Handbook for Gel-VRLA-Batteries

Part 2:
Installation, Commissioning and Operation

"Sonnenschein A 400"
"Sonnenschein A 500"
"Sonnenschein A 600"
"Sonnenschein A 700"
./.
„Sonnenschein SOLAR"
„Sonnenschein SOLAR BLOCK"
"Sonnenschein A 600 SOLAR"

CONTENT

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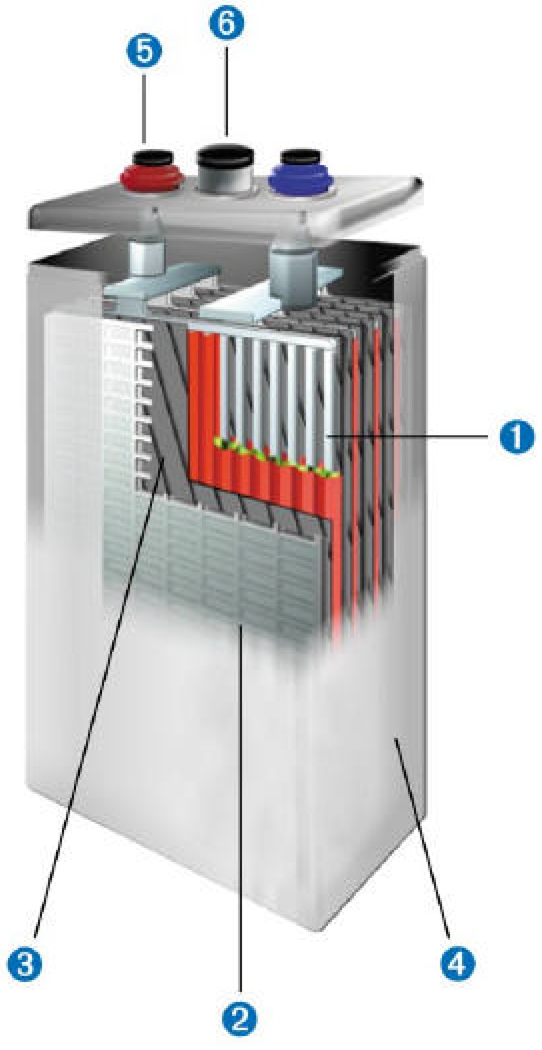
Part 2: Installation, Commissioning and Operation

DESIGN OF A
Gel VALVE-REGULATED LEAD ACID CELL (TYPE OPzV)

(Gel = with gelled electrolyte, is not visible in the picture below.
Other details are symbolical.)



❶ *Pos. plates: Robust tubular plates consisting of a lead calcium alloy, optimized for high corrosion resistance*

❷ *Neg. plates: Grid plate construction consisting of lead calcium alloy*

❸ *Separator: Microporous and robust, for electrical separation of the positive and negative plates and optimized for low internal resistance*

❹ *Housing: SAN, on request flame retardant ABS according UL 94-V0*

❺ *Poles: Screw connection for easy and safe assembly and maintenance-free connection with excellent conductivity*

❻ *Valves: Release gas in case of excess pressure and protects the cell against atmosphere*

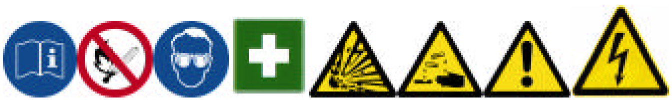
1. DELIVERY / RECEPTION

- 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 / monoblocs or by referring to a battery drawing.
- Check the package or pallet for integrity.
- Do not stack one pallet above the other.
- Keep 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.
- 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 written on the order. Damage coverage depends on the sales contract.

2. SAFETY

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

- Do not smoke.
- Use tools with insulated handles to tighten connections.
- Check that the connections between the cells / monoblocs are fitted correctly.
- Never place tools on the batteries (metal tools are particularly dangerous).
- Never lift the cells / monoblocs at the terminals.
- Never use a synthetic cloth or sponge to clean the cells / monoblocs. Use water (wet cloth) without additives.
- Avoid shocks.
- Even when disconnected, a battery remains charged.
- Always wear insulating gloves and glasses.
- Read the "Installation Instruction" and "Operating Instruction" carefully. See Appendix A 3 for more information.



A500, < 25 Ah only

3. STORAGE

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

3.1 Preconditions

The storage location should provide the following functions:

- Shelter the cells / monoblocs from harsh weather and risk of flooding.
- Protect the batteries against any overheating risk induced by direct exposure to the sun radiation or by their amplification through glass walls.
- Protect the batteries from any risk of electric shock resulting from short-circuiting by a conductive object or from a building up of conductive dust.
- Avoid any risk of mechanical shock caused by dropping objects onto the cell / monobloc or by dropping the cell / monobloc itself.
- Avoid contamination of the lids by dust etc.

3.2 Storage Conditions

- The temperature has an impact on the self-discharge rate (see fig. 1 and 2). Hence, it is important to store the batteries in a fully charged condition in a cool but frost-free room.

- Storage on a pallet wrapped in plastic material is authorized. It is not recommended however 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. This hydration has no affect on the battery operation or service life if no corrosion occurs.

- It is forbidden to stack one pallet above the other.

- Avoid storing unpacked cells / monoblocs on sharp-edged supports.

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

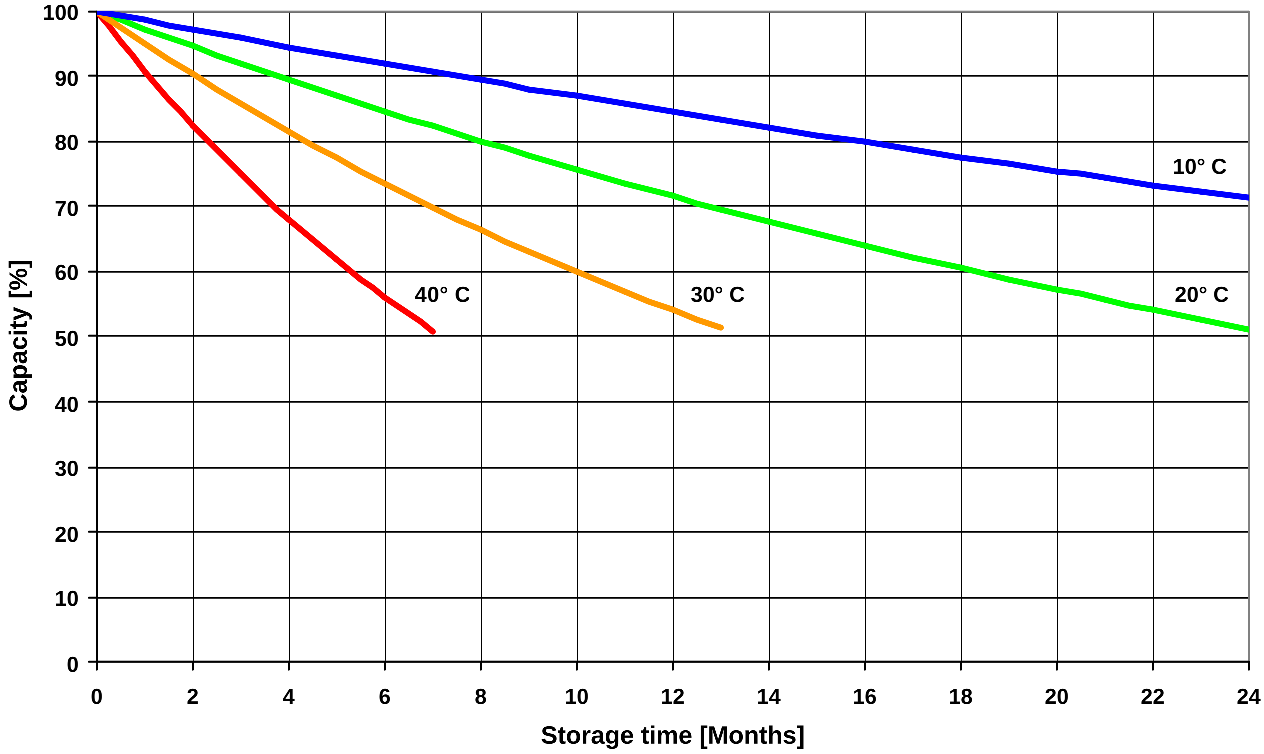
3.3 Storage Time

The maximum storage time at ≤ 20° C is

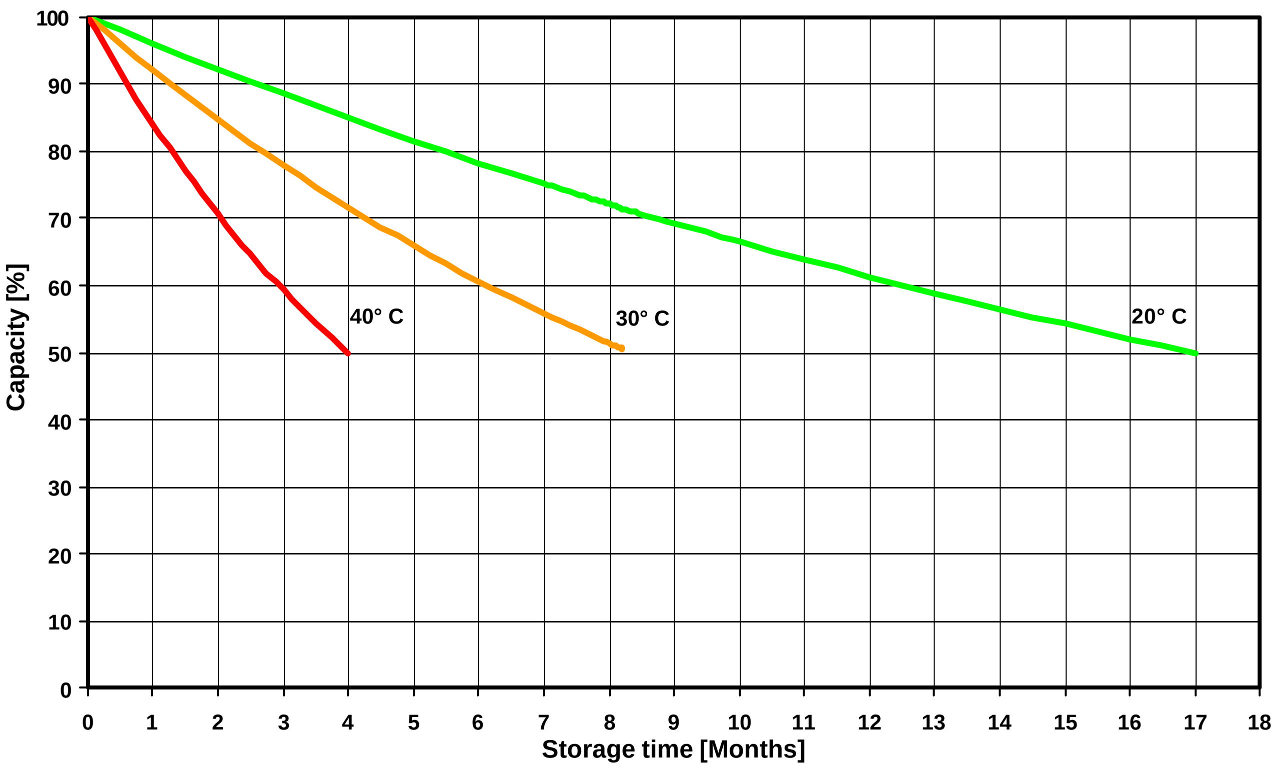
24 months for standard Gel-batteries (fig. 1) and
17 months for Gel-solar batteries (fig. 2).

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 recharging operations.



<u>Fig. 1:</u> Self-Discharge vs. Temperature (standard Gel-batteries)



<u>Fig. 2:</u> Self-Discharge vs. Temperature (Gel-solar batteries)

3.4 Measures for Battery Storage

- The storage area and ambient, respectively, must be clean and well maintained.

- Appropriate inventory turnover based on a FIFO-method ("First In – First Out") will result in a higher operating quality of the products.

- If the battery casings must be cleaned (prior to their installation) never use solvents or abrasives. Use water (wet cloth) without additives.

- For extended storage periods it is recommended to check the „open-circuit" voltage 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.

Trickle charging *) should be considered necessary when the measured open circuit voltage (OCV) is $<$ 2.07 Vpc.

*) Trickle charging means continuous charge at a low rate, approximately equivalent to the internal losses of the battery and suitable to maintain the battery in a fully charged state. It can be carried out either by IU-charging (= float charging) or I-charging (constant current) with limited current.

- Trickle charging mode in storage

Constant current- constant voltage (IU-) charging (15 to 35° C)

Max. voltage [Vpc]	Min. voltage [Vpc]	Max. current [A]	Charging time [h] at max. voltage
2.40	2.25 2.30 *)	3.5 * I_{10}	48

*) SOLAR, SOLAR BLOCK

Depending on the chargers 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.

Constant current (I-) charging (15 to 30° C)

Measured OCV [Vpc]	Current [A]	Charging time [h]
2.05	0.5 * I_{10}	14
2.06	0.5 * I_{10}	13
2.07	0.5 * I_{10}	12

For temperatures below 15° C it is recommended to charge the battery 20 hours.

4. INSTALLATION

4.1 Battery Rooms, Ventilation and General Requirements

General rules and guidelines about battery rooms, their ventilation and electrical requirements regarding installations are mentioned in Appendix A 1.
For more information see also "Installation Instruction" (Appendix A 3).

4.2 Preliminary Steps

- Check each cell / monobloc separately by measuring the open circuit voltage.

2 Volt cell:	$U \geq 2.07$ V
6 Volt monobloc:	$U \geq 6.21$ V
12 Volt monobloc:	$U \geq 12.42$ V

- Check that the battery racks are stable and horizontal. For the shelf assemblies with 4 levels of 2 rows or 5 levels of 3 rows, the assembly should be anchored with the building.

- If EXIDE Technologies has supplied drawings for the installations, the cells / monoblocs should be installed accordingly.

- Precautions must be taken if batteries are being installed in metallic cabinets or on racks. Keep an air safety distance of at least 10 mm between insulated cables and electrically conductive parts, or use additional insulation for cell / monobloc connectors.

- 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 monoblocs shall be approx. 10 mm, at least 5 mm.
  See appendix A 1 and standard EN 50 2727-2 (/1/) especially for battery room ventilation requirements.

- The use of metal clamps on the cells / monoblocs is not recommended. A system made of insulating material should be used.

- The grounding of racks or cabinets should be carried out in accordance with the technical rules relevant to the country of installation.

- Standards referring to installation, cabinets, equipment or battery rooms are:
  EN 50 091-I (/2/), IEC 896-2 (/3/) (draft IEC 60896-21 (/4/)) and EN 50272-2 (/1/).

4.3 Actual Assembly

- For assembly operations: Use insulated tools. It is recommended to protect yourself by wearing insulating gloves, protection glasses and to remove any metal objects such as watches or any other items of jewelry, especially in the case of installation in a cabinet (see also the paragraph relating to safety).

- Moderately lubricate the inserts and connections using silicone grease. The use of a petroleum-based lubricant is not recommended

- The connections should be tightened by means of a torque wrench, set to the following:

A connections:	8 ± 1 Nm
G5/M5 connections:	5 ± 1 Nm
G6/M6 connections:	6 ± 1 Nm
M8 male connections:	8 ± 1 Nm
M8 female and M 10 connections:	20 ± 1 Nm

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

4 V monoblocs:	0.03 V per bloc
6 V monoblocs:	0.04 V per bloc
12 V monoblocs:	0.05 V per bloc

- Batteries with a nominal voltage > 75 V require an EC conformity declaration in acc. with the low voltage directive (73/23/EEC), which confirms that the CE marking is applied to the battery. The company installing the battery is responsible for the declaration and applying the CE marking. For more information, see /5/.

4.4 Parallel Arrangements

The most battery manufacturers, standards and guidelines recommend a maximum of 4 strings in parallel. It is possible to have more strings in parallel without reducing the life of the battery or getting problems with the battery.

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

- General: The same voltage drops must be realized from each string to the end connector regardless if a string consists of one unit (single cell / monobloc) or several units. This can be achieved by proper choice of cable lengths, cable diameters and arrangement (for instance, by cross-wise configuration).

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

- The minimum cable size for the end connectors of a string is 25 mm^2/100 Ah string capacity.

- The end-connector cables must be placed on a copper bar with at least 100 mm^2/100 Ah string capacity with the lowest possible distance.

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

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

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. By using the parallel strings the reliability of the system is increased due to the redundancy. Neither the lifetime nor the reliability will be reduced.

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 /6/.

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 and check that the different strings are at the same potential before connecting them together.

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: In order to make sure the battery is fully charged the following IU-charge methods can be applied:

  Option 1: Float charge $\geq$ 72 hours.
  Option 2: 2.40 Vpc $\geq$ 16 hours (max. 48 hours) followed by float charge $\geq$ 8 hours.

  The current available to the battery should be between 10 A/100 Ah and 35 A/100Ah of the 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 necessary. 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 6.6.2

  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, A 600 SOLAR and A700
  2.27 Vpc for A400
  2.30 Vpc for A500, SOLAR and SOLAR BLOCK

  All charging (float, boost) must be carried out according to an IU-characteristic with limit values: I-constant: ± 2%; U-constant: ± 1%. These limits describes the tolerance of rectifiers used. 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).

- 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 strain the electrodes, which can shorten the battery life.

