IEC 60086-1

Edition 13.0 2021-04
REDLINE VERSION

INTERNATIONAL STANDARD

colour inside

Primary batteries –
Part 1: General

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INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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PRIMARY BATTERIES –

Part 1: General

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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This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition IEC 60086-1:2015. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

International Standard IEC 60086-1 has been prepared by IEC technical committee 35: Primary cells and batteries.

This thirteenth edition cancels and replaces the twelfth edition published in 2015. This edition constitutes a technical revision.

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

a) a compliance checklist was added as an Annex H;
b) definitions were harmonized with the other 60086 series documents;
c) the nominal voltage of the zinc air system is now listed as either 1,4 V or 1,45 V;
d) Annex F for calculation of MAD values was simplified;
e) a validity period for testing was added;
f) the accelerated aging test at 45 °C was changed from 13 to 4 weeks;

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

FDIS	Report on voting
35/1465/FDIS	35/1469/RVD

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

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

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

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

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

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

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 document using a colour printer.

INTRODUCTION

The technical content of this part of IEC 60086 provides fundamental requirements and information on primary cells and batteries. All batteries within the IEC 60086 series are considered dry cell batteries. In this sense, IEC 60086-1 is the main component of the IEC 60086 series and forms the basis for the subsequent parts. For example, this part includes elementary information on definitions, nomenclature, dimensions and marking. While specific requirements are included, the content of this part tends to explain methodology (how) and justification (why).

Over the years, this part has been changed to improve its content and remains under continual scrutiny to ensure that the publication is kept up to date with the advances in both battery and battery-powered device technologies.

~~NOTE~~ Safety ~~information is~~ requirements and recommendations are available in IEC 60086-4, IEC 60086-5 and IEC 62281. Specifications are available in IEC 60086-2 and IEC 60086-3. Environmental aspects are dealt with in IEC 60086-6.

PRIMARY BATTERIES –

Part 1: General

1 Scope

This part of IEC 60086 is intended to standardize primary batteries with respect to dimensions, nomenclature, terminal configurations, markings, test methods, typical performance, safety and environmental aspects.

~~As a primary battery classification tool, electrochemical systems are also standardized with respect to system letter, electrodes, electrolyte, nominal and maximum open circuit voltage.~~

~~NOTE The requirements justifying the inclusion or the ongoing retention of batteries in the IEC 60086 series are given in Annex A.~~

This document on one side specifies requirements for primary cells and batteries. On the other side, this document also specifies procedures of how requirements for these batteries are to be standardised.

As a classification tool for primary batteries, this document specifies system letters, electrodes, electrolytes, and nominal as well as maximum open circuit voltage of electrochemical systems.

The object of this part of IEC 60086 is to benefit primary battery users, device designers and battery manufacturers by ensuring that batteries from different manufacturers are interchangeable according to standard form, fit and function. Furthermore, to ensure compliance with the above, this part specifies standard test methods for testing primary cells and batteries.

This document also contains requirements in Annex A justifying the inclusion or the ongoing retention of batteries in the IEC 60086 series.

2 Normative references

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

IEC 60086-2:2015~~–1~~, *Primary batteries – Part 2: Physical and electrical specifications*

IEC 60086-3~~:2011~~, *Primary batteries – Part 3: Watch batteries*

IEC 60086-4~~:2014~~, *Primary batteries – Part 4: Safety of lithium batteries*

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

~~1 To be published.~~

3 Terms and definitions

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

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

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

3.1
application test
simulation of the actual use of a battery in a specific application

3.2
battery
one or more cells electrically connected and fitted in a case, with terminals, markings and protective devices etc., as necessary for use

[SOURCE:IEC 60050-482:2004, 482-01-04, modified – removal of "fitted with devices necessary for use.]

3.3
button (cell or battery)
small round cell or battery where the overall height is less than the diameter, containing aqueous electrolyte

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

[SOURCE: IEC 60050-482:2004 482-02-40]

3.4
cell
basic functional unit, consisting of an assembly of electrodes, electrolyte, container, terminals and usually separators, that is a source of electric energy obtained by direct conversion of chemical energy

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

3.5
closed-circuit voltage
CCV
voltage across the terminals of a battery when it is on discharge

[SOURCE:IEC 60050-482:2004, 482-03-28, modified – "voltage between the terminals of a cell or battery" replaced by "voltage across the terminals of a battery".]

3.6
coin (cell or battery)
~~see button (cell or battery)~~
lithium button (cell or battery)
small round cell or battery where the overall height is less than the diameter, containing non-aqueous electrolyte

Note 1 to entry: The nominal voltage of lithium batteries is typically greater than 2 V.

Note 2 to entry: See button (cell or battery).

3.7
cylindrical (cell or battery)
round cell or battery in which the overall height is equal to or greater than the diameter

[SOURCE:IEC 60050-482: 2004, 482-02-39, modified – "cell with a cylindrical shape" replaced with "round cell or battery"]

3.8
discharge (of a primary battery)
operation during which a battery delivers current to an external circuit

3.9
dry (primary) **battery**
primary battery in which the liquid electrolyte is essentially immobilized

[SOURCE:IEC 60050-482:2004, 482-04-14, modified – replacement of "containing an immobilized electrolyte.]

~~**3.10**~~
~~**effective internal resistance – DC method**~~
~~the internal d.c. resistance of any electrochemical cell is defined by the following relation:~~

$$R_i\,(\Omega) = \frac{\Delta U\,(\mathrm{V})}{\Delta i\,(\mathrm{A})}$$

3.10
end-point voltage
EV
specified voltage of a battery at which the battery discharge is terminated

[SOURCE:IEC 60050-482:2004, 482-03-30]

3.11
leakage
unplanned escape of electrolyte, gas or other material from a cell or battery

Note 1 to entry: Leakage in this sense should not be confused with the test evaluation criteria for leakage specified in Clause 4 and Clause 5 of this document.

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

3.12
minimum average duration
MAD
minimum average time on discharge which is met by a sample of batteries

Note 1 to entry: The discharge test is carried out according to the specified methods or standards and designed to show conformity with the standard applicable to the battery types.

3.13
nominal voltage (of a primary battery)
~~V_n~~ U_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~~ U_n.]

3.14
open-circuit voltage
OCV
voltage across the terminals of a cell or battery when it is off discharge

3.15
primary (cell or battery)
cell or battery that is not designed to be electrically recharged

3.16
round (cell or battery)
cell or battery with circular cross section

3.17
service output (of a primary battery)
service life, or capacity, or energy output of a battery under specified conditions of discharge

3.18
service output test
test designed to measure the service output of a battery

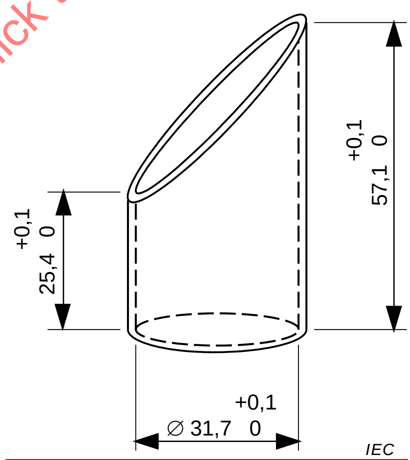
Note 1 to entry: A service output test may be prescribed, for example, when

a) an application test is too complex to replicate;

b) the duration of an application test would make it impractical for routine testing purposes.

~~**3.20**~~
~~**small battery**~~
~~cell or battery fitting entirely within the limits of the truncated cylinder as defined in Figure 1~~

~~*Inner dimensions in millimetres (mm)*~~



~~**Figure 1 – Ingestion gauge**~~

3.19
storage life
duration under specified conditions at the end of which a battery retains its ability to perform a specified service output

[SOURCE:IEC 60050-482:2004, 482-03-47, modified – "function" replaced by "service output".]

3.20
terminals (of a primary battery)
conductive parts of a battery that provide connection to an external circuit

4 Requirements

4.1 General

4.1.1 Design

Primary batteries are sold mainly in consumer markets. In recent years, they have become more sophisticated in both chemistry and construction, for example both capacity and rate capability have increased to meet the growing demands from new, battery-powered equipment technology.

When designing primary batteries, the aforementioned considerations shall be taken into account. Specifically, their dimensional conformity and stability, their physical and electrical performance and their safe operation under normal use and foreseeable misuse conditions shall be assured.

Additional information on equipment design can be found in Annex B.

4.1.2 Battery dimensions

The dimensions for individual types of batteries are given in IEC 60086-2 and IEC 60086-3.

4.1.3 Terminals

4.1.3.1 General

Terminals shall be in accordance with Clause 6 of IEC 60086-2:2015.

Their physical shape shall be designed in such a way that they ensure that the batteries make and maintain good electrical contact at all times.

They shall be made of materials that provide good electrical conductivity and resistance to corrosion.

4.1.3.2 Contact pressure resistance

Where stated in the battery specification tables or the individual specification sheets in IEC 60086-2, the following applies:

– a force of 10 N applied through a steel ball of 1 mm diameter at the centre of each contact area for a period of 10 s shall not cause any apparent deformation which might prevent satisfactory operation of the battery.

NOTE See also IEC 60086-3 for exceptions.

4.1.3.3 Cap and base

This type of terminal is used for batteries which have their dimensions specified according to Figures 1 to 7 of IEC 60086-2:2015 and which have the cylindrical side of the battery insulated from the terminals.

4.1.3.4 Cap and case

This type of terminal is used for batteries which have their dimensions specified according to Figures 8, 9, 10, 14, 15 and 16 of IEC 60086-2:2015, but in which the cylindrical side of the battery forms part of the positive terminal.

4.1.3.5 Screw terminals

This contact consists of a threaded rod in combination with either a metal or insulated metal nut.

4.1.3.6 Flat contacts

These are essentially flat metal surfaces adapted to make electrical contact by suitable contact mechanisms bearing against them.

4.1.3.7 Flat or spiral springs

These contacts comprise flat metal strips or spirally wound wires which are in a form that provides pressure contact.

4.1.3.8 Plug-in-sockets

These are made up of a suitable assembly of metal contacts, mounted in an insulated housing or holding device and adapted to receive the corresponding pins of a mating plug.

4.1.3.9 Snap fasteners

4.1.3.9.1 General

These contacts are composed of a combination comprising a stud (non-resilient) for the positive terminal and a socket (resilient) for the negative terminal.

They shall be of suitable metal so as to provide efficient electrical connection when joined to the corresponding parts of an external circuit.

4.1.3.9.2 Snap fastener

This type of terminal consists of a stud for the positive terminal and a socket for the negative terminal. These shall be made from nickel plated steel or other suitable material. They shall be designed to provide a secure physical and electrical connection, when fitted with similar corresponding parts for connection to an electrical circuit.

4.1.3.10 Wire

Wire leads may be single or multi-strand flexible insulated tinned copper. The positive terminal wire covering shall be red and the negative black.

4.1.3.11 Other spring contacts or clips

These contacts are generally used on batteries when the corresponding parts of the external circuit are not precisely known. They shall be of spring brass or of other material having similar properties.

4.1.4 Classification (electrochemical system)

Primary batteries are classified according to their electrochemical system.

Each system, with the exception of the zinc-ammonium chloride, zinc chloride-manganese dioxide system, has been allocated a letter denoting the particular system.

The electrochemical systems that have been standardized up to now are given in Table 1.

Table 1 – Standardized electrochemical systems

Letter	Negative electrode	Electrolyte	Positive electrode	Nominal voltage V	Maximum open circuit voltage V
No letter	Zinc (Zn)	Ammonium chloride, zinc chloride	Manganese dioxide (MnO_2)	1,5	1,73
A	Zinc (Zn)	Ammonium chloride, zinc chloride	Oxygen (O_2)	1,4	1,55
B	Lithium (Li)	Organic electrolyte	Carbon monofluoride $(CF)_x$	3,0	3,7
C	Lithium (Li)	Organic electrolyte	Manganese dioxide (MnO_2)	3,0	3,7
E	Lithium (Li)	Non-aqueous inorganic	Thionyl chloride ($SOCl_2$)	3,6	3,9
F	Lithium (Li)	Organic electrolyte	Iron disulfide (FeS_2)	1,5	1,83
G	Lithium (Li)	Organic electrolyte	Copper (II) oxide (CuO)	1,5	2,3
L	Zinc (Zn)	Alkali metal hydroxide	Manganese dioxide (MnO_2)	1,5	1,68
P	Zinc (Zn)	Alkali metal hydroxide	Oxygen (O_2)	1,4 or 1,45	1,59
S	Zinc (Zn)	Alkali metal hydroxide	Silver oxide (Ag_2O)	1,55	1,63
W	Lithium (Li)	Organic electrolyte	Sulphur dioxide (SO_2)	3,0	3,05
Y	Lithium (Li)	Non-aqueous inorganic	Sulfuryl chloride (SO_2Cl_2)	3,9	4,1
Z	Zinc (Zn)	Alkali metal hydroxide	Nickel oxyhydroxide (NiOOH)	1,5	1,78

NOTE 1 The value of the nominal voltage is not verifiable; therefore it is only given as a reference.

NOTE 2 The maximum open-circuit voltage (3.14) is measured as defined in 5.5 and 6.8.1.

NOTE 3 When referring to an electrochemical system, common protocol is to list negative electrode first, followed by positive electrode, i.e. lithium-iron disulfide.

NOTE 4 Reference to the electrochemical systems of this table usually appears in a simplified form such as, for example, "B and C system batteries" or "batteries of the no letter system".

4.1.5 Designation

The designation of primary batteries is based on their physical parameters, their electrochemical system as well as modifiers, if needed.

A comprehensive explanation of the designation system (nomenclature) can be found in Annex C.

4.1.6 Marking

4.1.6.1 General ~~(see Table 2)~~

For an overview of marking requirements refer to Table 2. With the exception of ~~small~~ batteries too small to mark with all items (see 4.1.6.2), 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 Examples of the common designations can be found in Annex D of IEC 60086-2:2015.

4.1.6.2 Marking of smaller batteries (see Table 2)

a) Batteries designated in the IEC as small Some batteries, mainly category 3 and category 4 batteries, have a surface too small to accommodate all markings shown in 4.1.6.1. For these batteries the designation 4.1.6.1a) and the polarity 4.1.6.1c) shall be marked on the battery. All other markings shown in 4.1.6.1 may be given on the immediate packing instead of on the battery.

b) For P-system batteries, 4.1.6.1a) may be on the battery, the sealing tab or the package. 4.1.6.1c) may be marked on the sealing tab and/or on the battery. 4.1.6.1b), 4.1.6.1d) and 4.1.6.1e) may be given on the immediate packing instead of on the battery. The nominal voltage may be marked either 1,4 V or 1,45 V.

c) Caution for ingestion of swallowable batteries shall be given. Refer to current valid versions of IEC 60086-4:2014 (7.2 a) and 9.2) and IEC 60086-5:2011 (7.1 l) and 9.2) for details.

Table 2 – Marking requirements

Marking	Batteries with the exception of small batteries too small to accommodate all markings	Small batteries Batteries too small to accommodate all markings	
			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]

Key

A: shall be marked on the battery

B: may be marked on the immediate packing instead of 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 IEC 60086-4:2014 (7.2a) and 9.2) and IEC 60086-5:2011 (7.1l) and 9.2) for details.

4.1.6.3 Marking of batteries regarding method of disposal

Marking of batteries with respect to the method of disposal shall be in accordance with local legal requirements.

4.1.7 Interchangeability: battery voltage

Primary batteries as presently standardized in the IEC 60086 series can be categorized by their standard discharge voltage U_s[2]. For a new battery system, its interchangeability by voltage is assessed for compliance with the following Formula (1):

$$n \times 0,85\ U_r \leq m \times U_s \leq n \times 1,15\ U_r$$

$$n \times 0,85\ U_r \leq m \leq U_s \leq n \times 1,15\ U_r \quad (1)$$

where

n is the number of cells connected in series, based on reference voltage U_r;

m is the number of cells connected in series, based on standard discharge voltage U_s;

U_r is the reference voltage;

U_s is the standard discharge voltage.

Currently, two voltage ranges that conform to the above formula have been identified. They are identified by reference voltage U_r, which is the midpoint of the relevant voltage range.

Voltage range 1, U_r = 1,40 V: Batteries having a standard discharge voltage $m \times U_s$ equal to or within the range of $n \times$ 1,19 V to $n \times$ 1,61 V.

Voltage range 2, U_r = 3,20 V: Batteries having a standard discharge voltage $m \times U_s$ equal to or within the range of $n \times$ 2,72 V to $n \times$ 3,68 V.

The term Details on the standard discharge voltage and related quantities, as well as the methods of their determination, are given in Annex D.

NOTE For single-cell batteries and for multi-cell batteries assembled with cells of the same voltage range, m and n will be identical; m and n will be different for multi-cell batteries if assembled with cells from a different voltage range than those of an already standardized battery.

Voltage range 1 encompasses all presently standardized batteries with a nominal voltage of 1,5 V, i.e. "no-letter" system, systems A, F, G, L, P, S and Z.

Voltage range 2 encompasses all presently standardized batteries with a nominal voltage of 3 V, i.e. systems B, C, E, W and Y.

Because batteries from voltage range 1 and voltage range 2 show significantly different discharge voltages, they shall be designed to be physically non-interchangeable. Before standardizing a new electrochemical system, its standard discharge voltage shall be determined in accordance with the procedure given in Annex D to resolve its interchangeability by voltage.

WARNING Failure to comply with this requirement can present safety hazards to the user, such as fire, explosion, leakage and/or device damage. This requirement is necessary for safety and operational reasons.

[2] The standard discharge voltage U_s was introduced to comply with the principle of experimental verifiability. Neither the nominal voltage nor the maximum off-load voltage complies with this requirement.

4.2 Performance

4.2.1 Discharge performance

Discharge performance of primary batteries is specified in IEC 60086-2.

4.2.2 Dimensional stability

The dimensions of batteries shall conform to the relevant specified dimensions as given in IEC 60086-2 and IEC 60086-3 at all times during discharge testing under the standard conditions given in this specification.

NOTE 1 An increase in battery height of 0,25 mm can occur with button and coin cells of the B, C, G, L, P and S systems, if discharged below end-point voltage.

NOTE 2 For certain button cells (coin cells) of the C and B systems, a decrease in battery height may occur as discharge continues.

As information for battery compartment manufacturers, for certain coin cells of the C and B systems, a decrease in battery height can occur if discharged below end-point voltage.

4.2.3 Leakage

When batteries are stored and discharged under the standard conditions given in this document, no leakage shall occur.

4.2.4 Open-circuit voltage limits

The maximum open-circuit voltage of batteries shall not exceed the values given in Table 1.

4.2.5 Service output

Discharge durations, initial and delayed, of batteries shall meet the requirements given in IEC 60086-2.

4.2.6 Safety

When designing primary batteries, safety under conditions of intended use and foreseeable misuse as prescribed in IEC 60086-4 and IEC 60086-5 shall be considered.

4.2.7 Validity of testing

Portable primary batteries shall be subjected to the tests, as required in the 60086 series. Test results remain valid until a design change or requirement revision has been made. Retesting is required when:

a) a battery specification changes by more than 0,1 g or 20 % mass, whichever is greater, for the cathode, anode or electrolyte;
b) a battery specification changes that would lead to a failure of any of the tests;
c) there is an addition of new tests or requirements; or
d) there is a requirement change that would lead to a failure on any of the tests.

5 Performance – Testing

5.1 General Capacity testing versus application and service output testing

For the preparation of standard methods of measuring performance (SMMP) of consumer goods, refer to Annex E.

A capacity of a primary battery may be established by electrical discharge tests as detailed in D.2.3. However, under consumer usage conditions, the capacities realised from electrical discharge test methods can vary.

The following factors/variables dramatically impact on optimum capacity realisation.

a) The current demand from the external electrical circuit/device.

b) The frequency of current demand (continuous or intermittent usage).

c) The minimum voltage at which the device will satisfactorily operate (cut off voltage).

d) The temperature of operation.

From the variables listed in a) to d), high current demand for prolonged periods coupled with a high cut off voltage and low temperature represents the worst case conditions resulting in significant capacity loss.

Because the electrically or chemically derived capacity of a primary battery cannot be reliably used in any calculation of ultimate battery performance it is nevertheless essential to convey to the user some idea of battery performance/life when used in typical battery powered devices. It should however be noted that such designated 'application tests' (defined in 60086-2) may not entirely replicate a device/application there being many variations, each with differing electrical requirements in the marketplace. Furthermore battery performance may be further affected by one or more of the conditions in a) to d) above.

~~The following~~ Annex E has therefore been derived from ISO/IEC Guide 36:1982 (now withdrawn).

5.2 Discharge testing

5.2.1 General

The discharge tests in this document fall into two categories:

– application tests;

– service output tests.

In both categories of tests, discharge loads are specified in accordance with 6.4.

The test methods of determining the load and test conditions are as given in 5.2.2 and 5.2.3.

5.2.2 Application tests

5.2.2.1 General

a) The equivalent resistance is calculated from the average current and average operating voltage of the equipment under load. Constant current or constant power loads are also permitted for applications exhibiting these types of power demand patterns.

b) The functional end-point voltage and the equivalent resistance load, current load, or constant power values are obtained from typical application equipment measurements.

c) The median class defines the load value and the end-point voltage to be used for the discharge test.

d) If the data are concentrated in two or more widely separated groups, more than one test may be required.

Application tests may be accelerated by discharge load, daily period duty cycle, or both. The specified values for load and time intermittency should take the following factors into consideration:

– discharge efficiency of the battery relative to the application,

– typical duty cycle use patterns for the application,
– total time to conduct the test typically not to exceed 30 days.

Some fixed resistance tests have been chosen to permit simplicity of design and ensure reliability of the test equipment, despite the fact that, in specific instances, constant current or constant wattage tests may be a better representation of the application.

In the future, alternative or additional load conditions may be necessary to effectively represent the range of applications in use. It is likely that the load characteristics of a particular category of equipment will change with time in a developing technology.

The precise determination of the functional end-point voltage of the equipment is not always possible. The discharge conditions are at best a compromise selected to represent a category of equipment which may have widely divergent characteristics.

Nevertheless, in spite of these limitations, the derived application test is the best approach known for the estimation of battery capability for a particular category of equipment.

NOTE In order to minimize the proliferation of application tests, the tests specified should target ~~to be~~ those appliances accounting for 80 % of the market by battery designation.

5.2.2.2 Application tests with multiple loads

For application tests with multiple loads, the load order during a cycle shall start with the heaviest load and move to the lightest load unless otherwise specified.

5.2.3 Service output tests

For service output tests, the value of the load resistor should be selected such that the service output approximates 30 days.

When full capacity is not realized within the required time scale, the service output may be extended to the shortest suitable duration thereafter by selecting a discharge load of ~~higher~~ lower ohmic value, as defined in 6.4.

5.3 Conformance check to a specified minimum average duration

In order to check the conformance of a battery to any discharge test specified in IEC 60086-2 and 60086-3, the test shall be carried out as follows:

a) Test eight batteries.
b) Calculate the average without the exclusion of any result.
c) If this average is equal to or greater than the specified figure and no more than one battery has a service output of less than 80 % of the specified figure, the batteries are considered to conform to service output.
d) If this average is less than the specified figure and/or more than one battery has a service output of less than 80 % of the specified figure, repeat the test on another sample of eight batteries and calculate the average as previously.
e) If the average of this second test is equal to or greater than the specified figure and no more than one battery has a service output of less than 80 % of the specified figure, the batteries are considered to conform to service output.
f) If the average of the second test is less than the specified figure and/or more than one battery has a service output of less than 80 % of the specified figure, the batteries are considered not to conform and no further testing is permitted.
g) For the purposes of verifying compliance with this document, conditional acceptance ~~may~~ shall be given after completion of the initial discharge tests.

NOTE Discharge performance of primary batteries is specified in IEC 60086-2.

5.4 ~~Calculation method of the specified~~ Guidance for considering proposed value of ~~a~~ minimum average duration

This ~~method~~ guidance is described in Annex F.

5.5 OCV testing

Open-circuit voltage shall be measured with the voltage measuring equipment specified in 6.8.1.

5.6 Insulation resistance

For batteries with insulating labels, cases or jackets, the resistance between externally exposed surfaces of the battery and either terminal shall be equal to or greater than 5 MΩ at $500^{+100}_{\ 0}$ V, applied for up to 60 s.

5.7 Battery dimensions

Dimensions shall be measured with the measuring equipment specified in 6.8.2.

5.8 Leakage and deformation

After the service output has been determined under the specified environmental conditions, the discharge shall be continued in the same way until the closed circuit voltage drops for the first time below 40 % of the nominal voltage of the battery. The requirements of 4.1.3, 4.2.2 and 4.2.3 shall be met.

