BENEFITS AND RELIABILITY OF DISCHARGE TESTING USING SHORT-TIME BATTERY RATINGS

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INTRODUCTION

Reliability of standby batteries is essential in many vital applications and the systems need to be inspected and tested at regular intervals. These tests may be characterized as diagnostic, defined as collecting measurement results indicating battery problems, or actual discharge tests to measure the true battery capacity.

There are several methods available for doing battery diagnostics like cell voltage monitoring or impedance/conductance/internal resistance measurements. This presentation is not covering these methods but instead presenting a different approach for doing discharge testing using a short term capacity rating instead of the standard 8h-rating.

BATTERY CAPACITY

The battery capacity is determined by the discharge current, the discharge time, the end voltage and the temperature. A specific battery design has a different capacity rating depending on the discharge current and time. These figures are given in the battery specifications from the manufacturer. An example of typical values for a lead-acid battery is given in table 1.

Table 1. Battery Capacity in Ah at Constant Current Discharge

Battery	**Discharge Time**		**End Voltage 1.75V**				
	0.5h	**1h**	**2h**	**3h**	**5h**	**8h**	**10h**
OPzV200	171	116	74	55	38	27	22
OPzV420	288	211	139	105	73	50	42
			End Voltage 1.90 V				
OPzV200	103	77	53	42	30	21	18
OPzV420	158	128	93	75	54	40	34

CAPACITY (DISCHARGE) TESTING

Procedures for capacity testing of lead-acid batteries are described in ANSI/IEEE 450 (Ref. 1) and IEC 896-1 (Ref. 2). The standards cover how a battery should be tested and also give recommendations on testing intervals and when to exchange the battery. In this presentation we will not describe or go into any details in the standards. The method of discharge testing is well defined and also how to interpret the results. Basically the standard recognizes a battery as degraded if the capacity drops more than 10% of rated capacity and replacement is recommended when the capacity is below 80% of the manufacturers rating.

SHORT-TIME TESTING

Typical practice for discharge testing is to use the 8h rating and run the test for approx 8h or more depending on the actual battery capacity. An alternative to this is to test the battery to its short-time capacity rating (i.e 1h). Furthermore, if the load box gives you the opportunity to externally measure the total load current, you do not need to disconnect the battery from the standard load. The procedure is described as follows:

- Disconnect the battery charger.
- Connect the load box in parallel with the normal battery load.
- Set the discharge current as specified by the manufacturer for 1h discharge.
- Run the test to the specified end voltage <u>or</u> the specified 1h-capacity. Monitor the battery/cell voltages closely to be able to stop the test if the voltages are dropping rapidly, indicating a degraded battery.
- Disconnect the load box and turn on the charger.

If the test is successful you will know that the battery has at least 100% of the 1h-capacity rating and the battery will still have some 25-50% remaining of its 8h-capacity thus reducing the need for bringing in a spare battery when running the test. Furthermore, much less time is required to recharge the battery after a 1h-discharge test than after an 8h-discharge (Ref. 3). A typical recharge time after a 100%, 8h-discharge is 50h to retrieve 100% capacity while a 1h-test needs only 20-30h recharge of the battery.

TEST EQUIPMENT

A typical test setup includes a battery load box and some kind of datalogger for recording cell voltages and temperature. Sometimes also specific gravity and battery terminal/connector losses are measured and preferably these recordings should be recorded/stored together with battery data and cell voltages to accomplish good comparisons between measurements taken at different times.

An example of a portable load box and a datalogger with computer software is shown in figure 1. The load box is shown together with an additional external load and each unit has a discharge power capability of 7.2kW. Selectable voltage settings makes it possible to test batteries from 12 to 240V (Ref. 4).

The datalogger may be used both for cell voltage monitoring without doing discharge and for cell voltage measurements during a discharge test with a separate data structure for each type of test. You may also use the unit to measure terminal/connector losses, temperature and specific gravity measurements (Ref. 5).

MEASUREMENT RESULTS

Some discharge tests have been performed to check the method. Both "good" and "bad" batteries have been tested. The following table is a summary of the results obtained before the deadline of this paper.

Critical parameters in all battery tests are the state of charge and temperature. Without claiming full laboratory conditions for the different measurements, the batteries were charged according to the manufacturers recommendations and the temperature was monitored throughout the tests.

