DETECTION OF DISTRIBUTED UPS BATTERY INFANT MORTALITY

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INTRODUCTION

There are mission critical equipment configurations where the installation window is available for only a short duration. The successful completion of the installation requires permission from the client to interrupt the configuration, skilled technical personnel, pre tested equipment units to be installed and a planned outage schedule. This paper describes the performance testing of 50 each 1KVA UPS systems with detached one-hour battery installation at twenty different locations, 1000 total installations across the USA. Failure of the UPS or battery after the installation was not acceptable.

CONFIGURATION OVERVIEW

The infant mortality of UPS electronics can be predicted and calculated. Inspection and testing of equipment before installation will identify damage due to shipping. The UPS battery is the unknown element especially for infant mortality failures. The best method to identify these failures is to establish a pre installation test to determine the health of the battery. The testing preferred is performance load testing of the battery module. The battery consists of two parallel strings of three 12 Volt VRLA 7 Ampere hour batteries. Testing at the point of installation was necessary as this was the final staging of the UPS equipment prior to operation.

BATTERY ASSEMBLY

The factory of assembly for the battery packs uses the VRLA batteries that are in the commercial shipping pipeline. These individual batteries can be of different manufacturing dates by months. Many of the batteries are not completely charged as delivered to the assembly facility. The individual batteries are assembled into 36 Volt battery packs and then fast charged to provide a level of initial charge to allow for 6 months of storage and transportation. A Voltage test is performed before shipment to assure the batteries have accepted a charge. The battery form factor is a 2U nineteen inch rack mount package with a 30 Amp DC connector for interfacing to the UPS module.

FACTORY INSPECTION

To provide a performance baseline for the battery and UPS at the factory a sample of ten of the UPS and battery were paired and performance tested after a full battery charge with the same VA load as the fielded electronics. The initial factory audit testing was inconsistent. UPS run time varied greatly after the load test and voltages after the test exercise were low on many battery modules. One UPS/battery run time was only 10%. Inspection of the UPS units used in the performance test revealed no operational problems. Inspection in detail of each of the battery modules revealed issues with the assembly wiring, age of the individual batteries in the battery module and degradation of the individual batteries due to several causes.

The UPS and battery module are COTS products available in several input/output voltage combinations. The purchase plan was to procure the UPS as a component part from available vendors. During the initial testing of the UPS and battery modules the demonstrated diversity in battery module performance required a standard of measurement to provide proof of performance at the time of installation.

The decision to performance test 100% of the battery modules was made. The full load test of the battery module would reduce its expected life and require a prolonged test cycle. The selected test method was to use the manufacturers suggested load test of 900W for 30 seconds. This test load was prototyped and checked as a standard with a UPS and battery configuration to baseline the battery performance. The standalone battery tester performed the test sequence with identical results to the UPS configuration in a test mode.

TEST EQUIPMENT

To perform stand alone testing of the battery a load test type of battery tester was preferred. At first a performance test was established using the UPS module with a calibrated test load. The use of the UPS plus multiple interface cables and support electronics proved successful but proved to be a complex configuration with a large footprint. To provide a simpler and effective test it was desirable to have the functionality of the UPS and calibrated test load in a convenient portable instrument. A survey of commercial battery testers was made to identify the available units that would meet the requirements. The test specification for load testing the battery was provided by the UPS manufacturer.

Several commercial battery testers were examined and one was selected that met all the requirements including construction to withstand severe handling and transportation cycles. The tester was required to indicate the before and after test battery voltages and current load during the test sequence.

The following voltage test parameters were established:
Maximum acceptable battery voltage 40.8.
Voltage at charge completion 40.5.
Average charged battery voltage 39.9.
Average discharge 900W for 30 sec end voltage36.6.
Average discharged battery low limit voltage 34.2.
Discharged battery UPS shutdown voltage 32.4.

The battery module less than 6 months old with a full charge voltage of 40.5 would fall between 36.5vdc and 36.6vdc after the test sequence was applied.

This is the data from the first factory test sequence:

BATTERY UUT	1	2	3	4	5	6	7	8	9	10
START VOLTS	39.1	39.2	38.6	38.8	37.2	36.8	37.3	37.9	38.7	38.9
END VOLTS	36.0	35.8	34.7	34.7	33.9	31.1	33.6	32.9	28.1	34.2
AGE IN MTS	6	6	8	8	11	11	11	11	8	8

Note: Battery No. 9 loose wire connector on one string.

