IEC 60086-4

Edition 6.0 2025-01

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Primary batteries –
Part 4: Safety of lithium batteries

Piles électriques –
Partie 4: Sécurité des piles au lithium

IEC 60086-4:2025-01 (en-fr)

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CONTENTS

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PRIMARY BATTERIES –

Part 4: Safety of lithium batteries

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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IEC 60086-4 has been prepared by technical committee 35: Primary cells and batteries. It is an International Standard.

This sixth edition cancels and replaces the fifth edition published in 2019. This edition constitutes a technical revision.

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

a) Added definitions for leakage and venting, in addition to the test criteria;
b) Revised overdischarge test;
c) Revised marking requirements;
d) Revised criteria for the child resistant packaging test;
e) Changed the purpose of Annex F from "informative" to "normative";

f) Added a new Annex G with additional measures against misuse of batteries not intended for consumer replacement;

g) Integrated the contents of Interpretation Sheet 1 (IEC 60086-4:2019/ISH1:2020);

h) In Clause 3, terms were reordered according their functions: basic terms, electrochemical systems, battery shapes, battery sizes, electrical characteristics, specifications, safety aspects, failure modes;

i) In 6.4.4, the exemption for the shock acceleration for lithium primary batteries was reduced from 12 kg to 4,482 kg in order to reflect the fact that this is the threshold in IEC 62281, Test T-4, where the peak acceleration decreases below 150 g_n.

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

Draft	Report on voting
35/1571/FDIS	35/1579/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.

NOTE 1 The following print types are used:

– instructions/warnings for consumers: *in italic type.*

A list of all parts in the IEC 60086 series, under the general title *Primary batteries*, 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.

NOTE 2 The attention of National Committees is drawn to the fact that equipment manufacturers and testing organizations may need a transitional period following publication of a new, amended or revised IEC document in which to make products in accordance with the new requirements and to equip themselves for conducting new or revised tests. It is the recommendation of the committee that the content of this document be adopted for implementation nationally not earlier than 2 years from the date of publication. The transitional period applies specifically to changes in Table 10. In the meantime, the previous edition can still be ordered by contacting your local IEC member National Committee or the IEC Secretariat.

IMPORTANT – The "colour inside" logo on the cover page of this document indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

The concept of safety is closely related to safeguarding the integrity of people and property. This document specifies tests and requirements for lithium batteries and has been prepared in accordance with ISO/IEC guidelines, taking into account all relevant national and international standards which apply.

Lithium batteries are different from conventional primary batteries using aqueous electrolyte in that they contain flammable materials.

Consequently, it is important to carefully consider safety during design, production, distribution, use, and disposal of lithium batteries. Based on such special characteristics, lithium batteries for consumer applications were initially small in size and had low power output. There were also lithium batteries with high power output which were used for special industrial and military applications and were characterized as being "technician replaceable". The first edition of this document was drafted to accommodate this situation.

However, from around the end of the 1980s, lithium batteries with high power output started to be widely used in the consumer replacement market, mainly as a power source in camera applications. Since the demand for such lithium batteries with high power output significantly increased, various manufacturers started to produce these types of lithium batteries. As a consequence of this situation, the safety aspects for lithium batteries with high power output were included in the second edition of this document.

Primary lithium batteries both for consumer and industrial applications are well-established safe and reliable products in the market, which is at least partly due to the existence of safety standards such as this document and, for transport, IEC 62281. The fourth edition of this document reflected minor changes which became necessary in order to keep it harmonized with IEC 62281 and to continuously improve the user information about safety related matters.

Guidelines addressing safety issues during the design of lithium batteries are provided in Annex A. Annex B provides guidelines addressing safety issues during the design of equipment where lithium batteries are installed. Both Annex A and Annex B reflect experience with lithium batteries used in camera applications and are based on [22][1].

The ingestion hazard of coin cell batteries has become an issue and was addressed in the fifth and sixth editions of this document by several independent measures such as the development of a new safety sign "KEEP OUT OF REACH OF CHILDREN" as well as the introduction of child resistant packaging.

A new Annex G addresses measures against misuse of cells and batteries not intended for consumer replacement.

