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INTERNATIONAL STANDARD

NORME INTERNATIONALE

Flow battery energy systems for stationary applications – Part 2-2: Safety requirements

Systèmes de production d'énergie à batteries d'accumulateurs à circulation d'électrolyte pour les applications stationnaires – Partie 2-2: Exigences de sécurité

IEC 62932-2-2:2020-02(en-fr)

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FLOW BATTERY ENERGY SYSTEMS FOR STATIONARY APPLICATIONS –

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FOREWORD

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International Standard IEC 62932-2-2 has been prepared by IEC technical committee 21: Secondary cells and batteries, in collaboration with IEC technical committee 105: Fuel cell technologies.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
21/1029/FDIS	21/1035/RVD

Full information on the voting for the approval of this International Standard 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.

A list of all parts in the IEC 62932 series, published under the general title *Flow battery energy systems for stationary applications*, can be found on the IEC website.

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- withdrawn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.

INTRODUCTION

A flow battery system (FBS) can be utilized in a flow battery energy system (FBES). Such an FBES can consist of:

– a flow battery system,
– a power conversion system,
– other equipment and surroundings.

The FBES is connected to the external power input/output via a point of connection (POC).

This document covers the domain of the FBES, as shown in Figure 1. Energy to the auxiliary systems such as the battery management system (BMS), the battery support system (BSS), and the power conversion system (PCS) may be supplied by one of the following:

a) direct connection to the external power source;
b) the internal power source of the FBES or FBS itself.

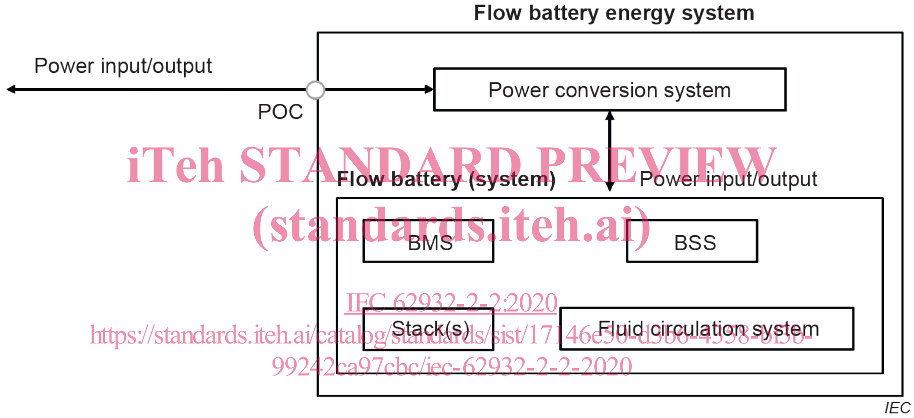

Figure 1 – Flow battery energy system

FLOW BATTERY ENERGY SYSTEMS FOR STATIONARY APPLICATIONS –

Part 2-2: Safety requirements

1 Scope

This part of IEC 62932 applies to flow battery systems for stationary applications and their installations with a maximum voltage not exceeding 1 500 V DC in compliance with IEC 62932-1.

This document defines the requirements and test methods for risk reduction and protection measures against significant hazards relevant to flow battery systems, to persons, property and the environment, or to a combination of them.

This document is applicable to stationary flow battery systems intended for indoor and outdoor commercial and industrial use in non-hazardous (unclassified) areas.

This document covers significant hazards, hazardous situations and events, with the exception of those associated with natural disaster, relevant to flow battery systems, when they are used as intended and under the conditions foreseen by the manufacturer including reasonably foreseeable misuse thereof.

The requirements described in this document are not intended to constrain innovations. When considering fluids, materials, designs or constructions not specifically dealt with in this document, these alternatives are evaluated as to their ability to yield levels of safety equivalent to those specified in this document.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60079-10-1, *Explosive atmospheres – Part 10-1: Classification of areas – Explosive gas atmospheres*

IEC 60364-4-41, *Low-voltage electrical installations – Part 4-41: Protection for safety – Protection against electric shock*

IEC 60364-4-43, *Low-voltage electrical installations – Part 4-43: Protection for safety – Protection against overcurrent*

IEC 60364-6, *Low voltage electrical installations – Part 6: Verification*

IEC 61936-1, *Power installations exceeding 1 kV a.c. – Part 1: Common rules*

IEC 62485-2:2010, *Safety requirements for secondary batteries and battery installations – Part 2: Stationary batteries*

IEC 62932-1, *Flow battery energy systems for stationary applications – Part 1: Terminology and general aspects*

ISO 7010, *Graphical symbols – Safety colours and safety signs – Registered safety signs*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 62932-1 apply.

