21/1155/CDV

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IEC TC 21 : SECONDARY CELLS AND BATTERIES	
SECRETARIAT: France	SECRETARY: Mr Yves Boudou
OF INTEREST TO THE FOLLOWING COMMITTEES: SC 21A,TC 120	PROPOSED HORIZONTAL STANDARD: ☐ Other TC/SCs are requested to indicate their interest, if any, in this CDV to the secretary.
FUNCTIONS CONCERNED: ☐ EMC ☐ ENVIRONMENT ☐ QUALITY ASSURANCE ☒ SAFETY	
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TITLE:

Requirements for reuse of secondary batteries

PROPOSED STABILITY DATE: 2027

NOTE FROM TC/SC OFFICERS:

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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General requirements for repurposing of secondary batteries

FOREWORD

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International Standard IEC 63330 has been prepared by IEC technical committee 21: Secondary cells and batteries.

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

FDIS	Report on voting
21/XX/FDIS	21/XX/RVD

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

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

100 • reconfirmed,
101 • withdrawn,
102 • replaced by a revised edition, or
103 • amended.
104

INTRODUCTION

Increasing concerns about the global warming, air quality and energy saving have been encouraging the utilization of rechargeable energy storage systems for different applications such as electric mobility. In parallel, technical advance in secondary batteries, especially in lithium-ion batteries, provides the market with practical option to repurpose the used batteries and battery systems that may maintain substantial performance even after the end of use of original equipment such as electric vehicle.

In order to foster such new business and to accelerate effective and safe utilization of energy source, it is indispensable to establish a basic international standard for evaluation of safety and performance of used batteries and battery systems, which derive from different equipment with different histories, and will be repurposed for different applications.

This document intends to provide basic requirements and procedure how to evaluate the performance and safety of used batteries and battery systems, and also provide general requirements for application of repurposed batteries.

General requirements for repurposing of secondary batteries

1 Scope

This document provides general requirements for repurposing of secondary cells, modules, battery packs and battery systems, herein also referred to as "PRODUCT", that are originally manufactured for other applications such as electric vehicles.

This document specifies the procedure to evaluate the performance and safety of used PRODUCT for repurposing.

This document also provides basic requirements for application of repurposed PRODUCT.

This document targets secondary lithium PRODUCT mainly, but not exclusively.

The redox flow batteries are not covered by this document.

NOTE - General guidance for reuse of secondary lithium cells and batteries is provided in IEC 63338 (under development).

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 terminological databases for use in standardization at the following addresses:

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

3.1
repurposing
operation by which PRODUCT that are not waste are used again in a different application to when first placed on the market

Note 1 to entry: In this document, PRODUCT is cell, battery, module, battery pack and battery system.

Note 2 to entry: The repurposing in this document includes usage of used battery for the same type of purpose as original equipment, with change of battery pack composition.

Note 3 to entry: Alternative common terms for repurposing include "second use" and "second life".

3.2
secondary cell
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

3.3
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) and monitoring circuitry

[SOURCE: IEC 62619: 202x, 3.10]

3.4
battery pack
energy storage device, which is comprised of 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: It may incorporate a protective housing and be provided with terminals or other interconnection arrangements.

[SOURCE: IEC 62619: 202x, 3.10]

3.5
battery system
system which comprises one or more cells, modules or battery packs and has a battery management system capable of controlling current in case of overcharge, overcurrent, overdischarge, and overheating

Note 1 to entry: The battery system may have cooling or heating units. More than one battery systems may constitute a larger battery system. The battery system is sometimes also referred to as a battery.

[SOURCE: IEC 62619: 202x, 3.11, modified - The second preferred term and Note 1 have been deleted.]

3.6
battery management system
BMS
electronic system associated of a battery which has functions to control current in case of overcharge, overcurrent, overdischarge, and overheating and which monitors and/or manages its state, calculates secondary data, reports that data and/or controls its environment to influence the battery's safety, performance and/or service life

Note 1 to entry: Overdischarge cut off is not mandatory.

Note 2 to entry: The function of the BMS can be assigned to the battery pack or to equipment that uses the battery.

Note 3 to entry: The BMS can be divided and it can be found partially in the battery pack and partially on the equipment that uses the battery.

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

[SOURCE: IEC 62619: 202x, 3.12, modified - Note 1 to Note 3 have been modified.]