Table 1. Battery Capacity Measurements

Battery no	Specified Capacity	Test Method	Measured Capacity	Remaining Capacity
1	133Ah (5h)	Full discharge	130Ah (98%)	
	92Ah (1h)	Full discharge (one year later)	80Ah (87%)	
2	25.2Ah (8h)	Full discharge	33.8Ah (134%)	
	12.8Ah (1h)	Full discharge	21.2Ah (166%)	
		1h full discharge + 8h test	21.2Ah (166%)	7.45Ah (29%)
		1h/100% + 8h test	>100% (1.88V end voltage)	14.1Ah (56%)
3	50.4Ah (8h)	Full discharge	17.3Ah (34%)	
	25.6Ah (1h)	Full discharge	3.5Ah (13%)	
		1h full discharge + 8h test	3.5Ah (13%)	7.8Ah (15%)
4	101Ah (8h)	Full discharge	67Ah (67%)	
	49Ah (1h)	Full discharge	14.7Ah (30%)	
		1h full discharge + 8h test	14.7Ah (30%)	25.5Ah (25%)

As shown in the table, a "good" battery such as no 2 shows high capacity ratings both in the 8h and 1h-test. An interesting result is that the battery even after a 166% 1h-discharge has 29% remaining 8h-capacity. In the 1h/100% test, stopped at 12.8Ah with an end voltage of 1.88V and thus indicating a capacity well over 100%, the remaining 8h-capacity is 56%. Normally this should be sufficient to clear a fault in a substation even if the battery power is needed shortly after the discharge test.

The no 1 battery is an 8 year old valve regulated battery in a typical substation. The battery has been tested annually and is showing a tendency to degrade. In the 5h-test the measured capacity was close to 100% and in the 1h-test, performed one year later, the capacity was 87% thus indicating that the short-time discharge can be used to reveal malfunctions in the battery.

Some "bad" batteries have been tested to verify that a short time test will not give an overestimated capacity of a degraded battery. As seen from the results the degraded batteries fail the 1h-test. The difference between measured and rated capacity is larger for the 1h-test compared to the 8h-test and the 1h-capacity is significantly lower than the measured 8h-value.

CONCLUSIONS

Short-time testing has clear advantages compared to a standard 8h-test.

- Less testing time
- Less charging time
- Less need for a spare battery during/after the test
- Remaining capacity after the test

The important question is whether the 1h test is as reliable as the 8h-test. So far our results show that the 1h-test is not overrating the capacity of a degraded battery. Instead we get a lower 1h-capacity and it is not likely that a battery will meet a 1h-specification but fail an 8h-rating.

Clearly, testing a battery to the specified load and time is the true way to determine that the battery fullfills the design requirements. In discussions with different battery manufacturers they state that a battery failing a 1h-test do not neccessarily mean that the battery fails an 8h-test. This means that if you have a "bad" 1h-reading you should do an 8h-test before you decide to exchange the battery. On the other hand it is not likely for a battery to pass a 1h-test and fail an 8h-test which means that as long as the battery meets its 1h-rating you do not need an 8h-test. Comments on this are welcome!

When discussing testing procedures with battery users you will find that the routines for battery maintenance vary widely. Some do not perform any kind of testing very often referring to the widely spread misunderstanding that discharge testing will severely affect the expected lifetime of the battery. Knowing that a lead-acid battery can withstand hundreds of discharge cycles and even if you strictly follow the IEEE standard the number of discharge tests will rarely exceed 10 throughout the lifetime of the battery, this is clearly a false statement. However, even in this aspect, short-time discharge testing will cause less stress on the battery.

Others do partial discharge, sometimes just turning off the charger and using the normal battery load when measuring cell voltages, sometimes adding an extra load for 25-50% discharge. For these customers, short-time discharge testing will give more reliable results with just a minor change in their testing procedure.

For users already following the IEEE-standard, short-time testing will save a lot of time and in many cases also the need for bringing is a spare battery for the test.

SUMMARY

A modified battery discharge test based on short-time 1h-ratings is presented. The method has several advantages such as shorter testing/recharge time and less need for spare batteries during the test. The test procedure is described and measurements using this method has been performed on "good", "average" and "bad" batteries. The results indicate that batteries meeting the 1h-rating will also pass a standard 8h discharge test.