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

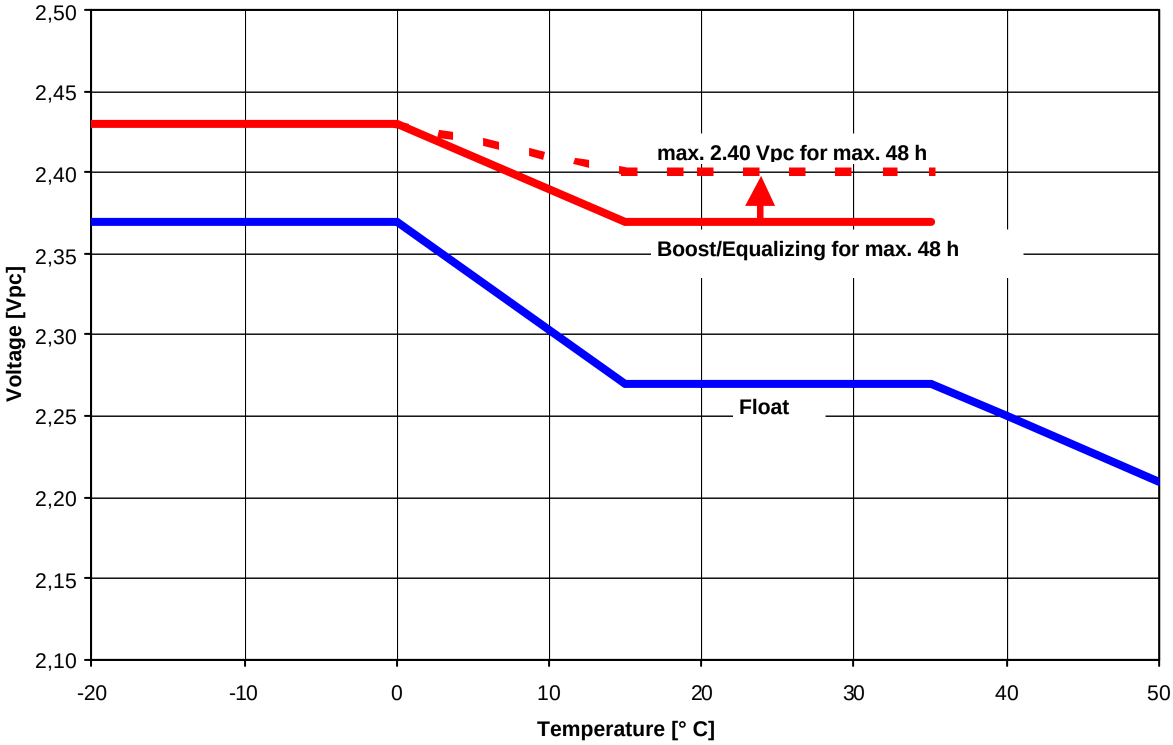


Fig. 3: A 400, Charging Voltage vs. Temperature

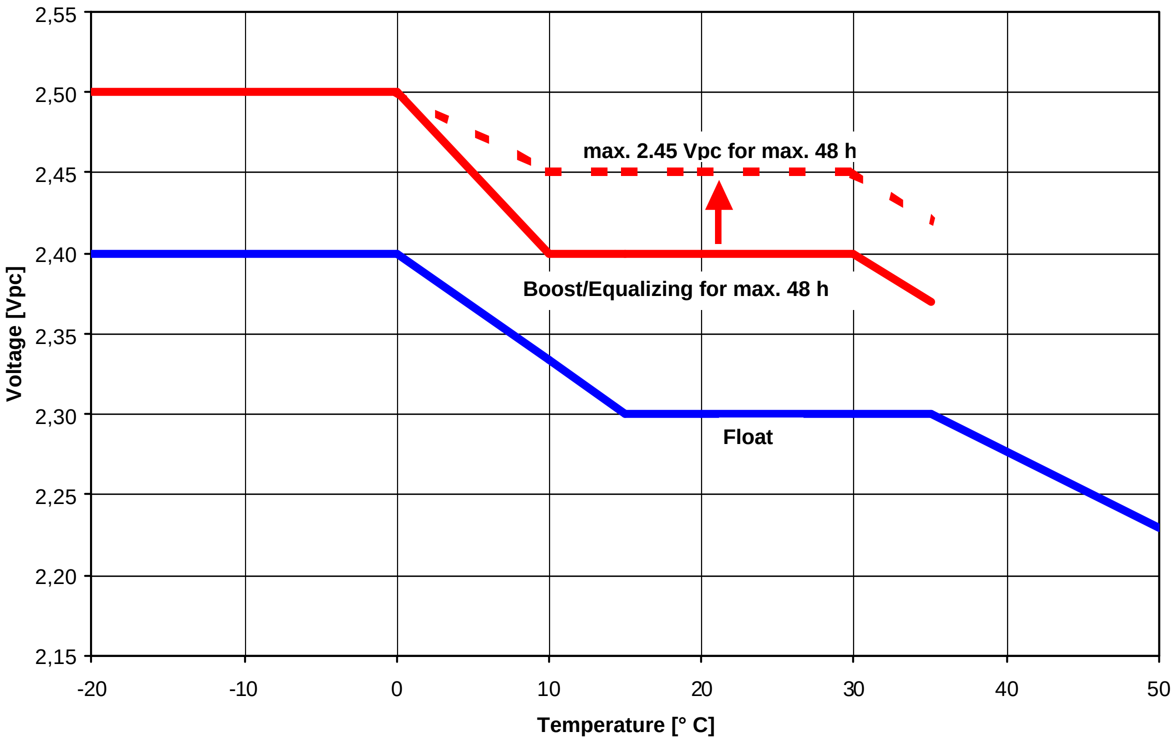


Fig. 4: A 500, Charging Voltage vs. Temperature

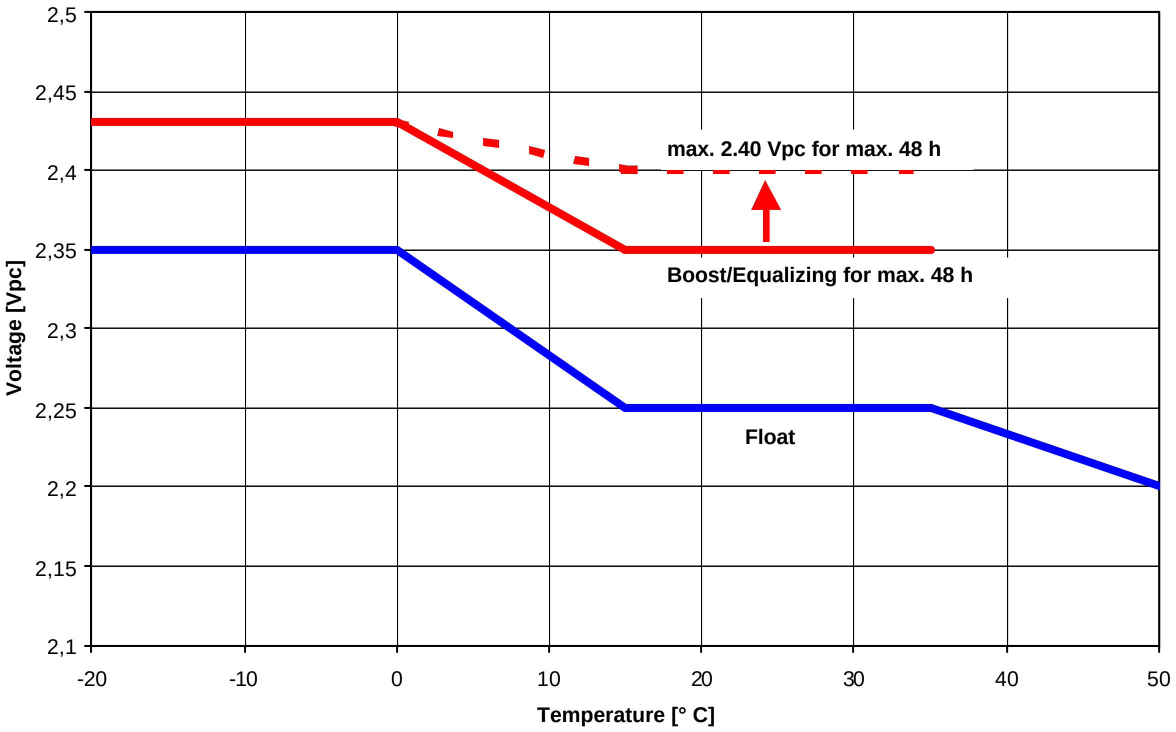


Fig. 5: A 600 and A 700, Charging Voltage vs. Temperature

Float Voltage Deviation

- The individual cell or bloc float voltages may deviate within a string from the average value set as shown in figures 6, 7 and 8. Theses figures are representative as the variations and limits depends on the battery type and number of cells per monobloc. The following table gives an overview about all the battery types and their variations from the average value under float charge conditions. The “Typical Decrease” and “Typical Increase” is always equivalent to the progress shown in fig. 6 to 8.

	2V	4V	6V	8V	12V
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	--	--

- 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.
- It is a normal effect and well described in /7/.

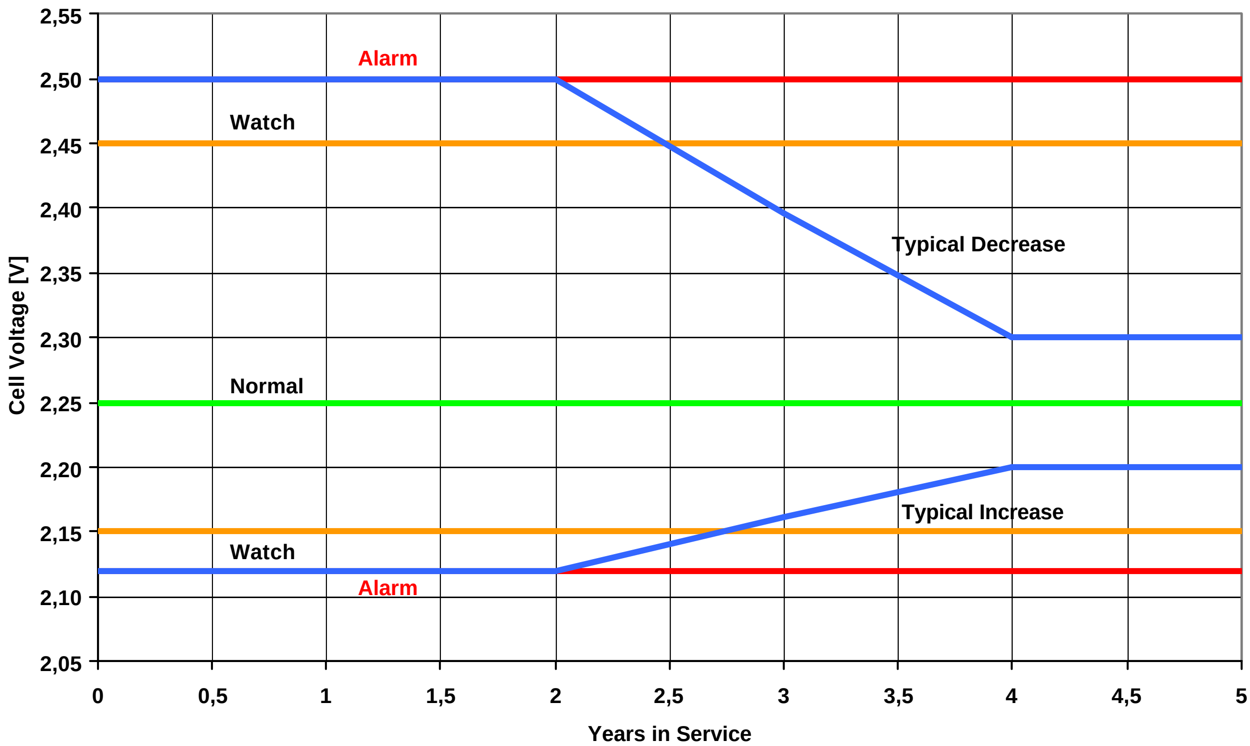


Fig. 6: Float Voltage Deviation in A 600 Batteries

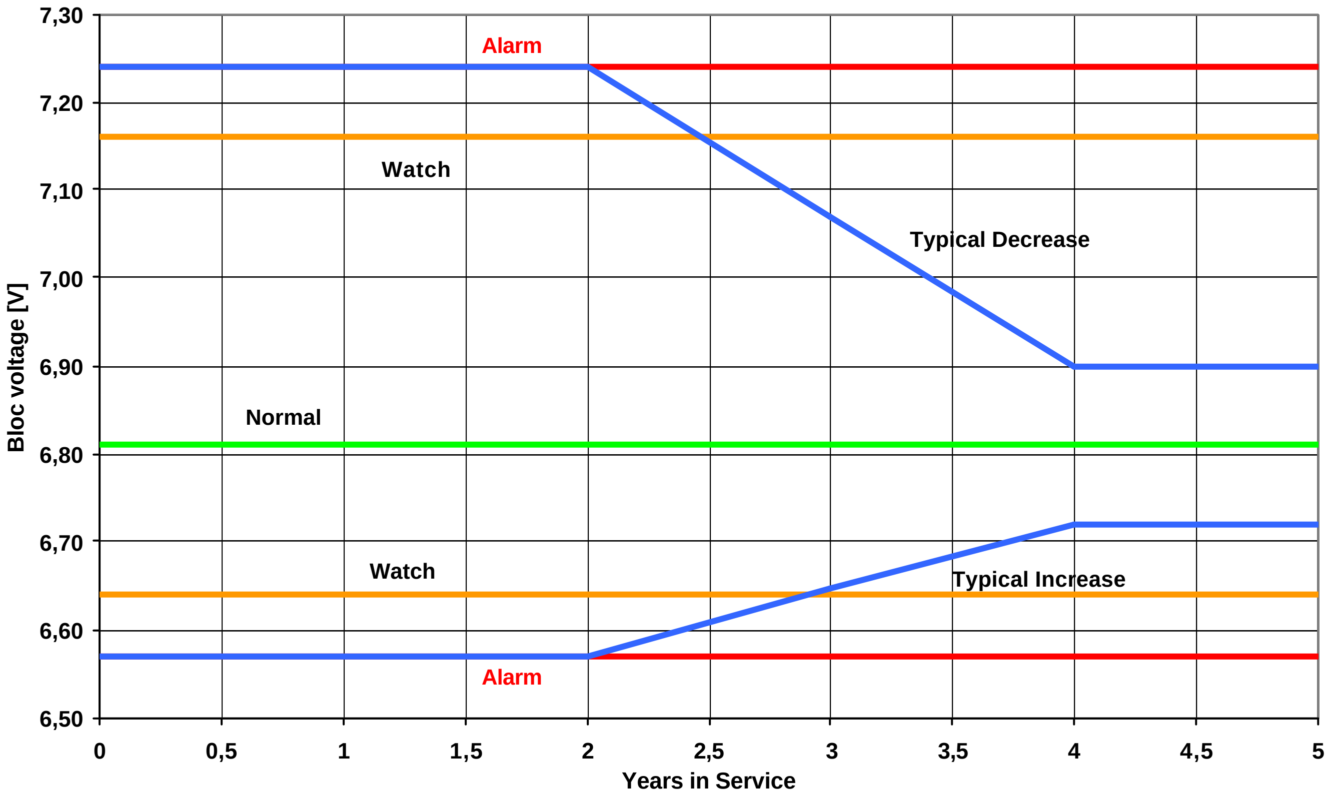


Fig. 7: Float Voltage Deviation in A 400 Batteries (6V-blocs)

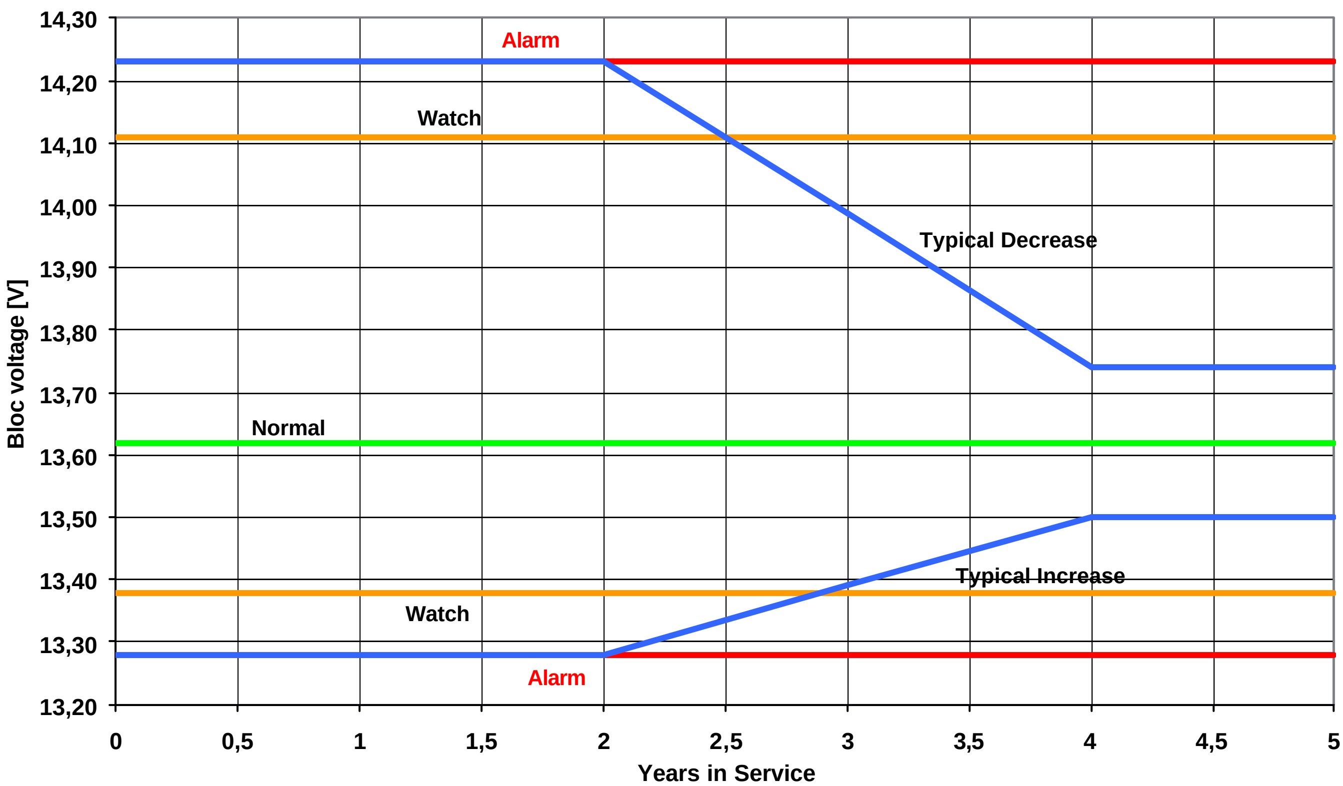


Fig. 8: Float Voltage Deviation in A 400 Batteries (12V-blocs)

6.2 Charging Conditions

- 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 informative values of time required to recharge a battery under float voltage or enhanced voltage (Boost charge) up to 2.40 Vpc (at 20° C) depending on depth of discharge (DOD) and initial current.
  Charging Gel-solar batteries: See chapter 6.6.2.

- 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.

  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
100%:	10 hours

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

For how to use the charts see fig. 9 and 10 as examples. Further graphs are shown in Appendix A 2.

Fig. 9: 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 would need a little bit more than 24 hours.

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

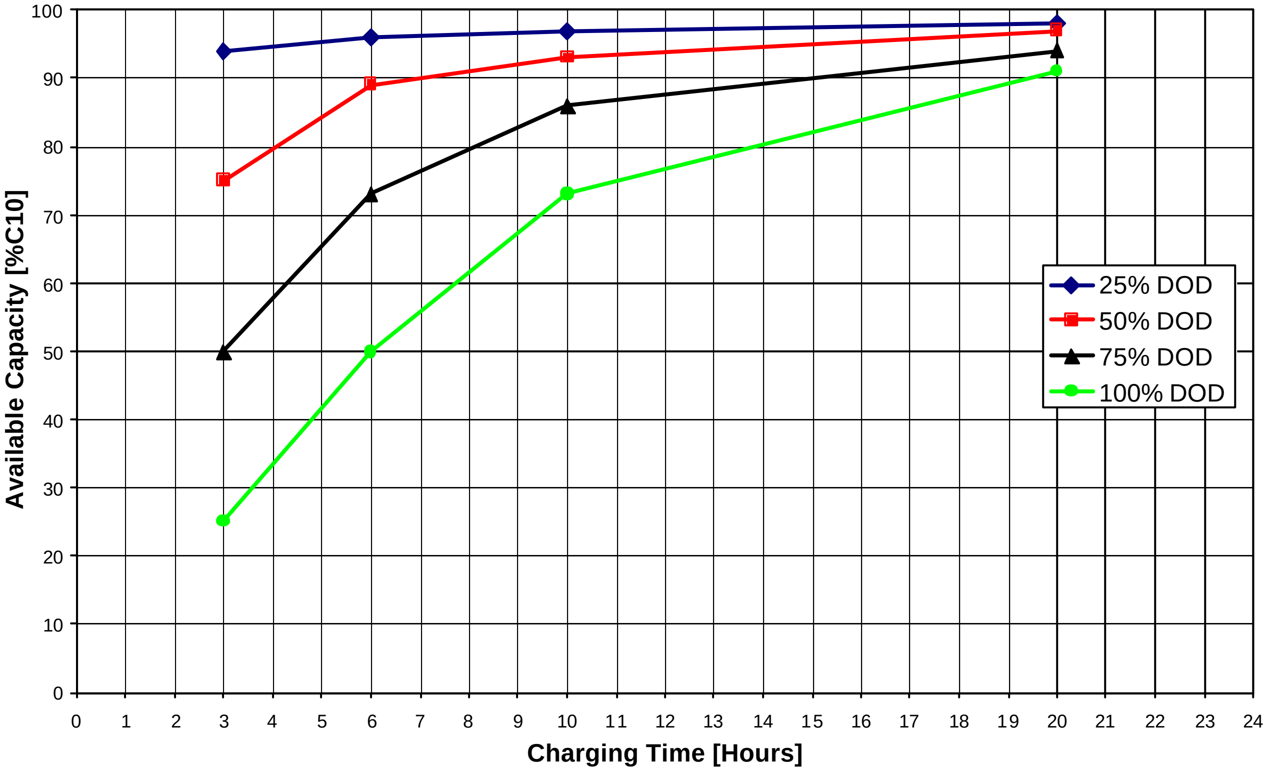


Fig. 9: Re-charging at 2.25 Vpc, 1 * I_{10}

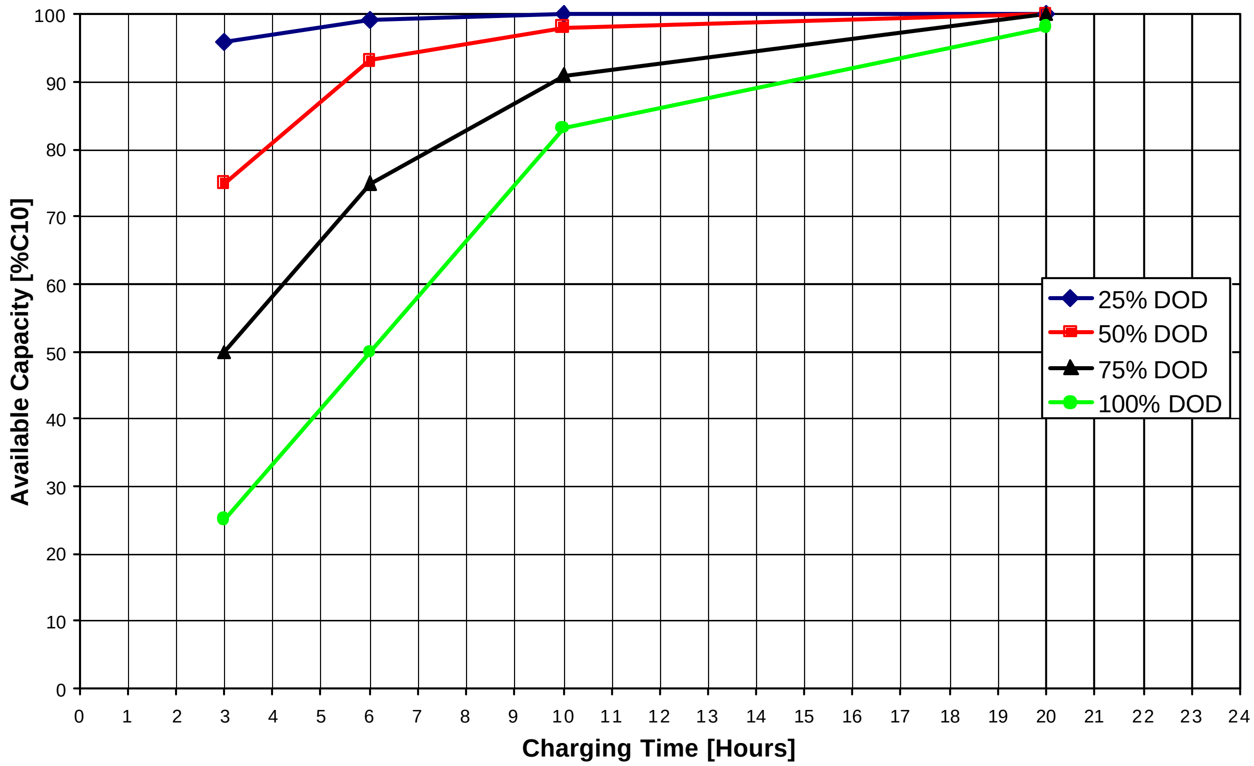


Fig. 10: Re-charging at 2.40 Vpc, 1 * I_{10}

6.3 Efficiency of Re-Charging

- Ah-Efficiency

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

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.

