IEC 62933-4-2

Edition 1.0 2025-02

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Electric energy storage (EES) systems –
Part 4-2: Guidance on environmental issues – Assessment of the environmental impact of battery failure in an electrochemical based storage system

Systèmes de stockage de l'énergie électrique (EES) –
Partie 4-2: Recommandations relatives aux problèmes environnementaux – Évaluation de l'impact environnemental d'une défaillance de batterie dans un système de stockage d'énergie électrochimique

IEC 62933-4-2:2025-02(en-fr)

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ELECTRICAL ENERGY STORAGE (EES) SYSTEMS –

Part 4-2: Guidance on environmental issues – Assessment of the environmental impact of battery failure in an electrochemical based storage system

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

Draft	Report on voting
120/387/FDIS	120/403/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

A list of all parts in the IEC 62933 series, published under the general title *Electrical energy storage (EES) systems*, can be found on the IEC website.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

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- withdrawn, or
- revised.

ELECTRICAL ENERGY STORAGE (EES) SYSTEMS –

Part 4-2: Guidance on environmental issues – Assessment of the environmental impact of battery failure in an electrochemical based storage system

1 Scope

This part of IEC 62933 defines the requirements for evaluating and reporting the negative impact on the environment caused by the failure of a cell, flow cell, battery or flow battery in the accumulation subsystem of a battery energy storage system (BESS).

The batteries within this scope used in a BESS are classified according to the type of their electrolyte. These electrolyte types are aqueous, non-aqueous or solid.

The environmental impacts directly caused by the failure of other components of the BESS are not within the scope of this document.

2 Normative references

There are no normative references in this document.

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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

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

3.1.1
cell
basic functional unit, consisting of an assembly of electrodes, electrolyte, container, terminals and usually separators, that is a source of electric energy obtained by direct conversion of chemical energy

[SOURCE: IEC 60050-482:2004, 482-01-01, modified – the Note has been deleted.]

3.1.2
flow cell
secondary cell characterized by the spatial separation of the electrodes and the movement of the energy storage fluids

[SOURCE: IEC 62932-1:2020, 3.1.14, modified – the Note has been deleted.]

3.1.3
flow battery
two or more flow cells electrically connected including all components for use in an electrochemical energy storage system

3.1.4
battery
one or more cells fitted with devices necessary for use, for example case, terminals, marking and protective devices

[SOURCE: IEC 60050-482:2004, 482-01-04]

3.1.5
battery system
assembly of batteries or flow batteries installed on racks or in cabinets with associated electrical, electromechanical, environmental control components and ready to operate

3.1.6
battery management system
BMS
electronic system associated with a battery which has functions to control current in case of overcharge, overcurrent, overdischarge and overheating and which monitors and/or manages the battery's state, calculates secondary data, reports that data and/or controls its environment to influence the battery's safety, performance and/or service life

[SOURCE: IEC 62619:2022, 3.12, modified – the Notes have been deleted.]

3.1.7
failure
loss of ability of the cell, flow cell, battery or flow battery to perform as required

Note 1 to entry: This failure results in a fault of the accumulation subsystem and by derivation, of the BESS.

[SOURCE IEC 60050-192:2015, 192-03-01, modified – replaced "item" with "the cell, flow cell, battery or flow battery", notes have been deleted and added new Note 1.]

3.1.8
failure cause
set of circumstances that leads to failure

Note 1 to entry: A failure cause can originate during specification, design, manufacture, transportation, installation, operation or maintenance of an item

[SOURCE: IEC 60050-192:2015, 192-03-11]

3.1.9
environment
natural and man-made surroundings in which an EES system is installed, operates and interacts, including buildings and facilities, air, water, land, natural resources, flora, fauna (including human inhabitants) of those surroundings

[SOURCE: IEC 60050-904:2014, 904-01-01, modified – expansion of the scope to include man-made surroundings, dynamic interactions, and specific EES system contexts.]

3.1.10
system integrator
entity that specializes in planning, coordinating, building, implementing and testing of systems

3.1.11
manufacturer
entity that produces the specified item and owns the manufacturing process by which it was created

3.2 Abbreviated terms

BESS	battery energy storage system
BMS	battery management system
EES	electrical energy storage
HVAC	heating, ventilation and air conditioning
LFP	lithium iron phosphate
LTO	lithium titanium oxide
MSDS	material safety data sheet
NCA	nickel cobalt aluminium oxide
NMC	nickel manganese cobalt oxide
PCS	power conversion system
POC	point of connection
SDS	safety data sheet
SOC	state of charge
SOH	state of health
VRLA	valve regulated lead acid

4 General

The environmental impact of a battery failure depends on the battery type, design and structures. This document provides guidance and requirements on how to identify the potential impacts on the environment when the battery of an electrochemical energy accumulation system fails.

