Mandatory monitoring?

Monitoring batteries can be an expensive and involved business, but the costs in lost revenue and damaged equipment can be far higher, discusses *Nick Flaherty.*

Testing and monitoring banks of batteries is becoming an increasingly important topic. New standards on testing are emerging, partly as a result of the rise in use of Uninterruptible Power Supplies (UPS). The economics of the industry (particularly telecoms), is putting pressure on costs in every part of the business.

At the most fundamental level, if you want to be reasonably sure your batteries operate when you need them to, then some form of monitoring is necessary. The level of testing and monitoring is currently being debated and that depends on the design of the system and the types of battery used.

But there are also system level issues. The best monitoring systems cannot compensate for the fundamental loss of battery knowledge in a company or for poorly designed systems. When an office block in Sacramento, California, was evacuated, staff followed standard procedure and switched off the air-conditioning and left the UPS on charge. "The temperature went way up and the batteries went into thermal runaway and blew the roof off," says chair of the stationary battery committee at the IEEE and business development manager for North America at battery maker Saft, Jim McDowall.

The aim of monitoring is to prevent these situations happening and to provide warning when the cells are degrading and will not provide the required current and voltage. This is particularly relevant for back-up cells that may have to sit for months or even years without being used but may be called on to produce high current outputs quickly after long dormant periods.

Regular testing and cycling of the cells is vital, surely? Some parts of the industry are challenging that traditional way of thinking.

The claim for Valve Regulated Lead Acid (VRLA), batteries is that they are maintenance free. Yet these batteries only have a life of between seven and ten years and there are significant potential problems with them, particularly with monitoring.

"The VRLA is typically marketed and sold as a maintenance free product but it is more accurately described as 'maintenance resistant'," says Verizon Wireless America senior engineer Bruce Fountain. "Unfortunately the VRLA battery doesn't respond consistently to maintenance and exhibits a very short service life, typically under seven years." Moreover, the battery sometimes fails abruptly and catastrophically - with no warning.

"There are some users who have come to believe that the investment in VRLA battery maintenance is fruitless," he says. "They contend that no matter how much labour is expended, the VRLA battery tends to fail even when predictive data suggest otherwise. These users perform

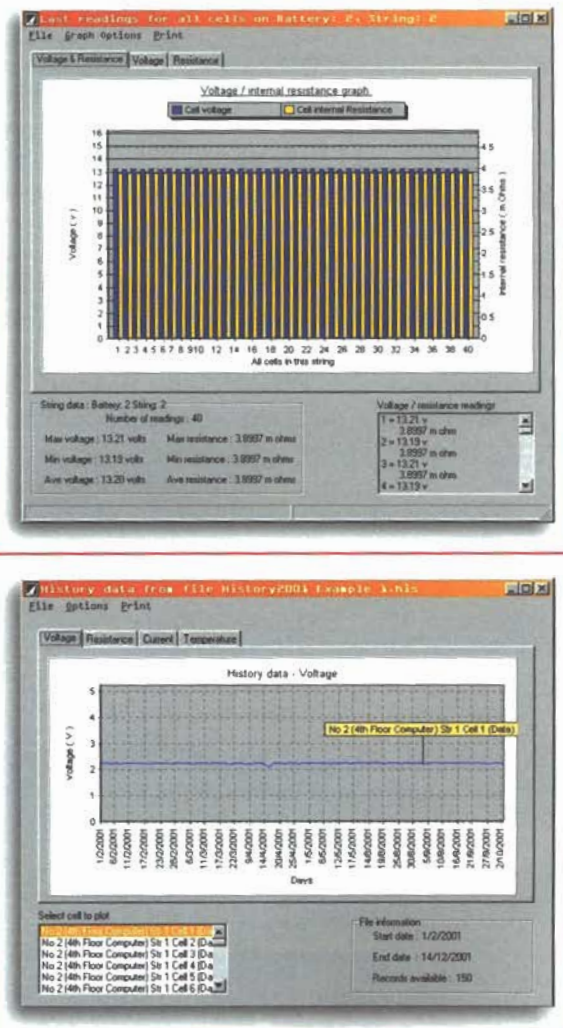

Figure 1 (top) & 2 (NDSL): Monitoring a string of cells with CellWatch

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>
> *Verizon Wireless America senior engineer Bruce Fountain*

minimal or no maintenance and feel that this approach is no less effective or leaves them no more exposed than with more intensive and costly maintenance programmes.

