

INTERNATIONAL STANDARD

IEC 61951-2

Second edition
2003-04

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

Part 2: Nickel-metal hydride

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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

Part 2: Nickel-metal hydride

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 61951-2 has been prepared by subcommittee 21A: Secondary cells and batteries containing alkaline or other non-acid electrolytes, of IEC technical committee 21: Secondary cells and batteries.

This second edition cancels and replaces the first edition published in 2001 of which it constitutes a technical revision.

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

FDIS	Report on voting
21A/374/FDIS	21A/380/RVD

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

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

IEC 61951 series, published under the general title *Secondary cells and batteries containing alkaline or other non-acid electrolytes – Portable sealed rechargeable single cells*, consists of the following parts:

- Part 1: Nickel-cadmium
- Part 2: Nickel-metal hydride.

The committee has decided that the contents of this publication will remain unchanged until 2008-06. At this date, the publication will be

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- withdrawn;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

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

Part 2: Nickel-metal hydride

1 Scope

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

2 Normative references

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.

IEC 60050-486, *International Electrotechnical Vocabulary – Chapter 486: Secondary cells and batteries*

IEC 60051 (all parts), *Direct acting indicating analogue electrical measuring instruments and their accessories*

IEC 60086 (all parts), *Primary batteries*

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

IEC 60485, *Digital electronic d.c. voltmeters and d.c. electronic analogue-to-digital converters*

IEC 61959, *Secondary cells and batteries containing alkaline or other non-acid electrolytes – Mechanical tests for sealed portable secondary cells and batteries¹*

3 Definitions

For the purposes of this document, the definitions contained in IEC 60050-486 and the following apply:

3.3.1

small prismatic cell

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

¹ To be published.

3.3.2**cylindrical cell**

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

3.3.3**button cell**

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

3.3.4**nickel-metal hydride cell**

cell containing a nickel hydroxide compound for the positive electrode and a hydrogen absorbing alloy for the negative electrode

3.3.5**sealed cell**

cell which remains closed and does not release either gas or liquid when operated within the limits of charge and temperature specified by the manufacturer. The cell is equipped with a safety device to prevent dangerously high internal pressure. The cell does not require addition to the electrolyte and is designed to operate during its life in its original sealed state

NOTE The nickel-metal hydride cell, however, may release gas towards the end of its life due to the accumulation of hydrogen in the cell.

3.3.6**nominal voltage**

nominal voltage of a sealed nickel-metal hydride rechargeable single cell: 1,2 V

3.3.7**portable cell**

cell designed mainly for use in an easily hand-carried battery

3.3.8**rated capacity**

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 7.2.1

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) $\pm 0,1$ % for time.

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

For assistance in selecting instrumentation, see the IEC 60051 series for analogue instruments and IEC 60485 for digital instruments. 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

Sealed nickel-metal hydride small prismatic rechargeable single cells shall be designated by the letters "HF" 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 HF 18/07/49 designation identifies a small prismatic cell, with a maximum width of 18 mm, a maximum thickness of 7 mm and a maximum height of 49 mm.

5.1.2 Cylindrical cells

Sealed nickel-metal hydride cylindrical rechargeable single cells shall be designated by the letters "HR" followed by a letter L, M, H or X which signifies:

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

NOTE 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;
- H up to $7,0 I_t$ A;
- X up to and above $7,0 I_t$ A.

When a cell is intended for permanent charge at elevated temperatures, typically higher than $40\text{ }^{\circ}\text{C}$, a letter "T" is placed after the letter L, M, 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, H or X.

The group of three (or four) letters shall then be followed by two groups of figures 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 battery, the designation of Table 2 shall also be marked on the cell.

EXAMPLE 1 HRL 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 HRLT 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 HRXR 23/43 designation identifies a cylindrical cell of very high discharge rate capability, which is also intended for rapid charge, with a maximum diameter of 23 mm and a maximum height of 43 mm.

