THE HIGH COST OF MAINTAINING YOUR VRLA BATTERIES / THE HIGH COST OF NOT MAINTAINING YOUR VRLA BATTERIES

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ABSTRACT

This paper examines the real dollar costs involved in the maintenance programs and the risk/cost associated with not maintaining VRLA batteries and discusses a proposal for an alternative approach to battery maintenance.

INTRODUCTION

This paper is based on interviews, and IEEE and battery manufacturers' recommendations. It is understood that the end user will ultimately determine what actions are taken (or not taken) to maintain and monitor battery performance. It is our intention to compile and present information related to the actual costs to maintain "maintenance free" VRLA batteries in a 24 cell telecom configuration, as well as suggest that cost savings can be realized through the investment in automated battery maintenance technology. It is hoped that this will inspire a re-evaluation of the true costs related to VRLA battery systems.

SUMMARY OF MAINTENANCE RECOMMENDATIONS

Maintenance routines/practices come from various sources. These can be generally divided into two categories: Standards based and current practices.

Standards

Reviewing standards for VRLA battery maintenance (primarily IEEE 1188) in addition to battery manufacturer's guidelines gives a range of recommendations, some of which require inspections on a monthly basis, while others are less stringent, extending the duration out to three months or longer. The typical interval between recommended maintenance visits is three months or one quarter. The six month, 12 month, and 24 month visits are generally the basic quarterly visit with additional tasks added. The recommended maintenance schedules for various battery manufacturers were compiled and summarized in Table 1. (For a comprehensive look at each recommendation, please see Appendix A.)

	Monthly	Quarterly	Six Month	Twelve Month	Twenty four Month
String Voltage	I,P,A,H	I,G,C,I,H	C,P,A,H	I,G,C,A	
Unit Voltage		I,G,C,H	C,P,A,H	I,G,C,A	
Float current	I,P	I,C,H	C,P,H	I,C	
Visual Inspection	I,A	I,C	C,A,H	I,C,A	
Ambient Temp	I,P	I,G,C,H	C,P,H	I,G,C	
Unit Temp		I,C	C,P	I,C	
Hardware tightness		G	P,H	I,G,C,A	
Ohmic values		I	C	I	
Capacity Test				I,C	I,C,P,H
IEEE1188 = I, Power Battery = P, Panasonic= A, GNB = G, C&D = C , Hawker = H					

Table 1

CURRENT PRACTICE

Current practice was explored by contacting service organizations and battery users and inquiring as to the extent of their maintenance programs for VRLA battery installations. These answers ranges from quarterly site visits, with a measurement of plant voltage and the voltage of a pilot cell, to "We don't do any maintenance on VRLA batteries; we just replace them every three years."

For the purposes of this paper, I attempted to create an average maintenance schedule based on each individual schedule. (See Table 2.) This average does not meet each and every recommendation from Appendix A, but attempts to meet a majority of the recommendations. The title of this paper, “The high cost of maintaining your VRLA batteries / The high cost of not maintaining your VRLA batteries,” alludes to both extremes. Let’s analyze each case in more detail.

	Monthly	Quarterly	Six Month	Twelve Month
String Voltage		X	X	X
Unit Voltage		X	X	X
Float current		X	X	X
Visual Inspection		X	X	X
Ambient Temp		X	X	X
Unit Temp				
Hardware tightness			X	X
Ohmic values		X	X	X
Capacity Test				X

Table 2

THE HIGH COST OF MAINTAINING BATTERIES

Risks associated with a maintenance visit.
There are additional risks associated with opening an enclosure to perform maintenance. These might include disturbing wiring, human error, dropped tools, and similar accidents. While these are certainly worth noting, they are difficult to assign a real dollar cost. There is also the very real risk that, despite taking all of the recommended maintenance steps, an unmonitored site could still experience a battery failure or reduced holdup time resulting in lost revenue, fines, customer dissatisfaction, and the potential of equipment damage.

