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INTERNATIONAL STANDARD

colour inside

Railway applications – Rolling stock – Batteries for auxiliary power supply systems –
Part 3: Lead acid batteries

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RAILWAY APPLICATIONS – ROLLING STOCK – BATTERIES FOR AUXILIARY POWER SUPPLY SYSTEMS –

Part 3: Lead acid batteries

FOREWORD

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IEC 62973-3 has been prepared by IEC technical committee 9: Electrical equipment and systems for railways. It is an International Standard.

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

Draft	Report on voting
9/3041/FDIS	9/3066/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/publications.

A list of all parts in the IEC 62973 series, published under the general title *Railway applications – Rolling stock – Batteries for auxiliary power supply systems*, 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- withdrawn, or
- revised.

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RAILWAY APPLICATIONS – ROLLING STOCK – BATTERIES FOR AUXILIARY POWER SUPPLY SYSTEMS –

Part 3: Lead acid batteries

1 Scope

This part of IEC 62973 establishes the framework for the electrical interfaces to the train, and the sizing (e.g., capacity, cell number, to meet the requested load profile) and operation of lead acid batteries of the VRLA type for auxiliary power supply systems on rolling stock of railways and complements IEC 62973-1, unless otherwise specified.

This document provides guidance and links to standards for the required battery qualification tests procedures and safety measures to be implemented.

The cited normative references for lead acid batteries provide multiple requirements and tests applicable for their qualification.

In this document, the most appropriate clauses of these cited standards have been selected and adapted as needed to reflect the intended use of these batteries as auxiliary power sources on rolling stock of railways.

The battery-specific requirements for subcomponents of battery systems such as containers, charging controls, temperature probes, nameplates and similar are covered in this document as needed.

Charging systems are excluded from the scope of this document.

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 60896-21:2004, *Stationary lead-acid batteries – Part 21: Valve regulated types – Methods of test*

IEC 60896-22:2004, *Stationary lead-acid batteries – Part 22: Valve regulated types – Requirements*

IEC 61373:2010, *Railway applications – Rolling stock equipment – Shock and vibration tests*

IEC TS 61430, *Secondary cells and batteries – Test methods for checking the performance of devices designed for reducing explosion hazards – Lead-acid starter batteries*

IEC TR 61431:2020, *Guidelines for the use of monitor systems for lead-acid traction batteries*

IEC 62485-2:2010, *Safety requirements for secondary batteries and battery installations – Part 2: Stationary batteries*

IEC 62498-1:2010, *Railway applications – Environmental conditions for equipment – Part 1: Equipment on board rolling stock*

IEC 62973-1:2018, *Railway applications – Rolling stock– Batteries for auxiliary power supply systems – Part 1: General requirements*

ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions in IEC 62973-1:2018, and the following 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

NOTE All typical battery related descriptions are defined in IEC 60050-482.

3.1.1
lead dioxide lead battery
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

[SOURCE: IEC 60050-482:2004, 482-05-01, modified – Note has been deleted.]

3.1.2
battery information system
data collection system to provide optional additional information and guidance for battery operation and maintenance

3.1.3
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 or battery cannot normally receive additions to the electrolyte.

[SOURCE: IEC 60050-482:2004, 482-05-15]

3.1.4
finite element analysis
FEA
numerical mathematical analysis method simulating the mechanical behaviour of an assembly

3.1.5
line replaceable unit
LRU
modular component of equipment designed to be replaced at an operating location whilst the equipment remains in the operating environment

3.1.6
state of charge
SOC
<of a lead acid battery> level of charge in ampere hours of the battery relative to its rated capacity in ampere hours and expressed in percentage points

Note 1 to entry: A term interrelated with SOC, is the term depth of discharge (DOD), i.e., the level of discharge in ampere hours of the battery system when related to the same rated capacity in ampere hours and expressed in percentage points and where, by convention, 0 % DOD equals to 100 % SOC and 100 % DOD equals to 0 % SOC.

Note 2 to entry: The real capacity of the battery may be different from the rated, i.e., declared capacity.

3.1.7
rated capacity
C_n
<of a lead-acid battery of VRLA type> capacity value of a battery system determined under specified conditions as per IEC 60896-21 and IEC 60896-22, and declared by the battery manufacturer

3.1.8
battery system
battery
system that includes battery tray(s), battery crate(s), monobloc(s), electrical components and/or equipment and associated electromechanical components and connections

3.2 Abbreviated terms

AC	Alternating Current
AGM	Absorbent Glass Mat
DC	Direct Current
U_B	Rated battery voltage
U_T	Test voltage

4 General requirements

4.1 Definitions of components of a battery system

The main components of a lead acid battery and their interdependence are shown in Figure 1.