5.1.3 Button cells

Sealed nickel-metal hydride button rechargeable single cells shall be designated by the letters "HB" 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 HB 116/054 designation identifies a button cell, with a maximum diameter of 11,6 mm and a maximum height of 5,4 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-metal hydride or Ni-MH;
- 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.

NOTE In general, sealed nickel-metal hydride 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:

- 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

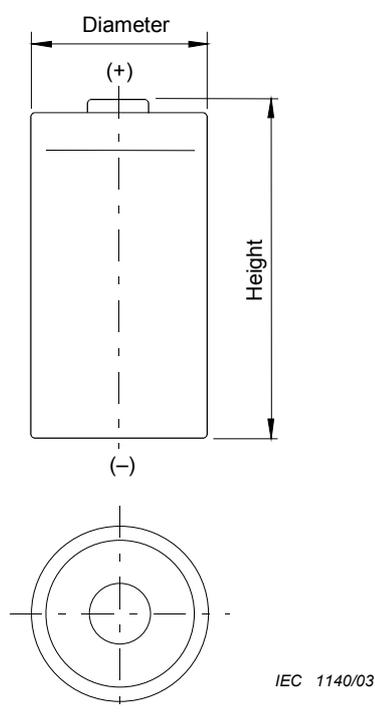


Figure 1 – Jacketed cylindrical cells

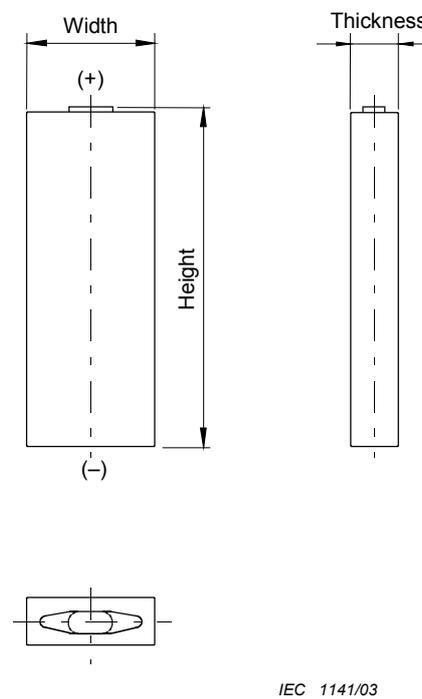


Figure 2 – Jacketed small prismatic cells

6.1.1 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	Height mm
HF 15/08/49	14,5	7,4	48,2
HF 15/09/49	14,5	8,3	48,2
HF 18/07/36	17,3	6,1	35,7
HF 18/07/49	17,3	6,1	48,2
HF 18/09/49	17,3	8,3	48,2
HF 18/07/68	17,3	6,1	67,3
HF 18/11/68	17,3	10,7	67,3
HF 18/18/68	17,3	17,3	67,3
HF 23/11/68	22,7	10,7	67,3
HF 23/15/68	22,7	14,5	67,3

Width tolerances: 0, -1,0
Thickness tolerances: 0, -0,7, -1,0
Height tolerances: 0, -1,0, -1,5

6.1.2 Cylindrical cells

6.1.2.1 Cells dimensionally interchangeable with primary batteries

Table 2 gives the requirements relative to the dimensions for jacketed cylindrical cells which are dimensionally interchangeable with primary batteries.

Table 2 – Cylindrical cells dimensionally interchangeable with primary batteries

Cell designation ^a	Corresponding primary battery ^b IEC 60086	Dimensions
HR 03	R 03	All dimensions shall be in accordance with IEC 60086-2
HR 6	R 6	
HR 14	R 14	
HR 20	R 20	

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

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

6.1.2.2 Cells not dimensionally interchangeable with primary batteries

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

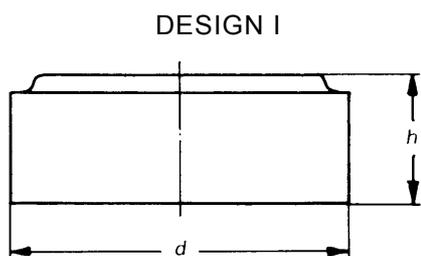
Table 3 – Dimensions of jacketed cylindrical cells not dimensionally interchangeable with primary batteries