Safety is freedom from unacceptable risk. There can be no absolute safety: some risk will remain. Therefore a product, process or service can only be relatively safe. Safety is achieved by reducing risk to a tolerable level determined by the search for an optimal balance between the ideal of absolute safety and the demands to be met by a product, process or service, and factors such as benefit to the user, suitability for purpose, cost effectiveness, and conventions of the society concerned.

As safety will pose different problems, it is impossible to provide a set of precise provisions and recommendations that will apply in every case. However, this document, when followed on a judicious "use when applicable" basis, will provide reasonably consistent standards for safety.

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1 Numbers in square brackets refer to the Bibliography.

PRIMARY BATTERIES –

Part 4: Safety of lithium batteries

1 Scope

This part of IEC 60086 specifies tests and requirements for primary lithium batteries to ensure their safe operation under intended use and reasonably foreseeable misuse.

NOTE Primary lithium batteries that are standardized in IEC 60086-2 are expected to meet all applicable requirements herein. It is understood that consideration of this part of IEC 60086 might also be given to measuring and/or ensuring the safety of non-standardized primary lithium batteries. In either case, no claim or warranty is made that compliance or non-compliance with this part of IEC 60086 will fulfil or not fulfil any of the user's particular purposes or needs.

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 60086-1:2021, *Primary batteries – Part 1: General*

IEC 60086-2, *Primary batteries – Part 2: Physical and electrical specifications*

IEC 62281, *Safety of primary and secondary lithium cells and batteries during transport*

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

NOTE Certain definitions taken from IEC 60050-482, IEC 60086-1, and ISO/IEC Guide 51 are repeated below for convenience.

3.1
cell
basic functional unit, consisting of an assembly of electrodes, electrolyte, container, terminals and usually separators, that is a source of electric energy obtained by direct conversion of chemical energy

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

3.2
battery
one or more cells electrically connected and fitted in a case, with terminals, markings and protective devices etc., as necessary for use

[SOURCE: IEC 60050-482:2004, 482-01-04, modified – "fitted with devices necessary for use, for example case" replaced by "electrically connected and fitted in a case", addition of "etc., as necessary for use".]

3.3
component cell
cell contained in a battery

3.4
lithium cell
cell containing a non-aqueous electrolyte and a negative electrode of lithium or containing lithium

[SOURCE: IEC 60050-482:2004 482-01-06, modified – removal of Note.]

3.5
coin cell
coin battery
lithium button cell
lithium button battery
small round cell or battery where the overall height is less than the diameter, containing non-aqueous electrolyte.

Note 1 to entry: The nominal voltage of lithium batteries is typically greater than 2 V. See also the definition of "button cell" in IEC 60086-5

Note 2 to entry: See 7.3 for proposed use of the alternative terms.

Note 3 to entry: The terms "lithium button cell" and "lithium button battery" were provided as alternative terms for "coin cell" and "coin battery" in order to prevent the use of the terms "button cell" and "button battery" which would be confusing as they have a different meaning, see part 1 of this standard.

Consequently, the terms "coin cell" and "coin battery" should be omitted in those languages where they have no meaningful literal equivalent.

[SOURCE: IEC 60050-482:2004 482-02-40, modified – terms modified, Note replaced.]

3.6
cylindrical cell
cylindrical battery
round cell or battery in which the overall height is equal to or greater than the diameter

[SOURCE: IEC 60050-482:2004, 482-02-39, modified – "cell with a cylindrical shape" replaced by "round cell or battery".]

3.7
prismatic cell
prismatic battery
cell or battery having the shape of a parallelepiped whose faces are rectangular

[SOURCE: IEC 60050-482:2004, 482-02-38]

3.8
large cell
cell with a gross mass of more than 500 g

3.9
large battery
battery with a gross mass of more than 12 kg

3.10
nominal voltage
suitable approximate value of the voltage used to designate or identify a cell, a battery or an electrochemical system

[SOURCE: IEC 60050-482:2004, 482-03-31]

3.11
open circuit voltage
OCV, U_{OC}, off-load voltage
voltage across the terminals of a cell or battery when no external current is flowing

[SOURCE: IEC 60050-482:2004, 482-03-32, modified – alternative terms "OCV, U_{OC}, off-load voltage" added, "across the terminals" added, "when the discharge current is zero" replaced with "when no external current is flowing".]

