INTERNATIONAL STANDARD

IEC 60086-4

Second edition
2000-03

Primary batteries –

Part 4:
Safety of lithium batteries

Piles électriques –

Partie 4:
Sécurité des piles au lithium

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For general terminology, readers are referred to IEC 60050: *International Electrotechnical Vocabulary* (IEV).

For graphical symbols, and letter symbols and signs approved by the IEC for general use, readers are referred to publications IEC 60027: *Letter symbols to be used in electrical technology*, IEC 60417: *Graphical symbols for use on equipment. Index, survey and compilation of the single sheets* and IEC 60617: *Graphical symbols for diagrams*.

* See web site address on title page.

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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PRIMARY BATTERIES –

Part 4: Safety of lithium batteries

FOREWORD

1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the 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, the IEC publishes International Standards. 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. The 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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3) The documents produced have the form of recommendations for international use and are published in the form of standards, technical specifications, technical reports or guides and they are accepted by the National Committees in that sense.
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6) Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. The IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 60086-4 has been prepared by IEC technical committee 35: Primary cells and batteries.

This second edition cancels and replaces the first edition, published in 1996, and constitutes a technical revision.

The text of this standard is based on the following documents:

FDIS	Report on voting
35/1114/FDIS	35/1125/RVD

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

This publication has been drafted in accordance with the ISO/IEC Directives, Part 3.

Annexes A, B and C are for information only.

IEC 60086 consists of the following parts, under the general title Primary batteries:

– Part 1: General
– Part 2: Specification sheets
– Part 3: Watch batteries
– Part 4: Safety of lithium batteries
– Part 5: Safety of batteries with aqueous electrolyte

The committee has decided that the contents of this publication will remain unchanged until 2002.

At this date the publication will be

- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

INTRODUCTION

The concept of safety is closely related to safeguarding the integrity of people and property. This standard specifies requirements and tests 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 take safety precautions very carefully 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 applications and were characterized as being “technician replaceable”.

The first edition of IEC 60086-4 (1996) was drafted to accommodate the above situation.

However, from around the end of the 1980s, lithium batteries with high power output have 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 has significantly increased in recent years, various manufacturers have started to produce these types of lithium batteries. As a consequence of this situation, the safety aspects for lithium batteries with high power output have been included in this second edition of IEC 60086-4.

Safety is a balance between freedom from hazard and other requirements to be met by the product. There can be no absolute safety. Even at the highest level of safety, the product can only be relatively safe. In this respect, decision-making is based on risk evaluation and safety judgement.

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 standard, when followed on a judicious “use when applicable” basis, will provide reasonably consistent standards for safety.

PRIMARY BATTERIES –

Part 4: Safety of lithium batteries

1 Scope

This International Standard specifies tests and requirements for primary lithium batteries to ensure their safe operation under intended use and reasonably foreseeable misuse.

2 Normative reference

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent edition of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 60086-1:1996, *Primary batteries – Part 1: General*

3 Definitions

For the purpose of this part of IEC 60086, the definitions given in IEC 60086-1 (some of which are repeated below for convenience) and the following definitions apply.

3.1
battery (primary)
one or more primary cells, including case, terminals and marking

3.2
button battery
small round battery, where the overall height is less than the diameter; batteries complying with IEC 60086-1, figures 2, 3 and 4

3.3
cell (primary)
a source of electrical energy obtained by the direct conversion of chemical energy, that is not designed to be charged by any other electrical source

3.4
consumer batteries
batteries readily available in the commercial retail market and that are considered user replaceable, i.e. replaceable without the need of special tools

3.5
cylindrical battery
primary battery with cylindrical geometry where the overall height is equal to or greater than the diameter; batteries complying with IEC 60086-1, figures 1A and 1B

3.6
depth of discharge (DOD)
percentage of rated capacity discharged from a battery

3.7
distortion
any change in physical dimensions exceeding 10 %

3.8
explosion, battery (battery explosion)
an instantaneous release wherein solid matter from any part of the battery is propelled to a distance greater than 25 cm away from the battery

3.9
fire
combustion of cell/battery components with emission of flame

3.10
harm
physical injury and/or damage to health or property

3.11
hazard
a potential source of harm

3.12
high power battery
a battery that can deliver most of its energy within a short time at ambient temperature

3.13
industrial batteries
batteries not normally available to the consumer. Such batteries are often referred to as "technician replaceable" because of the skill required for their handling and installation

3.14
intended use
the use of a product, process or service under conditions or for purposes in accordance with specifications and instructions provided by the supplier, including information for publicity purposes

3.15
leakage
unplanned escape of electrolyte, gas or other material from a battery

3.16
low power battery
a battery that cannot deliver most of its energy within a short time at ambient temperature

3.17
nominal voltage
a suitable approximate value of voltage used to identify the voltage of a primary battery

3.18
open circuit voltage (OCV)
voltage across the terminals of a battery when no external current is flowing

3.19
overheating
a condition when battery temperature rises above the temperature range specified by the manufacturer

3.20
prismatic battery
primary battery with non-round geometry; batteries not complying with 4.3 of IEC 60086-1

