NEWSLETTER FOR MANUFACTURING COMMUNITY

Maintenance Circle

Word for the day: **LEAD-ACID BATTERY**

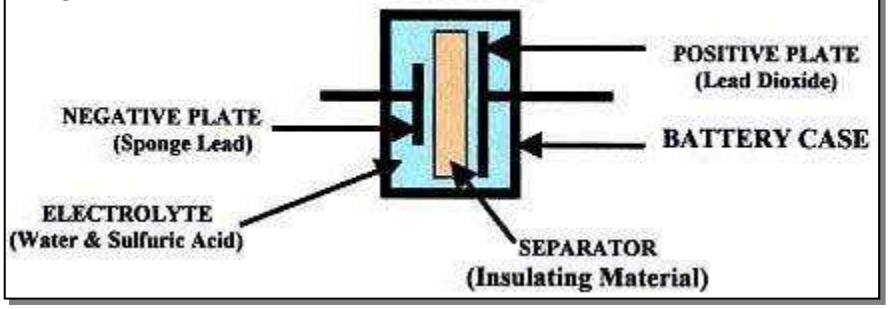
After enjoying a good weekend, people walk into shop floor even before the sun is shining in east to start another day's hectic work. It is a beautiful winter morning and no work seems to be moving without a hot cup of coffee. Clock is ticking and machines are being cleaned, initial checks are done and all warm-up activities are completed. Two hours have almost passed and regular production has just begun. Machines are warming up to reach their target speeds. Day's production schedule indicates some product is very urgent and needs to be manufactured within shortest possible time. Suddenly you see all the machines coming to a sudden halt and there is a total black out. State electricity has tripped due to some short circuit in sub-station. The pressure to manufacture is mounting up and someone runs to DG room and starts the generator. Alas! The engine does not crank even one turn. It is confirmed without any doubt that the beautiful looking lead-acid batteries are "dead" and do not have any power to crank the engine. On a war footing, someone runs around the city and arranges for the batteries and production starts after an irreplaceable downtime of three hours. One shift is already lost and delivery is badly hit. Two tiny but heavy lead-acid batteries bought entire shop floor to a grinding halt and made everyone's life terrible.

Lead-Acid Battery – Why did it fail (or as we all say why did it die!) on a Monday morning and spoiled the entire show? The most obvious reason was least attention given to its regular and preventive maintenance activities and someone forgot to charge the battery over the weekend. This week, let us go little deeper and understand the background of a lead-acid battery, which if not taken care of, could lead to major plant / machine shutdowns.

What is a lead-acid battery? It is the assembly of two dissimilar metal plates – usually Lead Oxide & Sponge Lead – separated by an insulating plate (usually fiberglass based material) and dipped inside the acid bath, called "electrolyte." The chemical reaction between metal plates and electrolyte produces a potential difference – DC voltage – that will be used to drive different applications ranging from starting an engine to support a large UPS system. Electrolyte is a mixture of sulfuric acid (H_2SO_4) and distilled water in certain ratio. Batteries are broadly classified as PRIMARY CELL & SECONDARY CELL type. All non-rechargeable batteries like the ones used for remote control, toys, clocks fall under first category. All chargeable batteries, including Lead-acid type belong to second category. We will limit our exploration to lead-acid type in subsequent paragraphs.

The lead-acid batteries are constructed from individual units called "cell." The voltage rating and current discharging capacity of a battery will be decided by number of cells present. Figure-1 shows the basic components of a "cell." The most commonly used storage batteries will have six cells assembled together inside a heavy housing. *These cells do not "generate" electricity on their own. They have to be charged by an external source, usually an alternator (or dynamo) or a stand-alone battery charger unit.*

Figure-1



The size of plates and quantity of electrolyte decides battery capacity, which is measured in "Ampere Hours" (AH). For example, a 12V 180AH battery can supply 180 ampere of current for 1 hour or 90 ampere for 2 hours or 45 ampere for 4 hours. Figure-2 shows the construction of a standard 12V battery. Actually, the

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12V battery is an assembly of 6 cells, each capable of storing 2.1 volts when fully charged. So, a fully charged & healthy battery should read 12.6 volts under no load, in open circuit condition.

