IEC 60086-5

Edition 5.0 2021-09
REDLINE VERSION

INTERNATIONAL STANDARD

colour inside

Primary batteries –
Part 5: Safety of batteries with aqueous electrolyte

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INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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PRIMARY BATTERIES –

Part 5: Safety of batteries with aqueous electrolyte

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition IEC 60086-5:2016. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

IEC 60086-5 has been prepared by IEC technical committee 35: Primary cells and batteries. It is an International Standard.

This fifth edition cancels and replaces the fourth edition published in 2016. This edition constitutes a technical revision.

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

a) revised information for safety dealing with keeping batteries out of the reach of children;
b) removal of the method to determine the insulation resistance;
c) changes to the test matrix;
d) revision of the over-discharge test;
e) revised definition and note for "button cell" or "button battery" in 3.2;
f) revised method for evaluation of an explosion, moved from 3.6 to 6.2.1.

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

FDIS	Report on voting
35/1471/FDIS	35/1472/RVD

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

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

A list of all parts in the IEC 60086 series, published under the general title *Primary batteries*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

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

NOTE The attention of National Committees is drawn to the fact that equipment manufacturers and testing organizations may need a transitional period following publication of a new, amended or revised IEC document in which to make products in accordance with the new requirements and to equip themselves for conducting new or revised tests.

It is the recommendation of the committee that the content of this document be adopted for implementation nationally not earlier than 2 years from the date of publication. The transitional period applies specifically to Table 7.

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

INTRODUCTION

The concept of safety is closely related to safeguarding the integrity of people and property. This part of IEC 60086 specifies tests and requirements for primary batteries with aqueous electrolyte and has been prepared in accordance with ISO/IEC guidelines, taking into account all relevant national and international standards which apply. Also included in this document is guidance for appliance designers with respect to battery compartments and information regarding packaging, handling, warehousing and transportation.

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

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

PRIMARY BATTERIES –

Part 5: Safety of batteries with aqueous electrolyte

1 Scope

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

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60086-1:2015, *Primary batteries – Part 1: General*

IEC 60086-2:2015, *Primary batteries – Part 2: Physical and electrical specifications*

~~IEC 60068-2-6, *Environmental testing – Part 2-6: Tests – Test Fc: Vibration (sinusoidal)*~~

~~IEC 60068-2-27, *Environmental testing – Part 2-27: Tests – Test Ea and guidance: Shock*~~

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

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

~~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 by permanent means, fitted in a case, with terminals, markings and protective devices etc., as necessary for use

[SOURCE: IEC 60050-482:2004, 482-01-04 [1], modified – The definition has been revised.]

3.2
button cell
button battery
small round cell or battery where the overall height is less than the diameter, containing aqueous electrolyte

Note 1 to entry: In English, the term "button (cell or battery)" is only used for non-lithium batteries while the term "coin (cell or battery)" is used for lithium batteries only. In languages other than English, the terms "coin" and "button" are often used interchangeably, regardless of the electrochemical system. See coin (cell or battery), lithium button (cell or battery) in IEC 60086-1 and IEC 60086-2.

[SOURCE: IEC 60050-482:2004, 482-02-40, modified – The second term "coin cell" has been deleted, the definition has been revised and the note has been replaced with a new 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, modified – The note has been deleted.]

3.4
component cell
cell contained in a battery

3.5
cylindrical battery
cylindrical cell
round cell or battery with a cylindrical shape in which the overall height is equal to or greater than the diameter

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

3.6
explosion (battery explosion)
the cell or battery opens and solid components are forcibly expelled

3.7
fire
flames are emitted from the test cell or battery

3.6
intended use
use in accordance with information provided with a product or system, or, in the absence of such information, by generally understood patterns of usage

[SOURCE: ISO/IEC Guide 51:2014, 3.6 [2]]

3.9
leakage
unplanned escape of electrolyte from a cell or battery

[SOURCE: IEC 60050-482:2004, 482-02-32]

3.7
nominal voltage
V_n U_n
<of a primary battery> 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, modified – (addition of "(of a primary battery)" and symbol V_n) The domain and symbol have been added.]

3.8
primary cell
primary battery
cell or battery that is not designed to be electrically recharged

3.9
prismatic cell
prismatic battery
cell or battery having the shape of a parallelepiped whose faces are rectangular

[SOURCE: IEC 60050-482:2004, 482-02-38, modified ~~(deletion of "qualifies a")~~ – "cell" and "battery" have been added to the term and "qualifies a" has been deleted.]

3.10
protective device
device such as fuse, diode or other electric or electronic current limiter designed to interrupt the current flow in an electrical circuit

3.11
reasonably foreseeable misuse
use of a product or system in a way not intended by the supplier, but which can result from readily predictable human behaviour

[SOURCE: ISO/IEC Guide 51:~~1999~~2014~~, 3.14, modified ("process or service" replaced by "or system" and "may" replaced by "can" and deletion of the Note)~~ 3.7, modified – The notes have been deleted.]

3.12
round cell
round battery
cell or battery with circular cross section

3.13
safety
freedom from risk which is not tolerable

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

3.14
undischarged
state of ~~charge of~~ a primary cell or battery ~~corresponding to~~ at 0 % depth of discharge

~~**3.18**~~
~~**venting**~~
~~release of excessive internal pressure from a cell or battery in a manner intended by design to preclude explosion~~

4 Requirements for safety

4.1 Design

4.1.1 General

Batteries shall be so designed that they do not present a safety hazard under conditions of normal (intended) use.

4.1.2 Venting

All batteries shall incorporate a pressure relief feature or shall be so constructed that they will relieve excessive internal pressure at a value and rate which will preclude explosion. If encapsulation is necessary to support cells within an outer case, the type of encapsulant and the method of encapsulation shall not cause the battery to overheat during normal operation nor inhibit the operation of the pressure relief feature.

The battery case material and/or its final assembly shall be so designed that, in the event of one or more cells venting, the battery case does not present a hazard in its own right.

~~4.1.3 Insulation resistance~~

~~The insulation resistance between externally exposed metal surfaces of the battery excluding electrical contact surfaces and either terminal shall be not less than 5 MΩ at 500 $V^{+100\ V}_{-0\ V}$ applied for a minimum of 60 seconds.~~

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.

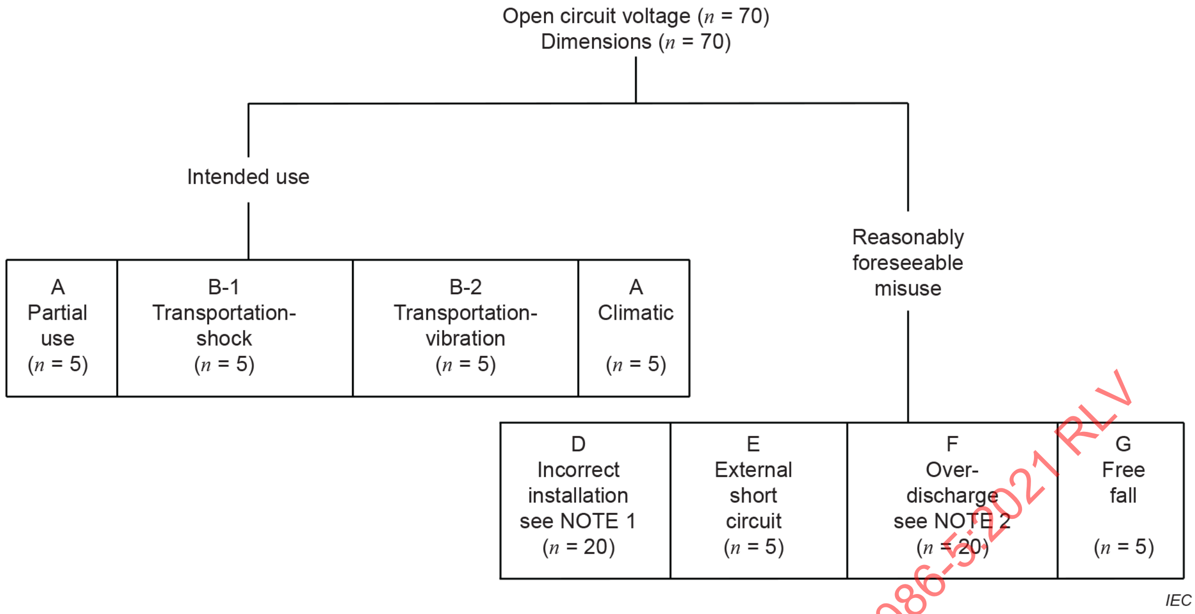
5 Sampling

5.1 General

Samples should be drawn from production lots in accordance with accepted statistical methods and shall meet the requirements specified for dimensions and open circuit voltage set forth in IEC 60086-2. Samples failing to meet these requirements shall be discarded and new samples selected.

5.2 Sampling for type ~~approval~~ testing

The number of samples drawn for type ~~approval~~ testing is given in Figure 1.



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 discharged (5 sets).

Figure 1 – Sampling for ~~type approval~~ tests and number of batteries required

5.3 Validity of testing

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

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

b) a battery specification change would lead to a failure of any of the tests;

c) there is an addition of new tests or requirements; or

d) there is a requirement change that would lead to a failure of any of the tests.

6 Testing and requirements

6.1 General

6.1.1 Applicable safety tests

Applicable safety tests are shown in Table 1. The tests described in Table 2 and Table 6 are intended to simulate conditions which the battery is likely to encounter during intended use and reasonably foreseeable misuse.

Table 1 – Test matrix

System letter	Negative electrode	Electrolyte	Positive electrode	Nominal voltage per cell V	Form	Applicable tests						
						A	B-1 B-2	C	D	E	F	G
No letter	Zinc (Zn)	Ammonium chloride, Zinc chloride	Manganese dioxide (MnO_2)	1,5	R	x	x	x	x	x	x	x
					B	NR						
					Pr	x	x	x	x	x	x	x
					M	x	x	x	NR	x	~~x~~ NR	x
A	Zinc (Zn)	Ammonium chloride, Zinc chloride	Oxygen (O_2)	1,4	R	x	x	x	NR	x	x	x
					B	NR						
					Pr	x	x	x	x	x	x	x
					M	x	x	x	NR	x	x	x
L	Zinc (Zn)	Alkali metal hydroxide	Manganese dioxide (MnO_2)	1,5	R	x	x	x	x	x	x	x
					B	x	x	x	NR	x	NR	x
					Pr	x	x	x	x	x	x	x
					M	x	x	x	NR	x	NR	x
P	Zinc (Zn)	Alkali metal hydroxide	Oxygen air (O_2)	1,4 or 1,45	R	NR						
					B	NR	~~x~~ NR	~~x~~ NR	NR	~~x~~ NR	NR	~~x~~ NR
					Pr	x	x	x	x	x	x	x
					M	NR						
S	Zinc (Zn)	Alkali metal hydroxide	Silver oxide (Ag_2O)	1,55	R	x	x	x	NR	x	NR	x
					B	x	x	x	NR	x	NR	x
					Pr	x	x	x	x	x	x	x
					M	NR						

Test description:

A: storage after partial use
B-1: transportation-shock
B-2: transportation-vibration
C: climatic-temperature cycling
D: incorrect installation
E: external short circuit
F: overdischarge
G: free fall

Key

R: cylindrical (3.5)
B: button (3.2)
Pr: prismatic single cell (3.11)
M: multicell

x: Required
NR: Not required

If necessary, follow the discharge conditions of the IEC 60086-2 service output test. Systems L and S button cells or batteries under ~~250 mAh capacity and system P button cells or batteries under 700 mAh capacity~~ 3,5 g are exempt from any testing.

6.1.2 Cautionary notice

WARNING – The tests in this document 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, these tests shall be carried out at an ambient temperature of 20 °C ± 5 °C.

6.2 Evaluation of test criteria

6.2.1 Explosion

An explosion is considered to have occurred when there is an instantaneous release wherein solid matter from any part of the battery is propelled to a distance greater than 25 cm away from the battery.

6.2.2 Fire

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

6.2.3 Leakage

Leakage is considered to have occurred if there is an unplanned escape of electrolyte from a cell or battery.

6.2.4 Venting

Venting is considered to have occurred if there is a release of excessive internal pressure from a cell or battery in a manner intended by design to preclude explosion.

6.3 Intended use

6.3.1 Intended use tests and requirements

Table 2 – Intended use tests and requirements

Test		Intended use simulation	Requirements
Electrical test	A	Storage after partial use	No leakage (NL) No fire (NF) No explosion (NE)
Environmental tests	B-1	Transportation-shock	No leakage (NL) No fire (NF) No explosion (NE)
	B-2	Transportation-vibration	No leakage (NL) No fire (NF) No explosion (NE)
Climatic-temperature	C	Climatic-temperature cycling	No fire (NF) No explosion (NE)

6.3.2 Intended use test procedures

6.3.2.1 Test A – Storage after partial use

a) Purpose

This test simulates the situation when an appliance is switched off and the installed batteries are partly discharged. These batteries may be left in the appliance for a long time or they are removed from the appliance and stored for a long time.

b) Test procedure

An undischarged battery is discharged under an application~~/~~ or service output test condition, with the ~~lowest resistive~~ load ~~test as~~ defined in IEC 60086-2 resulting in the longest test duration until the service life falls by 50 % of the highest minimum average duration (MAD) value, followed by storage at 45 °C ± ~~5~~ 2 °C for 30 days.

The temperature tolerance of ±2 °C is for the temperature maintain period and a brief over-shoot in temperature is allowed during the transition period.

c) Requirements

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

6.3.2.2 Test B-1 – Transportation-shock

a) Purpose

This test simulates the situation when an appliance is carelessly dropped with batteries installed in it. This test condition is generally specified in IEC 60068-2-27 [3][1].

b) Test procedure

An undischarged battery shall be tested as follows.

The shock test shall be carried out under the conditions defined in Table 3 and the sequence in Table 4.

Shock pulse – The shock pulse applied to the battery shall be as follows:

Table 3 – Shock pulse

Acceleration		Waveform
Minimum average acceleration first three milliseconds	Peak acceleration	
75 g_n	125 g_n to 175 g_n	Half sine
NOTE g_n = 9,806 65 m/s².		

Table 4 – Test sequence of the shock test

Step	Storage time	Battery orientation	Number of shocks	Visual examination periods
1	–	–	–	Pre-test
2	–	[a]	1 each	–
3	–	[a]	1 each	–
4	–	[a]	1 each	–
5	1 h	–	–	–
6	–	–	–	Post-test

[a] The shock shall be applied in each of three mutually perpendicular directions.

Step 1 Record open circuit voltage in accordance with 5.2.

Steps 2 to 4 Apply shock test specified in Table 3 and the sequence in Table 4.

Step 5 Rest battery for 1 h.

Step 6 Record examination results.

c) Requirements

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

6.3.2.3 Test B-2 – Transportation-vibration

a) Purpose

[1] Numbers in square brackets refer to the bibliography.

This test simulates vibration during transportation. This test condition is generally specified in IEC 60068-2-6 [4].

b) Test procedure

An undischarged battery shall be tested as follows.

The vibration test shall be carried out under the following test conditions and the sequence in Table 5.

Vibration – A simple harmonic motion shall be applied to the battery having an amplitude of 0,8 mm, with a total maximum excursion of 1,6 mm. The frequency shall be varied at the rate of 1 Hz/min between the limits of 10 Hz and 55 Hz. The entire range of frequencies (10 Hz to 55 Hz) and return (55 Hz to 10 Hz) shall be traversed in (90 ± 5) min for each mounting position (direction of vibration).

Table 5 – Test sequence of the vibration test

Step	Storage time	Battery orientation	Vibration time	Visual examination periods
1	–	–	–	Pre-test
2	–	[a]	(90 ± 5) min each	–
3	–	[a]	(90 ± 5) min each	–
4	–	[a]	(90 ± 5) min each	–
5	1 h	–	–	–
6	–	–	–	Post-test

[a] The vibration shall be applied in each of three mutually perpendicular directions.

Step 1 Record open circuit voltage in accordance with 5.2.

Steps 2 to 4 Apply the vibration specified in 6.3.2.3 in the sequence in Table 5.

Step 5 Rest battery for 1 h.

Step 6 Record examination results.

c) Requirements

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

6.3.2.4 Test C – Climatic-temperature cycling

a) Purpose

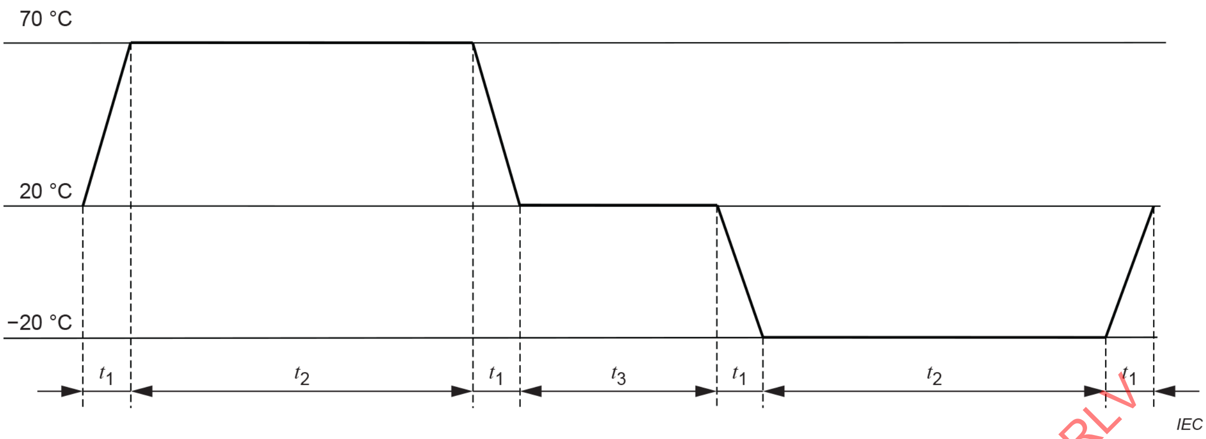
This test assesses the integrity of the battery seal which may be impaired after temperature cycling.

b) Test procedure

An undischarged battery shall be tested under the following procedure.

Temperature cycling procedure (see 1) to 7) below and/or Figure 2)

1) Place the batteries in a test chamber and raise the temperature of the chamber to 70 °C ± 5 °C within t_1 = 30 min.
2) Maintain the chamber at this temperature for t_2 = 4 h.
3) Reduce the temperature of the chamber to 20 °C ± 5 °C within t_1 = 30 min and maintain at this temperature for t_3 = 2 h.
4) Reduce the temperature of the chamber to –20 °C ± 5 °C within t_1 = 30 min and maintain at this temperature for t_2 = 4 h.
5) Raise the temperature of the chamber to 20 °C ± 5 °C within t_1 = 30 min.
6) Repeat the sequence for a further nine cycles.
7) After the 10th cycle, store the batteries for seven days prior to examination.



t_1 = 30 min

t_2 = 4 h

t_3 = 2 h

Figure 2 – Temperature cycling procedure

c) Requirements

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

6.4 Reasonably foreseeable misuse

6.4.1 Reasonably foreseeable misuse tests and requirements

Table 6 – Reasonably foreseeable misuse tests and requirements

Test		Misuse simulation	Requirements
Electrical tests	D	Incorrect installation	No fire (NF) No explosion (NE)[a]
	E	External short circuit	No fire (NF) No explosion (NE)
	F	Overdischarge	No fire (NF) No explosion (NE)
Environmental test	G	Free fall	No fire (NF) No explosion (NE)

[a] See NOTE 2 of 6.4.2.1 b).

6.4.2 Reasonably foreseeable misuse test procedures

6.4.2.1 Test D – Incorrect installation (four batteries in series)

a) Purpose

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

b) Test procedure

Four undischarged batteries of the same brand, type and origin shall be connected in series with one reversed (B1) as shown in Figure 3. The circuit shall be completed for 24 h or until the battery case temperature has returned to ambient.

The resistance of the inter-connecting circuitry shall not exceed 0,1 Ω.

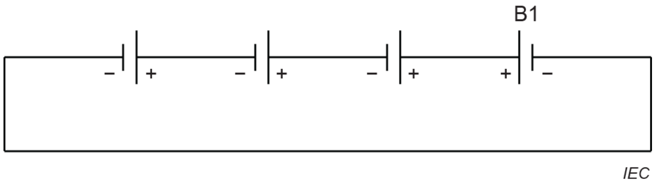


Figure 3 – Circuit diagram for incorrect installation (four batteries in series)

NOTE 1 The circuit in Figure 3 simulates a typical misuse condition.

NOTE 2 Primary batteries are not designed to be charged. However, reversed installation of a battery in a series of three or more exposes the reversed battery to a charging condition. Although cylindrical batteries are designed to relieve excessive internal pressure, it is possible that in some instances an explosion ~~may not~~ cannot be precluded.

c) Requirements

There shall be no fire and no explosion during this test (see NOTE 2 of 6.4.2.1 b)).

6.4.2.2 Test E – External short circuit

a) Purpose

This misuse may occur during daily handling of batteries.

b) Test procedure

An undischarged battery shall be connected as shown in Figure 4. The circuit shall be completed for 24 h or until the battery case temperature has returned to ambient. The resistance of the inter-connecting circuitry shall not exceed 0,1 Ω.

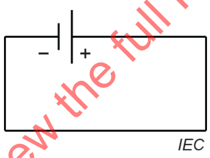


Figure 4 – Circuit diagram for external short circuit

c) Requirements

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

6.4.2.3 Test F – Overdischarge

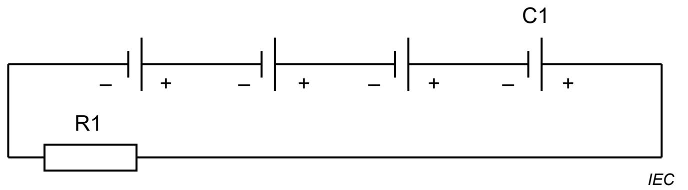
a) Purpose

~~This test simulates the condition when one (1) discharged battery is series-connected with three (3) other undischarged batteries.~~ This test simulates and determines the effect of placing a discharged battery in a circuit with undischarged batteries (i.e. mixing new with used or old batteries).

b) Test procedure

One undischarged battery (C1) is discharged under the application or service output test condition, with the highest MAD value (expressed in time units), as defined in IEC 60086-2, until the on-load voltage falls to (n × 0,6 V) where n is the number of cells in the battery. Then, three undischarged batteries and one discharged battery (C1) of the same brand, type and origin shall be connected in series as shown in Figure 5. The discharge shall be continued ~~until the total on-load voltage falls to four times (n × 0,6 V)~~ for 24 h.

