Find out if Battery Monitoring is Right for You

What kind of savings can you expect from utilizing CellSPY Battery Monitoring?

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CellSPY
Battery Monitoring

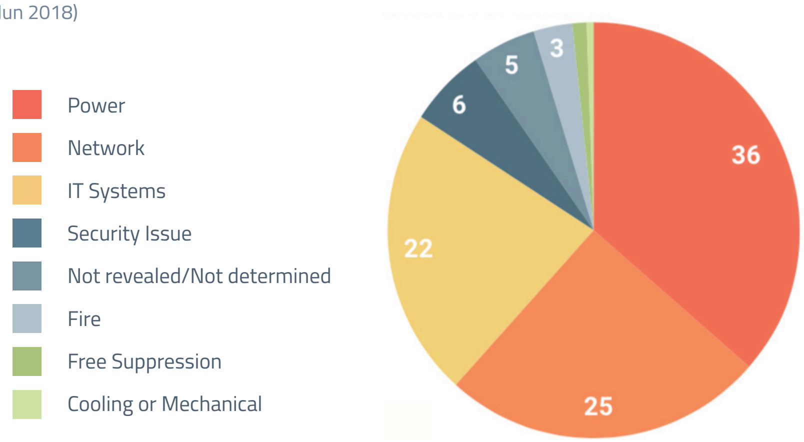
CellSPY was developed to reduce costly battery maintenance programs and mitigate the risk of costly outages due to battery failure. This white paper, in conjunction with our calculator will help you understand whether battery monitoring is a valuable tool for your organization. By entering your data center specifications such as data center size, number of strings, batteries per string, etc we can help quantify the benefits of our system. At Emsys Design we don't believe in outlandish claims. All estimates used in our ROI calculator have been pulled from independent third party studies and the most conservative numbers have been used.

Quantifying
Risk of Outages

"Downtime is common and may even be increasing, despite many advances". A 2018 Data Center Survey conducted by the Uptime Institute, with responses from 1,104 data center operators and IT practitioners, showed approximately half (48%) of those surveyed experienced "at least one outage in the past three years". The biggest cause of outages was a loss of on-site power, cited by 33% of respondents. This was the most common outage cause, followed by network failure.[1] These results align closely with causes of big public failures recorded since early 2016 which showed Power Outages accounting for 36% of all failures.

FIGURE 01

Causes of 100 major public outage
(Jan 2016- Jun 2018)



Source: Uptime Institutes. June 2018

The Ponemon Institute's 2016 study found that "UPS system failure continues to be the number one cause of unplanned data center outages, accounting for one quarter of all such events".[2] Of these UPS failures, batteries are cited to be the leading culprit, responsible for as much as 65% of UPS failures.[3] Using the most conservative estimates from the Ponemon and Uptime Institutes, we can find the expected risk of a battery caused unplanned outage to be placed at about 4% over a 3 year period.

The Uptime Institutes 2018 report concluded "There is a widespread belief that advances in IT systems and software have made IT services far more resilient, especially when coupled with highly engineered data center operations and well-drilled, process-oriented facilities staff. But this research proves that the levels of complexity and sensitivity in modern data center and IT operations, coupled with the high level of interdependence, may be working against that trend. Operators, this survey suggests, are struggling to keep pace. The result is that expensive and damaging failures keep occurring, and when they do, diagnosis and quick recovery can be challenging. Over time, experience and new technologies will no doubt lead to improvements, but diligence, investment, and planning are clearly required; it is, above all, a management issue."

Quantifying Cost of an Outage

Because outage costs are difficult to quantify and largely depend on an individual basis, we won't go too far into the specifics. In general, average outage costs climbed from $505,502 in 2010 to $740,357 in 2016, marking a 38% net increase.[2][3] In the period from Jan. 2016 to June 2018, Uptime Institute recorded 10 outages that were "extremely" serious- meaning they caused a very serious loss of revenue and posed an existential threat to the data center operator.[1] Three of these were a result of power failure. Costs on extremely large outages can be measured in the tens of millions.[1]

Primary casues of Ten big "category outages"	
IT Systems	3
Network	3
Power	3
Cooling	2

How CellSPY can mitigate battery related outages

Our Battery Monitoring and Management system provides real time Voltage, Temperature, Resistance, and Ripple Voltage readings for every single battery. Sampling rates can be as low as 100ms, except for resistance which is measured once daily, giving you complete visibility of your battery health. Additionally our configurable alarming gives operators peace of mind. Once alarm parameters are set, we can alert operators to system issues through modbus and snmp, or with more serious alarms, we can send sms or email alerts, further reducing risk of human error. Since the release of CellSPY in 2008, we have never had a customer experience a battery related outage with our system properly configured.

