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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 62485-3:2010

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CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

SAFETY REQUIREMENTS FOR SECONDARY BATTERIES AND BATTERY INSTALLATIONS –

Part 3: Traction batteries

FOREWORD

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International Standard IEC 62485-3 has been prepared by IEC technical committee 21: Secondary cells and batteries.

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

FDIS	Report on voting
21/712/FDIS	21/719/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- withdrawn,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 AC and 1 500 V DC respectively and describe the principal measures for protection against hazards generally from electricity, gas emission and electrolyte.

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

2 Normative references

The following referenced documents are indispensable for the application 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 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
(rechargeable) cell
single cell
assembly of electrodes and electrolyte which constitutes the basic unit of a secondary battery

NOTE This assembly is contained in an individual case and closed by a cover.

3.2
lead dioxide-lead (acid) battery
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 (secondary) cell
a secondary cell having a cover provided with an opening through which gaseous products may escape

3.5
valve regulated (secondary) cell
secondary cell which is closed under normal conditions but has an arrangement which allows the escape of gas if the internal pressure exceeds a predetermined value. The cell cannot normally receive addition to the electrolyte

3.6
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. The cell may be equipped with a safety device to prevent dangerously high internal pressure

NOTE 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 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 The electrolyte may be a liquid, solid or a gel.

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

3.12
charge
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 a cell and thus storage of energy as chemical energy occurs

3.13
equalisation charge
extended charge which ensures complete charging 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
overcharging (of a cell or battery)
continued charging after the full charge of a cell or battery

NOTE Overcharge is also the act of charging beyond a certain limit specified by the manufacturer.

3.16
discharge
discharging (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
(battery) peripheral equipment
equipment installed on the battery, which supports or monitors the operation of the battery, e.g. central water filling system, electrolyte agitation system, battery monitoring system, central de-gassing system, battery connectors (plugs and sockets), thermal management system, etc

3.18
charging room
room or closed area intended specifically for recharging batteries. The room may also be used for battery maintenance

3.19
charging area
open area designated and made suitable for recharging batteries. The area may also be used for battery maintenance

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 DC, 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 may 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 DC or less.

4.3.2 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.

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 60364-4-41,411.1.

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 DC, protective measures against both direct and indirect contact are required.

Battery compartments with batteries having a nominal voltage exceeding 120 V DC shall be locked and have restricted access for 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 DC, 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 DC 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 DC 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 DC, a trailing cable of grade H01ND2, 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

When working on live equipment, appropriate procedures shall be implemented so to reduce the risk of injury and only insulated tools according to IEC 60900 shall be used.

To minimize the risk of injury, the following measures 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 minimising exposure of energized conductive parts;
– all metallic personal objects shall be removed from the 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 making contact with the floor or parts bonded to earth.

NOTE It is strongly advisable that batteries, having a nominal voltage above 120 V DC and undergoing maintenance, are divided into sections consisting of 120 V DC (nominal) or less.

5.3 Battery insulation

5.3.1 General

This clause 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 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 tray, 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 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 higher than the nominal voltage of the battery, but no more than 100 V DC or three times the nominal voltage (see EN 1175-1).

6 Provisions against explosion hazards by ventilation

6.1 Gas generation

During charge processes, gases are emitted from all secondary cells and batteries excluding 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 may be created if the hydrogen concentration exceeds 4 $\%_{vol}$ hydrogen in air.

In order to avoid detrimental heat development and excessive gassing of the batteries, care shall be taken to use battery chargers with appropriate size and performance characteristics for the batteries to be charged.

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 de-rating 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;
– 26,8 Ah decompose 9 g H_2O into 1 g H_2 + 8 g O_2.

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.

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 artificial ventilation, the concentration of hydrogen is kept below this safe limit. The necessary ventilation airflow for a battery location or compartment shall be calculated by use of one of the two following formulae.

