Discover®

ENERGY STORAGE

SOPzV Gel Tubular Plate Battery

Operating Manual

TUBULAR GEL SOPzV
2V CELLS

REV A

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Overview

Certain configuration, installations, service, and operating tasks should only be performed by qualified personnel in consultation with local utilities and/or authorized dealers. Qualified personnel should have training, knowledge, and experience in:

- Installing electrical equipment
- Applying applicable installation codes
- Analyzing and reducing hazards involved in performing electrical work
- Installing and configuring batteries

No responsibility is assumed by Discover for any consequences arising out of the use of this material.

Visit discoverbattery.com for the most recent version of published documents.

Read instructions carefully and place them close to the battery.

Use protective glasses, gloves and clothing when working on batteries. Always make safe working practices a priority.

No smoking. Do not expose batteries to flames, or sparks, as it may cause an explosion.

Clothing contaminated by acid should be washed in water.

Batteries with this symbol can be recycled.

Risk of explosion and fire. CAUTION: Battery terminals and connector are always under voltage. Do not place tools or other metal objects on the battery. Avoid short circuits!

Electrolyte is highly corrosive.

Batteries and cells are heavy. Ensure secure installation! Use only suitable handling equipment and lifting gear.

Dangerous Voltage!

Do not mix with other industrial or household waste. Contact your servicing Discover® dealer for proper battery return and recycling!

1. Safety

1.1 Do's

- Do protect terminals from short circuit before, during, and after installation
- Do wear electrically insulated gloves
- Do use electrically insulated tools
- Do wear eye protection
- Do wear safety toe boots / shoes
- Do read user manual for battery handling instructions
- Do secure battery safely

1.2 Do Not's

- Do not operate or store battery outside of operating limits
- Do not short circuit battery
- Do not puncture battery
- Do not expose battery to flames, or incinerate
- Do not open battery case or dissemble battery
- Do not wear rings, watches, bracelets or necklaces when handling or working near battery
- Do not drop or crush battery
- Do not lift battery by the terminal cables
- Do not expose battery to water or other fluids
- Do not expose battery to direct sunlight
- Do not dispose of battery
- Do not connect with other types of batteries
- Do not expose battery to high temperatures

2. Delivery and Storage

2.1 Receiving Inspection

- Inspect for missing components.
- Check against the shipping/packing documents.
- Inspect each package or pallet for integrity and electrolyte leakage.
- Record receipt date and inspection data results, and notify your servicing dealer of any damage. Take photographs if necessary.

2.2 Storage

- Store the battery in a dry, clean, ventilated, cool and frost-free location.
- Do not expose the cells to direct sunlight as damage to the container and cover may occur.
- Do not stack pallets on top of each other. DO NOT store unpacked cells/blocks on sharp-edged supports. Storage on a pallet and wrapped in plastic material (shrink wrap) is permitted except in rooms where the temperature fluctuates significantly, or when high relative humidity can cause condensation under the plastic. With time this condensation can cause a whitish hydration on the terminals and current leakage leading to high self-discharge.
- Protect the batteries from any risk of electric shock from short- circuiting poles/terminals with conductive objects or from the building up of conductive dust.
- Maintain the same storage conditions for all batteries within the same batch. Batteries are normally supplied charged. Depending upon storage conditions, storage time may be limited. In order to prevent batteries from becoming over discharged during storage do not store them for more than 3 months at 20°C/68°F, 2 months at 25°C/80°F, or 1 month at 40°C/104°F before performing a re-fresh charge. Failure to observe these conditions may result in significantly reduced capacity and service life
- Record dates and conditions for all charges during storage.

2.3 Unpacking and Handling

- Never lift cells by the terminal posts. Lifting cells heavier than 25 kg/55 lb should be made with lifting belts
- Never drag or roll the battery!
- The batteries are fully charged before shipment. Do not short circuit.
- Check for evidence of leakage. All cells or blocks with visible defects should be rejected.

