# IEC 62660-2

Edition 2.0 2018-12
REDLINE VERSION

# INTERNATIONAL STANDARD



colour inside

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

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CONTENTS

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

## Part 2: Reliability and abuse testing

## FOREWORD

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International Standard IEC 62660-2 has been prepared by IEC technical committee 21: Secondary cells and batteries.

This second edition cancels and replaces the first edition published in 2010. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) The procedure of forced discharge test has been clarified (6.4.3.2).
b) "Cell block" has been added to the scope (Clause 1).
c) Option of temperature cycling test with electrical operation has been deleted (6.3.2).
d) The test conditions for overcharge test have been revised (6.4.2.2).

The text of this International Standard is based on the following documents:

| FDIS | Report on voting |
|---|---|
| 21/976/FDIS | 21/986/RVD |

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

This document 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 document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

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- withdrawn,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

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# INTRODUCTION

The commercialization 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~~ the rapid spread of hybrid electric vehicles and the emergence of 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 document specifies 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 other IEC standards. For automobile application, it is important to note the usage specificity; i.e. the design 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 document 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 document does not provide any pass-fail criteria for the tests, but specifies a standard classification of descriptions for test results.

This document is associated with ~~ISO 12405-1 and ISO 12405-2~~ ISO 12405-4 [1][1].

IEC 62660-1 [2] specifies the performance testing of lithium-ion cells for electric vehicle application.

IEC 62660-3 [3] specifies the safety requirements of lithium-ion cells for electric vehicle application.



[1] Numbers in square brackets refer to the Bibliography.

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

## Part 2: Reliability and abuse testing

## 1 Scope

This part of IEC 62660 specifies test procedures to observe the reliability and abuse behaviour of secondary lithium-ion cells and cell blocks used for propulsion of electric vehicles including battery electric vehicles (BEV) and hybrid electric vehicles (HEV).

NOTE 1 Secondary lithium-ion cells used for propulsion of plug-in hybrid electric vehicles (PHEV) can be tested by the procedure either for BEV application or HEV application, according to the battery system design, based on the agreement between the cell manufacturer and the customer.

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

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

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

NOTE 2 Cell blocks can be used as an alternative to cells according to the agreement between the cell manufacturer and the customer.

NOTE 3 The safety requirements of lithium-ion cells for electric vehicle application are defined in IEC 62660-3 [3].

## 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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*

ISO/TR 8713, *Electrically propelled road vehicles – Vocabulary*

## 3 Terms and definitions

For the purposes of this document, the terms and definitions given in ~~IEC 60050-482~~ ISO/TR 8713 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

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

**3.2**
**cell block**
group of cells connected together in parallel configuration with or without protective devices, e.g. fuse or positive temperature coefficient resistor (PTC), not yet fitted with its final housing, terminal arrangement and electronic control device

**3.3**
**hybrid electric vehicle**
**HEV**
vehicle with both a rechargeable energy storage system and a fuelled power source for propulsion

**3.4**
**rated capacity**
$C_n$
~~quantity of electricity $C_3$Ah (ampere-hours) for BEV and $C_1$Ah for HEV declared by the manufacturer~~
capacity value of a cell in ampere hours (Ah) determined under specified conditions and declared by the cell manufacturer

Note 1 to entry: $n$ in $C_n$ is the time base in hours (h). In this document, $n$ = 3 for BEV application and $n$ = 1 for HEV application unless otherwise specified.

**3.5**
~~**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).~~

reference test current in amperes (A) which is expressed as

$I_t = C_n / 1$

Note 1 to entry: 1 has a dimension of time in hours (h).

Note 2 to entry: See IEC 61434:1996 [4], Clause 2.

**3.6**
**room temperature**
temperature of 25 °C ± 2 K

**3.7**
**secondary lithium-ion cell**
**cell**
secondary single cell whose electrical energy is derived from the insertion and extraction reactions of lithium ions between the anode and the cathode

Note 1 to entry: The secondary lithium-ion 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.

**3.8**
**state of charge**
**SOC**
available capacity in a battery cell 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.

NOTE Test and measurement can be conducted under fixing conditions recommended by the cell manufacturer.

### 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 MΩ/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 or cell block 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 cell manufacturer shall be followed.

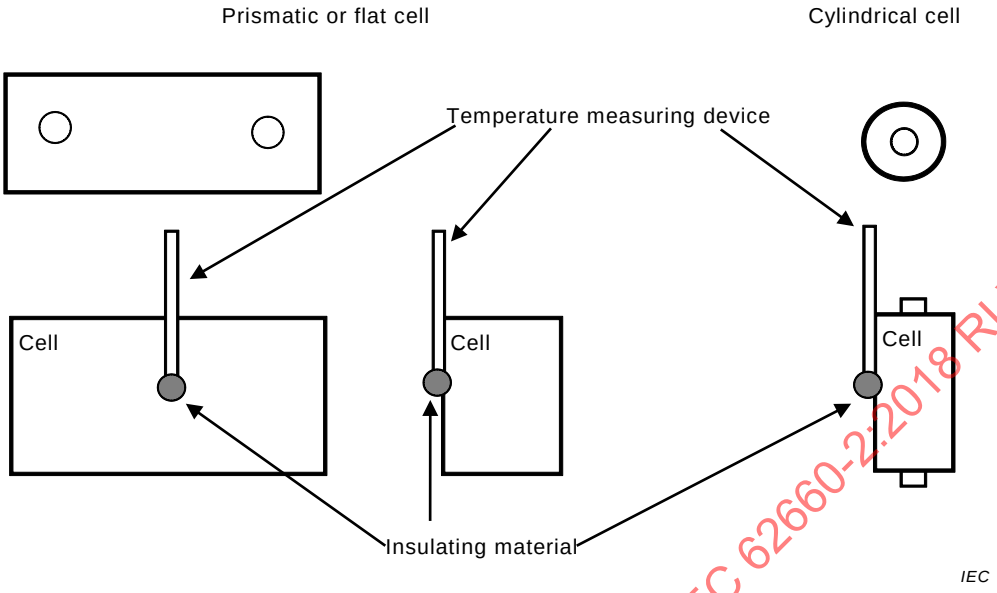


**Figure 1 – Example of temperature measurement of cell**

### 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 the following 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.~~

### 4.4 Thermal stabilization

For the stablization of cell temperature, the cell shall be soaked to a specified ambient temperature for a minimum of 12 h. This period may 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.

## 5 Electrical measurement

### 5.1 General charge conditions

Unless otherwise stated in this document, 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 an end-of-discharge voltage specified by the cell manufacturer. Then, the cell shall be charged according to the charging method declared by the cell manufacturer at room temperature.

### 5.2 Capacity

The capacity of a cell shall be measured in accordance with the following phases.

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

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

Phase 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 cell 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 cell manufacturer and the customer. Selective test conditions are provided in Annex A.

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

**Table 1 – Discharge conditions**

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

Phase 3 – Measure the discharge ~~endurance~~ duration until the specified end-of-discharge voltage is reached. Calculate the capacity of cell expressed in Ah up to three significant figures, by multiplying the discharge current (A) with the discharge duration (h).

### 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 document.

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

Phase 2 – The cell shall be left at rest at room temperature in accordance with 4.4.

Phase 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.

## 6 Reliability and abuse tests

### 6.1 General

For all the tests specified in Clause 6, the test installation shall be reported including fixing and wiring of the cell. If necessary, to prevent deformation, the cell may be maintained during the test in a manner that does not violate the test purpose.

Before each test, the cell shall be stabilized at room temperature according to 4.4, unless otherwise specified.

The value of SOC may be changed according to the agreement between the customer and the cell manufacturer.

### 6.2 Mechanical test

#### 6.2.1 Vibration

##### 6.2.1.1 Purpose

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

##### 6.2.1.2 Test

The test shall be performed as follows.

a) Adjust the SOC of the 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 RMS acceleration value shall be 27,8 m/s$^2$. The power spectrum density (PSD) ~~vs~~ plotted against frequency is shown in Figure 2 and Table 2. The maximum frequency shall be 2 000 Hz.

