

A close-up photograph of a worker's hands, wearing grey work gloves, using a red and black tool to work on a large, industrial lead-acid battery. The battery is composed of many cells with yellow caps. The worker is wearing a high-visibility yellow and white safety vest. The background is slightly blurred, showing more of the battery bank and some cables.

THE ULTIMATE GUIDE TO LEAD-ACID BATTERY LONGEVITY

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INTRODUCTION

For over 70 years, Battery Builders, LLC has proudly produced the finest industrial lead-acid batteries that the industry offers.

Some of the top manufacturers in the world prefer our batteries for their value, rugged durability, and power performance. Starting in 1950, BBI has grown into a major provider of cost-effective DC battery solutions for industrial and commercial motive power applications. We pride ourselves on manufacturing highly economical, low maintenance, and recyclable custom battery systems for round-the-clock use.

Lead-acid batteries are rechargeable batteries that use lead and sulfuric acid to charge and discharge electrical energy. When lead is submerged in sulfuric acid, it creates a controlled chemical reaction. The reaction then causes the battery to generate electricity. This reaction can then be reversed to recharge the battery later on.

The main materials that compose a lead-acid battery include:

- **Lead peroxide (PbO₂):** the dark brown, hard, and brittle substance that forms the positively charged plate
- **Sponge lead (Pb):** pure lead in a soft sponge condition that acts as the negatively charged plate
- **Dilute sulfuric acid (H₂SO₄):** with a 3:1 ratio of acid to water, a majority of the heat released in dilution comes from the hydration of the hydrogen ions. It is highly ionized, a strong acid, and a good electrolyte

Lead-acid batteries have several benefits including:

- **Cost:** lead-acid batteries provide major cost efficiencies compared to lithium-based counterparts
- **Reliability:** made from a proven and well-understood technology. When crafted conscientiously, lead-acid batteries are extremely durable and provide long-lasting service
- **Low Self-Discharge:** lead-acid batteries have one of the lowest rates of self-discharge among rechargeable battery systems at about 40% per year
- **High Discharge Rates:** lead-acid batteries have the capacity for high discharge rates

Lead-acid batteries are still popularly used in their improved form today across a range of fields, including:

- **Forklifts:** battery-run forklifts have almost entirely replaced those powered by natural gas. Besides cheaper operating costs, electrically-powered forklifts eliminate the danger of noxious exhaust fumes or carbon monoxide buildup in an enclosed space
- **Aircraft Tugs:** aircraft towing equipment is critical to maneuvering planes on the ground into tight spaces or within busy transit corridors. Lead-acid batteries provide aircraft tugs a reliable source of power to meet their demanding application
- **Zambonis:** Zambonis are ice resurfacing machines used at skating rinks to maintain ice quality. Lead-acid batteries are a natural fit for this application, delivering consistent power when the Zamboni is needed

Proper maintenance is essential to maintaining the durability, reliability, and lifespan expected of a lead-acid battery. Reference the Battery Maintenance Checklist below for a list of best practices. Always contact your forklift or battery dealer for proper service and repair, or for assistance with any questions.

1. Never smoke or have open flame or spark near a battery.
2. Always wear personal safety equipment when inspecting, servicing, or working near batteries.
3. Always maintain correct electrolyte levels as specified.
4. Always keep the top of the battery clean and dry.
5. Always ensure no metal objects come into contact with the battery.
6. Always add distilled or appropriate water only. If spillovers occur, contact your battery expert for service.
7. Discharge batteries no more than 80% of their rated capacity. Equalize charge once a week.
8. Never place a hot battery on charge or in operation. If the battery is hot (+115°F), contact your battery expert for inspection.
9. Always perform and record electrolyte and cell voltage readings, at minimum, on a quarterly basis or every 75 discharge cycles.
10. When batteries are equipped with steel covers, open lids when charging and ensure adequate ventilation exists in all areas where batteries are being charged.

