Discover W5™

Who
What
Where
When
Why

A comprehensive guide to AGM, Gel and Flooded batteries

Table of Contents **Page**

Disclaimer
This information is published as an aid to our members, associates, customers and to the public. The information herein is based on sound engineering principles, research, manufacturing know how, extensive years of field experience and technical judgments from within the industry, and is subject to change in light of developments in technology, industry updates, market and field experience. Use or adoption of the information contained in this and any associated documents is voluntary. The writer denies any warranties or guarantees expressed or implied in connection with the following information.

Section I –

Introduction

Discover Valve-regulated lead-acid (VRLA) technology encompasses both gelled electrolyte, absorbed glass mat (AGM) and Advanced AGM batteries. All three types are valve-regulated and have significant advantages over flooded lead-acid products. The following information is provided in order that Discover™ distributors, dealers, jobbers, installers, retailers and consumers might better understand and represent the wide array of benefits, features and overall advantage of the Discover™ line of batteries.

Benefits and Features

Professional Series EV Advanced AGM and Gel Batteries, Designed and Engineered for Dependability in Commercial, Industrial, Public and Private applications; Mobility and Home Medical Equipment (HME) , Broadband and Cable TV (CATV), Uninterruptible Power Supplies (UPS) and Telecommunication, Photovoltaic, Solar and Renewable Energy, Electronic and Security, Marine and RV, Golf and Electric Vehicle, Aerial Lifts and Fork Lifts, Floor Machines and Robotics.

• *In Doors* • *Out Back* • *Off Shore* • *On Duty*

Discover™ Professional Series Batteries have the Features and Benefits that matter to your customers and you!

Advanced AGM and Gel

- Completely sealed valve regulated construction.
- Flame arresting pressure regulated safety sealing valves for safety, operating pressure management and protection against atmospheric contamination (excess oxygen being absorbed by negative plates).
- Computer-aided 99.994% pure heavy-duty lead calcium grid designs.
- Tank formed plates: guarantees evenly formed and capacity matched plates.
- Discover™ proprietary Vision Max® Paste Formula.
- Anchored plate groups to guard against vibration.
- Proprietary Discover™ Alpha Vision® Advanced Gel processes.
- Proprietary Vision Guard® separators promote reduced resistance, oxidation and smooth electron movement in all Gel types.
- Measured and Immobilized electrolyte.
- Multi step anti-stratification gelled electrolyte.
- Vacuum filling and weighing processes.
- Advanced technology for efficient gas recombination of up to 99.9% and freedom from electrolyte maintenance.
- Wide range of operating temperatures (-40°F to 140°F) (-60°F to 160°F Gel).
- Low self discharge rates (Approx. 1%-3% monthly at 68.F – 77.F)
- High impact reinforced strength copolymer polypropylene cases and flat top designed covers that are rugged and vibration resistant.
- Thermally welded case to cover bonds that eliminate leakage.
- Copper and stainless steel alloy terminals and hardware.
- Multi-terminal options with terminal protectors.
- Removable carry handles.
- Industry leading size and performance options.
- Classified as “NON-SPILLABLE BATTERY” Not restricted for Air (IATA/ICAO) Provision 67, Surface (DOT-CFR-HMR49)or Water (Classified as non-hazardous per IMDG amendment 27) transportation
- Can be used in any orientation – Upside down is not recommended – Do not charge up side down!
- Compatible with sensitive electronic equipment.
- Quality Assurance processes with ISO (4400/992579), QS and TUV Certification EMC tested, CE, ETTS Germany (G4M19906-9202-E-16)
- Requested Tellcordia & Bellcore compliance
- UL recognized and approved components (MH29050).

Section II

Working with Batteries

Caution

Lead-acid batteries contain sulfuric acid which is a highly corrosive poison and will produce gasses when recharged and explode if ignited. This can **hurt** you! When working with batteries, you need to have plenty of ventilation, remove your jewelry, wear protective eyewear (safety glasses) and clothing, and exercise caution. Do not allow battery electrolyte to mix with salt water. Even small quantities of this combination will produce Chlorine gas that can **kill** you! Whenever possible follow the manufacturer's instructions.

CAUTION / DANGER:

Lead-acid batteries contain a sulfuric acid electrolyte, which can be poisonous and is highly corrosive. Flooded Lead Acid batteries will produce gasses when discharging and re-charging which can explode!
When working with batteries, you need to have plenty of ventilation, remove your jewelry, wear protective eyewear (safety glasses) and clothing, and exercise caution.

Do not allow battery electrolyte to mix with salt water. Even small quantities of this combination will produce Chlorine gas that can KILL you!

Safety First

Although Poison Danger, Safety and Caution information is dispersed through the following information, we will list the basics below;

Danger of Exploding Batteries
Batteries contain sulfuric acid and they produce explosive mixtures of hydrogen and oxygen. Because self-discharge action generates hydrogen gas even when the battery is not in operation make sure batteries are stored and worked on in well ventilated areas. ALWAYS wear safety glasses and a face shield when working on or near batteries.

When working with batteries

1. Always wear proper eye, face and hand protection.
2. Keep sparks flames and cigarettes away from the battery.
3. Do not remove or damage vent caps.
4. Do not open in any way Sealed Valve Regulated batteries.
5. Cover vents with a damp cloth to minimize gas seepage.
6. Make sure work area is well ventilated.
7. Never lean over battery while testing, boosting or charging.

When installing batteries

1. Disconnect ground cable first.
2. Note position of Positive (+) and negative (-) cables. Mark cables for correct connection to the new battery.
3. Remove old batteries.
4. Clean terminals and cable connections. Broken, frayed, brittle, kinked or cut cables should be replaced.
5. Clean and/or paint and repair battery compartment and hold down.
6. Install and secure the new battery. Be careful not to ground the terminals on any metal mounting, fixture or body part.
7. Connect the cables tightly. Connect the ground cable last to avoid sparks.

When charging batteries

1. Before operating the charger make sure to read and understand the instructions that come with the charger. Never attempt to charge a battery without first reviewing and understanding the instructions for the charger being used.

2. Always charge batteries in a well ventilated area.
3. Always wear protective for your eyes.
4. Never charge a visibly damaged battery.
5. Never charge a frozen battery.
6. Connect the charger leads to the battery; red (+) positive lead to the positive (+) terminal of the battery and the black (-) negative lead to the negative (-) terminal. If the battery is still in the vehicle connect the negative lead to the engine block to serve as a ground. If the vehicle is positive grounded, connect the positive lead to the engine block. To be absolutely positive make sure that the battery is completely disconnected from the equipment and hook the charger leads up accordingly.
7. Make sure that the charger lead – both at the charger and the battery side of the leads - connections are tight.
8. If the charger has a battery type selector switch (I.E. Flooded, Gel, or AGM), set it to the proper location.
9. Set the timer if it is available and turn the charger on.
10. If the battery becomes hot or if violent gassing or spewing of electrolyte – in the case of flooded battery types – occurs, reduce the charge rate or temporarily halt the charger. If after you restart the charger and/or reduce the charge rate these events repeat themselves take the battery to a professional to be evaluated.
11. Always turn the charger OFF before removing the leads from the battery to avoid dangerous sparks.

When handling battery acid

1. Battery acid – or electrolyte – is a solution of sulfuric acid and water that can destroy clothing and burn skin. Use extreme caution when handling electrolyte and keep an acid neutralizing solution – such as baking soda, household ammonia mixed with water – readily available in the event of a spill. (remember high school chemistry class when you learned that you can add acid to water when mixing BUT never the other way around)
2. Always wear eye protection.
3. If electrolyte is splashed into the eye, immediately force the eye open and flood with clean cool water. Get medical attention immediately.
4. If electrolyte is somehow taken internally, drink large amounts of water or milk. DO NOT induce vomiting. Get medical attention immediately.
5. Neutralize with baking soda any electrolyte that spills in the work area, rinse with water.

When booster cables are used

1. When jump starting, always wear proper eye protection.
2. Never lean over the battery.
3. Do not jump start a damaged battery.
4. Do not jump start a frozen battery.
5. Inspect both batteries before connecting booster cables. Be sure vent caps are tight and level, place a damp cloth over the vents of both batteries.
6. Make sure the vehicles are not touching.
7. Make sure both ignition switches are turned to the OFF position.
8. Connect positive (+) booster cable lead to the (+) terminal of the discharged battery.
9. Connect the other end of the positive (+) booster cable to the positive (+) terminal of the boosting battery.
10. Connect the negative (-) cable to the negative (-) terminal of the boosting battery.
11. Make the final connection of the Negative (-) cable to the engine block of the stalled vehicle, away from the battery. If this is not possible be careful when connecting the negative (-) cable to the discharged battery as the electrical current may jump at the discharged terminal creating a spark.
12. Start vehicle and remove cables in the REVERSE order of there connection.

CALIFORNIA Proposition 65 Warning

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.

Section III

Battery Types

There are many types of batteries currently in production today throughout the world. However we concern ourselves here with the Lead Acid Battery. Lead Acid Batteries are generally classified first by the process used in there **construction** (Sealed Valve Regulated Starved Electrolyte, Sealed Valve regulated Gelled electrolyte, Sealed Maintenance Free Flooded and Open Vent Maintenance Free Flooded, Low Maintenance or Maintainable Flooded), secondly by the **chemistry** used in the production of the batteries grids or plates (Calcium/Calcium, Calcium/Antimony hybrids, Low Antimony and High Antimony) and thirdly by there **application** or how they are used (Starting, Cycling, Starting/Cycling combinations, Float and Float/Cyclic). Not to get to technical – but to rebuff those who feel I'm being too vague – I will acknowledge that every manufacturer has a secret sauce that they inject into the Lead Calcium or Lead Antimony alloys used in their respective plate production.

Construction

Sealed batteries are Starved Absorbed Glass Mat Electrolyte, Starved Gelled Electrolyte and Flooded Electrolyte in there construction. In the Flooded Electrolyte types a solution of sulfuric acid and water is used that can spill out of the battery if it is tipped. Even the Sealed Maintenance Free Flooded batteries will eventually spill there electrolyte if left on the side or upside down for any length of time. Sealed and Starved or Gelled Electrolyte types use a solution of sulfuric acid and water suspended in a gel or a absorbing glass-mat. The Sealed Non-spill able characteristic of these batteries is a by product of there construction and how they work - More on this later.

Chemistry

Amongst other things, the alloy (chemistry) used in the production of the battery will dictate how well the battery will cycle, how long it will live when properly maintained, how much it will gas when being discharged and recharged and how much water it will use. Typically calcium/calcium alloys will use less water and will live better in heat. They may not cycle as long as antimony alloys but they will deliver current quickly and efficiently. The higher Antimony alloys will generally produce batteries that will deliver very good cycle time but will use more water in the process and will require more maintenance. Hybrid alloys will perform somewhere in between. Discover™ uses every alloy in its broad range of products allowing us to meet the needs of the requirement.

Advantages and disadvantages of the different types of battery Construction and Chemistry

Gelled Electrolyte Advantages:

- Totally maintenance-free
- Air transportable
- Spill proof / leak proof
- No corrosion
- Superior deep cycle life
- Installs upright or on side (side installation may lose about 10% capacity)
- Very low to no gassing (unless overcharged)
- Compatible with sensitive electronic equipment
- Superior shelf life
- Superior recharge ability (from 0% to 90% in 4 hours)
- Superior recharge ability (from 0% to 100% in 6 hours)
- No recharge current limitation @ 13.8 volts
- Rugged and vibration-resistant
- Very safe at sea with no chlorine gas in bilge (due to sulfuric acid and salt water mixing)
- Operates in wet environments…even under 30 feet of water
- Will not freeze to –20°F/-30°C (if fully charged)
- Lowest cost-per-month (cost / months of life)
- Lowest cost-per-cycle (cost / life cycles) – Up to 12% more cycles than Discover Advanced AGM EV batteries when discharged capacity exceeds 80%.
- Up to 3 times the cycling ability of standard AGM when discharged capacity exceeds 50%
- Up to 4 times the cycling ability of standard AGM when discharged capacity exceeds 80%

Gelled Electrolyte Disadvantages:

- Higher initial cost
- Heavier weight
- Water cannot be replaced if continually overcharged
- Typically can not be used to replace flooded or AGM types without adjusting or replacing the applications existing chargers.
- Automatic temperature-sensing, voltage-regulated chargers must be used and Charge voltage **must** be limited (14.2 to 14.5 volts maximum at 25°C/77°F

Absorbed Electrolyte Advantages:

- Totally maintenance-free
- Air transportable
- Spill proof / leak proof
- No corrosion
- Installs upright or on side
- Lower cost than gel cell batteries
- Compatible with sensitive electronic equipment
- Very low to no gassing (unless overcharged)
- Excellent for starting and stationary applications
- Superior for shorter duration/higher rate discharges
- Superior under extreme cold conditions when fully charged
- Superior shelf life
- Superior recharge ability (from 0% to 90% in 4 hours)
- Superior recharge ability (from 0% to 100% in 6 hours)
- Rugged and vibration-resistant
- Very safe at sea with no chlorine gas in bilge (due to sulfuric acid and salt water mixing)
- Operates in wet environments…even under water
- Typically no need to replace or adjust the applications existing chargers when replacing flooded type batteries.

Absorbed Electrolyte Disadvantages:

- Shorter cycle life than gel in very deep cycle applications
- Automatic temperature-sensing, voltage-regulated chargers **must** be used
- Water cannot be replaced if continually overcharged
- Charge voltage **must** be limited (14.4 to 14.7 volts maximum at 25°C/77°F)

Flooded Electrolyte Advantages:

- Lowest initial cost
- Good for higher current applications
- Water can be added (if accessible)
- Excellent for starting applications
- More tolerant of improper recharge voltages
- Certain designs are good for deep cycle applications
- Replacements readily available
- Good under extreme cold conditions when fully charged

Flooded Electrolyte Disadvantages:

- Spill able
- Operates upright only
- Shorter shelf life
- Fewer shipping options
- Cannot be installed near sensitive electronic equipment
- Watering will be required (if accessible)
- Higher long term cost per cycle when labor and material costs are calculated
- Requires high levels of maintenance and safety practices.

Application

A batteries construction and chemistry therefore dictates what application it is better suited for. Both from the stand point of performance and maintenance requirements. These applications will range from pure starting to pure cycling or deep cycling, but many applications have needs somewhere in between. This document covers both Sealed and Flooded batteries. Discover™ Sealed Lead Acid batteries can be substituted in virtually any Flooded lead-acid battery application (in conjunction with well-regulated charging), as well as excel in applications where traditional flooded batteries cannot be used. Because of their unique features and benefits, Discover™ batteries are particularly well suited for;

Deep Cycle, Deep Discharge Applications

- Marine Trolling
- Electric Vehicles
- Portable Power
- Personnel Carriers
- Electronics
- Wheelchairs
- Floor Scrubbers
- Marine & RB House Power
- Sailboats
- Golf Cars
- Commercial deep cycle application

Standard AGM types will not perform as well as Discover™ Advanced AGM or Gel in Deep Cycling applications.

Standby and Emergency Backup Applications

- UPS (Uninterrupted Power Systems)
- Emergency Lighting
- Village Power & Lighting
- Telephone Switching
- Computer Backup
- Cable TV
- Solar Power
- Aids to Navigation
- Remote Monitoring
- Cathodic Protection

Standard AGM types will not perform as well as Discover™ Advanced AGM or Gel in High Rate discharge applications.

Unusual and Demanding Applications

- Race Cars
- Off-road Vehicles
- Marine & RV Starting
- Air-transported Equipment
- Wet Environments
- Diesel & Industrial Commercial Equipment Starting
- Commercial starting

Sales Channels

(see also “How can I Manage the risks associated with batteries in my organization?)

Today’s purchase decisions are increasingly being made by safety supervisors, legal teams and cost accountants. Mining operations, transit companies, cities, airport authorities and manufacturing organizations – to name just a few multi-bank operator (MBOs) channels - are all required to implement rigorous risk management programs. These programs enable them to manage workplace hazards that may affect their employees, their communities and their environments. Failure to do so can result in injury and lead to civil or even criminal charges. With Discover™ batteries you can help them reduce these risks. Discover™ has responded to their requests for sealed non-spill able batteries in “DROP IN” replacement sizes. Products that – over the life of the product – save them money and time in service costs and compensation claims. The Discover™ line of batteries has been designed and engineered with the footprints, performance and terminal options to respond to ALL of their needs. From button terminals to Dual SAE / T type terminals to drop terminals for 4D and 8D types, the options are many. Matching chargers are also available…………The Discover™ line of batteries and chargers gives you an opportunity to develop sales in areas that were not available before, where the customer is appreciative of the unique features and benefits and where margins can be maintained and protected. For example;

- Air & Marine Emergency Service Centers / Navigation
- Airline Equipment and Supplies
- Bicycle Equipment and Sales
- Boat Equipment and Supplies
- Boat Manufacturing, Repair and Rigging
- Business Machines
- City, County, Airport Authorities
- Crisis Centers
- Communication Companies
- Elevator Equipment and Supplies
- Fire Equipment and Supplies
- Gas Companies
- Hospital Equipment and Supplies
- Hotels and Casinos
- Janitorial Supplies
- Lighting
- Manufacturing facilities
- Medical Supplies
- Mining Operations
- Motels
- Motorcycles
- Office Machines
- Oilfield Equipment and Supplies
- Pagers
- Pet Stores
- Photographers
- Physician Equipment and Supplies
- Police Supplies
- Property Management Companies
- Radio Stations
- Recreational Vehicles
- Rent to Own Stores
- Rental Equipment
- Research labs
- Security Equipment and Supplies
- Surveying instruments, Equipment and Supplies
- Television Stations
- Telecom. Equipment Services and Supplies
- Trailer manufacturing and Sales
- Transit Authorities
- Utility Boards and Companies
- Vending Equipment and Supplies
- Wheelchair and Mobility
- X-ray Equipment and Supplies

Don't forget the TOTAL industry around the Photovoltaic (SOLAR) business!

- Alternative Energy Companies
- Dealers networks of the Solar panel companies
- Residential Grid Tie Systems
- Residential Water Pumping
- Residential RV and Marine
- Residential Remote Home Systems
- Commercial and Industrial Grid Tie Systems
- Commercial and Industrial Communications
- Commercial and Industrial Oil and Gas
- Commercial and Industrial Traffic
- Commercial and Industrial Railroad
- Commercial and Industrial Lighting
- Commercial and Industrial Rural Development
- Commercial and Industrial Government/Military
- Commercial and Industrial Greenhouses

Section IV

How can I manage the risks associated with batteries in my organization?

CAUTION / DANGER:

Lead-acid batteries contain a sulfuric acid electrolyte, which can be poisonous and is highly corrosive. Flooded Lead Acid batteries will produce gasses when discharging and re-charging which can explode!
When working with batteries, you need to have plenty of ventilation, remove your jewelry, wear protective eyewear (safety glasses) and clothing, and exercise caution.

Do not allow battery electrolyte to mix with salt water. Even small quantities of this combination will produce Chlorine gas that can KILL you!

Your service manager suddenly remembers that he hasn't inspected or serviced the batteries in the ???. It's been longer than anyone imagined and regular charging has depleted the water and created a build up of hydrogen gas. The wrench of the technician he sent to service the batteries slips just as he is leaning over to visually check the water level. The wrench creates a spark causing the excess hydrogen to explode, injuring the technician. Can this be prevented? Can the potential for this type of accident be managed?

Your cable repair truck is traveling to a service call. The driver is forced to slam on the brakes, cut off by another driver. The violent movement of the truck causes a can of cleaning solvent to fall and land across the terminals of a replacement battery he is carrying. The battery arcs, the aerosol container explodes, rupturing the aerosol container and damaging the battery case. Battery acid mixes with the solvent creating a dangerous situation for the driver. This situation and the use of flooded batteries put your company at risk for employee claims and DOT violations. Can this be prevented? Can the risks be better managed?

As a Multi-Station, Multi-System or Multi-Bank Operator, you are required to implement a rigorous risk management program that protects you, your employees, the community and the environment. You must be aware of the hazards associated with using batteries (particularly flooded batteries), Transportation Hazards, Community "Right to Know Acts", Environmental Compliances and more.

Discover™ dealers are trained, willing and able to help you reduce the chance of accidents. Because Discover™ has the largest range of Sealed Valve Regulated batteries in the world. Discover™ dealers can supply you with a battery to fit your needs. Battery options that will not gas, (unless they are overcharged) reducing the chance of explosions. In fact from as much as 1 in 1000 for flooded batteries to as little as 1 in 1000000 for Sealed Gel batteries, plus they never need filling.

By using Discover™ batteries you limit your risks associated with the DOT. Flooded batteries are considered hazardous material. Because of related dangers your drivers must have a Commercial Drivers License with a hazardous materials endorsement. And, you may be limited from carrying any other hazardous material in the vehicle at the same time. (Such as cleaners, petroleum's etc.) Discover™ batteries are sealed non-spill able and they are labeled as such. Because they are clearly labeled and shipped with terminal protectors, they are exempt from certain restrictive DOT regulations.

If ignited in a fire, the plastics, lead and acid contained in a battery can cause toxic fumes. Therefore the Community Right to Know Act requires reporting for batteries if sulfuric acid is present in quantities over 500 lbs (225 kgs.) and/or lead in quantities over 10000 lbs. (4500 kgs.). Storing 12 standard cable TV back up batteries or 12 standard golf cart batteries may make you liable to report as the acid content exceeds the limits. Many don't and there is never a problem until something bad happens! Then, well, violators are subject to fines up to $25,000.00. Discover™ dealers can make just in time deliveries of your battery needs and help keep you updated with the information needed to comply with emergency planning in your communities.

Failure to dispose of used batteries can also lead to huge fines and criminal penalties. Used batteries not properly managed might end up in the hands of metal dealers who might dump the sulfuric acid to get at the lead. If your batteries are found in the garbage or a landfill you can be fined and held liable for cleanup costs. Discover™ dealers can also manage your risk associated with the environment. As professionals they collect and dispose of scrap everyday under strict transportation and reporting guidelines. They will provide this service to you also. By using Discover™ sealed valve regulated batteries from Discover™ approved dealers you can reduce many of your potential liabilities and better mange the risks associated with batteries within your organization. For more information be sure to read the section on "How do I compare and make an informed buying decision when deciding between Flooded, AGM, Advanced AGM, Series 700 Gel and/or Gel batteries".

Guidance in Completing the Tier II Chemical Inventory Report

In 1986, Congress reauthorized and amended the Hazardous Waste Superfund Clean-up Regulations (a.k.a. SARA). Title III of SARA created the Emergency Planning and Community Right-to-Know Act (EPCRA), which required industrial facilities to provide information to the:

- Local fire fighters regarding the chemical hazards at your facility in the event that they must respond to a fire;
- Local Emergency Planning Committee so they can adequately prepare an emergency response plan for the community; and
- People in the community because they have a right-to-know the chemical hazards in their community

The report is known as the Tier II Chemical Inventory Report and is due March 1st of every year. The Tier II report must be submitted to the State Emergency Response Commission, the Local Emergency Planning Committee, and to the fire department with jurisdiction over the facility. It is important to note that some states and local agencies have different rules, fees, and unique forms so it is necessary to contact the local emergency response agency for information for your locality.

The Tier II report requires the following information:

- Facility information such as address, SIC code and the names of people who would be responsible in the event of an emergency at this facility and their 24-hour phone numbers;
- Chemical information such as, the chemical name, CAS No., the physical state of the chemical (solid, liquid, gas), pure chemical or a mixture, the physical and health hazards (fire, reactive, sudden release of pressure, or immediate or delayed health hazards);
- Inventory quantities such as the average, maximum quantity and the number of days per year;
- Storage conditions, such as the type of container, temperature and pressure; and
- Storage location, preferably a location description that is related to an attached site plan.

Additionally, the EPA has created a list of "Extremely Hazardous Substances" that must be reported on the Tier II, if stored above the threshold planning quantity. The Extremely Hazardous Substances (EHS) and their threshold planning quantities are listed in the Title III Consolidated List of Lists. This list and additional instruction for Tier II reporting is accessible at:

http://yosemite.epa.gov/oswer/ceppoweb.nsf/content/tier2.htm

How and why is Tier II reporting applicable to batteries?

Owners or operators of facilities storing lead-acid batteries are required to determine whether Tier II reporting thresholds are exceeded for batteries stored at their facility. The chemicals of concern are lead and sulfuric acid. It is important to note that sulfuric acid is also an EHS and the reporting threshold is 500 lbs. Lead is a hazardous substance and the reporting threshold is 10,000 lbs.

Although it would appear that a manufactured battery would meet the definition of an exempt "article," OSHA specifically excluded lead-acid batteries from the Article Exemption in a 1997 letter from the Acting Director of the Office of Health Compliance Assistance to the Texas Department of Health. The Deputy Project Director stated that, "Because - workers service batteries, which leads to exposure - an MSDS would be required and the facility owner or operator would need to report the sulfuric acid at 500 pounds, the lead at 10,000 pounds, and any other chemicals to which the worker is exposed to at the applicable threshold."

The following information is necessary in completing this Tier II report:

Chemical Name	Lead	Sulfuric Acid
EHS	No	Yes
CAS No.	007439-92-1	007664-93-9
Reporting Threshold	10,000 lbs.	500 lbs
Pure or Mixture	Pure	Mixture
Physical State	Solid	Liquid
Physical or Health Hazard	Delayed Health Hazard	Immediate Health Hazard

As facility owners or operators, you must survey all facility equipment and systems containing reportable batteries to determine whether the reporting thresholds are exceeded for the total weight of pure sulfuric acid and the total weight of lead contained in all of the reportable batteries on site.

To determine if the thresholds are exceeded, you will need to know the type of batteries and then consult your Discover dealer. If you do not know the model number of the batteries or you can not contact a dealer, then you must estimate the weight of batteries and then multiply this by 18% (a battery is estimated to contain 18% of its weight as pure sulfuric acid) and this will provide the estimated total weight of pure sulfuric acid at your facility.

Note that if the threshold is exceeded at any time during the year, you must report the materials that exceed the threshold on a Tier II by March 1 of the following year.

Companies in the United States of America should visit the following web site for more information on Tier II reporting:

http://yosemite.epa.gov/oswer/ceppoweb.nsf/content/lr-other.htm

Section V

What are AGM, Gel and Flooded Batteries

What is a Gel battery?

