Handbook for Stationary Gel-VRLA-Batteries

Part 2: Installation, Commissioning and Operation

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, Military Batteries, 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' valve regulated 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 “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].


A500, < 25 Ah only

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 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 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

The maximum storage time at ≤ 20° C is

24 months for standard Gel-batteries (fig. 1) and
17 months for Gel-solar-batteries (fig. 2).

The shorter storage time of solar-batteries is due to a small amount of phosphoric acid added to the electrolyte. Phosphoric acid increases the number of cycles but increases the self-discharge rate slightly.

Higher temperatures cause higher self-discharge and shorter storage time between re-charging operations.

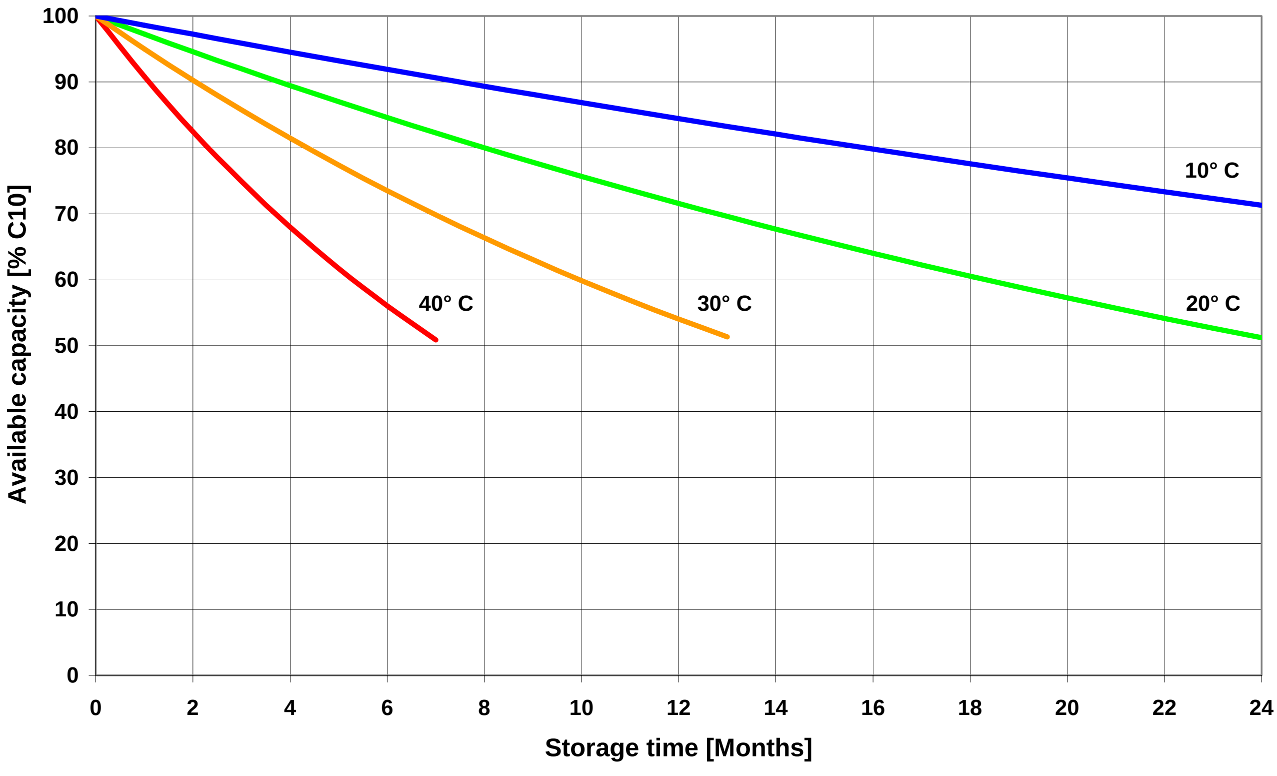


Fig. 1: Available Capacity vs. Storage Time at different Temperatures (standard Gel-Batteries)

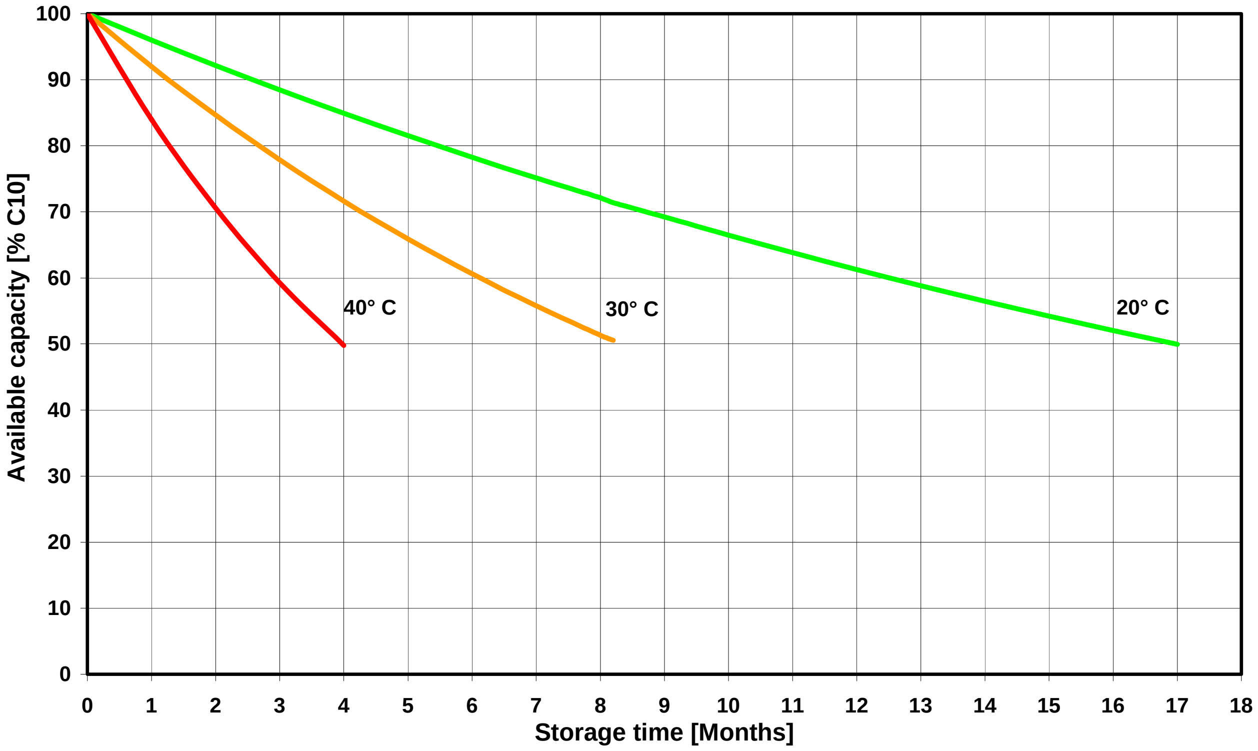


Fig. 2: Available Capacity vs. Storage Time at different Temperatures (Gel-Solar-Batteries)

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 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) in the following intervals:

  - storage at 20° C: after a storage period of 12 months, then every 3 months afterwards,
  - storage at 30° C: after a storage period of 6 months, then every 2 months afterwards.

Refreshing charging is necessary if the measured OCV is < 2.07 Volts per cell.

- 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	2.25 2.30 *)	unlimited	48

*) SOLAR, SOLAR BLOCK

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 2.25 Vpc (2.30 Vpc respectively) 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 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

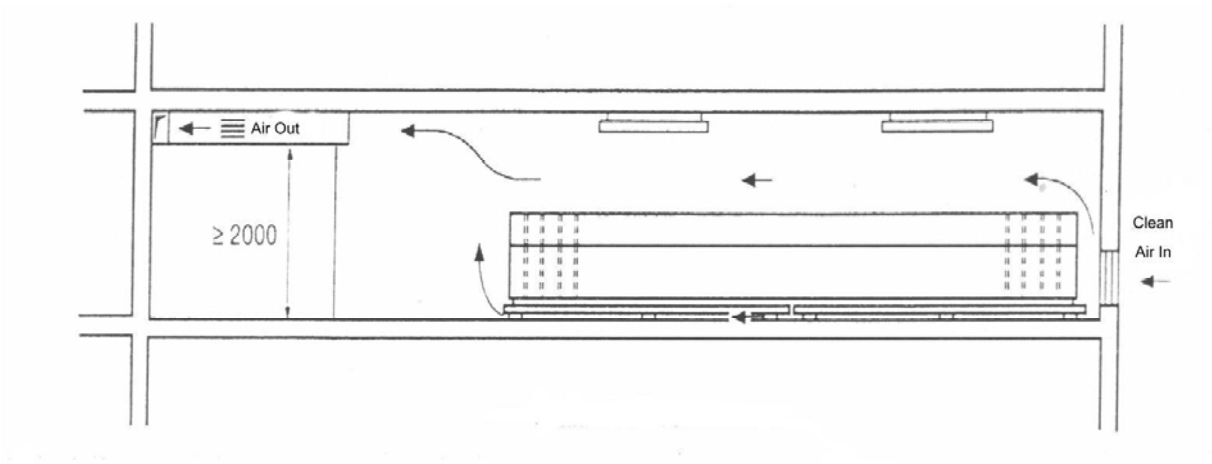
for battery nominal voltage ≤ 500 V: 50 kΩ ≤ R ≤ 10 MΩ
for battery nominal voltage > 500 V: 100 kΩ ≤ R ≤ 10 MΩ

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…:

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

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:

$$A \geq 28 \cdot Q \text{ [cm}^2\text{]}$$

(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:

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

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%$_{vol}$ 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 $\sqrt[3]{1/N}$ ..."

<u>Example 1:</u>

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

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

<u>Example 2:</u>

12 V-block, six cells, one opening in the top cover, vented type, 100 Ah.
Float charge → I_{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

<u>Example 3:</u>

Cell, VRLA-type, one vent, 100 Ah.
Float charge → I_{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 ≥	2.07 V
6 V-block:	U ≥	6.21 V
12 V-block:	U ≥	12.42 V

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

- 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.

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

A-connectors:	(8 ± 1) Nm
G5/M5-connectors:	(5 ± 1) Nm
G6/M6-connectors:	(6 ± 1) Nm
M8-male connectors:	(8 ± 1) Nm
F-M8-connectors:	(20 ± 1) Nm
Exception: M8-female conn. A600 block:	(12 ± 1) Nm
F-M10-conncetors:	(17 ± 1) Nm

- 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

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

- 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 ≥ 72 hours.
  Option 2: 2.40 Vpc ≥ 16 hours (max. 48 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 100 Ah nominal capacity).

6. Operation

6.1 Float Voltage and Float Current

- A temperature related adjustment of the charge voltage within the operating temperature of 15° C to 35° C is not allowed. If the operating temperature is permanently outside this range, the charge voltage has to be adjusted as shown in figures 3, 4 and 5.

  Gel-solar-batteries: See also chapter 6.8.2

  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:

  2.25 Vpc for A600, A600 block, A600 SOLAR and A700
  2.27 Vpc for A400
  2.30 Vpc for A500, SOLAR and SOLAR BLOCK

  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 [5]. 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 during three hours.

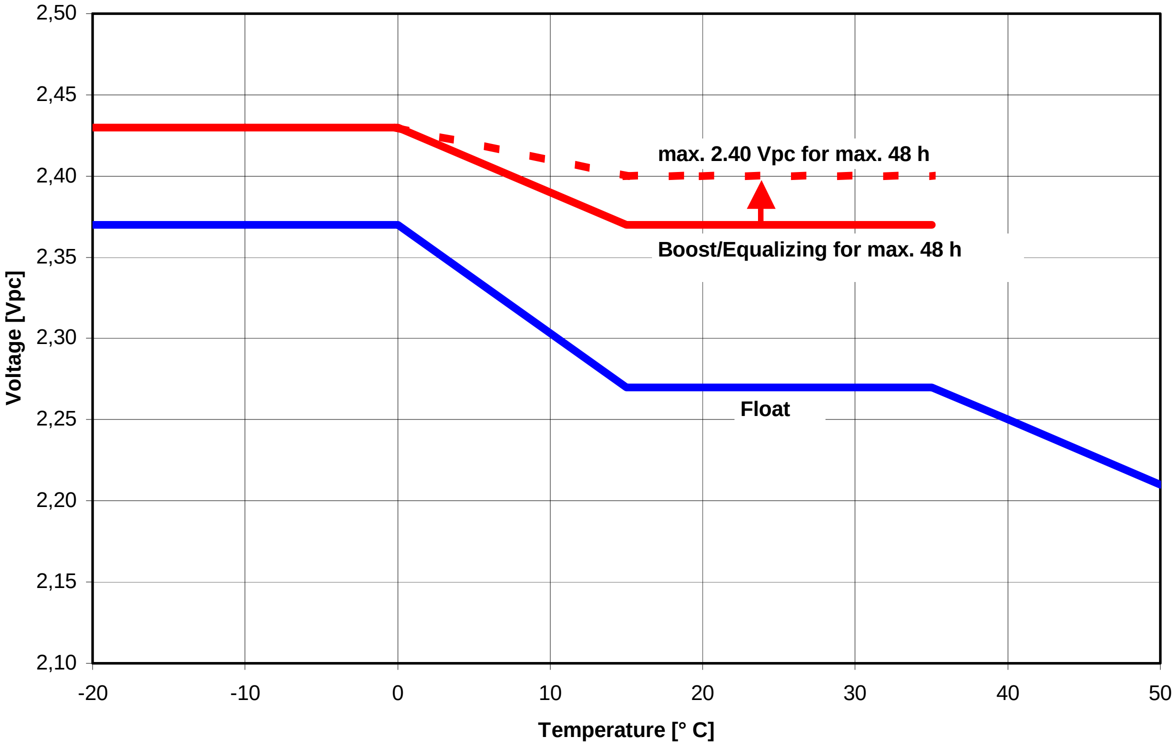


Fig. 3: A400 - Charging Voltage vs. Temperature

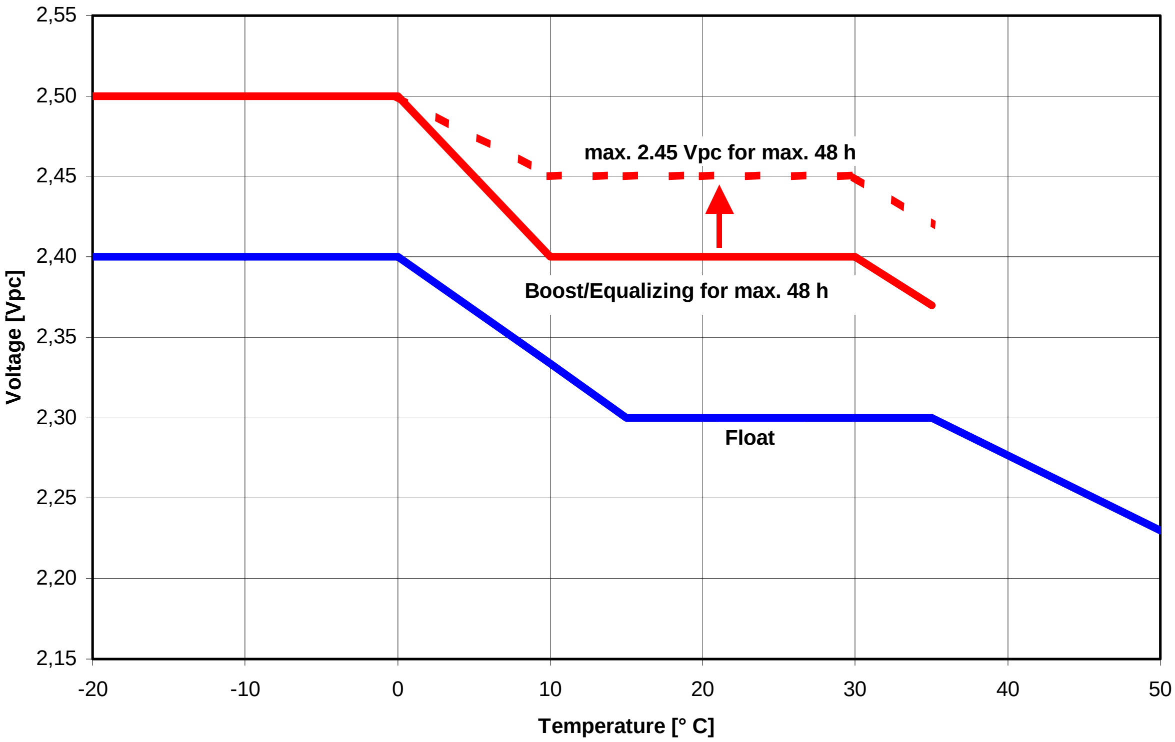


Fig. 4: A500, (SOLAR, SOLAR BLOCK) - Charging Voltage vs. Temperature

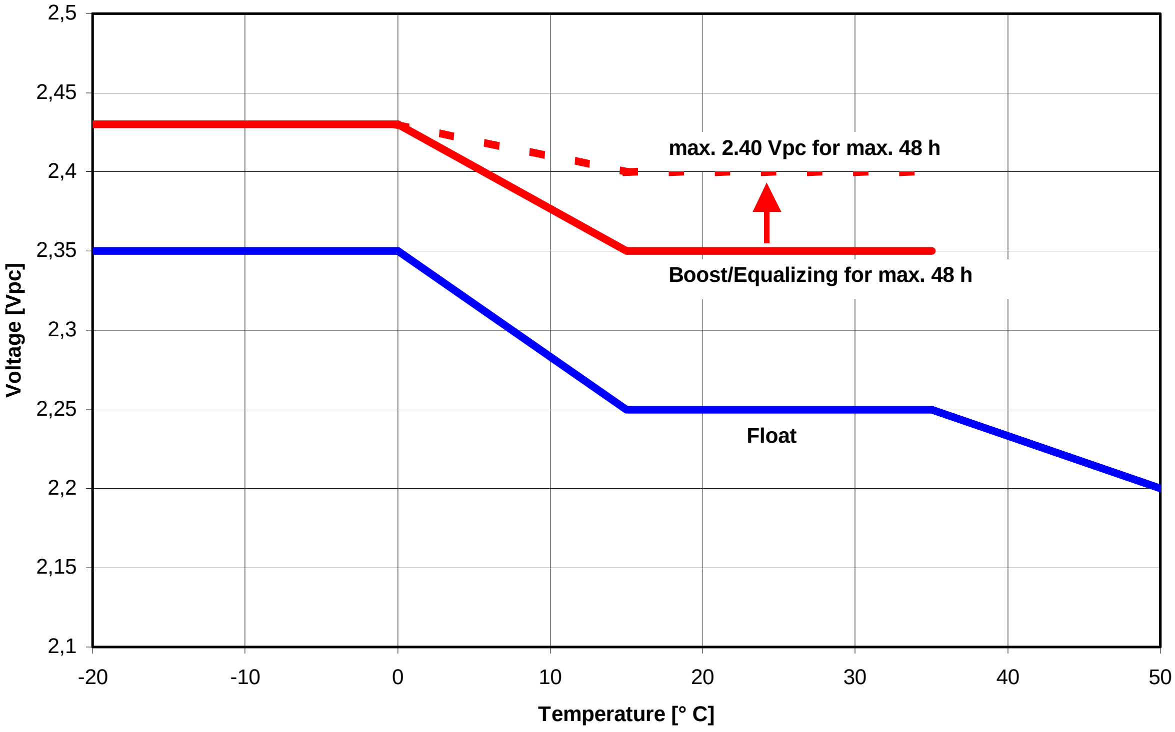


Fig. 5: A600, A600 block, (A600 SOLAR), A700 - Charging Voltage vs. Temperature

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" [6] 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 set as shown in figures 6 to 16. The following table 3 gives an overview about all the battery types and their variations from the average value under float charge conditions acc. to 6.1.

	2 V-cells	4 V-blocks	6 V-blocks	8 V-blocks	12 V-blocks
A400	--	--	+0.35/-0.17	--	+0.49/-0.24
A500	+0.2/-0.1	+0.28/-0.14	+0.35/-0.17	+0.40/-0.20	+0.49/-0.24
A600	+0.2/-0.1	--	+0.35/-0.17	--	+0.49/-0.24
A700	--	+0.28/-0.14	+0.35/-0.17	--	--

Table 3: Permissible float voltage deviation from the settings acc. to 6.1.
The values correspond to the criterion “Watch” in fig. 6 to 16.

- This deviation is even stronger after the installation and within the first two or three years of operation. It is due to different initial states of recombination and polarization within the cells. In the course of the years it comes to a restriction of the spreading range acc. to fig. 6 to 16 (“Typical increase”, “Typical decrease”, respectively).
  It is a normal effect and well described in [7].

