BS EN 60086-4:2015

BSI Standards Publication

Primary batteries

Part 4: Safety of lithium batteries

bsi.

...making excellence a habit.™

National foreword

This British Standard is the UK implementation of EN 60086-4:2015. It is identical to IEC 60086-4:2014. It supersedes BS EN 60086-4:2007, which will be withdrawn on 8 October 2017.

The UK participation in its preparation was entrusted to Technical Committee CPL/35, Primary cells.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Published by BSI Standards Limited 2015

ISBN 978 0 580 79834 4
ICS 29.220.10

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 January 2015.

Amendments/corrigenda issued since publication

Date	Text affected

EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 60086-4

January 2015

ICS 29.220.10

Supersedes EN 60086-4:2007

English Version

Primary batteries - Part 4: Safety of lithium batteries (IEC 60086-4:2014)

Piles électriques - Partie 4: Sécurité des piles au lithium (IEC 60086-4:2014)

Primärbatterien - Teil 4: Sicherheit von Lithium-Batterien (IEC 60086-4:2014)

This European Standard was approved by CENELEC on 2014-10-08. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels

Foreword

The text of document 35/1324/FDIS, future edition 4 of IEC 60086-4, prepared by IEC TC 35 "Primary cells and batteries" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 60086-4:2015.

The following dates are fixed:

• latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2015-07-09
• latest date by which the national standards conflicting with the document have to be withdrawn	(dow)	2017-10-08

This document supersedes EN 60086-4:2007.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC [and/or CEN] shall not be held responsible for identifying any or all such patent rights.

Endorsement notice

The text of the International Standard IEC 60086-4:2014 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 60027-1:1992	NOTE Harmonized as EN 60027-1:1992.
IEC 60068-2-6:1995	NOTE Harmonized as EN 60068-2-6:1995.
IEC 60068-2-27:1987	NOTE Harmonized as EN 60068-2-27:1987.
IEC 60068-2-31:2008	NOTE Harmonized as EN 60068-2-31:2008.
IEC 60086-5:2011	NOTE Harmonized as EN 60086-5:2011.
IEC 60617 (Series)	NOTE Harmonized as EN 60617 (Series).
IEC 62133	NOTE Harmonized as EN 62133.
IEC 61960	NOTE Harmonized as EN 61960.
IEC 62281	NOTE Harmonized as EN 62281.

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

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.

NOTE 1 When an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cenelec.eu.

Publication	Year	Title	EN/HD	Year
IEC 60086-1	2011	Primary batteries -- Part 1: General	EN 60086-1	2011
IEC 60086-2	-	Primary batteries -- Part 2: Physical and electrical specifications	EN 60086-2	-

CONTENTS

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 % predischarged	20 (see Note 2)	n/a
	75 % predischarged	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 % predischarged (5 sets).

NOTE 3 Four batteries connected in series, one of which is 75 % predischarged (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	

[a] Only one test shall be applied, test F or test G.

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

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

[d] Test applies to the component cells.

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.

6.1.5 Predischarge

Where a test requires predischarge, the test cells or batteries shall be discharged to the respective depth of discharge on a resistive load with which the rated capacity is obtained or at 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, from 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 immediately after the test is less than 90 % of its voltage prior to the test. This requirement is not applicable to test cells and batteries in 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 there is visible escape of electrolyte or other material from the test cell or battery, or the loss of material (except battery casing, handling devices or labels) from the test cell or battery such that the mass loss exceeds the limits in Table 3.

In order to quantify mass loss $\Delta m / m$, the following equation is provided:

$$\Delta m / m = \frac{m_1 - m_2}{m_1} \times 100\,\%$$

Where

m_1 is the mass before a test;

m_2 is the mass after that test.

Table 3 – Mass loss limits

Mass of cell or battery m	Mass loss limit $\Delta m / m$
$m < 1$ g	0,5 %
1 g $\leq m \leq$ 75 g	0,2 %
$m > 75$ g	0,1 %

6.2.4 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.

6.2.5 Fire

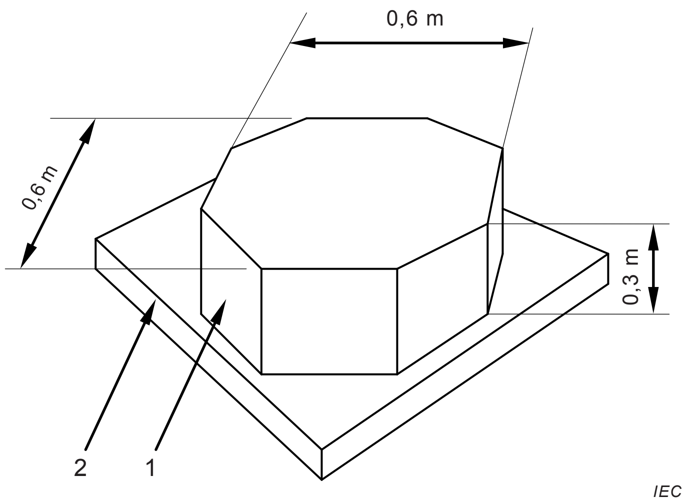
A fire is considered to have occurred if, during a test, flames are emitted from the test cell or battery.

6.2.6 Rupture

A rupture is considered to have occurred if, during a test, a cell container or battery case has mechanically failed, resulting in expulsion of gas, spillage of liquids, or ejection of solid materials but no explosion.

6.2.7 Explosion

An explosion is considered to have occurred if, during a test, solid matter from any part of a cell or battery has penetrated a wire mesh screen as shown in Figure 1, centred over the cell or battery on the steel plate. The screen shall be made from annealed aluminium wire with a diameter of 0,25 mm and a grid density of 6 to 7 wires per cm.



NOTE The figure shows an aluminium wire mesh screen (1) of octagonal shape resting on a steel plate (2).

Figure 1 – Mesh screen

6.3 Tests and requirements – Overview

This standard provides safety tests for intended use (tests A to D) and reasonably foreseeable misuse (tests E to M).

Table 4 contains an overview of the tests and requirements for intended use and reasonably foreseeable misuse.

Table 4 – Tests and requirements

Test number		Designation	Requirements
Intended use tests	A	Altitude	NL, NV, NC, NR, NE, NF
	B	Thermal cycling	NL, NV, NC, NR, NE, NF
	C	Vibration	NL, NV, NC, NR, NE, NF
	D	Shock	NL, NV, NC, NR, NE, NF
Reasonably foreseeable misuse tests	E	External short-circuit	NT, NR, NE, NF
	F	Impact	NT, NE, NF
	G	Crush	NT, NE, NF
	H	Forced discharge	NE, NF
	I	Abnormal charging	NE, NF
	J	Free fall	NV, NE, NF
	K	Thermal abuse	NE, NF
	L	Incorrect installation	NE, NF
	M	Overdischarge	NE, NF
Tests A through E shall be conducted in sequence on the same cell or battery. Tests F and G are provided as alternatives. Only one of them shall be conducted.			
Key NC: No short-circuit NE: No explosion NF: No fire NL: No leakage NR: No rupture NT: No excessive temperature rise NV: No venting See 6.2 for a detailed description of the test criteria.			

