FIELD EXPERIENCE, CAPACITY TESTING OF GNB ABSOLYTE BATTERIES, PRE AND POST REHYDRATION

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INTRODUCTION

While it is understood that there are two basic valve-regulated lead acid (VRLA) designs, which are absorbed glass mat, often referred to as AGM, and gelled electrolyte which is referred to as gelled, this paper will concern itself with the AGM design cells, as that is the type that has the largest installed base in the larger (over 200AH) cells. The batteries in this study are all manufactured by GNB, at least 6 years old when the study was started, and are of the 75 amps per positive series (75A21, 75A23, and 75A25).

VRLA batteries have become the dominant battery of choice in applications that require co-location of the battery system with the electronic equipment, and often personnel. There are a variety of reasons this has occurred, some of these reasons are valid, some are misunderstanding of the batteries true requirements (both maintenance and environmental), and some are just marketing hype.

Some of the valid reasons are:

- The lack of ability to install a separate battery room with outside ventilation capabilities.
- The lack of acid confinement ability.
- The distance from the battery room to the load.
- Code requirements.
- Lack of available floor space to install a vented battery system.
- Power density per cube.

Some of the misunderstandings, that have led users to installing VRLA batteries are:

- They require less maintenance than vented cells.
- They off gas less than vented cells.
- They will fulfill any need in any situation.
- They can be installed just about anywhere in any configuration.
- Are able to perform in any environment.
- Can be relied on to perform as specified if the user only follows the manufacturer's equirements.

The VRLA marketing hype includes:

- The battery is maintenance free.
- Can be used in all applications.
- Has the same life as a vented battery (20 year life).
- Is as reliable as the vented battery.
- Able to leap tall buildings.

History has shown us that the VRLA battery has:

- More premature failures.
- More catastrophic failures.
- More capacity test failures.
- Less reliability than their vented counterparts.
- The need for more monitoring than it's vented counterpart.

Many of these problems could be avoided if the users would perform maintenance checks that included internal ohmic measurements.

In this paper we are going to demonstrate a correlation between internal ohmic measurements and cell capacity, and how water additions affect both. Notice that I am not saying that internal ohmic measurements will predict exact capacity, but we will demonstrate that these measurements will show the user when capacity degradation has occurred, and will show which cells are problem cells. In addition, we will show that on charge voltage readings, are almost useless in determining the cell's condition.

MANUFACTURER'S PUBLISHED CHARGING AND MAINTENANCE REQUIREMENTS

CHARGING

Float voltage.	2.23 to 2.27 VPC at 77 degrees F.
Equalize voltage.	2.30 to 2.35 VPC when any cell is below 2.18 volts, or the float voltage range within the string is greater than 0.10 volt

MAINTENANCE REQUIREMENTS

Every 12 months read and record the following.

1. Individual cell voltages
2. Battery terminal voltages
3. Ambient temperature

It is stated that quarterly readings are desirable.

I commend the battery manufacturer for stating that quarterly readings are desirable, and the above requirements may give the user a warm and fuzzy feeling, but they do ABSOLUTELY NOTHING to assure the user of an operable system. These requirements leave out the one check that can alert the user to impending problems. That one check is the measuring the internal ohmic values.

The IEEE 1188-1996 standard, which is the IEEE Recommended Practice for Maintenance, Testing, and Replacement of Valve-Regulated Lead-Acid (VRLA) Batteries for Stationary Applications, recommends that internal ohmic measurements be performed every quarter. This specific requirement was placed in the 1188 document so that the user would have adequate time to detect the changes that occur when a cell is degrading internally, prior to failure, without having to frequently load test.

In all of our testing, in absolutely no case did the float voltage indicate any sign of a problem, whereas the capacity tests discovered cells that had capacities as low as 3 %, and as high as over 106%. The float voltage of all the cells was between 2.23 and 2.29 volts per cell, with the majority between 2.24 and 2.26 volts. The oldest of these strings was 7 years old when this study was started, and all had been in climate controlled telecommunications environments, and charging systems.

CASE STUDIES

To demonstrate the value of re-hydration and internal ohmic measurements, there will be 3 case studies illustrated. The string capacities when initially tested had ranged from a low of 24% to a high of 41%. At the completion of both mass and selective re-hydration, all of the string capacities had increased substantially, with a final high range of 91% to 106%

All of the case studies are 48 volt systems. Two of the systems are comprised of one 24 cell string, and one of the systems is comprised of two 24 cell strings.

TEST PROCEDURES

The internal ohmic values were measured using both impedance and resistance methods. These gave us different values, but they both tracked capacity accurately.

