CAPACITY TESTING OF NICAD BATTERIES - THE INFLUENCE OF IEC DATA ON EXPECTED RESULTS AND OPTIMIZATION OF THE APPLICATION ENGINEERING WHEN SELECTING THIS TECHNOLOGY

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Abstract

Nickel cadmium batteries are widely regarded as the most reliable industrial stationary battery available today even when exposed to extremes of environment and abusive charge regimes. Nevertheless some users of nickel cadmium batteries experience disappointment when carrying out capacity tests in accordance with IEEE1106 recommendations. This paper describes the effect of utilizing discharge data generated by IEC methodology in capacity testing from constant potential charge conditions. The paper also discusses the importance of referring to the initial application engineering of the battery for capacity testing over life and a possible error in IEEE1106 pass / fail criteria.

Introduction

Nickel cadmium batteries are utilized in many standby applications today, particularly where environmental extremes are involved. Nickel cadmium batteries do not suffer physical degradation of the plates over life (as do lead acid systems) consequently there is "no sudden, unpredicted loss of battery capacity or performance" (IEEE1184-1994). Nevertheless, over the past several years we have heard concerns regarding the performance of nicad batteries being tested to satisfy owners that the remaining battery capacity is sufficient to undertake the duty that it was designed for. The following is a discussion of some factors that influence the results of the test - often to give a false "poor" result - and lead to a premature retiring of a perfectly good battery.

IEC623 Discharge Data vs. Constant Potential Data

The standard used by most nicad battery manufacturers to generate their original ratings and discharge data is IEC623-1990. This standard lays out a Charge/Discharge regime that should be followed in order to derive a capacity or rating for a given battery. Manufacturers all have a level playing field for rating their various products by utilizing this standard for their original data.

An abbreviation of the conditions are as follows:

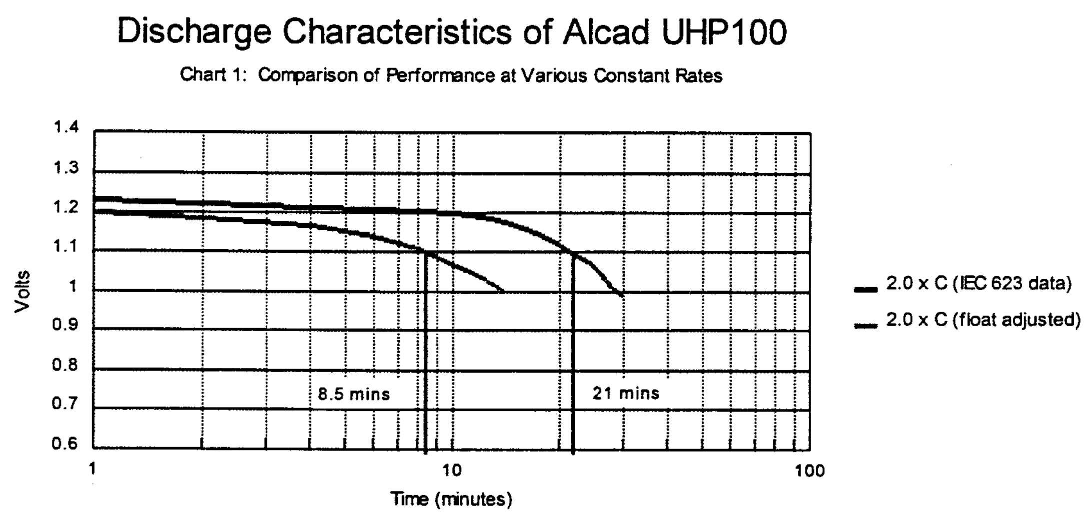
Step 1. Discharge cell at 0.2C5 to 1.00vpc at 20°C.

