
Wheelchairs —

Part 31:

**Lithium-ion battery systems and
chargers for powered wheelchairs —
Requirements and test methods**

Fauteuils roulants —

*Partie 31: Systèmes de batteries lithium-ion et chargeurs pour
fauteuils roulants motorisés — Exigences et méthodes d'essai*

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by Technical Committee ISO/TC 173, *Assistive products*, Subcommittee SC 1, *Wheelchairs*.

A list of all parts in the ISO 7176 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

This document was developed to standardize requirements for use of lithium-ion batteries in wheelchairs.

Lithium-ion batteries provide performance enhancements relative to batteries with other chemistries, but operation outside specified limits can pose unacceptable risks. It is important not to overlook conditions that occur not only when charging using the wheelchair battery charger, but during operation of the wheelchair, which can charge the battery system when decelerating and/or travelling down a slope. In many cases, the wheelchair controller can be considered part of the battery system and charging system combined.

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Wheelchairs —

Part 31:

Lithium-ion battery systems and chargers for powered wheelchairs — Requirements and test methods

WARNING — The use of this document can involve hazardous materials, operations and equipment. This document does not purport to address all of the safety or environmental problems associated with its use. It is the responsibility of users of this document to take appropriate measures to ensure the safety and health of personnel and the environment prior to application of this document. Particular care should be taken regarding the possible emission of toxic fumes resulting from lithium battery fires.

1 Scope

This document specifies requirements and test methods for lithium-ion batteries and battery systems intended for use in electrically powered wheelchairs, and their charging systems.

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.

ISO 7176-8, *Wheelchairs — Part 8: Requirements and test methods for static, impact and fatigue strengths*

ISO 7176-14, *Wheelchairs — Part 14: Power and control systems for electrically powered wheelchairs and scooters — Requirements and test methods*

ISO 7176-25:2022, *Wheelchairs — Part 25: Lead-acid batteries and chargers for powered wheelchairs — Requirements and test methods*

IEC 60335-2-29:2016+Amd 1:2019, *Household and similar electrical appliances — Safety — Part 2-29: Particular requirements for battery chargers*

IEC 60417, *Graphical symbols for use on equipment — Registered symbols*

IEC 60529, *Degrees of protection provided by enclosures (IP Code)*

IEC 62133-2, *Secondary cells and batteries containing alkaline or other non-acid electrolytes - Safety requirements for portable sealed secondary lithium cells, and for batteries made from them, for use in portable applications - Part 2: Lithium systems*

IEC 61960-3, *Secondary cells and batteries containing alkaline or other non-acid electrolytes - Secondary lithium cells and batteries for portable applications - Part 3: Prismatic and cylindrical lithium secondary cells and batteries made from them*

IEC 62619:2017, *Secondary cells and batteries containing alkaline or other non-acid electrolytes - Safety requirements for secondary lithium cells and batteries, for use in industrial applications*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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

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

3.1

cell

battery cell

basic manufactured unit providing a source of electrical energy by direct conversion of chemical energy, that consists of electrodes, separators, electrolyte, container and terminals, and that is designed to be charged electrically

[SOURCE: IEC 62133-2:2017, 3.7]

3.2

battery pack

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

Note 1 to entry: Some battery management functions are, by necessity, integrated into the battery; others may need to be integrated into the control and drive system.

Note 2 to entry: It may incorporate a protective housing and be provided with terminals or other interconnection arrangement.

[SOURCE: IEC 62619:2017, 3.10, modified]

3.3

module

battery module

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

[SOURCE: IEC 62133-2:2017, 3.9, modified]

3.4

lithium-ion battery

secondary battery with an organic solvent electrolyte and positive and negative electrodes which utilize an intercalation compound in which lithium is stored

Note 1 to entry: A lithium ion battery does not contain lithium metal.

[SOURCE: IEC 482-05-07, modified]

3.5

battery management system

BMS

electronic system associated with a battery which has functions to maintain safety and prevent damage

3.6

battery system

battery

system which comprises one or more cells, modules or battery packs

Note 1 to entry: The battery system can have cooling or heating units.

[SOURCE: IEC 62619:2017, 3.11, modified]

3.7

cell imbalance

difference between cell conditions that can cause a hazard if allowed to progress

EXAMPLE Significant divergence between cell voltages.

