THE CRITICAL NATURE OF STATIONARY BATTERY MAINTENANCE

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INTRODUCTION

Stationary batteries are one of the most critical aspects of an emergency power supply system, and yet they are the most overlooked and neglected part of the system. During power outages, they are called upon to provide backup power for critical electrical systems which keep data, life safety and key production equipment in operation until a generator set or another secondary power source comes online.

For example, generator sets at a hospital can take up to 10 seconds to begin accepting loads, so batteries provide the power necessary to bridge that time gap. No surgeon wants to be in the middle of an operation without properly maintained batteries when a utility outage occurs.

The applications protected by batteries are numerous and critical, and batteries are frequently forgotten until an outage occurs. Lack of maintenance is usually only discovered when batteries are unable to support the intended load.

LEAD-ACID BATTERY OPERATION

Lead-acid batteries produce electricity through chemical reactions involving two dissimilar metallic materials in a current-carrying solution, called electrolyte. This is true of primary disposable batteries as well as secondary rechargeable batteries, such as those found in automobiles and UPS applications.

In lead-acid batteries, the two dissimilar metallic materials are lead and lead oxide in a sulphuric acid electrolyte, which react to produce electricity.

In the past, voltage and specific gravity were primarily used to test batteries. The voltage and specific gravity of lead-acid batteries basically follow the status of the sulphate. If a battery is fully charged, the sulphate will be in the acid, and with few exceptions the battery's voltage and specific gravity will have normal values. If the battery is discharged, the voltage will be low and, since there is some sulphate on the plates, the specific gravity will also have a low value. Ideally, the sum of all the cell voltages should be equal to the output voltage of the charger.

These methods measure the battery charge and not battery health, which is much more important. If the battery has a normal voltage, it doesn't reflect the health of the battery, and when the voltage is abnormal, it may indicate a potential problem or simply mean that the battery is discharged to some extent.

BATTERY TESTS

Battery testing can be done too frequently or not frequently enough. The frequency of testing is typically tied to the customer's perception of his risk and what he is willing to do to mitigate that risk. Numerous tests can be performed, including specific gravity, voltage, cell temperature, ambient temperature, float current, ripple current, discharge current and time, intercell connection resistance, internal ohmic testing and capacity or load testing. Several of these tests are explained below to help you better understand how to fully determine the condition of a stationary battery.

TEMPERATURE

Both ambient and battery temperature can have a significant effect on the life of a battery. For every increase of 10° C in battery temperature above 20°C, the battery life is halved. For example, a 20-year vented lead-acid battery maintained at 35° C instead of the specified 25° C most likely will last only about 10 years.

FLOAT VOLTAGE

Voltage readings are an important part of the testing process, and the sum of the voltages for all of the batteries in the bank must equal the charger output voltage, excluding resistive losses. If a voltage reading is abnormal, then the condition of the battery should be investigated further.

However, a voltage reading can be one of the most misleading indicators of a battery system's health. If a reading is normal, it means the charger is functioning properly, but it says nothing at all about a battery's condition. While a normal voltage reading does not provide an indication of battery capacity, an abnormal voltage should prompt further investigation.

SPECIFIC GRAVITY

Specific gravity measures the amount of sulphate in the acid of a lead-acid battery. Specific gravity measurements do not really provide much insight into determining when a battery may fail, as there are no studies which show a correlation between specific gravity and battery health.

Normally, the specific gravity of a battery changes very little after the first 3 to 6 months of a battery's life, and any initial change is due to the completion of the formation process, which converts inactive paste material into active material by reacting with the sulfuric acid.

Sometimes a low specific gravity reading reflects plate sulphation, which can be caused by setting the charger voltage too low.

Lead-acid batteries contain sulphate in one of two states: on the plates (discharged) or in the sulfuric acid (charged). The specific gravity reading imitates the voltage reading, so it is an indicator of the state of charge. If the battery is discharged, some of the sulphate migrates to the plates and the acid has a lower specific gravity. If the battery is fully charged, all of the sulphate is in the acid and the specific gravity is normal.

FLOAT CURRENT

There are two types of DC current put on a battery: recharge current and float current. Recharge current flows to a battery to recharge it after a discharge event, while float current is applied to a battery to keep it in a fully charged state. Whenever there is a difference between the voltage of the battery and the battery charger setting, a current will flow. When a battery is fully charged, the only current that will flow is the float current, since a lead-acid battery is always naturally trying to self-discharge. Because the self-discharge is small – usually less than 1% per week – the difference between the charger voltage and the battery voltage is small, so the float current is also low. Float current will vary with battery size; the larger the battery, the larger the float current.

Float current can increase for a few different reasons, including ground faults and internal battery faults. Ground faults occur in a floating system when current tracks from the battery to the metal rack or enclosures of a battery system, causing additional current to flow from the battery charger to make up for the loss of current in the grounded battery. Internal battery faults cause more current to flow to a cell in the battery and tend to cause the remainder of the cells to be overcharged, causing premature failure of the battery.

In valve-regulated lead-acid (VRLA) batteries, the float current can signal a thermal runaway condition, which occurs when a battery becomes overcharged or experiences high ambient temperatures. If the battery is unable to dissipate the heat fast enough, it will overheat and possibly explode or create a thermal event. Measuring the float current of a VRLA battery can help avoid a failure and possible damage to the equipment protected by the battery.

