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REDLINE VERSION

INTERNATIONAL STANDARD

colour inside

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

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PRIMARY BATTERIES –

Part 5: Safety of batteries with aqueous electrolyte

FOREWORD

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International Standard IEC 60086-5 has been prepared by IEC Technical Committee 35: Primary cells and batteries.

This fourth edition cancels and replaces the third edition published in 2011. This edition constitutes a technical revision.

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

a) The definition of explosion was changed to suitable sentence in order to harmonize in IEC 60086 series;
b) To prevent removal of hydrogen gas, we revised it to the suitable sentence,
c) To prevent misuse, the battery compartments with parallel connections were revised to the suitable sentence.
d) To clarify the method to determine the insulation resistance.

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

FDIS	Report on voting
35/1360/FDIS	35/1361/RVD

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

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

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

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- withdrawn,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

IMPORTANT – The “colour inside” logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this publication 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 standard 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 standard, 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, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60086-1~~:2011~~, *Primary batteries – Part 1: General*

IEC 60086-2~~:2011~~, *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 terms and definitions given in IEC 60086-1 as well as~~ the following terms and definitions apply.

NOTE Certain definitions taken from IEC 60050-482, IEC 60086-1, and IEC Guide 51 are repeated below for convenience.

3.1
battery
one or more cells electrically connected 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, modified definition]

3.2
button (cell or battery)
small round cell or battery where the overall height is less than the diameter~~; batteries complying with Figures 3 and 4 of IEC 60086-2~~

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.

3.3
cell
basic functional unit, consisting of an assembly of electrodes, electrolyte, container, terminals and usually separators that is a source of electric energy obtained by direct conversion of chemical energy

[SOURCE: IEC 60050-482:2004, 482-01-01]

3.4
component cell
cell contained in a battery

3.5
cylindrical (cell or battery)
round cell or battery 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 ("cell with a cylindrical shape" replaced by "round cell or battery")]

3.6
explosion (battery explosion)
~~an instantaneous release wherein solid matter from any part of the battery is propelled to a distance greater than 25 cm away~~
the cell or battery opens and solid components are forcibly expelled

~~**3.6**~~
~~**harm**~~
~~physical injury or damage to the health of people.~~

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

~~**3.7**~~
~~**hazard**~~
~~potential source of harm~~

~~[ISO/IEC Guide 51:1999, 3.5]~~

3.7
fire
flames are emitted from the test cell or battery

3.8
intended use
~~use of a product, process or service in accordance with information provided by the supplier~~
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:~~1999~~ 2014, 3.6]

3.9
leakage
unplanned escape of electrolyte~~, gas or other material~~ from a cell or battery

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

3.10
nominal voltage (of a primary battery)
V_n
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)]

3.11
primary (cell or battery)
cell or battery that is not designed to be electrically recharged

3.12
prismatic (cell or 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")]

3.13
protective devices
devices such as fuses, diodes or other electric or electronic current limiter designed to interrupt the current flow in an electrical circuit

3.14
reasonably foreseeable misuse
use of a product~~, process~~ or ~~service~~ system in a way not intended by the supplier, but which ~~may~~ can result from readily predictable human behaviour

[SOURCE: ISO/IEC Guide 51:1999, 3.14, modified ("process or service" replaced by "or system" and "may" replaced by "can" and deletion of the Note)]

~~**3.15**~~
~~**risk**~~
~~combination of the probability of occurrence of harm and the severity of that harm~~

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

3.15
round (cell or battery)
cell or battery with circular cross section

3.16
safety
freedom from ~~unacceptable~~ risk which is not tolerable

[SOURCE: ISO/IEC Guide 51:~~1999~~ 2014, 3.14]

3.17
undischarged
state of charge of a primary cell or battery corresponding to 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.

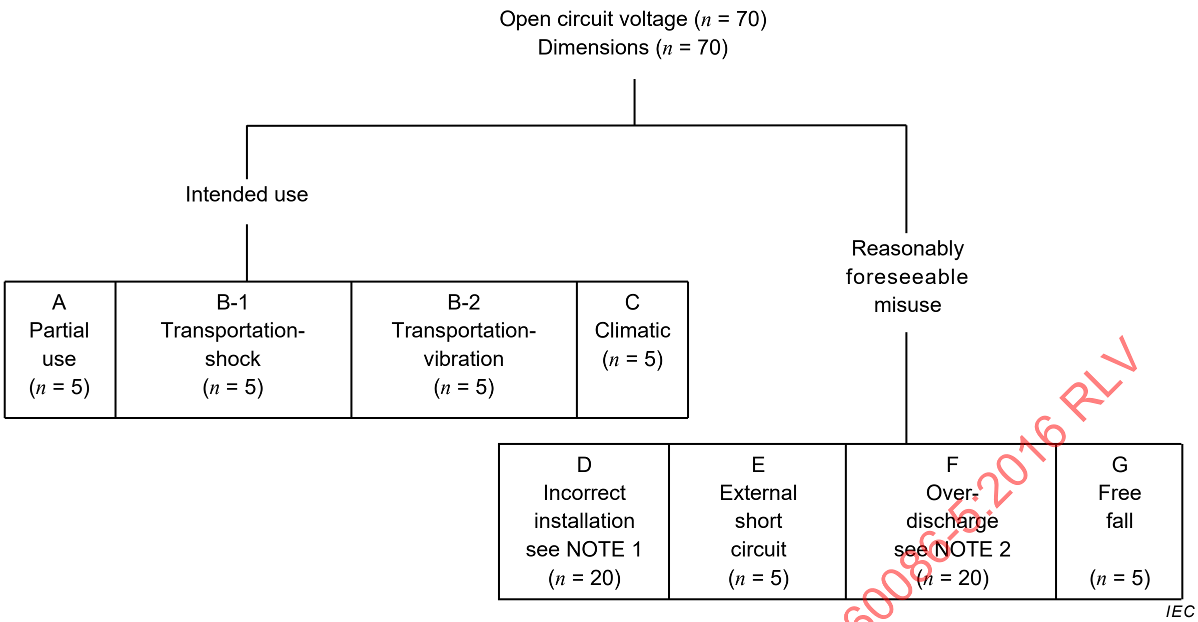
5 Sampling

5.1 General

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

5.2 Sampling for type approval

The number of samples drawn for type approval 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

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 Tables 2 and 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	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	R	NR						
					B	NR	x	x	NR	x	NR	x
					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 (3.12)
M: multicell

x: required
NR: Not required

Systems L and S button cells or batteries under 250 mAh capacity and system P button cells or batteries under 700 mAh capacity are exempt from any testing.

6.1.2 ~~Safety~~ Cautionary notice

WARNING

These tests call for the use of procedures which ~~may~~ 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 Intended use

6.2.1 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)

6.2.2 Intended use test procedures

6.2.2.1 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/service output test condition, with the lowest resistive load test as defined in IEC 60086-2 until the service life falls by 50 % of the minimum average duration (MAD) value, followed by storage at 45 °C ± 5 °C for 30 days.

c) Requirements

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

6.2.2.2 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.

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 = 9,80665 m/s^2.		

Table 4 – Test sequence

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.

a) Requirements

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

6.2.2.3 Test B-2 – Transportation-vibration

a) Purpose

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

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

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 6.2.2.3 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.

6.2.2.4 Test C – Climatic-temperature cycling

a) Purpose

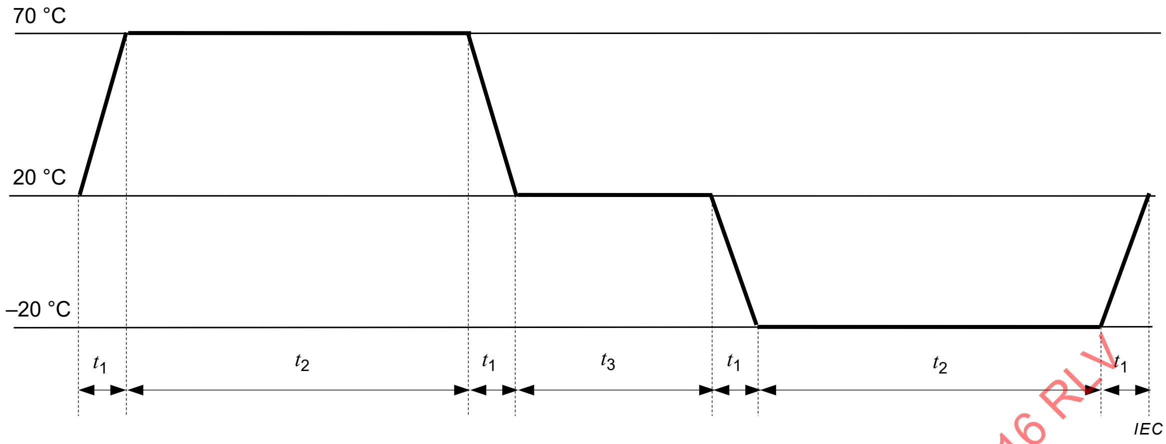
This test assesses the integrity of the battery seal which may be impaired after temperature cycling.

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.

6.3 Reasonably foreseeable misuse

6.3.1 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)*
	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)
* See NOTE 2 of 6.3.2.1b)			

6.3.2 Reasonably foreseeable misuse test procedures

6.3.2.1 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.

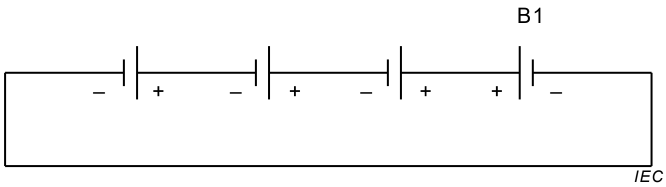


Figure 3 – Circuit diagram for incorrect installation (four batteries in series)

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, in some instances an explosion may not be precluded. ~~Therefore, the user should be clearly advised to install batteries correctly with regard to polarity (+ and –) to avoid this hazard. (See 9.1f)).~~

c) Requirements

There shall be no fire and no explosion during this test (see NOTE 2 of 6.3.2.1b)).

