Handbook for Stationary Vented Lead-Acid Batteries

Part 2:
Installation, Commissioning and Operation

EXIDE TECHNOLOGIES
INDUSTRIAL ENERGY

Contents

1. Transport, Delivery and Stock Receipt

1.1 Land-Carriage of Vented and VRLA Batteries

Cells / blocks must be transported in an upright position.

Batteries without any visible damage are not defined as dangerous goods under the regulations for transport of dangerous goods by road (ADR) or by railway (RID).

The must be protected against short circuits, slipping, falling down or damaging. Cells / blocks may be stacked on pallets on a suitable way and if secured (ADR and RID, special provision 598). It is prohibited to staple pallets.

No dangerous traces of acid shall be found on the exteriors of the packaging unit.

Cells / blocks whose containers leak or are damaged must be packed and transported as class 8 dangerous goods under UN no. 2794.

1.2 Sea Transport of Vented Batteries

Vented cells / blocks, filled with acid, must be packed and transported as dangerous goods acc. to IMDG.

Classification:

UN-no.:	2794
Class:	8

The transport in wooden crates or on pallets is permitted if the following additional regulations are observed:

- Cells / blocks must be transported in upright position, must not show signs of damages, must be protected against short circuits, slipping, falling down or damaging.
- It is prohibited to staple cells.
- Blocks can be stapled secured by isolating intermediate layers if the poles are not loaded by the above lying units.
- It is prohibited to staple pallets.
- Electrolyte must not escape from the cell / the block being in a declination of 45 degree.

1.3 Sea Transport of VRLA Batteries

The following exemplary mentioned lines of products*) are not classified as dangerous goods acc. to IMDG because they fulfill also the IATA-clause A 67:

Sonnenschein	GF-Y, GF-V, A200, A400, A500, A600, A600 SOLAR, A700, dryfit military, SOLAR and SOLAR BLOCK

Absolyte
Element (former: Champion)
Marathon
Sprinter
Powerfit

1.4 Air Transport of Unfilled Vented Lead-Acid Batteries

There are no restrictions for the transport.

1.5 Air Transport of Filled Vented Lead-Acid Batteries

Filled and charged vented batteries are dangerous goods with regard to air transport and can be jet by freight planes only. Hereby, the IATA packaging regulation 800 must be observed.

1.6 Air Transport of VRLA Batteries

The following exemplary mentioned lines of products*) are not classified as dangerous goods acc. to the IATA-clause A 67:

Sonnenschein	GF-Y, GF-V, A200, A400, A500, A600, A600 SOLAR, A700, dryfit military, SOLAR and SOLAR BLOCK

Absolyte
Element (former: Champion)
Marathon
Sprinter
Powerfit

*) Certificates on request

1.7 Abbreviations

ADR: The European Agreement Concerning the International Carriage of Dangerous Goods by Road (covering most of Europe).

RID: Regulations concerning the International Carriage of Dangerous Goods by Rail (covering most of Europe, parts of North Africa and the Middle East).

IMDG: The International Maritime Dangerous Goods Code.

IATA: The International Air Transportation Association (worldwide).

ICAO: Civil Aviation Organization’s Technical Instructions for the Safe Transport of Dangerous Goods by Air.

1.8 Delivery and Stock Receipt

- EXIDE Technologies’ vented batteries are delivered from our factories, logistic centers or via our distributors.
- The delivery items can be identified either by the number and type of cells / blocks or by referring to a battery drawing.
- Check the package or pallet for integrity.
- Do not stack one pallet above the other.
- Heed handling instructions stated on the packages.
- During transportation take all precaution to avoid breaking those products which are considered to be „fragile“ and have been identified as such.
- EXIDE Technologies chooses for all products a package suitable for the kind of dispatch. If any damage is observed during unloading the goods, the carrier should be notified within 48 hours.
- Parcels are insured up to the delivery address acc. to the order, if this is agreed by the sales contract.

2. Safety

For any operation on the batteries, from storage to recycling, the following safety rules should be observed:

- Read "Commissioning Instructions and Report", "Installation Instructions" and "Operating Instructions" (see appendix 2) thoroughly.
- No smoking.
- Always wear protective rubber gloves, glasses and clothing (incl. safety shoes).
- Even when disconnected, a battery remains charged. The metallic parts of a battery are electrically active.
- Always use isolated tools.
- Never place tools on the batteries (in particular, metallic parts can be dangerous).
- Check torques in case of unsecured screw connections of inter-cell and inter-block connectors (see appendix 2)
- Never pull up or lift cells / blocks at the terminals.
- Avoid impacts or abrupt loads.
- Never use synthetic clothes or sponges to clean the cells / blocks, but water only (wet clothes) without additives [1].

3. Storage

In the users interest the storage time should be as short as possible.

3.1 Preconditions and Preparations

Remove and avoid, respectively, contaminations on surfaces, dust etc..

The storage location should fulfill the following preconditions:

- Protect the cells / blocks from harsh weather, moisture and flooding.
- Protect the cells / blocks from direct or indirect sun radiation
- The storage area and ambient, respectively, must be clean, dry, frost-free (see also chapter 3.2) and well looked after.
- Cells / blocks must be protected from short-circuits by metallic parts or conductive contaminations.
- Cells / blocks must be protected from dropping objects, from falling down and falling over.

3.2 Storage Conditions

- The temperature has an impact on the self-discharge rate of filled and charged cells and blocks (see fig. 1 and 2).
- Storage on a pallet wrapped in plastic material is permitted, in principle. However, it is not recommended in rooms where the temperature fluctuates significantly, or if high relative humidity can cause condensation under the plastic cover. With time, this condensation can cause a whitish hydration on the poles and lead to high self-discharge by leakage current.
  As an exception filled and fully charged lead-acid batteries can be stored also at temperatures below zero if dry surface of cells or blocks is guaranteed and if condensation or dew effects or similar cannot occur.
- Stacking of pallets is not permitted.
- Avoid storing of unpacked cells / blocks on sharp-edged supports.

- It is recommended to realize the same storage conditions within a batch, pallet or room.

3.3 Storage Time

3.3.1 Filled and Charged Cells / Blocks

The maximum storage time at a temperature of 20° C is 3 months. After that refreshing charging is necessary. The intervals for refreshing chargings are kept short in order to avoid or to minimize so-called “shedding” (which can occur especially at the poles and straps) and possible consequences (short circuits).

Higher temperatures cause higher self-discharge and shorter storage time between re-charging operations (see fig. 1 and 2). OGi-cells have a slightly higher self-discharge rate because the also slightly higher antimony content even if within the <3 %-criterion.

3.3.2 Unfilled and Charged (Dry, Pre-charged) Cells / Blocks

The storage time of dry, per-charged cells / blocks is unlimited. The positive electrodes are protected by their PbO_2-layer, the negative electrodes by an extra conservation. The protection and the conservation, respectively, can go down due to climatic influences (changing humidity, strong temperature fluctuations) (see commissioning instructions in appendix 2).

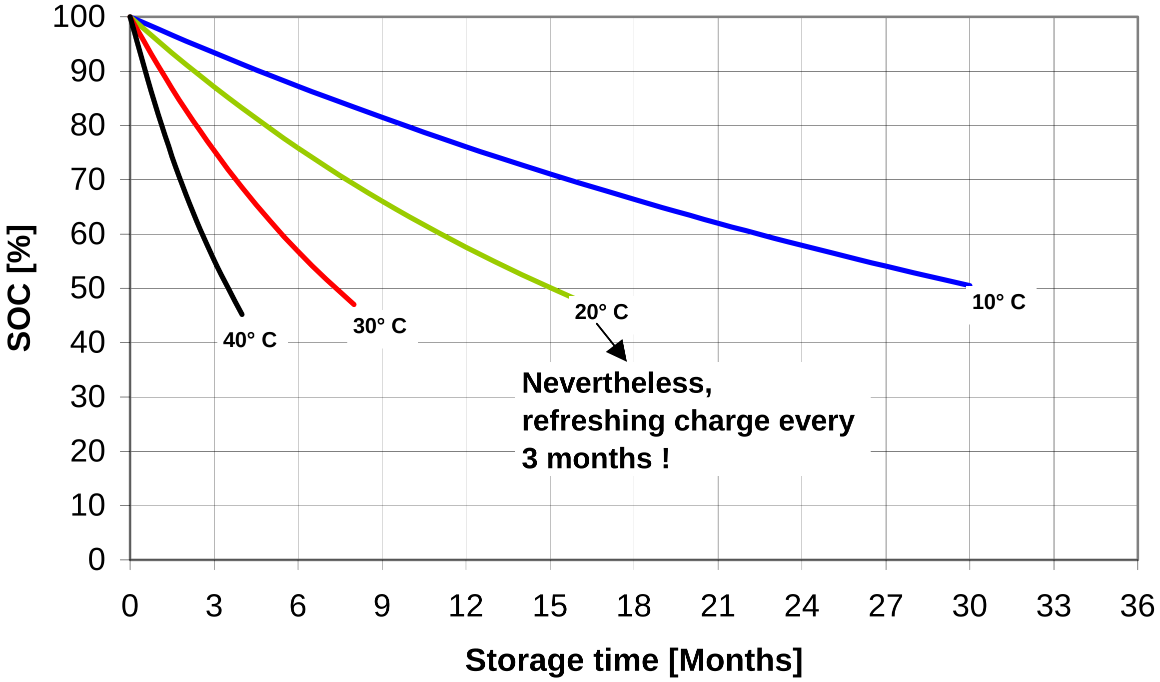


Fig. 1: OGi-Cells - State of Charge (SOC) respectively available Capacity vs. Storage Time at different Temperatures

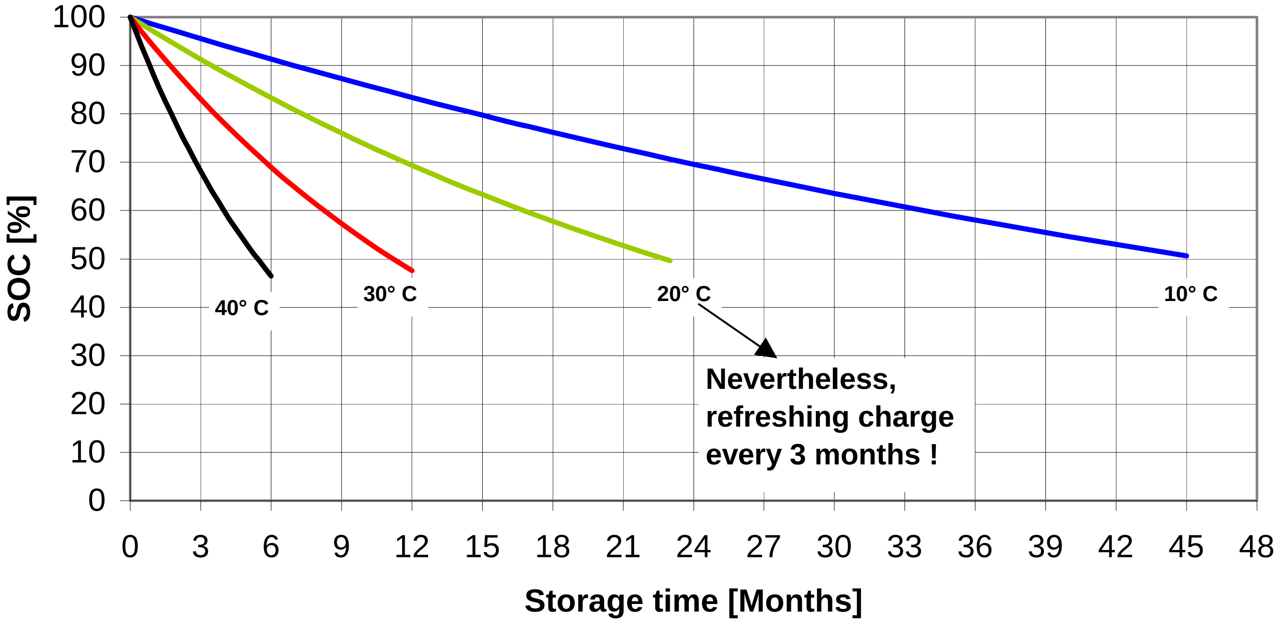


Fig. 2: GroE, OPzS, OCSM, Energy Bloc - State of Charge (SOC) respectively available Capacity vs. Storage Time at different Temperatures

3.4 Measures during Storage or Taking out of Operation

- Appropriate inventory turnover based on a FIFO-method ("First In – First Out") avoids over-storage.

- The following measures go also for filled and charged cells / blocks taken out of operation temporary.

- If cells / blocks must be cleaned, never use solvents, but water (wet clothes) without additives [1].

- For extended storage periods it is recommended to check the open-circuit voltage (OCV) of filled and charged cells / blocks in the following intervals:

  - storage at 20° C: after 3 months, then every 3 months afterwards,
  - storage at 30° C: after 1 month, then every month afterwards.

  Refreshing charging is necessary if the measured OCV is < 2.05 Volts per cell (= Vpc) (GroE: < 2.03 Vpc).

- Refreshing charging: IU-charging (constant current / constant voltage-charging) at temperatures between 15 and 35° C:

Max. voltage [Vpc]	Min. voltage [Vpc]	Current [A]	Charging time [h] at max. voltage
2.40	2.23	unlimited	72

Table 1: Charge voltages and charge time

- Depending on the charger the charging time shall be extended by 24 hours for every 0.04 V less than the maximum voltage, in which 2.23 Vpc is still the minimum voltage.

- Alternatively to regular refreshing charges, float charge operation acc. to chapter 6.1 can be applied in case of temporary taking out of operation.

4. Assembly and Installation

4.1 Battery Rooms, Ventilation and General Requirements

General: This is a guideline only and consists of excerpts from national and international standards and guidelines. See EN 50272-2 [2] for detailed information. Also, follow up commissioning instructions/report, installation instructions and operating instructions (see appendix 2).

4.1.1 Temperature

The battery room temperature should be between + 10° C and + 30° C. Optimal temperature is the nominal temperature 20° C. The maximum temperature difference between cells or blocks, respectively, within a string must not exceed 5 degree C (5 Kelvin).

4.1.2 Room Dimensions and Floor Composition

Battery rooms' height shall be at least 2 m above the operating floors. Floors shall be reasonable level and able to support the battery weight.
The floor surface must be electrolyte resistant for usage of vented batteries. This precaution is not necessary for valve regulated batteries.

Notice:
Electrolyte resistant floor surface is not necessary in case of vented batteries, if they are placed in trays. Those trays must hold at least the amount of electrolyte of one cell or block.

From EN 50272-2 [2]: "…The floor area for a person standing within arm's reach of the battery (see note 2) shall be electrostatic dissipative in order to prevent electrostatic charge generation. The resistance to a groundable point measured according to IEC 61340-4-1 shall be less than 10 MΩ.

Conversely the floor must offer sufficient resistance R for personnel safety. Therefore the resistance of the floor to a groundable point when measured in accordance with IEC 61340-4-1 shall be

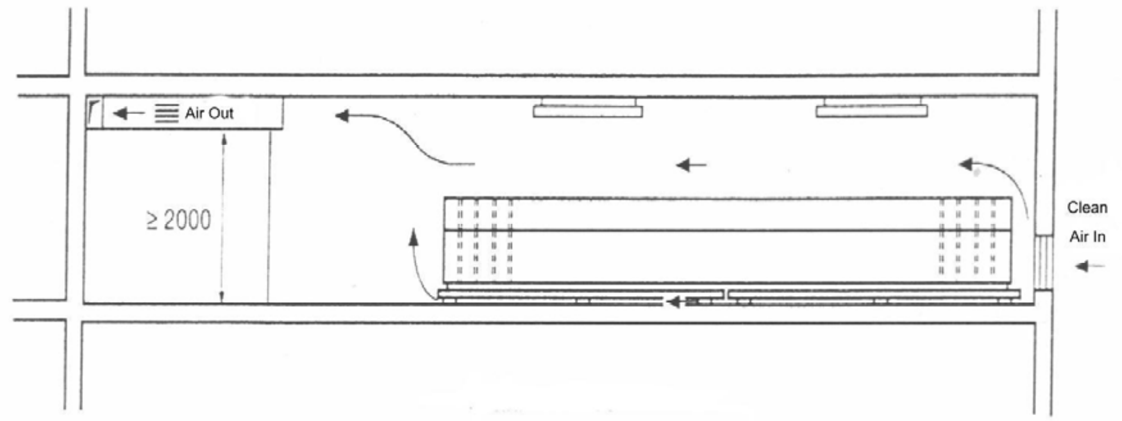
for battery nominal voltage ≤ 500 V: 50 kΩ ≤ R ≤ 10 MΩ
for battery nominal voltage > 500 V: 100 kΩ ≤ R ≤ 10 MΩ

Note 1:
To make the first part of the requirement effective, the personnel shall wear anti-static footwear when carrying out maintenance work on the battery. The footwear shall comply with EN 345.

Note 2:
Arm's reach: 1.25 m distance (For definition of arm's reach see HD 384.4.41.)…"

Room inlets and outlets: The way of air circulation should be as shown below.

A minimum distance between inlet and outlet of 2 m is requested acc. to EN 50272-2 [2], if inlet and outlet are located on the same wall.



4.1.3 Ventilation

Battery rooms must be vented acc. to EN 50272-2 [2] in order to dilute gas (hydrogen and oxygen) evolved with charging and discharging and to avoid explosions. Therefore, "EX"-protected electrical installation is not necessary. It must be designed for wet room conditions.

Do not install batteries in airtight enclosures.

Spark generating parts must have a safety distance to cell or block openings (respectively valves) as specified in EN 50272-2 [2].

Heaters with naked flame or glowing parts or devices are forbidden. Heater's temperature must not exceed 300° C.

Hand lamps are only allowed with switches and protective glass according to protection class II and protection class IP 54.

4.1.3.1 Ventilation Requirements

From EN 50272-2 [2]: „ …The minimum air flow rate for ventilation of a battery location or compartment shall be calculated by the following formula…:

$$Q = 0.05 \bullet n \bullet I_{gas} \bullet C_{rt} \bullet 10^{-3} \, [m^3/h]$$

With n = number of cells

I_{gas} = $I_{float\ or\ boost}$ [mA/Ah] relevant for calculation (see table 2)

C_{rt} = capacity C_{10} for lead acid cells (Ah), U_f = 1.80 V/cell at 20 °C...”

The following table states the values for I_{gas} to be used:

Operation	Vented cells (Sb < 3%)	VRLA cells
Float charging	5	1
Boost charging	20	8

Table 2: I_{gas} acc. to EN 50272-2 [2] for IU- and U-charging depending on operation and lead acid battery type (up to 40° C operating temperature). The gas producing current I_{gas} can be reduced to 50 % of the values for vented cells in case of use of recombination vent plugs (catalyst).

With natural ventilation (air convection) the minimum inlet and outlet area is calculated as follows:

$$A \geq 28 \bullet Q \, [cm^2]$$

(Air convection speed ≥ 0.1 m/s)

Example 1:

Given: 220 V battery, 110 cells, C_{10} = 400 Ah, vented type, Antimony (Sb) < 3 % (LA) in float service.
Calculation of fresh air necessary:

$$Q = 0.05 \bullet n \bullet I_{gas} \bullet C_{rt} \bullet 10^{-3} \; [m^3/h]$$

With n = 110
I_{gas} = 5 (see table 2)
C_{rt} = 400

$Q = 11\ m^3/h$ $A \geq 308\ cm^2$

Example 2:

Same battery as in example 1, but VRLA-type.

I_{gas} = 1 to be used (instead of 5).

$Q = 2.2\ m^3/h$ $A \geq 62\ cm^2$

Note:
A calculation program is available on request.

4.1.3.2 Close Vicinity to the Battery

From EN 50272-2 [2]: „…In the close vicinity of the battery the dilution of explosive gases is not always secured. Therefore a safety distance extending through air must be observed within which sparking or glowing devices (max. surface temperature 300 °C) are prohibited. The dispersion of explosive gas depends on the gas release rate and the ventilation close to the source of release. For calculation of the safety distance d from the source of release the following formula applies assuming a hemispherical dispersal of gas...

Note:
The required safety distance d can be achieved by the use of a partition wall between battery and sparking device.

Where batteries form an integral part of a power supply system, e.g. in a UPS system the safety distance d may be reduced according to the equipment manufacturers safety calculations or measurements. The level of air ventilation rate must ensure that a risk of explosion does not exist by keeping the hydrogen content in air below 1%$_{\mathbf{vol}}$ plus a safety margin at the potential ignition source…“.

Taking into account the number of cells results in the following formula for the safety distance d:

$$d = 28.8 \cdot \left(\sqrt[3]{N}\right) \cdot \sqrt[3]{I_{gas}} \cdot \sqrt[3]{C_{rt}} \quad \text{[mm] *)}$$

*) "…Depending on the source of gas release the number of cells per block battery (N) or vent openings per cell involved (1/N) must be taken into consideration, i. e. by the factor $\sqrt[3]{N}$, respectively $\sqrt[3]{1/N}$ ..."

Example 1:

Cell, vented type, one vent, 100 Ah.
Float charge → $I_{\mathbf{gas}}$ = 5 (acc. to table 2).

Safety distance d = 28.8 • 1 • 1.71 • 4.64 = 228.5 mm → 230 mm

Example 2:

12 V-block, six cells, one opening in the top cover, vented type, 100 Ah.
Float charge → $I_{\mathbf{gas}}$ = 5 (acc. to table 2).

$\sqrt[3]{N}$ = 1.82, because six cells

Safety distance d = 28.8 • 1.82 • 1.71 • 4.64 = 415.8 mm → 420 mm

Example 3:

Cell, VRLA-type, one vent, 100 Ah.
Float charge → $I_{\mathbf{gas}}$ = 1 (acc. to table 1).
Safety distance d = 28.8 • 1 • 1 • 4.64 = 133.6 mm → 135 mm

Example 4:

Cell, vented type, one vent, 1500 Ah.
Boost charge → I_{gas} = 20 (acc. to table 2)
Safety distance d = 28.8 • 1 • 2.71 • 11.45 = 893.6 mm → 895 mm

Example 5:

Cell, vented type, three vents, 3000 Ah.
Boost charge → I_{gas} = 20 (acc. to table 2)

$\sqrt[3]{1/N}$ = 0.69 because three vents per cell

Safety distance d = 28.8 • 0.69 • 2.71 • 14.42 = 776.6 mm → 780 mm

4.1.4 Electrical Requirements (Protection, Insulation, Resistance etc.)

To prevent a build-up of static electricity when handling batteries, material of clothing, safety boots and gloves are required to have a surface resistance of $\leq 10^8\ \Omega$, and an insulation resistance of $\geq 10^5\ \Omega$.

From EN 50272-2 [2]: "…The minimum insulation resistance between the battery's circuit and other local conductive parts should be more than 100 Ω per Volt (of battery nominal voltage) corresponding to a leakage current < 10 mA…

Note:
The battery system should be isolated from the fixed installation before this test is carried out. Before carrying out any test check for hazardous voltage between the battery and the associated rack or enclosure…."

In case of battery systems with > DC 120 V nominal voltage battery racks or cabinets made from metal shall either be connected to the protective conductor (grounding) or insulated from the battery and the place of installation (chapter 5.2 in EN 50272-2 [2]). This insulation must withstand 4000 V AC for one minute.

Note:
Protection against both direct and indirect contact shall only be used for

battery installations with nominal voltages up to DC 120 V. In these cases the requirements for metal battery stands and cabinets specified in chapter 5.2 of EN 50272-2 [2] do not apply.

Touch protection must be provided for all active parts at voltages > 60 V DC with insulation, covers or shrouds and distance.

4.1.5 Installation (Racks, Cabinets)

Batteries shall be installed in clean, dry locations. Batteries must be secured against dropping objects and protected from dust.

The course width between battery rows is equal to 1.5 times the cell depth (replacement) but minimum 600 mm (acc. to EN 50272-2 [2]).

The minimum distance for > 120 V between active parts is 1.5 m or insulation, insulated cover etc.

The recommended minimum distance between cells or blocks (of VRLA type) is 10 mm. At least 5mm are requested acc. to EN 50272-2 [2] (at the largest dimension). Thus, in order to allow heat dissipation.

Racks and cabinets shall have a distance of at least 100 mm to the wall for a better placement of connections and better access for cleaning.

Batteries must allow service with normal insulated tools (acc. to EN 50272-2 [2]).

Batteries with a nominal voltage ≥ 75 V requires an EC-declaration of conformity from the installer of the battery in accordance with the low-voltage directive (73/23/EEC). The declaration of conformity confirms that the installation of the battery was carried out in acc. with the applicable standards and that the CE-symbol was fixed at the battery. The installer of the battery system is responsible for the declaration and fixing the CE-symbol. See [3] for more information.

4.2 Preparations

- Measure the open circuit voltage (OCV) at each cell / block. The OCV-values should be:

2 V-cell:	U ≥ 2.05 V (GroE: 2.03 V)
6 V-block:	U ≥ 6.15 V
12 V-block:	U ≥ 12.30 V

  During the measurements attention shall be paid to the correct polarity (possible wrong assembly inside).

  Dry, pre-charged cells and blocks must be filled by acid and commissioned first (see chapter 5.2).

- If drawings were supplied by EXIDE Technologies, they must be kept during the assembly.

- The racks or cabinets should provide adequate ventilation above and below to allow the heat produced by the batteries and their charging system to escape. The distance between cells or blocks shall be approx. 10 mm, but at least 5 mm. See appendix 2 and standard EN 50272-2 [2].

- The grounding of racks or cabinets should be carried out in acc. with EN 50272-2 [2].

4.3 Actual Assembly

- Use insulated tools for the assembly. Wear rubber gloves, protective glasses and protective clothing (incl. safety shoes). Remove metallic objects like watches and jewelry (see also chapter 2.).

- The installation must be carried out only with the supplied original accessories, e.g. connectors, or with accessories recommended by EXIDE Technologies. The same goes for spare parts in case of later repairs.

- Pole inserts and contact areas of connectors must be moistened slightly by acid-free pole grease. Don't use any substances based on paraffin.

- The screw-connections should be tightened by the following torques:

GroE, OCSM	OPzS Energy Bloc	OGi-cells < 250Ah	 ≥ 260Ah
(25 ±1) Nm	(20 ±1) Nm	(8 ±1) Nm	(25 ±1) Nm

Table 3: Torques

- Check the overall battery voltage. It should comply with the number of cells / blocks connected in series. The open circuit voltage (OCV) of individual cells must not vary from each other by more than 0.02 V. With regard to blocks, the maximum OCV-deviations are as follows:

  4 V-blocks: 0.03 V
  6 V-blocks: 0.04 V
  12 V-blocks: 0.05 V

- If necessary, the transportation plugs to be removed and replaced by the delivered plugs.

4.4 Parallel Arrangements

The most battery manufacturers, standards and guidelines recommend a maximum of 4 strings in parallel. More than 4 parallel strings are quite possible without reducing the life.

Preconditions and features for 2 up to 10 strings in parallel:

- The connector cables for positive and negative terminals of each battery string must have the same length.

- It is a must to have a circuit breaker for each string or, at least, for every two strings.

- The strings must have the same number of cells and temperature.

Parallel connection of strings with different capacities as well as different age is possible. The current during both, discharge and re-charging, will be split acc. to the capacity or age, respectively. For more information, see [4].

If these requirements are fulfilled paralleling of up to 10 strings is possible. All battery performance data have to be applied to the end terminal of each string.

Also, the type of lead-acid batteries may differ as long as the requested charging voltage (Vpc) per string is fulfilled.

Always connect the individual series strings first. Check that the different strings have the same state of charge, means similar open circuit voltages. After that, connect the strings in parallel.

5. Commissioning

5.1 Commissioning of Filled and Charged Cells / Blocks

- For float charge applications, commissioning after a storage period or assembly in accordance with the conditions specified above, commissioning consists merely of connecting the battery to its charging system.

- The charge voltage should be adjusted in accordance with the specifications as described in chapter 6.1.

- The safety systems: Fuses, circuit breakers and insulation monitoring shall be all tested independently.

- If a capacity test is requested, for instance, for an acceptance test on site, make sure the battery is fully charged. For this, the following IU-charge methods can be applied:

  Option 1: Float charge ≥ 2 weeks.
  Option 2: 2.40 Vpc ≥ 72 hours (max. 96 hours) followed by float charge ≥ 8 hours.

