BS EN 61951-1:2014

BSI Standards Publication

Secondary cells and batteries containing alkaline or other non-acid electrolytes — Portable sealed rechargeable single cells

Part 1: Nickel-cadmium

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National foreword

This British Standard is the UK implementation of EN 61951-1:2014. It is identical to IEC 61951-1:2013. It supersedes BS EN 61951-1:2003 which is withdrawn.

The UK participation in its preparation was entrusted by Technical Committee PEL/21, Secondary cells and batteries, to Subcommittee PEL/21/1, Secondary cells and batteries containing alkaline and other non-acidic electrolytes.

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

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English Version

Secondary cells and batteries containing alkaline or other non-acid electrolytes - Portable sealed rechargeable single cells - Part 1: Nickel-cadmium (IEC 61951-1:2013)

Accumulateurs alcalins et autres accumulateurs à électrolyte non-acide - Accumulateurs individuels portables étanches - Partie 1: Nickel-cadmium (CEI 61951-1:2013)

Akkumulatoren und Batterien mit alkalischen oder anderen nichtsäurehaltigen Elektrolyten - Tragbare wiederaufladbare gasdichte Einzelzellen - Teil 1: Nickel-Cadmium (IEC 61951-1:2013)

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

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

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Foreword

The text of document 21A/521/FDIS, future edition 3 of IEC 61951-1, prepared by SC 21A, Secondary cells and batteries containing alkaline or other non-acid electrolytes, of IEC TC 21, Secondary cells and batteries, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 61951-1:2014.

The following dates were fixed:

– latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2014-11-16
– latest date by which the national standards conflicting with the EN have to be withdrawn	(dow)	2016-11-19

This European Standard supersedes EN 61951-1:2003.

EN 61951-1:2014 includes the following significant technical changes with respect to EN 61951-1:2003:

— addition of several new cell sizes;

— introduction of a new cell type J;

— creation of Annex A: Capacity of batteries measurement.

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

Endorsement notice

The text of the International Standard IEC 61951-1:2013 was approved by CENELEC as a European Standard without any modification.

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

IEC 60051 series	NOTE	Harmonized in EN 60051 series.
IEC 61434	NOTE	Harmonized as EN 61434.

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

The following referenced documents are indispensable for the application 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.

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

Publication	Year	Title	EN/HD	Year
IEC 60050-482	-	International Electrotechnical Vocabulary - Part 482: Primary and secondary cells and batteries	-	-
IEC 60086-1		Primary batteries - Part 1: General	EN 60086-1[1)]	
IEC 60086-2		Primary batteries - Part 2: Physical and electrical specifications	EN 60086-2[2)]	-
IEC 60410	-	Sampling plans and procedures for inspection by attributes	-	-
IEC 61959	-	Secondary cells and batteries containing alkaline or other non-acid electrolytes - Mechanical tests for sealed portable secondary cells and batteries	EN 61959	-
IEC 62133	-	Secondary cells and batteries containing alkaline or other non-acid electrolytes - Safety requirements for portable sealed secondary cells, and for batteries made from them, for use in portable applications	EN 62133	-

[1)] EN 60086-1 is superseded by EN 60086-1:2011, which is based on IEC 60086-1:2011.

[2)] EN 60086-2 is superseded by EN 60086-2:2011, which is based on IEC 60086-2:2011.

CONTENTS

SECONDARY CELLS AND BATTERIES CONTAINING ALKALINE OR OTHER NON-ACID ELECTROLYTES – PORTABLE SEALED RECHARGEABLE SINGLE CELLS –

Part 1: Nickel-cadmium

1 Scope

This part of IEC 61951 specifies marking, designation, dimensions, tests and requirements for portable sealed nickel-cadmium small prismatic, cylindrical and button rechargeable single cells, suitable for use in any orientation.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

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

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

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

IEC 61959, *Secondary cells and batteries containing alkaline or other non-acid electrolytes – Mechanical tests for sealed portable secondary cells and batteries*

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in the IEC 60050-482 and the following apply.

3.1
nominal voltage
suitable approximate value of voltage used to designate or identify the voltage of a cell or a battery

Note 1 to entry: The nominal voltage of a sealed nickel-cadmium rechargeable single cell: 1,2 V

Note 2 to entry: The nominal voltage of a battery of n series connected cells is equal to n times the nominal voltage of a single cell.

[SOURCE: IEC 60050-482:2004, 482-03-31, modified – Addition of Notes 1 and 2 to entry.]

3.2
rated capacity
capacity value of a cell or battery determined under specified conditions and declared by the manufacturer

Note 1 to entry: The rated capacity is the quantity of electricity C_5 Ah (ampere-hours) declared by the manufacturer which a single cell can deliver during a 5 h period when charging, storing and discharging under the conditions specified in 7.3.2.

Note 2 to entry: The capacity of battery is the quantity of electricity C_5 Ah (ampere-hours) declared by the manufacturer which a battery can deliver during a 5 h period, when charged, stored and discharged under the procedure described in Annex A.

[SOURCE: IEC 60050-482:2004, 482-03-15, modified – Addition of Notes 1 and 2 to entry.]

3.3
small prismatic cell
cell in the form of a rectangular parallelepiped whose width and thickness dimensions are not more than 25 mm

3.4
cylindrical cell
cell of circular cross-section in which the overall height is equal to, or greater than, the overall diameter

3.5
button cell
cell of a circular cross-section in which the overall height is less than the overall diameter

3.6
nickel-cadmium cell
secondary cell containing a nickel hydroxide compound for the positive electrode, cadmium compound for the negative electrode, and potassium hydroxide or other alkaline solution as electrolyte. Positive electrodes are isolated from negative electrodes by a separator

3.7
sealed cell
cell which remains closed and does not release either gas or liquid when operated within the limits specified by the manufacturer

Note 1 to entry: The cell is equipped with a safety device to prevent dangerously high internal pressure.

Note 2 to entry: The cell does not require addition to the electrolyte and is designed to operate during its life in its original sealed state.

[SOURCE: IEC 60050-482:2004, 482-05-17, modified – The existing note has been developed into Notes 1 and 2 to entry.]

4 Parameter measurement tolerances

The overall accuracy of controlled or measured values, relative to the specified or actual values, shall be within the following tolerances:

a) ±1 % for voltage;

b) ±1 % for current;

c) ±1 % for capacity;

d) ±2 °C for temperature;

e) ±0,1 % for time;

f) ±0,1 mm for dimensions;

g) ±5 % for humidity.

These tolerances comprise the combined accuracy of the measuring instruments, the measurement techniques used and all other sources of error in the test procedure.

The details of the instrumentation used shall be provided in each report of results.

5 Cell designation and marking

5.1 Cell designation

5.1.1 Small prismatic cells and cylindrical cells

5.1.1.1 General

Sealed nickel-cadmium small prismatic rechargeable single cells and cylindrical rechargeable single cells shall be designated by a letter L, M, J, H or X which signifies:

- low rate of discharge (L);
- medium rate of discharge (M);
- high medium rate of discharge (J);
- high rate of discharge (H);
- very high rate of discharge (X).

NOTE 1 These cells are typically but not exclusively used for the following discharge rates:

- L up to 0,5 I_t A;
- M up to 3,5 I_t A;
- J up to 5,0 I_t A;
- H up to 7,0 I_t A;
- X up to and above 15 I_t A.

NOTE 2 These currents are expressed as multiples of I_t A, where I_t A = C_5 Ah/1 h (see IEC 61434).

When a cell is intended for permanent charge at elevated temperatures, typically higher than 40 °C, a letter "T" is placed after the letter L, M, J, H or X.

When a cell is intended for permanent charge at elevated temperatures, typically higher than 50 °C, a letter "U" is placed after the letter L, M, J, H or X.

When a cell is intended for rapid charge, typically at 1,0 I_t A, a letter “R” is placed after the letter L, M, J, H or X.

5.1.1.2 Small prismatic cells

Sealed nickel-cadmium small prismatic rechargeable single cells shall be designated by the letters “KF” followed by a letter L, M, J, H or X followed by three groups of figures, each one separated by a solidus:

a) the two figures to the left of the first solidus shall indicate the maximum width specified for the cell, expressed in millimetres, rounded up to the next whole number;

b) the two figures in the middle shall indicate the maximum thickness specified for the cell, expressed in millimetres, rounded up to the next whole number;

c) the two figures to the right of the second solidus shall indicate the maximum height specified for the cell, expressed in millimetres, rounded up to the next whole number.