The quarterly maintenance visit. (Table 3)
The maintenance recommendations for VRLA batteries, on average, require a site visit every 120 days. The maintenance typically required during these visits consists of measuring and recording battery string voltage, string current, unit (monobloc) or pilot cell voltage, and possibly some sort of impedance or conductance tests. The collection of these pieces of data can be expected to take somewhere in the neighborhood of 1 hour per visit of actual measurement time. Add in an additional 30 minutes of setup/tear down time and you arrive at 1 ½ hours. Add another one hour of travel time and one hour to analyze the data and generate a report and the figure jumps to 3 ½ hours of time for a “simple” quarterly visit.

Task	Duration
Travel	30 min.
Setup	15 min.
Maintenance	1 Hour
Cleanup	15 min.
Travel	30 min.
Report	1 hour
Total Time:	3 ½ hours

Table 3

The six month maintenance visit.
The more involved requirements of a six month visit include all of the quarterly tasks, with the addition of checking connection hardware. If this takes an additional ½ hour, a six month visit can be expected to take four hours.

The 12 month maintenance visit. (Table 4)
IEEE 1188 recommends the performance of a capacity test at every 25% interval of expected battery life (as opposed to warranted life). Most battery manufacturers recommend capacity testing every twelve months after the first couple of years of battery service. If the user was to take a “middle ground” approach, capacity testing will be performed every twelve months. A discharge test of a four string, 48 volt battery bank takes 2+ days (travel time x2, setup and tear down x2, two hours of discharge time per string (8 hours) plus at least 1 hour to analyze the data and generate a report). The yearly visit should include collecting all of the data normally collected during a six month visit. For the purposes of this analysis, it will be assumed that the efficient worker will accomplish the routine data collection over the course of the two days he/she is on site.

Day 1	
Travel	30 min.
Setup	15 min.
Discharge String 1	2 hours
Setup	15 min.
Discharge String 2	2 hours
Cleanup	15 min.
Travel	30 min.
Day 2	
Travel	30 min.
Setup	15 min.
Discharge String 3	2 hours
Setup	15 min.
Discharge String 4	2 hours
Cleanup	15 min.
Travel	30 min.
Report	1 Hour
Total Time:	2 Days

Table 4

Total yearly maintenance costs.
Summing the time required by the different visits and tests, we arrive at three and one half (3 ½) days of test labor per year per site. If we assume two workers @ $65/hour/worker, the figure rises to $4440/year/installation. Service contracts and consolidation of sites will likely be able to reduce this figure.

Total cost per year for a maintained, four string at 100 Amp/Hour per string -48V battery bank.
An estimated installation price to replace an entire battery bank as described is $2000.[1] A 12v 100 amp/hour monobloc can be expected to cost $175. A four string – 48 volt battery bank contains 16 monoblocs. Summing these costs, we arrive at $4800. Assume that a maintained battery bank will require replacement of three monoblocs over a five year life. (For simplicity, assume that the entire bank is replaced after five years.) The total cost of the battery bank is $5325. Amortize this over five years and add the earlier maintenance figure of $4440/year and we arrive at $5505 per year.

THE HIGH COST OF NOT MAINTAINING BATTERIES

This section is meant to address the "I'll just replace the batteries every X years" approach to VRLA battery maintenance. After all, aren't VRLA batteries maintenance free? With this approach, the battery user hopes to replace the batteries before there is a significant risk of battery failure. As the no maintenance approach to VRLA batteries exposes the user to considerably more risk of battery failure, it is appropriate to address the cost of failure at this point. The cost of failure is difficult to define. Much depends upon the individual characteristics of the installation and the type of failure. A best case failure could translate into a totally defective battery bank that would cause a momentary outage while a backup generator comes online. A battery that fails prematurely could equate to several hours of outage while a generator is en route to the installation. A worst case scenario could result in the total loss of a site due to a thermal runaway and resultant fire in an enclosure. This type of event could mean an extended outage while waiting for replacement equipment to arrive on site. If the reader is a battery user, I encourage you to formulate your own numbers for this section. For the moment, let us assume that most strings of VRLA batteries will last three years without any significant maintenance. To ensure that there are a minimum number of battery failures, a zero maintenance approach would dictate that 100% of the batteries are replaced every three years. If most monoblocs will last for 5 years, it could be stated that we are replacing perhaps greater than 80% of our batteries two years earlier than needed. If this is the case, for a site containing four -48 volt strings of 100 amp/hour batteries (16 monoblocs), we would be discarding 12.8 "good" monoblocs two years earlier than needed.