The modules were inspected for the cause of the variation. It was discovered there was a mix of the individual 12 Volt batteries in the module. There was a wide variation of battery age but within the usage guidelines established by the battery manufacturer. Battery modules that were fully charged with matching date code batteries within 6 months of age performed as expected. Individual battery terminal connections were suspect in some battery packs.

At this point in time the contract with the UPS manufacturer had to be modified to reflect the requirement for matched date codes at the time of battery module manufacturing within 3 months. A second set of factory tests were performed with batteries of matching date codes and less than 3 months of age. The performance testing was successful with UPS operation exceeding 100% of the manufacturers UPS run time ratings. The battery modules were shipped to short-term storage and staged for national delivery to each facility within 6 months.

This is the data from the second factory test sequence:

BATTERY UUT	1	2	3	4	5	6	7	8	9	10
START VOLTS	39.9	39.9	40.2	40.1	39.9	39.8	39.9	40.1	40.1	39.9
END VOLTS	37.6	36.9	37.7	38.0	37.9	37.9	37.9	38.0	37.9	37.8
AGE IN MTS	2	2	2	2	2	2	2	2	2	2

INSTALLATION SITE 1

One day before the installation of the UPS and battery the battery was placed on charge. The charging method for the batteries was a three-stage VRLA qualified commercial charger. A six-hour stabilization time was allowed after charging before any testing was performed. The load test set was selected to simulate a nominal discharge rate of 900W for 30 seconds with voltage measurements before and after. A commercial high quality battery load tester, was selected and testing commenced.

This is the data from the first field test sequence:

BATTERY UUT	1	2	3	4	5	6	7	8	9	10
START VOLTS	39.9	39.9	40.2	40.1	39.9	39.8	39.9	40.1	40.1	39.9
END VOLTS	37.8	37.9	37.8	38.0	37.9	37.7	37.8	38.0	37.8	37.8
BATTERY UUT	11	12	13	14	15	16	17	18	19	20
START VOLTS	39.8	39.9	40.1	40.1	39.9	39.9	39.8	40.0	40.0	39.9
END VOLTS	37.8	32.6	37.6	38.0	37.8	37.9	37.7	38.0	30.3	37.7
BATTERY UUT	21	22	23	24	25	26	27	28	29	30
START VOLTS	39.9	39.8	40.2	40.2	40.0	39.9	39.8	40.0	40.1	39.9
END VOLTS	37.6	29.2	38.2	38.1	37.9	37.8	34.7	38.0	37.9	37.8

Note: Battery 12 and 19 corroded terminals on battery due to over watering of battery during manufacturing.
Battery 22 disconnected 2nd string connector.
Battery 27 loss of capacity.

The results were less than expected. The variations were caused by several different conditions, individual 12 Volt battery infant mortality capacity loss, minor corrosion of 12 Volt string battery terminals, over watered leaking VRLA battery and disconnected cables on the parallel battery string allowing full voltage but reduced capacity. The battery modules that tested at lower than expected capacity, the battery modules were charged and the same test process was followed. The performance testing at installation was rejecting 7% to 10% on of all battery assemblies.

INSTALLATION SITE 2

The second site installation was performed in the same manner as the first. One day before the installation of the UPS and battery the battery was placed on charge. A six-hour stabilization time was allowed after charging before any testing was performed. The load test set was selected to simulate a nominal discharge rate of 900W for 30 seconds with voltage measurements before and after. The results were as follows:

This is the data from the second field test sequence:

BATTERY UUT	1	2	3	4	5	6	7	8	9	10
START VOLTS	39.8	39.9	40.0	40.1	39.9	39.9	39.8	40.0	40.1	39.9
END VOLTS	37.7	37.8	37.9	38.0	37.9	37.8	37.8	38.1	38.2	37.8
BATTERY UUT	11	12	13	14	15	16	17	18	19	20
START VOLTS	39.9	39.8	40.0	40.0	40.0	39.9	39.9	40.1	40.0	39.8
END VOLTS	37.7	37.6	37.7	38.0	37.8	37.9	37.7	38.0	37.9	37.7
BATTERY UUT	21	22	23	24	25	26	27	28	29	30
START VOLTS	39.8	39.8	40.1	40.0	40.0	39.9	39.9	40.1	40.1	39.8
END VOLTS	37.7	37.6	34.1	38.1	37.9	37.7	31.7	38.0	37.9	37.8

Note: Battery 23 and 27 disconnected 2nd string connector.

SUMMARY

The UPS installations were successful due to the extensive pre-test of the battery modules. The test of the battery modules at the 20 installation locations identified battery modules that would have prematurely failed or suffered performance variations that were not acceptable. One year after the completed installations at each site no additional failures have been detected with periodic test.