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Usability Evaluation Method for VRLA Battery Measuring Equipment

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Abstract

This paper presents a method for evaluating the availability of lead-acid battery test equipment and designs the corresponding evaluation mathematical model. International standard IEC60896-2 specifies the lead-acid battery internal resistance level. Because the internal resistance value is usually micro-Ohm level and the lead-acid battery has special electrochemical characteristics, it's very difficult to measure it. Until now no authority can officially provides the actual resistance value for a given battery. However, the industry has agreed that the internal resistance will gradually increases during the use of the battery and the performance of the battery has close relationship with the change of the internal resistance, so even if the measurement equipment can not measure the absolute actual resistance, but as long as the battery can be measured a small change in internal resistance, it has a high availability. In this paper, we propose a micro-incremental verification method and a mathematical model to facilitate, accurately and quickly verify whether the battery internal resistance test equipment can accurately and stably measure the internal resistance of the battery, and provide technical verification reference for selecting the battery measuring equipment.

Keywords: battery internal resistance, micro incremental, internal resistance test accuracy

1. Introduction

Lead-acid batteries provide backup power and have been widely used in DC power systems and uninterruptible power supply system. As the last defense of safe, whether the battery can work well is very important. Battery experts in the field have widely recognized that battery resistance directly affects the actual capacity of the battery and the use of performance, the battery resistance, especially the increase in resistance is an important indicator of battery performance degradation. Therefore, it's very important to monitor the changes of the battery internal resistance after using the battery and ensure the performance of the battery.

Although the IEC60896-2 standard specifies the resistance level of the lead-acid battery and define a standard secondary discharge method to measure the internal resistance of the battery, the secondary discharge method requires a smooth control of very short and high current and measurement (for example, to test 800AH battery, we should control 5 seconds and 1600A current discharge), this measurement method is currently only applicable to the laboratory, commercial battery testing equipment will generally use their own research and development technology, which led to the bad situation that there is no uniform standard for internal resistance measurements, and the relevant national certification laboratories do not provide standard actual measurements. Which led to dilemma, resistance value measured by different measurement equipment is different and we have no idea that which test value is correct.

However, in the current application environment, even if the test results have some differences (of course, the reference standard should not deviate too much, such as the theoretical value of 300 micro-ohms, measured values of 250 micro-ohm to 350 micro-Ohms are acceptable), but if the test equipment has good stability, repeatability and sensitivity, then through the internal resistance change can also infer the battery performance changes, such as the internal resistance from 300 micro-ohm gradually increased to 400 micro-Ohms, the device can accurately measure its trend, will be able to judge the performance of the battery to provide a reliable reference.

In this paper, the methods and mathematical models for evaluating the internal resistance test equipment of lead-acid battery are considered, also we consider the change rate of internal resistance, the change rate of micro-incremental resistance, and the allowable repetition test precision of the equipment itself. This data model validates the measurement stability, repeatability and sensitivity of the battery resistance test equipment to infer the availability of the equipment.

The mathematical model is also suitable for other battery measurement equipment, such as lithium batteries and super capacitors, etc., but in the actual battery maintenance process, monitoring the internal resistance changes for lead-acid batteries is more important because of its electrochemical properties and very small internal resistance value, it is difficult to measure the actual value, we do not have the official reference value of the case, the method mentioned in this paper is particularly useful. Relative to the resistance of lead-acid batteries (usually tens of micro-ohms to several hundreds micro-ohms), lithium battery resistance is relatively large (usually tens of milliohms), it is easy to measure, so this method has little significance used for evaluation of lithium battery measurement equipment.

