

INTERNATIONAL STANDARD

IEC
60086-1

Ninth edition
2000-11

Primary batteries –

Part 1: General

Piles électriques –

*Partie 1:
Généralités*



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INTERNATIONAL ELECTROTECHNICAL COMMISSION

PRIMARY BATTERIES –

Part 1: General

FOREWORD

- 1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the 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, the IEC publishes International Standards. 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. The 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 ninth edition cancels and replaces the eighth edition and its amendments 1 and 2, published in 1996, and constitutes a technical revision.

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

FDIS	Report on voting
35/1131/FDIS	35/1141/RVD

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

This publication has been drafted in accordance with the ISO/IEC Directives, Part 3.

Annexes A, B, C, D and E form an integral part of this standard.

Annex F, G and H are for information only.

The committee has decided that the contents of this publication will remain unchanged until 2001. At this date, the publication will be

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- withdrawn;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

IEC 60086 consists of the following parts, under the general title: Primary batteries:

- Part 1: General
- Part 2: Physical and electrical specifications¹⁾
- Part 3: Watch batteries
- Part 4: Safety of lithium batteries
- Part 5: Safety of batteries with aqueous electrolyte¹⁾

A bilingual version of this standard may be issued at a later date.

¹⁾ To be published.

INTRODUCTION

The technical content of this part of IEC 60086 provides fundamental requirements and information on primary cells and batteries. In this sense, part 1 is the main component of IEC 60086 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).

The objective of IEC 60086-1 is to benefit primary battery users, device designers and battery manufacturers by ensuring that batteries from different manufacturers are interchangeable according to a standard form, fit and function. Furthermore, to ensure compliance with the above, this part specifies standard test methods for testing primary cells and batteries.

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. This current revision is the result of a reformatting initiative, as well as some content changes, aimed at making it more user-friendly, less ambiguous, and on a cross-reference basis, fully harmonized with other parts of IEC 60086 (such as IEC 60086-2 and IEC 60086-3).

NOTE Safety information has been removed from IEC 60086-1 and is now available in IEC 60086-4 and IEC 60086-5.

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PRIMARY BATTERIES –

Part 1: General

1 Scope

The purpose of this part of IEC 60086 is to standardize primary batteries with respect to their electrochemical system, dimensions, nomenclature, terminal configurations, markings, test methods, typical performance, safety and environmental aspects.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 60086. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of IEC 60086 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of IEC and ISO maintain registers of currently valid International Standards.

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

IEC 60086-3:1995, *Primary batteries – Part 3: Watch batteries*

IEC 60086-4:2000, *Primary batteries – Part 4: Safety of lithium batteries*

IEC 60086-5, *Primary batteries – Part 5: Safety of batteries with aqueous electrolyte*²⁾

IEC 60410:1973, *Sampling plans and procedures for inspection by attributes*

IEC 61429:1995, *Marking of secondary cells and batteries with the international recycling symbol ISO 7000-1135*

ISO 3951:1989, *Sampling procedures and charts for inspection by variables for percent non-conforming*

ISO/IEC Directives – Part 2: 1992

3 Definitions

For the purpose of this part of IEC 60086, the following definitions apply.

3.1

application test

test which simulates the actual use of a battery in a specific application, for example "portable lighting", "tape recorder" or "transistor radio" test

²⁾ To be published.

3.2**discharge (of a primary battery)**

operation during which a battery delivers current to an external circuit

3.3**dry (primary) battery**

primary battery in which the liquid electrolyte is immobilized

3.4**effective internal resistance – DC method**

resistance of any electrical component determined by calculating the ratio between the voltage drop ΔU across this component and the range of current Δi passing through this component and causing the voltage drop $R = \Delta U / \Delta i$

NOTE As an analogy, the internal d.c. resistance R_i of any electrochemical cell is defined by the the following relation:

$$R_i (\Omega) = \frac{\Delta U (V)}{\Delta i (A)} \quad (1)$$

The internal d.c. resistance is illustrated by the schematic voltage transient as given below:

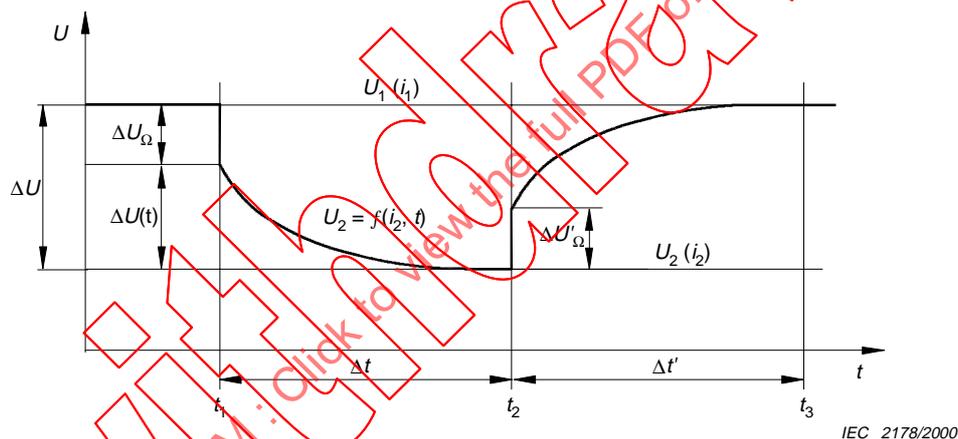


Figure 1 – Schematic voltage transient

As can be seen from this diagram, the voltage drop ΔU of the two components differs in nature, as shown in the following relation:

$$\Delta U = \Delta U_{\Omega} + \Delta U (t) \quad (2)$$

The first component ΔU_{Ω} for $(t = t_1)$ is independent of time, and results from the increase in current Δi according to the relation:

$$\Delta U_{\Omega} = \Delta i \times R_{\Omega} \quad (3)$$

In this relation, R_{Ω} is a pure ohmic resistance. The second component $\Delta U (t)$ is time dependent and is of electrochemical origin.

