Motive Power

Battery Service Manual

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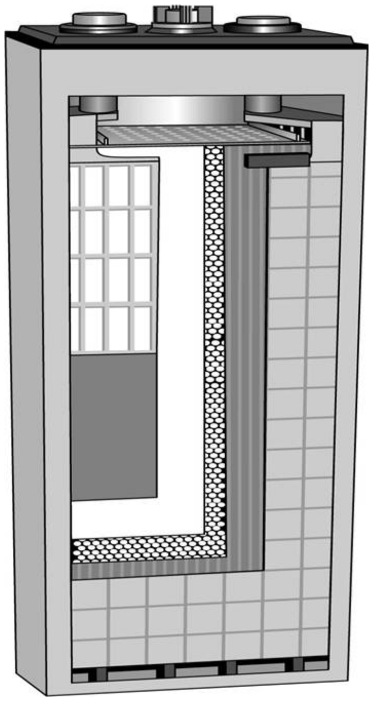
Introduction

As the global world markets demand more energy efficiency products and green energy technology, lead acid batteries have always played a lead role in clean and cost effective renewable energy power. With these trends, batteries are becoming one of the key elements of energy storage, whether in powering industrial electric forklifts, cars or power storage for solar and wind and back-up power systems. Batteries will continue to be a leading component in renewable electric power.

However, the world demand for batteries has impacted the lead market causing the cost of lead to more than double over the last several years. Once the battery is purchased, the level of care and maintenance will have a direct effect on the overall life of the battery. The more care given, the greater the battery life expectancy. Given that batteries play such a vital role in production and moving material, batteries should receive a high level of attention as part of a routine preventative maintenance program. The purpose of this manual is to provide you the user, with enough information to understand and properly maintain these batteries and insure a safe and productive working environment.

Batteries are a very reliable source of power; however battery repairs should only be done by a trained and skilled battery technician. This is due to the dangers involved with batteries, which include Sulfuric Acid, Hydrogen Gas and Electrical Shock. Crown Battery has a large network of skilled and knowledgeable service agents and dealers that can assist you in properly caring for your battery needs. Whether you need to purchase batteries, require technical advice or battery/charger service, your local Crown Dealer has the tools to provide you with the very best in customer support.

Construction & Operation



A motive power battery is a portable energy source for supplying DC (direct current) to electric vehicles. Crown Battery manufactures lead-acid motive power batteries. A motive power battery consists of cells connected in a series and assembled in a tray, typically made out of steel. The battery can be assembled in many shapes and sizes, depending on the voltage and ampere-hour (AH) capacities.

Cells are the main component in a lead-acid battery. Each cell consists of positive and negative plates alternating; there is always one more negative plate than positive plate.

The positive plate consisted of the positive grid and active material. The positive grid is cast from premium antimonial alloy and designed to withstand the rigors of deep cycling and maximum current capabilities. The positive grid uses offset internal wires are designed for less internal resistance and maximum active material retention. The active material is manufactured with premium lead oxide and mixed with additives to exact specifications using the latest state-of-the-art equipment, applied uniformly and cured under atmospherically controlled conditions to assure optimum chemical conversation.

The negative plate is manufactured to specifications that uniformly balance the negative to positive active material for maximum performance and chemical efficiency.

Motive power batteries generally have model numbers that look like the following: 12-85-13. In this example the 12 shows how many cells are in the battery, each cell has a nominal voltage of two volts. The 85 shows the AH capacity of each plate and the 13 shows how many plates are in each cell, to calculate the AH capacity take the number of positive plates (remember there is one more negative than positive) and multiply it by the AH capacity of the plate. In this example that would mean this battery is a 24 volt battery with an AH capacity of 510. The number of cells will always show you the voltage of the battery and the cell type will always show the AH capacity of the battery.

How a Battery Works

A battery is a storage device which stores energy in a chemical form and releases the energy on demand in an electrical form. The battery releases power by the reaction of the electrolyte (acid and water) with the active material in the plates.

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 is a solution of sulfuric acid (H_2SO_4) and water. The specific gravity of the electrolyte is between 1.275 and 1.290. The open circuit voltage of each cell is 2.12 to 2.18 volts.

The Discharging of a Battery

When a battery is connected to an electrical load, the stored energy is release as DC electrical energy. During the process of conversion, the internal components of the cells undergo a change chemically.

The sulfuric acid (H_2SO_4) combines with the lead peroxide (PbO_2) of the positive plates and the sponge lead (Pb) of the negative plates and transforms them to lead sulfate ($PbSO_4$).

The reaction may be shown as follows:

PbO_2	1	Pb	1	$2H_2SO_4$	$\longrightarrow$	$2PbSO_4$	1	$2H_2O$
Lead peroxide	1	Sponge lead	1	Sulfuric acid	$\longrightarrow$	Lead sulfate	1	Water

The Charging of a Battery

The chemical energy in a battery is restored by charging the battery, reversing the discharge reaction. During the charge and especially towards the end of it, hydrogen and oxygen gas are produced by the electrolytic breakdown of water on the plates surface.

The reaction may be shown as follows:

$2H_2O$	$\longrightarrow$	$2H_2$	1	0_2
Water		Hydrogen Gas	1	Oxygen gas

How a Battery is Rated

The vehicle specifications, application and type of operation help determine the battery voltage and AH capacity that is selected. A battery is rated by its capacity to deliver or discharge energy over a set period of time and that capacity is expressed in ampere-hours (AHs). The North American standard is a six hour rate.

For example, a battery rated at 510 AH at a six-hour rate can deliver 85 amperes continuously for six hours before it becomes fully discharged.

Many factors, such as plate size, number of plates per cell, specific gravity of the electrolyte and the rate of discharge help determine the AH capacity. Most motive power/traction batteries are rated at a six-hour rate, at 77°F and at the manufacturer's specified fully charged specific gravity (1.275-1.290); actual AH capacity availability will vary with any change.