EXAMPLE KFL 18/07/49 designation identifies a small prismatic cell of low discharge rate capability, with a maximum width of 18 mm, a maximum thickness of 7 mm and a maximum height of 49 mm.

5.1.1.3 Cylindrical cells

Sealed nickel-cadmium cylindrical rechargeable single cells shall be designated by the letters “KR” followed by a letter L, M, J, H or X followed by two groups of figures, each one separated by a solidus:

a) the two figures to the left of the solidus shall indicate the maximum diameter specified for the cell, expressed in millimetres, rounded up to the next whole number;

b) the two figures to the right of the solidus shall indicate the maximum height specified for the cell, expressed in millimetres, rounded up to the next whole number.

When a manufacturer designs a cell with dimensions and tolerances which make it interchangeable with a primary cell, the designation of Table 2 shall also be marked on the cell.

EXAMPLE 1 KRL 33/62 designation identifies a cylindrical cell of low discharge rate capability, with a maximum diameter of 33 mm and a maximum height of 61,5 mm.

EXAMPLE 2 KRLT 33/62 designation identifies a cylindrical cell of low discharge rate capability, intended for permanent charge at elevated temperatures, with a maximum diameter of 33 mm and a maximum height of 61,5 mm.

EXAMPLE 3 KRHR 23/43 designation identifies a cylindrical cell of high discharge rate capability, intended for rapid charge, with a maximum diameter of 23 mm and a maximum height of 43 mm.

For cells dimensionally interchangeable with primary cells, the following single or double figures following the letter L, M or R may indicate:

- 20- size D
- 14- size C
- 6- size AA
- 03- size AAA

EXAMPLE 4 KRMR03 designation identifies a sealed nickel-cadmium cylindrical rechargeable single cell, of medium discharge rate capability, also intended for rapid charge, dimensionally interchangeable with primary cell and whose type designation is AAA.

5.1.2 Button cells

Sealed nickel-cadmium button rechargeable single cells shall be designated by the letters “KB” followed by a letter L, M or H which signifies:

- low rate of discharge (L);
- medium rate of discharge (M);
- high rate of discharge (H).

The group of three letters shall then be followed by two groups of figures separated by a solidus:

a) the three figures to the left of the solidus shall indicate the maximum diameter specified for the cell, expressed in tenths of millimetres, rounded up to the next whole number;

b) the three figures to the right of the solidus shall indicate the maximum height specified for the cell, expressed in tenths of millimetres, rounded up to the next whole number.

EXAMPLE KBL 116/055 designation identifies a button cell of low discharge rate capability, with a maximum diameter of 11,6 mm and a maximum height of 5,5 mm.

5.2 Cell termination

This standard does not specify cell termination.

5.3 Marking

5.3.1 Small prismatic cells and cylindrical cells

Each jacketed cell supplied without connections shall carry durable markings giving the following minimum information:

- sealed, rechargeable nickel-cadmium or Ni-Cd;
- cell designation as specified in 5.1 (in addition, it is permissible for a manufacturer to use his own type designation);
- rated capacity;
- nominal voltage;
- recommended charge rate and time or permanent charge current for “T” cells;
- polarity;
- date of manufacture (which may be in code);
- name or identification of manufacturer or supplier;
- mark for promoting useful use of cell resources.

  NOTE 1 This mark is applied where a recycling programme is available.

NOTE 2 In general, sealed nickel-cadmium rechargeable single cells with connection tabs need no labels if they form an integral part of a battery, in which case, the battery itself is marked with the above information.

5.3.2 Button cells

Each button cell supplied without connection shall carry durable markings giving the following minimum information:

- cell designation as specified in 5.1;
- polarity;
- date of manufacture (which may be in code);
- name or identification of manufacturer or supplier.

6 Dimensions

6.1 Small prismatic cells and cylindrical cells

6.1.1 General

Dimensions of cells, shown in Figure 1 and Figure 2, are given in Tables 1, 2 and 3.

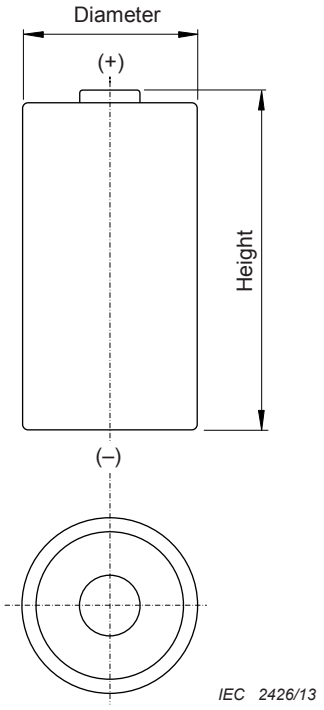


Figure 1 – Jacketed cylindrical cells

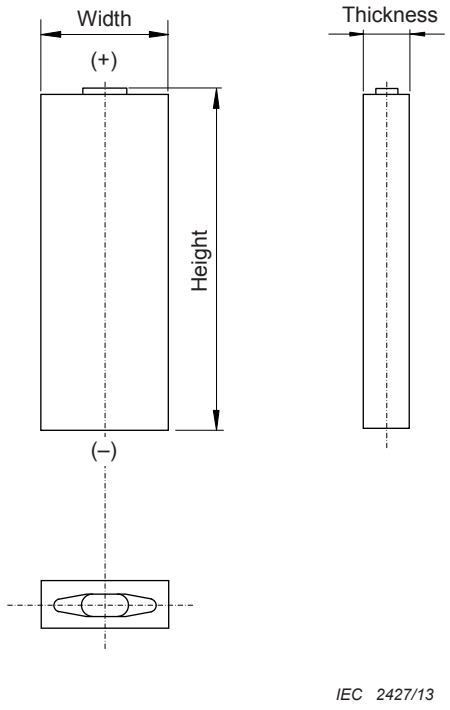


Figure 2 – Jacketed small prismatic cells

6.1.2 Small prismatic cells

Table 1 shows the dimensions for jacketed small prismatic cells.

Table 1 – Dimensions of jacketed small prismatic cells

Cell designation	Width mm		Thickness mm		Overall height mm	
KF 18/07/41	17,3	0 –1,0	6,1	0 –0,7	40,2	0 –1,0
KF 18/07/49	17,3		6,1		48,2	
KF 18/09/49	17,3		8,3		48,2	
KF 18/07/68	17,3		6,1		67,3	0 –1,5
KF 18/09/68	17,3		8,3		67,3	
KF 18/11/68	17,3		10,5	0 –1,0	67,3	
KF 18/18/68	17,3		17,3		67,3	
KF 23/15/68	23,0		14,7		67,3	

6.1.3 Cylindrical cells

6.1.3.1 Cells dimensionally interchangeable with primary cells

Table 2 gives the requirements relative to the dimensions for jacketed cylindrical cells which are dimensionally interchangeable with primary cells, as shown in Figure 3.

Table 2 – Dimensions of jacketed cylindrical cells dimensionally interchangeable with primary cells

Cell designation [a]	Type designation (reference) [b]	Corresponding primary cell [c]	Nominal voltage (V)	Dimensions (mm)										
				A	B	C	D[d]	E	F		G	Φ		ΦP
				Max	Min	Min	-	Max	Max	Min	Min	Max	Min	Max
KR03	AAA	R03 LR03	1,2	44,5	(43,3)	4,3		0,5	3,8	(2,0)	0,8	10,5	9,5	0,4
KR6	AA	R6 LR6		50,5	(49,2)	7,0		0,5	5,5	(4,2)	1,0	14,5	13,5	0,5
KR14	C	R14 LR14		50,0	(48,6)	13,0		0,9	7,5	(5,5)	1,5	26,2	24,9	1,0
KR20	D	R20 LR20		61,5	(59,5)	18,0		1,0	9,5	(7,8)	1,5	34,2	32,3	1,0

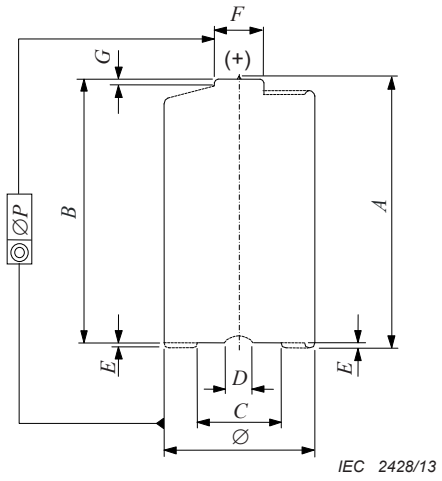
NOTE Figures in parentheses are reference values.