3.5**end-point voltage**

specified closed circuit voltage at which a service output test is terminated

3.6**leakage**

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

3.7

minimum average duration (MAD)

minimum average time on discharge which is met by a set of batteries

NOTE 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.

3.8

nominal voltage of a primary battery

suitable approximate value of voltage used to identify the voltage of a primary battery

3.9

on-load voltage

closed circuit voltage (CCV)

voltage across the terminals of a battery when it is on discharge

3.10

open-circuit voltage (OCV)

off-load voltage

voltage across the terminals of a battery when no external current is flowing

3.11

primary battery

one or more primary cells, including case, terminals and marking

3.12

primary cell

source of electrical energy obtained by the direct conversion of chemical energy not designed to be charged by any other electrical source

3.13

service output (of a primary battery)

service life, or capacity, or energy output of a battery under specified conditions of discharge

3.14

service output test

test designed to measure the service output of a battery

NOTE 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.

3.15

storage life

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

3.16

terminals (of a primary battery)

conductive parts provided for the connection of a battery to external conductors

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.

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

Terminals shall be in accordance with clause 7 of IEC 60086-2.

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 adequate electrical conductivity and corrosion protection.

4.1.3.1 Contact pressure resistance

When mentioned 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.

4.1.3.2 Cap and base

This type of terminal is used for batteries which have their dimensions specified according to figures 1, 2, 3 or 4 of IEC 60086-2, and which have the cylindrical side of the battery insulated from the terminals.

4.1.3.3 Cap and case

This type of terminal is used for batteries which have their dimensions specified according to figures 2, 3 or 4 of IEC 60086-2, but in which the cylindrical side of the battery forms part of the positive terminal.

4.1.3.4 Screw terminals

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

4.1.3.5 Flat contacts

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

4.1.3.6 Flat or spiral springs

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

4.1.3.7 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 corresponding pins of a mating plug.

4.1.3.8 Snap-fasteners

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.

4.1.3.8.1 Spacing of contacts

The spacing between the stud and socket is given in the following table, and applies from centre to centre. The stud always forms the positive connection and the socket the negative connection on the battery.

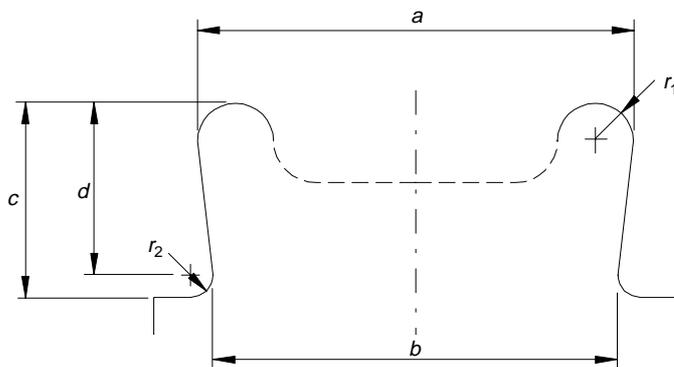
Table 1 – Spacing of contacts

Nominal voltage V	Standard mm	Miniature mm
9	35 ± 0,4	12,7 ± 0,25

4.1.3.8.2 Non-resilient snap-fastener connectors (studs)

Dimensions are given in millimetres.

All dimensions not specified are free. The shape of the stud shall be chosen so that the dimensions specified are conformed to.



IEC 2179/2000

Figure 2 – Standard stud

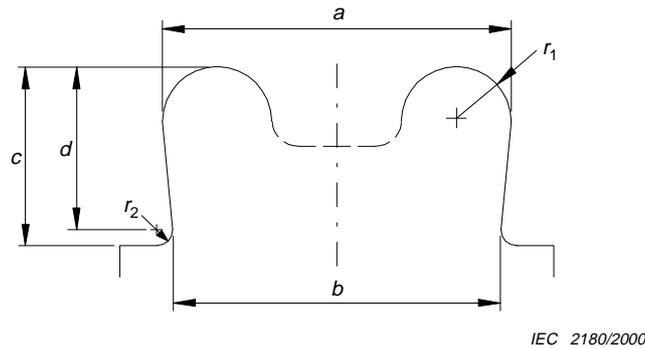


Figure 3 – Miniature stud

Table 2 – Snap-fastener connectors

	Standard mm	Miniature mm
<i>a</i>	$7,16 \pm 0,05$	$5,72 \pm 0,05$
<i>b</i>	$6,65^{+0,07}_{-0,05}$	$5,38 \pm 0,05$
<i>c</i>	$3,20 \pm 0,1$	$3,00 \pm 0,1$
<i>d</i>	$2,67 \pm 0,05$	$2,54 \pm 0,05$
<i>r</i> ₁	$0,61^{+0,05}_{-0,08}$	$0,9^{+0,1}_{-0,3}$
<i>r</i> ₂	$0,4^{+0,3}_0$	$0,3^{+0,2}_0$

4.1.3.8.3 Resilient snap-fastener connectors (sockets)

Dimensions and requirements:

The dimensions of the resilient (socket) parts of snap-fastener connectors are not specified as such. The properties shall be such that:

- the resiliency ensures that the standardized studs can be properly mated;
- good electrical contact is maintained.

