

Battery Technology for Data Centers and Network Rooms: Site Planning

White Paper # 33

APC[®]
Legendary Reliability[®]

Executive Summary

The site requirements and costs for protecting information technology and network environments are impacted by the choice of UPS battery technology. This paper will discuss how battery technologies impact site requirements.

Introduction

Batteries for uninterruptible power systems (UPS) are almost universally of the lead acid type and are of one of the following three technologies:

1. Vented (Flooded or Wet Cells)
2. Valve Regulated (VRLA)
3. Modular Battery Cartridges (MBC)

Please refer to the APC White Paper, “Battery Technology for the Data Centers and Network Rooms – Battery Options,” for more details

Adaptability

Installations of UPS to support a data centers or network rooms generally fall into one of the following categories:

1. New Construction – full utilization at startup
2. New Construction – fractional utilization at startup, with plans for full utilization later
3. Upgrade – Installing new UPS within existing environment

A new site in the design stage allows the customer many options. The battery technology choice is open and its requirements can be built into the design.

In a situation where a new facility will not be utilized completely at startup, the capital, depreciation, and maintenance costs favor a battery system that can adapt and grow with the expanding load. The alternative is to design for “worst case,” never knowing if long-term projections will change.

As the site requirements become controlled by the existing environment, as in an upgrade scenario, the need for an adaptable and flexible battery solution increases further since there may be many constraints on the design and installation.

Battery systems with complex site requirements are less adaptable. They are less expandable, less easy to locate, less portable, and require more support infrastructure. The factors affecting the site requirements, and consequently the adaptability, of the various battery technologies are described in the following sections.

Planning Issues

Once power and runtime requirements have been decided on, the planning for the battery needs can be assessed. There are six main issues with a number of sub-issues to consider when choosing a battery

technology; engineering, weight, space, installation, security, and maintenance. Table 1 below provides an overview of how the battery technology affects each of these considerations.

Table 1 – Planning issues by battery technology

Engineering/Weight/Space/Installation/Security/Maintenance

	Flooded	VRLA	MBC
Site specific engineering required	Major	Moderate to none	Little to none
Immovable location	Yes	Varies	No
Weight	Heaviest	Moderate	Moderate
Space Required	High	Moderate	Low
Difficulty of Increasing Batteries (runtime)	High	Moderate	Low
Service Clearances	High	Moderate	Low
Forklift Access Required	Yes	Varies	No
Separate Room Required	Yes	Varies	No
Spill Containment Required	Yes	Varies	No
Mechanical and Electrical Assembly	Yes	Yes	No
Acid filling required	Yes	No	No
Shock hazard during assembly	Yes	Yes	No
Replacement shock hazard	Yes	Varies	No
Maintenance Shock Hazard	Yes	Varies	No
Annual Maintenance	Yes	Yes	No
Quarterly Maintenance	Yes	No	No

Engineering

Site-specific engineering can be an expensive part of a battery installation. A cost of \$150 per hour of work is typical. New construction would require the most engineering, while upgrades usually involve less engineering. The safety and regulatory requirements of flooded batteries require extensive engineering. Flooded batteries, which must be in dedicated rooms with dedicated ventilation and spill containment, require the most engineering, while MBC batteries require the least.

Weight

Lead acid batteries are very heavy. Floor loading and ease of handling should be considered. If not installing the batteries on the ground floor, consult with the building structural engineer to ensure the floor can handle the loading. As VLRA batteries and MBC can be located in IT rooms, access floor loading must also be addressed. The weight and footprint should be provided to the access floor vendor so they can determine the proper solution. The typical and easiest solution is to put heavier duty tiles, under-floor platform or spreader plates where the equipment is to be located.

VRLA batteries are usually shipped installed in a cabinet. This may present a problem in a data center with access flooring because of the large “rolling” load. While the tile in the final location might be properly rated,

the standard aisle tiles may not be able to handle the battery cabinet passing over it. Sheets of plywood are placed on the floor to spread the load across more tiles. Systems using MBC do not have this problem, as the frame is empty and MBC are added one at a time once it is in its final location.