6.4 Tests for intended use

6.4.1 Test A: Altitude

a) Purpose

This test simulates air transport under low pressure conditions.

b) Test procedure

Test cells and batteries shall be stored at a pressure of 11,6 kPa or less for at least 6 h at ambient temperature.

c) Requirements

There shall be no leakage, no venting, no short-circuit, no rupture, no explosion and no fire during this test.

6.4.2 Test B: Thermal cycling

a) Purpose

This test assesses cell and battery seal integrity and that of their internal electrical connections. The test is conducted using temperature cycling.

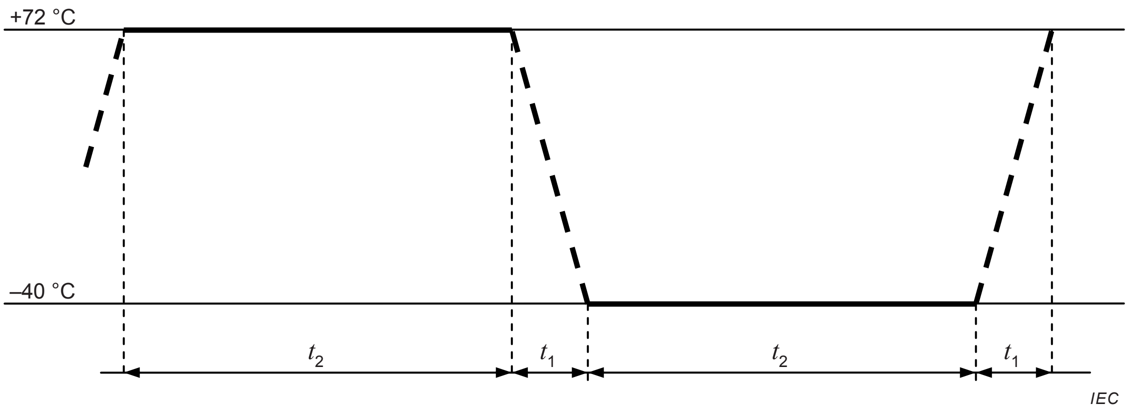
b) Test procedure

Test cells and batteries shall be stored for at least 6 h at a test temperature of 72 °C, followed by storage for at least 6 h at a test temperature of –40 °C. The maximum time for transfer to each temperature shall be 30 min. Each test cell and battery shall undergo this procedure 10 times. This is then followed by storage for at least 24 h at ambient temperature.

NOTE Figure 2 shows one of ten cycles.

For large cells and batteries the duration of exposure to the test temperatures shall be at least 12 h instead of 6 h.

The test shall be conducted using the test cells and batteries previously subjected to the altitude test.



Key

t_1 ≤ 30 min

t_2 ≥ 6 h (12 h for large cells and batteries)

Figure 2 – Thermal cycling procedure

c) Requirements

There shall be no leakage, no venting, no short-circuit, no rupture, no explosion and no fire during this test.

6.4.3 Test C: Vibration

a) Purpose

This test simulates vibration during transport. The test condition is based on the range of vibrations as given by ICAO [2].

b) Test procedure

Test cells and batteries shall be firmly secured to the platform of the vibration machine without distorting them and in such a manner as to faithfully transmit the vibration. Test cells and batteries shall be subjected to sinusoidal vibration according to Table 5 which shows a different upper acceleration amplitude for large batteries. This cycle shall be repeated 12 times for a total of 3 h for each of three mutually perpendicular mounting positions. One of the directions shall be perpendicular to the terminal face.

The test shall be conducted using the test cells and batteries previously subjected to the thermal cycling test.

Table 5 – Vibration profile (sinusoidal)

Frequency range		Amplitudes	Duration of logarithmic sweep cycle (7 Hz – 200 Hz – 7 Hz)	Axis	Number of cycles
From	To				
f_1 = 7 Hz	f_2	a_1 = 1 g_n	15 min	X	12
f_2	f_3	s = 0,8 mm		Y	12
f_3	f_4 = 200 Hz	a_2		Z	12
and back to f_1 = 7 Hz				Total	36

NOTE Vibration amplitude is the maximum absolute value of displacement or acceleration. For example, a displacement amplitude of 0,8 mm corresponds to a peak-to-peak displacement of 1,6 mm.

Key

f_1, f_4 lower and upper frequency

f_2, f_3 cross-over frequencies;

f_2 ≈ 17,62 Hz; and

f_3 ≈ 49,84 Hz, except for large batteries, where f_3 ≈ 24,92 Hz

a_1, a_2 acceleration amplitude

a_2 = 8 g_n except for large batteries, where a_2 = 2 g_n

s displacement amplitude

NOTE g_n = 9,80665 m / s^2

c) Requirements

There shall be no leakage, no venting, no short-circuit, no rupture, no explosion and no fire during this test.

6.4.4 Test D: Shock

a) Purpose

This test simulates rough handling during transport.

b) Test procedure

Test cells and batteries shall be secured to the testing machine by means of a rigid mount which will support all mounting surfaces of each test cell or battery. Each test cell or battery shall be subjected to 3 shocks in each direction of three mutually perpendicular mounting positions of the cell or battery for a total of 18 shocks. For each shock, the parameters given in Table 6 shall be applied.

Table 6 – Shock parameters

	Waveform	Peak acceleration	Pulse duration	Number of shocks per half axis
Cells or batteries except large ones	Half sine	150 g_n	6 ms	3
Large cells or batteries	Half sine	50 g_n	11 ms	3

NOTE g_n = 9,80665 m / s²

The test shall be conducted using the test cells and batteries previously subjected to the vibration test.

c) Requirements

There shall be no leakage, no venting, no short-circuit, no rupture, no explosion and no fire during this test.

6.5 Tests for reasonably foreseeable misuse

6.5.1 Test E: External short-circuit

a) Purpose

This test simulates conditions resulting in an external short-circuit.

b) Test procedure

The test cell or battery shall be stabilized at an external case temperature of 55 °C and then subjected to a short-circuit condition with a total external resistance of less than 0,1 Ω at 55 °C. This short-circuit condition is continued for at least 1 h after the cell or battery external case temperature has returned to 55 °C.

The test sample shall be observed for a further 6 h.

The test shall be conducted using the test samples previously subjected to the shock test.

c) Requirements

There shall be no excessive temperature rise, no rupture, no explosion and no fire during this test and within the 6 h of observation.

6.5.2 Test F: Impact

a) Purpose

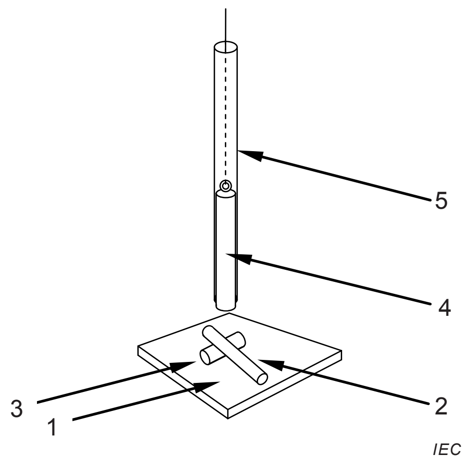
This test simulates mechanical abuse from an impact that can result in an internal short circuit.

b) Test procedure

The impact test is applicable to cylindrical cells greater than 20 mm in diameter.

