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NSB OPzV Batteries

Tubular Gel Technology

NSB OPzV Battery Application Manual

Table of Contents

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Application

Installation

1 *Introduction*

NorthStar's OPzV series of batteries are designed for excellent cycling capability, long float life and high reliability to ensure trouble-free backup power for a wide variety of applications. For example:

1) Hybrid/cycling applications with long backup times
2) Base stations
3) Long back up times with higher load for remote base stations
4) Solar and wind sites
5) UPS
6) Utility and switchgear
7) Peak shaving applications and more

Sections 1 through 19 are applicable for both series. Sections 20 and 21 are operation guidelines for solar and hybrid applications.

General installation and maintenance guidelines for both series is in sections 22 through 32.

2 *Description*

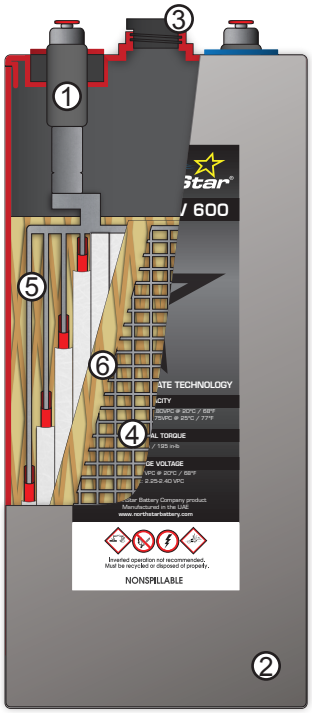
NorthStar's OPzV product family includes two different series of batteries: a standby battery (OPzV series) with slightly higher capacity and a solar battery (Solar OPzV series) that is optimized for longer cycle life. The OPzV Solar contains an addition of phosphoric acid which extends cyclic life at the expense of capacity, please consult capacity tables for guidance.

The OPzV product line is intended for back-up and cyclic applications.

All NSB OPzV batteries utilizes a robust tubular positive electrode design with maintenance-free and leakage-free construction through electrolyte suspension in fumed silica gel.

The schematic drawing in the drawing below illustrates the many component parts of a NSB OPzV cell:

1) Terminal with rubber grommet and brass insert
2) Battery container in ABS material
3) Valve assembly with umbrella valve and filter
4) Negative grid (Here shown without paste)
5) Positive grid with tubular gauntlet (Here shown without active material for clarity)
6) Micro-porous separator of with ribs



3 *Description of Function*

The design encompasses two very reliable design elements, the gelled electrolyte and the tubular positive plate. The gelled electrolyte mean that the cells can work both upright and lying down without stratification occurring.
The tubular plate design mean that the active material is confined very strongly to the grid which mean that the active material remains in very good contact enabling a multitude of cycles.

The NSB OPzV/Solar uses active materials which mean that the water losses are kept to a minimum.

4 *Accomodation*

Batteries built from OPzV cells need accommodation fulfilling the following.

Dry and cool place
Air flow for cooling
Air exchange to expel hydrogen
Place in front for servicing

Dry and cool place

The recommended temperature range is 10°C-30°C. Operation outside of this range is permitted observe that the life is shorter at elevated temperature and capacity is stated at 20°C.

Air flow for cooling

Where batteries are used in a cyclic duty one needs the air to move around the cells because heat is generated when the cells are cycled. As a rule the estimated losses can be up to 15% of the discharged energy. An example: A 48 V battery is discharged twice a day delivering 4 h back-up and 2 kW of power each instance. (42 A x 4 h approximately) Then the heat that needs to be removed can be estimated.

Qloss (heat loss from the battery) = 2(twice a day) x 2 kW x 4 h x 0,15 = 2400 Wh. If we distribute this over the 24 h we have an average cooling demand of:

Pcooling (cooling power to keep a consistant temperature) = 2400Wh/24h = 100 W

Air exchange to expel hydrogen

Valve regulated batteries emit some hydrogen due to unavoidable reaction occurring in the cells. It is a slow process and the amounts are minimal. NorthStar Battery recommends the international standard for safety of stationary batteries to be followed, IEC 62485-2.

In essence this mean that the battery needs ventilation that corresponds to the total amount of the cells and their capacities. NorthStar uses this as an example of the needs of a nominally 48 V 1000 Ah battery (consisting of 24 cells)

With float only 1,3 m3/h
With boost voltage 6,8 m3/h

5 End Of Discharge Voltage (EODV)

Discharging too much capacity from the batteries is detrimental and each battery installation shall have protection for overdischarge. A minimum End-Of-Discharge Voltage (EODV) should be used to avoid over-discharge.
The EODV must be adjusted based on the intended discharge times. The following table provides a guide for EODVs at various discharge rates.

