ZVEI: Die Elektroindustrie

Information brochure

Battery single block monitoring

Life insurance for your emergency lighting

Imprint

Battery single block monitoring

Life insurance for your emergency lighting

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1 Introduction

Rechargeable batteries serve as power sources for safety lighting and safety power supply systems. It is essential that they function reliably. If the power source is not available or only available to a limited extent, safety lighting or safety power supply systems cannot fulfill their tasks in an emergency. This endangers the safety of people in the building.

For many years, EN 50171 and DIN VDE V 0108-100-1 have defined monitoring criteria for the regular inspection of the functionality of a battery system, which only refer to the battery system as a whole. However, experience in the use of batteries shows that monitoring each individual battery block provides valuable additional information in order to be able to react to impending damage and failures in a timely and appropriate manner.

Therefore, the current draft prEN 50171:2019 recommends battery monitoring systems that can monitor individual blocks.

2 Structure and possible operating state of a lead-acid battery

In a lead-acid battery, the electrodes consist of lead or lead dioxide (negative and positive pole) and the electrolyte of diluted sulphuric acid. The battery is enclosed in an acid-proof housing.

Fig. 1a: Schematic structure of a charged battery

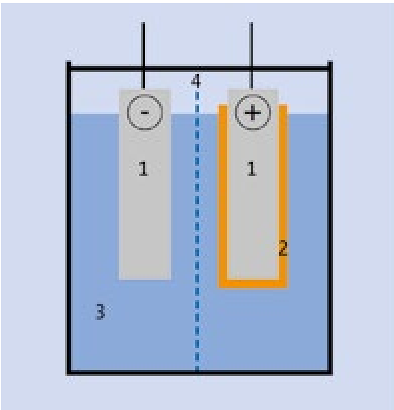
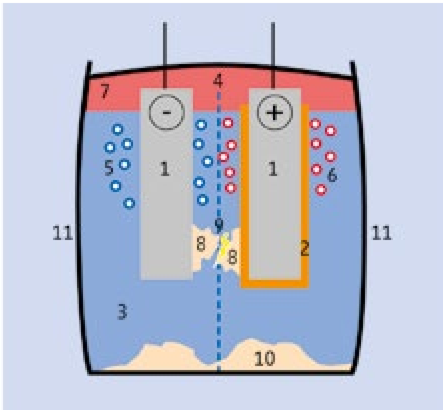


Fig. 1b: Operation and possible operating state of a charged battery

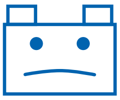


- 1 Lead electrode: positive and negative pole.
- 2 Lead dioxide: The lead dioxide coating makes one electrode the positive pole of the battery.
- 3 Sulphuric acid: electrolyte that reacts chemically with the electrodes.
- 4 Separator: Prevents direct contact between electrodes at high packing density.
- 5 Hydrogen gas forms during overcharging by electrolysis [1].
- 6 Oxygen gas is formed in the event of overcharging by electrolysis and self-discharge.
- 7 Oxyhydrogen gas: Explosive mixture of hydrogen and oxygen gas.
- 8 Lead dendrites formed on both electrodes.
- 9 Possible short circuit due to formed lead dendrites.
- 10 Sulphate sump: fallen lead sulphate (only for closed batteries).
- 11 Deformation due to heat and pressure.

[1] Electrolysis = splitting of water into hydrogen and oxygen gas when electric current flows through it.

3 Causes of typical battery failures

External factors that may result in battery failure:

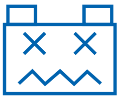


I. Transport / Storage

- Transport damage to the battery blocks
- Battery subject to prolonged period in storage without charge
- Storage temperature too high

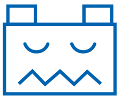
II. Assembly / Placement

- Corroded pole surface (increased contact resistance)
- Loose battery connectors (increased contact resistances)
- Dirty battery surface (leakage currents, earth fault, short circuit)
- Overheating at the installation site (solar radiation, etc.)
- Air conditioning / air circulation of the battery environment (temperature of the battery, uneven temperature distribution, battery block distances)
- Reverse polarity assembly
- Incorrect mounting orientation (horizontal/vertical) of the battery blocks



