The Complete Guide

To

Battery Monitoring

V2.0

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The Complete Guide To Battery Monitoring v2.0

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Introduction

Lights go out. Screens go black. Millions invested on power backup systems. Batteries checked on schedule… but the power is out and so is your company.

What are the chances you will experience this scenario? Chances are much greater than you think, because your backup power system relies on simple yet unpredictable backup batteries in order to operate.

Overloaded utilities, anomalies in the power grid, extreme weather conditions and the risk of terrorism are major concerns for business contingence planers. Power failures are a fact of life and the key consideration that drives your investment in the first place for mission critical power backup systems.

The ***Complete Guide to Battery Monitoring***, newly published in 2004 and now in its second revised version, gives valuable insight to the inherent unpredictability of batteries. An industry first, the document identifies various battery failure modes and the incredible speed at which battery failure can occur.

Provided examples of battery failure modes were extracted from BTECH's unique archive of actual battery problems documented by BTECH's battery monitoring systems at wide range of customers. This information helps you better understand your actual risk of battery failure and improve your chances of avoiding catastrophic failure in a power outage.

What we know

Battery reliability is inherently unpredictable and the reason for 85% of catastrophic UPS failures. Companies with scheduled battery maintenance programs do not avoid the risk of catastrophic failure, because brand new batteries and batteries under warranty conform to the statistical potential for failure:

- Approximately 3% of new batteries will fail during the warranty period
- In-warranty batteries in normal use can actually deteriorate (go bad) in a 2-week timeframe
- Just one bad battery can cause the entire string to fail

Reasons for the inherent unreliability of batteries span a very wide range of possible causes such as design snafus, manufacturing process issues, poor quality control, lack of care in storage and transportation, environmental factors and application stresses. In some cases, scheduled battery changes actually introduced problems due to shoddy workmanship or mechanical connectivity failures.

Additionally, battery testing at installation and at periodic intervals can give customers a false sense of security. Once installed, many unnoticed factors such as power grid issues, environmental conditions and charging stresses caused by demanding UPS applications all contribute to create a high risk of battery failure. To give some insight:

- A temperature increase of 18º reduces battery life by 50%

- A 20% reduction in storage capacity puts a battery at great risk of failure if asked to perform, and according to IEEE standards, it should be replaced immediately.

Look At the Many Examples

This document provides you the vital information to help you understand:

- Your false sense of security and the actual exposure to high risk you currently have for a catastrophic shut down of your facility in a power outage

- The catch 22 of currently accepted battery maintenance plans and methods perpetuates an ineffective cycle that is inadequate and unable detect or prevent common battery problems

- Why the “monitoring feature” supplied with typical UPS or Battery Charging Systems is misleading and does little to decrease your risk of failure

- How BTECH unique technology, now in its 5th generation, works as your early warning system around the clock to detect and warn you to each and every developing problem…reducing your risk to near zero

12 Case Studies Show the Harsh Reality

This document is based on real world experience gained over more than 14 years and over 3000 installations - not theories, concepts or hype. We have extracted 12 battery failure mode cases from our one-of-a kind database to share with you.

Questions and Answers

Once read, you rightfully will and should have many questions. We cannot answer them all in this document. The two Q&A Sections should help answer some of your questions: general questions follow are first, with more technical questions at the end.

Should you need further answers call our hotline 973-683-9950, e-mail us your questions to sales@btechinc.com or visit our website at http://www.btechinc.com. We understand your risks and concerns and will supply the answers you need.

Answers to Your Questions

Section 1: Why Choose Battery Monitoring?

Why should I monitor my batteries? I already have a quarterly maintenance contract with my UPS or Battery Service Provider.

The Number One Question!
Answer: Your quarterly maintenance contract is not adequately protecting you. Have you ever had a backup battery failure right after your battery service? If so, you are not alone. Statistics have shown in a variety of sources that over 85% of UPS and power backup failures are due to the batteries or management of them. These failures occur to users of batteries who regularly maintain their batteries on a schedule. Simply put, maintaining your batteries in this way can never reduce this 85% number – batteries are inherently unpredictable and can fail in as little as two weeks, at any time in their life cycle. By managing your batteries by solid measurement data, you will reduce your risk of battery failure from 85% to near 0%.

Don't current IEEE standards address this problem?

Answer: The IEEE has not addressed the need for battery monitoring...yet. The case studies and experience presented are newly documented here comes from over 10 years of monitoring customer's battery systems in the real world. BTECH's trend analysis and data puts us ahead of the curve, since we have detected and published the problems and their data first.

We believe that the current IEEE standards for maintaining batteries are inadequate to ensure they will perform in emergencies. Their recommendations were developed well before the era of mission critical data and call centers, before the widespread acceptance of sealed valve-regulated "VRLA" batteries, and long before battery monitoring even existed! We are sure that once the technical community has a better understanding of the risks involved and the reliability of the data you can get with a good ohmic battery monitoring system, the IEEE recommendations will change, because they have to. Mission critical sites need to learn how to manage their battery systems according to measurement data to minimize this risk or outsource the battery monitoring to experts.

Section 2: All About Battery Monitoring

How does Battery Monitoring help?

Answer: For the first time, trended battery measurement data can detect impending battery failures before your backup system is affected! You will know in advance, which batteries should be replaced and have the time to act. We will document in this guide – from data at actual customer sites – just how accurate the predictive nature of our data is, and show you how to analyze the data for yourself. You will be amazed how fast failures can occur in the sealed VRLA batteries that are now so popular – in some cases, *within 2 weeks!* In addition, the failure of these VRLA's is catastrophic – meaning your UPS with one bad battery can drop the load! The data shows you how serious this problem really is. Now, you can do something about it.

How Does Battery Monitoring Work?

Answer: The technique is actually very simple! BTECH places a sensing wiring harness over each of your batteries. Over this harness, we measure each individual battery cell voltage, impedance and temperature, plus current and voltage during a discharge. The data is stored in the monitoring system controller and trended with BTECH's software package. The controller alerts you of alarm conditions via e-mail, cell phone text message or your facility management system. Trending of the battery cell impedance has proven to show the relative health of the battery. With knowledge of the battery's baseline impedance, it is possible to correlate the impedance rise with a meaningful determination of the end of its service life.

Section 3: About Your UPS or Charger

Doesn't my UPS or battery charger already monitor my batteries?

Answer: Caution: All monitoring systems are not the same – and the UPS and battery charger methods are not predictive. They cannot detect developing problems. In other words, your UPS system is at risk long before the alarms are tripped. It's startling to learn monitoring performed by these systems cannot provide adequate protection. Because UPS systems only monitor conditions on the battery bus, no UPS monitors tracks and trends individual battery health. In short, such monitoring systems do not provide adequate protection, because they can't detect *individual* battery failures – they only look at the string as a whole. In addition, these systems typically look only at the overall string voltage (and possibly the discharge cycle). The UPS system cannot pick out the failed battery and enable you to replace it before your system is at risk, which is the only way to be sure your system will perform when it needs to.

Section 4: Costs of Battery Monitoring

Doesn't your system just add to my costs?

Answer: The battery monitoring system will actually help you reduce costs and save money. If the BTECH system eliminates just one battery system failure; you will save many thousands of dollars in potential lost revenue, data and productivity. The BTECH system will also allow you to prevent or reduce un-planned emergency visits, unnecessary testing (disruptive load bank testing etc.) and extra maintenance visits. The BTECH system has also enabled our customers to extend the life of their battery systems thus reducing the frequency of complete battery change-outs. The battery monitoring system also measures individual cell or unit voltage and current, both during float and discharge cycles. Ambient temperature and the temperature of each cell are also measured. Since the battery monitoring system is collecting the same battery management data that your service provider is collecting, the manual and labor-intensive work will be significantly reduced. In addition, you are getting this data 365 days per year instead of four!

Why should I install a Monitoring System if we can buy new batteries for just a small amount more?

Answer: Up to 3% of batteries fail during the warranty period, and you need some way to pick out the failed cells quickly before they affect your new system. Installing a new battery system does not reduce the risk of battery failure! Our extensive list of case studies shows that your backup battery system has the potential to fail at any point in its service life. We have seen failures after the initial discharge acceptance test, failures after one year of service, and after two. The bottom line is that only by installing a battery monitoring system and managing your batteries by measurement data can you be sure your batteries will perform as specified! The BTECH system is a one-time investment designed to perform during the entire life span of the critical power system. Battery replacements are expensive and disruptive to the operation of the facility, typically the BTECH system will save at least one wholesale battery replacement during the systems lifespan, when given all the cost factors the system pays for itself more than once over and typically in three to five years.

Show me an example how my costs can be lowered.

By moving to a revised battery management plan incorporating the data from the monitoring system, you will be able to save money by reducing the amount of routine service visits your battery service provider makes to your site, and reduce the amount of work they have to perform. You can also reduce the amount of planned discharges as well. Our ROI analysis shows typical savings after the second year of implementing our battery management recommendations listed at the end of the paper – and we're not even factoring in the savings associated with eliminating the risk due to battery failure and downtime.

Section 5: Other Battery Monitoring Systems and Techniques

How does your system compare with other monitoring systems?

Answer: With unique, patented technology now and the largest installed base, BTECH is by far the world's leader. With over 3000 systems installed, we have the proven experience that's second to none. Here are some of the reasons why BTECH is the best choice:

- **BTECH systems monitor as close to the cell level as possible.** Avoid monitoring systems that only look at the string as a whole – they are ineffective.
- **BTECH systems are not powered by your batteries and do not utilize DC Resistance discharge testing as the main method**. Other systems remove power from the batteries. In fact, an independent study was done that showed that this type of measurement eventually causes a decline in the ability of a battery string to attain a full recharge. The BTECH S5 System utilizes an AC Impedance measurement that is both passive to the battery string and load, verified in writing by two major manufacturers of batteries after extensive testing. The AC measurement (Impedance) imposes a 215Hz signal on the battery string and then measures the resultant AC mV drop across each cell divided by the imposed AC current will provide the calculation for Z (Impedance). The load signal is carefully selected between 5 and 20A so as not to bring the voltage of the battery below its open circuit voltage during measurement making sure BTECH does not impose a stressful load test on the batteries.
- **BTECH is unaffected by AC ripple and does not use AC ripple to measure impedance**. Because the AC ripple is dependant on the load, systems that claim to measure impedance with the AC ripple, or a standard 60Hz signal, inherently cannot provide stable and accurate measurements.
- **Only BTECH systems can provide measurement accurate and consistent enough to predict failure in your large battery systems in time.** The lowest measurement other systems can make is 0.25mΩ, which is not low enough for most large (over 300AH batteries), which can have baseline impedances as low as 0.10mΩ. BTECH is sensitive enough to measure impedances as low as 0.10mΩ with +/- 0.01mΩ repeatability. Because of this lack of sensitivity, others often quote jar or multi-cell level monitoring to meet their baseline, rendering the monitoring system ineffective – see the point below.
- **BTECH strongly recommends single cell level monitoring wherever possible. Never accept the jar or multi-cell level monitoring that others offer to lower cost,** especially with flooded (wet) cell or large VRLA battery systems. Many companies quote jar or multi-cell level monitoring, which basically renders the monitoring system ineffective. In BTECH's view, no electronics have the sensitivity to detect the small percentage changes in impedance or voltage over multiple cells fast enough to provide the early-warning capability the system was designed for!
- **BTECH systems meet or exceed all IEEE recommendations for battery monitoring, without the need for deep DC discharge testing.** Others have claimed that they meet the IEEE "better" than BTECH, because they use a deep DC discharge to achieve their measurements. Quite the contrary: BTECH's system is better in two ways: one, our AC method is more accurate and two, we do not place a detrimental and costly load on the battery system.
- **Our factory engineered and manufactured wiring harnesses improve reliability while cutting installation time in half**. All other systems require their harness to be configured in the field - often by inexperienced technicians – which takes more time and gives greater room for error.
- **No Monitoring System is Safer to Install and Maintain**. BTECH's Unique Quick-Disconnect Safety Fuses simplify battery replacements and protect personnel during installation and maintenance.
- **BTECH offers the most comprehensive software package**, with comprehensive warranty reporting.
- **No PC is required in the battery room to run the BMS**.
- **Standard S5 features unmatched in the industry:**
    1. Individual string current monitoring for multi-string and multi-cabinet battery systems
    2. RS-232 and USB for local data acquisition; Ethernet and Modem for remote data acquisition
    3. Six (6) user-configurable dry contact alarm outputs with 4 binary inputs
    4. Modbus over TCP/IP for easy third party software integration.

