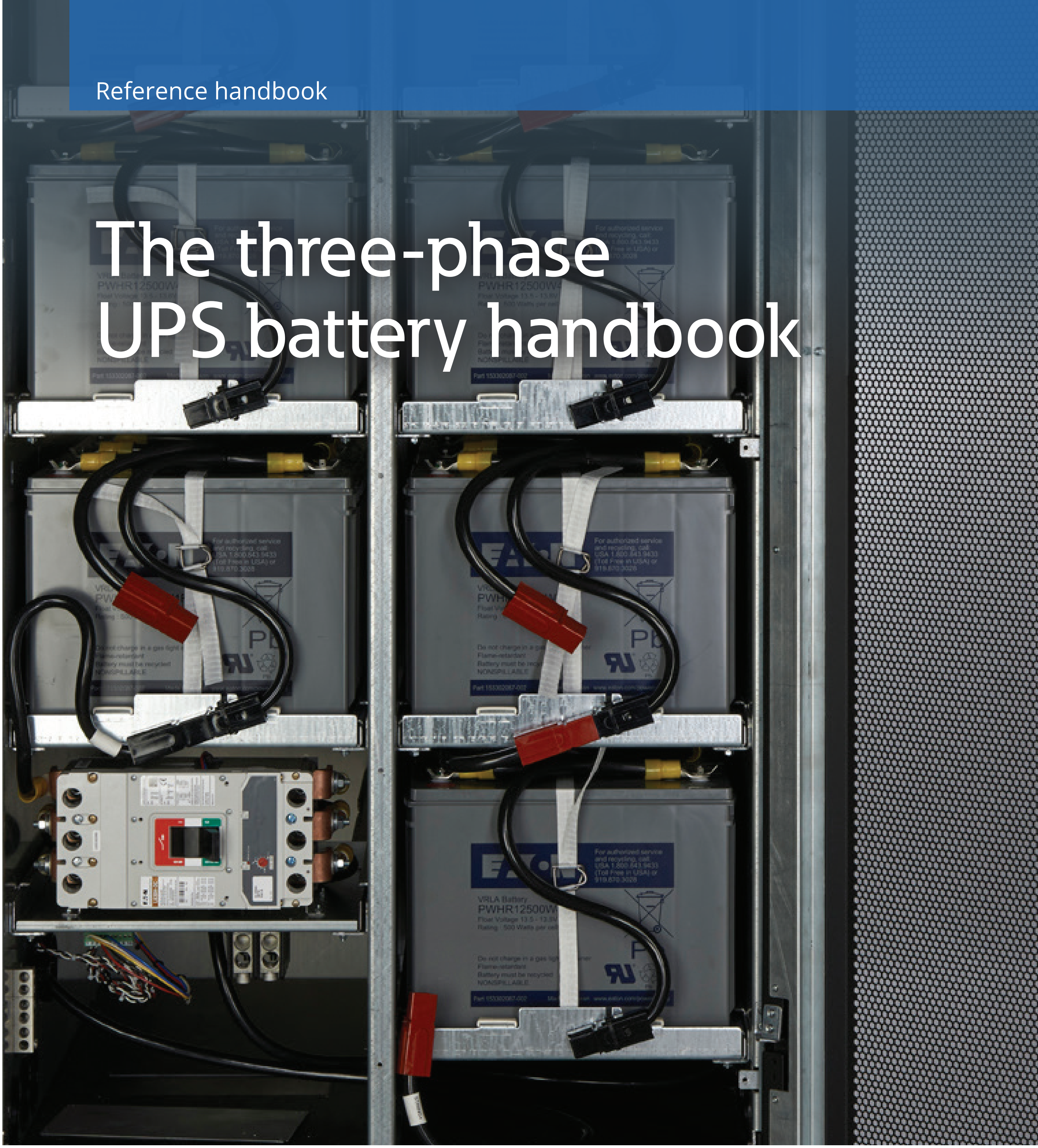
Reference handbook



The three-phase UPS battery handbook

Powering Business Worldwide

The three-phase UPS battery handbook

Understanding your UPS battery can extend its life, save you time and boost your bottom line.

Battery failure is a leading cause of UPS load loss. Knowing how to properly maintain UPS batteries will help you manage your IT power more efficiently and avoid power-related headaches.

Improvements in battery technology have been evolutionary rather than revolutionary. Capabilities such as advanced charging regimens, software management for accurate remaining life information and firmware that adds intelligence to batteries have reduced, but not eliminated, the risks of UPS battery failure. Considering all of the factors that could affect your UPS battery's performance is a wise practice—after all, even large installations with many batteries are vulnerable to the failure of a single one of them.

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Overview

UPS battery overview

The three battery types typically used in UPSs are: valve-regulated lead-acid (VRLA), also known as sealed or maintenance-free, lithium-ion and vented lead acid (VLA), also called flooded-cell. VRLA batteries usually have lower up-front costs but a shorter lifetime than VLA, usually around five years. Flooded-cell batteries require more advanced maintenance but have a longer lifetime, up to 20 years. Lithium-ion batteries are smaller and lighter than the above types, while offering a 10 year life; they have changed the traditional status quo for UPS use, with costs similar to VRLA and new energy storage applications with UPS systems, such as grid-sharing and peak shaving, now viable. These new capabilities provide more than just backup time; they can contribute to significant cost savings in day-to-day operations.

1. VRLA

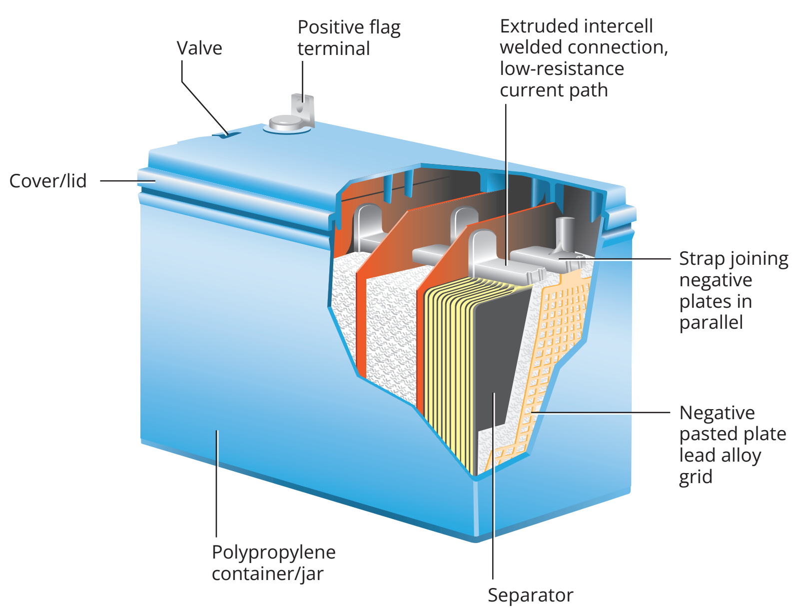
VRLA batteries are sealed, usually within styrene acrylonitrile plastic. They have the advantage of containing no sloshing acid that might leak or drip out when inverted or handled roughly. The term valve-regulated refers to the method of gas release. If the gas pressure becomes too great inside the battery, the valve will vent when it reaches a certain pressure.

VRLA batteries are frequently used in UPS or other high-rate applications

During the charging of a lead-acid battery, hydrogen is normally liberated. In a vented battery, the hydrogen escapes into the atmosphere. In a VRLA battery, the hydrogen recombines with oxygen inside the battery, so water loss is minimized. Under normal float conditions, virtually all the hydrogen and oxygen is recombined. Re-sealable valves vent non-recombined gases only if pressure exceeds a safety threshold.