- The current available for charging can be unlimited up to achieving the constant voltage level (guide values: 10 A and 35 A per 100Ah nominal capacity).

- Nominal electrolyte densities:
  - GroE: 1.22 kg/l at 20° C
  - OPzS, OPzS-Block, Energy Bloc, OGi ≤ 250 Ah: 1.24 kg/l at 20° C
  - OPzS-Solar: 1.24 kg/l at 25° C
  - OCSM, OGi ≥ 260 Ah: 1.26 kg/l at 20° C
  - Enersol T: 1.26 kg/l at 25° C
  - Enersol: 1.28 kg/l at 25° C

  Permissible tolerance during operation: ± 0.01 kg/l

5.2 Commissioning of Unfilled and Charged (Dry, Pre-charged) Cells / Blocks

5.2.1 General Items

- The commissioning is carried out by filling the cells respectively blocks with sulphuric acid in the necessary density.

  Densities of filling acid:

- GroE:	1.21 kg/l at 20° C
- OPzS, OPzS-Block, Energy Bloc, OGi ≤ 250 Ah:	1.23 kg/l at 20° C
- OPzS-Solar:	1.23 kg/l at 25° C
- OCSM, OGi ≥ 260 Ah:	1.25 kg/l at 20° C
- Enersol T:	1.25 kg/l at 25° C
- Enersol:	1.27 kg/l at 25° C

  The rest time after filling should be at minimum 2 hours, to ensure that the plate material is completely activated. Depending on the total number of cells on minimum 4 to 8 cells (pilot cells) the temperature and the electrolyte density has to be measured and to be recorded in the commissioning report.

- On non-transparent containers the vent plugs remain open, to being able to observe, if at the end of the charging all cells show an even gassing. It is important that the initial charging is carried out completely, which is possible only, if the charging voltage is > 2.35 Vpc. Interruptions have to be possibly avoided. The commissioning has to be recorded in the commissioning report.

- During the commissioning charge the cell voltage of the pilot cells has to be measured and after completion of the commissioning charge the cell voltage, the electrolyte density and the temperature of all cells has to be measured and recorded in the commissioning report including the time.

- The electrolyte temperature must not exceed 55° C. If necessary, the charging needs to be interrupted.

5.2.2. Commissioning Charge with Constant Current / Constant Voltage (IU-Charging Regime)

A charging voltage of (2.35 to 2.4) Vpc is necessary. The charging current at the beginning of the charging should be minimum 5 A per 100 Ah C10. The electrolyte density during charging is slowly increasing only. Therefore the charging time, to achieve a minimum electrolyte density, corresponding to a nominal density of minus 0.01 kg/l, can take several days. After the necessary electrolyte density has been achieved a switch over to the float charge voltage in accordance with the operating instructions (see appendix 2) should be carried out. The density of the electrolyte will increase during operation to the nominal value.

5.2.3 Commissioning Charge with Constant Current (I-Charging Regime) or Downdraft Current (W-Charging Regime)

The maximum allowed currents can be taken from following table 4:

Charging regime	Charging current per 100 Ah C_{10}
I-charging regime	5.0 A
W-charging regime at: 2.0 Vpc 2.4 Vpc 2.65 Vpc	 14 A 7.0 A 3.5 A

Table 4: Charging regimes and charging currents

Charging has to be carried out till all cells have achieved a voltage of minimum 2.6 V, all cells show an increase of electrolyte density to the nominal value of ± 0.01 kg/l and these values do not increase during additional 2 hours. After this a switch over to the float charge voltage in accordance with 6.1 (see also the operating instructions, appendix 2) should be carried out.

5.2.4 Extended Commissioning Charge

- Because of long lasting storage or climatic influences (humidity, temperature fluctuation) the charging condition of the cells will decrease. This makes an extended commissioning charge in accordance with the following process necessary:

  - Charging with 15 A per 100 Ah C_{10} till 2.4 Vpc are achieved (approx. 3 to 5 hours),
  - 14 hours charging with 5 A per 100 Ah C_{10} (voltage exceeds 2.4 Vpc),
  - One hour break,
  - 4 hours charging with 5 A per 100 Ah C_{10}.

- The last two items have to be repeated till all cells have achieved a voltage of minimum 2.6 V, all cells show an increase of electrolyte density to a nominal value of ± 0.01 kg/l and these values do not increase during additional 2 hours. After this a switch over to the float charge voltage in accordance with 6.1 (see also the operating instructions, appendix 2) should be carried out.

- In case of a necessary capacity test, e.g. an acceptance test on site, the battery has to be charged before testing > 8 hours with the float charge voltage.

5.3 Electrolyte and Water for Topping up

5.3.1 Acid for Filling

After dilution with water to values of > 1.30 kg/l, the impurities should in no case exceed the values mentioned in the following table 5.

Cons. no.	Impurities		mg/l max.
1	metal of platinum group		0.05
2	rhenium		0.1
3	copper		0.5
4	other metals of the hydrogen sulfide group beside than lead, e.g. arsenic, antimony, bismuth, tin, selenium, tellurium		
		individually	1.0
		all together	2.0
5	manganese, chromium, titanium, nickel		
		individual	0.2
6	iron		30
7	other metals of the ammonium sulfide group beside than aluminum and zinc,		
	e.g. cobalt	individually	1.0
		all together	2.0
8	halogens calculated as chloride		5
9	nitrogen as nitrate		10
10	nitrogen as e.g. ammonia		50
11	volatile organic acids calculated as acetic acid		20
12	oxidable organic substances calculated as $KMnO_4$-consumption		30
13	annealing residue		250

Table 5: Permitted impurities of diluted sulphuric acid as filling acid for lead-acid batteries in the density range of ≤ 1.30 kg/l (acc. to [5])

5.3.2 Operating Electrolyte

For the operating electrolyte the maximum values of the following table 6 are valid.

Cons. no.	Impurities		mg/l[2)] max.
1	metals of platinum group		n.n[1)]
2	rhenium		n.n[1)]
3	copper		n.n[1)]
4	tellurium and selenium	individually	1.0
5	other metals of the hydrogen sulfide group		
	beside than lead, e.g. arsenic, bismuth,	individually	3.0
		all together	6.0
6	antimony		
	a) Gro-, GroE-, OGi-cells		3
	b) GiS-, PzS-, OPzS-cells		10
7	manganese, chromium, titanium, nickel		
		individually	0.2
8	iron		100
9	other metals of the ammonium sulfide group		
	beside than aluminum and zinc, e.g. cobalt,	individually	1.0
		all together	2.0
10	halogen calculated as chloride		
	a) Gro-, GroE-, OGi-, OPzS-cells		50
	b) GiS-, PzS-cells		500
11	nitrogen as nitrate		10
12	nitrogen as e.g. ammonia		50
13	volatile organic acids as acetic acid		30
14	oxidable organic substances calculated as		
	$KMnO_4$-consumption		50

1) These metals will be separated completely on the negative electrode. The influence of these pollutants will increase the self-discharge.
2) It is impossible to mention generally valid limiting values for metals. The for batteries harmful contents are among others depending on type, age and operating conditions of the cell.

Table 6: Permissible impurities of diluted sulphuric acid as operating electrolyte for lead acid batteries in the density range of ≤ 1.30 kg/l (acc. to [5])

5.3.3 Refill Water

The refill water is cleaned and the maximum values mentioned in the following table 7 are valid.

Cons. no.	Impurities		mg/l max.
1	evaporation residue		10
2	oxidable organic substances, calculated as $KMnO_4$-consumption		20
3	metals of the hydrogen sulfide group (Pb, Sb, As, Sn, Bi, Cu, Cd)		
	each element	individually	0.1
		all together	0.5
4	metals of the ammonium sulfide group (Fe, Co, Ni, Cu, Cr)		
	each element	individually	0.1
		all together	0.5
5	halogens calculated as chloride		0.5
6	nitrogen as nitrate		2.0
7	nitrogen as e.g. ammonia		40

Table 7: Chemical requirements for cleaned water (acc. to [5]).
The mentioned value are not allowed to be exceeded.

5.3.4 Mixing of Sulphuric Acid

A high heat evolution must be taken into consideration when mixing concentrated sulphuric acid. Therefore hard rubber or heat resistant plastic containers should be used only, no glass containers.

The necessary electrolyte to fill dry-charged cells will be made by mixing of (de-mineralized / completely desalinized) water and sulphuric acid of a density of e.g. 1.71kg/l. Highest caution has to be taken. The sulphuric acid has to be added to the cleaned water in a thin jet only by permanently stirring of the cleaned water. It shall never be handled vice versus, which means pouring water to the sulphuric acid. This causes the risk of explosion!

To achieve the exact amount of electrolyte with the desired density the mentioned values of fig. 3 have to be taken.

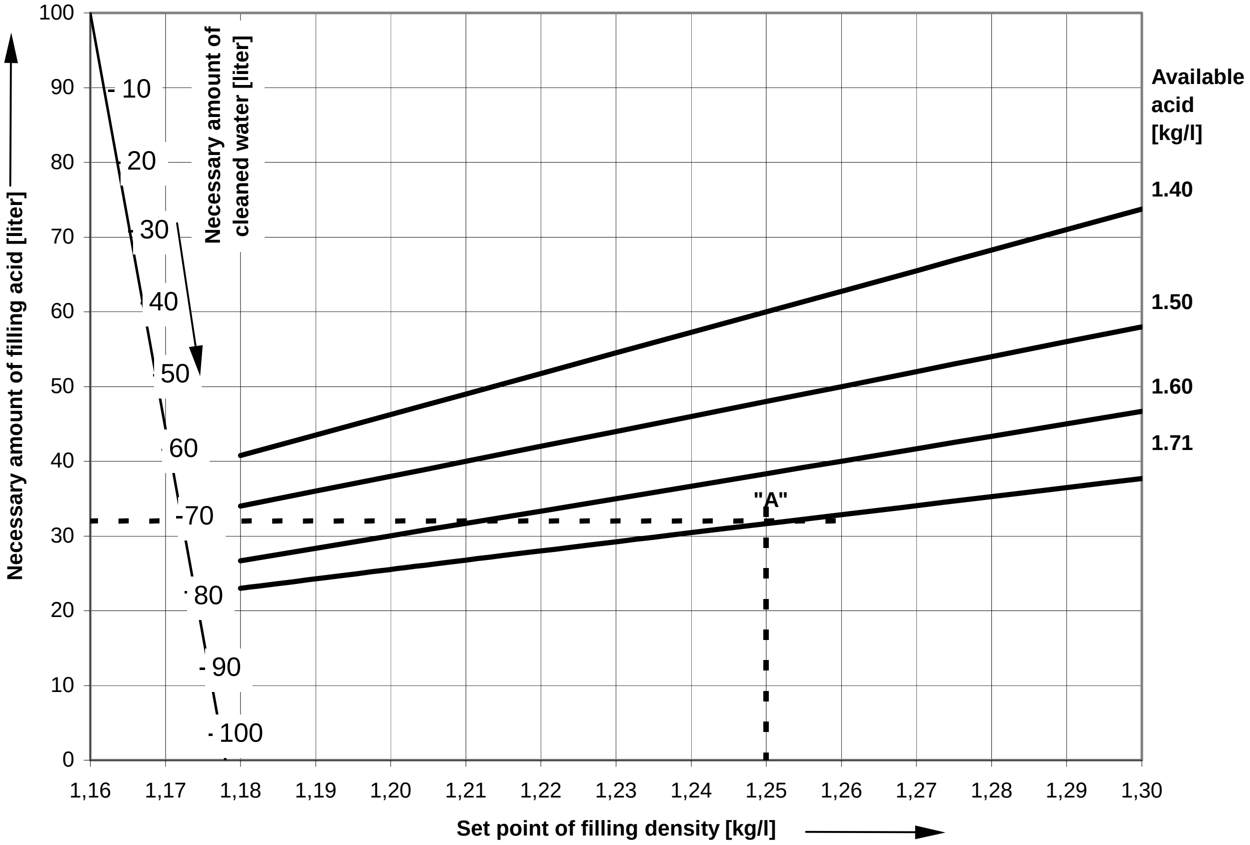


Fig. 3: Amount of Acid and Water versus Set Point of Filling Acid

<u>Example:</u>

40 liters of filling acid with a density of 1.25 kg/l are needed. Available is sulphuric acid with a density of 1.71 kg/l.

In the diagram of Fig. 3 the dot “A“ has to be determined at the intersection point of the vertical axis at 1.25 kg/l “Set point of the filling acid density” and the suitable axis 1.71kg/l “Available acid”.

If now a horizontal line from dot “A“ to y-axis is drawn, the intersection point to 71 liter “Necessary amount of cleaned water “ and 32 liter “Necessary amount of filling acid” shows up.

These amounts 71 liters of cleaned water
+ 32 liters of sulphuric acid with a density of 1.71 kg/l

result, because of contraction, in 100 liter of electrolyte with a density of 1.25 kg/l.
The in diagram Fig 3 mentioned amounts are related to 100 liters and 20°C.

For 40 liters of filling acid the following is needed:

$$0.4 \cdot 71 \text{ liters} = 28.4 \text{ liters of cleaned water}$$
$$+\ 0.4 \cdot 32 \text{ liters} = 12.8 \text{ liters acid with a density of } 1.71 \text{ kg/l.}$$

The density is depending on the temperature (fig. 4), and see also chapter 6.10.

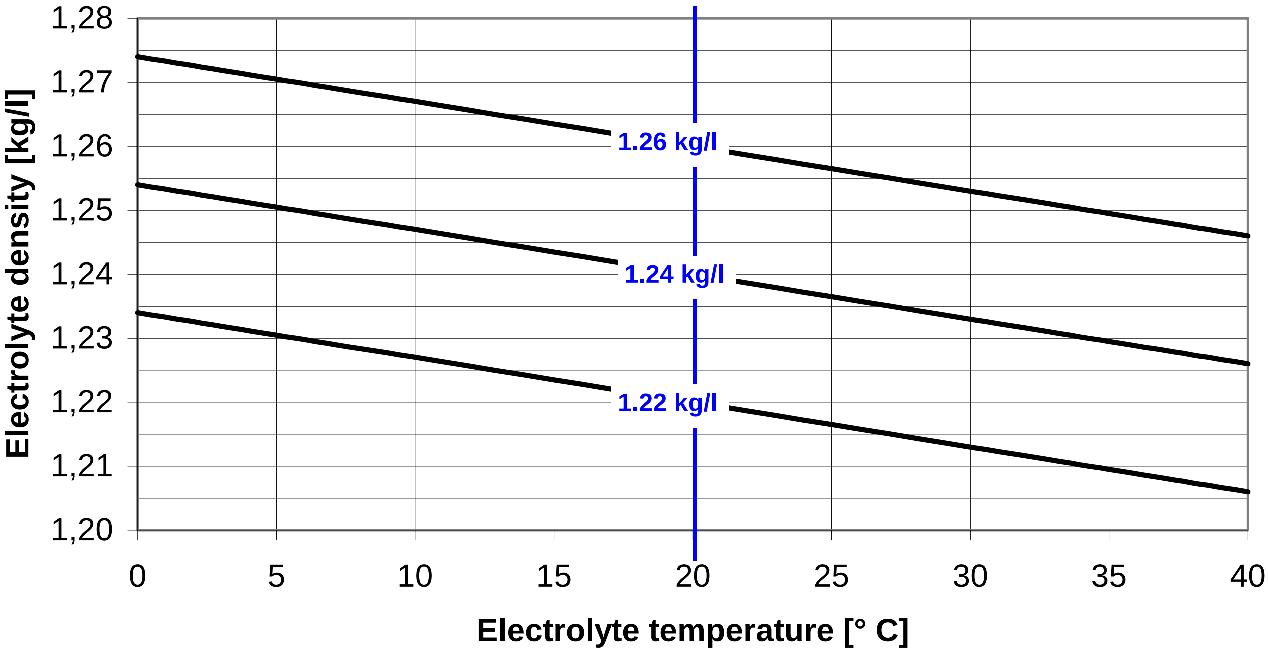


Fig. 4: Electrolyte Density versus Electrolyte Temperature

5.3.5 Adjustment of Operating Electrolyte Density

The operating electrolyte density may need adjustment because e.g. incorrect filling. Here, two cases must be distinguished:

Case A: The measured electrolyte density is too high (at nominal temperature and nominal electrolyte level).

$$x = \frac{(b - a) \bullet 1000}{b - 1}$$

Case B: The measured electrolyte density is too low (at nominal temperature and nominal electrolyte level).

$$y = \frac{(a - b) \bullet 1000}{c - b}$$

wherein

x = amount of electrolyte to be replaced by water in cm^3/l

y = amount of electrolyte to be replaced by acid of higher density in cm^3/l

a = kg/l H_2SO_4 of the required density

b = kg/l H_2SO_4 of the measured density

c = kg/l H_2SO_4 with higher density used for the adjustment

6. Operation

6.1 Float Voltage and Float Current

- A temperature related adjustment of the charge voltage within the operating temperature of 10° C to 30° C is not necessary. If the operating temperature is permanently outside this range, the charge voltage has to be adjusted as shown in figures 5 and 6.

  The float charge voltage should be set as follows. Hereby, the Volts per cell multiplied by the number of cells must be measured at the end terminals of the battery:

  2.23 Vpc for OPzS, OPzS-Block, OPzS Solar, OGi, Energy Bloc, GroE;
  2.25 Vpc for OCSM, EnerSol, Enersol T.

  All charging (float, boost, equalizing) must be carried out according to an IU-characteristic with limit values: I-phase: ± 2%; U-phase: ± 1%. These limits are acc. to the standard DIN 41773, part 1 [6]. The charge voltage shall be set or corrected, respectively, to the values mentioned above.

- In the case of installation in cabinets or in trays, the representative ambient temperature measurement is achieved at a height of 1/3. The sensor should be placed in the center of this level.

- The location of battery temperature sensors depends on the probes. The measurement shall be carried out either at the negative terminals (pointed metallic probes or probes with loop-shape) or on the plastic housing (flat probes to be placed on top or on one side in the center).

- As a clue about the fully charged state the following rough formula can be used: The battery is fully charged if the residual charge current does not change anymore considerably during three hours. The mixing of electrolyte can take much longer and is finished if the nominal electrolyte density can be measured.

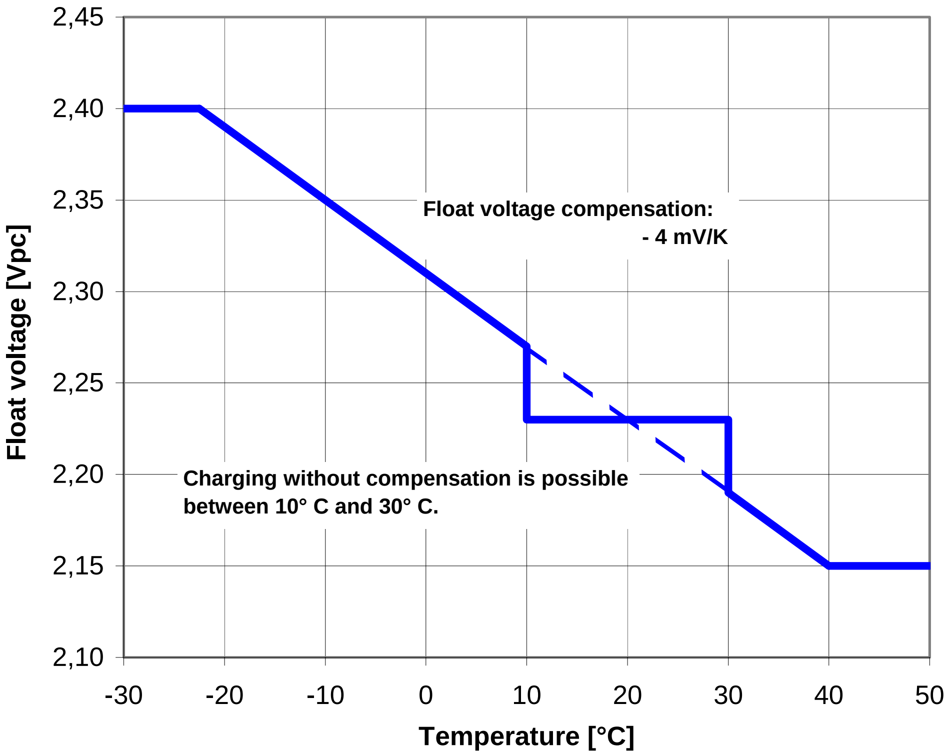


Fig. 5: Float Voltage versus Temperature – OPzS, OPzS-Block, OPzS Solar, OGi, Energy Bloc, GroE

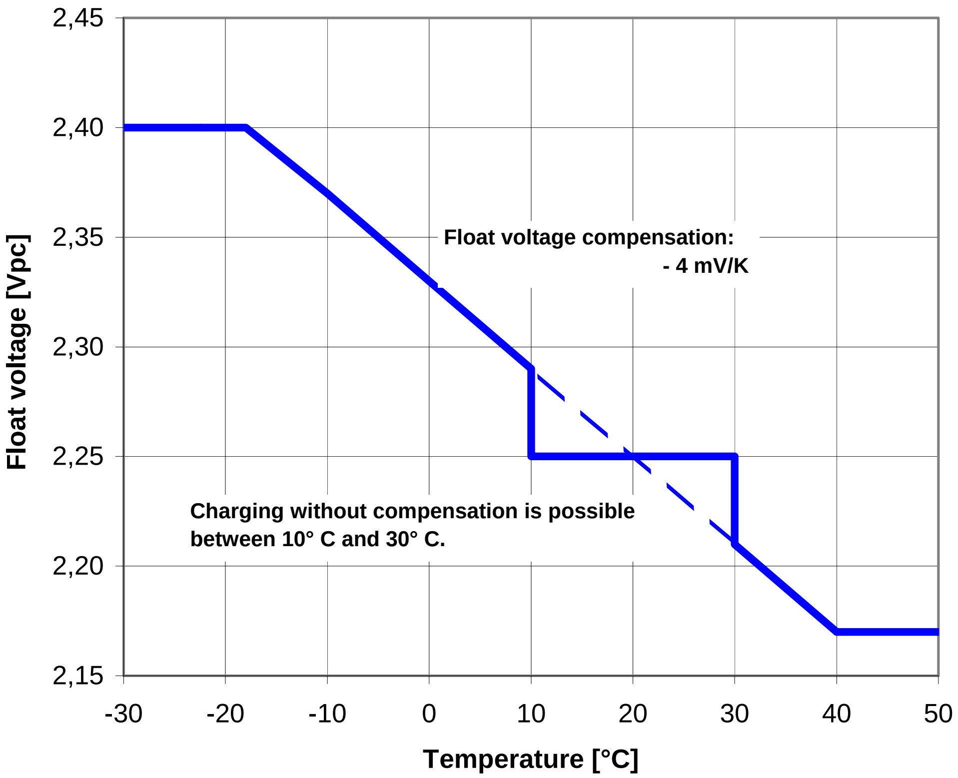


Fig. 6: Float voltage versus Temperature - OCSM, Enersol, Enersol T

6.2 Superimposed AC Ripple

Depending on the electrical equipment (e.g. rectifier, inverter), its specification and charging characteristics alternating currents flow through the battery superimposing onto the direct current during charge operation.

Alternating currents and the reaction from the loads may lead to an additional temperature increase of the battery and “shallow cycling” (i.e. cycling with low depths of discharges), which can shorten the battery life.

Possible influences are in detail:

- over-charging and accelerated corrosion,
- evolution of hydrogen (water loss, drying-out),
- deterioration of capacity by insufficient charge factor.

The effects depend on amplitude and frequency of the superimposed AC ripple.

When recharging up to 2.4 Vpc the actual value of the alternating current is occasionally permitted up to 10 A (RMS = effective value) per 100 Ah nominal capacity. In a fully charged state during float charge or standby parallel operation the actual value of the alternating current shall be as low as possible but must not exceed 5 A (RMS) per 100 Ah nominal capacity (see also EN 50272-2 [2]).

The information leaflet “Considerations on service life of stationary batteries” [7] demonstrates how critical the influence of the superimposed AC ripple is with regard to the different lead-acid battery systems “vented” and “VRLA”. Herein, different limits for the superimposed AC ripple (RMS-value) are recommended for float charge operation or standby parallel operation, respectively:

Frequencies > 30 Hz:

Maximum 2 A per 100 Ah C_{10} for vented lead-acid batteries.
Maximum 1 A per 100 Ah C_{10} for VRLA batteries.

Frequencies < 30 Hz:

Maximum 5 A per 100 Ah C_{10} for both battery systems as mentioned above.

Therefore, different influences are attributed to the AC ripples depending on their frequency:

> 30 Hz:

- no or neglectable conversion of active material because too quick changes of direction of the current, but
- increase of battery temperature,
- increased water loss,
- accelerated corrosion.

< 30 Hz:

- significant conversion of active material because slow changes of direction of the current and therefore
- lack of charge and
- consumption by cycling.

Lack of charge can occur especially if the portion of negative half-waves exceeds the portion of positives, or if the shape of the wave is distorted toward higher amplitudes of the negative half-waves. Increasing the float voltage by approx. 0.01 up to 0.03 Vpc can help in those cases. But, this should be a temporary measure only.

Highest matter of concern should be the exclusion of too high superimposed AC ripples by the appropriate design of the equipment from the beginning, or the immediate detection of reasons for their occurrence (e.g. by a defective capacitor) later on and corrective actions.

6.3 Float Voltage Deviation

- The individual cell or block float voltages may deviate within a string from the average value 2.23 or 2.25 Vpc, respectively. The following table 8 gives an overview about all the battery types and their variations from the average value under float charge conditions.

2 V-cells	4 V-blocks	6 V-blocks	10 V-blocks	12 V-blocks
+0.1/-0.05	+0.14/-0.07	+0.17/-0.09	+0.22/-0.11	+0.24/-0.12

Table 8: Permissible float voltage deviation from the set average value 2.23 or 2.25 Vpc, respectively

From that, the deviation ranges result as shown in table 9.

	2 V	4 V	6 V	10 V	12 V
OPzS OGi Energy Bloc	2.18-2.33	4.39-4.60	6.60-6.86	11.04-11.37	13.26-13.62
GroE	2.18-2.33	--	--	--	--
OCSM	2.20-2.35	--	--	--	--

Table 9: Permissible range of the float voltage in Vpc. Reference value is the given average value 2.23 or 2.25 Vpc, respectively, acc. to chapter 6.1.

6.4 Charging Times

- The constant current – constant voltage (IU) charging mode is the most appropriate to achieve a very long service life to vented lead-acid batteries. The following diagrams give guide values of time required to recharge a battery at float voltage or enhanced voltage (Boost charge) up to 2.40 Vpc (at 20° C) depending on depth of discharge (DOD) and initial current.

- How to interpret the diagrams:

  At voltages higher than the float charge voltage, an automatic switch down to the lower float voltage level follows after having reached the initial U-constant level.

  Example:

  IU-charging with 2.40 Vpc. If the voltage has reached 2.40 Vpc, the voltage will be switched down to 2.25 Vpc. Keeping the voltage at 2.40 Vpc results in clearly shorter recharging times.

  Parameters:

  - Charge voltage 2.23, 2.3 and 2.4 Vpc
  - Charging current 0.5, 1.0, 1.5 and 2.0 • I_{10}
  - Depth of discharge (DOD) 25, 50, 75 and 100% C_{10}

  Different DODs obtained by different discharge rates:

25%: 10 minutes,
50%: 1 hour,
75%: 3 hours and
100%: 10 hours.

Higher currents will not lead to relevant gain of recharging time. Lower currents will prolong the recharging time significantly.

See fig. 7 and 8 as examples for how to use the diagrams. A survey of all available diagrams can be found in appendix 1.

Fig. 7: 2.23 Vpc, 1 • I_{10}. A battery discharged to 50% DOD would be re-chargeable to 80 % available capacity within 4 hours. A full re-charge would need up to 48 hours.

Fig. 8: 2.40 Vpc, 1 • I_{10}. The same battery discharged to 50% DOD would be recharged to 80% within 3.7 hours but full re-charged within 20 hours.

