IEC 60086-4

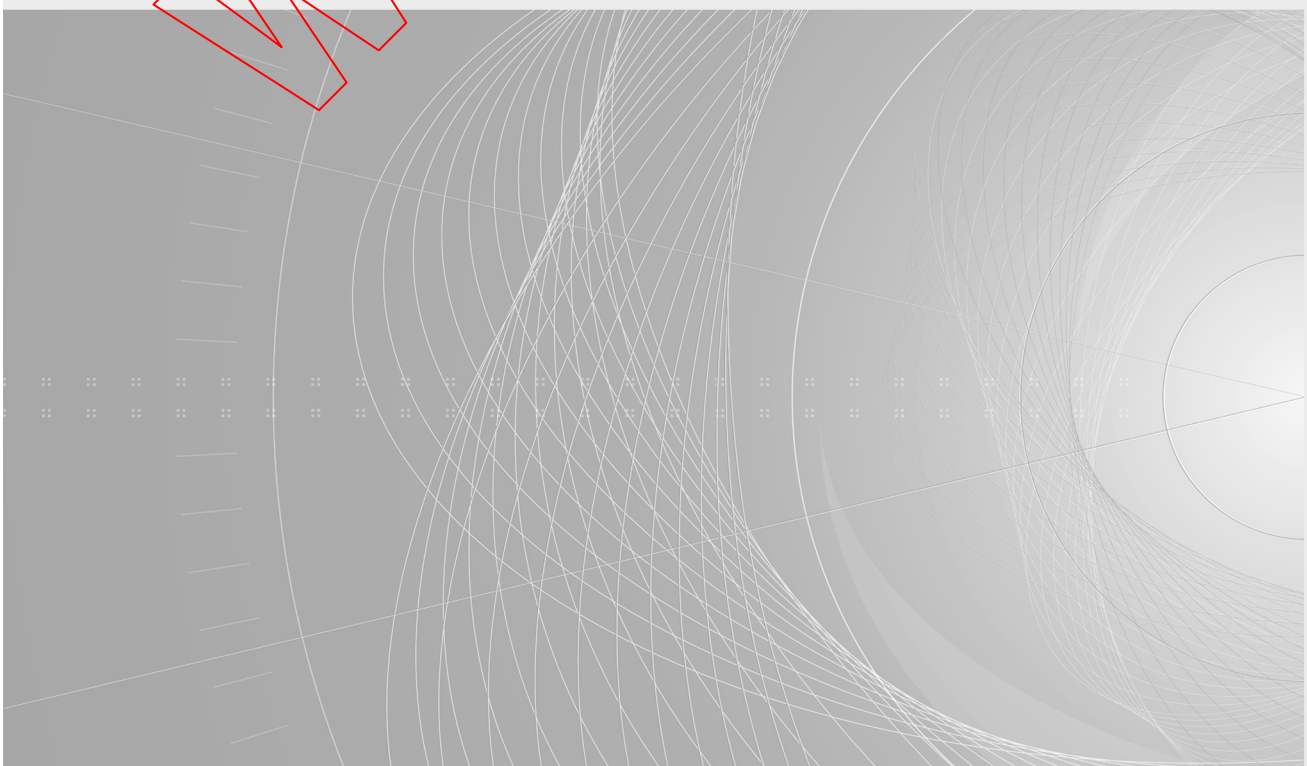
Edition 3.0 2007-09

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Primary batteries –
Part 4: Safety of lithium batteries

Piles électriques –
Partie 4: Sécurité des piles au lithium



IEC 60086-4:2007

IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland
Email: inmail@iec.ch
Web: www.iec.ch

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Email: csc@iec.ch
Tél.: +41 22 919 02 11
Fax: +41 22 919 03 00

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PRIMARY BATTERIES –

Part 4: Safety of lithium batteries

FOREWORD

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

This third edition cancels and replaces the second edition published in 2000. It is the result of a reformatting initiative aimed at making this part more user-friendly, less ambiguous and, from a cross-reference point of view, fully harmonized with other parts of IEC 60086.

The major technical changes, with regard to the previous edition, concern:

a) Harmonisation with IEC 62281 [11][1]
b) The tests were renumbered and partly revised or deleted. One test (F: Impact) was added for compliance with IEC 62281. The table shows the old and new test numbers as well as tests that were added. The test number in brackets indicates major changes of the test procedure.

[1] Figures in square brackets refer to the Bibliography.