A gel battery is a lead-acid electric storage battery that:

- Is sealed using special pressure valves and should never is opened.
- Typically uses Calcium/Calcium metal alloys.
- With proper maintenance, is completely maintenance-free.
- Uses gelled electrolyte.
- Uses a recombination reaction to prevent the escape of hydrogen and oxygen gases normally lost in a flooded lead-acid battery (particularly in deep cycle applications).
- Is non-spill able, and therefore can be operated in virtually any position with little capacity lost. However, upside-down installation is not recommended.

What is an AGM battery?

An AGM battery is a lead-acid electric storage battery that:

- Is sealed using special pressure valves and should never be opened.
- Typically uses Calcium/Calcium metal alloys.
- With proper maintenance, is completely maintenance-free.
- Has its entire electrolyte absorbed in separators consisting of a sponge-like mass of matted glass fibers.
- Uses a recombination reaction to prevent the escape of hydrogen and oxygen gases normally lost in a flooded lead-acid battery (particularly in any cycling applications).
- Is non-spill able, and therefore can be operated in virtually any position. However, upside-down installation is not recommended.

What is a Flooded battery?

A Flooded battery is a lead acid electric storage battery that:

- Can be both sealed and open-vented.
- Can use High Antimony, Low Antimony or Calcium metal alloys or a combination of Calcium and Low Antimony (hybrid).
- Requires maintenance in cyclic applications.
- Its entire electrolyte volume is free to move within the cell with nothing to prevent the escape of hydrogen and oxygen gases normally lost during charging and discharging (particularly in deep cycle applications).
- Escaping gasses can be detrimental to sensitive electronic equipment.
- Is spill able, and therefore can only be operated in an up right position. This includes sealed maintenance free versions of the flooded battery type.

What is a Discover™ Gelled electrolyte battery?

A Discover™ Gelled electrolyte battery is a lead acid electric storage battery that:

- Is sealed using special pressure valves and should never be opened.
- With proper maintenance, is completely maintenance-free.
- Uses proprietary Calcium/Calcium metal alloys.
- Uses ultra pure refined and gelled electrolyte.
- Uses proprietary European separators.
- Uses a recombination reaction to prevent the escape of hydrogen and oxygen gases normally lost in a flooded lead-acid battery (particularly in deep cycle applications).
- Is non-spill able, and therefore can be operated in virtually any position. However, upside-down installation is not recommended.
- Thick advanced motive power plate designs for extended cycle life.
- Computer-generated grid designs to optimize high power density.
- Advanced plate pasting and curing procedures.
- Tank formed plates.
- Heavier duty plate straps.

- Is produced in accordance with ISO, QS and TUV requirements.
- Uses Underwriters Laboratories (UL) recognized components
- Advanced terminal designs and options.
- Can achieve a minimum 400 to 1000 cycles at >80% DOD using proper charging methods.
- Can achieve a minimum 700 to 3200 cycles at >50% DOD using proper charging methods.
- Can achieve in excess of 1500 to 4500 cycles at a 30% average DOD using proper charging methods.
  (life cycles vary by battery voltage, capacity and size)

What is the Discover™ 700 Series Gel battery?

The Discover™ 700 Series Gel battery is a lead-acid electric storage battery that:

- Is sealed using special pressure valves and should never be opened.
- With proper maintenance, is completely maintenance-free.
- Uses ultra pure refined and gelled electrolyte
- Uses a recombination reaction to prevent the escape of hydrogen and oxygen gases normally lost in a flooded lead-acid battery (particularly in deep cycle applications).
- Is non-spill able, and therefore can be operated in virtually any position. However, upside-down installation is not recommended.
- Extra thick advanced motive power plate designs for extended cycle life
- Computer-generated grid designs to optimize high power density
- Advanced plate pasting and curing procedures
- Tank formed plates
- Heavier duty plate straps
- Advanced terminal designs and options
- Incorporates proprietary manufacturing techniques
- Vision Guard© separators
- Vision Max© paste formulas and processes
- Can achieve a minimum 700 cycles at >80% DOD using proper charging methods
- Can achieve in excess of 3000 cycle at a 30% average DOD using proper charging methods.
  (life cycles vary by battery voltage, capacity and size. 700 series Gel types are typically used in mobility applications. 700 series products are not available in larger footprints)

What is the Discover™ Advanced AGM battery?

A Discover™ Advanced AGM is a lead acid electric storage battery that:

- Is sealed using special pressure valves and should never be opened.
- With proper maintenance, is completely maintenance-free.
- Has its entire electrolyte absorbed in separators consisting of a sponge-like mass of matted glass fibers.
- Uses a recombination reaction to prevent the escape of hydrogen and oxygen gases normally lost in a flooded lead-acid battery (particularly in deep cycle applications).
- Is non-spill able, and therefore can be operated in virtually any position. However, upside-down installation is not recommended.
- Uses advanced motive power plate designs for extended cycle life
- Uses computer-generated grid designs to optimize high power density
- Uses advanced plate pasting and curing procedures
- Has tank formed plates
- Has heavier duty plate straps
- Double insulating plate separators
- Vision Max© paste formulas and processes
- Can achieve a minimum 400 to 600 cycles at 50-80% DOD using proper charging methods
- Can achieve a minimum 700 to 1000 cycles at 30-50% DOD using proper charging methods.
- Can achieve in excess of 900 to 1500 cycles at a 30% average DOD using proper charging methods.
- Can achieve in excess of 5000 cycles at a 10% average DOD using proper charging methods.
  (life cycles vary by battery voltage, capacity and size)

Section VI

What are the differences between gel batteries and absorbed glass mat (AGM) batteries?

Both are recombinant batteries. Both are sealed and valve-regulated and are considered non-spill able and both are considered "acid-starved." In a gel battery, the electrolyte does not flow like a normal liquid. IN AGM batteries all liquid electrolyte is trapped in a sponge-like matted glass fiber separator material.

The "acid-starved" condition of gel and AGM batteries protects the plates during heavy deep-discharges. The gel battery is more starved, giving more protection to the plate; therefore, it is better suited for super-deep discharge applications.

Due to the physical properties of the gelled electrolyte, gel battery power declines faster than an AGM battery's as the temperature drops below 32°F. AGM batteries excel for high current, high power applications and in extremely cold environments.

Flooded batteries are more easily replaced by AGM batteries than Gel batteries as Gel batteries require different charging algorithms (mainly lower finishing voltages) to excel and live than do either AGM or Flooded types.

Note that the difference between Gel and AGM batteries for higher current, high power applications is very small until extremely low temperatures are experienced. Please see the section "*Temperature affects a batteries available Capacity*", later in this document.

Section VII

What is the difference between VRLA (Gel or AGM) batteries and traditional wet or flooded batteries?

Wet batteries do not have special pressurized sealing vents, as they do not work on the recombination principle. They contain liquid electrolyte that can spill and cause corrosion if tipped or punctured. Therefore, they are not air transportable without special containers. They cannot be shipped via Express Courier or Parcel Post or used near sensitive electronic equipment. They can only be installed "upright." Because of the cost in time (man-hours), products (distilled water etc), damaged clothing, and polluted environments when being charged and/or discharged wet batteries may actually end up costing more money over the life of the battery than do high quality VRLA batteries. Some brands of wet or flooded batteries are also marketed and sold as sealed or maintenance free, but they are still flooded cell batteries - not "acid-starved" - and they DO NOT have the same pressurized venting system.

Wet batteries lose capacity and become permanently damaged if:

- Left in a discharged condition for any length of time, due to sulfation. This is especially true of High or Low Antimony and/or Hybrid types.
- They are continually over-discharged, due to active material shedding. This is especially true of automotive starting types and "so-called" marine/RV combination cycling/starting batteries now being sold by most manufacturers as cheap alternatives to true cycling batteries.

Section VIII

Frequently asked General Questions and Answers

How does a Gel or AGM (VRLA) battery work?

VRLA batteries are designed using proven gas recombination technology which removes the need for regular water addition by controlling the evolution of hydrogen and oxygen during charging. This means that the oxygen normally produced on the positive plates of all lead-acid batteries is absorbed by the negative plate. This suppresses the production of hydrogen at the negative plate. Water (H_20) is produced instead, retaining the moisture within the battery. **It never needs watering, and should never be opened** as this would "poison" the battery with additional oxygen from the air.

This feature makes VRLA batteries ideal and the first choice for cyclic applications that are indoors, used in enclosed areas and/or used near sensitive equipment

CAUTION/DANGER:

Lead-acid batteries contain a sulfuric acid electrolyte, which can be poisonous and is highly corrosive. Flooded Lead Acid batteries will produce gasses when discharging and re-charging which can explode!
When working with batteries, you need to have plenty of ventilation, remove your jewelry, wear protective eyewear (safety glasses) and clothing, and exercise caution.

Do not allow battery electrolyte to mix with salt water. Even small quantities of this combination will produce Chlorine gas that can KILL you!

Do VRLA batteries have a "memory" like ni-cad batteries?

One of the major disadvantages of nickel-cadmium (ni-cad) batteries is that after shallow discharge cycles, the unused portions of the electrodes "remember" the previous cycles and are unable to sustain the required discharge beyond the depth of the previous cycles. The capacity is lost and can only be restored by slowly discharging completely (generally outside the application), and properly recharging. VRLA batteries do not exhibit this "use it" or "lose it" capacity robbing effect known as memory. It is important to note however that if any lead acid battery is left unattended for extended periods of time its ability to do its job will be diminished and eventually extinguished.

Why use calcium grids in VRLA batteries for deep cycle applications? Some say calcium grids don't do well in flooded deep cycle applications.

Flooded calcium alloy makes a very efficient low resistance battery, excellent for starting and low DOD cycling applications. However, when deeply discharged, the plates release all their available power, eventually causing plate shedding and active material fall-out. In contrast, with flooded antimony batteries, the antimony helps lock the active material onto the grid. Therefore, the plate does not shed as easily, which extends the deep cycle (DOD) life of the battery when compared to flooded calcium.

A high quality Discover™ VRLA calcium alloy battery is also very efficient with low resistance. However, when deeply discharged, the electrolyte is used up before the plates are totally discharged because the battery is "acid-starved." This feature:

- Limits the discharge the plates can deliver.
- Protects the plates from shedding due to deep discharge.
- Extends the life of the battery.

Why do Discover™ Gel and AGM batteries have longer cycle life than others?

Some of the major features that contribute to a long cycle life in Discover™ VRLA batteries are:

- Super pure grid alloys which incorporate proprietary additives that increase the surface area of the plate which ultimately helps to retard corrosion and extend the life of the grid.
- Using thicker grids (>3.5mm) achieves more corrosion resistance than thinner grids.
- Discover™ VRLA batteries are protected against deep discharge because they are "acid-starved." This means that the battery uses the power in the acid before it uses the power in the plates. Therefore, the plates are never subjected to destructive ultra-deep discharges.

- With proper temperature-sensing, voltage-regulated charging Discover™ VRLA batteries will never need water.
- Discover™ High Quality Gel batteries contain ultra-premium Vision Guard© poly, ribbed glass-mat, dual-insulating separators which will not break down in service. The glass mat embeds itself into the plate, which retards life-shortening shedding.
- Discover™ High quality AGM batteries contain separators at the ideal compression and ideal saturation to achieve the best balance between capacity utilization and recombination efficiency. The dual insulating separators also help to prevent separator misalignment and treeing or shorting at the bottom and sides of the plates. The glass mat embeds itself into the plate, which retards shedding.

Why do Discover™ VRLA batteries have excellent shelf life as compared to others?

Higher quality Superior grids, premium separators and pure electrolyte make the difference. Impurities in the lead alloy, separators and electrolyte cause tiny currents inside a cell which eventually discharge the battery and shorten its shelf life. Premium inter-cell welds block the minute cell-to-cell currents that cause self-discharge. Some VRLA batteries are sold, or are misinterpreted by the purchaser to have Deep Cycle ability when in fact they are just general purpose VRLA batteries.

Can VRLA batteries be installed in sealed battery boxes?

No! Never install any type of battery in a completely sealed container. Although most of the normal gasses (oxygen and hydrogen) produced in a VRLA battery will be recombined as described above, and not escape, oxygen and hydrogen will escape from the battery in an overcharge condition (as is typical of any type battery). For safety's sake, these potentially explosive gasses must be allowed to vent to the atmosphere and must never be trapped in a sealed battery box or tightly enclosed space!

Can VRLA batteries be used as starting batteries as well?

Discover™ VRLA batteries will work in starting applications as long as the charging voltage is regulated appropriately. Many vehicle regulators are set too high for gel batteries; therefore, the charging system may require adjustment to properly recharge a gel battery for best performance and life. Both Gel and AGM batteries excel as combination cranking / reserve capacity storage batteries. In low temperatures AGM batteries will perform better than Gelled electrolyte batteries. As a general rule, if you are going to use a true deep cycle Advanced AGM, Gel or Flooded battery as a starting battery also, you should increase the reserve capacity of the original battery by between 20 and 30%. Modern engines with fuel injection and electronic ignition generally take much less battery power to start, however most have larger ampere hour requirements as a result of there growing list of accessories.

Note that the difference between Gel and AGM batteries for higher current, high power applications is very small until extremely low temperatures are experienced. Please see the section "How does Temperature affect a batteries available Capacity", later in this document.

Do I need to do anything special when installing batteries on or near water?

Installing batteries in marine applications (especially salt water) requires some special attention. The cable used needs to be marine approved and should be tinned copper. If you use any other type of cable be prepared to spray and coat the cable and connections with silicone. Use silicone lined heat shrink tubing to cover terminal connections. The main concern is obviously keeping the marine atmosphere away from any exposed terminals or connections.

CAUTION / DANGER:

Lead-acid batteries contain a sulfuric acid electrolyte, which can be poisonous and is highly corrosive. Flooded Lead Acid batteries will produce gasses when discharging and re-charging which can explode!
When working with batteries, you need to have plenty of ventilation, remove your jewelry, wear protective eyewear (safety glasses) and clothing, and exercise caution.

Do not allow battery electrolyte to mix with salt water. Even small quantities of this combination will produce Chlorine gas that can KILL you!

Why can't / shouldn't VRLA batteries be opened?

VRLA (Valve-Regulated Lead-Acid) batteries, sometimes called SLA (Sealed Lead-Acid) batteries or SVR (Sealed Valve-Regulated) batteries work on a recombination principle. Oxygen gas is produced at the positive plates during charge. The charged negative plates react first with this oxygen and subsequently with the electrolyte. Water is produced and the negative plates are very slightly discharged. Additional charging recharges the negative plates instead of producing hydrogen gas. Since very little hydrogen and oxygen is lost and the water (H_20) is retained, we say that the gasses have recombined. To work properly, the oxygen produced must be retained in the battery until the reaction is completed. Positive pressure allows the gas to be retained. If any VRLA (gelled or absorbed electrolyte) battery is overcharged, gas will be vented from the valves. Hydrogen as well as oxygen will be released. If continued, the electrolyte will eventually dry out and the battery will fail prematurely. This is why charging limits are so critical. In a sealed battery a balance is maintained between the hydrogen, oxygen and charge. If a VRLA battery is opened, or leaks, the negative plates are exposed to extra oxygen from the atmosphere. This excess oxygen upsets the balance. The negative plates become discharged. The positive plates may be subsequently severely overcharged. The battery will fail prematurely.

Why do some VRLA batteries bulge? Why do some VRLA batteries appear "sucked in"? Are these visual signs of a faulty or plugged pressure relief valve?

To prevent the permanent loss of gases so that recombination has time to take place, each cell can hold approx. 1.6 pounds per square inch (psi) of pressure without venting. Batteries with very large cells - such as the 4D, 8D, GC and scrubber types - will bulge somewhat as this normal pressure builds. This is especially true in higher temperatures, because the polypropylene case is pliable. Therefore, a certain amount of bulge is normal. The valves only let gas out, never in. A partial vacuum can form within a sealed battery under various circumstances. Battery temperature and ambient pressure play a role, but predominantly the recombination and discharge reactions are responsible. After charging ends, the recombination reaction continues until most of the oxygen in the battery is consumed. The total volume within the battery decreases slightly during a discharge. Deeply discharged batteries often have a "sucked-in" appearance. Batteries with large cells may display this appearance even when fully charged. If a battery bulges severely on charge, this is not normal. It is an indication of a blocked valve or an overcharge situation. Such a battery should be removed from service. A sucked-in appearance can also be normal. A sucked-in-battery should be charged, but if it remains sucked-in after charging, the appearance can safely be ignored; however, if only a single cell displays or lacks this appearance a load test would be prudent.

Can I store my sealed battery in my garage during the winter or will it freeze?

Both types of our sealed batteries can be stored in temperatures as low as -25°F without freezing provided the batteries are fully charged.

Are Discover™ Gel and AGM batteries approved for air transportation?

Yes. Our VRLA batteries are approved for air transport by the F.A.A., I.A.T.A. and the D.O.T. This information is stated on a label located on the battery.

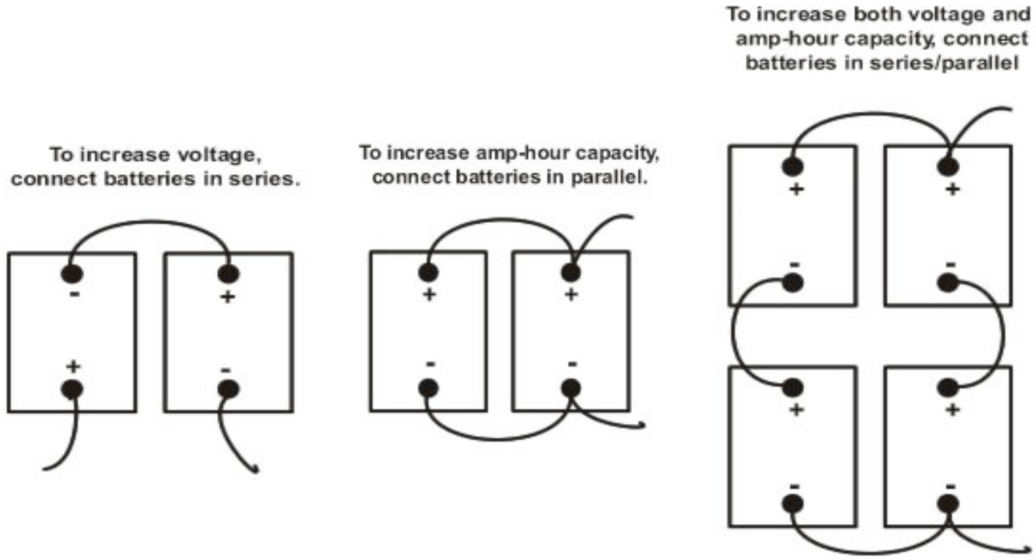
Why am I not getting the run time I expect from my new Discover™ Gel or AGM battery?

Discover™ batteries are made with thicker plates than other batteries. It is because of these thick plates that we are able to get longer cycle life from our batteries. The downside is that it takes longer for all the material inside these plates to become active. It takes approximately 20-25 cycles (and as many as 75-100) to break the battery in.

How do I increase the capacity of my battery and system?

Your individual batteries capacity can not be increased from its original capacity. However, strings of batteries can be easily connected together to increase a systems voltage and / or its capacity.

To increase the voltage of a system you must connect multiple batteries in Series. To increase a systems capacity (amp hours, reserve capacity etc.) connect multiple batteries in Parallel. To increase both the systems voltage and the capacity, connect multiple batteries in Series and in parallel.



If more capacity is required, as mentioned above multiple batteries can be connected in parallel (positive terminal of Battery One to the positive terminal of Battery Two and so on). Only new and identical batteries should be used. If you connect two 12-volt batteries in parallel and they are identical in type, age and capacity, you can potentially double you original capacity. If you connect two that are not the same type, you will either overcharge the smaller of the two, or you will undercharge the larger of the two. If you connect two identical – but one older – you will definitely reduce the life of the new one. When connecting in series or parallel and to prevent recharging problems, do not mix old and new batteries or ones of different types. Cable lengths should be kept short and cable must be sized large enough to prevent significant voltage drops. There should be a maximum of 0.2 volts (200 milli-volts) or less drop between batteries.

An excellent and easy to understand free booklet on multi-battery applications, "Introduction to Batteries and Charging Systems", can be downloaded from http://www.surepower.com

Can I store my battery on a concrete floor?

A hundred years ago when battery cases were made of porous materials - such as wood - storing batteries on concrete floors would accelerate their discharge. This is no longer a problem as modern battery cases, made of polypropylene or hard rubber are sealed against external leakage which causes discharge. However, the top of the battery must be kept clean and dry. *Temperature stratification within large batteries could accelerate the self-discharge if the battery is sitting on a cold floor in a warm room or is installed in a submarine.*

Will a battery explode?

Recharging a flooded lead-acid battery normally produces hydrogen and oxygen gasses into the atmosphere. While spark retarding vent caps can help prevent battery explosions, they occur when jumping, connecting or disconnecting charger or battery cables, and starting the engine. While not fatal, battery explosions cause thousands of eye and burn injuries each year. When battery explosions occur when starting an engine, here is the usual sequence of events: One or more cells had a concentration of hydrogen gas *above 4.1%* because the vent cap was plugged or a defective valve did not release the gas. The electrolyte levels fell below the top of the plates due to high under hood temperatures, overcharging, or poor maintenance. A low resistive bridge or "treeing" formed between the top of the plates such that when the current started to flow, it caused an arc or spark in one of the cells. That combination of events ignites the gas, blows the battery case cover off and spatters electrolyte all over the engine compartment. The largest number of battery explosions while starting an engine occurs in hot climates. When an explosion happens, thoroughly rinse the engine compartment with water, and then wash it with a solution of one-pound baking soda to one gallon of warm water to neutralize the residual battery acid. Then thoroughly rewash the engine compartment with water. Using Discover™ Advanced AGM or Gel batteries can significantly reduce the possibility of battery explosions.

Do batteries last longer in hot climates than in cold ones?

Batteries used in colder or moderate conditions can last between twice and three times as long as batteries used in hot climates. Heat kills batteries! Keep your alkaline batteries in the fridge! In the northern states or Canada the life expectancy of a battery is between 48 and 54 months. In the Southern States like Florida the average life expectancy of standard batteries is about 18 to 23 months. This data is based on normal usage and very good charge and discharge conditions. Users of Deep cycle batteries can expect to get between one and four years of service from there batteries when being charged, discharged and maintained properly, regardless of the climate in which they are being used.

Section IX

Frequently asked Charge / Discharge Questions and Answers

What is the Peukert Effect?

The Peukert effect describes how a batteries capacity is directly affected by the speed at which it is discharged. The Peukert value is directly related to the internal resistance of the battery. The higher the internal resistance, the higher the losses while charging and discharging, especially at higher currents. This means that the faster a battery is discharged, the lower its ampere hour capacity. Conversely, if it is drained slower, the AH capacity is higher. This is why – when comparing batteries – the ampere hour rate is taken into consideration when looking at the batteries rating. Some suppliers rate their batteries at the 100 hour rate, some at the 20 hour rate, and some at a 10, 8, 6 or 5 hour rate. "*See What should I look for when buying deep cycle batteries?"*

Battery Council International gives the following table for assistants in comparing batteries rated at various Amp Hour rates and times.

20 hour	125%	3 hour	82%
6 hour	100%	2 hour	72%
5 hour	95%	1 hour	55%
4 hour	89%		

Does depth of discharge affect cycle life?

Yes! Work it harder and longer and it will fail sooner. But remember don't work it at all or very often and life cycle will be reduced also! Discover™ batteries have been designed for dependability and performance while being USED in the toughest of applications.

Typical Cycling Ability vs. Depth of Discharge (DOD) Comparison **

DOD	700 Series Gel	Gel	Advanced AGM	Standard AGM	Deep Cycle Flooded
> 80%	750	500	300	100	115
> 70%	900	750	450	125	145
> 50%	1300	1200	1000	150	225
> 30%	1700	1500	1500	350	500
< 30%	3500	3500	3500	1200	1500
< 10%	6500	6500	5500	3000	3500

** Actual results will vary depending upon application, charging regime, temperature etc. For direct comparison you must pay close attention to the test temperature, the amp ours removed, and the discharge and recharge rates and times for each product being compared!

How can I convert 25 amp Reserve Capacity to Amp Hours at a 25 amp discharge rate?

To convert RC to Ampere-Hours at the 25 amp rate, multiply RC by .4167. More ampere-hours (or RC) are better in every case when looking for a deep cycle battery. Within the same battery footprint or industry group size, the battery with higher ampere hours (or RC) will tend to deliver longer cycle lives. This conversion method will allow you to convert and compare competitive data.

Why can't high quality VRLA batteries be discharged too low?

High quality VRLA batteries are designed to be "**acid-starved**." This means that the power (sulfate) in the acid is used before the power in the plates. This design protects the plates from ultra-deep discharges. Ultra-deep discharging is what causes life-shortening plate shedding and accelerated positive grid corrosion which can destroy a battery.

How often should I equalize my Discover™ GEL and AGM Batteries?

Discover™ VRLA Batteries never need to be equalized. Here is why: One reason why batteries are equalized is to combat voltage separation from cell to cell within a battery. A 12-volt battery is composed of six 2-volt cells connected in series internally. A 12-volt battery reading 12.8 volts on a voltmeter should equal 2.133 volts per cell. However, when batteries are manufactured and activation or formation is done in a one shot process, where the plates are activated within the battery, one cell may receive more or less electrolyte than the other five cells of that battery. When this happens the battery's individual cell voltages after formation may be unequal: 2.123 - 2.133 - 2.143 - 2.113 -2.123 - 2.14…. "The total battery voltage after formation (12.80) is fine, but cell by cell they are different."

As a battery is discharged, the cells with the lower voltage will be drained further than the cells at the higher voltage. As the same battery is charged, the cells with the high voltage will be fully charged before the cells with the lower voltage. The more a battery is cycled, the more the cell separation takes place. Equalizing batteries helps to bring all the cells of a battery to the same voltage.

Discover batteries are manufactured and formed using a tank formation procedure to activate the plates. This process guarantees equally formed and voltage matched plates. The extra handling of the plates provides an additional inspection step in the process to verify plate quality. Plates for hundreds of batteries are formed in a tank all at once. This provides not only the opportunity for equality plate to plate within a batteries cell and cell to cell within a battery, but also a balance from battery to battery within a batch.

But don't I have to equalize my Discover™ Gel batteries to prevent stratification?

