Operating Instructions

Stationary solar valve regulated lead-acid batteries (VRLA)

WARNINGS

Observe operating instructions and position them within sight of the battery! Work only on batteries under instruction of skilled personnel!

When working on batteries wear safety glasses and protective clothing! Comply with accident prevention rules as well as with DIN VDE 0510 and DIN EN 50110-1 (VDE 0105-1)!

No smoking! Do not expose the battery to an open flame, a glowing fire or sparks as explosion and fire hazards exist.

Acid splashes in the eyes or on the skin must be washed out or off with plenty of water. Then see a doctor immediately. Clothing exposed to acid should be washed out with water without delay.

Dangerous voltage!

The electrolyte (diluted sulphuric acid) is highly corrosive. Under normal operating conditions contact with electrolyte is prevented. In case of damage of the container contact with the gelled sulphuric acid has to be avoided. It is highly corrosive as well.

Block batteries or cells are heavy! Ensure secure installation! Only use suitable lifting and transport equipment!

Explosion and fire hazard due to explosive gases escaping from the battery. Caution! Metal parts of the battery are always live, therefore do not place items or tools on the battery! Avoid short circuits!

Usage of the battery which does not comply with the OPERATING INSTRUCTIONS, repairs carried out non-approved with spare parts, use of additives in the electrolyte or unauthorised interference with the battery will invalidate any claim for warranty.

Used batteries with this symbol are reusable goods and must be returned to the recycling process or must be disposed in accordance with the rules of the country concerned.

General

Valve regulated lead-acid batteries must not be topped up with water through their entire life. The valves must not be opened, because access of oxygen discharges the cells. During charging the cells will release hydrogen through the valve. Observe the ventilation instruction EN 50272-2.

1. Installing the battery

Install the racks or cabinets provided for the installation in the correct location. Inspect all cells/blocks for mechanical damage. Cells/blocks may be operating in upright or – if ordered and designated correspondingly – in horizontal position. Use our Installation instruction and for horizontal installation pay attention to our Supplement to the Installation instruction. For all horizontal installations only flexible connectors are to be used. Having battery strings connected in parallel, care must be taken that the same thermal environment and the same electric connection resistance are applied. Therefore normally not more than 4 partial batteries are connected in parallel. Set up the cells/blocks with the correct polarity. The distance between cells/blocks should be 10 mm. If necessary the surfaces of the poles and connectors have to be cleaned. For multipole cells all poles have to be connected by connectors with same diameter and length. The connectors have to be firmly seated by tightening the terminal screws with a torque of 22 ± 1 Nm for OPzV. Cable connectors have to be secured during mounting by a fixing tool for connector installation. Observe the Installation Instruction. The temperature difference within a battery string should be smaller than 3 K to avoid differences in voltages and in the general behaviour of separate cells/blocks.

2. Commissioning

Connect the battery to the DC power supply, with the charger switched off, battery fuses removed and the load disconnected, ensuring that the polarity is correct: Positive terminal of the battery to the positive terminal of the charger. If the cells/blocks have been stored for more than 4 weeks, check the open-circuit voltage (OCV) before start of charging to ascertain the optimum commissioning charge:

- Charging according to 4.2c, if the cells have OCV's ≥2.08 V. If the cells have OCV's <2.08 V charging according to 4.2b or 4.2d. In case of 4.2d charge one day per month storage time to equalise the state of charge of the cells/blocks.
- If cells have OCV´s <0.02 V below average, contact the battery manufacturer. The first charge should be monito-

red to ensure that limits of voltages, currents and temperatures are not exceeded and that no unacceptable values occur. When charging is finished switch off the charger or switch over to float charging as per 4.2c.

3. Operation

For the assembly and operation of stationary battery installations EN 50272-2 applies. Solar batteries should be operated with charge controllers which prevent a deep discharge of the battery. Avoid direct sunlight.

3.1 Operation modes: stand-by and buffer

In this case the load, the DC power supply and the battery are connected permanently in parallel. Thereby the charging voltage is the operational voltage of the battery and also the system voltage.

a) During stand-by operation (float) the DC power supply must be always able to provide the maximum load current and the battery charging current. The battery only supplies current, if the DC power supply fails. The charging voltage at 20 °C (68 °F) must be set to (2.25 V ± 1 %) x number of cells. The number of cells per block is given by the nominal block voltage divided by 2 V.

b) During buffer operation the DC power supply is not always able to provide the maximum load current. The load current temporarily exceeds the rated current of the DC power supply. During this time the battery supplies current. Depending on the load and after having consulted the battery manufacturer, the charging voltage should be set at (2.25 to 2.30 V) x number of cells.

