IEC 63338

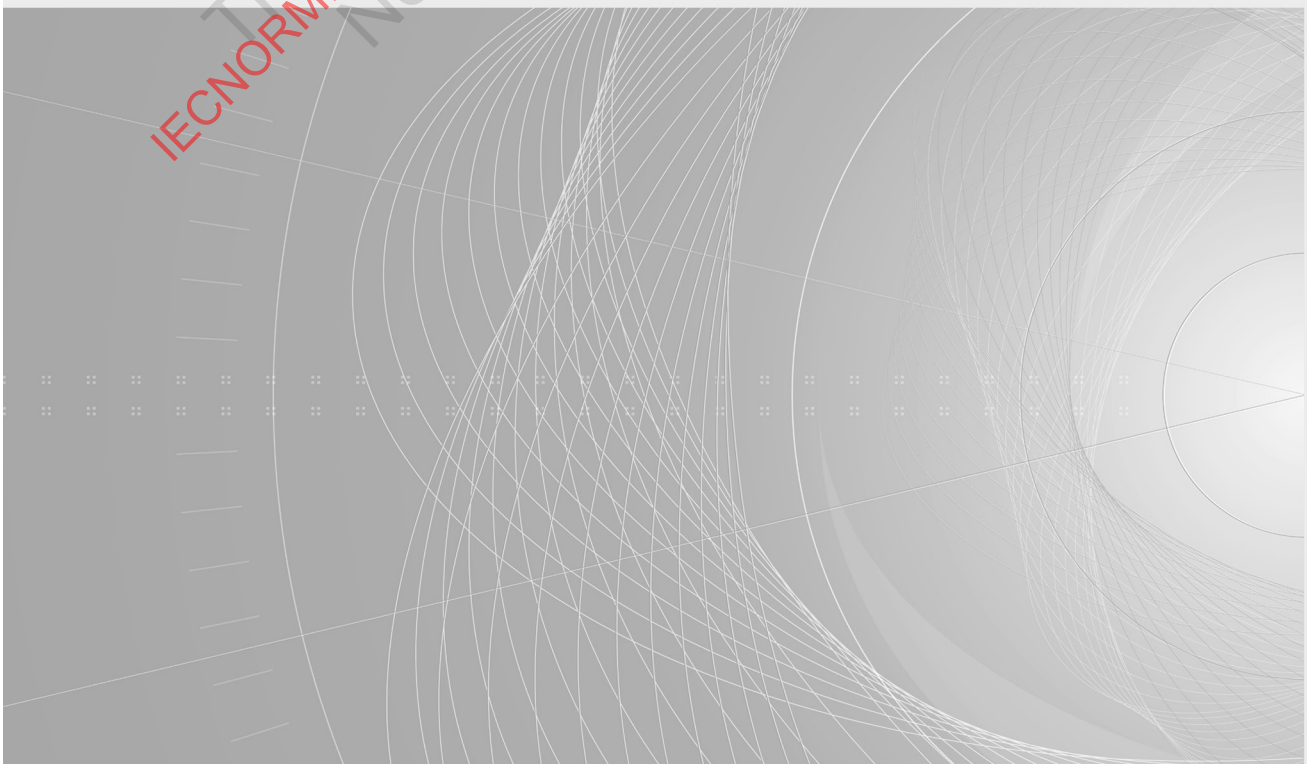
Edition 1.0 2024-08

INTERNATIONAL STANDARD

NORME INTERNATIONALE

General guidance on reuse and repurposing of secondary cells and batteries

Recommandations générales relatives à la réutilisation et à la réaffectation des accumulateurs et des batteries d'accumulateurs



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COMMISSION

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CONTENTS

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GENERAL GUIDANCE ON REUSE AND REPURPOSING OF SECONDARY CELLS AND BATTERIES

FOREWORD

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IEC 63338 has been prepared by subcommittee 21A: Secondary cells and batteries containing alkaline or other non-acid electrolytes, of IEC technical committee 21: Secondary cells and batteries. It is an International Standard.

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

Draft	Report on voting
21A/885/FDIS	21A/899/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.

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- withdrawn, or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.

INTRODUCTION

Based on the principles of life cycle thinking (LCT) and environmentally conscious design (ECD), secondary battery reuse and repurposing are a means to reduce raw material consumption. However, there are potential safety risks to consider before reusing or repurposing a battery. These should be thoroughly addressed before considering any kind of reuse or repurposing operations. Further, it is essential that all reused or repurposed batteries or sub-units of batteries comply with all safety, transport and product testing at the same level as new battery products (except tests requiring destructive sampling).

The primary purpose of this document is to provide basic guidance on the environmental aspects of reuse and repurposing of relevant cells and batteries; basic guidance on safety risks for the reuse and repurposing of relevant cells and batteries; basic guidance on original manufacturer warning notice on the applicability of a product for reuse or repurposing; and useful information regarding reuse and repurposing and relevant cell and battery regulations and standards to interested parties.

Additionally, various regions and countries are currently developing requirements and regulations for the reuse and repurposing of secondary cells and batteries, especially those used for the propulsion of electric road vehicles, after being extracted at their end of life. These differing requirements and regulations could lead to technical or safety issues in the use of these batteries. Thus, this document can assist nations and regions in setting up secondary battery reuse and repurposing regulations.