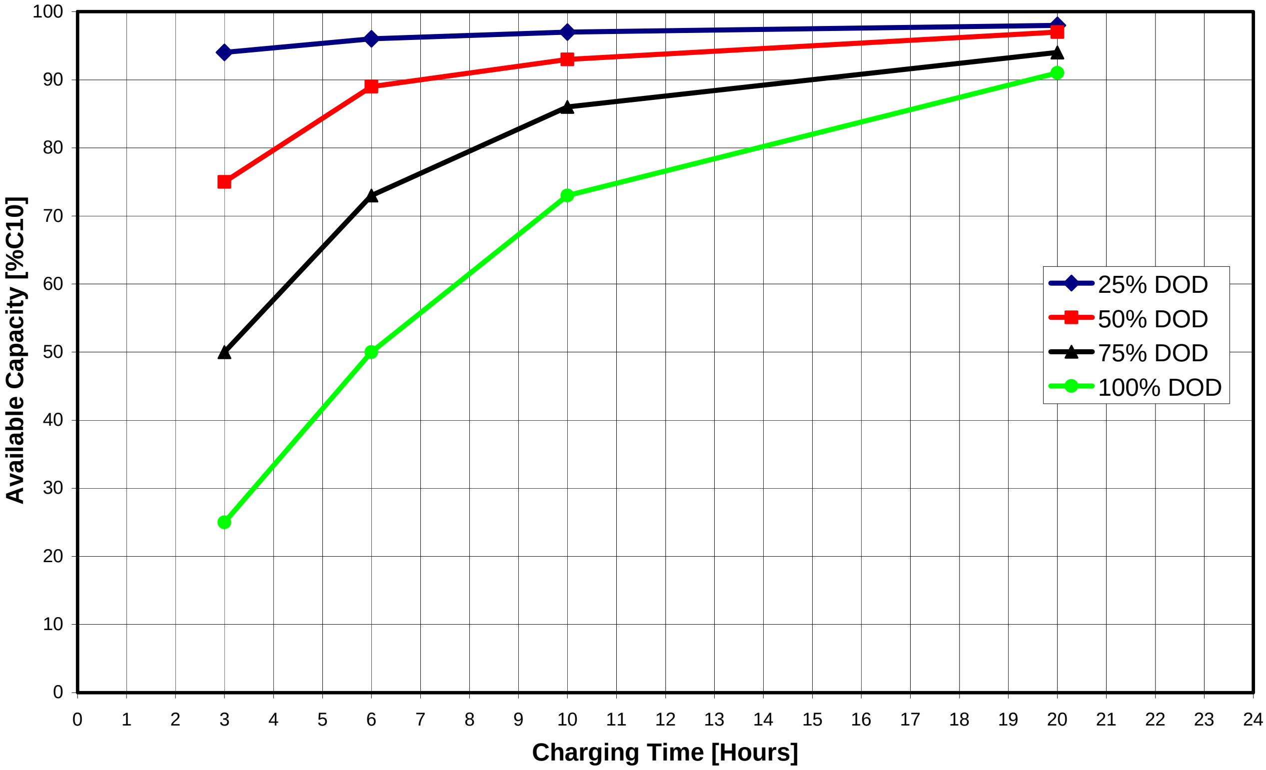


Fig. 7: Available Capacity vs. Charging Time at 2.23 Vpc,
Charging Current 1 • I_{10}, DOD = Depth of Discharge

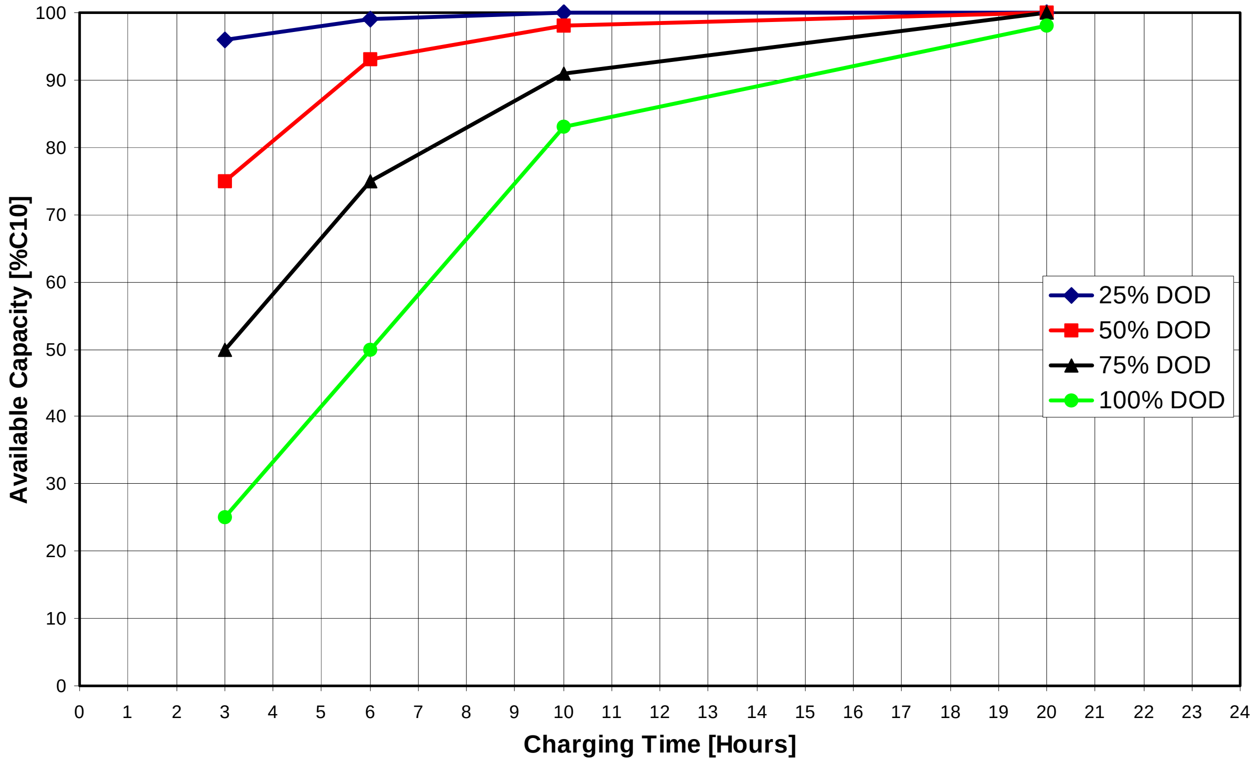


Fig. 8: Available Capacity vs. Charging Time at 2.40 Vpc,
Charging Current 1 • I_{10}, DOD = Depth of Discharge

6.5 Efficiency of Re-Charging

6.5.1 Ah-Efficiency

Definition: $$\text{Ah-Efficiency} = \frac{\text{Discharged Ah}}{\text{Re-charged Ah}}$$

Reciprocal value = Charge coefficient (re-charged Ah/discharged Ah)

Normal charge coefficients (pre-set charging time, for instance, 24 hours):

1.20 (discharge rate 10 hours)
1.25 (discharge rate 1 hour)
1.30 (discharge rate 10 minutes)

Ah-efficiency = 1/1.20 …1/1.30 = 83%…77%

Explanations:
The necessary charge coefficient increases with increasing discharge rate (as the depth of discharge (DOD) decreases). Thus, because ohmic losses, heat generation by recombination etc. are relatively same for a given charging time.

6.5.2 Wh-Efficiency

In addition to item "Ah-Efficiency", average voltages during discharge and re-charging have to be taken into account.

Definition: $$\text{Wh-Efficiency} = \frac{\text{Discharged Ah} \bullet \text{Average Voltage Discharge}}{\text{Re-charged Ah} \bullet \text{Average Voltage Recharge}}$$

Example:
Discharge: Battery C_{10} = 100 Ah
10h discharge, rate: I_{10} → discharged: C_{10} = 100 Ah (100% DOD)

Average voltage during C_{10}-discharge: 2.0 Vpc (estimated)

Recharging: IU-Charging 2.23 Vpc, 1• I_{10}

Expected re-charging time (incl. charge coefficient 1.20): 32 hours

Estimate for average voltage during re-charging: The voltage increases from 2.1 Vpc to 2.23 Vpc during 9 hours → average 2.16 Vpc.

The voltage is constant at 2.23 Vpc for (32-9) hours = 23 hours.

Estimated average voltage during 32 hours: 2.21 Vpc

$$\text{Wh-efficiency} = \frac{100\ \text{Ah} \bullet 2.0\ \text{Vpc}}{120\ \text{Ah} \bullet 2.23\ \text{Vpc}}$$

$$= 0.754 = 75\ \%$$

6.6 Equalizing Charge

Because it is possible to exceed the permitted load voltages, appropriate measures must be taken, e.g. switch off the load.

Equalizing charges are required after deep-discharges and/or inadequate charges or if the individual cell or block voltages are outside the specified range as shown in tables 8 and 9, respectively, in chapter 6.3.

They have to be carried out as follows:

- Up to 72 hours at max. 2.40 Vpc.
- The charge current is unlimited up to achieving U-constant.
- The cell / block temperature must never exceed 55°C. If it does, stop charging or switch down to float charge to allow the temperature to decrease.

Classic-Solar-batteries with system voltages ≥ 48 V

Every one to three months:

Method 1: IUI
IUI-phase = up to voltages from 2.35 to 2.40 Vpc at 20°C

U-phase = until switching at a current of 1.2 A/100 Ah to the second I-phase.
I-phase = 1.2 A/100 Ah for 12 hours.

Method 2: IUI (pulsation)
I-phase = up to voltages from 2.35 to 2.40 Vpc at 20°C
U-phase = until switching at a current of 1.2 A/100 Ah to the second I-phase (pulsed)
I-phase = charging of 2 A/100 Ah for 8-12 hours where the pulses are 15 min. 2 A/100 Ah and 15 min. 0 A/100 Ah.

6.7 Discharge, Capacity Tests

6.7.1 General Items

- Discharge must not be continued below the final discharge voltage acc. to the equivalent discharge current.
- Deeper discharges must not be carried out unless specifically agreed with EXIDE Technologies.
- Recharge immediately following a full or partial discharge.

6.7.2 Capacity Tests

- It must be guaranteed that the battery is fully charged before the capacity test. Regarding batteries being in operation already, an equalizing charge must be carried out in case of any doubt.
- Vented lead-acid batteries are delivered filled and charged or unfilled and charged (dry, pre-charged). For the last, in general a full charge is ensured by a commissioning carried out properly.
  Filled and charged and just installed vented batteries show a lack of capacity due to transport and storage. The degree of self-discharge depends on duration and ambient temperature. An estimate is possible roughly only by the rest voltage. Therefore, a specific refreshing charge is important in case of any acceptance tests at site immediately after the installation of a system (see for this "5. Commissioning").

- If possible, the total battery voltage and the single voltages shall be measured in both, float charge operation and open circuit.

- Capacity tests should be carried out acc. to IEC 60896-11 [8]. The voltage of the single cells or blocks shall be recorded automatically or measured by hand. In the last case, the values shall be recorded at least after 25 %, 50 % and 80 % of the expectable discharge time, and afterward in reasonable intervals so that the final discharge voltage can be included.

- The test shall be ended if one of the following criteria is fulfilled, whichever comes first:

  - The battery voltage has reached n • U_f [Vpc], with n = number of cells per string and U_f = final discharge voltage per cell.

    Example:
    U_f = 1.75 Vpc, n = 24 cells,
    battery voltage = 24 cells • 1.75 Vpc = 42 V

  - The weakest cell is fallen down to
    U_{min} = final discharge voltage U_f [Vpc] – 0.2 V

    Example:
    Final discharge voltage U_f = 1.75 Vpc. Therefore, the weakest cell may have: $U_{min} = U_f - 0.2\ V = 1.55\ V$.

Single cells and blocks must be handled from different points of view, because statistics plays a role in case of blocks. Therefore, the following baselines results for calculations:

Minimum permitted voltage (U_{min}) per single cell:
$U_{min} = U_f$ [V/cell] – 0.2 V

Minimum permitted voltage (U_{min}) per block:
$U_{min} = U_f$ [V/block] - $\sqrt{n} \bullet 0.2$ V

(U_f = final discharge voltage, n = number of cells)

Therefore, the following values result:

2 V	4 V	6 V	10 V	12 V
- 0.2	- 0.28	- 0.35	- 0.45	- 0.49

Tab. 8: Voltage tolerances at the end of discharge

Example:
12 V block battery
Final discharge voltage U_f = 1.75 Vpc
Final discharge voltage per block: U_f = 10.50 V
Calculation: 10.50 V – 0.49 V = 10.01 V
Minimum permitted voltage per block: U_{min} = 10.01 V

- The initial temperature is conclusive for the correction of the test result. It shall be between 15 and 35° C acc. to IEC 60896-11 [8] .

  Proceeding:

  The test results in a measured capacity

  C [Ah] = I [A] • t [h]

  Then, the temperature corrected capacity $C_{corr.}$ [Ah] results in

$$C_{corr.} = \frac{C}{1 + \lambda (\vartheta - 20)}$$ with

  temperature coefficient λ = 0.006 for tests of > C1 or
  0.01 for tests of $\leq$ C1, respectively,
  initial temperature ϑ in ° C.

- There are no regulations regarding the frequency of capacity tests to be carried out. The user can decide as he wants. But, testing too frequently doesn't make sense, because the result reflects only a momentary state of the battery anyway. Extreme testing could be equivalent to cycling.

  Following an example for a conceivable proceeding in case of a OPzS-battery (service life 15 to 20 years at 20° C):

  first test after 1 or 2 years *);
  after that, every 3 to 5 years;
  annual as soon as the capacity begins to drop continuously.

*) Instead of the first test after 1 or 2 years it can be also the acceptance test after the commissioning

6.8 Cyclical Operation

6.8.1 General Items

Vented lead-acid batteries can be used also in discharge-charging-mode (a cycle consists of a discharge and a re-charging).

Classic-Solar-batteries (especially Enersol T, OPzS Solar) are optimized for cyclical application.

Following the numbers of cycles for different battery types:

GroE: 200 cycles *)
OGi, Energy Bloc: 600 cycles *)
OPzS, OPzS-Block, OCSM: 1500 cycles *)

Enersol T: 1500 cycles *)
OPzS Solar: 2000 cycles *)

*) Discharge conditions acc. to IEC 60896-11 [8]: 20° C, discharge for 3 h at a current of $I = 2.0 \bullet I_{10}$. This is equivalent to a depth of discharge (DOD) of 60% C_{10}.

The possible numbers of cycles depends on different parameters, i.e. sufficient re-charging, depth of discharge (DOD) and temperature.

Deeper discharge (higher DOD) results in a lower number of cycles because the active material is much more stressed and stronger re-charging is necessary (corrosion !). Therefore, lower DODs results in higher numbers of cycles. See figures 9 to 13 for details.

Fig. 12 and 13 show a different correlation to IEC 60896-11 [8] on the y-axis.
Examples:

- „100 %" → 100 % of 60 % DOD (based on C_{10}) = 60 % DOD (…C_{10})
- „50 %" → 50 % of 60 % DOD (based on C_{10}) = 30 % DOD (…C_{10}).

The correlation between DOD and number of cycles is not always exact proportional. It depends also on the ratio amount of active material versus amount of electrolyte.

With regard to influence of temperature on number of cycles the same rules shall be used as for influence on service life (see chapter 6.10).

Note:
The cycle life (calculated number of years with a specified daily DOD) can never exceed the service life! The cycle life is rather less than the service life due to non-expectable influences.

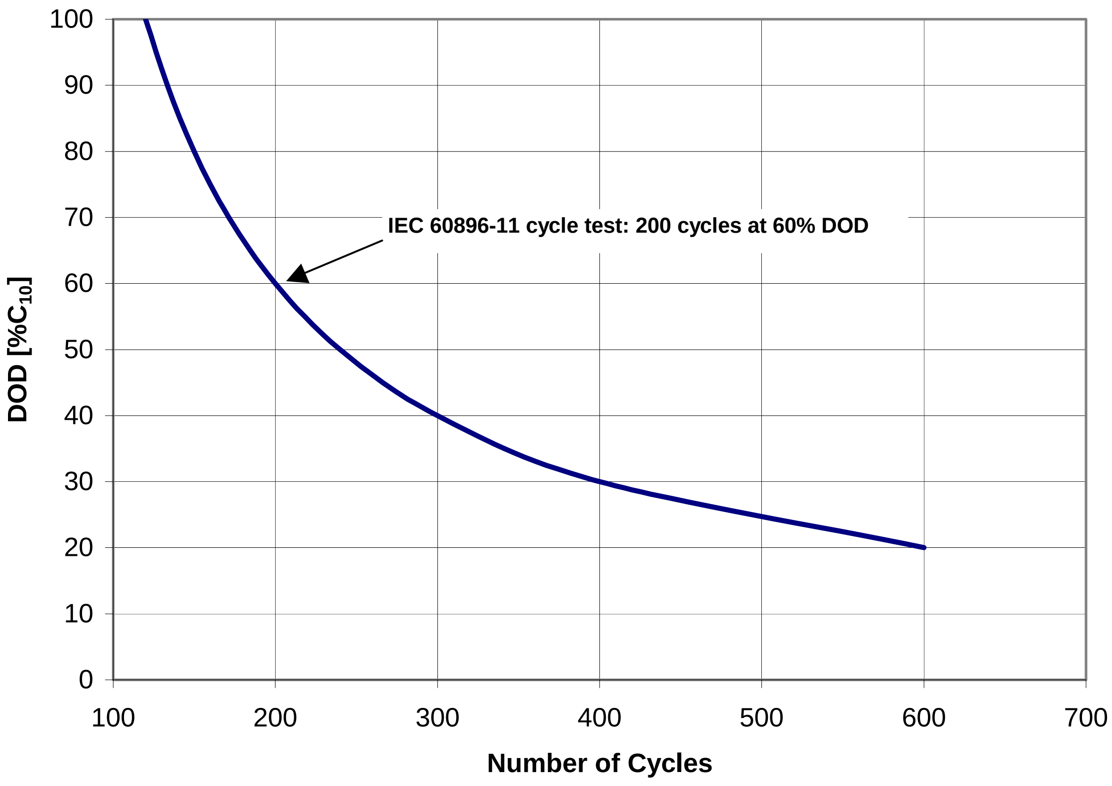


Fig. 9: GroE – Number of Cycles vs. Depth of Discharge (DOD)

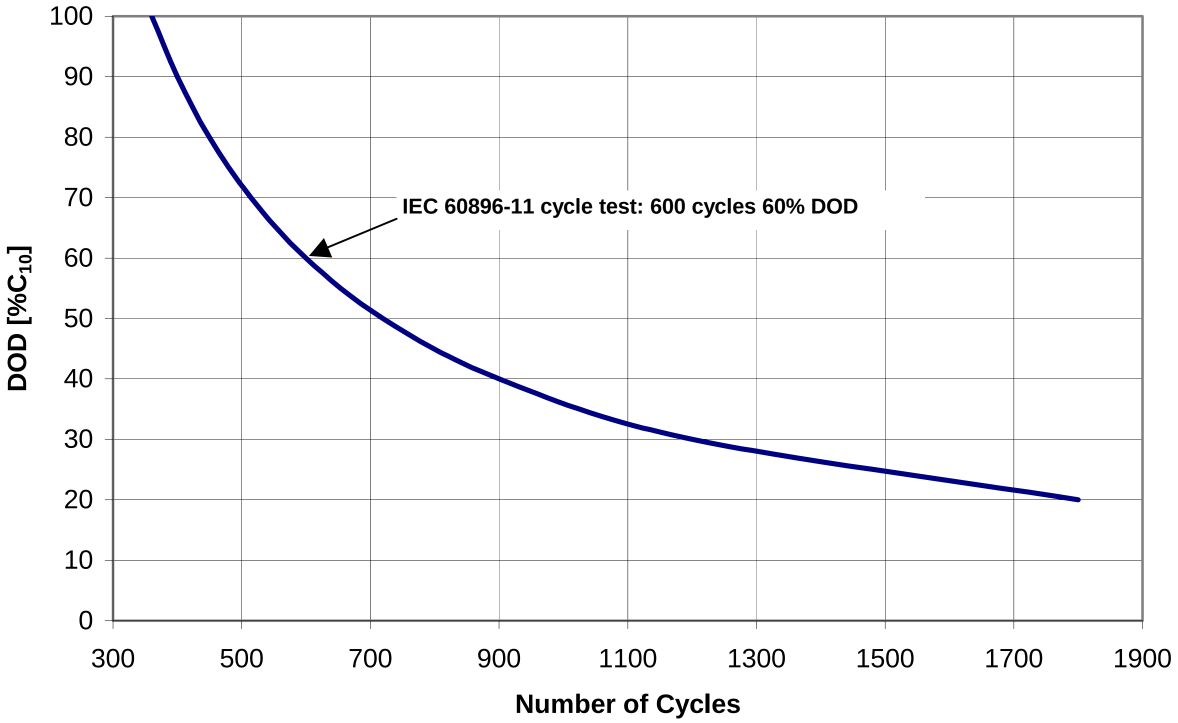


Fig. 10: OGi, Energy Bloc – Number of Cycles vs. Depth of Discharge (DOD)

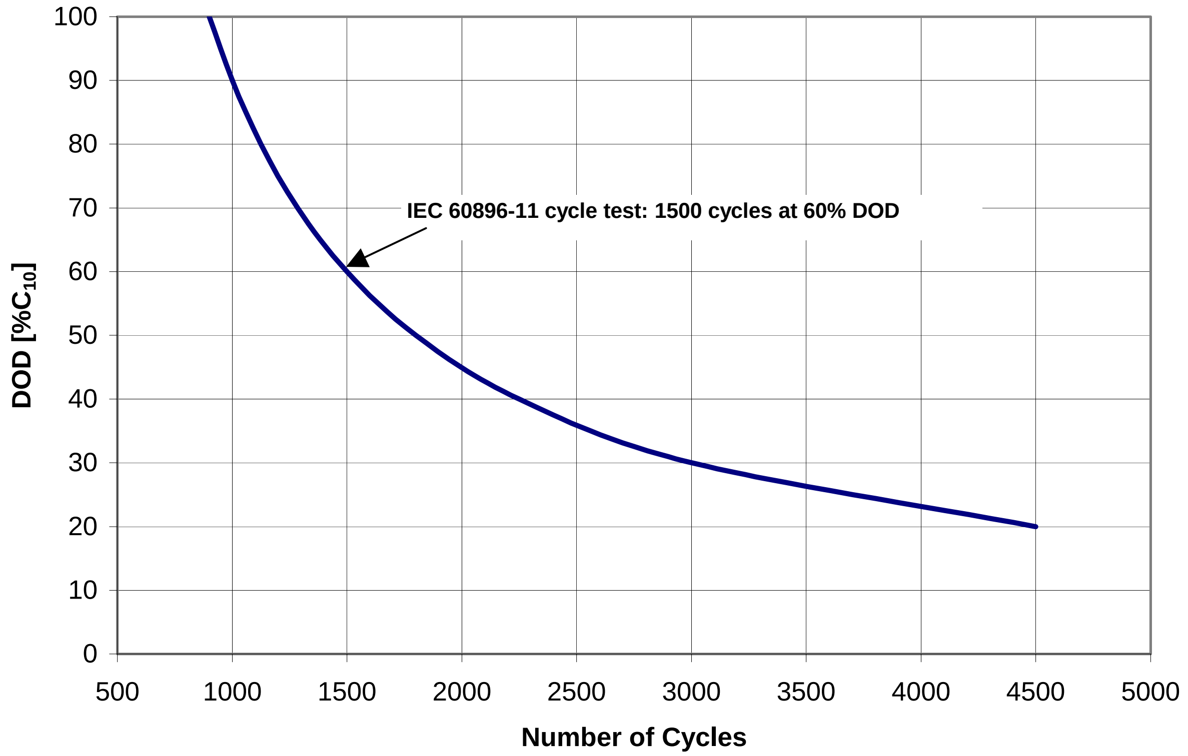


Fig. 11: OPzS, OPzS-Block, OCSM - Number of Cycles vs. Depth of Discharge (DOD)

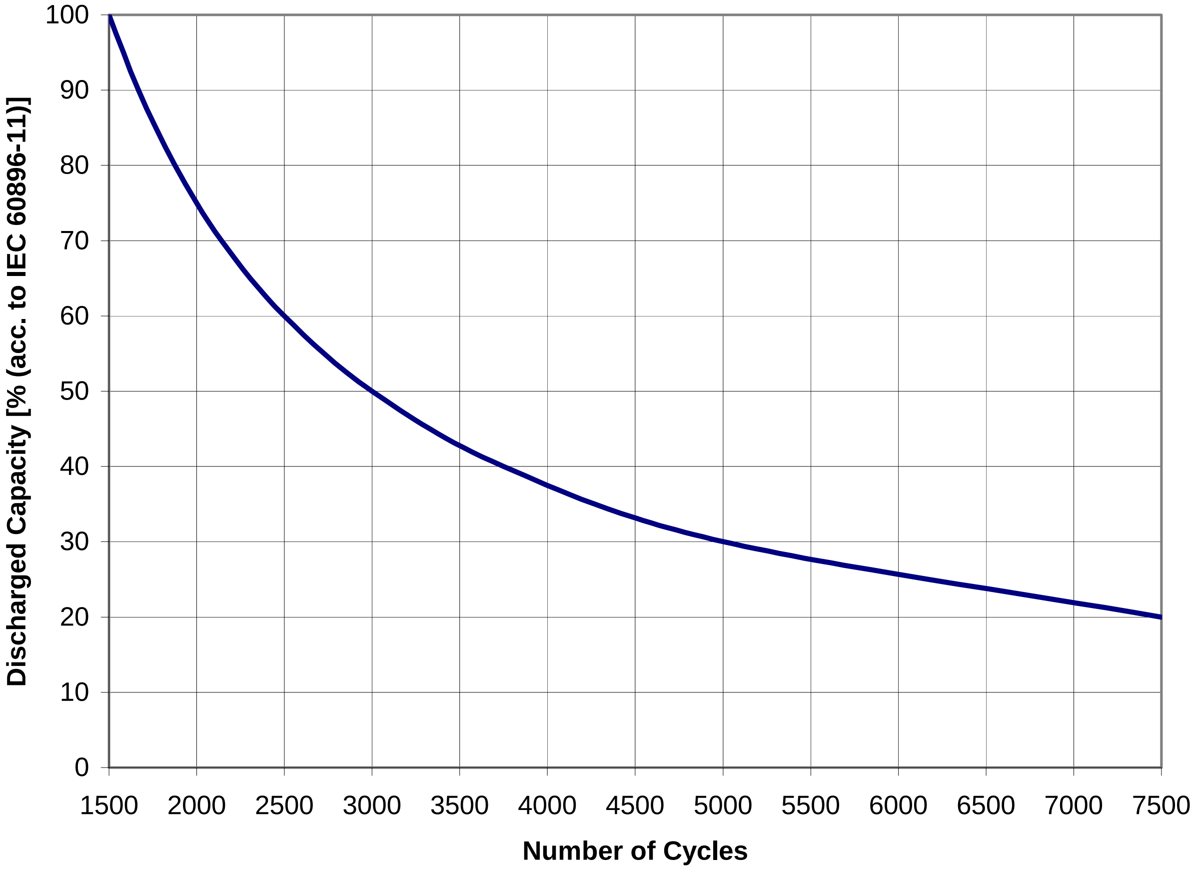


Fig. 12: Enersol T - Number of Cycles vs. Depth of Discharge (DOD)

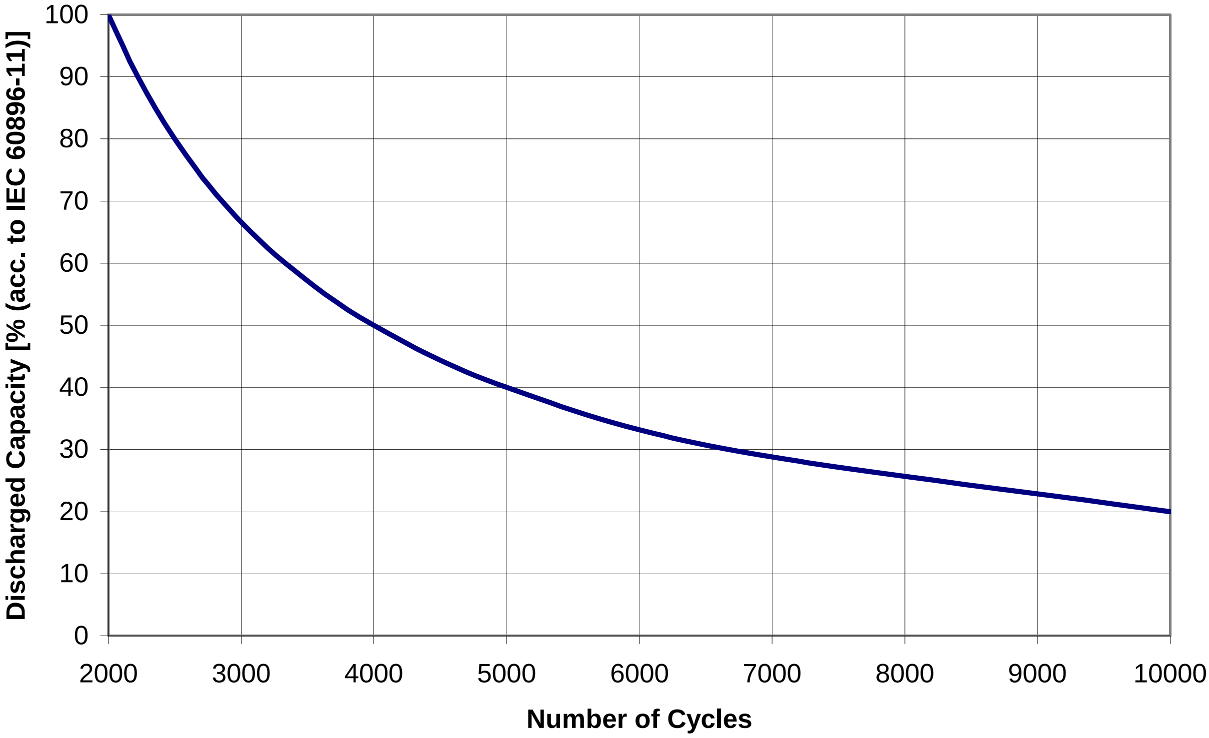


Fig. 13: OPzS Solar - Number of Cycles vs. Depth of Discharge (DOD)

6.8.2 Special Considerations about Classic-Solar-Batteries

- Solar-Module(s)

  - Sufficient power is necessary for charging the battery
  - Realization of an optimal installation (criteria, e.g.: alignment, angle of inclination, shading, possible pollution).