Discharge times (Hours)	EODV
1-3	1.67 V
3-8	1.75 V
8-24	1.80 V
24-240	1.85 V

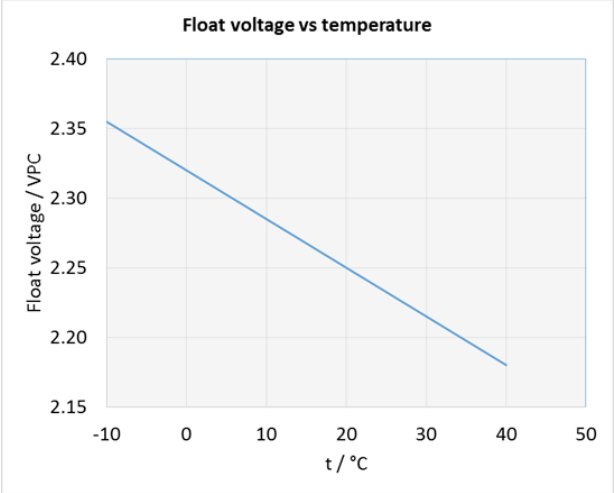
6 Discharge Rate

In this document, the charge and discharge rates (Amps) are expressed as multiples of I10, where I10 is the current for a 10-hour discharge to 100% Depth-Of Discharge (DOD).
These values serve to normalize data across a range of battery cell sizes.

Consider the following example:
10-h discharge capacity NSB 6 OPzV 600 = 714 Ah
(EODV = 1.80 VPC @ 25°C).
1 x I10 = 1 x (10-h discharge current)
1 x I10 (NSB 6 OPzV 600) = 1 x 71.4 A = 71.4 A
2 x I10 (NSB 6 OPzV 600) = 2 x 71.4 A = 142.8 A

7 Float Charge

The recommended float voltage is 2.25 VPC at +20°C (+68°F) with a tolerance of ±1%. If the battery cell temperature increases above this level, a thermal compensation of -3.5 mV/cell/°C is required for safe operation and achieving optimal life. Conversely, if the temperature decreases below 20°C, the voltage should be increased by 3.5 mV/cell/°C. See graph below:



8 *Operation of the battery in standby operation with frequent power interruptions*

During operation of the battery in standby applictions with frequent power interruptions it is recommend that the boost charge functionality of the power system is turned on. (The boost charge increases the voltage setting for the charge above the float charge voltage and is turned on if a substantial discharge has occurred).

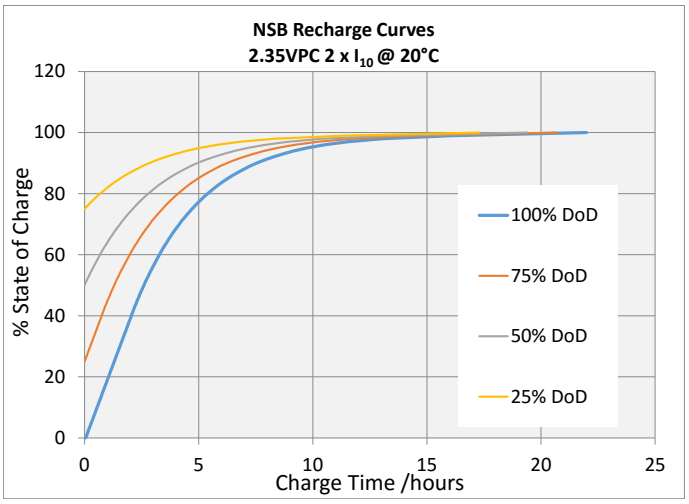
The duration of the boost charge should not be longer than 5 hours at the boost charge level alternatively it can be turned off earlier if the current has decreased to a low value < 0,05*C10. The reccommended boost charge voltage is 2.35- 2.40 V per cell.

9 *Charge Current Limit*

After a discharge the battery can be recharged at the float charge voltage. The battery charging current should be limited to 5 x I10.

