IEC 62660-3

Edition 2.0 2022-03

INTERNATIONAL STANDARD

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Secondary lithium-ion cells for the propulsion of electric road vehicles – Part 3: Safety requirements

Éléments d'accumulateurs lithium-ion pour la propulsion des véhicules routiers électriques – Partie 3: Exigences de sécurité

IEC 62660-3:2022-03(en-fr)

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMMISSION ELECTROTECHNIQUE INTERNATIONALE

ICS 29.220.20; 43.120

ISBN 978-2-8322-1083-3

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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

Part 3: Safety requirements

FOREWORD

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IEC 62660-3 has been prepared by IEC technical committee 21: Secondary cells and batteries. It is an International Standard.

This second edition cancels and replaces the first edition published in 2016. This edition constitutes a technical revision.

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

a) The new method for the internal short-circuit test has been added in 6.4.4.2.2 and Annex C, as an alternative option to the test in 6.4.4.2.1.
b) The vibration test has been deleted.
c) The test conditions of overcharge (6.4.2.2) have been partially revised.

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

Draft	Report on voting
21/1133/FDIS	21/1137/RVD

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

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

A list of all 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 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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SECONDARY LITHIUM-ION CELLS FOR THE PROPULSION OF ELECTRIC ROAD VEHICLES –

Part 3: Safety requirements

1 Scope

This part of IEC 62660 specifies test procedures and acceptance criteria for safety performance of secondary lithium-ion cells and cell blocks used for propulsion of electric vehicles (EV) including battery electric vehicles (BEV) and hybrid electric vehicles (HEV).

This document determines the basic safety performance of cells used in a battery pack and system under intended use and reasonably foreseeable misuse or incident, during the normal operation of the EV. The safety requirements of the cell in this document are based on the premise that the cells are properly used in a battery pack and system within the limits for voltage, current and temperature as specified by the cell manufacturer (cell operating region).

The evaluation of the safety of cells during transport and storage is not covered by this document.

NOTE 1 The safety performance requirements for lithium-ion battery packs and systems are defined in ISO 6469-1. The specifications and safety requirements for lithium-ion battery packs and systems of electrically propelled mopeds and motorcycles are defined in ISO 18243. IEC 62619 covers the safety requirements for the lithium-ion cells and batteries for industrial applications, including, for example, forklift trucks, golf carts, and automated guided vehicles.

NOTE 2 Lithium cells, modules, battery packs, and battery systems are regulated by International Air Transport Association (IATA) and International Maritime Organization (IMO) for air and sea transport, and, regionally, by other authorities, mainly for land transport. Refer to IEC 62281 for additional information.

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 62619:—[1], *Secondary cells and batteries containing alkaline or other non-acid electrolytes – Safety requirements for secondary lithium cells and batteries, for use in industrial applications*

IEC 62660-2:2018, *Secondary lithium-ion cells for the propulsion of electric road vehicles – Part 2: Reliability and abuse testing*

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.

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[1] Second edition under preparation. Stage at the time of publication: IEC FDIS 62619:2021.

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
BEV
battery electric vehicle
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)) and not yet fitted with its final housing, terminal arrangement or electronic control device

3.3
cylindrical cell
cell with a cylindrical shape in which the overall height is equal to or greater than the diameter

[SOURCE: IEC 60050-482:2004, 482-02-39]

3.4
explosion
failure that occurs when a cell container opens violently and its solid contents are forcibly expelled

3.5
fire
emission of flames from a cell or cell block for more than 1 s

Note 1 to entry: Sparks and arcing are not considered as flames.

3.6
HEV
hybrid electric vehicle
vehicle with both a rechargeable energy storage system and a fuelled power source for propulsion

3.7
internal short-circuit
unintentional electrical connection between the negative and positive electrodes inside a cell

3.8
leakage
visible escape of liquid electrolyte from a part, except for a vent, such as the case, sealing part, and/or terminals of the cell

3.9
nominal voltage
suitable approximate value of the voltage used to designate or identify a cell

[SOURCE: IEC 60050-482:2004, 482-03-31, modified – Deletion of "a battery or an electrochemical system" at the end of the definition.]