What happens inside a battery? When a charged battery is connected to load, a chemical reaction occurs between the Lead plates and sulfuric acid, which produces electricity. This chemical reaction continues for certain duration which depends on I) Present voltage level of battery II) Current drawn by load III) Condition of the battery. The battery continues to generate electricity and voltage will be completely "discharged" and it eventually "dies." You can imagine the battery as equivalent to an air-receiver. Once the compressed air is consumed up to certain point, the consuming equipment starts and receiver needs to be "re-filled" again.

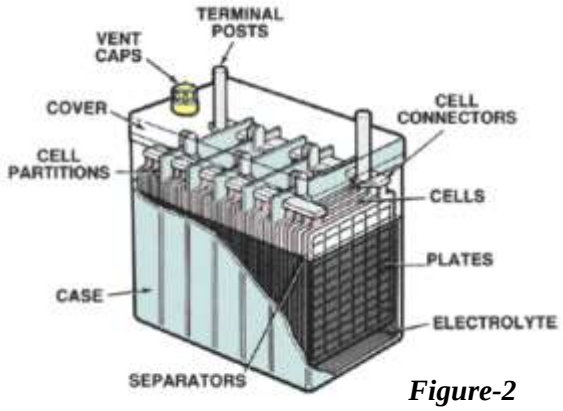
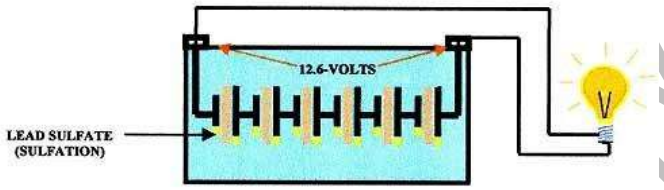
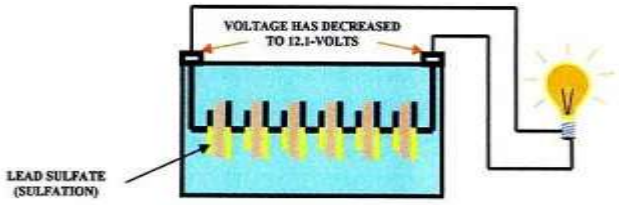


Figure-2

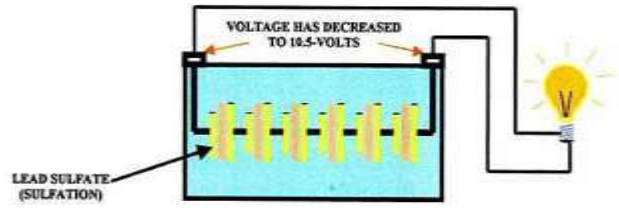
The chemical reaction produces a by-product called "Lead Sulfate" ($PbSO_4$) which gets continuously deposited on the plates by a process called **sulfation**. Once the plates are completed coated, the battery will not be able to discharge further. At this level, it should usually measure 10.6 volts. Figure-3 explains three stages before battery completely discharges.



Stage-1 – Battery is fully charged – Very less deposit of lead sulfate on the plates. Bulb will be very bright. Battery reads 12.6V



Stage-2 – Battery is partially discharged – Increased deposit of lead sulfate on the plates. Bulb will be moderately bright. Battery reads 11V



Stage-3 – Battery is almost discharged – Large deposit of lead sulfate on the plates. Bulb will begin to dim. Battery reads 10.6 V

Figure-3

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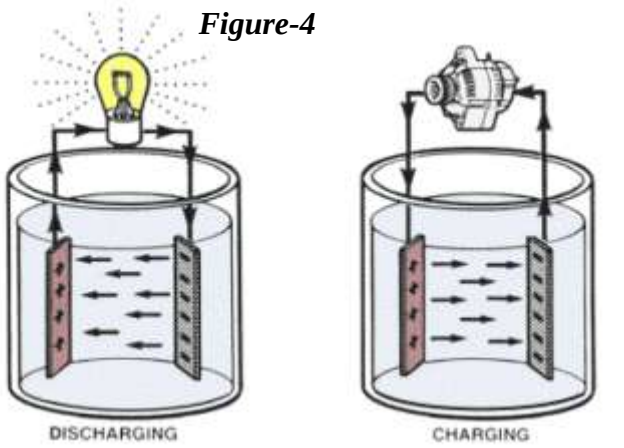
Once the lead sulfate gets deposited on plates, no further discharging is possible and it cannot support the desired load. So, the battery must be charged now from an external source. If the battery is connected an alternator (dynamo) charging & discharging cycle continues without our intervention. Figure-4 depicts both these processes with simple graphic. When an external voltage is supplied to charge batteries, the lead sulfate undergoes "reverse reaction" which converts the chemical back to lead and Sulfuric acid. This reaction releases hydrogen & oxygen gases which must be discharged thru vent holes. Hence, during charging process, the vent holes must be kept open & must not be blocked. These gases are flammable and preventing them from getting discharged may cause batteries to explode. Modern batteries have automatic pressure release vent holes that open if gaseous pressure inside battery increases beyond certain specified level.