3. Installation and Commissioning Charge

3.1 Installation and Battery Room Design

- All electrical protective measures, devices, accommodation and ventilation of the battery installation area must be in accordance with all local rules and governmental regulations.
- The battery should be installed in a clean and dry area and protected against dropped items and dirt.
- Avoid placing the battery in a hot place or in direct sunlight.
- The location or arrangement of cells should result in no greater temperature difference than 3°C/5°F between cells or blocks within a connected string at any given time.
- Avoid conditions that result in spot heating or cooling, as temperature variations will cause electrical imbalances in the battery. For better cooling and temperature management ensure the installation allows for adequate air flow around each cell or block. Keep 10mm/0.5in distance between cells or blocks.
- The layout of the battery room or installation area must allow for easy access to the batteries. The recommended minimum distance between battery rows is 1.5 times the depth of the row.
- Racks or cabinets shall be located 100mm/4in from the wall.
- Be sure to provide adequate space and lighting for inspection, maintenance, testing, and cell/block replacement. Space should also be provided to allow the operation of lifting equipment and for taking measurements (cell voltage and temperature) during service.

3.2 Cells in Parallel Strings

Discover® Tubular Gel cells/blocks may be connected in parallel to increase capacity, current capability and/or discharge durations. In the case of each parallel connected string, only use batteries of the same voltage, capacity, design and age.

The resistance and ampacity of the cables or connector bars in each string must be the same, e.g. same cross-section, same length and same conductor type (copper, aluminum). In addition, each string should be equipped with disconnect capabilities (circuit breakers) for maintenance and safety purposes.

Discover® recommends a maximum of 4 strings parallel: If the following steps are fulfilled it is possible to have more strings in parallel without reducing battery life or cells/blocks getting out of balance if the following requirements are fulfilled:

- The same voltage drop must be realized from each string to the end connection (load and ground). This can be achieved by proper choice of cable lengths, cable diameters and arrangement for crosswise connection configurations
- The connector cables for positive and negative terminals of each battery string must have the same length
- It is a must that each string has a manually operated switching device that also automatically opens or breaks the circuit in the event of an over current (circuit breaker).
- Each string must have the same number of cells
- Each string must be exposed to the same heat or temperature potential.
- Always connect the individual series strings first and then check that the different strings are at the same potential before connecting them together on the bus.

Notes:

- The combined performance data of all of the cells will be realized at the end pole/terminal of each string.
- Battery life or reliability will not be negatively affected if this form of paralleling is done correctly.
- Parallel connection of strings with different capacities as well as different ages is possible (the age and capacity of the batteries within each string must be the same).
- The current during both discharge and charge will be split according to the capacity or age of the batteries respectively.

3.3 Cells in Series Strings

- Discover® Tubular Gel cells/blocks may be connected in series to increase system voltage.
- In the case of each series connected string, only use batteries of the same voltage, capacity, design and age.
- The resistance of the cables or connector bars in each string must be the same, e.g. same cross-section, same length and same conductor type (copper, aluminum).
- Each string should be equipped with disconnect capabilities (breakers) for maintenance and safety purposes.

3.4 Pre-installation Control

- Check cells for evidence of leakage.
- All cells with visible defects such as cracked jars or containers, loose terminal posts, or other unrecoverable problems shall be rejected.
- Before installation, in cases where the battery container is dirty, wipe with a water-moistened anti-static cloth only.

3.5 Electrical Connections

- Ensure that the cells are installed and connected in the correct polarity.
- Check that all contact surfaces are clean. If required, clean poles/terminals with a brass brush/pad.
- You may slightly lubricate terminal inserts and connections with silicone grease. Petroleum-based lubricants are not recommended.
- Tighten the terminal screws using a torque loading of 23 Nm or 17 Ft-lbs. Electrical connections between cells/blocks or cells/ blocks on separate levels or racks should be made making sure to minimize mechanical strain on the battery poles/ terminals.
- For systems where the total battery voltage is measured at the controller, use oversized cables between the controller and the battery to minimize the voltage drop.
- Check the battery's total voltage. It should match the number of cells/blocks connected in series. If the measurement is not as expected, recheck the connections for proper polarity.
- The installer of the battery is responsible for conformity to local electrical standards.
- For future identification, apply individual cell numbers in sequence starting from one end of the series string. Also apply identification letters or numbers for the parallel strings.
- Only connect the battery to the DC power supply after ensuring that the polarity is correct, the charger is switched off, and the load is disconnected.

