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Electrical energy storage (EES) systems - Part 5-2: Safety requirements for grid-integrated EES systems - Electrochemical-based systems

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Electrical energy storage (EES) systems - Part 5-2: Safety requirements for grid-integrated EES systems - Electrochemical-based systems

FOREWORD

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IEC 62933-5-2 has been prepared by IEC technical committee 120: Electrical Energy Storage (EES) systems. It is an International Standard.

This second edition cancels and replaces the first edition published in 2020. This edition constitutes a technical revision.

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

a) New BESS categories: This document created new BESS energy categories “E-LI” (integrated within one enclosure), and “E-LS”(separated by two or more enclosures), because the safety measures are different for systems with one enclosure and systems with multiple enclosures.
b) Location risk: This document added information about differences in risk depending on location.

repurposed batteries, a reference to the new standard IEC 629933-5-3 was added.

d) Protection from fire hazards: Based on an analysis of BESS fires occurring around the world, the number of fire propagation measures have been significantly increased.

e) System validation and test: Test methods and criteria have been clarified. In addition, the validation of measures against gas generation and fire spread has been significantly revised.

This International Standard is to be used in conjunction with IEC 62933-5-1:2024.

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

Draft	Report on voting
120/415/FDIS	120/436/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.

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.

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.

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

– reconfirmed,

– withdrawn, or

– revised.

All the electrical energy storage systems (EESS) follow the general safety requirements as described in IEC 62933-5-1, which is based on a system approach. This document follows the same structure as IEC 62933-5-1 and provides additional requirements for electrochemical-based EESS. The additional requirements are provided for the following reasons:

a) Electrochemical-based EESS can be integrated into a significant range of electrical grids.

b) The level of safety requirements awareness can vary between utilities, system integrators, operators and end-users.

c) Although the safety of individual subsystems is generally covered by international standards at ISO and IEC levels, the safety matters that arise due the combination of electrochemical accumulation subsystems and any electrical subsystems are not always considered. Electrochemical-based EESS are complex at the systems level due to the variety of potential battery options and configurations, including the combination of subsystems (e.g. control systems for electrochemical accumulation subsystems, electrochemical accumulation subsystems, power conversion subsystems and auxiliary subsystems). Compliance with standards and related material produced specifically for the safety of subsystems cannot be sufficient to reach an acceptable level of safety for the overall system.

d) Electrochemical-based EESS can have additional safety hazards, due, for example, to the presence of chemicals, the emission of toxic gases, chemicals spilt around the electrochemical accumulation subsystems and to events critical for safety from electrochemical accumulation subsystems that cause safety issues for the entire electrochemical-based EESS. They can cause loss of power at any part of the systems and buildings that can result in additional threats to safety. From a systems perspective, these individual hazards can have a system wide impact.

This part of IEC 62933 primarily describes safety aspects for people and, where appropriate, safety matters related to the surroundings and living beings for grid-connected energy storage systems where an electrochemical storage subsystem is used.

This document is applicable to the entire life cycle of BESS (from design to end of service life management).

This document provides further safety provisions that arise due to the use of an electrochemical storage subsystem (e.g. battery system) in EES systems that are beyond the general safety considerations described in IEC 62933-5-1.

This document specifies the safety requirements of an "electrochemical" energy storage system as a "system" to reduce the risk of harm or damage caused by the hazards of an electrochemical energy storage system due to interactions between the subsystems as presently understood.

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 60068-2-52, *Environmental testing - Part 2-52: Tests - Test Kb: Salt mist, cyclic (sodium chloride solution)*

IEC 60079-7:2015, *Explosive atmospheres - Part 7: Equipment protection by increased safety "e"*
IEC 60079-7:2015/AMD1:2017

IEC 60079-13, *Explosive atmospheres - Part 13: Equipment protection by pressurized room "p" and artificially ventilated room "v"*

IEC 60079-29 (all parts), *Explosive atmospheres - Gas detectors*

IEC 60364 (all parts), *Low-voltage electrical installations*

IEC 60364-4-44, *Low-voltage electrical installations - Part 4-44: Protection for safety - Protection against voltage disturbances and electromagnetic disturbances*

IEC 60364-6:2016, *Low voltage electrical installations - Part 6: Verification*

IEC 60529, *Degrees of protection provided by enclosures (IP Code)*

IEC 60664-1:2020, *Insulation coordination for equipment within low-voltage systems - Part 1: Principles, requirements and tests*