III. Commissioning

- Incorrect charging voltage/temperature compensation setting
- Wrong picking load
- Level or density of electrolyte incorrectly adjusted or not checked



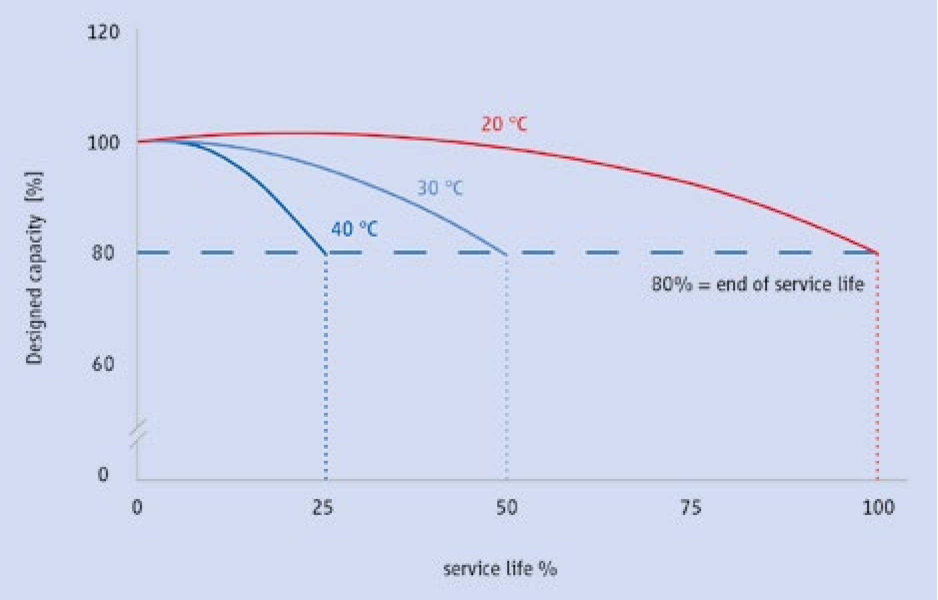
IV. Operation

- inadequate maintenance
- Malfunctions of the charging technology
- AC ripple of the charging current
- Operating parameters change due to external influences (temperature, current, voltage, charging characteristic, charging time, deep discharge)
- Operation does not correspond to the original design (frequent charge/discharge cycles due to high mains failure rates).
- Air conditioning / ventilation fails
- Failure to check the capacity of normative and manufacturer-specific specifications

4 Service life of batteries

Data sheet specifications typically apply to a nominal temperature of 20 °C. The ideal operating temperature range is 20 °C ± 5 K. Higher temperatures shorten the service life (see Fig. 2), lower temperatures reduce the available capacity. (Source: ZVEI Division Battery, information sheet no. 19, August 2019)