Cell designation ^a	Diameter mm	Height mm
HR 11/45	10,5	44,5
HR 11/51	10,5	50,5
HR 11/67	10,5	67,0
HR 15/43	14,5	43,0
HR 15/49	14,5	49,0
HR 15/51	14,5	50,5
HR 17/29	17,0	28,5
HR 17/43	17,0	43,0
HR 17/50	17,0	50,0
HR 17/67	17,0	67,0
HR 23/34	23,0	34,0
HR 23/43	23,0	43,0
HR 26/47	25,8	47,0
HR 26/50	25,8	50,0
HR 33/36	33,0	36,0
HR 33/62	33,0	61,5
HR 33/91	33,0	91,0

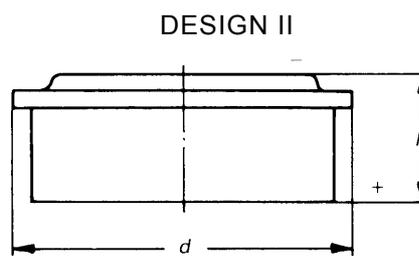
^a The letters HR to be followed by L, M, H or X and T and/or R as appropriate (see 5.1).

6.2 Button cells

Cells shall be constructed as design I or II.



IEC 2883/2000



IEC 2884/2000

NOTE The polarity of design I is not standardized.

Figure 3 – Button cells

Table 4 shows the dimensions of sealed nickel-metal hydride button rechargeable single cells.

Table 4 – Dimensions of button cells

Cell designation	Overall diameter d mm	Overall height h mm
HB 079/054	7,9	5,4
HB 116/054	11,6	5,4
HB 156/064	15,6	6,4
HB 222/048	22,2	4,8
HB 252/061	25,2	6,1
HB 252/065	25,2	6,5
HB 252/078	25,2	7,8
HB 347/060	34,7	6,0

7 Electrical tests

Charge and discharge currents for the tests in accordance with this clause 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.

7.1 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 $20\text{ °C} \pm 5\text{ °C}$, at a constant current of $0,1 I_t$ A, for 16 h.

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

7.2 Discharge performance

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

7.2.1 Discharge performance at 20 °C

The cell shall be charged in accordance with 7.1. After charging, the cell shall be stored in an ambient temperature of $20\text{ °C} \pm 5\text{ °C}$, for not less than 1 h and not more than 4 h.

The cell shall then be discharged in an ambient temperature of $20\text{ °C} \pm 5\text{ °C}$ and as specified in Tables 5 or 6. The duration of discharge shall be not 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	M/MT	H/HT	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 I_t A and 10 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 7.1 and discharging at 0,2 I_t A in an ambient temperature of 20 °C ± 5 °C according to 7.2.1.

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

Discharge conditions		Minimum discharge duration h/min
Rate of constant current A	Final voltage V	
0,2 I_t ^a	1,0	5 h
1,0 I_t	0,9	35 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.

7.2.2 Discharge performance at 0 °C

The cell shall be charged in accordance with 7.1. After charging, the cell shall be stored, in an ambient temperature of 0 °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 0 °C ± 2 °C and as specified in Tables 7 or 8. The duration of discharge shall be not less than the values specified in Tables 7 or 8.

Table 7 – Discharge performance at 0 °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	M/MT	H/HT	X
0,2 I_t	1,0	2 h	4 h	4 h	4 h 30 min
1,0 I_t	0,9	–	36 min	42 min	48 min
2,0 I_t ^a	0,8	–	–	15 min	21 min
3,0 I_t ^a	0,8	–	–	–	12 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 shall consist of charging at 0,1 I_t A in accordance with 7.1 and discharging at 0,2 I_t A in an ambient temperature of 20 °C ± 5 °C according to 7.2.1.

Table 8 – Discharge performance at 0 °C for button cells

Discharge conditions		Minimum discharge duration h/min
Rate of constant current A	Final voltage V	
0,2 I_t	1,0	4 h
1,0 I_t	0,9	27 min

7.2.3 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 7.2.1 and 7.2.2.

