BS EN 62620:2015

BSI Standards Publication

Secondary cells and batteries containing alkaline or other non-acid electrolytes — Secondary lithium cells and batteries for use in industrial applications

...making excellence a habit.™

National foreword

This British Standard is the UK implementation of EN 62620:2015. It is identical to IEC 62620:2014.

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.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Published by BSI Standards Limited 2015

ISBN 978 0 580 74263 7
ICS 29.220.30

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 30 June 2015.

Amendments/corrigenda issued since publication

Date	Text affected

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 62620

January 2015

ICS 29.220.30

English Version

Secondary cells and batteries containing alkaline or other non-acid electrolytes - Secondary lithium cells and batteries for use in industrial applications (IEC 62620:2014)

Accumulateurs alcalins et autres accumulateurs à électrolyte non acide - Éléments et batteries d'accumulateurs au lithium pour utilisation dans les applications industrielles (IEC 62620:2014)

Akkumulatoren und Batterien mit alkalischen oder anderen nichtsäurehaltigen Elektrolyten - Lithium-Akkumulatoren und -batterien für industrielle Anwendungen (IEC 62620:2014)

This European Standard was approved by CENELEC on 2014-12-30. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

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.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

CENELEC

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

CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels

Ref. No. EN 62620:2015 E

Foreword

The text of document 21A/561/FDIS, future edition 1 of IEC 62620, 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 approved by CENELEC as EN 62620:2015.

The following dates are fixed:

–	latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2015-09-30
–	latest date by which the national standards conflicting with the document have to be withdrawn	(dow)	2017-12-30

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

Endorsement notice

The text of the International Standard IEC 62620:2014 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	Harmonised in EN 60051 series (not modified).
IEC 61434	NOTE	Harmonised in EN 61434 (not modified).
IEC 61960	NOTE	Harmonised as EN 61960 (not modified).
IEC 62660 Series	NOTE	Harmonised in EN 62660 series (not modified).

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

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.

NOTE 1 When an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cenelec.eu.

Publication	Year	Title	EN/HD	Year
IEC 60050-482	2004	International Electrotechnical Vocabulary (IEV) -- Part 482: Primary and secondary cells and batteries	-	-
ISO/IEC Guide 51	-	Safety aspects - Guidelines for their inclusion in standards	-	-

CONTENTS

FOREWORD ... 4
1 Scope ... 6
2 Normative references ... 6
3 Terms and definitions ... 6
4 Parameters measurement tolerances ... 8
5 Marking and designation ... 8
5.1 Marking ... 8
5.2 Cell designation ... 10
5.3 Battery designation ... 12
5.3.1 General ... 12
5.3.2 Battery structure formulation ... 13
5.4 Cell or battery termination ... 13
6 Electrical tests ... 13
6.1 General ... 13
6.2 Charging procedure for test purposes ... 14
6.3 Discharge performance ... 14
6.3.1 Discharge performance at +25 °C ... 14
6.3.2 Discharge performance at low temperature ... 15
6.3.3 High rate permissible current ... 15
6.4 Charge (capacity) retention and recovery ... 16
6.4.1 General ... 16
6.4.2 Test method ... 16
6.4.3 Acceptance criterion ... 16
6.5 Cell and battery internal resistance ... 17
6.5.1 General ... 17
6.5.2 Measurement of the internal a.c. resistance ... 17
6.5.3 Measurement of the internal d.c. resistance ... 17
6.6 Endurance ... 18
6.6.1 Endurance in cycles ... 18
6.6.2 Endurance in storage at constant voltage (permanent charge life) ... 19
7 Type test conditions ... 20
7.1 General ... 20
7.2 Sample size ... 20
7.3 Conditions for type approval ... 21
7.3.1 Dimensions ... 21
7.3.2 Electrical tests ... 22
Annex A (informative) Battery structure information ... 23
A.1 Example 1 ... 23
A.2 Example 2 ... 23
A.3 Example 3 ... 23
A.4 Example 4 ... 23
A.5 Example 5 ... 24
A.6 Example 6 ... 24
A.7 Example 7 ... 25
A.8 Example 8 ... 25

A.9 Example 9 ... 26
Bibliography ... 27

Figure 1 – Test sequence ... 21
Figure A.1 – Structure 3S ... 23
Figure A.2 – Structure 2P ... 23
Figure A.3 – Structure 3S2P ... 23
Figure A.4 – Structure 2P4S ... 24
Figure A.5 – Structure 2P4S3P ... 24
Figure A.6 – Structure (2P4S)3P ... 25
Figure A.7 – Structure (3S2P)3P ... 25
Figure A.8 – Structure (5S)4S ... 26
Figure A.9 – Structure ((3S2P)3P)2S ... 26

Table 1 – Marking ... 10
Table 2 – Discharge performance at +25 °C ± 5 °C ... 14
Table 3 – Discharge performance at low temperature ... 15
Table 4 – Discharge current values for high rate permissible test ... 16
Table 5 – Constant discharge current used for measurement of the internal d.c. resistance ... 18
Table 6 – Type test ... 20
Table 7 – Severe conditions ... 22

INTERNATIONAL ELECTROTECHNICAL COMMISSION

SECONDARY CELLS AND BATTERIES CONTAINING ALKALINE OR OTHER NON-ACID ELECTROLYTES – SECONDARY LITHIUM CELLS AND BATTERIES FOR USE IN INDUSTRIAL APPLICATIONS

FOREWORD

International Standard IEC 62620 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.

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

FDIS	Report on voting
21A/561/FDIS	21A/572/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.

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

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

SECONDARY CELLS AND BATTERIES CONTAINING ALKALINE OR OTHER NON-ACID ELECTROLYTES – SECONDARY LITHIUM CELLS AND BATTERIES FOR USE IN INDUSTRIAL APPLICATIONS

1 Scope

This International Standard specifies marking, tests and requirements for lithium secondary cells and batteries used in industrial applications including stationary applications.

When there exists an IEC standard specifying test conditions and requirements for cells used in special applications and which is in conflict with this standard, the former takes precedence. (e.g. IEC 62660 series on road vehicles).

The following are some examples of applications that utilize the cells and batteries under the scope of this standard.

- Stationary applications: telecom, uninterruptible power supplies (UPS), electrical energy storage system, utility switching, emergency power and similar applications.
- Motive applications: fork-lift truck, golf cart, AGV, railway, and marine, excluding road vehicles.

Since this standard covers batteries for various industrial applications, it includes those requirements, which are common and minimum to the various applications.

This standard applies to cells and batteries. If the battery is divided into smaller units, the smaller unit can be tested as the representative of the battery. The manufacturer clearly declares the tested unit. The manufacturer may add functions, which are present in the final battery, to the tested unit.

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 60050-482:2004, *International Electrotechnical Vocabulary (IEV) – Part 482: Primary and secondary cells and batteries*

ISO/IEC Guide 51, *Safety aspects – Guidelines for their inclusion in standards*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-482 and ISO/IEC Guide 51 as well as the following apply.

3.1
charge recovery
capacity recovery
capacity that a cell or battery can deliver after the charge following the charge retention test

Note 1 to entry: Charge retention is defined in 3.2.