10 *Charging Time*

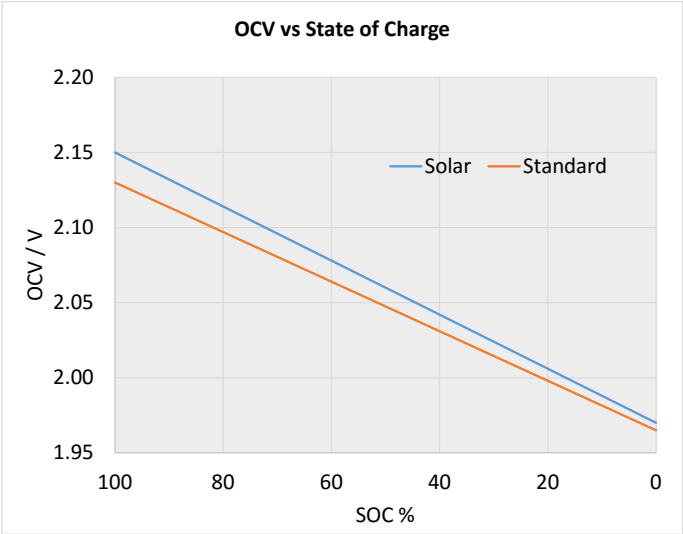
Typical recharge behavior can be estimated according to the following chart.



11 *Commissioning charge*

Batteries lose charge while in transit or during storage. For this reason, a freshening charge should be given before putting the battery into service. Recommended charge settings at the ambient temperature range of 20°C to 25°C are as follows:

16 hours at constant voltage of 2.35 VpC at 20°C (68°F) to 25 °C (77°F). Current limitation: 1.5 x I10.



12 *IU Charge*

The IU charge is normally used for fast recharging or in cycle use. IU charge consists of two phases:

1st phase: Constant current-recommended rate 2 to 5 x I10. The voltage increases up to a limited voltage of 2.35 VpC.

2nd phase: Constant voltage of 2.35 VpC. The absorbed current decreases. Once the current has reached a low and constant value (approx. 0.005A per Ah) the battery should be considered fully charged and the rectifier/charger voltage adjusted to the temperature compensated float level (2.25VPC @ 20°C). For safety reasons, the second phase should not last more than 10 hours.

13 *Equalizing or Boost Charge*

After deep discharges or after repeated inadequate recharging an equalizing or boost charge shall be carried out using the settings in the commissioning charge paragraph.

14 Operating Temperature

The permissible operating temperature range is -20°C to 55°C. The recommended operating temperature range is +10°C to +30°C. All technical data in this document relates to the rated temperature of +20°C (if not otherwise specifically stated).

Higher temperatures reduce the operational life and lower temperatures reduce the available capacity.

15 Storage Times

Storage time for charged cells is limited and dependent on storage temperature. The recommended maximum storage time is as follows:

Storage temperature	20°C	30°C	40°C
OPzV	24 months	13 months	7 months

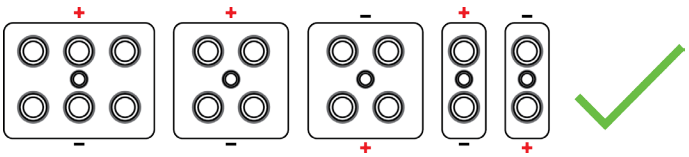
Stored OPzV batteries must be recharged @ min 50% capacity. During the storage time, the Open Circuit Voltage (OCV) must periodically be checked. Battery cells with OCV below 2.10 VpC must be recharged providing constant voltage of 2.35 VpC with current limitation of 0.15 C10 (A), for 24 hours.

The OCV of a fully charged battery should be between 2.12-2.14 VpC. Failure to observe the above conditions may result in a greatly reduced capacity and service life or in permanent damage to the cells.

16 Installation

NSB OPzV cells can be installed vertically, standing, or horizontally, laying down in suitable racks.

When storing horizontally ensure that the internal plates are vertical (to check this is correct, the positive and negative terminals should be above or below each other, i.e. not on the same level, as per diagram below):



The rack location and ventilation system should be such that the maximum temperature differential between cells does not exceed 3°C (5°F). A minimum distance of 10 mm is recommended between each cell to allow for airflow and cooling of the cells.

Do not expose cells to direct sunlight in the final installation, avoid direct sunlight during transportation and installation phase.

Operation (non-cycling)

Any position allowed, no restrictions in capacity.
Note: if cells are exposed to higher temperature fluctuations please contact, application engineering department.