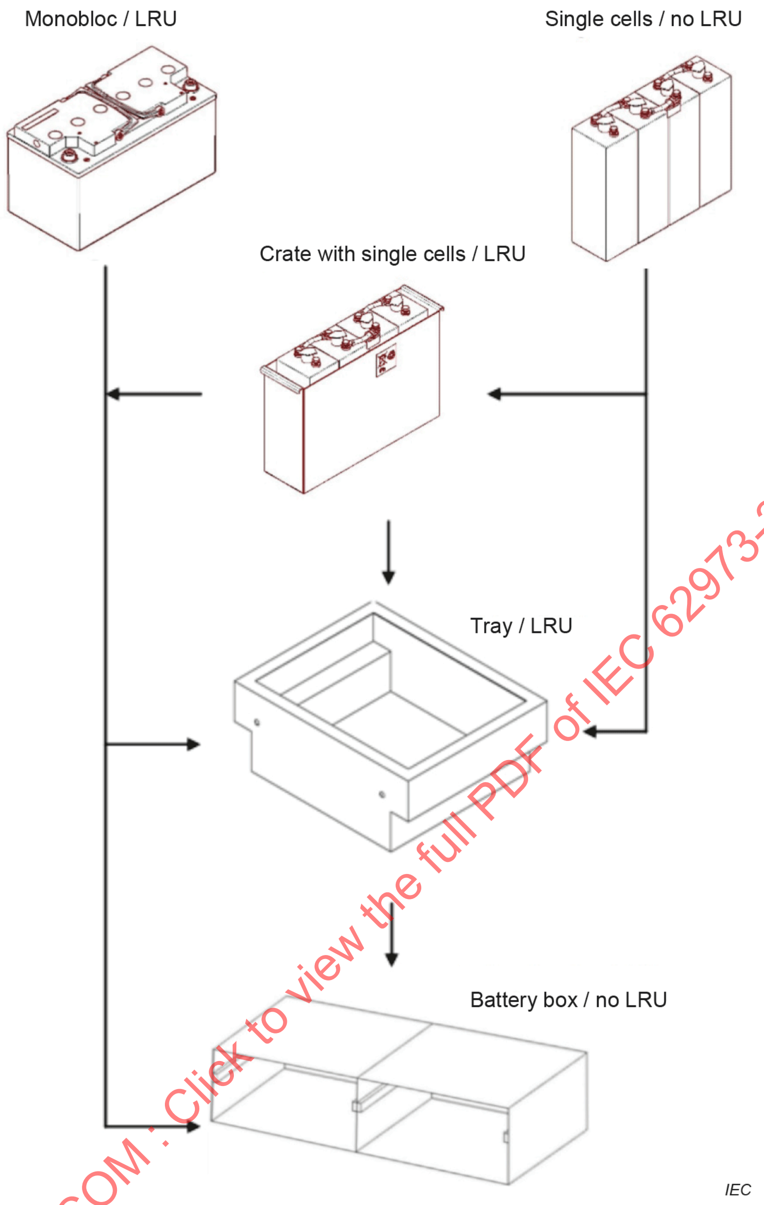


Figure 1 – Definition of single cells, monobloc, crate, tray and battery box

Some batteries may not include all of the above components, e.g., single cells may be installed in a tray without crates. The designation LRU denotes its status of a line replaceable unit.

4.2 Description of lead acid battery types

4.2.1 General

A lead acid battery consists of an assembly of single cells or multiple-cell monoblocs. Each cell contains stacks of several positive and negative plates that are separated by a separator, immersed in electrolyte and connected through plate straps to the positive and negative terminals. These extend to the outside of the cell or monobloc housing and serve as interconnection points.

In the fully charged state the active material of the negative plate consists of lead and the active material of the positive plate consists of lead dioxide.

In a discharged state the active material in both the positive and negative plates contain variable amounts of the discharge reaction product, i.e., lead sulphate ($PbSO_4$).

The electrolyte is dilute sulphuric acid (typically 40 % in weight), the density or concentration of which depends on the specific cell design and state of charge.

As the electrolyte participates in the electro-chemical reactions, its density and concentration are reduced during discharge in proportion of the ampere hours discharged.

4.2.2 Lead acid batteries with valve-regulated cell design and immobilized electrolyte

In the valve-regulated cell design the electrolyte is immobilized with a gelling agent (fumed SiO_2) or with an AGM. This induces voids in the volume occupied by the electrolyte facilitating fast gas transport and oxygen recombination.

The following cell types are in use on rolling stock.

Cell type a) built with either grid-type negative and positive plates or with grid-type negative plates and tubular-type positive plates. The electrolyte is present in the form of a stiff gel.

Cell type b) built with grid-type negative and positive plates and with a limited amount of electrolyte immobilized in an AGM.

An oxygen recombination reaction is operative in such cells and monoblocs reducing gassing and electrolyte water loss.

The cells do not allow or require electrolyte level maintenance and can be operated in vertical and horizontal position.

4.3 Environmental conditions

The system integrator or end user shall specify the ambient air temperature range in which the battery is to be operated so that the most appropriate cell and monobloc design can be provided by the battery manufacturer.

IEC 62498-1:2010 lists in Table 2 the appropriate inside vehicle compartment temperature ranges identified as class T1 to TX.

Lead acid batteries can operate with proper safeguards in the temperature range from −25 °C to +55 °C.

Operation outside this range impair service performance and life.

High battery temperatures accelerate battery ageing.

Low battery temperatures reduce actual available battery capacity.

It is recommended that not only the temperature level itself but also the cumulated duration at a given temperature level shall be taken into consideration when battery life is to be anticipated.

Further environmental conditions to be taken in consideration are:

- Humidity: according to IEC 62498-1:2010
- Shock and vibration: according to IEC 61373:2010
- Altitude: according to IEC 62498-1:2010

Deviations may be agreed between end user and/or system integrator and cell/battery manufacturer.

4.4 System requirements

4.4.1 System voltage

The low voltage supply network has to allow operation of the connected equipment within the minimum and maximum limits of the voltage range according to Table 1 of IEC 62973-1:2018.

The operation of the battery as power source shall occur within the agreed voltage limits resulting from the resolved requirements of the battery manufacturer, system integrator and end user.

The voltage during discharge of the battery system varies with elapsed time and current levels. The actual cell design, state of charge (SOC), ageing, and ambient temperature additionally influence this voltage. A discharge is terminated when a defined minimum battery system voltage is reached as per Table 1 of IEC 62973-1:2018, taking into consideration for example the voltage drop in connection cables.

To avoid excessive withdraw of capacity from the battery system and prevent a deep discharge or polarity reversal of one or more cells in the battery system, the lower voltage limit has to be taken into consideration for the battery sizing.

The typical evolution of cell voltage during a discharge is shown in Figure 2 as function of the discharge current expressed in multiples of the rated 5 h current or I_5.