- Wh-Efficiency

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

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

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

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

$$= 0.854 = 85\ \%$$

6.4 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 or if the individual cell or bloc voltages are outside the specified range as shown in fig. 6, 7 and 8.

They have to be carried out as follows:

Up to 48 hours at max. 2.40 Vpc.
The charge current must not exceed 35 A/100 Ah nominal capacity.
The cell / bloc 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 3 48 V

Every one to three months:

Method 1: IUI

I-phase =	up to voltage acc. to fig.17 (chapter 6.6.2) 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. 17 (chapter 6.6.2) 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.

6.5 Discharge

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 recommended for the discharge time.
- Deeper discharges must not be carried out unless specifically agreed with EXIDE Technologies.
- Recharge immediately following complete or partial discharge.
- Capacity tests should be carried out acc. to IEC 896-2 (/3/) and draft IEC 60896-21 (/4/), respectively.

<u>What about the weakest unit during a capacity test</u> ?

- One has to look at single cells and blocs from different point of view. Statistics must be included when talking about blocs.
- The <u>weakest single cell</u> can drop down to

  (U_f = final voltage, U_{min} = minimum voltage)

  U_{min} = Final voltage U_f [Vpc] - 0.2 V

  Example: Battery final voltage U_f = 1.75 Vpc

  ➔ Weakest cell can have $U_{min} = U_f - 0.2V = 1.55$ V

- The <u>weakest</u> bloc can drop to

  U_{min}/bloc = final voltage (U_f * n/bloc) - ($\sqrt{n}$ * 0.2 Vpc)

  (n = number of cells per bloc)

Example: Battery final voltage $U_f = 1.75$ Vpc

➔ Weakest bloc can have $U_{min} = U_f - \sqrt{n} * 0.2V$

12 V-bloc: $U_f = 1.75 V * 6 = 10.5 V$
6 V-bloc: $U_f = 1.75 V * 3 = 5.25 V$

➔ a 12 V-bloc can have 10.01 V
➔ a 6 V-bloc can have 4.90 V

6.6 Cyclical Application

6.6.1 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 (/3/)*):

A 500: 600 cycles
A 400: 600 cycles
A 700: 700 cycles
A 600: 1200 cycles

SOLAR: 800 cycles
SOLAR BLOCK: 1200 cycles
A 600 SOLAR: 1600 cycles

*) Discharge conditions acc. to IEC 896-2: 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 lower number of cycles because the active mass is much more stressed and stronger re-charging necessary (corrosion !). Therefore, lower DODs results in higher numbers of cycles. See figures 11 to 16 for details (fig. 14 to 16 with other correlation to IEC 896-2 on x-axis).

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 6.8).

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

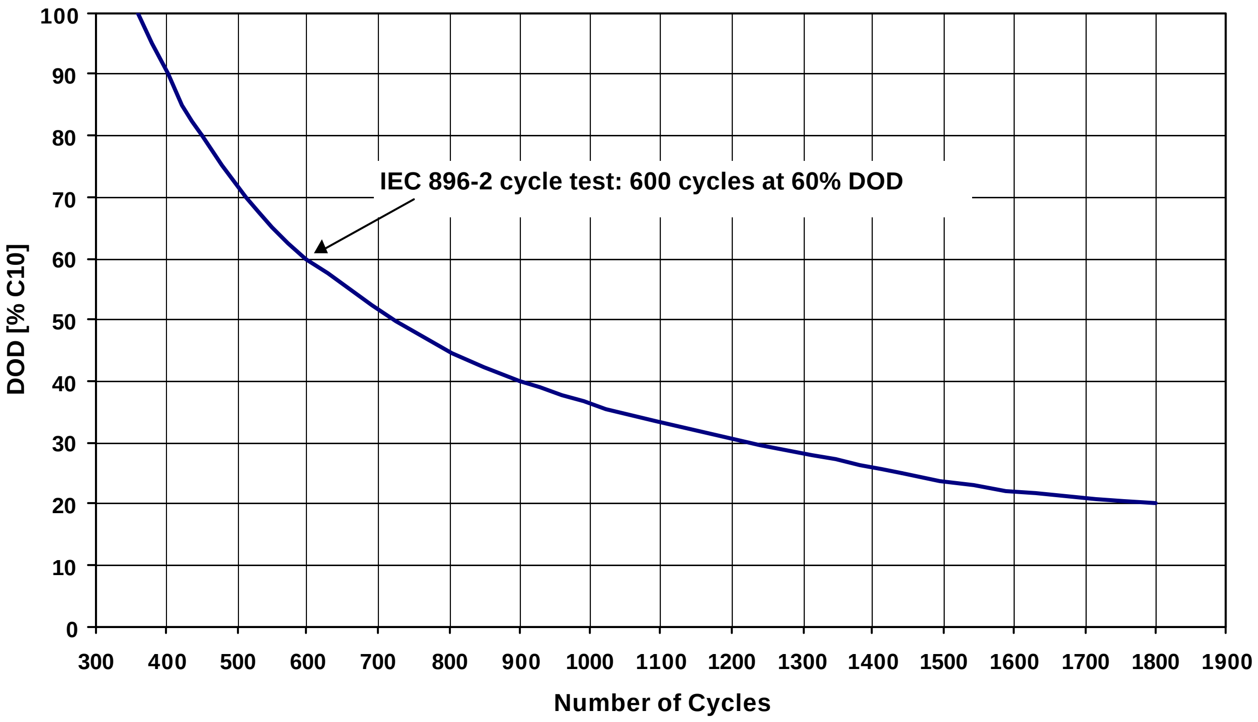


Fig. 11: A 500, A 400; Number of Cycles vs. Depth of Discharge (DOD)

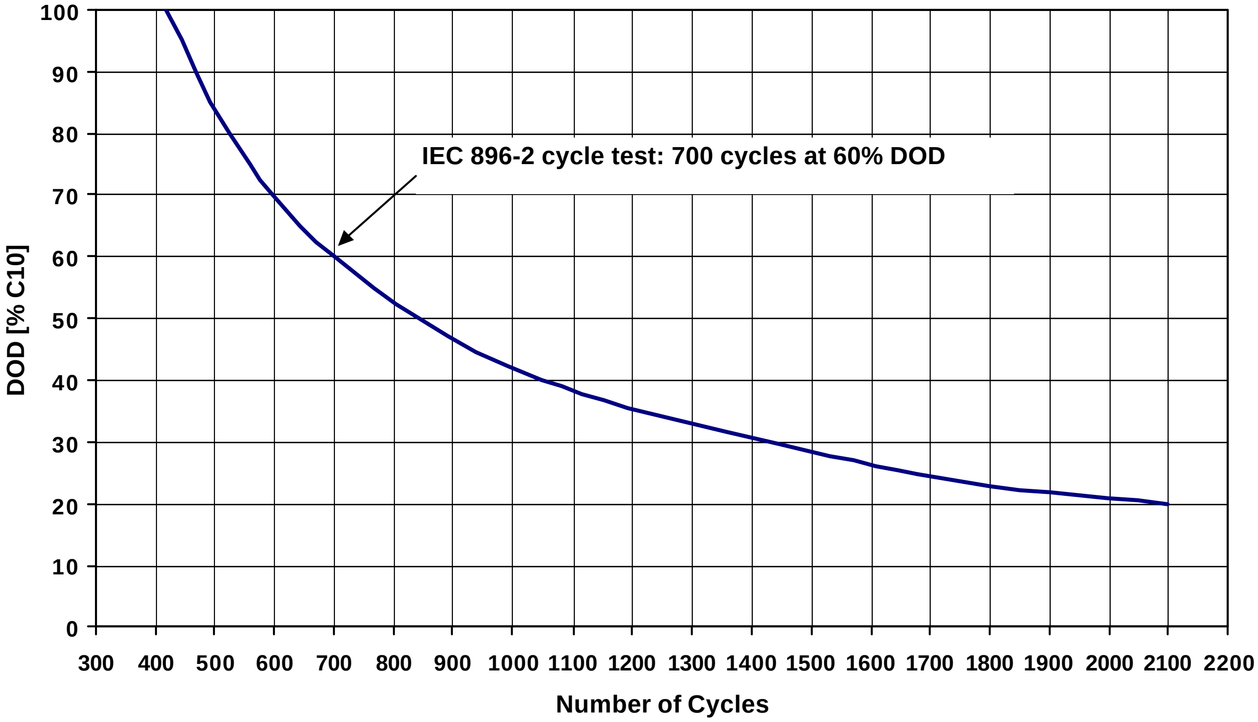


Fig. 12: A 700; Number of Cycles vs. Depth of Discharge (DOD)

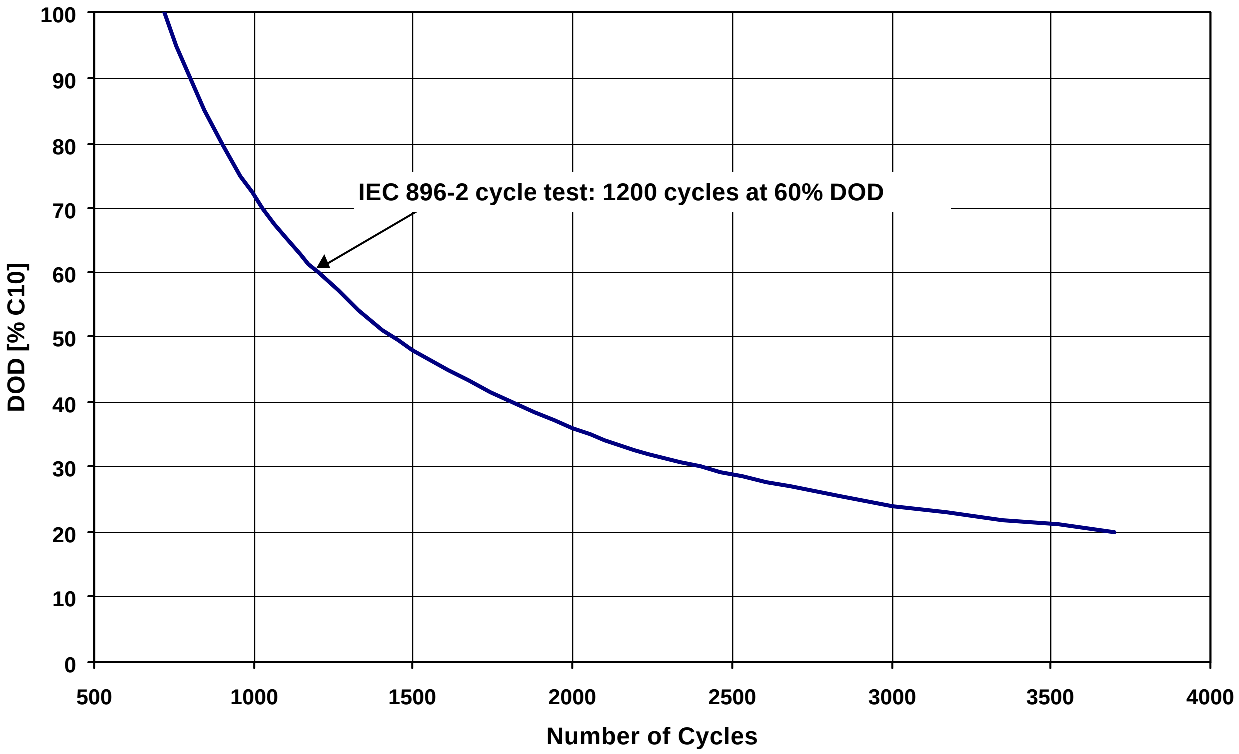


Fig. 13: A 600, Number of Cycles vs. Depth of Discharge (DOD)

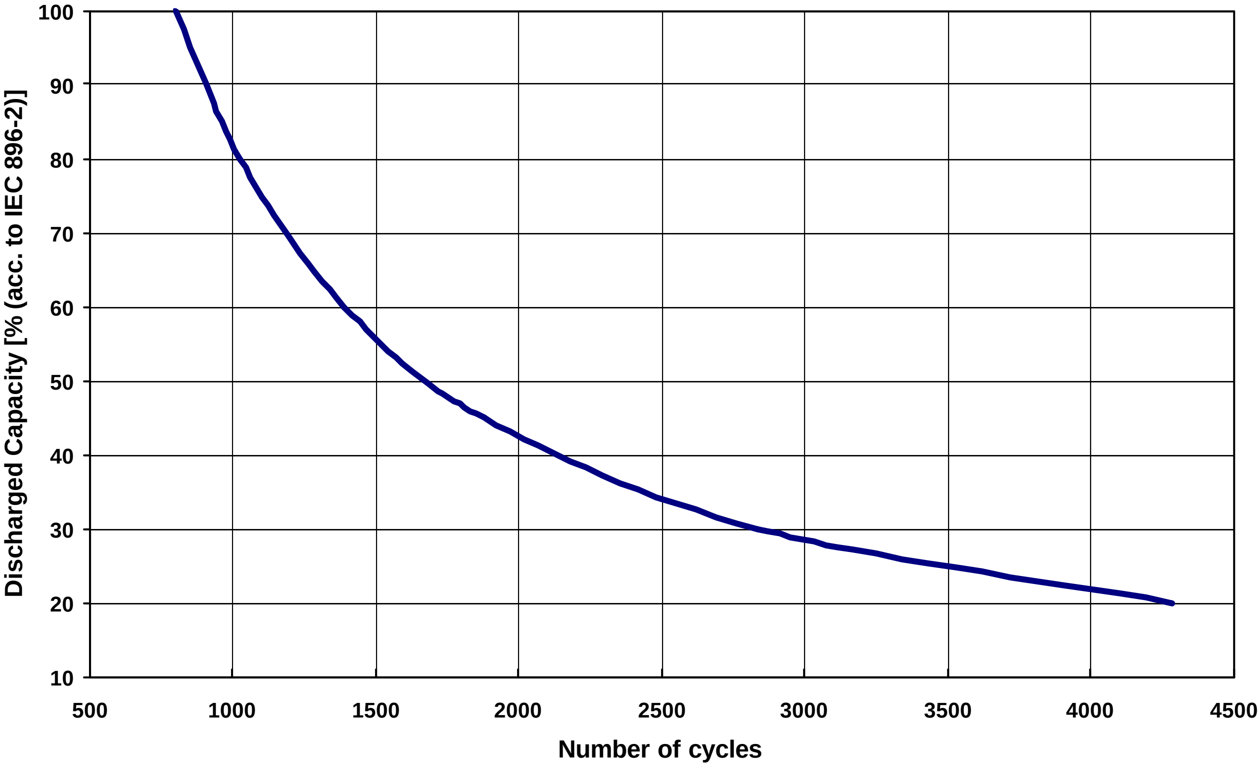


Fig. 14: SOLAR, Number of Cycles vs. Depth of Discharge (DOD)

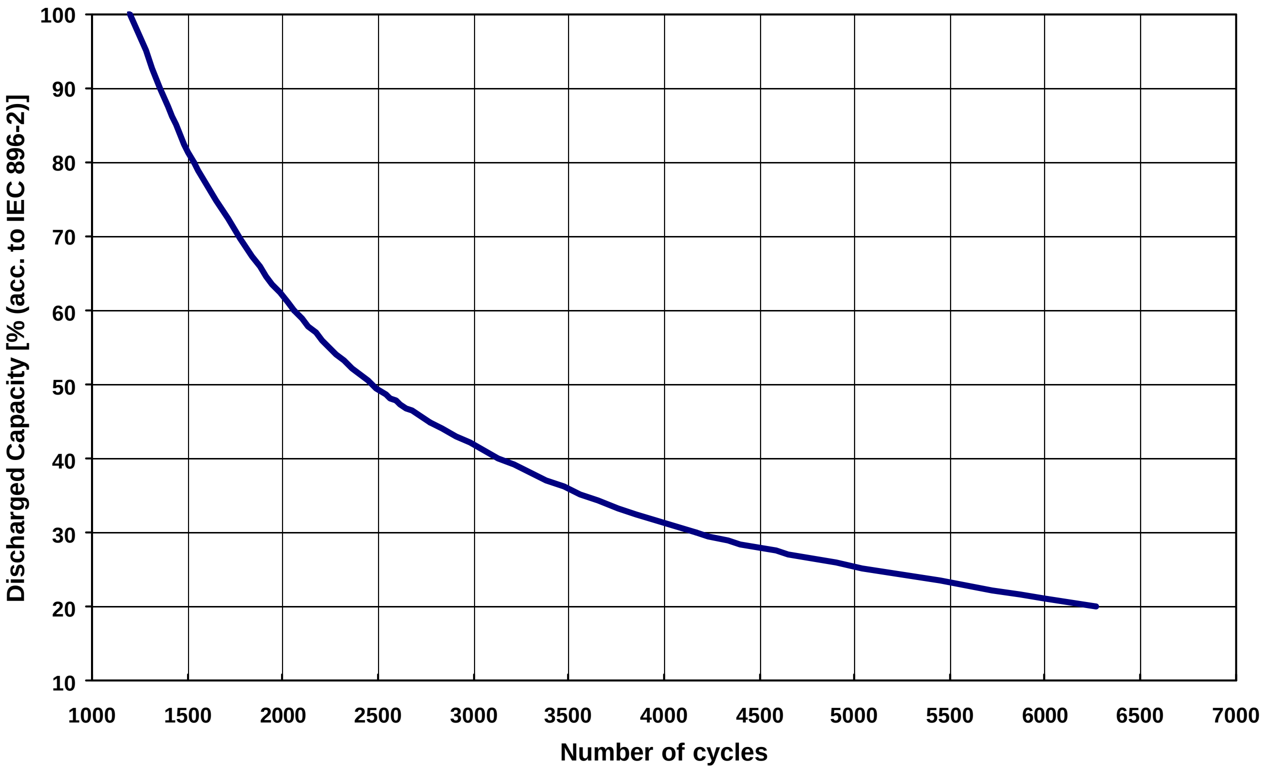


Fig. 15: SOLAR BLOCK, Number of Cycles vs. Depth of Discharge (DOD)

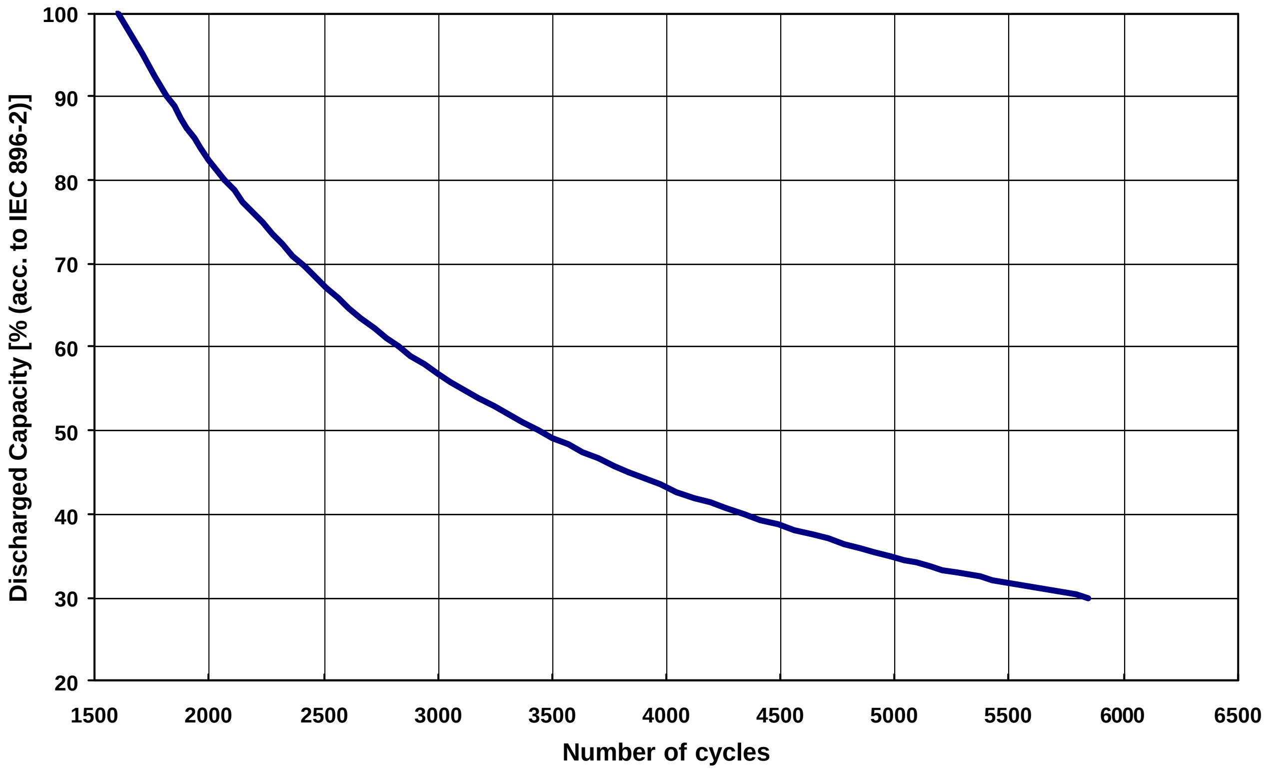


Fig. 16: A 600 SOLAR, Number of Cycles vs. Depth of Discharge (DOD)

6.6.2 Special Considerations about Gel-Solar Batteries

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 close 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 returned Ampere-hours?
- Optimum daily discharge: $\leq$ 30% of C_{10}, typically 2 to 20 % C_{10}

Battery Sizing: Guideline

Standard IEEE P1013/D3, April 1997 (/8/) inclusive worksheet and example

Battery Sizing: Summary

- System must be well designed. Feel safe !
- 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 made such that temperature differences between individual cells/blocs do not exceed 3 degree Celsius (Kelvin).

