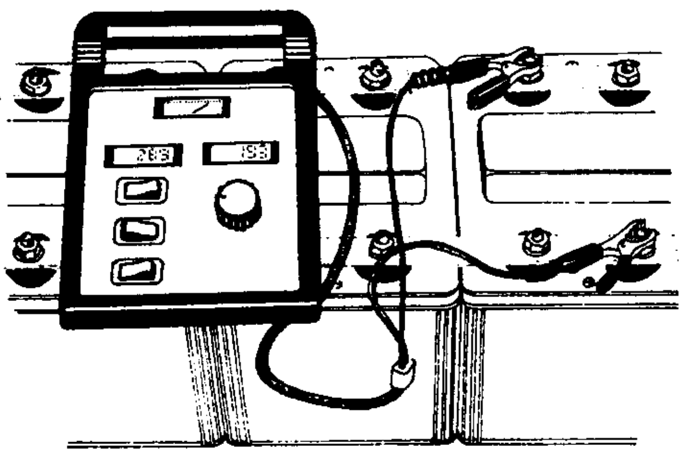
Field Experience of Testing VRLA Batteries by Measuring Conductance - May 1994

FIELD EXPERIENCE OF TESTING VRLA BATTERIES BY MEASURING CONDUCTANCE

Copy of a paper presented To:

8th Battery Conference and Exhibition



ERA TECHNOLOGY

National Motorcycle Museum,
Solihull, West Midlands, UK
Wednesday 11 May 1994

by:
M W Kniveton
British Telecommunications plc, UK

Reprinted 4/94

FIELD EXPERIENCE OF TESTING VRLA BATTERIES BY MEASURING CONDUCTANCE

3y: M W KNIVETON,
BRITISH TELECOMMUNICATIONS plc, UK

BIOGRAPHICAL NOTES

Mark Kniveton has been employed by BT for 19 years and although starting his career as a telecoms apprentice soon transferred to Power & Building Engineering Services where he obtained an HNC in electrical engineering from Exeter college. He is now employed as a Network Support Manager specialising in providing technical support and advice for the Wales & West zone from the Network Operations Unit located in Bristol.

ABSTRACT

The paper will communicate the problems associated with large scale valve regulated lead-acid (VRLA) battery management and share the experience of large scale conductance testing by a BT zone.

Concentrating on real field examples of battery failures and the high maintenance costs associated with preventing these failures the paper will adequately describe the total quality approach to appreciating the real problem and the process of providing a solution.

The paper will detail the improvements and the shortcomings of the conductance method of measuring in-service VRLA batteries including:

- *Accuracy of Measurements*
- *Cost savings in capital and man-ours*
- *Methods and testing procedures*
- *Control and management of a battery replacement programme*

The summary will offer improvements in testing VRLA batteries and the necessary support systems to enable the most economic and commercially viable management of battery stock.

1. INTRODUCTION

Since 1984 BT has utilized valve regulated lead-acid (VRLA) battery technology in all new telecoms power equipment. The design advantages of reduced accommodation requirements, low maintenance and improved system reliability enabled power equipment to keep pace with the digital telecommunication modernisation programme.

The expected life of the VRLA product was anticipated to be 10 years. Costs at the 10 year turn around were favourable in comparison with the flooded cells and the whole picture looked good. Then after 3 or 4 years came the bad news. The new VRLA technology seemed flawed by mass production techniques and a lack of product knowledge by the users.

For whatever reason battery failures were causing expensive system downtime and, importantly for BT, posing a major threat to providing a superior quality network.

The consequences of a total battery collapse and the failure of traditional methods to detect end-of-life exasperated the problem by delaying maintenance programmes. A total lack of confidence in the VRLA product dismayed maintenance teams.

This paper charts the progress made to date by one division of BT to tackle the early problems and looks at future battery management initiatives that promise to regain technical control at minimum cost.

2. BACKGROUND

All modern power systems within the BT network employ VRLA batteries as the primary power source in the event of a break in the public mains supply. If the duration of the break exceeds 30 seconds the secondary power source, standby generators, automatically provides an alternative mains supply and the batteries return to float/standby working. For additional security reasons the nominal battery reserve time is a minimum of 1 hour.

All but the smallest power systems contain multiple batteries installed in a parallel string configuration for additional security. However, this policy is seen as costly, both initially and concurrently when replacements are required. The cost of providing this additional security has also been questioned when failures have occurred at sites containing parallel strings. The same failure mechanisms evident at work in all strings.

3. SYSTEM FAILURE ANALYSIS

Despite a large investment in modern power systems, containing the very latest technology, BT's network has been increasingly at risk due to VRLA battery failure. To prevent further system downtime and to gain an understanding of the problem a study of all network power failures was commissioned.

Analysis of the cause of system downtime revealed a weakness within computer or telecoms systems to restore rapidly after a power failure. Further analysis of the cause of the power failures, and especially the role of the battery, showed that 95% of all incidents were caused by the immediate failure of the battery system. Had the battery maintained the load, even for just 5 minutes, these failures would have been prevented due to the provision of the standby generators.

