

PowerChain Management solutions

# The UPS Battery Handbook



**EATON**

*Powering Business Worldwide*

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## The UPS Battery Handbook

### **Understanding your UPS battery can extend battery life, prevent costly downtime and save time and money**

It's well understood that the battery in a UPS is the most vulnerable part of the system. In fact, battery failure is a leading cause of load loss. Knowing how to maintain and manage your UPS batteries will extend battery life and save you time and trouble in the future.

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 adding intelligence to the batteries have reduced, but not eliminated, the risks inherent in depending on any battery. Therefore it is prudent, if not essential, to take a close look at what may be increasing your risk of unexpected load loss from a failing UPS battery. After all, even large installations with many batteries are vulnerable to the failure of a single battery.

# UPS battery overview

There are primarily two kinds of batteries used in UPSs — valve-regulated lead-acid (VRLA) batteries, also known as sealed or maintenance-free, and wet-cell (also called flooded-cell). VRLA batteries usually have lower up-front costs but have a shorter lifetime than wet-cell, usually around five years. Wet-cell batteries require more advanced maintenance but have a longer lifetime, up to 20 years.



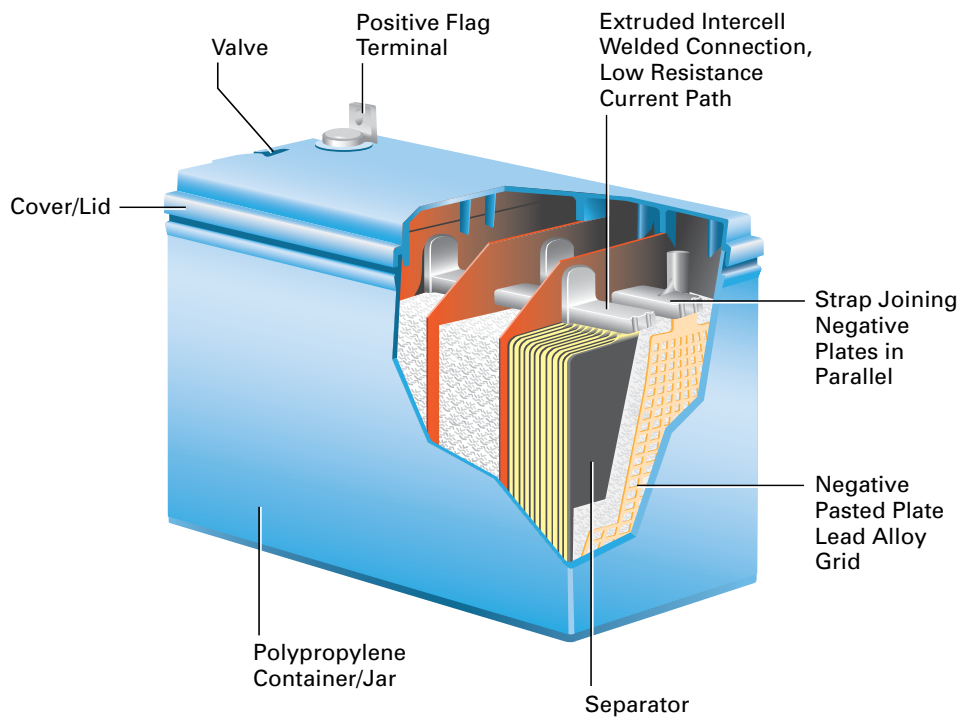
**VRLA batteries are frequently used in UPS or other high-rate applications.**

## VRLA

VRLA batteries are sealed, usually within polypropylene plastic. VRLAs were developed because they have the advantage of containing no sloshing liquid 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.

During 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, so water loss is minimized. Under normal float conditions, virtually all of the hydrogen and oxygen is recombined. Re-sealable valves vent non-recombined gases only when 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 cannot be added, recombination of water is critical to the life and health of a VRLA battery. Any factor that increases the rate of evaporation or water loss reduces the life of the battery. Such factors can include ambient temperature and heat from the charging current.