When liquid electrolyte or acid stratifies, the heavier charged ions actually sink to the bottom of the cell, leaving discharged acid at the top. This allows the top of the plates to oxidize and corrode reducing performance and shortening life. The bottoms of the plates also corrode due to the action of the higher strength acid. This can happen in stand alone solar or telecom applications because the battery never moves. Discover Gelled electrolyte batteries use electrolyte mixed to a thick consistency which prevents stratification, as a result equalization is not recommended.

WARNING – DO NOT EQUALIZE CHARGE GEL OR AGM BATTERIES! Equalizing is an "over voltage-over charge" performed on flooded lead acid batteries after they have been fully charged. It helps to eliminate stratification and sulfation, two of many conditions that can reduce the overall performance and life of a flooded battery. Balance charge modes are included in all NEXEN Discover™ Industrial Commercial charges offered for sale wherever our Discover™ VRLA products are sold. Balance Charging is similar to an equalize charge cycle but is performed at a lower voltage. Battery Council International BCIS-04 Rev. Draft Dec02 3.8.2 states that for **Flooded** batteries "An equalizing charge is allowed in conjunction with constant voltage charging to promote electrolyte mixing and to insure complete recharge. The equalizing charge must not exceed 3 hours and should be used cautiously to avoid excessive overcharge. For VRLA batteries, no equalizing charge should be used unless specifically recommended by the manufacturer."

How does a battery recharge?

The process is the same for all types of lead-acid batteries: flooded, gel and AGM. The actions that take place during discharge are the reverse of those that occur during charge. The discharged material on both plates is lead sulfate ($PbSO_4$). When a charging voltage is applied, charge flow occurs. Electrons move in the metal parts; ions and water molecules move in the electrolyte. Chemical reactions occur at both the positive and negative plates converting the discharged material into charged material. The material on the positive plates is converted to lead dioxide (PbO_2); the material on the negative plates is converted to lead (Pb). Sulfuric acid is produced at both plates and water is consumed at the positive plate. If the voltage is too high, other reactions will also occur; Oxygen is ripped form water molecules at the positive plates and released as a gas; Hydrogen gas is released at the negative plates – unless, oxygen gas can reach the negative plates first and "recombine" into H_20. A battery will "gas" near the end of charge because the charge rate is too high for the battery to accept. A temperature-compensating voltage-regulating charger, which automatically reduces the charge rate as the battery approaches the fully charged state, eliminates most of this gassing**. It is extremely important not to charge batteries for long periods of time at rates which cause them to gas** because they use water, which in sealed valve-regulated batteries cannot be replaced. Of course, no battery should be overcharged for a long period of time…even at low rates using so-called "trickle charges." In a fully charged battery, most of the sulfate is in the sulfuric acid. As the battery discharges, some of the sulfate begins to form on the plates as lead sulfate ($PbSO_4$). As this happens, the acid becomes more diluted, and its specific gravity drops as water replaces more of the sulfuric acid. A fully discharged battery has more sulfates in the plates than in the electrolyte. It is also important to prevent batteries from being undercharged.

How do Gel or AGM (VRLA) batteries recharge and are there any special precautions?

While VRLA batteries accept a charge extremely well due to their low internal resistance, any battery will be damaged by continual under or overcharging. Capacity is reduced and life is shortened. Overcharging is especially harmful to any VRLA battery because of the sealed design. Overcharging dries out or evaporates the electrolyte by driving the oxygen and hydrogen out of the battery through the pressure relief valves. Performance and life are reduced. If a battery is continually undercharged, a power-robbing layer of sulfate will build up on the positive plate, which acts as a barrier to recharging. Premature plate shedding can also occur. Performance is reduced and life is shortened. Therefore, **it is critical that a charger be used that limits voltage**. The charger must be temperature-compensated to prevent under or overcharging due to ambient temperature changes.

Why are Gel and AGM batteries so charge sensitive and why is charge voltage so critical?

All lead-acid batteries give off hydrogen from the negative plate and oxygen from the positive plate during charging. VRLA batteries have pressure-sensitive valves. Without the ability to retain pressure within the cells, hydrogen and oxygen would be lost to the atmosphere, eventually drying out the electrolyte and separators. Voltage is electrical pressure. Charge (ampere-hours) is a quantity of electricity. Current (amperes) is electrical flow (charging speed). A battery can only store a certain quantity of electricity. The closer it gets to being fully charged, the slower it must be charged. Temperature also affects charging. If the right pressure (voltage) is used for the temperature, a battery will accept charge at its ideal rate. If too much pressure is used, charge will be forced through the battery faster than it can be stored. Reactions other than the charging reaction occur to transport this current through the battery – mainly gassing. Hydrogen and oxygen are given off faster than the recombination reaction. This raises the pressure until the pressure relief valve opens. The gas lost cannot be replaced. Any VRLA battery will dry out and fail prematurely if it experiences excessive overcharge. **Note**: It is the pressure (voltage) that initiates this problem – a battery can be “over-charged” (damaged by too much voltage) even though it is not fully “charged.” This is why charging voltage must be carefully regulated and temperature compensated.

What will happen to my VRLA batteries life by not controlling the charge voltage?

As mentioned before VRLA batteries are voltage sensitive. In fact all batteries are voltage sensitive. If you continually charge your VRLA battery over the recommended levels you will shorten the life of your battery. Our tests have shown that you will reduce the life of your battery by between 5% and 7% for every 1/10th volt above the voltage recommended. For example if you continually charge your battery at (depending upon the temperature) a temperature compensated value of 14.50 volts when it should be at 14.10 volts (4 tenths over), you can expect to reduce the life expectancy of your battery by 20% to 30%.

How long does it take to recharge a fully discharged Gel or AGM (VRLA) battery?

A specific time is difficult to determine because recharging depends on so many variables:

- Depth of discharge
- Temperature
- Size and efficiently of the charger
- Age and condition of the battery

It will take about 60% of the total charge time to bring a VRLA battery from 0% charged to 80-90% charged. It will take the remaining 40% of the total charging time to put the last 10-20% of the charge back into the battery. Charge is a quantity of electricity equal to rate of flow (Amperes) multiplied by time (hours), and is usually expressed in Ampere-hours (Ah). The charge rate in amps - once the charger has been turned on for 1 to 2 minutes - will indicate the approximate charge time in hours.

A battery with a 0% state of charge is defined as having been discharged to a point when the terminal voltage is equal to or less than 1.75 volts per cell (10.50 Volts for a 12 volt battery)– measured under a steady load at the batteries 20-hour rate at 80°F. (The 20-hour rate is the batteries capacity divided by 20 hours).
Typically, the charge (capacity of the re-charge) that must be returned to a VRLA battery to achieve a 100% state of charge is from 110% to 120% of the charge removed. *For comparison purposes the returned charge for flooded electrolyte batteries needs to be between 110% and 130% of the charge removed.*

NOTE that variables such as the rate of charging current, ambient temperature during charge cycle and the control of the voltage during the charging cycle will impact the ability of the battery to be properly replenished and the ongoing performance of the battery.

IMPORTANT: Always use an automatic temperature-sensing, voltage-regulated charger! Set charger at 14.2 to 14.5 volts at 25°C/ 77°F for gel, or 14.4 to 14.7 volts at 25°C/ 77°F for AGM. Do not exceed 14.5 volts for gel or 14.7 volts for AGM.

In many respects, undercharging is as harmful as overcharging. Keeping a battery in an undercharged condition allows the positive grids to corrode and the plates to shed, dramatically shortening life. Also, an undercharged battery must work harder than a fully charged battery, which contributes to shortened life as well. An undercharged battery has a greatly reduced capacity. It may easily be inadvertently over-discharged and eventually damaged.

How often should I charge my wheelchair (scooter) batteries?

If you use your wheelchair on a daily basis then you should charge it daily. You do not want to get caught out with low batteries! This is especially important if you use your chair or scooter outside of your home. If you only use your chair or scooter periodically then charge before you intend to use it and again after to keep them at the ready. The ideal recharge time would be when your gauge or voltmeter shows that the battery is about 50%. But remember, use it or loose it. IF you do not use the battery and just keep it on charge – or perpetually leave it in a discharged condition - you will eventually damage its ability to meet your chairs/scooters power needs.

How can you tell if a battery is fully charged?

The only true way to tell if a VRLA battery is fully charged is by using a good voltmeter to determine the open circuit voltage (OCV). Accessible flooded type batteries can also use a hydrometer.

Charge %	Digital Voltmeter Open Circuit Voltage (OCV)		
	Flooded	Gel	AGM
100%	12.80-12.60	12.95-12.85	12.90-12.80
75%	12.40	12.65	12.60
50%	12.20	12.35	12.30
25%	12.00	12.00	12.00
0%	11.80	11.80	11.80

Divide the above values in half for 6 volt batteries or by six to determine cell voltage. The TRUE OCV can ONLY be measured after the battery has been removed from the charge or discharge load for 24 hours.

What do I do if I have to store my batteries outside for winter?

VRLA batteries can be stored in sub-freezing temperatures as low as -25.F—35.F as long as they are fully charged prior to storage. The self-discharge rate of fully-charged batteries is very low in these conditions and they will not require charging for many months; however, if your VRLA batteries do freeze, they may not always recover. To attempt recovery bring them inside and let them sit until the temperature of the battery reaches the temperature of the room, Approx. 68.F. Then charge the batteries normally. And hope for the best. You may have to cycle the battery a couple of times before making a decision on its final condition.

What is the freezing point of electrolyte?

Digital Voltmeter Open Circuit Voltage	Approximate State-of-Charge	Hydrometer Average Cell Specific Gravity	Electrolyte Freeze Point
> 12.65	100%	> 1.265	-75° F (-59.4° C)
> 12.45	75%	> 1.225	-55° F (-48.3° C)
> 12.24	50%	> 1.190	-34° F (-36.7° C)
> 12.06	25%	> 1.155	-16° F (-26.7° C)
> 11.89	Discharged	> 1.120	-10° F (-23.3° C)

How can I measure my batteries “State of Charge”?

If the battery's temperature – or electrolyte in flooded types - is above 110° F (43.3° C), allow it to cool. To determine the battery's state-of-charge with the battery's temperature at 80° F (26.7° C), use the following table. The table assumes that a 12.65 voltage reading or a 1.265 specific gravity reading represents a fully charged battery. For other battery or electrolyte temperatures, use the Temperature Compensation table below to adjust the Open Circuit Voltage for VRLA batteries or Specific Gravity readings for flooded types.

State of Charge

Digital Voltmeter Open Circuit Voltage	Approximate State-of-Charge	Hydrometer Average Cell Specific Gravity	Electrolyte Freeze Point
> 12.65	100%	> 1.265	-75° F (-59.4° C)
> 12.45	75%	> 1.225	-55° F (-48.3° C)
> 12.24	50%	> 1.190	-34° F (-36.7° C)
> 12.06	25%	> 1.155	-16° F (-26.7° C)
> 11.89	Discharged	> 1.120	-10° F (-23.3° C)

Temperature Compensation

Electrolyte Temperature °F / °C	Add or Subtract to Hydrometers / Digital Voltmeter reading	Electrolyte Temperature °F / °C	Add or Subtract to Hydrometers / Digital Voltmeter reading
160° / 71.1°	+.032 / +.192	150° / 65.6°	+.028 / +.168
140° / 60.0°	+.024 / +.144	130° / 54.4°	+.020 / +.120
120° / 48.9°	+.016 / +.096	110° / 43.3°	+.012 / +.072
100° / 37.8°	+.008 / +.048	90° / 32.2°	+.004 / +.024
80° / 26.7°	0 / 0	70° / 21.1°	-.004 / -.024
60° / 15.6°	-.008 / -.048	50° / 10°	-.012 / -.072
40° / 4.4°	-.016 / -.096	30° / -1.1°	-.020 / -.120
20° / -6.7°	-.024 / -.144	10° / -12.2°	-.028 / -.168
0° / -17.8°	-.032 / -.192		

How do I temperature compensate my hydrometer readings?

If you are using a non-temperature compensated hydrometer, make the adjustments shown in the table above. For example, at 30° F (-1.1° C), the specific gravity reading would be 1.245 for a 100% State-of-Charge. At 100° F (37.8° C), the specific gravity would be 1.273 for 100% State-of- Charge. This is why using a temperature compensated hydrometer is highly recommended and more accurate than other means when testing flooded battery types. For non-sealed batteries, check the specific gravity in each cell with a hydrometer and average the readings.

How do I temperature compensate my voltmeter readings?

If you are using a digital voltmeter make the adjustments indicated in the table above. For example, at 30° F (-1.1° C), the voltage reading would be 12.53 for a 100% State-of-Charge. At 100° F (37.8° C), the voltage would be 12.698 for 100% State-of-Charge. For sealed batteries, measure the Open Circuit Voltage across the battery terminals with an accurate digital voltmeter. This is the only way you can determine the State-of-Charge on sealed flooded or VRLA batteries. Some sealed flooded batteries have a built-in hydrometer, which only measures the State-of-Charge in one of its cells. If the built-in indicator is clear or light yellow, then the battery has a low electrolyte level and needs to be replaced. If the State-of-Charge is 75% using either the specific gravity or voltage test or the built-in hydrometer indicates “bad” (usually dark), then the battery needs to be recharged.

How can you tell if a battery has been damaged by under or overcharging?

The only way is with a load test. Use the same procedure for VRLA batteries that you would use with a flooded cell battery:

a. Recharge if the open circuit voltage is below 75%
b. If adjustable, set the load at three times the 20 hour rate.
c. Apply the load for 15 seconds. The voltage should stabilize above 9.6 volts while on load.
d. If the battery has a CCA rating you can apply a load equal to the rating for 15 seconds. The voltage should stabilize above 9.6 volts while on load. To apply a more determined test – if your

load tester has the ability - you may apply a load equal to 100% of the rated CCA for 30 seconds. The voltage should stabilize above 7.2 volts while on load.

e. If below 9.6 volts (7.2 volts for the 100% CCA test), recharge and repeat test.
f. If below 9.6 volts (7.2 volts for the 100% CCA test) a second time, replace the battery.

NOTE that for the above tests to be completely accurate these tests should be performed with the battery temperature being stabilized at -18°C/ 0°F.

How can I tell if I have a battery problem or a charging problem?

A voltmeter is still the most valuable tool when troubleshooting sealed batteries. (see "How can you tell if a battery is fully charged?" above) When checking batteries always start by checking the voltage. In multi-12 volt systems such as a 24-volt system, we know the chances for two bad batteries are less than 1 in 10,000. So what we need to determine is which battery is bad, if either battery is bad or if something else is wrong. This is accomplished by checking the voltage of each battery separately. We can not just check the total voltage. We might incorrectly assume the bank is good when by checking them individually we find that one has a voltage of 12.70 and the other a voltage of 12.1. Combined they looked good, but separately they were not! Multiple 12 volt battery banks charge and discharge together almost as one when hook in series. A wide voltage separation between two 12 volt batteries in a 24 volt system indicates that you may need to replace both batteries. If both batteries read similar voltage, they should be fully charged before doing any further testing. If both batteries are below 12.0 volts, the question becomes, why?" Is the battery charger working correctly? Could there be a problem with the applications wiring or other components. You can determine this once you know the voltage of each battery.

What is a thermal runaway?

The appropriate charge voltage depends on the battery temperature. A warmer battery requires a reduced voltage. If the voltage is not reduced the current accepted by the battery increases. When the current increases heating within the battery increases. This can continue in a loop feeding on itself with the battery temperature and charging current rising to destructive levels. This is thermal runaway. Gel batteries are much less susceptible to thermal runaway than AGM batteries. Batteries may become more susceptible with increasing age. Without a recombination reaction, flooded batteries convert most excess charging energy to gas, not heat. This makes them almost immune from the thermal runaway.

Thermal runaway can be prevented with:

- Temperature compensation monitoring at the battery – not at the charger.
- Limiting charging currents to appropriate levels
- Allowing for adequate air circulation around the batteries.
- Using timers, or Ampere-hour counters.
- Using smart chargers that recognize the signature of a thermal runaway which will shut the charger down.

How do I know if a charger is "Gel friendly" or "AGM friendly"?

Unfortunately, many chargers on the market claim to be gel "friendly" or "OK for sealed batteries", but are not. Some overcharge the batteries, while others may not fully charge the batteries. Some chargers claim to be "smart." Some "smart" chargers do a good job, others do not. The best choice of charger often depends on the application. Use only "voltage-regulated" or "voltage-limited" chargers. **Standard constant current or taper current chargers must not be used**. Almost all applications require temperature sensing and voltage compensation. Beware; many chargers measure the ambient temperature which could be significantly different from the battery's internal temperature. **Low frequency current ripple (to about 333Hz) can be detrimental** to sealed batteries depending on the application. On applications where the charger is connected continuously to a float voltage, especially where simultaneous charge and discharge may occur, the level of current ripple must be a consideration.

If you are not sure if a charger is performing properly, following this procedure;

a. Using a fully discharged VRLA battery (OCV about 11.8V) and a digital voltmeter, record the initial open circuit voltage at the battery terminals.
b. Using an automatic charger as described above, set voltage if adjustable (14.2V for gel, 14.5V for AGM models).
c. Connect and start charging. Record initial on-charge voltage and current.

d. Each hour or so, check and record the on-charge voltage across the battery terminals. Except for occasional, brief "blips" or pluses, the voltage should not exceed the voltage limits noted in "b" above.
e. At the end of charge (when the current is very low or goes to zero) check and record the voltage. Note that the charger may have turned off by then.
f. The disconnected battery should be at 100% or above after a 24 hour rest.

During the charging time, the charger should not have exceeded the limit (except for occasional, brief pulses). This indicates that the charger is working properly. Keep in mind that the voltage limit is at 77°F/25°C. Charging at higher or lower temperatures will change this limit.
A temperature-sensing charger should always be used when charging VRLA batteries, as manual adjustments are never accurate and exceeding temperature limits will damage any battery.

Discover™ has developed a complete line of chargers specifically designed for its Discover™ products with the capability to charge all other types of lead acid batteries as well. Please enquire with a Discover™ dealer!

What is a safe charge rate or voltage setting for outdoor applications with wide temperature fluctuations if a temperature-sensing charger is not available?

NOTE!
There is no fixed voltage setting or current that will work. A temperature-sensing, voltage-regulated charger must be used. Anything else will damage any battery and cause premature failure! It may be possible to limit this potential by using an ambient temperature sensing charger and assuming that the battery temperature is similar to the surrounding temperature. NOTE however that the temperature of the battery will fluctuate during discharge and recharge and this fact will eventually damage the battery and cause premature failure if not controlled. If the recommended charger is not available then limiting the charge current and extending the charge time will lesson the chance of damaging the battery.

What is float charging? What float voltage is recommended?

This type of charge continually monitors and maintains a pre-set battery voltage, regardless of charge conditions. These chargers are used in stationary, emergency back-up power, emergency lighting, and other applications. Most high quality AGM and Gel chargers will have an alternative float cycle in its finishing charge algorithm. The frequency of discharge and temperature will dictate a more exact setting. For example, the more frequent the discharge, the higher the suggested recharge voltage should be to ensure that the recharge time is sufficient to maintain the batteries proper performance. The typical float voltage for monitoring and maintaining is between 2.25 and 2.30 volts per cell at 25°C/77°F.

Will driving my car fully recharge my battery?

Some factors affecting a car charging system's ability to charge are; how much current from the alternator is diverted to the battery to charge it; how long the current is available and at what temperature the charging activity is taking place. Generally, idling the engine or on short "stop-and-go trips" during bad or hot weather or at night will not recharge a battery. A long daytime trip in warm weather should recharge a battery.
How long will a Deep Cycle battery last on a single charge?

Discharging batteries - like charging - depends on a number of factors. These include, but are not limited to, the initial state-of-charge, the depth-of-discharge, the age and original capacity of the battery, the load and the temperature at the time of discharge. To estimate the cycle life - at 70° F (21.1° C) – divide the ampere hour rating by the load in amps. For example; a new 72-ampere-hour battery with a 10-amp load should last approximately 7.2 hours. As the battery ages, this capacity will be reduced.

Will a battery lose its charge sitting in storage?

Depending on the batteries type of plate and grid alloy, batteries will have a self-discharge or internal electrochemical "leakage" of between 1% and 15% per month. This will cause the battery to become sulfated and fully discharged over time. Higher temperatures accelerate this process. A battery stored at 95° F (35° C) will self discharge twice as fast than one at 75° F (23.9° C). Discover™ Advanced AGM or Gel batteries will naturally discharge at approximately; 2% per month when stored at 8°C/46°F; 3% per month when stored at 20°C/68°F; 5% per month when stored at 30°C/86°F; 10% per month when stored at 40°C/104°F.

How can I tell if my battery needs to be replaced?

You should replace the battery, if one or more of the following conditions occur: If there is a .05 (sometimes expressed as 50 “points”) or more difference in the specific gravity reading between the highest and lowest cell. This means the flooded battery you are testing has a weak or dead cell(s). If the battery will not recharge to a 75% or more state-of-charge level or if the built-in hydrometer still does not indicate “good” (usually green or blue which is 65% state-of-charge or better) then the battery should be replaced. If a digital voltmeter indicates 0 volts, you have an open cell and you should replace the battery. If the digital voltmeter indicates 10.45 to 10.65 volts, you probably have a shorted cell or a severely discharged battery. A shorted cell is caused by plates touching, sediment (“mud”) build-up or “treeing” between the plates. If the battery is fully charged or has a “good” built-in hydrometer indication, then you can test the capacity of the battery by applying a known load and measuring the time it take to discharge the battery until 20% capacity is remaining. Normally a discharge rate that will discharge a battery in 20 hours can be used. For example, if you have an 80-ampere-hour rated battery, then a load of four amps would discharge the battery in approximately 20 hours (or 16 hours down to the 20% level). New batteries can take up to 50 charge/discharge cycles before they reach their rated capacity. Depending on your application, batteries with 50% or less of their original capacity are considered to be bad. I think that batteries that do not reach 80% of there original capacity should be replaced. If the battery passes the load test, you should recharge it as soon as possible to restore it to peak performance and to prevent lead sulfation. Always consider the temperature when making your evaluation and that the batteries are being properly charged.

How can I tell if my battery has reached the end of its useful life?

Different types of batteries use test procedures that allow different end of life criteria. For example an electric vehicle or standard deep cycle product would be considered to be at its end of life when it was not able to deliver 50% of its rated capacity while a golf cart battery would not be determined to be at its end of life until it was not able to produce at least 1.75 volts per cell during 40 minutes of discharge at 75 amperes. Most official tests to determine the cycle life of a battery are performed in laboratories, under controlled circumstances and temperatures. For the average user, it is important to make sure that the battery is being charged properly and that the temperature during evaluation was not extreme. (between (18° and 28°C for example)

Typical AGM Charge and Float Voltages at Various Temperature Ranges

Temp.	**Charge**		**Float**		**Temp.**
°F	**Standard**	**Maximum**	**Standard**	**Maximum**	**°C**
! 120	13.60	13.90	12.80	13.00	! 49
110 – 120	13.80	14.10	12.90	13.20	43 – 49
100 –110	13.90	14.20	13.00	13.30	38 – 43
90 – 100	14.00	14.30	13.10	13.40	32 – 38
80 – 90	14.10	14.40	13.20	13.50	27 – 32
70 – 80	14.30	14.60	13.40	13.70	21 – 27
60 – 80	14.45	14.75	13.55	13.85	16 – 21
50 – 60	14.60	14.90	13.70	14.00	10 – 16
40 – 50	14.80	15.10	13.90	14.20	4 – 10
40	15.10	15.40	14.20	14.50	4
Discover™ AGM					
77°F	14.20	14.72	13.40	13.80	25°C

Typical Gel Charge and Float Voltages at Various Temperature Ranges

Temp.	**Charge**		**Float**		**Temp.**
°F	**Standard**	**Maximum**	**Standard**	**Maximum**	**°C**
! 120	13.00	13.30	12.80	13.00	! 49
110 – 120	13.20	13.50	12.90	13.20	44 – 48
100 –109	13.30	13.60	13.00	13.30	38 – 43
90 – 99	13.40	13.70	13.10	13.40	32 – 37
80 – 89	13.50	13.80	13.20	13.50	27 – 31
70 – 79	13.70	14.00	13.40	13.70	21 – 26
60 – 69	13.85	14.15	13.55	13.85	16 – 20
50 – 59	14.00	14.30	13.70	14.00	10 – 15
40 – 39	14.20	14.50	13.90	14.20	5 – 9
39	14.50	14.80	14.20	14.50	4
Discover™ Gel					

77°F	14.10	14.50	13.35	13.75	25°C

Typical Flooded Charge and Float voltages at Various Temperature Ranges

Temp.	Charge		Float		Temp.
°F	Standard	Maximum	Standard	Maximum	°C
! 120	14.10	14.40	12.80	13.00	! 49
110 – 120	14.20	14.50	12.90	13.20	44 – 48
100 –109	14.25	14.55	13.00	13.30	38 – 43
90 – 99	14.30	14.60	13.10	13.40	32 – 37
80 – 89	14.40	14.70	13.20	13.50	27 – 31
70 – 79	14.42	14.75	13.40	13.70	21 – 26
60 – 69	14.45	14.80	13.55	13.85	16 – 20
50 – 59	14.48	14.80	13.70	14.00	10 – 15
40 – 39	14.50	14.80	13.90	14.20	5 – 9
39	14.55	14.85	14.20	14.50	4

Equalization voltage for flooded batteries should be maintained at a maximum of 15.60 volts at 80°F. Make sure to correct the charging voltage to compensate for temperatures above and below 80°F. Add .028 volt per cell for every 10 degrees below 80°F and subtract .028 volt per cell for every 10 degrees above 80°F.

Section X

Gel Battery Charging

The first stage in a 3 or 4 stage charging algorithm is the “Bulk Stage”. Typically the Bulk Stage is a “Constant Current” (CC) charge but may also be Constant Power, Pulse Current or Taper Charge. In this stage the optimum charge current should be limited to less than or equal to 20 amps per 100 ampere hour (20 hour rate) of battery capacity or .2C. This stage should end when the cell voltage is = to 2.38-2.42V/Cell at 25°C/77°F. The maximum time in hours should = 1.2 times the DOD (in AH) divided by the average charge current in amps. If this time is exceeded, charging should be stopped and the battery and/or charge process should be analyzed. This stage will represent approximately 60% of the total charge time. The battery will be nearing 80%-90% charged at the end of this stage.

