Leaflet No. 38

Application-related requirements for the operation of stationary lead-acid and lithium-ion batteries

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Verband der Elektro- und Digitalindustrie

1. Objective

Stationary batteries are used for countless applications in the field of power supply in daily life, which in all cases serve the safety of people, manufacturing processes or data storage. In the context of advancing electrification, not only lead batteries, but increasingly also storage systems in lithium-ion-technology are being used. This document is intended to describe the application-related requirements for the stationary operation of lead-acid- and lithium-ion-batteries for users.

2. Scope

This document applies to:

- stationary battery systems
- the operation of lead-acid and lithium-ion batteries in shared or separate battery rooms
- Users who operate and maintain both technologies
- Planners of battery rooms

3. Application-related requirements

When considering application-related requirements for the operation of stationary lead-acid and lithium-ion battery systems, there are major system-related differences. While a lead-acid battery system is usually combined to form a complete system by interconnecting individual battery cells or blocks on site, this is already done at the manufacturer in the case of lithium-ion batteries as a result of a required battery management system.

Safety requirements such as:

- Protection against direct contact with active parts
- Protection against indirect contact with active parts
- Protection by automatic shutdown
- Protection by equipment of protection class II
- Protection by electrical isolation
- Protection against both direct and indirect contact (protective extra-low voltage)

Safety requirements must be met for on-site installation and, if applicable, documented by a CE marking. In the case of lithium-ion storage systems, this is ensured by a risk assessment, appropriate functional tests, or compliance with the low-voltage and EMC directives on the part of the manufacturer.

3.1 Requirements for the installation site

Stationary battery systems are primarily electrical equipment that ensure the supply of critical infrastructure elements in the event of a power failure. Depending on the storage technology used in each case, the individual discharge characteristics, the system voltage, or even the chemical structure for operation can result in different requirements for the installation site. These relate to:

a.) Shutdown and disconnection of the battery system

Since lithium-ion batteries have a lower internal resistance than lead batteries, their short-circuit current is significantly higher for the same battery voltage and capacity. This must be taken into account in particular when planning and projecting the associated disconnection devices, as well as when avoiding short circuits and protecting against the effects of the electric current.

b.) Shutdown and disconnection of the battery system

- Lead batteries:
    i. Ventilation of the battery room
    ii. Distance from ignition sources in the immediate area
    iii. Electrolyte leakage

- Li-Ion-batteries:
  1. Charging mode
  2. Overcharge or overdischarge under fault conditions
  3. Leakage of chemical substances

While storage systems with aqueous electrolytes emit ignitable oxyhydrogen gas under maintenance or heavy charging due to water electrolysis and require ventilation of the battery room as well as a safe distance to possible ignition sources, this is not necessary when using Li-ion batteries.

However, the latter systems require meticulous compliance with the current, voltage and temperature limits specified by the manufacturer in order to avoid irreversible damage to cells or the battery system. The use of battery management systems (BMS) with associated communication to the battery charger is mandatory and therefore state of the art today. To ensure that the safety of the storage system does not suffer in the event of a fault, the BMS must also be designed in such a way that, for example, the charging voltage is reduced in the event of danger or the battery system is completely disconnected in the event of overvoltage or undervoltage. The same applies to the loss of communication between BMS and charging technology. According to EN IEC 62485-5, the associated shutdown devices must be designed redundantly or must comply with a suitable SIL (Safety Integrity Level) level.

Operators of battery systems do not usually come into contact with the chemical substances used in the battery cells. However, an exception arises in the event of damage to the respective cell containers.

Diluted sulfuric acid from lead batteries can cause burns on contact. Electrolytes in lithium-ion batteries tend to irritate the skin. In both cases, affected contact areas of the skin or eyes must be flushed immediately and sufficiently with water and then treated medically. In addition, Li-ion batteries can lead to the release of hazardous gases and even fire in the event of malfunction or damage; under these circumstances, evacuation of personnel from the battery room is mandatory.

c.) Housing and premises

Both lead-acid and lithium-ion batteries must be housed in protected rooms, which, depending on the size of the system, may also have to be lockable.

The following factors should be taken into account when selecting the premises:

a. Protection against external hazards, e.g. fire, water, impact, vibration, vermin;
b. Protection against hazards emanating from the battery, e.g. high voltage, explosion hazard;
c. Hazards due to electrolyte, corrosion and earth leakage effects;
d. Protection against access by unauthorised personnel;
e. Protection against extreme environmental influences, e.g. temperature, UV radiation, humidity, air pollution.

In addition to general requirements such as the load-bearing capacity of the floor, the standard-compliant construction of the battery system or the technical design of anti-panic doors in lockable rooms, there are also technology-related requirements to consider.

These are:

a. Lead batteries:
   i. Venting the battery room to the atmosphere outside the building
   ii. Maintaining safe distances from potential ignition sources
   iii. Compliance with the normative leakage resistance of the floor in the vicinity of the battery
   iv. Electrolyte-impermeable floor or installation of electrolyte collection trays underneath closed lead-acid batteries.
   v. When installed in enclosures, this must have adequate chemical resistance to the corrosive action of the electrolyte and also prevent leaking electrolyte from causing short circuits.

b. Li-Ion-batteries:
   i. Protection against the spread of fire

d.) Working on or near batteries

For emergency evacuation, an unobstructed escape route with a minimum width of 600 mm (lead) and 750 mm (Li-ion) must be kept clear at all times.

urthermore, work on batteries (lead and Li-ion) or within the safety distance with potential ignition sources (grinding, soldering, welding, etc.) may only be carried out by trained personnel who have been made aware of the associated dangers. In addition to monitoring sparking, especially in the case of lead batteries with liquid electrolyte, disconnect the battery from the charger before starting work and remove the potentially ignitable gas mixture in the head area of the cells and block batteries using a stream of compressed air, nitrogen or an inert gas.

