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INTERNATIONAL STANDARD

NORME INTERNATIONALE

Secondary lithium-ion cells for the propulsion of electric road vehicles – Part 1: Performance testing

Éléments d'accumulateurs lithium-ion pour la propulsion des véhicules routiers électriques – Partie 1: Essais de performance

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IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland
Email: inmail@iec.ch
Web: www.iec.ch

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Tél.: +41 22 919 02 11
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SECONDARY LITHIUM-ION CELLS FOR THE PROPULSION OF ELECTRIC ROAD VEHICLES –

Part 1: Performance testing

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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International Standard IEC 62660-1 has been prepared by IEC technical committee 21: Secondary cells and batteries.

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

FDIS	Report on voting
21/728/FDIS	21/732/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.

A list of all the parts in the IEC 62660 series, published under the general title *Secondary lithium-ion cells for the propulsion of electric road vehicles*, can be found on the IEC website.

The committee has decided that the contents of this amendment and the base 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.

INTRODUCTION

The commercialisation of electric road vehicles including battery, hybrid and plug-in hybrid electric vehicles has been accelerated in the global market, responding to the global concerns on CO_2 reduction and energy security. This, in turn, has led to rapidly increasing demand for high-power and high-energy density traction batteries. Lithium-ion batteries are estimated to be one of the most promising secondary batteries for the propulsion of electric vehicles. In the light of rapidly diffusing hybrid electric vehicles and emerging battery and plug-in hybrid electric vehicles, a standard method for testing performance requirements of lithium-ion batteries is indispensable for securing a basic level of performance and obtaining essential data for the design of vehicle systems and battery packs.

This standard is to specify performance testing for automobile traction lithium-ion cells that basically differ from the other cells including those for portable and stationary applications specified by the other IEC standards. For automobile application, it is important to note the usage specificity; i.e. the designing diversity of automobile battery packs and systems, and specific requirements for cells and batteries corresponding to each of such designs. Based on these facts, the purpose of this standard is to provide a basic test methodology with general versatility, which serves a function in common primary testing of lithium ion cells to be used in a variety of battery systems.

This standard is associated with ISO 12405-1-and ISO 12405-2[1].

IEC 62660-2 specifies the reliability and abuse testing for lithium-ion cells for electric vehicle application.

1 Under consideration.

SECONDARY LITHIUM-ION CELLS FOR THE PROPULSION OF ELECTRIC ROAD VEHICLES –

Part 1: Performance testing

1 Scope

This part of IEC 62660 specifies performance and life testing of secondary lithium-ion cells used for propulsion of electric vehicles including battery electric vehicles (BEV) and hybrid electric vehicles (HEV).

The objective of this standard is to specify the test procedures to obtain the essential characteristics of lithium-ion cells for vehicle propulsion applications regarding capacity, power density, energy density, storage life and cycle life.

This standard provides the standard test procedures and conditions for testing basic performance characteristics of lithium-ion cells for vehicle propulsion applications, which are indispensable for securing a basic level of performance and obtaining essential data on cells for various designs of battery systems and battery packs.

NOTE 1 Based on the agreement between the manufacturer and the customer, specific test conditions may be selected in addition to the conditions specified in this standard. Selective test conditions are described in Annex A.

NOTE 2 The performance tests for the electrically connected lithium-ion cells may be performed with reference to this standard.

NOTE 3 The test specification for lithium-ion battery packs and systems is defined in ISO 12405-1 and ISO 12405-2 (under consideration).

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

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*

3 Terms and definitions

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

3.1
battery electric vehicle
BEV
electric vehicle with only a traction battery as power source for vehicle propulsion

3.2
hybrid electric vehicle
HEV
vehicle with both a rechargeable energy storage system and a fuelled power source for propulsion

3.3
rated capacity
quantity of electricity C_3 Ah (ampere-hours) for BEV and C_1 Ah for HEV declared by the manufacturer

3.4
reference test current
I_t
current in amperes which is expressed as

I_t (A) = C_n (Ah)/ 1 (h)

where

C_n is the rated capacity of the cell ;

n is the time base (hours).

