CAN A LEAD ACID BATTERY USER ACHIEVE "GUARANTEED" BATTERY PERFORMANCE?

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INTRODUCTION

This paper will attempt to provide practical and useable answers to the question of achieving guaranteed battery performance as stated in the title. It's important to note that this paper is directed almost entirely toward the use of the Valve Regulated Lead Acid (VRLA) battery, although references to the Vented Lead Acid (VLA) or Flooded battery are made throughout.

This author has over 20 years of experience that includes purchasing, installing, operating, testing, and replacing lead acid batteries – primarily in the telecommunications environment. Please note that this paper does not cite any specific lab data or field data to prove the statements made herein, but instead relies on the user's observations and experiences to support the statements and conclusions. So the real intent of this paper is to relate key points and convey what I have learned and gained through experience, so that you, the user can use these "learnings" to your advantage.

GUARANTEED BATTERY PERFORMANCE

What do we mean by "guaranteed" battery performance? It is not possible to give a single answer for all lead acid batteries. Rather, we are able to offer a discrete answer for each battery type and application the battery is deployed into. Fundamentally speaking however, I would say that *guaranteed performance can be characterized by a battery system that delivers uninterrupted power throughout its designated service period, while maintaining at least 80% of its rated capacity*.

To begin with, let's understand the applications being discussed and the battery types being used for each.

- VLA-Flooded rectangular cells in float service - telecom application (very low cycling).
- AGM type VRLA cells in float service - telecom application (very low cycling)
- VLA-Flooded rectangular cells in short duration, deep discharge – quick recharge UPS standby application (moderate cycling)
- AGM type VRLA cells in short duration, deep discharge – quick recharge UPS standby application (moderate cycling)

USEABLE SERVICE LIFE

The useable service life of the battery means the duration of time by which the tested battery capacity remains at or above 80%. Cell capacity levels below 80% are considered a failed cell and would be covered under warranty by lead acid battery manufacturers.

What is the useable service life for these battery systems? Here is what you can realistically expect for lead acid battery *useable service life*:

1. Vented Lead Acid (Flooded) Batteries can achieve a 20 year useable service life in Telecom applications, and 9 to 15 years in UPS applications.
2. Valve Regulated Lead Acid (VRLA) Batteries can achieve 7 to 8 year useable service life in Telecom applications, and 2 to 5 years in UPS applications.

I believe my statement on service life expectancy for the VLA Battery pretty well agrees with what the typical manufacturer is communicating to their customers. However, my statement on the 7 to 8 year useable VRLA service life is definitely NOT what the manufacturers market to their customers (which are typically 10 to 20 years with some type of warranty to match those periods).

Alright, but suppose you don't accept this at face value. What then, is the basis for my stating that the VRLA useable service life in telecom float service application is but 7 to 8 years?

Answer #1: Twenty years of usage and calibrated load testing data on tens of thousands of cells, the results of which indicate that as a *battery system* (i.e. the entire battery string not the individual cell) we do not see greater than 80% tested capacity, for longer than 7 to 8 years.

Answer #2: Since the flooded battery will provide 20 years of service which we all know to be true, and since it's the same basic lead acid grid, paste, and electrochemistry, then how is it that I can't get more than 7 to 8 years with the VRLA battery service life? Yes it is the same basic electrochemistry, but the answer is really pretty simple and straightforward. The inherent design limitations of the VRLA prevent it from achieving significantly longer life, and here are some basic reasons why:

- VRLA batteries have ZERO excess water. This of course is why they are aptly referred to as the "Starved Electrolyte Battery". The electrolyte is almost entirely captured and absorbed into the glass mat separator between the plates – hence the term Absorbed Glass Mat (AGM). To illustrate what I mean, if you were to cut it open, turn it upside down, after an hour you might get as much as a teaspoon full of acid.
- VRLA batteries are steadily losing the electrolyte (water) that they have, simply because the basic recombinant chemical reaction is not 100% efficient and they will vent (off gas) through a pressure regulated valve. Hence the name Valve Regulated.
- This drying out of the plates causes capacity loss (much faster than their aqueous VLA counterparts).
- VRLA Grids are typically thinner and subject to mechanical failures sooner than the thicker grids found in their VLA counterparts.
- VRLA specific gravity is higher than VLA and consequently grid corrosion occurs at a faster rate.
- Pressure is required to maintain electrolyte contact with the battery plates, but is quite difficult to maintain over life of the battery.
- Heat dissipation is more difficult to manage and depends somewhat on all of the other factors remaining constant.

So this battery simply ages, loses capacity faster, and is more susceptible to early or sudden failures due to these various factors that depend on each other and which we cannot control. The frustrating part is that we just cannot see these variables at work like we can in the flooded battery.

