UPS WITH A BATTERY SYSTEM 101. EDUCATION FOR THE END USER: HELP IS ON THE WAY!

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ABSTRACT

Generally a 10 kva to 250 kva Uninterruptable Power Supply (UPS) system is designed to provide a controlled, conditioned and regulated AC output power to a load as well as providing a specific amount of battery runtime during a utility failure. These UPS's are typically used for emergency lighting, life safety, data centers, telephone rooms and audio / visual equipment. Valve regulated lead acid (VRLA) batteries are typically specified for these applications, however vented lead acid (VLA) or nickel cadmium (NiCad) batteries have been specified by the end user as well.

Traditionally some of the main problems that occur on a UPS with a battery system is that it has been improperly installed, undersized for the application, incorrect testing during commissioning (or worse not tested at all), and not given any maintenance or testing after the UPS with a battery system has been placed into service. This paper's intent is to educate the end user and provide recommendations on how to properly size, install, commission test and maintain your UPS with a battery system.

THE FUNDAMENTALS ON SELECTING A UPS WITH A BATTERY SYSTEM

Generally when an end user decides it is time for a UPS with a battery system, the basic questions are asked:

- What AC voltage is required (input / output)?
- What is the present load (AC amps)?
- What will the growth be in five – ten years (AC amps)?
- How much runtime should the batteries provide during a utility failure?
- What are the dimensions of the UPS and battery system?

At this point an end user can refer to a sales literature sheet and select a UPS and battery system. Typically a UPS with a battery system is specified at 100 % load of the UPS with a 15 minute VRLA battery runtime. If an end user decides on VLA or a NiCad battery system, a telephone call is typically placed to the UPS manufacturer for battery runtime details.

EDUCATION

The above questions are the basics on selecting a UPS with battery system, however there are many factors to consider. The most common topology of a UPS with a battery system is the dual conversion technology with a line up and match battery cabinet with VRLA batteries. The following outline will help educate the end user on what should be expected, documented and performed when sizing, planning, installing, starting-up, commission testing, maintaining your UPS with a VRLA, VLA or NiCad battery system.

The advantages of different types of battery charging, the five 9 reliability, TVSS (transient voltage surge suppression), an external wrap around bypass, generator back-up, dual inputs, connectivity, UPS and battery redundancy, battery monitoring, battery alloys, battery terminal positions, etc can be presented in a future presentation

SIZING

Sizing for your UPS with a battery system can be simple if the right questions are asked. The most important part is to not undersize or oversize your system and to create a budget that everyone can agree upon. The following is a suggestive list of questions that should be asked and documented.

The following IEEE document can be used for an additional reference:

IEEE Standard 1184 "*IEEE Guide for Batteries for Uninterruptible Power Supply Systems*"

- What AC voltage is required (input / output)?
- What is our present load (AC amps)?
- What will our growth be in five – ten years (AC amps)?
- How much runtime should the batteries provide during a utility failure?
- What are the dimensions of the UPS and a 15 minute VRLA battery system?
- Does this application require VLA or NiCad's?
  - Who will be installing the VLA or NiCad's?
    - Typically, VLA / NiCad installation is a special project and the UPS manufacturer will provide the installation of the racking, spill containment and battery installation.
  - What type of spill containment is needed?
    - VLA batteries require a different type of neutralizing agent than NiCad batteries.
  - How many racks with how many tiers are needed?
  - Can the batteries be in the same room?
    - What wire size is needed between the UPS and battery system?
  - How many hydrogen sensors should be installed?
  - How many eye wash stations need to be provided?
  - Over current protection:
    - What fuse / breaker size is needed?
    - What are the dimensions?
    - Where will this be located?
- What will our budget allow?
- How much revenue and / or productivity will be lost if there is a failure?
- Are there any structural improvements needed for the UPS and battery system?
- Is the UPS and battery system upgradeable?
  - Can we increase the UPS's output in the field
  - Is space available to increase our battery system
- Heating / Cooling / Air flow
  - What will the BTU's (British Thermal Units) of the UPS with a battery system be in all modes of operation?
  - What is necessary to keep the room(s) where the UPS and a battery system to the manufacturer's optimum operating range?