The second stage is the “Absorption Stage”. Typically this stage is a Constant Voltage (CV) stage where the terminal voltage is maintained at 2.38-2.42V/Cell at 25°C/77°F (adjusting for temperature). The charge current is maintained until current acceptance drops by less than .1 ampere over a 1 hour period. This stage should take the battery to 100% charged and should not take longer than 10-12 hours. If this time is exceeded, charging should be stopped and the battery and/or charge process should be analyzed.

The third stage is the “Float Stage” or maintenance and monitor stage. This step is generally not needed if; no load is present when the batteries device is not in operation; the batteries device is used on a regular basis and does not sit idle for lengthy periods of time. Float voltage should be maintained at 2.25-2.30 V/Cell.

If a “Balance Mode” is included in the charging algorithm it would typically happen after the “Absorption Stage”. This would become the third stage and the “Float Stage” would then become the fourth stage. A balance mode is similar to an Equalize function for flooded batteries but is performed at a lower voltage.

To compensate for battery temperature not at 25°C, subtract 0.005 V/Cell for each 1°C above 25°C, and add 0.005 V/Cell for each 1°C below 25°C

Section XI

AGM Battery Charging

The first stage in a 3 or 4 stage charging algorithm is the “Bulk Stage”. Typically the Bulk Stage is a “Constant Current” (CC) charge but may also be Constant Power, Pulse Current or Taper Charge. In this stage the optimum charge current should be limited to less than or equal to 30 amps per 100 ampere hour (20 hour rate) of battery capacity or .3C. This stage should end when the cell voltage is = to 2.4-2.45V/Cell at 25°C/77°F. The maximum time in hours should = 1.2 times the DOD (in AH) divided by the average charge current in amps. If this time is exceeded, charging should be stopped and the battery and/or charge process should be analyzed. This stage will represent approximately 60% of the total charge time. The battery will be nearing 80%-90% charged at the end of this stage.

The second stage is the “Absorption Stage”. Typically this stage is a Constant Voltage (CV) stage where the terminal voltage is maintained at 2.4-2.45V/Cell at 25°C/77°F (adjusting for temperature). The charge current is maintained until current acceptance drops by less than .1 ampere over a 1 hour period. This stage should take the battery to 100% charged and should not take longer than 10-12 hours. If this time is exceeded, charging should be stopped and the battery and/or charge process should be analyzed.

The third stage is the “Float Stage” or maintenance and monitor stage. This step is generally not needed if; no load is present when the batteries device is not in operation; the batteries device is used on a regular basis and does not sit idle for lengthy periods of time. Float voltage should be maintained at 2.25-2.30 V/Cell.

If a “Balance Mode” is included in the charging algorithm it would typically happen after the “Absorption Stage”. This would become the third stage and the “Float Stage” would then become the fourth stage. A balance mode is similar to an Equalize function for flooded batteries but is performed at a lower voltage.

Section XII

Frequently asked Temperature related Q&A's

Why does temperature have such a dramatic effect on batteries?

Temperature is a major factor in battery performance, shelf life, charging and voltage control. At higher temperatures there is dramatically more chemical activity inside a battery than at lower temperatures. Battery capacity is reduced as temperature goes down, and increased as temperature goes up. This is why your car battery has reduced performance on a cold winter morning, and why capacity needs to be taken into account when sizing your battery for use in different environments. The standard rating for batteries is at room temperature (25°C/77°F). At approximately -22°F (-27°C), battery capacity drops by 50%. At freezing capacity is reduced by 20%. Capacity is increased at higher temperatures. At 122°F a batteries capacity will be increased by about 10-15%. As mentioned earlier, battery charging voltage also changes with temperature. It will vary from about 2.74 volts per cell at -40°C to 2.3 volts per cell at 50°C. This is why temperature sensing and compensating chargers are so important.

The Thermal Mass of larger batteries and battery banks introduces more things to think about. Because some of these batteries have so much mass, they will change internal temperature much slower than the surrounding air temperature. A large insulated battery bank may vary as little as 10° over 24 hours internally, even though the air temperature varies from 20° to 70° degrees. In these circumstances external thermo couples – attached and insulated to one of the positive terminals - are a good idea. The sensor will then read very close to the actual internal battery temperature.

Even though battery capacity at high temperatures is higher, battery life is shortened. Battery capacity is reduced by 50% at -22°F - but battery life will be increased by as much as 60%. Battery life is reduced in half for every 15°F over 77°. This is true for any type of Lead-Acid battery. In places that experience extreme temperatures, batteries may be sold with different electrolyte specific gravities. These will be higher in colder areas and lower in hotter environments. Much of the information we have given here needs to be reinterpreted in these cases.

Typical Self-Discharge of VRLA Batteries at Different Temperatures

A fully charged batteries shelf life will discharge at approx;

2% per month when stored at 8°C/46°F
3% per month when stored at 20°C/68°F
5% per month when stored at 30°C/86°F
10% per month when stored at 40°C/104°F

Batteries kept in storage while discharged will not perform as intended when put into service. Battery inventories should be constantly checked and re-charged when necessary. A Battery in storage should never be allowed to discharge more than 45-50% of its original capacity.

How does temperature affect a batteries available capacity!

A batteries available capacity varies at various temperatures. As the ambient temperature rises a batteries ability to deliver current increases. As the temperature falls, so does the batteries ability to deliver current. **NOTE that even though a batteries ability to deliver current goes up as temperature rises, prolonged operation at extreme temperatures (>40.C) will shorten the life of the battery.**

To calculate approximate capacity correlation due to temperature, add or subtract the % adjustments shown in the following table:

Discharge Time	0.C	5.C	10.C	15.C	20.C	25.C	30.C	35.C	40.C
<30 Min	-20%	-15%	-12%	-8%	-3%	0%	+5%	+8%	+10%
30-60 Min	-18%	-13%	-11%	-7%	-2%	0%	+4%	+6%	+8%
>60 Min	-16	-12%	-10%	-6%	-1%	0%	+3%	+4%	+5%

Section XIII

What should I look for when buying deep cycle batteries?

The most important consideration in buying a deep cycle battery is the Ampere-Hour or Reserve Capacity rating that will meet or exceed your requirements. Most deep cycle batteries are rated in discharge rates of 100 hours, 20 hours, 10 hours or 8 hours. The higher the discharge, the lower the capacity due to the Peukert Effect and the internal resistance of the battery. Reserve Capacity (RC) is the number of minutes a fully charged lead acid battery at 80° F (26.7° C) can be discharged at 25 amps before the voltage falls below 1.75 volts per cell (100% DOD). To convert RC to Ampere-Hours at the 25 amp rate, multiply RC by .4167. More ampere-hours (or RC) are better in every case. Within the same battery footprint or industry group size, the battery with higher ampere hours (or RC) will tend to deliver longer cycle lives.

The “Battery Council International” manual BCIS-05 Rev. Dec02 provides some guidance regarding comparing amp hour capacity relationships. In it they state that “for guidance in establishing rates, ampere hour capacity relationships are approximately”:

20 hour	125%	3 hour	82%
6 hour	100%	2 hour	72%
5 hour	95%	1 hour	55%
4 hour	89%		

Finally, the available space and any weight restrictions will have to be considered in determining the appropriate battery.

Section XIV

How do I compare and make an informed buying decision when deciding amongst the size, weights and performance options available?

Discover™ has made available the LARGEST AGM/Gel product line in the world! This means that you have a number of size and performance options to choose from when making your purchase decision. First consider the following;

- Do you have any size restrictions (Height, total W x L area available)
- Do you have multiple areas available for batteries? If so, how far apart are they and are they similar in area?
- Is the area hard to get to or is it going to be easy to get heavy batteries installed?
- Do you have weight restrictions? Both on a per battery basis and as a total installation!
- Will the installed batteries be easy to service? **If not, DO NOT consider Flooded types!**
- Is the installation area serviced by a dedicated exhaust fan? **If not, DO NOT consider Flooded types!**
- What type of battery(s) are you using now?
- What type of charging system do you have?

With these questions answered and understood, you are now ready to consider the options available to you. Make sure you have read and understand the section above on: **How do I increase the capacity of my battery and system and the section below on** and the section below on **How do I compare and make an informed buying decision when deciding between Flooded, Advanced AGM, or Gel batteries?**

Consider – as an example - that you are going to replace two flooded 8D batteries.

Each battery is approx. 21in (533mm) L x 11in (282mm) wide x 9in (250mm) H with a total height to the top of the terminals of 9.9in (250mm). The average weight across the industry is about 150 lbs. The average Amp Hour across the industry is between 200 and 230.

From the Discover™ product line you have many replacement options. You can choose exact replacements by using the 8D types available or you could replace them by fitting (in the same space);

Connection	Total Qty	Type	AH Each c/20	AH Total c/20	Weight Each Lbs/Kgs	Weight Total Lbs/Kgs	In the same area as 1 8D
Original	2	EV8D	290	290	180/82	360/164	
Parallel	6	EV24D	>84	>500	50/23	300/138	3 will fit
Series/Parallel 3 sets of 2	6	EVGC6	>200	>600	69/31	414/186	3 will fit
Series/Parallel 3 sets of 2	6	EV250	>260	>780	82/37	492/222	3 will fit
		Will be approx. 2in (50mm) higher					
Series/Parallel 3 sets of 2	6	EV305	>310	>930	107/49	642/294	3 will fit
		Will be approx. 5in (125mm) higher					
Series/Parallel 3 sets of 2	6	EVL16	>390	>1170	122/55	732/330	3 will fit
		Will be approx. 7in (175mm) higher					

Hopefully you are getting the picture of how you can use the many types, sizes and performance options available to replace or upgrade your system. There are many other types available if you have flexibility within your installation area.

NOTE: In the interest of safety and performance Multi battery systems must be engineered and installed properly! An excellent and easy to understand free booklet on multi-battery applications, "Introduction to Batteries and Charging Systems", can be downloaded from http://www.surepower.com

Section XV

How do I compare and make an informed buying decision when deciding between Flooded, Advanced AGM, or Gel batteries?

CAUTION / DANGER:

Lead-acid batteries contain a sulfuric acid electrolyte, which can be poisonous and is highly corrosive. Flooded Lead Acid batteries will produce gasses when discharging and re-charging which can explode!
When working with batteries, you need to have plenty of ventilation, remove your jewelry, wear protective eyewear (safety glasses) and clothing, and exercise caution.

Do not allow battery electrolyte to mix with salt water. Even small quantities of this combination will produce Chlorine gas that can KILL you!

Because of the growing number of performance rating schemes - and/or ways to value your buying decision in the market today - it has become difficult to make a decision that doesn't come with some form of buyer's remorse at a later date. Following are some of the more obvious things to watch out for when buying;

- ☹ Some companies rate their Reserve Capacities (minutes that the battery will deliver a discharge current) at 23 amps instead of the industry standard (BCI published) way of establishing Reserve Capacity which is at 25 amps.

- ✍ Amp Hour (AH) ratings can be at 5 hour, 10 hour, 20 hour and even 100 hour rates, so make sure you are comparing the same rate.

  The "Battery Council International" manual BCIS-05 Rev. Dec02 provides some guidance regarding comparing amp hour capacity relationships. In it they state that "for guidance in establishing rates, ampere hour capacity relationships are approximately":

20 hour	125%	3 hour	82%
6 hour	100%	2 hour	72%
5 hour	95%	1 hour	55%
4 hour	89%		

- ? Cranking Amps (the ability of the battery to deliver a higher starting current over a shorter period for engine starting) are given at different temperatures, so make sure that you compare the published "Cranking Amps" of each battery at the same temperature. CCA or Cold Cranking Amps at 0.F/-18.C is the industry standard rating. You may see ratings published at CA, MCA, MCCA and HCA. All reputable suppliers will publish the CCA.

- ✏ Some companies invent their own rating system;
  Recognizing that the process of comparing deep cycle batteries should be simplified, An American based manufacturer of batteries invented a new labeling system incorporating the "Lifetime Energy Unit" (LEU). This was their way of attempting to help a buyer determine the lifetime performance and value of any given battery in the market. Simply stated, and in the words of the SANTA FE SPRINGS, CA. manufacturer;

"Lifetime Energy Units signify the number of kilowatt-hours of energy a battery delivers over its lifetime. The bigger the number, the more total work the battery can perform. Before the introduction of LEUs, accurately determining battery performance and value required complex calculations. Engineers compute the true worth of a battery as the total energy it contains, measured in kilowatt-hours (KWH). To derive a number for KWH, they build a curve that profiles the relationship between run time and number of cycles. The area under the curve is the total energy the battery delivers over its lifetime. When amp-hours are multiplied by battery voltage, the result is the battery's capacity in watt-hours. The next step - comparing a battery's value - is also simplified. By dividing the LEU by the battery's price, the prospective purchaser obtains a value figure (energy units per dollar) that ensures an apples-to-apples comparison between competing products."

Discover™ completely rejects this position. As with the variations in determining Reserve Capacity and Cranking Amps - mentioned earlier - this is NOT a recognized Battery Council International (BCI) method for rating or comparing batteries as suggested by the manufacturer. In fact the manufacturer leaves out the exact method of determining LEUs in order that an exact comparison be done, which was their stated purpose for establishing the rating. This creates a situation where two suppliers could use two sets of methodology to determine their respective LEUs, making reasonable comparisons impossible. This implies that the LEU idea or concept in practice is simply a marketing tool with no real scientific basis for engineers as the manufacturer suggests. In fact however, LEUs – as a way of helping buyers make an informed decision – would work very well if the buyer was given some additional pieces of data (data that IS available from other manufacturers and that could be used to make meaningful comparisons);

1. The exact discharge control methods (test procedures) used in determining the batteries "Cycle Time" (what discharge rate and to what depth is the battery discharged?).
2. Whether or not the batteries can be pre-conditioned before running the procedure.
3. The resulting ampere hours of power discharged per cycle
4. The re-charge control methods (test procedures) prior to the next discharge procedure.
5. The exact control methods used in determining the batteries "Life Cycles".
6. The resulting ampere hours of power discharged over the life of the battery.

In addition to the problems listed above for making good performance comparison amongst different batteries, using the LEU marketing tool to make a serious value comparison is equally flawed. The value comparison requires more in the way of details also. Some, but certainly not all of the issues to be examined and required in determining value are;

1. Time and Supply costs associated with servicing the battery (as recommended by the manufacturer) to ensure it achieves its assumed life cycles.
2. Costs associated with Workers Safety and Clothing needs (as recommended by the manufacturer).
3. Cost associated with Environmental Issues, Storage and Equipment Damage resulting from the emission of free hydrogen molecules during discharge and re-charge.
4. Freight/time costs and/or restrictions related to shipping.

If these data were know the buyer would then be able to determine the true energy units per dollar, or lifetime energy value as suggested by the manufacturer who introduced the LEU calculation.

It is our opinion that to determine the actual best "bang for your buck", for batteries in cycling applications, you should gather the following information and perform the following calculations;

Information

A. Determine the amount of energy the battery will deliver in its Life using test procedures recognized by world wide manufacturers and published in the BCI technical manual. This information should be available from all manufacturers and should include;

- Discharge current used (25Amps, 75Amps, 20 hour rate, etc.)
- Discharge time (Cycle Life) to an effective 100% depth of discharge (1.75 volts per cell)
- Discharge cycles (Life Cycles) achieved before the battery could not deliver at least 50% of its original rated capacity.

Note: Different types of batteries use test procedures that allow different end of life criteria. For example an electric vehicle or standard deep cycle product would be considered to be at its end of life when it was not able to deliver 50% of its rated capacity while a golf cart battery would not be determined to be at its end of life until it was not able to produce at least 1.75 volts per cell during 40 minutes of discharge at 75 amperes.

Determine the number of times the battery will have to be serviced in its life time as recommended by the manufacturer. Remember that the manufacturers published battery life data will be the best achievable in the best of circumstances. Therefore you must use the manufacturers recommended service schedule. For time/cost analysis we recommend you use an average of 10 minutes per service per battery.

B. Determine the average per hour/minute costs of service people in your organization

This number varies by region and industry - should not include anything but direct labor costs. You can safely use a figure of $18.00 - $25.00 per hour ($.30 - $.42 per minute) without benefits etc. One transit authority stated that their direct labor cost associated with maintaining batteries in each of their transit buses was $180.00 per year. We recommend $22.00 as an average hourly cost ($.367 per minute).

C. Cost of service materials over the life of the battery such as; distilled or specially treated water - using a per cell fluid usage by volume of 20% on an average cell volume of 2.35l/80oz and a 75% consumption efficiency or between $.02-$.04 per oz. Battery fluid volumes are as low as 5l/169oz and as high as 16l/540oz ; cleaning and neutralizing agents at 1oz per battery or $.25 per battery per service; special clothing; repair and replacement of battery boxes and trays and more.

D. Cost Per Battery

- Purchase price of the battery
- Freight or handling charges (overland or can they be shipped via courier or air)

Calculation

Estimate the cost of materials used when servicing the battery as recommended by the manufacturer. For comparison it is reasonable to use just $1.70 each time for distilled water, cleaning and neutralizing agents and ignore the other variable costs). Multiply this amount by the number of years the manufacturer says the battery will last in the application. Multiply the result by the number of times the manufacturer says the battery should be serviced per year to achieve the published life expectancy. Our experience shows most manufacturers will recommend you service flooded batteries at least once per month. Two of the “Worlds” leading manufacturers and sellers of Flooded, Gel and AGM Deep Cycle batteries state the following on their web sites;

”Flooded batteries need water. More importantly, watering must be done at the right time and in the right amount or else the battery’s performance and longevity suffers. Water should always be added after fully charging the battery. Prior to charging, there should be enough water to cover the plates.”

“Batteries should be watered after charging unless plates are exposed before charging. If exposed, plates should be covered by approximately 1/8" of acid. Check acid level after charge. The acid level should be kept 1/4" below the bottom of the fill well in the cell cover. Water used to replenish batteries should be distilled or treated not to exceed 200 T.D.S. (total dissolved solids...parts per million). Particular care should be taken to avoid metallic contamination (iron).”

“As batteries age, their maintenance requirements change. This means longer charging time and/or higher finish rate (higher amperage at the end of the charge). Usually older batteries need to be watered more often. And, their capacity decreases. Periodic battery testing is an important preventative maintenance procedure. Hydrometer readings of each sell (fully charged) gives an indication of balance and true charge level. Imbalance could mean the need for equalizing, is often a sign of improper charging or a bad cell. Voltage checks (open circuit, charged and discharged) can locate a bad battery or weak battery. Load testing will pick out a bad battery when other methods fail. A weak battery will cause premature failure of companion batteries”

This would suggest that the worlds leading manufacturers of flooded deep cycle batteries recommend that service is required – particularly as the battery ages – **BEFORE** and **AFTER** *every* charge/discharge cycle. In some cases they suggest that failing to do so will void the warranty.

If you cycle the battery 2 times per week the battery will last approximately 3 years following the manufacturers recommended service procedures. (We use the manufacturers published life cycle data in the following comparisons).

This means your <u>per battery</u> service material costs will be at least $1.70 x 12 services per year x 3 years = $61.20; If you service as the manufacturers suggest it will be as much as $1.70 x 104 services per year x 3 years = $530.40. To achieve excellent 3 year life - cycled two times per week – flooded batteries need to be serviced at least once every 4 cycles or bi-monthly. $1.70 x 3 years x 26 services = $132.60 per battery. Every user of deep cycle batteries is familiar with dried out “rotten egg” smelling batteries, the result of NOT maintaining a proper service schedule over the life of the battery. ***In all of our***

comparisons we calculate service costs based on the flooded batteries being service after 6 to 8 cycles. Well below that recommended by the leading manufacturers.

NOTE: that when asked, more than 80% of equipment managers could not produce or describe a "battery service schedule" - for equipment under their supervision - that use cycling batteries.

In our opinion if you were to match a flooded battery against a Discover™ Advanced AGM or Gel battery - of the same size and AH rating for use in the same application - you would find the following data to be a conservative representation of the comparable costs. Note that we have shown "cost per cycle" data for the Discover™ Advanced AGM and Gel at optimum, at drastically reduced and at 60% of the published life expectancy of a flooded battery. We present the results against a flooded battery that performs to its maximum as stated by its manufacturer. We do this even though we show the flooded battery being serviced after 6 or 8 charge-discharge cycles and not after every charge/discharge cycle as the manufacturer required to achieve their published results.

Discover™ believes that – as a result of their design which requires less service, and assuming proper charging methods – Discover™ Advanced AGM and Gel batteries will out-value flooded batteries as it is more likely that the standards of service for the flooded batteries will not be met in the real world and as a result will not meet the manufacturers required levels to achieve maximum life. We make these reduced life expectancy comparisons in anticipation of positions that will be taken by Discover™ competitors and other detractors that Discover™ products will not deliver the same life cycles as a flooded battery.

Additionally, in the following comparisons, we do not take into consideration any of the other issues, inconveniences and/or costs associated with servicing, working with or having sensitive equipment around flooded batteries. These would include, but are not limited to, damaged and/or special clothing, battery compartment repairs, air quality problems, workers compensation claims, occupational health issues, hazardous materials handling requirements, shipping restrictions and damage to service areas from acid and corrosive by product spills.

Some of the most interesting and relevant results of the following study are that;

- The more competitive and demanding the channel (jobber/installer/large user) the more compelling and feasible the switch to Discover™ product becomes.

- The larger the bank of batteries used, the more important costs associated with service becomes and the more compelling and feasible the switch to Discover™ product becomes.

We think the results will surprise you and bring into focus why this is such an opportunity for Discover™ users to greatly reduce their operational costs, and risks to their employees, communities and the environment that the use of flooded batteries currently presents.

Single 6 volt Floor Scrubber and HD Lift battery

Type (L16)	List Price	Total Service and Material Costs	Total Costs	Average per Cycles Cost
DC Flooded	$259.99	$445.70	$705.69	$1.41
DC Advanced AGM	$359.99	$33.03	$393.02	$.65 ($.98) ($1.31)
DC Gel	$429.99	$33.03	$463.02	$.77 ($.92) ($1.54)

DC Flooded 6 Volt 350AH / 500 cycle life (>80% DOD)battery / $304.60 in 83 services over 3 years at 10 minutes each at $.367 per minute / $141.10 in materials.

DC Advanced AGM 6 Volt 350AH / 600 (400) (300) cycle life (>80% DOD) battery / $33.03 in 18 services over 3 years at 5 minutes each at $.367 per minute / No materials

DC Gel 6 Volt 350AH / 600 (500) (300) cycle life (>80% DOD) battery / $33.03 in 18 services over 3 years at 5 minutes each at $.367 per minute / No materials

Type (L16)	Fleet/Jobber Price	Total Service and Material Costs	Total Costs	Average per Cycles Cost
DC Flooded	$155.99	$445.70	$601.69	$1.20
DC Advanced AGM	$215.99	$33.03	$249.02	$.41 ($.62) ($.83)
DC Gel	$257.99	$33.03	$291.02	$.48 ($.58) ($.97)

12 volt Floor Scrubber and HD Lift battery

Type (L16 x 2)	List Price	Total Service and Material Costs	Total Costs	Average per Cycles Cost
DC Flooded (2)	$519.99	$501.97	$1021.96	$2.04
DC Advanced AGM (2)	$719.99	$33.03	$753.02	$1.25 ($1.88) ($2.51)
DC Gel (2)	$859.99	$33.03	$463.02	$1.48 ($1.78) ($2.97)

DC Flooded 12 Volt 350AH / 500 cycle life (>80% DOD) battery / $260.57 in 71 services over 3 years at 5 minutes (2 batteries) each at $.367 per minute / $241.40 (2 batteries) in materials.

DC Advanced AGM 12 Volt 350AH / 600 (400) (300) cycle life (>80% DOD) battery / $33.03 in 18 services over 3 years at 5 minutes each at $.367 per minute / No materials

DC Gel 12 Volt 350AH / 600 (500) (300) cycle life (>80% DOD) battery / $33.03 in 18 services over 3 years at 5 minutes each at $.367 per minute / No materials

Type (L16 x 2)	Fleet/Jobber Price	Total Service and Material Costs	Total Costs	Average per Cycles Cost
DC Flooded (2)	$311.99	$501.97	$813.96	$1.63
DC Advanced AGM (2)	$431.99	$33.03	$465.02	$.77 ($1.16) ($1.55)
DC Gel (2)	$515.99	$33.03	$549.02	$.91 ($1.09) ($1.83)

Single Scrubber, HD Deep Cycle and Marine Trolling battery

Type (DC31)	List Price	Total Service and Material Costs	Total Costs	Average per Cycles Cost
DC Flooded	$129.99	$204.06	$334.05	$1.11
DC Advanced AGM	$209.99	$33.03	$243.02	$.48 ($.81) ($1.35)
DC Gel	$219.99	$33.03	$253.02	$.50 ($.72) ($1.40)

DC Flooded 12 Volt 130AH / 300 cycle life (>80% DOD) battery / $139.46 in 38 services over 3 years at 10 minutes each at $.367 per minute / $64.60 in materials.

DC Advanced AGM 12 Volt 110AH / 500 (300) (180) cycle life (>80% DOD) battery / $33.03 in 18 services over 3 years at 5 minutes each at $.367 per minute / No materials

DC Gel 12 Volt 97AH / 500 (350) (180) cycle life (>80% DOD) battery / $33.03 in 18 services over 3 years at 5 minutes each at $.367 per minute / No materials

Type (DC31)	Fleet/Jobber Price	Total Service and Material Costs	Total Costs	Average per Cycles Cost
DC Flooded	$77.99	$204.06	$282.05	$.94
DC Advanced AGM	$125.99	$33.03	$159.02	$.31 ($.53) ($1.06)
DC Gel	$131.99	$33.03	$165.02	$.33 ($.47) ($.1.09)

Single Scrubber, HD Deep Cycle and Marine Trolling battery

Type (DC27)	List Price	Total Service and Material Costs	Total Costs	Average per Cycles Cost
DC Flooded	$119.99	$204.06	$344.45	$1.38
DC Advanced AGM	$179.99	$33.03	$213.02	$.42 ($.71) ($1.42)
DC Gel	$199.99	$33.03	$233.02	$.46 ($.66) ($1.55)

DC Flooded 12 Volt 115AH / 250 cycle life (>80% DOD) battery / $139.46 in 38 services over 3 years at 10 minutes each at $.367 per minute / $64.60 in materials.

