HOPPECKE
POWER FROM INNOVATION

Installation, commissioning and operating instructions

for valve-regulated stationary lead-acid batteries

Similar to the illustration

Installation, commissioning and operating instructions
for valve-regulated stationary lead-acid batteries

Type und Design: Koerdt Promo4you GmbH, 59929 Brilon

Preface

Valued customer,

Thank you for choosing a HOPPECKE product.

Please read this documentation carefully and completely before performing any tasks using the lead-acid batteries. This documentation contains important information regarding safe and correct unpacking, storage, installation commissioning, operation and maintenance of lead-acid batteries. Non-compliance with these safety instructions can lead to severe personal injury and material damage. HOPPECKE is not responsible or liable for direct or indirect injury or damage resulting from improper use of this product; all warranty claims become null and void.

HOPPECKE reserves the right to make changes to the contents of this documentation. HOPPECKE Batterien GmbH & Co. KG is not responsible for errors in this documentation. HOPPECKE is not liable for direct damage related to the use of this documentation.

Our products are undergoing constant development. For this reason, there may be discrepancies between the product that you have purchased and the product as represented in this documentation. Please keep this documentation so that it is immediately available for all personnel who must perform work in connection with the batteries.

If you have questions, we would be happy to help you: You can reach us via email:

info@hoppecke.com

or by phone on working days between the hours of 8 am and 4 pm (CET) at the following number:

Telephone +49(0)2963 61-0
Fax +49(0)2963 61-481.

Your Team from
HOPPECKE Batterien GmbH & Co. KG

Postal address:

HOPPECKE Batterien GmbH & Co. KG
P.O. Box 11 40
D-59914 Brilon

Germany

Head office address:

HOPPECKE Batterien GmbH & Co. KG
Bontkirchener Straße 1
D-59929 Brilon-Hoppecke
Telephone +49(0)2963 61-0
Fax +49(0)2963 61-449
Internet www.hoppecke.com
Email info@hoppecke.com

Used Symbols

The following safety notes need to be observed. Listed symbols are used multiple times for safety relevant information:

Danger!

Personal health, batteries or the environment are at risk.
Failure to observe this hazard notice can lead to severe or fatal injury.

Attention!

Batteries, materials or the environment are at risk. Personal safety is not at risk.
Failure to observe this notice can lead to malfunction or damage to the batteries. In addition, material and environmental damage may occur.

Risk of explosion or blast, splashing of hot or molten substances.
Explosion and fire hazard, avoid short circuits!
Avoid electrostatic charge and discharge/sparks.
Failure to observe this hazard notice can lead to severe or fatal injury.

Risk of corrosion caused by leaking electrolyte.
Electrolyte is strongly corrosive.

Electrical voltages hazardous to health may cause fatal injury.
Metal parts of the battery are always alive, therefore do not place items or tools on the battery.
Failure to observe this hazard notice can lead to severe or fatal injury.

Warning! Risks caused by batteries.

Do not smoke!
Do not use any naked flame or other sources of ignition.
Risk of explosion and fire!

General prohibition

Observe these instructions and keep them located near the battery for future reference.
Work on batteries only after instruction by qualified personnel.

Wear protective goggles and clothing while working on batteries.
Observe the accident prevention rules as well as EN 50272-2 und EN 50110-1.

Wear conductive shoes.

General order

Any acid splashes on the skin or in the eyes must be rinsed with plenty of clean water immediately. Then seek medical assistance.
Spillages on clothing should be rinsed out with water!

Recycling

Pb

Spent batteries have to be collected and recycled separately from normal household wastes.

General notice or tip for better understanding and optimum use of the battery or batteries.

0 Safety notices

0.1 General Information

Danger!

Incorrect use of the products described here can lead to personal and material damage.
HOPPECKE is not responsible or liable for direct or indirect personal and material damages which occur as a result of handling the products described here.

Risk of explosion and fire, avoid short circuits.
Attention! Metal parts of the battery or batteries are always live, so never place foreign objects or tools on top of the batteries.
Electrostatic discharges can ignite oxyhydrogen gas and therefore cause an explosion of the battery! Exploding parts can lead to heavy injuries.

Electrolyte is highly corrosive.
In normal operation, it is not possible to come into contact with electrolyte. If the battery casing is destroyed, leaked bonded electrolyte is just as corrosive as liquid electrolyte..
Leaking electrolyte is harmful to the eyes and skin. Refer also to *chap. 2.3, Safety precautions*!

Attention!

Incomplete or insufficient maintenance can lead to unexpected battery failure or reduction of battery power. Maintenance work must be completed once every six months by authorized technical specialists in accordance with the instructions in this documentation.

Danger!

Work on batteries, especially installation and maintenance should be performed by trained HOPPECKE specialists (or by personnel authorized by HOPPECKE) only; personnel must be familiar with battery handling and the required precautionary measures. Unauthorized persons must keep away from the batteries!

Without proper and regular maintenance of the batteries by HOPPECKE specialists (or personnel authorized by HOPPECKE), the safety and reliability of the power supply during operation cannot be ensured.

Sealed lead-acid batteries are always filled before delivery. Sealed stationary lead-acid battery cells must not be refilled with water during the entire battery service life. Overpressure valves are used as sealing plugs. These plugs cannot be opened without damaging.

HOPPECKE offers the following type ranges as valve regulated lead-acid (VRLA) batteries:

net.power
OPzV
OPzV bloc solar.power
OPzV solar.power
power.bloc OPzV
power.com HC
power.com SB
power.com XC
rail.power
solar.bloc

Following symbols and pictograms are pictured on each battery cell or on each battery block:

Read the instruction for installation, commissioning and operation carefully.

Always wear protective goggles and cloths.

Avoid naked flames and sparks.

General danger warning.

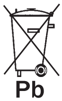
Risk of electrical voltage.

Risk of chemical burns through electrolyte.

Risk of explosion, avoid short circuits, electrostatic charge and discharge/sparks.

Battery with low concentration of antimony.

Used batteries with this symbol have to be recycled.



Used batteries which are not sent for recycling are to be disposed of as special waste under all relevant regulations.

0.2 Safety instructions for working with lead-acid batteries

When working on batteries, always observe the safety regulations documented in DIN EN 50110-1 (VDE 0105-1) Operation of electrical installations:

- Always proceed in the correct order when installing and removing the battery and when connecting it to the charger.
- Pay attention to the polarity!
- Make sure the connections are tight.
- Use only battery charger leads that are in perfect technical condition and that have adequate cross-sections.
- Batteries must not be connected or disconnected while current is flowing or while the charger is switched on.
- Before opening the load circuit, make sure that the charger is in a switched-off state by measuring the voltage.
- Secure the charger to prevent it from being switched back on again!
- Heed the instructions given in the operating manual provided by the manufacturer of the battery charger.

Danger!

Under certain conditions, there is a risk caused by electrical battery voltage and in the event of a short circuit, extremely high short circuit currents may flow.

There is a risk of explosion and fire due to explosive gas.

Observe the following regulations (IEEE standards valid for USA only):

– ZVEI publication „Instructions for the safe handling of electrolyte for lead-acid accumulators.“

– VDE 0510 Part 2: 2001-12, in accordance with EN 50272-2:2001: „Safety requirements for secondary batteries and battery installations - Part 2: Stationary batteries“.

– DIN EN 50110–1 (VDE 0105–1): Operation of electrical installations; German version EN 50110-1:2004.

– IEEE Standard 485–1997: „Recommended Practice for Sizing Large Lead Acid Storage Batteries for Generating Stations.“

– IEEE Standard 1187–2002: „Recommended Practice for Installation Design and Installation of Valve Regulated Lead-Acid Storage Batteries for Stationary Applications“.

– IEEE Standard 1188–2005: „Recommended Practice for Maintenance, Testing and Replacement of Valve Regulated Lead-Acid (VRLA) Batteries for Stationary Applications“.

– IEEE Standard 1189–2007: „Guide for Selection of Valve-Regulated Lead-Acid (VRLA) Batteries for Stationary Applications“.

– IEEE Standard 1375–1998: „Guide for Protection of Stationary Battery Systems“.

– DIN EN 50110-1 (VDE 0105-1): “Company of electrical instructions” ; German copy EN 50110-1:2004

Batteries contain corrosive acids which can lead to chemical burn on skin and eyes if the battery is damaged.

You must wear safety goggles while handling the battery!
Wear all the intended personal safety clothing while handling the batteries.

1. When renewing old batteries, ensure that all electrical loads are switched off before removing the old battery (separators, fuses, switches). This must be carried out by qualified personnel.

Danger!

2. Remove all wrist watches, rings, chains, jewelry and other metal objects before working with batteries.

3. Use insulated tools only.

4. Wear insulating gloves and protective shoes (refer to also to *Chap. 2.2*).

Danger!

5. Never place tools or metal components on top of the batteries.

Danger!

6. Make sure that the battery or batteries are not mistakenly grounded. If the system is grounded, terminate the connection.
   Touching a grounded battery by mistake can result in severe electric shock. The risk caused by an incorrect connection can be significantly reduced by terminating the ground connection.

Attention!

7. Before establishing connections, make sure to check the correct polarity - better one too many times than one too few.

Danger!

8. Filled lead-acid batteries contain highly explosive gas (hydrogen/air mixture). Never smoke, handle open flames or create sparks near the batteries. Always avoid electrostatic discharge; wear cotton clothing and ground yourself if necessary.

9. Use only suitable hoisting devices with sufficient carrying capacity. If lifting the battery, use the hoisting belt specified by HOPPECKE. Hook the belt sling onto to the battery so that the battery cannot fall out of the belt (if necessary, get help from another person). Wear the appropriate safety clothing and safety equipment.

Danger!

10. Never carry batteries by the battery terminals.

Attention!

11. These batteries contain lead and cannot under any circumstances be disposed of with household waste or at a waste dump at the end of their service life (for more information, *refer to Chap. 1.4*).

Table of contents

1 General information

The electrolyte of sealed lead-acid batteries is fixed in a glass fiber fleece (AGM) or gel. Therefore an upright or horizontal installation of battery cells or blocks is basically possible. The generation of oxyhydrogen gas is extremely reduced by an internal recombination circle. Sealed lead-acid battery cells or battery blocks are not sealed gas tightly. The integrated valve has to open by pressure overload. Sealed lead-acid batteries must not be opened. HOPPECKE offers numerous sealed lead-acid batteries as single cells (nominal voltage 2 V) or blocks (nominal tension:6 V or 12 V) for different applications. For example: OPzV, OPzV solar.power, power. bloc OPzV, OPzV bloc solar.power, power.com XC, power.com HC , power.com SB, net.power and solar.bloc.

1.1 Safety precautions

Danger!

Read this documentation carefully and completely before performing any tasks using the batteries. This documentation contains important information regarding the safe and correct unpacking, storage, installation commissioning, operation and maintenance of filled lead-acid batteries.

Danger!

To ensure your own safety as well as the safety of your colleagues and the system, it is essential that you have read and understood all instructions in this documentation and adhere to them strictly. If you have not understood the information contained in this documentation or if local regulations and conditions apply which are not covered by the documentation (or run contrary to the information in this documentation), please contact your local HOPPECKE representative. You can also contact us at our head office directly.

Danger!

If you are conducting any work on or with the battery system, it is essential that you familiarize yourself with the installation, operation and maintenance of lead-acid batteries.

1.2 Technical data

1.2.1 Example for single cell

Each single cell/each battery block has an own identification plate on the top side of the cell/block cap. Refer to the example below.

5 OPzV 250
2V 250Ah C_N / 267 Ah C_{10}
U_{float} = 2,25 V/cell
! upright position only !
Made in Germany
non spillable

Example: The information on the identification plate is as follows:
5 OPzV 250

5	=	number of positive plates
OPzV	=	battery type
250	=	Nominal capacity C_{10} (capacity during discharge with ten hours´ current (I_{10}) over a discharge time of 10 h (t_{10}))
267	=	actual capacity C_{10} (capacity of discharge with 10 h current)

1.2.2 Identification plate battery

The identification plate of the entire battery system can be found on the battery rack or inside the battery cabinet.
The nominal voltage, the number of cells/blocks, the nominal capacity ($C_{10} = C_N$) and the battery type are listed on the identification plate of the system.

Fig. 1–1: Example for type plate on battery rack

1.3 CE-Mark

Effective as of 1 January 1997, the EC declaration of conformity 2006/95/EC (Low Voltage Directive) and the corresponding CE marking for the battery system are required for batteries with a nominal voltage between 75 V and 1500 V DC.
The installer of the battery system is responsible for displaying the declaration and affixing the CE label on or next to the battery's identification plate.

1.4 Disposal and recycling

Used batteries with this marking are recyclable goods and must be sent for recycling.

Attention!

Pb

Used batteries which are not sent for recycling are to be disposed of as special waste under all relevant regulations.

We offer our customers our own battery return system. All lead acid batteries are taken to the secondary lead smelting plant at our HOPPECKE site, observing the provisions of the German

– recycling and waste law
– battery regulations
– transport approval regulations
– together with the general principles of environmental protection and our own corporate guidelines.

The HOPPECKE smelting plant is the only lead smelter in Europe certified under

– DIN EN ISO 9001 (processes and procedures),
– DIN EN ISO 14001 (environmental audit),
– and specialist disposal regulations covering specialist disposal with all associated waste codes for storage, treatment and recycling.

For further information: +49(0)2963 61-280.

1.5 Service

HOPPECKE has a worldwide service network that you should take advantage of. HOPPECKE service is there for you whenever you need specialist consultation for installation of the battery system, parts and accessories or system maintenance. Contact us or your local HOPPECKE representative.

HOPPECKE service:
Email: service@hoppecke.com

Refer to the HOPPECKE website for contact data of all international HOPPECKE branches:
Internet: www.hoppecke.com

2 Safety

2.1 General

If the casing of a sealed lead-acid battery is damaged, small quantities of electrolyte, acid mist or hydrogen gas may leak out. Always take the normal safety precautions when working with lead-acid batteries.

Consider all instructions and engineer standards, as mentioned in chapter 0.2.

2.2 Personal safety equipment, protective clothing, equipment

If working with lead-acid batteries, the following equipment must be provided at the very least:
– Insulated tools
– Protective shoes
– Rubber gloves
– Fire extinguisher
– Rubber apron
– Protective goggles
– Face shield
– Face mask
– Emergency eye wash (recommended).

To avoid electrostatic charging, all textiles, protective shoes and gloves worn while working with batteries must have a surface resistance of $<10^8$ ohm and an insulation resistance of $\geq 10^5$ ohm (refer EN 50272-2 and DIN EN ISO 20345:2011 Personal protective equipment - Safety footwear). If possible wear ESD shoes.

Danger!

Remove all wrist watches, rings, chains, jewelry and other metal objects before working with batteries.
Never smoke, handle open flames or create sparks near the batteries.
Never place tools or metal components on top of the batteries.

The use of proper tools and safety equipment can help to prevent injury or reduce the severity of injury in case of an accident.

2.3 Safety precautions

2.3.1 Sulfuric acid

Sealed lead-acid batteries are safe when used properly. However, they contain diluted sulfuric acid (H_2SO_4) that is bonded in gel or glass mat. The bonded sulfuric acid is extremely corrosive and can cause serious injury. Further information to sulfuric acid can be found in the attached material safety data sheet.
Note also the information in the attached ZVEI leaflet “Instructions for the safe handling of lead-acid accumulators (lead-acid batteries)”.

2.3.2 Explosive gases

Danger!