The VRLA battery is really a pretty sensitive beast, not unlike an unruly teenager. They have been with us for a while, encountered some pressures, can't find a means to relieve it, the severity of their condition is not recognized soon enough, become unstable and likely cause's significant distress, if not tragedy.

Another analogy which maybe better characterizes how the VRLA battery compares to the VLA 20 year battery (considered the industry standard), is made by comparing two standard rectifier types. In similar fashion to how the VRLA battery has largely replaced the flooded battery in many applications over the past 20 years; the switch mode high frequency rectifier has largely replaced the ferro-resonant rectifiers, and now dominates the industry. So let's think look at the Controlled Ferro Resonant Rectifier as compared to the High Frequency Switch mode rectifier. Larger footprint versus smaller footprint; lower efficiency versus higher efficiency; lower energy density versus higher energy density; heavy, reliable, almost bulletproof versus light, sensitive, almost delicate and susceptible. I see this as exactly analogous to comparing the VLA and the VRLA battery. One is heavy, large, and very reliable, while the other is lighter, space efficient, sensitive and not as reliable.

Aside from service life, what else do I need to know about and consider? Let's review a few other key items such as: What is practical and useful in maintenance, monitoring and testing, what to expect from the battery and supplier, and what not to expect.

Let's start with some things that you *should expect*:

1. You should expect to enjoy 20 years (more or less) service life from your VLA rectangular flooded cell battery system in float service applications (i.e. like telecom).
2. You should expect to replace your VRLA battery system sooner than you planned.
3. If you have an Ohmic Value baseline agreement with the VRLA battery manufacturer, you should expect this value to differ greatly from that which you measure after the battery is placed in service. (This is one way the battery company uses to protect itself from the inaccuracies and variability of ohmic testing).

What you *should not expect*:

1. Don't expect a VRLA battery system (key word is system) to deliver / perform above 80% capacity for more than 7 to 8 years.
2. Don't expect maintenance or monitoring to extend your VRLA battery life. Once it has been put in service, there is NOTHING you can do to extend its service lifespan. But you might say to me, not so fast buddy, what about watering the battery? Well yes, you can add water and maybe a catalyst – and you work with that if you want. *But this is usually not well accepted by the manufacturer, intrusive to the battery, costs money, time, yields iffy results, and one never knows the right time to do it, or how long it will help, etc.* Also keep in mind this is really meant to help your battery REACH full service life (not to extend it).
3. Don't expect the Battery Supplier to exercise warranty coverage UNLESS you have ironclad language defining each performance parameter in your warranty contract. Otherwise – you are in for an expensive fight!

OK, so if you accept the statement that a 7 to 8 year service life is all you can achieve, then what must I do to guarantee that my VRLA battery "system" will reach the 7 to 8 year life?

CAN'T! There is nothing I can do to *absolutely* guarantee this. No amount of vigilance, monitoring, online checks, discharge tests, watering, catalysts, etc., can absolutely guarantee this.

So if I really can't guarantee performance, then why are we talking about this?? Because this is Battcon and this is why Battcon exists ☺. More to the point, because the general industry belief is that we can and we must achieve guaranteed performance. Anything less is unacceptable. The entire user community knows that it simply must do anything and everything possible to **ELIMINATE** any possibility of a service failure resulting from the battery system.

MAINTENANCE, MONITORING AND TESTING

What about non-invasive (online) maintenance? Come on now, with float voltage, float current, online ohmic measurements, temperature readings, automatic voltage temperature compensation, a perfect physical environment with good ventilation, 77°F temperatures, and clean ripple free battery charging (rectifiers), surely I can always know the condition of my battery right? Yes, I can get a very good read on the battery condition at that moment, but none of this can accurately predict the future of my battery. It cannot tell me how much life I have left, or what might be aging or what may be failing inside the battery, etc.

Well then what about remote monitoring? Surely this will help me determine the condition of my battery, and its future health right? At least that's what a lot of marketing indicates about the various monitoring products out there, so how about it? Well, not quite. Monitoring can only tell you at best, the same information that you obtain by manually taking those same online measurements described in the online maintenance paragraph above. The difference is monitoring does this remotely, BUT, monitoring cannot "SEE" the battery case expanding, cracking, or the post growing out of the jar, or "smell" the hydrogen sulfide gas venting during a slow developing thermal scenario. Monitoring does not really "see and know" the physical environment the battery is in, and the effects the environment may be causing.