6.2.2 Standard formula

The standard formula shall be used with any type of conventional battery charger when charging vented or valve-regulated lead-acid batteries or vented nickel-cadmium batteries:

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

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; Remark: for calculations at 25 °C, the value of q at 0 °C shall be multiplied by factor 1,095;
s	= 5, general safety factor;
n	is the number of cells;
$I_{\text{gas standard}}$	= gassing current equal to 30 % of the rated output current of the involved charger [A];
z	= 1,0 for vented batteries;
z	= 0,25 for valve-regulated batteries de-rating factor due to internal gas recombination.

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

$$Q = 0{,}05 \times n \times I_{\text{gas standard}} \times z \ \text{[m}^3\text{/h]}$$

NOTE 1 A 48 V vented lead-acid traction battery consisting of 24 cells is to be charged from a charger with output rating 48 V/ 80 A. According to the above definitions, the value of $I_{\text{gas standard}} = 0{,}30 \times 80 = 24$ [A] and the value of $z = 1{,}00$.

The ventilation air flow requirement amounts to $Q = 0{,}05 \times 24 \times 24 \times 1{,}00 = 28{,}8$ [m^3/h].

NOTE 2 A 24 V valve-regulated lead-acid wheel-chair battery consisting of 12 cells is to be charged from a charger with output rating 24 V/10 A. According to the above definitions, the value of $I_{gas\ standard} = 0{,}30 \times 10 = 3{,}0$ [A] and the value of $z = 0{,}25$.

The ventilation air flow requirement amounts to $Q = 0{,}05 \times 12 \times 3{,}0 \times 0{,}25 = 0{,}45$ [m^3/h].

6.2.3 Special formula

Regardless of 6.2.2, the following special formula can be used with conventional chargers with controlled voltage and current output performance when detailed information on chargers, charging profiles and battery types are available and ventilation air flow optimization is desired

$$Q = v \times q \times s \times n \times I_{gas\ special} \times C_n / 100 \qquad [m^3/h]$$

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 ;
  Remark: for calculations at 25 °C, the value of q at 0 °C shall be multiplied by factor 1,095;
- s = 5, general safety factor;
- n is the number of cells;
- $I_{gas\ standard}$ = gassing current in A/100 Ah rated battery capacity (C_5) per Table 1.

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

$$Q = 0{,}05 \times n \times I_{gas\ special} \times C_n / 100 \quad [m^3/h]$$

For calculation of the required ventilation air flow at least the minimum values of the gassing current $I_{gas\ special}$ [A/100 Ah] as per Table 1 shall be used.

Table 1 – Gas producing current I_{gas} respectively typical end of charge current in A per 100 Ah rated capacity, when charging with IU or IUI-chargers

Charger characteristics	Gassing current $I_{gas\ special}$ in A /100 Ah (minimum values)			
	Vented lead acid battery cells	**Valve regulated lead acid cells**	**Vented nickel cadmium cells**	**Sealed nickel cadmium or nickel metal hydride cells**
IU charging	(2,4 V/cell max.) 2	(2,4 V/cell max) 1,0	(1,55 V/cell max) 5	Consult manufacturer of cells and charger
IUI charging	Current in 3rd charging step but not less than 5	Current in 3rd charging step but not less than 1,5	Current in 3rd charging step but not less than 5	

NOTE 1 A 24 V valve-regulated lead-acid traction battery consisting of 12 cells with a nominal capacity of 256 Ah is to be charged with an adequate IU-charger with a voltage setting of max 28,8 V. The voltage setting corresponds to 28,8/12 = 2,40 V/ cell and thus the $I_{gas\ special}$ value of 1,0 A/100 Ah of Table 1 applies.

The ventilation air flow requirement amounts to: $Q = 0{,}05 \times 12 \times 1{,}0 \times 256/100 = 1{,}54$ [m^3/h].

NOTE 2 A 48 V vented nickel-cadmium battery consisting of 40 cells with a nominal capacity of 180 Ah is to be charged with an IUI charger having an output current of 6,3 A in the 3rd charging step, corresponding to 6,3/180 = 0,035 A/Ah = 3,5 A/100 Ah. This is less than the minimum allowed value of $I_{gas\ special}$ per Table 1. Therefore at