2. Accuracy Evaluation Scheme Design of Resistance Measurement Device for Lead-acid Battery

2.1 Design Principle

The resistance value of the VRLA battery varies from tens of micro-ohms to several thousand micro-ohms depending on the capacity, and its regression trend is related to its internal resistance increment. According to the current large number of tested data, if the battery's internal resistance base value gradually increased by about 50%, its capacity will degenerate to about 80%, once the battery degeneration to 80% capacity will quickly degenerate, so 80% of the capacity of the battery reliability of the demarcation point. The use of internal resistance trends to determine the battery performance changes require measurement equipment can be very accurate measurement of its trend changes. As mentioned earlier, in the case of actual resistance value without reference standard, it is very important to be able to monitor the small change of internal resistance. Assume that for the same battery, A device measures its internal resistance base value of 100 micro-ohms, B device measures the internal resistance of the value of 120 micro-ohms. We re-measure it 5 years later, A device measures resistance value of 150 micro-Ohms, B device measures resistance value of 180 micro-Ohms, the change percent is 50%, so the trend provided by A or B equipment has the same effect.

So we can series resistance with a certain resistance in the preparation of the accuracy, error and other related parameters in the battery test circuit and use an evaluation mathematical model. Resistance to simulate the incremental change in the internal resistance, so that the entire test circuit both with the electrochemical characteristics of the battery, but also to achieve increased analog resistance. Through the series resistance of different resistance, and taking into account the internal resistance of the measured value, incremental size and equipment to repeat the measurement error.

2.2 Simulated Lead-Acid Battery Resistance Increase in the Implementation of Micro-Increase

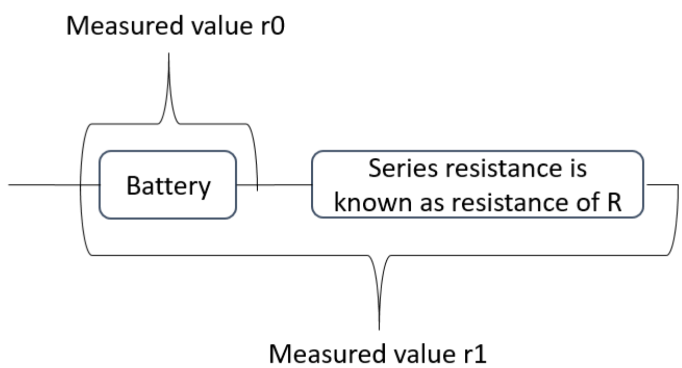

Figure 1. Connection method

This method is achieved by calibrating a series of power micro resistors (typically a shunt with a high thermal stability which is very important for micro additions) that is known in series with a pole in the measured battery. As shown in Figure 1, with the battery resistance test equipment were tested r0 and r1, and then calculate the measured incremental value:

$$\Delta r = r1 - r0 \tag{1}$$

Compared with the known R value, calculate the measurement error δ:

$$\delta = (|\Delta r - R| / R) * 100\% \tag{2}$$

By replacing the different calibrated series of power trace resistors (typically 10%, 20%, 30% of the internal resistance values measured by the battery resistance test method specified in IEC 60896-2 and GB / T 19638.2-2005, (e.g., 2V, 6V, 12), and a series of internal resistance increment measurement error values δ1, δ2, ... δn are obtained by replacing the batteries with different number of hours and different volts. And then calculate the calculated difference and the error value of the average square error σ:

$$\overline{\delta} = \frac{\delta 1 + \delta 2 + \cdots + \delta n}{n} \tag{3}$$

$$\sigma = \sqrt{\frac{(\delta 1 - \overline{\delta})^2 + (\delta 2 - \overline{\delta})^2 + \cdots + (\delta n - \overline{\delta})^2}{n}} \tag{4}$$

By the σ can be identified by the battery resistance test equipment to verify the value of the battery resistance of the measurement error average square deviation.

2.3 Incremental Test Steps and Test Data

The test is carried out as follows:

1) Use the BMMS2000 battery on-line monitoring device manufactured by eTocsin company with repetitive accuracy of ± 2% to measure the internal resistance of a battery 10 times and calculate the average value;
2) 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, 100% of the average value of the shunt are calibrated according to the average.
3) Respectively series shunt and respectively measure its resistance value.
4) Replace the batteries with different ampere-hour. repeat 1) -3) steps.