The test cell or component cell is placed on a flat smooth surface. A stainless steel bar (type 316 or equivalent) with a diameter of 15,8 mm ± 0,1 mm and a length of at least 60 mm or of the longest dimension of the cell, whichever is greater, is placed across the centre of the test sample. A mass of 9,1 kg ± 0,1 kg is dropped from a height of 61 cm ± 2,5 cm at the intersection of the bar and the test sample in a controlled manner using a near frictionless, vertical sliding track or channel with minimal drag on the falling mass. The vertical track or channel used to guide the falling mass shall be oriented 90 degrees from the horizontal supporting surface.

The test sample is to be impacted with its longitudinal axis parallel to the flat surface and perpendicular to the longitudinal axis of the stainless steel bar lying across the centre of the test sample (see Figure 3).



NOTE The figure shows a flat smooth surface (1) and a stainless steel bar (2) which is placed across the centre of the test sample (3). A mass (4) is dropped at the intersection in a controlled manner using a vertical sliding channel (5).

Figure 3 – Example of a test set-up for the impact test

Each test cell or component cell shall be subjected to one impact only.

The test sample shall be observed for a further 6 h.

The test shall be conducted using test cells or component cells that have not been previously subjected to other tests.

c) Requirements

There shall be no excessive temperature rise, no explosion and no fire during this test and within the 6 h of observation.

6.5.3 Test G: Crush

a) Purpose

This test simulates mechanical abuse from a crush that can result in an internal short circuit.

b) Test procedure

The crush test is applicable to prismatic, flexible[2], coin cells and cylindrical cells not more than 20 mm in diameter.

A cell or component cell is to be crushed between two flat surfaces. The crushing is to be gradual with a speed of approximately 1,5 cm / s at the first point of contact. The crushing is to be continued until one of the three conditions below is reached:

1) The applied force reaches 13 kN ± 0,78 kN;

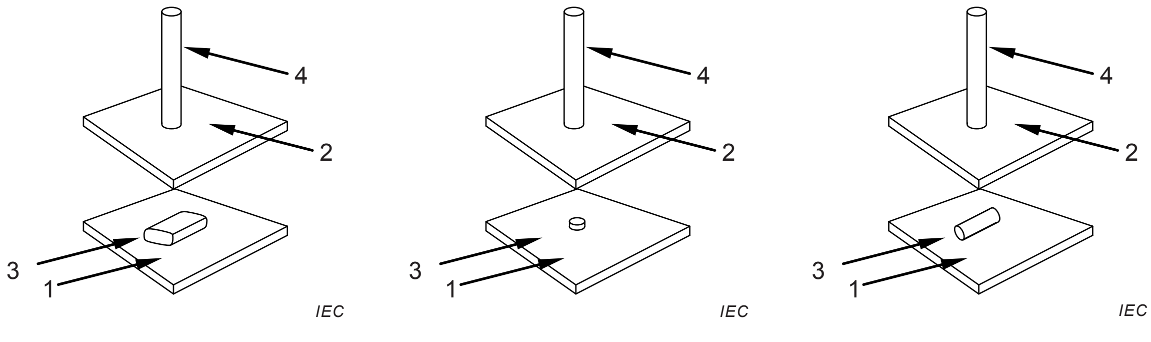
   EXAMPLE: The force can be applied by a hydraulic ram with a 32 mm diameter piston until a pressure of 17 MPa is reached on the hydraulic ram.

2) The voltage of the cell drops by at least 100 mV; or

3) The cell is deformed by 50 % or more of its original thickness.

As soon as one of the above conditions has been obtained, the pressure shall be released.

A prismatic or flexible cell shall be crushed by applying the force to the side with the largest surface area. A coin cell shall be crushed by applying the force on its flat surfaces. For cylindrical cells, the crush force shall be applied perpendicular to the longitudinal axis. See Figure 4.



a) Prismatic or flexible cell **b) Coin cell** **c) Cylindrical cell**

NOTE Figures 4a) to 4c) show two flat surfaces (1 and 2) with batteries (3) of different shapes placed between them for crushing, using a piston (4).

Figure 4 – Examples of a test set-up for the crush test

Each test cell or component cell is to be subjected to one crush only.

The test sample shall be observed for a further 6 h.

---

2 The term “flexible cell” is used in this document in place of the term “pouch cell” which is used in [19]. It is also used in place of the terms “cell with a laminate film case” and “laminate film cell”.

The test shall be conducted using test cells or component cells that have not previously been subjected to other tests.

c) Requirements

There shall be no excessive temperature rise, no explosion and no fire during this test and within the 6 h of observation.

6.5.4 Test H: Forced discharge

a) Purpose

This test evaluates the ability of a cell to withstand a forced discharge condition.

b) Test procedure

Each cell shall be force discharged at ambient temperature by connecting it in series with a 12 V direct current power supply at an initial current equal to the maximum continuous discharge current specified by the manufacturer.

The specified discharge current is obtained by connecting a resistive load of appropriate size and rating in series with the test cell and the direct current power supply. Each cell shall be force discharged for a time interval equal to its rated capacity divided by the initial test current.

This test shall be conducted with fully discharged test cells or component cells that have not previously been subjected to other tests.

c) Requirements

There shall be no explosion and no fire during this test and within 7 days after the test.

6.5.5 Test I: Abnormal charging

a) Purpose

This test simulates the condition when a battery is fitted within a device and is exposed to a reverse voltage from an external power supply, for example memory back-up equipment with a defective diode (see 7.1.2). The test condition is based upon UL 1642 [17].

b) Test procedure

Each test battery shall be subjected to a charging current of three times the abnormal charging current I_c specified by the battery manufacturer by connecting it in opposition to a d.c. power supply. Unless the power supply allows for setting the current, the specified charging current shall be obtained by connecting a resistor of the appropriate size and rating in series with the battery.

The test duration shall be calculated using the formula:

$$t_d = 2{,}5 \times C_n / (3 \times I_c)$$

where

t_d is the test duration. In order to expedite the test, it is permitted to adjust the test parameters such that t_d does not exceed 7 days;

C_n is the nominal capacity;

I_c is the abnormal charging current declared by the manufacturer for this test.

c) Requirements

There shall be no explosion and no fire during this test.

6.5.6 Test J: Free fall

a) Purpose

This test simulates the situation when a battery is accidentally dropped. The test condition is based upon IEC 60068-2-31 [7].

b) Test procedure

The test batteries shall be dropped from a height of 1 m onto a concrete surface. Each test battery shall be dropped six times, a prismatic battery once from each of its six faces, a round battery twice in each of the three axes shown in Figure 5. The test batteries shall be stored for 1 h afterwards.

The test shall be conducted with undischarged test cells and batteries.