The value of the resistor (R1) shall be approximately four times the lowest value from the resistive load tests specified for that battery in IEC 60086-2. The final value of the resistor (R1) shall be the nearest value to that ~~prescribed~~ specified in 6.4 of IEC 60086-1:2015.



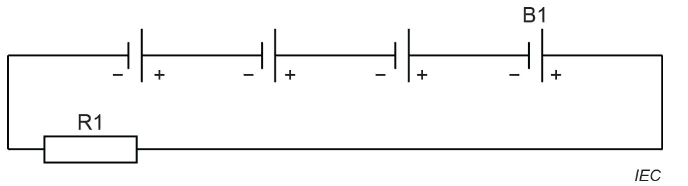


Figure 5 – Circuit diagram for overdischarge

c) Requirements

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

6.4.2.4 Test G – Free fall test

a) Purpose

This test simulates the situation when a battery is accidentally dropped. The test condition is based upon IEC 60068-2-31 [5].

b) Test procedure

Undischarged 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 on each of its six faces, a round battery twice in each of the three axes shown in Figure 6. The test batteries shall be stored for 1 h afterwards.

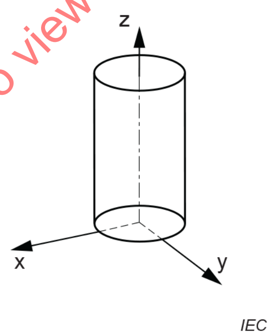


Figure 6 – XYZ axes for free fall

c) Requirements

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

7 Information for safety

7.1 Precautions during handling of batteries

When used correctly, primary batteries with aqueous electrolyte provide a safe and dependable source of power. However, battery misuse or abuse may result in leakage, or in extreme cases, fire and/or explosion.

a) Always insert batteries correctly with regard to the polarities (+ and –) marked on the battery and the equipment.

Batteries which are incorrectly placed into equipment may be short-circuited, or charged. This can result in a rapid temperature rise causing venting, leakage, explosion and personal injury. See Annex B for additional details.

b) 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 and/or handbag with keys or coins can be short-circuited. This may result in venting, leakage, explosion and personal injury.

c) Keep batteries out of the reach of children

Especially 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 7. In case of ingestion of a cell or a battery, the person involved should seek medical assistance promptly. Ingested button cells with less than 2 V do not exhibit the potential to cause chemical burns within a short time. If such cells have passed through the oesophagus, established medical practice is to monitor and allow the cell(s) to naturally pass.

NOTE 1 Refer to in Annex D, Clause D.1 for more details.

NOTE 2 Refer to [6] for general information on hazards.

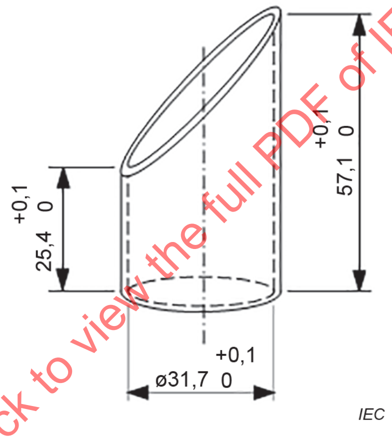


Figure 7 – Ingestion gauge

d) Do not charge batteries.

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

e) Do not force discharge batteries.

When batteries are force discharged with 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 may result in venting, leakage, explosion and personal injury.

f) Do not mix old and new 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 old batteries are used together, some batteries may be over-discharged due to a difference of voltage or capacity. This can result in venting, leakage and explosion and may cause personal injury.

g) 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 may occur causing damage to the appliance and/or personal injury.

h) Do not ~~heat~~ expose batteries to heat.

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

i) Do not weld or solder directly to batteries.

The heat from welding or soldering directly to a battery may cause internal short-circuiting resulting in venting, leakage and explosion and may cause personal injury.

j) Do not dismantle batteries.

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

k) Do not deform batteries.

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

l) Do not dispose of batteries in fire.

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

NOTE Refer to [6].

m) Do not allow children to replace batteries without adult supervision.

n) Do not encapsulate and/or modify batteries.

Encapsulation, or any other modification to a battery, may result in blockage of the pressure relief vent mechanism(s) and/or prevent removal of hydrogen gas generated in the batteries (see also Clause B.6). This may lead to explosion and personal injury. Advice from the battery manufacturer should be sought if it is considered necessary to make any modification.

o) 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 may result in venting, leakage and explosion and personal injury; one of the best ways to avoid this happening is to store unused batteries in their original packaging.

p) 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. portable lighting, toys~~, etc.~~). Although most batteries on the market today are provided with protective jackets or other means to contain leakage, a battery that has been partially or completely exhausted may be more prone to leak than one that is unused.

7.2 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.

7.3 Handling of battery cartons

Battery cartons should be handled with care. Rough handling might result in battery damage. This can cause leakage, explosion, or fire.

7.4 Display and storage

a) Batteries shall be stored in well-ventilated, dry and cool conditions.

High temperature or high humidity may cause deterioration of the battery performance or surface corrosion.

b) Battery cartons should not be piled up in several layers (or should not exceed a specified height).

   If too many battery cartons are piled up, batteries in the lowest cartons may be deformed and electrolyte leakage may occur.

c) When batteries are stored in warehouses or displayed in retail stores, they should not be exposed to direct sun rays for a long time or placed in areas where they get wet by rain.

   When batteries get wet, their insulation resistance decreases, self-discharge may occur and rust may be generated.

d) Do not mix unpacked batteries so as to avoid mechanical damage and/or short circuit among each other.

   When mixed together, batteries may be subjected to physical damage or overheating resulting from external short circuit. Leakage and/or explosion may then occur. To avoid these possible hazards, batteries should be kept in their packaging until required for use.

e) See Annex A for additional details.

7.5 Transportation

When loaded for transportation, battery packages should be so arranged to minimize the risk of falling for example one from the top of another. They should not be stacked so high that damage to the lower packages occurs. Protection from inclement weather should be provided.

7.6 Disposal

a) Do not dismantle batteries.

b) Do not dispose of batteries in fire except under conditions of controlled incineration.

c) Primary batteries may be disposed of via the communal refuse arrangements, provided that no local rules to the contrary exist.

d) Where there is provision for the collection of used batteries, the following should be considered:

   - Store collected batteries in a non-conductive container.
   - Store collected batteries in a well-ventilated area. Since some used batteries may still contain a residual charge, they could be short-circuited, charged or force discharged and thereby evolve hydrogen gas. If collection containers and storage areas are not properly ventilated, hydrogen gas can build up and explode in the presence of an ignition source.
   - Do not mix collected batteries with other materials. Since some used batteries may still contain a residual charge, they could be short-circuited, charged or force discharged. The subsequent possible heat generation can ignite flammable wastes such as oily rags, paper or wood and can cause a fire.
   - Consider protecting used battery terminals, particularly those batteries with high voltage, to preclude short circuits, charging and force discharging, for instance, by means of covering battery terminals with insulating tape.
   - Failure to observe these recommendations may result in leakage, fire, and/or explosion.

8 Instructions for use

a) Always select the correct size and grade 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 those of the equipment prior to battery installation.

d) Ensure that the batteries are installed correctly with regard to polarity (+ and –).

e) Remove batteries from equipment which is not to be used for an extended period of time.

f) Remove exhausted batteries promptly.

9 Marking and packaging

9.1 General batteries ~~(see Table 7)~~

With the exception of ~~small batteries~~ swallowable button cells (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 trademark of the manufacturer or supplier;
f) cautionary advice.

Refer to Table 7, "General batteries", for an overview of marking requirements for general batteries.

NOTE The common designation can be found in Annex D of IEC 60086-2:2015.

9.2 ~~Marking of small batteries (see Table 7)~~ Swallowable button cells

a) ~~Batteries designated in IEC as small, mainly category 3 and category 4 batteries have a surface too small to accommodate all markings shown in 9.1.~~ For ~~these~~ swallowable batteries, i.e. those that fit entirely within the ingestion gauge (Figure 7) the designation 9.1 a) and the polarity 9.1 c) shall be marked on the battery. All other required markings shown in 9.1, except 9.1 f), may be given on the immediate packaging instead of on the battery.
b) For P-system batteries, 9.1 a) may be marked on the battery, the sealing tab or the immediate packaging 9.1 c) may be marked on the sealing tab and/or on the battery. 9.1 b), 9.1 d) and 9.1 e) may be given on the immediate packaging instead of on the battery.
c) When batteries are intended for direct sale in consumer-replaceable applications, a caution for ingestion of swallowable batteries shall be given. Refer to 7.1 c) and Annex D for details. Caution for other risks is optional.

Refer to Table 7, "swallowable button cells", for an overview of marking and packaging requirements along with Annex E for child resistant packaging recommendations for swallowable button cells.

9.3 Safety pictograms

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

Table 7 – Marking and packaging requirements

~~Marking~~	~~Batteries with the exception of small batteries~~	~~Small batteries~~	
			~~P-system batteries~~
~~a) Designation, IEC or common~~	~~A~~	~~A~~	~~C~~
~~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~~	~~A~~	~~B~~	~~B~~
~~c) Polarity of the positive (+) terminal~~	~~A~~	~~A~~	~~D~~
~~d) Nominal voltage~~	~~A~~	~~B~~	~~B~~
~~e) Name or trade mark of the manufacturer or supplier~~	~~A~~	~~B~~	~~B~~
~~f) Cautionary advice~~	~~A~~	~~B[a]~~	~~B[a]~~

~~A: shall be marked on the battery.~~

~~B: may be marked on the immediate packing instead on the battery.~~

~~C: may be marked on the battery, the sealing tab or the immediate packing.~~

~~D: may be marked on the sealing tab and/or on the battery.~~

~~[a] Caution for ingestion of swallowable batteries shall be given. Refer to 7.1 l).~~

List item	General batteries	Swallowable button cells					
		d < 16 mm		16 mm ≤ d < 20 mm		d ≥ 20 mm	
Electrochemical system		**P**	**L, S**	**P**	**L, S**	**P**	**L, S**
a) Designation, IEC or common	B	C	B	C	B	C	B
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	B						
c) Polarity of the positive (+) terminal	B	D	B	D	B	D	B
d) Nominal voltage	B						
e) Name or trademark of the manufacturer or supplier	B						
f) Cautionary advice	B						
g) Caution for ingestion of swallowable batteries, see also 7.1 c) and Annex D		P[a]	P[a]	P[a]	P[a]	P[a]	B[a] + P[a]
h) Child resistant packaging	NR	NR	NR	NR	R[a,b]	NR	R[a,b]

Key

d: Diameter

B: Marking required on cell/battery

C: Marking required on battery, sealing tab or immediate packaging

D: Marking required on sealing tab and/or the battery

P: Marking required on immediate packaging

R: Child resistant packaging

NR: Not required

empty cell: Marking may appear on cell/battery and/or immediate packaging

[a] See Foreword for transition period.

[b] When batteries are intended for direct sale in consumer replaceable applications.

Annex A
(informative)

Additional information on display and storage

The purpose of this annex is to describe good practices for display and storage (see also 7.4) in general terms and, more specifically, to warn against procedures known from experience to be harmful. It takes the form of advice to battery manufacturers, distributors, users, and equipment designers.

Storage and stock rotation

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

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

c) Batteries which have been cold-stored should be put into use as soon as possible after return to ambient temperature.

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

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

f) 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.

g) Batteries should 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 should be adequately marked.

Annex B
(informative)

Battery compartment design guidelines

B.1 Background

B.1.1 General

In order to meet the ever-growing advances in battery-powered equipment technology, primary batteries have become more sophisticated in both chemistry and construction with resultant improvements to both capacity and rate capability. Resulting from these continuing developments and recognizing the need for both safety and optimum battery performance it was established that the majority of reported battery failures resulted from electrical abuse generally arising from consumer accidental misuse.

The following text and figures are intended to aid the battery-powered equipment designer to significantly reduce or eliminate such battery failures.

B.1.2 Battery failures resulting from poor battery compartment design

Poor battery compartment design may lead to reversed battery installation or to short-circuiting of the batteries.

B.1.3 Potential hazards resulting from battery reversal

If a battery is reversed in a circuit with three or more batteries in series as shown in Figure B.1, the following potential hazards exist:

a) charging of the reversed battery;

NOTE 1 The charging current is limited by the external circuit/load.

b) gas generation within the reversed battery;

c) vent activation of the reversed battery;

d) leakage of electrolyte from the reversed battery.

NOTE 2 Battery electrolytes are harmful to body tissues.

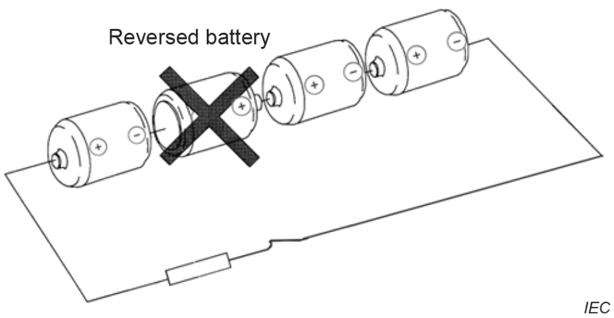


Figure B.1 – Example of series connection with one battery reversed

B.1.4 Potential hazards resulting from a short circuit

a) heat generation resulting from high current flow;

b) gas generation;

c) vent activation;

d) electrolyte leakage;

e) heat damage to insulating jackets (e.g. shrinkage).

NOTE Battery electrolytes are harmful to body tissues and generated heat can cause burns.

B.2 General guidance for appliance design

B.2.1 Key battery factors to be first considered

These guidelines are essentially directed toward cylindrical batteries with sizes ranging from R1 to R20. The battery systems involved are commonly referred to as alkaline manganese and zinc carbon. Whilst the two systems are interchangeable they should never be used in combination.

The following physical differences between the two systems and permitted design features should be noted during the early phases of battery compartment design.

a) The positive terminal of the alkaline manganese battery is connected to the battery case.

b) The positive terminal of the zinc carbon battery is insulated from the battery case.

c) Both battery types have an outer insulated jacket. This may be of paper, plastic or other non-conductive material. On occasion, the outer jacket may be metallic (conductive); in such instances this is insulated from the basic unit.

d) When forming the negative contact it should be noted that the corresponding battery terminal may be recessed. (For clarification refer to IEC 60086-1:2015, 4.1.3). To ensure good electrical contact, completely flat negative equipment contacts should be avoided.

e) Under no circumstances should battery connectors or any part of the equipment circuitry come into contact with the battery jacket. Any design of battery compartment permitting this, risks the possibility of a short circuit.

~~NOTE For example,~~ Conical or helical springs used for negative connection should compress uniformly when the battery is inserted and not bridge across to the battery jacket. (Spring connection to the positive terminal of a battery is not recommended.)

B.2.2 Other important factors to consider

a) It is recommended that companies producing battery-powered equipment should maintain close liaison with the battery industry. The capabilities of existing batteries should be taken into account at design inception. Whenever possible, the battery type selected should be one included in IEC 60086-2.

b) Design compartments so that batteries are easily inserted and do not fall out.

c) Design compartments to prevent easy access to the batteries by young children.

d) Dimensions should not be tied to a particular battery manufacturer as this can create problems when replacements of different origin are installed. Only consider the battery dimensions and tolerances defined within IEC 60086-2 when designing the battery compartment. The battery compartment should be designed such that it accommodates the increase in battery height in accordance with IEC 60086-2:2015, Clause 5, Note.

e) Clearly indicate the type of battery to use, the correct polarity alignment (+ and –) and directions for insertion.

f) Although batteries are very much improved regarding their resistance to leakage, it can still occasionally occur. When the battery compartment cannot be completely isolated from the equipment, it should be positioned so as to minimize possible equipment damage from battery leakage.

g) Design equipment circuitry such that equipment will not operate below 0,7 V per battery (0,7 V × n_s where n_s is the number of batteries connected in series). To continue discharging below this level may result in unfavourable chemical reactions within the battery/batteries resulting in leakage.

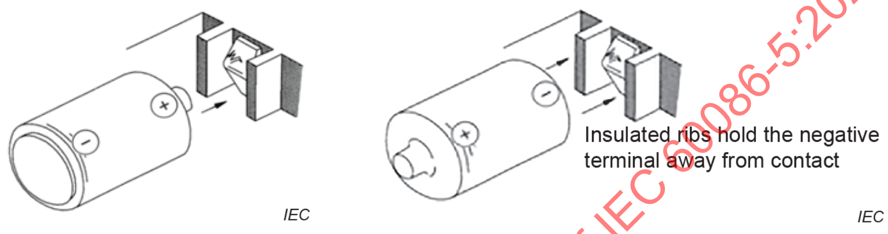
B.3 Specific measures against reversed installation

B.3.1 General

To overcome the problems associated with the reversed placement of a battery, consideration should be given at the design stage to ensure that batteries cannot be installed incorrectly or, if so installed, will not make electrical contact.

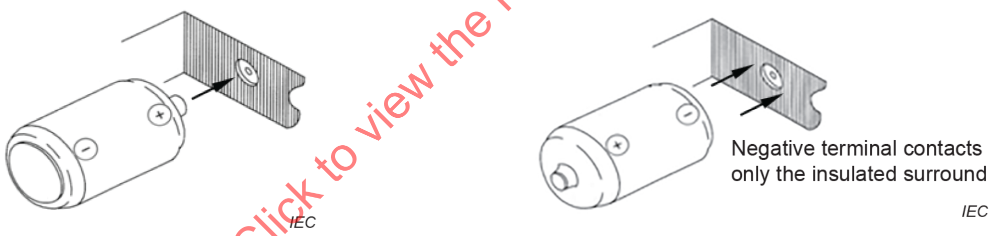
B.3.2 Design of the positive contact

Some suggestions for the R03, R1, R6, R14 and R20 size battery compartments are illustrated in Figure B.2 and Figure B.3 below. Provision should also be made to prevent unnecessary movement of batteries within the battery compartment. Battery contacts should be shielded to prevent contact during reverse installation.



a) Correct insertion of the battery **b) Incorrect insertion of the battery**

Figure B.2 – Positive contact recessed between ribs

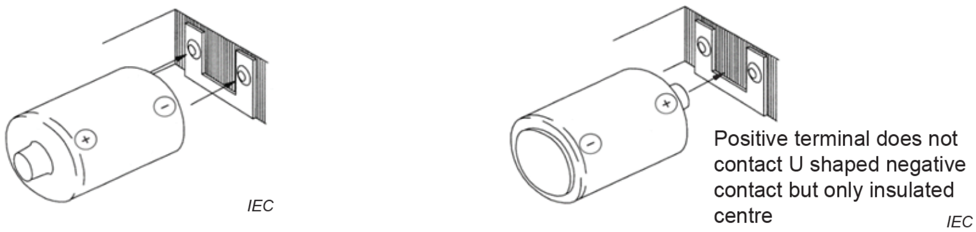


a) Correct insertion of the battery **b) Incorrect insertion of the battery**

Figure B.3 – Positive contact recessed within surrounding insulation

B.3.3 Design of the negative contact

The following suggestion is given for R03, R1, R6, R14 and R20 size battery compartments (see Figure B.4).



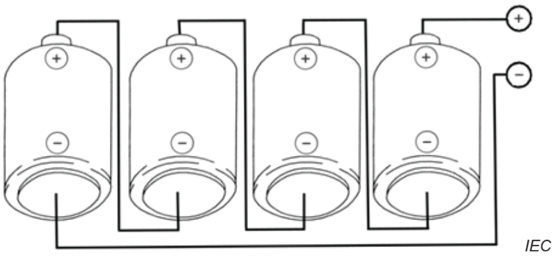
a) Correct insertion of the battery **b) Incorrect insertion of the battery**

Figure B.4 – Negative contact U-shaped to ensure no positive (+) battery contact

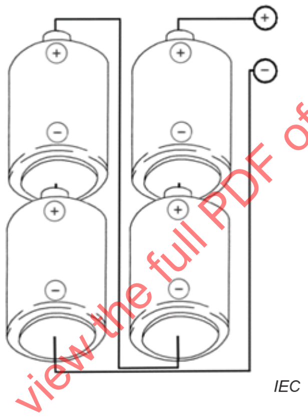
B.3.4 Design with respect to battery orientation

In order to avoid reverse insertion of batteries, it is recommended that all batteries have the same orientation. Examples are shown in Figure B.5 a) and Figure B.5 b).

Figure B.5 a) shows the preferred battery arrangement inside a device while Figure B.5 b) shows an alternative recommendation.



a) Preferred battery orientation



b) Alternative recommendation for battery orientation

NOTE 1 In Figure B.5 a), protection of the positive contact in a is as shown in Figure B.2 and Figure B.3.

NOTE ~~1~~ 2 In Figure B.5 b), protection of the contacts is in Figure B.2 or Figure B.3 for the positive and Figure B.4 for the negative contact.

NOTE ~~2~~ 3 The arrangement in Figure B.5 b) is only considered practical for R14 and R20 size batteries due to the small negative terminal area (dimension C of the relevant specification) of the other sizes.

