FRONT TERMINAL 10-YEAR LIFE VRLA BATTERIES IN LARGE UPS APPLICATIONS

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INTRODUCTION

UPSs came on the scene with the advent of large commercial computers that required high quality AC power along with a reserve energy storage to continue supplying power for an orderly shutdown in the event that the primary AC power failed. At the time there were very few choices as far as the type of battery for energy storage. In the lead acid category, the only batteries available were the flooded type that was commonly used as reserve in DC Power applications. The UPS market has grown considerably, with the range of battery energy storage options now from a few watt-hours to several mega watt-hours. During this period a new type of lead acid battery, the Valve Regulated Lead Acid (VRLA) was invented. Initially these batteries were produced in the single and double-digit ampere-hour sizes. Over the past two decades the VRLA product has matured and the sizes now range up to 3000 AH for single cell units and 250 AH for six cell modules. The VRLA battery and especially the front terminal, ten year design life type have several unique features that make it an excellent choice in large UPS applications, defined as systems of 500 KVA and larger, where flooded batteries have usually been applied.

BACKGROUND

The flooded lead acid battery is a mature product having enjoyed over a century of fine-tuning. Countless variations of alloys, grid geometry, grid thickness, separators and jar material have been tried, tested and employed. As reported at Battcon 2005 (1), one particular design of flooded lead acid has proven to have a very long service life. Much of this knowledge and experience is transferable to the VRLA design. It is simply a matter of economics as to whether or not it should be applied to a particular VRLA design.

DISTINGUISHING FEATURE OF THE FLOODED AND VRLA CELLS

The primary distinction between the VRLA and the Flooded Cell is the quantity of electrolyte incased in each cell. The lead acid system is unusual in that the electrolyte serves two functions. It serves as an ionic conductor between the positive and negative elements and also as part of the active material during the discharge reaction. That is, the sulfuric acid supplies the SO_4 ion to the discharge product (Pb SO_4).

The flooded cell, with its excess electrolyte, has superior capacity performance in low rate (>C/10) discharges. This is due to the fact that at low rates the SO_4 ions in the bulk electrolyte have time to diffuse to the discharge sites on both plates. The effect of the excess acid in a flooded cell is clearly evident in the plot given in Figure 1.

The flooded cell also enjoys superior heat handling capability making thermal runaway a very rare occurrence. This is due in part to the thermal conductivity of the bulk electrolyte but mostly because the excess electrolyte limits oxygen recombination by slowing the diffusion of oxygen between the plates. The VRLA cell, on the other hand requires a very high level of oxygen recombination to limit water loss and therefore operates at a higher power level while on trickle charge. This can sometimes lead to thermal runaway in very warm environments if certain fault conditions persist. However, by recognizing this possibility, it can be avoided with a minimum of effort.

In a VRLA cell the electrolyte is held in contact with the plates by the wicking action of the separator. The height of the plates in a VRLA cell is limited by capillary action. The quality of the separator material, the compression between the plates and specific gravity are the parameters which determine the maximum height for a VRLA cell or monobloc. Therefore, designing larger Ah VRLA cells or batteries usually means expanding in a direction perpendicular to gravity.