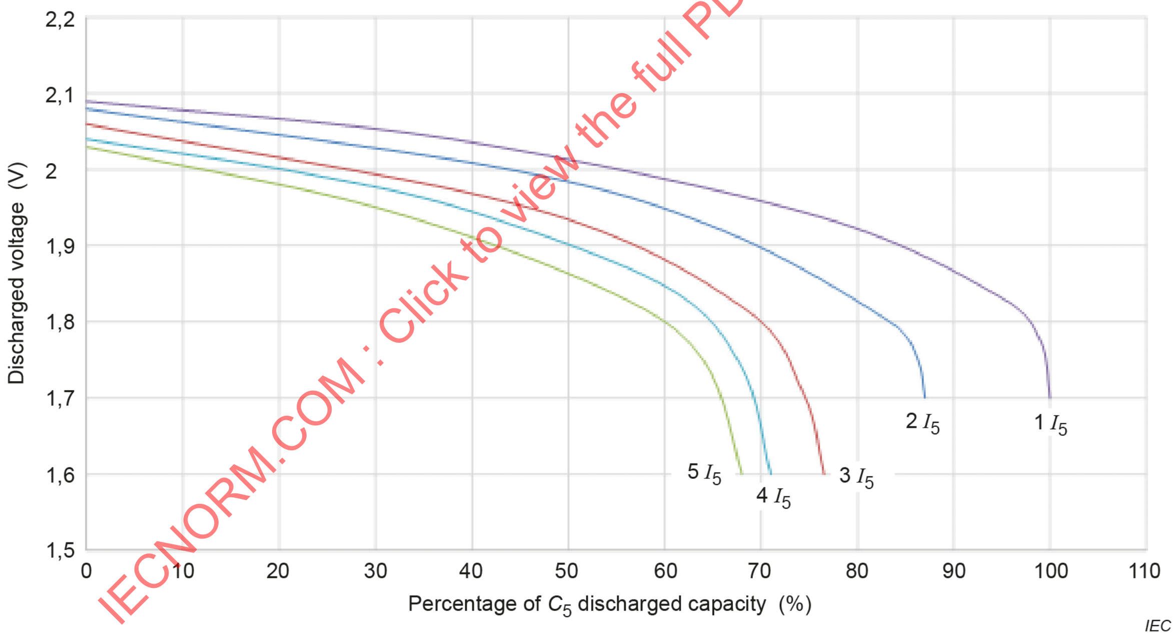
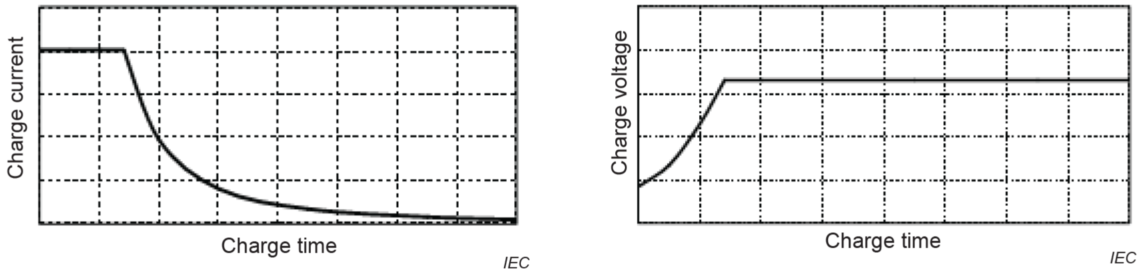


Figure 2 – Example of the evolution of the voltage of a VRLA cell when discharged with multiples of the 5 h rated current versus percentage of the 5 h rated capacity

The evolution of charge current and charge voltage, during a constant-current-constant-voltage (IU or CCCV) charge of a lead acid battery is shown in Figure 3.



a) **Example of charge current curve** b) **Example of charge voltage curve**

Figure 3 – Examples of current and voltage evolution during charge

4.4.2 Charging requirements

The proper battery charging conditions are specified by the battery manufacturer and shall follow Table 1. Table 2 provides some typical charging parameters to be considered for the battery system.

Table 1 – Requirements for battery system charge operations

Activity	Requirement
Float charge mode operation	A regulated constant-current-constant-voltage charge with the capability of float voltage compensation according to the battery system temperature shall be used
Boost charge mode operation (if applicable)	A regulated constant-current-constant-voltage charge with: a) the capability of boost voltage compensation according to the battery temperature; b) a boost charge activation trigger algorithm; c) a boost charge duration limiter; shall be used
Charge voltage control	The actual float and boost voltage shall not deviate, in the constant voltage phase, by more than 1 % from the set value
Battery voltage monitoring	The voltage shall be measured with the voltage sensing leads placed as close as possible to the positive and negative terminals of the battery system
Charge current control	The actual charge current shall not deviate, in the constant current phase, by more than 1 % from the set value
Charge current ripple mitigation	The AC ripple level of the charge current shall not exceed the values recommended in IEC 62485-2:2010, Table 2 In no case shall the current ripple induce a discharge of the battery
Temperature compensation	The temperature related correction factors of the float and boost charge voltage shall be provided by the battery manufacturer and in the format of Figure 4 and Figure 5 and Table 3 and Table 4 The correction factors shall be implemented in the charge control logic
Temperature monitoring	The actual temperature of the cells and monoblocs shall be determined with an appropriate sensor placed, with preference, directly on the hottest cell or monobloc of the battery system
Data loss default action	In case of a loss of battery voltage information, the charge of the battery system shall be stopped
The above numerical values are of informative value only. Limit values are as indicated or as specified by the agreement between the battery manufacturer, system integrator and end user.	

Table 2 – Typical lead acid battery charge parameters

Float charge conditions	
Float voltage	2,15 V/cell to 2,30 V/cell at 25 °C for unlimited duration and corrected for battery temperature
	Temperature correction factor -0,003 V/K/cell to -0,005 V/K/cell
Boost charge conditions	
Boost voltage	2,30 V/cell to 2,45 V/cell at 25 °C and corrected for battery temperature Boost charge duration not to exceed 8 h
	Temperature correction factor -0,003 V/K/cell to -0,005 V/K/cell
Charging current	2 I_5 maximum
The above numerical values are of informative value only. The battery manufacturer specifies values applicable to the battery in consideration.	

The purpose of the temperature compensation of the float or boost voltage is to adjust the amount of charge current flowing through the battery when the ambient temperature increases or decreases.