A VRLA battery is distinguished from a flooded-cell battery by the rate at which oxygen is evolved from the positive plate and diffused to the negative plate, ultimately forming water. This rate is several orders of magnitude faster than a flooded-cell battery. Because water can't be added, its recombination is critical to the life and health of the battery. Any factor that increases the evaporation rate or water loss—such as ambient temperature and heat from the charging current—reduces the battery life.

The shelf life of a VRLA battery is the length of time a battery can stand, open circuited, before it can no longer be recovered to full capacity with a single charge. Shelf life is determined by the length of time it takes the battery to lose 40%–50% of its initial capacity due to self-discharge.



Internal and external components of a valve-regulated lead-acid (VRLA) battery

2. Lithium-ion

Lithium-based batteries have significant benefits over alternative DC storage techniques for UPS applications. The technology has matured in heavy-duty applications like electric vehicles and is considered ideal for critical power backup. Small size and light weight are the primary benefits, but additional features like built-in battery management (not just monitoring), make lithium-ion an attractive alternative to traditional batteries.

In addition, their high cycle-count (charge/discharge cycles), 10-year service life and faster recharge times compared with lead-acid batteries allows their use in non-traditional UPS applications, like grid sharing, peak shaving and industrial or process control support.

The lithium-ion battery management system is deployed in each battery, as well as in a system level master controller. It manages charge current, voltage and cell voltage balance, while making adjustments as necessary to eliminate any chance of overtemperature. If temperatures rise above safe levels, the management system independently disconnects the battery or string via multiple different disconnection means, and notifies the user via the battery cabinet monitor and an alarm on the UPS. In the U.S., vendors must undergo a flame propagation test (UL9540A) to provide data on how a battery system will perform during a thermal event. Successful test results help address safety concerns.

Overall, a lithium-ion battery system provides lower TCO through comparable costs to other batteries combined with CapEx savings via a longer replacement interval and its ability to operate at higher ambient temperatures.

Lithium-ion battery systems provide a reliable and flexible solution that ensures 24/7 system uptime

3. VLA

VLA, or wet-cell, batteries have thick lead-based plates that are flooded with an acid electrolyte. This is a highly reliable design when properly maintained—failures normally don't occur until halfway through their 20-year pro-rated life, at which time the failure mode is most often a short circuit. This situation is not an extreme emergency because any one shorted cell only affects overall reserve time by a very small percentage.

While VLA batteries are reliable and long-lasting, they have downsides as well. They require more safety measures and a space-consuming separate battery room.

Regardless of the differences in UPS battery types, each require monitoring and maintenance to ensure maximum life and system availability.

Flooded-cell batteries require more advanced maintenance but have a longer battery service life

Other common causes of UPS failure

Did you know? Batteries may be the #1 contributor to UPS failure, but there are three other vulnerable components that shouldn't be overlooked:

Capacitors: A capacitor is a fairly simple device that stores and releases electrical energy. It can be as small as a thumbnail or as large as a soda can. A typical UPS contains a dozen or more capacitors of different types and sizes. Like batteries, capacitors degrade over time. There may not be visible effects upon failure, but one failure will leave other capacitors to work harder and shorten their lifespans.

Filters: Because dust may block air filters and cause a UPS to shut down due to overheating, they must be inspected every month. Replacing filters is an inexpensive component of an effective UPS maintenance plan.

Fans: They may slow down or stall as they age, and a resulting over temperature condition will shut down the UPS unexpectedly. Watch for fan fail alarms every week and plan for replacement at the 8-10 year mark at the latest.

Battery arrangement and power

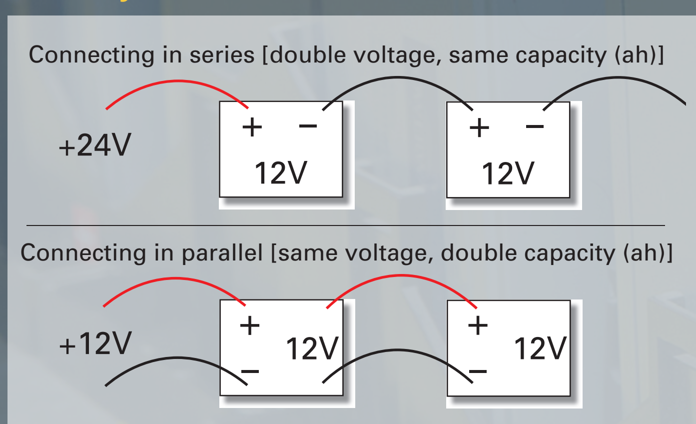
In most UPSs, you don't use just one cell at a time. Cells are typically normally grouped together serially to form higher voltages and in parallel to form higher currents. In a serial arrangement, the voltages add up. In a parallel arrangement, the currents add up.

However, batteries are not quite linear in real-world operation. For example, all batteries have a maximum current they can produce; a 500 milliamp-hour battery can't produce 30,000 milliamps for one second because there's no way for its chemical reactions to happen that quickly. It's also important to realize that at higher current levels, batteries can produce a lot of heat, which wastes some of their power.

Like all batteries, UPS batteries are electrochemical devices. A UPS uses a lead-acid storage battery in which the electrodes are grids of lead containing lead oxides that change in composition during charging and discharging, and the electrolyte is dilute sulfuric acid. In other words, they contain components that react with each other to create DC electrical current. Lithium-ion batteries operate similarly, but with different internal materials. These components are:

- **Electrolyte**: The medium that provides the ion transport mechanism between the positive and negative electrodes of a cell, immobilized in VRLA batteries (in liquid form in flooded-cell batteries)
- **Grid**: A perforated or corrugated lead or lead alloy plate used as a conductor and support for the active material
- **Anode**: The terminal where the current flows in
- **Cathode**: The terminal where the current flows out
- **Valve** (used in VRLA batteries): Used to vent the build-up of gas that goes beyond pre-determined levels
- **Separator**: A device used for the physical separation and electrical isolation of electrodes of opposing polarities
- **Jar**: The container holding the battery components

Replacement batteries for data room battery cabinets



Series connection

Connecting the positive terminal of a cell/battery to the negative terminal of the next cell/battery increases the voltage of the battery network while keeping the capacity constant.

Parallel connection

Connecting all the positive or negative poles of several batteries increases the capacity of a battery network while maintaining a constant voltage.

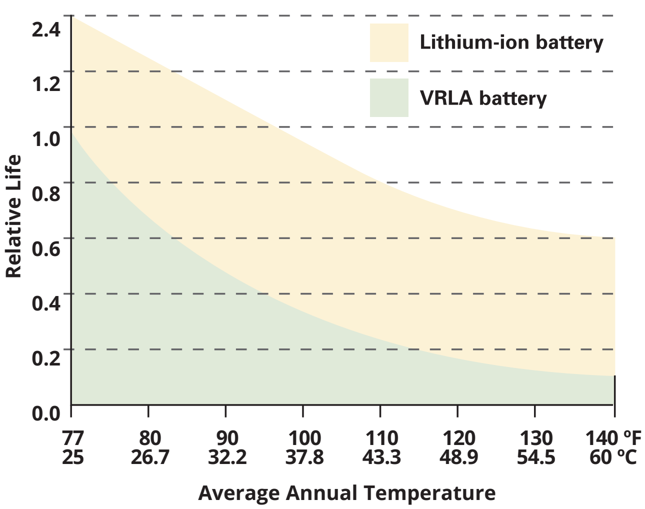
Battery facts

Four factors that affect battery life

Batteries have limited life, usually showing a slow degradation of capacity until they reach 80% of their initial rating, followed by a comparatively rapid failure. Regardless of how or where a UPS is deployed and what size it is, there are four primary factors that affect battery life: ambient temperature, battery chemistry, cycling and maintenance.