The expected users of this document are the following: original manufacturers (including cell and battery or application), qualified reuse and repurposed application manufacturers (e.g. with approval in writing from the original manufacturer to reuse or repurpose); national, regional, and local authorities that establish secondary battery reuse and repurposing regulations; and national, regional, and local authorities that revise secondary battery reuse and repurposing regulations.

However, other stakeholders are not precluded from using this document.

National and regional standards and voluntary stewardship programs are given priority over the matters covered in this document.

Table 1 contains an overview of different standards on reuse and repurposing of batteries and Battery Energy Storage Systems (BESS) developed by IEC/TC 21 Secondary cells and batteries and IEC/TC 120 Electrical Energy Storage (EES) systems. The purpose of Table 1 is to inform users of these standards about the existence of the other standards listed in the table and give a concise overview of the outline of those standards. It also identifies areas of possible overlap and informs users in these cases which of the standards takes precedence.

Table 1 – Standards on reuse and repurposing of batteries and battery energy storage systems (BESS)

		IEC 63338		IEC 63330-1		IEC 62933-4-4		IEC 62933-5-3	
Title		General guidance on reuse and repurposing of secondary cells and batteries		Repurposing of secondary batteries – Part 1: General requirements		Electrical energy storage (EES) systems – Part 4-4: Environmental requirements for battery-based energy storage systems (BESS) with reused batteries		Electrical energy storage (EES) systems – Part 5-3: Safety requirements for grid-integrated EES systems – Performing unplanned modification of electrochemical based system	
Scope		Secondary lithium ion and Ni-MH		Repurposing of secondary batteries and systems (excluding redox flow/Ni-MH/Pb batteries)		BESS using reused batteries		Energy storage systems	
		Battery	System	Battery	System	Battery	System	Battery	System
Requirements	**General**			No overlap: Clause 4 Clause 5 Clause 6					
	Environment					Support: Annex A (info)	No overlap: Clause 4 Clause 5 Clause 6 Clause 7 Annex B (info)		
	Safety			Priority: Clause 4 Clause 5 Clause 6	Support: Clause 6 (ESS) No overlap: Clause 6 (other)			Support: Annex A (Info)	No overlap: Clause 5 Clause 6 Clause 7 Clause 8 Priority: Clause 9
	Assessment			Priority: Clause 5	Support: Clause 6 (ESS) No overlap: Clause 6 (other)				

		IEC 63338		IEC 63330-1		IEC 62933-4-4		IEC 62933-5-3	
Guidance	**General**	No overlap: Clause 4							
	Environment	No overlap: Clause 9							
	Safety	Priority: Clause 5 Clause 6 No overlap: Clause 7 Clause 8							

GENERAL GUIDANCE ON REUSE AND REPURPOSING OF SECONDARY CELLS AND BATTERIES

1 Scope

This document applies to the reuse and repurposing of secondary lithium ion and nickel-metal hydride cells and batteries after extraction from the application for which they were first placed on the market (hereafter "relevant cells and batteries").

This document does not permit reuse or repurposing of single cells or cell assemblies if battery lifetime traceability data are not recorded. See Clause 4. Swappable batteries such as those used in e-scooters are removed and installed by the user (such as for charging) without conducting a safety assessment (such as battery lifetime traceability data assessment) as part of intended use, which is not considered reuse or repurposing. This document does not cover system component reuse and repurposing. The original manufacturer can be contacted to confirm suitability of components for reuse and repurposing.

Figure 1 illustrates the scope of this document in the product life stage.

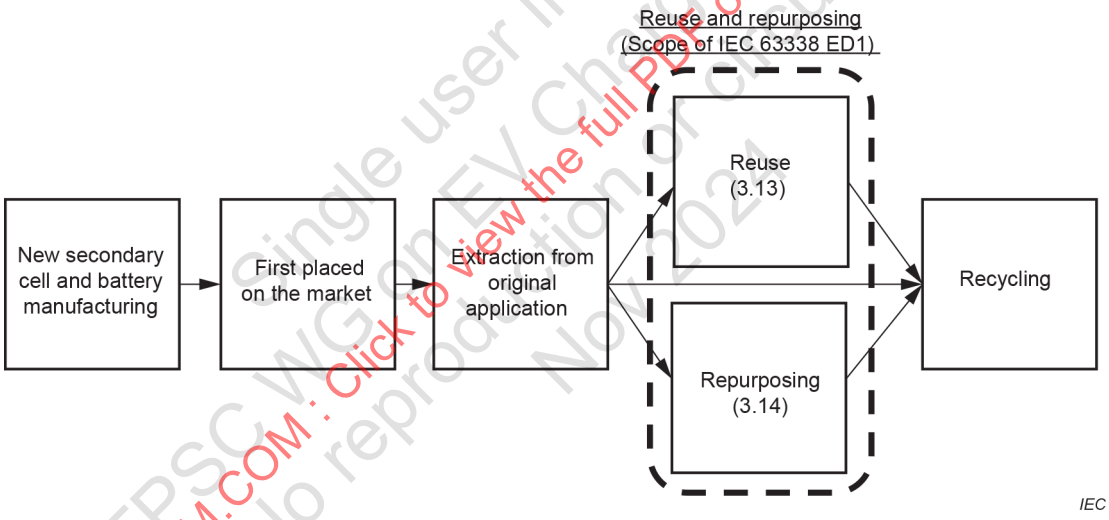


Figure 1 – Scope of this document

2 Normative references

There are no normative references in this document.