This adjustment prevents not only battery overheating and excessive electrolyte water loss at high temperatures, but also assures the achievement of faster full charge at low temperatures.

The cell or monobloc manufacturer shall provide the appropriate reference values for this compensation at cell/monobloc level (slope).

The battery system manufacturer shall define the optimized number of cells/monoblocs to best fit the voltage limits at train level as specified in Table 1 of IEC 62973-1:2018 as shown in Figure 4 and Table 3, based on the actual battery system design .

Charging permanently with a voltage above or below the cell or monobloc manufacturer specified limits cause accelerated ageing and a premature loss of capacity. A periodic charge under boost charge conditions may be recommended by the battery manufacturer to assure an equalisation of the individual cell voltages.

The battery system manufacturer shall also provide the value of the maximum battery temperature above which all charge has to be terminated/inhibited.

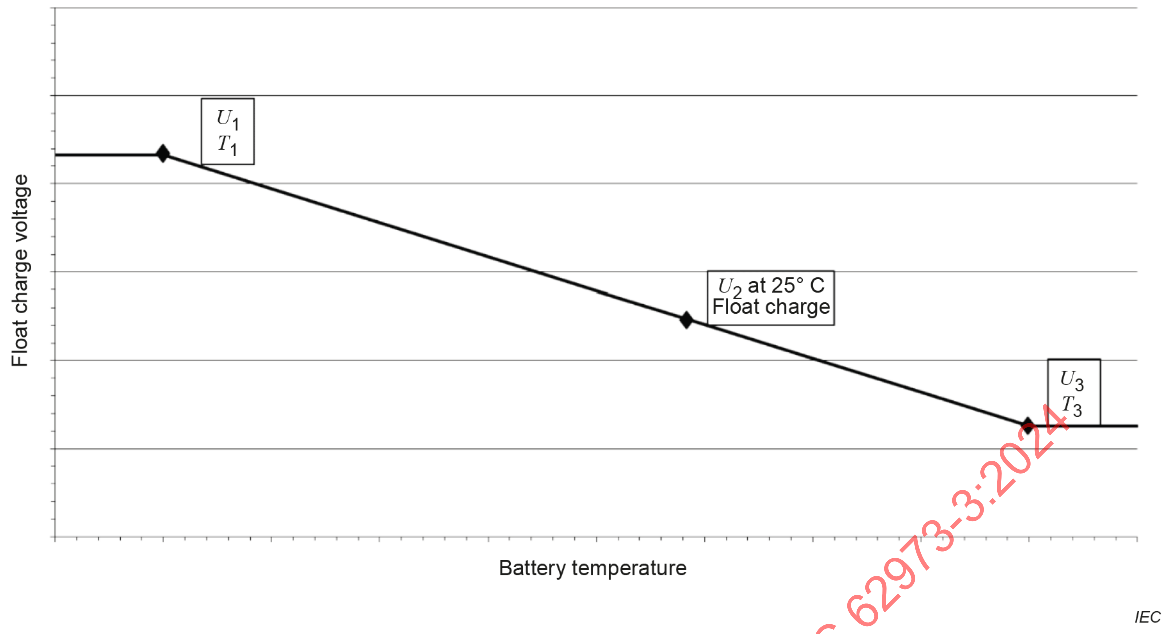


Figure 4 – Temperature versus voltage response graph for float charge operation

Table 3 – Voltage and temperature reference levels for float charge operation

Reference point	U in V/cell	T in °C of the battery	Slope of voltage compensation per K in 0,00X V/K deviation from the 25 °C reference temperature
1	U_1	T_1	To be provided by the cell or monobloc manufacturer
2	U_2	T_2 (25 °C)	
3	U_3	T_3	
T_1 and T_3 are the result of set point (25 °C) and slope.			

The temperature monitoring in Table 3 shall be according to Table 1.

A boost charge is carried out so as to speed up the full recharge of the battery or equalize diverging cell capacities and voltages. As the boost voltage is significantly higher than the float voltage, the danger of a resulting thermal runaway increases and a correction of the voltage as function of battery temperature becomes even more imperative.

The cell or monobloc manufacturer shall provide the appropriate reference values for this compensation at cell/monobloc level (slope).

The battery system manufacturer shall define the optimized number of cells/monoblocs to best fit the voltage limits at train level as specified in Table 1 of IEC 62973-1:2018 as shown in Figure 5 and Table 4, based on the actual battery design.

The battery manufacturer shall specify under which conditions a boost charge shall be initiated and terminated.