3.10
pouch cell
cell having the shape of a parallelepiped whose faces are rectangular and with a prismatic flexible laminate film case

3.11
prismatic cell
cell having the shape of a parallelepiped whose faces are rectangular and with a prismatic hard case

[SOURCE: IEC 60050-482:2004, 482-02-38, modified − The word "cell" has been added to the term, "qualifies a cell or a battery" has been replaced with "cell" in the definition, and "and with a prismatic hard case housing" has been added.]

3.12
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: The subscript 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.

Note 2 to entry: Term and definition based on IEC 60050-482:2004, 482-03-15.

3.13
reference test current
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, Clause 2.

3.14
rupture
mechanical failure of a container case of a cell induced by an internal or external cause, resulting in exposure or spillage but not ejection of materials

3.15
secondary lithium-ion cell
secondary single cell whose electrical energy is derived from the insertion/extraction reactions of lithium-ions between the negative electrode and the positive electrode

Note 1 to entry: A secondary cell is a manufactured unit providing a source of electrical energy by direct conversion of chemical energy. The cell consists of electrodes, electrolyte, container, terminals and, if any, separators. The electrode can be monopolar or bipolar; the current collector of the former has active material of single polarity and the latter has positive and negative electrode active materials. The electrolyte includes an ionic conductive liquid or solid, or a mixture of them. The cell is designed to be charged electrically.

Note 2 to entry: Where the term "cell" is used alone in this document, it refers to a secondary lithium-ion cell.

3.16
SOC
state of charge
quantity of electricity stored in a cell expressed as a percentage of rated capacity

3.17
upper limit charging voltage
highest charging voltage in the cell operating region, which is specified by the cell manufacturer

Note 1 to entry: Information on the cell operating region is provided in Annex A.

[SOURCE: IEC 62133-2:2017, 3.19, modified − Note to entry added.]

3.18
venting
release of excessive internal pressure from a cell in a manner intended by design to preclude rupture or explosion

4 Test conditions

4.1 General

Unless otherwise stated in this document, cells shall be tested at room temperature. For the purposes of this document, room temperature is 25 °C ± 2 K.

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

Cell blocks can be tested as an alternative to cells in accordance with the agreement between the cell manufacturer and the customer.

Concerning the cell for plug-in hybrid electric vehicles (PHEV), the cell manufacturer can select either the test condition of BEV application or of HEV application.

NOTE Test and measurement can be conducted in a fixture as 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.