Lead-acid batteries can release an explosive mixture of hydrogen and oxygen gases. Severe personal injury could occur in the event of an explosion of this mixture.
– Always wear the recommended protective clothing (protective goggles, insulated gloves and protective shoes, etc.)
– Use the correct tools only („non-sparking“ with insulated grips, etc.).

– Eliminate all potential sources of ignition such as sparks, flames, arcs.
– Prevent electrostatic discharge. Wear cotton clothing and ground yourself when you are working with the batteries directly.

Danger!

In case of fire, extinguish using water or CO_2 extinguisher only.
Do not point the fire extinguisher directly at the battery or batteries to be extinguished. There is a risk that the battery casing may break as a result of thermal tension. In addition, there is a risk of static charging on the surface of the battery. This could result in an explosion. Switch off the charging voltage of the battery. If extinguishing a fire, use a breathing apparatus with a self contained air supply. If using water to extinguish a fire, there is a risk that the water/ foam could react with the electrolyte and result in violent spatter. For this reason, wear acid-resistant protective clothing. Burning plastic material may produce toxic fumes. If this should occur, leave the location as quickly as possible if you are not wearing the breathing apparatus described above.

Danger!

If using CO_2 fire extinguishers, there is a risk that the battery could explode as a result of static charging.
Note also the information in the attached ZVEI leaflet "Instructions for the safe handling of lead-acid accumulators (lead-acid batteries)".

2.3.3 Electrostatic discharge

All lead-acid-batteries produce hydrogen and oxygen while operating, particularly during charging. These gases leak from the battery in the ambience. Based on the mandatory natural or technical ventilation it can be assumed that a flame able oxyhydrogen concentration exists only in the close proximity of the battery. A flame able mixture of oxyhydrogen always exists inside the battery cells. This effect does not depend on the battery technology, design or manufacturer, rather than a specific characteristic of all lead-acid batteries. The energy needed for an ignition of oxyhydrogen is quite low and can be caused differently. Examples: Open flame, fire, glowing sparks or flying firebrands from grinding, electric spark from switches or fuses, hot surface areas >200°C and – an underestimated cause – electrostatic discharge.

Measures to avoid the ignitions of detonating gas through electrostatic discharges
The development of electrostatic discharges on the battery or on your body or on clothes can be avoided if you consider the information below:

Do not wipe the battery with an arid fabric especially made of synthetic material.
Rubbing on surfaces of plastic material (battery jars are typically made of plastic material) causes electrostatic charges.

Clean the surface of batteries with water- moistened cotton fabric only. By using a water-moistened cotton fabric you avoid the buildup of electrostatic charges.

While working on batteries do not rub your clothes (e.g. made of wool) on the battery. Thereby electrostatic charges could build up on the battery jar, your body or on your clothes.

Wear suitable shoes and clothing with special surface resistance that avoid the buildup of electrostatic charge. Thereby the buildup of electrostatic charge on the body and clothing can be avoided.

Do not remove self-adhesive labels, from the battery without special safety measures.
Removing plastic labels can build up electrostatic charges, which can ignite oxyhydrogen gas.

Before pulling off the label, wipe the battery moist.

2.3.4 Electric shock and burns

Danger!

Batteries can cause severe electric shock. If there is a short circuit, very strong currents may be present. Do not touch any bare battery components, connectors, clamps or terminals.
In battery systems with a nominal voltage of over 1,500 V DC, you must provide equipment for splitting the batteries into cell groups with voltages lower than 1,500 V DC. In order to prevent serious injury as a result of electric shock or burns, be very cautious when performing any work on the battery system.
Always wear the recommended protective clothing (insulated rubber gloves and rubber shoes, etc.) and always use insulated tools or tools made of non-conductive material.
Remove all wrist watches, rings, chains, jewelry and other metal objects before working with batteries.

Before conducting work on the battery system...
Determine whether the battery system is grounded. We do not recommend this. If the system is grounded, terminate the connection.
Touching a grounded battery by mistake can result in severe electric shock. This risk can be significantly reduced by removing the ground connection. However, the racks (or cabinets) used to hold the batteries do need to be well grounded or completely insulated.

If a battery system is grounded...

There is a voltage between the ground and the ungrounded terminal. If a grounded person touches this terminal, there is risk of fatal injury. There is also a risk of short circuit if dirt or acid on the ungrounded terminal come in contact with the battery rack.

If an additional ground connection is made by some cells within the (grounded) battery system, there is a risk of short circuit, fire and explosion.

If a battery system is not grounded...

If an accidental ground connection is made by some cells within the battery system, voltage is created between the ground and the ungrounded terminal. The voltage can be dangerously high - risk of fatal injury due to electric shock.

If a second accidental ground connection is made, there is a risk of short circuit, fire and explosion.

If you have questions about these instructions or any other questions regarding safety when working with a battery system, please contact your local HOPPECKE representative. You can also contact us at our head office directly.

3 Transportation damages

3.1 General

We take great care in packaging the batteries that we send to you so that they arrive without damage. We strongly recommend that you inspect the delivery for possible shipping damage as soon as it arrives.

For road transportation, filled lead-acid rechargeable batteries are not treated as dangerous goods if
– They are undamaged and sealed
– They are protected from falling, shifting and short circuit
– They are firmly secured to a pallet
– There are no dangerous traces of acids, lye, etc. on the outside of the packaging

It is essential that loads on road vehicles are properly secured.

Danger!

Monobloc batteries/battery cells are very heavy (depending on type between ca. 10kg and max. 240kg per cell/bloc). Wear protective shoes. Use only the appropriate transportation equipment for transport and installation.

Attention!

3.2 Delivery completeness and externally visible damage

Check immediately upon delivery (while the carrier is still present) to make sure that your shipment is complete (compare with the delivery note). In particular, check the number of battery pallets and the number of boxes with accessories. Then inspect the goods for possible shipping damage.

Note all
– damages to the outer packaging
– visible stains or moisture that might indicate electrolyte leakage

If the delivery is incomplete or damaged as a result of shipping
– Write a short defect notice on the delivery note before signing it.
– Ask the carrier for an inspection and note the name of the inspector.
– Compose a defect report and send it to us and to the carrier within 14 days.

3.3 Defects

Observe all required safety measures to avoid electric shock.
Keep in mind that you are handling live batteries. Observe all instructions in *Chap. 2 “Safety”*.

Unpack the goods as soon as possible upon delivery (the sooner, the better) and inspect them for any defects in case commissioning should be carried out promptly.

The sealed batteries are always filled before delivery.

Check the entire scope of delivery to make sure that it matches the detailed delivery note (or the packing list).
Failure to promptly inform the carrier of defects or incompleteness could result in the loss of your claims.
If you have questions regarding incomplete shipments or damage to the delivered products, please contact your local HOPPECKE representative. You can also contact us at our head office directly.

4 Storage

4.1 General

After receiving the batteries, you should unpack, install and charge them as soon as possible. If this is not possible, store the batteries fully-charged in a dry, clean, cool and frost-free location. Excessively high storage temperatures may result in accelerated self-discharge and premature aging. Do not expose the batteries to direct sunlight.

Attention!

Do not stack the pallets with the batteries as this can cause damage which is not covered under the warranty.

4.2 Storage time

Attention!

If the cells/batteries are to be stored for a long period of time, store them fully-charged in a dry, frost-free location. Avoid direct sunlight. To prevent damage to the batteries, an equalizing charge must be performed after a maximum storage period of six months (see *Chap. 6.2.5*). Calculate this exact time starting on the day of delivery. By the end of the max. storage time charge acceptance might be declined during battery recharge. Hence, HOPPECKE recommends a suitable process of charging, which assures a gentle full charge of the battery (refer to *Chap. 6.2.5*). If storage temperatures exceed 20 °C, more frequently equalizing charges may be necessary (at temperatures around 40 °C monthly charges). Refer also to *figure 4–1* to retrieve max. storage times for different storages temperatures. Failure to observe these conditions may result in sulfating of the electrode plates and significantly reduced capacity and service life of the battery. Battery recharge during storage time should be carried out max. twice. The battery should be operated in continuous float charge mode thereafter.
Battery service life commences with delivery of the battery or batteries from the HOPPECKE plant. Storage times have to be added completely to the service life.

Attention!

Required process for charging the batteries by achievement of max. storage duration:
Charge with constant power of 1 A or 2 A per 100 Ah C_{10} battery capacity. Interrupt charging when all cell voltages have rised to min 2.65 V/cell (refer also to *Chap. 6.2*).

4.3 Preparing for a several-month storage period

If the storage time extends over a period of several months, make sure to provide an appropriate charger so that the charging tasks can be performed promptly as previously described. For temporary storage, arrange the blocks/cells so that they can be temporarily connected in series for charging. The batteries should remain on their pallets until final installation.

To avoid having to perform the previously described work, we strongly recommend that you connect the battery or batteries to the regular charging voltage supply within six months. Failure to observe the recharging intervals will render the warranty null and void.

Attention!

Observe ventilation requirements *(refer to Chap. 5.2.1.1)* even for charging of temporarily connected cells.

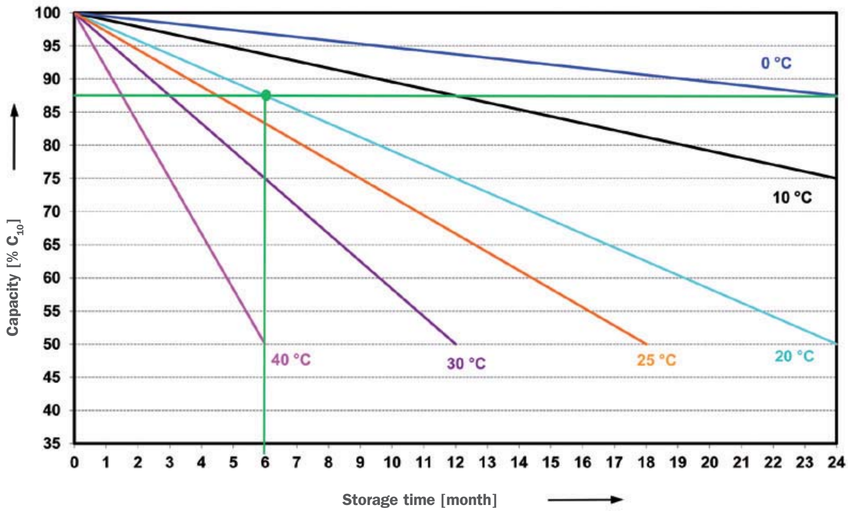


Fig. 4–1: Available Capacity vs. storage time

5 Installation

5.1 Demands on the erection site

Danger!

When renewing old batteries, ensure that all electrical loads are switched off before removing the old battery (separator, fuses, switches).
This must be carried out by qualified personnel.

If you have questions regarding battery system installation, please contact your local HOPPECKE representative. You can also contact us at our head office directly.

If choosing an installation location, determining space requirements and performing the installation, observe the relevant installation drawing if it is available.
The floor must be suitable for battery installation; it must:
– have a suitable load-carrying capacity,
– be sufficiently conductive,
– be at ground level (max. thickness of backing elements under racks and cabinets: 6 mm),
– be as free of vibration as possible (otherwise a special rack is required).
Within the EU, follow VDE 0510 Part 2: 2001-12, in accordance with EN 50272-2: 2001: „Safety requirements for secondary batteries and battery installations - Part 2: Stationary batteries“.

Requirement	Our recommendation
Ventilation source	 Danger! Sufficient room ventilation is absolutely required to limit the hydrogen concentration (H2 concentration) in the ambient air of the battery room to a value of <2% by volume. Hydrogen is lighter than air. Make sure that hydrogen does not accumulate (e.g., in the ceiling area). Ventilation and deaeration openings should be placed near the ceiling. (see also *Chap. 5.2.1.1* and *Chap. 5.2.1.2*).
Environment	The ambience should be clean and dry. Water, oil and dirt must be kept away from the cell surface.
Passageway width in front of and between the battery racks (and cabinets)	Europe: Passageway width = 1.5 x cell width (installation depth), at least 500 mm (see also EN 50272–2). USA: 36“ or. 915 mm HOPPECKE recommendation: If possible at the installation location: 1 m. Otherwise: in accordance with local regulations.
Minimum distances	
Rack to wall	50 mm
Battery to wall	100 mm
Conductive parts to ground	1.500 mm for U_{nom} or U_{part} >120 V VDC between non-insulated and grounded parts (e.g. water lines)
Battery end terminals	1.500 mm for U_{nom} >120 V DC
Battery to sources of ignition	See calculation of the safety distance *Chap. 5.1.1.*
Upper surface of battery to next tier of rack or bottom of the next cabinet	250 mm It mus be possible to measure the voltage.
Access door	Lockable and fire retardant (T90).
Lighting	Recommend: at least 100 lx.
Labeling	Warning signs in accordance with EN 50272–2.  Warning sign depicting risk of electrical voltage only necessary if battery voltage exceeds 60V DC.
Risk of explosion	No sources with ignition (e.g. open flame, glowing objects, electrical switches, sparks) near to the cell openings.
Ambient temperature	The recommended operating temperature ist between 10 °C and 30 °C. The optimal temperature is 20 °C ± 5 K. Higher temperatures shorten the service life of the battery. All technical data is valid for the nominal temperature of 20 ° C. Lower temperatures decrease battery capacity. Exceeding the limit temperatures of 55 °C is not permissible. Avoid operating at temperatures en excess of 45 °C for long periods of time. Batteries should not exposed to direct sunlight or near heat sources.
Ambient air	The air in the battery room must be free of impurities, e.g. suspended matter, metal particles or flammable gases. The humidity should be at a maximum of 85%.
Earthing	If you ground the racks or battery cabinets, make sure that you use a connection to a reliable grounding point.
Battery installation	We recommend that batteries are properly installed in HOPPECKE battery racks or cabinets. The use of other operator-specific solutions may render the warranty for the batteries null and void.
Country-specific regulations	Some countries require batteries and racks to be installed in collection tanks. Please observe all local regulations and contact you local HOPPECKE representative if necessary.

Tab. 5–1: Demands on the erection site

5.1.1 Calculation of safety distance

In close proximity of the batteries the dilution of explosive gases is not always given. Therefore a safety distance has to be realized by a clearance, in which there must not be any sparking or glowing equipments (max. surface temperature 300°C). The diffusion of the oxyhydrogen depends on the gas release and the ventilation close to the battery. For the following calculation of the safety distance ‘d’ it can be assumed that the oxyhydrogen expands spherical. Figure 5.1 depicts a graphic approximation of the safety distance ‘d’ depending on the battery capacity. Subsequently a detailed calculation is shown.

Safety clearance:
Required safety clearance needs to be calculated according to formula stated in EN 50272–2.