NOTE For ~~watch~~ button and coin batteries, the visual examination for leakage is carried out in accordance with ~~Clause 8~~ the respective clauses of IEC 60086-3~~:2011~~ and IEC 60086-5.

6 Performance – Test conditions

6.1 Storage and discharge conditions

Storage before discharge testing and the actual discharge test are carried out under well-defined conditions. Unless otherwise specified, the conditions given in Table 3 shall apply. Discharge conditions shown are further referred to as standard conditions.

Table 3 – Conditions for storage before and during discharge testing

~~Type of test~~	~~Storage conditions~~			~~Discharge conditions~~	
	~~Temperature °C~~	~~Relative humidity % RH~~	~~Duration~~	~~Temperature °C~~	~~Relative humidity[d] % RH~~
~~Initial discharge test~~	~~20 ± 2 [a]~~	~~55 ± 20~~	~~60 days maximum after date of manufacture~~	~~20 ± 2~~	~~55 +20 / -40~~
~~Delayed discharge test~~	~~20 ± 2 [a]~~	~~55 ± 20~~	~~12 months~~	~~20 ± 2~~	~~55 +20 / -40~~
~~Delayed discharge test (high temperature) [b]~~	~~45 ± 2 [c]~~	~~55 ± 20~~	~~13 weeks~~	~~20 ± 2~~	~~55 +20 / -40~~

~~[a] During short periods the storage temperature may deviate from these limits without exceeding (20 ± 5) °C.~~

~~[b] This test is carried out when a storage test at high temperature is required. Performance requirements are the subject of agreement between the manufacturer and the customer.~~

~~[c] Batteries to be stored unpacked.~~

~~[d] Except "P" system: (55 ± 10) % RH.~~

Type of test	Storage conditions			Discharge conditions	
	Temperature °C	Relative humidity % RH	Duration	Temperature °C	Relative humidity[d] % RH
Initial discharge test	20 ± 5 [a]	55 + 20 / -40	60 days maximum after date of manufacture	20 ± 2	55 + 20 / -40
Delayed discharge test[e]	20 ± 5 [a]	55 + 20 / -40	12 months	20 ± 2	55 + 20 / -40
Delayed discharge test (high temperature) [b,e]	45 ± 2 [c]	55 ± 20	4 weeks	20 ± 2	55 + 20 / -40

a During short periods the storage temperature may deviate from these limits without exceeding (20 ± 10) °C.

b This test is carried out when a storage test at high temperature is required. Performance requirements are the subject of agreement between the manufacturer and the customer.

c Batteries to be stored unpacked.

d Except "P" and "A" system: (55 ± 10) % RH.

e The performance should meet or exceed the percentage of minimum average duration (MAD) value.

6.2 Commencement of discharge tests after storage

The period between the completion of storage and the start of a delayed discharge test shall not exceed 14 days.

During this period the batteries shall be kept at (20 ± 2) °C and (55 + 20 / −40) % RH (except for P-system batteries where the relative humidity shall be (55 ± 10) % RH).

At least one day in these conditions shall be allowed for normalization before starting a discharge test after storage at high temperature.

6.3 Discharge test conditions

6.3.1 General

In order to test a battery it shall be discharged as specified in IEC 60086-2 or IEC 60086-3 until the voltage on load drops for the first time below the specified end-point. The service output may be expressed as pulses, duration, capacity, or energy.

6.3.2 Compliance

When IEC 60086-2 or IEC 60086-3 specify service outputs for more than one discharge test, batteries shall meet all of these requirements in order to comply with this document.

6.4 Load resistance

The value of the resistive load (which includes all parts of the external circuit) shall be as specified in the relevant specification sheet and shall be accurate to ±0,5 %.

When formulating new tests, the resistive loads shall, whenever possible, be as shown in Table 4 together with their decimal multiples or sub-multiples.

Table 4 – Resistive loads for ~~new~~ tests

Values in ohms

1,00	1,10	1,20	1,30	1,50	1,60	1,80	2,00
2,20	2,40	2,70	3,00	3,30	3,60	3,90	4,30
4,70	5,10	5,60	6,20	6,80	7,50	8,20	9,10

6.5 Time periods

The periods on-discharge and off-discharge shall be as specified in IEC 60086-2.

When formulating new tests, whenever possible, one of the following daily periods should be adopted from Table 5.

Table 5 – Time periods for ~~new~~ tests

1 min	5 min	10 min	30 min	1 h
2 h	4 h	12 h	24 h (continuous)	—

Other cases are specified in IEC 60086-2, if necessary.

6.6 Test condition tolerances

Unless otherwise specified, the tolerances given in Table 6 shall apply.

Table 6 – Test condition tolerances

Test parameter	Tolerance	
Temperature	±2 °C	
Load	±0,5 %	
Voltage	±0,5 %	
Relative humidity	+20 / −40 % RH except “P” and “A” systems ±10 % RH	
Time ~~“accuracy”~~	**Discharge time t_d**	**Tolerance**
	$0 < t_d \le 2$ s	±5 % of t_d
	2 s $< t_d \le 100$ s	±0,1 s
	$t_d > 100$ s	±0,1 % of t_d

6.7 Activation of ‘P’-system batteries

A period of at least 10 min shall elapse between activation and the commencement of electrical measurement.

6.8 Measuring equipment

6.8.1 Voltage measurement

The accuracy of the measuring equipment shall be ≤ 0,25 % and the precision shall be ≤ 50 % of the value of the last significant digit. The internal resistance of the measuring instrument shall be ≥ 1 MΩ.

6.8.2 Mechanical measurement

The accuracy of the measuring equipment shall be ≤ 0,25 % and the precision shall be ≤ 50 % of the value of the last significant digit.

7 Sampling and quality assurance

The use of production and incoming inspection sampling plans or product quality indices should be agreed between the manufacturer and the purchaser.

Where no agreement is specified, refer to ISO 2859 and ~~ISO 21747~~ ISO 22514-2 for sampling and quality compliance assessment advice.

8 Battery packaging

A code of practice for battery packaging, shipment, storage, use and disposal can be found in Annex G.

Annex A
(normative)

Criteria for the standardization of batteries

Batteries and electrochemical systems shall meet the following requirements to justify their initial inclusion or ongoing retention in the IEC 60086 series:

a) The battery or batteries of this electrochemical system are in mass production.

b) The battery or batteries of this electrochemical system are available in several market places of the world.

c) ~~The battery is produced by at least two independent manufacturers, the patent holder(s) of which~~ Patent items shall conform to the requirements contained in 2.14 of the ISO/IEC Directives, Part 1:2019, Reference to patented items.

d) The battery is produced in at least two different countries or alternatively, if produced in only one country, the battery is purchased by other international and independent battery manufacturers and sold under their company label.

The items of Table A.1 shall be included in any new work proposal to standardize a new individual battery or electrochemical system.

Table A.1 – Items necessary to standardize

Individual battery	Electrochemical system
Conformance statement to items a) to d) above	Conformance statement to items a) and b) above
Designation and electrochemical system	Recommended designation letter
Dimensions (including drawings)	Negative electrode
Discharge conditions	Positive electrode
Minimum average duration(s)	Nominal voltage
	Maximum open circuit voltage
	Electrolyte

Annex B
(informative)

Recommendations for equipment design

B.1 Technical liaison

It is recommended that companies producing battery-powered equipment 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. The equipment should be permanently marked with the IEC designation, grade and size of battery which will give optimum performance.

B.2 Battery compartment

B.2.1 General

Design compartments so that batteries are easily inserted and do not fall out. The dimensions and design of compartments and contacts should be such that batteries complying with this document will be accepted. In particular, the equipment designer should not ignore the tolerances given in this document, even if a national standard or a battery manufacturer calls for smaller battery tolerances.

The design of the negative contact should make allowance for any recess of the battery terminal.

Clearly indicate the type of battery to use, the correct polarity alignment and directions for insertion.

Use the shape and/or the dimensions of the positive (+) and negative (−) battery terminals in compartment designs to prevent the reverse connection of batteries. Positive (+) and negative (−) battery contacts should be visibly different in form to avoid confusion when inserting batteries.

Battery compartments should be electrically insulated from the electric circuit and positioned so as to minimize possible damage and/or risk of injury. Only the battery terminals should physically contact the electric circuit. Care should be taken in the choice of materials and the design of contacts to ensure that effective electrical contact is made and maintained under conditions of use even with batteries at the extremes of dimensions permitted by this document. Battery and equipment terminals should be of compatible material and low electrical resistance.

For battery compartments with parallel connections ~~are not recommended since a wrongly placed battery will result in charging conditions~~, refer to IEC 60086-5.

Equipment designed to be powered by air-depolarized batteries of either the "A" or "P" system shall provide for adequate air access. For the "A" system, the battery should preferably be in an upright position during normal operation. For "P" system batteries conforming to Figure 9 of IEC 60086-2:2015, positive contact should be made on the side of the battery, so that air access is not impeded.

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

The battery compartment should be clearly and permanently marked to show the correct orientation of the batteries. One of the most common causes of dissatisfaction is the reversed placement of one battery in a set, which may result in battery leakage and/or explosion and/or fire. To minimize this hazard, battery compartments should be designed so that a reversed battery will result in no electrical circuit.

The associated circuitry should not make physical contact with any part of the battery except at the surfaces intended for this purpose.

Designers are strongly advised to refer to IEC 60086-4 and IEC 60086-5 for comprehensive safety considerations.

B.2.2 Limiting access by children

Apparatus should be designed to prevent children from removing the battery~~ by one of the following methods:~~.

~~A tool, such as a screwdriver or coin, is required to open the battery compartment; or~~

~~The battery compartment door/cover requires the application of a minimum of two independent and simultaneous movements of the securing mechanism to open by hand.~~

~~If screws or similar fasteners are used to secure the door/cover providing access to the battery compartment, the fasteners should be captive to ensure that they remain with the door/cover. This does not apply to side panel doors on larger devices which are necessary for the functioning of the equipment and which are not likely to be discarded or left off the equipment.~~

Refer to information for safety found in IEC 60086-4 and IEC 60086-5.

B.3 Voltage cut-off

In order to prevent leakage resulting from a battery being driven into reverse, the equipment voltage cut-off should not be below the battery manufacturer's recommendation.

Annex C
(normative)

Designation system (nomenclature)

C.1 General

The battery designation system (nomenclature) defines as unambiguously as possible the physical dimensions, shape, electrochemical system, nominal voltage and, where necessary, the type of terminals, rate capability and special characteristics.

This annex is divided into two clauses:

- Clause C.2 defines the designation system (nomenclature) in use up to October 1990.
- Clause C.3 defines the designation system (nomenclature) in use since October 1990 to accommodate present and future needs.

C.2 Designation system in use up to October 1990

C.2.1 General

This clause applies to all batteries which have been standardized up to October 1990 and will remain valid for those batteries after that date.

C.2.2 Cells

A cell is designated by a capital letter followed by a number. The letters R, F and S define round, flat (layer built) and square cells, respectively. The letter, together with the following number[3], is defined by a set of nominal dimensions.

Where a single-cell battery is specified, the maximum dimensions of the battery instead of the nominal dimensions of the cell are given in Table C.1, Table C.2 and Table C.3. Note that these tables do not include electrochemistries, except for the no letter system, or other modifiers. These other parts of the designation system (nomenclature) follow in C.2.3, C.2.4 and C.2.5. These tables only provide core physical designations for single cells or single batteries.

NOTE The complete dimensions of these batteries are given in IEC 60086-2 and IEC 60086-3.

3 At the time this system was applied, numbers were allocated sequentially. Omissions in the sequence arise because of deletions or by the different approach to numbering used even before the sequential system.

Table C.1 – Physical designation and dimensions of round cells and batteries

Dimensions in millimetres

Physical designation	Nominal cell dimensions		Maximum battery dimensions	
	Diameter	Height	Diameter	Height
R06	10	22	–	–
R03	–	–	10,5	44,5
R01	–	–	12,0	14,7
R0	11	19	–	–
R1	–	–	12,0	30,2
R3	13,5	25	–	–
R4	13,5	38	–	–
R6	–	–	14,5	50,5
R9	–	–	16,0	6,2
R10	–	–	21,8	37,3
R12	–	–	21,5	60,0
R14	–	–	26,2	50,0
R15	24	70	–	–
R17	25,5	17	–	–
R18	25,5	83	–	–
R19	32	17	–	–
R20	–	–	34,2	61,5
R22	32	75	–	–
R25	32	91	–	–
R26	32	105	–	–
R27	32	150	–	–
R40	–	–	67,0	172,0
R41	–	–	7,9	3,6
R42	–	–	11,6	3,6
R43	–	–	11,6	4,2
R44	–	–	11,6	5,4
R45	9,5	3,6	–	–
R48	–	–	7,9	5,4
R50	–	–	16,4	16,8
R51	16,5	50,0	–	–
R52	–	–	16,4	11,4
R53	–	–	23,2	6,1
R54	–	–	11,6	3,05
R55	–	–	11,6	2,1
R56	–	–	11,6	2,6
R57	–	–	9,5	2,7
R58	–	–	7,9	2,1
R59	–	–	7,9	2,6
R60	–	–	6,8	2,15
R61	7,8	39	–	–
R62	–	–	5,8	1,65
R63	–	–	5,8	2,15
R64	–	–	5,8	2,70
R65	–	–	6,8	1,65
R66	–	–	6,8	2,60
R67	–	–	7,9	1,65
R68	–	–	9,5	1,65
R69	–	–	9,5	2,10
R70	–	–	5,8	3,6
NOTE The complete dimensions of these batteries are given in IEC 60086-2 and IEC 60086-3.				

Table C.2 – Physical designation and nominal overall dimensions of flat cells

Dimensions in millimetres

Physical designation	Diameter	Length	Width	Thickness
F15	-	14,5	14,5	3,0
F16	-	14,5	14,5	4,5
F20	-	24	13,5	2,8
F22	-	24	13,5	6,0
F24	23	–	–	6,0
F25	-	23	23	6,0
F30	-	32	21	3,3
F40	-	32	21	5,3
F50	-	32	32	3,6
F70	-	43	43	5,6
F80	-	43	43	6,4
F90	-	43	43	7,9
F92	-	54	37	5,5
F95	-	54	38	7,9
F100	-	60	45	10,4
NOTE The complete dimensions of these batteries are given in IEC 60086-2.				

Table C.3 – Physical designation and dimensions of square cells and batteries

Dimensions in millimetres

Physical designation	Nominal cell dimensions			Maximum battery dimensions		
	Length	Width	Height	Length	Width	Height
S4	–	–	–	57,0	57,0	125,0
S6	57	57	150	–	–	–
S8	–	–	–	85,0	85,0	200,0
S10	95	95	180	–	–	–
NOTE The complete dimensions of these batteries are given in IEC 60086-2.						

In some cases, cell sizes which are not used in IEC 60086-2 have been retained in these tables because of their use in national standards.

C.2.3 Electrochemical system

With the exception of the zinc-ammonium chloride, zinc chloride-manganese dioxide system, the letters R, F and S are preceded by an additional letter which denotes the electrochemical system. These letters can be found in Table 1.

C.2.4 Batteries

If a battery contains one cell only, the cell designation is used.

If a battery contains more than one cell in series, a numeral denoting the number of cells precedes the cell designation.

If cells are connected in parallel, a numeral denoting the number of parallel groups follows the cell designation and is connected to it by a hyphen.

If a battery contains more than one section, each section is designated separately, with a slash (/) separating their designation.

C.2.5 Modifiers

In order to preserve the unambiguity of the battery designation, variants of one basic type are differentiated by the addition of a letter X or Y to indicate the different arrangements or terminals and P or S to indicate different performance characteristics.

C.2.6 Examples

R20	A battery consisting of a single R20-size cell of the zinc-ammonium chloride, zinc chloride-manganese dioxide system.
LR20	A battery consisting of a single R20-size cell of the zinc-alkali metal hydroxide-manganese dioxide system.
3R12	A battery consisting of three R12-size cells of the zinc-ammonium chloride, zinc chloride-manganese dioxide system, connected in series.
4R25X	A battery consisting of four R25-size cells of the zinc-ammonium chloride, zinc chloride-manganese dioxide system, connected in series and with spiral spring contacts.

C.3 Designation system in use since October 1990

C.3.1 General

This clause applies to all new sizes considered for standardization after October 1990.

The basis for this designation system (nomenclature) is to convey a mental concept of the battery through the designation system. This is accomplished by using a diameter, from a cylindrical envelope, and a height related concept for all batteries, round (R) and non-round (P).

This clause also applies to single-cell batteries and multi-cell batteries with cells in series and/or parallel connection.

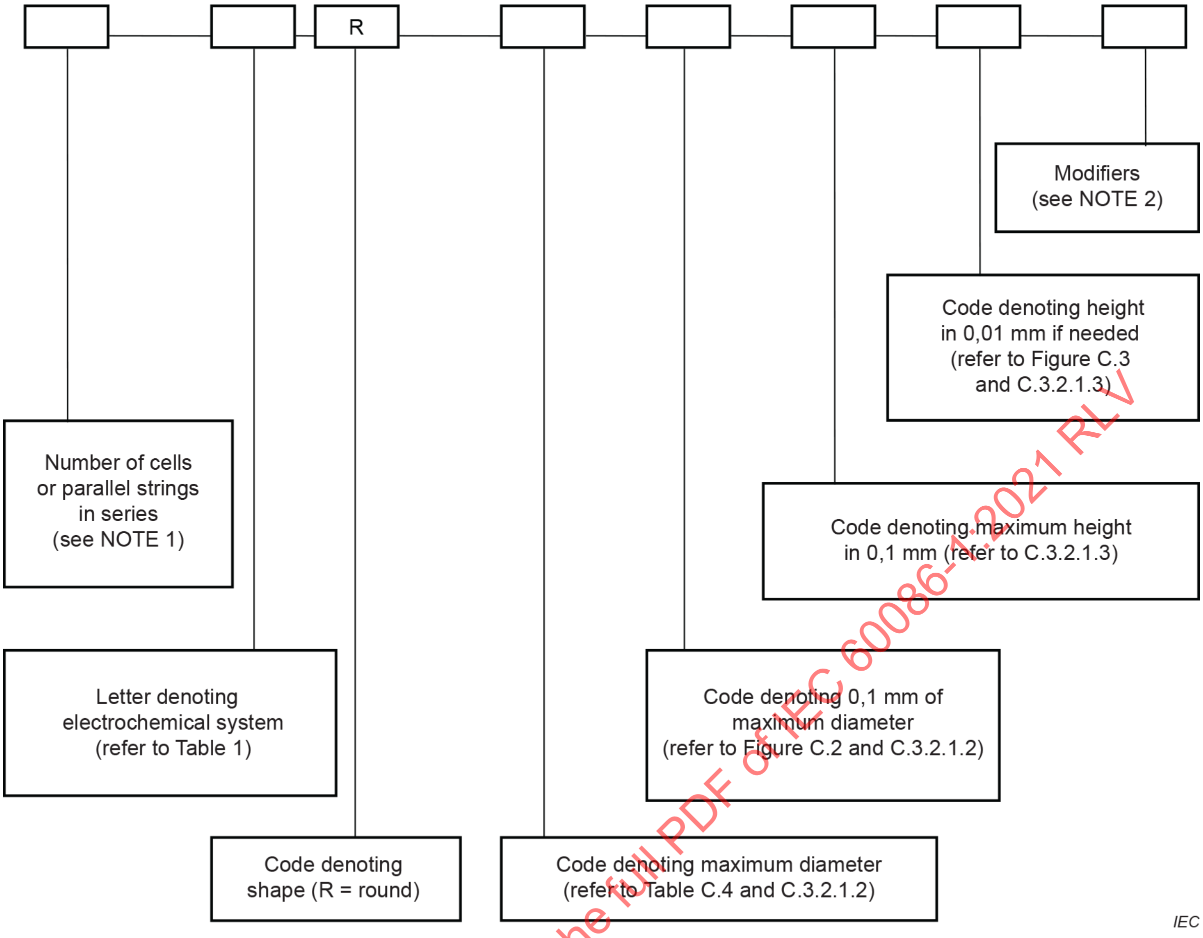
For example a battery of maximum diameter 11,6 mm and a height of maximum 5,4 mm is designated as R1154 preceded by a code for its electrochemical system, as described in this clause.

C.3.2 Round batteries

C.3.2.1 Round batteries with diameter and height less than 100 mm

C.3.2.1.1 General

The designation for round batteries with a diameter and height less than 100 mm is as shown in Figure C.1.



NOTE 1 The number of cells or strings in parallel is not specified.

NOTE 2 Modifiers are included to designate for example specific terminal arrangement, load capability and further special characteristics.

Figure C.1 – Designation system for round batteries: d_1 < 100 mm; height h_1 < 100 mm

C.3.2.1.2 Method for assigning the diameter code

The diameter code is derived from the maximum diameter.

The diameter code number is:

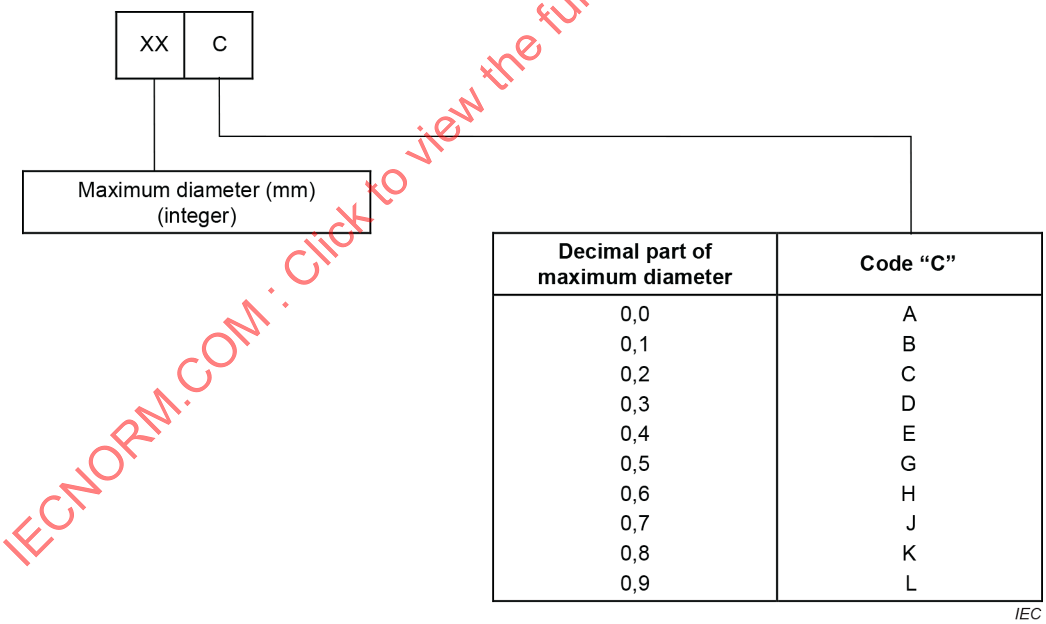
a) assigned according to Table C.4 in case of a recommended diameter;

b) assigned according to Figure C.2 in case of a non-recommended diameter.

Table C.4 – Diameter code for recommended diameter

Dimensions in millimetres

Code	Recommended maximum diameter	Code	Recommended maximum diameter
4	4,8	20	20,0
5	5,8	21	21,0
6	6,8	22	22,0
7	7,9	23	23,0
8	8,5	24	24,5
9	9,5	25	25,0
10	10,0	26	26,2
11	11,6	28	28,0
12	12,5	30	30,0
13	13,0	32	32,0
14	14,5	34	34,2
15	15,0	36	36,0
16	16,0	38	38,0
17	17,0	40	40,0
18	18,0	41	41,0
19	19,0	67	67,0



Decimal part of maximum diameter	Code "C"
0,0	A
0,1	B
0,2	C
0,3	D
0,4	E
0,5	G
0,6	H
0,7	J
0,8	K
0,9	L

Figure C.2 – Diameter code for non-recommended diameters

C.3.2.1.3 Method for assigning the height code

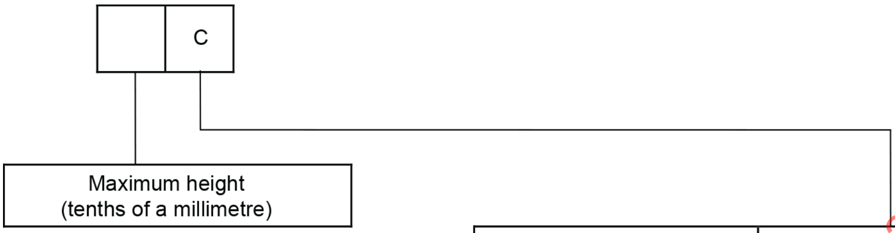
The height code is the number, denoted by the integer of the maximum height of the battery, expressed in tenths of a millimetre (e.g. 3,2 mm maximum height is denoted 32).