Figure-4

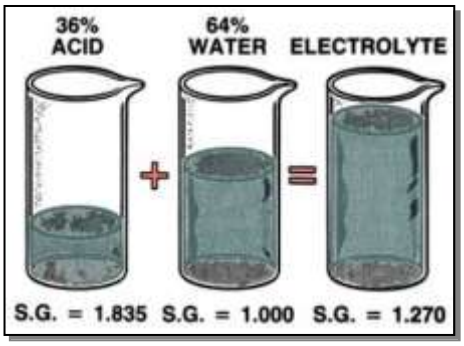


The chargers for batteries are available with different options. A simple 12V battery charger supplies 13.6V at rated current. But with 13.6V, a fully discharged battery may need around 100 hours to reach its full voltage level. To reduce charging time, the initial charge voltage is "boosted" to around 14.4 volts. Once battery reaches 90% of its charge level, voltage is reduced to 13.6 volts and maintained at that level. Advanced microprocessor controlled battery chargers continuously monitor the charge level – by sensing charge current – and regulates the charge voltage.

Sometimes, even with sufficient & probably repeated charging the battery may not retain its charge and fails to perform. This could be possibly due to reduction in the chemical quality of "electrolyte." Specific gravity is the most widely used and common accepted method of checking the "health" of electrolyte. A commercial hydrometer with different color bands is used to quickly check this parameter.

What is specific gravity? Technically it is defined as the "ratio of density of any liquid to the density of water at a specific temperature" and indicates the weight of the liquid. The standard density of water at assumed to be about 1000 kg / m^3. The density of pure sulfuric acid (H_2SO_4) is 1835 kg / m^3; so Sulfuric acid's specific gravity will be = 1835 / 1000 = 1.835, which means that it is 1.835 times heavier than water under same condition. As another example, density of petrol is around 737 kg / m^3 and hence its specific gravity is 0.737 indicating that it is lighter than water.

When distilled water and pure sulfuric are mixed to form an electrolyte inside the battery, its specific gravity changes. Initially, 36% of acid is mixed with 64% of distilled water and specific gravity will be 1.27 for a fully charged battery. As a regular practice, the specific gravity reading is taken for each cell in the battery pack and values are compared. Maximum allowable variation between highest & lowest reading is **0.05**. Refer to an example chart at the bottom of this page for diagnosing the battery condition looking at specific gravity value for different charge levels and for each cell.



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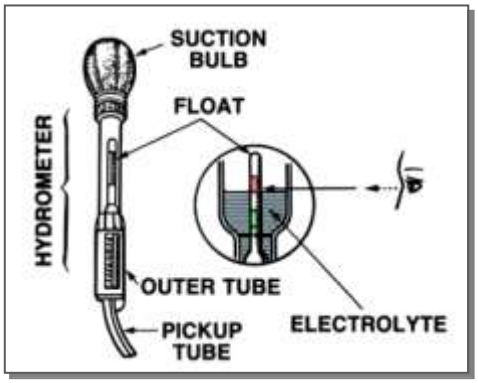

The specific gravity of electrolyte is checked using a simple ball type hydrometer. Recall the popularity of using hydrometer for checking water mixed with milk in a dairy farm!! It is still used by many to check how much water is mixed with milk or vice-versa!! A typical hydrometer will have three regions indicating high, correct and low specific gravity values of electrolyte. Adjacent figure explains various components of a typical hydrometer. A small ball floats inside the tube indicating the specific gravity value. Ball should be in yellow region for a good, fully charged battery. When in red region, it indicates higher specific gravity and in lower region, it indicates less specific gravity. Adding distilled water and / or charging the battery are two methods of correcting specific gravity. If no improvement occurs even after repeated exercises, battery (or the failed cell) must be replaced.