4.1.3.9 Wire

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

4.1.3.10 Spring clips

Spring clips are generally used on batteries not readily available to the consumer, 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 3.

Table 3 – Standardized electrochemical systems

Letter	Negative electrode	Electrolyte	Positive electrode	Nominal voltage V	Maximum open circuit voltage V
-	Zinc	Ammonium chloride, Zinc chloride	Manganese dioxide	1,5	1,725
A	Zinc	Ammonium chloride, Zinc chloride	Oxygen	1,4	1,55
B	Lithium	Organic electrolyte	Carbon monofluoride	3	3,7
C	Lithium	Organic electrolyte	Manganese dioxide	3	3,7
E	Lithium	Non-aqueous inorganic	Thionyl chloride (SOCl ₂)	3,6	3,9
F	Lithium	Organic electrolyte	Iron disulfide (FeS ₂)	1,5	1,83
G	Lithium	Organic electrolyte	Copper (II) oxide (CuO)	1,5	2,3
L	Zinc	Alkali metal hydroxide	Manganese dioxide	1,5	1,65
P	Zinc	Alkali metal hydroxide	Oxygen	1,4	1,68
S	Zinc	Alkali metal hydroxide	Silver oxide (Ag ₂ O)	1,55	1,63

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 is measured as defined in 5.4 and 6.7.1.

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.

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 A.

4.1.6 Marking

4.1.6.1 General

With the exception of batteries designated as small, each battery shall be marked with the following information:

- a) designation;
- b) year and month or week of manufacture, which may be in code, or the expiration of a guarantee period, in clear;
- c) polarity of terminals (when applicable);
- d) nominal voltage;
- e) name or trade mark of the manufacturer or supplier.

4.1.6.2 Small batteries

- a) When this subclause is invoked in IEC 60086-2, 4.1.6.1a) and 4.1.6.1c) shall be marked on the battery. Subclauses 4.1.6.1b), 4.1.6.1d) and 4.1.6.1e) may be given on the immediate package 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 of the battery and/or on the battery. Subclauses 4.1.6.1b), 4.1.6.1d) and 4.1.6.1e) may be given on the immediate package instead of on the battery.
- c) Caution for ingestion of small batteries shall be taken. 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. Where required, refer to IEC 61429.

4.1.7 Interchangeability: battery voltage

Primary batteries as presently standardized in IEC 60086 can be categorized by their standard discharge voltage U_s ³⁾. For a new battery system, its interchangeability by voltage is assessed for compliance with the following formula:

$$n \times (U_r - 15\%) \leq m \times U_s \leq n \times (U_r + 15\%)$$

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 .

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, $U_r = 1,4$ (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, $U_r = 3,2$ (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 standard discharge voltage and related quantities, as well as the methods of their determination, are given in annex G.

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 about 1,5 (V), i.e. "no-letter" system, systems A, F, G, L, P and S.

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

³⁾ 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.

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 G 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 and IEC 60086-3.

4.2.2 Dimensional stability

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

NOTE 1 An increase in battery height of 0,25 mm can occur with button cells of the B, C, G, L and P 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.

4.2.3 Leakage

When batteries are stored and discharged under the standard conditions given in this specification, 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 4.1.4.

4.2.5 Service output

Discharge durations, initial and delayed, of batteries shall meet the requirements given in IEC 60086-2 and IEC 60086-3.

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.

5 Performance – Testing

5.1 General

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

5.2 Discharge testing

The discharge tests in this standard fall into two categories:

- application tests;
- service output tests.

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

The methods of determining the load and test conditions are as follows:

5.2.1 Application tests

- a) The equivalent resistance is calculated from the average current and average operating voltage of the equipment under load.
- b) The functional end-point voltage and the equivalent resistance value are obtained from the data on all the equipment measured.
- c) The median class defines the resistance 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.
- e) In selecting the daily discharge period, the total weekly usage of the equipment is considered.

The daily period then becomes the nearest preferred value (see 6.5) to one-seventh of the total weekly usage.

NOTE 1 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 load conditions may become unavoidable. It is also inevitable 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 2 In order to minimize the proliferation of application tests, the tests specified should be those accounting for 80 % of the market by battery size.

5.2.2 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 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, any of the application tests or service output tests specified in IEC 60086-2 and IEC 60086-3 may be chosen.

The test shall be carried out as follows:

- a) Test nine 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 80 % of 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 nine 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.

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

5.4 Calculation method of the specified value of minimum average duration

This method is described in annex D.

5.5 OCV testing

Open-circuit voltage shall be measured with the voltage measuring equipment specified in 6.7.1.

5.6 Battery dimensions

Dimensions shall be measured with the measuring equipment specified in 6.7.2.

5.7 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 batteries, the visual examination for leakage shall be carried out in accordance with clause 9 of IEC 60086-3.

6 Performance – Test conditions

6.1 Pre-discharge conditioning

Storage before discharge testing and the actual discharge test is carried out under well defined conditions. Unless otherwise specified, the conditions given in table 4 shall apply. Discharge conditions shown are further referred to as standard conditions.