3.2
charge retention
capacity retention
capacity that a cell or battery can deliver after storage, at a specific temperature, for a specific time without subsequent recharge as a percentage of the rated capacity

3.3
final voltage
end-of-discharge voltage
specified closed circuit voltage at which the discharge of a cell or battery is terminated

3.4
nominal voltage
suitable approximate value of the voltage used to designate or identify a cell or a battery

Note 1 to entry: The cell or battery manufacturer may provide the nominal voltage.

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.]

3.5
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_n Ah (ampere-hours) declared by the manufacturer which a single cell or battery can deliver during a n h period when charging, storing and discharging under the conditions specified in 6.3.1. n is 5 for an E, M and H discharge rate type cell or battery. n is 8, 10, 20 or 240 for an S discharge rate type battery.

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

3.6
cell
secondary lithium cell
secondary cell where electrical energy is derived from the insertion/extraction reactions of lithium ions or oxidation/reduction reaction of lithium between the negative electrode and the positive electrode

Note 1 to entry: The cell typically has an electrolyte that consists of a lithium salt and organic solvent compound in liquid, gel or solid form and has a metal or a laminate film casing. It is not ready for use in an application because it is not yet fitted with its final housing, terminal arrangement and electronic control device.

3.7
cell block
group of cells connected together in parallel configuration with or without protective devices (e.g. fuse or PTC) and monitoring circuitry

Note 1 to entry: It is not ready for use in an application because it is not yet fitted with its final housing, terminal arrangement and electronic control device.

3.8
module
group of cells connected together either in a series and/or parallel configuration with or without protective devices (e.g. fuse or PTC) and monitoring circuitry

3.9
battery pack
energy storage device, which is comprised of one or more cells or modules electrically connected

Note 1 to entry: It may incorporate a protective housing and be provided with terminals or other interconnection arrangement. It may include protective devices and control and monitoring, which provides information (e.g. cell voltage) to a battery system.

3.10
battery system
battery
system which incorporates one or more cells, modules or battery packs; it has a battery management system

Note 1 to entry: It may have cooling or heating units.

3.11
battery management system
BMS
electronic system associated with a battery which monitors and/or manages its state, calculates secondary data, reports that data and/or controls its environment to influence the battery's safety, performance and/or service life and has the functions to cut off in case of over charging, over current and over heating

Note 1 to entry: The function of the BMS can be assigned to the battery pack or to equipment that uses the battery.

Note 2 to entry: A BMS is sometimes also referred to as a BMU (battery management unit).

4 Parameters measurement tolerances

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

a) ±0,5 % for voltage;

b) ±1 % for current;

c) ±2 °C for temperature;

d) ±0,1 % for time;

e) ±1 % for dimensions.

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 any report of results.

5 Marking and designation

5.1 Marking

The marking items shown in Table 1 are indicated on the cell, battery system or instruction manual. When marked on the cell or battery system, each cell or battery system that is installed or maintained shall carry clear and durable markings giving the information.

The following options are allowed:

- if there are designations on a battery system, designations are not necessary on the battery pack, module or cell;

- if there are designations on a battery pack, designations are not necessary on the module and cell;
- if there are designations on a module, designations are not necessary on the cell.

However, for a transportable unit (i.e. a unit that is being shipped), it is necessary to provide the marking information on the main transportable unit or in its instruction manual. Furthermore, if there is a marking matter of arrangement between the purchaser and the manufacturer, it shall comply with the agreement.

See Table 1.

Each cell or battery that is installed or maintained shall carry clear and durable markings giving the following information:

- secondary (rechargeable) Li or Li-ion;
- polarity (can be deleted if there is an agreement between cell and pack manufacturer);
- date of manufacture (which may be in code);
- name or identification of manufacturer or supplier;
- rated capacity;
- nominal voltage;
- appropriate caution statement.

The model name and manufacturing traceability shall be marked on the cell and battery surface. The other items listed above can be marked on the smallest package or supplied with the cell or the battery.

The following information shall be marked on or supplied with the cell or the battery:

- disposal instructions;
- recommended charge instructions.

The following information shall be marked on the cell or when there is no marking place on the cell, it shall be marked in the manual.

- cell designation as specified in 5.2.

Table 1 – Marking

Marking information	Cell	Cell block Module or Battery pack	Battery system
Secondary (rechargeable) Li or Li-ion	R	R	R
Polarity (see NOTE 1)	R	R	R
Date of manufacture (which may be in code)* (see NOTE 2)	R	R	R
Name or identification of manufacturer or supplier	R	R	R [a]
Rated capacity	R	R	R [b]
Calculated rated capacity* [c]	--	--	R
Method for calculating rated capacity* [c]	--	--	R
Nominal voltage	R	R	R
Watt-hour* (see NOTE 3)	V	V	V
Appropriate caution statement (Including disposal instructions)	R	R	R
Cell designation as specified in 5.2	R	--	--
Battery designation as specified in 5.4	-	R	R
Recommended charge instructions	R	R	R

"R" = required; "V" = voluntary, "--" = unnecessary or not applicable

a It is necessary to mark designations on the main battery system.

b Tested by main battery system; shall be indicated on the main battery system.

c If evaluated by testing the split unit of a battery system; it shall be indicated as the rated capacity and shall be the amount calculated by a reasonable method.

For example:
Measured rated capacity of module: 10 Ah
Number of modules connected in parallel: 5
Calculated rated capacity (Ah) = 10 Ah × 5 = 50 Ah

NOTE 1 There is an exception, see 5.1.

NOTE 2 The date can be in the form of a code.

NOTE 3 Watt-hour (Wh) designation on cell, module, battery pack or battery system is the rated capacity (Ah) or calculated rated capacity (Ah) as defined in table footnote [c] multiplied by the nominal voltage of the cell, module, battery pack or battery system according to the following formula:

Watt-hour (Wh) = Rated capacity (Ah) or Calculated rated capacity (Ah) × Nominal voltage (V)

5.2 Cell designation

Cells shall be designated with following form:

$$A_1A_2A_3/N_2/N_3/N_4/A_4/T_LT_H/N_C$$

where

A_1 designates the negative electrode basis in which:

- I is carbon;
- T is titanium;
- X is other material.

A_2 designates the positive electrode basis in which:

- C is cobalt;
- F is iron;
- Fp is iron phosphate;
- N is nickel;
- M is manganese;
- Mp is manganese phosphate;
- V is vanadium;
- X is other material.

A_3 designates the shape of the cell in which:

- R is cylindrical;
- P is prismatic (including cell with laminate film case).

A_4 designates the rate capability of the cell in which:

- E is low rate long-time discharge type;
- M is medium rate discharge type;
- H is high rate discharge type.

NOTE 1 These types of cells are typically but not exclusively used for the following discharge rates at + 25 °C:

- E up to 0,5 I_t A,
- M up to 3,5 I_t A,
- H up to and above 7,0 I_t A.

