ACCEPTANCE INSPECTION AND TESTING OF NEW STATIONARY BATTERIES

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ABSTRACT

Acceptance inspection and testing of a new stationary battery is performed to insure that the battery purchased can perform to the manufacturer's specification and meets all the procurement specification requirements. This is important because the battery manufacturer's specification is generally used to size and select the battery for the application. The acceptance inspection and test, typically performed at the battery manufacturer's factory has long been overlooked by the battery end user for various reasons including time, economics and lack of guidance. Accurate specification and performance of an acceptance inspection and test of a stationary battery by properly trained and qualified personnel can optimize battery life and performance thereby increasing the reliability of the standby power system. Currently, standards exist which describe recommended practices for maintenance, testing and replacement of batteries in stationary applications however, these standards do not necessarily provide guidance for acceptance inspection and testing of a new battery. This paper will address the specification and performance of this inspection and test, and the acceptance and cell selection criteria for new lead acid and nickel cadmium batteries used in stationary applications.

INTRODUCTION

The stationary battery as an energy storage device has long played an important role in standby power applications for electric utility, telecommunications and industrials controls. With increased emphasis put on power quality and uniterruptible power the stationary battery has found new applications, namely in uniterruptible power supplies (UPS). . With all these applications comes a high expectation of the stationary battery system and a requirement for reliable life and performance of the battery. Correct sizing and selection of the battery for the application is crucial for reliable service as is correct installation and a proper maintenance and testing program over the service life of the battery. However many new batteries are put into service without a proper acceptance inspection and test. This inspection and test is as important as any other test performed on the battery during it's service life. Properly performed, this inspection and test can identify a battery or individual cells that do not meet the manufacturer's and procurement specification requirements. A provision for performing an acceptance inspection and test should be included in the procurement specification for the new battery along with acceptance criteria. Following the performance of the acceptance inspection and test by qualified personnel, all inspection results and test data should be carefully evaluated by the battery manufacturer and the battery end user representative. Cells that will make up the battery can then be selected based on the inspection results and test data.

SPECIFICATION

The procurement specification for a new stationary battery should require the performance of an acceptance inspection and test. The specification should clearly state the following:

- Location of the acceptance inspection and test.
- Party responsible for performing the acceptance inspection and test.
- Personnel representing the battery end user who will be present.
- Certified test and measurement equipment required.
- Inspection and test prerequisites.
- Inspections and tests to be performed.
- Discharge rate and end voltage for capacity load test (ASNI/IEEE Acceptance Test).

- Acceptance and cell selection criteria.

Procurement specifications often include an acceptance criteria for only battery capacity. A battery end user may specify that the battery shall be able to deliver at least 100% of the manufacturer's rated capacity at a specific rate to a specific end voltage at the time of delivery. In most cases, the end user will receive a battery that meets this specification. However, the battery may be comprised of cells that are at some value below 100% capacity and some cells that are above 100% capacity resulting in an average of 100%. The cells that are below 100% may never reach 100% capacity during their service life and may in fact experience a shorter life which at some point could affect the overall capacity of the battery. Ideally, the end user would prefer a 100% capacity battery in which all cells are at 100% of the manufacturer's rated capacity. In order to assure this, the procurement specification must clearly state that **all cells** that make up the battery must be able to deliver at least 100% of the manufacturer's rated capacity at a specific rate to a specific end voltage at the time of delivery.

INSPECTION AND TEST

The acceptance inspection and test of a new vented lead acid, valve regulated lead acid (VRLA) and nickel cadmium stationary battery should include 1) a comprehensive review of all manufacturing documents related to the construction of the cells that will be inspected and tested 2) a visual and mechanical inspection of all cells 3) electrical testing and 4) verification of all accessories for the battery that were identified in the procurement specification or were included in the purchase order. It is important that all prerequisites that were identified in the procurement specification are met prior to performing the inspection and test. All inspections and tests with the exception of the capacity load test should be performed with the battery on float charge at the battery manufacturer's recommended float voltage per cell. Any equalize, high rate or conditioning charge should be completed a minimum of 72 hours for lead acid and 24 hours for nickel cadmium prior to the start of the acceptance inspection and test.

Location

Although the inspection and test can be performed at the installation site following receipt of the battery, the preferred location for the acceptance inspection and test of a new stationary battery is at the battery manufacturer's facility for the following reasons:

> A rejected battery or individual cells do not have to be shipped back to the manufacturer. This will help keep any increase in the project time schedule that can occur from a failed acceptance inspection and test to a minimum.
>
> The battery end user representative can select the individual cells that will make up the battery based on the inspection results and test data .
>
> The battery manufacturing processes and quality control records can be witnessed.