The duration of discharge shall be not less than the values specified in Table 5 for discharge at 20 °C ± 5 °C and in Table 7 for discharge at 0 °C ± 2 °C.

7.3 Charge (capacity) retention

The charge (capacity) retention shall be determined by the following test. After charging in accordance with 7.1, 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 cells shall be discharged under the conditions specified in 7.2.1 at a rate of 0,2 I_t A.

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

- 3 h for small prismatic cells and cylindrical cells;
- 3 h 45 min for button cells.

7.4 Endurance

7.4.1 Endurance in cycles

Prior to the endurance in cycles 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 9,10, 11 and 12. 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 The actual cell temperature, not the ambient temperature, determines cell performance.

7.4.1.1 Small prismatic, button and cylindrical cells

Table 9 – Endurance in cycles for small prismatic, button and cylindrical 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, 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 a discharge duration of less than 3 h. The total number of cycles obtained when the test is completed shall be not less than:

- 500 for L/LR, M/MR, H/HR or X/XR cells;
- 50 for LT, MT or HT cells;
- 500 for button cells.

7.4.1.2 Cylindrical cells (accelerated test procedures)

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 7.4.1.1.

7.4.1.2.1 H or X cells

Table 10 – Endurance in cycles for H or X 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	0,3 I_t A for 4h ^a	30 min	1,0 I_t A to 1,0 V	90 min
49	0,3 I_t A for 4h ^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 4h	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 be not less than 500.

7.4.1.2.2 X cells

Table 11 – Endurance in cycles for 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 1h ^a	30 min	5,0 I_t A to 0,8 V	42 min
49	1,0 I_t A for 1h ^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 be not less than 500.

7.4.1.2.3 HR or XR cells

Table 12 – Endurance in cycles for HR or XR 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	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 $-\Delta V$ or $\Delta T/\Delta t$ 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 be not less than 500.

7.4.2 Permanent charge endurance

7.4.2.1 Small prismatic and button cells

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

7.4.2.2 L, M, H or X cylindrical 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 in an ambient temperature of $20\text{ °C} \pm 5\text{ °C}$. Charge and discharge shall be carried out at constant current throughout, using the conditions specified in Table 13.

Table 13 – Permanent charge endurance for L, M, H or X 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 charging.

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

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

7.4.2.3 LT, MT or HT cylindrical cells

The permanent charge endurance test shall be performed in three steps according to the conditions specified in Table 14.

It consists of:

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

NOTE The temperature of $+70\text{ °C}$ has been selected to simulate four years of permanent charge operation at $+40\text{ °C}$.

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

The cell shall then be charged and discharged at constant currents under the conditions specified in Table 14 while maintained in an ambient temperature of $+40\text{ °C} \pm 2\text{ °C}$ or $+70\text{ °C} \pm 2\text{ °C}$ 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 $+40\text{ °C}$ the cell is stored in an ambient temperature of $+70\text{ °C} \pm 2\text{ °C}$ 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 The 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 14. The duration of discharge shall be not less than the values specified in Table 14.

Table 14 – Permanent charge endurance for LT, MT or HT cells

Cycle number	Ambient temperature	Charge	Discharge A or B ^a	Minimum discharge duration
1	+40 °C ± 2 °C	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	No requirement
2		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 h 45 min
3		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	42 min
4	+70 °C ± 2 °C	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	No requirement
5		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	
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	+40 °C ± 2 °C	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	No requirement
8		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	2 h 30 min
9		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	24 min
^a A: for LT, MT or HT cells B: for MT or HT cells only				

7.5 Charge acceptance at constant voltage

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

Charging at constant voltage is not recommended.

7.6 Overcharge

7.6.1 Small prismatic, 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 at $20\text{ °C} \pm 5\text{ °C}$, 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 $20\text{ °C} \pm 5\text{ °C}$, 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 $20\text{ °C} \pm 5\text{ °C}$, for not less than 1 h and not more than 4 h.