3.21
rated capacity
capacity of a battery determined under conditions specified in the relevant standard (if applicable) and declared by the manufacturer or supplier. Also sometimes referred to as nominal capacity

3.22
reasonably foreseeable misuse
the use of a product, process or service under conditions or for purposes not intended by the supplier, but which may happen, as a result of common human behaviour

3.23
risk
the probable rate of occurrence of a hazard causing harm and the degree of severity of the harm

3.24
safety
freedom from unacceptable risk of harm

3.25
venting
the release of excessive internal pressure from a battery in a manner intended by design to preclude explosion

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, button/coin, and prismatic configuration. It is necessary to consider all relevant safety aspects at the battery design stage, recognizing the fact that they may differ considerably, depending on the specific lithium system, power output 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) Batteries shall be designed to relieve excessive internal pressure (not applicable to low power industrial batteries).

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

4.2 Quality plan

The manufacturer shall prepare 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.

5 Sampling

Samples shall be taken randomly from production lots in accordance with accepted quality control procedures.

NOTE 1 Many tests in this standard require preliminary conditioning of the samples such as preliminary discharge or storage at elevated temperature.

NOTE 2 Details of sample size for type approval and conditioning are found in clause 6.

6 Testing and requirements

6.1 General

6.1.1 Safety notice

WARNING:

These tests call for the use of procedures which may result in injury if adequate precautions are not taken.

It has been assumed in the drafting of these tests that their execution is undertaken by appropriately qualified and experienced technicians using adequate protection.

6.1.2 Ambient temperature

Unless otherwise specified, the tests shall be carried out at (20 ± 5) °C.

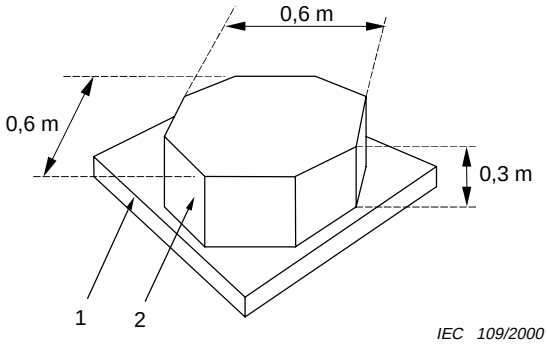
6.1.3 Explosion levels

In order to quantify the explosion as defined in 3.8, the following procedure is provided. The test battery is placed on the steel plate shown in figure 1. The mesh chamber is centred over the test battery. The test battery is then subjected to the relevant test procedure. The result shall be determined using the following two levels.

NE: battery does not explode.

NE2: battery explodes but ejected solid material does not pass through the mesh chamber specified in figure 1.

CAUTION
Avoid short-circuiting. For protection, the mesh chamber shall be in a place that is separated from the observer.



NOTE The figure shows an aluminium wire mesh chamber (2) of octagonal shape resting on a steel plate (1). The aluminium wire has a diameter of 0,25 mm. The mesh has 16 to 18 wires per 25,4 mm.

Figure 1 – Mesh chamber

6.1.4 Determination of weight loss

In order to quantify the weight loss referred to in table 2, the following procedure is provided.

$$\Delta W = \frac{W_1 - W_2}{W_1} \times 100\ \%$$

where

W_1 is the weight before the test;

W_2 is the weight after the test;

ΔW is the weight loss.

When weight loss does not exceed the values in table 1, it shall be considered as “no weight loss”.

Table 1 – Weight loss limits

Weight *W* of battery	Weight loss limit
$W \leq 1$ g	0,5 %
1 g < $W \leq 5$ g	0,2 %
$W > 5$ g	0,1 %

6.1.5 Predischarge

Where a test requires predischarge (25 %, 50 %, 75 % or 100 %), the test batteries shall be discharged to the respective depth of discharge with a resistive load with which the rated capacity is obtained or with a current specified by the manufacturer.

6.1.6 Additional batteries

Where additional batteries are required to perform a test, they shall be of the same type as the test battery.

Where additional batteries are required to perform a test, the total number n_i of batteries in series, including the test battery, shall be determined by calculating:

$$n = 12\ \text{V}/U_n$$

and determining n_i by rounding up n to the nearest decimal integer while $n_i \geq n_{min} = i$

where

U_n is the nominal voltage of one battery;

n_i is the total number of batteries;

n_{min} is the minimum number (2 or 3) of batteries given in the respective test description.

EXAMPLE 1 Let the minimum number of batteries be given as $n_{min} = 2$ and let the test battery have a nominal voltage $U_n = 3{,}6$ V. Calculate $n = 3\frac{1}{3}$ and determine $n_2 = 4$.

EXAMPLE 2 Let the minimum number of batteries be given as $n_{min} = 3$ and let the test battery have a nominal voltage $U_n = 10$ V. Calculate $n = 1{,}2$ and determine $n_3 = 3$.

6.2 Intended use

6.2.1 Sampling, test sequence and requirements

Figure 2 gives an overview of the test sequence and samples to be taken for intended use tests while table 2 contains the requirements.