Total cost per year for a non-maintained, four string at 100 Amp/Hour per string -48V battery bank.
An estimated installation price to replace an entire battery bank as described is $2000. A 12v 100 amp/hour monoblock can be expected to cost approximately $175. A four string – 48 volt battery bank contains 16 monoblocs for a total cost of $2800 plus $2000 for installation. Because of no maintenance program, we are replacing this battery bank after three years, so we amortize the $4800 over three years to arrive at $1600 per year. The reader might be thinking that this approach seems more economically prudent than the maintenance approach detailed earlier. This might indeed be the case, but, before embarking on this path, please consider the increased risk of an undetected thermal runaway or other undetected failure.

PROPOSED AUTOMATED APPROACH TO BATTERY MAINTENANCE

There is little doubt with regards to the value of battery monitoring systems. There is also no shortage of papers presented that support this position. We would like to propose a better approach. By combining the functionality of both monitoring and control, a battery maintenance system allows the end user to detect defective or weak cells, reducing the number of times that a human being must visit the installation, and by optimizing the electrical environment "felt" by the battery, a battery maintenance system is capable of extending the useful life of the battery.[2] While there are many approaches to automatically maintaining the battery to enhance its life, a shortcoming exists in that there are not currently any systems that combine the ability to optimize the battery's environment while also having the ability to automatically test the performance of those same batteries. A review of the prior sections contained in this paper indicates that one of the most costly maintenance activities is a discharge test of the battery. We propose that, by blocking the individual battery strings from the battery bus, not only can we optimize the environment of the battery, we can perform a string by string discharge test automatically. Because of the automatic nature of the test, it can be performed at the time of lowest risk without requiring human supervision or intervention.

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[1] Based on interview with Ken Ashlin of Custom Power Service. Based on four 48 volt strings or 100 amp/hour VRLA batteries. Includes Rigger, engineering documentation, turn-up.

[2] Jones, et al. Recharging VRLA Batteries for Maximum Life

String float current.
There has been increased interest in monitoring the float current of battery strings in order to detect the start of thermal runaway.[3 4] A more effective method is to both monitor and control the float current on a string by string basis. By controlling the current from the rectifier into each string and eliminating the opportunity for one battery string to "feed" the runaway current to another, the risk of thermal runaway is greatly reduced.

Cost savings through automated maintenance.
Returning to the recommended maintenance practices, we see that there are two tasks that appear on the list that no automated system can easily do. These are retorquing the battery connectors and visually inspecting the state of the battery. A visual inspection and retorquing of the battery should take no more than one hour and, allowing for travel and reporting time, the entire procedure should require no more than three hours. We would propose that constant battery monitoring will allow for an increase in the time between visual inspections and retorquing to one year. Based on these assumptions, the use of battery monitoring/automated maintenance equipment could reduce the amount of maintenance labor from 3½ days (28 hours) to 3 hours per year. Again, assuming a labor rate of $65/hr, this is a savings of (25 hours @ $65) $1625 per year. This figure makes no allowance for the reduced risk of thermal runaway or the reductions in the risks introduced by human intervention. If a no-maintenance approach is normally taken, the monitoring/maintaining of a battery system should reduce the number of good batteries that are replaced before their time.

Total cost per year for an automatically maintained, four string at 100 Amp/Hour per string -48V battery bank.
As before, an estimated installation price to replace an entire battery bank as described is $2000. A 12v 100 amp/hour monoblock can be expected to cost $175. A four string – 48 volt battery bank contains 16 monoblocs. Summing these costs, we arrive at $4800. Assume that a maintained battery bank will require replacement of three monoblocs over a five year life. (For simplicity, assume that the entire bank is replaced after five years.) The total cost of the battery bank is $5325. Amortize this over five years and add the non-automated portion of yearly maintenance (visual inspection and retorquing) of three hours at $65/hour/year and we arrive at $1260 per year. Adding $250 per year for automated maintenance equipment (this equipment will outlast the battery bank and is assumed to be re-used), the total figure becomes $1510 per year.