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

3.2 Abbreviated terms

BMS battery management system

BSS battery support system

EES electrical energy storage

FBES flow battery energy system

FBS flow battery system

FMEA failure mode and effects analysis

FTA fault tree analysis

GHS global harmonized system

HAZOP hazard and operability study

MSDS material safety data sheet

PCS power conversion system

POC point of connection

SDS safety data sheet

UPS uninterruptible power system

4 Procedure of the risk analysis

A written risk analysis shall be performed on an FBES to ensure that:

a) all reasonably foreseeable hazards and hazardous events, including reasonably foreseeable misuse throughout the anticipated lifetime, have been identified;

b) the risk for each of these hazards has been estimated from the combination of its probability of occurrence and of its foreseeable severity;

c) the two factors which determine each one of the estimated risks (probability and severity) have been eliminated or reduced to a level not exceeding the acceptable risk level as far as reasonably possible according to the following principles in the order given:
   - eliminate hazards or reduce risks by inherent design measures,
   - take necessary protective measures in relation to risks that cannot be reduced by inherent design measures,
   - inform intended users and where appropriate other persons of the residual risks, indicate whether any particular training is required and specify any need to use personal protective equipment.

For example, failure mode and effects analysis (FMEA), fault tree analysis (FTA) methods, hazard and operability study (HAZOP), and/or the following International Standards shall be used as guidance:

- IEC 60812;
- IEC 61025.

5 Safety requirements and protective measures

5.1 General

Each secondary battery has a different structure and therefore only the features critical or specific to the flow battery shall be taken into consideration. The flow battery energy system as shown in Figure 1 differs from other secondary batteries, in that a system for circulating the electrolyte is present. The fluid circulating system consists of tanks, pumps, piping, sensors and some safety-relevant devices.

From a chemical safety point of view, since fluid is contained in tanks, pipes and stacks, the sealing is an important factor. There is also the possibility of hazardous gases being present, requiring that appropriate countermeasures be implemented.

Clause 5 specifies the safety requirements and protective measures in consideration of the above-mentioned aspects.

5.2 Risk information

The manufacturer shall provide the user with risk information based on the risk analysis to describe hazards and the appropriate measures taken or to be taken for mitigation purposes.

The information shall include a safety data sheet (SDS).

The information can be provided in the form of a user manual. See the recommended structure for user manual in Annex A.

5.3 Electrical hazards

5.3.1 Electrical shock

The FBS is an electrical energy storage device and contains hazardous live parts of DC and/or AC voltage which can cause a risk of electrical shock. Electrolyte is to be considered as carrying dangerous voltages.

Batteries are sources of dangerous voltages and energy (current flow) also when they are not connected to an external power circuit. In flow batteries the amount of residual energy is, when no electrolyte circulates, limited to the charge stored in the electrolyte remaining in the stack itself. In all cases protective measures according to IEC 60364-4-41 shall be implemented.

5.3.2 Short-circuits

The electrical energy stored in an FBS can be released in an inadvertent and uncontrolled manner due to short-circuiting the terminals. Because of its considerable level of energy and subsequent high current, the heat generated can melt metal, produce sparks, cause explosion, or vaporize fluid.

To avoid short-circuits, protective devices such as insulation shrouds, fuses and circuit breakers shall be installed in a way that a short-circuit does not occur under any foreseeable conditions. For the type of conductor arrangement of unprotected sections, IEC 60364-4-43 shall be taken into consideration.

For protective measures, the FBS shall mitigate a short-circuit fault which occurs outside stacks by:

– stopping the supply of energy and fluids to the flow battery cells;
– stopping PCS and opening circuit breaker(s); and,
– interrupting the short-circuit current path by using fuses between stacks.

It is suggested that each stack has a fuse to break the short-circuit path. Specific location and quantity of fuses and/or circuit breakers shall be agreed and decided between the manufacturer and the system user in consideration of cell protection and system safety.

The intrinsic safety of the stack under short-circuit conditions shall be verified according to Annex B.

5.3.3 Leakage currents

In a system in which no point of the battery installation is directly connected to earth, ground faults in the FBS are, due to the large amount of fluid in the fluid handling parts (pumps, pipes, stacks, tanks), a particular problem, and system operators shall be well informed of this matter. Ground faults can cause the following significant risks:

– electrocution when a person accesses the fluid leaking from piping, cells and/or other components of the fluid system;

NOTE 1 In this case a person's body becomes a part of the circuit of the leakage current.

– arcs and fire when short-current is established by the fluid leaking from piping, cells and/or other components of the fluid system.

NOTE 2 The criticality of arcs and fire depend on the electrical conductivity of the fluid. If the fluid has low electrical conductivity, leakage current is small and severity of the risk is low. This also depends on the configuration of stacks. Thus, the detection level is designed taking dangerous leakage current level into account.

The circuit of the FBS shall be properly insulated from other local conductive parts. The minimum insulation resistance between the battery circuit and other local conductive parts shall meet the requirements of IEC 62485-2:2010, 6.4. The minimum insulation resistance between them shall be greater than 100 Ω per volt of the nominal voltage of the FBS.

The insulation shall resist the environmental effects of temperature, dampness, dust, gases, steam, and mechanical stress.