BTECH Monitoring Center Background

When BTECH developed the first stationary battery monitoring system based on trend analysis, the importance of assisting the customer in learning about their batteries and battery problems was understood from the beginning. BTECH keeps an extensive reference database of battery measurement data for customers and helps them in recognizing problem batteries. Our collection of battery failure data is unique and allows us to claim an understanding of battery failure that is unmatched in the industry.

Today, BTECH actively monitors batteries at hundreds of customer sites. Many Fortune 50 customers place their trust in the ability of our battery monitoring systems and our staff of trained battery experts to assure their systems will work when needed. The failure analysis published here is the result of over ten years of collecting and analyzing battery failure data.

How to Read the Graphs

The monitoring of individual battery voltage, impedance and temperature gives a wealth of data to analyze. Let us go over each of the data types and their significance to battery health. Case studies that illustrate the relationships between these measurements will follow afterwards – and will show you how to analyze the data from your BTECH monitoring system yourself!

Impedance – BTECH pioneered the on-line measurement of impedance to determine battery health. In the early 1990s – the early days of the company – we needed to convince the technical community that this was a valid argument. Fast forward to 2004 – today impedance is accepted after being proven in a large number of technical papers to be a leading indicator of battery failure. Generally, one can state that when the impedance rises 30% or more above the baseline or initial impedance (values given by the battery manufacturers and defined by battery type and size) that the battery is at risk and is probably in its failure mode. Rapid impedance rise is more common in the sealed VRLA or “maintenance-free” batteries; with larger flooded or wet cell batteries, impedance can also predict impending failure.

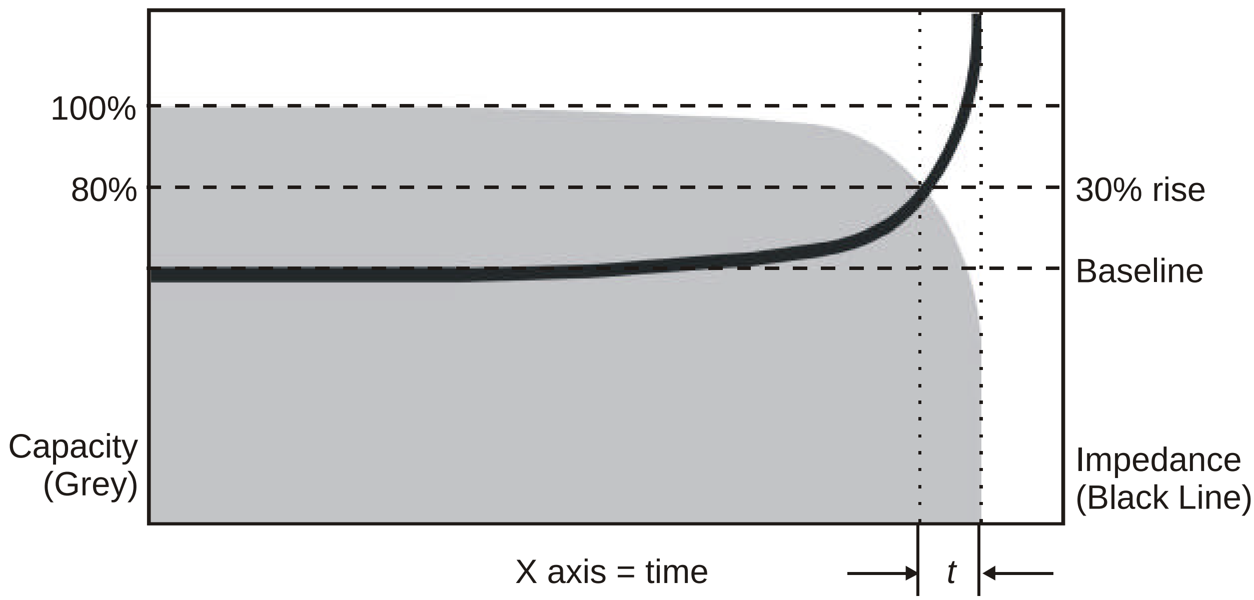
Voltage – Voltage has traditionally been the way battery service personnel would detect bad batteries. In general, when the individual cell or unit voltage has declined significantly, the battery has been at risk for considerable time – especially with VRLA batteries. Most often – but not always - voltage change lags impedance. On larger (1000 AH+) wet cell batteries, voltage can change before impedance. The monitoring system will detect these changes and make you aware of them.

Temperature – One of the most overlooked measurements is temperature. The ambient temperature of the batteries significantly affects service life. For every 18º above the standard reference of 77ºF, your service life decreases by 50% our monitoring systems have detected several cases where customers have switched off air conditioning systems to save money on weekends and then wondered why their batteries were failing early! We have also detected failed air conditioning systems at remote sites this way.

Graph Types: The Complete Guide shows battery data in a variety of formats:
System Snapshot: Voltage and/or Impedance measurements made at one specific time are shown for all of the cells or batteries in the string
Voltage and/or Impedance vs. Time: Trended voltage and/or Impedances are shown vs. time. Each data point represents a weekly measurement, which is typically all that is needed to detect problems in advance.
Discharge Voltage vs. Time: During a discharge, a data log is created with saved voltage vs. time data with the time in seconds. This is used to display battery performance during the discharge.

Battery Lifecycle Explained: VRLA Batteries

BTECH's Battery Life Cycle Graph



BTECH's battery lifecycle graph displays important relationships between impedance and capacity for VRLA batteries. Some important points that stand out:

- The baseline impedance, which is measured for each battery in the string by the BTECH monitoring system after the system has passed the initial discharge test, equates to 100% capacity when the battery is new.

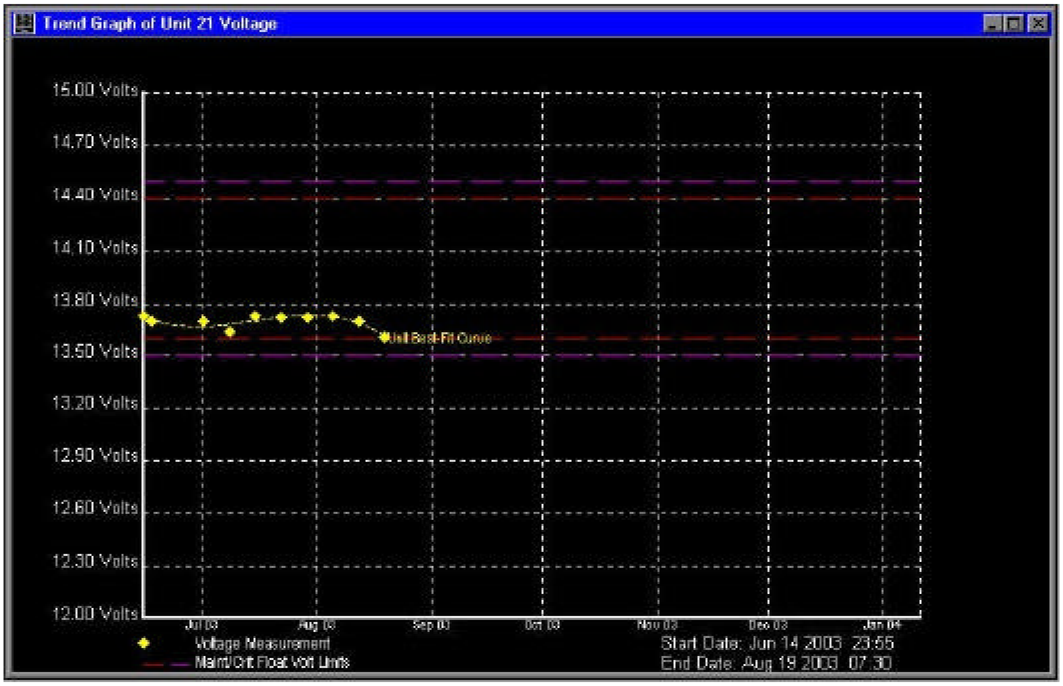
- A 30% rise in impedance above the baseline roughly equates to 80% battery capacity, which is the point at which the IEEE recommends immediate replacement. Based on recommendations of a number of battery manufacturers, BTECH has adopted the 30% value as the critical impedance alarm point – the time for the user to schedule a service visit to possibly replace the battery.

- The behavior of the battery after the 80% capacity point is reached is unpredictable, making the time from the 80% point to outright failure, as displayed on the graph as "t", indefinable.

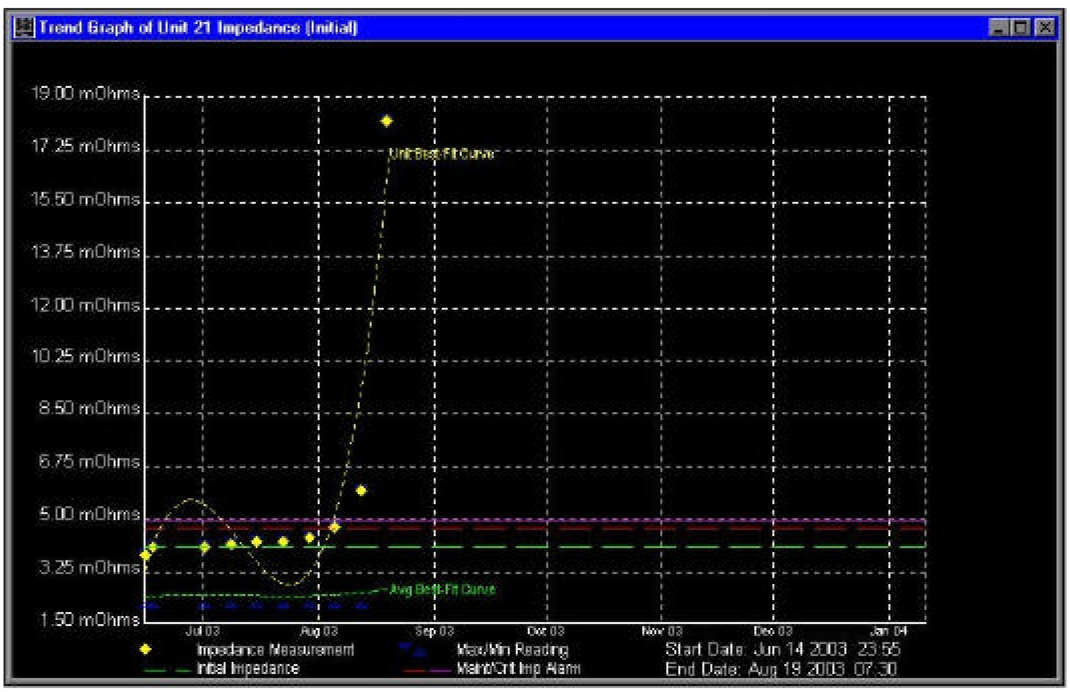
- Because the behavior of VRLA batteries has been demonstrated by BTECH to be unpredictable, capacity remaining or time remaining functions built into current UPS systems or competitive monitoring systems are inherently inaccurate. BTECH believes it is technically impossible to provide accurate time-remaining data.