Old	New	Test designation
C-3	A	Altitude
(C-1)	B	Thermal cycling
B-1	C	Vibration
B-2	D	Shock
D-1	E	External short circuit
	F	Impact
E-2	G	Crush
	H	Forced discharge
D-4	I	Abnormal charging
E-1	J	Free fall
F-1	K	Thermal abuse
D-3	L	Incorrect installation
D-6	M	Overdischarge

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

CDV	Report on voting
35/1240/CDV	35/1250/RVC

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 2.

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 publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

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- withdrawn;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

INTRODUCTION

The concept of safety is closely related to safeguarding the integrity of people and property. This standard 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 standard 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 standard.

The major target of the third edition of this standard was to harmonize it with the transport tests for lithium batteries that were published in IEC 62281 [11].

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 B reflect experience with lithium batteries used in camera applications and are based on document[18] of the bibliography.

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 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 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 standard will fulfil or not fulfil any of the user's particular purposes or needs.

2 Normative references

The following referenced documents are indispensable for the application 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, *Primary batteries – Part 1: General*

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

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

NOTE Certain definitions taken from IEC 60050-482 and IEC 60086-1 are repeated below for convenience.

3.1
aggregate lithium content
total lithium content of the cells comprising a battery

3.2
battery
one or more cells fitted with devices necessary for use, for example case, terminals, marking and protective devices

[IEV 482-01-04:2004]

3.3
button cell
coin cell
cell with a cylindrical shape in which the overall height is less than the diameter, e.g. in the shape of a button or a coin

[IEV 482-02-40:2004]

3.4
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

[IEV 482-01-01:2004]

3.5
component cell
cell contained in a battery

3.6
cylindrical cell
cell with a cylindrical shape in which the overall height is equal to or greater than the diameter
[IEV 482-02-39:2004]

3.7
depth of discharge
percentage of rated capacity discharged from a battery

3.8
fully discharged
state of charge of a cell or battery corresponding to 100 % depth of discharge

3.9
harm
physical injury or damage to health of people, or damage to property or the environment
[ISO/IEC Guide 51:1999, 3.3]

3.10
hazard
potential source of harm
[ISO/IEC Guide 51:1999, 3.5]

3.11
intended use
use of a product, process or service in accordance with information provided by the supplier
[ISO/IEC Guide 51:1999, 3.13]

3.12
large battery
battery in which the aggregate lithium content is more than 500 g

3.13
large cell
cell in which the lithium content is more than 12 g

3.14
lithium cell
cell containing a non-aqueous electrolyte and a negative electrode of lithium or containing lithium
[IEV 482-01-06:2004]

3.15
nominal voltage
suitable approximate value of the voltage used to designate or identify a cell, a battery or an electrochemical system
[IEV 482-03-31:2004]

3.16
open circuit voltage (OCV, U_{OC}, off-load voltage)
voltage across the terminals of a battery when no external current is flowing
[IEV 482-03-32:2004, modified]

3.17
prismatic
qualifies a cell or a battery having the shape of a parallelepiped whose faces are rectangular

[IEV 482-02-38:2004]

3.18
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

3.19
rated capacity
capacity value of a cell or battery determined under specified conditions and declared by the manufacturer

[IEV 482-03-15:2004, modified]

3.20
reasonably foreseeable misuse
use of a product, process or service in a way not intended by the supplier, but which may result from readily predictable human behaviour

[ISO/IEC Guide 51:1999, 3.14]

3.21
risk
combination of the probability of occurrence of harm and the severity of that harm

[ISO/IEC Guide 51:1999, 3.2]

3.22
safety
freedom from unacceptable risk

[ISO/IEC Guide 51:1999, 3.1]

3.23
undischarged
state of charge of a primary cell or battery corresponding to 0 % depth of discharge

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 configurations. 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 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.

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

5.1 General

Samples should be drawn from production lots in accordance with accepted statistical methods.

5.2 Test samples

The number of test samples is given in Table 1 below. 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.

NOTE Test G is provided as an alternative for test F depending on which of them is more appropriate to simulate an internal short-circuit for the relevant cell design.