Charging

The charging of Gel-solar batteries shall be carried out acc. to fig. 17.

A temperature related adjustment of the charge voltage within the operating temperature of 15° C to 35° C is not necessary. If the operating temperature is permanently outside this range, the charge voltage has to be adjusted as shown in fig. 17.

Solar batteries have also to be operated at States-of-Charge (SOC) less than 100% due to seasonal and other conditions, for instance (acc. IEC 61427, /9/):

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.

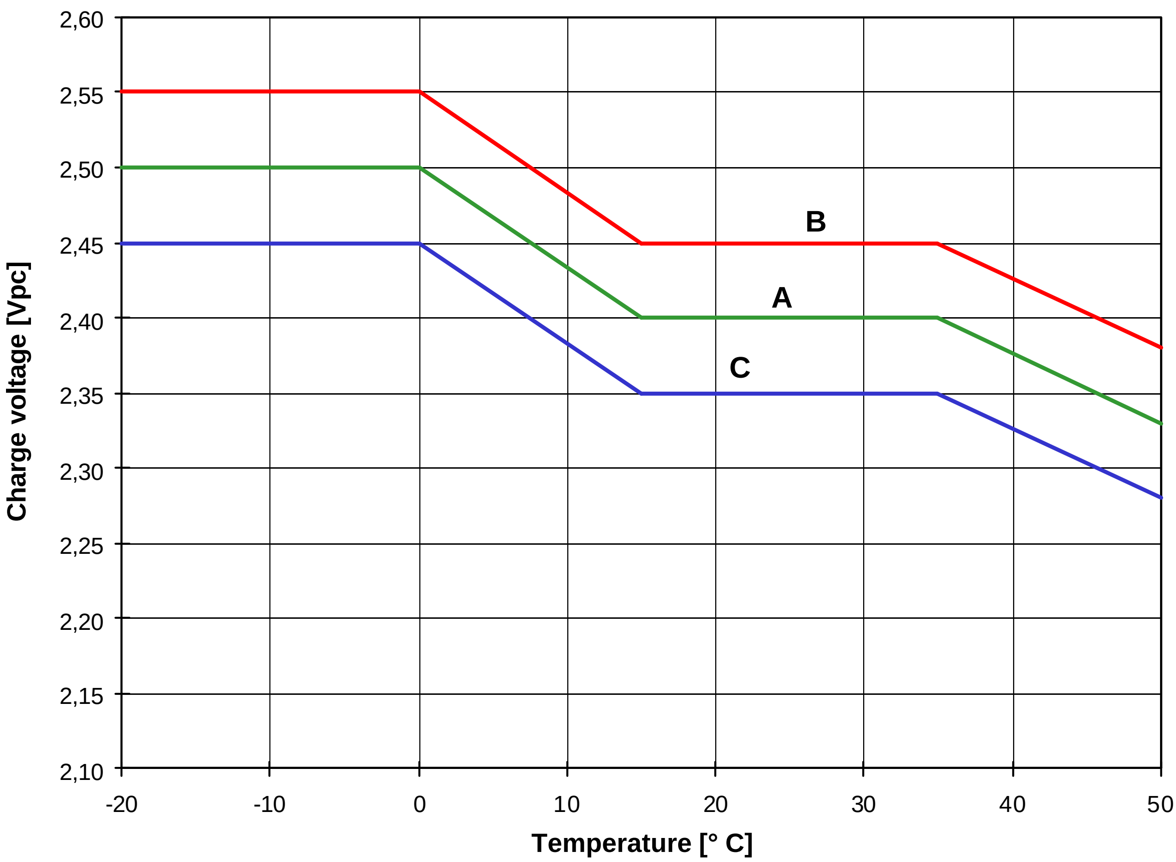


Fig. 17: Charging of Gel-solar batteries depending on charge mode and temperature

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.

6.7 Internal Resistance R_i

- The internal resistance R_i is determined acc. to IEC 896-2 (/3/). 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. 18 below. Hereby, the R_i-value at 0% DOD (fully charged) and 20° C, respectively, is the base line (R_i-factor = 1).

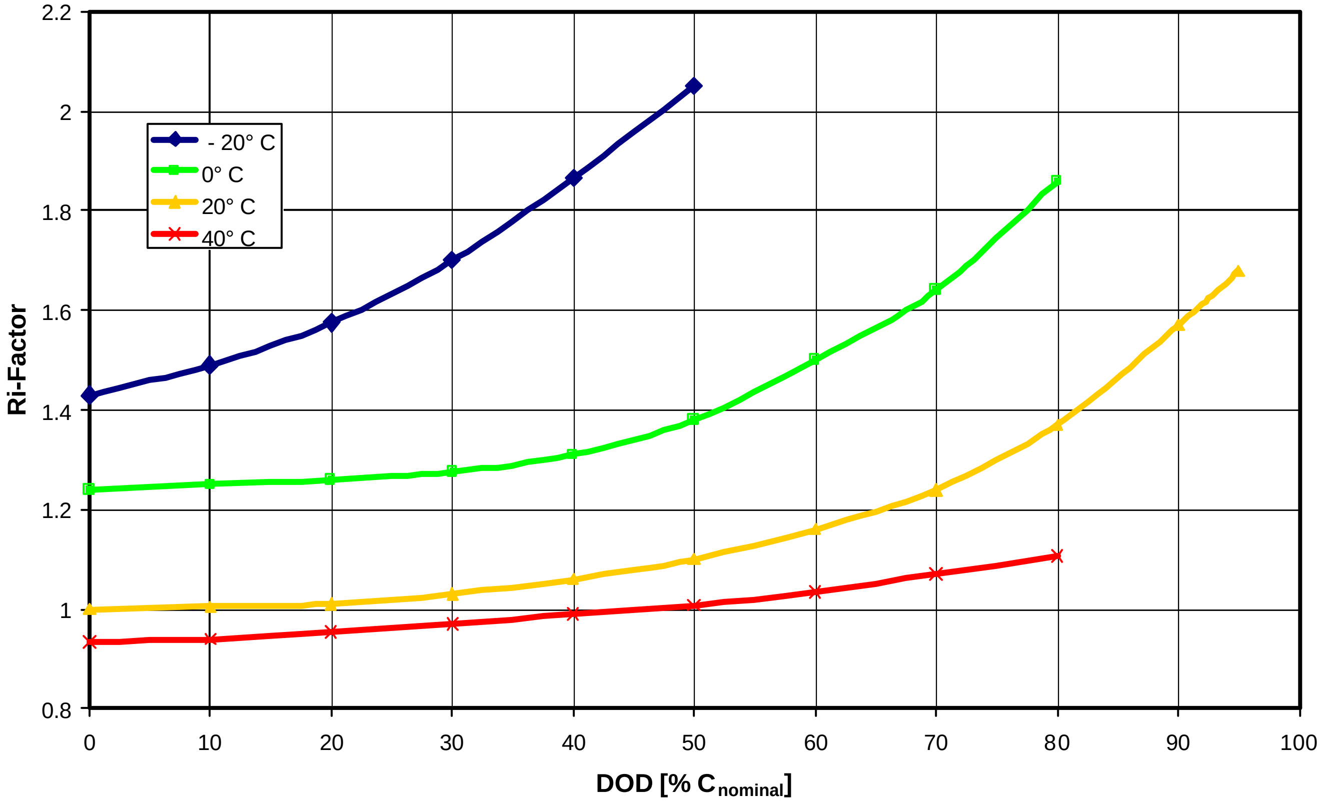


Fig. 18: Internal Resistance R_i vs. Depth of Discharge (DOD) and Temperature

6.8 Influence of Temperature

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

- Expected service life at 20° C and with occasional discharges:

  A 500: 6 years
  A 400: 10 years
  A 700: 12 years
  A 600: 15 to 18 years

  SOLAR: 5 to 6 years
  SOLAR BLOCK: 7 to 8 years
  A 600 SOLAR: 12 to 15 years

  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.

- Gel-batteries are designed to be operated within a wide temperature range –40° C and +55° C.
- Below approx. –15° C, there is a risk of freezing in depending on the depth of discharge. On the other hand it is possible to use the batteries at lower temperatures, under specific conditions (contact your EXIDE Technologies representative).
- The battery temperature affects the available capacity, as shown in fig. 19 and 20.
- High temperatures affect batteries' service life acc. to a common "rule of thumb" (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 (A 400, A 500 and A 700; 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 A 600 with positive tubular plates (to be applied to A 600 SOLAR too regarding influence on number of cycles). The influence of temperature is less than for other batteries. In fact, an increase of 10° C will cause a life reduction of about 30% only.

Reasons:

1. 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.
2. 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.
3. 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.

For more details see figures 21 and 22.

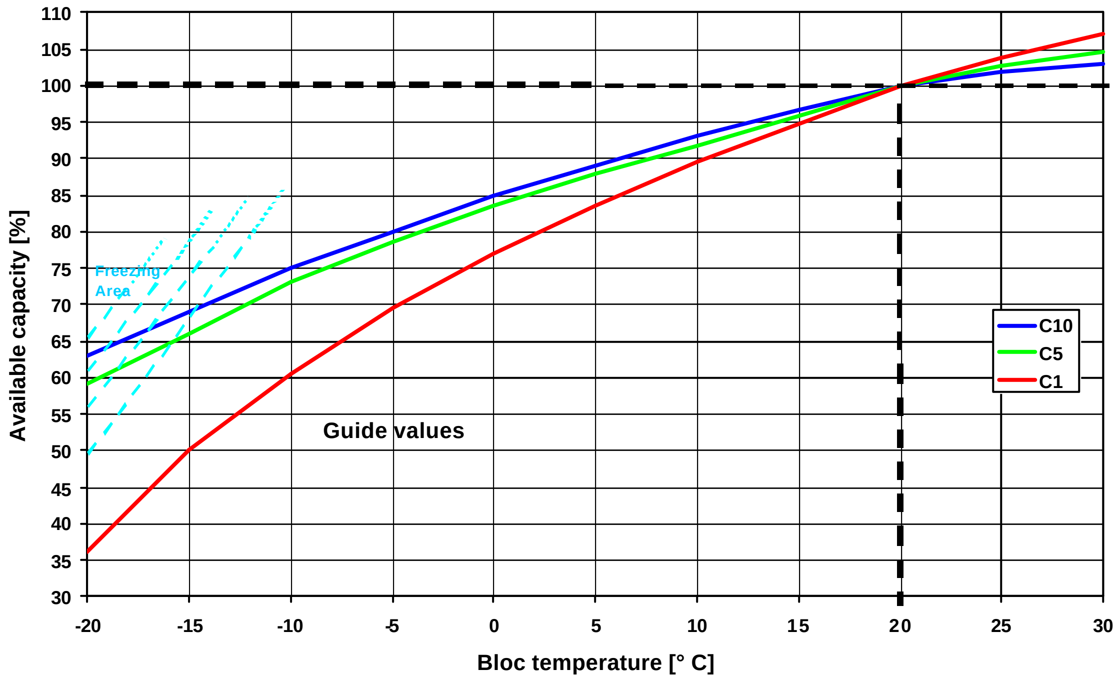


Fig. 19: A 400, A 500, SOLAR, SOLAR BLOCK:
Capacity (% rated capacity) vs. Temperature

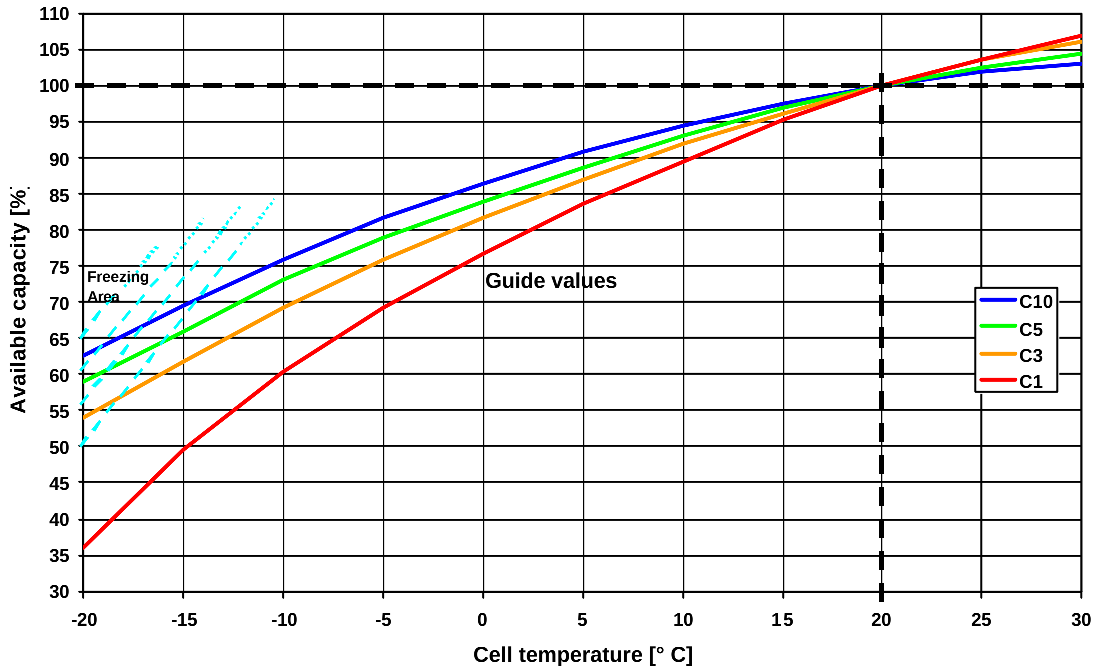


Fig. 20: A 600, A 600 SOLAR, A 700:
Capacity (% rated capacity) vs. Temperature

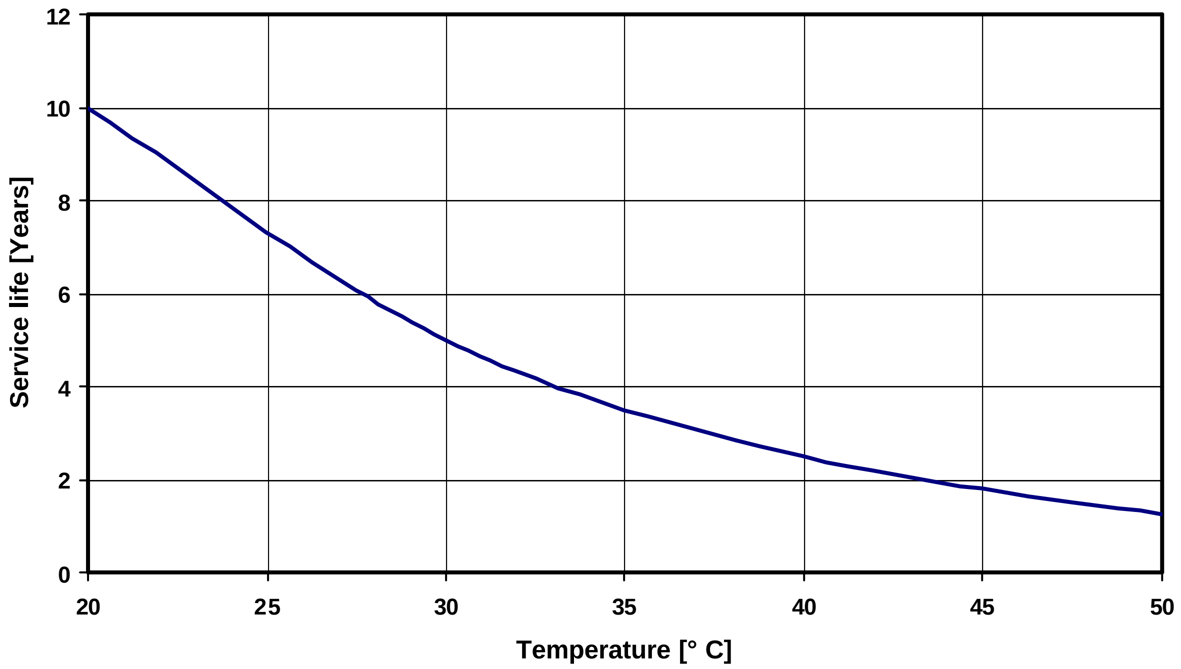


Fig. 21: A 400, Service Life vs. Temperature (following law of "Arrhenius"). Equivalent graphs can be established for A 500 and A 700 based on 6 and 12 years, respectively, at 20° C. The equivalents for SOLAR and SOLAR BLOCK regarding number of cycles (years at 20° C = 100% number of cycles.

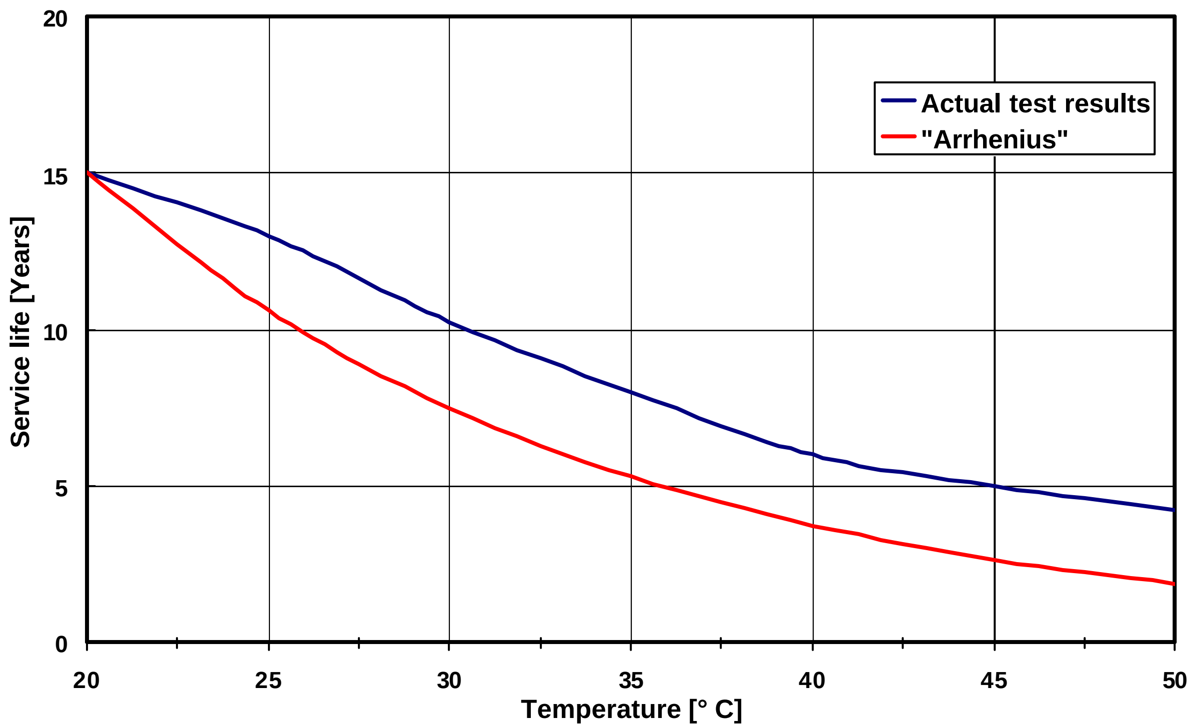


Fig. 22: A 600, Service Life vs. Temperature. A 600 follows the blue curve. The equivalent for A 600 SOLAR regarding number of cycles (15 years at 20° C = 100% number of cycles).