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
product
goods or service

[SOURCE: IEC 63218:2021, 3.1, modified – "any" has been deleted from the definition.]

3.2
electric road vehicle
electric vehicle with only a traction battery as power source for vehicle propulsion (battery electric vehicle) or vehicle with both a rechargeable energy storage system and a fuelled power source for propulsion (hybrid electric vehicle)

[SOURCE: IEC 62660-1:2018, 3.1 and IEC 62660-1:2018, 3.2, modified – The terminological entries have been merged and the terms have been replaced with "electric road vehicle".]

3.3
waste battery
cells or batteries which the holder discards or intends or is required to discard

Note 1 to entry: Assessment of used batteries for possibility to repurpose is included in IEC 63330 ED1

[SOURCE: IEC 63218:2021, 3.2 modified – "cells or" added to the definition.]

3.4
environment
surroundings in which an organization operates, including air, water, land, natural resources, flora, fauna, humans and their interrelationships

Note 1 to entry: Surroundings in this context extend from within an organization to the global system.

[SOURCE: IEC 63218:2021, 3.3]

3.5
environmental aspect
element of an organization's activities or products that interacts or can interact with the environment

Note 1 to entry: An environmental aspect can cause (an) environmental impact(s). A significant environmental aspect is one that has or can have one or more significant environmental impact(s).

Note 2 to entry: Significant environmental aspects are determined by the organization applying one or more criteria.

Note 3 to entry: Activities of the organization are those related to the design and development.

[SOURCE: IEC 60050-901:2013, 901-07-02, modified – "interacts or" added to the definition, and note to entry replaced with three new notes to entry.]

3.6
environmental impact
change to the environment, whether adverse or beneficial, wholly or partly resulting from a product environmental aspect

[SOURCE: IEC 60050-904:2014, 904-01-03, modified – "environmental aspects" replaced with "a product environmental aspect".]

3.7
environmentally conscious design
ECD
systematic approach which takes into account environmental aspects in the design and development process with the aim to reduce adverse environmental impacts

[SOURCE: IEC 60050-904:2014, 904-01-13]

3.8
life cycle
consecutive and interlinked stages of a product system, from raw material acquisition or generation from natural resources to the final disposal

[SOURCE: IEC 60050-901:2013, 901-07-12]

3.9
life cycle thinking
LCT
consideration of all relevant environmental aspects during the entire life cycle of products

[SOURCE: IEC 60050-901:2013, 901-07-14]

3.10
life cycle assessment
LCA
compilation and evaluation of the inputs, outputs and the potential environment impacts of a product system throughout its life-cycle

[SOURCE: IEC 60050-901:2013, 901-07-13]

3.11
end of life
EOL
life cycle stage of a product starting when it is finally removed from its intended use-phase

[SOURCE: IEC 60050-901:2013, 901-07-15]

3.12
recycling
processing of waste materials for the original purpose or for other purposes, excluding energy recovery

[SOURCE: IEC 60050-901:2013, 901-07-10, modified – note to entry omitted.]

3.13
reuse
operations by which secondary batteries are used again in the same application as when first placed on the market

Note 1 to entry: See Annex C for alternative common terms.

Note 2 to entry: When reuse of secondary batteries is as originally intended from the design stage, this is considered "originally intended reuse". When reuse of secondary batteries is not originally intended from the design stage, this is considered "originally unintended reuse".

Note 3 to entry: An example of reuse is when a battery is extracted from an electric vehicle (EV), its battery lifetime traceability data is assessed, its battery management system (BMS) operating region is narrowed, and it is used again in another less demanding EV.

3.14
repurposing
operation by which secondary batteries are used again in a different application to when first placed on the market

Note 1 to entry: See Annex C for alternative common terms.

Note 2 to entry: When repurposing of secondary batteries is as originally intended from the design stage, this is considered "originally intended repurposing". When repurposing of secondary batteries is not originally intended from the design stage, this is considered "originally unintended repurposing".

Note 3 to entry: An example of repurposing is when a battery is extracted from an EV, its battery lifetime traceability data is assessed, its BMS operating region is narrowed, and it is used again in another less demanding application such as an energy backup system for telecom equipment.

3.15
reuse or repurposed application
application in which a cell or battery or battery system is used after undergoing reuse or repurposing operations

3.16
secondary cell
basic manufactured unit providing a source of electrical energy by direct conversion of chemical energy, that consists of electrodes, separators, electrolyte, container and terminals, and that is designed to be charged electrically

[SOURCE: IEC 62133-1:2017, 3.7]

3.17
secondary battery
assembly of secondary cell(s) which may include associated safety and control circuits and case, ready for use as a source of electrical energy characterized by its voltage, size, terminal arrangement, capacity and rate capability

Note 1 to entry: The term "secondary battery" includes single cell batteries.

[SOURCE: IEC 63218:2021, 3.20]

3.18
battery system
battery
system which comprises one or more cells, modules or battery packs

Note 1 to entry: The battery system has a battery management system to cut off in case of overcharge, overcurrent, overdischarge, and overheating.

Note 2 to entry: Overdischarge cut-off is not mandatory if there is an agreement between the battery manufacturer and the customer.

Note 3 to entry: The battery system may have cooling or heating units. More than one battery system may constitute a larger battery system. The battery system is sometimes also referred to as a battery.