What about Discharge Load Capacity Testing? Well yes, I could take the battery offline, and discharge test it using a calibrated load bank to irrefutably prove its actual available capacity at that point in time. That is the single most effective thing I can do, but from a user standpoint, this is also the most difficult thing to do, primarily because of the resources required. It's expensive (requires skilled personnel), time consuming, involves risk (live connections to the network), and even still, this does not *guarantee* me any certain amount of future battery performance or life. It does tell me exactly what capacity I have at that point in time, which is certainly the best indicator of battery health and aging that I can obtain.

What about Warranties? However long and iron clad your negotiated warranty with the battery manufacturer is, this does not prevent failure or guarantee performance. It simply provides you free replacement systems (hopefully) when yours fails.

With all that said, it should start to become clear that this discussion is really moving toward our industry's favorite adjective for insufficient budget funding: *Calculated Risk*. How much maintenance, monitoring and testing do I need to provide the battery reliability I can live with? Because battery systems and their fragility or susceptibility are poorly understood by management, the choice made (by management) is an economic decision that typically goes something like this: "We are only allocating X dollars for this, and that's all were going to get. Besides, that should be more than enough to minimize/eliminate any risk. Make it happen."

So now we are down to it. What methods can effectively and economically be used to "eliminate risk"?

It's all about banking on historical statistical data, combined with some amount of maintenance, or monitoring, or testing, or all three **–** in order to mitigate (effectively eliminate) the user's risk of a battery failure.

Battery Cell voltage, float current, temperature, mid string voltage measurements, etc. First, how are these measurements obtained? These measurements are easily taken online and are not very time consuming to perform. These measurements can be taken manually with hand held test equipment, or with an automatic monitoring system that provides remote visibility.

These measurements alone are not sufficient to define the battery condition. But, like in Ohmic testing, using historical experience and measurement statistics against the battery reference data has taught us what to expect, so we know something about these measured parameters. We know what values to expect when the battery is healthy, and we know approximately what the threshold values are to indicate the battery is in some degree of advanced age and / or trouble. But again, we cannot use this information to accurately predict what amount of future life the battery will deliver. We can only use the statistical knowledge and parameters that we expect to see in healthy batteries, to tell us that *everything points* to the battery being OK at that point in time.

Ohmic (online) Testing: How do you do this online measurement? You can buy a hand held test set and do it manually while the battery is operating (this is a non-invasive, almost benign measurement), or you can employ a monitoring system that does it for you.

Over the past twenty years, what have we learned about Ohmic testing of the VRLA battery? We have learned to argue with each other a great deal for hours and hours at every conference and forum, about conductance vs. resistance vs. impedance testing. In fact all three of these methods are successful in what they are designed to accomplish. But they do not measure capacity, they measure change. I will repeat: OHMIC TESTING DOES NOT MEASURE CAPACITY. IT MEASURES CHANGE!

Online Ohmic testing cannot measure every internal change occurring in the battery either. It simply measures a numerical change from an earlier measurement. That's it. It's imperfect but it has proven quite useful and has come to be considered the mainstay of VRLA online measurements. Over the years we have learned to track these changes, and have found that the magnitude of Ohmic change can be a rough indicator of cell capacity change. We can't say how much capacity exactly, because the Ohmic measurements DO NOT correlate directly to capacity measurements. But we can generally agree that something like a 30% to 40% Ohmic change is roughly equivalent to a 20% capacity change , or something similar to that. Whatever that number is, ultimately depends on what you negotiate in your warranty contract with the battery manufacturer you are doing business with.

But what about predicting future capacity and remaining life? Does this Online Ohmic test do that? NOPE. Ok then what's the use beyond warranty criteria? By knowing and accepting that you have a finite life to begin with (7 to 8 years), if one determines to religiously perform this type of online Ohmic testing on a frequent enough basis, then by tracking the changes over time, the pattern established can provide the user with a reasonable indication of the battery degradation and aging profile. With this you can make educated judgments on its current condition and remaining future life (that is if it doesn't suddenly fail somewhere along the way).

But even with these online measurements and with load capacity testing, there is still no way around the fact that some internal mechanisms and aging processes inside the VRLA battery cannot be seen or known through these measurements. So what to do?

What you can do is one of, a combination of, or all of, these online and offline measurements and tests, at a frequency often enough to satisfy *your definition of guaranteed performance*. To determine what that should be, let's examine what various user groups have done and what kind of results they get. In my career I have seen all of the following:

Some users do absolutely nothing (expend no effort to inspect, maintain or monitor) and expect the battery to last 10 years or longer (because supplier said it would). Most often this type of user is surprised with sudden unexpected battery failures accompanied by loss of service. An even worse case is loss of service due to a battery thermal runaway type of event which has proven to damage equipment and is extremely dangerous to humans.