Table 4 – Conditions for storage before and during discharge testing

Type of test	Storage conditions °C	Relative humidity %	Duration	Discharge conditions °C	Relative humidity %
Initial discharge test	20 ± 2 ^a	60 ± 15	60 days maximum after date of manufacture	20 ± 2	60 ± 15
Delayed discharge test	20 ± 2 ^a	60 ± 15	12 months	20 ± 2	60 ± 15
Delayed discharge test (high temperature) ^b	45 ± 2 ^c	50 ± 15	13 weeks	20 ± 2	60 ± 15

^a During short periods only, the storage temperature may deviate from these limits without exceeding 20 °C ± 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 customer.

^c Batteries to be stored unpacked.

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 °C ± 2 °C and 60 % ± 15 % 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

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

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

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 load, expressed in ohms, shall, whenever possible, be as follows:

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

together with their decimal multiples or sub-multiples.

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:

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

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

6.6 Activation of 'P'-system batteries

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

6.7 Measuring equipment

6.7.1 Voltage measurement

The accuracy of the measuring equipment shall be $\leq 0,25\%$ and the precision shall be $\leq 50\%$ of the value of the last significant digit. The internal resistance of the measuring instrument shall be $\geq 1\text{ M}\Omega$.

6.7.2 Mechanical measurement

The accuracy of the measuring equipment shall be $\leq 0,025\%$ and the precision shall be $\leq 50\%$ of the value of the last significant digit.

7 Sampling and quality assurance

The use of sampling plans or product quality indices may be agreed between manufacturer and purchaser.

Where no agreement is specified the options in 7.1 and/or 7.2 are recommended.

7.1 Sampling

7.1.1 Testing by attributes

When testing by attributes is required, the sampling plan chosen shall be in accordance with the specifications of IEC 60410. The individual parameters to be tested and the acceptable quality level (AQL) values shall be defined (a minimum of three batteries of the same type shall be tested).

7.1.2 Testing by variables

When testing by variables is required, the sampling plan chosen shall be in accordance with ISO 3951. The individual parameters to be tested, the sample size and the acceptable quality level (AQL) shall be defined.

7.2 Product quality indices

Consideration may be given to utilizing one of the indices below as a means for assessing and ensuring product quality.

7.2.1 Capability index (Cp)

Cp is an index that represents the capability of a process. It explains how much of the tolerance range could be used up by the within sample process variation, σ' , and is defined as $Cp = (USL - LSL) / \text{Process Width}$ where Process Width is expressed as $6\bar{R}/d_2$. If the ratio is ≥ 1 and centered, the process is capable of making parts to specification. However, at $Cp = 1$, automatically 2 700 parts per million are outside of specifications.

NOTE USL = upper specification limit; LSL = lower specification limit.

7.2.2 Capability index (Cpk)

Cpk is another process capability index that tells whether the process is capable of meeting tolerances and whether the process is centered around the target value.

Like Cp, it is assumed the samples come from a stable process and variation is random variation, measured as within sample variation, \bar{R}/d_2 , from the control chart, where $\sigma' = \bar{R}/d_2$.

Cpk is the minimum of:

$$\frac{USL - \bar{X}}{3\sigma'} \quad \text{or} \quad \frac{\bar{X} - LSL}{3\sigma'}$$

7.2.3 Performance index (Pp)

Pp is a process performance index that explains how much of the tolerance range is used up by the total variation in the system. It is a measure of how the system is actually performing because all sources of variation are included in σ'_T . This σ'_T is calculated by taking all the observations as one large sample. Pp is defined as $(USL - LSL) / 6\sigma'_T$.

7.2.4 Performance index (Ppk)

Ppk is another process performance index that is a measure of actual process performance as Pp above, but like Cpk it also tells how well the process is centred.

Ppk is the minimum of:

$$\frac{USL - \bar{X}}{3\sigma'_T} \quad \text{or} \quad \frac{\bar{X} - LSL}{3\sigma'_T}$$

where σ'_T includes all sources of variation in the system.

8 Battery packaging

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

Annex A (normative)

Designation system (nomenclature)

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.

A.1 defines the designation system (nomenclature) in use up to October 1990.

A.2 defines the designation system (nomenclature) in use since October 1990 to accommodate present and future needs.

A.1 Designation system in use up to October 1990

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

A.1.1 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 number⁴⁾, 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 tables A.1, A.2 and A.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 A.1.2, A.1.3 and A.1.4. These tables only provide core physical designations for single cells or single batteries.

⁴⁾ 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 A.1 – Physical designation and dimensions of round cells and batteries¹⁾

Physical designation	Nominal cell dimensions mm		Maximum battery dimensions mm	
	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

¹⁾ The complete dimensions of batteries are given in IEC 60086-2 and IEC 60086-3.

Table A.2 – Physical designation and nominal overall dimensions of flat cells¹⁾

Physical designation	Dimensions in millimetres			
	Diameter	Length	Width	Thickness
F15	23	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		–	–	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

¹⁾ The complete dimensions of batteries are given in IEC 60086-2 and IEC 60086-3.

Table A.3 – Physical designation and dimensions of square cells and batteries¹⁾

Physical designation	Nominal cell dimensions mm			Maximum battery dimensions mm		
	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	–	–	–

¹⁾ The complete dimensions of batteries are given in IEC 60086-2 and IEC 60086-3.

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.