The maximum height is specified as follows:

a) for flat contact terminals, the maximum height is the overall height including the terminals;

b) for all other types of terminals, the maximum height is the maximum overall height excluding the terminals (i.e. shoulder-to-shoulder).

If the height in hundredths of a millimetre needs to be specified, the hundredth of a millimetre may be denoted by a code according to Figure C.3.



Decimal part of height mm	Code "C"
0,00	A
0,01	B
0,02	C
0,03	D
0,04	E
0,05	G
0,06	H
0,07	J
0,08	K
0,09	L

IEC

NOTE The hundredths of a millimetre code is only used when needed.

EXAMPLE 1 LR1154: A battery consisting of a round cell or string in parallel with a maximum diameter of 11,6 mm (Table C.4) and a maximum height of 5,4 mm, of the zinc-alkali metal hydroxide-manganese dioxide system.

EXAMPLE 2 LR27A116: A battery consisting of a round cell or string in parallel with a maximum diameter of 27 mm (Figure C.2) and a maximum height of 11,6 mm, of the zinc-alkali metal hydroxide-manganese dioxide system.

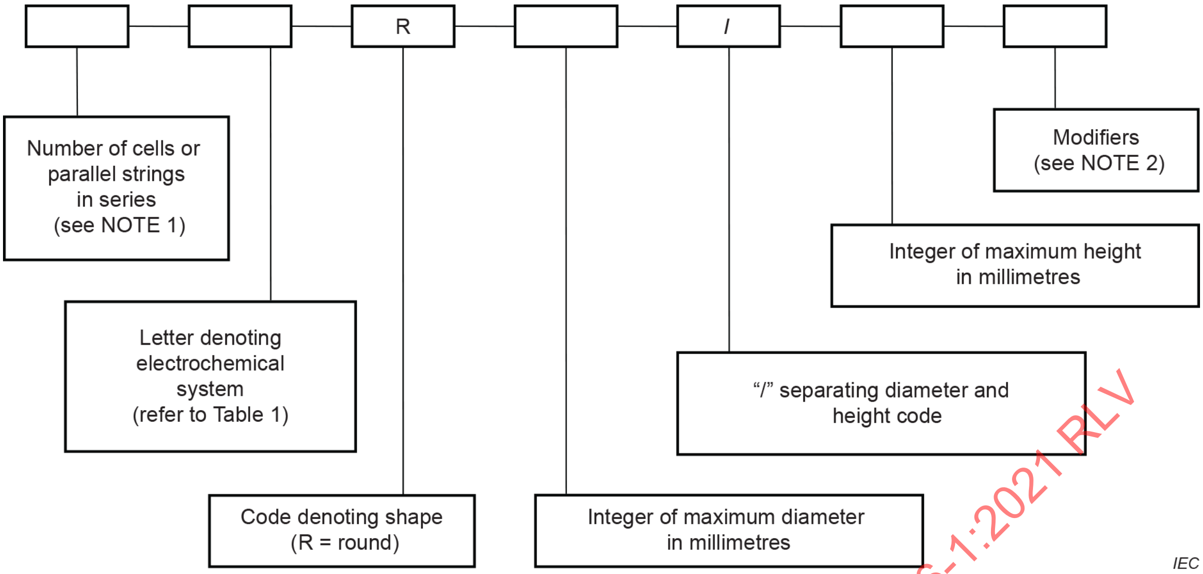
EXAMPLE 3 LR2616J: A battery consisting of a round cell or string in parallel with a maximum diameter of 26,2 mm (Table C.4) and a maximum height of 1,67 mm (Figure C.3), of the zinc-alkali metal hydroxide-manganese dioxide system.

Figure C.3 – Height code for denoting the hundredths of a millimetre of height

C.3.2.2 Round batteries with diameter and/or height over or equal to 100 mm

C.3.2.2.1 General

The designation for round batteries with a diameter and/or height ≥ 100 mm is as shown in Figure C.4.



NOTE 1 The number of cells or strings in parallel is not identified.

NOTE 2 Modifiers are included to designate for example specific terminal arrangement, load capability and further special characteristics.

Figure C.4 – Designation system for round batteries: d_1 ≥ 100 mm; height h_1 ≥ 100 mm

C.3.2.2.2 Method for assigning the diameter code

The diameter code is derived from the maximum diameter.

The diameter code number is the integer of the maximum diameter of the battery expressed in millimetres.

C.3.2.2.3 Method for assigning the height code

The height code is the number denoting the integer of the maximum height of the battery, expressed in millimetres.

The maximum height is specified as follows:

a) for flat contact terminals (e.g. batteries according to Figures 1, 7, 8 and 9 of IEC 60086-2:2015), the maximum height is the overall height including the terminals;

b) for all other types of terminals, the maximum height is the maximal overall height excluding the terminals (i.e. shoulder-to-shoulder).

EXAMPLE 5R184/177: A round battery consisting of five cells or strings in parallel of the zinc-ammonium chloride, zinc chloride-manganese dioxide system, connected in series, having a diameter of 184,0 mm and a shoulder-to-shoulder maximum height of 177,0 mm.

C.3.3 Non-round batteries

C.3.3.1 General

The designation system for non-round batteries is as follows:

An imaginary cylindrical envelope is drawn, encompassing the surface from which the terminals first emerge from the battery case.

Using the maximum dimensions of length (l) and width (w), the diagonal is calculated, which is also the diameter of the imaginary cylinder.

For the designation, the integer of the diameter of the cylinder in millimetres and the integer of the maximum height of the battery in millimetres is applied.

The maximum height is specified as follows:

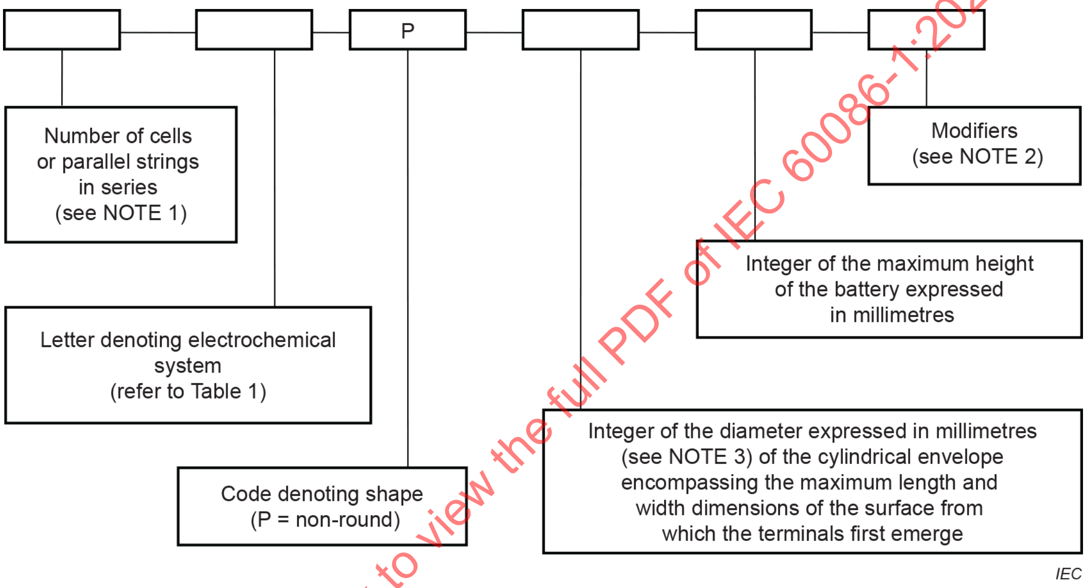
a) for flat contact terminals, the maximum height is the overall height including the terminals;

b) for all other types of terminals, the maximum height is the maximum overall height excluding the terminals (i.e. shoulder-to-shoulder).

NOTE In the event there are two or more terminals emerging from different surfaces, the one with the highest voltage applies.

C.3.3.2 Non-round batteries with dimensions < 100 mm

The designation for non-round batteries with dimensions < 100 mm is as shown in Figure C.5.



NOTE 1 The number of cells or strings in parallel is not identified.

NOTE 2 Modifiers are included to designate, for example, specific terminal arrangement, load and further special characteristics.

NOTE 3 In case the height needs to be discriminated in tenths of a millimetre, the letter code shown in Figure C.7 applies.

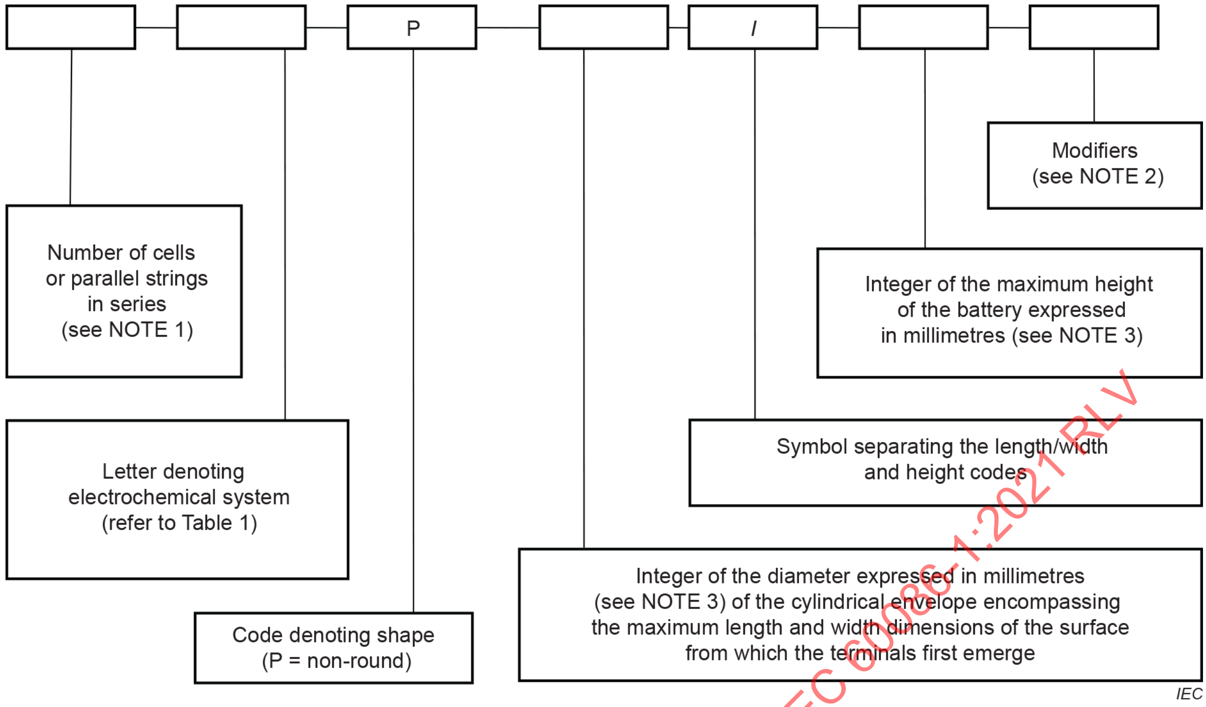
EXAMPLE 6LP3146: A battery consisting of six cells or strings in parallel of the zinc-alkali metal hydroxide-manganese dioxide system, connected in series with a maximum length of 26,5 mm, a maximum width of 17,5 mm, and a maximum height of 46,4 mm. The integer of the diameter of this surface (l and w) is calculated according to:

$$\sqrt{l^2 + w^2} = 31{,}8 \text{ mm; integer} = 31$$

Figure C.5 – Designation system for non-round batteries, dimensions < 100 mm

C.3.3.3 Non-round batteries with dimensions ≥ 100 mm

The designation for non-round batteries with dimensions ≥ 100 mm is as shown in Figure C.6.



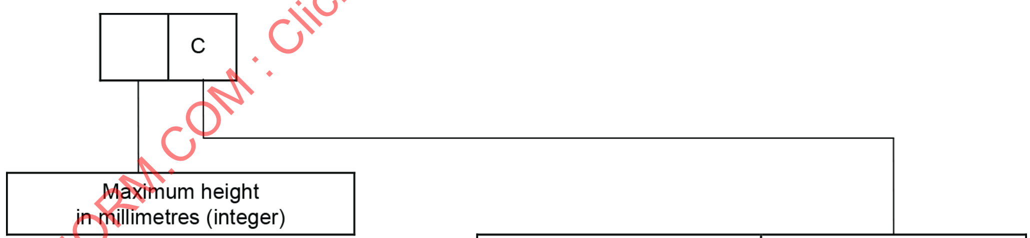
NOTE 1 The number of cells or strings in parallel is not identified.

NOTE 2 Modifiers are included to designate, for example, specific terminal arrangement, load and further special characteristics.

NOTE 3 In case the height needs to be discriminated in tenths of a millimetre, the letter code shown in Figure C.7 applies.

EXAMPLE 6P222/162: A battery consisting of six cells or strings in parallel of the zinc-ammonium chloride, zinc chloride-manganese dioxide system, connected in series, with a maximum length of 192 mm, a maximum width of 113 mm, and a maximum height of 162 mm.

Figure C.6 – Designation system for non-round batteries, dimensions ≥ 100 mm



Decimal part of height mm	**Code**
0,0	A
0,1	B
0,2	C
0,3	D
0,4	E
0,5	G
0,6	H
0,7	J
0,8	K
0,9	L

IEC

NOTE The tenths of a millimetre code is only used when needed.

Figure C.7 – Height code for discrimination per tenth of a millimetre

C.3.4 Ambiguity

In the unlikely event that two or more batteries would have the same diameter of the encompassing cylinder and the same height, the second one will be designated with the same designation extended with “–1”.

Table C.5 – Physical designation and dimensions of round cells and batteries based on Clause C.2

Dimensions in millimetres

Physical designation	Maximum battery dimensions	
	Diameter	Height
R772	7,9	7,2
R1025	10,0	2,5
R1216	12,5	1,6
R1220	12,5	2,0
R1225	12,5	2,5
R1616	16,0	1,6
R1620	16,0	2,0
R2012	20,0	1,2
R2016	20,0	1,6
R2020	20,0	2,0
R2025	20,0	2,5
R2032	20,0	3,2
R2320	23,0	2,0
R2325	23,0	2,5
R2330	23,0	3,0
R2354	23,0	5,4
R2420	24,5	2,0
R2425	24,5	2,5
R2430	24,5	3,0
R2450	24,5	5,0
R3032	30,0	3,2
R11108	11,6	10,8
2R13252	13,0	25,2
R12A604	12,0	60,4
R14250	14,5	25,0
R15H270	15,6	27,0
R17335	17,0	33,5
R17345	17,0	34,5
R17450	17,0	45,0

NOTE The complete dimensions of these batteries are given in IEC 60086-2 and IEC 60086-3.

Table C.6 – Physical designation and dimensions of non-round batteries based on Clause C.2

Dimensions in millimetres

Physical designation	Designation (original)	Maximum battery dimensions		
		Length	Width	Height
2P3845	2R5	34,0	17,0	45,0
2P4036	R-P2	35,0	19,5	36,0

NOTE 1 The actual used designation of these batteries is 2R5 and R-P2 since these batteries were already recognized under these numbers before they were standardized.

NOTE 2 The complete dimensions of these batteries are given in IEC 60086-2.

Annex D
(informative)

Standard discharge voltage U_s – Definition and method of determination

D.1 Definition

The standard discharge voltage U_s is typical for a given electrochemical system. It is a unique voltage in that it is independent of both the size and the internal construction of the battery. It only depends on its charge-transfer reaction. The standard discharge voltage U_s is defined by Equation (D.1).

$$U_s = \frac{C_s}{t_s} \times R_s \tag{D.1}$$

where

U_s is the standard discharge voltage;

C_s is the standard discharge capacity;

t_s is the standard discharge time;

R_s is the standard discharge resistor.

D.2 Determination

D.2.1 General considerations: the *C/R*-plot

The determination of the discharge voltage U_d is accomplished via a C/R-plot (where C is the discharge capacity of a battery; R is the discharge resistance). For illustration, see Figure D.1, which shows a schematic plot of discharge capacity C versus discharge resistor R_d [4] in normalized presentation, i.e. $C(R_d)/C_p$ is plotted as a function of R_d. For low R_d-values, low $C(R_d)$-values are obtained and vice versa. On the gradual increase of R_d, discharge capacity $C(R_d)$ also increases until finally a plateau is established and $C(R_d)$ becomes constant [5]:

$$C_p = \text{constant} \tag{D.2}$$

which means $C(R_d)/C_p = 1$ as indicated by the horizontal line in Figure D.1. It further shows that capacity $C = f(R_d)$ is dependent on the cut-off voltage U_c: the higher its value, the larger the fraction ΔC that cannot be realised during discharge.

NOTE Under plateau conditions, capacity C is independent of R_d.

The discharge voltage U_d is determined by Equation (D.3).

$$U_d = \frac{C_d}{t_d} \times R_d \tag{D.3}$$

---

4 Subscript d differentiates this resistance from R_s; see Equation (D.1).

5 For very long periods of discharge time Cp may decrease due to the battery's internal self-discharge. This may be noticeable for batteries having a high self-discharge, for example 10 % per month or above.

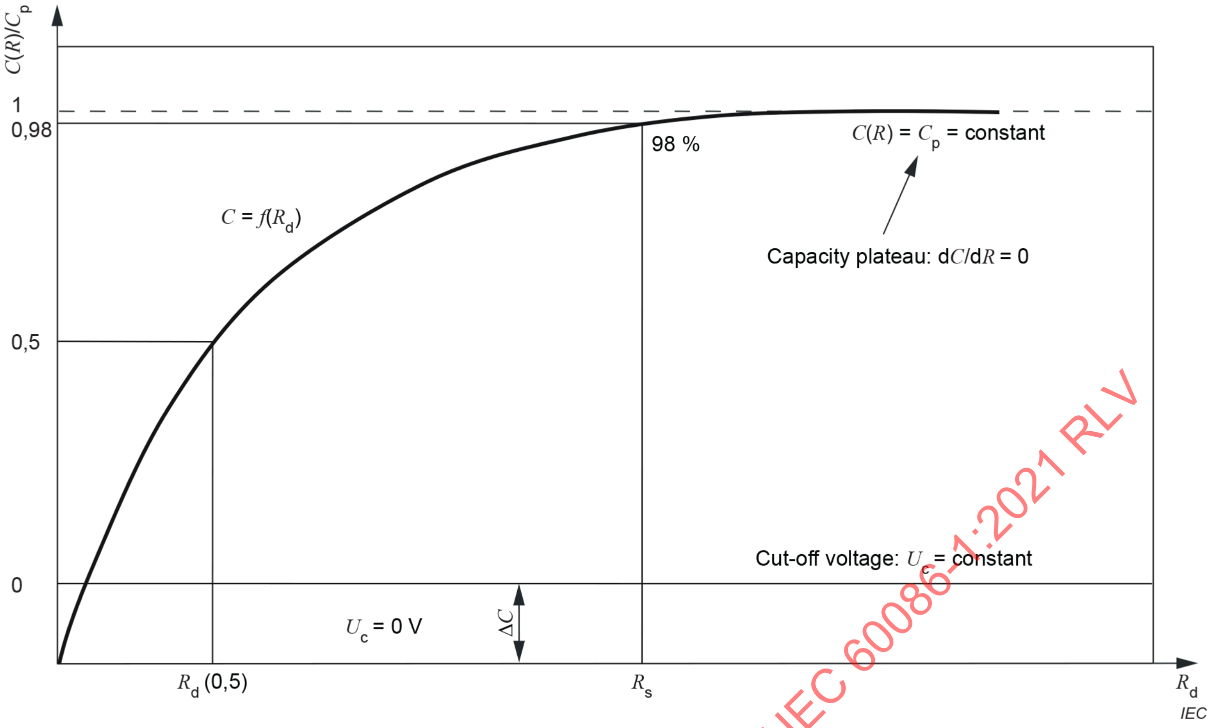


Figure D.1 – Normalized *C*/*R*-plot (schematic)

The quotient C_d/t_d of Equation (D.3) represents the average current i(avg) when discharging the battery through discharge resistor R_d for a given cut-off voltage U_c = constant. This relation may be written as:

$$C_d = i(\text{avg}) \times t_d \qquad \text{(D.4)}$$

For $R_d = R_s$ (standard discharge resistor) Equation (D.3) changes to the Equation (D.1), and consequently Equation (D.4) changes to:

$$C_s = i(\text{avg}) \times t_s \qquad \text{(D.5)}$$

The determination of i(avg) and t_s is accomplished according to the method described in D.2.3 and illustrated by Figure D.2.

D.2.2 Determination of the standard discharge resistor R_s

The determination of U_s is best achieved by that discharge resistor R_d that yields 100 % capacity realization. The time to perform this discharge may be of long duration. To reduce this time, a good approximation for U_s is achieved by Equation (D.6).

$$C_s(R_s) = 0{,}98\ C_p \qquad \text{(D.6)}$$

This means that 98 % capacity realization is considered to be of sufficient accuracy for the determination of the standard discharge voltage U_s. This is achieved when discharging the battery through the standard discharge resistor R_s. Its factor 0,98 or above is not decisive, because U_s remains practically constant for $R_s \leq R_d$. Under this condition, the exact realization of a 98 % capacity realization is not crucial.

D.2.3 Determination of the standard discharge capacity C_s and standard discharge time t_s

For illustration refer to Figure D.2, which represents a schematic discharge curve of a battery.

Figure D.2 addresses areas A1 below and A2 above the discharge curve. Under

$$A1 = A2 \quad \text{(D.7)}$$

the average discharge current i(avg) is obtained. The condition described by Equation (D.7) does not necessarily address the mid-point of discharge, as indicated in Figure D.2. The time of discharge t_d is determined from the cross-over point for $U(R,t) = U_c$. The discharge capacity is obtained from Equation (D.8).

$$C_d = i(\text{avg}) \times t_d \quad \text{(D.8)}$$

The standard capacity C_s is obtained for $R_d = R_s$, changing Equation (D.8) to Equation (D.9)

$$C_s = i(\text{avg}) \times t_s \quad \text{(D.9)}$$

a method which permits the experimental determination of the standard discharge capacity C_s and the standard discharge time t_s needed for determination of the standard discharge voltage U_s (see Equation (D.1)).

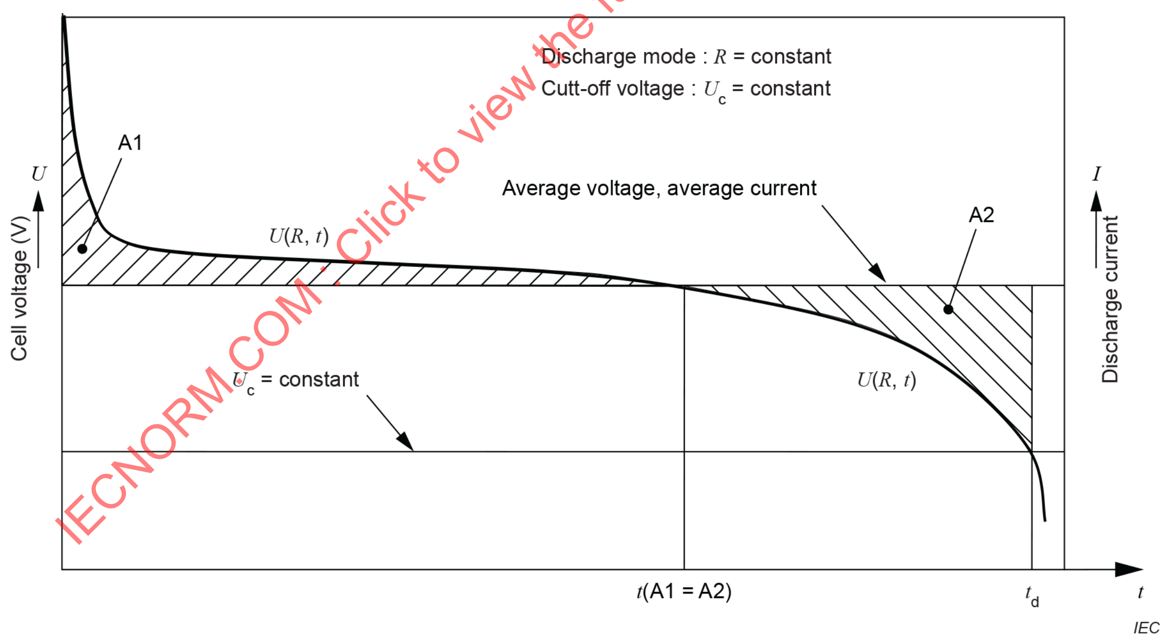


Figure D.2 – Standard discharge voltage (schematic)

D.3 Experimental conditions to be observed and test results

For the experimental determination of the C/R-plot, 10 individual discharge results are recommended, each one being the average of ~~nine~~ eight batteries; these data are to be evenly distributed over the expected range of the C/R-plot. It is recommended to take the first discharge value at approximately 0,5 C_p as indicated in Figure D.1. The last experimental value should be taken at approximately $R_d \approx 2 \times R_s$. The data gathered may then be graphically presented in the form of a C/R-plot according to Figure D.1. From this plot the R_d-value is to be determined leading to approximately 98 % C_p. The standard discharge voltage U_s yielding a 98 % capacity realization should deviate by less than −50 mV from that value yielding a 100 % capacity realization. Differences within this mV range will only be caused by the charge-transfer reaction caused by the system under investigation.