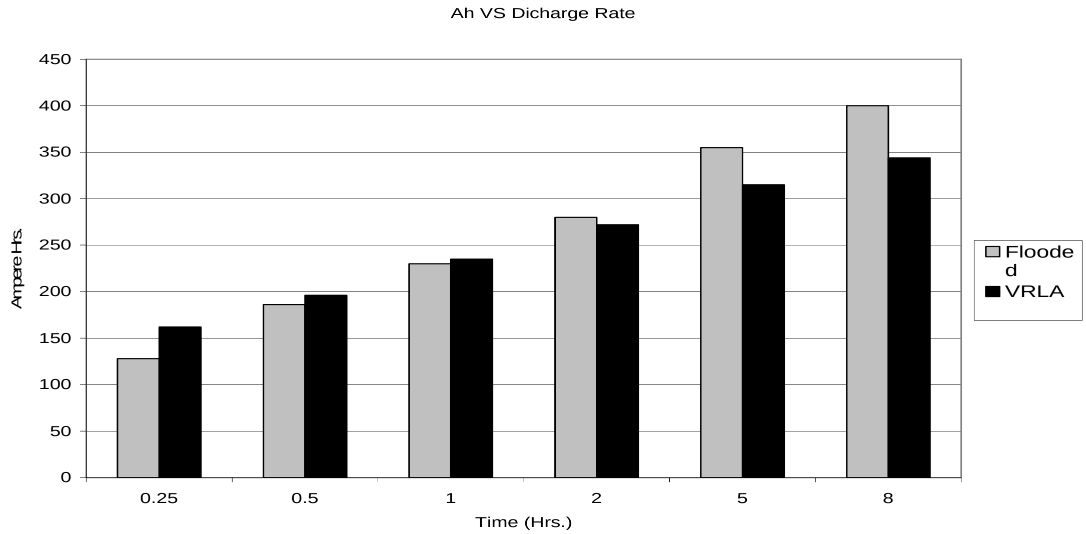

Figure 1. AH VS Discharge Rate for Flooded and VRLA (400 Ah @ C/8).

All of the above would appear to question the wisdom of applying the VRLA design to high voltage UPS usage. However, with the maturation of the VRLA product and development of larger monoblock sizes, there are significant advantages that ensue from the limited and immobilized electrolyte in the VRLA design. The fact that electrolyte level does not have to be maintained in the VRLA cell eliminates the routine maintenance of checking the electrolyte level and making periodic water additions. This eliminates the need for working space between the top of the battery and the shelf above, which in most cases is a foot or more. The clearance requirement between the top of the battery and the shelf above is even further minimized in the Front Access VRLA battery. Figures 2, 3, are photographic examples of typical cabinet arrangements for both the top and front access type VRLA batteries which illustrate this point.

Figure 2. Close-up of 10Yr. Top Terminal Battery Installed in Cabinet.

Figure 3. Ten Year Front Access Batteries in Cabinets.

There is very little excess electrolyte in VRLA cells, defined as the amount of acid that would seep out of a cell should a hole be drilled in the bottom of the jar. This is typically less than an ounce. The limited amount of acid in a VRLA cell proves to be major advantage in shipping and installation. The fact that very little acid would escape from an accidental breakage greatly reduces the packaging required for shipping. VRLA batteries are often shipped completely installed and wired up in a power cabinet on a shipping pallet. In such cases the batteries are moved to their final destination, and plugged in.

The limited electrolyte quantity usually exempts a VRLA plant from requiring a spill containment system, eye wash stations and emergency shower facilities. This gives greater flexibility in locating the battery plant and reduces site preparation costs.

DISTINCTION BETWEEN 10 AND 20 YEAR LIFE VRLA BATTERIES

Presently, VRLA batteries are manufactured in ampere-hour sizes ranging from a few Ah up to several thousand Ah. The smaller Ah cells are generally packaged in monoblocs of three or six cells (i.e. 6 or 12 V units). These batteries are generally constructed with thinner plates, smaller terminals and through- the- wall inter-cell connections. This type of construction does not lend itself to a 20-year design life. At some point the individual cells become large enough that it becomes impractical to place them in monoblocs. At this point, the single cell units are constructed with grid thickness designed for a 20-year life. These large, single cell units are packaged in racks, commonly referred to as modules, and shipped on pallets. The racks are then inter-connected to form a full battery string at the customer’s location. This is not quite as convenient as having a full string in a totally enclosed cabinet but still easier than unpacking up to 240 flooded cells and putting them on a rack. Figure 4 demonstrates a 1050 Ah, 48 Volt system.

Figure 4. 48VDC, 20 Year Design Battery, 1050 AH AT C/8.