A.1.2 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 3.

A.1.3 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.

A.1.4 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 C, P or S to indicate different performance characteristics.

A.1.5 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.

A.2 Designation system in use since October 1990

This clause applies to all batteries 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).

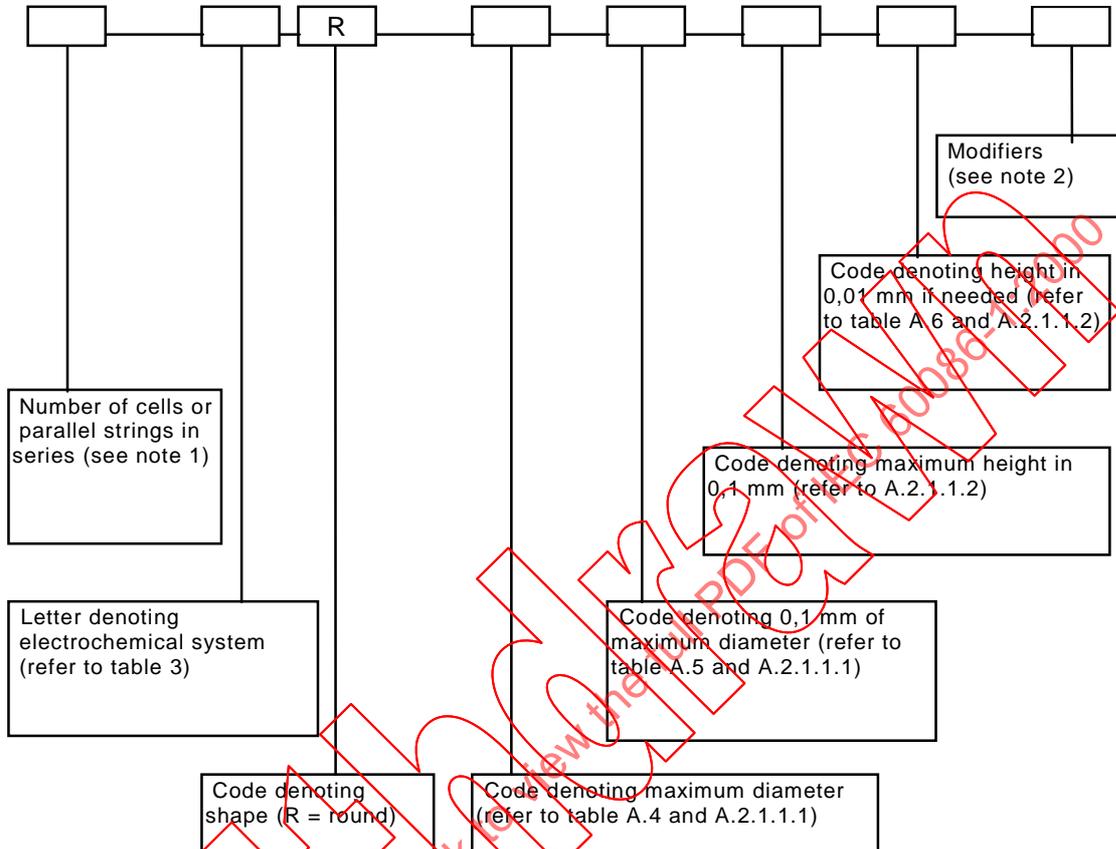
This clause also applies to single-cell batteries and multi-cell batteries with cells in series and/or parallel connection.

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.

A.2.1 Round batteries

A.2.1.1 Round batteries with diameter and height less than 100 mm

The designation for round batteries with a diameter and height less than 100 mm is as follows:



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.

A.2.1.1.1 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 A.4 in case of a recommended diameter;
- b) assigned according to table A.5 in case of a non-recommended diameter.

Table A.4 – Diameter code for recommended diameters

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

Table A.5 – Diameter code for non-recommended diameters

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

Diagram illustrating the diameter code structure: A box containing 'XX' and 'C' is connected to a box labeled 'Maximum diameter (mm) (integer)'. A line from the 'C' box points to the table below.

A.2.1.1.2 Method for assigning the height code

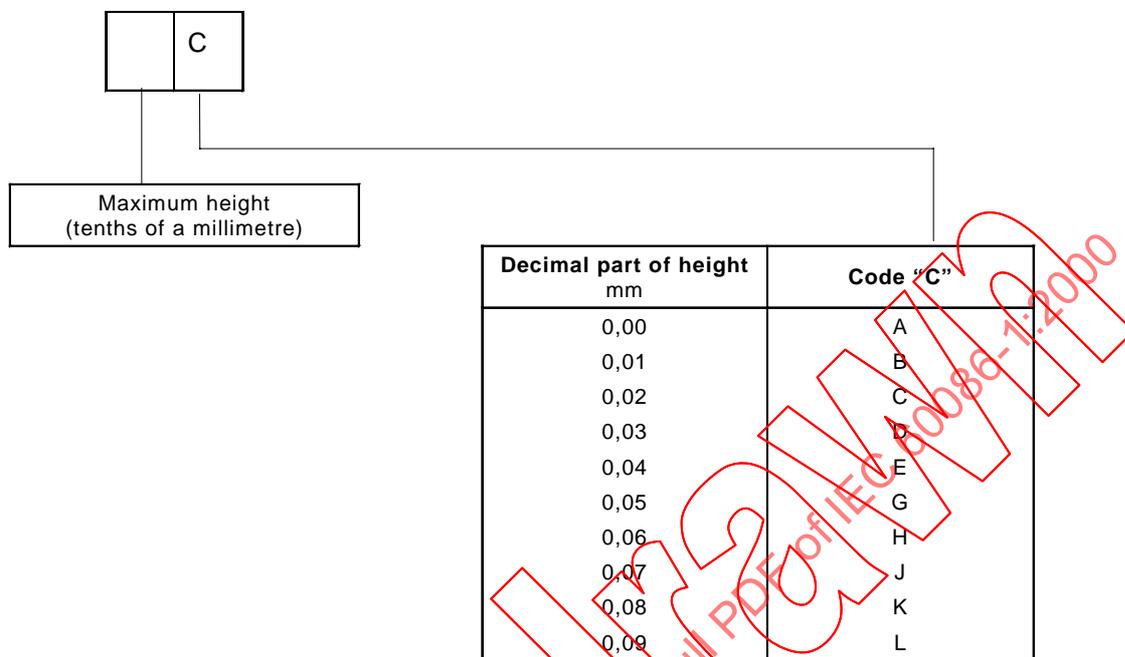
The height code is the number, denoted by the integer of the maximum height of the battery, expressed in tenths of a millimetre (e.g. 3,2 mm maximum height is denoted 32).