Flooded batteries are placed into large open racks. These batteries are filled with liquid electrolyte, so once in place they are difficult to move. A forklift or cell lifting device is usually required. A flooded battery can weigh about 40% more and occupy twice as much space as VRLA or MBC batteries.

The smaller size of VRLA batteries means more power can be placed into a smaller footprint, but. This benefit is sometimes offset by an increase in floor loading. These batteries are usually placed into equipment racks or cabinets. They can be moved, with some effort, after they have been put into place.

MBC can also place significant weight in a small footprint. By design the number of MBC in a cabinet is variable. Always specify the maximum frame weight, even if not fully loading the frame with batteries. One benefit of this design is the ability to very easily relocate the MBC cabinet if needed because the modules can be removed.

Space

Maximizing the use of space is a top priority for many data centers. Historically, a company would install a large mainframe and keep it in use for 15 years. Flooded batteries were a good match for this systems with their long life. Improvements or upgrades to the mainframe did little to alter the physical space needed for the UPS and batteries.

Today faster and smaller equipment is installed daily in the data center. The data center has become a machine in motion. Space planning is difficult, as forecasts for data center space may be revised considerably over time. In many cases the utilization has fallen short of forecasts and rigid designs have become a serious liability. In the other extreme, build outs have filled the data center and expansion has limited growth. The supporting infrastructure to a data center can represent 40-50% of the overall space allocated. Batteries are a large component of the infrastructure and the right technology chosen for the right situation can represent a substantial savings in space.

The expense of compliance with safety codes (See the APC White Paper: Battery Technology for Data Centers and Network Rooms – Safety Codes) limits the use of flooded batteries to larger installations, usually above 400kW. The cost of having a controlled access room, spill containment, and the space required for maintenance represents a large, immovable, fixed cost.

VRLA batteries offer a more flexible solution. The lower level of electrolyte usually eliminates the need for expensive regulatory compliance. These batteries can require smaller service clearances, can be moved because they don't spill, and can be contained within a locked cabinet. These benefits allow for greater flexibility and reduced cost. Design considerations must be made for replacement, as their life is only 5-7 years.

MBC have all the advantages of VRLA with even more flexibility. The service clearances, while still required, can be incorporated more efficiently. The “plug in” nature of the design reduces wiring and connection clearances. The MBC and its cabinets can be moved or added to as changes happen.

Installation

All battery types should be handled carefully. Batteries are heavy and may require special means for transport or lifting. The weight of the UPS or battery cabinet must be taken into consideration in both the final location and the route the product will travel. If not using your batteries right away, store in a cool, dry location and place under charge.

Flooded battery installation precautions must be taken immediately upon receipt. Once the batteries are received and transported to their final location, only skilled, experienced battery technicians should handle them. . Flooded cells are almost always wired on-site in open frames that must be assembled on-site

“Dry-charged” batteries are shipped, fully charged, without any electrolyte added to them. The batteries are placed in their final location, usually open rack for easy access. Electrolyte is added and the specific gravity is measured on each cell.

The installation process for VRLA batteries can vary. Most UPS manufacturers package these batteries as a system inside the UPS or a battery cabinet. Generally the contractor installing or commissioning the UPS will make the final connections between the UPS and the batteries. VRLA batteries are shipped charged and will arrive on site at 80-90% of capacity.

By contrast, MBC come in modules that connect into pre-manufactured cabinets that are wheeled into place. The final location should be checked to withstand the weight of the cabinet. No special skills are required for assembly, wiring, and acid handling with MBC.

Security

All batteries represent a hazard and must be handled with care. The batteries for UPS operation are connected in series/parallel strings creating hazardous voltages and high levels of amp hour capacity.

1. **Electrical Shock Hazard:** A UPS system can have over a DC voltage bus over 200 Volts DC. This represents a serious electrical shock hazard. This hazard will be always present, even when the battery system is off-line.
2. **Short Circuit Hazard:** Batteries have low internal impedances and are capable of very high levels of short circuit current. The battery or its terminal connections can explode or molten metal can splatter from the battery and wiring if a short circuit occurs.