[a] Cell designations shall be in accordance with the nomenclature rules given in IEC 60086-1.

[b] In some countries these cell types are also known as AAA (R 03); AA (R 6); C (R 14); D (R 20).

[c] Carbon zinc cells (R) and alkaline primary cells (LR) shall be compliant with the provisions of IEC 60086-2, respectively.

[d] There is no specification for the value “D” for sealed nickel-cadmium cylindrical rechargeable single cells interchangeable with primary cells.



Key

A maximum overall height of the cell;

B minimum distance between the flats of the positive and the negative contacts;

C minimum outer diameter of the negative flat contact surface;

D maximum inner diameter of the negative flat contact surface;

E maximum recess of the negative flat contact surface;

F maximum diameter of the positive contact within the specified projection height;

G minimum projection of the flat positive contact;

∅ maximum and minimum diameters of the cell;

∅*P* concentricity of the positive contact.

Figure 3 – Jacketed cells dimensionally interchangeable with primary cells

6.1.3.2 Cells not dimensionally interchangeable with primary cells

Table 3 shows the dimensions for jacketed cells which are not dimensionally interchangeable with primary cells.

Table 3 – Dimensions of jacketed cylindrical cells not dimensionally interchangeable with primary cells

Cell designation [a]	Diameter mm		Height mm	
KR 8/43	7,8		42,5	
KR 11/16	10,5		16,0	
KR 11/45	10,5		44,5	
KR 12/30	12,0		30,0	
KR 15/18	14,5		17,5	
KR 15/29 [b]	14,5		28,7	
KR 15/30	14,5		30,0	
KR 15/43	14,5		43,0	
KR 15/48 [b]	14,5	0	48,0	
KR 15/49 [b]	14,5	–0,7	49,0	
KR 15/51	14,5		50,5	0
KR 15/65 [b]	14,5		65,0	–1,5
KR 17/18	17,0		17,5	
KR 17/29	17,0		28,5	
KR 17/43	17,0		43,0	
KR 17/50	17,0		50,0	
KR 17/66	17,0		66,0	
KR 17/67 [b]	17,0		67,0	
KR 23/27	23,0		26,5	
KR 23/34	23,0		34,0	
KR 23/43	23,0		43,0	
KR 23/50 [b]	23,0		50,0	
KR 26/31	25,8	0	31,0	
KR 26/50	25,8	–1,0	50,0	
KR 33/36	32,1		36,3	0
KR 33/44	33,0		44,0	–2,0
KR 33/60	33,0		60,0	
KR 33/62	33,0		61,5	
KR 33/91	33,0		91,0	
KR 44/71	43,5	0	71,0	0
KR 44/91	43,5	–2,5	91,0	–2,5
KR 44/146	43,5		146,0	

[a] The letters KR to be followed by L, M, J, H or X and T, U and/or R as appropriate (see 5.1.1.3).

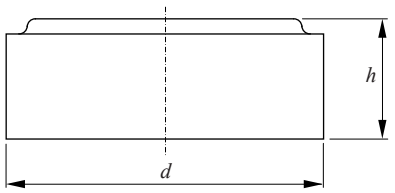
[b] 6 new cells

6.2 Button cells

Dimensions of cells, shown in Figure 4, are given in Table 4.

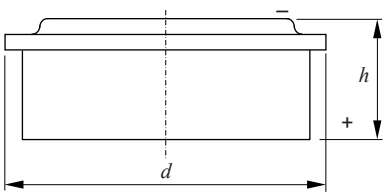
Cells shall be constructed as design I or II.

Design I



IEC 2429/13

Design II



IEC 2430/13

NOTE The polarity of design I is not standardized.

Figure 4 – Button cells

Table 4 shows the dimensions for sealed nickel-cadmium button rechargeable single cells.

Table 4 – Dimensions of button cells

Cell designation [a]	Overall diameter, *d* mm	Overall height, *h* mm
KB 116/055 [b]	11,6	5,5
KB 156/048	15,6	4,8
KB 156/061	15,6	6,1
KB 222/050	22,2	5,0
KB 229/055	22,9	5,5
KB 232/030	23,2	3,0
KB 232/055	23,2	5,5
KB 232/067	23,2	6,7
KB 252/064	25,2	6,4
KB 252/077	25,2	7,7
KB 252/095	25,2	9,5
KB 346/055	34,6	5,5
KB 346/098	34,6	9,8
KB 432/081	43,2	8,1
KB 505/105	50,5	10,5

0 –0,3 (overall diameter, KB 116/055 to KB 232/067)

0 –0,4 (overall diameter, KB 252/064 to KB 505/105)

0 –0,6 (overall height, KB 116/055 to KB 232/055)

0 –1,0 (overall height, KB 252/077 to KB 252/095)

0 –0,6 (overall height, KB 346/055 to KB 346/098)

0 –1,0 (overall height, KB 432/081 to KB 505/105)

[a] The letters KB shall be followed by L, M or H as appropriate (see 5.1.2).

[b] KB 116/055 may be interchangeable with primary cell R 44.

7 Electrical tests

7.1 General

Charge and discharge currents for the tests in accordance with this Clause 7 and with Clause 5 shall be based on the rated capacity (C_5 Ah). These currents are expressed as multiples of I_t A, where I_t A = C_5 Ah/1 h.

In all tests, except where noted, no leakage of electrolyte in liquid form shall be observed.

7.2 Charging procedure for test purposes

Unless otherwise stated in this standard, the charging procedure for test purposes shall be carried out in an ambient temperature of 20 °C ± 5 °C and a relative humidity of 65 % ± 20 %, at a constant current of 0,1 I_t A for 16 h. The tests shall be performed within one month of the arrival date or the purchasing date.

Prior to charging, the cell shall have been discharged in an ambient temperature of 20 °C ± 5 °C, at a constant current of 0,2 I_t A, down to a final voltage of 1,0 V.

7.3 Discharge performance

7.3.1 General

The following discharge tests in 7.3.2 to 7.3.4 shall be carried out in the sequence given.

7.3.2 Discharge performance at 20 °C

The cell shall be charged in accordance with 7.2. After charging, the cell shall be stored, in an ambient temperature of 20 °C ± 5 °C, for not less than 1 h and not more than 4 h.

The cell shall then be discharged in an ambient temperature of 20 °C ± 5 °C and as specified in Tables 5 or 6. The duration of discharge shall not be less than the values specified in Tables 5 or 6.

The 0,2 I_t A discharge test is performed in order to verify the declared rated capacity of the cell.

Table 5 – Discharge performance at 20 °C for small prismatic cells and cylindrical cells

Discharge conditions		Minimum discharge duration h/min			
Rate of constant current A	Final voltage V	Cell designation			
		L/LT/LU	M/MT/MU/J/JT	H/HT/HU	X
0,2 I_t [a]	1,0	5 h	5 h	5 h	5 h
1,0 I_t	0,9	–	42 min	48 min	54 min
5,0 I_t [b]	0,8	–	–	6 min	9 min
10,0 I_t [b]	0,7	–	–	–	4 min

[a] Five cycles are permitted for this test. The test shall be terminated at the end of the first cycle which meets the requirement.

[b] Prior to the 5,0 I_t A and 10,0 I_t A tests, a conditioning cycle may be included if necessary. This cycle shall consist of charging at 0,1 I_t A in accordance with 7.2 and discharging at 0,2 I_t A, in an ambient temperature of 20 °C ± 5 °C, according to 7.3.2.

Table 6 – Discharge performance at 20 °C for button cells

Discharge conditions		Minimum discharge duration h/min		
Rate of constant current	Final voltage	Cell designation		
A	V	L	M	H
0,2 I_t [a]	1,0	5 h	5 h	5 h
1,0 I_t	1,0	–	48 min	51 min
5,0 I_t [b]	0,8	–	–	6 min

[a] Five cycles are permitted for this test. The test shall be terminated at the end of the first cycle which meets the requirement.

[b] Prior to the 5 I_t A test, a conditioning cycle may be included if necessary. This cycle shall consist of charging at 0,1 I_t A in accordance with 7.2 and discharging at 0,2 I_t A, in an ambient temperature of 20 °C ± 5 °C, according to 7.3.2.