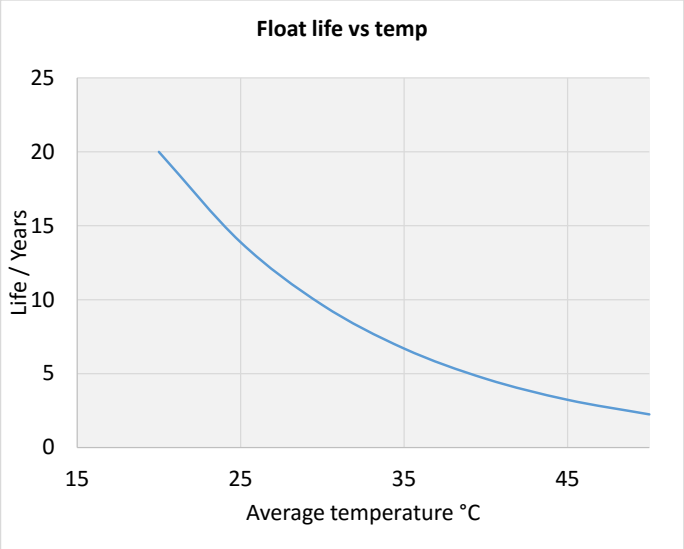
Operation (cycling)

Any position allowed up to NSB2-1800. For any higher capacity contact application engineering. Vertical, up-right installation no restrictions. Horizontal operation allowed up to NSB2-1800. For any higher capacity contact application engineering.

17 Temperature Effect on Float Life

Under normal standby operation, or float operation, the OPzV batteries are being constantly over-charged. This small overcharge is an effect of the float current and this happens in all float applications. Due to this small overcharge, over time, the lead within the positive plates undergo slow corrosion, which is a normal aging mechanism.

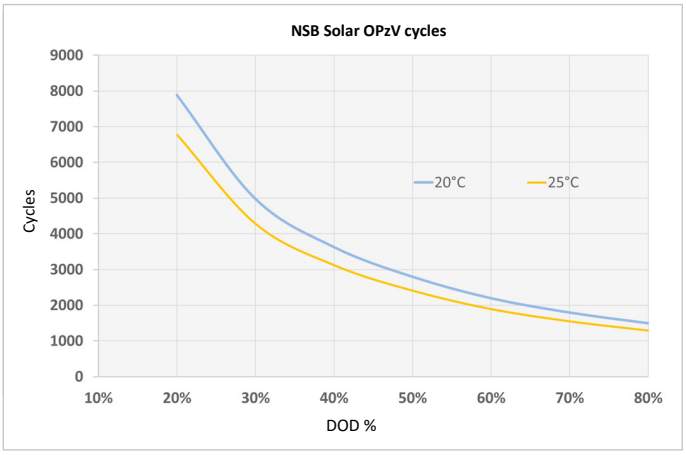
The rate of this process increases with increasing temperature and, as a result, the temperature of cells has a large effect on their float life.



For example, if the temperature rises from the recommended operating temperature of +20°C, to +45°C, the expected life of the battery cells will decrease from 20-years to approximately 4-years.

18 Cycle Life at Different Depth of Discharge (DOD)

The Depth of Discharge (DOD) of the OPzV battery has a significant impact on the number of charge/discharge cycles that can expected from the battery throughout its lifetime. DOD is expressed as a percentage of rated capacity delivered during discharge. The following chart can be used to estimate the cycle life of NorthStar OPzV Solar batteries.



For example, if a 1000Ah cell delivers 100Ah during a discharge period then the DOD would be 10%. As the DOD per cycle increases, the cycle life of the cell will decrease.

19 Temperature Effect on Cycle Life

Temperature also has a marked effect on the cycle life of an OPzV battery. As the temperature increase from 20°C the cycle life decreases

20 Operation Guidance for Hybrid Applications

NSB Solar is designed for repeated cyclic duty as will occur for instance when stand-alone Diesel Generating sets are operated together with batteries in order to decrease the run time of the Diesel generators. It is recommended that the charging time shall be long enough to fully charge the battery between cycles.

Guidance on design values for the charging time will be found in section 10 and end-of charge criteria will be found in section 12.

Design value for the numbers of cycles achievable depending on depth of discharge (DOD) is found in section 18.

21 Operation Guidance for Solar Applications

Solar photovoltaic operation: The batteries are used where a generator is not available and the batteries are charged using photovoltaic panels when the sun shines and where the batteries provide necessary power during times when there is too little sunshine.

In this application, it is necessary to control the amount of charge in times of plentiful sunshine. For the times of prolonged darkness, it is advisable to not deplete the batteries too much by observing the recommended end-of discharge voltages.

22 *Installation and Safety Instructions*

Warning: Risk of fire, explosion, or burns. Do not disassemble, heat above specified upper temperature limits, or incinerate.