3.7
rated capacity
C_n
capacity value of a cell or battery in ampere hour (Ah) determined under specified conditions and declared by the cell manufacturer

3.8
state of charge
SOC
capacity in a battery expressed as a percentage of rated capacity

3.9
operating region
conditions during charging and discharging in which the cell operates within the range of voltage, current and temperature as specified by the cell manufacturer to ensure the safe use of the cell

Note 1 to entry: The limits of the operating region are specified for the minimum safety, and different from the charging voltage and temperature to optimize the performance of the cell such as cycle life.

3.10
operating range
conditions during charging and discharging in which the battery system operates within the range of voltage, current and temperature as specified by the system manufacturer to ensure the safe use of the battery system

Note 1 to entry: Figure B.2 shows the relation between the operating range and the operating region.

3.11
safety design
battery design to avoid or control systematic failures and to detect or control random hardware failures, or mitigate their harmful effects

3.12
systematic failure
failure related in a deterministic way to a certain cause, that can only be eliminated by a change of the design or of the manufacturing process, operational procedures, documentation or other relevant factors

3.13
random hardware failure
failure that can occur unpredictably during the lifetime of battery and that follows a probability distribution

3.14
failure
termination of an intended behavior of battery due to a fault manifestation

3.15
fault
abnormal condition that can cause battery to fail

3.16
service life
total period of useful life of PRODUCT in operation which is specified for original usage

Note 1 to entry - For secondary cells and batteries, the service life may be expressed in time, number of charge/discharge cycles, capacity in ampere hours (Ah) and operating conditions (temperature range, C rate, depth of discharge, etc.).

Note 2 to entry - The service life does not equal the guarantee or warrantee period provided by the original manufacturer.

Note 3 to entry - The service life is not clearly specified for vehicle propulsion application.

[SOURCE: IEC 60050-482:2004, 482-03-46, modified]

3.17
residual usable period
remaining period of service life or estimated remaining period of useful life of battery in operation

3.18
usable period for repurposing
period usable in secondary application specified by designer of system with repurposed PRODUCT

3.19
basic system design
design of repurposed PRODUCT in order to use repurposed PRODUCT safely in system or subsystem for energy storage

4 General requirements

4.1 Structure of repurposing

Typical structure for repurposing of PRODUCT is shown in Figure 1. In this document, requirements for the following phases are specified:

– removal of PRODUCT from original equipment
– inspection and assessment of used PRODUCT
– storage of PRODUCT to be repurposed
– basic system design using repurposed PRODUCT