DC Advanced AGM 12 Volt 96AH / 500 (300) (150) cycle life (>80% DOD) battery / $33.03 in 18 services over 3 years at 5 minutes each at $.367 per minute / No materials

DC Gel 12 Volt 87AH / 500 (350) (150) cycle life (>80% DOD) battery / $33.03 in 18 services over 3 years at 5 minutes each at $.367 per minute / No materials

Type (DC27)	Fleet/Jobber Price	Total Service and Material Costs	Total Costs	Average per Cycles Cost
DC Flooded	$71.99	$204.06	$276.05	$1.10
DC Advanced AGM	$107.99	$33.03	$141.02	$.28 ($.47) (.94)
DC Gel	$119.99	$33.03	$153.02	$.30 ($.43) ($.1.02)

Dual 12 volt HD Deep Cycle house and Marine Trolling batteries

Type (DC24 x 2)	List Price	Total Service and Material Costs	Total Costs	Average per Cycles Cost
DC Flooded (2)	$219.99	$324.44	$544.43	$1.97
DC Advanced AGM (2)	$319.99	$33.03	$353.02	$.70 ($1.17) ($2.13)
DC Gel (2)	$359.99	$33.03	$393.02	$.78 ($1.12) ($2.38)

DC Flooded 12 Volt 200AH / 275 cycle life (>80% DOD) battery / $195.24 in 38 services over 3 years at 7 minutes each (2 batteries) at $.367 per minute / $129.20 in (2 batteries) materials.

DC Advanced AGM 12 Volt 160AH / 500 (300) (165) cycle life (>80% DOD) battery / $33.03 in 18 services over 3 years at 5 minutes each at $.367 per minute / No materials

DC Gel 12 Volt 87AH / 500 (350) (165) cycle life (>80% DOD) battery / $33.03 in 18 services over 3 years at 5 minutes each at $.367 per minute / No materials

Type (DC24 x 2)	Fleet/Jobber Price	Total Service and Material Costs	Total Costs	Average per Cycles Cost
DC Flooded (2)	$131.99	$324.44	$456.43	$1.66
DC Advanced AGM (2)	$191.99	$33.03	$225.02	$.45 ($.75) ($1.36)
DC Gel (2)	$215.99	$33.03	$249.02	$.49 ($.71) ($.1.51)

Single Golf Cart or Electric Vehicle battery

Type (GC)	List Price	Total Service and Material Costs	Total Costs	Average per Cycles Cost
DC Flooded	$99.99	$402.75	$502.74	$.100 ($.84)
DC Advanced AGM	$189.99	$33.03	$223.02	$.44 ($.59) ($.67)
DC Gel	$199.99	$33.03	$233.02	$.46 ($.54) ($.70)

DC Flooded 6 Volt 210AH / 500 (600) cycle life (>80% DOD) battery / $275.25 in 75 services over 3 years at 10 minutes each at $.367 per minute / $127.50 in materials.

DC Advanced AGM 6 Volt 210AH / 500 (375) (330) cycle life (>80% DOD) battery / $33.03 in 18 services over 3 years at 5 minutes each at $.367 per minute / No materials

DC Gel 6 Volt 200AH / 500 (425) (330) cycle life (>80% DOD) battery / $33.03 in 18 services over 3 years at 5 minutes each at $.367 per minute / No materials

Type (GC)	Fleet/Jobber Price	Total Service and Material Costs	Total Costs	Average per Cycles Cost
DC Flooded	$59.99	$402.75	$462.74	$.93 ($.77)
DC Advanced AGM	$113.99	$33.03	$147.02	$.29 ($.39) ($.45)
DC Gel	$119.99	$33.03	$153.02	$.30 ($.36) ($.46)

36 volt Golf Cart and Electric Vehicle battery bank

Type (GC x 6)	List Price	Total Service and Material Costs	Total Costs	Average per Cycles Cost
DC Flooded (6)	$599.99	$1654.38	$2254.37	$4.50
DC Advanced AGM (6)	$1139.99	$198.18	$1338.18	$2.67 ($3.57) ($4.05)
DC Gel (6)	$1199.99	$198.18	$1398.18	$2.79 ($3.28) ($4.23)

DC Flooded 36 Volt 210AH / 500 cycle life (>80% DOD) battery / $858.78 in 78 services over 3 years at 30 minutes (6 batteries) at $.367 per minute / $795.60 in (6 batteries) materials.

DC Advanced AGM 36 Volt 210AH / 500 (375) (330) cycle life (>80% DOD) battery / $198.18 in 18 services over 3 years at 30 minutes (6 batteries) at $.367 per minute / No materials

DC Gel 36 Volt 200AH / 500 (425) (330) cycle life (>80% DOD) battery / $198.18 in 18 services over 3 years at 30 minutes (6 batteries) at $.367 per minute / No materials

Type (GC x 6)	Fleet/Jobber Price	Total Service and Material Costs	Total Costs	Average per Cycles Cost
DC Flooded (6)	$359.99	$1654.38	$2014.37	$4.02
DC Advanced AGM (6)	$683.99	$198.18	$882.18	$1.76 ($2.35) ($2.67)
DC Gel (6)	$719.99	$198.18	$918.18	$1.83 ($2.16) ($2.78)

48 volt Golf cart and Electric Vehicle battery bank

Type (GC8 x 6)	List Price	Total Service and Material Costs	Total Life Costs	Cycle Cost
DC Flooded (6)	$719.99	$1654.38	$2374.37	$4.74
DC Advanced AGM (6)	$1259.99	$198.18	$1458.17	$2.91 ($3.88) ($4.42)
DC Gel (6)	$1319.99	$198.18	$1518.17	$3.03 ($3.57) ($4.60)

DC Flooded 48 Volt 170AH / 500 cycle life (>80% DOD) battery / $858.78 in 78 services over 3 years at 30 minutes (6 batteries) at $.367 per minute / $795.60 in (6 batteries) materials.

DC Advanced AGM 48 Volt 170AH / 500 (375) (330) cycle life (>80% DOD) battery / $198.18 in 18 services over 3 years at 30 minutes (6 batteries) at $.367 per minute / No materials

DC Gel 48 Volt 170AH / 500 (425) (330) cycle life (>80% DOD) battery / $198.18 in 18 services over 3 years at 30 minutes (6 batteries) at $.367 per minute / No materials

Type (GC8 x 6)	Fleet/Jobber Price	Total Service and Material Costs	Total Costs	Average per Cycles Cost
DC Flooded (6)	$431.99	$1654.38	$2086.37	$4.17
DC Advanced AGM (6)	$683.99	$198.18	$882.18	$1.76 ($2.71) ($3.52)
DC Gel (6)	$719.99	$198.18	$918.18	$1.83 ($2.16) ($3.67)

Multiple 12 volt Marine and Photo Voltaic house bank

Type (8D x 5)	List Price	Total Service and Material Costs	Total Costs	Average per Cycles Cost
DC Flooded (5)	$1399.99	$1951.17	$3351.16	$3.35
DC Advanced AGM (5)	$2249.99	$165.15	$2415.14	$2.41 ($3.22) ($4.02)
DC Gel (5)	$2499.99	$165.15	$2665.14	$2.66 ($3.13) ($4.44)

DC Flooded 12 Volt 1080AH / 1000 cycle life (>80% DOD) battery / $1288.17 in 78 services over 3 years at 45 minutes (5 batteries) at $.367 per minute / $663.00 in (5 batteries) materials.

DC Advanced AGM 12 Volt 1275AH / 1000 (750) (600) cycle life (>80% DOD) battery / $165.15 in 18 services (x 5 batteries) over 3 years at 5 minutes each at $.367 per minute / No materials

DC Gel 12 Volt 1175AH / 1000 (850) (600) cycle life (>80% DOD) battery / $165.15 in 18 services (x 5 batteries) over 3 years at 5 minutes each at $.367 per minute / No materials

Type (8D x 5)	Fleet/Jobber Price	Total Service and Material Costs	Total Costs	Average per Cycles Cost
DC Flooded (5)	$839.99	$1951.17	$2791.16	$2.79
DC Advanced AGM (5)	$1349.99	$165.15	$1515.14	$1.51 ($2.02) ($3.03)
DC Gel (5)	$1499.99	$165.15	$1665.14	$1.66 ($1.95) ($3.33)

24 volt Scrubber and HD Deep Cycle battery

Type (1850 x 2)	List Price	3 Year Service and Material Costs	3 Year Total Costs	3 Year per Cycles Cost
DC Flooded (2)	$479.99	$665.96	$1145.95	$2.29
DC Advanced AGM (2)	$919.99	$33.03	$953.02	$1.90 ($2.54) ($2.88)
DC Gel (2)	$999.99	$33.03	$1033.02	$2.06 ($2.29) ($3.13)

DC Flooded 24 Volt 200AH / 500 cycle life (>80% DOD)battery / $400.76 in 78 services over 3 years at 7 minutes each battery at $.367 per minute / $265.20 in materials.

DC Advanced AGM 24 Volt 225AH / 500 (375) (330) cycle life (>80% DOD) battery / $33.03 in 18 services over 3 years at 5 minutes each at $.367 per minute / No materials

DC Gel 24 Volt 200AH / 500 (450) (330) cycle life (>80% DOD) battery / $33.03 in 18 services over 3 years at 5 minutes each at $.367 per minute / No materials

Type (1850 x 2)	Fleet/Jobber Price	3 Year Service and Material Costs	3 Year Total Costs	3 Year per Cycles Cost
DC Flooded (2)	$287.99	$665.96	$953.95	$1.90
DC Advanced AGM (2)	$551.99	$33.03	$585.02	$1.17 ($1.56) ($1.77)
DC Gel (2)	$599.99	$33.03	$633.02	$1.26 ($1.40) ($1.91)

CAUTION! Don't forget the improved safety and protection of your self, your workers and your equipment when using Discover™ GEL or Advanced AGM products versus standard flooded type batteries!

CAUTION / DANGER:

Lead-acid batteries contain a sulfuric acid electrolyte, which can be poisonous and is highly corrosive. Flooded Lead Acid batteries will produce gasses when discharging and re-charging which can explode! When working with batteries, you need to have plenty of ventilation, remove your jewelry, wear protective eyewear (safety glasses) and clothing, and exercise caution. ***Do not allow battery electrolyte to mix with salt water. Even small quantities of this combination will produce Chlorine gas that can KILL you!***

Section XVI

Servicing Batteries

Inspection
There are many tools that may help in properly caring for and maintaining batteries. Below is a list of basic items that are recommends for this task:
Recommended Equipment:

- Insulated tools sized to match nuts, bolts and cables in use
- Distilled water for flooded batteries (if not available good clean tap water is better than nothing)
- Voltmeter
- Hydrometer for flooded batteries
- Post cleaner and wire brush
- Baking Soda
- Petroleum Jelly
- Goggles, Gloves (wear polyester clothing)
- Fire extinguisher

CAUTION: Always wear protective clothing, gloves, and goggles when handling batteries, electrolyte, and charging your battery.

Batteries should be carefully inspected on a regular basis in order to detect and correct potential problems before they can do harm. It is a great idea to start this routine when the batteries are first received.

Examine the outside appearance of the battery

- Look for cracks in the container
- Check the battery, posts and connections to make sure they are clean, free of dirt, fluids and corrosion
- Any fluids on or around the battery may be an indication that electrolyte is spilling, leaching or leaking out. Pay close attention to this if it is a flooded battery you are checking as a low electrolyte situation in the battery may cause excessive gassing and ultimately dispense fluid on or around the battery
- All battery cables and their connections should be tight, intact, and NOT broken or frayed
- Replace any damaged batteries
- Replace any damaged cables
- Re-torque all connector bolts. See manufacturer's recommendations for torque values.

Proper Initial and annual Maintenance Torque Values for Connection Hardware are:

Flooded:

Automotive SAE:	50 to 80 in.-lbs. (5.6~10NM)
Automotive Side terminals:	70 to 90 in.-lbs. (7.9~10.2NM)
Wing nut terminals:	90 to 105 in.-lbs. (10.2~12NM)
T stud type terminals:	120 to 180 in.lbs. (13~20NM)
L, LT, UT terminals:	95 to 120 in.-lbs. (11~14NM)

VRLA:

X terminals (U1) terminals:	40 in.-lbs. (4.5 NM)
Light Duty L terminals:	40 to 50 in.-lbs. (4.5~5.6NM)
Standard Duty L terminals:	60 to 80 in.-lbs. (6.5~10NM)
Heavy Duty L terminals:	90 to 110 in.-lbs. (10.2~12.5NM)
Button type terminals:	Can vary greatly. 25 to 110 in.-lbs.(2.8~12.4NM)

WARNING: Do not over tighten terminals. Doing so can result in post breakage, post meltdown, and fire.

Always follow the manufacturer's instructions.

Testing

Visual inspection alone is not sufficient to determine the overall health of the battery. Both open-circuit voltage and specific gravity readings (for flooded batteries) can give a good indication of the battery's charge level, age, and health. Routine voltage and gravity checks will not only show the state of charge but also help spot signs of improper care, such as undercharging, overcharging and over-watering in the case of flooded batteries, and possibly even locate a bad or weak battery. The following steps outline how to properly perform routine voltage and specific gravity testing on batteries.

Specific Gravity Test

DO NOT ADD WATER BEFOR TESTING (Flooded batteries only)

1. Fill and drain the hydrometer 2 to 4 times before pulling out a sample.
2. There should be enough sample electrolyte in the hydrometer to completely support the float.
3. Take a reading, record it, and return the electrolyte back to the cell.
4. To check another cell, repeat the 3 steps above.
5. Check all cells in the battery.
6. Replace the vent caps and wipe off any electrolyte that might have been spilled.
7. Correct the readings to 80° F:

Add .004 to readings for every 10° above 80° F, (6° above 26° C)
Subtract .004 for every 10° below 80° F, (6° below 26° C)

8. Compare the readings.
9. Check the state of charge using "Open Circuit Voltage" table below.

The readings should be at or above the factory specification or 1.280 ± .005. If any specific gravity readings register low, then follow the steps below.

1. Check and record voltage level(s).
2. Put battery(s) on a complete charge.
3. Take specific gravity readings again.

If any specific gravity readings still register low then follow the steps below.

1. Check voltage level(s).
2. Perform equalization charge. Refer to the Equalizing section for the proper procedure.
3. Take specific gravity readings again.

If any specific gravity reading still registers lower than the factory specification or 1.280 ± .005 then one or more of the following conditions may exist:

1. The battery is old and approaching the end of its life.
2. The battery was left in a state of discharge too long.
3. Electrolyte was lost due to spillage or overflow.
4. A weak or bad cell is developing.
5. Battery was watered excessively previous to testing

Batteries in conditions 1 - 4 should be taken to a specialist for further evaluation or retired from service.

Open-Circuit Voltage Test

For accurate voltage readings, batteries must remain idle (no charging, no discharging) for at least 8 hrs, preferably 24 hrs.

1. Disconnect all loads from the batteries.
2. Measure the voltage using a DC voltmeter.
3. Check the state of charge with the Table below
4. Charge the battery if it registers 0% to 75 % charged

After charge, if the battery registers below the Temperature Compensated values illustrated in **"How can you tell if a battery is fully charged"** or **"How can I measure my batteries State of Charge"**, the following conditions may exist:

1. The battery was left in a state of discharge too long.
2. The battery has a bad cell.

Batteries in these conditions should be taken to a specialist for further evaluation or retired from service.

How can you tell if a battery is fully charged?

The only true way to tell if a VRLA battery is fully charged is by using a good voltmeter to determine the open circuit voltage (OCV). Accessible flooded type batteries can also use a hydrometer.

Charge %	Digital Voltmeter Open Circuit Voltage (OCV)		
	Flooded	Gel	AGM
100%	12.80-12.60	12.95-12.85	12.90-12.80
75%	12.40	12.65	12.60
50%	12.20	12.35	12.30
25%	12.00	12.00	12.00
0%	11.80	11.80	11.80

Divide the above values in half for 6 volt batteries or by six to determine cell voltage. The TRUE OCV of a battery can ONLY be measured after the battery has been removed from the charge or discharge load for 24 hours.

Watering (Flooded batteries only)

Flooded batteries need water. More importantly, watering must be done at the right time and in the right amount or else the battery's performance and longevity suffers.
Water should always be added after fully charging the battery. Prior to charging, there should be enough water to cover the plates. If the battery has been discharged (partially or fully), the water level should also be above the plates. Keeping the water at the correct level after a full charge will prevent having to worry about the water level at a different state of charge.
Depending on the local climate, charging methods, application, etc. it is recommended that batteries be checked a minimum of once a month and/or once every 7 discharge –charge cycles until you get a feel for how thirsty your batteries are.

Important things to remember:

1. Do not let the plates get exposed to air. This will damage (corrode) the plates.
2. Do not fill the water level in the filling well to the cap. This most likely will cause the battery to overflow acid, consequently losing capacity and causing a corrosive mess.
3. Do not use water with a high mineral content. Use distilled or de-ionized water only.

CAUTION: The electrolyte is a solution of acid and water so skin contact should be avoided.

Step by step watering procedure: (Flooded batteries only)

1. Open the vent caps and look inside the fill wells.
2. Check electrolyte level; the minimum level is at the top of the plates.
3. If necessary add just enough water to cover the plates at this time.
4. Put batteries on a complete charge before adding any additional water (refer to the Charging section)
5. Once charging is completed, open the vent caps and look inside the fill wells.
6. Add water until the electrolyte level is 1/8" below the bottom of the fill well.
7. A piece of rubber can be used safely as a dipstick to help determine this level.

8. Clean, replace, and tighten all vent caps.

WARNING: Never add acid to a battery.

Cleaning

Batteries seem to attract dust, dirt, and grime. Keeping them clean will help you spot trouble signs if they appear and avoid associated problems...

1. Check that all vent caps are tightly in place (flooded batteries)
2. Clean the battery top with a cloth or brush and a solution of baking soda and water.
3. When cleaning, do not allow any cleaning solution, or other foreign matter to get inside the battery. (flooded batteries)
4. Rinse with water and dry with a clean cloth.
5. Clean battery terminals and the inside of cable clamps using a post and clamp cleaner.
6. Clean terminals will have a bright metallic shine.
7. Reconnect the clamps to the terminals and thinly coat them with petroleum jelly (Vaseline) to prevent corrosion.
8. Keep the area around batteries clean and dry.

Storage

Periods of inactivity can be extremely harmful to lead acid batteries. When placing a battery into storage, follow the manufacturer's recommendations and/or the recommendations below to insure that the battery remains healthy and ready for use.
The most important things to avoid:

1. Freezing. Avoid locations where freezing temperature is expected. Keeping battery at a high state of charge will also prevent freezing. Freezing results in irreparable damage to battery's plates and container. **NOTE** that if a battery is kept completely charged the chances of it freezing are very small.
2. Heat. Avoid direct exposure to heat sources, such as radiators or space heaters. Temperatures above 80.F / 26.C accelerate the battery's self-discharge characteristics. **NOTE** that heat causes more damage to a battery than cold ever will, so keep your battery storage area as cool as possible without going to extremes.
3. **NOTE** that storing your battery on concrete will not damage your battery!

Step by step storage procedure

1. Completely charge the battery before storing.
2. Store the battery in a cool, dry location, protected from the elements.
3. During storage, monitor the specific gravity (flooded) or voltage. Batteries in storage should be given a boost charge when they show a charge of less than 75%. See "Open Circuit Voltage" table above.
4. Completely charge the battery before re-activating.
5. For optimum performance, equalize the batteries (flooded) before putting them back into service. Refer to the Equalizing section for this procedure. **WARNING – DO NOT EQUALIZE CHARGE GEL OR AGM BATTERIES!**

Selecting a Charger

Most deep cycle applications have some sort of charging system already installed for battery charging (e.g. solar panels, inverter, golf car charger, alternator, etc.). However, there are still systems with deep cycle batteries where an individual charger must be selected. Also when changing between Flooded, AGM and Gel type batteries the existing charger may need to be changed and/or the voltage cutoffs reset. Most high quality scrubbers and sweepers have selector switches built into there systems that allow the user to change between Flooded and Gel type batteries.

What follows will help in making a proper selection.

There are many types of chargers available today. They are usually rated by their voltage and there start rates or the rate in amperes that the charger will supply at the beginning of the charge cycle. When selecting a charger, the charge rate should be between 10% and 30% of the battery's 20-hour AH capacity. For example, a battery with a 20-hour capacity rating of 100 AH should use a charger rated between approximately 10 and 30 amps (for multiple battery charging use the AH rating of the entire bank to determine the charger rating required). Chargers with lower ratings can be used but the charging time will be increased.

We recommend using our NEXEN Discover™ line of chargers which can be matched specifically with your battery. NEXEN Discover™ chargers prolong battery life with their charging profile. Alternatively we recommend using a 3-stage voltage compensating and temperature sensing charger. These chargers usually have three distinct charging stages: bulk, acceptance, and float. Some chargers that claim to have an equalize mode or stage should not be used on AGM or GEL batteries. NEXEN chargers have "Balance Charge" modes included in there "single cycle" charge algorithms. Balance Charging is similar to an equalize charge but is performed at a lower voltage.

Charging

Charging batteries properly requires administering the right amount of current at the right voltage. The original instructions for your charging equipment should be referenced for proper charging. Here is list of helpful items to remember when charging.

1. Become familiar with and follow the instructions issued by the charger manufacturer.
2. Batteries should be charged after each period of use.
3. Lead acid batteries do not develop a memory and need not be fully discharged before recharging.
4. Charge flooded batteries only in well-ventilated areas. Keep sparks or flames away from a charging battery.
5. Verify charger voltage settings are correct for the type of battery you are charging (Flooded, AGM or Gel)
6. Correct the charging voltage to compensate for temperatures above and below 25°C/77°F.

Compensation for battery temperature above or below 25°C/77°F can be made by subtracting 0.005 volts per cell for each 1°C above 25°C or by adding 0.005 volts per cell for each 1°C below 25°C. Add .028 volt per cell for every 10° below 77° F and subtract .028 volt per cell for every 10° above 77° F.

7. Check water level on flooded batteries (see the Watering section).
8. Tighten all vent caps on flooded batteries before charging.
9. Prevent overcharging the batteries. Overcharging causes excessive gassing (water breakdown), heat buildup, and battery aging in flooded batteries and will dry out the electrolyte and damage VRLA batteries.
10. Prevent undercharging the batteries. Undercharging causes stratification.
11. Do not charge a frozen battery; allow it to thaw at room temperature.
12. Avoid charging at temperatures above 50°C/125°F.

IMPORTANT: Always use an automatic temperature-sensing, voltage-regulated charger! Set charger at 14.2 to 14.5 volts at 25°C/ 77°F for gel, or 14.4 to 14.7 volts at 25°C/ 77°F for AGM and/or Flooded. Do not exceed 14.5 volts for gel or 14.7 volts for AGM.

Equalizing (Flooded batteries only)

Many experts recommend that batteries be equalized periodically, ranging anywhere from once a month to once or twice per year. However, we only recommend equalizing when low or wide ranging specific gravity (± .015) is detected after fully charging a battery.

Equalizing is an "over voltage - overcharge" performed on flooded lead acid batteries after they have been fully charged. It helps to eliminate stratification – the uneven distribution of acid - and sulfation – the build up of sulfate crystals on the plates. These are two of many conditions that can reduce the overall performance and life of a flooded battery. An Equalize charge – or equalizing – should only be used on flooded batteries when specific gravity readings vary from cell to cell at +/-.015 on a fully charged battery.

Equalize charging should not be performed on AGM or Gel batteries. "Balance Charge" modes are included in all our NEXEN Industrial Commercial charges. Balance Charging is similar to an equalize charge cycle but is performed at a lower voltage.

Step by Step Equalizing

- Verify the battery(s) are flooded type.
- Remove all loads from the batteries.
- Connect battery charger.

- Set charger to equalizing mode.
- Start charging batteries.
- Batteries will begin gassing and bubbling vigorously.
- Take specific gravity readings every hour.
- Equalization is complete when specific gravity values no longer rise during the gassing stage.

NOTE: Many chargers do not have an equalization setting so this procedure can't be carried out.

Discharging

Discharging batteries is a function of your application. Below is list of helpful items;

- Shallow Depth of Discharges (DOD) will result in a longer battery life. <50% DOD is recommended.
- 75-80% DOD is the maximum safe discharge for flooded and AGM batteries.
- Do not discharge flooded batteries >80%. This will damage (or kill) the battery. Recommend operating DOD for flooded batteries is 50% to 75% of capacity.
- A periodic equalization charge for flooded batteries is a must.
- Do not leave batteries deeply discharged for any length of time.
- Lead acid batteries do not develop a memory and need not be fully discharged before recharging.
- Batteries should be charged after each period of use.
- Batteries that charge up but cannot support a load are most likely bad and should be tested.

Charging Information Recap for AGM and Gel batteries

1.
Only charge gel cells using a confirmed and reliable, temperature sensing, voltage regulated charger. Never use a constant current charger!

2.
Charging Current or Amps is the flow of electricity. Every battery can only store, deliver or receive a certain amount of electricity. Voltage is electrical pressure. The amount of voltage dictates the rate at which the amps will be forced into the battery during the re-charge process. The temperature at which this process is taking place also effects charging. When the right pressure is used – at the right temperature – the battery will be charged at its optimal rate. If to much pressure is used, current or charge will be forced through the battery faster than it can be stored. This will cause the battery to give off hydrogen and oxygen faster than it can be recombined leading to the destruction of the battery. A warmer battery accepts re-charge easier.

3.
At 25°C/77°F keep charging current in the range of 2.38 volts to 2.42 volts per cell for Gel cell batteries.

4.
At 25°C/77°F keep charging voltage in the range of 2.4 volts to 2.45 volts per cell for AGM batteries.

5.
Compensation for battery temperature above or below 25°C/77°F can be made by subtracting 0.005 volts per cell for each 1°C above 25°C or by adding 0.005 volts per cell for each 1°C below 25°C. Add .028 volt per cell for every 10o below 77o F and subtract .028 volt per cell for every 10o above 77o F.

6.
When re-charging - consider that to replenish the ampere hours removed in the discharge process - you will need to replace 110% to 120% of the charge removed. Also, the time it will take to re-charge will depend on certain variables such as the depth of the discharge, the ambient and battery temperature, the age/condition of the battery and the chargers overall features. Typically you should expect that it will take 60% of the charge time to return the battery to within 90% of its original capacity. It will take the remaining 40% of the charge time to completely recharge the battery.

