



EAGLE EYE WHITE PAPER

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Overview

A properly implemented maintenance program will aid in prolonging battery life, prevent avoidable battery failures, reduce premature battery replacement, ensure that the battery systems is charged properly at full capacity and deliver it the stored energy to the load when required. Eagle Eye's maintenance procedures are based on the recommendations issued by the specific battery manufacturer and the following applicable IEEE (Institute of Electrical and Electronics Engineers) standards.

- IEEE Standard 450-2010 – *Recommended Practice for Maintenance, Testing and Replacement of Vented Lead-Acid (VLA) Batteries for Stationary Applications.*
- IEEE Standard 1106-2005, *Recommended Practice for Maintenance, Testing and Replacement of Vented Nickel Cadmium Batteries for Stationary Applications.*
- IEEE Standard 1188-2005 - *Recommended Practice for Maintenance, Testing and Replacement of Valve-Regulated Lead-Acid (VRLA) Batteries for Stationary Applications.* Accompanied by IEEE Standard 1188a-2014. *Amendment 1 – Updated VRLA Maintenance Considerations.*

The IEEE Standards provide recommended practices and schedule for maintenance and testing, as well as guidance for determining when batteries should be replaced. According to the standards, battery systems under normal float charge conditions should receive a general inspection at least once per month with more in-depth inspections occurring on a quarterly and annual basis. According to the standards, it is recommended that VLA (flooded) batteries be capacity tested within the first two years of service, with additional testing to take place every 5 years (This is more frequent for VRLA batteries). When the battery shows signs of degradation (decrease in 10% from last test) or is below 90% of the manufacturers rated capacity it is recommended that the batteries be capacity tested annually. Once the battery capacity is determined to be less than 80%, it is recommended that the battery be replaced since at this capacity, the rate of deterioration is increasing even though there may be ample capacity to meet the existing load requirements.

While the IEEE Standards reflect the ideal level of maintenance, Eagle Eye recognizes that battery users may have more stringent or less strict requirements and these can be accommodated and if necessary, a custom maintenance procedure can be written.

In addition, Eagle Eye offers battery monitoring and testing equipment that can assist and automate many of the requirements for battery maintenance.

Scope of Work – Vented Lead-Acid (VLA) Batteries

Monthly Inspections

1. Using a calibrated and properly rated meter, measure and record the DC float voltage and current at the battery terminals.
2. Record the battery charger output current and voltage readings.
3. Measure and record the pilot cell(s) if used, voltage and electrolyte temperature.
4. Visually inspect all cells for the proper electrolyte level and add deionized water as needed. Record any abnormalities.
5. Visually inspect battery jars for cracks or evidence of electrolyte leakage. Record abnormalities and take corrective actions as needed.
6. Visually inspect for any evidence of corrosion at the terminals, connectors, racks or cabinets. Record abnormalities and take corrective actions as needed.
7. Measure and record ambient temperature.
8. Check for any unintentional battery grounds.
9. Clean all battery surfaces of foreign material.
10. Check the battery room/building for proper operating ventilation, HVAC and lighting. Ensure that there is unobstructed access and egress path around the battery. Check for proper operating safety equipment (i.e. eye wash, spill containment, etc.). Record any abnormalities.
11. Verify battery-monitoring systems are operational (if installed).

Quarterly Inspections

At least once per quarter, a monthly inspection will be augmented as follows:

1. Measure and record all cell voltages
2. In the case of a lead-antimony battery, measure and record the specific gravity of 10% of the cells and float charging current.
3. For chemistries other than lead-antimony and where float current is not used to monitor the state of charge, measure and record the specific gravity 10% or more of the battery cells.
4. Where ohmic measurements are being employed as a trending tool, measure and record the internal ohmic value of each cell/unit.
5. Measure the electrolyte temperature of 10% or more of the battery cells.