When determining C_s and t_s according to D.2.3, the following cut-off voltages are to be employed in accordance with IEC 60086-2:

Voltage range 1: U_c = 0,9 V Voltage range 2: U_c = 2,0 V

The experimentally determined standard discharge voltages U_s ~~(SDV)~~ shown in Table D.1 are only given to permit the interested expert to check its reproducibility.

Table D.1 – Standard discharge voltage by system

System letter	No letter	C	E	F	L	S	W	Y	Z
U_s ~~(SDV)~~ V	1,30	2,90	3,50	1,48	1,30	1,55	2,8	3,5	1,56

The determination of U_s for systems A, B, G and P is under consideration. System P is a special case, because its U_s value depends on the type of catalyst for oxygen reduction. Since system P is an open system to air, the environmental humidity as well as the pick-up of CO_2 after the activation of the system, is of additional influence. For system P, U_s values of up to 1,37 V may be observed.

Annex E
(informative)

Preparation of standard methods of measuring performance (SMMP) of consumer goods

NOTE This annex has been derived from ISO/IEC Guide 36:1982, Preparation of standard methods of measuring performance (SMMP) of consumer goods (withdrawn 1998).

E.1 General

Information useful to consumers on the performance of consumer goods needs to be based on reproducible standard methods of measuring performance (i.e. test methods that lead to results having a clear relationship to the performance of a product in practical use and that are to be used as a basis for information to consumers about the performance characteristics of the product).

As far as possible, specified tests should take into account limitations in test equipment, money and time.

E.2 Performance characteristics

The first step in the preparation of a SMMP is to establish as complete a list as possible of the characteristics that are relevant in the sense discussed in Clause E.1.

NOTE Once such a list has been drawn up, consideration can be given to selecting those attributes of a product that are most important to consumers making purchase decisions.

E.3 Criteria for the development of test methods

A test method should be given for each of the performance characteristics listed. The following points should be taken into consideration:

a) the test methods should be defined in such a way that the test results correspond as closely as possible to the performance results as experienced by consumers when using the product in practice;

b) it is essential that the test methods are objective and give meaningful and reproducible results;

c) details of the test methods should be defined with a view to optimum usefulness to the consumer, taking into account the ratio between the value of the product and the expenses involved in performing the tests;

d) where use has to be made of accelerated test procedures, or of methods that have only an indirect relationship to the practical use of the product, the technical committee should provide the necessary guidance for correct interpretation of test results in relation to normal use of the product.

Annex F
(informative)

Calculation method for the specified value of minimum average duration

The calculation method for the specified value of minimum average duration shall be carried out as follows:

a) Prepare minimum 10 weeks' data of duration values which are randomly selected.

b) Calculate average $\bar{x}$ of duration values $\times$ of eight samples from each population.

Remark: If some values are out of 3 σ of that population, eliminate these values from the calculation of $\bar{x}$.

c) Calculate the average $\bar{\bar{x}}$ of the above average values $\bar{x}$ of each population and also $\sigma_{\bar{x}}$.

d) Minimum average duration value to be provided by each country:

$$A: \bar{\bar{x}} - 3\,\sigma_{\bar{x}}$$

$$B: \bar{\bar{x}} \times 0{,}85$$

Calculate both A and B; define the larger value of the above two as its minimum average duration.

Annex F
(informative)

Guidance for proposing value of minimum average duration

F.1 General

The minimum average duration (MAD) value set for each discharge mode of each designation in the IEC 60086 series is a minimum level that should be satisfied to ensure the quality of the primary battery.

Therefore, when setting the new MAD value for the IEC 60086 series, IEC experts should discuss the proposed MAD value based on the value calculated by the following procedure, and determine the MAD value with validation.

The MAD value should be determined by considering the actual situation of market utilization and the performance difference due to differences in manufactures, etc.

F.2 Sampling

- Prepare battery samples of same model, same brand, and same grade.
- The discharge test should be started within 60 days maximum after manufacture.
- The sample size should be at least six lots, and eight pieces per lot.

F.3 Calculation method

- Calculate the average duration value $\bar{x}$ of all samples in which lot unit are regarded as one population.
- If some values are not within 3 σ of the average duration value $\bar{x}$ in each population, add new and same number of the samples excluded and calculate the average duration value $\bar{x}$ of all samples again after eliminating these values from the population.
- Repeat until all values of the samples in each population are within 3 σ of the average value $\bar{x}$ in the population.
- Calculate the total average $\bar{\bar{x}}$ and the standard deviation $\sigma_{\bar{x}}$ of the average values $\bar{x}$ of each population.
- Calculate both A and B.

  $A = \bar{\bar{x}} - 3\,\sigma_{\bar{x}}$

  $B = \bar{\bar{x}} \times 0{,}85$
- The larger value of A or B is the proposed value of minimum average duration.

Annex G
(normative)

Code of practice for packaging, shipment, storage, use and disposal of primary batteries

G.1 General

The greatest satisfaction to the user of primary batteries results from a combination of good practices during manufacture, distribution and use.

The purpose of this code is to describe these good practices in general terms. It takes the form of advice to battery manufacturers, distributors and users.

G.2 Packaging

The packaging shall be adequate to avoid mechanical damage during transport, handling and stacking. The materials and pack design shall be chosen so as to prevent the development of unintentional electrical conduction, corrosion of the terminals and ingress of moisture.

G.3 Transport and handling

Shock and vibration shall be kept to a minimum. For instance, boxes should not be thrown off trucks, slammed into position or piled so high as to overload battery containers below. Protection from inclement weather should be provided.

G.4 Storage and stock rotation

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

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

Although the storage life of batteries at room temperature is good, storage is improved at lower temperatures (e.g. in cold rooms −10 °C to +10 °C or in deep-freeze conditions below −10 °C), provided special precautions are taken. The batteries shall be enclosed in special protective packaging (such as sealed plastic bags or variants) which should be retained to protect them from condensation during the time they are warming to ambient temperature. Accelerated warming is detrimental.

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

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

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

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

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

G.5 Displays at sales points

When batteries are unpacked, care should be taken to avoid physical damage and electrical contact. For example, they should not be jumbled together.

Batteries intended for sale should not be displayed for long periods in windows exposed to direct sunlight.

The battery manufacturer should provide sufficient information to enable the retailer to select the correct battery for the user's application. This is especially important when supplying the first batteries for newly purchased equipment.

Test meters do not provide reliable comparison of the service to be expected from good batteries of different grades and manufacture. They do, however, detect serious failures.

G.6 Selection, use and disposal

G.6.1 Purchase

The correct size and grade of battery most suitable for the intended use should be purchased. Many manufacturers supply more than one grade of battery in any given size. Information on the grade most suited to the application should be available at the sales point and on the equipment.

In the event that the required size and grade of battery of a particular brand is not available, the IEC designation for electrochemical system and size enables an alternative to be selected. This designation should be marked on the battery label. The battery should also clearly indicate the voltage, name or trade mark of the manufacturer or supplier, the date of manufacture, which may be in code, or the expiration of a guarantee period, in clear, as well as the polarity ~~(+ and –)~~ (+). For some batteries, part of this information may be on the packaging (see 4.1.6.2).

G.6.2 Installation

Before inserting batteries into the battery compartment of the equipment, the contacts of both equipment and batteries should be checked for cleanliness and correct positioning. If necessary, clean with a damp cloth and dry before inserting.

It is of extreme importance that batteries are inserted correctly with regard to polarity (+ and −). Follow equipment instructions carefully and use the recommended batteries. Failure to follow the instructions, which should be available with the equipment, can result in malfunction and damage of the equipment and/or batteries.

G.6.3 Use

It is not good practice to use or leave equipment exposed to extreme conditions, for example radiators, or cars parked in the sun, etc.

It is advantageous to remove batteries immediately from equipment which has ceased to function satisfactorily, or when not in use for a long period (e.g. cameras, photoflash, etc.).

Be sure to switch off the equipment after use.

Store batteries in a cool, dry place and out of direct sunlight.

G.6.4 Replacement

Replace all batteries of a set at the same time. Newly purchased batteries should not be mixed with partially exhausted ones. Batteries of different electrochemical systems, grades or brands should not be mixed. Failure to observe these precautions may result in some batteries in a set being driven beyond their normal exhaustion point and thus increase the probability of leakage.

G.6.5 Disposal

Primary batteries may be disposed of via the communal refuse arrangements, provided no contrary local legal requirements exist. Refer to IEC 60086-4 and IEC 60086-5 for further details.

Annex H
(informative)

Compliance checklist

Subclause(s)	Item
4.1.2 & 5.7	Dimensions
4.1.3	Terminals
4.1.3.2	Contact pressure resistance
4.1.3.9	Snap fasteners
4.1.3.10	Wire
4.1.3.11	Other spring contacts of clips
4.1.6	Marking
4.2.2	Dimensional stability
4.2.3	Leakage
4.2.4	Open-circuit voltage limits
4.2.5	Service output
5.3	Conformance check to a specified minimum average duration
5.8	Leakage and deformation

Bibliography

IEC 60050-482, *International Electrotechnical Vocabulary (IEV) – Part 482: Primary and secondary cells and batteries*

IEC 60086-6, *Primary batteries – Part 6: Guidance on environmental aspects*

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

ISO/IEC Guide 36:1982, *Preparation of standard methods of measuring performance (SMMP) of consumer goods* (withdrawn 1998)

ISO 2859, *Sampling procedures for inspection by attributes ~~Package~~*

~~ISO 21747, *Statistical methods – Process performance and capability statistics for measured quality characteristics*~~

ISO 22514-2:2017, *Statistical methods in process management – Capability and performance – Part 2: Process capability and performance of time-dependent process models*

ISO/IEC Directives Part 1:2019, *Procedures for the technical work – Procedures specific to IEC*

IEC 60086-1

Edition 13.0 2021-04

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Primary batteries –
Part 1: General

Piles electriques –
Partie 1: Généralités

IEC 60086-1:2021-04(en-fr)

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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PRIMARY BATTERIES –

Part 1: General

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 60086-1 has been prepared by IEC technical committee 35: Primary cells and batteries.

This thirteenth edition cancels and replaces the twelfth edition published in 2015. This edition constitutes a technical revision.

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

a) a compliance checklist was added as an Annex H;
b) definitions were harmonized with the other 60086 series documents;
c) the nominal voltage of the zinc air system is now listed as either 1,4 V or 1,45 V;
d) Annex F for calculation of MAD values was simplified;
e) a validity period for testing was added;
f) the accelerated aging test at 45 °C was changed from 13 to 4 weeks;

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

FDIS	Report on voting
35/1465/FDIS	35/1469/RVD

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

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

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

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

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

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

INTRODUCTION

The technical content of this part of IEC 60086 provides fundamental requirements and information on primary cells and batteries. All batteries within the IEC 60086 series are considered dry cell batteries. In this sense, IEC 60086-1 is the main component of the IEC 60086 series and forms the basis for the subsequent parts. For example, this part includes elementary information on definitions, nomenclature, dimensions and marking. While specific requirements are included, the content of this part tends to explain methodology (how) and justification (why).

Over the years, this part has been changed to improve its content and remains under continual scrutiny to ensure that the publication is kept up to date with the advances in both battery and battery-powered device technologies.

Safety requirements and recommendations are available in IEC 60086-4, IEC 60086-5 and IEC 62281. Specifications are available in IEC 60086-2 and IEC 60086-3. Environmental aspects are dealt with in IEC 60086-6.

PRIMARY BATTERIES –

Part 1: General

1 Scope

This part of IEC 60086 is intended to standardize primary batteries with respect to dimensions, nomenclature, terminal configurations, markings, test methods, typical performance, safety and environmental aspects.

This document on one side specifies requirements for primary cells and batteries. On the other side, this document also specifies procedures of how requirements for these batteries are to be standardised.

As a classification tool for primary batteries, this document specifies system letters, electrodes, electrolytes, and nominal as well as maximum open circuit voltage of electrochemical systems.

The object of this part of IEC 60086 is to benefit primary battery users, device designers and battery manufacturers by ensuring that batteries from different manufacturers are interchangeable according to standard form, fit and function. Furthermore, to ensure compliance with the above, this part specifies standard test methods for testing primary cells and batteries.

This document also contains requirements in Annex A justifying the inclusion or the ongoing retention of batteries in the IEC 60086 series.

2 Normative references

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

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

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

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

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

3 Terms and definitions

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

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

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

3.1
application test
simulation of the actual use of a battery in a specific application

3.2
battery
one or more cells electrically connected and fitted in a case, with terminals, markings and protective devices etc., as necessary for use

[SOURCE:IEC 60050-482:2004, 482-01-04, modified – removal of "fitted with devices necessary for use.]

3.3
button (cell or battery)
small round cell or battery where the overall height is less than the diameter, containing aqueous electrolyte

Note 1 to entry: See coin (cell or battery), lithium button (cell or battery).

[SOURCE: IEC 60050-482:2004 482-02-40]

3.4
cell
basic functional unit, consisting of an assembly of electrodes, electrolyte, container, terminals and usually separators, that is a source of electric energy obtained by direct conversion of chemical energy

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

3.5
closed-circuit voltage
CCV
voltage across the terminals of a battery when it is on discharge

[SOURCE:IEC 60050-482:2004, 482-03-28, modified – "voltage between the terminals of a cell or battery" replaced by "voltage across the terminals of a battery".]

3.6
coin (cell or battery)
lithium button (cell or battery)
small round cell or battery where the overall height is less than the diameter, containing non-aqueous electrolyte

Note 1 to entry: The nominal voltage of lithium batteries is typically greater than 2 V.

Note 2 to entry: See button (cell or battery).

3.7
cylindrical (cell or battery)
round cell or battery in which the overall height is equal to or greater than the diameter

[SOURCE:IEC 60050-482: 2004, 482-02-39, modified – "cell with a cylindrical shape" replaced with "round cell or battery"]

3.8
discharge (of a primary battery)
operation during which a battery delivers current to an external circuit

3.9
dry (primary) **battery**
primary battery in which the liquid electrolyte is essentially immobilized

[SOURCE:IEC 60050-482:2004, 482-04-14, modified – replacement of "containing an immobilized electrolyte.]

3.10
end-point voltage
EV
specified voltage of a battery at which the battery discharge is terminated

[SOURCE:IEC 60050-482:2004, 482-03-30]

3.11
leakage
unplanned escape of electrolyte, gas or other material from a cell or battery

Note 1 to entry: Leakage in this sense should not be confused with the test evaluation criteria for leakage specified in Clause 4 and Clause 5 of this document.

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

3.12
minimum average duration
MAD
minimum average time on discharge which is met by a sample of batteries

Note 1 to entry: The discharge test is carried out according to the specified methods or standards and designed to show conformity with the standard applicable to the battery types.

3.13
nominal voltage (of a primary battery)
U_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 U_n.]

3.14
open-circuit voltage
OCV
voltage across the terminals of a cell or battery when it is off discharge

3.15
primary (cell or battery)
cell or battery that is not designed to be electrically recharged

3.16
round (cell or battery)
cell or battery with circular cross section

3.17
service output (of a primary battery)
service life, or capacity, or energy output of a battery under specified conditions of discharge

3.18
service output test
test designed to measure the service output of a battery

Note 1 to entry: A service output test may be prescribed, for example, when

a) an application test is too complex to replicate;

b) the duration of an application test would make it impractical for routine testing purposes.

3.19
storage life
duration under specified conditions at the end of which a battery retains its ability to perform a specified service output

[SOURCE:IEC 60050-482:2004, 482-03-47, modified – "function" replaced by "service output".]

3.20
terminals (of a primary battery)
conductive parts of a battery that provide connection to an external circuit

4 Requirements

4.1 General

4.1.1 Design

Primary batteries are sold mainly in consumer markets. In recent years, they have become more sophisticated in both chemistry and construction, for example both capacity and rate capability have increased to meet the growing demands from new, battery-powered equipment technology.

When designing primary batteries, the aforementioned considerations shall be taken into account. Specifically, their dimensional conformity and stability, their physical and electrical performance and their safe operation under normal use and foreseeable misuse conditions shall be assured.

Additional information on equipment design can be found in Annex B.

4.1.2 Battery dimensions

The dimensions for individual types of batteries are given in IEC 60086-2 and IEC 60086-3.

4.1.3 Terminals

4.1.3.1 General

Terminals shall be in accordance with Clause 6 of IEC 60086-2:2015.

Their physical shape shall be designed in such a way that they ensure that the batteries make and maintain good electrical contact at all times.

They shall be made of materials that provide good electrical conductivity and resistance to corrosion.

4.1.3.2 Contact pressure resistance

Where stated in the battery specification tables or the individual specification sheets in IEC 60086-2, the following applies:

– a force of 10 N applied through a steel ball of 1 mm diameter at the centre of each contact area for a period of 10 s shall not cause any apparent deformation which might prevent satisfactory operation of the battery.

NOTE See also IEC 60086-3 for exceptions.

4.1.3.3 Cap and base

This type of terminal is used for batteries which have their dimensions specified according to Figures 1 to 7 of IEC 60086-2:2015 and which have the cylindrical side of the battery insulated from the terminals.

4.1.3.4 Cap and case

This type of terminal is used for batteries which have their dimensions specified according to Figures 8, 9, 10, 14, 15 and 16 of IEC 60086-2:2015, but in which the cylindrical side of the battery forms part of the positive terminal.

4.1.3.5 Screw terminals

This contact consists of a threaded rod in combination with either a metal or insulated metal nut.

4.1.3.6 Flat contacts

These are essentially flat metal surfaces adapted to make electrical contact by suitable contact mechanisms bearing against them.

4.1.3.7 Flat or spiral springs

These contacts comprise flat metal strips or spirally wound wires which are in a form that provides pressure contact.

4.1.3.8 Plug-in-sockets

These are made up of a suitable assembly of metal contacts, mounted in an insulated housing or holding device and adapted to receive the corresponding pins of a mating plug.

4.1.3.9 Snap fasteners

4.1.3.9.1 General

These contacts are composed of a combination comprising a stud (non-resilient) for the positive terminal and a socket (resilient) for the negative terminal.

They shall be of suitable metal so as to provide efficient electrical connection when joined to the corresponding parts of an external circuit.

4.1.3.9.2 Snap fastener

This type of terminal consists of a stud for the positive terminal and a socket for the negative terminal. These shall be made from nickel plated steel or other suitable material. They shall be designed to provide a secure physical and electrical connection, when fitted with similar corresponding parts for connection to an electrical circuit.

4.1.3.10 Wire

Wire leads may be single or multi-strand flexible insulated tinned copper. The positive terminal wire covering shall be red and the negative black.

4.1.3.11 Other spring contacts or clips

These contacts are generally used on batteries when the corresponding parts of the external circuit are not precisely known. They shall be of spring brass or of other material having similar properties.

4.1.4 Classification (electrochemical system)

Primary batteries are classified according to their electrochemical system.

Each system, with the exception of the zinc-ammonium chloride, zinc chloride-manganese dioxide system, has been allocated a letter denoting the particular system.

The electrochemical systems that have been standardized up to now are given in Table 1.

Table 1 – Standardized electrochemical systems

Letter	Negative electrode	Electrolyte	Positive electrode	Nominal voltage V	Maximum open circuit voltage V
No letter	Zinc (Zn)	Ammonium chloride, zinc chloride	Manganese dioxide (MnO_2)	1,5	1,73
A	Zinc (Zn)	Ammonium chloride, zinc chloride	Oxygen (O_2)	1,4	1,55
B	Lithium (Li)	Organic electrolyte	Carbon monofluoride $(CF)_x$	3,0	3,7
C	Lithium (Li)	Organic electrolyte	Manganese dioxide (MnO_2)	3,0	3,7
E	Lithium (Li)	Non-aqueous inorganic	Thionyl chloride ($SOCl_2$)	3,6	3,9
F	Lithium (Li)	Organic electrolyte	Iron disulfide (FeS_2)	1,5	1,83
G	Lithium (Li)	Organic electrolyte	Copper (II) oxide (CuO)	1,5	2,3
L	Zinc (Zn)	Alkali metal hydroxide	Manganese dioxide (MnO_2)	1,5	1,68
P	Zinc (Zn)	Alkali metal hydroxide	Oxygen (O_2)	1,4 or 1,45	1,59
S	Zinc (Zn)	Alkali metal hydroxide	Silver oxide (Ag_2O)	1,55	1,63
W	Lithium (Li)	Organic electrolyte	Sulphur dioxide (SO_2)	3,0	3,05
Y	Lithium (Li)	Non-aqueous inorganic	Sulfuryl chloride (SO_2Cl_2)	3,9	4,1
Z	Zinc (Zn)	Alkali metal hydroxide	Nickel oxyhydroxide (NiOOH)	1,5	1,78

NOTE 1 The value of the nominal voltage is not verifiable; therefore it is only given as a reference.

NOTE 2 The maximum open-circuit voltage (3.14) is measured as defined in 5.5 and 6.8.1.

NOTE 3 When referring to an electrochemical system, common protocol is to list negative electrode first, followed by positive electrode, i.e. lithium-iron disulfide.

NOTE 4 Reference to the electrochemical systems of this table usually appears in a simplified form such as, for example, “B and C system batteries” or “batteries of the no letter system”.

4.1.5 Designation

The designation of primary batteries is based on their physical parameters, their electrochemical system as well as modifiers, if needed.

A comprehensive explanation of the designation system (nomenclature) can be found in Annex C.

4.1.6 Marking

4.1.6.1 General

For an overview of marking requirements refer to Table 2. With the exception of batteries too small to mark with all items (see 4.1.6.2), 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 Examples of the common designations can be found in Annex D of IEC 60086-2:2015.

4.1.6.2 Marking of smaller batteries

a) Some batteries, mainly category 3 and category 4 batteries, have a surface too small to accommodate all markings shown in 4.1.6.1. For these batteries the designation 4.1.6.1a) and the polarity 4.1.6.1c) shall be marked on the battery. All other markings shown in 4.1.6.1 may be given on the immediate packing instead of on the battery.

b) For P-system batteries, 4.1.6.1a) may be on the battery, the sealing tab or the package. 4.1.6.1c) may be marked on the sealing tab and/or on the battery. 4.1.6.1b), 4.1.6.1d) and 4.1.6.1e) may be given on the immediate packing instead of on the battery. The nominal voltage may be marked either 1,4 V or 1,45 V.

c) Caution for ingestion of swallowable batteries shall be given. Refer to current valid versions of IEC 60086-4 and IEC 60086-5 for details.

Table 2 – Marking requirements

Marking	Batteries with the exception of batteries too small to accommodate all markings	Batteries too small to accommodate all markings	
			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]

Key
A: shall be marked on the battery
B: may be marked on the immediate packing instead of 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 IEC 60086-4 and IEC 60086-5 for details.

4.1.6.3 Marking of batteries regarding method of disposal

Marking of batteries with respect to the method of disposal shall be in accordance with local legal requirements.

4.1.7 Interchangeability: battery voltage

Primary batteries as presently standardized in the IEC 60086 series can be categorized by their standard discharge voltage U_s. For a new battery system, its interchangeability by voltage is assessed for compliance with the following Formula (1):

$$n \times 0{,}85\ U_r \le m \le U_s \le n \times 1{,}15\ U_r \tag{1}$$

where

n is the number of cells connected in series, based on reference voltage U_r;

m is the number of cells connected in series, based on standard discharge voltage U_s;

U_r is the reference voltage;

U_s is the standard discharge voltage.

Currently, two voltage ranges that conform to the above formula have been identified. They are identified by reference voltage U_r, which is the midpoint of the relevant voltage range.

Voltage range 1, U_r = 1,40 V: Batteries having a standard discharge voltage $m \times U_s$ equal to or within the range of $n \times 1{,}19$ V to $n \times 1{,}61$ V.

Voltage range 2, U_r = 3,20 V: Batteries having a standard discharge voltage $m \times U_s$ equal to or within the range of $n \times 2{,}72$ V to $n \times 3{,}68$ V.