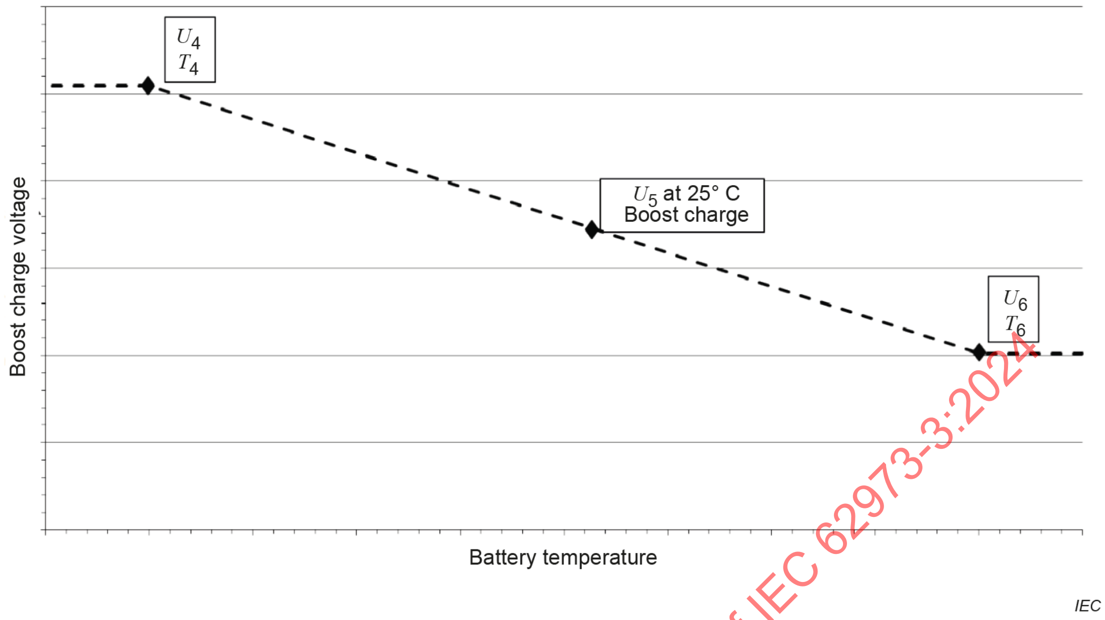


Figure 5 – Temperature versus voltage response graph for boost charge operation

Table 4 – Voltage and temperature reference levels for boost charge operation

Reference point	*U* in V/cell	*T* in °C of the battery	Slope of voltage compensation per K in 0,00Y V/K deviation from the 25 °C reference temperature	Conditions specified for initiating and terminating a boost charge	Minimum interval between two boost charges as specified in hours or events
4	U_4	T_4	To be provided by the cell or monobloc manufacturer	To be provided by the battery system manufacturer	To be provided by the battery system manufacturer
5	U_5	T_5(25 °C)			
6	U_6	T_6			
T_4 and T_6 are the result of set point (25 °C) and slope.					

The temperature monitoring in Table 4 shall be according to Table 1.

4.4.3 Discharging performances

4.4.3.1 General

The discharge requirement of the specified load profile(s) shall be met.

4.4.3.2 Load profile

The load profile reflects the actual current and/or power and/or resistive loads versus time requirement of the auxiliary battery in rolling stock application. The load profile shall be associated with an operating temperature range (maximum and minimum temperatures as specified by the system integrator or end user, as per 4.4.5 of IEC 62973-1:2018) and system voltage limits. Typical load profiles are shown in IEC 62973-1:2018 as examples only.

Such a load profile may incorporate requirements for extended discharge durations and low or high temperature performance and others such as fulfillment level over service life.

The system integrator or end user shall provide these load profiles and associated conditions.

4.4.4 Charge retention(self-discharge)

Batteries lose capacity when stored in open circuit. This loss is quantified under normalized conditions with the pertinent test clause in IEC 60896-21:2004.

The battery manufacturer shall provide guidance for the maximum possible duration of storage in open circuit before a recharge, as specified for such a task, becomes necessary. The influence of storage temperature shall be provided by the battery manufacturer.

4.4.5 Requirements for battery sizing

The selection of the battery, capable of meeting the energy demands as auxiliary power source on rolling stock, i.e., its sizing shall be carried out by the battery system manufacturer.

The required parameters for sizing are listed in Table 5 and shall be provided by the system integrator or end user.

Table 5 – Input parameters required for the sizing of the battery to be provided by the system integrator or end user

Required parameters	Information format
Load profile(s)	Load expressed in A or W or Ω over time or combinations thereof
Ambient air temperature	Relevant ambient air temperature range i.e., minimum and maximum battery system ambient temperature
Operating voltage window	Relevant voltage range according to the planned or present auxiliary power supply system of the rolling stock Possible voltage drops in connections and cables to and from the battery shall not be overlooked
Required cycle capability	Total number of discharges to be achieved with the most demanding load profile
Required service life in calendar months	Service life in months based on required cycle capability and specified air temperatures
Extended discharge event	Load expressed in A or W or Ω over time or combinations thereof Number of events per year
Performance margins for future loads	List of potential future performance level(s) amendments
User-specific demands, conditions or constraints	Any additional information and specifications

All ancillary conditions shall be made available to the battery manufacturer as early and as complete as possible, so as not to impair or delay the battery sizing activity.

At an appropriate stage of the battery sizing process, the battery manufacturer shall provide feedback to the system integrator and/or end user on the actual sized battery by providing data as per Table 6.

Table 6 – Output parameters provided at the conclusion of the sizing of the battery to be provided by the battery system manufacturer

Required parameters	Information format
Load profile(s)	Voltage versus time curves or similar curves of the battery when a discharge with the load profile(s) is carried out at the upper and lower temperature limits of the specified air temperature range
Ambient air temperature	Confirmation of operability of the battery system within the minimum and maximum battery system ambient temperatures
Operating voltage window	Maximum and minimum voltage of the battery under the selected load profile and operating temperature conditions Float voltage value at 25 °C Temperature correction factor as per Table 3 and Figure 4 Boost voltage value at 25 °C Temperature correction factor and operating conditions as per Table 4 and Figure 5
Required cycle capability	Number of achievable discharges with a specified load profile when operated at 25 °C Cycle capability derating when operated at the upper air temperature limit
Required service life in calendar months	Achievable service life in months when operated at 25 °C with a specified load profile Service life derating when operated permanently at the upper air temperature limit
Extended discharge event	Achievable extended discharge duration, in minutes at 25 °C, when the battery is continued to be discharged, at the end of a regular load profile discharge, with the specified power or current or resistive load of the specified extended-duration load profile
Performance margins for future loads	Spare performance available under specified conditions
User-specific demands, conditions or constraints	Information as applicable

4.5 Safety and protection requirements

4.5.1 General

The battery crates, trays and boxes and connection hardware shall be stable against the action of chemicals such as traces of battery electrolyte, hydraulic fluids, salt solutions and similar. IEC 62498-1:2010 provides further guidance for the environmental conditions to be encountered in railway applications.

The choice of the materials shall assure that no degradation of load-carrying or electrical isolation properties occur.

See also 6.4 for ventilation of battery system box and vent plugs with flame barriers.

The proper qualification test shall be defined by mutual agreement between the battery manufacturer, system integrator and/or end user.

4.5.2 Deep discharge of batteries

Lead acid batteries may experience deep discharge conditions in service on rolling stock when an excessive amount of capacity is withdrawn or a specific low voltage is reached during a discharge.