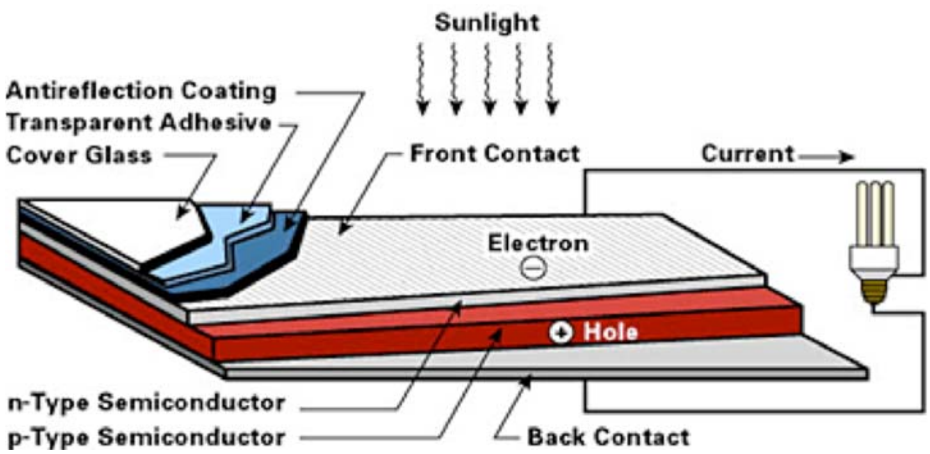
7.
As an alternative to continuous constant voltage charging - to speed the charge process - it is acceptable to charge both Gel and Absorbed Electrolyte Cells by first bulk charging them at up to 30amps per 100AH of 20hr capacity (.3CA) to an end voltage of 2.45 volts per cell at 25°C. This bulk charge must be followed by a finishing stage where the terminal voltage is maintained between 2.38 to 2.42 volts per cell for Gel cells and 2.4 to 2.45 volts per cell for absorbed electrolyte cells – both at 25°C/77°F. This final stage will see the current fall off as the voltage rises. If the battery is to be maintained and the charger left in a float

mode, the current should be managed to maintain a float voltage of between 2.25 and 2.30 volts per cell at 25°C/77°F.

8.
The process of re-charging a battery should be considered completed when the charge rate drops below or equal to the batteries self-discharge rate. For example a 100AH battery with a 3% self discharge rate should be considered to be re-charged when the charge rate reaches and remains stable at 3 amps.

Frequently asked Solar industry Q&A's

How do solar panels (cells) generate electricity?

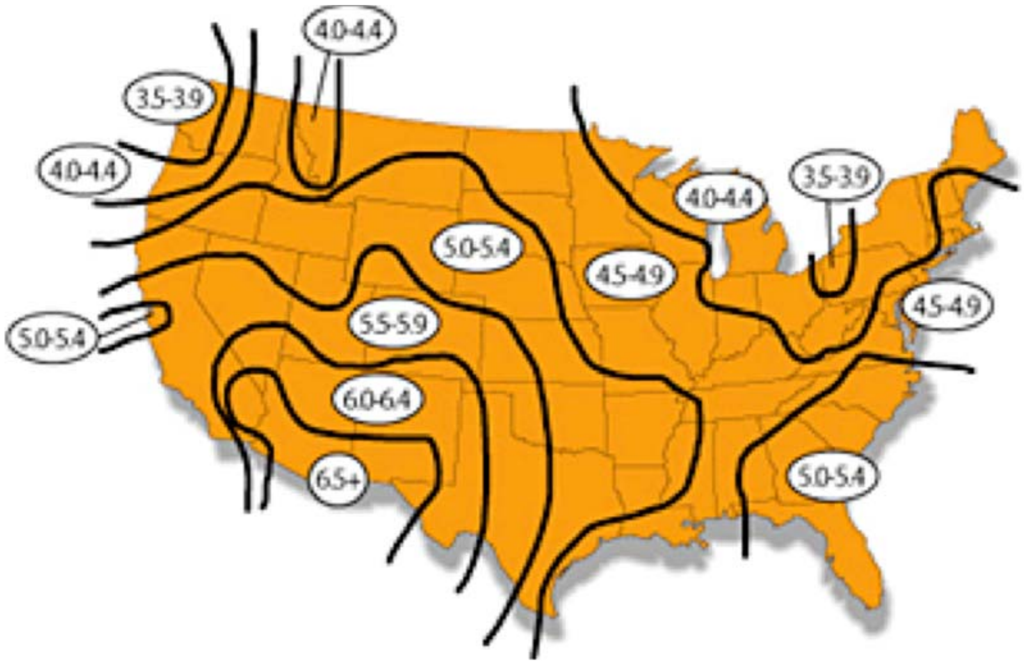


Kyocera

Photocells (photovoltaic or "PV") can be thought of as a direct current (DC) generator or charger powered by the sun. When light photons of sufficient energy strike a solar cell, they knock electrons free in the silicon crystal structure forcing them through an external circuit (battery or direct DC load), and then returning them to the other side of the solar cell to start the process all over again. The voltage output from a single crystalline solar cell is about ½ Volt with an amp output that is directly proportional to the cell's surface area (approximately 7 amps for a 6 inch square multi-crystalline solar cell). In typical solar module there will be 30 to 36 cells connected in series. This produces a solar module with a 12V nominal output (17V peak output) that can then be wired in series and/or parallel with other solar modules to form a complete solar array capable of charging a 12, 24 or 48 volt battery bank.

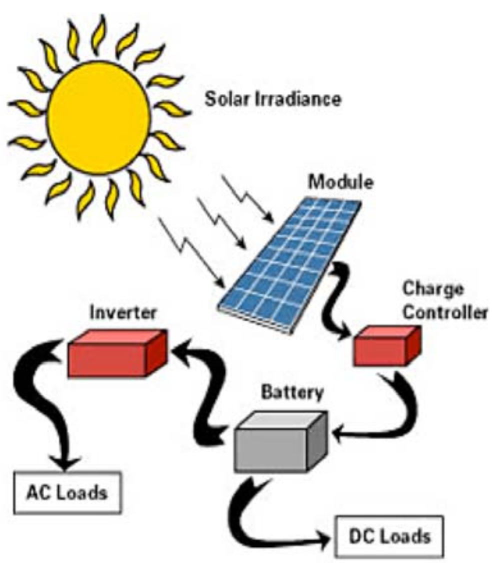
Will solar work in my location?

The suns solar activity is universal. Although some locations are better than others, solar will work anywhere. Irradiance is a measure of the sun's power available at the earth's surface. It is typically expressed in kilowatts per square meter. It averages about 1000 watts per square meter. With typical crystalline solar cell efficiency (14-16%), we can expect to generate about 140-160W per square meter off of solar cells placed in full sun. Irradiance multiplied by time equals Insolation. Insolation is a measure of the available energy from the sun and is expressed in terms of "full sun hours" (i.e. 4 full sun hours = 4 hours of sunlight at an irradiance level of 1000 watts per square meter). Obviously different parts of the world receive more sunlight than others which results in more "full sun hours" per day. The solar insolation zone map below gives you a general idea of the "full sun hours per day" for different zones. You have to extend the zones north and south for reference zones in Canada and Mexico.



Kyocera

For reference purposes above zones can be extended north and south into Canada and Mexico.



Kyocera

How much will a system cost for my 2000 square foot home?

Unfortunately there is no per square foot "average" since the cost of a system actually depends on your daily energy usage and how many full sun hours you receive per day; And if you have other sources of electricity. To accurately size a system to meet your needs, you need to know how much energy you use per day. If your home is connected to the utility grid, simply look at your monthly electric bill. You can design a system that will meet your needs using this information.

Can I use all of my normal 120/240 VAC appliances?

The simple answer is maybe but not likely. Older homes with older appliances and fixtures are less efficient. When you install a renewable energy system for your home, you become your own power company so every kilowatt hour (kwh) of energy you use means more equipment. More equipment means more cost. Appliances that operate at 240 Volts Alternating Current (VAC) are impractical loads to run on solar. Alternatives such as propane or natural gas should be considered for space and water heating and cooking. Also, along with designing a passive solar design into new construction, an evaporative cooling system should be considered instead of compressor based AC units. After electrical heating loads refrigeration and lighting is typically the largest user of 120 VAC energy. You should make sure that you get the most energy efficient units available when purchasing refrigeration and lighting. Conservation is the law in renewable energy. For every dollar you spend replacing your inefficient appliances, you will save three dollars in the cost of a renewable energy system to run them.

What components do I need for a grid-tie system?

Grid-tie systems are inherently simpler than either grid-tie with battery back-up or stand-alone solar systems. Other than safety disconnects, mounting structures and wiring a grid-tie system is just solar modules and a grid-tie inverter! Today's sophisticated grid-tie inverters incorporate most of the components needed to convert direct current (DC) from the modules to alternating current (AC), track the maximum power point of the modules to operate the system at peak efficiencies and terminate the grid connection if grid power is interrupted form the utility.

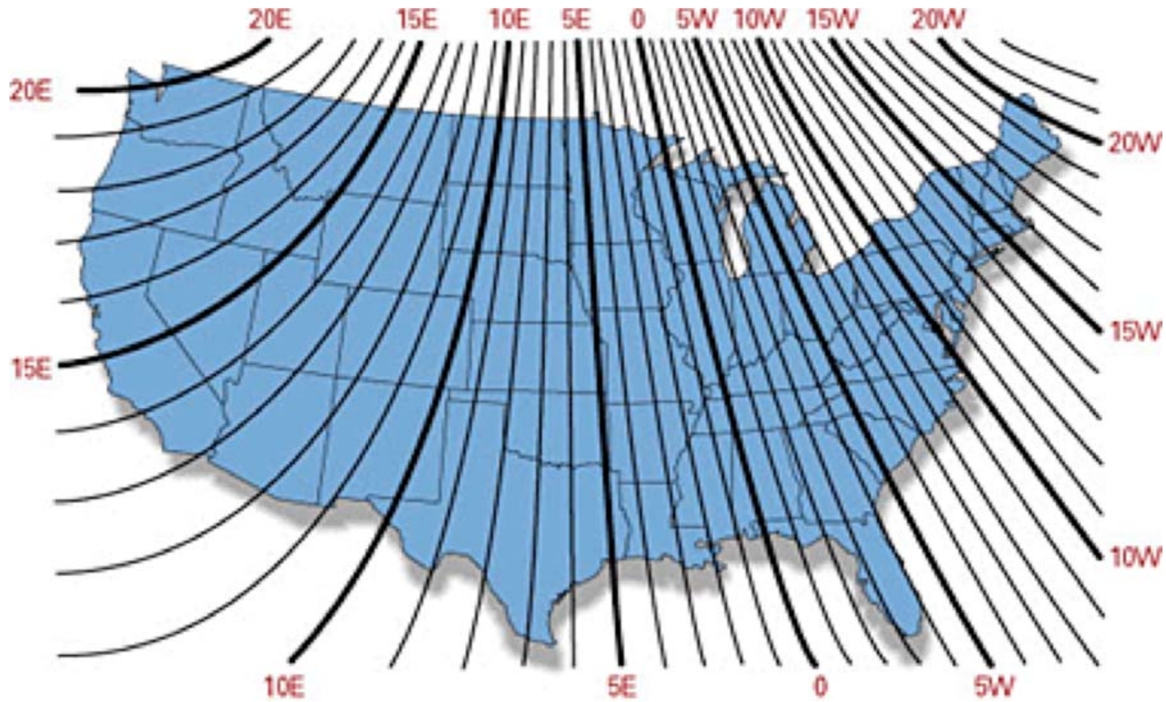
What components do I need for a complete solar system?

There are many components that make up a complete solar system, but the 4 main items are: solar modules, charge controller(s), Discover™ batteries, and inverter(s). The solar modules are physically mounted on a mount structure and the DC power they produce is run through a charge controller before it goes on to the battery bank to be stored. The two main functions of a charge controller are to prevent the battery from being overcharged and eliminate any reverse current flow from the batteries back to the solar modules at night or in reduced light. The battery bank stores the energy produced by the solar array during the day for use at anytime of day or night. Discover™ batteries are available in many footprints with many storage capacities. The inverter takes the DC energy stored in the batteries and inverts it to 120 VAC to run the AC appliances.

What type of solar module mounting structure should I use?

There are four basic types of mount structures: roof/ground, top-of-pole, side-of-pole and tracking mounts, each having their own pros and cons. For example roof mount structures typically keep the wire run distances between the solar array and battery bank to a minimum, which is good. But they also require roof penetrations in multiple locations (a potential source of leakage) and they require expensive ground fault protection (GFP) (a requirement in article 690-5 of the National Electrical Code). Ground mounted solar arrays do not require GFP but they do require fairly precise foundation setup and are more susceptible to vandalism and excessive snow accumulation at the bottom of the array. Next are pole-top mounts which are relatively easy to install. After squarely securing a pole (steal or treated wood etc.) into the ground, the solar modules are mounted and racked on top of the pole. Pole-top mounts are a better choice for cold climates because snow slides off easily however they may be hard to clean. Pole-side mounts are easy to install, are typically used for small numbers of solar modules (1-4) for remote lighting systems where an pole exists to attach them to. Last but not least are the trackers, which increase the daily number of full sun hours and are used for solar water pumping applications. Trackers are extremely effective in the summer time when water is needed the most. In northern climates (or zones further away from the equator), typical home energy usage peaks in the winter when a tracker mount will make very little difference. A less expensive fixed roof, ground or pole-top mount with more modules will perform better in the winter than fewer modules on a tracker. However, in southern climates (or areas closer to the equator) your energy usage peaks in the summer and a tracker system may be the better solution.

Where should I mount the solar modules and what direction should I face them?



Kyocera

If your site is in the Northern Hemisphere you need to aim your solar modules to the true south direction (the reverse is true for locations in the Southern Hemisphere) to maximize your daily energy output. For many locations there is quite a difference between magnetic south and true south, so please consult the declination map above before you setup your mount structure. The solar modules should be tilted up from horizontal to get a better angle at the sun and help keep the modules clean by shedding rain or snow. For best year round power output with the least amount of maintenance, you should set the solar array facing true south (or north if in the southern hemisphere) at an angle to the horizon equal to the degrees of latitude of your position. If you plan to adjust your solar array tilt angle seasonally, a good rule of thumb to go by is latitude minus 15° in the summer, latitude in the spring/fall and latitude plus 15° in the winter. Most mount structures provide for a seasonal adjustment of the tilt angle from horizontal to 65°.

Should I set my system's battery bank up at 12, 24 or 48 VDC?

The PV industry really began with the 12V recreational vehicle market. These systems were typically small (1-2 solar modules) and had all 12 VDC loads. As the solar industry matured and entered the home market, systems became much larger (16+ solar modules) and no longer used DC loads exclusively. Most home systems today are 24 or 48 VDC since the higher system voltage gives you a lot more flexibility as to how far away you can place your solar modules from the battery bank as compared to a 12V system. For a given power output, a higher system voltage reduces your amperage flow (but not your power) which allows you to use a smaller and less expensive gauge wire for your solar to battery and battery to inverter wire runs. Of course, if you already have a lot of 12VDC loads this may be the deciding factor in what voltage you set your system up at. Most grid-tied systems operate at 48 volts or higher.

Should I wire my home for AC or DC loads?

It depends on the size of the system and what type of loads you want to run. DC appliances are usually more efficient than AC since you don't have to worry about the loss through the inverter, but DC loads are typically more expensive and harder to find than their AC counterparts. Small cabin and RV systems are typically wired DC while most home systems are wired for AC loads exclusively. With improvements in inverter efficiency AC is the way to go for home systems. Another advantage AC has over DC is that the voltage drop for a 120VAC circuit is much less than a 12VDC circuit carrying the same power, which allows you to use smaller gauge wire.

Can I use PV to heat water or for space heating?

No. Photovoltaic cells convert the sun's energy into DC electricity at a relatively low efficiency level. (14-18%), Therefore trying to operate a high power electric heating element on PV's would be very inefficient and expensive. Solar thermal (or passive solar) is the direct heating of air or water from the heat of the sun and is much more efficient for heating applications than photovoltaic. (A black barrel full of water kept in the sun).

Section XVIII

Glossary

A

Advanced Battery Management
A three-stage charging system designed to prolong the service life of UPS batteries. By charging the batteries only when necessary, battery life is significantly improved. Charging stage one: quickly recharges battery to approximately 90% of capacity. Charging stage two: fully charges the battery to 100%. Charging stage three: rest mode prevents overcharging. Charging stage one is initiated after a power outage or periodic UPS self-test.

AC
Alternating Current electrical power supplied by a utility company or from an AC generator.

AC Distribution
A module in the power system that distributes AC power to other power system modules.

AC Metering
Measurement of AC power input voltage and current parameters by sampling. The results of the measurements are used to calculate the rms (Route Mean Squared) equivalents for voltage, current and power, and also calculate the power factor and frequency.

AC Utility
The electric power furnished by an electric power utility company.

Active Load Share
A current sharing scheme controlled by the supervisory module that adjusts the output voltage of individual rectifiers so that all rectifiers in a DC power system produce the same output current.

Active Voltage Control
The supervisory module adjusts the rectifier output voltages to maintain a constant DC power system voltage (measured at the output or battery) independent of load fluctuations during normal operation.

Agent
A software program that acts as a focal point for data collection and configuration of a specific network entity (hardware or software). SNMP agents provide data to management stations regarding the operation and configuration of devices on a network.

Alternating Current (AC)
Current which changes (or alternates) direction at regular intervals. Since the current flows in one direction for the same amount of time that it flows in the opposite direction, the average value of the current flow is zero.

Ampere (Amp or A)
The unit of measure for current. One ampere is the amount of electricity per second that flows through a conductor such as a wire.

AVC
Active Voltage Control

B

Bandwidth
The data a cable can carry measured in bits per second (bps).

Battery Backup
A battery or a set of batteries in a UPS system. Its purpose is to provide an alternate source of power if the main source is interrupted.

Battery Capacity
The battery ampere-hour capacity at full charge, standard temperature, and at a specified (usually C10) discharge rate.

Battery Charger
A device or a system which provides the electrical power needed to keep the battery backup fully charged.

Battery Current Limit
System voltage control that limits the battery charge current to a preset value.

Bi-Directional Converter
A device which changes (or converts) alternating-current power to direct-current power and vice versa.

Blackout
A total loss of the AC utility (commercial power).

Boost
See buck and boost.

Brownout
A reduction in the voltage of the AC utility without complete loss of power.

Buck and Boost
A proprietary voltage regulation process used when an over-voltage or Under-voltage situation occurs in the UPS. Under-voltage is boosted to make the voltage greater, and over-voltage is bucked to reduce it. The result is less reliance on the UPS battery, extending overall battery life.

Bus Voltage
The actual voltage supplied to the load as measured at the bus bars.

Bypass
A circuit used to change the path of the electrical power so that it goes around (or bypasses) its normal path. In the UPS, the bypass circuit is used to route the power around the major electronics in the UPS so they can be serviced without power interruption.

C

C5
Symbol for ampere-hour capacity of a battery at the 5-hour discharge rate, to a specified end voltage.

C10
Symbol for ampere-hour capacity of a battery at the 10-hour discharge rate, to a specified end voltage.

C20
Symbol for ampere-hour capacity of a battery at the 20-hour discharge rate, to a specified end voltage.

CE
Conformite Europeene (European Conformity)

Circuit Breaker (CB)
A device for manually opening (breaking) or closing a circuit to interrupt or apply electric power to an electrical apparatus. A circuit breaker can also open a circuit automatically when it senses an overload.

Clean Power
Electrical power which has been conditioned and/or regulated to remove electrical noise from the output power.

Configuration file
The information or data loaded into and the supervisory module that controls the behavior of an power system to suit the particular requirements of a customer's site or installation.

Configurations Database
This is the total set of configurable parameters.

Conformite Europeene (European Conformity)
CE marking is used to signify that a product complies with all the applicable performance and safety standards adopted by the members of the European Union and is therefore certified for sale in European Union countries.

Converter
A device which changes electrical energy from one form to another, such as from alternating current to direct current.

Current
Amount of electricity that flows through a conductor, such as a wire.

Current Share
A process used to balance output currents between rectifiers. See Active Current Share.

D

DC
Direct Current

DC Distribution (DCD)
A module in the power solution that distributes DC power to the loads. It also provides protection for the load cables.

DC Distribution - Fused version (DCF)
A DC Distribution module that uses fuses for protection.

DC Distribution - Miniature Circuit Breaker (MCB) version (DCM)
A DC Distribution module that uses miniature circuit breakers for protection.

Delta Connection
A method of connecting a three-phase source or load in series for a closed circuit (3-wire, plus ground).

Digital Input
An input which recognizes an open-circuit and short-circuit.

Digital Output
A voltage free relay contact.

Direct Current (DC)
A type of current which never reverses its direction. Since the current flows in only one direction, the average value of the current cannot be zero unless the current has stopped flowing.

Double-Conversion
A UPS design in which the primary power path consists of a rectifier and inverter. Double-conversion isolates the output power from all input anomalies such as low voltage, surges and frequency variations by converting AC to DC to AC. See Online UPS.

Dry Contact
Isolated contacts through which the end user supplies an external circuit. Dry contact UPSs provide basic communication capabilities such as monitoring and shutdown.

E

Efficiency
The ratio of the output power from the UPS to the input power from the utility. This shows the percentage of the input power that is available as useful output power. For example, a UPS that is 95% efficient delivers 95% of the utility power it receives to the load. The remaining power takes the form of dissipated heat.

EMC
Electro Magnetic Compatibility.

Emergency Shutdown
Used to instantly or quickly shutdown all of the electrical power available to the UPS and the load. An emergency shutdown device is usually used during a crisis to prevent damage to the UPS and the load. Some computer-room installations require a Remote Emergency Power Off (REPO) capability as part of their security/safety system.

Equalize
This is the process of increasing the Float Voltage to the Equalize Voltage to recharge or equalize the batteries.

Event
An alarm activation or de-activation.

F

Fast Charge
Increasing the Operating Voltage after a battery discharge, following an AC failure, to give a rapid battery recharge. Typically at a constant current charge rate higher than .3C. (1/3 the batteries rated ampere-hour capacity)

Fault Tolerance
The ability of a system to continue operating in the event of a fault.

Filtering
A method of removing noise from the output of a UPS preventing “dirty power” from reaching connected equipment.

Float Voltage
The set output voltage of the DC power system (not including temperature compensation or other adjustments).

Frequency
The number of cycles (oscillation positive and negative) completed in one second. Defined as Hertz. In North America, utility power completes 60 cycles per second, (60 Hertz).

Full Load
The greatest load that a circuit is designed to carry under specific conditions; any additional load is considered an overload.

G

Graphic User Interface (GUI)
A computer system using graphics images on the screen rather than text to display applications information for the user.

Ground (GND)
A conductor connected between a circuit and the soil.

H

Hardware Default Voltage
The rectifier output fail-safe operating voltage used if the rectifier microprocessor fails.

Hardwired
Describes any equipment connected to its power source by hardware attached directly to terminal blocks or distribution panels.

Harmonic Distortion
The presence of harmonics that change the AC voltage waveform from a simple sinusoidal to complex waveform. Harmonic distortion can be generated by a load and fed back to the AC utility line, causing power problems to other equipment on the same circuit.

Heterogeneous Network
A network with a multitude of workstations, and operating systems, and a variety of application types from different vendors.

High Rupturing Capacity (HRC) (fuse)
A precisely rated fuse which will operate under high fault current conditions, without self-destructing.

Homogeneous Network
A network of components - workstation, server, operating system from the same vendor, or compatible equipment that can run under the same network or operating system.

Hot-Swappable Batteries
A feature which enables the user to change UPS batteries without powering down the connected load.

Hot-Swappable Power Modules
A feature which enables the user to change UPS power modules without powering down the connected load.

I

I/O
Input/Output

Input Line Cord
The covered bundle of wiring connected to the input terminals of the UPS. The end of the cord not connected to the UPS is connected, via an input plug, to an AC utility outlet supplying power to the UPS.

Input Plug
Connected to the end of the input line cord. To be plugged into an AC utility outlet receptacle.

Internal Bypass
UPS circuitry which provides a redundant power path is referred to as an Internal Bypass. If there is an internal UPS fault, the connected load will still be supplied with unconditioned utility power.

Inverter
An Inverter is a machine, device, or system that changes direct current (DC) power into alternating current (AC) power.

Isolation
The separation - often through the use of an isolation transformer - of one section of a system in order to avoid undesired electrical influences that may occur in another section.

Isolation Transformer
An Isolation Transformer uses isolated windings that physically separate the primary and secondary windings. Although the two windings are physically disconnected, the magnetic field in the windings of the primary creates (induces) electrical power in the secondary winding. In this way the electrical power available at the input can be transferred to the output. An isolation transformer does not transfer unwanted noise and transients from the input circuit to the output windings. This attenuation, or reduction in amplitude, could be as high as one million to one.

L

LCD
Liquid Crystal Display

LEDs
Light Emitting Diodes that inform users of various power conditions and operations.

Line-interactive
A UPS containing an off-line inverter that must transfer on during a blackout, but provides faster transfer times than an off-line UPS and Power conditioning and surge suppression functions which protect the connected load.

Load
Equipment that receives power from a UPS.

Load Bus
The bus to which the Load equipment is connected.

Load Segments
Groups of receptacles on the rear panel of a UPS which can be independently controlled.

Load Shedding
The ability to selectively shut off a set of UPS output receptacles, extending the capacity of the UPS battery. Some UPS models are able to shed less critical loads by turning off selected output receptacles during an extended power failure while maintaining power to the more critical load(s) on the remaining output receptacles.

Low Voltage Disconnect (LVD)
A module in the power system that disconnects the load from the batteries from the when the battery voltage falls below a preset value. The LVD reconnects the load to the batteries when the battery voltage rises above a preset value.

M

Management Information Base (MIB)
The structure of the database in an power system.

Manual Bypass Switch (MBS)
A manually operated transfer switch used to bypass the major electronics in the UPS, so the UPS can be serviced without power interruption.

Mapping
The process of assigning physical entities to logical entities, e.g. when a particular analogue channel (internal or external) is assigned to be the channel used for measuring the bus voltage.

Maximum System Current (MSC)
The maximum current that can be supplied by or from a power system (excluding batteries) under all conditions. The MSC is normally 120% of the systems rated current.

MCB
A Miniature Circuit Breaker is a precisely rated, re-settable circuit protection device.

MDV
A Metal Oxide Varistor is a non-linear semiconductor device used for surge protection or voltage limiting.