3.8**rated capacity**

capacity value of a cell or battery determined under specified conditions and declared by the manufacturer

3.9**fire**

emission of flames from a cell, module, battery pack, or battery system

[SOURCE: IEC 62619:2017, 3.17]

3.10**battery charging system**

battery charger, battery system and interconnecting components in the charging circuit, including connectors and protective devices

Note 1 to entry: Parts of the battery charging system can be in the wheelchair.

3.11**safety extra-low voltage****SELV**

voltage not exceeding 42 V between conductors and between conductors and earth, the no-load voltage not exceeding 50 V

Note 1 to entry: When safety extra-low voltage is obtained from the supply mains, it is to be through a safety isolating transformer or a convertor with separate windings, the insulation of which complies with double insulation or reinforced insulation requirements.

Note 2 to entry: The voltage limits specified are based on the assumption that the safety isolating transformer is supplied at its rated voltage.

[SOURCE: IEC 60335-1:2020, 3.4.2, modified]

3.12**safety isolating transformer**

transformer, the input winding of which is electrically separated from the output winding by an insulation at least equivalent to double insulation or reinforced insulation, that is intended to supply a battery charging circuit having an output voltage not exceeding 120 V ripple-free direct current

Note 1 to entry: Ripple-free means an r.m.s. ripple voltage not exceeding 10 % of the DC component.

[SOURCE: IEC 60335-2-29:2016+Amd 1:2019, 3.4.3]

3.13**thermal runaway**

heat generation caused by uncontrolled exothermic reactions inside the cell

[SOURCE: ISO 6469-1:2019/Amd:2022, 3.38]

4 Lithium-ion batteries**4.1 Battery performance and safety requirements****4.1.1 General**

Lithium-ion batteries shall conform to IEC 62133-2.

4.1.2 Fire

It is important that thermal runaway within a cell does not result in fire of the entire battery system or in fire propagating outside the battery system.

The battery system shall conform to IEC 62619:2017, 7.3.3.

4.1.3 Battery cyclic endurance

The cyclic endurance of a battery is defined by the number of charge/discharge cycles it can perform under specific conditions.

The manufacturer shall declare the number of charge/discharge cycles when tested in accordance with IEC 61960-3.

4.2 Requirements for battery management systems

4.2.1 General

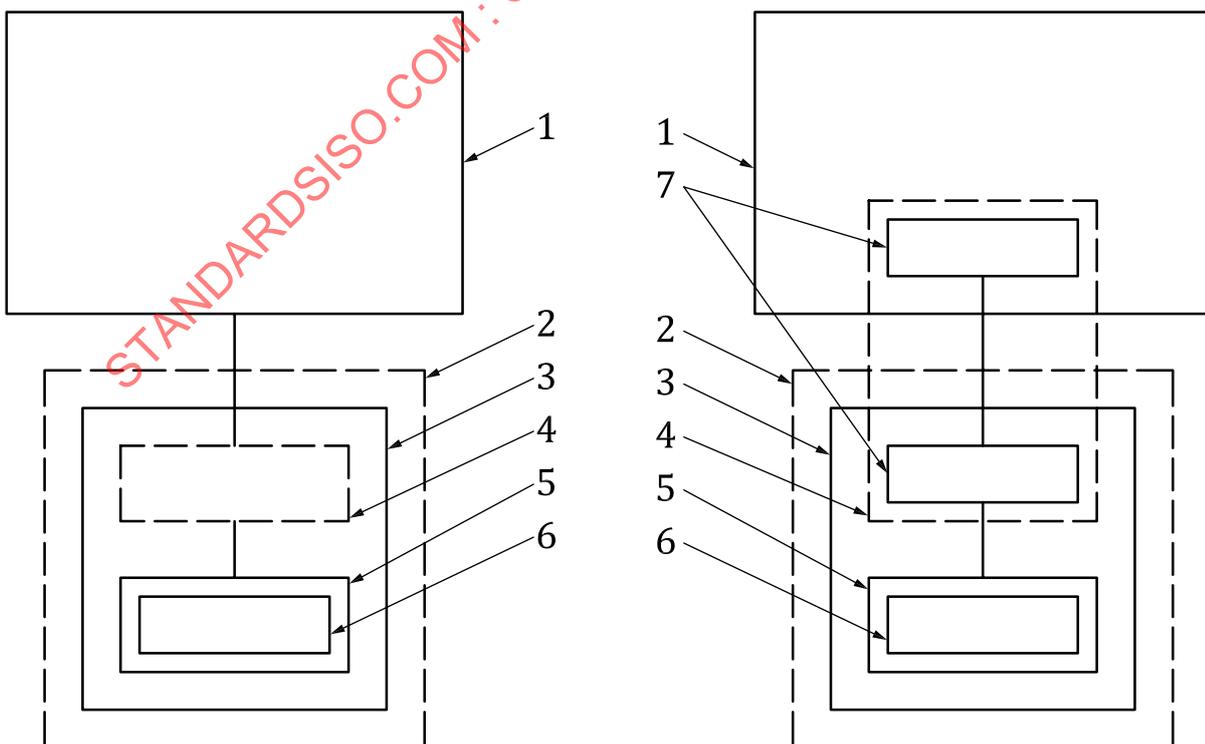
Figure 1 shows examples of possible locations of a BMS, including BMS subsystems.