The effectiveness of the battery maintenance programme was also questioned. In particular the role of traditional test discharging to load. This had been the trigger that caused some of the failures. Problems were also experienced in resourcing the battery testing programme, with the result that many batteries remained untested.

The analysis indicated a requirement for a quick battery testing method that need only show whether a battery is within bands of capacity tolerance as opposed to specific ampere/Hr readings. An indication of good, failing or failed could be acceptable and prevent a system failure.

4. TESTING REQUIREMENTS

The requirements of a suitable testing method would have to clearly indentify battery failure and indicate battery state-of-health. The duration of the test should be no greater than 10 minutes per battery installation to enable all batteries to be tested at least once a year. The test data should also enable the accurate prediction of the future requirements of a battery replacement programme. The necessary hardware had to be robust and portable enough for field technician use and the total cost of the equipment had to be recovered in savings within 2 years.

The remote discharging of batteries via command signals was seen as a future possibility but the cost of installing the necessary hardware and communication links in the numbers required prevented its deployment in the short term.

The method of manual discharging to the connected load presupposes a healthy battery and the data obtained would vary depending on the load and the condition of any parallel battery. This method of testing was in general use and has been proven to cause system failures and provide little indication of future life expectancy or effective state-of-health.

The emergence of electronic battery testers that could quickly indicate the state-of-health and ultimately the capacity of a battery by measuring the batteries own internal conductance offered the most promising solution and after a small field trial, a total of 40 Midtron 2600 conductance testers were purchased.

5. ACCURACY & EFFECTIVENESS

The conductance testers inject a low amplitude test signal of 25 Hz and measure the resultant current. Conductance which is the inverse of impedance is calculated and displayed as a percentage of the 100% original value. Any degradation of this value is the result of failure mechanisms at work within the monobloc. Previous work by Feder, Croda, Champlin and Hlavac[1] has shown a relationship between capacity and conductance.

Each test takes approx. 30 seconds per monobloc and each battery of 8 blocs approx. 10 minutes including updating the battery log. All tests to date have been taken off line as the ac component from the charging source will cause the battery tester to oscillate and is difficult to read with any accuracy.

It is anticipated that future models will incorporate noise reduction components and this will enable on line testing.

All evaluation and testing compared conductance readings against actual timed discharges to a constant load. Conductance measurements were made using a Midtronics 2600 conductance meter and all 100Ah 6V monoblocs were manufactured between 1988 & 1992.

6. RESULTS

Figure 1 shows a high correlation between conductance values and discharge time for the VRLA product manufactured by company A. Accuracy is much better than expected

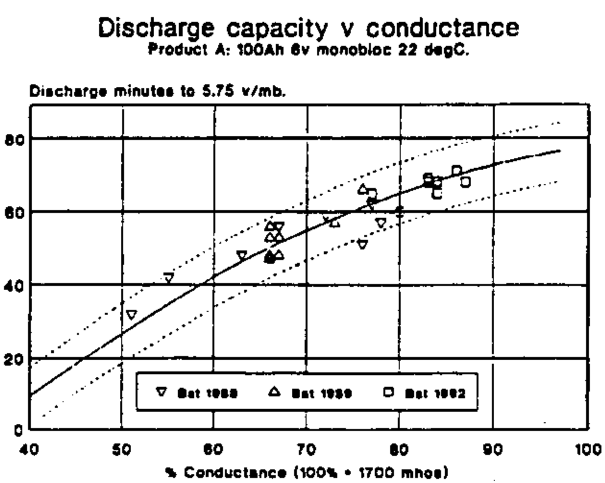


Fig 1.

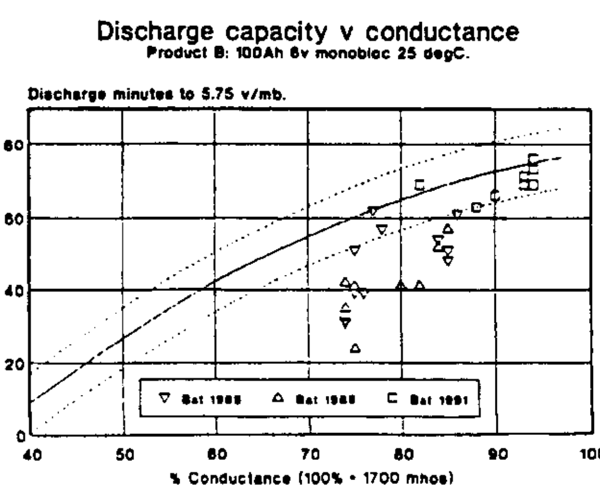


Fig 2.

and found to be within +/-2.5 minutes of predicted discharge time. These tests confirm earlier studies by B. Jones[2].