Figure B.5 – Design with respect to battery orientation

B.3.5 Dimensional considerations

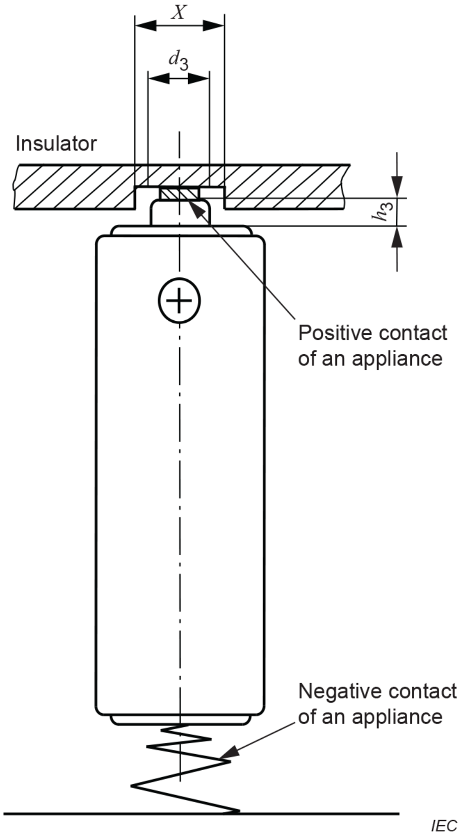
Table B.1 provides critical dimensional details relating to the battery terminals and the recommended dimensions for the devices positive contact. By making reference to Figure B.6, and designing in accordance with the dimensions shown in Table B.1, subsequent reversal of a battery, such that its negative terminal is presented to the devices positive contact, will result in a "fail safe" situation, i.e. there will be no electrical contact.

Table B.1 – Dimensions of battery terminals and recommended dimensions of the positive contact of an appliance in Figure B.6

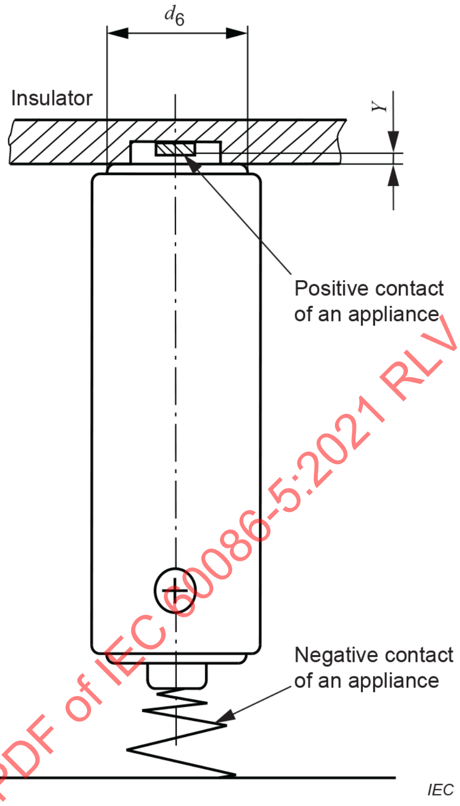
Dimensions in millimetres

Relevant dry batteries	Dimension of the negative battery terminal	Dimension of the positive battery terminal		Recommended dimensions of the positive contact of an appliance in Figure B.6	
	d_6 [a] minimum	d_3 [a] maximum	h_3 [a] minimum	X	Y
R20, LR20	18,0	9,5	1,5	9,6 to 11,0	0,5 to 1,4
R14, LR14	13,0	7,5	1,5	7,6 to 9,0	0,5 to 1,4
R6, LR6	7,0	5,5	1,0	5,6 to 6,8	0,4 to 0,9
R03, LR03	4,3	3,8	0,8	3,9 to 4,2	0,4 to 0,7
R1, LR1	5,0	4,0	0,5	4,1 to 4,9	0,1 to 0,4

[a] Refer to IEC 60086-2.



a) Correct insertion



b) Incorrect insertion

Key

d_6 minimum outer diameter of the negative flat contact surface

d_3 maximum diameter of the positive contact within the specified projection height

h_3 minimum projection of the flat positive contact

X diameter of the recessed hole as a positive contact with the positive battery terminal. X should be bigger than d_3 but smaller than d_6.

Y Depth of the recessed hole as a positive contact with the positive battery terminal. Y should be smaller than h_3.

NOTE Positive contact of an appliance is recessed within the surrounding insulation.

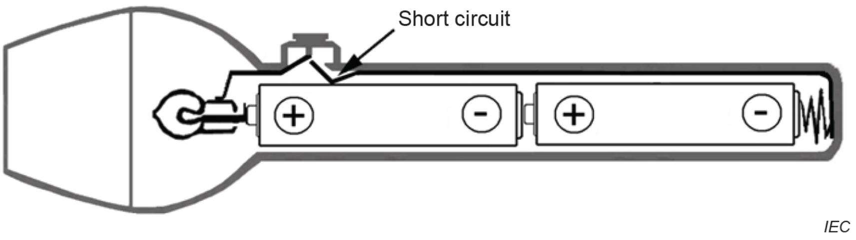
Figure B.6 – Example of the design of a positive contact of an appliance

The diameter of the recessed hole is larger than the diameter (d_3) of the positive battery terminal but is smaller than the diameter (d_6) of the negative battery terminal. The insertion of the battery in Figure B.6 a) is correct. In Figure B.6 b) the reverse insertion of the battery is shown; in this instance the negative terminal of the battery only contacts the surrounding insulation thereby preventing electrical contact.

B.4 Specific measures to prevent short-circuiting of batteries

B.4.1 Measures to prevent short-circuiting due to battery jacket damage

In alkaline manganese batteries, the steel case, which is covered by an insulating jacket (see B.2.1 c)), has the same voltage as the positive terminal. Should the insulating jacket be cut or pierced by any conductive circuitry within an appliance, a short circuit may occur as shown in Figure B.7. (It should be noted that the damage described above can be aggravated if the appliance is subjected to physical abuse, e.g. abnormal vibration, dropping~~, etc~~).



NOTE 1 The potential hazards resulting from a short circuit are defined in B.1.3.

NOTE 2 Whilst the example shown in Figure B.7 commonly relates to alkaline manganese battery systems, the batteries addressed in this annex are interchangeable (see B.2.1).

Figure B.7 – Example of a short circuit where a switch is piercing the battery insulating jacket

Prevention: insulating material positioned as shown in Figure B.8 prevents the switch from damaging the battery jacket.

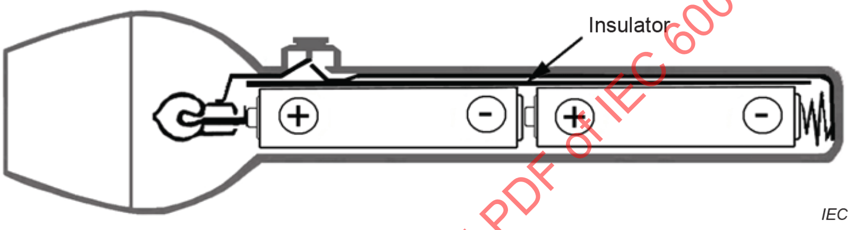


Figure B.8 – Typical example of insulation to prevent short circuit

It is also essential that no part of the equipment or equipment circuitry, including rivets or screws, used to secure the battery contacts, etc. is allowed to contact the battery case~~/~~ or jacket.

B.4.2 Measures to prevent external short circuit of a battery caused when coiled spring contacts are employed for battery connection

Placement of a battery (positive (+) end foremost) as shown in Figure B.9 may result in distortion of the negative (–) spring contact and subsequent cutting and piercing of the battery insulating jacket when a battery is inserted against the spring as shown in Figure B.10.

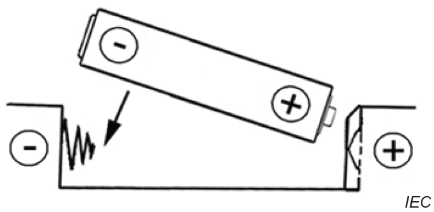
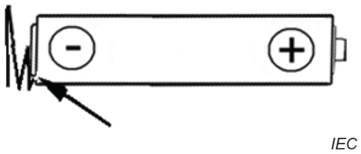
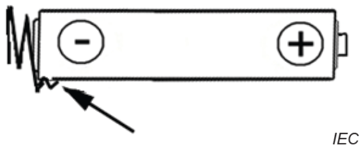


Figure B.9 – Insertion against spring (to be avoided)



a) Spring slides underneath the jacket and contacts the metal can



b) Jacket is punctured

Figure B.10 – Examples showing distorted springs

Prevention: in order to eliminate the possible incidents shown in Figure B.10, it is recommended that the design of the battery compartment allows the battery, when correctly inserted (negative terminal first), to evenly compress the coil spring as shown in Figure B.11. The insulated guide above the negative (–) connections in Figure B.11 ensures this.

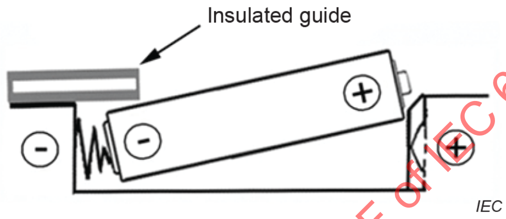


Figure B.11 – Example of protected insertion

The end of the spring coil i.e. that part in final contact with the battery should be bent toward the centre of the coil so that no sharp edges are presented to the battery jacket.

The spring wire should be of sufficient diameter as specified in Table B.2. The spring contact pressure should be sufficient to ensure that the batteries make and maintain good electrical contact at all times. However, the spring contact pressure should not be so great as to preclude easy battery insertion and removal. Excessive spring contact pressure can cause cutting or piercing of the insulating jacket or contact deformation.

This can lead to a short circuit and/or leakage.

Table B.2 contains details on the recommended diameters of the spring wire.

Spring coil contacts should only contact the negative terminals of cylindrical batteries.

Table B.2 – Minimum wire diameters

Dimensions in millimetres

Battery type		Minimum wire diameter
R20	LR20	0,8
R14	LR14	0,8
R6	LR6	0,4
R03	LR03	0,4
R1	LR1	0,4

B.5 Special considerations regarding recessed negative contacts

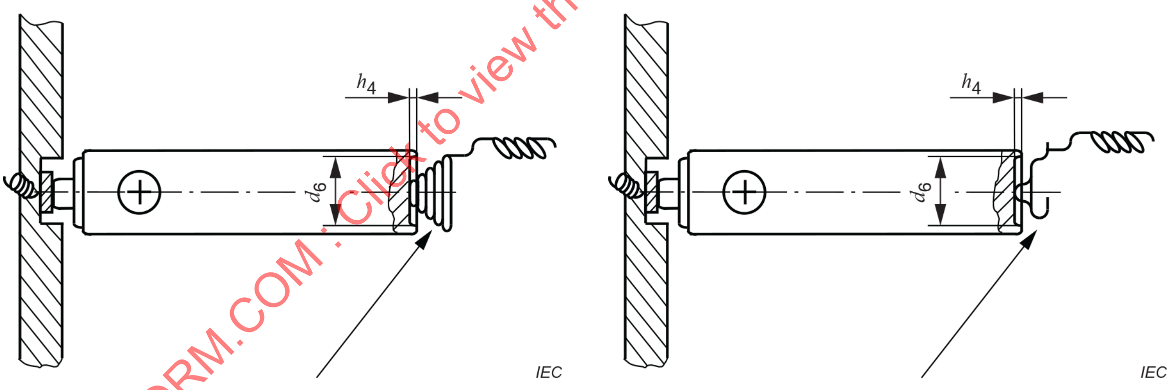
IEC 60086-2 specifies the maximum recess of the negative battery terminal from the external jacket. Many R20, LR20, R14 and LR14 batteries have a recessed negative terminal. Some batteries are provided with projections of insulating resin on the negative terminal in order to prevent electrical contact if the battery is reversed.

~~NOTE~~ It is imperative that the above shapes and dimensions of negative battery terminals are taken into account during the early stage of the design of the negative contact of an appliance. Specific precautions of three (3) kinds of contacts which are generally used are described in the following.

a) When a spring coil is used as the negative contact of an appliance: the diameter of the coil which interfaces with the battery should be smaller than d_6, where d_6 is the external diameter of the contact surface of the negative battery terminal.

b) Where a sheet metal is cut and formed to make a negative contact (see Figure B.12), it is essential that the dimensions h_4 and d_6, as defined in Table B.3, are noted and acted upon. As shown in Figure B.12 a projection~~/~~ or pip should be provided. This projection~~/~~ or pip should be of sufficient depth to overcome any recess in the battery terminal (dimension h_4). Failure to follow this advice may result in loss of battery contact.

c) Where it is proposed to employ a flat metal plate as the negative contact of an appliance, it is essential that one or more "pips" or projection(s) are provided to ensure battery contact. The projection(s) should be of sufficient depth to overcome any recess in the negative terminal of the battery (dimension h_4) and be placed within the confines of the battery terminal contact area (dimension d_6).



a) **Spring coil** b) **Plate spring contact**

Figure B.12 – Example of negative contacts

Table B.3 – Dimensions of the negative battery terminal

Dimensions in millimetres

Battery type	Maximum recessed dimension of negative battery terminal h_4 [a]	External diameter of the contact surface of negative battery terminal d_6 [a]
R20, LR20	1,0	18,0
R14, LR14	0,9	13,0
R6, LR6	0,5	7,0
R03, LR03	0,5	4,3
R1, LR1	0,2	5,0

[a] Refer to IEC 60086-2.

It should be stressed that battery compartment dimensions should not be tied to dimensions and tolerances of a particular manufacturer as this can create problems if replacements of different origin are installed.

For dimensional details, particularly those related to the positive and negative terminals, reference should be made to Figure 1a and Figure 1b of IEC 60086-2:2015 and the relevant battery specifications contained in IEC 60086-2.

B.6 Waterproof and non-vented devices

It is important that hydrogen gas generated in the batteries is either removed by recombination reaction or allowed to escape; otherwise a spark could ignite the entrapped hydrogen/ and air mixture resulting in an explosion of the device. The advice of the battery manufacturer should be sought at the design stage of such applications. (See added statement in 7.1 n))

B.7 Other design considerations

a) Only the battery terminals should physically contact the electric circuit. Battery compartments should be electrically insulated from the electric circuit and positioned so as to minimize possible damage and/or risk of injury resulting from battery leakage.

b) Much equipment is designed to operate with alternative power supplies (e.g. mains, additional batteries, etc.) and this is particularly relevant to primary battery memory back-up applications. In these situations, the circuitry of the equipment should be so designed to either

   1) prevent charging of the primary battery, or

   2) include primary battery protective devices, for example a diode, such that the reverse charging current from the protective device(s) to which the primary battery would be subjected does not exceed that recommended by the battery manufacturer.

   Any intended protective device circuit should be selected so as to be appropriate to the type and electrochemical system of the primary battery concerned and preferably not subject to single component failure. It is recommended that equipment designers obtain advice from the battery manufacturer concerning the primary battery memory back-up protection device circuit.

   Failure to observe these precautions may lead to short service life, leakage or explosion.

c) Positive (+) and negative (–) battery contacts should be visibly different in form to avoid confusion when inserting batteries.

d) Select terminal contact materials with the lowest electrical resistance and compatible with battery contacts.

e) Battery compartments should be non-conductive, heat resistant, non-flammable and have good heat radiation. They should not deform when a battery is inserted.

f) Equipment designed to be powered by air-depolarized batteries of either the A or P system should provide for adequate air access. For the A system, the battery should preferably be in an upright position during normal operation.

g) Battery compartments with parallel connections are not permissible, unless it can be clearly demonstrated that the reversal of one or more batteries does not affect safety.

h) Series connection of batteries with multiple voltage outputs as shown in Figure B.13 is not recommended since a discharged section may be driven into reverse voltage.

EXAMPLE In Figure B.13, two batteries are discharging through resistor R1; if, following their discharge, the switch is positioned toward the R3 circuit, forced discharging of the former two batteries ~~may~~ can occur.

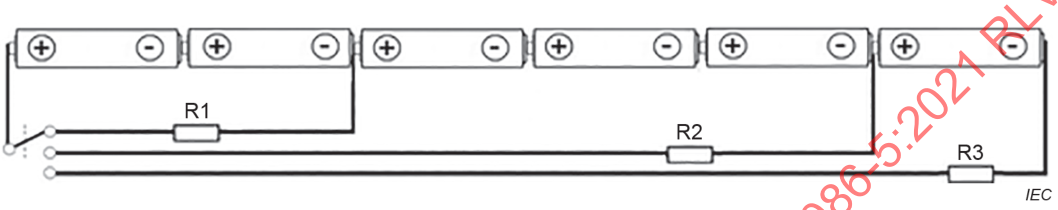


Figure B.13 – Example of series connection of batteries with voltage tapping

Potential hazards arising from forced discharging (driving into reverse voltage) are:

1) gas generation within the forced discharged battery/batteries;
2) vent activation;
3) electrolyte leakage.

NOTE Battery electrolytes are harmful to body tissues.

Annex C
(informative)

Safety pictograms

C.1 General

Cautionary advice to fulfil the marking requirements in this document 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.

C.2 Pictograms

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

Table C.1 – Safety pictograms

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

Reference	Pictogram	Cautionary advice
E	 ~~NOTE Under consideration to replace pictogram E~~ 	KEEP OUT OF REACH OF CHILDREN NOTE 1 See 7.1 c) for critical safety information. NOTE 2 The pictogram "KEEP OUT OF REACH OF CHILDREN" was standardized in ISO 7010:2019/AMD 2:2020 under the reference M055 [7]. The blue colour and the arrow of the ISO safety sign are not required.
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.~~		

C.3 Recommendations for use

The following recommendations are provided for use of the pictograms.

a) Pictograms should be clearly legible.

b) Whilst colours can be used, they should not detract from the information displayed. If colours are used, the background of pictograms E and 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, pictograms D and J are meant as alternatives for a similar purpose.

Annex D
(informative)

Use of the KEEP OUT OF REACH OF CHILDREN safety sign

D.1 General

Accidental ingestion of button cells has become an object of public concern. If a button cell gets stuck in the oesophagus, electrolysis of water and the generation of hydroxide ions may occur. These hydroxide ions form a strong alkaline solution which can lead to chemical burns and serious injury.

The new safety sign KEEP OUT OF REACH OF CHILDREN shown in Table C.1 (required for button cells with a diameter equal to or greater than 16 mm which are intended for direct sale in consumer replaceable applications) should give parents who have children a heads-up as a mandatory action sign even if the intended product is safe in the usual sense for adults.

D.2 Safety sign

When a safety sign is used to convey the message that these swallowable button cells (i.e. can fit in the ingestion gauge, see Figure 7) should be kept out of the reach of children, the following best practices apply. The safety sign recommendation and cautionary advice for use on battery packaging are given in Table C.1, safety pictogram E.

D.3 Best practices for marking the packaging

Packaging of swallowable button cells (i.e. can fit in the ingestion gauge, see Figure 7) should be marked with the safety pictogram E of Table C.1 to alert the purchaser of the increased risk of such cells.

a) Refer to Table 7 for marking requirements on packaging.
b) The safety sign should be on contrasting background. The background should cover at least 50 % of the area of the pictogram.
c) The size of the safety sign should be 6 mm in diameter or larger.
d) If the text "KEEP OUT OF REACH OF CHILDREN" is used, it should contrast with the background colour on which it is printed.

Annex E
(informative)

Child resistant packaging

E.1 General

E.1.1 General

Accidental ingestion of button cells has become an object of public concern. When a button cell gets stuck in the oesophagus, its voltage causes the electrolysis of water and the generation of hydroxide ions. These hydroxide ions form a strong alkaline solution and can cause chemical burns, perforation of soft tissue, and in severe cases can cause death.

This annex provides an approach for childproof packaging of button cells in order to help in preventing their accidental ingestion.

E.1.2 Applicability

The following recommendations apply to consumer type button cells as specified in Table 7.

E.1.3 Packaging design

E.1.3.1 Single cell packaging

The packaging for button cells should meet one of the following:

a) packaging strength as described in E.1.3.3, or
b) packaging requirements based on local legislation or standardization [8], [9], [10], if applicable.

E.1.3.2 Multi-cell packaging

Each cell containment in a multi-cell packaging should meet the above requirements even when another cell containment is removed from the packaging.

E.1.3.3 Packaging strength

The packaging strength should be such that the packaging passes the tests described in Clause E.2.

E.2 Packaging tests

E.2.1 General

The following test methods were developed based on the analysis of the behaviour of children in a test where they were required to try and open button cell packaging within a limited time. The tests should be conducted by an instructed person or, alternatively, if necessary, using suitable equipment.

E.2.2 Test items

a) Bending test

   Hold the packaging with one hand close to one of its short sides and hold the cell with the other hand. Bend the packaging until one hand touches the other hand as shown in Figure E.1. This is a guide for the bending angle: 150° or more.

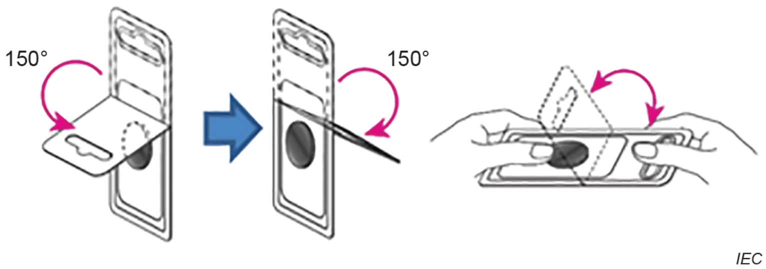


Figure E.1 – Bending test

b) Torsion test

Following is an explanation of how and how many times to twist the packaging and in which order to proceed.

① First time – Hold the packaging with the fingers of one hand on each of its shorter sides from the state of 0° (neutral state without torsion). Twist it diagonally with a torsion angle of 45° in opposite directions as shown in Figure E.2.

② Second time – Twist it diagonally 90° (45° back + 45° opposite direction) in opposite directions to the direction twisted the first time.

③ Third time – Return to neutral state without torsion (45° back).

④ Movements ①, ② and ③ are counted as one time (one reciprocation) and are repeated 25 times (25 reciprocations).

Figure E.2 shows the movements of the torsion test. The red and blue lines represent the left and right edge of the packaging. The triangles and circles were added to keep track of the orientation during movements.