IEC 60812, *Failure modes and effects analysis (FMEA and FMECA)*

IEC 61000-1-2, *Electromagnetic compatibility (EMC) - Part 1-2: General - Methodology for the achievement of functional safety of electrical and electronic systems including equipment with regard to electromagnetic phenomena*

requirements for equipment intended to perform functions in a safety-related system (functional safety) in industrial locations

IEC 61025, *Fault tree analysis (FTA)*

IEC 61660-1, *Short-circuit currents in d.c. auxiliary installations in power plants and substations - Part 1: Calculation of short-circuit currents*

IEC 61660-2, *Short-circuit currents in d.c. auxiliary installations in power plants and substations - Part 2: Calculation of effects*

IEC 61882, *Hazard and operability studies (HAZOP studies) - Application guide*

IEC 61936-1:2021, *Power installations exceeding 1 kV AC and 1,5 kV DC - Part 1: AC*

IEC 62305-2*, Protection against lightning - Part 2: Risk management*

IEC 62368-1, *Audio/video, information and communication technology equipment - Part 1: Safety requirements*

IEC 62477-1:2022, *Safety requirements for power electronic converter systems and equipment - Part 1: General*

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

IEC 62619:2022, *Secondary cells and batteries containing alkaline or other non-acid electrolytes - Safety requirements for secondary lithium cells and batteries, for use in industrial applications*

IEC 62933-1, *Electrical energy storage (EES) systems - Part 1: Vocabulary*

IEC 62933-5-1:2024, *Electrical energy storage (EES) systems - Part 5-1: Safety considerations for grid integrated EES systems - General specification*

IEC 62933-5-3:2023, *Electrical energy storage (EES) systems - Part 5-3: Safety requirements for grid-integrated EES systems - Performing unplanned modification of electrochemical based system*

ISO/IEC 31010, *Risk management - Risk assessment techniques*

ISO/IEC Guide 51:2014, *Safety aspects - Guidelines for their inclusion in standards*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 62933-1, IEC 62933-5-1, and the following 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

IEC 62933-1 prevail, unless otherwise specified here.

3.1
type test
conformity test made on one or more items representative of the production

[SOURCE: IEC 60050-151:2001, 151-16-16]

3.2
routine test
conformity test made on each individual item during or after manufacture

[SOURCE: IEC 60050-151:2001, 151-16-17]

3.3
battery management system
BMS
electronic system associated with a battery which has functions to controlling current in case of overcharge, overcurrent, over discharge, and overheating and which monitors and/or manages its 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 removed.]

3.4
system integrator
manufacturer which integrates the individual subsystem and completes functions properly as a single system

4 Basic guidelines for safety of BESS

4.1 General

An assessment and reduction of risk associated with the BESS as manufactured and as intended to be installed shall be conducted in accordance with the procedure shown in Figure 1.

