HAWKER SERVICE MANUAL

Table of Contents

Graphs & Illustrations

INTRODUCTION

Batteries have been a part of our lifestyle for so long that many of us tend to take them for granted. Batteries are expected to perform reliably and trouble-free with little or no attention. In plant environments where large quantities of materials must be moved, lack of proper attention can result in reduced battery life, inefficient materials handling, damage to lift-truck equipment, and a poor return on capital investment. Because they play such a vital role in materials handling in most segments of industry, batteries should receive a great deal of attention in any plant program of care and preventative maintenance.

Ideally, batteries should be handled by trained and skilled personnel—not only because of the financial investment, but also due to the inherent dangers involved with battery handling and maintenance. The purpose of this manual is to assist those responsible for this care and maintenance in obtaining the most efficient service from their batteries using procedures which provide the safest possible environment.

Industrial batteries manufactured today are usually warranted to deliver a total of 1,500 cycles. A cycle is normally considered to be one discharge and one recharge. At a frequency of one cycle per day, a five-year life is expected. Many factors can alter the life achieved by the user. With adequate care and preventative maintenance, 2,100 cycles are entirely within reason. It is thought by veteran battery service personnel that if users would focus on four areas, normal battery life would greatly increase and as much as 75% of battery repair costs experienced today would not be required. These areas are as follows:

1. *Proper watering*
2. *Regular cleaning and neutralizing*
3. *Maintaining batteries at a proper temperature*
4. *Discharging to as near 80% of capacity as possible prior to recharging*

Caution

The experienced battery maintenance and repair specialist is aware of the dangers involved with the handling of lead-acid industrial batteries and with the acid and gases ever present when using batteries. As a reminder to those who may not fully understand these hazards, the following warning label is placed on each HAWKER battery shipped:

DANGER	DANGER
DO NOT smoke or use an open flame, DO NOT create arcs or sparks, and DO NOT use other sources of ignition near this battery. HYDROGEN GAS, which may explode if ignited, is produced by this battery, especially when on charge. Good ventilation will reduce the explosion hazard.	SULFURIC ACID, which is corrosive and may cause burns, has been diluted with water to form the liquid in this battery. Keep it away from the eyes, skin, and clothing. In case of contact, flush immediately with water. Always obtain medical attention when the eyes are affected.

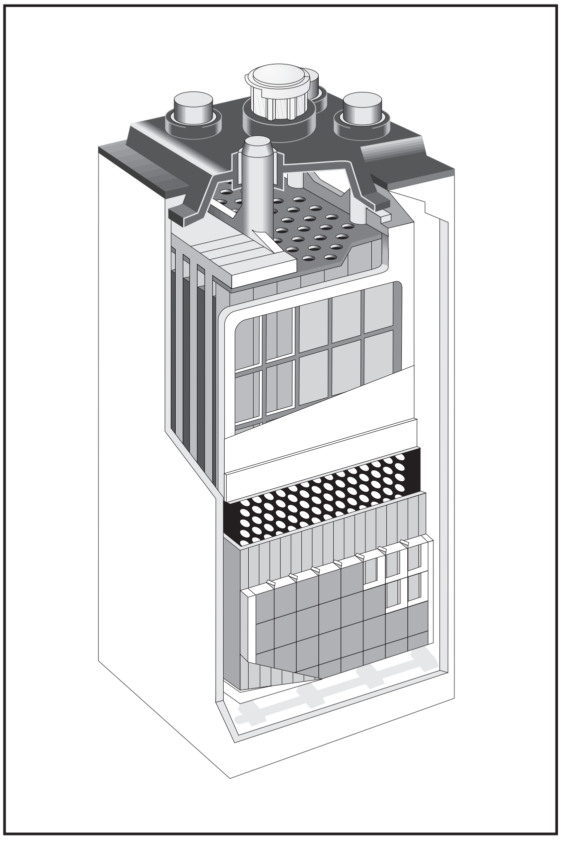
Additional precautions and safety measures to be observed by those handling batteries are covered in the section entitled "Safety & Handling." We strongly recommend that you read this section before handling or repairing batteries.

CONSTRUCTION & OPERATION

A lead-acid motive power battery is a portable energy source for supplying direct (DC) electrical current to electric vehicles. It consists of two or more cells connected in a series and assembled into a metal or fiberglass tray or container. This type of battery comes in a wide variety of shapes, voltages, and ampere-hour (AH) capacities.

Each cell of a battery contains a group of positive and negative plates, interleaved so that positives and negatives alternate. The negative plates outnumber the positives by one. The positive plate consists of active material (lead dioxide) retained within the positive grid lattice. The material is held firmly against the grid with a retention system incorporating a fiberglass mat, stran mat, Koroseal retainer, and a plastic boot. This assembly is then enclosed in a polyethylene envelope which provides insulation and edge protection.

The negative active material (sponge lead) is maintained within the thinner negative grid. No retention system is used on the negative plate as there is only slight shedding of the active material throughout its normal service life. The positive and negative plates are insulated from each other by the polyethylene sleeve separator surrounding the positive plate assembly. All the positive plates in each cell are paralleled by connection to the positive strap. All the negative plates in each cell are paralleled by connection to the negative strap. The plates and insulating materials are later submerged in a solution of sulfuric acid and water, called electrolyte, and housed in an acid-proof polypropylene container called a jar. A polypropylene cover with holes through which the positive and negative posts protrude are then welded to the jar. A removable vent cap allows access into the cell through the cover for the purpose of water addition and cell inspection via hydrometer readings.



Cell design

Each cell has a nominal voltage of two volts, thus, a 6-cell battery is referred to as a 12-volt battery, and an 18-cell battery as a 36-volt battery, etc. Increasing or decreasing the number of plates or the physical size of the cell has no effect on the battery voltage, but does affect the AH capacity. Nominal battery voltage is affected by increasing or decreasing the number of cells in the series circuit.

How a Battery Works

A battery is a device which stores energy in a chemical form and releases that energy on demand in an electrical form to an external load, such as a motor. The battery releases power by the reaction of the electrolyte with the active material of positive and negative plates (electrodes).

In a fully charged battery, the positive active material is lead dioxide (PbO_2); the negative active material is sponge lead (Pb); and the electrolyte, which has a specific gravity of 1.280 or above, is a solution of sulfuric acid (H_2SO_4) and water. The open circuit voltage of each cell is 2.12 volts.

The Discharging Battery

When a battery is connected to an electrical load, the stored energy is released in the form of DC electrical energy. During the process of energy conversion, the internal components of the battery cells undergo a chemical change.

The sulfuric acid (H_2SO_4) combines with the lead peroxide (PbO_2) of the positive plates and with the sponge lead (Pb) of the negative plates and transforms them both to lead sulfate ($PbSO_4$). The reversible reaction may be shown as follows:

$$PbO_2 \quad 1 \quad Pb \quad 1 \quad 2H_2SO_4 \xrightarrow[\text{DISCHARGE}]{} 2PbSO_4 \quad 1 \quad 2H_2O$$

$$\text{Lead peroxide} \quad 1 \quad \text{Sponge lead} \quad 1 \quad \text{Sulfuric Acid} \xrightarrow[\text{DISCHARGE}]{} \text{Lead Sulfate} \quad 1 \quad \text{Water}$$

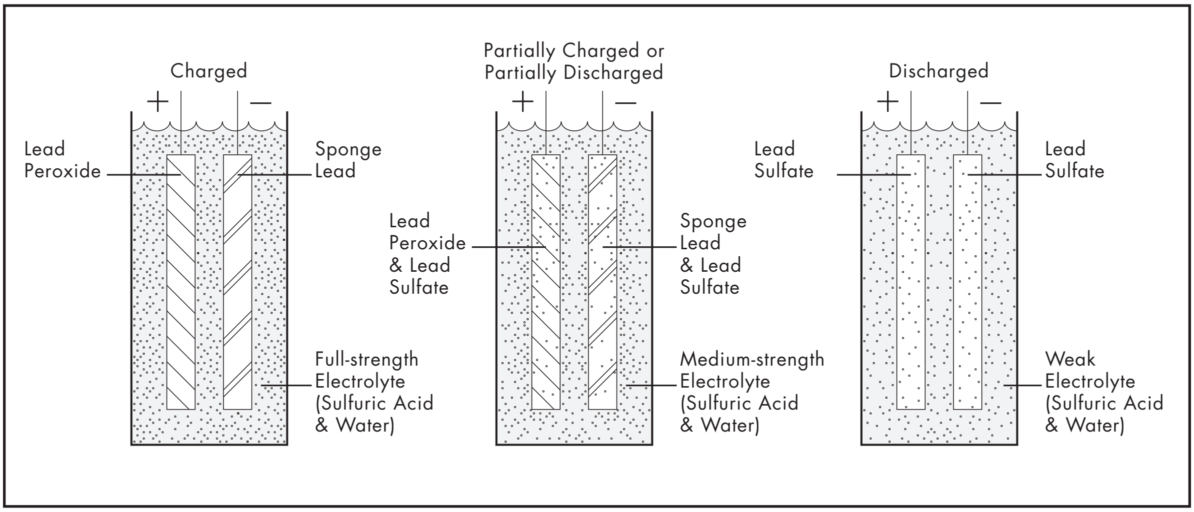
The Charging Battery

The chemical energy in the battery is restored by charging the battery, thereby reversing the discharge reaction. During the charge and especially toward the end of it, hydrogen and oxygen gas are produced by the electrolytic breakdown of water on the plate surfaces.

Chemically the reaction is:

$$2H_2O \xrightarrow[\text{ELECTRICITY}]{} 2H_2 \quad 1 \quad O_2$$

$$\text{Water} \qquad \text{Hydrogen Gas} \quad 1 \quad \text{Oxygen Gas}$$



The charge/discharge process

How a Battery's AH Capacity is Rated

The vehicle configuration, application, and type of operation to be performed determine the battery voltage and AH capacity selected. A battery is rated by its capacity to deliver or discharge electrical energy over a period of time, and the capacity is expressed in AHs.

For example, a battery rated at 300 AH at a six-hour rate can deliver 50 amperes continuously for six hours before it reaches a fully discharged condition. The six-hour rate is the standard used by the North American battery industry when measuring capacity for motive power batteries.

Numerous factors, such as plate size, the number of plates in a cell, the specific gravity of the electrolyte, and the rate of discharge all help determine the AH capacity. All batteries are rated at the six-hour rate, at 77°F, and at the manufacturer's specified fully charged specific gravity. Actual AH capacity available will vary with any deviation in the rate of discharge, battery temperature, or fully charged specific gravity of electrolyte.

Ampere-Hour (AH)

AH Rating 5 current (in amperes) 3 time (in hours)

> *Examples:*
>
> *300 amperes for 1 hour* 5 *300 AH (at one-hour rate)*
>
> *100 amperes for 6 hours* 5 *600 AH (at six-hour rate)*

Kilowatt-Hour (KWH)

Another method of measuring battery capacity includes both the AHs and average voltage during the discharge process. This measure is called watt-hours or kilowatt-hours, (watt hour ÷ 1000). Kilowatt-hour (KWH) capacity indicates the capacity a battery can deliver under certain conditions as nominal average battery voltages may vary dependent on the operations.

Watt-Hour Rating 5 current (in amperes) 3 time (in hours) 3 average voltage 5 AHs 3 average voltage (as designated by the battery manufacturer)

Kilowatt-Hour Rating 5 watt-hour rating 4 1000 = AHs 3 average voltage 4 1000

> *Example:*
>
> *What is the KWH rating of a 18-cell, 680 AH battery with average discharge voltage of 1.94 volts per cell**
>
> *KWH* 5 *680 AH* 3 *18 x 1.94 volts* 4 *1000* 5 *23.77 KWH*
>
> ** The average discharge of voltage of POWERLINE™, WATER LESS®, VARTA® PERFECT and TOP POWER® is 1.94 volts per cell. ENERGY-PLUS™ has an average discharge voltage of 1.94 volts per cell.*

Standard Test Conditions

Time:	6 hours
Final Battery Voltage:	1.70 volts/cell 3 number of cells in battery
Temperature:	77°F (average)

Capacity Discharge Test

A capacity discharge test determines if a specific battery delivers its rated capacity. "Capacity Testing" is explained on page 33.

AHs, per Positive Plate

This term is defined as the rating of a specific size or type of positive plate expressed in AHs at the six-hour rate. There is one more negative plate than positive plates in a cell. Therefore, to calculate the AHs per positive plate in a specific type of battery, first subtract one from the total number of plates in the cell and then divide by two.

> *Example:*
>
> *Determine the AHs per positive plate in a type 18-85-17 battery which is rated at 680 AHs. The "17" indicates there are 17 plates per cell.*
>
> *17* 2 *1* 5 *16*
> *16* 4 *2* 5 *8 positive plates per cell*
> *680 AHs* 4 *8 positive plates* 5 *85 AHs per positive plate*

Battery Voltage & AH Capacity

North American battery manufacturers currently specify the type of the battery using a series of alphanumerical digits. For instance, a HAWKER battery may have a nomenclature of the following: **6-85W-13.**

Here we have all the information available to identify the battery as to voltage and capacity.

6 5 *the number of cells in the series comprising the battery*

85 5 *the AH capacity rating of each positive plate*

W 5 *Cell Type* *EP=ENERGY-PLUS™*
W=WATER LESS®
F=Powerline™
V=VARTA®
(No Letter Indicates Top Power®)

13 5 *the total number of plates contained within each cell (six positive plates + seven negative plates)*

Thus, in this case we have a six-cell, 12-volt battery with each cell containing 13 plates, both positive and negative. Knowing we have one more negative than positive in each cell, every cell contains six positive plates, each rated to deliver 85 AHs. 6 3 85 = 510, representing a 12-volt, 510 AH battery.

In the case of Hawker Energy-Plus™ Batteries which employ multi-plate technology, a different system is used:

Example 12-E600

12 - Designates the number of cells

E - Designates the cell height

E = 85 AH Equivalent

C = 100 AH Equivalent

X = 125 AH Equivalent

600 = Designates the AH rating

A 12-85F 13 (510 AH) and A 12-E600 (600AH) are the same physical size.

Effects of Rate of Discharge on AH Capacity

As the rate of discharge is increased, the amount of active material available to the electrolyte is restricted, thus limiting the available AH capacity. Conversely, if the discharge process is extended for a period longer than the six-hour standard, the AH capacity available will be increased.

Effects of Electrolyte Temperature on AH Capacity

As the electrolyte temperature varies from 77°F, the capacity available from the battery also varies. Low temperatures increase the viscosity of the electrolyte, impeding its circulation in the pores of the plates, thus decreasing the AH capacity available. At elevated temperatures, the reverse is true, increasing the capacity of the battery. At temperatures above 120°F, the charging current of conventional charging equipment may rise out of control, permanently damaging the battery. This is commonly referred to as "thermal runaway."