The battery manufacturer shall specify when a deep discharge occurred either in terms of:

a) of ampere-hours discharged in discharge events between two charges and referred to the rated capacity;
b) when the voltage on discharge falls below a defined limit for a significant period of time.

The battery manufacturer shall specify the proper charging conditions and eventual additional maintenance operations required to counteract and mitigate negative effects of such deep discharges.

The battery manufacturer shall also, if feasible, adapt the cell design in such a way that a permanent damage due to deep discharges can be prevented.

An extended discharge is a discharge with a duration, for example, significantly longer than 20 h. If such a discharge is happening and has been authorized according to Table 6 by the battery manufacturer, then no negative effects are to be encountered.

In case of discharge beyond the "authorized" discharge as part of the load profile, a low current and long duration boost charge as specified by the battery manufacturer should be carried out for recharging.

4.5.3 Temperature compensation during charging

The monitoring of the temperature of the battery is essential and shall provide the appropriate input for the temperature-related adjustment of the float or boost charge voltage. It shall also detect and prevent thermal runaway conditions of the cells or monoblocs.

The temperature probe shall be in corrosion resistant material and securely affixed to a cell or monobloc in the potentially hottest part of the battery.

The sensing part of a thermostat or cut-off switch, if planned, shall be installed at the same location.

The numerical values of compensation are to be provided by the cell or monobloc manufacturer.

In the case of failure of the temperature sensor, the battery charge voltage shall be set to the battery manufacturer specified default value and inhibit uncontrolled battery charge.

4.6 Fire protection

The fire protection requirements, which can include performance criteria as per burning classification, smoke generation and toxicity limits shall be specified by the end user or system integrator according to standard(s) applicable to the country or region of the intended use of the battery. All components within the battery system shall fullfill the requirements as specified.

The supplier of the battery crate or battery box shall be responsible for certifying the required fire protection level if not otherwise agreed upon.

4.7 Maintenance

The battery manufacturer shall provide instructions for battery commissioning, preventive and corrective maintenance. The frequency of maintenance shall follow the requirements of the battery manufacturer and adapted, as needed, to the practices of end user.

4.8 Charging characteristics

Charging characteristics are to be selected in a way to ensure an appropriate charge level under all operating conditions.

5 Optional components of a battery system

5.1 General

Additional components may be added to the battery system to provide information on the state of the battery, enhance its performance or to add safeguards.

5.2 Battery information system

A lead acid battery information system (BIS) can be installed as an option, but is not required or necessary for the operation of the battery. This is an accessory system and should be qualified separately. Guidance for battery parameters to be monitored and resulting actions can be found for example in IEC TR 61431:2020.

5.3 Battery heater

In applications where the ambient air temperature is below 0 °C for significant periods of the year, it may be convenient to install heating pads or other equivalent devices.

Such heating pads can assure a more appropriate cell temperature resulting in increased battery capacity and charge acceptance. This avoids the need of oversizing of the battery just for the low temperature periods of the year.

If heating pads or similar devices are used, then their satisfactory action shall be verified by confirming that the steady state temperature difference within the battery or batteries in series is less than 3 K, while discharging and charging with the specified load profile at the lowest planned operating temperature.

The cell or monobloc manufacturer shall provide guidance for their proper selection, installation and ultimate integration into the charge voltage management to the battery system manufacturer.

5.4 Thermostat or cut-off switch

The battery system for auxiliary power supply on rolling stock has to provide essential power to protect persons and equipment.

The availability of emergency power from the battery shall not be impaired by the fact that the battery temperature is exceeding its maximum operating level.

Any use of thermostats or cut-off switches in such a system shall be assessed against the need to assure uninterrupted power for the rolling stock.

In case of a single device, it should be located as close as possible to the temperature sensor in the battery system and its action shall not cause the ignition of hydrogen gas in its vicinity.

High battery temperatures in lead acid batteries not only cause an acceleration of ageing, a reduction of time to failure, but also an increase generation of hydrogen. These conditions are to be taken in consideration in battery sizing and battery ventilation calculation according to IEC 62485-2:2010.

6 Mechanical design of battery system

6.1 General

The finalized layout of the battery system is a compromise between required levels of cycling operation, accessibility and availability of space and requires coordination between all parties. Cells or monoblocs can be installed vertically or horizontally. Figure 6 shows the examples of convenient horizontal installations of VRLA cells and monoblocs.

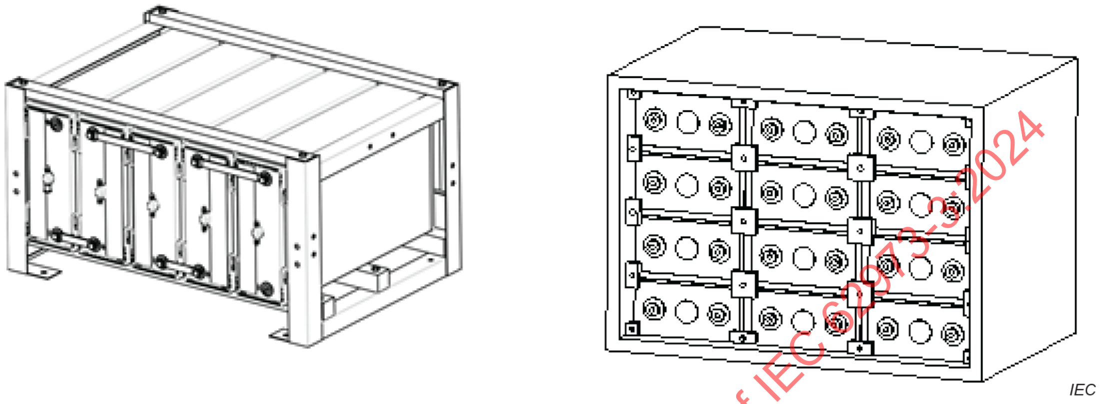


Figure 6 – Examples of horizontal installation of VRLA cells and monoblocs

6.2 Interface mechanism

The configurations specified in IEC 62973-1:2018 are also used for installations of lead acid batteries.