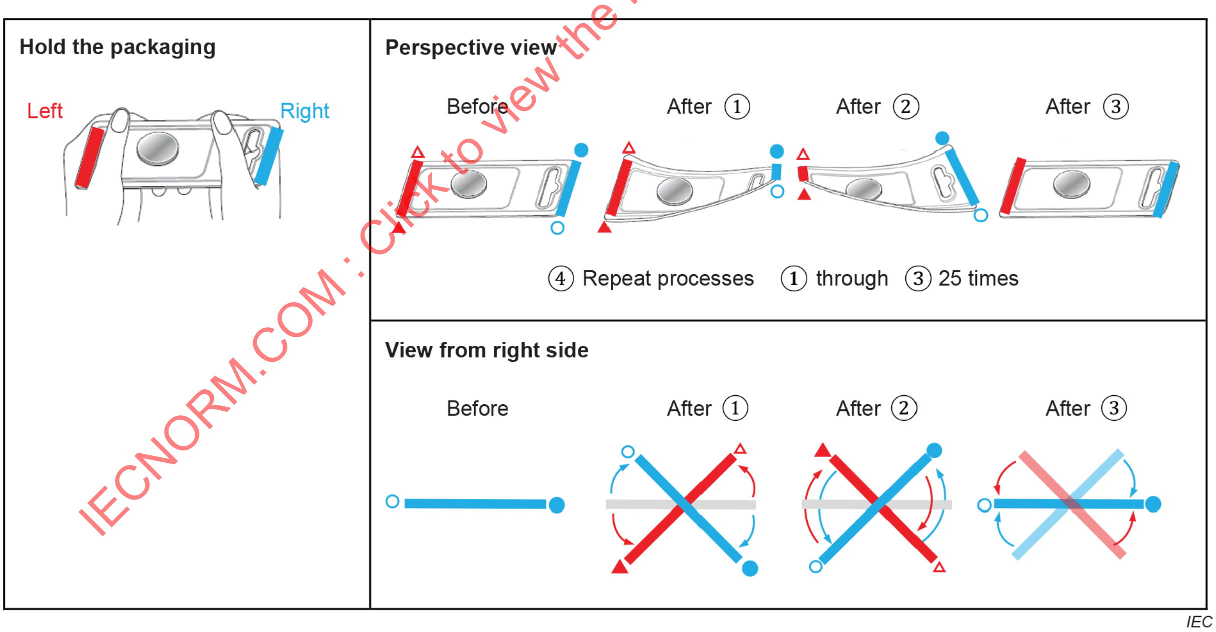


Figure E.2 – Torsion test

c) Tearing test

Try to tear the cell compartment with your hands as shown in Figure E.3. Alternatively use suitable equipment and apply a force of at least 25 N.

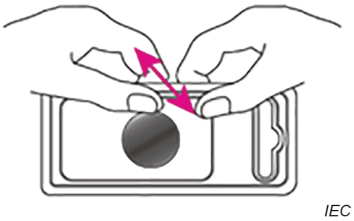


Figure E.3 – Tearing test

d) Pushing test

Try to push the cell out of the compartment with your hands. Alternatively pull with a mass of at least 5 kg for 30 s, as shown in Figure E.4.

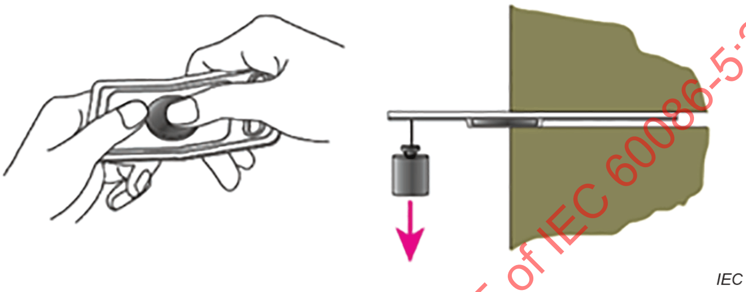


Figure E.4 – Pushing test

E.2.3 Test procedure

The test procedure is conducted with ten sample packagings. Each sample is subjected to a series of tests in the order and frequency outlined in Table E.1.

Table E.1 – Test procedure

Order	Test item		Number of times
(1)	a)	Bending test	50
(2)	b)	Torsion test	25
(3)	c)	Tearing test	1
(4)	b)	Torsion test	25
(5)	a)	Bending test	50
(6)	c)	Tearing test	1
(7)	d)	Pushing test	1

E.2.4 Criteria

Each test sample should meet the following criteria.

a) each cell should be kept in its packaging until the end of the test series, and

b) in order to prevent a child from pulling the cell out from its compartment, the packaging should not open too wide. The maximum allowable size of an opening in the packaging is 6 mm diameter for a round hole and 10 mm length for a slit. See Figure E.5 for maximum packaging openings.

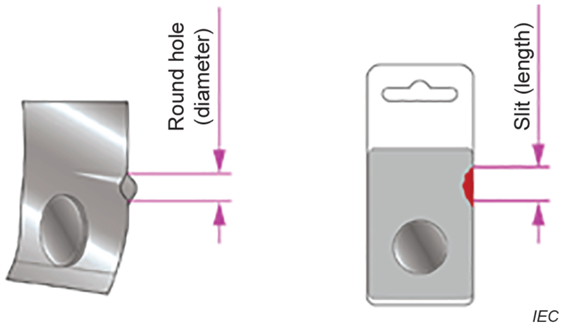


Figure E.5 – Maximum packaging opening

Bibliography

[1] IEC 60050-482, *International Electrotechnical Vocabulary (IEV) – Part 482: Primary and secondary cells and batteries* (available at http://www.electropedia.org)

[2] ISO/IEC Guide 51:2014, *Safety aspects – Guidelines for their inclusion in standards*

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

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

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

[6] ISO/IEC Guide 50:2014, *Safety aspects – Guidelines for child safety in standards and other specifications*

[7] ISO 7010:2019, *Graphical symbols – Safety colours and safety signs – Registered safety signs*
ISO 7010:2019/AMD 2:2020

[8] USA:16 CFR §1700.15(b)(1)

[9] EN 862, *Packaging – Child-resistant packaging – Requirements and testing procedures for non-reclosable packages for non-pharmaceutical products*

[10] AS 5808-2009, *Child-resistant packaging – Requirements and testing procedures for non-reclosable packages for non-pharmaceutical products*

[11] IEC 60086-3, *Primary batteries – Part 3: Watch batteries*

[12] IEC 60086-4, *Primary batteries – Part 4: Safety of lithium batteries*

~~[3] ISO/IEC Guide 50: 2015, *Safety aspects – Guidelines for child safety*~~

~~[4] ISO/IEC Guide 51:2014, *Safety aspects – Guidelines for their inclusion in standards*~~

~~[5] IEC 60050-482:2004, *International Electrotechnical Vocabulary – Part 482: Primary and secondary cells and batteries*~~

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

IEC 60086-5

Edition 5.0 2021-09

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Primary batteries –
Part 5: Safety of batteries with aqueous electrolyte

Piles électriques –
Partie 5: Sécurité des piles à électrolyte aqueux

IEC 60086-5:2021-09(en-fr)

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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PRIMARY BATTERIES –

Part 5: Safety of batteries with aqueous electrolyte

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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IEC 60086-5 has been prepared by IEC technical committee 35: Primary cells and batteries. It is an International Standard.

This fifth edition cancels and replaces the fourth edition published in 2016. This edition constitutes a technical revision.

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

a) revised information for safety dealing with keeping batteries out of the reach of children;
b) removal of the method to determine the insulation resistance;
c) changes to the test matrix;
d) revision of the over-discharge test;
e) revised definition and note for "button cell" or "button battery" in 3.2;
f) revised method for evaluation of an explosion, moved from 3.6 to 6.2.1.

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

FDIS	Report on voting
35/1471/FDIS	35/1472/RVD

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

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

A list of all parts in the IEC 60086 series, published under the general title *Primary batteries*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

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

NOTE The attention of National Committees is drawn to the fact that equipment manufacturers and testing organizations may need a transitional period following publication of a new, amended or revised IEC document in which to make products in accordance with the new requirements and to equip themselves for conducting new or revised tests.

It is the recommendation of the committee that the content of this document be adopted for implementation nationally not earlier than 2 years from the date of publication. The transitional period applies specifically to Table 7.

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

INTRODUCTION

The concept of safety is closely related to safeguarding the integrity of people and property. This part of IEC 60086 specifies tests and requirements for primary batteries with aqueous electrolyte and has been prepared in accordance with ISO/IEC guidelines, taking into account all relevant national and international standards which apply. Also included in this document is guidance for appliance designers with respect to battery compartments and information regarding packaging, handling, warehousing and transportation.

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

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

PRIMARY BATTERIES –

Part 5: Safety of batteries with aqueous electrolyte

1 Scope

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

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60086-1:2015, *Primary batteries – Part 1: General*

IEC 60086-2:2015, *Primary batteries – Part 2: Physical and electrical specifications*

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
battery
one or more cells electrically connected by permanent means, fitted in a case, with terminals, markings and protective devices etc., as necessary for use

[SOURCE: IEC 60050-482:2004, 482-01-04 [1], modified – The definition has been revised.]

3.2
button cell
button battery
small round cell or battery where the overall height is less than the diameter, containing aqueous electrolyte

Note 1 to entry: See coin (cell or battery), lithium button (cell or battery) in IEC 60086-1 and IEC 60086-2.

[SOURCE: IEC 60050-482:2004, 482-02-40, modified – The second term "coin cell" has been deleted, the definition has been revised and the note has been replaced with a new 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, modified – The note has been deleted.]

3.4
component cell
cell contained in a battery

3.5
cylindrical battery
cylindrical cell
round cell or battery with a cylindrical shape in which the overall height is equal to or greater than the diameter

[SOURCE: IEC 60050-482:2004, 482-02-39, modified – In the definition, "cell" has been replaced by "round cell or battery".]

3.6
intended use
use in accordance with information provided with a product or system, or, in the absence of such information, by generally understood patterns of usage

[SOURCE: ISO/IEC Guide 51:2014, 3.6 [2]]

3.7
nominal voltage
U_{n}
<of a primary battery> 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, modified – The domain and symbol have been added.]

3.8
primary cell
primary battery
cell or battery that is not designed to be electrically recharged

3.9
prismatic cell
prismatic battery
cell or battery having the shape of a parallelepiped whose faces are rectangular

[SOURCE: IEC 60050-482:2004, 482-02-38, modified – "cell" and "battery" have been added to the term and "qualifies a" has been deleted.]

3.10
protective device
device such as fuse, diode or other electric or electronic current limiter designed to interrupt the current flow in an electrical circuit

3.11
reasonably foreseeable misuse
use of a product or system in a way not intended by the supplier, but which can result from readily predictable human behaviour

[SOURCE: ISO/IEC Guide 51:2014, 3.7, modified – The notes have been deleted.]

3.12
round cell
round battery
cell or battery with circular cross section

3.13
safety
freedom from risk which is not tolerable

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

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

4 Requirements for safety

4.1 Design

4.1.1 General

Batteries shall be so designed that they do not present a safety hazard under conditions of normal (intended) use.

4.1.2 Venting

All batteries shall incorporate a pressure relief feature or shall be so constructed that they will relieve excessive internal pressure at a value and rate which will preclude explosion. If encapsulation is necessary to support cells within an outer case, the type of encapsulant and the method of encapsulation shall not cause the battery to overheat during normal operation nor inhibit the operation of the pressure relief feature.

The battery case material and/or its final assembly shall be so designed that, in the event of one or more cells venting, the battery case does not present a hazard in its own right.

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.

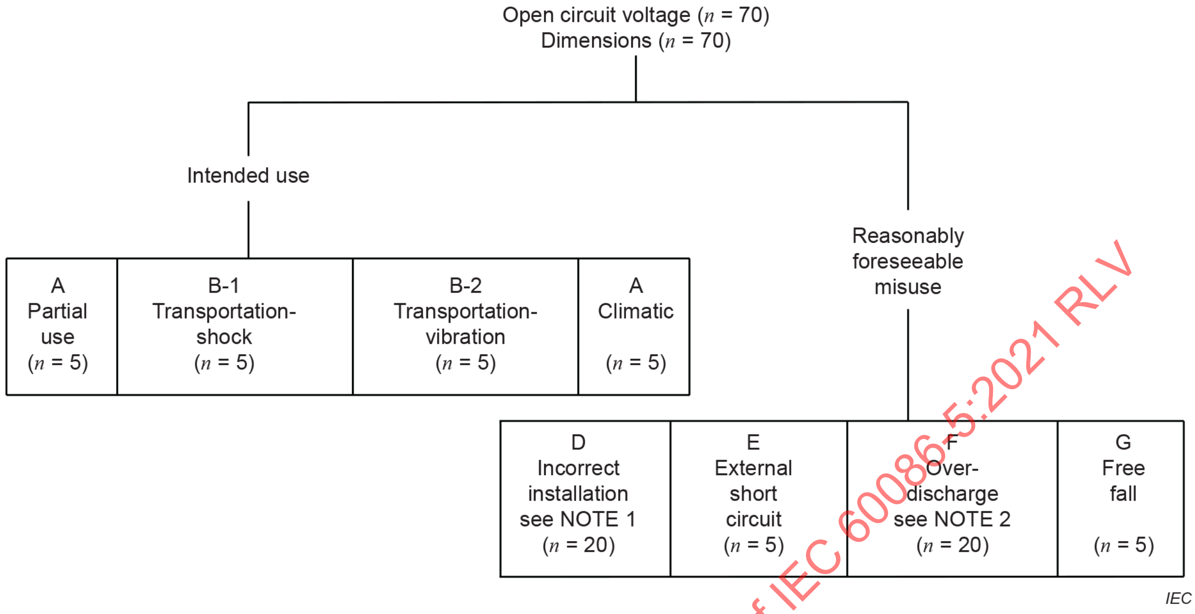
5 Sampling

5.1 General

Samples should be drawn from production lots in accordance with accepted statistical methods and shall meet the requirements specified for dimensions and open circuit voltage set forth in IEC 60086-2. Samples failing to meet these requirements shall be discarded and new samples selected.

5.2 Sampling for type testing

The number of samples drawn for type testing is given in Figure 1.



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 discharged (5 sets).

Figure 1 – Sampling for tests and number of batteries required

5.3 Validity of testing

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

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

b) a battery specification change would lead to a failure of any of the tests;

c) there is an addition of new tests or requirements; or

d) there is a requirement change that would lead to a failure of any of the tests.

6 Testing and requirements

6.1 General

6.1.1 Applicable safety tests

Applicable safety tests are shown in Table 1. The tests described in Table 2 and Table 6 are intended to simulate conditions which the battery is likely to encounter during intended use and reasonably foreseeable misuse.

Table 1 – Test matrix

System letter	Negative electrode	Electrolyte	Positive electrode	Nominal voltage per cell V	Form	Applicable tests						
						A	B-1 B-2	C	D	E	F	G
No letter	Zinc (Zn)	Ammonium chloride, Zinc chloride	Manganese dioxide (MnO_2)	1,5	R	x	x	x	x	x	x	x
					B	NR						
					Pr	x	x	x	x	x	x	x
					M	x	x	x	NR	x	NR	x
A	Zinc (Zn)	Ammonium chloride, Zinc chloride	Oxygen (O_2)	1,4	R	x	x	x	NR	x	x	x
					B	NR						
					Pr	x	x	x	x	x	x	x
					M	x	x	x	NR	x	x	x
L	Zinc (Zn)	Alkali metal hydroxide	Manganese dioxide (MnO_2)	1,5	R	x	x	x	x	x	x	x
					B	x	x	x	NR	x	NR	x
					Pr	x	x	x	x	x	x	x
					M	x	x	x	NR	x	NR	x
P	Zinc (Zn)	Alkali metal hydroxide	Oxygen air (O_2)	1,4 or 1,45	R	NR						
					B	NR	NR	NR	NR	NR	NR	NR
					Pr	x	x	x	x	x	x	x
					M	NR						
S	Zinc (Zn)	Alkali metal hydroxide	Silver oxide (Ag_2O)	1,55	R	x	x	x	NR	x	NR	x
					B	x	x	x	NR	x	NR	x
					Pr	x	x	x	x	x	x	x
					M	NR						

Test description:

A: storage after partial use
B-1: transportation-shock
B-2: transportation-vibration
C: climatic-temperature cycling
D: incorrect installation
E: external short circuit
F: overdischarge
G: free fall

Key

R: cylindrical (3.5)
B: button (3.2)
Pr: prismatic single cell (3.11)
M: multicell

x: Required
NR: Not required

If necessary, follow the discharge conditions of the IEC 60086-2 service output test. Systems L and S button cells or batteries under 3,5 g are exempt from any testing.

6.1.2 Cautionary notice

WARNING – The tests in this document 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, these tests shall be carried out at an ambient temperature of 20 °C ± 5 °C.

6.2 Evaluation of test criteria

6.2.1 Explosion

An explosion is considered to have occurred when there is an instantaneous release wherein solid matter from any part of the battery is propelled to a distance greater than 25 cm away from the battery.

6.2.2 Fire

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

6.2.3 Leakage

Leakage is considered to have occurred if there is an unplanned escape of electrolyte from a cell or battery.

6.2.4 Venting

Venting is considered to have occurred if there is a release of excessive internal pressure from a cell or battery in a manner intended by design to preclude explosion.

6.3 Intended use

6.3.1 Intended use tests and requirements

Table 2 – Intended use tests and requirements

Test		Intended use simulation	Requirements
Electrical test	A	Storage after partial use	No leakage (NL) No fire (NF) No explosion (NE)
Environmental tests	B-1	Transportation-shock	No leakage (NL) No fire (NF) No explosion (NE)
	B-2	Transportation-vibration	No leakage (NL) No fire (NF) No explosion (NE)
Climatic-temperature	C	Climatic-temperature cycling	No fire (NF) No explosion (NE)

6.3.2 Intended use test procedures

6.3.2.1 Test A – Storage after partial use

a) Purpose

This test simulates the situation when an appliance is switched off and the installed batteries are partly discharged. These batteries may be left in the appliance for a long time or they are removed from the appliance and stored for a long time.

b) Test procedure

An undischarged battery is discharged under an application or service output test condition, with the load defined in IEC 60086-2 resulting in the longest test duration until the service life falls by 50 % of the highest minimum average duration (MAD) value, followed by storage at 45 °C ± 2 °C for 30 days.

The temperature tolerance of ±2 °C is for the temperature maintain period and a brief over-shoot in temperature is allowed during the transition period.

c) Requirements

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

6.3.2.2 Test B-1 – Transportation-shock

a) Purpose

This test simulates the situation when an appliance is carelessly dropped with batteries installed in it. This test condition is generally specified in IEC 60068-2-27 [3][1].

b) Test procedure

An undischarged battery shall be tested as follows.

The shock test shall be carried out under the conditions defined in Table 3 and the sequence in Table 4.

Shock pulse – The shock pulse applied to the battery shall be as follows:

Table 3 – Shock pulse

Acceleration		Waveform
Minimum average acceleration first three milliseconds	Peak acceleration	
75 g_n	125 g_n to 175 g_n	Half sine
NOTE g_n = 9,806 65 m/s^2.		

Table 4 – Test sequence of the shock test

Step	Storage time	Battery orientation	Number of shocks	Visual examination periods
1	–	–	–	Pre-test
2	–	[a]	1 each	–
3	–	[a]	1 each	–
4	–	[a]	1 each	–
5	1 h	–	–	–
6	–	–	–	Post-test
[a] The shock shall be applied in each of three mutually perpendicular directions.				

Step 1 Record open circuit voltage in accordance with 5.2.

Steps 2 to 4 Apply shock test specified in Table 3 and the sequence in Table 4.

Step 5 Rest battery for 1 h.

Step 6 Record examination results.

c) Requirements

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

6.3.2.3 Test B-2 – Transportation-vibration

a) Purpose

This test simulates vibration during transportation. This test condition is generally specified in IEC 60068-2-6 [4].

b) Test procedure

An undischarged battery shall be tested as follows.

The vibration test shall be carried out under the following test conditions and the sequence in Table 5.

[1] Numbers in square brackets refer to the bibliography.

Vibration – A simple harmonic motion shall be applied to the battery having an amplitude of 0,8 mm, with a total maximum excursion of 1,6 mm. The frequency shall be varied at the rate of 1 Hz/min between the limits of 10 Hz and 55 Hz. The entire range of frequencies (10 Hz to 55 Hz) and return (55 Hz to 10 Hz) shall be traversed in (90 ± 5) min for each mounting position (direction of vibration).

Table 5 – Test sequence of the vibration test

Step	Storage time	Battery orientation	Vibration time	Visual examination periods
1	–	–	–	Pre-test
2	–	[a]	(90 ± 5) min each	–
3	–	[a]	(90 ± 5) min each	–
4	–	[a]	(90 ± 5) min each	–
5	1 h	–	–	–
6	–	–	–	Post-test

[a] The vibration shall be applied in each of three mutually perpendicular directions.

Step 1 Record open circuit voltage in accordance with 5.2.

Steps 2 to 4 Apply the vibration specified in 6.3.2.3 in the sequence in Table 5.

Step 5 Rest battery for 1 h.

Step 6 Record examination results.

c) Requirements

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

6.3.2.4 Test C – Climatic-temperature cycling

a) Purpose

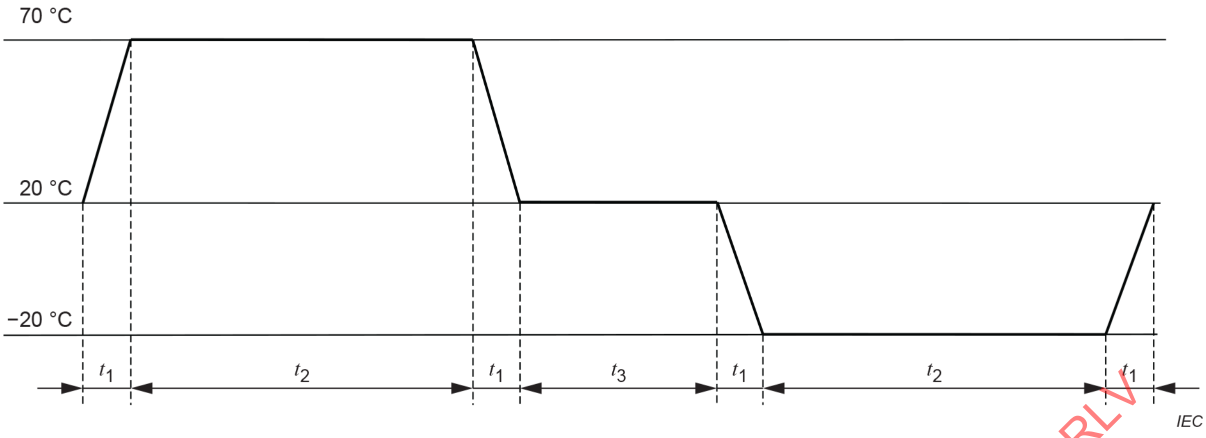
This test assesses the integrity of the battery seal which may be impaired after temperature cycling.

b) Test procedure

An undischarged battery shall be tested under the following procedure.

