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A Few Notes on Batteries

Although DC power is not exactly a high frequency technology, it is required for operation of all electronic equipment. In particular, batteries are important for communications systems, providing backup during power outages, as well as being the main power storage and delivery devices in remote sites powered by wind or solar energy.

A new book [1] has an excellent chapter on battery systems for telecommunications facilities. For this column, we'll summarize some of the basic information about batteries presented in that chapter.

Battery Types

Most storage battery systems use lead-acid batteries. These batteries are either "wet cell" or vented lead-acid (VLA) type, or the semi-sealed valve-regulated lead-acid (VRLA) type. VLA cells are available with capacities from 50 to 8000 Ah, while VRLA cells are typically offered in capacities from 50 to 2000 Ah.

Lead-acid batteries store energy through an electrochemical conversion process involving the lead negative plate, the lead dioxide positive plate and the sulfuric acid electrolyte. The reaction is described by the following diagram:

$$Pb + PbO_2 + 2H_2SO_4 \underset{\leftarrow \textit{Charge}}{\overset{\textit{Discharge} \rightarrow}{\text{———}}} 2PbSO_4 + 2H_2O$$

The single most important part of battery systems is the management of discharge-charge cycles. If discharged too deeply or if not charged properly, the cells can quickly be rendered useless by build up of lead sulfate or damaged by overheating.

Although VLA batteries generally provide greater capacity per unit purchase cost, they require much more maintenance. Electrolyte levels must be maintained, electrolyte condition monitored (by measuring specific gravity) and the storage location must be ventilated to avoid build-up of gases, which may include explosive hydrogen gas.

Most new systems use VRLA batteries, which are described variously as "maintenance free" (a misnomer), "sealed lead acid" or SLA, "absorbent glass mat" or AGM, "gel cell" and others. Low maintenance is the primary advantage of VRLA over VLA batteries, while the main disadvantage is a somewhat shorter lifetime, compared to a well-maintained VLA system. Another small disadvantage is the inability to examine the condition of VRLA cells because they are packaged in opaque containers and, with their low maintenance, are usually placed in less-accessible locations.

Discharge, Charge and Float

Beginning with a full charge (2.16 V/cell typical), lead acid batteries are rated in ampere-hours (Ah) at a specific discharge rate. Typically, the maximum energy is extracted when a battery is discharged at a 10-hour rate. Battery Ah ratings are usually specified for either an 8-hr or 10-hr discharge rate—be sure to use the same rate when comparing batteries.

Thus, a 100 Ah at 10 hour rate battery can deliver 10 amps for 10 hours, then the cell voltage reaches the minimum allowable (1.75 V) and must be charged. A well-designed system will have a low-voltage disconnect to avoid further discharge, which would ruin the battery.

Batteries are 85 to 90% efficient in accepting a charge, which means that a 100 Ah battery requires 110 to 118 Ah of charging. When fully discharged, the acceptance of charge begins slowly, but increases rapidly after the cell voltage is raised slightly and continues to be high until about 80% of capacity is reached.

During the period of high charge acceptance, the charging system should limit charging current to a level that will not cause thermal runaway, which can easily damage the battery and its housing—causing leaks that usually result in severe corrosion from the acid. The charging system should have a control system that monitors both cell temperature and voltage-while-charging, adjusting charging current to keep those parameters within safe limits.

Once fully charged, a battery will self-discharge if left alone. To maintain a full charge, a "float" voltage is applied, usually 2.20 to 2.25 V/cell. The float voltage may be temperature compensated in some installations, particularly if high temperatures are expected.

Charging rates and float voltage must be matched to the exact type of battery used. There are variations in construction among manufacturers, including the use of different alloys in the plates. Each battery model will have an optimum set of parameters that will result in best performance and longest operational lifetime.

Reference

1. Whitman D. Reeve, *dc Power System Design for Telecommunications*, IEEE Press and John Wiley & Sons, Inc., 2007. ISBN 13-978-0-471-6816-1 and 10-0-471-68161-X, Ch. 4.