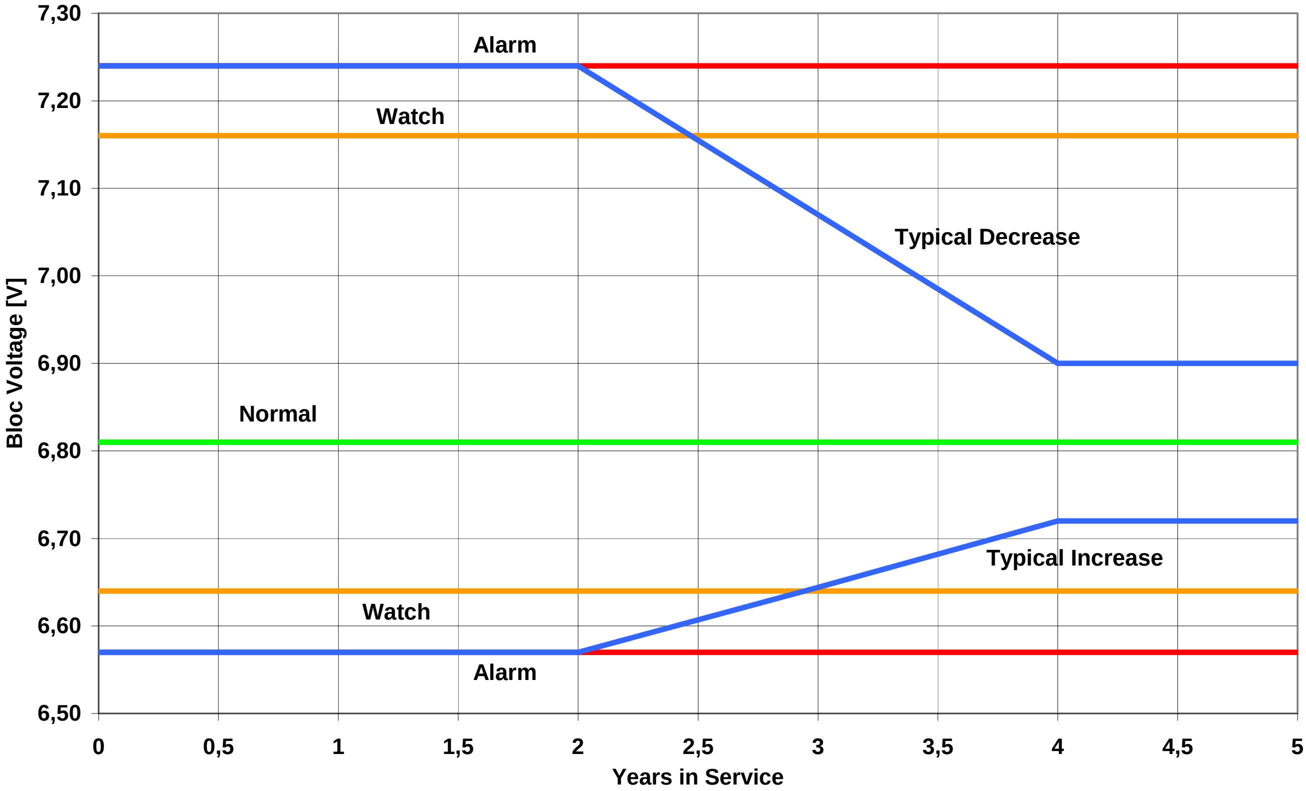


Fig. 6: A400 (6 V) – Float Voltage Deviation vs. Years

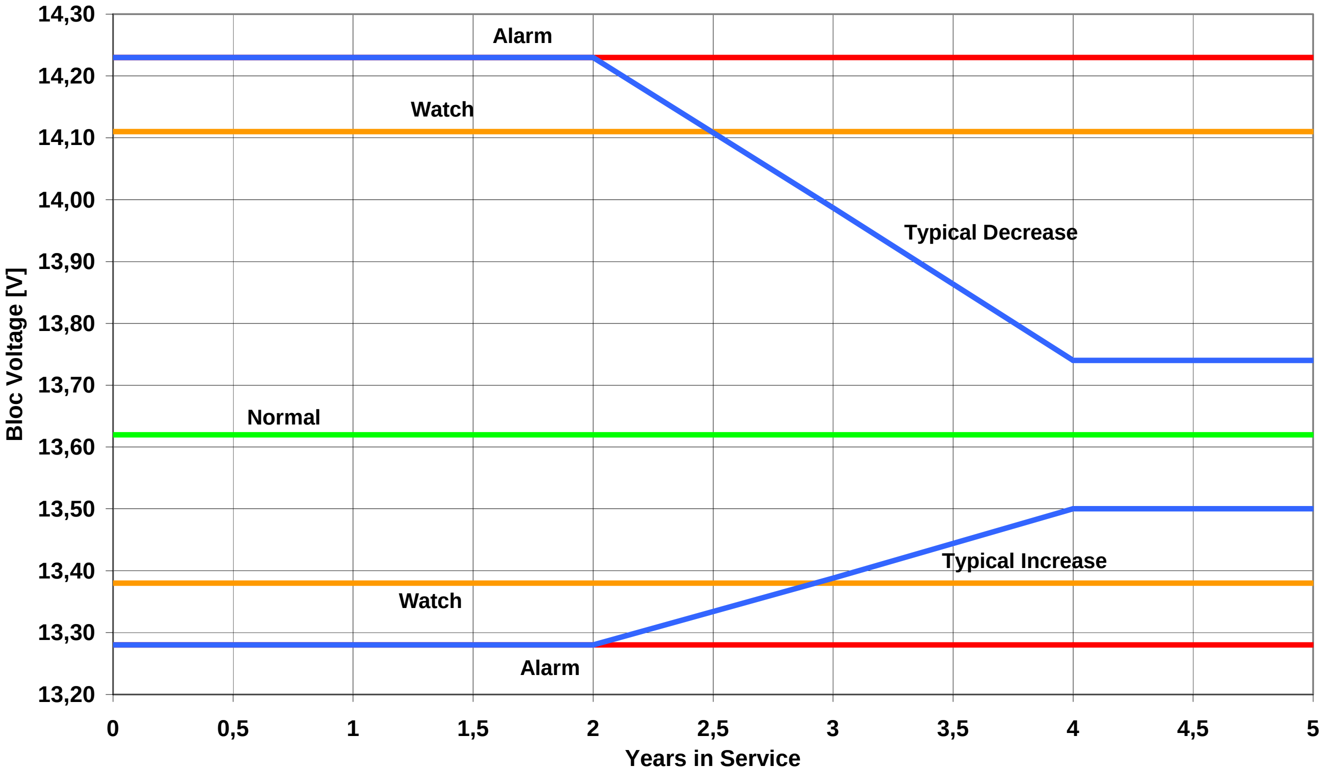


Fig. 7: A400 (12 V) – Float Voltage Deviation vs. Years

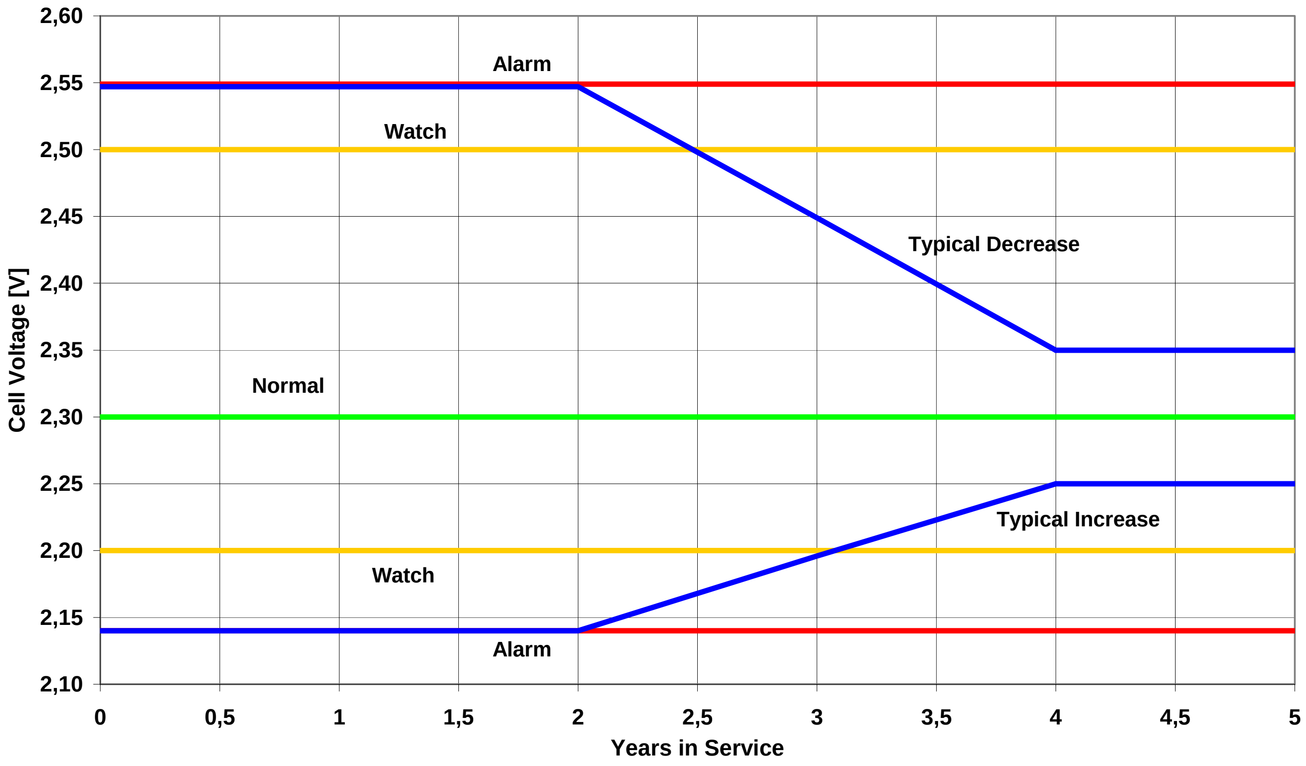


Fig. 8: A500 (2 V) – Float Voltage Deviation vs. Years

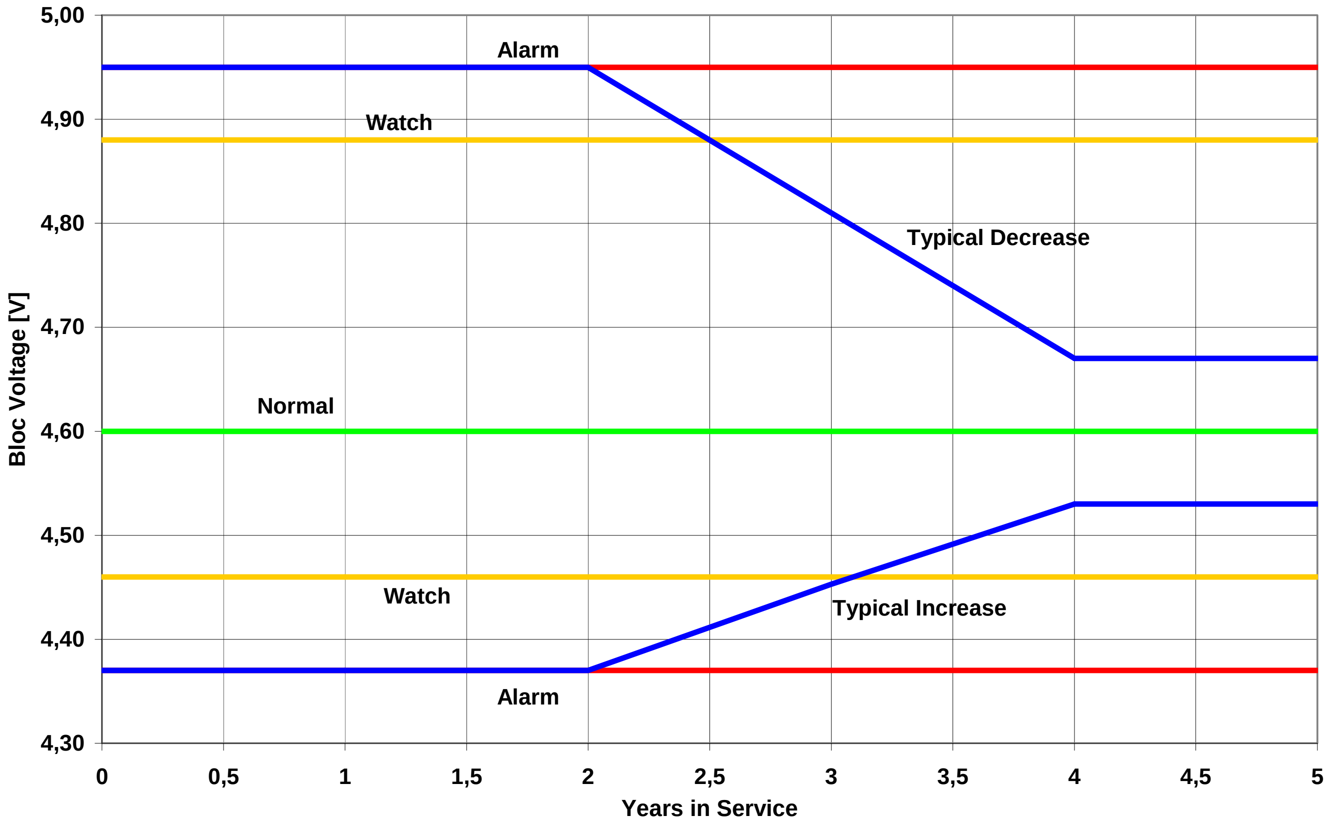


Fig. 9: A500 (4 V) – Float Voltage Deviation vs. Years

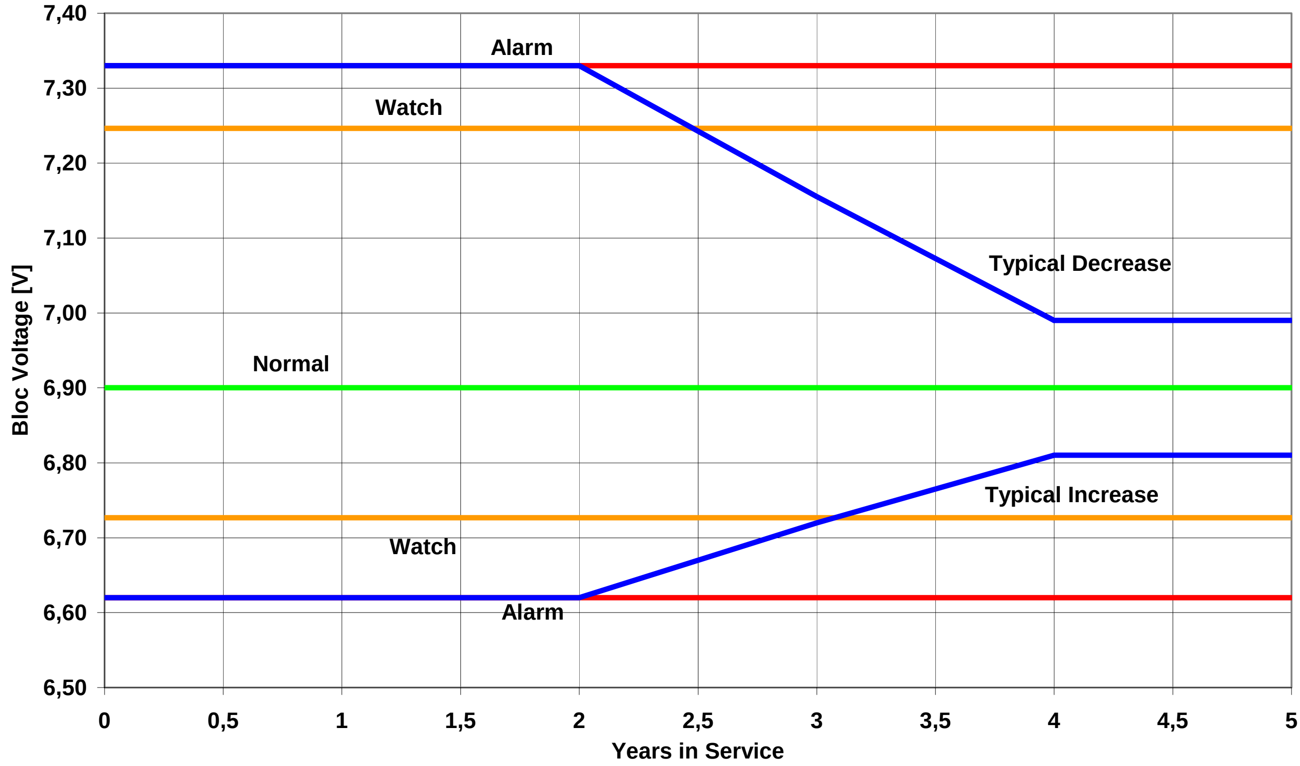


Fig. 10: A500 (6 V) – Float Voltage Deviation vs. Years

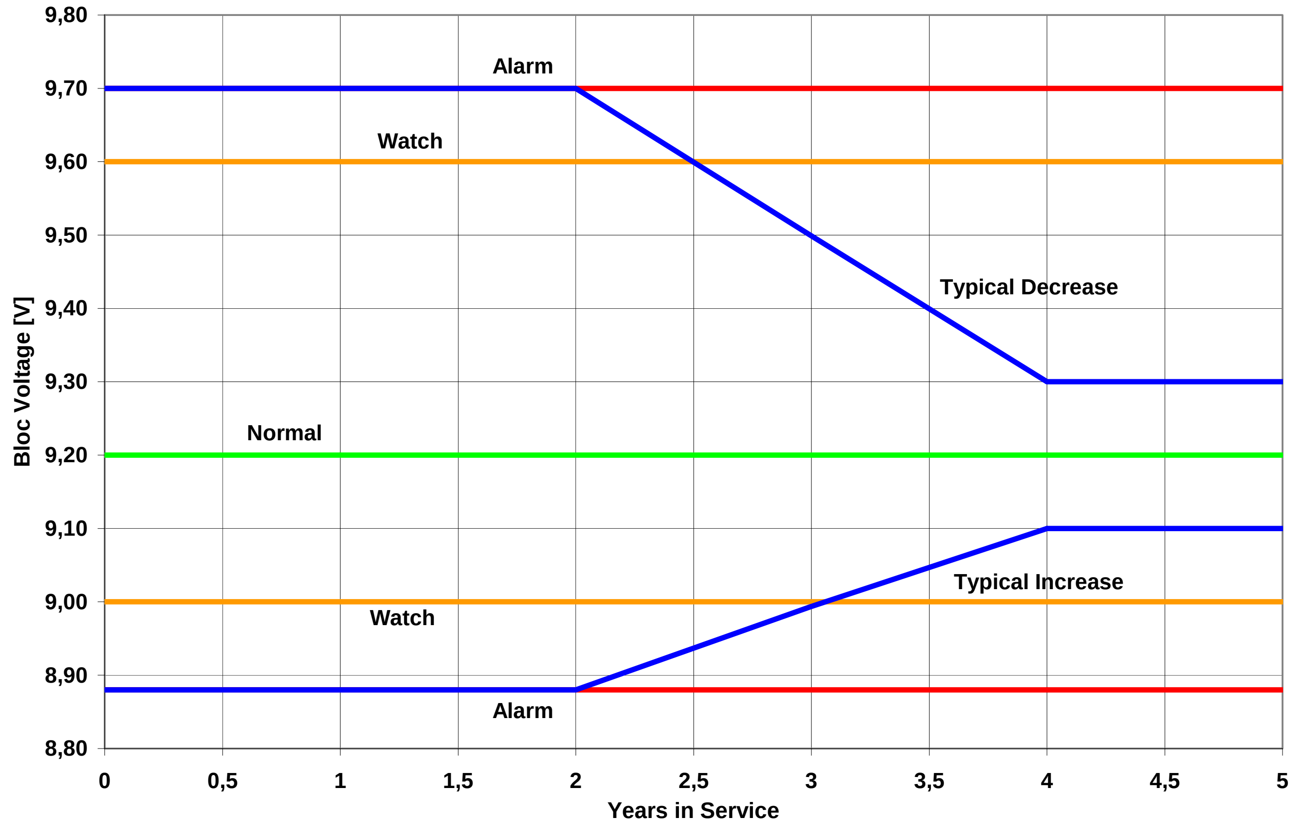


Fig. 11: A500 (8 V) – Float Voltage Deviation vs. Years

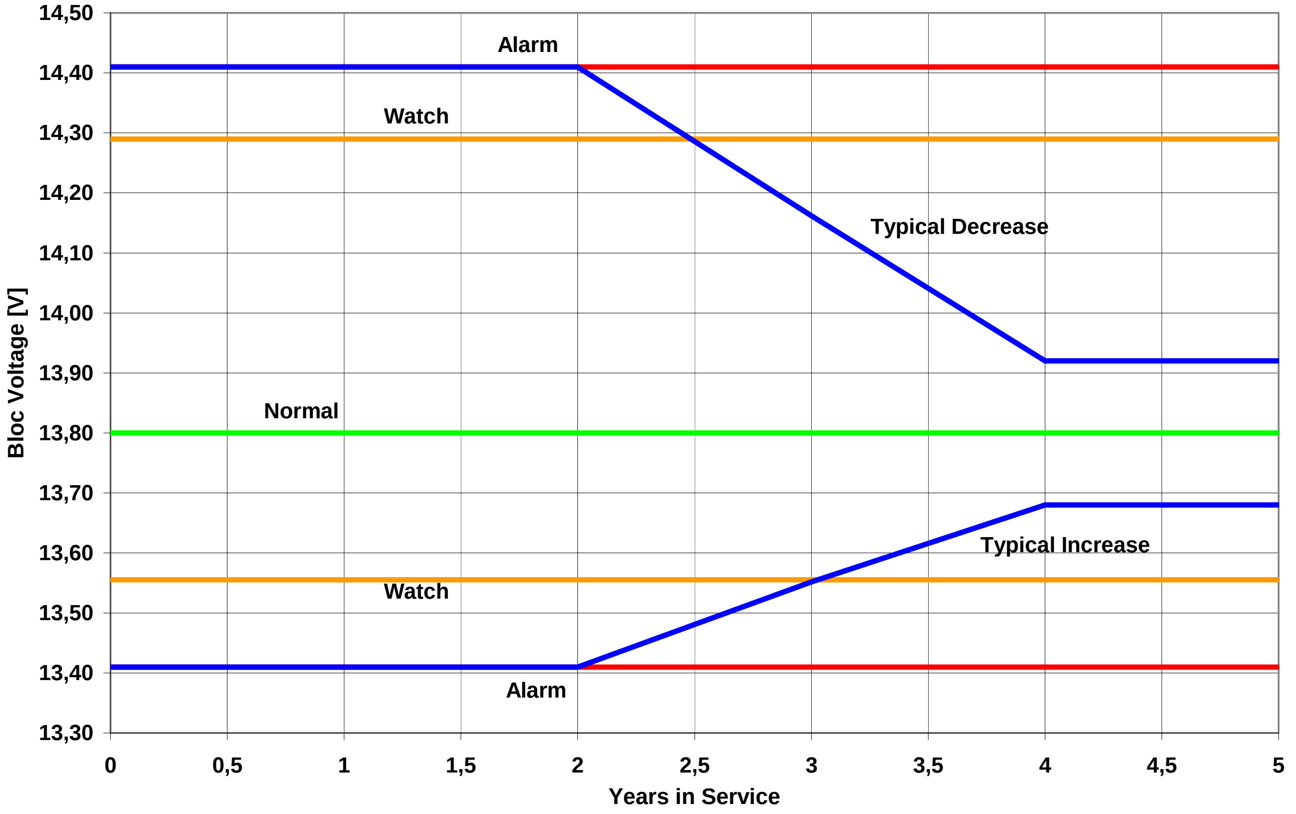


Fig. 12: A500 (12 V) – Float Voltage Deviation vs. Years

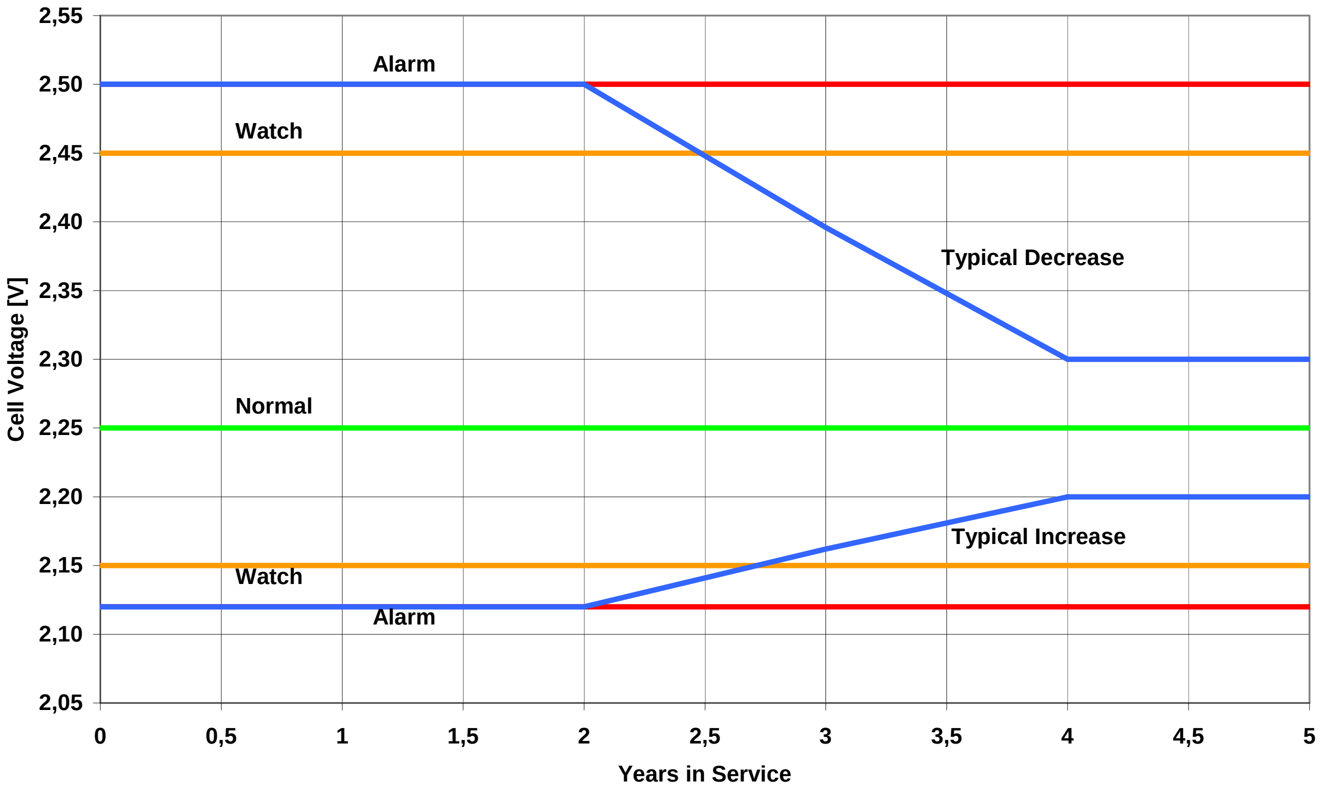


Fig 13: A600 (2 V) – Float Voltage Deviation vs. Years

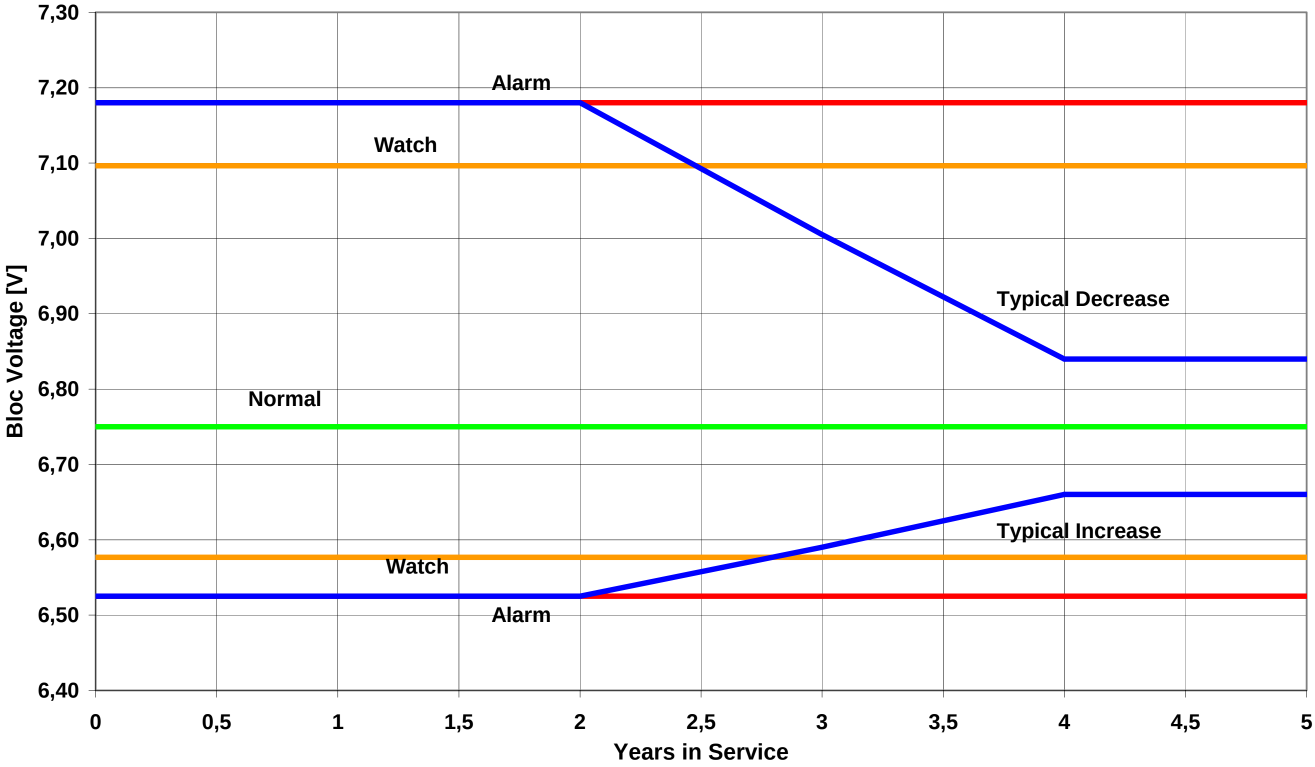


Fig. 14: A600 (6 V), A700 (6 V) – Float Voltage Deviation vs. Years

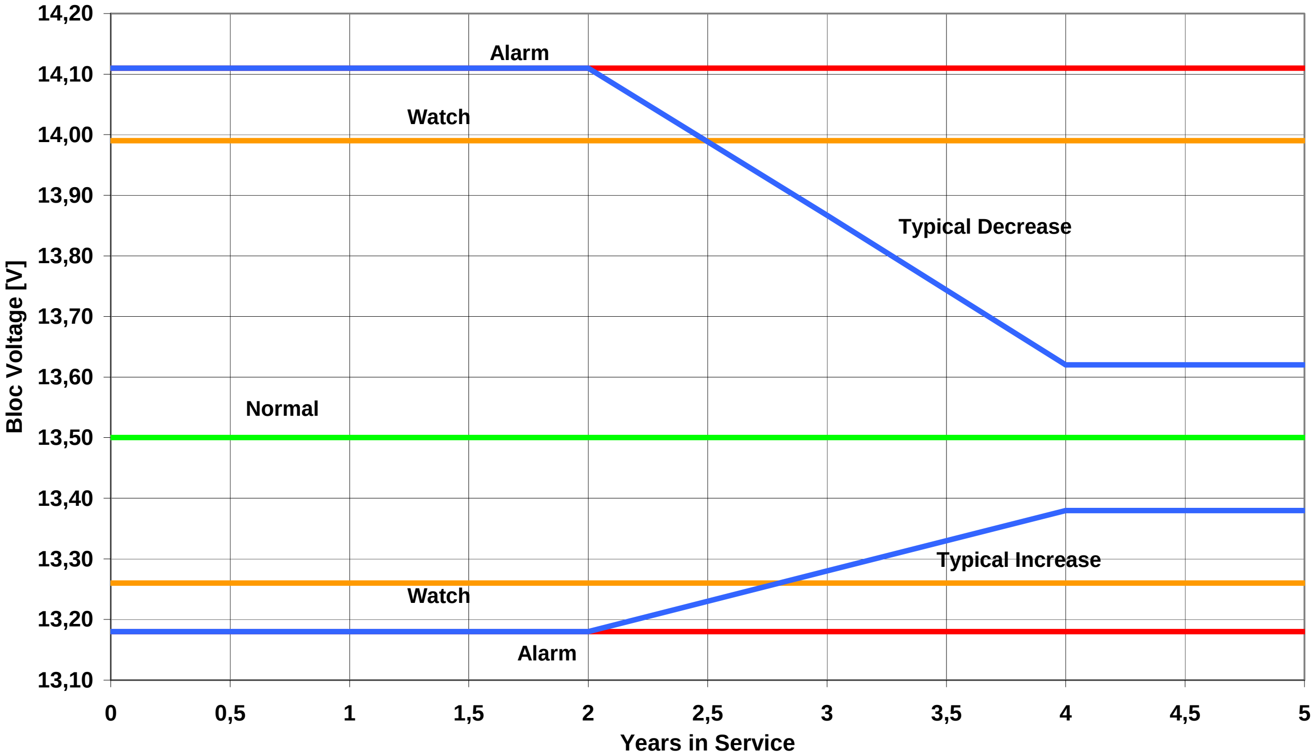


Fig. 15: A600 (12 V) - Float Voltage Deviation vs. Years

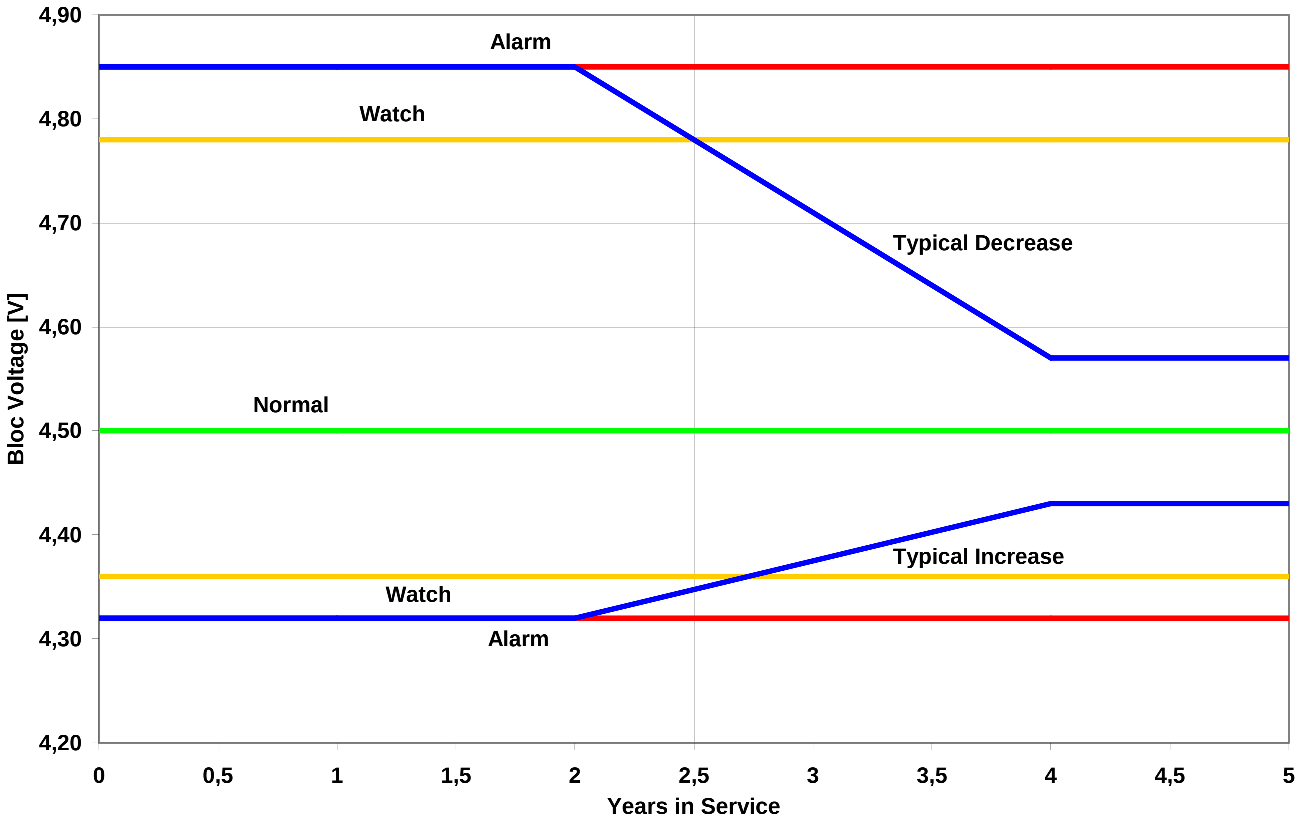


Fig. 16: A700 (4 V) – Float Voltage Deviation vs. Years

6.4 Charging Times

- The constant current – constant voltage (IU) charging mode is the most appropriate to achieve a very long service life to VRLA batteries. The following diagrams below 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.
  2.25 Vpc can be applied only to A600, A600 block and A700, because the float charge voltages are higher for other battery types.
  Charging Gel-solar-batteries: See chapter 6.8.2.

- 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. Maintaining at 2.40 Vpc results in clear shorter recharging times.

Parameters:
- Charge voltage 2.25, 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. 17 and 18 as examples for how to use the diagrams. A survey of all available diagrams can be found in appendix 1.

Fig. 17: 2.25 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 can need up to 48 hours.

Fig. 18: 2.40 Vpc, 1 • I_{10}. The same battery discharged to 50% DOD would be recharged to 80% within 3.7 hours but fully re-charged within 20 hours.

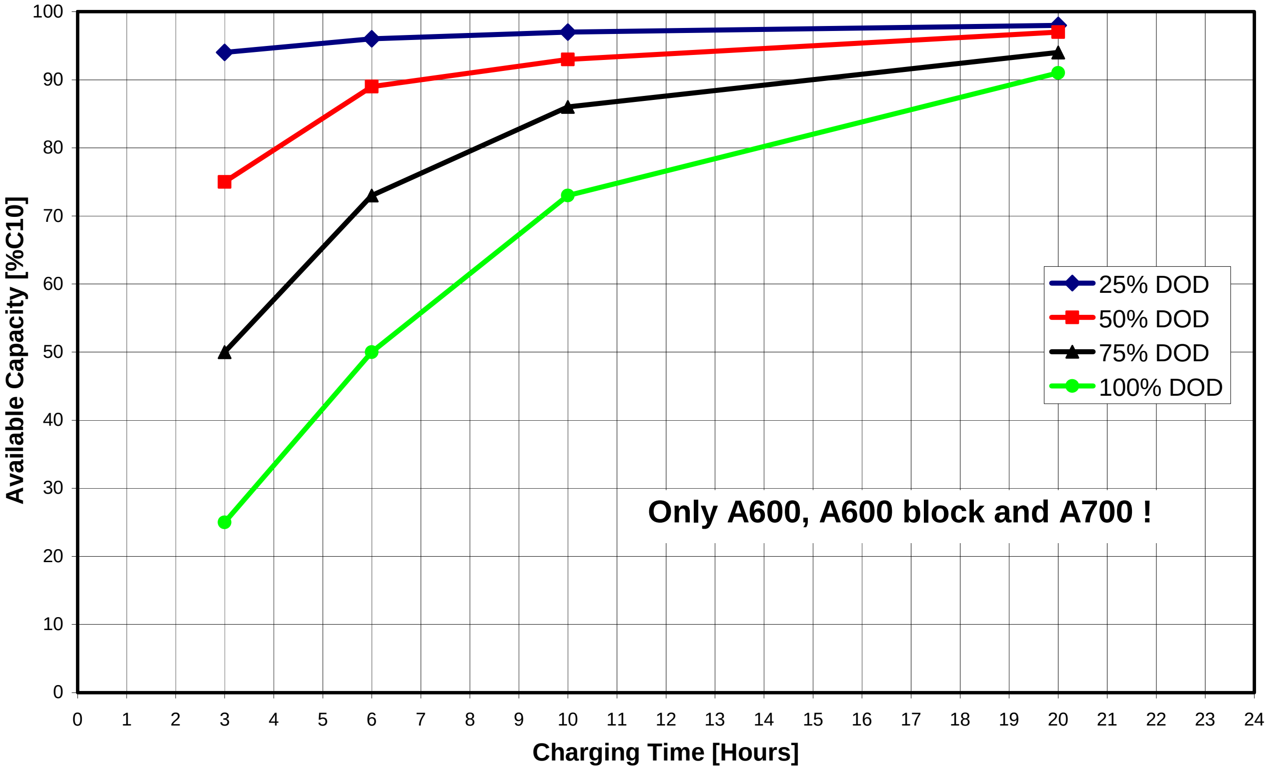


Fig. 17: Available Capacity vs. Charging Time at 2.25 Vpc, Charging Current 1 • I_{10}, DOD = Depth of Discharge

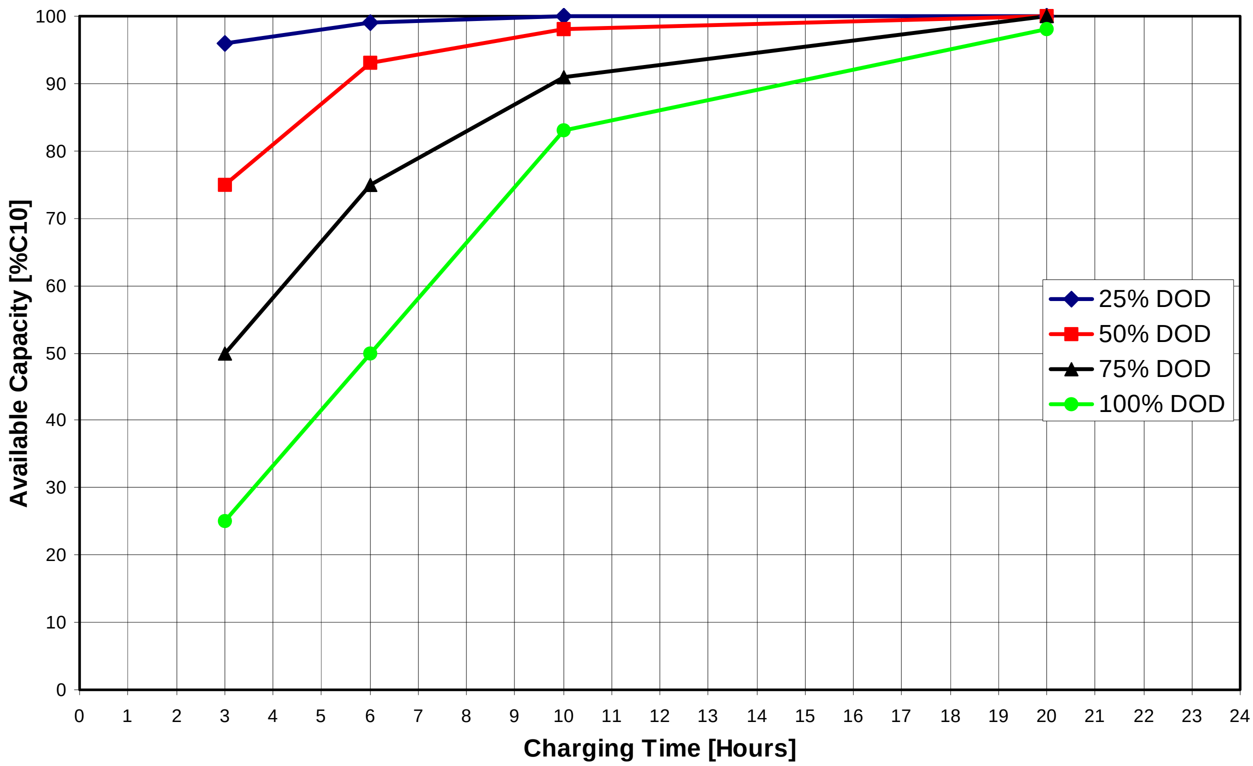


Fig. 18: Available Capacity vs. Charging Time at 2.40 Vpc, Charging Current 1 • I_{10}, DOD = Depth of Discharge

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):

1.05 (discharge rate 10 hours)
1.10 (discharge rate 1 hour)
1.20 (discharge rate 10 minutes)

Ah-efficiency = 1/1.05 …1/1.20 = 95%…83%

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 2.25 Vpc, 1• I_{10},

Expected re-charging time (incl. charge coefficient 1.05): 32 hours

Estimate for average voltage during re-charging: The voltage increases from 2.1 Vpc to 2.25 Vpc during 9 hours → average 2.17 Vpc.

