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Uninterruptible Power System (UPS): Reliable Power

by ***Thomas M. Divine III****, P.E.*

Along with the explosive growth in data processing equipment over the last decade has come an unyielding demand for high-quality, continuous electrical power.

Selecting and maintaining the right Uninterruptible Power System for your facility

That demand is normally met by an uninterruptible power system (UPS). Finding the right UPS can be a challenging task. In order to obtain the maximum benefit, facility managers must select an appropriate UPS for the critical load and maintain it to ensure it is in proper operating condition. When selecting a UPS, managers must consider the size of the critical load, reliability requirements, battery run time, future expansion, and budget constraints. The size of the critical load determines the capacity of the initial installation. The UPS must have adequate capacity to reliably serve the critical load and possible additional loads without immediate expansion. The excess capacity of the UPS will depend on the facility's plans for expansion of the supported load. As a general rule, the UPS capacity should be 150 to 200 percent of the initial installed load. For small critical loads involving a single computer or a few racks, a single-phase desktop or rack-mounted UPS may be the optimal solution. For larger critical loads, such as data centers, free-standing three-phase modules are generally installed.

System reliability requirements will determine the configuration of the power system. Very high requirements will lead to a system with multiple UPS modules and multiple battery banks with at least one redundant module so the system is capable of reliably serving the load if one module fails or undergoes maintenance. Loads with lower requirements can be served with a single UPS module with a static bypass switch to provide utility or generator power during periods when the module is out of service. Reliability requirements are driven by the consequences of a power failure. If an outage results in lost revenue, failure to meet contractual obligations, or a loss of customer goodwill, it is generally appropriate to install a redundant system.

The *battery run time* of a UPS is the length of time the UPS can reliably supply power to the critical load after input power has failed. Battery run time is usually established as the length of time required for connected data processing equipment to save data files and shut down in an orderly fashion, along with a margin of safety, which is about 50 percent. Typical battery run time is 15 minutes. Batteries are very heavy and can present a large dead load to the supporting structure. A structural engineer should review the proposed installation and determine whether modifications are necessary to support the load.

Requirements for future expansion will affect the configuration of the UPS and will determine space requirements for future modules and battery banks. Depending on the expected timing of planned expansion, it may be more economical initially to install a single module and add more modules as they are required, rather than installing a single larger module. Managers that intend to install additional capacity in the future should consider the electrical infrastructure required to support the maximum critical load and must carefully guard spaces allocated for expansion to ensure those spaces are not filled with other equipment when larger capacity is required. Budgetary constraints, in terms of initial cost and ongoing maintenance costs, play a key role in determining the final UPS design. Often, a system that satisfies other considerations will be simply too expensive to implement, and some functionality or system reliability must be sacrificed in order to keep costs in line. UPS design often represents a compromise between competing goals.

Battery Maintenance

Only trained personnel should perform UPS battery maintenance. UPS batteries generate voltages that are dangerous and even lethal. Battery racks and cabinets often provide very little working space for connecting probes or tightening bolts, and unintentional contacts can happen easily. The similarity of sealed UPS batteries to the more familiar and benign automobile batteries can make the danger easy to overlook.

The requirements for an effective battery maintenance program depend to a degree on the type of batteries installed. *Flooded cell* batteries, whose electrolyte is visible through its glass container, generally deliver higher performance for a greater length of time, but have higher initial costs and advanced maintenance requirements. *Valve-regulated* batteries, also known as *sealed* or *maintenance-free* batteries, have a lower cost up front and require less maintenance than flooded cell batteries but also have higher internal resistance

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and shorter life. Under optimal conditions, flooded cell batteries may last 20 years, while the average expected lifetime of valve-regulated batteries is seven years.

An effective battery maintenance program must include regular inspections, adjustments, and testing of the UPS batteries, with thorough records of all readings. On a monthly basis, trained technicians should visually inspect batteries and racks for signs of corrosion or leakage, measure and record the float voltage and current of the entire bank, note the electrolyte level in each cell, record the voltage and electrolyte density of selected cells, and log the ambient temperature. They should also verify that spill containment materials are available, emergency wash stations are operational, and the battery room exhaust system is functioning. Quarterly maintenance typically includes monthly inspection items, in addition to recording the voltage readings for each cell and electrolyte temperature of selected cells. Annually, intercell resistance readings for each cell connection and internal resistance of each cell should be documented. Annual maintenance also involves re-torquing connecting bolts and measurement of the exhaust airflow with remedial action, if required. Annual maintenance procedures should also be performed after a high-current discharge.