We initially inspected these systems including taking internal ohmic measurements, and then followed with a load test. The load tests were all performed on line without taking the batteries out of service. This was accomplished by adding load to the existing site load, to arrive at a rate that was the manufacturer's temperature compensated published rate for the particular model battery. It was agreed that this was the safest and most economical way to perform these tests, while still providing adequate protection for the site.

These test sites were chosen to determine if the addition of water would improve the performance of the battery strings. Until this time, battery systems had been replaced based on performance during discharge test results and site load requirements. Until the user implemented the use of internal ohmic measurements, they had been load testing batteries based on a predetermined schedule which was based on age, and had no real idea of the condition of the site until they load tested it. Once they started using internal ohmic measurements, they were able to decide which sites were really in need of load testing.

When it was discovered that there was a possibility that cells that had failed their capacity tests could possibly be salvaged, by the addition of water, the decision was made to proceed with a program of water addition and testing to determine if this in reality was a viable program.

TEST SITES

The three sites chosen had all been capacity tested in the fall of 1994, all had failed. The first site consisted of two strings of 75A25 cells, the second site was a single string of 75A21 cells, and the third site was a single string of 75A23 cells.

REHYDRATION PROCEDURE

The rehydration procedure per GNB is to remove the valve, listen for a release of pressure, and add the predetermined amount of distilled water.

GNB visited each site and added a specific amount of water to each cell, based upon the model. Following this water addition the cells were placed on equalize for 24 hours. Approximately one week later we again measured internal ohmic values, and performed capacity tests. The figures show the improvements. Site one went from 41% to 81%, site two went from 26% to 91%, and site three went from 24% to 96%. In all of these sites, as can be seen from the graphs, the internal ohmic values dropped substantially.

At site one, which was the main test site, GNB returned within two weeks, and at the direction of the customer, added still more water to cells that were selected by the customer. In some cases this was 800 mili-liters, in addition to the original 470 mili-liters.

Following this additional watering and a wait of 5 days, the site was again load tested. This time the capacity was 105% of it's rated capacity. This was an increase of over 150% above it's initial test. To determine whether the capacity was coming from the water addition, or the cycling, we ran an additional load test approximately one week later, without adding any additional water to any cells. The battery performed at 106% of it's rating. This 1% increase we attribute to the discharging and recharging.

No further action was taken at this site until 12/96 when this site was again inspected, and it was discovered that the internal ohmic values were increasing. During 3/97 the site was again inspected and load tested. From graph 1 you can see that the internal ohmic values have increased, and the capacity has dropped to 74%.

In graph 2 are shown the internal ohmic values of all the cells in string B of site 1, as they were measured, over time. It is easy to see that as water was added, the internal ohmic measurements decreased. It is also easy to see that as they increased the capacity dropped.

Graph 3 is the second site, which was a single string of 75A21 cells. These cells had an average internal value of 856 microhms in 8/94 and capacity tested at 26% of their rated capacity. These cells also were watered by GNB. In 3/95 the internal cell values averaged 394 microhms and the system made 96% of it's rated capacity. This increase in capacity was predicted by it's internal ohmic values. In 2/97 we again inspected and load tested this system. The internal values increased to an average of 549 microhms, and when load tested the system performed at 50% of it's rated capacity.

Graph 4 shows the changes in internal ohmic values through the years. Again it is easy to see the changes as the cells were rehydrated, and then as they again began to dry out.

Graph 5 is the third site, which is a single string of 75A23 cells. These cells had an average internal ohmic value of 649 microhms in 8/94 and capacity tested at 24% of their rated capacity. Following GNB's water addition, the capacity rose to 96% and the internal values dropped to 373 microhms. In 3/97 the internal values had risen to an average of 492 microhms, and the capacity had fallen to 76%.

Graph 6 shows the changes in internal ohmic values of this system, and as with the other strings, the changes can be easily identified.

CONCLUSION

In all the cells, the internal ohmic values predicted the general condition and capacity of the cells. In none of the cells did the cell voltages give any indication of the capacity or performance capability of the cells. This was only predicted by the internal ohmic values. In no case did any cell have an acceptable internal ohmic reading and perform poorly. In all cases, a cell that had a high internal ohmic value performed poorly.

The addition of water to GNB Absolyte batteries based on model only will restore some capacity, but will not restore all available lost capacity. In some cases, it required substantial additional water to bring some of the cells back to full capacity. The only way to restore all available capacity is to add water based on internal ohmic values.