- Charge Controller

  - Designed to control over-charging
  - Designed to prevent deep discharge
  - Optional temperature correction
  - Critical to battery life (i.e. voltage settings)

- Battery Sizing: General Considerations

  - Minimize voltage drop
  - Use oversized cables
  - Locate battery and load closed to PV panel
  - Choose a large enough battery to store all available PV current
  - Ventilate or keep battery cool, respectively, to minimize storage losses and to minimize loss of life
  - Is a Diesel generator available for boost charge ?

- Battery Sizing: Details

  - Hours/days of battery reserve requested?
  - Final discharge voltage of the battery?
  - Load/profile: Momentary, running, parasitic current?
  - Ambient temperature: maximum, minimum, average?
  - Charging: voltage, available current, time? “Balance” of withdrawn and re-charged Ampere-hours?
  - Optimum daily discharge: $\leq$ 30% of C_{10}, typically 2 to 20 % C_{10}
  - Recommended maximum depth of discharge during long-duration discharges $\geq$ 72 h: 80% of C_{100}. This is equal an addition of 25% to the calculated capacity C_{100}.

- Battery Sizing: Guideline

  - Standard IEEE P1013/D3, April 1997 [9] inclusive worksheet and example

- Battery Sizing: Summary

  - System must be well designed.
  - System must fulfill the expectations throughout the year!
  - Right design of panel, charge controller and battery!
  - Load and sun light must be in equilibrium (how many hours/days in summer/winter ?)
  - The whole system with as less as possible maintenance, especially in rural areas

- Temperature Difference

  The battery installation shall be done on such a way that temperature differences between individual cells/blocks do not exceed 3 degree Celsius (Kelvin).

- Charging

  The charging of Classic-solar batteries shall be carried out acc. to the operating instructions which goes with this (see appendix 2).

  Solar batteries have to be operated also at States-of-Charge (SOC) less than 100% due to seasonal and other conditions, for instance (acc. IEC 61427 [10]):

  Summer: 80 to 100% SOC,
  Winter: down to 20% SOC.

  The charge voltage must be increased or equalizing charges must be given if the nominal electrolyte density is not achieved at least monthly.

6.9 Internal Resistance R_i

- The internal resistance R_i is determined acc. to IEC 60896-11 [8]. It is an important parameter when computing the size of batteries. A remarkable voltage drop at the beginning of a discharge, especially at high discharge rates equal and less than 1 hour, must be taken into account.

- The internal resistance R_i varies with depth of discharge (DOD) as well temperature, as shown in the following fig. 14 and 15. Hereby, the R_i-value at 0% DOD (fully charged) and 20° C, respectively, is the base line (R_i-factor = 1).
  The R_i-basic value can be taken from the equivalent catalogue.

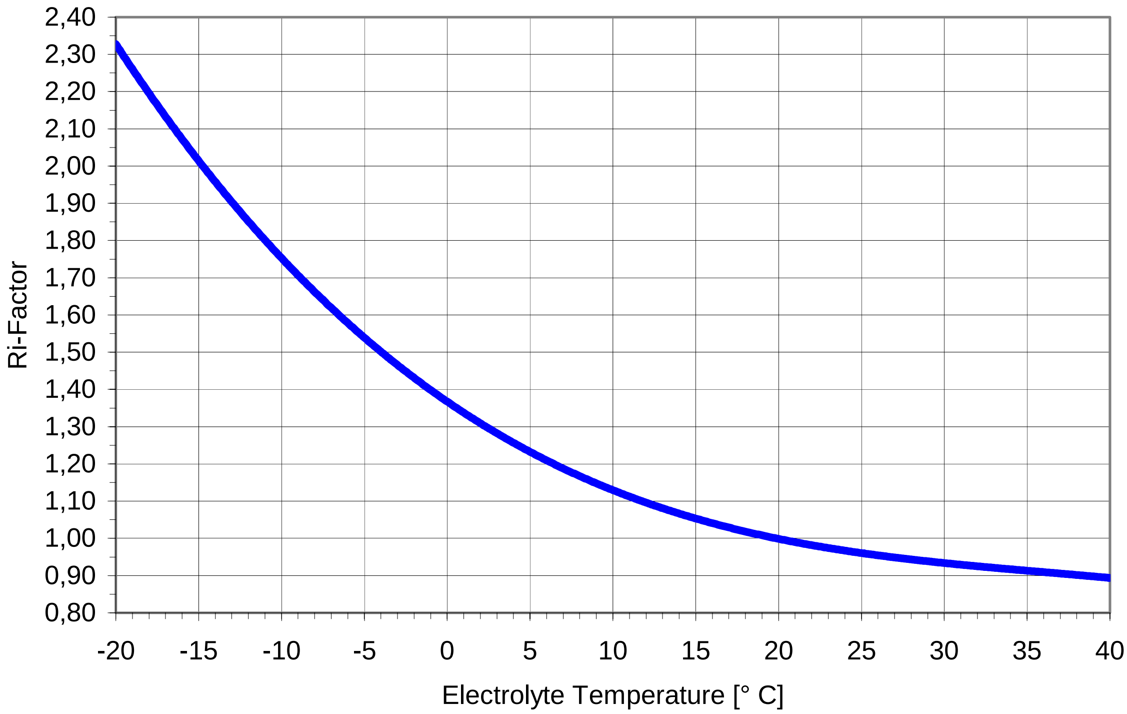


Fig. 14: R_i -Factor vs. Electrolyte Temperature

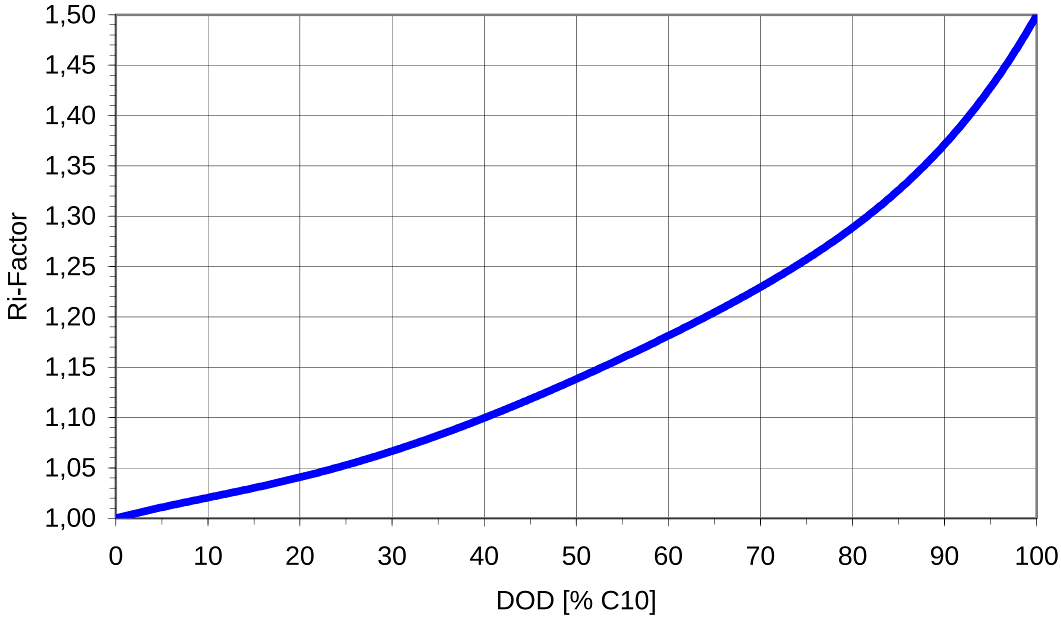


Fig.15: R_i - Factor vs. Depth of Discharge (DOD)

6.10 Influence of Temperature

The design of vented lead-acid batteries allows the use in a wide temperature range from – 20° C to + 55° C.

6.10.1 Influence of Temperature on the Electrolyte Density

The electrolyte density depends on the temperature. Higher temperatures reduce, lower temperatures increase the electrolyte density. The equivalent coefficient is – 0.0007 kg/l per K (compare 5.3).

There is a risk at temperatures of approx. less than –5° C regarding freezing-in of the electrolyte depending on the depth of discharge, see fig. 16 .

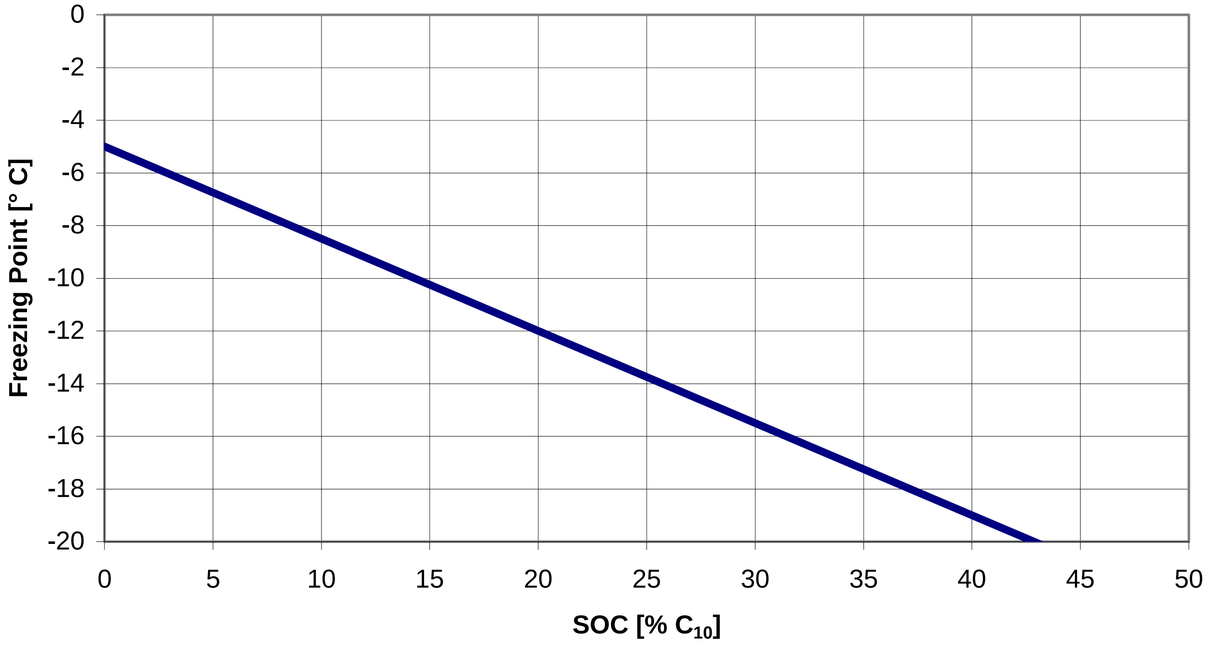


Fig. 16: Electrolyte Freezing Point vs. Sate of Charge (SOC)

6.10.2 Influence of Temperature on Capacity, Service Life and Endurance in Cycles

- 20° C (25° C for “Classic-Solar”) is the nominal temperature and the optimal temperature regarding capacity and service life. Lower temperatures reduce the available capacity and prolong the re-charge time. Higher temperatures reduce the lifetime and the number of cycles.

- The battery temperature influences the capacity as shown in fig. 17.

- Common service life applied to the nominal capacity, 20° C and with occasional discharges:

GroE:	20 to 25 years
OCSM:	15 to 20 years
OPzS ≤ 3000 Ah:	15 to 20 years
OPzS > 3000 Ah:	15 years
OPzS Block:	13 to 15 years
OGi-cells:	13 to 15 years
Energy Bloc:	13 to 15 years

in comparison to the determined design life applied to the nominal capacity and 20° C:

GroE:	25 years
OCSM:	20 years
OPzS ≤ 3000 Ah:	20 years
OPzS > 3000 Ah:	15 years
OPzS Block:	15 years
OGi-cells:	15 years
Energy Bloc:	15 years

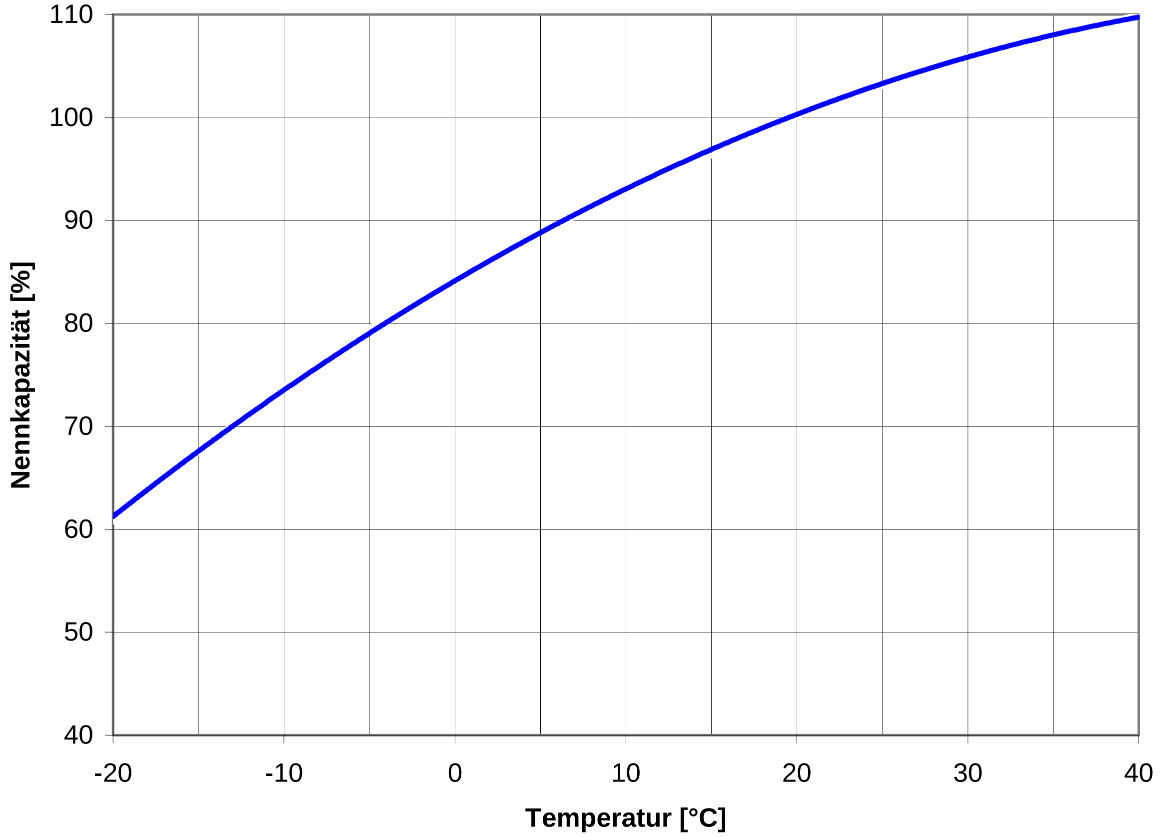


Fig. 17: Nominal Capacity vs. Temperature

- High temperatures affect batteries' service life acc. to a common rough formula (law of "Arrhenius"):

  The corrosion rate is doubled per 10° C. Therefore, the lifetime will be halved per 10° C increase.

Example: 15 years at 20° C becomes reduced to 7.5 years at 30° C

This is even valid for all batteries with positive grid plate design.

There are exceptions where the influence doesn't follow the law of "Arrhenius", - that's for OCSM, OPzS and OPzS Block with positive tubular plates (to be applied to Enersol T and OPzS SOLAR too regarding influence on number of cycles). The influence of temperature is less than for other batteries. For instance, an increase of 10 degrees from 20 to 30° C will cause a life reduction of about 30% only instead of 50%.

Reasons:

- Casting of the positive spine frame on high-pressure die-casting machines. Hereby, the injection pressure is 100 bar. That assures a very fine grain structure high resistant to the corrosion process.

- The active material, but also the corrosion layer is under high pressure by the gauntlets avoiding a growth of corrosion layer as fast as in positive grid plate designs.

- The spines are covered by an approx. 3 mm layer of active material. Therefore, the spines are not stressed by conversion of active material and electrolyte as much as in grid plates. The conversion occurs mainly in the outer parts of the tubular plates.

Fig. 18 and 19 show the dependency of the service life on the temperature for different lines of products.
Fig. 20 and 21 are regarding the influence of temperature on the endurance in cycles (number of cycles).

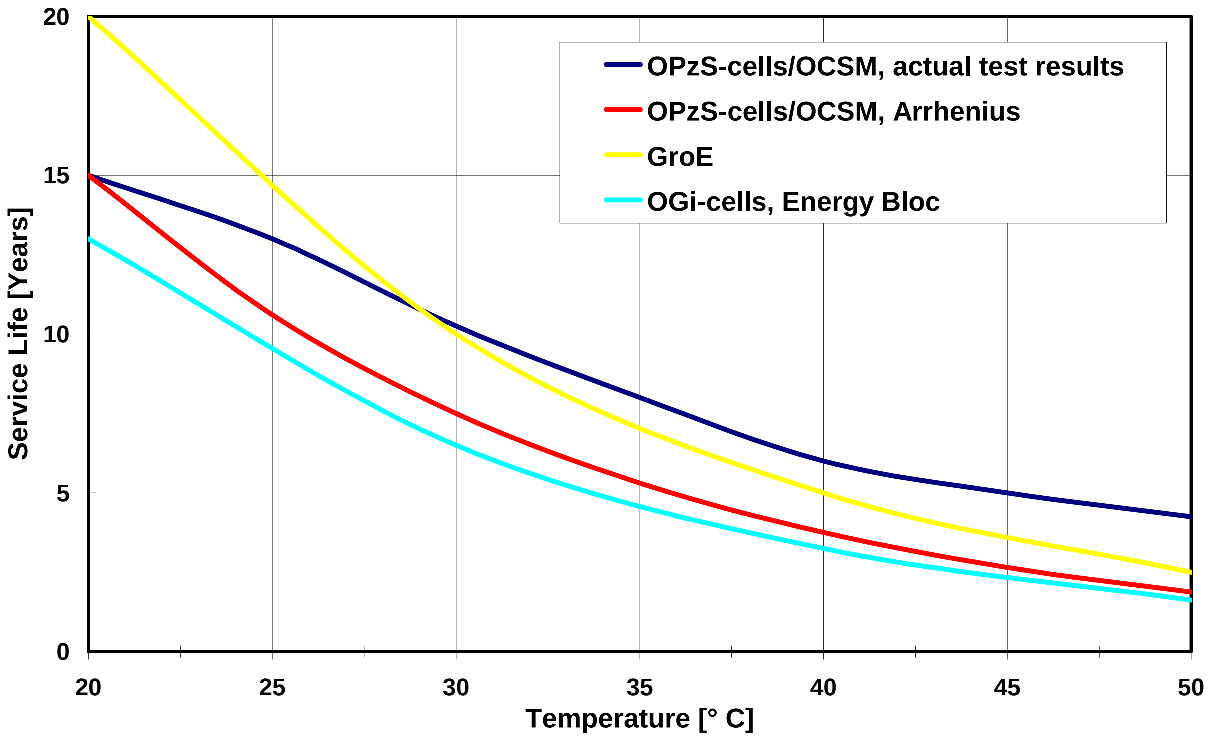


Fig. 18: GroE, OCSM, OPzS, OGi, Energy Bloc – Service Life vs. Temperature. The blue curve is valid in practice.

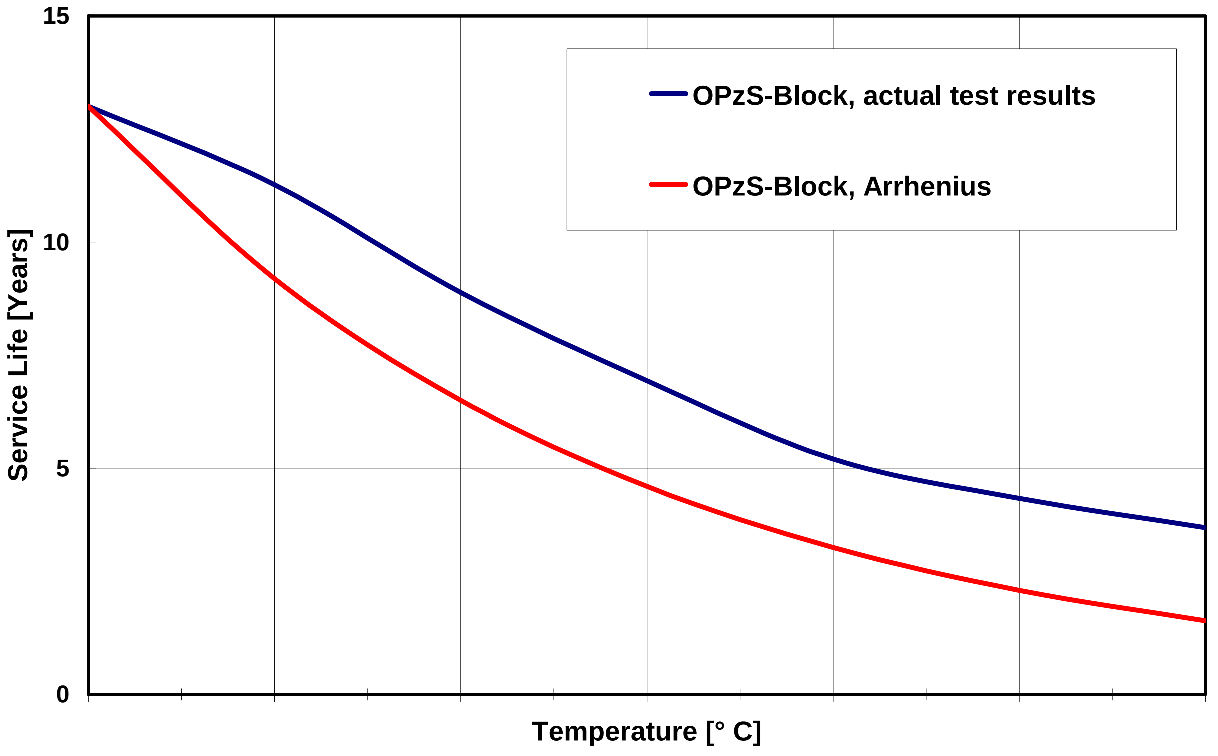


Fig. 19: OPzS-Block – Service Life vs. Temperature. The blue curve is valid in practice.

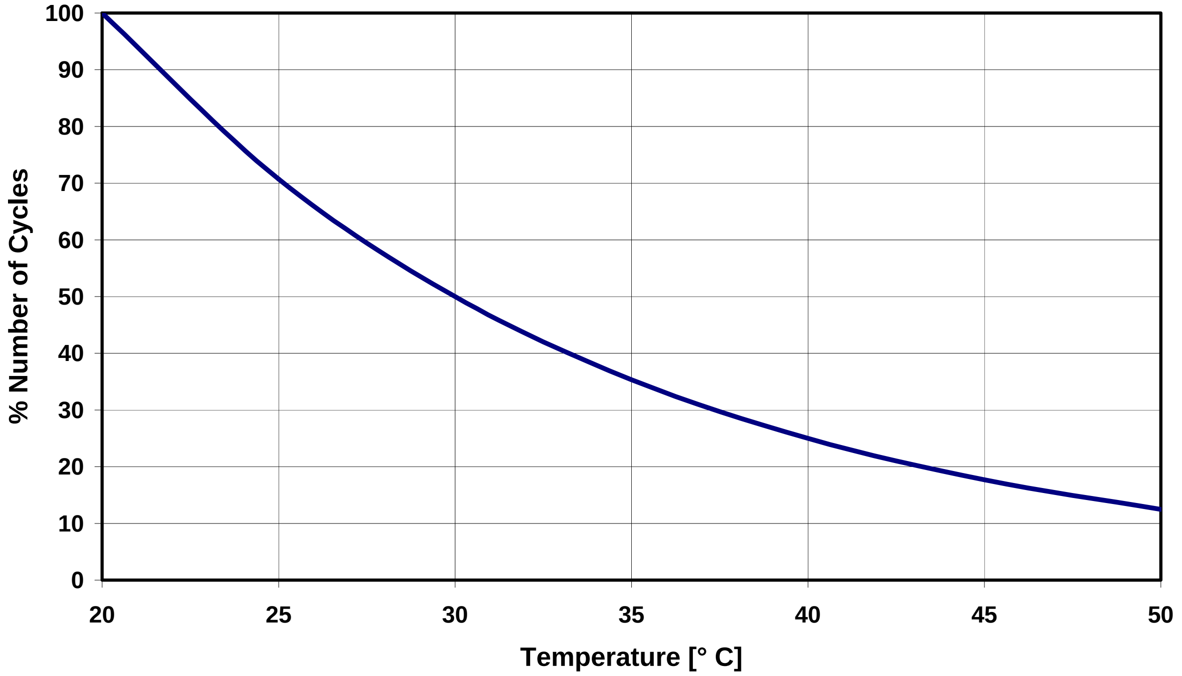


Fig. 20: GroE, OGi, Energy Bloc – Endurance in Cycles (in % of number of cycles) vs. Temperature

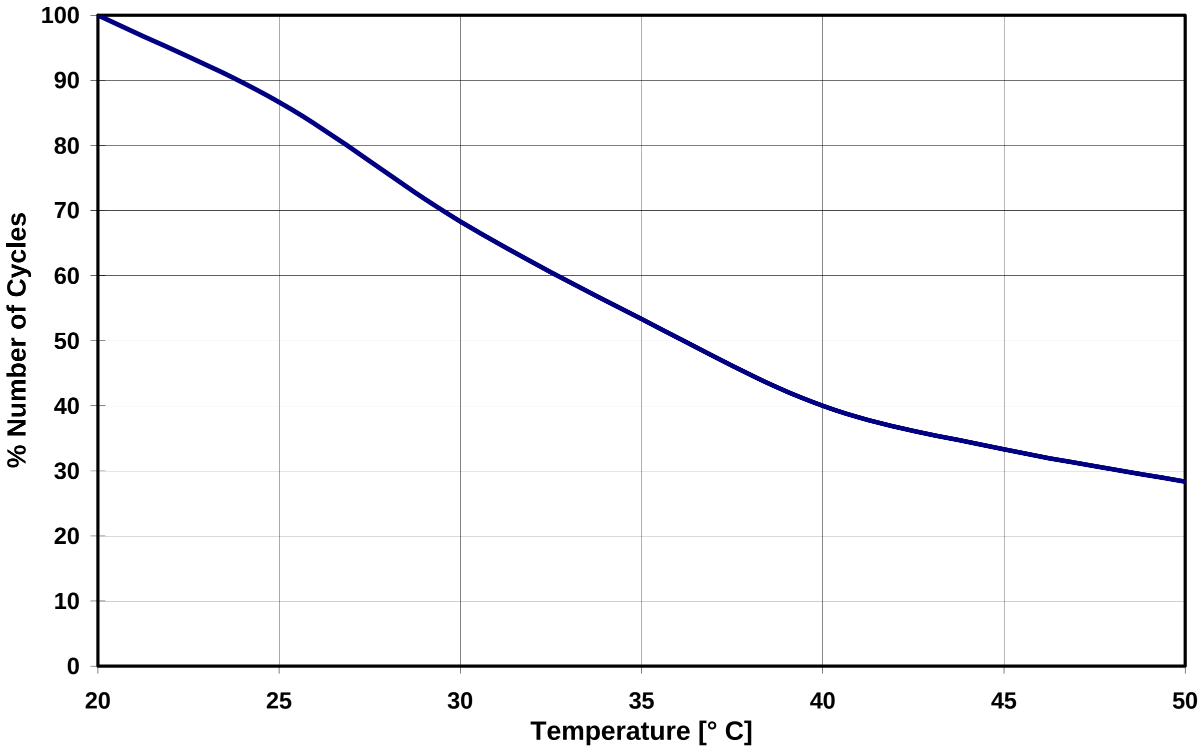


Fig. 21: OCSM, OPzS, Enersol T, OPzS Solar – Endurance in Cycles (in % of number of cycles) vs. Temperature

6.11 Maintenance and Checks

6.11.1 General Items and Checks acc. to Operating Instructions

- Periodic inspections and maintenance are necessary regarding:

  - charge voltage and current settings,
  - the discharge conditions,
  - the temperature levels,
  - the storage conditions,
  - the cleanliness of the battery and equipment
  - and other conditions relevant to safety issues and battery's service life (battery room ventilation, for example).

