IEC 62933-5-3

Edition 1.0 2023-10

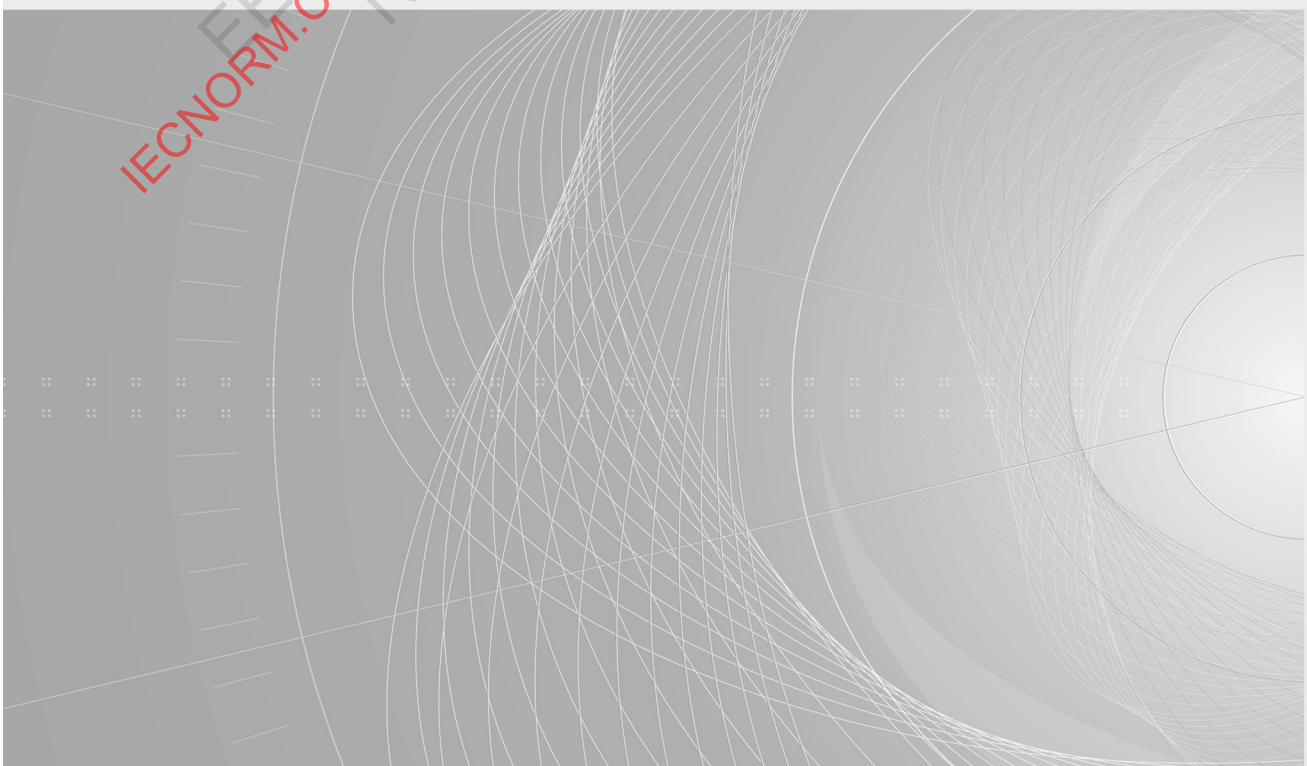
INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

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

Systèmes de stockage de l'énergie électrique (EES) – Partie 5-3: Exigences de sécurité pour les systèmes EES intégrés dans un réseau – Modification non programmée d'un système électrochimique



IEC 62933-5-3:2023-10(en-fr)

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ELECTRICAL ENERGY STORAGE (EES) SYSTEMS –

Part 5-3: Safety requirements for grid-integrated EES systems – Performing unplanned modification of electrochemical based system

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This International Standard is to be used in conjunction with IEC 62933-5-2:2020.

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

Draft	Report on voting
120/331/FDIS	120/335/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 (ESS) 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- withdrawn, or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.

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INTRODUCTION

The initial design or planning cannot cover all modifications that are made to a BESS over its lifetime. Unplanned modifications entail a careful evaluation of their potential impact on the safety of the BESS.

This document provides safety requirements, considerations and procedures when unplanned modifications of the BESS are carried out.

Appropriate attention is given to safety issues in the relative redesign, installation, commissioning, operation and maintenance phases during such modification activities of the BESS.

Unplanned modifications which are dealt with in this document are:

- changes in energy storage capacity;
- changes of chemistries, design and manufacturer of the accumulation subsystem;
- changes of a subsystem component using non-OEM parts;
- changes to the mode of operation;
- changes of the installation site;
- changes in an accumulation subsystem due to an installation of reused or repurposed batteries.

ELECTRICAL ENERGY STORAGE (EES) SYSTEMS –

Part 5-3: Safety requirements for grid-integrated EES systems – Performing unplanned modification of electrochemical based system

1 Scope

This part of IEC 62933 applies to those instances when a BESS undergoes unplanned modifications. Such modifications can involve one or more of the following:

- changes in energy storage capacity;
- changes of chemistries, design and manufacturer of the accumulation subsystem;
- changes of a subsystem component using non-OEM parts,
- changes to the mode of operation,
- changes of the installation site, or
- changes in an accumulation subsystem due to an installation of reused or repurposed batteries.

Any such modification can impair the original state of safety of the BESS.

This document complements IEC 62933-5-2, which relates to the overall safety aspects of a BESS. The requirements covered by this document are applied in addition to the requirements in IEC 62933-5-2 in accordance with each situation.

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 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 62933-2-1:2017, *Electrical energy storage (EES) systems – Part 2-1: Unit parameters and testing methods – General specification*

IEC 62933-5-2:2020, *Electrical energy storage (EES) systems – Part 5-2: Safety requirements for grid-integrated EES systems – Electrochemical-based systems*

IEC 63330[1], *General requirements for repurposing of secondary batteries*

IEC 63338[2], *General guidance on reuse and repurposing of secondary cells and batteries*

[1] Under preparation. Stage at the time of publication: IEC AFDIS 63330:2023.

[2] Under preparation. Stage at the time of publication: IEC CDV 63338:2023.

3 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
battery operating range
range of parameters to ensure the safe use of the accumulation subsystem

Note 1 to entry: Examples of parameters are voltage, current, temperature, SOC, SOE and so on.

3.2
critical stakeholder
stakeholder (IEV 904-01-10) related to the part or component whose modification, installation, or removal affects the safe operation of the BESS

3.3
unplanned modification
modification that has not been intended to be carried out or planned prior to the start of operation of the BESS

Note 1 to entry: IEC 62933-5-2:2020, 7.13.1, “Operation and maintenance” deals with a planned modification.