7.3.3 Discharge performance at –18 °C

The cell shall be charged in accordance with 7.2. After charging, the cell shall be stored in an ambient temperature of –18 °C ± 2 °C for not less than 16 h and not more than 24 h.

The cell shall then be discharged in an ambient temperature of –18 °C ± 2 °C and as specified in Tables 7, 8 or 9. The duration of discharge shall not be less than the values specified in Tables 7, 8 or 9.

Table 7 – Discharge performance at –18 °C for small prismatic cells

Discharge conditions		Minimum discharge duration h/min
Rate of constant current A	Final voltage V	
0,2 I_t	1,0	3 h
1,0 I_t	0,9	15 min

Table 8 – Discharge performance at –18 °C for cylindrical cells

Discharge conditions		Minimum discharge duration h/min						
Rate of constant current	Final voltage	Cell designation						
A	V	L/LT/LU	M	MT/MU	J	H	HT/HU	X
0,2 I_t	1,0	2 h	3 h	2 h	3 h	3 h	2 h	4 h
1,0 I_t	0,9	–	15 min	10 min	15 min	30 min	20 min	36 min
2,0 I_t [a]	0,8	–	–	–	–	9 min	6 min	13 min
3,0 I_t [a]	0,8	–	–	–	–	–	–	7 min

[a] Prior to the 2,0 I_t A and 3,0 I_t A tests, a conditioning cycle may be included if necessary. This cycle consists of charging at 0,1 I_t A in accordance with 7.2 and discharging at 0,2 I_t A in an ambient temperature of 20 °C ± 5 °C, according to 7.3.2.

Table 9 – Discharge performance at –18 °C for button cells

Discharge conditions		Minimum discharge duration h/min		
Rate of constant current A	Final voltage V	Cell designation		
		L	M	H
0,2 I_t	1,0	–	2 h 45 min	3 h
1,0 I_t	0,9	–	12 min	30 min
2,0 I_t [a]	0,8	–	–	9 min

[a] Prior to the 2,0 I_t A test, a conditioning cycle may be included if necessary. This cycle shall consist of charging at 0,1 I_t A in accordance with 7.2 and discharging at 0,2 I_t A in an ambient temperature of 20 °C ± 5 °C, according to 7.3.2.

7.3.4 Discharge performance for rapid charge cells (R cells)

R cells shall be charged at a constant current of 1,0 I_t A for 1,2 h or other appropriate charge termination method as recommended by the cell manufacturer, followed by a charge at 0,1 I_t A for 2 h in an ambient temperature of 20 °C ± 5 °C. After charging, the cell shall be stored and discharged as specified in 7.3.2 and 7.3.3.

The duration of discharge shall not be less than the values specified in Table 5 for discharge at 20 °C ± 5 °C and in Table 8 for discharge at –18 °C ± 2 °C.

7.4 Charge (capacity) retention

The charge (capacity) retention shall be determined by the following test. After charging in accordance with 7.2, the cell shall be stored on open circuit for 28 days. The average ambient temperature shall be 20 °C ± 2 °C. The temperature may be allowed to vary within the range of 20 °C ± 5 °C for short periods during the storage.

The cell shall be discharged under the conditions specified in 7.3.2 at a rate of 0,2 I_t A.

The duration of discharge after 28 days of storage at 20 °C shall not be less than:

- 3 h for small prismatic cells;
- 3 h 15 min for cylindrical cells;
- 3 h 15 min for H button cells;
- 3 h 45 min for L and M button cells.

7.5 Endurance

7.5.1 Endurance in cycles

7.5.1.1 General

Prior to the endurance in cycle test, the cell shall be discharged at a constant current of 0,2 I_t A to a final voltage of 1,0 V.

The following endurance test shall then be carried out, irrespective of cell designation, in an ambient temperature of 20 °C ± 5 °C. Charge and discharge shall be carried out at constant current throughout, in accordance with the conditions specified in Tables 10, 11, 12, 13 and 14. Precautions shall be taken to prevent the cell-case temperature from rising above 35 °C during the test, by providing a forced air draught if necessary.

NOTE Actual cell temperature, not the ambient temperature, determines cell performance.

7.5.1.2 Small prismatic and cylindrical cells not dimensionally interchangeable with primary cells

Table 10 – Endurance in cycles for small prismatic cells and cylindrical cells not dimensionally interchangeable with primary cells

Cycle number	Charge	Stand in charged condition	Discharge
1	0,10 I_t A for 16 h	None	0,25 I_t A for 2 h 20 min [a]
2 to 48	0,25 I_t A for 3 h 10 min	None	0,25 I_t A for 2 h 20 min [a]
49	0,25 I_t A for 3 h 10 min	None	0,25 I_t A to 1,0 V
50	0,10 I_t A for 16 h	1 h to 4 h	0,20 I_t A to 1,0 V [b]

[a] If the cell voltage drops below 1,0 V, the discharge may be discontinued.

[b] It is permissible to allow sufficient open-circuit rest time after the completion of discharge at cycle 50, so as to start cycle 51 at a convenient time. A similar procedure may be adopted at cycles 100, 150, 200, 250, 300, 350, 400 and 450.

Cycles 1 to 50 shall be repeated until the discharge duration on any 50th cycle becomes less than 3 h. At this stage, a repeat capacity measurement as specified for cycle 50 shall be carried out.

The endurance test is considered complete when two such successive capacity cycles give discharge duration of less than 3 h. The total number of cycles obtained when the test is completed shall not be less than:

- 400 for small prismatic cells;
- 500 for L/LR, M/MR, J/JR, H/HR or X/XR cylindrical cells;
- 50 for cylindrical cells LT/LU, MT/MU, JT or HT/HU.

7.5.1.3 Cylindrical cells dimensionally interchangeable with primary cells

The cells shall be tested in accordance with 7.5.1.2.

The total number of cycles obtained when the test is completed shall not be less than 500.

7.5.1.4 Cylindrical cells (accelerated test procedures)

7.5.1.4.1 General

In order to accelerate the test or to use cycling conditions approximating those in actual applications, one of the following alternative procedures relevant to the cell may be carried out as an alternative to 7.5.1.2.

7.5.1.4.2 H or X cells

Table 11 – Endurance in cycles for H or X cells

Cycle number	Charge	Stand in charged condition	Discharge	
			Conditions	Total duration including subsequent rest
1	0,1 I_t A for 16 h	30 min	1,0 I_t A to 1,0 V	90 min
2 to 48	0,3 I_t A for 4 h [a]	30 min	1,0 I_t A to 1,0 V	90 min
49	0,3 I_t A for 4 h [a]	24 h	1,0 I_t A to 1,0 V	90 min
50	0,1 I_t A for 16 h	1 h to 4 h	0,2 I_t A to 1,0 V	[b]

[a] Or appropriate charge termination, as recommended by the manufacturer.

[b] It is permissible to allow sufficient open-circuit rest time after the completion of discharge at cycle 50, so as to start cycle 51 at a convenient time. A similar procedure may be adopted at cycles 100, 150, 200, 250, 300, 350, 400 and 450.

Cycles 1 to 50 shall be repeated until the discharge duration to the final voltage of 1,0 V on any 49th cycle becomes less than 30 min or until the discharge duration to the final voltage of 1,0 V on any 50th cycle becomes less than 3 h. At this stage, a repeat capacity measurement as specified for cycle 50 shall be carried out and if the discharge time is less than 3 h again the test is terminated.

The total number of cycles obtained when the test is completed shall not be less than 500.

7.5.1.4.3 X cells

Table 12 – Endurance in cycles for cylindrical X cells

Cycle number	Charge	Stand in charged condition	Discharge	
			Conditions	Total duration including subsequent rest
1	0,1 I_t A for 16 h	30 min	5,0 I_t A to 0,8 V	42 min
2 to 48	1,0 I_t A for 1 h [a]	30 min	5,0 I_t A to 0,8 V	42 min
49	1,0 I_t A for 1 h [a]	24 h	5,0 I_t A to 0,8 V	42 min
50	0,1 I_t A for 16 h	1 h to 4 h	0,2 I_t A to 1,0 V	[b]

[a] Or appropriate charge termination, as recommended by the manufacturer

[b] It is permissible to allow sufficient open-circuit rest time after the completion of discharge at cycle 50, so as to start cycle 51 at a convenient time. A similar procedure may be adopted at cycles 100, 150, 200, 250, 300, 350, 400 and 450.