Effects of Fully Charged Specific Gravity on AH Capacity

As the fully charged specific gravity of a battery is altered, so also is the capacity. If a battery is designed to deliver its rated AH capacity as a specific gravity of 1.290, a reduction in the fully charged specific gravity will reduce the available capacity. Similarly, an increase in fully charged specific gravity will increase capacity. Care must be exercised at all times, however, to make sure that the specific gravity is not above the manufacturer's specifications, as battery life will be seriously diminished. Increasing the fully charged specific gravity above the manufacturer's recommendations will shorten battery life and will void any manufacturer's warranty.

Major causes of reduced specific gravities are improper watering and overcharging. Refer to the graph on page 23 for specific gravities of HAWKER batteries. Care should be exercised that acid is not added to battery cells.

SAFETY & HANDLING

A lead-acid battery by its very nature exposes personnel to several potentially dangerous elements: sulfuric acid, explosive gases, electricity, and heavy weight.

1. A solution of *sulfuric acid* and water is used as the electrolyte in lead-acid batteries, and has a concentration of sulfuric acid by weight of 37% to 43% in a fully charged condition. This corresponds to a concentration by volume of 25% to 30%. Even in a diluted state, sulfuric acid is a strong oxidizing agent and can burn skin and eyes and produce holes in clothing made of materials such as cotton and rayon.
2. An *explosive mixture* of hydrogen and oxygen is produced in the battery during the charging process. These gases can cause the battery cells to explode if a spark or flame are present. Due to the lightness of hydrogen, it should readily diffuse into the atmosphere before it can collect into an explosive mixture. However, if not properly dispersed, it can explode if a means of ignition is present.
3. *Electricity* is produced by the battery, and while most persons cannot "feel" voltages below 35 to 40 volts, all batteries should be regarded as potentially dangerous. A lead-acid battery is capable of discharging at extremely high rates, and under a direct short of even a few cells, can cause much damage and serious injury.
4. The *weight* of industrial batteries can crush hands and feet if care is not taken during handling. The average motive power battery weighs in excess of 2,000 pounds. Adequate and proper handling equipment should always be provided.

Safety Procedures

In 1970, the United States Congress passed the Occupational Safety and Health Act (OSHA). This act established the minimal conditions and acceptable standards for safe and healthful working conditions. The safety procedures suggested in this manual have been compiled from standards developed over the years by professional and technical organizations and by battery manufacturers and users who have the experience necessary to create the most effective safety standards. They exceed the minimum standards of OSHA for personal safety and include procedures for safeguarding equipment as well. For the purposes of making the information easier to find, the safety procedures have been grouped according to where they would logically be needed while working with batteries or charging equipment. The groups are identified as (1) Handling and Changing Batteries, (2) Charging Batteries, (3) Handling Acid, and (4) Repairing Batteries.

Note: The information presented is of a general nature and should NOT BE CONSTRUED AS A LEGAL OPINION.

Handling and Changing Batteries

Wearing Jewelry

Personnel who work around batteries should not wear jewelry made of conductive material. Metal items can short-circuit a battery and in the process become hot enough to cause a severe burn.

Removing Batteries

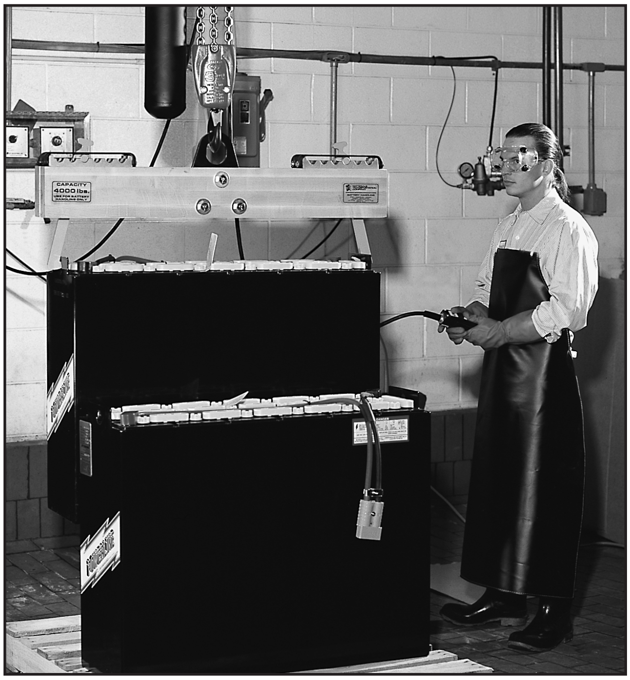
If a battery is to be removed from a truck, (1) bring the fork to ground level, (2) open the electrical circuit of the truck (turn key or switch off), (3) set the brakes or chock the wheels, and (4) unplug the battery. The same procedure applies if the battery is to be charged in the truck. Never try to move a battery by pulling its cables.

Batteries should be changed or charged only by personnel who are trained and authorized to perform these jobs.

Protected Chain Hoists

In cases where commercial battery handling equipment is not available, batteries may be handled with protected chain hoists. Chain hoists should be equipped with a chain container or bucket to prevent a dangling chain from shorting the battery.

If a container or bucket is not available, the battery may be covered with a nonconductive material such as plywood or plastic. An insulated battery lifting beam can be used with almost any type of overhead hoist.



The safe way to lift a battery is to use an insulated lifting beam with safety latch. This reduces the possibility of damaging the tray and shorting the cell connectors.

Protective Eyeglasses and Headgear

The use of safety glasses and safety hats made of a nonconductive material is suggested when batteries are being handled or serviced.

Lifting Batteries

Steel-trayed batteries have holes or eyes for lifting. Using the eyes in conjunction with an insulated battery lifting beam with safety latch and an overhead hoist is the recommended way to lift a battery. If a battery is lifted with two chains attached to a hoist at a single, central point forming a triangle, the procedure is unsafe and can damage the steel tray.

Battery as a Counterbalance

In most industrial trucks, a battery is used as a counterbalance for a carried load. Before installing a new or different battery, check with the manufacturer of the truck for the recommended range of battery weight. The battery service weight is usually stamped into the steel tray near one of the lifting holes. A battery with the wrong weight can change the center of gravity of the truck and cause it to upset.

Charging Batteries

Charging Rooms

Plants that change batteries at the end of each shift should have one or more centralized areas designated for battery changing. These battery charging areas should be equipped with overhead hoists, conveyors, and cranes or their equivalents for handling batteries safely and conveniently.

Make sure proper safety gear is worn when handling or servicing batteries.

Battery charging areas should be adequately ventilated, either through natural or forced ventilation. “Adequate ventilation” is difficult to define as it is dependent upon a variety of factors such as number and size of batteries being charged at one time, room size, ceiling height, airtightness of the building, etc.

No Smoking, No Open Flame

Because an explosive mixture of gas can exist in and around charging batteries, anything that could ignite the gas, such as open flame, arc, spark, or smoking materials should be prohibited in battery charging areas. It is recommended that “No Smoking” signs be posted prominently in charging areas.

Insulated Battery Charging Racks

When batteries are charged in racks, the racks should be insulated to prevent the possibility of sparking. The supports on which a battery rests should be made of nonconductive materials or be suitably insulated.

Charger Connections

Before connecting a battery to, or disconnecting it from a charger, the charger should be turned off. Live leads can cause sparking and arcing as well as undesirable pitting of the contact surfaces of plugs or connectors.

Fire-Fighting Equipment

In addition to automatic sprinkler equipment that might be present, charging areas should be equipped with a suitable hand-operated fire extinguisher. Consult local fire authorities or your insurance carrier for the class and size needed and for recommended mounting locations.

Ventilation

The ventilation system in a charging room should conform to local codes and ordinances. If the average hydrogen concentration throughout the charging room does not exceed 1% by volume, the ventilation is considered to be satisfactory. (Concentrations between 4% and 74% are explosive.) A variety of instruments such as combustible gas indicators and flammable vapor indicators are commercially available for continuous and automatic analysis of hydrogen concentrations in the air. Contact HAWKER if more information on these indicators is desired.

When charging an enclosed or covered battery, whether it remains in the truck or is placed on the rack, always keep the battery tray cover and the truck compartment cover open throughout the entire charging period. Opening the covers helps to cool the battery and disperse the gases.

Battery Gassing

The gases given off by a lead-acid storage battery on charge are due to the electrolytic breakdown (electrolysis) of water in the electrolyte to produce hydrogen and oxygen. Gaseous hydrogen is produced at the negative plate, while oxygen is produced at the positive. Hydrogen is the gas which is potentially problematic. It will burn explosively when ignited if the air contains between 4% and 74% hydrogen (less than 4% or more than 74% hydrogen will not explode). Hydrogen, which is the lightest known gas, is 14 times lighter than air and rises and disperses very rapidly.

Normally, insignificant quantities of gases are released by a battery during the first part of the charge, as most of the charging current is used in charging the battery. Only during the last stages of the charge does the process become inefficient, so that an increasing portion of the current is used up by the creation of heat and gases.

If, instead of being used to charge the battery, an ampere-hour of charge is used completely to produce gas, it will create 0.01474 cubic feet, or 0.418 liters, of hydrogen per cell at standard temperature and pressure. Stated another way, 68 AH of charge, used completely to produce gas, will create approximately one cubic foot of hydrogen per cell.

To determine exactly how much hydrogen is released by a battery at any moment of the charge is rather difficult, as each case will be different. However, the total amount released may be approximated by the following method. It is based on the concept that a completely discharged 100 AH battery requires 100 AH of charge to bring it to full charge, plus overcharge needed to make up for inefficiencies of charging such as heating and gassing.

The calculation assumes all the overcharge is used to produce gas.

K 5 the number of cells in the battery.

W 5 percentage overcharge assumed to be given to the battery. Assume this is 20% unless the actual percentage is known. This is the percent of the charge which is "wasted" in creating heat and gas. Further, assume it is all used to create gases.

B 5 the volume of hydrogen produced by one AH of charge. Use 0.01474 to get cubic feet. Use 0.418 to get liters.

C 5 rated six-hour capacity of the battery in AHs. This is also the number of AHs a fully discharged battery must accept to be fully charged.

H 5 the volume of hydrogen produced during the charge.

$$(H) \; 5 \; (K) \; 3 \; \frac{W}{100} \; 3 \; (B) \; 3 \; (C)$$

$$H \; 5 \; \frac{KWBC}{100}$$

For example:

How many cubic feet of hydrogen are released while charging an 18-75-15 (18-cell) battery (525 AH capacity) if it receives 20% overcharge?

$$H \; 5 \; \frac{KWBC}{100}$$

$$H \; 5 \; \frac{18 \; 3 \; 20 \; 3 \; 0.01474 \; 3 \; 525}{100}$$

H 5 *27.9 cubic feet of hydrogen*

Assume this gas is released during the last four hours of an eight-hour charge. Then calculating a rough rate of hydrogen release is possible.

Example:

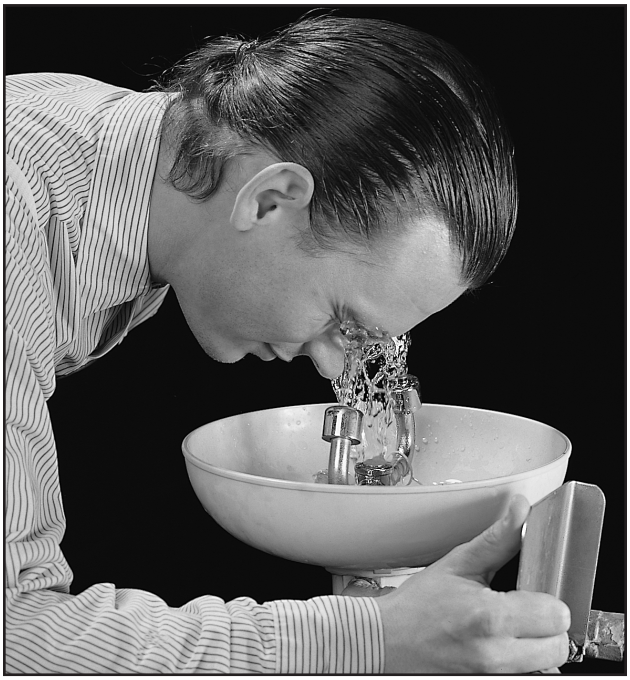
$\frac{27.9}{4}$ 5 *approx. 7 cubic feet per hour*

Eyewash and Emergency Shower Facilities

The kinds of equipment available for eyewash and acid neutralization vary widely as to capability and cost. Regardless of the equipment selected, it should be located in the immediate work area. The three most popular types of equipment are described below.

- **Chemical Burn Station**. This is the lowest cost type of safety equipment. It consists of a plastic squeeze bottle containing a buffering solution for the relief of acid burns on skin, clothing, or in the eyes. The bottle usually holds about a quart of solution. It is held in a brightly colored, molded receptacle about 1½ feet square that can be mounted on the walls of the battery charging areas or battery repair shops. Its use is practical in smaller battery charging areas and at battery repair shops where acid with a specific gravity of 1.400 or higher is not handled. Before installing chemical burn station equipment, check to see if it is acceptable to your company's Safety and Medical Departments.

- **Eyewash Fountain**. A water fountain–type of device with two openings that facilitate washing both eyes at once. This type of safety equipment is useful when 1.400 specific gravity acid is regularly used for gravity adjustment, etc.
- **Deluge Shower**. This is a shower-type device with a handle or foot treadle for turning it on full force. When high specific gravity sulfuric acid (above 1.400) is handled regularly, it is recommended that a deluge shower and an eyewash station be installed.



Eyewash station.

Vent Caps Stay In

Keep the vent caps in the cells at all times, except when removal is necessary to service or repair the cells. This precaution reduces the probability of electrolyte splash and prevents foreign matter from entering and damaging the cells.

Handling Acid

Acid Splash in the Eyes

Acid splashing into the eyes is the most dangerous condition possible while handling higher specific gravity acid or electrolyte. If splashing occurs, the eyes should be immediately flooded gently with running water for at least 15 minutes. Medical attention should be obtained as quickly as possible. Special care should be taken to check for persons wearing contact lenses. If acid splashes into the eyes, the lenses should be removed and the eyes thoroughly rinsed. WARNING: Do not place a buffering or neutralizing agent in the eyes without the approval of your Safety Department.

Acid Splash on Skin

Acid or electrolyte spilled or splashed on the skin should be washed off with running water. If a burn develops, report the incident to a supervisor and seek medical treatment.

Acid Splash on Clothing

When acid splashes on clothing, use a weak solution of bicarbonate of soda to neutralize the acid. When clothes are soaked with acid or acid is splashed over large areas of clothing, remove the clothing, neutralize the acid with bicarbonate of soda, and/or rinse with running water. The sooner the clothing is rinsed, the less likely it is that the clothing will be damaged.