Fig. 2: Dependence of the service life of batteries on the ambient temperature

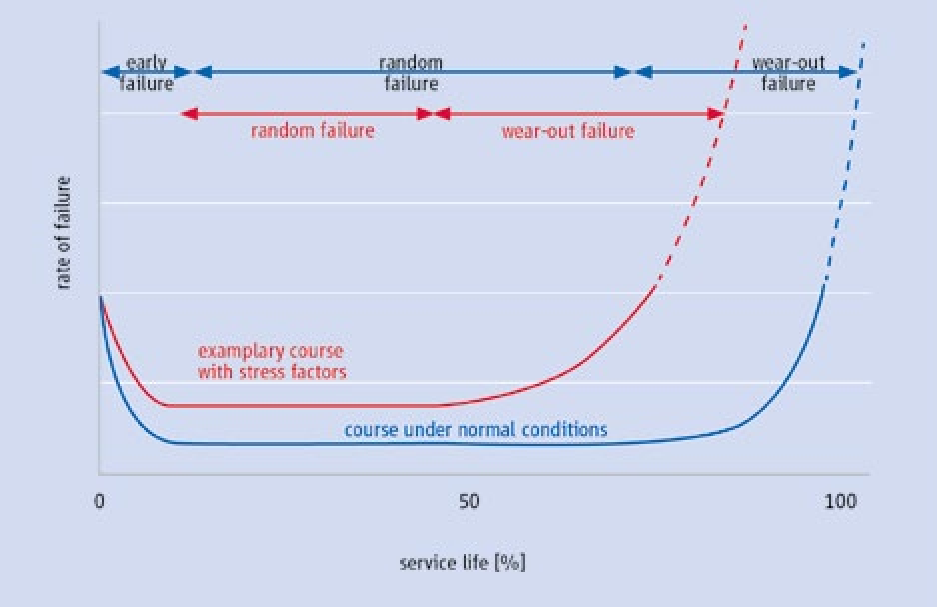


For example, at an ambient temperature of 30 °C, the service life is already reduced by half.

5 Battery failure rate

The failure rate or failure probability of batteries has the typical course shown in Fig. 3 (so-called "bathtub curve"). Three failure categories are to be distinguished here:

Fig. 3: Failure history of batteries



Early failures: The failure rate in this section is essentially determined by manufacturing defects of the product or by faulty installation / commissioning.

Random failures: The failure rate in this range is essentially determined by the operating conditions (see section 3).

Wear-out failures: During this period, the first wear failures occur, i.e. the end of the service life is reached for some of the batteries. The onset and rate of wear failures are strongly dependent on care and maintenance

6 Effect of battery damage

An intact battery system and the provision of the energy required in an emergency are prerequisites for a functioning safety lighting and safety power supply system. Therefore, the operator has the obligation to check, maintain and service them.

The following example shows the effect that a slight pre-damage of individual battery blocks can have. In the first duration test (also called capacity test), all measured values are still inconspicuous. However, if the ambient temperature is too high, the slight pre-damage increases continuously. If the block voltages are checked manually, the first consequences will not be detected until the next duration test a year later. Immediate repair of the battery system would now be unavoidable to prevent further damage. Changed electrical measured values (here: lower block voltages) are an indication of an expected defect. If such a change occurs, this leads, for example, to an increase in the charging voltage at the remaining blocks, which in turn leads to an increase in temperature there. If this is ignored, as described in this example, a total failure of the battery system or even an explosion can be the result.

Fig. 4a: Check under load at the beginning and end of the duration test

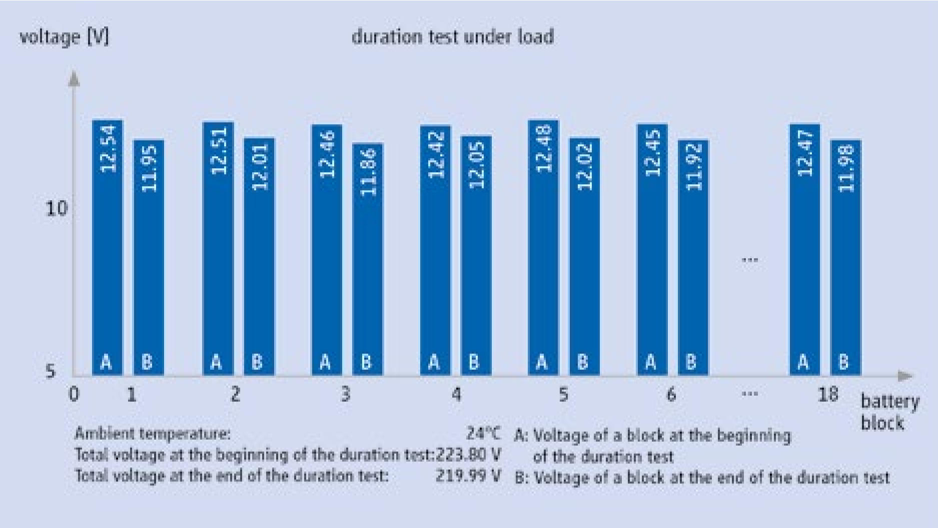


Fig. 4b: Inspection under load at the beginning and end of the duration test one year later