SPECIFIC GRAVITY READING	CHARGE LEVEL
1.270	100%
1.230	75%
1.190	50%
1.145	25%
1.100	0%

Ordinary water should not be added to adjust specific gravity. The minerals & other contaminants react with electrolyte / lead plates and reduce the battery life. Care should also be taken not to overcharge the battery. Overcharging DOES NOT improve voltage level or DOES NOT increase battery life. It will only result in some of solid lead-sulfate deposition at the bottom, which is called "stratification" and can deteriorate battery's life.

Cell #1	Cell #2	Cell #3	Cell #4	Cell #5	Cell #6
1.260	1.230	1.240	1.220	1.190	1.250

This simple reading shows that 5th cell is almost failing. It may also indicate over addition of more distilled water to the cell (electrolyte dilution). A charging cycle may increase specific gravity to acceptable level. First cell needs to be diluted to reduce specific gravity level. Normally, a good charging cycle and re-check confirms the values. If certain cells repeatedly read below acceptable level, that cell (or entire battery) must be replaced at the earliest.

To measure the voltage across the battery for assessing its condition, all loads – battery wires – must be removed. It is preferable to measure this "open circuit voltage" with a digital multi-meter than a conventional analog meter for better accuracy. Refer the table below for various voltage values.

100% Charge	75% Charge	50% Charge	25% Charge	0% Charge
12.6 V	12.4 V	12.2 V	12 V	< 11.9 V

A list of facts & myths about lead-acid battery is given below. Understanding these will help prolong the battery's life and prevent untoward downtime of end equipment.

Charging:

✓ Overcharging does not increase the life of battery; it only deteriorates the lead plates

✓ Equalizing charge is usually done on a new battery and NOT regularly

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✓ Boost charging – with higher voltage – should be done only up to 90% of battery capacity

✓ Undercharging will not remove the lead sulfate deposit and can reduce battery's load carrying capacity

✓ Battery terminals must be tight and should not have any corrosion deposits to help good charging

✓ Remove vent caps – not applicable for SMF (**S**ealed **M**aintenance **F**ree) batteries, discussed in subsequent articles – when charging

✓ Batteries last longer with continuous charging than keeping it discharged for long time

✓ When charging ensure that the electrolyte temperature does not exceed 45° to 50° C (113° to 122° F)

Electrolyte

✓ Battery cells should not be topped up with sulfuric acid. Only distilled water must be always used

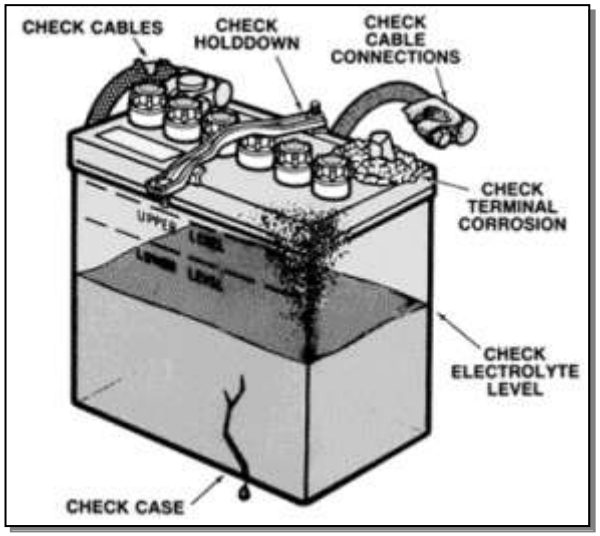
✓ Provide enough breathing space around batteries – it is good for battery as well as your health

✓ Do not top-up when either battery is hot or under load. Top up only when battery is disconnected from load and is at room temperature

✓ Measure specific gravity at room temperature only

General

Refer to adjacent picture for common check points on a battery. Don't let battery become a silent killer of productivity in your shop floor. Independent of whether it is used as a stand-by for utility, used as power source in fork lifts, UPS take proper care and provide sufficient preventive maintenance. It is always a good idea to keep separate log book identifying following points:



- Cell specific gravity readings
- Battery voltage reading in volts
- Charging current in amperes
- Approximate battery temperature
- Charging time required

Any deviation from a nominal value will immediate point some defect in the battery and sufficient preventive action can be initiated. Battery is a product that needs constant & proper maintenance to have prolonged life & reduce monetary implications.

Remember: A poorly maintained battery does not only cause extensive downtimes, but by disposing them early will also seriously pollute environment with hazardous lead contents.