Protective Clothing

Normal work clothing can be worn in battery charging and battery repair areas for routine battery work. Acid-resistant clothing is not as susceptible to acid damage as garments made of cotton, rayon, or similar materials. Appropriate personal protective equipment such as that listed below should be worn when servicing batteries:

- acid-resistant gloves
- acid-resistant arm gauntlets
- acid-resistant apron
- acid-resistant boots
- acid-resistant cover goggle or cup goggle plus face shield

Pouring Acid

A carboy tilter or safety siphon should be used when acid is removed from a carboy container. A venting device in a carboy will provide uninterrupted flow and prevent splashing. Never move a carboy of acid without its protective box. Store acid carboys in a cool place and keep them out of the direct sunlight.

Storing Acid and Electrolyte

Battery electrolyte and sulfuric acid solutions should be stored only in covered containers made of chemically inert material such as lead, glass, or acid-resistant plastics. Avoid using nylon containers as nylon has poor acid-resistant characteristics.

Protecting Floors in Battery and Charger Rooms

The floors in battery and charger rooms should be sloped toward a sump. Acid spillage should be neutralized before discharging into a sewer. Even though the floor is protected with an acid-resistant coating, it should nonetheless be washed down with water after an acid spillage. Check all local and EPA ordinances to make certain you are in full compliance with all regulations governing the use, maintenance, and disposal of lead-acid batteries.

Neutralizing Acids and Electrolyte

Sulfuric acid can be neutralized with several different chemicals. All should be handled with great care. We recommend using a commercially produced neutralizing agent.

INSTALLATION

Receiving a Battery

Inspecting the Shipping Container. Immediately upon receiving a battery, inspect the outside of the corrugated container (or crate) and the pallet. Look for wet spots on the sides and bottom. Wet spots generally indicate that the battery jars are broken or that the battery was tipped over in transit.

Making a Claim. Shipments are generally made FOB, HAWKER plant or stocking locations. Therefore, making a claim to the carrier is the responsibility of the customer. If there is evidence that the battery was damaged in shipment, a proper claim should be filed with the carrier.

The services of a professional industrial battery repair specialist may be required to evaluate the extent of the damage. Contact HAWKER or the nearest HAWKER representative.

Lifting Batteries. The ideal rig for lifting batteries is an overhead hoist equipped with an adjustable, insulated battery lifting beam as illustrated on page 10.

When attached to the lifting "eyes" of a battery, the lifting beam exerts a vertical pull on the eyes. This method prevents damage to a battery that would occur using lifting methods that tend to squeeze or stretch the battery tray.

If there is a possibility that the chain or cable of the hoist might come into contact with the battery post, cover the battery with a piece of plywood or another type of nonconductive material.

Immediate Repairs to Damaged Batteries. If the electrolyte level in a particular cell drops quickly after water is added, the jar in this cell is leaking and should be replaced. When service facilities and personnel are available, replacement of the leaking jar should be made within one week of discovery.

If repairs cannot be made, contact the nearest HAWKER Sales Office or Service Location for other arrangements.

Placing a Battery in Service

First confirm that the battery was not damaged in shipment. Then, give it a freshening charge of three to six hours (see freshening charge for details, page 19), and top up electrolyte levels as needed (see "adding water", page 23). The battery is now ready for installation.

Installing the Battery

The battery compartment of the vehicle must be well ventilated to allow the heat generated by the battery during discharge to dissipate. The battery compartment should also have drain openings in the floor.

Most vehicle manufacturers are aware of both these needs and have provided the necessary louvers, slots, and/or holes in the battery compartment. If the battery is to be installed in a metal compartment, make sure the compartment is clean and dry prior to installation.

Seat the battery in the compartment firmly and evenly, then block it into position. Many vehicles have adjustable clips for blocking the battery into place. Allow ¼" to ½" clearance between the block (or clip) and the battery tray. Do not wedge the battery into the compartment, because some room is needed for expansion. All vent caps must be in place. Uncapped cells will allow the electrolyte to splash and cause corrosion in the tray and vehicle and will eventually lead to a loss of battery capacity.

MAINTENANCE

Today's industrial battery is designed and built to give anywhere from 1,000 to 2,000 operation/charge cycles, depending on the application and the operating environment. If such a battery were to complete one cycle per work day, the life expectancy would be four to eight years.

Exactly how much life a battery will provide depends to a great extent on how well you take care of your battery.

The following maintenance procedures, properly carried out at the proper time, will go a long way toward prolonging the life of the battery and making it more efficient.

Routine battery maintenance consists of four functions:

- Properly charging the battery
- Adding water as needed
- Cleaning as required
- Maintaining battery at proper temperatures

Instruments for Inspecting Batteries

Three testing instruments are required to check batteries accurately and efficiently: a voltmeter, a hydrometer, and a thermometer.

The specify gravity and open circuit voltage readings are normally in direct proportion to each other after voltage stabilization; therefore, either a voltmeter or hydrometer can be used to check the battery. The use of the voltmeter is a faster method of approximating the state of charge in each individual cell and can dramatically reduce the time required for routine battery checking.

When using the voltmeter method of battery checking, take specific gravity readings on the two cells having the highest and lowest voltage readings. This will confirm the state of charge in both cells and accurately pinpoint the difference in the state of charge between them. The voltmeter is used when on-charge or on-discharge voltage readings are needed.

When reading a hydrometer, it is important to hold the syringe at eye level and in a vertical position. Be sure the float does not stick to the hydrometer barrel and is floating freely, not in contact with either the top or bottom of the barrel. The correct hydrometer reading is an imaginary line drawn across the scale at the lowest level of the electrolyte.

To read the individual cell voltages of a battery, place the positive lead of the voltmeter on the positive terminal of a cell, and the negative lead of the voltmeter to the negative terminal of the same cell. Cell voltages must be read to the 1/100th of a volt. Example: 2.12, 2.09, etc.

A battery thermometer is read like any normal thermometer. If the thermometer does not have specific gravity corrections marked on its scale, refer to the "Specific Gravity Temperature Chart" on page 20 to determine the specific gravity correction.

The HAWKER Hydrometer has an extra-long scale to make reading more accurate. For ease of correcting for temperature, the specific gravity corrections are marked on the scale of the HAWKER Thermometer.

Battery Charging

By far the most important part of routine maintenance is the proper charging of your batteries. When a battery is connected to the charger, DC current is distributed through the battery in a direction opposite to that which occurred during the discharge process. During the charge, the sulfate ions are driven from the positive and negative plates into the electrolyte solution, and the plates are returned to lead peroxide (positive) and sponge lead (negative). The electrolyte begins to increase in specific gravity. Since the plates within a battery are able to accept DC current at any rate in amperes which does not exceed the number of AHs required to complete the charge, the current in the starting portion of the charge is usually determined by the charger manufacturer.

Once the output amperage of the charger begins to exceed the number of AHs required for charge completion, the result is generation of oxygen and hydrogen gas, overheating of the battery, and degrading of the positive plates. For this reason, chargers are designed to rapidly reduce the rate at a point where it is assumed the battery is 80% charged.

Although deleterious to the battery, some gassing action is necessary to prevent stratification of electrolyte. A prime advantage of the HAWKER LIFEPLUS® 2000 charger is periodic stirring of electrolyte throughout the charge cycle, eliminating the need for heavy gassing in the last portion of the charge.

Ideally batteries will be charged on the HAWKER LIFEPLUS® 2000 battery charger. With the LIFEPLUS® 2000, there is no chance of a mismatch between the charger and the battery as the charger relies on dynamic interrogation of the battery to determine the precise amount of recharge needed, regardless of voltage, AH capacity, age of the battery, or state of discharge.

If the battery is to be charged on a conventional charger, it is important to ensure that the capacity of the charger is correctly matched to that of the battery. Failure to do so will result in permanent damage to the battery, charger, or both. Also, conventional chargers should be equipped with a dependable automatic start/stop control. Information on either the LIFEPLUS® 2000 charger or automatic start/stop circuits is available from your HAWKER Sales Office or Service Location.

All that is necessary for routine charging is knowledge that the charger is functioning properly. This is accomplished by periodic inspection and adjustment of the equipment, which can be performed by an outside professional charger repair specialist; however, a basic knowledge of what is involved in the charging operation, plus a brief description of the more important types of charging and when they should be used, should provide valuable information in the event of charger malfunction or for charging operations not using fully automatic equipment.

Types of Charging

There are a number of different charging methods, but for purposes of this manual, only three need explanation. These are: Cycle Charge, Equalizing Charge, and Freshening Charge.

Cycle Charge

This is the complete recharge of a battery after is has been fully or partially discharged during the normal operation. Typically, a cycle charge is based on an eight-hour charging cycle but can, depending on need, be extended.

Equalizing Charge

Each cell of a battery has slight differences in uniformity of construction and content. These slight differences cause some cells to take less charge than the other cells in the battery. After a time, the state of charge of the cells which require more charge than the others will drift back in voltage and specific gravity, and the battery will not deliver its full capacity. To bring the cells with a lower state of charge up to the same level as the others, the battery is given an "equalizing charge." The cells with a higher state of charge will be somewhat overcharged, to bring the cells with a below-normal state of charge up to full charge.

Years ago, when lift trucks and mine locomotives were used lightly or sometimes stored during slack seasons, frequent equalizing charges (sometimes weekly) were recommended by battery manufacturers. Today, this inflexible kind of equalizing schedule is not recommended. Instead, the recommended frequency of equalization depends on how often the batteries are cycled and the depth of the cycles.

The frequency of equalization can dramatically affect the operational costs of the vehicle. Unnecessary equalizing charges, in addition to consuming electricity, can result in significant loss of battery life caused by unnecessary overcharge.

The following examples will give you a good idea of a reasonable battery equalizing schedule for a specific battery operation.

- For batteries that are cycled only once or twice a week to an average depth of 30% to 60%, a monthly equalizing charge is usually sufficient to keep them fully charged.
- Batteries that are discharged regularly—three or more cycles per week to an average discharge depth of 60% to 80% of their rating—can usually be kept healthy by equalizing them every two months.
- Batteries that are cycled four to eight times a month at any depth normally require equalizing about once a month to keep them in healthy condition.
- Batteries that are cycled five or more times a week at an average discharge depth of 60% to 100% may not need equalizing charges unless stored.

Freshening Charge

A freshening charge is used to bring a battery to a fully charged condition before it is placed in service or when it has been standing idle for a short period. It takes about three hours at the finish charge rate (three to six amperes per 100 AH of the battery's six-hour capacity rating). See "Some DOs and DON'Ts of Effective Battery Maintenance," page 27.

The Charging Process

When a battery is placed on charge, the opposite action of battery discharge takes place. That is, the sulfate in the active material of the plates is driven back into the electrolyte. This reduces the sulfate in the plates and increases the specific gravity of the electrolyte, and the electrochemical process continues until the on-charge cell voltages reach 2.50 to 2.70 volts per cell, depending on the type of charging equipment used.

Finish rate or "normal" rate is that current which can be used safely any time charging is required, and which can be continued after the completion of initial charge without a significant increase in the temperature resulting from overcharge. Generally speaking, it is between three to six amperes per 100 hours of the battery's six-hour rate capacity. The chart "Typical Recharging Characteristics," page 22, shows this finish charging rate. The curves are typical of the recharge of an 18-cell battery which was discharged 725 AH and shows specific gravity, current voltage, and cell temperature.

Note that after approximately four hours of charge, when the battery is at about 80% of its nominal full charge, the charging current is reduced to a lower rate and maintained until charging is complete. When the battery is fully charged, the current should be stopped or reduced to a very low rate.

How to Determine if a Battery is Properly Charged

If the battery charging equipment is the counter voltage sensing type and is functioning properly, and if the battery is in a healthy condition, there is little chance your battery will be improperly charged. If some doubt about its operation exists, the following checks are a quick way of insuring that you are properly and fully charging your batteries:

- Charging current readings level off to the finishing rate
- Charging voltage stabilizes
- No rise in specific gravity
- Normal gassing (Excessive gassing is defined on page 21 under "Gassing.")
- No excessive heat generated in the battery

Overcharging

An excessive amount of charge results in high battery temperature, reducing the battery's service life.

Overheating

To obtain maximum service life from a battery, it should be charged and operated at electrolyte temperatures below 115°F. Above this temperature, overheating occurs. Overheating will damage the battery and shorten its normal expected service life. The extent of the damage and loss of service life depend on how high the temperature rises, how often the overheating occurs, and how long the batteries are subjected to high temperatures.

A healthy battery charged on a properly functioning charger will have a 10°F to 20°F rise in temperature when fully charged from a completely discharged state. What causes a battery to go beyond this range and overheat? The temperature rise is affected by several variable factors:

- Temperature of the battery when put on charge
- Age and condition of the battery
- Start, intermediate, and finish rate of the charger
- The amount of overcharge given the battery

Electrolyte Temperature	Point Correction
140°	+21
137°	+20
134°	+19
131°	+18
128°	+17
125°	+16
122°	+15
119°	+14
116°	+13
113°	+12
110°	+11
107°	+10
104°	+9
101°	+8
98°	+7
95°	+6
92°	+5
89°	+4
86°	+3
83°	+2
80°	+1
77°	No Correction
74°	−1
71°	−2
68°	−3
65°	−4
62°	−5
59°	−6
56°	−7
53°	−8
50°	−9
47°	−10
44°	−11
41°	−12
38°	−13
35°	−14
32°	−15
29°	−16
26°	−17
23°	−18
20°	−19
17°	−20
14°	−21

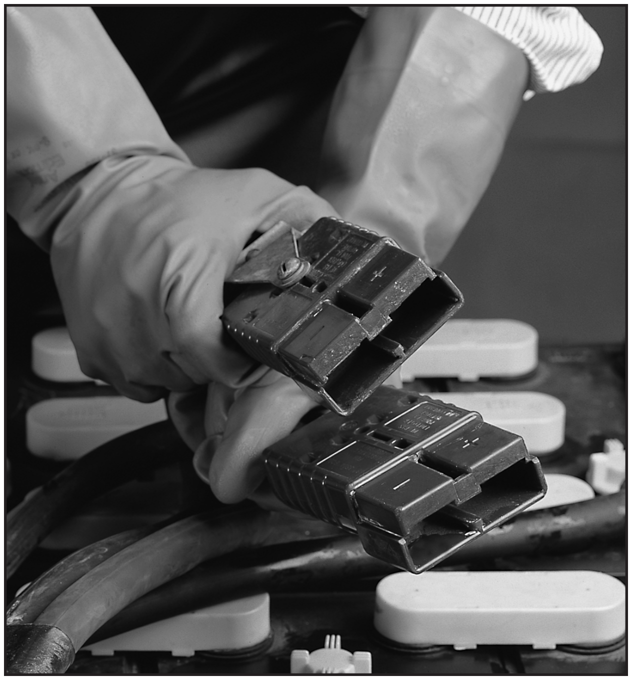
Specific Gravity Temperature Chart

In lift-truck operations, a battery can overheat because of the operating requirements of the truck, as well as the operating environment. If a lift truck requires almost continuous current draws that are higher than normal, the temperature will rise. Ideally, for this operation, a "cool" battery whose temperature is 90°F or lower should be installed in the truck. However, if the lift-truck operation starts with an overheated battery whose temperature is over 115°F, the continuous high current draws will tend to make the temperature rise even higher and battery damage is likely.