Some users do absolutely nothing (expend no effort to inspect, maintain, or monitor), and proactively replace the VRLA battery on a 3 to 4 year schedule and they count on that replacement interval to provide them "guaranteed performance". These users cannot entirely avoid failures but they count on the short replacement interval.

Some user groups spare no expense or effort to inspect, maintain, monitor, and test their VRLA battery systems by hiring this work out – often times without knowing the quality of vigilance they are paying for. They even have remote monitoring programs in place (except the person or people on the remote end don't understand well enough what data they are reading). Often these users may get frustrated with the resource and economic expenditures when they realize they have NOT elongated the battery life and have occasionally suffered early and sudden failures despite all these efforts.

RECOMMENDATIONS

So what is the best or right thing to do? My answer is *always using a flooded battery product* whenever it's possible. But in the majority of today's applications, this is simply not practical or possible. Therefore, a combination of basic things starting with:

1. NEVER EVER rely on a single VRLA battery string. Always deploy at least Two VRLA battery strings in parallel to provide whatever your specified capacity requirement is.
2. Ensure the physical environment has proper ventilation, and temperature control.
3. Ensure the battery charger /rectifier is set to the correct float charge voltage and has a "clean" output.
4. Ensure that you initialize/install the battery system in accordance with the manufacturer's requirements. Note that most VRLA batteries do not require initialization if they are put in before a specified time frame or if the open circuit voltage is above a specified level.
5. During installation, ensure you measure and verify the battery intercell connections are exactly where they should be.
6. Using a calibrated load, discharge capacity test the battery system within 30 to 120 days of installation.

The importance of these fundamental 6 items cannot be overstated. This provides the user a very high degree of confidence. The user now knows that one battery string will not take his service down. The user knows that nothing has been left to chance on the quality of the initialization and installation and all baseline measurements are valid. The user knows the true condition of his battery systems within 6 months of the installation. Accomplishing this greatly increases the probability for your battery systems to perform to their full expected service life duration.

7. Perform inspections, perform online Ohmic testing, float voltage measurements, float current measurements, temperature measurements, and offline discharge testing through maintenance and/or monitoring to the degree you can afford to do so. **Do No Less Than:** monthly inspections; annual online measurements; and offline discharge testing once every 3 years (or sooner).

Accomplishing the routines specified in the item 7 paragraph above, gives the user the best possible guarantee. The user can expect the VRLA battery system to perform through its expected service life, OR, he will be warned ahead of an early battery failure. Of course there can be exceptions and that is why there is no TRUE ABSOLUTE guarantee. However, controlling the environment and accomplishing steps 1 to 7 gives the user a **virtual guarantee** to reach end of life without mishap, and gives the user the best chance of being warned ahead of an impending failure so he can take necessary actions before such would occur.

How much of everything listed in item 7 should a user consider to be prudent and enough? My recommendation is monthly inspections using a skilled and a practiced eye along with temperature and float current measurements. Annual Ohmic testing (which automatically includes cell voltage measurements), and discharge load capacity testing every 3 years. In my experience, this practice has proven effective and I have yet to lose service to a battery failure when following this. I have also replaced my VRLA battery systems on a 6 to 7 year interval. If you say to me, but this is a drastic amount of work, then I would agree with you. Yes it is, although the monthly and annual Ohmic readings are very easily and quickly done. But the load capacity testing is most important and is most resource intensive!

Would I consider a monitoring system? Maybe, although I basically think of it as an add-on. In my view, the choice for or against monitoring all depends on logistics and site specific situations. For some users this could become very fundamental to your battery vigilance program. Others may not benefit or need it at all.

SUMMARY AND CONCLUSIONS

Over the past twenty something years, these three questions continue to haunt the Telecom user:

(1) Can I maintain my VRLA Battery?
(2) Can I determine its condition and remaining service life at any given point in time?
(3) Will a remote monitoring system for my VRLA battery justify the investment?

As I alluded to throughout the paper, there are really no absolute answers. I could answer No, No, and No and make arguments as I have in this paper, but that is not the end of the story. The end of the story and the real answer for “Can I guarantee battery performance?” is:

If my battery service life expectations are realistic, and if I perform the basic installation requirements to set a baseline, and I maintain vigilance and periodic testing of my battery, then I can be as sure as one can be of reliable service. Is this a guarantee? Maybe not in the truest sense of the word, but ***Yes, the user knows what he has put into this battery and also knows what he will get out of it. In my language, this is a definitive guarantee of reliable performance.***

Oh yeah, that nagging question: What is the price for all of this? As a user, the price doesn’t matter, or shouldn’t matter. At whatever cost to me, it is a drop in the ocean compared to a loss of service due to a preventable battery failure.