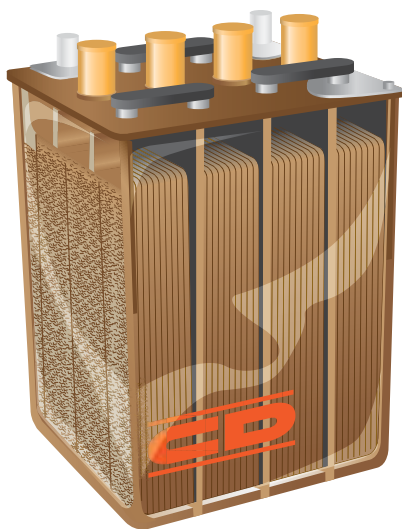
**Internal and external components of a valve-regulated lead-acid (VRLA) battery.**



## Wet-cell/flooded-cell

Wet-cell/flooded-cell batteries have thick lead-based plates that are flooded with an acid electrolyte. This is a highly reliable design — 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. However, while they are very reliable with a long life, there are downsides to wet-cell batteries as well. They require more safety measures, and a space-consuming separate battery room to use this technology.

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



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

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. These components include:

- **Electrolyte** – The medium that provides the ion transport mechanism between the positive and negative electrodes of a cell; in VRLA batteries the electrolyte is immobilized, while in flooded-cell batteries it is in liquid form
- **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



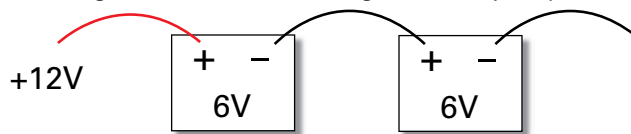
Wet cell batteries in a large battery room application

## Battery arrangement and power

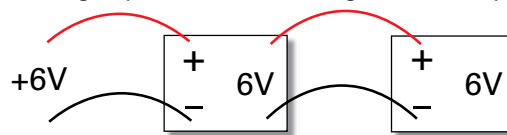
In most UPSs, you do not use just one cell at a time. They are normally grouped together serially to form higher voltages, or in parallel to form higher currents. In a serial arrangement, the voltages add up. In a parallel arrangement, the currents add up.

However, batteries are not quite as linear as the two graphics to the right depict. For example, all batteries have a maximum current they can produce—a 500 milliamp-hour battery cannot produce 30,000 milliamps for one second, because there is no way for the battery's chemical reactions to happen that quickly. And at higher current levels, batteries can produce a lot of heat, which wastes some of their power.

Connecting in series [double voltage, same capacity (ah)]



Connecting in parallel [same voltage, double capacity (ah)]



### Series connection

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

# Four factors that impact battery life

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

## 1. Ambient temperature

The rated capacity of a battery is based on an ambient temperature of 25°C (77°F). It is important to realize that any variation from this operating temperature can alter the performance of the battery and shorten its expected life. To help determine battery life in relation to temperature, remember that for every 8.3°C (15°F) average annual temperature above 25°C (77°F), the life of the battery is reduced by 50 percent.

## 2. Battery chemistry

UPS batteries are electrochemical devices whose ability to store and deliver power slowly decreases over time. Even if you follow all of 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 percent of rated capacity. Each discharge and subsequent recharge reduces the relative capacity of the battery by a small percentage. The length of the discharge cycle determines the reduction in battery capacity.

Lead-acid chemistry, like others used in rechargeable batteries, can only undergo a maximum number of discharge/recharge cycles before the chemistry is depleted. Once the chemistry is depleted, the cells fail and the battery must be replaced.

## 4. Maintenance

Service and maintenance of the batteries are critical to the reliability of the UPS. 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 do not require fluid.

Without regular maintenance, your UPS battery may experience heat-generating resistance at the terminals, 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. Battery life is often promoted based on design life, that is, how long the battery can be expected to perform under ideal conditions.