3.4
OEM part
part supplied to or by an original equipment manufacturer (OEM)

Note 1 to entry: OEM parts are generally used to manufacture new equipment and can also be purchased for maintenance and repair.

Note 2 to entry: A part that is not an OEM part is called “non-OEM part”.

3.5
relocation
<of an EES system> moving of an installation physically from its current location which requires disconnecting from the initial point of connection (POC) and connecting it at new location to another POC

3.6
reused battery
battery that is used again in the same application as it was used for when commissioned the first time

3.7
repurposed battery
battery that is used again in a different application as it was used for when commissioned the first time

3.8
residual usable period
actual or estimated remaining length of service life

3.9
safety margin
<of an EES system> margin defined within the battery operating range considering the system application, environmental conditions and so on for safe operation of the BESS

3.10
safe-operating range
<of an EES system> range excluding the safety margin from the battery operating range

4 General requirements on performing unplanned modifications

The BESS, including the batteries, can be exposed to the following changes in safety conditions during its operation:

1) changes due to changes in the surrounding environment,
2) changes due to unplanned modifications of the BESS,
3) changes due to ageing, and
4) changes due to modifications planned at the time of the initial design.

This document describes the safety measures that shall be taken for BESS in the event of items 1) and 2) above. The events of items 3) and 4) should be considered and addressed at the time of initial design of the BESS, which is under the scope of IEC 62933-5-2.

NOTE 1 The modifications that occur in the BESS can be at the component, subsystem or system level. While the primary focus of this document is on changes in safety and their evaluation at the system level, the process can also require evaluation at the component or subsystem level (e.g., interactions between subsystems).

Figure 1 shows the modifications that affect safety, which are made by the subdivision of changes in item 1) and item 2). This document deals with the modifications shown in the yellow boxes in Figure 1.

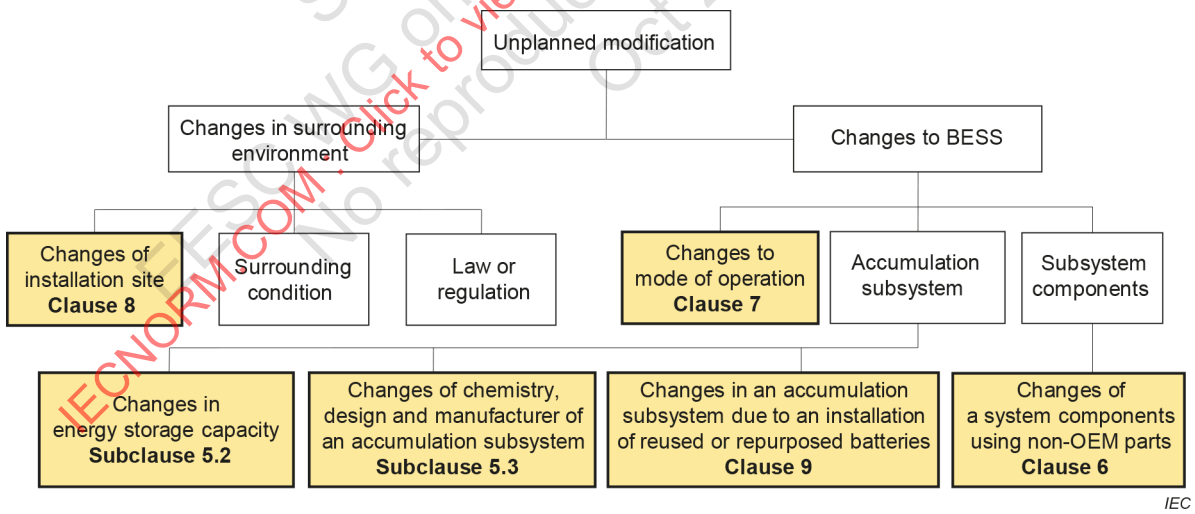


Figure 1 – Major modifications and their classification

An unplanned modification of a BESS can result in conditions where multiple safety related conditions are potentially affected at the same instance.

In such an event, the impact on safety of the individual modifications is to be assessed and all the resulting risk mitigation actions are to be implemented. The detailed requirements of assessment or measures, etc., are described in Clause 5 to Clause 9 of this document.

A wide range of stakeholders are involved in the modification process. Examples of stakeholders are shown in Table 1. The requirements described in this document shall be met as appropriate in cooperation with the stakeholders.

NOTE 2 Responsibility for ensuring the BESS safety depends on each case and local regulations.

Table 1 – Examples of relevant stakeholders

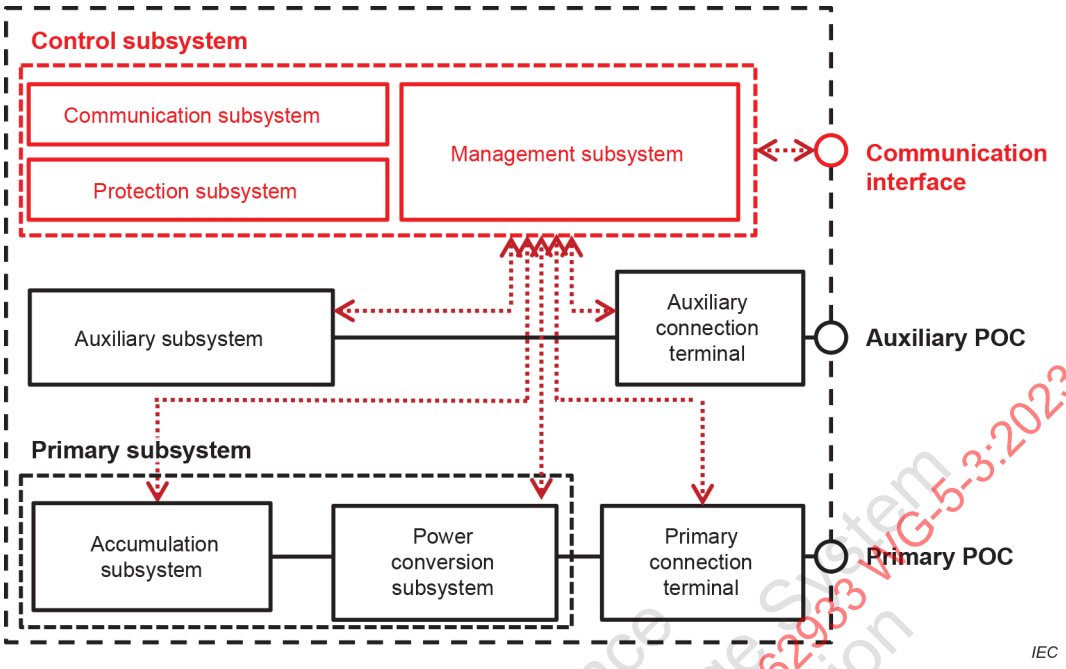
Type of stakeholders	Specific examples of stakeholders
Ownership	Owner
	User
Operation	Operator
	Service provider
Engineering, procurement and construction (EPC)	Project manager and administrator
	Overall system integrator
	Subsystem integrator
	Integrator performing modification *
Component	Component manufacturer
	Component vendor
	Additional component manufacturer *
	Additional component vendor *
Certification body	Certification authority of original parts
	Certification authority of additional parts *
Local	Local government
	Fire-fighting agency
NOTE The stakeholders with "*" marking can be involved in cases where there are modifications with additional parts (e.g. Clause 5, Clause 6 and Clause 9).	