3.6 Commissioning Charge

The initial charge is very important for the future battery operation and the battery's service life. It is performed as a "Commissioning charge" as listed in paragraph 4.2.1. Keep records in the battery's logbook. Discover Commissioning Logs are available online at discoverbattery.com/en/resources/

3.7 Discharging

It is recommended for a system to be sized for no greater than 50% Depth of Discharge (DOD). A deep discharge will provide more capacity to operate loads but exposes the battery to sulphation and reduces the service life. After a deep discharge, it is recommended to charge a battery back to full State of Charge (SOC) as soon as possible to preserve capacity life.

The longer the battery stays at a low Depth of Discharge, the greater the exposure to sulphation and capacity loss. If the battery is left at a low Depth of Discharge for extended periods of time, sulphation damages may become unrecoverable through equalization charges

OVER-DISCHARGE PROTECTION

Maximum Depth of Discharge limits should not be managed solely based on Ah-counters (counting the ampere- hours into and out of the battery). Monitoring the battery voltage against the low- voltage disconnect setting (LVD) should always be included.

- The system designer or installer shall adjust and confirm the LVD settings based on the actual conditions of the system.
- For systems where the voltage is measured at the controller and not on the battery, the voltage drop on the connections to the battery shall be considered.
- For mission critical systems with the load directly connected on the battery, an alarm or other method of user feedback must be included to provide information about the battery status when DoD exceeds the design limits.

Reference LVD / I10	20% DOD	2.05 Vpc
	50% DOD	1.97 Vpc
	80% DOD	1.91 Vpc

3.8 Charging

The most common type of charging method can be grouped into three phases: bulk, absorption, and float charge. An additional balance phase can be performed on a routine maintenance-as-required basis.

The Bulk charge accounts for charging the battery from anywhere between 0% up to 80% state of charge. The absorption phase charges the battery from 80% to nearly 100% state of charge. Lastly, a float charge supplies a controlled voltage and amperage to bring the battery to a complete full charge.
For specific charge programming instructions, please refer to the documents provided by the charger manufacturer.

The battery temperature must be monitored during charge. It should never exceed 50°C/122°F. If the upper temperature limits are reached, the charge shall be interrupted or the charge voltage should be reduced to float voltage for a period of time sufficient enough to allow the battery to cool down. Operation can continue once the temperature stabilizes below 50°C/122°F.

SUPERIMPOSED ALTERNATING CURRENTS
Depending on the charger type and charging characteristic curve, alternating currents flow through the battery during charging and are superimposed onto the charging direct current. These superimposed alternating currents and the reaction of the loads lead to additional heating of the battery or batteries and create a cyclical strain on the electrodes. This might result in premature aging of the battery. These alternating currents (AC ripple current) must not exceed 3A per 100 Ah of C10 nominal capacity. In order to achieve the optimum service life on float charge, a maximum effective value of the alternating current of 1.35 A per 100 Ah nominal capacity is recommended.

3.8.1 Commissioning Charge

Batteries lose charge while in transit or during storage. For this reason, a refresh charge should be given before putting the battery into service. The charge voltage should be set for 12 hours at constant voltage with current limitations as listed below. The battery should be considered fully charge when individual cell voltages have not risen for a period of 4 hours.
The surface temperature must not exceed 40°C (104°F). Recommended charge settings are as follows:

Constant Voltage	2.35 V/Cell at 20°C/(68°F)
Current Limit	15A per 100Ah C10 rating
Time Limitation	Max. 12 hrs

During commission, measure the cell voltage of the cells and after commissioning, measure the cell voltage and surface temperature of each cell and log this data. Discover Commissioning Logs are available online at https://discoverbattery.com/en/resources/

3.8.2 Charge Parameters

- The charge voltage should be set as shown in the table below.
- The battery should be considered fully charged when the individual cell voltages have not risen for a period of 4 hours and the inverter/charger adjust to float voltage.