"Based on my personal experience, service life can reach design life in a flooded battery but does not in a VRLA product," he says.

So there is a trade-off between the investment in monitoring - whether human or automated - and the risk that this investment is wasted (see box on p40).

But some companies such as British telecoms company BT, have moved over to VRLA and have addressed the issue with a modular systems approach. "A lot of companies such as BT are taking a more modular approach with VRLA systems and are following the philosophy that if one of the strings fails you still have a significant backup time from the other strings that are sized for several hours of backup," says McDowall. "That works very well in that environment with multiple strings but that's not good for UPS applications which have a very short run time because the battery doesn't have the same efficiency at twice the load," he says. "For example, backup designed for 15 minutes with two strings can only be a minute or less on one string.

"They have done the best they can to address the shortcomings of the product," he says. "They try to mitigate the impact of battery failures as you will never get total assurance from a maintenance operation with today's batteries."

While McDowall points to other technologies as a way around this, he does admit that it is taking time to convince customers. "That's the reason for choosing Nickel Cadmium (NiCd), batteries. Would you rather be changing out VRLA every four or five years or adding water to a NiCd every five years, particularly if you have the possibility of thermal runaway. But so far it's not a choice many people have taken because they are taking other routes such as temperature monitoring in the charger," adds McDowell.

Remote electronic monitoring is seen as the way around the problem of sending an experienced engineer around many different sites to take measurements by hand but there are issues that need to be addressed. "There's not much point in having a monitor that generates reams and reams of data if you don't act on it," says McDowall. "Take a

Testing and sizing batteries

Sizing batteries is part of the specification of a system but the need to test them with a discharge test is part of the monitoring schedule and, it turns out, this test is dependent on the original sizing specification.

In the previous IEEE1188-1996 standard, a battery would be sized at 125% of its life and tested at its rated current. If it reaches 80% of its expected time, then it passes. While that is fine for the battery systems in applications such as telephone exchanges and wireless base stations, it just doesn't work for UPS systems that may have to draw a higher current for a shorter period of time, according Jim McDowall.

The changes in 1188-2003 now specify a different way of testing for capacity in monitoring tests for VRLA batteries. These corrections have already been made in the latest version of IEEE 450 for VLA batteries and will be included in the next version of IEEE 1106 for NiCd batteries.

What the standards have said in the past is to test the battery by discharging at the published performance for the test time. So for a one-hour test time, you take the data sheet for the 60A battery and discharge at 60A and if it can't supply the rated current for 80% of the time, (48 minutes), then it fails. But that is not the way it was sized. The 60 A battery is actually a 48 A battery sized for aging, so it is expected to support a 48 A load for one hour. So it should be discharged at 48 A but the data for 48 A is not published for a 60 A battery.

The problem shows up particularly with UPS batteries where the discharge time is much smaller. For example, if you take a particular VRLA battery size at ten minutes rate and apply the1.25 aging factor you get 18minutes at the same load. But if you use IEEE 450 with a fixed 100A load and expect 18 minutes, it is likely to fail after 14 minutes. Under the standard, the battery fails the test, but you only sized it to last 10 minutes, so it should pass. "It doesn't make sense," said McDowall. "It's the testing that is causing the battery to be condemned when, for the load, it's perfectly fine."

The complexity of the problem shows up in the calculations: For a 100 A battery that needs to run for ten minutes, the battery should be sized at 125 A. But you want to run the test at 100 A and if you get eight minutes it passes the test. What you then have to do is look up the eight-minute performance for that battery (say 113A), and compare it to the test current. So the capacity rating is 100A/113A x 100. "Now the sizing and the testing work together rather than as separate plans," says McDowall.

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Saft business development manager for North America Jim McDowall,

telco like BT - they have hundreds of installations, thousands of battery strengths and if they had monitoring on each one they would be generating so much data they would need to look at the deployment costs of that - they are enormous and very, very difficult to justify."

But monitoring does require a certain level of intelligence in the monitor. For example, one has to look at differences in temperature between ambient and the electrolyte and the case temperature for VRLA monitoring; the rate of change of the voltage plus the ohmic measurements and their difference – these are not just straight measurements.