1. Ambient temperature

The rated capacity of a battery is based on an ambient temperature of 25°C (77°F). Any variation from this operating temperature can alter the battery's performance and shorten its expected life. To help determine battery life in relation to temperature, remember that for every 8.3°C (46.9°F) average annual temperature above 25°C (77°F), the life of the battery is reduced by 50%.



Optimum operating temperature for a VRLA and lithium-ion battery is 25°C (77°F). High ambient temperature allows unnecessary large quantities of charge current to flow which results in a shorter service life.

What can go wrong with batteries?

Condition	Cause
Plate separation	Repeated cycling (charging and discharging), damage during handling and shipping and overcharging
Grid corrosion	Normal aging, operating in an acidic environment and high temperatures
Internal short circuit	Heat (plates expand causing shorts), separator failure, handling and shipping and grid corrosion
External short circuit	Human error (shorting terminals) and leaks
Sulfation of plates	Sitting discharged for an extended period, not on charge or being undercharged, such as battery shelf life being exceeded past manufacturer's guidelines
Excessive gassing	Often due to high temperatures or overcharging; electrolyte volume is decreased
Drying out	Excessive gassing, high temperatures or overcharging, resulting in too little electrolyte for battery to function and provide full backup time

2. Battery chemistry

UPS batteries are electrochemical devices whose ability to store and deliver power slowly decreases over time. Even if you follow all the guidelines for proper storage, usage and maintenance, batteries still require replacement after a certain period of time.

3. Cycling

During a utility power failure, a UPS operates on battery power. Once utility power is restored, or a switch to generator power is complete, the battery is recharged for future use. This is called a discharge cycle. At installation, the battery is at 100% of rated capacity. Each discharge and subsequent recharge reduces its relative capacity by a small percentage, albeit a much smaller percentage for lithium-ion chemistry. The length of the discharge cycle determines the reduction in battery capacity.

Lead-acid and lithium-ion batteries have a limited number of discharge/recharge cycles before the chemistry is depleted, but lithium-ion cycle count is based on a number of full discharges and a number of shallow discharges. It is typically multiple times that of lead acid. Once the chemistry is depleted, the cells fail and the battery must be replaced.

4. Maintenance

Battery service and maintenance are critical to UPS reliability. A gradual decrease in battery life can be monitored and evaluated through voltage checks, load testing or monitoring. Periodic preventive maintenance extends battery string life by preventing loose connections, removing corrosion and identifying bad batteries before they can affect the rest of the string.

Even though sealed batteries are sometimes referred to as maintenance-free, they still require scheduled maintenance and service. Maintenance-free simply refers to the fact that they don't require water to be added regularly.

Without regular maintenance, your UPS battery may experience heat-generating resistance at the terminals or inside the jar, improper loading, reduced protection and premature failure. With proper maintenance, the end of battery life can be accurately estimated and replacements scheduled without unexpected downtime or loss of backup power.

Battery life: design life vs. actual life

Determining battery life can be a tricky business. It's often promoted based on design life, defined as how long the battery can be expected to perform under ideal conditions.

An estimate of actual battery life must take into consideration the four factors discussed on this page that can affect it.

Battery disposal

Batteries that are replaced can still contain a significant amount of hazardous waste, including the electrolyte and lead. Therefore, you must comply with EPA guidelines for the disposal of all UPS batteries. There are essentially two main categories of disposal, one for spent batteries and another for spills. The primary ways to handle these two categories are:

Spent batteries

Send to a secondary lead smelter for recycling. For lithium-ion, return to the original vendor or an authorized third-party recycler equipped to handle lithium batteries.

Spilled batteries

Place neutralized leaked material into sealed containers and dispose of as hazardous waste, as applicable. Large water-diluted spills, after neutralization and testing, should be managed in accordance with approved local, state and federal requirements, as well as the battery manufacturer's Material Safety Data Sheet (MSDS). Consult your state environmental agency and/or the EPA.

Recycling

One of the most successful recycling efforts in the world is for lead-acid batteries. According to Battery Council International, more than 99% of lead-acid batteries were recycled between 2017 and 2021. Many states require lead-acid batteries be recycled and several options exist to dispose of used batteries, including:

- If you're engaged with Eaton on a battery upgrade or replacement, we'll take your old batteries and recycle them for you
- Check your local phone book for a local recycler, or search for a recycler at www.earth911.com
- Some automotive stores accept batteries for recycling
- Many municipalities have recycling locations that will accept batteries for recycling. When disposing of batteries in this manner, be sure to get a dated receipt clearly detailing what batteries were dropped off, including quantities with the recycler's full name, address and phone noted in the unlikely event you get audited.

Lithium-ion recycling

Lithium-ion batteries contain no toxic materials, but should be recycled or re-used, i.e. redeployed in solar, home backup or refurb automotive use.

Battery maintenance for extended life

Quantifying the combined effect of the four factors that affect battery life discussed on the previous page is difficult. It is important to determine when a battery is near the end of its useful life while it still works, before the critical load is left unprotected. The only sure way to determine battery capacity is to perform a battery run-down test. The UPS module is taken off line, connected to a load bank and operated at rated power until the specified runtime elapses or the unit shuts down due to low battery voltage. If battery capacity is less than 80% of its rated capacity, the battery should be replaced.

Thermal scanning of battery connections during the battery run-down test identifies loose connections. This test gives you the chance to see the battery during an extended, high-current discharge. Scanning should take place during discharge and recharge cycles.

An effective UPS battery maintenance program must include regular inspections, adjustments and testing, with thorough records kept of all readings. Trained technicians should:

- Inspect batteries and racks or cabinets for signs of corrosion or vertical return alignment leakage
- Measure and record the float voltage and current of the entire bank
- Record the terminal voltage of selected batteries
- Check the electrolyte level in each cell, if visible
- Check voltage balance and internal temperature of lithium-ion cells
- Log the ambient temperature
- Compare data collected to previous maintenance inspections to accurately identify issues

Spot replacement of batteries

Batteries in series are similar to a string of holiday lights. When one unit fails, the entire string no longer works and it can be difficult to determine which battery has failed.

The most effective way to combat this potential problem is to "spot" replace bad batteries that are less than three years old. While the four factors affecting battery life play a large role in determining when a battery is vulnerable to failure, there's no precise way to predict battery failure. The only way to identify bad batteries early enough for spot replacement is through continuous battery monitoring and scheduled maintenance. Spot replace bad VRLA batteries that are less than three years old and replace the whole string between the fourth and fifth year (10th year for lithium-ion).

Used batteries: Good for the environment?

Which commonly used product has the highest rate of recyclability? Paper? Only 73% of paper is recycled for reuse. Aluminum at 54% and glass at 25% also fall short of the leader. More than 99% of all battery lead is recycled. Lead-acid batteries top the list of most highly recycled consumer products.

The processes for lead-acid battery recycling support agriculture needs and enhance energy conservation. Beyond the successful reuse of nearly 100% of the battery components, lead recycling facilities harness radiant heat from their furnaces to offset traditional heating costs. Residual sulfur trapped during recycling is processed into fertilizer. Even the plastic casings are crushed into pellets and are used to manufacture new battery covers and cases.

Recycling lead is also more energy efficient than smelting or mining new lead. The recycled lead can be refined into new alloy repeatedly, giving it unmatched sustainability and cost stability—a trait unlike most raw materials.

Lithium batteries from a UPS are highly likely to have a 'second life' in a solar or energy storage application, before ultimately being recycled. Contact the battery vendor to see if this is available.