Volumes of a hemisphere:

$$V_h = \frac{2}{3} \times \pi \times d^3$$

Air volume flow required to reduce the concentration of generated hydrogen H_2 in the air to 4% max.:

$$Q_{gas} = 0{,}05 \times \langle n \rangle \times I_{gas} \times C \times 10^{-3} \left(\frac{m^3}{h}\right)$$

$$Q_{gas} = \frac{V_h}{t}$$

Required radius of the hemisphere:

$$d = 28{,}8 \times (\sqrt[3]{n}) \times \sqrt[3]{I_{gas}} \times \sqrt[3]{C} \ \text{(mm)}$$

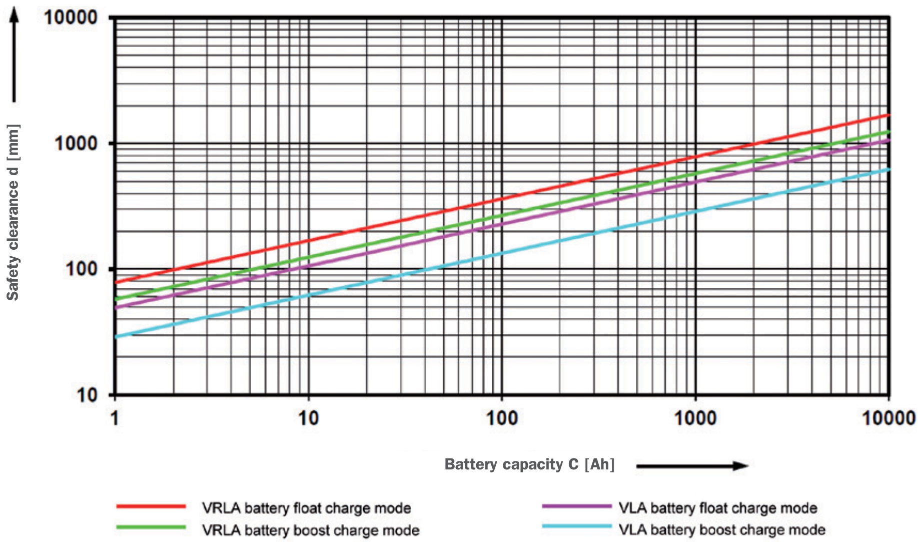


Fig. 5–1: Safety distance based on battery capacity (Source HOPPECKE)

5.2 Filling the cells

Sealed lead-acid batteries are always filled before delivery. Sealed stationary lead-acid battery cells must not be refilled with water during the entire battery service life. Overpressure valves are used as sealing plugs. These plugs cannot be opened without damaging.

5.2.1 Check

Make sure that the installation and ventilation requirements according to EN50272-2:2001 are met.
Should commission charging be carried out using higher amperage than you established for the type of ventilation equipment, then you must increase the ventilation in the battery room (e.g. using additional portable fans) according to the amperage applied.
Increased ventilation has to be applied during commissioning and for one hour afterwards. The same applies for occasional special battery charging processes.

5.2.1.1 Ventilation - preventing explosion

It is impossible to stop gases from being generated while charging batteries; therefore, the hydrogen concentration in the air must be reduced with sufficient ventilation. Do not use sparking equipment near batteries.

The following could act as sources of ignition for gas explosions:

– open flames
– flying sparks
– electrical, sparking equipment
– mechanical, sparking equipment
– electrostatic charge.

Observe the following measures to prevent gas explosions:

– sufficient natural or technical ventilation
– no heating using open flames or glowing objects (T > 300°C)
– separate battery compartments with individual ventilation
– anti-static clothing, shoes and gloves (according to applicable DIN and EN regulations)
– surface conductivity resistance: $<10^8\ \Omega$ and insulating resistance $\geq 10^5\ \Omega$
– hand-held lights with power cable without switch (protection class II)
– hand-held lights with battery (protection category IP54)
– warning and regulatory signs.

The ventilation requirements for battery rooms, cabinets or compartments are based on the required reduction of the concentration of hydrogen generated during charging and safety factors which include battery aging and the potential for fault (“worst case”).

5.2.1.2 Ventilation - calculation for ventilation requirements of battery rooms

Air volume flow Q:

$$Q = v \times q \times s \times n \times I_{Gas} \times \frac{C}{100\,Ah}$$

v = dillution factor = 96% air/4% H_2 = 24
q = quantity of hydrogen generated = 0.42 10^{-3} m^3/Ah
s = safety facotr = 5
n = number of cells
I_{Gas} = current per 100 Ah
C = nominal capacity of the battery

Sum of factors:

$$v \times q \times s = 0{,}05$$

$$Q = 0{,}05 \times n \times I_{Gas} \times \frac{C}{100\,Ah}$$ with Q in m³/h, I_{Gas} in A

$$I_{Gas} = I_{float} \text{ bzw. } I_{boost} \times f_g \times f_s$$

Parameter	Lead-acid batteries sealed cells
f_g: Gas emissions factor	0.2
f_s: Safety factor for gas emissions (includes 10% faulty cells and aging)	5
U_{float}: Float charge voltage, V/cell	2.27
I_{float}: Typical float charge current, mA per Ah	1
I_{gas}: Current (float charge), mA per AH (used only for calculating the air volume flow for float charge)	1
U_{boost}: Boos charge voltage, V/cell	2.40
I_{boost}: Typical boost charge current, mA per Ah	8
I_{gas}: Current (boost charge), mA per Ah (used only for calculating the air volume flow for boost charge)	8

Tab. 5–2: Recommended current values (recommendation for European standards) (Extract from the DIN EN 50272-2)

If designing the ventilation in battery rooms, depending on the structural conditions, either „natural ventilation“ or „technical ventilation“ can be used.

Observe the following points:

Natural ventilation:
– intake and exhaust openings required
– minimum cross-section (free opening in wall) (A in cm², Q in m³/h) (given that: v_{air} = 0.1 m/s)
– increased ventilation through chimney effect (air routing)
– exhaust released outside (not into air-conditioning systems or surrounding rooms).

Technical ventilation:
– increased ventilation using fan (generally extractor fans)
– air flow rate according to air volume flow Q
– air drawn in must be clean
– if large amounts of gas are released during charging, continued ventilation is required for 1 h after charging is complete
– for multiple batteries in one room: required air flow = $\sum Q$
– avoid a ventilation short circuit by ensuring that there is sufficient distance between the intake and exhaust opening.

In case of a technical (forced) ventilation the charger shall be interlocked with the ventilation system or an alarm shall be actuated to secure the required air flow for the selected charging mode.

Another sample calculation for battery room ventilation is available in Required ventilation for hydrogen generated by batteries, *Chap. 10, „Required ventilation for hydrogen generated by batteries“.*

5.3 Conducting an open-circuit-voltage measurement

Before installing the batteries, conduct an open-circuit voltage measurement of the individual cells or monobloc batteries to determine their state of charge and to make sure that they are functioning properly. Fully-charged cells with an electrolyte temperature of 20 °C should have an open-circuit voltage as listed in *Tab. 5–3*.
The open-circuit voltages of the individual cells of a battery must not differ more than 0.02 V from one another.

Type of cell/monobloc battery	Technical guidelines	Open-circuit voltage
OPzV	DIN 40742	2,080 V ... 2,140 V/Z
power.bloc OPzV	DIN 40744	2,080 V ... 2,140 V/Z
net.power 12 V 100 and 12 V 150	—	2,080 V ... 2,140 V/Z
net.power 12 V 92 and 170 Ah	—	2,100 V ... 2,160 V/Z
power.com SB	—	2,080 V ... 2,140 V/Z
power.com HC	—	2,080 V ... 2,140 V/Z
OPzV solar.power	—	2,080 V ... 2,140 V/Z
OPzV bloc solar.power	—	2,080 V ... 2,140 V/Z
solar.bloc	—	2,080 V ... 2,140 V/Z
power.com XC	—	2,100 V ... 2,160 V/Z

Tab. 5–3: Open circuit voltages for different cells/block batteries

The following open-circuit voltage deviations are acceptable for monobloc batteries:
– 4 V monobloc 0.03 V/block
– 6 V monobloc 0.04 V/block
– 12 V monobloc batteries 0.05 V/block

High temperatures decrease the open-circuit voltage while lower temperatures increase it. A deviation of 15 K from the nominal temperature changes the open-circuit voltage by 0.01 V/cell. **Please consult your local HOPPECKE representative regarding larger deviations.**

5.4 Installation tools and equipment

The batteries are delivered on pallets and the required accessories are located in separate packaging units. Observe all information from the previous sections.

Danger!

For the installation, you will require your personal safety equipment, protective clothing, safety tools and other equipment as described in *Chap. 2.2*.

Equipment	Available?
Lifting conveyor (forklift truck, lift truck or small mobile crane or similar device to aid in battery installation)	
Chalk line and chalk (optional)	
Plastic spirit level (optional)	
Torque wrench	
Backing elements (max. 6 mm) for installing the racks (cabinets) (optional)	
Ratchet set (optional)	
Wrench and ring wrench set with insulated grips	
Screwdriver with insulated grip	
Paper towels or cloths (made of cotton; do not use cloths made out of synthetic fibers as there is a risk of static charging), moisturised with water	
Brushes with hard plastic bristles (optional)	
Plastic measuring tape	
Safety equipment and protective clothing	
Aeronix® battery terminal grease	
Insulating mats for covering conductive parts	

Tab. 5–4: Equipment for installation

5.5 Rack installation

We recommend that batteries are properly installed in HOPPECKE battery racks or HOPPECKE battery cabinets. The use of other operator-specific solutions may render the warranty for the batteries null and void.
HOPPECKE produces different types of racks. For installation information, see the separate documentation included with each rack.

Danger!

Observe the special requirements and regulations when installing battery racks in seismic areas!

Danger!

The installation location must fulfill the conditions described in *Chap. 5.1*.
Comply with the minimum distances listed in *Tab. 5–1*.

*Fig. 5–2:
Step rack (left) and
tier rack (right)*

1. If the installation drawing is available, mark the outlines of the racks on the installation surface using chalk.
2. The installation surface must be level and rigid. If backing elements are used, make sure that the thickness does not exceed 6 mm.
3. Carefully set up the racks and arrange them horizontally.
4. The distances of the support profiles must correspond to the dimensions of the cell or monobloc battery.
5. Check rack stability and ensure that all screwed and clamp connectors are firmly secured.
6. If necessary, ground the racks or rack parts.

Attention!

If using wooden racks: you must fit a flexible connector between each rack joint.

5.6 Cabinet installation

Alternatively, you may choose to install the batteries in HOPPECKE cabinets.
The cabinets can be delivered with batteries already installed or battery installation can take place on-site.
HOPPECKE provides different types of cabinets.

Danger!

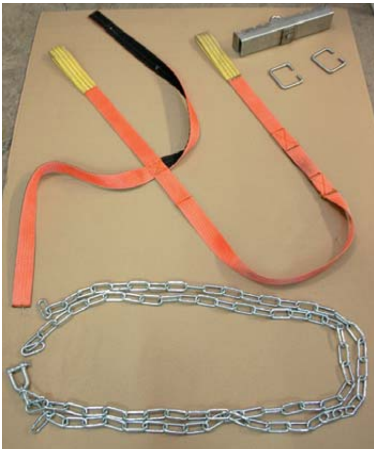
The installation location must fulfill the conditions described in *Chap. 5.1*.
Comply with the minimum distances listed in *Tab. 5–1*.

Fig. 5–3: Battery cabinet

If installing block batteries with L- connectors you should consider, that L- connectors have to be mounted before positioning the battery block in the battery cabinet.
Note: The L - connectors are not intended for high current applications (e.g. UPS). Please contact your local HOPPECKE representative in case of questions.

5.7 Handling the batteries

Be very careful when lifting and moving the batteries as a falling battery could cause personal injury or material damage. Always wear protective shoes and safety goggles.
The battery attached to a hoisting belt must be guided manually by one person so that it remains in a horizontal position and so that it does not slide out of the rope sling.
If guiding the battery hooked to a hoisting belt, make sure to wear acid-resistant, non-slip gloves.
Always lift batteries from below and never lift batteries using the terminals as this can destroy the battery.
Before installing the battery, visually check to make sure that it is in perfect condition.



Install the battery in accordance with VDE 0510 Part 2: 2001-12 (in accordance with EN 50272-2: 2001).
For example, you must cover conductive parts using insulating mats.
Make sure that all terminals are covered with insulating caps.
If lifting the battery, use the hoisting belt specified by HOPPECKE as shown in *Fig. 5–4*.
Note that the hoisting belt sling needs to be adjusted with the Velcro for different battery cell dimensions.
Use the auxiliary equipment shown in *Fig. 5–4* (cross beam, chain, snap hooks, ring eyelets).
The maximal bearing capacity of the hoisting belt amounts to 340 kg.

Fig. 5–4: Components of HOPPECKE hoisting belt

The procedure is as follows:

Fig. 5–5

Fig. 5–6

Fig. 5–7

Fig. 5–8

Fig. 5–9

Fig. 5–10

Fig. 5–11

1. Lay the belt sling over the battery from above so that the sewn end of the belt lies on the long side of the battery and faces upwards *(Fig. 5–5).*
2. Tilt the battery to the side slightly and push the hoisting belt underneath the battery, positioning it in the center *(Fig. 5–6)*.
   Use only the HOPPECKE hoisting belt. When using a normal rope sling, there is a risk that the battery could slide in the sling or fall out of the sling.
3. Pull the end of the belt upwards through the loop *(Fig. 5–7)*.
   Both ends of the belt must be at the same height over the battery.
4. Slide both ring eyelets into the ends of the hoisting belt *(Fig. 5–8)*.
   Make sure that the opening in the ring eyelet is at the top and that the ring eyelet is not bent open. Otherwise there is a risk that the battery could fall.
5. Attach the cross beam to the hoist (e.g. crane or forklift truck) using the chain and the snap hooks. Take the necessary precautions to make sure that the chain does not slide off of the forklift.
6. Hang both ring eyelets with the hoisting belt in the cross beam *(Fig. 5–9)*. Always position the eyelets in the notches on the cross beam.
7. Pull the hoisting belt slowly and guide the battery manually.
   The battery must always be transported in a vertical position *(Fig. 5–10)*.
8. Transport the battery to the installation location, e.g. step rack or tier rack.
9. Lubricate the profiles of the rack slightly with soft soap.
10. Carefully place the battery onto the rack.
11. Remove the hoisting belt from the battery.

Figures *Fig. 5–5* to *Fig. 5–11* show an example for „OPzV“ battery handling.

OPzV batteries (up to 12 OPzV 1500) and OPzV solar. power (up to 12 OPzV 1700) can also be installed horizontally in racks or cabinets.

Make sure that all terminals are oriented correctly *(see also examples to the handling in chapter 5.7 „Handling the batteries“).*

Important: If mounting horizontally, you must order the „horizontal“ variant.

Standard OPzV-and OPzV solar.power cells may only be installed and operated in vertical position.

5.8 General information on connecting the batteries

Attention!

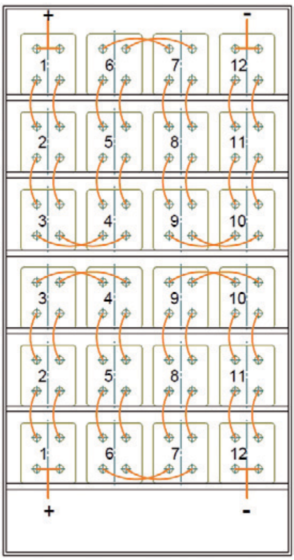
If connecting the batteries, always establish the serial connections first followed by the parallel connection. Do not reverse this procedure.
Before connecting, check to make sure that the batteries have the correct polarity.

To establish the serial connection, arrange the batteries so that the positive terminal of one battery is positioned as near as possible to the negative terminal of the next battery.

If sealed stationary batteries are connected in parallel, observe the following:

1. Only battery strings with the same length and voltage may be connected with one another. Cross connecting the individual strings between the cells should be avoided because strings could be very long. Cross connections mask bad cells and blocks and could cause individual battery strings to overload.
2. Only batteries of the same type and same state of charge should be connected (same battery type, plate size and plate design).
3. The environmental conditions should be the same for each string connected in parallel. In particular, avoid temperature discrepancies between the individual strings/batteries.
4. In order to ensure consistent current distribution, make sure that the connectors and end connections are set up so that the individual supply lines connected to the consumer have the same electrical resistance ratio.
5. The commissioning date of the batteries should be the same (batteries of the same age, identical storage time and same state of charge).