Effects of Rate of Discharge on AH Capacity

As the discharge rate is increased, the active material available to the electrolyte is decreases, limiting the available AH capacity. In opposition if the discharge process is extended beyond 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 also varies. Lower temperatures increase the viscosity of the electrolyte making its circulation in the pores of the plates more difficult, decreasing the AH capacity. Higher temperatures, the opposite is true, increasing the capacity. At temperatures above 120°F the charging current of conventional charging equipment may rise out of control, damaging the battery permanently ("thermal runaway").

Effects of Specific Gravity on AH Capacity

As the fully charged specific gravity of a battery changes so does the capacity of the battery. If a battery is designed to deliver it's rated AH capacity with a specific gravity of 1.275-1.290, a reduction in the fully charged specific gravity will reduce the available capacity. An increase in the fully charged specific gravity will increase capacity. It is important to keep the specific gravity within the manufacturer's recommendations; anything outside of those recommendations will result in reduced battery life and premature failure.

Safety

A lead-acid motive power battery can be an extremely useful and safe source of electrical power. On the other hand, if improperly used it can be an extremely dangerous piece of equipment. The difference between the two conditions is determined by the care and safety procedures exercised in handling batteries. Before considering the safety procedures, first consider the hazards inherent to a lead-acid battery.

The Hazards

A lead-acid battery, by its construction exposes working personnel to four potentially dangerous elements: sulfuric acid, explosive gasses, electricity and heavy weight.

A **sulfuric acid** solution is used as the electrolyte in lead-acid storage batteries and has a concentration of approximately 40% by weight of sulfuric acid in water. Even in this diluted state, sulfuric acid is a strong oxidizing agent and can burn the skin and eyes; and "eat" holes in clothes made of many common materials such as cotton and rayon.

An **explosive mixture** of oxygen and hydrogen is produced in a lead-acid storage battery during the charging process. The two gasses can combine explosively if a spark or flame ignites them. Because hydrogen is so light it normally floats away and disperses into the air before it can be collected into an explosive mixture. If it accumulates into gas pockets, however, it will explode when ignited.

The battery on discharge produces electricity and while most people cannot "feel" voltages through their bodies below 35 to 40 volts, all motive power batteries should be regarded as potentially dangerous. A lead-acid battery is capable of discharging extremely high rates and under conditions of direct shorting can cause much damage and serious injury.

The **weight** of these heavy batteries can crush hands and feet if care is not taken when charging and handling them. Adequate and proper handling equipment should be provided. The average lift truck battery weighs over 2000 pounds.

The Safety Procedures

In 1970 Congress passed the Occupation Safety and Health Act (OSHA). The act established the minimal acceptable standards for safe and healthy working conditions. The act not only pinpoints the responsibility of the employer and employee, but also establishes the penalties for disregarding the standards. It would be well to remember that OSHA standards are minimum requirements. The safety procedures suggested in the manual have been compiled from standards developed over the years by profession and technical organizations and by battery manufacturers and users who have had the experience necessary to create the most effective safety standards. They exceed the minimum standards of OSHA for personnel safety and include procedures for safeguarding equipment as well.

NOTE: The information presented is of a general nature. It should not be construed as a legal opinion.

Handling & 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 sever burn.

Removing Batteries

If a battery is to be removed from a truck, (1) open the electrical circuit of the truck (turn key or switch off), (2) set the brake or chock the wheels and (3) 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

For handling batteries, 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 non-conducting material such as plywood or plastic. An insulated battery-lifting beam can be used with any type of overhead hoist. The safe way to lift a battery uses an insulated lifting beam. It reduces the possibility of damaging the tray and shorting the cell connectors.

Protective Eyeglasses, Headgear and Footwear

The use of safety glasses and safety hats made of a non-conducting material is suggested when batteries are being handled or serviced. Steel-toed shoes are also recommended.

Lifting Batteries

Steel trayed batteries have holes or eyes for lifting. The eyes used in conjunction with an insulated battery-lifting beam 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 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 Rooms

Plants that change batteries at the end of each shift should have one or more centralized areas designed for battery charging. These battery charging areas should be equipped with overhead hoists, conveyors, cranes or their equivalents for handling batteries safely and conveniently. Battery charging areas should be adequately ventilated, either through natural or forced ventilation. "Adequate ventilation" is difficult to define as it is dependent on a variety of factors such as; number and size of batteries being charged at one time, room size, ceiling height, air tightness of the building, etc.

No Smoking, No Open Flame

Due to the explosive mixture of gas that can exist in and around charging batteries, anything that could ignite gas, such as an open flame, an arc, spark or smoking 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 non-conductive materials or be suitably insulated.

Charger Connections

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

Firefighting Equipment

In addition to automatic sprinkler equipment that may be present, charging areas should also be equipped with suitable hand-operated fire extinguishers. Consult local fire authorities or your insuring 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 1.5% by volume or exceed 2% by volume in any one location, the ventilation is considered to be satisfactory. (Concentrations between 4% and 74% are explosive).

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 will help 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 that creates the problem. It will burn explosively when ignited if the air contains between 4% and 74%. Hydrogen, which is the lightest known gas, is fourteen 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.

Eye-Wash 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 brightly-colored, molded receptacle about 1 ½ 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 Safety and Medical Departments.

- **Eyewash Fountain:** A water fountain-type of device with two openings that facilitates 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.

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 it happens, the eyes should immediately be flooded gently with running water for at least 15 minutes, followed as quickly as possible with an examination by a physician. Special care should be taken to check for persons wearing contact lenses. The lenses should be removed if acid gets into the eyes, and then thoroughly rinsed with water. WARNING: Do not place a buffering or neutralizing agent in the eyes without the expressed approval of your Safety Director.

Acid Splash on Skin

Acid or electrolyte spilled or splashed on the skin should be washed off under running water. If a burn develops, it should be reported to a supervisor and treated medically.