The cell shall then be discharged at $20\text{ °C} \pm 5\text{ °C}$ at a constant current of $0,2 I_t$ A to a final voltage of 1,0 V.

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

7.6.2 LT, MT or HT cylindrical cells

The ability of the cell to withstand an overcharge shall be determined by the following test performed at $0\text{ °C} \pm 2\text{ °C}$ in circulating air.

Prior to this test, the cell shall be discharged in an ambient temperature of $20\text{ °C} \pm 5\text{ °C}$ at $0,2 I_t$ A to a final voltage of 1,0 V and stored, at $0\text{ °C} \pm 2\text{ °C}$, 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 15. The discharge condition A or B may be chosen to suit the user's requirements.

Table 15 – Overcharge at 0 °C

Charge	Discharge A ^a	Discharge B ^a
	LT, MT, HT cells	MT, HT cells
$0,05 I_t$ A for 28 days	$0,2 I_t$ A to 1,0 V	$1,0 I_t$ A to 0,9 V

^a The discharge is carried out immediately on completion of charging.

The duration of discharge shall be not less than that specified in Table 7.

7.6.3 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 $20\text{ °C} \pm 5\text{ °C}$, at a constant current of $0,2 I_t$ A, to a final voltage of 1,0 V.

The cell shall be charged in an ambient temperature of $20\text{ °C} \pm 5\text{ °C}$ 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 48 h. After this charging operation, the cell shall be stored, in an ambient temperature of $20\text{ °C} \pm 5\text{ °C}$, for not less than 1 h and not more than 4 h.

The cell shall then be discharged at $20\text{ °C} \pm 5\text{ °C}$ at a constant current of $0,2 I_t$ A to a final voltage of 1,0 V.

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

7.7 Safety 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 safety vent. This test should not be performed on this type of cell.

The cell shall undergo a forced discharge in an ambient temperature of $20\text{ °C} \pm 5\text{ °C}$, at a constant current of $0,2 I_t$ A, to a final voltage of 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 $20\text{ °C} \pm 5\text{ °C}$, 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.

7.8 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 $20\text{ °C} \pm 5\text{ °C}$, at a constant current of $0,2 I_t$ A, to a final voltage of 1,0 V. It shall then be charged in accordance with:

- 7.1 for button cells, small prismatic cells, L, M, H, X, LT, MT or HT cylindrical cells;
- 7.2.3 for R cylindrical cells.

The cell shall then be stored on open circuit, at a mean temperature of $20\text{ °C} \pm 5\text{ °C}$ and a relative humidity of $65\% \pm 20\%$ for 12 months.

During the storage period, the ambient temperature shall not, at any time, fluctuate beyond the limits of $20\text{ °C} \pm 10\text{ °C}$.

After completion of the storage period, the cell shall be discharged in an ambient temperature of $20\text{ °C} \pm 5\text{ °C}$, at a constant current of $0,2 I_t$ A, to a final voltage of 1,0 V and then charged in accordance with:

- 7.1 for button cells, small prismatic cells, L, M, H, X, LT, MT or HT cylindrical cells;
- 7.2.3 for R cylindrical cells.

The cell shall then be discharged at each rate of constant current appropriate to cell designation as specified in 7.2.1. 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 be not 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 may be agreed, pending satisfactory results on discharge after storage.

7.9 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 $20\text{ °C} \pm 5\text{ °C}$ 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 $+55\text{ °C} \pm 2\text{ °C}$ 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 $+55\text{ °C} \pm 2\text{ °C}$. Charge and discharge shall be carried out at constant currents, using the conditions specified in Table 16. The discharge conditions A or B may be chosen to suit the users' requirements.

Table 16 – 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	$0,05 I_t$ 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	$0,05 I_t$ 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.		

7.10 Internal resistance

The internal resistance of sealed nickel-metal hydride 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 7.1. After charging, the cell shall be stored, in an ambient temperature of $20\text{ °C} \pm 5\text{ °C}$, 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 $20\text{ °C} \pm 5\text{ °C}$.