If the installation does not comply with all of the above mentioned guidelines, you have to charge each string separately and connect them in parallel afterwards.



In general, connect the batteries using the shortest possible cables. Normally, cells are connected in series with alternating polarity, resulting in the shortest possible connector length.

Batteries of type range OPzV (up to 12 OPzV 1500) and OPzV solar.power (up to 12 OPzV solar.power 1700) can also be mounted horizontally in racks or cabinets. These are optional variants for horizontal operation. These variants need to be ordered extra. *Fig. 5–12* depicts an example for connection of horizontal oriented battery cells.

Fig. 5–12: Example of a horizontal arrangement of the batteries with OPzV-cells in a battery cabinet

5.9 Putting the cells/blocks into the racks

1. Apply some soft soap to the profiles of the rack so that the batteries can be adjusted sideways more easily once they have been placed onto the rack.

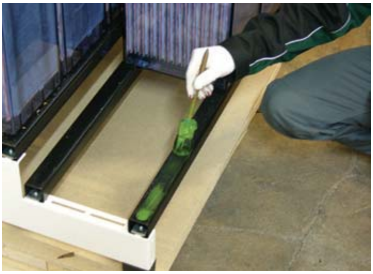


Fig. 5–13: Greased support profiles

2. Position the batteries one after another into the racks so that they are angled and level with the correct polarity. Remove all transportation and hoisting equipment.

For large batteries, it is required that you begin installation in the center of the rack.
When using tier racks, install the batteries on the bottom rack first.

Attention!

When handling the batteries, observe the instructions in *Chap. 5.7*.
Place the batteries carefully onto the profiles of the rack, otherwise the battery casing could be damaged.
When placing the batteries on the rack, do not allow the batteries to knock up against one another. This could destroy the batteries!

Danger!

The battery connection terminals + and - must under no circumstance be short-circuited. This also applies also to the + and – pole of the entire battery string. Be very careful when using step racks.

Attention!

3. Slide the blocks (or cells) to either side until the distance between the batteries is approx. 10 mm *(Fig. 5–14)*. If connectors are used, these determine the distance between the batteries. When sliding the batteries sideways in the racks, do not push them at the middle; instead, push them at the corners as these are stronger. Push batteries using your hands only; never use a tool.

Fig. 5–14: 10 mm clearance between the batteries

4. Final step: Count all cells/blocks and check for completeness.

5.10 Connecting the batteries

The batteries are in their final position and can now be connected.

5.10.1 Connection terminals

The battery terminals of the types solar.bloc 12 V 58 – 12 V 90 have been greased at the factory using Aeronix® battery terminal grease. Inspect each terminal for visible damage or oxidation. If necessary you should clean the terminal by using a brush (with hard plastic bristles). Re-grease by using the above mentioned terminal grease.
Other sealed lead acid battery types don't need to be greased because the terminals are rubber molded.

5.10.2 Type of connection cable

The battery system that you received is designed to produce a specified amount of power (kW) or current (A) at a particular voltage for a certain period of time (standby time).
You should be familiar with these parameters (U, kW, A). If this is not the case, please contact your local HOPPECKE representative.

The battery system was designed so that the electrical energy is available at the battery terminals. Limit voltage drop between the battery terminals and electrical loads to an absolute minimum. If the voltage drop is too large, the backup time of the battery system may be reduced.
Observe the following information:

1. Keep the cable length between the batteries and the charging rectifier/USV as short as possible.
2. The cable cross-section should be calculated so that voltage drop is negligible even at a high current flow. Use the cross-section of the cable provided to calculate the voltage drop at the nominal current. If in doubt, use cable with a cross-section that is one size larger.

Danger!

The connection cable must be short-circuit proof or double-wall insulated. That means:

- The insulation strength of the cable is higher than the max. system voltage or
- there is a distance of at least 100 mm between wiring and electrically conductive parts or
- connectors must be furnished with additional insulation.
- Avoid mechanical stress on the cell/battery terminals. Protect cables with large cross-sections using cable ties and cable clamps.

The connection cables between the main connection terminals and the charging rectifier or UPS should be flexible conductors.

5.10.3 Clamping batteries using battery connectors

There are screwed row, step and tier connectors *(see Fig. 5–15)*.
Row connectors are used to connect the individual cells/monobloc batteries, step connectors are used to connect the individual steps to one another (for use with step racks) and the tier connectors are used to connect the tiers (for use with tier racks).

Fig. 5–15: Using row connectors and step connectors

Attention!

Row, step, tier and end connectors are designed as screwed connectors. After loosening a connection, the assembly screws must always be replaced.

5.10.4 Installing the screwed connectors

Fig. 5–16: Screwed connector installation

1. The batteries are connected using the insulated row connectors (Fig. 5–16). When establishing the serial connection, the batteries are arranged so that the negative terminal of one battery is connected to the positive terminal of the next battery until the entire system has reached the necessary voltage.

Attention!

Make sure that you do not cause mechanical damage to the terminals.

2. Attach the connectors as shown in *Fig. 5–15.* First attach the screws by hand only so that you can make final adjustments to the cells and connectors.
3. Tighten the screws using a torque wrench. The recommended torque is 20 Nm ±1 Nm.

Attention!

It is very important to tighten screws thoroughly as a loose connection can become very hot and result in ignition or explosion.
Screws are approved for single use only!

4. If necessary, fit the connectors and end terminals (connection plates) with insulating covers.

5.10.5 Clamping connection plates onto the batteries

There are a total of 11 different types of connection plates *(see Fig. 5–15)*. Connection plates are always used when wires must be connected to cells with multiple battery terminals.

Attention!

We strongly recommend that you use original HOPPECKE connection plates when connecting wires to cells with multiple battery terminal pairs. Using other solutions may lead to overheating, risk of fire and increased electrical contact resistance!

Fig. 5–17: Installing the end terminals (connection plates)

Installation of standard connection plates

Screw the connection brackets onto the end terminals of the battery *(see Fig. 5-17)*.

Attention!

Make sure that you do not cause mechanical damage to the terminals.

2. First attach the screws by hand only so that you can make final adjustments to the cells, connection brackets and connection plates. Fix the connection plate to the connection bracket of the battery with a torque of 20Nm.
3. Afterwards tighten the pole screws using a torque wrench The recommended torque is 20 Nm ±1 Nm.

Attention!

It is very important to tighten screws thoroughly as a loose connection can become very hot and result in ignition or explosion.

5.11 Connect the battery system to the DC power supply

Attention!

Make sure that all installation work has been performed properly before connecting the battery system to the charging rectifier or UPS.

1. Measure the total voltage (target value = sum of open-circuit voltages of the individual cells or monobloc batteries).
2. If necessary: label the cells or monobloc batteries visibly with continuous numbers (from the positive terminal to the negative terminal of the battery). HOPPECKE includes number stickers in your shipment.
3. Attach polarity labels for the battery connections.
4. Complete the identification plate in this documentation *(see Chap. 1.2)*.
5. Attach safety marking signs (these include: „Danger: batteries“, „Smoking prohibited“ and, for battery voltages >60 V, „Dangerous voltage“). Attach further marking signs according to local requirements.
6. Attach the safety notices *(see Chap. 0)*.
7. If necessary: Clean the batteries, the racks and the installation room.

Danger!

Never clean batteries using feather dusters or dry towels.
Danger of electrostatic charging and gas explosion. We recommend cleaning the batteries using damp cotton cloths or paper towels.

8. Connect the battery system to the charging rectifier/UPS using the end connections („plus to plus“ and „minus to minus“) and proceed as described in *Chap. 5.13*.

The connection cables between the end connections of the battery and the charging rectifier or UPS should be flexible conductors.
Inflexible wires could transfer vibrations, which could loosen the connection under certain circumstances.
The cables must be supported so that no mechanical load can be transferred to the connection terminals (cable trays, cable ducts, cable clamps).

5.12 Commissioning charge (initial charge)

Normally, by the time of installation, batteries are no longer fully charged. This applies especially to batteries that have been in storage for a long period of time *(see Chap. 4)*. In order to charge the cells to the optimum level as quickly as possible, you must first perform an initial charge. The initial charge (time-restricted) is a „boost charge“.

1. Familiarize yourself with the maximum voltage that the charge rectifier can deliver without damaging the peripherals.
2. Divide this maximum value by the number of battery cells (not batteries) connected in series. This is the maximum cell voltage for the initial charge.
3. Set the voltage so that average cell voltages are at a max. of 2.35V per cell. The initial charge can take up to 48 hours.

It is important for this initial charge to be carried out completely.
Avoid interruptions if at all possible.
Log the commissioning in the commissioning report *(see Inspection record)*.

4. During commissioning, measure the cell voltage of the pilot cells and after commissioning, measure the cell voltage and surface temperature of each cell and log this data in the commissioning report along with the time.

Danger!

The surface temperature must not exceed 55 °C. If necessary, the charge operation must be interrupted, till the temperature drops below 45 °C.

5.12.1 Commissioning charge with constant voltage (IU characteristic curve)

– A charge voltage of max. 2.35 V per cell is required.
– The max. charge current should not be higher than 20 A per 100 Ah C10.
– If the max. temperature of 55 °C is exceeded, the charge operation must be interrupted or
– you must temporarily switch to float charging to allow the temperature to drop.
– The end of commissioning charge is reached when the cell or bloc voltage no longer rises for a period of 2 hours.

5.12.2 Extended commissioning charge

Extended storage or climatic influences (humidity, temperature fluctuations) reduce the charging state of the cells. This makes an extended commissioning charge necessary.

Conduct the extended commissioning charge according to the following procedure:
1. Charge at 10 – 15 A per 100 Ah C10 until 2,35 V/cell is achieved (approx. 3–5 hours).
2. Charge at 2,35 V/cell until charging current has reached 1 A per 100 Ah.
3. Charge with 1 A per 100 Ah for 4 hours (cell voltage will exceed 2,35 V/cell).

6 Battery operation

DIN VDE 0510 Part 1 and EN 50272–2 apply for the operation of stationary battery systems.

Attention!

The recommended operating temperature for lead-acid batteries is between 10 °C and 30 °C. Technical data is valid for the nominal temperature of 20 °C. The ideal operating temperature range is 20 °C ±5 K. Higher temperatures shorten the service life of the battery. Lower temperatures decrease battery capacity. Exceeding the limit temperature of 55 °C is not permissible. Avoid operating at temperatures in excess of 45 °C for long periods of time.

6.1 Discharging

Attention!

Never allow the final discharge voltage of the battery to drop below the voltage corresponding to the discharge current.
Unless the manufacturer has specified otherwise, no more than the nominal capacity is to be discharged. Immediately after discharge (including partial discharge), charge the battery completely.

6.2 Charging - general

Depending on how the batteries are used, charging is to be carried out in the operating modes described in *Chap. 6.2.1* to *Chap. 6.2.4*.

Apply the charging procedure with limit values in accordance with DIN 41773 (IU characteristic curve).

Attention!

Superimposed alternating currents
Depending on the charger type and charging characteristic curve, alternating currents flow through the battery during charging and are superimposed onto the charging direct current. These superimposed alternating currents and the reaction of the loads lead to additional heating of the battery or batteries and create a cyclical strain on the electrodes. This might result in premature aging of the battery.

Attention!

After recharging and continuous charging (float charging) in standby parallel operation or floating operation, the effective value of the superimposed alternating current is not permitted to exceed 5 A per 100 Ah nominal capacity.
In order to achieve the optimum service life for sealed lead-acid batteries on float charge, a maximum effective value of the alternating current of 1 A per 100 Ah nominal capacity is recommended.

Attention!

Temperature-related adjustment of the charge voltage
Within the operating temperature range of 15 °C to 25 °C, temperature-related adjustment of the charge voltage is not necessary.
If the operating temperature is constantly outside this temperature range, the charge voltage must be adjusted.
The temperature correction factor is approx. -0.005 V/cell per K.

Temperature [°C]	-10	0	10	20	30	40
Charge voltage [V/Cell]	2.40	2.35	2.30	2.25	2.20	2.15

Tab. 6–1: Corrected charge voltage in relation to charge temperature for battery types with 2.25 V/cell float charge at T_{nom}

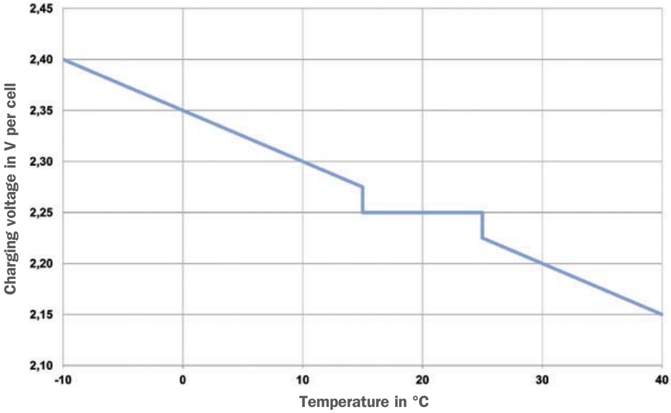


Fig. 6–1: Temperature related float charge voltage adjustment


Attention!

Maximum charge currents
Up to 2.4 V/cell the battery is able to absorb the maximum current the battery charger provides. Using the IU-characteristic according to the DIN 41773 a charging current of 5A to 20A per 100Ah rated capacity (C_{10}) is recommended.

6.2.1 Standby parallel operation

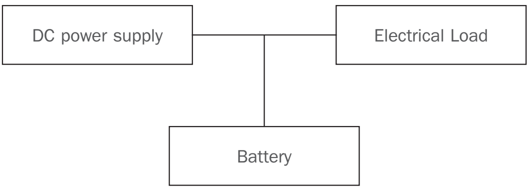


Fig. 6–2: Standby parallel operation

The following is characteristic for this operating mode:
– Consumers, direct current source and battery are connected in parallel.
– The charge voltage is the operating voltage of the battery and the system voltage at the same time.
– The direct current source (charging rectifier) is capable of supplying the maximum load current and the battery charge current at any time.
– The battery only supplies current when the direct current source fails.
– The charge voltage should be set at *(see Tab. 6–2)* x number of cells in series (measured at the battery's terminals).
– To reduce the recharging time, a charging stage can be applied in which the charge voltage is max 2,40 V x number of cells (standby parallel operation with recharging stage).
– Automatic changeover to the charge voltage of *(see Tab. 6-2)* x number of cells in series occurs after charging.

Battery type	Float charge voltage
OPzV	2.25 ± 1% V/cell
power.bloc OPzV	2.25 ± 1% V/cell
net.power 12 V 100 and 150 Ah	2.25 ± 1% V/cell
net.power 12 V 92 and 170 Ah	2.27 ± 1% V/cell
power.com XC	2.27 ± 1% V/cell
power.com SB	2.25 ± 1% V/cell
power.com HC	2.25 ± 1% V/cell
OPzV solar.power	2.25 ± 1% V/cell
OPzV bloc solar.power	2.25 ± 1% V/cell
solar.bloc	2.25 ± 1% V/cell

Tab. 6–2: Float charge voltage adjustment in standby parallel operaion

6.2.2 Floating operation

The following is characteristic for this operating mode:
- Consumers, direct current source and battery are connected in parallel.
- The charge voltage is the operating voltage of the battery and the system voltage at the same time.
- The direct current source is not able to supply the maximum load current at all times. The load current intermittently exceeds the nominal current of the direct current source. During this period the battery supplies power.
- The battery is not fully charged at all times.
- Therefore, depending on the number of discharges, the charge voltage must be set to approx. (2.27 to 2.30 V) x the number of cells connected in series.