		< 0°C (32°F)	0°C (32°F) / 15°C (59 °F)	15 (59 °F) / -35°C (95 °F)	35°C (95 °F) / -50°C (122°F)
2VDC	Bulk & Absorption Charge Voltage	2.43 V	2.4 – 2.43 V	2.35 – 2.4 V	2.35 V
	Float Voltage	2.35 V	2.25 – 2.35 V	2.25 V	2.2 – 2.25 V
	Balance/Boost Voltage[1]	2.43 V	2.4 – 2.43 V	2.35 – 2.4 V	2.35 V
24VDC	Bulk & Absorption Charge Voltage	29.16 V	28.8V - 29.16V	28.2 – 28.8 V	28.2 V
	Float Voltage	28.2 V	27 - 28.2 V	27 V	26.4 -27 V
	Balance/Boost Voltage[1]	29.16 V	28.8 - 29.16 V	28.2 - 28.8 V	28.2 V
48VDC	Bulk & Absorption Charge Voltage	58.32 V	57.6- 58.32 V	56.4 – 57.6 V	56.4 V
	Float Voltage	56.4 V	54 - 56.4 V	54 V	52.8 - 54. V
	Balance/Boost Voltage[1]	58.32 V	57.6 - 58.32 V	56.40 – 57.6 V	56.4 V

(1) Maximum 48 hours or if the current has decreased to a value lower than 5 Amps per C10 capacity rate.

BULK PHASE
The constant current setting for the bulk phase is recommended to be set at 10%-15% of the C10 capacity rate [Ah] of the battery. For example, if the battery is rated at 422 Ah at C10, then the recommended charge current is 42 A to 63 A. Charging at higher currents than the recommended levels may cause the battery bank to overheat and incur damage.

ABSORPTION PHASE
After the battery has been charged to 80% state of charge, the charger will switch to the programmed Absorption settings for the remaining 20% charge. In this phase, as the battery approaches full charge, the current begins to decrease in response to the increasing internal resistance of the battery.

FLOAT PHASE
The float phase is the third phase in the charging process. A float charge is required to maintain a battery at full charge as there may be some minor self-discharge.

END AMPS
End Amps or Return Amps is the current when the battery is fully charged and no longer accepts a charge. When the current reaches the End Amps set point, the charger will turn off. The recommended setting is 2% of the C10 Ah rating. For example, if the battery is 422 Ah at the C10 rate, then the recommended End Amps setting is 8.4 Amps.

3.8.3 Balancing / Boost charge

To avoid permanent capacity loss and acid stratification in cycling operation the goal is to achieve a complete recharge (100% SoC) after every discharge. Capacity loss and acid stratification will threaten the battery's state of health.

The less complete the daily recharge is, the more frequently a balance charge will be required to protect the battery from sulphation and lagging cells. Depending on the cycling frequency, balancing of the battery bank is recommended every 60 to 180 days. When short charging times are used then balance charges are required at frequent intervals, preferably every month.

Balance charges are also required after incidents of excessive stress for the battery (deep discharges with inadequate charges) or when the individual cell or block voltages show excessive deviation from the average (lagging cells and solvation problems). Should the voltage in individual cells deviate from the average value more than the following limits, perform a balance charge. Balance charge is generally required when the total spread between cells is greater than 0.04V under float charge conditions.

Perform the balance/boost charge as follows:
1. Balance charge voltage is 2.35-2.4 Vpc for a maximum duration of 48 hours. The charge current must not be higher than 15 A per 100 Ah C10 nominal capacity.
2. If the maximum temperature exceeds 45 °C, terminate the charging process or switch to float charge to allow the temperature to drop.
3. The end of the balance charge is reached if the current has decreased to a value lower than 5A per 100Ah C10 rating

3.9 Temperature Limits

Temperature is important to monitor as it affects the voltage readings. Depending on the battery temperature, the voltage set points may require adjustment. For an accurate temperature measurement, the temperature sensor, if included with the charge equipment, must be properly mounted to the side of the cell casing below the electrolyte.