Typical working environments where batteries must operate in an overheated condition are in a foundry, where ambient temperatures reach 120°F and higher, and in heavy-duty operations where they must be charged every five to six hours with no time for cooling before a charge. The latter problem can often be alleviated by having more than two batteries per truck. For the former, an inexpensive way to cool the battery is by directing a fan over its intercell connectors; since they conduct about 60% of the heat out of the battery, the battery will cool rapidly. Always charge with battery covers or truck compartments open.

Operating and charging batteries at elevated temperatures is a frequent cause of battery damage and reduced service life. An experienced battery technician, given the levels of operating and charging temperatures and the time span for which they are held, can estimate the percentage of service life lost.

The estimated loss, expressed as a percent, can serve as the basis for deciding whether to invest in extra batteries or battery cooling equipment. If this kind of professional judgment is not available in your plant or operation, contact your nearest HAWKER Sales Office or Service Location.

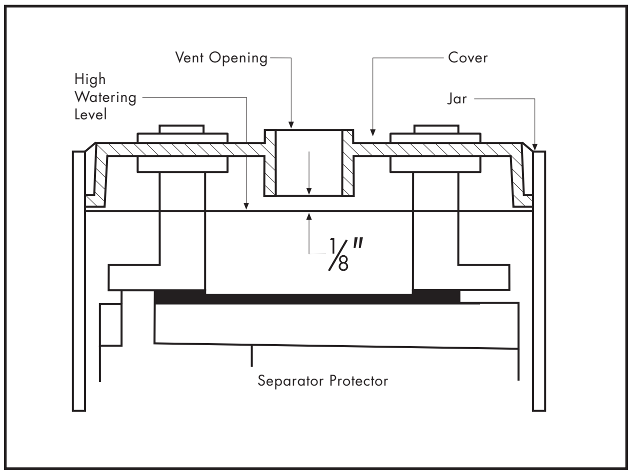


Keyed connectors eliminate the possibility of hooking up a battery to the wrong charger or vehicle. The differently keyed connector housings prevent these connectors from being interconnected.

Keyed Connectors

Sometimes batteries of several different voltages and AH capacities are charged at the same centralized location. Precautions must be taken to ensure that batteries are charged on chargers with matching voltages and AH ratings.

Rather than relying on employees to place the batteries on the correct chargers, we recommend using plugs and connectors of different types or color keys. Contact the nearest HAWKER Sales Office or Service Location for more information on the various kinds of charging plugs and connectors that are available.

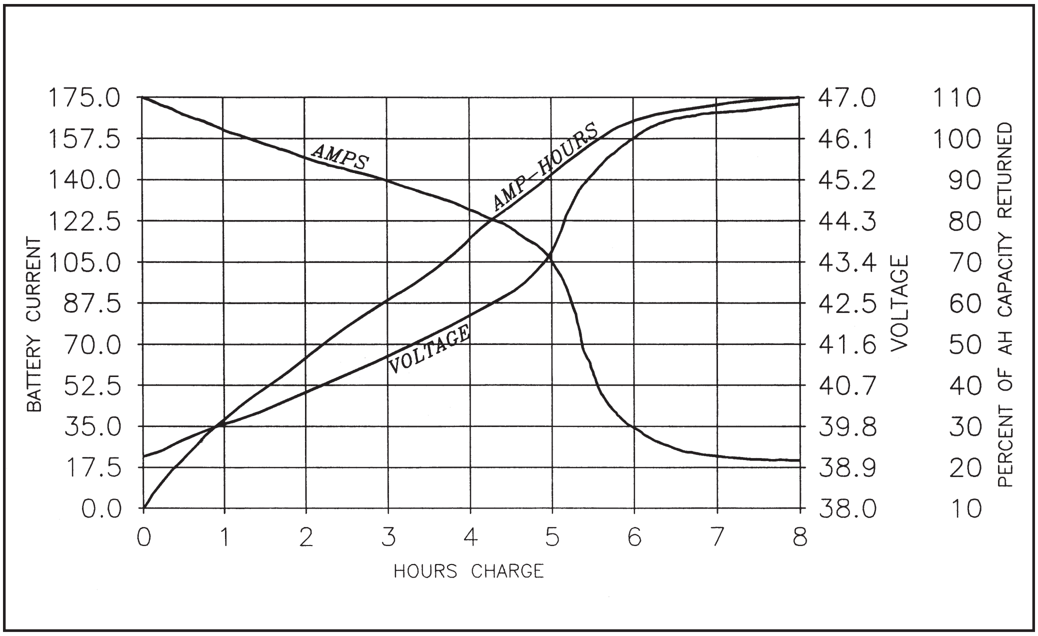


The electrolyte level must be kept between the "high watering level" and the separator protector as shown in the sketch. Caution: Do not overfill. Moisture on the tops of the batteries indicates overfilling has occurred.

Gassing

When a battery is charging, the electrolytic breakdown of the water in the electrolyte produces oxygen on the positive plate and hydrogen on the negative plate. This is normal; however, if a high charging rate is continued after the battery has been brought to the gassing voltage, the gassing becomes excessive and abnormally large amounts of hydrogen and oxygen are produced. The best indication of excessive gassing is very noticeable bubbling action of the electrolyte.

Hydrogen is a highly combustible gas and will explode on ignition when its concentration in air reaches any level between 4% and 74% (Below 4% the concentration is too weak; above 74% there is not enough oxygen left in the air to support combustion). If you have reason to suspect



Typical Recharging Characteristics. Typical charge return to an 18-cell battery discharged at 80%, using a HAWKER LIFEGUARD ® charger.

excessive gassing, troubleshoot the battery and charging equipment. An unusually high usage of water indicates that excessive gassing is occurring.

Undercharging

Undercharging a battery, even to a small degree, if continued, leads to excessive sulfation. The same is true of batteries which have been left standing in an uncharged state for an extended period. High temperatures rapidly accelerate sulfation when batteries are left standing in a partially charged condition. The cells of a sulfated battery will give low specific gravity and open circuit voltage readings.

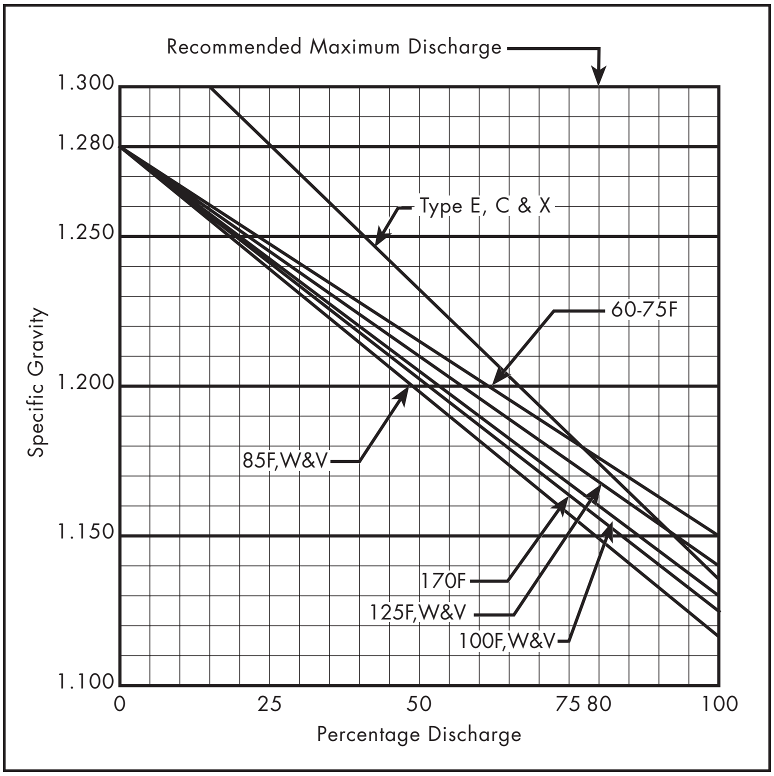
On charge, voltage readings will be unusually high. The battery will not become fully charged after a single normal charge when sulfation has taken place over a prolonged period.

Treatment of Sulfated Batteries

Careful attention to the following steps often will restore a sulfated battery to good operating condition.

1. Thoroughly clean the battery. (See page 26 for battery cleaning instructions.)
2. Bring the electrolyte level to proper height by adding water.
3. Put the battery on charge at the prescribed finishing rate or less until the rated AH capacity has been returned to the battery. Record the voltage and specific gravity. Correct the specific gravity readings using the chart shown on page 20. If temperature at any time during these procedures exceeds 115°F, stop the charger and allow the battery to cool to 90°F or below before continuing the charge. Continue charging the battery until the specific gravity, corrected for temperature, shows no change during a four-hour period, taking hourly readings. With automatic charging equipment, the battery may have to be placed on equalizing charge two or three times. If a battery is badly sulfated, the specific gravity may rise only 30 or 40 points (.030 to .040) during this first charge.

4. Place the battery into service and discharge it to a fully discharged condition. The chart at right shows the specific gravity of a 100% discharged battery. (The battery can be discharged through a bank of resistors, if desired.)
5. Charge the battery again until the specific gravity shows no change during a four-hour period.
6. Repeat the charge/discharge process until the specific gravity rises to within 30 points of a fully charged battery. Then place the battery back into normal service.



Recommended Maximum Discharge. The final specific gravity of a battery depends upon depth of discharge, temperature, initial specific gravity, and battery type.

Although the specific gravities may be lower than normal, they should not vary much from cell to cell. If they do, problems other than sulfation may be present. If the spread between the highest and lowest specific gravity readings is 50 points (.050) or more, refer to the "Troubleshooting Chart" on page 37 to help identify the problem.

If the battery has not responded to the above treatment, it should be replaced.

The final specific gravity of a battery depends upon depth of discharge, temperature, its initial specific gravity, and battery type.

Adding Water

Generally, a certain amount of water loss is normal in all batteries, and it should be replaced with "pure" tap water or distilled water. In some areas around the country, tap water may contain chemicals or other impurities harmful to batteries. If in doubt about the suitability of the local tap water, read the information following entitled "Water Suitability and Water Analysis." If water is needed, add just enough to bring the electrolyte to the proper level as illustrated on page 21 and also in the "Ten Commandments of Good Battery Care" posters and cards, which are available upon request.

Batteries should be filled only at the end of the charging cycle. Overfilling is the most common error made when watering because it can cause tray corrosion and loss of capacity. Since corrosion can cause EXTENSIVE DAMAGE to batteries and vehicles, extreme caution must be taken to avoid overfilling the batteries.

The information in "Tray Corrosion," page 24, identifies the cause and effects, and suggests how to prevent it. The information in "Watering Schedule," page 25, can help you to establish a reasonable and economical watering schedule.

Water Suitability and Water Analysis

Most tap water in the United States is suitable as replacement water in lead-acid storage batteries. There are few locales where certain quantities of specific impurities will reduce battery life significantly enough to justify the use of distilled or a more "pure" water. The NEMA recommendation for battery replacement water lists the following maximum allowable impurities (parts per million):

Total Solids	350	ppm
Chlorides	25	ppm
Nitrates as NO_3	10	ppm
Iron as Fe	4	ppm

Occasionally, tap water has a small amount of nickel, manganese, chromium, or copper contamination. Depending on the quantity, these contaminants also can significantly affect battery life.

If the HAWKER analysis indicates that the tap water in your locale is not suitable for batteries, it is possible that a more suitable tap water might be found within a reasonable distance and transported to your location more economically than purchasing distilled water or water purifying equipment.

Tray corrosion can shorten battery life significantly. It is most often caused by overwatering.

Tray Corrosion

Most motive power battery trays are made of steel that is protected with an acid-resistant coating. Regardless of how good the coating is, if a break exposes the steel tray to sulfuric acid spilled from the battery, the acid will corrode the tray. How quickly the tray corrodes depends on how much and how often acid is spilled on top of the battery and how often the battery is cleaned.

Checking water level.

The major cause of tray corrosion is overwatering or overfilling a battery. When overfilled, the electrolyte will spill on top of the battery. Although the water in the electrolyte will evaporate, the highly concentrated acid solution remains and gives the appearance of dampness. If the acid is not removed, the tray will eventually corrode. To prevent corrosion, battery surfaces should be cleaned and neutralized any time the accumulation of dampness or acid becomes significant.

The only way to prevent overfilling is by not exceeding the level listed in the "Ten Commandments of Battery Care." A good technique to follow in watering batteries is to use a flashlight focused on the vent hole being watered. Watch the level of the electrolyte rise, and stop the watering the instant the proper level is reached. Each cell is filled in the same way. Cell-filling equipment that automatically fills the batteries to proper levels is available. Contact the nearest HAWKER Sales Office or Service Location for details.

In addition to causing tray corrosion, the accumulation of acid in conjunction with the corrosion can cause grounds. Two significant grounds can create an external short through the case of the battery. As a result, some or all of the cells will continually discharge. And as the current-carrying ability of the multiple grounds increases, further complications such as jar leakage, overheating, cell failure, etc., can occur. Furthermore, grounds can also cause serious problems or failures in the electronic controls or electrical components of the vehicle.

To test for a ground in a battery, set the voltmeter to handle the full open circuit voltage of the battery being tested. Place the positive probe on the positive terminal of the battery and the negative probe on a spot of the steel tray where bare steel is exposed. Make sure that the negative probe penetrates the paint to the steel. To detect the location of the ground, move the positive probe from intercell to intercell connector until the lowest voltage reading is found. This will be the grounded cell.

To clear the ground, clean and neutralize the top of the cell. If the ground is still present, remove the cell and check for leaks. Reseal with plastic welder, if necessary.

Watering—Regular Vent Caps

Watering—Flip-top Vent Caps

Watering Schedule

Low electrolyte level in a cell can cause the plates to oxidize and shorten the life of the cell and the battery. To prevent this needless and wasteful damage, water should be added often enough to keep the electrolyte level above the perforated separator protectors. Ideally, a watering policy or schedule should be adopted and followed strictly. One of two systems can be used. In the first, the electrolyte level of two or three cells is checked each time the battery is charged. In the second, water is added to all of the batteries assigned to each charging area on a regular time schedule. The electrolyte levels are also spot-checked periodically to determine if the proper levels are being maintained.

Determining a reasonable and proper battery watering time schedule could be easy or difficult, depending on how widely the following three factors vary:

- Frequency of charge (daily, 1½ times a day, three times a week, etc.)
- 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 in good condition. Also, some cell types have a greater water storage capacity than others.

Depending on the preceding variable factors, the batteries assigned to a specific charging area will require watering at different intervals. The frequency of watering is best determined by firsthand experience. EXAMPLE: If some batteries have low electrolyte levels when a weekly watering schedule is followed, change the schedule to twice a week.

Cleaning a battery

The WATER LESS® battery is specifically designed to be watered only once every 90 days, in normal applications, one cycle per day. The electrolyte level should still be spot-checked periodically to determine if the proper levels are being maintained.

Cleaning

To prevent tray corrosion and its associated problems, batteries must be cleaned and dried routinely.