The operation, under conditions licensed by the local authorities, of the BESS including its batteries and flow batteries, is considered to occur without any negative environmental impact.

5 Failure of the electrochemical accumulation system in a BESS resulting in environmental issues

5.1 General

A failure is defined in this document as a loss of ability of the cell, flow cell, battery or flow battery in the electrochemical accumulation subsystem to perform as required. This failure results in a fault of the accumulation subsystem and, by derivation, can result also in a failure of the BESS with possibly environmental issues.

For the present document, those failure-inducing causes are considered if the subsequent failure(s) of the cell, flow cell, battery or flow battery in the electrochemical accumulation subsystem negatively impact(s) the environment surrounding the BESS.

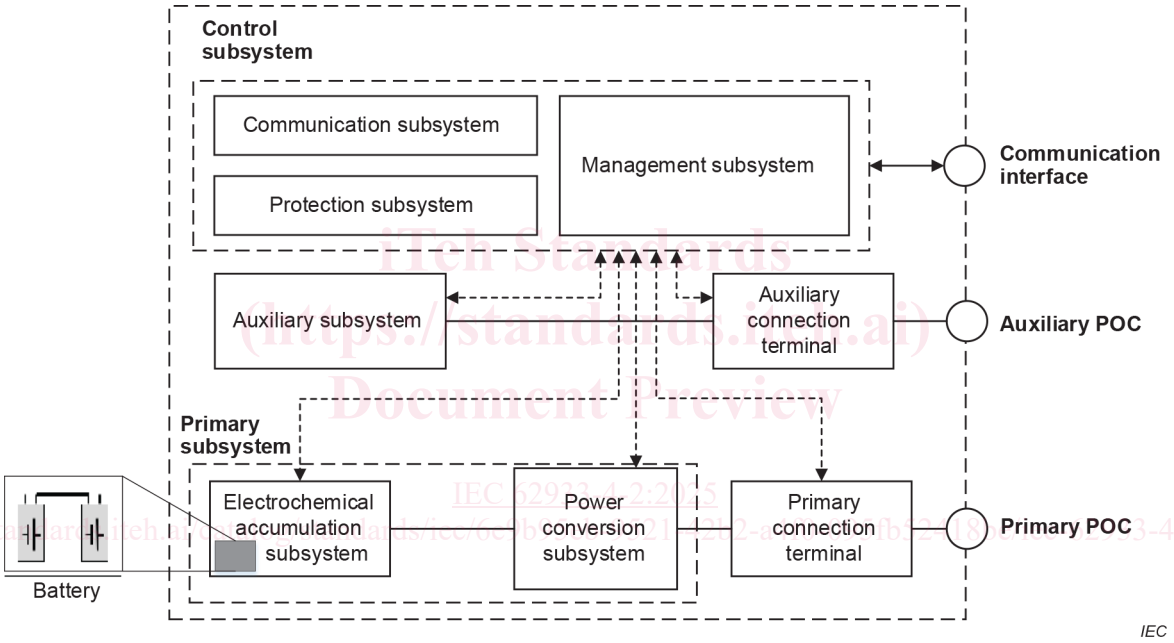
The failure causes to be considered in this document are the result of:

1) electrochemical accumulation subsystem internal causes such as a fault developing due to weakness of materials or of an assembly or divergent chemical or electrochemical reactions; or
2) electrochemical accumulation subsystem external causes such as a fault developing due to a failure of ancillary equipment, unfavourable environmental conditions or loss of essential parameters, data and functions needed for safe operation.

Failures of other subsystems of the BESS are not assessed within this document for their direct negative impact on the environment.

5.2 View of the subsystem structure in a BESS and the battery-related failure site

The typical subsystems architecture of a BESS is shown in Figure 1 with the location of the battery highlighted



NOTE The location of the electrochemical accumulation subsystem and its battery are highlighted in the dark grey box.

Figure 1 – Example of a BESS structure

5.3 Classification of BESS types

The BESS types are categorized in Table 1, according to IEC 62933-5-2, into five types based on the specific features of the installed electrochemical storage system, i.e. the installed battery type and its electrolyte.

