

Deka[®]
SOLAR
PHOTOVOLTAIC BATTERIES

Gel System/2V
Installation and Operation Manual



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⚠ DANGER

 HIGH VOLTAGE... RISK OF SHOCK. DO NOT TOUCH UNINSULATED TERMINALS OR CONNECTORS.	 SHIELD EYES EXPLOSIVE GASES CAN CAUSE BLINDNESS OR INJURY.	 NO • SPARKS • FLAMES • SMOKING	 SULFURIC ACID CAN CAUSE BLINDNESS OR SEVERE BURNS.
------------------------------------------------------------------------------------------------------------	--------------------------------------------------------------------------------	----------------------------------------------------	------------------------------------------------------------------------

DO NOT REMOVE VENT VALVE. WARRANTY VOID IF VENT VALVE IS REMOVED. VENTILATE WELL WHEN IN AN ENCLOSED SPACE AND WHEN CHARGING.

SEE INSTALLATION, MAINTENANCE AND OPERATION INSTRUCTIONS FOR IMPORTANT SAFETY PRECAUTIONS. REPAIR SHOULD BE PERFORMED ONLY BY A QUALIFIED SERVICE TECHNICIAN.

California
 Proposition 65
 Warning

Batteries, battery posts, terminals and related accessories contain lead and lead compounds, and other chemicals known to the state of California to cause cancer and birth defects or other reproductive harm. **Wash hands after handling.**

BATTERIES
AND OTHER RELATED PARTS
CONTAIN LEAD

WARNING:
 Battery posts, terminals and related accessories contain lead and lead compounds, chemicals known to the State of California to cause cancer and reproductive harm.
 Batteries also contain other chemicals known to the State of California to cause cancer.
WASH HANDS AFTER HANDLING!

Form No. 1214 Rev. 0/08 Must be posted on every battery near batteries.

Only trained and authorized personnel should install, repair or charge batteries.

When used properly, a lead-acid renewable energy battery is a safe, dependable source of electrical power. However, if proper care and safety precautions aren't exercised when handling a battery, it can be an extremely dangerous piece of equipment.

There are four hazardous elements when handling a lead-acid battery: sulfuric acid, explosive gases, electricity, and weight.

SAFETY PRECAUTIONS

Protective Equipment

Although VRLA (Valve Regulated Lead-Acid) batteries can vent or leak small amounts of electrolyte, electrical safety is the principle but not the only concern for safe handling. Per IEEE 1188 recommendations, the following minimum set of equipment for safe handling of the battery and protection of personnel shall be available:

1. **Safety glasses with side shields, or goggles, or face shields as appropriate. (Consult application specific requirements)**
2. Electrically insulated gloves, appropriate for the installation.
3. Protective aprons and safety shoes.
4. Portable or stationary water facilities in the battery vicinity for rinsing eyes and skin in case of contact with acid electrolyte.
5. Class C fire extinguisher.
6. Acid neutralizing agent.
7. Adequately insulated tools.
8. Lifting devices of adequate capacity, when required.

Procedures

The following safety procedures should be followed during installation: **(Always wear safety glasses or face shield when working on or near batteries.)**

1. These batteries are sealed and contain no free electrolyte. Under normal operating conditions, they do not present any sulfuric acid danger. However, if the battery jar or cover is damaged, sulfuric acid could be present. **Sulfuric acid is harmful to the skin and eyes. Flush affected area with water immediately and consult a physician if splashed in the eyes.**
Consult MSDS for additional precautions and first aid measures.
2. **Prohibit smoking and open flames, and avoid arcing in the immediate vicinity of the battery.**
3. Do not wear metallic objects, such as jewelry, key chains, while working on batteries. Do not store un-insulated tools in pockets or tool belt while working in vicinity of battery.
4. Keep the top of the battery dry and clear of tools and other foreign objects.
5. Provide adequate ventilation **(per IEEE standard 1187 and/or Federal, State & Local codes)** and follow recommended charging voltages.
6. Extinguishing media: Class ABC extinguisher.
Note: CO₂ may be used but not directly on the cells due to thermal shock and potential cracking of cases.
7. **Never** remove or tamper with the pressure relief valves unless for cell replacement. Warranty void if vent valve is removed.

8. Inspect all flooring and lifting equipment for functional adequacy.
9. Adequately secure battery modules, racks, or cabinets to the floor.
10. Connect support structures to ground system in accordance with applicable codes.
11. The below IEEE Standards contain additional information. Other standards may be relevant to your specific application.
IEEE 1187 – Recommended Practice for Installation Design of VRLA Batteries
IEEE 1188 – Recommended Practice for Maintenance, Testing, of VRLA Batteries
IEEE 937 – Recommended Practice for Installation & Maintenance of Lead-Acid Batteries for Photovoltaic (PV) Systems
IEEE 1013 – Recommended Practice for Sizing Lead-Acid Batteries for Stand-Alone Photovoltaic (PV) Systems
IEEE 1526 – Recommended Practice for Testing the Performance of Stand-Alone Photovoltaic Systems
IEEE 1578 – IEEE Recommended Practice for Stationary Battery Electrolyte Spill Containment and Management
IEEE 1660 – Guide for Application and Management of Stationary Batteries Used in Cycling Service.