- Periodic discharges can be used to assess the available operating endurance, to detect faulty cells / blocks and aging symptoms of the battery, in order to consider battery replacement in due time.

- Keep the battery clean and dry to avoid leakage currents. Plastic parts of the battery, especially containers, must be cleaned with pure water without additives.

- At least every 6 months measure and record:

  - Battery voltage
  - Electrolyte density, electrolyte temperature and voltage of several cells / blocks (approx. 20%)
  - Battery-room temperature

- Annual measurement and recording:

  - Battery voltage
  - Voltage of all cells / blocks
  - Electrolyte densities and electrolyte temperatures of all cells
  - Battery-room temperature

  Annual visual checks:

  - Screw connections (screw connections without locking devices have to be checked for tightness)
  - Battery installation and arrangement
  - Ventilation

If the cell / block voltages (average float charge voltage at 2.23 or 2.25 Vpc acc. to chapter 6.1) are outside the range as mentioned in table 9 (see chapter 6.3) the service agent should be contacted.
Deviations of the battery voltage from the average value depending on the battery type and the number of cells have to be corrected (see chapter 6.1).

6.11.2 Battery Testers and Battery Monitoring

Sometimes, other methods than capacity tests are offered for checking the state-of-health, state-of-charge or capacity of batteries. This equipment is based on any of the following ohmic methods: conductance, impedance, DC-resistance.

So-called battery testers are portable. Any of ohmic methods as mentioned above can be included in battery monitoring systems. Hereby, monitoring means the system works on-line and is permanently connected to the battery.

Either battery testers or monitoring system, the above mentioned ohmic methods can be used in order to follow up trending of data. But, they can never replace a standardized capacity test.

Thus, because none of the above mentioned methods can supply absolute results. In fact, the results of measurements depend on the concrete method (frequency, amplitude etc.), the operator (battery testers!) and other parameters, i.e. temperature and location of probes on the cells or blocks. For more information, see also [11] and [12].

The following guideline can be used for the interpretation of impedance / conductance / resistance measurements:

- If impedance or conductance measurements are used for VRLA batteries it is recommended to install the battery and keep it for at least two days on float charge. After the two days and a maximum of seven days the first readings should be taken. These readings represent the initial impedance/conductance values for the blocks or cells.

- It is then recommended to take impedance/conductance readings every 6 or 12 months. If the application is considered as very critical in terms of reliability of power supply the readings can be taken more often.

- The interpretation of impedance/conductance values can not end with a conclusion of full capacity, low capacity or no capacity. Therefore the following recommendations can be made:

  - If impedance/conductance values of blocks or cells change more than 35 % to negative direction*), compared to the initial value, a boost charge for 12 hours followed by 2 days on float charge is recommended firstly. The measurement must be repeated. If the values are not decreasing below the 35 % criteria, a capacity test should be carried out for the battery.

  - If impedance/conductance values of blocks or cells measured have a negative deviation*) of more than 35 %, compared to the average value (per battery), a boost charge for 12 hours followed by 2 days on float charge is recommended firstly. The measurement must be repeated. If the values are not decreasing below the 35 % criteria, a capacity test should be carried out for the battery.

  - If no initial values are measured for a battery, only the second method can be applied.

  *) impedance to higher values and conductance to lower values

All impedance/conductance measurements can be compared to each other only if the temperature does not differ more than +/- 2° C.

For favorable deviations (impedance lower or conductance higher) no activity is needed (unless it complies with low DC float voltage) because this changing is related to the normal capacity increase of batteries put in float charge operation.

If a cell or a block is changed based on impedance/conductance measurement and returned to the manufacturer for investigation it is strongly recommended to write the measured value with permanent ink on the cell or block.

6.11.3 Cleaning of Batteries

- The cell vent plugs must not be removed or opened, but must keep closed the cells [1].

- It is allowed to clean the plastic parts of the battery, especially the cell containers, by water respectively water-soaked clothes only without additives [1].

- After the cleaning, the battery surface has to be dried on a suitable way, for instance, by compressed air or by clothes [1].

7. Recycling, Reprocessing

Lead-acid batteries is recoverable commercial ware. EXIDE Technologies' factories recycle used lead and see oneself as a part of the entire life cycle of a battery with regard to environmental protection. Contact your EXIDE Technologies representative. He will inform you about further details.

This holds also for used cells / blocks.

The transport of used accumulators is subject to special regulations. Therefore, it is recommended to order a company specialized in packaging and in making out of freight papers.

Details about the transport of used accumulators can be found in the information leaflet of the ZVEI "Taking back of used industrial batteries acc. to the battery decree" [13].

8. List of References

[1] Information leaflet "Cleaning of Batteries" of the working group "Industrial Batteries" in the ZVEI (Central Association of German Electrical and Electronic Manufacturers), Frankfurt/M., edition October 2006

[2] European standard EN 50272-2 "Safety requirements for secondary batteries and battery installations, Part 2: Stationary batteries", June 2001

[3] “Council Directive of 19 February 1973 on the harmonization of laws of member of states relating to electrical equipment designed for use within certain voltage limits (73/23/EEC)” (so-called “Low Voltage Directive”), amended in 1993 by the Directive 93/68/EEC, the so-called “CE marking Directive”

[4] B. A. Cole, R. J. Schmitt, J. Szymborski (GNB Technologies): “Operational Characteristics of VRLA Batteries Configured in Parallel Strings”, proceedings INTELEC 1998

[5] Information leaflet “Requirements on electrolyte and topping-up water for lead-acid batteries” of the working group “Industrial Batteries” in the ZVEI (Central Association of German Electrical and Electronic Manufacturers), Frankfurt/M., edition July 1999 (available in German language only)

[6] German standard DIN 41774, part 1 “Semiconductor rectifier equipment with IU-characteristic for the charging of lead-acid batteries – Guidelines”, edition February 1979 (this standard is available in German language only)

[7] Information leaflet “Considerations on service life of stationary batteries” of the working group “Industrial Batteries” in the ZVEI (Central Association of German Electrical and Electronic Manufacturers), Frankfurt/M., edition July 2008

[8] International standard IEC 60896-11 “Stationary lead-acid batteries, Part 11: Vented types – General requirements and methods of test”, first edition December 2002

[9] International standard IEEE P1013/D3: “IEEE Recommended Practice for Sizing Lead-Acid Batteries for Photovoltaic (PV) Systems”, draft April 1997

[10] International standard IEC 61427 “Secondary cells and batteries for photovoltaic energy systems (PVES) - General requirements and methods of test”, second edition 2005-05

[11] B. A. Cole, R. J. Schmitt (GNB Technologies): “A Guideline for the Interpretation of Battery Diagnostic Readings in the Real World”, Battconn ’99

[12] PPT-Presentation “Monitoring” (EXIDE Technologies, GCS), October 2002

[13] Information leaflet “Taking back of used industrial batteries acc. to the battery decree” of the working group “Industrial Batteries” in the ZVEI (Central Association of German Electrical and Electronic Manufacturers), Frankfurt/M., edition July 2007 (available in German language only)

Appendix 1: Available Capacity vs. Charging Time

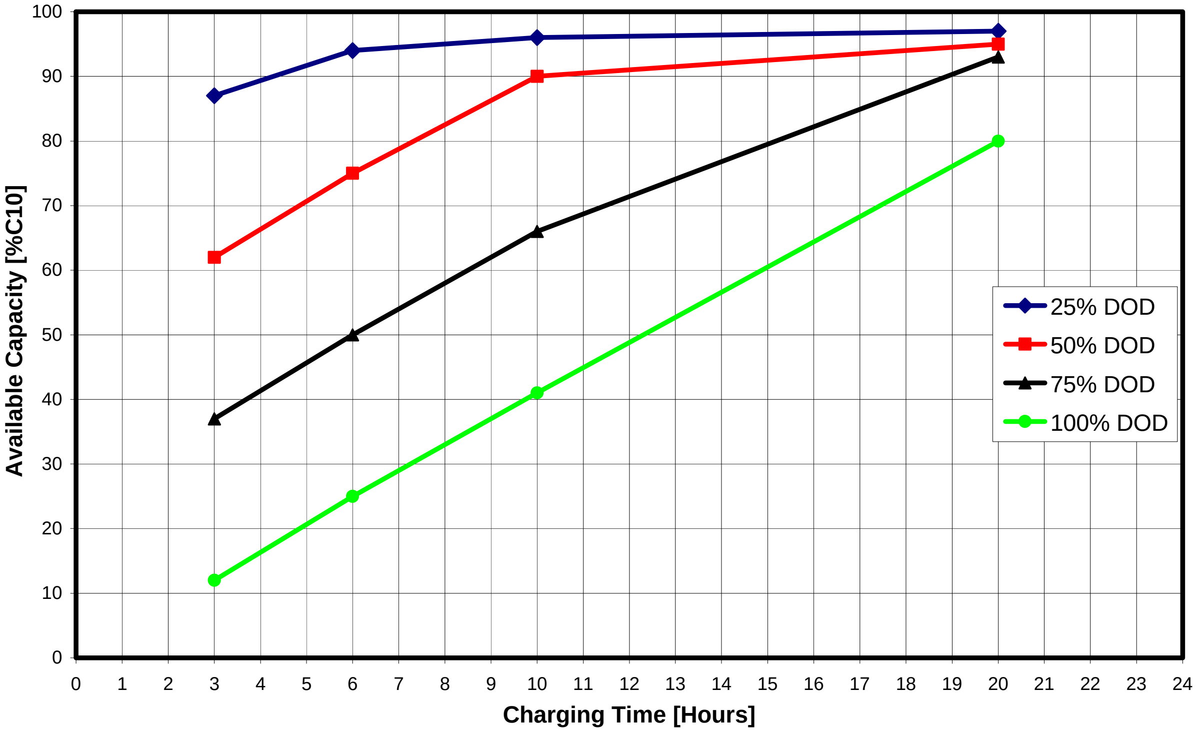


Fig. 22: Available Capacity versus Charging Time at 2.23 Vpc, Charging Current 0.5 • I_{10}, DOD = Depth of Discharge

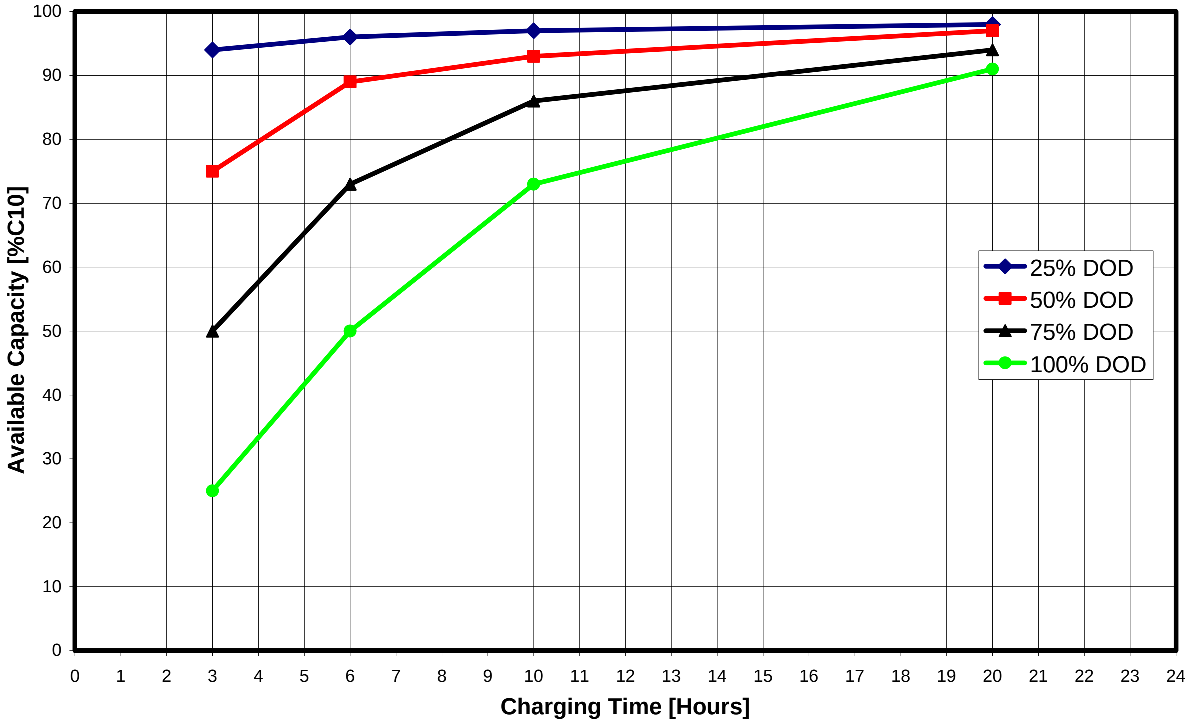


Fig. 23 (same as fig. 7 in chapter 6.4): Available Capacity vs. Charging Time at 2.23 Vpc, Charging Current 1 • I_{10}, DOD = Depth of Discharge

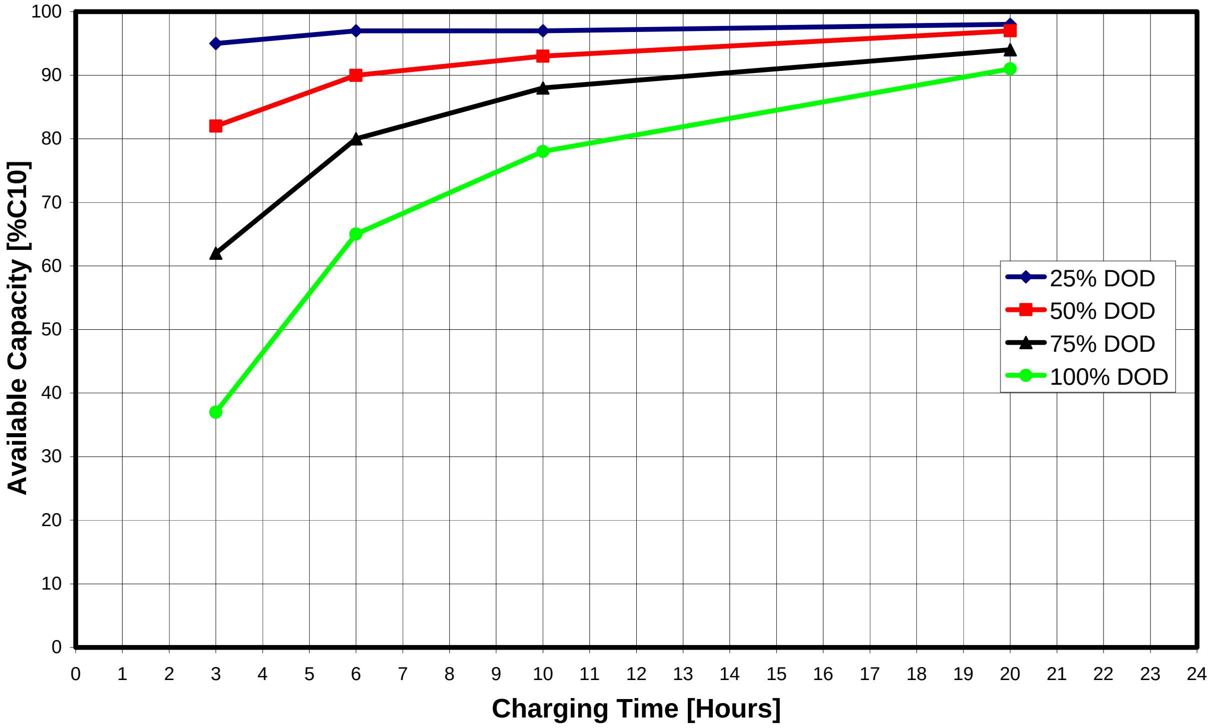


Fig. 24: Available Capacity versus Charging Time at 2.23 Vpc, Charging Current 1.5 • I_{10}, DOD = Depth of Discharge

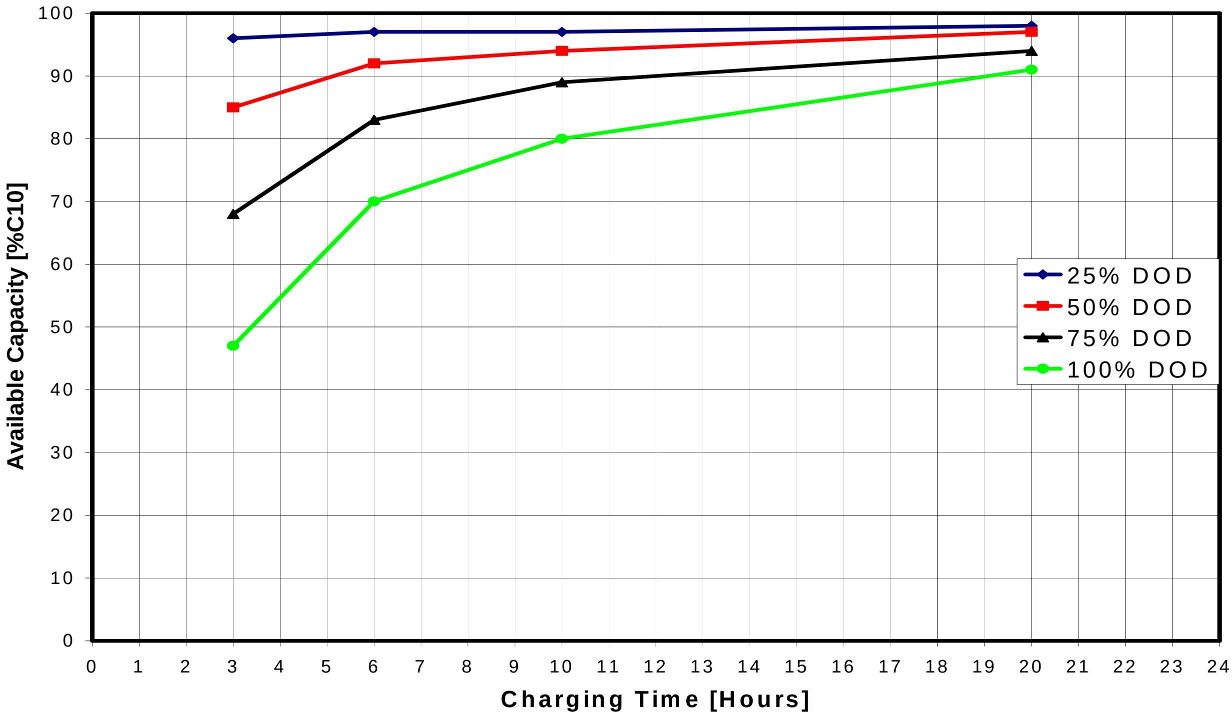


Fig. 25: Available Capacity versus Charging Time at 2.23 Vpc, Charging Current 2 • I_{10}, DOD = Depth of Discharge

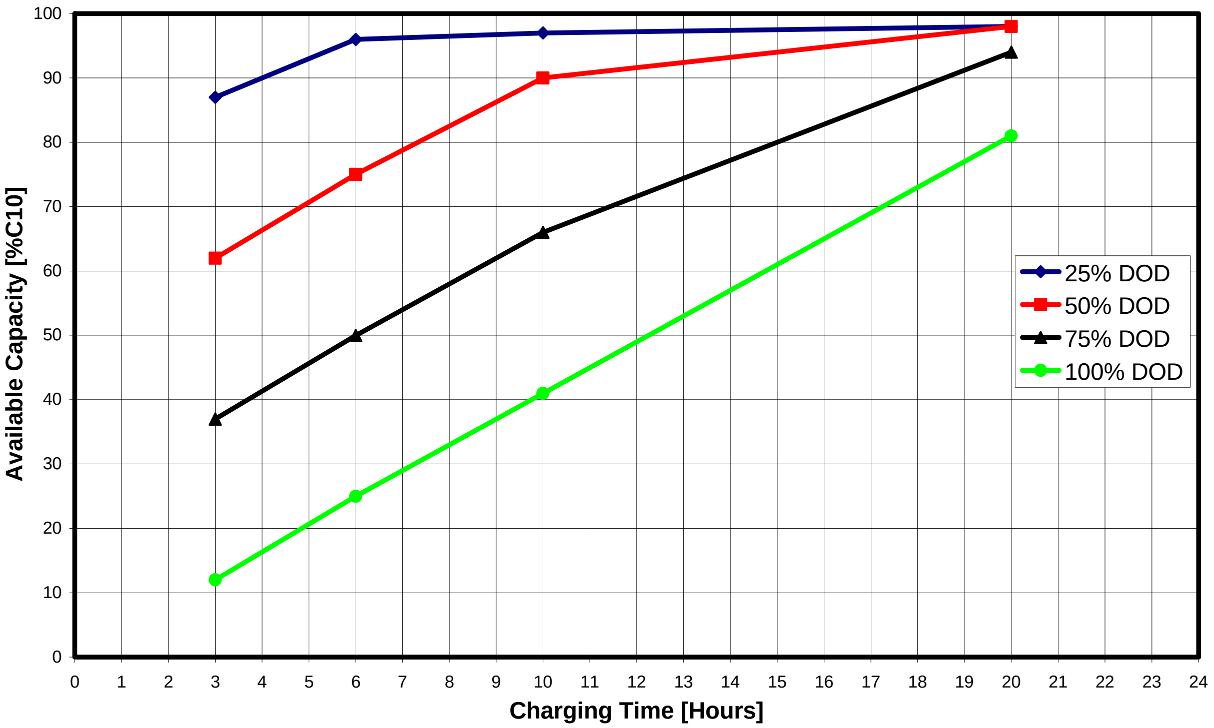


Fig. 26: Available Capacity versus Charging Time at 2.30 Vpc, Charging Current 0.5 • I_{10}, DOD = Depth of Discharge

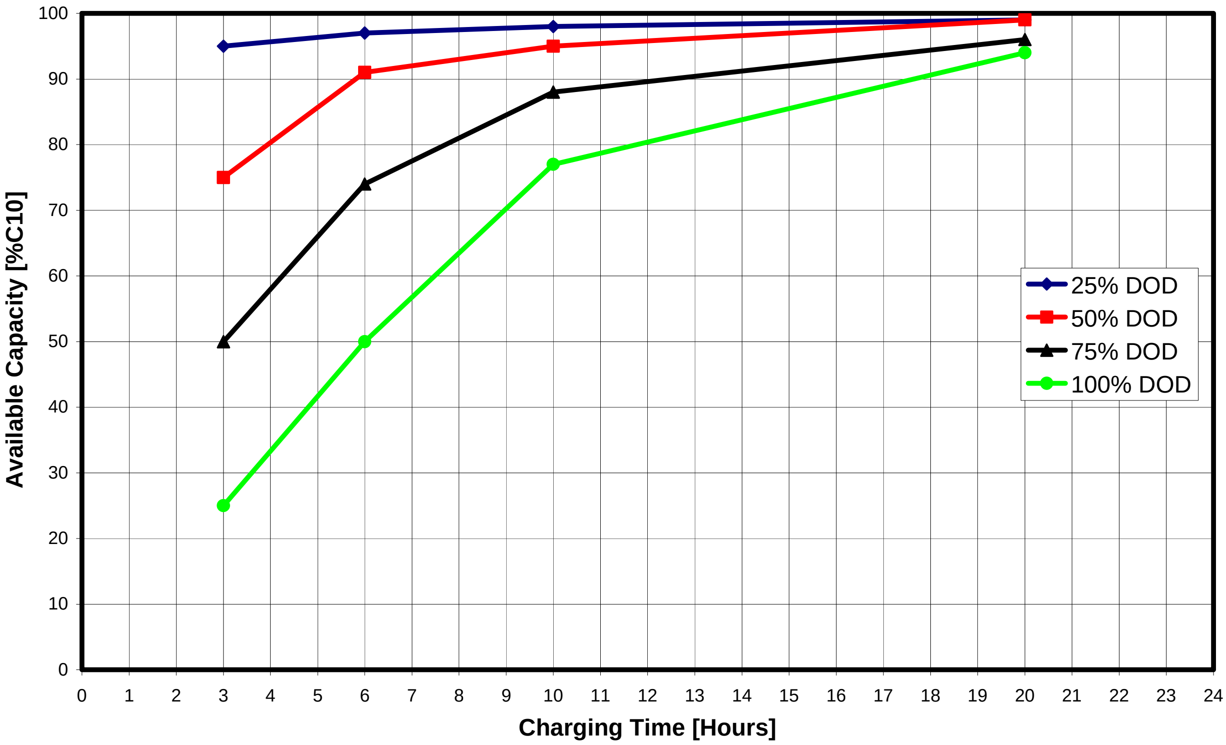


Fig. 27: Available Capacity versus Charging Time at 2.30 Vpc, Charging Current 1 • I_{10}, DOD = Depth of Discharge