Acid Splash on Clothing

When acid is splashed on clothing, use a weak solution of bicarbonate of soda to neutralize the acid. When clothes are soaked or splashed over large areas, they may be removed, the acid neutralized with bicarbonate of soda and/or rinsed in running water until free of acid. The sooner the clothing is rinsed, the less chance of damage to the material.

Care should be taken not to spill acid into acid-resistant boots. Boots should be checked prior to each wearing to make sure that they are dry and that no acid or chemical has been left inside.

Protective Clothing

Normal working 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. If sulfuric acid with specific gravity higher than 1.400 is handled during gravity adjustments, etc., the following protective clothing and equipment can be used:

- Acid resistant gloves
- Acid resistant arm gauntlets
- Acid resistant apron
- Acid resistant boots
- Plastic face shield

Quick Response Acid Spill Kit

OSHA 1926.441 (a) (5) states that face shields, aprons and rubber gloves shall be provided for workers handling batteries or acids. OSHA 1926.441 (a) (7) states that facilities shall be provided for flushing and neutralizing spilled electrolyte. In compliance with OSHA standards Powerhouse Cleaners put together a Quick Response Acid Spill Kit. This kit is a 5 gallon pail that can be set in any station where a worker may handle acid or charge a battery.

Powerhouse Cleaners Quick Response Acid Spill Kit contains:

- (1) 2 Gallon Acid Absorber & Neutralizer
- 1 Small broom and pan
- 1 Goggle
- 1 Apron
- 1 Pair overboot
- 1 Acid absorbent & neutralizing sock
- 1 MSDS sheet
- 1 Instruction booklet
- 1 Headgear with face shield
- 1 Pair rubber gloves
- 1 Disposable bag
- (1) 5 Gallon resealable bucket with lid.

Receiving & Installation

Inspect Package

Upon receiving a battery, inspect immediately for any damage that may have occurred while in transit. Look for broken or missing wood blocking boards that secure the battery and keep it from shifting on the pallet. Broken boards may indicate that the battery may have tipped over and that a closer inspection should be performed. Wet spots on top and sides of the battery generally indicate that the battery has been tipped over and there may be some electrolyte loss or internal damage. Any damage or electrolyte loss should only be corrected by a qualified professional battery repairperson as soon as possible.

Filing a Claim

If there is evidence that the battery was damaged in transit, be sure that you make note of it on the shipping papers. Keep in mind that if you sign the shipping papers receiving the damaged battery, you will be responsible for filing a damage claim with the carrier. Depending on the extent of the damage, you may wish to refuse delivery and the battery will be returned to and the claim filed by Crown Battery.

Some in transit damage can cause serious internal problems that may have an effect on overall battery life and performance. Contact your Crown battery representative to have it evaluated by a professional battery person.

Freshening Charge

After the battery has been received and there are no visible signs of damage, the battery should be given a freshening. A freshening charge should be given to bring the battery to a fully charged condition before placing it into service. It will take approximately three hours at the finish rate to bring the battery to a full charged condition. Battery chargers with auto/start/stop using the equalizing charge mode will charge the battery and terminate the charge cycle after the required charge time.

NOTE: This battery was shipped with the correct electrolyte level from the factory. The electrolyte levels may settle during shipping, causing variances in the levels. Do not add water until the battery has been given a freshening charge. If water is needed, follow the basic battery care instructions included with the battery.

Installation Instructions

The battery should fit within the battery compartment of the lift truck. If there is additional space, the battery must be blocked to keep it from sliding or moving within the compartment. Make sure that the battery cables and power connector will plug into the lift truck connector. Make sure any excess cable is kept within the confines of the battery or truck compartment to prevent damage to the power cables. The battery must be charged on a battery charger that matches the battery voltage and amp hour capacity for the duty cycle required. If you are not sure of the correct size requirements, contact your local Crown Battery representative.

Routine Maintenance

Today's industrial battery is designed and built to give anywhere from 1000 to 2000 operations/charge cycles, depending on the application and the operating environment. If such a battery were to complete one cycle per workday, 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 correct time, will go a long way toward extending the life of the battery and making it more efficient.

Routine battery maintenance consists of three functions:

1. Properly charging the battery.
2. Adding water as needed, and
3. Cleaning as required.

Instruments for Inspecting Batteries

Three testing instruments are required to check batteries accurately and efficiently: a voltmeter, hydrometer and thermometer. The specific gravity and open circuit voltage readings are normally in direct proportion to each other; consequently, a voltmeter or hydrometer can be used to check the battery. The use of the voltmeter is a faster method of approximating the individual cell state of charge and can reduce dramatically the time required for routine battery checking. When using the voltmeter method, take specific gravity readings on the two cells having the highest and lowest voltage readings. This will confirm both cells state of charge 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.

A battery thermometer is read like a normal thermometer. A proper thermometer should have specific gravity correction marked on its scale.

The hydrometer has an extra-long scale to make readings more accurate. For ease of correcting for temperature, the specific gravity corrections are marked on the scale of the thermometer. The cell tester (voltmeter) has a 1.5 to 3.0 volt scale and an easy-to-handle, one-piece terminal probe.

Battery Charging

Without a doubt the most important part of routine maintenance is the proper charging of the batteries. Generally speaking, lead-acid batteries may be charged at any rate of current which does not cause excessive “gassing” of the electrolyte and does not produce temperatures in excess of 115°F (125°F is acceptable for infrequent, short periods). Fortunately, today’s automatic voltage controlled chargers take the guess work out of charging. Assuming the battery is well maintained 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. Periodic inspection and adjustment of the charging equipment can be performed by an outside professional charger repair technician. A basic knowledge, however, 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 automatic charger malfunction or for charging operations not using fully automatic equipment.

Types of Charging

There are a number of different charging methods: although only four need explanation. They are: Cycle Charge, Equalizing Charge, Freshening Charge and Opportunity/Fast Charging.