6.3.2.2 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.

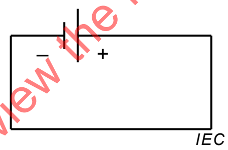


Figure 4 – Circuit diagram for external short circuit

c) Requirements

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

6.3.2.3 Test F – Overdischarge

a) Purpose

This test simulates the condition when one (1) discharged battery is series-connected with three (3) other undischarged batteries.

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 ($n \times 0{,}6$ 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 ($n \times 0{,}6$ V).

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 in 6.4 of IEC 60086-1:2015.

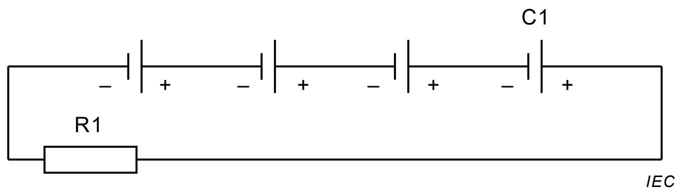


Figure 5 – Circuit diagram for overdischarge

c) Requirements

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

6.3.2.4 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.

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.

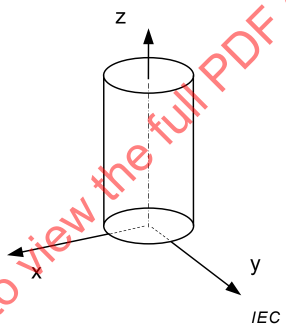


Figure 6 – XYZ axes for free fall

c) Requirements

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

7 Information for safety

7.1 ~~Safety~~ 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.

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) 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.

d) 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.

e) 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.

f) 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.

g) Do not heat batteries

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

h) 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.

i) 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.

j) 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.

k) 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.

l) 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.

NOTE Refer to [3].[1]

1 Numbers in square brackets refer to the bibliography.

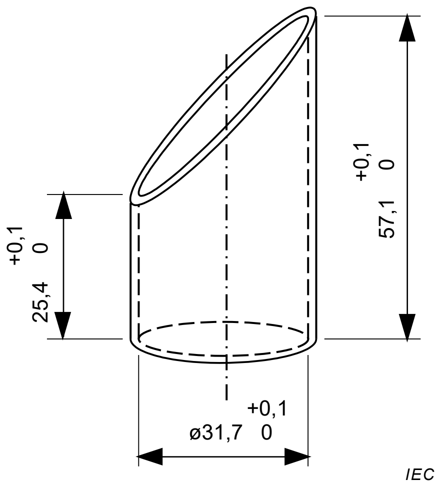


Figure 7 – Ingestion gauge ~~(Inner dimensions)~~

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 ~~safety vent mechanism(s) and subsequent~~ pressure relief vent mechanism(s) and/or prevent removal of hydrogen gas generated in the batteries (see also 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. ~~still cameras, photoflash,~~ 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 ~~may~~ might result in battery damage ~~and impaired electrical performance and may result in~~. This can cause leakage, explosion, or ~~possibly~~ 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 minimise the risk of falling e.g. 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 also 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

9.1 General (see Table 7)

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

a) designation, IEC or common;

b) expiration of a recommended usage period or year and month or week of manufacture. The year and month or week of manufacture may be in code;

c) polarity of the positive (+) terminal;

d) nominal voltage;

e) name or trade mark of the manufacturer or supplier;

f) cautionary advice.

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

9.2 Marking of small batteries (see Table 7)

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 batteries the designation 9.1 a) and the polarity 9.1 c) shall be marked on the battery. All other markings shown in 9.1 may be given on the immediate packing instead of on the battery.

b) For P-system batteries, 9.1 a) may be on the battery, the sealing tab or the immediate packing. 9.1c) 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 packing instead of on the battery.

c) Caution for ingestion of swallowable batteries shall be given. Refer to 7.1 l) for details.

Table 7 – Marking 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).			

9.3 Safety pictograms

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

Annex A
(informative)

Additional information ~~to 7.4~~ on display and storage

The purpose of this annex is to describe ~~these~~ 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 packing. 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 packing (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 recognising 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 The charging current 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 Battery electrolytes are harmful to body tissues.

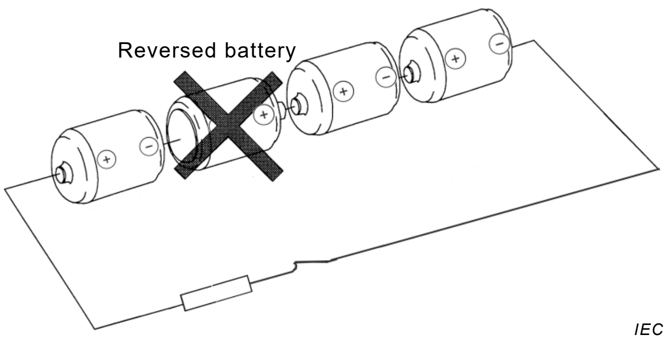


Figure B.1 – Example of series connection with one battery reversed

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 ~~(not parallel)~~ 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.

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 minimise 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 Figures B.2 and 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.

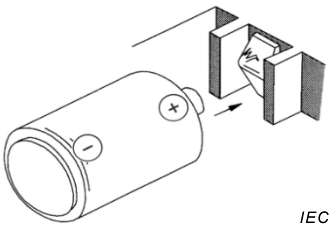


Figure B.2a – Correct insertion of the battery

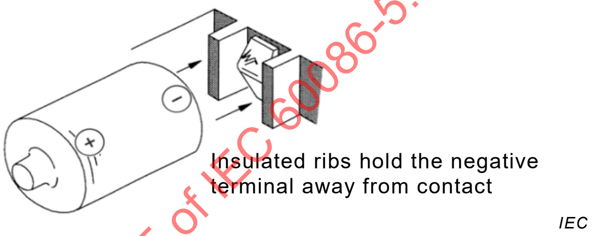


Figure B.2b – Incorrect insertion of the battery

Figure B.2 – Positive contact recessed between ribs

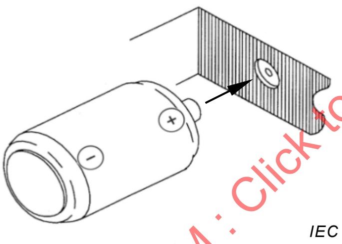


Figure B.3a – Correct insertion of the battery

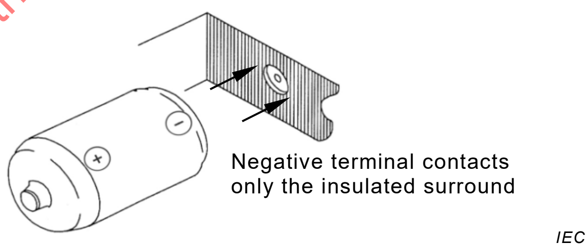


Figure B.3b – Incorrect insertion of the battery

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).

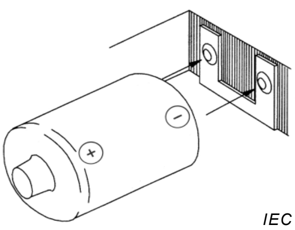


Figure B.4a – Correct insertion of the battery

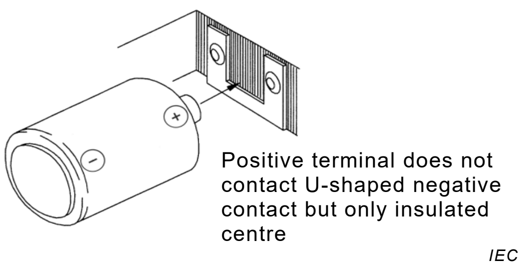


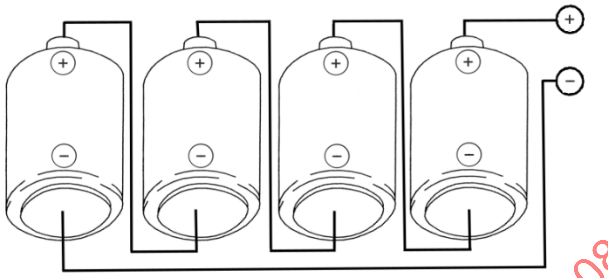
Figure B.4b – Incorrect insertion of the battery

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

B.3.4 Design with respect to battery orientation

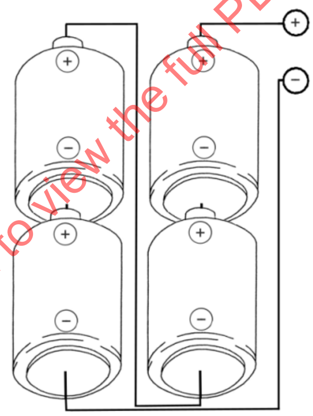
In order to avoid reverse insertion of batteries, it is recommended that all batteries have the same orientation. Examples are shown in Figures B.5a and B.5b.

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



NOTE Protection of the positive contact ~~should be~~ is as shown in Figures B.2 and B.3.

Figure B.5a – Preferred battery orientation



NOTE 1 Protection of the contacts ~~should be as shown~~ is in Figures B.2 or B.3 for the positive and Figure B.4 for the negative contact.

NOTE 2 This arrangement (Figure B.5b) 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.5b – Alternative recommendation for battery orientation

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

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] (mm-minimum)	d_3 [a] (mm-maximum)	h_3 [a] (mm-minimum)	X mm	Y mm
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.