Cycles 1 to 50 shall be repeated until the discharge duration to the final voltage of 0,8 V on any 49th cycle becomes less than 5 min or until the discharge duration to the final voltage of 1,0 V on any 50th cycle becomes less than 3 h. At this stage, a repeat capacity measurement as specified for cycle 50 shall be carried out and if the discharge time is less than 3 h again the test is terminated.

The total number of cycles obtained when the test is completed shall not be less than 500.

7.5.1.4.4 HR or XR cells

Table 13 – Endurance in cycles for HR or XR cells

Cycle number	Charge	Stand in charged condition	Discharge	Total duration including subsequent rest
1	0,1 I_t A for 16 h	30 min	1,0 I_t A to 1,0 V	90 min
2 to 48	1,0 I_t A for [a]	30 min	1,0 I_t A to 1,0 V	90 min
49	1,0 I_t A for [a]	24 h	1,0 I_t A to 1,0 V	90 min
50	1,0 I_t A for [a] plus 0,1 I_t A for 2 h	1 h to 4 h	0,2 I_t A to 1,0 V	[b]

[a] With appropriate charge termination, as recommended by the manufacturer, for example use –ΔV or ΔT/Δt control method.

[b] It is permissible to allow sufficient open-circuit rest time after the completion of discharge at cycle 50, so as to start cycle 51 at a convenient time. A similar procedure may be adopted at cycles 100, 150, 200, 250, 300, 350, 400 and 450.

Cycles 1 to 50 shall be repeated until the discharge duration to the final voltage of 1,0 V on any 49th cycle becomes less than 30 min or until the discharge duration to the final voltage of 1,0 V on any 50th cycle becomes less than 3 h. At this stage, a repeat capacity measurement as specified for cycle 50 shall be carried out and if the discharge time is less than 3 h again the test is terminated.

The total number of cycles obtained when the test is completed shall not be less than 500.

7.5.1.5 Button cells

Table 14 – Endurance in cycles for button cells

Cycle number	Charge	Stand in charged condition	Discharge
1	0,1 I_t A for 16 h	5 h	0,2 I_t A for 3 h
2 to 48	0,1 I_t A for 8 h	1 h	0,2 I_t A for 3 h
49	0,1 I_t A for 8 h	1 h	0,2 I_t A to 1,0 V [a]
50	0,1 I_t A for 16 h	1 h	0,2 I_t A to 1,0 V [a]

[a] It is permissible to allow sufficient open-circuit rest time after the completion of discharge at cycles 49 and 50, so as to start the following cycle at a convenient time. A similar procedure may be adopted at cycles 100, 150, 200, 250, 300 and 350.

Cycles 1 to 50 shall be repeated until the discharge duration on any 50th cycle becomes less than 3 h. At this stage, a repeat capacity measurement as specified for cycle 50 shall be carried out.

The endurance test is considered complete when two successive capacity measurement cycles give discharge duration of less than 3 h. The total number of cycles successfully completed shall not be less than 400 for M and H cells and 300 for L cells.

7.5.2 Permanent charge endurance

7.5.2.1 Small prismatic cells

There is no requirement for permanent charge endurance tests on small prismatic cells.

7.5.2.2 L, M, J, H or X cylindrical cells and L, M or H button cells

Prior to this test, the cell shall be discharged at 0,2 I_t A to a final voltage of 1,0 V.

The following permanent charge endurance test shall be carried out at an ambient temperature of 20 °C ± 5 °C. Charge and discharge shall be carried out at constant current throughout, using the conditions specified in Table 15 for cylindrical cells and in Table 16 for button cells.

Table 15 – Permanent charge endurance for L, M, J, H or X cylindrical cells

Cycle number	Charge	Discharge [a]
1	0,05 I_t A for 91 days	0,2 I_t A to 1,0 V
2	0,05 I_t A for 91 days	0,2 I_t A to 1,0 V
3	0,05 I_t A for 91 days	0,2 I_t A to 1,0 V
4	0,05 I_t A for 91 days	0,2 I_t A to 1,0 V

[a] The discharge is carried out immediately on completion of the charging.

Precautions shall be taken to prevent cell-case temperature from rising above 25 °C during the test by providing forced air draught if necessary.

The discharge duration at cycle 4 shall not be less than 3 h.

Table 16 – Permanent charge endurance for button cells

Cycle number	Charge for L or M cells	Charge for H cells	Discharge [a]
1	0,01 I_t A for 91 days	0,05 I_t A for 91 days	0,2 I_t A to 1,0 V
2	0,01 I_t A for 91 days	0,05 I_t A for 91 days	0,2 I_t A to 1,0 V
3	0,01 I_t A for 91 days	0,05 I_t A for 91 days	0,2 I_t A to 1,0 V
4	0,01 I_t A for 91 days	0,05 I_t A for 91 days	0,2 I_t A to 1,0 V

[a] The discharge is carried out immediately upon completion of discharge.

Precautions shall be taken to prevent cell-case temperature from rising above 30 °C during the test by providing forced air draught if necessary.

The discharge duration at cycle 4 shall not be less than 3 h.

7.5.2.3 LT, MT or HT cylindrical cells

The permanent charge endurance test shall be performed in three steps according to the conditions specified in Table 17.

It consists of:

- a charge acceptance test at +40 °C;
- an ageing period of six months at +70 °C;
- a final charge acceptance test to check the cell's performance after ageing.

NOTE The six months ageing period and the temperature of +70 °C have been selected to simulate four years of permanent charge operation at +40 °C.

Prior to this test, the cell shall be discharged at 0,2 I_t A at 20 °C ± 5 °C to a final voltage of 1,0 V and stored, in an ambient temperature of +40 °C ± 2 °C, for not less than 16 h and not more than 24 h.

The cell shall then be charged and discharged at constant current under the conditions specified in Table 17 while maintained in an ambient temperature of +40 °C ± 2 °C or +70 °C ± 2 °C respectively as appropriate.

The discharge conditions A or B may be chosen to suit the user's requirements. The discharge is carried out immediately on completion of charging.

After performing the first charge acceptance test at +40 °C the cell is stored, in an ambient temperature of +70 °C ± 2 °C, for not less than 16 h and not more than 24 h.

During the ageing period of six months at +70 °C, precautions shall be taken to prevent the cell-case temperature from rising above +75 °C by providing a forced air draught, if necessary.

NOTE Actual cell case temperature, not the ambient temperature, determines cell performance.

The discharge duration of the three cycles at +70 °C shall be recorded. Leakage of electrolyte shall not occur during this test.

After completion of the ageing period, the cell shall be stored, in an ambient temperature of +40 °C ± 2 °C for not less than 16 h and not more than 24 h. The three cycles at +40 °C of the initial charge acceptance test are then repeated using the conditions specified in Table 17. The duration of the discharge shall not be less than the values specified in Table 17.

Table 17 – Permanent charge endurance for LT, MT, or HT cylindrical cells

Cycle number	Ambient temperature	Charge	Discharge A or B [a]	Minimum discharge duration
1		0,05 I_t A for 48 h	A: 0,2 I_t A to 1,0 V or	No requirement
			B: 1,0 I_t A to 1,0 V	No requirement
2	+40 °C ± 2 °C	0,05 I_t A for 24 h	A: 0,2 I_t A to 1,0 V or	3 h 45 min
			B: 1,0 I_t A to 1,0 V	42 min
3		0,05 I_t A for 24 h	A: 0,2 I_t A to 1,0 V or	3 h 45 min
			B: 1,0 I_t A to 1,0 V	42 min
4		0,05 I_t A for 60 days	A: 0,2 I_t A to 1,0 V or	
			B: 1,0 I_t A to 1,0 V	
5	+70 °C ± 2 °C	0,05 I_t A for 60 days	A: 0,2 I_t A to 1,0 V or	No requirement
			B: 1,0 I_t A to 1,0 V	
6		0,05 I_t A for 60 days	A: 0,2 I_t A to 1,0 V or	
			B: 1,0 I_t A to 1,0 V	
7		0,05 I_t A for 48 h	A: 0,2 I_t A to 1,0 V or	No requirement
			B: 1,0 I_t A to 1,0 V	No requirement
8	+40 °C ± 2 °C	0,05 I_t A for 24 h	A: 0,2 I_t A to 1,0 V or	2 h 30 min
			B: 1,0 I_t A to 1,0 V	24 min
9		0,05 I_t A for 24 h	A: 0,2 I_t A to 1,0 V or	2 h 30 min
			B: 1,0 I_t A to 1,0 V	24 min

[a] A: for LT, MT or HT cells.
B: for MT or HT cells only.