3.2 General terms for discharging

a) Discharge: A battery is discharged when it supplies an electrical current by switching of the charger and connecting the load with the battery poles. During discharge, the active materials Pb and PbO2 with the sulphuric acid are converted to lead sulphate and water. **Batteries have to be recharged immediately after a partial or complete discharge but at least within a period of 1 week up to 4 weeks to 100 %.**

b) Self discharge: If the battery voltage is permanently less than floating voltage (see 4.2c) - e.g. without charge or voltage too small - the battery discharges by itself. It results in a loss of capacity and possible sulphation of the electrodes.

c) Voltage drop: When discharged with currents higher than I100, a fully charged battery shows a voltage drop in the beginning (about 5 %) of the discharge, followed by a voltage maximum at about 10 % of discharge time. The presence and the depth of this drop can be a fine indicator for the state of charge (SOC) before discharging.

d) Discharge regimes: Discharge capacities and voltages are specified in point 9. Discharges subjected to operation are limited to 80 % DOD. The end cell voltage for all discharges of 10 hours or longer is 1.8 V/cell. No more than specified capacities are to be discharged. Charge immediately after discharge as well as after partial discharge.

4. Charging

4.1 Charging with alternative power supply

When using an alternative power supply, the battery charger is not always able to supply the maximum load current. The load current can exceed the nominal current of the battery charger. The battery supplies power during this period and the battery will be discharged. In photovoltaic installations normally IU-characteristic is used (see chapter 4.2a). The initial constant current phase („I") will be named "bulk phase". The final voltage criteria to stop that phase should be adjusted according the following table:

Depth of Discharge (DOD)	Charging voltage
< 0.4 C_{10}	2.30 – 2.35 V/cell
≥ 0.4 C_{10}	2.35 – 2.40 V/cell*

* In accordance with item 4.2d the charging time at those increased voltages shall be limited to maximum 72 h. If no discharge follows then switch to standby operation.

Observe the values of point 4.2d to adjust the equalising charge at the charge controller. The charge controller and the battery must be sized properly. Manufacturer instructions for the charger are to be considered. Especially off-grid systems should be dimensioned in such a way, that the batteries will be fully charged daily; it is advisable to avoid discharges to more than 30 % DOD. After deep discharge or after inadequate recharging an equalising charging as per item 4.2d is necessary.

At stand-by operation without cycling the batteries should be operated at float charge with (2.25 V/cell ± 1 %) x number of cells.

4.2 Charging with external charger

Charging must only be carried out with direct current. Chargers with IU-, IUI- or W-characteristics according to DIN 41773, DIN 41776 and DIN 41774 may be used.

a) IU- (or IUU-) characteristics: Starting with a given initially constant charging current ("I") the cell or battery voltage reaches the given final value which depends on the charging requirement by the application. The charger automatically switches then to constant operating voltage ("U", 3.1a). As long as the gassing voltage is not reached 2.4 V/cell, the charging current is limited only by the charger. Typical values for constant currents are 0.5 to 2.0 times I10. Typical constant voltages are 2.25, 2.27, 2.35, 2.40 V/cell. The different voltages are given by the application. Please see exact values in section „4.3 Special cases". The IUU-characteristic provides a switching point after a higher first constant voltage to operating voltage.

b) IUI-characteristics: IUI charging is an effective method to recharge batteries in short times and for cracking sulphation. At first, an IU-characteristic is applied to the battery. After a given time held out at constant voltage, the charging method is then extended by using a reduced constant current ("I"). This current is limited to 1.5 A/100 Ah C10.

The cell or battery voltage reaches values between 2.60 and 2.75 V/cell. Check if loads have to be disconnected before. If temperatures higher than 45 °C (113 °F) occur, the charging has to be interrupted. The fully charged state is reached, when the cell voltages have not risen for a period of 2 h during a charge with constant current.

c) Float charge (float voltage): A battery is float charged, when the electrodes are sufficiently polarised in that quantity that the floating current compensates the self discharge rate (see 3.2b) of the battery. A fully charged battery remains at 100 % SOC while being floated.