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

T_L is the low temperature grade defined in 6.3.2. The information shall be indicated by the sign + or – followed by the temperature value in °C (e.g. -30, 0, +10);

T_H is the high temperature grade defined in 6.6.2. The information shall be indicated by the sign + or – followed by the temperature value in °C (e.g. +40, +50). If a cell is designed only for cycle application, ***T_H*** should be mentioned as "NA";

N_C is the percentage (rounded down to every 5 % step) obtained by the ratio of capacity at 500 cycles by the rated capacity. Refer to 6.6.1 and 6.3.1. If a cell is designed only for stand-by application, ***N_C*** should be mentioned as "NA";

N_2 is the maximum diameter (if R) or the maximum thickness (if P) in mm rounded up to the next whole number;

N_3 is the maximum width (if P) in mm rounded up to the next whole number (***N_3*** not shown if R);

N_4 is the maximum overall height in mm rounded up to the next whole number.

NOTE 3 If any dimension is less than 1 mm, the units used are tenths of millimetres and the single number is written tN such as "t1" for 0,1 mm.

EXAMPLE 1 ----**INR54/222/H/-20+50/70** would designate a cylindrical Li-ion secondary cell, with a nickel-based positive electrode. Its maximum diameter is between 53 mm and 54 mm, and its overall height is between 221 mm and 222 mm. It is designed for high discharge rate. Its low temperature grade is -20 °C. Its high temperature grade is 50 °C. It applies for both cycle and stand-by application. Its capacity retention after 500 cycles to rated capacity is between 70 % and 74 %.

EXAMPLE 2 ---**ICP25/150/150/E/0+60/60** would designate a prismatic Li-ion secondary cell, with a cobalt-based positive electrode. Its maximum thickness is between 24 mm and 25 mm, its maximum width is between 149 mm and 150 mm, and its overall height is between 149 mm and 150 mm. It is designed for low discharge rate over a long period. Its low temperature grade is 0 °C. Its high temperature grade is 60 °C. It applies for both cycle and stand-by application. Its capacity after 500 cycles to rated capacity is between 60 % and 64 %.

EXAMPLE 3 ---**INR50/150/M/-30NA/75** would designate a cylindrical Li-ion secondary cell, with a nickel-based positive electrode. Its maximum diameter is between 49 mm and 50 mm, and its overall height is between 149 mm and 150 mm. It is designed for medium discharge rate. Its low temperature grade is -30 °C. Its high temperature grade is NA. It applies for cycle application only. Its capacity retention after 500 cycles to rated capacity is between 75 % and 79 %.

EXAMPLE 4 ---**IMP50/240/150/M/-30+10/NA** would designate a prismatic Li-ion secondary cell, with a manganese-based positive electrode. Its maximum thickness is between 49 mm and 50 mm, its maximum width is between 239 mm and 240 mm, and its overall height is between 149 mm and 150 mm. It is designed for a medium discharge rate. Its low temperature grade is -30 °C. Its high temperature grade is 10 °C. It applies for stand-by application only.

5.3 Battery designation

5.3.1 General

Batteries shall be designated with following form:

$$A_1A_2A_3/N_2/N_3/N_4/[S_1]A_4/T_LT_H/N_C$$

where

A_1 designates the negative electrode basis in which:

- I is carbon;
- T is titanium;
- X is other materials.

A_2 designates the positive electrode basis in which:

- C is cobalt;
- F is iron;
- Fp is iron phosphate
- N is nickel;
- M is manganese;
- Mp is manganese phosphate;
- V is vanadium;
- X is other materials.

A_3 designates the shape of the cell in which:

- R is cylindrical;
- P is prismatic (including cell with laminate film case).

A_4 designates the rate capability of the battery in which

- S is very low rate long-time discharge type;
- E is low rate long-time discharge type;
- M is medium rate discharge type;
- H is high rate discharge type.

NOTE 1 These types of cells are typically but not exclusively used for the following discharge rates at +25 °C.

- S up to 0,125 I_t A,
- E up to 0,5 I_t A,
- M up to 3,5 I_t A,
- H up to and above 7,0 I_t A.

T_L is the low temperature grade defined in 6.3.2. The information shall be indicated by the sign + or – followed by the temperature value in °C (e.g. -30, 0, +10);

T_H is the high temperature grade defined in 6.6.2. The information shall be indicated by the sign + or – followed by the temperature value in °C (e.g. +40, +50). If a battery is designed only for cycle application, T_H should be mentioned as “NA”.

N_C is the percentage (rounded down to every 5 % step) obtained by the ratio of capacity at 500 cycles by the rated capacity. Refer to 6.6.1 and 6.3.1. If a battery is designed only for stand-by application, N_C should be mentioned as “NA”.

N_2 is the maximum diameter (if R) or the maximum thickness (if P) in mm rounded up to the next whole number;

N_3 is the maximum width (if P) in mm rounded up to the next whole number (N_3 not shown if R);

N_4 is the maximum overall height in mm rounded up to the next whole number;

NOTE 2 If any dimension is less than 1 mm, the units used are tenths of millimetres and the single number is written tN such as "t1" for 0,1 mm.

S_1 is the battery structure formulation shown in 5.3.2.

EXAMPLE 1 ---**ICP200/150/150/[7S]E/0+50/75** would designate a battery composed of 7S connected prismatic Li-ion secondary cells, with a cobalt-based positive electrode. Its cell maximum thickness is between 199 mm and 200 mm, its cell maximum width is between 149 mm and 150 mm, and its cell overall height is between 149 mm and 150 mm. It is designed for low discharge rate over long period. Its low temperature grade is 0 °C. Its high temperature grade is +50 °C. Its capacity after 500 cycles to rated capacity is between 75 % and 79 %.

EXAMPLE 2 ----**INR54/222[4P3S]H/-20+50/80** would designate a battery composed of 4P-3S connected cylindrical Li-ion secondary cells, with a nickel-based positive electrode. Its cell maximum diameter is between 53 mm and 54 mm, and its cell overall height is between 221 mm and 222 mm. It is designed for high discharge rate. Its low temperature grade is -20 °C. Its high temperature grade is +50 °C. Its capacity after 500 cycles to rated capacity is between 80 % and 84 %.

5.3.2 Battery structure formulation

The battery designation should include the breakdown structure of the battery. The descriptive path followed to formulate the battery is from the smallest entity to the largest one.

a) It describes the number of cells in the minimum constitutive entity and on the right side of the number describes their connection mode in series (S) or in parallel (P).

See Figures A.1 and A.2.

b) In case that the minimum constitutive entities are connected in series or in parallel, it describes the number of the minimum constitutive entities, and on the right side of the number describes their connection mode in series (S) or in parallel (P).

See Figures A.3 and A.4.

c) In case of the larger constitutive entities, it describes the symbols on the right side in the same way as mentioned above.

When some constitutive entities can be divided for ease of handling or transportation, these entities can be distinguished from other entities by bracketing.

Some examples are shown in Figure A.5 through Figure A.9.

5.4 Cell or battery termination

This standard does not specify cell or battery termination.

6 Electrical tests

6.1 General

Electrical tests are applied to cells and/or batteries. If the battery is divided in smaller units, the unit can be tested as the representative of the battery. The manufacturer shall clearly declare the tested unit. The manufacturer may add, to the tested unit, functions which are present in the final battery.

The manufacturer can use "cell block(s)" instead of "cell(s)" at any test that specifies "cell(s)" as the test unit in this document. The cell manufacturer shall clearly declare the test unit for each test.

Charge and discharge currents for the tests shall be based on the value of the rated capacity (C_n Ah). These currents are expressed as a multiple of I_t A, where: I_t A = C_n Ah/1 h.