Sometimes minor spills or overflows of electrolyte occur due to overfilling. Instead of giving the battery a general cleaning at this time, the moisture can be removed with rags or paper towels. (These should be disposed of immediately.) The frequency of a general cleaning depends upon two factors:

- How quickly dust, dirt, oil, and other foreign matter accumulate on the top of the battery
- How quickly the electrolyte spillage accumulates

When the top of a battery is dirty or looks damp, it is ready for a general cleaning. Cleaning could be necessary as often as every two weeks or as infrequently as every six months, depending on the battery's environment and the care it receives.

To give a battery a general cleaning, use hot water with a commercially available neutralizing detergent solution.

Apply the solution to the top of the battery with a clean paintbrush, working it under the intercell connectors and the terminals to loosen the grime and neutralize the acid. If baking soda is in the solution, apply the mixture until the "fizzing" action stops. (An ammonia solution will not "fizz.") Then rinse the battery with clear, hot water from a low-pressure hose to remove all traces of the solution and loose dirt. Cold water works, but hot water cleans better.

DURING ANY CLEANING, BUT PARTICULARLY WHEN USING A NEUTRALIZING/ DETERGENT SOLUTION, MAKE CERTAIN THAT ALL VENT CAPS ARE TIGHTLY IN PLACE.

Some DOs and DON'Ts of Effective Battery Maintenance

As is true with almost any piece of industrial equipment, proper maintenance not only keeps it operating to its design specifications, but also helps prolong the equipment's service life. Industrial batteries are no exception. The following maintenance tips, if followed, can help achieve top performance over thousands of hours of operation.

1. DO maintain the proper electrolyte level. Avoid overfilling, as this damages the battery.
2. DO charge properly. Check charger controls and instruments periodically. Calibrate meters as needed.
3. DO repair damage promptly. Major damage means an idle investment. Minor damage, if not quickly repaired, can soon lead to major damage.
4. DON'T overcharge. Many batteries deliver short service life from too much charge.
5. DON'T discharge over 80% for maximum battery life. Over-discharging is one cause of less-than-normal battery life. And, as a battery nears complete discharge, its operating efficiency decreases substantially.
6. DO use batteries according to the manufacturer's recommendations. Using a smaller capacity battery than is called for is a sure way to ruin an expensive investment.
7. DON'T place metal objects on a battery. They can "arc" or short-circuit the battery.
8. DO replace at 80% of capacity. When a battery cannot deliver more than 80% of its normal capacity after a charge, it's time to replace it. A battery in poor condition can cause low-voltage operation in the vehicle and result in substantial damage to its electrical components.
9. DO keep accurate records. They provide an accurate history of the battery and permit replacement of worn units in time to forestall production stoppages. Accurate records also indicate whether a battery is being abused.
10. DO give periodic equalizing charges as described on page 19.
11. DO check batteries periodically—cell voltages, specific gravities, and electrolyte levels.
12. DO make regular visual inspections to determine spillage, corrosion, damage to the case, and similar problems.
13. DO keep idle batteries charged. When stored for extended periods, batteries should be given a freshening charge periodically, as well as immediately before use.

BATTERY RECORDS

The Purpose of Keeping Records

Plants with more than just a few batteries find that records of battery cycles, maintenance, and repair are indispensable for an effective battery maintenance program. In developing a records system, a number of procedures should be considered:

1. Establish a battery identification system, giving each battery a code number. For example, a multiple-digit system, such as 1001, 1002, etc. can be used for all 36-volt, 750 AH batteries and 2001, 2002, etc., can specify all 12-volt, 450 AH batteries, etc.
2. The specific gravity of the pilot cell or cells of a battery should be recorded before and after each charge. Pilot cells are one or more designated cells whose specific gravity is checked to determine the general state of charge in the battery. The vent caps of pilot cells are usually a different color than the rest of the vent caps.
3. Provide a means of recording the number of cycles on a cumulative basis to date, as well as maintenance and repair information.

Types of Forms and Their Use

Many types of recording forms have been created by companies for their own private use. These forms, although similar in many respects, vary according to the individual plant's needs.

The obvious and primary value of these types of records is that they provide historical records of the performance of individual batteries, the tests performed, and repairs completed. A closer look at any individual battery's records can reveal a number of other interesting and helpful pieces of information.

- Recording specific gravity at the beginning and end of each cycle will pinpoint any irregularities in the condition of the battery or its use in operation.
- Records of specific gravity of the battery when it is brought in for recharging indicate whether the battery is being abused and/or used in a low-voltage condition.
- Maintenance and repair records often point to battery abuse and also gauge a specific battery's performance.
- Continuing monthly and yearly records help to pinpoint a battery's cycle age and control the battery inventory and replacement programs.

HAWKER

HAWKER
BATTERY DISCHARGE TEST

Type____________________ Capacity___________ Serial Number____________ Date______________ Tested by__________

Start Temp._________ Finish Temp________ Time Started_______a.m. p.m. Finish Rate_________ Discharge Rate___________

Open Circuit Volts	Specific Gravity	On Charge Volts	On Charge Gravity	Positive CAD	Negative CAD	1st Hr. Read	2nd Hr. Read	3rd Hr. Read	4th Hr. Read	5th Hr. Read	6th Hr. Read	End User Charger Type
1												Comments
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												
13												
14												
15												
16												
17												
18												
19												
20												
21												
22												
23												
24												

Battery Discharge Test

PERIODIC BATTERY INSPECTION

The Purpose and Frequency of Inspections

The investment in motive power batteries can be considerable. To protect this investment, it is recommended that both batteries and chargers be inspected periodically. This general type of inspection, which is a form of preventative maintenance, should not be confused with the inspection carried out for troubleshooting a battery to pinpoint a specific problem.

If minor problems in batteries and chargers can be identified early, then adjusted or repaired, battery damage can be avoided. A battery inspection often reveals improper routine maintenance and operational procedures, which can lead to extensive battery and vehicle damage. Inspection can also identify batteries in poor condition so they can be replaced immediately or at some suitable time in the future.

Establishing a battery inspection timetable suitable for all users is difficult, because battery usage and the quality of routine maintenance differ from one plant to the next. However, if routine maintenance is average and the batteries are cycled once a day, five days a week, an annual inspection should be sufficient to identify any problems.

With rare exceptions, few vehicle repairmen have the necessary training and experience to identify and correct the subtle battery and charger problems that can occur. But, it is relatively easy for the experienced professional serviceman equipped with special instruments and tools to identify the problems. If your organization does not have a trained battery and charger repair specialist, we recommend that you contact the nearest HAWKER Sales Office or Service Location to inquire about the cost of these periodic inspections by a professional.

A troubleshooting procedure, chart, and list of diagnostic hints appear in the "Troubleshooting" section of this manual beginning on page 33.

How to Inspect a Battery

The more complex and extensive battery inspecting, testing, and diagnostic work is often best handled by experienced motive power battery technicians. This manual is not intended to be a complete source for the training of a battery technician, although it provides a good foundation. The following instructions can show an electrician or vehicle repair specialist how to gather and record basic information that can help pinpoint the source of a battery problem.

1. If the battery is still in the vehicle, turn off the power switch and disconnect the battery by unplugging it from the vehicle.
2. Allow the battery to remain on open circuit (without charging or discharging) for 30 minutes or longer.
3. Prepare a form similar to the illustrated "Field Inspection Report" on the following page. Fill in the necessary data on the top of the form, i.e., battery type, serial number, etc.
4. Read and record the specific gravity and open circuit voltage (cell volts) for all cells of the battery. The positive terminal cell of the entire battery is recorded as cell #1, etc., following the intercell connectors to the last cell which is the negative terminal cell of the battery.
5. Read and record the pilot cell temperature. If the battery is being tested on charge or discharge, record the "reading at ___ amps."
6. Record the temperature-corrected specific gravity readings. Use a temperature correction thermometer, or refer to the "Specific Gravity Temperature Chart" on page 20 to correct the specific gravity reading for temperature. Use the pilot cell temperature for the temperature correction of all the battery's cells. It is not necessary to read the temperature of every cell unless the temperature difference between the center cells of the battery and the outside cells of the battery is 12°F or more.

HAWKER

FIELD INSPECTION REPORT

Company ______________________ **Date** ______________

Address ______________________________________

______________________ **Telephone** ______________

Battery Type __________ **Battery Capacity** _______ **Battery Serial Number** ______________

BATTERY USAGE & CONDITION

A.H. capacity and volts on truck I.D. plate:__________
Type of lift truck: ______________________
Number of shifts truck is used each day: __________
Tray conditions: ______________________
Cell covers: Clean Dry Leakers
Are vent caps tightly in place? Yes No
I/C Connectors ________ Cable condition ________
Type of water added: ______________________
Are lift interrupts installed? Yes No
Are cycle & maintenance records available? Yes No

A.H. ____________ Volts ______________
Number of batteries per truck: ______________
Number of days per week truck used: __________
Connector condition: ______________________
General appearance: ______________________
Electrolyte levels: ______________________
Date water added: ______________________
Water addition frequency: ______________________
Are lift interrupts calibrated? Yes No

BATTERY CHARGER & CONDITION

Charger Manufacturer ______________ Charger Type: MAG.AMP FERRO SCR OTHER
Model ______________________ D.C. Output: ______ AMPS ______ Volts ______ A.H.
Are batteries charged in charging area with battery covers open? Yes No
Type of charging time control? ______________ AC Input ________ Volts AC ____________

INDIVIDUAL CELL READINGS

Are cell readings taken while battery is in lift truck? Yes No Temp. of battery in truck _____ºF
Charger rate readings taken: ______ AMPS Ambient temp.: ______ºF

Cell #	Open Circuit		On Charge		ºF
	Volts	Sp. Gr.	Volts	Sp.	
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					
11.					
12.					

Cell #	Open Circuit		On Charge		ºF
	Volts	Sp. Gr.	Volts	Sp.	
13.					
14.					
15.					
16.					
17.					
18.					
19.					
20.					
21.					
22.					
23.					
24.					

Special comments ______________________________________

____

____

Person seen: ______________________ Travel time: ______________ hours

Signed ______________________

Field Inspection Report

TROUBLESHOOTING

There might be times when a battery does not perform to expectations, or times when a specific symptom such as overheating, high water usage, etc. indicates that a problem exists or indicates the possibility of impending trouble.

To help identify conditions, pinpoint problems, and offer solutions is the purpose of this Troubleshooting section. The following diagnostic hints, detailed instructions for capacity and cadmium electrode testing, and Troubleshooting Chart can go a long way in helping to correct minor problems before they become major expenses.

Some Diagnostic Hints

These hints can help pinpoint the source of battery problems.

1. While a battery is on charge, feel the intercell connectors. A hot connector usually indicates an overheated battery, defective cell(s), or a bad connector burn.
2. An accumulation of moisture and/or tray corrosion on the bottom of a battery or a vehicle battery compartment often indicates that one or more jars are leaking.
3. Unequal cell specific gravities in a new battery indicate that the battery might have been tipped over and that the cells with the lower specific gravities have lost electrolyte.

   If a battery is inspected shortly after it is watered and prior to charging, the specific gravity readings may be low and uneven. The specific gravities will level out after the battery is fully charged.
4. Watering to the proper level is the most difficult procedure to control in routine battery maintenance. Overwatering causes tray corrosion and results in the multiple problems discussed on pages 37 and 38.
5. A defective or out-of-adjustment battery charger can create considerable damage before the cause is discovered. Vehicle operators should be trained to report “hot” batteries. Battery maintenance personnel should report to their supervisors when chargers do not reduce the charging rate at the end of every charge.
6. Continual over-discharge dramatically shortens battery life. Avoid over-discharging by using battery protectors in the lift trucks; or obtain more batteries—with higher capacity, if possible—and charge them more frequently.
7. If the spread between the lowest and highest cell specific gravity in an older battery is .050 or more, the battery will probably deliver less than 80% of its rated capacity and may need to be replaced. (Read “Capacity Testing” below for more details.)
8. As a battery ages, the positive plates “grow” in length and push the post of the battery up until it becomes noticeable. The positive post of every cell cover in the battery will be higher than the negative post, and the covers may appear to be tilted. When the positive posts of all the cell covers are 3⁄16″ to 1⁄4″ higher than the negative posts, the battery is probably worn out and beyond economical repair.
9. Most battery problems can be avoided or corrected by strictly following the “Ten Commandments of Good Battery Care.”

Capacity Testing

A capacity test enables you to determine the capacity a battery actually delivers as compared to its rated capacity. If all other testing methods fail, this test can help determine if a battery should be replaced. When a battery delivers less than 80% of its rated capacity, the remaining capacity will rapidly decrease with each additional cycle. Logically, therefore, it should be replaced before some of its cells fail and cause low-voltage operation of the vehicle, which can result in damage to the truck’s electrical system.

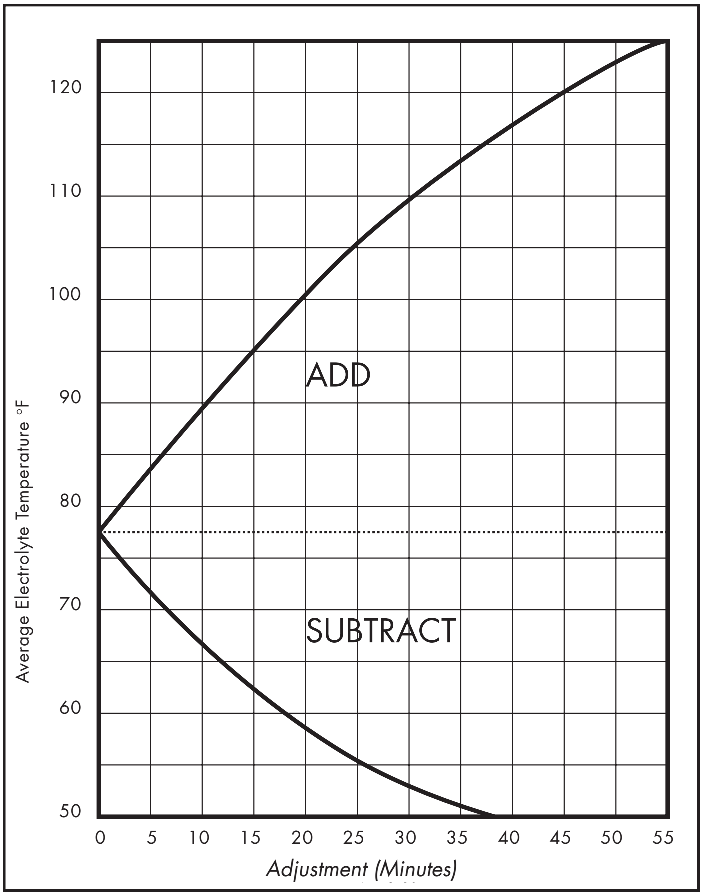
A capacity test is performed by discharging a fully charged battery at a fixed rate while carefully following specific test conditions, methods, and procedures.