The voltage is constant at 2.25 Vpc for (32-9) hours = 23 hours.

Estimated average voltage during 32 hours: 2.23 Vpc

$$\text{Wh-efficiency} = \frac{100\ \text{Ah} \cdot 2.0\ \text{Vpc}}{105\ \text{Ah} \cdot 2.23\ \text{Vpc}}$$

$$= 0.854 = 85\ \%$$

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 fig. 6 to 16.

They have to be carried out as follows:

Up to 48 hours at max. 2.40 Vpc.
The charge current is unlimited up to achieving U-constant.
The cell / block temperature must never exceed 45°C. If it does, stop charging or switch down to float charge to allow the temperature to decrease.

Gel-solar-batteries with system voltages ≥ 48 V

Every one to three months:

Method 1: IUI
IUI-phase = up to voltage acc. to fig. 26 (chapter 6.8.2) 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 4 hours.

Method 2: IUI (pulsation)
I-phase = up to voltage acc. to fig. 26 (chapter 6.8.2) 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 4-6 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

Even if Gel-VRLA batteries are deep-discharge resistant, their service life can be affected by too many and successive deep-discharges.

Therefore:

- 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.
- VRLA batteries are delivered always in fully charged state. But, new installed VRLA 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 60896-21 [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 18 and 27° C acc. to IEC 60896-21 [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

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

  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 OPzV-battery (service life 15 to 18 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

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

Gel-solar batteries are optimized for cyclical application (additive to electrolyte: phosphoric acid, - increases the number of cycles).

The following numbers of cycles are specified acc. to IEC 896-2 [9]*):

A500:	600 cycles
A400:	600 cycles
A700:	700 cycles
A600 block:	1000 cycles
A600:	1200 cycles
SOLAR:	800 cycles
SOLAR BLOCK:	1200 cycles
A600 SOLAR:	1600 cycles

*) Discharge conditions acc. to IEC 896-2 [9]: 20° C, discharge for 3 h at a current of I = 2.0 • 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 19 to 25 for details.

Fig. 23 to 25 show a different correlation to IEC 896-2 [9] 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.

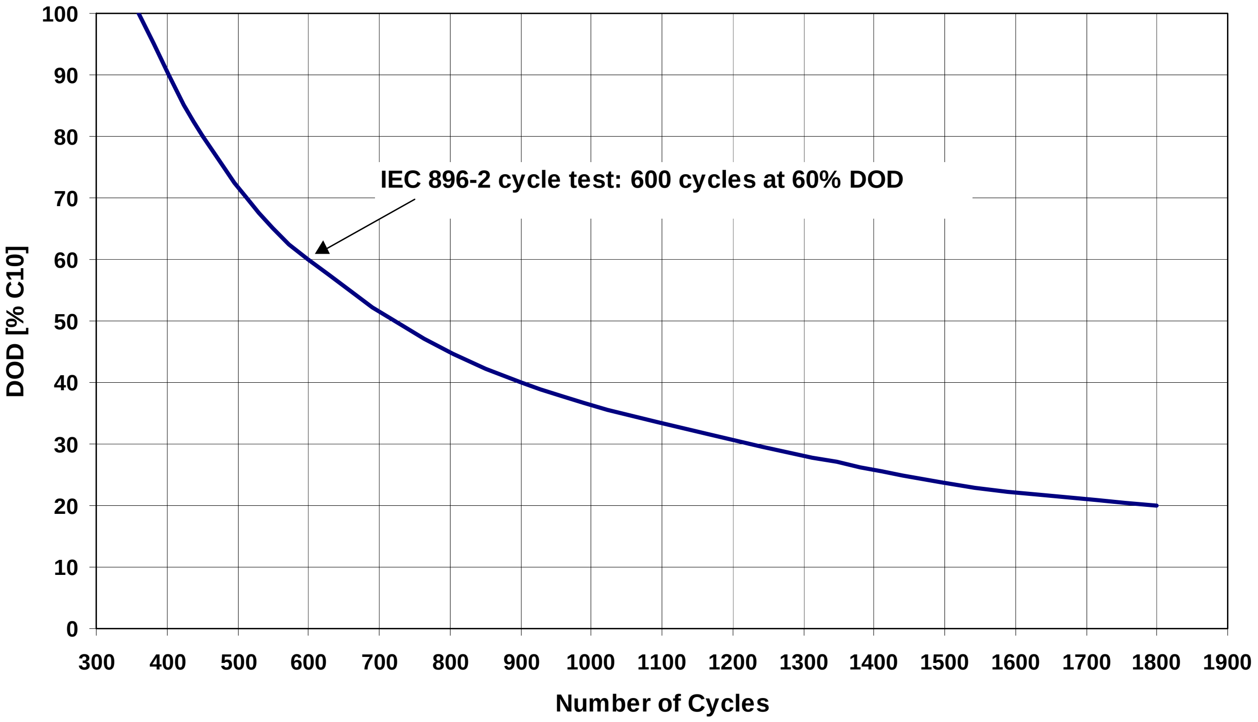


Fig. 19: A500, A400 - Number of Cycles vs. Depth of Discharge (DOD)

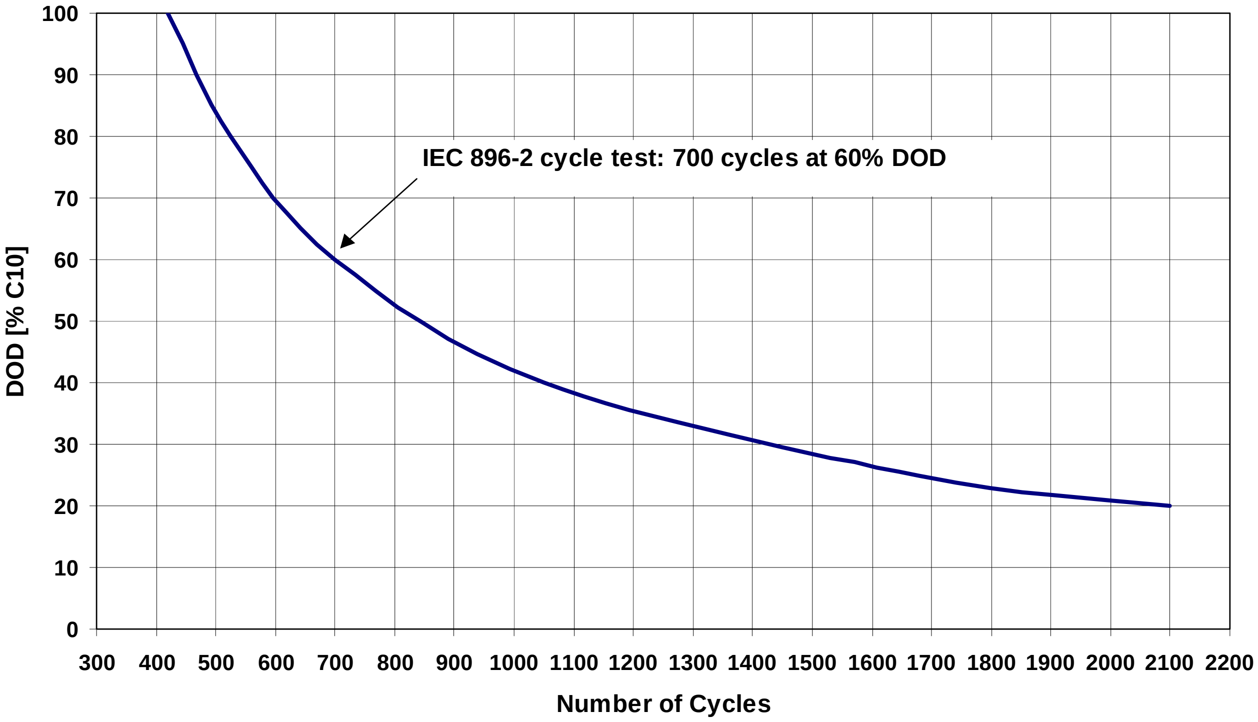


Fig. 20: A700 - Number of Cycles vs. Depth of Discharge (DOD)

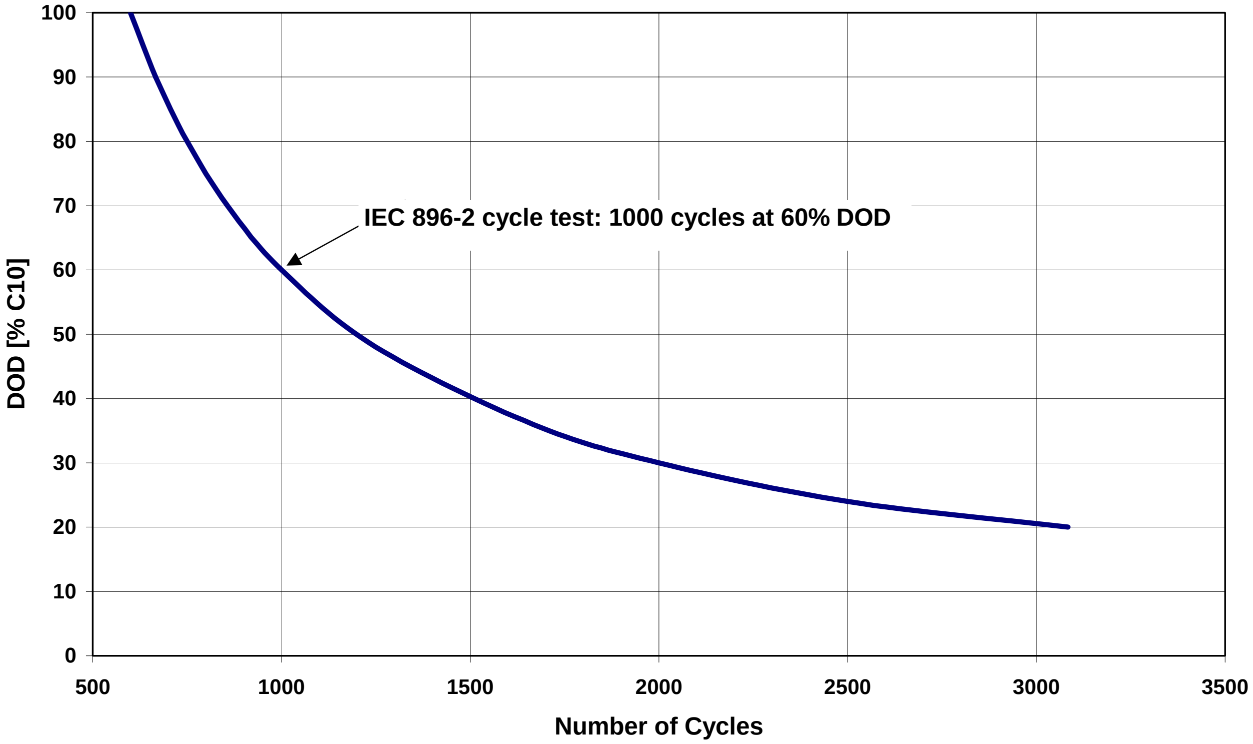


Fig. 21: A600 block - Number of Cycles vs. Depth of Discharge (DOD)

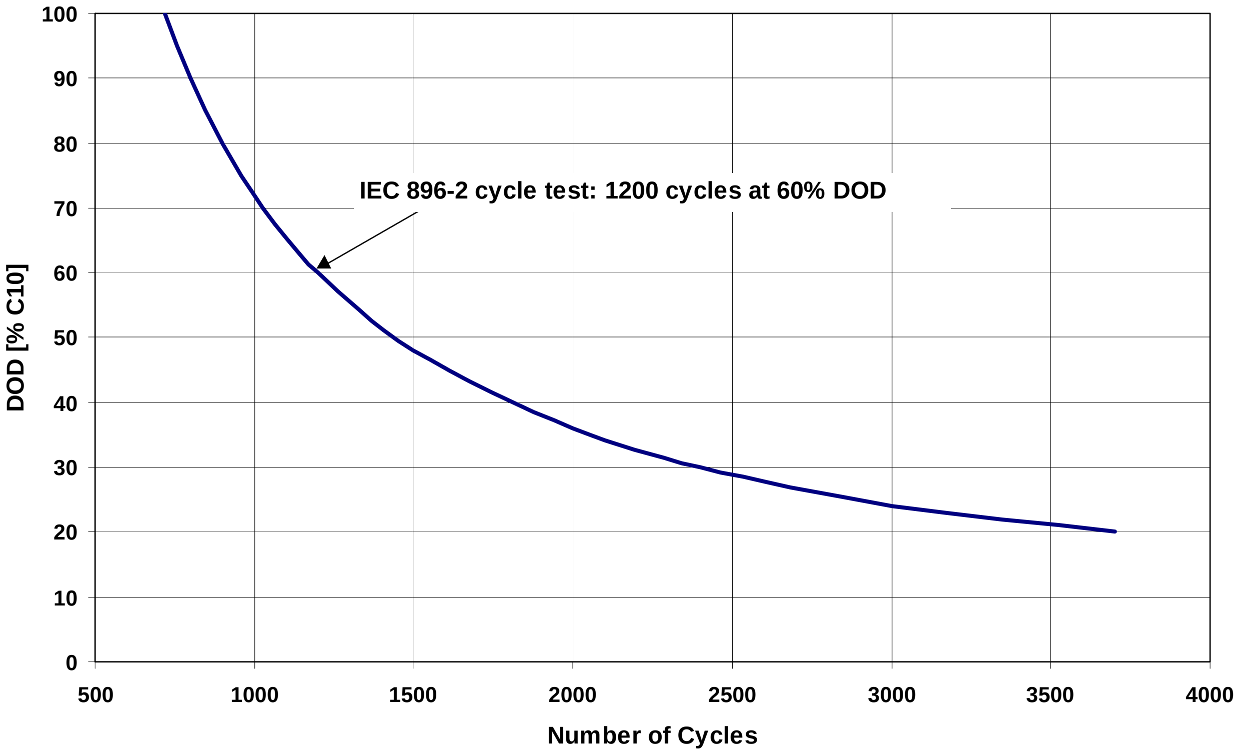


Fig. 22: A600 - Number of Cycles vs. Depth of Discharge (DOD)