Hazardous Elements

Sulfuric Acid: The electrolyte in a lead-acid storage battery is a diluted solution of sulfuric acid and water. Although the acid content in the solution is only about 37%, it is still a strong corrosive agent and can burn skin and eyes and create holes in many types of fabric. **(See Protective Equipment.)**

Explosive Gases: When a lead-acid battery is being charged, it produces an explosive mixture of hydrogen and oxygen gases. Make sure that all vent areas are kept clean and not obstructed so that any gas is safely vented from the battery. Never smoke, use an open flame, or create an arc or sparks on or near a battery without first eliminating explosive gases from the cells you're working on.

Electricity: An electric shock hazard exists for persons who come in contact with live parts of batteries when the voltage is over 50 volts. The higher the voltage, the greater the electric shock hazard. In addition, metallic objects coming in contact with exposed cell connectors will cause a short and can become very hot. Even shorts involving a single cell can become hot enough to cause severe burns.

Weight: These batteries are of significant weight. Serious injury can occur if batteries are not handled carefully during installation, removal or transport. Use proper lifting equipment and techniques at all times.

First Aid for Acid Splash

Eyes: Flush immediately with gently running water for at least 15 minutes. Seek immediate medical attention. For contact lens wearers, remove the lens before the eyes are flushed. A buffering or neutralizing agent should not be used in the eyes without the approval of medical or safety personnel.

Skin: Wash affected area under running water and apply a chemical burn treatment. Severe burns require immediate medical attention.

Clothing: If large areas of clothing have been splashed or soaked with sulfuric acid, the clothing must be removed and the acid must be treated with non-corrosive water based neutralizing agent (ex: baking soda/water solution), that is user safe and environmentally compliant. After treatment rinse with running water. If clothing is treated immediately, chances of damage to the material are lessened. Acid-resistant boots should always be checked before wearing to be sure that there are no traces of acid inside.

BATTERY LOCATION

When planning a battery system the following requirements should be considered:

- Space**
- Floor Preparation**
- Battery Racking System**
- Ventilation**
- Environment**
- Distance from Operating Equipment**
- Safety Equipment**

Space

It is recommended that aisle space be provided in front of all battery racks be a minimum of 36.0" (915mm). The design should meet all applicable local, state and federal codes and regulations.

Floor Preparation

It is recommended to consult with a structural engineer to determine if the existing floor will withstand the weight of the battery and the battery racking system. The floors in which the battery will be located should have an acid-resistant coating and be sloped toward a sump. Any battery spills should be neutralized with non-corrosive, water based neutralizing chemical (ex: baking soda/water solution) that is user safe and environmentally compliant. The area should always be washed with clean water to remove any acid neutralizing chemical residue.

Battery Racking System

The battery should not be installed directly on a floor. There should be some type of barrier/racking between the floor and the batteries. This barrier/racking should be sufficient to handle the weight of the battery. The battery racking system must be suitably insulated to prevent sparking and eliminate any grounding paths.

Adequate space and accessibility for taking individual cell voltage should be considered. If installed in an earthquake seismic zone, battery racking system must be of sufficient strength and anchoring. Battery rack design should be reviewed by structural engineer.

Ventilation

It is the responsibility of the installer to provide detailed methods or engineering design required by Federal, State and Local regulations to maintain safe levels of hydrogen in battery rooms/enclosures.

The rate of hydrogen evolution is highest when the battery is on charge. Explosive mixtures of hydrogen in air are present when the hydrogen concentration is greater than or equal to 4% by volume. To provide a margin of safety, battery room/enclosure must be ventilated to limit the accumulation of hydrogen gas under all anticipated conditions. This margin of safety is regulated by Federal, State and Local codes and is typically limited to 1 to 2% by volume of the battery room/enclosure. Consult all applicable codes to determine specific margin of safety. Hydrogen gas calculations can be determined by using proper formulas.

Hydrogen gas is lighter than air and will accumulate, creating pockets of gas in the ceiling. The ventilation system should be designed to account for and eliminate this situation. Ventilation system must be designed to vent to the outside atmosphere by either natural or mechanical means in order to eliminate the hydrogen from the battery room/enclosure.

Environment

Batteries should be located in a clean, cool and dry place and isolated from outside elements. The selected area should be free of any water, oil and dirt from accumulating on the batteries.

Distance from Operating Equipment

Battery systems are sized based on a specific load (Amps or Watts) for a specific run time to a specific end voltage. Battery performance is based on these values, as measured at the battery terminals.

For proper operation of the battery system the following should be considered:

- Distance between battery system and operating systems should be kept at the shortest distant possible
- Cables are to be of proper gauge to handle system loads and minimize voltage drops.
- All cable lengths from battery system to operating system should be of the same wire gauge and length.

The above is to ensure the battery cable used will be able to carry the charge/discharge current & minimize the voltage drop between equipment.

Electrical equipment should not be installed above the batteries, because of the corrosive fumes being released from the battery(ies).