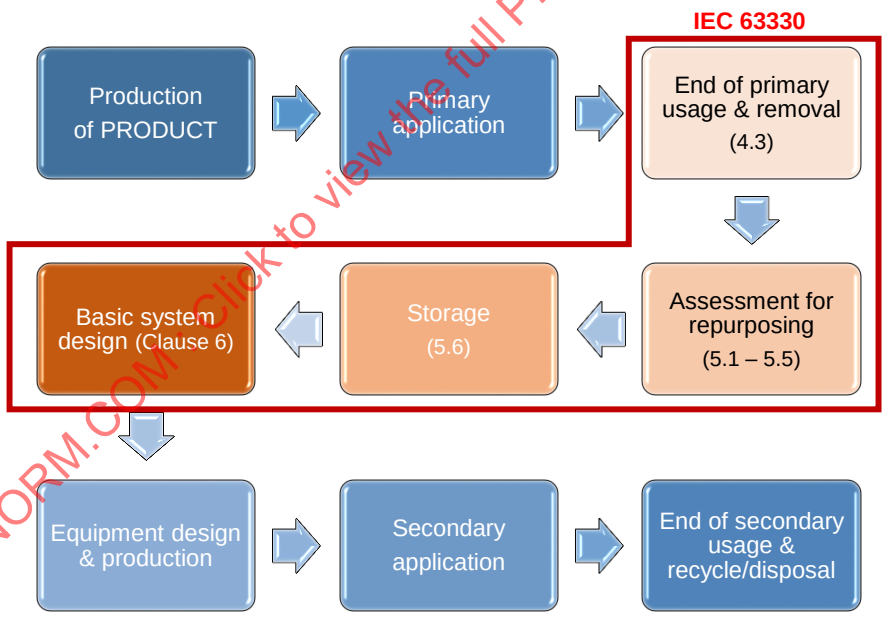
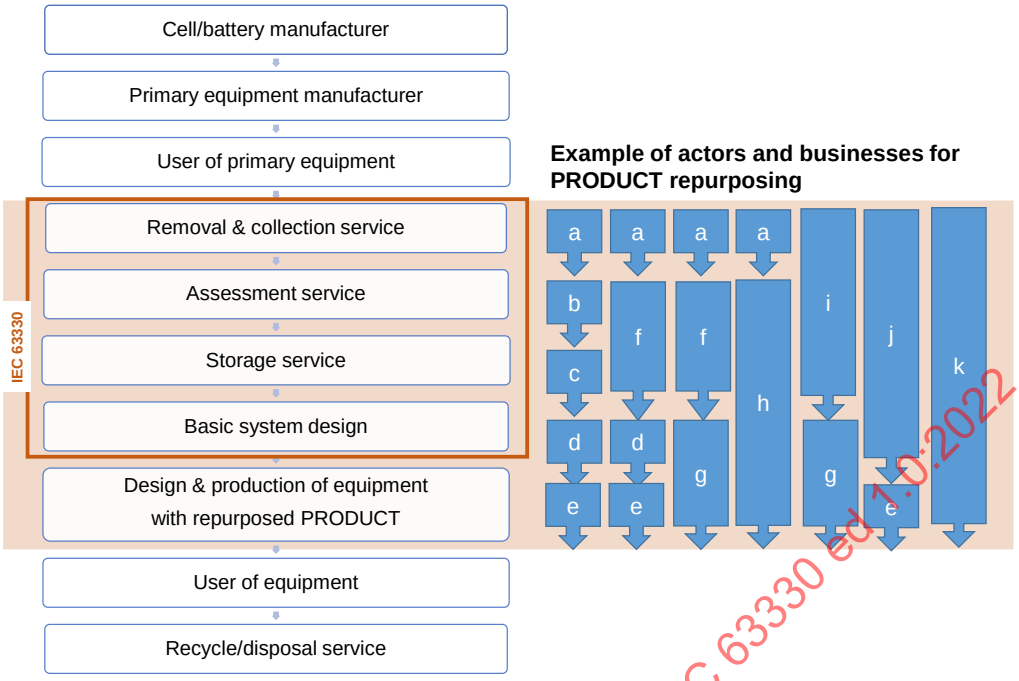


Figure 1 – Typical structure of PRODUCT repurposing

Figure 2 shows examples of actors for PRODUCT repurposing.



Key

a - k actors per business

Figure 2 – Example of actors for PRODUCT repurposing

This document may be applied for the PRODUCT that is repurposed after the second use. If the PRODUCT is repurposed for multiple times, all the data on primary usage (Table 1) and subsequent usage(s) shall be assessed.

NOTE - For specific requirements for electrical energy storage (EES) systems using reused battery, see IEC 62933-4-4 (under development) and IEC 62933-5-3 (under development).

4.2 Relevant data

Data required for repurposing of PRODUCT are as follows:

1) basic information
– manufacturer of original equipment
– chemistry
– manufacture year and month
– serial number, if available
– battery pack dismantling safety procedure

2) data on primary usage
– operating range
– history of failure
– residual performance
– residual usable period at the end of primary usage
– storage

NOTE - If the PRODUCT is repaired according to the specification by the manufacturer, relevant data should be provided.

3) data for designing system with repurposing PRODUCT

- operating range
- usable period for repurposing
- performance design
- safety design

Annex A provides example of data templates to be used for collection and management of data from1) to 3).

4.3 Removal of used PRODUCT and external damage check

Used PRODUCT shall be removed from the original equipment as instructed in a dismantle or disassembly manual issued by the original equipment manufacturer. If such instructions are not available, relevant local rules or standards shall be applied with special caution for high voltage hazards. The removal of battery systems may result in harm if adequate precautions are not taken. The removal should only be performed by qualified and experienced persons using adequate protection.

For PRODUCT from an electric vehicle application, it is recommended to obtain the data on usage and failure before removal from the vehicle using e.g. vehicle diagnostic device.

After removal from original equipment, the PRODUCT shall be checked externally as follows:

- Make sure there is no leakage of electrolyte by visual confirmation or by using an odor sensor. If fluid leakage is detected in liquid cooled battery pack, the PRODUCT shall be identified as damaged unless coolant leakage or water ingress.

Used PRODUCT with external damage, e.g. severe deformation, crack or blemish in the outer case of the PRODUCT, shall not be repurposed, and are recommended to be recycled or disposed according to relevant laws or regulations.

Used PRODUCT without external damage shall be assessed for feasibility of repurposing according to Clause 5.

