Optimize the UPS to Minimize the Downs

UPS battery selection is critical in mission critical environments

The battery system is an essential part of an uninterruptible power supply (UPS), but, in many cases, can be the weak link to the reliability of a critical environment. The two main types of battery systems utilized by most UPS systems in use today are the valve-regulated lead acid (VRLA) battery and the flooded battery, sometimes referred to as vented or wet-cell battery systems.

The flooded battery is referred to as vented because it allows gases to escape during the recharge process. These batteries lose fluids during the recharge process, requiring replenishment, which means regular maintenance is a necessity.

The VRLA battery is considered to be a sealed battery system, although it does have a pressure-relief valve. These systems do not require as much maintenance as wet-cell battery systems. If these batteries are overcharged or exposed to high temperatures, they release gases into the air.

Most wet-cell or flooded-cell batteries have a 20-year life, while VRLA batteries come in five-, 10-, and 20-year life options. The stated life for a battery system will be dependant on the load served, the number of discharges, the depth of the discharges, and the temperature of the environment where they are installed.

Temperature is a key factor in the actual life of a battery system. VRLA battery systems will operate at extreme temperatures, but these systems are rated at 77°F. The ideal operating temperature for most VRLA battery systems is between 68° and 77°. Systems that function in higher temperatures will have a reduced battery life. These types of battery systems will have a 50% reduction in life for every 18° in excess of 77°. Systems that operate in cooler temperatures will have a reduction in total backup time. It is imperative to maintain certain temperatures in battery rooms to ensure the reliability and long life of battery systems.

VRLA battery systems that are deeply discharged — 70% to 80% of the total depth of discharge — can cause problems. Battery systems that are only partially discharged will reduce the recharge voltage at the float voltage and will, in turn, reduce the voltage in the battery.

It is important to limit the recharge current in VRLA batteries to minimize the potential damage to the system. At 77°, a VRLA battery can tolerate a 25% current limitation of the ampere hour rating of the battery. For a 500-Ah battery, the recharge current should be 125 A above the load being served. Below 77°, the system can tolerate 30% of the current rating. At 90°, the battery system can tolerate 20% of the current rating. A charge current limit of 20% to 25% is recommended.

VRLA batteries create more internal heat than flooded batteries because of the recombination of oxygen at the negative plate. Additionally, the reduced electrolyte level in VRLA reduces the amount of heat that is conducted away from the battery plates.

While the flooded-cell batteries can provide for longer battery life, these systems can take up considerably more space and require more ventilation and monitoring requirements. Typically, wet-cell batteries are continuously releasing hydrogen gas into the air and are required to be installed in their own dedicated battery rooms. However, VRLA battery systems recombine the hydrogen inside the battery to make water; gas is only released when overheating or overcharging occurs, and normal ventilation for human occupancies typically exceeds the ventilation requirements for these systems.

REAL-WORLD EXAMPLES

A recent project required a total of 3,000 kVA of UPS modules in each uninterruptible power supply equipment room, with seven minutes worth of wet-cell batteries stacked two rows high. Therefore, an adjacent and separate 550-square-foot battery room was needed. This battery room required spill containment, a ventilation system, and hydrogen sensors.

On another project, a 225-kVA modular UPS system was provided, with 12 minutes of VRLA battery backup. The batteries for this system were in two separate cabinets adjacent to the UPS module. The total space, including front clearances, was approximately 40 square feet. On a kVA x minutes of battery basis, the VRLA battery layout would provide about 68 kVA x minutes / square foot. In the wet-cell example noted above, a 3,000-kVA UPS system with 7 minutes of battery backup required a separate room with front and rear access on each of the battery racks. On a kVA x minutes of battery basis, the wet-cell battery layout would provide about 38 kVA x minutes/square foot. As you can see, in this example, the VRLA battery provided for higher levels of kVA – minutes per square foot of required battery space. This example illustrates a larger wet-cell system in comparison to a smaller VRLA system. The actual kVA – minutes per square foot ratio between other systems will vary based on actual kVA utilized and total backup time required, in addition to the actual battery rack configuration and clearances required.

FIGURE 1. Shown here is of a two-tiered row of wet-cell batteries. A single 750-kVA uninterruptible power supply module required twice the amount of batteries that are shown in the picture for seven minutes of total battery backup time.

REQUIREMENTS

Large UPS systems typically utilize wet-cell battery systems, while smaller UPS systems typically use VRLA battery systems.

NFPA Chapter 52 dictates additional requirements for battery systems that exceed certain amounts of electrolytes. NFPA Chapter 52.1 states, "Stationary lead acid battery systems having an electrolyte capacity of more than 100 gallons in sprinkled buildings or 50 gallons in unsprinkled buildings used for facility standby power, emergency power, or uninterruptible power supplies shall be in accordance with Chapter 52." Additionally, Chapter 52.3.3.1 indicates that, "Battery systems shall be housed in the same room as the equipment that they support. Large systems will also require spill control stipulated by 52.3.4.1."

Based on NFPA Chapter 52.3.6, ventilation is required unless rooms and cabinets are in accordance with the mechanical code and one of the following criteria are provided.

1. The ventilating system shall be designed to limit the maximum concentration of hydrogen to 1% of the total volume of the room during the worst-case event of simultaneous "boost" charging of all the batteries in accordance with nationally recognized standards.