SAFETY EQUIPMENT

Fire Suppression

Hand-operated fire extinguishes should be available in the battery room even if the areas are equipped with automatic sprinkler systems. For information on extinguisher class, size and mounting locations, consult local fire authorities or your insurance carrier.

Signage

Because of the explosive gas mixtures generated while charging batteries, anything that could ignite the gas, such as sparks, open flames, an electrical arc, smoking, etc., must be prohibited in the charging areas. To serve as a prominent reminder, "NO SMOKING" signs should be posted in all battery room areas.

Eye Wash Facilities

Emergency eye wash and acid neutralization facilities should be located in the immediate work area for easy access. The three most popular types of eye wash and acid neutralizing equipment are the chemical burn station, deluge shower, and eye wash fountain.

Consult all applicable Local, State, and Federal codes to ensure compliance.

BATTERY OPERATION

There are several factors that affect the operation of the battery concerning its ability to deliver capacity and life expectancy.

Storage

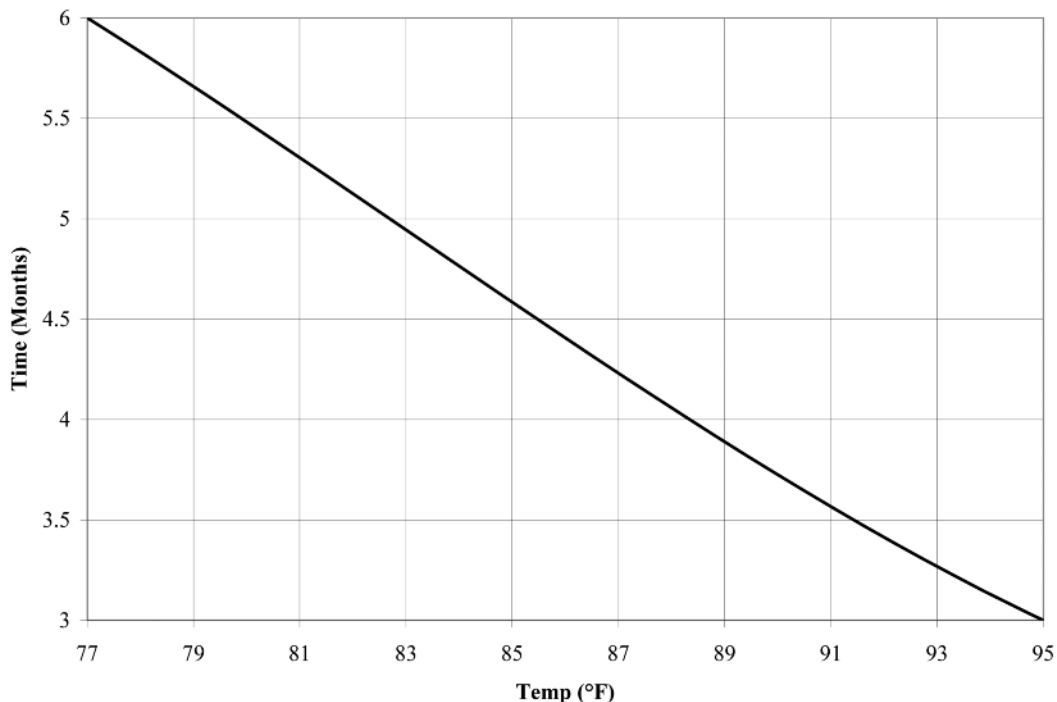
1. Cells should be stored indoors in a clean, level, dry, cool location. Recommended storage temperature is 0°F to 90°F (-18°C to 32°C).
2. Stored lead-acid batteries self discharge and must be given a boost charge to prevent permanent performance degradation.

0°F to 77°F (-18°C to 25°C) storage:

Batteries should be recharged three months from date of manufacture.

>77°F (25°C) storage:

Use the chart below for recharge intervals. Voltage readings should be taken on a monthly basis. Cells that reach 2.10 volts per cell (vpc) should be recharged regardless of scheduled interval. Record dates and conditions for all charges during storage.



3. If a boost charge is required: the recommended charge is 24 hours at a constant voltage equal to 2.42 volts per cell
4. Do not store beyond 12 months.

Temperature

Many chemical reactions are effected by temperature, and this is true of the reaction that occurs in a storage battery.

The chemical reaction of a lead-acid battery is slowed down by a lowering of the electrolyte temperature that results in less capacity. A battery that will deliver 100% of rated capacity at 77° F will only deliver 65% of rated capacity at 32° F.

Excessive heat will increase the natural corrosion factors of a lead-acid battery. This increase corrosion of the positive plates contributes greatly to reducing the overall life of the battery.

Depth of Discharge (DoD)

Depth of discharge is a function of design. The deeper the discharge per cycle the shorter the life of the battery. A cycle is a discharge and its subsequent recharge regardless of depth of discharge.

Systems should be designed for shallow discharges. The result of shallower discharges is typically a larger capacity battery at prolonged battery life.

Charging

Majority of battery capacity/life issues can be traced to improper charging.

Improper charging settings may lead to an overcharging or undercharging condition.

