WHITE PAPER

UPS Battery Monitoring and Maintenance

The Preferred Back up Method

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Preface

Interxion customer feedback indicates that the Co-Location industry is now the preferred choice of organizations looking for a provider with the mission critical infrastructure to host their vital applications. More specifically, customers are looking for a provider that is hardware, software, and network vendor-neutral. Cloud and Carrier neutral Co-Location offers the broadest range of connectivity solutions as well as access to a marketplace of both traditional and cloud-based IT service providers. These offerings are scarce in Corporate or Cloud Data Centres.

As one of the leading Co-Location providers, Interxion has gained much experience fulfilling customer requirements. As a result, it has become clear that potential Interxion customers who want to entrust their mission critical IT loads to a Co-Location provider, prefer the Static UPS battery as their backup system.

One of the reasons customers prefer Static UPS battery backup systems is that they provide the best autonomy time. This aspect is vital to supporting critical loads during mains failure. They also help to reduce the risk of Genset emergency supply start failure that could potentially lead to loss of load and customers.

While Static UPS Battery backup systems provides essential protection against power losses that would interfere with workloads, disrupt service to customers, and potentially damage an organization's reputation, they require constant monitoring and timely servicing. This whitepaper provides information on how to implement battery monitoring, testing, and maintenance schedules that can help predict premature UPS Battery failure, extend expected service life, and maintain UPS Battery performance.

Lex Coors.

1 Introduction

The Data Centre UPS provides clean power and protection of the attached load by utilising the power stored in the battery. Any interruption that exceeds the acceptable input window or drop out of the mains, the UPS will immediately transfer to battery operation to ensure the proper power quality to the load. Examples of improper quality are: instability of the mains frequency, harmonic distortion, voltage highs/lows and disturbances such as a high-frequency transients or oscillations.

A battery connected to a UPS is both a crucial operational element and a vulnerable part of the system. In fact, battery failure is a leading cause of load losses. Data centre personnel must carefully monitor the battery state to maintain and manage UPS batteries – particularly for the preventive ambition of detecting issues before they escalate into potential incidents that may result in service disruptions. These disruptions may in their simplest form lead to either momentary or complete loss of power that causes data loss of the IT load connected, undermining the business continuity.

The purpose of this document is to provide information on how to implement battery monitoring, testing, and maintenance schedules that can help predict premature UPS Battery failure, extend expected service life, and maintain UPS Battery performance

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2 Battery Monitoring

2.1 Battery Design Life versus actual Service Life

UPS Batteries have a limited life, usually displaying a slow degradation of capacity until they reach 80 percent of their initial rating, followed by a comparatively rapid failure.

Minimum service life for a battery is around five years or 80% capacity of its initial rating. 80% capacity is the threshold point where the battery is considered to be the End of Life (EOL) and after which the batteries rapidly fails. Water cannot be added to a VRLA battery. Oxygen escapes from the positive plate and disperses to the negative plate, forming water. This recombination process is a critical element to health of this type of battery.

Determining battery life is not an exact science and is often incorrectly based on how long the battery is expected to last under perfect conditions. Regardless of the size or type of UPS deployment, there are four primary factors that affect UPS battery life: ambient temperature, battery chemistry, charging and poor maintenance as described in the sections below

2.1.1 Ambient Temperature

Excessive battery room temperature is a general problem for all kinds of batteries and especially for UPS batteries with high internal power loss. The higher the temperature, the higher the float current will be at a given voltage. The increased current leads to increased power losses, when the internal temperature in the battery rises above the ambient temperature. The greater the rise in internal temperature, the greater the power losses and the greater the difference between an internal temperature and ambient temperature. This phenomenon leads to an unexpectedly short life and in rare situations also thermal runaway.

2.1.2 Battery Chemistry

The electrochemical nature of UPS batteries causes them to lose the ability to store and deliver power slowly over time. Even with appropriate storage, usage, and maintenance, batteries still require replacement.

2.1.3 Charging

At installation, the battery is at 100% of the rated capacity. Each time the battery discharges and recharges due to utility power failure or some other power loss event, it loses a percentage of its capacity. The length of the discharge cycle determines the reduction in battery capacity. Once the battery reaches its maximum number of discharge and recharge cycles, the battery will fail and must be replaced

2.1.4 How Charging is controlled by the UPS

Currently, UPS systems utilize a current-voltage charging method where the UPS reverts to float charging when the battery is full. However, if the float voltage is too high, it will accelerate the corrosion of the positive side of the battery. If the float voltage is too low, the battery will slowly discharge.

When an already fully charged battery is subjected to float voltage for long periods of time, it may result in the steady degradation of the positive which can substantially reduce battery life.

2.1.5 Depth of Discharges

The depth of discharge is also harmful to UPS batteries. If the depth of discharge frequently exceeds more than 80% the number of cycles (discharge-charge) the battery can withstand is greatly reduced.