The Problem with Maintenance Programs

Aside from minimizing costs related to outages and battery life extension, our battery monitoring system is often able to pay for itself on maintenance cost reductions alone. Quarterly maintenance programs are expensive and prone to human error. Teams are sent to collect battery measurements to ensure there are no issues. But batteries can deteriorate significantly and fail in between maintenance checks. Individuals testing battery resistance can get wildly different measurements by taking measurements on different parts of the battery- and consistently measuring on the exact same location of every battery isn't feasible. When hundreds and thousands of batteries are tested by individuals, human error becomes a very real factor. Data derived from maintenance programs is therefore less plentiful, less reliable, and at a higher price point.

Extending Battery Longevity

Another significant savings point on our system is the increase in battery longevity. Factors such as charge voltage, temperature, ripple current all significantly impact battery life. With our system, customers have the data to ensure they are getting the most out of their system.

Charge Voltage

The most common natural failure for lead-acid batteries is positive plate corrosion. This factor is unavoidable but it is further accelerated when batteries are overcharged. Undercharging batteries on the other hand, is also harmful as it leads to diminished life due to sulfating, which damages the plates. Batteries with low voltage see reduced capacity due to self discharge phenomena.

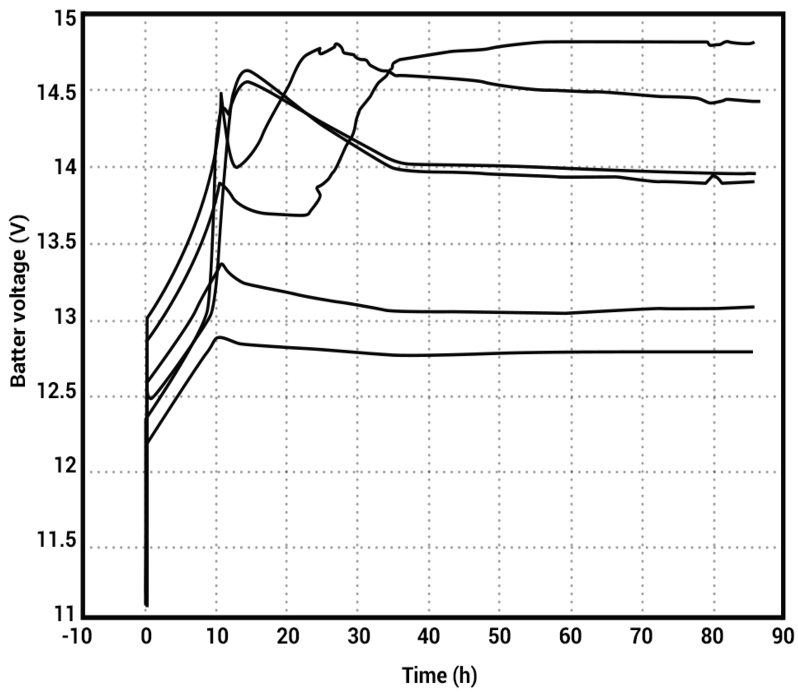
Individual cells within a battery string differ due to manufacturing variations, temperature gradients, aging effects, etc. As cells are charged and discharged, dissimilarities in voltage grow. Stronger cells will be continually overcharged, accelerating their positive plate corrosion and shortening life, while weaker cells will be continually undercharged, leading to sulfating and reduced capacity. This effect leads to rapid degradation of performance and even string failure.

The question naturally arises, is there a better way to fully charge all batteries within a string, without subjecting stronger cells to extended periods of overcharge? CellSPY's charge balancing feature was implemented with this in mind. The real goal is to match State of Charge (SOC) of all batteries in a string. For lead-acid cells in steady state, voltage matching on the order of 10 mV corresponds to SOC match on the order of 5%. So our equalization process ensures any cell-to-cell differences are under 10mV.[5]

The figure below illustrates a 72V string with no charge balancing in place.

