DATA POWER MONITORING CORPORATION

SUDDEN IMPEDANCE/RESISTANCE RISE (SIRR)

A discussion on a common cause of Stationary Battery related UPS failures

Version 2.1

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With over 25 years of facilities management experience, Mike brings to Data Power Monitoring a true 'end user' perspective to our ongoing strategy and operations. Mike was most recently the U.S. Facilities Operations Manager for 28 data centers (3.1 million sq. ft.) at Cable & Wireless (formerly Exodus/Digital Island sites). Prior to Cable & Wireless, Mike managed operations for Johnson Controls at both Bank of America & Charles Schwab.

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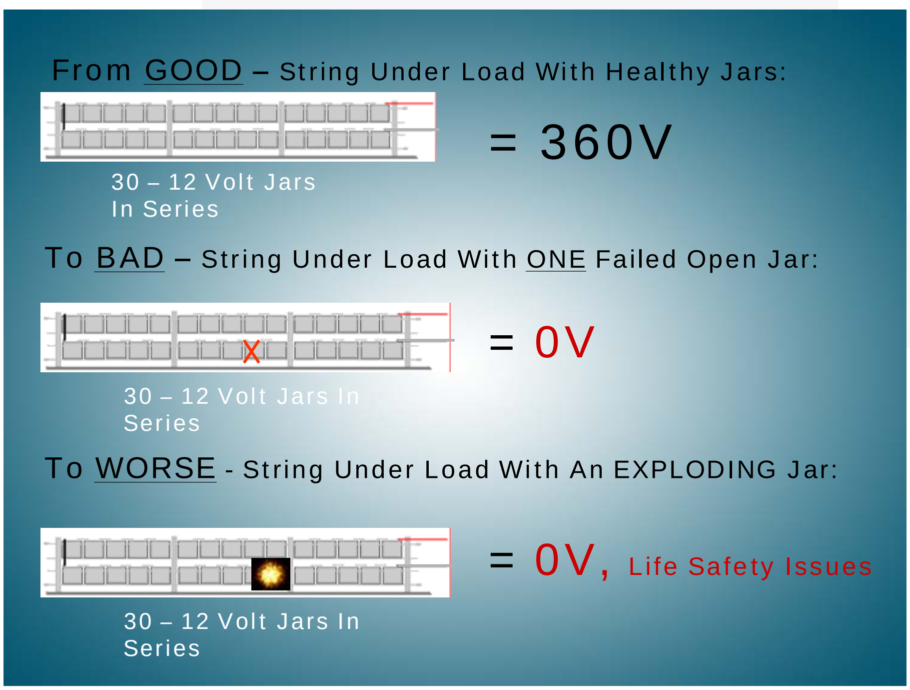
Background

A catastrophic power failure has just occurred; the Facilities Manager is explaining to the CIO "why" the data center power failed when the UPS was supposed to work.

FM: *The UPS manufacturer found an "Open Jar".*
CIO: *What in the world is an Open Jar?*
FM: *Sorry, a Jar is a battery; the UPS has 40 batteries connected together in a string. If one battery "opens, fails" the string is broken much like old series wired Christmas tree lights, and the UPS fails.*
CIO: *When were the batteries checked last?*
FM: *About 6 weeks ago, we performed quarterly maintenance. Everything checked out. These batteries are only 3 years old. This shouldn't have happened!*
CIO: *This outage will take a week to recover from and cost more than $1,000,000. What do we tell the CFO?*

Abstract

Sudden Impedance/Resistance Rise (SIRR) in a Stationary Battery is indicated by an exponential rise of internal resistance over a period of 2-4 weeks. **SIRR**, which can occur at anytime in the serviceable life of a battery, is a common form of battery failure. A **SIRR** battery jar (if not replaced) will open, jeopardizing the integrity and reliability of the UPS. In the worst case, a failed open jar can even explode under load conditions, jeopardizing safety.



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Importance of a robust battery maintenance/monitoring program:

Best Practice battery maintenance/inspection and monitoring on stationary batteries requires two key elements. 1) Quarterly maintenance and inspection, &. 2) A weekly monitoring program (at a minimum.) The reliability of any UPS system will be impaired if either program is compromised or omitted.

Maintenance and inspection programs: a) insure proper torque of external connections b) discover signs of jar swelling, electrolyte leakage, corrosion and or bacterial growth, etc c) provides a crosscheck and review of monitoring data.