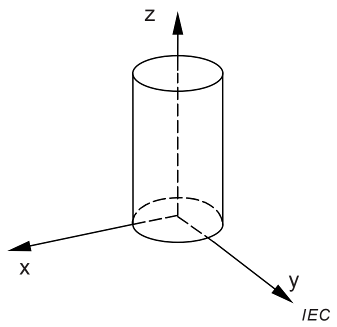


Figure 5 – Axes for free fall

c) Requirements

There shall be no venting, no explosion and no fire during this test and within the 1 h of observation.

6.5.7 Test K: Thermal abuse

a) Purpose

This test simulates the condition when a battery is exposed to an extremely high temperature.

b) Test procedure

A test battery shall be placed in an oven and the temperature raised at a rate of 5 °C/min to a temperature of 130 °C at which the battery shall remain for 10 min.

c) Requirements

There shall be no explosion and no fire during this test.

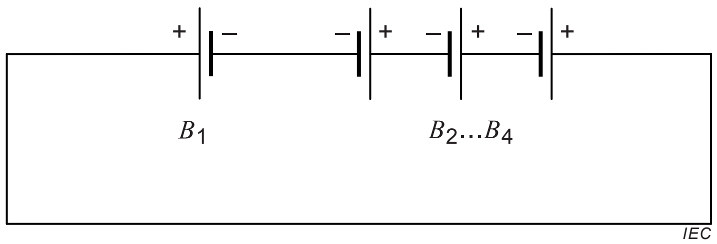
6.5.8 Test L: Incorrect installation

a) Purpose

This test simulates the condition when one single cell battery in a set is reversed.

b) Test procedure

A test battery is connected in series with three undischarged additional single cell batteries of the same brand and type in such a way that the terminals of the test battery are connected in reverse. The resistance of the interconnecting circuit shall be no greater than 0,1 Ω. The circuit shall be completed for 24 h or until the battery case temperature has returned to ambient (see Figure 6).



Key

B_1 Test cell

$B_2 \ldots B_4$ Additional cells, undischarged

Figure 6 – Circuit diagram for incorrect installation

c) Requirements

There shall be no explosion and no fire during this test.

6.5.9 Test M: Overdischarge

a) Purpose

This test simulates the condition when one discharged single cell battery is connected in series with other undischarged single cell batteries. The test further simulates the use of batteries in motor powered appliances where, in general, currents over 1 A are required.

NOTE CR17345 and CR15H270 batteries are widely used in motor powered appliances where currents over 1 A are required. The current for non standardized batteries may be different.

b) Test procedure

Each test battery shall be predischarged to 50 % depth of discharge. It shall then be connected in series with three undischarged additional single cell batteries of the same type.

A resistive load R_1 is connected in series with the assembly of batteries in Figure 7 where R_1 is taken from Table 7.

The test shall be continued for 24 h or until the battery case temperature has returned to ambient.

The test shall be repeated with 75 % predischarged test batteries.

Table 7 – Resistive load for overdischarge

Battery type	Resistive load R_1 Ω
CR17345	8,20
CR15H270	8,20

NOTE Table to be modified or expanded when additional batteries of a spiral construction are standardized.

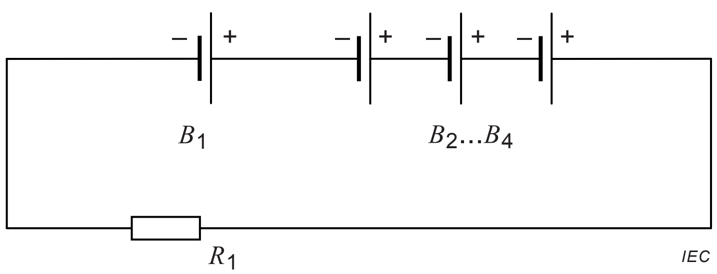
EXAMPLE When CR17345 and CR15H270 batteries were standardized, R_1 was determined from the end voltage of the assembly in Figure 7, using the formula

$$R = 4 \times 2{,}0 \text{ V} / 1 \text{ A}$$

where

2,0 V is the end voltage taken from the specification tables in IEC 60086-2; and 1 A is the test current.

R_1 was then found by rounding R to the nearest value in Table 6 of IEC 60086-1:2011.



Key

B_1 Test battery, 50 % predischarged and, in separate tests, 75 % predischarged.

$B_2 \ldots B_4$ Additional batteries, undischarged

R_1 Resistive load

Figure 7 – Circuit diagram for overdischarge

c) Requirements

There shall be no explosion and no fire during this test.

6.6 Information to be given in the relevant specification

When this standard is referred to in a relevant specification, the parameters given in Table 8 shall be given in so far as they are applicable:

Table 8 – Parameters to be specified

Item	Parameters	Clause and/or subclause
a)	Predischarge current or resistive load and end-point voltage specified by the manufacturer	6.1.5
b)	Shape: prismatic, flexible, coin or cylindrical; Diameter: not more than 20 mm or greater than 20 mm.	6.5.2 and 6.5.3
c)	Maximum continuous discharge current specified by the manufacturer for test H NOTE Forced discharge of a cell can occur when it is connected in series with other cells and when it is not protected with a bypass diode.	6.5.4
d)	Rated capacity specified by the manufacturer for test H	6.5.4
e)	Abnormal charging current declared by the manufacturer for test I NOTE Abnormal charging of a cell can occur when it is connected in series with other cells and one cell is reversed or when it is connected in parallel with a power supply and the protective devices do not operate correctly.	6.5.5
f)	Normal reverse current declared by the manufacturer which can be applied to the battery during its operating life NOTE Normal reverse current flow through a cell can occur when it is connected in parallel with a power supply and the protective devices are operating properly.	7.1.2

6.7 Evaluation and report

When a report is issued, the following list of items should be considered:

a) name and address of the test facility;
b) name and address of applicant (where appropriate);
c) a unique test report identification;
d) the date of the test report;
e) design characteristics of the test cells or batteries according to 4.1;
f) test descriptions and results, including the parameters according to 6.6;
g) type of the test sample(s): cell, component cell, battery or battery assembly;
h) weight of the test sample(s);
i) lithium content of the sample(s);
j) a signature with name and status of the signatory.

7 Information for safety

7.1 Safety precautions during design of equipment

7.1.1 General

See also Annex B for guidelines for designers of equipment using lithium batteries.

7.1.2 Charge protection

When incorporating a primary lithium battery into a circuit powered by an independent main power source, protective devices shall be used in order to prevent charging the primary battery from the main power source, for example

a) a blocking diode and a current limiting resistor (see Figure 8a);

b) two series blocking diodes (see Figure 8b);

c) circuits with a similar blocking function based on two or more independent protective devices;

provided that the first protective device is capable of limiting the charging current through the lithium battery to the normal reverse current specified by the manufacturer which can be applied to the battery during its operating life, while the second protective device is capable of limiting the charging current to the abnormal charging current specified by the battery manufacturer and used for conduction of test I, Abnormal charging. The circuit shall be so designed that at least one of these protective devices remains operational when any one component of the circuit fails.

a) Diode and resistor **b) Two diodes**

Figure 8 – Examples of safety wiring for charge protection

7.1.3 Parallel connection

Parallel connection should be avoided when designing battery compartments. However, if required, the battery manufacturer shall be contacted for advice.