Appropriate personal protective equipment is essential when working on batteries or any UPS equipment

Battery safety

The materials in batteries make them volatile and therefore potentially hazardous. Performing regular maintenance on your UPS batteries can go a long way toward preventing unsafe situations.

Sulfuric acid is very combustible and its contact with organic materials may cause fire and explosion. It also reacts violently with strong reducing agents, metals, sulfur trioxide gas, strong oxidizers and water. Contact with metals may produce toxic sulfur dioxide fumes and may release flammable hydrogen gas.

For lead compounds, avoid contact with strong acids, bases, halides, halogenates, potassium nitrate, permanganate, peroxides, nascent hydrogen and reducing agents. Lithium-ion batteries actually contain no toxic substances and pose no hazard in normal handling. If a battery case is broken, consult the vendor’s material safety data sheet (MSDS) for appropriate action. Different lithium-ion battery models use a variety of chemical components and safety procedures will vary.

You should always refer to the material safety data sheet for specific precautionary measures. Primary steps for safe handling and use are noted below.

Spills or leaks (for lead-acid batteries)

Stop the flow of materials and contain/absorb small spills with dry sand, earth or vermiculite. Don’t use combustible materials. If possible, carefully neutralize spilled electrolyte with soda ash, sodium bicarbonate or lime. Wear acid-resistant clothing, boots and gloves, and a face shield. Do not allow discharge of un-neutralized acid to drain into the sewer.

Battery storage and recharge

Batteries lose charge or self-discharge due to slight differences in local areas of the plates that discharge the battery. In effect, there are tiny batteries inside that are not open-circuited and will discharge locally some of the active material. Self-discharge of the battery occurs continuously whether the battery is standing open-circuited or operating in the UPS. When the charger is on, a portion of the float current (i.e. small current flowing through the battery) goes toward overcoming self-discharge and keeps the battery fully charged.

When your UPS battery has lost significant charge while not in use, recharging (or restoring electric charge of your UPS through another source) may be necessary. Proper recharging within the stated shelf life will maintain the runtime to that of a new battery. If a battery has lost significant charge in storage, Eaton recharges it and adds a new label noting the next “recharge by” date. Locate the label on your battery to find the recharge date and appropriately manage your battery maintenance.

If a battery system in the field is approaching the recharge date and the UPS will not be installed before that date, then plans should be made to recharge the batteries. UPS systems can be connected to a temporary feed to recharge the batteries. In some cases, external battery charging systems can be brought in to perform a refreshening charge. Use the Original Equipment Manufacturer (OEM) to recharge batteries in the field to guarantee that the battery manufacturers’ guidelines are met and your warranty is maintained.

Failure to put the battery system in service or failure to recharge before the “recharge by” date will result in a permanent loss of battery capacity as well as cancellation of the battery warranty.

Battery date code chart for UPS productions:

Supplied	Date code identifier
Eaton	YYMMDD
CSB	YYMMDD
C&D Dynasty	MMYY
Enersys	MMYYY
Enersys High Rate	DDMMMYY
Northstar	YYDDD (Julian)
Panasonic	MMDDYY
Yuasa / B&B	YYMMDD

Battery FAQ

1. What is the "end of useful life"?

The IEEE defines "end of useful life" for a UPS battery as being the point when it can no longer supply 80% of its rated capacity in ampere-hours. When your battery reaches 80% of its rated capacity, the aging process accelerates and the battery should be replaced.

2. How can I ensure that my UPS batteries are maintained and serviced properly?

With proper maintenance, battery life can be predicted and replacements scheduled without interrupting your operations. These are IEEE and OEM recommendations for general maintenance:

- Comprehensive maintenance programs with regular inspections
- Re-torque all connections, as required
- Load testing
- Cleaning the battery area, as required

3. Do I have to replace my UPS batteries with the same brand of batteries?

Eaton recommends that if you use brand X and need to replace one or two batteries in the string, you should use the same brand because it will have the same characteristics. If you need to replace the whole battery system, then you can change brands with fewer risks.

4. Are maintenance-free batteries maintenance free?

Though sealed batteries are sometimes referred to as maintenance-free, they still require scheduled maintenance and service. The term maintenance-free refers to the fact that they don't require fluid. Preventive maintenance is the key to maximizing your UPS battery service life.

5. What about battery disposal?

It's imperative that your service technicians adhere to EPA and UN guidelines for the disposal of all UPS batteries. Remember, it's the owner's responsibility to make sure these guidelines are followed.

6. Is there any difference between the batteries used by smaller UPSs, from 250 VA to 3 kVA, and the ones used by larger UPSs?

While basic battery technology, and the risks to battery life, remain the same regardless of UPS size, there are some inherent differences between small and large applications. Smaller UPSs typically have only one VRLA battery that supports the load and needs maintenance. As systems get larger, increasing battery capacity to support the load gets more complicated. Larger systems may require multiple strings of batteries, introducing complexity to battery maintenance and support. Individual batteries must be monitored to prevent a single bad battery from taking down an entire string and putting the load at risk. Also, as systems get larger, flooded-cell batteries become more common. The differences in battery maintenance between VRLA and flooded-cell batteries discussed earlier apply.

7. Our facility was damaged by a flood and our batteries were partially submerged in water. What should we do?

The first concern in this situation is safety. Containing any contamination is critical to preventing hazards to workers and the environment.

8. My UPS has been in storage for over a year. Are the batteries still good?

As batteries sit unused, with no charging regimen, their battery life will decrease. On average batteries lose 3% of capacity every 30 days they sit uncharged, due to the self-discharge characteristics of lead-acid batteries. It is imperative that they are charged periodically during storage according to the battery manufacturer's guidelines for temperature, charge duration and resting period or permanent loss of it's capacity will occur. Note that lithium-ion batteries' shelf life is 6 months at 25°C before an inspection is required.

9. What is thermal runaway?

Thermal runaway occurs when the heat generated in a lead-acid cell exceeds its ability to dissipate it, which can lead to a thermal breakdown, especially in sealed cells. The heat generated in the cell may occur without any warning and may be caused by overcharging, excessive charging, internal physical damage, internal short circuit or a hot environment.

Thermal runaway incident

Thermal runaway effects on adjacent battery cabinet

10. Is it safe to transport sealed batteries?

VRLA batteries marked as "non-spillable" are safe and approved for all transportation methods as long as the container is free of blemishes and local DOT regulations are followed. However, lithium-ion battery shipments are governed under UN Class 9 requirements and designated procedures.

11. What is the difference between hot-swappable and user-replaceable batteries?

Hot-swappable batteries can be changed out while the UPS is running. User-replaceable batteries are usually found in smaller UPSs and require no special tools or training to replace. Batteries can be both hot-swappable and user-replaceable. Note that proper Personal Protective Equipment (PPE) may be required. Please check your user's guide for details on your UPS batteries , and note that local codes may disallow hot swap activities.

12. If I add more batteries to a UPS, can I add more load?

Adding more batteries to a UPS can increase the battery runtime to support the load, but it doesn't increase the UPS capacity. Be sure your UPS is adequately sized for your load, then add batteries in parallel to fit your runtime needs.

13. What is the average lifespan of UPS batteries?

The standard service lifespan for VRLA batteries is three to five years; lithium-ion, 10 years, and for flooded-cell batteries it's up to 20 years. However, expected life can vary greatly due to environmental conditions, number and depth of discharge cycles, and adequate maintenance. Having a regular schedule of battery maintenance and monitoring will ensure you know when your batteries are reaching their end-of-life.

14. If I have the serial number from the Eaton UPS or battery cabinet, can I find out how old the batteries are?

Every Eaton battery has a manufacturer date code that indicates when it was made. The battery or battery cabinet will also feature a sticker for each time the batteries have been recharged while in storage. Stored batteries require charging periodically to avoid loss of capacity. Recharging stored batteries doesn't affect battery warranty as long as it does not exceed a battery manufacturer's guidelines for the number of recharges before it is put into service.