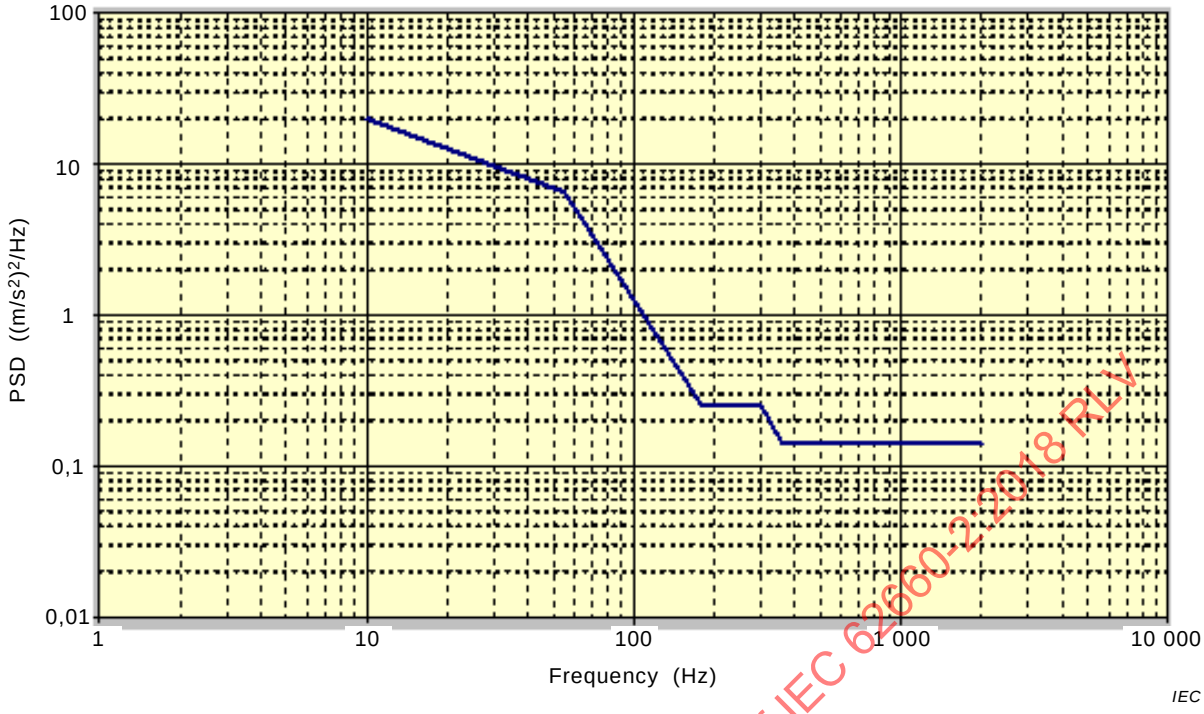


**Figure 2 – PSD of acceleration ~~vs.~~ plotted against frequency**

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

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



#### 6.2.1.3 Test results

The following shall be measured and recorded as test results:

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

### 6.2.2 Mechanical shock

#### 6.2.2.1 Purpose

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

#### 6.2.2.2 Test

The test shall be performed as follows.

a) Adjust the SOC of the 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.~~

#### 6.2.2.3 Test results

The following shall be measured and recorded as test results:

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

### 6.2.3 Crush

#### 6.2.3.1 Purpose

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

#### 6.2.3.2 Test

The test shall be performed as follows.

a) Adjust the SOC of the 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 consisting of a 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 a direction nearly perpendicular to a larger side of a layered face of positive and negative electrodes inside the 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 the initial cell dimension occurs, or the force of 1 000 times the weight of the cell is 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.

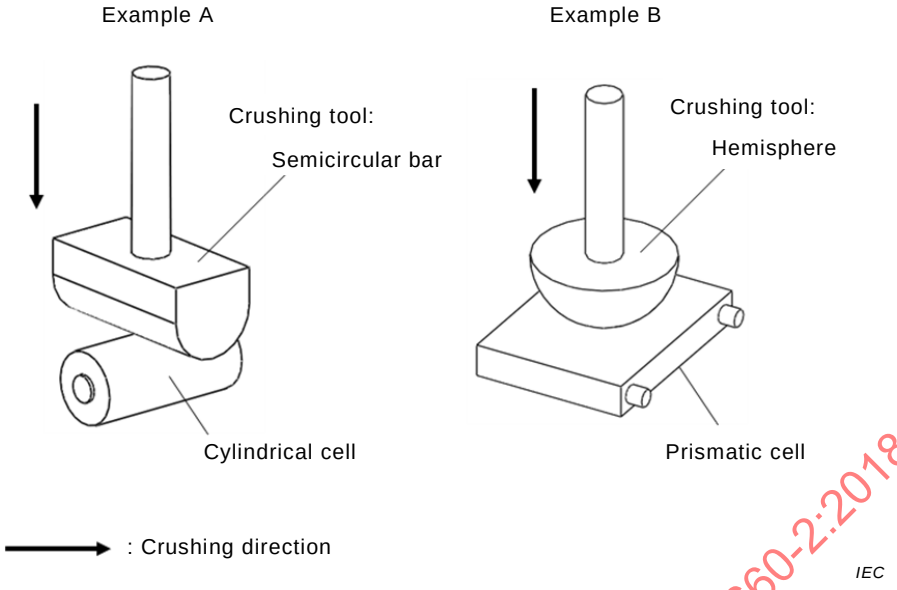


**Figure 3 – Examples of crush test**

#### 6.2.3.3 Test results

The following shall be measured and recorded as test results:

- form of crushing tool;
- crushing speed;
- cell voltage during the test;
- cell temperature during the test;
- condition of the cell at the end of the test in accordance with the description specified in Clause 7.

### 6.3 Thermal test

#### 6.3.1 High temperature endurance

##### 6.3.1.1 Purpose

This test is performed to characterize cell responses to high-temperature environment.

##### 6.3.1.2 Test

The test shall be performed as follows.

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

b) The cell, stabilized at room temperature, shall be placed in a gravity or circulating air-convection oven. The oven temperature shall be raised at a rate of 5 K/min to a temperature of 130 °C ~~± 2 K~~. The cell shall remain at this temperature for 30 min before the test is discontinued.

~~NOTE~~ If necessary, to prevent deformation, the cell may be maintained during the test in a manner that does not violate the test purpose. The manner to prevent deformation should be representative of cells inside battery systems and battery packs.

##### 6.3.1.3 Test results

The following shall be ~~measured and~~ recorded as test results:

- condition of the cell at the end of the test in accordance with the description specified in Clause 7.

It is recommended to measure the cell temperature and voltage, and oven temperature during the test.

### 6.3.2 Temperature cycling

#### 6.3.2.1 Purpose

This test is performed to characterize thermal durability of a cell by exposing at low and high temperature environment alternately to cause expansion and contraction of cell components.

#### 6.3.2.2 Test

~~Either of the test procedures specified in 6.2.2.1.1 or 6.2.2.1.2 shall be performed according to the agreement between the customer and the manufacturer.~~

~~**6.2.2.1.1 Test without electrical operation**~~

The test shall be performed as follows.

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

b) Perform the temperature cycling in accordance with ISO 16750-4 as shown in Table 4. The minimum operating temperature shall be −40 °C or $T_{min}$ specified by the cell manufacturer and the maximum operating temperature shall be 85 °C or $T_{max}$ specified by the cell manufacturer. Perform 30 test cycles as specified.