6.2.3 Switch mode operation (charge/discharge operation)

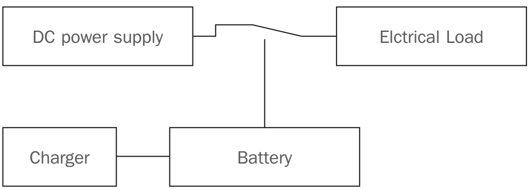


Fig. 6–3: Switch mode operation

The following is characteristic for this operating mode:
- When charging, the battery is separated from the consumer.
- The max. charge voltage of the battery is 2.4 V/cell.
- The charging process must be monitored.
- At 2.4 V/cell, if the charge current has dropped to 1.5 A per 100 Ah nominal capacity, you must switch to float charging as described in *Chap. 6.2.4.*
- The battery may be connected to the consumer if required.

6.2.4 Float charging

Float charging is used to keep the battery or batteries in a fully charged state and corresponds to a large extent to the charge type, mentioned in *chapter 6.2.1.*

Use a charger that complies with the specifications described in DIN 41773 (IU characteristic curve). Set the voltage so that average voltage is 2.25 V ±1 % (2.27 ±1 % for net.power 12 V 92/170 Ah and power.com XC).

6.2.5 Equalizing charge (correction charge)

Under normal circumstances equalizing charges are not required.
If there are unacceptably large discrepancies between the cell voltages of the individual cells at float charge *(see Tab. 6–3)*, an equalizing charge must be performed.
Equalizing charges are necessary after exhaustive discharges, after inadequate charging, if the cells have been held at non-uniform temperatures for long periods of time or if the voltage value of one or more cells has dropped below the critical threshold as specified in *Tab. 6–3* during operation.

Type			Float charge voltage	
OPzV, power.bloc OPzV, net.power 12 V 100 und 12 V 150Ah, power.com SB, power.com HC, OPzV solar.power, OPzV bloc solar.power, solar.bloc			2.25 ± 1%	
net.power 12 V 92 and 170 Ah, power.com XC			2.27 ± 1%	
Voltage per unit	**2 V**	**4 V**	**6 V**	**12 V**
Tolerance float charge voltage for single cells	-0.10 V/+0.20 V	-0.14 V/+0.28 V	-0.17 V/+0.35 V	-0.25 V/+0.50 V

Tab. 6–3: Float charge voltage

Attention!

As the max. permitted load voltage might be exceeded, it must be clarified in advance whether the loads can be disconnected for the duration of the equalizing charge.

Perform the equalizing charge as follows:

1. Charging with IU characteristic up to max. voltage U = 2.4 V/cell up to 48 hours. The charge current must not be higher than 20 A per 100 Ah nominal capacity.
2. If the maximum temperature exceeds 45 °C, terminate the charging process or switch to float charge to allow the temperature to drop.
3. The end of the equalizing charge is reached when the cell voltage do not rise for a period of 2 hours.

Required process for charging the batteries by achievement of max. storage duration:
Refer to *Chap. 4*.

Note that float charge voltages of lead-acid batteries with electrolytes fixed in gel can fluctuate significantly within the first four years after initial commissioning. The voltages range in an area between ca. 2.12 V/cells and 2.5 V/cell +/-1%. The black lines in *fig. 6-4* depict this area of float charge voltage for the first five years of battery service life. The exact development of the voltage values can not be determined in advance. *Fig. 6-4* depicts rather the trend of this typical behaviour and related reasonable alarm thresholds.
Background: The scattering of float charge voltages of gel batteries is a normal phenomenon and has no negative impact on the efficiency or capacity of the battery cells. This voltage scattering leads to a balanced internal gas recombination within the battrey string with the result of lower voltage differences and improved cell-internal oxygen and hydrogen recombination rates. This pro-

cess can neither be accelerated through cyclitzation of the battery, nor by raised charge voltages. The normal equalizing charge voltage leads optimally to a homogeneous gel structure and a high efficency of the battery over the entire service life.

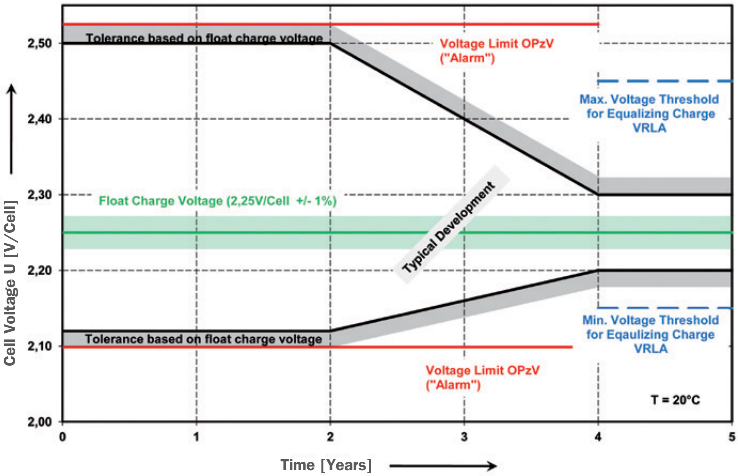


Fig. 6–4: Trend of float charge voltage over service life of gel batteries.

7 Settings for charging HOPPECKE OPzV solar.power batteries

This chapter contains instructions for charging of HOPPECKE OPzV solar.power battery cells and battery blocks in solar applications.

7.1 General Charging Characteristic

The chart below (refer to fig 7-1) demonstrates the OPzV solar.power recharge characteristic (IU-characteristic) after a discharge of 50% DoD (Depth of Discharge).

Parameters (example):

- Charging voltage: 2.4 V/cell
- Charging current: 10 A / 100 Ah battery capacity (C_{10}[1])
- Charging factor: 1.1 (110%)

The development of the state of charge (SoC) parameter is represented by the blue line; charging current by the red line and charging voltage by the green line. Although 100% SoC are reached after approx. 7 hours a total recharge time of 10 to 11 hours is needed in order to reach the charging factor (here 110%).

Charging shall generally be performed according to IU characteristic.

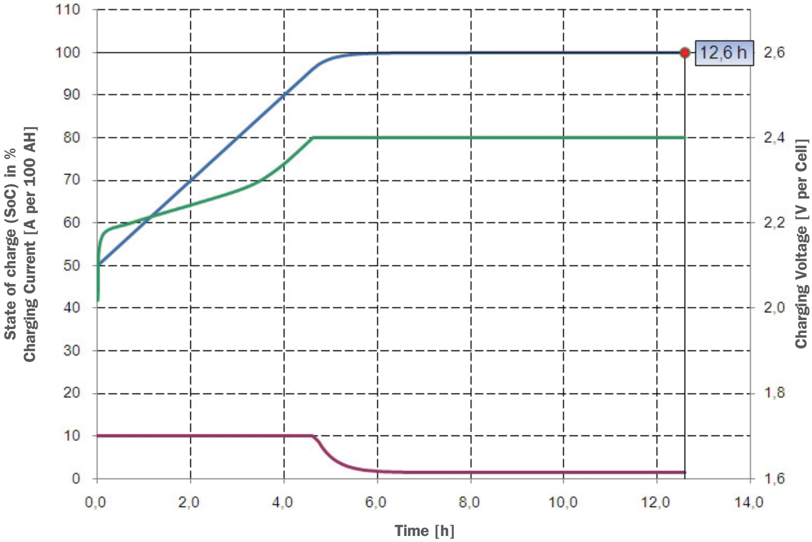


Fig. 7–1: Charging characteristic of OPzB solar.power cell at 50% DoD

7.2 General hints for battery charging in solar off-grid applications

Charging procedure shall be compliant to IU- or IUI_a – characteristic (refer to example fig. 7-1.). Recommended charging voltages for cyclical applications[2] are depicted in *fig. 7-2*.

7.3 Standard charge procedures

IU characteristic:

There are two variants which can be applied for regular recharge after every discharge:

1. Boost charge (charger equipped with two-stage controller): Charge with boost charge voltage *(refer to curve C in fig. 7-2)* for max. 2 hours per day. The charging voltage has to be reduced after max. 2 h in boost voltage stage *(refer to curve A in fig. 7-2)*. Charging current should range at 5 A to 20A3 per 100 Ah battery capacity (C_{10}). After the charging current has reached 1 A/100 Ah battery capacity (C_{10}) the charging voltage needs to be adjusted to normal float charge voltage for standby batteries as given in the HOPPECKE operating instructions (2.25 V/cell at temperature between 15 °C and 35 °C).
2. Charger without voltage switching
   Charge with standard charge voltage *(refer to curve B in fig. 7-2)*. Charging current should range at 5A to 20A3 per 100Ah battery capacity (C_{10}). After the charging current has reached 1A/100Ah battery capacity (C*10*) the charging voltage needs to be adjusted to normal float charge voltage for standby batteries as given in the HOPPECKE operating instructions (2.25 V/cell at temperature between 15 °C and 35 °C).

1) Available battery capacity depends on discharge current for lead acid batteries. This effect is caused by different material utilization.
2) Every battery discharge phase followed by a battery charge phase is referred to as a (battery) cycle.
3) The higher the charge current (in the range of 5A to 20A/100Ah) the shorter the required charging time.

IUI_a characteristic:
Charge with IU-characteristic as described above. Keep the charging current at 1 A/100 Ah nominal battery capacity (C_{10}) as soon as the current has dropped to this value during constant U-phase. During Ia phase the charging voltage should not exceed 2.8 V/C. I_a phase should last either 2 or 4 hours *(refer also to chapter 7.5)*.

7.4 Equalizing Charge

Equalizing charges are required after (deep) discharges with depth of discharge (DoD) of ≥ 80% and/or inadequate charges. They have to be executed as follows:
- Max. 2.4 V/Cell up to 48 hours *(refer to curve A in fig. 7-2)*.
- Charging current shall not exceed 20 A/100 Ah of nominal battery capacity (C_{10}).
- The cell/bloc temperature must never exceed 45 °C. If it does, stop charging or revert to float charge in order to allow temperature to fall.
- The end of equalization charge is reached when the cell voltages do not change during a period of 2 hours.

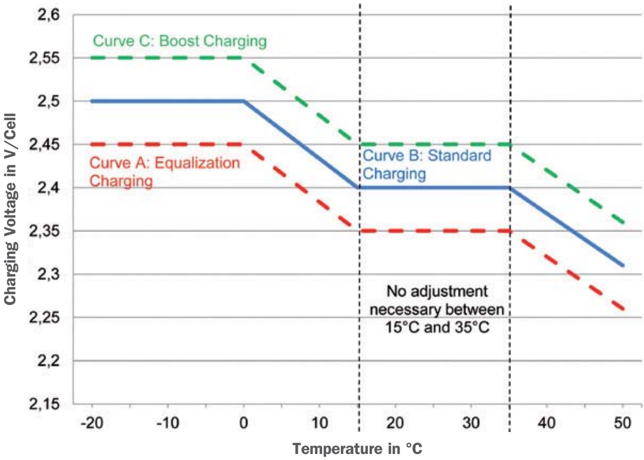


Fig. 7–2: Charging voltage as a function of temperature in solar cycling operation

7.5 Charging procedure for cyclic applications

HOPPECKE recommends battery recharging according to the following guideline:
1. After every discharge, recharge battery to at least 90% state of charge according to these figures:

Depth of Discharge (DoD)	2.4 V/C
15-50% DoD	Fig. *7–12*
55-100% DoD	Fig. *7–13*

2. After every 5 nominal throughputs, 10 cycles or 10 days (whatever occurs first), recharge battery with IUIa characteristic. I_a phase with I = 1 A/100 Ah nominal battery capacity (C_{10}) for two hours.
3. After every 10 nominal throughputs, 20 cycles or 20 days (whatever occurs first), recharge battery with IUIa characteristic. I_a phase with I = 1 A/100 Ah nominal battery capacity (C_{10}) for four hours.

The following figures depict examples for battery cycles:

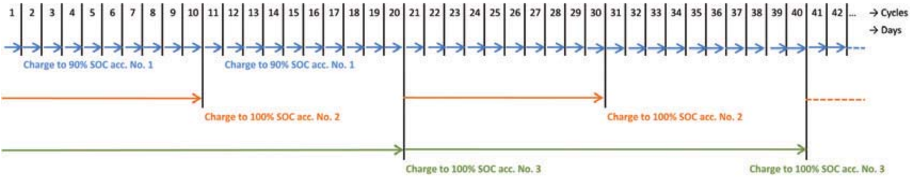


Fig. 7–3: One battery cycle per day

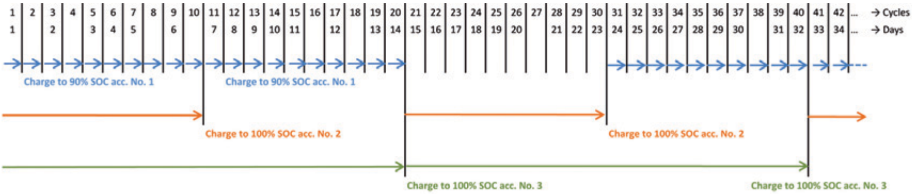


Fig. 7–4: Phase with more than one battery cycle per day

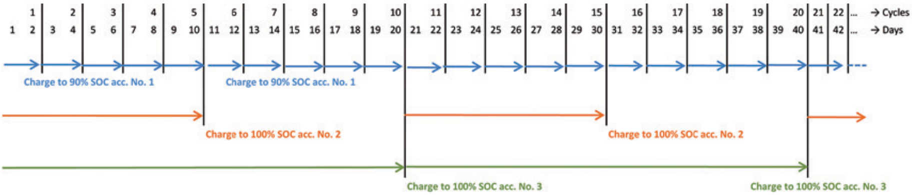


Fig. 7–5: Battery cycles ranging longer than one day

7.6 Charging currents

Recommended DC charging current range for boost and equalization mode is 5 to 20 A[4]/100 Ah nominal capacity (C_{10}).

7.7 Alternating currents

Depending on the charging equipment, its specification and its characteristics, superimposed alternating currents may contribute to battery charging current. Alternating currents and the corresponding reaction by the connected electrical loads may lead to an additional battery temperature increase, and – consequently - to a shortened battery service life as a result of stressed electrodes (micro cycling).
The alternating current must not exceed 1A (RMS) / 100 Ah nominal capacity.

4) The higher the charge current (in the range of 5 A to 20 A/100 Ah) the shorter the required charging time.

7.8 Temperature influence on battery performance and lifetime

7.8.1 Temperature influence on battery capacity

Battery capacity depends significantly on ambient temperature. Lead acid batteries loose capacity with decre-asing temperature and vice versa, as shown in *fig. 7-6*. This should be considered when sizing the battery.

Temperature range for OPzV solar.power batteries:

Possible temperature range: -20 °C to 45 °C
Recommend temperature range: 15 °C to 35 °C

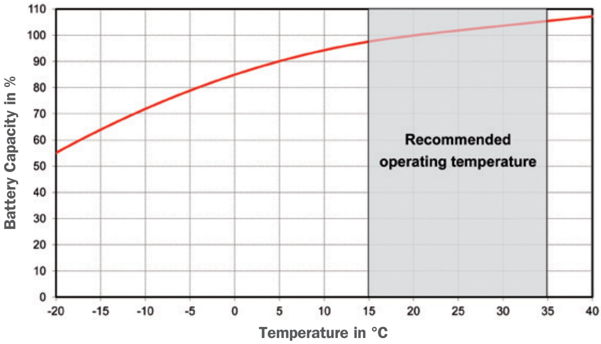


Fig. 7–6: OPzV solar.power: Dependency of battery capacity on temperature

7.8.2 Temperature influence on battery lifetime

As corrosion processes in lead acid batteries are significantly depending on battery temperature, the battery design lifetime is directly related to the ambient temperature.
As rule of thumb it can be stated that the speed of corrosion doubles per 10K increase (rule by Arrhenius). Thus battery service life will be halved in case the temperature rises by 10K.
The following graph *(refer to fig. 7-7)* shows this relationship. The diagram depicts operation in float charge mode. Additionally, the cycling lifetime has to be taken into account.