3.5
room temperature
temperature of 25 °C ± 2 K

3.6
secondary lithium ion cell
secondary single cell whose electrical energy is derived from the insertion/extraction reactions of lithium ions between the anode and the cathode

NOTE 1 The secondary cell is a basic manufactured unit providing a source of electrical energy by direct conversion of chemical energy. The cell consists of electrodes, separators, electrolyte, container and terminals, and is designed to be charged electrically.

NOTE 2 In this standard, cell or secondary cell means the secondary lithium ion cell to be used for the propulsion of electric road vehicles.

3.7
state of charge
SOC
available capacity in a battery expressed as a percentage of rated capacity

4 Test conditions

4.1 General

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

4.2 Measuring instruments

4.2.1 Range of measuring devices

The instruments used shall enable the values of voltage and current to be measured. The range of these instruments and measuring methods shall be chosen so as to ensure the accuracy specified for each test.

For analogue instruments, this implies that the readings shall be taken in the last third of the graduated scale.

Any other measuring instruments may be used provided they give an equivalent accuracy.

4.2.2 Voltage measurement

The resistance of the voltmeters used shall be at least 1 M Ω /V.

4.2.3 Current measurement

The entire assembly of ammeter, shunt and leads shall be of an accuracy class of 0,5 or better.

4.2.4 Temperature measurements

The cell temperature shall be measured by use of a surface temperature measuring device capable of an equivalent scale definition and accuracy of calibration as specified in 4.2.1. The temperature should be measured at a location which most closely reflects the cell temperature. The temperature may be measured at additional appropriate locations, if necessary.

The examples for temperature measurement are shown in Figure 1. The instructions for temperature measurement specified by the manufacturer shall be followed.

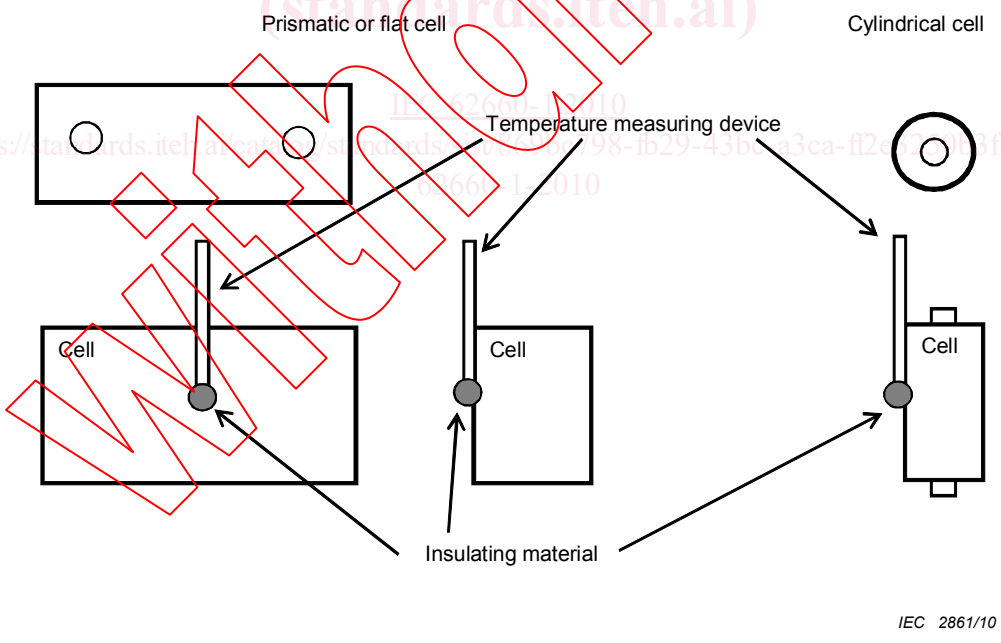


Figure 1 – Example of temperature measurement of cell

4.2.5 Other measurements

Other values including capacity and power may be measured by use of a measuring device, provided that it complies with 4.3.

4.3 Tolerance

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

a) ±0,1 % for voltage;

b) ±1 % for current;

c) ± 2 K for temperature;

d) ±0,1 % for time;

e) ±0,1 % for mass;

f) ±0,1 % for dimensions.