5 Changes to an accumulation subsystem

5.1 General

The intention of Clause 5 is to describe safety requirements, considerations and processes to follow for situations where changes are made to an accumulation subsystem in a BESS.

Clause 5 describes the requirements when an accumulation subsystem (see Figure 2) undergoes unplanned modifications.



NOTE "POC" means "point of connection".

Figure 2 – Example of BESS architecture

The unplanned modifications of the accumulation subsystem described in Clause 5 are:

- changes in energy storage capacity;
- changes of chemistry and design of an accumulation subsystem.

5.2 Changes in energy storage capacity

5.2.1 General

Subclause 5.2 specifies the safety requirements, considerations and processes for situations where the energy storage capacity of the electrochemical accumulation subsystem is changed.

The energy storage capacity of the BESS can be modified when batteries are removed due to their failures or added to meet a higher energy demand or a modified operating mode.

NOTE "Energy storage capacity of the BESS" means the total energy capacity of electrochemical accumulation subsystems.

Such changes modify the voltage versus time profile during discharge and charge and possibly bring the batteries to voltage, temperature and SOC values that were not originally planned.

This can mean that the existing safety measures become inadequate and the safety of the BESS can be impaired.

The possible negative consequences of capacity changes are:

a) dielectric breakdowns and loss of the electrical insulation levels resulting in dangerous voltages on operator-accessible surfaces;

b) electric shock risks arising from changes causing malfunction of protective measures and devices;

c) increases of the fire load level necessitating adjustment of firefighting measures and their capabilities;

d) increases in the amount of thermal energy released by the accumulation subsystem to be handled by the heat, ventilation and air conditioning (HVAC);

e) increases of the quantity of chemicals to be handled in an emergency;

f) voltage and capacity imbalances between aged and new batteries causing accelerated ageing;

g) management/control subsystem errors when the batteries that are added to increase capacity have different operating conditions and are installed in the same management/control section as existing batteries;

h) increases in the occurrence of operator and maintenance personnel mistakes;

i) decreases in available space for operator and maintenance engineer to do work properly.

The risk assessment shall be done in accordance with IEC 62933-5-2 in the first stage of planning and before any other work, and the necessary corrective measures concerning hardware and software shall be undertaken in accordance with the assessment results.

5.2.2 Safety requirements in the redesign phase

In order to maintain the safety level of the BESS, the following actions are required in the redesign phase:

- The safety level of the capacity-modified BESS shall not be less than that present prior to the modification.
- If the change of capacity results in a change of the BESS category as defined in IEC 62933-5-2:2020, Table 1, then the appropriate safety measures shall be implemented in the modified BESS.
- The suppliers of the existing BESS shall approve in writing the capacity modification.
- The general safety protection systems (e.g. deflagration protection, ventilation subsystem) of the BESS shall be updated to reflect the capacity modification.

In cases where it is difficult to modify or add safety measures to an existing BESS due to space or other restrictions, the following reinforcement of risk reduction measures shall be undertaken:

Inherently safe design: Set the conditions and parameters sufficiently to ensure the safety of the accumulation subsystem. For example, narrow the SOC range or the operation temperature range, etc.

Guards and protection: If the prevention of fire propagation at the accumulation subsystem level cannot be ensured, add a protection measure against fire propagation (e.g. fireproof boards or walls) to prevent fire propagation at the cubicle, building, or container levels.

Information for use: Use on-site labels to distinguish between the added accumulation subsystem and existing one. Set warning devices (audible alerts, visible signals) and remote alerts to distinguish between the added one and the existing one so that prompt and accurate responses can be made in the event of trouble.

5.2.3 Safety requirements in the installation and commissioning phase

The modification of the capacity of the BESS entails access, by installation personnel, to components carrying dangerous voltages or containing toxic compounds.

In order to maintain the safety of the BESS and workers, the following actions are required in the installation and commissioning phase:

- The necessary safety measures for the workers shall be defined prior to the commencement of work.
- All activities shall be assessed in advance for the risk due to live electrical parts that cannot be adequately protected, and shall comply with live electrical work standards.

- All procedures shall be reviewed to ensure that all activities are carried out in an appropriate way considering the result of risk assessment, especially from the perspective of work on live power sources and toxic chemicals. Local regulations can apply.
- All procedures shall be reviewed to ensure that only qualified personnel with an established chain of command and open communication channels to the BESS operator carry out the work.

If the capacity modification is carried out without powering down the BESS, then all safety measures listed below are required.

- The battery string to be modified or added shall stay disconnected from any live circuit until completion of the modification.
- The battery string to be modified shall be broken down in sub-units so that each sub-unit does not carry dangerous voltage.

  NOTE The definition of "dangerous voltages" depends on local regulations.

- Appropriate protective measures shall be provided with for workers.

During installation, the following measures shall be taken:

- The BESS shall be powered down and all components carrying dangerous voltage shall be fully insulated to the appropriate IP and insulation class level.
- The enclosure of the BESS, where the modification work is carried out, shall be free from any toxic liquid, vapor and gas and well ventilated during any presence of installation personnel.
- Personal protection equipment (PPE) for protection against hazards in the BESS shall be made available to the involved personnel.
- The inspection of the correct connection and placement of sensing and monitoring devices and also of cooling and ventilation air channels of the BESS shall be carried out in accordance with an installation checklist prior to the reactivation.
- The BESS control software shall be verified that it implements the parameters related to the capacity modifications.

5.2.4 Safety requirements for the operation and maintenance

The modification of the capacity of the BESS entails a modification of operating conditions, operating procedures and maintenance activities.

- Prior to the restart of operation and to minimize risks, the following items of the capacity-modified BESS and associated operating procedures shall be verified and documented:
  - operation plan (including service life),
  - operating conditions,
  - monitored items (including parts, subsystem and whole system level),
  - inspected items (including parts, subsystem and whole system level),
  - education and training,
  - emergency procedure training, and
  - all hardware and software changes carried out including their sources and specifications.
- The documentations shall be reviewed by the critical stakeholders of the BESS and formally approved.
- The revised operation and maintenance instruction document, with a clear identification of its version and validity, shall be distributed to all stakeholders and the expired version recalled.