SECTION I – DANGER

Health	Physical	Environmental
  		

PROPOSITION 65 WARNING: Battery posts, terminals and related accessories contain lead, lead compounds, chemicals known to the State of California to cause cancer and reproductive harm. Batteries also contain other chemicals known to the State of California to cause cancer. Wash hands after handling.

WARNING: Risk of fire, explosions or burns. Do not disassemble, heat above 53°C / 125°F or incinerate. Not recommended for inverted use. Follow product charging instructions.

Manufactured by:
Battery Builders
 Naperville, IL 60564
 630-851-5800



SHIELD EYES,
EXPLODING GASES
CAN CAUSE BLINDNESS
OR INJURY



NO
• SPARKS
• FLAMES
• SMOKING



SULFURIC ACID
CAN CAUSE
BLINDNESS OR
SEVERE BURNS



FLUSH EYES
IMMEDIATELY
WITH WATER
GET MEDICAL
HELP FAST



KEEP OUT OF
THE REACH
OF CHILDREN



READ
INSTRUCTIONS

DO NOT TIP
OR OPEN



KEEP VENT CAPS TIGHTLY IN PLACE.	VENTILATE WELL WHEN IN AN ENCLOSED SPACE AND WHEN CHARGING.
BATTERY HEAVY. WILL CAUSE INJURY IF DROPPED.	REPAIR SHOULD BE PERFORMED ONLY BY A QUALIFIED SERVICE TECHNICIAN.

Fig.1

HYDROGEN GAS FROM BATTERIES OR CELLS IS HIGHLY FLAMMABLE. DO NOT SMOKE, USE AN OPEN FLAME, OR CREATE SPARKS IN THE VICINITY OF BATTERIES. ENSURE PROPER VENTILATION WHEN IN AN ENCLOSED SPACE OR WHEN CHARGING.

THE BATTERIES OR CELLS CONTAIN SULFURIC ACID WHICH CAN CAUSE SEVERE BURNS. DO NOT GET IN EYES, IN CONTACT WITH SKIN, OR ON CLOTHING. IN CASE OF CONTACT, FLUSH IMMEDIATELY FOR 15

MINUTES WITH CLEAN WATER. OBTAIN MEDICAL ATTENTION IF THE EYES ARE AFFECTED.

PERSONAL SAFETY EQUIPMENT IS RECOMMENDED WHEN WORKING WITH BATTERIES OR CELLS AND SHOULD BE USED IN ACCORDANCE WITH LOCAL REQUIREMENTS INCLUDING SAFETY GLASSES, GOGGLES, OR A FACE SHIELD.

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SECTION II – BATTERY SAFETY

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

Thanks to their longevity, durability, and reliability, lead-acid batteries are a preferred choice for motive power applications. Providing reliable power to electric forklift trucks for material handling, airport tuggers, and even resurfacing the ice at hockey rinks, when used properly, a lead-acid battery is a safe, dependable source of electrical power.

However, if proper care and safety precautions aren't adhered to, it can be an extremely dangerous piece of equipment. The four most hazardous elements in a lead-acid battery are sulfuric acid, explosive gases, electricity, and weight.

Explosive Gases

A lead-acid battery produces a mixture of hydrogen and oxygen gases when it is being charged. This poses risk of explosion if a battery on charge is exposed to an open flame, arc, or spark.

Prior to charging, ensure all vent caps are unclogged and securely attached to the battery so any gas is safely vented.

DO NOT SMOKE, USE AN OPEN FLAME, OR CREATE SPARKS IN THE VICINITY OF INDIVIDUAL CELLS OR BATTERIES. ENSURE PROPER VENTILATION WHEN IN AN ENCLOSED SPACE OR WHEN CHARGING.

Always reference the manufacturer's Owner's and Operation Manual for complete details and requirements of your specific charger.

Sulfuric Acid

The electrolyte in a lead-acid battery is a diluted solution of sulfuric acid and water. Although the acid content in the solution is relatively low, it is extremely corrosive and can burn skin, eyes, and fabric.