Capacity= $\frac{\textit{Runtime}}{\textit{6 hours*}}$

Example: A 600 AH battery at 77°F fully charged at the six-hour rate is discharged at 100 amperes (600 AH 4 six hours) until it reaches a final battery voltage of 1.70 volts per cell times the number of cells in the battery. If this final battery voltage is reached in five hours, the battery delivered 83.3% of its rated capacity.

$\frac{\textit{5 hours}}{\textit{6 hours*}}$ 3 *100% = 83.3%*

*The six-hour rated discharge time is based upon an average electrolyte temperature of 77˚ F (25˚C). For batteries whose average electrolyte temperature is above 85˚F or below 70˚F, a correction to the six-hour rated time must be made. To correct for temperatures, use the graph to the right to add or subtract time to/from the six-hour number.



Temperature Correction for Capacity Testing

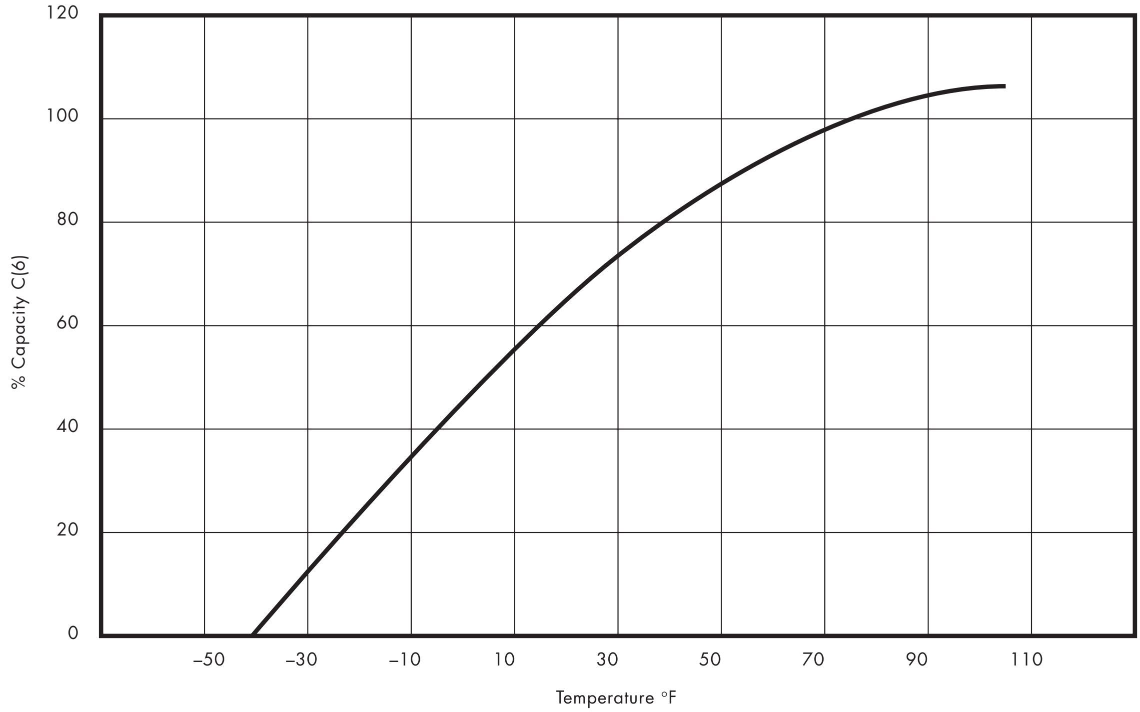
For example, a battery with an average electrolyte temperature of 100˚F calls for a 20 minute increment to the six-hour rated time (360 + 20 =380 minutes or 6.33 hours). Likewise, a battery with an average electrolyte temperature of 55˚F calls for a 25 minute reduction to the six-hour rated time (360 - 25=335 minutes or 5.58 hours).

The graphs on page 35 demonstrate the effects of temperature and rate of discharge on battery capacity.

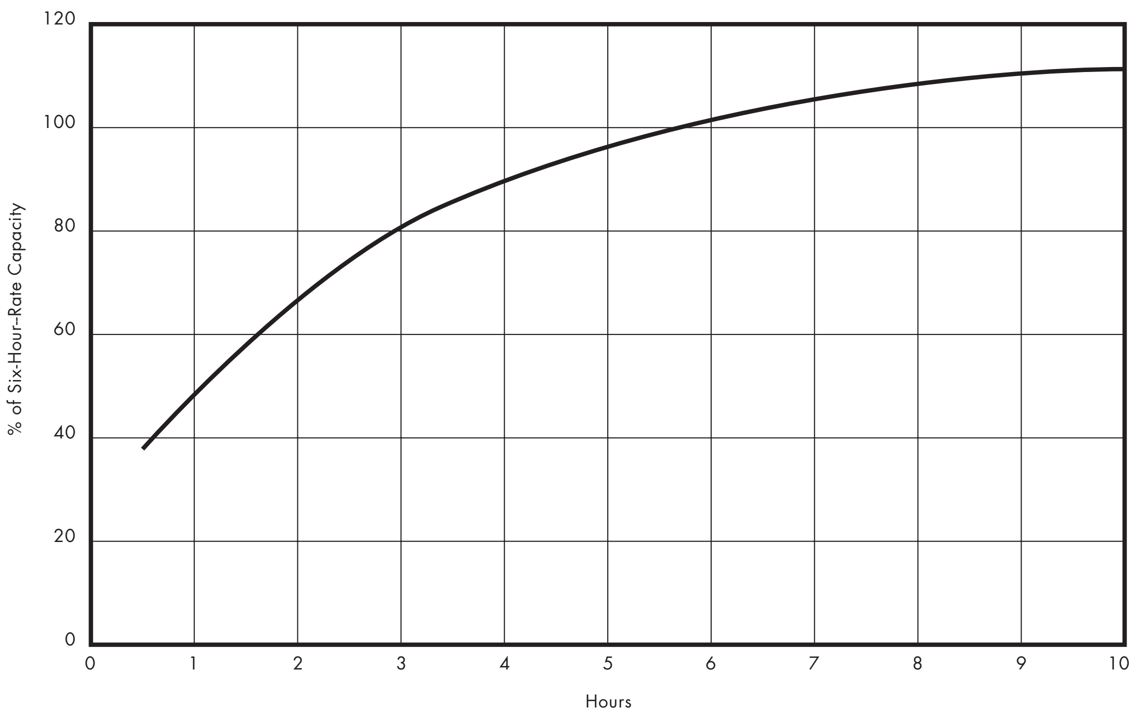
We recommend the test conditions, methods, and procedures specified in Battery Council International Standards No. BCI-1-2 (4/97), "Determination of Capacity of Lead Acid Industrial Storage Batteries for Motive Power Service." Copies of this publication can be obtained at a nominal cost by addressing inquires to:

Battery Council International
401 North Michigan Ave.
Chicago, IL 60611
Telephone (312) 644-6610

The rated capacity of a HAWKER battery is indicated on the nameplate. If it is illegible, contact the nearest HAWKER Sales Office or Service Location.



Available Capacity vs. Temperature

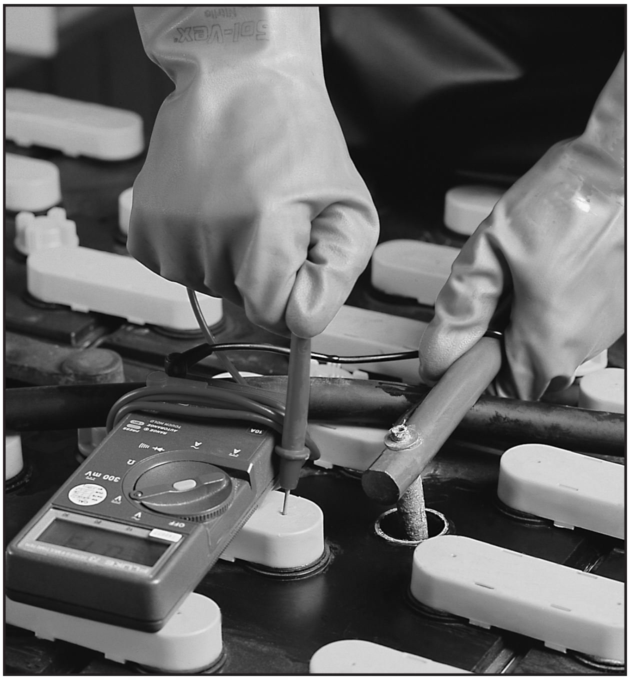


Percentage of Available Capacity vs. Rate of Discharge

Cadmium Electrode Testing

Cadmium electrode testing is a more detailed test of a cell and is used to determine whether internal inspection or repair of the cell is required. The cadmium electrode test is given at the end of the charge while the battery is still on charge at the finish rate.

In order to prepare the surface of a new cadmium electrode, it should be soaked in sulfuric acid for several days. If the cadmium electrode was stored dry before use, re-soak it for at least 30 minutes so the readings will be accurate. Cadmium electrodes should be free of dirt, etc., in order to obtain proper readings. Use the format shown on the "Field Inspection Report" on page 32 to record the various readings and other data, such as battery type, serial number, etc. To take the positive cadmium reading of a cell, connect the cadmium electrode to the negative lead of a voltmeter with a 0–3 volt full-scale range.



If any doubt exists as to whether a cell should be removed from the battery for inspection or repair, the cadmium electrode test can help you make the decision.

Connect the positive lead of the voltmeter by probe to the positive terminal of the cell. Immerse the cadmium electrode in the electrolyte of the cell (see photo above) and move it around frequently to prevent the formation of gas bubbles and to obtain a good, positive cadmium reading.

The example below shows the positive cadmium readings of the cells of a battery in a fully charged condition at a temperature of 77°F.

Cell No.	*On-Charge Voltage*	*Positive Cadmium*	*Negative Cadmium*
1	*2.65*	*2.45*	*2.20*
2	*2.45*	*2.50*	*1.05*
3	*2.67*	*2.51*	*2.16*
4	*2.45*	*2.26*	*2.19*
5	*2.65*	*2.45*	*2.20*
6	*2.65*	*2.45*	*2.20*

Referring to the table, note that cell #4 has a low on-charge voltage of 2.45. This, plus the fact that the positive cadmium reading is also quite low, is an indication that the cell should be inspected internally for trouble. Cell #2 also shows a lower-than-normal on-charge voltage. Notice that in both cases, a problem is indicated by a cell voltage reading being out of line with the other cell voltage readings in the battery. In the case of cell #2, however, the positive cadmium reading is normal, suggesting possible trouble with the negative plates. Several conditions, including contaminated electrolyte, can cause this. The "Unequal Cell Voltages" section of the Troubleshooting Chart on page 38 lists other possible causes of below-normal cell voltages.

Troubleshooting Chart

Symptom	Probable Cause	Possible Remedy
Battery overheats during charge	1. Malfunctioning charging equipment	1. Replace or repair defective charger parts (timer, voltage sensitive relay, control board, etc.).
	2. Charging equipment out of adjustment	2. a. Adjust start and/or finish charging rates. b. Adjust charge termination, voltage sensitive electronic device, or relay.
	3. Defective or weak cell(s)	3. Replace or repair problem cell(s). (See "Repair vs. Replacement," page 39.)
	4. Battery worn out and beyond economical repair	4. Replace battery. (See "Repair vs. Replacement," page 39.)
	5. High resistance connection within the battery	5. Check for hot wires, cells, intercell connectors, charging plugs, etc. Repair or replace defective component.
	6. Low electrolyte level	6. Water battery to proper level and charge immediately after cooling.
	7. Battery charged in the vehicle with battery compartment closed or the tray cover closed	7. Open the compartment during charge or charge the battery out of the truck with the tray cover opened.
	8. Battery over 115°F when placed on charge	8. Allow battery to cool below 90°F before charging. Use cooling fans to speed the process.
Battery overheats during discharge	1. Any probable cause listed under "Battery overheats during charge"	1. Any possible remedy listed under "Battery overheats during charge"
	2. Worn out bearings, brakes dragging, or other vehicle problem causing high current draws	2. Repair or replace defective lift-truck parts.
	3. Over-discharge of battery	3. a. Require drivers to return battery for recharge when vehicle begins to slow down. b. Install battery protector on vehicles.

Symptom	Probable Cause	Possible Remedy
Low electrolyte level	1. Cracked or broken jar(s)	1. Replace jar(s) and adjust gravity.
	2. Cell missed when watered	2. Pay more careful attention when watering.
	3. Defective or weak cell(s)	3. Repair or replace cell(s). (See "Repair vs. Replacement," page 39.)
	4. Frequent overcharge	4. See items 1 and 2 in "Battery overheats during charge," page 37.
	5. Battery not regularly watered	5. Water battery regularly. (See "Watering Schedule," page 25.)
Unequal cell voltages	1. Grounds in battery	1. Replace jar(s) and adjust gravity.
	2. There is a "tap" off the battery for auxiliary equipment (radio, light, etc.)	2. Periodically change "tap" to other portions of the battery.
	3. Battery sluggish due to lack of work	3. Repair or replace cell(s). (See "Repair vs. Replacement," page 39.)
	4. Leaking cell or cover	4. Check for leakage and repair.
	5. Defective or weak cell(s)	5. Repair or replace cell.
	6. Battery worn out and beyond economical repair	6. Replace battery.
	7. Acid loss in a few cells from battery tipping over	7. Adjust specific gravity. (See "Specific Gravity Temperature Chart," page 20.)
	8. Frequent overwatering causing electrolyte loss due to flooding	8. Fill to proper level (see page 23) and adjust specific gravity (see page 20).
Unequal specific gravities among cells	1. Any probable cause listed under "Unequal cell voltages"	1. Any possible remedy listed under "Unequal cell voltages"
	2. Battery just watered and water not mixed with electrolyte	2. Place battery on charge and read one hour after gassing begins.
	3. Improper gravity adjustment after a cell change	3. Adjust gravity. (See "Specific Gravity Temperature Chart," page 20.)

BATTERY REPAIRS

Repair vs. Replacement

There are times when a decision to repair or replace a damaged battery is clear-cut. Frequently, however, a decision either way is debatable. The following information is offered to assist you in making that decision more confidently and competently.

It is not unusual for a forklift-truck battery to have a service life of six years or 1,800 cycles when the depth of cycle, operating temperatures, quality of maintenance, etc. are properly controlled.

A good general rule is if a battery has one or two years of one-cycle-per-day service and has not been exposed to overcharging, over-discharging, high operating temperatures, or been misused in any other way, and if the repair costs do not exceed 50% of the replacement cost, it is probably more economical to repair it than to replace it. Remember: a physically damaged battery or one that has been damaged by over-discharging may have hidden damage.

Before undertaking major repairs, give the battery an equalizing charge and read all the specific gravities. Review the instructions provided in the "How to Inspect a Battery" section on page 31. If all the undamaged cells are within .030 points of specific gravity of a fully charged battery (see chart on page 23 for the proper full charge specific gravity), the battery can probably be repaired economically.