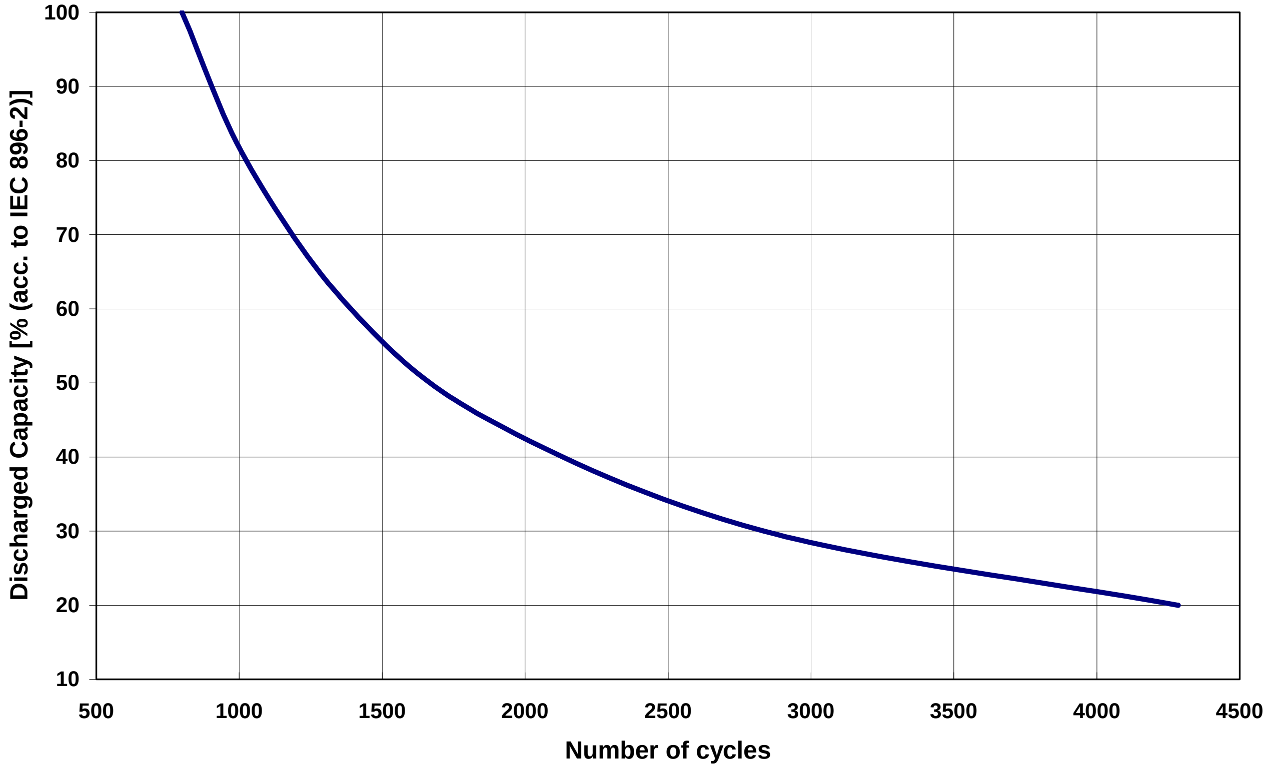


Fig. 23: SOLAR - Number of Cycles vs. Depth of Discharge (DOD)

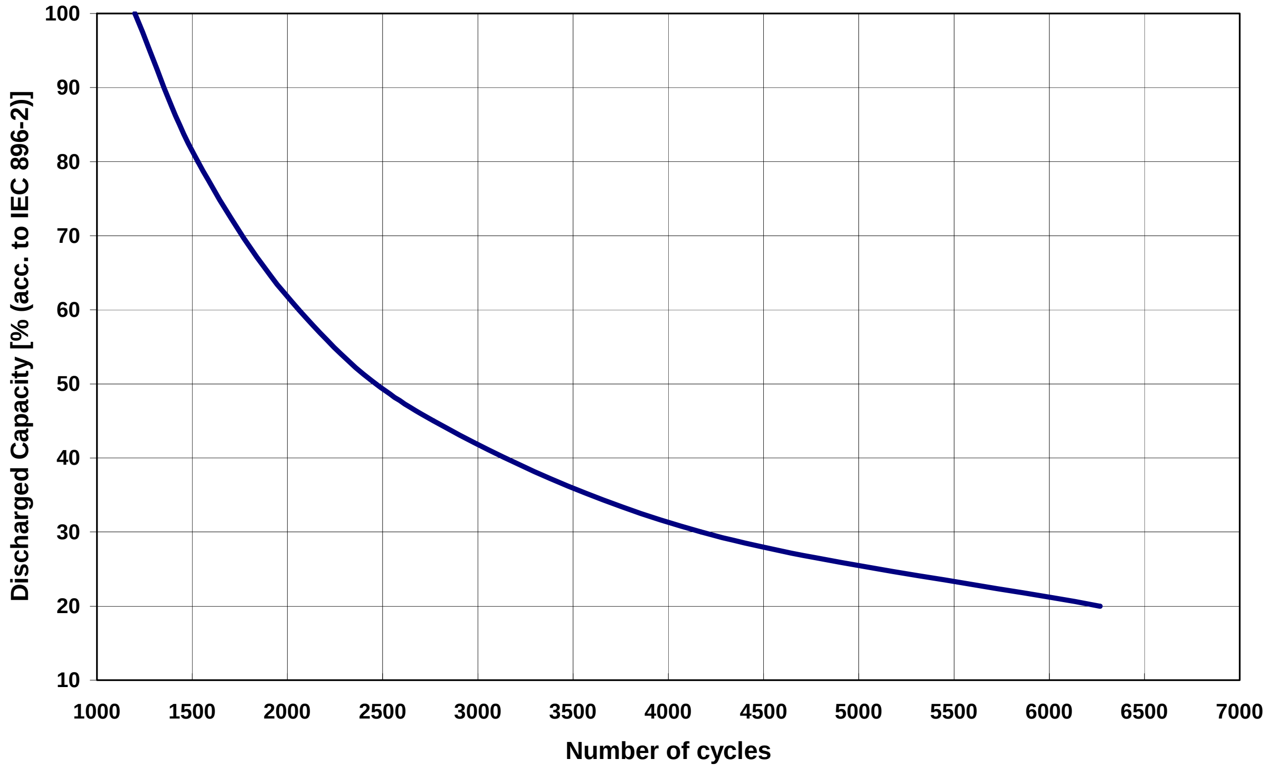


Fig. 24: SOLAR BLOCK- Number of Cycles vs. Depth of Discharge (DOD)

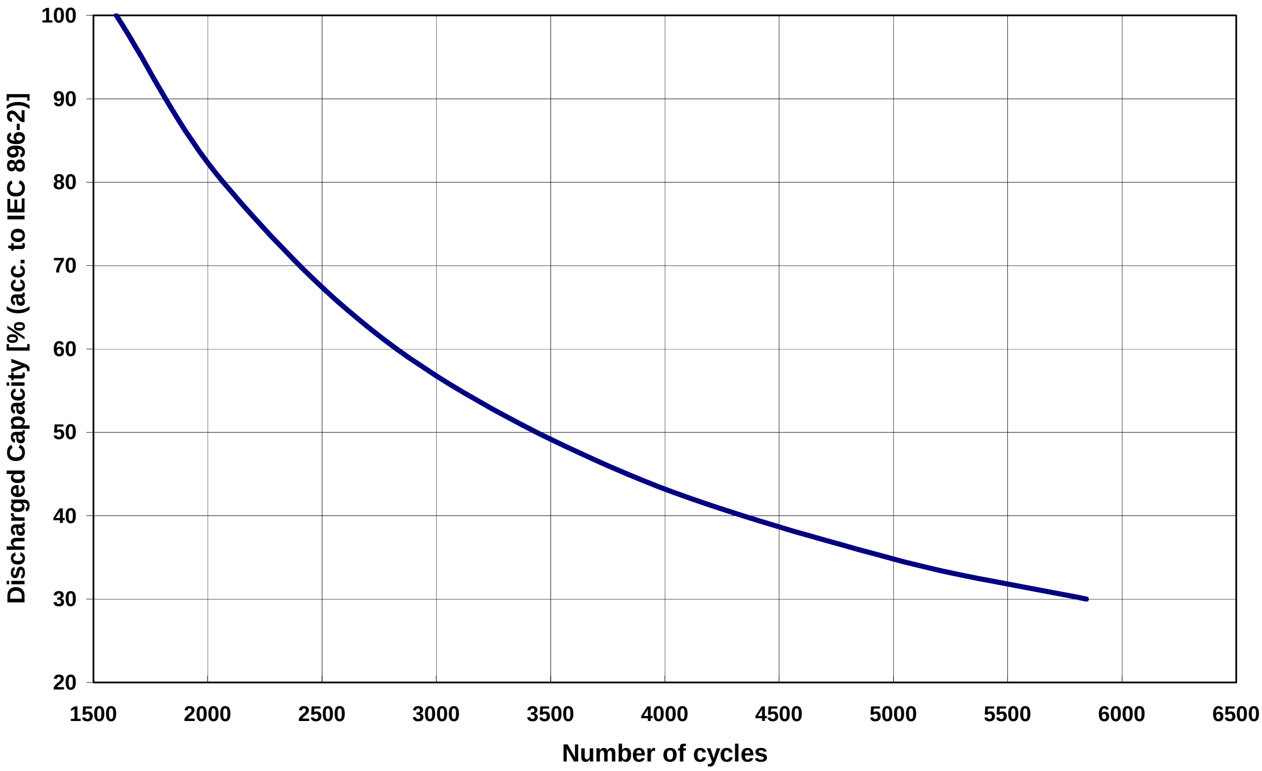


Fig. 25: A600 SOLAR - Number of Cycles vs. Depth of Discharge (DOD)

6.8.2 Special Considerations about Gel-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 (a must for VRLA batteries)
  - 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 [10] 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?)
    - Automotive batteries are not suitable for use in professional solar systems.
    - 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 Gel-solar-batteries shall be carried out acc. to fig. 26.
    A temperature related adjustment of the charge voltage within the operating temperature of 15° C to 35° C must not be applied. If the operating temperature is permanently outside this range, the charge voltage has to be adjusted as shown in fig. 26.

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 [11]):

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

Therefore, equalizing charges should be given every 3 to 12 months depending on the actual SOC values over a longer period.

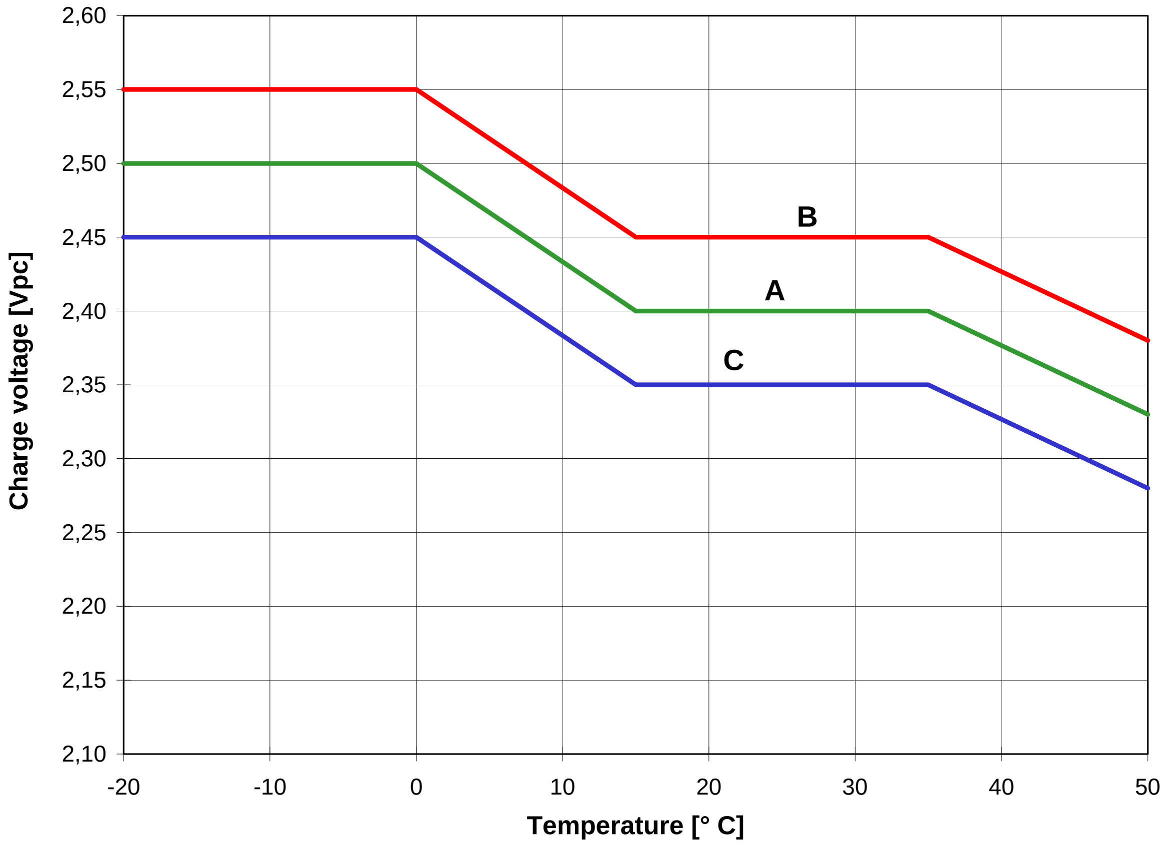


Fig. 26: Charging of Gel-Solar-batteries depending on Charge Mode and Temperature:

- With switch regulator (two-step controller): Charge on curve B (max. charge voltage) for max. 2hrs per day, then switch over to continuous charge - Curve C
- Standard charge (without switching) - Curve A
- Boost charge (Equalizing charge with external generator): Charge on curve B for max. 5hrs per month, then switch over to curve C.

6.9 Internal Resistance R_i

- The internal resistance R_i is determined acc. to IEC 60896-21 [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 fig. 27 below. 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.

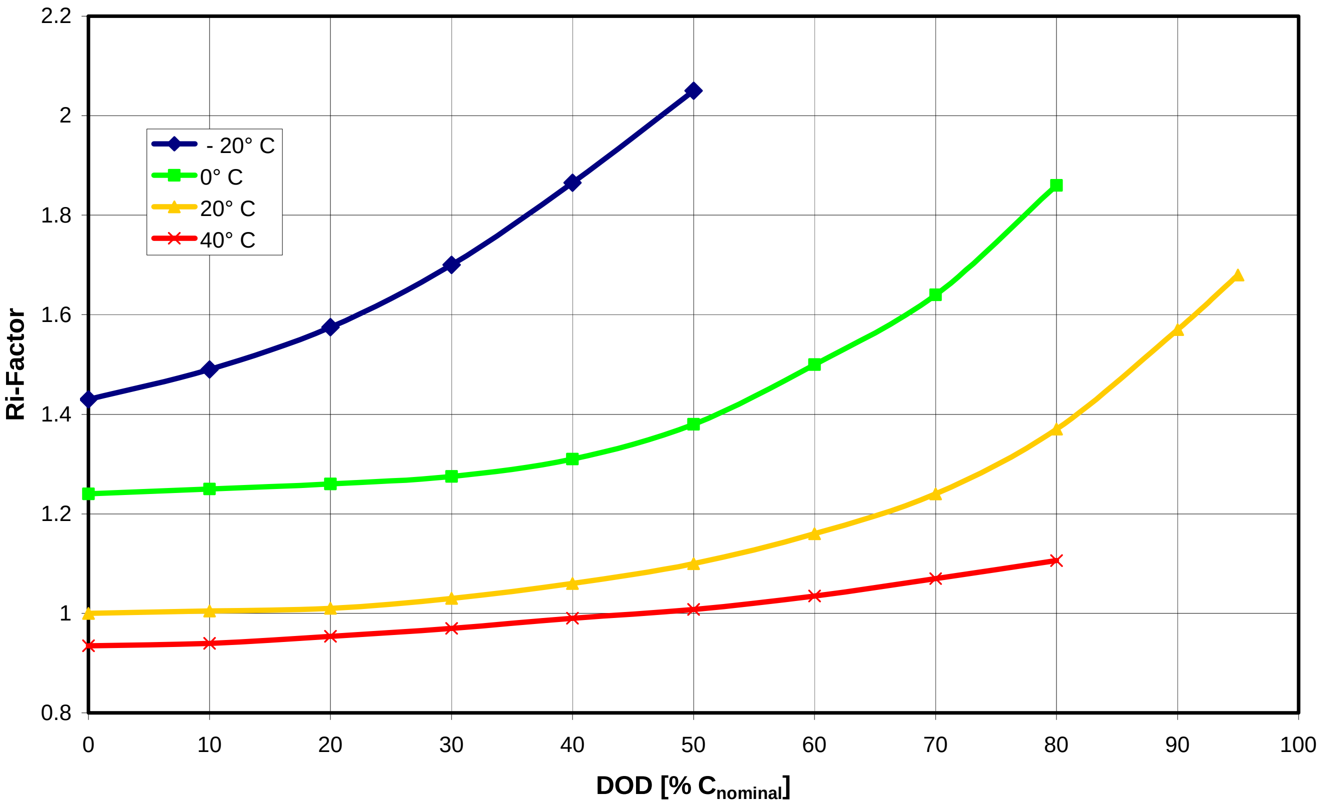


Fig. 27: Internal Resistance R_i vs. Depth of Discharge (DOD) and Temperature

6.10 Influence of Temperature

- The design of Gel-batteries allows the use in a wide temperature range from – 40° C to + 55° C.

- There is a risk at temperatures of approx. less than -15° C regarding freezing-in of the electrolyte depending on the depth of discharge and the withdrawn capacity, respectively.

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

- The battery temperature influences the capacity as shown in fig. 28 and 29.

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

A500:	> 6 years
A400:	> 10 years
A700:	12 years
A600 block:	13 to 15 years
A600:	15 to 18 years
SOLAR:	5 to 6 years
SOLAR BLOCK:	7 to 8 years
A600 SOLAR:	12 to 15 years

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

A500:	7 years
A400:	12 years
A700:	> 12 years
A600 block:	15 years
A600:	18 years

SOLAR, SOLAR BLOCK and A600 SOLAR are designed for cyclical application only.

Even if Gel-solar-batteries are not optimized for standby application, they can be used for that too. The achievable service life is shorter than for standard Gel-batteries with equivalent design because phosphoric acid is added in order to increase the number of cycles. Phosphoric acid increases the corrosion rate and the self-discharge rate slightly.

- 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 (A400, A500 and A700; to be applied to SOLAR and SOLAR BLOCK too regarding influence on number of cycles).

  There is one exception where the influence doesn't follow the law of "Arrhenius", - that's for A600 (cells and blocks) with positive tubular plates (to be applied to A600 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. 30 to 34 show the dependency of the lifetime on the temperature for different lines of products. Fig. 35 and 36 are regarding the influence of temperature on the endurance in cycles (number of cycles).

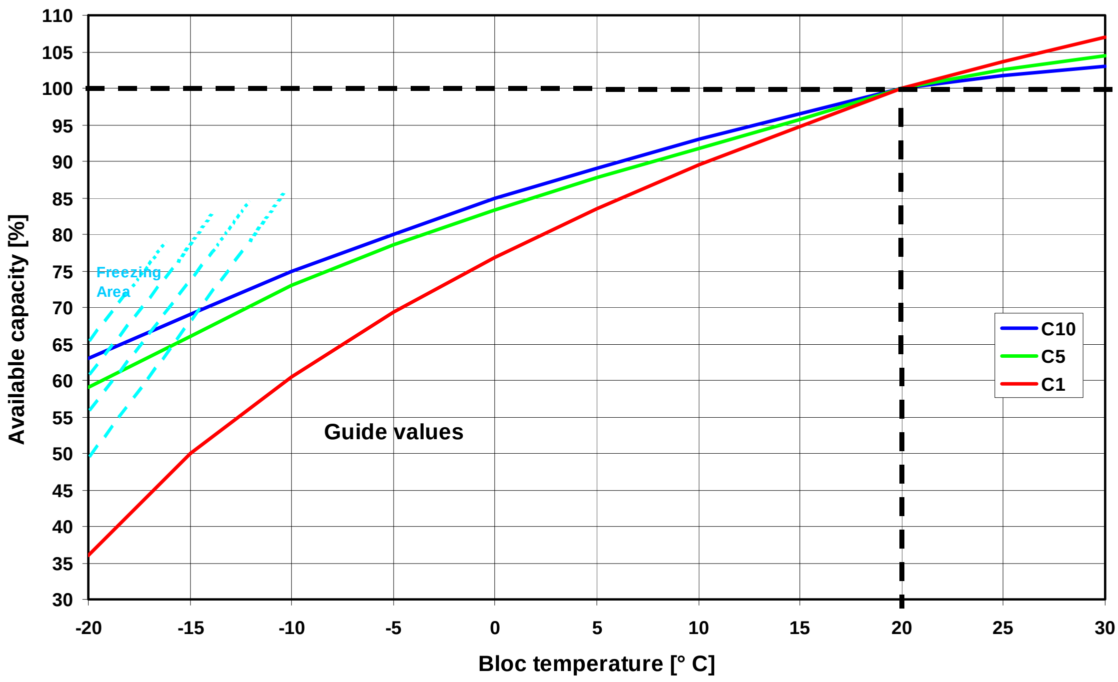


Fig. 28: A400, A500, SOLAR, SOLAR BLOCK -
Capacity (% Rated Capacity) vs. Temperature

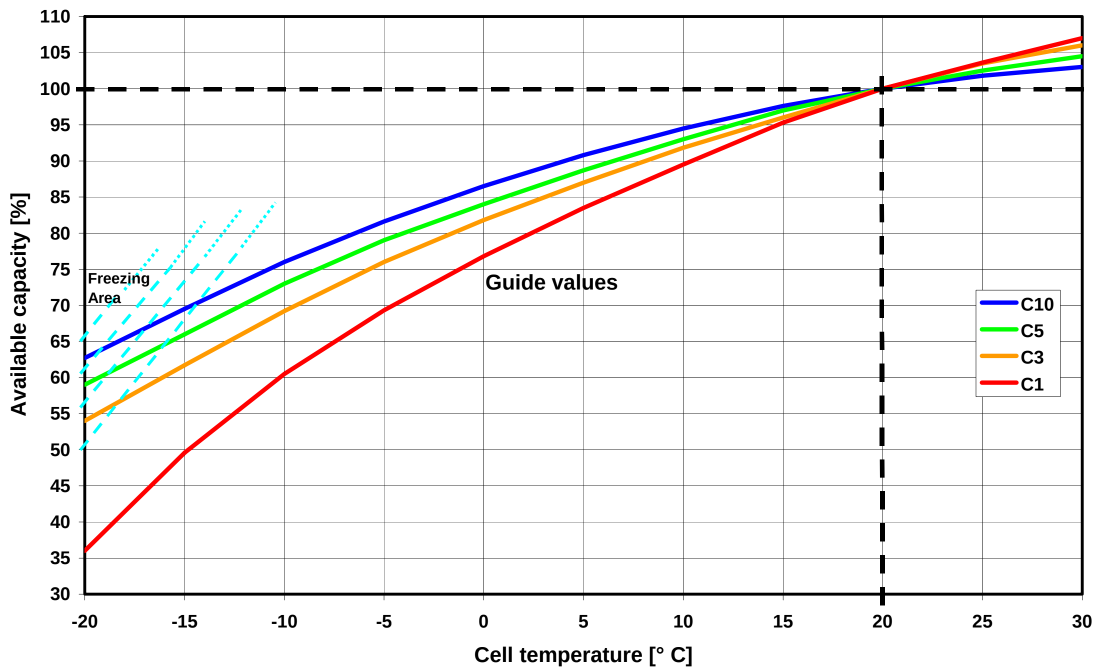


Fig. 29: A600, (A600 SOLAR), A700 – Capacity (% Rated Capacity) vs. Temperature

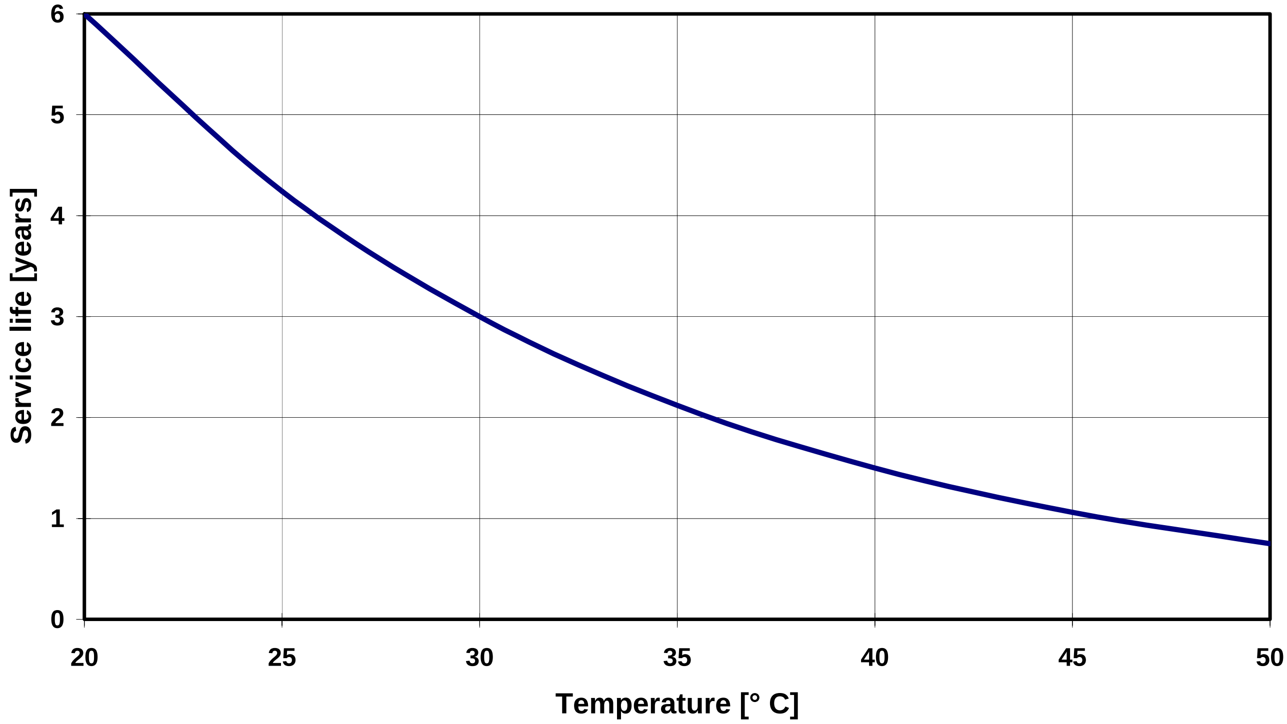


Fig. 30: A500 - Service Life vs. Temperature (following law of “Arrhenius”).