First Aid for Acid Contact

- **Eyes:** flush eyes immediately with running water for a minimum of 15 minutes and seek medical attention as soon as possible. If contact lenses are in the eyes, remove the lenses before flushing. Do not use a neutralizing agent without prior recommendation from a medical or safety professional.
- **Skin:** immediately wash affected area under cold running water and apply a chemical burn treatment. If the burn is severe, seek medical attention as soon as possible.
- **Clothing:** if a large area of clothing has come in contact with sulfuric acid, immediately remove the clothing and neutralize with a water-based neutralizing chemical and rinse under running water.

Electricity

Lead-acid batteries create an electric shock hazard when the voltage is over 50V. Metallic objects coming in contact with exposed connectors will cause a short and increase temperature severe enough to cause burns if coming in contact with skin or clothing.

Weight

The average lead-acid battery weighs over 2,000 pounds and can cause serious injury if handled improperly during installation, removal, or transportation. Proper lifting equipment and techniques must be used at all times. Hoists should be equipped with a non-metallic bucket to avoid electric shorts.

SECTION III – CHARGING SAFETY

Always reference the manufacturer's Owner's and Operation Manual for complete details and requirements of your specific charger.

Safety Precautions

The below safety precautions must be taken when charging a battery:

- Always wear protective eyewear when checking the electrolyte levels in a stored battery
- Keep all open flames, sparks, and matches away from the charging area. Never smoke in or around the battery charging area
- Keep truck compartments open when a battery is being charged in order to help prevent temperatures from becoming too hot and to keep the gases dispersed
- Hand-operated fire extinguishers should be available in all charging areas
- Before removing a battery from a truck, ensure the truck's electrical circuit is off, the battery unplugged, and the truck's emergency brake is on
- Always use the stop button before connecting or disconnecting a battery from a charger. Live leads can cause a spark and poses risk of explosion if gases are present
- Ensure all connections between the battery and the charger are tight and are not broken or damaged
- Vent caps should be kept firmly in place at all times
- Never plug the charger connector into the lift truck connector

Improper Charging

Always reference the manufacturer's Owner's and Operation Manual for complete details and requirements of your specific charger.

Improper charging of a lead-acid battery can significantly reduce the battery's capacity and life. Undercharging can create residual sulfation on plates, ultimately reducing performance of the cells. Alternatively, severe overcharging can create excessive gassing and very high battery temperatures, resulting in unusually high water use. The temperature of a battery should never exceed 115°F.

SECTION IV – LEAD-ACID BATTERY BASICS

Ampere Hour (AH)

The energy capability of a lead-acid battery is typically represented in ampere-hours (AH). The AH capacity is the number of amp hours at the 6 hour rate. Amp hours are calculated by multiplying the number of positive plates in a cell by the amp rating of the positive plate.

For example, an 85-13 cell = 510 AH; 85 amp rated positive multiplied by 6 positive plates = 510 ampere hours. Increasing or decreasing the number of plates that make up a battery will impact the battery's total capacity.

Kilowatt Hours (KWH)

The capacity of a lead-acid battery can also be expressed in kilowatt hours (KWH). KWH is calculated by multiplying the plate rating by the number of positive plates by 1.93, divided by 1000, times the number of cells. 1.93 is used by Battery Builders, LLC as the average volts per cell and may vary by manufacturer.

For example, a 12-085-07 battery has a plate rating of 85 with a total of 3 positive plates and 12 total cells. $((85 \times 3 \times 1.93) / 1000) \times 12 = 5.91$ KWH. Increasing or decreasing the number of cells will change the KWH.

Specific Gravity

Specific gravity is used as one indicator of the state of charge of a battery or cell. Specific gravity refers to the ratio of weight of the electrolyte (acid / water mixture) to the weight of an equal volume of water at a given temperature. The chemical reactions that occur during a battery's discharge decreases the density of the sulfuric acid electrolyte, thereby decreasing the specific gravity to a value near that of pure water. The specific gravity will then increase during the recharging process.