7.10.1 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 $1,0\text{ kHz} \pm 0,1\text{ kHz}$ for a period of 1 s to 5 s.

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

$$R_{ac} = \frac{U_a}{I_a} \Omega$$

where

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

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

NOTE 1 The alternating current should be 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 should be made in such a way that voltage measurement contacts are separate from contacts used to carry current.

7.10.2 Measurement of the internal d.c. resistance

The cell shall be discharged at a constant current of value I_1 , as specified in Table 17. 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 17 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:

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

where

I_1, I_2 are the constant discharge currents;

U_1, U_2 are the appropriate voltages measured during discharge.

Table 17 – Constant discharge currents used for measurement of d.c. resistance

Current	Cell designation		
	HRL ^a	HRM ^a HRH ^a	HRX
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. Conditions for approval and acceptance

9 Type approval and batch acceptance

9.1 Type approval

9.1.1 Type approval for small prismatic cells and button cells

For type approval, the sequence of tests and sample sizes given in Table 18 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 test in group A, after which they are divided into five groups at random according to the sample sizes shown in Table 18.

The number of defective cells tolerated per group, and in total, is given in Table 18. 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 18 – Sequence of tests for type approval for small prismatic cells and for button cells

Group	Sample size	Clause or subclause	Tests	Number of defective cells tolerated	
				Per group	In total
A	27	5.3 6 7.2.1 7.2.1	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	7.2.2 7.2.2	Discharge at 0 °C, at 0,2 I _t A Discharge at 0 °C, at 1,0 I _t A	1	
C	5	7.6 7.7	Overcharge Safety device operation	0	
D	5	7.4	Endurance in cycles	1	
E	6	7.3	Charge (capacity) retention	1	
F	5	7.8 7.2.1	Storage Discharge at 20 °C, at 0,2 I _t A	1	

9.1.2 Type approval for cylindrical cells

For type approval, the sequence of tests and sample sizes given in Table 19 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 test in group A, after which they are divided into six groups at random according to the sample sizes shown in Table 19.

The number of defective cells tolerated per group, and in total, is given in Table 19. 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 19 – 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 7.2.1 7.2.1	Marking Dimensions Discharge at 20 °C at 0,2 I_t A Discharge at 20 °C at 1,0 I_t A (M, 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	7.2.2 7.2.2	Discharge at 0 °C at 0,2 I_t A Discharge at 0 °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	7.6 7.7	Overcharge Safety device operation	0	
D	5	7.4.1	Endurance in cycles	1	
E	5	7.4.4 7.7	Permanent charge endurance Safety device operation	1 0	
F	6	7.3	Charge retention	1	
G	5	7.8 7.2.1 7.2.1	Storage Discharge at 20 °C at 0,2 I_t A Discharge at 20 °C at 1,0 I_t A (M, 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" cells or "R" cells.

9.2 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 20.

Table 20 – Recommended test sequence for batch acceptance

Group	Clause or subclause	Inspection/tests	Recommendation	
			Inspection level	AQL %
A	As agreed	Visual inspection		
		– absence of mechanical damage	II	4
		– absence of corrosion on case and terminals	II	4
		– number, position and secure fittings of connection tabs	S3	1
		– absence of liquid electrolyte on case and terminals	II	0,65
B	6 As agreed 5.3	Physical inspection		
		– dimensions	S3	1
		– weight	S3	1
		– marking	S3	1
C	7.2.1 7.2.1	Electrical inspection		
		– open-circuit voltage and polarity	II	0,65
		– discharge at 20 °C at 0,2 I_t A	S3	1
		– discharge at 20 °C at 1,0 I_t A	S3	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.

Bibliography

IEC 61434, *Secondary cells and batteries containing alkaline or other non-acid electrolytes – Guide to the designation of current in alkaline secondary cell and battery standards*



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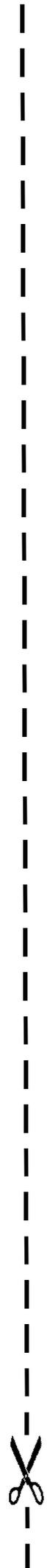
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