~~BATTERY MAINTENANCE~~, ~~BATTERY MONITORING~~, BATTERY MANAGEMENT WHAT'S IN A NAME?

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A LITTLE BIT OF HISTORY

Back in 1964, the batteries used in critical applications were looked after by skilled technicians, and valve-regulated lead-acid battery (VRLA) technology was but a gleam in the developer's eye. Battery service was, in the majority of cases, an in-house task. Routine visual inspection, the scheduled collection of voltage and specific gravity readings, coupled with the experience of the technicians and their local knowledge, was what made it all work.

With the growth of computers and the associated uninterruptible power systems (UPS), VRLA batteries started to become the dominant technology, in part because they were marketed as maintenance free. The term 'maintenance free" referred to the fact that you didn't need to add water, but the problem was that you couldn't measure the specific gravity and, since the cases were opaque, you couldn't see the condition of the plates either.

Some 18 years ago, the first products were developed to measure the internal ohmic value of a battery cell and to use this value as a guide to the battery's condition. A change in this value over time is now accepted as one of the best indicators of the battery's condition.

Unfortunately, it still remains a common misconception that these batteries don't require maintenance; however, the truth is, while they may not require regular watering, they do have to be monitored regularly to ensure that failing cells or blocks are replaced as required, if anything approaching the battery design life is to be achieved.

Today, there is very little about everyday life that is not dependant on electricity in some form or another. This has lead to an explosive growth in the number of lead acid batteries installed worldwide, and the majority of these are now VRLA batteries. The problem is that a great many of them are being used in critical power applications without any understanding of their limitations. With all these batteries being installed, and very few companies with personnel dedicated to maintenance, battery service should be a growing business. However, the truth is that the number of experienced and fully employed battery technicians is now probably less than in 1964. So why has the growth of battery services not kept pace with battery sales? People need to realize that, although VRLA batteries are hardly the model of reliability, things could be much better with the correct service plan in place.

WHAT ARE WE DOING WRONG?

The authors believe that the principal reason for this is a failure to update the service model and maintenance procedures to keep up with modern business practices. Today, there is a general acceptance that nothing is perfect, so business in general operates on the basis of calculated risk. In order to assess that risk, it is necessary to predict and understand the failure mechanisms that can occur in every aspect of business and to use that data to take corrective action.

In the context of batteries, if we look at the service practices in use today, they fall into the category of preventative maintenance. This means that the batteries are checked on a fixed schedule, after which a report is generated as to the current condition of the battery by identifying the cells that have failed since the last service. The idea is, if the user changes that cell, it will prevent a possible future failure due to that cell.

There is seldom any detailed analysis and projections as to the level of risk associated with the cell identified as bad or the possible risk of the battery failing to support the load on discharge, based on the overall condition of all the cells.

Even if predictions of early failure are provided, they are often ignored or disputed. This is because, in many cases, one company may identify the failing cells, and the replacement of those cells may be the responsibility of others. Replacement may also require authorization and a separate purchase order by the customer before the cell can be replaced.

Due to the lack of battery knowledge in most companies, there is little understanding about the risk associated with failing cells. For example, if, before the bad cells can be replaced, there is a power failure with no loss of critical power, (which is always a possibility depending on the failure mode of the cells and the length of the discharge), the management at all levels may well discount the value of the information being provided by the battery service company and, as a result, eliminate battery maintenance. This is not the ideal situation for a product that is the weak link in every critical power system.

A NEW BUSINESS MODEL

If we are to establish a new business model for battery service that is based on risk management, then it is important that we understand and define how the customers perceive risk and what kind of information they are looking for.

This will vary from industry to industry and from customer to customer, so this new business model can no longer be the "cookie cutter" approach of one plan fits all. For example, in the data center environment, the risk perceptions could be:

- The computer and network operations staff relies on the batteries as part of a critical power system to support all their critical equipment. Consequently, these people need to understand the extent to which the critical power system is compromised because of failing or failed battery cells. Will the critical power system function as designed should utility power fail? Real time data in the form of runtime predictions during the loss of utility power is also a requirement, especially in those applications where safety and security of personnel are the primary concern.