The industry standard of a fully charged industrial battery is a specific gravity of 1.285-1.295.

Battery Weight as a Counterbalance

In order for most lift trucks to operate safely, the battery is used as a counterbalance to the load being carried. It is essential that if a new or different battery is being used, it must fall within the minimum and maximum battery weight range of the truck manufacturer / model. The battery weight information can typically be found on the nameplate of the truck while a battery's service weight can typically be found stamped on the tray near the lifting ears. Always ensure that this weight is in the proper range.

SECTION V – BBI NOMENCLATURE

Battery Builders, LLC uses the nomenclature below to identify its battery models:

For example, a BBI battery SKU of 12-085-13

The first number (12) indicates the number of cells in the battery. Similarly, as each cell has a nominal voltage of two (2) volts, this also indicates the battery's voltage (24V).

The second number (85) represents the positive plate rating, or plate capacity. Here, one positive plate is 85 amps. The amp hours can then be calculated by multiplying the number of positive plates by the plate rating ($6 \times 85 = 510 \text{ AH}$).

The third number (13) indicates the total number of plates, both positive and negative, in the cell. The last number will always be an odd number as there is always one more negative plate than positive plate. In this example, there are six (6) positive plates and seven (7) negative.

SECTION VI – INSTALLATION AND USE

Receiving a Battery

After receiving your lead-acid battery, ensure there is no damage that may have resulted during shipping.

Inspect every cell's electrolyte level to ensure it is above the moss guard (Figure 2). If the electrolyte is not at proper levels, contact your forklift or battery dealer for proper service and repair. Do not attempt to discharge or charge the battery.

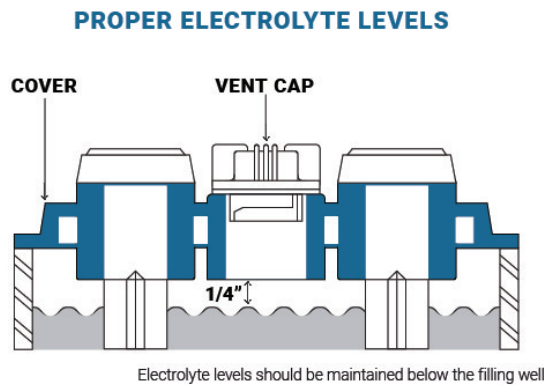


Fig.2

Storing a Battery

A battery can be stored for up to one year when it is fully charged and the electrolyte is at proper levels. If choosing to store your battery, ensure it is in a cool, dry, well-ventilated area away from direct sunlight or other heat sources. It is recommended that a freshening charge take place when the specific gravity falls below the standard 1.285, or approximately every 60-90 days.

Ensure the battery is being stored at room temperature. Never store a battery in a refrigerated atmosphere.

Placing a Charged Battery in Service

Before putting a new or stored battery into service, perform a freshening charge to ensure all cell voltages have stabilized. Ideally, a battery should always be below 90°F when installed in a vehicle.

When installing a lead-acid battery, ensure that the truck's compartment is clean, free of dust or debris, has no corrosion, and the ventilation is not obstructed in any way.

Use proper lifting equipment and techniques to set the battery securely in the truck compartment and anchor it into position, using any vehicle anchoring clips if available. Ensure the proper clearance between the battery tray and the compartment does not exceed $\frac{1}{2}$ ".

Battery Inspection

Lead-acid batteries should be routinely inspected to avoid potential damage, unexpected problems, or improper maintenance. When performing an inspection of your battery, record basic information for tracking and timestamps if needed. Key items that should always be looked for include:

- Corrosion on the battery tray, terminals, or intercell connectors
- Leaks or damage
- Damaged cable leads, terminals, or connectors
- Damages, clogged, or missing vent caps

Contact your forklift or battery dealer if any parts need to be repaired or replaced.