PRE-INSTALLATION PLANNING

After an end user has determined the size of their UPS and the type of battery system needed, the next step is to understand the environment where the UPS with the battery system is going to be installed. Considerations includes inside delivery, unloading, entry access, weight considerations and moving the equipment into the final resting place. The most important part is to not have complications during delivery and not have another attempt on a second delivery due to communication issues. The UPS and battery manufacturer's operating and installation manual should always be followed. The following is a list of considerations that should documented.

- Unloading:
  - How long will it take to unload all pieces of equipment?
  - How long will the dock be occupied?
    - Generally, in urban areas, there is a 15 – 30 minute window where a vehicle can be parked during normal business hours.
- Where can all the pieces of equipment be stored, when the installation area is not available?
  - If this is a new construction site, the equipment may sit for a day to a week or even longer.
- What type of loading dock and equipment is available?
  - Is the dock ground level?
  - Is the dock standard dock height?
  - Is an adjustable dock available?
  - Does the dock have a fork lift available?
  - Does the dock have pallet jacks available?

- What capacity is the freight elevator?
  - The battery cabinet or battery pallets may need to be broken down due to the weight.
- What times can the freight elevator be occupied for an extended amount of time?
  - The freight elevator may be reserved to off - hours operation, due to building policies.
- What type of floor protection is needed between the loading lock and the final resting place?
- Is this a high security area?
  - The end user may be able to provide a temporary clearance badge for the installers during the installation.
- What obstructions may need to be removed between the loading dock and the final resting place?
- What are the local building codes for VRLA, VLA and NiCad installations?
- What are the environmental conditions where the UPS and battery system are to be installed?
  - What type of construction will be performed during and after the UPS and the battery system is in position?
  - New construction site:
    - Will the HVAC (Heating Ventilating and Air Conditioning) system be commissioned prior to the UPS and battery system installation?
- What is the manufacturer's specification clearance for a UPS with a line up and match battery cabinet or a VLA / NiCad racking and tier spacing.
- EPO (Emergency or Equipment Power Off) device?
  - What are the local building codes?
  - Do the UPS and / or battery system require a normally open, normally closed contactor or a relay device?
  - What additional items are needed to integrate the UPS and battery system to the EPO device?

INSTALLATION

After the pre-installation planning is complete, the installation of the UPS and battery system should be effortless. Generally, an electrical contractor is hired to position the UPS with the battery cabinet and install all of the AC and DC electrical wiring as well as submitting an Installation Checklist form to the UPS manufacturer. The UPS manufacturer's Technical Support team is always available to answer any questions that the end user and / or electrical contractor will have during the installation. If the application requires VLA / NiCad installation, typically the UPS manufacturer will provide the installation of the racks, spill containment and battery installation. The manufacturer's operating and installation manual should be followed, in addition, the following IEEE documents can be used for additional references:

IEEE Standard 484, "*IEEE Recommended Practice for Installation Design and Installation of Vented Lead – Acid Batteries for Stationary Applications*"

IEEE Standard 1106, "*IEEE Recommended Practice for Installation, Maintenance, Testing and Replacement of Vented Nickel-Cadmium Batteries for Stationary Applications*"

IEEE Standard 1187, "*IEEE Recommended Practice for Installation Design and Installation of Valve-Regulated Lead-Acid Batteries for Stationary Applications*"

IEEE Standard 1657, "*IEEE Recommended Practice for Personnel Qualifications for Installation and Maintenance of Stationary Batteries*"

The following is a suggestive list that should verified during the UPS and battery system installation.

- Is there any damage to the UPS and / or batteries, and is there any electrolyte leakage?
- Is there sufficient clearance for future UPS and battery maintenance or replacement?
- Wire size & protection devices for the following, per the manufacturer's specifications:
  - AC input fuses / breaker sizes.
  - AC output fuses / breaker sizes.
  - DC fuses / breaker sizes.
- AC and DC wire sizes:
  - AC phase wire size, AC neutral wire size (if applicable) and ground wire size.
  - DC wire size (positive and negative) and ground wire size.
  - Emergency or Equipment Power Off (EPO) operation on the UPS and battery system.
    - What type of device is being installed?

