IEC 62485-6

Edition 1.0 2021-01

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Safety requirements for secondary batteries and battery installations – Part 6: Safe operation of lithium ion batteries in traction applications

Exigences de sécurité pour les batteries d'accumulateurs et les installations de batteries – Partie 6: Fonctionnement en toute sécurité des batteries ions-lithium dans les applications de traction

IEC 62485-6:2021-01(en-fr)

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CONTENTS

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SAFETY REQUIREMENTS FOR SECONDARY BATTERIES AND BATTERY INSTALLATIONS –

Part 6: Safe operation of lithium ion batteries in traction applications

FOREWORD

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International Standard IEC 62485-6 has been prepared by IEC technical committee 21: Secondary cells and batteries.

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

FDIS	Report on voting
21/1071/FDIS	21/1077/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 parts in the IEC 62485 series, published under the general title *Safety requirements for secondary batteries and battery installations*, 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- withdrawn,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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SAFETY REQUIREMENTS FOR SECONDARY BATTERIES AND BATTERY INSTALLATIONS –

Part 6: Safe operation of lithium ion batteries in traction applications

1 Scope

This part of IEC 62485 applies to battery installations used for electric off-road vehicles; it does not cover the design of such vehicles.

Examples of the main applications are:

– industrial
  - cleaning machines,
  - trucks for material handling, for example, lift trucks, tow trucks, automatic guided vehicles,
  - electrically propulsed lifting platforms;
– other applications
  - electric powered boats and ships.

This document covers the safety aspects of battery installations in such applications. This document does not cover railway vehicles, for traction railway application, see IEC 62928.

This document does not cover batteries and battery installations for the propulsion of electric road vehicles. In the event of there being a variation of requirements between this document and those of a relevant product standard (e.g. goods vehicles, bicycles, wheel chairs, golf carts), then the product standard requirements take precedence.

Lithium ion cells and batteries used in traction industrial application are intended to fulfil safety requirements in accordance with IEC 62619.

The maximum voltages are limited to AC 1 000 V and to DC 1 500 V, and the principal measures for protection against hazards, generally from electricity, gas emission and electrolyte to prevent fire and explosion are described.

This document provides requirements on safety aspects associated with the installation, use, inspection, maintenance and disposal of lithium ion batteries. Batteries containing lithium metal are not covered by this document.

In general, the safety requirements for secondary batteries and battery installations – General safety information and definitions are specified for lead-acid, nickel-cadmium and nickel-metal hybrid batteries in accordance with IEC 62485-1.

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 60204-1, *Safety of machinery – Electrical equipment of machines – Part 1: General requirements*

IEC 60364-4-41:2005, *Low-voltage electrical installations – Part 4-41: Protection for safety – Protection against electric shock*
IEC 60364-4-41:2005/AMD1:2017

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

IEC 61000-1-2, *Electromagnetic compatibility (EMC) – Part 1-2: General – Methodology for the achievement of functional safety of electrical and electronic systems including equipment with regard to electromagnetic phenomena*

IEC 61000-6-1, *Electromagnetic compatibility (EMC) – Part 6-1: Generic standards – Immunity standard for residential, commercial and light-industrial environments*

IEC 61000-6-2, *Electromagnetic compatibility (EMC) – Part 6-2: Generic standards – Immunity standard for industrial environments*

IEC 61000-6-3, *Electromagnetic compatibility (EMC) – Part 6-3: Generic standards – Emission standard for residential, commercial and light-industrial environments*

IEC 61000-6-4, *Electromagnetic compatibility (EMC) – Part 6-4: Generic standards – Emission standard for industrial environments*

IEC 61000-6-7, *Electromagnetic compatibility (EMC) – Part 6-7: Generic standards – Immunity requirements for equipment intended to perform functions in a safety-related system (functional safety) in industrial locations*

IEC 61140, *Protection against electric shock – Common aspects for installation and equipment*

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*

IEC 62620:2014, *Secondary cells and batteries containing alkaline or other non-acid electrolytes –Secondary lithium cells and batteries for use in industrial applications*

ISO 3864 (all parts), *Graphical symbols – Safety colours and safety signs*

EN 1175-1:2011, *Safety of industrial trucks – Electrical requirements – Part 1: General requirements for battery powered trucks*

UN Regulation No. 100 (UN R 100):2011, *Uniform provisions concerning the approval of vehicles with regard to specific requirements for the electric power train*

3 Terms and definitions

For the purposes of this document, the following terms and definitions 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
secondary lithium cell
cell
secondary cell where electrical energy is derived from the insertion/extraction reactions of lithium ions or oxidation/reduction reaction of lithium between the negative electrode and the positive electrode

Note 1 to entry: The cell typically has an electrolyte that consists of a lithium salt and organic solvent compound in liquid, gel or solid form and has a metal or a laminate film casing.