- The only way to ensure the integrity of your VRLA battery system is to replace the failing battery in the string when the impedance rises 30%, when the data from BTECH's monitoring system tells you.

Example #1 – Rapid Impedance Failure in 2 Weeks



Unit #21 Voltage vs. Time

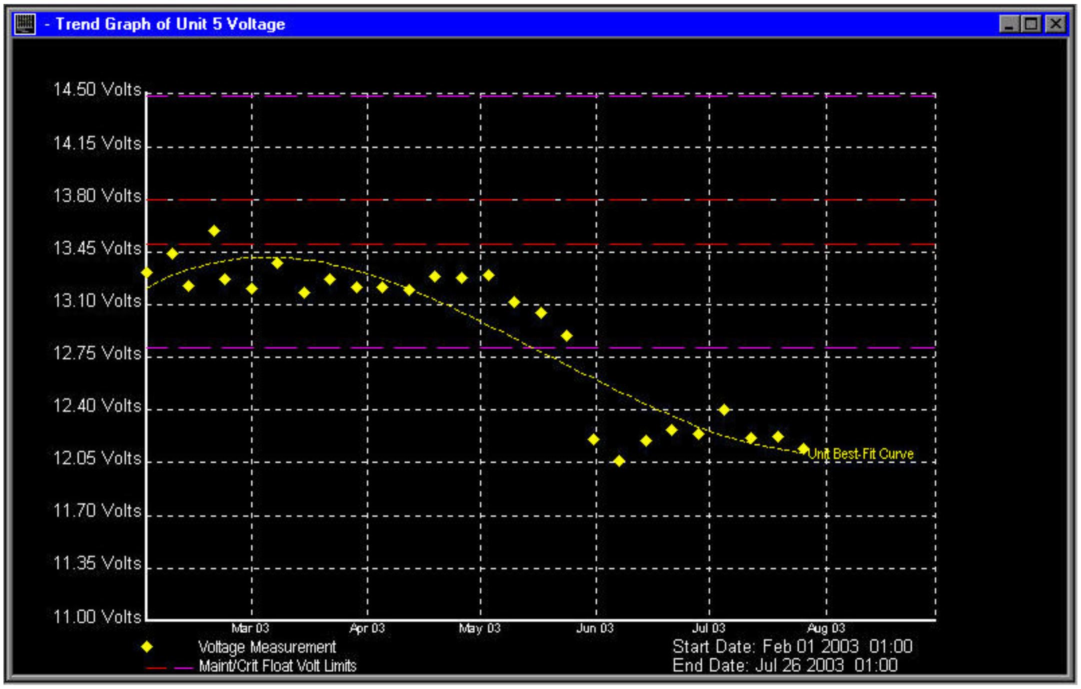


Unit #21 Impedance vs. Time

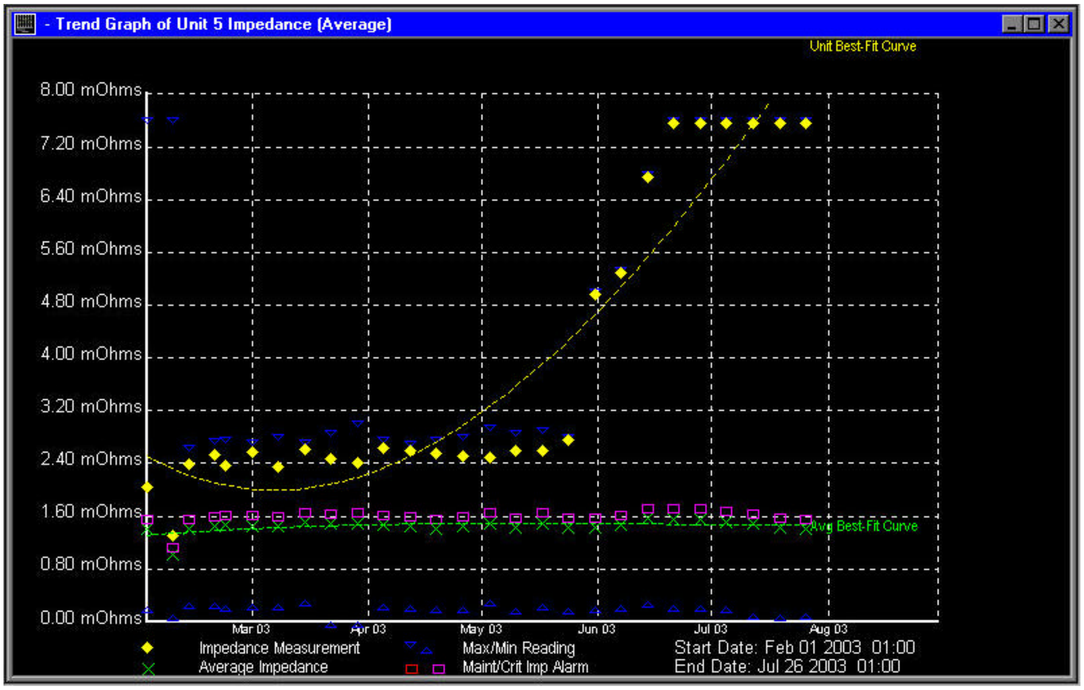
***Background*:** Unit #21 illustrates a classic impedance and voltage trend observed at the BTECH Monitoring Center. The graph finds impedance rising rapidly within a 2-week period, showing the importance of weekly monitoring. Despite the 300% rise in impedance, the voltage change is negligible, proving that voltage cannot be used to verify battery health.

***Conclusion*:** The UPS that this unit supports is at risk of failure, and depending on where the customer is in their battery maintenance schedule; this failed unit may go undetected for several months. Using BTECH's system, the user replaced the bad unit before it posed a risk.

Example #2: Detrimental Effects of a Deep Discharge



Unit #5 Voltage vs. Time

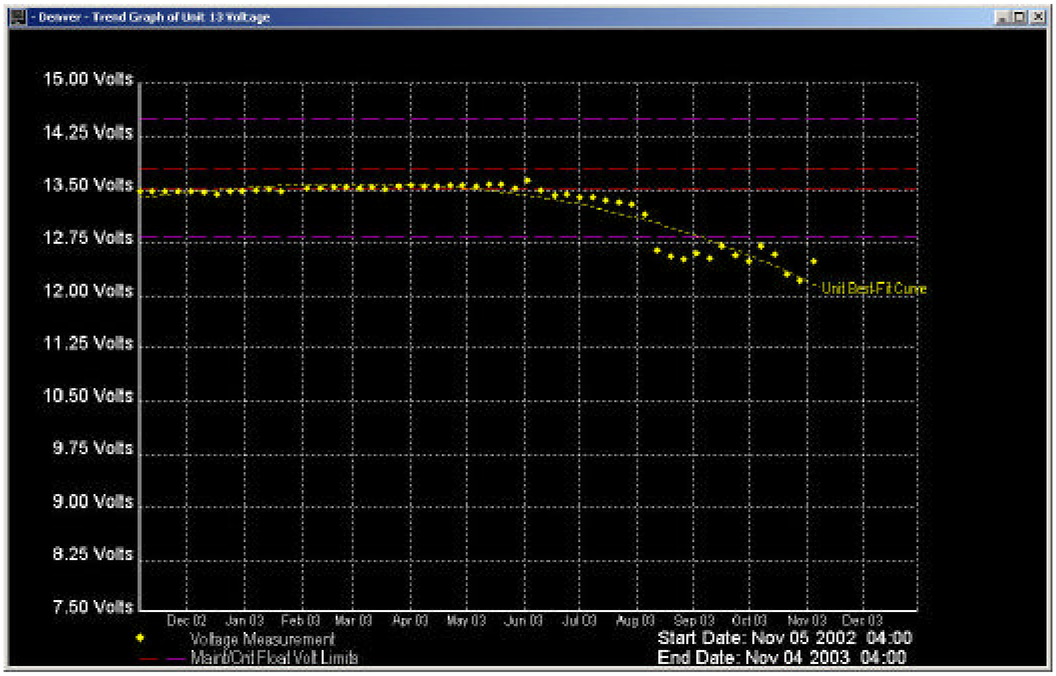


Unit #5 Impedance vs. Time

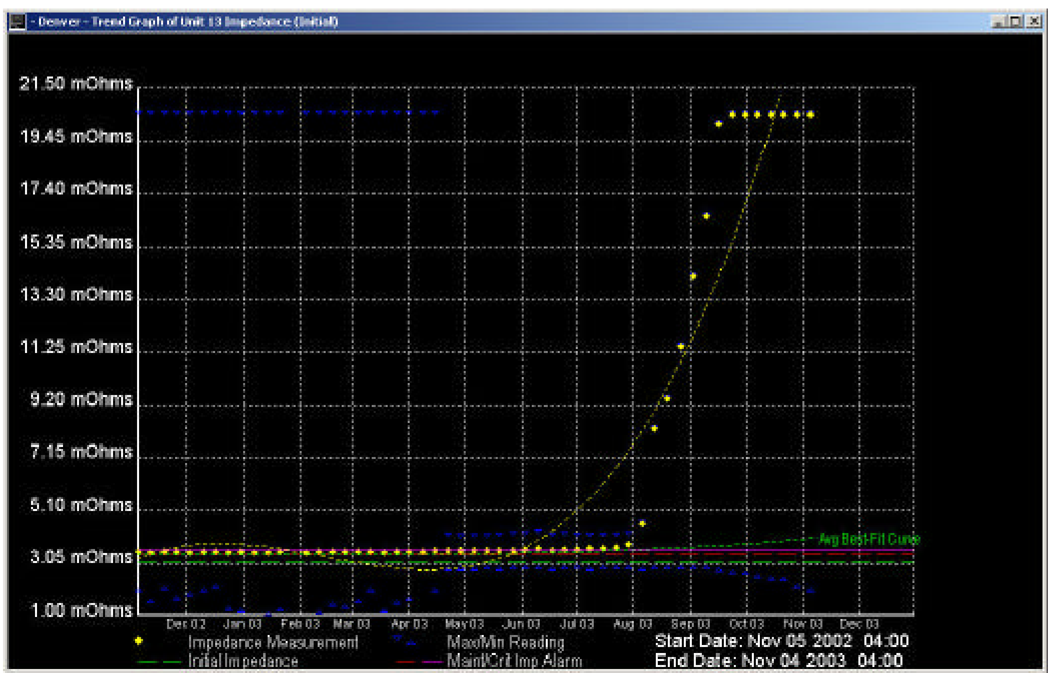
Background: This site experienced a deep discharge in the end of May. The graphs of Unit 5 show impedance starting at 90% above the initial base line and finishing above 750%. In this case, the impedance and voltage track together. The rapid impedance rise follows the discharge – from the graph signatures we can deduce that one cell of the battery is failing.

Conclusion: The 750% impedance rise is significant enough to conclude that the battery string would fail open upon the next discharge - showing that after a successful discharge one cannot assume that the second will also be successful.