6.3 Shock and vibration

The battery shall be able to withstand shock and vibration as specified in IEC 61373:2010. See also 10.2.5.

6.4 Ventilation of battery box

All batteries with aqueous electrolyte generate hydrogen when charged, discharged or on open circuit. Hydrogen is released from the cell and/or monobloc to the surrounding equipment volumes via the vent plug.

Equipping all vent plugs with flame barriers qualified according to IEC TS 61430 shall prevent the ignition of the hydrogen-oxygen mixture in the interior of the cells.

Hydrogen released from the cells and monoblocs into the surrounding volume shall be properly diluted by natural ventilation only, so to prevent local hydrogen concentrations from exceeding 4 % in volume.

Due to their intrinsic design features, the resulting ventilation requirement against explosion hazards shall be met, as defined in Clause 7 and Annex B of IEC 62485-2:2010.

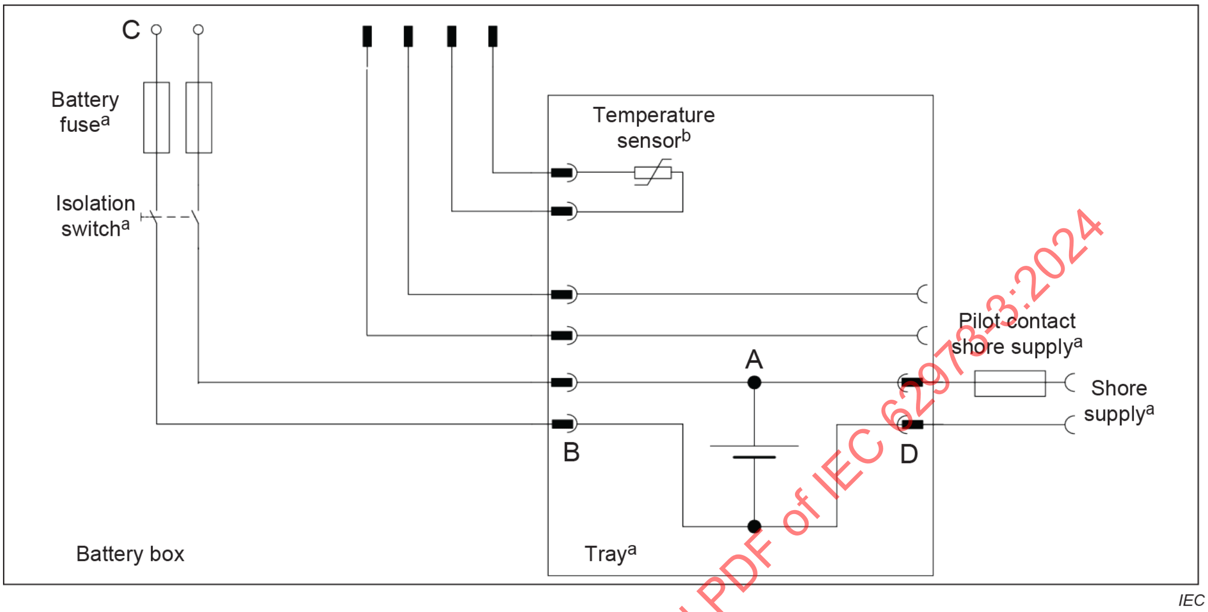
The calculation of the ventilation requirements should always use the conditions specified under boost charge. This can enhance heat removal from the cells and monoblocs if they are installed in a confined location.

Heat removal under boost charge condition shall be verified by the battery system manufacturer.

7 Electrical interface

7.1 General

Typical electrical interfaces are shown in Figure 7.



Key

A Battery terminal (cell or monobloc)

B Tray terminal

C Main terminal (complete battery system)

D Shore supply connector (also possibly mounted directly on a tray)

[a] If applicable

[b] Preferable installed close to a cell or monobloc to achieve low thermal lag

Figure 7 – Typical schematic view of an electrical interface of a battery system

7.2 External electrical connections interface

Different external electrical connection designs may be used depending on the lead acid battery construction and requirements of the system integrator or end user. General guidance is presented in IEC 62973-1:2018.

8 Markings

8.1 Safety signs

8.1.1 Outside the box

The safety signs as outlined in IEC 62973-1:2018 shall be applied.

8.1.2 Tray, crate or other places inside the box

The safety signs as outlined in IEC 62973-1:2018 shall be applied.

8.1.3 Cells and monoblocs

The marking of cells and monoblocs shall comply with 6.6 of IEC 60896-21:2004 and 6.6 of IEC 60896-22:2004, but restricted to the polarity sign at the positive terminal, manufacturer name, type designation, date of manufacture in *mm.yyyy* format. A label or marking showing intercell screw tightening torque and a unique serial number of the cell or monobloc may be added as appropriate.

In order to ensure environmentally friendly material recycling, the requirements of IEC 60896-22:2004, 6.7 are to be observed for the cells and monoblocs.

8.2 Nameplate

8.2.1 Battery box

The nameplate of the box shall include the following information:

– serial number;
– part number;
– weight including the box housing and fastening device (e.g., frame attached to the battery box);
– revision level (if applicable);
– name of the battery manufacturer;
– battery-chemistry designation (lead acid).

Upon agreement between the end user and manufacturer, other information such as nominal voltage and rated capacity can be added.

NOTE A “nameplate” (IEC 60050-151:2001, 151-16-12) is also known as “rating plate” or “identification label”.

8.2.2 Nameplates on tray, crate or other nameplates inside the box

The nameplate on each tray and crate, shall replicate the content of the nameplate on the battery box as per 8.2.1. In case of multiple trays and crates in the same battery box, they shall carry a sequential numbering of 1 through n with their installation sequence reported in the battery operation or maintenance manual.

9 Storage and transportation conditions

9.1 Transportation

The transport of lead acid batteries of the VRLA type is governed by their UN 2800 hazard class identification number. Other or local regulations may apply.

9.2 Storage

Batteries shall be stored fully charged, at as low as possible temperature, non-condensing humidity conditions and not exposed to direct sunlight.