Attaching the sensor to other parts of the battery may provide an inaccurate representation of the battery temperature. Failure to monitor the temperature accurately may cause overcharging or undercharging. The operating temperature should not exceed 50°C. As a precaution, there should be a charge cut-off to prevent the battery bank from operating at temperatures greater than 50°C (122°F).

Sub-zero temperatures may cause electrolyte freezing and irreversible damage with increasing depth of discharge (DoD). The minimum safe temperature versus the cell depth of discharge:

Depth of Discharge (DoD)	<20%	20% – 40%	40% - 60%	60% - 80%
Freezing Point	-40°C / -40°F	-30°C / -22°F	-20°C / -4°F	-15°C / 5°F

3.10 Charge Current Limits

Charging current in general should not exceed 30A/100Ah C10 rating. Using a charging current during bulk/absorption of 10A to 15A per 100AH C10 rating is recommended.

4. Battery Maintenance

VISUAL INSPECTION AND CLEANING INSTRUCTIONS

Check for any visible defects such as cracked jars, loose terminal posts and oxidized connectors. To avoid leakage currents and the associated risk of fire, keep the battery dry and clean. Clean with clear water. Do not use any solvents or detergents. Avoid electrostatic charges. Discover Maintenance Logs are online available at discoverbattery.com/en/resources/

BI-ANNUAL MAINTENANCE

- Check/record battery voltage
- Deviation testing of cell voltages (deviations signal imbalance cells)
- Deviation testing of cell temperatures (deviations signal short circuit)
- Check if balanced charge is applied
- Confirm daily DoD per cell
- Confirm max DoD per cell does not exceed the allowed limit
- Confirm charging factor is within acceptable limits
- Confirm that charge settings correspond to recommendations

ANNUAL MAINTENANCE

- Further to the bi-annual maintenance, do the following:
- Check/record battery voltage
- Deviation testing of cell voltage (deviations signal imbalance cells)
- Deviation testing of cell temperatures (deviations signal short circuit)
- Check/record if connectors are firmly tightened.
- Inspect/record the racks for corrosion or loss of integrity
- Check/record if ventilation is sufficient.
- Check/record battery room temperature

5. Storage

If lead acid batteries are to be taken out of operation for extended periods of time, they must be placed fully charged in a dry, frost-free room. To avoid damage, perform periodical balance charging or permanent float charging.

6. Transport

Be sure that all cells are protected against short-circuit. Be sure to document and transport all cells or batteries according to local department of transportation rules and regulations.

7. Recycling

Discover's lead acid batteries are recyclable products. All Discover Factory Warehouses and servicing dealers are qualified to accept and handle all used lead acid batteries. Contact Discover® or your servicing dealer for details.

8. Troubleshooting and Frequently Asked Questions

The following is a list of common concerns and questions regarding system setup, battery charging and maintenance procedures. Please refer to these as general guidelines. For further assistance with your specific system setup, please contact your installer.

WHAT CAUSES THE BATTERY TERMINAL TO MELT?

Battery terminals melting is most common because of improper connections causing high resistance and heat generation.

- Loose connections
- Over-tightened connections
- Improper sized cables (too small).
- Corroded connections
- Improper use of washers/lock washers.
- Too many connections on the same terminal

WHY DO THE BATTERIES BULGE?

Some case bulging is normal from the weight of electrolyte. New battery cases tend to "relax" after filling with electrolyte.

- If case bulging is a concern upon receipt of a new product, please notify your Distributor immediately
- In the case of excessive bulging- your batteries may have been exposed to temperatures of over 50°C (122°F). The high temperature may cause the plates/chassis to swell and expand. If this occurs, the batteries may fail prematurely
- The batteries may have frozen due to excessive exposure to cold temperatures.

WHAT CAUSES A BATTERY TO LOSE CAPACITY?

The capacity loss may be due to sulphation, overheating, or over-discharging. If there is capacity loss, the battery bank may no longer support an increase in load.

- A balance charge may be necessary
- Verify the temperature sensors are properly mounted and the operation settings are adjusted to the appropriate battery temperature

WHY IS THE CHARGING CURRENT TO THE BATTERY BANK SO LOW?