The general rule provided above varies when you are evaluating repair vs. replacement for an older battery or for one that has extensive damage.

A battery that has 900 to 1,500 cycles (or three to five years of service) and requires repairs totaling 25% or more of the replacement cost should probably be replaced instead of repaired. The final determination depends mainly upon how many more cycles/years of service the battery can be expected to deliver after the repairs are completed. An experienced industrial battery repair specialist is best able to make this determination. If you don't feel confident in making this judgment yourself, contact your local HAWKER Sales Office or Service Location.

After estimating the remaining service life, the final decision to repair or replace is made mathematically. For example, if the estimated repair cost is $200 and the replacement cost is $1,200, the estimated service life remaining after the repair must exceed one year (300 cycles) to justify the repair cost. Otherwise, replacement is the more economical choice.

HAWKER ENVIROLINK™
(VRLA) SEALED BATTERIES
Installation and Operating Instructions

SAFETY PRECAUTIONS

Warning

- The HAWKER ENVIROLINK™ batteries are supplied in a charged condition.
- Avoid all short-circuits between opposite polarity terminals because the cell will produce very high short-circuit current.

Keep Away From Flames

During the charge, avoid:

- A hydrogen concentration over the battery.
- Flames and all spark sources close to the battery.

Tools

Use tools with insulated handles. Do not place or drop metal objects on top of the battery.

Remove rings, wristwatches and articles of clothing with metal parts that might come into contact with the battery terminals.

DESCRIPTION

- The traction battery with gas recombination is a closed system and does not require topping-up with distilled or demineralized water.
- It is closed by a vent plug which must never be removed. This plug is equipped with a safety valve in case of pressure build up in the cell.

CONSTRUCTION

- ENVIROLINK™ battery cells are the same design as classical positive tubular plate cells, except for 2 main points:
  - o The lead antimony alloy in the positive and negative plates are replaced by a lead calcium tin alloy.
  - o The electrolyte is not free, but gelled.

RECEIVING THE SHIPMENT

- Check:
  - o Battery and charger condition.
  - o The presence of the vent plugs.

STORAGE

- Store the battery in a dry, clean and frost free area, before and after operating.
- For an easy recharge of the batteries, it is advised not to store without recharge for more than:

  2 months at 86° F

  3 months at 68° F
- Recharge before putting the battery into service.

VENTILATION

- ENVIROLINK™ batteries emit no gas in normal operation. Under some conditions, however (particularly severe overcharging), hydrogen and oxygen gases can be emitted. Therefore, a special charging room is not required, but charging should always take place in a well-ventilated area and away from any open flames.
- All installations must comply with the current state regulations in force at the time of installation/usage.

BATTERY CHARGE

- Before charging, check the presence of the vent plugs on cells.
- The temperature range of use for the battery is between 59° F and 95° F. Any use outside of this range must be approved by a HAWKER service technician. The best ambient tempertature for usage is 77° F - 86° F.
- Charge only on a charger approved by HAWKER.
- The charger has to be equipped with an approved charge profile by Hawker.
- The charging time for an 80% discharged battery is:
  - o 8 hours by using a LIFEPLUS® charger.
  - o 8-10 hours with a LIFEGUARD® EL charger.
  - o 12-16 hours with the LIFEGUARD® on-board charger.
- The charger stops automatically when the recharge is complete.
- **Refresh Charge** - Once the battery is fully charged and remains connected to either the LIFEPLUS® or LIFEGUARD® EL charger, a five-minute refresh charge is conducted after every five hours to ensure the battery remains fully charged.
- **Equalization Charge** - When using a LIFEPLUS® charger or LIFEGUARD® EL charger, a 2-hour equalization charge is automatically conducted if the battery remains connected to the charger for an additional 12 hours after full charge.

BATTERY OPERATION

- Check:
  - o The battery is clean.
  - o The presence of the vent plugs. Never remove the vent plugs, which are equipped with safety valves.
- Control the polarity on the battery connectors and on the charger connectors in order to avoid a reverse charge and battery and/or charger damage.
- Use specific connectors, if available, for this type of battery in order to avoid accidental connection to the wrong type of charger.
- Never change the charger cable.
- Never directly connect an electric appliance to the battery cell. This could lead to an imbalance of the cells during the recharge resulting in: a loss of capacity, the risk of insufficient dischage time and/or damage to the cells. This may affect the battery's warranty.
- Charge before using.

BATTERY DISCHARGE

- The nominal operating temperature is 77° F.
- The capacity of the battery varies with temperature and is reduced considerably under 32° F.
- Recharge the battery after a discharge.
- Never leave a battery discharged for a long time.

Discharge	Recharge
40% or more	Every day
Less than 40%	Every second day

- An energy cut-off set at 1.85VPC on the lift truck, pallet truck, cleaning machine or other electrical vehicles should be installed.
- The battery obtains its full capacity after about 10 charges and discharge cycles.

BATTERY LIFE

- The optimum lifetime of the battery depends on the operating conditions (temperature and depth of discharge).
- Normal operating battery temperature is 59° F - 95° F but optimal battery life is obtained for a battery temperature of 77° F - 86° F.
- High temperatures reduce battery life.

BATTERY LIFE - Continued

- Avoid applications when:
  - o No rest time is available to cool the battery
  - o Battery duty is too high leading to an increase of battery temperature during operation.
- Limit the discharge to 80% DOD.

BATTERY CHECK

After normal charge, during the last hour, measure:

- the total voltage.
- the voltage per cell.

DEFAULT

For all failures or defaults of the battery, the charger or any other accessories, please contact your local HAWKER representative.

WARRANTY

The non-accordance to these operating and maintenance instructions may lead to withdrawal of the warranty.

MAINTENANCE

- Never remove the vent plugs.
- Never dismantle the vent plugs or remove the safety valve from the cell.
- In case of accidental damage of the vent plugs, contact your local HAWKER representative for replacement.
- Never add any solutions to this product including distilled or demineralized water or any other product.

1- Daily maintenance

- Keep the battery clean and dry, in order to avoid self-discharge and current leakage.
- Recharge the battery if necessary.
- Check that the vent plugs and connectors are in good condition.

2 - Monthly / quarterly maintenance

- Carry out end of charge voltage readings.
- If the discharge time of the battery is not sufficient, check:
  - o The work required (application) is compatible with the battery capacity.
  - o The setting of the charger.

MAINTENANCE - Continued

3- Yearly or bi-annual maintenance

- Internal dust removal from the charger.
- Electrical connections: test all the connections (sockets, cables, contacts).

SAFETY PRECAUTIONS

- Use protective clothing for handling, maintenance or repairing the batteries:
  - eye protection, safety boots
  - gloves, aprons and acid resistant clothes
- Durng the charge:
  - do not remove the vent plugs from the cells
  - avoid sparks or flames near the battery
- It is imperative:
  - to ensure good ventilation in the battery room or the charging area
  - do not create electric sparks
  - only use insulated tools
  - do not keep metal objects near the battery (accidental short-circuits due to contact between the battery and any metal objects might occur).

GLOSSARY

Accumulator: Another term for a secondary battery; name derives from the fact that electric energy is accumulated in the form of chemicals. This term, pertaining to a storage cell or battery, is employed today in countries outside the USA.

Acetic Acid ($C_2H_4O_2$): An organic acid liberated by reaction between wood and dilute sulfuric acid. It is injurious to positive plates.

Acid: In the lead-acid storage battery industry, "acid" implies "sulfuric acid" and is used to describe the electrolyte or liquid in the cell.

Activation: Process for making a dry, charged cell functional by introducing electrolyte. See "FORMATION."

Active Materials: The materials in a battery which react chemically to produce electrical energy. In a lead-acid battery, the active materials are lead dioxide (positive) and sponge lead (negative).

Air Oxidized: A charged negative plate that has been removed from the electrolyte and permitted to discharge in an air atmosphere with the evolution of heat. Plates so treated must be recharged before they are capable of producing any useful electrical energy.

Alloy: A combination of two or more metals as a mixture, solution, or compound. See "ANTIMONIAL LEAD ALLOY," "CALCIUM LEAD ALLOY."

Alternating Current: A pulsating electric current in which the direction of flow is rapidly changed so that a terminal becomes, in rapid succession, positive then negative.

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

Ammeter: An instrument for measuring electrical current. See "AMPERE-HOUR METER."

Ampacity: Current-carrying capacity in amperes.

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

Ampere-Hour (AH): A measure of the volume of electricity, being one ampere for one hour, or 3,600 coulombs. It is used to express battery capacity and is registered by an AH meter, or is obtained by multiplying the current in amperes by the length of time that the current is maintained.

Ampere-Hour Capacity: The number of AHs which can be delivered under specified conditions of temperature, rate of discharge, and final voltage.

Ampere-Hour Efficiency: The electrochemical efficiency expressed as the ratio of the AH output to the AH input required for the recharge.

Ampere-Hour Meter: An instrument that registers the quantity of electricity in AHs.

Anode: An electrode through which current enters any conductor of the nonmetallic class. Specifically, an electrolytic anode is an electrode at which negative ions are discharged, positive ions are formed, or other oxidizing reactions occur.

Antimonial Lead Alloy: The most common alloy used in battery castings. The percentage of antimony varies from 0.5% to 12%. Other substances are also included in small quantities, either by way of a certain amount of inescapable impurity or by design to improve castings or the properties of the cast part.

Antimony (Sb): A hard, brittle, silver-white metal of the arsenic family that has a high luster.

Assembly: 1. The process of combining the various parts of cells and batteries into the finished product. 2. Any particular arrangement of cells, connectors, and terminals to form a battery suited for a desired application.

Automotive Battery (SLI): Battery of three or six cells used for starting ignition of automobiles, trucks, buses, etc.

Average Voltage: The average value of the voltage during the period of charge or discharge.

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

Boost Charge: A partial charge given to a storage battery, usually at a high rate for a short period. It is employed in motive power service when the capacity of a battery is not sufficient for a full day's work and is usually detrimental to the battery's life.

Boot: Plastic piece used at foot of plate, especially a wrapped plate, for retention and insulation.

Bridge: The ribs or elements supporting a structure, molded or cut to fit into the bottom of a ribless jar or container to provide sediment space under the element, thereby preventing short circuits.

Burning: The welding together of two or more lead or lead alloy parts, such as plates, straps, or connectors, by means of heat; in some cases, additional metal is supplied by a stick called a burning stick.

Burning Stick: A lead or lead alloy stick of convenient size used as a supply of joining metal in lead burning.

Cadmium (Cd): A metallic element highly resistant to corrosion; used as a protective plating on certain steel parts and fittings.

Cadmium Electrode: A third electrode for separate measurements of the electrode potential of positive and negative plate groups.

Calcium Lead Alloy: A lead base alloy that in certain applications can be used for battery parts in place of antimonial lead alloys; most common use is in stationary cells.

Capacity: See "AMPERE-HOUR CAPACITY."

Capacity Test: A test wherein the battery is 100 % discharged at constant current at room temperature to a cutoff voltage of usually 1.70 volts/cell.

Car Lighting Battery: An auxiliary storage battery designed to supply the lighting and air conditioning requirements of railroad cars while running at low speeds. An axle-driven generator charges the battery and supplies the load requirements when the train operates at normal speeds.

Carbon Black: Finely divided carbon obtained by burning a gaseous hydrocarbon under controlled conditions; used as an ingredient in negative expanders.

Cast: To form a molten substance into a definite shape by pouring or forcing the liquid material into a mold and allowing it to solidify (freeze).

Casting: A metallic item, such as one or more grids, straps, or connectors, produced by pouring or forcing molten metal into a mold and allowing it to solidify.

Cathode: An electrode through which current leaves any conductor of the nonmetallic class. Specifically, an electrode cathode is an electrode at which positive ions are discharged, negative ions are formed, or other reducing reactions occur.

Cell (Primary): A cell designed to produce electric current through an electrochemical reaction which is not efficiently reversible and hence the cell, when discharged, cannot be efficiently recharged by an electric current.

Cell (Storage): A cell which, after being discharged, may be restored to a charged condition by an electric current flowing in a direction opposite to the flow of current when the cell discharges.

CEMF: Counter electromotive force.

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

Charged and Dry: A battery assembled with dry, charged plates and no electrolyte.

Charged and Wet: A fully charged battery containing electrolyte and ready to deliver current.

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

Charging Plug: The male half of a quick connector which contains both the positive and negative leads.

Charging Rate: The charging rate of a storage battery is the current (expressed in amperes) at which the battery is charged.

Charging Receptacle: The female half of a quick connector which contains both the positive and negative leads.

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

Communication Battery: See "TELEPHONE BATTERIES."

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

Constant Potential Charge: See "CONSTANT VOLTAGE CHARGE."

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

Container: Housing for one or more cells, commonly called a "JAR."

Cover: The lid or cover of an enclosed cell, generally made of the same material as the jar of the container and through which extend the posts and the vent plug.

Creepage: The travel of electrolyte up the surface of electrodes or other parts of the cell above the level of the main body of electrolyte.

Curing: Chemical conversion process which changes lead oxides and sulfuric acid to mixtures of tetrabasic lead sulfate, other basic lead sulfates, basic lead carbonates, etc., which consequently will form desired structures of Pb or PbO_2 on negative or positive plates during formation.

Current: The time rate of flow of electricity, normally expressed as amperes; like the flow of a stream of water.

Cycle: A discharge and its subsequent recharge.

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

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

Dielectric Test: An electric test performed on certain jars, containers, and other insulating materials to determine their dielectric breakdown strength.

Diffusion: The intermingling or distribution of the particles or molecules of a liquid.

Direct Current (DC): A unidirectional current in which the changes in value are either zero or so small that they are inconsequential.

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

Discharge Rate: Batteries discharged to meet any time rate between three hours and eight hours are considered as having been normally discharged.

Dry Charged: A negative plate which has been subjected to the dry charging process.

Dry Charging: Manufacturing process whereby tank-formed negative plates (or elements) are washed free of acid and then dried. Specific methods include use of vacuum, super-heated steam, combustion gases, hot kerosene, etc.

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

Electrolysis: Electrochemical reaction which causes the decomposition of a compound, either liquid, molten, or in solution.

Electrolyte: Any substance which disassociates into two or more ions when dissolved in water; solutions of electrolyte conduct electricity and are composed by it. In the lead-acid battery industry, the word "electrolyte" implies a dilute solution of sulfuric acid.

Electromotive Force (EMF): Electrical pressure or potential expressed in terms of volts.

Element: Assembly of a positive plate group, a negative plate group, and separators.

Emergency Lighting Service: Float service batteries used in places of public assembly, hospital operating rooms, bank vaults, etc. which supply light in the event of power failures.

End Gravity: The specific gravity of a cell at the end of a prescribed (usually six- to eight-hour) discharge.

End to End (E to E): A method of assembling cells in relation to one another.

Energy Density: Ratio of battery energy content in watt-hours to battery weight or volume.

Equalizing Charge: An extended charge given to ensure the complete restoration of active materials in all the plates of the cells.