If available and not damaged, the module and BMS of battery packs and systems may be reused even if the battery pack/system has a damaged outer case. Degree of damage and, if possible, cause of damage of outer case shall be recorded.

5 Diagnosis and assessment of used PRODUCT

5.1 General

The diagnosis and assessment of used PRODUCT for feasibility of repurposing and applicability to specific equipment shall be made according to the data on primary usage in Table 1. The data in Table 1 are indispensable to ensure the safety and performance of used PRODUCT for repurposing. If the data in Table 1 are not available, the PRODUCT shall not be repurposed.

The other data, for example, insulation resistance, EMC, operating region of cell, may be assessed according to the agreement of the data provider, if indispensable for a specific application of repurposing.

NOTE The data provider is original equipment manufacturer, cell/battery manufacturer, or administrator of relevant data.

335 **Table 1 - Data on primary usage for repurposing assessment**

Clause of this document	Data on primary usage
5.2	Data on operating range
5.3	Data on history of failure
5.4	Data on residual performance
5.5	Data on residual usable period at the end of primary usage
5.6	Data on storage

336 ## 5.2 Operating range

337 The operating range of PRODUCT for primary usage shall be confirmed.

338 The data on operating range shall include the following:

339 – upper limit operating temperature
340 – lower limit operating temperature
341 – upper limit charging voltage
342 – lower limit discharging voltage
343 – maximum charging current
344 – maximum discharging current

345 The operating region of cell shall be confirmed, if necessary.

346 ## 5.3 History of failure of primary equipment

347 Used PRODUCT with one or more of the following failure data shall not be repurposed:

348 – overcharge
349 – overdischarge
350 – overcurrent
351 – overtemperature
352 – insulation failure
353 – accident

354 The other data may be assessed according to the agreement of data provider, if
355 indispensable for specific application of repurposing.

356 When the failure is limited to an insulation failure, the PRODUCT may be repurposed provided
357 that there is no evidence of water exposure, and the insulation resistance is higher than the
358 specified value.

359 When the failure data is limited to an accident, the PRODUCT may be repurposed provided
360 that there is no evidence of external or internal damage.

361 NOTE The history of accident can be confirmed, e.g. for electric vehicle, by incident data in electronic control unit,
362 such as history of high voltage cutoff.

363 ## 5.4 Residual performance

364 The actual capacity of used PRODUCT shall be measured according to e.g. standards
365 applicable to the primary equipment. The measuring method shall be recorded. The

366 measuring conditions include charging condition (upper and lower voltage, charge current and
367 charging time), discharge current, cut-off voltage, and temperature.

368 The actual capacity of PRODUCT of electric vehicle application may be obtained through an
369 on-board PRODUCT performance indicating function, before removal from the vehicle.

370 NOTE - Additional parameters may be measured or obtained in order to specify the residual performance including
371 resistance, power, energy efficiency, self-discharge rate, spread in cell voltage, etc. according to standards or
372 other documents applicable to the primary equipment.

373 ### 5.5 Residual usable period at the end of primary usage

374 The residual usable period of used PRODUCT shall be assessed:

375 – according to the estimated usable period specified by the original equipment manufacturer
376 after deduction of age of service of the primary equipment, or;
377 – according to the age of service and history of primary usage.

378 NOTE - The history of primary usage includes, for example, data on remaining life of contactors and residual
379 capacity.

380 If the used PRODUCT have been stored after the primary usage and before application to a
381 new equipment, the period of such storage shall also be deducted from the usable period.

382 ### 5.6 Storage

383 The PRODUCT for repurposing shall be stored under controlled conditions until the
384 application to equipment.

385 The PRODUCT in storage shall:

386 – be kept dry;
387 – be kept away from heat and fire;
388 – be kept away from direct sunlight;
389 – be kept away from high temperature;
390 – not be dropped and stepped.

391 The PRODUCT shall not be repurposed, if the storage data are not available. The following
392 storage data shall be recorded:

393 – SOC or voltage of PRODUCT at the beginning of storage
394 – ambient temperature of storage
395 – period and beginning date of storage

396 If the SOC or voltage after the storage is below the lower limit of operating range of
397 equipment for secondary use, the PRODUCT shall not be repurposed.

398 ## 6 Requirements for application of repurposed PRODUCT

399 ### 6.1 General

400 The applicability of repurposed PRODUCT to an equipment shall be determined according to
401 the data in Clause 5, and the specifications required by the equipment to be applied.

