What would you do if you found pallets of VRLA batteries in your warehouse that had manufacturing dates of 3.5 years ago, and never been charged?

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Abstract
What would you do if you discovered thousands of dollars or hundreds of thousands of dollars' worth of brand new 2 volt VRLA batteries in your warehouse that were 3 – 4 years old and never had been unpacked or freshen charged? These could be in the warehouse of a company that your company just acquired, or possibly they could have been for a project that got backed off for many years and forgotten, or for whatever reason.

Would you (1) Call the recycler? or (2) Call the manufacturer? or (3) Attempt to use them? If you chose # 1, you just threw that money away for your company. The correct answer is a combination of 2 and 3. Of course, if they were vented lead acid cells, # 1 would be correct. In reality, most people would choose # 1 and, in their mind, think they were doing the correct thing for their company.

This paper will show how VRLA batteries that have been "lost" and then "found" many years later can be recovered back into useful cells that will deliver 100% of their rated capacity when tested, and how one user has reported on successful 10 years of performance from "lost" battery strings.

Introduction
As everyone who has been in the stationary battery industry well understands, be it manufacturers, designers, installers, or users, there is a limit to the amount of time that you are allowed to let a lead acid battery set without being given a freshening charge after it has been shipped. Typically, this has been in the 6 month range. There are, of course, variances to that time frame, but normally 6 months is the magic number if you want the manufacturer to honor their warranty. Most manufacturers will allow you some leeway with that time frame but not a lot of time. And rightly so, as they do not have the data to prove that their products will withstand extended storage times or the conditions that the batteries are stored in.

We are going to tell you a story about one such occurrence, where a user discovered a pallet of batteries in their warehouse that had been lost in their records, as well as out of sight and out of mind. No one presently at the facility knew just why this pallet was purchased, even though they are the same model as four of the sixteen strings at this facility. The majority of the batteries at this facility are sixty cell (120 volt) systems used for protection and control. The facility is a gas fueled peaking plant site with multiple units.

It was a fluke that I was visiting that plant for the first time and, during discussions with the person responsible for their battery systems, along with most of the other equipment there, it was brought up that they had found this pallet of batteries and did not know what to do, since they were all date coded 08-2010. Our company had previously brought 2 volt VRLA batteries back to useful service that were two years old, but never more than that. I offered to take two cells (there are two cells in each metal can) back with me to experiment with, to see if they would recover or not. Luckily, these are rather small cells, the EnerSys model DDm 50-13, and only weigh about 100 pounds, so we put them in the back of my car and I went off on my rounds. I made no promises and did not hold out a lot of hope, but the user had nothing to lose, as this was going to be my experiment on my dime.

Historic and educational

As most will recall, VRLA batteries started off in a less than spectacular way, or actually some could say that the beginning years were, in fact, quite spectacular with the various reasons for early life failures, and PCL (premature capacity loss), as well as some of the failures were quite enlightening (get it? – enlightening!!!).

That was then and this is now. As with any new technology, there was a lot more to it than first met the designer's eyes, and they suffered through one design flaw and learning curve after another until the technology was finally understood well enough to really provide a useful and reliable life. As a modern comparison, one just needs to look at the issues that another battery technology is going through at the present time. Tremendous energy densities, but occasionally there are failures, and they are even more catastrophic and enlightening. But I am sure that over time they will understand and correct the issues that are causing their sudden and violent failures. And then they can spend the next 20 years trying to get users to forget the old designs that were not mature and to instead think about the good benefits of the technology.

All reputable manufacturers will honor their written warranties if the battery cells receive a freshening charge within 6 months of shipment, but will balk at cells that have been setting longer than that. This is obviously the correct position for them to take, as they will have no idea how severely self-discharge will have impacted the cells. There are some manufacturers that are extending that "shelf life" part of their warranty for some of their VRLA models. No one that I know of would expect that batteries that had been off charge for 3 years or longer would be of any use. However, in this paper you will see that it is indeed quite easy to recover 2 volt VRLA AGM cells from a number of manufacturers. Just how long that period is and what is required to accomplish a recovery will surely depend upon the condition of the cell/s at the time of the recovery attempt, and the manufacturer.