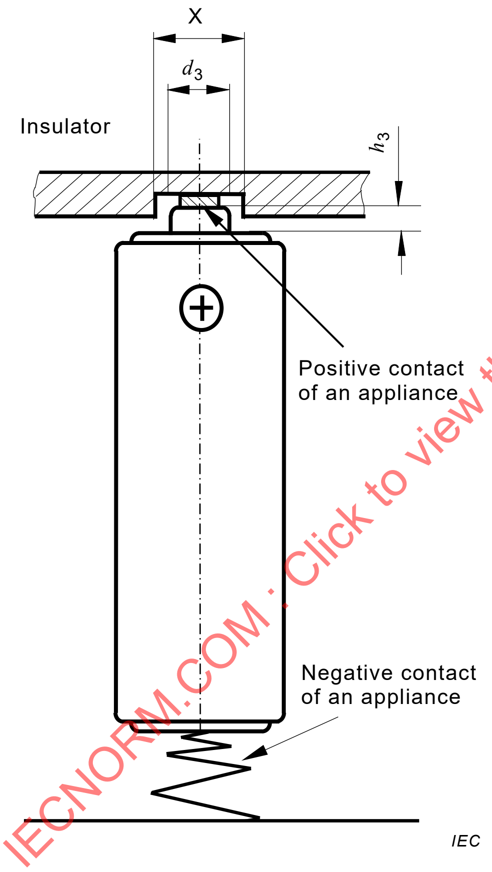


Figure B.6a – Correct insertion

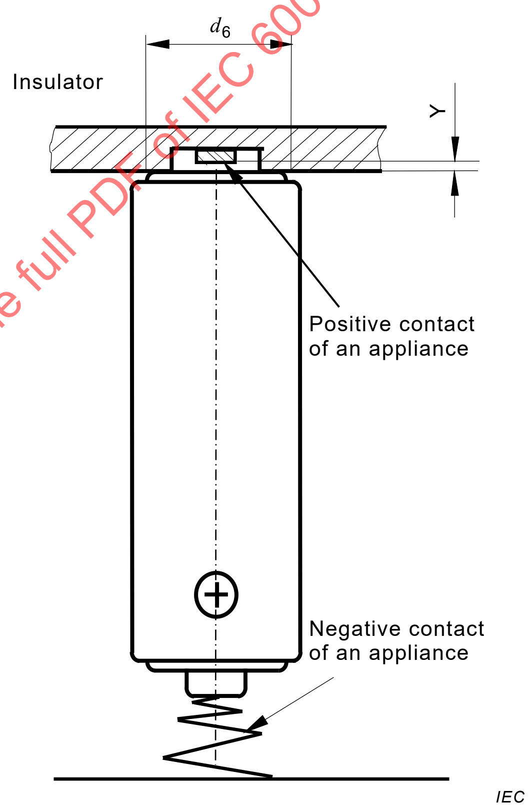


Figure B.6b – Incorrect insertion

NOTE Positive contact of an appliance is recessed within 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.6a is correct. In Figure B.6b 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.

The letter codes in Figure B.6 are as follows:

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;

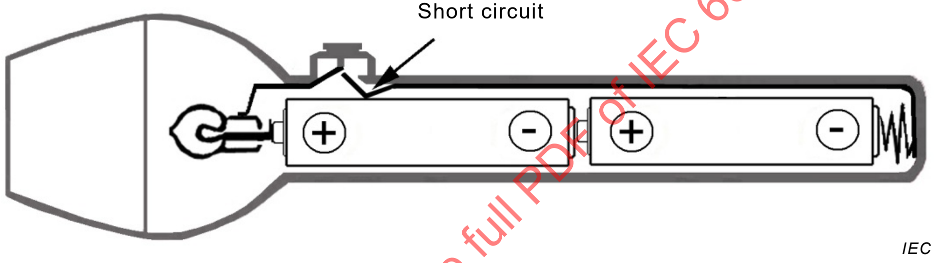
X Diameter of the recessed hole as a positive contact with the positive battery terminal. X should be bigger than d_3 but smaller than d_6;

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

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, 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.

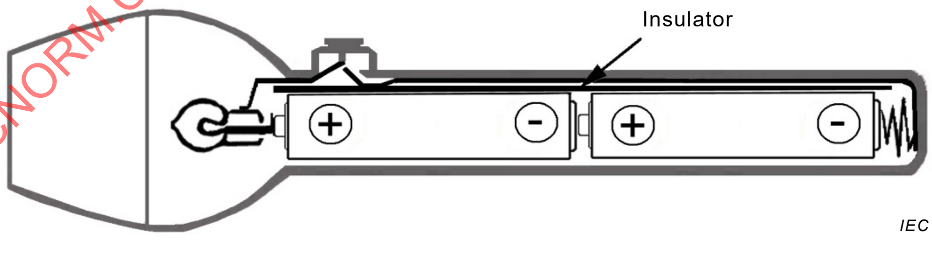


Figure B.8 – Typical example of insulation to prevent short circuit

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/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.

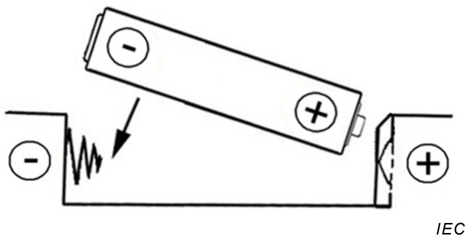


Figure B.9 – Insertion against spring (to be avoided)

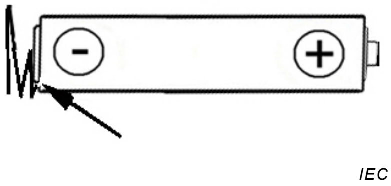


Figure B.10a – Spring slides underneath the jacket and contacts the metal can

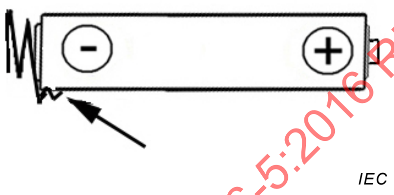


Figure B.10b – Jacket is punctured

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.

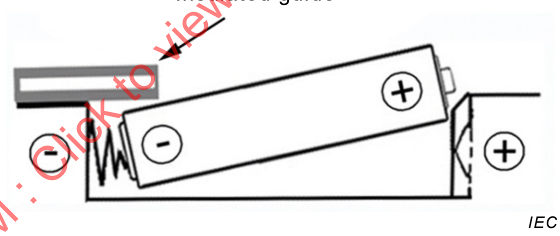


Figure B.11 – One example of protected insertion

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

Battery type		Minimum wire diameter mm
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 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/pip should be provided. This projection/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'/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).

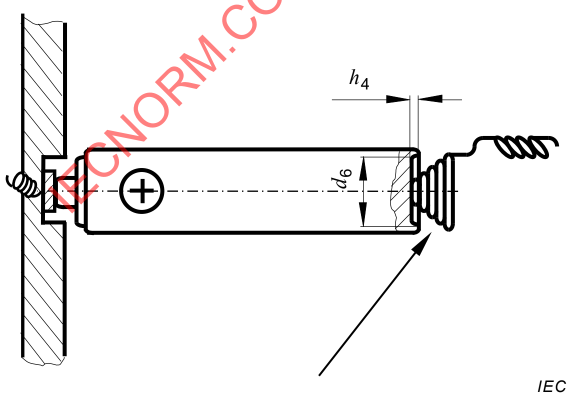


Figure B.12a – Spring coil

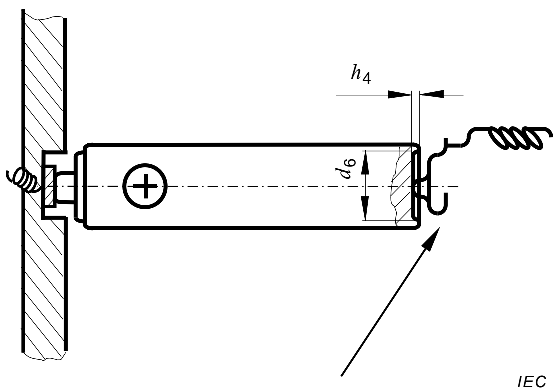


Figure B.12b – Plate spring contact

Figure B.12 – Example of negative contacts

Table B.3 – Dimensions of the negative battery terminal

Battery type	Maximum recessed dimension of negative battery terminal h_4[a] mm	External diameter of the contact surface of negative battery terminal d_6[a] mm
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] Reference 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/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 paragraph 7.1n)

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 minimise 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-depolarised 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) Parallel connections are not recommended since an incorrectly placed battery causes continuous discharge of the batteries even if the device is not switched on. To overcome the problem of reversed placement described above and with the end user in mind, consideration should be given to the arrangement in Figure B.5a and Figure B.5b.

WARNING In some parallel battery circuits the discharge current can be similar to that of a battery under short circuit conditions.

Potential hazards arising from the reversal of a battery in a parallel circuit are described in B.1.3.

NOTE In extreme cases, battery explosion may occur.

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 occur.

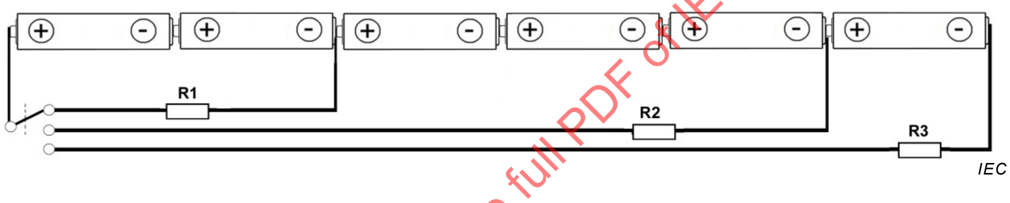


Figure B.13 – Example of series connection of batteries with voltage tapping

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

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 ~~Overview~~ General

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

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

C.2 Pictograms

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

Table C.1 – Safety pictograms *(1 of 3)*

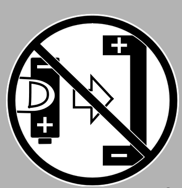
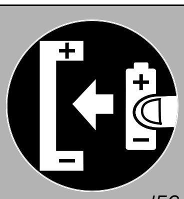
Reference	Pictogram	Cautionary advice
A	 *IEC*	DO NOT CHARGE
B	 *IEC*	DO NOT DEFORM / DAMAGE
C	 *IEC*	DO NOT DISPOSE OF IN FIRE
D	 *IEC*	DO NOT INSERT INCORRECTLY
NOTE The grey shading highlights a white margin appearing when the pictogram is printed on coloured or black background.		