Because flooded cell batteries are located in open battery racks they should be in a secure area away from untrained persons. The open racks provide the needed ventilation and maintenance, but also allow access to high voltage connections. This openness, while required for maintenance, presents a substantial hazard. The battery room should have restricted access to prevent any unauthorized entrance.

VRLA batteries are usually behind a cabinet door. Only authorized persons trained in the maintenance of batteries and the UPS should have access inside the cabinet. A locked cabinet will prevent an unknowing person from creating a hazard.

MBC are packaged to reduce the risk of shock and are approved by independent testing laboratories for handling. The batteries and electrical connections are contained within the module. Each MBC is individually fused.

Maintenance

All batteries require maintenance and monitoring. It is estimated that VRLA battery maintenance requires at least 25 hours of service per year for a small UPS battery cabinet¹. This can vary for different battery technologies and the monitoring employed on those systems. Maintenance can be a double-edged sword. Battery cabinets are hazardous to work in and during maintenance a problem can be created resulting in the shutdown of the system. Human error occurs, so reducing the amount of maintenance required is generally better for availability.

Vented (flooded) batteries require regular maintenance for proper operation. To be successful, the program needs to be regular, consistent, follow standard procedures, and be well documented. For flooded battery systems, IEEE 450 Standard² requires general inspections (monthly), quarterly, annual, and following special circumstances. In order to prevent a battery from drying out, water must be added and the specific gravity of each battery must be measured. Watering must be done at the right time and in the right amount or else the battery's performance and longevity suffers³. This requires visual inspection and direct contact with batteries. This and retorquing of connections are a necessary part of a regular maintenance schedule. Only skilled, trained battery technicians should service flooded batteries.

VRLA batteries have been called "maintenance free". However it would be wrong to assume these batteries require little or no attention. Monitoring may prevent a failed cell or battery from going un-detected. Accurate monitoring of VRLA batteries must be done to report the health and runtime. If the UPS system does not constantly monitor the batteries, then more manual servicing should be employed. Large systems with heavy lead post connections should have their connections retorqued annually. IEEE – 1188 Standard⁴ recommends a scheduled maintenance program for VRLA battery systems: general inspections (monthly), quarterly, annual, and following special circumstances. Monitoring systems can be installed to provide information on the health of the battery system and may reduce the need for extensive servicing.

MBC are nearly "maintenance free" as they rely on external monitoring to notify the user of a fault. . Accurate monitoring of the MBC is critical because the batteries and connections contained inside the

module are inaccessible to the user. The internal connections in a MBC are welded or use spring terminals instead of bolt connections and therefore do not require retorquing. The monitoring is done by the intelligence placed in the UPS for this function. The only maintenance is to respond to alarms and to replace faulty modules. Replacement is simple as they are hot-swappable when connected in parallel strings. Normal UPS operation is still available during the battery replacement process. Both VRLA batteries and MBC have a shorter life (expected 5 years) than flooded batteries (15 years). A maintenance plan will require replacing these batteries 2-3 times more often than flooded cells. This disadvantage is offset by the simpler replacement procedure for VRLA and MBC batteries.

Conclusions

IT systems present a rapidly changing requirement for data center infrastructure. Fast response to this change can be difficult but can be facilitated by the appropriate selection of UPS battery technology.

The different battery technologies now available vary considerably in their site planning requirements and in their ability to create battery systems that can adapt to changing requirements.

A typical data center design process focuses on power and runtime as the drivers in battery selection and cost. An alternative approach is to focus on how adaptable the battery system needs to be to changing requirements. This approach can give rise to dramatic savings over the life of the system.

References

-
- 1 Alber & Leissle, Albercorp Application Note, "Battery Monitoring: Why Not Do it Right," Page 3
 - 2 IEEE 450, Institute of Electrical and Electronics Engineers, "Recommended Practice for the Maintenance, Testing, and Replacement of Vented Lead Acid Batteries for Stationary Applications
 - 3 http://www.trojan-battery.com/customer_care_battery_maint5.html
 - 4 IEEE 1188, Institute of Electrical and Electronics Engineers, "Recommended Practice for the Maintenance, Testing, and Replacement of Valve Regulated Lead Acid Batteries for Stationary Applications