

INTERNATIONAL STANDARD

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**Primary batteries –
Part 4: Safety of lithium batteries**

**Piles électriques –
Partie 4: Sécurité des piles au lithium**

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INTERNATIONAL STANDARD

NORME INTERNATIONALE



**Primary batteries –
Part 4: Safety of lithium batteries**

**Piles électriques –
Partie 4: Sécurité des piles au lithium**

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COMMISSION

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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 fourth edition cancels and replaces the third edition published in 2007. This edition constitutes a technical revision.

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

- a) Harmonisation with the second edition of IEC 62281 [12]¹;
- b) Alternative protective circuits in 7.1.1;

¹ Numbers in square brackets refer to the Bibliography.

- c) More information regarding risks of swallowing lithium batteries in (former) 7.2.m) and promotion of this item to 7.2a);
- d) A new Annex D with pictograms for some of the safety precautions in 7.2.

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

FDIS	Report on voting
35/1324/FDIS	35/1332/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 2.

NOTE The following print types are used:

- requirements: in roman type;
- 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 publication will remain unchanged until the stability 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- withdrawn,
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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.

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 standard and, for transport, IEC 62281. The fourth edition of this standard therefore reflects only 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 B reflect experience with lithium batteries used in camera applications and are based on [20].

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 documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60086-1:2011, *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, IEC 60086-1, and IEC Guide 51 are repeated below for convenience.

3.1

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")]

3.2

coin cell

coin battery

small round cell or battery where the overall height is less than the diameter

Note 1 to entry: In English, the term "coin (cell or battery)" is used for lithium batteries only while the term "button (cell or battery)" is only used for non-lithium batteries. In languages other than English, the terms "coin" and "button" are often used interchangeably, regardless of the electrochemical system.

[SOURCE: IEC 60050-482:2004, 482-02-40, modified (term "button" deleted, NOTE "In practice terms, the term coin is used exclusively for non-aqueous lithium cells." replaced with a different note)]

3.3**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]

3.4**component cell**

cell contained in a battery

3.5**cylindrical (cell or 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")]

3.6**depth of discharge****DOD**

percentage of rated capacity discharged from a battery

3.7**fully discharged**

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

3.8**harm**

physical injury or damage to health of people, or damage to property or the environment

[SOURCE: ISO/IEC Guide 51:1999, 3.3]

3.9**hazard**

potential source of harm

[SOURCE: ISO/IEC Guide 51:1999, 3.5, modified (removal of NOTE)]

3.10**intended use**

use of a product, process or service in accordance with information provided by the supplier

[SOURCE: ISO/IEC Guide 51:1999, 3.13]

3.11**large battery**

battery with a gross mass of more than 12 kg

3.12**large cell**

cell with a gross mass of more than 500 g

3.13**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)]

3.14**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]

3.15**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”)]

3.16**prismatic cell****prismatic battery**

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

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

3.17**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

3.18**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)]

3.19**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

[SOURCE: ISO/IEC Guide 51:1999, 3.14]

3.20**risk**

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

[SOURCE: ISO/IEC Guide 51:1999, 3.2]

3.21

safety

freedom from unacceptable risk

[SOURCE: ISO/IEC Guide 51:1999, 3.1]

3.22

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, 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.

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 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. 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.

Table 1 – Number of test samples

Tests	Discharge state	Cells and single cell batteries ^a	Multi-cell batteries
Tests A to E	Undischarged	10	4
	Fully discharged	10	4
Test F or G	Undischarged	5	5 component cells
	Fully discharged	5	5 component cells
Test H	Fully discharged	10	10 component cells
Tests I to K	Undischarged	5	5
Test L	Undischarged	20 (see Note 1)	n/a
Test M	50 % pre-discharged	20 (see Note 2)	n/a
	75 % pre-discharged	20 (see Note 3)	n/a
^a single cell batteries containing one tested component cell do not require re-testing unless the change could result in a failure of any of the tests.			
Key: n/a: not applicable			
NOTE 1 Four batteries connected in series with one of the four batteries reversed (5 sets).			
NOTE 2 Four batteries connected in series, one of which is 50 % pre-discharged (5 sets).			
NOTE 3 Four batteries connected in series, one of which is 75 % pre-discharged (5 sets).			

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.

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 ^a	x ^a	x	x	x	x	x ^b	x ^c
m	x	x	x	x	x	x ^{a, d}	x ^{a, d}	x ^d	x	x	x	n/a	n/a
Test description:								Key:					
Intended use tests				Reasonably foreseeable misuse tests				Form					
A: Altitude				E: External short-circuit				s: cell or single cell battery					
B: Thermal cycling				F: Impact				m: multi cell battery					
C: Vibration				G: Crush				Applicability					
D: Shock				H: Forced discharge				x: applicable					
				I: Abnormal charging				n/a: not applicable					
				J: Free fall									
				K: Thermal abuse									
				L: Incorrect installation									
				M: Overdischarge									
<p>^a Only one test shall be applied, test F or test G.</p> <p>^b Only applicable to CR17345, CR15H270 and similar type batteries of a spiral construction that could be installed incorrectly and charged.</p> <p>^c Only applicable to CR17345, CR15H270 and similar type batteries of a spiral construction that could be overdischarged.</p> <p>^d Test applies to the component cells.</p>													

6.1.2 Safety notice

WARNING: These tests call for the use of procedures which can 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 an ambient temperature of 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 dimensions;
- 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.