Table C.1 – *(2 of 2)*

Reference	Pictogram	Cautionary advice
E	 NOTE Under consideration to replace pictogram E	KEEP OUT OF REACH OF CHILDREN NOTE See 7.1 l) for critical safety information
F		DO NOT MIX DIFFERENT TYPES OR BRANDS
G		DO NOT MIX NEW AND USED
H		DO NOT OPEN / DISMANTLE
I		DO NOT SHORT CIRCUIT

Table C.1 – *(3 of 2)*

J		INSERT CORRECTLY
NOTE The grey shading highlights a white margin appearing when the pictogram is printed on coloured or black background.		

C.3 ~~Instructions~~ Recommendations for use

The following ~~instructions~~ recommendations are provided for use of the pictograms.

a) Pictograms ~~shall~~ should be clearly legible.

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

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

Bibliography

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

[2] 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:~~1999~~ 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*

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

IEC 60086-5

Edition 4.0 2016-07

INTERNATIONAL STANDARD

NORME INTERNATIONALE

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

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

IEC 60086-5:2016-07(en-fr)

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

____

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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International Standard IEC 60086-5 has been prepared by IEC Technical Committee 35: Primary cells and batteries.

This fourth edition cancels and replaces the third edition published in 2011. This edition constitutes a technical revision.

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

a) The definition of explosion was changed to suitable sentence in order to harmonize in IEC 60086 series;
b) To prevent removal of hydrogen gas, we revised it to the suitable sentence,
c) To prevent misuse, the battery compartments with parallel connections were revised to the suitable sentence.
d) To clarify the method to determine the insulation resistance.

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

FDIS	Report on voting
35/1360/FDIS	35/1361/RVD

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

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

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

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

INTRODUCTION

The concept of safety is closely related to safeguarding the integrity of people and property. This 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 standard 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 standard, 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, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

IEC 60086-2, *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.

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, modified definition]

3.2
button (cell or battery)
small round cell or battery where the overall height is less than the diameter

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.

3.3
cell
basic functional unit, consisting of an assembly of electrodes, electrolyte, container, terminals and usually separators that is a source of electric energy obtained by direct conversion of chemical energy

[SOURCE: IEC 60050-482:2004, 482-01-01]

3.4
component cell
cell contained in a battery

3.5
cylindrical (cell or battery)
round cell or battery 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 ("cell with a cylindrical shape" 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

3.8
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]

3.9
leakage
unplanned escape of electrolyte from a cell or battery

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

3.10
nominal voltage (of a primary battery)
V_n
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)]

3.11
primary (cell or battery)
cell or battery that is not designed to be electrically recharged

3.12
prismatic (cell or 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")]

3.13
protective devices
devices such as fuses, diodes or other electric or electronic current limiter designed to interrupt the current flow in an electrical circuit

3.14
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, 3.14, modified ("process or service" replaced by "or system" and "may" replaced by "can" and deletion of the Note)]

3.15
round (cell or battery)
cell or battery with circular cross section

3.16
safety
freedom from risk which is not tolerable

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

3.17
undischarged
state of charge of a primary cell or battery corresponding to 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.

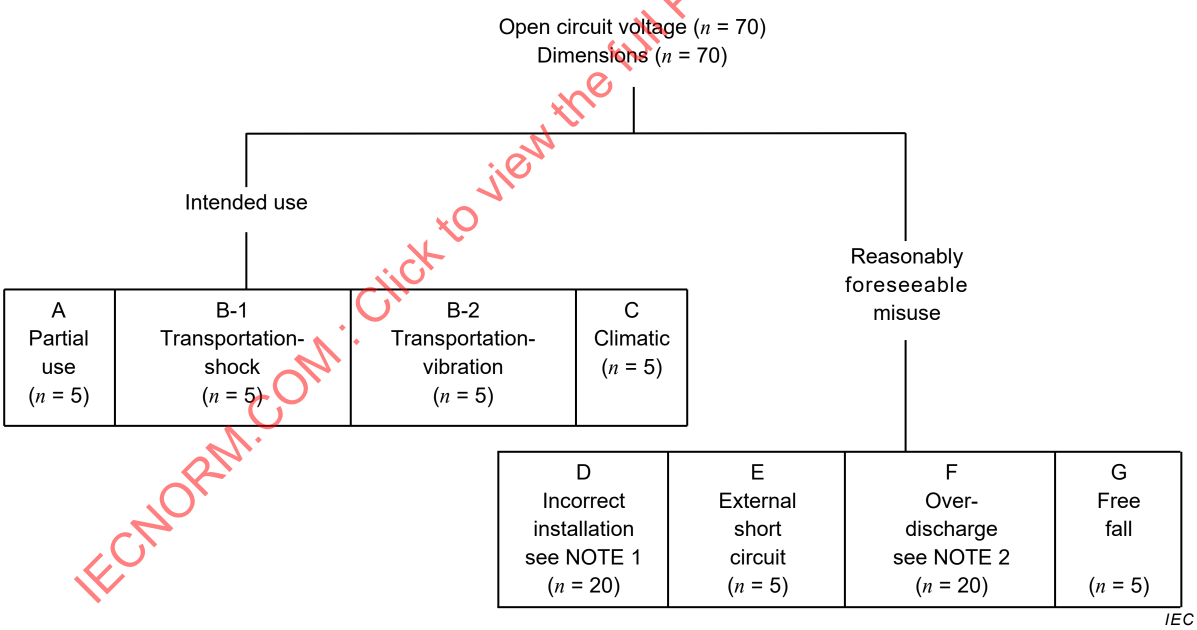
5 Sampling

5.1 General

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

5.2 Sampling for type approval

The number of samples drawn for type approval 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

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 Tables 2 and 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	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	R	NR						
					B	NR	x	x	NR	x	NR	x
					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 (3.12)
M: multicell

x: required
NR: Not required

Systems L and S button cells or batteries under 250 mAh capacity and system P button cells or batteries under 700 mAh capacity are exempt from any testing.

6.1.2 Cautionary notice

WARNING

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

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

6.1.3 Ambient temperature

Unless otherwise specified, these tests shall be carried out at an ambient temperature of 20 °C ± 5 °C.

6.2 Intended use

6.2.1 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)

6.2.2 Intended use test procedures

6.2.2.1 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/service output test condition, with the lowest resistive load test as defined in IEC 60086-2 until the service life falls by 50 % of the minimum average duration (MAD) value, followed by storage at 45 °C ± 5 °C for 30 days.

c) Requirements

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

6.2.2.2 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.

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 = 9,80665 m/s².		

Table 4 – Test sequence

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.

6.2.2.3 Test B-2 – Transportation-vibration

a) Purpose

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

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

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 6.2.2.3 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.

6.2.2.4 Test C – Climatic-temperature cycling

a) Purpose

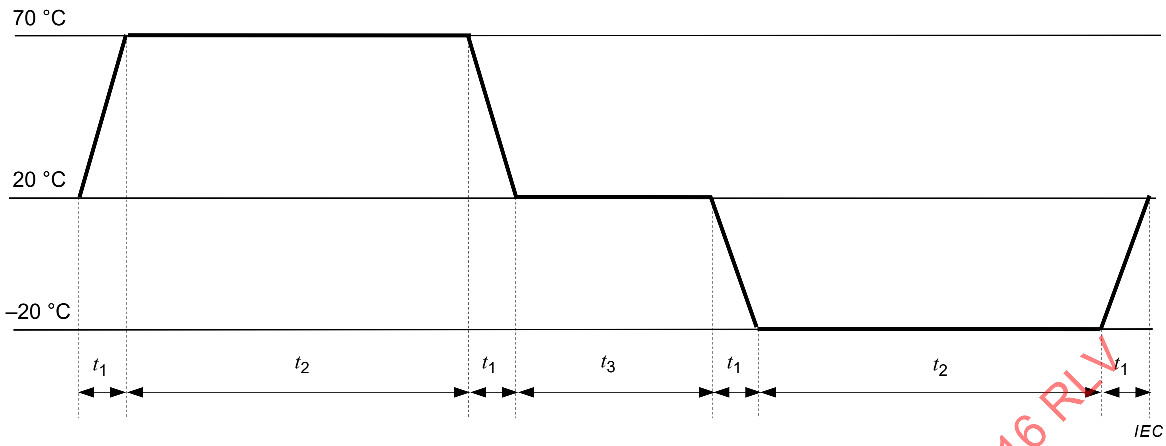
This test assesses the integrity of the battery seal which may be impaired after temperature cycling.

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.

6.3 Reasonably foreseeable misuse

6.3.1 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)*
	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)
* See NOTE 2 of 6.3.2.1b)			

6.3.2 Reasonably foreseeable misuse test procedures

6.3.2.1 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.

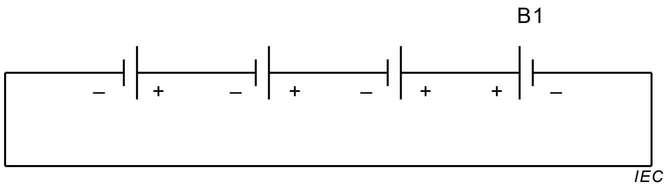


Figure 3 – Circuit diagram for incorrect installation (four batteries in series)

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, in some instances an explosion may not be precluded.

c) Requirements

There shall be no fire and no explosion during this test (see NOTE 2 of 6.3.2.1b)).

6.3.2.2 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.

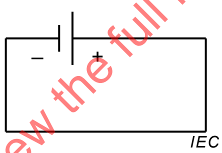


Figure 4 – Circuit diagram for external short circuit

c) Requirements

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

6.3.2.3 Test F – Overdischarge

a) Purpose

This test simulates the condition when one (1) discharged battery is series-connected with three (3) other undischarged batteries.