- The unplanned replacement of a battery can be a major budget buster in most companies, so the planning and finance staff would benefit from being given adequate warning as to when a battery will have to be replaced. A secondary but important factor would be to provide indication as to the extent by which a battery's life is being shortened due to environmental conditions or simply the failure to allocate funds to the replacement of failed cells.

- Upper management can also benefit, as they are now more than ever at risk from failing to ensure that all regulatory requirements are being met. The ability to automatically generate reports that show compliance will reduce and limit that risk. Also, with today's increased concerns over pollution and conservation, a company with a comprehensive battery management plan will clearly demonstrate that it is employing the best business practices and will be in compliance with any future regulatory requirements.

By now it should be clear that what we are talking about is not selling "preventive maintenance," but the focus needs to be selling the customer on the concept of "management" and the introduction of "predictive maintenance."

UNDERSTANDING THE COMPETITION

It should be noted that we haven't used the word "battery" when we talk about management. One of the reasons for this is that, although the batteries are typically the element that is of greatest risk of failure, the customer may not see them as a separate entity. This is because they are often seen as an integral component of a critical power system, such as the UPS. The manufacturers of these products have realized this and, over the years, started to included them in their service plans to add revenue, but seldom given them the level of attention have they actually required.

This may, however, be changing, as one of the UPS manufacturers has added an advanced battery management feature to highlight the importance of the battery within the UPS. ABM, as it is known, cycles the battery through a charge, discharge, and rest cycle. This is intended to help extend battery life by reducing the time the battery is on float and, at the same time, test the viability of the battery once a cycle. The cycle time, however, is not a fixed duration, as it is determined by the size of the battery and the number of discharges detected. This means that the period during which ohmic measurements could be made at a known state of charge is very limited and undefined. So, although probably not the intention, this feature makes conventional maintenance visits by third party companies difficult if not impossible to schedule.

INCREASING THE SCOPE

In the past, service companies have often worked through the facility's staff to obtain contracts and provide battery service. But in today's business environment, facilities management may in itself be an outsourced service, and they may not welcome the use of third parties to do battery maintenance.

In order to convince customers to return responsibility for the batteries to the battery service company, they will have to be educated and convinced that the batteries are truly the critical element of any power system and that, in order to minimize risk, they need to be the primary focus of a service strategy and not an ancillary part of another service plan.

One of the ways this can be done is to include all the batteries within the critical power infrastructure, including, UPS, utility batteries (including generator starting), and telecommunication power systems under a single contract and to include the alarm monitoring of all the associated power electronics as part of that contract.

What we are talking about is not battery management, per se, but critical power management.

CRITICAL POWER MANAGEMENT DEFINED

It is important to define what we mean by management in this context. The following functions should be part of any management program:

- Collection and analysis of sufficient data to provide customers with a reasonable assessment of the current risk interpreted, presented in a manner that can be clearly understood by the user.
- The replacement of any faulty cells in a timely manner.
- The reporting and interpretation of any associated equipment alarms within the context of system reliability.

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For some service companies, the idea of assessing the level of risk rather than simply reporting failed cells may be the biggest challenge. In “Lies, Dammed Lies and Statistics”[1] a paper presented at Battcon in 2005, there is a detailed explanation as to how to use statistics to help define battery reliability. Although the paper is aimed at using statistics to design reliability into a battery system and its maintenance program, the formula for the Risk Priority Number (RPN) can be adapted to use live data, rather than statistics, to establish a real-time value for risk.

Data Collection and Analysis

Measuring and collecting data on a regular basis is a prerequisite in establishing risk. As can be seen by the graphs in Fig. 1, failure can occur over a short period of time and seldom will fail conveniently just before the maintenance visit.