6.9 Inspections and Maintenance

6.9.1 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 / monoblocs 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" 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 / blocs (approx. 20%)
  - Surface temperature of several cells / blocs
  - Battery- room temperature

  If the cell / bloc voltages differ from the average float charge voltage by more than a specified +/- tolerance as stated in fig. 6 to 8 or if the surface temperature difference between cells / blocs exceeds 5 K, the service agent should be contacted.

In addition, annual measurement and recording:

- Voltage of all cells / blocs
- Surface temperature of all cells / blocs
- Battery- room temperature

Annual visual checks:

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

6.9.2 “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 monoblocs. For more information, see also /10/ and /11/.

- The following guideline can be used for 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 blocs 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:

1. If impedance/conductance values of blocs 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.
2. If impedance/conductance values of blocs 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.
3. If no initial values are measured for a battery method 2 can be applied only.

*) 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 positive (impedance lower or conductance higher) deviations 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 bloc or cell is changed based on impedance/conductance measurement and returned to the manufacturer for investigation we strongly recommend to write the measured value with permanent ink on the bloc or cell.

7. RECYCLING

Lead-acid batteries are recyclable products. Recognizing the need to be involved in the whole lifecycle of a battery and to protect the environment, EXIDE Technologies' factories recycle used lead. Contact your EXIDE Technologies representative who will advise you on this matter.

8. LIST OF REFERENCES

/1/ European standard EN 50272-2 "Safety requirements for secondary batteries and battery installations, Part 2: Stationary batteries", June 2001

/2/ European standard EN 50091-1 "Uninterruptible power systems (UPS); Part 1: General and safety requirements", 1993

/3/ International standard IEC 896-2 "Stationary lead-acid batteries – General requirements and methods of test - Part 2: Valve regulated types"

/4/ International standard (Draft, second edition 2002) IEC 60896-21 "Stationary Lead-Acid Batteries, Part 2: Valve Regulated Types, Section 1: Functional characteristics and methods of test"

/5/ "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"

/6/ B. A. Cole, R. J. Schmitt, J. Szymborski (GNB Technologies): "Operational Characteristics of VRLA Batteries Configured in Parallel Strings", proceedings INTELEC 1998

/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 IEEE P1013/D3: "IEEE Recommended Practice for Sizing Lead-Acid Batteries for Photovoltaic (PV) Systems", draft April 1997

/9/ International standard IEC 61427 “Secondary Cells and Batteries for Solar Photovoltaic Energy Systems, - General Requirements and Methods of Test”, draft (IEC 21/548/CD: 2001)

/10/ B. A. Cole, R. J. Schmitt (GNB Technologies): “A Guideline for the Interpretation of Battery Diagnostic Readings in the Real World”, Battconn ’99

/11/ PPT-Presentation “Monitoring” (Exide Technologies, GCS), October 2002

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Appendix A 1

Battery Rooms, Ventilation, Installations

General: This is a guideline only and consists of excerpts from national and international standards and guidelines. See EN 50 272-2 and equivalent national standards (for instance, DIN VDE 0510-1) for further and more detailed information. Also, follow up "Operating Instructions" and "Installation Instructions".

1. Temperature

The battery room temperature should be between + 5° C and + 30° C. Optimal temperature is the nominal temperature 20° C (or 25° C, respectively, for American products).
The maximum temperature difference between cells or blocs, respectively, within a string must not exceed 5 degree C (Kelvin, K).

2. Room Dimensions and Floors

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 50 272-2: "…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

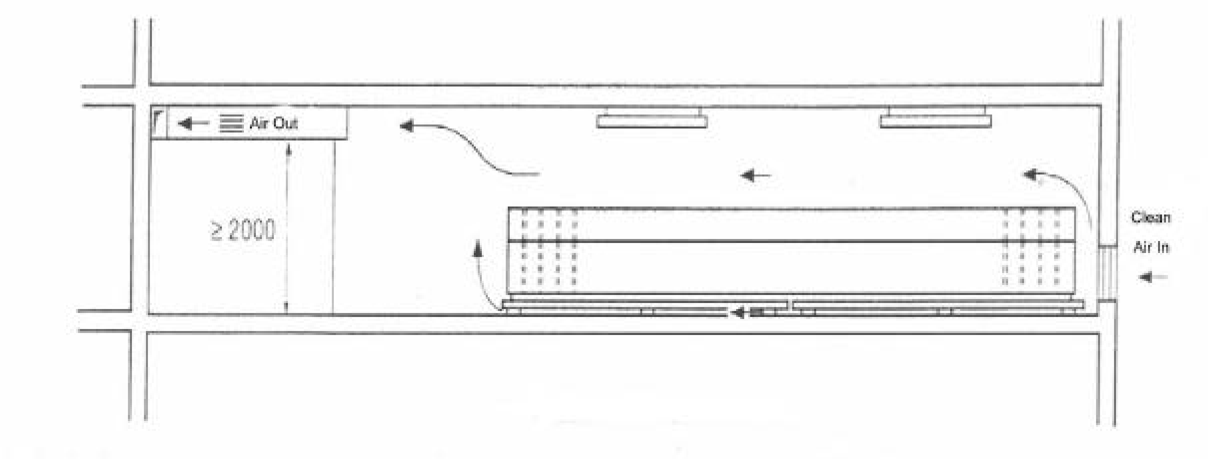
for battery nominal voltage ≤ 500 V: $50\ k\Omega \le R \le 10\ M\Omega$
for battery nominal voltage > 500 V: $100\ k\Omega \le R \le 10\ M\Omega$

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 50 272-2, if inlet and outlet are located on the same wall.



3. Ventilation

Battery rooms must be vented acc. to EN 50 272-2 in order to dilute gas (hydrogen and oxygen) evolved with charging and discharging and to avoid explosions. Therefore, the electrical installation must not be "EX" protected. 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 bloc openings (respectively valves) as specified in EN 50272-2.

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.

3.1. Ventilation requirements

From EN 50 272-2: „ …The minimum air flow rate for ventilation of a battery location or compartment shall be calculated by the following formula…:

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

With n = number of cells

I_{gas} = $I_{float\ or\ boost}$ [mA/Ah] relevant for calculation (see Table 1)

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 $\mathbf{I_{gas}}$ to be used:

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

Table 1: $\mathbf{I_{gas}}$ acc. to EN 50 272-2 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:

$$\mathbf{A\ ^{3}\ 28 \times Q\ [cm^2]}$$

(Air convection speed ≥ 0.1 m/s)

Example 1:

Given: 220 V battery, 110 cells, C_{10} = 400 Ah, vented type, Antimony (Sb) < 3 % (LA) in Float service

Calculation of fresh air necessary:

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

With n = 110
I_{gas} = 5 (see table 1)
C_{rt} = 400

$Q = 11\ m^3/h$ **$A\ ^{3}\ 308\ cm^2$**

Example 2:

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

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

$Q = 2.2\ m^3/h$ **$A\ ^{3}\ 62\ cm^2$**

Note: A calculation program is available on request.

3.2 Close vicinity to the battery

From EN 50 272: „…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:

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

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

Example 3:

Cell, vented type, one vent, 100 Ah. Float charge → I_{gas} = 5 (acc. to table 1).

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

Example 4:

12V-monobloc, **six cells, one opening in the top cover**, vented type, 100 Ah,
Float charge → I_{gas} = 5 (acc. to table 1).

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

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

Example 5:

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 6:

Cell, vented type, one vent, 1500 Ah. Boost charge → I_{gas} = 20 (acc. to table 1)

Safety distance d = 28.8 · 1 · 2.71 · 11.45 = 893.6 mm → 895 mm

Example 7:

Cell, vented type, three vents, 3000 Ah. Boost charge → I_{gas} = 20 (acc. to table 1)

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

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

4. Electrical Requirements (protection, insulation, resistance etc.)

To prevent a build-up of static electricity when handling batteries, clothing/materials, 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 50 272-2: "…The minimum insulation resistance between the battery's circuit and other local conductive parts should be greater 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). 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 do not apply.

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

> NOTE: Breakers are not necessary in case of small load power (≤ 30 W) if the nominal voltage does not exceed 12 V. Precautions must be taken to avoid fires in case of failures.

Insulation is necessary or a distance of at least 10 mm for ≥ 24 V potential difference to avoid parasitic currents (fire protection !).

5. Installation (racks, cabinets)

Batteries shall be installed in clean, dry locations. Batteries must be secured against dropping items and dirt.

The course width between battery rows is equal to 1.5 times the cell depth (replacement) but minimum 600 mm (acc. to EN 50 272-2).

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 blocs (of VRLA type) is 10 mm. At least 5mm are requested acc. to EN 50272-2 (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 be easy assessable and must allow service with normal insulated tools (EN 50272-2).

CE symbol : Any battery with a nominal voltage greater than 75 V requires an EC declaration of conformity in accordance with the low-voltage directive with the proper CE symbol for the battery. The installer of the battery system is responsible for the issue of the declaration and attachment of the CE symbol.

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.

Appendix A 2: Charging Time vs. Voltage and Current (see also fig. 9, 10)