Visual and Mechanical Inspection

The following should be verified for vented lead acid, VRLA and nickel cadmium cell types:

1. Compare battery nameplate with drawings and specifications.
2. Manufactured date code.
3. Cell serial numbers.
4. A corrosion resistant nameplate with clearly legible lettering is provided for each cell.
5. The positive and negative terminal posts of each cell are clearly marked.
6. Inspect physical and mechanical condition of each cell/jar (i.e. jar and cover integrity, electrolyte leakage, terminal post integrity).
7. Post terminals and connections are free of corrosion.
8. Cells are connected using inter-cell or inter-jar connectors and hardware that is specified for the cell type by the battery manufacturer. NOTE: The connectors and hardware used for the acceptance inspection and test should not be shipped with the battery to the installation site. The battery manufacturer should ship new and unused connectors and hardware.
9. All connections are tightened to the battery manufacturer's torque specification.

10. Proper application of manufacturer's approved corrosion inhibiting grease on contact surface areas of all connections and connection hardware.

The following visual and mechanical inspections should also be made for **vented lead acid** cells only:

1. Flame arresters that are specified for the cell type are provided and properly installed on each cell.
2. Condition of cell plates, internal conduction path and any evidence of sediment on inside bottom of cell.
3. Post seals are free of electrolyte leakage.
4. Verify the electrolyte level of each cell is at the battery manufacturer's recommended reference point .
5. Measure and record electrolyte temperature of 10% of the cells.
6. Measure and record the electrolyte specific gravity of each cell.
7. Calculate and record the electrolyte temperature corrected specific gravity for each cell.

The following visual and mechanical inspections should also be made for **VRLA** cells only:

1. Measure and record the temperature of the negative terminal of each cell/jar.

The following visual and mechanical inspections should also be made for **nickel cadmium** cells only:

1. Verify proper electrolyte levels.
2. Flame arresters that are specified for the cell type are provided and properly installed on each cell.
3. Post seals are free of electrolyte leakage.
4. Measure electrolyte specific gravity.

Electrical Test

The following electrical test should be performed on new vented lead acid, VRLA and nickel cadmium stationary batteries:

1. Measure and record each cell/jar voltage and total battery voltage with the battery on float charge.
2. Reference electrode measurements (vented lead acid only).
3. Cell/jar internal ohmic test.
4. Capacity load test in accordance with manufacturer's and battery end users specifications and the following applicable ANSI/IEEE standard:

    ANSI/IEEE Std 450-1995, Recommended Practice for Maintenance, Testing and Replacement of Vented Lead Acid Batteries for Stationary Applications.

    ANSI/IEEE Std 1106-1995, Recommended Practice for Installation, Maintenance, Testing and Replacement of Vented Nickel-Cadmium Batteries for Stationary Applications.

    ANSI/IEEE Std. 1188-1996, Recommended Practice for Maintenance, Testing, and Replacement of Valve-Regulated Lead-Acid (VRLA) Batteries for Stationary Applications.

ACCEPTANCE AND CELL SELECTION CRITERIA

The acceptance criteria for each cell parameter should be clearly specified in the battery procurement specification. All acceptance criteria should be based on the battery manufacturer's specifications and the battery end user's allowable limits. All inspection and test results should be carefully evaluated by the battery manufacturer and the battery end user representative at the conclusion of the acceptance inspection and test. Cells that will make up the battery should be selected based on results of the visual and mechanical inspections, the electrical tests, capacity load test and cell compatibility.

Cell Date Code and Serial Number

Cells selected to make up the battery should have been manufactured in the same production run. This typically can be verified by the manufactured date code and serial number applied to each cell. The date codes on all cells should be the same and the serial numbers should be consecutive. Cells from different production runs can have slight differences in operating and performance characteristics due to differences and changes in the manufacturing process and cell component material (i.e. lead oxides, sulfuric acid, expanders for lead acid cells) from one production run to another. These differences in operating and performance characteristics can be seen as a wide variance in individual cell voltage at float voltage and in cell internal impedance.

VRLA Negative Terminal Temperature

Temperature of the negative terminal of each VRLA cell should not be greater than 5° F (3° C) above ambient in a free standing condition.

Specific Gravity

The temperature corrected electrolyte specific gravity should be determined for each vented lead acid cell at full charge to verify that the cells contain the correct concentration of sulfuric acid specified by the battery manufacturer for the cell type and model. Most vented lead acid battery manufacturers specify that the electrolyte may range ±.010 points within a battery for any of the nominal values at 77° F (25° C) with the electrolyte level at the manufacturer's recommended reference point. For the purposes of cell selection criteria during an acceptance inspection and test of a new vented lead acid battery, the author prefers a range of ±.005 points of the nominal value at 77° F (25° C) with the electrolyte level at the manufacturer's recommended reference point

The electrolyte specific gravity for nickel cadmium cells should also be measured during the acceptance inspection and test to verify that the concentration of potassium hydroxide meets the battery manufacturer's specification. This measurement is performed strictly as a quality verification and is not a measurement of the cells' state of charge. It is important to note that specific gravity measurement on a nickel cadmium cell must be performed with a hydrometer that is used strictly for potassium hydroxide. A hydrometer that is used for lead acid cells should **never** be used on nickel cadmium cells.