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 ($n \times 0{,}6$ 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 ($n \times 0{,}6$ V).

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 in 6.4 of IEC 60086-1:2015.

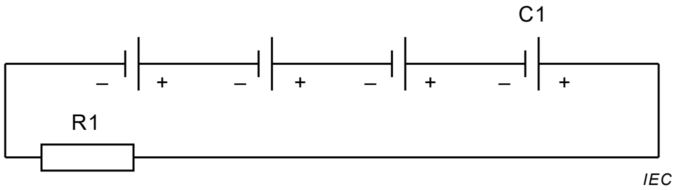


Figure 5 – Circuit diagram for overdischarge

c) Requirements

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

6.3.2.4 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.

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.

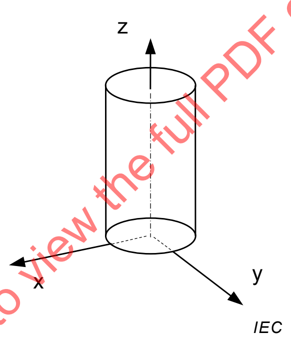


Figure 6 – XYZ axes for free fall

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.

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) 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.

d) 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.

e) 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.

f) 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.

g) Do not heat batteries

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

h) 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.

i) 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.

j) 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.

k) 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.

l) 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.

NOTE Refer to [3].[1]

1 Numbers in square brackets refer to the bibliography.

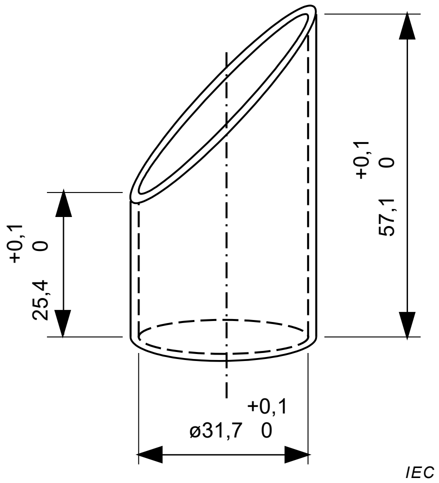


Figure 7 – Ingestion gauge

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 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 minimise the risk of falling e.g. 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 also 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

9.1 General (see Table 7)

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

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

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

9.2 Marking of small batteries (see Table 7)

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 batteries the designation 9.1 a) and the polarity 9.1 c) shall be marked on the battery. All other markings shown in 9.1 may be given on the immediate packing instead of on the battery.
b) For P-system batteries, 9.1 a) may be on the battery, the sealing tab or the immediate packing. 9.1c) 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 packing instead of on the battery.
c) Caution for ingestion of swallowable batteries shall be given. Refer to 7.1 l) for details.

Table 7 – Marking 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).			

9.3 Safety pictograms

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

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 packing. 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 packing (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 recognising 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 The charging current 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 Battery electrolytes are harmful to body tissues.

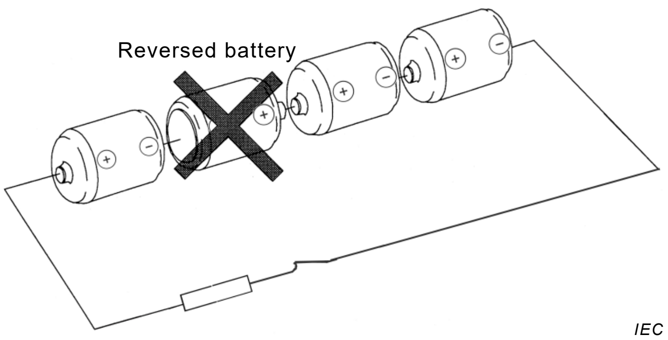


Figure B.1 – Example of series connection with one battery reversed

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.

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 minimise 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 $\times$ 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 Figures B.2 and 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.

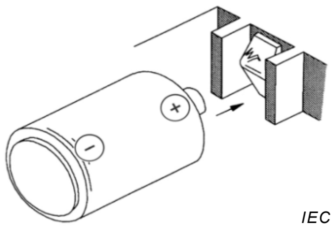


Figure B.2a – Correct insertion of the battery

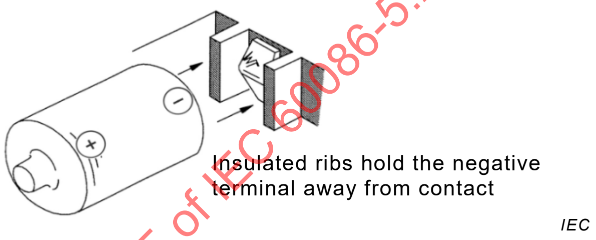


Figure B.2b – Incorrect insertion of the battery

Figure B.2 – Positive contact recessed between ribs

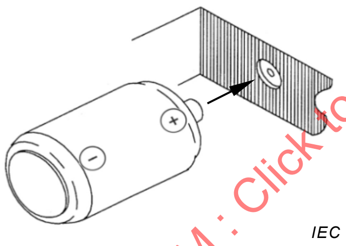


Figure B.3a – Correct insertion of the battery

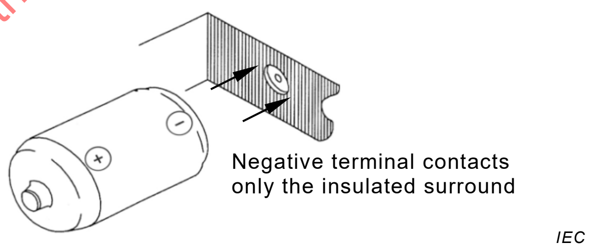


Figure B.3b – Incorrect insertion of the battery

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).

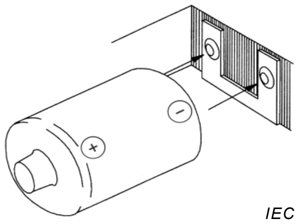


Figure B.4a – Correct insertion of the battery

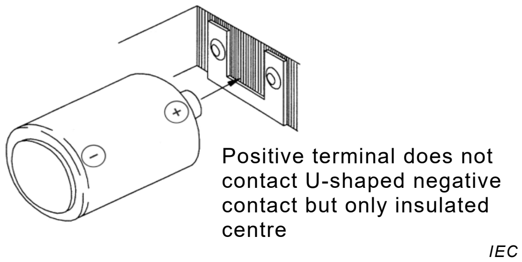


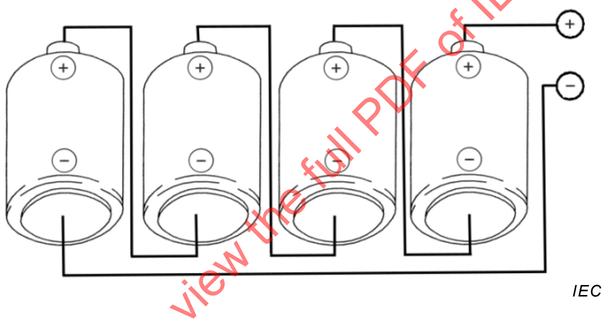
Figure B.4b – Incorrect insertion of the battery

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

B.3.4 Design with respect to battery orientation

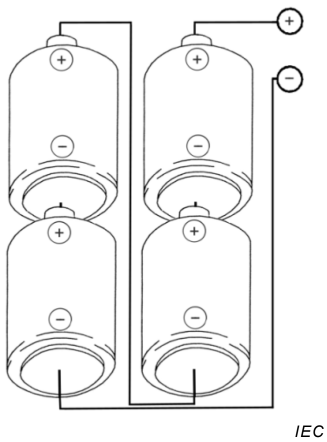
In order to avoid reverse insertion of batteries, it is recommended that all batteries have the same orientation. Examples are shown in Figures B.5a and B.5b.

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



NOTE Protection of the positive contact is as shown in Figures B.2 and B.3.

Figure B.5a – Preferred battery orientation



NOTE 1 Protection of the contacts is in Figures B.2 or B.3 for the positive and Figure B.4 for the negative contact.

NOTE 2 This arrangement (Figure B.5b) 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.5b – Alternative recommendation for battery orientation

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

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] (mm-minimum)	d_3[a] (mm-maximum)	h_3[a] (mm-minimum)	X mm	Y mm
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.

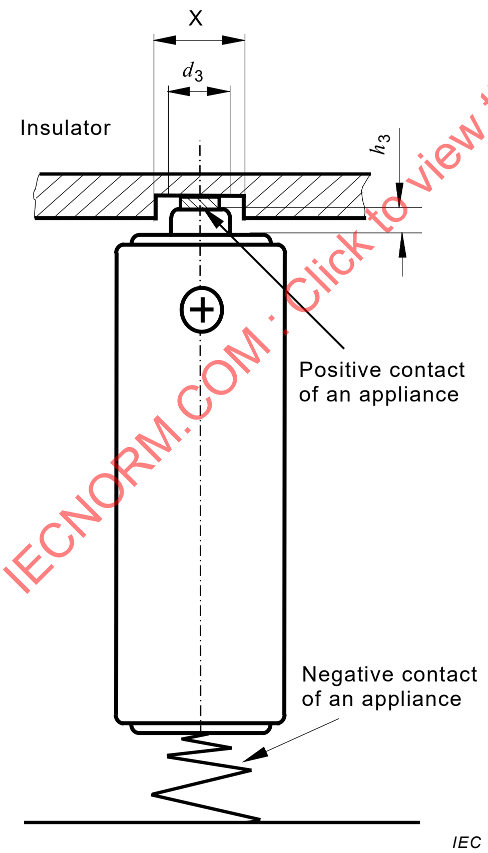


Figure B.6a – Correct insertion

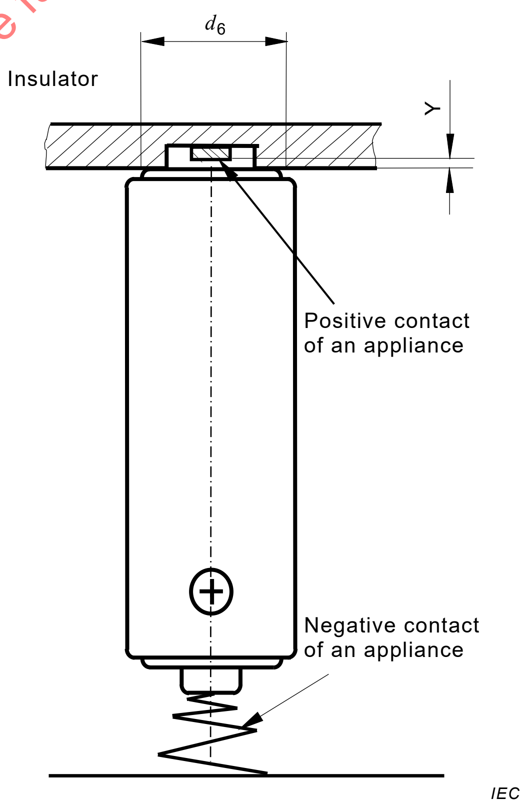


Figure B.6b – Incorrect insertion

NOTE Positive contact of an appliance is recessed within 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.6a is correct. In Figure B.6b 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.