[SOURCE: IEC 62619:2022, 3.11, modified – The wording "and has a battery management system capable of controlling current in case of overcharge, overcurrent, overdischarge, and overheating" omitted from the definition and Note 1 to entry added (existing notes renumbered).]

3.19
battery pack
energy storage device, which comprises one or more cells or modules electrically connected and has monitoring circuitry which provides information (e.g. cell voltage) to a battery system to influence the battery's safety, performance and/or service life

Note 1 to entry: The battery pack may incorporate a protective housing and be provided with terminals or other interconnection arrangements.

[SOURCE: IEC 62619:2022, 3.10]

3.20
lithium ion cell
Li-ion cell
secondary cell with an organic solvent electrolyte and positive and negative electrodes which utilize an intercalation or insertion compound in which lithium is stored

Note 1 to entry: Lithium ion cells do not include lithium metal.

[SOURCE: IEC 60050-482:2004, 482-05-07, modified – The term "lithium ion battery" has been replaced with the "lithium ion cell" and the term "Li-ion cell" has been added; "or insertion" added to the definition and "battery" replaced with "cell" in the definition and note to entry.]

3.21
lithium ion battery
Li-ion battery
secondary battery with assembly of secondary lithium ion cells

3.22
nickel-metal hydride cell
Ni-MH cell
cell containing a nickel hydroxide compound for the positive electrode, a hydrogen absorbing alloy for the negative electrode, and potassium hydroxide or other alkaline solution as electrolyte, and not releasing either gas or liquid when operated within the limits specified by the manufacturer

Note 1 to entry: A sealed cell may be equipped with a safety device to prevent a dangerously high internal pressure and is designed to operate during its life in its original sealed state.

[SOURCE; IEC 63115-1:2020, 3.1, modified – The word "sealed" deleted from the term and the term "Ni-MH cell" added; "See IEC 60050-482:2004, 482-05-17" omitted from the note to entry.]

3.23
nickel-metal hydride battery
Ni-MH battery
secondary battery with assembly of nickel-metal hydride cells

3.24
state of health
SOH
secondary battery's state of degradation calculated as a percentage of its original specifications

Note 1 to entry: Considers factors such as permanent capacity loss, resistance, cycle life, etc.

3.25
module
group of cells connected together either in a series and/or parallel configuration with or without protective devices (e.g. fuse or positive temperature coefficient device (PTC)) and monitoring circuitry

[SOURCE: IEC 62619:2022, 3.9]

3.26
battery management system
BMS
electronic system associated with a battery which has functions to cut off in case of overcharge, overcurrent, overdischarge, and overheating and which monitors and/or manages its battery state, calculates secondary battery data, reports that data and/or controls its battery environment to influence the battery's safety, performance and/or service life

Note 1 to entry: Overdischarge cut-off is not mandatory if there is an agreement between the battery manufacturer and the customer.

Note 2 to entry: The function of the BMS can be assigned to the battery pack or to the application that uses the battery. (See IEC 62619:2022, 8.2.1 for Li-ion and IEC 63115-2:2021, 7.1 for Ni-MH).

Note 3 to entry: The BMS can be divided and it can be found partially in the battery pack and partially on the application that uses the battery. (See IEC 62619:2022, 8.2.1 for Li-ion and IEC 63115-2:2021, 7.1 for Ni-MH).

Note 4 to entry: The BMS is sometimes also referred to as a BMU (battery management unit).

[SOURCE: IEC 62619:2022, 3.12, modified – In the definition, "control current" is replaced with "cut-off" and "environment" is replaced with "battery environment. In Note 1 to entry, "battery manufacturer" is replaced with "cell manufacturer", and the second sentence is added. In Note 2 to entry "equipment" is replaced with "application" and the second sentence is replaced. In Note 3 to entry, "equipment" is replaced with "application", and the second sentence is replaced.]

3.27
original manufacturer
manufacturer(s) of cells, batteries, battery systems (original battery manufacturer), battery packs and/or the application for which they are first placed on the market (original application manufacturer), who determines whether reuse or repurposing is intended from the design stage

Note 1 to entry: Intention to reuse or repurpose is determined by approval in writing from the original battery manufacturer and/or original application manufacturer. Even if the original battery and application manufacturers are the same, the intention to reuse or repurpose is clarified via the label (see 7.2).

3.28
battery provider
party that is responsible for relevant cells and batteries, but is not the original manufacturer or reuse or repurposed application manufacturer

Note 1 to entry: The battery provider can be a distributor, trader, or similar and engages with the original manufacturer and reuse or repurposed application manufacturer with approval in writing.

3.29
operating region
conditions during charging and discharging in which the cell operates within its voltage, current and temperature range as specified by the cell manufacturer

3.30
portable battery
battery for use in an end-use product or in an appliance which is conveniently hand-carried

Note 1 to entry: Applications which use portable batteries typically do not record battery lifetime traceability data.

[SOURCE: IEC 63218:2021, 3.22, modified – Note to entry added.]

4 General considerations

In order to reduce adverse environmental impacts, the opportunity to use materials again should be considered as part of environmentally conscious design (ECD). Examples include the recovery and reuse or repurposing of products (e.g., electronic subassemblies, semiconductor devices, and safety devices), which are physically combined with batteries. However, it is not always possible and can sometimes be extremely difficult to effectively and safely reuse or repurpose batteries that are collected, because there is a possibility of having received damaged batteries which can affect safety. The size and original application of a secondary cell or battery will have a large impact on whether reuse or repurposing can be considered. Examples of types of batteries that shall not be reused or repurposed are single cells or cell assemblies if battery lifetime traceability data is not recorded (see 6.2). Originally unintended reuse or repurposing can have a much higher safety risk than originally intended reuse or repurposing.