Weekly monitoring provides predictive failure analysis by trending: a) jar internal and battery interconnection resistance b) jar/string voltage c) battery and ambient temperatures d) UPS discharge data.

This paper focuses on one element/benefit of weekly monitoring in preventing **SIRR** related power outages.

Data Power Monitoring Corporation (DPMC) Recommended Practices

DPMC recommends that stationary batteries should be investigated when the battery monitoring system indicates an impedance/resistance rises of 15% (maintenance threshold) of the initial ohmic values and replaced when they exceed 20% (replacement threshold) of the initial ohmic values.

The decision to replace a battery should always be independently confirmed by conducting a jar level performance capacity test. Never perform a capacity test on any battery that is suspect of being open or shorted. The discharge test should be conducted by qualified personal as per the manufacturer's specification for pass/fail criteria.

Basing measurements on the delta between the initial ohmic value and the current ohmic value is a critical element of string life. The initial impedance/resistance of a battery can vary from the manufacturer’s specification by up to 20% with no observed affect in battery life or performance. Therefore a battery specified with an internal resistance of 2.25mΩ can have an initial range from 2.3-2.7mΩ. The replacement threshold can vary from 2.875-3.375mΩ.

Changes in temperature and/or changes in test equipment, impact measured values significantly. Always ensure that the same, calibrated testing device is used through the life of a given battery.

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Replacing batteries at an artificial "standard" threshold can be costly. Replacing batteries prematurely in a string impacts the life of the string. One key criterion for string replacement is that the string be replaced when 25% (maximum) of the batteries have been replaced. As a battery ages, the internal impedance/resistance normally rises. Each new battery introduced into a string has a lower impedance/resistance than the surrounding batteries due to their age. This lower impedance/resistance impacts the charge rate of the neighboring batteries (I=E/R). Introduce enough new batteries into the string and the string can become imbalanced, overcharging some batteries while undercharging others, accelerating the aging of the entire string.

Trend Graphs

Chart 1 shows a flooded battery with an initial impedance/resistance of 0.67mΩ. The maintenance threshold on this battery would be 0.77mΩ and the replacement threshold would be 0.8mΩ. This battery was installed in December 1998 and trended normally until late May 22, 2000. A "Spot Test" associated with quarterly maintenance on June 19, 2000 would have shown this battery to be within acceptable standards, the voltage level may have called for a recommendation to equalize the string. **SIRR** is clearly indicated from June 26 to July 10 and the battery was replaced by July 17. The **Voltage Trend** demonstrates a corresponding fall in voltage sometimes associated with the rise in impedance/resistance.