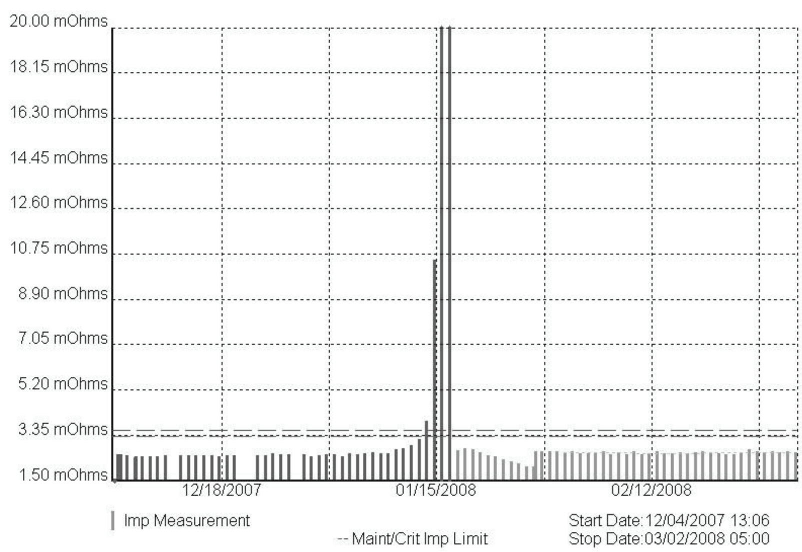

Figure 1: Cell going open circuit over a period of 3 days

While this bad cell would have been clearly identified at the next inspection, even with a rigorously implemented three month inspection schedule, the power system could have been at an increased level of risk for almost three months before the problem was identified.

That clearly demonstrates that the frequency at which the data is collected is the key to making this work. The problem is that, as the costs of travel and skilled labor are continuously rising, any plan that calls for increasing the number of scheduled visits to site is probably a nonstarter.

An alternative would be to get the user to collect the data using a portable monitor and to send the data to the service company for analysis. This would work particularly well where there are multiple smaller systems and would allow the data to be collected more frequently. The portable monitor could be sold outright to the customer, but a better approach might be to lease the monitor to the customer and amortize the cost over the life of the contract.

The approach that will generate most data is to install monitoring equipment at each battery location and allow that data to be collected by a remote system for analysis and publishing. In a perfect world, the data could be collected using the Interne, but, in real life, local network security and other considerations will typically limit access to the monitors, so alternative communications methods may have to be considered.

Cell Replacement

Bad cells need to be identified and replaced as soon as possible, especially those that fail during the initial warranty period, so cell replacement has to be priced into the contract and should not require the user to approve or issue additional purchase orders.

To limit liability of the service company under such a plan, the maximum number of cells to be replaced within any year of the contract can be defined. Typically, a failure rate above the level set would indicate a battery that requires inspection and remedial action by the manufacturer.

During the first year, when even the most basic warranty is in place, the replacements should always be new product. However as the battery ages, while changing the failing cell or jar will reduce the risk of complete battery failure, it is a recognized fact that, if the replacement batteries are not properly conditioned before installation, they may limit the life of the remaining cells.

One option for the most critical applications is to maintain a number of spare cells or blocks on charge, which will then age at the same rate as the battery and can be used for replacement. Another alternative would be for the service company to identify and recover serviceable product from battery strings that are being replaced, categorize them with respect to age and ohmic resistance, and use these units as midlife replacement.

System Risk

In the earlier graph, we can easily identify the failing cell, but what we can't establish from that limited data is the effect that cell would have during a discharge. Establishing that requires that we understand and are able to interrelate data such as:

- The actual load on the battery during discharge
- The length of time the battery has been installed
- Average ambient temperature
- The overall rise in ohmic resistance since it was installed
- The average ohmic resistance rise of the whole battery
- The configuration of the battery and the location of any other questionable cells
- Any equipment failures within the power equipment that may impact redundant operation

If all that information is available, then a reasonable assessment of risk can be achieved. The important thing is that the data then needs to be presented to the customer in a manner that clearly describes the applicable risk to the user.