Step 2. Recharge cell at 0.2C5 amps for 8 hours at +20°C

Step 3. Open circuit stand for 1-4 hours then discharge at chosen rate (10C5, 5C5 etc.). From the voltage performance of the cell manufacturers are then able to allocate the design as low, medium, high rate or ultra high rate cells.

You will notice that this methodology for generating data is significantly different to the actual method of charging in the real world. Normally constant potential charging is utilized by almost all stationary battery users. To ensure that data used for battery sizing is reproducible from float charge (constant potential) conditions the nicad industry has for over 10 years supplied data that is de-rated for real world charging conditions. Unfortunately not every company has published this data in their main (commercial) documentation and some users and test companies are utilizing data sheets that have only the IEC data in them. This has led to significant errors being made in test rates chosen, particularly where old data sheets are still kept with the battery and referred to for test rates.

Example of 30 Minute Data for Alcad "UHP100" high rate nicad cell



High rate cells at a temperature of 20 +/- 5°C
C = Published rated capacity

Due to the relatively flat nature of the curves a small de-rating of the available performance shows an enormous "apparent" loss of capacity if uncorrected IEC623 data is chosen for a test rather than float corrected data. This can lead users to conclude that they have a battery with little capacity. A replacement is made of a perfectly serviceable cell with the associated unexpected expense. In the example shown in chart 1 a test company choosing to test a 100Ahr high rate cell at the 2C5 rate using data drawn up from IEC623 would expect to see a run time of 21 minutes before reaching 1.10vpc. In fact they will see 8.5 minutes and perhaps conclude that the "capacity" of the battery is a mere 40% ((8.5/21)*100=40%). Thus, for a battery that has been sized using "off float" data, it is clearly very important to pick the same data for capacity testing nickel cadmium batteries.

Unfortunately as a company we have seen many perfectly good batteries prematurely decommissioned and less reliable systems installed in their place as a result of this misunderstanding.

End of Life Criteria

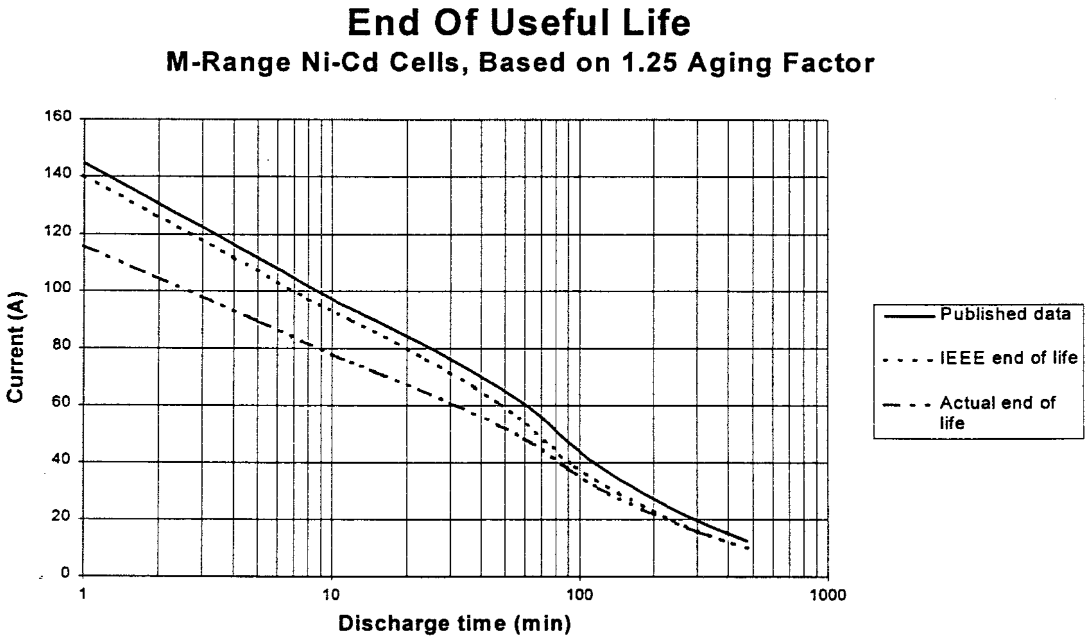
When we size batteries today we generally apply an aging factor chosen in accordance with IEEE1115. Very often this is 125%, and we apply this to the calculated uncorrected size. As an example we would take a calculated 100Ahr cell and multiply that by 1.25 to arrive at an installed 125Ahr.