N

National Electrical Code (NEC)
The code of standards and practices for the U.S. electrical and electronics industry. Developed by the National Fire Protection Association of Quincy, Mass. and first published in 1896.

Network Transient Protector
An in and out RJ11 jack for telephone/modem protection (120V models only) or RJ45 for 10Base-T network cable. It isolates connected equipment such as modem and fax machines from “back door” power surges.

Noise
Random, sporadic, or multi-frequency electrical signals that become part of a transmission making the signal or information more difficult to identify.

Nominal System Voltage
The DC output voltage generally used to describe a type of system, usually 24 V or 48 V.

Nominal Value
A designated value which has been accepted for the sake of convenience. For instance, nominal voltages are values assigned to circuits so that the voltages of the circuits can be conveniently discussed as 120 Vac nominal units, or 230 Vac nominal units.

Null Modem Cable
A special cable for connecting two RS-232 ports or devices directly, in place of a modem connection.

N+X UPS Redundancy
This form of redundancy provides reliable UPS operation by eliminating any single point of failure within the UPS.

O

Off-line UPS
A UPS type which feeds power to the load directly from the utility and then transfers to battery power via an inverter after utility drops below a specified voltage. The delay between utility power loss and inverter startup can be long enough to disrupt the operation of some sensitive loads. Also called a standby UPS.

Online UPS
A UPS in which the inverter is on during normal operating conditions supplying conditioned power to the load through an inverter or converter that constantly controls the AC output of the UPS regardless of the utility line input. In the event of a utility power failure, there is no delay or transfer time to backup power.

Outlet
Any point on a wiring system where current is taken to supply electrical power for a load.

Output Enable Delay
The delay between the start of primary side switching and the start of output current walk in. This is in two parts: a fixed hardware delay controlled by the secondary side control circuits and an adjustable delay controlled by the microprocessor. During this period the output voltage is at the minimum of approximately 40 V.

Overload
A condition in which the load wants more from the power source (such as a UPS) than the power source has been designed to supply.

Over-voltage Shutdown (OVSD)
A protection method that will shutdown any rectifier module with an output voltage over a preset maximum value.

P

Parallel Online UPS
Online UPS technology or installations that provide redundant sources of conditioned backup power so that the critical load is protected even in the event of UPS component failure.

Power Factor (PF)
The ratio of total real power, (W) to the total apparent power in volt-amperes (VA);W/VA.

Power Management Software
Provides monitoring and shutdown for UPS and connected load.

Power System
A rack module, single rack or several parallel connected racks, providing DC power to a single DC bus.

Preset Voltage
The voltage that a rectifier will default to if communications with the Supervisory Module is lost. Generally, this is set to the float voltage by the Supervisory Module.

PSTN
Public Switched Telephone Network

R

Rack mount UPS
UPS that can be mounted in a rack along with servers, hubs, and other devices.

Rated Rectifier Current
The maximum output current of a rectifier at 58V for a 48 V (nominal) rectifier, or 29 V for a 24 V (nominal) rectifier.

Rated System Current
The sum of the rated rectifier currents in the power system.

Raw Power
Electrical power which may or may not contain unwanted electrical signals.

Receptacle
A contact device installed at an outlet designed to accept a single plug. Receptacles on the rear of a UPS accept plugs from supported system equipment such as computers or monitors.

Rectifier
A module fitted to the power system that converts AC input power to regulated DC output power.

Rectifier Bus
The bus to which the outputs of the rectifiers are connected.

Rectifier Magazine
A module in the power system used to connect the rectifiers to other modules in the power system.

Rectifier Voltage
The voltage to which the rectifiers are set. This is assumed to be the same for each rectifier and does not include current share adjustments.

Redundancy
Duplication of elements in a system or installation to enhance the reliability or continuity of operation.

Regulation
The act of limiting voltage – using various methods - to a set range.

Reserve
Battery time remaining to end of discharge

RFI
Radio Frequency Interference

RM
Rectifier Magazine

RMS
Route Mean Squared

RS-232
Also called serial ports; a method of communicating digital information in which the data bits are transmitted sequentially over one line.

RS-232C
A common point-to-point hardware configuration for serial communications.

RS-485
A multi-drop hardware configuration for serial communications. There is no intrinsic method of bus collision detection in RS-485, so higher layers in the protocol stack must take this into account.

S

Scalable UPS
A UPS that allows for expandability; for example, enables a UPS to accommodate a larger load by purchasing additional power modules.

Simple Network Management Protocol (SNMP)
A request-response protocol that collects management information from network devices and provides a way to set and monitor configuration parameters.

Sine Wave
The sinusoidal wave form exhibited by alternating current.

Single-Phase Power (1Ø)
Power that is provided by a single source which normally includes one hot lead and a grounded (neutral) return line.

Slope Discrimination Method
A design format that causes the Over Voltage Shutdown set point to fall with increasing load.

SNMP
Simple Network Management Protocol

Square Wave
Output waveform generated by very basic, low-cost UPSs. Functions adequately for less sensitive loads, but may not provide acceptable quality input for some types of electronic equipment.

Standby Power System
See Off-Line UPS.

Start-On-Battery
Enables user to power up UPS in the absence of utility power.

Start Up Delay
The interval between power on and the start of current walk in. It is the sum of the Primary Enable Delay and the fixed and adjustable portions of the Output Enable Delay.

Status LEDs
Light Emitting Diodes (LEDs) that show the status of the UPS when they light up or turn off.

Step Wave
(Modified Sine wave) Enhanced version of square wave that provides adequate input for some more sensitive loads, but still not as high quality as a sine wave.

Supervisory Module
The module that monitors and controls the operation of the DC power system.

Surge
A transient (or momentary) wave of current, potential, or power in an electric circuit.

System Voltage
The nominal voltage of the power system, equal to the nominal voltage of the rectifier modules. 48 V or 24 V.

T

Temperature Compensation
Adjustment of the rectifier output voltage to provide the optimum charging voltage for the battery. One of the components in system voltage control, calculated by the Supervisory Module calculation based on battery temperature.

Temperature Sensor
A sensor that is used to produce a variable electrical output representing the temperature of a component, typically a battery.

Terminal Block
An insulating base equipped with terminals for connecting secondary and control wiring. Used on hardwired equipment, such as a UPS, when input plugs and output receptacles are either impractical or unavailable.

Terminal
A connector for attaching a conductor to an electrical apparatus.

Three-Phase Power (3Ø)
Power that is provided by a single source with three outputs with a phase difference of 120 ° between any two of the three voltages and currents.

Transfer Switch
A switch which will transfer current from one circuit path to another without interrupting the flow of the current.

Transformer (T)
A device that raises or lowers the voltage of an alternating current electrical source.

Transient
The fast radical change in a smooth sine wave that occurs in both voltage and current waveforms during the transition from one steady-state operating condition to another.

Trickle Charge
With the trickle charging process, the battery receives a constant voltage feeding a low current. Constant use of this method dries the electrolyte and corrodes the plate, reducing potential battery service life by up to 50 percent.

Two-Phase Power
Power which is provided by a single source with two outputs which may be 180 degrees out of phase or 120 degrees out of phase.

U

UL
Underwriters Laboratories. An approval organization based in the United States.

Uninterruptible Power System (UPS)
A system designed to automatically provide power, without delay or transients, when the normal power supply is incapable of supplying acceptable power. Some UPSs also filter and/or regulate utility power.

UPS Topology
Overall term describing the internal circuitry of a UPS. There are three basic UPS topologies: standby (off-line), line-interactive, and online.

User-Replaceable Batteries
User replaceable batteries allow the user to easily exchange UPS batteries, once the unit has been turned off.

V

Volt (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.

Volt-Ampere (VA)
Voltage (V) multiplied by the current (ampere); apparent power. For instance, a device rated at 10 amps and 120 V has a VA rating of 1200 or 1.2 kVA.

W

Walk-In-Time
The time that the rectifier takes to reach rated output current after the Start Up Delay. The slope is fixed so that a lower output current will have a shorter walk in period.

Walk-In
The process of gradually ramping up rectifier output voltage (and current) at start up to prevent a large input current surge.

Watt (W)
The unit of measure for true power. Watts = VA x Power Factor

Wye Connection
A three-phase source of load connection, with a single common junction and three phase lines out or in

Section XIX

Solar industry Glossary

ABSORBER
The absorber is that part of a solar thermal collector that receives the incident radiant energy and transforms it into heat energy.

ACTIVE SOLAR THERMAL SYSTEM
A system that traps the sun's energy with solar collectors and uses an electromechanical subsystem to move that energy to its point of intended use for water heating, space heating, pool heating, industrial process heat, electrical generation and space cooling.

ALTERNATING CURRENT (AC)
An electrical current in which the direction of electron flow reverses periodically, usually many times per second. Most U.S. household electrical systems use AC current rated at 120 volts and 60 cycles per second.

ALTERNATOR
An mechanical device that generates alternating current electricity.

ALTITUDE ANGLE
The angle of the sun above the horizon, measured in degrees. In winter, the sun is at a low solar altitude, and in the summer, the sun is at a high solar altitude.

AMMETER
A device used for measuring the current (amperage) at any point in an electrical circuit.

AMORPHOUS SILICON
A thin-film PV silicon cell having no crystalline structure.

AMPACITY
Refers to the highest safe amount of electrical current through conductors, over current devices, or other electrical equipment. Ampacity is determined by the cross-sectional area and the material of the conductor, or the manufacturer's equipment rating.

AMPERE (AMP; A, I)
The rate of flow of electrical charge. Unit of electrical current. One volt across one ohm of resistance causes a current of one ampere. One ampere is equal to 6.235 x 10^18 electrons (one coulomb) per second passing a given point in a circuit.

AMPERE-HOUR (AMP-HOUR; AH)
A measure of electron flow over time, used to measure battery capacity and state of charge. For example, a current of 1 amp drawn from a battery for 10 hours would result in 10 amp-hours of charge cycling through the battery.

AMPERE-HOUR METER
An instrument that monitors electron flow over time. Amp-hours are the product of electron flow (in amperes) and time (in hours).

AMPLITUDE
Generally refers to the maximum and minimum voltage attained by an alternating or pulsed current in each complete cycle or pulse of that current.

ANGLE OF INCIDENCE
The angle between the sun's rays and a line perpendicular to the active surface of a solar module or collector, in degrees.

ANGLE OF INCLINATION
The angle that a solar collector or PV module is positioned above horizontal.

ANODE
(Battery) The electrode within a battery cell that undergoes the chemical process of oxidation. Electrically, the anode is the cell's positive terminal.

(Water heater) An aluminum or magnesium sacrificial rod installed within steel tanks that is used to help prevent corrosion of the tank itself.

ARRAY
Any number of photovoltaic modules connected together electrically to provide a single electrical output.

AWG
American Wire Gauge, a set of standards in the U.S. specifying the diameter of wire. A higher number indicates smaller wire.

AZIMUTH
The angle between true south and a point on the horizon, measured in degrees east or west of true south.

BALANCE OF SYSTEMS (BOS)
Parts or components of a photovoltaic system other than the photovoltaic array or other generating equipment.

BALLAST
A circuit used to condition and stabilize an electric current, for example, in a fluorescent light.

BATCH SOLAR HOT WATER HEATER
The simplest of solar hot water systems. A tank of water within a glass-covered insulated enclosure aimed at the sun. Water is heated in the tank and then flows to the load or an auxiliary water heater.

BATTERY
Two or more electrochemical cells electrically interconnected in an appropriate series/parallel arrangement to provide the required operating voltage and capacity levels. Under common usage, the term battery also applies to a single cell if it constitutes the entire electrochemical storage system.

BATTERY CAPACITY
The total maximum charge, expressed in ampere-hours, that can be withdrawn from a cell or battery under a specific set of operating conditions including discharge rate, temperature, state of charge, age, and cutoff voltage.

BATTERY CELL
The simplest operating unit in a storage battery. It consists of one or more positive electrodes or plates, electrolyte that permits ionic conduction, one or more negative electrodes or plates, separators between plates of opposite polarity, a container for all the above, and posts or other terminals for electrical connection.

BATTERY CYCLE LIFE
The number of cycles, to a specified depth of discharge, that a cell or battery can undergo before failing to meet its specified capacity or efficiency performance criteria.

BATTERY LIFE
The period during which a cell or battery is capable of operating above a specified capacity or efficiency performance level. With lead-acid batteries, end-of-life is generally considered when a fully charged cell can deliver only 80 percent of its rated capacity. Beyond this state of aging, deterioration and loss of capacity begins to accelerate rapidly. Life may be measured in cycles or years, depending on the type of service for which the cell or battery is intended.

BETZ LIMIT
The theoretical maximum energy that a wind generator can extract from the wind—59.6 percent.

BIOMASS
Any organic matter available on a renewable basis, including agricultural crops, wastes, and residues; wood, wood wastes, and residues; animal wastes and municipal wastes; and aquatic plants.

BIOFUELS (BIOMASS FUELS)
Biomass converted directly to energy or converted to liquid or gaseous fuels, such as ethanol methane, and hydrogen.

BLADE
The energy-capturing, aerodynamically designed part of a wind turbine, which interacts directly with the wind.

BLOCKING DIODE
A semiconductor connected in series with a solar-electric cell or cells and a storage battery to keep the battery from discharging through the cell when there is no output, or low output, from the solar cell. It can be thought of as a one-way valve that allows electrons to flow forwards, but not backwards.

BRAKE
Device for stopping a wind turbine. This can be an electric brake that shorts the output of the turbine (dynamic braking), or a mechanical brake that physically stops the rotation, as with a brake drum and shoe.

BREAKER
A manually operable switching device that also automatically opens a circuit in the event of over current.

BRITISH THERMAL UNIT (BTU)
The amount of heat required to raise the temperature of one pound (one pint) of water, one degree Fahrenheit. 1 watt-hour = 3.413 BTU.

BULK CHARGE
The initial phase of battery charging, when the largest amount of energy is put into the battery.

BUSS
An electrical connection component that can accept multiple cables or wires. Also bus, bus bar, or bus bar

BYPASS DIODE
A semiconductor device connected in parallel with a series block of parallel PV strings to prevent current from flowing back through any shaded or failed modules in the same block.

CAPACITANCE
An electrical effect in AC circuits that results in amperage peaking before voltage.

CATHODE
The electrode within a battery cell that undergoes the chemical process of reduction. Electrically, the cathode is the negative terminal of the cell.

CATHODIC PROTECTION
Systems that protect metal from corrosion by running small electrical currents along the metal. Most often used to protect well heads, and oil, gas, and water pipelines.

CELL (battery)
A single unit of an electro-chemical device capable of producing an electrical current by converting chemical energy into electrical energy. The cell is the basic unit used to store energy in the battery. The cell contains an anode, a cathode, and the electrolyte. A battery usually consists of several cells electrically connected together to produce higher voltages. (Sometimes the terms cell and battery are used interchangeably).

CELL (solar)
The smallest, basic photovoltaic device that generates electricity when exposed to light.

CHARGE CONTROLLER
A component of photovoltaic systems that controls the charging of the battery to protect the batteries from overcharge and over discharge. The charge controller may also indicate the system operational status. Standard charge controllers vary the current (A) based on preset voltage set points.

CHARGE RATE
The current applied to a cell or battery to restore its available capacity, specified in relation to total battery size. A C/20 rate is a charge rate that is 1/20th of the total battery capacity. Also called a "20-hour rate."

CIRCUIT
A group of electrical components that make a complete electrical path, providing some function.

CIRCUIT BREAKER
See BREAKER.

CLOSED LOOP SYSTEM
A solar hot water system of which no part is vented to the atmosphere or fed with fresh liquid. The system liquid, usually some form of antifreeze solution, is re-circulated. Closed loop solar systems are also known as glycol systems and indirect systems.

COB CONSTRUCTION
A traditional building technique using hand formed lumps of earth mixed with sand and straw.

COLLECTOR LOOP
The plumbing loop in a solar hot water system that includes the solar collectors. The collectors heat the fluid in the collector, and the heated fluid can be used directly (if water) or the heat can be exchanged to a potable water loop.

COMBINER BOX
A box where wires from individual PV modules or strings are combined into larger wires to run to the battery bank. Can also contain over current protection devices.

COMPACT FLUORESCENT LIGHT (CFL)
A smaller version of standard fluorescent lamps that can directly replace incandescent lights. CFLs use 65 to 80 percent less energy, while producing the same lumens.

CONCENTRATOR
A photovoltaic module that includes optical components, such as lenses, to direct and concentrate sunlight onto a solar cell of smaller area. Most concentrator arrays must directly face or track the sun.

CONDUCTION
Heat transfer from a hot object to a colder object through direct contact.

CONDUCTOR
A material with relatively low resistance through which electricity will readily flow—wires, cables, bus bars. The most common conductors are copper and aluminum.

CONDUIT
Metal or plastic tubing designed to protect electrical conductors.

CONTINUOUS OUTPUT RATING
The maximum amount of power an inverter may deliver to a load (or loads) for a sustained period of time.

CONVECTION
Heat transfer by the movement of fluid (usually air or water).
Heat transfer through either the natural or forced movement of air.

CONVERTER

An electronic device for DC power that steps up voltage and steps down current proportionally (or vice-versa).

CRYSTALLINE SILICON
A type of PV cell made from a single crystal or polycrystalline slice of silicon.

CURRENT
Flow rate of electrons. See AMPERE.

CUTOFF VOLTAGE
Electrical equipment setting for the voltage level at which a battery is considered to be empty, and the discharge process is terminated. Most commonly found in inverters and charge controllers that include a feature for low voltage disconnection.

CYCLE
One complete charge/discharge cycle of a battery.
An AC sine wave's movement from zero to maximum positive, through zero, to maximum negative, and back to zero.

CYCLE LIFE
Cycle life is the number of cycles a cell or battery will undergo before being considered "worn out." This point is usually defined as when the battery's capacity has decreased to 80 percent of its initial rated capacity.

DAYLIGHTING
The placement of windows and skylights to provide natural interior lighting and to reduce daytime electrical demand.

DAYS OF AUTONOMY
The number of consecutive days that a stand-alone renewable energy system will meet a defined load without additional energy input.

DC
Direct current. A one-way flow of electrons. Typical sources of direct current are solar-electric cells, rectifiers, and direct current generators. To be used for typical 120 volt or 220 volt household appliances, DC must be converted to AC (alternating current).

DC MOTOR, BRUSHLESS
High-technology motor used in centrifugal-type DC submersible pumps and other applications. The motor is filled with oil to keep water out. An electronic system is used to precisely alternate the current, causing the motor to spin.

DC MOTOR, BRUSH-TYPE
The traditional DC motor, in which small carbon blocks called "brushes" conduct current into the spinning portion of the motor. They are used in many applications, including DC surface pumps and also in DC submersible diaphragm pumps. Brushes naturally wear down after years of use, and may be replaced.

DC MOTOR, PERMANENT MAGNET
A variable speed motor that uses permanent magnets instead of wound coils. Reduced voltage (in low sun) produces proportionally reduced speed, and causes no harm to the motor.

DEEP-CYCLE BATTERY
A battery designed to regularly discharge 50 to 80 percent of its capacity before recharging.

DEGREE DAY
A quantitative index reflecting demand for energy to heat or cool buildings. Heating and cooling degree days show the difference between the mean daily temperature and a 65°F base. The higher the heating degree days at any location, the colder the winter. The higher the cooling degree days at any location, the hotter the summer.

DELTA T
Difference in temperature.

DEPTH OF DISCHARGE (DOD)
The ampere-hours removed from a fully charged cell or battery, expressed as a percentage of rated capacity. For example, the removal of 25 ampere-hours from a fully charged 100 ampere-hour rated cell results in a 25 percent depth of discharge. Depth of discharge is the opposite of state of charge (SOC).

DHW
Domestic hot water: refers to any system that provides hot water for household use.

DIFFERENTIAL CONTROLLER
An electronic switch that turns off or on based on the difference between two temperatures. In a solar hot water system, the controller measures the temperature at the collector and compares it to the water temperature in a storage tank to turn the pump on or off.

DIGITAL MULTIMETER (DMM)
A device with multiple electrical measurement capabilities, such as voltage, amperage, resistance, etc., commonly usable for both AC and DC circuits. It has a digital display.

DIODE
A semiconductor device that allows electrical current in only one direction.

DIRECT CURRENT (DC)
An electrical current that moves in one direction only.

DIRECT GAIN
In passive solar heating, a direct gain system relies on the sunshine to directly hit the substance or mass being heated. Direct gain systems used today usually rely on a layer(s) of glass to assist in holding the heat within a space where the heat is desirable.

DISCHARGE RATE
The rate at which energy is being drained from a battery.

DISCONNECT
Switch gear used to connect or disconnect components in a system.

DOWNWIND
In relation to a wind turbine, the direction away from the source of wind. A downwind turbine has its blades on the downwind side of the tower.

DRAFT TUBE
A tube added to the outfall of a hydro turbine to increase energy production by taking advantage of the drop in the tailrace.

DRAINBACK SYSTEM
A solar hot water system that only fills the collector when the temperature differential is appropriate. The water that is circulated through the collectors is stored in a reservoir. Draining the collectors provides freeze protection.

DRAINDOWN SYSTEM
A solar hot water system that uses a special drain down valve that redirects the collector fluid and drains it down when the collector system pump is not operating. These systems have been prone to failure and are not recommended.

DUTY CYCLE
The fraction of time a device or load actually uses energy in a unit of time. For example, a load that uses energy for 5 seconds out of every 10 seconds has a 50 percent duty cycle.

EARTH
Synonymous with “ground.”

EFFICIENCY (PV modules)
The ratio of power output of a photovoltaic cell to the incident power from the sun or simulated sun sources under specified standard insulation conditions. A solar cell that converts 1/10 of the sun's energy that strikes its surface to electricity has an efficiency of 10 percent.

EFFICIENCY
The effectiveness of a device to convert energy from one form to another, or to transfer energy from one body to another. An electric pump that is 60 percent efficient converts 60 percent of the input energy into work—pumping water. The remaining 40 percent becomes waste heat.

ELECTRICAL POTENTIAL
Same as VOLTAGE.

ELECTRIC CURRENT
The rate at which electrons flow through an electrical conductor, usually measured in amperes (amps).

ELECTRICITY
Energy flow resulting from the flow of charged particles, such as electrons or ions.

ELECTROLYSIS
The breaking down of a chemical compound into simpler compounds or elements by the passage of electricity through the chemical compound. Commonly used to describe the extraction of hydrogen (and oxygen) from water.

ELECTROLYTE
The fluid in a battery, which is the medium of ion transport within an electrochemical cell. It provides a path for electron transfer between the anode and cathode of a battery cell.

ELECTROMAGNETIC RADIATION (EMR)
Magnetic radiation produced by a changing electrical current, such as alternating current (AC).

ELECTRON
A negatively charged particle. The movement of electrons in an electrical conductor constitutes an electric current.

EMBODIED ENERGY
The energy consumed by all of the processes associated with the production of a material. This includes the energy required in mining, transport, manufacturing, administration, use, disposal, etc.

ENERGY
The amount of work that a system or entity can do (potential energy) or is doing (kinetic energy), measured in joules. The product of power and time, measured in watt-hours. 1,000 watt-hours = 1 kilowatt-hour (KWH).

ENERGY DENSITY
A ratio of a battery or cell's capacity to either its volume or weight. Volumetric energy density is expressed in watt-hours per cubic inch. Weight energy density is expressed in watt-hours per pound.

ENGINE
A machine that converts energy into mechanical force or motion. Sources of energy include heat, chemical reaction, potential energy of elevated water, etc.

EQUALIZATION
The process of restoring all cells in a battery to an equal state-of-charge. For lead-acid batteries, this is a charging process designed to bring all cells to 100 percent state-of-charge.

EQUALIZING CHARGE
A continuation of normal battery charging, at a voltage level slightly higher than the normal end-of-charge voltage, in order to provide cell equalization within a battery.

EQUINOX (SPRING & FALL)
The time when the sun crosses the plane of the earth's equator, making night and day of equal length all over the earth, occurring about March 21st and September 21st.

EVAPORATION
The process of a liquid changing its state into a gas when heat is added. In the most common occurrence on earth, water evaporation requires 970 BTUs per pound (pint).

FEATHERING
In wind generators, this refers to an adjustment of the blades so that they catch less wind. This can prevent damage to the machine in high winds.

FINISH CHARGE
The final stage of battery charging, when the battery is charged at a slow rate over a long period of time.

FLAGGING
Noticeable deformation of trees from prevailing winds. Flagging is an indication of an effective wind site. Lack of flagging is not necessarily an indication of a poor wind site.

FLAT PLATE COLLECTOR
A solar thermal collector that converts the sun's radiation into heat on a flat surface. Does not use reflecting surfaces or lens arrangements to concentrate the sun's energy.

FLOAT CHARGE
A trickle charge to keep a battery fully charged at a safe voltage level with minimal gassing.

FLOAT SERVICE
A battery operation in which the battery is normally connected to an external current source; for instance, a battery charger that supplies the battery load under normal conditions, while also providing enough energy input to the battery to make up for its internal losses, thus keeping the battery always at full charge and ready for service.

FLOW
In hydro-electric terms, flow refers to the quantity of water supplied to a water source or exiting a nozzle per unit of time. Commonly measured in gallons per minute.

FLUORESCENT LIGHT
An electric lamp coated on its inner surface with phosphor and containing mercury vapor. When bombarded with electrons, the vapor emits ultraviolet light that causes the phosphor to emit visible light.

FRANCIS TURBINE
A type of reaction hydro-turbine used in low to medium heads. It consists of fixed vanes on a shaft. Water flows down through the vanes and out sideways.

FREESTANDING TOWER
A wind generator tower with no guy wires. This can be either a lattice tower or a monopole. Freestanding towers are the most expensive type of tower, requiring large excavations and large amounts of concrete.

FRICTION LOSS
Lost energy due to friction.

In hydro systems, pipe sized too small can lead to serious friction losses.
In any belt drive system, there will be some losses due to friction.

FULL SUN
The full sun condition is the amount of power density received at the surface of the earth at noon on a

clear day—about 1 KW per m^2, or 1 Sun. Lower levels of sunlight are often expressed as 0.5 sun or 0.1 sun.

FURLING
Reducing a wind generator's swept area to protect it from high winds. Common furling methods are to tilt the rotor (blades) up or sideways out of the wind, or to feather (twist) the blades to degrade the airfoil.

FUSE
An electrical device that is designed to break a circuit by melting an internal conductor when the current in the circuit exceeds the maximum considered safe for the conductors or devices in the circuit.