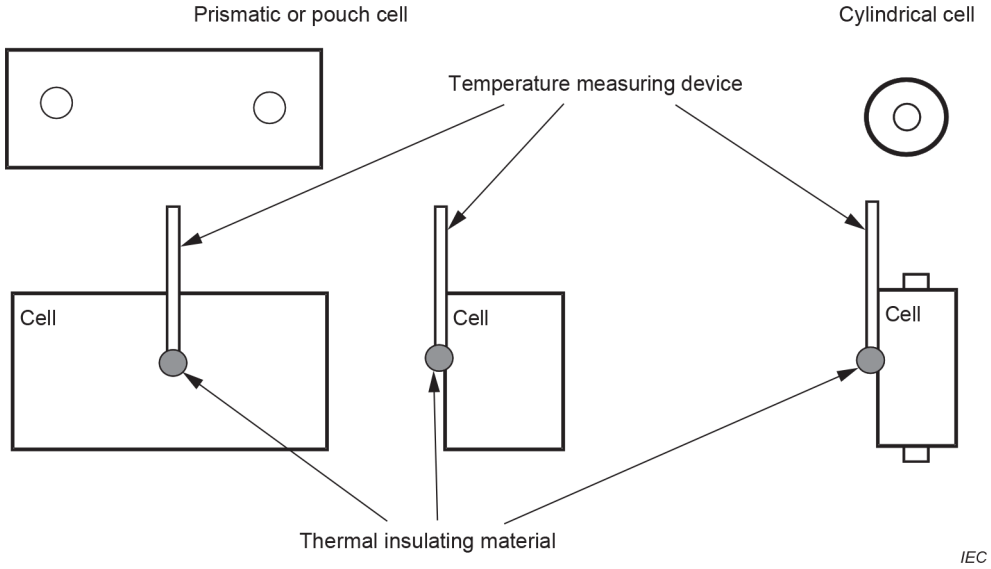


Figure 1 – Example of temperature measurement of cell

4.2.5 Other measurements

Other values may be measured by use of a measuring device, provided 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 stabilization 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 the electrical measurement, the cell shall be charged as follows.

Prior to charging, the cell shall be discharged at room temperature at a constant current of 1/3 I_t (A) for BEV application and 1 I_t (A) for HEV application down to an end-of-discharge voltage specified by the cell manufacturer. Then, the cell shall be charged at room temperature according to the charging method declared by the cell manufacturer.

5.2 Capacity

Before the SOC adjustment in 5.3, the capacity of the test cell shall be confirmed to be the rated value in accordance with the following phases.

1) Phase 1 – The cell shall be charged in accordance with 5.1. After charge, the cell temperature shall be stabilized in accordance with 4.4.
2) Phase 2 – The cell shall be discharged at room temperature at a constant current of 1/3 I_t (A) for BEV application and at 1 I_t (A) for HEV application to the end-of-discharge voltage that is specified by the cell manufacturer.
3) Phase 3 – Measure the discharge duration until the specified end-of-discharge voltage is reached, and calculate the capacity of the cell expressed in Ah up to three significant figures.

5.3 SOC adjustment

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

1) Phase 1 – The cell shall be charged in accordance with 5.1.
2) Phase 2 – The cell shall be left at rest at room temperature in accordance with 4.4.
3) Phase 3 – The cell shall be discharged at a constant current of 1/3 I_t (A) for BEV application and of 1 I_t (A) for HEV application 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 Safety tests

6.1 General

For all the tests specified in this Clause 6, the test installation shall be reported, including the method used for fixing and wiring of the cell. If necessary, to prevent deformation, the cell may be maintained during the test in a manner that complies with the test purpose.

The tests shall be performed on cells that are not more than six months old. The number of cells under each test can be determined according to the agreement between the cell manufacturer and the customer. A cell block may be used for testing in place of a single cell in accordance with the agreement between the cell manufacturer and the customer.

The number and type of test samples (cell or cell block) shall be provided in a test report.

Each test shall end with the one-hour observation period, unless otherwise specified in this document.

Warning: THE TESTS USE PROCEDURES WHICH MAY RESULT IN HARM IF ADEQUATE PRECAUTIONS ARE NOT TAKEN. TESTS SHOULD ONLY BE PERFORMED BY QUALIFIED AND EXPERIENCED TECHNICIANS USING ADEQUATE PROTECTION. TO PREVENT BURNS, CAUTION SHOULD BE TAKEN FOR THOSE CELLS WHOSE CASES MAY EXCEED 75 °C AS A RESULT OF TESTING.

6.2 Mechanical tests

6.2.1 Mechanical shock

6.2.1.1 Purpose

This test is performed to simulate mechanical shocks to a cell that may occur during the normal operation of the vehicle, and to verify the safety performance of the cell under such conditions.

6.2.1.2 Test

The test shall be performed in accordance with 6.2.2.2 of IEC 62660-2:2018.

6.2.1.3 Acceptance criteria

During the test, the cell shall exhibit no evidence of leakage, venting, rupture, fire or explosion.