The charging current will decrease as the batteries become fully charged. If the charge current is low, the end of charge cycle may have been reached. Verify that the charger is near the end of the Absorption phase or in Float voltage phase. If so, low current is normal at this stage of charging.

- The battery bank self-regulates charge current. The voltage can be controlled and adjusted to a high or low setting, however the amp output to the battery bank cannot be controlled and will drop as the batteries reach a full state of charge.
- When the charge current decreases to 2% of the battery C10 capacity, the charge is essentially complete.

WHY DOES THE VOLTAGE RISE VERY QUICKLY CAUSING THE CHARGER TO SHUT OFF WHEN I BEGIN TO CHARGE MY BATTERY BANK?

This is often an indication of sulphated batteries which can be confirmed by completing a load test.

- An increase in Absorption time may be necessary to sufficiently charge the battery to full SOC.
- If the battery bank is heavily sulphated

WHY DOES THE BATTERY BANK NOT REACH THE BULK VOLTAGE SETTING WHEN CHARGING?

If the system is not reaching the Bulk voltage, the charger voltage and/or Amp output to the battery bank may be too low. To ensure sufficient charge, the output should be approximately 10%-15% of the C10 capacity rating of the battery bank. Another cause may be from DC loads running on the system during the charge cycle and reducing the current supplied to the battery bank.

- Verify that the charging settings meet the recommended charging parameters and that the charger output (Amps) is sufficient to meet the capacity requirements of the battery bank.

WHAT DO I DO IF THE BATTERY TEMPERATURES ARE VERY HIGH?

If at or nearing 50˚C (122˚F), shut off the charger and allow the batteries to cool.
If a single battery or cell in a string is hot, this may indicate a cell failure or short. Verify the voltage readings from each battery, and perform a load test to identity any cell failures.

WHAT CAUSES THE BATTERY COVER TO CRACK, SHATTER AND/OR DISLODGE FROM THE CASE? (NOT AFFECTING THE POSITIVE AND NEGATIVE TERMINALS OR CONNECTIONS)

The ignition of hydrogen gas may have caused the battery cover to crack. This sometimes occurs during a charge where a loose connection at the terminal creates a spark and ignites hydrogen gas produced from the cell. If the battery case has split or cracked along the sides, the battery may have frozen in the past.

9. Definitions and Abbreviations

- Ampacity: The allowable current-carrying capacity of a conductor measured in amps. Ampacity is the current, in Amperes, that a conductor can carry continuously under the conditions of use without exceeding its temperature rating.
- Battery Capacity: The power a battery can deliver from full charge at standard temperature, and at a specified (usually C10) discharge rate.
- Circuit Breaker: Is an automatically operated electrical switch designed to protect an electrical circuit from damage caused by overload or short circuit. Its basic function is to detect a fault condition and interrupt current flow. Unlike a fuse which operates once and then must be replaced, a circuit breaker can be reset (either manually or automatically) to resume normal operation.
- DoD: Depth of Discharge or how deeply the battery has been dis-charged. Like the fuel gauge of your car, DoD is the measure of how much fuel you have used.
- I10: The constant current (I) discharge rate that can be maintain for 10 hours (10).
- MDDoD: Maximum Daily Depth of Discharge allowable
- MDoD: Maximum allowable Depth of Discharge
- OCV: Open Circuit Voltage: The voltage across the cell/ block or battery terminals with no load applied. The maximum possible voltage across a PV array, module, or cell with no load.
- SoC: State of Charge or how much energy is still available to be discharged. Like the fuel gauge of your car, SoC is the measure of how much gas you have left.
- V: The unit of measure for voltage. Voltage is the electrical pressure which forces the current to flow in a conductor such as a wire.
- VPC: Volts per Cell. The voltage of each individual cell, each cell in a block or each cell in a battery. The system voltage of your battery is the sum of the individual volts per cell.
- 100AH C10: Battery has a capacity (C)of 100 amp hours (AH) when rated at the 10 hour (C10) rate.