whitepaper

COMPARING DIFFERENT TYPES OF UPS BATTERIES (LEAD ACID, PURE LEAD & LI-ION)

BACKGROUND TO UPS BATTERIES - LEAD ACID
For facilities with uninterruptible power supplies (UPS), lead acid batteries have long been the proven and preferred method of energy storage.

They store charge by the electrochemical conversion of lead-based compounds contained in their positive and negative electrodes, and their reactions to sulphuric acid in a water-based electrolyte.

Flooded or vented lead acid (VLA) designs dominated the market for many years due to their high levels of reliability. They came at a very high initial cost, but often provided a long service life of 12-15 years.

VLA batteries produce oxygen gas at the positive electrode and hydrogen at the negative electrode, which causes water loss.

These types of battery require specialised and time-consuming maintenance, as the cells require periodic topping up with water.

NEXT LEVEL - VALVE-REGULATED LEAD ACID
Sealed valve-regulated lead acid (VRLA) batteries offered the advantages of lower upfront costs and reduced maintenance compared to flooded designs, albeit with a shorter lifespan.

VRLA products used with UPS systems are most often absorbed glass mat (AGM) batteries. They contain a special porous microfiber glass separator between the positive and negative plates that absorbs the battery's acid and prevents it from flowing too freely.

The glass mat contains enough electrolyte for the battery to deliver its total capacity but is slightly under-saturated so there are voids present.

These voids make it possible for the gaseous oxygen produced at the positive electrode to migrate to the negative electrode. There it recombines with the hydrogen ions in the electrolyte to form water.

This eliminates the need to regularly 'top up' the batteries with water and is the primary reason why VLRA batteries are often referred to as 'maintenance free'.

VRLA batteries are sealed inside a case with a valve, which vents to release gas if the internal pressure gets too much.

Because they are sealed, they can be mounted either vertically or horizontally. This enables flexible use of compartments, rackmount trays or external battery cabinets.

IN PARTNERSHIP WITH

A VIABLE ALTERNATIVE? PURE LEAD AGM

Data centre operators and other customers are always looking for ways to reduce costs.

In response, lead acid battery manufacturers increasingly turn to high purity lead (>99.99%) to both increase lifespan and enable higher temperature tolerance.

Standard lead acid batteries tend to have a solid metallic grid to carry the current, filled with a lead oxide paste to create the current.

This active material is responsible for the reaction that occurs inside the battery and dictates many of the cell's characteristics, such as the float current requirements.

As the name implies, pure lead versions use freshly mined, virgin lead as the raw material for the grid. Both the positive and negative plates are essentially all lead, which helps to reduce grid corrosion.

They also use pure lead to produce the active paste. This means the float charge required to keep a cell fully charged can be reduced, which limits the heat generated during charging.

An obvious knock-on effect of this is the amount of corrosion produced while on charge will reduce, extending the lifespan of the battery.

As touched on previously, VRLA batteries are not meant to be watered, which leads to a shorter life than VLA batteries.

However, there are devices called catalysts that can be added to a lead acid battery to capture the gases generated and recombine them into water, which decreases the speed that the paste dries out.

Such devices have been frequently deployed in VLA batteries and are now being used with VRLAs too, where it does help to slow the ageing of a battery, albeit only slightly.

One final possibility involves combining the catalyst with a special pure lead battery construction.

This creates something battery manufacturers such as C&D Technologies call an 'Advanced Pure Lead' category. These products can rival lithium-ion in terms of life expectancy.

A LOOK AT LITHIUM-ION BATTERIES

Apart from lead, there are other materials used in UPS battery manufacturing.

For example, Nickel-Cadmium (NiCd) batteries used to be a popular option for telecoms installations. They are still used in environments that have very high ambient temperatures, such as the Middle East.

However, NiCd batteries are extremely expensive and because both nickel and cadmium are highly toxic materials, the end-of-life disposal and recycling costs are prohibitive too.

Lithium-ion (Li-ion) batteries have long been used in electronic devices such as laptops and smartphones, while they are core elements in the growth of electric vehicles.

Thanks to the increased demand from the EV sector, overall costs have come down significantly, making them a more viable solution for various backup applications such as UPS, telecommunications, and energy storage (i.e. solar and wind).

Compared to VRLA, these batteries employ a variety of chemical compounds which accept and release lithium-ions during charge and discharge. The electrolyte is an oily liquid which is stable at twice the voltage of acid electrolytes. It also doesn't generate any gasses.

Lithium-ion batteries can deliver the equivalent power density of a VRLA in less than half the space.

They also have up to 50 times the cycle life and work well in high temperatures, potentially allowing customers to reduce cooling costs.

