IEC 62660-2

Edition 1.0 2010-12

# INTERNATIONAL STANDARD

# NORME INTERNATIONALE

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## Secondary lithium-ion cells for the propulsion of electric road vehicles – Part 2: Reliability and abuse testing

## Éléments d'accumulateurs lithium-ion pour la propulsion des véhicules routiers électriques – Partie 2: Essais de fiabilité et de traitement abusif

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## Éléments d'accumulateurs lithium-ion pour la propulsion des véhicules routiers électriques – Partie 2: Essais de fiabilité et de traitement abusif

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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

## Part 2: Reliability and abuse testing

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International Standard IEC 62660-2 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 |
|---|---|
| 21/727/FDIS | 21/731/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.

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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- withdrawn,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
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# 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 reliability and abuse requirements of lithium-ion batteries is indispensable for securing a basic level of safety and obtaining essential data for the design of vehicle systems and battery packs.

This standard is to specify reliability and abuse 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. For the requirements for cells differ depending on the system designs of battery pack or vehicle, and should be evaluated by the users, this standard does not provide any pass-fail criteria for the tests, but specifies a standard classification of descriptions for test results.

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

IEC 62660-1 specifies the performance testing of lithium-ion cells for electric vehicle application.

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[1] Under consideration.

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

## Part 2: Reliability and abuse testing

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## 1 Scope

This part of IEC 62660 specifies test procedures to observe the reliability and abuse behaviour 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 standard test procedures and conditions for basic characteristics of lithium-ion cells for use in propulsion of battery and hybrid electric vehicles. The tests are indispensable for obtaining essential data on reliability and abuse behaviour of lithium-ion cells for use in various designs of battery systems and battery packs.

This standard provides standard classification of description of test results to be used for the design of battery systems or battery packs.

NOTE 1 The reliability and abuse tests for the electrically connected lithium-ion cells may be performed with reference to this standard.

NOTE 2 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 60068-2-64, *Environmental testing – Part 2-64: Tests – Test Fh: Vibration, broadband random and guidance*

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*

ISO 16750-3, *Road vehicles – Environmental conditions and testing for electrical and electronic equipment – Part 3: Mechanical loads*

ISO 16750-4, *Road vehicles – Environmental conditions and testing for electrical and electronic equipment – Part 4: Climatic loads*

## 3 Terms and definitions

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

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**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 cells 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.

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## 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.

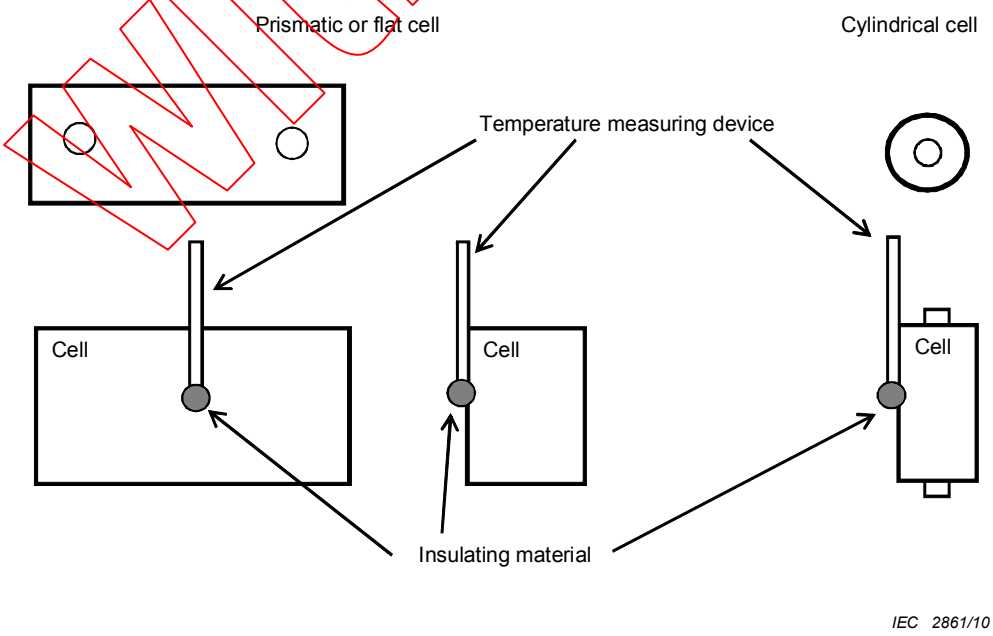


**Figure 1 – Example of temperature measurement of cell**

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#### 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 Electrical measurement

### 5.1 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.

### 5.2 Capacity

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

Step 1 – The cell shall be charged in accordance with 5.1.

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 In addition to Table 1, specific test conditions may be selected based on the agreement between the manufacturer and the customer. Selective test conditions are shown in Table A.1 in Annex A.

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

**Table 1 – Discharge conditions**

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

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

### 5.3 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 5.1.

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 × 3 h for BEV application and (100 – $n$)/100 × 1 h for HEV application, where $n$ is SOC (%) to be adjusted for each test.

## 6 Reliability and abuse tests

For all the tests specified in this clause, the test installation shall be reported including fixing and wiring of the cell.

### 6.1 Mechanical test

#### 6.1.1 Vibration

This test is performed to characterize cell responses to vibration assumed in the use of vehicle.

##### 6.1.1.1 Test

The test shall be performed as follows.

a) Adjust the SOC of cell to 100 % for BEV application, and to 80 % for HEV application in accordance with 5.3.

b) Perform the test referring to IEC 60068-2-64 random vibration. Use test duration of 8 h for each plane of the test cell.

c) The r.m.s. acceleration value shall be 27,8 m/s$^2$. The power spectrum density (PSD) vs. frequency is shown in Figure 2 and Table 2. The maximum frequency shall be 2 000 Hz.