Estimating actual battery life relies on taking into consideration the four factors that can impact battery 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
Excessive gassing	Often due to high temperatures or overcharging
Drying out	Excessive gassing, high temperatures or overcharging

# 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, for spent batteries and for spills. The primary ways to handle these two categories are:

## Spent batteries

Send to secondary lead smelter for recycling.

## 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. Consult state environmental agency and/or federal EPA.

## Recycling

Recycling lead-acid batteries is one of the most successful recycling efforts in the world. According to Battery Council International, more than 97% of lead-acid batteries were recycled between 1997 and 2001. Many states require lead-acid batteries be recycled, and several options exist to dispose of used batteries including:

- If you are engaged with Eaton on a battery upgrade or replacement, Eaton will take your old batteries and recycle them for you.
- If you participate in Eaton's UPSgrade program, we take the old UPS and recycle it. Visit [www.eaton.com/upsgrade](http://www.eaton.com/upsgrade) for details.
- Check your local phone book for a local recycler, or search for a recycler at <http://earth911.com/>.
- Some automotive stores often accept batteries for recycling.
- Many municipalities have dump or recycling locations that will accept batteries for recycling. When disposing of batteries in this manner, be sure to get a receipt clearly detailing what batteries were dropped off, when, quantity, and has the recycler's full name, address and phone on it in the unlikely event you get audited.

# Battery maintenance for extended life

Quantifying the combined effect of these four factors is difficult. You need a way to determine when a battery is near the end of its useful life in order to replace it 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 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 percent 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 both discharge and recharge cycles.

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

- Inspect batteries and racks for signs of corrosion or leakage
- Measure and record the float voltage and current of the entire bank
- Record the voltage and electrolyte density of selected battery cells
- Check the electrolyte level in each cell
- Log the ambient temperature

## 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. When a battery or group of batteries connected in a series ceases to work, not only is the battery string no longer functional, but 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 is no precise way to ensure that battery failure can be predicted. The only way to identify bad batteries early enough for spot replacement is through continuous battery monitoring and scheduled maintenance.



**Spot replace bad batteries that are less than three years old and replace the whole string between the fourth and fifth year.**

# Battery safety

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

Sulfuric acid is very combustible and 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.

You should always refer to the material safety data sheet for specific precautionary measures. However, the following are primary steps for safe handling and use.

## Spills or leaks

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

## Handling and storage

Store batteries in cool, dry, well-ventilated areas with impervious surfaces and adequate containment in the event of spills. Batteries should also be stored under roof for protection against adverse weather conditions. Separate them from incompatible materials. Store and handle only in areas with adequate water supply and spill control. Avoid damage to containers. Keep away from fire, sparks and heat.

State and local governments may have regulations over how and where your UPS batteries are installed, usually depending on the amount of electrolyte the batteries contain. Flooded cell batteries require special ventilation because of the amount of hydrogen they emit and their liquid electrolyte. They are usually stored away from the load and other equipment. VRLA batteries are much less hazardous due to their immobilized electrolyte so they are often not subject to the more stringent regulations covering flooded-cell batteries and are often located in the data center or near the protected load.



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



# 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 percent of its rated capacity in ampere-hours. When your battery reaches 80 percent 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 they will have the same characteristics. If you need to replace the whole string 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 do not require fluid. Preventive maintenance is the key to maximizing your UPS battery service life.

## 5. What about the disposal of batteries?

It is imperative that your service technicians adhere to EPA guidelines for the disposal of all UPS batteries. Remember, it is 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 large and small applications. First, 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, wet-cell batteries become much more common. The differences in battery maintenance between VRLA and wet-cell batteries discussed earlier in this handbook apply.

## 7. Our facility was damaged by a flood and our batteries were partially submerged in water. What should I 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. Due to the self-discharge characteristics of lead-acid batteries, it is imperative that they be charged periodically during storage. Otherwise, permanent loss of capacity will occur. To prolong shelf life without charging, store batteries at 10°C (50°F) or less.

## 9. What is thermal runaway?

Thermal runaway occurs when the heat generated in a lead-acid cell exceeds its ability to dissipate that heat, which can lead to an explosion, 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.