"But then you are talking about quite a bit of added cost and no monitor does a visual inspection for example for electrolyte coming out of the positive seal - it's not going to be long before that cell fails - there's a good chance that oxygen is getting into the cell. If you could see that you could take corrective action a long time before you see changes in the ohmic values," says McDowall.

Part of the problem is that the people with the necessary battery skills are no longer in the company. "Unfortunately the days are gone when you had a battery specialist or a subject matter specialist (SME) - that's one of the downsides of early retirement." There is another problem with that loss of expertise, says McDowall: "If you don't have the knowledge needed to interpret visual indication then a monitoring system might be the next best thing. But if you don't have the expertise to know what the problems are then you are unlikely to be able to justify the monitoring system to management."

But monitoring is becoming more popular, particularly in UPS applications.

"The economics of monitoring are no different from the economics of the UPS itself," says NDSL chief executive/founder Alan Denny, which supplies the CellWatch monitoring system across America and Europe. Around 85% of NDSL products are installed in UPS back-up battery systems in companies ranging from financial and insurance organisations to the military and air traffic control systems. The remainder falls into telecoms or emergency lighting in factories.

"The US is more attuned to monitoring," he says. "If you went back to the 1990s people did question why they need UPS but now they don't, regardless of any payback period

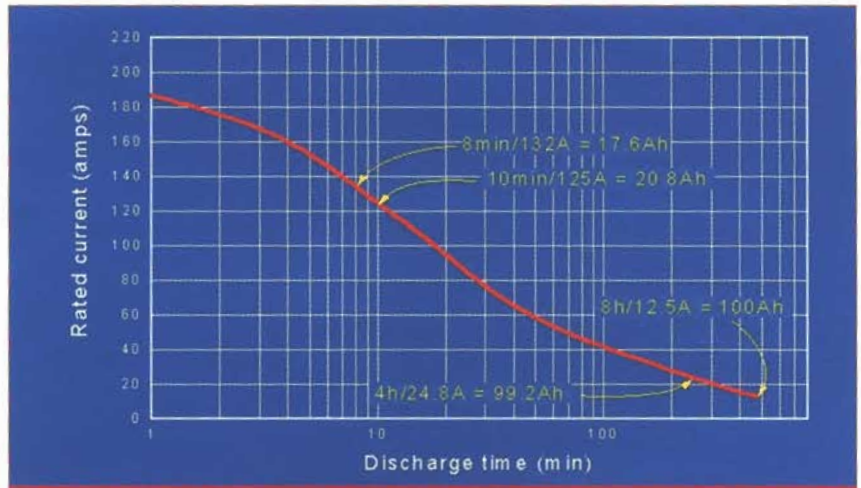

Figure 3: Rating data is more critical with the short discharge times of UPS systems

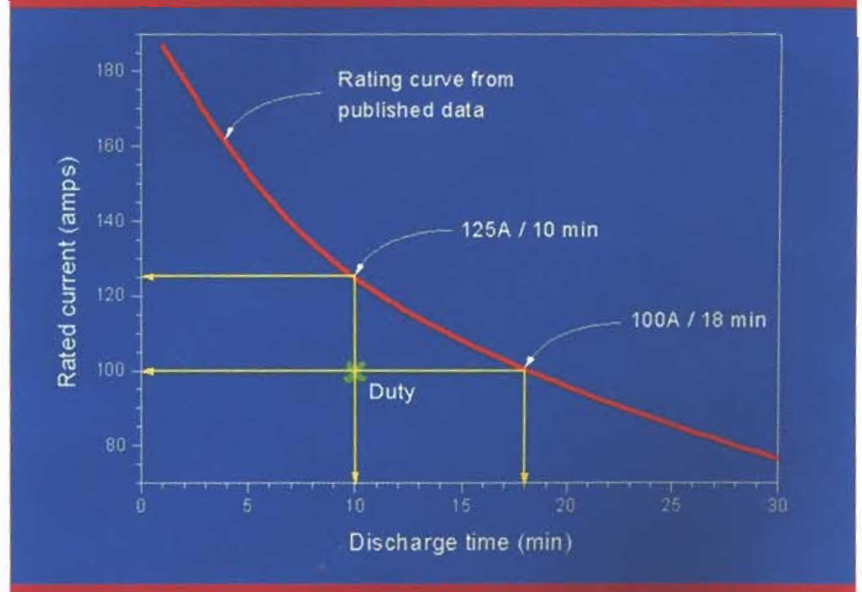

Figure 4: The difference in testing the battery at its aged capacity and its specified capacity.