5.3 Changes of chemistries, design and manufacturer of an accumulation subsystem

5.3.1 General

Subclause 5.3.1 specifies the safety requirements, considerations and processes when the chemistry and design of the electrochemical accumulation subsystem in BESS are changed.

Over its lifetime, a BESS and its batteries can be modified by replacement with or addition of accumulation subsystems whose chemical and electrochemical make-up and design differ from the existing ones.

If carried out without adequate precautions, such changes in the electrochemical energy storage system can significantly impair the safety of the modified BESS.

The addition of or replacement with a different battery chemistry can involve a change in category "C".

The definition of "different battery chemistry" does not always depend on the definition in the category "C" of IEC 62933-5-2. There are often multiple chemistries within a particular category that can impact the BESS when mixed during a modification even though still falling within the same category. Examples of different batteries chemistry modifications that do or do-not impact their categorization are shown in Table 2.

Table 2 – Examples of different batteries chemistry modifications and their categorization

Case No.	Detail	Change of category "C"
Case 1	Replacement of a part of the accumulation subsystem, which is composed of Mn-based lithium-ion batteries with NMC (nickel-manganese-cobalt) lithium-ion batteries	No change in category "C" (Remains in category "C-A")
Case 2	Replacement with a battery whose model number has changed due to discontinuation	No change in category "C"
Case 3	Addition to an accumulation subsystem of a category "C-B" to a category "C-A" BESS	Change from category "C-A" to category "C-Z"

The multiplication of designs and chemistries of the accumulation subsystem present in a BESS results in a related increase in failure scenarios and hence the necessity for implementing multiple safety measures in parallel.

The possible negative consequences of installing an electrochemical accumulation subsystem which has a different chemistry or design, or both, from the existing one are:

a) electric shock risks arising from malfunctions of protective measures and devices caused by incompatibilities of new and existing accumulation subsystem;
b) a change of the fire load level necessitating adjustment of firefighting measures and their capabilities;
c) a change of the amount of thermal energy released by the accumulation subsystem to be handled by heat, ventilation and air conditioning (HVAC);
d) a change of the chemicals and their quantity to be handled in an emergency;
e) management/control subsystem errors when the batteries that are added to increase capacity have different specifications and are installed in the same management/control section as existing batteries;
f) increase in the occurrence of operator and maintenance personnel mistakes; and
g) decrease in available space for operator and maintenance engineer to do work properly.

The risk assessment shall be done in accordance with IEC 62933-5-2 in the first stage of planning and before any other work, and the necessary corrective measures concerning hardware and software shall be undertaken in accordance with the assessment results.

5.3.2 Safety requirements in the redesign phase

In order to maintain the safety level of the BESS, the following actions are required in the redesign phase:

- The safety level of the chemistry and design of the accumulation subsystem's modified BESS shall not be less than that present prior to the modification.
- If the change of chemistry and design of the accumulation subsystem results in a change of the BESS category as defined in IEC 62933-5-2:2020, Table 1, then the appropriate mandated safety measures shall be implemented in the modified BESS.
- The suppliers of the existing BESS shall confirm the modification of the chemistry and design of the accumulation subsystem in the BESS and make a judgement on whether the modification can be performed. The modification shall not be performed unless the suppliers approve the implementation of the modification from a safety perspective.
- When installing accumulation subsystems which have a different chemistry category "C" from the existing one, the section where the accumulation subsystem is installed shall be operated separately with its own and independent control and auxiliary subsystem.
- The general safety protection systems (e.g., deflagration protection, ventilation subsystem) of the BESS shall be updated to reflect the presence of a new chemistry and design of the accumulation subsystem.

Where it is difficult to modify or add safety measures to an existing BESS due to installation space or other restrictions, the following additional risk reduction measures shall be implemented:

Inherently safe design: Set the conditions and parameters sufficiently to ensure the safety of the accumulation subsystem. For example, narrow the SOC range or the operational temperature range, etc.

Guards and protection: If the prevention of fire propagation at the accumulation subsystem level cannot be ensured, add a protection measure against fire propagation (e.g. fireproof boards or walls) to prevent fire propagation at the cubicle, building, or container levels.

Information for use: Use on-site labels to distinguish between the added accumulation subsystem and the existing one. Set warning devices (audible alerts, visible signals) and remote alerts to distinguish between the added one and the existing one so that prompt and accurate responses can be made in the event of trouble.

5.3.3 Safety requirements in the installation and commissioning phase

The modification of the chemistry and design of the accumulation subsystem in the BESS entails access by installation personnel, to components carrying dangerous voltage or containing toxic compounds.

In order to maintain the safety of both the BESS and workers, the following actions are required in the installation and commissioning phase:

- The necessary safety measures for the workers shall be defined prior to the commencement of work.
- All activities shall be assessed in advance for the risk due to live electrical parts that cannot be adequately protected, and be made in compliance with the standards related to live electrical work.
- All procedures shall be reviewed to ensure that all activities are carried out in an appropriate way considering the result of risk assessment, especially from the perspective of work on live power sources and toxic chemicals. Local regulations can apply.

- All procedures shall be reviewed to ensure that only qualified personnel with an established chain of command and open communication channels to the BESS operator carry out the work.

If the modification is carried out without powering down the BESS, then all safety measures listed below are required.

- The battery string to be modified or added shall stay disconnected from any live circuit until completion of the modification.
- The battery string to be modified shall be broken down into sub-units so that each sub-unit does not carry dangerous voltages.

NOTE The definition of “dangerous voltages” depends on local regulations.

- Appropriate protective measures shall be provided with for workers.

During installation, the following measures shall be taken:

- The BESS shall be powered down and all components carrying dangerous voltages shall be fully insulated to the appropriate IP and insulation class level.
- The enclosure of the BESS, where the modification work is carried out, shall be free from any toxic liquid, vapor and gas and well ventilated during any presence of installation personnel.
- Personal protection equipment (PPE) for protection against hazards in the BESS shall be made available to the involved personnel.
- The inspection of the correct connection and placement of sensing and monitoring devices as well as cooling and ventilation air channels of the BESS shall be carried out in accordance with an installation checklist prior to the reactivation.
- The BESS control software shall be verified that it implements the parameters related to the modification of the chemistry and design of the accumulation subsystem.

5.3.4 Safety requirements for the operation and maintenance

The modification of the chemistry and design of the accumulation subsystem’s modified BESS entails a modification of operating conditions, operating procedures and maintenance activities.

- Prior to the restart of operation and to minimize risks, the following items of the chemistry and design of the accumulation subsystem’s modified BESS and associated operating procedures shall be verified and documented:
  - operation plan (including service life),
  - operating conditions,
  - monitored items (including parts, subsystem and whole system level),
  - inspected items (including parts, subsystem and whole system level),
  - education and training,
  - emergency procedure, and
  - all hardware and software changes carried out including their sources and specifications.
- The documentations shall be reviewed by the critical stakeholders of the BESS and formally approved.
- The revised operation and maintenance instruction document, with a clear identification of its version and validity, shall be distributed to all stakeholders and the expired version recalled.