Example #3 –Ignoring the Warning: Another 2-Week Failure



Unit #13 Voltage vs. Time

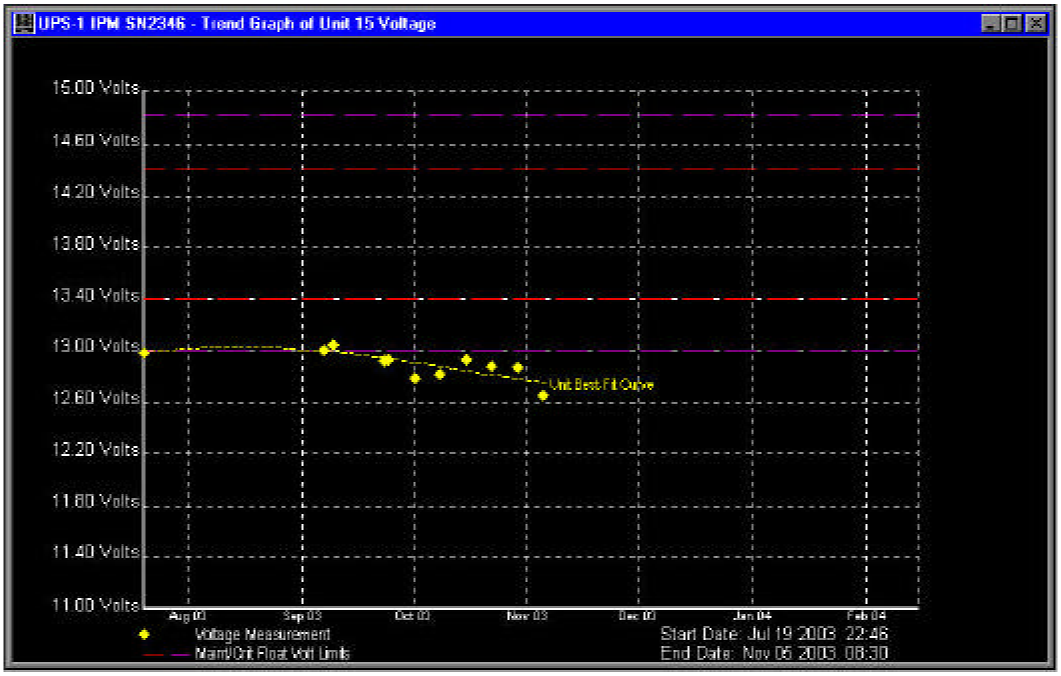


Unit #13 Impedance vs. Time

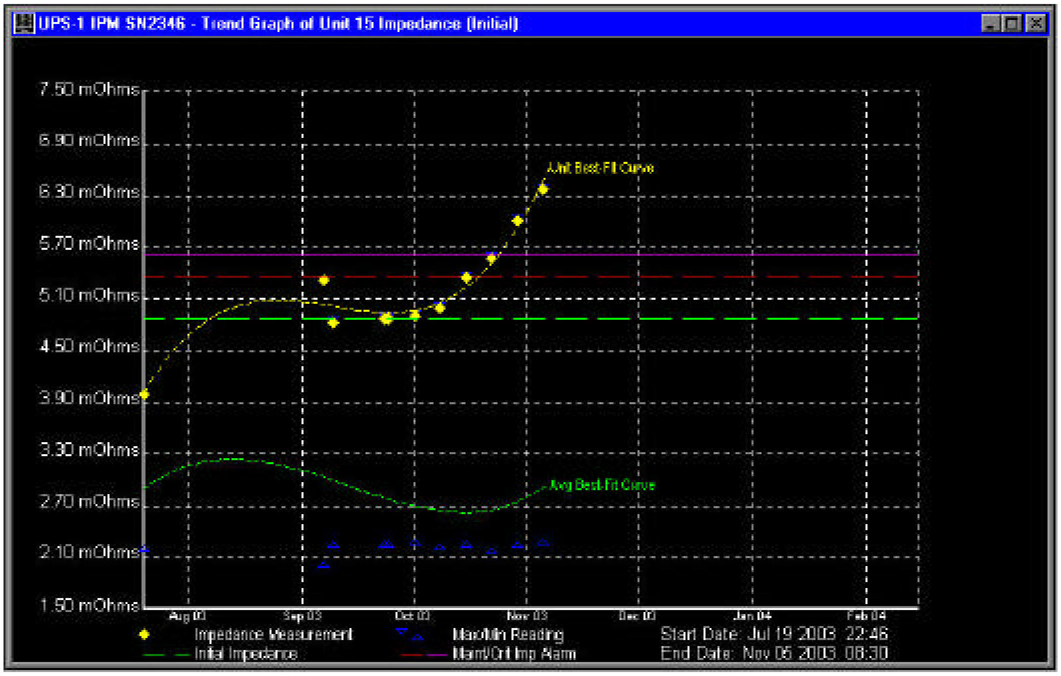
Background: Unit 13 demonstrates the impedance rising 700% over an 8-week period, beginning in August, with a failed condition probable after the second week

Conclusion: BTECH informed the customer of the problem, but this UPS system continued to be at risk for additional 17 weeks. The operator elected to ignore the warning – but it is almost certain that the unit would have collapsed under load, eliminating the window of time to transfer to the generator. This was at a major data processing center – thankfully, the power did not trip in this period!

Example #4 –Finding Defects In a New Installation



Unit #15 Voltage vs. Time

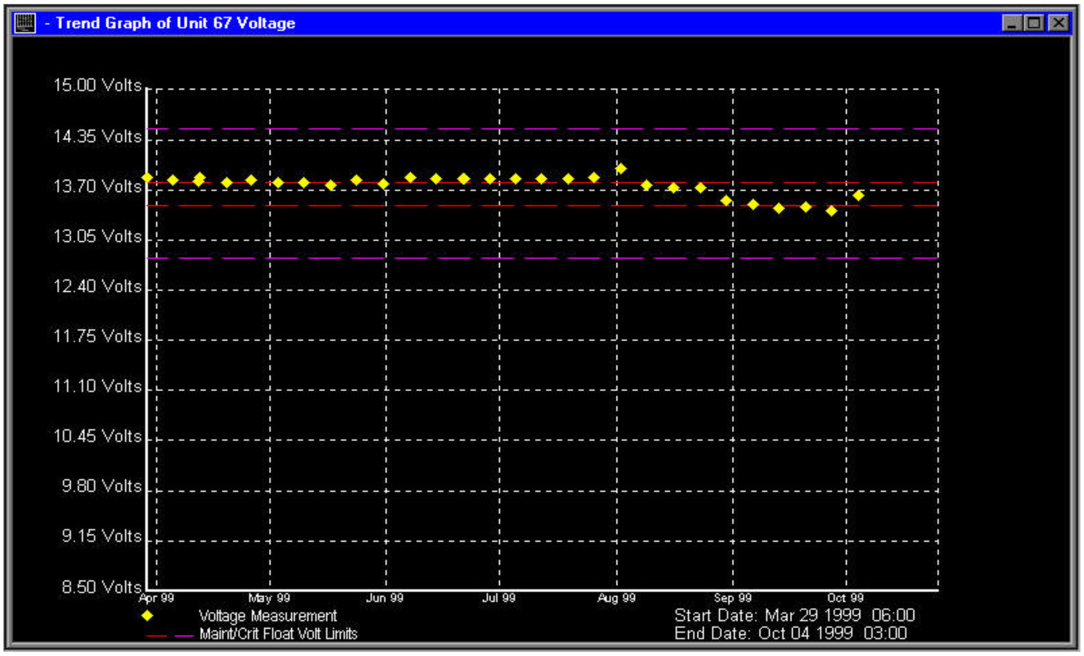


Unit #15 Impedance vs. Time

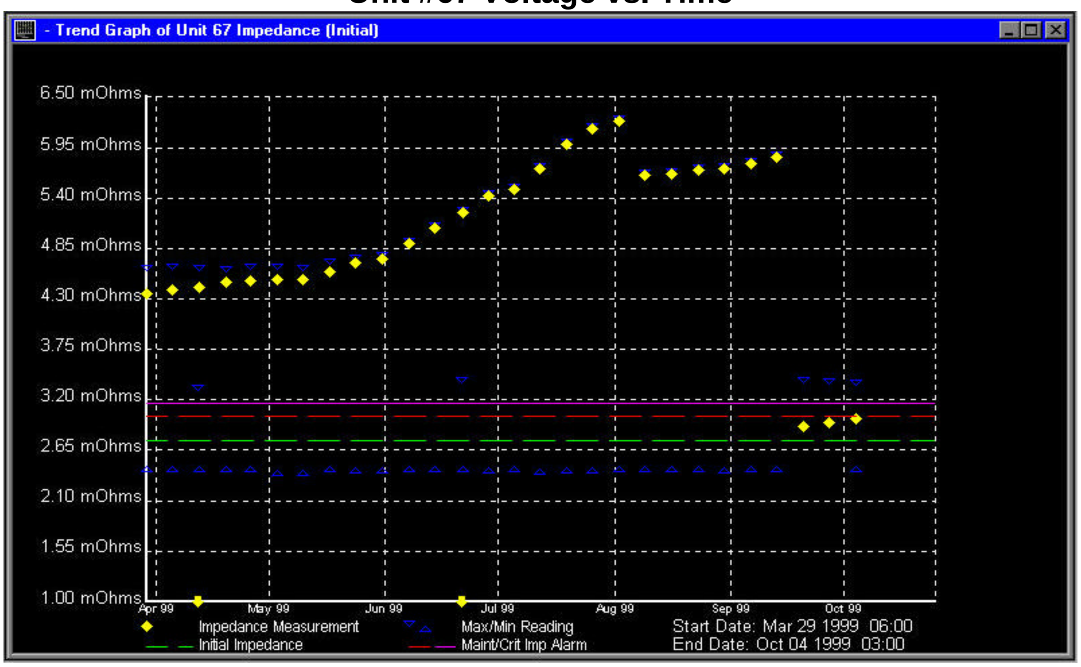
Background: Unit 15 demonstrates a classic impedance curve – but in this case, the UPS and the batteries are only months old, and two failing units were found. The August to September lag in the data shown is the gap between installation and the issuance of a monitoring contract.

Conclusion: This UPS system is at risk 3 months after installation, with the ability to make run time already severely affected. Using this data, the customer was able to substantiate a warranty claim. The customer would not have known of this problem unless they installed the BTECH monitoring system.