"Like any other monitoring system, the investment is worthless unless qualified individuals watch and interpret the information."

Data Power Monitoring president Bart Cotton

you have to have it. Now in the US people don't question why they need battery monitoring. In the UK and Europe there is still the question of payback. If you look at the labour costs of taking measurements manually then in two or three years you get a payback."

But Denny does acknowledge that price is an issue and NDSL has developed a lower cost system that connects to an existing network. "For example we installed a monitoring system at a major UK bank with 4,000 cells last year. Someone who has 32 or 64 cells doesn't want all the bells and whistles of a system for a large bank."

There are alternative approaches such as using smart chargers but there is still a need for these types of monitoring systems because having smarter chargers is not necessarily enough. "The question is whether a smart charger provides the right information Today we can provide voltage and internal resistance per cell and that's the key aspect as opposed to the string voltage. A number of times we have installed the monitoring system and instantly recognised battery faults that have not been picked up previously," says Denny.

Another approach to battery monitoring is to out-source the monitoring and analysis "Remote battery monitoring should be done by experts, who have proper training and experience for this task," says Data Power Monitoring company president Bart Cotton which uses battery systems from Btech. "Like any other monitoring system, the investment is worthless unless qualified individuals watch and interpret the information."

NDSL is seeing the same issue and working on an expert system that will take the data and flag up potential problems to less skilled people, argues Denny.

Data Power Monitoring has found that based on its collected data, over 90% of VRLA failure indications are due to the battery itself while the reverse is true of the flooded or vented product where it is the monitoring that has been the problem.

"Outsourced battery monitoring specialists can determine battery state of health quickly and can predict future problems which require maintenance and/or replacement," says Denny.

He cites an example where individual units can be replaced rather than a whole string, extending the useful life of the battery string. Typically, when approximately 20% of battery units have been replaced, it is time to consider a new battery string due to unacceptable battery capacity variances within the string. In addition, aging trends of the whole battery system become more important and recommendations can be made regarding battery string replacements in time to prevent a failure.

There are four points to remember, says Cotton:

- Battery monitoring equipment is only as effective as the people who interpret the data or information,
- When evaluating battery monitoring, consider the significant and un-budgetable costs of downtime versus the budgetable cost of predictive monitoring;
- Ensure that all monitors are accessible from anywhere at any time;
- Battery monitoring is a 7x24x365 proposition.

And monitoring is the dominant trend: "I think we are starting to approach the time then we will see more self monitoring batteries, " says McDowall. "You already see that with Lithium-Ion based batteries that have monitoring at each cell for voltage blocking. Then there's no point in monitoring at the voltages because you know what they are - if one goes astray. The system is either self-correcting or shuts itself down. We're heading towards that situation," says McDowell. ◻

Economics of monitoring

Verizon Wireless has performed an economic analysis of the value of monitoring compared to the consequences of not doing it:

Maintenance required	Small Sites	Large sites
Man hours per year	25-35	65-75
Annual cost per site	$2000	$6000

Source: Verizon Wireless

These costs do not include logging, tracking, reviewing and analysing the maintenance data that is collected, which incurs further costs. However, the cost of not doing anything is considerable says Verizon Wireless senior engineer Bruce Fountain. An outage of one hour for a switch site is around $800,000 - for seven days, that escalates to over $20m with the lost revenues. With thermal runaway, the damage to the switch and the office can cost $2.5m.