15. Will Eaton replace batteries for other manufacturers' UPSs?

Yes. Eaton batteries work on nearly all other manufacturers' UPSs. In addition, we have extensive knowledge of Best Power, Tripp Lite, Deltec, IPM and Exide Electronics models because these product lines were purchased by Eaton.

16. What are the risks associated with a lack of battery maintenance?

The primary risks of improperly maintained batteries are: load loss, fire, property damage and personal injury.

17. Who are the major battery manufacturers?

There are many battery manufacturers, but the major ones are: C&D, Enersys, CSB, Samsung, Yuasa, Panasonic and GS – to name a few.

18. If I have one bad battery, should I only replace that faulty battery, or replace the entire battery string?

Having one faulty battery doesn't mean you have to replace the entire battery string, which can be very costly. You can replace the bad battery with a fully charged unit, but you also need to test the health of the entire string to the cell level to identify whether additional strain from the faulty battery damaged other units.

All it takes is one bad battery to ruin an entire string and bring your systems down during a power outage or other interruption. There is no precise way to predict battery failure. Continuous battery monitoring and scheduled maintenance are the most effective ways to identify bad batteries early enough for spot replacement.

19. Why do batteries fail?

Batteries can fail for a multitude of reasons, but common reasons are:

- High or uneven temperatures
- Inaccurate float charge voltage
- Loose inter-cell links or connections
- Loss of electrolyte due to drying out or damaged case
- Lack of maintenance, aging

20. What is the importance of power density when talking about batteries?

Batteries differ markedly in the number of watts per cell. A higher density battery provides more runtime for the footprint. You may even find you can reach your runtime requirements with fewer battery cabinets, which reduces upfront and lifetime costs of battery preventive maintenance.

21. How is battery performance generally measured?

Batteries are generally rated for 100+ discharges and recharges, but many show a marked decline in charging capacity after as few as 10 discharges. The exception is lithium-ion batteries which are typically rated for a larger number of discharges over their service life. The lower the charge the battery can accept, the less runtime it can deliver. Look for batteries with a high-rate design that sustains stable performance for a long service term.

22. When are 10-year design life VRLA batteries typically replaced in standard UPS applications?

UPS battery life depends on a number of factors, including operating temperature, number and duration of discharges, and if regular preventive maintenance is performed. While it's theoretically possible for VRLA batteries to last 10 years under optimum conditions, the industry typically recommends full replacement between years four and five for reliability purposes in UPS applications. Note that lithium-ion battery typical replacement interval is 10 years.

23. How can I determine the age of a battery?

Batteries shipped on or after January 1, 2000 have a four-digit shipping code with the first two digits as the year and the following two as the month in which the battery was shipped from the factory. For example, a code of 1710 would be interpreted as 2017, October.

Eaton battery products and services

Eaton's line of premium batteries for Eaton three-phase UPS models is backed by a service network of trained and qualified battery service technicians

Eaton battery services overview

Eaton provides a comprehensive set of services for batteries.

- **Battery preventive maintenance/onsite inspection**: technicians test, inspect, clean and analyze battery performance and provide a detailed report that includes any recommendations for corrective action
- **Eaton battery:** includes options to replace individual batteries or the entire string
- **Eaton Cellwatch:** Comprehensive battery monitoring
- **10% partial replacement coverage:** coverage for parts and labor for a bad battery up to 10% of the total count of batteries installed
- **Customer Support Center:** complete 24x7 command center for all Eaton services

For more information on Eaton batteries, please visit Eaton.com/UPSbatteries

Battery preventive maintenance

Preventive maintenance ensures uptime and extends battery life by eliminating problems before they happen. Whether a battery fails from defect or deterioration, the best time to find out is during preventive maintenance service, not when the battery is called on to support the critical load. Eaton will custom design a preventive maintenance package that's best for you, including the following features:

- Comprehensive maintenance schedule for your VRLA or flooded-cell batteries per IEEE guidelines
- Measure cell voltage levels
- Visual inspection for leaks or bad cells
- Spot check for connection torques
- Load testing
- Inspection of battery environment
- Detailed hard copy of battery test and inspection results
- Written inspection report and recommendation

This also includes spot replacement of batteries. When we identify one or two bad batteries, we replace them immediately onsite if the Eaton technician has replacements available at the time of the preventive maintenance regimen, or schedule prompt replacement if batteries need to be ordered.

Eaton VRLA battery models available

Model	Warranty	Labor adder
Eaton 12V 34W battery	2-year parts/1-year labor	2-year parts/2-year labor
Eaton 12V 120W battery	2-year parts/1-year labor	2-year parts/2-year labor
Eaton 12V 200W battery	3-year parts/1-year labor	3-year parts/3-year labor
Eaton 12V 280W battery	3-year parts/1-year labor	3-year parts/3-year labor
Eaton 12V 330W battery	3-year parts/1-year labor	3-year parts/3-year labor
Eaton 12V 390W battery	3-year parts/1-year labor	3-year parts/3-year labor
Eaton 12V 502W battery	3-year parts/1-year labor	5-year parts/5-year labor
Eaton 12V 540W battery	3-year parts/1-year labor	3-year parts/3-year labor
Eaton 12V 620W battery	3-year parts/1-year labor	3-year parts/3-year labor
Eaton 12V 651W battery	3-year parts/1-year labor	5-year parts/5-year labor

Eaton batteries

As a part of our commitment to delivering the highest reliability in power availability, Eaton offers a line of premium batteries for our three-phase UPS models. Eaton batteries combine field-proven performance and quality at competitive pricing and are backed by our network of trained battery customer service engineers.

Prior to using a battery in an Eaton product, a thorough review of the performance, manufacturing and design data is conducted. The presence of specific attributes of the design and manufacturing process, important for UPS battery use, is confirmed.

Following the review and assuming the outcome is successful, a statistically significant sample of the batteries is obtained from the manufacturer. This sample is required to have been built from the manufacturer's existing process for that battery. A series of tests and physical examinations are conducted on this sample; including a set of discharges using various loads to characterize the performance of the battery, charge tests and tests for float current stability at normal to high-float voltages. Failures or inconsistencies in performance are investigated further and reviewed by the manufacturer. In some cases, a tear-down analysis is performed to identify the cause of the problem. If the battery is found acceptable and all open issues are resolved, a limited series of discharges, with recharge, are performed.

This intense and thorough quality testing ensures that Eaton batteries are ready for peak performance at their stated capacity as soon as they're deployed.

Why Eaton batteries?

Proven performance. Eaton batteries have been thoroughly tested by our engineering team and shown to adhere to our stringent performance and quality specifications.

High power density. An optimized design delivers more watts per cell and more power per volume than other batteries on the market. As a result, Eaton batteries provide more runtime per footprint and dollar.

High-rate design. Charge after charge, batteries approved for the Eaton brand sustain high runtime levels, while performance of non-qualified batteries drop off markedly after only 10 discharges.

Extended warranty coverage. Eaton offers a full three years (excluding 34W and 120W battery models which are two years) of parts coverage with full (not pro-rated) replacement of any failed battery. In the unlikely event a replacement battery fails within the first year, Eaton will send a technician on-site to install the replacement battery at no charge. With regional stocking locations, we can get replacement batteries to you quickly.

Expert technical support. Eaton batteries are backed by our service network of trained and qualified battery service engineers who are available to install and maintain your batteries. Beyond the warranty period, you can choose battery monitoring services and maintenance plans that take the guesswork and administrative tasks out of battery management.