A battery from a given range that is 25% larger in ampere hours than another from the same range will provide 25% more current for a given discharge time. For a fixed discharge current ,however, the battery will provide more than a 25% increase in discharge time. This is because the battery is more efficient over longer discharges.

The actual end of life therefore (the point at which the battery will no longer provide its original 100 Ah requirements) is when the battery will no longer give 80% (1/1.25 * 100) of it's published **current** for a given time.

IEEE1106 on the other hand defines the end of life when the battery will no longer deliver 80% of the "as new" battery run time at a chosen rate. The difference between these two approaches to end of useful life definition are illustrated on Chart 1a.

Chart 1a



The useful life is represented by the area between the published data curve and the end-of-life curve. The very small area that results from the IEEE end of life criterion goes a long way towards explaining the unsatisfactory results obtained with IEEE 1106 testing.

The chart clearly demonstrates that the IEEE1106 definition of end of life is incorrect.

Premature Replacement - IEEE 1106 Condemning Batteries with >100% Duty Capabilities

As an example of the problem consider the following (30 minutes has been chosen for the examples in this discussion as it is a commonly used test period by many test and service technicians to enable testing to be completed at a given site in one day):

If we size a battery to deliver 110A for 30 minutes to 1.10VPC and then apply a 1.25 aging factor we would purchase a cell that can deliver 137.5A when new . In the case of medium rate nicads and for the sake of this example this would require an Alcad M190P cell.

The M190P is capable of 110 A for 56 minutes to 1.10VPC.

<u>Remember here that the original load requirement was 110A for 30 minutes.</u>

If you undertake a test in accordance with IEEE1106 you are told to replace the installed battery when the RUN TIME is less than 80% of original spec.(IEEE1106-1995 Sec 9.5) as we chose a 1.25 aging factor. For the M190P cell that would translate to looking for a battery that delivers 110A for 44.8 minutes!

<u>If you follow the instructions in IEEE1106 you would replace that battery - even though it is delivering 50% more run time than was originally required.</u>

In this example with a 25% aging factor as a user you should not be concerned with obtaining 80% of the "as new" run time but 80% of the "as new" current for the originally designed run time.

Nickel cadmium batteries have no mechanical failure modes to consider (such as positive grid corrosion seen in lead acid systems) which lends additional weight to the fact that if this user were to replace the battery he would be condeming an installation that would have at least as much life left in it than has already expired when you consider the original load requirements.