Temperature cycling procedure (see 1) to 7) below and/or Figure 2)

1) Place the batteries in a test chamber and raise the temperature of the chamber to 70 °C ± 5 °C within t_1 = 30 min.
2) Maintain the chamber at this temperature for t_2 = 4 h.
3) Reduce the temperature of the chamber to 20 °C ± 5 °C within t_1 = 30 min and maintain at this temperature for t_3 = 2 h.
4) Reduce the temperature of the chamber to –20 °C ± 5 °C within t_1 = 30 min and maintain at this temperature for t_2 = 4 h.
5) Raise the temperature of the chamber to 20 °C ± 5 °C within t_1 = 30 min.
6) Repeat the sequence for a further nine cycles.
7) After the 10th cycle, store the batteries for seven days prior to examination.



t_1 = 30 min

t_2 = 4 h

t_3 = 2 h

Figure 2 – Temperature cycling procedure

c) Requirements

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

6.4 Reasonably foreseeable misuse

6.4.1 Reasonably foreseeable misuse tests and requirements

Table 6 – Reasonably foreseeable misuse tests and requirements

Test		Misuse simulation	Requirements
Electrical tests	D	Incorrect installation	No fire (NF) No explosion (NE)[a]
	E	External short circuit	No fire (NF) No explosion (NE)
	F	Overdischarge	No fire (NF) No explosion (NE)
Environmental test	G	Free fall	No fire (NF) No explosion (NE)

[a] See NOTE 2 of 6.4.2.1 b).

6.4.2 Reasonably foreseeable misuse test procedures

6.4.2.1 Test D – Incorrect installation (four batteries in series)

a) Purpose

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

b) Test procedure

Four undischarged batteries of the same brand, type and origin shall be connected in series with one reversed (B1) as shown in Figure 3. The circuit shall be completed for 24 h or until the battery case temperature has returned to ambient.

The resistance of the inter-connecting circuitry shall not exceed 0,1 Ω.

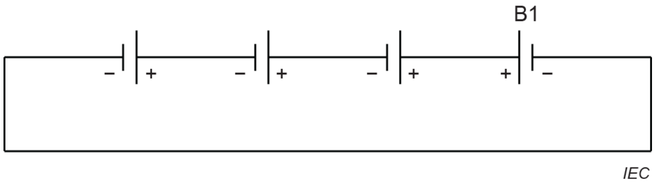


Figure 3 – Circuit diagram for incorrect installation (four batteries in series)

NOTE 1 The circuit in Figure 3 simulates a typical misuse condition.

NOTE 2 Primary batteries are not designed to be charged. However, reversed installation of a battery in a series of three or more exposes the reversed battery to a charging condition. Although cylindrical batteries are designed to relieve excessive internal pressure, it is possible that in some instances an explosion cannot be precluded.

c) Requirements

There shall be no fire and no explosion during this test (see NOTE 2 of 6.4.2.1 b)).

6.4.2.2 Test E – External short circuit

a) Purpose

This misuse may occur during daily handling of batteries.

b) Test procedure

An undischarged battery shall be connected as shown in Figure 4. The circuit shall be completed for 24 h or until the battery case temperature has returned to ambient. The resistance of the inter-connecting circuitry shall not exceed 0,1 Ω.

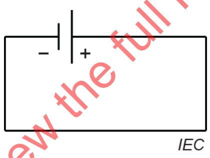


Figure 4 – Circuit diagram for external short circuit

c) Requirements

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

6.4.2.3 Test F – Overdischarge

a) Purpose

This test simulates and determines the effect of placing a discharged battery in a circuit with undischarged batteries (i.e. mixing new with used or old batteries).

b) Test procedure

One undischarged battery (C1) is discharged under the application or service output test condition, with the highest MAD value (expressed in time units), as defined in IEC 60086-2, until the on-load voltage falls to (n × 0,6 V) where n is the number of cells in the battery. Then, three undischarged batteries and one discharged battery (C1) of the same brand, type and origin shall be connected in series as shown in Figure 5. The discharge shall be continued for 24 h.

The value of the resistor (R1) shall be approximately four times the lowest value from the resistive load tests specified for that battery in IEC 60086-2. The final value of the resistor (R1) shall be the nearest value to that specified in 6.4 of IEC 60086-1:2015.

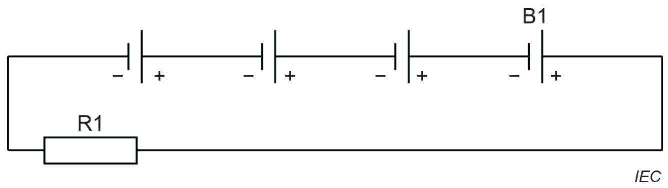


Figure 5 – Circuit diagram for overdischarge

c) Requirements

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

6.4.2.4 Test G – Free fall test

a) Purpose

This test simulates the situation when a battery is accidentally dropped. The test condition is based upon IEC 60068-2-31 [5].

b) Test procedure

Undischarged 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 on each of its six faces, a round battery twice in each of the three axes shown in Figure 6. The test batteries shall be stored for 1 h afterwards.

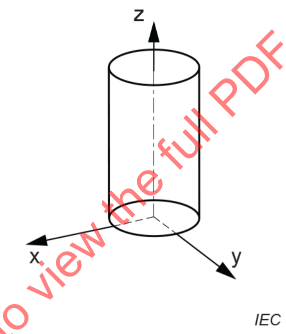


Figure 6 – XYZ axes for free fall

c) Requirements

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

7 Information for safety

7.1 Precautions during handling of batteries

When used correctly, primary batteries with aqueous electrolyte provide a safe and dependable source of power. However, battery misuse or abuse may result in leakage, or in extreme cases, fire and/or explosion.

a) Always insert batteries correctly with regard to the polarities (+ and –) marked on the battery and the equipment.

Batteries which are incorrectly placed into equipment may be short-circuited, or charged. This can result in a rapid temperature rise causing venting, leakage, explosion and personal injury. See Annex B for additional details.

b) 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 and/or handbag with keys or coins can be short-circuited. This may result in venting, leakage, explosion and personal injury.

c) Keep batteries out of the reach of children

Especially 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 7. In case of ingestion of a cell or a battery, the person involved should seek medical assistance promptly. Ingested button cells with less than 2 V do not exhibit the potential to cause chemical burns within a short time. If such cells have passed through the oesophagus, established medical practice is to monitor and allow the cell(s) to naturally pass.

NOTE 1 Refer to in Annex D, Clause D.1 for more details.

NOTE 2 Refer to [6] for general information on hazards.

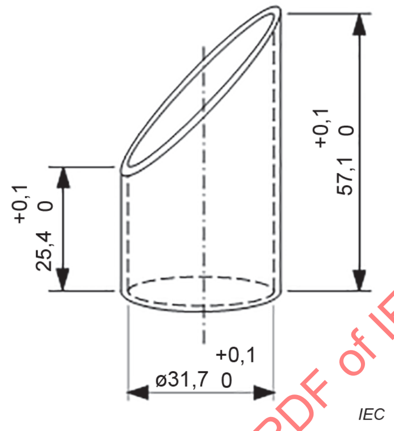


Figure 7 – Ingestion gauge

d) Do not charge batteries.

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

e) Do not force discharge batteries.

When batteries are force discharged with 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 may result in venting, leakage, explosion and personal injury.

f) Do not mix old and new 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 old batteries are used together, some batteries may be over-discharged due to a difference of voltage or capacity. This can result in venting, leakage and explosion and may cause personal injury.

g) 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 may occur causing damage to the appliance and/or personal injury.

h) Do not expose batteries to heat.

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

i) Do not weld or solder directly to batteries.

The heat from welding or soldering directly to a battery may cause internal short-circuiting resulting in venting, leakage and explosion and may cause personal injury.

j) Do not dismantle batteries.

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

k) Do not deform batteries.

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

l) Do not dispose of batteries in fire.

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

NOTE Refer to [6].

m) Do not allow children to replace batteries without adult supervision.

n) Do not encapsulate and/or modify batteries.

Encapsulation, or any other modification to a battery, may result in blockage of the pressure relief vent mechanism(s) and/or prevent removal of hydrogen gas generated in the batteries (see also Clause B.6). This may lead to explosion and personal injury. Advice from the battery manufacturer should be sought if it is considered necessary to make any modification.

o) 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 may result in venting, leakage and explosion and personal injury; one of the best ways to avoid this happening is to store unused batteries in their original packaging.

p) 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. portable lighting, toys). Although most batteries on the market today are provided with protective jackets or other means to contain leakage, a battery that has been partially or completely exhausted may be more prone to leak than one that is unused.

7.2 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.

7.3 Handling of battery cartons

Battery cartons should be handled with care. Rough handling might result in battery damage. This can cause leakage, explosion, or fire.

7.4 Display and storage

a) Batteries shall be stored in well-ventilated, dry and cool conditions.

High temperature or high humidity may cause deterioration of the battery performance or surface corrosion.

b) Battery cartons should not be piled up in several layers (or should not exceed a specified height).

If too many battery cartons are piled up, batteries in the lowest cartons may be deformed and electrolyte leakage may occur.

c) When batteries are stored in warehouses or displayed in retail stores, they should not be exposed to direct sun rays for a long time or placed in areas where they get wet by rain.

When batteries get wet, their insulation resistance decreases, self-discharge may occur and rust may be generated.

d) Do not mix unpacked batteries so as to avoid mechanical damage and/or short circuit among each other.

When mixed together, batteries may be subjected to physical damage or overheating resulting from external short circuit. Leakage and/or explosion may then occur. To avoid these possible hazards, batteries should be kept in their packaging until required for use.

e) See Annex A for additional details.

7.5 Transportation

When loaded for transportation, battery packages should be so arranged to minimize the risk of falling for example one from the top of another. They should not be stacked so high that damage to the lower packages occurs. Protection from inclement weather should be provided.

7.6 Disposal

a) Do not dismantle batteries.

b) Do not dispose of batteries in fire except under conditions of controlled incineration.

c) Primary batteries may be disposed of via the communal refuse arrangements, provided that no local rules to the contrary exist.

d) Where there is provision for the collection of used batteries, the following should be considered:

- Store collected batteries in a non-conductive container.
- Store collected batteries in a well-ventilated area. Since some used batteries may still contain a residual charge, they could be short-circuited, charged or force discharged and thereby evolve hydrogen gas. If collection containers and storage areas are not properly ventilated, hydrogen gas can build up and explode in the presence of an ignition source.
- Do not mix collected batteries with other materials. Since some used batteries may still contain a residual charge, they could be short-circuited, charged or force discharged. The subsequent possible heat generation can ignite flammable wastes such as oily rags, paper or wood and can cause a fire.
- Consider protecting used battery terminals, particularly those batteries with high voltage, to preclude short circuits, charging and force discharging, for instance, by means of covering battery terminals with insulating tape.
- Failure to observe these recommendations may result in leakage, fire, and/or explosion.

8 Instructions for use

a) Always select the correct size and grade 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 those of the equipment prior to battery installation.

d) Ensure that the batteries are installed correctly with regard to polarity (+ and –).

e) Remove batteries from equipment which is not to be used for an extended period of time.

f) Remove exhausted batteries promptly.

9 Marking and packaging

9.1 General batteries

With the exception of swallowable button cells (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 trademark of the manufacturer or supplier;

f) cautionary advice.

Refer to Table 7, "General batteries", for an overview of marking requirements for general batteries.

NOTE The common designation can be found in Annex D of IEC 60086-2:2015.

9.2 Swallowable button cells

a) For swallowable batteries, i.e. those that fit entirely within the ingestion gauge (Figure 7) the designation 9.1 a) and the polarity 9.1 c) shall be marked on the battery. All other required markings shown in 9.1, except 9.1 f), may be given on the immediate packaging instead of on the battery.

b) For P-system batteries, 9.1 a) may be marked on the battery, the sealing tab or the immediate packaging. 9.1 c) may be marked on the sealing tab and/or on the battery. 9.1 b), 9.1 d) and 9.1 e) may be given on the immediate packaging instead of on the battery.

c) When batteries are intended for direct sale in consumer-replaceable applications, a caution for ingestion of swallowable batteries shall be given. Refer to 7.1 c) and Annex D for details. Caution for other risks is optional.

Refer to Table 7, "swallowable button cells", for an overview of marking and packaging requirements along with Annex E for child resistant packaging recommendations for swallowable button cells.

9.3 Safety pictograms

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

Table 7 – Marking and packaging requirements

List item	General batteries	Swallowable button cells					
		d < 16 mm		16 mm ≤ *d* < 20 mm		*d* ≥ 20 mm	
Electrochemical system		**P**	**L, S**	**P**	**L, S**	**P**	**L, S**
a) Designation, IEC or common	B	C	B	C	B	C	B
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	B						
c) Polarity of the positive (+) terminal	B	D	B	D	B	D	B
d) Nominal voltage	B						
e) Name or trademark of the manufacturer or supplier	B						
f) Cautionary advice	B						
g) Caution for ingestion of swallowable batteries, see also 7.1 c) and Annex D		P[a]	P[a]	P[a]	P[a]	P[a]	B[a] + P[a]
h) Child resistant packaging	NR	NR	NR	NR	R[a,b]	NR	R[a,b]

Key

d: Diameter

B: Marking required on cell/battery

C: Marking required on battery, sealing tab or immediate packaging

D: Marking required on sealing tab and/or the battery

P: Marking required on immediate packaging

R: Child resistant packaging

NR: Not required

empty cell: Marking may appear on cell/battery and/or immediate packaging

[a] See Foreword for transition period.

[b] When batteries are intended for direct sale in consumer replaceable applications.

Annex A
(informative)

Additional information on display and storage

The purpose of this annex is to describe good practices for display and storage (see also 7.4) in general terms and, more specifically, to warn against procedures known from experience to be harmful. It takes the form of advice to battery manufacturers, distributors, users, and equipment designers.

Storage and stock rotation

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

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

c) Batteries which have been cold-stored should be put into use as soon as possible after return to ambient temperature.

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

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

f) 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.

g) Batteries should 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 should be adequately marked.

Annex B
(informative)

Battery compartment design guidelines

B.1 Background

B.1.1 General

In order to meet the ever-growing advances in battery-powered equipment technology, primary batteries have become more sophisticated in both chemistry and construction with resultant improvements to both capacity and rate capability. Resulting from these continuing developments and recognizing the need for both safety and optimum battery performance it was established that the majority of reported battery failures resulted from electrical abuse generally arising from consumer accidental misuse.

The following text and figures are intended to aid the battery-powered equipment designer to significantly reduce or eliminate such battery failures.

B.1.2 Battery failures resulting from poor battery compartment design

Poor battery compartment design may lead to reversed battery installation or to short-circuiting of the batteries.

B.1.3 Potential hazards resulting from battery reversal

If a battery is reversed in a circuit with three or more batteries in series as shown in Figure B.1, the following potential hazards exist:

a) charging of the reversed battery;

NOTE 1 The charging current is limited by the external circuit/load.

b) gas generation within the reversed battery;

c) vent activation of the reversed battery;

d) leakage of electrolyte from the reversed battery.

NOTE 2 Battery electrolytes are harmful to body tissues.

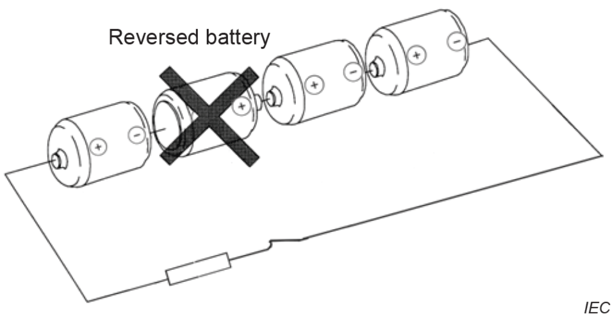


Figure B.1 – Example of series connection with one battery reversed

B.1.4 Potential hazards resulting from a short circuit

a) heat generation resulting from high current flow;

b) gas generation;

c) vent activation;

d) electrolyte leakage;

e) heat damage to insulating jackets (e.g. shrinkage).

NOTE Battery electrolytes are harmful to body tissues and generated heat can cause burns.

B.2 General guidance for appliance design

B.2.1 Key battery factors to be first considered

These guidelines are essentially directed toward cylindrical batteries with sizes ranging from R1 to R20. The battery systems involved are commonly referred to as alkaline manganese and zinc carbon. Whilst the two systems are interchangeable they should never be used in combination.

The following physical differences between the two systems and permitted design features should be noted during the early phases of battery compartment design.

a) The positive terminal of the alkaline manganese battery is connected to the battery case.

b) The positive terminal of the zinc carbon battery is insulated from the battery case.

c) Both battery types have an outer insulated jacket. This may be of paper, plastic or other non-conductive material. On occasion, the outer jacket may be metallic (conductive); in such instances this is insulated from the basic unit.

d) When forming the negative contact it should be noted that the corresponding battery terminal may be recessed. (For clarification refer to IEC 60086-1:2015, 4.1.3). To ensure good electrical contact, completely flat negative equipment contacts should be avoided.

e) Under no circumstances should battery connectors or any part of the equipment circuitry come into contact with the battery jacket. Any design of battery compartment permitting this, risks the possibility of a short circuit.

Conical or helical springs used for negative connection should compress uniformly when the battery is inserted and not bridge across to the battery jacket. (Spring connection to the positive terminal of a battery is not recommended.)

B.2.2 Other important factors to consider

a) It is recommended that companies producing battery-powered equipment should maintain close liaison with the battery industry. The capabilities of existing batteries should be taken into account at design inception. Whenever possible, the battery type selected should be one included in IEC 60086-2.

b) Design compartments so that batteries are easily inserted and do not fall out.

c) Design compartments to prevent easy access to the batteries by young children.

d) Dimensions should not be tied to a particular battery manufacturer as this can create problems when replacements of different origin are installed. Only consider the battery dimensions and tolerances defined within IEC 60086-2 when designing the battery compartment. The battery compartment should be designed such that it accommodates the increase in battery height in accordance with IEC 60086-2:2015, Clause 5, Note.

e) Clearly indicate the type of battery to use, the correct polarity alignment (+ and –) and directions for insertion.

f) Although batteries are very much improved regarding their resistance to leakage, it can still occasionally occur. When the battery compartment cannot be completely isolated from the equipment, it should be positioned so as to minimize possible equipment damage from battery leakage.

g) Design equipment circuitry such that equipment will not operate below 0,7 V per battery (0,7 V × n_s where n_s is the number of batteries connected in series). To continue discharging below this level may result in unfavourable chemical reactions within the battery/batteries resulting in leakage.

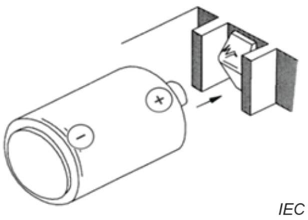
B.3 Specific measures against reversed installation

B.3.1 General

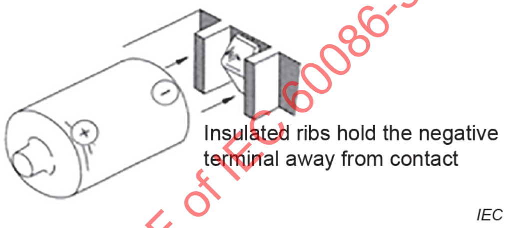
To overcome the problems associated with the reversed placement of a battery, consideration should be given at the design stage to ensure that batteries cannot be installed incorrectly or, if so installed, will not make electrical contact.

B.3.2 Design of the positive contact

Some suggestions for the R03, R1, R6, R14 and R20 size battery compartments are illustrated in Figure B.2 and Figure B.3 below. Provision should also be made to prevent unnecessary movement of batteries within the battery compartment. Battery contacts should be shielded to prevent contact during reverse installation.

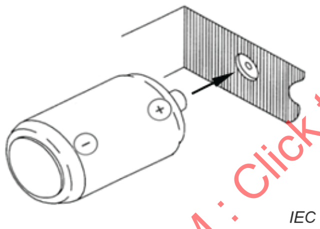


a) Correct insertion of the battery

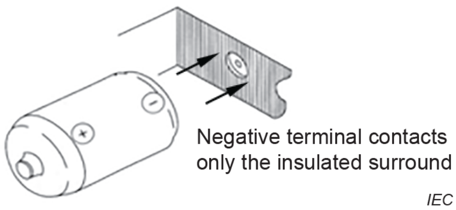


b) Incorrect insertion of the battery

Figure B.2 – Positive contact recessed between ribs



a) Correct insertion of the battery

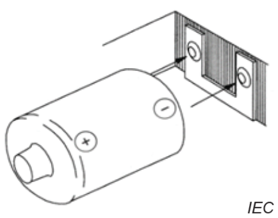


b) Incorrect insertion of the battery

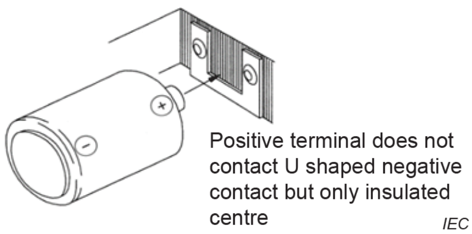
Figure B.3 – Positive contact recessed within surrounding insulation

B.3.3 Design of the negative contact

The following suggestion is given for R03, R1, R6, R14 and R20 size battery compartments (see Figure B.4).



a) Correct insertion of the battery



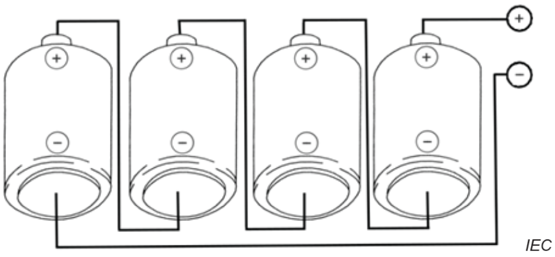
b) Incorrect insertion of the battery

Figure B.4 – Negative contact U-shaped to ensure no positive (+) battery contact

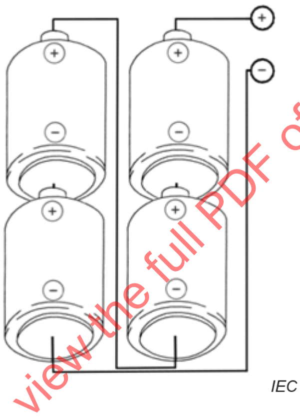
B.3.4 Design with respect to battery orientation

In order to avoid reverse insertion of batteries, it is recommended that all batteries have the same orientation. Examples are shown in Figure B.5 a) and Figure B.5 b).