Considering the influence of the repeatability of the measuring device itself and the magnitude of the internal resistance microinstruction (ie, the absolute range of the error precision of the device repeatability and the variability of the micro-increment size), we will divide the increment into two groups to define The average standard deviation of the measurement error of the incremental value is calculated from 20% to 50% of the reference standard of 50% ~ 100%

The following is the measured data:

Table 1. Group A: (serials resistance of 20%, 30%, 40%, 50%)

Average resistance $\overline{R}$	Proportion	Actual value after increment added	Mesured value after increment added	Measurement error (%)
1139	20%	1364	1344	8.89
	30%	1472	1450	6.61
	40%	1597	1573	5.24
	50%	1706	1680	4.59
702	20%	852	839	8.67
	30%	919	904	6.91
	40%	977	961	5.82
	50%	1060	1043	4.75
426	20%	501	493	10.67
	30%	551	542	7.20
	40%	593	584	6.59
	50%	643	633	4.61
215	20%	265	261	8.00
	30%	282	277	7.46
	40%	290	285	6.67
	50%	315	310	5.00
145	20%	170	167	12.00
	30%	195	192	6.00
	40%	212	209	4.48
	50%	220	216	5.33

The average value of the error and the average variance of the error are: δ + σ = 6.77% + 2.01% = 8.78%.

Table 2. Group B: (serials resistance of 50%, 70%, 80%, 90%, 100%)

Average resistance $\overline{R}$	proportion	Actual value after increment added	Mesured value after increment added	Measurement error %
1139	50%	1706	1680	4.59
	60%	1814	1787	4.00
	70%	1939	1910	3.63
	80%	2039	2008	3.44
	90%	2164	2132	3.12
	100%	2289	2255	2.96
702	50%	1060	1044	4.47
	60%	1127	1110	4.00
	70%	1202	1184	3.60
	80%	1269	1250	3.35
	90%	1327	1307	3.20
	100%	1402	1381	3.00
426	50%	643	633	4.61
	60%	676	666	4.00
	70%	726	715	3.67
	80%	759	748	3.30
	90%	801	789	3.20
	100%	851	838	3.06
215	50%	315	310	5.00
	60%	340	335	4.00
	70%	365	360	3.33
	80%	382	376	3.59
	90%	407	401	3.13
	100%	440	433	3.11
145	50%	220	217	4.00
	60%	220	218	2.67
	70%	245	241	4.00
	80%	262	258	3.42
	90%	270	266	3.20
	100%	295	291	2.67

The average value of the error and the average variance of the error are: $\overline{\delta} + \sigma = 3.58\% + 0.57\% = 4.15\%$.

From the above test results, we can draw the following conclusions:

The internal resistance increment test of BMMS2000 with online monitoring device of eTocsin with repetition accuracy of ± 2% was used. The incremental error and incremental error variance of the two sets of data were

A) group A (20%, 30%, 40%, 50%) is 8.78%

B) group B (50%, 60%, 70%, 80%, 90%, 100%) is 4.15%

Therefore, the value 15% of group A (20%, 30%, 40%, 50% increase in the incremental increment + incremental error variance) and the value 5% of group B(50%, 60%, 70%, 80% %, 100% increase in the incremental increment + incremental error variance) are able to effectively determine the on-line monitoring device measurement accuracy and stability.

4. Results

This article describes the verification of lead-acid battery internal resistance test equipment to measure the accuracy and stability of the increment is easy to implement, fast and accurate features. In the development of incremental error + incremental error variance evaluation criteria should take full account of the theoretical value of the battery resistance, incremental size, test equipment, measurement accuracy and repeat the error and other parameters to finalize a reasonable evaluation criteria for the user to select high-availability measurement equipment to provide technical verification averages to solve the current problem of non-standard.

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