The maximum height is specified as follows:

- For flat contact terminals, the maximum height is the overall height including the terminals.
- 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 table A.6.

Table A.6 – Height code for denoting the hundredths of a millimetre of height



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 A.4), and a maximum height of 5,4 mm, of the zinc-alkali metal hydroxide-manganese dioxide system.

EXAMPLE 2

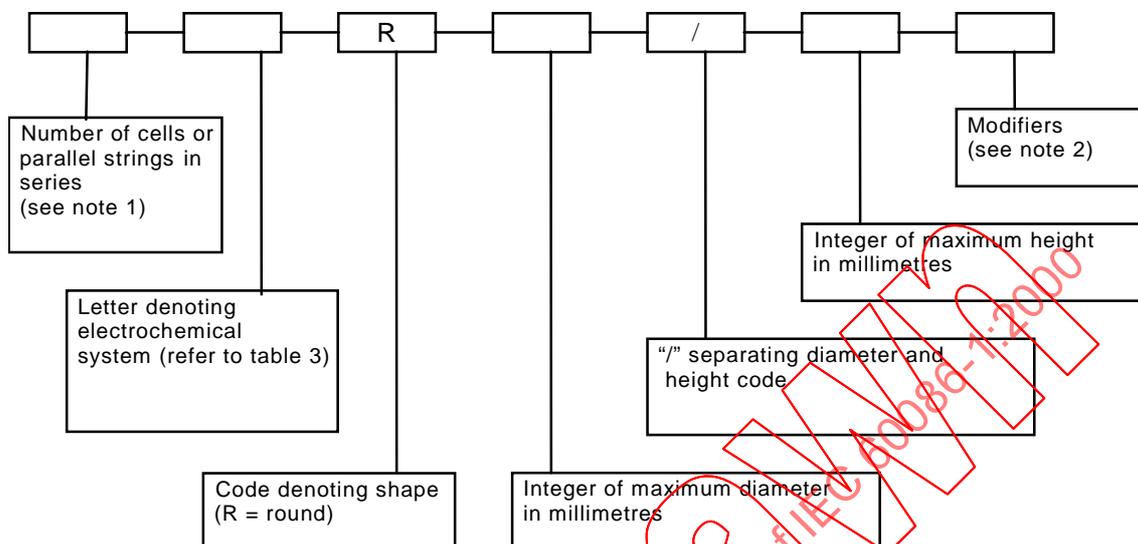
LR27A116 A battery consisting of a round cell or string in parallel with a maximum diameter of 27 mm (table A.5), and a maximum height of 11,6 mm, of the zinc-alkali metal hydroxide-manganese dioxide system.

EXAMPLE 3

LR2616J A battery consisting of a round cell or string in parallel with a maximum diameter of 26,2 mm (table A.4), and a maximum height of 1,67 mm (table A.6), of the zinc-alkali metal hydroxide-manganese dioxide system.

A.2.1.2 Round batteries with diameter and/or height over or equal to 100 mm

The designation for round batteries with a diameter and/or height of over or equal to 100 mm is as follows:



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.

A.2.1.2.1 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.

A.2.1.2.2 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:

- For flat contact terminals (e.g. batteries according to figures 1-4 of IEC 60086-2), the maximum height is the overall height including the terminals.
- 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.

A.2.2 Non-round batteries

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.