In case anyone thinks that this experiment is ground breaking, you are incorrect. This is not new news and surely all manufacturers know of this recovery capability, as they all participate in INTELEC and INFOBAT, as well as at this conference. Back at INTELEC 2002, Robert Szasz (1) first reported on AT&T Canada's experiment with recovering 40 battery strings that were all between 3 and 4 years old which had become acquired during a recent company merger in 2001. Thirty of the strings had been manufactured in 1997 and received a boost charge at some time within their first year in storage, and ten were manufactured in 1998 and had no records of any charging during their storage for up until their discovery in 2001. At INFOBAT 2003 (2), he reported on the continued improvement in the strings at approximately twenty-four months of service at the twenty-two sites where these battery strings were deployed. He reported that they calculated a savings of $294,944 by recovering these strings instead of purchasing new. At INFOBATT 2005 (3), he again reported on continued improvement after four years in service with these strings with before and after boost charging and before and after water additions and/or catalyst additions. All of these batteries performed well during the August 14, 2003 blackout, with no strings failing during the outage. And, last but not least, at this conference in 2011, he reported on their success in the usage of those cells 10 years after they had initially been found after setting off charge at between 3 and 4 years. The cells were 14 years old and in service successfully!

Smile for the camera

The following picture shows the two cell can that we performed the recovery process on. As can be observed, they look just like any newly manufactured cells, with the only difference being the date codes. This recovery occurred in February 2014 and the cells were date coded August 2010. This is 42 months for those monthly challenged. Three and a half years of setting off charge in a warehouse in Florida! This was going to be an interesting experiment with nothing to lose but a little time, and knowledge to be gained.

As can be seen, they look brand new and in no way damaged or deformed.

Procedure for recovery

The following is the general procedure that anyone can follow if they attempt to do this on their own, but they might want to keep the individual cell voltage limited to 2.5 volts at standard temperature. As can be seen, it is not too complicated. With these cells, there was no need for any rehydration of any kind. We did, however, add a catalyst following the testing in order to maintain the recovered capacity.

The procedure utilized for recovery of the cells that we experimented on differs slightly from the respective procedures that the respective manufacturers' used for the recovery processes for the Robert Szasz project. What the process was that each manufacturer used was dependent upon which manufacturer was performing the recovery attempt on their own cells. One used a high rate charge, which was a combination of constant voltage and then constant current charging, with the addition of water, and then the addition of a catalyst as a final step, and the other used initial high rate charging and then later additions of water. Based upon our initial findings with these two cells, we determined that no water addition was needed at this time. As you will see, we did high rate charge the cells to gain the initial recovery and then, to maintain that recovery, we installed catalysts in the cells. At this time, we have no idea if at some point in the future there may or may not be a need for water additions to obtain the maximum life and performance, but we do know that these cells are performing just like brand new ones, and that is news to most users.

Battery Research procedure used for this successful recovery attempt:

Step 1. Measure and record individual cell values. This is to determine the depth of self-discharge (SG), and to establish a baseline set of values for measuring the success of the recovery process. These baseline values are not to be confused with the baseline values that are established on a new string after a few months in service, as recommended in IEEE 1188. The values in this process are only for observing the changes from the beginning to the end during this recovery process.

Step 2. Connect a battery charger that will provide at least a C/20 charge current and that will be able to reach 2.40 VPC at standard temperature. Set the voltage per cell on the charger at 2.40 VPC (or slightly higher) at standard temperature and commence charging and start timing the charge process. It really is not important if the cell voltages are 2.4 or 2.7, but between 2.4 and 2.5 is where we like to see them.