The base for starting reuse or repurposing operations is an approval in writing between the reuse or repurposed application manufacturers and the original manufacturers (and battery provider if applicable). This is needed to improve safety and performance in reused or repurposed batteries based on Clause 5, Clause 6, Clause 7, and Clause 8 of this document as well as based on the original manufacturers' safety information for both batteries and battery components.

The original manufacturer should be responsible for the original use of relevant cells and batteries and should not be responsible for the reuse or repurposing of relevant cells and batteries.

NOTE 1 Approval in writing can be contractual agreement, a memorandum of understanding, approval to reuse or repurpose via the original battery label, etc.

This document outlines and provides guidance on the safety risks associated with reuse and repurposing. Additionally, this document provides guidance on coordination between the original and reuse or repurposed application and battery manufacturers regarding the applicability of a product for reuse or repurposing. Refer to Annex A for the guidance checklist of recommendations before reuse or repurposing of relevant secondary cells and batteries.

If this document is observed, the risk of occurrence of the following hazards is reduced:

a) fire,

b) explosion,

c) leakage of cell electrolyte,

d) venting,

e) rupture of the casing of cell, module, battery pack, and battery system with exposure of internal components,

f) electrical hazards,

g) impaired functional safety.

NOTE 2 Potential risks are described in IEC 62619:2022, and IEC 63115-2:2021.

5 Consideration of safety risks associated with reuse and repurposing

5.1 General

Secondary batteries including secondary lithium ion and nickel-metal hydride are generally available on the market for use in applications such as electric vehicles (EVs), energy storage systems, PCs and mobile phones.

Among them, secondary lithium ion batteries are widely used in portable devices to EVs and large-scale systems such as energy storage systems because of their high energy density and charge/discharge efficiency. In addition, nickel-metal hydride batteries are widely used in portable applications that accept alkaline batteries, in energy storage systems, and in vehicles as part of hybrid electric systems.

Secondary lithium ion batteries are widely available on the market due to their excellent characteristics as energy storage devices, but compared to other battery chemistries, there are high risks of safety incidents from secondary lithium ion batteries, and even more care has to be taken when designing, producing and using (including reuse and repurposing) secondary lithium ion battery systems and packs. These are strictly regulated in transport, safety and product design standards to improve safety in cells, battery packs or systems, and under all operating conditions as specified by the cell or battery manufacturer. Nickel-metal hydride batteries are safer from a chemistry point of view, however deviation from the use conditions intended by the original battery manufacturer can still result in safety issues.

Therefore, in actual use, safety is improved by using battery systems that are designed with functional safety methods so as not to deviate from the specified usage and handling methods.

If components (or modules) are removed or exchanged from a safely designed battery system, or the battery system is modified (hardware, software) without checking battery lifetime traceability data or considering appropriate design to improve safety, safety related incidents are more likely to occur (or happen).

The reuse or repurposed application manufacturer shall confirm whether reuse or repurposing is permissible and assess battery lifetime traceability data using the methods described in 6.2.1 and 6.2.2.

The following relevant cells and battery safety standards and regulations should be referred to.

For example, automotive / vehicle:

- IEC 62660-3
- IEC 61982-4
- ISO 6469-1

NOTE The original manufacturer can consider UN ECE R100, UN ECE R136, and UN GTR No. 20.

Stationary:

- IEC 62619
- IEC 63056
- IEC 62933-5-2:2020
- IEC 63115-2

5.2 Lithium ion systems

5.2.1 Lithium ion cells

Lithium ion cells are energy storage devices that utilise the movement of lithium ions to perform mutual conversion between chemical energy and electrical energy, and realize mutual energy conversion by causing a specific electrochemical reaction during charging and discharging. In order to maintain safety and performance, and achieve smooth energy conversion, it is essential to ensure the intended electrochemical reactions occur without side reactions. For those reasons, cell manufacturers should specify how to use and handle each cell. If this method of use or handling is deviated from, the chemical energy stored in the cell will not be properly controlled, abnormal reactions will progress rapidly, and the energy cannot be contained in the cell. This can result in safety incidents such as fire, explosion, leakage, venting and rupture.

5.2.2 Lithium ion battery systems

The usage and handling methods specified in 5.2.1 include many outside factors that are controlled at the battery level, such as charge and discharge voltage, current range, and temperature range. Battery systems shall be configured to prevent abnormal events, and to improve safety by electrically and mechanically controlling and protecting the battery.