Floating voltage	Battery type
2.25 V/cell ± 1 %	PVV and PVVM

d) Equalising or boost charge: Charging method with increased gassing activity at higher cell voltages (>2.33 V/cell), done with either increased constant voltage (e.g. 2.33 to 2.40 V/cell) or constant current. Equalisation charges are to be done at least once at year. The application of this method shall be time (max.

72 h) and temperature limited to max. 45 °C (113 °F). When using constant currents, they are to be limited to 1.5 A/100 Ah C10. On exceeding the temperature maximum, the charging must either be stopped or proceeded with reduced current or be switched to float charge to allow the temperature to drop. The equalising charge is completed, when the cell voltages have not risen for a period of 2 h during a charge with constant current.
e) Ripple currents: During recharging up to 2.40 V/cell the RMS value of the AC ripple current may reach temporarily max. 20 % of the RMS value of the charging current. After recharging and at standby (float) or buffer operation the RMS value of the ripple current must not exceed 5 % of the RMS value of the charging current.

4.3 Special cases

a) Charging a new battery: Can be done by using IU- or IUI-characteristics (4.2a and 4.2b) with increased voltage of 2.33 to 2.40 V/cell. Charging times:

IU	IUI
Min. 1 day	Approx. 8 to 12 hours

b) Recharging: After a discharge the battery can be recharged at operating voltage (see 4.2c). This can take weeks until months for a complete recharge. To reduce the charging time the recharging can be carried out by using IUU-characteristics (4.2a) with increased voltage (2.33 to 2.40 V/cell) x number of cells with automatic reduction (switching point) to the operating voltage under 3.1a. Recharging times are dependent on the charging current available; as a rule they run to 12 to 24 hours at initial currents between 2 x I10 to 0.5 x I10. Using IUI-characteristics is also recommended.
c) Deep discharges/inadequate charged batteries: After deep discharges recharging with IUI-characteristic (4.2b) at 100 % SOC is necessary immediately. After inadequate recharging an equalising charge (4.2d) is to be done.

4.4 Battery temperature and related charging voltage

All technical data refer to the nominal temperature of 20 °C (68 °F). The recommended temperature range is 10 °C (50 °F) to 30 °C (86 °F). Higher temperatures reduce the operational life. Lower temperatures reduce the available capacity. Exceeding the temperature limit of 45 °C (113 °F) up to 55 °C (131 °F) is acceptable only for short periods. A temperature-related adjustment of the charging voltage within monthly averaged battery temperature of 10 °C (50 °F) to 45 °C (113 °F) must not be made. A decrease of the charging voltage at temperatures above 20 °C (68 °F) endangers the fully charged state of the battery. Below 10 °C (50 °F) in the monthly average the charging voltage should be increased (0.003 V/cell per K) for a faster recharging.

5. Maintenance

To avoid leakage currents and the associated risk of fire keep the battery dry and clean. Cleaning with clean water, no detergents, no solvents. Avoid electrostatic charges. During whole life time, the battery needs not to be refilled with water. The electrolyte is diluted sulphuric acid and fixed as GEL made with microporous SiO2.
To be measured and listed every 6 months:
- battery voltage
- voltages of some cells/blocks (pilot cells)
- surface temperatures of pilot cells/blocks and the room temperature

Every 12 months:
- Voltages and surface temperatures of all cells/blocks have to be measured and listed.
- Connectors, racks and ventilation have to be visually checked and restored if necessary. Should the float charge voltage of single cells deviate more than +0.2 V or -0.1 V from the average value (see 4.2c) and should the surface temperatures of different cells/blocks deviate more than 3 K, the customer service should be called.

6. Tests

Tests must be conducted according to IEC 60896-21.

7. Storage and taking out of operation

Should batteries be stored or taken out of operation for extended periods, they must be stored fully charged in a dry frost-free room. To avoid damage one of the two charging methods has to be selected:
a) Equalising charging every 6 months. If the average room temperatures are higher than 25 °C (77 °F), shorter intervals are necessary.
b) Float charging as under 4.2c.