	Please read and observe the installation and operation instructions in this document.
	When working on batteries wear appropriate Personal Protective Equipment (PPE). As a minimum (depending on area and location more may be required) safety glasses with side shields, rubber gloves and protective clothing. All metallic personal objects, such as rings, watches, bracelets, etc. should be removed before starting work on the battery
	Do not expose the battery to an open flame or other ignition source. During operation an explosive mixture of hydrogen gas may accumulate.
	Battery terminals are always energized and, if short-circuited, cause electrical arcing. Always use insulated tools.
	Batteries are heavy objects. Use proper handling equipment safety gear during installation.
Pb	Inappropriate lead acid battery disposal can result in environmental contamination. Please dispose of batteries according to local regulations.
Pb	Battery may be returned, shipping pre-paid, to the manufacturer or any distributor for recycling.
	Batteries contain concentrated sulfuric acid in water. Any fluid found outside the batteries should be regarded as acid.
	Clean all acid splash in eyes or on skin with plenty of clean water. Then seek medical help. Acid on clothing is to be washed with water
	Risk of explosion or fire. Avoid any short circuit. Metallic parts under voltage on the battery, do not place tools or items on top of the battery.

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

Pb	**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.**	Pb

23 *General*

Valve regulated batteries of gelled tubular type OpzV do not need water additions during operation. Safety regulations may apply depending on which country the batteries is installed. In absence of specific local regulation NorthStar Battery recommends that IEC 62485-2 is followed.

24 *Requirements and Preparations for Installation*

1. Before installation ensure that the battery room/cabinet is clean and dry and is furnished with a lockable door. Check that the room/cabinet is marked according to local regulations.

The IEC 62485-2 gives guidelines on how to find the necessary ventilation for a given amount of batteries based on its size (number of cells and capacity).

Local regulations may require other ventilation demands. In general rooms that are not sealed on purpose will provide necessary ventilation while cabinets need to be designed for batteries.

2. Check deliveries for completeness and damage. If necessary, clean all parts before assembling.

3. Observe all documentation included with the delivery (e. g. battery-, rack-, cabinet-assembly drawings).

4. Before replacing old batteries ensure that all electric leads are switched off.

5. Open-circuit voltage measurements of individual cells or block batteries. Ensure correct polarity.

25 *Racks*

Align the racks according to the installation drawing. The placement of the racks/cabinets in the room should be such as to make the servicing of the cells easy – Leave enough free space in front of the batteries. In absence of local regulations the IEC 62485-2 shall be consulted.

Also to be considered is that the battery racks/cabinets are all placed in a similar temperature. If the racks are placed in different temperatures their operation is compromised – As a rule of thumb the temperature difference should be less than 3°C.

26 Putting the Cells into Place

For heavy cells use lifting implements to assist putting the cells in place. In the first hand lift the cells into position. When lifting is not possible and sliding has to be used – Take every precaution to avoid scratching the cells!
When putting cells into horizontal position in shelves – Remember to orient the terminals the right direction. Look in the assembly drawing for the battery for correct orientation.

27 Connecting the Cells

Start with connecting the intercell connectors. Observe where the end terminals shall be according to the assembly drawing.Connect the cells with the connectors that have been supplied and observe the torque setting 22 Nm when tightening the bolts.

When all the cells have been connected – Check the terminal voltage! It should be the sum of all voltages. If it deviates some of the units may have been reversed. Check again and reorient the misplaced unit.

28 Putting the Batteries into Operation

Check that the circuit breaker is in off position. Verify with a volt meter. Turn on the system and verify that the positive battery cable has the right polarity, ie positive. Turn it off again.

Connect the battery cables at the power system side and then connect them at the battery terminals. Then turn the power system on.

29 Maintenance

Every 6 months stand by operation
The individual voltages and float currents shall be measured and recorded as well as surface temperatures.
Cleanliness of battery shall be checked.
For the first 12 month of operation the variations in cell voltages is expected to be high. (2,14 V< U < 2,50 V)
If deviations do not decrease after 12 months of operation the battery needs additional equalization.

30 Storage

The battery should be stored in a dry cool place. If temperature is high the battery needs to be recharged whenever the average cell voltage is below 2,08 V per cell.

31 Transport

Batteries showing no damage are not treated as dangerous goods according to the road and railway regulations if they are protected against short circuits, sliding, overturning, damage as well as secured and stacked on pallets in a suitable way.

32 Contact Information

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