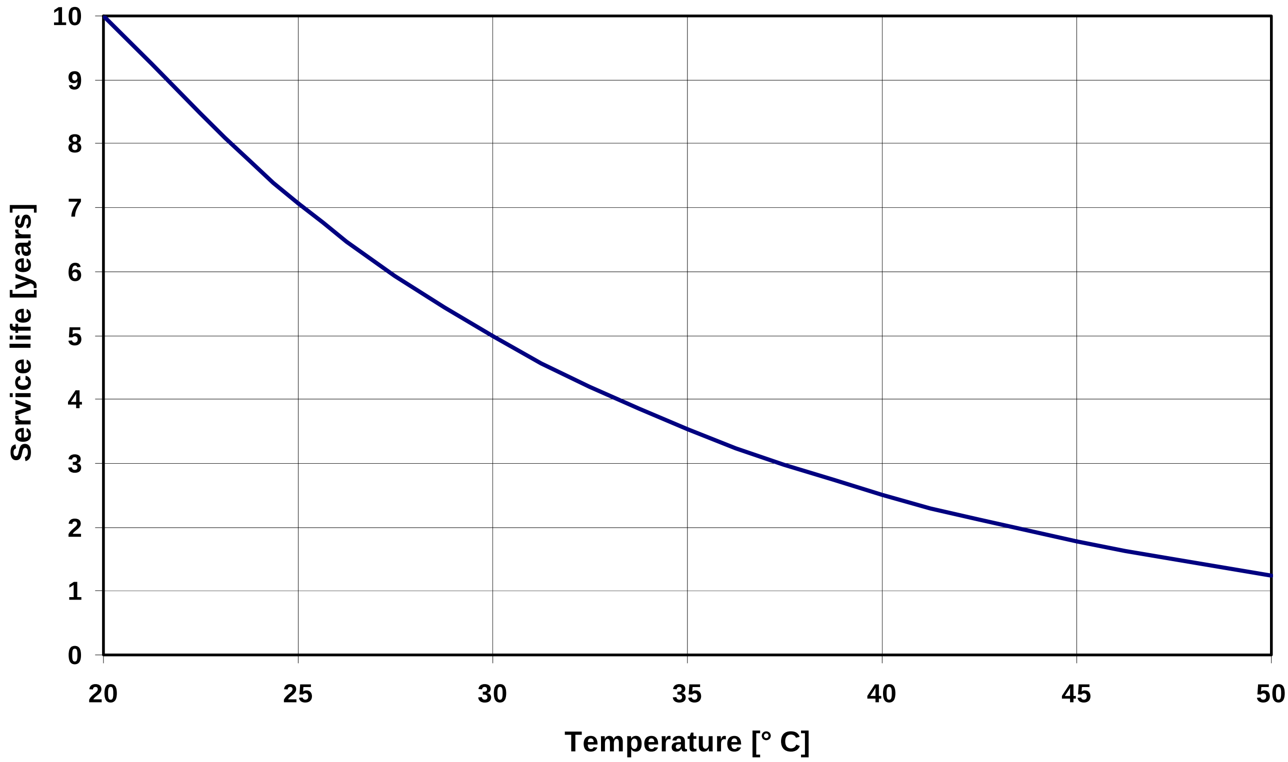


Fig. 31: A400 - Service Life vs. Temperature (following law of “Arrhenius”)

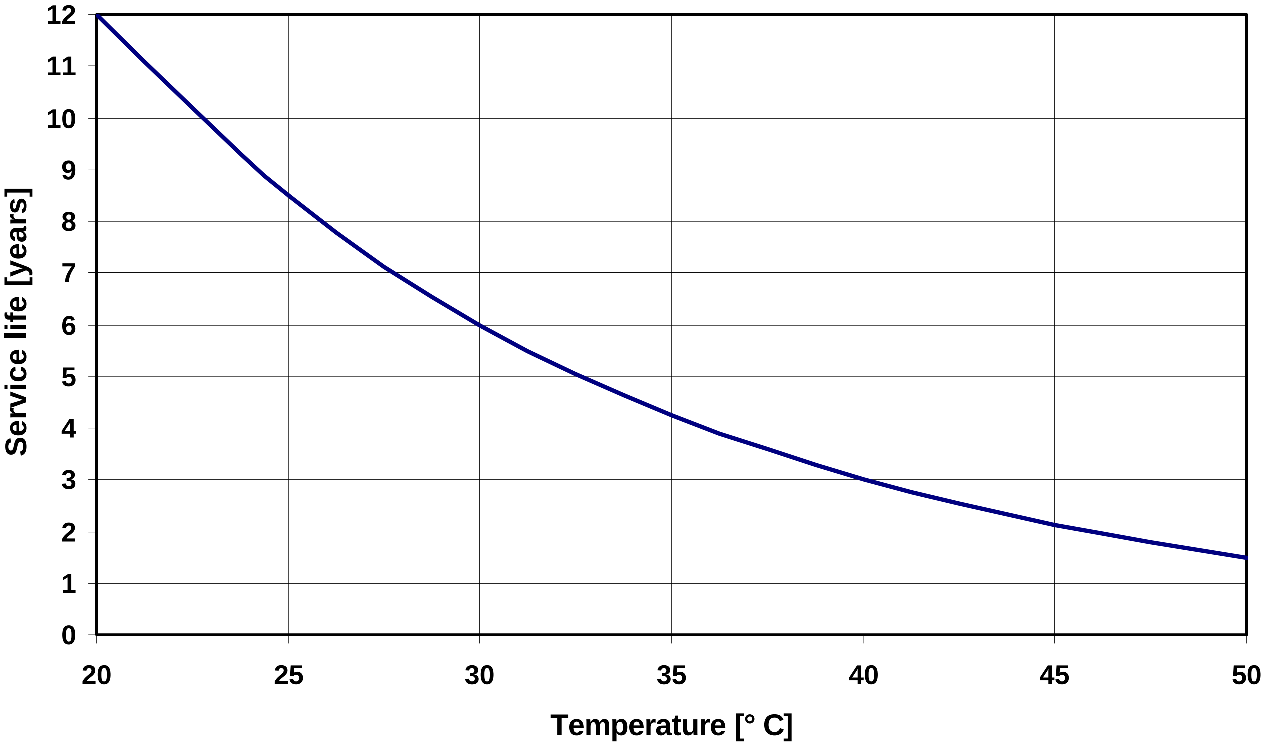


Fig. 32: A700 - Service Life vs. Temperature (following law of "Arrhenius")

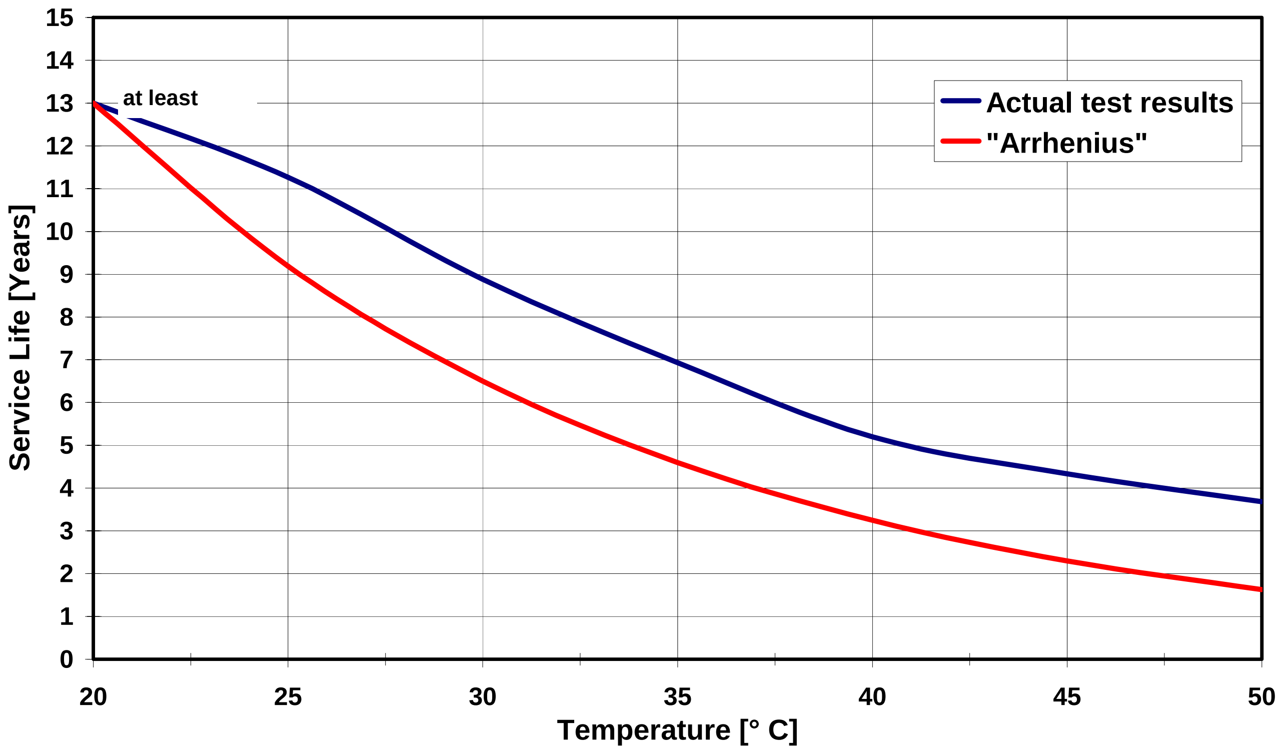


Fig. 33: A600 block - Service Life vs. Temperature. The blue curve is valid in practice.

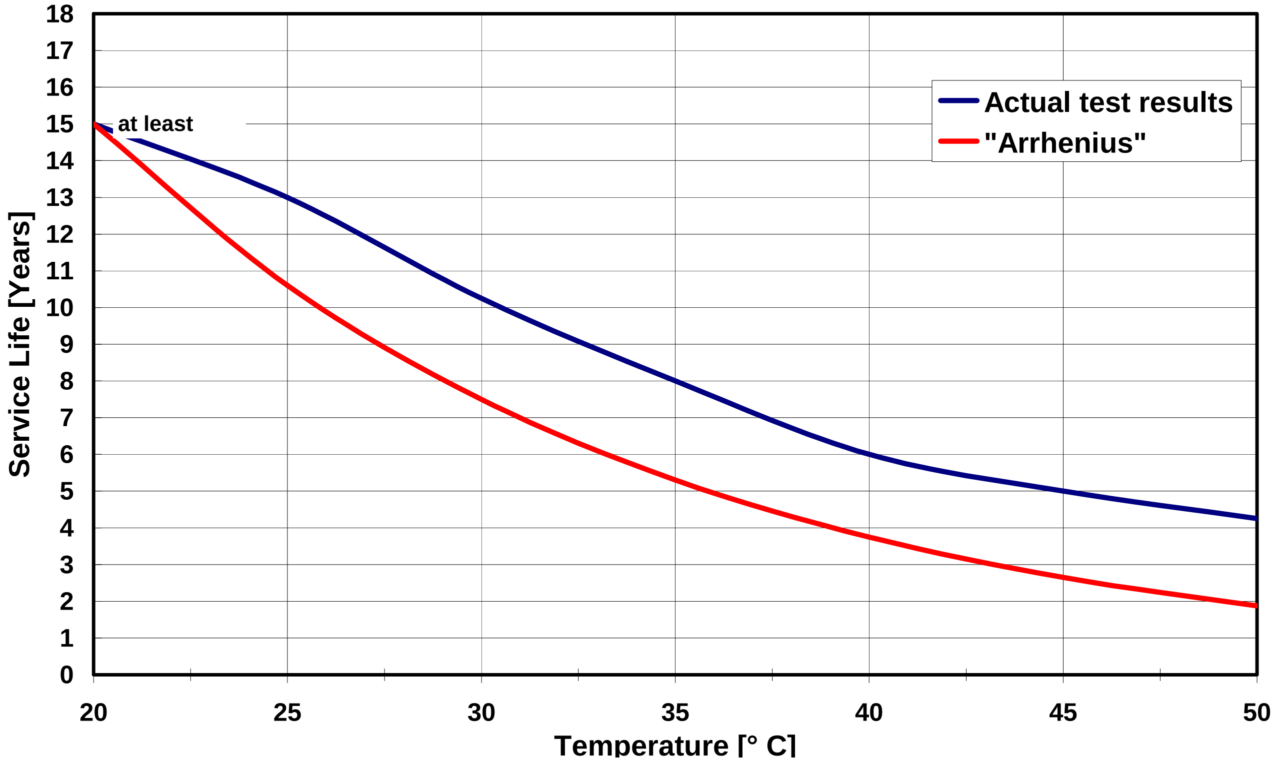


Fig. 34: A600 - Service Life vs. Temperature. The blue curve is valid in practice.

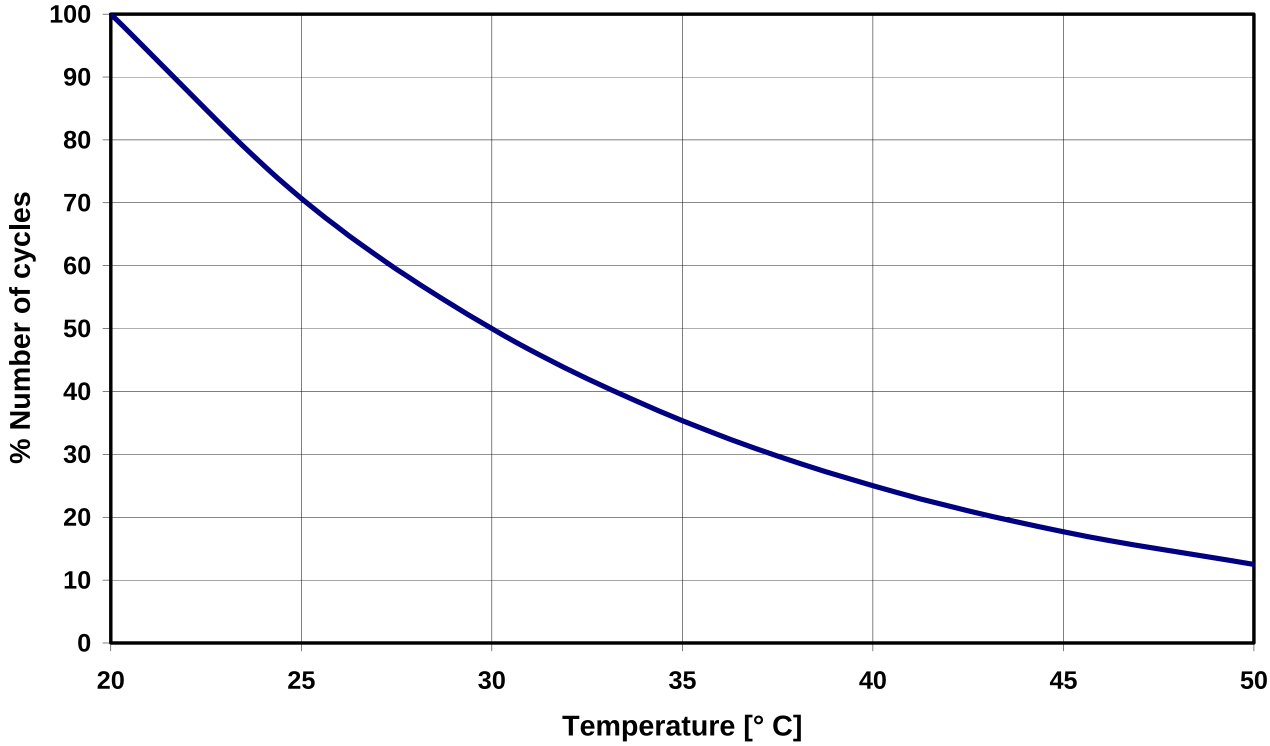


Fig. 35: A400, A500, A700, SOLAR, SOLAR BLOCK - Endurance in Cycles (in % of number of cycles) vs. Temperature

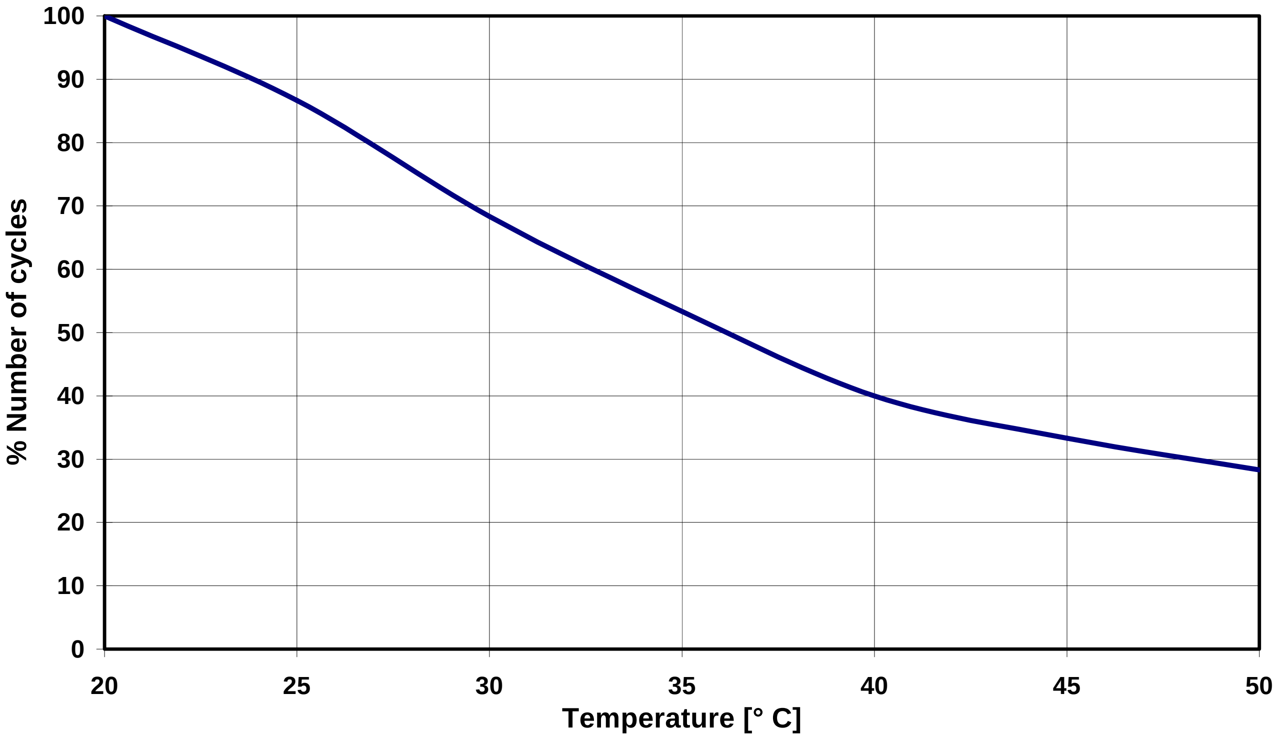


Fig. 36: A600, A600 block, A600 SOLAR -
Endurance in Cycles (in % of number of cycles) vs. Temperature

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.

- VRLA batteries do not require topping-up water. That's the reason why they were called "maintenance-free". Pressure valves are used for sealing and cannot be opened without destruction. Therefore, they are defined as "Valve-Regulated" lead-acid batteries (VRLA batteries).

- Even if VRLA batteries are called "maintenance-free" sometimes, they need control (see operating instructions, appendix 2, for details):

- 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 several cells / blocks (approx. 20%)
  - Surface temperature of several cells / blocks
  - Battery- room temperature

- Annual measurement and recording:

  - Battery voltage
  - Voltage of all cells / blocks
  - Surface temperature of all cells / blocks

- 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 differ from the average float charge voltage acc. to item 6.1 by more than a specified +/- tolerance as stated in fig. 6 to 16 or if the surface temperature difference between cells / blocks exceeds 5 K, 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).

6.10.2 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 [12] and [13].

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 vents must not be opened.
- 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 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 sees 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" [14].

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] 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)

[6] 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

[7] F. Kramm, Dr. H. Niepraschk (Akkumulatorfabrik Sonnenschein GmbH): "Phenomena of Recombination and Polarization for VRLA Batteries in Gel Technology", proceedings INTELEC 1999

[8] International standard IEC 60896-21 "Stationary Lead-Acid Batteries, Part 2: Valve Regulated Types, Section 1: Functional characteristics and methods of test", first edition February 2004

[9] International standard IEC 896-2 "Stationary lead-acid batteries – General requirements and methods of test – Part 2: Valve regulated types", first edition November 1995

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

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

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

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

[14] 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)

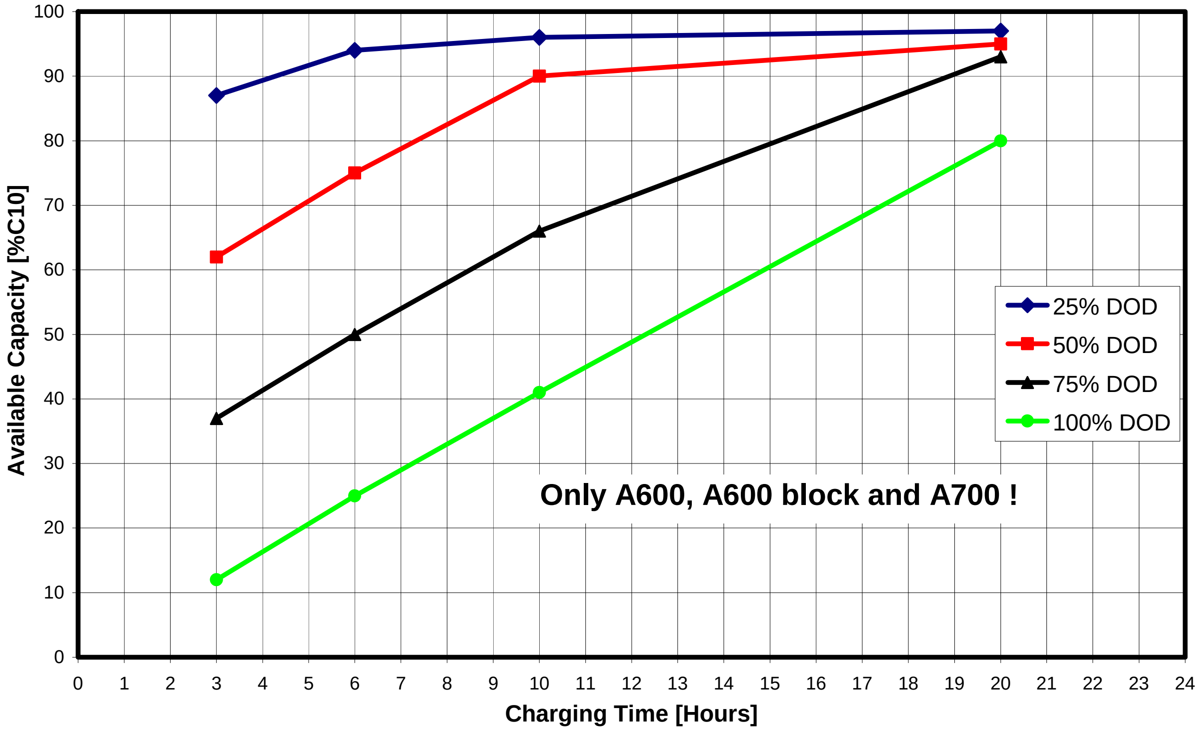


Fig. 37: Available Capacity versus Charging Time at 2.25 Vpc, Charging Current 0.5 • I_{10}, DOD = Depth of Discharge

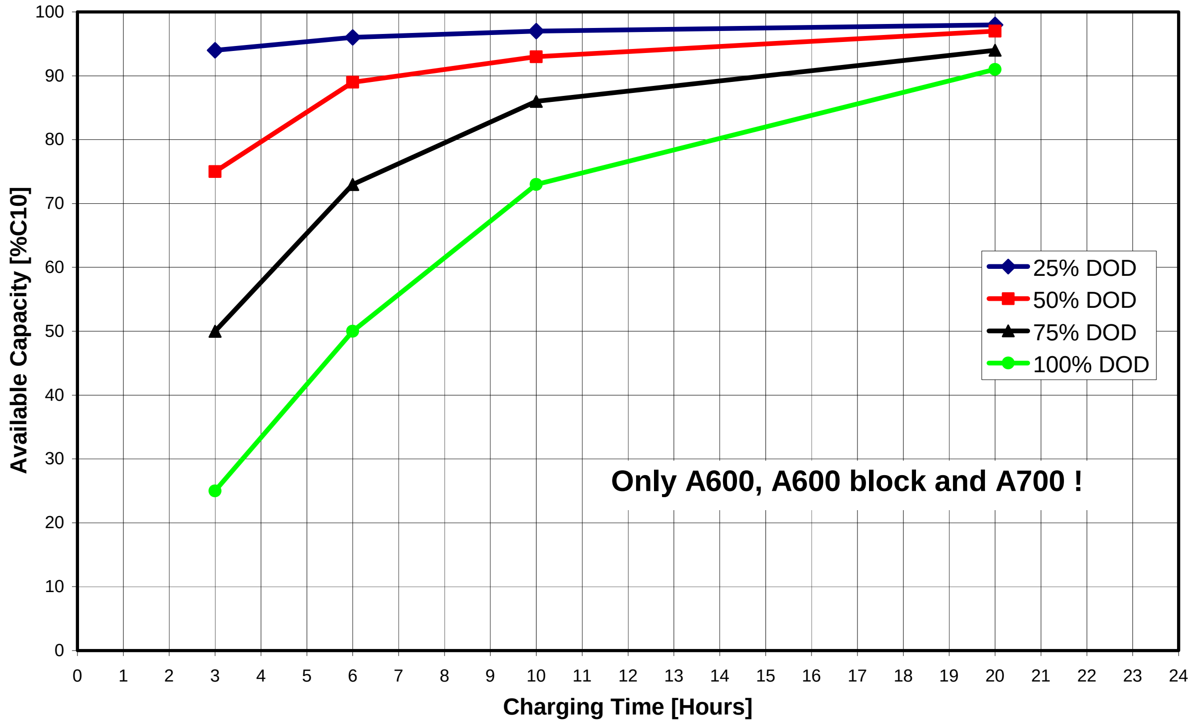


Fig. 38 (same as fig. 17 in chapter 6.4): Available Capacity vs. Charging Time at 2.25 Vpc, Charging Current 1 • I_{10}, DOD = Depth of Discharge

