IEC 62485-3

Edition 2.0 2014-07

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Safety requirements for secondary batteries and battery installations – Part 3: Traction batteries

Exigences de sécurité pour les batteries d'accumulateurs et les installations de batteries – Partie 3: Batteries de traction

IEC 62485-3:2014-07(en-fr)

IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00
info@iec.ch
www.iec.ch

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMMISSION ELECTROTECHNIQUE INTERNATIONALE

PRICE CODE
CODE PRIX S

ICS 29.220.20; 29.220.30; 43.040.10

ISBN 978-2-8322-1690-3

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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 62485-3 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) a comprehensive revision of Clause 6, presenting a unified and changed formula for the calculation of the required ventilation air flow during battery charging;
b) addition of requirements for properties of floor material and battery changing equipment in Clause 9.

The text of this standard is based on the following documents:

FDIS	Report on voting
21/834/FDIS	21/843/RVD

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

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts of the IEC 62485 series can be found, under the general title *Safety requirements for secondary batteries and battery installations*, on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

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- withdrawn,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

SAFETY REQUIREMENTS FOR SECONDARY BATTERIES AND BATTERY INSTALLATIONS –

Part 3: Traction batteries

1 Scope

This part of the IEC 62485 applies to secondary batteries and battery installations used for electric vehicles, e.g. in electric industrial trucks (including lift trucks, tow trucks, cleaning machines, automatic guided vehicles), in battery powered locomotives, in electric vehicles (e.g. goods vehicles, golf carts, bicycles, wheelchairs), and does not cover the design of such vehicles.

This International Standard covers lead dioxide-lead (lead-acid), nickel oxide-cadmium, nickel-oxide-metal hydride and other alkaline secondary batteries. Safety aspects of secondary lithium batteries in such applications will be covered in their own appropriate standards.

The nominal voltages are limited to 1 000 V a.c. and 1 500 V d.c. respectively and the principal measures for protection against hazards generally from electricity, gas emission and electrolyte are described.

It provides requirements on safety aspects associated with the installation, use, inspection, maintenance and disposal of batteries.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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 60900, *Live working – Hand tools for use up to 1 000 V a.c. and 1 500 V d.c.*

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

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

3 Terms and definitions

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

3.1
secondary cell
cell which is designed to be electrically recharged

Note 1 to entry: The recharge is accomplished by way of a reversible chemical reaction.

3.2
lead dioxide lead battery
accumulators (deprecated)
secondary battery with an aqueous electrolyte based on dilute sulphuric acid, a positive electrode of lead dioxide and a negative electrode of lead

3.3
nickel oxide cadmium battery
secondary battery with an alkaline electrolyte, a positive electrode containing nickel oxide and a negative electrode of cadmium

3.4
vented cell
a secondary cell having a cover provided with an opening through which products of electrolysis and evaporation are allowed to escape freely from the cell to the atmosphere

3.5
valve regulated lead-acid battery
VRLA
secondary battery in which cells are closed but have a valve which allows the escape of gas if the internal pressure exceeds a predetermined value

Note 1 to entry: The cell cannot normally receive addition to the electrolyte.

3.6
gas-tight sealed cell
gas-tight sealed secondary cell
secondary cell which remains closed and does not release either gas or liquid when operated within the limits of charge and temperature specified by the manufacturer

Note 1 to entry: The cell may be equipped with a safety device to prevent dangerously high internal pressure.

Note 2 to entry: The cell does not require addition to the electrolyte and is designed to operate during its life in its original sealed state.

3.7
secondary battery
two or more secondary cells connected together and used as a source of electrical energy

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

3.9
monobloc battery
battery with multiple separate but electrically connected cell compartments each of which is designed to house an assembly of electrodes, electrolyte, terminals and interconnections and possible separator

Note 1 to entry: The cells in a monobloc battery can be connected in series or parallel.