Cycle Charge

This is the complete recharge of a battery after it has been fully or partially discharged during normal operation. In general, a cycle charge is based on an 8-hour charging cycles, but can be extended, depending on need.

Equalizing Charge

Each cell of a battery has slight differences in uniformity of construction and content. These differences cause some cells to take less charge than the other cells in the battery. After a while the state of charge of the cells, which require more charge than the others will drift back in capacity 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 in order to bring the cells with a below normal state of charge up to full charge.

The recommended frequency of equalization is dependent upon 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 overcharge. The following examples will give you a good idea of a reasonable battery-equalizing schedule for a specific battery operation.

1. For batteries that are cycled only once or twice a week to an average depth of 30%-60%, a monthly equalizing charge is sufficient to keep them fully charged.

2. Batteries that are discharged regularly- three or more cycles per week and to an average discharge depth of 60%-80% of their rating- can be kept healthy by equalizing them every two months.

3. Batteries that are cycled four to eight times a month at any dept require equalizing about every month to keep them in a healthy condition.

4. Batteries that are cycled five or more times a week at an average discharge of 60%-80% 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 (3-6 amperes per 100-ampere hours of the battery's 6-hour capacity rating).

Opportunity/ Opportunity Fast Charge

Opportunity or Opportunity Fast Charging (OFC) is a relatively new technology utilizing intelligent high frequency chargers. The theory being that you have one battery, one truck and one charger. The battery will never leave the truck and the battery is placed on charge at every opportune time (breaks, lunches, etc). Opportunity charge is generally between 25-30 amperes per 100 ampere hour while Opportunity Fast Charge is generally 45-55 amperes per 100 ampere hour.

Opportunity Charge will keep the battery operating between 20% and 80% of its state of charge throughout the work week and then on the weekend and equalize charge is performed. OFC will allow you to charge a battery up to 80% in two hours or less.

If the charger is rated higher than the connector on the battery, battery modifications will be needed. These modifications include but are not limited to; dual cables, dual intercell connectors, cooling fans, battery recording device, thermistors and pilot contacts. The dual cables are required because the high amp output of the charger which is limited to the ampere-hour rating of the battery connector. The other modifications are required to control the increase of higher internal battery temperatures. The battery recording device allows the manufacturer and the user to diagnose problems and to correct and fine tune the operating system. Modifications to the system can be made by a adjusting the charger settings. (adjust back the amp output, auto equalize settings, etc.).

Please contact your local Crown Battery Representative to see if Opportunity or Opportunity Fast Charge will work for you.

The Charging Process

When a battery is placed on charge, the opposite action of battery discharging takes place; 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 the charge without causing excessive gassing or high temperature resulting from overcharge. The finish rate is shown on the nameplate of Crown Batteries. Generally, the finish rate is 3.5 amperes per 100 hours of the battery's 6-hour rated capacity. A partially or completely discharged battery can safely handle currents much higher than the finish rate, but as it approaches full charge, whatever charging rate is used must be reduced to the finish rate.

Determining if a Battery is Properly Charged

If the battery charging equipment is functioning properly and if the battery is in a healthy condition, there is little chance for an improperly charged battery. If some doubt about its operation exists the following checks are a quick way to determine a proper, fully charged battery:

1. Charging current readings will level off to the finishing rate.
2. Charging voltage stabilizes.
3. No rise in specific gravity.
4. Normal gassing

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 temperatures below 115°F. Above this temperature, overheating occurs. Overheating can damage the battery and shorten its normal expected service life. The extent of the damage and service life loss depends on how high the temperature, 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 factors:

1. Age and condition of the battery.
2. Battery temperature compared to ambient temperature.
3. Start, intermediate and finish rate of the charger.
4. The amount of overcharge given the battery.

SPECIFIC GRAVITY TEMP CORRECTIONS

Electrolyte Temperature °F	(°C)	Point Correction
140	(60)	21
137	(58)	20
134	(57)	19
131	(55)	18
128	(53)	17
125	(52)	16
122	(50)	15
119	(48)	14
116	(47)	13
113	(45)	12
110	(43)	11
107	(41)	10
104	(40)	9
101	(38)	8
98	(37)	7
95	(35)	6
92	(33)	5
89	(32)	4
86	(30)	3
83	(28)	2
80	(27)	1
77	(25)	No Correction
74	(23)	-1
71	(22)	-2
68	(20)	-3
65	(18)	-4
62	(17)	-5
59	(15)	-6
56	(13)	-7

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. If the lift truck operations start with an overheated battery, whose temperature is above 115°F, the continuous high current draws will tend to make the temperature rise even higher and battery damage is likely.

Typical working environment 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 cooling before 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 and since they conduct 60% of the heat out of the battery, the battery will cool rapidly. Charge the battery with the covers open always. Operating and charging batteries at elevated temperatures is a frequent cause of battery damage and loss of service life. An experienced lift truck battery man, given the levels of operation and charging temperatures and 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, higher capacity batteries or battery cooling equipment.

Keyed Connectors

Sometimes batteries of several different voltages and ampere-hour capacities are charged at the same time, at the same centralized location. Precautions must be taken to make sure that batteries are charged on chargers with mating voltages and ampere-hour ratings. Rather than rely on the persons placing the batteries on the charges, we recommend the use of plugs and connectors of different types or the use of keyed and color-coded connectors.

Gassing

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

Hydrogen is a highly combustible gas and will explode on ignition when its concentration in air reaches any level between 4% and 74%. If you have reason to suspect 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 continuously, leads to excessive "sulfation". The same is true of batteries, which have been left standing in an undercharged state for an extended period of time. High temperatures rapidly accelerate sulfation when batteries are left standing in a partially charged conditions. 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 of time.