The letter codes in Figure B.6 are as follows:

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;

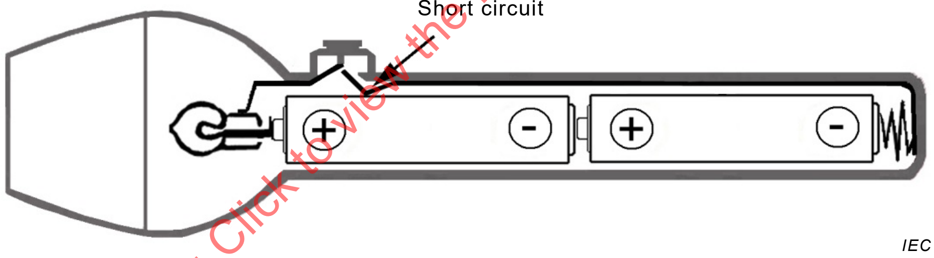
X Diameter of the recessed hole as a positive contact with the positive battery terminal. X should be bigger than d_3 but smaller than d_6;

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

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, 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.

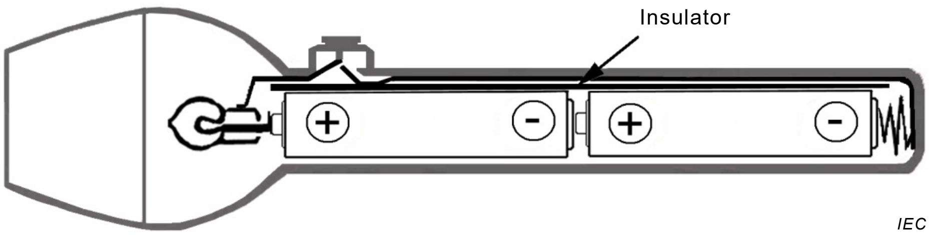


Figure B.8 – Typical example of insulation to prevent short circuit

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/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.

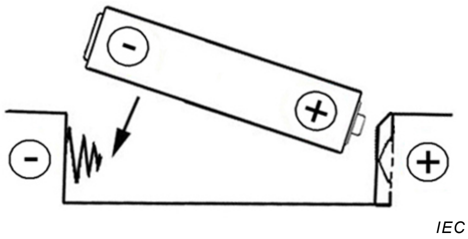


Figure B.9 – Insertion against spring (to be avoided)

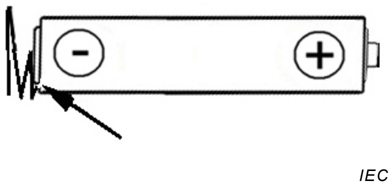


Figure B.10a – Spring slides underneath the jacket and contacts the metal can

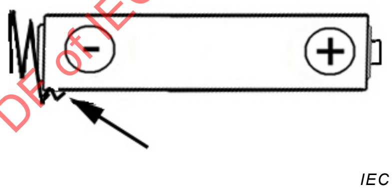


Figure B.10b – Jacket is punctured

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.

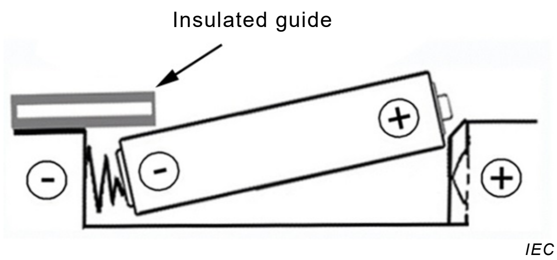


Figure B.11 – One example of protected insertion

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

Battery type		Minimum wire diameter mm
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 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/pip should be provided. This projection/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’/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).

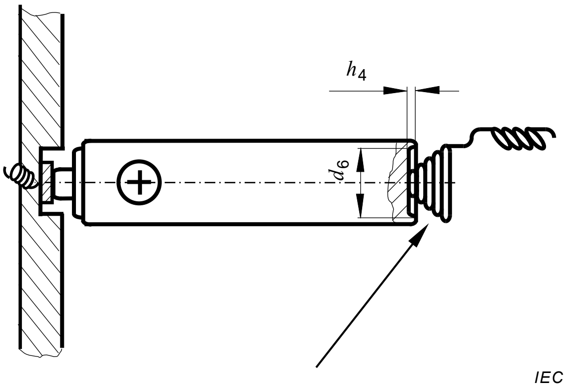


Figure B.12a – Spring coil

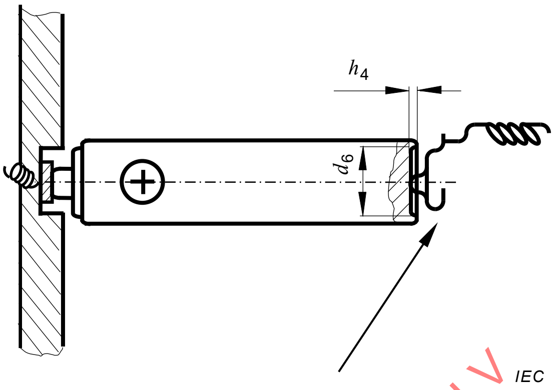


Figure B.12b – Plate spring contact

Figure B.12 – Example of negative contacts

Table B.3 – Dimensions of the negative battery terminal

Battery type	Maximum recessed dimension of negative battery terminal h_4 [a] mm	External diameter of the contact surface of negative battery terminal d_6 [a] mm
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] Reference 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/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 paragraph 7.1n)

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 minimise 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-depolarised 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 occur.

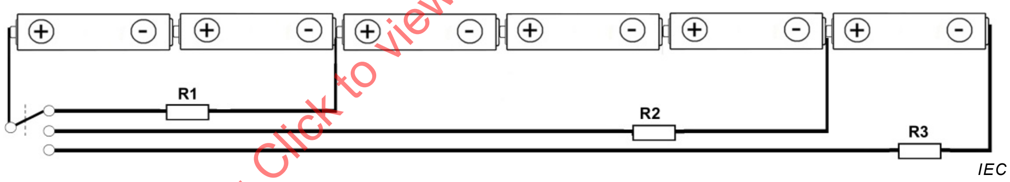


Figure B.13 – Example of series connection of batteries with voltage tapping

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

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

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

C.2 Pictograms

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

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

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

Table C.1 *(2 of 2)*

Reference	Pictogram	Cautionary advice
E	 NOTE Under consideration to replace pictogram E	KEEP OUT OF REACH OF CHILDREN NOTE See 7.1 l) for critical safety information
F		DO NOT MIX DIFFERENT TYPES OR BRANDS
G		DO NOT MIX NEW AND USED
H		DO NOT OPEN / 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 pictogram J should be blue and the circle and diagonal bar of the other pictograms should be red.

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

Bibliography

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

[2] 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*

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

SOMMAIRE

COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

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PILES ÉLECTRIQUES –

Partie 5: Sécurité des piles à électrolyte aqueux

AVANT-PROPOS

1) La Commission Electrotechnique Internationale (IEC) est une organisation mondiale de normalisation composée de l'ensemble des comités électrotechniques nationaux (Comités nationaux de l'IEC). L'IEC a pour objet de favoriser la coopération internationale pour toutes les questions de normalisation dans les domaines de l'électricité et de l'électronique. A cet effet, l'IEC – entre autres activités – publie des Normes internationales, des Spécifications techniques, des Rapports techniques, des Spécifications accessibles au public (PAS) et des Guides (ci-après dénommés "Publication(s) de l'IEC"). Leur élaboration est confiée à des comités d'études, aux travaux desquels tout Comité national intéressé par le sujet traité peut participer. Les organisations internationales, gouvernementales et non gouvernementales, en liaison avec l'IEC, participent également aux travaux. L'IEC collabore étroitement avec l'Organisation Internationale de Normalisation (ISO), selon des conditions fixées par accord entre les deux organisations.
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La Norme internationale IEC 60086-5 a été établie par le comité d'études 35 de l'IEC: Piles.

Cette quatrième édition annule et remplace la troisième édition parue en 2011. Cette édition constitue une révision technique.

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

a) La définition du terme explosion a été modifiée pour l'harmoniser avec les autres définitions de la série IEC 60086;
b) Empêcher l'élimination de l'hydrogène, la phrase a été révisée,
c) Empêcher les mauvais usages, la phrase sur les compartiments avec des piles connectées en parallèle a été révisée.
d) La méthode de détermination de la résistance d'isolement a été clarifiée.

Le texte de cette norme est issu des documents suivants:

FDIS	Rapport de vote
35/1360/FDIS	35/1361/RVD

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

Cette publication a été rédigée selon les Directives ISO/IEC, Partie 2.