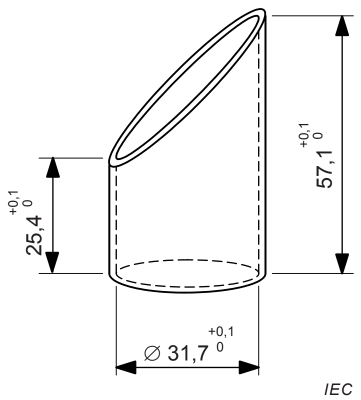
7.2 Safety precautions during handling of batteries

When used correctly, lithium batteries provide a safe and dependable source of power. However, if they are misused or abused, leakage, venting or in extreme cases, explosion and/or fire can result.

a) *Keep batteries out of the reach of children*

In particular, keep batteries which are considered swallowable out of the reach of children, particularly those batteries fitting within the limits of the ingestion gauge as defined in Figure 9. In case of ingestion of a cell or battery, seek medical assistance promptly. Swallowing lithium coin cells or batteries can cause chemical burns, perforation of soft tissue, and in severe cases can cause death. They must be removed immediately if swallowed. See Figure 10 for an example of appropriate warning text.

NOTE Refer to [14] for general information on hazards from batteries.



Dimensions in millimetres

NOTE This gauge defines a swallowable component and is defined in ISO 8124-1 [16].

Figure 9 – Ingestion gauge

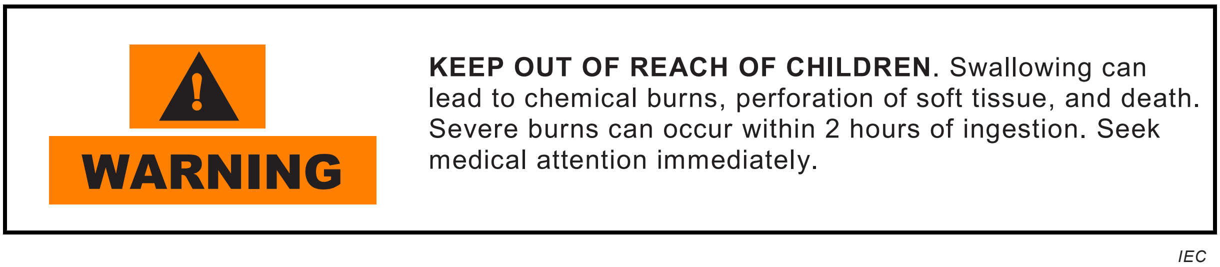


Figure 10 – Example for warning against swallowing, particularly lithium coin cell batteries

b) *Do not allow children to replace batteries without adult supervision*

c) *Always insert batteries correctly with regard to polarity (+ and –) marked on the battery and the equipment*

When batteries are inserted in reverse they might be short-circuited or charged. This can cause overheating, leakage, venting, rupture, explosion, fire and personal injury.

d) *Do not short-circuit batteries*

When the positive (+) and negative (–) terminals of a battery are in electrical contact with each other, the battery becomes short-circuited. For example loose batteries in a pocket with keys or coins, can be short-circuited. This can result in venting, leakage, explosion, fire and personal injury.

e) *Do not charge batteries*

Attempting to charge a non-rechargeable (primary) battery can cause internal gas and/or heat generation resulting in leakage, venting, explosion, fire and personal injury.

f) *Do not force discharge batteries*

When batteries are force discharged by means of an external power source, the voltage of the battery will be forced below its design capability and gases will be generated inside the battery. This can result in leakage, venting, explosion, fire and personal injury.

g) *Do not mix new and used batteries or batteries of different types or brands*

When replacing batteries, replace all of them at the same time with new batteries of the same brand and type. When batteries of different brand or type are used together or new and used batteries are used together, some batteries might be over-discharged / force discharged due to a difference of voltage or capacity. This can result in leakage, venting, explosion or fire, and can cause personal injury.

h) *Exhausted batteries should be immediately removed from equipment and properly disposed of*

When discharged batteries are kept in the equipment for a long time, electrolyte leakage can occur causing damage to the equipment and/or personal injury.

i) *Do not heat batteries*

When a battery is exposed to heat, leakage, venting, explosion or fire can occur and cause personal injury.

j) *Do not weld or solder directly to batteries*

The heat from welding or soldering directly to a battery can cause leakage, venting, explosion or fire, and can cause personal injury.

k) *Do not dismantle batteries*

When a battery is dismantled or taken apart, contact with the components can be harmful and can cause personal injury or fire.

l) *Do not deform batteries*

Batteries should not be crushed, punctured, or otherwise mutilated. Such abuse can cause leakage, venting, explosion or fire, and can cause personal injury.

m) *Do not dispose of batteries in fire*

When batteries are disposed of in fire, the heat build-up can cause explosion and/or fire and personal injury. Do not incinerate batteries except for approved disposal in a controlled incinerator.

n) *A lithium battery with a damaged container should not be exposed to water*

Lithium metal in contact with water can produce hydrogen gas, fire, explosion and/or cause personal injury.

o) *Do not encapsulate and/or modify batteries*

Encapsulation or any other modification to a battery can result in blockage of the safety vent mechanism(s) and subsequent explosion and personal injury. Advice from the battery manufacturer should be sought if it is considered necessary to make any modification.

p) *Store unused batteries in their original packaging away from metal objects. If already unpacked, do not mix or jumble batteries*

Unpacked batteries could get jumbled or get mixed with metal objects. This can cause battery short-circuiting which can result in leakage, venting, explosion or fire, and personal injury. One of the best ways to prevent this from happening is to store unused batteries in their original packaging.

q) *Remove batteries from equipment if it is not to be used for an extended period of time unless it is for emergency purposes*

It is advantageous to remove batteries immediately from equipment which has ceased to function satisfactorily, or when a long period of disuse is anticipated (e.g. camcorders, digital cameras, photoflash, etc.). Although most lithium batteries on the market today are highly leak resistant, a battery that has been partially or completely exhausted might be more prone to leak than one that is unused.

7.3 Packaging

The packaging shall be adequate to avoid mechanical damage during transport, handling and stacking. The materials and packaging design shall be chosen so as to prevent the development of unintentional electrical contact, short-circuit, shifting and corrosion of the terminals, and afford some protection from the environment.

7.4 Handling of battery cartons

Battery cartons should be handled with care. Rough handling might result in batteries being short-circuited or damaged. This can cause leakage, explosion, or fire.

7.5 Transport

7.5.1 General

Tests and requirements for the transport of lithium cells or batteries are given in IEC 62281 [12].

Regulations concerning international transport of lithium batteries are based on the UN Recommendations on the Transport of Dangerous Goods [18].

Regulations for transport are subject to change. For the transport of lithium batteries, the latest editions of the following regulations should be consulted.

7.5.2 Air transport

Regulations concerning air transport of lithium batteries are specified in the Technical Instructions for the Safe Transport of Dangerous Goods by Air published by the International Civil Aviation Organization (ICAO) [2] and in the Dangerous Goods Regulations published by the International Air Transport Association (IATA) [1].