START UP

UPS with a 15 minute battery cabinet installation:

After the electrical installation is complete and an Installation Checklist is accepted, a Start-Up date is scheduled. Generally the scope or work for the UPS Field Service Engineer is the following:

- Verify all the electrical wiring is terminated properly and there are no loose connections.
- Remove all shipping materials inside the battery cabinet.
- Verify the UPS and battery system internal electrical wiring did not loosen during transit.
- Record the wire size and protection devices.
- Verify/Record that the AC input voltage and phase rotation is correct.
- Verify/Record that the DC voltage and polarity from the battery cabinet to the UPS is correct.
- Start the UPS.
- Verify/Record that the display voltage and current values are equal to the actual measured values.
- Verify/Record all settings and calibrations.
- Test the UPS in all modes of operation.
- Clean the UPS, battery and cabinet.

UPS with a VLA / NiCad installation:

The following items are added to the scope of work:

- Verify all shipping caps / transport seals are removed and flame arrestors are installed.
- Verify that all connections are at the proper tightness.
- Verify all electrolyte levels are not below the minimum line.
- Initial charge / Commissioning charge.
  - The available charging amperage varies depending on the size of the UPS.
- Clean the UPS, battery and racks.

After the Start-Up is complete and the batteries are fully charged (increase the water levels as need for VLA / NiCad batteries), data collection is used to eliminate any early problems and this also creates a baseline for tending and predictive analysis on the battery system. The following is a general list of items that is recorded:

- Total battery voltage (VDC)
- Float current (IDC)
- Ripple Voltage (VAC)
- Ripple Current (IAC)
- Individual voltages (VDC)
  - Monoblock voltages for VRLA's
  - Cell voltages for VLA / NiCad's
- Ambient room temperature.
- Ohmic measurements for VRLA Monoblocks and VLA cells.
- Electrolyte temperatures for VLA and NiCad cells.
- Jar and Negative post temperatures for Monoblocks.
- Specific Gravities for VLA cells.
- Amount of deionized or distilled water that is added.
- UPS load current (IAC) for all 3 phases.
  - A balanced inverter decreases AC Ripple Voltage and Current as well as providing an accurate load percentage.

COMMISSION TESTING

Commission Testing is the best customer acceptance test that can be preformed once the UPS and the battery system has been Installed, Started-Up and the batteries are fully charged. Typically the commission test involves an AC load bank (in a well ventilated area) connected to the UPS output and there are a series of functional performance tests on the UPS and battery system. The following should be considered for testing equipment as well as functional performance tests.

Test Equipment (that has been calibrated in the last 12 months):

- Digital Multimeter (DMM) for voltages and frequency.
- AC / DC current clamp.
- Power monitoring recording device for the following:
  - AC input / output.
    - Voltage, current and frequency waveform capturing.
  - DC voltage and current.
- Thermal scanner (capable of image capturing)

Functional Performance Testing:

- EPO activation.
  - For safety reasons, The EPO activation needs to be verified FIRST!, this will completely de-activate the UPS and battery system in case of an emergency.
- Burn-in test:
  - A burn-in is a test where the UPS system has a 100% load for a specific amount of time. (For example, a 250 kva UPS has an output (inverter) load of 250kVA). A typical burn-in test is 4 hours (or longer if the end user desires).
- Transient Load test:
  - A transient load test typically consists of increasing, decreasing and increasing the UPS's output (inverter) load from 0 % to 100 % in a specific amount of time.
- Overload test:
  - An overload test typically consists of the UPS system being able to handle a 101 % to 150 % inverter overload.

- Battery discharge test:
  - A battery discharge test is when an UPS system is at 100% load and the input breaker is opened, simulating a utility failure, and the battery system provides DC power to the inverter for a specific amount of time, per the manufacturer's specifications.