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

4.4 Test temperature

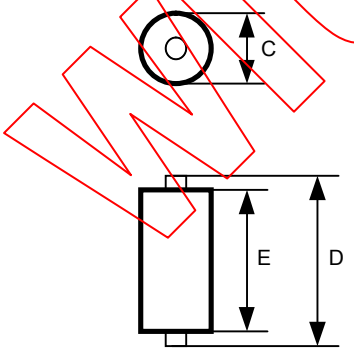
If not otherwise defined, before each test the cell shall be stabilized at the test temperature for a minimum of 12 h. This period can be reduced if thermal stabilization is reached. Thermal stabilization is considered to be reached if after one interval of 1 h, the change of cell temperature is lower than 1 K.

Unless otherwise stated in this standard, cells shall be tested at room temperature using the method declared by the manufacturer.

5 Dimension measurement

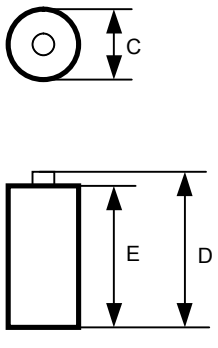
The maximum dimension of the total width, thickness or diameter, and length of a cell shall be measured up to three significant figures in accordance with the tolerances in 4.3.

The examples of maximum dimension are shown in Figures 2a to 2f.



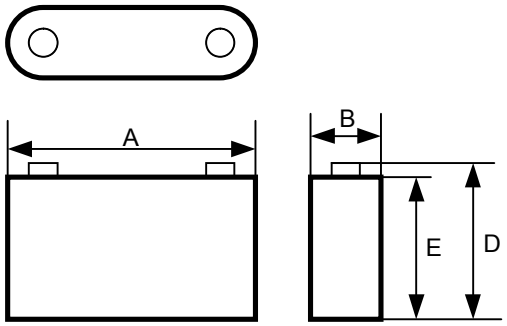
IEC 2862/10

Figure 2a – Cylindrical cell (1)



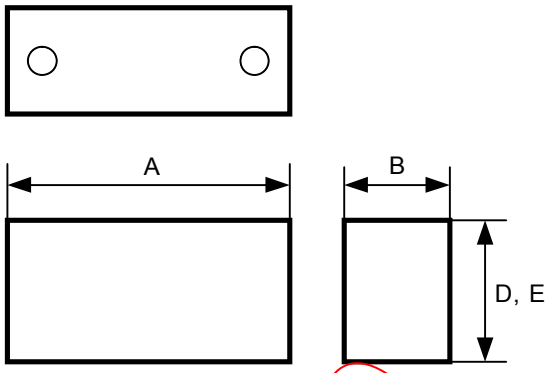
IEC 2863/10

Figure 2b – Cylindrical cell (2)



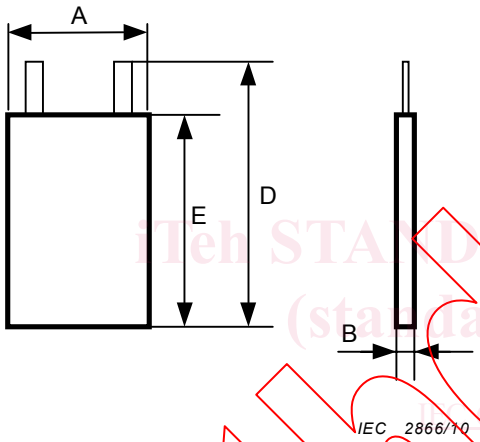
IEC 2864/10

Figure 2c – Prismatic cell (1)



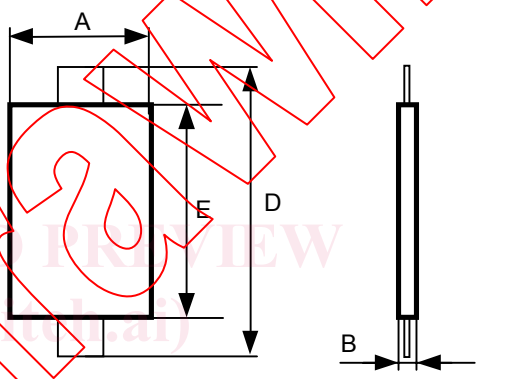
IEC 2865/10

Figure 2d – Prismatic cell (2)



IEC 2866/10

Figure 2e – Flat cell (1)



IEC 2867/10

Figure 2f – Flat cell (2)

Key

A total width

B total thickness

C diameter

D total length (including terminals)

E total length (excluding terminals)

Figure 2 – Examples of maximum dimension of cell

6 Mass measurement

Mass of a cell is measured up to three significant figures in accordance with the tolerances in 4.3.