7.5.2.4 JT cylindrical cells

The following permanent charge endurance test shall be carried out in order to establish the number of charge/discharge cycles that a cell may accumulate under the following conditions.

Prior to this test, the cell shall be discharged at 0,2 I_t A at 20 °C ± 5 °C to a final voltage of 1,0 V and stored, in an ambient temperature of +55 °C ± 2 °C, for not less than 16 h and not more than 24 h.

The cell shall then be charged at a constant current of 0,033 I_t A for 28 days while maintained in an ambient temperature of +55 °C ± 2 °C and discharged, in the same ambient temperature, at 1,0 I_t A to a final voltage of 1,1 V.

The endurance test is considered complete when two successive capacity measurement cycles give discharge duration of less than 30 min. The total number of cycles successfully completed shall not be less than 6.

7.5.2.5 LU, MU or HU cylindrical cells

The permanent charge endurance test shall be performed in three steps according to the conditions specified in Table 18.

It consists of:

- a charge acceptance test at +50 °C;
- an ageing period of twelve months at +70 °C;
- a final charge acceptance test to check the cell's performance after ageing.

NOTE The twelve months ageing period and the temperature of +70 °C have been selected to simulate four years of permanent charge operation at +50 °C.

Prior to this test, the cell shall be discharged at 0,2 I_t A at 20 °C ± 5 °C to a final voltage of 1,0 V and stored, in an ambient temperature of +50 °C ± 2 °C, for not less than 16 h and not more than 24 h.

The cell shall then be charged and discharged at constant current under the conditions specified in Table 18 while maintained in an ambient temperature of +50 °C ± 2 °C or +70 °C ± 2 °C respectively as appropriate.

The discharge conditions A or B may be chosen to suit the user's requirements. The discharge is carried out immediately on completion of charging.

After performing the first charge acceptance test at +50 °C the cell is stored, in an ambient temperature of +70 °C ± 2 °C, for not less than 16 h and not more than 24 h.

During the ageing period of twelve months at +70 °C, precautions shall be taken to prevent the cell-case temperature from rising above +75 °C by providing a forced air draught, if necessary.

NOTE Actual cell case temperature, not the ambient temperature, determines cell performance.

The discharge duration of the three cycles at +70 °C shall be recorded. Leakage of electrolyte shall not occur during this test.

After completion of the ageing period, the cell shall be stored, in an ambient temperature of +50 °C ± 2 °C for not less than 16 h and not more than 24 h. The three cycles at +50 °C of the initial charge acceptance test are then repeated using the conditions specified in Table 18. The duration of the discharge shall not be less than the values specified in Table 18.

Table 18 – Permanent charge endurance for LU, MU, or HU cylindrical cells

Cycle number	Ambient temperature	Charge	Discharge A or B [a]	Minimum discharge duration
1		0,05 I_t A for 48 h	A: 0,2 I_t A to 1,0 V or	No requirement
			B: 1,0 I_t A to 1,0 V	No requirement
2	+50 °C ± 2 °C	0,05 I_t A for 24 h	A: 0,2 I_t A to 1,0 V or	3 h 45 min
			B: 1,0 I_t A to 1,0 V	42 min
3		0,05 I_t A for 24 h	A: 0,2 I_t A to 1,0 V or	3 h 45 min
			B: 1,0 I_t A to 1,0 V	42 min
4		0,05 I_t A for 120 days	A: 0,2 I_t A to 1,0 V or	
			B: 1,0 I_t A to 1,0 V	
5	+70 °C ± 2 °C	0,05 I_t A for 120 days	A: 0,2 I_t A to 1,0 V or	No requirement
			B: 1,0 I_t A to 1,0 V	
6		0,05 I_t A for 120 days	A: 0,2 I_t A to 1,0 V or B: 1,0 I_t A to 1,0 V	
7		0,05 I_t A for 48 h	A: 0,2 I_t A to 1,0 V or	No requirement
			B: 1,0 I_t A to 1,0 V	No requirement
8	+50 °C ± 2 °C	0,05 I_t A for 24 h	A: 0,2 I_t A to 1,0 V or	2 h 30 min
			B: 1,0 I_t A to 1,0 V	24 min
9		0,05 I_t A for 24 h	A: 0,2 I_t A to 1,0 V or	2 h 30 min
			B: 1,0 I_t A to 1,0 V	24 min

[a] A: for LU, MU or HU cells.
B: for MU or HU cells only.

7.6 Charge acceptance at constant voltage

This standard does not specify a charge acceptance test at constant voltage.

Charging at constant voltage is not recommended.

7.7 Overcharge

7.7.1 Small prismatic cells

The ability of the cell to withstand an overcharge shall be determined by the following test.

Prior to this test, the cell shall be discharged in an ambient temperature of 20 °C ± 5 °C, at a constant current of 0,2 I_t A, down to a final voltage of 1,0 V.

The cell shall then be charged, in an ambient temperature of 20 °C ± 5 °C, at a constant current of 0,1 I_t A, for 48 h. After this charging operation, the cell shall be stored, in an ambient temperature of 20 °C ± 5 °C, for not less than 1 h and not more than 4 h.

The cell shall then be discharged at 20 °C ± 5 °C, at a constant current of 0,2 I_t A to a final voltage of 1,0 V.

The duration of discharge shall not be less than 5 h.

7.7.2 L, M, H or X cylindrical and button cells

The ability of the cell to withstand an overcharge shall be determined by the following test.

Prior to this test, the cell shall be discharged in an ambient temperature of 20 °C ± 5 °C, at a constant current of 0,2 I_t A, to a final voltage of 1,0 V.

The cell shall then be charged, in an ambient temperature of 20 °C ± 5 °C, at a constant current of 0,1 I_t A, for 28 days. After this charging operation, it shall be stored, in an ambient temperature of 20 °C ± 5 °C, for not less than 1 h and not more than 4 h.

The cell shall then be discharged at 20 °C ± 5 °C, at a constant current of 0,2 I_t A to a final voltage of 1,0 V.

The duration of discharge shall not be less than,

- 5 h for cylindrical cells;
- 4 h 15 min for button cells.

7.7.3 LT/LU, MT/MU or HT/HU cylindrical cells

The ability of the cell to withstand an overcharge shall be determined by the following test performed at 0 °C ± 2 °C in circulating air.

Prior to this test, the cell shall be discharged, in an ambient temperature of 20 °C ± 5 °C, at a constant current of 0,2 I_t A, to a final voltage of 1,0 V and stored, at 0 °C ± 2 °C for not less than 16 h and not more than 24 h.

Charge and discharge shall be carried out at constant current, using the conditions specified in Table 19. The discharge conditions A or B may be chosen to suit the user's requirements.

Table 19 – Overcharge at 0 °C

Charge	Discharge A [a]	Discharge B [a]
	LT/LU, MT/MU, HT/HU cells	MT/MU, HT/HU cells
0,05 I_t A for 28 days	0,2 I_t A to 1,0 V	1,0 I_t A to 1,0 V
[a] The discharge is carried out immediately on completion of the charging.		

The duration of discharge shall not be less than:

- 4 h 15 min on discharge A, or
- 36 min on discharge B.

7.7.4 J cylindrical cells

The ability of the cell to withstand an overcharge shall be determined by the following test performed at +5 °C ± 2 °C in circulating air.

Prior to this test, the cell shall be discharged, in an ambient temperature of 20 °C ± 5 °C, at a constant current of 0,2 I_t A, to a final voltage of 1,0 V and stored, at +5 °C ± 2 °C, for not less than 16 h and not more than 24 h.

The cell shall then be charged, in an ambient temperature of +5 °C ± 2 °C, at a constant current of 0,1 I_t A, for 48 h. After this charging operation, the cell shall be stored, in an ambient temperature of 20 °C ± 5 °C, for not less than 16 h and not more than 24 h.

The cell shall then be discharged at 20 °C ± 5 °C at a constant current of 0,2 I_t A to a final voltage of 1,0 V.

The duration of discharge shall not be less than 5 h.

7.7.5 JT cylindrical cells

The ability of the cell to withstand an overcharge shall be determined by the following test performed at +5 °C ± 2 °C in circulating air.