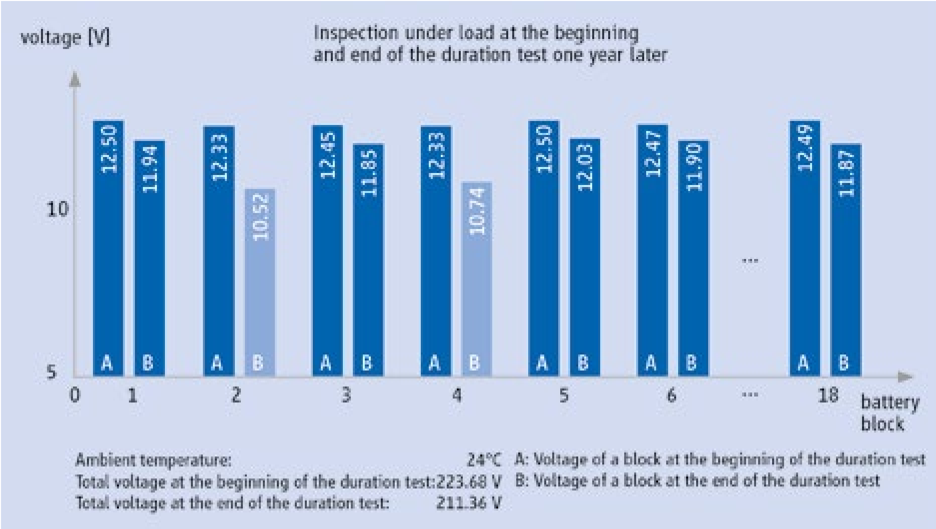
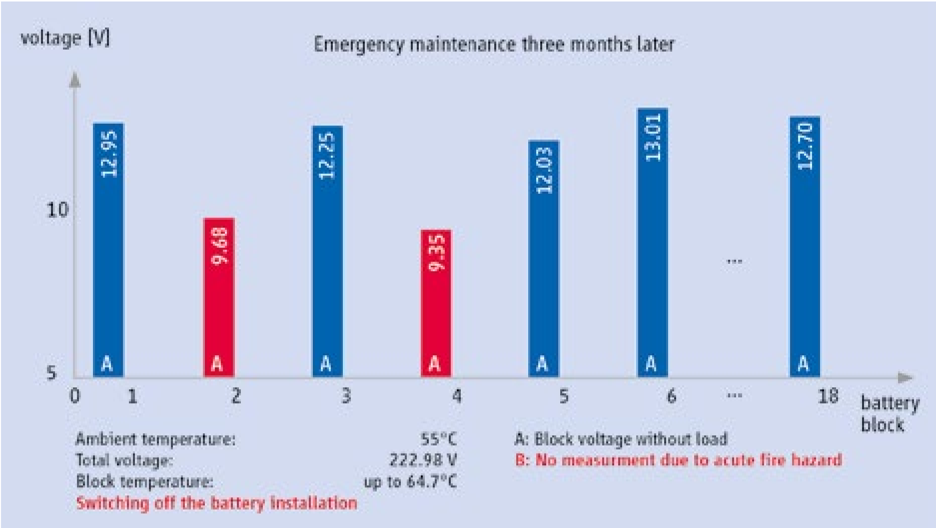


Fig. 4c: Emergency maintenance operation three months later, during which measurement B had to be cancelled due to an acute fire hazard.



In the specific case example, a reduced block voltage was already documented on two blocks during the first duration test under load shown above. The battery system was not immediately repaired. This increased the temperature of the battery blocks, which affected adjacent blocks. Within a few weeks, the battery temperature rose to over 60 °C, and the heat input into the battery room caused the room temperature to rise to 55 °C (self-reinforcing effect).