Note 2 to entry: A cell is not ready for use in an application because it is not yet fitted with its final housing, terminal arrangement and electronic control device.

3.2
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 60500-482:2004, 482-05-07]

3.3
electrolyte
liquid or solid substance containing mobile ions which render it ionically conductive

Note 1 to entry: The electrolyte may be liquid, solid or a gel.

[SOURCE: IEC 60500-482:2004, 482-02-29]

3.4
battery management system
BMS
electronic system associated with a battery which has functions to control current in case of overcharge, overcurrent, overdischarge, and overheating, and which monitors and/or manages the state of the battery, calculates secondary data, reports that data and/or controls its environment to influence the battery's safety, performance and/or service life

Note 1 to entry: Overdischarge cut off is not mandatory if there is an agreement on this between the cell manufacturer and the customer.

Note 2 to entry: The function of the battery management system (BMS) can be assigned to the battery pack or to equipment that uses the battery.

Note 3 to entry: The BMS can be divided and it can be found partially in the battery pack and partially on the equipment that uses the battery.

Note 4 to entry: The BMS is sometimes also referred to as a BMU (battery management unit).

3.5
nominal voltage
suitable approximate value of the voltage used to designate or identify a cell or a battery

Note 1 to entry: The cell or battery manufacturer may provide the nominal voltage.

Note 2 to entry: The nominal voltage of a battery of n series connected cells is equal to n times the nominal voltage of a single cell.

[SOURCE: IEC 60050-482:2004, 482-03-31, modified – Omission of "electrochemical system" from the definition, and addition of Notes 1 and 2.]

3.6
overcharge
<of a cell or battery> continued charging after the full charge of a secondary cell or battery

Note 1 to entry: Overcharge is also the act of charging beyond a certain limit specified by the manufacturer.

[SOURCE: IEC 60500-482:2004, 482-05-44, modified – The domain has been added and the wording "of a fully charged" has been replaced with "after the full charge of" in the definition.]

3.7
overdischarge
state of the battery when one or more cells of the battery are discharged below their lower limit discharge voltage

3.8
traction battery
secondary battery which is designed to provide the propulsion energy for electric vehicles

3.9
lower limit discharging voltage
lowest discharging voltage in the cell operating region specified by the cell manufacturer

3.10
external short-circuit
abnormally high current discharge due to a conductive fault over parts at opposite polarity either within the battery circuitry or over the external terminals

3.11
internal short-circuit
electrical conduction through insulation within the cell due to cell manufacturing defects, cell design faults or damage due to abuse of the cell during its use

3.12
module
group of cells connected together either in a series and/or parallel configuration with or without protective devices (e.g. fuse or positive temperature coefficient device (PTC)) and monitoring circuitry

3.13
battery system
battery
system which comprises one or more cells, modules or battery packs and has a battery management system capable of controlling current in case of overcharge, overcurrent, overdischarge and overheating

Note 1 to entry: Overdischarge cut off is not mandatory if there is an agreement on this between the cell manufacturer and the customer.

Note 2 to entry: The battery system may have cooling or heating units. A larger battery system may comprise more than one battery system. The battery system is sometimes also referred to as a battery.

3.14
cell block
group of cells connected together in parallel configuration with or without protective devices (e.g. fuse or positive temperature coefficient device (PTC)) and monitoring circuitry

Note 1 to entry: It is not ready for use in an application because it is not yet fitted with its final housing, terminal arrangement and electronic control device.

3.15
battery pack
energy storage device comprised of one or more cells or modules electrically connected, and has monitoring circuitry which provides information (e.g. cell voltage) to a battery system to influence the battery's safety, performance and/or service life

Note 1 to entry: It may incorporate a protective housing and be provided with terminals or other interconnection arrangements.