Example #5 – Effects of Re-Torquing – Unnecessary Maintenance



Unit #67 Voltage vs. Time

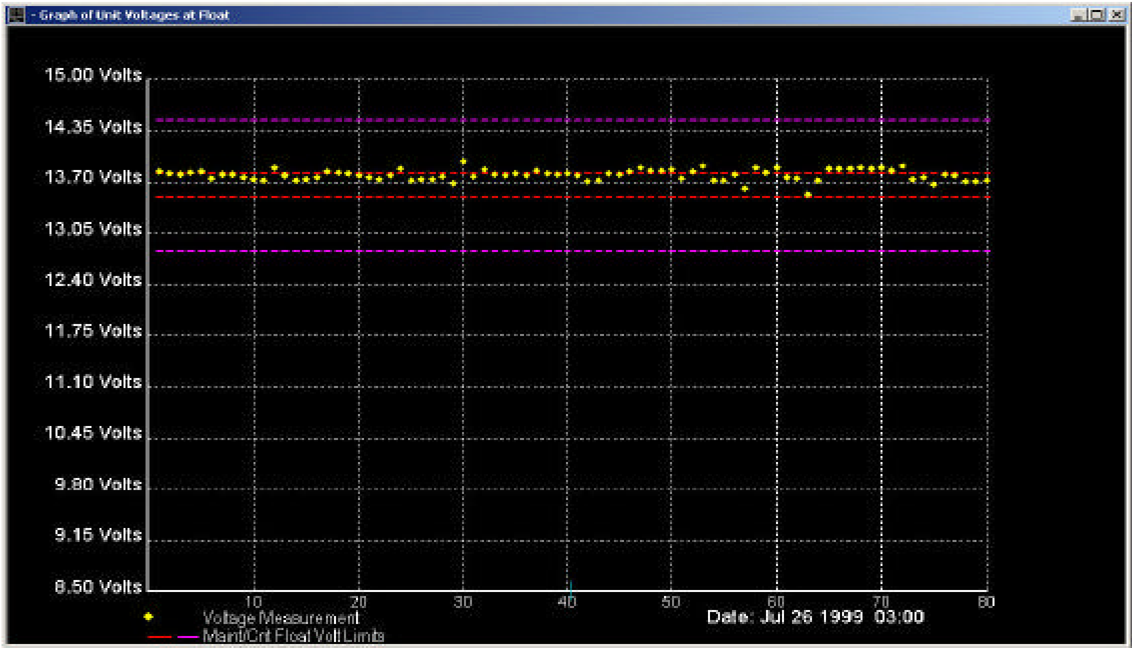


Unit #67 Impedance vs. Time

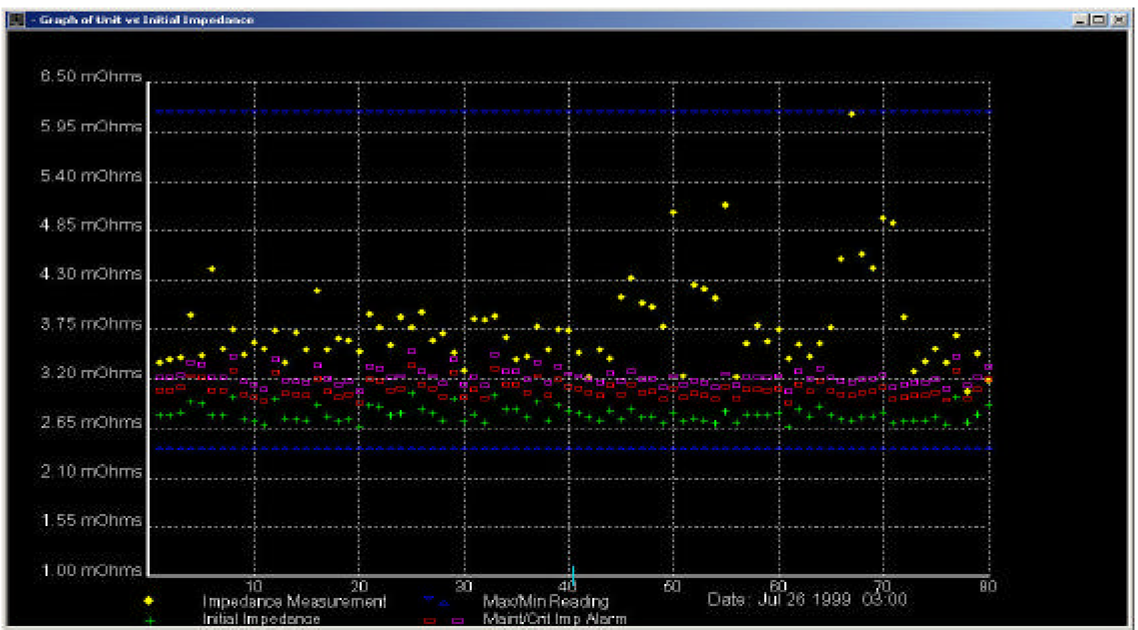
Background: Unit #67 shows impedance starting at 80% and finishing at 120% above the baseline. In this case, the customer had battery maintenance performed in the beginning of August, hoping to cure the failing unit. Although re-torquing the connections lowered the impedance, the unit continued to exist in a failed state. The customer replaced the unit in the middle of September during a second service call.

Conclusion: The customer would have saved the cost of the second service call If the customer had replaced the failed battery by looking at the data in mid-June, and the time UPS was at risk could have been shortened by three months!

Example #6 – Effects of Elevated Temperature



Two Cabinets of 40 Batteries – Voltage vs. Unit Number

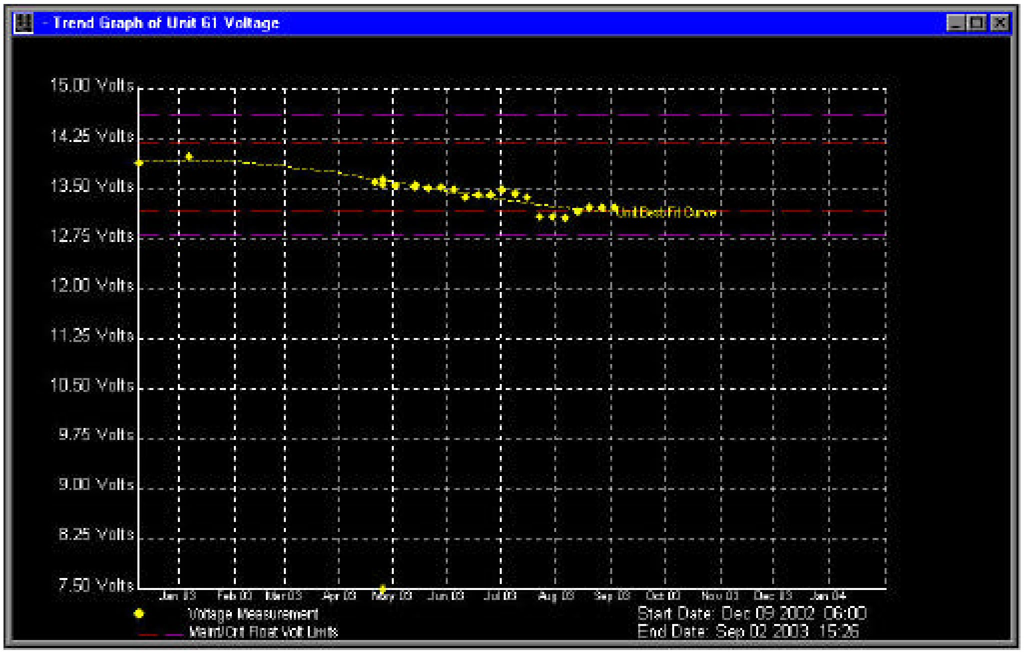


Two Cabinets of 40 Batteries – Impedance vs. Unit Number

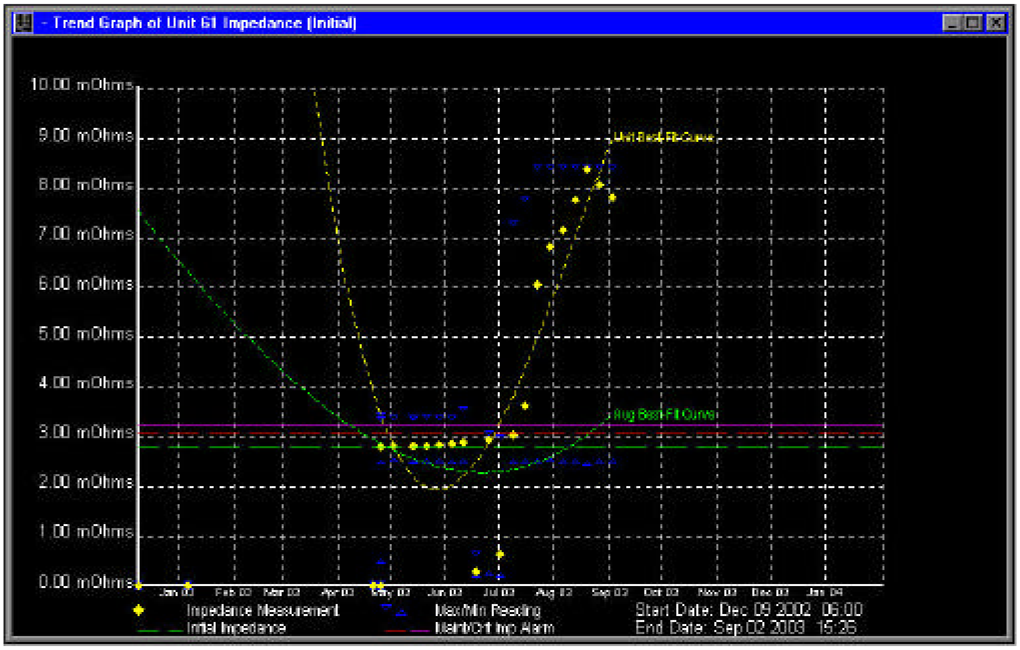
Background: These two parallel 40 battery strings are only 2 years old, yet the impedance shows they have “Failed” with a 50 to 100% rise overall. The Service Provider was adamant that the strings were “OK” on this mission critical system - the voltages measured were within acceptable limits. However, temperature monitoring showed ambient over 80° and the interior of the battery cabinets over 90° - clearly showing these batteries were subject to cell dry-out.

Conclusion: The monitoring of battery temperature is also important, as elevated operating temperatures severely affect battery service life. We have seen elevated temperatures causing “burping”, accelerating dry-out. This is also another example where voltage does not relate to battery health - all voltages are within “norm”. Note the reaction of the battery service provider, who would not believe the monitoring system data.