C_n is the rated capacity declared by the manufacturer in ampere hours (Ah), and n is the time base in hours (h) for which the rated capacity is declared. n is 5 for E, M and H discharge rate type cells or batteries, n is 8, 10, 20 or 240 for S discharge rate type batteries.

See Table 2.

6.2 Charging procedure for test purposes

Prior to charging, the cell or battery shall be discharged at 25 °C ± 5 °C at a constant current of $1/n\ I_t$ A, down to a specified final voltage.

Unless otherwise stated in this standard, cells or batteries shall be charged, in an ambient temperature of 25 °C ± 5 °C, using the method declared by the manufacturer.

NOTE The final voltage in discharge tests is declared by the manufacturer. All tests are performed with the same final voltage value. For example, the manufacturer cannot use different final voltage values for discharge performance tests at 25 °C ± 5 °C, at low temperature, for the endurance tests, etc.

6.3 Discharge performance

6.3.1 Discharge performance at +25 °C

This test verifies the rated capacity of a cell or battery.

Step 1 – The cell or battery shall be fully charged in accordance with 6.2.

Step 2 – The cell or battery shall be stored in an ambient temperature of 25 °C ± 5 °C, for not less than 1 h and not more than 4 h.

Step 3 – The cell or battery shall then be discharged in the same ambient temperature and as specified in Table 2 to the final voltage specified by the manufacturer in 6.2.

Step 4 – The capacity (Ah), delivered during step 3, shall not be less than that specified for this characteristic in Table 2.

Table 2 – Discharge performance at +25 °C ± 5 °C

Discharge conditions		Minimum discharge capacity			
Rate of constant current	Final voltage declared by the manufacturer	Discharge rate type			
A	V	S	E	M	H
$(1/n)\ I_t$	Refer to 6.2	100 % C_n Ah			
$0,2\ I_t$ [a]	Refer to 6.2		100 % C_5 Ah	100 % C_5 Ah	100 % C_5 Ah
$1,0\ I_t$	Refer to 6.2		–	95 % C_5 Ah	95 % C_5 Ah
$5,0\ I_t$ [b]	Refer to 6.2		–	–	90 % C_5 Ah

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

[b] Prior to the 5 I_t A discharge tests, a conditioning cycle may be included if necessary. This cycle shall consist of charging and discharging in accordance with 6.2.

6.3.2 Discharge performance at low temperature

This test identifies the temperature at which a capacity of not less than 70 % of the rated capacity can be achieved.

This test verifies the discharge performance at low temperature of the cell or battery. It shall be measured in accordance with the following steps.

Step 1 – The cell or battery shall be fully charged in accordance with 6.2.

Step 2 – The cell or battery shall be stored for not less than 16 h and not more than 24 h at an ambient “target” test temperature which is specified by the manufacturer.

Step 3 – The cell or battery shall then be discharged at the same target test temperature and at the discharge rates specified in Table 3 to the manufacturer’s declared final voltage as defined in 6.2.

Step 4 – The capacity (Ah), delivered during step 3 shall be not less than that specified for the cell type and discharge currents in Table 3.

The cell or battery’s low temperature discharge performance can be declared at 10 °C intervals, such as +10 °C, 0 °C, -10 °C and -20 °C. The declared temperature should be in the range of the target test temperature and target test temperature plus 10 °C. For example if the test is performed at -27 °C, the declared temperature should be –20 °C. The temperature grade is the highest temperature among the tests for discharge rate type M and H. For example if an “H” type cell has a discharge capacity higher than 70 % of the rated capacity: at –30 °C with 0,2 I_t A, at –20 °C, with 1,0 I_t A and at –10 °C with 5,0 I_t A, the temperature grade is judged as “–10 °C”.

Table 3 – Discharge performance at low temperature

Discharge conditions		**Minimum discharge capacity**			
Rate of constant current	**Final voltage declared by the manufacturer**	**Discharge rate type**			
A	V	S	E	M	H
$(1/n)\ I_t$	Refer to 6.2	70 % Cn Ah	–	–	–
0,2 I_t	Refer to 6.2		70 % C_5 Ah	70 % C_5 Ah	70 % C_5 Ah
1,0 I_t	Refer to 6.2		–	70 % C_5 Ah	70 % C_5 Ah
5,0 I_t	Refer to 6.2		–	–	70 % C_5 Ah

6.3.3 High rate permissible current

6.3.3.1 General

This test is to evaluate the ability of an “H” or “M” type cell or battery to withstand high currents.

6.3.3.2 Test method

Step 1 – The cell or battery shall be fully charged in accordance with 6.2.

Step 2 – The cell or battery shall be stored for not less than 1 h and not more than 4 h in an ambient temperature of 25 °C ± 5 °C.

Step 3 – It shall then be discharged for 5 ± 0,1 s at 25 °C ± 5 °C and at the currents specified in Table 4. During the discharge the terminal voltage shall be recorded.

Step 4 – The capacity at 0,2 I_t A of the cell or battery is measured according to 6.3.1.

Table 4 – Discharge current values for high rate permissible test

Discharge rate type	Rate of constant current
S	N/A
E	N/A
M	Minimum 6 I_t A
H	Minimum 20 I_t A

6.3.3.3 Acceptance criterion

No fusing, no deformation of the cell or battery case, and no leakage shall be observed. In addition, the cell or battery voltage during the discharge shall show no discontinuity. The capacity of the cell or battery shall be not less than 95 % of the rated capacity.

6.4 Charge (capacity) retention and recovery

6.4.1 General

This test determines firstly the capacity which a cell retains after storage for an extended period of time, and secondly the capacity that can be recovered by a subsequent recharge.

6.4.2 Test method

Step 1 – The cell shall be charged in accordance with 6.2.

Step 2 – The cell shall be stored in an ambient temperature of 25 °C ± 5 °C, for 28 days.

Step 3 – The cell shall be discharged in an ambient temperature of 25 °C ± 5 °C, at a constant current of 0,2 I_t A, until its voltage is equal to the specified final voltage in accordance with 6.2.

Step 4 – The cell shall then be charged in accordance with 6.2, within 24 h following the discharge of step 3.

Step 5 – The cell shall be stored, in an ambient temperature of 25 °C ± 5 °C, for not less than 1 h and not more than 4 h.

Step 6 – The cell shall be discharged, in an ambient temperature of 25 °C ± 5 °C, at a constant current of 0,2 I_t A, until its voltage is equal to the specified final voltage in accordance with 6.2.

6.4.3 Acceptance criterion

The charge retention value which is the value of the discharged capacity obtained at Step 3 shall be not less than 85 % of the rated capacity.

The charge recovery value which is the value of the discharged capacity obtained at Step 6 shall be not less than 90 % of the rated capacity.

6.5 Cell and battery internal resistance

6.5.1 General

This test determines the internal resistance of a secondary lithium cell or battery. The alternating current (a.c.) method is only applied for the cell. The direct current (d.c.) method is applied for the cell and for the battery.

It is not necessary to discharge and charge the cell for re-adjusting the charge level between conducting the a.c. and d.c. measurements.

Step 1 – The cell or battery shall be charged in accordance with 6.2.