**Table 4 – Temperatures and time duration for temperature cycling**

| Cumulative time<br>min | Temperature<br>°C |
|---|---|
| 0 | ~~25~~ 20 |
| 60 | $T_{min}$ |
| 150 | $T_{min}$ |
| 210 | ~~25~~ 20 |
| 300 | $T_{max}$ |
| 410 | $T_{max}$ |
| 480 | ~~25~~ 20 |

~~**6.2.2.1.2 Test with electrical operation**~~

~~The test shall be performed as follows.~~

~~a) Adjust the SOC of cell to 80 % for BEV application, and to 60 % for HEV application in accordance with 5.3.~~

~~b) Perform the temperature cycling in accordance with ISO 16750-4 as shown in Table 5. The minimum operating temperature shall be −20 °C and the maximum operating temperature shall be 65 °C.~~

~~c) Perform the following current profiles during each temperature cycle:~~

~~– BEV current profile in accordance with Figure 4 and Table 6;~~

~~– HEV current profile in accordance with Figure 6 and Table 7.~~

~~d) Perform 30 test cycles as specified.~~

**Table 5 – Temperatures and time duration for temperature cycling**

| Cumulative time<br>min | Temperature<br>°C |
|---|---|
| 0 | 25 |
| 60 | –20 |
| 150 | –20 |
| 210 | 25 |
| 300 | 65 |
| 410 | 65 |
| 480 | 25 |

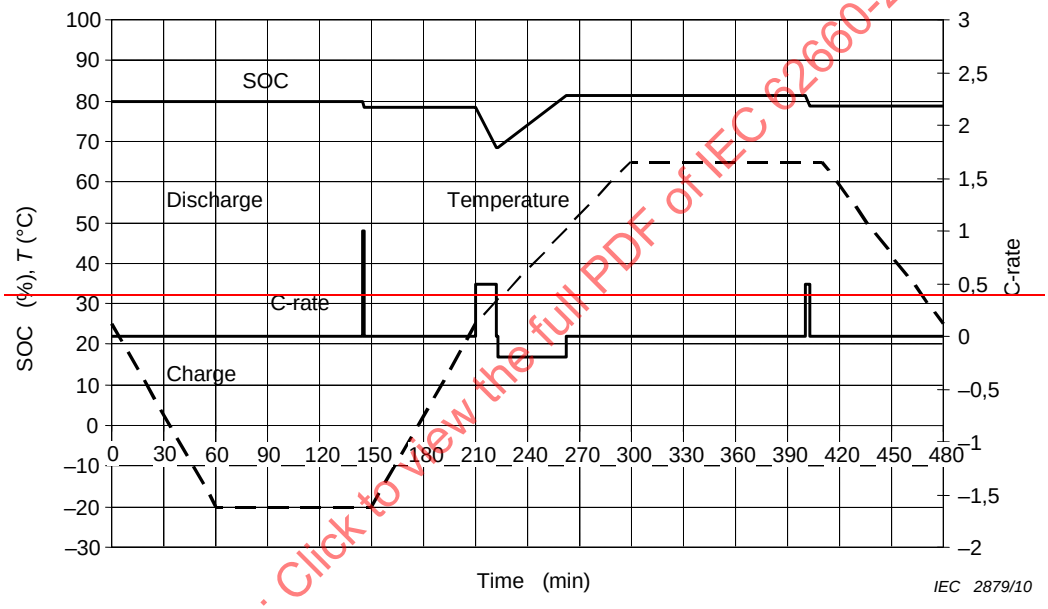


**Figure 4 – BEV current profile for temperature cycling**

**Table 6 – Test steps and BEV current profile**

| BEV current profile | | | | Background information | | |
|---|---|---|---|---|---|---|
| Step | Step time min | Cumulative time min | C-rate | Delta SOC % | SOC % | Example |
| | 0 | 0 | 0 | | 80 | |
| 1 | 145 | 145 | 0 | 0 | 80 | |
| 2 | 1 | 146 | 1 | –1,67 | 78,33 | 1 min driving |
| 3 | 64 | 210 | 0 | | | |
| 4 | 12 | 222 | 0,5 | –10 | 68,33 | 12 min driving |
| 5 | 1 | 223 | 0 | | | |
| 6 | 39 | 262 | –0,2 | 13 | 81,33 | charging |
| 7 | 138 | 400 | 0 | | | |
| 8 | 3 | 403 | 0,5 | –2,5 | 78,83 | 3 min driving |
| 9 | 77 | 480 | 0 | | 78,83 | |

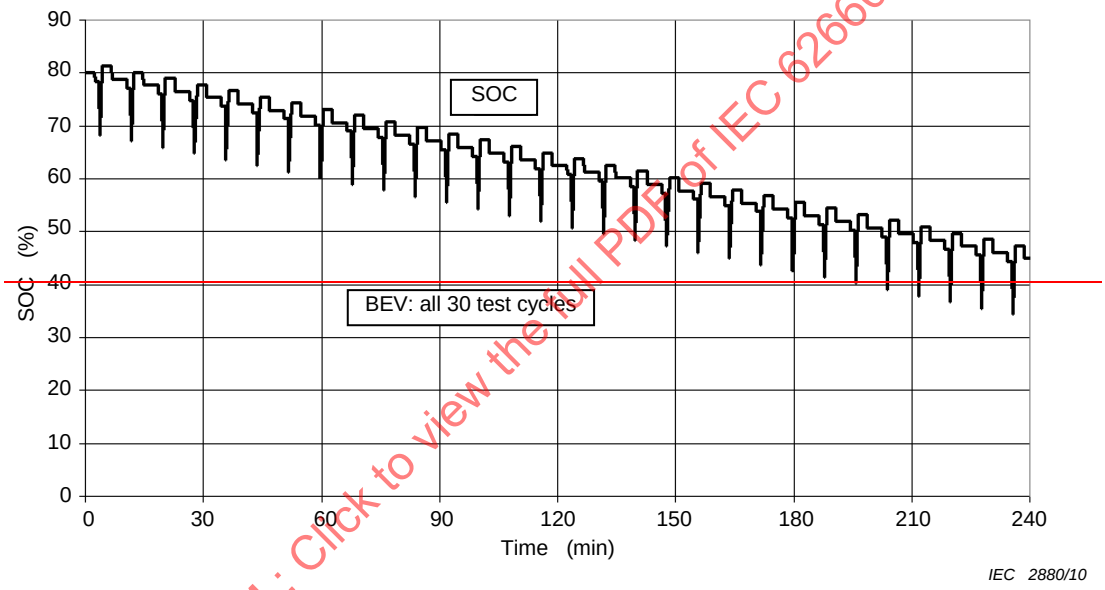


**Figure 5 – SOC level over all test cycles – BEV application**

Figure 5 shows the SOC level over the cumulative test time for a BEV application.

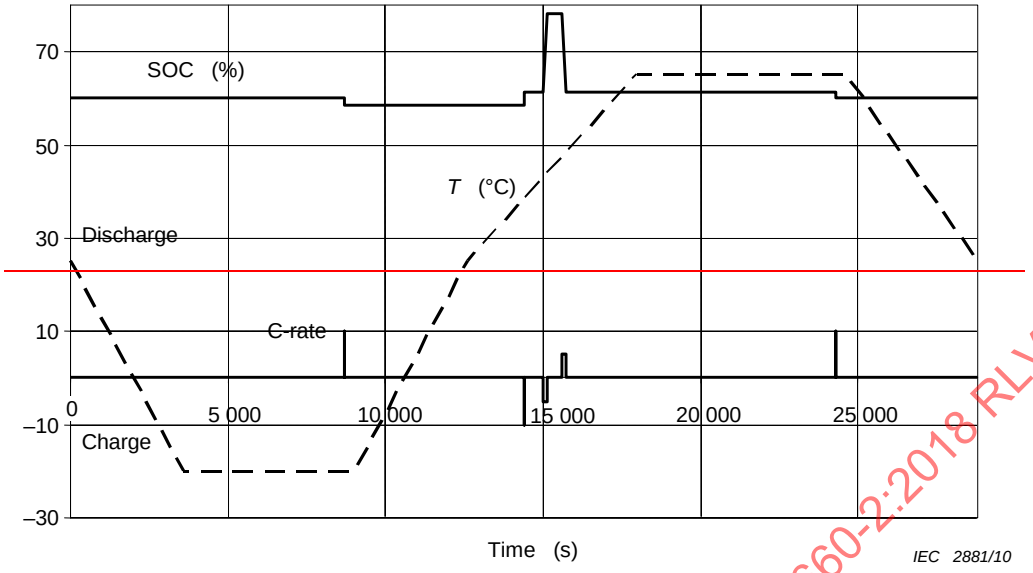


**Figure 6 – HEV current profile for temperature cycling**

**Table 7 – Test steps and HEV current profile**

| HEV current profile | | | | Background information | | |
|---|---|---|---|---|---|---|
| Step | Step time s | Cumulative time s | C-rate | Delta SOC % | SOC % | Example |
| | 0 | 0 | 0 | | 60 | |
| 1 | 8 700 | 8 700 | 0 | | 60 | |
| 2 | 5 | 8 705 | 10 | –1,39 | 58,61 | 5 s cold start |
| 3 | 5 695 | 14 400 | 0 | | | |
| 4 | 10 | 14 410 | –10 | 2,78 | 61,39 | 10 s recuperation |
| 5 | 590 | 15 000 | 0 | | | |
| 6 | 120 | 15 120 | –5 | 16,7 | 78,09 | 2 min charging |
| 7 | 480 | 15 600 | 0 | | | |
| 8 | 120 | 15 720 | 5 | –16,7 | 61,39 | 2 min driving |
| 9 | 8 580 | 24 300 | 0 | | | |
| 10 | 5 | 24 305 | 10 | –1,39 | 60 | 5 s hot start |
| 11 | 4 495 | 28 800 | 0 | | 60 | |

#### 6.3.2.3 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;
- condition of the cell at the end of the test in accordance with the description specified in Clause 7;
- cell voltage, current and temperature shall be continuously recorded during each cycle.