Figure 2 shows the same tests applied to VRLA products manufactured by company B. These results do not indicate a correlation between conductance and discharge time and studies are continuing to offer an explanation. However results from field use do show that severe low capacity, the cause of service failures, is easily recognised from low conductance values. Studies are continuing into the rate of decay from a good reading to a potential failure to establish the predictability of measurements with this make of bloc. However the importance of failure feedback before it becomes service effecting over a large statistical sample has been extremely valuable.

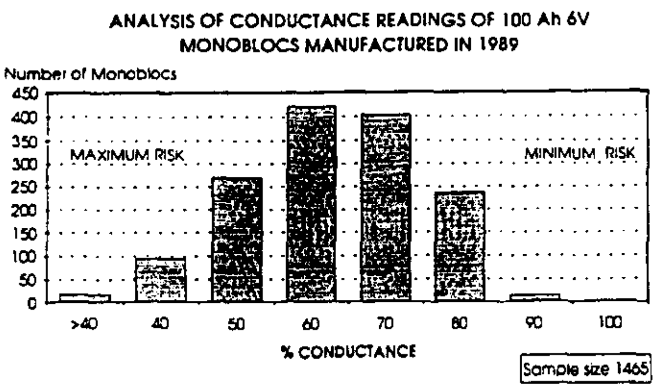


Figure 3.

Figure 3 shows a number of severe low capacity blocs found by conductance. This test of a whole years production by manufacturer B was undertaken when failure reports indicated serious defects. All tests were concluded within 2 weeks as opposed to discharge tests that would have taken months and all redeemable action was prioritised and managed according to the conductance results. This action enabled a much clearer assessment of the size of the perceived problem and much better management of the necessary corrective action.

7. PERFORMANCE MONITORING

The monitoring of conductance results and the constant comparison of like with like coupled to the close monitoring of individual failures makes up a part of the picture of performance monitoring. BT has in place quality monitoring systems that include a close relationship with the battery manufacturers who regularly inspect their in-service products throughout their life at designated sites. The manufacturers also provide laboratory feedback on failed monoblocs. Smaller statistical samples of timed discharge results also play a part in predicting performance trends. All of this information is of value in determining where and when battery replacement is necessary.

8. MANAGING A BATTERY REPLACEMENT PROGRAMME

The problems of managing a battery replacement programme are based upon timing and cost. If a program is delayed an increase in service failures could result although costs will be less as battery life has (artificially) been extended. The importance of the feedback from performance monitoring enables a more managed approach and the measuring of conductance has a major part to play in providing a reliable standard indicator for the majority of a battery stock.

From **Figure 1** ageing as measured by conductance and translated into remaining capacity can be used to determine a theoretical end-of-life depending upon application (strategic importance, multiple strings, load current) and economic pressure. Tests have been carried out by prolonging battery life by rationalising healthy conductance batches and replacing less whole batteries. This has an obvious financial benefit although the rate of ageing towards the end of life varies between products and will require further monitoring. Replacing individual blocs with new products has been discouraged for this very reason. A battery will only be as good as its weakest link.

Careful budgeting requires accurate predictions years in advance, the measuring of conductance for some products can provide that degree of confidence and save many man-hours testing which can be put to much better use in replacing batteries. The necessity of holding an accurate database containing information such as: Make, Date of Manufacture, Type, Load, Power System, and Location is an **essential** requirement of this process.

9. COST SAVING AND CONDUCTANCE

The major cost saving has been in time spent on preventative maintenance. Before conductance testing, many man-hours were spent testing batteries off-line due to the fear of causing system downtime and the great majority were testing healthy. The introduction of conductance testing has enabled this majority to be proven quickly and therefore created more time to find the batteries that will fail. 15 to 20 batteries can be tested by conductance measurement in the time it takes to test one battery off-line. Failures are also diagnosed quickly and corrective action taken immediately.

The savings associated by preventing failures are nearly impossible to quantify in plain financial terms as the resulting damage to a quality image can be even more costly.

10. CONCLUSION

In summary the measuring of conductance to prove VRLA batteries has been a great improvement from the more traditional methods both in detecting failures and in reducing maintenance time. It is anticipated that improvements in measuring techniques and VRLA battery production will further enhance the meters capability.

This field report has shown:

- Conductance testing is faster and more cost effective than traditional methods.
- Conductance testing has been more effective at finding failures than traditional methods.
- Correlation between conductance and discharge time is not apparent in all makes of VRLA battery.
- Where correlation is high conductance values can be used to predict the requirements of a battery replacement programme.
- Conductance can be used to detect gross failure in all makes of VRLA battery.

11. REFERENCES

1. D. Feder, T.G. Croda, K. Champlin and M.J. Hlavac: *Field and Laboratory Studies to Assess the State-of Health of Valve Regulated Lead Acid Batteries; Part 1 - Conductance/ Capacity Correlation Studies.* Intelec 1992 proceedings.

2. B.Jones: *Conductance Monitoring of Recombination Lead Acid Batteries:* Eleventh International Lead Conference 1993.