Table 1 – Classification of BESS types

BESS type designation	Distinguishing design features
C-A	Cell with non-aqueous electrolyte (e.g., Li-ion)
C-B	Cell with aqueous electrolyte (e.g., Pb acid, NiMH)
C-C	Cell with solid electrolyte and operating above 250 °C or defined as HT (high temperature) cell (e.g., NaS, NaNiCl)
C-D	Cell with aqueous but recirculating electrolyte or defined as flow cell (e.g., V5+/V2+)
C-Z	Cell with any other electrochemical couple, electrolyte and energy storage concept or combinations thereof (e.g., Li metal with solid electrolyte, electrochemical double layer capacitors)

The classification of the battery types used in a BESS and listed in Table 1 is subject to evolutions as advances in battery technology bring changes in electrolytes and cell designs.

The attributes of a BESS type designation, based on the installed battery and reported in the environmental impact assessment document, are only informative in nature. They do not release the system integrator and battery manufacturer carrying out the environmental impact assessment of a battery failure according to this document, from considering all features of the battery or flow battery of the BESS at hand.

5.4 Failure of batteries in the electrochemical accumulation subsystem of a BESS

The failure sites in the electrochemical accumulation subsystem in this document are highlighted in Figure 2.

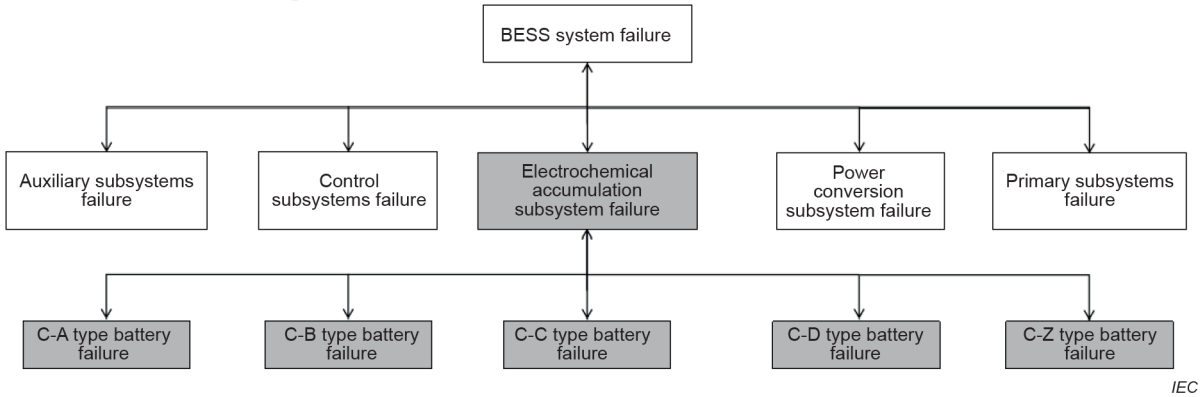


Figure 2 – Failure sites in the electrochemical accumulation subsystem within the scope of this document (highlighted in grey)

6 Guidelines for assessing the environmental impact of a failure of the battery of the electrochemical accumulation subsystem of the BESS

6.1 General

Batteries and flow batteries are equipment containing reactive metals and chemicals and are also sources of uninterruptable flows of electrical energy. These components and effects can be released into the environment in an uncontrolled fashion when the battery or flow battery in the accumulation subsystem fails.

The system integrator of the BESS, therefore, carries out, in collaboration with the electrochemical accumulation subsystem, a systematic assessment of when and how wear-out, ageing, deterioration, damage, non-compliance, environmental factors, flawed operation(s) or outright failure(s) of a constituent of the BESS result in failures of the electrochemical accumulation subsystem with a subsequent impact on the environment.

To ensure a structured assessment of the failures, an overview of the cell designs is presented in Annex D. This is followed in Annex B by an overview of the environmental impacts resulting, upon a failure, from the battery and flow battery materials, their reactions and associated disruptive electric effects.

In 6.2 a structured set of root causes of such failures is presented. These root causes reflect the multiple origins of a failure of the battery or flow battery in a BESS and are applicable to the designs C-A to C-Z, respectively.

6.2 Root causes of battery and flow battery failures resulting in impact on the environment

6.2.1 General

Internal and external causes that can result in a failure of the cell, flow cell, battery or flow battery and possibly have an impact on the environment, are reviewed and enumerated below.

Potential failures are systematically listed below, which are further the result of root causes depicted in Figure 3.