The BMS can report to the wheelchair controller

- cell voltages and temperatures,
- battery current, and
- estimated state of charge and state of health,

and can balance the voltages or states of charge among individual cells. The controller can use the information reported by the BMS to limit power, such as charging power during regeneration while the wheelchair is decelerating and/or travelling down a slope, in order to prevent cut-off by the BMS.

EXAMPLE Reducing wheelchair speed and/or activating a shunt regulator.



- a) All functions of BMS are in the battery pack b) BMS functions are divided between battery pack and controller

Key

- 1 controller
- 2 battery system
- 3 battery pack
- 4 BMS
- 5 module(s)
- 6 cell(s)
- 7 BMS subsystem

Figure 1 — Examples of BMS locations and battery system configurations

4.2.2 Functional requirements

The battery management system shall provide the following functions:

- a) cell over-voltage protection;
- b) cell under-voltage protection;
- c) battery over-current protection;
- d) battery over-temperature protection;
- e) battery under-temperature protection;
- f) battery status, including state of charge, information necessary for indication to the operator and/or for operation of the wheelchair.

NOTE A cut-off function can be a suitable means of protection.

The battery management system should provide the following functions:

- cell imbalance protection,
- balancing of voltages or states of charge among individual cells,
- sufficient information to allow the controller to limit power.

Conformity is verified by reviewing documentation provided by the wheelchair manufacturer, controller manufacturer, BMS manufacturer, and/or battery manufacturer.

4.2.3 Electromagnetic compatibility (EMC)

It is expected that when a BMS is installed in a wheelchair in accordance with the BMS manufacturer's instructions, that the wheelchair will meet applicable requirements for electromagnetic compatibility. Related requirements can be found in ISO 7176-21 and IEC 60601-1-2.

4.2.4 Climatic tests

It is expected that when a BMS is installed in a wheelchair in accordance with the BMS manufacturer's instructions, the wheelchair will meet applicable requirements for climatic tests. Related requirements can be found in ISO 7176-9.

5 Requirements for the battery charging system

5.1 Charger connector

5.1.1 General

Correct selection of charger connector is important to

- ensure connector compatibility between battery chargers, and the wheelchair's batteries, and
- prevent dangerous incompatibility.

The connector chosen shall

- have a suitable current and voltage rating,
- be configured to suit the wheelchair battery,
- provide a means for the connected wheelchair to detect that the connector is mated, regardless of whether power is applied, to support a drive inhibit function, and
- have the male connector on the output of the charger.

The connector shall meet the requirements of ISO 7176-14 for the charging connection.

NOTE 1 The shape of the connector housing, the connector's interface and positioning can contribute considerably to the ergonomics of use and safety of operation.

NOTE 2 Different lithium-ion batteries can require different charging routines to suit their chemistry or voltage, therefore a unique connector can be required to ensure compatibility.

NOTE 3 Inhibit is used to prevent wheelchair movement when the battery charger is connected. The pin is commonly connected to the battery negative.

5.1.2 XLR battery charger connector

If a battery charger intended for charging lithium ion batteries has a 3-pin XLR output connector, the connection of the battery charger to a wheelchair fitted with lead acid batteries with a compatible 3-pin XLR charging connector shall not present a hazard.

The 3-pin XLR connector shall meet the requirements of ISO 7176-25 for 3-pin XLR connectors.

