Batteries Division

ZVEI: Die Elektroindustrie

## ZVEI information leaflet No. 34

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# Evaluation of measured values for capacity assessment of stationary lead-acid batteries

## 1. Objective

Methods other than capacity tests are increasingly used to assess the state of charge or capacity of stationary lead-acid batteries. Such methods are based on one of the following methods: impedance (AC resistance), admittance (AC conductance).

This leaflet is intended to illustrate the significance of different measured values and methods for capacity evaluation.

## 2. Scope of application

The measurement methods described in this leaflet can be used for individual cells or block batteries as well as for complete battery systems.

## 3. Measured values and methods

### 3.1 Open circuit voltage

The measurement of the open circuit voltage is usually used to estimate the residual capacity of cells / block batteries. It is mainly used for storing batteries or for batteries that have been taken out of service. These must have been separated from the charging device for at least 20 hours.

This method is suitable for new to moderately aged batteries.

For the relation of the open circuit voltage to the remaining capacity, information can be requested from the battery manufacturers.

### 3.2 Float charging voltage and float charging current

The float charge voltage must be set according to the manufacturer's specifications. If operating temperatures fluctuate strongly, temperature compensation of the voltage can be carried out in accordance with the manufacturer's specifications. If the float charge voltage no longer rises during charging and the charging current (and, with vented batteries, the electrolyte density) remains constant within 2 hours, it can be assumed that the battery is fully charged (state of charge = 100 %).

Note: with vented batteries, the float charge current increases during the service life. This is an indirect indicator of battery ageing

### 3.3 Impendance

The impedance can be determined during operation of the battery system. For this purpose, the float charge voltage is superimposed with an alternating voltage signal and the impedance is calculated from this in the measuring device. The impedance thus measured is not comparable with the - ohmic - internal resistances published by the battery manufacturers and determined with DC voltages and currents in accordance with DIN EN IEC 60896-11 (vented batteries) or DIN EN IEC 60896-21 (VRLA batteries). Similarly, the real part output by impedance measuring devices is not comparable with the ohmic internal resistance, since the impedance values determined depend on the measuring frequency of the used measuring device.

Due to the large number of instruments and thus also the measuring methods used, reference values of the battery manufacturers are not or only to a limited extent available. An initial measurement of the values should therefore be carried out 2 - 3 days after installation and operation of the fully charged cells/block batteries in trickle charge. With this measurement the reference values for regularly recurring measurements are determined. In order to ensure the comparability of the measured values over the service life of the battery system, it is important to always measure under the same conditions (fully charged, same

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temperature ...), and with the same instrument technology, measuring tips and leads of the same shape and dimensions. Especially with multi terminal cells (more than one terminal per polarity), the result may depend on the arrangement of the measuring tips (e.g. measurement at directly opposite terminals or diagonally across the cell). For comparability of the measured values, the measurement must always be carried out with the same arrangement.

It is recommended to carry out measurements at intervals of 6 or 12 months thereafter. For critical applications in terms of system reliability and availability, measurements may also be performed at shorter intervals.

No direct conclusion on the available capacity can be made from the measured absolute impedance values. As relative measurements, however, they allow conclusions to be drawn about

1. the current status of individual cells/blocks compared to previous measurements. For this purpose, the current measured value of the cell/block is compared with previously measured values. Deviations between the measured values of individual cells/blocks are to be evaluated in relation to the variation of previous measurements
2. the current status of the battery compared to the status of the battery at an earlier point in time. For this purpose, the mean value of the current measured values of all cells/blocks is compared with the mean value of the measured values of all cells/blocks at an earlier point in time of the battery life.

Which relative deviations are to be considered as normal and which measures are to be taken for which relative deviations can be requested from the battery manufacturer.

The change of the impedance has a significant influence on the short-term discharge (high current application, see also ZVEI leaflet No. 19). As a result, the end of service life (80 % of the projected autonomy time) is reached significantly earlier.