The average lifetime of a UPS battery is 1200 cycles, but should not be discharged to more than 70% of its capacity to maintain 1200 cycles. Going beyond the 80% depth of discharge reduces the number of cycles exponentially.

2.1.6 Size of Ripple on the Charging Current from the UPS

The ripple current is the periodic residual variation of the DC output on the Power Factor Corrected (PFC) /Input stage on the UPS, derived from the AC input current on the UPS. This ripple occurs due to incomplete suppression of the AC waveform from the input. The ripple current is damaging to the life of any battery because it charges/discharges the battery. Ripple currents higher than 5Arms/100 Ah or five percent (5%), will speed up the corrosion in the positive. This action in turn raises the internal resistance of the block that leads to an increase battery temperature as a result of internal power loss.

2.2 Things that can go wrong with UPS Batteries

The table below provides a list of possible UPS battery conditions and their related causes.

Plate Separation:	Repeated cycling (charging and discharging), damage during handling and shipping, and overcharging
Grid Corrosion:	Normal aging, operating in an acidic environment and high temperatures
Internal Short Circuit:	Grid corrosion, heat causing the plates to expand touching each other, break-down of the separator, incorrect handling
External Short Circuit:	Human error (shorting terminals) and leaks
Sulfation of Plates:	Sitting discharged for an extended period, not on charge or being under-charged
Excessive Gassing:	Often due to high temperatures or overcharging
Drying Out:	High ambient temperatures or block temperatures due to overcharging, which leads to excessive gassing,

2.3 Inadequate Maintenance

VRLA batteries are often referred to as maintenance free. However, this only implies that they do not require liquid in the form of water. Without regular monitoring and maintenance UPS battery systems may experience:

- Inadequate connection at the block terminals leading to high resistance, which eventually will generator heat
- Uneven/unbalanced loading among blocks and/or strings
- Premature Failure

2.4 Battery Maintenance, Monitoring, and Capacity Testing

Quantifying the combined effect of the factors that affect battery life discussed is difficult. We need a way to determine when a battery is near the end of its useful life so it can be replaced while it still works and before the critical load is left unprotected.

Battery testing and maintenance are critical to UPS reliability. A gradual decrease in battery life can be monitored and evaluated through voltage checks, load testing or monitoring. Periodic preventive maintenance extends battery string life by preventing loose connections, removing corrosion and identifying bad batteries before they can affect the rest of the string. Sealed batteries are sometimes referred to as maintenance-free. However, they still require scheduled maintenance and service and without it, your UPS battery may experience heat-generating resistance at the terminals, improper loading, reduced protection that leads to premature failure.

While battery monitoring and maintenance provide good spot check feedback, the only sure way to determine battery capacity is to perform a battery run-down test. The module is taken offline, connected to a load bank and operated at rated power until the specified runtime elapses, or the unit shuts down due to low battery voltage. If battery capacity is less than 80 percent of its rated capacity, battery replacement is strongly recommended.

2.4.1 Automated Battery Capacity Testing

An automated process utilised for observing, verifying and retaining a continuous record of the battery condition and makes capacity testing easier. The record obtained from the automated testing allows the Data Centre personnel to forecast the trend of the battery performance. Some UPS manufacturers do offer their UPS' with sophisticated automated capacity testing of the connected battery system. Users that have adopted the automated process can simply enter the actual battery data and testing parameters and let technology do the rest. This method offers minimum invasion and downtime that could potentially disrupt service to the IT load.

2.4.2 Manual Battery Capacity testing

The manual battery capacity testing applies to those Data Centres that have batteries installed without the automated process performed by the UPS. While more time consuming than automated testing, the manual testing process ensures that installed UPS battery systems function as designed and allows for replacement of battery blocks before actual failure occurs.

Applying either an automated process via UPS built-in functions or the manual process for all UPS batteries will assist in predicting the batteries EOL and your decision process on when to replace batteries.

2.5 Battery Test Schedules

2.5.1 Prior to putting into service

Prior to putting a battery system into service, an acceptance test should be used to determine whether the battery meets its designed performance.

The test must meet the specific discharge performance and autonomy time relating to the design specification requirements. All inspections must be completed before performing an on-site acceptance test. Batteries may have less than rated capacity when delivered. The initial capacity of every cell upon delivery should be at no less than 100% of rated capacity. An acceptance test should also establish the baseline capacity for trending purposes whenever automated or manual test procedures are applied.

2.5.2 After putting into service

After the batteries have been commissioned, they must undergo periodic performance testing. When establishing the interval between tests, factors such as design life and operating temperature should be considered. We recommend that the performance test interval should not be greater than 25% of the expected service life or two years, whichever is less. However, the UPS incorporated automated battery monitoring function offers an ease of testing and can be activated to run more often. Increasing the frequency, provides sufficient sample rates to obtain enough data for trending purposes.