6 Changes of a system component using non-OEM parts

6.1 General

Clause 6 specifies the safety requirements, considerations and processes when components of the BESS are changed or modified thought the use non-OEM parts.

Over its service life, a BESS can require repairs, replacements or modifications to parts and components.

Such changes can occur with both OEM parts and non-OEM parts whose specifications and performance differ from that originally specified and installed in the BESS.

The replacement of safety critical components implemented with non-OEM parts can significantly impair the safety of the modified BESS if carried out without adequate precautions.

The possible negative consequences of replacement or modification using non-OEM parts are:

a) electric shock risks arising from changes causing malfunction of the protective measures and devices;
b) damage of subsystem or parts caused by specification mismatch;
c) excessive heat generation caused by specification mismatch; and
d) increase in the occurrence of operator and maintenance personnel mistakes.

When safety relevant BESS components are replaced with non-OEM parts, a confirmation of compatibility is important.

Examples of safety relevant subsystems and components are shown in Table 3.

Table 3 – Examples of subsystem and safety relevant components

Subsystems	Components
Management subsystem	System controller or energy management, or both Archival data storage
Communication subsystem	Communication and monitoring system Archival data storage
Protection subsystem	Access control and intrusion warning system
Auxiliary subsystem	Fire and smoke detection Fire suppression and extinguishing system
Power conversion subsystem	Converter and control logic
Others	HVAC system Fuses Personal protective equipment (PPE)

The following shall be confirmed to judge whether the non-OEM parts have enough conformity with the BESS in advance of deployment:

- specification of the BESS,
- operating conditions, and
- characteristics of the accumulation subsystem.

The risk assessment shall be done in accordance with IEC 62933-5-2 in the first stage of planning and before any other work, and the necessary corrective measures concerning hardware and software shall be undertaken in accordance with the assessment results.

6.2 Safety requirements in the redesign phase

In order to maintain the safety level of the BESS, the following actions are required in the redesign phase:

- The safety level of the BESS that is modified with non-OEM parts shall not be less than that present prior to the modification.
- If the original OEM parts are not available, the suppliers of the existing BESS shall approve in writing the use of non-OEM parts in the BESS.
- The general safety protection systems (e.g., deflagration protection, ventilation subsystem) of the BESS shall be updated to reflect the presence of non-OEM parts.
- In the sourcing process for non-OEM parts, preference should be given to companies that have a documented quality control and certification system and parts traceability.

6.3 Safety requirements in the installation and commissioning phase

The modification of BESS with non-OEM parts entails access, by installation personnel, to critical components carrying dangerous voltages.

In order to maintain the safety of the BESS and workers, the following actions are required in the installation and commissioning phase:

- The necessary safety measures for the workers shall be defined prior to the commencement of work.
- All activities shall be assessed in advance for the risk due to live electrical parts that cannot be adequately protected, and be made in compliance with the standards related to live electrical work.
- All procedures shall be reviewed to ensure that all activities are carried out in an appropriate way considering the result of risk assessment., especially from the perspective of work on live power sources. Local regulations can apply.
- All procedures shall be reviewed to ensure that only qualified personnel with an established chain of command and open communication channels to the BESS operator carry out the work.

When the modification is carried out without powering down the BESS, then all safety measures listed below are required:

- The component to be installed or exchanged shall stay disconnected from any live circuit until completion of the modification.
- The site or circuit where the modification is carried out shall be placed in a state that does not carry dangerous voltages.

  NOTE The definition of “dangerous voltages” depends on local regulations.

- Appropriate protective measures shall be provided with for workers.

During installation, the following measures shall be taken:

- The BESS shall be powered down and all components carrying dangerous voltages shall be fully insulated to the appropriate IP and insulation class level.
- When workers are present, the enclosure of the BESS, where the modification work is carried out, shall be free from any toxic liquid, vapor and gas and well ventilated.
- Personal protection equipment (PPE) for protection against hazards in the BESS shall be made available to the involved personnel.

- Prior to the reactivation, an inspection of the correct connection and placement of sensing and monitoring devices as well as cooling and ventilation air channels of the BESS shall be carried out in accordance with an installation checklist.
- The BESS control software shall be verified that it implements the parameters related to considering the presence of non-OEM parts.
- The conformity of non-OEM parts to the BESS shall be verified by the critical stakeholders.

6.4 Safety requirements for the operation and maintenance

The modification of the BESS with non-OEM parts involves a change to the operating conditions, operating procedures and maintenance activities.

- Prior to the restart of operation and to minimize risks, the following items of the modified BESS and associated operating procedures shall be verified and documented:
  - operation plan (including service life),
  - operating conditions,
  - monitored items (including parts, subsystem and whole system level),
  - inspected items (including parts, subsystem and whole system level),
  - education and training,
  - emergency procedure, and
  - all hardware and software changes carried out including their sources and specifications.
- The documentations shall be reviewed by the critical stakeholders of the BESS and formally approved.
- The revised operation and maintenance instruction document, with a clear identification of its version and validity, shall be distributed to all stakeholders and the expired version recalled.

7 Changes to mode of operation

7.1 General

Clause 7 specifies the safety requirements, considerations and processes when the operating mode of a BESS is changed.

The operation of an installed BESS can be modified, for example, by increasing the energy exchange levels and rates or widening the operating temperature window.

Such changes of operating mode can be implemented via changes in the control software of the BESS.

Such changes, which can be achieved with relative ease, can result in increased safety risks to the BESS that are overlooked.

If the BESS is used for an application that is unplanned in the initial design, the protection and countermeasures provided in the BESS can be inadequate.

This can mean that the existing safety measures are not adequate and the safety of the BESS can be impaired.

The possible negative consequences of changes to the operating mode are:

a) electric shock risks arising from malfunctions of protective measures and devices caused by the changes;

b) an increase of the fire load level necessitating adjustment of firefighting measures and their capabilities; and

c) an increase of the occurrence of operator and maintenance personnel mistakes.

The risk assessment shall be done in accordance with IEC 62933-5-2 in the first stage of planning and before any other work, and the necessary corrective measures concerning hardware and software shall be undertaken in accordance with the assessment results.

NOTE Clause 7 applies only to those cases where the changes to the mode of operation were not already planned nor embedded in the operating plan and software of the BESS.

7.2 Safety requirements in the redesign phase

In order to maintain the safety level of the BESS, the following actions are required in the redesign phase:

- The safety level of the BESS with modified operating mode shall not be degraded compared to that present prior to the modification.
- The intended future operational limits shall be analysed for their impact on safety, based on existing design and control measures and maintenance procedures.
- Software updates and algorithms shall be verified by simulation.
- The suppliers of the existing BESS shall approve in writing the modified operating mode of the BESS.
- The general safety protection systems (e.g., deflagration protection, ventilation subsystem) of the BESS shall be updated to reflect the modified operating mode. When changes are made, the following risk reduction measures shall be implemented:

  Inherently safe design: Review the operational temperature range when changing the SOC range or charge/discharge rate of the accumulation subsystem. When the operational temperature range is changed, a review of the SOC range and charge/discharge rate shall be conducted.

