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TECHNICAL REPORT

Guidelines for the use of monitor systems for lead-acid traction batteries

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FOREWORD

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IEC TR 61431, which is a Technical Report, has been prepared by IEC technical committee 21: Secondary cells and batteries.

This second edition cancels and replaces the first edition, published in 1995. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) The guidelines have been streamlined in terms of technical content and focussed for automatic monitoring systems.

The text of this Technical Report is based on the following documents:

Enquiry draft	Report on voting
21/1044/DTR	21/1053A/RVDTR

Full information on the voting for the approval of this Technical Report can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

GUIDELINES FOR THE USE OF MONITOR SYSTEMS FOR LEAD-ACID TRACTION BATTERIES

1 Scope

This document is an informative document relating to aspects of automatic monitor systems as utilized in lead-acid traction battery applications. It lists the characteristics and features that need to be monitored and evaluated to properly assess the operative status of a traction battery. Guidance concerning the accuracy and reliability of the generated information is also provided.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

No terms and definitions are listed in this document.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

4 Desirable characteristics and features

4.1 General

This Clause 4 lists relevant characteristics and features, which, if measured or implemented, would contribute information towards the assessment of the operational condition of a lead acid traction battery. The characteristics are not listed in any order of priority.

The battery monitor system (BMOS) described in this document is a device solely collecting and reporting data and should not be confused with a battery management system (BMS) actively controlling the battery.

4.2 Physical location of the monitoring device

The device may be installed in one of the following locations:

a) directly on the battery,

b) on the charger,

c) on the vehicle.

Location a) is the preferred option as it provides continuous and continued monitoring. Option b) and c) require additional methods to properly identify which battery is currently being monitored. This requires a unique battery ID to be made available for battery recognition. Such an ID could be stored for example on an RFID tag, a 2D QR code, NFC device or similar information depositories.

If the device is directly integrated into the battery, the unique battery ID can be stored in the device itself and the above-mentioned methods of battery identification are not needed.

4.3 State of charge indication or "fuel gauge"

The precise knowledge of the state of charge or driving range capability is a key functionality of a monitor system. The device should allow these values to be displayed in a fuel gauge manner with an acceptable error tolerance and without the necessity to undertake a capacity test. Low state of charge or driving range should be indicated by an alarm signal.

4.4 Battery temperature information

Battery temperature is a crucial measuring parameter. The location of the temperature probe should be selected so as to measure the electrolyte temperature of the hottest cell of the battery.

When the battery is powering equipment operated for example in cold storage warehouses, the probe should be preferably located at the coolest cell of the battery.

The actual value and its integration over service time are essential to predict discharge capacities, adjust recharge conditions and predict battery lifetime.

4.5 High battery temperature warning

Temperatures in excess of 60 °C over a period of several hours can cause rapid degradation of the battery. In batteries with valve regulated cells, such temperature levels may cause a thermal runaway within a few hours leading to copious gas evolution and ultimate destruction of the cells. A specific high temperature warning signal should be generated by the monitor system to alert the operator.

4.6 Low temperature warning

Storage temperatures below −5 °C may cause electrolyte freezing in a discharged battery. The monitor system should generate an adequate warning signal for information purposes only.

4.7 Electrolyte level indication

In vented cells the correct filling level of the electrolyte is crucial to achieve service life. This requires a periodic topping up of the electrolyte level with deionized or distilled water. The actual electrolyte level is generally displayed visually on each cell with a floating device integrated in the vent or watering plug. The electrolyte level of a selected cell, i.e. the pilot cell, can be also transmitted via appropriate electrical circuits to the monitor system. Low electrolyte levels should trigger a warning signal calling for inspection and, if confirmed, for addition of water. It is however recommended that an additional visual inspection be carried out periodically as floating level sensors may get stuck, erroneously indicating an adequate filling level or causing an overfilling.

4.8 Electrolyte level maintenance log

The frequency of water additions and quantities needed increase as the vented battery ages. Operating conditions and/or latent defects may further increase the need for maintenance. The date of electrolyte level adjustments and, if accessible, the quantity of re-filled water should therefore be recorded in a maintenance records section of the monitor system. This is of particular relevance if an automatic watering system controlled by the charger is used. This generally requires the monitoring system to be located in the charger or to be able to communicate with the charger.