7 Electrical measurement

During each test, voltage, current and temperature shall be recorded.

7.1 General charge conditions

Unless otherwise stated in this standard, prior to electrical measurement test, the cell shall be charged as follows.

Prior to charging, the cell shall be discharged at room temperature at a constant current described in Table 1 down to a end-of-discharge voltage specified by the manufacturer. Then, the cell shall be charged according to the charging method declared by the manufacturer at room temperature.

7.2 Capacity

Capacity of cell shall be measured in accordance with the following steps.

Step 1 − The cell shall be charged in accordance with 7.1.

After recharge, the cell temperature shall be stabilized in accordance with 4.4.

Step 2 − The cell shall be discharged at specified temperature at a constant current I_t (A) to the end-of-discharge voltage that is provided by the manufacturer. The discharge current and temperatures indicated in Table 1 shall be used.

NOTE Selective test conditions are shown in Table A.1 in Annex A.

The method of designation of test current I_t is defined in IEC 61434.

Table 1 – Discharge conditions

Temperature °C	Discharge current A	
	BEV application	HEV application
0	1/3 I_t	1 I_t
25		
45		

Step 3 − Measure the discharge duration until the specified end-of discharge voltage is reached, and calculate the capacity of cell expressed in Ah up to three significant figures.

7.3 SOC adjustment

The test cells shall be charged as specified below. The SOC adjustment is the procedure to be followed for preparing cells to the various SOCs for the tests in this standard.

Step 1 - The cell shall be charged in accordance with 7.1.

Step 2 - The cell shall be left at rest at room temperature in accordance with 4.4.

Step 3 - The cell shall be discharged at a constant current according to Table 1 for $(100 - n)/100 \times 3$ h for BEV application and $(100 - n)/100 \times 1$ h for HEV application, where n is SOC (%) to be adjusted for each test.

7.4 Power

7.4.1 Test method

The test shall be carried out in accordance with the following procedure.

a) Mass measurement

Mass of the cell shall be measured as specified in Clause 6.

b) Dimension measurement

Dimension of the cell shall be measured as specified in Clause 5.

c) Current-voltage characteristic test

Current-voltage characteristics shall be determined by measuring the voltage at the end of the 10 second pulse, when a constant current is discharged and charged under the conditions specified below.

1) SOC shall be adjusted to 20 %, 50 %, and 80 % according to the procedure specified in 7.3.

2) The cell temperature at test commencement shall be set to 40 °C, 25 °C, 0 °C, and –20 °C.

3) The cell is charged or discharged at each value of the current corresponding to the respective rated capacity level, and the voltage is measured at the end of the 10 s pulse. The range of the charge and discharge current shall be specified by the manufacturer, and the standard measurement interval shall be 1 s. If the voltage after 10 s exceeds the discharge lower limit voltage or charge upper limit voltage, the measurement data shall be omitted.

NOTE The charge/discharge limits at low temperature specified by the manufacturer should be taken into account.

Table 2 shows examples of charge and discharge current according to the applications. If it is required, the maximum current for charge and discharge is specified by the cell manufacturer (I_{max}). This value can be reduced according to the agreement with the customer. The maximum charge and discharge current can be applied after the measurement at 5 I_t for BEV application and 10 I_t for HEV application. I_{max} value changes depending on SOC, test temperature and charge or discharge state.

Table 2 – Examples of charge and discharge current

Application	Charge and discharge current A				
BEV	1/3 I_t	1 I_t	2 I_t	5 I_t	I_{max}
HEV	1/3 I_t	1 I_t	5 I_t	10 I_t	I_{max}

4) 10-min rest time shall be provided between charge and discharge pulses as well as between discharge and charge pulses. However, if the cell temperature after 10 min is not within 2 K of test temperature, it shall be cooled further; alternatively, the rest time duration shall be extended and it shall be inspected whether the cell temperature then settles within 2 K. The next discharging or charging procedure is then proceeded with.

5) The test is performed according to the scheme shown in Figure 3a and Figure 3b.