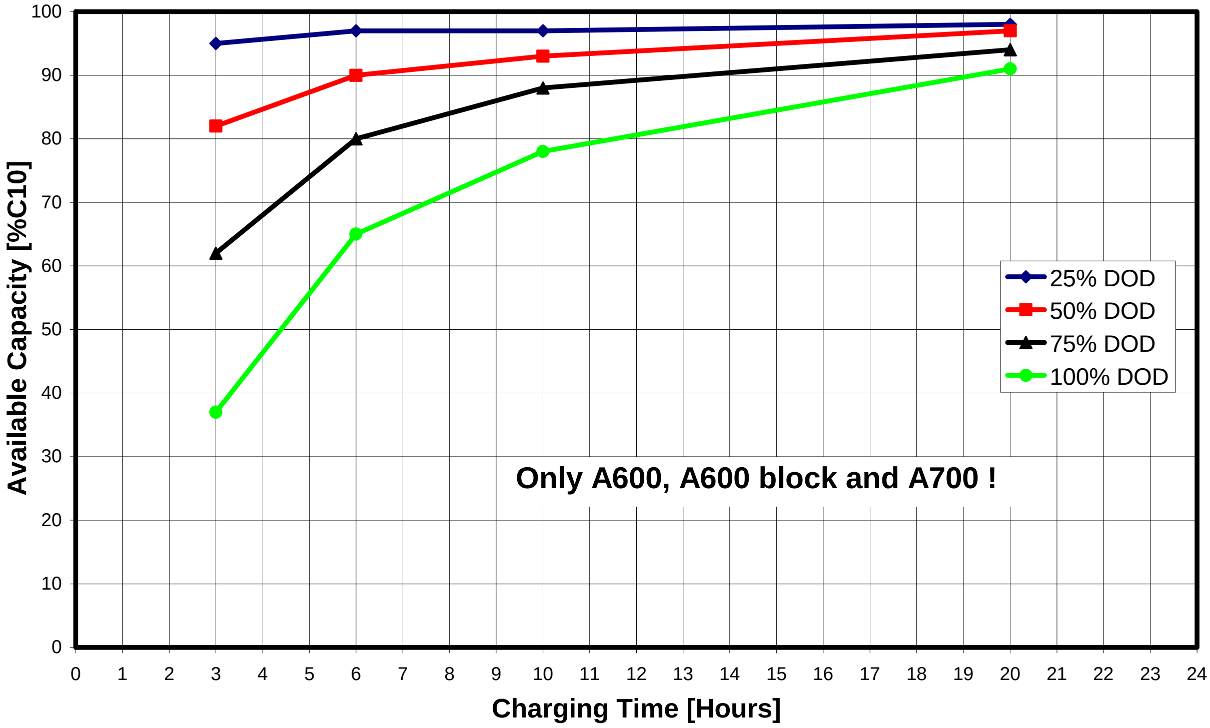


Fig. 39: Available Capacity versus Charging Time at 2.25 Vpc, Charging Current 1.5 • I_{10}, DOD = Depth of Discharge

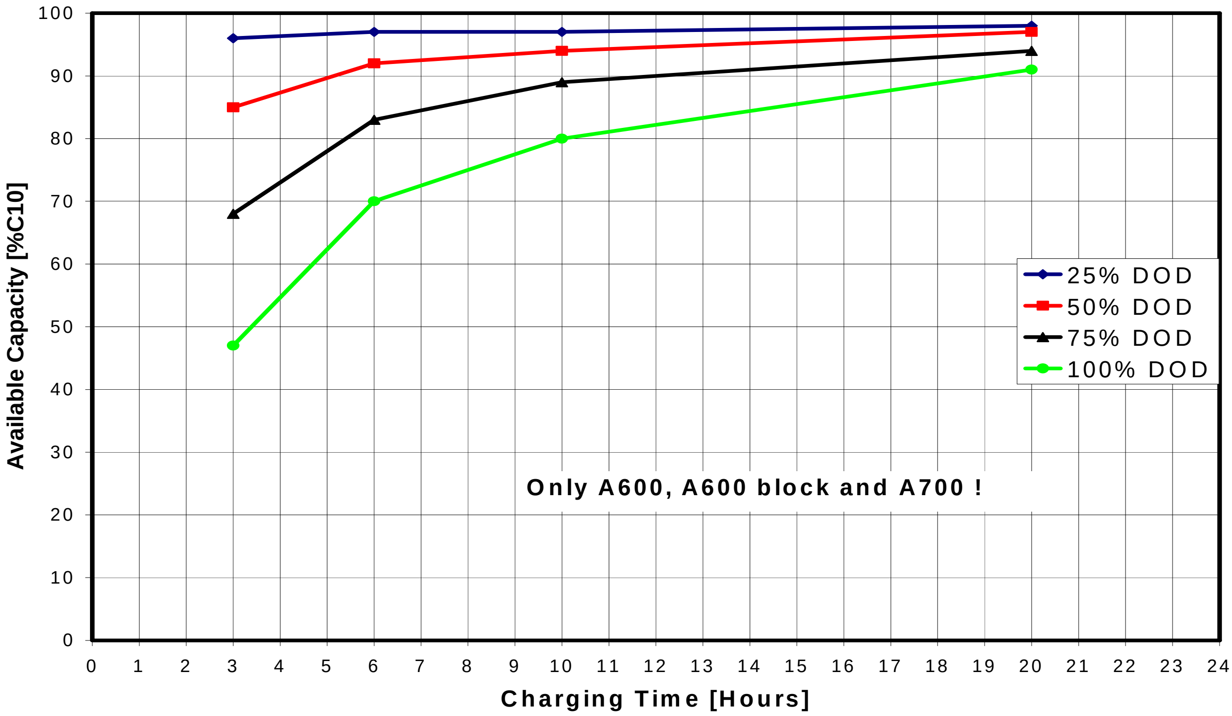


Fig. 40: Available Capacity versus Charging Time at 2.25 Vpc, Charging Current 2 • I_{10}, DOD = Depth of Discharge

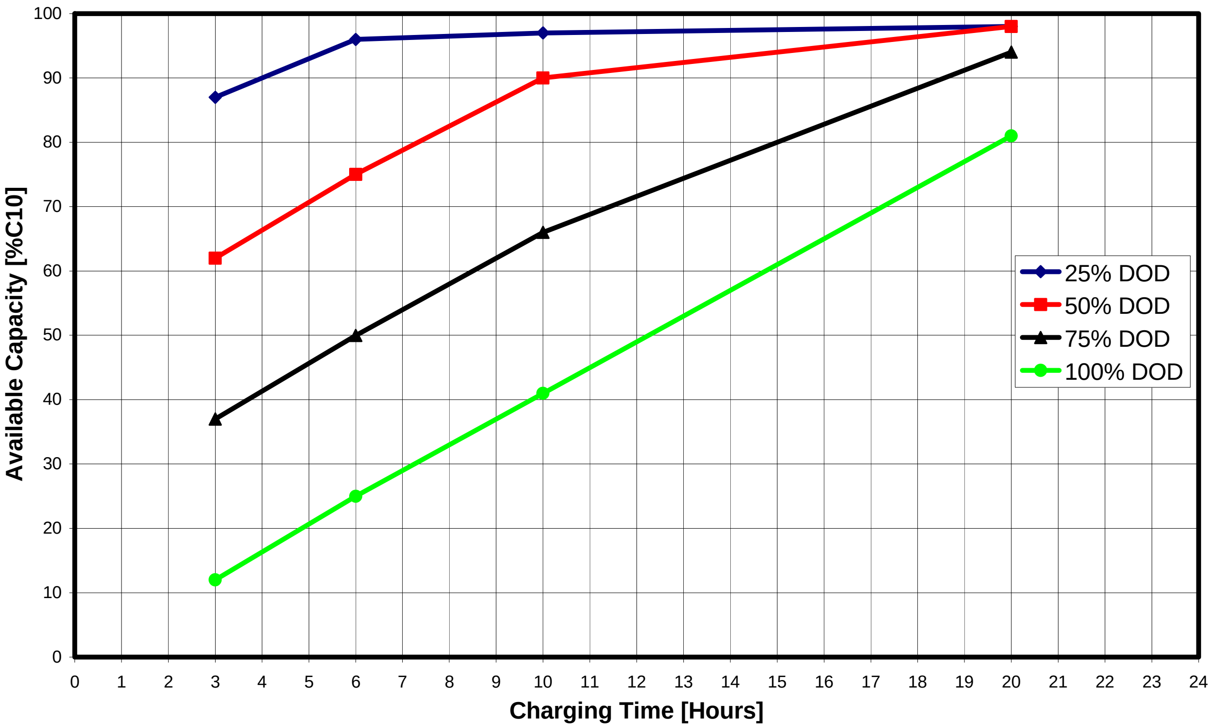


Fig. 41: Available Capacity versus Charging Time at 2.30 Vpc, Charging Current 0.5 • I_{10}, DOD = Depth of Discharge

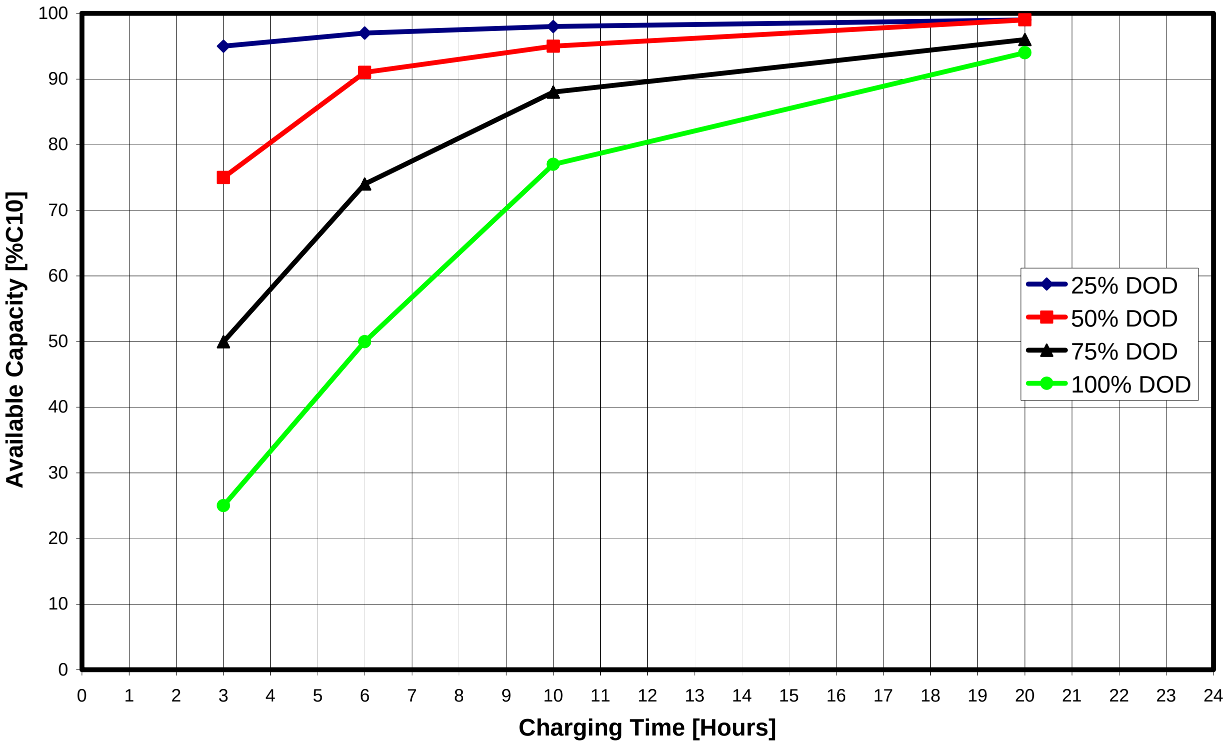


Fig. 42: Available Capacity versus Charging Time at 2.30 Vpc, Charging Current 1 • I_{10}, DOD = Depth of Discharge

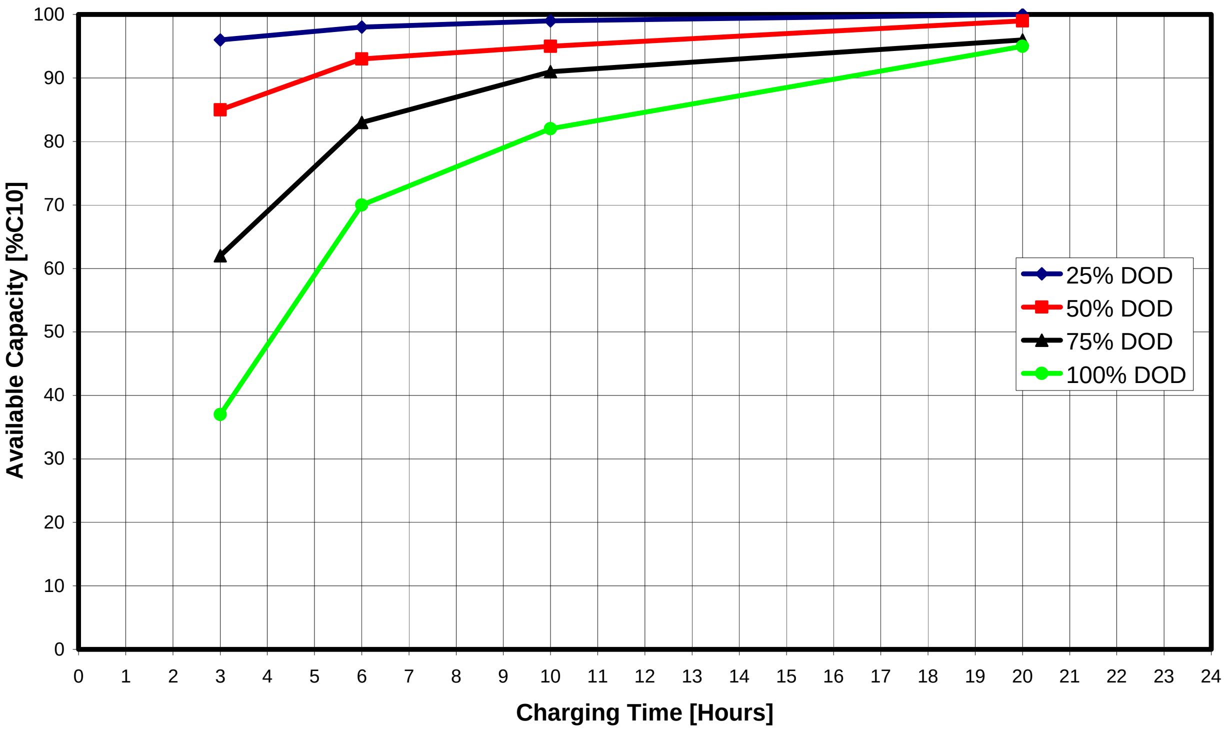


Fig. 43: Available Capacity versus Charging Time at 2.30 Vpc, Charging Current 1.5 • I_{10}, DOD = Depth of Discharge

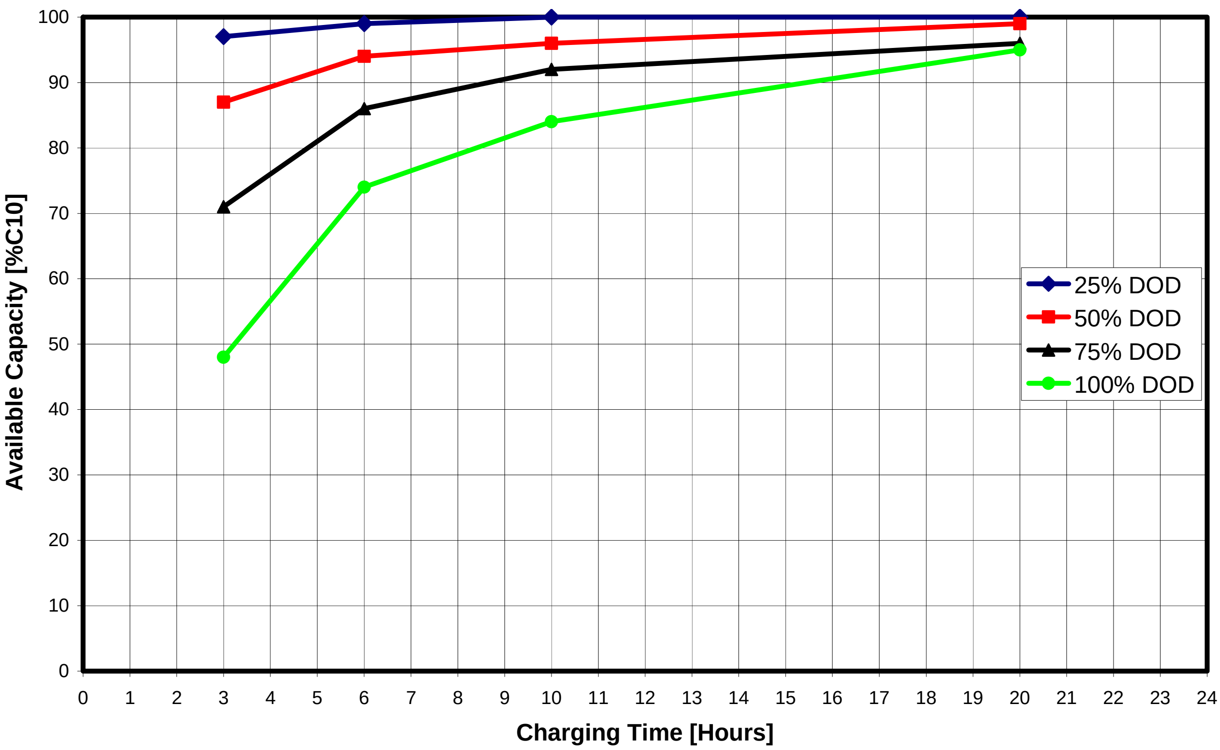


Fig. 44: Available Capacity versus Charging Time at 2.30 Vpc, Charging Current 2 • I_{10}, DOD = Depth of Discharge

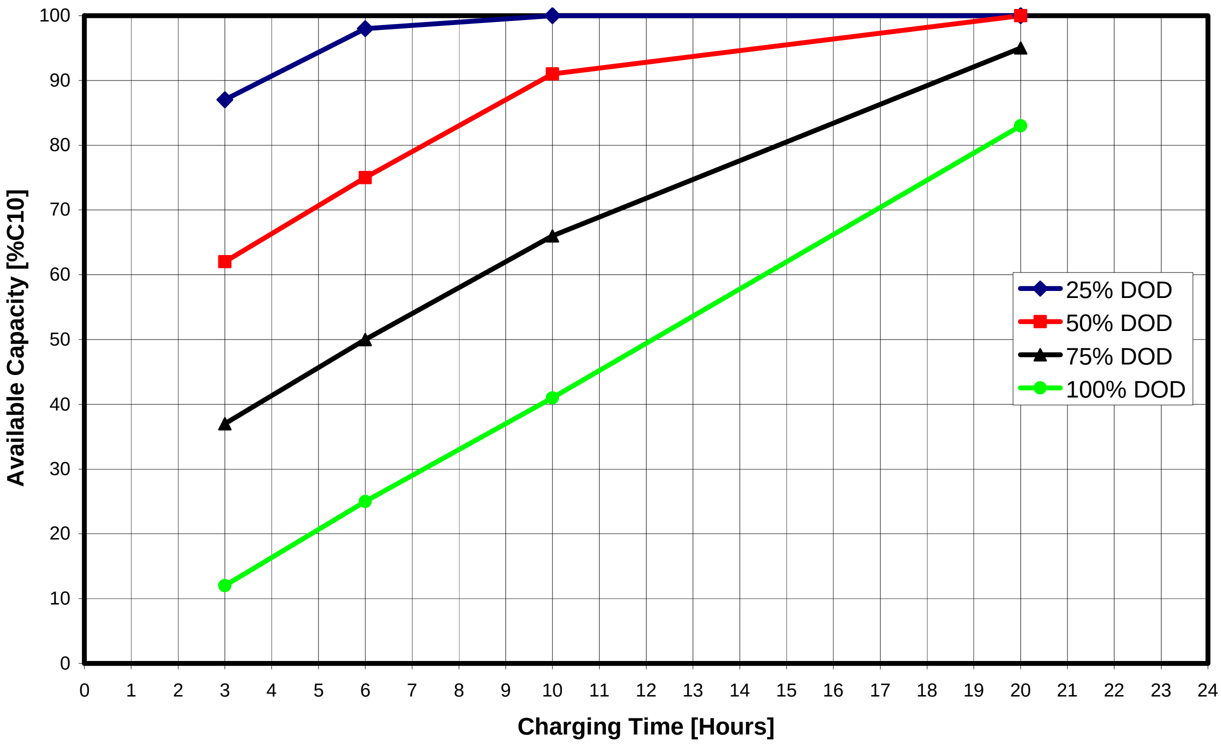


Fig. 45: Available Capacity versus Charging Time at 2.40 Vpc, Charging Current 0.5 • I_{10}, DOD = Depth of Discharge

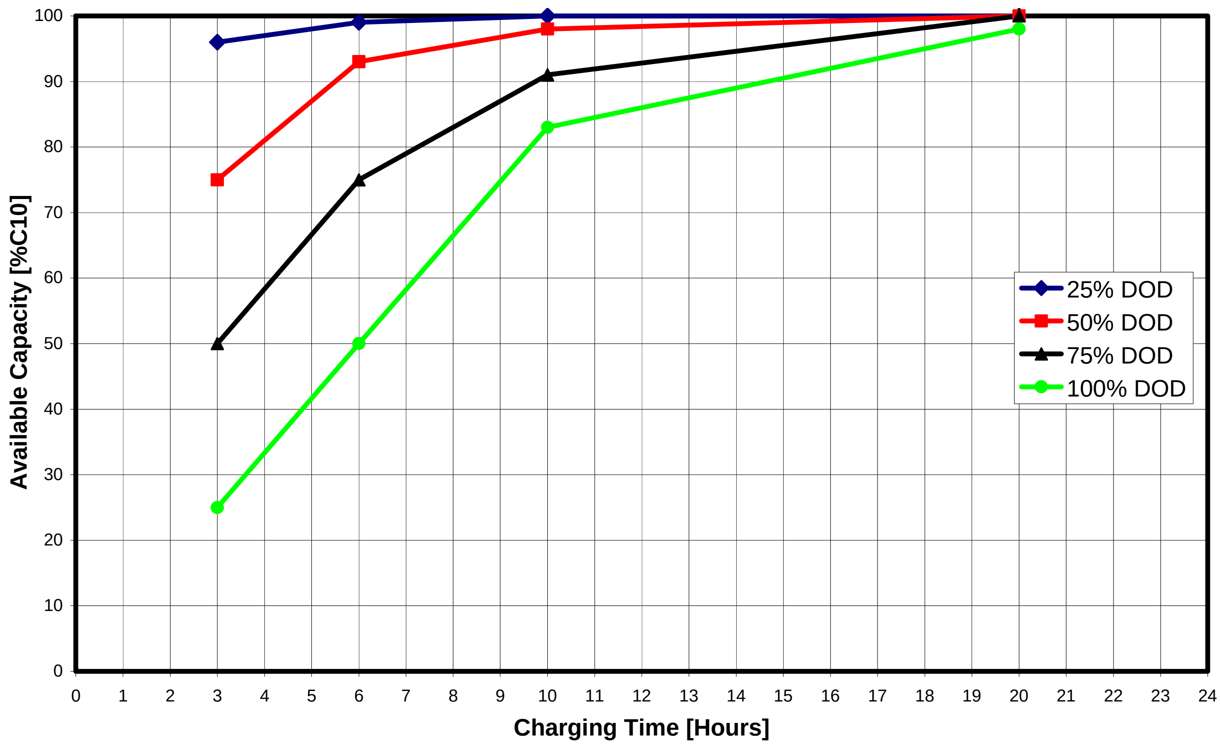


Fig. 46 (same as fig. 18 in chapter 6.4): Available Capacity vs. Charging Time at 2.40 Vpc, Charging Current 1 • I_{10}, DOD = Depth of Discharge

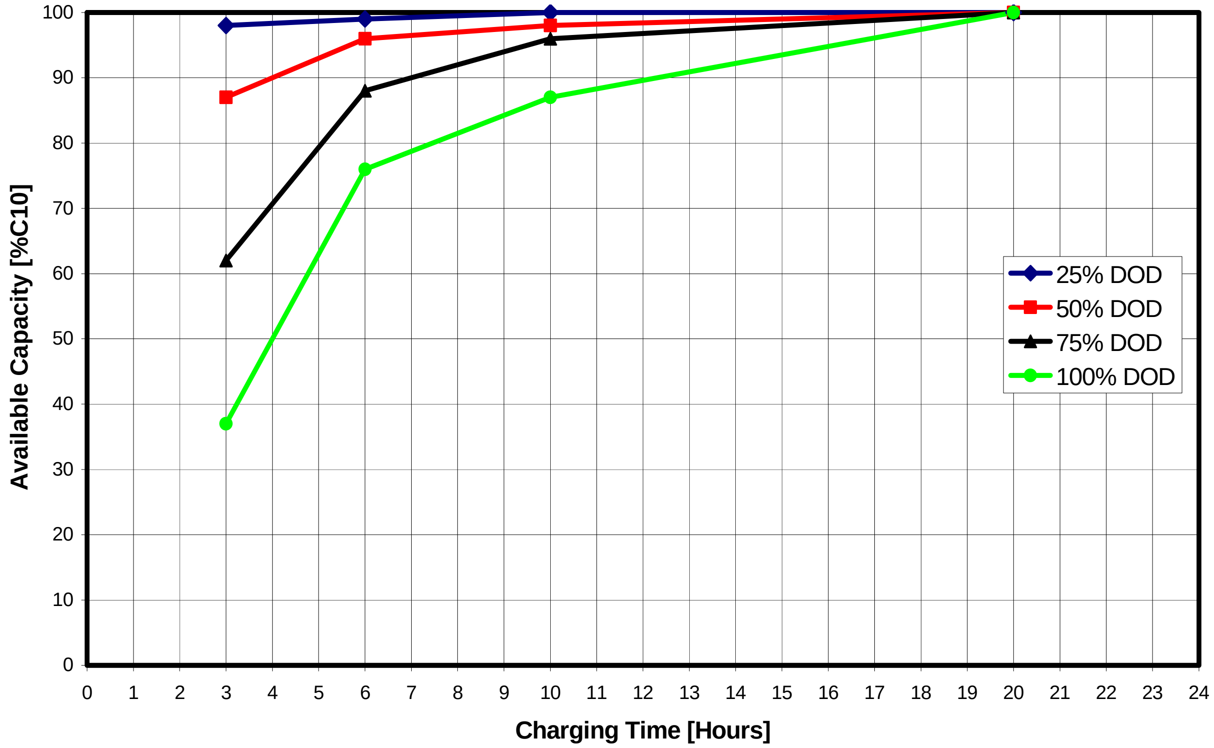


Fig. 47: Available Capacity versus Charging Time at 2.40 Vpc, Charging Current 1.5 • I_{10}, DOD = Depth of Discharge

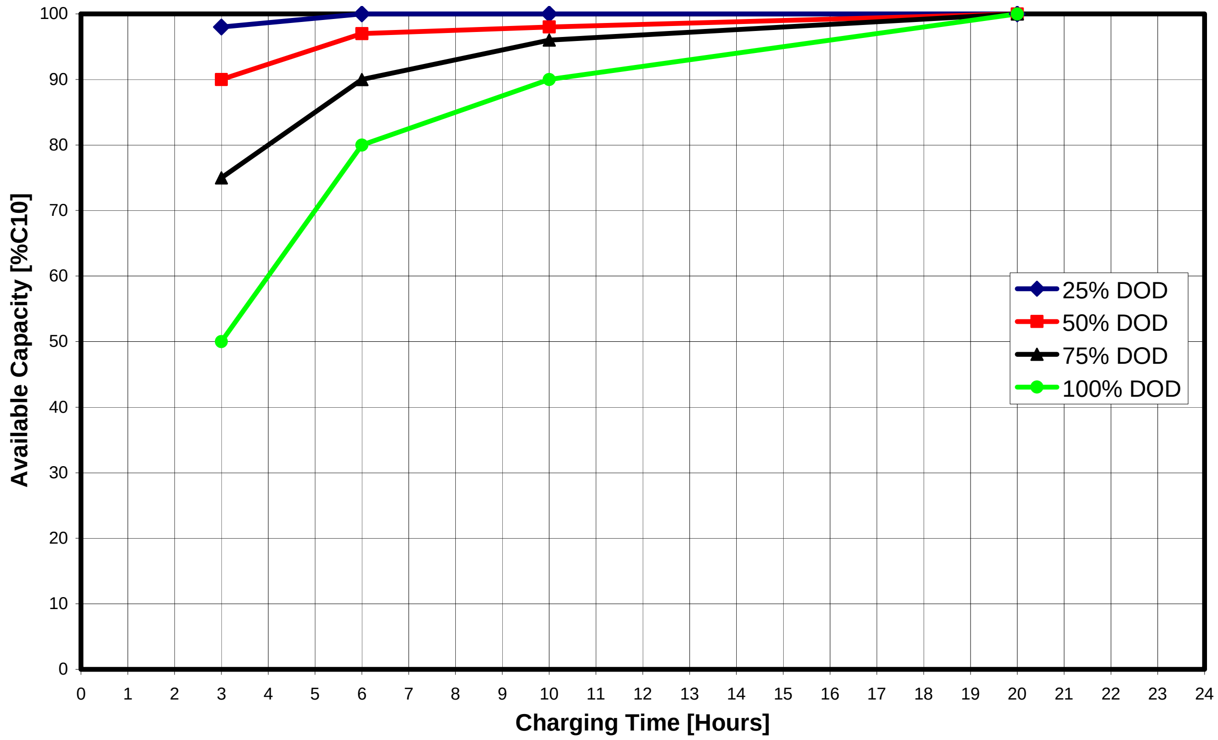


Fig. 48: Available Capacity versus Charging Time at 2.40 Vpc, Charging Current 2 • I_{10}, DOD = Depth of Discharge

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

"Installation Instruction"
"Operating Instruction-Stationary valve regulated lead acid batteries
"Operating Instruction…SOLAR, SOLAR BLOCK, A600 SOLAR"

81700094

Installation instruction

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

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- 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.