MAINTENANCE

The best way to ensure that the UPS and battery system investment will provide the reliability that is required is to have regularly scheduled maintenance. This maximizes the UPS and battery system up-time availability, reduces premature failures and can provide a budget timeline for a complete battery replacement opposed to having a battery replacement cost that is unexpected.

The following IEEE documents can be used for additional references:

IEEE Standard 450, "*Recommended Practice for Maintenance, Testing and Replacement of Vented Lead – Acid Batteries for Stationary Applications*"

IEEE Standard 1106, "*Recommended Practice for Installation, Maintenance, Testing and Replacement of Vented Nickel-Cadmium Batteries for Stationary Applications*"

IEEE Standard 1188, "*Recommended Practice for, Maintenance, Testing and Replacement of Valve-Regulated Lead-Acid Batteries for Stationary Applications*"

IEEE Standard 1657, "*Recommended Practice for Personnel Qualifications for Installation and Maintenance of Stationary Batteries*"

During the UPS maintenance, a portion of the maintenance will require the load to be on utility power (bypass). The general scope of work for a UPS Field Service Engineer is the following:

Maintenance for the UPS:

- Complete visual and mechanical inspection.
- Event log review.
  - The event log will typically time stamp temperature issues, utility failures, electronic failures, battery system failures and inverter overloads.
- Record AC input / output voltage and current measurements and verify them from the UPS display.
- Record DC voltage and current measurements and verify from the UPS display.
- Record AC ripple voltage and current from the DC buss.
- Perform any upgrades, if needed.
- Perform the UPS self test:
  - Based upon the battery settings in the UPS firmware, the self test will pass or fail the battery system.
- Test the UPS in all modes of operation.
- Clean the UPS, battery and cabinet.

Maintenance for the VRLA, VLA or NiCad battery system:

- Flush the water on the eyewash stations.
- Complete visual inspection and record any issues with the batteries, cabinet / racking and cleanliness.
- Record Individual voltages (VDC)
  - Monoblock voltages for VRLA's
  - Cell voltages for VLA / NiCad's
- Record ambient room temperature.
- Record Ohmic measurements for VRLA and VLA's.
- Record Electrolyte temperatures for VLA and NiCad batteries.
- Record battery container and Negative post temperatures issues for Monoblocks.
- Specific Gravities for VLA cells.
- Verify torque on all connections.
- Add deionized or distilled water (if required) and record the amount.
- Corrosion removal (if needed).
- Clean the UPS, battery and racks.

RESULTS FROM THE MAINTENANCE REPORT:

The maintenance report provides a snap shot on the current status of the UPS and battery system as well as, how to proceed with corrective actions.

General list of corrective actions:

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- UPS AC and DC capacitors.
- Excessive amount of corrosion.
- VRLA, VLA, NiCad battery container breaches.
- Dirty or broken Flame arrestor(s)
- Broken Withdraw tube(s)
- Ohmic Value(s).
- Voltage issues:
  - Monoblock voltages for VRLA (VDC)
  - Individual cell voltages for VLA / NiCad (VDC)
- Specific Gravities for VLA
- Temperature issues.
  - Electrolyte temperature.
  - Negative post temperature
  - Ambient room temperature
- Monoblock bulging and venting.
- VLA: plate growth and sulfation
- A portion or complete battery replacement.

SUMMARY

The UPS system will have zero issues with the exception of replacing the AC and DC filter capacitors due to age. The battery system is the major component of the UPS that requires constant attention. Your UPS is only as reliable as your battery system.

My experience:

When it has been determined that a complete battery needs be replaced, there are two typical situations.

1) The budget is available when an end user has been diligent on scheduling the recommended preventative maintenances.

2) The budget is not available when the recommended preventative maintenances are not followed and this question is almost always asked. *"Can I just replace the worst ones?"*

The application required a certain amount of battery runtime when the system was sized; doing otherwise endangers the battery system, battery room environment and the equipment that is being protected. Don't just get by!

Nobody gets a pat on the back for being proactive but everyone is involved when there is a failure.