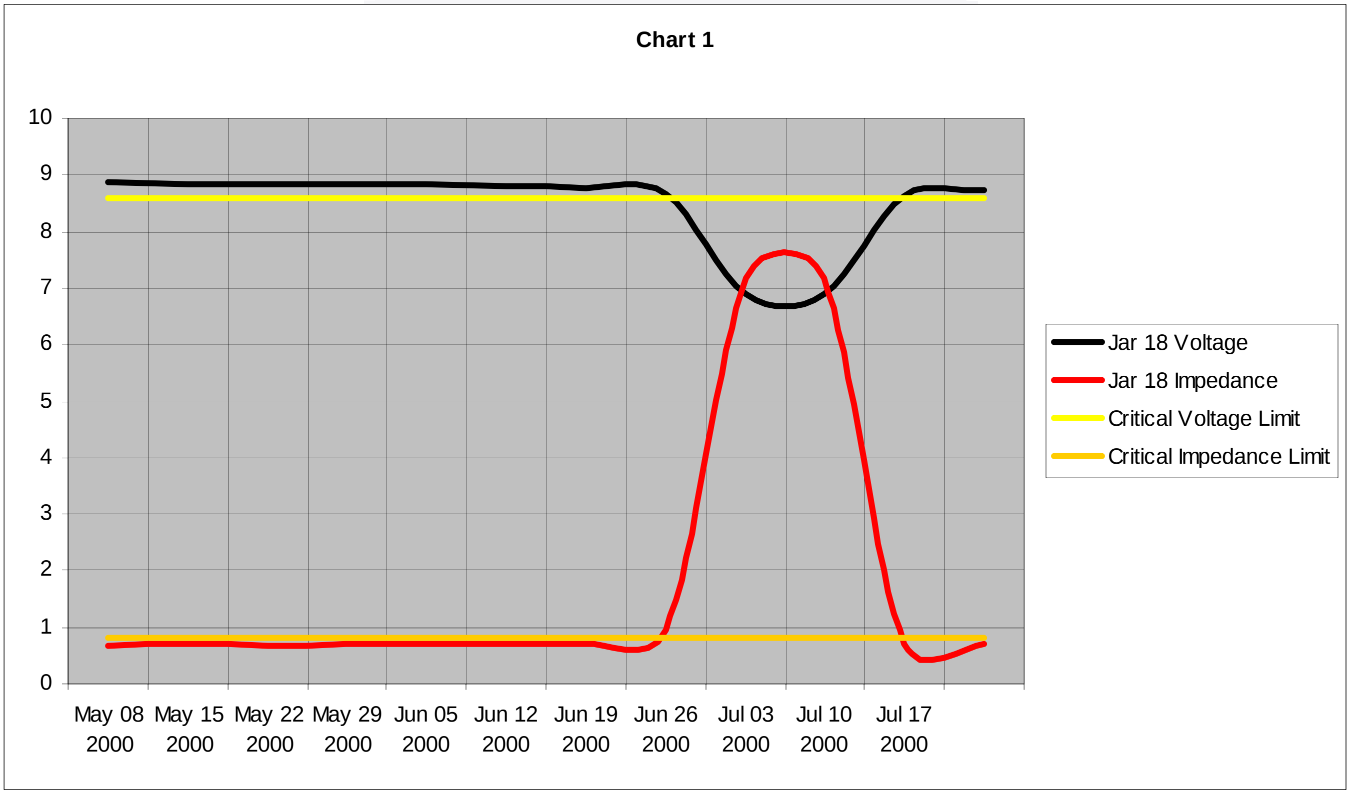

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Chart 2 shows a flooded battery with an initial impedance/resistance of 0.69mΩ. The maintenance threshold on this battery would be 0.79mΩ and the replacement threshold would be 0.83mΩ. This battery was installed in July 2000 replacing the battery in **Chart 1** and trended normally until late February 2001. This case could be considered infant mortality as the battery failed in only 7 months.