Figure B.5 a) shows the preferred battery arrangement inside a device while Figure B.5 b) shows an alternative recommendation.



a) Preferred battery orientation



b) Alternative recommendation for battery orientation

NOTE 1 In Figure B.5 a), protection of the positive contact in a is as shown in Figure B.2 and Figure B.3.

NOTE 2 In Figure B.5 b), protection of the contacts is in Figure B.2 or Figure B.3 for the positive and Figure B.4 for the negative contact.

NOTE 3 The arrangement in Figure B.5 b) is only considered practical for R14 and R20 size batteries due to the small negative terminal area (dimension C of the relevant specification) of the other sizes.

Figure B.5 – Design with respect to battery orientation

B.3.5 Dimensional considerations

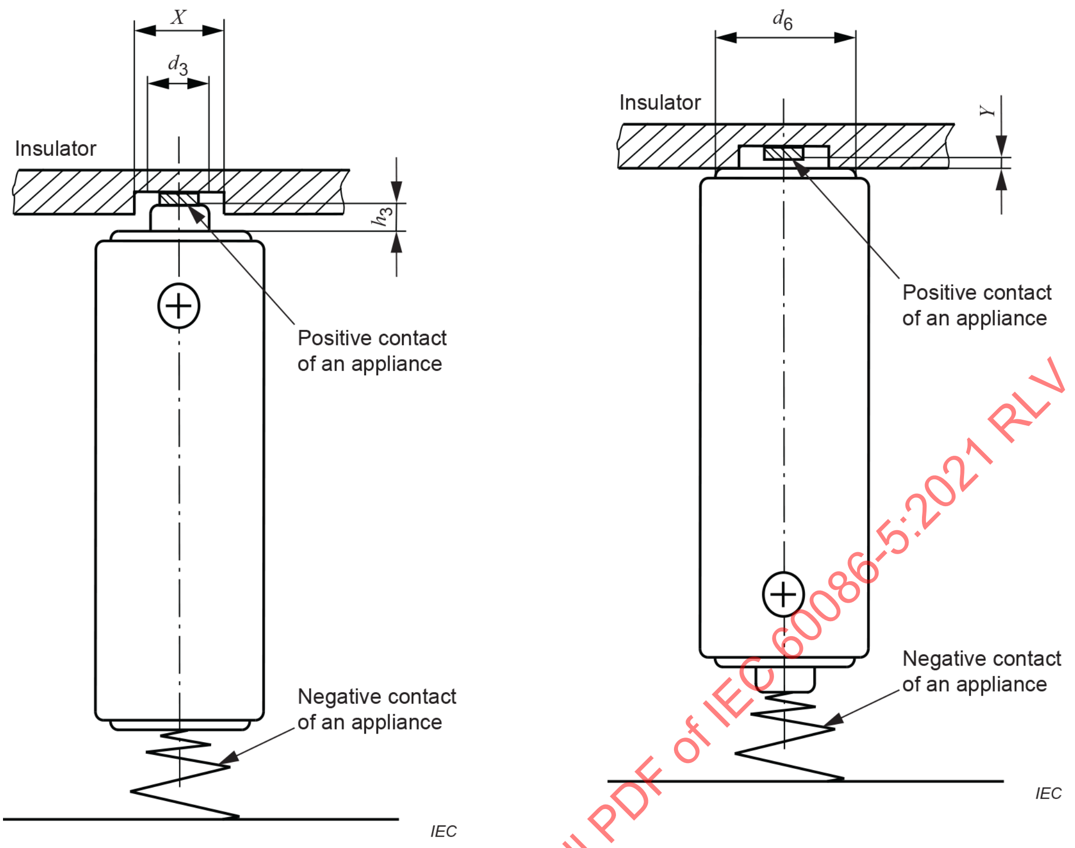
Table B.1 provides critical dimensional details relating to the battery terminals and the recommended dimensions for the devices positive contact. By making reference to Figure B.6, and designing in accordance with the dimensions shown in Table B.1, subsequent reversal of a battery, such that its negative terminal is presented to the devices positive contact, will result in a "fail safe" situation, i.e. there will be no electrical contact.

Table B.1 – Dimensions of battery terminals and recommended dimensions of the positive contact of an appliance in Figure B.6

Dimensions in millimetres

Relevant dry batteries	Dimension of the negative battery terminal	Dimension of the positive battery terminal		Recommended dimensions of the positive contact of an appliance in Figure B.6	
	d_6 [a] minimum	d_3 [a] maximum	h_3 [a] minimum	X	Y
R20, LR20	18,0	9,5	1,5	9,6 to 11,0	0,5 to 1,4
R14, LR14	13,0	7,5	1,5	7,6 to 9,0	0,5 to 1,4
R6, LR6	7,0	5,5	1,0	5,6 to 6,8	0,4 to 0,9
R03, LR03	4,3	3,8	0,8	3,9 to 4,2	0,4 to 0,7
R1, LR1	5,0	4,0	0,5	4,1 to 4,9	0,1 to 0,4

[a] Refer to IEC 60086-2.



a) Correct insertion **b) Incorrect insertion**

Key

d_6 minimum outer diameter of the negative flat contact surface

d_3 maximum diameter of the positive contact within the specified projection height

h_3 minimum projection of the flat positive contact

X diameter of the recessed hole as a positive contact with the positive battery terminal. X should be bigger than d_3 but smaller than d_6.

Y Depth of the recessed hole as a positive contact with the positive battery terminal. Y should be smaller than h_3.

NOTE Positive contact of an appliance is recessed within the surrounding insulation.

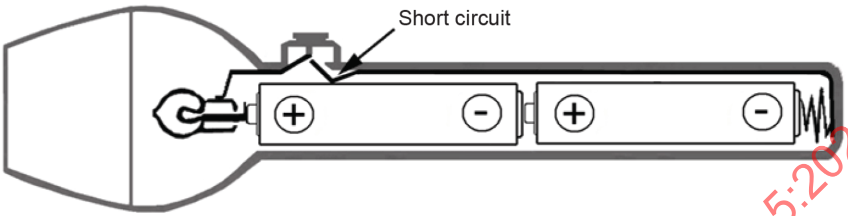
Figure B.6 – Example of the design of a positive contact of an appliance

The diameter of the recessed hole is larger than the diameter (d_3) of the positive battery terminal but is smaller than the diameter (d_6) of the negative battery terminal. The insertion of the battery in Figure B.6 a) is correct. In Figure B.6 b) the reverse insertion of the battery is shown; in this instance the negative terminal of the battery only contacts the surrounding insulation thereby preventing electrical contact.

B.4 Specific measures to prevent short-circuiting of batteries

B.4.1 Measures to prevent short-circuiting due to battery jacket damage

In alkaline manganese batteries, the steel case, which is covered by an insulating jacket (see B.2.1 c)), has the same voltage as the positive terminal. Should the insulating jacket be cut or pierced by any conductive circuitry within an appliance, a short circuit may occur as shown in Figure B.7. (It should be noted that the damage described above can be aggravated if the appliance is subjected to physical abuse, e.g. abnormal vibration, dropping).



NOTE 1 The potential hazards resulting from a short circuit are defined in B.1.3.

NOTE 2 Whilst the example shown in Figure B.7 commonly relates to alkaline manganese battery systems, the batteries addressed in this annex are interchangeable (see B.2.1).

Figure B.7 – Example of a short circuit where a switch is piercing the battery insulating jacket

Prevention: insulating material positioned as shown in Figure B.8 prevents the switch from damaging the battery jacket.

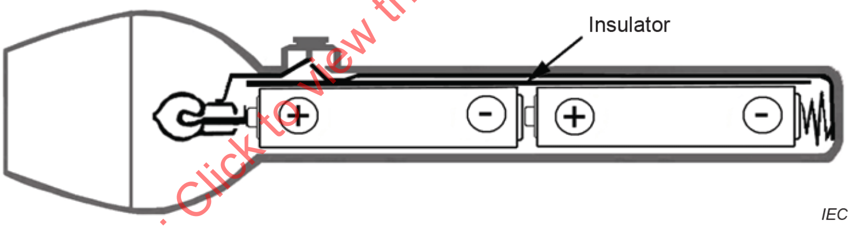


Figure B.8 – Typical example of insulation to prevent short circuit

It is also essential that no part of the equipment or equipment circuitry, including rivets or screws, used to secure the battery contacts, etc. is allowed to contact the battery case or jacket.

B.4.2 Measures to prevent external short circuit of a battery caused when coiled spring contacts are employed for battery connection

Placement of a battery (positive (+) end foremost) as shown in Figure B.9 may result in distortion of the negative (–) spring contact and subsequent cutting and piercing of the battery insulating jacket when a battery is inserted against the spring as shown in Figure B.10.

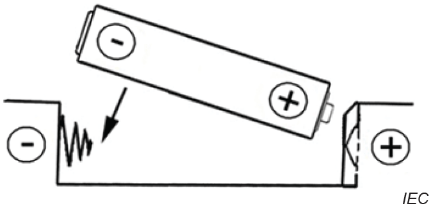
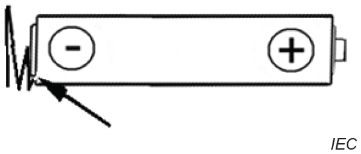
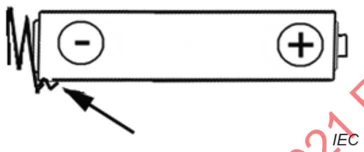


Figure B.9 – Insertion against spring (to be avoided)



a) **Spring slides underneath the jacket and contacts the metal can**



b) **Jacket is punctured**

Figure B.10 – Examples showing distorted springs

Prevention: in order to eliminate the possible incidents shown in Figure B.10, it is recommended that the design of the battery compartment allows the battery, when correctly inserted (negative terminal first), to evenly compress the coil spring as shown in Figure B.11. The insulated guide above the negative (–) connections in Figure B.11 ensures this.

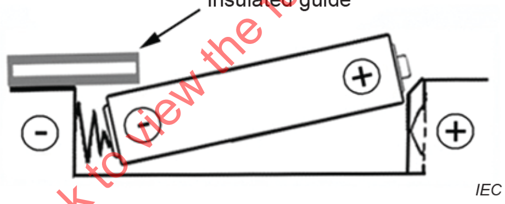


Figure B.11 – Example of protected insertion

The end of the spring coil i.e. that part in final contact with the battery should be bent toward the centre of the coil so that no sharp edges are presented to the battery jacket.

The spring wire should be of sufficient diameter as specified in Table B.2. The spring contact pressure should be sufficient to ensure that the batteries make and maintain good electrical contact at all times. However, the spring contact pressure should not be so great as to preclude easy battery insertion and removal. Excessive spring contact pressure can cause cutting or piercing of the insulating jacket or contact deformation.

This can lead to a short circuit and/or leakage.

Table B.2 contains details on the recommended diameters of the spring wire.

Spring coil contacts should only contact the negative terminals of cylindrical batteries.

Table B.2 – Minimum wire diameters

Dimensions in millimetres

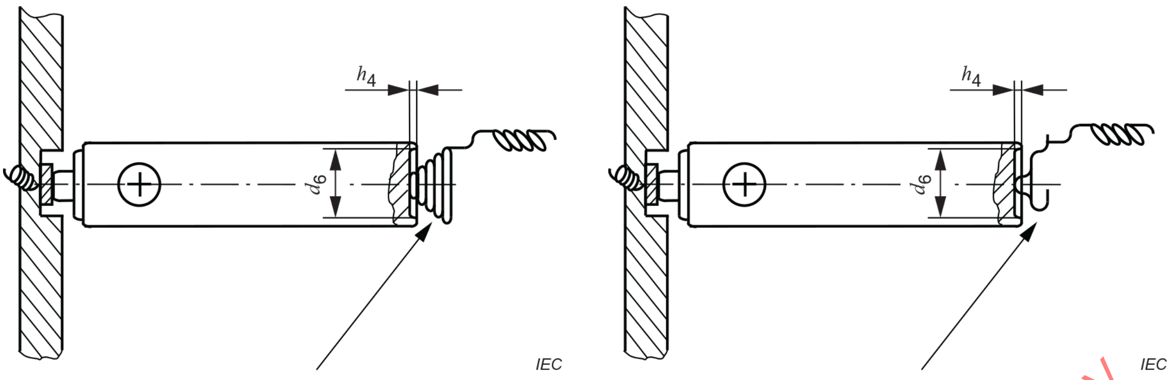
Battery type		Minimum wire diameter
R20	LR20	0,8
R14	LR14	0,8
R6	LR6	0,4
R03	LR03	0,4
R1	LR1	0,4

B.5 Special considerations regarding recessed negative contacts

IEC 60086-2 specifies the maximum recess of the negative battery terminal from the external jacket. Many R20, LR20, R14 and LR14 batteries have a recessed negative terminal. Some batteries are provided with projections of insulating resin on the negative terminal in order to prevent electrical contact if the battery is reversed.

It is imperative that the above shapes and dimensions of negative battery terminals are taken into account during the early stage of the design of the negative contact of an appliance. Specific precautions of three (3) kinds of contacts which are generally used are described in the following.

a) When a spring coil is used as the negative contact of an appliance: the diameter of the coil which interfaces with the battery should be smaller than d_6, where d_6 is the external diameter of the contact surface of the negative battery terminal.
b) Where a sheet metal is cut and formed to make a negative contact (see Figure B.12), it is essential that the dimensions h_4 and d_6, as defined in Table B.3, are noted and acted upon. As shown in Figure B.12 a projection or pip should be provided. This projection or pip should be of sufficient depth to overcome any recess in the battery terminal (dimension h_4). Failure to follow this advice may result in loss of battery contact.
c) Where it is proposed to employ a flat metal plate as the negative contact of an appliance, it is essential that one or more "pips" or projection(s) are provided to ensure battery contact. The projection(s) should be of sufficient depth to overcome any recess in the negative terminal of the battery (dimension h_4) and be placed within the confines of the battery terminal contact area (dimension d_6).



a) Spring coil b) Plate spring contact

Figure B.12 – Example of negative contacts

Table B.3 – Dimensions of the negative battery terminal

Dimensions in millimetres

Battery type	Maximum recessed dimension of negative battery terminal h_4 [a]	External diameter of the contact surface of negative battery terminal d_6 [a]
R20, LR20	1,0	18,0
R14, LR14	0,9	13,0
R6, LR6	0,5	7,0
R03, LR03	0,5	4,3
R1, LR1	0,2	5,0
[a] Refer to IEC 60086-2.		

It should be stressed that battery compartment dimensions should not be tied to dimensions and tolerances of a particular manufacturer as this can create problems if replacements of different origin are installed.

For dimensional details, particularly those related to the positive and negative terminals, reference should be made to Figure 1a and Figure 1b of IEC 60086-2:2015 and the relevant battery specifications contained in IEC 60086-2.

B.6 Waterproof and non-vented devices

It is important that hydrogen gas generated in the batteries is either removed by recombination reaction or allowed to escape; otherwise a spark could ignite the entrapped hydrogen and air mixture resulting in an explosion of the device. The advice of the battery manufacturer should be sought at the design stage of such applications. (See added statement in 7.1 n))

B.7 Other design considerations

a) Only the battery terminals should physically contact the electric circuit. Battery compartments should be electrically insulated from the electric circuit and positioned so as to minimize possible damage and/or risk of injury resulting from battery leakage.

b) Much equipment is designed to operate with alternative power supplies (e.g. mains, additional batteries) and this is particularly relevant to primary battery memory back-up applications. In these situations, the circuitry of the equipment should be so designed to either

1) prevent charging of the primary battery, or
2) include primary battery protective devices, for example a diode, such that the reverse charging current from the protective device(s) to which the primary battery would be subjected does not exceed that recommended by the battery manufacturer.

Any intended protective device circuit should be selected so as to be appropriate to the type and electrochemical system of the primary battery concerned and preferably not subject to single component failure. It is recommended that equipment designers obtain advice from the battery manufacturer concerning the primary battery memory back-up protection device circuit.

Failure to observe these precautions may lead to short service life, leakage or explosion.

c) Positive (+) and negative (–) battery contacts should be visibly different in form to avoid confusion when inserting batteries.
d) Select terminal contact materials with the lowest electrical resistance and compatible with battery contacts.
e) Battery compartments should be non-conductive, heat resistant, non-flammable and have good heat radiation. They should not deform when a battery is inserted.
f) Equipment designed to be powered by air-depolarized batteries of either the A or P system should provide for adequate air access. For the A system, the battery should preferably be in an upright position during normal operation.
g) Battery compartments with parallel connections are not permissible, unless it can be clearly demonstrated that the reversal of one or more batteries does not affect safety.
h) Series connection of batteries with multiple voltage outputs as shown in Figure B.13 is not recommended since a discharged section may be driven into reverse voltage.

EXAMPLE In Figure B.13, two batteries are discharging through resistor R1; if, following their discharge, the switch is positioned toward the R3 circuit, forced discharging of the former two batteries can occur.

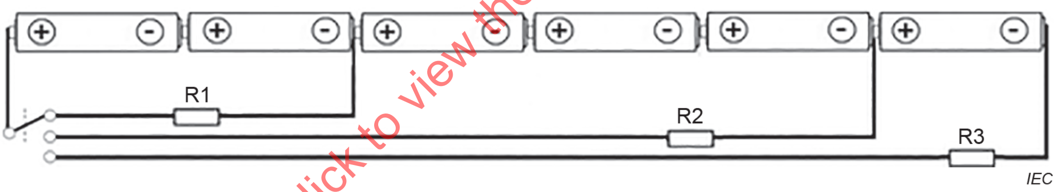


Figure B.13 – Example of series connection of batteries with voltage tapping

Potential hazards arising from forced discharging (driving into reverse voltage) are:

1) gas generation within the forced discharged battery/batteries;
2) vent activation;
3) electrolyte leakage.

NOTE Battery electrolytes are harmful to body tissues.

Annex C
(informative)

Safety pictograms

C.1 General

Cautionary advice to fulfil the marking requirements in this document 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.

C.2 Pictograms

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

Table C.1 – Safety pictograms

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

Reference	Pictogram	Cautionary advice
E		KEEP OUT OF REACH OF CHILDREN NOTE 1 See 7.1 c) for critical safety information. NOTE 2 The pictogram "KEEP OUT OF REACH OF CHILDREN" was standardized in ISO 7010:2019/AMD 2:2020 under the reference M055 [7]. The blue colour and the arrow of the ISO safety sign are not required.
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

C.3 Recommendations for use

The following recommendations are provided for use of the pictograms.

a) Pictograms should be clearly legible.

b) Whilst colours can be used, they should not detract from the information displayed. If colours are used, the background of pictograms E and 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, pictograms D and J are meant as alternatives for a similar purpose.

Annex D
(informative)

Use of the KEEP OUT OF REACH OF CHILDREN safety sign

D.1 General

Accidental ingestion of button cells has become an object of public concern. If a button cell gets stuck in the oesophagus, electrolysis of water and the generation of hydroxide ions may occur. These hydroxide ions form a strong alkaline solution which can lead to chemical burns and serious injury.

The new safety sign KEEP OUT OF REACH OF CHILDREN shown in Table C.1 (required for button cells with a diameter equal to or greater than 16 mm which are intended for direct sale in consumer replaceable applications) should give parents who have children a heads-up as a mandatory action sign even if the intended product is safe in the usual sense for adults.

D.2 Safety sign

When a safety sign is used to convey the message that these swallowable button cells (i.e. can fit in the ingestion gauge, see Figure 7) should be kept out of the reach of children, the following best practices apply. The safety sign recommendation and cautionary advice for use on battery packaging are given in Table C.1, safety pictogram E.

D.3 Best practices for marking the packaging

Packaging of swallowable button cells (i.e. can fit in the ingestion gauge, see Figure 7) should be marked with the safety pictogram E of Table C.1 to alert the purchaser of the increased risk of such cells.

a) Refer to Table 7 for marking requirements on packaging.
b) The safety sign should be on contrasting background. The background should cover at least 50 % of the area of the pictogram.
c) The size of the safety sign should be 6 mm in diameter or larger.
d) If the text "KEEP OUT OF REACH OF CHILDREN" is used, it should contrast with the background colour on which it is printed.

Annex E
(informative)

Child resistant packaging

E.1 General

E.1.1 General

Accidental ingestion of button cells has become an object of public concern. When a button cell gets stuck in the oesophagus, its voltage causes the electrolysis of water and the generation of hydroxide ions. These hydroxide ions form a strong alkaline solution and can cause chemical burns, perforation of soft tissue, and in severe cases can cause death.

This annex provides an approach for childproof packaging of button cells in order to help in preventing their accidental ingestion.

E.1.2 Applicability

The following recommendations apply to consumer type button cells as specified in Table 7.

E.1.3 Packaging design

E.1.3.1 Single cell packaging

The packaging for button cells should meet one of the following:

a) packaging strength as described in E.1.3.3, or
b) packaging requirements based on local legislation or standardization [8], [9], [10], if applicable.

E.1.3.2 Multi-cell packaging

Each cell containment in a multi-cell packaging should meet the above requirements even when another cell containment is removed from the packaging.

E.1.3.3 Packaging strength

The packaging strength should be such that the packaging passes the tests described in Clause E.2.

E.2 Packaging tests

E.2.1 General

The following test methods were developed based on the analysis of the behaviour of children in a test where they were required to try and open button cell packaging within a limited time. The tests should be conducted by an instructed person or, alternatively, if necessary, using suitable equipment.