  Guards and protection: Review the operation of heat, ventilation and air conditioning (HVAC) systems, etc., to ensure that an appropriate temperature environment is maintained when heat generation from transducers/transformers, auxiliary equipment, and conductors/terminals is anticipated. Ensure that the voltage/current sensor and the current fuse or overcurrent protection are equipped when the SOC range or charge/discharge rate are modified.

  Information for use: Changes shall be made known to all critical stakeholders. The history and considerations related to the change shall be kept in writing and in chronological order. Troubleshooting of software installation interruptions and errors shall be conducted and the results shall be documented, stored and shared with critical stakeholders.

7.3 Safety requirements in the installation and commissioning phase

The modification of the BESS operating mode entails access, by installation personnel, to critical components of the IT infrastructure.

In order to maintain the safety of the BESS and workers, the following actions are required in the installation and commissioning phase:

- The necessary safety measures for the workers shall be defined prior to the commencement of work.
- All activities shall be assessed in advance for the risk due to live electrical parts that cannot be adequately protected, and be made in compliance with the standards related to live electrical work.
- All procedures shall be reviewed to ensure that all activities are carried out in an appropriate way considering the result of risk assessment, especially from the perspective of work on live power sources and IT infrastructure and its maintenance. Local regulations can apply.

- All procedures shall be reviewed to ensure that only qualified personnel with an established chain of command and open communication channels to the BESS operator carry out the work.

When the operating mode modification is carried out without powering down the BESS, then all safety measures listed below are required.

- The battery strings shall stay disconnected from each other until completion of the modification.
- The sub-unit in which the modification is to be made shall be shut down and electrically disconnected from the other units and equipment. No one other than the worker shall approach the sub-unit until the completion of both the modification and the verification process.
- Appropriate protective measures shall be provided with for workers.

During installation, particular attention is required as follows:

- The BESS shall be powered down and all components carrying dangerous voltages shall be fully insulated to the appropriate IP and insulation class level.
- Personal protection equipment (PPE) for protection against hazards in the BESS shall be made available to the involved personnel.
- The inspection of the correct upload of the values of the new operating mode of the BESS shall be carried out prior to the reactivation.
- The correct and adequate modification of ancillary equipment impacted by the change of the operating mode shall be verified in accordance with a checklist prior to the reactivation of the BESS.
- Operation conditions (e.g. electrical, thermal energy released) should be confirmed by simulation.

7.4 Safety requirements for the operation and maintenance

The modification of the BESS operating modes entails a modification of operating conditions, operating procedures and maintenance activities.

- Prior to the restart of operation and to minimize risks, the following items of the modified BESS and associated operating procedures shall be verified and documented:
  - operation plan (including service life),
  - operating conditions,
  - monitored items (including parts, subsystem and whole system level),
  - inspected items (including parts, subsystem and whole system level),
  - education and training,
  - emergency procedure, and
  - all hardware and software changes carried out including their sources and specifications.
- The documentations shall be reviewed by the critical stakeholders of the BESS and formally approved.
- The revised operation and maintenance instruction document, with a clear identification of its version and validity, shall be distributed to all stakeholders and the expired version recalled.

8 Changes of installation site

8.1 General

Clause 8 specifies the safety requirements, considerations and processes when the BESS is relocated and installed at a new site.

A BESS can be relocated and installed at a new site following changes in usage patterns.

Such changes of installation site can involve significant transport activity, a major reshuffling of hardware and an exposure to changed environmental conditions such as temperature, humidity, air pressure, airborne salinity levels, geological disturbances and earthquakes.

The BESS can be also moved from an outdoor to an indoor location or vice versa with associated changes to the impact on the surrounding population.

This can mean that the existing safety measures are not adequate and the safety of the BESS can be impaired.

The possible negative consequences of changes of the installation site are:

a) electric shock risks due to misconnection during relocation work;

b) an increase of the amount of thermal energy to be handled by the heat, ventilation and air conditioning (HVAC) due to environmental temperature change;

c) delay of the arrival of service and fire-fighting crews and their equipment due to failure to provide information on access to new site of BESS; and

d) an increase of the occurrence of operator and maintenance personnel mistakes.

The risk assessment shall be done in accordance with IEC 62933-5-2 in the first stage of planning and before any other work, and the necessary corrective measures concerning hardware and software shall be undertaken in accordance with the assessment results.

Appropriate regulations on the transport of dangerous goods should be taken into account (e.g. UN Recommendations on the Transport of Dangerous Goods - Model Regulations, and Manual of Tests and Criteria).

8.2 Safety requirements in the redesign phase

In order to maintain the safety level of the BESS, the following actions are required in the redesign phase:

- The safety level of the relocated and reinstalled BESS shall not be less than that present prior to the site change.
- The following issues shall be reviewed in preparation of the relocation and reinstallation activity:
  - physical and environmental conditions of the reinstallation site,
  - logistics of the transport to the new installation site in terms of electrical, chemical, environmental and human constraints,
  - dismantling procedures of the existing BESS,
  - reuse of existing BESS components,
  - reassembly procedures of the BESS at the new site,
  - additional protection measures or their modification as required by the environment at the new location,
  - application for an operating license from local authorities as required, and
  - training of personnel at the new site.

8.3 Safety requirements in the installation and commissioning phase

The relocation and reinstallation of a BESS can entail access, by installation personnel, to critical features and components carrying dangerous voltages or containing toxic compounds.

In order to maintain the safety of the BESS and workers, the following actions are required in the installation and commissioning phase:

- The necessary safety measures for the workers shall be defined prior to the commencement of any work.
- All activities shall be assessed in advance for the risk due to live electrical parts that cannot be adequately protected, and be made in compliance with the standards related to live electrical work.
- All procedures shall be reviewed to ensure that all activities are carried out in an appropriate way considering result of risk assessment, especially from the perspective of work on live power sources and toxic chemicals. Local regulations can apply.
- All procedures shall be reviewed to ensure that only qualified personnel with an established chain of command and open communication channels to the BESS operator carry out the work.
- The component to be re-installed shall stay disconnected from any live circuit until completion of the installation.
- All components shall be placed in such a state that they do not carry dangerous voltages.

  NOTE The definition of “dangerous voltages” depends on local regulations.
- The operators shall have completed the necessary education and training.
- Appropriate protective measures shall be provided with for workers.
- The information for disaster response and the safety of responding firefighters shall be provided to local fire-fighting agencies.