3.10
electrolyte
liquid or solid substance containing mobile ions which render it ionically conductive

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

3.11
gassing of a cell
evolution of gas resulting from the electrolysis of water in the electrolyte of the cell

3.12
charging of a battery
operation during which a secondary cell or battery is supplied with electrical energy from an external circuit which results in chemical changes within the cell and thus storage of energy as chemical energy

3.13
equalisation charge
extended charge to ensure an equal state of charge of all cells in a battery

3.14
opportunity charging
use of free time during a work period to top up the charge and thus extend the work period of a battery whilst avoiding excessive discharge

3.15
overcharge
continued charging of a fully charged secondary cell or battery

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

3.16
discharge
discharge of a battery
operation during which a battery delivers, to an external circuit and under specified conditions, electrical energy produced in the cells

3.17
peripheral equipment
battery peripheral equipment
equipment installed on the battery, which supports or monitors the operation of the battery

Note 1 to entry: Examples are a central water filling system, an electrolyte agitation system, a battery monitoring system, a central de-gassing system, the battery connectors (plugs and sockets), a thermal management system, etc.

3.18
charging room
room or closed area intended specifically for recharging batteries

Note 1 to entry: The room may also be used for battery maintenance.

3.19
charging area
open area designated and made suitable for recharging batteries

Note 1 to entry: The area may also be used for maintenance of batteries and battery related equipment.

4 Protection against electric shock by the battery and charger

4.1 General

Measures shall be taken on traction batteries and in traction battery charging installations for protection against either direct contact or indirect contact, or against both direct and indirect contact.

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

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

4.2 Protection against both direct and indirect contact

On batteries and in battery charging installations 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 Protection against direct and indirect contact when discharging the traction battery on the vehicle (battery disconnected from charger/mains)

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

NOTE The nominal voltage of a lead dioxide - lead cell (lead acid) is 2,0 V, that of a nickel oxide – cadmium or nickel oxide - metal hydride cell is 1,2 V. When these cells are boost charged, their voltage can reach 2,7 V in lead acid or 1,6 V in nickel oxide based systems.

However, for other reasons, e.g. short circuits, mechanical damage etc., all batteries in electrical vehicles shall be protected against direct contact of live parts, even if the battery nominal voltage is 60 V d.c. or less.

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

NOTE Batteries with nominal voltage up to and including 120 V d.c. are regarded as safe power sources for SELV-systems (safety extra low voltage) or PELV-systems (protective extra low voltage), see IEC 60364-4-41:2005,411.1.

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 protection against direct contact of live parts is ensured only by obstacles or placing out of reach, access to the battery accommodation shall be restricted to trained and authorized personnel only, and the battery accommodation shall be marked by appropriate warning labels (see Clause 11).

For batteries having a nominal voltage exceeding 120 V d.c., protective measures against both direct and indirect contact are required.

Battery compartments with batteries having a nominal voltage exceeding 120 V d.c. shall be locked and have access restricted to trained and authorized personnel only and shall be marked by appropriate warning labels (see Clause 11).

For batteries with a nominal voltage exceeding 120 V d.c., 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 Protection against direct and indirect contact when charging the traction battery

When battery chargers with safe galvanic separation from the feeding mains are used according to IEC 61140, the protective measures SELV or PELV shall be applied. If the nominal voltage of the battery does not exceed 60 V d.c. protection against direct contact is not formally 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, e.g. short circuits, mechanical damage etc., all batteries in electrical vehicles shall be protected against direct contact of live parts, even if the battery nominal voltage is 60 V d.c. or less.

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

5.1 Cables and cell connectors

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

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

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

When a trailing cable is used, the protection against short circuits shall be improved by the use of single core cable according to IEC 60204-1. However, where the battery nominal voltage is less than or equal to 120 V d.c., a trailing cable of grade H01N2D, for higher flexibility, can be used.

The battery terminal cables shall be fixed in a manner that prevents tensile and torsional strain on the battery terminals.