8. Transport

The cells/batteries are protected against short-circuit. They are not subject to the German Regulations on Dangerous Goods carried on road and railway (GGVSEB) of the ADR, if they show no damage, are protected against sliding, falling over and damaging and are piled up on pallets appropriately (ADR, Chapter 3.3, Special Provisions 598 and 238). There must not be dangerous traces of acid visible on the outside of the packages. During sea transport of cells/batteries the rules of IMDG-Code (GGVSEE, Chapter 3.2, Special Provisions 29 and 238) must be followed.

9. Technical data

Sun Station OPzV Phaesun		L x W x H	weight	R_i	I_k	capacity							Terminal
		mm	kg	mΩ	kA	Ah (C1)	Ah (C10)	Ah (C20)	Ah (C72)	Ah (C100)	Ah (C120)	Ah (C240)	
340307	2 OPzV 140	105x208x420	12,4	1,63	1,31	71	121	134	153	157	158	165	M10
340308	3 OPzV 210	105x208x420	17,1	1,13	1,88	107	182	202	229	236	238	247	M10
340309	4 OPzV 280	105x208x420	19,4	0,885	2,42	143	243	268	306	314	318	331	M10
340310	5 OPzV 350	126x208x420	23,3	0,730	2,94	179	304	336	383	393	397	412	M10
340311	6 OPzV 420	147x208x420	27,4	0,625	3,43	215	364	404	460	472	477	496	M10
340312	5 OPzV 550	126x208x535	31,4	0,680	3,16	254	447	506	570	583	589	609	M10
340313	6 OPzV 660	147x208x535	36,9	0,582	3,69	303	529	598	671	686	693	715	M10
340314	7 OPzV 770	168x208x535	42,4	0,512	4,19	350	610	688	770	788	795	820	M10
340315	6 OPzV 900	147x208x710	49,5	0,458	4,68	418	729	834	943	968	978	1.012	M10
340316	7 OPzV 1050	215x193x710	60,4	0,367	5,85	493	858	980	1116	1140	1154	1195	M10
340317	8 OPzV 1200	215x193x710	67,3	0,326	6,58	560	970	1106	1252	1280	1296	1344	M10
340318	9 OPzV 1350	215x235x710	75,5	0,284	7,55	632	1090	1252	1418	1450	1464	1524	M10
340319	10 OPzV 1500	215x235x710	82,5	0,247	8,68	703	1200	1382	1562	1600	1620	1675	M10
340320	11 OPzV 1650	215x277x710	90,8	0,245	8,77	765	1320	1512	1713	1750	1764	1836	M10
340321	12 OPzV 1800	215x277x710	97,7	0,219	9,81	836	1440	1644	1857	1900	1920	1989	M10
340322	11 OPzV 2090	215x277x855	108,2	0,235	9,14	864	1570	1772	2023	2070	2088	2169	M10
340323	12 OPzV 2280	215x277x855	116,5	0,210	10,23	944	1710	1918	2181	2230	2256	2337	M10
340324	13 OPzV 2470	215x400x815	131,4	0,178	12,04	1041	1890	2120	2426	2490	2508	2592	M10
340325	14 OPzV 2660	215x400x815	141,2	0,168	12,73	1126	2070	2320	2678	2740	2772	2880	M10
340326	15 OPzV 2850	215x400x815	147,9	0,160	13,39	1193	2170	2420	2772	2840	2868	2976	M10
340327	16 OPzV 3040	215x400x815	156,2	0,152	14,07	1267	2300	2580	2937	3000	3036	3144	M10
340328	17 OPzV 3230	215x490x815	173,6	0,138	15,49	1360	2480	2780	3182	3260	3300	3408	M10
340329	18 OPzV 3420	215x490x815	181,4	0,130	16,52	1438	2610	2920	3348	3420	3468	3576	M10
340330	19 OPzV 3610	215x490x815	189,6	0,127	16,87	1509	2740	3080	3506	3590	3624	3744	M10
340331	20 OPzV 3800	215x490x815	197,8	0,115	18,66	1595	2870	3220	3664	3750	3792	3912	M10
340332	22 OPzV 4180	215x580x815	219,1	0,107	19,94	1759	3210	3600	4118	4220	4272	4416	M10
340333	24 OPzV 4560	215x580x815	235,4	0,101	21,19	1906	3470	3900	4442	4550	4596	4752	M10
340334	26 OPzV 4940	215x580x815	248,4	0,095	22,42	2034	3650	4060	4608	4710	4764	4920	M10