Inverter/Charge Controller Settings

Proper inverter/charge controller settings are necessary to ensure peak battery performance and life. All bulk, absorption, float and equalize settings should be verified they are within the battery manufacturers settings. These settings include but are not limited to; voltage, current and time. **Default setting should not be presumed to be correct. For battery systems located in an uncontrolled temperature environment, temperature compensation should be used.**

BATTERY OPERATION continued

Stand-Alone/Off-Grid Systems

Absorption stage time should be set to optimize the available sun hours during the winter or cloudy months. If improperly set, there is a risk of undercharging the battery system.

For battery systems located in an uncontrolled temperature environment, temperature compensation should be used.

Maintenance

IEEE 1188 suggests batteries be checked on a monthly, quarterly and yearly basis. Each time period requires different checks. Maintenance log should be initiated at time of installation. Typical checks consist of voltage and visual inspections. Periodic verification of voltages will ensure battery being fully charged and operating properly. If any conditions are found that are out of specifications, corrections should be made.

A good battery maintenance program is necessary to protect life expectancy and capacity of the battery.

BATTERY INSTALLATION

Receiving a Battery

After receiving a battery, examine the crate and pallet for signs of damage. If you see any wet spots, the battery may have been damaged during transit. Be careful when handling a crate or packing material that's contaminated with spilled electrolyte. Chemical burns can result if skin or clothing comes in contact with the spillage.

Inspect the packing material under the tray for signs of leakage. All damaged components should be inspected by your East Penn representative.

Call your East Penn representative immediately. **Do not attempt to discharge or charge the battery.**

Lifting Batteries

Always use the proper lifting equipment to reduce the risk of tray damage, shorting and possible injury.

Chain hoists used to handle batteries should be equipped with a non-metallic container or bucket to prevent the chains from dangling and possibly causing a short by coming in contact with exposed intercell connectors on the battery top. If no protection is available, cover the battery with a non-conducting insulating material such as plywood or heavy plastic.

Installing Batteries

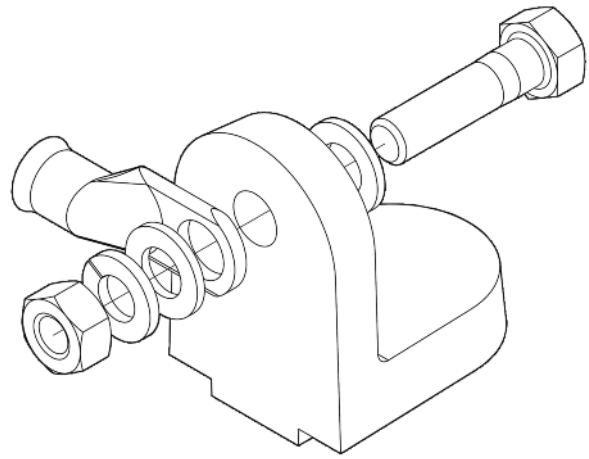
There should be some type of barrier/racking between the floor and the batteries. Battery rack(s) should be installed per rack manufacturer's instructions. Battery rack should be securely anchored to the floor. Floor anchoring and its design are the responsibility of the owner and should meet all Local, State and/or Federal codes.

Caution should be observed when installing battery on racking system. Consult battery layout to ensure batteries are installed in the correct polarity order. Batteries are shipped assembled and charged.

Battery terminals should be cleaned of all oils, greases or corrosion prior to installing cables. The surface of the battery terminals may be cleaned using a stiff-bristle nonmetallic brush/pad until a clean bright surface is accomplished.

Ensure all inter-battery connections and battery cables are properly connected and polarity is correct. All inter-battery cables should be of the same length and wire gauge. Cables should be at minimum length to reduce voltage drop. Use a voltmeter to confirm correct polarity. Lug bolt hole should be 5/16" in diameter. Hardware supplied with battery should be used. All battery connections should be torque to 150 in/lb.

All parallel connections should be of the same length and wire gauge and be terminated at a common bus. This will ensure all parallel battery strings are being discharged and charged at the same voltage and current.



Charging Safety

There are several important safety precautions that should be taken when charging a battery:

- **Do not use open flames when around batteries.**
- **Keep all open flames, sparks and matches away from the charging area. DO NOT SMOKE around the charging area.**
- **Only properly trained personnel understanding all safety measures, charging parameters and required maintenance prior to charging should charge batteries.**
- **The charger should be OFF before connecting it to the battery.**
- **All mechanical connections on the battery and charger should be tight. Torque all connections to specification. Loose connections can overheat and cause arcing that could cause a gassing cell to explode, or cables to become hot to the touch.**
- **Covers on battery trays should be kept open while charging to promote cooling and allow gas to escape.**
- **The charger should be OFF before disconnecting the battery.**

Connecting/Disconnecting Charger

Always turn the charger OFF before connecting or disconnecting a battery. Live leads can cause arcing and sparking, which could cause an explosion if battery gases are present. In addition, the contact surfaces of the plugs or connectors will become pitted over time.

BATTERY SYSTEM OPERATION

There are several factors that affect the operation of the battery concerning its ability to deliver capacity and life expectancy. Many chemical reactions are affected by temperature, and this is true of the reaction that occurs in a storage battery. The chemical reaction of a lead-acid battery is slowed down by a lowering of the electrolyte temperature that results in less capacity. A battery that will deliver 100% of rated capacity at 77° F (25°C) will only deliver 65% of rated capacity at 32°F (0°C).