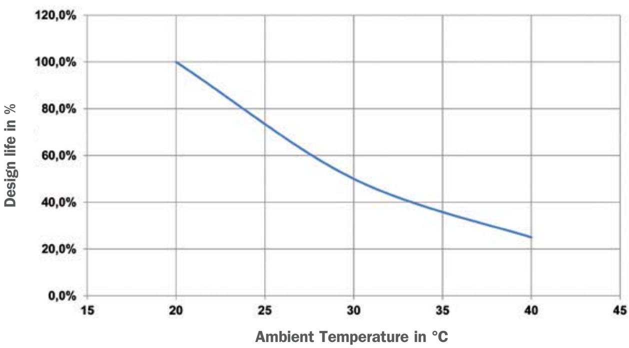


Fig. 7–7: Design life of OPzV solar.power cell as a function of ambient temperature (standby application in float charge operation with 2.25 V/cell)

7.9 Influence of cycling on battery behavior

7.9.1 Cycle life time depending on depth of discharge

Cycle lifetime is defined as number of discharging and charging cycles until the actual remaining battery capacity drops below 80% of the nominal capacity (C_{10}). The cycle lifetime of a lead acid battery is directly depending on the regular depth of discharge (DoD) during these cycles. Depending on different types of batteries and the design of the plates and electrodes, the cycle lifetime may vary significantly.
The following chart *(refer to fig. 7-8)* shows the cycling behavior of a HOPPECKE OPzV solar.power under ideal operating conditions. The cycle life refers to one discharge per day. Cycle life cannot exceed stated service life under float charge conditions.

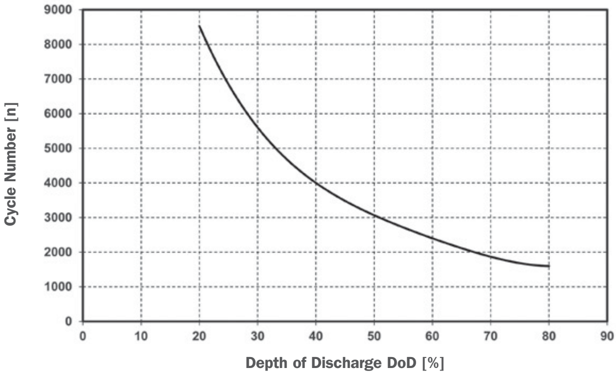


Fig. 7–8: Cycle lifetime of OPzV solar.power as a function of DoD (at 20°C)

7.9.2 Cycle life time depending on ambient temperature

Since design life mainly depends on temperature, the cycle lifetime is affected by temperature as well. *Fig. 7-9* depicts this relation for a regular battery depth of discharge of 80%.

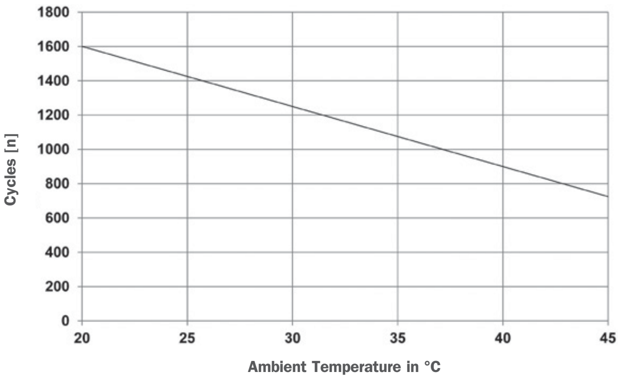


Fig. 7–9: Cycle lifetime of OPzV solar.power as a function of ambient temperature

The following figure depicts dependency of cycle life on depth of discharge and temperature.

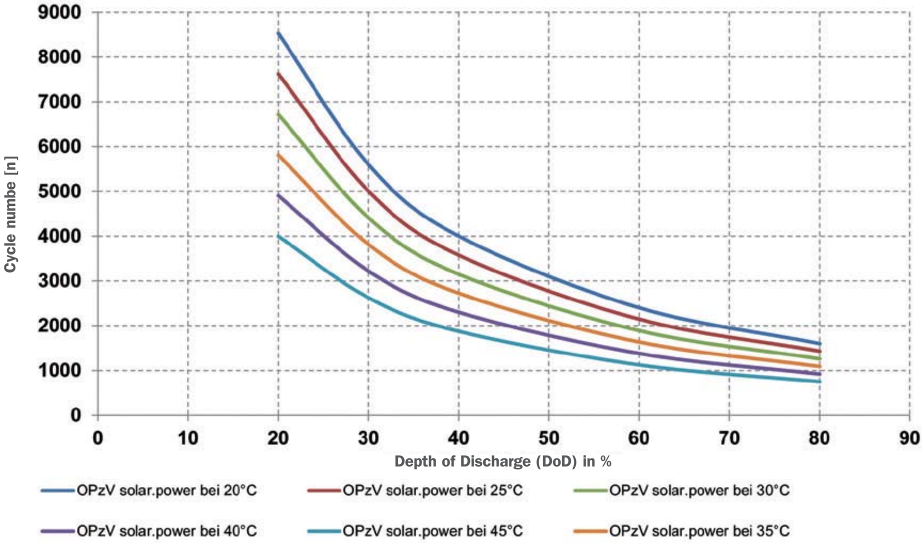


Fig. 7–10: Cycle lifetime of OPzV solar power depending on DoD and temperature

7.9.3 Electrolyte freezing point depending on depth of discharge (DoD)

The freezing point of the electrolyte (sulfuric acid) rises with increasing depth of discharge.
In case the battery is exposed to cold ambient temperatures (< 0°C) the maximum depth of discharge has to be decreased in order to avoid electrolyte freezing and potential damages of the cell jar. *Fig. 7-11* shows an example for this relation. Example: If depth of discharge is below 60% the operating temperature must not be below -23.4 °C.

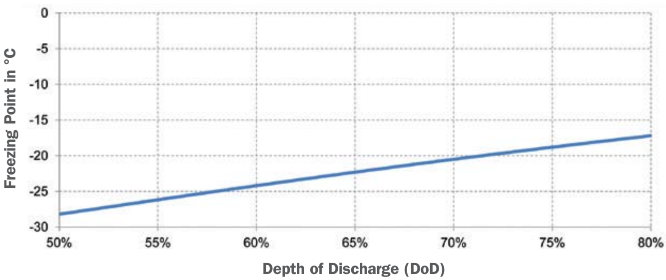


Fig. 7–11: Electrolyte freezing point as a function of depth of discharge (DoD)

7.10 Remarks to warranty management

Above mentioned information about battery performance and lifetime, particularly concerning the charging procedure and the influence of temperature and cycling, affect terms of warranty as well.
In case of a warranty claim the customer / battery operator needs to prove the compliance of above mentioned parameters with the allowed / recommended limits. Corresponding measurement logs have to be sent to the battery manufacturer. These protocols shall clearly demonstrate that the lifetime of the affected battery has not been shortened by the application and associated parameters.
The expected service life mentioned by the battery manufacturer is valid for operation under optimal conditions only. Therefore, it is not possible to solely derive warranty claims from information on the expected service life provided by the manufacturer.

For special demanding operational conditions as well as for solar and off-grid applications the expected battery service lifetime is heavily influenced by above mentioned operational conditions. In order to decide whether a battery failure was caused by manufacturing defects or operational conditions, above mentioned parameters need to be monitored and registered on a regular basis. These data have to be forwarded to the manufacturer for further analysis.

HOPPECKE recommends the usage of a battery monitoring system for monitoring and logging of critical data. Please contact your local HOPPECKE representative for information on HOPPECKE battery monitoring equipment and accessories.

7.11 Recharge-time diagrams

The following diagrams depict approximately necessary recharge times with IU-characteristic as a result of the maximum possible charging current and the actual depth of discharge (DoD) at begin of the recharge phase.

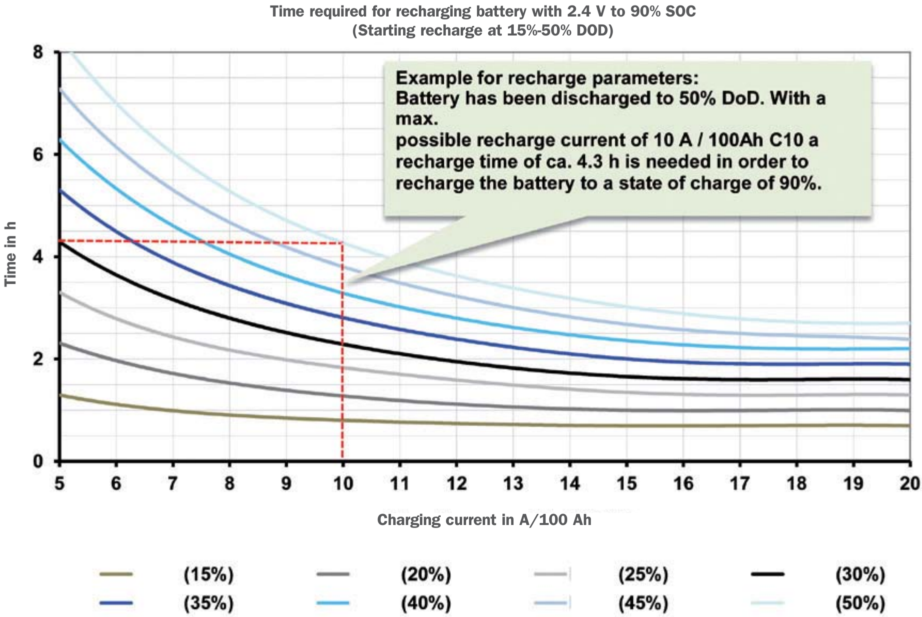


Fig. 7–12: Recharge after every discharge (starting between 15% and 50% DoD)

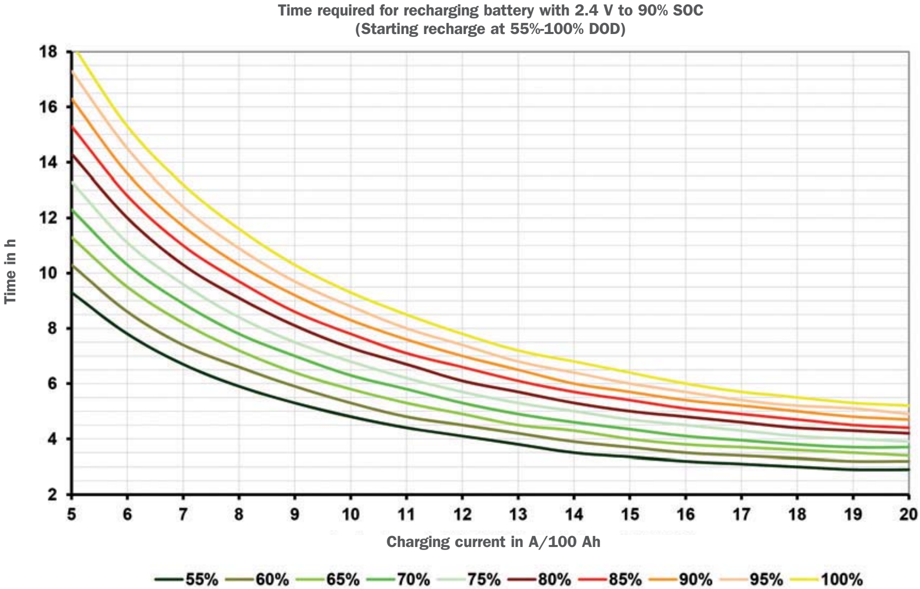


Fig. 7–13: Recharge after every discharge (starting between 55% and 100% DoD)

8 Battery maintenance

To ensure the reliability and longevity of your battery system, regular maintenance is required. Document the type and scope of maintenance work performed as thoroughly as possible. These records can be very helpful if troubleshooting is required and are a prerequisite for making warranty claims.

8.1 Work to be performed every six months

Take the following measurements and record the measurement values:
1. Voltage of the complete battery system.
2. Individual voltage of selected cells or monobloc batteries.
3. Surface temperature of selected cells or monobloc batteries.
4. Temperature in battery room.

If the cell voltage deviates from the average float charge voltage by more than +0.2 V/cell or -0.1 V/cell and/or if the surface temperature of various cells or monobloc batteries differs by more than 5 K, contact customer service.
Also note specifics of lead-acid batteries with electrolytes, fixed in gel. *(see chapter 6.2.5)*

8.2 Work to be performed annually

Take the following measurements and record the measurement values:
1. Voltage of the complete battery system.
2. Individual voltage of **all** cells or monobloc batteries.
3. Surface temperature of **all** cells or monobloc batteries.
4. Temperature in battery room.
5. Perform a visual check of **all** screwed connectors.
6. Check **all** screwed connectors to make sure that they are firmly secured.
7. Visual check of battery racks or battery cabinets.
8. Check to make sure that the battery room is properly ventilated and deaerated.

HOPPECKE recommends the use of a stationary battery monitoring system for the inspection of relevant data. Please contact your local HOPPECKE representative for further information.

8.3 Cleaning of the battery

Danger!

Cleaning the batteries on a regular basis is necessary to maintain battery availability and to meet accident prevention regulations.
Batteries should be cleaned at least once per year. Note the following points:
- While cleaning the batteries you must wear safety goggles and saftey clothes. To avoid electrostatic charges while handling the batteries your clothes, safety shoes and saftey gloves must have a surface resistance of <= 10^80 hm.

Danger!

– Do not use dry cleaning cloth!

– Plastic parts of the batteries, especially the cell container, have to be cleaned with water or water moistened cleaning cloth without additives.
- After cleaning the battery surface has to be dried with apporiate measures, like moist antistatic cleaning cloth (e.g. cotton).

9 Testing the battery system

9.1 Performing the capacity test (short form)

For tests, proceed as directed in EN 60896-21: „Stationary lead acid batteries - Part 21: Valve regulated types - Methods of test“ (IEC 60896-21:2004).
In addition, note special test instructions, e.g. in accordance with DIN VDE 0100–710 and DIN VDE 0100–718.

The following is the short form of the procedure for testing the actual capacity of your battery system. Also observe all instructions in *Chap. 9.2*.

We recommend performing an equalizing charge on the battery system (as described in Chap. 6.2.5) before performing this test.
Perform the equalizing charge no more than 7 days in advance and no less than 3 days in advance!

1. Make sure that all connections are clean, secure and noncorroded.
2. During normal battery operation, measure and record the following parameters:
   – Individual voltage of all cells or monobloc batteries.
   – Surface temperature of at least one out of every ten cells or monobloc batteries.
   – Voltage of the complete battery system.
3. Interrupt the connection between the battery system that you wish to test and the charger and all consumers.
4. Prepare an adjustable load that you can connect to the battery system. The load current must correspond to the maximum permitted current for which the battery is designed.
5. Prepare a shunt that you can connect in series with the load.
6. Prepare the voltmeter so that you can test the total voltage of the battery.
7. Connect the load, the shunt and the voltmeter. Simultaneously start a time measurement.
8. Keep the load current constant and measure the voltage of the battery system in regular time intervals.
9. Check the row connectors (block connectors), step connectors and tier connectors for excessive heating.
10. Calculate the capacity of the battery system using the following formula:
    Capacity (% at 20°C) = (T_a/T_s) x 100
    T_a = actual discharge time until the permitted minimum voltage is reached.
    T_s = theoretical discharge time until the permitted minimum voltage is reached.
11. Reconnect the battery system as originally connected and perform a boost charge *(see Chap. 5.13)*.