The actual service life of a UPS battery may be significantly less than the expected design life. The recommended interval assumes that an on-site acceptance test was performed with acceptable results. Acceptable results are defined as the capacity of each cell exceeding 90%, and the capacity of all cells are within 10% of the average cell performance.

Annual performance tests of battery capacity should occur on any battery that shows signs of degradation or has reached 85% of the service life expected for the application. Degradation occurs when the battery capacity drops more than 10% from its capacity on the previous performance test or is below 90% of the manufacturer's rating.

UPS batteries are potentially dangerous and precautions must be taken during handling and installation. The safety precautions listed below are mandatory and should be followed in all battery installation and maintenance activities. Work on batteries requires proper safety tools plus protective equipment, a number of safety precautions and procedures, but should, in general, be performed only by trained and business knowledgeable personnel.

The recommended minimum safety equipment that must be available to protect personnel while handling UPS batteries:

1. Safety glasses with side shields, goggles, or face shields, as appropriate.
2. Electrically insulated gloves, appropriate for the installation
3. Protective aprons and safety shoes
4. Portable or stationary water facilities in the battery vicinity for rinsing eyes and skin in case of contact with acid electrolyte
5. Class C fire extinguisher. Note that some manufacturers do not recommend the use of CO_2 fire extinguishers due to the potential for thermal shock
6. Acid neutralizing agent
7. Adequately insulated tools
8. Lifting devices of adequate capacity, when required

The protective procedures outlined below should be followed:

1. Use caution when working on batteries because they present a shock and arcing hazard
2. Check the voltage to ground (ac and dc) before working around the battery. If the voltage is other than anticipated, or is considered to be in an unsafe range, do not work on the battery until the situation is understood and/or corrected. Wear protective equipment suitable for the voltage
3. Prohibit smoking and open flame, and avoid arcing in the immediate vicinity of the battery
4. Provide adequate ventilation, and follow the manufacturer's recommendations during charging
5. Ensure unobstructed egress from the battery work area
6. Avoid the wearing of metallic objects such as jewellery while working on the battery
7. Ensure that work area is suitably illuminated

8. Follow the manufacturer’s recommendations regarding cell orientation
9. Follow the manufacturer’s instructions regarding lifting and handling of cells

The safety procedures outlined below should be followed:

1. Restrict all unauthorized personnel from the battery area
2. Keep the battery clear of all tools and other foreign objects
3. Avoid static build up by having personnel contact ground periodically while working on batteries
4. Do not remove the pressure relief valves without the battery manufacturer’s approval
5. Inspect and test instrumentation for safe working condition

3 Maintenance

3.1 General

A good battery maintenance program supported by automatic battery monitoring or manual testing helps to determine the need for battery replacement. Battery maintenance should be performed by personnel who have knowledge and experience with UPS batteries and their related safety precautions.

3.2 Inspection

When possible, all inspections should be made under normal float conditions. Readings should be taken in accordance with the manufacturer's instructions. Measurements and observations should be recorded for future comparisons. A general inspection should include a check and record of the following:

1. Overall float voltage measured at the battery terminals
2. Charger output current and voltage
3. Voltage of each cell
4. Ambient temperature
5. Calibration of the battery temperature sensor, which is used to control the float voltage of the UPS
6. The condition of ventilation and monitoring equipment
7. Cell-to-cell and terminal connection detail resistance of entire battery
8. AC ripple current and/or voltage imposed on the battery and consult the manufacturer
9. Visual individual cell/unit condition check to include
    a. Cell/unit integrity for evidence of corrosion at terminals, connections, racks, or cabinet
    b. General appearance and cleanliness of the battery, the battery rack or cabinet, and battery area, including accessibility
    c. Cover integrity and check for cracks in cell/unit or leakage of electrolyte
    d. Excessive jar/cover distortion
10. DC float currents (per string). This should be measured using equipment that is accurate at low(typically less than 1 A) current

4 Battery Replacement Criteria

- The recommended practice is to replace a cell/unit or the battery if its capacity is below 80% of the manufacturer's rating. The timing of the replacement is a function of the sizing criteria used and the capacity margin available, as compared with the design requirements.
- A capacity of 80% shows that the cell/unit/battery rate of deterioration is increasing even if there is sufficient capacity to meet the load requirements of the system.
- Physical characteristics, such as abnormally high cell/unit temperatures are often determinants for complete battery or individual cell/unit replacements.
- Replacement cell/units shall have electrical characteristics compatible with existing cell/units. Individual replacement cells or units are not usually recommended as the battery nears its end of life.
- The vendor recommendations regarding the maximum percentage of units (cells or monoblocs) within one string is an average of max 25% (depends on type and topology) within half of expected service life. If the battery is older the whole string should be replaced.

5 Records

- Data should be recorded at the time of installation and as specified during each inspection. Data records should also contain reports on corrective actions and the results of all tests.
- Correct interpretation of data obtained from inspection, corrective actions, and tests are important to the operation and life of the batteries.