Discharge Voltage Curve

To estimate battery voltage during a constant current discharge at various DoD (Depth of Discharge) consult chart Discharge Voltage Curve in Appendix B.

NOTE: Battery voltage can vary depending on temperature, age and condition of battery.

CHARGING PARAMETERS

Bulk Charge:
Current limited to 15% of C20 or 3 times I20.

Absorption Charge:
2.37 vpc to 2.42 vpc

Float Charge:
2.25 vpc to 2.30 vpc

Equalize:
2.43 vpc to 2.48 vpc

To determine the correct system voltage, multiple the number of cells connected in series by the above values.

Charging

The majority of battery capacity/life issues can be traced to improper charging.

Improper charging settings may lead to an overcharging or undercharging condition.

Inverter/Charge Controller Settings

Proper inverter/charge controller settings are necessary to ensure peak battery performance and life. All bulk, absorption, float and equalize settings should be verified they are within the battery manufacturers settings. These settings include but are not limited to; voltage, current and time. **Default setting should not be presumed to be correct.**

Stand-Alone/Off-Grid Systems

Absorption stage time should be set to optimize the available sun hours during the winter or cloudy months. If improperly set, there is a risk of undercharging the battery system.

For battery system located in an uncontrolled temperature environment, temperature compensation should be used.

Charge Current

To properly determine the amount of charge current required, the following variables are to be considered:

- DoD (Depth of Discharge)
- Temperature
- Size and efficiency of the charger
- Age and condition of battery(ies)

Maximum charge current should be limited to 15% of the C20 Ahr rate for the battery(ies) being used in the system.

Example: G75-19 C20 rate – 776Ahr

Max. recharge rate: 776Ahr x 0.15 = 116A

Calculating Recharge Time

The following can be used as a guideline for determining recharge times:

85% to 90% SoC (State of Charge)

Time (hrs) = (Ahr x 1.2)/Ic

Note: Ic should be < 20% of C20

Ahr = Amp Hours removed during discharge.

Ic = Maximum current available to battery from charger.

C20 = C20 rate in Ahr

East Penn Mfg recommends returning 120% of Ahr removed to insure 100% SoC (State of Charge).

The below chart details OCV & to SoC:

% SoC	OCV Voltage
100	2.15 – 2.18
75	2.12
50	2.07
25	2.01
0	1.97

Note: True OCV of a battery can only be determined after the battery has been removed from the load (charge or discharge) for 24 hours.

Placing Battery into Service

Battery voltage of each individual cell as well as ambient temperature should be taken and recorded prior to battery being placed on charge. See Battery Maintenance Report Appendix A

Proper charging is essential for maximum battery life.

A temperature compensated voltage regulated charger is recommended to be used in renewable energy applications.

When a discharged battery is initially placed on charge, it draws a current equal or close to the charger's maximum output. As the battery's voltage rises, the charger output should adjust to the changing voltage to assure a safe, efficient charging rate during all stages of the charge.

A freshening charge at the absorption charge rate should be given to a new battery before putting it into service. The battery should be cool; less than 90°F (32°C), when it is installed.

Proper maintenance is essential to obtain long life and maximum efficiency from any renewable energy battery. Carefully following a scheduled maintenance routine will help increase battery performance and prolong service life. Maintain an accurate records system of battery cycles and maintenance/repair work for each battery. A records system is particularly important for operations that use a large number of batteries.

If you don't already have one, these procedures should help you create a reliable records system:

1. Assign a code/identification number to each battery/cell.
2. Record the voltage and ambient temperature of the battery room when the battery is first received and equalized, and **before and after each charge.**
3. At least once each month, measure and compare the voltage of all the cells. The readings should be uniform from cell to cell. If the range of the on-charge cell voltage readings is more than 0.15 volts, the battery could be showing signs of cell failure. Contact your authorized East Penn representative.
4. Remember to accurately record the number of cycles, ambient temperature and voltage readings; and all maintenance and repair information for every battery. Maintenance Report Appendix A is an example of a basic record-keeping form.

BATTERY MAINTENANCE

Batteries should be inspected periodically to avoid damage resulting from previously undetected problems or improper maintenance and operational procedures.

Look for:

- Corrosion on the tray, terminals or intercell connectors.
- Leaks or damage to the tray.
- Damaged cable leads, terminals or connections.
- Damaged, clogged or missing vent caps.

Repair or replace any damaged parts and thoroughly clean the battery. In case of serious damage or for major repairs, contact nearest authorized East Penn representative.

Before taking any voltmeter readings, the battery should be fully charged. Take voltage readings for each cell and record the readings on your battery inspection form. Use the battery's positive terminal cell as cell #1 and follow the intercell connectors to the last cell (the battery's negative terminal cell). Look for any unusual readings that might indicate a problem cell.

Neutralizing Acid and Electrolyte

For cleaning batteries, non-corrosive, water based battery cleaning products are all that should be used. For user safety and environmental regulatory compliance, the cleaning liquid should contain no hazardous chemical ingredients. Even some products labeled "Battery Cleaner" must be avoided because of hazardous ingredients and damage to batteries and related equipment.