Details on the standard discharge voltage and related quantities, as well as the methods of their determination, are given in Annex D.

NOTE For single-cell batteries and for multi-cell batteries assembled with cells of the same voltage range, m and n will be identical; m and n will be different for multi-cell batteries if assembled with cells from a different voltage range than those of an already standardized battery.

Voltage range 1 encompasses all presently standardized batteries with a nominal voltage of 1,5 V, i.e. "no-letter" system, systems A, F, G, L, P, S and Z.

Voltage range 2 encompasses all presently standardized batteries with a nominal voltage of 3 V, i.e. systems B, C, E, W and Y.

Because batteries from voltage range 1 and voltage range 2 show significantly different discharge voltages, they shall be designed to be physically non-interchangeable. Before standardizing a new electrochemical system, its standard discharge voltage shall be determined in accordance with the procedure given in Annex D to resolve its interchangeability by voltage.

WARNING Failure to comply with this requirement can present safety hazards to the user, such as fire, explosion, leakage and/or device damage. This requirement is necessary for safety and operational reasons.

4.2 Performance

4.2.1 Discharge performance

Discharge performance of primary batteries is specified in IEC 60086-2.

4.2.2 Dimensional stability

The dimensions of batteries shall conform to the relevant specified dimensions as given in IEC 60086-2 and IEC 60086-3 at all times during discharge testing under the standard conditions.

An increase in battery height of 0,25 mm can occur with button and coin cells of the G, L, P and S systems, if discharged below end-point voltage.

As information for battery compartment manufacturers, for certain coin cells of the C and B systems, a decrease in battery height can occur if discharged below end-point voltage.

4.2.3 Leakage

When batteries are stored and discharged under the standard conditions given in this document, no leakage shall occur.

4.2.4 Open-circuit voltage limits

The maximum open-circuit voltage of batteries shall not exceed the values given in Table 1.

4.2.5 Service output

Discharge durations, initial and delayed, of batteries shall meet the requirements given in IEC 60086-2.

4.2.6 Safety

When designing primary batteries, safety under conditions of intended use and foreseeable misuse as prescribed in IEC 60086-4 and IEC 60086-5 shall be considered.

4.2.7 Validity of testing

Portable primary batteries shall be subjected to the tests, as required in the 60086 series. Test results remain valid until a design change or requirement revision has been made. Retesting is required when:

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

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

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

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

5 Performance – Testing

5.1 Capacity testing versus application and service output testing

For the preparation of standard methods of measuring performance (SMMP) of consumer goods, refer to Annex E.

A capacity of a primary battery may be established by electrical discharge tests as detailed in D.2.3. However, under consumer usage conditions, the capacities realised from electrical discharge test methods can vary.

The following factors/variables dramatically impact on optimum capacity realisation.

a) The current demand from the external electrical circuit/device.

b) The frequency of current demand (continuous or intermittent usage).

c) The minimum voltage at which the device will satisfactorily operate (cut off voltage).

d) The temperature of operation.

From the variables listed in a) to d), high current demand for prolonged periods coupled with a high cut off voltage and low temperature represents the worst case conditions resulting in significant capacity loss.

Because the electrically or chemically derived capacity of a primary battery cannot be reliably used in any calculation of ultimate battery performance it is nevertheless essential to convey to the user some idea of battery performance/life when used in typical battery powered devices. It should however be noted that such designated 'application tests' (defined in 60086-2) may not entirely replicate a device/application there being many variations, each with differing electrical requirements in the marketplace. Furthermore battery performance may be further affected by one or more of the conditions in a) to d) above.

Annex E has therefore been derived from ISO/IEC Guide 36:1982 (now withdrawn).

5.2 Discharge testing

5.2.1 General

The discharge tests in this document fall into two categories:

– application tests;

– service output tests.

In both categories of tests, discharge loads are specified in accordance with 6.4.

The test methods of determining the load and test conditions are as given in 5.2.2 and 5.2.3.

5.2.2 Application tests

5.2.2.1 General

a) The equivalent resistance is calculated from the average current and average operating voltage of the equipment under load. Constant current or constant power loads are also permitted for applications exhibiting these types of power demand patterns.

b) The functional end-point voltage and the equivalent resistance load, current load, or constant power values are obtained from typical application equipment measurements.

c) The median class defines the load value and the end-point voltage to be used for the discharge test.

d) If the data are concentrated in two or more widely separated groups, more than one test may be required.

Application tests may be accelerated by discharge load, daily period duty cycle, or both. The specified values for load and time intermittency should take the following factors into consideration:

- discharge efficiency of the battery relative to the application,
- typical duty cycle use patterns for the application,
- total time to conduct the test typically not to exceed 30 days.

Some fixed resistance tests have been chosen to permit simplicity of design and ensure reliability of the test equipment, despite the fact that, in specific instances, constant current or constant wattage tests may be a better representation of the application.

In the future, alternative or additional load conditions may be necessary to effectively represent the range of applications in use. It is likely that the load characteristics of a particular category of equipment will change with time in a developing technology.

The precise determination of the functional end-point voltage of the equipment is not always possible. The discharge conditions are at best a compromise selected to represent a category of equipment which may have widely divergent characteristics.

Nevertheless, in spite of these limitations, the derived application test is the best approach known for the estimation of battery capability for a particular category of equipment.

NOTE In order to minimize the proliferation of application tests, the tests specified should target those appliances accounting for 80 % of the market by battery designation.

5.2.2.2 Application tests with multiple loads

For application tests with multiple loads, the load order during a cycle shall start with the heaviest load and move to the lightest load unless otherwise specified.

5.2.3 Service output tests

For service output tests, the value of the load resistor should be selected such that the service output approximates 30 days.

When full capacity is not realized within the required time scale, the service output may be extended to the shortest suitable duration thereafter by selecting a discharge load of lower ohmic value, as defined in 6.4.

5.3 Conformance check to a specified minimum average duration

In order to check the conformance of a battery to any discharge test specified in IEC 60086-2 and 60086-3, the test shall be carried out as follows:

a) Test eight batteries.

b) Calculate the average without the exclusion of any result.

c) If this average is equal to or greater than the specified figure and no more than one battery has a service output of less than 80 % of the specified figure, the batteries are considered to conform to service output.

d) If this average is less than the specified figure and/or more than one battery has a service output of less than 80 % of the specified figure, repeat the test on another sample of eight batteries and calculate the average as previously.

e) If the average of this second test is equal to or greater than the specified figure and no more than one battery has a service output of less than 80 % of the specified figure, the batteries are considered to conform to service output.

f) If the average of the second test is less than the specified figure and/or more than one battery has a service output of less than 80 % of the specified figure, the batteries are considered not to conform and no further testing is permitted.

g) For the purposes of verifying compliance with this document, conditional acceptance shall be given after completion of the initial discharge tests.

NOTE Discharge performance of primary batteries is specified in IEC 60086-2.

5.4 Guidance for considering proposed value of minimum average duration

This guidance is described in Annex F.

5.5 OCV testing

Open-circuit voltage shall be measured with the voltage measuring equipment specified in 6.8.1.

5.6 Insulation resistance

For batteries with insulating labels, cases or jackets, the resistance between externally exposed surfaces of the battery and either terminal shall be equal to or greater than 5 MΩ at 500^{+100}_{0} V, applied for up to 60 s.

5.7 Battery dimensions

Dimensions shall be measured with the measuring equipment specified in 6.8.2.

5.8 Leakage and deformation

After the service output has been determined under the specified environmental conditions, the discharge shall be continued in the same way until the closed circuit voltage drops for the first time below 40 % of the nominal voltage of the battery. The requirements of 4.1.3, 4.2.2 and 4.2.3 shall be met.

NOTE For button and coin batteries, the visual examination for leakage is carried out in accordance with the respective clauses of IEC 60086-3 and IEC 60086-5.

6 Performance – Test conditions

6.1 Storage and discharge conditions

Storage before discharge testing and the actual discharge test are carried out under well-defined conditions. Unless otherwise specified, the conditions given in Table 3 shall apply. Discharge conditions shown are further referred to as standard conditions.

Table 3 – Conditions for storage before and during discharge testing

Type of test	Storage conditions			Discharge conditions	
	Temperature °C	Relative humidity % RH	Duration	Temperature °C	Relative humidity[d] % RH
Initial discharge test	20 ± 5 [a]	55 + 20 / -40	60 days maximum after date of manufacture	20 ± 2	55 + 20 / -40
Delayed discharge test[e]	20 ± 5 [a]	55 + 20 / -40	12 months	20 ± 2	55 + 20 / -40
Delayed discharge test (high temperature) [b,e]	45 ± 2 [c]	55 ± 20	4 weeks	20 ± 2	55 + 20 / -40

[a] During short periods the storage temperature may deviate from these limits without exceeding (20 ± 10) °C.

[b] This test is carried out when a storage test at high temperature is required. Performance requirements are the subject of agreement between the manufacturer and the customer.

[c] Batteries to be stored unpacked.

[d] Except “P” and “A” system: (55 ± 10) % RH.

[e] The performance should meet or exceed the percentage of minimum average duration (MAD) value.

6.2 Commencement of discharge tests after storage

The period between the completion of storage and the start of a delayed discharge test shall not exceed 14 days.

During this period the batteries shall be kept at (20 ± 2) °C and (55 + 20 / −40) % RH (except for P-system batteries where the relative humidity shall be (55 ± 10) % RH).

At least one day in these conditions shall be allowed for normalization before starting a discharge test after storage at high temperature.

6.3 Discharge test conditions

6.3.1 General

In order to test a battery it shall be discharged as specified in IEC 60086-2 or IEC 60086-3 until the voltage on load drops for the first time below the specified end-point. The service output may be expressed as pulses, duration, capacity, or energy.

6.3.2 Compliance

When IEC 60086-2 or IEC 60086-3 specify service outputs for more than one discharge test, batteries shall meet all of these requirements in order to comply with this document.

6.4 Load resistance

The value of the resistive load (which includes all parts of the external circuit) shall be as specified in the relevant specification sheet and shall be accurate to ±0,5 %.

When formulating new tests, the resistive loads shall, whenever possible, be as shown in Table 4 together with their decimal multiples or sub-multiples.

Table 4 – Resistive loads for tests

Values in ohms

1,00	1,10	1,20	1,30	1,50	1,60	1,80	2,00
2,20	2,40	2,70	3,00	3,30	3,60	3,90	4,30
4,70	5,10	5,60	6,20	6,80	7,50	8,20	9,10

6.5 Time periods

The periods on-discharge and off-discharge shall be as specified in IEC 60086-2.

When formulating new tests, whenever possible, one of the following daily periods should be adopted from Table 5.

Table 5 – Time periods for tests

1 min	5 min	10 min	30 min	1 h
2 h	4 h	12 h	24 h (continuous)	—

Other cases are specified in IEC 60086-2, if necessary.

6.6 Test condition tolerances

Unless otherwise specified, the tolerances given in Table 6 shall apply.

Table 6 – Test condition tolerances

Test parameter	Tolerance	
Temperature	±2 °C	
Load	±0,5 %	
Voltage	±0,5 %	
Relative humidity	+20 / −40 % RH except “P” and “A” systems ±10 % RH	
Time	**Discharge time t_d**	**Tolerance**
	$0 < t_d \leq 2$ s	±5 % of t_d
	2 s $< t_d \leq 100$ s	±0,1 s
	$t_d > 100$ s	±0,1 % of t_d

6.7 Activation of ‘P’-system batteries

A period of at least 10 min shall elapse between activation and the commencement of electrical measurement.

6.8 Measuring equipment

6.8.1 Voltage measurement

The accuracy of the measuring equipment shall be ≤ 0,25 % and the precision shall be ≤ 50 % of the value of the last significant digit. The internal resistance of the measuring instrument shall be ≥ 1 MΩ.

6.8.2 Mechanical measurement

The accuracy of the measuring equipment shall be ≤ 0,25 % and the precision shall be ≤ 50 % of the value of the last significant digit.

7 Sampling and quality assurance

The use of production and incoming inspection sampling plans or product quality indices should be agreed between the manufacturer and the purchaser.

Where no agreement is specified, refer to ISO 2859 and ISO 22514-2 for sampling and quality compliance assessment advice.

8 Battery packaging

A code of practice for battery packaging, shipment, storage, use and disposal can be found in Annex G.

Annex A
(normative)

Criteria for the standardization of batteries

Batteries and electrochemical systems shall meet the following requirements to justify their initial inclusion or ongoing retention in the IEC 60086 series:

a) The battery or batteries of this electrochemical system are in mass production.

b) The battery or batteries of this electrochemical system are available in several market places of the world.

c) Patent items shall conform to the requirements contained in 2.14 of the ISO/IEC Directives, Part 1:2019, Reference to patented items.

d) The battery is produced in at least two different countries or alternatively, if produced in only one country, the battery is purchased by other international and independent battery manufacturers and sold under their company label.

The items of Table A.1 shall be included in any new work proposal to standardize a new individual battery or electrochemical system.

Table A.1 – Items necessary to standardize

Individual battery	Electrochemical system
Conformance statement to items a) to d) above	Conformance statement to items a) and b) above
Designation and electrochemical system	Recommended designation letter
Dimensions (including drawings)	Negative electrode
Discharge conditions	Positive electrode
Minimum average duration(s)	Nominal voltage
	Maximum open circuit voltage
	Electrolyte

Annex B
(informative)

Recommendations for equipment design

B.1 Technical liaison

It is recommended that companies producing battery-powered equipment 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. The equipment should be permanently marked with the IEC designation, grade and size of battery which will give optimum performance.

B.2 Battery compartment

B.2.1 General

Design compartments so that batteries are easily inserted and do not fall out. The dimensions and design of compartments and contacts should be such that batteries complying with this document will be accepted. In particular, the equipment designer should not ignore the tolerances given in this document, even if a national standard or a battery manufacturer calls for smaller battery tolerances.

The design of the negative contact should make allowance for any recess of the battery terminal.

Clearly indicate the type of battery to use, the correct polarity alignment and directions for insertion.

Use the shape and/or the dimensions of the positive (+) and negative (−) battery terminals in compartment designs to prevent the reverse connection of batteries. Positive (+) and negative (−) battery contacts should be visibly different in form to avoid confusion when inserting batteries.

Battery compartments should be electrically insulated from the electric circuit and positioned so as to minimize possible damage and/or risk of injury. Only the battery terminals should physically contact the electric circuit. Care should be taken in the choice of materials and the design of contacts to ensure that effective electrical contact is made and maintained under conditions of use even with batteries at the extremes of dimensions permitted by this document. Battery and equipment terminals should be of compatible material and low electrical resistance.

For battery compartments with parallel connections, refer to IEC 60086-5.

Equipment designed to be powered by air-depolarized batteries of either the "A" or "P" system shall provide for adequate air access. For the "A" system, the battery should preferably be in an upright position during normal operation. For "P" system batteries conforming to Figure 9 of IEC 60086-2:2015, positive contact should be made on the side of the battery, so that air access is not impeded.

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

The battery compartment should be clearly and permanently marked to show the correct orientation of the batteries. One of the most common causes of dissatisfaction is the reversed placement of one battery in a set, which may result in battery leakage and/or explosion and/or fire. To minimize this hazard, battery compartments should be designed so that a reversed battery will result in no electrical circuit.

The associated circuitry should not make physical contact with any part of the battery except at the surfaces intended for this purpose.

Designers are strongly advised to refer to IEC 60086-4 and IEC 60086-5 for comprehensive safety considerations.

B.2.2 Limiting access by children

Apparatus should be designed to prevent children from removing the battery. Refer to information for safety found in IEC 60086-4 and IEC 60086-5.

B.3 Voltage cut-off

In order to prevent leakage resulting from a battery being driven into reverse, the equipment voltage cut-off should not be below the battery manufacturer's recommendation.

Annex C
(normative)

Designation system (nomenclature)

C.1 General

The battery designation system (nomenclature) defines as unambiguously as possible the physical dimensions, shape, electrochemical system, nominal voltage and, where necessary, the type of terminals, rate capability and special characteristics.

This annex is divided into two clauses:

– Clause C.2 defines the designation system (nomenclature) in use up to October 1990.
– Clause C.3 defines the designation system (nomenclature) in use since October 1990 to accommodate present and future needs.

C.2 Designation system in use up to October 1990

C.2.1 General

This clause applies to all batteries which have been standardized up to October 1990 and will remain valid for those batteries after that date.

C.2.2 Cells

A cell is designated by a capital letter followed by a number. The letters R, F and S define round, flat (layer built) and square cells, respectively. The letter, together with the following number[1], is defined by a set of nominal dimensions.

Where a single-cell battery is specified, the maximum dimensions of the battery instead of the nominal dimensions of the cell are given in Table C.1, Table C.2 and Table C.3. Note that these tables do not include electrochemistries, except for the no letter system, or other modifiers. These other parts of the designation system (nomenclature) follow in C.2.3, C.2.4 and C.2.5. These tables only provide core physical designations for single cells or single batteries.

NOTE The complete dimensions of these batteries are given in IEC 60086-2 and IEC 60086-3.

1 At the time this system was applied, numbers were allocated sequentially. Omissions in the sequence arise because of deletions or by the different approach to numbering used even before the sequential system.

Table C.1 – Physical designation and dimensions of round cells and batteries

Dimensions in millimetres

Physical designation	Nominal cell dimensions		Maximum battery dimensions	
	Diameter	Height	Diameter	Height
R06	10	22	–	–
R03	–	–	10,5	44,5
R01	–	–	12,0	14,7
R0	11	19	–	–
R1	–	–	12,0	30,2
R3	13,5	25	–	–
R4	13,5	38	–	–
R6	–	–	14,5	50,5
R9	–	–	16,0	6,2
R10	–	–	21,8	37,3
R12	–	–	21,5	60,0
R14	–	–	26,2	50,0
R15	24	70	–	–
R17	25,5	17	–	–
R18	25,5	83	–	–
R19	32	17	–	–
R20	–	–	34,2	61,5
R22	32	75	–	–
R25	32	91	–	–
R26	32	105	–	–
R27	32	150	–	–
R40	–	–	67,0	172,0
R41	–	–	7,9	3,6
R42	–	–	11,6	3,6
R43	–	–	11,6	4,2
R44	–	–	11,6	5,4
R45	9,5	3,6	–	–
R48	–	–	7,9	5,4
R50	–	–	16,4	16,8
R51	16,5	50,0	–	–
R52	–	–	16,4	11,4
R53	–	–	23,2	6,1
R54	–	–	11,6	3,05
R55	–	–	11,6	2,1
R56	–	–	11,6	2,6
R57	–	–	9,5	2,7
R58	–	–	7,9	2,1
R59	–	–	7,9	2,6
R60	–	–	6,8	2,15
R61	7,8	39	–	–
R62	–	–	5,8	1,65
R63	–	–	5,8	2,15
R64	–	–	5,8	2,70
R65	–	–	6,8	1,65
R66	–	–	6,8	2,60
R67	–	–	7,9	1,65
R68	–	–	9,5	1,65
R69	–	–	9,5	2,10
R70	–	–	5,8	3,6

NOTE The complete dimensions of these batteries are given in IEC 60086-2 and IEC 60086-3.

Table C.2 – Physical designation and nominal overall dimensions of flat cells

Dimensions in millimetres

Physical designation	Diameter	Length	Width	Thickness
F15	-	14,5	14,5	3,0
F16	-	14,5	14,5	4,5
F20	-	24	13,5	2,8
F22	-	24	13,5	6,0
F24	23	–	–	6,0
F25	-	23	23	6,0
F30	-	32	21	3,3
F40	-	32	21	5,3
F50	-	32	32	3,6
F70	-	43	43	5,6
F80	-	43	43	6,4
F90	-	43	43	7,9
F92	-	54	37	5,5
F95	-	54	38	7,9
F100	-	60	45	10,4
NOTE The complete dimensions of these batteries are given in IEC 60086-2.				

Table C.3 – Physical designation and dimensions of square cells and batteries

Dimensions in millimetres

Physical designation	Nominal cell dimensions			Maximum battery dimensions		
	Length	Width	Height	Length	Width	Height
S4	–	–	–	57,0	57,0	125,0
S6	57	57	150	–	–	–
S8	–	–	–	85,0	85,0	200,0
S10	95	95	180	–	–	–
NOTE The complete dimensions of these batteries are given in IEC 60086-2.						

In some cases, cell sizes which are not used in IEC 60086-2 have been retained in these tables because of their use in national standards.

C.2.3 Electrochemical system

With the exception of the zinc-ammonium chloride, zinc chloride-manganese dioxide system, the letters R, F and S are preceded by an additional letter which denotes the electrochemical system. These letters can be found in Table 1.

C.2.4 Batteries

If a battery contains one cell only, the cell designation is used.

If a battery contains more than one cell in series, a numeral denoting the number of cells precedes the cell designation.

If cells are connected in parallel, a numeral denoting the number of parallel groups follows the cell designation and is connected to it by a hyphen.

If a battery contains more than one section, each section is designated separately, with a slash (/) separating their designation.

C.2.5 Modifiers

In order to preserve the unambiguity of the battery designation, variants of one basic type are differentiated by the addition of a letter X or Y to indicate the different arrangements or terminals and P or S to indicate different performance characteristics.

C.2.6 Examples

R20	A battery consisting of a single R20-size cell of the zinc-ammonium chloride, zinc chloride-manganese dioxide system.
LR20	A battery consisting of a single R20-size cell of the zinc-alkali metal hydroxide-manganese dioxide system.
3R12	A battery consisting of three R12-size cells of the zinc-ammonium chloride, zinc chloride-manganese dioxide system, connected in series.
4R25X	A battery consisting of four R25-size cells of the zinc-ammonium chloride, zinc chloride-manganese dioxide system, connected in series and with spiral spring contacts.

C.3 Designation system in use since October 1990

C.3.1 General

This clause applies to all new sizes considered for standardization after October 1990.

The basis for this designation system (nomenclature) is to convey a mental concept of the battery through the designation system. This is accomplished by using a diameter, from a cylindrical envelope, and a height related concept for all batteries, round (R) and non-round (P).

This clause also applies to single-cell batteries and multi-cell batteries with cells in series and/or parallel connection.

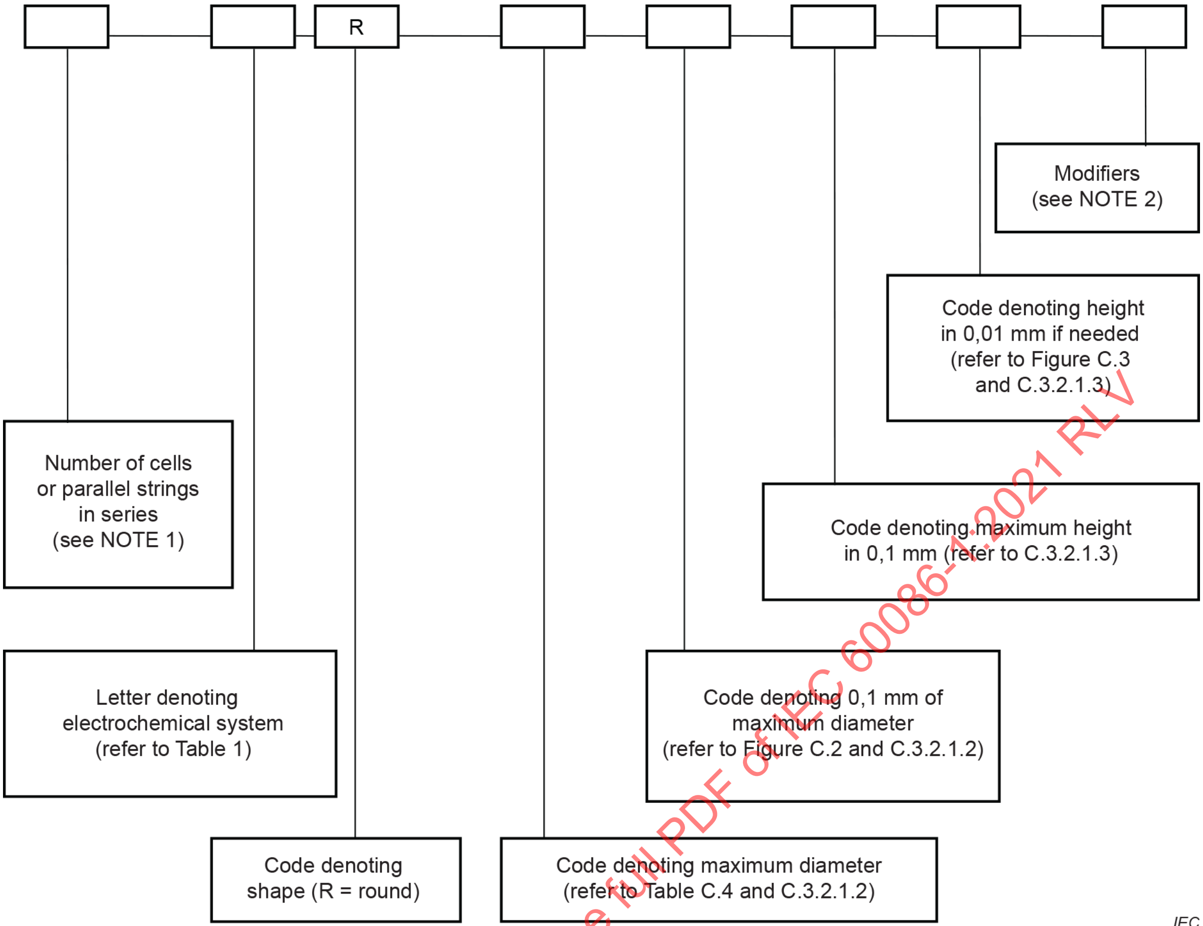
For example a battery of maximum diameter 11,6 mm and a height of maximum 5,4 mm is designated as R1154 preceded by a code for its electrochemical system, as described in this clause.