### 6.4 Electrical test

NOTE If necessary, to prevent deformation, the cell may be maintained during the test in a manner that does not violate the test purpose.

#### 6.4.1 External short circuit

##### 6.4.1.1 Purpose

This test is performed to characterize cell responses to external short circuit.

#### 6.4.1.2 Test

The test shall be performed as follows.

a) Adjust the SOC of the cell to 100 % in accordance with 5.3.

b) The cell adjusted as in a) shall be stored at room temperature, and then be short-circuited by connecting the positive and negative terminals with an external resistance for 10 min. The total external resistance shall be equal to or less than 5 mΩ as agreed between the customer and the cell manufacturer.

#### 6.4.1.3 Test results

The following shall be measured and recorded as test results; the sample rate for voltage and current recording shall be ≤ 10 ms:

– cell voltage during the test;

– cell current during the test. If the accuracy deviates from the requirements of 4.3, it shall be reported;

– cell temperature during the test;

– total external resistance value;

– condition of the cell at the end of the test in accordance with the description specified in Clause 7.

### 6.4.2 Overcharge

#### 6.4.2.1 Purpose

This test is performed to characterize cell responses to overcharge.

#### 6.4.2.2 Test

The test shall be performed as follows.

a) Adjust the SOC of the cell to 100 % in accordance with 5.3.

b) ~~Continue charging the cell beyond the 100 % SOC with charging current 1 $I_t$ for BEV application and 5 $I_t$ for HEV application at room temperature using a power supply sufficient to provide the constant charging current. The overcharge test shall be discontinued when the voltage of cell reaches twice the maximum voltage specified by the manufacturer, or the quantity of electricity applied to the cell reaches 200 % SOC equivalent.~~

Continue charging the cell beyond the 100 % SOC with a charging current agreed by the customer and the cell manufacturer at room temperature using a power supply sufficient to provide the constant charging current. The overcharge test shall be discontinued when the applied voltage reaches a value agreed between the customer and the supplier, or until charging is disabled by the cell protective device, if any, or until the cell fails.

#### 6.4.2.3 Test results

The following shall be measured and recorded as test results:

– cell voltage during the test;

– cell current during the test;

– cell temperature during the test;

– condition of the cell at the end of the test in accordance with the description specified in Clause 7.

### 6.4.3 Forced discharge

#### 6.4.3.1 Purpose

This test is performed to characterize cell responses to over discharge.

#### 6.4.3.2 Test

~~Discharge a fully discharged cell at $1I_t$A for 90 min.~~

The test shall be performed as follows.

a) Adjust the SOC of the cell to 0 % in accordance with 5.3.

b) Continue discharging the cell beyond the 0 % SOC at $1I_t$ (A) for 90 min at room temperature.

#### 6.4.3.3 Test results

The following shall be measured and recorded as test results:

– cell voltage during the test;

– cell current during the test;

– cell temperature during the test;

– condition of the cell at the end of the test in accordance with the description specified in Clause 7.

## 7 Description of test results

The results of tests specified in this document shall be recorded with the descriptions in Table 5. Each test result may include multiple descriptions. The test results may be described with relevant materials such as photos.

**Table 5 – Test result description**

| Description | Effect |
|---|---|
| No effect | No effect. No change in appearance. |
| Deformation | Change or deformation in appearance including swelling. |
| Venting | Escape of liquid electrolyte from vent or venting with mist release.<br>NOTE For the pouch cell, the intended venting mechanism can be a controlled opening of the cell casing. |
| Leakage | Visible escape of liquid electrolyte from a part except vent, such as casing, sealing part and/or terminals. |
| Smoking | Release of fumes, including possible soot particles, from vent. |
| Rupture | Mechanical failure of the container case of the cell induced by an internal or external cause, resulting in exposure or spillage but not ejection of materials. ~~Including smoking at the rupture~~ |
| Fire | Emission of flames from a cell or cell block for more than 1 s.<br>NOTE Sparks and arcing are not considered as flames. |
| Explosion | Failure that occurs when a cell container opens violently and major components are forcibly expelled. |

# Annex A
(informative)

## Selective test conditions

Annex A provides additional and selective conditions for the capacity test specified in 5.2. The test conditions "r" in Table A.1 are specified in this document. In addition, the test conditions "a" may be selected based on the agreement between the cell manufacturer and the customer.

**Table A.1 – Capacity test conditions**

| Application | Discharge current | Cell temperature | | | |
|---|---|---|---|---|---|
| | | −20 °C | 0 °C | 25 °C | 45 °C |
| BEV | 0,2 $I_t$ | a | a | a | a |
| | 1/3 $I_t$ | a | r | r | r |
| | 1 $I_t$ | a | a | a | a |
| | 5 $I_t$ | a | a | a | a |
| HEV | 0,2 $I_t$ | a | a | a | a |
| | 1/3 $I_t$ | a | a | a | a |
| | 1 $I_t$ | a | r | r | r |
| | 10 $I_t$ | a | a | a | a |
| | $I_{dmax}$ | a | a | a | a |

~~If the data deviation is larger than that of 1 $I_t$ and 1/3 $I_t$, it shall be indicated.~~

## Bibliography

~~ISO 12405-1, *Road vehicles – Electrically propelled road vehicles – Test specification for lithium-ion battery packs and systems – Part 1: High power application*[2]~~

~~ISO 12405-2, *Road vehicles – Electrically propelled road vehicles – Test specification for lithium-ion battery packs and systems – Part 2: High energy application that defines tests and related requirements for battery systems*[3]~~

[1] ISO 12405-4, *Electrically propelled road vehicles – Test specification for lithium-ion traction battery packs and systems – Part 4: Performance testing*

[2] IEC 62660-1, *Secondary lithium-ion cells for the propulsion of electric road vehicles – Part 1: Performance testing*[4]

[3] IEC 62660-3, *Secondary lithium-ion cells for the propulsion of electric road vehicles – Part 3: Safety requirements*

[4] IEC 61434:1996, *Secondary cells and batteries containing alkaline or other non-acid electrolytes – Guide to the designation of current in alkaline secondary cell and battery standards*