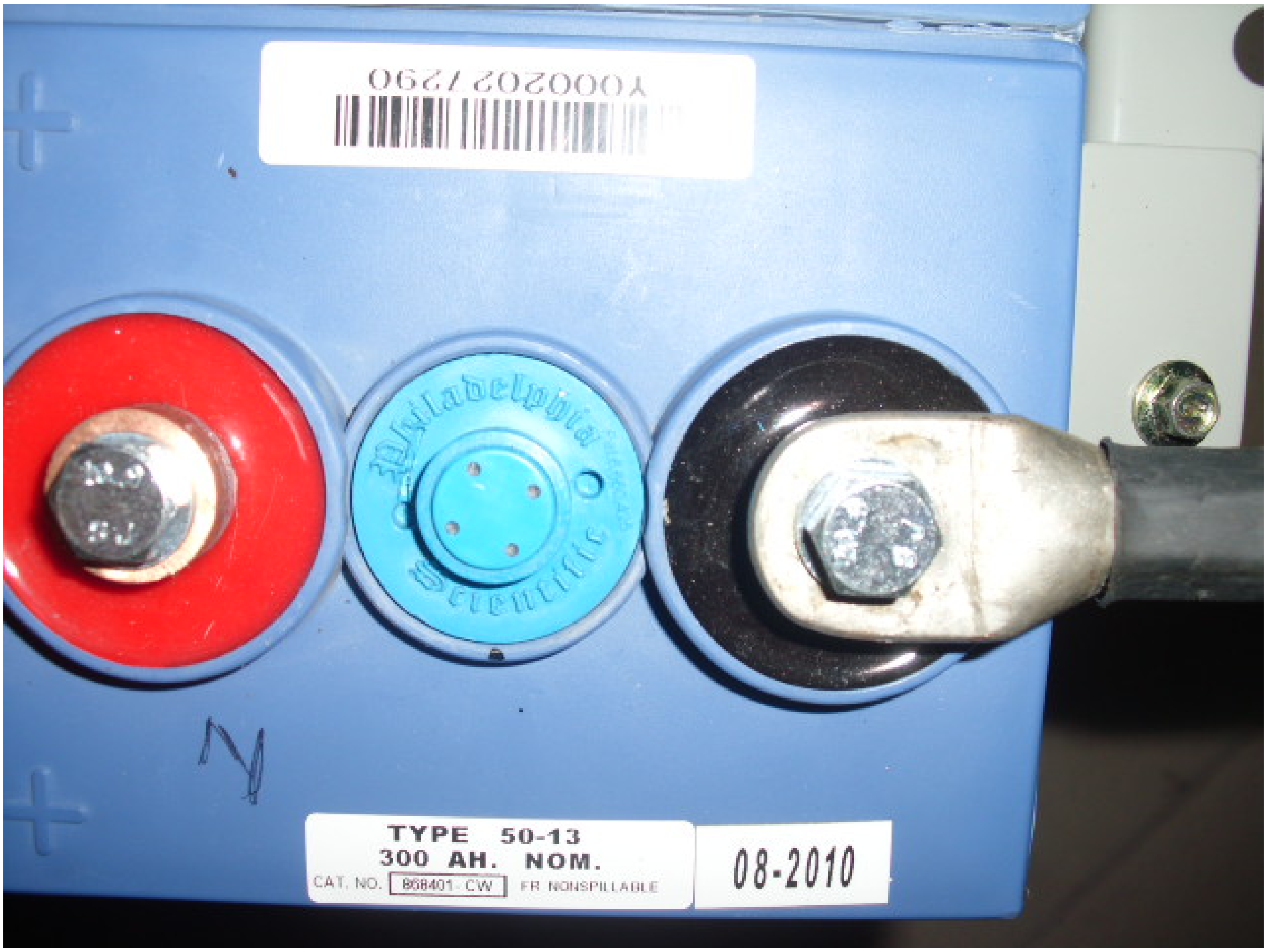
Step 3. Monitor the cell voltage, charging current and cell temperatures throughout the charging process. This could be as infrequently as every 12 hours or as frequently as every three hours. You need to use some common sense with this, as your goal is to recharge the cells, and drive any sulfates off of the plates, but not to cook the cells. The goal also is to get each cell to 2.40 VPC and to get the current going through the cells to less than 0.10 ampere per 100AH at the 8 hour rate (300AH = 0.30 ampere). If the cell temperature rises to above 37.8°C (100°F), pause the charging, let the cells cool until within 5 degrees of the normal ambient temperature, and then re-commence the boost charging of the cells.

Step 4. The amount of time required cannot be determined ahead of time; you must observe the average cell voltage and charge current. Our first charging attempt took 110 hours (we then ran a discharge test at the published one hour rate to 1.75 VPC), while the second charge only required a little over 50 hours.

Step 5. Return the voltage to the correct manufacturers recommended value for the ambient temperature, wait a minimum of three days and record the cells values. Your cells are now ready for a capacity test. You obviously need to fully recharge the cells after each discharge test, as everyone understands, so I will not go into that here.

Suffice to say that for cells to repeat their performance in subsequent capacity or discharge tests, they must be fully recharged. Also, it should be understood that many VRLA batteries will benefit from an annual equalize charge, but they must be monitored during that activity and, if they have failed a capacity test, they will benefit from a Special Recovery Process as listed in the IEEE 1188a-2014, in Section 5.3.3. IEEE 1188a-2014 is Amendment 1: Updated VRLA Maintenance Considerations, to IEEE 1188-2005. This process is not listed in any previous IEEE 1188 publications.

The following is a picture of cell 1 after the recovery process and with the catalyst equipped vent installed.



Capacity test results

The following are charts and graphs that show the results of two discharge tests on each of the two cells. Each test was run at the full published one hour rate (60 minutes) of 169 amps to an end voltage of 1.75 volts, and the results were time corrected for the initial cell temperature per the IEEE 1188 standard. We ran two discharge tests on each cell. The first discharge test was run within twenty-four hours of the cells coming off their high rate charge. The second discharge test the cells had been on float at 2.25 volts for seven days.

The initial cell temperatures for the cells for test one was 19.44°C (67°F) and for test two discharge tests the initial cell temperatures was 22.78°C (73°F).