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

5.2 Protective measures during maintenance

In order to minimize the risk of injury during work on live equipment, only insulated tools according to IEC 60900 shall be used and the following appropriate procedures shall be implemented:

– batteries shall not be connected or disconnected before the load or charging current has been switched off;

– battery terminal and connector covers shall be provided which allow routine maintenance whilst minimizing exposure of energized conductive parts;
– 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 d.c., insulated protective clothing and/or local insulated coverings shall be required to prevent personnel making contact with the floor or parts bonded to earth. Insulated protective clothing and floor covering material shall be anti-static.

For reasons of safety, it is strongly advisable that batteries having a nominal voltage above 120 V d.c. are divided into sections of 120 V d.c. (nominal) or less before maintenance work is commenced.

5.3 Battery insulation

5.3.1 This subclause does not apply to batteries used in electrically propelled road vehicles where the battery insulation requirement is covered by particular standards for that application.

5.3.2 A new, filled and charged battery shall have an insulation resistance of at least 1 MΩ when measured between a battery terminal and metallic tray, 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.

5.3.3 A battery in use, having a nominal voltage not higher than 120 V d.c., 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 tray, vehicle frame or other conductive supporting structure. If the nominal battery voltage exceeds 120 V d.c. 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 with the sections, including metal battery containers, electrically connected.

5.3.4 The insulation resistance of the vehicle and traction battery shall be checked separately. The resistance test voltage shall be equal to or higher than the nominal voltage of the battery, but no more than 100 V d.c. or three times the nominal voltage (also see EN 1175-1).

NOTE Measurement can be implemented according to the procedure described in EN 1987-1:1997, 6.2.1.

6 Provisions against explosion hazards by ventilation

6.1 Gas generation

During charge processes, gases are emitted from all secondary cells and batteries using aqueous electrolyte, with the exception of gastight (secondary) cells. This is a result of the electrolysis of the water by the overcharging current. Gases produced are hydrogen and oxygen. When emitted into the surrounding atmosphere, an explosive mixture is created if the hydrogen concentration exceeds 4 % hydrogen in air.

In order to avoid abusive charging and/or excessive gassing, the charger type, its rating and characteristics shall be properly matched to the battery type in accordance with the manufacturer's instructions. In particular for valve-regulated lead-acid batteries and other types of recombination type batteries it is crucial that an appropriate charger type is used. Also see 6.2.3.

When gas emission is determined experimentally with battery test standards and the value found is lower than that used in the present standard, then no reduction of the ventilation requirements shall be admissible. If the experimental gas emission value is higher than the value assumed in the present standard, then the ventilation requirements shall be adapted i.e. increased.

When a cell reaches its fully charged state, water electrolysis occurs according to the Faraday's law. Under standard conditions i.e at 0 °C and 1 013 hPA (STP under IUPAC):

– 1 Ah decomposes 0,336 g H_2O into 0,42 l H_2 + 0,21 l O_2;
– 3 Ah decompose 1 cm^3 (1 g) of H_2O;

When the operation of the charge equipment is stopped, the emission of gas from the cells will substantially subside within one hour. However, precautions are still necessary after this time, as gas trapped within the cells can be released suddenly due to movement of the battery when it is refitted to the vehicle or when the vehicle moves in service. Some additional gas also can be produced during service e.g. owing to regenerative braking.

6.2 Ventilation requirements

6.2.1 General

The ventilation requirements of this subclause shall be met whether the battery is charged on or off the vehicle.

The purpose of ventilating a battery location or enclosure is to maintain the hydrogen concentration below the 4 % hydrogen threshold. Battery accommodation rooms are to be considered as safe from explosions, when by natural or forced ventilation, the concentration of hydrogen is kept below this limit.

The required minimum ventilation airflow for a battery charging room, charging area or battery compartment shall be calculated by use of the formula presented in 6.2.2. Where local regulations call for lower average hydrogen concentration, e.g. for environmental hygienic reasons, the rate of ventilation shall be increased accordingly. Also see 6.3.