CONCLUSION

We have discussed three different approaches to maintaining VRLA batteries. The dollar costs to purchase, install, and maintain these batteries were calculated and are summarized here:

Fully Maintained:	$5505 per year.
Non-maintained:	$1600 per year.
Automatically maintained:	$1510 per year.

There are additional costs involved with batteries that vary from site to site that have not been addressed here. Particularly difficult to quantify is the cost related to the increased risk of undetected battery failure. It is the hope of the author that this work will stimulate further thought, particularly with regard to the actual "cost" of the risks involved with under-maintained batteries.

[3] Brown, Arnold J; An Innovative Digital Float Current Measurement Technique – Part One, BATTCON 1999, Vol. 1, 1999
[4] Brown, Arnold J; An Innovative Digital Float Current Measurement Technique – Part Two, BATTCON 2000, Vol. 1, 2000

APPENDIX A

MAINTENANCE BACKGROUND INFORMATION

IEEE 1188-1996, "IEEE Recommended Practice for Maintenance, Testing, and Replacement of Valve-Regulated Lead-Acid Batteries for Stationary Applications."

(Note: Some recommendations taken from the unreleased draft number 4)

Monthly general inspection.
Overall float voltage.
Charger output current and voltage.
Ambient temperature.
Float current per string.
Visual inspection.

Quarterly inspection.
Monthly inspection items.
Ohmic values for cell or unit (monobloc).
Temperatures of negative terminal of each cell/unit.
Voltage of each cell or unit.

Yearly
Monthly and quarterly items.
Cell to cell and terminal resistance of entire battery.
AC ripple current and voltage imposed on the battery.

The 1188 spec also recommends periodic performance tests based on the expected life (not the warrantee period). The recommendation is 25% of the expected service life or two years, whichever is less.

BATTERY MANUFACTURERS' RECOMMENDATIONS AND WARRANTEE REQUIREMENTS

GNB "Installation and Operating Instructions for ABSOLYTE IIP" Rev 9/94

Quarterly Recommended.
- String voltage
- Pilot unit voltage
- Ambient temperature

Yearly (minimum to maintain warranty)
- Quarterly readings
- Individual unit voltages
- Inter-unit connections

Johnson Controls "Dynasty VRLA Battery Periodic Maintenance Instructions" Rev 10/96

Quarterly
- Ambient temperature
- Visual inspection
- Float voltage.
- Check for ground faults
- Battery system float current.
- Pilot battery temperature
- Unit (monobloc) level float voltage
- System equalization voltage (if applicable)

Semi-annual
- Quarterly checks
- Measure the resistance/impedance/conductance of the individual units and monitor trends over time and watch for dramatic changes over time.

Annual Maintenance
- Semi-annual checks.
- Check torque of hardware.

24 month
- Discharge test at service load
- After 85% capacity repeat this yearly.

Hawker "Installation, Operation and Maintenance Instructions for Valve Regulated Lead Acid Battery Types" 4/96

Monthly
- Check charger float voltage

Quarterly
- Check charger float voltage
- Charger float current
- Ambient temperature
- Unit voltages

Six month
- Check charger float voltage
- Charger float current
- Ambient temperature
- Unit voltages
- Check torque values
- Visual inspection

Twenty four month
- Discharge test
- (As end of life approaches discharge every twelve months.)

Power Battery "Battery Application Field Service Manual, Valve Regulated Lead Acid Batteries" No revision date noted.

Monthly
- Float voltage
- Ambient temp
- Float current

Six Months
- Monthly checks
- Unit terminal temperature
- Unit float voltages
- Check tightness of terminal connections
- Tightness of rack or shelf hardware.

Twenty Four Months Checks
- Capacity (discharge tests)

Panasonic "Installation, Operation and Maintenance Manual, MSE Valve Regulated Lead Acid Batteries" print date 3/99

Monthly
- Total string float voltage
- Visual inspection

Six month check
- Total string float voltage
- Individual unit voltage
- Visual inspection

Twelve month check
- Six month items
- Check connection torque.