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.

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

Hot-swappable batteries allow the batteries to 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. Please check your user manual for details on your UPS batteries.



## 12. How is battery runtime affected if I reduce the load on the UPS?

The battery runtime will increase if the load is reduced. As a general rule, if you reduce the load by half, you triple the runtime.

## 13. 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. However, adding more batteries to the UPS does not increase the UPS capacity. Be sure your UPS is adequately sized for your load, then add batteries to fit your runtime needs.

## 14. What is the average lifespan of UPS batteries?

The standard lifespan for VRLA batteries is three to five years, and for wet-cell batteries is up to 20 years. However, expected life can vary greatly due to environmental conditions, number and depth of discharge cycles, and adequate maintenance. Have a regular schedule of battery maintenance and monitoring to ensure you know when your batteries are reaching their end-of-life.

## 15. Why are batteries disconnected on small, single-phase UPSs when they are shipped?

This is so that they are in compliance with Department of Transportation regulations.

## 16. 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 the battery 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 during storage to avoid loss of capacity. Recharging stored batteries does not affect battery warranty.

## 17. Will Eaton replace batteries for another manufacturer's UPS?

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

## 18. 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.

## 19. Who are the major battery manufacturers?

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

## 20. If I have one bad battery, should I only replace that faulty battery, or replace the entire string of batteries?

Batteries in series are similar to a string of holiday lights. When one unit fails, the entire string no longer works. When a battery or group of batteries connected in a series ceases to work, not only is the battery string no longer functional but 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 is no precise way to ensure that battery failure can be predicted. The only way to identify bad batteries early enough for spot replacement is through continuous battery monitoring and scheduled maintenance.

## 21. 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

## 22. 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 that you can reach your runtime requirements with fewer battery cabinets, which reduces upfront costs and lifetime costs of battery preventive maintenance.

## 23. How is battery performance generally measured?

Batteries are generally rated for 100+ discharges and recharges, but many batteries show a marked decline in charging capacity after as few as 10 discharges. 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.

# Eaton battery products and services

## Eaton battery services overview

**Eaton provides a comprehensive set of services for batteries.**

- Battery preventive maintenance/onsite inspection – technician tests, inspects, cleans and analyzes battery performance and provides a detailed report that includes any recommendations for corrective action
- Eaton battery – includes options to replace individual batteries or the entire string
- Eaton CellWatch – 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 7x24 command center for all of Eaton's services

## 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 upon to support the critical load. Eaton will custom design a preventive maintenance package that is best for you, including the following features:

- Comprehensive maintenance schedule for your VRLA or wet-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 at that time because Eaton technicians have the batteries with them when they perform the preventive maintenance regimen.

## Eaton batteries

As a part of its commitment to delivering the highest reliability in power availability, Eaton offers a line of premium batteries for Eaton three-phase UPS models. Eaton batteries combine field-proven performance and quality at competitive pricing and are backed by Eaton's 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 in the use of a battery in a UPS, is confirmed.

Following the review and assuming the outcome was 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. These include 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 has been 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 are deployed.



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 Models available

Model	Warranty	Labor adder
<b>Eaton 12V 34W battery</b>	2-year parts/1-year labor	2-year parts/2-year labor
<b>Eaton 12V 120W battery</b>	2-year parts/1-year labor	2-year parts/2-year labor
<b>Eaton 12V 200W battery</b>	3-year parts/1-year labor	3-year parts/3-year labor
<b>Eaton 12V 280W battery</b>	3-year parts/1-year labor	3-year parts/3-year labor
<b>Eaton 12V 330W battery</b>	3-year parts/1-year labor	3-year parts/3-year labor
<b>Eaton 12V 390W battery</b>	3-year parts/1-year labor	3-year parts/3-year labor
<b>Eaton 12V 500W battery</b>	3-year parts/1-year labor	3-year parts/3-year labor

## Why Eaton batteries?

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

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

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

**Extended warranty coverage.** Eaton offers a full three years of parts coverage, with full (not pro-rated) replacement of any failed battery. In the unlikely event that 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 Eaton's 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.