Table 1 – Number of test samples

	Cells and single cell batteries		Multi cell batteries	
Number of samples for tests A to E	Undischarged	Fully discharged	Undischarged	Fully discharged
	10	10	4 [a]	4 [a]
Number of samples for tests F or G	Undischarged	Fully discharged	No battery tests required but the component cells shall have passed the test	
	5 (button and cylindrical) 10 (prismatic)	5 (button and cylindrical) 10 (prismatic)		
Number of samples for test H	Undischarged	Fully discharged	No battery tests required but the component cells shall have passed the test	
	NA	10		
Number of samples for tests I to K	Undischarged	Fully discharged	Undischarged	Fully discharged
	5	NA	5	NA
Number of samples for test L	Undischarged	Fully discharged	NA	
	5 (+ 15) [b]	NA		
Number of samples for test M	50 % predischarged	75 % predischarged	NA	
	5 (+15) [b]	5 (+15) [b]		

Key:

NA: Not applicable.

[a] When testing batteries, unless the component cells or batteries made from them have been tested before, the number of test batteries shall be at least such that the number of component cells contained in them equals the number of test cells required for that test.

EXAMPLE 1 If a battery with 2 component cells is tested, the number of test batteries shall be 5. If the component cells or batteries made from them have been tested before, the number of test batteries shall be 4.

EXAMPLE 2 If a battery with 3 or more component cells is tested, the number of test batteries shall be 4.

[b] Undischarged additional cells in brackets.

6 Testing and requirements

6.1 General

6.1.1 Test application matrix

Applicability of test methods to test cells and batteries is shown in Table 2 below.

Table 2 – Test application matrix

Form	Applicable tests												
	A	B	C	D	E	F	G	H	I	J	K	L	M
s	x	x	x	x	x	x	x	x	x	x	x	x [a]	x [b]
m	x	x	x	x	x	NA [c]	NA [c]	NA [c]	x	x	x	NA	NA

Test description:

Intended use tests

A: Altitude
B: Thermal cycling
C: Vibration
D: Shock

Reasonably foreseeable misuse tests

E: External short-circuit
F: Impact
G: Crush
H: Forced discharge
I: Abnormal charging
J: Free fall
K: Thermal abuse
L: Incorrect installation
M: Overdischarge

Key:

Form
s: cell or single cell battery
m: multi cell battery

Applicability
x: Applicable
NA: Not applicable

[a] Only applicable to CR17345, CR15H270 and similar type batteries of a spiral construction that could be installed incorrectly and charged.

[b] Only applicable to CR17345, CR15H270 and similar type batteries of a spiral construction that could be overdischarged.

[c] No battery tests required but the component cells shall have passed the test.

6.1.2 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.

6.1.3 Ambient temperature

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

6.1.4 Parameter measurement tolerances

The overall accuracy of controlled or measured values, relative to the specified or actual parameters, shall be within the following tolerances:

a) ± 1 % for voltage;

b) ± 1 % for current;

c) ± 2 °C for temperature;

d) ± 0,1 % for time;

e) ± 1 % for dimension;

f) ± 1 % for capacity.

These tolerances comprise the combined accuracy of the measuring instruments, the measurement techniques used, and all other sources of error in the test procedure.

6.1.5 Predischarge

Where a test requires predischarge, the test cells or 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 cells

Where additional cells are required to perform a test, they shall be of the same type and, preferably, of the same production lot as the test cell.

6.2 Evaluation of test criteria

6.2.1 Short-circuit

A short-circuit is considered to have occurred during a test if the open-circuit voltage of the cell or battery after the test is less than 90 % of its voltage immediately prior to the test. This requirement is not applicable to test cells and batteries at fully discharged states.

6.2.2 Excessive temperature rise

An excessive temperature rise is considered to have occurred during a test if the external case temperature of the test cell or battery rises above 170 °C.

6.2.3 Leakage

Leakage is considered to have occurred during a test if electrolyte, gas or other material escapes from the test cell or battery in a manner not intended by design.

6.2.4 Mass loss

In order to quantify mass loss Δm / m, the following equation is provided:

$$\Delta m / m = \frac{m - m_1}{m} \times 100\ \%$$

where

m is the mass before a test;

m_1 is the mass after that test.

Mass loss is considered to have occurred if, during a test, the maximum values given in Table 3 are exceeded.

Table 3 – Maximum mass loss

Mass of battery m	Maximum mass loss Δm / m %
$m \leq 1$ g	0,5
1 g < $m \leq 5$ g	0,2
$m > 5$ g	0,1

6.2.5 Venting

Venting is considered to have occurred if, during a test, an excessive build up of internal gas pressure escapes from a cell or battery through a safety feature designed for this purpose. This gas may include entrapped materials.