7.5.3 Sea transport

Regulations concerning sea transport of lithium batteries are specified in the International Maritime Dangerous Goods (IMDG) Code published by the International Maritime Organization (IMO) [13].

7.5.4 Land transport

Regulations concerning road and railroad transport are specified on a national or multilateral basis. While an increasing number of regulators adopt the UN Model Regulations [18], it is recommended that country-specific transport regulations be consulted before shipping.

7.6 Display and storage

a) *Store batteries in well ventilated, dry and cool conditions*

   High temperature or high humidity can cause deterioration of the battery performance and/or surface corrosion.

b) *Do not stack battery cartons on top of each other exceeding a specified height*

   If too many battery cartons are stacked, batteries in the lowest cartons might be deformed and electrolyte leakage can occur.

c) *Avoid storing or displaying batteries in direct sun or in places where they get exposed to rain*

   When batteries get wet, their insulation resistance might be impaired and self-discharge and corrosion can occur. Heat can cause deterioration.

d) *Store and display batteries in their original packing*

   When batteries are unpacked and mixed they can be short-circuited or damaged.

   See Annex C for additional details.

7.7 Disposal

Batteries may be disposed of via communal refuse arrangements provided no local rules to the contrary exist.

During transport, storage and handling for disposal, the following safety precautions should be considered:

a) *Do not dismantle batteries*

Some ingredients of lithium batteries might be flammable or harmful. They can cause injuries, fire, rupture or explosion.

b) *Do not dispose of batteries in fire except under conditions of approved and controlled incineration*

Lithium burns violently. Lithium batteries can explode in a fire. Combustion products from lithium batteries can be toxic and corrosive.

c) *Store collected batteries in a clean and dry environment out of direct sunlight and away from extreme heat*

Dirt and wetness might cause short-circuits and heat. Heat might cause leakage of flammable gas. This can result in fire, rupture or explosion.

d) *Store collected batteries in a well-ventilated area*

Used batteries might contain a residual charge. If they are short-circuited, abnormally charged or force discharged, leakage of flammable gas might be caused. This can result in fire, rupture or explosion.

e) *Do not mix collected batteries with other materials*

Used batteries might contain residual charge. If they are short-circuited, abnormally charged or force discharged, the generated heat can ignite flammable wastes such as oily rags, paper or wood and cause a fire.

f) *Protect battery terminals*

Protection of terminals should be considered by providing insulation, particularly for those batteries with a high voltage. Unprotected terminals might cause short-circuits, abnormal charging and forced discharge. This can result in leakage, fire, rupture or explosion.

8 Instructions for use

a) *Always select the correct size and type of battery most suitable for the intended use. Information provided with the equipment to assist correct battery selection should be retained for reference.*
b) *Replace all batteries of a set at the same time.*
c) *Clean the battery contacts and also those of the equipment prior to battery installation.*
d) *Ensure that the batteries are installed correctly with regard to polarity (+ and –).*
e) *Remove exhausted batteries promptly.*

9 Marking

9.1 General

With the exception of small batteries (see 9.2), each battery shall be marked with the following information:

a) designation, IEC or common;
b) expiration of a recommended usage period or year and month or week of manufacture. The year and month or week of manufacture may be in code;
c) polarity of the positive (+) terminal;
d) nominal voltage;
e) name or trade mark of the manufacturer or supplier;
f) cautionary advice;
g) caution for ingestion of swallowable batteries, see also 7.2 a).

9.2 Small batteries

For batteries that fit entirely within the Ingestion Gauge (Figure 9) the designation 9.1 a) and the polarity 9.1c) shall be marked on the battery, while all other markings shown in 9.1 may be given on the immediate package. However, when batteries are intended for direct sale in consumer-replaceable applications, caution for ingestion 9.1g) shall also be marked on the immediate package.

9.3 Safety pictograms

Safety pictograms that could be considered for use as an alternative to written cautionary advice are provided in Annex D.

Annex A
(informative)

Guidelines for the achievement of safety of lithium batteries

The guidelines given in Figure A.1 were followed during the development of high power batteries for consumer use. They are given here for information.

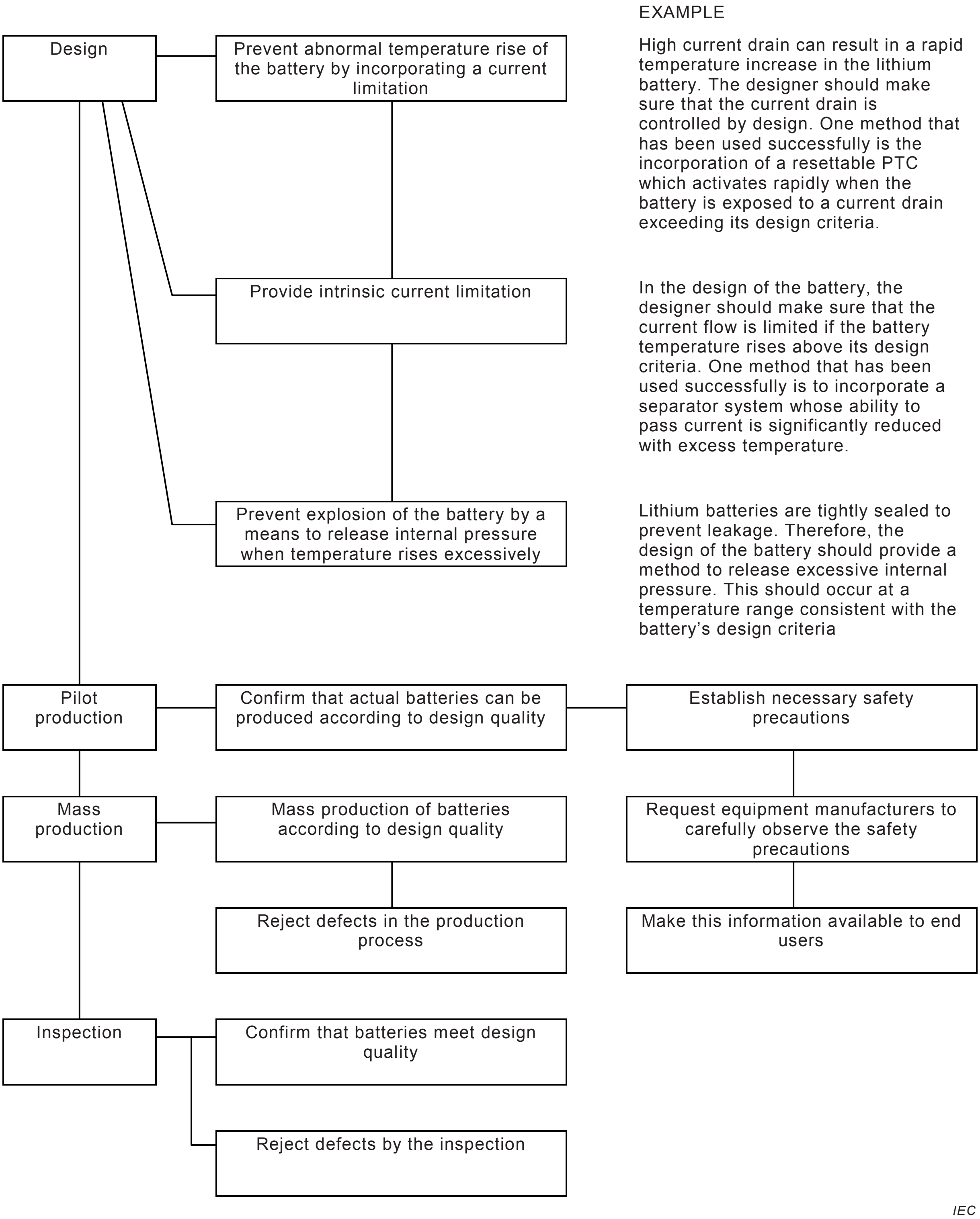


Figure A.1 – Battery design guidelines

Annex B
(informative)

Guidelines for designers of equipment using lithium batteries

Table B.1 sets out the guidelines to be used by designers of equipment which employs lithium batteries (see also IEC 60086-5:2011 [8], Annex B, for guidelines for the design of battery compartments).