During transportation, particular attention is required as follows:

- The BESS shall be protected not to be damaged based on the measures and information provided by BESS manufacturer.

During temporary storage, the following measures shall be taken:

- The BESS and its components shall be protected so that they are not damaged due to water, temperature, airborne salt, human errors and similar.
- Additional external protection, monitoring, and protective measures shall be taken during temporary storage to prevent electrical discharge, chemical spills or gas emission.
- A loss of operational history data stored in the BMS (battery management system) due to loss of power to the data storage devices shall be prevented.

During installation, the following measures shall be taken:

- The BESS shall be powered down and all components carrying dangerous voltages shall be fully insulated to the appropriate IP and insulation class level.
- The enclosure of the BESS, where the installation work is carried out, shall be free from any toxic liquid, vapor and gas, and well ventilated during any presence of installation personnel.
- Personal protection equipment (PPE) for protection against hazards in the BESS shall be verified so that necessary update is done in accordance with the conditions at the new location, and be made available to the involved personnel.
- Prior to the reactivation, an inspection of the correct connection and placement of sensing and monitoring devices as well as cooling and ventilation air channels of the BESS shall be carried out in accordance with an installation checklist.

- The BESS control software shall be verified that it implements the parameters considering the conditions at the new location.

8.4 Safety requirements for the operation and maintenance

The reinstallation of the BESS entails a modification of operating conditions, operating procedures and maintenance activities.

- Prior to the restart of operation and to minimize risks, the following items of the reinstalled BESS and associated operating procedures shall be verified and documented:
  - operation plan (including service life),
  - operating conditions,
  - monitored items (including parts, subsystem and whole system level),
  - inspected items (including parts, subsystem and whole system level),
  - education and training,
  - emergency procedure, and
  - all hardware and software changes carried out including their sources and specifications.
- The documentations shall be reviewed by the critical stakeholders of the BESS and formally approved.
- The revised operation and maintenance instruction document, with a clear identification of its version and validity, shall be distributed to all stakeholders and the expired version recalled.

9 Changes in an accumulation subsystem due to an installation of reused or repurposed batteries

9.1 General

Clause 9 specifies the safety requirements, considerations and processes when reused or repurposed batteries are installed in the accumulation subsystem of the BESS.

Batteries of the BESS can be derived from installations or systems where they have been operated in specific applications for sizable periods of time.

When the batteries of these installations and systems reach the end of their service life, their energy exchange capabilities and residual usable period can however still be adequate for their reuse or repurpose, for example in a BESS.

The reuse or repurpose of such batteries can cause increased safety risks in a BESS due to their unknown or uncertain SOH when arriving from the original usage. Adequate steps for the selection of batteries, their characterization, system design, monitoring and operation can be necessary as measures against the risk increasing due to the possibility that an accumulation subsystem with reused or repurposed batteries cannot have the same sufficient safety margin as when using new batteries.

The possible negative consequences of installing a reused or repurposed battery into an accumulation subsystem of a BESS are:

a) electric shock risks arising from improper protective features and devices caused by not taking into account the ageing of accumulation subsystem including enclosure and related protection measures;

b) fire risk and load level necessitating adjustment of the firefighting features and their capabilities, considering the ageing of batteries;

c) fire and explosion risks due to the venting of flammable gases caused by decomposition of the electrolyte;

d) the amount of thermal energy to be handled by the heat, ventilation and air conditioning (HVAC) that shall be addressed differently than when new batteries are used, due to ageing; and

e) the possibility of chemical spillage due to the deterioration of the pack or any other enclosure.

The risk assessment shall be done in accordance with IEC 62933-5-2 in the first stage of planning and before any other work, and the necessary corrective measures concerning hardware and software shall be undertaken in accordance with the assessment results.

9.2 Safety requirements in the design phase

9.2.1 General

In order to preserve the safety level of the BESS, case-specific preventive activities are to be carried out when reused or repurposed batteries are installed into the accumulation subsystem in the BESS.

This activity can concern an existing BESS to which reused or repurposed batteries are added or a newly planned BESS.

The intention of 9.2 is to describe the requirements for the activities in the designing phase of the BESS using reused or repurposed batteries.

9.2.2 Validation of history data

The key for achieving a safe BESS with reused or repurposed batteries is an exhaustive collection and analysis of the battery design and usage data accumulated from its original use stage.

When reused or repurposed batteries are installed in a BESS, the original design and use data of the reused or repurposed batteries shall be kept until the end of the system life cycle, shown in Figure 3.

The data shall be kept and transferred from the original use stakeholders to be used for designing the BESS, in order to estimate the residual usable period of the battery, or deciding any other safety issues.

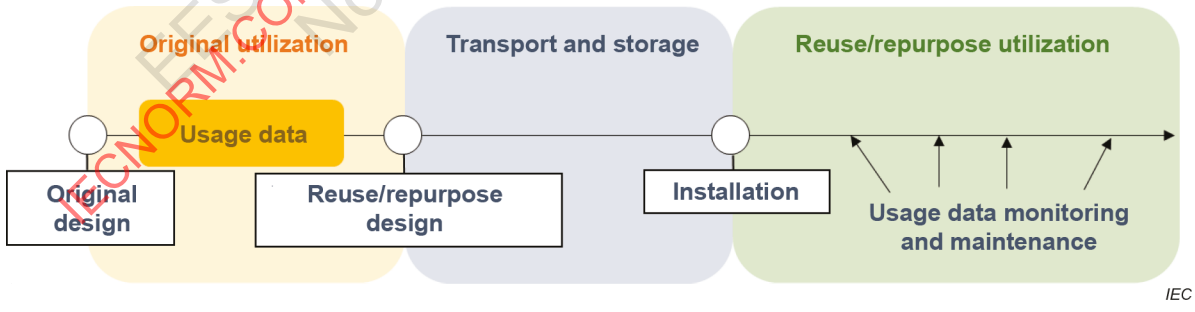


Figure 3 – Life cycle of reused or repurposed battery

The accumulation subsystem including its use data shall be designed and validated in accordance with the requirements of IEC 63330 and IEC 63338.

The following items of the accumulation subsystem using reused or repurposed batteries shall be available for the evaluation of their safety in the planning phase of the new BESS. The history shall cover in principle the entire period from the manufacturing of the device to this planning and design phase:

- OEM company information,
- manufacturing conditions used (related to BESS safety),
- traceability of battery materials (related to BESS safety),
- battery chemistry,
- primary configuration (in accordance with IEC 63330),
- safety design at the original use – intrinsic safety design, guards and protection devices, and information (related to BESS safety),
- battery operating range, usage parameters and requirements (in accordance with IEC 63330),
- recommended operation conditions specified by the OEM company,
- performance data sheets, operating instructions and associated material safety data sheets (MSDS),
- maintenance log,
- failure history including minor ones (e.g., overcharge, over-discharge, overcurrent, overtemperature, insulation failure, accident), and
- historical data collected from the BMS (battery management system) during the whole operation life of the batteries (related to BESS safety, in accordance with IEC 63338 battery lifetime traceability data).