Prior to this test, the cell shall be discharged, in an ambient temperature of 20 °C ± 5 °C, at a constant current of 0,2 I_t A, to a final voltage of 1,0 V and stored, at 5 °C ± 2 °C, for not less than 16 h and not more than 24 h.

The cell shall then be charged, in an ambient temperature of +5 °C ± 2 °C, at a constant current of 0,05 I_t A, for 96 h. After this charging operation, the cell shall be stored, in an ambient temperature of 20 °C ± 5 °C, for not less than 16 h and not more than 24 h.

The cell shall then be discharged at 20 °C ± 5 °C at a constant current of 1,0 I_t A to a final voltage of 1,1 V.

The duration of discharge shall not be less than 37 min.

7.7.6 R cylindrical cells

The ability of the cell to withstand an overcharge shall be determined by the following test.

Prior to this test, the cell shall be discharged in an ambient temperature of 20 °C ± 5 °C, at a constant current of 0,2 I_t A to a final voltage of 1,0 V.

The cell shall then be charged, in an ambient temperature of 20 °C ± 5 °C, at a constant current of 1,0 I_t A for 1,2 h or other appropriate charge termination such as $-\Delta V$ or as recommended by the manufacturer. Then charging should be continued, in the same ambient temperature, at a constant current of 0,1 I_t A for 28 days. After this charging operation, the cell shall be stored, in an ambient temperature of 20 °C ± 5 °C, for not less than 1 h and not more than 4 h.

The cell shall then be discharged in an ambient temperature of 20 °C ± 5 °C, at a constant current of 0,2 I_t A, to a final voltage of 1,0 V.

The duration of discharge shall not be less than 5 h.

7.8 Gas release device operation

Warning: **EXTREME CAUTION SHALL BE EXERCISED WHEN CARRYING OUT THIS TEST ! CELLS SHALL BE TESTED INDIVIDUALLY, AND IT SHOULD BE NOTED THAT CELLS FAILING TO MEET THE REQUIREMENT COULD BURST WITH EXPLOSIVE FORCE EVEN AFTER THE CELL HAS BEEN DISCONNECTED FROM THE CHARGE CURRENT.**

FOR THIS REASON, THE TEST SHALL BE CARRIED OUT IN A PROTECTIVE CHAMBER.

The following test shall be carried out in order to establish that the safety device of the cell will operate to allow the escape of gas when the internal pressure exceeds a critical value.

NOTE Some button cells do not have a gas release vent. This test is not applicable on this type of cell.

The cell shall undergo a forced discharge in an ambient temperature of 20 °C ± 5 °C, at a constant current of 0,2 I_t A to a final voltage of 0,0 V.

The current shall then be increased to 1,0 I_t A and the forced discharge continued in the same ambient temperature of 20 °C ± 5 °C for 60 min.

During and at the end of this discharge, the cell shall not disrupt or burst. Leakage of electrolyte and deformation of the cell are acceptable.

7.9 Storage

Storage should be carried out according to the recommendations of the manufacturer.

Prior to this test, the cell shall be discharged, in an ambient temperature of 20 °C ± 5 °C, at a constant current of 0,2 I_t A, to a final voltage of 1,0 V.

The cell shall then be stored on open circuit at a mean temperature of 20 °C ± 5 °C and at a relative humidity of 65 % ± 20 % for 12 months.

During the storage period, the ambient temperature shall not at any time fluctuate beyond the limits of 20 °C ± 10 °C.

After completion of the storage period, the cell shall be charged in accordance with:

- 7.2 for button cells, small prismatic cells, L/LT/LU, M/MT/MU, J/JT, H/HT/HU, X cylindrical cells;
- 7.3.4 for R cylindrical cells.

The cell shall then be discharged at each rate of constant current appropriate to cell designation as specified in 7.3.2. Five cycles are permitted for this test. The test shall be terminated at the end of the first cycle which meets the requirement.

The minimum discharge duration for each rate of constant current shall not be less than 80 % of the values specified in Tables 5 or 6.

NOTE In the case of a quality acceptance procedure, provisional approval of cell performance can be agreed, pending satisfactory results on discharge after storage.

7.10 Charge acceptance at +55 °C for LT, MT or HT cylindrical cells

This test is not a requirement. It will be used as reference of performance and is applicable to LT, MT or HT cylindrical cells only.

The cell shall be discharged, in an ambient temperature of 20 °C ± 5 °C, at a constant current of 0,2 I_t A, to a final voltage of 1,0 V and stored, in an ambient temperature of +55 °C ± 2 °C, for not less than 16 h and not more than 24 h.

The charge acceptance test shall then be carried out in an ambient temperature of +55 °C ± 2 °C. Charge and discharge shall be carried out at constant currents, using the conditions specified in Table 20. The discharge conditions A or B may be chosen to suit the users' requirements.

Table 20 – Charge and discharge at +55 °C

Cycle number	Charge	Discharge A or B [a]
1	0,05 I_t A for 48 h	A: 0,2 I_t A to 1,0 V or B: 1,0 I_t A to 1,0 V
2 [b]	0,05 I_t A for 24 h	A: 0,2 I_t A to 1,0 V or B: 1,0 I_t A to 1,0 V
3 [b]	0,05 I_t A for 24 h	A: 0,2 I_t A to 1,0 V or B: 1,0 I_t A to 1,0 V

[a] Discharge A is used with LT, MT or HT cells. Discharge B is used with MT or HT cells.

[b] The duration of discharge of cycles 2 and 3 shall be recorded and provided in any report of results.

7.11 Trickle charge acceptance for JT cylindrical cells

The ability of the cell to withstand a trickle charge acceptance A and B shall be determined by the following test.

The cell shall be discharged, in an ambient temperature of 20 °C ± 5 °C, at a constant current of 0,2 I_t A, to a final voltage of 1,0 V and stored, in an ambient temperature using the conditions specified in Table 21, for not less than 16 h and not more than 24 h.

The cell shall then be charged and discharged, in the same ambient temperature, at constant currents, using the conditions specified in Table 21.

The duration of discharge shall not be less than the values specified in Table 21.

Table 21 – Trickle charge acceptance for JT cylindrical cells

Condition	Ambient temperature	Charge	Discharge	Minimum duration of discharge
A (45 °C)	45 °C ± 2 °C	0,033 I_t A for 48 h	1,0 I_t A to 1,1 V	37 min
A (5 °C)	5 °C ± 2 °C	0,033 I_t A for 48 h	1,0 I_t A to 1,1 V	37 min
B (45 °C	45 °C ± 2 °C	0,04 I_t A for 24 h	1,0 I_t A to 1,1 V	25 min
B (5 °C)	5 °C ± 2 °C	0,04 I_t A for 24 h	1,0 I_t A to 1,1 V	25 min

7.12 Internal resistance

7.12.1 General

The internal resistance of sealed nickel-cadmium small prismatic or cylindrical rechargeable single cells shall be checked either by the alternating current (a.c.) or by the direct current (d.c.) method.

Should the need arise for the internal resistance to be measured by both a.c. and d.c. methods on the same cell, then the a.c. method shall be used first, followed by the d.c. method. In this case, it is not necessary to discharge and charge the cell between conducting a.c. and d.c. methods.

Prior to the measurements, the cell shall be discharged at 0,2 I_t A to a final voltage of 1,0 V. The cell shall be charged in accordance with 7.2. After charging, the cell shall be stored, in an ambient temperature of 20 °C ± 5 °C, for not less than 1 h and not more than 4 h.

The measurement of internal resistance shall be carried out in an ambient temperature of 20 °C ± 5 °C.

7.12.2 Measurement of the internal a.c. resistance

The alternating r.m.s. voltage, U_a, shall be measured when applying to the cell an alternating r.m.s. current, I_a, at the frequency of 1,0 kHz ± 0,1 kHz for a period of 1 s to 5 s.

The internal a.c. resistance, R_{ac}, is given by

$$R_{ac} = \frac{U_a}{I_a} \quad [\Omega]$$

where

U_a is the alternating r.m.s. voltage;

I_a is the alternating r.m.s. current.

NOTE 1 The alternating current is selected so that the peak voltage stays below 20 mV.

NOTE 2 This method will measure the impedance which, in the range of frequency specified, is approximately equal to the resistance.

NOTE 3 Connections to the battery terminals are made in such a way that voltage measurement contacts are separate from contacts used to carry current.