Step 2 – The cell or battery shall be stored, in an ambient temperature of 25 °C ± 5 °C, for not less than 1 h and not more than 4 h.

Step 3 – The cell or battery shall be discharged at 25 °C ± 5 °C until the capacity discharged becomes equal to 50 % ± 10 % of the rated capacity.

Step 4 – The measurement of internal resistance shall be performed in accordance with 6.5.2 (cell only) and 6.5.3 in an ambient temperature of 25 °C ± 5 °C.

6.5.2 Measurement of the internal a.c. resistance

6.5.2.1 Measurement

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

NOTE 1 All voltage measurements are made at the terminals of the cell independently of the contacts used to carry current.

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

NOTE 3 This method will measure the impedance, which at the frequency specified is approximately equal to the resistance.

6.5.2.2 Acceptance criterion

The internal a.c. resistance of the cell shall not be greater than the value of R_{ac}, declared by the manufacturer.

6.5.3 Measurement of the internal d.c. resistance

6.5.3.1 Measurement

This test verifies the internal d.c. resistance of the cell or battery. It shall be measured in accordance with the following steps.

Step 1 – The cell or battery shall be discharged at a constant current of value I_1 as specified in Table 5. At the end of a discharge period of 30 ± 0,1 s, the discharge voltage U_1 under load shall be measured and recorded.

Step 2 – The discharge current shall then be immediately increased to a value of I_2 as specified in Table 5 and the corresponding discharge voltage U_2 measured under load and recorded again at the end of a discharge period of 5,0 ± 0,1 s.

Table 5 – Constant discharge current used for measurement of the internal d.c. resistance

Discharge current	Discharge rate type			
	S	E	M	H
I_1	1/5n It or more A	0,04 I_t A	0,2 I_t A	1,0 I_t A
I_2	1/n It or more A	0,2 I_t or more A	1,0 I_t or more A	5,0 I_t or more A
NOTE All voltage measurements are made at the terminals of the cell or battery independently of the contacts used to carry current.				

The internal d.c. resistance, R_{dc}, of the cell or battery 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.

6.5.3.2 Acceptance criterion

The internal d.c. resistance of the cell or battery shall be not greater than the value of R_{dc}, declared by the manufacturer.

6.6 Endurance

6.6.1 Endurance in cycles

6.6.1.1 General

This test is conducted on cells or batteries which are designed for cycle applications (discharge and charge repeating them by turns).

This test verifies the capacity of the cell after 500 cycles. It shall be measured in accordance with the following steps.

6.6.1.2 Measurement

Step 1 – The cell or battery shall be discharged at 25 °C ± 5 °C at a constant current of 1/n I_t A, down to a specified final voltage. The final voltage shall be the same as that declared by the manufacturer according to 6.2.

Step 2 – The cell or battery shall be charged, in an ambient temperature of 25 °C ± 5 °C, using the method declared by the manufacturer.

Step 3 – The cell or battery shall be discharged, in an ambient temperature of 25 °C ± 5 °C, at a constant current of 1/*n* *It* A, until its voltage is equal to the specified final voltage. The final voltage shall be the same as that declared by the manufacturer according to 6.2.

NOTE 1 If the manufacturer would like to shorten the time to conduct step 3, the following discharge currents are declared and used: 0,5 I_t A * for E type cell or battery, 1,0 I_t A * for M and H type cell or battery.

Step 4 – Steps 2 and 3 shall be repeated for 500 cycles.

Step 5 – After completing 500 cycles, the capacity measured in discharge at 1/*n* I_t A is determined according to 6.3.1.

Step 6 – The retention rate shall be calculated from the rated capacity and the capacity measured in step 5.

NOTE 2 *n* is 5 for E, M and H discharge rate type cells or batteries; *n* is 8, 10, 20 or 240 for S discharge rate type batteries.

6.6.1.3 Acceptance criterion

The capacity of the cell or battery shall not be less than 60 % of the rated capacity after 500 cycles.

6.6.2 Endurance in storage at constant voltage (permanent charge life)

6.6.2.1 General

This test is conducted on cells or batteries which are designed for stand-by applications.

This test verifies the upper limit of the storage temperature specified by the manufacturer in which a minimum capacity of 85 % of the rated capacity is maintained after 90 days of storage at a constant voltage corresponding to a 100 % state of charge (SOC).

6.6.2.2 Measurement

Step 1 – The cell or battery shall be discharged at 25 °C ± 5 °C at a constant current of 1/*n* I_t A, down to a specified final voltage.

Step 2 – The cell or battery shall be charged at the target test temperature using the method declared by the manufacturer.

Step 3 – The cell or battery shall be kept at the target test temperature during 90 days in charge at constant voltage corresponding to 100 % state of charge.

NOTE 1 For cells or batteries which are not charged by a “constant voltage charging method” or charged without the long “constant voltage charging” period, the constant charging voltage is specified in accordance with the following method:

Step a) Store the cells or batteries for not less than 1 h and not more than 4 h after step 2.

Step b) Measure the open circuit voltage of cells or batteries.

Step c) Define the voltage measured in step b) as the constant charging voltage.

Step 4 – The cell or battery shall be stored for not less than 8 h and not more than 16 h, in open circuit, in an ambient temperature of 25 °C ± 5 °C.

Step 5 – The capacity measured in discharge at 1/*n* I_t A is determined according to 6.3.1.

Step 6 – The percentage of rated capacity shall be calculated from the rated capacity and the capacity measured in step 5.

NOTE 2 n is 5 for E, M and H discharge rate type cells or batteries, n is 8, 10, 20 or 240 for S discharge rate type batteries.

6.6.2.3 Acceptance criterion

The capacity of the cell or battery shall not be less than 85 % of the rated capacity after 90 days.

The declared temperature should be in the range of the target test temperature and target test temperature minus 10 °C. For example in the case of test performed at 57 °C, the declared temperature should be 50 °C.

7 Type test conditions

7.1 General

The type test conditions and protocol should be agreed between the manufacturer and the customer. When this is not the case, the following type test conditions shall apply.

7.2 Sample size

Tests are made with the number of cells, cell blocks or batteries specified in Table 6, using cells or batteries that are stored under the condition specified by the manufacturer and that are not more than six months old. Unless otherwise specified, tests are carried out in an ambient temperature of 25 °C ± 5 °C.

NOTE Test conditions are for type tests only. The limit of six months is introduced for consistency and does not imply that battery performance is reduced after six months.

Table 6 – Type test

Test	Clause / Subclause	Cell or Cell block [a]		Battery [b]	
		E	M, H	S, E	M, H
Discharge performance at +25 °C	6.3.1	Y	Y	Y	Y
Discharge performance at low temperature	6.3.2	Y	Y	Y	Y
High rate permissible current	6.3.3	–	Y	–	Y
Charge (capacity) retention and recovery	6.4	Y	Y	–	–
Internal a.c. resistance	6.5.2	Y	Y	–	–
Internal d.c. resistance	6.5.3	Y	Y	Y	Y
Endurance in cycle [c]	6.6.1	Y	Y	Y	Y
Endurance in storage at constant voltage (permanent charge life) [d]	6.6.2	Y	Y	Y	Y

Key

"Y" indicates that the test is required: the sample number is at least one.

"-" indicates that the test is not required.