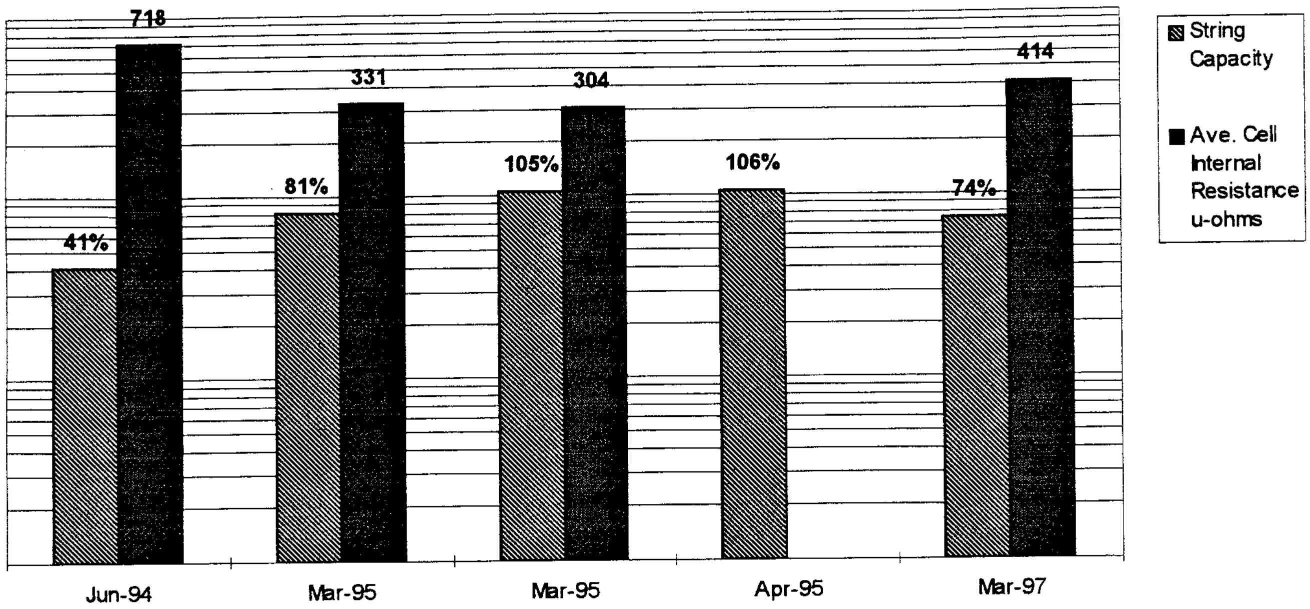
Following the addition of water to the cells, we have observed some cells become leakers, and for some cells to exhibit abnormal positive plate growth. This is not in all cases, but in enough, that we are re-evaluating the long term benefit of rehydration, which we at one time thought was a solution to the main problem with these cells.

We presently continue to add water to cells in situations where the user needs to be protected, but we no longer believe that rehydration is a permanent solution, but rather a short term one. These cells need to be inspected on a continued basis, as the cells may continue to dry out or change internally.

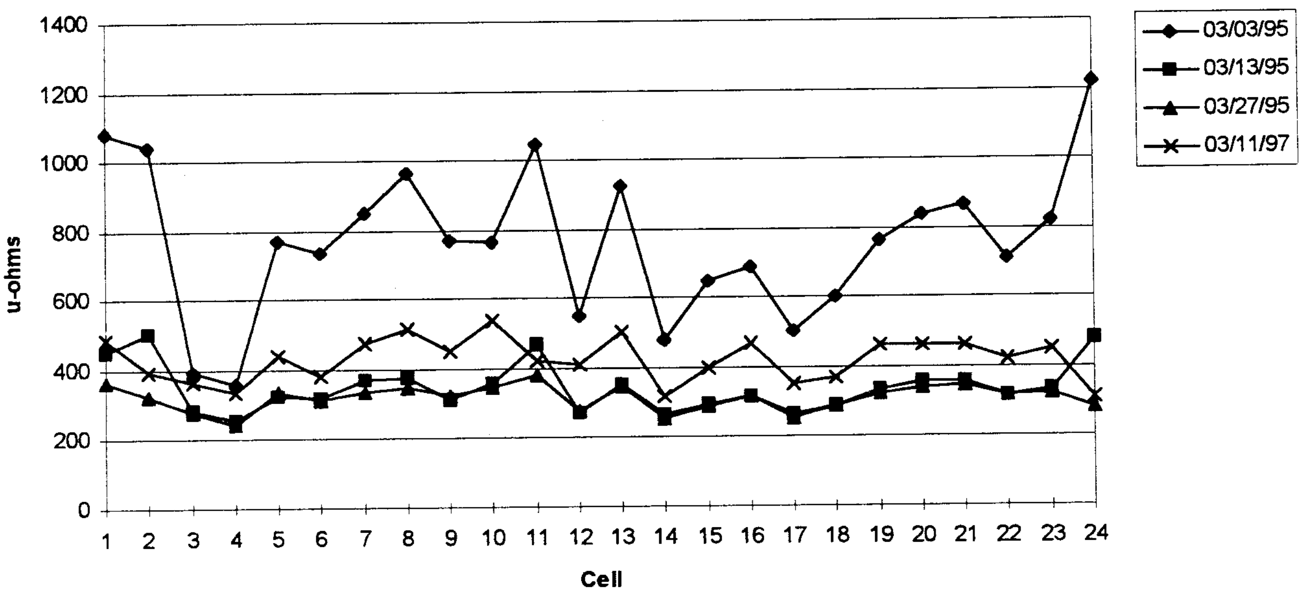
ACKNOWLEDGMENT:

I want to take this opportunity to give a special thanks to Asa Waters of SPRINT, who without his willingness to listen to the concept of impedance testing when we first presented it to him years ago "long before it was widely accepted", plus his foresight, cooperation, support, and assistance, this study would not have been possible. Thank you ASA.

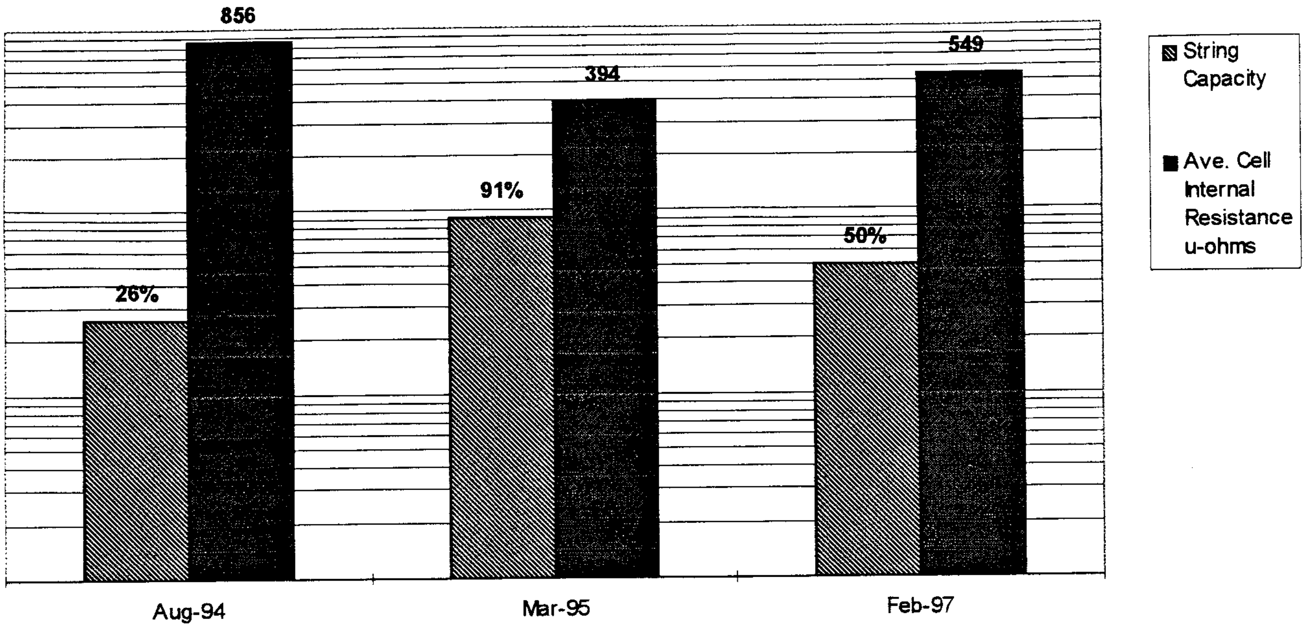
Graph 1 - 75A25



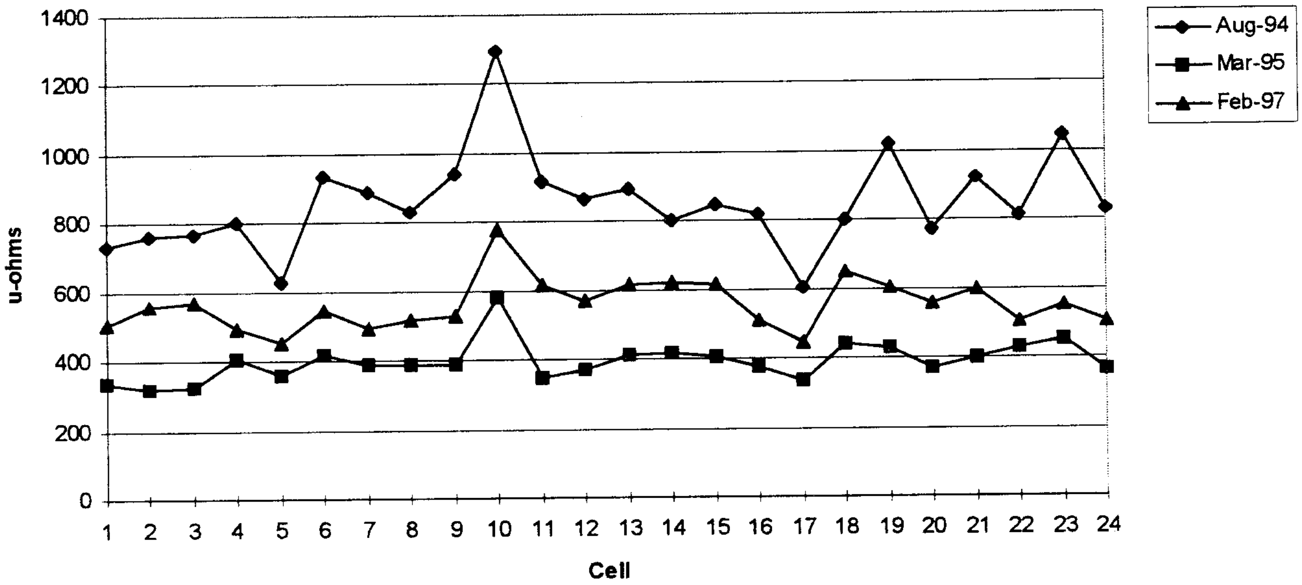
Graph 2 - 75A25



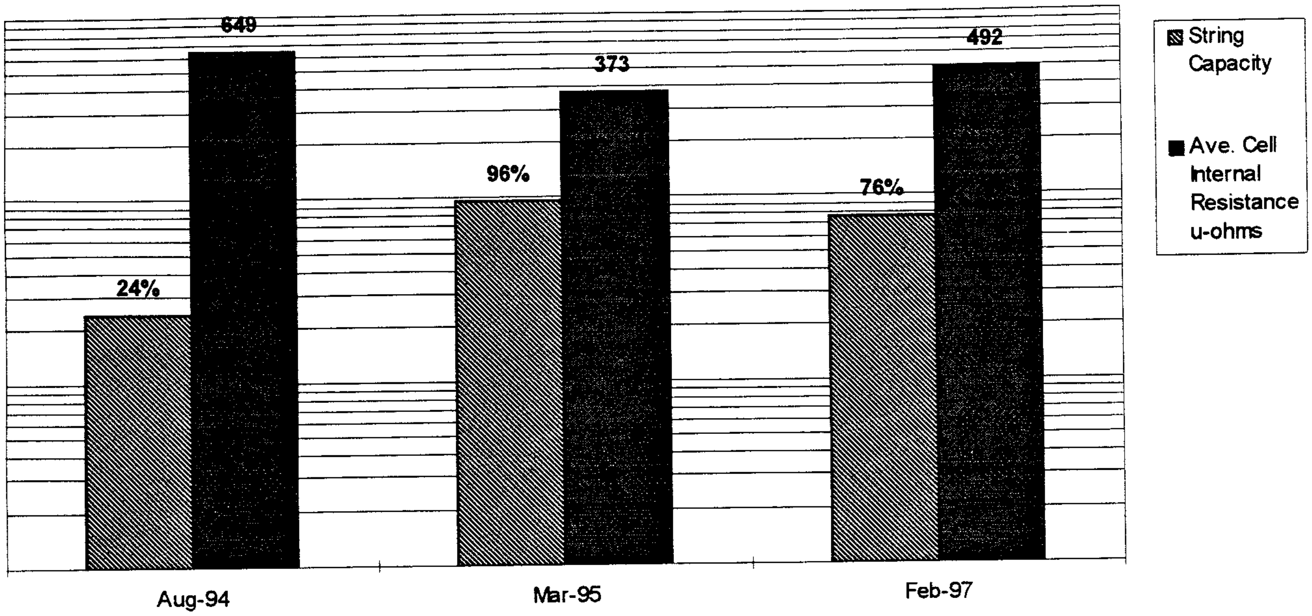
Graph 3 - 75A21



Graph 4 - 75A21



Graph 5 - 75A23



Graph 6 - 75A23