Due to the high energy capacity and increased complexity of lithium-ion batteries, an advanced battery management system (BMS) is essential to ensure proper and safe operation.

The BMS can individually monitor and control each cell using electronic circuits to maintain balanced states of charge. The information gathered can also help to accurately predict the state of health and ageing of each battery.

However, despite improvements in the manufacturing process helping to reduce the overall cost of lithium-ion batteries, the basic raw materials are still harder to extract and therefore much more expensive than lead.

While its extended lifespan can help customers with their overall total cost of ownership (TCO) and sustainability goals, they should take a holistic look and consider the environmental impact of manufacturing for each technology, as well as the cost and process for proper, safe disposal at their end of service life.

Even though there have been advances in developing more cost-effective ways to properly recycle lithium-ion batteries, the process is nowhere near the well-developed process for dealing with end-of-life lead acid batteries.

COMPARING THE PROS & CONS

- ***Lead Acid Batteries***

Standard VRLA batteries continue to be the go-to choice for many mission-critical installations because of their proven track record of reliability and relatively low upfront costs.

Emerging technologies obviously take time to build a foothold in the market, but the alternatives are slowly starting to gain traction.

The drawbacks of lead acid batteries are as apparent as the benefits. Firstly, they only truly perform at their best in highly regulated, temperature-controlled conditions.

Most traditional lead acid batteries are rated at 20-25°C, with every 10°C rise in temperature said to reduce life expectancy by as much as 50%. Pure lead technology can help to reduce this impact, although not to the levels seen in lithium-ion.

Data centres can combat this by using energy intensive cooling systems, or if they do run at higher than recommended temperatures, they could be compromising the life expectancy of their battery systems.

Compared to pure lead and lithium-ion alternatives, standard VRLA batteries also have a shorter design, service, and shelf life.

- ***Pure Lead AGM Batteries***

Pure lead AGM batteries provide the same performance and maintenance benefits as standard VRLA, with the added advantages of higher temperature tolerance, reduced cooling costs, quicker recharge times, longer lifespan, longer storage times, and safe discharge for sub-5 minutes of runtime.

The use of high purity materials in both the grid and paste limits corrosion, which helps to make the cells more predictable as they approach their end of life.

This means systems can be designed with autonomy closer to what is truly required, namely a smaller battery that will help offset what are still higher upfront costs versus standard VRLA.

- ***Lithium-Ion Batteries***

Finally, lithium-ion offers even higher power density, and a longer design, service, and shelf life than either VLRA or pure lead batteries.

The obvious drawback is that although the cost is becoming more competitive, it is still a significantly more expensive initial investment. Also due to its chemistry composition, it isn't considered as safe as lead acid option due to the risk of fire.

Customers should consider the total cost of ownership (TCO) when evaluating all the different options. This will help them fully understand the costs associated with each technology.

Another recommendation when comparing the lifespan of different technologies is to take note of the standard warranty offered by the manufacturers.

While design life and service life are obviously important values that deserve consideration, they can easily be impacted by changes in the parameters how the batteries are used that are perhaps not always clear to customers.

AT A GLANCE COMPARISON

	Standard VRLA	Pure Lead	Advanced Pure Lead	Lithium-Ion
Shelf Life	6 months	2 years	2 years	2 years
Design Life	5-10 years	12+ years	16 years	15 years
Service Life	3-5 years @ 20°C	5-8 years @ 25°C	8-12 years @ 25°C	10 years
Standard Warranty	3 years	5 years	8 years	10 years
Temperature Tolerance	20-25°C	30°C+	30°C+	40°C
Cooling Costs	High	Lower	Lower	Even lower
Standard Maintenance Interval	Quarterly	Quarterly/ Semi-Annual	Semi-Annual/ Annual	Annual
Upfront Cost	Lowest	0-15% higher than VRLA	5-15% higher than Pure Lead	15-30% higher than Pure Lead
Total Cost of Ownership (~15 years) *	£300,000 ($380,000)	£210,000 ($270,000)	£175,000 ($220,000)	£285,000 ($360,000)

** Indicative costs only based on a working assumption of 1MW of power for 5 minutes EOL and replacing the batteries at the end of the warranty period.*

ABOUT C&D TECHNOLOGIES

C&D Technologies manufactures and designs innovative battery systems for storing and transmitting electrical power, primarily for standby power applications.

Telecom, utilities, cable, broadband, government, infrastructure, UPS, renewable energy, and other mission-critical sectors depend on us to protect their data and keep their systems running.

Headquartered in Horsham, Pennsylvania, C&D has manufacturing facilities in the United States, Mexico, and China and a joint venture operation in China. C&D Technologies also owns Trojan Battery Company.

For further details visit www.cdtechno.com

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