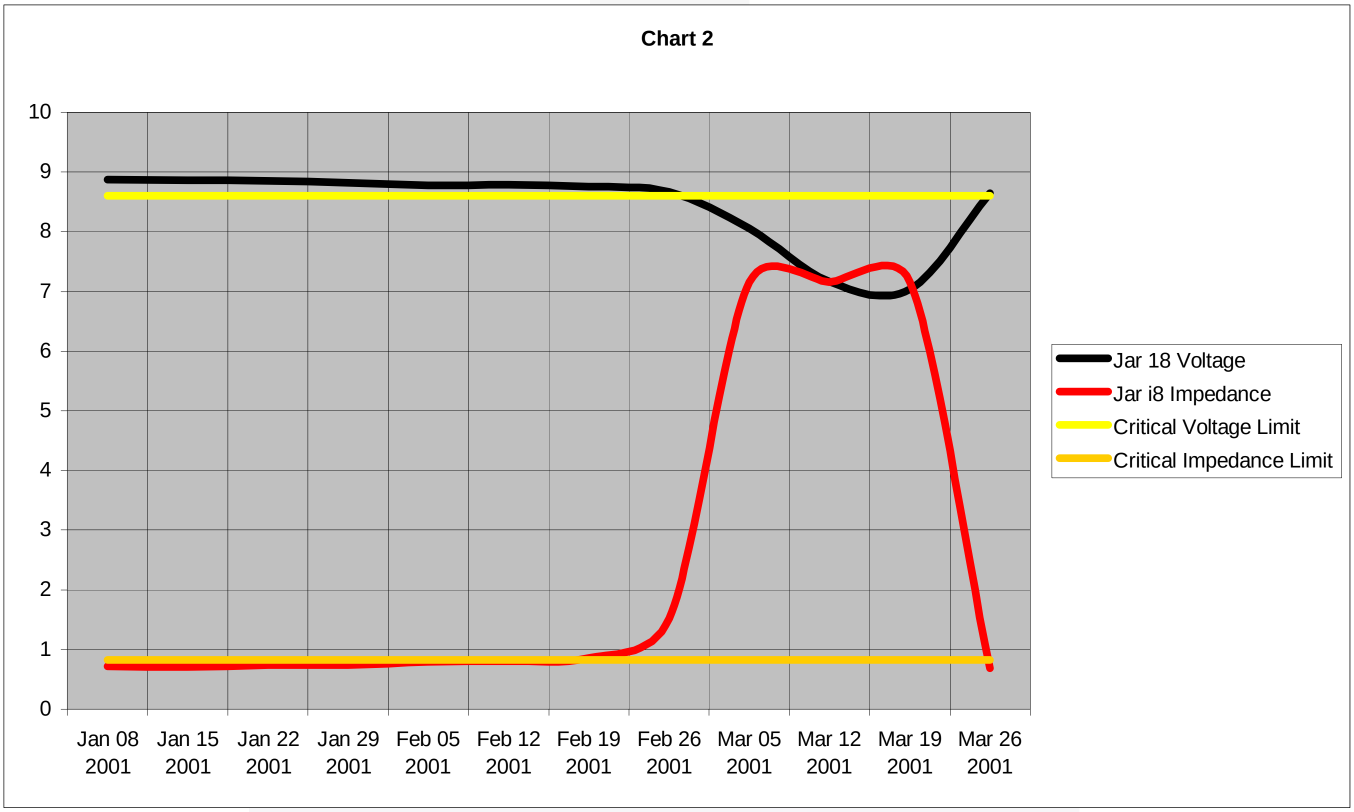

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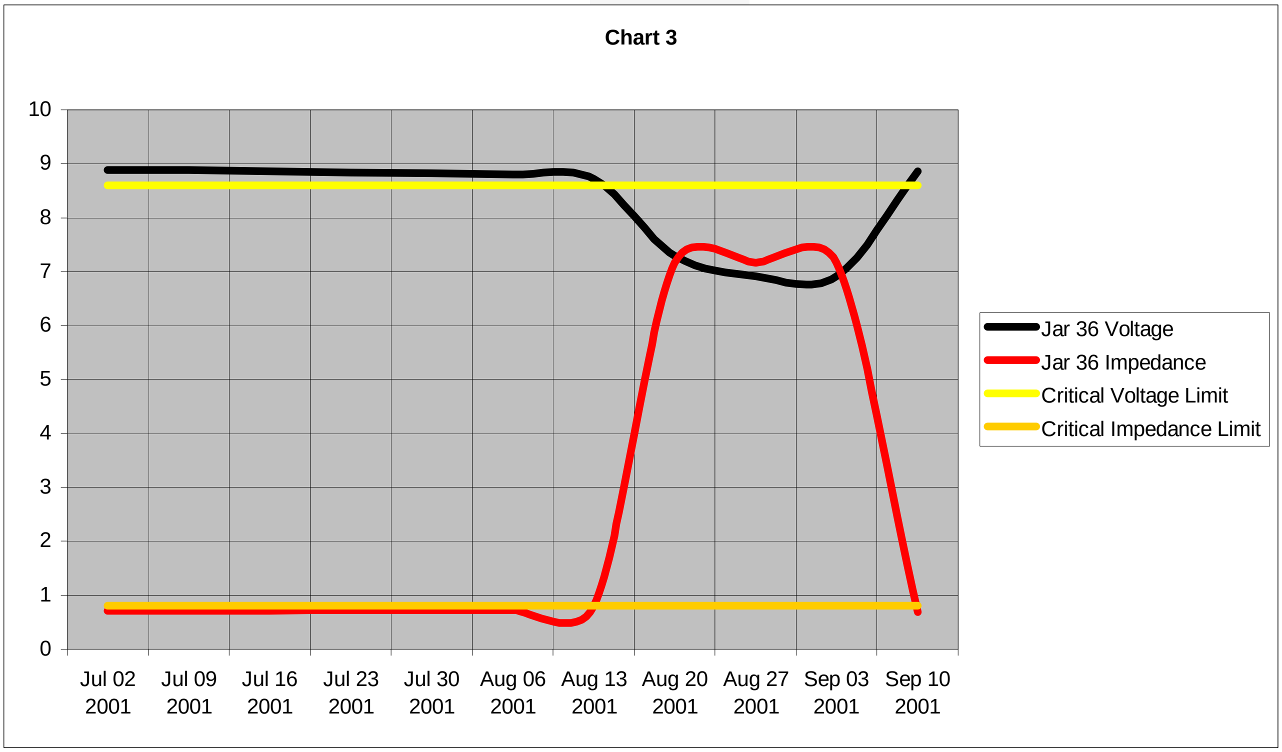
Chart 3 shows a flooded battery with an initial impedance/resistance of 0.69mΩ. The maintenance threshold on this battery would be 0.79mΩ and the replacement threshold would be 0.83mΩ. This battery was installed in December 1998 and trended normally until late August 2001.