6.2.2 Crush

6.2.2.1 Purpose

This test is performed to simulate external load forces that may cause deformation of a cell, and to verify the safety performance of the cell under such conditions.

6.2.2.2 Test

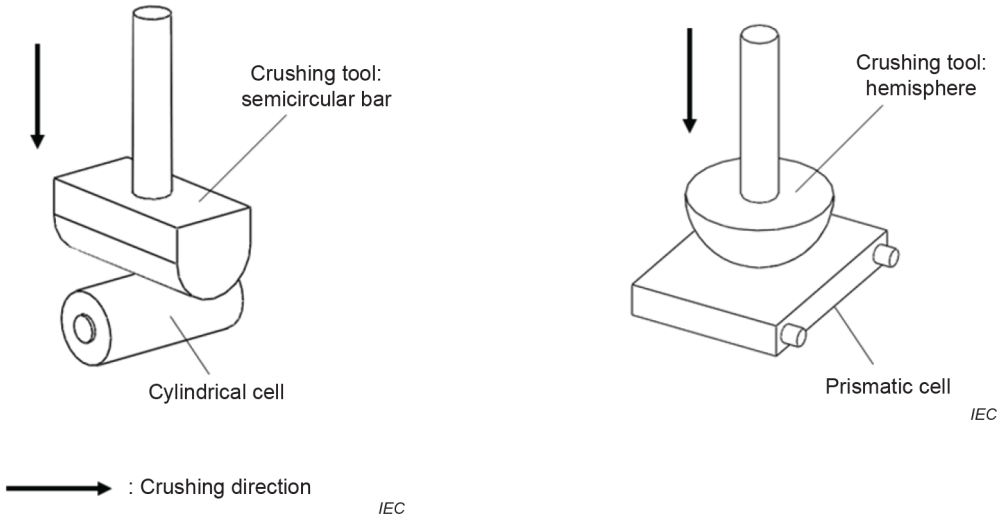
The test shall be performed as follows:

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

b) the cell shall be placed on an insulated rigid flat supporting surface, and a force shall be applied to it with a crushing tool made of a solid material in the shape of a round or semicircular bar, or in the shape of a sphere or hemisphere with a 150 mm diameter. The force for the crushing shall be applied in a direction nearly perpendicular to a larger side of the layered face of the positive and negative electrodes inside the cell. The force shall be applied to the approximate centre of the cell as shown in Figure 2. The crush speed shall be less than or equal to 6 mm/min;

NOTE The round bar can be used to crush a cylindrical cell, and the sphere can be used to crush a prismatic cell or pouch cell.

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 a force of 1 000 times the weight of the cell is applied, whichever comes first. The cells shall be under observation for 24 h or until the cell temperature declines by 80 % of the maximum temperature rise, whichever occurs sooner.



a) **Example for cylindrical cell**

b) **Example for prismatic cell**

Figure 2 – Example of crush test

6.2.2.3 Acceptance criteria

During the test, the cell shall exhibit no evidence of fire or explosion.

6.3 Thermal test

6.3.1 High temperature endurance

6.3.1.1 Purpose

This test is performed to simulate a high-temperature environment that the cell may experience during the reasonably foreseeable misuse or incident of the vehicle, and to verify the safety performance of the cell under such conditions.

6.3.1.2 Test

The test shall be performed as follows:

a) adjust the SOC of the cell to 100 % for BEV applications, and to 80 % for HEV applications 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 130 °C ± 2 K. The cell shall remain at this temperature for 30 min. Then, after the heater is turned off, the cell shall be observed for 1 h in the oven.

6.3.1.3 Acceptance criteria

During the test, the cell shall exhibit no evidence of fire or explosion.

6.3.2 Temperature cycling

6.3.2.1 Purpose

This test is performed to simulate the anticipated exposure to low and high environmental temperature variations which can result in expansion and contraction of cell components, and to verify the safety performance of the cell under such conditions.