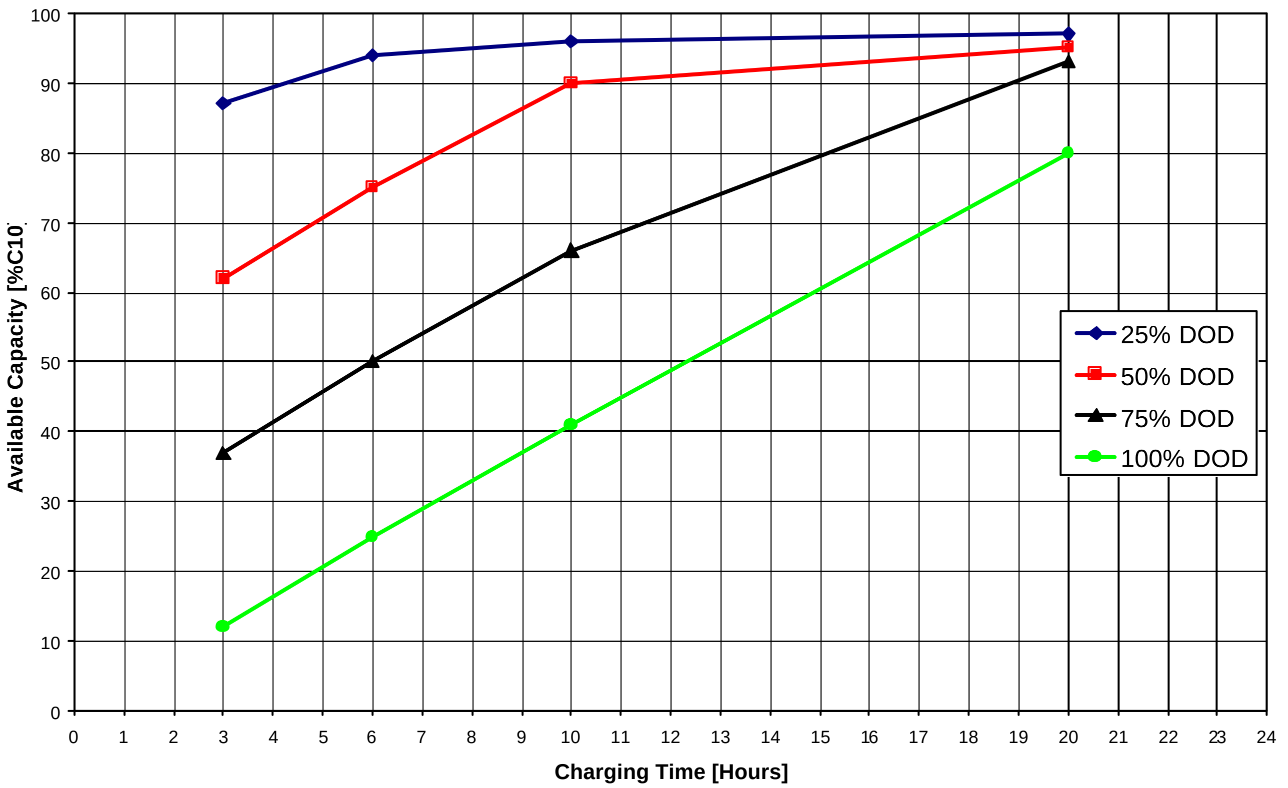


Fig. 23: Re-charging at 2.25 Vpc and 0.5 * I_{10}

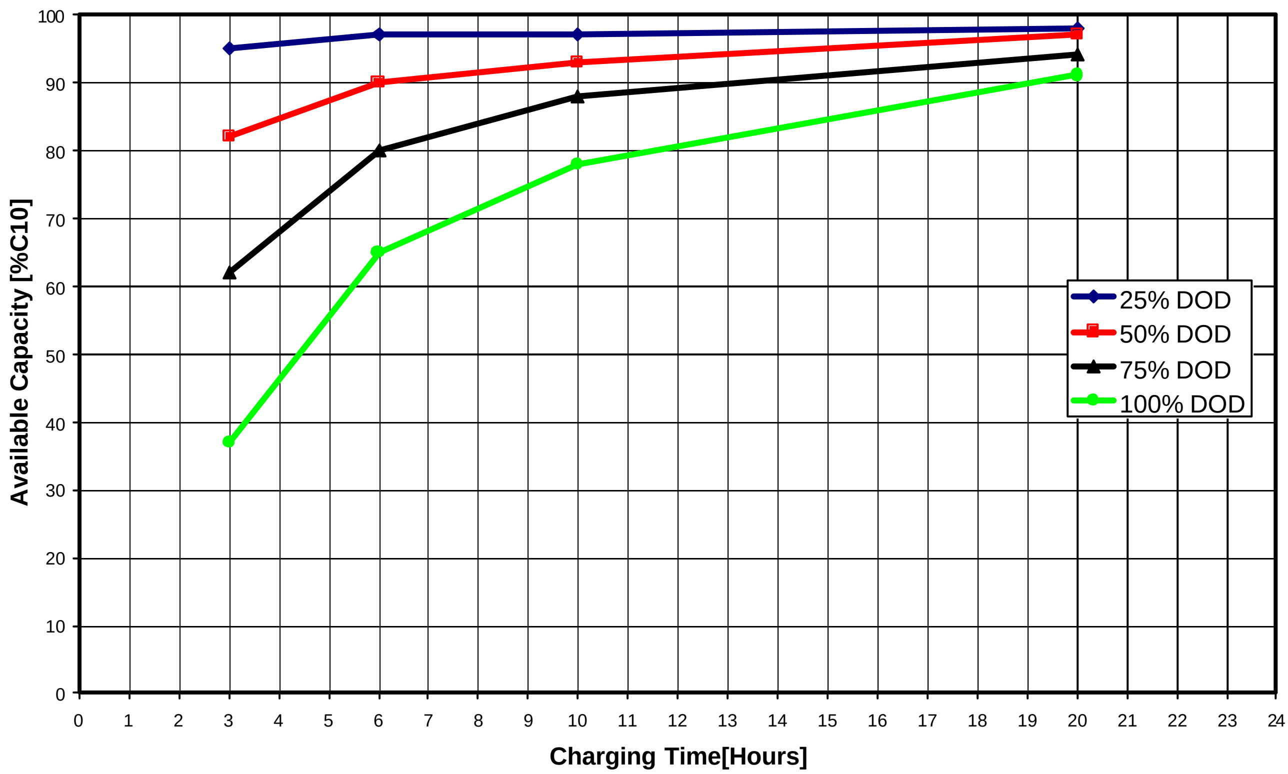


Fig. 24: Re-charging at 2.25 Vpc and 1.5 * I_{10}

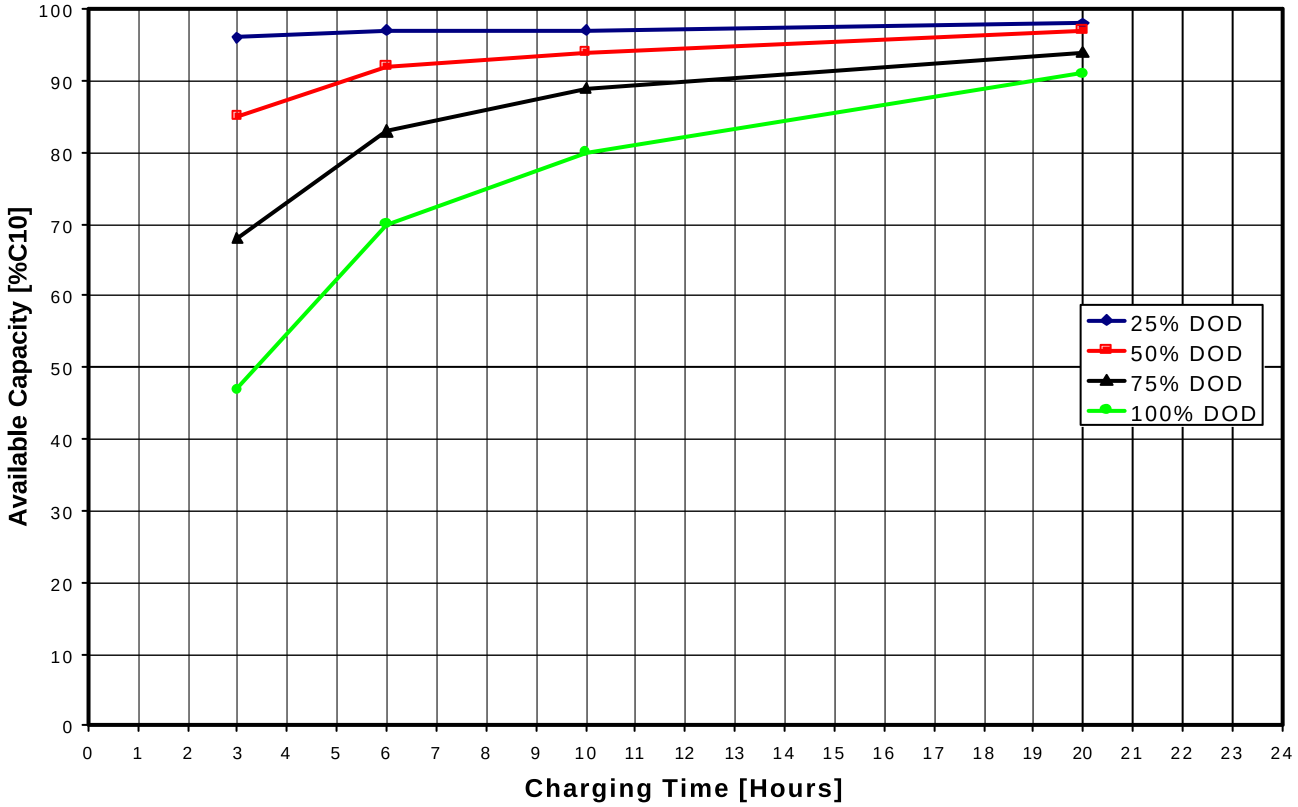


Fig. 25: Re-charging at 2.25 Vpc and 2 * I_{10}

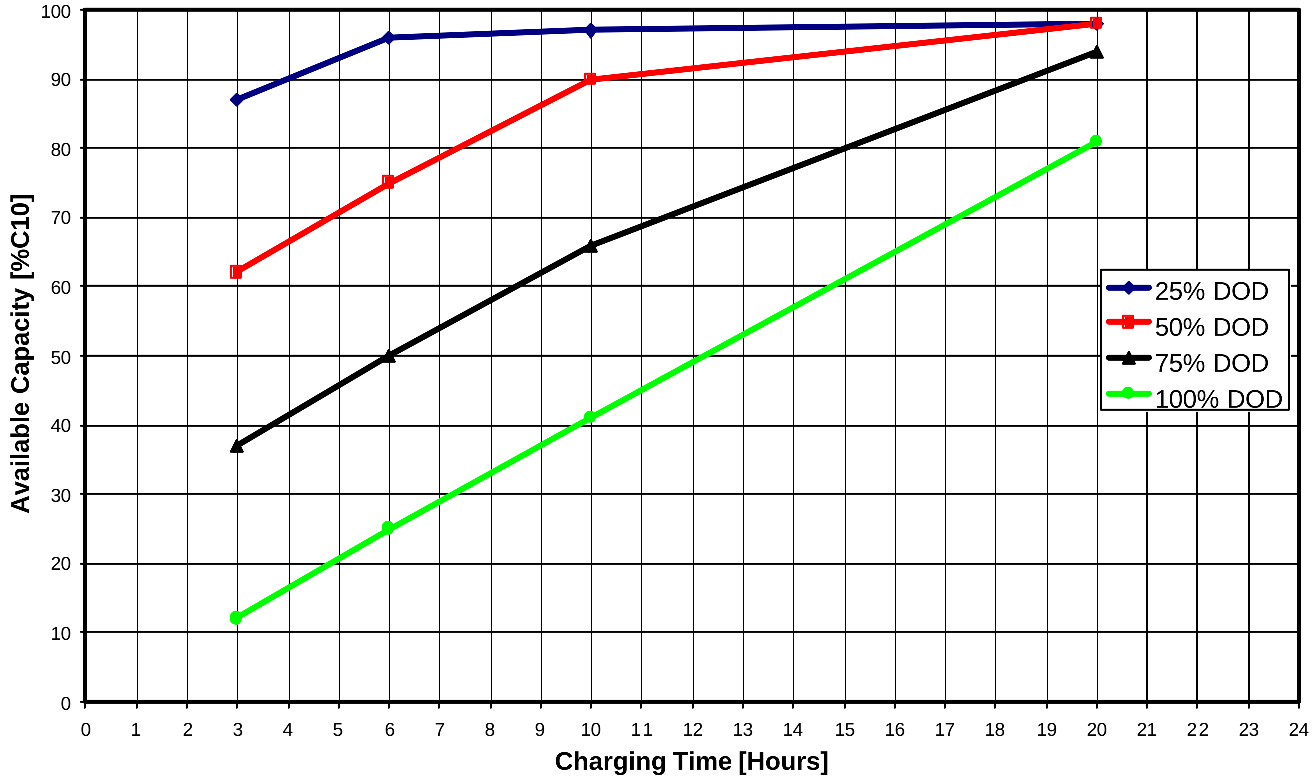


Fig. 26: Re-charging at 2.30 Vpc and 0.5 * I_{10}

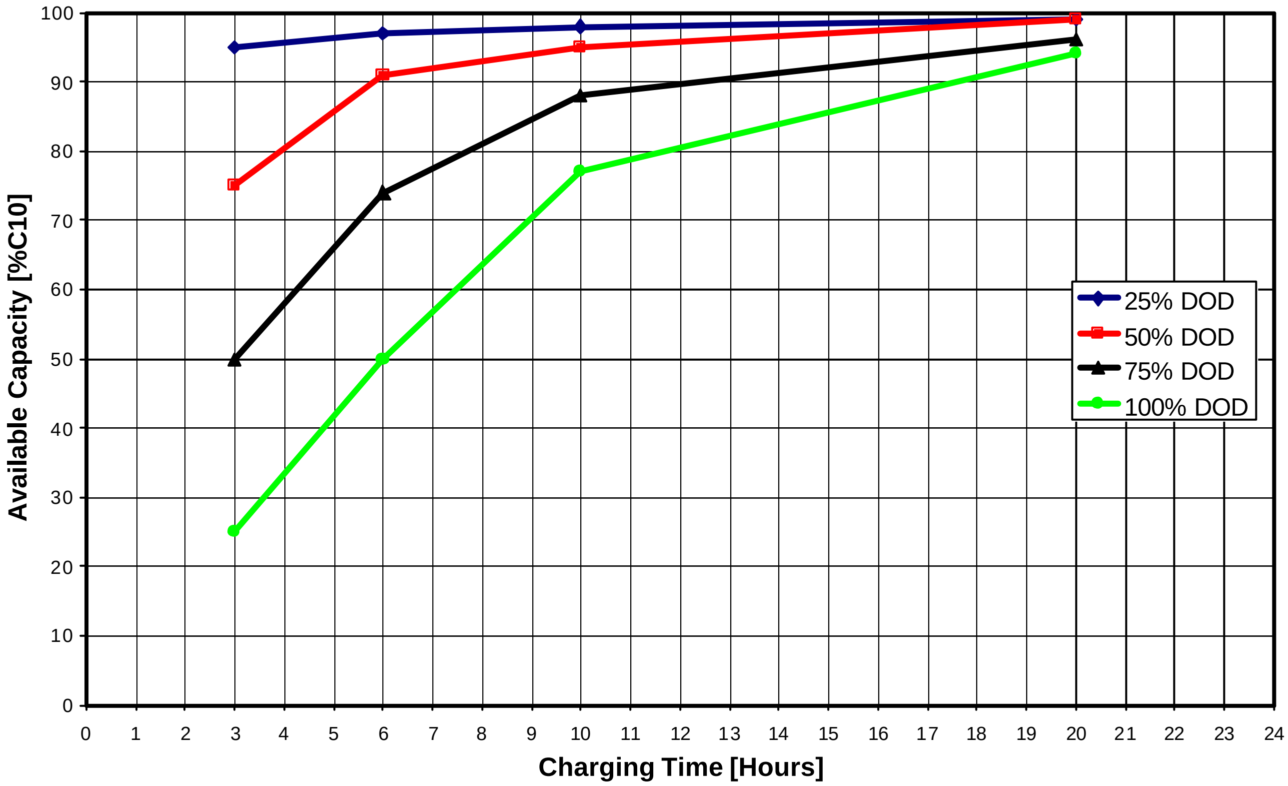


Fig. 27: Re-charging at 2.30 Vpc and 1 * I_{10}

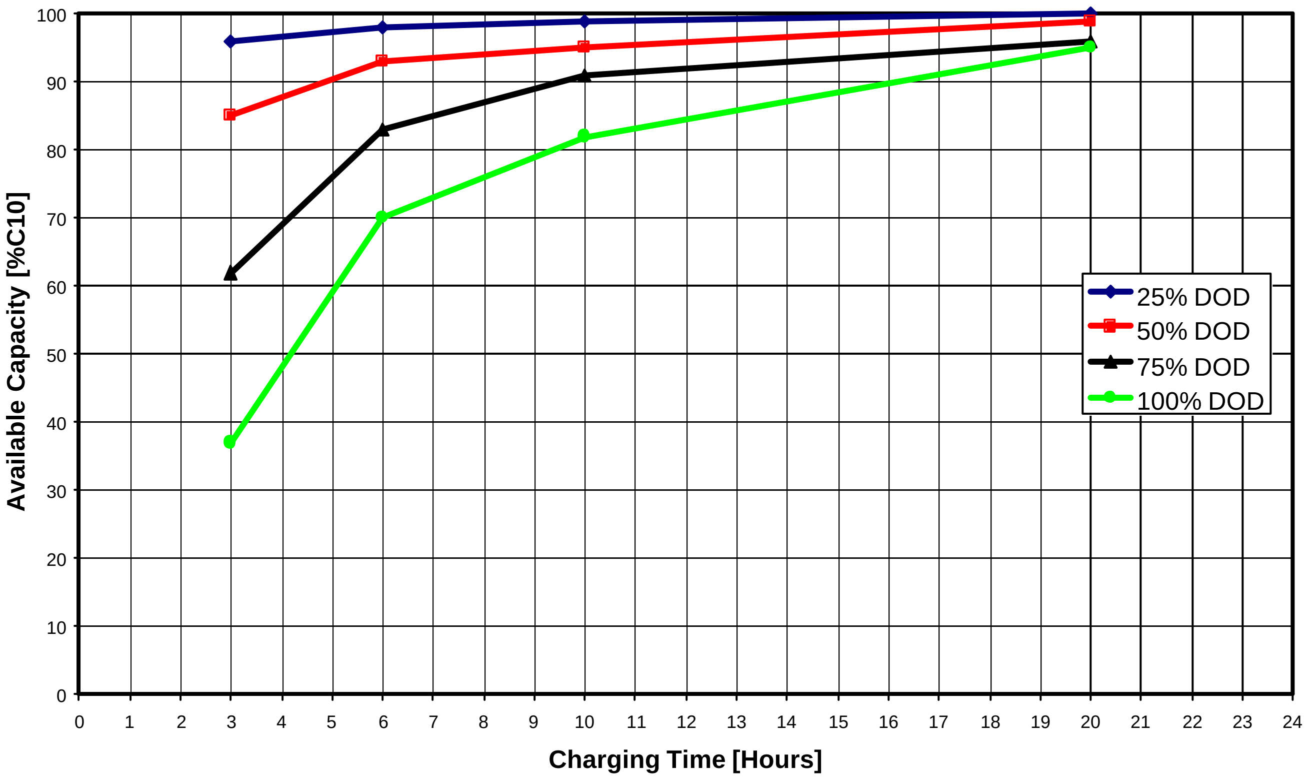


Fig. 28: Re- charging at 2.30 Vpc and 1.5 * I_{10}

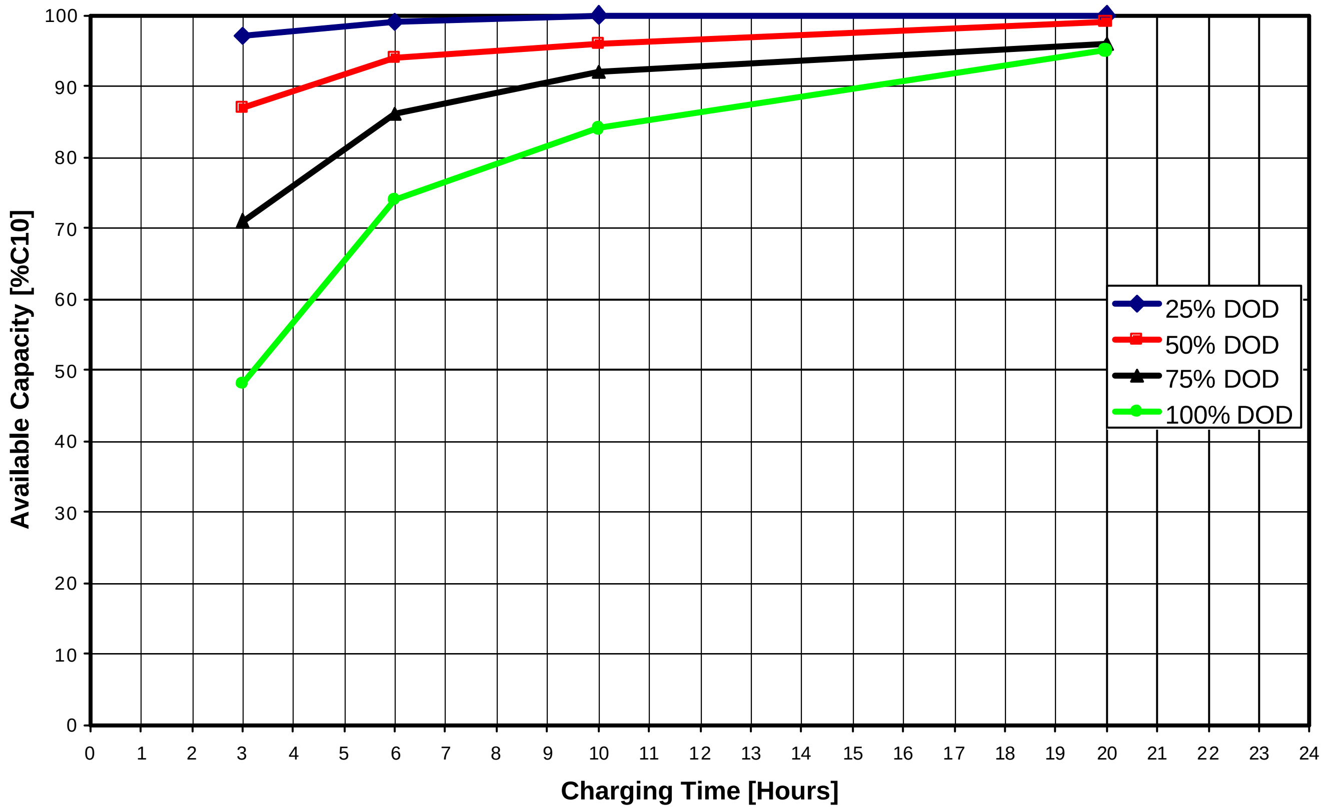


Fig. 29: Re-charging at 2.30 Vpc and 2 * I_{10}

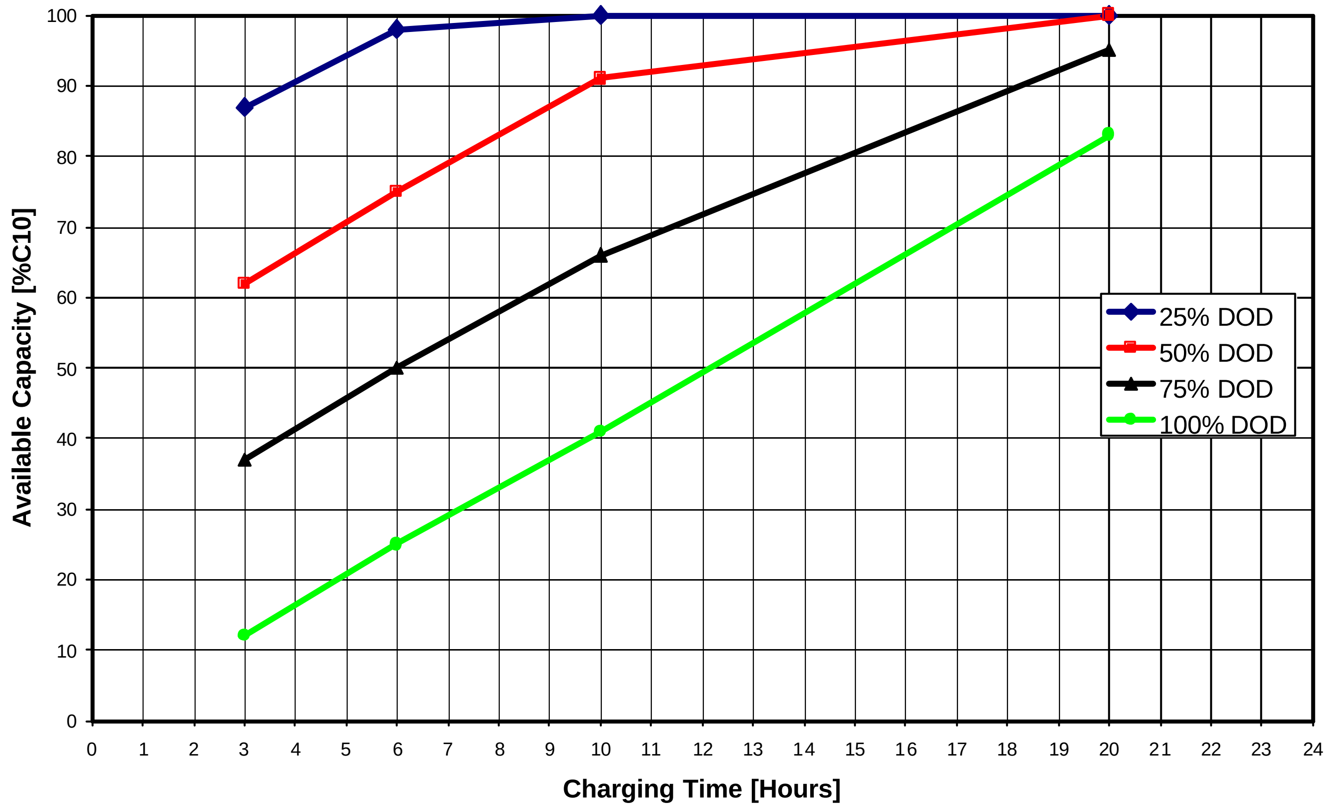


Fig. 30: Re-charging at 2.40 Vpc and 0.5 * I_{10}

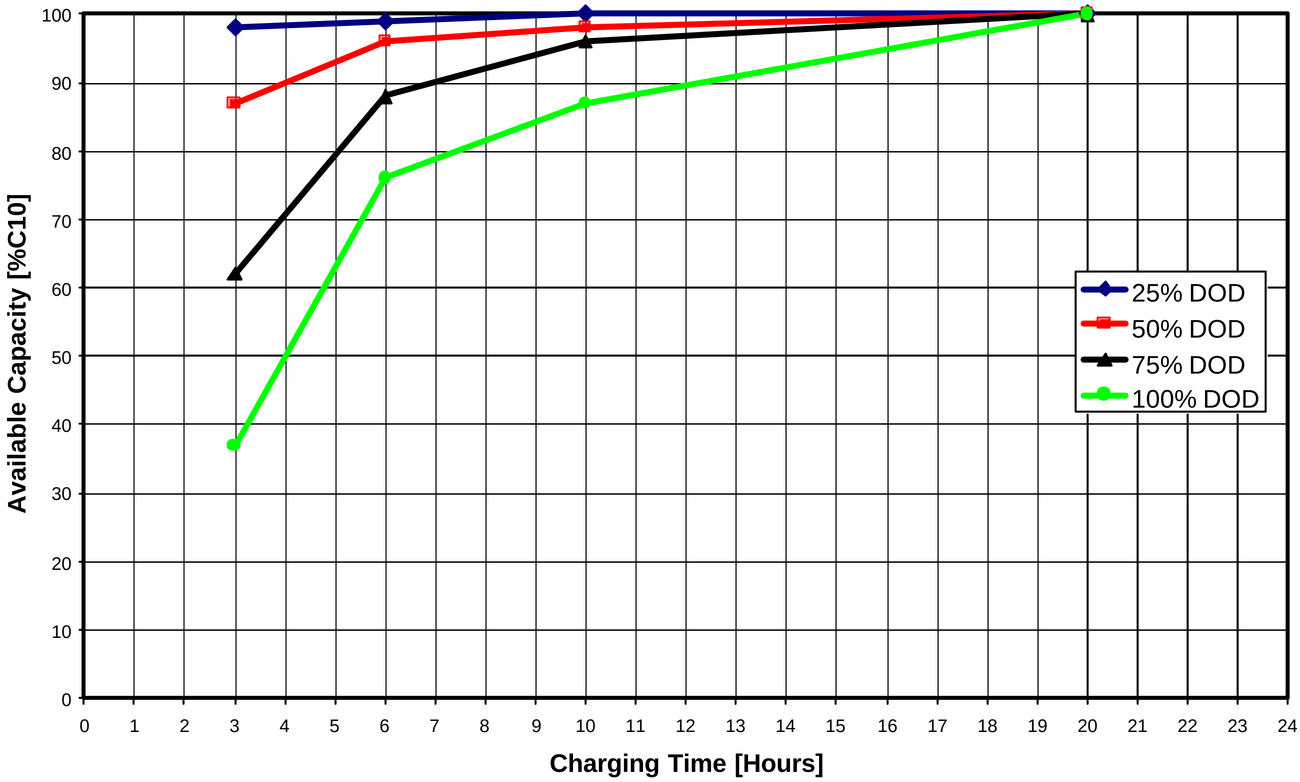


Fig. 31: Re-charging at 2.40 Vpc and 1.5 * I_{10}

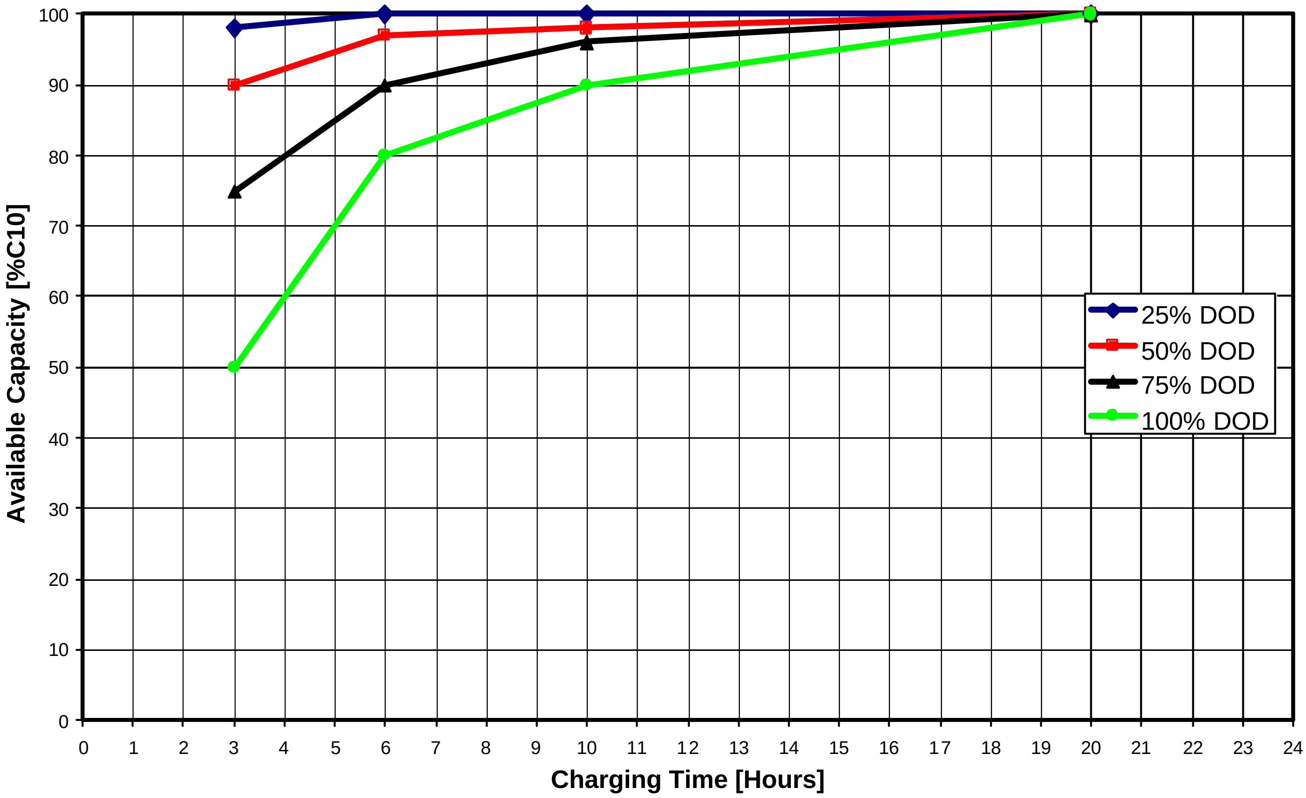


Fig. 32: Re-charging at 2.40 Vpc and 2 * I_{10}

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: Dec. 2003

APPENDIX 3: Instructions

"Installation Instruction"
"Operating Instruction-Stationary valve regulated lead acid batteries
"Operating Instruction…SOLAR, SOLAR BLOCK, A 600 SOLAR"

35 0 35340 10

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

	• Observe these instructions and keep them located nearby 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. • Risc 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, DIN VDE 0510, VDE 0105 Part 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 shortcircuits. Caution! Metal parts of the battery are always alive, therefore do not place items or tools on the battery.
	• Electrolyte is very corrosive. In normal working conditions the contact with the electrolyte 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!