Acid spills are common in battery rooms. When acid spills occur it is critical to minimize:

1. Health and safety risk to personnel and the environment.
2. Damage to batteries, equipment, and surrounding surfaces.
3. Time to neutralize, absorb, and clean-up.
4. Disposal costs of waste materials.
5. Regulatory compliance risks and fines.

Neutralizing acid absorbers and spill kits have the performance attributes required when dealing with acid spills. The PH neutral dry and non-hazardous waste is easy to sweep-up and dispose as non-hazardous waste.

Performing a Test Discharge

To determine if a battery can deliver its rated capacity, a test discharge, or capacity test, can be performed. This test helps determine the “health” of a battery and whether or not it should be replaced.

Only experienced battery technicians should be allowed to prepare a battery for discharge testing and to conduct the actual discharge test.

The test is conducted by discharging a fully charged battery at a specific rate until the battery voltage drops to a predetermined volts per cell, times the number of cells in the battery.

By noting the time elapsed between when the battery was put on discharge and when the final voltage was reached, you can determine whether the battery is delivering its rated capacity:

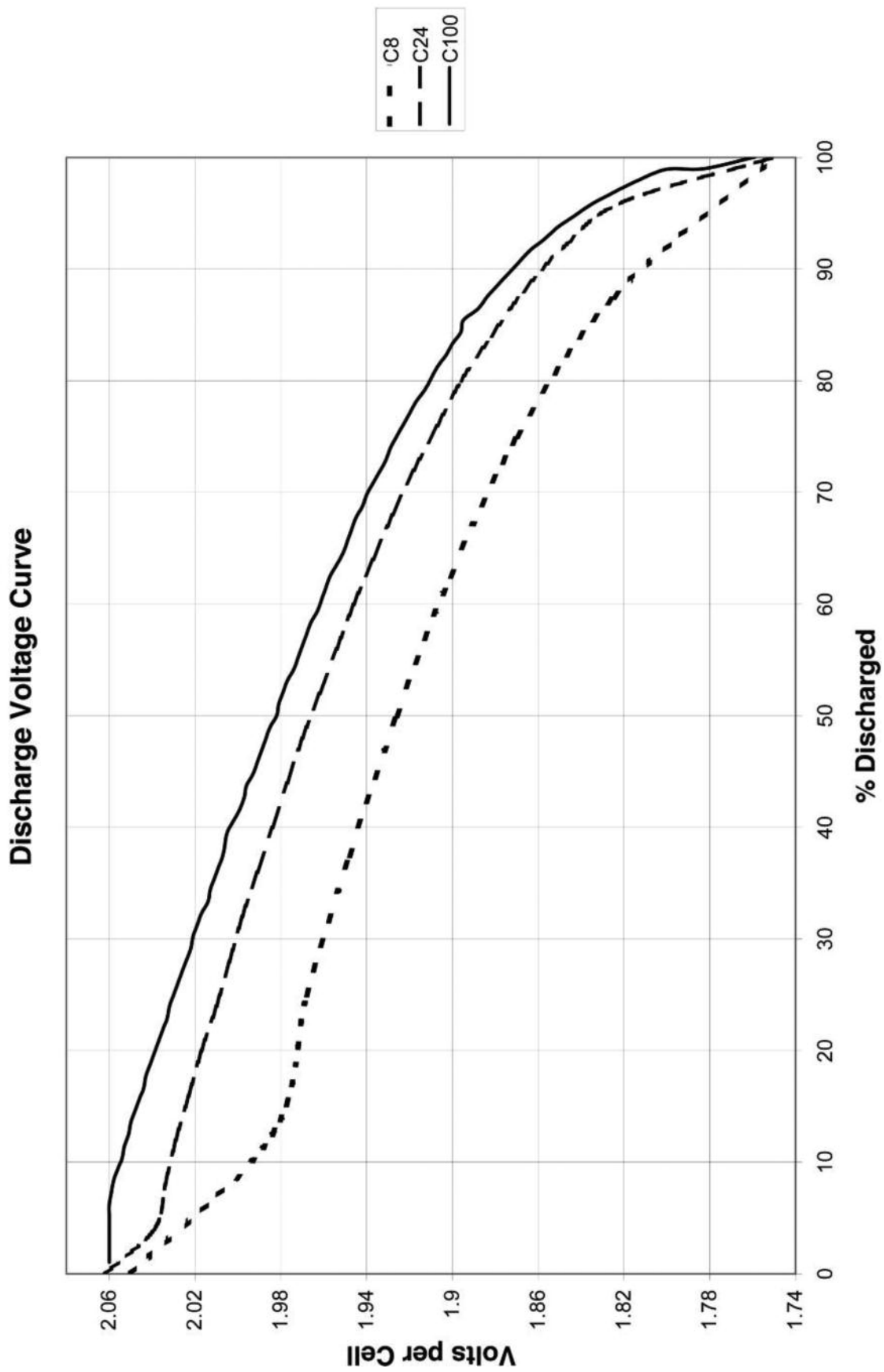
1. Give the battery an equalizing charge.
2. Start the test and record the starting time.
3. Record individual cell voltages and overall battery voltages during the first hour at 10 minutes, 30 minutes and then 60 minutes. After the first hour, take hourly readings until the first cell voltage reaches 1.80 volts per cell. From this point on, record the voltage of the cells every 5 minutes.
4. Carefully monitor the voltage of the low cells and as the voltage of each cell drops below the predetermined final voltage, record the time.
5. When the majority of the cells reach termination value, stop the test. Do not let any cells go into reversal.
For example, if the test was run at the 360 minute rate was terminated after 336 minutes; the capacity percentage would be 93%
6. If the test indicates that less than 50% of the battery's rated capacity is being delivered, the battery should be either repaired or replaced, depending upon its age and overall condition.