Treatment of Sulfated Batteries

Lead Acid Motive Power Batteries can become unbalanced or sulfated if they are not recharged or equalize charged on a regular basis. Likewise over-discharging or unbalanced discharge can cause low uneven cell voltages. The treatment for restoring the battery to its full potential involves charging and discharging the battery in a very tightly controlled manor. This is a last resort remedy in order to salvage a battery that's been allowed to get into this condition. This may or may not be successful, as sulfate is extremely hard to remove from the cell plates and if let in this condition, may not be reversible.

Step 1.

A. Charge the battery as normal to a fully charged condition.
B. Record all individual cell voltages and specific gravities. These readings will be used later to measure how successful the treatment was.
C. Starting with a cool (less than 80°F) fully charged battery, charge the battery at 2.5 amps per 100 amps of battery capacity. A 24-85FC-21 has a capacity of 850 A.H. Therefore the charge rate would be 21 amps. Charge the battery for at least 24 hours. Stop the charge, if the battery temperature goes to 120°F or higher.

Step 2.

A. Let the battery cool back down to about 80°F
B. The battery can now be discharged. Using a discharge rate of 1.33 per 100 amps of the battery capacity. A 24-85FC-21 battery with a capacity of 850 amps will need to be discharged at 11-12 amps for 96 hours. DO NOT allow any cell to fall below 1.50 volts while on discharge. Stop the discharge test if any cell falls below 1.50 volts.

Step 3.

A. Charge the battery as normal to a fully charged condition.
B. Record all individual cell voltages and specific gravities.
C. Compare the readings to the initial readings taken and note if there is any increase in gravity and voltage.

Step 4.

A. If the treatment restored the battery to normal conditions (Sp. Gr. 1.285-1.300 and voltage 2.13 – 2.18) and all cells are fairly equal and the treatment was successful.
B. If the readings are still uneven or no improvement was gained, then repeat steps #1 thru #3

Step 5.

A. If after the second series of treatment the battery does not improve, the battery should be considered unrepairable and should be replaced.

Adding Water

A certain amount of water loss is normal in all batteries and it should be replaced with "pure" tap or distilled water. In some areas around the country, tap water may contain chemicals or other impurities harmful to batteries. If water is needed, add just enough to bring the electrolyte to the proper level. Batteries should be filled only at the end of the charging cycle. Overfilling is the most common error made when watering and it can cause tray corrosion. Since tray corrosion can cause extensive damage to batteries and vehicles, extreme caution must be taken to avoid overfilling the batteries.

Tray Corrosion

Motive power battery trays are mostly made of steel that is protected with an acid resistant coating. Regardless of how good the coating is, if a break in the coating 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.

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, batteries should be cleaned any time the accumulation of dampness or acid becomes significant.

A good technique to follow while watering batteries is to use a flashlight focused on the vent hole being watered. Visually watch the electrolyte level rise and stop watering the instant the proper level is reached. Each cell is filled the same way. Cell filling equipment that automatically fills batteries to the proper level is available.

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 continually discharge. As the current carrying ability of the multiple grounds increases, further complications such as jar leakage, overheating, cell failure, etc., can occur. Additionally grounds can also cause serious problems or failures in the electronic controls and 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 the 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 the top of the battery of acid and corrosion and dry. If the ground is still present, reseal the battery with asphaltic compound.

Watering Schedule

Lowe electrolyte level in a cell can cause the plates to oxidize and shorten the life of the cell and the battery. To prevent, 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 changed. 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:

1. Frequency of charge (daily, 1 ½ times a day, three times a week, etc.).
2. Water storage capacity of the specific cell type.
3. 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 first-hand experience. Example: if some batteries have low electrolyte levels when a weekly watering schedule is followed, change the schedule to twice a week.

Cleaning

To prevent corrosion and the resultant problems, batteries must be cleaned and dries 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. (This should be immediately disposed of.)

The frequency of a general cleaning depends upon two factors:

1. How quickly dust, dirt, oil, and other foreign matter accumulates on the top of the battery, and
2. How quick the electrolyte spillage accumulates.

When the top of a battery is “dirty” or looks damp, it is ready for a general cleaning. It could be as often as every two weeks or as infrequent as every six months, depending on the battery’s environment and the care it receives. The average battery needs general cleaning every three months.

To give a battery a general cleaning, use Powerhouse Cleaner’s 3 Step Process (Corrosion Remover, Battery Cleaner, Rinse).

Powerhouse’s Corrosion Remover was developed specifically for the removal of heavy corrosion and acid neutralization. For use, spray onto the corroded areas (will turn a rust looking color) and let sit for at least 10 minutes.

Powerhouse’s Battery Cleaner is a mixture of 2 parts cleaning detergent to 1 part acid neutralizer. Battery Cleaner is OSHA compliant and environmentally safe. For use, spray across the entire battery and let sit for at least 10 minutes.

After the Corrosion Remover and Battery Cleaner have both sat for at least 10 minutes the battery can now be rinsed. The corrosion and acid should be neutralized and can be washed down the drain (note if lead pieces from the top of the battery are in the water they should be disposed of properly.)

During any cleaning, but particularly when using Powerhouse Cleaners, make certain that all vent caps are tightly in place.

Effective Battery Maintenance

As is true with any piece of industrial equipment, proper maintenance not only keeps it operating to its design specifications, but also helps prolong the equipments life. The following effective battery maintenance tips can help achieve the best performance out of your industrial battery.

1. Maintain the proper electrolyte level. Avoid overfilling.
2. Charge properly, check charger controls and instruments periodically. Calibrate meters as needed.
3. Repair any damage promptly. Minor damage, if not repaired in a timely manner, can lead to major damage.
4. Don’t overcharge, many batteries deliver short service life from too much charge.
5. Don’t discharge over 80% state of charge. Over-discharging is one cause of short battery life and as a battery nears complete discharge, its operating efficiency decreases substantially.
6. Use the batteries according to the manufacturer’s recommendations.
7. Don’t place metal objects on a battery as they can “arc” or short-circuit the battery.
8. 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. Keep accurate records. They provide an accurate history of the battery and indicate whether a battery is being abused.
10. Give periodic equalizing charges.
11. Check batteries periodically- cell voltages, specific gravities and electrolyte levels.
12. Make regular visual inspections to determine spillage, corrosion, damage to the case and similar problems.
13. Keep idle batteries charged. When stored for extended periods, batteries should be given a freshening charge periodically and immediately before use.