REFERENCES

1. ANSI/IEEE Std 450-1987, "*IEEE Recommended Practice for Maintenance, Testing, and Replacement of Large Lead Storage Batteries for Generating Stations and Substations*"
2. IEC 896-1, "*Stationary Lead-Acid Batteries, General Requirements and Methods of Test*"
3. Chloride Powersafe, "*Specifiers Manual*"
4. Programma Electric, "*Battery Load Unit Torkel 720, User's Manual*"
5. Programma Electric, "*Battery Management System TMC-2001, User's Manual*"

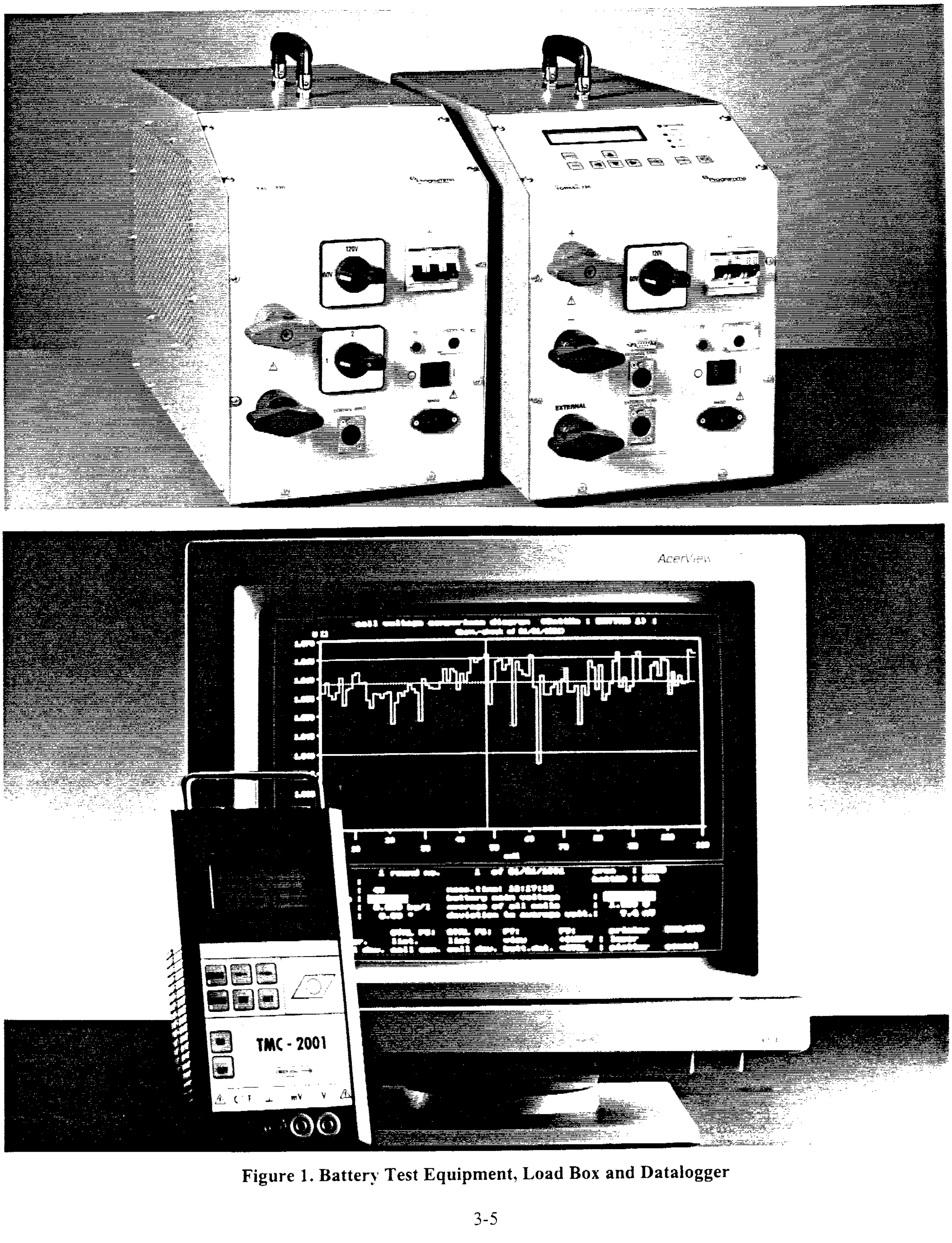

Figure 1. Battery Test Equipment, Load Box and Datalogger