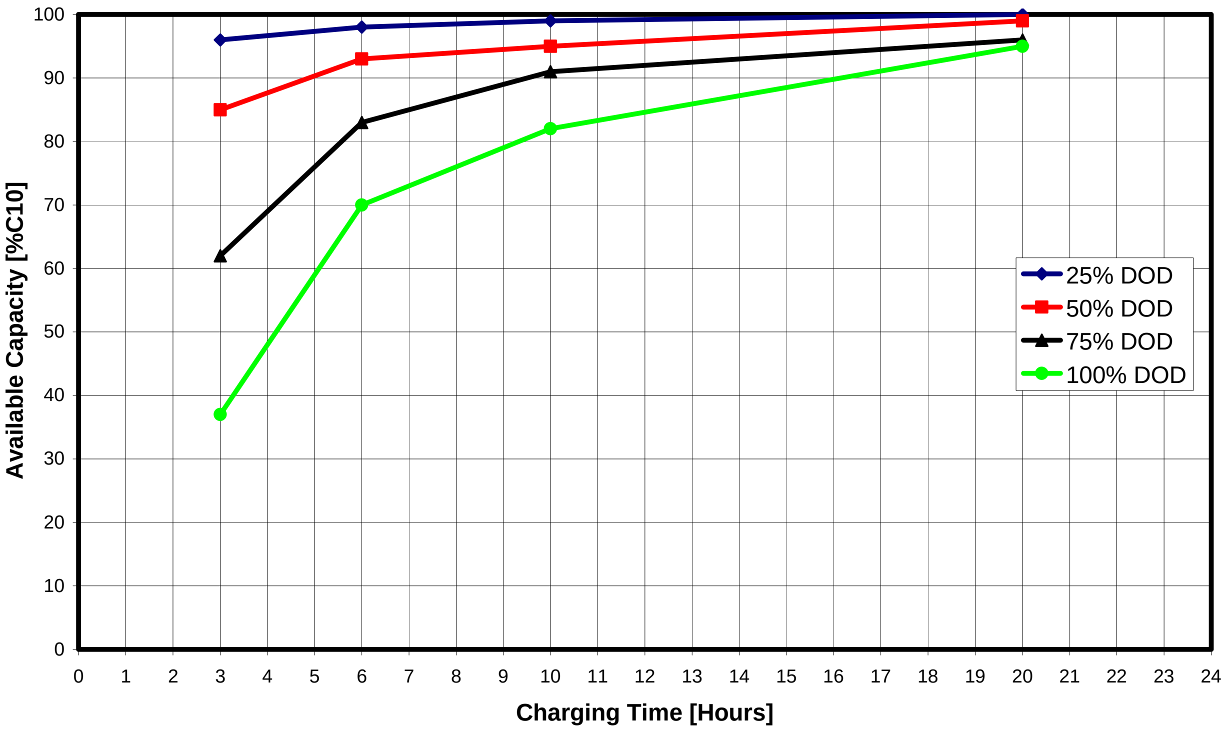


Fig. 28: Available Capacity versus Charging Time at 2.30 Vpc, Charging Current 1.5 • I_{10}, DOD = Depth of Discharge

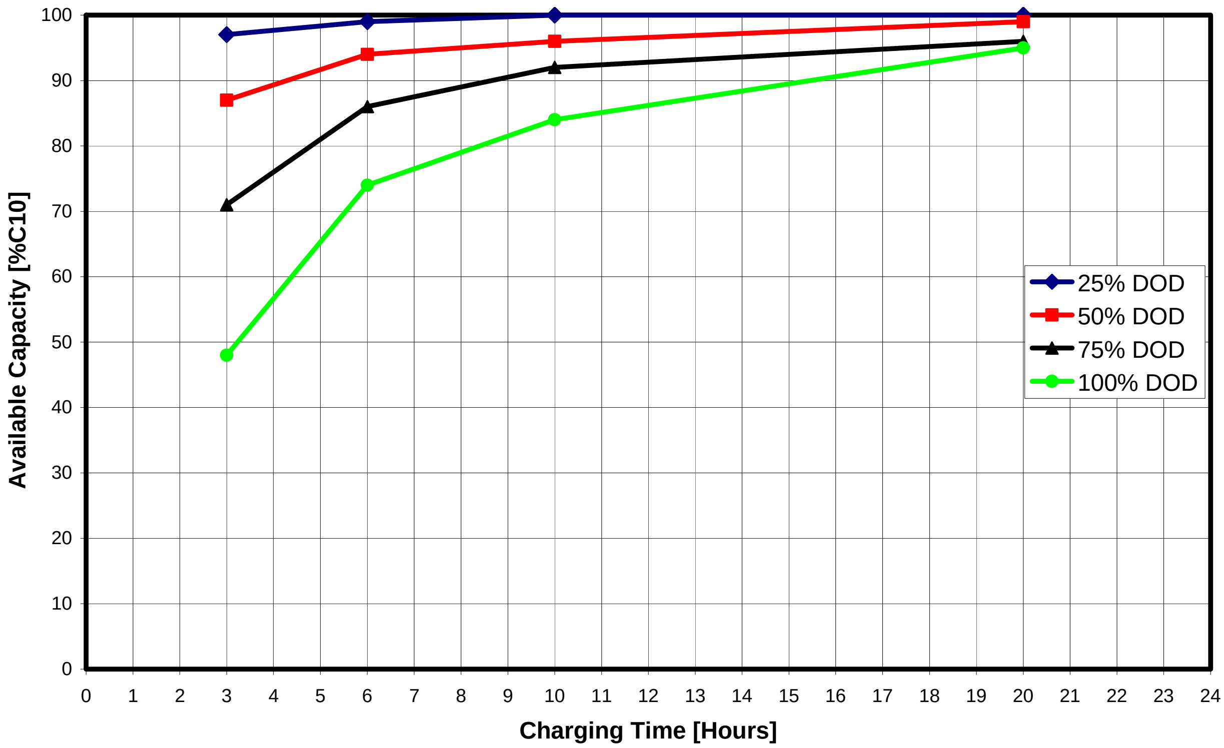


Fig. 29: Available Capacity versus Charging Time at 2.30 Vpc, Charging Current 2 • I_{10}, DOD = Depth of Discharge

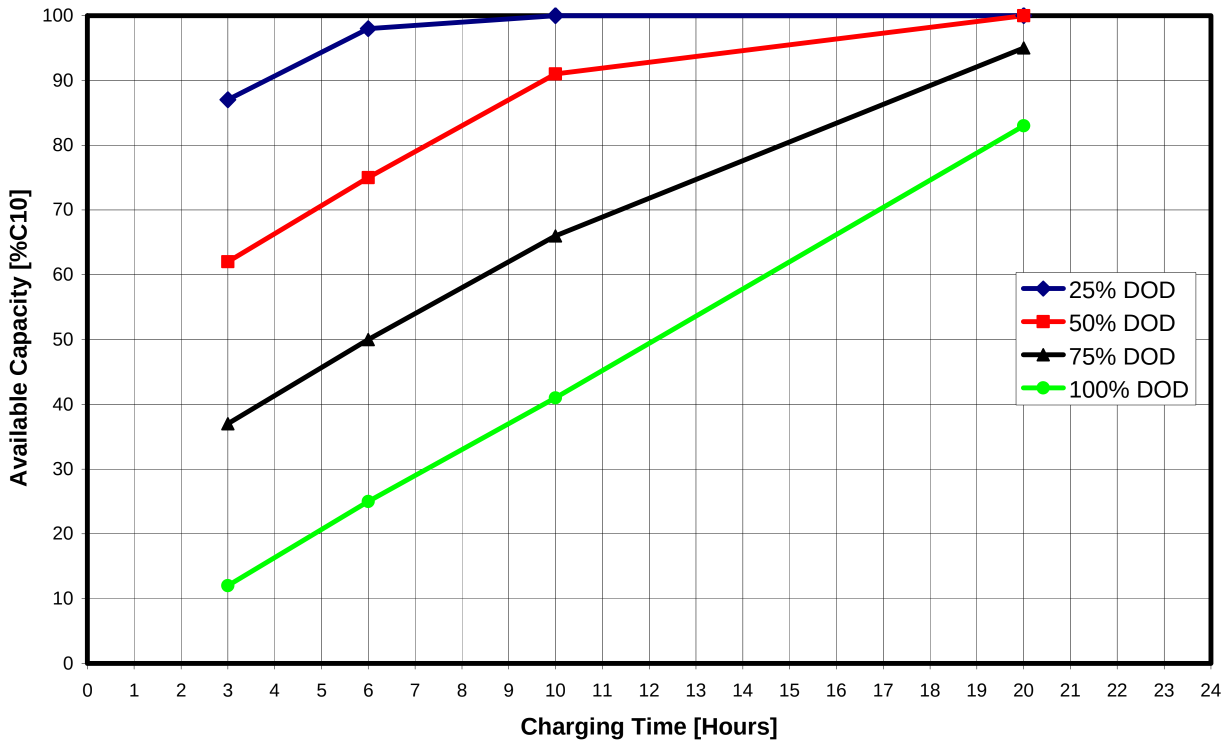


Fig. 30: Available Capacity versus Charging Time at 2.40 Vpc, Charging Current 0.5 • I_{10}, DOD = Depth of Discharge

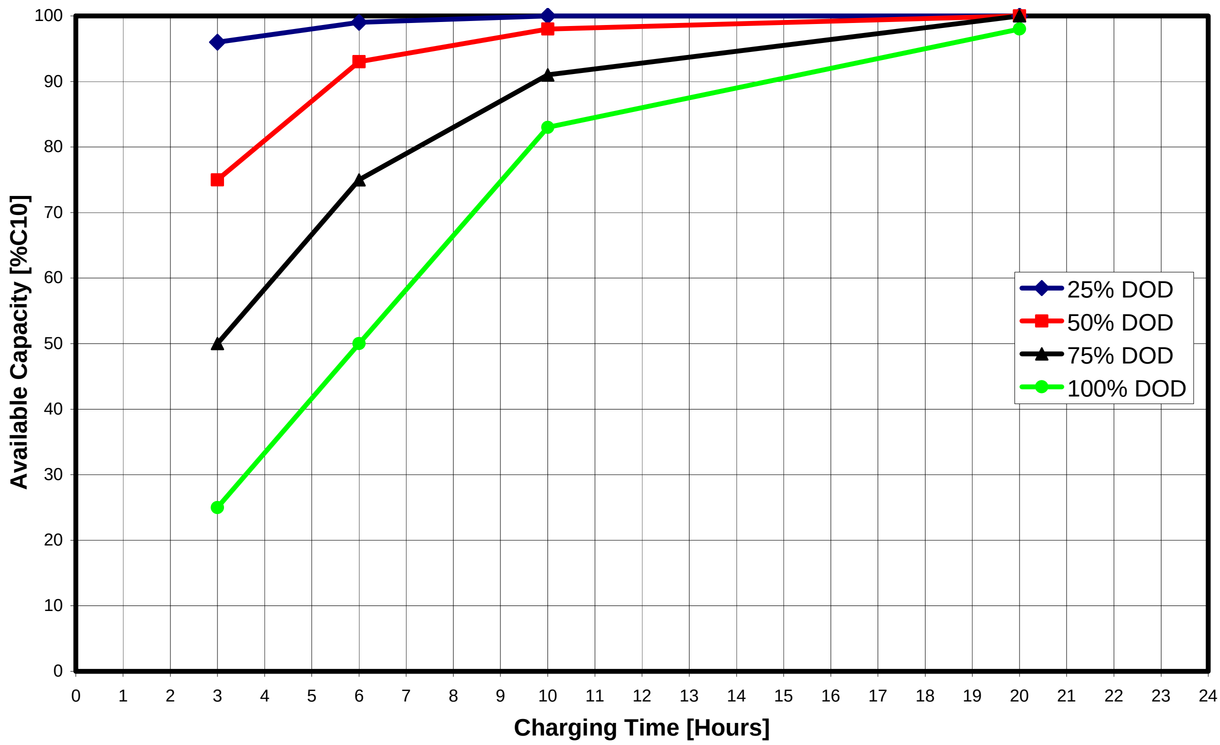


Fig. 31 (same as fig. 8 in chapter 6.4): Available Capacity vs. Charging Time at 2.40 Vpc, Charging Current 1 • I_{10}, DOD = Depth of Discharge

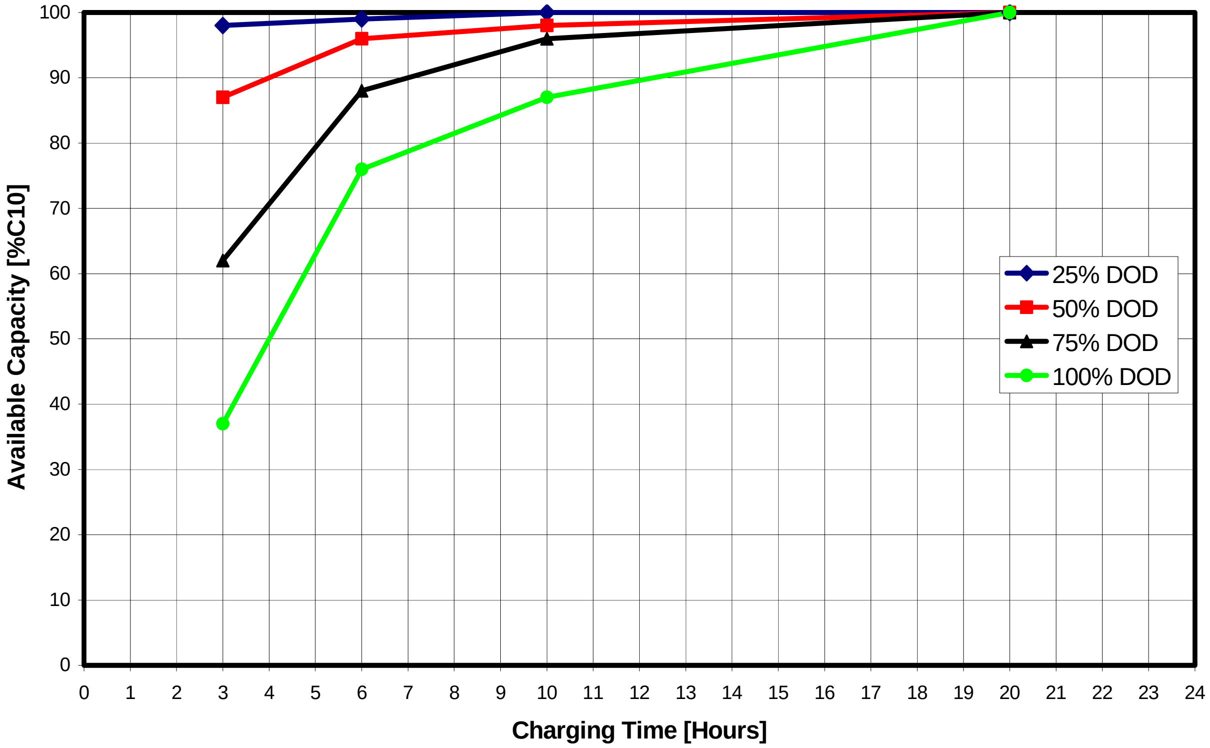


Fig. 32: Available Capacity versus Charging Time at 2.40 Vpc, Charging Current 1.5 • I_{10}, DOD = Depth of Discharge

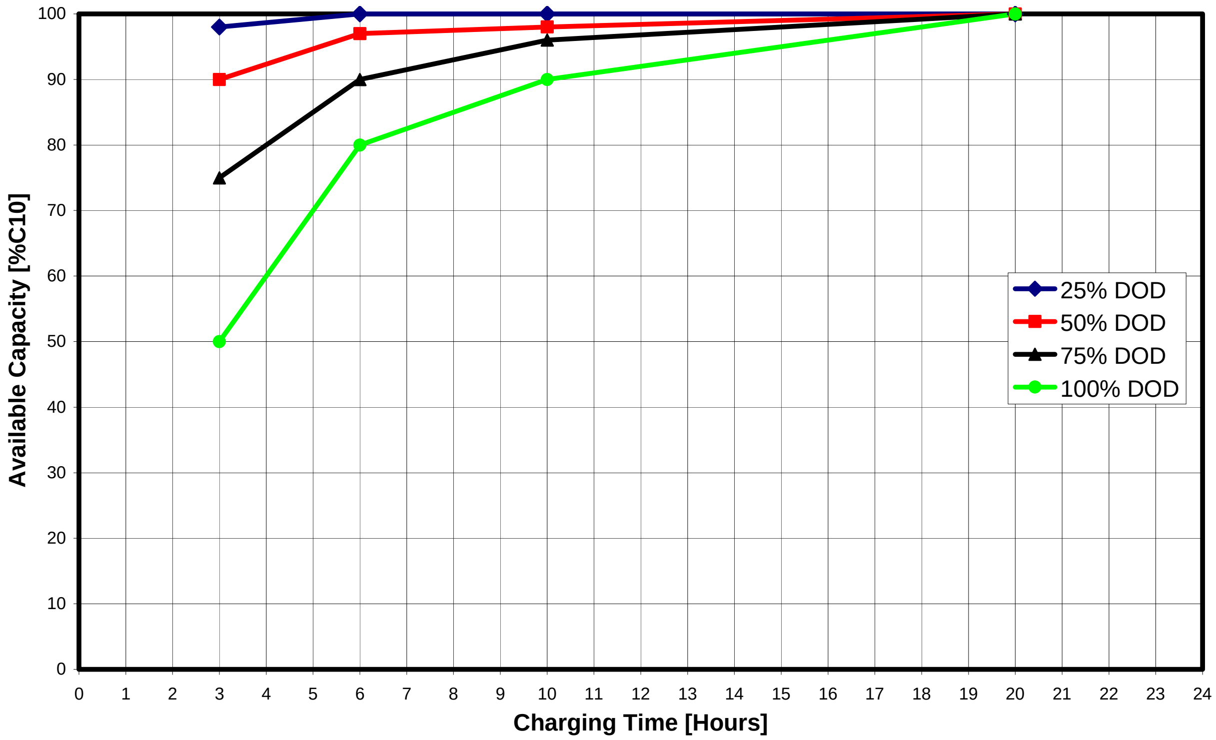


Fig. 33: Available Capacity versus Charging Time at 2.40 Vpc, Charging Current 2 • I_{10}, DOD = Depth of Discharge

Important Notice: The manufacturer of batteries EXIDE Technologies do not take over responsibility for any loyalties resulting from this paper or resulting from changes in the mentioned standards, neither for any different national standards which may exist and has to be followed by the installer, planner or architect.

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State: November 2008

Appendix 2: Instructions

"Commissioning instructions and report…"
"Installation instructions…"
"Classic Range…Operating instructions…"
"Classic Solar…Operating instructions…"

Commissioning instructions and report
for a vented lead-acid battery

EXIDE TECHNOLOGIES
INDUSTRIAL ENERGY

Nominal data

- Nominal voltage: ____________ V
- Nominal capacity: ____________ Ah
- Battery-no.: ____________
- Cells / blocs: ____________
- Type: ____________

Commissioned by ________________________

Started on ____________ Completed on ____________

- Follow installation instructions! Work on batteries to be carried out only upon instruction by skilled personnel, whist observing the commissioning and/or operating instructions!
- No smoking!
  Do not expose batteries to naked flames, glowing embers or sparks, as this may cause the battery to explode.
- Use protective glasses and clothes when working on batteries. Pay attention to the accident-prevention rules as well as EN 50272-2 and EN 50110-1.
- Electrolyte splashes in the eyes or on the skin must be washed away with plenty of clean water. In allcases consult a doctor immediately! Clothing contaminated by electrolyte should be washed in water.
- Risk of explosion and fire, avoid short circuits! Caution: Metal parts of the battery are allways live. Do not place tools or other metal objects on the battery!
- Electrolyte is highly corrosive!
- Monobloc batteries and cells are very heavy. Ensure secure installation! Use only suitable handling equipment, tools and measuring instruments.
- Dangerous electric voltage!
  Caution! Metal parts of the battery are always alive, therefore do not place items or tools on the battery.

Non-compliance with commissioning instructions and installations or repairs made with other than original accessories and spare parts or with accessories and spare parts not recommended by the battery manufacturer or repairs made without authorization and use of additives for the electrolytes (alleged enhancing agents) render the warranty void.
The commissioning report must be filled in and returned to the battery manufacturer.

Pb

Spent batteries have to be collected and recycled separately from normal household wastes (EWC 160601). The handling of spent batteries is described in the EU Battery Directive (91/157/EEC) and their national transitions (UK: HS Regulation 1994 No. 232, Ireland: Statory Instrument No. 73/2000). Contact your supplier to agree upon the recollection and recycling of your spent batteries or contact a local and authorized Waste Management Company.

1. Checks
The battery system as well as the charger must be checked to be free from mechanical damage. All screws within the circuit must be tightened in accordance with the operating instructions for the battery, establishing safe contact.
The charger must be checked for its readiness for working. Check for correct polarity. Before filling the cells it has to be ensured that the guidelines of EN 50272-2 and EN 50110-1 regarding the installation and ventilation are observed. If the current applied during the commissioning is greater than what the ventilation system is designed for, the ventilation of the battery room must be increased for the duration of commissioning and for an hour afterwards depending on the charge current applied, e.g. by additional portable ventilators. The same applies to occasional special charging treatment of batteries.

2. Filling the cells
The filling acid with the density defined in table 1 must meet the purity standards laid down in DIN 43 530 part 2.
If concentrated sulphuric acid has been delivered, the mixing instructions must be observed.
The temperature of the filling acid shall range between 15° C and 30° C. Prior to filling, the temperature is to be measured and recorded in the commissioning report.

Upon removal of the transport plugs or upon opening the vent plugs, the cells shall be filled up to the lower electrolyte level indication.
Acid-resistant filling devices are to be used for this purpose.
Transport plugs may not be used during the battery operation. They must be replaced by vent plugs, which are included in the delivery.

Table 1: Electrolyte density in kg/l at 20° C

Cell type	Filling density [kg/l]	Nominal density [kg/l]
GroE	1.21	1.22
OPzS, EB, OGi $\leq$ 250 Ah	1.23	1.24
OCSM, OGi $\geq$ 260 Ah	1.25	1.26

Higher temperature reduce the electrolyte density, lower temperatures increase it. The relevant correction factor is 0.0007 kg/l per K.

Example: Electrolyte density of
1.23 kg/l at 35° C corresponds to a density of 1.24 kg/l at 20° C.

3. Rest period
Once the cells have been filled, they must rest for a period of 2 hours. Afterwards the temperature and electrolyte density must be measured in at least 4 to 8 cells (pilot cells), depending on the total number, and the results must be entered in the commissioning report. If the temperature rise is less than 5 K and the electrolyte density has not decreased by more than 0.02 kg/l below the density of the filling acid, a simplified commissioning charge, as described at 4.1 and/or 4.2 is sufficient.
If one of the deviations is greater, an extended commissioning charge, as described at 4.3, is required.

4. Commissioning
The vent plugs in non-transparent containers stay open, in order to be able to see whether towards the end of charging all cells are gassing evently. It is important that the first charging is carried out completely. This is possible only at a charge voltage greater than 2.35 V/cell.
Interruptions should be avoided if possible. The commissioning data shall be recorded in the commissioning report sheet overleaf. During commissioning the cell voltage shall be measured at the pilot cells and upon completion of commissioning, cell voltage, electrolyte density and temperature shall be recorded in the commissioning report, including indication of time.
The electtolyte temperature must not exceed 55° C. If necessary, the charging must be interrupted.

4.1 Commissioning charge at constant voltage (IU characteristics)
A charge voltage of 2.35 - 2.4 V/cell is required. The initial charge current should be at least 5 A per 100 Ah C_{10}.
In the course of charging, the electrolyte density increases only slowly, therefore it may take several days of charging until a minimum density, i.e. the nominal electrolyte density -0.01 kg/l is reached. Afterwards the charger must be switched over to float charge operation as described in the operation instructions. During operation the electrolyte density will reach the nominal value.

4.2 Commissioning charge at constant current (I characteristics) or at descending current (W-characteristic)
The maximum admissible currents are shown in table 2.

Table 2: maximum admissible charge currents in A per 100 Ah C_{10} for I and W charging

Charging caracteristic	Charge current
I caracteristic	5 A
W caracteristic ati:	
2.0 V/ell	14.0 A
2.4 V/cell	7.0 A
2.65 V/cell	3.5 A

Charging must be continued until
– all cells have reached a voltage of at least 2.6 V,
– the electrolyte density in all cells has increased to the nominal value ± 0.01 kg/l, and until these values do not increase any more for another 2 hours

Afterwards switch over to float charge voltage as described in the operating instructions.

4.3 Extended commissioning charge
Long storage periods or climatic influences (humidity, temperature variations) cause a decrease in the state of the charge of the cells.
In these cases an extended commissioning charge is required as follows:
1. Charge at 15 A per 100 Ah C_{10} until 2.4 V/cell are reached (approx. 3-5 hours),
2. Charge for 14 hours at 5 A per 100 Ah C_{10} (voltage rises higher than 2.4 V/cell)
3. Pause of one hour
4. 4 hours charging at 5 A per 100 Ah C_{10}

Points 3 and 4 are to be repeated until
– all cells have reached a voltage of at least 2.6 V/cell
– the electrolyte density in all cells has increased to the nominal value ± 0.01 kg/l, an until these values do not increase any more for another 2 hours.

Afterwards switch over to float charge voltage, as described in the operating instructions.

4.4 Electrolyte level adjustment
Once the commissioning is completed, the electrolyte level must be adjusted to the top level indication by using filling acid.

4.5 Electrolyte density adjustment
If at the end of commissioning the electrolyte density turns out to be too high, part of the electrolyte must be replaced by purified water pursuant to DIN 43 530 part 4.
The electrolyte density of the individual cells should not vary by more than 0.01 kg/l. If the variations are any greater, the electrolyte density must be adjusted and afterwards an equalising charge is to be carried out as described in the operating instructions.

5. Note:
Leaks or spills of acid must be carefully removed and/or neutralised. A soda solution (1 kg soda to 10 litres of water) or other neutralising agents can be used for this purpose. Neutralising agents must not get into the cell. Finally the battery surface is to be cleaned (ZVEI instruction leaflet "Cleaning of batteries" refers). The instructions given in the ZVEI leaflet ”Safety data sheet for battery acid (dilute sulphuric acid)” are to be followed.
Concerning the operation of the battery the operating instructions apply.

6. Commissioning report

– Was the acid delivered by the battery manufacturer? yes ☐ no ☐
– If not, was the filling acid analysed for chlorine, iron or other detrimental metals? yes ☐ no ☐
– What was the test result? ____________
– What was the density of the new acid prior to filling? ________ kg/l at ________ ° C
– Filling with acid started on ____________ at ________ h at cell no. ________
– Filling with acid was completed on ____________ at ________ h at cell no. ________
– Average ambient temperature ____________ ° C

Pilot cells [1] Measurement 2 h after filling	No.	No.	No.	No.	No.	No.	No.	No.
Elektrolyte density [kg/l]								
Elektrolyte temperature [° C]								
Elektrolyte density corrected temperature (v. point 2) [kg/l]								

[1] Cell- or bloc-No.

The electrolyte density in monobloc batteries is to be measured in the cell next to the positive terminal.

Commissioning charge was carried out in accordance with paragraph 4.1 ☐ 4.2 ☐ 4.3 ☐

Commissioning charge was started on ____________ (date) at ____________ (time)

Once every hour during the first 6 hours of commissioning charge the cell voltage, electrolyte density and temperature are to be measured on at least 4 pilot cells and the results are to be recorded. At the end of commissioning another 3 measurements are to be taken once every hour.

Time	Pilot cell / bloc 1			Pilot cell / bloc 2			Pilot cell / bloc 3			Pilot cell / bloc 4		
	d [kg/l]	δ [° C]	U [V]	d [kg/l	δ [° C]	U [V]	d [kg/l	δ [° C]	U [V]	d [kg/l]	δ [° C]	U [V]

Time	Pilot cell / bloc 5			Pilot cell / bloc 6			Pilot cell / bloc 7			Pilot cell / bloc 8		
	d [kg/l]	δ [° C]	U [V]	d [kg/l	δ [° C]	U [V]	d [kg/l]	δ [° C]	U [V]	d [kg/l	δ [° C]	U [V]

At monobloc batteries the cell voltage (if not possible, the monobloc voltage) and the electrolyte density are to be measured in the cell next to the positive terminal

Cell/bloc voltages and electrolyte densities of all cells at a mean electrolyte temperature of _____________ ° C at the end of commissioning charge before switching over to float charge operation.

1)	Voltage [V]	Density [kg/l]	1)	Voltage [V]	Density [kg/l]	1)	Voltage [V]	Density [kg/l]	1)	Voltage [V]	Density [kg/l]	1)	Voltage [V]	Density [kg/l]
1			46			91			136			181		
2			47			92			137			182		
3			48			93			138			183		
4			49			94			139			184		
5			50			95			140			185		
6			51			96			141			186		
7			52			97			142			187		
8			53			98			143			188		
9			54			99			144			189		
10			55			100			145			190		
11			56			101			146			191		
12			57			102			147			192		
13			58			103			148			193		
14			59			104			149			194		
15			60			105			150			195		
16			61			106			151			196		
17			62			107			152			197		
18			63			108			153			198		
19			64			109			154			199		
20			65			110			155			200		
21			66			111			156			201		
22			67			112			157			202		
23			68			113			158			203		
24			69			114			159			204		
25			70			115			160			205		
26			71			116			161			206		
27			72			117			162			207		
28			73			118			163			208		
29			74			119			164			209		
30			75			120			165			210		
31			76			121			166			211		
32			77			122			167			212		
33			78			123			168			213		
34			79			124			169			214		
35			80			125			170			215		
36			81			126			171			216		
37			82			127			172			217		
38			83			128			173			218		
39			84			129			174			219		
40			85			130			175			220		
41			86			131			176			221		
42			87			132			177			222		
43			88			133			178			223		
44			89			134			179			224		
45			90			135			180			225		

1) Cell or bloc no.