Discharge Test 1, Cell 1				Discharge Test 1, Cell 2		
TIME	**VOLTS**	**AMPS**		**TIME**	**VOLTS**	**AMPS**
0	2.198	000.0		0	2.187	000.0
5	1.957	169.6		5	1.962	170.5
10	1.952	171.2		10	1.957	167.4
15	1.941	163.5		15	1.942	179.0
20	1.929	165.3		20	1.941	167.2
25	1.916	164.1		25	1.931	167.4
30	1.903	162.8		30	1.922	166.5
35	1.890	161.5		35	1.905	169.5
40	1.870	159.7		40	1.891	167.8
45	1.956	166.8		45	1.878	167.0
50	1.843	164.7		50	1.858	170.8
55	1.825	165.2		55	1.837	171.2
60	1.807	163.4		60	1.819	170.5
65	1.784	161.3		65	1.799	168.3
70	1.759	158.4		70	1.769	166.4
72	1.750	157.5		74	1.750	165.6
	AVG. AMPS 163.67				**AVG. AMPS 169.0**	

To say that these were pleasant surprises would indeed be an understatement.

Cell 1 performed at 128% of its rated capacity at the one hour rate using the time correction calculation for the IEEE 1188 Standard. Cell 2 performed at 131% of its rated capacity at the one hour rate using the time correction calculation for the IEEE 1188 Standard.

This was indeed puzzling, as the cells had sat off charge for less than 24 hours. Both the IEEE 450 and the IEEE 1188 state that the battery (cells) being discharge tested must be off of equalize for at least 72 hours. Normally, the intent is that the cells will have come off of an equalize charge and been put on charge at the recommended float voltage value.

We then placed the cells back onto a boost recharge, followed by seven days of float, and repeated the experiment. The following is the report on the second discharge test. The initial temperature of the cells for the second test was 22.8°C (73°F).

Discharge Test 2, Cell 1

TIME	VOLTS	AMPS
0	2.219	000.0
5	1.986	173.3
10	1.979	172.1
15	1.969	171.9
20	1.959	171.2
25	1.949	170.1
30	1.937	169.3
35	1.925	168.1
40	1.912	167.0
45	1.892	172.2
50	1.877	170.9
55	1.860	169.1
60	1.843	167.4
65	1.825	167.3
70	1.793	172.9
75	1.771	169.4
78	1.750	167.2
	AVG. AMPS 169.96	

Discharge Test 2, Cell 2

TIME	VOLTS	AMPS
0	2.198	000.0
5	1.977	169.1
10	1.970	167.4
15	1.957	172.3
20	1.948	171.4
25	1.937	169.0
30	1.912	174.6
35	1.900	173.2
40	1.898	166.4
45	1.876	170.7
50	1.867	169.1
55	1.842	168.7
60	1.822	167.2
65	1.799	168.2
70	1.767	171.0
72	1.750	169.1
	AVG. AMPS 169.83	

Cell 1 performed at 133% of its rated capacity at the one hour rate using the time correction calculation for the IEEE 1188 Standard. Cell 2 performed at 123% of its rated capacity at the one hour rate using the time correction calculation for the IEEE 1188 Standard.

Conclusions

As everyone knows, no one can make a battery recover that is internally or externally damaged, so it makes sense that these cells have not fallen apart internally, or become so severely sulfated that those sulfates could not be driven back into solution with this charging procedure. Exactly why these VRLA cells from EnerSys and the ones from C&D and from GNB that Robert Szasz recovered years ago is beyond the scope of this experiment. We did not initially nor do we now care about why they can do this. What we do care about is that we have proven that present day VRLA 2 volt cells are much more robust and forgiving than their vented brethren, as I do not believe that any VLA cells will withstand this type of abuse. For users, this proof should give them the knowledge that, if for any reason, they happen to discover some very old 2 volt VRLA cells that got "lost" for whatever reason, that they just might be able to recover that asset. After all, Robert Szasz demonstrated that he saved his company almost $300,000 and that he still had functioning battery systems 10 years after the recovery processes. You could, too.

Since this experiment was just that, AN EXPERIMENT, with no foregone conclusions, these results should be an eye opener for a number of people, plus be a confirmation that VRLA cells have come a long way since their initial introductions a long time ago, and that their ability to withstand abuse far exceeds vented cells.

References

1. Szasz, Robert, "Bringing Back to Life an AT&T Canada Venture." Proceedings of INTELEC 2002 PAPER 32.2.
2. Szasz, Robert, "VRLA Boosted Batteries: An Allstream Experience." Infobatt2003-Toronto.
3. Szasz, Robert, "Report on Results of 2003 and 2004 Presentations of VRLA Boosted Batteries and Remote Battery Monitoring Respectively." Infobatt2005-Toronto.
4. Szasz, Robert, "VRLA Boosted Batteries – 10 Years Later: An MTS Allstream Success Story." Battcon 2011.