Storage batteries have limited life, usually showing a slow degradation of capacity until they reach 80 percent of their initial rating, followed by a comparatively rapid failure. The number and depth of discharge cycles, ambient temperature, and charging characteristics affect battery life. The combined effect of these factors is difficult to quantify. Therefore, managers need a means to determine when a battery is near the end of its useful life in order to replace it while it is still working and before the critical load is left unprotected. The only sure way to determine battery capacity is to perform a *battery run-down* test. The module under test is taken off line, connected to a load bank, and operated at rated power until the specified battery run time elapses or the unit shuts down due to low battery voltage. If the observed battery capacity is 80 percent or less of its rated capacity, the battery should be replaced.

Thermal scanning of battery connections during the battery run-down test will identify loose or marginal connections. This test is normally the manager's only opportunity to observe the battery during an extended, high-current discharge. Scanning should be performed during the discharge and recharge cycles.

The optimal maintenance interval for battery run-down testing is a matter of some debate in the industry. The test is expensive and inconvenient, requires a large load bank, and necessitates removing a UPS module from service and exposing the critical load to a greater hazard of interruption. Usually, the test must be performed during off-peak hours on a weekend. Managers understandably prefer to delay or avoid this test whenever possible. A reasonable testing interval is two years until the battery reaches 85 percent of rated capacity, and annually thereafter. Some experts maintain that this test can be avoided by rigorously monitoring internal resistance of all cells and inferring remaining capacity from those measurements. Others claim the battery test can be performed by removing input power for a short period with the critical load attached, with battery capacity inferred from the test results. However, load testing is the only accepted method for determining battery capacity.

A battery monitoring system can automate a significant portion of battery maintenance tasks, including electrical measurements and record keeping. The system can routinely perform voltage, current, and resistance readings and make the data readily available to an analyst. Battery monitoring systems range in function from a simple *hit counter*, which records the number of discharge events, to highly sophisticated systems that continuously log electrical data and present it in graphic form. While these systems can reduce routine maintenance costs, they are quite expensive.

Managers have a variety of options with regard to battery maintenance. They may elect to perform all maintenance tasks with in-house personnel, hire outside specialists, or perform some tasks in-house while using contract personnel for less frequent or more specialized maintenance.

UPS Maintenance

Similar to UPS battery maintenance, UPS module maintenance is complex and should be performed only by personnel trained by the UPS manufacturer. UPS modules are power devices and can deliver dangerous voltages to unwary personnel. Modules are designed to provide maximum power in minimum footprint; consequently, maintenance spaces are generally cramped. UPS design varies considerably among manufacturers, and specialized knowledge is necessary to properly identify inspection and maintenance points within the unit.

Routine maintenance of the UPS consists of a variety of inspections, measurements, calibrations and preventive actions. The affected module is shut down for these procedures and the remaining modules – or, in non-redundant systems, a standby generator or the local electric utility – provide power to the load until the module returns to service. The maintenance team inspects the interior of the unit for corrosion and heat damage, records and adjusts the battery charger float voltage, calibrates metering and protection functions, tightens power connections, cleans the module, and performs other unit-specific maintenance activities as recommended by the manufacturer. If the manufacturer's service group maintains the module, it will implement engineering change notices while the module is out of service.

During the battery run-down test, the internal power connections and components should be thermally scanned to identify poor or marginal connections. Scanning should be repeated during the recharge cycle to ensure that rectifier components are adequately scanned.

Selecting a UPS and developing an effective maintenance program is a complex endeavor that requires detailed analysis, specific knowledge of available systems and equipment requirements, and a thorough understanding of facility goals and constraints. Facility managers can get assistance from equipment manufacturers, especially with regard to specific maintenance requirements, or engage an independent consultant to help weigh the costs and benefits of equipment selection, sizing and configuration and develop a maintenance plan that provides system reliability and longevity within the facility's budget.

Thomas M. Divine, P.E.
TDivine@ssr-inc.com
(713) 784-8211