4 Protection against electric shock by the battery and charger

4.1 General

Measures should be taken for protection against direct contact (basic protection) and against indirect contact (fault protection) with hazardous voltages while the traction batteries are installed in the vehicle and during battery charging procedures.

These measures are described in detail in IEC 60364-4-41 and IEC 61140. The following subclauses describe the typical measures to be taken for traction battery installations and the resulting adaptions.

The appropriate equipment standard IEC 61140 applies to batteries and direct current distribution circuits located inside equipment.

4.2 Basic protection and fault protection

For batteries when installed in the vehicle and in battery charging installations if removed from the vehicle for charging, protection against direct contact with live parts shall be ensured in accordance with IEC 60364-4-41.

The following protective measures against direct contact apply:

– protection by insulation of live parts;
– protection by barriers or enclosures;
– protection by obstacles;
– protection by placing out of reach.

The following protective measures against indirect contact apply:

– protection by automatic disconnection or signalling;
– protection by protective insulation;
– protection by earth-free local equipotential bonding;
– protection by electrical separation.

4.3 Basic protection and fault protection when discharging the traction battery on the vehicle (battery disconnected from charger/mains)

4.3.1 Batteries up to and including 60 V DC

For batteries having a nominal voltage up to and including 60 V DC, protection against electric shock caused by direct contact is not formally required as long as the whole battery installation corresponds to the conditions for safety extra-low voltage (SELV) or protective extra-low voltage (PELV).

However, for other reasons, for example, short-circuits and mechanical damage, there should be protection against direct contact with live parts of all batteries in electrical vehicles, even if the battery nominal voltage is 60 V DC or less.

NOTE Batteries with nominal voltage up to and including 120 V DC are regarded as safe power sources for SELV systems (safety extra-low voltage) or PELV systems (protective extra-low voltage), see IEC 60364-4-41:2005, 414.1.1.

4.3.2 For batteries exceeding 60 V DC up to and including 120 V DC

For batteries having a nominal voltage above 60 V DC and up to and including 120 V DC, protection against electric shock caused by direct contact is required.

The following protective measures apply:

– protection by insulation of live parts;
– protection by barriers or enclosures;
– protection by obstacles;
– protection by placing out of reach.

If the basic protection of live parts is ensured only by obstacles or by placing out of reach, access to the battery compartment shall be restricted to trained and authorized personnel only, and the battery compartment shall be marked by appropriate warning labels (see Clause 12). This requirement does not apply to an inherently safe design of the battery regarding electric shock.

4.3.3 Batteries exceeding 120 V DC but not exceeding 1 500 V DC

For batteries having a nominal voltage exceeding 120 V DC, but not exceeding 1 500 V DC, protective measures against both direct and indirect contact are required.

Battery compartments shall be locked and have access restricted to trained and authorized personnel only and shall be marked with appropriate warning labels (see Clause 12).

The following protective measures against indirect contact apply:

– protection by electrical insulation of live parts;
– protection by earth-free equipotential local bonding;
– protection by automatic disconnection or signalling.

4.4 Basic protection and fault protection when charging the traction battery

When battery chargers with safe reinforced isolation from the mains supply are used according to IEC 61140, the protective measures SELV or PELV should be applied. If the nominal voltage of the battery does not exceed 60 V DC, basic protection is not required as long as the total installation corresponds to conditions of SELV or PELV.

When the battery charger does not comply with these requirements, then the protective measures against direct and indirect contact shall be applied according to IEC 60364-4-41.

However, for other reasons, for example, short-circuits, mechanical damage, all batteries in electrical vehicles shall be protected against direct contact with live parts, even if the battery nominal voltage is 60 V DC or less.

If protection by barriers or enclosures is applied, the minimum degrees of protection required shall be according to IEC 60529, IP2X or IPXXB.

The battery enclosure or compartment shall have adequate protection from the effects of moisture and excessive dust.

This battery enclosure or compartment shall be defined under agreement between the battery system manufacturer and the upper system designer (such as vehicle designer). The IP class of the battery enclosure or compartment shall be declared by its manufacturer or designer.

The pollution degree influences the creepage and clearances distances. The battery shall fulfil the relevant safety standards for the respective end application with regards to clearances and creepage distances (e.g. IEC 60664 series).