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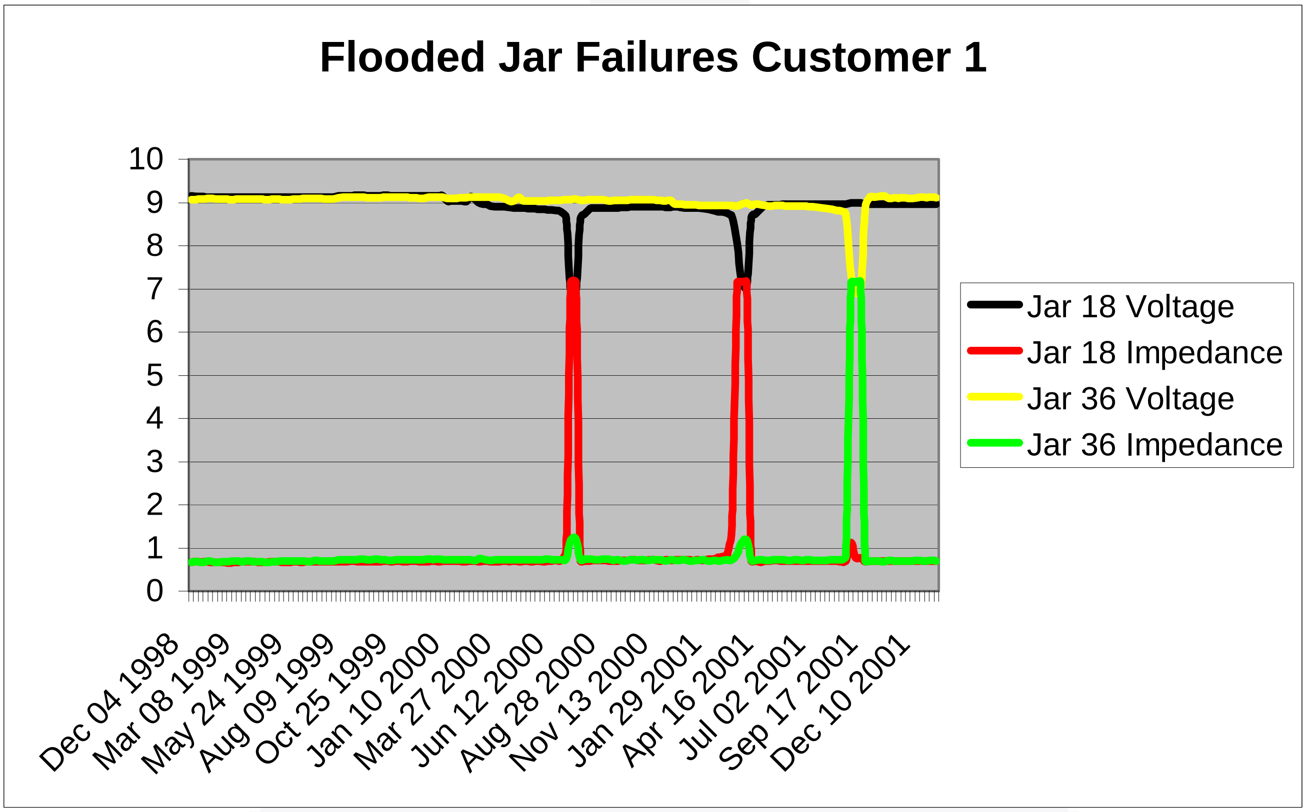
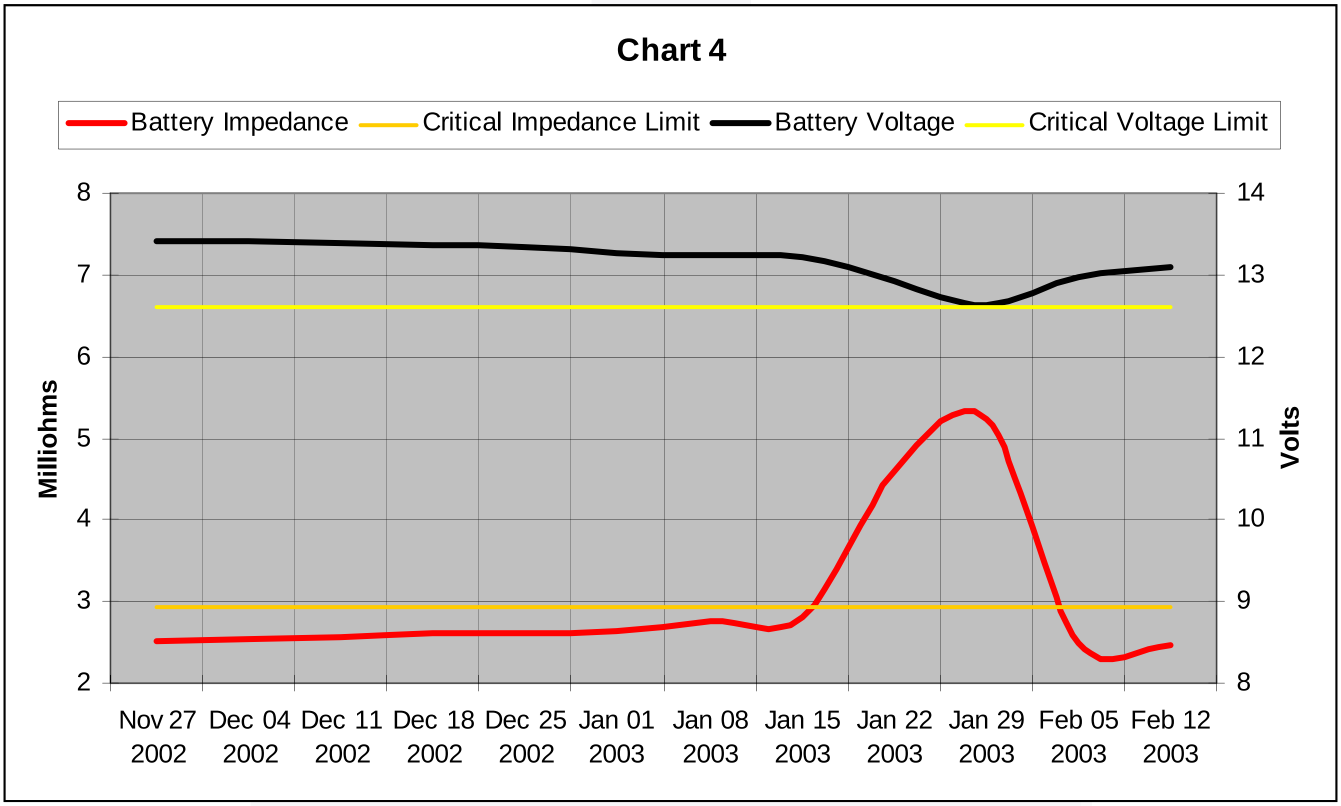
Charts 1-3 are all from the same string of batteries installed at a well designed and well operated Tier III datacenter of a major financial institution. This string and the redundant system at this site have been less eventful as the strings matured.