Expander: An additive agent, either organic or inorganic or a mixture of both, blended with the other ingredients of negative paste. The purpose of expanders is to delay shrinking and solidifying of the sponge lead of the finished plate, thereby enhancing negative plate capacity.

Filling Gravity: The specific gravity of acid used in the filling of batteries.

Final Voltage: The cutoff voltage of a battery; the prescribed voltage reached when the discharge is considered complete.

Finishing Rate: The finishing rate for a storage battery is the rate of charge, expressed in amperes, to which the charging current for some types of lead batteries is reduced near the end of charge to prevent excessive gassing and temperature rise.

Flat Plate: A general term referring to pasted plates.

Flooded battery: A battery that utilizes free flowing and contains removable vent caps so that water can be added.

Flying Leads: Any fixed terminal cable in which the terminal or plug end of the bale is unsupported and allowed to hang freely along the side of the battery.

Formation or **Forming Charge:** An initial charging process during which the raw paste within the plates is electrochemically converted into charged active material—lead dioxide being formed in the positive plates and sponge lead in the negative plates.

Formed: Plates that have undergone formation are said to have been "formed."

Freshening Charge: A charge given batteries in storage to replace the standing loss and to ensure that every plate in every cell is periodically brought to a full state of charge.

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

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

Gelled Electrolyte: Electrolyte which has been immobilized by addition of silica powder or other gelling agent.

Glass Mat: Fabric made from glass fibers with a polymeric binder such as styrene, acrylic, furfural, starch; used to help to retain positive active material.

Gravity: Refers to specific gravity.

Gravity Drop: The number of points reduction or drop of the specific gravity of the electrolyte upon discharge of the cell.

Grid: A metallic framework employed in a storage cell or battery for conducting the electric current and supporting the active material.

Group: One or more plates of a type (positive or negative) which are burned to a post and strap.

High Rate: On charge, any rate higher than the normal finishing rate.

Hydration (Lead): Reaction between water and lead or lead compounds. Lead does not react with strong solutions of sulfuric acid, but gravities lower than those found in discharged cells are apt to produce hydration. Hydration is observed as white coating on both plate groups and separators in a cell.

Hydrometer: Device used to indicate density or specific gravity of electrolyte solutions.

Hydroset: Curing process for negative and positive plates wherein free lead in the plate is oxidized and total free lead is reduced to a small percentage.

Indicator: Devices employed to show a battery's state of charge or its water level.

Initial Voltage: The initial voltage of a battery is the closed-circuit voltage at the beginning of a discharge. It is usually measured after the current has allowed for a sufficient period for the rate of change of voltage to become practically constant.

Intercell Connector: Conductor of lead, lead alloy, or lead-plated copper which is used to connect two battery caps.

Internal Resistance: The resistance within the cell or battery to the flow of an electric current, measured by the ratio of the change in voltage at the terminals corresponding to a specified change in current for short time intervals.

Jar: Cell container, made by injection molding, roto-molding, or thermoforming.

Jar Formation: The forming of plates in the cell jar or container after they have been assembled.

Kilovolt (KV): One thousand volts.

Kilowatt (KW): One thousand watts.

Kilowatt-Hours (KWH): A measure of energy or work accomplished; 1,000 watt-hours.

Lamp Black: Finely powdered carbon; used as an ingredient in negative plate expander.

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

Lead Burning: Welding of lead or lead alloy parts.

Lead Dioxide (PbO_2): A brown oxide of lead which is the active material in a fully formed positive plate.

Lead Hydrate: A white compound of lead of indefinite composition formed by the reaction of very dilute electrolyte or water on metallic lead or lead alloy parts.

Lead Oxide: A general term used to describe any of the finely divided lead oxides used to produce paste for storage batteries.

Lead Peroxide: See "LEAD DIOXIDE."

Lead Sponge (Pb): The chief component of the active material of a fully charged negative plate.

Lead Sulfate ($PbSO_4$): A compound resulting from the chemical action of sulfuric acid on oxides of lead or lead metal itself.

Life: Number of cycles of satisfactory operation.

Lifting Ear: An extension on the side walls of a battery tray provided with a hole or slot, by means of which the battery can be lifted.

Lignin: Generic name for noncellulosic wood fraction which, as lignin sulfonic acid or desulfonated LSA, acts as an organic expander for lead-acid batteries.

Litharge (PbO): A yellowish-red oxide of lead (monoxide), sometimes used in making active material.

Local Action: The loss of otherwise usable chemical energy by currents which flow within the cell of a battery regardless of its connections to an external circuit.

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

Lug: Portion of grid used for support of the plate group, usually along the top edge of grid, as "hanging lug"; also, tab on grid used for connection of plate to strap and other plates.

Machine Casting: A fully or semiautomatic grid or small parts casting operation.

Manual Discharge: Capacity test wherein the connection and disconnection of the battery and the test load are done by the operator and the disconnection is made after all cells have reached the prescribed voltage. With fixed-resistance loads, boost cells are used to keep the discharge rate fairly constant as the test cell voltages drop rapidly near the final voltage. Electronic load manual discharges generally do not require boost cells.

Microporous Separator: A grooved-type separator made of any material in which the pores are numerous and microscopically small.

Millivolt (MV): One thousandth of a volt.

Modified Constant Voltage Charge: A charge in which the voltage of the charging circuit is held substantially constant, but a fixed resistance is inserted in the battery circuit, producing a rising voltage characteristic at the battery terminals as the charge progresses.

Mold: A cast iron or steel form which contains the cavity into which molten metal is introduced to produce a casting of definite shape and outline.

Mold Coat: A preparation applied to metal molds in spray form which acts as both a mold release agent and as an insulator against rapid heat transfer.

Mold Spray: See "MOLD COAT."

Moss: Dendritic crystals of lead (Pb) which sometimes grow at high current density areas of negative plates, e.g., along edges, at feet, or at plate lugs; may cause a short circuit within cell.

Moss Shield: Plastic or hard rubber perforated sheet which insulates the gaps between negative plates and the positive strap, and between positive plates and the negative strap.

Motive Power Battery: A cycle service battery designed to supply the energy necessary to propel and operate electrically powered industrial trucks, street vehicles, and mine locomotives.

Negative Plate: The grid and active material to which current flows from external circuit when the battery is discharging.

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

Ohm: A unit of electrical resistance.

Oil of Vitriol: Concentrated commercial sulfuric acid commonly referred to as OV.

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

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

Organic Expander: An expander formulation which typically contains barium sulfate and a lignin-type organic compound, with small amount of other materials.

Oxide (of lead): A compound of lead and oxygen in one of several proportions, such as gray oxide, litharge, or red lead, used to prepare battery paste.

Parallel Assembly: The arrangement of cells within a battery in which two or more cells are connected across a common terminal so that any current flow divides itself between the connected cells.

Parallel Connection: See "PARALLEL ASSEMBLY."

Partition: An interior dividing wall in a tray container.

Paste: Mixture of lead oxide with water, sulfuric acid, and sometimes other ingredients.

Paste Consistency: A term used to include all of the physical characteristics of the paste density, plasticity, and texture.

Pasting: Battery assembly operation wherein paste is applied to grids by hand or by machine.

Pb: Chemical symbol for lead.

PbO: Chemical symbol for litharge.

PbO_2: Chemical symbol for lead dioxide (peroxide).

Pellet: That portion of pasted material contained in grid section framed by adjacent horizontal and vertical members exclusive of forming bars.

Perforated Retainer: A thin sheet of perforated plastic material installed so as to cover each face of a positive plate to prevent the loss of active material. It is normally used in conjunction with one or more layers of glass insulating material.

Pilot Cell: A selected cell of a storage battery whose temperature, voltage, and specific gravity are assumed to indicate the condition of the entire battery.

Plate Centers: The distance between center lines of adjoining plates of opposite polarity in a cell. The plate center is, therefore, one half of the size of a strap center upon which the plates of a like polarity are burned.

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

Polarization: The change in voltage at the terminals of the cell or battery when a specified current is flowing, equal to the difference between the actual and the equilibrium (constant open circuit condition) potentials of the plates, exclusive of the voltage drop.

Porosity: The ratio of interstices (voids) in a metal to the volume of its mass.

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

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

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

Rated Capacity: The AHs of discharge that can be removed from a fully charged secondary cell or battery at a specific constant discharge rate at a specified discharge temperature and at a specified cutoff voltage.

Raw Plate: An unformed plate.

Recombination: A process in which hydrogen and oxygen are combined during recharge to form water.

Rectifier: A device which converts alternating current (AC) into unidirectional current (DC) by virtue of a characteristic permitting appreciable flow of current in only one direction.

Red Lead (Pb_3O_4): A red oxide of lead sometimes used in making active material.

Reference Electrode: Electrode used to measure acid concentration or plate state of charge.

Resistance: The opposition that a conductor offers to the passage of an electrical current, usually expressed in ohms.

Resistor: A device used to introduce resistance into an electrical circuit.

Retainer: A sheet of glass mat, perforated or slotted rubber, plastic, or some other satisfactory material installed on each face of the positive plates in certain types of cells to deter the loss of active material.

Reversal: A change in normal polarity of the cell or battery.

Rib: A vertical or nearly vertical ridge or a grooved separator or spacer.

Rib Block: Bridge used in some smooth bottom jars to evenly support the element.

Run Down: A small portion of metal that has dropped onto a plate, group, or element in the course of burning; may result in a short circuit.

Sealing: Manufacturing operation for attaching covers to jars.

Secondary Lead: Reclaimed lead as opposed to virgin lead.

Sediment: The leady sludge or active material shed from the plates and found in the bottom of cells.

Sediment Space: The portion of a jar or container compartment beneath the element, provided to accommodate a certain amount of sediment from the wearing of the plates without short-circuiting.

Self-Discharge: Loss of charge due to local action.

Separator: A device employed in a storage battery for preventing metallic contact between the plates of opposite polarity within the cell, while allowing passage of electrolyte. See “MICROPOROUS SEPARATOR.”

Series Cells: All cells in a battery. The term has become common since the cells are usually connected in “series.” The name would still apply to distinguish the difference between cells even if the cells are connected in “multiple.”

Series Parallel Connection: The arrangement of cells within a battery in which two or more strings of series-connected cells, each containing the same number of cells, are connected in parallel in order to increase the capacity of the battery.

Service Life: See “LIFE.”

Shedding: Loss of active material from the plates.

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

Sleeve Separator: The protective polyethylene separator that surrounds the positive plates thus insulating the positive and negative plates from each other.

SLI Battery: Battery for automotive use in starting, lighting, and ignition.

Sliver, Slyver: Extremely fine, parallel glass fiber used next to positive plate in retainers to retard shedding.

Smelting: The process by which the major portion of lead and antimony are recovered from scrapped batteries and battery manufacturing scrap.

Soaking: A process whereby certain types of plants are soaked in sulfurous acid after pasting. Soaking provides a protective surface, as well as a supply of sulfate helpful in jar formation and tank formation.

Soda Ash: Sodium carbonate (Na_2CO_3), used to neutralize acid spills or effluent containing sulfuric acid.

Spalling: Shredding of active material, usually from positives plates, during formation due to incomplete or improper plate curing.

Sponge Lead (Pb): The chief material of a fully charged negative plate. It is a porous mass of lead crystals.

Stacking: Cell assembly operation wherein plates and separators are alternately piled in a burning box prior to cast-on or burning-on of straps and posts.

Stacking Fixture or **Stacking Jig:** The fixture or device used to stack and burn elements.

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

Starting Rate: The number of amperes at which the charging of a storage battery may be begun without producing gassing or bubbling of the electrolyte, or a cell temperature in excess of 110°F (43°C).

State of Charge: The amount of electrochemical energy left in a cell or battery.

Stationary Battery: A storage battery designed for service in a permanent position.

Strap: Hand-welded or cast-on piece of lead or lead alloy used to connect plates into groups and to connect the groups to the post.

Strap Center: Spacing between centers of adjacent plates in a group.

Stratification: As applied to electrolyte, it is layers of high gravity acid in the lower portions of a cell, where they are out of touch with the ordinary circulation of the electrolyte and thus of no use.

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

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

Sulfuric Acid (H_2SO_4): The principle acid compound of sulfur. Sulfuric acid of a high purity and in dilute form is the electrolyte of lead-acid storage cells.

Tank Formations: The electrolytic processing of plates in large tanks of acid, at a point of manufacture prior to assembly. See "FORMATION."

Telephone Batteries: Storage batteries of a wide range of capacities and types which are used in most of the operations involved in telephone communication. Often they are floated across rectifiers and provide voltage stabilization, noise reduction, and emergency power.

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

Terminals: The points at which the external circuit is connected.

Tinning: The process of coating a metal surface with a thin layer of molten tin or tin alloy.

Top Pour: A term that describes a method of casting in which the molten metal is poured into a gated mold.

Tray: Steel enclosures for motive power battery cells.

Treeing: Growth of a lead dendrite or filament through a hole, crack, or large pore of a separator, whereby the cell is short-circuited. See "MOSS."

Trickle Charge: A continuous charge at a low rate approximately equal to the internal losses and suitable to maintain the battery in a fully charged condition.

Tubular Plate: Positive battery plate made from a cast spine and porous tubes which are filled with paste or dry oxide.

Unactivated Storage Life: The period of time before a dry, charged cell deteriorates to have less than a specified capacity.

Uncharged: The condition of a battery assembled with formed plates but not yet having received its initial charge; batteries are classified as either uncharged and moist, or uncharged and dry.

Uncharged and Dry: A condition in which a battery or cell may be shipped to a customer. This indicates that the battery is assembled with formed plates and dry separators without electrolyte; filling and a charge are required.

Uncharged and Moist: A condition in which a battery or cell may be shipped to a customer. This indicates that the battery is assembled with formed plates and moist or wet separators without electrolyte; filling and a long charge are required.

Unformed: A term used to describe any plate which has not been electrolytically formed; it may be dry or moist, cured or uncured, soaked or unsoaked.

Useful Acid: The volume of acid above the lower edges of the plates which takes part in the discharge reactions that occur within a cell.

Vacuum Cell Filler: A device used to fill cells in the charging room in which a vacuum is used to withdraw the air displaced by the filling electrolyte.

Valve-Regulated (VRLA) Battery: VRLA means 'valve-regulated lead acid' battery. A VRLA type battery that operates under gas combination process is a closed system and never needs water or electrolyte added. It is closed by a vent plug valve that can vent in case of pressure build up in the cell.

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

Vent Baffle: A thin disc located in a vent cap or plug to deflect spray back into the cell.

Vent Cap: See "VENT PLUG."

Vent Plug: The piece or assembly of pieces employed to seal the vent and filling well of a cell cover except for a small hole in the plug itself which permits the escape of gas. Vent plugs are usually held in place either by threads or by a quarter-turn catch (bayonet vent plug), or by snapping into place.

Vent Well: The hole or holes in a cell cover through which gas escapes, fluids are added, or the electrolyte level is checked. The vent plug or vent assembly fits into the vent well.

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