Prior to taking any readings of the specific gravity, ensure the battery is at a full charge. Use the battery's positive terminal as cell #1 and follow the intercell connectors to the last cell, taking specific gravity and voltage readings for each cell and recording the results. Voltage readings should be taken to the onehundredth of a volt (i.e. 2.13). Take note of any unusual readings and contact your forklift or battery dealer if appropriate.

SECTION VI – INSTALLATION AND USE (CONT'D)

Adding Water

It is normal for a lead-acid battery to lose water during evaporation and electrolysis during charge, cycling, and discharge. You must ensure that the electrolyte level in the cells does not drop below the top of the separator protector (Figure 2). Low electrolyte levels in a battery cell can cause the plates to oxidize and shorten the life of the cell and the battery. To prevent electrolyte levels from falling too low, water should be checked and added weekly.

Water should only be added after the battery is fully charged.

Ideally, a watering schedule should be adopted and strictly followed. As a best practice, water should be added to all of the batteries assigned to each charging area on a regular time schedule. The electrolyte levels should also be spot checked periodically to determine if the proper levels are being maintained. Determining a reasonable and proper battery watering time schedule is dependent on how widely the following three factors vary:

- Frequency of charge
- Water storage capacity of the specific cell type
- Age and condition of the battery

Older batteries and those in poor condition will consume water more rapidly than newer batteries and those that have been properly maintained. Additionally, some cell types have a greater water storage capacity than others.

Watering Frequency

In single shift applications operating under moderate ambient temperatures, lead-acid batteries require 'topping-off' of cells after 5-6 discharge/charge periods. This ensures that no part of the element is exposed to Oxygen as plate areas that are not immersed entirely by electrolyte will become sulfated. Operating a lead-acid battery with low electrolyte levels results in power loss and the permanent damage to the plates. Batteries operating with appropriate electrolyte levels will not experience 'boil-overs'.

Opportunity charging and fast charging operations can expect a higher frequency of maintenance. Batteries are charged and recharged multiple times a day, some as much as 3 times normal operation. In the case of 36, 48, and 80V batteries, centrally located cells will generally require additional water demands than perimeter cells.

Water Quality

Only approved water should be used when watering cells as impurities and minerals such as Aluminum, Copper, Iron, Lead, Mercury, and Uranium can be found in your average tap water and can damage your battery's operational capabilities. The presence of these contaminants as your battery is charged at high rates can significantly reduce its lifespan. As the lead-acid battery works to generate electricity, the contaminants in the acid solution inhibit the electro-chemical reaction. The end result is an increase in cell resistance, causing elevated temperatures and early plate degradation. Distilled or de-ionized water is typically best for watering cells.

SECTION VII – BATTERY MAINTENANCE & TROUBLESHOOTING

Proper maintenance of your lead-acid battery is essential to obtain long life and maximum efficiency.

Following a scheduled maintenance routine will help ensure proper performance and prolonged service life. Contact your forklift or battery dealer with help in establishing an appropriate maintenance schedule for your industrial battery.

A key to an effective battery maintenance schedule is keeping an accurate system of records, including battery cycles and any repair work that has been completed.

Consider the tips at right when designing a record system for your application:

- Assign a unique ID to each battery and charger. Use prefixes / suffixes to identify batteries by size, voltage, shift, truck make / model, etc.
- Designate a pilot cell on each battery, ideally located near the center of the battery. Record the specific gravity, voltage, and temperature of the cell when the battery is initially received and equalized. The readings taken on the pilot cell are considered to represent all cells within the battery. Ensure you are always using the same cell for these readings
- Measure and compare the specific gravity of all cells at a minimum on a quarterly basis. The readings should be consistent across all the cells. If a reading when fully charged falls below industry standard (1.285), the electrolyte levels should be checked and replenished. Contact your forklift or battery dealer for assistance in properly troubleshooting

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