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 for fully charged cells at an electrolyte temperature of 20 °C are as follows:

OPzS-cells	DIN 40736	2.08±0.01 [Vpc]
OPzS-monobloc batt.	DIN 40737	2.08±0.01 [Vpc]
OCSM-cells		2.10±0.01 [Vpc]
GroE-cells	DIN 40738	2.06±0.01 [Vpc]
OGi-monobloc batteries		2.10±0.01 [Vpc]
OGi-cells		2.10±0.01 [Vpc]
OGiV-monobloc batt.	DIN 40741, part 1	2.10±0.01 [Vpc]
Other OGiV-monobloc batteries	Depending on construction	2.08–2.14* [Vpc]
OPzV-cells	DIN 40742 (draft)	2.08–2.14* [Vpc]
OPzV-monobloc batt.	DIN 40744 (draft)	2.08–2.14* [Vpc]

* according to manufacturer's information

The open-circuit voltage of the individual cells must not vary from each other by more than 0.02 V. With regard to monobloc batteries, the maximum deviations of the open-circuit voltage are as follows:

4 V monobloc batteries	0.03 V/bloc
6 V monobloc batteries	0.04 V/bloc
12 V monobloc batteries	0.05 V/bloc

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 <u>non-insulated</u> 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. 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 sealed) 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 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.

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issued: April 2002

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/blocs and technical data in these instructions)
- Nominal discharge current $I_N = I_{10}$; I_{20} : C_N / 10 h; C_N / 20h
- 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 nearby 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, DIN VDE 0510, VDE 0105 Part 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 the contact with electrolyte 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/monoblocs 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, repairs made with other than original parts, or repairs made without authorization (e. g. opening of valves) render the warranty void.

Pb

Disposal of Batteries
Batteries marked with the recycling symbol should be processed via a recognized recycling agency. By agreement, they might be returned to the manufacturer. Batteries must not be mixed with domestic or industrial waste.

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

Type	10-32x0.425	G-M5	M6	M8	M12	
Marathon L	--	--	6 Nm	8 Nm	25 Nm	--
Marathon M	6 Nm	--	11 Nm	--	--	--
Sprinter P	--	--	6 Nm	8 Nm	--	--
Sprinter S	--	--	11 Nm	--	--	--
Powerfit S300	--	5 Nm	6 Nm	8 Nm	--	--
Powerfit S500	--	--	6 Nm	8 Nm	--	--
	G-M5	M5	G- M6	A / M8	M8	F-M10
A400	5 Nm	--	6 Nm	8 Nm	--	20 Nm
A500	5 Nm	--	6 Nm	8 Nm	--	--
A600	--	--	--	--	20 Nm	--
A700	--	6 Nm	--	--	20 Nm	--

All torques apply with a tolerance of ± 1 Nm

Table 1: Terminal torque

1. Start Up
Check all cells/blocs 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 DIN VDE 0510 part1 (draft) and 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 DIN VDE 0510 part 1, draft) 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	Nominal Temp.
Marathon L	2.27 Vpc	20°C
Marathon M	2.27 Vpc	25°C
Sprinter P	2.27 Vpc	25°C
Sprinter S	2.27 Vpc	25°C
Powerfit S300	2.27 Vpc	20°C
Powerfit S500	2.27 Vpc	20°C
A400	2.27 Vpc	20°C
A500	2.30 Vpc	20°C
A600	2.25 Vpc	20°C
A700	2.25 Vpc	20°C

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).

	Voltage on boost charge stage	Nominal Temp.
Marathon L	2.33-2.40 Vpc	20°C
Marathon M	2.33-2.40 Vpc	25°C
Sprinter P	2.33-2.40 Vpc	25°C
Sprinter S	2.33-2.40 Vpc	25°C
Powerfit S300	2.33-2.40 Vpc	20°C
Powerfit S500	2.33-2.40 Vpc	20°C
A400	2.33-2.40 Vpc	20°C
A500	2.35-2.45 Vpc	20°C
A600	2.33-2.40 Vpc	20°C
A700	2.33-2.40 Vpc	20°C

Table 3: Voltage on boost charging stage

Automatic change over to charging voltage **acc. to table 2** should be applied.

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	Nominal temp.
Marathon L	2.27 Vpc	20°C
Marathon M	2.29-2.33 Vpc	25°C
Sprinter P	2.30 Vpc	25°C
Sprinter S	2.29-2.33 Vpc	25°C
Powerfit S300	2.27 Vpc	20°C
Powerfit S500	2.27 Vpc	20°C
A400	2.27 Vpc	20°C
A500	2.30-2.35 Vpc	20°C
A600	2.27-2.30 Vpc	20°C
A700	2.27-2.30 Vpc	20°C

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 5** (max. values). The charging process must be monitored. If the charge current reduces to less than 1.5A/100Ah with the values given in table 5 the mode switches to float charge acc. to item 2.3 (switches after reaching value acc to table 5).

	Max. switch-mode voltage	Nominal Temp.
Marathon L	2.35 Vpc	20°C
Marathon M	2.40 Vpc	25°C
Sprinter P	2.35 Vpc	25°C
Sprinter S	2.40 Vpc	25°C
Powerfit S300	2.35 Vpc	20°C
Powerfit S500	2.35 Vpc	20°C
A400	2.35 Vpc	20°C
A500	2.45 Vpc	20°C
A600	2.35 Vpc	20°C
A700	2.35 Vpc	20°C

Table 5: Switch-mode operation charge voltage (max. values)

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 have to be carried out **acc. to table 6** for up to 48 hours as follows:
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.

	Max. equalizing charge voltage	Max. charge current
Marathon L	2.40 Vpc	20A/100Ah
Marathon M	2.40 Vpc	35A/100Ah
Sprinter P	2.40 Vpc	20A/100Ah
Sprinter S	2.40 Vpc	35A/100Ah
Powerfit S300	2.40 Vpc	20A/100Ah
Powerfit S500	2.40 Vpc	20A/100Ah
A400	2.40 Vpc	35A/100Ah
A500	2.45 Vpc	35A/100Ah
A600	2.40 Vpc	35A/100Ah
A700	2.40 Vpc	35A/100Ah

Table 6: Equalizing charge voltage (max. values)

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 7** (guide values).

	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 S300	10 to 30 A per 100Ah
Powerfit S500	10 to 30 A per 100Ah
A400	10 to 35 A per 100Ah
A500	10 to 35 A per 100Ah
A600	10 to 35 A per 100Ah
A700	10 to 35 A per 100Ah

Table 7: Charging currents

2.7 Temperature

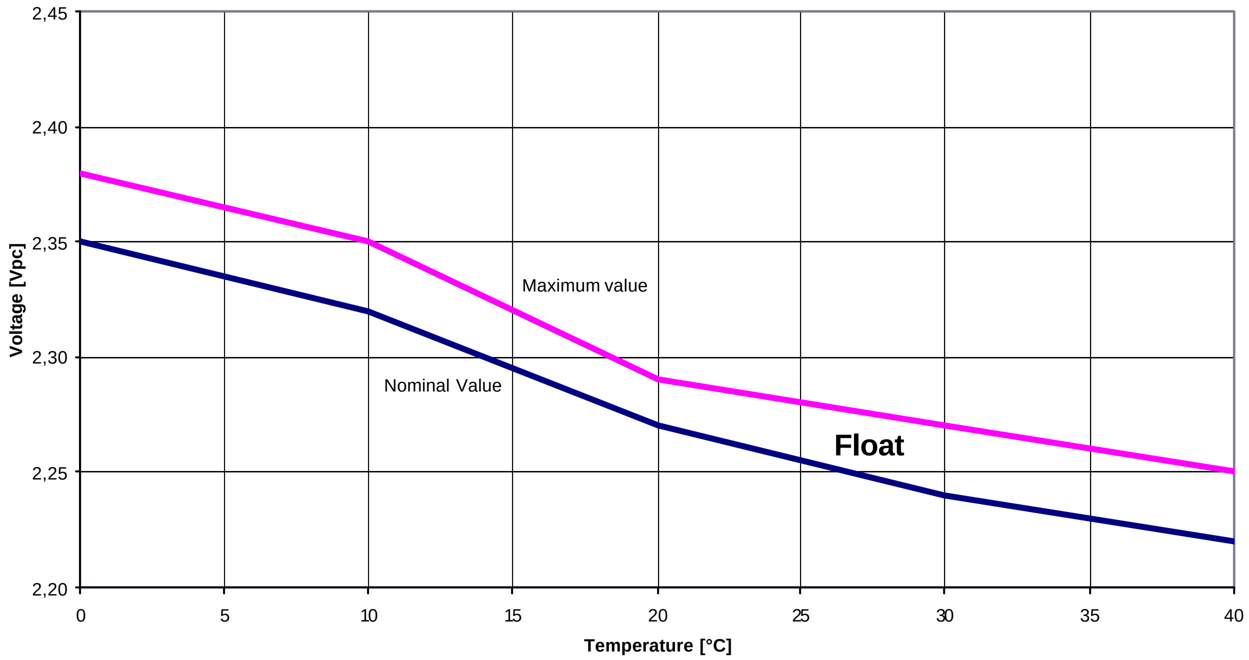
The recommended operation temperature range for lead acid batteries is 10°C to 30°C (best nominal temperature ± 5K). Higher temperatures will seriously reduce service life. Lower temperatures reduce the available capacity.
The absolute maximum temperature is 55°C and should not exceed 45°C in service.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

2.8 Temperature related charge voltage

The temperature correction factor has to be applied **acc. to the following figures.**
A temperature related adjustment of the charge voltage must not be applied within a specified temperature range (**see table 8**).
If the operation temperature is constantly outside this range, the charge voltage has to be adjusted.

	No temp. correction to be applied
Marathon L	---
Marathon M	---
Sprinter P	---
Sprinter S	---
Powerfit S300	---
Powerfit S500	---
A400	15°C to 35°C
A500	15°C to 35°C
A600	15°C to 35°C
A700	15°C to 35°C

Table 8: No Temperature correction



The charging voltage should be set to the nominal value, the maximum value must not be exceeded

Fig. 1: Marathon L, Sprinter P and Powerfit S; Charging Voltage vs. Temperature

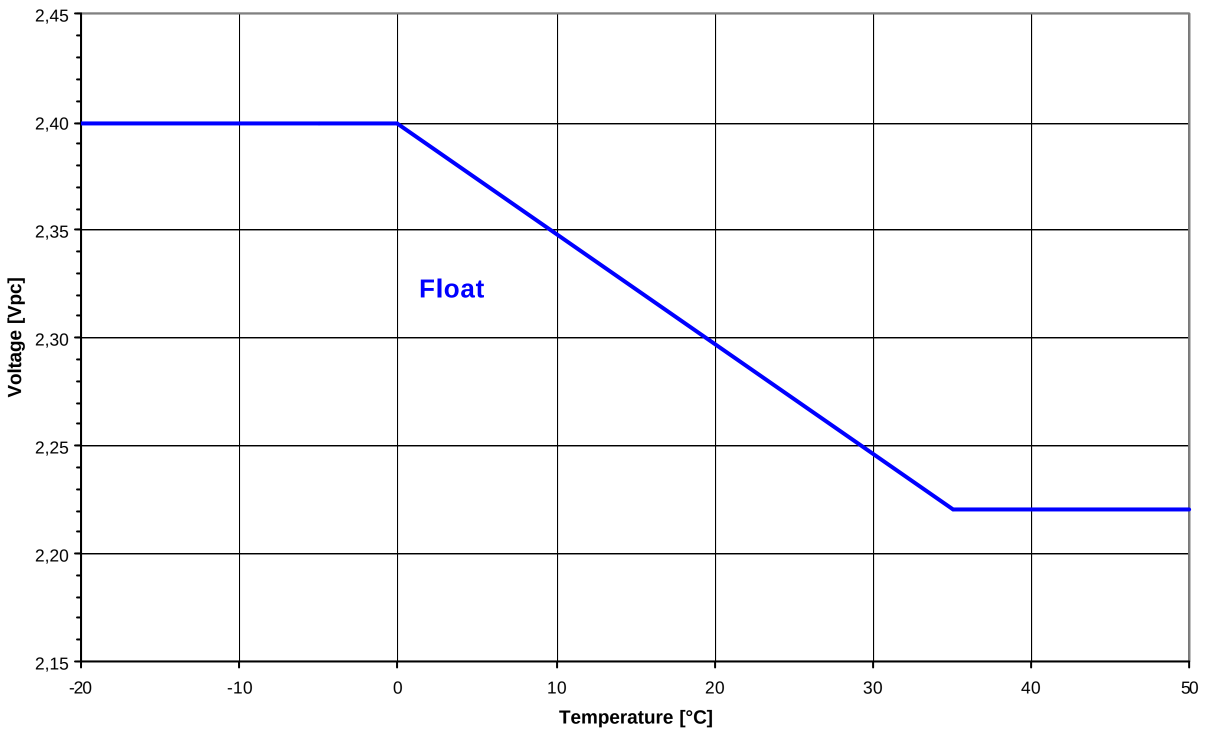


Fig. 2: Marathon M, Sprinter S; Charging Voltage vs. Temperature

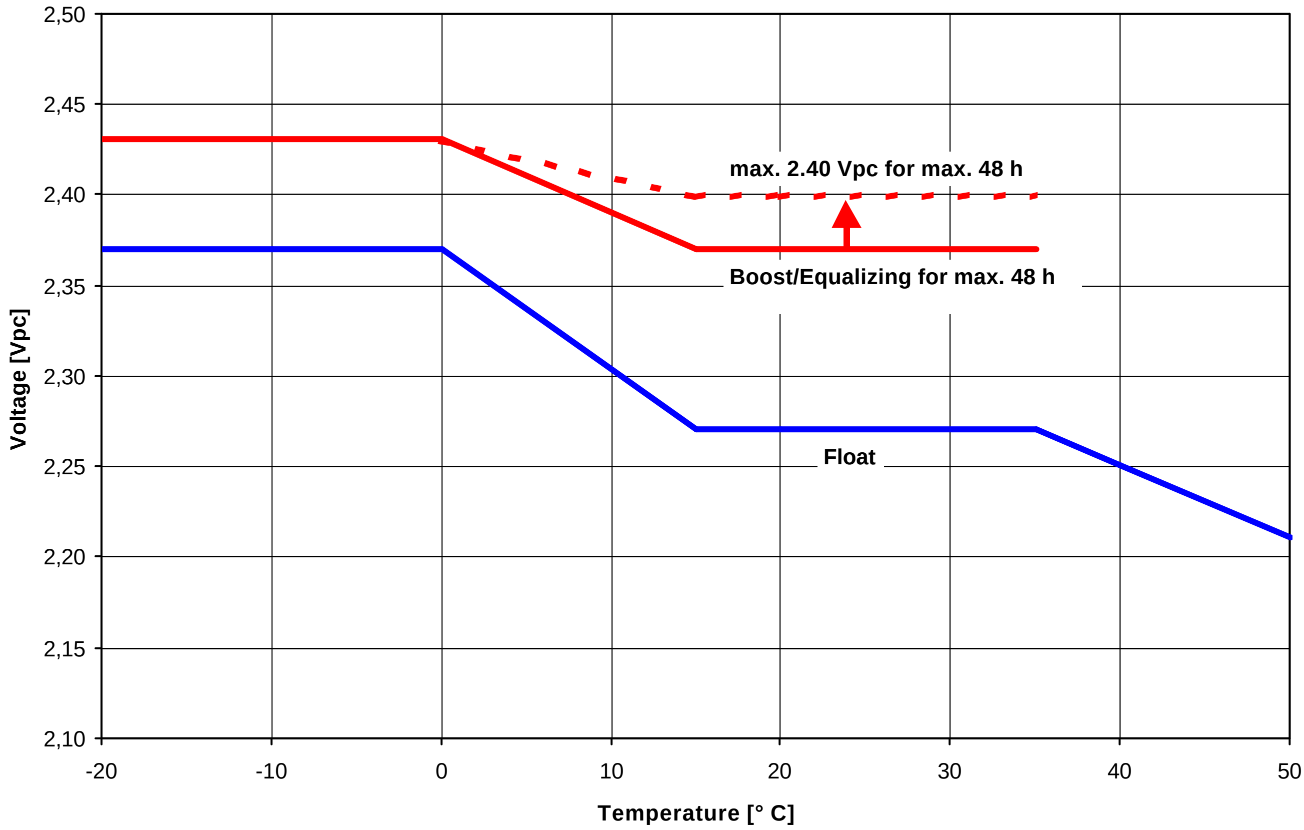


Fig. 3: A 400; Charging Voltage vs. Temperature

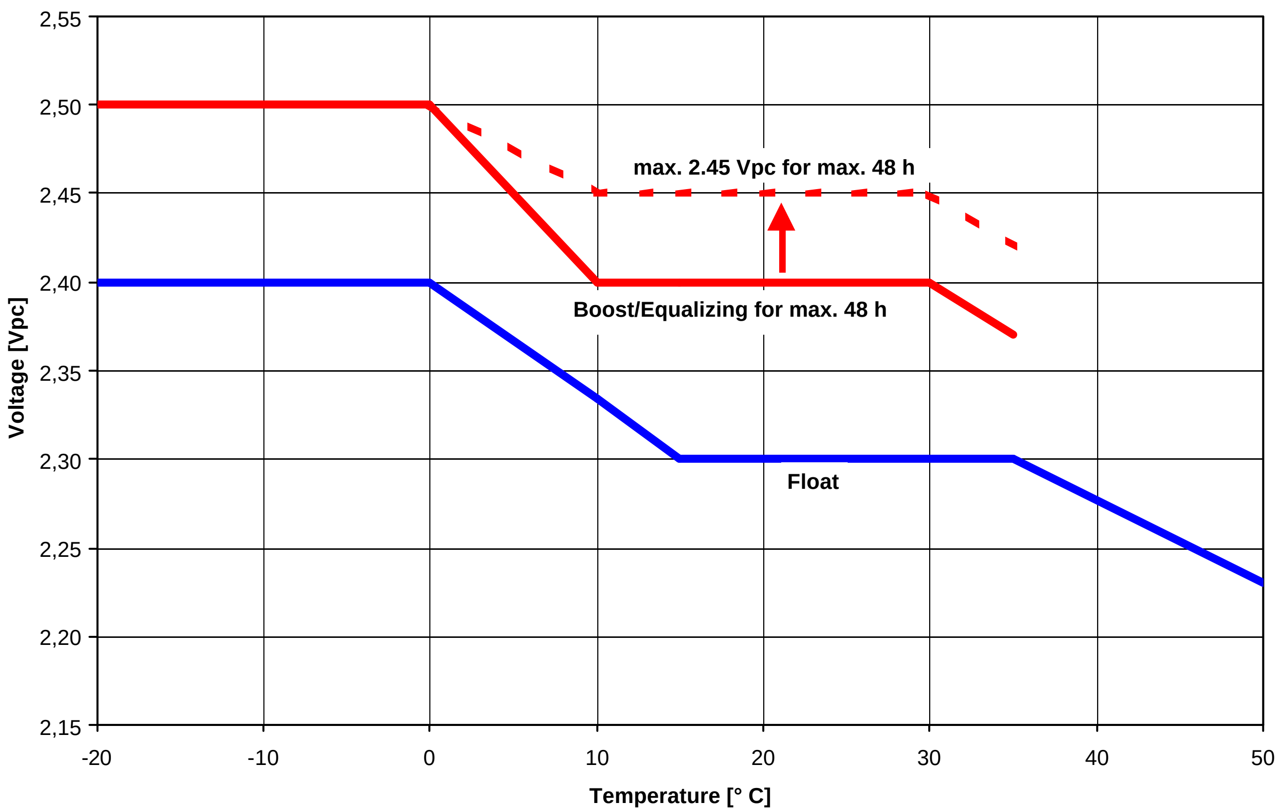


Fig. 4: A 500; Charging Voltage vs. Temperature

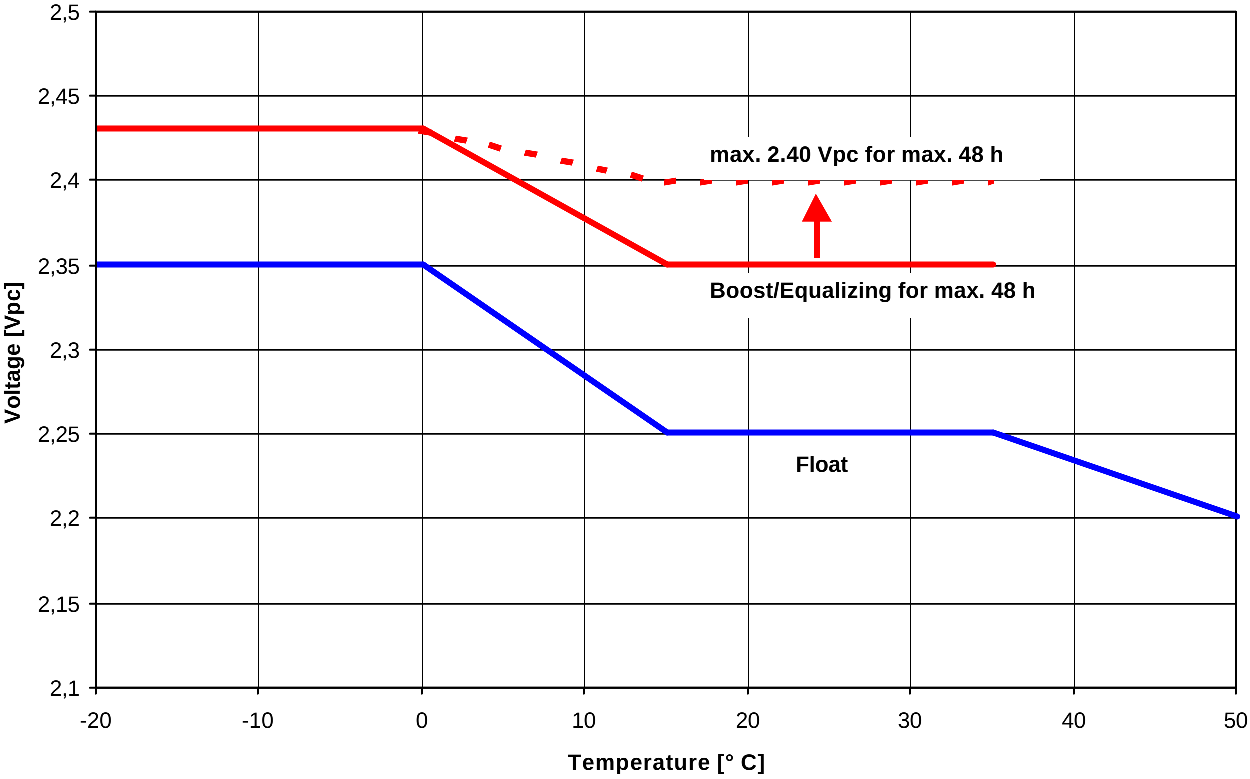


Fig. 5: A 600, A 700; Charging Voltage vs. Temperature

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. 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
- Voltage of several cells/blocs
- Surface temperature of several cells/blocs
- Battery-room temperature

If the cell voltage differs from the average float charge voltage by more than the values in given in **table 9**, or if the surface temperature difference between cells / monoblocs exceeds 5K, the service agent should be contacted.