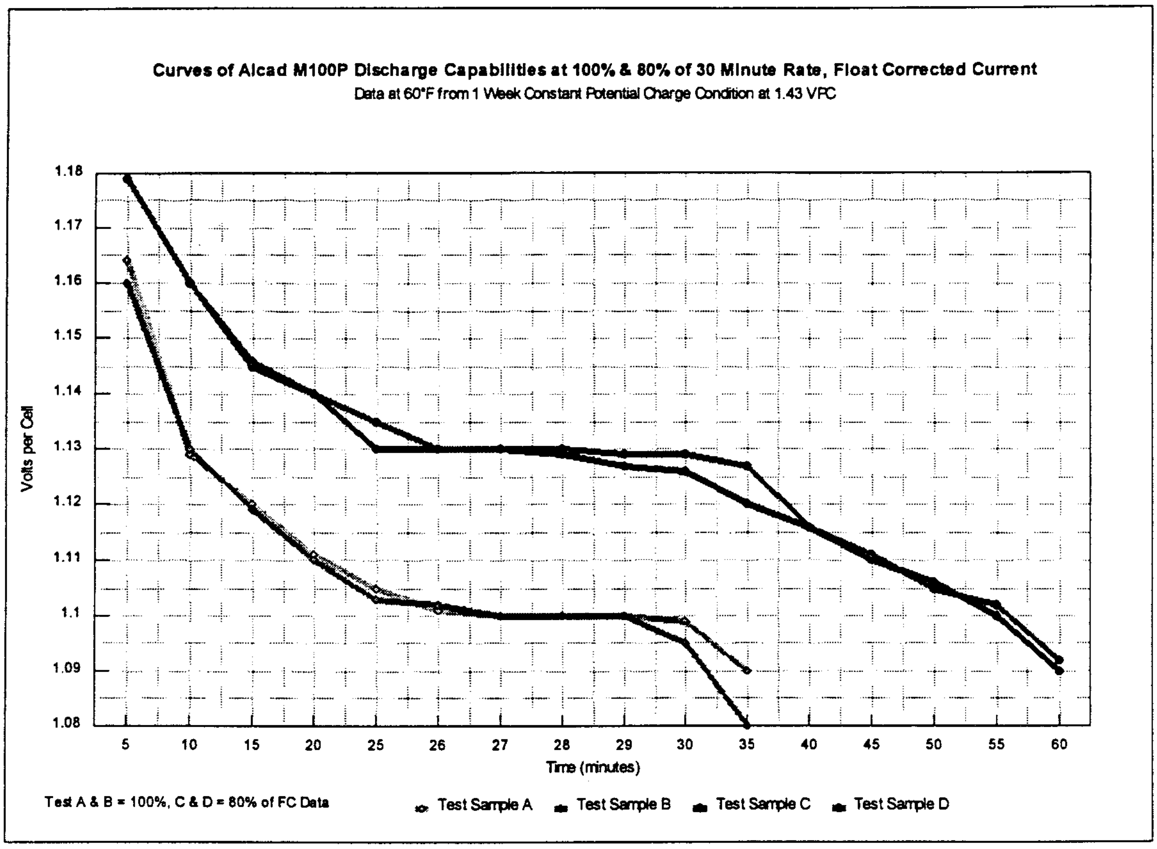
This is an economic nonsense.

Clearly then there is a serious defect in the standard IEEE1106 and this probably more than any other factor, has caused users to decommission perfectly serviceable nicad batteries.

<u>Pass / Fail Criteria - A Percentage of Current or a Percentage of Time?</u>

We wished to demonstrate that the approach above is correct and so Alcad placed a bank of 40 cells M100P on a constant potential charge for 7 days at 1.43vpc Battery temp: 60°F. We discharged two sets of 10 of these new cells at the published 30 minute rate (76.4A) to 1.10vpc and the remaining two sets of 10 cells at 80% of the published 30 minute rate to 1.10vpc. (see chart 2) The battery temperature was 60°F but no temperature derating was made. Nevertheless the effect is clear......looked at one way the same cell is capable of almost 100% more run time with 80% of published current. Or looked at another way for a 25% increase in current you would halve the time taken to reach a given end voltage at these shorter (<2 hour) discharge rates.

Chart 2.



CONCLUSION

Nicad batteries continue to perform reliably in service with many hundreds of thousands of installations never reporting a field failure. Yet inappropriate testing has "failed" many batteries. The test companies and users with their own test equipment have been utilizing an ANSI/IEEE standard with a fundamental flaw in it's methodology (IEEE1106). This same flaw is embedded in IEEE450 for lead acid batteries. In recognition that there is controversy over this issue IEEE Standards Coordinating Committee 29 has assigned a working group to consider the issues and make a recommendation to SCC29 for action.

Acknowledgments

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Note: "Nicad" is a registered trademark of Saft America Inc., Valdosta, GA