4.9 Uniformity of cell properties in a battery

A traction battery is an assembly of multiple 2 V single cells or 4 V, 6 V, or 12 V monoblocs. The status of each individual cell contributes to the energy delivery capability, charge acceptance and service life expectancy of the battery itself. Ideally the voltage of each cell of the battery should be monitored continuously to detect present or developing anomalies. These voltages should be measured and recorded, for example, at 1 min intervals and with a 10 mV resolution and displayed in such a way that absolute voltage levels, or the deviation from the average cell voltage are displayed in a colour graduated way (green to orange to red to blinking red) according to defined deviations or absolute values. This display should replicate the layout of the cells in the battery so that the operator can by guided properly to carry out further inspections or correlate cell property values with the location of local heat sources, loose connectors, etc.

4.10 Battery commissioning date

In order to properly correlate and gauge the monitored battery characteristics and features, the date of first use or commissioning should be made available to the monitor system and embedded in the most appropriate way in the battery identification tag as per 4.2.

4.11 Battery configuration

In this document, and in particular in 5.4, it is assumed that the battery is configured by connecting cells, monoblocs and batteries in series only and not in parallel.

5 Evaluation and analysis

5.1 State of charge indication or "fuel gauge"

The state of charge or SoC of a battery refers to the number of ampere hours discharged in relation to a reference capacity value. This reference value may be the 5-hour rated capacity value as declared by the manufacturer. However, this calculated value represents only a simple "ampere hour" accounting-based state-of-charge (SoC) value, i.e.

$$Q_{est} = C_N - Q_{dis} \text{ (Ah)}$$

where

Q_{est} is the capacity estimated to be available for further discharge expressed in ampere hours;

C_N is the rated capacity expressed in ampere hours;

Q_{dis} is the capacity discharged expressed in ampere hours.

This is a very simplified approach as the actual battery capacity may no longer relate to the rated capacity value due to insufficient charging, ageing, temperature and discharge current level effects.

Summing up the discharged ampere hours and subtracting them from an assumed arbitrary 100 % state of charge at the beginning of the charging procedure can yield an ad-hoc state of charge indication. Such a calculation needs in any case to take into account the ampere hours recharged during possible opportunity charging or braking energy recovery.

A more precise indication of the state of charge of a lead-acid battery or expected autonomy time or remaining driving range of the vehicle should consider multiple impacts of the actual discharge parameters and conditions on the effective available battery capacity.

5.2 Battery temperature information

The temperature of the electrolyte in the cell has a major impact on cell capacity and life.

Increased battery temperatures accelerate ageing. The battery lifetime is diminished by 50 % for every 10 °C above the rated 30 °C reference temperature.

For proper operation, any traction battery assembly in steel trays or similar should ensure a homogenous cell temperature with the temperature difference between the hottest and coldest cell not exceeding 3 °C. If the battery is split into two or more separate trays on the vehicle, then additional attention should be given to suitable probe location and temperature homogeneity.

The location of the temperature probe should be chosen appropriately to reflect either the average electrolyte or cell or battery temperature with a preference towards locations where higher than average temperatures are present.

The probe can be inserted into the electrolyte or between the walls of two adjacent cells or monoblocs. The probe may also be attached to the lead part of a terminal. However, the value found should represent the internal cell or electrolyte temperature and not localized hot spots due to ohmic heating caused by loose or undersized connectors.

Adequate corrosion protection of the probe and connecting leads is mandatory.

In addition to the temperature at the probe location, the temporal distribution of the temperature should be also recorded.

In Table 1 the variables t_1 through t_5 can be used to accumulate residence times of the battery at different temperature levels. Warnings and alert should be sent when the temperature exceeds the warning levels listed in Table 2.

For this purpose, the actual time, preferably in in minutes, during which the temperature of the battery was within a certain range should be documented in conjunction with the unique ID number of the battery, if applicable.

Table 1 – Residence times and related temperature ranges

Duration within the selected temperature range	Temperature range for vented cells °C	Temperature range for valve-regulated cells °C
t_1	< 10	< 10
t_2	10 to 40	10 to 30
t_3	40 to 50	30 to 40
t_4	50 to 55	40 to 45
t_5	> 55	> 45

Table 2 – Temperature warning levels

Action	Temperature range for vented cells °C	Temperature range for valve-regulated cells °C
Send warning	≥ 55	≥ 45
Send high temperature alert	≥ 60	≥ 55

5.3 Water consumption

Vented cells require a periodic adjustment of the electrolyte level with addition of distilled or deionized water according to the specific, cell-design related manufacturer's instructions.