Annual Inspections

At least once per year, the quarterly inspection will be augmented as follows:

1. In the case of a lead-antimony battery, measure and record specific gravity and electrolyte temperature of all cells.
2. For chemistries other than lead-antimony, and where float current is not used to monitor the state of charge, measure and record the specific gravity of all the battery cells.
3. Carry out a detailed visual inspection of each cell.
4. Measure and record cell-to-cell and terminal connection resistance. (If the resistance value is more than 20% above the established baseline value or string average, the connection should be disassembled, cleaned, reconnected, and re-tested.)
5. Inspect and verify the structural integrity of the battery rack or cabinet

Scope of Work – VRLA Battery Inspections

Monthly Inspections

1. Using a calibrated and properly rated meter, measure and record the DC float voltage and current at the battery terminals. If multiple strings involved, record the float current for each string.
2. Measure and record the battery charger output current and voltage readings at the charger output.
3. Visually inspect all cells/units for evidence of corrosion at terminals, inter-cell connectors, case seals and pressure relief valves.
4. Visually inspect cell/unit cover integrity and check for cracks in the cell/unit or leakage of electrolyte.
5. Visually inspect cell/unit for excessive jar or cover distortion.
6. Measure and record ambient temperature.
7. Check for any unintentional battery grounds.
8. Clean all battery surfaces of foreign material.
9. Check the battery room/building for proper operating ventilation, HVAC and lighting. Ensure unobstructed egress path around the battery. Check for proper operating safety equipment (i.e. eye wash, spill containment, etc.). Record any abnormalities.
10. Verify battery-monitoring systems are operational (if installed).

Quarterly Inspections

At least once per quarter, a monthly inspection will be augmented as follows:

1. Measure and record all cell/unit voltages.
2. Measure and record cell/unit internal ohmic values.
3. Measure and record the temperature of the negative terminal of each cell/unit.

Annual Inspections

At least once per year, the quarterly inspection will be augmented as follows:

1. Measure and record cell to cell and terminal connection resistance. If the resistance value is more than 20% above the baseline value, or string average, the connection should be disassembled, cleaned, reconnected, retorqued and re-tested.
2. Measure and record the AC ripple current and/or voltage imposed on the battery.

Scope of Work – Nickel Cadmium Cells

Monthly Inspections

1. Using a calibrated and properly rated meter, measure and record the DC float voltage and current at the battery terminals.
2. Record the battery charger output current and voltage readings.
3. Visually inspect cell/unit for evidence of corrosion at terminals, connections, racks, or cabinets.
4. Visually inspect cell/unit cover integrity and check for cracks in the cell/unit or leakage of electrolyte.
5. Visually inspect all cells for the proper electrolyte level and add de-ionized water as needed. Record any abnormalities.
6. Measure and record pilot cell electrolyte temperature.
7. Measure and record ambient temperature.
8. Check for any unintentional battery grounds.
9. Clean all battery surfaces of foreign material.
10. Check the battery room/building for proper operating ventilation, HVAC and lighting. Ensure unobstructed egress path around the battery. Check for proper operating safety equipment (i.e. eye wash, spill containment, etc.). Record any abnormalities.
11. Verify battery-monitoring systems are operational (if installed).

Semiannual Inspections

At least once every 6 months, a monthly inspection will be augmented as follows:

1. Measure and record all cell voltages.

Annual Inspections

At least once per year, the semiannual inspection will be augmented as follows:

1. Check and record the Inter-cell connection torque
2. Verify the integrity of the battery rack.
3. Check the condition and resistance of all inter-cell, inter-tier and take off connections. If any anomalies occur, disassemble the connection, clean and retorque.

Capacity Testing

A battery capacity test will consist of a controlled current discharge of the battery systems in order to determine the capacity at the rate determined by the load reserve time requirements or at the manufacturer's claimed performance rate for a specified time. The discharge current will be maintained within +/- 1% until the battery voltage measured at the battery terminals equals an average of the required low voltage limit. (For example, 60 cells x 1.75V = 105VDC battery terminal voltage)

A battery capacity test system will be used to conduct the discharge test. The test system consists of a micro-processor controller and a variable resistive load bank which is programmed for a constant current discharge. Alarm circuits will warn the operator of a performance problem or automatically shut-down the test. A data-logger built into the system will monitor and record the following parameters before, during and immediately after the test:

- Overall Battery voltage
- Individual cell voltages
- Current
- Time
- Battery and ambient temperature

The data acquired by the test is then analyzed to determine the measured ampere-hour or wattage capacity of the battery system and to determine the integrity of the inter-cell connections. The measured capacity of the battery system will be corrected for temperature and compared to the manufacturer's published performance data.

An auxiliary battery system can be provided (max. 250VDC) in order to support load equipment while the battery under test is off-line.

Reporting

Eagle Eye can issue reports of the findings of each inspection and/or capacity test. The report will provide a summary of all findings for each system as well as the supporting data. Any recommended corrective actions will be detailed/