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EXIDE TECHNOLOGIES INDUSTRIAL ENERGY

81700094

Installation instruction

for stationary lead acid batteries (Batteries / Stands / Cabinets)

EXIDE TECHNOLOGIES INDUSTRIAL ENERGY

- Observe these Instructions and keep them located near the battery for future reference. Work on the battery should only be carried out by qualified
- personnel.

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

- While working on batteries wear protective eye-glasses and clothing.
- Observe the accident prevention rules as well as EN 50 272-2, EN 50110-1.

- An acid splash on the skin or in the eyes must be flushed with plenty of clean water immediately. Then seek medical assistance.
- Spillages on clothing should be rinsed out with water.

- Explosion and fire hazard, avoid short circuits.

- Electrolyte is very corrosive. In normal working conditions the contact with the electolyte is impossible. If the cell or monobloc container is damaged do not touch the exposed electrolyte because it is corrosive.

- Cells and monoblocs are heavy! Always use suitable handling equipment for transportation.
- Handle with care because cells and monoblocs are sensitive to mechanical shock.

- Dangerous electric voltage!
  Caution! Metal parts of the battery are always alive, therefore do not place items or tools on the battery.

Non-compliance with installation instruction, installations or repairs made with other than original accessories and spare parts or with accessories and spare parts not recommended by the battery manufacturer or repairs made without authorization (e. g. opening of valves on VRLA batteries) and use of additives for the electrolytes on flooded batteries (alleged enhancing agents) render the warranty void.

1. Installation preconditions and preparations

1.1
Prior to commencing installation, ensure that the battery room is clean and dry and that it has a lockable door. The battery room must meet the requirements in accordance with EN 50 272-2 and be marked as such. Pay attention to the following aspects:

– Load bearing capacity and nature of the floor (transport paths and battery room)

– Electrolytic resistance of the area where the battery is to be installed

– Ventilation

To ensure trouble free installation, coordination should be made with other personnel working in the same area.

1.2
Check delivery for complete and undamaged components. If necessary, clean all parts prior to installation.

1.3
Follow instructions in the documentation supplied (e.g. installation drawings for battery, stand, cabinet).

1.4
Prior to removing old batteries always ensure that all of the leads have been disconnected (load-break switches, fuses, insulations). This must be carried out only by personnel authorised to perform circuit operations.

WARNING: **Do not carry out any unauthorised circuit operation!**

1.5
Carry out open circuit voltage measurements on the individual cells or monobloc batteries. At the same time, ensure that they are connected in the correct polarity. As for unfilled and charged batteries, these measurements can only be taken after commissioning. The open-circuit voltages of fully charged cells at temperature of 20 °C are as follows:

Product range flooded (Classic)

OPzS-cells	DIN 40736	2.08 Vpc ± 0.01
OPzS-blocs	DIN 40737	2.08 Vpc ± 0.01
OCSM-cells		2.10 Vpc ± 0.01
GroE-cells	DIN 40738	2.06 Vpc ± 0.01
OGi-cells ≤ 250 Ah		2.08 Vpc ± 0.01
OGi-cells ≥ 260 Ah		2.10 Vpc ± 0.01
OGi-blocs		2.10 Vpc ± 0.01
Energy Bloc		2.08 Vpc ± 0.01

Product range VRLA (Gel, AGM)

OPzV-cells	DIN 40742	min. 2.12 Vpc
OPzV-blocs	DIN 40744	min. 2.12 Vpc
OGiV-blocs		min. 2.14 Vpc

The open-circuit of the individual cells / blocs must not vary from each other by more than the approved values in the table below.

Product range	flooded	VRLA (Gel, AGM)
Singlecell	0.02 V	0.04 V
4 V-bloc	0.04 V	0.08 V
6 V-bloc	0.06 V	0.12 V
10 V-bloc	0.10 V	–
12 V-bloc	0.13 V	0.24 V

Higher temperatures cause the open-circuit voltage to be lower, whereas lower temperatures cause it to be higher. At a deviation of 15 K from the nominal temperature, the open circuit-voltage changes by 0.01 Vpc. If the deviation is any higher, contact the supplier.

2. Stands

2.1
Locate the stands/racks within the battery room in accordance with the installation plan. If an installation plan does not exist, observe the following minimum distances:

– From the wall: 100 mm all around, with regard to cells or monoblocs, or 50 mm, concerning of the stands.

– At a nominal voltage or partial voltage >120 V: 1.5 metres between non-insulated leads or connectors and grounded parts (e.g. water pipes) and/or between the battery terminals. During the installation of the batteries, ensure that EN 50 272-2 part 2 is observed (e.g. by covering electrically conductive parts with insulating mats).

– Width of aisles: 1.5 x cell width (built-in depth), but not less than 500 mm.

2.2
Balance battery stands horizontally, using the balance parts supplied, or adjustable insulators. The distances of the base rails must correspond to the dimensions of the cells or monobloc batteries. For horizontal installation of blocks/cells please ensure, that the beam does not support the lid/cover of blocks/cells see drawing 1. Check the stands for stability and all screwed and clamped joints for firm connection. Earth (ground) the stand or parts of the stand, if required. Screwed joints must be protected against corrosion.

2.3
Check cells or monobloc batteries for perfect condition (visual check, polarity).

2.4
Place cells or monobloc batteries on the stand one after another, ensuring correct polarity. For large cells it is useful to start installing the cells in the middle of the stand:

– Align cells or monobloc batteries parallel to each other. Distance between cells or monobloc batteries approx. 10 mm, at least 5 mm.
– If necessary, clean the contacting surfaces of the terminals and connectors.
– Place and screw intercell or monobloc connectors, using an insulated torque wrench (for correct torque value refer to battery operating instructions). If applicable, observe special instructions with regard to the intercell connectors (e.g. welded connectors).
– Place the series, step or tier connectors supplied and screw them together, observing the given torque values.
– Avoid short circuits! Use leads of at least 3 kV breakdown voltage or keep an air distance of approx. 10 mm between the leads and electrically conductive parts, or apply additional insulation to the connectors. Avoid applying any mechanical force on the cell/battery poles.
– If applicable, remove transport plugs and replace by operational plugs.
– Check electrolyte level. (Observe operating instructions / commissioning instructions).
– Measure total voltage (nominal voltage: sum of open circuit voltages of the individual cells or monobloc batteries).
– If necessary sequentially number the cells or monobloc batteries in a visible place between the positive terminal of the battery and the negative terminal of the battery.
– Apply polarity signs for the battery leads.
– Attach safety marking, type lable and operating instructions in a visible place.
– If necessary, fit insulating covers for cell / monobloc connectors and terminals.

3. Cabinets
3.1
Cabinets with **built-in** battery:

– Install the battery cabinet at the location assigned, observing the accident prevention rules.
– Leave additional space from the wall for possible or planned cable entries.
– If applicable, remove transport protection from the built-in cells or monobloc batteries.
– Check cells or monobloc batteries for correct positioning and for any mechanical damage.

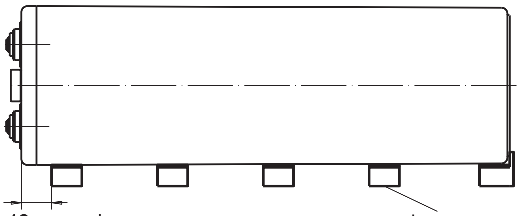
3.2
Cabinets with **separately delivered** cells or monobloc batteries:

– Only filled and charged cells and/or monobloc batteries (vented or valve regulated) are built into cabinets.
– Assemble cabinet, place and align at the assigned location (observe the accident prevention rules).
– Place cells or monobloc batteries in the cabinet, in accordance with the installation plan, use the enclosed cellular rubber according drawing 2 and the defined distances, connect electrically and apply markings (see point 2.4).

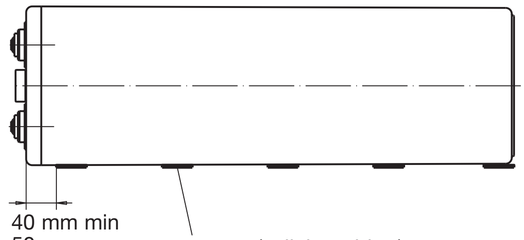
4. CE marking
From 1 January 1997, batteries with a nominal voltage from 75 V onwards require an EC conformity declaration in accordance with the low voltage directive (73/23/EWG), which entails that the CE marking is applied to the battery.
The company installing the battery is responsible for supplying the declaration and applying the CE marking.

WARNING:
Prior to connecting the battery to the charger, ensure that all installation work has been duly completed.

Drawing 1



Drawing 2



For drawing 1 and 2
Number or supports:

4 OPzV	200	-	6 OPzV	300	=	3 pieces
5 OPzV	350	-	7 OPzV	490	=	4 pieces
6 OPzV	600	-	12 OPzV	1200	=	5 pieces
15 OPzV	1500	-	24 OPzV	3000	=	6 pieces

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EXIDE TECHNOLOGIES INDUSTRIAL ENERGY

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Classic™

EXIDE TECHNOLOGIES
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Classic Range: GroE, OPzS-LA, OCSM-LA, OGi-LA, Energy Bloc Operating Instructions for stationary lead acid batteries

Nominal data

- Nominal voltage U_N : 2.0 V x number of cells
- Nominal capacity $C_N = C_{10}$: 10h discharge (see type plate on cells and technical data in these instructions)
- Nominal discharge current $I_N = I_{10}$: C_N / 10h
- Final discharge voltage U_f : see technical data in these instructions
- Nominal temperature t_N : 20° C

Assembly by: ______________ EXIDE Technologies order no.: ______________ date: ______________

Commissioned by: ______________ date: ______________

Safety signs attached by: ______________ date: ______________

- Observe these Instructions and keep them located near the battery for future reference!
- Work on the battery should only be carried out by qualified personnel.

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

- While working on batteries wear protective goggles and clothing!
- Observe the accident prevention rules as well as EN 50272-2, EN 50110-1!

- 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!

- Explosion and fire hazard, avoid short circuits.

- Electolyte is strongly corrosive!

- Blocks/cells are very heavy! Make sure they are installed securely! Only use suitable means of transport!
- Block/cell containers are sensitive to mechanical damage.
- Handle with care!

- Caution! Dangerous voltage.
- Metal parts of the battery are always alive, therefore do not place items or tools on the battery!

Non-compliance with operating instructions and installations or repairs made with other than original accessories and spare parts or with accessories and spare parts not recommended by the battery manufacturer or repairs made without authorization and use of additives for the electrolytes (alleged enhancing agents) render the warranty void.

Pb

Spent batteries have to be collected and recycled separately from normal household wastes (EWC 160601). The handling of spent batteries is described in the EU Battery Directive (91/157/EEC) and their national transitions (UK: HS Regulation 1994 No. 232, Ireland: Statory Instrument No. 73/2000). Contact your supplier to agree upon the recollection and recycling of your spent batteries or contact a local and authorized Waste Management Company.

1. Start Up

Check all cells/blocks for mechanical damage, correct polarity and firmly seated connectors. The following torques apply to the cell types:

GroE, OCSM, OGi-Block	OPzS	Energy Block	OGi-Cells ≤ 250Ah	OGi-Cells ≥ 260Ah
25Nm ±1	20Nm±1	12Nm±1	8Nm ±1	25Nm ±1

Put covers on the terminals if necessary. Check the electrolyte level in all cells and if necessary top up to maximum level with purified water as acc. to DIN 43530 Part 4. Connect the battery with the correct polarity to the charger (pos. pole to pos. terminal). The charger must not be switched on during this process, and the load must not be connected. Switch on charger and start charging following item 2.2.

2. Operation

For the installation and operation of stationary batteries EN 50 272-2 is mandatory.

The battery must be installed in a way which prevents ambiance-dependent temperature differences of >10 K arising. The spacing between the cells or blocs should be 10 mm and at least 5 mm in rack mounting.

2.1 Discharge

Discharge must not be continued below the voltage recommended for the discharge time. Deeper discharges must not be carried out unless specifically agreed with the manufacturer. Recharge immediately following complete or partial discharge.

2.2 Charging

All charging characteristics with their specific data, described in
DIN 41773 (IU-characteristic)
DIN 41774 (W-characteristic)
DIN 41776 (I-characteristic)
may be used. According to the charging equipment, specification and characteristics alternating currents flow through the battery superimposing onto the direct current during charge operation.
Alternating currents and the reaction of the loads may lead to an additional temperature increase of the battery, and strain the electrodes with possible damage (see point 2.5), which can shorten the battery life. Depending on the installation, charging (acc. to DIN EN 50272-2) may be carried out in following operations:

a) Standby Parallel Operation

Here the load, battery and battery charger are continuously in parallel. Thereby, the charge voltage is the operation voltage and at the same time the battery installation voltage.

With the standby parallel operation, the battery charger is capable, at any time, of supplying the maximum load current and the battery charging current. The battery only supplies current when the battery charger fails. The charge voltage measured at the end terminals of the battery shout be set at see table. To reduce the charging time, a boost-charging stage can be applied in which the charge voltage of (2.33 - 2.40) Vpc ±1% x number of cells can be adjusted (standby parallel operation with boost recharging stage). Automatic changeover to charging voltage acc. to table.

b) Buffer Operation

With buffer operation, the battery charger is not able to supply the maximum load current at all times. The load current intermittently exceeds the nominal current of the battery charger. During this period the battery supplies power. This results in the battery not being fully charged at all times. Therefore, depending on the load the charge voltage must be set at (2.27 - 2.30) Vpc ±1% x number of cells. This has to be carried out in accordance with the manufacturers instructions.
Recommended charge voltage:

Range	Charge voltage
GroE, OPzS-LA, OGi-LA, Energy Block	2.23V ±1% x number of cells
OCSM-LA	2.25V ±1% x number of cells

c) Switch mode operation
When charging, the battery is separated from the load. Towards the end of the charging process the charge voltage of the battery is 2.6 V - 2.75 V times the number of cells. The charging process must be monitored (see points 2.4, 2.5 and 2.6). On reaching a fully charged state, the charging process must be stopped or switched to float charge as in point 2.3.

d) Battery Operation (charge-/discharge operation)
The load is supplied by the battery only, whereby the charge voltage of the battery towards the end of the charging process can be 2.6 V - 2.75 V times the number of cells. The charging process must be monitored (see points 2.4, 2.5 and 2.6). On reaching a fully charged state, the charging process must be switched off. The battery can be switched to the load as required.

2.3 Maintaining full charge (float charging)
The devices used must comply with the stipulations under DIN 41773. They are to be set so that the average cell voltage is see table 2.2 and the electrolyte density should not decrease over a lengthy period.

2.4 Equalizing charge
Because it is possible to exceed the permitted load voltages, appropriate measures must be taken, e.g. switch off the load.
Equalizing charges are required after deep discharges and/or inadequate charges. They can be carried out as follows:
– at constant voltage of max. 2.4 Vpc up to 72 hours
– with I- or W-characteristic as in point 2.6.

The electrolyte temperature must never exceed 55° C. If it does, stop charging or revert to float charge to allow the temperature to drop.
The end of the equalizing charge is reached when the electrolyte density and the cell voltages no longer increase over a period of 2 hours.

2.5 Alternating currents
When recharging up to 2.4 Vpc under operation modes 2.2 the value of the alternating current is occasionally permitted to reach 20 A (RMS) per 100 Ah nominal capacity.
When recharging over 2.4 Vpc the RMS value may not exceed 10 A per 100 Ah nominal capacity. In a fully charged state during float charge or standby parallel operation the actual value of the alternating current must not exceed 5 A (RMS) per 100 Ah nominal capacity.

2.6 Charging currents
The charging currents are not limited during standby parallel operation or buffer operation.
Exceeding this voltage increases water decomposition. The charging currents per 100 Ah nominal capacity shown in the following table most not be exceeded.

Charging procedure	Cell series		Cell voltage
	GroE	OGi, OPzS, OCSM, Energy Block	
I-characteristic	6.5A	5.0A	2.60V-2.75V
W-characteristic	9.0A 4.5A	7.0A 3.5A	at 2.40V at 2.65V

2.7 Temperature
The recommended operating temperature range for lead acid batteries is 10° C to 30° C. All technical data apply to the nominal temperature 20° C.

The ideal operating temperature is 20° C ± 5 K. Higher temperatures will seriously reduce service life. Lower temperatures reduce the available capacity. The absolute maximum temperature is 55° C.

2.8 Temperature-related charge voltage
A temperature related adjustment of the charge voltage within the operating temperature of 10° C to 30° C is not necessary. If the operating temperature is constantly outside this range, the charge voltage has to be adjusted.
The temperature correction factor is -0.004 Vpc per K. If the temperature is constantly in excess of 40° C, the factor is -0.003 Vpc per K.

2.9 Electrolyte
The electrolyte is diluted sulphuric acid. The nominal electrolyte density (± 0.01 kg/l) is based on 20° C when fully charged and with the maximum electrolyte level. Higher temperatures reduce electrolyte density, lower temperatures increase electrolyte density. The appropriate correction factor is -0.0007 kg/l per K.
Example: electrolyte density of 1.23 kg/l at 35° C corresponds to a density of 1.24 kg/l at 20° C or an electrolyte density of 1.25 kg/l at 5° C corresponds to a density of 1.24 kg/l at 20° C.

3. Battery maintenance and control
The electrolyte level must be checked regularly. If it drops to the lower electrolyte level mark, purified water must be added in accordance with DIN 43530 Part 4 (maximum conductivity 30 µS/cm). Keep the battery clean and dry to avoid leakage currents. Plastic parts of the battery, especially containers, must be cleaned with pure water without additives.

At least every 6 months measure and record:
- Battery voltage
- Voltage of some cells/block batteries
- Electrolyte temperature of some cells
- Battery-room temperature
- Electrolyte density of some cells

Annual measurement and recording:
- Voltage of all cells/block batteries
- Electrolyte temperature of all cells
- Electrolyte density of all cells

If the cell voltages deviate by more than + 0.1 V or -0.05 V from the average charge retention voltage (for blocks see table), call customer service.

	4V-block	6 V-block	10 V-block	12 V-block
+	0.14 V	0.17 V	0.22 V	0.24 V
-	0.07 V	0.09 V	0.11 V	0.12 V

Annual visual check:
- Screw connections
- Screw connections without locking devices have to be checked for tightness
- Battery installation and arrangement
- Ventilation

4. Tests
Tests have to be carried out according to IEC 60896-1. Special instructions like DIN VDE 0107 and DIN VDE 0108 have to be observed.

5. Faults
Call the services agents immediately if faults in the battery or charging unit are found. Recorded data as described in item 3. must be made available to the service agent. It is recommended that a service contract is taken out with your agent.

6. Storage and taking out of operation
To store or decommission cells/blocks for a longer period of time They should be fully charged and stored in a dry and cold but frost-free room, away From direct sunlight. To avoid damage the following charging methods can be chosen:
To prevent damage, choose the following charging methods:
1. Equalizing charges every three months as described under point 2.4.
   At average ambient temperatures of more than the nominal temperature shorter intervals can be necessary.
2. Float charging as under point 2.3.

7. Transport
To prevent any leakage of electrolyte, the cells/block batteries must be transported in an upright position. Cells/block batteries without any visible damage are not defined as hazardous goods under the regulations for transport of hazardous goods by road (ADR) or by railway (RID). They must be protected against short circuits, slipping, upsetting or damaging. Block batteries may be suitably stacked and secured on pallets (ADR and RID, special provision 598). It is prohibited to stack pallets. No dangerous traces of acid may be found on the exteriors of the packing units. Cells/block batteries whose cases leak or are damaged must be packed and transported as class 8 hazardous goods under UN no. 2794.

8. Technical data
The nominal voltage, the number of cells, the nominal capacity ($C_{10} = C_N$) and the battery type are described on the type plate. Other capacities (C_n) at different discharge currents (I_n) with the corresponding discharge times (t_n) see table 8.1.1 - 8.1.5.

8.1 Measurements, weights and capacities at different discharge times and final discharge voltage

8.1.1 Stationary lead acid batteries type OPzS-LA acc. to DIN 40736 and DIN 40737

with positive tubular plates and negative grid plates, Nominal electrolyte density 1.24 kg/l

Blocks

	Discharge data								Measurements and weights				
	Capacity [Ah]				discharge current [A]				Length max.	Width max.	Height [1] max.	Weight with acid	Weight acid
Discharge time [h]	10	5	3	1	10	5	3	1					
Final discharge voltage [Vpc]	1.80	1.80	1.75	1.65	1.80	1.80	1.75	1.65	[mm]	[mm]	[mm]	approx. [kg]	approx. [kg]
12V 1 OPzS 50 LA	59.0	47.5	42.0	27.9	5.90	9.50	14.0	27.9	275	208	385	35	15
12V 2 OPzS 100 LA	101	85.5	77.7	55.5	10.1	17.1	25.9	55.5	275	208	385	45	14
12V 3 OPzS 150 LA	150	128	112	83.0	15.0	25.7	37.5	83.0	383	208	385	64	19
6V 4 OPzS 200 LA	203	174	150	113	20.3	34.9	50.0	113	275	208	385	41	13
6V 5 OPzS 250 LA	255	214	186	135	25.5	42.8	62.0	135	383	208	385	56	20
6V 6 OPzS 300 LA	303	255	223	165	30.3	51.0	74.5	165	383	208	385	63	20

Cells

2 OPzS 100 LA	128	113	102	71.8	12.8	22.6	34.3	71.8	105	208	398	13.7	5.2
3 OPzS 150 LA	168	147	134	91.7	16.8	29.5	44.9	91.7	105	208	398	15.2	5.0
4 OPzS 200 LA	214	188	171	118	21.4	37.6	57.1	118	105	208	398	16.6	4.6
5 OPzS 250 LA	265	231	210	145	26.5	46.3	70.0	145	126	208	398	20.0	5.8
6 OPzS 300 LA	316	274	247	171	31.6	54.9	82.6	171	147	208	398	23.3	6.9
5 OPzS 350 LA	380	325	291	211	38.0	65.0	97.3	211	126	208	513	26.7	8.1
6 OPzS 420 LA	455	389	348	246	45.5	77.8	116	246	147	208	513	31.0	9.3
7 OPzS 490 LA	530	453	408	280	53.0	90.6	136	280	168	208	513	35.4	10.8
6 OPzS 600 LA	680	560	501	364	68.0	112	167	364	147	208	688	43.9	13.0
7 OPzS 700 LA	750	615	552	401	75.0	123	184	401	147	208	688	47.2	12.8
8 OPzS 800 LA	910	760	678	502	91.0	152	226	502	212	193	688	59.9	17.1
9 OPzS 900 LA	980	820	729	541	98.0	164	243	541	212	193	688	63.4	16.8
10 OPzS 1000 LA	1140	945	843	620	114	189	281	620	212	235	688	73.2	21.7
12 OPzS 1200 LA	1370	1125	1008	733	137	225	336	733	212	277	688	86.4	26.1
12 OPzS 1500 LA	1700	1385	1239	853	170	277	413	853	212	277	838	108.0	33.7
14 OPzS 1750 LA	1800	1465	1311	904	180	293	437	904	212	277	838	114.0	32.7
16 OPzS 2000 LA	2250	1835	1641	1180	225	367	547	1180	215	400	815	151.0	50.0
18 OPzS 2250 LA	2450	1995	1785	1250	245	399	595	1250	215	400	815	158.0	48.0
20 OPzS 2500 LA	2800	2280	2040	1465	280	456	680	1465	215	490	815	184.0	60.0
22 OPzS 2750 LA	3000	2445	2187	1570	300	489	729	1570	215	490	815	191.0	58.0
24 OPzS 3000 LA	3350	2730	2442	1710	335	546	814	1710	215	580	815	217.0	71.0

[1] The above mentioned height can differ depending on the used vents

8.1.2 Stationary lead acid cells type OCSM-LA
with positive tubular plates and negative copper stretch metal grid plates, Nominal electrolyte density 1.26 kg/l

	Discharge data								Measurements and weights				
	Capacity [Ah]				discharge current [A]				Length max.	Width max.	Height [1] max.	Weight with acid approx.	Weight acid approx.
Discharge time [h]	10	5	3	1	10	5	3	1					
Final discharge voltage [Vpc]	1.80	1.80	1.75	1.70	1.80	1.80	1.75	1.70	[mm]	[mm]	[mm]	[kg]	[kg]
2 OCSM 160	160	140	127	91.0	16.0	28.0	42.6	91.0	124	206	522	12.5	8.3
3 OCSM 240	240	210	191	136	24.0	42.0	63.9	136	124	206	522	20.9	8.1
4 OCSM 320	320	280	255	182	32.0	56.0	85.2	182	124	206	522	23.9	7.9
5 OCSM 400	400	350	318	227	40.0	70.0	106	227	124	206	522	26.9	7.5
6 OCSM 480	480	420	381	273	48.0	84.0	127	273	145	206	522	31.5	8.1
7 OCSM 560	560	490	447	318	56.0	98.0	149	318	166	206	522	36.1	8.7
5 OCSM 575	575	500	453	325	57.5	100	151	325	145	206	698	41.6	11.5
6 OCSM 690	690	600	543	399	69.0	120	181	399	145	206	698	44.8	10.9
7 OCSM 805	805	700	636	455	80.5	140	212	455	210	191	698	58.1	16.6
8 OCSM 920	920	800	726	520	92.0	160	242	520	210	191	698	61.3	16.0
9 OCSM 1035	1030	900	816	585	103	180	272	585	210	233	698	71.4	19.7
10 OCSM 1150	1150	1005	909	650	115	201	303	650	210	233	698	74.6	19.1
11 OCSM 1265	1260	1105	999	715	126	221	333	715	210	275	698	84.8	22.8
12 OCSM 1380	1380	1205	1089	780	138	241	363	780	210	275	698	88.0	22.2
11 OCSM 1595	1590	1350	1221	858	159	270	407	858	210	275	848	108.7	28.7
12 OCSM 1740	1740	1475	1332	936	174	295	444	936	210	275	848	114.3	27.3
14 OCSM 2030	2030	1720	1554	1092	203	344	518	1092	214	399	824	140.5	40.8
16 OCSM 2320	2320	1965	1776	1248	232	393	592	1248	214	399	824	151.5	37.9
18 OCSM 2610	2610	2210	1998	1404	261	442	666	1404	214	489	824	182.0	52.0
20 OCSM 2900	2900	2460	2220	1560	290	492	740	1560	214	489	824	193.0	48.3
22 OCSM 3190	3190	2705	2442	1716	319	541	814	1716	214	579	824	223.5	61.6
24 OCSM 3480	3480	2950	2664	1872	348	590	888	1872	214	579	824	234.5	58.7

[1] The above mentioned height can differ depending on the used vents

8.1.3 Stationary lead acid bloc batteries Energy Bloc
with positive and negative grid plates, Nominal electrolyte density 1,24 kg/l
Antimony < 3% (see EN 50272-2)

	Discharge data								Abmessungen und Gewichte				
	Capacity [Ah]				discharge current [A]				Length max.	Width max.	Height [1] max.	Weight including acid approx.	Weight of acid approx.
Discharge time [h]	10	5	3	1	10	5	3	1					
Final discharge voltage [Vpc]	1.80	1.80	1.80	1.75	1.80	1.80	1.80	1.75	[mm]	[mm]	[mm]	ca. [kg]	ca. [kg]
EB 1230	30.0	26.5	23.1	17.3	3.00	5.30	7.70	17.3	273	204	358	28.7	12.7
EB 1260	61.0	52.5	46.2	34.7	6.10	10.5	15.4	34.7	273	204	358	33.9	11.8
EB 1285	85.0	75.5	66.6	50.3	8.50	15.1	22.2	50.3	273	204	358	39.1	10.7
EB 12110	105	96.0	84.9	64.7	10.5	19.2	28.3	64.7	273	204	358	44.2	10.6
EB 12145	141	126	111	83.8	14.1	25.2	37.0	83.8	381	204	358	57.8	15.2
EB 12160	158	144	127	97.1	15.8	28.8	42.5	97.1	381	204	358	64.2	15.1
EB 6215	211	184	162	121	21.1	36.9	54.0	121	273	204	358	41.2	11.6
EB 6230	226	201	177	134	22.6	40.3	59.2	134	273	204	358	43.4	11.1
EB 6240	237	216	191	145	23.7	43.2	63.7	145	273	204	358	46.0	11.0
EB 6310	302	263	231	173	30.2	52.7	77.2	173	381	204	358	56.9	16.80
EB 6335	332	290	255	190	33.2	58.0	85.0	190	381	204	358	59.6	16.40
EB 6350	339	302	266	201	33.9	60.5	88.,8	201	381	204	358	62.3	15.80