Table B.1 – Equipment design guidelines *(1 of 3)*

Item	Sub-item	Recommendations	Possible consequences if the recommendations are not observed
(1) When a lithium battery is used as main power source	(1.1) Selection of a suitable battery	Select most suitable battery for the equipment, taking note of its electrical characteristics	Battery might overheat
	(1.2) Number of batteries (series connection or parallela connection) to be used and method of use	a) Multicell batteries (2CR5, CR-P2, 2CR13252 and others); one piece only	If the capacity of batteries in series connection is different, the battery with the lower capacity will be overdischarged. This can result in electrolyte leakage, overheating, rupture, explosion or fire
		b) Cylindrical batteries (CR17345 and others); less than three pieces	
		c) Coin type batteries (CR2016, CR2025, CR11108 and others); less than three pieces	
		d) When more than one battery is used, different types should not be used in the same battery compartment	
		e) When batteries are used in parallel[a] protection against charging should be provided	If the voltages of batteries in parallel connection are different, the battery with the lower voltage will become charged. This can result in electrolyte leakage, overheating, rupture, explosion or fire
	(1.3) Design of battery circuit	a) Battery circuit shall be isolated from any other power source	Battery might be charged. This can result in electrolyte leakage, overheating, rupture, explosion or fire
		b) Protective devices such as fuses shall be incorporated in the circuit	Short-circuiting a battery can result in electrolyte leakage, overheating, rupture, explosion or fire

[a] See 7.1.3.

Table B.1 *(2 of 3)*

Item	Sub-Item	Recommendations	Possible consequences if the recommendations are not observed
(2) When a lithium battery is used as back-up power source	(2.1) Design of battery circuit	The battery should be used in separate circuit so that it is not force discharged or charged by the main power source	Battery might be over-discharged to reverse polarity or charged. This can result in electrolyte leakage, overheating, rupture, explosion or fire
	(2.2) Design of battery circuit for memory back-up application	When a battery is connected to the circuit of a main power source with the possibility of being charged, a protective circuit must be provided with a combination of diode and resistor. The accumulated amount of the leakage current of the diode should be below 2 % of the battery capacity during expected life time	Battery might be charged. This can result in electrolyte leakage, overheating, rupture, explosion or fire
(3) Battery holder and battery compartment		a) Battery compartments should be designed so that if a battery is reversed, open circuit is achieved. Battery compartments should be clearly and permanently marked to show the correct orientation of batteries	Unless protection is provided against battery reversal, damage to equipment can occur from resultant electrolyte leakage, overheating, rupture, explosion or fire
		b) Battery compartments should be designed so that batteries other than the specified size cannot be inserted and make contact	Equipment might be damaged or might not operate
		c) Battery compartments should be designed to allow generated gases to escape	Battery compartments might be damaged when internal pressure of the battery becomes too high due to gas generation
		d) Battery compartments should be designed to be water proof	
		e) Battery compartments should be designed to be explosion proof when tightly sealed	
		f) Battery compartments should be isolated from heat generated by the equipment	Battery might be deformed and leak electrolyte due to excessive heat
		g) Battery compartments should be designed so that they cannot easily be opened by children	Children might remove batteries from the compartment and swallow them

Table B.1 *(3 of 3)*

Item	Sub-Item	Recommendations	Possible consequences if the recommendations are not observed
(4) Contacts and terminals		a) Material and shape of contacts and terminals should be selected so that effective electric contact is maintained	Heat might generate at the contact due to insufficient connection
		b) Auxiliary circuit should be designed to prevent reverse installation of batteries	Equipment might be damaged or might not operate
		c) Contact and terminal should be designed to prevent reverse installation of batteries	Equipment might be damaged. Battery might cause electrolyte leakage, overheating, rupture, explosion or fire
		d) Direct soldering or welding to a battery should be avoided	Battery might leak, overheat, rupture, explode or catch fire
(5) Indication of necessary precautions	(5.1) On the equipment	Orientation of batteries (polarity) should be clearly indicated at the battery compartment	When a battery is inserted reverse and charged, it can result in electrolyte leakage, overheating, rupture, explosion or fire
	(5.2) In the instruction manual	Precautions for the proper handling of batteries should be indicated	Batteries might be mishandled and cause accidents

Annex C
(informative)

Additional information on display and storage

This annex provides additional details concerning display and storage of lithium batteries to those already given in 7.6.

The storage area should be clean, cool, dry, ventilated and weatherproof.

For normal storage, the temperature should be between +10 °C and +25 °C and should never exceed +30 °C. Extremes of humidity (over 95 % and below 40 % relative humidity) for sustained periods should be avoided since they are detrimental to both batteries and packings. Batteries should therefore not be stored next to radiators or boilers nor in direct sunlight.

Although the storage life of batteries at room temperature is excellent, storage is improved at lower temperatures provided that special precautions are taken. The batteries should be enclosed in special protective packing (such as sealed plastic bags or variants) which should be retained to protect the batteries from condensation during the time they are warming to ambient temperature. Accelerated warming is harmful.

Batteries which have been cold-stored may be put into use after return to ambient temperature.

Batteries may be stored fitted in equipment or packages, if determined suitable by the battery manufacturer.

The height to which batteries may be stacked is clearly dependent on the strength of the packaging. As a general rule, this height should not exceed 1,5 m for cardboard packages or 3 m for wooden cases.

The above recommendations are equally valid for storage conditions during prolonged transit. Thus, batteries should be stored away from ship engines and not left for long periods in unventilated metal box cars (containers) during summer.

Batteries shall be dispatched promptly after manufacture and in rotation to distribution centres and on to the users. In order that stock rotation (first in, first out) can be practised, storage areas and displays should be properly designed and packs adequately marked.

Annex D
(informative)

Safety pictograms

D.1 General

Cautionary advice to fulfil the marking requirements in this standard has, on a historical basis, been in the form of written text. In recent years, there has been a growing trend toward the use of pictograms as a complementary or alternative means of product safety communication.

The objectives of this annex are: (1) to establish uniform pictogram recommendations that are tied to long-used and specific written text, (2) to minimize the proliferation of safety pictogram designs, and (3) to lay the foundation for the use of safety pictograms instead of written text to communicate product safety and cautionary statements.