402 The following shall be evaluated for each application and for each PRODUCT.

403 – operating range

– safety
– performance
– usable period for repurposing

Table 2 shows the guidance of reference clauses depending on system designs with used PRODUCT.

If the repurposed PRODUCT is used without change in system design under the environmental and usage conditions with the load not exceeding that of the original equipment, the safety design, performance design and residual usage period of the primary usage can be applied.

If the system design is changed from the primary usage, the safety design, performance design and usable period shall be proved and assessed for repurposing.

NOTE 1 - The environmental and usage conditions include:

- installation environment;
- ambient temperature;
- humidity;
- dust;
- vibration;
- high power (kW) and high frequency charge/discharge;
- cell fixing condition inside module, etc.

Table 2 - Reference clauses for repurposed PRODUCT applications

System design		Safety design	Performance design	Usable period
Hardware design	Software design			
Change from primary usage? No / Yes	Change from primary usage? No / Yes	Safety design of primary usage applicable (6.3)	Performance design of primary usage applicable (6.4)	Usable period of primary usage applicable (6.5)
		Safety design for repurposing to be proved (B.3)	Performance design for repurposing to be proved (B.4)	Usable period for repurposing to be determined (B.5)

NOTE 2 - An example for cases where system design change is not required is that PRODUCT was originally designed considering some specific secondary usages. Examples of the systems with design change from the original equipment are as follows:

– stationary energy storage system next renewable source of energy (photovoltaic, wind)
– optimization of electricity consumption by industrial/trade offices
– service solution for grid support
– other applications like powerwalls, EV fast charging stations

6.2 Operating range

System applying the repurposed PRODUCT should be designed to be used within the operating range of the PRODUCT for primary usage (see 5.2).

The operating range of repurposing PRODUCT shall include the following:

– upper limit operating temperature
– lower limit operating temperature
– upper limit charging voltage
– lower limit discharging voltage
– maximum charging current
– maximum discharging current

For the operating range of used PRODUCT of which the system design is changed, see B.2.

6.3 Safety design

Safety of repurposed PRODUCT shall be assessed and secured according to the data on primary usage as specified in Clause 5 and safety design of system applying the repurposing PRODUCT.

If the age of service of the PRODUCT at the end of primary usage goes beyond the service life or if the service life is not specified, the safety of repurposed PRODUCT shall be determined according to the assessment of age of service and history of primary usage.

NOTE - Aging of the PRODUCT can incur unstable electrode condition and leakage of electrolyte due to decrease of airtightness, and can cause hazardous events.

The PRODUCT is designed as a system including BMS to secure the safety of primary equipment. If the PRODUCT is repurposed without change from originally designed system, and within the operating range and under the environmental and usage conditions with the load not exceeding that of the original equipment, the safety design of the battery system is maintained.

For used PRODUCT of which the system design is changed from primary usage, and when the safety design of original equipment is not applicable, see B.3.

6.4 Performance design

The PRODUCT is designed to ensure the required performance of primary equipment. If the PRODUCT is repurposed without change from originally designed system, within the operating range of original equipment, and to be used at the environmental and usage conditions with the load not exceeding that of the original equipment, the performance design of the battery system is maintained.

NOTE - The usage environment includes installation environment, ambient temperature, humidity and charging/discharging cycles.

The performance includes, e.g.:

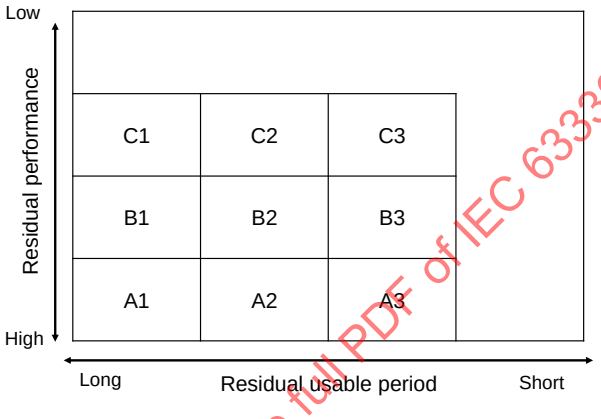
a) capacity
b) resistance
c) power
d) energy efficiency
e) self-discharge
f) others

The repurposed PRODUCT shall have performance required by the equipment to be applied. The residual performance of used PRODUCT is as specified in 5.4.

The performance of repurposed PRODUCT may be remeasured according to relevant standard for equipment to be applied.

