USING & CHARGING SLA BATTERIES

Sealed lead-acid or 'SLA' batteries are a development from the familiar 'flooded' lead-acid battery which has been used for many years in cars and trucks. This is the oldest type of secondary battery, developed nearly 150 years ago by the French physician Gaston Planté.

The flooded lead-acid battery has cells using positive plates of lead oxide, negative plates of porous 'spongy' metallic lead and sulphuric acid as the electrolyte. The SLA form is essentially very similar except that the electrolyte is in the form of a gel rather than a liquid, and largely absorbed in porous insulating separator sheets placed between the plates. The plates (electrodes) are also made from alloys of lead containing calcium and tin, designed to absorb the gasses produced when lead-acid cells are overcharged. This allows the cells to be sealed, apart from a safety valve.

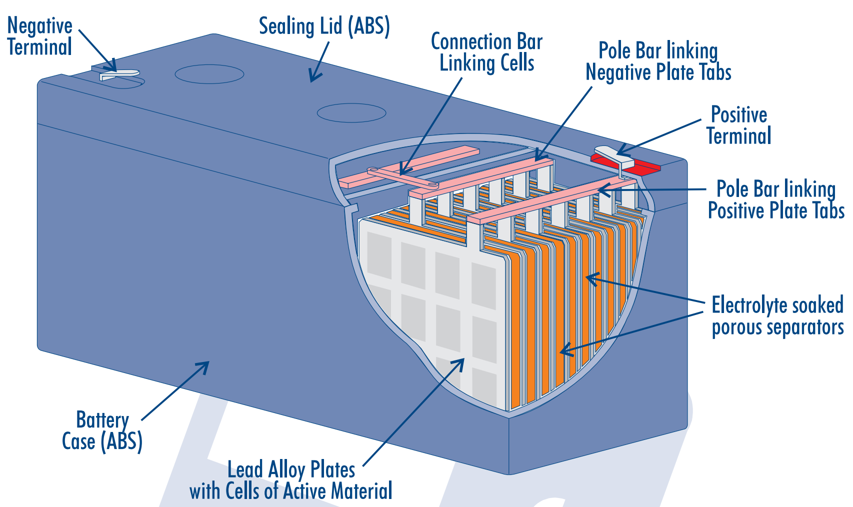

Fig.1: The construction of a typical 6V sealed lead-acid battery, with one cell broken open. The sealing valve and vent details have been omitted for clarity.

The basic construction of a typical multi-cell SLA battery is shown in Fig.1. Both positive and negative plates are in the form of rectangular grid frames, with multiple sequences of alternating plates and separators used to fill each cell. The terminal tabs of all the positive plates in each cell are connected together by 'pole bar' collector strips at the top, and the negative plates are connected together in the same way. Further strips used to interconnect the cells and connect to the main battery terminals. The entire battery is fitted into a multi-chamber case of ABS plastic, with each cell fitted with a safety valve to relieve pressure in the event of serious over-charging.

Because water is not lost during the discharging and recharging processes, SLA batteries require virtually no maintenance and can be used in almost any position.

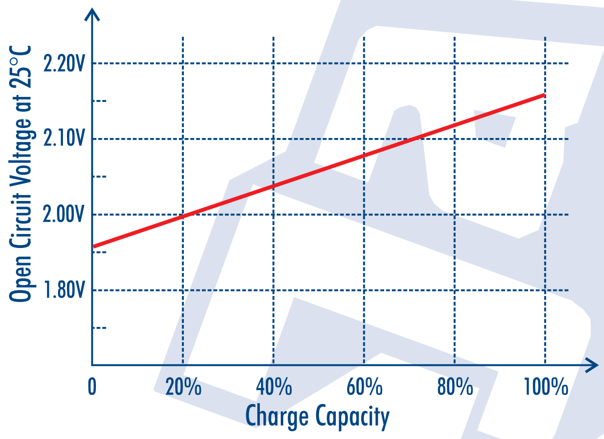

Fig.2: The open-circuit terminal voltage of an SLA cell is a fairly good guide to its state of charge. Multiply the typical voltage figures shown by three for a nominal '6V' battery, and by six for a '12V' battery.

However because they are never fully charged in the theoretical sense, SLAs tend to have the *lowest energy density* of any of the sealed rechargeables — typically only 30 watt-hours per kilogram.

As SLAs are also the cheapest of the rechargeables, this makes them best suited for applications where low-cost power storage is the main consideration, and bulk and weight are of lesser importance. Such applications include electric wheelchairs and golf buggies, etc.

SLAs have the *lowest self-discharge rate* of any of the rechargeables — only about 5% per month. They do not suffer from the memory effect displayed by NiCad and NiMH batteries, and are therefore quite suitable for shallow cycling applications where they spend most of their time connected to a trickle or float charger. In fact unlike NiCad batteries, they *prefer* shallow cycling. This makes them much more suitable for emergency-standby applications such as UPSs and emergency lighting systems.

Although SLAs do prefer shallow cycling to deep cycling, they are nevertheless capable of supplying occasional heavy discharges without adverse effect.