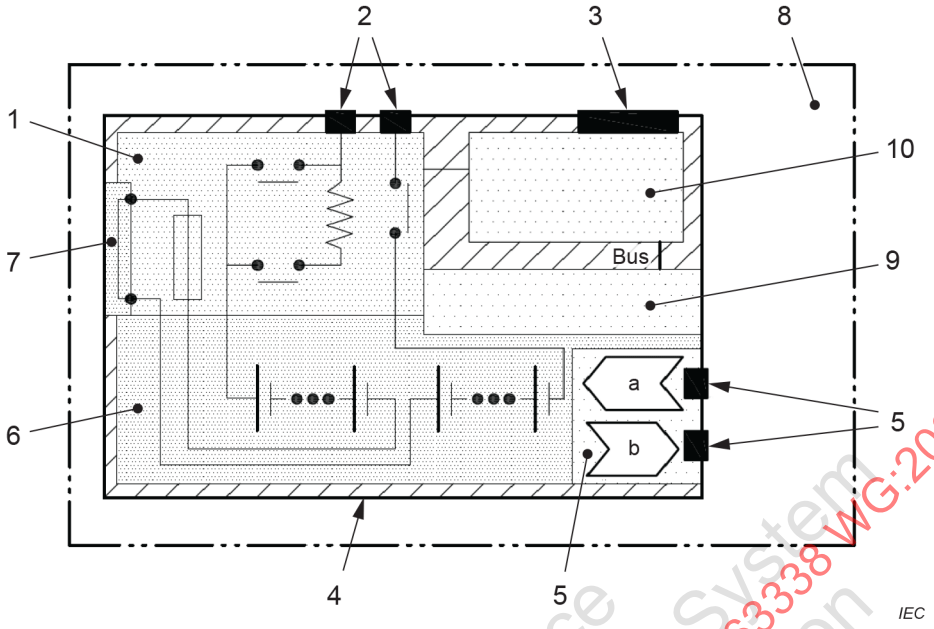
NOTE 1 Further details can be found in IEC 62619:2022, Annex A.

Lithium ion battery systems are designed with consideration of safety and battery characteristics based on the requirements and conditions of the application while complying with the cell usage and handling methods specified by the battery manufacturer. In a safely designed battery system, it is necessary to configure each functional element via methods such as functional safety and to secure a sufficient level of safety against foreseeable events. A battery system configuration example is shown in Figure 2 (source: ISO 12405-4:2018, Annex A). Although not shown in the figure, a dedicated charger and external cooling device, if necessary, are included in a safely designed battery system.

Figure 2 shows one example of a battery system. It includes a BMS, which in some cases can also be outside the battery system. As an example, a vehicle battery can have an integrated BMS or a BMS implemented in a control unit in a different place within the vehicle. This should be considered when removing the battery system from the vehicle and possibly reusing or repurposing it.

Further, a battery system is individually designed and, depending on application, the topology can be different. Thus, the BMS can also be outside the battery pack, in a separate control unit or even in the charger or in the application it powers. This is dependent on the system design and topology. Thus, a solution cannot be prescribed in general, but should be considered individually. Care should be taken especially on this point, when removing a battery system from an application, regardless of whether it is a vehicle, light electric vehicle or stationary system.

NOTE 2 Further details on the BMS can be seen in IEC 62619:2022, 8.2.1.



Key

1 Electric circuit (contactors, fuses, wiring)
2 Connectors for power line
3 Connectors for battery management system
4 Normal use impact-resistance case
5 Cooling device and connections (a: in, b: out)
6 Cell assembly
7 Service disconnect
8 Battery pack
9 Cell electronics
10 Battery management system

SOURCE: ISO 12405-4:2018, Figure A.1, reproduced with the permission of the authors.

Figure 2 – Battery system configuration example

5.3 Nickel systems

5.3.1 Nickel-metal hydride cells

The nickel-metal hydride cell makes electrochemical use of the reversibility of the hydrogen absorption/release reaction in the hydrogen absorbing alloy. The cell uses a nickel hydroxide compound for the positive electrode, a hydrogen absorbing alloy for the negative electrode, and an aqueous alkaline solution for the electrolyte, which includes constituents such as potassium hydroxide (KOH). During charging, the electrolytic reaction of water causes the hydrogen, which forms in atomic form on the surface of the hydrogen absorbing alloy in the negative electrode, to diffuse into and be absorbed by the alloy (charge reaction). During discharge, the absorbed hydrogen reacts with the hydroxide ions at the surface of the hydrogen absorbing alloy to once again become water (discharge reaction).

5.3.2 Nickel-metal hydride cells and battery systems

Nickel-metal hydride cells and batteries have a higher tolerance to overcharge and overdischarge than secondary lithium ion batteries. However in the event of excessive overcharge and overdischarge, internal pressure can build inside the cells and leakage can occur. Nickel-metal hydride cells and batteries have a gas release vent in order to prevent excessive pressure, however in extreme conditions, deterioration can occur. For example, in a large assembly of cells, heat can accumulate around the innermost cells in case of overcharge at high temperatures and battery life will be reduced. When utilizing an assembly of cells in an application, heat dissipation should be considered. In order to minimize these safety risks, nickel-metal hydride cells and batteries should not be used outside of the conditions intended by the battery manufacturer.

Nickel-metal hydride battery systems are designed with consideration of safety and battery characteristics based on the requirements and conditions of the application while complying with the cell usage and handling methods specified by the battery manufacturer. In a safely designed battery system, each functional element is configured via methods such as functional safety to secure sufficient safety against reasonably foreseeable misuse.

When designing an assembled nickel-metal hydride pack it is necessary to install protective devices in consideration of charger abnormalities or external short circuits. Attach a temperature sensor (i.e., NTC thermistor) to the battery pack to detect abnormal temperatures on the batteries during charging. Depending on the charging and discharging conditions, a combination of a thermostat (circuit breaker), temperature fuse, current fuse, PTC thermistor, etc. is included in the battery pack to detect abnormal temperatures on the battery pack and cut off the current as shown in Figure 3.