3.12
rated capacity
capacity value of a cell or battery determined under specified conditions and declared by the manufacturer

[SOURCE: IEC 60050-482:2004, 482-03-15, modified – "cell or" added.]

3.13
depth of discharge
DOD
percentage of rated capacity discharged from a cell or battery

3.14
undischarged
state of a primary cell or battery at 0 % depth of discharge

3.15
fully discharged
state of a cell or battery at 100 % depth of discharge

3.16
harm
injury or damage to the health of people, or damage to property or the environment

[SOURCE: ISO/IEC Guide 51:2014, 3.1]

3.17
hazard
potential source of harm

[SOURCE: ISO/IEC Guide 51:2014, 3.2]

3.18
risk
combination of the probability of occurrence of harm and the severity of that harm

[SOURCE: ISO/IEC Guide 51:2014, 3.9, modified – removal of Note.]

3.19
safety
freedom from risk which is not tolerable

[SOURCE: ISO/IEC Guide 51:2014, 3.14]

3.20
intended use
use in accordance with information provided with a product or system, or, in the absence of such information, by generally understood patterns of usage

[SOURCE: ISO/IEC Guide 51:2014, 3.6]

3.21
reasonably foreseeable misuse
use of a product, process or system in a way not intended by the supplier, but which may result from readily predictable human behaviour

[SOURCE: ISO/IEC Guide 51:2014, 3.7, modified – removal of Notes.]

3.22
protective devices
devices such as fuses, diodes or other electric or electronic current limiters designed to interrupt the current flow, block the current flow in one direction or limit the current flow in an electrical circuit

3.23
leakage
unplanned escape of electrolyte, gas or other material from a cell or battery

Note 1 to entry: Leakage in this sense should not be confused with the test evaluation criteria for leakage specified in Clause 6.

3.24
venting
release of excessive internal pressure from a cell or battery in a manner intended by design

Note 1 to entry: Venting in this sense should not be confused with the test evaluation criteria for venting specified in Clause 6.

4 Requirements for safety

4.1 Design

Lithium batteries are categorized by their chemical composition (anode, cathode, electrolyte), internal construction (bobbin, spiral) and are available in cylindrical, coin and prismatic configurations. It is necessary to consider all relevant safety aspects at the battery design stage, recognizing the fact that they can differ considerably, depending on the specific lithium system, power capability and battery configuration.

The following design concepts for safety are common to all lithium batteries:

a) Abnormal temperature rise above the critical value defined by the manufacturer shall be prevented by design.
b) Temperature increases in the battery shall be controlled by a design which limits current flow.
c) Lithium cells and batteries shall be designed to relieve excessive internal pressure or to preclude a violent rupture under conditions of transport, intended use and reasonably foreseeable misuse.

If, in particular cases, this design concept cannot be implemented, the organisational requirements described in Annex G shall apply.

See Annex A for guidelines for the achievement of safety of lithium batteries.

4.2 Quality plan

The manufacturer shall prepare and implement a quality plan defining the procedures for the inspection of materials, components, cells and batteries during the course of manufacture, to be applied to the total process of producing a specific type of battery. Manufacturers should understand their process capabilities and should institute the necessary process controls as they relate to product safety.

5 Type testing and sampling

5.1 Validity of testing

Lithium cells or batteries shall be subjected to the tests, as required in this document. Testing remains valid until a design change or requirement revision has been made. Retesting is required when:

a) a battery specification changes by more than 0,1 g or 20 % mass, whichever is greater, for the cathode, anode or electrolyte;

b) a battery specification change would lead to a failure of any of the tests;
c) there is an addition of new tests or requirements; or
d) there is a requirement change that would lead to a failure of any of the tests.

5.2 Test samples

Samples should be drawn from production lots in accordance with accepted statistical methods. The number of test samples is given in Table 1. The same test cells and batteries are used for tests A to E in sequence. New test cells and batteries are required for each of tests F to M.