Easy installation. No special harnesses are needed when these batteries are installed with new UPSs. Harnesses are readily available for legacy UPSs.

Eaton Cellwatch battery monitoring system monitors key performance indicators for each individual battery to provide adequate time to detect and replace a bad battery, mitigating the risk of downtime

Eaton Cellwatch

Eaton Cellwatch is an advanced battery monitoring system for three-phase UPSs. All information collected by Eaton Cellwatch is gathered at a central monitoring unit, where it's analyzed on Windows®-compatible software. The system uses fiber-optic technology, which is non-conducting and introduces no electrical noise, so all readings are precise and accurate.

Eaton Cellwatch provides continuous monitoring of your batteries to allow you to proactively identify and address battery issues. This includes:

- Monitoring of voltage, internal resistance and temperature
- Immediate warning and specific battery identification of deterioration and imminent failure
- Reduction of the possibility of damage to entire battery string
- Replacement based on actual battery condition, preventing costly premature replacement
- Minimum of 120 days of activity history, enabling you to trend individual battery and string performance
- Continuous monitoring of string and battery discharge currents ranging from 25A to 1000A
- Programmable alarm functions
- Remote monitoring capabilities (optional)
- May be used to detect thermal runaway in advance

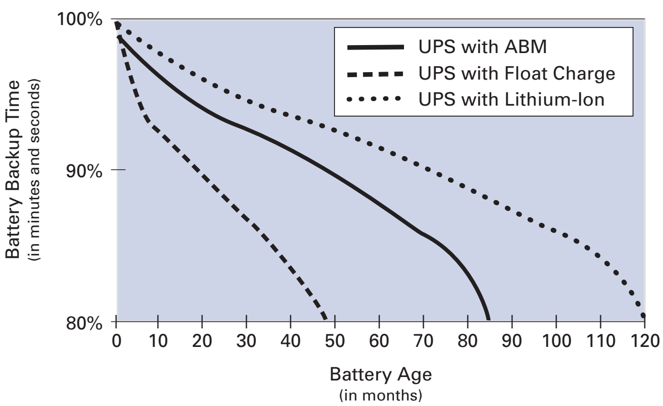
Thermal runaway

Thermal runaway is the most dangerous and potentially catastrophic situation involving lead-acid batteries. It occurs when the heat generated in a lead-acid cell exceeds its ability to dissipate it, which can lead to a thermal breakdown, especially in sealed cells. The heat generated in the cell may occur without any warning signs and may be caused by overcharging, excessive charging, internal physical damage, internal short circuit or a hot environment.

By monitoring every jar or cell in the battery system for signs of failure, Eaton Cellwatch is uniquely suited to find the causes and symptoms of thermal runaway before damage occurs.

Extending battery service life

Eaton's ABM® technology uses a unique three-stage charging technique that significantly extends battery service life and optimizes recharge time compared to traditional trickle charging. An integrated battery management system tests and monitors battery health and remaining lifetime and provides advance notification to guide preventive maintenance. Optional temperature-compensated charging, available on some UPS models, monitors temperature changes and adjusts the charge rate accordingly to properly charge the battery and greatly extend battery life. A variable battery bus accommodates 384V to 480V configurations, so the battery capacity can be matched to your exact runtime requirements—either a specific runtime, an extension to existing battery runtime or legacy battery installations. With remote monitoring of the UPS and battery system, Eaton is able to respond to alarms and real-time battery data to avert potential battery problems. Note: ABM is not applicable for flooded-cell or lithium-ion systems.



Although batteries are sold with a variety of published life spans, the fact is, some demonstrate a useful life of as little as three to five years. Eaton's exclusive ABM technology significantly increases the life of VRLA UPS batteries.

Eaton PredictPulse Insight

Remote monitoring and management is like a second set of eyes that keeps tabs on your equipment 24 hours a day, 7 days a week and will notify you of any issues. PredictPulse™ Insight is a monitoring and management service that collects and analyzes data from connected power infrastructure devices, providing us with the insight needed to make recommendations and take action on your behalf. Once activated, managed devices send parametric data to Eaton's monitoring center every 15 minutes. We compare current and historical performance data against specified parameters to determine if anything is out of the ordinary. At the same time, the data appears on your PredictPulse dashboard and alarms in the mobile app. If something is amiss, we'll notify you of the alarm and how we recommend addressing it.

This means less time spent managing IT equipment, reduced risk, access to real-time status information and expedited repairs. You'll also receive a report each month summarizing the past 30 days of status, performance, alarms and upcoming service needs.

The Eaton Customer Monitoring Center stands ready to assist 24x7

Customer Monitoring Center

Eaton's global 24x7 service operations command center is a hardened, secure facility for all UPS product service scheduling, technical support and remote monitoring support.

Customer support staff are trained to qualify and prioritize all incoming calls using defined processes, complemented by a knowledge database, with tech support and domain experts at their disposal 24x7.

The benefits of the Customer Monitoring Center include:

- **Increased reliability** via remote diagnostic and remote repair tools delivered by Eaton product experts
- **Expedited service** response to critical UPS and battery alarms (reduces risk and cost of downtime)
- **24x7 notification** of critical alarms or trends
- **Eases customer hassle** of managing battery health
- **Saves time** for busy facility or IT managers
- **Enhanced internal self-monitoring** resources and capabilities
- **Monthly reports** designed for both technical and non-technical use
- **Development of trending database** on both UPS and battery

Products & Services

Maintaining uptime, even in the world's worst weather

The Mt. Washington Observatory can't have any interruptions in power, which is why we have the Eaton UPS. We're collecting data continuously, and those types of instruments do not like interruptions in power. It's also holding together our entire IT infrastructure.

Cyrena-Marie Briedé, director of summit operations

The Mt. Washington Observatory (MWO) is a private, non-profit scientific and educational institution dedicated to advancing the understanding of the natural systems that create the Earth's weather and climate. The summit of Mt. Washington is home to some of the most dangerous and unpredictable weather in the world, so MWO maintains a mountaintop station to conduct research, oversee educational programs and collect real-time data that feeds into the National Weather Service's forecast models.

At an elevation of 6,288 feet, the observatory is prone to direct lightning strikes; during winter, conditions become even more treacherous with ice, snow and blistering hurricane-force wind gusts—all of which can knock out electricity.

In winter, the Mt. Washington Observatory is an ice and snow palace, battered by hurricane-force wind gusts

Years ago, MWO deployed a 15 kVA Eaton 9355 uninterruptible power system (UPS) with more than 170 minutes of runtime to help ensure that even when the most extreme weather hits, the organization can continue gathering and storing vital data.

When an outage happens, the 9355 immediately kicks on to keep MWO's systems operating until its generator can power up. Although this usually takes just a matter of seconds, without a highly reliable UPS to bridge the gap, those seconds could result in holes in the organization's 80-year continuous weather history.

While the 9355 performed flawlessly through the years, by 2014, its batteries needed to be replaced. The MWO IT team reached out to Eaton to arrange a battery replacement and get the UPS on a service plan.

Discovering that MWO had reduced its equipment since the UPS was first installed, Eaton's service team determined that 90 minutes of runtime—rather than the originally slotted 170 minutes— would be more than sufficient for the organization.

The field technicians trekked to the top of Mt. Washington with four new strings of batteries for the observatory. They safely removed 32 trays of batteries and two cabinets—about 3,840 pounds of materials. This helped MWO significantly consolidate its UPS solution, saving valuable space at the summit.

Eaton's reliable service was invaluable to the staff at MWO. "We're in an extreme environment here...we have to fix things on site and there's no hardware store just down the street," said an IT specialist at MWO. "Even in the best of conditions, we're a difficult place to get to. Eaton still manages to provide service on a regular basis and when we need it."