	1 hour	6 hours	12 hours	24 hours	7 days
DC power system failure					
Revenue lost	$115,200	$591,200	$1.36m	$2.74m	$19.3m
Repair	$.75m	$.75m	$.75m	$.75m	$.75m
Labour	$3,360	$3,360	$3,360	$3,360	$3,360
Total	**$868,580**	**$1.44m**	**$2.13m**	**$3.52m**	**$20.1m**
Thermal runaway					
Switch damage	$2m	$2m	$2m	$2m	$2m
Office damage	$0.5m	$0.5m	$0.5m	$0.5m	$0.5m
Total	**$2.5m**	**$2.5m**	**2.5m**	**$2.5m**	**$2.5m**

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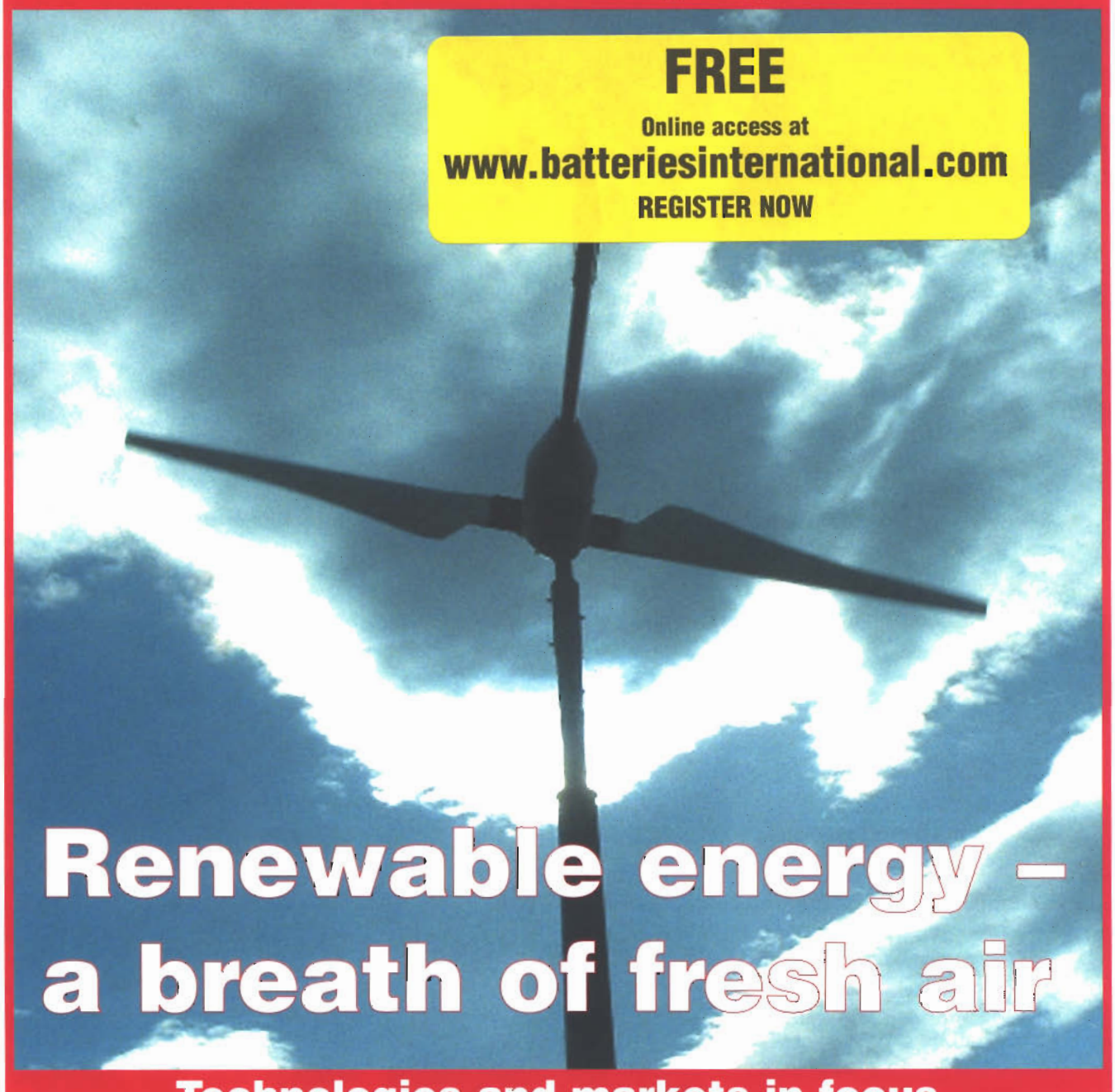

Technologies and markets in focus

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