GASSING
The production of hydrogen and oxygen gas from one or more of the electrodes in the cells of a battery. Gassing commonly results from the electrolysis of water in the electrolyte during charging.

GENERATOR
A device that converts mechanical energy into electrical energy.

GEOTHERMAL HEAT PUMP
A type of heat pump that uses the ground, ground water, or ponds as a heat source and heat sink, rather than outside air. Compare to HEAT PUMP.

GIN POLE
Either of two different types of devices used with wind generator towers. With a tilt-up tower, it describes the lever that helps tilt the tower up. With a fixed tower, it describes a temporary crane used to raise tower sections or the wind generator.

GLYCOL (Propylene Glycol)
An antifreeze, heat transfer fluid that is circulated through closed loop solar hot water collectors.

GOVERNOR
A device that limits the output of another device, such as a wind generator.

GOVERNING
Limiting the output of a device. In respect to small wind generators, governing normally happens through furling.

GRID
Transmission line network used to distribute electrical energy, generally by a commercial power utility.

GRID LINES
Metallic contacts fused to the surface of a solar cell to provide a low resistance path for electrons to flow out to the cell interconnect wires.

GRID-TIE SYSTEM
A renewable energy system that is connected to the utility grid, selling excess energy back to the utility. Also called a utility-interactive system.

GROUND
The connection of electrical components to the earth and/or each other for the purposes of dissipating static charge or protecting against a short circuit or lightning.

GROUND FAULT
Unwanted current path to ground.

GROUND MOUNT
A photovoltaic (PV) rack designed to be installed on the ground or other flat surface.

GROUND ROD (ELECTRODE)
A metal rod (typically 5/8 inch diameter) that is driven into the earth (typically 8 feet deep) and is electrically connected to the negative conductor and/or any metal parts, wiring enclosures, or conduit of an electrical circuit.

GUY WIRES
Steel cables that support a tower.

HEAD
The difference in elevation between two parts of a liquid-based system. In hydro power, the difference between a source of water and the location at which the water from that source may be used (synonym: vertical drop). With pumps, the vertical distance the pump must move the water.

HEADRACE
A flume or channel that feeds water into a hydro turbine.

HEAT EXCHANGER
A device that is used to transfer heat between fluids or gases through an intervening surface.

HEAT PUMP
A device typically used for heating and cooling of buildings by drawing from or dissipating into the ambient temperature of air or water. When cooling, a heat pump works like a refrigerator. When heating, it also works like a fridge, except the heat produced is used to heat a space.

HEAT SINK
A medium or container to which heat flows. Thermal mass walls and floors in a passive solar home act as a heat sink during the day.

HEAT TRANSFER
Heat is transferred from one substance or location to another by three methods—radiation, convection and conduction. The sun's rays are a good example of radiation; warm air rising is heat movement by convection; and touching a hot iron or frying pan with your hand is heat transfer by conduction.

HERTZ (Hz)
Cycles per second. Generally refers to the number of complete cycles of the AC sine wave per second, or the frequency at which a radio or computer processor works.

HYDRO-ELECTRICITY
Any electricity that is generated by the flow of water.

HYDROGEN FUEL CELL
A device that converts hydrogen to DC electricity.

HYDROMETER
A hydrometer is an instrument for measuring the density of liquids in relation to the density of water. The hydrometer is used to indicate the state of charge in lead-acid cells by measuring the specific gravity of the electrolyte.

HYDRONIC HEATING SYSTEM
A type of heating system where water is heated in a solar collector or boiler, and is pumped to heat exchangers or radiators in rooms. Radiant floor systems have a grid of tubing laid out in the floor for distributing the heat. Temperature of the space is controlled by regulating the flow and/or temperature of the circulating water.

HORSEPOWER
A measure of the capacity to generate energy or do work. 1 horsepower = 746 watts.

HYBRID SYSTEM
An energy system consisting of two or more generating subsystems, such as the combination of a wind turbine or diesel generator and a photovoltaic system.

INCANDESCENT LIGHT
An electric lamp that is evacuated or filled with an inert gas and contains a filament (commonly tungsten). The filament emits visible light when heated to extreme temperatures by electric current through it. Incandescent light bulbs are one of the most inefficient ways to light a home. They produce a great deal of heat along with the light, and use three to four times as much energy for the same light output as compact fluorescent light bulbs.

INDUCTION MOTOR (AC)
A type of electric motor that requires a high surge to start, and a stable voltage supply, making it a challenge to run using a solar-electric system.

INSOLATION
The amount of sunlight reaching an area. Usually expressed in watts per square meter.

INTAKE
In a hydro system, the structure that receives the water and feeds it into the penstock (pipeline). Usually incorporates screening or filtering to keep debris and aquatic life out of the system.

INVERTER
A device that converts DC electricity (anywhere from 12 to 600 VDC) to AC electricity (typically 120/240 VAC).

ION
An electrically charged particle or molecule.

ISC
See SHORT CIRCUIT CURRENT.

IV CURVE
The graphical representation of the current versus the voltage of a photovoltaic cell, module, or array as the load is increased from zero voltage to maximum voltage, under standard test conditions.

JACK PUMP
A submerged pump mechanically activated by a rod extending above the well head to a reciprocating engine, motor or any other rotating device.

JOULE
The standard unit of energy (SI). One joule equals one watt-second, and 3600 joules = one watt-hour.

KILOWATT (KW)
One thousand watts.

KILOWATT-HOUR
One thousand watt-hours. Unit of energy used to perform work (energy and work are equivalent in units, energy being the potential value and work the achieved value).

Fuel equivalents: One barrel of crude oil contains roughly 1,700 KWH

One ton of coal contains roughly 7,500 KWH

One gallon of gasoline contains roughly 37 KWH

One cubic foot of natural gas contains 0.3 KWH

One ton of uranium ore contains 164 million KWH

1.34 horsepower-hours.

1 KWH = 3,400 BTU. Can be compared to 860 calories (food energy value).

LATITUDE
A location's distance north or south of the equator measured in degrees.

LIGHT EMITTING DIODE (LED)
A semiconductor device composed of a PN junction designed such that electrons cause visible light during their migration across the junction.

LIGHTNING ARRESTOR
Devices that protect electronics from lightning-induced surges by carrying the charge to ground.

LINE/WIRE LOSS
The voltage drop or energy loss due to the resistance of wire in an electrical circuit. See VOLTAGE DROP

LINEAR CURRENT BOOSTER (LCB)
An electronic circuit that matches PV output directly to a motor by converting unneeded voltage to higher usable current. Used in array-direct water pumping.

LOAD
Refers to equipment that is powered by electricity. Usually expressed in terms of amperes or watts. Any device or appliance that uses energy (such as a light or pump).

LOW-E GLASS
Glass coated with layers of metal or metal oxide. The coating emits very little radiation in the long-wave (infrared) spectrum, which diminishes heat loss from the building interior, and reduces heat gain in hot weather.

LUMEN
A unit of measurement quantifying the amount of light emitted from a light source.

MAGNETIC DECLINATION
The number of degrees east or west of true south from magnetic south.

MAXIMUM POWER POINT
The point on a PV module's voltage/amperage curve where the product of current and voltage is a maximum (measured in watts).

MAXIMUM POWER POINT TRACKING (MPPT)
Electronically tracking the maximum power point of a PV module to achieve the highest possible output, by (in simplest terms) using surplus voltage to boost amperage.

MICROHYDRO
Hydro-electric plants producing more than 100 watts and less than 2,000 watts.

MODULE
The smallest no divisible, self-contained, and environmentally protected physical structure housing interconnected photovoltaic cells and providing a single DC electrical output. Commonly called a "panel."

MOTOR
A device that converts electrical energy into mechanical energy.

MULTICRYSTALLINE CELL
See POLYCRYSTALLINE CELL

NANOHYDRO
Any hydro plant that produces less than 100 watts.

NATIONAL ELECTRICAL CODE (NEC)
A document that describes the legal standards for residential and commercial wiring practices with safety as the prime objective. Many U.S. jurisdictions base their wiring inspections on the *NEC*.

NET METERING
State by state legislation that requires utilities to purchase renewably produced electricity at the same price that they sell it, until a building's monthly or annual energy use is offset.

NOMINAL VOLTAGE
A reference voltage used to describe batteries, modules, or systems (for example, a 12 volt or 24 volt battery, module, or system).

NOSECONE
The pointed piece farthest toward the wind on a wind generator, designed primarily for cosmetic purposes, but also protects the blade attachment points and generator from the weather.

OFF-PEAK
The period of low energy demand, as opposed to maximum or peak demand.

ON-PEAK
Energy supplied during periods of relatively high system demands as specified by the utility.

OHM (Ω)
The unit that quantifies a material's resistance to electron flow.

OHM'S LAW
Basic formula defining the relationship between voltage, amperage, and resistance. Commonly stated as E = I x R, or Voltage = Amperage x Resistance.

OPEN CIRCUIT
When an electrical circuit is interrupted by breaking the path at one or more points, stopping the electrons from flowing. A light switch opens an electrical circuit when it turns off the light.

OPEN CIRCUIT VOLTAGE (VOC)
The maximum possible voltage across a PV array, module, or cell. The voltage across the terminals of a photovoltaic cell, module, or array with no load applied when the cell is exposed to standard insulation conditions, measured with a voltmeter.

OPEN LOOP SYSTEM
A fresh water or "direct" solar hot water system, generally for use in freeze-free climates.

ORIENTATION
Placement according to the directions N, S, E, or W.

OUTGASSING
The emission of gasses by a material. See also GASSING.

OVERCURRENT
Current that exceeds the rated current of the equipment or the ampacity of a conductor, resulting from overload, short circuit, or ground fault.

OVERCURRENT DEVICE
A safety fuse or breaker designed to open a circuit when an over current occurs.

PARALLEL CONNECTION
An electrical circuit with more than one possible path for electron flow. When wiring PV modules, this wiring configuration increases amperage (current), while voltage remains the same. Parallel wiring is positive to positive (+ to +) and negative to negative (- to -). Opposite of a series connection.

PASSIVE SOLAR
Any use of the sun's energy in a manner that is found in nature without the use of mechanical aid like pumps or fans. For example, heating a thermal mass (a concrete wall or slab, for instance) during the day with direct sunlight, and using the stored heat in that mass to warm a greenhouse or home at night.

PAYBACK
The period of time it takes for an energy generating device or system to pay for itself in fuel savings.

PEAK LOAD
The maximum load or electrical power draw occurring in a given period of time.

PEAK POWER POINT
Operating point of the IV (current-voltage) curve for a photovoltaic cell or module where the product of the current value times the voltage value is a maximum. Also called the “maximum power point.”

PEAK SUN HOURS
The equivalent number of hours per day when solar irradiance averages 1,000 watts per meter squared.

PELTON WHEEL
A common impulse turbine runner—the wheel that receives the water, changing the pressure and flow of the water to circular motion to drive an alternator, generator, or machine. Pelton wheels (named after inventor Lester Pelton) are made with a series of cups or “buckets” cast onto a hub.

PENSTOCK
The pipe in a hydro system that carries the water from the intake to the turbine.

PHANTOM LOAD
A device that consumes energy even when its switch is off, such as the digital clock on a VCR.

PHOTON
The actual (physical) particle unit of light, as the electron is a particle of electric charge. Solar-electric modules use photons to generate electricity. Photons not captured by the cell are either reflected, pass through the panel, or are converted to heat in the solar array.

PHOTOVOLTAIC ARRAY
A collection of solar modules connected in series, parallel, or series-parallel combination to provide greater voltage, current, or power than can be furnished by a single solar module. Solar-electric arrays can be designed to furnish any desired voltage, current, or power.

PHOTOVOLTAIC CELL
A device composed of specially prepared semiconductor material or material combinations exhibiting the ability to convert incident solar energy directly into electrical energy.

PHOTOVOLTAIC EFFECT
The phenomenon that occurs when photons, the particles in a beam of light, knock electrons loose from the atoms they strike. When this property of light is combined with the properties of semiconductors, electrons flow in one direction across a junction, setting up a voltage. With the addition of circuitry, electrons will flow and electrical energy will be available.

PHOTOVOLTAIC MODULE
A PV module consists of series and/or parallel wired cells typically made from layered silicon crystals that convert light energy to DC electricity. The number of modules in a given system varies depending on the combined load being powered.

PIPE LOSS (Frictional head loss)
The amount of energy or pressure lost due to friction between a flowing liquid and the inside surface of a pipe.

P-N JUNCTION
The semiconductor junction in a photovoltaic cell that shunts electrons into a circuit. Electrons are bumped across this junction by photons (light particles).

POLE MOUNT
A PV mount that is installed on the top or side of a pole usually set in concrete. Can be fixed or seasonally tilted.

POLYCRYSTALLINE CELL
A wafer of silicon with a multi-grained structure. All grains have the same atomic crystal lattice, however, each grain has a unique orientation in space, producing a unique reflection of light, resulting in a "patchy" mottled appearance. AKA multi crystalline cell.

POST AND BEAM CONSTRUCTION
A traditional building technique in which post and beam framing units are the basic load-bearing members. Post and beams may be of wood, structural steel, or concrete. In this system, there are fewer framing members, leaving more open space for in-fill. Often used in straw bale construction.

POWER
The rate of energy use or generation per unit time, measured in watts. 1 watt = 1 joule per second.

POWER FACTOR
The ratio of real power (watts) to apparent power (volt-amps) in an AC circuit. Power factor describes the offset between voltage and amperage peaks in AC. 1 is called “unity” power factor, and is when voltage and amperage peak at the same time—they are then said to be “in phase.” Power factor is calculated by dividing W by VA.

PRESSURE
The “push” behind liquid or gas in a tank, reservoir, or pipe. Water pressure is directly related to “head”—the height of the top of the water over the bottom. Every 2.31 feet of vertical head gives 1 psi (pound per square inch) of water pressure.

PRIMARY CELL
A primary cell is an electrochemical cell (battery) that cannot be recharged. The chemical process within the primary cell is only one way—discharge. When a primary cell is discharged it is discarded. Common flashlight batteries are primary cells; they are disposable batteries that should be avoided.

PSI
See PRESSURE.

PULSE WIDTH MODULATION (PWM)
Varying the amount of DC energy sent to a load or other device by changing the length of time a pulse is left on compared to when it is off. The wider the pulse, the greater the energy transfer.

PURPA
The Public Utility Regulatory Policies Act, passed in 1978. Requires utilities to purchase excess generation from small-scale generators. However, without net metering, this can amount to a fraction of retail prices.

PV
See PHOTOVOLTAIC

PV ARRAY
Two or more photovoltaic modules wired in series or parallel.

PV ARRAY-DIRECT
The use of electricity directly from a photovoltaic array, without batteries or other electrical storage. Many solar water pumps work this way, using a tank to store water.

RADIATION
The sun's energy that comes to earth in the form of direct, diffuse, and reflected rays.

The transfer of heat through electromagnetic waves, without heating the air between objects.

RADIOTELEPHONE
A two-way radio system that enables use of a regular telephone but with radio instead of wires.

RATED CAPACITY
The manufacturer's specification for the amount of charge that may be stored in a battery, commonly expressed in amp-hours at a specific rate of discharge.

RATED WATT
The manufacturer's specification for power output of a generating device. In most cases, this is not the most accurate measure to look at, since it predicts output only for ideal circumstances.

RATE OF CHARGE
The amount of energy per unit time that is being added to the battery. Rate of charge is commonly expressed as a ratio of the battery or cell's rated capacity to charge duration in hours. Example: A C/20 rate on a 100 AH battery would be 5 amps, the capacity of the battery divided by 20.

REGULATOR
A device that prevents overcharging of batteries by controlling the charge cycle, and usually adjustable to conform to specific battery needs. Regulators do not step the voltage down, but control the rate of charge so the battery stays at a specified voltage. Also called CHARGE CONTROLLER.

RENEWABLE ENERGY
Flows of energy that are regenerative or virtually inexhaustible from natural ecological cycles. Most commonly includes solar (electric and thermal), biomass, geothermal, wind, tidal, wave, and hydro power sources.

RESISTANCE
Refers to how well a material conducts a flow of electrons, measured in ohms ( ). Resistance is the property of materials to impede a flow of electrons through the material. All materials have some resistance. Those of low resistance are known as conductors, while those of high resistance are known as insulators. The unit used to measure resistance is the Ohm ( ).

RESISTOR
A device with a known amount of resistance used in electrical circuits.

REST VOLTAGE
The voltage of a fully charged cell or battery that is neither being charged or discharged.

RF (radio frequency)
Any radiation of a frequency that may be received or radiated by radios. Common usage: RF interference (RFI); refers to the interference of radio frequency radiation with the operation of devices or appliances such as radios, televisions, computers, etc.

RMS
Root mean square; defines a time averaged value of a varying sinusoidal parameter, such as AC voltage, amperage, or wattage. The square root of the average of the squares of a set of numbers.

ROOF MOUNT
A PV or solar collector rack intended to be installed on a roof. For PVs, its elevation angle can be fixed or seasonally adjustable.

ROTOR
The blades of a wind generator, shaped to spin when exposed to wind, harnessing the wind's energy.

RUNNER
The part of a hydro turbine that accepts the water and turns its energy into rotating motion.

R-VALUE
The measure of a material's resistance to heat flow. The higher the R-value, the greater its insulating capabilities.

QUARTZ-HALOGEN LIGHT
An incandescent lamp filled with halogen gas. Somewhat more efficient than standard incandescents.

SECONDARY CELL
Secondary cells are batteries (electrochemical cells) that are rechargeable. The chemical reaction within the secondary cell is reversible, allowing the cell to be recharged many times.

SELF-DISCHARGE
The tendency of all batteries to lose energy. Self-discharge represents energy lost to internal chemical reactions within the cell. This energy is not and cannot be used from the battery or cell's output terminals.

SENSOR (Temperature)
Sensing device that changes its electrical resistance according to temperature. Used in the control system of a solar thermal system to measure collector and storage tank temperatures.

SERIES CONNECTION
A wiring configuration used to increase voltage from more than one supply. Series wiring is positive to negative (+ to -) or negative to positive (- to +). Opposite of parallel connection. Series circuits have only one possible path for electron flow.

SERIES REGULATOR
A device that prevents overcharging of a battery by disconnecting the charging source as the battery voltage approaches some upper limit.

SERIES STRING
A group of PV modules or batteries wired in series.

SHORT CIRCUIT
A circuit in which two source leads of opposite polarity or dissimilar potential are connected directly to each other with no regulation or load in between, allowing the full energy potential of the source to flow through the circuit. A short circuit will trip the breaker or fuse, and may damage components, or even cause a fire.

SHORT CIRCUIT CURRENT (ISC)
The current between two points in a circuit when the points are electrically connected with a conductor with essentially zero resistance. Normally applied to PV modules, which can be short circuited safely because they are limited current devices.

SHUNT (noun)
1. A resistive load through which electron flow is diverted, typically used to heat air or water.

2. A component with a precise, known resistance used to determine amperage by measuring the voltage across it and using Ohm's law ($I = V/R$).

SHUNT (verb)
To divert electrical current to a separate circuit or load.

SHUNT REGULATOR
A device that prevents overcharging of a battery by diverting some (or all) of the charging current to a resistive load when the battery voltage reaches a preset upper limit.

SIDE-OF-POLE MOUNT
A PV mount installed on the side of a pole. May be fixed or seasonally adjustable.

SILICON
A nonmetallic element, which when specially treated, is sensitive to light and capable of transforming light

into electricity. Silicon is the basic material of most beach sand, and is the raw material used to manufacture most photovoltaic cells.

SINGLE CRYSTAL CELL
A wafer of silicon that has a perfect, continuous, crystal lattice (on the atomic level).

SITE EVALUATION
An estimation of a location for its potential for solar, hydro, or wind power.

SOLAR THERMAL COLLECTORS
A solar collector is a device designed to absorb incident solar radiation and to transfer the energy to the fluid or air passing through it.

SOLAR COOKER
A device that converts the sun's energy into heat energy, which is then used to cook food.

SOLAR-ELECTRIC CELL
See PHOTOVOLTAIC CELL

SOLAR-ELECTRIC MODULE
See PHOTOVOLTAIC MODULE

SOLAR ENERGY
Energy coming directly from the Sun.

SOLSTICE (SUMMER & WINTER
The longest and shortest days of the year. The longest day (Summer Solstice) is about June 21st in the Northern Hemisphere. The shortest day (Winter Solstice) is about December 21st in the Northern Hemisphere.

STAND-ALONE SYSTEM
A system that operates independently of the utility lines. It may draw supplementary electricity from the utility, but is not capable of providing electricity to the utility.

STANDARD TEST CONDITIONS (STC)
The standardized conditions of 1,000 watts per meter squared of solar insulation at 25°C (77°F) for testing PV module ratings.

STATE OF CHARGE (SOC)
A ratio, expressed in percent, of the energy remaining in a battery in relation to its capacity when fully charged.

STORAGE BATTERY
See BATTERY and SECONDARY CELL.

STRATIFICATION
The movement of heat by convection in gasses and liquids causes heat to stratify in layers, the warmest being on top. Stratification is caused by gravity, since the warmer gases and liquids are less dense than the cooler layers.

STRAW BALE CONSTRUCTION
A building technique using straw bales for the walls. See POST AND BEAM CONSTRUCTION.

STRUCTURAL INSULATED PANELS (SIPs)
A no-cavity solid building system of wall and roof panels "sandwiching" polystyrene insulation between an outer and inner sheathing panel (typically oriented strand board (OSB) or metal).

SUSTAINABLE
A material or energy source, which if managed carefully, will provide at current levels indefinitely.

SULFATION
The formation of lead-sulfate crystals on the plates of a lead-acid battery, which decreases battery capacity by impeding the opportunity for chemical reaction within a cell. Sulfation can be caused by leaving the battery in a discharged state for long periods of time.

SURGE CAPACITY
The maximum amount of AC power an inverter may deliver to a load (or loads) for a short period of time, such as when starting a motor.

SWEPT AREA
The area (in square feet or meters^2) that a wind generator's rotor (blades) sweep. This is the collector area for a wind generator. The larger the collector, the more energy it will capture.

SWITCH
A device that breaks an electrical circuit, halting the flow of electrons through the circuit.

TAIL
The part of a wind generator that makes the rotor face into the wind. Often the tail is also involved in governing the machine, by folding down or sideways to swing the rotor out of the wind.

TAILRACE
The pipe, flume, or channel in a hydroelectric system that carries the water from the turbine runner back to the stream or river.

THERMAL BREAK
A material of low thermal conductivity placed in such a way as to reduce the flow of heat between two materials of high thermal conductivity.

THERMAL MASS
A material that has the ability to absorb, store, and release heat energy. The more heat energy that is required to change the temperature of high-density materials (concrete, bricks, tiles), the more thermal mass the materials have.

THERMOSYPHON
Passive solar hot water systems that rely on the natural convection of liquids to collect energy. Designed with the tank above the collection surface.

THIN FILM
A PV manufacturing technique where silicon is vapor deposited, a few molecules thick, onto another material.

TILT ANGLE
A fixed angle measured from the horizontal to which a solar array is tilted. The tilt angle is chosen to maximize the array output. Depending upon latitude, season, and time of day, the optimum angle will vary.

TILT-UP TOWER
A non-climbable wind generator tower that tilts up and down to allow installation and servicing of the turbine on the ground. Normally these employ a gin pole—a horizontal lever arm that helps raise and lower the tower.

TOP-OF-POLE MOUNT
See POLE MOUNT.

TRACKER
A mounting rack for a PV array that automatically tilts to follow the daily path of the sun through the sky. A "tracking array" will produce more energy through the course of the day than a "fixed array" (non-tracking), particularly during the long days of summer. Some trackers are single-axis while others are dual-axis.

TRANSFORMER
An electrical device that steps up voltage and steps down current proportionally (or vice-versa). Transformers work with AC only.

TRASH RACK
A large strainer at the input to a hydro system. Used to remove debris from the water before it enters the pipe.

TURBINE
An engine that produces rotary motion through reaction or impulse, or both, with moving fluid or gas. The resultant rotary motion is usually used to drive an alternator generator.

TURGO
In hydroelectric systems, a type of impact hydro runner optimized for lower heads and higher volumes than a Pelton runner.

UNINTERRUPTIBLE POWER SUPPLY (UPS)
A power supply providing continuous, uninterruptible service—commonly used in telecommunications and computer networks.

UPWIND
In relation to a wind turbine, toward the wind. An upwind turbine has its blades on the upwind side of the tower.

UTILITY GRID
Commercial electrical energy distribution system. Synonyms: Mains, Grid.

UTILITY-INTERTIE (UI) SYSTEM
See GRID-TIE SYSTEM.

VOLT (V)
The volt is the unit used in the measurement of electromotive force (electrical “pressure”). A standard electrical definition of the volt is: an electromotive force of 1 volt is necessary to move a current of 1 ampere through a 1 Ω resistor. It is often also referred to as electrical potential difference or potential difference.

VOLTAGE
A measure of the force or "push" given the electrons in an electrical circuit; a measure of electrical potential. Analogy: pressure in a water pipe. AKA Potential.

VOLTAGE DROP
Loss of voltage (electrical pressure) caused by the resistance in wire and electrical devices. Proper wire sizing will minimize voltage drop, particularly over long distances. Voltage drop is determined by four factors: wire size, current (amps), voltage, and length of wire. Water analogy: friction loss in pipe.

VOLTAGE, NOMINAL
A way of naming a range of voltage to a standard. Example: A “12 volt nominal” system may operate in the range of 10 to 20 Volts. We call it “12 volts” for simplicity.

VOLTAGE, OPEN CIRCUIT
See OPEN CIRCUIT VOLTAGE

VOLTAGE, PEAK POWER POINT (Vpp)
The voltage at which a photovoltaic module or array generates at the highest power (watts). A “12 volt nominal” PV module will typically have a peak power voltage of around 17 volts. A PV array-direct solar pump should reach this voltage in full sun conditions. In a higher voltage array, it will be a multiple of this voltage.

VOLTMETER
A device for measuring the voltage difference between any two points in an electrical circuit.

WATT

Unit of power. Power is the rate of generating or using energy. One watt is the power developed or dissipated in a one volt circuit in which there is a current of one ampere (6.28 million million electrons per second). Watts = amps X volts.

WATT-HOUR

A unit of measurement quantifying an amount of energy used or generated. A load that consumes 1 watt for 10 hours uses 10 watt-hours.