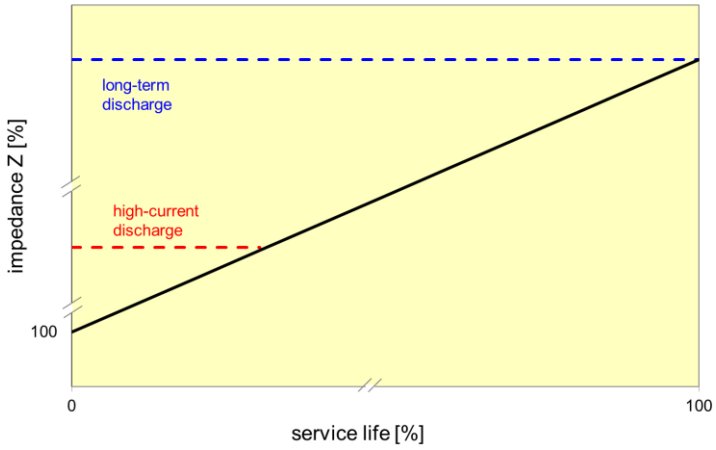

Fig 1: schematic course of the impedance over the service life

In standby parallel operation, the change in impedance is mainly caused by the corrosion of the positive grids. In the case of VRLA batteries, the drying out of the immobilized electrolyte must be added. Therefore, with VRLA batteries larger changes compared to vented batteries are to be expected in the same period of time.

The parallel connection of electrodes in cells not only increases the cell capacity but also reduces the impedance. This can lead to changes of the impedance in the area of measuring device tolerance and thus lead to misinterpretations

### 3.4 Admittance

For the admittance measurement the same applies analogously as described in 3.3 for impedance. However, the admittance decreases during the service life.

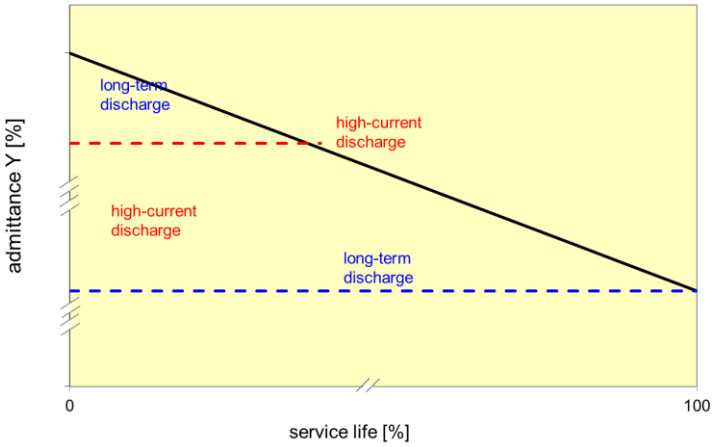

Fig 2: schematic course of the admittance over the service life

### 3.5 Capacity tests

As a rule, capacity tests must be carried out according to the requirements specified in
- DIN EN IEC 60896-11, chapter 14, for vented lead-acid batteries, or
- DIN EN IEC 60896-21, chapter 6.11, for VRLA (AGM, Gel) lead-acid batteries.

Particular attention should be paid to the preparation of the capacity test:

- The batteries must be fully charged.
- For vented batteries, the electrolyte level must be set to the maximum level. If the electrolyte level has been corrected before the capacity test, it must be ensured that the electrolyte is mixed with an equalization charge before the test begins in order to eliminate capacity deviations due to electrolyte stratification.
- If the battery system has been demonstrably operated for several weeks in float charge prior to the capacity test, the test can be started immediately.
- If the battery system was prepared before the capacity test with a boost or equalization charge, e.g. after correction of the electrolyte level (see above), the rest period of at least one hour before the start of the test prescribed in the above-mentioned standards must be observed. In order to improve the conductivity of the battery, a longer rest period should be sought.

For the evaluation of the test result, special attention must be paid to the following

- The cut-off criterion is the final discharge voltage in accordance with DIN EN IEC 60896-11, chapter 14.6 for vented batteries, or DIN EN IEC 60896-21, chapter 6.11.10 for VRLA batteries,
- the temperature correction of the determined capacity based on the initial temperature of the battery (electrolyte temperature with vented batteries, temperature of the housing for VRLA batteries)

Deviating from normative requirements, there are no fixed rules for the frequency of capacity tests to be carried out. Too frequent testing can cause additional stress for the battery system.

The following intervals are often used:

First test after commissioning of the battery system, then every three to five years. As soon as the capacity begins to fall continuously, annual tests should be carried out.

As an alternative to testing directly after commissioning, the first test can be performed one or two years after commissioning.

In addition to the usual 10-hour nominal capacity, tests with shorter discharge times (one, three, five hours) can also be selected in order to make a qualified statement.

## 4. Summary

Measurements of float charge current, impedance and admittance can be used to determine the aging progress of a battery system. Changes in impedance/admittance serve as an indication to perform additional capacity or load tests.

The determination of the actual battery capacity is only possible with a capacity test according to the mentioned standards

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