D.2 Pictograms

The pictogram recommendations and cautionary advice are given in Table D.1.

Table D.1 – Safety pictograms *(1 of 2)*

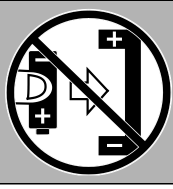
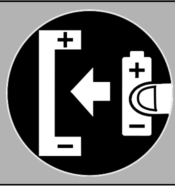
Reference	Pictogram	Cautionary advice
A		DO NOT CHARGE
B		DO NOT DEFORM OR DAMAGE
C		DO NOT DISPOSE OF IN FIRE
D		DO NOT INSERT INCORRECTLY
NOTE The grey shading highlights a white margin appearing when the pictogram is printed on coloured or black background.		

Table D.1 *(2 of 2)*

Reference	Pictogram	Cautionary advice
E	 NOTE Under consideration to replace pictogram E in IEC 60086-5:2011 [8], Table C.1	KEEP OUT OF REACH OF CHILDREN NOTE See 7.2a) for critical safety information
F		DO NOT MIX DIFFERENT TYPES OR BRANDS
G		DO NOT MIX NEW AND USED
H		DO NOT OPEN OR DISMANTLE
I		DO NOT SHORT CIRCUIT
J		INSERT CORRECTLY
NOTE The grey shading highlights a white margin appearing when the pictogram is printed on coloured or black background.		

D.3 Instruction for use

The following instructions are provided for use of the pictograms.

a) Pictograms shall be clearly legible.

b) Whilst colours are permitted, they shall not detract from the information displayed. If colours are used, the background of pictogram J should be blue and the circle and diagonal bar of the other pictograms should be red.

c) Not all of the pictograms need to be used together for a particular type or brand of battery. In particular, pictogram D and J are meant as alternatives for a similar purpose.

Bibliography

[1] IATA, International Air Transport Association, Quebec: *Dangerous Goods Regulations* (revised annually)

[2] ICAO, International Civil Aviation Organization, Montreal: *Technical Instructions for the Safe Transport of Dangerous Goods by Air* (revised biennially)

[3] IEC 60050-482:2004, *International Electrotechnical Vocabulary – Chapter 482: Primary and secondary cells and batteries*

[4] IEC 60027-1:1992, *Letter symbols to be used in electrical technology – Part 1: General*

[5] IEC 60068-2-6:1995, *Environmental testing – Part 2-6: Tests – Test Fc: Vibration (sinusoidal)*

[6] IEC 60068-2-27:1987, *Environmental testing – Part 2-27: Tests – Test Ea and guidance: Shock*

[7] IEC 60068-2-31:2008, *Environmental testing – Part 2-31: Tests – Test Ec: Rough handling shocks, primarily for equipment-type specimens*

[8] IEC 60086-5:2011, *Primary batteries – Part 5: Safety of batteries with aqueous electrolyte*

[9] IEC 60617 (all parts), *Graphical symbols for diagrams* (avaiable at http://std.iec.ch/iec60617)

[10] IEC 62133, *Secondary cells and batteries containing alkaline or other non-acid electrolytes – Safety requirements for portable sealed secondary cells, and for batteries made from them, for use in portable applications*

[11] IEC 61960, *Secondary cells and batteries containing alkaline or other non-acid electrolytes – Secondary lithium cells and batteries for portable applications*

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

[13] IMO, International Maritime Organization, London: *International Maritime Dangerous Goods (IMDG) Code* (revised biennially)

[14] ISO/IEC GUIDE 50:2002, *Safety aspects – Guidelines for child safety*

[15] ISO/IEC GUIDE 51:1999, *Safety aspects – Guidelines for their inclusion in standards*

[16] ISO 8124-1, *Safety of toys – Part 1: Safety aspects related to mechanical and physical properties*

[17] UL 1642, *Underwriters Laboratories, Standard for Lithium batteries*

[18] United Nations, New York and Geneva: *Recommendations on the Transport of Dangerous Goods, Model Regulations* (revised biennially)

[19] United Nations, New York and Geneva: 2011, *Recommendations on the Transport of Dangerous Goods, Manual of Tests and Criteria, Chapter 38.3*

[20] Battery Association of Japan: *Guideline for the design and production of safe Lithium batteries for camera application, 2nd edition, March 1998*

This page deliberately left blank

This page deliberately left blank

British Standards Institution (BSI)

BSI is the national body responsible for preparing British Standards and other standards-related publications, information and services.

BSI is incorporated by Royal Charter. British Standards and other standardization products are published by BSI Standards Limited.

About us

We bring together business, industry, government, consumers, innovators and others to shape their combined experience and expertise into standards -based solutions.

The knowledge embodied in our standards has been carefully assembled in a dependable format and refined through our open consultation process. Organizations of all sizes and across all sectors choose standards to help them achieve their goals.

Information on standards

We can provide you with the knowledge that your organization needs to succeed. Find out more about British Standards by visiting our website at bsigroup.com/standards or contacting our Customer Services team or Knowledge Centre.

Buying standards

You can buy and download PDF versions of BSI publications, including British and adopted European and international standards, through our website at bsigroup.com/shop, where hard copies can also be purchased.

If you need international and foreign standards from other Standards Development Organizations, hard copies can be ordered from our Customer Services team.

Subscriptions

Our range of subscription services are designed to make using standards easier for you. For further information on our subscription products go to bsigroup.com/subscriptions.

With **British Standards Online (BSOL)** you'll have instant access to over 55,000 British and adopted European and international standards from your desktop. It's available 24/7 and is refreshed daily so you'll always be up to date.

You can keep in touch with standards developments and receive substantial discounts on the purchase price of standards, both in single copy and subscription format, by becoming a **BSI Subscribing Member**.

PLUS is an updating service exclusive to BSI Subscribing Members. You will automatically receive the latest hard copy of your standards when they're revised or replaced.

To find out more about becoming a BSI Subscribing Member and the benefits of membership, please visit bsigroup.com/shop.

With a **Multi-User Network Licence (MUNL)** you are able to host standards publications on your intranet. Licences can cover as few or as many users as you wish. With updates supplied as soon as they're available, you can be sure your documentation is current. For further information, email bsmusales@bsigroup.com.

Revisions

Our British Standards and other publications are updated by amendment or revision.

We continually improve the quality of our products and services to benefit your business. If you find an inaccuracy or ambiguity within a British Standard or other BSI publication please inform the Knowledge Centre.

Copyright

Useful Contacts:

Customer Services
Tel: +44 845 086 9001
Email (orders): orders@bsigroup.com
Email (enquiries): cservices@bsigroup.com

Subscriptions
Tel: +44 845 086 9001
Email: subscriptions@bsigroup.com

Knowledge Centre
Tel: +44 20 8996 7004
Email: knowledgecentre@bsigroup.com

Copyright & Licensing
Tel: +44 20 8996 7070
Email: copyright@bsigroup.com

BSI Group Headquarters

389 Chiswick High Road London W4 4AL UK

bsi.

...making excellence a habit.™