The Purpose of Record Keeping

Plants with more than just a few batteries find that keep 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. A multiple-digit system such as 1001, 1002, etc. for all 36- volt, 680 ampere-hour batteries and 2001, 2002, etc. for all 48 volt, 850 ampere-hour batteries, etc.

2. The specific gravity of the “pilot” cell or cells of a battery should be recorded before and after each charge. Pilot cell(s) are one or more designated cells whose specific gravity is checked to determine the general state of charge in the battery. Pilot cells are usually identified with their vent caps colored differently than the rest.

3. Provide a means of recording the number of cycles on a cumulative basis to date, plus maintenance and repair information.

4. Lastly, there has been a trend in all industries to computerize all types of facts, figures and other such data. We feel the data gathered during equipment usage, specifically batteries and chargers, should also be part of this technological advancement.

Trouble Shooting, Testing & Inspections

Problem	Probable Cause	Remedy
Low Electrolyte Level.	1. Cracked or broken jars. 2. Lack of watering. 3. Frequent Overcharging. 4. Battery tipped over.	1. Replace jars. 2. More care required. Liquid level must always cover the top of the battery's plates. 3. Check charging equipment. 4. Add water, give equalizing charge and adjust gravities.
Unequal Cell Voltages	1. Overdischarging. 2. Weak or defective cells. 3. Acid loss due to tipping or overwatering. 4. Corroded or dirty battery top. 5. Grounds in battery. 6. Impurities in cell electrolyte. 7. Battery used infrequently. 8. Lack of equalizing charges.	1. Give equalizing charge. 2. Repair or replace battery. 3. Give equalizing charge and adjust gravities. 4. Neutralize and clean top. 5. Clean battery. 6. Add only distilled or approved water. 7. Give deep discharge and equalizing charge. 8. Give equalizing charges periodically.
Battery overheats on charge.	1. Charging equipment not operating correctly. 2. Charging equipment incorrectly adjusted. 3. Weak or defective cells. 4. Battery worn out. 5. High resistance connection. 6. Low electrolyte level. 7. Battery too warm when placed on charge. 8. Battery being charged in truck compartment with cover closed. 9. Battery too deeply discharged.	1. Repair or replace charger. 2. Adjust starting and finishing rates. 3. Repair or replace battery. 4. Replace. 5. Check for hot cables, poor plug solder joints, bad connector burns. 6. Water battery to correct level. Allow to cool and recharge. 7. Cool battery with fans or water to below 90° F before starting charge. 8. Remove from truck and open cover while charging. 9. Limit discharge to 80% of rated capacity.

Problem	Probable Cause	Remedy
Battery not working a full shift.	1. Battery is undersized. 2. Battery not fully charged at beginning of shift. 3. Week or defective cells. 4. Grounds or Shorts. 5. Battery has exceeded useful operating life. 6. Vehicle has electrical or mechanical problems.	1. Replace with a battery of adequate capacity for the work load required. 2. Check chargers and charging schedules. Fully charged gravity is 1.290 for a standard and 1.320 for high gravity batteries. 3. Repair or replace battery. 4. Clean battery and remove any visible corrosion. 5. Replace battery. 6. Troubleshoot and repair vehicle.
Battery overheats on discharge.	1. Excessive load 2. Battery not fully charged prior to work assignment. 3. Battery overdischarged. 4. Electrolyte levels low. 5. High current draws due to worn out equipment. 6. Operating truck in high surrounding temperatures.	1. Do not exceed capacity of equipment. 2. Give full charge before returning to truck. 3. Limit discharge to 80% of rated capacity. 4. Water battery to correct level, allow to cool and recharge. 5. Repair brakes, worn out bearings etc. 6. Provide cool charging facilities for recharge.
Unequal specific gravities.	1. All probable causes listed under "Unequal Cell Voltages". 2. Battery recently watered and insufficient time allowed for mixing. 3. Improper gravity adjustment after cell replacement.	1. All remedies listed under "Unequal Cell Voltages". 2. Charge at finish rate for 1 hour after gassing begins. 3. Adjust gravity.

The Purpose and Frequency of Inspections

Motive Power batteries have a life expectancy of five years or longer. To ensure that the battery lives up to its full potential, it is recommended that both batteries and chargers be inspected periodically. A general inspection should not be confused with an inspection carried out for troubleshooting to identify a specific problem.

If minor problems in batteries and chargers can be identified and repaired early, major battery damage can be avoided. A battery inspection often reveals improper routine maintenance and operational procedures, which can lead to major battery and vehicle damage. Inspection can also identify batteries in poor condition so they can be replaced in a timely manner.

The Crown Battery inspection report can be found on page 28.

How to Inspect a Battery

The following instructions can help an electrician or vehicle repair specialist gather and record basic information that can help pinpoint the source of a battery problem. Once the source is pinpointed, extensive inspecting and testing can be done by battery technicians (contact Crown Battery for the closest technician).

1. If the battery is still in the vehicle, turn off the power switch and unplug the battery from the vehicle.

2. Allow the battery to remain on open circuit (do not charge or discharge) for 30 minutes or longer.

3. Prepare the Crown Battery Inspection Report (found on page 28). Fill in the data as best as you can. Be sure to include battery type, serial number, etc.

4. Read and record the specific gravity and open circuit voltage for all cells of the battery.

5. Read and record the pilot cell temperature.

6. Record the temperature-corrected specific gravity readings. Use a temperature correction thermometer or refer to the chart on page 17 to correct the specific gravity reading for temperature. Use the pilot cell temperature for the temperature correction of all the cells. It is not necessary to read the temperature of every cell unless the temperature difference between center cells and outside cells of the battery is 12°F or more.