5 Prevention of short-circuits and protection from other effects of electric current

5.1 Cables and connectors

Cables and connectors shall be insulated to prevent short-circuits.

If protection against short-circuits cannot be provided by overcurrent protection devices for battery-specific reasons, then the connecting cables between the charger and battery fuse, charger and battery, and between battery and vehicle shall be protected against short-circuits and earth fault.

Protection for battery alone is only possible by a fuse. Other protection like earth fault can be realized by overcurrent protection circuit.

NOTE 1 "Overcurrent protection device for specific reasons" means protection against overcurrent between battery terminals.

NOTE 2 Short-circuits can also occur between points other than battery terminals.

The cables shall meet the requirements of IEC 60204-1.

The battery terminal cables shall be fixed in a manner that prevents tensile and torsional strain on the battery terminals (see also 5.1 of IEC 62485-3:2014).

Insulation shall be resistant to the effects of anticipated environmental ambient influences such as temperature, electrolyte, water, dust, commonly occurring chemicals and mechanical stress.

5.2 Protective measures during maintenance

In order to minimize the risk of injury during work on live equipment, the use of insulated tools according to IEC 60900 is recommended and all necessary measures depending on the type of the battery shall be taken to ensure safe work on the battery:

– all metallic personal objects shall be removed from the operator's hands, wrists and neck before starting work;

– for battery systems where the nominal voltage is above 120 V DC, insulated protective clothing and/or local insulated coverings shall be required to prevent personnel from making contact with the floor or parts bonded to earth;

– batteries shall not be connected or disconnected before the load or charging current has been switched off;
– battery terminals and connector covers shall be provided which allow routine maintenance whilst minimizing exposure of energized conductive parts;
– maintenance shall only be carried out by authorized persons.

5.3 Battery insulation

5.3.1 Insulation resistance

A new and charged battery shall have an insulation resistance as specified by the vehicle manufacturer when measured between both battery terminals and metallic container, vehicle frame or other conductive supporting structure. Where the battery is fitted into more than one container, this requirement applies with the sections, including metal battery containers, electrically connected. There is an exemption from this insulation resistance requirement when the battery is installed in a chassis-bonded system.

5.3.2 Insulation resistance measurement

Unless specified by the manufacturer, a battery having a nominal voltage not higher than 120 V DC, shall have an insulation resistance of at least 50 Ω multiplied by the nominal battery voltage but not less than 1 kΩ when measured between a battery terminal and metallic container, vehicle frame or other conductive supporting structure. If the nominal battery voltage exceeds 120 V DC, an isolation resistance of at least 500 Ω multiplied by the nominal battery voltage is required. Where the battery is fitted into more than one container, this requirement applies to the sections, including metal battery containers that are electrically connected.

If AC high-voltage buses and DC high-voltage buses are galvanically isolated from each other, isolation resistance between the high-voltage bus and the electrical chassis shall have a minimum value of 100 Ω/volt of the working voltage for DC buses, and a minimum value of 500 Ω/volt of the working voltage for AC buses. The measurement shall be conducted according to "Isolation resistance measurement method for vehicle based tests" of UN R 100:2011.

6 Provisions against hazards

6.1 General

Within the standard temperature range, secondary cells can be charged at the maximum charge current, which is specified from a safety point of view. Lithium ion cells shall always be operated within the operating region values specified by the manufacturer (voltage, temperature, current) in accordance with Annex A of IEC 62619:2017 and Annex A.

It is of prime importance that the charging current during the last portion of the charging procedure is kept at a level appropriate for the battery type used. Therefore the use of a controlled charger, which considers the cells operating region (e.g. by the BMS communication) is essential otherwise batteries run the risk of total destruction, explosion or thermal runaway.

6.2 Charging modes

Within the standard temperature range, secondary cells can be charged at the maximum charge current, which is specified from a safety point of view.

Unless specified by the manufacturer, the usual charging mode for lithium ion traction batteries is the constant current or constant voltage charge (IU- characteristic).

NOTE The regulation of charge voltage can be carried out by the charger in communication with the BMS.

For fast charge the recommendations of the manufacturer for current/voltage regulation and the end-of-charge voltage have to be applied.