~~[2] Under consideration.~~

~~[3] Under consideration.~~

~~[4] To be published.~~

# IEC 62660-2

Edition 2.0 2018-12

# INTERNATIONAL STANDARD

# NORME INTERNATIONALE

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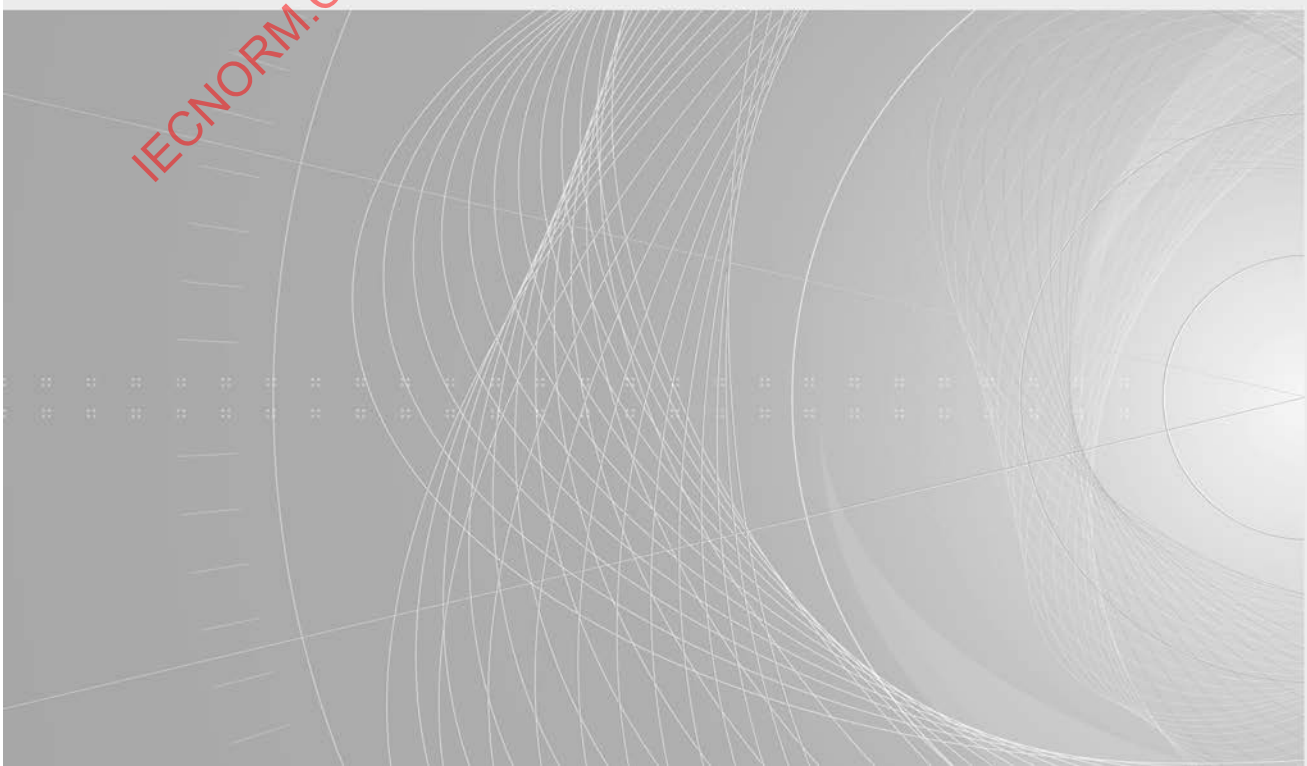
## Secondary lithium-ion cells for the propulsion of electric road vehicles – Part 2: Reliability and abuse testing

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



IEC 62660-2:2018-12(en-fr)

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

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

## Part 2: Reliability and abuse 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 62660-2 has been prepared by IEC technical committee 21: Secondary cells and batteries.

This second edition cancels and replaces the first edition published in 2010. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) The procedure of forced discharge test has been clarified (6.4.3.2).
b) "Cell block" has been added to the scope (Clause 1).
c) Option of temperature cycling test with electrical operation has been deleted (6.3.2).
d) The test conditions for overcharge test have been revised (6.4.2.2).

The text of this International Standard is based on the following documents:

| FDIS | Report on voting |
|---|---|
| 21/976/FDIS | 21/986/RVD |

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

This document 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 document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

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

**IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.**

# INTRODUCTION

The commercialization 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 the rapid spread of hybrid electric vehicles and the emergence of 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 document specifies 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 other IEC standards. For automobile application, it is important to note the usage specificity; i.e. the design 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 document 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 document does not provide any pass-fail criteria for the tests, but specifies a standard classification of descriptions for test results.

This document is associated with ISO 12405-4 [1][1].

IEC 62660-1 [2] specifies the performance testing of lithium-ion cells for electric vehicle application.

IEC 62660-3 [3] specifies the safety requirements of lithium-ion cells for electric vehicle application.



1 Numbers in square brackets refer to the Bibliography.

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

## Part 2: Reliability and abuse testing

## 1 Scope

This part of IEC 62660 specifies test procedures to observe the reliability and abuse behaviour of secondary lithium-ion cells and cell blocks used for propulsion of electric vehicles including battery electric vehicles (BEV) and hybrid electric vehicles (HEV).

NOTE 1 Secondary lithium-ion cells used for propulsion of plug-in hybrid electric vehicles (PHEV) can be tested by the procedure either for BEV application or HEV application, according to the battery system design, based on the agreement between the cell manufacturer and the customer.

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

NOTE 2 Cell blocks can be used as an alternative to cells according to the agreement between the cell manufacturer and the customer.

NOTE 3 The safety requirements of lithium-ion cells for electric vehicle application are defined in IEC 62660-3 [3].

## 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 60068-2-64, *Environmental testing – Part 2-64: Tests – Test Fh: Vibration, broadband random and guidance*

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*

ISO/TR 8713, *Electrically propelled road vehicles – Vocabulary*

## 3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/TR 8713 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

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

**3.2**
**cell block**
group of cells connected together in parallel configuration with or without protective devices, e.g. fuse or positive temperature coefficient resistor (PTC), not yet fitted with its final housing, terminal arrangement and electronic control device

**3.3**
**hybrid electric vehicle**
**HEV**
vehicle with both a rechargeable energy storage system and a fuelled power source for propulsion

**3.4**
**rated capacity**
$C_n$
capacity value of a cell in ampere hours (Ah) determined under specified conditions and declared by the cell manufacturer

Note 1 to entry: $n$ in $C_n$ is the time base in hours (h). In this document, $n$ = 3 for BEV application and $n$ = 1 for HEV application unless otherwise specified.

**3.5**
$I_t$
reference test current in amperes (A) which is expressed as

$I_t = C_n / 1$

Note 1 to entry: 1 has a dimension of time in hours (h).

Note 2 to entry: See IEC 61434:1996 [4], Clause 2.

**3.6**
**room temperature**
temperature of 25 °C ± 2 K

**3.7**
**secondary lithium-ion cell**
**cell**
secondary single cell whose electric energy is derived from the insertion and extraction reactions of lithium ions between the anode and the cathode

Note 1 to entry: The secondary lithium-ion cell is a basic manufactured unit providing a source of electric energy by direct conversion of chemical energy. The cell consists of electrodes, separators, electrolyte, container and terminals, and is designed to be charged electrically.

**3.8**
**state of charge**
**SOC**
capacity in a cell 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.

NOTE Test and measurement can be conducted under fixing conditions recommended by the cell manufacturer.

## 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 MΩ/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 or cell block 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 cell manufacturer shall be followed.

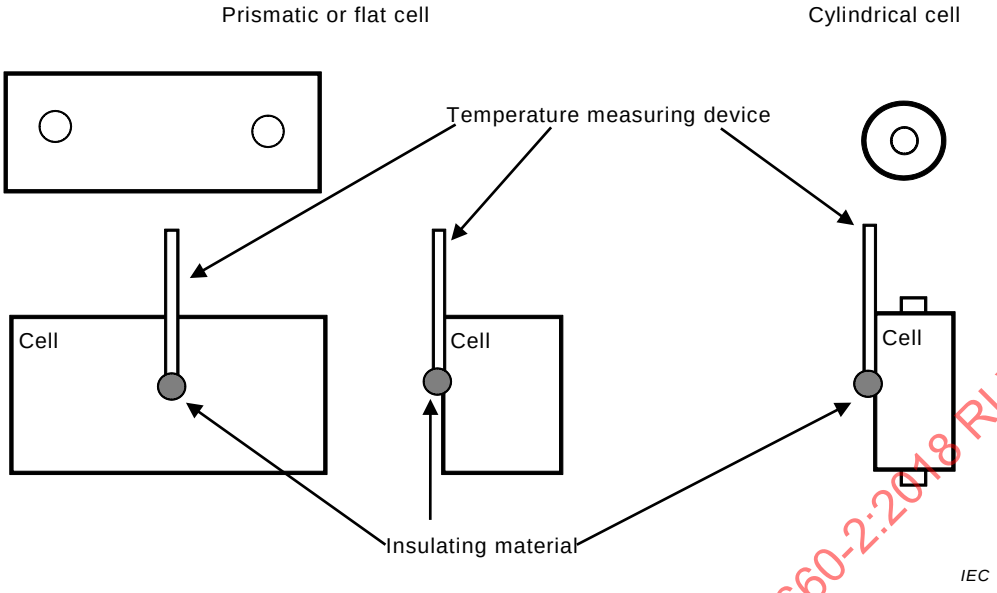


**Figure 1 – Example of temperature measurement of cell**

#### 4.2.5 Other measurements

Other values 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 the following 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 Thermal stabilization

For the stablization of cell temperature, the cell shall be soaked to a specified ambient temperature for a minimum of 12 h. This period may 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.