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

Le comité a décidé que le contenu de cette publication ne sera pas modifié avant la date de stabilité indiquée sur le site web de l'IEC sous "http://webstore.iec.ch" dans les données relatives à la publication recherchée. A cette date, la publication sera

- reconduite,
- supprimée,
- remplacée par une édition révisée, ou
- amendée.

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 et elle a été établie conformément aux lignes directrices ISO/IEC en prenant en compte les normes nationales et internationales correspondantes. Cette norme donne également des lignes directrices 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 exister. Même au niveau le plus élevé de sécurité, le produit peut n'offrir qu'une sécurité relative. A cet égard, la prise de décision repose sur l'évaluation des risques et les jugements sur la sécurité.

Compte tenu des différents problèmes posés par la sécurité, il est impossible de fournir un ensemble de dispositions et de recommandations précises qui s'appliqueront à chaque cas. Cependant, la présente norme, si elle est suivie de manière judicieuse, c'est à dire en "l'utilisant lorsqu'elle est applicable", fournira 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 des essais et des exigences pour les piles à électrolyte aqueux pour assurer leur fonctionnement sûr dans des conditions d'utilisation prévue et de mauvais usage raisonnablement prévisible.

2 Références normatives

Les documents suivants sont cités en référence de manière normative, en intégralité ou en partie, dans le présent document et sont indispensables pour son application. 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, *Piles électriques – Partie 1: Généralités*

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

IEC 60068-2-6, *Essais d'environnement – Partie 2-6: Essais – Essai Fc: Vibrations (sinusoïdales)*

IEC 60068-2-27, *Essais d'environnement – Partie 2-27: Essais – Essai Ea et guide: Chocs*

IEC 60068-2-31, *Essais d'environnement – Partie 2-31: Essais – Essai Ec: Choc lié à des manutentions brutales, essai destiné en premier lieu aux matériels*

3 Termes et définitions

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

NOTE Certaines définitions de l'IEC 60050-482, de l'IEC 60086-1 et du Guide ISO/IEC 51 sont répétées ci-dessous par commodité.

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

3.2
bouton (élément ou pile)
petit élément ou petite pile de forme ronde dont la hauteur totale est inférieure au diamètre

Note 1 à l'article: Le terme anglais "button" (bouton) est utilisé uniquement pour les piles qui ne sont pas au lithium et le terme anglais "coin" (pièce de monnaie) est utilisé uniquement pour les piles au lithium. Dans les autres langues, le terme bouton est utilisé quel que soit le système électrochimique.

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]

3.4
élément composant
élément contenu dans une pile

3.5
(élément ou pile) 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, modifiée ("élément de forme cylindrique" remplacé par "élément rond ou pile ronde")]

3.6
explosion (explosion de pile)
ouverture d'un élément ou d'une pile avec éjection violente des composants solides

3.7
feu
émission de flammes provenant d'un élément ou d'une pile d'essai

3.8
utilisation prévue
utilisation conforme aux informations fournies avec un produit ou un système ou, en l'absence de telles informations, conforme aux schémas d'utilisation généralement reconnus

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

3.9
fuite
perte imprévue d'électrolyte provenant d'un élément ou d'une pile

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

3.10
tension nominale (d'une pile)
V_n
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 (ajout de "(d'une pile)" et du symbole V_n)]

3.11
pile
élément ou pile qui n'est pas conçu(e) pour être rechargé(e) électriquement

3.12
(élément ou 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 (suppression de "qualifie un")]

3.13
dispositifs 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

3.14
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: ISO/IEC Guide 51:1999, 3.14, modifié ("d'un procédé ou d'un service" remplacé par "ou d'un système" et suppression de la Note)]

3.15
(élément ou pile) rond(e)
élément ou pile de section circulaire

3.16
sécurité
absence de risque intolérable

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

3.17
non déchargé
état de charge d'une pile correspondant à une profondeur de décharge de 0 %

3.18
dégazage
dégagement de pression interne excessive d'un élément ou d'une pile de manière prévue par la conception pour empêcher une explosion

4 Exigences relatives à la sécurité

4.1 Conception

4.1.1 Généralités

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

4.1.2 Dégazage

Toutes les piles doivent incorporer une fonction de limitation de la pression, ou doivent être construites de manière à éviter une pression interne excessive, avec une valeur et un débit qui empêchent les explosions. Si l'encapsulation est nécessaire pour le maintien des éléments à l'intérieur d'un boîtier extérieur, le type d'encapsulant et la méthode d'encapsulation ne doivent pas provoquer la surchauffe de la pile en fonctionnement normal ni entraver 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, dans l'éventualité d'un dégazage d'un ou plusieurs éléments, le boîtier de la pile ne présente pas lui-même de danger.

4.1.3 Résistance d'isolement

La résistance d'isolement entre les surfaces métalliques de la pile exposées à l'extérieur, à l'exclusion des surfaces de contact électriques, et l'une des bornes ne doit pas être inférieure à 5 MΩ à 500 $V^{+100\,V}_{-0\,V}$ pendant au moins 60 secondes.

4.2 Plan de qualité

Le fabricant doit préparer et mettre en œuvre un plan de qualité définissant les procédures pour l'examen des matériaux, des composants, des éléments et des piles au cours de la fabrication, devant être appliquées au processus complet de production d'un type spécifique de pile. Il convient que les fabricants comprennent leurs capacités de processus et qu'ils engagent les contrôles de processus nécessaires dans la mesure où ils sont liés à la sécurité des produits.

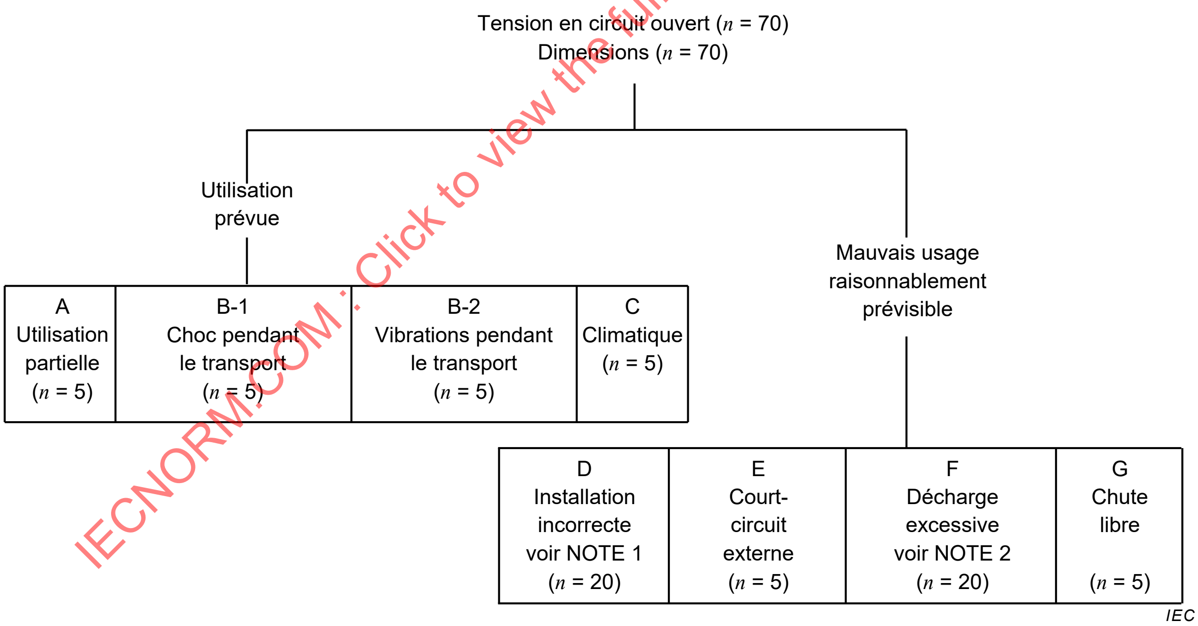
5 Echantillonnage

5.1 Généralités

Il convient de prélever des échantillons dans les lots de production conformément aux méthodes statistiques acceptées.

5.2 Echantillonnage pour l'homologation de type

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



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

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

Figure 1 – Echantillonnage pour essais d'homologation de type et nombre exigé de piles

6 Essais et exigences

6.1 Généralités

6.1.1 Essais de sécurité applicables

Les essais de sécurité applicables sont présentés au Tableau 1.

Les essais décrits aux Tableaux 2 et 6 sont destinés à simuler les conditions que la pile est susceptible de rencontrer au cours de l’utilisation prévue et du mauvais usage raisonnablement prévisible.

Tableau 1 – Matrice d’essai

Lettre du système	Électrode négative	Électrolyte	Électrode 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	Bioxyde 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	x	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	Bioxyde 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 (O2)	1,4	R	NR						
					B	NR	x	x	NR	x	NR	x
					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						

Description d'essai:

A: stockage après utilisation partielle
B-1: choc pendant le transport
B-2: vibrations pendant le transport.
C: cycles de température (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 (3.12)
M: multiélément

x: exigé
NR: Non exigé

Les éléments ou piles boutons des systèmes L et S d'une capacité de 250 mAh et les éléments ou piles boutons du système P d'une capacité de 700 mAh sont exemptés d'essai.

6.1.2 Mention d'avertissement

AVERTISSEMENT

Ces essais 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 estimé qu'ils seraient effectués par des techniciens qualifiés et expérimentés utilisant des protections adéquates.

6.1.3 Température ambiante

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

6.2 Utilisation prévue

6.2.1 Essais et exigences en utilisation prévue

Tableau 2 – Essais et exigences en 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 température (climatiques)	Aucun feu (NF) Aucune explosion (NE)

6.2.2 Procédures d'essais en utilisation prévue

6.2.2.1 Essai A – Stockage après utilisation partielle

a) Objet

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

b) Procédure d'essai

Une pile non déchargée est déchargée dans les conditions d'essai d'application/de service utile, avec l'essai de charge résistive la plus faible comme défini dans l'IEC 60086-2 jusqu'à ce que la durée de vie en service chute de 50 % de la valeur de la durée moyenne minimale (MAD), avec ensuite un stockage à 45 °C ± 5 °C pendant 30 jours.

c) Exigences

Il ne doit pas y avoir de fuite, de feu ou d'explosion pendant cet essai.