INSPECTION REPORT

AGENT	
CUSTOMER	LOCATION
CONTACT	PHONE

WARRANTY NO.	
DATE	
TYPE	
SERIAL NO.	
CUSTOMER I.D. NO.	

AS RECEIVED		
CELL	SP. GR.	O.V.
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		
22		
23		
24		

CHARGER
MFG
MODEL
S/N
AUTO/START/STOP YES NO

BATTERY LAYOUT

CABLE POSITION ____________________ LENGTH ____________________________

CONNECTOR ____________________________

X__________ Y____________ Z_____________ COVER ________ TRAY NO. __________

VISUAL INSPECTION

STEEL TRAY	OK	ACID RUNS	CORRODED	______________________
POS CABLE	OK	REPAIR	REPLACE	______________________
NEG CABLE	OK	REPAIR	REPLACE	______________________
CONN./CONTACTS	OK	REPAIR	REPLACE	______________________
INTERCELLS	OK	REPAIR	REPLACE	______________________
CELL COVERS	OK	REPAIR	REPLACE	______________________
VENT COVERS	OK	REPAIR	REPLACE	______________________
CELL JARS	OK	REPAIR	REPLACE	______________________
COMPOUND	OK	REPAIR	REPLACE	______________________
ELECTROYLTE	OK	CLOUDY	DARK	______________________
CORROSION	NONE	MODERATE	HEAVY	______________________
POS PLATE GROWTH		NO _______	YES ______	
VOLTS TO GROUND ___________________				

INTERNAL INSPECTION CELL NO.

POS. PLATE	SOFT	HARD	SHEDDING	______________________
NEG. PLATE	SOFT	HARD	SHEDDING	______________________
GRID WIRES	OK	BRITTLE	CORRODED	______________________
MOSSINGS	NONE	MILE	HEAVY	______________________
SEDIMENT	NONE	1/2 FULL	FULL	______________________
SEPARATORS	OK	DAMAGED	MISALIGNED	______________________
LEAD POSTS	OK	CRACKED	BROKEN	______________________
LEAD STRAPS	OK	CRACKED	BROKEN	______________________
OTHER				

COMMENTS

SI-4030

Capacity Testing

A capacity test enables you to determine the capacity a battery actually delivers as compared to its rated capacity. This test can help determine if a battery should be repaired or replaced. When a battery delivers less than 80% of its rated capacity, the remaining capacity will decrease with each additional cycle. It should be replaced before its cells fail and cause low-voltage operation of the vehicle, which can cause damage to the trucks electrical system.

A capacity test is performed by discharging a fully charged battery at a fixed rate (see chart on page 30) while monitoring specific test conditions, methods and procedures.

The six-hour rated discharge time is based on an electrolyte temperature of 77°F (25°C). Any deviation to that temperature, a correction to the six-hour rated time must be made. To correct for temperatures, please use the chart below.

PROCEDURES FOR CAPACITY DISCHARGING	
1)	Battery must be fully charged.
2)	Specific gravities must be at manufacturers specifications, otherwise they must be adjusted accordingly.
3)	Battery should be allowed to cool down prior to testing. Ideally, the temperature should be 75°F to 85°F. Otherwise the voltages will be affected by the temperature and the capacity must be temperature corrected.
4)	Battery should be discharged within 24 hours of completion of charging and acid adjustment.
5)	Any cells that are dead must be taken out of circuit.
6)	Starting procedures:
	a) Discharge rate is battery amp hour capacity divided by 6 (based upon a 6 hour test.)
	b) Record the following information:
	1) Model and serial number
	2) Age
	3) Starting Temperature
	4) Amp hour capacity
	5) Discharge rate (test amps)
	6) Hours test is based on (6 hours is standard)
	7) Date tested
	8) Time test started
	9) Cutoff voltage 1.70 volts X number of cells
	c) Turn on discharge panel and set the rate to the proper rate at starting time.
	1) Monitor rate throughout the test and keep adjusting it to the exact rate.
	2) Record every cell voltage at 1 hour intervals up to the 4th hour. At 4 hours the reading are taken every 1/2 hour until cut off voltage.
	3) Record total voltage and temperature at each interval as cell voltages.
	4) Any cell that fails while the test is still in progress must be taken out of circuit. Remove intercell and jump out the cell. Continue with test.
	5) Continue the test until the total battery voltage equals the cutoff voltage. If you jump out any cells then the cutoff voltage will be based upon the number of cells remaining.

100% CAPACITY ASSURANCE			
Discharge Time vs. Temperature			
Temp at Start of Discharge	Time required (6 Hr. Rate)	Temp at Start of Discharge	Time required (6 Hr. Rate)
60°	5 hrs. 31 min	87°	6 hrs. 14 min
61°	5 hrs. 33 min	88°	6 hrs. 15 min
62°	5 hrs. 35 min	89°	6 hrs. 16 min
63°	5 hrs. 36 min	90°	6 hrs. 16 min
64°	5 hrs. 38 min	91°	6 hrs. 18 min
65°	5 hrs. 40 min	92°	6 hrs. 19 min
66°	5 hrs. 42 min	93°	6 hrs. 20 min
67°	5 hrs. 44 min	94°	6 hrs. 21 min
68°	5 hrs. 45 min	95°	6 hrs. 22 min
69°	5 hrs. 47 min	96°	6 hrs. 23 min
70°	5 hrs. 49 min	97°	6 hrs. 24 min
71°	5 hrs. 51 min	98°	6 hrs. 25 min
72°	5 hrs. 53 min	99°	6 hrs. 25 min
73°	5 hrs. 55 min	100°	6 hrs. 26 min
74°	5 hrs. 57 min	101°	6 hrs. 27 min
75°	5 hrs. 58 min	102°	6 hrs. 28 min
76°	5 hrs. 59 min	103°	6 hrs. 29 min
77°	6 hrs.	104°	6 hrs. 30 min
78°	6 hrs. 2 min	105°	6 hrs. 31 min
79°	6 hrs. 3 min	106°	6 hrs. 31 min
80°	6 hrs. 4 min	107°	6 hrs. 32 min
81°	6 hrs. 6 min	108°	6 hrs. 33 min
82°	6 hrs. 7 min	109°	6 hrs. 33 min
83°	6 hrs. 8 min	110°	6 hrs. 34 min
84°	6 hrs. 9 min	111°	6 hrs. 34 min
85°	6 hrs. 11 min		
86°	6 hrs. 12 min		

