Maintenance and Testing of Battery Systems

The electrical maintenance and testing requirements for utility, industrial and large commercial facilities vary significantly depending on the electrical infrastructure of the facility. For this discussion, we will focus on battery systems within that infrastructure.

A battery consists of two or more cells electrically connected to form a discrete electrical source. These electrical sources are typically described in terms of dc voltage and ampere-hour ratings. A battery, when combined with a charging and alarming system, is referred to as a battery system. A cell is the basic electrochemical unit used to store electrical energy. Cells are typically either sealed or vented. Sealed cells have also been described as valve regulated lead acid (VRLA) and, when properly maintained, typically last between five to ten years before replacement. Sealed cells are typically less expensive to purchase and install so they have been used in systems of up to 500 kVA. Vented cells have been described as wet, vented lead acid (VLA), or flooded lead acid (FLA) and, when properly maintained, typically last between 15 to 20 years before replacement. Wet cells are typically used in systems where the capacity exceeds 100 kVA. For purposes of further discussion, we will describe these battery systems as either “sealed batteries” or “wet batteries.”

Batteries systems, either when combined with an uninterruptible power source (UPS) or as a stand-alone system, consist of a charging system, which provides a float voltage, and the battery and provide standby emergency power in the event of a power failure. Therefore, batteries keep many vital subsystems operating such as protective relay equipment, power distribution systems, communication systems, and computer-based data systems when normal power sources are suspect.

IEEE Standard 450 details the recommended testing and maintenance for large, stationary, vented batteries while IEEE Standard 1188 describes the recommended practices for sealed VRLA batteries. As stated in IEEE Standard 450, the practices recommended in these standards “serve as a valuable aid in maximizing battery life, preventing avoidable failures, and reducing premature replacement.”

Battery Maintenance and Testing

At a minimum, annual testing, verification, and inspection of a battery system should be performed. The annual preventive maintenance, which should be performed for both wet and sealed battery systems, includes the following:

- Inspect each cell for terminal corrosion and cell condition;
- Inspect battery rack and/or cabinet for structural integrity;
- Test for the cell-to-cell and terminal connection resistance;
- Test each cell voltage and total battery voltage;
- Verify appropriate charger float and equalizing voltage levels;
- Clean terminals and battery surfaces, as needed;
- Verify battery area ventilation is operable and that suitable eye-wash equipment is present.
For wet battery systems, the following additional tests and verifications should be performed:

- Test each cell for specific gravity and temperature;
- Verify electrolyte level in each cell;
- Verify presence and condition of flame arrestors.

For sealed battery systems, negative post temperatures for each cell should also be tested and verified to be within manufacturer’s recommendations.

Additional quarterly or semiannual inspections should be performed if the age and condition of the battery warrant the activity and it is determined that the battery system is critical to the reliability of the associated power system. As with all electrical systems, infrared thermographic surveys should also be performed on battery systems on at least an annual basis.

The addition of an occasional load test of the battery system should be considered as the battery system ages or other problems are identified. In support of this recommendation for load testing, there are some other more sophisticated testing methods that can and should be performed more regularly to accurately determine battery health. These methods measure the internal ohmic values of the battery or associated cells.

Ohmic measurement using the battery’s or cell’s own voltage is one of the oldest and most reliable test methods for battery systems. A load is applied to a cell or a small string of cells lasting a few seconds. The load current must be high enough to produce a delta voltage well above the system noise voltage. The drop in voltage divided by the input current provides an accurate and repeatable resistance value. Alber’s CRT-300 Cellcorder is an example of this type of instrument.

Ohmic measurement using ac voltage is also a generally accepted test method for battery systems. An instrument applies an ac signal across a cell or string of cells at a known frequency between 80-100 hertz. From this signal the conductance in mhos or Siemens or the impedance in ohms is determined. A major benefit to using an ac ohmic test is the ability to estimate a battery’s capacity without performing an extensive discharge or load test. Midtronic’s Celltron series or the Megger BITE testers are examples of these types of instruments.

**Safety**

Battery systems are unique from other electrical systems in that you cannot just turn them off for maintenance or corrective action. Therefore, shock and arc flash protection in accordance with NFPA 70E requirements should be implemented. To complicate things further, battery systems have special ventilation requirements and, in the case of wet batteries, hazardous chemicals are present and produced throughout the life of the battery. This situation results in applying additional special precautions when testing and maintaining battery systems. Goggles or face shields, acid resistant gloves, protective aprons, and insulated tools should be used when working with battery systems. An eyewash station and a class C fire extinguisher should be immediately available and operable when servicing battery systems.

**Battery Test Results**

For sealed or wet batteries, the cell voltage value should be in accordance with manufacturer’s published data. Cell voltage above or below 0.05 volts of the average is indicative of a problem with the cell.

For flooded lead-acid battery systems, specific gravity is useful in evaluating the state of charge. For most telecommunication and substation battery systems, a specific gravity of 1.215 is expected for each wet cell. For most UPS-related battery systems, a specific gravity of 1.250 is typical for each cell. If the specific gravity drops by .015 to .020 from these values, it may be indicative of inadequate charger float voltage or a problem with a cell holding a charge. Remember, specific gravity should always be adjusted for internal cell temperature differences from 25 degrees C at a rate of .001 for every 1.67 degrees C difference. Also, electrolyte levels should be taken into consideration when evaluating specific gravity. Cells with low electrolyte levels typically need water added and, therefore, will have a higher specific gravity.

For sealed battery systems, the negative post temperature should be consistent for all cells within the battery and should be in accordance with manufacturer’s published data. A variation of post temperature is indicative of a problem with the cell.

A cell’s internal resistance provides useful information in detecting problems and can be used for indicating when a battery should be replaced. However, resistance alone does not provide a linear correlation to the battery’s capacity. The increase in cell resistance only relates to aging and provides some failure indications. Rather than relying on an absolute resistance reading, service technicians take a snapshot of the cell resistances when the battery is installed and then measure the subtle changes as the cells age. An increase in resistance of 25 percent over an initial baseline or similar cells indicates a performance drop to about 80 percent.
A battery’s measured conductance correlates linearly with its ability to deliver current. As conductance declines, so does a battery’s ability to meet its specified capacity and supply energy. A decrease in conductance of 25 percent over an initial baseline or similar cells indicates a performance drop to about 80 percent.

In conclusion, battery systems are typically installed in support of electrical systems which are critical to the user. Based on this criticality and associated reliability requirements, battery systems should be inspected and tested on a regular frequency to maximize battery life, prevent avoidable failures, and reduce premature battery replacement.

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