For more detailed information on capacity testing, contact East Penn Manufacturing Company or your local authorized East Penn representative.

TROUBLESHOOTING

SYMPTOMS	POSSIBLE CAUSES		REMEDY	
Battery overheats during charge	1	Malfunctioning charger equipment	1	Repair or replace charger equipment
	2	Charge controller/inverter voltage settings out of specification	2	Adjust voltage settings per battery manufacturers recommendations
	3	Defective or weak cell(s)	3	Replace problem cell(s)
	4	High resistance connection within battery	4	Check for hot wires, cells, intercell connections, charging cables. Repair or replace defective component(s)
Battery not able to supply power as when initially installed	1	Battery not fully charged	1	Charge battery until current has stabilized
	2	Weak, leaking or defective cell(s) in battery	2	Replace problem cell(s)
	3	Ground or shorts in battery	3	Remove grounds or shorts
	4	Battery used beyond its useful life	4	Replace battery with equal or higher capacity battery
	5	PV Electrical system problem	5	Troubleshoot PV electrical system
	6	Battery undercharged for long period of time and now sulfated	6	Verify charge controller/Inverter charge settings are within recommendations. Recharge battery until battery is at full state of charge. Perform discharge test.
Battery charge voltage readings do not change during ambient temperature variations	1	Temperature compensation not present or not working	1	Verify temperature compensation is installed and working correctly
Low electrolyte	1	Jar(s) or cover(s) showing signs of cracking	1	Replace cracked cell(s)
	2	Defective or weak cell(s)	2	Replace problem cell(s)
	3	Frequent overcharge	3	See items 1 & 2 in "battery overheats during charge"
Unequal cell voltages	1	Battery used beyond its useful life	1	Replace battery with equal or higher capacity battery
	2	Weak, leaking or defective cell(s) in battery	2	Replace problem cell(s)

APPENDIX B



GLOSSARY

Absorption (Regulation) Charge The charger will attempt to hold its output voltage constant while the battery continues to absorb charge (draw charging current) from the charger. The rate at which the battery continues to absorb charge in this mode gradually slows down. The amplitude of the charger current is gradually decreasing. The charge current is falling and the battery voltage is flat (constant).

Acid In the lead-acid storage battery industry, "acid" implies "sulfuric acid".

Ambient Temperature The temperature of the surrounding cooling medium, such as gas or liquid, which comes into contact with the heated parts of the apparatus, usually refers to room or air temp.

Ampacity Current carrying capacity in amperes.

Ampere (Amp) The practical unit of electric current that is equivalent to the steady state current produced by one volt applied across a resistance of one ohm. It is one tenth of an ampere.

Ampere-Hour (Ahr) A measure of the volume of electricity, being one ampere for one hour, or 3600 coulombs. It is used to express battery capacity, and is registered by an ampere hour meter, or is obtained by multiplying the current in amperes by the length of time that the current is maintained.

Ampere-Hour Capacity The number of ampere-hours which can be delivered under specified conditions as to temperature, rate of discharge, and final voltage.

Battery (Storage) A storage battery is a connected group of two or more storage cells (common usage permits this term to be applied to a single cell used independently). Batteries are sometimes referred to as "Accumulators" since electric energy is accumulated by chemical reaction.

Bulk Charge Current is applied to the batteries at the maximum safe rate they will accept until voltage rises to near (80-90%) full charge level.

Capacity See *AMPERE HOUR CAPACITY*

Capacity Test A test wherein the battery is discharged at constant current at room temperature to a cutoff voltage of usually 1.70 volts/cell.

Cell (Storage) A storage (secondary) cell is an electrolytic cell for the generation of electric energy in which the cell after being discharged may be restored to a charged condition by an electric current flowing in a direction opposite to the flow of current when the cell discharges.

Charged The condition of a storage cell when at its maximum ability to deliver current. The positive plate contains a maximum of lead peroxide and a minimum of sulfate, while the negative plates contain a maximum of sponge lead and a minimum of sulfate, and the electrolyte will be at maximum specific gravity.

Charging The process of converting electrical energy to stored chemical energy. In the lead-acid system, charging converts Lead Sulfate ($PbSO_4$) in the plates to Lead Peroxide (PbO_2) (positive) or Lead (Pb) (negative plate).

Charging Rate The current expressed in amperes at which the battery is charged.

Circuit A system of electrical components through which an electric current is intended to flow. The continuous path of an electric current.