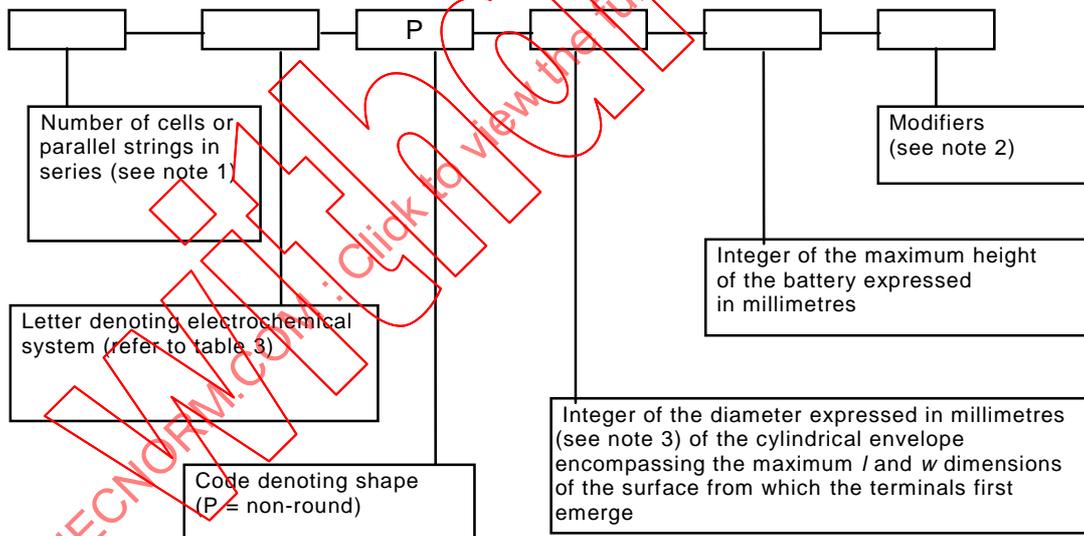
The maximum height is specified as follows:

- 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.

A.2.2.1 Non-round batteries with dimensions less than 100 mm

The designation for non-round batteries with dimensions less than 100 mm is as follows:



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 table A.7 applies.

EXAMPLE

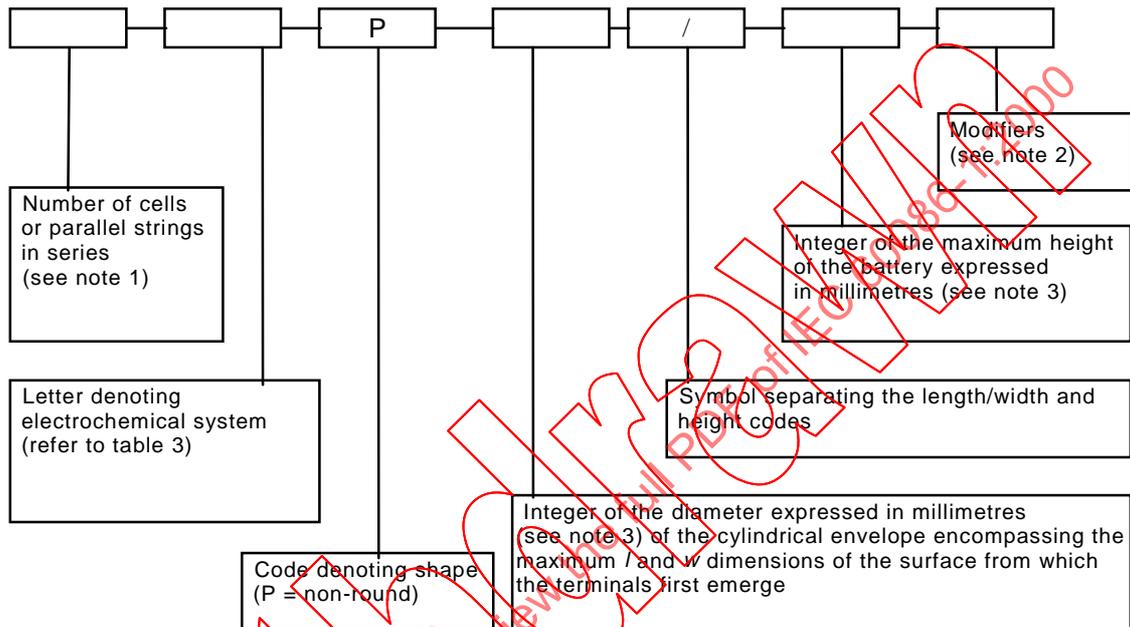
6LP3146 A battery consisting of six cells or strings in parallel of the zinc-alkali metal hydroxide-manganese dioxide system, connected in series with a maximum length of 26,5 mm, a maximum width of 17,5 mm, and a maximum height of 46,4 mm.

The integer of the diameter of this surface (l and w) is calculated according to:

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

A.2.2.2 Non-round batteries with dimensions equal to or over 100 mm

The designation for non-round batteries with dimensions equal to or over 100 mm is as follows:

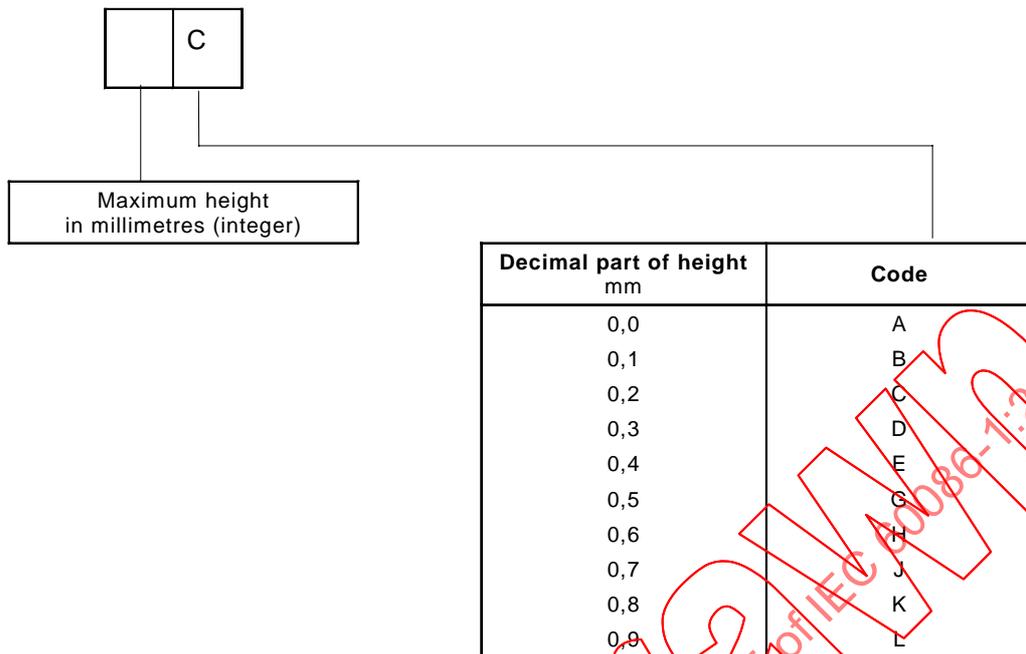


NOTE 1 The number of cells or strings in parallel is not identified.

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 table A.7 applies.

Table A.7



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

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.

A.2.3 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 A.8 – Physical designation and dimensions of round cells and batteries ¹⁾
based on clause A.2 of the designation system (nomenclature)**

Physical designation (new system)	Nominal cell dimensions mm		Maximum battery dimension mm	
	Diameter	Height	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
R17335	–	–	17,0	33,5
R17450	–	–	17,0	45,0

¹⁾ The complete dimensions of batteries are given in IEC 60086-2 and 60086-3.

**Table A.9 – Physical designation and dimensions of non-round batteries based
on clause A.2 of the designation system (nomenclature) ¹⁾**

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

NOTE 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.

¹⁾ The complete dimensions of batteries are given in IEC 60086-2 and 60086-3.

Annex B (normative)

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

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 and, more specifically, to warn against procedures known from experience to be harmful. It takes the form of advice to battery manufacturers, distributors and users.

B.1 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.

B.2 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.

B.3 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 % and below 40 % relative humidity) 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), providing 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 harmful.

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.

B.4 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.

B.5 Selection, use and disposal

B.5.1 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).

B.5.2 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.

B.5.3 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. cine-cameras, photoflash, etc.).

Be sure to switch off the equipment after use.

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

B.5.4 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.

B.5.5 Disposal

Primary batteries may be disposed of via the communal refuse arrangements, provided no contrary local legal requirements exist.

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Annex C (normative)

Equipment design

C.1 Technical liaison

It is recommended that companies producing battery-powered equipment should maintain close liaison with the battery industry. The capabilities of existing batteries should be taken into account at design inception. Whenever possible, the battery type selected should be one included in IEC 60086-2. The equipment should be permanently marked with the IEC designation, grade and size of battery which will give optimum performance.

C.2 Battery compartment

Battery compartments should be easily accessible. 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 publication will be accepted. In particular, the equipment designer should not ignore the tolerances given in this standard, 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.

Equipment intended for use by children should have battery compartments which are tamper-proof.

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 standard. Battery and equipment terminals should be of compatible material and low electrical resistance.

Battery compartments with parallel connections are not recommended since a wrongly placed battery will result in charging conditions.

Equipment designed to be powered by air-depolarized batteries of either the "A" or "P" system must 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 4 of IEC 60086-2, 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 shall 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.

C.3 Voltage cut-off

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

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Annex D (normative)

Calculation method for the specified value of minimum average duration

- a) Prepare minimum 10 weeks' data of duration values which are randomly selected.
- b) Calculate average \bar{x} of duration values x of nine samples from each population.
Remark: If some values are out of 3σ 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 E (normative)

Guidelines for the standardization of batteries

- a) Cells and batteries shall meet the following requirements to justify their initial inclusion or on-going retention in the IEC 60086 series:
 - 1) The battery is in mass production.
 - 2) The battery is available in several market places of the world.
 - 3) The battery is produced currently by at least two independent manufacturers, the patent holder(s) of which shall conform to the requirements of annex A to ISO/IEC Directives – Part 2.
 - 4) The battery is produced in at least two different countries or, alternatively, the battery is purchased by other international and independent battery manufacturers and sold under their company label.
- b) Necessary items to include in any new work proposal to standardize a new individual battery:
 - 1) Conformance statement to item a) above.
 - 2) Designation and electrochemical system.
 - 3) Dimensions (including drawings).
 - 4) Discharge conditions.
 - 5) Minimum average duration(s).

Annex F (informative)

Preferred dimensions for primary batteries

The use of the dimensional matrix is a recommendation only and will never become compulsory.

Nevertheless, a voluntary use of these recommended preferred dimensions would help to cut down on a further proliferation of dimensions and would help to avoid overlapping ranges of dimensional tolerances.

The dimensional matrix covers a range starting at 0,1 mm and ending at 650 mm in selected steps of approximately 10 % (9,7 %, 10,1 % and 10,7 %, see table F.1). It offers four different classes of tolerance, namely –1,0 %, –2,5 %, –5,0 %, and –7,5 %. The tolerances refer to the same maximum dimensions. The preferred series for height, width, diameter and length are mathematically labelled to ease further data processing.

The dimensional matrix complies with the principles of selected values and variety control to be observed according to the ISO/IEC Directives, part 2 when setting up international standards.