E.2.2 Test items

a) Bending test

   Hold the packaging with one hand close to one of its short sides and hold the cell with the other hand. Bend the packaging until one hand touches the other hand as shown in Figure E.1. This is a guide for the bending angle: 150° or more.

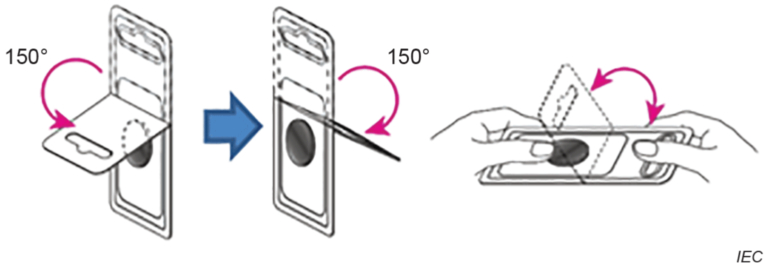


Figure E.1 – Bending test

b) Torsion test

Following is an explanation of how and how many times to twist the packaging and in which order to proceed.

① First time – Hold the packaging with the fingers of one hand on each of its shorter sides from the state of 0° (neutral state without torsion). Twist it diagonally with a torsion angle of 45° in opposite directions as shown in Figure E.2.

② Second time – Twist it diagonally 90° (45° back + 45° opposite direction) in opposite directions to the direction twisted the first time.

③ Third time – Return to neutral state without torsion (45° back).

④ Movements ①, ② and ③ are counted as one time (one reciprocation) and are repeated 25 times (25 reciprocations).

Figure E.2 shows the movements of the torsion test. The red and blue lines represent the left and right edge of the packaging. The triangles and circles were added to keep track of the orientation during movements.

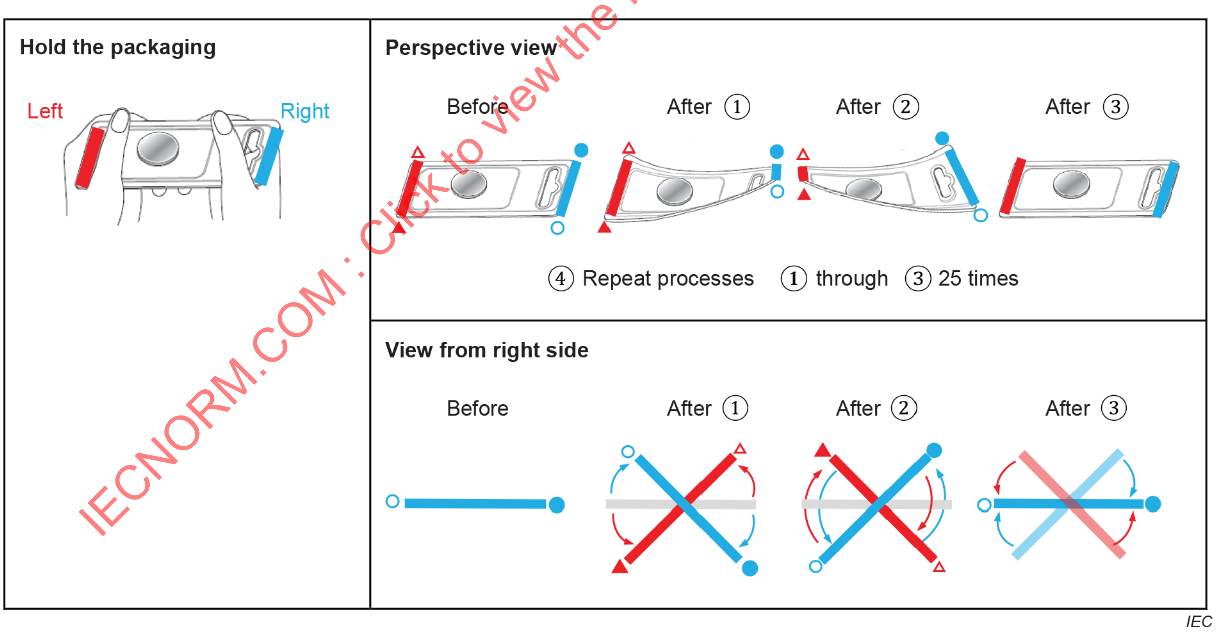


Figure E.2 – Torsion test

c) Tearing test

Try to tear the cell compartment with your hands as shown in Figure E.3. Alternatively use suitable equipment and apply a force of at least 25 N.

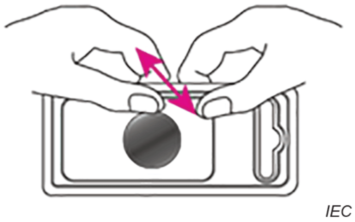


Figure E.3 – Tearing test

d) Pushing test

Try to push the cell out of the compartment with your hands. Alternatively pull with a mass of at least 5 kg for 30 s, as shown in Figure E.4.

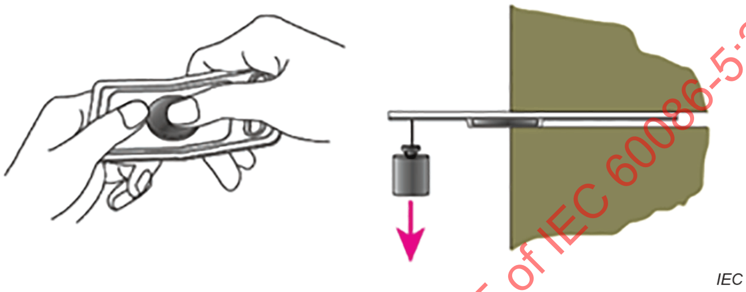


Figure E.4 – Pushing test

E.2.3 Test procedure

The test procedure is conducted with ten sample packagings. Each sample is subjected to a series of tests in the order and frequency outlined in Table E.1.

Table E.1 – Test procedure

Order	Test item		Number of times
(1)	a)	Bending test	50
(2)	b)	Torsion test	25
(3)	c)	Tearing test	1
(4)	b)	Torsion test	25
(5)	a)	Bending test	50
(6)	c)	Tearing test	1
(7)	d)	Pushing test	1

E.2.4 Criteria

Each test sample should meet the following criteria.

a) each cell should be kept in its packaging until the end of the test series, and

b) in order to prevent a child from pulling the cell out from its compartment, the packaging should not open too wide. The maximum allowable size of an opening in the packaging is 6 mm diameter for a round hole and 10 mm length for a slit. See Figure E.5 for maximum packaging openings.

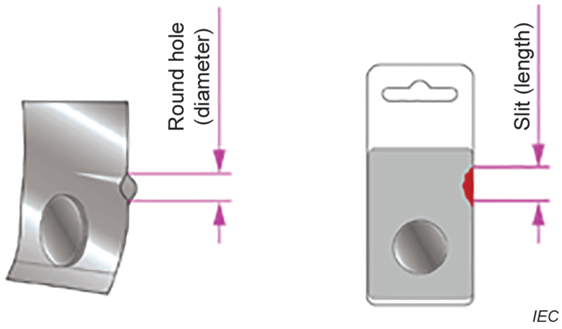


Figure E.5 – Maximum packaging opening

Bibliography

[1] IEC 60050-482, *International Electrotechnical Vocabulary (IEV) – Part 482: Primary and secondary cells and batteries* (available at http://www.electropedia.org)

[2] ISO/IEC Guide 51:2014, *Safety aspects – Guidelines for their inclusion in standards*

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

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

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

[6] ISO/IEC Guide 50:2014, *Safety aspects – Guidelines for child safety in standards and other specifications*

[7] ISO 7010:2019, *Graphical symbols – Safety colours and safety signs – Registered safety signs*
ISO 7010:2019/AMD 2:2020

[8] USA:16 CFR §1700.15(b)(1)

[9] EN 862, *Packaging – Child-resistant packaging – Requirements and testing procedures for non-reclosable packages for non-pharmaceutical products*

[10] AS 5808-2009, *Child-resistant packaging – Requirements and testing procedures for non-reclosable packages for non-pharmaceutical products*

[11] IEC 60086-3, *Primary batteries – Part 3: Watch batteries*

[12] IEC 60086-4, *Primary batteries – Part 4: Safety of lithium batteries*

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

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SOMMAIRE

COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

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PILES ÉLECTRIQUES –

Partie 5: Sécurité des piles à électrolyte aqueux

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L'IEC 60086-5 a été établie par le comité d'études 35 de l'IEC: Piles. Il s'agit d'une Norme internationale.

Cette cinquième édition annule et remplace la quatrième édition parue en 2016. Cette édition constitue une révision technique.

Cette édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente:

a) révision des informations de sécurité relatives au maintien des piles hors de portée des enfants;
b) suppression de la méthode de détermination de la résistance d'isolement;
c) modifications de la matrice d'essai;

d) révision de l'essai de décharge excessive;

e) révision de la définition et de la note pour le terme "élément bouton" ou "pile bouton" en 3.2;

f) révision de la méthode d'évaluation d'une explosion, qui a été déplacée du 3.6 au 6.2.1.

Le texte de cette Norme internationale est issu des documents suivants:

FDIS	Rapport de vote
35/1471/FDIS	35/1472/RVD

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à son approbation.

La langue employée pour l'élaboration de cette Norme internationale est l'anglais.

Le présent document a été rédigé selon les Directives ISO/IEC, Partie 2, il a été développé selon les Directives ISO/IEC, Partie 1 et les Directives ISO/IEC, Supplément IEC, disponibles sous www.iec.ch/members_experts/refdocs. Les principaux types de documents développés par l'IEC sont décrits plus en détail sous www.iec.ch/standardsdev/publications.

Une liste de toutes les parties de la série IEC 60086, publiées sous le titre général *Piles électriques*, se trouve sur le site web de l'IEC.

Le comité a décidé que le contenu du présent document ne sera pas modifié avant la date de stabilité indiquée sur le site web de l'IEC sous webstore.iec.ch dans les données relatives au document recherché. A cette date, le document sera

- reconduit,
- supprimé,
- remplacé par une édition révisée, ou
- amendé.

NOTE L'attention des Comités nationaux est attirée sur le fait que les fabricants d'appareils et les organismes d'essai peuvent avoir besoin d'une période transitoire après la publication d'un nouveau document IEC, ou d'un document amendé ou révisé, pour fabriquer des produits conformes aux nouvelles exigences et pour adapter leurs équipements aux nouveaux essais ou aux essais révisés.

Le comité recommande que le contenu du présent document soit adopté pour application nationale au plus tôt 2 ans après la date de publication. La période transitoire s'applique spécifiquement au Tableau 7.

IMPORTANT – Le logo "colour inside" qui se trouve sur la page de couverture du présent document indique qu'il contient des couleurs qui sont considérées comme utiles à une bonne compréhension de son contenu. Les utilisateurs devraient, par conséquent, imprimer ce document en utilisant une imprimante couleur.

INTRODUCTION

La notion de sécurité est étroitement liée à la protection de l'intégrité des personnes et des biens. La présente partie de l'IEC 60086 spécifie les exigences et essais pour les piles à électrolyte aqueux. Elle a été établie conformément aux lignes directrices ISO/IEC en prenant en compte les normes nationales et internationales correspondantes. Le présent document donne également des recommandations pour les concepteurs d'appareils concernant les compartiments de piles et des informations relatives à l'emballage, à la manipulation, à l'entreposage et au transport.

La sécurité consiste en un équilibre entre l'absence de risques de dommages et d'autres exigences auxquelles le produit doit satisfaire. La sécurité absolue ne peut pas être assurée. Même au niveau de sécurité le plus élevé, le produit ne peut offrir qu'une sécurité relative. A cet égard, la prise de décision repose sur une évaluation des risques et sur une appréciation de la sécurité.

Compte tenu des différents problèmes posés par la sécurité, il n'est pas possible de fournir un ensemble de dispositions et de recommandations précises qui s'appliquent à chaque cas. Cependant, le présent document, s'il est suivi de manière judicieuse, c'est-à-dire en "l'utilisant lorsqu'il est applicable", fournit des dispositions suffisamment cohérentes en matière de sécurité.

PILES ÉLECTRIQUES –

Partie 5: Sécurité des piles à électrolyte aqueux

1 Domaine d'application

La présente partie de l'IEC 60086 spécifie les essais et exigences pour les piles à électrolyte aqueux afin d'assurer leur fonctionnement sûr dans les conditions d'utilisation prévue et en cas de mauvais usage raisonnablement prévisible.

2 Références normatives

Les documents suivants sont cités dans le texte de sorte qu'ils constituent, pour tout ou partie de leur contenu, des exigences du présent document. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

IEC 60086-1:2015, *Piles électriques – Partie 1: Généralités*

IEC 60086-2:2015, *Piles électriques – Partie 2: Spécifications physiques et électriques*

3 Termes et définitions

Pour les besoins du présent document, les termes et définitions suivants s'appliquent.

L'ISO et l'IEC tiennent à jour des bases de données terminologiques destinées à être utilisées en normalisation, consultables aux adresses suivantes:

- IEC Electropedia: disponible à l'adresse http://www.electropedia.org/
- ISO Online browsing platform: disponible à l'adresse http://www.iso.org/obp

3.1
batterie
un ou plusieurs éléments connectés électriquement de façon permanente, placés dans un boîtier, qui comporte des bornes, des marquages et des dispositifs de protection, etc., selon les besoins de l'utilisation

[SOURCE: IEC 60050-482:2004, 482-01-04, [1], modifié – La définition a été révisée.]

3.2
élément bouton
pile bouton
petit élément ou petite pile de forme ronde dont la hauteur totale est inférieure au diamètre et qui contient de l'électrolyte aqueux

Note 1 à l'article: Voir "(élément ou pile) bouton au lithium" dans l'IEC 60086-1 et l'IEC 60086-2.

[SOURCE: IEC 60050-482:2004, 482-02-40, modifié – Le second terme "pile bouton" a été ajouté, la définition a été révisée et la note a été remplacée par une nouvelle note.]

3.3
élément
unité fonctionnelle de base, consistant en un assemblage d'électrodes, d'électrolyte, de conteneur, de bornes et généralement de séparateurs, qui est une source d'énergie électrique obtenue par transformation directe d'énergie chimique

[SOURCE: IEC 60050-482:2004, 482-01-01, modifié – La note a été supprimée.]

3.4
élément composant
élément contenu dans une pile

3.5
pile cylindrique
élément cylindrique
élément rond ou pile ronde de forme cylindrique dont la hauteur totale est supérieure ou égale au diamètre

[SOURCE: IEC 60050-482:2004, 482-02-39, modifié – Dans la définition, "élément" a été remplacé par "élément rond ou pile ronde".]

3.6
utilisation prévue
utilisation conforme aux informations fournies avec un produit ou un système ou, en l'absence de telles informations, conforme aux profils d'utilisation généralement entendus

[SOURCE: Guide ISO/IEC 51:2014, 3.6 [2]]

3.7
tension nominale
U_n
<d'une pile> valeur approchée appropriée d'une tension utilisée pour désigner ou identifier un élément, une pile ou un système électrochimique

[SOURCE: IEC 60050-482:2004, 482-03-31, modifié – Le domaine et le symbole ont été ajoutés.]

3.8
pile
élément ou pile qui n'est pas conçue pour être rechargée électriquement

3.9
élément parallélépipédique
pile parallélépipédique
élément ou pile ayant la forme d'un parallélépipède dont les faces sont rectangulaires

[SOURCE: IEC 60050-482:2004, 482-02-38, modifié – "élément" et "pile" ont été ajoutés au terme, et "qualifie un élément ou une batterie" a été remplacé par "élément ou pile".]

3.10
dispositif de protection
dispositif tel que coupe-circuit à fusibles, diode ou autre limiteur de courant électrique ou électronique conçu pour interrompre la circulation du courant dans un circuit électrique

3.11
mauvais usage raisonnablement prévisible
utilisation d'un produit ou d'un système dans des conditions ou à des fins non prévues par le fournisseur, mais qui peut provenir d'un comportement humain envisageable

[SOURCE: Guide ISO/IEC 51:2014, 3.7, modifié – Les notes ont été supprimées.]

3.12
élément rond
pile ronde
élément ou pile de section circulaire

3.13
sécurité
absence de risque intolérable

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

3.14
non déchargé
état de charge d'une pile qui correspond à une profondeur de décharge de 0 %

4 Exigences relatives à la sécurité

4.1 Conception

4.1.1 Généralités

Les piles doivent être conçues de manière à ne présenter aucun danger pour la sécurité dans des conditions d'utilisation normale (prévue).

4.1.2 Dégazage

Toutes les piles doivent incorporer une fonction de limitation de la pression, ou doivent être construites de manière à éviter un dégagement de pression interne excessive, selon une valeur et un débit qui empêchent les explosions. Si une encapsulation est nécessaire pour maintenir les éléments à l'intérieur d'un boîtier externe, le type d'encapsulant et la méthode d'encapsulation ne doivent pas provoquer une surchauffe de la pile en fonctionnement normal ni compromettre la fonction de limitation de la pression.

Le matériau du boîtier de la pile et/ou son assemblage final doivent être conçus de sorte que, en cas de dégazage d'un ou de plusieurs éléments, le boîtier de la pile ne présente pas un danger intrinsèque.

4.2 Plan qualité

Le fabricant doit préparer et mettre en œuvre un plan qualité qui définit les procédures d'examen des matériaux, des composants, des éléments et des piles au cours de la fabrication, et qui doit être appliqué à l'ensemble du processus de production d'un type de pile spécifique. Il convient que les fabricants comprennent leurs capacités de processus et qu'ils engagent les contrôles de processus nécessaires lorsque ces processus impliquent la sécurité des produits.

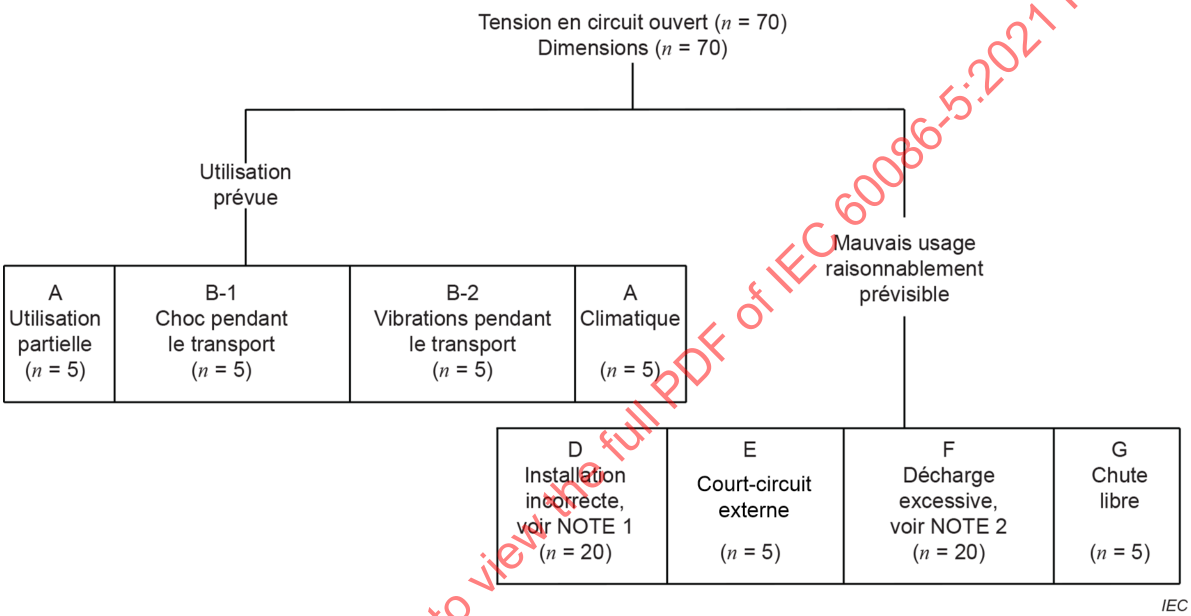
5 Echantillonnage

5.1 Généralités

Il convient de prélever des échantillons dans les lots de production conformément aux méthodes statistiques acceptées. Ces échantillons doivent satisfaire aux exigences de dimensions et de tension en circuit ouvert spécifiées dans l'IEC 60086-2. Les échantillons qui ne satisfont pas à ces exigences doivent être rejetés, et de nouveaux échantillons doivent alors être choisis.

5.2 Echantillonnage pour les essais de type

Le nombre d'échantillons prélevés pour les essais de type est indiqué à la Figure 1.



NOTE 1 Quatre piles connectées en série en inversant l'une des quatre piles (5 jeux).

NOTE 2 Quatre piles connectées en série dont l'une est déchargée (5 jeux).

Figure 1 – Echantillonnage pour les essais et nombre de piles exigé

5.3 Validité des essais

Les éléments ou piles à électrolyte aqueux doivent être soumis aux essais, conformément aux exigences du présent document. Les essais demeurent valides jusqu'à une modification de la conception ou une révision des exigences. De nouveaux essais sont exigés dans les cas suivants:

a) la spécification de la masse de la pile varie de plus de 0,1 g ou 20 %, si cette dernière valeur est la plus élevée, pour la cathode, l'anode ou l'électrolyte;

b) une modification des spécifications de la pile entraîne un échec à l'un des essais;

c) de nouveaux essais ou de nouvelles exigences sont formulés; ou

d) la modification d'une exigence entraîne un échec à l'un des essais.

6 Essais et exigences

6.1 Généralités

6.1.1 Essais de sécurité applicables

Le Tableau 1 répertorie les essais de sécurité applicables. Les essais décrits dans le Tableau 2 et le Tableau 6 ont pour objet de simuler les conditions que la pile est susceptible de rencontrer au cours de l'utilisation prévue et en cas de mauvais usage raisonnablement prévisible.