PREDICTIVE MAINTENANCE

A key element in this new critical power management model is to convert the current preventive maintenance structure used for most critical power systems to one that is predictive. Under a predictive maintenance plan, service visits are scheduled as required, based on the analysis of data rather than the fixed schedule of traditional maintenance plans. This means that, logically, the company managing the critical power systems should be a battery specialist, as this is the area in which most of the risk management needs to occur, and where it will provide the greatest benefits in both cost saving and increased reliability.

While it may initially appear that, in order to compete at this level, the companies involved would need to be fully integrated power service companies, this is not the case. Although a fully integrated company would have the infrastructure required already in place, the change from preventive to predictive may be much more difficult than in a smaller, more agile company.

It is also true that a company specializing in battery service may not have the capability or want the responsibility of servicing the actual power equipment involved. But they do understand batteries and the impact that maladjusted power equipment can have on them, something that the other service organizations don't always seem to recognize.

They also have the ability to coordinate the collection and distribution of all relevant alarm and operating data, not only to the user, but also to other specialist maintenance organizations for additional analysis. By assuming responsibility for the coordination of all service visits, they would provide the end user with a single point of contact for all critical power related business.

THE BUSINESS CASE

So how do we make this a profitable venture? The key is that the contracts need to be for multiple years, as single year contracts do not allow for development of true predictive maintenance plan.

The following graphs are based on servicing a single UPS, with three battery cabinets each, with forty 12V VRLA units. The preventive maintenance is based on four scheduled site visits per year, and additional site visits are included to cover the failed monoblocks that have to be changed out every year. The quantities identified for change out per year vary, based on the typical bathtub failure curve. Travel time is set at one hour and mileage costs are calculated using the current IRS reimbursement rate. An inflation rate of 2.5% per year is applied, and two person teams are used for all tasks.

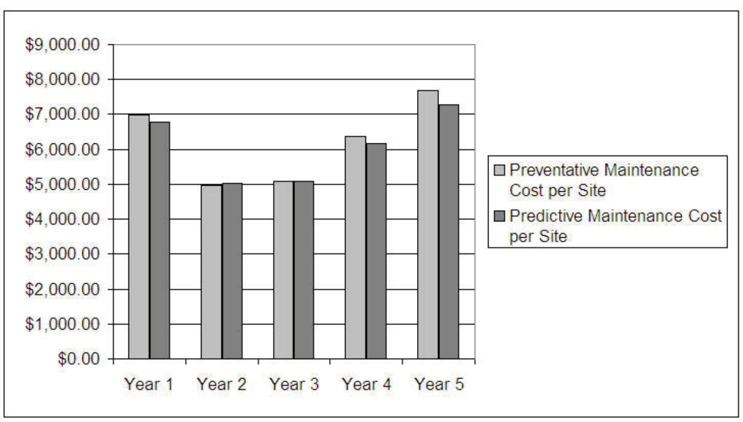

Figure 2: Comparison of Preventive vs. Predictive Costs per Site

The predictive maintenance costs include lease payments on the monitoring system over a five year period and a yearly fee per monoblocks to cover monitoring expenses. Change out costs for the failed units is the same as in the preventive model.

In the model used above, which is typical of configurations currently being serviced, there is very little difference between the costs involved in providing predictive as against preventative maintenance when it comes to setting a price for the customer. Obviously, there would be additional charges to the customer to cover the management function and the interface with the third party service contractors. The real difference is in how the costs are allocated by reducing the number of truck rolls required for preventive maintenance visits.