## 5 Electrical measurement

### 5.1 General charge conditions

Unless otherwise stated in this document, 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 an end-of-discharge voltage specified by the cell manufacturer. Then, the cell shall be charged according to the charging method declared by the cell manufacturer at room temperature.

### 5.2 Capacity

The capacity of a cell shall be measured in accordance with the following phases.

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

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

Phase 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 cell manufacturer. The discharge current and temperatures indicated in Table 1 shall be used.

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

**Table 1 – Discharge conditions**

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

Phase 3 – Measure the discharge duration until the specified end-of-discharge voltage is reached. Calculate the capacity of cell expressed in Ah up to three significant figures, by multiplying the discharge current (A) with the discharge duration (h).

### 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 document.

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

Phase 2 – The cell shall be left at rest at room temperature in accordance with 4.4.

Phase 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.

## 6 Reliability and abuse tests

### 6.1 General

For all the tests specified in Clause 6, the test installation shall be reported including fixing and wiring of the cell. If necessary, to prevent deformation, the cell may be maintained during the test in a manner that does not violate the test purpose.

Before each test, the cell shall be stabilized at room temperature according to 4.4, unless otherwise specified.

The value of SOC may be changed according to the agreement between the customer and the cell manufacturer.

### 6.2 Mechanical test

#### 6.2.1 Vibration

##### 6.2.1.1 Purpose

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

##### 6.2.1.2 Test

The test shall be performed as follows.

a) Adjust the SOC of the 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 RMS acceleration value shall be 27,8 m/s$^2$. The power spectrum density (PSD) plotted against frequency is shown in Figure 2 and Table 2. The maximum frequency shall be 2 000 Hz.

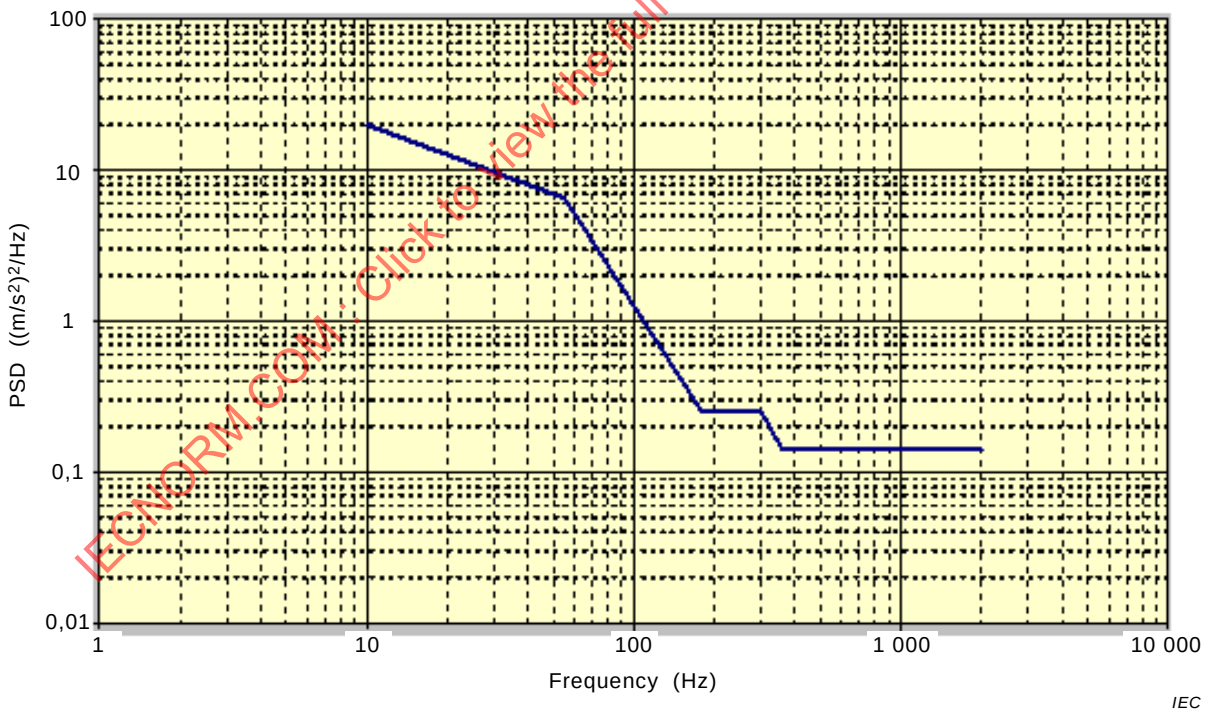


**Figure 2 – PSD of acceleration plotted against frequency**

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

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

#### 6.2.1.3 Test results

The following shall be measured and recorded as test results:

- cell voltage and capacity before and after the test;
- condition of the cell at the end of the test in accordance with the description specified in Clause 7.

### 6.2.2 Mechanical shock

#### 6.2.2.1 Purpose

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

#### 6.2.2.2 Test

The test shall be performed as follows.

a) Adjust the SOC of the 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 |

#### 6.2.2.3 Test results

The following shall be measured and recorded as test results:

- cell voltage and capacity before and after the test;
- condition of the cell at the end of the test in accordance with the description specified in Clause 7.

### 6.2.3 Crush

#### 6.2.3.1 Purpose

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

#### 6.2.3.2 Test

The test shall be performed as follows.

a) Adjust the SOC of the 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 consisting of a 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 a direction nearly perpendicular to a larger side of a layered face of positive and negative electrodes inside the 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 the initial cell dimension occurs, or the force of 1 000 times the weight of the cell is 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.

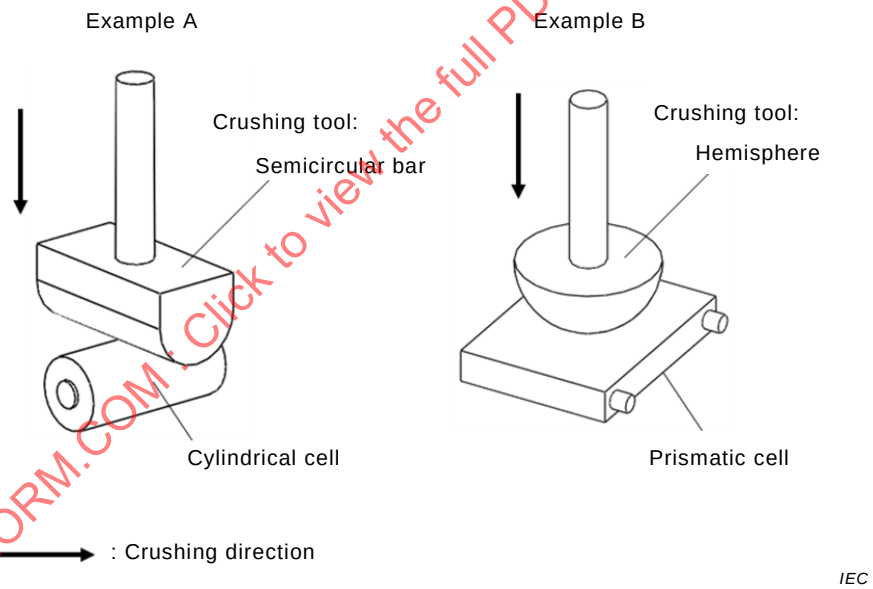


**Figure 3 – Examples of crush test**

#### 6.2.3.3 Test results

The following shall be measured and recorded as test results:

- form of crushing tool;
- crushing speed;
- cell voltage during the test;
- cell temperature during the test;
- condition of the cell at the end of the test in accordance with the description specified in Clause 7.

### 6.3 Thermal test

#### 6.3.1 High temperature endurance

##### 6.3.1.1 Purpose

This test is performed to characterize cell responses to high-temperature environment.

##### 6.3.1.2 Test

The test shall be performed as follows.

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

b) The cell, stabilized at room temperature, shall be placed in a gravity or circulating air-convection oven. The oven temperature shall be raised at a rate of 5 K/min to a temperature of 130 °C. The cell shall remain at this temperature for 30 min before the test is discontinued. If necessary, to prevent deformation, the cell may be maintained during the test in a manner that does not violate the test purpose. The manner to prevent deformation should be representative of cells inside battery systems and battery packs.

##### 6.3.1.3 Test results

The following shall be recorded as test results:

- condition of the cell at the end of the test in accordance with the description specified in Clause 7.