Required performance of repurposed PRODUCT depends on the applications. For the same application, the PRODUCT with the same level of residual performance and usable period should be used. The PRODUCT with different level of performance may be used for the same application if the safety of system is confirmed according to 6.3.

Figure 3 shows an example of classification according to the residual performance level and usable period, which can be used to evaluate the homogeneity of repurposed PRODUCT. The PRODUCT classified as A1 group, for example, has relatively long usable period and high performance, and may be used for system which require the PRODUCT with relatively high specifications.



Key

A1 - A3, B1 - B3, C1-C3 example classification of repurposed PRODUCT per performance and usable period

Figure 3 – Example of classification of repurposed PRODUCT

The residual performance level of the repurposed PRODUCT in Figure 3 can be classified by some performance criteria such as capacity, resistance, average cell balancing mismatch, etc. Table 3 shows an example of a sorting method using the performance level. In this method, the worst criterion level determines the bin, for example, a PRODUCT with capacity level A_c1, resistance level A_r2 and average cell balancing mismatch level A_b1 goes into bin A2.

Table 3 - Example of classification of repurposed PRODUCT by performance level

Performance level						Bin
Residual capacity ratio (Ah/Ah %)		Internal resistance ratio (Ω/Ω %)		Average cell balancing mismatch (mV)		
range of value	level	range of value	level	range of value	level	
100 - a	A_c1	100 - a'	A_r1	0 - a''	A_b1	A1
a - b	A_c2	a' - b'	A_r2	a'' - b''	A_b2	A2
b - c	B_c1	b' - c'	B_r1	b'' - c''	B_b1	B1
c - d	B_c2	c' - d'	B_r1	b'' - c''	B_b1	B2
< d	C_c	> d' %	C	> c''	C	Recycling

For used PRODUCT of which the system design is changed from the primary usage, and when the performance design of original equipment is not applicable, see B.4.

6.5 Usable period for repurposing

System applying repurposed PRODUCT shall be designed according to the residual usable period of PRODUCT as specified in 5.5.

The usable period for repurposing depends on the design, operating range, environmental and usage conditions and purpose of equipment applying the repurposed PRODUCT. If the PRODUCT are repurposed without change from originally designed system, and within the operating range and under the environmental and usage conditions with the load not exceeding that of the original equipment, the usable period for repurposing is equal to the residual usable period.

When the environmental and usage conditions of equipment applying the repurposing PRODUCT are different from those of the primary equipment, the usable period shall be determined taking those differences into consideration.

The SOC window should be considered and can be reduced.

Usable period of PRODUCT peripherals such as BMS, contactor and fuse shall also be assessed.

For used PRODUCT of which the system design is changed from the primary usage, and when the residual usable period of original equipment is not applicable, see B.5.

Annex A
(informative)

Example of data templates

This annex provides example of templates for the data specified in Clause 4, 5 and 6. Table A.1 shows an example of template for data on PRODUCT that are required for repurposing. Table A.2 provides an example of template for data to be used for application of repurposed PRODUCT.

Table A.1 – Example of template for data on PRODUCT to be repurposed

Item		Data on PRODUCT to be repurposed			
Manufacturer					
Chemistry					
Model & Type					
Manufacture year and month					
Serial number (if available)					
Battery pack dismantling safety procedure					
Operating range of primary usage					
	Temperature	upper limit		lower limit	
	Voltage	upper limit		lower limit	
	Current	upper limit		lower limit	
History of failure		☐ No overcharge ☐ No overdischarge ☐ No overcurrent ☐ No overtemperature ☐ No insulation failure ☐ No accident			
History of usage, if available		☐ Charging history not exceeding the specified operating range ☐ Discharging history not exceeding the specified operating range			
Actual capacity					
Age of service					
Estimated usable period (if available)					
Storage					
	SOC or voltage at the beginning of storage				
	Ambient temperature of storage				
	Period and beginning date of storage				

525

526 **Table A.2 – Example of template for data on application of repurposed PRODUCT**

Item		Data on application of repurposed PRODUCT			
Operating range of repurposed PRODUCT					
	Temperature	upper limit		lower limit	
	Voltage	upper limit		lower limit	
	Current	upper limit		lower limit	
Capacity					
Estimated usable period					
Safety design		☐ The safety design of original equipment is applicable. ☐ The safety design of system with used PRODUCT is applicable.			
Classification (if any)					
Applicable equipment					

527