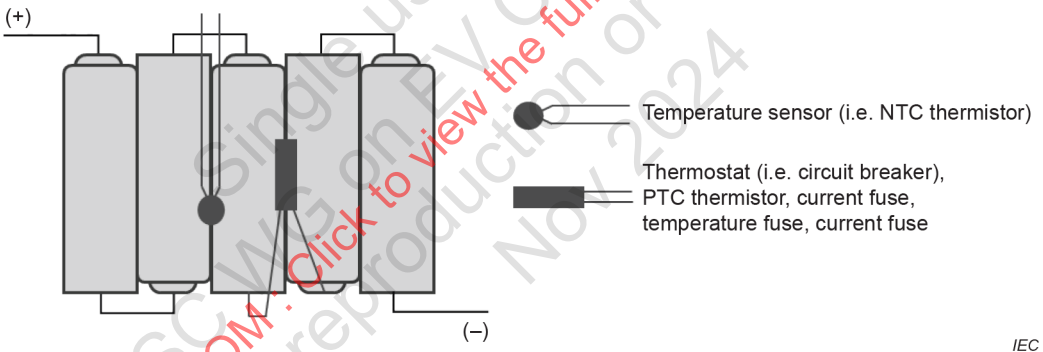


Figure 3 – Example of protection device installation

6 Considerations for reused or repurposed battery systems

6.1 General

Unlike new cells, cells that have undergone original use are exposed to varying environments, usage and handling history, and degree of damage and deterioration, resulting in inconsistent quality. In addition, this inconsistency is not limited to a single characteristic, but is complex and diversified. These result in issues when making estimates and selecting specific parameters. Also, evaluation via sampling is difficult and inaccurate. For safety evaluation of relevant cells and batteries, most existing safety standard test methods are destructive tests, which are not suitable for the evaluation of reused or repurposed batteries of non-uniform quality, and general methods for non-destructive safety evaluation are not established at the time of publication of this document. The safety evaluation of relevant cells and batteries shall be conducted using battery lifetime traceability data to confirm that appropriate usage and handling parameters (as decided at the design stage) were not exceeded during original use, and that they can be maintained during reuse or repurposing. Therefore, single cells shall not be reused or repurposed without appropriate battery lifetime traceability data (see 6.2.2).

If there are differences in safety goals between the original use and the repurposed application, differences in standards for these applications can exist. These differences should be considered and evaluated. In some cases, it can be necessary to perform tests on new cells or modules.

The impact on existing parts or product qualifications and/or evaluations caused by extraction of parts, such as modules, cells or other components, should be considered and evaluated. This is true for all disassembly and assembly measures performed on a battery system to build a repurposed application.

6.2 Determining suitability for reuse or repurposing (based on battery lifetime traceability data)

6.2.1 General

In order to improve safety during reuse or repurposing, i.e., the decision as to whether or not a relevant cell or battery can be reused or repurposed, shall be determined based on battery lifetime traceability data recorded during original use and any subsequent storage period. Therefore, relevant cells and batteries extracted from applications that do not have battery lifetime traceability data shall not be reused or repurposed. The type of battery lifetime traceability data varies depending on application and design, however 6.2.2 should be referred to for general examples.

The reuse or repurposed application manufacturer should confirm the status of the following items based on reuse/repurposing standards (local laws, regulations and other legal or governmental requirements can apply):

– safety,
– product quality,
– standard testing history (e.g. safety and transport),
– end of life treatment,
– recycling.

The development of battery health checks should also be considered as a future option and based on risk assessment. The following parameters should be considered:

– capacity,
– internal resistance (at different, characteristic frequencies, etc.).

The responsibility for all this development and health checks lies with the reuse or repurpose manufacturer.

The original manufacturer shall be consulted as to the minimum capacity level of a cell which is safe for operation.

The battery lifetime traceability data may be stored in the battery management system, in other data storage devices in the application, or in external data storage devices.

NOTE A health check cannot show details of the internal state inside the cell regarding safety or failure probability.

Regarding removal of original labels, see 8.1.

6.2.2 Battery lifetime traceability data

Battery lifetime traceability data includes original use data, storage data after extraction, and data recorded during the reuse or repurposing assessment such as described in the bullet list of this Subclause 6.2.2. Battery lifetime traceability data is useful for the reuse or repurposing assessment. The reuse or repurposed application manufacturer shall contact the original manufacturer in order to access the battery lifetime traceability data. The following are examples of battery lifetime traceability data that the reuse or repurposed application manufacturer should access.

History of:

- Overcharge
- Overdischarge
- Overcurrent
- Overtemperature
- Insulation failure
- Accidents (e.g. external short-circuit, insulation failure, excessive shock and/or vibration, abnormal storage, BMS self-diagnosis result)
- Storage conditions (e.g. storage period, environment, etc.).

6.3 Safety evaluation of reused or repurposed batteries

Regarding the redesign of relevant secondary batteries, the use and BMS conditions in which relevant secondary batteries are first placed on the market (as designed by the original manufacturer) should not be modified at the time of reuse or repurposing without approval in writing from of the original manufacturer.