[1] The above mentioned height can differ depending on the used vents

8.1.4 Stationary lead acid batteries type GroE acc. to DIN 40 738
with positive plates and negative grid plates, Nominal electrolyte density 1.22 kg/l

	Discharge data								Measurements and weights				
	Capacity [Ah]				discharge current [A]				Length max.	Width max.	Height [1] max.	Weight with acid approx.	Weight acid approx.
Discharge time [h]	10	5	3	1	10	5	3	1					
Final discharge voltage [Vpc]	1.80	1.80	1.775	1.75	1.80	1.80	1.775	1.75	[mm]	[mm]	[mm]	[kg]	[kg]
3 GroE 75	75	76.5	68.4	50.7	7.50	15.3	22.8	50.7	182	153	411	17.5	6.6
4 GroE 100	100	102	91.2	67.6	10.0	20.4	30.4	67.6	182	153	411	19.7	6.4
5 GroE 125	125	127	114	84.5	12.5	25.5	38.0	84.5	182	153	411	21.9	6.2
6 GroE 150	150	153	136	101	15.0	30.6	45.6	101	182	153	411	24.1	6.0
7 GroE 175	175	178	159	118	17.5	35.7	53.2	118	182	153	411	26.3	5.8
8 GroE 200	200	204	182	135	20.0	40.8	60.8	135	182	228	411	33.2	9.4
9 GroE 225	225	229	205	152	22.5	45.9	68.4	152	182	228	411	35.4	9.2
10 GroE 250	250	255	228	169	25.0	51.0	76.0	169	182	228	411	37.6	9.0
11 GroE 275	275	280	250	185	27.5	56.1	83.6	185	182	228	411	39.8	8.8
12 GroE 300	300	306	273	202	30.0	61.2	91.2	202	182	228	411	42.0	8.6
13 GroE 325	325	331	296	219	32.5	66.3	98.8	219	182	338	411	52.5	14.1
14 GroE 350	350	357	318	236	35.0	71.4	106	236	182	338	411	54.7	13.8
15 GroE 375	375	382	342	253	37.5	76.5	114	253	182	338	411	56.9	13.6
16 GroE 400	400	408	363	270	40.0	81.6	121	270	182	338	411	59.1	13.3
17 GroE 425	425	433	387	287	42.5	86.7	129	287	182	338	411	61.3	13.0
18 GroE 450	450	459	408	304	45.0	91.8	136	304	182	338	411	63.5	12.7
5 GroE 500	500	462	438	307	50.0	92.5	146	307	328	268	590	95	34
6 GroE 600	600	555	525	369	60.0	111	175	369	328	268	590	104	33
7 GroE 700	700	645	612	430	70.0	129	204	430	328	268	590	113	32
8 GroE 800	800	740	699	492	80.0	148	233	492	328	268	590	122	31
9 GroE 900	900	830	786	553	90.0	166	262	553	328	268	590	131	30
10 GroE 1000	1000	925	876	615	100	185	292	615	328	268	590	140	29
11 GroE 1100	1100	1015	963	676	110	203	321	676	328	268	590	149	28
12 GroE 1200	1200	1110	1050	738	120	222	350	738	328	348	590	170	39
13 GroE 1300	1300	1200	1137	799	130	240	379	799	328	348	590	179	38
14 GroE 1400	1400	1295	1224	861	140	259	408	861	328	348	590	188	37
15 GroE 1500	1500	1385	1314	922	150	277	438	922	328	348	590	197	36
16 GroE 1600	1600	1480	1401	984	160	296	467	984	328	438	590	222	49
17 GroE 1700	1700	1570	1488	1045	170	314	496	1045	328	438	590	231	48
18 GroE 1800	1800	1665	1575	1107	180	333	525	1107	328	438	590	240	47
19 GroE 1900	1900	1755	1662	1168	190	351	554	1168	328	438	590	249	46
20 GroE 2000	2000	1850	1752	1230	200	370	584	1230	328	438	590	258	45
21 GroE 2100	2100	1940	1839	1291	210	388	613	1291	328	528	590	285	58
22 GroE 2200	2200	2035	1926	1353	220	407	642	1353	328	528	590	294	57
23 GroE 2300	2300	2125	2013	1414	230	425	671	1414	328	528	590	303	56
24 GroE 2400	2400	2220	2100	1476	240	444	700	1476	328	528	590	312	55
25 GroE 2500	2500	2310	2190	1537	250	462	730	1537	328	573	590	325	60
26 GroE 2600	2600	2405	2277	1599	260	481	759	1599	328	573	590	334	59

[1] The above mentioned height can differ depending on the used vents

8.1.5 Stationary lead acid batteries type OGi (LA)
with positive and negative grid plates, Nominal electrolyte density 1.26 kg/l,
* Nominal electrolyte density 1.24 kg/l

Block battery

	Discharge data								Measurements and weights				
	Capacity [Ah]				discharge current [A]				Length max. [mm]	Width max. [mm]	Height 1) max. [mm]	Weight with acid approx. [kg]	Weight acid approx. [kg]
Discharge time [h]	10	5	3	1	10	5	3	1					
Final discharge voltage [Vpc]	1.80	1.77	1.75	1.67	1.80	1.77	1.75	1.67					
12V 1 OGi 28 LA	28	25.5	22.8	16.5	2.8	5.1	7.6	16.5	272	205	370	35.2	12.7
12V 2 OGi 55 LA	55	49.5	45.0	33.0	5.5	9.9	15.0	33.0	272	205	370	42.4	11.6
12V 3 OGi 83 LA	83	75.0	68.1	50.0	8.3	15.0	22.7	50.0	272	205	370	49.7	10.7
12V 4 OGi 110 LA	110	99.5	90.0	66.0	11.0	19.9	30.0	66.0	272	205	370	56.5	10.4
12V 5 OGi 137 LA	137	138.5	112.2	82.5	13.7	27.7	37.4	82.5	380	205	370	73.0	16.5
12V 6 OGi 165 LA	165	148.5	135.0	99.0	16.5	29.7	45.0	99.0	380	205	370	80.0	15.1
6V 7 OGi 192 LA	192	173.5	157.2	115.0	19.2	34.7	52.4	115.0	272	205	370	49.6	12.3
6V 8 OGi 220 LA	220	198.5	180.3	131.5	22.0	39.7	60.1	131.5	272	205	370	53.1	11.6
6V 9 OGi 247 LA	247	223.0	202.2	148.0	24.7	44.6	67.4	148.0	380	205	370	65.0	18.7
6V 10 OGi 275 LA	275	248.0	225.3	164.0	27.5	49.6	75.1	164.0	380	205	370	67.4	17.9
6V 11 OGi 302 LA	302	272.5	247.2	180.0	30.2	54.5	82.4	180.0	380	205	370	71.3	17.2
6V 12 OGi 330 LA	330	298.0	270.3	197.0	33.0	59.6	90.1	197.0	380	205	370	75.0	16.5

Single cell

2 OGi 50 LA*	50	45.0	36.6	26	5.0	9.0	12.2	26	69	160	351	6.3	2.3
3 OGi 75 LA*	75	67.5	54.6	39	7.5	13.5	18.2	39	69	160	351	7.0	2.1
4 OGi 100 LA*	100	90.0	71.4	51	10.0	18.0	23.8	51	125	160	384	11.5	4.9
6 OGi 150 LA*	150	135.0	107.4	75	15.0	27.0	35.8	75	125	160	384	13.3	4.6
8 OGi 200 LA*	200	177.5	143.1	98	20.0	35.5	47.7	98	155	160	384	16.8	5.8
10 OGi 250 LA*	250	222.5	178.8	120	25.0	44.5	59.6	120	194	160	384	20.9	7.3
4 OGi 260 LA	260	224.5	186.3	129	26.0	44.9	62.1	129	124	206	528	20.8	8.2
5 OGi 325 LA	325	280.0	233.1	161	32.5	56.0	77.7	161	124	206	528	22.9	7.9
6 OGi 370 LA	370	312.5	268.2	192	37.0	62.5	89.4	192	124	206	528	24.7	7.5
7 OGi 410 LA	410	347.5	303.0	224	41.0	69.5	101.0	224	124	206	528	26.6	7.3
8 OGi 440 LA	440	382.5	339.0	255	44.0	76.5	113.0	255	124	206	528	28.5	7.1
9 OGi 470 LA	470	417.5	375.0	287	47.0	83.5	125.0	287	124	206	528	30.6	6.9
10 OGi 530 LA	530	465.0	420.0	316	53.0	93.0	140.0	316	145	206	528	34.0	8.1
11 OGi 580 LA	580	515.0	465.0	346	58.0	103.0	155.0	346	166	206	528	38.3	9.8
12 OGi 620 LA	620	562.5	513.0	375	62.0	112.5	171.0	375	166	206	528	40.0	9.4
12 OGi 730 LA	730	585.0	579.0	383	73.0	117.0	193.0	383	254	210	528	50.3	17.5
14 OGi 800 LA	800	715.0	636.0	482	80.0	143.0	212.0	482	254	210	528	52.6	15.9
16 OGi 880 LA	880	770.0	687.0	520	88.0	154.0	229.0	520	254	210	528	56.6	15.5
19 OGi 1000 LA	1000	857.5	762.0	578	100.0	171.5	254.0	578	254	210	528	62.5	14.9
16 OGi 1260 LA	1260	1117.5	1002.0	718	126.0	223.5	334.0	718	233	210	699	78.2	18.3
18 OGi 1340 LA	1340	1187.5	1065.0	763	134.0	237.5	355.0	763	233	210	699	85.2	19.7
20 OGi 1520 LA	1520	1347.5	1209.0	869	152.0	269.5	403.0	869	275	210	699	95.2	22.3
22 OGi 1600 LA	1600	1420.0	1272.0	915	160.0	284.0	424.0	915	275	210	699	102.5	23.3

1) The above mentioned height can differ depending on the used vents

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Classic Solar EnerSol, EnerSol T, OPzS Solar Operating Instructions for stationary lead acid batteries

Nominal data

- Nominal voltage U_N : 2.0 V x number of cells
- Nominal capacity $C_N = C_{120}$: 120h discharge (see type plate and technical data in these instructions)
- Nominal discharge current $I_N = I_{120}$: C_N / 120h
- Final discharge voltage U_f : see technical data in these instructions
- Nominal temperature t_N : 25° C

Assembly by: ____________ EXIDE Technologies order no.: ____________ date: ____________

Commissioned by: ______________________________ date: ____________

Security signs attached by: ______________________________ date: ____________

- Observe these Instructions and keep them located near the battery for future reference!
- Work on the battery should only be carried out by qualified personnel.

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

- While working on batteries wear protective goggles and clothing!
- Observe the accident prevention rules as well as EN 50272-2, EN 50110-1!

- 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!

- Explosion and fire hazard, avoid short circuits.

- Electrolyte is strongly corrosive!

- Blocs/cells are very heavy! Make sure they are installed securely! Only use suitable means of transport!
- Bloc/cell containers are sensitive to mechanical damage.
- Handle with care!

- Caution! Dangerous voltage.
- Metal parts of the battery are always alive, therefore do not place items or tools on the battery!

Non-compliance with operating instructions and installations or repairs made with other than original accessories and spare parts or with accessories and spare parts not recommended by the battery manufacturer or repairs made without authorization and use of additives for the electrolytes (alleged enhancing agents) render the warranty void.

Pb

Spent batteries have to be collected and recycled separately from normal household wastes (EWC 160601). The handling of spent batteries is described in the EU Battery Directive (91/157/EEC) and their national transitions (UK: HS Regulation 1994 No. 232, Ireland: Statory Instrument No. 73/2000). Contact your supplier to agree upon the recollection and recycling of your spent batteries or contact a local and authorized Waste Management Company.

1. Start Up

Check all cells/blocs for mechanical damage, correct polarity and firmly seated connectors. The following torques apply to the cell types:

Ener Sol A-Pol	EnerSol T (M 10)	OPzS Solar (M 8)
8Nm ±1	25Nm±1	20Nm ±1

Put on the terminal covers if necessary. Check the electrolyte level in all cells and if necessary top up to maximum level with purified water acc. to DIN 43530 Part 4. Connect the battery with the correct polarity to the charger (pos. pole to pos. terminal). The charger must not be switched on during this process, and the load must not be connected. Switch on charger and start charging following acc. to 2.2.

If there is only an alternative source of energy available, then the battery must be charged until the cell voltage is the same in all cells and the electrolyte density has reached the nominal value (see technical data). The loads must be switched off during charging. The insulation resistance measured at the disconnectedloads and charger should be at least 1MΩ with new batteries. The insulation resistance for batteries in operation should be 100 Ω per volt nominal voltage e.g. 24V-unit = 2400 Ω

2. Operation

For the installation and operation of stationary batteries EN 50 272-2 is mandatory.

The battery should always be operated using a charge controller and deep discharge protection. The battery must be installed so that it is not in direct sunlight and in a way which prevents ambiance-dependent temperature differences of >10 K arising. The spacing between the cells or blocs should be 10 mm and at least 5 mm in rack mounting.

2.1 Discharge

Discharge must not be continued below the voltage recommended for the discharge time. Deeper discharges must not be carried out. Discharg should not exceed the nominal capacity. Unless otherwise indicated by the manufacturer.

Recharge immediately following complete or partial discharge. A battery is regarded as discharged when the electrolyte density is < 1.13 kg/l at 25° C. This corresponds to a discharge level of ca. 80 % of the nominal value. An electrolyte density of < 1.13 kg/l is a deep discharge. Deep discharge reduces the lifetime of the battery.

2.2 Charging

a) using an external charger

All charging characteristics with their specific data, described in
DIN 41773 (IU-characteristic)
DIN 41774 (W-characteristic)
DIN 41776 (I-characteristic)
may be used. Depending on to the charging equipment, specification and characteristics, alternating currents flow through the battery superimposing onto the direct current during charge operation.

Alternating currents and the reaction from the loads (inverter) may lead to an additional temperature increase of the battery, and strain the electrodes causing possible damage (see point 2.5), which can shorten the battery life.

When charging, the battery is disconnected from the load. Towards the end of the charging process the charge voltage of the battery is 2.6 V - 2.75 V times the number of cells. The charging process must be monitored (see points 2.4, 2.5 and 2.6). On reaching a fully charged state, the charging process must be stopped or switched to the charge voltage as in table 1. For charge current see point 2.6.

b) with alternative power supply

When using power supply units with solar modules or wind generators, the battery charger is not able to supply the maximum load current at all times. The load current intermittently exceeds the nominal current of the battery charger. During this period the battery supplies power. This results in the battery not being fully charged at all times. Therefore, depending on the load the charge voltage must be set at 2.23 - 2.35 Vpc ±1% x number of cells. This has to be carried out in accordance with the manufacturers instructions.

Recommended charge voltage

Range	charge voltage per cell
EnerSol	2.30V
EnerSol T	2.30V
OPzS Solar	2.28V

Table 1

The charge must be sufficient to reach the nominal value (see technical data) once a month. If this is not the case, it is necessary to increase the charge voltage (see table 1) or carry out an equalizing charge acc. to 2.4 every month.

2.3 Maintaining full charge (float charging)

The devices used must comply with the stipulations under DIN 41773. They are to be set so that the average cell voltage is as in table 1 and the electrolyte density should not decrease over a lengthy period, if necessary the charge voltage must be increased acc. to table 1.

2.4 Equalizing charge

Because it is possible to exceed the permitted load voltages, appropriate measures must be taken, e.g. switch off the load.
Equalizing charges are required after deep discharges and/or inadequate charges.
They can be carried out as follows:

a) Using alternative form of power supply
   – at constant voltage of max. 2.4 Vpc up to 72 hours (the number of hours increases with less charging current acc.to table 2).
b) Using an external charger
   – at constant voltage of max. 2.4 Vpc up to 72 hours
   – with I- or W-characteristic as in point 2.6.

The electrolyte temperature must never exceed 55° C. If it does, stop charging or revert to float charge to allow the temperature to drop.
The end of the equalizing charge is reached when the electrolyte density and the cell voltages no longer increase over a period of 2 hours.

2.5 Alternating currents

When recharging up to 2.4 Vpc under operation modes 2.2 the value of the alternating current is occasionally permitted to reach 20 A (RMS) per 100 Ah nominal capacity.
When recharging over 2.4 Vpc the RMS value may not exceed 10 A per 100 Ah nominal capacity. In a fully charged state during float charge or standby parallel operation the value of the alternating current must not exceed 5 A (RMS) per 100 Ah nominal capacity.

2.6 Charging currents

When charging with the IU-characteristic of up to voltage of 2.4Vpc, the charging currents are not limited during standby parallel operation.
Exceeding this voltage increases water decomposition. The charging currents per 100 Ah nominal capacity shown in the following table most not be exceeded.

Charging procedure	Cell series EnerSol, EnerSol T OPzS Solar	Cell voltage
I-characteristic	5.0A	2.60V-2.75V
W-characteristic	7.0A 3.5A	at 2.40V at 2.65V

Table 2

2.7 Temperature

The recommended operating temperature range for lead acid batteries is 10° C to 30° C. All technical data apply to the nominal temperature 25° C (OPzS Solar =20° C). **The ideal operating temperature is 25° C ± 5 K.**
Higher temperatures will seriously reduce service life. Lower temperatures reduce the available capacity. The absolute maximum temperature is 55° C.

2.8 Temperature-related charge voltage

A temperature related adjustment of the charge voltage within the operating temperature of 10° C to 30° C is not necessary. If the operating temperature is constantly outside this range, the charge voltage has to be adjusted.
The temperature correction factor is -0.004 Vpc per K. If the temperature is constantly in excess of 40° C, the factor is -0.003 Vpc per K.

2.9 Electrolyte

The electrolyte is diluted sulphuric acid. The nominal electrolyte density (± 0.01 kg/l) is based on 25° C (OPzS Solar = 20° C) when fully charged and with the maximum electrolyte level. Higher temperatures reduce electrolyte density, lower temperatures increase electrolyte density. The appropriate correction factor is -0.0007 kg/l per K.
Example: electrolyte density of 1.23 kg/l at 35° C corresponds to a density of 1.24 kg/l at 20° C or an electrolyte density of 1.25 kg/l at 5° C corresponds to a density of 1.24 kg/l at 20° C.

3. Battery maintenance and control

The electrolyte level must be checked regularly. If it drops to the lower electrolyte level mark, purified water must be added in accordance with DIN 43530 Part 4 (maximum conductivity 30 µS/cm). Keep the battery clean and dry to avoid leakage currents. Plastic parts of the battery, especially containers, must be cleaned with clean water without additives.

Monthly measurements and recording:

- Battery voltage
- Voltage of some cells/bloc batteries
- Electrolyte temperature of some cells
- Battery-room temperature
- Electrolyte density of some cells

Annual measurements and recording:

- Voltage of all cells/bloc batteries
- Electrolyte temperature of all cells
- Electrolyte density of all cells

It is necessary to carry out an equalizing charge acc. to 2.4 if the cell/bloc voltages differ more than those in table 3 below. For average charge voltage see table 1.

	Upper value	Lower Value
2V cells	+ 0.2V	- 0.1V
6V blocs	+ 0.35V	- 0.17V
12V blocs	+ 0.48V	- 0.24V

Table 3

Annual visual check:

- Screw connections
- Screw connections without locking devices have to be checked for tightness
- Battery installation and arrangement
- Ventilation the battery room

4. Tests

Tests have to be carried out according to IEC 896-11. Special instructions like VDE 0107 and EN 50172 have to be observed.

5. Faults

Call the service agents immediately if faults in the battery or charging unit are found. Recorded data as described in point 3. must be made available to the service agent. It is recommended that a service contract is taken out with your agent.

6. Storage and taking out of operation

To store or decommission cells/blocs for a longer period of time, they should be fully charged and stored in a dry and cold but frost-free room, away from direct sunlight. To avoid damage, the following charging methods can be chosen:

1. Equalizing charges every three months as described under point 2.4. Average ambient temperatures of more than 30° C may make more frequent equalizing charges necessary.
2. Float charging as under point 2.3.

7. Transport

To prevent any leakage of electrolyte, the cells/bloc batteries must be transported in an upright position. Cells/bloc batteries without any visible damage are not defined as hazardous goods under the regulations for transport of hazardous goods by road (ADR) or by rail (RID). They must be protected against short circuits, slipping, upsetting or damaging. Bloc batteries may be suitably stacked and secured on pallets (ADR and RID, special provision 598). It is prohibited to stack pallets. No dangerous traces of acid may be found on the exteriors of the packing units. Cells/bloc batteries whose cases leak or are damaged must be packed and transported as class 8 hazardous goods under UN no. 2794.

8. Technical data

The nominal voltage, the number of cells, the nominal capacity ($C_{10} = C_N$) and the battery type are described on the type plate. See table 8.1.1 - 8.1.3 other capacities (C_n) at different discharge currents (I_n) with the corresponding discharge times (t_n).

8.1 Measurements, weights and capacities (C_n) at different discharge times (t_n) and final discharge voltage (U_f)

8.1.1 Stationary lead acid bloc batteries type EnerSol
with positive and negative grid plates, Nominal electrolyte density 1.28 kg/l

	Discharge data				Measurements and weights				
	Capacity [Ah]		Discharge current [A]		Length max. [mm]	Width max. [mm]	Height [1] max. [mm]	Weight including acid approx. [kg]	Weight acid approx [kg]
Discharge time [h]	120	100	120	100					
Final discharge voltage [Vpc]	1.85	1.85	1.85	1.85					
EnerSol 50	53	52	0.44	0.52	207	175	190	13.6	3.5
EnerSol 65	66	65	0.55	0.65	246	175	190	17.1	4.6
EnerSol 80	80	78	0.67	0.78	278	175	190	20.4	5.6
EnerSol 100	99	97	0.83	0.97	353	175	190	25.2	6.8
EnerSol 130	132	130	1.10	1.30	348	175	190	35.2	10.0
EnerSol 175	179	175	1.49	1.75	513	223	223	46.5	12.2
EnerSol 250	256	250	2.13	2.50	518	276	242	63.0	18.6

[1] The above mentioned height can differ depending on the used vents

8.1.2 Stationary lead acid cells type EnerSol T
with positive and negative grid plates, Nominal electrolyte density 1.26 kg/l

	Discharge data								Measurements and Weights				
	Capacity [Ah]				Discharge current [A]				Length max. [mm]	Width max. [mm]	Height [1] max. [mm]	Weight including acid approx. [kg]	Weight acid approx. [kg]
Discharge time [h]	120	48	24	10	120	48	24	10					
Final discharge voltage [V]	1.85	1.80	1.80	1.80	1.85	1.80	1.80	1.80					
EnerSol T 370	367	361	314	280	3.06	7.52	13.08	28.0	83	198.5	445	17.3	5.1
EnerSol T 460	459	451	393	350	3.82	9.39	16.37	35.0	101	198.5	445	21.0	6.3
EnerSol T 550	551	542	471	420	4.59	11.29	19.62	42.0	129	198.5	445	24.7	7.5
EnerSol T 650	648	656	571	517	5.40	13.66	23.79	51.7	129	198.5	508	29.5	8.6
EnerSol T 760	756	766	666	604	6.30	15.95	27.75	60.4	147	198.5	508	31.0	10.0
EnerSol T 880	876	854	779	714	7.30	17.79	32.45	71.4	147	198.5	556	38.0	11.0
EnerSol T 1000	1001	976	890	816	8.34	20.33	37.08	81.6	165	198.5	556	43.1	12.6
EnerSol T 1130	1126	1098	1002	919	9.38	22.87	41.75	91.9	183	198.5	556	47.7	14.1
EnerSol T 1250	1251	1220	1113	1021	10.42	25.41	46.37	102.1	201	198.5	556	52.8	15.6

[1] The above mentioned height can differ depending on the used vents

8.1.3 Stationary lead acid bloc batteries type OPzS Solar bloc batteries and single cells
with positive tubular plates and negative grid plates, Nominal electrolyte density 1.24 kg/l

Bloc battery

	Discharge data								Measurements and Weights				
	Capacity [Ah]				Discharge current [A]				Length max. [mm]	Width max. [mm]	Height [1] max. [mm]	Weight including acid approx. [kg]	Weight acid approx. [kg]
Discharge time [h]	120	48	24	10	120	48	24	10					
Final discharge voltage [V]	1.85	1.80	1.80	1.80	1.85	1.80	1.80	1.80					
12V OPzS Solar 70	82.7	78.4	69.4	51.5	0.7	1.6	2.9	5.2	275	208	285	35	15
12V OPzS Solar 140	139.9	141.6	118.7	103.0	1.2	3.0	4.9	10.3	275	208	285	45	14
12V OPzS Solar 210	208.3	187.5	167.0	154.5	1.7	3.9	7.0	15.5	383	208	393	64	19
6V OPzS Solar 280	294.0	296.2	250.8	206.0	2.5	6.2	10.5	20.6	275	208	285	41	13
6V OPzS Solar 350	364.1	374.2	311.5	257.5	3.0	7.8	13.0	25.8	383	208	393	56	20
6V OPzS Solar 420	417.7	420.8	354.6	309.0	3.5	8.8	14.8	30.9	383	208	393	63	20

Single cell

OPzS Solar 190	190	165	145.0	128.0	1.6	3.4	6.0	12.8	105	208	405	13.7	5.2
OPzS Solar 245	245	215	190.0	169.0	2.0	4.5	7.9	16.9	105	208	405	15.2	5.0
OPzS Solar 305	305	270	240.0	216.0	2.5	5.6	10.0	21.6	105	208	405	16.6	4.6
OPzS Solar 380	380	330	300.0	267.0	3.2	6.9	12.5	26.7	126	208	405	20.0	5.8
OPzS Solar 450	450	395	355.0	319.0	3.8	8.2	14.8	31.9	147	208	405	23.3	6.9
OPzS Solar 550	550	480	430.0	391	4.6	10.0	17.9	39.1	126	208	520	26.7	8.1
OPzS Solar 660	660	575	515.0	468	5.5	12.0	21.5	46.8	147	208	520	31.0	9.3
OPzS Solar 765	765	670	600.0	545	6.4	14.0	25.0	54.5	168	208	520	35.4	10.8
OPzS Solar 985	985	860	770	700	8.2	17.9	32.1	70.0	147	208	695	43.9	13.0
OPzS Solar 1080	1080	940	845	772	9.0	19.6	35.2	77.2	147	208	695	47.2	12.8
OPzS Solar 1320	1320	1150	1030	937	11.0	24.0	42.9	93.7	215	193	695	59.9	17.1
OPzS Solar 1410	1410	1225	1105	1009	11.8	25.5	46.0	100.9	215	193	695	63.4	16.8
OPzS Solar 1650	1650	1440	1290	1174	13.8	30.0	53.8	117.4	215	235	695	73.2	21.7
OPzS Solar 1990	1990	1730	1550	1411	16.6	36.0	64.6	141.1	215	277	695	86.4	26.1
OPzS Solar 2350	2350	2090	1910	1751	19.6	43.5	79.6	175.1	215	277	845	108.0	33.7
OPzS Solar 2500	2500	2215	2015	1854	20.8	46.1	84.0	185.4	215	277	845	114.0	32.7
OPzS Solar 3100	3100	2755	2520	2317	25.8	57.4	105.0	231.7	215	400	815	151.0	50.0
OPzS Solar 3350	3350	2985	2740	2523	27.9	62.2	114.2	252.3	215	400	815	158.0	48.0
OPzS Solar 3850	3850	3430	3135	2884	32.1	71.5	130.6	288.4	215	490	815	184.0	60.0
OPzS Solar 4100	4100	3650	3355	3090	34.2	76.0	139.8	309.0	215	490	815	191.0	58.0
OPzS Solar 4600	4600	4100	3765	3450	38.3	85.4	156.9	345.0	215	580	815	217.0	71.0

[1] The above mentioned height can differ depending on the used vents

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