[a] The manufacturer can use a cell block instead of a single cell for the tests. The test report shall indicate whether a cell or cell block is used for each test in the test results.

[b] If a battery system can be divided into smaller unit, the divided unit can be used for the tests. When the smaller unit is used, the test can be performed by applying the function equipped in battery system. If the smaller divided unit is used for the tests, the tests should be performed under the same charge and discharge conditions as the battery system. The test report should clearly indicate about tested unit.

[c] The test is performed for cell, cell block or battery designed either for cycle application or for cycle and stand-by application.

[d] The test is performed for cell, cell block or battery designed either for stand-by application or for cycle and stand-by application.

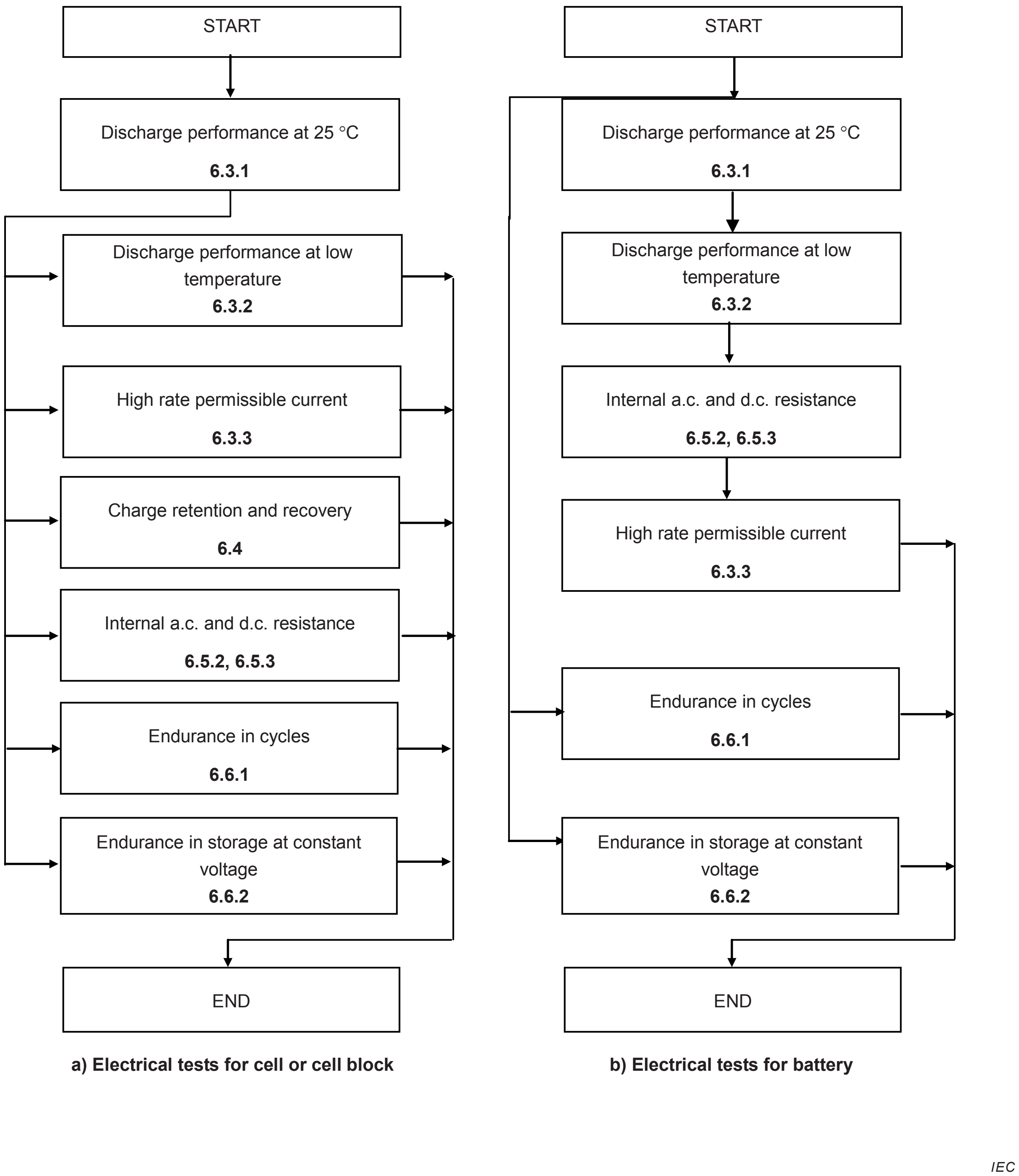

Figure 1 – Test sequence

7.3 Conditions for type approval

7.3.1 Dimensions

The dimensions of the cell, cell block or battery shall not exceed the manufacturer specified values including tolerances.

7.3.2 Electrical tests

7.3.2.1 The manufacturer shall declare the rated capacity (C_5 Ah) of the cell, cell block or battery based on its performance under the conditions specified in 6.3.1 and Table 6.

7.3.2.2 In order to meet the requirements of this standard, all samples shall meet all the performances specified in Table 6. The minimum levels for meeting the requirements of the electrical tests are expressed as percentages of the rated capacity.

7.3.2.3 The test results can be replaced by the results performed under the more severe condition which are specified in Table 7.

Table 7 – Severe conditions

Test	Clause/Subclause	Test current
Discharge performance at +25 °C	6.3.1	100 % ~ 120 %
Discharge performance at low temperature	6.3.2	100 % ~ 120 %
High rate permissible current	6.3.3	100 % ~ 120 %
Charge (capacity) retention and recovery	6.4	100 % ~ 120 %
Internal d.c. resistance	6.5.3	100 % ~ 120 %
Endurance in cycle	6.6.1	100 % ~ 120 %
Endurance in storage at constant voltage (permanent charge life)	6.6.2	100 %~ 120 %

Annex A
(informative)

Battery structure information

A.1 Example 1

Figure A.1 shows three cells connected in series to form the structure 3S.

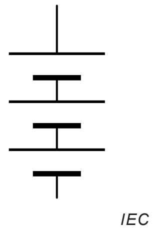

Figure A.1 – Structure 3S

A.2 Example 2

Figure A.2 shows two cells connected in parallel to form the structure 2P.

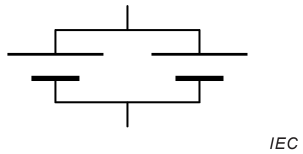

Figure A.2 – Structure 2P

A.3 Example 3

Figure A.3 shows three cells connected in series, with a similar series string connected in parallel to form the structure 3S2P.

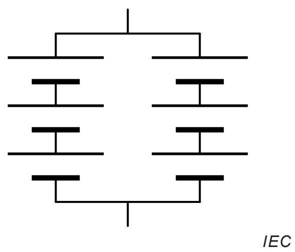

Figure A.3 – Structure 3S2P

A.4 Example 4

Figure A.4 shows two cells connected in parallel, with three similar parallel strings connected in series to form the structure 2P4S.