C.3.2 Round batteries

C.3.2.1 Round batteries with diameter and height less than 100 mm

C.3.2.1.1 General

The designation for round batteries with a diameter and height less than 100 mm is as shown in Figure C.1.



NOTE 1 The number of cells or strings in parallel is not specified.

NOTE 2 Modifiers are included to designate for example specific terminal arrangement, load capability and further special characteristics.

Figure C.1 – Designation system for round batteries: d_1 < 100 mm; height h_1 < 100 mm

C.3.2.1.2 Method for assigning the diameter code

The diameter code is derived from the maximum diameter.

The diameter code number is:

a) assigned according to Table C.4 in case of a recommended diameter;

b) assigned according to Figure C.2 in case of a non-recommended diameter.

Table C.4 – Diameter code for recommended diameter

Dimensions in millimetres

Code	Recommended maximum diameter	Code	Recommended maximum diameter
4	4,8	20	20,0
5	5,8	21	21,0
6	6,8	22	22,0
7	7,9	23	23,0
8	8,5	24	24,5
9	9,5	25	25,0
10	10,0	26	26,2
11	11,6	28	28,0
12	12,5	30	30,0
13	13,0	32	32,0
14	14,5	34	34,2
15	15,0	36	36,0
16	16,0	38	38,0
17	17,0	40	40,0
18	18,0	41	41,0
19	19,0	67	67,0

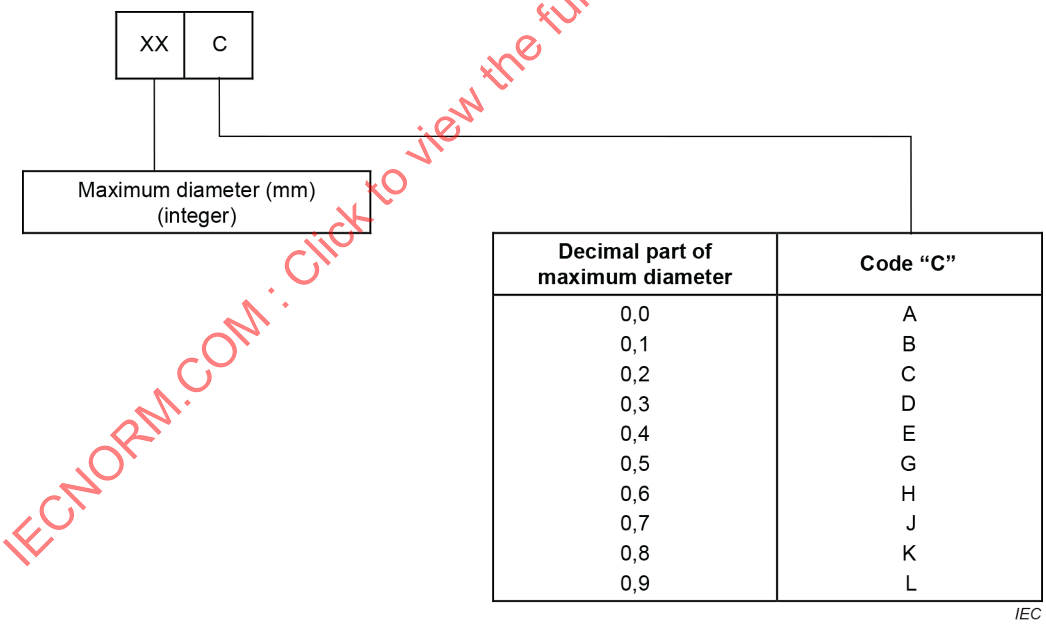


Figure C.2 – Diameter code for non-recommended diameters

C.3.2.1.3 Method for assigning the height code

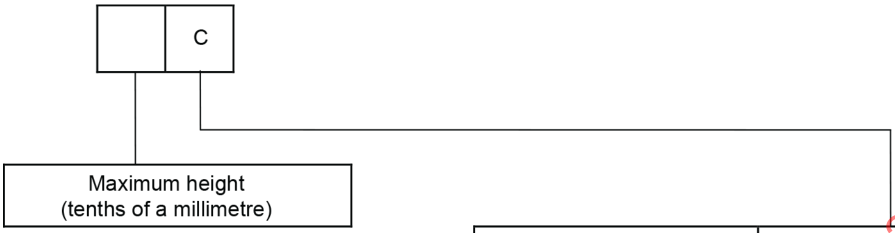
The height code is the number, denoted by the integer of the maximum height of the battery, expressed in tenths of a millimetre (e.g. 3,2 mm maximum height is denoted 32).

The maximum height is specified as follows:

a) for flat contact terminals, the maximum height is the overall height including the terminals;

b) for all other types of terminals, the maximum height is the maximum overall height excluding the terminals (i.e. shoulder-to-shoulder).

If the height in hundredths of a millimetre needs to be specified, the hundredth of a millimetre may be denoted by a code according to Figure C.3.



Decimal part of height mm	Code "C"
0,00	A
0,01	B
0,02	C
0,03	D
0,04	E
0,05	G
0,06	H
0,07	J
0,08	K
0,09	L

IEC

NOTE The hundredths of a millimetre code is only used when needed.

EXAMPLE 1 LR1154: A battery consisting of a round cell or string in parallel with a maximum diameter of 11,6 mm (Table C.4) and a maximum height of 5,4 mm, of the zinc-alkali metal hydroxide-manganese dioxide system.

EXAMPLE 2 LR27A116: A battery consisting of a round cell or string in parallel with a maximum diameter of 27 mm (Figure C.2) and a maximum height of 11,6 mm, of the zinc-alkali metal hydroxide-manganese dioxide system.

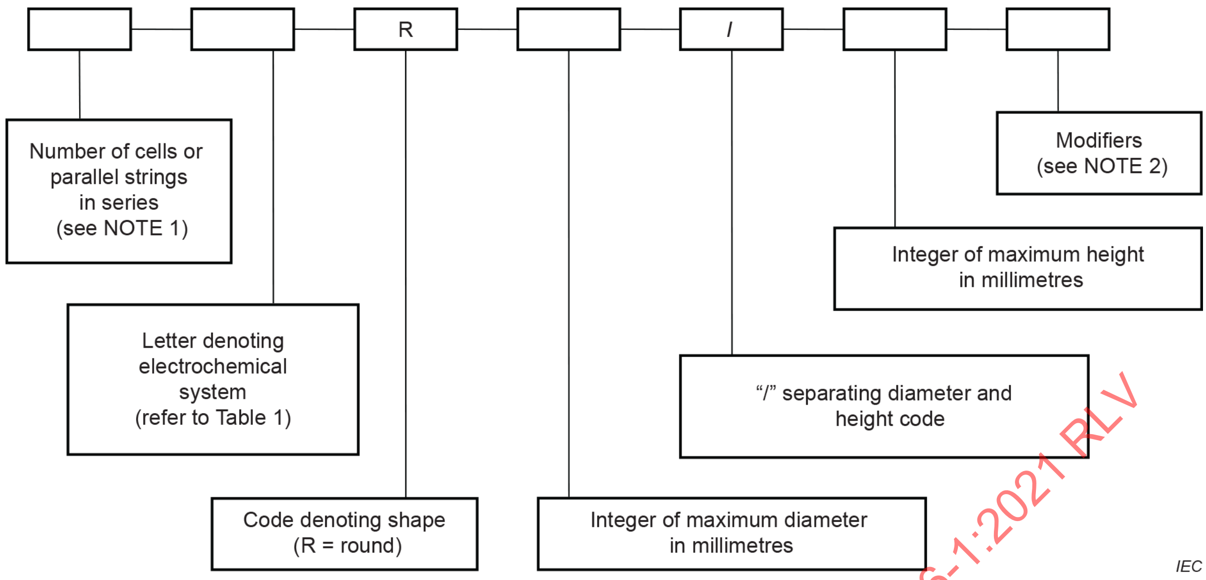
EXAMPLE 3 LR2616J: A battery consisting of a round cell or string in parallel with a maximum diameter of 26,2 mm (Table C.4) and a maximum height of 1,67 mm (Figure C.3), of the zinc-alkali metal hydroxide-manganese dioxide system.

Figure C.3 – Height code for denoting the hundredths of a millimetre of height

C.3.2.2 Round batteries with diameter and/or height over or equal to 100 mm

C.3.2.2.1 General

The designation for round batteries with a diameter and/or height ≥ 100 mm is as shown in Figure C.4.



NOTE 1 The number of cells or strings in parallel is not identified.

NOTE 2 Modifiers are included to designate for example specific terminal arrangement, load capability and further special characteristics.

Figure C.4 – Designation system for round batteries: d_1 ≥ 100 mm; height h_1 ≥ 100 mm

C.3.2.2.2 Method for assigning the diameter code

The diameter code is derived from the maximum diameter.

The diameter code number is the integer of the maximum diameter of the battery expressed in millimetres.

C.3.2.2.3 Method for assigning the height code

The height code is the number denoting the integer of the maximum height of the battery, expressed in millimetres.

The maximum height is specified as follows:

a) for flat contact terminals (e.g. batteries according to Figures 1, 7, 8 and 9 of IEC 60086-2:2015), the maximum height is the overall height including the terminals;

b) for all other types of terminals, the maximum height is the maximal overall height excluding the terminals (i.e. shoulder-to-shoulder).

EXAMPLE 5R184/177: A round battery consisting of five cells or strings in parallel of the zinc-ammonium chloride, zinc chloride-manganese dioxide system, connected in series, having a diameter of 184,0 mm and a shoulder-to-shoulder maximum height of 177,0 mm.

C.3.3 Non-round batteries

C.3.3.1 General

The designation system for non-round batteries is as follows:

An imaginary cylindrical envelope is drawn, encompassing the surface from which the terminals first emerge from the battery case.

Using the maximum dimensions of length (l) and width (w), the diagonal is calculated, which is also the diameter of the imaginary cylinder.

For the designation, the integer of the diameter of the cylinder in millimetres and the integer of the maximum height of the battery in millimetres is applied.

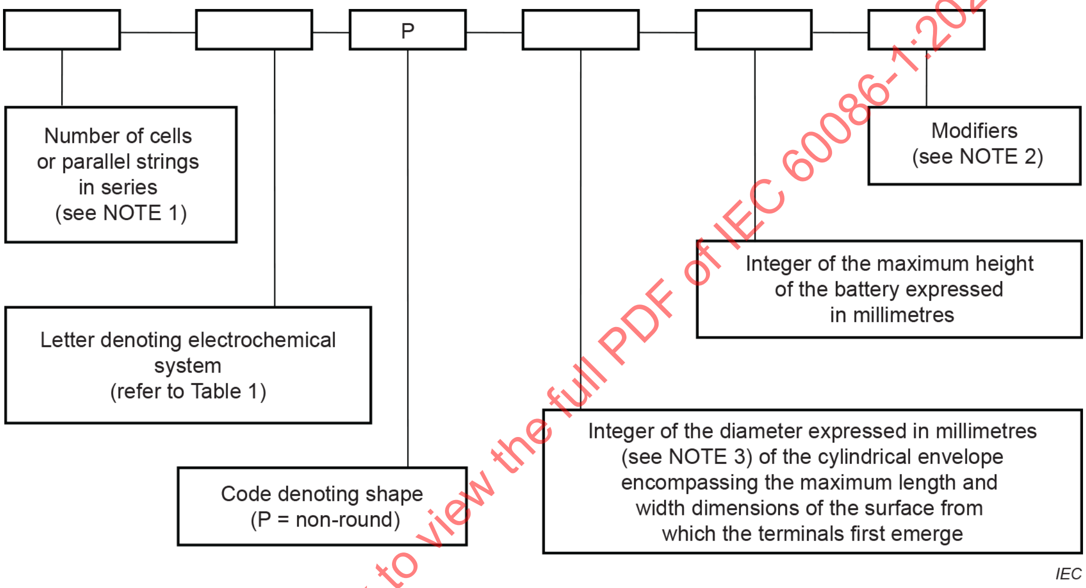
The maximum height is specified as follows:

a) for flat contact terminals, the maximum height is the overall height including the terminals;
b) for all other types of terminals, the maximum height is the maximum overall height excluding the terminals (i.e. shoulder-to-shoulder).

NOTE In the event there are two or more terminals emerging from different surfaces, the one with the highest voltage applies.

C.3.3.2 Non-round batteries with dimensions < 100 mm

The designation for non-round batteries with dimensions < 100 mm is as shown in Figure C.5.



NOTE 1 The number of cells or strings in parallel is not identified.

NOTE 2 Modifiers are included to designate, for example, specific terminal arrangement, load and further special characteristics.

NOTE 3 In case the height needs to be discriminated in tenths of a millimetre, the letter code shown in Figure C.7 applies.

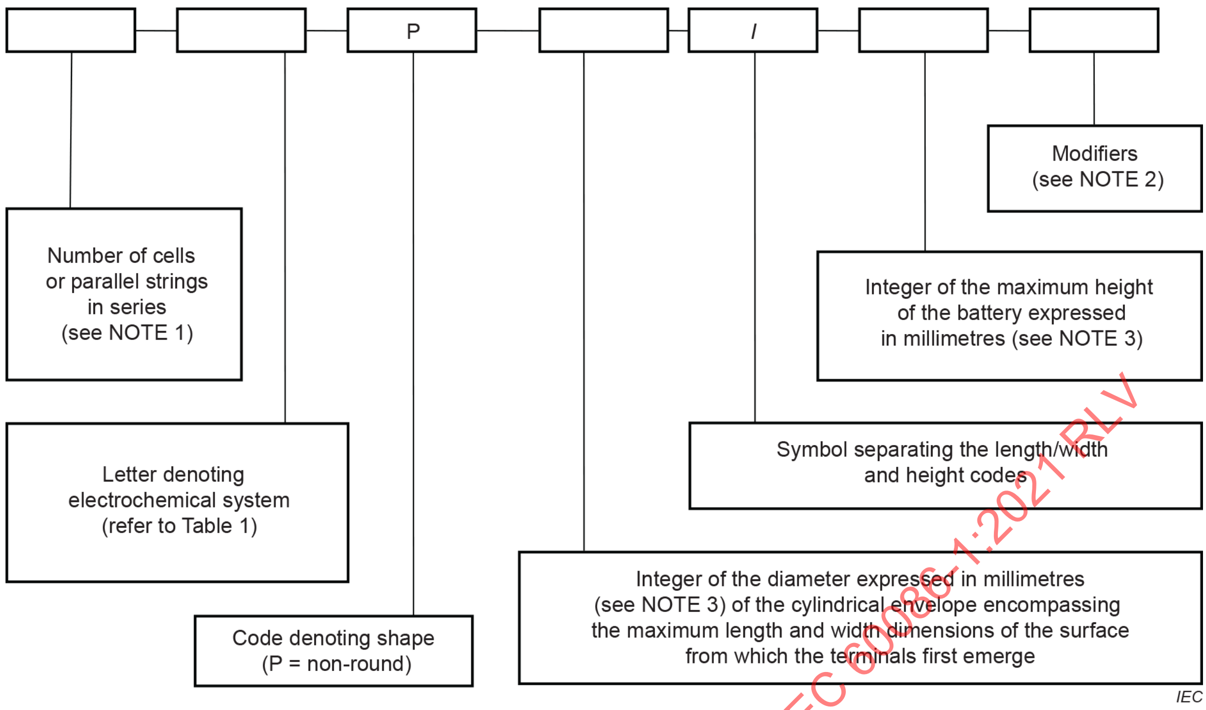
EXAMPLE 6LP3146: A battery consisting of six cells or strings in parallel of the zinc-alkali metal hydroxide-manganese dioxide system, connected in series with a maximum length of 26,5 mm, a maximum width of 17,5 mm, and a maximum height of 46,4 mm. The integer of the diameter of this surface (l and w) is calculated according to:

$$\sqrt{l^2 + w^2} = 31{,}8 \text{ mm; integer} = 31$$

Figure C.5 – Designation system for non-round batteries, dimensions < 100 mm

C.3.3.3 Non-round batteries with dimensions ≥ 100 mm

The designation for non-round batteries with dimensions ≥ 100 mm is as shown in Figure C.6.



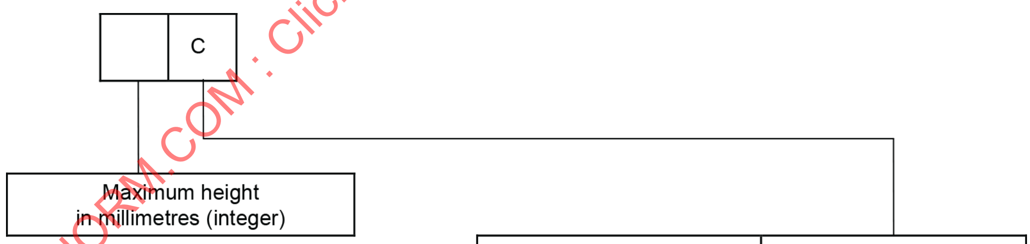
NOTE 1 The number of cells or strings in parallel is not identified.

NOTE 2 Modifiers are included to designate, for example, specific terminal arrangement, load and further special characteristics.

NOTE 3 In case the height needs to be discriminated in tenths of a millimetre, the letter code shown in Figure C.7 applies.

EXAMPLE 6P222/162: A battery consisting of six cells or strings in parallel of the zinc-ammonium chloride, zinc chloride-manganese dioxide system, connected in series, with a maximum length of 192 mm, a maximum width of 113 mm, and a maximum height of 162 mm.

Figure C.6 – Designation system for non-round batteries, dimensions ≥ 100 mm



Decimal part of height mm	**Code**
0,0	A
0,1	B
0,2	C
0,3	D
0,4	E
0,5	G
0,6	H
0,7	J
0,8	K
0,9	L

IEC

NOTE The tenths of a millimetre code is only used when needed.

Figure C.7 – Height code for discrimination per tenth of a millimetre

C.3.4 Ambiguity

In the unlikely event that two or more batteries would have the same diameter of the encompassing cylinder and the same height, the second one will be designated with the same designation extended with “–1”.

Table C.5 – Physical designation and dimensions of round cells and batteries based on Clause C.2

Dimensions in millimetres

Physical designation	Maximum battery dimensions	
	Diameter	Height
R772	7,9	7,2
R1025	10,0	2,5
R1216	12,5	1,6
R1220	12,5	2,0
R1225	12,5	2,5
R1616	16,0	1,6
R1620	16,0	2,0
R2012	20,0	1,2
R2016	20,0	1,6
R2020	20,0	2,0
R2025	20,0	2,5
R2032	20,0	3,2
R2320	23,0	2,0
R2325	23,0	2,5
R2330	23,0	3,0
R2354	23,0	5,4
R2420	24,5	2,0
R2425	24,5	2,5
R2430	24,5	3,0
R2450	24,5	5,0
R3032	30,0	3,2
R11108	11,6	10,8
2R13252	13,0	25,2
R12A604	12,0	60,4
R14250	14,5	25,0
R15H270	15,6	27,0
R17335	17,0	33,5
R17345	17,0	34,5
R17450	17,0	45,0

NOTE The complete dimensions of these batteries are given in IEC 60086-2 and IEC 60086-3.

Table C.6 – Physical designation and dimensions of non-round batteries based on Clause C.2

Dimensions in millimetres

Physical designation	Designation (original)	Maximum battery dimensions		
		Length	Width	Height
2P3845	2R5	34,0	17,0	45,0
2P4036	R-P2	35,0	19,5	36,0

NOTE 1 The actual used designation of these batteries is 2R5 and R-P2 since these batteries were already recognized under these numbers before they were standardized.

NOTE 2 The complete dimensions of these batteries are given in IEC 60086-2.

Annex D
(informative)

Standard discharge voltage U_s – Definition and method of determination

D.1 Definition

The standard discharge voltage U_s is typical for a given electrochemical system. It is a unique voltage in that it is independent of both the size and the internal construction of the battery. It only depends on its charge-transfer reaction. The standard discharge voltage U_s is defined by Equation (D.1).

$$U_s = \frac{C_s}{t_s} \times R_s \tag{D.1}$$

where

U_s is the standard discharge voltage;

C_s is the standard discharge capacity;

t_s is the standard discharge time;

R_s is the standard discharge resistor.

D.2 Determination

D.2.1 General considerations: the *C/R*-plot

The determination of the discharge voltage U_d is accomplished via a C/R-plot (where C is the discharge capacity of a battery; R is the discharge resistance). For illustration, see Figure D.1, which shows a schematic plot of discharge capacity C versus discharge resistor R_d [2] in normalized presentation, i.e. $C(R_d)/C_p$ is plotted as a function of R_d. For low R_d-values, low $C(R_d)$-values are obtained and vice versa. On the gradual increase of R_d, discharge capacity $C(R_d)$ also increases until finally a plateau is established and $C(R_d)$ becomes constant [3]:

$$C_p = \text{constant} \tag{D.2}$$

which means $C(R_d)/C_p = 1$ as indicated by the horizontal line in Figure D.1. It further shows that capacity $C = f(R_d)$ is dependent on the cut-off voltage U_c: the higher its value, the larger the fraction ΔC that cannot be realised during discharge.

NOTE Under plateau conditions, capacity C is independent of R_d.

The discharge voltage U_d is determined by Equation (D.3).

$$U_d = \frac{C_d}{t_d} \times R_d \tag{D.3}$$

2 Subscript d differentiates this resistance from R_s; see Equation (D.1).

3 For very long periods of discharge time Cp may decrease due to the battery's internal self-discharge. This may be noticeable for batteries having a high self-discharge, for example 10 % per month or above.

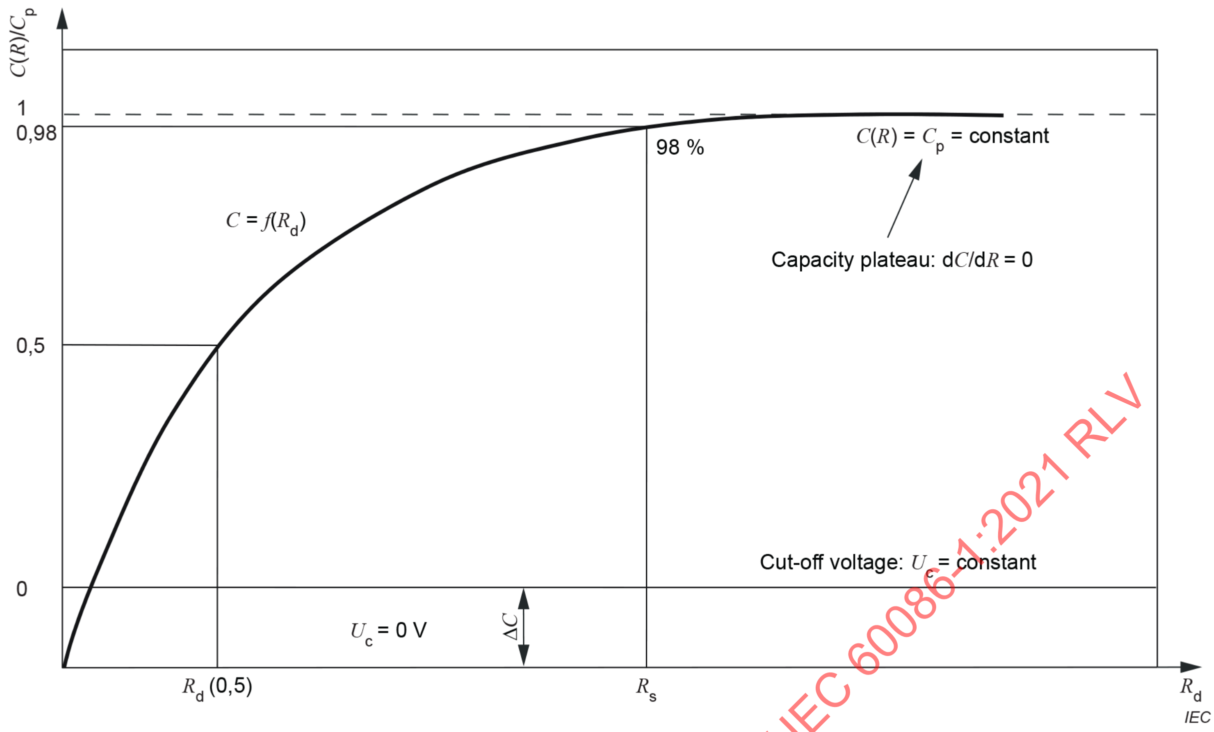


Figure D.1 – Normalized *C/R*-plot (schematic)

The quotient C_d/t_d of Equation (D.3) represents the average current i(avg) when discharging the battery through discharge resistor R_d for a given cut-off voltage U_c = constant. This relation may be written as:

$$C_d = i(\text{avg}) \times t_d \qquad \text{(D.4)}$$

For $R_d = R_s$ (standard discharge resistor) Equation (D.3) changes to the Equation (D.1), and consequently Equation (D.4) changes to:

$$C_s = i(\text{avg}) \times t_s \qquad \text{(D.5)}$$

The determination of i(avg) and t_s is accomplished according to the method described in D.2.3 and illustrated by Figure D.2.