With a more compact UPS solution, real-time system updates and the addition of an environmental monitoring probe, MWO is in an excellent position to preserve its 80-year weather history and capture as much data as possible during extreme weather.

Battery glossary

Absorbed electrolyte – Electrolyte that's been immobilized in an absorbent separator.

Absorbed electrolyte cell – A cell, usually a valve-regulated sealed lead-acid type, which utilizes absorbed electrolyte.

Absorged glass mat (AGM) battery – Designed with electrolytes held in thin glass fibers woven into a mat to increase surface area enough to hold sufficient electrolyte on the cells for their lifetime. AGM batteries are also known as "starved electrolyte" or "dry" because the fiberglass mat has no excess fluid.

Accessories – The components required to complete the battery installation, including connectors, flame-arrestor vents, cell numbers and hardware.

Activation charge – The process of making a dry-charged cell functional by introducing electrolyte and charging.

Active material – The material in the electrodes (plates) of the cell that reacts chemically to produce electric energy when the cell discharges, which is restored to its original composition during the charge process.

Actual capacity – The total number of ampere-hours that could be withdrawn from a cell based on a specific set of operating conditions (including initial state-of-charge, discharge rate, initial cell temperature and end voltage) and the age of the cell.

Ambient temperature – The average temperature of the surrounding air that comes into contact with the battery.

Anode – The electrode in an electrochemical cell where oxidation takes place. During discharge, the negative electrode of the cell is the anode. During charge, this reverses and the positive electrode of the cell is the anode.

As found (condition) – A term used to inform the person performing a capacity test that the battery should be tested without performing certain checks, so the test results will reflect the effect (good or bad) of the maintenance practice followed for the installation.

Average temperature – The average of the individual cell temperatures of all the cells in a battery.

Average voltage – The average of the individual cell voltages of all the cells in a battery. This term may be applied to a variety of conditions, including average float voltage and average discharge voltage.

Battery – Two or more cells connected together electrically. Cells may be connected in series or parallel, or both, to provide the required operating voltage and current levels.

Battery charger – An apparatus that restores the charge of a secondary battery. Also known as a rectifier.

Battery duty cycle – The load a battery is expected to supply for a specified time period.

Battery management system – Required for lithium-ion systems, this monitors and controls cell balance and can take action to disconnect a failing battery string automatically.

Battery monitor – A piece of equipment used to monitor various parameters of a battery, such as individual cell voltage, battery voltage and temperature.

Battery nominal voltage – The nominal voltage of one cell multiplied by the number of cells in the battery.

Battery rack – A structure used to support a group of cells. The most common rack material is steel with a corrosion-resistant coating.

Boost charge – An overcharge of any length.

Cathode – The electrode in an electrochemical cell where reduction takes place. During discharge, the positive electrode of the cell is the cathode. During charge, this reverses and the negative electrode of the cell is the cathode.

Carbonization – A condition where the electrolyte becomes contaminated with potassium carbonate to a point where it influences cell performance.

Capacity – The ampere-hour capacity assigned to a cell by the manufacturer for a given discharge time, at a specified electrolyte temperature and specific gravity to a given end-of-discharge voltage.

Cell – The basic electrochemical unit, characterized by an anode and cathode, used to receive, store and deliver electrical energy.

Cell temperature – The temperature at which a cell is operating. In the U.S., the reference for cell temperature is 25°C (77°F).

Charge – The conversion of electrical energy into chemical energy within a secondary cell.

Closed-circuit voltage – The voltage of a cell when it's discharging.

Constant current charge – A charge in which the current output of the charge is maintained at a constant value. Sometimes this may be accomplished using two-rate charging.

Constant voltage charge – A charge in which the potential voltage at the output terminals of the battery charger is maintained at a constant value.

Cycle – A discharge and subsequent charge of a cell.

Coup de fouet – describes the fast voltage drop and subsequent recovery of the battery voltage at the beginning of a discharge.

Density – The weight of a given volume of electrolyte at a specified temperature.

Depth of discharge – The ampere-hours removed from a fully charged battery, expressed as a percentage of its rated capacity at the applicable discharge rate.

Discharge – The conversion of chemical energy into electrical energy within a cell.

Discharge rate – The rate in amperes at which current is delivered by the battery.

Dry-charged cell – A cell that's been assembled with its plates dry, and in a charged state, ready to be activated by the addition of electrolyte...allowing easier shipping and storage.

Efficiency – The electro-chemical efficiency, expressed as a percent, of the ratio of the ampere-hour output of the battery, to the ampere-hour input required to restore the initial state of charge.

Electrode – The site at which the electrochemical reaction takes place.

Electrolyte – A conducting medium in which the flow of electric current takes place.

Element – The positive and negative plate groups with separators assembled for one cell.

End cell – A cell that can be added to or removed from a battery circuit to adjust battery voltage.

End voltage – The cell voltage at which the discharge is terminated.

Energy density – The ratio of the available energy from a cell to its volume or weight.

Flame-arrestor vent – A cell-venting device that prevents the propagation of an external flame into the cell.

Flame-retardant material – A material capable of limiting the propagation of a fire beyond the area of influence of the energy source that initiated it.

Float current – The current drawn by a cell that's being float charged.

Float voltage – The voltage applied during full-float operation.

Flooded-cell – A cell design that's characterized by an excess of free electrolyte, and in which the products of electrolytes, such as gasses, and evaporation, can freely exit the cell through a vent. (Also see wet-cell.)

Freshening charge – A charge given to a battery following non-use or storage.

Full-float operation – Operation of a DC system with the battery, battery charger and load connected in parallel, with the battery charger supplying the normal DC load plus any self-discharge or charging current, or both, required by the battery.

Fully-charged – The condition that exists following a long-term constant current charge.

Gassing – Evolution of gas by one or more of the plates in a cell, resulting from electrolysis of water into hydrogen and oxygen within a cell during charging, overcharging or local action. Lithium-ion batteries, if overcharged, may emit small amounts of gasses (CO2, CO, Phosphorus Oxide). See the vendor's MSDS for safety measures.

Gelled electrolyte – Electrolyte that's been immobilized by the addition of a gelling agent.

Gelled electrolyte cell – A cell, usually lead-acid or VRLA, that uses gelled electrolyte.

General purpose cell – A cell designed to supply a duty cycle requiring a high current for a short period of time followed by a low current for a long period of time. This term is used in the U.S. for cells designed for switchgear tripping, generating stations and control applications.

Grid – A framework for a plate in a cell that supports or retains the active material and conducts the electric current.

High level line – A line on the side of a jar that shows the maximum level of electrolyte that should be present in a cell.

High performance cell – A cell designed to supply a duty cycle requiring a high current for a short period of time.

Hit – Indicates that a standby battery has been discharged.

Hit counter – A device used to record the number of discharges experienced by a battery.

Hydration (lead-acid cell) – A condition caused by discharging a cell, and failing to recharge it in a timely manner.

Immobilized electrolyte – Electrolyte that's retained by a gel or absorbent mat.

Initial charge – The charge given to a new battery before placing it in service.

Initial voltage – The closed-circuit voltage at the beginning of a discharge.

Integrity test – A test used to detect conduction path problems.

Inter-cell connection resistance – The total electrical resistance of the connection between the terminals of two cells that are electrically connected to each other.

Inter-cell connector – An electrical conductor used to connect adjacent cells on the same rack.

Inter-cell connector safety cover – An insulated cover placed over the inter-cell connector and post, used to prevent accidental contact by personnel or accidental short circuiting of the cell.

Inter-rack connector – An electrical conductor used to connect cells on two separate racks, most often insulated copper wire.