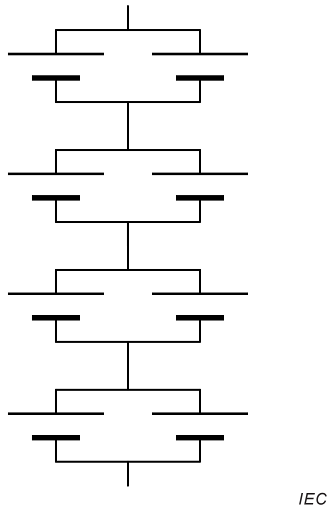

Figure A.4 – Structure 2P4S

A.5 Example 5

Figure A.5 shows two cells connected in parallel, with three similar parallel strings connected in series to form the group 2P4S, which is then connected in parallel with two similar groups to form the final structure 2P4S3P.

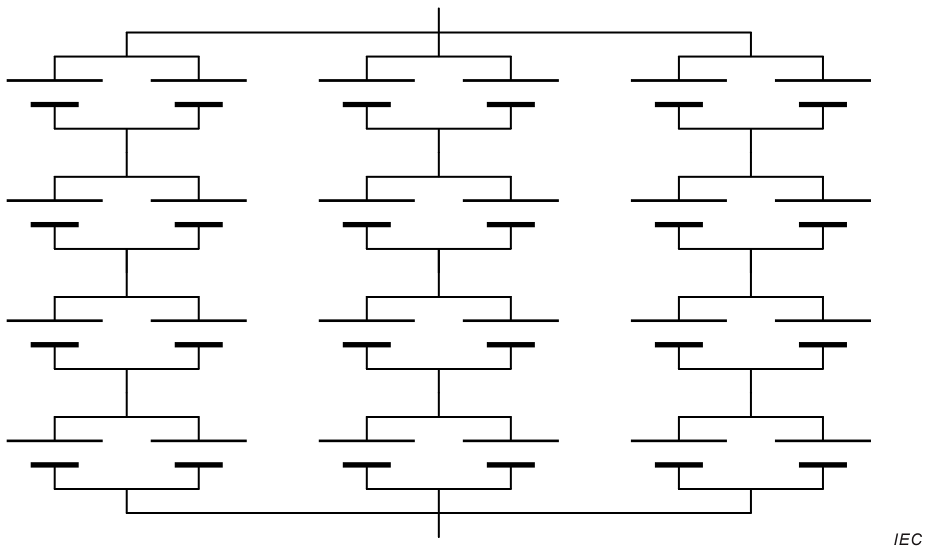

Figure A.5 – Structure 2P4S3P

A.6 Example 6

Figure A.6 shows a group of two cells connected in parallel, with three similar parallel strings connected in series to form the group 2P4S, which is then connected in parallel with two similar groups to form the final structure (2P4S)3P. The structure (2P4S)3P can be divided into 2P4S strings for ease of handling or transportation.

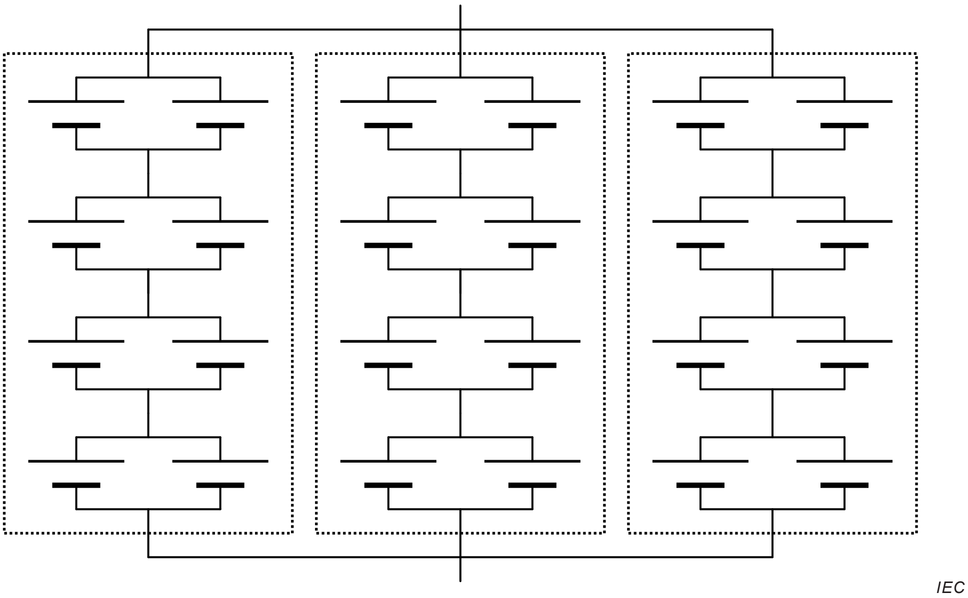

Figure A.6 – Structure (2P4S)3P

A.7 Example 7

Figure A.7 shows a group of three cells connected in series, with a similar series string connected in parallel to form the group 3S2P, which is then connected in parallel with two similar groups to form the final structure (3S2P)3P. The structure (3S2P)3P can be divided into 3S2P strings for ease of handling or transportation.

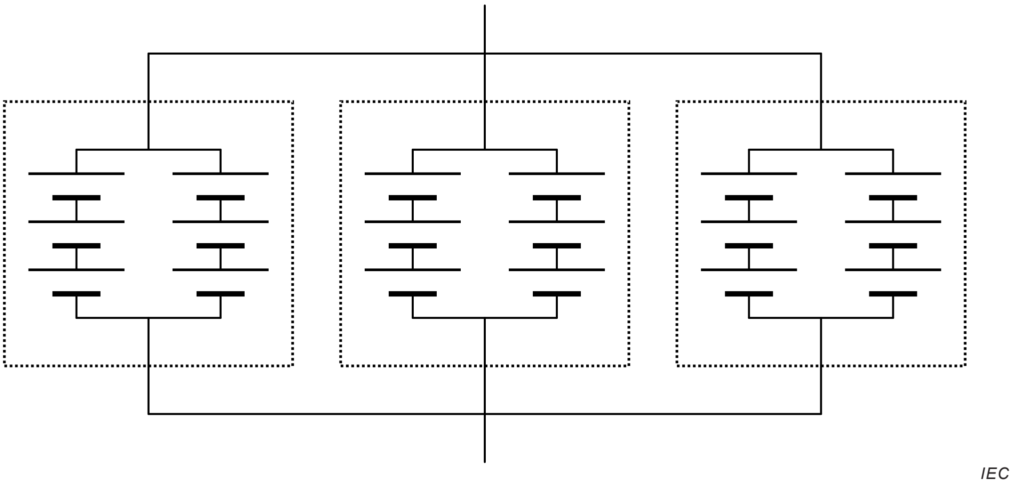

Figure A.7 – Structure (3S2P)3P

A.8 Example 8

Figure A.8 shows five cells connected in series to form a group 5S, which is then connected in series with three similar groups to form the final structure (5S)4S. The structure (5S)4S string units can be divided into 5S strings for ease of handling or transportation.