Annual measurement and recording:
- Voltage of all cells / blocs
- Surface temperature of all cells/blocs
- Battery-room temperature
- Insulation-resistance acc. to DIN 43539 part1

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 896-2, DIN 43539 part 1 and 100 (draft). Special instructions like DIN VDE 0107 and DIN VDE 0108 have to be observed.

Capacity test
Capacity test (for instance, acceptance test on site): In order to make sure the battery is fully charged, the following IU-charge methods can be applied. For different types see **table 10**

The current available to the battery must be between 10A /100Ah and 35A/ 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 our agent.

6. Storage and taking out of operation
To store or decommission cells/blocs for a longer period of time they should be fully charged and stored in a dry frost-free room. To avoid damage the following charging-methods can be chosen:
1. Annual equalizing-charge acc. to 2.4. in average ambient temperatures of more than 20°C shorter intervals may be necessary.
2. Float charging as detailed in 2.3.

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

	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 S300	--	--	+0.35/-0.17	--	+0.49/-0.24
Powerfit S500	--	--	+0.35/-0.17	--	+0.49/-0.24
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 9: Criteria for voltage measurements

	Option 1	Option2
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 S300	2.27 Vpc ≥ 48 hours	2.40 Vpc ≥ 16 h (max. 48h) followed by 2.27 Vpc ≥ 8h
Powerfit S500	2.27 Vpc ≥ 48 hours	2.40 Vpc ≥ 16 h (max. 48h) followed by 2.27 Vpc ≥ 8h
A400	2.27 Vpc ≥ 48 hours	2.40 Vpc ≥ 16 h (max. 48h) followed by 2.27 Vpc ≥ 8h
A500	2.30 Vpc ≥ 48 hours	2.40 Vpc ≥ 16 h (max. 48h) followed by 2.30 Vpc ≥ 8h
A600	2.25 Vpc ≥ 72 hours	2.40 Vpc ≥ 16 h (max. 48h) followed by 2.25 Vpc ≥ 8h
A700	2.25 Vpc ≥ 48 hours	2.40 Vpc ≥ 16 h (max. 48h) followed by 2.25 Vpc ≥ 8h

Table 10: Preparation for capacity test

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 bloc 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 bloc battery type acc. to **table11**
c1 = Coefficient for actual free volume inside the cabinet acc. to **table 12**
c2 = Coefficient for actual battery temperature acc. to table 2
c3 = Coefficient for actual numbers of blocs in total

Therefore, it is possible to calculate using the tables 11 and 12 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

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

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

Battery bloc type	Nominal voltage [V]	C10 [Ah], 1.80 Vpc, 20° C	Constant k
M12V45	12	45	**1842**
M12V90FT	12	85	**1324**
M12V105FT	12	100	**1107**
M12V125FT	12	121	**930**
M12V155FT	12	150	**750**
M6V200	6	200	**873**
S12V500	12	130	**648**
A 412/26 FT	12	26	**2999**
A 412/37 FT	12	37	**2107**
A 412/48 FT	12	48	**1624**
A 412/85 FT	12	85	**1048**
A 412/110 FT	12	110	**810**
A 412/85 F10	12	85	**786**

Table 11: Constant k for different bloc 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 12: 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

9.1.1. Powerfit S

Discharge time t_n	10 min	30 min	1 h	3 h	5 h	10 h	20 h
Capacity C_n [Ah]	$C_{1/6}$	$C_{1/2}$	C_1	C_3	C_5	C_{10}	C_{20}
Capacity in % of the nominal capacity C_{20}	40 %	50 %	55 %	80 %	83 %	86 %	100 %
U_f in Volt per cell	1.60	1.70	1.74	1.78	1.79	1.80	1.75

Example:
C_3 (S 512/25) = 80 % * 25 Ah = 20 Ah

All technical data refer to 20° C.

9.1.2. Sprinter P

Type	Nominal voltage [V]	15 min.-power, U_f = 1.60 V per cell [W]	Capacity C_{10}, U_f = 1.80 V per cell [Ah]
P12V570	12	570	21
P12V600	12	600	24
P12V875	12	875	41
P12V1220	12	1220	51
P12V1575	12	1575	61
P12V2130	12	2130	86
P 6V1700	6	1700	122
P 6V2030	6	2030	178

The battery is 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.

9.1.3 Sprinter S

Type	Nominal voltage [V]	C_{10} [Ah] U_f = 1.80 V per cell	Constant power [Watt per cell] U_f = 1.67 V per cell					
			5 min	10 min	15 min	30 min	60 min	90 min
S12V120(F)	12	24	242	151	117	72	41	29
S12V170(F)	12	40	323	215	167	102	58	41
S12V285(F)	12	70	543	365	285	169	96	69
S12V300(F)	12	69	654	415	306	180	105	76
S12V370(F)	12	87	723	484	373	230	131	92
S12V500(F)	12	131	864	615	505	310	176	126
S6V740(F)	6	175	1446	970	746	458	262	184

All technical data refer to 25°C.

9.1.4 Marathon L

Discharge time t_n	10 min	30 min	1 h	3 h	5 h	10 h
Capacity C_n [Ah]	$C_{1/6}$	$C_{1/2}$	C_1	C_3	C_5	C_{10}
L12V15	6.5	8.1	9.5	12.3	12.5	14.0
L12V24	10.7	13.3	15.1	20.4	21.0	23.0
L12V32	14.1	17.7	20.5	27.3	29.5	31.5
L12V42	19.6	25.0	28.5	37.2	38.5	42.0
L12V55	21.6	28.2	34.5	42.9	48.0	55.0
L12V80	30.3	40.0	48.8	61.5	69.0	80.0
L6V110	48.5	62.0	73.5	98.4	104.0	112.0
L6V160	66.6	89.5	105.0	126.3	142.0	162.0
L2V220	87.1	120.5	141.0	178.2	194.0	220.0
L2V270	104.1	148.5	162.0	218.4	238.0	270.0
L2V320	130.7	180.5	214.0	261.0	283.5	320.0
L2V375	152.4	212.0	250.0	306.0	332.5	375.0
L2V425	160.9	234.0	274.0	345.0	375.0	425.0
L2V470	186.6	264.0	305.0	382.2	419.5	470.0
L2V520	204.1	290.0	337.0	423.0	466.5	520.0
L2V575	220.8	317.5	372.0	468.0	516.0	575.0
U_f [V] (2 V cell)	1.60	1.70	1.74	1.78	1.79	1.80
U_f [V] (6 V bloc)	4.80	5.10	5.22	5.34	5.37	5.40
U_f [V] (12 V bloc)	9.60	10.20	10.44	10.68	10.74	10.80

All technical data refer to 20°C.

9.1.5 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					
			0.5 h	1 h	1.5 h	3 h	5 h	10 h
M12V30T	12	28	36.9	21.2	15.1	8.4	5.5	2.9
M12V40(F)	12	40	51.3	30.5	21.5	11.9	7.6	4.1
M12V45F	12	46	57.8	33.2	24.0	13.5	8.7	4.7
M12V70(F)	12	72	90.8	51.6	36.8	20.6	13.4	7.4
M12V90(F)	12	90	107.0	65.7	46.6	25.9	16.7	9.2
M6V190(F)	6	190	246.0	144.9	102.0	56.0	35.9	19.5
M12V90FT	12	90	109.0	64.8	46.4	25.3	16.3	8.8
M12V105FT	12	104	118.4	71.8	51.6	29.2	19.2	10.6
M12V125FT	12	125	145.3	90.4	65.3	38.1	24.0	12.7
M12V155FT	12	155	179.4	105.8	77.7	44.4	28.8	15.7

All technical data refer to 25°C.

9.2. GEL

9.2.1 A 400

Discharge time t_n		10 min	30 min	1 h	3 h	5 h	10 h
Capacity C_n [Ah]		$C_{1/6}$	$C_{1/2}$	C_1	C_3	C_5	C_{10}
A406/165		52.98	80.10	95.1	132.0	143.5	165.0
A412/5.5		1.83	2.80	3.4	4.5	5.0	5.5
A412/8.5		2.67	3.85	4.7	6.3	7.0	8.5
A412/12.0		3.67	5.50	6.8	9.0	10.5	12.0
A412/20.0		6.50	39.10	11.5	15.0	16.5	20.0
A412/32.0		11.25	16.55	20	26.7	29.0	32.0
A412/50.0		15.95	24.00	29.4	40.8	44.5	50.0
A412/65.0		19.38	28.95	41.7	51.9	57.5	65.0
A412/85.0		27.70	42.65	52.2	68.4	74.5	85.0
A412/90.0		24.23	37.50	43.7	58.8	66.0	90.0
A412/100.0		30.52	45.65	53.3	72.3	85.0	100.0
A412/120.0		38.08	55.90	70.6	87.9	98.0	120.0
A412/180.0		53.03	79.25	95.8	138.0	152.0	180.0
19“	A412/26.0	9.00	13.00	16.00	21.00	23.00	26.00
	A412/37.0	12.20	17.00	21.00	29.00	31.00	37.00
	A412/48.0	17.00	25.00	30.00	40.00	43.00	48.00
23“	A412/85.0	27.00	40.00	51.00	68.00	75.00	85.00
	A412/110.0	35.00	52.00	66.00	88.00	97.00	110.00
U_f [V] (6 V bloc)		4.8	4.8	4.95	5.1	5.1	5.4
U_f [V] (12 V bloc)		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	10 min	30 min	1 h	3 h	5 h	10 h	20 h
Capacity C_n	$C_{1/6}$	$C_{1/2}$	C_1	C_3	C_5	C_{10}	C_{20}
A502/10.0	4.8	6.4	7.1	9.0	9.5	10.0	10.0
A504/3.5	1.4	1.95	2.3	3.0	3.15	3.3	3.5
A506/1.2	0.5	0.67	0.8	1.05	1.1	1.0	1.2
A506/3.5	1.4	1.95	2.3	3.0	3.15	3.3	3.5
A506/4.2	1.1	1.75	2.5	3.8	3.95	4.0	4.2
A506/6.5	2.6	3.5	4.0	4.8	5.5	6.3	6.5
A506/10.0	4.8	6.4	7.1	9.0	9.5	10.0	10.0
A508/3.5	1.4	1.95	2.3	3.0	3.15	3.3	3.5
A512/1.2	0.5	0.67	0.8	1.05	1.1	1.0	1.2
A512/2.0	0.8	0.11	1.5	1.8	1.85	1.9	2.0
A512/3.5	1.4	1.95	2.3	3.0	3.15	3.3	3.5
A512/6.5	2.6	3.8	4.0	4.8	5.5	6.3	6.5
A512/10.0	4.8	6.4	7.1	9.0	9.5	10.0	10.0
A512/16.0	7.0	9.0	10.6	13.8	14.5	15.0	16.0
A512/25.0	7.8	11.45	14.4	18.6	20.5	22.0	25.0
A512/30.0	11.4	16.3	20.1	24.6	26.5	27.0	30.0
A512/40.0	14.1	19.5	24.0	28.5	34.0	36.0	40.0
A512/55.0	19.3	27.5	35.7	43.0	46.5	50.0	55.0
A512/60.0	22.2	31.0	37.1	48.6	52.0	56.0	60.0
A512/65.0	22.6	33.8	41.0	53.7	58.5	62.0	65.0
A512/85.0	33.1	47.5	59.0	69.0	75.5	80.0	85.0
A512/115.0	37.8	58.5	67.0	84.0	95.0	104.0	115.0
A512/120.0	44.5	62.0	74.0	89.7	96.0	102.0	120.0
A512/140.0	50.5	71.5	85.4	105.3	113.0	119.0	140.0
A512/200.0	68.5	101	120.0	151.8	164.0	173.0	200.0
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 bloc)	3.2	3.2	3.3	3.4	3.4	3.6	3.5
U_f [V] (6 V bloc)	4.8	4.8	4.95	5.1	5.1	5.4	5.25
U_f [V] (8 V bloc)	6.4	6.4	6.6	6.8	6.8	7.2	7.0
U_f [V] (12 V bloc)	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

The nominal voltage, the number of cells, the nominal capacity ($C_{10} = C_N$) and the battery type are described on the cell label. Other capacities (C_n) at different discharge currents (I_n) and discharge times (t_n) can be calculated with the help of the following example and table below.

Example:
Calculation of the 5h discharge data:
Type plate on cell: 6 OPzV 600
Code : with single cells the nominal voltage is not shown
6 = n = Number of positive plates (pl)
OPzV = Type = Stationary/tubular/valve regulated
600 = nominal capacity in Ah(C_{10}), capacity of discharge with 10 h-current (I_{10}) for a time of 10 h (t_{10})

Calculation of the plate type:

C_{10}/n = 600 Ah/ 6 pl = 100 Ah/pl

Calculation of the 5h capacity (C_5) of the battery:

$C_5 = (C_5/pl) \times n$ = 86Ah/pl x 6 = 516 Ah

Calculation of the 5h discharge current (I_5):

$I_5 = C_5/t_5$ = 516Ah/ 5h = 103.2 A

Calculation of the final discharge voltage (U_f):
The final discharge cell voltage U_f (1.77 V) at a discharge time of t_n = 5 h is listed in the table.

Stationary lead acid batteries OPzV (DIN 40742) with pos. tubular plates and neg. grid plates

Discharge time t_n	1 h	3 h	5 h*	10 h
Capacity [Ah]/plate at t_n	C_1	C_3	C_5	C_{10}
50 Ah	26.5	37.5	43.0	50.0
70 Ah	37.0	52.5	60.0	70.0
100 Ah *	52.0	75.0	86.0	100.0
125 Ah	62.0	93.0	105.0	125.0
U_f in Volt per cell *	1.67	1.75	1.77	1.80

* Values for calculation examples

All technical data refer to 20° C.

9.2.4 A 700

Discharge time t_n	10 min	30 min	1 h	3 h	5 h	10 h
Capacity C_n [Ah]	$C_{1/6}$	$C_{1/2}$	C_1	C_3	C_5	C_{10}
A706/21	7.1	10.3	12.2	16.5	19.0	21.0
A706/42	14.2	20.5	24.4	33.0	38.0	42.0
A706/63	21.3	30.8	36.6	49.5	57.0	63.0
A706/84	28.3	41.0	48.8	66.0	76.5	84.0
A706/105	35.4	51.3	61.0	82.8	95.5	105.0
A706/126	42.5	61.5	73.2	99.3	114.5	126.0
A706/140	42.3	69.5	85.3	117.0	131.0	140.0
A706/175	52.9	86.9	106.6	146.4	163.5	175.0
A706/210	63.5	104.3	128.0	175.5	196.0	210.0
A704/245	74.1	121.7	149.3	204.9	229.0	245.0
A704/280	84.6	139.0	170.6	234.0	261.5	280.0
U_f [V] (4 V bloc)	3.2	3.2	3.3	3.4	3.4	3.6
U_f [V] (6 V bloc)	4.8	4.8	4.95	5.1	5.1	5.4

All technical data refer to 20° C.

35 0 33200 10

Sonnenschein SOLAR, SOLAR BLOCK, A 600 SOLAR
Operating Instruction 33200
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 50 272-2, DIN VDE 0510, VDE 0105 Part 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-compilance with operating instructions, repairs made with other than original parts, or repairs made without authorization (e. g. opening of valves) render the warranty void.

Pb

Disposal of Batteries

Batteries marked with the recycling symbol should be processed via a recognised recycling agency. By agreement, they may be returned to the manufacturer. Batteries must not be mixed with domestic or industrial waste.

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 DIN VDE 0510, part 1 (draft) and 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 have to be carried out as follows: Up to 48 hours at max. 2.40 Vpc. The charge current must not exceed 35 A/100 Ah nominal capacity. 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.

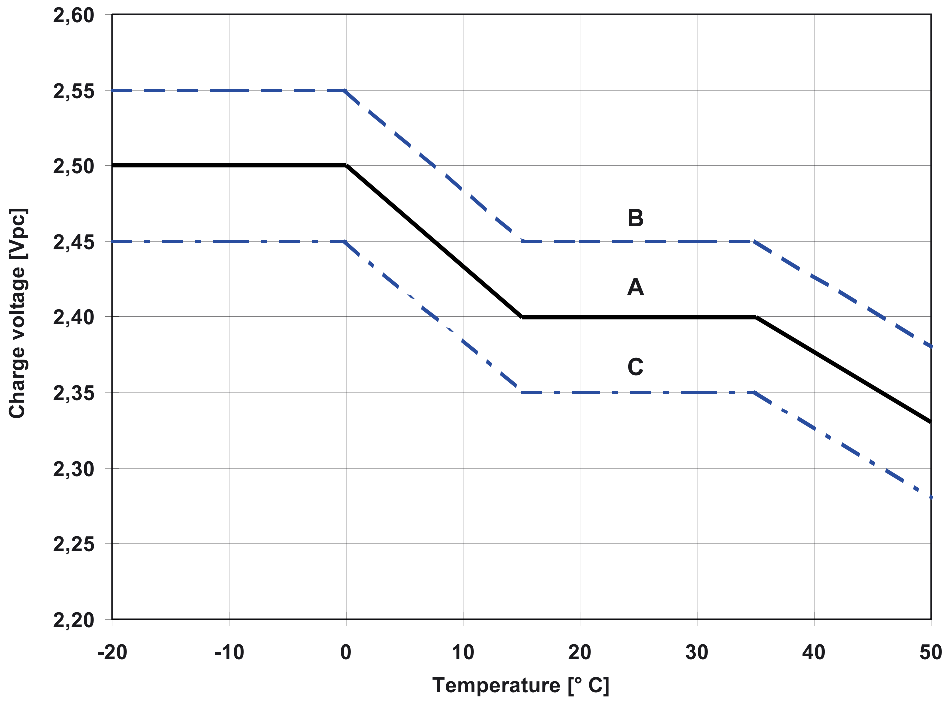


Fig. 1: Charge voltage vs. temperature for solar mode. Charge modes:

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
A temperature related adjustment of the charge voltage within the operating temperature of 15° C to 35° C is not necessary. If the operating temperature is constantly outside this range, the charge voltage has to be adjusted (see fig.1).

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 896-2, DIN 43539 part 1 and 100 (draft). Special instructions like DIN VDE 0107 and DIN VDE 0108 have to be observed.

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 V/Z	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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