a flow of electrons.

This process of ionisation within a battery converts neutral atoms into positive ions by removing electrons.

And negative ions by adding electrons.

Like the North and South poles of a magnet positively and negatively charged ions are attracted to and bond with each other to share electrons and form neutral atoms.

The negative plates, positive plates and the electrolyte are made of different compounds.

They all have a neutral charge as they have the same amount of protons as electrons.

The positive plates are made from lead dioxide.

The lead ions have a positive charge of $4+$ meaning that there are 4 less electrons than protons in each atom.

The oxygen ions known as oxide have a negative charge of $2-$ meaning that there are 2 more electrons than protons.

To form a neutral lead dioxide atom, the lead and oxide ions bond together to cancel out their charge state.

To achieve this, two oxygen ions bond with a single lead ion.

As two negatively charged oxygen ions are needed to cancel the positive charge of the lead ion we use the Greek word prefix di meaning two to identify the number of oxygen ions used.

This process results in the compound lead dioxide.

The negative plates are made from porous lead.

Porous lead has an equal number of protons and electrons and is therefore neutral in charge.

The electrolyte solution contains sulphuric acid which is a compound of hydrogen and sulphate ions.

The hydrogen ions have a positive charge of $1+$ meaning there is 1 less electron than protons in the atom.

The sulphate ions have a negative charge of $2-$ meaning there are two more electrons than protons in the atom.

In order to form a neutral sulphuric acid atom, the hydrogen and sulphate ions bond together to cancel out their charge state.

Two positively charged hydrogen ions are needed to cancel the negative charge of the sulphate ion.

This process results in the compound sulphuric acid.

Module 5 - Battery Discharge

The discharge process begins as soon as an electrical load is applied to the battery.

This takes the form of a chemical reaction between the negative plate and the sulphuric acid in the electrolyte solution.

The sulphuric acid begins to break down into positively charged hydrogen ions which move to the positive plate.

And negatively charged sulphate ions which move to the neutral porous lead atom on the negative plate.

The porous lead atom on the negative plate become ionised and negatively charged as the sulphate ion attempts to bond with it.

To complete the bonding process and achieve a neutral charge state the lead atom must become positively charged.

It therefore releases 2 negatively charged electrons.

The 2 free electrons can now flow through the electrical circuit through the applied load and on into the positive plate.

The two negatively charged electrons from the negative plate arrive at the positive plate and bond with the positively charged lead ion in the neutral lead dioxide atom.

This causes the charge of the lead ion to change from (4+) to (2+) as there are now only two more protons than electrons in the lead ion.

This alters what is known as the oxidation state of the lead ion.

Negatively charged sulphate ions produced from the breakdown of the sulphuric acid bond with the positively charged lead ion on the surface of the plate

This creates a neutral atom of lead sulphate and releases negatively charged oxygen ions into the electrolyte.

The two hydrogen ions approach and bond with the negatively charged oxygen ion creating a neutral atom of water.

The battery is now discharged.

Module 6 - Battery Recharge

When a charging source is applied to the battery the ionisation process between the positive plate and the electrolyte is reversed.

Two electrons are forcibly removed from the lead sulphate atom (PbSO_4) causing the charge and oxidation state of the lead ion to change from (2+) to (4+).

The 2 free electrons now flow back through the charging device into the negative plate.

There are now four more protons than electrons in the lead ion.

The water in the electrolyte begins to break down into positively charged hydrogen ions (H^+) and negatively charged oxygen ions (2^-).

The negatively charged oxygen ions move to the positive plate and displace sulphate ions into the electrolyte solution.

Two negatively charged oxygen ions bond with the positively charged lead ion creating a neutral atom of lead dioxide (PbO_2).

Two positively charged hydrogen ions approach and bond with the negatively charged sulphate ion in the electrolyte solution creating a neutral atom of sulphuric acid.

The two negatively charged electrons from the positive plate arrive at the negative plate and bond with the positively charged lead ion.

This displaces the negatively charged sulphate ion into the electrolyte creating a neutral porous lead atom on the negative plate.

Two positive hydrogen ions bond with the negatively charged sulphate ion in the electrolyte creating a neutral atom of sulphuric acid.

The battery is now recharged.

In this course we have been looking at individual atoms and molecules.

The plates and electrolyte solution contain countless numbers of atoms therefore these processes take place on a vast scale and continuously during discharge and recharge.