VRLA cells and monobloc batteries used for traction purpose enter their service life with an excess of electrolyte and with incomplete oxygen recombination and thus may basically produce the same amount of hydrogen as flooded cells or batteries until they reach a mature operational stage after a number of service cycles. The possible need of increased ventilation in connection with this shall be considered by the user.

6.2.2 Calculation of the minimum ventilation air flow

The following formula for the calculation of the required minimum ventilation air flow Q shall, with the exception of special chargers (see 6.2.4), be used with any type of properly matched unregulated or regulated battery charger when charging vented or valve-regulated lead-acid batteries or vented nickel-cadmium batteries:

$$Q = v \times q \times s \times n \times I_{gas} \ [m^3/h]$$

where

Q is the ventilation air flow in m^3/h;

v is the necessary dilution of hydrogen: $\frac{(100\ \% - 4\ \%)}{4\ \%} = 24$;

q $= 0,42 \times 10^{-3}\ m^3/Ah$ generated hydrogen at 0 °C;

For calculations at 25 °C, the value of q at 0 °C shall be multiplied by factor 1,091 5; this factor being derived from the general expression $(T+273)/273$, where T is the temperature in °C;

s = 5, general safety factor;

n is the number of cells;

I_{gas} is the gassing current value to be used for the calculation of ventilation air flow, see below.

The ventilation air flow calculation formula can be resolved into the following:

$$Q = 0{,}055 \times n \times I_{gas} \quad [m^3/h]$$

The formula is basically valid at 25 °C, but may, considering the safety factor used, be applied with no further adjustment up to the maximum operating temperature of the battery.

For the determination of I_{gas}, the following applies:

a) Where a regulated charger having an output characteristics independent of occurring input mains voltage variations is used, and for which the accurate value of charging current during the last portion of charging is known with certainty, then this value may be used for I_{gas} in the ventilation air flow calculation.

   If the value of charging current during the last portion of charging is not known with certainty, and a regulated multi-volt charger is used, then use the highest final charging current value it is capable of supplying for I_{gas}.

   The regulated charger manufacturer should be consulted for the value of charging current during the last portion of charging, when no values are known, to enable the use of this value for I_{gas} in the ventilation air flow calculation.

   NOTE 1 A 48 V lead-acid traction battery consisting of 24 cells is to be charged from a regulated charger delivering an end of charge current of maximum 30 A. According to the above definitions, the value of I_{gas} = 30 A. The ventilation air flow requirement at 25 °C amounts to Q = 0,055 × 24 × 30 = 39,6 [m^3/h].

b) For unregulated chargers and in all other cases where the end of charge current is not known with certainty, I_{gas} shall be set equal to 40% of the rated charger output current I_n:

$$I_{gas} = 0{,}4 \times I_n \text{ [A]}.$$

   NOTE 2 A 48 V lead-acid traction battery consisting of 24 cells is to be charged from a unregulated charger with an output rating of 48 V/ 100 A. According to the above definitions, the value of I_{gas} = 0,4 x 100 = 40 A. The ventilation air flow requirement at 25 °C amounts to Q = 0,055 × 24 × 40 = 52,8 [m^3/h].

6.2.3 Recommended charging practice

In order to reduce the risk of accidents and to ensure correct charging takes place it is essential that the charger and battery are properly matched. The manufacturer´s directions and recommendations for the selection of charger type, characteristics and size shall be followed.

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. For flooded batteries, abusive charging will cause abnormal temperature rise, excessive gassing and increased water consumption resulting in risk to safety of operation, increased maintenance work and reduced battery service life. Batteries working with recombination such as valve-regulated lead-acid (VRLA) batteries also run the risk of total destruction and explosion by thermal runaway. For the VRLA and other recombination batteries, the use of a controlled charger of appropriate size is essential.

If not otherwise stated by the battery manufacturer, the values presented in Table 1 can be used as a guideline for maximum charging current to be applied during the last portion of charging. The values shown in Table 1 are not intended for use as I_{gas} in the calculation of the required ventilation air flow (see 6.2.2).