<u>WARNING:</u> 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.

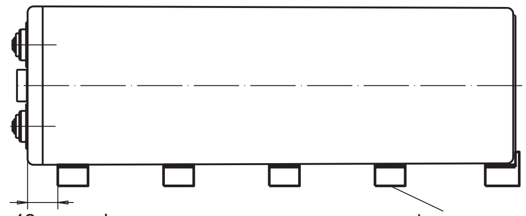
3.2
Cabinets with **separately delivered** cells or monobloc batteries:

- 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).

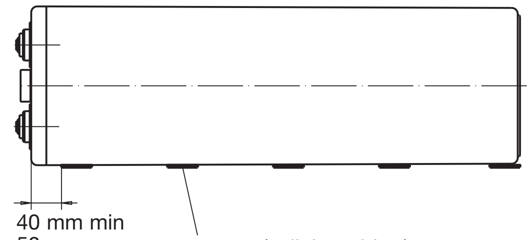
4. CE marking
From 1 January 1997, batteries with a nominal voltage from 75 V onwards require an EC conformity declaration in accordance with the low voltage directive (73/23/EWG), which entails that the CE marking is applied to the battery.
The company installing the battery is responsible for supplying 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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State: August 2008

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81700747

Operating Instruction
Stationary valve regulated lead-acid batteries

Nominal data

- Nominal voltage U_N : 2.0V x number of cells
- Nominal capacity $C_N = C_{10}$; C_{20} : 10 h; 20 h discharge (see type plate on cells/blocks and technical data in these instructions)
- Nominal discharge current $I_N = I_{10}$; I_{20} : C_N / 10 h; C_N / 20 h
- Final discharge voltage U_f : see technical data in these instructions
- Nominal temperature T_N : 20° C; 25° C

Assembly and CE-marking 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 eye-glasses and clothing.
- Observe the accident prevention rules as well as EN 50272-2 and EN 50110-1.
- Any acid splashes on the skin or in the eyes must be flushed with plenty of 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 contact with electrolyte is impossible. If the cell or block container is damaged do not touch the exposed electrolyte because it is corrosive.
- Cells and blocks are heavy. Always use suitable handling equipment for transportation.
- Handle with care because cells/blocks are sensitive to mechanical shock.
- Caution! Metal parts of the battery are always alive, therefore do not place items or tools on the battery!
- Keep children away from batteries.

Non-compliance with operating instructions, 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) 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.

Stationary valve regulated lead acid batteries do not require topping-up water. Pressure valves are used for sealing and cannot be opened without destruction.

AGM-Type	10-32x0.425	G-M5	F-M6	M-M6	M-M8	F-M8
Marathon L	--	--	--	6 Nm	8 Nm	20 Nm
Marathon M/M-FT	6 Nm	--	11 Nm	6 Nm	--	--
Sprinter P	--	--	--	6 Nm	8 Nm	--
Sprinter S	--	--	11 Nm	--	--	--
Powerfit S300	--	5 Nm	--	--	--	--
Powerfit S500	--	--	--	6 Nm	8 Nm	--

Gel-Type	G-M5	F-M5	G- M6	A	F-M8	F-M10
A 400	5 Nm	--	6 Nm	8 Nm	--	17 Nm
A 500	5 Nm	--	6 Nm	8 Nm	--	--
A 600 cells	--	--	--	--	20 Nm	--
A 600 blocks	--	--	--	--	12 Nm	--
A 700	--	6 Nm	--	--	20 Nm	--

All torques apply with a tolerance of ± 1 Nm

Table 1: Torque

1. Start Up

Check all cells/blocks for mechanical damage, correct polarity and firmly seated connectors. Torques as shown in table 1 apply for screw connectors.

Before installation the supplied rubber covers should be fitted to both ends of the connector cables (pole covers).
Control of insulation resistance:
New batteries: > 1M Ω
Used batteries: > 100 Ω/Volt

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 instruction no. 2.2.

2. Operation

For the installation and operation of stationary batteries EN 50 272-2 is mandatory.
Battery installation should be made such that temperature differences between individual units do not exceed 3 degrees Celsius (Kelvin).

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 must be carried out according to DIN 41773 (IU-characteristic with limit values: I-constant: ± 2%; U-constant: ± 1%).

Depending on the charging equipment, specification and characteristics alternating currents flow through the battery. Alternating currents and the reaction from the loads may lead to an additional temperature increase of the battery, and strain the electrodes with possible damages (see 2.5) which can shorten the battery life. Depending on the installation charging (acc. to 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 charging 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 charging voltage should be set **acc. to table 2** measured at the end terminals of the battery.

	Float voltage [Vpc]	Nominal temp. [° C]
Marathon L	2.27	20
Marathon M	2.27	25
Sprinter P	2.27	25
Sprinter S	2.27	25
Powerfit S 300	2.27	20
Powerfit S 500	2.27	20
A 400	2.27	20
A 500	2.30	20
A 600	2.25	20
A 700	2.25	20

Table 2: Float voltage

To reduce the charging time a boost charging stage can be applied in which the charging voltage **acc. to table 3** can be adjusted (standby-parallel operation with boost recharging stage). Automatic change over to charging voltage **acc. to table 2** should be applied.

	Voltage on boost charge stage [Vpc]	Nominal temp. [° C]
Marathon L	2.35-2.40	20
Marathon M	2.35-2.40	25
Sprinter P	2.35-2.40	25
Sprinter S	2.35-2.40	25
Powerfit S 300	2.35-2.40	20
Powerfit S 500	2.35-2.40	20
A 400	2.37-2.40	20
A 500	2.40-2.45	20
A 600	2.35-2.40	20
A 700	2.35-2.40	20

Table 3: Voltage on boost charging stage

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 fully charged at all times. Therefore, depending on the load the charge voltage must be set **acc. to table 4**. This has to be carried out in accordance with the manufacturers instructions.

	Voltage in buffer operation [Vpc]	Nominal temp. [° C]
Marathon L	2.27	20
Marathon M	2.29-2.33	25
Sprinter P	2.30	25
Sprinter S	2.29-2.33	25
Powerfit S 300	2.27	20
Powerfit S 500	2.27	20
A 400	2.27	20
A 500	2.30-2.35	20
A 600	2.27-2.30	20
A 700	2.27-2.30	20

Table 4: Charge voltage in buffer operation

c.) Switch-mode operation
When charging, the battery is separated from the load. The charge voltage of the battery must be set **acc. to table 3** (max. values). The charging process must be monitored. If the charge current reduces to less than 1.5A/100Ah nominal capacity, the mode switches to float charge acc. to item 2.3 or it switches after reaching the voltage value acc. to table 3.

d.) Battery operation (charge-/discharge operation)
The load is only supplied by the battery. The charging process depends on the application and must be carried out in accordance with the recommendations of the battery-manufacturer.

2.3 Maintaining the full charge (float charge)
Devices complying with the stipulations under DIN 41773 must be used. They are to be set so that the average cell voltage is **acc. to table 2**.

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 with 2.40 Vpc (A 500: 2.45 Vpc) for up to 48 hours and with unlimited current.
The cells / bloc temperature must never exceed 45° C. If it does, stop charging or revert to float charge to allow the temperature to drop.

2.5 Alternating currents
When recharging up to 2.40 Vpc under operation modes 2.2 the actual value of the alternating current is occasionally permitted to reach 10A (RMS)/100Ah 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) /100 Ah nominal capacity.

2.6 Charging currents
The charging currents are not limited during standby parallel operation or buffer operation without recharging stage. The charging current should range between the values given in **table 5** (guide values).

In cycling operation, the maximum current values as shown in **table 5** must not be exceeded.

	Charging current
Marathon L	10 to 30 A per 100Ah
Marathon M	10 to 35 A per 100Ah
Sprinter P	10 to 30 A per 100Ah
Sprinter S	10 to 35 A per 100Ah
Powerfit S 300	10 to 30 A per 100Ah
Powerfit S 500	10 to 30 A per 100Ah
A 400	10 to 35 A per 100Ah
A 500	10 to 35 A per 100Ah
A 600	10 to 35 A per 100Ah
A 700	10 to 35 A per 100Ah

Table 5: Charging currents

2.7 Temperature
The recommended operation temperature range for lead acid batteries is 10° C to 30° C (best: nominal temperature ± 5K). Higher temperatures will seriously reduce service life. Lower temperatures reduce the available capacity.
The absolute maximum temperature is 55° C and should not exceed 45° C in service.
All technical data refer to a nominal temperature of 20° C and 25° C respectively.

2.8 Temperature related charge voltage
The temperature related adjustment has to be carried out **acc. to the following figures 1 to 5**. An adjustment of the charge voltage must not be applied within a specified temperature range as shown in **table 6**.

	No adjustment within temperature range
A 400	15° C to 35° C
A 500	15°C to 35° C
A 600	15° C to 35° C
A 700	15° C to 35° C

Table 6: Temperature range without voltage adjustment

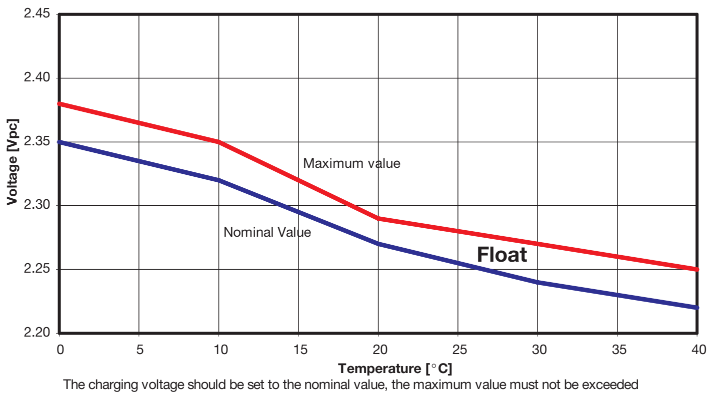

Fig. 1: Marathon L and Powerfit S; charging voltage vs. temperature

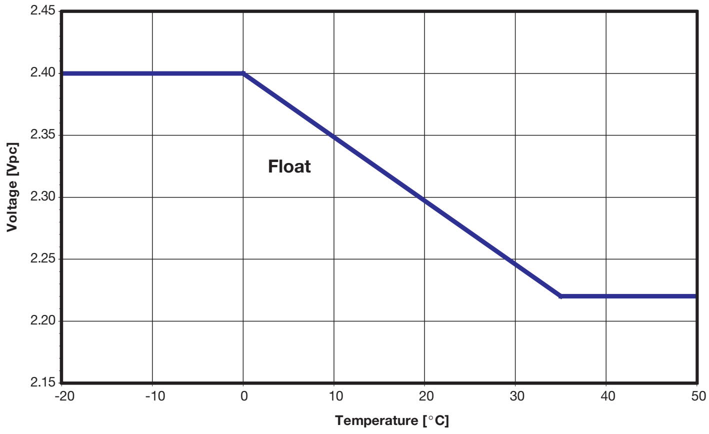

Fig. 2: Marathon M, Sprinter P, Sprinter S; charging voltage vs. temperature

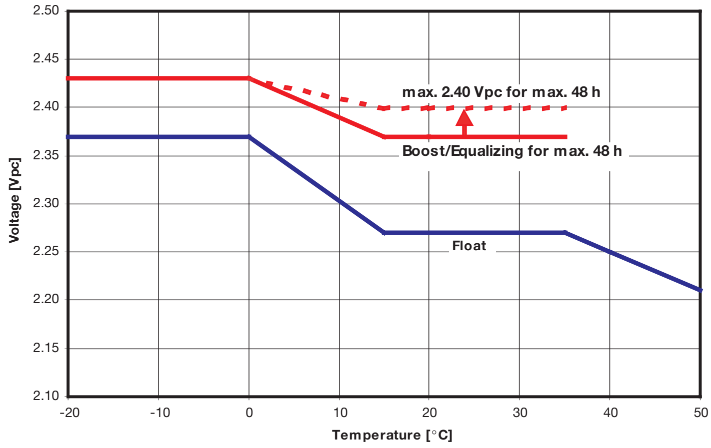

Fig. 3: A 400; charging voltage vs. temperature

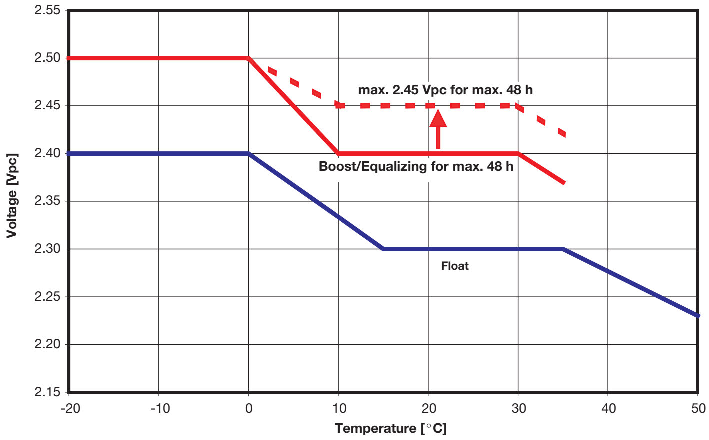

Fig. 4: A 500; charging voltage vs. temperature

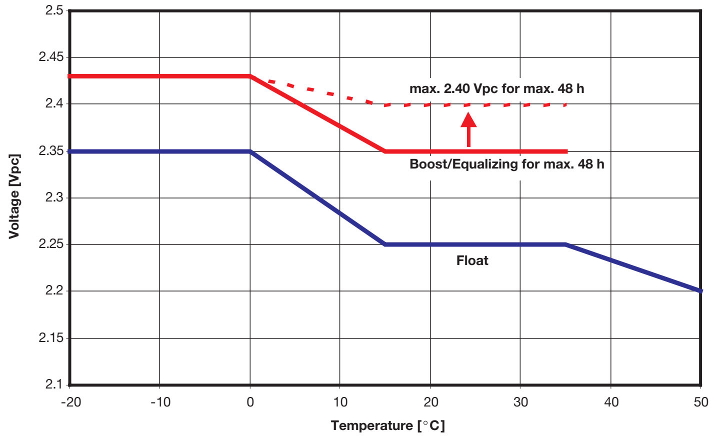

Fig. 5: A 600, A 700; charging voltage vs. temperature

2.9 Electrolyte

The electrolyte is diluted sulphuric acid and fixed in a glass mat for AGM products or in a gel for Sonnenschein products.

3. Battery maintenance and control

Keep the battery clean and dry to avoid creeping currents. The cleaning should be carried out acc. to the information leaflet „Cleaning of batteries“ published by ZVEI (German Electrical and Electronic Manufacturer Association, Working Group „Industrial Batteries“). Plastic parts of the battery, especially containers, must be cleaned with pure water without additives.

At least every 6 month measure and record:

- Battery voltage
- Float voltage of several cells/blocks
- Surface temperature of several cells/blocks
- Battery-room temperature

Annual measurement and recording:

- Battery voltage
- Float voltage of all cells / blocks
- Surface temperature of all cells/blocks
- Battery-room temperature
- Insulation-resistance acc. to DIN 43539 part1

If the cell or block voltage differ from the average float charge voltage by more than the values given in table 7, or if the surface temperature difference between cells / blocks exceeds 5K, the service agent should be contacted.

Deviations of the battery voltage from the value given in **table 2** (acc. to the number of cells) must be corrected.

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 60896-21, DIN 43539 part 1.
Special instructions like DIN VDE 0107 and EN 50172 have to be observed.

Capacity test

In order to make sure the battery is fully charged IU-charge methods as shown in **table 8** can be applied depending on the different battery types.

The current available to the battery must be between 10A /100Ah and 35A/ 100Ah of the nominal capacity.

	2V	4V	6V	8V	12V
Marathon L	+0.2/-0.1	--	+0.35/-0.17	--	+0.49/-0.24
Marathon M	--	--	+0.35/-0.17	--	+0.49/-0.24
Sprinter P	--	--	+0.35/-0.17	--	+0.49/-0.24
Sprinter S	--	--	+0.35/-0.17	--	+0.49/-0.24
Powerfit S 300	--	--	+0.35/-0.17	--	+0.49/-0.24
Powerfit S 500	--	--	+0.35/-0.17	--	+0.49/-0.24
A 400	--	--	+0.35/-0.17	--	+0.49/-0.24
A 500	+0.2/-0.1	+0.28/-0.14	+0.35/-0.17	+0.40/-0.20	+0.49/-0.24
A 600	+0.2/-0.1	--	+0.35/-0.17	--	+0.49/-0.24
A 700	--	+0.28/-0.14	+0.35/-0.17	--	--

Table 7: Criteria for voltage measurements

	Option 1	Option 2
Marathon L	2.27 Vpc ≥ 48 hours	2.40 Vpc ≥ 16 h (max. 48h) followed by 2.27 Vpc ≥ 8h
Marathon M	2.27 Vpc ≥ 48 hours	2.40 Vpc ≥ 16 h (max. 48h) followed by 2.27 Vpc ≥ 8h
Sprinter P	2.27 Vpc ≥ 48 hours	2.40 Vpc ≥ 16 h (max. 48h) followed by 2.27 Vpc ≥ 8h
Sprinter S	2.27 Vpc ≥ 48 hours	2.40 Vpc ≥ 16 h (max. 48h) followed by 2.27 Vpc ≥ 8h
Powerfit S 300	2.27 Vpc ≥ 48 hours	2.40 Vpc ≥ 16 h (max. 48h) followed by 2.27 Vpc ≥ 8h
Powerfit S 500	2.27 Vpc ≥ 48 hours	2.40 Vpc ≥ 16 h (max. 48h) followed by 2.27 Vpc ≥ 8h
A 400	2.27 Vpc ≥ 48 hours	2.40 Vpc ≥ 16 h (max. 48h) followed by 2.27 Vpc ≥ 8h
A 500	2.30 Vpc ≥ 48 hours	2.45 Vpc ≥ 16 h (max. 48h) followed by 2.30 Vpc ≥ 8h
A 600	2.25 Vpc ≥ 72 hours	2.40 Vpc ≥ 16 h (max. 48h) followed by 2.25 Vpc ≥ 8h
A 700	2.25 Vpc ≥ 48 hours	2.40 Vpc ≥ 16 h (max. 48h) followed by 2.25 Vpc ≥ 8h

Table 8: Preparation for capacity test (voltage values refer to the nominal temperature. In case of temperatures others than the nominal values see item 2.8)

5. Faults

Call the service agents immediately if faults in the battery or the 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 our 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 frost-free room.
To avoid damage the following charging methods can be chosen:

1. Annual refreshing charge acc. to item 2.4. Gel-batteries A400, A500, A600 and A700 can be stored without refreshing charge for maximum 24 months at ≤ 20°C. At average ambient temperatures of more than the nominal temperature shorter intervals can be necessary.

2. Float charging as detailed in 2.3.

7. Transport

Cells and 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). They must be protected against short circuits, slipping, upsetting or damaging. Cells/blocks may be suitable stacked and secured on pallets (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 packing unit.
Cells/blocks whose containers leak or are damaged must be packed and transported as class 8 dangerous goods under UN no. 2794.

8. Central degassing

8.1 General items

The ventilation of battery rooms and cabinets, respectively, must be carried out acc. to EN 50272-2 always. Battery rooms are to be considered as safe from explosions, when by natural or technical ventilation the concentration of hydrogen is kept below 4% in air.
This standard contains also notes and calculations regarding safety distance of battery openings (valves) to potential sources of sparks.

Central degassing is a possibility for the equipment manufacturer to draw off gas. Its purpose is to reduce or to delay, respectively, the accumulation of hydrogen in the ambient of the batteries by conducting hydrogen releasing the vents through a tube system to the outside. On such a way it is also possible to the equipment manufacturer to reduce the safety distance to potential sources of ignition.

Even if the gas releasing the vents will be conducted through the tube system outside, hydrogen (H_2) diffuses also through the battery container and through the tube wall.
The following calculation shows when the critical limit of 4% H_2 can be achieved using central degassing in a hermetic closed room (e.g. battery cabinet).

Only block batteries equipped by a tube junction for central degassing must be used for this application.

The installation of the central degassing must be carried out in acc. with the equivalent installation instructions. During each battery service also the central degassing must be checked (tightness of tubes, laying in the direction of the electrical circuit, drawing off the end of the tube to the outside).

8.2 Accumulation of hydrogen up to 4% in air

The following calculations are based on measurements and are related to cabinets.

The following equation was determined for calculating the numbers of days for achieving the critical gas mixture:

$$x = \frac{k_{/Bloc} * c1 * c2}{c3}$$

with:
- x = Days up to achieving 4% H_2 in air
- $k_{/Bloc}$ = Constant per specific block battery type acc. to **table 9**
- c1 = Coefficient for actual free volume inside the cabinet acc. to **table 10**
- c2 = Coefficient for actual battery temperature acc. to **table 10**
- c3 = Coefficient for actual numbers of blocks in total

Therefore, it is possible to calculate using the tables 9 and 10 after how many days the 4% H_2-limit can be achieved in the cabinet for the mentioned battery types, different configurations and conditions.

Calculation example:

48 V-battery (e.g. Telecom)
4 * M12V155FT → c3 = 4
→ k = 750
Free air volume 70% → c1 = 0.9
Battery temperature 20° C → c2 = 1

$$x = \frac{k_{/block} * c1 * c2}{c3} = 168 \text{ days}$$

The 168 days are reduced to 99 days only at 30° C because c2 = 0.59.

Battery block type	Nominal voltage [V]	C10 [Ah], 1.80 Vpc, 20° C	Constant k
M12V45F	12	45	**1842**
M12V35 FT	12	35	**2228**
M12V50 FT	12	47	**1659**
M12V60 FT	12	59	**1322**
M12V90 FT	12	85	**1324**
M12V105 FT	12	100	**1107**
M12V125 FT	12	121	**930**
M12V155 FT	12	150	**750**
M6V200	6	200	**873**
S12V500	12	130	**648**
A 412/85 F10	12	85	**786**
A 412/48 FT	12	48	**1624**
A 412/120 FT	12	110	**810**

Table 9: Constant k for different block battery types having central degassing

V_{free} [%]	c1	T [° C]	c2
10	0.13	≤ 25	1
15	0.19	26	0.91
20	0.26	28	0.73
25	0.32	30	0.59
30	0.38	32	0.48
35	0.45	34	0.40
40	0.51	36	0.34
45	0.58	38	0.29
50	0.64	40	0.25
55	0.70	42	0.21
60	0.77	44	0.18
65	0.83	46	0.16
70	0.90	48	0.14
75	0.96	50	0.12
80	1.02	52	0.11
85	1.09	54	0.10
90	1.15	55	0.09

Table 10: Coefficients for free air volume (c1) and temperature (c2)

8.3 Special conditions and instructions
The free air volume inside the cabinet has to be determined by the user.

The batteries must be monitored regarding temperature. Exceeding the limit of 55° C is not allowed.

Malfunctions of equipment and (or) batteries may lead to a faster accumulation of H_2 and, therefore, time reduction. In such a case, the above mentioned calculation methods cannot be applied anymore.

Discharge and re-charging at float voltage level can be carried out as much as necessary during the time (days) determined.

It is allowed to carry out monthly boost or equalizing charging for maximum 12 hours only and at the maximum allowed voltage level specified for the battery. For all applications in addition to this, e.g. buffer or cyclical operations, consultation with EXIDE Technologies is necessary.

The time (days) is valid for temperature compensated charge voltages acc. to the operating instructions and take into account aging effects of the battery (increasing residual charge current).

9. Technical Data
The following tables contain values of either capacities (C_n) or discharge rates (constant current or constant power) at different discharge times (t_n) and to different final voltages (U_f).

All technical data refer to either 20° C or 25° C (depends on battery type).

9.1 AGM - Types

9.1.1. Marathon L

Discharge time t_n	10 min	30 min	1 h	3 h	5 h	10 h	Length	Width	Height max.	Weight approx.
Capacity C_n [Ah]	$C_{1/6}$	$C_{1/2}$	C_1	C_3	C_5	C_{10}	[mm]	[mm]	[mm]	[kg]
L12V15	6.5	8.5	9.9	13.2	13.0	14.0	181	76	167	6.5
L12V24	10.6	13.9	15.8	21.0	21.5	23.0	168	127	174	10.0
L12V32	14.1	18.7	21.4	27.9	30.0	32.0	198	168	175	13.5
L12V42	19.6	25.7	29.4	38.1	39.5	42.0	234	169	190	18.5
L12V55	21.6	29.5	36.0	44.7	49.0	55.0	272	166	190	22.0
L12V80	30.3	41.5	51.2	65.1	71.0	80.0	359	172	226	30.0
L6V110	48.4	65.0	75.5	102.3	107.0	112.0	272	166	190	23.0
L6V160	66.6	93.5	111.0	133.5	146.0	162.0	359	171	226	31.5
L2V220	87.4	127.0	150.0	186.6	198.0	220.0	208	135	282	16.0
L2V270	106.3	155.5	183.0	229.2	243.0	270.0	208	135	282	18.3
L2V320	135.8	190.5	225.0	271.8	288.0	320.0	208	201	282	24.2
L2V375	155.8	221.5	262.0	318.0	337.5	375.0	208	201	282	26.5
L2V425	169.9	247.0	291.0	360.0	382.5	425.0	208	201	282	28.8
L2V470	186.6	277.0	324.0	399.0	428.5	470.0	208	270	282	32.6
L2V520	204.1	304.5	357.0	438.0	474.0	520.0	208	270	282	35.0
L2V575	220.8	334.5	394.0	486.0	520.0	575.0	208	270	282	37.3
U_f [V] (2 V cell)	1.60	1.60	1.60	1.70	1.75	1.80				
U_f [V] (6 V block)	4.80	4.80	4.80	5.10	5.25	5.40				
U_f [V] (12 V block)	9.60	9.60	9.60	10.20	10.50	10.80				

All technical data refer to 20° C.