5.1.3 XLR wheelchair charger connector

If an XLR connector is installed on a wheelchair with lithium-ion batteries, any battery charger that is normally used for charging lead-acid wheelchair batteries through an XLR connector shall charge the installed lithium-ion batteries in accordance with the battery manufacturer's specification. Or the lithium-ion batteries BMS should detect the incorrect voltage input and shut off the attempt to be charged.

The 3-pin XLR connector shall meet the requirements of ISO 7176-25 for 3-pin XLR connectors.

5.2 Battery charger function

5.2.1 Requirements

5.2.1.1 General

Battery chargers shall meet the requirements of IEC 60335-2-29.

NOTE IEC 60335-2-29 includes requirements for battery chargers having an output voltage exceeding safety extra-low voltage as defined in IEC 60335-1. Nevertheless, in some jurisdictions, battery chargers having an output voltage exceeding safety extra-low voltage might not be practicable due to constraints in local laws and/or regulations.

5.2.1.2 Off-board battery chargers

Off-board battery chargers intended for use only in dry indoor areas shall provide a degree of protection not less than IPX1 when tested as specified in IEC 60529. These battery chargers shall be labelled with "Only for use in dry indoor areas" or a symbol in accordance with IEC 60417-5957.

5.2.1.3 Carry-on battery chargers

Carry-on battery chargers, installed on-board battery chargers and off-board battery chargers intended for use in places other than dry indoor areas shall provide a degree of protection not less than IPX4 as specified in IEC 60529.

5.2.1.4 Carry-on and on-board chargers

In the case of on-board chargers, mount the battery charger as specified by the wheelchair manufacturer. Subject the wheelchair/charger combination to the multi-drum fatigue test and the kerb-drop fatigue test specified in ISO 7176-8.

On completion of the tests, the battery charger shall show no damage that could impair conformity with IEC 60335-2-29:2016, 8.1, 15.1.1, 16.3 and Clause 29, and connections shall not have worked loose.

Carry-on chargers shall conform to IEC 60335-2-29:2016+Amd 1:2019, 21.102.

5.2.1.5 Charger performance

It is important that the battery charger can recharge a depleted battery set to 80 % of its rated capacity within 8 h. A battery charger shall have a rated output current greater than or equal to

$$I_r = 0,8 \times C_r / 8$$

where

I_r is the rated output current of the battery charger;

C_r is the largest battery rated capacity specified for use with the charger, expressed in Ah.

Conformance is verified by inspection of documentation provided by the battery charger manufacturer, battery manufacturer, and/or wheelchair manufacturer.

5.2.1.6 Battery discharge

5.2.1.6.1 Requirement

A battery charger that is disconnected from the supply mains and left connected to the battery might draw an excessive current from the battery.

The current drawn from a correctly connected battery by a carry-on or off-board battery charger that is disconnected from the supply mains shall not exceed 10 mA.

5.2.1.6.2 Test method

Conformity is checked by adding to the output cable of the battery charger a means to measure the mean current when the battery charger is connected to a test voltage equal to the nominal voltage of the battery for which the battery charger is intended, $\pm 0,1$ V.

A power supply may be the source of the test voltage

5.2.1.7 Battery charger configuration

It shall not be possible to change the output voltage, the charging characteristics or other settings of the battery charger without the aid of a tool, key entry combination or similar means for restricting access (other than those intended to set the degree of charge to prevent overcharging caused by regeneration with a fully charged battery). If the means for restricting access is other than a tool, it shall not consist of operations which are performed in normal use of the battery charger.

Conformity is confirmed by inspection.

6 Instructions for use

6.1 Battery charger

The instructions for use for the battery charger shall conform to the requirements specified in ISO 7176-25:2022, 8.1.

Where a battery charger provides means to set the degree of charge of the battery, the instructions for use shall include instructions for operating such means and shall describe the circumstances in which the degree of charge should be changed.

6.2 Battery

Instructions for use containing the following information shall be provided with each battery:

- a) a specification that includes the following:
 - i) the battery chemistry;
 - ii) the nominal voltage;
 - iii) the rated capacity in ampere-hours and watt-hours;
 - iv) the operating temperature ranges;
 - v) the charging temperature range;
 - vi) the storage temperature range;
 - vii) dimensions of batteries;
 - viii) the cycle endurance in accordance with IEC 61960-3;
- b) cautions regarding operating the battery outside its specified operating temperature range shall be clearly identified and informed in the handling manual;
- c) cautions on battery installation or removal;
- d) cautions regarding the transport of the battery;