In order to maintain their performance, batteries shall be recharged in regular intervals according to the specifications of the battery system manufacturer, including its temperature dependency.

10 Testing

10.1 General

The certification of the VRLA cells and monoblocs and batteries thereof shall be carried with the cell, monobloc and battery defined by the battery manufacturer to meet the requirements laid down by the system integrator or end user as per Table 5.

Starting the tests from the beginning is not always possible due to constraints given by the response time to an inquiry, timely access to test facilities and other reasons.

The qualification of the selected cell, monobloc and battery system may be achievable with proxy test results obtained with identical test methods and conditions on cells, monoblocs and battery systems of identical design. The cell or monobloc manufacturer or battery system manufacturer shall certify with the document as described in Annex A that the cell, monobloc and battery system to be qualified is equivalent and represented by the cell, monobloc and battery system used in the proxy qualification test. This does not apply to routine tests.

The test classes are:

– Type tests on one or more items representative of the production;
– Routine tests on each individual item during or after manufacture.

10.2 Type test

10.2.1 General

The tests shall be carried out with an assembly of the exact cells or monoblocs selected for the project and demonstrate compliance with all the conditions specified by the test specification documents.

Annex A provides the possibility to declare the equivalency of a substitute test unit. Other particular tests, as pertinent, shall be agreed upon between the battery manufacturer, system integrator and end user.

10.2.2 Tests for cells and monoblocs

The appropriate standards for qualifying the valve regulated lead acid cells and monoblocs for duty on rolling stock of railways are IEC 60896-21:2004 (for test specifications) and IEC 60896-22:2004 (for the appropriate application-related requirements).

The tests outlined in Table 7 shall be carried out by the battery system manufacturer or third-party laboratories. Both entities shall have accreditation according to ISO/IEC 17025. This may be substituted by on-site witnessing of a certification company.

Table 7 – Type tests for cells and monoblocs

Test item	Subclause number	Requirement
Discharge capacity	6.11 of IEC 60896-21:2004	The capacity at the 3 h rate to 1,70 V/cell shall be C_a ≥ 95 % C_{rt}
Impact of low temperature service on capacity	6.19 of IEC 60896-21:2004	The abusive low temperature service capacity C_{als} shall be ≥ 0,95 with no mechanical damages
Float service with daily discharges	6.13 of IEC 60896-21:2004	The number of cycles shall by ≥ 300
Thermal runaway sensitivity	6.18 of IEC 60896-21:2004	Achieve at least 1 week below 60 °C at 2,45 V/cell and at least 24 h below 60 °C at 2,60 V/cell
Charge retention test	6.12 of IEC 60896-21:2004	The charge retaining factor shall be C_{rf} ≥ 70 % of C_{rt} (3 h rate)
Service life at an operating temperature of 40 °C	6.15 of IEC 60896-21:2004	The service life shall be ≥ 500 days
Impact of abusive over-discharge	6.17 of IEC 60896-21:2004	The unbalanced string over-discharge capacity factor shall be C_{aod} ≥ 0,80 and the cyclic over-discharge capacity factor shall be C_{aoc} ≥ 0,90
Protection against internal ignition from external spark sources	6.4 of IEC 60896-21:2004	No evidence of rapid combustion or explosion beyond the valve/barrier assemblies shall be found
For thermal runaway testing, the cells or monoblocs shall be arranged in a way to represent the layout of the battery system in the rolling stock. The cells and monoblocs in the test shall be exactly or as close as possible to that in the battery system on the rolling stock (see Annex A).		

10.2.3 Dielectric test

The details of the test and the requirement are specified in Annex B.

10.2.4 Load profile test

The test shall be carried out with an assembly of the exact cells or monoblocs (representative of the battery system) selected for the project and demonstrate compliance with all the conditions specified by the load test specification document as per Annex C. When robust numerical simulation methods exist, then such a test can be replaced with a numerical simulation by the cell or monobloc manufacturer and battery system manufacturer.

10.2.5 Shock and vibration test

The shock and vibration test shall be carried out on fully charged cells or monoblocs according to IEC 61373:2010 for category 1 class B body mounted items.

By agreement between the battery manufacturer, system integrator and end user, the shock and vibration test of trays and boxes can be replaced by a numerical simulation, e.g., with a finite element analysis (FEA).

The shock and vibration test of cells and monoblocs shall not be replaced by numerical simulation as no adequate structural models, replicating the behavior of cells and monoblocs exist. The battery system manufacturer can suggest appropriate type test samples with adequate technical justifications.

At the conclusion of the shock and vibration test the tested cells and monoblocs shall, after a full recharge, be capable to deliver at least 50 % of their rated 3 h capacity at 25 °C or as agreed between the battery manufacturer, system integrator and end user.

10.3 Routine test

10.3.1 General

The test is performed in order to verify the quality of a batch of delivered lead acid batteries.

The batch acceptance shall be based on a capacity test at the 3 h rate specified in 6.11 of IEC 60896-21:2004 and 6.11 of IEC 60896-22:2004, or as specified by the end user or system integrator.

The number of samples and their frequency of test shall be agreed between the battery system manufacturer, system integrator or end user.

10.3.2 Visual checks

The presence of relevant features and items, such as battery layout, ancillary components, markings and similar shall be verified according to the agreed drawing(s).

10.3.3 Dielectric test

This test shall be carried out by the battery manufacturer before the shipment of the cells and monoblocs assembled in a crate, tray or battery box.

The details of the test and the requirement are specified in Annex B.

10.3.4 Cell and monobloc voltages

The homogeneity of the individual cell and/or monobloc voltages in the battery system shall be verified by measuring their voltages not earlier than 48 h after the completion of the last full charge of the units and with the units in a thermally equilibrated state.

Cells and monoblocs in a battery system shall be delivered only if the open circuit voltage of each unit is:

a) within a specified and agreed range;
b) when no individual voltage value deviates more than 0,5 % from the mathematical average of the voltage values of the concerned batch.

The resolution of the voltage measurement shall be not less than 10 mV.