Before carrying out any test, the absence of hazardous voltage between the battery and the associated rack or enclosure shall be verified.

The battery shall be isolated from the external circuit before an insulation-to-ground resistance determination test is carried out.

The insulation shall be verified in accordance with the test method in 11.2.

Protective devices for detecting grounding faults shall be provided in the FBS or in the external system, such as a power conversion system, in order to account for a malfunction in the insulation.

5.4 Hazards of gaseous emissions

5.4.1 General

Flow batteries can produce gases that can be explosive (hydrogen), toxic (bromine), or corrosive, or that can affect the respiratory system. The quantities produced depend on the operating conditions of the FBS and their release to the environment shall be managed with adequate safety features (e.g. ventilation, absorption traps, scrubbers, voltage limits).

In general, gases are produced in the stacks and accumulated in the system. For example, in the case of the FBS, gases are accumulated in the top portion of the tanks.

Since gas generation and accumulation depend on the characteristics and construction of individual FBS, the gas hazard presents different levels of risk in individual FBS.

When hydrogen is produced in an FBS, for example, the generation rate of hydrogen increases as the FBS is charged above the rated voltage range. The correlation between the charging voltage and the gas generation cannot be expressed by a common equation, however, because the gas generation rate depends highly on the characteristics of cell components and fluids which can vary between manufacturers.

The gas emission and its mitigation shall be considered in the flow battery design process. It is suggested to install necessary gas monitoring equipment with alarms and appropriate interlocks.

5.4.2 Harmful gas

5.4.2.1 Explosive gas

The risk level of explosive gases increases if the following hazards coincide:

– generation and accumulation of combustible gases,
– their mixture with oxygen,
– presence of ignition sources.

The FBS shall have protective measures against the above hazards, including but not limited to:

– reduction in the generation of combustible gases,
– dilution of combustible gases,
– prevention of diffusion of gases outside the volume where they are generated,
– elimination of ignition sources,
– prevention of external oxygen ingress.

5.4.2.2 Toxic gas

The risks caused by toxic gases increase if the following hazards coincide:

– generation and accumulation of toxic gases,
– human access to the vicinity of toxic gases.

The FBS shall have protective measures against the above hazards, including but not limited to:

– elimination of toxic gases,
– dilution of toxic gases,
– collection of toxic gases by a scrubber,
– limitation of human access.

5.4.2.3 Corrosive gas

The risk level of corrosive gases increases if the following hazards coincide:

– generation and accumulation of corrosive gases,
– human access to the vicinity of corrosive gases.

The FBS shall have protective measures against the above hazards, including but not limited to:

– construction of the system with corrosion-resistant material,
– elimination of corrosive gases,
– dilution of corrosive gases,
– collection of corrosive gases by a scrubber,
– limitation of human access.

5.4.2.4 Gases affecting the respiratory system

There are cases where gases affecting the respiratory system are generated and accumulated. The risks caused by gases increase if the following hazards coincide:

– generation and accumulation of gases affecting the respiratory system,

– human access to the vicinity of gases affecting the respiratory system.

The flow battery system shall have protective measures against the above hazards, including but not limited to:

– elimination of gases affecting the respiratory system,

– dilution of gases affecting the respiratory system,

– collection of gases affecting the respiratory system by a scrubber,

– limitation of human access.

5.4.3 Ventilation

5.4.3.1 General

The manufacturer shall specify the ventilation requirements for the room where the FBS is installed. This specification shall involve warning signs, operator access limitation, mitigation of static discharges, numbers of air exchanges in m^3/h, required air flow patterns and exhaust direction. When the FBS is installed outdoors, the safety requirements and procedures for approaching personnel shall be specified. The manufacturer shall provide data and a measurement method used to determine the gas emission rating, and ventilation measures shall be implemented based on IEC 60079-10-1. Reference shall be made to the theoretical minimum ventilation flow rate to dilute the gases, which is given in IEC 60079-10-1.

Ventilation is required to ensure that no combustible or harmful gases reach a critical concentration level. The ventilation requirement shall be met by either one or a combination of the following methods:

– natural ventilation,

– forced ventilation through the room or enclosure.

5.4.3.2 Natural ventilation

When natural ventilation is used, battery rooms or enclosures shall be equipped with an inlet and an outlet for the air with a minimum free opening area which meets the ventilation requirements.

5.4.3.3 Forced ventilation

When forced ventilation is used, gases which are released from the FBS into the room or enclosure shall be expelled to the atmosphere using a ventilation system, which may combine an opening and fan. If forced ventilation is essential for the safe operation of the FBS, then an appropriate interlock shall prevent its operation when the forced ventilation is not operating or has failed.

5.4.4 Warning sign

Appropriate warning signs which prohibit sparks, smoking, open flame, and electrostatic discharges shall be placed at the entrance of the hazardous area as determined in accordance with IEC 60079-10-1.