Cell Voltage and Reference Electrode Measurements

Vented lead acid and VRLA cells that make up a battery that will be operated in float service should have a small variance in individual cell voltages at float voltage. Cells that are selected for a battery should have a voltage variance of no more than ±.04 volts from the per cell average on float charge. Closely matched cell voltages will help optimize the life and performance capability of a lead acid batteries in float service.

Another method to identify vented lead acid cells that have closely matched voltages is to perform reference electrode measurements using a mercury mercurous sulfate (MMS) reference electrode. In this case it is important to match positive plate potentials. In a lead acid cell, the positive plates are required to be properly polarized. Under-potential of the positive plates will accelerate grid corrosion which results in grid growth. Negatives plate potential of vented lead acid cells, particularly lead calcium technology is not as much of a concern because the negative plates of a lead acid cell have more capacity than the positive plates and recharge more efficiently. However , reference electrode measurements can identify cells that may have over-polarized negative plates caused by improper de-polarization during manufacturing. This will also show up as a high voltage cell on float charge when performing individual cell measurements. Cells left in this condition and placed into float service with other cells in a battery will unbalance the battery in terms of cell voltages. Cells in the battery that are "robbed" of voltage as a result of the higher voltage cells could eventually sulfate and short out. The battery manufacturer should be consulted for the expected positive and negative plate over-potential at float potential for the particular cell type and design.

Cell voltage criteria for nickel cadmium cells is not quite as critical as it is for lead acid cells. For example, over-potential of a nickel cadmium cell will not promote grid corrosion as in a lead acid cell and accelerate the life the cell. It can however, increase water consumption which may be categorized as more of a maintenance issue. It is generally accepted that nickel cadmium cell voltages should be > 1.35 volts at float charge. Reference electrode measurements of nickel cadmium cells during an acceptance inspection and test does not add any real value. This type of measurement would be reserved for diagnostics or troubleshooting of a failed cell. It is important to note that reference electrode measurements on nickel cadmium cells **should not** be performed with MMS reference electrodes. Instead, a material that is inert to the system such as a zinc reference electrode should be used.

Cell/Jar Internal Ohmic Test

An internal ohmic test of each cell using either impedance, conductance or resistance measurement techniques is an optional test that can provide additional data on cell condition. This data can help in the selection process of the cells that will make up the battery. Internal ohmic tests can verify the conduction path of the entire battery. For vented lead acid and VRLA cells internal ohmic tests have proven useful since it has been demonstrated that cell impedance increases as capacity decreases. For VRLA cells this test is even more useful since visual inspection of the internals such as the plates and the internal conduction path is not possible. For an acceptance inspection and test of a new stationary battery internal ohmic test can identify cells that may have a higher than normal or average internal impedance. Higher impedance cells may not be as compatible with cells of lower impedance in a battery string and may experience a failure or loss of capacity sooner than the other cells. The battery end user representative may want to consider not selecting a cell that exhibits this condition. If an internal ohmic test is performed as part of the acceptance inspection and test, the author suggests that any cell ohmic value in excess of 20% from the average or the battery manufacturer's expected value of the cells being tested at full charge be brought to the battery manufacturer's attention for further review and possible rejection.

Capacity Load Test (ANSI/IEEE Acceptance Test)

The capacity load test is performed to determine if the battery meets the manufacturer's published rating. The test should meet a specific discharge rate and duration relating to the battery manufacturer's rating and to the procurement specification requirements. All cells selected to make up the battery should meet the procurement specification capacity requirements for each cell. The following criteria should be used when selecting cells based on results of the capacity load test:

- Individual cell capacity meets or exceeds the procurement specification requirements.
- Variance in individual cell voltages at end of discharge should be minimal.

POST INSPECTION AND TEST REVIEW

The cells selected based on the acceptance inspection and test should be put on charge immediately following the capacity load test. The battery end user representative should confirm with the battery manufacturer the recharge methodology that will be used to assure that the selected cells are returned to a full state of charge prior to shipping. Also, the battery end user representative should confirm with the battery manufacturer any special shipping requirements for the battery.

All battery accessories that are part of the procurement specification requirements and are to be shipped with the battery should be verified. This may include cell numbers, hydrometers, thermometers, additional flame arresters, inter-cell connectors and hardware, installation and operating manuals, and any installation tools that may have been specified to be provided by the battery manufacturer.

CONCLUSION

The acceptance inspection and test should be performed on a new stationary battery to insure compliance with the procurement specification requirements and to protect the battery end user's investment. The proper performance of this inspection and test provides added assurance that the battery being placed into service will be in optimum condition and will perform as expected. Together with proper selection and sizing, application, installation, environmental conditions, and routine maintenance and testing, performance of an acceptance inspection and test will help the battery end user achieve expected performance and life their stationary battery.

REFERENCES

ANSI/IEEE Std 450-1995, Recommended Practice for Maintenance, Testing and Replacement of Vented Lead Acid Batteries for Stationary Applications.

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