The nominal terminal voltage of each SLA battery cell is 2.0 volts. However the actual terminal voltage varies over a fairly wide range, both above and below the 2.0V level, depending on the cell's temperature and state of charge. This allows the open-circuit voltage to be used as a fairly reliable indicator of the battery's state of charge, as shown in Fig.2.

Incidentally the capacity of SLA batteries varies significantly depending on the actual rate of discharge, and is usually highest at the 20-hour rate — i.e., when supplying a current of 0.05C. The nominal capacity rating is therefore usually given on the basis of this discharge rate.

Generally speaking manufacturers recommend that SLA batteries are not stored in a discharged state, nor allowed to remain in such a state for very long. This results in a condition known as *sulphation*, which is effectively a permanent reduction in energy storage capacity. In fact to avoid sulphation and achieve the longest battery life, it's usually recommended that batteries be recharged when the open-circuit cell voltage falls to 2.10V — corresponding to about 70% of total capacity. This corresponds to a terminal voltage of 6.3V for a '6V' battery and 12.6V for a '12V' battery.

SLA batteries typically achieve a working lifetime of about 300 - 500 cycles, depending on the depth of cycling and the operating temperature. This is significantly shorter than the lifetime of NiCads, and is due to a chemical reaction at the positive plates which gradually causes them to expand and change in composition. So the charge capacity of an SLA slowly falls, as the battery is cycled.

SLA charging & chargers

Unlike NiCads, SLAs are not really suitable for very fast charging. Most manufacturers recommend that they should not be charged in less than 5 hours, or at a charging current level of higher than 0.4C — although some SLAs are able to accept charging currents of up to 0.8C for at least the initial phase of charging, without adverse effects.

The simplest type of SLA charger is the *float charger*, so called because an SLA can be connected across the output of such a charger almost indefinitely without damage.

Essentially an SLA float charger consists of a DC power supply with an output voltage which is reasonably well regulated, to a level corresponding to 2.25V per battery cell (i.e., 6.75V for a '6V' SLA and 13.5V for a '12V' SLA). When a discharged battery is connected to this type of charger, a moderately high charging current flows at first, but gradually reduces as the stored charge level rises. By the time full charge is reached the current has dropped to a low and steady level, just sufficient to maintain the battery at full charge.

This is the system generally used in most of the lower-cost SLA chargers, and it gives a typical charging time of around 16 hours. Most SLA batteries will give very close to their maximum working life when used with this type of charger, so they're fine if you can accept this charging time.

By the way, it is not advisable to attempt speeding up the charging process with this type of charger by increasing the charging voltage. This can easily result in overcharging and the conversion of electrolyte into hydrogen and oxygen gas, building up the internal pressure — which can cause venting via the safety valve, and permanent reduction in the battery's capacity.

Where faster charging of SLAs is desirable, the charging period can be reduced to about 5-6 hours by using a more complicated two-stage process which combines an initial constant-current (CC) bulk charging phase with a constant-voltage (CV) top-up phase. This is the type of system used in more sophisticated 'fast' SLA chargers.

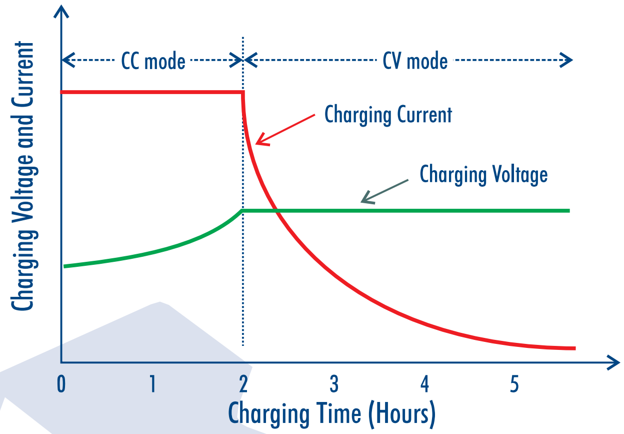

Fig.3: The voltage/current characteristics of a typical two-stage SLA charger, with automatic switching between the initial CC 'bulk' mode and the CV 'top-up' mode. Charging takes about 6 hours.

The voltage and current characteristics of a two-stage SLA charger are shown in Fig.3. As you can see, the discharged battery first receives a reasonably substantial CC charge, at a level of 0.4C or higher. This continues until the cell voltage reaches 2.45V per cell (i.e., 7.35V for a '6V' battery, 14.7V for a '12V' battery), whereupon the charger switches into CV mode and continues to apply this voltage while the remaining charge is stored. (The exact voltage level used for the CV stage should strictly be varied according to temperature, but this isn't often done. Note too that this voltage is an 'under charge' figure.)

During this second phase the charger monitors the current level, which gradually falls and finally stabilises when the battery is fully charged — typically after 5 or six hours. Then the charge is terminated.

Some high-end SLA chargers don't completely terminate the charging process when this fully charged state is reached, but instead switch the CV source voltage down to a lower 'float charge' level to maintain the battery in the fully charged state. This is generally the same level of 2.25V per cell used in low-cost SLA chargers. Chargers providing this additional feature are often called 'Three Mode' chargers.