7.12.3 Measurement of the internal d.c. resistance

The cell shall be discharged at a constant current of value I_1 as specified in Table 22. At the end of a discharge period of 10 s, the voltage U_1 during discharge shall be measured and recorded. The discharge current shall then be immediately increased to a constant value of I_2 as specified in Table 22 and the corresponding voltage U_2 during discharge shall be measured and recorded again at the end of a discharge period of 3 s.

All voltage measurements shall be made at the terminals of the cell independently of contacts used to carry current.

The internal d.c. resistance, $R_{dc,}$ of the cell shall be calculated using the following formula:

$$R_{dc} = \frac{U_1 - U_2}{I_2 - I_1} \quad [\Omega]$$

where

I_1, I_2 are the constant discharge currents;

U_1, U_2 are the appropriate voltages measured during discharge.

Table 22 – Constant discharge currents used for measurement of d.c. resistance

Current	Cell designation		
	KF, KRL [a]	KRM [a], KRJ [a], KRH [a]	KRX
I_1	0,2 I_t A	0,5 I_t A	1,0 I_t A
I_2	2,0 I_t A	5,0 I_t A	10,0 I_t A

[a] And corresponding “T” cells and “R” cells.

8 Mechanical tests

Mechanical tests shall be performed according to IEC 61959.

9 Safety requirements

Safety requirements shall be fulfilled according to IEC 62133.

10 Type approval and batch acceptance

10.1 General

Content of type approval and batch acceptance shall be agreed between supplier and purchaser. Unless otherwise agreed between supplier and purchaser, the following tests shall be performed.

10.2 Type approval

10.2.1 Type approval for small prismatic cells

For type approval, the sequence of tests and sample sizes given in Table 23 shall be used. Six groups of cells denominated A, B, C, D, E and F respectively, shall be tested. The total number of cells required for type approval is 27. This total includes an extra cell, permitting a repeat test to cover any incident which may occur outside the supplier's responsibility.

Tests shall be carried out in sequence within each group of cells. All cells are subjected to the tests in group A, after which they are divided into five groups at random according to the sample sizes shown in Table 23.

The number of defective cells tolerated per group, and in total, is given in Table 23. A cell is considered to be defective if it does not meet the requirements of all or part of the tests of a group.

Table 23 – Sequence of tests for type approval for small prismatic cells

Group	Sample size	Clause or subclause	Tests	Number of defective cells tolerated	
				Per group	In total
A	27	5.3 6.1 7.3.2 7.3.2	Marking Dimensions Discharge at 20 °C at 0,2 I_t A Discharge at 20 °C at 1,0 I_t A	0	3
B	5	7.3.3 7.3.3	Discharge at –18 °C at 0,2 I_t A Discharge at –18 °C at 1,0 I_t A	1	
C	5	7.7 7.8	Overcharge Gas release device operation	0	
D	5	7.5.1	Endurance in cycles	1	
E	6	7.4	Charge (capacity) retention	1	
F	5	7.9 7.3.2	Storage Discharge at 20 °C at 0,2 I_t A	1	

10.2.2 Type approval for cylindrical and button cells

For type approval, the sequence of tests and sample sizes given in Tables 24 and 25 shall be used. Seven groups of cells denominated A, B, C, D, E, F and G respectively, shall be tested.

The total number of cells required for type approval is 32. This total includes an extra cell, permitting a repeat test to cover any incident which may occur outside the supplier's responsibility.

Tests shall be carried out in sequence within each group of cells. All cells are subjected to the tests in group A, after which they are divided into six groups at random according to the sample sizes shown in Table 24 or 25.

The number of defective cells tolerated per group, and in total, is given in these tables. A cell is considered to be defective if it does not meet the requirements of all or part of the tests of a group.

Table 24 – Sequence of tests for type approval for cylindrical cells

Group	Sample size	Clause or subclause	Tests	Number of defective cells tolerated	
				Per group	In total
A	32	5.3 6.1 7.3.2 7.3.2	Marking Dimensions Discharge at 20 °C at 0,2 I_t A Discharge at 20 °C at 1,0 I_t A (M, J, H and X cells) [a] 5,0 I_t A (H and X cells) [a] 10,0 I_t A (X cells only)	0	3
B	5	7.3.3 7.3.3	Discharge at –18 °C at 0,2 I_t A Discharge at –18 °C at 1,0 I_t A (M,H and X cells) [a] 2,0 I_t A (H and X cells) [a] 3,0 I_t A (X cells only)	1	
C	5	7.7 7.8	Overcharge Gas release device operation	0	
D	5	7.5.1	Endurance in cycles	1	
E	5	7.5.2 7.7	Permanent charge endurance Gas release device operation	1 0	
F	6	7.4	Charge (capacity) retention	1	
G	5	7.9 7.3.2 7.3.2	Storage Discharge at +20 °C at 0,2 I_t A Discharge at +20 °C at 1,0 I_t A (M, J, H and X cells) [a] 5,0 I_t A (H and X cells) [a] 10,0 I_t A (X cells only)	1	

[a] And corresponding "T", "U" and "R" cells.

Table 25 – Sequence of tests for type approval for button cells

Group	Sample size	Clause or subclause	Tests	Number of defective cells tolerated	
				Per group	In total
A	32	5.3 6.2 7.3.2 7.3.2	Marking Dimensions Discharge at 20 °C at 0,2 I_t A Discharge at 20 °C at 1,0 I_t A (M and H cells) 5,0 I_t A (H cells only)	0	3
B	5	7.3.3	Discharge at –18 °C at 0,2 I_t A (M and H cells) 1,0 I_t A (M and H cells) 2,0 I_t A (H cells only)	1	
C	5	7.7 7.8	Overcharge Gas release device operation	0	
D	5	7.5.1	Endurance in cycles	1	
E	5	7.5.2	Permanent charge endurance	1	
F	6	7.4	Charge (capacity) retention	1	
G	5	7.9 7.3.2 7.3.2	Storage Discharge at 20 °C at 0,2 I_t A Discharge at 20 °C at 1,0 I_t A (M and H cells) 5,0 I_t A (H cells only)	1	

10.3 Batch acceptance

These tests are applicable to deliveries of individual cells.

The sampling procedure shall be established in accordance with IEC 60410. Unless otherwise agreed between supplier and purchaser, inspections and tests shall be performed using inspection levels and AQLs (acceptable quality level) recommended in Table 26.

Table 26 – Recommended test sequence for batch acceptance

Group	Clause or subclause	Inspection/tests	Recommendation	
			Inspection level	AQL %
A		Visual inspection:		
		– absence of mechanical damage	II	4
		– absence of corrosion on case and terminals	II	4
	As agreed	– number, position and secure fittings of connection tabs	S 3	1
		– absence of liquid electrolyte on case and terminals	II	0,65
B		Physical inspection:		
	Clause 6	– dimensions	S 3	1
	As agreed	– weight	S 3	1
	5.3	– marking	S 3	1
C		Electrical inspection:		
	As agreed	– open-circuit voltage and polarity	II	0,65
	7.3.2	– discharge at 20 °C at 0,2 I_t A	S 3	1
	7.3.2	– discharge at 20 °C at		
		1,0 I_t A (M, MT, MU and MR cells)	S 3	1
		5,0 I_t A (H, HT, HU and HR cells)	S 3	1
		10,0 I_t A (X cells only)	S 3	1

NOTE Two or more failures on a single cell are not cumulative. Only the failure corresponding to the lowest AQL is taken into consideration.

Annex A
(informative)

Procedure for measuring the capacity of a battery

The capacity of a battery is measured under the following procedure:

- Charge and discharge currents for this test shall be based on the rated capacity (C_5 Ah) of the battery. These currents are expressed as multiples of I_t A, where I_t A = C_5 Ah/1 h.
- Prior to charging, the battery shall be discharged in an ambient temperature of 20 °C ± 5 °C, at a constant current of 0,2 I_t A, until its voltage is equal to the specified end-of-discharge voltage.
- The charging procedure for the battery shall be carried out as recommended by the manufacturer in an ambient temperature of 20 °C ± 5 °C and a relative humidity of 65 % ± 20 %. This test shall be performed within one month of the arrival date or the purchasing date.
- After charging, the battery shall be stored in an ambient temperature of 20 °C ± 5 °C, for not less than 1 h and not more than 4 h. The battery shall then be discharged in an ambient temperature of 20 °C ± 5 °C, at a constant current of 0,2 I_t A, until its voltage is equal to the specified end-of-discharge voltage.

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