For more information on Eaton batteries, please visit [www.eaton.com/upsbatteries](http://www.eaton.com/upsbatteries)

# 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 is 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 that enables 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. Thermal runaway occurs when the heat generated in a lead-acid cell exceeds its ability to dissipate that heat, which can lead to an explosion, 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.

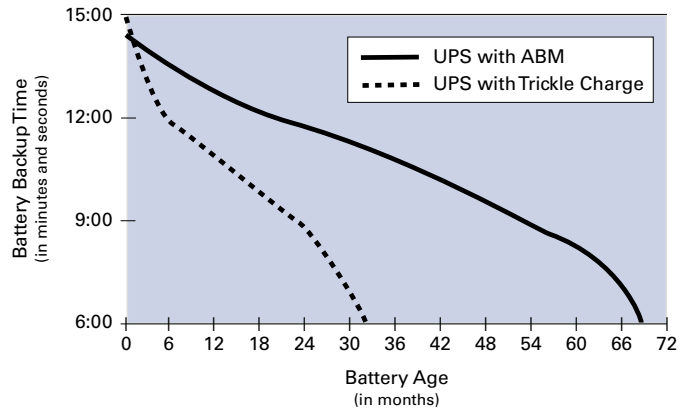
By monitoring every jar or cell in the battery system for signs of failure, Eaton Cellwatch is uniquely suited to find the causes and symptoms of thermal runaway before damage is caused.



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.

# 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 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.



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



The Eaton Customer Support Center stands ready to assist 7x24

## Customer Support Center

Eaton's global 7x24 service operations command center is a hardened, secure facility for all UPS product service scheduling, technical support, and remote monitoring support. Customer support staff is 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 7x24.

The benefits of the Customer Support 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 (reduce risk and cost of downtime)
- 7x24 notification of critical alarms or trends
- Ease 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

### Looking for replacement batteries for your Eaton UPS?

Use Eaton's online UPS Battery Selector tool (for small, single-phase units) to help you find the appropriate replacement batteries for your Eaton UPS.



[www.eaton.com/UPSbatteries](http://www.eaton.com/UPSbatteries)



# Battery glossary

**Absorbed electrolyte** –

Electrolyte that has been immobilized in an absorbent separator.

**Absorbed electrolyte cell** – A

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

**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 and 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 that 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 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 a cathode used to receive, store and deliver electrical energy.

**Cell temperature** – The

temperature at which a cell is operating. In the US, 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 is 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 potential 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.

**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

has been assembled with its plates dry, and in a charged state, ready to be activated by the addition of electrolyte. This allows easier shipping and storage.

**Efficiency** – The

electrochemical 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 the fire.

**Float current** – The current drawn by a cell that is being float charged.

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

**Flooded-cell** – A cell design that is 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 nonuse or storage.

**Full-float operation** – Operation of a DC system with the battery, the battery charger and the load all 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. Gassing may result from electrolysis of water into hydrogen and oxygen within a cell during charging, from overcharging or from local action.

**Gelled electrolyte** – Electrolyte that has 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 US 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 is retained by a gel or absorbent mat.

**Initial charge** – The charge given to a new battery before placing the battery 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, this connector is 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. However, hard rubber is sometimes used as well and nickel-cadmium cells may even 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 minimum or maximum of electrolyte level for the cell.

**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-plate 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 is 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 has 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 together.

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

**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 the cell.

**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.

**Secondary cell** – An electrochemical cell that is capable of being discharged and then recharged.

**Secondary battery** – Two or more secondary cells connected together 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 design this is 80%.

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

**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 together in series to form a battery.

**Sulphation (lead-acid cell)** – A state where the battery has developed an abnormal amount of sulphate and its capacity is impaired. This 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 condition.

**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 is sealed and fitted with a valve which opens to vent the cell whenever the internal pressure of the cell exceeds the pressure external to the cell 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.

**Wet-cell** – A cell design that is 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).



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