D.2.2 Determination of the standard discharge resistor R_s

The determination of U_s is best achieved by that discharge resistor R_d that yields 100 % capacity realization. The time to perform this discharge may be of long duration. To reduce this time, a good approximation for U_s is achieved by Equation (D.6).

$$C_s(R_s) = 0{,}98\ C_p \qquad \text{(D.6)}$$

This means that 98 % capacity realization is considered to be of sufficient accuracy for the determination of the standard discharge voltage U_s. This is achieved when discharging the battery through the standard discharge resistor R_s. Its factor 0,98 or above is not decisive, because U_s remains practically constant for $R_s \leq R_d$. Under this condition, the exact realization of a 98 % capacity realization is not crucial.

D.2.3 Determination of the standard discharge capacity C_s and standard discharge time t_s

For illustration refer to Figure D.2, which represents a schematic discharge curve of a battery.

Figure D.2 addresses areas A1 below and A2 above the discharge curve. Under

$$A1 = A2 \tag{D.7}$$

the average discharge current i(avg) is obtained. The condition described by Equation (D.7) does not necessarily address the mid-point of discharge, as indicated in Figure D.2. The time of discharge t_d is determined from the cross-over point for $U(R,t) = U_c$. The discharge capacity is obtained from Equation (D.8).

$$C_d = i(\text{avg}) \times t_d \tag{D.8}$$

The standard capacity C_s is obtained for $R_d = R_s$, changing Equation (D.8) to Equation (D.9)

$$C_s = i(\text{avg}) \times t_s \tag{D.9}$$

a method which permits the experimental determination of the standard discharge capacity C_s and the standard discharge time t_s needed for determination of the standard discharge voltage U_s (see Equation (D.1)).

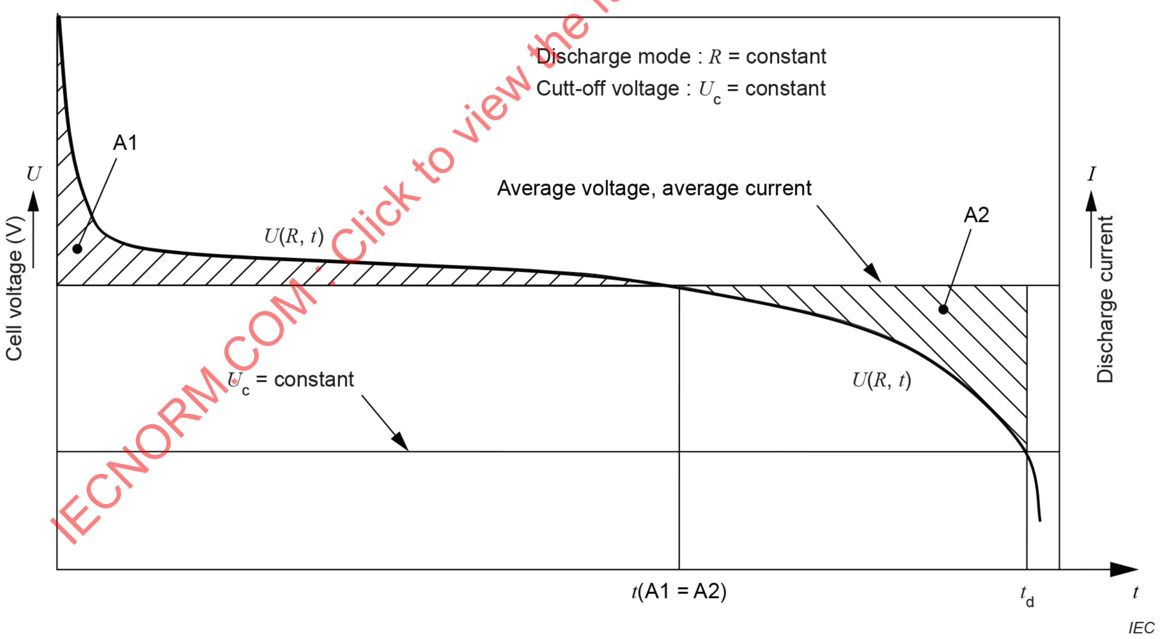


Figure D.2 – Standard discharge voltage (schematic)

D.3 Experimental conditions to be observed and test results

For the experimental determination of the C/R-plot, 10 individual discharge results are recommended, each one being the average of eight batteries; these data are to be evenly distributed over the expected range of the C/R-plot. It is recommended to take the first discharge value at approximately 0,5 C_p as indicated in Figure D.1. The last experimental value should be taken at approximately $R_d \approx 2 \times R_s$. The data gathered may then be graphically presented in the form of a C/R-plot according to Figure D.1. From this plot the R_d-value is to be determined leading to approximately 98 % C_p. The standard discharge voltage U_s yielding a 98 % capacity realization should deviate by less than −50 mV from that value yielding a 100 % capacity realization. Differences within this mV range will only be caused by the charge-transfer reaction caused by the system under investigation.

When determining C_s and t_s according to D.2.3, the following cut-off voltages are to be employed in accordance with IEC 60086-2:

Voltage range 1: U_c = 0,9 V Voltage range 2: U_c = 2,0 V

The experimentally determined standard discharge voltages U_s shown in Table D.1 are only given to permit the interested expert to check its reproducibility.

Table D.1 – Standard discharge voltage by system

System letter	No letter	C	E	F	L	S	W	Y	Z
U_s V	1,30	2,90	3,50	1,48	1,30	1,55	2,8	3,5	1,56

The determination of U_s for systems A, B, G and P is under consideration. System P is a special case, because its U_s value depends on the type of catalyst for oxygen reduction. Since system P is an open system to air, the environmental humidity as well as the pick-up of CO_2 after the activation of the system, is of additional influence. For system P, U_s values of up to 1,37 V may be observed.

Annex E
(informative)

Preparation of standard methods of measuring performance (SMMP) of consumer goods

NOTE This annex has been derived from ISO/IEC Guide 36:1982, Preparation of standard methods of measuring performance (SMMP) of consumer goods (withdrawn 1998).

E.1 General

Information useful to consumers on the performance of consumer goods needs to be based on reproducible standard methods of measuring performance (i.e. test methods that lead to results having a clear relationship to the performance of a product in practical use and that are to be used as a basis for information to consumers about the performance characteristics of the product).

As far as possible, specified tests should take into account limitations in test equipment, money and time.

E.2 Performance characteristics

The first step in the preparation of a SMMP is to establish as complete a list as possible of the characteristics that are relevant in the sense discussed in Clause E.1.

NOTE Once such a list has been drawn up, consideration can be given to selecting those attributes of a product that are most important to consumers making purchase decisions.

E.3 Criteria for the development of test methods

A test method should be given for each of the performance characteristics listed. The following points should be taken into consideration:

a) the test methods should be defined in such a way that the test results correspond as closely as possible to the performance results as experienced by consumers when using the product in practice;

b) it is essential that the test methods are objective and give meaningful and reproducible results;

c) details of the test methods should be defined with a view to optimum usefulness to the consumer, taking into account the ratio between the value of the product and the expenses involved in performing the tests;

d) where use has to be made of accelerated test procedures, or of methods that have only an indirect relationship to the practical use of the product, the technical committee should provide the necessary guidance for correct interpretation of test results in relation to normal use of the product.

Annex F
(informative)

Guidance for proposing value of minimum average duration

F.1 General

The minimum average duration (MAD) value set for each discharge mode of each designation in the IEC 60086 series is a minimum level that should be satisfied to ensure the quality of the primary battery.

Therefore, when setting the new MAD value for the IEC 60086 series, IEC experts should discuss the proposed MAD value based on the value calculated by the following procedure, and determine the MAD value with validation.

The MAD value should be determined by considering the actual situation of market utilization and the performance difference due to differences in manufactures, etc.

F.2 Sampling

- Prepare battery samples of same model, same brand, and same grade.
- The discharge test should be started within 60 days maximum after manufacture.
- The sample size should be at least six lots, and eight pieces per lot.

F.3 Calculation method

- Calculate the average duration value $\bar{x}$ of all samples in which lot unit are regarded as one population.
- If some values are not within 3 σ of the average duration value $\bar{x}$ in each population, add new and same number of the samples excluded and calculate the average duration value $\bar{x}$ of all samples again after eliminating these values from the population.
- Repeat until all values of the samples in each population are within 3 σ of the average value $\bar{x}$ in the population.
- Calculate the total average $\bar{\bar{x}}$ and the standard deviation $\sigma_{\bar{x}}$ of the average values $\bar{x}$ of each population.
- Calculate both A and B.

  $A = \bar{\bar{x}} - 3\,\sigma_{\bar{x}}$

  $B = \bar{\bar{x}} \times 0{,}85$
- The larger value of A or B is the proposed value of minimum average duration.

Annex G
(normative)

Code of practice for packaging, shipment, storage, use and disposal of primary batteries

G.1 General

The greatest satisfaction to the user of primary batteries results from a combination of good practices during manufacture, distribution and use.

The purpose of this code is to describe these good practices in general terms. It takes the form of advice to battery manufacturers, distributors and users.

G.2 Packaging

The packaging shall be adequate to avoid mechanical damage during transport, handling and stacking. The materials and pack design shall be chosen so as to prevent the development of unintentional electrical conduction, corrosion of the terminals and ingress of moisture.

G.3 Transport and handling

Shock and vibration shall be kept to a minimum. For instance, boxes should not be thrown off trucks, slammed into position or piled so high as to overload battery containers below. Protection from inclement weather should be provided.

G.4 Storage and stock rotation

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

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

Although the storage life of batteries at room temperature is good, storage is improved at lower temperatures (e.g. in cold rooms −10 °C to +10 °C or in deep-freeze conditions below −10 °C), provided special precautions are taken. The batteries shall be enclosed in special protective packaging (such as sealed plastic bags or variants) which should be retained to protect them from condensation during the time they are warming to ambient temperature. Accelerated warming is detrimental.

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

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

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

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

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

G.5 Displays at sales points

When batteries are unpacked, care should be taken to avoid physical damage and electrical contact. For example, they should not be jumbled together.

Batteries intended for sale should not be displayed for long periods in windows exposed to direct sunlight.

The battery manufacturer should provide sufficient information to enable the retailer to select the correct battery for the user's application. This is especially important when supplying the first batteries for newly purchased equipment.

Test meters do not provide reliable comparison of the service to be expected from good batteries of different grades and manufacture. They do, however, detect serious failures.

G.6 Selection, use and disposal

G.6.1 Purchase

The correct size and grade of battery most suitable for the intended use should be purchased. Many manufacturers supply more than one grade of battery in any given size. Information on the grade most suited to the application should be available at the sales point and on the equipment.

In the event that the required size and grade of battery of a particular brand is not available, the IEC designation for electrochemical system and size enables an alternative to be selected. This designation should be marked on the battery label. The battery should also clearly indicate the voltage, name or trade mark of the manufacturer or supplier, the date of manufacture, which may be in code, or the expiration of a guarantee period, in clear, as well as the polarity (+). For some batteries, part of this information may be on the packaging (see 4.1.6.2).

G.6.2 Installation

Before inserting batteries into the battery compartment of the equipment, the contacts of both equipment and batteries should be checked for cleanliness and correct positioning. If necessary, clean with a damp cloth and dry before inserting.

It is of extreme importance that batteries are inserted correctly with regard to polarity (+ and −). Follow equipment instructions carefully and use the recommended batteries. Failure to follow the instructions, which should be available with the equipment, can result in malfunction and damage of the equipment and/or batteries.

G.6.3 Use

It is not good practice to use or leave equipment exposed to extreme conditions, for example radiators, or cars parked in the sun, etc.

It is advantageous to remove batteries immediately from equipment which has ceased to function satisfactorily, or when not in use for a long period (e.g. cameras, photoflash, etc.).

Be sure to switch off the equipment after use.

Store batteries in a cool, dry place and out of direct sunlight.

G.6.4 Replacement

Replace all batteries of a set at the same time. Newly purchased batteries should not be mixed with partially exhausted ones. Batteries of different electrochemical systems, grades or brands should not be mixed. Failure to observe these precautions may result in some batteries in a set being driven beyond their normal exhaustion point and thus increase the probability of leakage.

G.6.5 Disposal

Primary batteries may be disposed of via the communal refuse arrangements, provided no contrary local legal requirements exist. Refer to IEC 60086-4 and IEC 60086-5 for further details.

Annex H
(informative)

Compliance checklist

Subclause(s)	Item
4.1.2 & 5.7	Dimensions
4.1.3	Terminals
4.1.3.2	Contact pressure resistance
4.1.3.9	Snap fasteners
4.1.3.10	Wire
4.1.3.11	Other spring contacts of clips
4.1.6	Marking
4.2.2	Dimensional stability
4.2.3	Leakage
4.2.4	Open-circuit voltage limits
4.2.5	Service output
5.3	Conformance check to a specified minimum average duration
5.8	Leakage and deformation

Bibliography

IEC 60050-482, *International Electrotechnical Vocabulary (IEV) – Part 482: Primary and secondary cells and batteries*

IEC 60086-6, *Primary batteries – Part 6: Guidance on environmental aspects*

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

ISO/IEC Guide 36:1982, *Preparation of standard methods of measuring performance (SMMP) of consumer goods* (withdrawn 1998)

ISO 2859, *Sampling procedures for inspection by attributes*

ISO 22514-2:2017, *Statistical methods in process management – Capability and performance – Part 2: Process capability and performance of time-dependent process models*

ISO/IEC Directives Part 1:2019, *Procedures for the technical work – Procedures specific to IEC*

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SOMMAIRE

COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

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PILES ÉLECTRIQUES –

Partie 1: Généralités

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 60086-1 a été établie par le comité d'études 35 de l'IEC: Piles.

Cette treizième édition annule et remplace la douzième édition parue en 2015. Cette édition constitue une révision technique.

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

a) une liste de contrôle de conformité a été ajoutée comme Annexe H;
b) les définitions ont été harmonisées avec les autres documents de la série IEC 60086;
c) la tension nominale du système zinc-air est désormais indiquée comme étant de 1,4 V ou 1,45 V;
d) l'Annexe F de calcul des valeurs de la MAD a été simplifiée;

e) une période de validité pour les essais a été ajoutée;

f) l'essai de vieillissement accéléré à 45 °C est passé de 13 semaines à 4 semaines;

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

FDIS	Rapport de vote
35/1465/FDIS	35/1469/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 internationale.

La version française de la norme n'a pas été soumise au vote.

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

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

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

Le comité a décidé que le contenu de ce document 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 au document recherché. A cette date, le document sera

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

INTRODUCTION

Le contenu technique de la présente partie de l'IEC 60086 fournit les exigences et des informations fondamentales sur les piles électriques. Toutes les piles relevant de la série IEC 60086 sont considérées comme étant des piles sèches. Dans ce contexte, l'IEC 60086-1 constitue la partie principale de la série IEC 60086 et sert de base aux autres parties. La présente partie inclut, par exemple, les informations élémentaires sur les définitions, la nomenclature, les dimensions et le marquage. S'il intègre des exigences spécifiques, le contenu de la présente partie tend surtout à expliquer la méthodologie (comment) et la justification (pourquoi).

Au fil des années, la présente partie a été modifiée pour en améliorer le contenu et elle fait l'objet d'un suivi permanent pour s'assurer que la publication est maintenue à jour avec les avancées, à la fois dans le domaine des piles électriques et des technologies, des dispositifs qui les utilisent.

Les exigences de sécurité et des recommandations sont données dans l'IEC 60086-4, dans l'IEC 60086-5 et dans l'IEC 62281. Les spécifications sont données dans l'IEC 60086-2 et dans l'IEC 60086-3. Les aspects environnementaux sont traités dans l'IEC 60086-6.

PILES ÉLECTRIQUES –

Partie 1: Généralités

1 Domaine d'application

La présente partie de l'IEC 60086 est destinée à normaliser les piles électriques en ce qui concerne les dimensions, la nomenclature, les configurations des bornes, les marquages, les méthodes d'essai, les caractéristiques types de fonctionnement, la sécurité et les aspects environnementaux.

Le présent document spécifie d'une part les exigences pour les piles électriques. D'autre part, le présent document spécifie également des procédures de normalisation des exigences relatives à ces piles.

En tant qu'outil de classification des piles électriques, le présent document spécifie les lettres des systèmes, les électrodes, les électrolytes et les tensions nominales, ainsi que maximales en circuit ouvert des systèmes électrochimiques.

L'objectif de la présente partie de l'IEC 60086 est d'assurer aux utilisateurs, aux concepteurs de dispositifs et aux fabricants de piles que les piles de différents fabricants sont interchangeables par leur forme, leur montage et leur fonction. De plus, pour assurer la conformité à ce qui précède, la présente partie spécifie des méthodes d'essai normalisées pour les piles électriques.

Le présent document contient également des exigences à l'Annexe A qui justifient l'introduction ou le maintien de piles dans la série IEC 60086.

2 Références normatives

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

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

IEC 60086-3, *Piles électriques – Partie 3: Piles pour montres*

IEC 60086-4, *Piles électriques – Partie 4: Sécurité des piles au lithium*

IEC 60086-5, *Piles électriques – Partie 5: Sécurité des piles à électrolyte aqueux*

3 Termes et définitions

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

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

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

3.1
essai d'application
simulation de l'utilisation réelle d'une pile dans une application spécifique

3.2
pile
un ou plusieurs éléments raccordés électriquement et placés dans un boîtier, équipés des dispositifs nécessaires pour l'emploi, par exemple bornes, marquage et dispositifs de protection

[SOURCE: IEC 60050-482:2004, 482-01-04, modifiée.]

3.3
(élément ou pile) **bouton**
petit élément ou petite pile de forme ronde dont la hauteur totale est inférieure au diamètre, contenant un électrolyte aqueux

Note 1 à l'article: Voir (élément ou pile) bouton, (élément ou pile) bouton lithium.

[SOURCE: IEC 60050-482:2004 482-02-40]

3.4
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]

3.5
tension de décharge
CCV
tension électrique aux bornes d'une pile pendant la décharge

Note 1 à l'article: L'abréviation "CCV" est dérivée du terme anglais développé correspondant "closed-circuit voltage".

[SOURCE: IEC 60050-482:2004, 482-03-28, modifiée – "tension électrique entre les bornes d'un élément ou d'une batterie" remplacé par "tension électrique aux bornes d'une pile".]

3.6
(élément ou pile) **bouton lithium**
petit élément ou petite pile de forme ronde dont la hauteur totale est inférieure au diamètre, contenant un électrolyte non aqueux

Note 1 à l'article: Typiquement, la tension nominale des piles au lithium est supérieure à 2 V.

Note 2 à l'article: Voir (élément ou pile) bouton.

3.7
(élément ou pile) **cylindrique**
élément ou pile de forme ronde dont la hauteur totale est supérieure ou égale au diamètre

[SOURCE: IEC 60050-482:2004, 482-02-39, modifiée – "élément de forme cylindrique" remplacée par "élément ou pile de forme ronde"]

3.8
décharge (d'une pile électrique)
opération par laquelle une pile fournit du courant à un circuit extérieur

3.9
pile (électrique) **sèche**
pile électrique dans laquelle l'électrolyte liquide est essentiellement immobilisé

[SOURCE: IEC 60050-482:2004, 482-04-14, modifiée – remplacement de "dont l'électrolyte est immobilisé".]

3.10
tension d'arrêt
EV
tension spécifiée pour laquelle la décharge de la pile est terminée

Note 1 à l'article: L'abréviation "EV" est dérivée du terme anglais développé correspondant "end-point voltage".

[SOURCE: IEC 60050-482:2004, 482-03-30]

3.11
fuite
perte imprévue d'électrolyte, de gaz ou d'autres substances provenant d'un élément ou d'une pile

Note 1 à l'article: Il convient de ne pas confondre les fuites dans ce contexte avec les critères d'évaluation des essais de fuite spécifiés à l'Article 4 et à l'Article 5 du présent document.

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

3.12
durée moyenne minimale
MAD
temps de décharge moyen minimal obtenu à partir d'un échantillon de piles

Note 1 à l'article: L'essai de décharge est réalisé conformément aux méthodes ou normes spécifiées et il est conçu afin de démontrer la conformité à la norme applicable aux types de piles.

Note 2 à l'article: L'abréviation "MAD" est dérivée du terme anglais développé correspondant "minimum average duration".

3.13
tension nominale (d'une pile électrique)
U_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, modifiée – ajout de "(d'une pile électrique)" et du symbole U_n.]

3.14
tension en circuit ouvert
OCV
tension électrique aux bornes d'un élément ou d'une pile lorsque le courant de décharge est nul

Note 1 à l'article: L'abréviation "OCV" est dérivée du terme anglais développé correspondant "open-circuit voltage".

3.15
(élément ou pile) **électrique**
élément ou pile qui n'est pas conçu pour être rechargé électriquement

3.16
(élément ou pile) **rond**
élément ou pile de section circulaire

3.17
capacité (d'une pile électrique)
durée utile ou capacité ou puissance d'une pile dans des conditions de décharge définies

3.18
essai de capacité
essai conçu pour mesurer la capacité d'une pile

Note 1 à l'article: Un essai de capacité peut être prescrit, par exemple, lorsque

a) un essai d'application est trop complexe à reproduire;

b) la durée d'un essai d'application le rend infaisable en pratique à des fins d'essais individuels de série.

3.19
durée de stockage
durée, dans des conditions spécifiées, à la fin de laquelle une pile a conservé son aptitude à fournir une capacité spécifiée

[SOURCE: IEC 60050-482:2004, 482-03-47, modifiée – "fonction" remplacée par "capacité".]

3.20
bornes (d'une pile électrique)
parties conductrices d'une pile destinées au raccordement à un circuit externe

4 Exigences

4.1 Généralités

4.1.1 Conception

Les piles électriques sont principalement vendues sur les marchés grand public. Au cours des dernières années, elles sont devenues plus sophistiquées à la fois du point de vue chimique et du point de vue de leur construction, par exemple leur capacité et leur aptitude à des décharges à régime élevé ont augmenté pour satisfaire aux besoins croissants des nouvelles technologies utilisant l'alimentation par pile.

Lors de la conception des piles électriques, les considérations indiquées ci-dessus doivent être prises en compte. En particulier, leur conformité dimensionnelle et leur stabilité, leurs performances physiques et électriques et leur fonctionnement en toute sécurité en utilisation normale, ainsi que dans les conditions de mauvais usage prévisible, doivent être assurés.

Des informations supplémentaires sur la conception des appareils peuvent être trouvées dans l'Annexe B.

4.1.2 Dimensions des piles

Les dimensions des types individuels de piles sont données dans l'IEC 60086-2 et l'IEC 60086-3.

4.1.3 Bornes

4.1.3.1 Généralités

Les bornes doivent être conformes à l'Article 6 de l'IEC 60086-2:2015.

Leur forme physique doit être conçue de manière à assurer que les piles offrent et maintiennent un bon contact électrique à tout moment.

Elles doivent être réalisées dans des matériaux qui offrent une bonne conductivité électrique et une résistance à la corrosion.