RIPPLE CURRENT

Ripple current is another parameter that should be measured on a regular basis to ensure proper charger operation. Ripple current is produced when a charger converts AC into DC. No charger has a 100% ripple-free conversion process, so filters are frequently added in certain applications. Ripple current typically does not become an issue until the charging equipment begins to degrade over time. If a failure occurs with a rectifier or diode – the major components in a charger – the output current will double and damage the battery string. An increase in ripple current to a point greater than about 5 amps rms for every 100Ah of battery capacity (5%) increases temperature and shortens battery life.

MONITORING BATTERY DISCHARGES

Battery monitoring systems are now being used more frequently to keep tabs on the operating parameters of battery systems. By monitoring the discharge current and time of a stationary battery, it is much easier to help determine how much life is still left in the battery system. Measuring the discharge current and time and then calculating the amp-hours removed and replaced helps to better determine the battery capacity. Performing these calculations can help avoid unnecessary capacity tests, which are expensive and damaging to the battery.

INTERCELL CONNECTION RESISTANCE

Nearly half of all battery issues are caused by loose or poor connections, so intercell connection resistance is one of the most important tests that can be performed on a regular basis to help ensure that the battery system will operate properly. If utility or primary power source outages are common, intercell connection resistance tests are crucial in uncovering loose and corroded connections in the cable or buswork that ties the battery system to the load.

Intercell connection resistance testing is usually performed along with ohmic testing and can be completed very quickly. By using a digital low resistance ohmmeter (DLRO) and the appropriate software, the results can be logged into a database to help uncover any issues in the system.

If outages are frequent, this test needs to be performed since the materials that comprise the connection hardware will expand and contract when large currents pass through these connections. These events loosen the hardware, causing connection issues that generate more heat and further deteriorate the connection. Ultimately, this can lead to losing a portion of the battery string, which affects the remaining capacity in the system. These connections need to be tightened to the proper torque on a regular basis to help maintain a good connection in the hardware.

CAPACITY TESTING

Capacity testing is the only true way to get an accurate value of the actual capacity of a battery. When this testing is performed properly, it can gauge a battery's health, determine its actual capacity, and estimate the remaining life of the battery.

Rated capacity values are provided by the battery manufacturer. All batteries have tables that illustrate the discharge current for the specified amount of time it takes to lower the cell voltage to a specific value, typically 1.75 or 1.80 volts per cell.

During the test, the current is maintained at a constant value. A test time should be selected to match the battery's duty cycle, typically 5 or 8 hours. It is expensive and very labor-intensive to set up the testing procedure for these lengths of time, which is partly why this type of testing is not done very often. This test can take up to 4 days before the entire process is completed, depending on the size of the bank and the amount of discharge required.

If the battery reaches the end discharge voltage at the same time as the specified test time, then the battery capacity equals 100% of its rated capacity. If the battery reaches the end of its discharge time at 80% or less of its capacity, then the battery needs to be replaced.

By increasing the amount of current used to discharge the battery, batteries can be tested for a shorter period of time than the duty cycle, as little as 1 hour in certain cases. A shorter test time removes less capacity from the battery, which reduces the man hours needed to perform the testing procedure as well as the time needed to recharge the battery following the test. However, it is important to keep an eye on the temperature of the battery at a higher rate of current flow.

IMPEDANCE AND RESISTANCE

Impedance is an internal ohmic test that measures the ability of a cell to deliver current. While there is no direct correlation of internal ohmic measurements to battery capacity, this test is still an excellent way to find weak batteries in the bank. Studies have revealed how well impedance and other internal ohmic tests work in finding weak cells.

The impedance test applies and measures an AC current signal while simultaneously measuring the AC voltage drop across the battery. Impedance is calculated by using Ohm's law: $Z = E/i$. Impedance is inversely proportional to capacity, so when capacity decreases, impedance increases.

This test can be completed quickly – usually in about an hour for a 40-jar UPS installation. It is also non-invasive, which means the test can be performed while the equipment is still in service.

INFORMATION ANALYSIS

What is done with the information and results that are acquired during testing? How do we interpret the data to help determine the existing capacity? Most importantly, how do we determine the remaining useful life of the battery?

With the advent of better testing methods, such as impedance testing, more useful data beyond voltage and specific gravity can now be obtained. A specialized database that includes all measured parameters can track and trend all battery data over time, providing a critical resource for determining the condition of batteries and banks.

Setting proper limits can help users get the most life from a battery without increasing risk, and limits should be set for each parameter measured. For example, float voltage limits should follow manufacturer's guidelines. Internal ohmic test limits are more debatable. In some cases, users will set a "failure limit" of 50% impedance increase for VRLA batteries from a predetermined baseline value. Float current limits tend to be less precise depending upon the size, age and alloy of the battery.

CONCLUSION

Batteries can fail or underperform for many reasons. With proper maintenance and testing, many of these failure modes can be reduced or eliminated, enabling customers to have total confidence in the ability of batteries to support critical equipment when needed. By performing these tests on a regularly scheduled basis, unplanned failures can be eliminated and the life cycle of the battery can be extended to its fullest potential, maximizing the performance of the entire battery system and keeping costs down.

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