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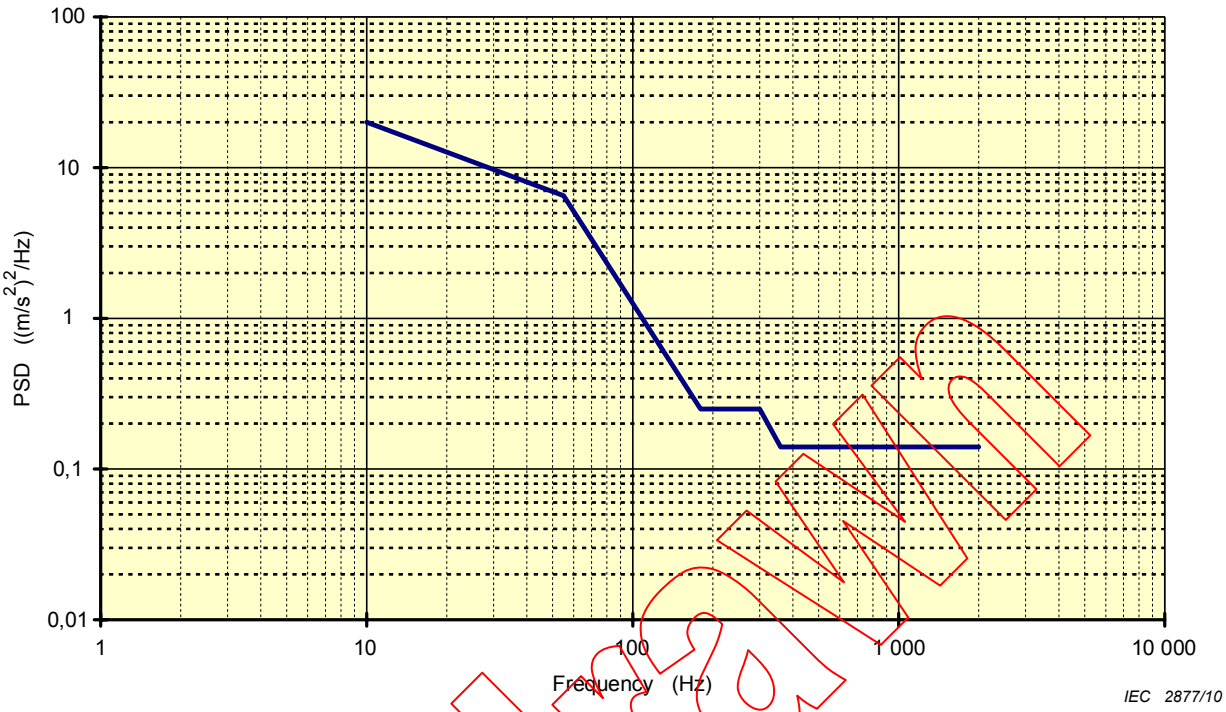


**Figure 2 – PSD of acceleration vs. frequency**

**Table 2 – Values for PSD and frequency**

| **Frequency** Hz | **PSD** $(m/s^2)^2/Hz$ |
|---|---|
| 10 | 20 |
| 55 | 6,5 |
| 180 | 0,25 |
| 300 | 0,25 |
| 360 | 0,14 |
| 1 000 | 0,14 |
| 2 000 | 0,14 |

#### 6.1.1.2 Test results

The following shall be measured and recorded as test results:

- cell voltage and capacity at the beginning and at the end of the test;
- conditions of cell at the end of test in accordance with the description specified in Clause 7.

### 6.1.2 Mechanical shock

This test is performed to characterize cell responses to mechanical shocks assumed in the use of vehicle.

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#### 6.1.2.1 Test

The test shall be performed as follows.

a) Adjust the SOC of cell to 100 % for BEV application and to 80 % for HEV application in accordance with 5.3.

b) Perform the test in accordance with ISO 16750-3 as shown in Table 3. Acceleration from the shock in the test shall be applied in the same direction as the acceleration of the shock that occurs in the vehicle. If the direction of the effect is not known, the cell shall be tested in all six spatial directions.

**Table 3 – Mechanical shock test – parameters**

| | |
|---|---|
| **Pulse shape** | half-sinusoidal |
| **Acceleration** | 500 m/s$^2$ |
| **Duration** | 6 ms |
| **Number of shocks** | 10 per test direction |

NOTE If more severe test parameters are requested by any regulation, such test conditions may be applied.

#### 6.1.2.2 Test results

The following shall be measured and recorded as test results:

- cell voltage and capacity at the beginning and at the end of the test;
- conditions of cell at the end of test in accordance with the description specified in 7.

### 6.1.3 Crush

This test is performed to characterize cell responses to external load forces that may cause deformation.

#### 6.1.3.1 Test

The test shall be performed as follows.

a) Adjust the SOC of cell to 100 % for BEV application and 80 % for HEV application in accordance with 5.3.

b) The cell shall be placed on an insulated flat surface and be crushed with a crushing tool of round or semicircular bar, or sphere or hemisphere with a 150 mm diameter. It is recommended to use the round bar to crush a cylindrical cell, and the sphere for a prismatic cell (see Figure 3). The force for the crushing shall be applied in direction nearly perpendicular to a layered face of positive and negative electrodes inside cell. The crushing tool shall be selected so that the cell is deformed nearly in proportion to the increase of crushing force.

c) The force shall be released when an abrupt voltage drop of one-third of the original cell voltage occurs, or a deformation of 15 % or more of initial cell dimension occurs, or the force of 1 000 times the weight of cell applied. The cells remain on test for 24 h or until the case temperature declines by 20 % of the maximum temperature rise, whichever is the sooner.

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