4.1.3.2 Résistance des contacts à la pression

Lorsque cela est indiqué dans les tableaux ou les feuilles de spécification des piles de l'IEC 60086-2, ce qui suit s'applique:

– une force de 10 N appliquée par l'intermédiaire d'une bille d'acier de 1 mm de diamètre au centre de chaque surface de contact pendant une durée de 10 s ne doit pas entraîner de déformation apparente qui pourrait empêcher un fonctionnement satisfaisant de la pile.

NOTE Voir aussi IEC 60086-3 pour les exceptions.

4.1.3.3 Capot et fond

Ce type de borne est utilisé pour les piles dont les dimensions sont celles spécifiées aux Figures 1 à 7 de l'IEC 60086-2:2015 et dont la paroi cylindrique de la pile est isolée des bornes.

4.1.3.4 Capot et boîtier

Ce type de borne est utilisé pour les piles dont les dimensions sont celles spécifiées aux Figures 8, 9, 10, 14, 15 et 16 de l'IEC 60086-2:2015, mais dont la paroi cylindrique de la pile fait partie de la borne positive.

4.1.3.5 Bornes à vis

Ce contact se compose d'une tige filetée combinée à un écrou métallique ou métallique isolé.

4.1.3.6 Contacts plats

Il s'agit de surfaces métalliques pratiquement plates assurant une liaison électrique convenable avec les contacts qui s'appuient sur elles.

4.1.3.7 Lames plates élastiques, ressorts spiralés

Ces contacts englobent les lames plates métalliques ou les fils enroulés en spirale qui sont disposés de manière à assurer un contact par pression.

4.1.3.8 Broches et alvéoles

Elles sont réalisées comme un assemblage convenable de contacts métalliques montés dans un support isolant ou un dispositif de maintien et elles sont adaptées pour recevoir les broches correspondantes du bouton.

4.1.3.9 Boutons pression

4.1.3.9.1 Généralités

Ces contacts sont constitués d'un bouton (non élastique) pour la borne positive et d'une douille (élastique) pour la borne négative.

Elles doivent être réalisées dans un métal convenable offrant une liaison électrique efficace lorsqu'elles sont assemblées aux parties correspondantes d'un circuit externe.

4.1.3.9.2 Bouton pression

Ce type de borne est constitué d'un bouton pour la borne positive et d'une douille pour la borne négative. Ces bornes doivent être réalisées dans un métal plaqué de nickel ou dans un matériau approprié. Elles doivent être conçues pour assurer une liaison électrique et physique sûre, lorsqu'elles sont équipées de parties correspondantes similaires pour le raccordement à un circuit électrique.

4.1.3.10 Fil

Les fils peuvent être souples en cuivre étamé isolé à un ou plusieurs brins. La gaine du fil positif doit être rouge et celle du fil négatif, noire.

4.1.3.11 Autres contacts ou pinces à ressort

Ces contacts sont généralement utilisés avec les piles lorsque les parties correspondantes du circuit extérieur ne sont pas connues avec précision. Ils doivent être en laiton ou dans un autre matériau ayant des propriétés équivalentes.

4.1.4 Classification (système électrochimique)

Les piles électriques sont classées en fonction de leur système électrochimique.

A l'exception du système zinc-chlorure d'ammonium et chlorure de zinc-bioxyde de manganèse, les autres systèmes sont désignés par une lettre.

Le Tableau 1 donne les systèmes électrochimiques qui ont été normalisés jusqu'à ce jour.

Tableau 1 – Systèmes électrochimiques normalisés

Lettre	Electrode négative	Electrolyte	Electrode positive	Tension nominale V	Tension maximale en circuit ouvert V
Pas de lettre	Zinc (Zn)	Chlorure d'ammonium, chlorure de zinc	Dioxyde de manganèse (MnO_2)	1,5	1,73
A	Zinc (Zn)	Chlorure d'ammonium, chlorure de zinc	Oxygène (O_2)	1,4	1,55
B	Lithium (Li)	Electrolyte organique	Monofluorure de carbone $(CF)_x$	3,0	3,7
C	Lithium (Li)	Electrolyte organique	Dioxyde de manganèse (MnO_2)	3,0	3,7
E	Lithium (Li)	Non aqueux minéral	Chlorure de thionyle ($SOCl_2$)	3,6	3,9
F	Lithium (Li)	Electrolyte organique	Disulfure de fer (FeS_2)	1,5	1,83
G	Lithium (Li)	Electrolyte organique	Oxyde de cuivre (II) (CuO)	1,5	2,3
L	Zinc (Zn)	Hydroxyde de métal alcalin	Dioxyde de manganèse (MnO_2)	1,5	1,68
P	Zinc (Zn)	Hydroxyde de métal alcalin	Oxygène (O_2)	1,4 ou 1,45	1,59
S	Zinc (Zn)	Hydroxyde de métal alcalin	Oxyde d'argent (Ag_2O)	1,55	1,63
W	Lithium (Li)	Electrolyte organique	Dioxyde de soufre (SO_2)	3,0	3,05
Y	Lithium (Li)	Non aqueux minéral	Chlorure de sulfuryle (SO_2Cl_2)	3,9	4,1
Z	Zinc (Zn)	Hydroxyde de métal alcalin	Oxyhydroxyde de nickel (NiOOH)	1,5	1,78

NOTE 1 La valeur de la tension nominale n'est pas vérifiable; c'est la raison pour laquelle, elle n'est donnée qu'à titre de référence.

NOTE 2 La tension maximale en circuit ouvert (3.14) est mesurée comme cela est défini en 5.5 et en 6.8.1.

NOTE 3 Lorsqu'on fait référence à un système électrochimique, le protocole commun consiste à indiquer l'électrode négative d'abord, puis l'électrode positive, c'est-à-dire lithium-disulfure de fer.

NOTE 4 Les références aux systèmes électrochimiques de ce tableau apparaissent généralement sous une forme simplifiée comme "batteries du système B et C" ou "batteries du système sans lettre".

4.1.5 Désignation

La désignation des piles électriques est fondée sur leurs paramètres physiques, leur système électrochimique, ainsi que sur des caractères particuliers, si nécessaire.

L'Annexe C donne une explication complète du système de désignation (nomenclature).

4.1.6 Marquage

4.1.6.1 Généralités

Pour un aperçu des exigences relatives au marquage, voir Tableau 2. A l'exception des piles trop petites pour être marquées avec tous les marquages (voir 4.1.6.2), chaque pile doit être marquée avec les informations suivantes:

a) désignation, IEC ou commune;

b) expiration de la période d'utilisation recommandée ou année et mois ou semaine de fabrication. L'année et le mois ou la semaine de fabrication peuvent être codés;

c) la polarité de la borne positive (+);

d) la tension nominale;

e) le nom ou la marque commerciale du fabricant ou du fournisseur;

f) les conseils de prudence.

NOTE Des exemples de désignations communes peuvent être trouvés dans l'Annexe D de l'IEC 60086-2:2015.

4.1.6.2 Marquage des petites piles

a) Certaines piles, principalement de catégorie 3 et de catégorie 4, ont une surface trop petite pour comporter tous les marquages indiqués en 4.1.6.1. Pour ces piles, la désignation de 4.1.6.1a) et la polarité de 4.1.6.1c) doivent être marquées sur la pile. Tous les autres marquages indiqués en 4.1.6.1 peuvent être donnés sur le premier emballage au lieu de l'être sur la pile.

b) Pour les piles du système "P", les informations de 4.1.6.1a) peuvent être indiquées sur la pile, sur le système d'obturation ou sur l'emballage. Les informations de 4.1.6.1c) peuvent être marquées sur le système d'obturation et/ou sur la pile. Les informations de 4.1.6.1b), de 4.1.6.1d) et de 4.1.6.1e) peuvent être indiquées sur le premier emballage au lieu de l'être sur la pile. La tension nominale peut être marquée soit 1,4 V, soit 1,45 V.

c) Un avertissement doit être donné concernant le danger d'ingestion des piles qui peuvent être avalées. Voir les versions actuelles valides de l'IEC 60086-4 et de l'IEC 60086-5 pour plus de détails.

Tableau 2 – Exigences relatives au marquage

Marquage	Piles à l'exception des piles trop petites pour comporter tous les marquages	Piles trop petites pour comporter tous les marquages	
			Piles du système P
a) Désignation, IEC ou commune	A	A	C
b) Expiration de la période d'utilisation recommandée ou année et mois ou semaine de fabrication. L'année et le mois ou la semaine de fabrication peuvent être codés	A	B	B
c) Polarité de la borne positive (+)	A	A	D
d) Tension nominale	A	B	B
e) Nom ou marque commerciale du fabricant ou du fournisseur	A	B	B
f) Conseils de prudence	A	B[a]	B[a]

Légende

A: doivent être marquées sur la pile

B: peuvent être marquées sur le premier emballage au lieu de l'être sur la pile

C: peuvent être marquées sur la pile, sur le système d'obturation ou sur le premier emballage

D: peuvent être marquées sur le système d'obturation et/ou sur la pile

[a] Un avertissement doit être donné concernant le danger d'ingestion des piles qui peuvent être avalées. Voir IEC 60086-4 et IEC 60086-5 pour plus de détails.

4.1.6.3 Marquage des piles concernant la mise au rebut

Le marquage concernant la mise au rebut des piles doit être conforme aux exigences légales locales.

4.1.7 Interchangeabilité: tension de la pile

Les piles électriques telles qu'elles sont normalisées à l'heure actuelle dans la série IEC 60086 peuvent être classées en catégories en fonction de leur tension de décharge normalisée, U_s. Pour un nouveau système de piles, son interchangeabilité est évaluée par la tension avec la Formule (1) suivante:

$$n \times 0{,}85\ U_r \leq m \leq U_s \leq n \times 1{,}15\ U_r \quad (1)$$

où

n est le nombre d'éléments connectés en série sur la base de la tension de référence, U_r;

m est le nombre d'éléments connectés en série sur la base de la tension de décharge normalisée, U_s;

U_r est la tension de référence;

U_s est la tension de décharge normalisée.

Actuellement, deux plages de tension conformes à la formule ci-dessus ont été identifiées. Elles sont identifiées par la tension de référence, U_r, qui est le point central de la plage de tension concernée.

Plage de tension 1, U_r = 1,40 V: piles ayant une tension de décharge normalisée, $m \times U_s$, égale à ou dans la plage de n × 1,19 V à n × 1,61 V.

Plage de tension 2, U_r = 3,20 V: piles ayant une tension de décharge normalisée, $m \times U_s$, égale à ou dans la plage de n × 2,72 V à n × 3,68 V.

Le terme de tension de décharge normalisée, les grandeurs connexes, ainsi que les méthodes de leur détermination, sont donnés à l'Annexe D.

NOTE Pour les piles à élément unique et pour les piles à plusieurs éléments de même plage de tension, m et n sont identiques; m et n sont différents pour les piles à plusieurs éléments qui ne sont pas de la même plage de tension qu'une pile déjà normalisée.

La plage de tension 1 englobe toutes les piles normalisées à l'heure actuelle ayant une tension nominale de 1,5 V, c'est-à-dire système sans lettre, systèmes A, F, G, L, P, S et Z.

La plage de tension 2 englobe toutes les piles normalisées à l'heure actuelle ayant une tension nominale de 3 V, c'est-à-dire les systèmes B, C, E, W et Y.

Etant donné que les piles de la plage de tension 1 et celles de la plage de tension 2 présentent des tensions de décharge très différentes, elles doivent être conçues pour ne pas être physiquement interchangeables. Avant de normaliser un nouveau système électrochimique, sa tension de décharge normalisée doit être déterminée conformément à la procédure donnée à l'Annexe D pour trouver une solution à son interchangeabilité par la tension.

AVERTISSEMENT Le non-respect de cette exigence peut présenter des dangers pour l'utilisateur, tels qu'incendie, explosion, fuite et/ou endommagements de dispositif. Cette exigence est nécessaire pour des raisons de sécurité et de fonctionnement.

4.2 Fonctionnement

4.2.1 Performance de décharge

Les performances de décharge des piles électriques sont spécifiées dans l'IEC 60086-2.

4.2.2 Stabilité dimensionnelle

Les dimensions des piles doivent être conformes aux dimensions spécifiées correspondantes données dans l'IEC 60086-2 et dans l'IEC 60086-3 à tout moment au cours des essais de décharge dans les conditions normalisées.

Une augmentation de la hauteur de la pile de 0,25 mm peut se produire avec les éléments boutons et boutons lithium des systèmes G, L, P et S, dans le cas d'une décharge inférieure à la tension d'arrêt.

A titre d'information pour les fabricants de compartiments des piles, pour certains éléments boutons lithium des systèmes C et B, une diminution de la hauteur de la pile peut se produire dans le cas d'une décharge inférieure à la tension d'arrêt.

4.2.3 Fuites

Lorsque les piles sont conservées et déchargées dans les conditions normalisées données dans le présent document, aucune fuite ne doit intervenir.

4.2.4 Limites de tension en circuit ouvert

La tension maximale en circuit ouvert des piles ne doit pas dépasser les valeurs données dans le Tableau 1.

4.2.5 Capacité

Les durées de décharge, initiale et après conservation, des piles doivent satisfaire aux exigences données dans l'IEC 60086-2.

4.2.6 Sécurité

Lors de la conception des piles électriques, il doit être tenu compte de la sécurité dans les conditions d'utilisation prévue et de mauvais usage prévisible comme cela est prescrit dans l'IEC 60086-4 et l'IEC 60086-5.

4.2.7 Validité des essais

Les piles électriques portables doivent être soumises aux essais, comme exigé dans la série IEC 60086. Les résultats des essais restent valides jusqu'à ce qu'une modification de la conception ou une révision des exigences ait été effectuée. De nouveaux essais sont exigés lorsque:

a) une spécification de masse de pile varie de plus de 0,1 g ou de 20 %, la plus grande des valeurs, pour la cathode, l'anode ou l'électrolyte;
b) la modification d'une spécification d'une pile entraînerait un échec des essais;
c) de nouveaux essais ou de nouvelles exigences sont ajoutés; ou
d) la modification d'une exigence entraînerait un échec des essais.

5 Performances – Essais

5.1 Essais de capacité par rapport aux essais d'application et de capacité

La préparation des méthodes normalisées d'essais d'aptitude à l'emploi (MNEA) des biens de consommation est présentée à l'Annexe E.

La capacité d'une pile électrique peut être établie par des essais de décharge électrique comme décrit en détail en D.2.3. Toutefois, dans des conditions d'utilisation par un consommateur, les capacités réalisées par des méthodes d'essai de décharge électrique peuvent varier.

Les facteurs et les variables présentés ci-dessous ont un effet important sur la réalisation optimale de la capacité.

a) la demande en courant des dispositifs et des circuits électriques externes.

b) la fréquence de la demande en courant (utilisation continue ou intermittente).

c) la tension minimale à laquelle le dispositif fonctionne de manière satisfaisante (tension de coupure).

d) la température de fonctionnement.

A partir des variables présentées de a) à d), une demande élevée en courant pendant des périodes prolongées et une tension de coupure élevée et à une basse température représentent les conditions les plus défavorables qui entraînent une perte importante de capacité.

Puisque la capacité d'origine électrique ou chimique d'une pile électrique ne peut pas être utilisée de manière fiable dans les calculs finals des performances, il est essentiel d'informer l'utilisateur sur les performances et la durée de vie des piles lorsqu'elles sont utilisées dans des dispositifs typiques alimentés par piles. Il convient toutefois de noter que ces "essais d'application" (définis dans l'IEC 60086-2) peuvent ne pas reproduire entièrement un dispositif ou une application du marché. En effet, ceux-ci comportent de nombreuses variations dont les exigences électriques sont différentes. En outre, les performances d'une pile peuvent être affectées par une ou plusieurs des conditions a) à d) présentées ci-dessus.

L'Annexe E a donc été tirée de l'ISO/IEC Guide 36:1982 (actuellement annulé).

5.2 Essai de décharge

5.2.1 Généralités

Les essais de décharge du présent document entrent dans deux catégories:

– les essais d'application;

– les essais de capacité.

Dans les deux catégories d'essais, les résistances de décharge sont spécifiées conformément à 6.4.

Les méthodes d'essai de détermination des conditions de décharge et d'essai sont données en 5.2.2 et en 5.2.3.

5.2.2 Essais d'application

5.2.2.1 Généralités

a) La résistance équivalente est calculée à partir du courant moyen et de la tension moyenne de fonctionnement des équipements en décharge. Des décharges à courant constant et à puissance constante sont également autorisées pour les applications présentant ces types de demandes de puissance.

b) La tension d'arrêt fonctionnelle et les valeurs de résistance équivalente, de décharge à courant constant ou à puissance constante sont obtenues à partir des mesures d'équipements d'applications typiques.

c) La classe médiane définit la valeur de la décharge et la tension d'arrêt à utiliser pour l'essai de décharge.

d) Si les données sont concentrées en deux ou plusieurs groupes très éloignés, plusieurs essais peuvent être exigés.

Les essais d'application peuvent être accélérés par la résistance de décharge, par un cycle de service journalier, ou par les deux. Il convient que les valeurs spécifiées pour la décharge et pour l'intermittence tiennent compte des facteurs suivants:

– l'efficacité de décharge de la pile en fonction de l'application,

– l'utilisation d'un cycle de service typique pour l'application,
– le temps total nécessaire pour réaliser l'essai ne dépasse pas 30 jours.

Certains essais sur résistance fixe ont été choisis pour simplifier la conception et assurer la fiabilité des appareils d'essai bien que dans certains cas particuliers, des essais à courant constant ou à puissance constante puissent constituer une meilleure représentation de l'application.

Dans le futur, des conditions de décharge supplémentaires ou alternatives pourront être nécessaires pour représenter la gamme des applications utilisées. Il est probable que les caractéristiques de décharge d'une catégorie particulière d'équipements changent avec le temps en raison du développement de la technologie.

La détermination précise de la tension d'arrêt de fonctionnement de l'équipement n'est pas toujours possible. Les conditions de décharge sont au mieux un compromis choisi pour représenter une catégorie d'équipements qui peut avoir des caractéristiques largement divergentes.

Toutefois, malgré ces limitations, l'essai d'application déterminé est la meilleure approche connue pour l'estimation des possibilités des piles pour une catégorie particulière d'équipements.

NOTE Pour limiter la prolifération des essais d'application, il convient que les essais spécifiés visent les appareils correspondant à 80 % du marché par désignation de pile.

5.2.2.2 Essais d'application avec plusieurs décharges

Pour les essais d'application avec plusieurs décharges, l'ordre des décharges au cours d'un cycle doit commencer par la décharge la plus importante et aller vers la décharge la plus faible, sauf spécification contraire.

5.2.3 Essais de capacité

Pour les essais de capacité, il convient de choisir la valeur de la résistance de décharge de manière à ce que la capacité soit restituée sur une période d'environ 30 jours.

Lorsque la pleine capacité n'est pas obtenue dans les délais exigés, la capacité peut être augmentée jusqu'à la plus courte durée adaptée qui suit en choisissant une résistance de décharge de valeur ohmique plus faible, comme défini en 6.4.

5.3 Vérification de conformité à une durée moyenne minimale spécifiée

Pour vérifier la conformité d'une pile à n'importe lequel des essais de décharge spécifiés dans l'IEC 60086-2 et l'IEC 60086-3, l'essai doit être réalisé de la manière suivante:

a) soumettre huit piles à l'essai.
b) calculer la moyenne en n'excluant aucun résultat.
c) si cette moyenne est supérieure ou égale à la valeur spécifiée et qu'une pile au plus a une capacité inférieure à 80 % de la valeur spécifiée, les piles sont considérées comme conformes en matière de capacité.
d) si cette moyenne est inférieure à la valeur spécifiée et/ou si plus d'une pile présente une capacité inférieure à 80 % de la valeur spécifiée, répéter l'essai sur un autre échantillon de huit piles et calculer la moyenne comme précédemment.
e) si la moyenne de ce deuxième essai est supérieure ou égale à la valeur spécifiée et qu'une pile au plus a une capacité inférieure à 80 % de la valeur spécifiée, les piles sont considérées comme conformes en matière de capacité.

f) si la moyenne du deuxième essai est inférieure à la valeur spécifiée et/ou si plus d'une pile a une capacité inférieure à 80 % de la valeur spécifiée, les piles sont considérées comme non conformes et il n'est pas autorisé de procéder à d'autres essais.

g) une acceptation conditionnelle doit être donnée à l'issue des essais de décharge initiaux afin de vérifier la conformité au présent document.

NOTE Les performances de décharge des piles électriques sont spécifiées dans l'IEC 60086-2.

5.4 Recommandations pour la prise en compte de la valeur proposée de durée moyenne minimale

Cette recommandation est décrite à l'Annexe F.

5.5 Essais de tension en circuit ouvert

La tension en circuit ouvert doit être mesurée avec l'équipement de mesure de tension spécifié en 6.8.1.

5.6 Résistance d'isolement

Pour les piles avec étiquettes, boîtiers ou gaines isolantes, la résistance entre les surfaces de la pile exposées à l'extérieur et l'une des bornes doit être supérieure ou égale à 5 MΩ à 500^{+100}_{0} V pendant au plus 60 s.

5.7 Dimensions des piles

Les dimensions doivent être mesurées avec l'équipement de mesure spécifié en 6.8.2.

5.8 Fuite et déformation

A l'issue de la détermination de la capacité dans les conditions d'environnement spécifiées, la décharge doit être maintenue de la même manière jusqu'à ce que la tension de décharge chute pour la première fois en dessous de 40 % de la tension nominale de la pile Les exigences de 4.1.3, de 4.2.2 et de 4.2.3 doivent être satisfaites.

NOTE Les piles boutons et boutons lithium, la recherche visuelle de fuites est réalisée conformément aux articles respectifs de l'IEC 60086-3 et de l'IEC 60086-5.

6 Performance – Conditions d'essai

6.1 Conditions de stockage et de décharge

Le stockage avant les essais de décharge et l'essai réel de décharge sont effectués dans des conditions bien définies. Sauf spécification contraire, les conditions données dans le Tableau 3 doivent s'appliquer. Dans la suite du texte, les conditions de décharge présentées sont dites conditions normalisées.

Tableau 3 – Conditions de stockage avant et pendant l'essai de décharge

Type d'essai	Conditions de stockage			Conditions de décharge	
	Température °C	Humidité relative % HR	Durée	Température °C	Humidité relative [d] % HR
Essai à l'état frais	20 ± 5 [a]	55 + 20 / -40	60 jours maximum après la date de fabrication	20 ± 2	55 + 20 / -40
Essai de décharge après conservation[e]	20 ± 5 [a]	55 + 20 / -40	12 mois	20 ± 2	55 + 20 / -40
Essai de décharge après conservation (haute température) [b,e]	45 ± 2 [c]	55 ± 20	4 semaines	20 ± 2	55 + 20 / -40

[a] La température de stockage peut dévier de ces limites uniquement pendant de courtes durées sans dépasser (20 ± 10) °C.

[b] Cet essai est réalisé lorsqu'un essai de stockage à haute température est exigé. Les exigences de performance sont soumises à accord entre le fabricant et le client.

[c] Les piles doivent être conservées sans emballage.

[d] A l'exception des systèmes "P" et "A": (55 ± 10) % HR.

[e] Il convient que les performances atteignent ou dépassent le pourcentage de la valeur de la durée moyenne minimale (MAD).

6.2 Commencement des essais de décharge après stockage

La période entre l'achèvement du stockage et le commencement de l'essai de décharge après stockage ne doit pas dépasser 14 jours.

Pendant cette période, les piles doivent être conservées à (20 ± 2) °C et (55 + 20 / −40) % d'humidité relative (sauf dans le cas des piles du système P pour lesquelles l'humidité relative doit être de (55 ± 10) % HR).

Il faut attendre au moins une journée dans ces conditions pour permettre un retour à l'équilibre avant de démarrer un essai de décharge après stockage à haute température.

6.3 Conditions d'essai de décharge

6.3.1 Généralités

Pour soumettre une pile à l'essai, celle-ci doit être déchargée comme cela est spécifié dans l'IEC 60086-2 ou dans l'IEC 60086-3 jusqu'à ce que la tension lors de la décharge chute pour la première fois en dessous de la tension d'arrêt spécifiée. La capacité peut être exprimée en impulsions, en durée, en capacité ou en énergie.

6.3.2 Conformité

Lorsque l'IEC 60086-2 ou l'IEC 60086-3 spécifient des capacités pour plusieurs essais de décharge, les piles doivent satisfaire à toutes ces exigences pour être conformes au présent document.

6.4 Résistance de décharge

La valeur de la charge résistive (y compris la résistance de toutes les parties du circuit extérieur) doit être la valeur indiquée dans la feuille de spécification individuelle; sa précision doit être de ±0,5 %.