FIGURE 02

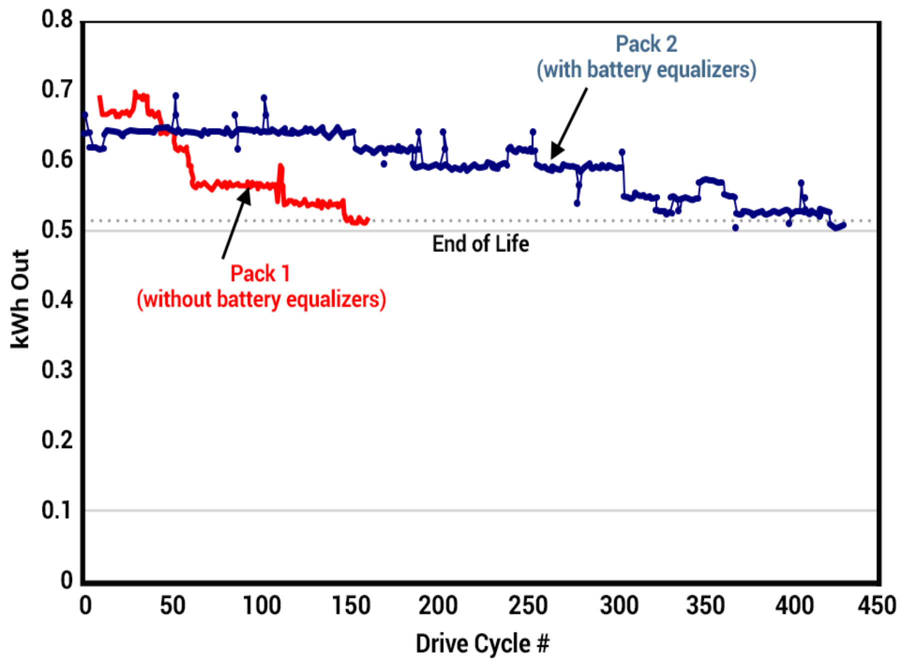
BEM09: 6 Batts. Charger (84V-Diode/1A)



As the charger pushes current through the string some cells will charge faster than others. Our battery monitors begin to draw current away from stronger cells, while allowing weaker cells to receive more charge. The result is less overcharging of strong cells and a better matched string.

The figure below examines the lifespan of two strings, one with charge balancing and one without.

FIGURE 03



With equalization in place, the second string of VRLA batteries accomplished at least 450 charge/discharge cycles. The first string which used only an equalization charge cycle reached only 140 cycles. It is evident from theory and practice, that charge balancing can help you get far more out your string than traditional methods. [4]

So in summary:

- With charge balancing in place, we can expect strings to show performance similar to individual cells.
- Failure modes associated with imbalance such as repeated undercharge of weak cells, leading to failure, are avoided
- Failure modes associated with repeated overcharge are diminished, increasing battery lifespan and reducing thermal runaway risk
- Increased interchangeability. Cells can be swapped out of strings as they go bad without introducing extra cell mismatch.

At least 4 independent published tests confirmed the performance benefits of voltage equalization, with the most modest group showing a 15% lifecycle improvement, despite less than optimal equalization technology in place on that group. Other studies showed lifecycle improvements to the degree of 3x. For more data on these studies see the papers [4][5] referenced in the appendix.

Temperature

The relationship between temperature and battery life has been extensively documented in academic literature. In fact, each degree C rise in battery temperature can decrease life due to grid corrosion by approximately 10% [6]. More conservative estimates place an 8.3C increase in temperature to reduce lead-acid battery life by around 50% or more.[4]

Our system provides the temperature at every battery post as well as collecting the ambient temperature to ensure that the batteries are being stored properly. If cabinets are not ventilated properly, certain batteries will be degraded at a faster rate than others due to differing temperature gradients. A single temperature sensor in a cabinet would not identify this issue.

In the case of temperature, CellSPY is able to provide data, but ultimately it is up to operators to act upon it and take corrective action to ensure they are getting more out for their batteries.

AC Ripple

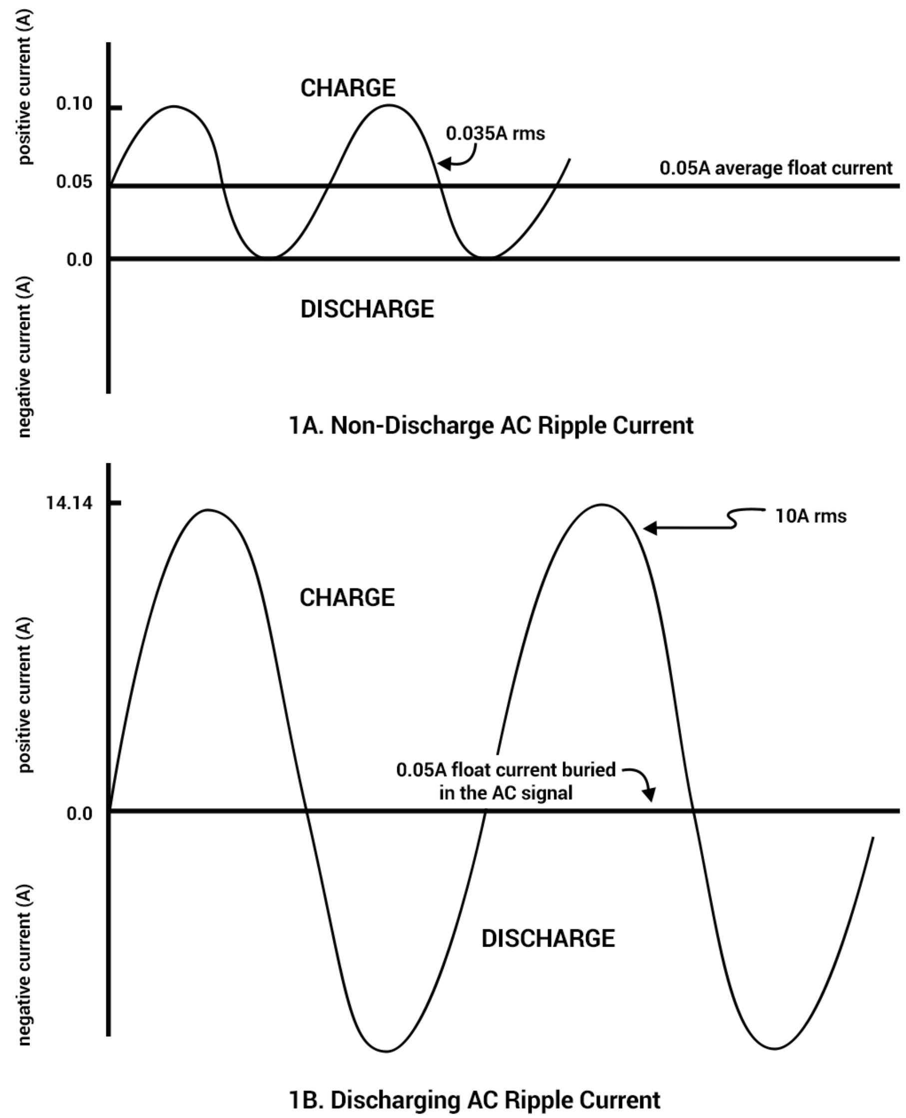
AC ripple can be characterized as one of two types- discharge and non-discharge.