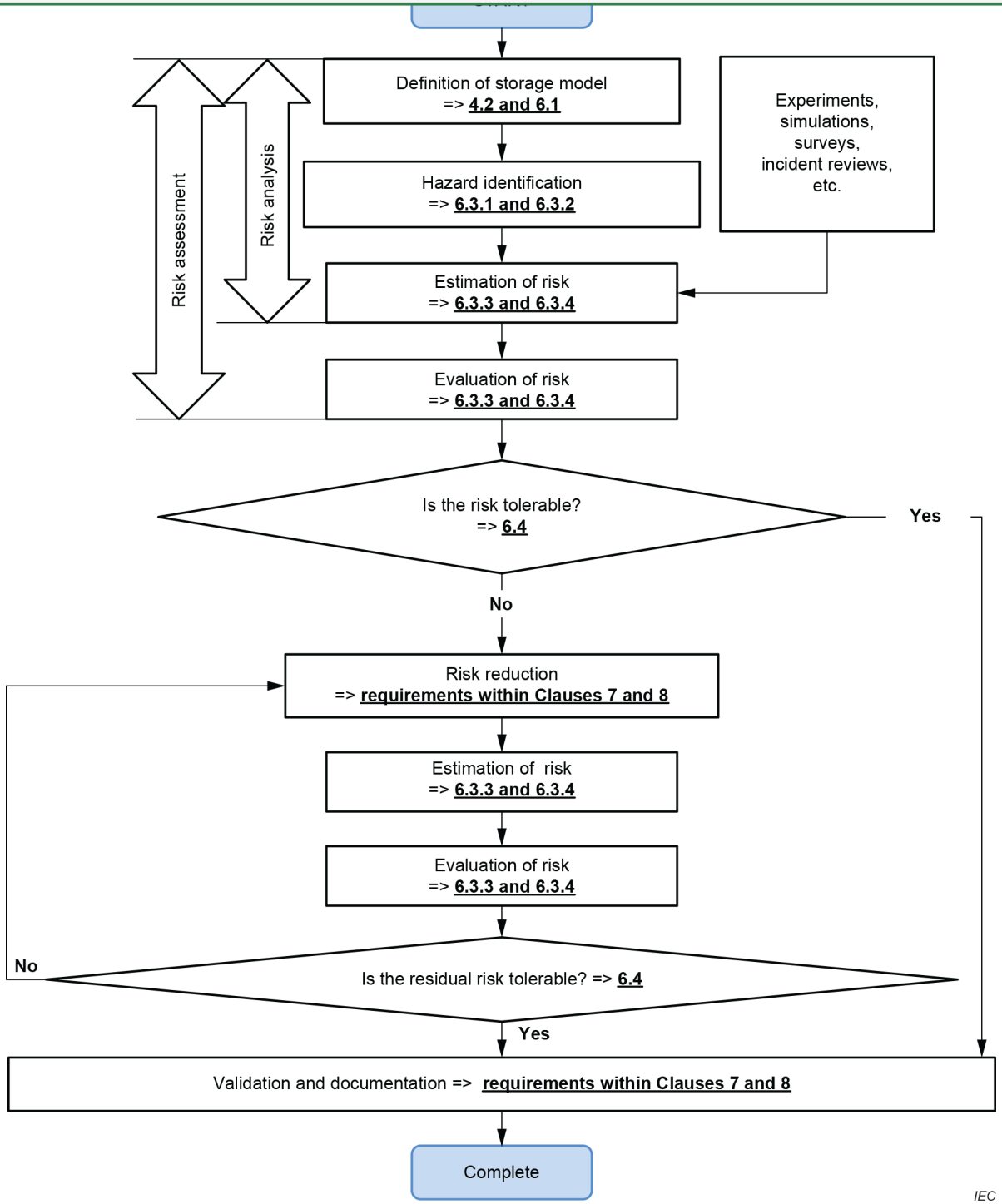

Figure 1 – General procedure for risk assessment and reduction of BESS

Risks can depend on many factors including location, chemistry and the size/scale (e.g. power) of the BESS and shall be assessed accordingly. The location of the BESS can range from single domestic situations, commercial and industrial applications to utility scale systems, and risks shall be assessed accordingly. Selection of chemistry for the electrochemical accumulation subsystem of the BESS can depend on the environment, performance characteristics and any associated costs and benefits.

"inherently safe design", "guards and protective devices", and "information for end users". Additional measures at the use phase (life cycle safety management) are also described in ISO/IEC Guide 51.

4.2 Approach to BESS safety

The design of the BESS and its intended installation and integration within the built environment shall accommodate the specific risks that arise during each phase of the BESS life cycle. These life cycle phases typically include, but are not limited to:

- manufacturing/final assembly and factory acceptance testing (see 7.10, 7.11, and 8.2);
- transport (see 7.10, 7.11, and 8.2);
- installation, commissioning and site acceptance testing (see 7.10, 7.11, 7.12 and 8.2);
- operation (see 7.13);
- maintenance and repair (see 7.13);
- repurposing or decommissioning (see 7.13).

During the installation process, soundness of communication among subsystems, which are critical to minimizing risk and facilitating incident response shall be ensured to avoid any malfunctions of the protection subsystems. After the installation of the BESS, these subsystems shall be verified by inspection or other suitable means so that their proper functions are assured before the BESS is placed into service.

All health, safety and environment (HSE) requirements applicable to the BESS as installed shall be satisfied during system maintenance and repair.

The safety design considerations and risk analysis for each identified life cycle phase shall be documented and supplied in accordance with Clause 6 and 7.13.