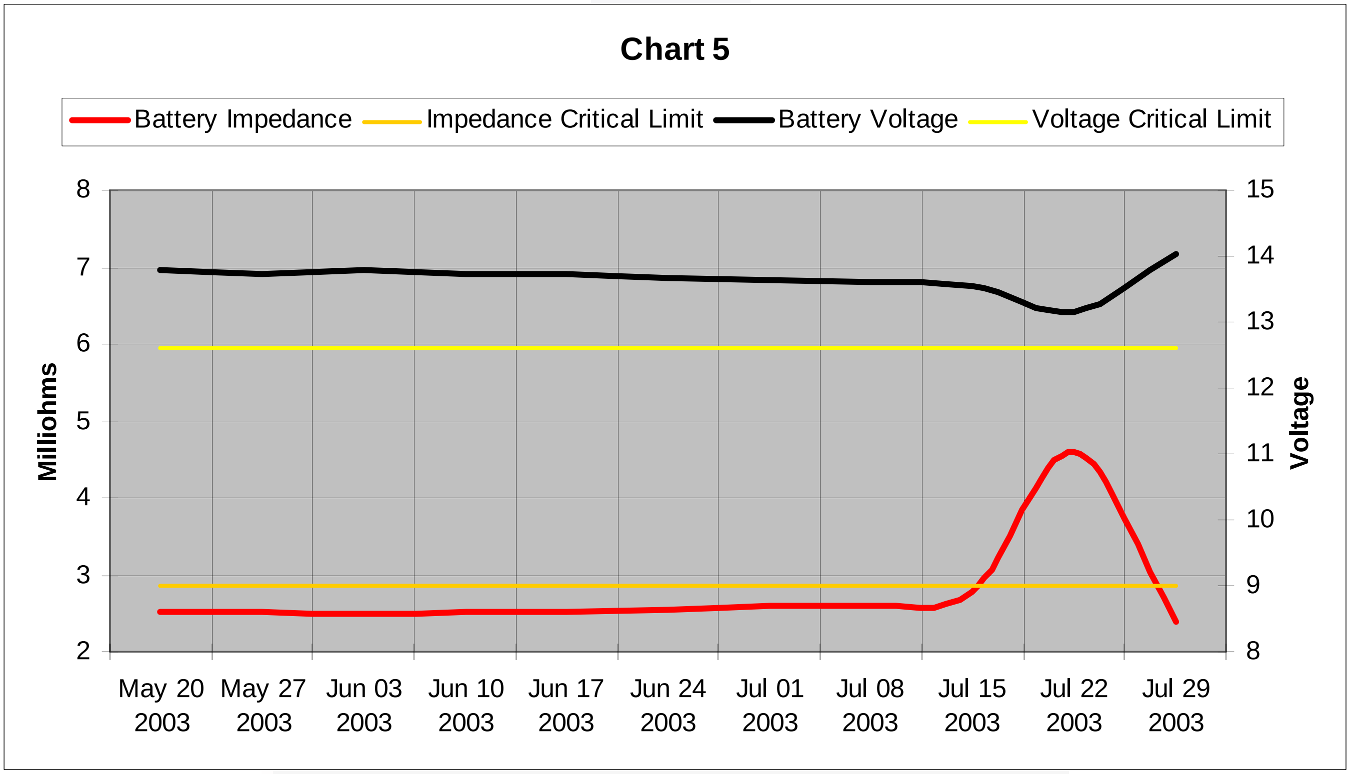
SUDDEN IMPEDANCE/RESISTANCE RISE (SIRR)