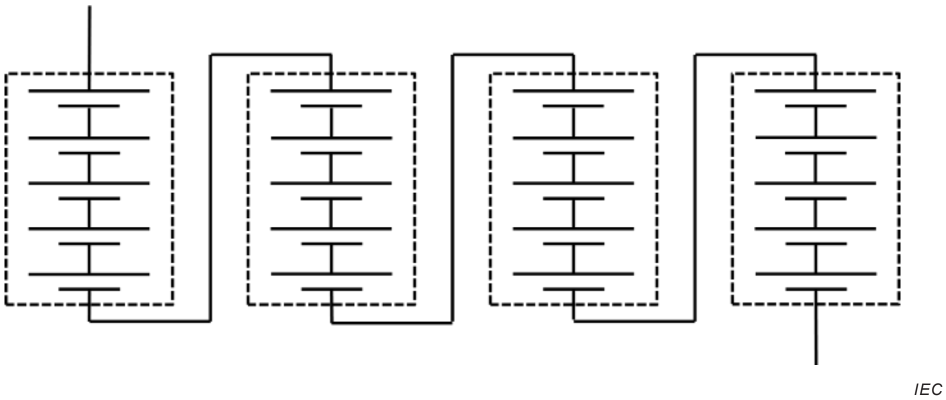

Figure A.8 – Structure (5S)4S

A.9 Example 9

Figure A.9 shows a group of three cells connected in series, with a similar series string connected in parallel to form a group 3S2P, which is then connected with two similar groups to form a new group (3S2P)3P. This group is in turn connected in series with a similar group to form the final structure ((3S2P)3P)2S. The structure ((3S2P)3P)2S can be divided into (3S2P)3P strings for ease of handling or transportation. And also the (3S2P)3P string units can be divided into 3S2P strings for ease of handling or transportation.

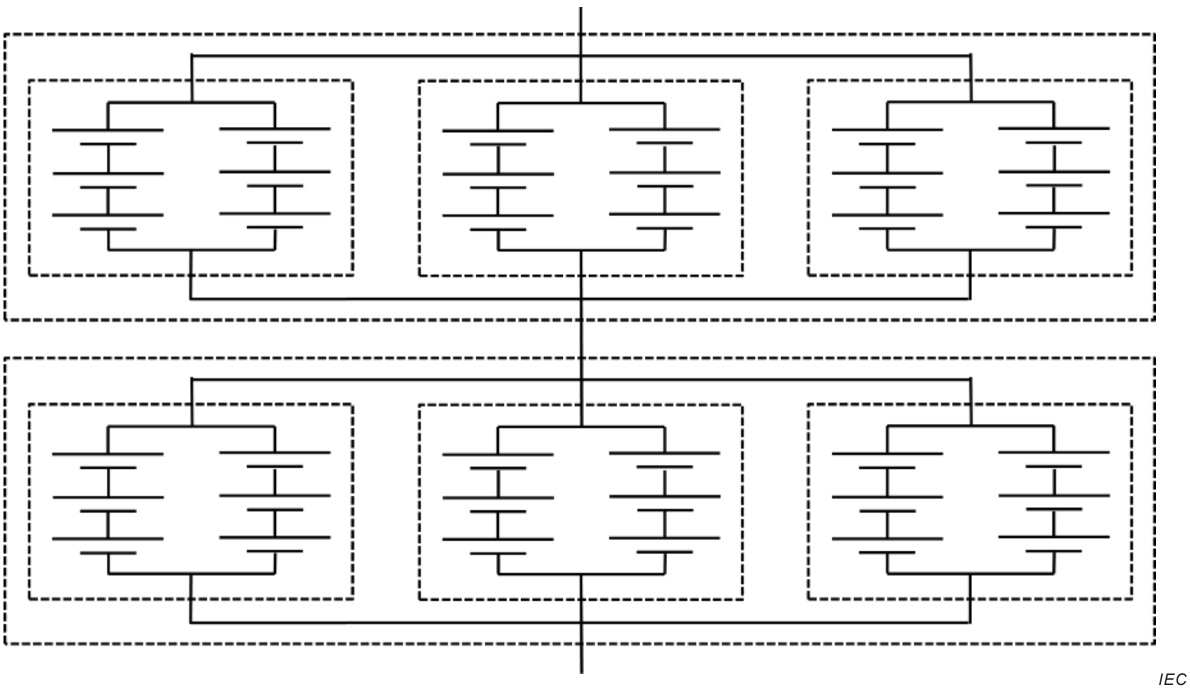

Figure A.9 – Structure ((3S2P)3P)2S

Bibliography

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

IEC 60485, *Digital electronic d.c. voltmeters and d.c. electronic analogue-to-digital convertors*[1]

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*

IEC 61960, *Secondary cells and batteries containing alkaline or other non-acid electrolytes – Secondary lithium cells and batteries for portable applications*

IEC 62660 (all parts), *Secondary lithium-ion cells for the propulsion of electric road vehicles*

---

1 This publication was withdrawn.

This page deliberately left blank

This page deliberately left blank

British Standards Institution (BSI)

BSI is the national body responsible for preparing British Standards and other standards-related publications, information and services.

BSI is incorporated by Royal Charter. British Standards and other standardization products are published by BSI Standards Limited.

About us

We bring together business, industry, government, consumers, innovators and others to shape their combined experience and expertise into standards -based solutions.

The knowledge embodied in our standards has been carefully assembled in a dependable format and refined through our open consultation process. Organizations of all sizes and across all sectors choose standards to help them achieve their goals.

Information on standards

We can provide you with the knowledge that your organization needs to succeed. Find out more about British Standards by visiting our website at bsigroup.com/standards or contacting our Customer Services team or Knowledge Centre.

Buying standards

You can buy and download PDF versions of BSI publications, including British and adopted European and international standards, through our website at bsigroup.com/shop, where hard copies can also be purchased.

If you need international and foreign standards from other Standards Development Organizations, hard copies can be ordered from our Customer Services team.

Subscriptions

Our range of subscription services are designed to make using standards easier for you. For further information on our subscription products go to bsigroup.com/subscriptions.

With **British Standards Online (BSOL)** you'll have instant access to over 55,000 British and adopted European and international standards from your desktop. It's available 24/7 and is refreshed daily so you'll always be up to date.

You can keep in touch with standards developments and receive substantial discounts on the purchase price of standards, both in single copy and subscription format, by becoming a **BSI Subscribing Member**.

PLUS is an updating service exclusive to BSI Subscribing Members. You will automatically receive the latest hard copy of your standards when they're revised or replaced.

To find out more about becoming a BSI Subscribing Member and the benefits of membership, please visit bsigroup.com/shop.

With a **Multi-User Network Licence (MUNL)** you are able to host standards publications on your intranet. Licences can cover as few or as many users as you wish. With updates supplied as soon as they're available, you can be sure your documentation is current. For further information, email bsmusales@bsigroup.com.

Revisions

Our British Standards and other publications are updated by amendment or revision.

We continually improve the quality of our products and services to benefit your business. If you find an inaccuracy or ambiguity within a British Standard or other BSI publication please inform the Knowledge Centre.

Copyright

Useful Contacts:

Customer Services
Tel: +44 845 086 9001
Email (orders): orders@bsigroup.com
Email (enquiries): cservices@bsigroup.com

Subscriptions
Tel: +44 845 086 9001
Email: subscriptions@bsigroup.com

Knowledge Centre
Tel: +44 20 8996 7004
Email: knowledgecentre@bsigroup.com

Copyright & Licensing
Tel: +44 20 8996 7070
Email: copyright@bsigroup.com

BSI Group Headquarters

389 Chiswick High Road London W4 4AL UK