Tableau 1 – Matrice d'essai

Lettre du système	Electrode négative	Electrolyte	Electrode positive	Tension nominale par élément V	Forme	Essais applicables						
						A	B-1 B-2	C	D	E	F	G
Pas de lettre	Zinc (Zn)	Chlorure d'ammonium, Chlorure de zinc	Dioxyde de manganèse (MnO_2)	1,5	R	x	x	x	x	x	x	x
					B	NR						
					Pr	x	x	x	x	x	x	x
					M	x	x	x	NR	x	NR	x
A	Zinc (Zn)	Chlorure d'ammonium, Chlorure de zinc	Oxygène (O_2)	1,4	R	x	x	x	NR	x	x	x
					B	NR						
					Pr	x	x	x	x	x	x	x
					M	x	x	x	NR	x	x	x
L	Zinc (Zn)	Hydroxyde de métal alcalin	Dioxyde de manganèse (MnO_2)	1,5	R	x	x	x	x	x	x	x
					B	x	x	x	NR	x	NR	x
					Pr	x	x	x	x	x	x	x
					M	x	x	x	NR	x	NR	x
P	Zinc (Zn)	Hydroxyde de métal alcalin	Oxygène (O_2)	1,4 ou 1,45	R	NR						
					B	NR	NR	NR	NR	NR	NR	NR
					Pr	x	x	x	x	x	x	x
					M	NR						
S	Zinc (Zn)	Hydroxyde de métal alcalin	Oxyde d'argent (Ag_2O)	1,55	R	x	x	x	NR	x	NR	x
					B	x	x	x	NR	x	NR	x
					Pr	x	x	x	x	x	x	x
					M	NR						

Descriptif des essais:

A: stockage après utilisation partielle
B-1: choc pendant le transport
B-2: vibrations pendant le transport
C: cycles de températures (climatiques)
D: installation incorrecte
E: court-circuit externe
F: décharge excessive
G: chute libre

Légende

R: cylindrique (3.5)
B: bouton (3.2)
Pr: monoélément parallélépipédique (3.11)
M: multiélément

x: exigé
NR: non exigé

Si nécessaire, suivre les conditions de décharge de l'essai de capacité spécifié dans l'IEC 60086-2. Les éléments ou piles boutons des systèmes L et S d'une masse inférieure à 3,5 g sont exemptés des essais.

6.1.2 Mention de mise en garde

AVERTISSEMENT – Les essais spécifiés dans le présent document font appel à des procédures qui peuvent entraîner des blessures si des précautions appropriées ne sont pas prises.

Lors de la rédaction de ces essais, il a été admis par hypothèse qu'ils seraient effectués par des techniciens qualifiés et expérimentés qui utilisent des équipements de protection adéquats.

6.1.3 Température ambiante

Sauf spécification contraire, les essais doivent être effectués à une température ambiante de 20 °C ± 5 °C.

6.2 Evaluation des critères d'essai

6.2.1 Explosion

Une explosion se caractérise par l'expulsion soudaine de fragments solides de la batterie à plus de 25 cm de la pile.

6.2.2 Feu

Un feu se caractérise par l'émission de flammes au niveau de l'élément ou de la pile soumise à l'essai.

6.2.3 Fuite

Une fuite se caractérise par une perte imprévue d'électrolyte au niveau d'un élément ou d'une pile.

6.2.4 Dégazage

Un dégazage se caractérise par un dégagement de pression interne excessive d'un élément ou d'une pile de manière prévue par la conception pour empêcher une explosion.

6.3 Utilisation prévue

6.3.1 Essais et exigences dans les conditions d'utilisation prévue

Tableau 2 – Essais et exigences dans les conditions d'utilisation prévue

Essai		Simulation d'utilisation prévue	Exigences
Essai électrique	A	Stockage après utilisation partielle	Aucune fuite (NL) Aucun feu (NF) Aucune explosion (NE)
Essais d'environnement	B-1	Choc pendant le transport	Aucune fuite (NL) Aucun feu (NF) Aucune explosion (NE)
	B-2	Vibrations pendant le transport	Aucune fuite (NL) Aucun feu (NF) Aucune explosion (NE)
Essais de températures (climatiques)	C	Cycles de températures (climatiques)	Aucun feu (NF) Aucune explosion (NE)

6.3.2 Procédures d'essai dans les conditions d'utilisation prévue

6.3.2.1 Essai A – Stockage après utilisation partielle

a) Objet

Cet essai simule la situation dans laquelle un appareil est mis hors tension et les piles installées sont partiellement déchargées. Les piles peuvent être laissées dans l'appareil pendant une durée prolongée, ou être enlevées de l'appareil et stockées pendant longtemps.

b) Procédure d'essai

Une pile non déchargée se décharge dans les conditions d'application ou lors d'un essai de capacité, avec la charge définie dans l'IEC 60086-2 déterminée à partir de la durée d'essai la plus longue jusqu'à ce que la durée de vie en service chute de 50 % de la valeur de la durée moyenne minimale (MAD, *Minimum Average Duration*) la plus élevée. La pile est ensuite stockée à 45 °C ± 2 °C pendant 30 jours.

La tolérance de ± 2 °C sur la température s'applique à la période de maintien de la température. Un bref dépassement de la température est admis pendant la période transitoire.

c) Exigences

Il ne doit se produire aucune fuite, ni feu ou explosion pendant cet essai.

6.3.2.2 Essai B-1 – Choc pendant le transport

a) Objet

Cet essai simule la situation dans laquelle un appareil tombe par négligence avec les piles installées à l'intérieur. Cette condition d'essai est généralement spécifiée dans l'IEC 60068-2-27 [3][1].

b) Procédure d'essai

Une pile non déchargée doit être soumise à l'essai suivant.

L'essai de chocs doit être effectué dans les conditions définies dans le Tableau 3 selon l'ordre indiqué dans le Tableau 4.

Impulsion de chocs – L'impulsion de chocs appliquée à la pile doit correspondre à ce qui suit:

Tableau 3 – Impulsion de chocs

Accélération		**Forme d'onde**
Accélération moyenne minimale trois premières millisecondes	Accélération de crête	
75 g_n	125 g_n à 175 g_n	Semi-sinusoïdale
NOTE g_n = 9,806 65 m/s².		

[1] Les chiffres entre crochets renvoient à la Bibliographie.

Tableau 4 – Séquence de l'essai de chocs

Etape	Durée de stockage	Orientation de la pile	Nombre de chocs	Périodes de réalisation de l'examen visuel
1	–	–	–	Avant l'essai
2	–	a	1 chacun	–
3	–	a	1 chacun	–
4	–	a	1 chacun	–
5	1 h	–	–	–
6	–	–	–	Après l'essai

[a] Le choc doit être appliqué dans chacune des trois directions mutuellement perpendiculaires.

Etape 1 Enregistrer la tension en circuit ouvert conformément au 5.2.

Etapes 2 à 4 Réaliser l'essai de chocs spécifié dans le Tableau 3 selon l'ordre indiqué dans le Tableau 4.

Etape 5 Laisser la pile au repos pendant 1 h.

Etape 6 Enregistrer les résultats de l'examen.

c) Exigences

Il ne doit se produire aucune fuite, ni feu ou explosion pendant cet essai.

6.3.2.3 Essai B-2 – Vibrations pendant le transport

a) Objet

Cet essai simule les vibrations occasionnées pendant le transport. Cette condition d'essai est généralement spécifiée dans l'IEC 60068-2-6 [4].

b) Procédure d'essai

Une pile non déchargée doit être soumise à l'essai suivant.

L'essai de vibrations doit être effectué dans les conditions d'essai suivantes selon l'ordre indiqué dans le Tableau 5.

Vibrations – Un mouvement harmonique simple doit être appliqué à la pile, avec une amplitude de 0,8 mm et une excursion maximale totale de 1,6 mm. La fréquence doit être modulée à raison de 1 Hz/min entre les limites de 10 Hz et de 55 Hz. L'ensemble de la plage de fréquences aller (10 Hz à 55 Hz) et retour (55 Hz à 10 Hz) doit être traversée en (90 ± 5) min pour chaque position de montage (sens des vibrations).

Tableau 5 – Séquence de l'essai de vibrations

Etape	Durée de stockage	Orientation de la pile	Durée d'application des vibrations	Périodes de réalisation de l'examen visuel
1	–	–	–	Avant l'essai
2	–	a	(90 ± 5) min chacun	–
3	–	a	(90 ± 5) min chacun	–
4	–	a	(90 ± 5) min chacun	–
5	1 h	–	–	–
6	–	–	–	Après l'essai

[a] Les vibrations doivent être appliquées dans chacune des trois directions mutuellement perpendiculaires.

Etape 1 Enregistrer la tension en circuit ouvert conformément au 5.2.

Etapes 2 à 4 Appliquer les vibrations spécifiées en 6.3.2.3 selon l'ordre indiqué dans le Tableau 5.

Etape 5 Laisser la pile au repos pendant 1 h.

Etape 6 Enregistrer les résultats de l'examen.

c) Exigences

Il ne doit se produire aucune fuite, ni feu ou explosion pendant cet essai.

6.3.2.4 Essai C – Cycles de températures (climatiques)

a) Objet

Cet essai évalue l'intégrité de l'étanchéité de la pile, qui peut être compromise après les cycles de températures.

b) Procédure d'essai

Une pile non déchargée doit être soumise à l'essai selon la procédure suivante.

Procédure de cycles de températures (voir 1) à 7) ci-dessous et/ou Figure 2).

1) Placer les piles dans une enceinte d'essai et porter la température de l'enceinte à 70 °C ± 5 °C en t_1 = 30 min.

2) Maintenir l'enceinte à cette température pendant t_2 = 4 h.

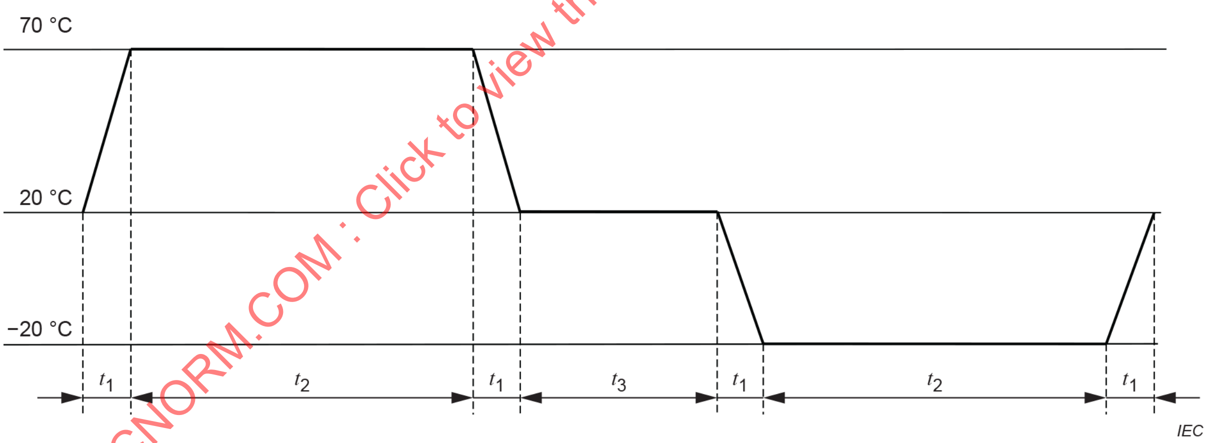
3) Abaisser la température de l'enceinte à 20 °C ± 5 °C en t_1 = 30 min et maintenir cette température pendant t_3 = 2 h.

4) Abaisser la température de l'enceinte à 20 °C ± 5 °C en t_1 = 30 min et maintenir cette température pendant t_2 = 4 h.

5) Porter la température de l'enceinte à 20 °C ± 5 °C en t_1 = 30 min.

6) Répéter la séquence sur neuf cycles supplémentaires.

7) Après le 10^{e} cycle, stocker les piles pendant 7 jours avant de les examiner.



t_1 = 30 min

t_2 = 4 h

t_3 = 2 h

Figure 2 – Procédure de cycles de températures

c) Exigences

Il ne doit se produire aucun feu ni explosion pendant cet essai.

6.4 Mauvais usage raisonnablement prévisible

6.4.1 Essais et exigences en cas de mauvais usage raisonnablement prévisible

Tableau 6 – Essais et exigences en cas de mauvais usage raisonnablement prévisible

Essai		Simulation de mauvais usage	Exigences
Essais électriques	D	Installation incorrecte	Aucun feu (NF) Aucune explosion (NE)[a]
	E	Court-circuit externe	Aucun feu (NF) Aucune explosion (NE)
	F	Décharge excessive	Aucun feu (NF) Aucune explosion (NE)
Essai d'environnement	G	Chute libre	Aucun feu (NF) Aucune explosion (NE)

[a] Voir NOTE 2 du 6.4.2.1 b).

6.4.2 Procédures d'essai en cas de mauvais usage raisonnablement prévisible

6.4.2.1 Essai D – Installation incorrecte (quatre piles en série)

a) Objet

Cet essai simule la situation dans laquelle l'une des piles d'un jeu de piles est inversée.

b) Procédure d'essai

Quatre piles non déchargées de la même marque, du même type et de la même origine doivent être connectées en série; la pile (B1) est inversée, comme cela est représenté à la Figure 3. Le circuit doit être maintenu pendant 24 h ou jusqu'à ce que la température du boîtier de la pile revienne à la température ambiante.

La résistance des circuits d'interconnexion ne doit pas dépasser 0,1 Ω.

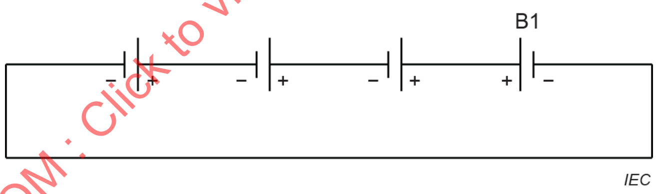


Figure 3 – Schéma de circuit d'une installation incorrecte (quatre piles en série)

NOTE 1 Le circuit de la Figure 3 simule un mauvais usage type.

NOTE 2 Les piles ne sont pas conçues pour être chargées. Cependant, si une pile est inversée dans un circuit qui comporte trois piles ou plus montées en série, la pile inversée s'expose à une condition de charge. Même si les piles cylindriques sont conçues pour éviter un dégagement de pression interne excessive, il est possible qu'une explosion ne puisse pas être exclue dans certains cas.

c) Exigences

Il ne doit se produire aucun feu ni explosion pendant cet essai (voir NOTE 2 du 6.4.2.1 b)).

6.4.2.2 Essai E – Court-circuit externe

a) Objet

Ce mauvais usage peut survenir au cours de la manipulation quotidienne des piles.

b) Procédure d'essai

Une pile non déchargée doit être connectée de la manière indiquée à la Figure 4. Le circuit doit être maintenu pendant 24 h ou jusqu'à ce que la température du boîtier de la pile revienne à la température ambiante. La résistance des circuits d'interconnexion ne doit pas dépasser 0,1 Ω.

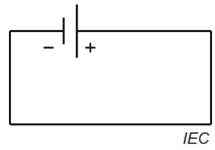


Figure 4 – Schéma de circuit d'un court-circuit externe

c) Exigences

Il ne doit se produire aucun feu ni explosion pendant cet essai.

6.4.2.3 Essai F – Décharge excessive

a) Objet

Cet essai simule et évalue la situation dans laquelle une pile déchargée est placée dans un circuit avec des piles non déchargées (c'est-à-dire lorsque des piles neuves sont installées conjointement avec des piles usagées ou anciennes).

b) Procédure d'essai

Une pile non déchargée (C1) se décharge dans les conditions d'application ou lors d'un essai de capacité, avec la valeur MAD la plus élevée (exprimée en unités de temps) définie dans l'IEC 60086-2, jusqu'à ce que la tension en charge chute à (n × 0,6 V) où n est le nombre d'éléments dans la pile. Ensuite, trois piles non déchargées et une pile déchargée (C1) de marque, de type et d'origine identiques doivent être connectées en série de la manière représentée à la Figure 5. La décharge doit être poursuivie pendant 24 h.

La valeur de la résistance (R1) doit être égale à environ quatre fois la valeur la plus faible obtenue lors des essais de charge résistive spécifiés pour la pile dans l'IEC 60086-2. La valeur finale de la résistance (R1) doit être la valeur la plus proche de celle spécifiée en 6.4 de l'IEC 60086-1:2015.

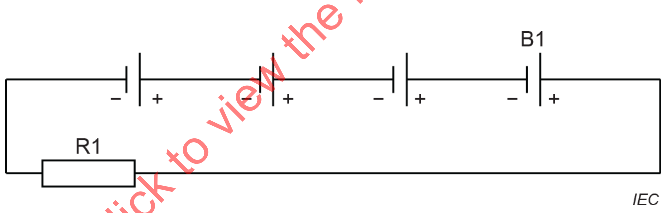


Figure 5 – Schéma de circuit d'une décharge excessive

c) Exigences

Il ne doit se produire aucun feu ni explosion pendant cet essai.

6.4.2.4 Essai G – Essai de chute libre

a) Objet

Cet essai simule la situation dans laquelle une pile tombe de manière accidentelle. La condition d'essai est issue de l'IEC 60068-2-31 [5].

b) Procédure d'essai

Des piles d'essai non déchargées doivent être lâchées d'une hauteur de 1 m sur une surface en béton. Chaque pile d'essai doit être lâchée à six reprises: une pile parallélépipédique une fois sur chacune de ses six faces et une pile cylindrique deux fois dans chacun des trois axes représentés à la Figure 6. Les piles d'essai doivent ensuite être stockées pendant 1 h.

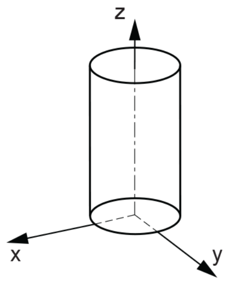


Figure 6 – Axes XYZ pour la chute libre

c) Exigences

Il ne doit se produire aucun feu ni explosion pendant cet essai.

7 Informations de sécurité

7.1 Précautions au cours de la manipulation des piles

Lorsqu'elles sont utilisées correctement, les piles à électrolyte aqueux fournissent une source de puissance sûre et fiable. Cependant, le mauvais usage d'une pile ou des négligences d'utilisation peut entraîner une fuite voire, dans des cas extrêmes, un feu et/ou une explosion

a) Toujours insérer les piles correctement en respectant les polarités (+ et –) marquées sur la pile et sur l'appareil.

   Les piles qui ne sont pas placées correctement dans l'appareil peuvent subir un court-circuit ou se charger. Cela peut donner lieu à un échauffement rapide susceptible de provoquer un dégazage, une fuite ou une explosion et d'occasionner des blessures corporelles. Se reporter à l'Annexe B pour plus d'informations.

b) Ne pas mettre les piles en court-circuit.

   Si les bornes positive (+) et négative (–) d'une pile sont en contact électrique entre elles, la pile subit un court-circuit. Par exemple, les piles placées en vrac dans une poche et/ou dans un sac à main qui contient des clés ou des pièces de monnaie peuvent subir un court-circuit. Cela peut entraîner un dégazage, une fuite ou une explosion et occasionner des blessures corporelles.

c) Tenir les piles hors de portée des enfants.

   Tenir les piles hors de portée des enfants, en particulier celles considérées comme susceptibles d'être avalées compte tenu du gabarit d'ingestion représenté à la Figure 7. En cas d'ingestion d'un élément ou d'une pile, il convient que la personne concernée consulte rapidement un médecin. Lorsqu'ils sont ingérés, les éléments boutons de moins de 2 V ne sont pas susceptibles d'occasionner des brûlures chimiques à court terme. Si de tels éléments ont traversé l'œsophage, la pratique médicale établie consiste à surveiller et faciliter leur élimination par les voies naturelles.

   NOTE 1 Pour plus d'informations, se reporter à l'Article D.1 de l'Annexe D.

   NOTE 2 Pour des informations générales sur les dangers, voir [6].

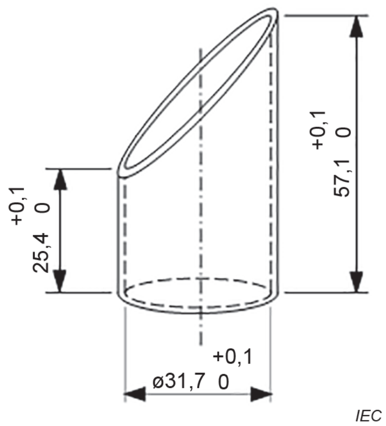


Figure 7 – Gabarit d'ingestion

d) Ne pas charger les piles.

Toute tentative de charge d'une pile non rechargeable peut provoquer un dégagement interne de gaz et/ou de chaleur et ainsi entraîner un dégazage, une fuite ou une explosion et occasionner des blessures corporelles.

e) Ne pas forcer la décharge des piles.

Lorsque la décharge des piles est forcée par une source d'énergie externe, la tension de la pile est forcée au-dessous de sa capacité de conception et des gaz sont produits à l'intérieur de la pile. Cela peut entraîner un dégazage, une fuite ou une explosion et occasionner des blessures corporelles.

f) Ne pas installer conjointement des piles anciennes et neuves ou des piles de marques ou types différents.

Lors du remplacement de piles, remplacer simultanément toutes les piles par des piles neuves de marque et type identiques.

Lorsque des piles de marque ou type différent sont utilisées ensemble ou que des piles neuves et anciennes sont utilisées ensemble, certaines d'entre elles peuvent se décharger de manière excessive en raison d'une différence de tension ou de capacité. Cela peut entraîner un dégazage, une fuite ou une explosion et peut occasionner des blessures corporelles.

g) Il convient de retirer immédiatement de l'appareil les piles déchargées et de les mettre au rebut conformément à la réglementation.

Lorsque des piles déchargées restent pendant une durée prolongée à l'intérieur d'un appareil, la fuite d'électrolyte peut provoquer des dommages à l'appareil et/ou des blessures corporelles.

h) Ne pas exposer les piles à la chaleur

Lorsqu'une pile est exposée à la chaleur, un dégazage, une fuite ou une explosion peuvent se produire et occasionner des blessures corporelles.

i) Ne pas souder ou braser directement sur des piles.

La chaleur dégagée par le soudage ou le brasage direct sur une pile peut provoquer des courts-circuits internes et ainsi entraîner un dégazage, une fuite ou une explosion, et peut occasionner des blessures corporelles.

j) Ne pas démonter les piles.

Lorsqu'une pile est démontée ou démantelée, le contact avec les composants peut être dangereux et peut provoquer des blessures corporelles, voire un feu.