- Performance degradation
  - inability to deliver rated energy (cause 1)
  - inability to accept rated energy (cause 2)
- System degradation
  - failed structural integrity (cause 3)
  - failed system integrity (cause 4)
- Subsystems degradation
  - failed accessory components (cause 5)
  - failed control subsystem (cause 8)
  - failed auxiliary subsystem (cause 9)
- Unexpected inputs from the POC/interface
  - failed environmental controls (cause 6)
  - failed electric integrity (cause 7)
- Unexpected external environment impacts to the system
  - environmental impacts (cause 10)

A schematic view of key proximate (immediate) root causes leading to failures is shown in Figure 3.

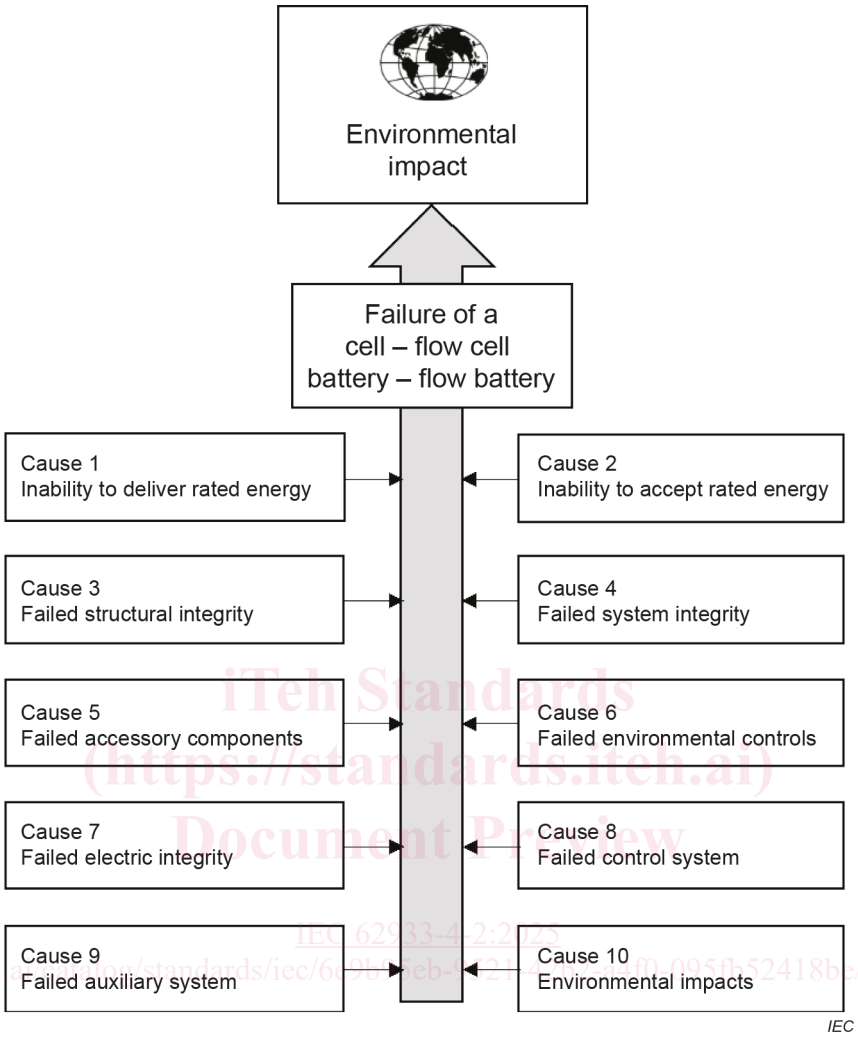


Figure 3 – Proximate root causes leading to a battery or flow battery failure in the BESS with associated environmental impacts

6.2.2 Root causes resulting in battery and flow battery failures

6.2.2.1 General

The assessment of the failures and their environmental impacts shall be carried out on the battery and its layout by the system integrator in collaboration with the battery or flow battery manufacturer. Local regulations can apply and can designate any other entity to perform the assessment.

This assessment shall be made available, in an appropriate format and detail, to the interested parties such as the BESS operator, licensing authorities, environmental protection agencies or other relevant entities for follow-up actions as needed. Local regulations can apply.

The assessment activity starts from the relevant proximate, i.e. close-by root cause(s), and details their resulting impacts on the cells, flow cell, battery and flow battery.

These impacts can lead to their failure resulting in a fault of the BESS.