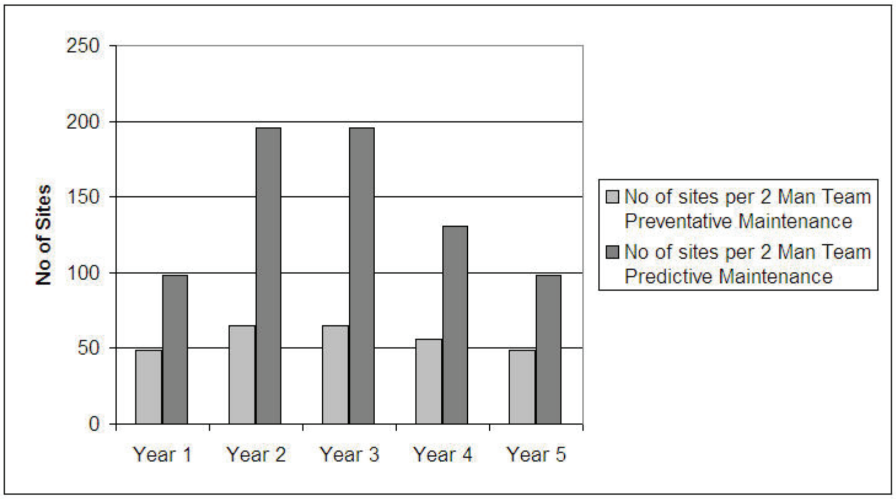

Figure 3: Number of Sites Serviced by a Single Two Person Team

In Figure 3, the actual number of sites shown on the graph that can be serviced by one two person team is unrealistic, as it is based on full utilization of the 1,968 work hours available in a year, after public holidays. It does, however, clearly show the increase in business that can be achieved by moving to a predictive model without increasing labor.

WHERE WILL ALL THIS BUSINESS COME FROM?

For 2008, the market for batteries supplied by US manufacturers and used in stationary applications within the USA is estimated to be $600 million,[2] broken down into the following categories.

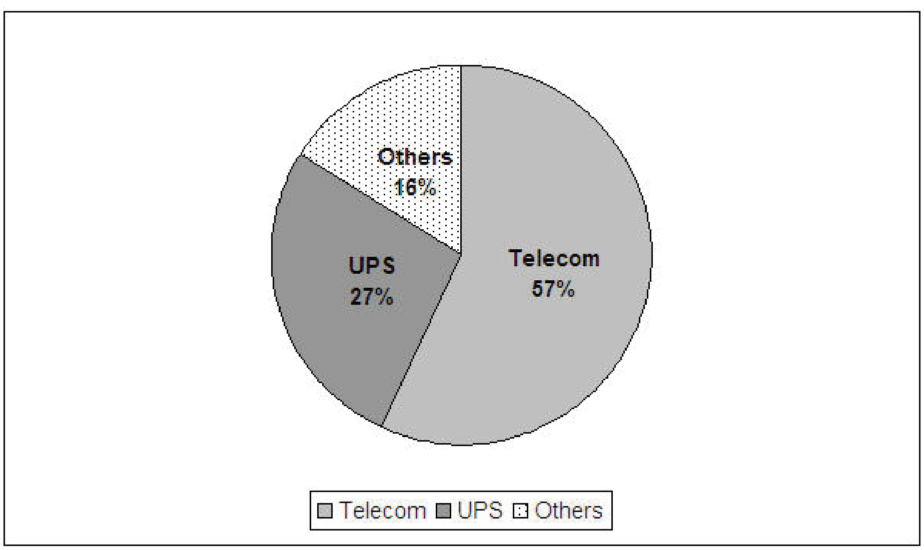

Figure 4: Estimated US Battery Sales By Category in 2008

Although no published data is available with respect to the percentage batteries under maintenance in any specific market, anecdotal evidence would indicate that less than 10% of the total market is actively being maintained. This represents a huge potential market that is presently being underserved by the current approach to battery service.

1964

So why was the year 1964 chosen as a reference point at the start of this paper? Well, that was the year Bob Dylan released "The Times They Are A-Changin" and, after all these years, the sentiment is still very appropriate. In particular, a couple of lines from that song are very prophetic.

"For he that gets hurt
Will be he who has stalled"

With due respect to all the players, the authors consider the battery service market to be "stalled" and trust that perhaps this paper will help a few less people get hurt.

REFERENCES

1 McDowall J "*Lies, Dammed Lies and Statistics: The Statistical Treatment of Battery Failures*" proceedings of BATTCON 2005

2 Bob Cullen "*The Industrial Battery Three-Year Forecast Report*" Battery Council International 118th Convention 2006