9.1.2. Marathon M

Type	Nominal voltage [V]	C_8 [Ah] 1.75 V per cell	Constant current discharge [A]. U_f = 1.75 V per cell						Length	Width	Height max.	Weight approx.
			0.5 h	1 h	1.5 h	3 h	5 h	10 h	[mm]	[mm]	[mm]	[kg]
M12V30T	12	30	36.9	21.2	15.1	8.40	5.50	2.90	171	130	186	10.7
M12V40(F)	12	40	51.3	30.5	21.5	11.9	7.60	4.10	198	167	189	17.8
M12V45F	12	45	57.8	33.2	24.0	13.5	8.70	4.70	220	121	254	17.5
M12V70(F)	12	70	90.8	51.6	36.8	20.6	13.4	7.40	260	174	235	27.8
M12V90(F)	12	90	107	65.7	46.6	25.9	16.7	9.20	306	174	235	32.8
M6V190(F)	6	190	246	144	102	56.0	35.9	19.5	306	174	235	33.5
M6V200	6	200	220	135	100	55.2	36.3	20.2	361	132	250	34.0
M12V35FT	12	35	44.0	26.5	14.0	10.2	6.60	3.50	280	107	189	14.0
M12V50FT	12	47	61.0	34.3	20.0	13.5	8.80	4.70	280	107	231	18.0
M12V60FT	12	59	68.8	40.1	26.0	16.6	11.0	6.00	280	107	263	23.0
M12V90FT	12	86	108	64.0	46.4	24.9	15.9	8.70	395	105	270	31.0
M12V105FT	12	100	115	70.0	51.6	28.5	18.7	10.3	511	110	238	35.8
M12V125FT	12	121	141	88.1	65.3	37.2	23.4	12.4	559	124	283	47.6
M12V155FT	12	150	174	103	77.7	43.2	28.1	15.4	559	124	283	53.8

All technical data refer to 25° C.

9.1.3. Sprinter P

Type	Nominal voltage [V]	15 min.-power [W], U_f = 1.60 V per cell	Capacity C_{10} [Ah], U_f = 1.80 V per cell	Length [mm]	Width [mm]	Height max. [mm]	Weight approx. [kg]
P12V570	12	570	21	168	177	126	9.5
P12V600	12	600	24	168	127	174	9.5
P12V875	12	875	41	198	168	175	14.5
P12V1220	12	1220	51	234	169	190	19.5
P12V1575	12	1575	61	272	166	190	24.0
P12V2130	12	2130	86	359	172	226	33.0
P 6V1700	6	1700	122	272	166	190	25.0
P 6V2030	6	2030	178	359	172	226	32.5

These batteries are especially designed for high rate discharges. Further details depending on the discharge time and cut off voltage must be taken from the actual product brochure.

All technical data refer to 25° C.

9.1.4. Sprinter S

Type	Nominal voltage [V]	C_8 [Ah] U_f = 1.80 V per cell	Constant power [Watt per cell]. U_f = 1.67 V per cell						Length [mm]	Width [mm]	Height max. [mm]	Weight approx. [kg]
			5 min	10 min	15 min	30 min	60 min	90 min				
S12V120(F)	12	24	242	151	117	72	41	29	173	167	166	12.1
S12V170(F)	12	40	323	215	167	102	58	41	198	167	189	16.4
S12V285(F)	12	70	543	365	285	169	96	69	260	174	235	27.8
S12V300(F)	12	69	654	415	306	180	105	76	260	174	235	28.7
S12V370(F)	12	87	723	484	373	230	131	92	306	174	235	33.4
S12V500(F)	12	131	864	615	505	310	176	126	344	172	288	48.1
S6V740(F)	6	175	1446	970	746	458	262	184	306	174	235	33.4

All technical data refer to 25° C.

9.1.5. Powerfit S 300

Type	Nominal voltage [V]	C_{20} [Ah] 1.75 V per cell	C_{10} [Ah] 1.75 V per cell	C_1 [Ah] 1.60 V per cell	Length [mm]	Width [mm]	Height max. [mm]	Weight approx. [kg]
S306/1.2 S	6	1.2	1.13	0.78	97	25	56	0.3
S306/4 S	6	4.0	3.80	2.62	70	47	106	0.9
S306/7 S	6	7.0	6.55	4.58	151	34	100	1.3
S306/12 S	6	12	11.4	7.86	151	50	100	2.1
S312/1.2S	12	1.2	1.13	0.78	97	45	59	0.6
S312/2.3 S	12	2.3	2.19	1.50	178	34	65	0.9
S312/3.2 S	12	3.2	3.00	1.96	134	67	66	1.3
S312/4 S	12	4.0	3.80	2.62	90	70	106	1.7
S312/7 S	12	7.0	6.64	4.58	151	65	98	2.6
S312/12 S	12	12	11.4	7.86	151	98	98	4.0
S312/18 G5	12	18	16.1	11.1	181	76	166	6.2
S312/26 G5	12	26	24.7	17.0	166	175	125	9.4
S312/40 G5	12	40	37.9	26.2	196	166	171	14.3

All technical data refer to 20° C.

9.1.6. Powerfit S 500

Type	Nominal voltage [V]	C_{20} [Ah] 1.75 V per cell	C_{10} [Ah] 1.75 V per cell	C_1 [Ah] 1.60 V per cell	Length [mm]	Width [mm]	Height max. [mm]	Weight approx. [kg]
S512/25	12	25.0	24.0	15.8	168	127	174	9.5
S512/38	12	38.0	36.0	23.2	198	168	175	13.5
S512/50	12	51.0	48.0	32.5	234	169	190	18.5
S512/60	12	61.0	58.0	40.8	272	166	190	23.0
S512/92	12	92.0	87.0	54.4	359	172	226	30.0
S506/130	6	128	121	80.0	272	166	190	23.0
S506/185	6	185	174	116	359	171	226	31.5

All technical data refer to 20°C.

9.2 GEL - Types

9.2.1. A 400

Discharge time t_n Capacity C_n [Ah]	10 min $C^1/_6$	30 min $C^1/_2$	1 h C_1	3 h C_3	5 h C_5	10 h C_{10}	Length [mm]	Width [mm]	Height max. [mm]	Weight approx. [kg]
A406/165	53.0	80.0	96.0	132	143.5	165	244	190	282	31.5
A412/5,5	1.83	2.80	3.40	4.80	5.00	5.00	152	66	98	2.5
A412/8,5	2.67	3.90	4.70	6.60	7.50	8.00	152	98	98	3.6
A412/12	3.83	5.50	6.80	8.70	10.0	12.0	181	76	156	5.6
A412/20	7.00	9.50	12.0	15.0	16.5	20.0	167	176	126	8.5
A412/32	11.3	16.5	20.0	26.7	29.0	32.0	210	175	181	14.1
A412/50	16.8	25.5	31.0	40.8	44.5	50.0	278	175	196	19.0
A412/65	19.3	29.0	42.0	51.9	57.5	65.0	353	175	220	23.5
A412/85	27.6	42.5	52.0	68.4	74.5	85.0	204	244	276	32.0
A412/90	29.5	44.5	53.0	72.9	81.5	90.0	284	267	237	35.0
A412/100	30.5	45.5	54.0	75.3	85.0	100	513	189	223	40.0
A412/120	38.0	56.0	71.0	87.9	98.0	120	513	223	223	49.0
A412/180	53.6	81.0	96.0	138	152	180	518	274	244	64.5
A412/120 FT	35.0	52.5	66.0	88.5	97.5	110	115	548	275	41.5
U_f [V] (6 V block)	4.8	4.8	4.95	5.1	5.1	5.4				
U_f [V] (12 V block)	9.6	9.6	9.9	10.2	10.2	10.8				

All technical data refer to 20° C.

9.2.2. A 500

Discharge time t_n Capacity C_n [Ah]	10 min $C^1/_6$	30 min $C^1/_2$	1 h C_1	3 h C_3	5 h C_5	10 h C_{10}	20 h C_{20}	Length [mm]	Width [mm]	Height max. [mm]	Weight approx. [kg]
A502/10	4.80	6.40	7.10	9.00	9.50	10.0	10.0	53	51	98	0.7
A504/3.5	1.40	1.95	2.30	3.00	3.00	3.00	3.50	91	35	64	0.5
A506/1.2	0.50	0.65	0.80	1.20	1.00	1.00	1.20	97	26	56	0.3
A506/3.5	1.40	1.95	2.30	3.00	3.00	3.00	3.50	135	35	64	0.7
A506/4.2	1.10	1.75	2.50	3.90	4.00	4.00	4.20	52	62	102	0.9
A506/6.5	2.60	3.50	4.00	4.80	5.50	6.00	6.50	152	35	98	1.3
A506/10	4.80	6.40	7.10	9.00	9.50	10.0	10.0	152	51	98	2.1
A508/3.5	1.40	1.95	2.30	3.00	3.00	3.00	3.50	179	34	64	1.0
A512/1.2	0.50	0.65	0.80	1.20	1.00	1.00	1.20	98	50	55	0.7
A512/2	0.80	1.10	1.50	1.80	2.00	2.00	2.00	179	34	64	1.0
A512/3.5	1.40	1.95	2.30	3.00	3.00	3.00	3.50	135	67	64	1.5
A512/6.5	2.60	3.50	4.00	4.80	5.50	6.00	6.50	152	66	98	2.6
A512/10	4.80	6.40	7.10	9.00	9.50	10.0	10.0	152	98	98	4.0
A512/16	7.00	9.00	10.6	13.8	14.5	15.0	16.0	181	76	167	6.0
A512/25	7.80	11.4	14.4	18.6	20.5	22.0	25.0	167	176	126	9.6
A512/30	11.4	16.3	20.1	24.6	26.5	27.0	30.0	197	132	180	11.1
A512/40	14.1	19.5	24.0	28.5	34.0	36.0	40.0	210	175	175	14.6
A512/55	19.3	27.6	35.7	42.9	46.5	50.0	55.0	261	135	230	18.8
A512/60	22.1	30.9	37.1	48.6	52.0	56.0	60.0	278	175	190	20.8
A512/65	22.5	33.8	40.9	53.7	58.5	62.0	65.0	353	175	190	24.0
A512/85	33.1	47.5	59.0	69.0	75.5	80.0	85.0	330	171	236	30.0
A512/115	37.8	58.5	67.0	84.0	95.0	104	115	286	269	230	40.0
A512/120	44.5	62.0	74.0	89.7	96.0	102	120	513	189	223	41.0
A512/140	50.5	71.5	85.4	105	113	119	140	513	223	223	48.0
A512/200	68.5	101	120	151	164	173	200	518	274	238	67.0
U_f [V] (2 V cell)	1.6	1.6	1.65	1.70	1.70	1.80	1.75				
U_f [V] (4 V block)	3.2	3.2	3.3	3.4	3.4	3.6	3.5				
U_f [V] (6 V block)	4.8	4.8	4.95	5.1	5.1	5.4	5.25				
U_f [V] (8 V block)	6.4	6.4	6.6	6.8	6.8	7.2	7.0				
U_f [V] (12 V block)	9.6	9.6	9.9	10.2	10.2	10.8	10.5				

All technical data refer to 20° C.

9.2.3. A 600

Type	DIN type designation	Nominal voltage [V]	C_1 [Ah]	C_3 [Ah]	C_5 [Ah]	C_{10} [Ah]	Length [mm]	Width [mm]	Height max. [mm]	Weight approx. [kg]
A612/100	12 V 2 OPzV 100	12	58.9	76.5	82.5	91.0	273	204	319	43
A612/150	12 V 3 OPzV 150	12	86.9	114.6	124.0	137.0	381	204	319	63
A606/200	6 V 4 OPzV 200	6	114.0	152.7	165.5	182.0	273	204	319	43
A606/300	6 V 6 OPzV 300	6	168.0	229.2	248.0	274.0	381	204	319	62
A602/200	4 OPzV 200	2	123.8	183.6	201.5	224.0	105	208	360	18
A602/250	5 OPzV 250	2	154.7	229.5	251.5	280.0	126	208	360	22
A602/300	6 OPzV 300	2	185.6	275.4	302.0	337.0	147	208	360	25
A602/350	5 OPzV 350	2	239.9	349.5	406.0	416.0	126	208	475	32
A602/420	6 OPzV 420	2	287.9	419.4	487.5	499.0	147	208	475	37
A602/490	7 OPzV 490	2	335.9	489.3	568.5	582.0	168	208	475	42
A602/600	6 OPzV 600	2	437.8	586.5	676.0	748.0	147	208	650	50
A602/800	8 OPzV 800	2	583.4	783.0	899.5	998.0	212	193	650	68
A602/1000	10 OPzV 1000	2	729.0	979.8	1123.0	1248.0	212	235	650	82
A602/1200	12 OPzV 1200	2	874.6	1176.3	1347.0	1497.0	212	277	650	98
A602/1500	12 OPzV 1500	2	958.9	1335.3	1445.5	1643.0	212	277	800	112
A602/2000	16 OPzV 2000	2	1278.5	1780.5	1927.5	2190.0	215	400	775	153
A602/2500	20 OPzV 2500	2	1598.1	2225.7	2409.5	2738.0	215	490	775	196
A602/3000	24 OPzV 3000	2	1917.8	2670.6	2891.0	3286.0	215	580	775	225
	U_f [V] (2 V cell)	--	1.60	1.70	1.75	1.80				
	U_f [V] (6 V block)	--	4.80	5.10	5.25	5.40				
	U_f [V] (12 V block)	--	9.60	10.20	10.50	10.80				

All technical data refer to 20° C.

9.2.4. A 700

Discharge time t_n / Capacity C_n [Ah]	10 min $C_{1/6}$	30 min $C_{1/2}$	1 h C_1	3 h C_3	5 h C_5	10 h C_{10}	Length [mm]	Width [mm]	Height max. [mm]	Weight approx. [kg]
A706/21	7.00	10.2	12.2	16.5	19.0	21.0	115	178	268	8.5
A706/42	14.1	20.5	24.4	33.0	38.0	42.0	115	178	268	10.1
A706/63	21.1	31.7	36.6	49.5	57.0	63.0	198	178	272	16.3
A706/84	28.3	41.0	48.8	66.0	76.5	84.0	198	178	272	18.3
A706/105	35.3	51.0	61.0	82.8	95.5	105.0	282	178	272	25.3
A706/126	42.5	61.5	73.2	99.3	114.5	126.0	282	178	272	26.2
A706/140	42.1	69.5	85.3	117.0	131.0	140.0	285	232	327	36.3
A706/175	52.8	86.5	106.0	146.4	163.5	175.0	285	232	327	39.7
A706/210	63.3	104.0	128.0	175.5	196.0	210.0	285	232	327	42.9
A704/245	74.0	121.5	149.0	204.9	229.0	245.0	250	232	327	35.5
A704/280	84.5	139.0	170.0	234.0	261.5	280.0	250	232	327	39
U_f [V] (4 V block)	3.2	3.2	3.3	3.4	3.4	3.6				
U_f [V] (6 V block)	4.8	4.8	4.95	5.1	5.1	5.4				

All technical data refer to 20° C.

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EXIDE TECHNOLOGIES
INDUSTRIAL ENERGY

Sonnenschein

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56029045

Sonnenschein SOLAR, SOLAR BLOCK, A 600 SOLAR
Operating Instruction
Stationary valve regulated lead acid batteries

Nominal data

- Nominal voltage U_N : 2.0 V x number of cells
- Nominal capacity $C_N = C_{100}$: 100h discharge (see type plate on cells/blocs and technical data in these instructions)
- Nominal discharge current $I_N = I_{100}$: $I_{100} = C_{100}$ / 100h
- 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: ____________

Security signs attached by: ____ date: ____________

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

- 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 50272-2, EN 50110-1.

- Any acid splashes on the skin or in the eyes must be flushed with plenty of clean water immediately. Then seek for medical assistance. Spillages on clothing should be rinsed out of 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/bloc container is damaged do not touch the exposed electrolyte because it is corrosive.

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

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

Non-compliance with operating instructions, 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) 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.

Stationary valve regulated lead acid batteries do not require topping-up water. Pressure valves are used for sealing and can not be opened without destruction.

1. Start Up

Check all cells/blocs for mechanical damage, correct polarity and firmly seated connectors. Apply the following torques for screw connectors:

G 5	G 6	A	M 8
5 ± 1 Nm	6 ± 1 Nm	8 ± 1 Nm	20 ± 1 Nm

Rubber covers shall be fitted to both ends of the connector cables (pole covers) before installation.

Control of insulation resistance:
New batteries: > 1M Ω
Used batteries: > 100 Ω/Volt.

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.

Battery installation should be made such that temperature differences between individual cells/blocs do not exceed 3 degrees Celsius (Kelvin).

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 must be carried out acc. to DIN 41773 (IU-characteristic).

Recommended charge voltages for cyclical application: See fig. 1 and item 2.8.

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 from the loads may lead to an additional temperature increase of the battery, and strain the electrodes with possible damages (see 2.5), which can shorten the battery life.

2.3 Maintaining the full charge (float charge)

Devices complying with the stipulations under DIN 41773 must be used. They are to be set so that the average cell voltage is as follows (within temperature range 15 to 35° C):

SOLAR, SOLAR BLOCK: 2.30 Vpc ± 1%
A 600 SOLAR: 2.25 Vpc ± 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: Up to 48 hours at max. 2.40 Vpc and with unlimited current. The cell/bloc temperature must never exceed 45° C. If it does, stop charging or revert to float charge to allow the temperature to drop.

For system voltages ≥ 48 V every one to three months:

Method 1: IUI

I-phase = up to voltage acc. to fig.1 at 20° C
U-phase = until switching at a current of 1.2 A/100Ah to the second I-phase
I-phase = 1.2 A/100Ah for 4 hours

Method 2: IUI pulse

I-phase = up to voltage acc. to fig. 1 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 4-6 hours where the pulses are 15 min. 2 A/100 Ah and 15 min. 0 A/100 Ah.

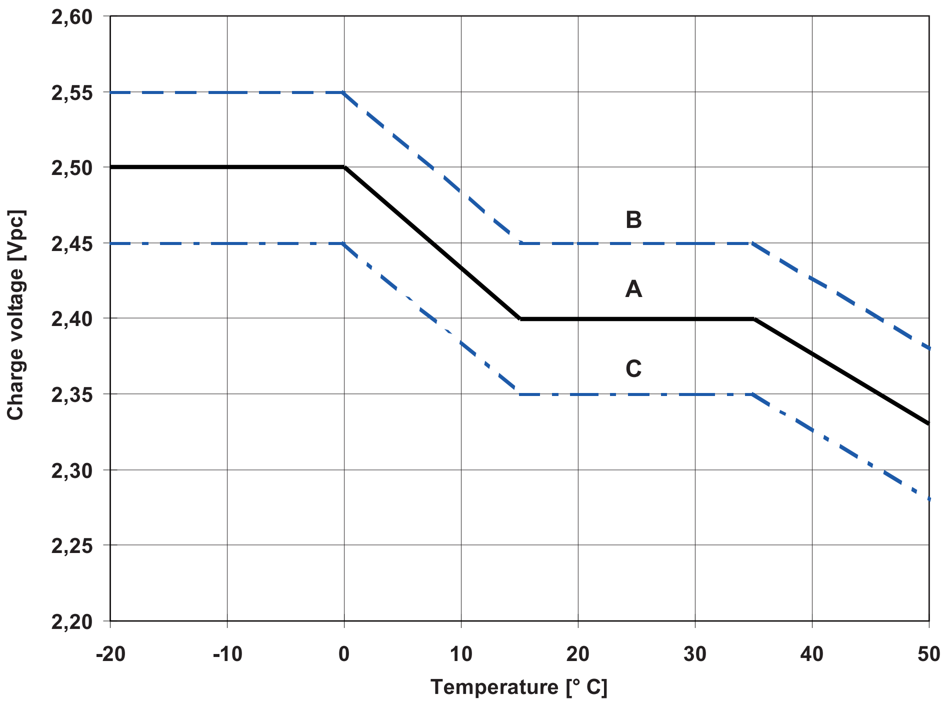

Fig. 1: Charge voltage vs. temperature for solar mode. Charge modes:
1) With switch regulator (two-step controller): Charge on curve B (max. charge voltage) for max. 2hrs per day, then switch over to continuous charge – Curve C
2) Standard charge (without switching) – Curve A
3) Boost charge (Equalizing charge with external generator): Charge on curve B for max. 5hrs per month, then switch over to curve C.

2.5 Alternating currents
When recharging acc. to fig.1 the actual value of the alternating current is occasionally permitted to reach 10 A (RMS)/ 100 Ah nominal capacity. In a fully charged state during float charge the actual value of the alternating current must not exceed 5 A (RMS)/ 100 Ah nominal capacity.

2.6 Charging currents
The charging current should range between 10 A to 35 A / 100Ah nominal capacity (guide values).

2.7 Temperature
The recommended operation temperature range for lead acid batteries is 10° C to 30° C (best 20° C ± 5 K). Higher temperatures will seriously reduce service life. Lower temperatures reduce the available capacity. The absolute maximum temperature is 55° C and should not exceed 45° C in service.

2.8 Temperature-related charge voltage
The temperature related adjustment has to be carried out acc. to fig. 1. An adjustment of the charge voltage must not be applied within a temperature range 15° C to 35° C.

2.9 Electrolyte
The electrolyte is diluted sulphuric acid and fixed in a gel.

3. Battery maintenance and control
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 several blocs/cells
– Surface temperature of several blocs/cells
– Battery-room temperature

If the bloc/cell voltages differ from the average float charge voltage by values more than specified in the following table or if the surface temperature difference between blocs/cells exceeds 5 K, the service agent should be contacted.

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

In addition, annual measurements and recording:
– Voltage of all blocs/cells
– Surface temperature of all blocs/cells
– Battery-room temperature

Annual visual checks:
– Screw connections
– Screw connections without locking device have to be checked for tightness.
– Battery installation and arrangement
– Ventilation

4. Tests
Tests have to be carried out according to IEC 60896-21, DIN 43539 part 1 and 100 (draft).

Capacity test, for instance, acceptance test on site: In order to make sure the battery is fully charged the following IU-charge methods must be applied: Option 1: float charge (see item 2.3), ≥ 72 hours. Option 2: 2.40 Vpc, ≥ 16 hours (max. 48 hours) followed by float charge (see item 2.3), ≥ 8 hours. The current available to the battery must be between 10 A/100 Ah and 35 A/100Ah of the nominal capacity

5. Faults
Call the service agents immediately if faults in the battery or the 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 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 sun light. To avoid damage the following charging methods can be chosen:

1. Maximum storage time is 17 months at ≤ 20° C. Equalizing charges will be required at higher temperatures, for instance, after 8.5 months at 30° C.
2. Float charging as detailed in 2.3.

7. Transport
Cells/bloc batteries 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). They must be protected against short circuits, slipping, upsetting or damaging. Cells/bloc batteries may be suitable stacked and secured on pallets (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 packing unit.
Cells/bloc batteries whose containers leak or are damaged must be packed and transported as class 8 dangerous goods under UN no. 2794.

8. Technical data:

Capacities at different discharge times and final discharge voltage.
All technical data refer to 20° C.

8.1 Sonnenschein SOLAR

Discharge time	1 h	5 h	10 h	20 h	100 h
Capacity	C_1 [Ah]	C_5 [Ah]	C_{10} [Ah]	C_{20} [Ah]	C_{100} [Ah]
S 12 / 6.6 S	2.9	4.6	5.1	5.7	6.6
S 12 / 17 G5	9.3	12.6	14.3	15	17
S 12 / 27 G5	15	22.1	23.5	24	27
S 12 / 32 G6	16.9	24.4	27	28	32
S 12 / 41 A	21	30.6	34	38	41
S 12 / 60 A	30	42.5	47.5	50	60
S 12 / 85 A	55	68.5	74	76	85
S 12 / 90 A	50.5	72	78	84	90
S 12 / 130 A	66	93.5	104.5	110	130
S 12 / 230 A	120	170	190	200	230
U_f (cell)	1.7 Vpc	1.7 Vpc	1.7 Vpc	1.75 Vpc	1.80 Vpc

8.2 Sonnenschein SOLAR BLOCK

Discharge time	1 h	5 h	10 h	20 h	100 h
Capacity	C_1 [Ah]	C_5 [Ah]	C_{10} [Ah]	C_{20} [Ah]	C_{100} [Ah]
SB 12 / 60	34	45	52	56	60
SB 12 / 75	48	60	66	70	75
SB 12 / 100	57	84	89	90	100
SB 12 / 130	78	101	105	116	130
SB 12 / 185	103	150	155	165	185
SB 06 / 200	104	153	162	180	200
SB 06 / 330	150	235	260	280	330
U_f (cell)	1.7 Vpc	1.7 Vpc	1.7 Vpc	1.75 Vpc	1.80 Vpc

8.3 Sonnenschein A 600 SOLAR

Discharge time	1 h	3 h	5 h	10 h	100 h
Capacity	C_1 [Ah]	C_3 [Ah]	C_5 [Ah]	C_{10} [Ah]	C_{100} [Ah]
4 OPzV 240	108	151	175	200	240
5 OPzV 300	135	189	219	250	300
6 OPzV 360	162	227	263	300	360
5 OPzV 400	180	252	292	350	400
6 OPzV 500	225	315	365	420	500
7 OPzV 600	270	378	438	490	600
6 OPzV 720	324	454	526	600	720
8 OPzV 960	432	605	701	800	960
10 OPzV 1200	540	756	876	1000	1200
12 OPzV 1400	630	882	1022	1200	1400
12 OpzV 1700	765	1071	1241	1500	1700
16 OPzV 2300	1035	1449	1679	2000	2300
20 OPzV 2900	1305	1827	2117	2500	2900
24 OPzV 3500	1575	2205	2555	3000	3500
U_f (cell)	1.67 Vpc	1.75 Vpc	1.77 Vpc	1.80 Vpc	1.85 Vpc

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