Example #7 – Effects of a Discharge #2



Unit #61 Voltage vs. Time

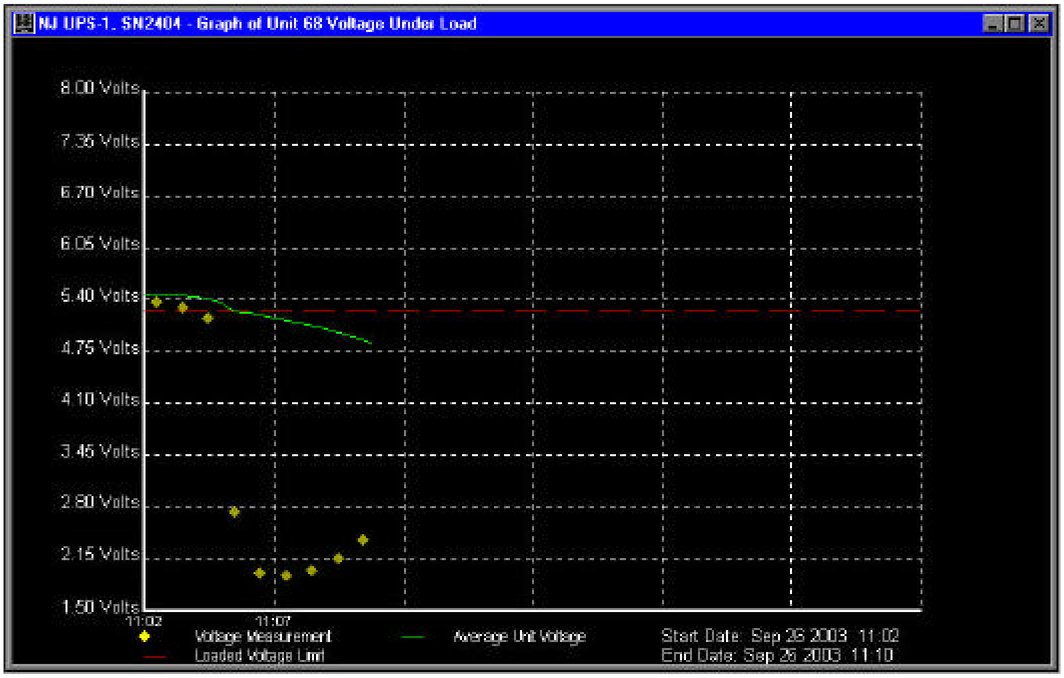


Unit #61 Impedance vs. Time

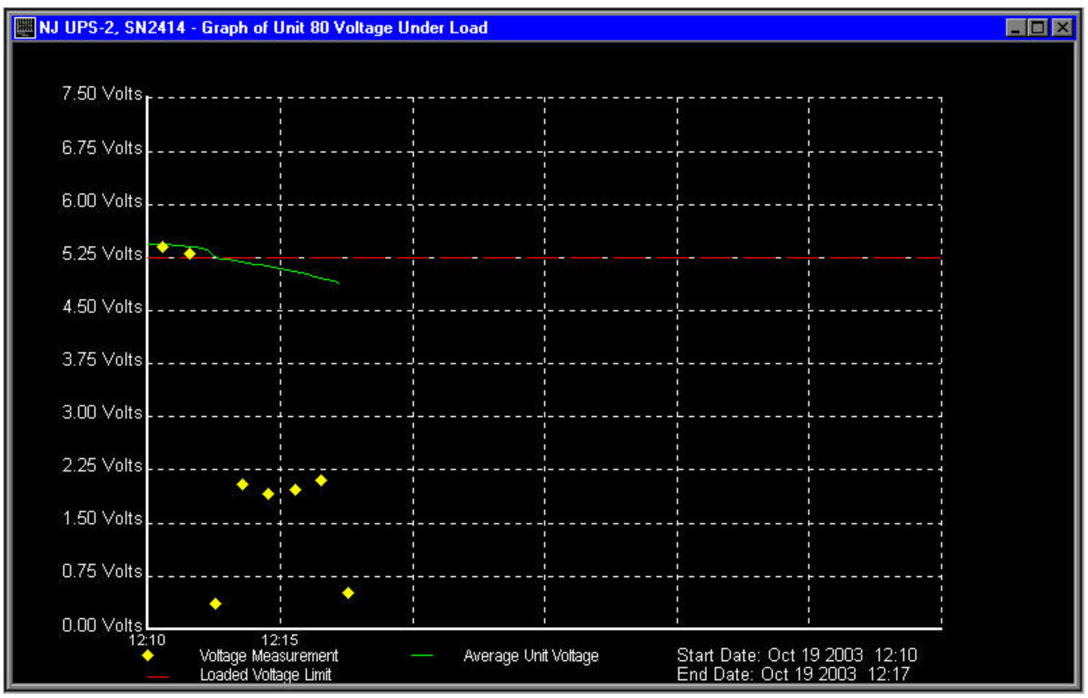
Background: These graphs of Unit 61 show how a discharge can have an immediate detrimental effect on individual batteries (#38 exhibited a similar trend). This battery string went under load in mid June. Although the discharge was successful, the impact on the two units was considerable - note the rapid rise in impedance following the discharge. The deterioration is significant enough that it is doubtful the string would carry the load again.

Conclusion: Again, another example where a successful discharge does not necessarily mean the second one will be successful. This is another case where active monitoring of the batteries can detect potential problems before they pose a risk.

Example #8 – Cell Reversal during Discharge Acceptance Testing



Unit #68 Voltage vs. Time – A 3-Cell Battery With a 1 Cell Reversal

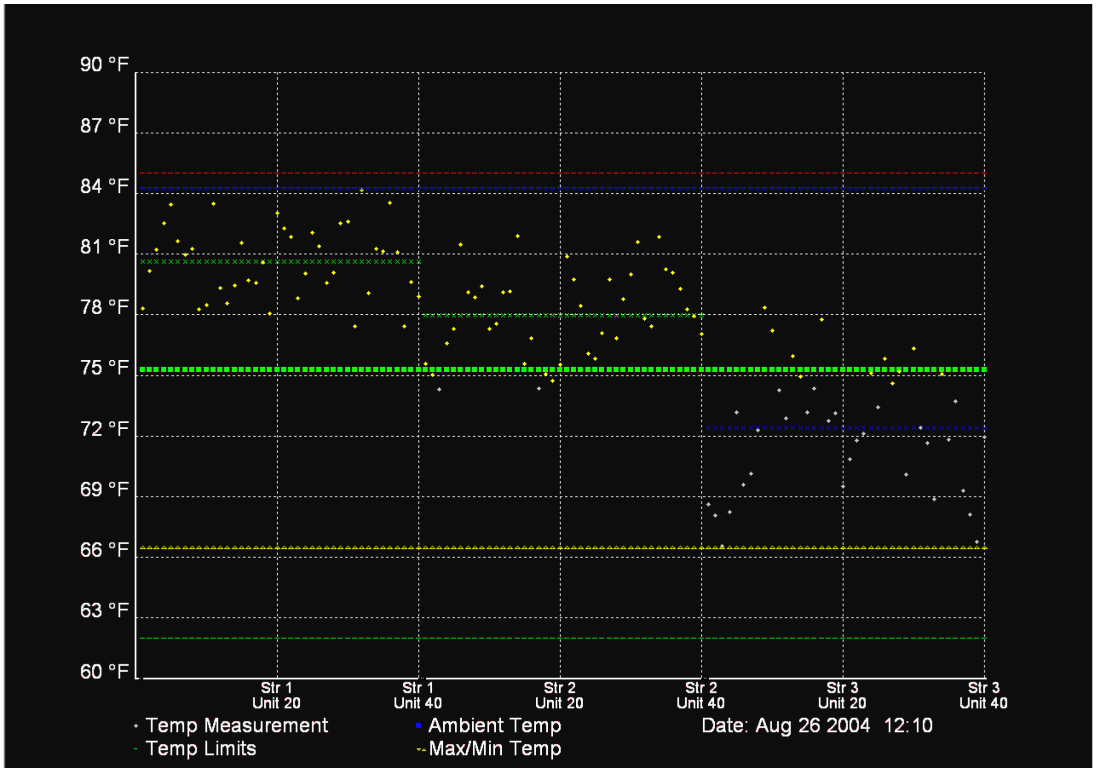


Unit #80 Voltage vs. Time - A 3-Cell Battery with a 1 Cell Reversal

Background: During discharge acceptance testing of brand-new redundant battery strings at a major client, two units opened under load and actually displayed cell reversal in a number of cells – a potentially hazardous situation that could result in an explosion. Note that one battery unit was bad *in each "redundant" string*. Both strings would have failed under a normal load.

Conclusion: BTECH's data from active battery monitoring is sensitive enough to analyze what happens to the batteries when they fail. In this case, the batteries were new – and BTECH's battery monitors provided the data to backup a major warranty claim.

Example #9 –Temperature Variations in Cabinets

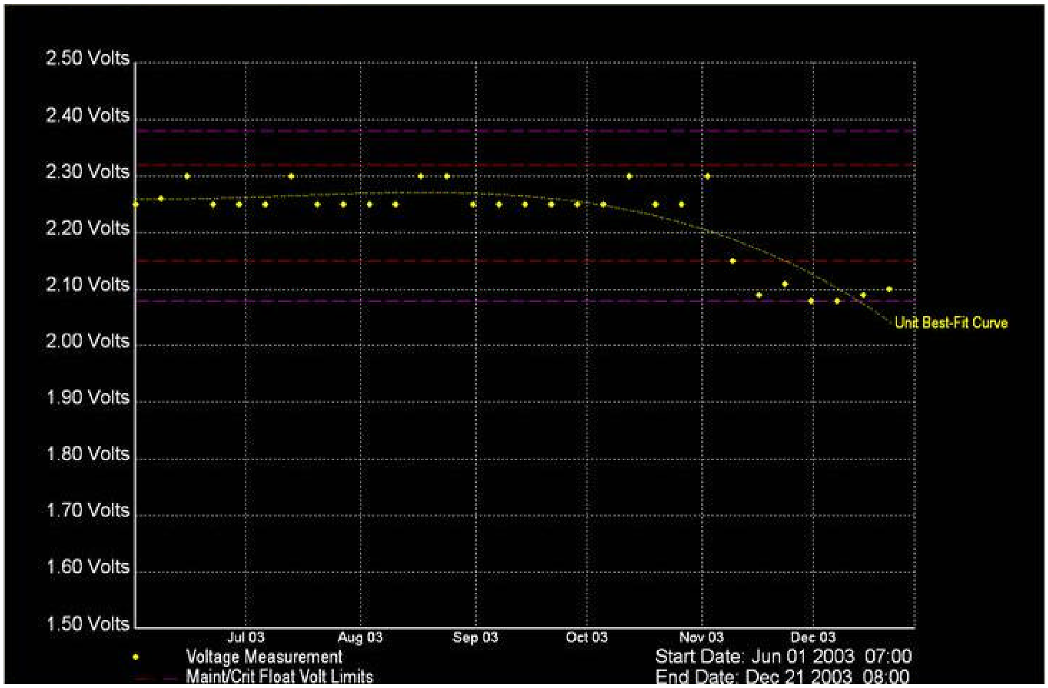


Three Cabinets of 40 Batteries – Temperature vs. Unit Number

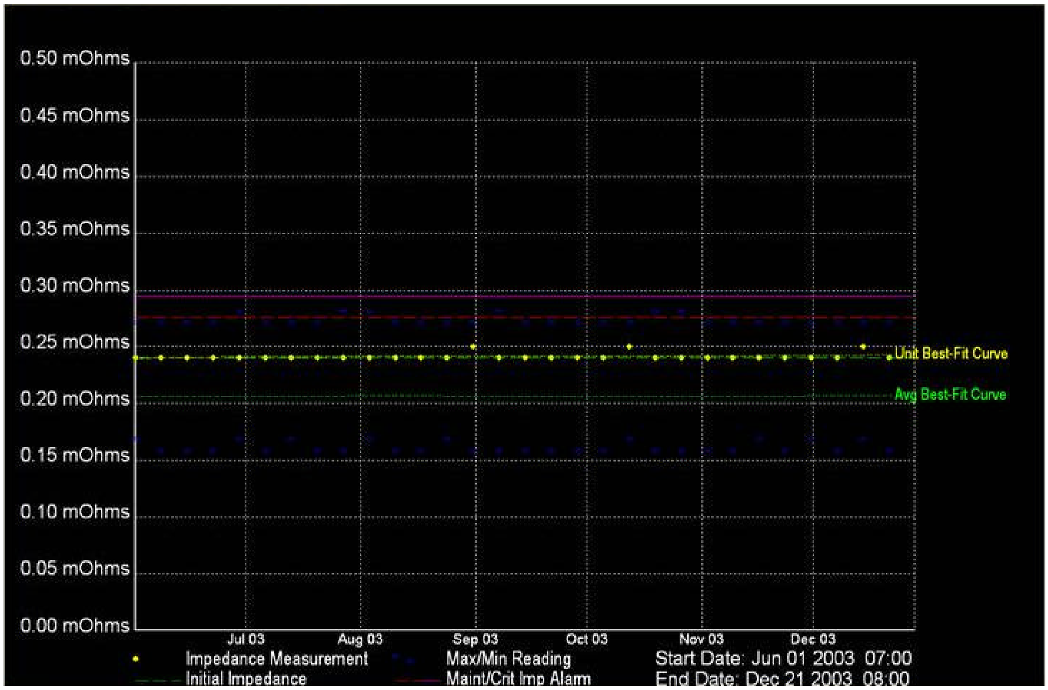
Background*:* These three cabinets on one UPS are located in a climate controlled room set to 68 degrees F, but due to their placement in the room, the actual temperatures measured in the cabinets vary from 66 to 84 degrees**.**

Conclusion: Operating temperature has a great influence on battery life, especially since the UPS charging circuit compensates for ambient temperature. If the actual battery temperatures differ from the reference temperature in the UPS, local over or undercharging could occur. The customer's choice of BTECH's option to monitor temperature of all of the units in the string alerted them to the problem. The cabinets were repositioned in the room to improve ventilation and the problem was solved.