9.2 Performing the capacity test (extended version)

Preparation
The best and quickest method for preparing batteries for testing is the IU charge method, also used for equalizing charges. Because it is possible to exceed the permitted load voltages, appropriate measures must be taken, e.g. disconnection of the consumers.
The IU characteristic curve with increased voltage (2.33 - 2.40 V) x number of cells is the most common charging characteristic used for commissioning the batteries.
The charge is performed with a constant voltage of max. 2.40 V/cell for up to 48 hours. The charge current should not be higher than 20 A per 100 Ah nominal capacity. If the elcetrolyte temperature of the cells/blocs exceeds the maximum of 45°C, terminate the charge or switch to float charge to allow the temperature to drop.

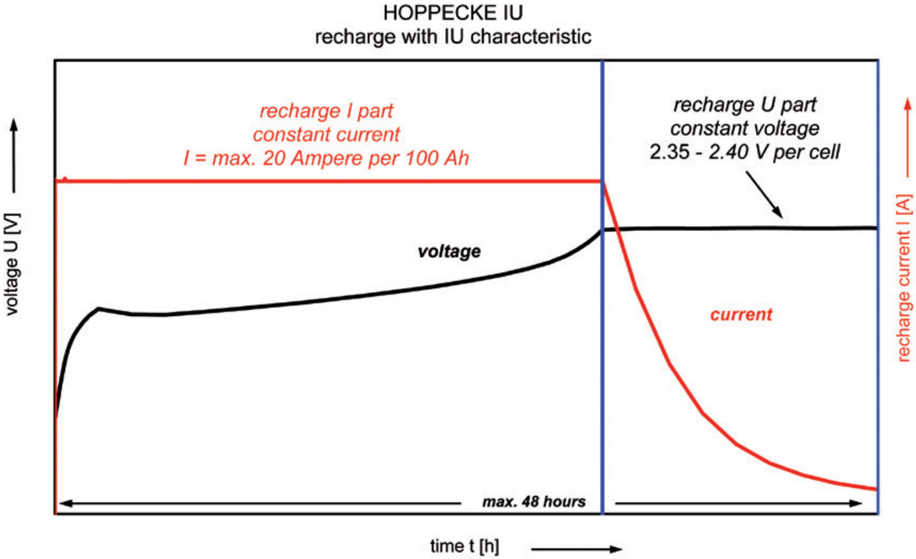


Fig. 9–1: IU characteristic

The IUIa charging method is an even better method for preparing the batteries; it is a charge with an additional constant current at the end of the charging. In contrast to the charge with constant voltage, in the last step, after IU charging, a constant charge current with 1.2 A per 100 Ah is applied for 3 hours. The charge voltage can then increase up to 2.65 V per cell.

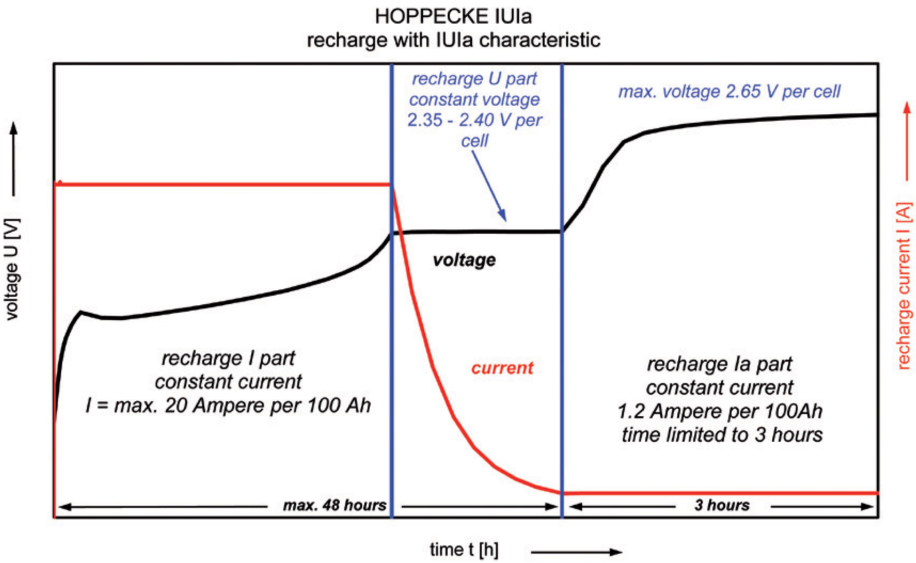


Fig. 9–2: IUIa characteristic

Note that an increased proportion of hydrogen is produced and that the battery room must be provided with sufficient ventilation.
While charging up to 2.40 V, the effective value of the superimposed alternating current is permitted to reach up to 10 A per 100 Ah nominal capacity (for a short time up to 20 A/100 Ah nominal capacity).
After recharging and continuous charging (float charging) in standby parallel operation or floating operation, the effective value of the superimposed alternating current is not permitted to exceed 5 A per 100 Ah nominal capacity.
Depending on storage time and storage conditions, the battery may require an additional charge for commissioning.
The battery is completely charged when the voltage and the charge current no longer change within a period of 2 hours.

9.3 Capacity test of the battery

Necessary accessories:

– Suitable electronic load or electrical resistance (with adjustable resistance value to adjust the discharge current or discharge load).
– Suitable current probe with sufficient precision for measuring the DC current or shunt for measuring the discharge current.
– Voltage measuring device for measuring the electrical voltage.
– Thermometer for measuring the battery temperature (surface temperature).
– Clock for measuring the discharge time.
– Project planning data table for selecting the correct discharge current or the correct discharge power.

Carry out the battery discharge in accordance with the regulations on performing capacity tests EN 60896–21. The discharge current and the discharge power are selected according to the project planning data tables up to a given final discharge voltage and the given potential of the existing loads.

Minimum precision requirements for the measuring devices (precision class):

For voltage measurement:	0.5
For current measurement:	0.5
For temperature measurement:	1 °C
For time measurement:	1%

Tab 9-1: Precision requirements for the measuring devices

During the capacity test, record the discharge current or discharge power, temperature, battery and cell-/block-voltage and discharge time at intervals of 10% of the discharge time. At least, record these values at 10 %, 50%, 80% and 95% of the discharge time.
Terminate the discharge when the battery voltage has reached the value n x U_f where n is the number of cells and U_f is the selected final discharge voltage per cell.
Also terminate the discharge when a cell has reached a voltage of $U = U_f$ – 200mV or a monobloc battery with n cells has reached a voltage of $U = U_f - \sqrt{n} \times 200$mV.

Example:
13 cells 6 OPzV 300
5 h - capacity test
End voltage of the battery = 23.40 V (for 13 cells)
Average voltage per cell = 1.80 V
minimum end voltage of individual cells = 1.60 V

Cell numer	Case A	Case B	Case C
1	1.84	1.84	1.79
2	1.83	1.86	1.80
3	1.83	1.87	1.81
4	1.84	1.87	1.80
5	1.84	1.86	1.81
6	1.85	1.86	1.79
7	1.69	1.87	1.78
8	1.84	1.86	1.80
9	1.83	1.59	1.81
10	1.85	1.84	1.81
11	1.84	1.85	1.80
12	1.84	1.85	1.79
13	1.85	1.85	1.79
Battery voltage	23.77 V	23.87 V	23.38 V

Tab 9-2: Measured cell voltages and total voltage after 95% of the discharge time has elapsed

Case A: a „weak cell," passed capacity test, battery okay
Case B: a faulty cell, failed capacity test, battery not okay
Case C: all cells okay, failed capacity test, battery not okay.

The battery must be charged immediately following the capacity test.
The measured capacity C (Ah) at the average start temperature ϑ is calculated as a product of the discharge current (in A) and the discharge time (in hours).
As the battery capacity is dependent on the temperature, the measured battery capacity needs to adjusted for temperature.
At temperatures higher than 20 °C nominal temperature, the battery capacity increases whereas the capacity decreases at lower temperatures. If the average start temperature ϑ deviates 20 °C from the reference temperature, the capacity must be corrected.
The start temperature is used to carry out the temperature correction in accordance with the standard DIN EN 60896-21 using the equation [1]:

$$C_a = \frac{C}{1 + \lambda\,(\vartheta - 20\,°C)} \qquad [1]$$

C = measured capacity
λ = correction factor (with $\lambda = 0.006$ for discharges >3 h and $\lambda = 0{,}01$ for discharges ≤ 3 h)
ϑ = start temperature
C_a = corrected capacity

According to the DIN EN 60896-21 standard, the battery has passed the capacity test when 95% of the required power is attained in the first capacity test. After the 5th discharge, 100% of the required power must be attained.
After discharging, a log must be made *(see Inspection record)*.

Attention!

When handling batteries (e.g. performing capacity tests) you must observe the safety requirements in accordance with DIN EN 50272 Part 2 (insulated tools, protective eyewear, protective clothing, gloves, ventilation, etc.)!

10 Troubleshooting

If malfunctions occur in the battery or charger, contact customer service immediately.
Measured data as described in Chap. 8.1 simplifies fault detection and elimination.
A service contract with us facilitates the timely detection of faults.

11 Required ventilation for hydrogen generated by batteries

Compliance with VDE 0510 Part 2 or DIN EN 50272 Part 2 is required to ensure safe ventilation and prevent dangerous mixtures of hydrogen and oxygen gases (hydrogen approx. 4 %).
Two values form the basis of the equation: the maximum permissible hydrogen concentration in the air is 4 % and the safety factor is 5. The equation can be derived accordingly:

$$v = \frac{100\% - 4\%}{4\%}$$ (Attenuation factor at maximum permissible hydrogen concentration)

$$q = 0{,}42 \times 10^{-3} \frac{m^3}{Ah}$$ (Quantiy of accumulated hydrogen per actual Ah capacity)

$$s = 5$$ (safety factor)

$$v \times q \times s = 0{,}05 \frac{m^3}{Ah}$$

This results in the total equation for the necessary ventilation in [in m³/h]:

Q_{air} = 0.05 x n x I_{gas} x C_N x 10^{-3}
I_{gas} = $I_{float} \times f_g \times f_s$ resp. $I_{gas} = I_{boost} \times f_g \times f_s$
Q_{air} = Necessary ventilation/air flow rate [in m^3/h]
n = Number of cells
I_{float} = Proportion of charge current in mA/Ah used for water dissociation on float charge per 1 Ah nominal capacity of the battery. = 1 mA/Ah
I_{boost} = Proportion of charge current in mA/Ah used for water dissociation on boost charge per 1 Ah nominal capacity of the battery. = 8 mA/Ah
C_N = Nominal capacity of the battery (C_{10} capacity).
f_g = Gas emissions factor. Proportion of the charge current responsible for hydrogen accumulation. = 0.2
f_s = Safety factor which includes the potential for faults resulting from a damaged cell (possible short circuit) and battery aging. = 5

Example 1:
A battery with 2 x 60 V (60 V nominal voltage), 4 OPzV 200 (200 Ah) is equivalent to 2 x 30 cells. The battery is on float charge at 2.25 V per cell.

C_N = Nominal capacity of the battery = 200 Ah
n = Number of cells = 2 x 30 cells
f_g = Gas emissions factor = 0.2
f_s = Safety factor = 5
I_{float} = 1 mA/Ah

$$Q_{air} = 0.05 \frac{m^3}{Ah} \times 2 \times 30 \text{ Cells} \times 1 \frac{mA}{Ah} \times 200 \text{ Ah} \times 1 \times 5 \times 0.2 \times 10^{-3}$$

$$Q_{air} = 0.6 \frac{m^3}{Ah}$$

Result: For a 60 V battery composed of 2 x 30 cells 4 OPzV 200 operating on float charge, an airflow of 0.6 m^3/h is required for proper ventilation.

What is the appropriate diameter for intake and exhaust openings with natural ventilation?
The necessary cross-section for ventilation openings can be calculated using the following formula:

$A = Q_{air} \times 28$

Q_{air} = Necessary ventilation [in m^3/h]

A = Necessary cross-section for ventilation openings [in cm^2]

$$A = 0.6 \frac{m^3}{h} \times 28 = 16.8 \text{ cm}^2$$

Result: Ventilation openings (intake and exhaust) with a cross-section of **16.8 cm^2** ensure ventilation with an airflow of 0.6 m^3/h.

What factors must be considered when installing a natural ventilation system?
If possible, the ventilation openings should be positioned on opposite walls. If they must both be on the same wall, make sure to maintain a distance of at least 2 m between the openings.

Inspection protocol

Battery/Number of the battery:	Oder number:
Checked by:	Department:
Equipment of testing:	Date:

Entladezeit [Min]																	
Entladestrom I [A]																	
Entladeleistung P [W]																	
Temperatur T [°C]																	
Gesamtspannung der Batterie U [V]																	

Nr.	Factory number	Cell voltage U [V] /block voltage U [V]																
01																		
02																		
03																		
04																		
05																		
06																		
07																		
08																		
09																		
10																		
11																		
12																		
13																		
14																		
15																		
16																		
17																		
18																		

ZVEI: Batterien

ZVEI information leaflet No. 1e
Edition September 2012

Instructions for the safe handling of lead-acid accumulators (lead-acid batteries)

The REACH-regulation (1907 /2006/EC) has replaced the directive on safety data sheets (91/155/EC). REACH describes the setting up and updating of safety data sheets for substances and preparations. For articles – like lead-acid batteries – safety data sheets are not required.

This leaflet addresses manufacturers of batteries and is meant to apply voluntarily.

The notes are meant to help to comply with legal requirements but do not replace them.

1. Substances / formulation and company name

Data on the product
Trade name

Lead-acid battery filled with diluted sulphuric acid

Data on the manufacturer:

Telephone:
Facsimile:

2. Hazardous substances

CAS-No.	Description	Content	R-phrases
7439-92-1	blue lead		–
7439-92-1	lead alloys with traces of As,Sb	34 Weight %	–
	lead-containing Battery paste	31 Weight %	R 61-20/22-33-62-52/53
7664-93-9	sulphuric acid	34 Weight %	R 35

3. Potential hazards

No hazards in case of an intact battery and observation of the instructions for use.

Lead-acid batteries have significant characteristics:

- They contain diluted sulphuric acid, which may cause servere acid burns.
- During the Charging process they develop hydrogen gas and oxygen, which unter certain circumstances may turn into an explosive mixture.
- They have an internal voltage, which – depending on their level – can be dangerous to the human body when touched.
- Standard EN 50272-2 includes safety requirements for batteries and battery installations and describes the basic precautions to protect against dangers deriving from electric currents, leaking gases or electrolytes.

This leaflet was prepared by the Working Group on Environment and Occupational Health of the ZVEI – German Electrical and Electronic Manufacturer's Association

Batteries are marked with the following hazard symbols:

The meaning of the hazard symbols is:


No smoking, no open flames, no sparks.


Wear safety goggles.


Sulphuric acid.


Observe operating instructions.


Explosive gas mixture.