A BESS that is designed and constructed to provide a specified level of reliability and durability shall include not only the levels of safety as a design feature of the overall system but also subsystem safety level which is necessary to achieve the specified level. At the subsystem level, all integrated electrochemical energy storage subsystems shall comply with appropriate safety standards (e.g. IEC 62477-1, IEC 62619).

Safety measures for interactions between subsystems shall be consistent with the result of the system level safety risk assessment.

Common BESS point of connection (POC) voltages, energy capacity, site occupancy and chemistry of electrochemical accumulation subsystem are distinguished as listed in Table 1.

Detailed implementation of safety measures required in Clause 7 and Clause 8 can be optimized in accordance with the result of the system risk assessment of BESS (see Clause 6) using the basic conditions in Table 1.

NOTE 1 Chemistries that are not in common widespread use for stationary applications are not considered in this document but can be considered in future editions.

NOTE 2 "Energy capacity" of BESS" means total energy capacity of electrochemical accumulation subsystems which are equipped behind one POC.

Features for categorization	Category denominations	Explanation
"POC voltage" where BESS is connected	V-L	Low: V ≤ 1 kV AC or 1.5 kV DC
	V-H	High: V > 1 kV AC or 1.5 kV DC
"Energy capacity" of BESS	E-S	Small: E ≤ 20 kWh
	E-LI	Large: E > 20 kWh / Integrated within one enclosure
	E-LS	Large: E > 20 kWh / Separated by two or more enclosures
"Site occupancy" in relation to electrochemical accumulation subsystem	S-O	Occupied site (see IEC 62933-1)
	S-U	Unoccupied site (see IEC 62933-1)
"Chemistry" of electrochemical accumulation subsystem	C-A	BESS using non-aqueous electrolyte battery (e.g. alkali ion based)
	C-B	BESS using aqueous electrolyte battery (e.g. Lead acid, Ni-based)
	C-C	BESS using high temperature battery (e.g. NaS, NaNiCl)
	C-D	BESS using flow battery
	C-Z	Others
NOTE 1 Denominations of BESS categorization are described as "V-X / E-X / S-X / C-X" in any requirements of this document (e.g. V-H / /E-LI / S-U / C-C). Some characteristics can be omitted if any limitation of category does not apply. NOTE 2 To apply this document to both BESS and other electrochemical based EESS including chemical based super-capacitors, the latter EESS are included in category "C-Z". NOTE 3 Combinations of two or more electrochemical accumulation chemistries are included in category "C-Z". NOTE 4 Li-based batteries are categorized as C-A, no matter whether those electrolytes are non-aqueous liquids or solid electrolytes (typically referred to as solid state).		

An example of BESS use can be described as shown in Table 2.

Table 2 – Examples of BESS application

Application environment	Site	Access restrictions/conditions during operation and maintenance
Residential	Installed in individual homes or shared by a small number of homes, apartments buildings or villas.	Can be placed in a location that is not accessible for regular maintenance without cooperation of the inhabitants of the home and is not part of a professional operating and maintenance regime.
	An example of using Table 1 in this BESS application environment can be as follows: "V-L / E-S or LI /S-O or U / C-A or B".	
Commercial	Installed in small businesses, shared by a large number of homes, etc., or a mixture of the above uses such as a street or a large apartment building.	Placed in a location that is accessible for regular maintenance during business hours and is usually part of a professional operating and maintenance regime.
	An example of using Table 1 in this BESS application environment can be as follows: "V-H or L / E-LI /S-O or U / C-A, B, C or D".	

environment		
Industrial	Installed in large businesses like factories, data centres, warehouses etc., or shared by a large number of homes, such as a city quarter.	Placed in a location that is accessible for regular maintenance during business hours and is part of a professional operating and maintenance regime.
	An example of using Table 1 in this BESS application environment can be as follows: "V-H / E-LI or E-LS /S-O or U / C-A, B, C or D".	
Utility	Connected directly to the utility grid.	Placed in a location that is continuously accessible for regular maintenance and is part of a professional operating and maintenance regime. The system is typically placed inside a restricted access area, or access to the system itself is restricted to authorized people.
	An example of using Table 1 in this BESS application environment can be as follows: "V-H / E-LS / S-O or U / C-A, B, C or D".	

4.3 BESS changes in ownership, control or use

In all cases where a transfer of ownership or operational responsibility occurs, the monitoring log information should be transferred to the new owner as part of the system documentation, including measures for complying with the requirements in 7.13.2 and 7.13.3. When it is necessary to control identified BESS risks, there should be clarification on the roles and responsibilities for managing and controlling any existing or new safety risks arising out of the changes that are planned or have taken place.