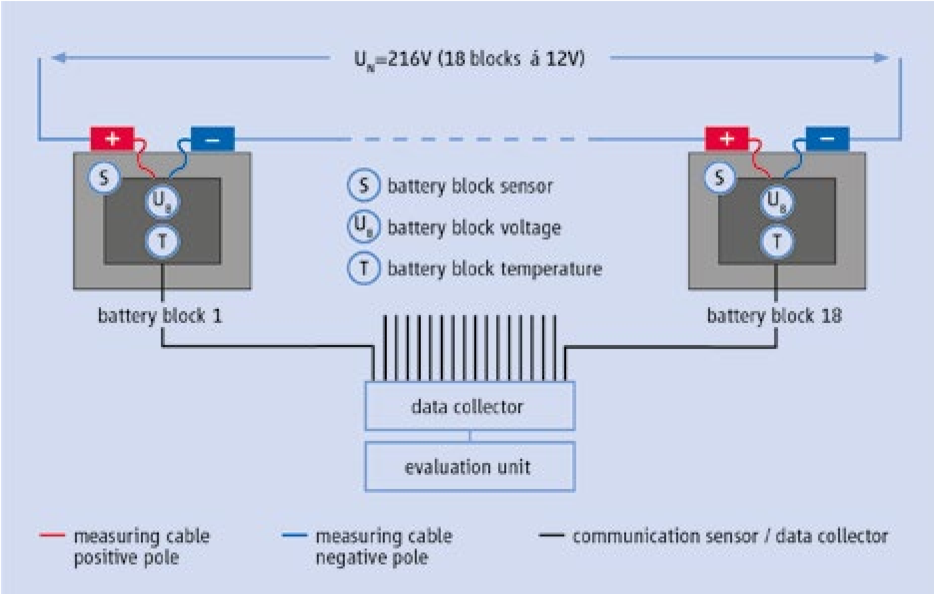
Ultimately, this led to the complete battery system shutting down and a replacement of all battery blocks became necessary.

Fig. 5: Manual temperature measurement on a battery (here: 64.7 °C)

Fig. 6: Example of a damaged battery

7 Structure of a single-block monitoring system

Fig. 7: Schematic structure of single-block monitoring system with battery block sensors, data collector and evaluation unit.



In most safety lighting installations, individual luminaire monitoring has long been standard and the usefulness of this function is undisputed. But what about the individual battery blocks of a safety power supply? If these do not work, the complete emergency lighting system will not function in the event of a mains failure. Thus, it is important to monitor the voltage and even the temperature of each individual battery block. Because even one defective battery block can - in the worst case - cause the entire power source to fail.

A battery block is a wearing part with a limited service life, which is highly dependent on environmental influences. As in any safety-relevant installation, such wearing parts must be monitored regularly.

Table 1: Overview of possible consequences of unnoticed battery damage

	capacity loss	failure of the battery system	fire or explosion of the battery system
in case of damage the installer is individually liable	+	+	+
limited availability of the building	(+)	+	+
damage of the building	–	–	+

The unrestricted availability of a safety power supply is therefore in the particular special interest of the building operator and should have his full attention at all times.

8 Summary

A non-functioning safety lighting system can have far-reaching consequences for the building operator. For example, a short-term closure of the building can result in financial losses from business interruptions and damages, through to reputational damage and legal action in the event of personal injury and possible fatal accidents.

Consistent and continuous battery monitoring contributes significantly to the reliability of safety lighting and safety power supply systems. By detecting possible early failures of individual battery blocks, these can be replaced in time without requiring the cost-intensive replacement of the entire battery set.

9 Bibliography

ZVEI Leaflet No. 19, Service life - considerations for stationary lead-acid batteries in standby parallel operation, published by ZVEI Battery Division, August 2019.

DIN EN 50171:2001 (VDE 0558-508), Central power supply systems
German version EN 50171:2001 + Corrigendum: 2001-08

Draft prEN 50171:2019, Central safety power supply systems

10 Image source

Figure 1a, 1b:	RP-Technik GmbH, Germany
Figure 2, 3:	ZVEI Battery Division Merkblatt Nr. 19
Figure 4a, 4b, 4c, 5:	Fischer Akkumulatorentechnik GmbH, Germany
Figure 6, 7:	Eaton CEAG Notlichtsysteme GmbH, Germany

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