Internal impedance – The resistance of a cell to an alternating current of a specific frequency.

Internal resistance – The resistance of a cell to an electric current within a cell.

Internal voltage drop – The product of the current passing through the cell.

Jar – The container that holds a cell or group of cells. Common jar materials include thermoplastics, but hard rubber is sometimes used as well and nickel-cadmium cells may be in steel containers. Jars for flooded lead-acid cells are normally transparent to allow inspection of the plate and sediment.

Jar-to-cover seal – The seal at the interface of the jar and cover.

Lead-acid cell – A secondary cell in which the electrolyte is a solution of sulfuric acid in water. Lead-acid cells include pure lead cells and lead alloy cells such as lead-antimony, lead-calcium and lead-selenium.

Level line – A line or set of lines on the sides of the jar used to indicate the cell's minimum or maximum of electrolyte level.

Lithium-ion cell – Lithium-ion cells, made of lithium and other metals and chemicals, are lighter and more energy dense than comparable lead acid cells. They are typically packaged in a 'module' that contains enough cells to attain the desired voltage and current capability. Each cell is comprised of metal electrodes, separators, internal fusing and vents, along with a management circuit that controls its balance of current and voltage, ensuring over-temperature conditions do not occur.

Local action – The internal losses of a battery standing on open-circuit or on float charge, without considering any losses incidental to any discharge.

Long duration cell – A cell designed to supply a duty cycle requiring a low current for a long period of time.

Low level line – A line on the side of a jar that represents the minimum level of electrolyte that should be present in a cell.

Modified-plante plate – A lead-alloy grid containing holes into which pure lead corrugate strips are placed.

Multi-cell container – A multi-compartment container in which each compartment may contain an individual cell.

Multi-cell unit – A multi-cell container in which cells are installed.

Negative plate – The electrode to which current flows from the external circuit when the cell is discharging.

Negative terminal – The terminal toward which positive charge flows in the external circuit, such as from the positive terminal, when the cell discharges.

NiCad battery – A sealed storage battery having a nickel anode, a cadmium cathode, and an alkaline electrolyte.

Nominal gravity – The specific gravity of the electrolyte selected for the determination of the rated capacity of the cell when it's fully charged.

Open-circuit voltage – The voltage of a cell with no current flow in either direction after the cell has had time to stabilize.

Overcharge – The forcing of current through a battery after it's been fully recharged.

Oxygen index – The minimum concentration of oxygen, expressed as volume percent, in a mixture of oxygen and nitrogen that will just support flaming combustion of a material initially at room temperature.

Oxygen recombination – A process whereby oxygen generated at the positive electrode recombines with hydrogen at the negative electrode to convert to water.

Oxygen recombination efficiency – A ratio of the quantity of oxygen recombined to the total amount of oxygen generated.

Parallel – The interconnection of cells in which all the like terminals are connected.

Parallel strings – The interconnection of two or more strings in which the like terminals of each string are connected.

Pasted plate – A grid filled with active material applied as a paste.

Performance test – A constant-current capacity test made on a battery after being placed in service to detect any change in the capacity determined by the acceptance test.

Pilot cell – A selected cell whose condition is assumed to indicate the condition of the entire battery.

Plante plate – A pure lead plate for a lead-acid cell in which the active material is formed directly from a lead substrate.

Plate – An assembly of active materials on a supporting framework grid, frame or support strip. (Also called an electrode.)

Pocket plate – A plate in which the active material is held in perforated metal pockets on a support strip. Usually used for nickel-cadmium cells.

Point (of specific gravity) – One-thousandth of specific gravity (SG).

Polarization – The change in voltage at the terminals of a cell when a specified current is flowing into it.

Positive plate – The electrode from which the current flows to the external circuit when the battery is discharging.

Positive terminal – The terminal from which the positive electric charge flows through the external circuit to the negative terminal when the cell discharges.

Power density – The ratio of the available power from a cell to its volume or weight.

Rated capacity – The ampere-hour capacity assigned to a cell by its manufacturer for a given discharge time, at a specified electrolyte temperature to a given end-of-discharge voltage.

Recombination vent – A vent in which most of the gasses escaping from the cell are catalytically recombined and returned to the cell as water.

Reference electrode – A special electrode that has a reproducible potential against which other electrode potentials can be referred.

Retainer – Any material that is used to prevent the loss of active material from the positive plate.

Reversal – A changing of the normal polarity of a cell.

Rundown test – A partial discharge test to a voltage other than the system designed and voltage.

Sealed, lead-acid (SLA) battery – non-spillable, maintenenace-free valve regulated batteries designed with vents that cannot usually be removed.

Secondary cell – An electro-chemical cell that's capable of being discharged and then recharged.

Secondary battery – Two or more secondary cells connected electrically.

Sediment – The active material that separates from the battery plates and falls to the bottom of the jar.

Self-discharge rate – The amount of capacity reduction occurring per unit of time in a battery as a result of self-discharge.

Separator – An ionic permeable, non-conductive spacer used to prevent metallic contact between plates of opposite polarity within a cell.

Series – The interconnection of cells in such a manner that the positive terminal of the first is connected to the negative terminal of the second and so on.

Service life – The period of time during which a fully charged battery is capable of delivering at least a specified percentage of its rated capacity. For most lead-acid battery designs this is 80%.

Shipping vent – The vent placed in the cell for the purpose of shipping it.

Specific gravity – The ratio of the weight of a given volume of electrolyte to the weight of an equal volume of water at a specified temperature.

Standby battery – A battery designed to function only when the normal source of power fails.

State-of-charge – The actual capacity of a cell, expressed as a percent of its rated capacity, that would be available if a discharge were to occur.

Stationary battery – A secondary battery designed for service in a permanent location.

Step rack – A rack in which cells are placed at different levels in a stepped arrangement.

Strap – The component in a cell where all the plates of like polarity are joined.

String – A common way to refer to a number of cells connected in series to form a battery system.

Storage life – Also known as shelf life is the period of time when a battery is in storage. During a battery's storage or shelf life, no current is flowing into the battery, which means there can be no corrosion of the positive grid inside the battery. Assuming standard operating procedures are followed, a battery's shelf life does not impact service life performance or warranty.

Sulphation (lead-acid cell) – A state where the battery has developed an abnormal amount of sulphate and its capacity is impaired which is different from normal sulphate that occurs during discharge.

Taper charge – A charge in which both current and voltage decrease over the recharge period.

Terminal – The part of a cell to which the external circuit is connected.

Thermal runaway – A condition in which a cell on charge or discharge will destroy itself through internal heat generation caused by high overcharge or over-discharge current or other abusive conditions.

Tier rack – A rack in which cells are placed directly above each other at different levels.

Trickle charge – A charge given to a battery with no external load connected to it to maintain it in a fully charged condition.

Valve – A normally sealed mechanism that allows for the controlled escape of gasses from within a cell.

Valve-regulated sealed lead-acid cell – A cell that's sealed and fitted with a valve opens to vent it whenever the internal pressure exceeds the external pressure by a set amount.

Vent – A device that allows the escape of gasses from within a cell.

Voltage efficiency – A ratio of the average voltage during discharge to the average voltage during recharge, under specified conditions.

Voltage spread – A term used to describe the difference between the highest and lowest individual cell voltage readings in a battery.

Volts per cell (VPC) – The voltage of each individual cell in a battery string.

Wet-cell – A cell design that's characterized by an excess of free electrolyte, and in which the products of electrolytes, such as gasses, and evaporation can freely exit the cell through a vent. (Also see flooded-cell.)

For more information, visit

Eaton.com/UPSbatteries

or call **1.800.356.5794**

Looking for additional information on lithium-ion batteries? Please visit

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