2. Continuous ventilation shall be provided at a rate of not less than 5.1 L/sec/m^2 of floor areas of the room or cabinet.

PROS AND CONS

Flooded-cell batteries require significantly more ventilation and monitoring requirements than VRLA batteries but typically provide for considerably longer battery life.

VRLA battery systems can experience thermal runaway. This can occur when heat is created during the charging process faster than it can be dissipated. These increased temperatures can make the system draw more current from the battery chargers. This extra current will make the system heat up even further. Eventually, the pressure within the battery reaches a point where the battery vents open and steam is released from the battery. With the release of water, the battery no longer accepts a charge and ceases to operate properly. Thermal runaway is typically not a problem in wet-cell batteries.

Wet-cell, or vented, batteries allow gases to escape during the charging process. VRLA batteries will only vent gases in failure mode. Many jurisdictions will not allow more than 1% of hydrogen concentrations because it can be combustible at higher concentration levels. Therefore, hydrogen monitoring is often required for wet-cell systems.

Battery monitoring is critical to ensure a long life of the battery system. Some monitoring equipment only counts the total number of charge and discharge cycles. It is essential to get a battery monitoring system that measures the internal resistance of each cell. This will give you a good idea of when a battery will fail, so replacement can occur systematically, prior to failure. In addition, a load discharge test can be completed to determine the strength of the battery system. However, some people feel that the load discharge test can prematurely fail the battery system and, therefore, do not perform these tests.

CHOICES OF TODAY AND TOMORROW

In addition to the VRLA and wet-cell battery systems, there are other battery systems available. Some of these systems include a modular battery cartridge (MDC), gel-cell battery, and absorbent glass-mat battery (AGM). The MDC is actually a VRLA battery system that is packaged into cartridges. If the appropriate mating plugs are available, these batteries can be plugged into the power supply.

Pure lead batteries are also a type of LVRA battery, but due to manufacturing issues, the industry moved away from this technology.

Fast forward to today: Advanced manufacturing and reduced costs have made pure lead batteries increasingly popular. As the name suggests, pure lead batteries have both positive and negative plates that are made of up to 99.9% pure lead — not a lead alloy. Because they are virtually free of impurities, they are designed to last up to three times longer than conventional flooded batteries. They have a higher acceptable operating temperature that can decrease cooling costs, a smaller footprint, and a longer shelf life. Pure lead is expected to become the standard in the future.

A gel-cell-type battery system contains a gel for the lead acid instead of a liquid, which means it will not leak if cracked. One disadvantage of the gel-cell battery system is that if the system is overcharged, voids can develop and stick to the battery plates. These voids can reduce the performance of the batteries.

AGM battery systems include glass mats that absorb the battery acid. These systems differ in operation from the gel-cell battery systems because, when voids occur, the voids float to the top of the container and do not stick to the glass mats. Unlike the gel-cell systems, the absorbent glass-mat systems can leak if the battery cracks.

A standby generator feeding life safety loads is required to startup within 10 seconds. Startup for these life safety systems can typically take six to eight seconds. For large generators feeding non-life safety loads, startup can take between 15 to 20 seconds. In either case, a UPS system with 30 seconds of battery backup would provide more than enough time to allow the generator to start and feed the critical facility loads. We typically see UPS systems with anywhere between a few minutes to an hour of battery time, based on full load. The concept behind the longer UPS runtimes is typically three-fold. First, the longer UPS system backup time allows the electrical distribution system maintenance personnel an opportunity to re-crank the generator a few times. Secondly, it gives the IT personnel time to organize an orderly shutdown of the critical systems. Thirdly, if the generators do not start, a longer UPS runtime would give the critical systems more of an opportunity to outlast the utility power outage.

The use of other UPS system technologies could provide the required backup power and eliminate the battery systems from the critical electrical distribution systems. The elimination of the battery systems would also do away with the associated room size, ventilation, spill containment, and monitoring issues. In addition, controlled temperatures are typically not required with other technologies. These other UPS system technologies include the flywheel, air compressor with flywheel, and other emerging technologies.

When a battery system choice is not clear, it may be prudent to provide a life cycle cost analysis for both the VRLA and the wet-cell battery system. A probability/reliability analysis would evaluate the reliability and availability of both systems. All factors must be considered to provide an accurate long-term cost assessment of both systems. These factors include: lost leasable floor space; ventilation, eyewash station, and maintenance and operation costs; spill containment; monitoring equipment; and potential downtime. Additionally, batteries must be disposed of in accordance with the Environmental Protection Agency (EPA). As a final measure, the cost of battery disposal must be considered in all life cycle cost analyses.

The electrical engineer or electrical distribution system designer needs to keep abreast of the potential UPS battery sources. The pros and cons of each system must be weighed with the client's objectives. A clear understanding of the technologies available and the applicable codes is required to ensure that the client's needs are being met in the most efficient way possible. ■

Keith Lane, P.E., RCDD, NTS, RTPM, LC ,LEED A.P., is president and CEO of Lane Coburn & Associates LLC. He has a strong background in both design-build and consulting electrical engineering. He is a nationally recognized speaker and has participated as an expert panelist for numerous national webcasts.

Scott Coburn is director of constructability for Lane Coburn & Associates LLC. Hehas more than 21 years of experience in electrical design, engineering, management, and budget control for an extensive range of projects, including biotech, data centers, and more.