4. First-aid measures

General Information:

Sulphuric acid	acts corrosive and damages tissue
after contact with skin	rinse with water, remove and wash wetted clothing
after inhalation of acid mist)*	inhale fresh air
after contact with the eyes)*	rinse under running water for serveral minutes
after swallowing)*	drink a lot of water immediately, and swallow activated carbon
Lead-containing battery paste	classified as toxic for reproduction
after contact with skin	clean with water and soap

***) seek the advice of a doctor.**

5. Fire-fighting measures

Suitable extinguishing agents
When electrical devices are set in fire in general water is the suitable extinguishing agent. For incipient fires CO_2 is the most effective agent. Fire brigades are trained to keep a distance of 1 m when extinguishing an electrical fire (up to 1 kV) with spray jet and a distance of 5 m with full jet. For electrical fires in electrical installations with voltages > 1 kV other distances are applicable depending on the respective voltage. For fires in photovoltaic installations other rules apply.

Unsuitable extinguishing agents
Powder fire extinguishers are not suitable, amongst others because of only minor efficiency, possible risks or collateral damages.

Special protective equipment
For larger stationary battery installations or larger stored quantities: protective goggles, respiratory and acid protective equipment, acid-proof clothing.

6. Measures to be taken in case of unintentional release

Cleaning / take-up procedures

Use a bonding agent, such as sand, to absorb split acid;

Use lime / sodium carbonate for neutralisation; dispose with due regard to the official local regulations, do not permit penetration into the sewage system, the earth or water bodies.

7. Handling and storage

Store frost-free under roof; prevent short circuits.

Protect plastic housings against exposition to direct sun radiation.

Seek agreement with local water authorities in case of larger quantities.

If batteries have to be stored in storage rooms, it is imperative that the instructions for use are observed.

8. Exposure limits and personal protective equipments

8.1 No exposure caused by lead and lead-containing battery paste.

8.2 Possible exposure caused by sulphuric acid and acid mist during filling and charging.

CAS-Nr.	7664-93-9	
R-phrases	R – 35	Causes severe burns.
S-phrases	S – 1/2	Keep looked up and out of reach of children.
	S – 26	In case of contact with eyes rinse immediately with plenty water and seek medical advice.
	S – 30	Never add water to this product (applies for concentrated acid only
	S – 45	In case of accident or if you feel unwell seek medical advice immediately (show the label where possible)
Threshold value on workplace	0,1 mg/m^3 *)	
Hazard symbol		C, corrosive
Personal protective equipment: Rubber, PVC gloves, acid-proof goggles, acid-proof clothing, safety boots.		

[3)] *0,5 mg/m3 at the lead battery production.*

9. Physical and chemical properties

Lead
Appearance:
form: solid
colour: grey
odour: odourless

Safety-related data
Solidification point: 327 ˚C
Boiling point: 1740 ˚C
Solubility in water (25 ˚C): low (0,15 mg/l)
density (20˚C): 11,35 g/cm^3
vapour pressure (20 ˚C)

Sulphuric acid (30 – 38,5 %)
form: liquid
colour: colourless
odour: odourless

Solidification point: – 35 bis – 60˚C
Boiling point: ca. 108 – 114 ˚C
Solubility in water (25 ˚C): complete
density (20 ˚C): 1,2 – 1,3 g/cm^3
vapour pressure (20 ˚C)

10. Stability and reactivity of sulphuric acid (30 to 38,5%)

- Corrosive, inflammable liquid.
- Thermal decomposition at 338 ˚C.
- Destroys organic materials such as cardboard, wood, textiles.
- Reacts with metals producing hydrogen.
- Vigorous reactions with lyes and alkalis.

11. Data on toxicology of the constituents

Sulphuric acid
acts intensely corrosive on skin and mucous membranes. The inhalations of mists may cause damage to the respiratory tract.

Lead and lead-containing battery paste
may cause damage to the blood, nerves, and kidneys when taken in. Lead-containing battery paste is classified as toxic for reproduction.

12. Data on the ecology of the constituents

Preliminary remark:
Relevant only if release is caused by destruction of the battery

Sulphuric acid
Water-polluting liquid within the meaning of the German Water-Resources Act (WHG) Water pollution class: 1 (mildly water polluting).

As described in section 6 use a bonding agent, such as sand, to absorb spilled acid or neutralise using lime / sodium carbonate. Dispose of under the locally applicable provisions.

Dispose with due regard to official local regulations,

Do not allow progression into the sewage system, soil or bodies of water.

Lead and lead-containing battery paste
are hardly soluble in water.

Lead can be dissolved in an acidic or alkaline environment. Chemical and physical treatment is required for elimination from water. Waste water containing lead must not be disposed of in untreated condition.

13. Recycling information

The points of sale, the manufacturers and importers of batteries, respectively the metal dealers take back dead batteries, and render them to the secondary lead smelters for processing.

Spent lead-acid batteries are not subject to accountability of the German Waste Prove Ordinance. They are marked with the recycling / return symbol and with a crossed-out roller container (cf. chapter 15 "Marking").

Spent lead-acid batteries are not allowed to be mixed with other batteries in order not to compliance the processing.

By no means may the electrolyte, the diluted sulphuric acid, be emptied in an inexpert manner. This process is to be carried out by the processing companies.

14. Transport instructions

14.1 Batteries, wet, filled with acid

Land transportation according to ADR/RID

- Special Provision 598: **no transport as dangerous goods** (new + spent batteries are not subject to other requirements of ADR/RID if they meet the requirements according to Special Provision 598)
- If the requirements of Special Provision 598 are not fulfilled the transport of new and spent batteries has **to be declared as dangerous goods** as follows:
- Hazard class: 8
- UN-no.: 2794
- Naming and description: BATTERIES, WET, FILLED WITH ACID
- Packing group: none
- Hazard label: 8
- ADR Tunnel restriction code: E

Sea transportation according to IMDG Code

- Hazard class: 8
- UN-no.: 2794
- Proper shipping name: BATTERIES, WET, FILLED WITH ACID
- Packaging group: none
- EmS: F-A, S-B
- Packaging Instruction: P 801
- Hazard label: 8

Air transportation according to IATA-DGR

- Class: 8
- UN-no.: 2794
- Proper shipping name: BATTERIES, WET, FILLED WITH ACID
- Hazard class: 8
- Packaging Instruction: 870

14.2 Batteries, wet, non-spillable

Land transportation according to ADR/RID

- Un-no.: 2800
- Hazard class: 8
- Proper shipping name: BATTERIES, WET, NON-SPILLABLE
- Packing group: none
- Packaging Instruction: P 003
- Hazard label: 8
- Special Provision 238 para. a) + b): **no transport as dangerous goods** (non-spillable batteries are not subject to other requirements of ADR/RID if they meet the requirements according to special provision 238. **An appropriate manufacturer`s confirmation is necessary.** Batteries which do not meet the requirements according to Special Provision 238 have to be packed and carried as listed in 14.1 Land transportation ADR/RID according to Special Provision 598.)

Sea transportation according to IMDG Code

- Hazard class: 8
- UN-no.: 2800
- Proper shipping name: BATTERIES, WET, NON-SPILLABLE
- Packing group: none
- Packaging Instructions: P 003 and PP 16
- Hazard label: 8
- EmS: F-A, S-B
- Special Provision 238 no. 1 + 2: **no transport as dangerous goods** (non-spillable batteries are not subject to other requirements of IMDG Code if they meet the requirements according to Special Provision 238. **An appropriate manufacturer`s confirmation is necessary.** Batteries which do not meet the requirements according to Special Provision 238 have to be packed as listed in 14.1 Sea transportation IMDG Code according to Packaging Instruction P 801 and carried as dangerous goods according to UN 2794.)

Air transportation according to IATA DGR

- Hazard class: 8
- UN-no.: 2800
- Proper shipping name: BATTERIES, WET, NON-SPILLABLE
- Packing group: none
- Packaging Instruction: 872
- Hazard label: 8
- Special Provision A 67: **no transport as dangerous goods** (non-spillable batteries are not subject to other requirements of IATA DGR if they meet the requirements of Special Provision A 67. Provided that poles are secured against short-circuit. **An appropriate manufacturer`s confirmation is necessary.** Batteries which do not meet the requirements according to Special Provision A 67 have to be packed as listed in 14.1 Air transportation IATA-DGR according to Packing Instruction 870 and carried as dangerous goods according to UN 2794.)

14.3 Batteries, damaged:

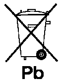
Land transportation according to ADR/RID

- Hazard class: 8
- UN-no.: 2794
- Proper shipping name: BATTERIES, WET, FILLED WITH ACID
- Packing group: none

- Packing Instruction P 801 a: **transport as dangerous goods** (packing in accu boxes)
  or Special Provision VV 14: **transport as dangerous goods** (in bulk)
- Hazard label: 8
- ADR Tunnel restriction code: E
- Note: these references can be applied by transportation of Lead-acid batteries of UN-no. 2800 as well.

15. Marking

In accordance with the German law governing the sale, return and environmentally sound disposal of batteries and secondary cells (Batteries Act – Batteriegesetz, BattG) from 25 June 2009 (national transposition of directive 2006/66/EC (battery directive) lead-acid batteries have to be marked with a crossed-out wheelie bin with the chemical symbol for lead Pb shown below.



In addition, the ISO-return / recycling symbol is rendered.

The manufacturer, respectively the importer of the batteries shall be responsible for the attachment of the symbols. In addition, a consumer / user information on the significance of the symbols has to be attached, which is required by the German Battery Ordinance quoted above as well as by the voluntary agreement of the battery manufactures concluded with the German Federal Minister of the Environment in September 1988.

The manufactures and sellers of the batteries subject to identification requirements (packaging, technical instructions, leaflets) shall be responsible for this information.

16. Other information

The data rendered above are based on today's knowledge, and do not constitute an assurance op properties. Existing laws and regulations have to be observed by the recipient pf the product in own responsibility.

ZVEI: Batterien

Editor:
ZVEI – Zentralverband Elektrotechnik- und Elektronikindustrie e. V.
Fachverband Batterien
Lyoner Straße 9
60528 Frankfurt

Fon.: +49 69 6302-283
Fax: +49 69 6302-362
Mail: batterien@zvei.org

Fachverband Batterien
Postfach 70 12 61
60591 Frankfurt am Main

Lyoner Straße 9
60528 Frankfurt am Main

Tel.: (0 69) 63 02-209
Fax: (0 69) 63 02-279
e-mail: batterien@zvei.org

Information Leaflet

Safety data sheet on accumulator acid (diluted sulphuric acid) (in compliance with EC Directive 91/155/EU)

1 Substance / formulation and company name

Data on the product:	**diluted sulphuric acid (1,22 . . . 1,29 kg/l)**
Trade name:	**accumulator acid**
Data on the manufacturer:	
Telephone:	Facsimile:

2 Composition / data on the constituents

Chemical characteristics:

Sulphuric acid:	30 . . . 38,5%ig, densitiy 1,22 . . . 1,29 kg/l
CAS-Number:	7664-93-9
EU-Number:	016-020-00-8
UN-Number:	2796
EINECS-Number:	231-639-5

3 Potential hazards

Diluted sulphuric acid may cause severe acid burns

4 First- aid measures

General instructions:	Remove soiled, wetted clothing immediately.
after contact to skin	Rinse with a lot of water immediately after contact to skin.
after inhalation of acid mist *)	Inhale fresh air.
after contact with the eyes *)	Rinse under running water for several minutes.
after swallowing *)	Drink a lot of water immediately, and swallow activated carbon.

**) Seek the advice of a doctor.*

This leaflet was prepared within the Committee on Environmental Affairs of the Division Batteries of the German Electrical and Electronic Manufacturers' Association, ZVEI.
(Revised Edition November 2003).

5 Fire-fighting measures

Suitable extinguishing agents in case of surrounding fires: CO_2 and solid existinguishing agent.

6 Measures to be taken in case of unintentional release

Cleaning / take-up procedures: Use a bonding agent, such as sand, to absorb spilt acid; use lime / sodium carbonate for neutralisation, dispose with due regard to the official local regulations.

7 Handling and storage

Store frost-free under roof. Seek agreement with local water authorities in case of larger quantities. Observe VAWS.

8 Exposure limits and personal protective equipment

Possible exposure caused by sulphuric acid and acid mist during filling and charging:

Threshold value on workplace:	0,1 mg/m^3 *
Personal protective equipment:	Rubber, PVC gloves, acid-proof goggles, acid proof clothing safety boots

*) 0,5 mg/m^3 at the lead battery production

9 Physical and chemical properties

Appearance	
form:	liquid
colour:	colourless
odour:	odourless
Safety-related data	
solidification point:	– 35 . . . – 60 ˚C
boiling point:	approx. 108 . . . 114 ˚C
Solubility in water:	complete
flash point:	N.A.
ignition temperature:	N.A.
lower explosive limit:	N.A.
densitiy (20 ˚C):	(1.2 – 1.3) g/cm^3
vapour pressure (20 ˚C):	*14.6 mbar*
bulk density:	N.A.
pH value:	< 1 (at 20 ˚C)
dynamic viscosity:	approx. 2.8 mPa . s (at 20 ˚C)

10 Stability and reactivity of the sulphuric acid (30 . . . 38.5 %)

– Corrosive, inflammable liquid.

– Thermal decomposition at 338 ˚C.

– Destroys organic materials, such as cardboard, wood, textiles.

– Reacts with metals producing hydrogen.

– Vigorous reactions with lyes and alkalis.

11 Data on the toxicology of the constituents

– acts intensely caustic on skin and mocous membranes, in low concentration already. The inhalation of mists may cause damage to the respiratory tract.

12 Data on the ecology of the constituents

– Water-polluting liquid within the meaning of the German Water Resources Act

– Water pollution class: 1 (mildly water polluting).

– In order to avoid damage to the sewage system, the acid has to be neutralised by means of lime or sodium carbonate before disposal.

– Ecological damage is possible by change of pH.

13 Instructions for processing / disposal

– The batteries have to be processed / disposed of with regard to the official local regulations.

14 Transport regulations

Land transport:	ADR RID	chapter 3.2, UN 2796 chapter 3.2, UN 2796
Description of the goods:	Battery, fluid, Acid Danger number: UN number:	 80 2796
Sea transport:	IMDG-Code	chapter 3.2, UN 2796
Air transport:	IATA-DGR	chapter 3.2, sulphuric acid
Other data:	Dispatch per mail service	impermissible

15 Regulations

Marking according to	German Regulations on Hazardous Materials	Identification requirement
Danger symbol		C, corrosive
R-phrases	35	Causes severe burns.
S-phrases	1 / 2	Keep locked up and out of reach of children
	26	In case of contact with eyes rinse immediately with plenty of water and seek medical advice
	30	Never add water to this product *)
	45	In case of accident or if you feel unwell seek medical advice immediately (show the label where possible.

**) applies for concentrated acid only, and not for refilling the battery with water*

National regulations:

Water pollution class:	1 (list material)
Other regulations:	To be observed in case of storage: German Water Resources Act

16 Miscellaneous data

The data rendered above are based on today's knowledge, and do not constitute an assurance of properties. Existing laws and regulations have to be observed by the recipient of the product in own responsibility.

Notes:

POWER FROM INNOVATION

Installation, commissioning and operating instructions

for valve-regulated stationary lead-acid batteries

POWER FROM INNOVATION

HOPPECKE Batterien GmbH & Co. KG

P.O. Box 1140 · D-59914 Brilon · Germany
Bontkirchener Straße 1 · D-59929 Brilon-Hoppecke

Phone +49(0)2963 61-0
Fax +49(0)2963 61-270

Email info@hoppecke.com
www.hoppecke.com