Chart 4 shows a VRLA battery with an initial impedance/resistance of 2.5mΩ. The maintenance threshold on this battery would be 3.0mΩ and the replacement threshold would be 3.125mΩ. This battery was installed in August 2000 and trended normally until late November 2002. The **Voltage Trend** demonstrates a corresponding fall in voltage sometimes associated with the rise in impedance/resistance. Also note that the replacement battery was not fully charged at the time of installation. This new battery was installed in an undercharged condition and took 8 weeks to equalize with the string.



SUDDEN IMPEDANCE/RESISTANCE RISE (SIRR)

Chart 5 shows a VRLA battery with an initial impedance/resistance of 2.4mΩ. The maintenance threshold on this battery would be 2.88mΩ and the replacement threshold would be 3.0mΩ. This battery was installed in February 2001 and trended normally until late July 2003. **SIRR** in this case occurred in just 2 weeks and the battery was replaced immediately. The **Voltage Trend** again demonstrates a corresponding fall in voltage sometimes associated with the rise in impedance/resistance but remains within limits. Voltage is the lagging indicator in up to 30% of battery failures. In this case the new battery was overcharged at the time of installation and remained above 2.27 volts per cell for 6 weeks. Float voltages exceeding 2.27 volts per cell will reduce battery life.



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Conclusion:

Power outages caused by **SIRR** batteries are 100% preventable. However, a weekly battery-monitoring program is required to prevent **SIRR** related power outages. **SIRR** is a major problem in the industry in both flooded and VRLA batteries. Unfortunately many data center operators are not aware of the risk of **SIRR.** DPMC has heard similar conversations to that of the FM, CIO, and CFO, from prospective customers after **SIRR** outages.

These graphs are from hundreds of examples of **SIRR** collected over the past 12 years by DPMC. DPMC currently monitors more than 250,000 batteries globally and has a database with over 25,000,000 data points on trended battery performance. Each day or week, voltage and impedance/resistance readings are polled by our servers and analyzed. Trends are identified using a combination of analysis by monitoring software and manual data analysis. When a trend develops customers are notified, and the failing batteries are replaced reducing the risk of an outage.

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