6.2.2.2 Essai B-1 – Choc pendant le transport

a) Objet

Cet essai simule la situation dans laquelle on laisse tomber par négligence un appareil avec les piles installées à l'intérieur. Cette condition d'essai est généralement spécifiée dans l'IEC 60068-2-27.

b) Procédure d’essai

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

L’essai de chocs doit être effectué dans les conditions définies dans le Tableau 3 et en suivant 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 = 9,80665 m/s^2.		

Tableau 4 – Séquence d'essai

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

[a] Le choc doit être appliqué dans chacune des trois directions perpendiculairement les unes par rapport aux autres.

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

Etape 2 à 4 Appliquer l'essai de chocs spécifié dans le Tableau 3 en suivant 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 pas y avoir de fuite, de feu ou d’explosion pendant cet essai.

6.2.2.3 Essai B-2 – Vibrations pendant le transport

a) Objet

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

b) Procédure d’essai

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

L’essai de vibration doit être effectué dans les conditions d’essai suivantes et en suivant l'ordre indiqué dans le Tableau 5.

Vibrations – Un mouvement harmonique simple doit être appliqué à la pile, l'amplitude étant de 0,8 mm, avec une excursion maximale totale de 1,6 mm. On doit faire varier la fréquence à un débit de 1 Hz/min entre les limites de 10 Hz et de 55 Hz. La plage entière de fréquences (10 Hz à 55 Hz) et retour (55 Hz à 10 Hz) doit être traversée en (90 min 5) min pour chaque position de montage (sens de vibrations).

Tableau 5 – Séquence d'essai

Étape	Durée de stockage	Orientation de la pile	Temps de vibration	Durées d'examen visuel
1	–	–	–	Avant essai
2	–	[a]	(90 ± 5) min chacun	–
3	–	[a]	(90 ± 5) min chacun	–
4	–	[a]	(90 ± 5) min chacun	–
5	1 h	–	–	–
6	–	–	–	Après essai

[a] Le choc doit être appliqué dans chacune des trois directions perpendiculairement les unes par rapport aux autres.

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

Etape 2 à 4 Appliquer la vibration spécifiée en 6.2.2.3 en suivant 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 pas y avoir de fuite, de feu ou d'explosion pendant cet essai.

6.2.2.4 Essai C – Cycles de température (climatiques)

a) Objet

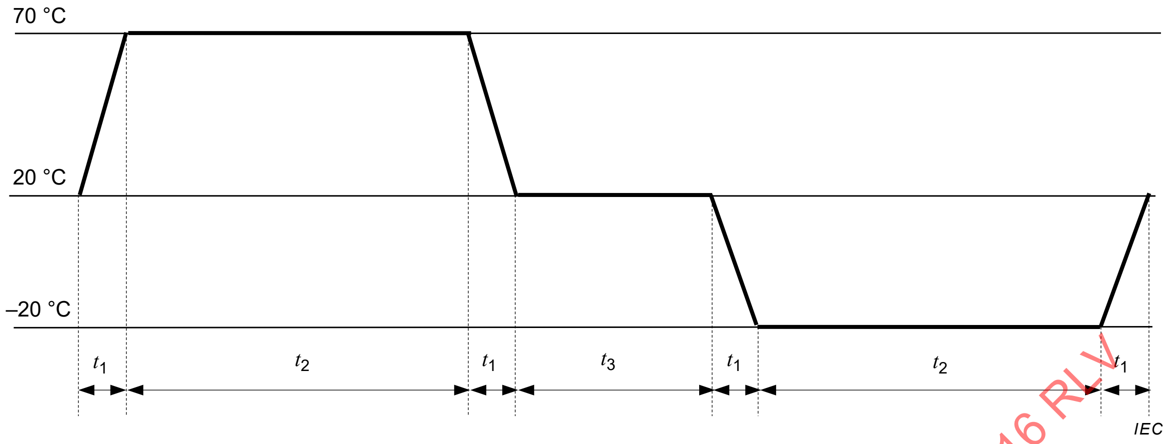
Cet essai évalue l'intégrité d'étanchéité de la pile, qui peut être affectée après les cycles de température.

b) Procédure d'essai

Une pile non déchargée doit être soumise aux essais dans le cadre de la procédure suivante.

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

1) Placer les piles dans une chambre d'essai et augmenter la température de la chambre pour atteindre 70 °C ± 5 °C en t_1 = 30 min.
2) Maintenir la chambre à cette température pendant t_2 = 4 h.
3) Faire baisser la température de la chambre pour atteindre 20 °C ± 5 °C en t_1 = 30 min et maintenir cette température pendant t_3 = 2 h.
4) Faire baisser la température de la chambre pour atteindre –20 °C ± 5 °C en t_1 = 30 min et maintenir cette température pendant t_2 = 4 h.
5) Augmenter la température de la chambre pour atteindre 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 sept jours avant examen.



t_1 = 30 min

t_2 = 4 h

t_3 = 2 h

Figure 2 – Procédure de cycles de températures

c) Exigences

Il ne doit pas y avoir de feu ou d'explosion pendant cet essai.

6.3 Mauvais usage raisonnablement prévisible

6.3.1 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)*
	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)
* Voir NOTE 2 de 6.3.2.1b)			

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

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

a) Objet

Cet essai simule les conditions dans lesquelles 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, dont une est inversée (B1) comme 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 soit revenue à la température ambiante.

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

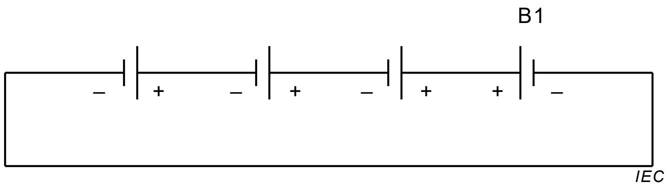


Figure 3 – Installation incorrecte (quatre piles en série)

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, une pile inversée à l'installation dans une série de trois ou plus est exposée à une condition de charge. Bien que les piles cylindriques soient conçues pour éviter une pression interne excessive, dans certains cas, il peut se produire une explosion.

c) Exigences

Il ne doit pas y avoir de feu ou d'explosion pendant cet essai (voir la NOTE 2 de 6.3.2.1b)).

6.3.2.2 Essai E – Court-circuit externe

a) Objet

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

b) Procédure d'essai

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

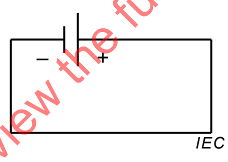


Figure 4 – Court-circuit externe

c) Exigences

Il ne doit pas y avoir de feu ou d'explosion pendant cet essai.

6.3.2.3 Essai F – Décharge excessive

a) Objet

Cet essai simule la condition où une (1) pile déchargée est connectée en série avec trois (3) autres piles non déchargées.

b) Procédure d'essai

Une pile non déchargée (C1) est déchargée dans les conditions d'essai d'application ou de service utile, avec la valeur MAD la plus élevée (exprimée en unités de temps), comme défini dans l'IEC 60086-2, jusqu'à ce que la tension en charge chute à ($n \times 0{,}6$ V) où n est le nombre d'éléments dans la pile. Ensuite, trois piles non déchargées et une pile déchargée (C1) de la même marque, du même type et de la même origine doivent être connectées en série comme représenté à la Figure 5. La décharge doit être poursuivie jusqu'à ce que la tension en charge totale chute à quatre fois (n × 0,6 V).

La valeur de la résistance (R1) doit être égale à environ quatre fois la valeur la plus faible 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 prescrite en 6.4 de l'IEC 60086-1:2015.

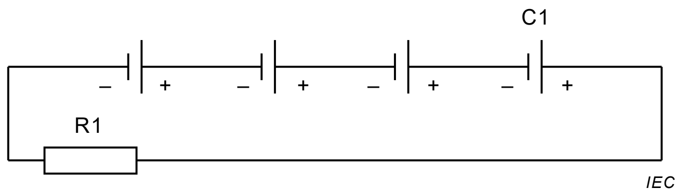


Figure 5 – Décharge excessive

c) Exigences

Il ne doit pas y avoir de feu ou d'explosion pendant cet essai.

6.3.2.4 Essai G – Essai de chute libre

a) Objet

Cet essai simule la situation dans laquelle on laisse tomber une pile accidentellement. La condition d'essai est fondée sur l'IEC 60068-2-31.

b) Procédure d'essai

Des piles d'essai non déchargées sont lâchées d'une hauteur de 1 m sur une surface en béton. Chaque pile d'essai est lâchée à six reprises, une pile parallélépipédique une fois sur chacune de ses six faces, 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.

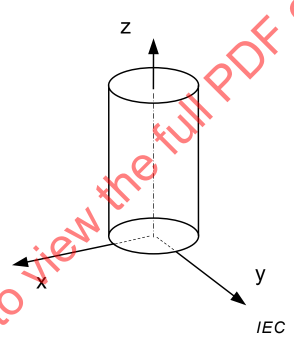


Figure 6 – Axes XYZ pour la chute libre

c) Exigences

Il ne doit pas y avoir de feu ou d'explosion pendant cet essai.

7 Informations relatives à la sécurité

7.1 Précautions au cours de la manipulation des piles

Si 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 peuvent entraîner des fuites ou, dans des cas extrêmes, des explosions et/ou un incendie.

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

Les piles qui sont placées de manière incorrecte dans l'appareil peuvent être court-circuitées, ou chargées. Cela peut donner lieu à un échauffement rapide provoquant des dégazages, des fuites, des explosions et des dommages corporels.

b) Ne pas court-circuiter les piles

Si les bornes positive (+) et négative (-) d'une pile sont en contact électrique entre elles, la pile subit un court-circuit. Par exemple des piles en vrac dans une poche ou dans un sac à main contenant des clés ou des pièces de monnaie peuvent être court-circuitées.