It is recommended to measure the cell temperature and voltage, and oven temperature during the test.

#### 6.3.2 Temperature cycling

##### 6.3.2.1 Purpose

This test is performed to characterize thermal durability of a cell by exposing at low and high temperature environment alternately to cause expansion and contraction of cell components.

##### 6.3.2.2 Test

The test shall be performed as follows.

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

b) Perform the temperature cycling in accordance with ISO 16750-4 as shown in Table 4. The minimum operating temperature shall be −40 °C or $T_{min}$ specified by the cell manufacturer and the maximum operating temperature shall be 85 °C or $T_{max}$ specified by the cell manufacturer. Perform 30 test cycles as specified.

**Table 4 – Temperatures and time duration for temperature cycling**

| Cumulative time<br>min | Temperature<br>°C |
|---|---|
| 0 | 20 |
| 60 | $T_{min}$ |
| 150 | $T_{min}$ |
| 210 | 20 |
| 300 | $T_{max}$ |
| 410 | $T_{max}$ |
| 480 | 20 |

#### 6.3.2.3 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;
- condition of the cell at the end of the test in accordance with the description specified in Clause 7;
- cell voltage and temperature shall be continuously recorded during each cycle.

### 6.4 Electrical test

#### 6.4.1 External short circuit

#### 6.4.1.1 Purpose

This test is performed to characterize cell responses to external short circuit.

#### 6.4.1.2 Test

The test shall be performed as follows.

a) Adjust the SOC of the cell to 100 % in accordance with 5.3.

b) The cell adjusted as in a) shall be stored at room temperature, and then be short-circuited by connecting the positive and negative terminals with an external resistance for 10 min. The total external resistance shall be equal to or less than 5 mΩ as agreed between the customer and the cell manufacturer.

#### 6.4.1.3 Test results

The following shall be measured and recorded as test results; the sample rate for voltage and current recording shall be ≤ 10 ms:

– cell voltage during the test;

– cell current during the test. If the accuracy deviates from the requirements of 4.3, it shall be reported;

– cell temperature during the test;

– total external resistance value;

– condition of the cell at the end of the test in accordance with the description specified in Clause 7.

#### 6.4.2 Overcharge

##### 6.4.2.1 Purpose

This test is performed to characterize cell responses to overcharge.

##### 6.4.2.2 Test

The test shall be performed as follows.

a) Adjust the SOC of the cell to 100 % in accordance with 5.3.

b) Continue charging the cell beyond the 100 % SOC with a charging current agreed by the customer and the cell manufacturer at room temperature using a power supply sufficient to provide the constant charging current. The overcharge test shall be discontinued when the applied voltage reaches a value agreed between the customer and the supplier, or until charging is disabled by the cell protective device, if any, or until the cell fails.

##### 6.4.2.3 Test results

The following shall be measured and recorded as test results:

– cell voltage during the test;

– cell current during the test;

– cell temperature during the test;

– condition of the cell at the end of the test in accordance with the description specified in Clause 7.

#### 6.4.3 Forced discharge

##### 6.4.3.1 Purpose

This test is performed to characterize cell responses to over discharge.

##### 6.4.3.2 Test

The test shall be performed as follows.

a) Adjust the SOC of the cell to 0 % in accordance with 5.3.

b) Continue discharging the cell beyond the 0 % SOC at $1 I_t$ (A) for 90 min at room temperature.

##### 6.4.3.3 Test results

The following shall be measured and recorded as test results:

– cell voltage during the test;

– cell current during the test;

– cell temperature during the test;

– condition of the cell at the end of the test in accordance with the description specified in Clause 7.

## 7 Description of test results

The results of tests specified in this document shall be recorded with the descriptions in Table 5. Each test result may include multiple descriptions. The test results may be described with relevant materials such as photos.

**Table 5 – Test result description**

| Description | Effect |
|---|---|
| No effect | No effect. No change in appearance. |
| Deformation | Change or deformation in appearance including swelling. |
| Venting | Escape of liquid electrolyte from vent or venting with mist release.<br>NOTE For the pouch cell, the intended venting mechanism can be a controlled opening of the cell casing. |
| Leakage | Visible escape of liquid electrolyte from a part except vent, such as casing, sealing part and/or terminals. |
| Smoking | Release of fumes, including possible soot particles, from vent. |
| Rupture | Mechanical failure of the container case of the cell induced by an internal or external cause, resulting in exposure or spillage but not ejection of materials. |
| Fire | Emission of flames from a cell or cell block for more than 1 s.<br>NOTE Sparks and arcing are not considered as flames. |
| Explosion | Failure that occurs when a cell container opens violently and major components are forcibly expelled. |

# Annex A
(informative)

## Selective test conditions

Annex A provides additional and selective conditions for the capacity test specified in 5.2. The test conditions "r" in Table A.1 are specified in this document. In addition, the test conditions "a" may be selected based on the agreement between the cell manufacturer and the customer.

**Table A.1 – Capacity test conditions**

| Application | Discharge current | Cell temperature | | | |
|---|---|---|---|---|---|
| | | −20 °C | 0 °C | 25 °C | 45 °C |
| BEV | 0,2 $I_t$ | a | a | a | a |
| | 1/3 $I_t$ | a | r | r | r |
| | 1 $I_t$ | a | a | a | a |
| | 5 $I_t$ | a | a | a | a |
| HEV | 0,2 $I_t$ | a | a | a | a |
| | 1/3 $I_t$ | a | a | a | a |
| | 1 $I_t$ | a | r | r | r |
| | 10 $I_t$ | a | a | a | a |
| | $I_{dmax}$ | a | a | a | a |

## Bibliography

[1] ISO 12405-4, *Electrically propelled road vehicles – Test specification for lithium-ion traction battery packs and systems – Part 4: Performance testing*

[2] IEC 62660-1, *Secondary lithium-ion cells for the propulsion of electric road vehicles – Part 1: Performance testing*

[3] IEC 62660-3, *Secondary lithium-ion cells for the propulsion of electric road vehicles – Part 3: Safety requirements*

[4] IEC 61434:1996, *Secondary cells and batteries containing alkaline or other non-acid electrolytes – Guide to the designation of current in alkaline secondary cell and battery standards*

SOMMAIRE

COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

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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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La Norme internationale IEC 62660-2 a été établie par le comité d'études 21 de l'IEC: Accumulateurs.

Cette deuxième édition annule et remplace la première édition parue en 2010. Cette édition constitue une révision technique.

Cette édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente:

a) La procédure d'essai de décharge forcée a été clarifiée (6.4.3.2).
b) Le concept de "bloc d'éléments" a été ajouté au domaine d'application (Article 1).

c) L'option d'essai de cycles de température avec fonctionnement électrique a été supprimée (6.3.2).

d) Les conditions d'essai relatives à l'essai de surcharge ont été révisées (6.4.2.2).

Le texte de cette Norme internationale est issu des documents suivants:

| FDIS | Rapport de vote |
|---|---|
| 21/976/FDIS | 21/986/RVD |

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à l'approbation de cette norme internationale.

Ce document a été rédigé selon les Directives ISO/IEC, Partie 2.

Une liste de toutes les parties de la série IEC 62660, publiées sous le titre général *Éléments d'accumulateurs lithium-ion pour la propulsion des véhicules routiers électriques*, peut être consultée sur le site web de l'IEC.

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# INTRODUCTION

La commercialisation des véhicules routiers électriques, comprenant les véhicules électriques à batterie, les véhicules électriques hybrides et les véhicules électriques hybrides rechargeables, a été accélérée sur le marché international, répondant ainsi aux préoccupations mondiales concernant la réduction du $CO_2$ et la sécurité en matière d'énergie. Par voie de conséquence, cela a conduit à une demande rapidement croissante de batteries de traction de forte puissance et de grande densité énergétique. Il est estimé que les batteries lithium-ion sont les accumulateurs les plus prometteurs pour la propulsion des véhicules électriques. Du fait de la diffusion rapide des véhicules électriques hybrides et de l'émergence des véhicules électriques à batterie et hybrides rechargeables, une méthode normalisée d'essai relative aux exigences de performance des batteries lithium-ion est indispensable pour fixer un niveau de sécurité de base et obtenir des données essentielles pour la conception des systèmes des véhicules et des packs de batteries.