When accommodating lead-acid and lithium-ion batteries in the same room, precautions shall be taken in accordance with the relevant safety standards for all systems. Special risks arising from the parallel operation of the storage systems shall be taken into account, e.g. corrosion of components on Li-ion batteries due to emitted acid aerosols or leakage of electrolyte in the case of lead-acid batteries.

3.2 Marking of battery installations

Due to the very wide range of applications for stationary battery systems, the nominal voltage and energy content as well as the electrochemistry used can vary greatly from one individual to another. Due to the resulting hazards for the user, a battery room must be marked with at least the following warning signs or notices in accordance with the ISO 3864 series of standards.

- „Dangerous voltage", for a battery voltage > 60 V DC;
- Sign for "Fire, open flames, smoking prohibited";
- Warning sign "Battery, battery room" to indicate corrosive electrolyte, explosive gases, dangerous voltages and currents.

Also, for reasons of safety and maintenance, each individual cell, monobloc battery or battery assembly unit must be easily and unambiguously identifiable by the application of numbers or/and letters for cells and batteries. In the case of Li-ion batteries, this identification may alternatively be applied to the top level of the storage system, making the identification on the cell of the battery and the module then no longer necessary.

For proper installation of a battery system, the following instructions must be supplied with and displayed near the battery.

a) Name of the manufacturer or supplier;
b) Type designation of the manufacturer or supplier;
c) Rated voltage of the battery;
d) Nominal or rated value of the capacity of the battery, including applicable rated values;
e) Name of the installer;
f) Date of putting into service;
g) Recommendations on safety and instructions on construction, operation and maintenance;
h) Disposal and recycling information.

Note: When using Li-Ion-batteries, only the specifications e) to h) are required!

3.3 Operation and maintenance

a.) Superimposed alternating part of the charging current

The alternating component in the battery's charging current is generated by the charger or the load, so both electrical links must be taken into account when determining the alternating component. Alternating components in the charging current of the batteries generate heat within the cells and must therefore be kept as low as possible for maximum service life.

For lead-acid batteries, the DC component of the float charge current must have a positive value at all times and be in the typical range of 0.1mA to 1mA per Ah of rated capacity. According to IEC 62485-2, the recommended upper limit for the rms value of the superimposed alternating current is 5A/100Ah in float charge mode and 10A/100Ah in heavy charge mode.

In contrast, in the case of lithium-ion batteries, the limits for current and voltage specified by the manufacturer must not be exceeded, even when taking into account a superimposed alternating current component.

b.) Charging methode

Charging methods are used to recharge batteries in a time specified by the application. In addition to a so-called W-characteristic (charging with constant resistance), which is only used in older lead-acid battery systems, modern charging methods with a combination of constant current and constant voltage are mainly used today for recharging lead-acid and lithium-ion batteries (IU-characteristics).

For the parameterisation of the charger, it is recommended to observe the respective manufacturer's specifications due to the different designs of lead batteries (closed, sealed, electrolyte densities, etc.) and different chemical composition of the components of Li-ion batteries.

c.) Discharge

In contrast to lead batteries, which can be operated reliably without a battery management system, such a device is mandatory for the safe operation of lithium-ion batteries. The maximum discharge current as well as the minimum discharge voltage are generally electronically limited to avoid deep discharge in these storage systems. The same applies to the temperature window specified by the manufacturer.

d.) Inspection and monitoring

To maintain operational readiness and for safety reasons, regular inspection of the battery and its operating environment is required.
For lead batteries, in accordance with the manufacturer's requirements, the inspection shall include the following control measures:

- Battery voltage settings at the battery terminals;
- Battery temperature;
- Trickle charge current;
- individual cell and block battery voltages;
- Specific gravity and electrolyte level, if applicable;
- Cleanliness and absence of electrolyte leakage;
- Strength or torque of cell and cable connections, if applicable;
- Airflow of ventilation.

For the safe operation of lithium-ion batteries, a so-called battery management system (BMS), which monitors and controls all parameters relevant to operation, is indispensable. For this reason, inspection work on these storage systems is usually limited to physical changes. These can be:

- Insulation defects
- Electrolyte leakage
- Deformations and swelling casings with advanced age

The aforementioned anomalies generally lead to the decommissioning of these storage systems!

3.4 Transport and storage

The packaging and transport of lead-acid and lithium-ion batteries are regulated by various national and international regulations, which must be checked in each individual case.

Attention: Specific conditions of carriage apply in each case for new, old, damaged and defective batteries.

Further information can be found in leaflet 5 Transport of batteries. (https://www.zvei.org/themen/merkblaetter-batteriewissen-kompakt).

4. Summary

A comparison of the safety requirements of stationary lead-acid and lithium-ion batteries according to IEC 62485-2 and IEC 62485-5 shows that there are many similarities with regard to the hazards caused by the electric current. Differences for the user result essentially from the respective electrochemical systems and the structure of both systems.

- Lead batteries:
  - Interconnection of individual components on site to form a complete system
  - No battery management system (BMS) necessary

- Li-Ion-batteries:
  - Installation of the storage system and integration of the BMS at the manufacturer's site
  - In the case of larger units in terms of capacity and voltage, if necessary, also join several memory modules together on site.
  - BMS mandatory

Publisher:
ZVEI e.V.
Verband der Elektro- und Digitalindustrie
Section Batteries
Lyoner Straße 9
60528 Frankfurt

Phone: +49 69 6302-283
E-Mail: batterien@zvei.org
www.zvei.org

zvei
electrifying
ideas