The decision to reuse or repurpose such batteries will hinge on a reliable determination of their conditions, data and their residual usable period in the planned BESS.

9.2.3 Estimation of residual usable period and performance

The residual usable period and performance of the BESS shall be estimated and calculated based on the current residual usable period and performance of the reused or repurposed battery and the future application of the BESS. In addition, it shall be confirmed that sufficient safety is ensured until the end of the usage period. The estimation, calculation and confirmation shall be implemented with one or more methods from the following.

1) Estimation using the original use design

   The differences between circumstances from the original use and after the reuse shall be confirmed. The necessity for redesign shall be considered based on the result of the confirmation. The reuse battery can keep the original life design if the result shows only tolerable risk.

2) Estimation with original use data

   The estimation shall be done using actual data or trend data which is measured as representative points over a period of time.

3) Estimation with a non-destructive inspection

   The estimation shall be done with some non-destructive inspection methods. Annex A describes examples of the estimation methods for a BESS using lithium-ion batteries.

9.2.4 Safety requirements in the design of safety

In order to preserve the safety level of the BESS, the following actions are required in the redesign phase:

1) Safety design at original use

   The safety design of the accumulation subsystem at original use shall be reviewed including the intrinsic safety design, guards and protection devices, and information. They are very useful for a BESS whose accumulation subsystem uses reused or repurposed batteries.

   The original BMS (battery management system) if reused or repurposed too, shall be reviewed for the relevance of the embedded control algorithm and compatibility with the future BESS and its operational management structure.

2) Failure history

The failure history in the original use, including electrical, mechanical and chemical failure history, shall be reviewed to avoid an accidental use of units with hidden defects and that are prone to incipient failures. The history is not limited to the battery's history, but also that of the original system or application which used that battery (e.g. a crash by an EV).

If the history has any incidents, the battery shall be treated carefully because battery trouble, ignition or thermal runaway, etc., can happen at intervals after an incident.

3) Current safety state of reused or repurposed battery

The current safety state can be estimated as follows:

a) Safety design and use data at original use

b) Destructive inspection by sampling

If there is a battery which has the same history as the ones to be used, the safety state can be estimated with destruction inspection using a sampling of the batteries.

The following measures related to sampling shall be taken:

- The sample shall be selected from the batteries that are estimated to have the greatest degradation based on the data.
- If the different battery types are mixed, the inspection shall be conducted for each type.
- The following data shall be considered in the sampling phase and inspection:
  i) service life,
  ii) number of years of use,
  iii) number of use cycles, and
  iv) operating environment temperature.
- The number of samples shall be two or more and the sampling targets shall be selected considering the above data.

NOTE 1 Generally, the most deteriorated batteries is selected for sampling based on the data as sampling method.

c) Non-destructive inspection

The estimation can be done with some non-destructive inspection methods. Annex A describes examples of the estimation methods.

4) Consideration of safe-operation range in inherently safe design

Since reused or repurposed batteries have deteriorated after original use, operational margin settings shall be considered to be stricter than those for the original use, in order to operate the BESS safely.

a) Safe-operating range of state of charge (SOC) of BESS

The SOC range of the BESS shall be narrowed from the original use in accordance with the category of IEC 62933-2-1:2017, 4.2, to which the application of the BESS with reused or repurposed batteries belongs as noted below.

i) Class A: Power intensive application

The upper and lower voltage limits shall be narrowed, with the level of reduction in the limits smaller than that of Class B because the range of use at the upper and lower limits of the SOC for Class A is typically smaller than that for Class B.

NOTE 2 Class A is a short-duration application that requires the EES system to input/output the required power over a duty cycle for a short period of time (for example, the EES system is charged and discharged in less than 1 h).

ii) Class B: Energy intensive application

The upper and lower voltage limits shall be narrowed with the level of reduction in the limits larger than that of Class A, because the range of use at the upper and lower limits of the SOC for Class B is typically greater than that for Class A.

NOTE 3 Class B is a long-duration application that requires the EES system to input/output the required power over a duty cycle for a long period of time (for example, the EES system is charged and discharged for more than 1 h).

iii) Class C: Back-up power application

Reduction in the upper voltage limit

NOTE 4 Class C is the EES system that is used to supply AC power to electric power grids in case of emergency, without relying on an external power source.

The above requirements can be waived in the following cases:

in the case of reuse and when the current rate after the reuse is set below the original use;

in the case of using batteries that have been safely designed and used on the basis of repurposing at the time of original use;

when 3)b) is performed and the disassembly analysis of the most deteriorated battery shows no change in safety from the time when the battery was new;

when 3)c) is performed and safety is found to be unchanged from the time when the battery was new.

b) Safe-operating range of operational temperature of the BESS

The operational temperature range of the reused or repurposed batteries in the BESS shall be narrowed from the original use and made closer to the range where safer operation is possible. This requirement can be waived in the following cases:

in the case of reuse and when environmental conditions remain the same,

when the temperature range in the environmental conditions is smaller than that of the original use,

when the temperature control of the accumulation subsystem is appropriately enhanced.

c) Safe-operating range of current of BESS

The range of current of the reused or repurposed batteries in BESS shall be narrowed from that of the original use. This requirement can be waived in the following cases:

in the case of reuse and when the upper limit of the current input/output remains the same,

when the current fuse or overcurrent protection of the accumulation subsystem is enhanced and the heat generation control is appropriately enhanced.

5) Necessity of adding guards and protection measures

Reused or repurposed batteries cannot be subjected to type testing like new batteries, and in most cases, safety certifications based on type testing for the new batteries are no longer applicable when they become reused or repurposed batteries. In these cases, "guard and protection" by use of external component(s) is more important than reliance on "intrinsic safety" for the safety design of the BESS when using reused or repurposed batteries compared to a BESS using new batteries.

The general safety protection systems of the BESS shall be designed to reflect the presence of reused or repurpose batteries.

The following measures shall be implemented.

– Prevention of fire propagation: Appropriate layout of the subsystem, guards and protections shall be implemented to prevent propagation between modules or any other enclosures, because it is difficult to conduct propagation tests (e.g., IEC 62619:2022, 7.3.3) for reused or repurposed batteries to confirm the possibility of propagation in the module level.

– Prevention of explosion: When using a battery with a structure that suppresses gas emissions inside the pack, the number and placement of gas sensors shall be decided carefully considering that the release of gas emissions can be delayed due to the battery structure.

– Firefighting: When using a battery with a highly sealed structure, the fire extinguishing system shall be designed to enhance the direct cooling effect of water and other extinguishing compounds because the extinguishing effect cannot be expected.