Example #10 – A Short Forms in a Flooded (Wet) Cell



Unit #213 Voltage vs. Time

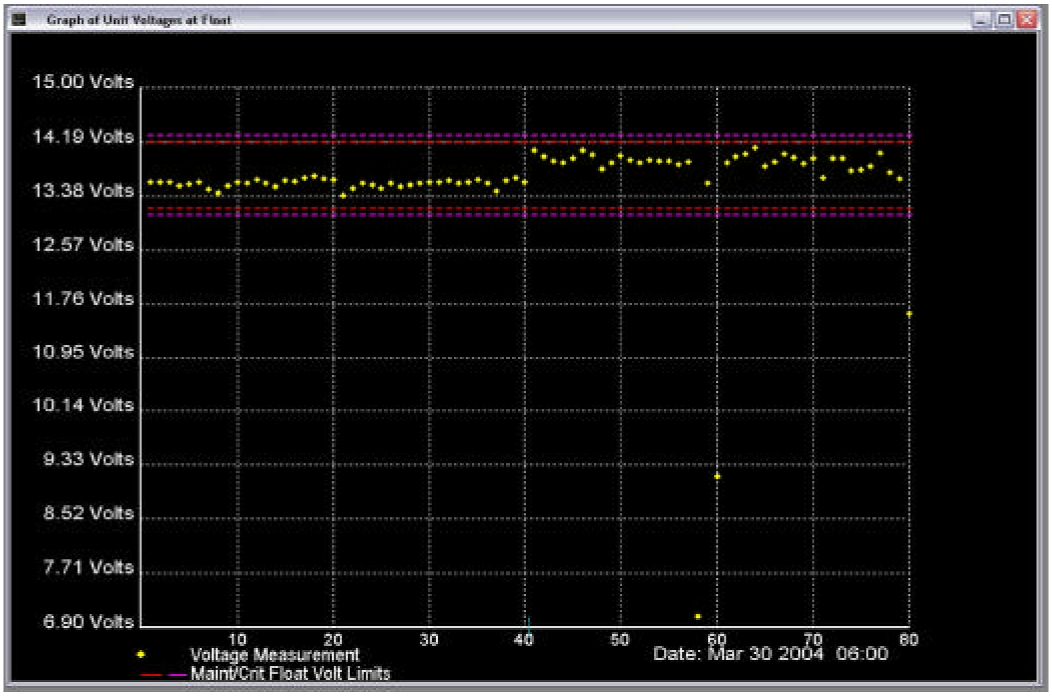


Unit #213 Impedance vs. Time

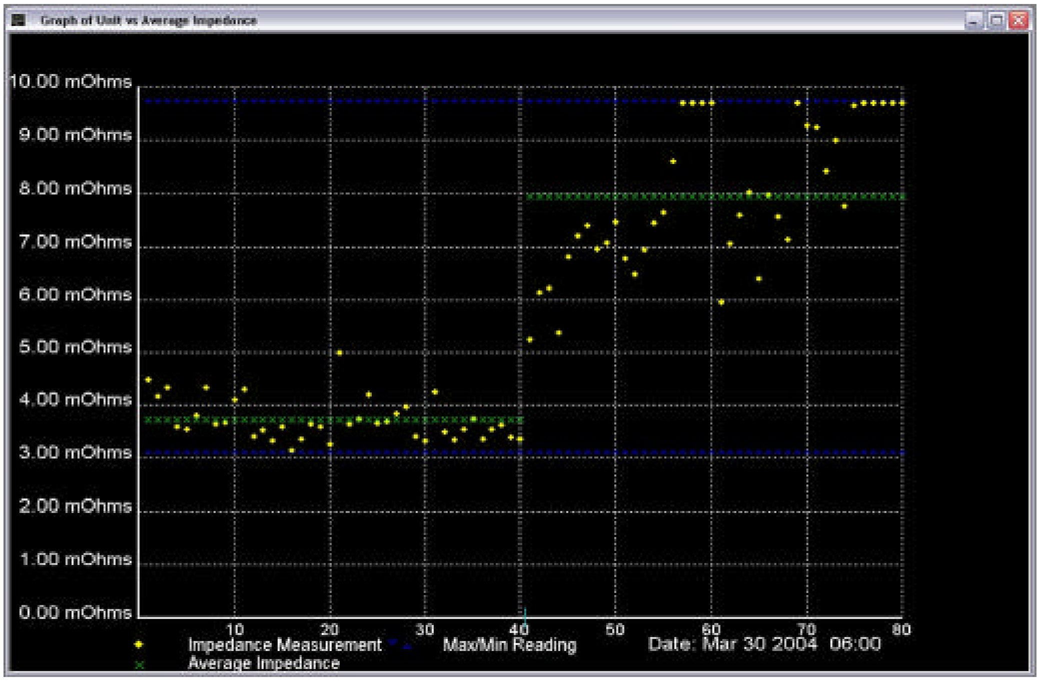
Background: Here is an interesting case on a large flooded (wet) cell string where the voltage change of one unit actually occurred before impedance. Voltages declined 10% quickly over a two-week period. From the graph, we were able to deduce that this battery had a small dendritic short, causing the voltage change. This customer needed to replace the unit immediately.

Conclusion: This is a great example where the monitoring system can provide measurement data good enough to understand what is happening with your batteries. Particularly with large flooded cells rated above 1000 Amp Hr, the change in impedance can actually lag the voltage.

Example #11 – Effects of Failed Batteries On Others



Two Cabinets of 40 Batteries – Voltage vs. Unit Number

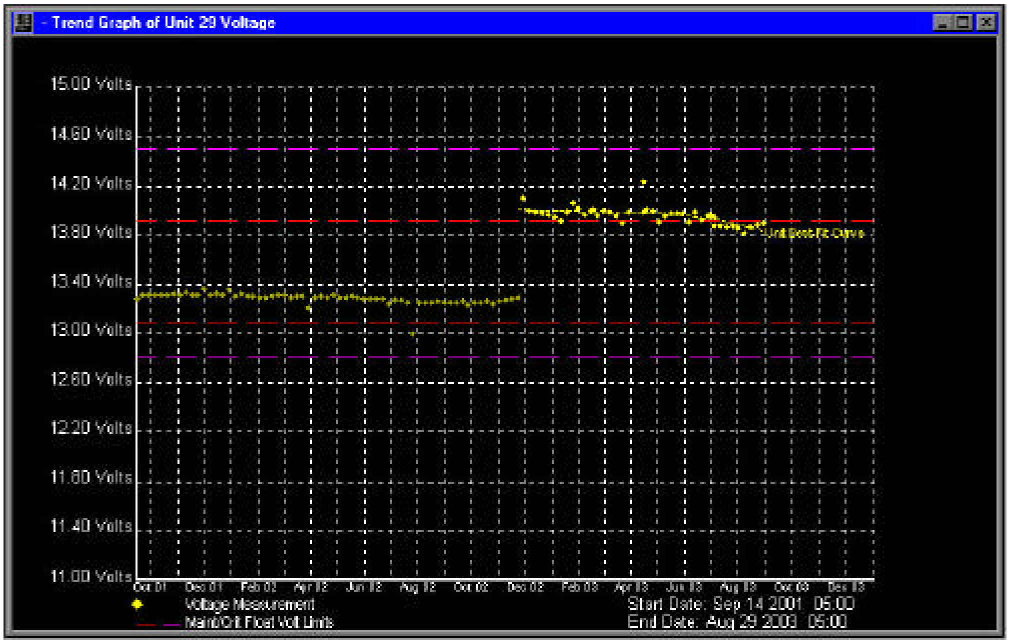


Two Cabinets of 40 Batteries – Impedance vs. Unit Number

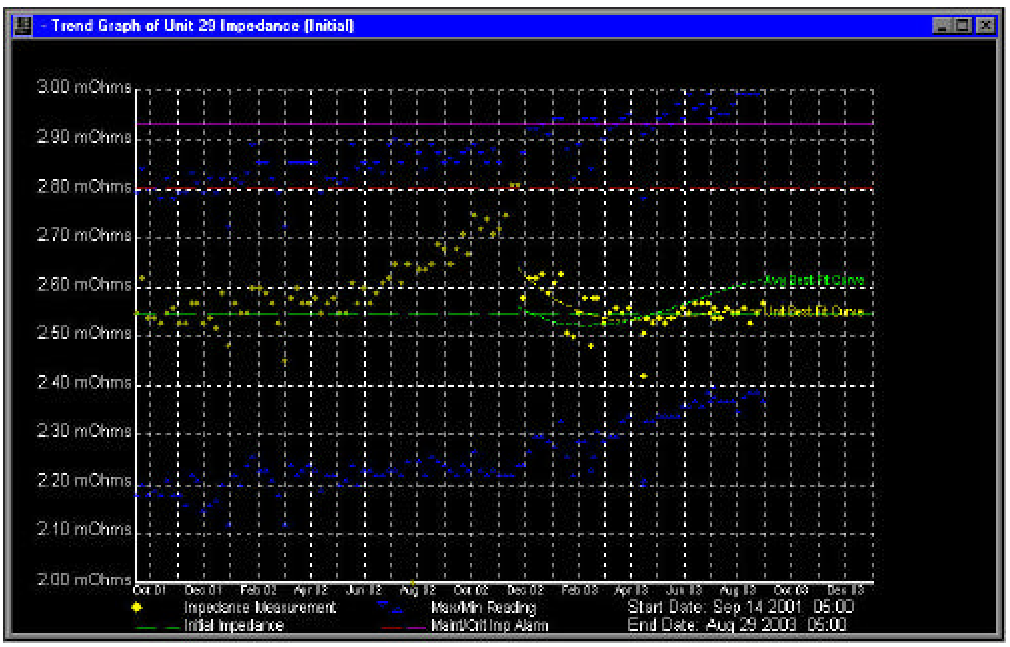
Background: The graph shows two cabinets of 40 sealed 12V batteries. One cabinet has failed, with average impedances over 100%. The Voltage graph tells an interesting story – over a period of nine months, the voltage of three units drop significantly, pulling the float voltage of the others in the string way above normal.

Conclusion: A great example to show how bad batteries affect others in the string – the lowered voltages of the failed units have driven up the float voltages of those remaining, possibly overcharging them. Changing these in time would have eliminated this problem.

Example #12 – A Tear-Down Analysis Confirms Battery Defect



Unit #29 Voltage vs. Time



Unit #29 Impedance vs. Time

Background: This is one of the most interesting cases BTECH has analyzed. Based on our recommendation, the customer replaced Unit 29after a little over one year in service.. We noted a 9.8 % rise in impedance and, although not "critical", BTECH Service elected to have the battery replaced.