Constant-Current Charge A charge in which the current is maintained at a constant value. (For some types of lead-acid batteries this may involve two rates called a starting and a finishing rate.)

Constant Voltage Charge A charge in which the voltage at the terminals of the battery is held at a constant value.

Cut-Off Voltage See *FINAL VOLTAGE*

Cycle A discharge and its subsequent recharge.

Cycle Service A type of battery operation in which a battery is continuously subjected to successive cycles of charge and discharge, e.g., motive power service.

Deep Discharge Removal of up to 80% of the rated capacity of a cell or battery.

Direct Current (DC) A direct current is a unidirectional current in which the changes in value are either zero or so small that they may be neglected.

Discharge The conversion of the chemical energy of the battery into electrical energy.

Discharged The condition of a storage cell when as the result of delivering current, the plates are sulfated, the electrolyte is exhausted, and there is little or no potential difference between the terminals.

Discharge Rate Batteries discharged to meet any time rate between 3 hours and 8 hours are considered as having been normally discharged.

Efficiency The ratio of the output of the cell or battery to the input required to restore the initial state of charge under specified conditions of temperature, current rate and final voltage.

Electrolyte Any substance which disassociates into two or more ions when dissolved in water. Solution of electrolyte conduct electricity and are decomposed by it. In the battery industry the word "electrolyte" implies a dilute solution of sulfuric acid.

Equalizing Charge An extended charge which is given to a storage battery to insure the complete restoration of active materials in all the plates of all the cells.

Final Voltage The cut-off voltage of a battery; The prescribed voltage reached when the discharge is considered complete.

Float Charging Application of a recharge at a very low rate and accomplished by connection to a buss whose voltage is slightly higher than the open circuit voltage of the battery.

Full Charge Gravity The specific gravity of the electrolyte with the cells fully charged and properly leveled.

Gassing The evolution of gases from one or more of the electrodes during electrolysis.

Gel Electrolyte A mixture of sulfuric acid and silica that immobilizes the electrolyte.

Lead (Pb) Chemical element used in lead-acid batteries (with sulfuric acid and other materials).

GLOSSARY

Lead Sulphate (PbSO₄) A compound resulting from the chemical action of sulfuric acid on oxides of lead or lead metal itself.

Life Number of years of satisfactory float operation or number of charge-discharge cycles for motive power operation.

Loss of Charge The capacity loss occurring in a cell or battery standing on open circuit as a result of local action.

Lug Portion of grid used for support of the plate group, usually along top edge of grid, as “hanging lug.” Also, tab on grid used for connection of plate to strap and other plates.

Millivolt (MV) One thousandth part of a volt.

Negative Terminal The terminal toward which current flows (as ordinarily conceived) in the external circuit from the positive terminal.

OHM A unit of electrical resistance.

Open Circuit The state of a battery when it is not connected to either a charging source or to a load circuit.

Open Circuit Voltage The voltage at its terminals when no appreciable current is flowing.

Plate A pasted grid, either formed or unformed.

Polarity An electrical condition determining the direction in which current tends to flow. By common usage the discharge current is said to flow from the positive electrode through the external circuit.

Positive Plates Consists of the grid and the active material from which current flows to the external circuit when the battery is discharging.

Positive Terminal The terminal from which current flows (as ordinarily conceived) through the external circuit to the negative terminal when the cell discharges.

Post Terminal or other conductor which connects the plate group strap to the outside of the cell.

Rated Capacity The ampere hours of discharge that can be removed from a fully charged secondary cell or battery, at a specific constant discharge rate at a specified discharge temperature and at specified cut off voltage.

Self Discharge Loss of charge due to local action.

Short Circuit Current The current which flows when the two terminals of a cell or battery are inadvertently connected to each other.

Standing Loss The loss of charge by an idle cell or battery, resulting from local action.

State of Charge (SoC) The amount of electrochemical energy left in a cell or battery.

Sulfated A term used to describe any plate or cell whose active materials contain an appreciable amount of lead sulfate.

Sulfation The formation of lead sulfate on a plate or cell as a result of discharge, self-discharge, or pickling.

Sulfuric Acid (H₂SO₄) The principal acid compound of sulfur. Sulfuric acid of a high purity and in dilute form is the electrolyte of lead-acid storage cells.

Temperature Correction In storage cells, the charging voltage vary inversely with temperature, while the open circuit voltage varies directly (though slightly) with temperature.

Terminals The terminals of a battery are the points at which the external circuit is connected.

Tray Steel enclosure for motive power battery cells.

Vent An opening provided to permit the escape of gas from a cell or mold.

Vent Assembly A one-way valve to keep the cell pressurized and safely release excessive pressure and gas due to overcharging, as well as keeping the cell from being contaminated by the atmosphere.

Volt The practical unit of measurement of electro-motive force or potential difference required to send a current of one ampere through a resistance of one ohm.

Voltage The difference of potential which exists between the terminals of a cell or battery, or any two points of an electrical circuit.

Voltage Range The difference between the maximum and minimum cell voltages that exist within a battery or string of cells when all of the cells are charging or discharging.

Voltmeter An instrument for measuring voltage.