Annex A provides further information regarding ownership of BESS.

5 Hazard considerations

The general hazard considerations for EESS in IEC 62933-5-1:2024, Clause 5, are applicable.

6 BESS system risk assessment

6.1 BESS structure

6.1.1 General characteristics

A storage model of the BESS with clarifying features as shown below shall be created for an appropriate safety risk assessment.

An example of a BESS including a primary POC, auxiliary POC and control subsystem is shown in Figure 2 and Table 2. In some cases, it is possible that one or more subsystems or components are not included. The communication arrangements between management, communication, protection and the other subsystems are shown as dotted arrow lines.

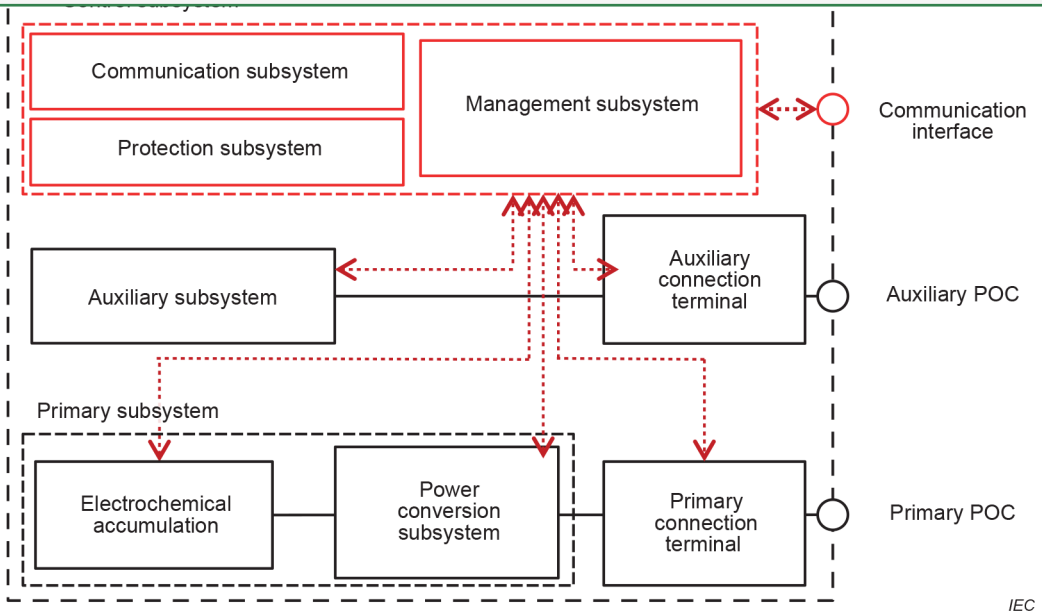

Figure 2 – An example of BESS architecture

NOTE Figure 2 is an example of a typical BESS architecture. There can be cases which do not fit in Figure 2.

Table 3 – Examples of components within subsystems of a BESS

Subsystems	Components
Management subsystem	System controller and/or energy management system
Communication subsystem	Operation panel (human interface), system communication and/or monitoring, meter communication
Protection subsystem	Relays (earth, overcurrent, over voltage, under voltage, over frequency, under frequency, etc.)
Auxiliary subsystem	Fire, heat, and/or smoke detection system(s), fire suppression system, HVAC (heating, ventilation and air conditioning), system anchors, auxiliary transformers, auxiliary power distribution switchgear, auxiliary power uninterruptible power supply (UPS)
Auxiliary connection terminal	Connection terminals, cable (type, fire rating, thermal rating, chemical rating, size and flexibility)
Electrochemical accumulation subsystem	Battery (incl. battery management system), communication devices, protective devices, mechanical fixing, cables, thermal management system NOTE There are many cases where BESS include multiple numbers or types of electrochemical accumulation subsystems
Power conversion subsystem	Transformer, AC/DC converter, inverter, power conditioning system (PCS) controller, switches
Primary connection terminal	Connection terminal, cable (type, thermal rating, chemical rating, size and flexibility)
Others	Room and/or building/enclosure, foundation, water supply, HVAC system of the building, fuses, safety markings