The customer made a subsequent warranty claim , which was denied by the battery manufacturer based on initial tests. BTECH was sure the battery was defective – we contracted a third party to do independent battery testing. We are going to include a summary of the report done by the independent battery consultant.

Test Summary

Unit 29 passed the all of the standard field tests.

- Battery passed open circuit test at greater than 80% capacity
- Battery passed visual case and seal inspection
- Battery passed short circuit test
- Battery passed Tiff test
- Battery passed 100 amp/30 second fast discharge test
- Battery passed voltage test after rapid discharge
- Battery passed recharge rate to .1 milliamperes
- Battery passed standing open circuit voltage test

Normally, these tests would indicate that the battery is good.

BTECH requested further testing.

- Battery failed 100 amp/30 minute discharge only 20% capacity to failure
- Battery passed Tiff test
- Battery failed second 100amp/30minute discharge, only 26% of capacity to failure

BTECH requested a teardown analysis, and found that Cell 1 had a ***manufacturing defect of an absent valve seal***. The cell was gradually drying out.

Conclusion

This report shows the sensitivity of BTECH's technology by detecting a failed unit that traditional testing methods would not have found in routine service, further demonstrating the ability of the BVS unit substantiate warranty claims.

How Batteries Fail

We have demonstrated many battery failure modes, and they arrive from many different reasons. Here's a partial list of them:

1) Cracks in battery unit cases, cell dry-out, post seal leaks, stuck valves, plate sulfation, dendritic shorts, cracked plates or separators and poor plate welds

2) Internal warping of the battery plates (batteries will still show full voltage)

3) Environmental factors, especially temperature – in one case monitoring information exposed administrative staff that shut off the air conditioning on weekends, resulting in temperatures exceeding 100 F in the battery room

4) Indefinite length of time sitting without a charge between the battery manufacture date and UPS system installation and commissioning

5) Battery manufacturing defects – monitoring data has shown up to 3% of batteries to be defective "out of the box" and others failing shortly after the warranty period

6) Frequent cycling

7) Inappropriate UPS float charge and equalization settings

8) Battery interconnections not properly torqued by maintenance personnel

A New Battery Management Recommendation

Based on the data presented here, BTECH recommends a new battery management program using continuous remote battery monitoring as its cornerstone. Managing batteries according to measurement data rather than a set schedule can eliminate risk due to battery failure At the same time reducing battery maintenance and replacement costs. Our proposal follows:

1) Continuous, remote monitoring of battery parameters including battery temperature and voltage in real time and impedance trended on a weekly or daily basis

2) Trained personnel analyze the data from a remote site or local central control room, at least on a weekly basis, and contact the facilities engineer or local battery service provider when a problem occurs

3) Problem batteries are replaced or serviced as needed

4) Physical inspection of batteries reduced to once per year for VRLA batteries and every six months for flooded (wet-cell) types

5) Battery string replacement extended to the point where total string impedance has increased 10% or number of replaced batteries exceeds 20% in the string.

Conclusion: A Call for Action

We've presented a plan here for you to implement in your data center, changing the way you are managing your batteries by using trend data. The trend data obtained from our online battery monitoring shows how critical the batteries are to your UPS system - especially since just one rogue battery is able to cause a complete system failure. BTECH's data has proven that UPS systems stand at risk of failure a greater portion of time than is realized.

BTECH recommends a shift in the way batteries are monitored and maintained. The current IEEE battery management recommendations cannot guarantee the batteries will function when needed. Only by moving to a battery management program based on real-time, data-based, continuous impedance measurement, can risk due to battery failure be virtually eliminated.

We will be happy to assist your implementation of this new recommendation by choosing the right battery monitoring system for your application and recommending a battery service provider who will use the data from our systems. To find out more about our products and services, visit http://www.btechinc.com, or call us at the number below!

Thomas Leonard, Vice President, COO is the managing partner and Michael Phillips the Sales Manager of BTECH, Inc.

Contact BTECH, Inc. at 973-983-1120 or visit *www.btechinc.com*

About BTECH's NEVERFAIL Battery Monitoring Partnership

***NEVERFAIL**sm* **isn't a product… it's a partnership between you and BTECH...** and a comprehensive program to ensure the integrity of your backup batteries that are so vital to your backup power systems.

Whether you depend on 2, 20 or 20,000 backup batteries, ***NEVERFAIL**sm* is the solution for you, and the program includes three critical elements:

1. BTECH's fifth generation Monitoring System, designed and configured for your unique battery system and installed by BTECH trained technicians;

2. Remote "around-the-clock" data collection, analysis and alarm reporting by BTECH's staff of trained experts;

3. Regular on-site inspections and preventative maintenance by BTECH – the vital human link – to observe and correct all risk factors.

NEVERFAIL is the result of BTECH's 14 years' experience and more than 3,000 installations worldwide. We hold patents to key battery monitoring technologies that produce consistent, reliable data from virtually every battery type and manufacturer.

You'll find our systems where critical backup power is needed most, including:

- Government agencies;
- Military installations;
- Public utilities;
- Fortune 500 multinationals;
- Business enterprises in every industry and on every continent, including Antarctica!

Testimonials from Our Wide Range of Customers

DATA CENTER / FINANCIAL

"Eleven years ago, we installed our first BTECH Battery Monitoring System, which promptly found a battery string that would fail open. Since then, we've installed over 30 BTECH systems nationwide for our critical UPS installations. The BTECH systems have proven to greatly reduce battery maintenance costs, extend the life of the batteries and virtually eliminate battery failure by being able to predict precisely which cells need to be replaced in advance. Based on our experience, I highly recommend BTECH Battery Monitoring Systems." *Samy Alim, ADP.*

ELECTRIC UTILITIES

"The BTECH system forewarned of more than 30 potential battery failures, allowing us to replace batteries before they fail. The only way to know how your batteries are performing is to monitor their performance… BTECH has provided flawless service in maintaining our battery-backup systems." *Ken Rheault, Consumers Energy Co*

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MUNICIPAL

"March 13, 1993… I remember it very well. We dropped our entire load on one of our two fully loaded 300kva UPS systems… On 6/30/94, life changed. We installed BTECH's Battery Validation System. Since that date, I have not had to "wonder" about the health of each individual battery… When hurricane season comes around, I honestly do not worry about the batteries… I've got data that tells me their present condition." *Rick Faircloth, Florida Dept of Law Enforcement.*

GOVERNMENT

"…Uninterruptible Power Supply systems completely depend on simple and unpredictable batteries to work. BTECH not only reduces our backup battery failure risk, but saves the county money by eliminating the need to blindly change out all 600 backup batteries on a strictly calendar basis. With BTECH on the job 365 days a year, we can identify and change only the deteriorating batteries which saves us time, money and makes us much more secure." *Don Novak, Multnomah County Oregon.*

HOSPITALS

"My department is responsible for ensuring the operation of vital facilities at the hospital. To avoid the impact of devastating blackouts, we employ the use of Backup Power Supply Systems. Since backup power systems rely on backup batteries, which can fail with no notice, we employ BTECH Battery Monitoring Systems. But it is BTECH's remote around the clock data collection and alarm monitoring service that is especially valuable. Within the last several months, BTECH's remote monitoring service identified 4 deteriorating batteries and, thanks to that early warning, we replaced them and solved a problem that would have gone undetected and put us at great risk." Darayes Bharda, *Robert Wood Johnson University Hospital.*

Answers to Your Technical Questions

1. Do you have any standard measurement data that can compare with S5's impedance data?

No, we do not have any independent measurement data on battery impedance. But what we have done is to verify our readings to several shunts of known resistance. The shunt value is known and we take a reading of the battery impedance and then we add the known shunt resistance in series with the battery. We then know that if our readings are correct the impedance should increase exactly by the known value of the shunt. We have verified this and by this method are within 0.5% accurate. Additionally, our measurements have been verified to be accurate with hand-held devices.

2. What is the accuracy of measurements of impedance, voltage, and current of the battery?

The impedance accuracy is +/- 0.5% of full-scale impedance. (Full-scale impedance is a function of the load plate current that is used for a particular installation). The voltage accuracy is +/- 0.02 volts from 1 to 15 volts. The current accuracy is dependent on the type of sensor being used. The shunt will give +/- 0.2% of full-scale accuracy and the C.T. will be +/-2% of full-scale accuracy.

3. We can use TCP/IP to access the remote sites. However, our office is equipped with VPN only. Any solution?

Most VPN solutions utilize TCP/IP by providing a tunnel for TCP/IP over TCP/IP so your office probably runs on TCP/IP. You can check with your IT staff or check what protocol your computer is setup to use in the Controller under Network Connections.

4. All the measuring instruments undergo regular calibrations. What about with S5?"

The units will be recalibrated during annual PM inspections. Calibrations are checked against actual readings with a simple voltmeter. A hand held current clamp can also be used and for impedance the method described in #1 can be used to verify the readings.

5. If a battery is determined bad by S5, how can we be sure that it really is bad? Is this a silly question?

Many technical papers have been written about impedance being a leading indicator of VRLA battery failure. The BTECH method is to remove the failing battery from the string before it is bad enough to affect the system's reliability. Please see this web page http://www.dynastybattery.com/cd_dyn/contact/tech_support/7546/7546data.htm for a general discussion of battery impedance vs. capacity and VRLA maintenance requirements.

6. Where does the criterion come from that a battery is gone dead when the internal impedance of a battery is over 120% of the initial impedance?

The assumption is made that the behavior of any battery that has a high impedance value is unpredictable. If you look at the graphs in the "Complete Guide" you can see that in general, once a battery's impedance starts to rise, it keeps rising until some point at which the battery could fail open. Because batteries have many failure modes and their failure points are determined somewhat by the load placed on them, it is impossible to state exactly at which point the battery has "gone dead".

7. If we don't have initial impedance data of batteries (here in Korea, manufacturers do not release the initial impedance), is there any means to calculate or test the initial impedance data?

There is no way to ***calculate*** the initial impedance values. The way to start in this case is to ***measure*** the initial impedance from the actual batteries and use this is the baseline measurement. The monitor can be commanded to perform a set of impedance measurements when the battery is newly installed which will then be stored in memory as the initial impedance measurements.

8. I have a portable impedance test unit, why should I buy your system?

A portable impedance test unit looks at the battery system as a snapshot in time. The BTECH BVS® watches a number of parameters and can send alarms 24/7 in addition to performing consistent measurements on a weekly basis without human intervention.

9. How long should it take me to review the data?

It will take approx. 10 to 15 minutes per week per Battery Monitoring System to analyze and review the collected data.

10. Why should I sign up for BTECH's *NEVERFAIL* Partnership Program?

It shifts the responsibility of reviewing and acting on the data from you to BTECH. We collect and analyze the battery measurement data and inform when action needs to be taken. Plus, we make sure your systems are in working order by including a yearly on-site visit.

11. Each time I look at the voltage data from a unit it has significantly changed. Why?

Put a meter on that unit and observe the readings. The unit may be so bad that it is floating along with the bus. On a 12vdc unit, it can change by up to 5vdc and, as a result, the reported vdc can look a lot different from read to read!

12. Can the Battery Monitoring System fix bad batteries?

No, it will only indicate units that may need to be replaced in advance of them failing.

13. How often should the Battery Monitoring System be programmed to collect data?

The default standard is once per week for unit voltage and impedance, which is sufficient to prevent problems, although the system can be set to perform this reading daily. Temperature, bus voltage, discharge current and power supply to BVS® are monitored 24/7.