Le présent document spécifie les essais de fiabilité et de traitement abusif des éléments lithium-ion destinés à la traction automobile qui diffèrent fondamentalement des autres éléments y compris ceux destinés aux applications portatives et fixes spécifiées par d'autres normes IEC. Dans le cas d'une application automobile, il est important de tenir compte de la spécificité d'usage, c'est-à-dire la diversité de conception des packs et des systèmes de batteries pour automobile, ainsi que la diversité des exigences spécifiques relatives aux éléments et aux batteries correspondant à chacune de ces conceptions. Basé sur ces faits, le but du présent document est de fournir une méthodologie fondamentale d'essai ayant une polyvalence générale, remplissant une fonction d'essais préliminaires communs pour les éléments lithium-ion destinés à être utilisés dans divers systèmes de batterie. Le présent document ne fournit aucun critère d'acceptation ou de refus pour les essais, mais spécifie une classification normalisée des descriptions de résultats d'essai.

Le présent document est associé à l'ISO 12405-4 [1][1].

L'IEC 62660-1 [2] spécifie les essais de performance des éléments lithium-ion pour application aux véhicules électriques.

L'IEC 62660-3 [3] spécifie les exigences de sécurité des éléments lithium-ion pour application aux véhicules électriques.



1 Les chiffres entre crochets se réfèrent à la Bibliographie.

# ÉLÉMENTS D'ACCUMULATEURS LITHIUM-ION POUR LA PROPULSION DES VÉHICULES ROUTIERS ÉLECTRIQUES –

## Partie 2: Essais de fiabilité et de traitement abusif

## 1 Domaine d'application

La présente partie de l'IEC 62660 spécifie les procédures d'essai destinées à observer la fiabilité et le comportement sous traitement abusif des éléments et des blocs d'éléments d'accumulateurs lithium-ion utilisés pour la propulsion des véhicules électriques, y compris les véhicules électriques à batterie (BEV) et les véhicules électriques hybrides (HEV).

NOTE 1 Les éléments d'accumulateurs lithium-ion pour la propulsion des véhicules électriques hybrides rechargeables (PHEV) peuvent être soumis à l'essai avec la procédure pour application BEV ou pour application HEV, selon la conception des systèmes de batteries, sur la base de l'accord entre le fabricant de l'élément et le client.

Le présent document spécifie les procédures et les conditions d'essai normalisées pour des caractéristiques fondamentales des éléments lithium-ion utilisés pour la propulsion des véhicules électriques à batterie d'accumulateurs et hybrides. Les essais sont indispensables pour obtenir des données importantes sur la fiabilité et sur le comportement sous traitement abusif des éléments lithium-ion utilisés dans différentes conceptions de systèmes de batteries et de packs de batteries.

Le présent document donne une classification normalisée de la description des résultats d'essai à utiliser pour la conception des systèmes de batteries et des packs de batteries.

NOTE 2 Des blocs d'éléments peuvent être utilisés à la place d'éléments conformément à l'accord entre le fabricant de l'élément et le client.

NOTE 3 Les exigences de sécurité des éléments lithium-ion pour application aux véhicules électriques sont définies dans l'IEC 62660-3 [3].

## 2 Références normatives

Les documents suivants cités dans le texte constituent, pour tout ou partie de leur contenu, des exigences du présent document. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

IEC 60068-2-64, *Essais d'environnement – Partie 2-64: Essais – Essai Fh: Vibrations aléatoires à large bande et guide*

ISO 16750-3, *Véhicules routiers – Spécifications d'environnement et essais des équipements électrique et électronique – Partie 3: Contraintes mécaniques*

ISO 16750-4, *Véhicules routiers – Spécifications d'environnement et essais des équipements électrique et électronique – Partie 4: Contraintes climatiques*

ISO/TR 8713, *Véhicules routiers électriques – Vocabulaire*

## 3 Termes et définitions

Pour les besoins du présent document, les termes et définitions de l'ISO/TR 8713, ainsi que les suivants s'appliquent.

L'ISO et l'IEC tiennent à jour des bases de données terminologiques destinées à être utilisées en normalisation, consultables aux adresses suivantes:

- IEC Electropedia: disponible à l'adresse http://www.electropedia.org/
- ISO Online browsing platform: disponible à l'adresse http://www.iso.org/obp

**3.1**
**véhicule électrique à batterie**
**BEV**
véhicule électrique comportant seulement une batterie d'accumulateurs de traction comme source d'énergie pour sa propulsion

Note 1 à l'article: L'abréviation "BEV" est dérivée du terme anglais développé correspondant "battery electric vehicle".

**3.2**
**bloc d'éléments**
groupe d'éléments connectés ensemble en parallèle avec ou sans dispositif de protection (fusible ou résistance du coefficient de température positif (CTP), par exemple), non encore équipé de son habillage final, ni de ses bornes et de dispositif de contrôle électronique

**3.3**
**véhicule électrique hybride**
**HEV**
véhicule comportant à la fois un système de stockage d'énergie électrique rechargeable et une source d'énergie à carburant pour sa propulsion

Note 1 à l'article: L'abréviation "HEV" est dérivée du terme anglais développé correspondant "hybrid electric vehicle".

**3.4**
**capacité assignée**
$C_n$
valeur de la capacité d'un élément en ampères-heures (Ah) déterminée dans des conditions spécifiées et déclarée par le fabricant de l'élément

Note 1 à l'article: $n$ dans $C_n$ est le temps de base en heures (h). Dans le présent document, $n = 3$ pour l'application BEV et $n = 1$ pour l'application HEV, sauf spécification contraire.

**3.5**
$I_t$
courant d'essai de référence en ampères (A), exprimé comme

$$I_t = C_n / 1$$

Note 1 à l'article: 1 a une dimension temporelle exprimée en heures (h).

Note 2 à l'article: Voir l'IEC 61434:1996 [4], Article 2.

**3.6**
**température ambiante**
température de 25 °C ± 2 K

**3.7**
**accumulateur lithium-ion**
**élément d'accumulateur**
accumulateur unitaire dont l'énergie électrique provient des réactions d'insertion et d'extraction d'ions lithium entre l'anode et la cathode

Note 1 à l'article: L'accumulateur lithium-ion est un dispositif unitaire manufacturé élémentaire fournissant une source d'énergie électrique par conversion directe de l'énergie chimique. Il est constitué d'électrodes, de séparateurs, d'électrolyte, du conteneur et des bornes; il est conçu pour être chargé électriquement.

**3.8**
**état de charge**
**SOC**
capacité d'un élément, exprimée en pourcentage de la capacité assignée

Note 1 à l'article: L'abréviation "SOC" est dérivée du terme anglais développé correspondant "state of charge".

# 4 Conditions d'essai

## 4.1 Généralités

Les caractéristiques des instruments de mesure utilisés doivent être données dans tous les rapports de résultats.

NOTE L'essai et les mesures peuvent être effectués dans des conditions de fixation recommandées par le fabricant de l'élément.

## 4.2 Instruments de mesure

### 4.2.1 Amplitude des dispositifs de mesure

Les appareils utilisés doivent permettre de mesurer les valeurs de tension et de courant. L'amplitude et les méthodes de mesure de ces instruments doivent être choisies de façon à garantir la précision spécifiée pour chaque essai.

Pour des instruments analogiques, cela implique que les lectures doivent être effectuées sur le dernier tiers de l'échelle graduée.

Tout autre instrument de mesure peut être utilisé dans la mesure où il donne une précision équivalente.

### 4.2.2 Mesure de la tension

La résistance des voltmètres utilisés doit être d'au moins 1 MΩ/V.

### 4.2.3 Mesure du courant

L'ensemble complet ampèremètre, shunt et fils doit être d'une classe de précision supérieure ou égale à 0,5.

### 4.2.4 Mesure de la température

La température de l'élément doit être mesurée à l'aide d'un dispositif de mesure de la température de surface permettant une définition d'échelle et une précision d'étalonnage équivalentes à celles spécifiées en 4.2.1. Il convient de mesurer la température à l'endroit qui reflète le mieux la température de l'élément ou du bloc d'éléments. La température peut être mesurée à d'autres endroits appropriés, si nécessaire.

La Figure 1 donne des exemples de mesure de la température. Les instructions de mesure de la température spécifiées par le fabricant de l'élément doivent être respectées.