The safety evaluation of reused or repurposed batteries differs from that of new batteries due to the non-uniformity of their quality, and due to sample batteries not being available for destructive testing. General methods for non-destructive safety evaluation are not yet established at the time of publication of this document. As a result, during the development of battery systems, batteries should be evaluated and tested for safety during both original use and reuse or repurposing. If a battery system has not been evaluated and tested for multiple uses, in order to improve safety, there should be no deviation from the originally designed use-conditions and system controls.

Limiting the usage parameter range for certain parameters is possible in risk assessment.

6.4 Reused or repurposed cell and battery operating region

The original relevant cell operating region (voltage range, the surface temperature of the cell, etc.) shall not be extended during reuse or repurposing and should be possibly narrowed in order to improve safety.

If the battery system is modified, the reuse or repurposed application manufacturer shall consult with the original manufacturer and should have the approval of the latter in writing for the operation. The reuse or repurposed application manufacturer should adhere to the functional safety requirements of IEC 61508-2, IEC 62619, IEC 60730-1:2022, Annex H, or other suitable functional safety standard.

7 Coordination of reuse or repurposing with the original manufacturer

7.1 General

The reuse or repurposing of relevant cells and battery packs or battery systems has safety risks including those discussed in Clause 5, and as a result, the reuse or repurposed application manufacturer shall confirm whether reuse or repurposing has been discouraged by the original manufacturer such as via the product label or other methods.

NOTE If reuse or repurposing-relevant information is not included on the product label or manual, refer to 7.2.4.

7.2 Warning notice on reuse or repurposing applicability

7.2.1 General

In some countries and regions, reuse or repurposed application product liability can be determined to be the responsibility of the original manufacturer rather than that of the reuse or repurposed application manufacturer. In order to avoid these issues, or for safety-related reasons, the reuse or repurposing manufacturer shall consult with the original manufacturer about the possibility of reuse or repurposing of the battery and under which conditions this may be done (laws and regulations can apply). In any case, the reuse or repurposed application manufacturer should accept product liability. However, if an original manufacturer wishes to discourage the reuse or repurposing of its products, other environmentally conscious design (ECD) principles based on IEC 62430:2019 should be considered as an alternative.

The manufacturer of the cell shall be consulted as to the capacity level of a cell which is safe for operation.

7.2.2 Originally intended reuse or repurposing (according to the original manufacturer)

If reuse or repurposing was originally intended by the original manufacturer, relevant cells and batteries should be labelled with a similar statement to the following, "Before reusing or repurposing this product, approval in writing should be obtained from the original manufacturer".

NOTE If reuse or repurposing was not originally intended by the original manufacturer, relevant cells and batteries can be labelled with a statement similar to the following, "This product was not designed to be reused or repurposed. It should not be used in any way other than as originally intended by the original manufacturer".

7.2.3 Warning notice requesting the original manufacturer's approval for reuse or repurposing

If reuse or repurposing was not decided upon by the original manufacturer, the reuse or repurposed application manufacturer shall contact the original manufacturer to determine whether reuse or repurposing is possible or not; and relevant cells and batteries should be labelled with a similar statement to the following: "May be reused or repurposed only after receiving approval in writing from the original manufacturer".

7.2.4 Absence of warning notice

Owing to limited space, it is possible that including a warning notice at the cell level will not be an option. As a result, warning notice information should be shared via QR code, barcode, or similar, included at the battery pack or module level, or included on the product instruction manual.

If a warning notice is not available, the reuse or repurposed application manufacturer shall contact the original manufacturer in order to determine whether reuse or repurposing is possible.

8 Recommendations for reuse or repurposed application manufacturers

8.1 Removal of original cell or battery label and markings

The decision to remove, replace, or amend original cell or battery labels and markings should be made based on approval in writing between the original manufacturer and the reuse or repurposed application manufacturers. This refers to labelling information, name and address, logo and all other corporate identity signs.

8.2 Affixation of label or marking specifying reuse or repurposing

Reuse or repurposed application manufacturers should mark or label batteries to specify that they have been reused or repurposed.

8.3 Prerequisites for reuse or repurposed application manufacturers

The reuse or repurposed application manufacturer shall prepare and implement a quality plan that defines procedures for the inspection of materials, components, cells, modules, battery packs, and battery systems; the quality plan shall cover the whole process of reuse or repurposing of cells and batteries (e.g., ISO 9001, etc.). Reuse or repurposed application manufacturers should understand their process capabilities and should institute the necessary process controls as they relate to the reuse or repurposed product's safety.

The following are recommended for reuse or repurposed application manufacturers:

– knowledge about original battery and its current state (including confirmation of original battery certification status);
– having sufficient skills (certified, job-specific);
– having professional tools and equipment;
– knowledge about production and remanufacturing processes;
– having test equipment.

NOTE The documents included in Annex B provide useful information on reuse and repurposing which can be referred to once the contents of this document are fully understood.

9 Environmental options if reuse or repurposing is not possible

At an original application's end-of-life, reuse or repurposing should be considered in order to minimise adverse environmental impacts over the application's lifecycle. However, if approval in writing to reuse or repurpose cannot be reached between the original manufacturer and the reuse or repurposed application manufacturer, or if as a result of battery assessment, it has been determined that reuse or repurposing cannot be safely conducted, local regulations as to the recycling of waste batteries can apply.

When economically feasible and determined by LCA to have a lesser environmental impact than the use of virgin materials, recycled battery materials should be reutilised in the manufacture of new cells and batteries.