ADVANTAGES OF THE TEN YEAR FRONT TERMINAL VRLA BATTERY

While considering the background data above, there are several advantages to the user when using the large 10-year design life front terminal battery in large UPS installations compared to the 20 year VRLA and flooded batteries. Let us examine these in some detail.

1. They can be shipped in a cabinet, fully installed and tested. When the battery system is preinstalled in the factory, it takes little additional effort to test the system. At many battery companies, for example, it is part of the factory acceptance test procedure to test the system at a high rate to ensure the systems performance. To assemble a 20 year VRLA battery and particularly a flooded battery in the factory for testing as a system is time consuming and costly.

2. Having the battery system supplied in a cabinet results in a relatively easy installation procedure, with cabinets dropped in place, connections made between cabinets and the UPS, and final continuity checks performed. This process should require a day or less, compared to 3-4 days for a 20 year VRLA and up to 10 days for a flooded system.

3. Using large VRLA monoblocks offers the user and installer great flexibility in using the space available for the battery installation. The battery units can be installed in cabinets, on standard racks, or custom racks made to fit unusual sites. Figure 5 shows an installation where the batteries had to be located on top of a building in a very high and narrow space. The racks were fabricated to fit, the batteries installed, and the assembly lifted to the top of the building by a crane. No other solution would fit the application.

4. The space required for a “traditional” solution for all the options favors the cabinet system with front terminal VRLA batteries. For a 750 KVA system with 15 minutes of backup, the cabinet system will require 20% less space than a flooded battery on a two-tier rack, and 25% less floor space in a 1 MVA system.

5. In the areas of safety and maintenance, the front terminal VRLA in cabinets is vastly simpler and safer to install, maintain and remove compared to flooded batteries. The terminals are all in a vertical plane, there is no free electrolyte to measure, no refilling required, no containment system to install and maintain and no special ventilation to install and maintain.

6. Many users value having redundant backup systems for critical loads so that if part of the backup system is out of commission for maintenance or repair, the load still has some protection. This is accomplished as a standard feature with the front terminal 10 year VRLA, and can be done with 20 year VRLA and flooded, but at significant additional cost in funds, space and maintenance requirements.

7. The initial cost favors the front terminal VRLA in cabinets, and even more in racks. The cost of the ten year battery cabinet system is approximately 65% of the flooded battery, and 60% of the 20 year VRLA for the 750 KVA system, and slightly lower for the 1MW battery. This does not include the cost of the containment system, safety equipment and ventilation required for flooded battery systems.

Figure 5. Custom Installation Possible with Ten Year FT VRLA.

Figure 6 summarizes these comparisons in matrix form for a 1 MVA system with at least 15 minutes of backup.

	10 Year Front Terminal	20 Year VRLA	20 Flooded
Battery Type	480 vdc 200 AH blocks	480 vdc 1680 AH cells	480 vdc 25 plate cell
Factory Tested	Routine	N/R Extra Cost	N/R Extra Cost
Installation	Roll-in / Plug-in	Moderate effort	High effort
Installation Flexibility	High	Moderate	Limited
Space Required	~92 Ft.2	~ 82 Ft.2	2Tier 121Ft2
Maintenance	Minimal	Minimal	Significant
Safety	High	Moderate	Low
Life	6-8 Yrs.	14-15 Yrs.	14-15 Yrs.
Redundancy	Built into the system	Possible, expensive	Possible, expensive
Initial Cost ($ U.S.)	~ $100K	~ $175K	~ $145K

Figure 6. Comparison Matrix for the 10, 20 Year VRLA and Flooded Batteries.

SUMMARY

We have shown that for large UPS, where traditionally only flooded batteries are available as a backup source, that 10 year front terminal VRLA batteries offer sufficient power, with advantages in installation, safety, ease of maintenance, space utilization and initial cost. Users, OEMs and resellers have options for backup power now that were not available in the past.