Non-Discharge AC ripple is of low amplitude and affects battery life by raising battery temperature and increasing the rate of grid corrosion. IEEE recommends that the negative post temperature does not exceed the ambient temperature by more than 3C when AC signal is present.

Discharge AC ripple is more serious and occurs when the voltage and current are sufficiently great so that the superimposed ripple current goes both positive and negative. In essence this superimposed AC is cycling the battery at some rate defined by the AC signal. This has been referred to as “high-frequency shallow cycling”. On the charge cycle, the fully charged battery is further overcharged with virtually all the current going into parasitic processes such as hydrogen evolution and oxygen recombination. On the discharge cycle the current goes into reducing the battery SOC, by a small amount. The DC float may increase to compensate but the process continues. The result is a rapid walk down of capacity for the battery on float. This process likely stops around 60-70% SOC, where charge and discharge resistance are balanced. More laboratory testing is needed to fully understand the extent of High Frequency Shallow Discharging on battery lifetime.[6]

FIGURE 04

Examples of Non-Discharge and Discharge Ripple Currents



In conclusion, AC ripple can play a role in deteriorating battery health. By collecting AC ripple data, CellSPY can notify operators to issues with their chargers.

Conclusion

We understand that growing complexity in data centers has made operations more difficult to manage. That's why our system was built with operators in mind. From the easiest installation on the market, to incredibly intuitive software, we built a system that makes our customers' lives easier.

Outages are getting more expensive and our monitoring/management system identifies anomalies before they can snowball into problems. We don't take shortcuts. Everything is done utilizing the latest technologies and standards. Similarly, we don't make any claims that are not rigorously supported by data.

To conduct an ROI analysis for your business, download our ROI calculator and enter the relevant information. Our estimates on life extension use the most conservative numbers from this white paper. However, if batteries are kept in suboptimal temperatures, or if faulty chargers are being used, premature failure will occur despite our system being in place. We will be able to identify cells before they fail, but life extension will not match data from the calculator. In general, customers will see points in savings from: Reduced annualized battery cost, reduced annualized battery installation cost, reduced battery maintenance cost, and reduced outage cost.

For a more comprehensive analysis into your business's needs, contact one of our sales engineers at sales@emsys-design.com and we will be happy to help.

References

[1] Lawrence, A. (2018). Uptime Institute data shows outages are common, costly, and preventable, Uptime Institute.
[2] (2016). Cost of Data Center Outages, Ponemon Institute
[3] (2010). National Survey on Data Center Outages, Ponemon Institute.
[4] K Belmokhtar, H Ibrahim, Z Féger, M Ghandour. Charge Equalization Systems for Serial Valve Regulated Lead-Acid (VRLA) Connected Batteries in Hybrid Power Systems Applications. Energy Procedia, Vol. 99, Pages 277-284, 30 November 2016
[5] Krein, Philip & Balog, Robert. (2002). Life extension through charge equalization of lead-acid batteries. INTELEC, International Telecommunications Energy Conference (Proceedings). 516 - 523. 10.1109/INTLEC.2002
[6] R. F. Nelson and M. A. Kepros, "Ac ripple effects on VRLA batteries in float applications," in Battery Conf. Appl. Advances, Long Beach, CA, Jan. 1999.

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