AMP HOUR CAPACITY & DISCHARGE RATES

TYPE	PLATES PER CELL	5	7	9	11	13	15	17	19	21	23	25	27	29	31	33
45S	6 HR A.H RATING	90	135	180	225	270	315	360	405	450	495	540	585	630	675	720
	Discharge Rate- Amps	15	22.5	30	37.5	45	52.5	60	67.5	75	82.5	90	97.5	105	112.5	120
55S	6 HR A.H RATING	110	165	220	275	330	385	440	495	550	605	660	715	770	825	880
	Discharge Rate- Amps	18.3	27.5	36.7	45.8	55	64.2	73.3	82.5	91.7	100.8	110	119.2	128.3	137.5	146.7
65S	6 HR A.H RATING	130	195	260	325	390	455	520	585	650	715	780	845	910	975	1040
	Discharge Rate- Amps	21.7	32.5	43.3	54.2	65	75.8	86.7	97.5	108.3	119.2	130	140.8	151.7	162.5	173.3
75S	6 HR A.H RATING	150	225	300	375	450	525	600	675	750	825	900	975	1050	1125	1200
	Discharge Rate- Amps	25	37.5	50	62.5	75	87.5	100	112.5	125	137.5	150	162.5	175	187.5	200
85S	6 HR A.H RATING	170	255	340	425	510	595	680	765	850	935	1020	1105	1190	1275	1360
	Discharge Rate- Amps	28.3	42.5	56.7	70.8	85	99.2	113.3	127.5	141.7	155.8	170	184.2	198.3	212.5	226.7
90S	6 HR A.H RATING	180	270	360	450	540	630	720	810	900	990	1080	1170	1260	1350	1440
	Discharge Rate- Amps	30	45	60	75	90	105	120	135	150	165	180	195	210	225	240
90L	6 HR A.H RATING	180	270	360	450	540	630	720	810	900	990	1080	1170	1260	1350	1440
	Discharge Rate- Amps	30	45	60	75	90	105	120	135	150	165	180	195	210	225	240
100S	6 HR A.H RATING	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600
	Discharge Rate- Amps	33.3	50	66.7	83.3	100	116.7	133.3	150	166.7	183.3	200	216.7	233.3	250	266.7
110S	6 HR A.H RATING	220	330	440	550	660	770	880	990	1100	1210	1320	1430	1540	1650	1760
	Discharge Rate- Amps	36.7	55	73.3	91.7	110	128.3	146.7	165	183.3	201.7	220	238.3	256.7	275	293.3
125S	6 HR A.H RATING	250	375	500	625	750	875	1000	1125	1250	1375	1500	1625	1750	1875	2000
	Discharge Rate- Amps	41.7	62.5	83.3	104.2	125	145.8	166.7	187.5	208.3	229.2	250	270.8	291.7	312.5	333.3
160S	6 HR A.H RATING			640	800	960	1120	1280	1440	1600						
	Discharge Rate- Amps			106.7	133.3	160	186.7	213.3	240	266.7						

C.B.M. Form No. PB-0998

3 HR Rate = 2 x 6 Hr Rate x 82%

Battery Repairs

It can be difficult to decide if a battery is worth repairing or if it should be replaced. When you have to make this decision, the most important things to consider are the battery's age, cycle life and service history.

If the battery is only 1 to 2 years old (300-600 cycles), if it hasn't been severely overcharged or over discharged and if the repair costs don't exceed 25% of the replacement costs, then it should probably be repaired.

On the other hand, if a battery has been on the job 3 or more years (900 or more cycles) or has extensive damage, requiring repairs totaling 25% or more of the replacement cost, it should probably be replaced.

CAUTION: ONLY EXPERIENCED PERSONNEL SHOULD ATTEMPT BATTERY REPAIRS!

If you don't have an experienced battery repair person, send the battery to your nearest authorized Crown Battery repair facility or arrange to have a Crown Battery service technician perform the repairs at your plant site.

BEFORE PERFORMING ANY REPAIRS, REMOVE THE BATTERY FROM THE LIFT TRUCK. ALWAYS WEAR SAFETY GLASSES AND A FACE SHIELD WHEN WORKING ON OR NEAR BATTERIES.

For more information on battery repairs please see Crown Battery's Battery Repair Guide.

Common Battery Terms

Acid – In the lead acid storage battery industry, “acid” implies “sulfuric acid”, and is used to describe the electrolyte or liquid in the cell.

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

Activation – The process for making a dry charged cell functional by introducing electrolyte.

Alloy – A combination of two or more metals, as a mixture, solution, or compound.

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

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

Ammeter – An ammeter is an instrument for measuring electrical current.

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.

Ampere-Hour Capacity – The ampere-hour capacity of a storage battery is the number of ampere-hours, which can be delivered under specified conditions such as temperature, rate of discharge and final voltage.

Ampere-Hour Efficiency – The ampere-hour efficiency of a storage battery is the electrochemical efficiency expressed as the ratio of the ampere-hours output to the ampere-hours input required for the recharge.

Ampere-Hour Meter – An ampere-hour meter is an instrument that registers the quantity of electricity in ampere-hours.

Antimonial Lead Alloy – Lead antimony alloy is the most common alloy used in battery castings. The percentage of antimony varies from ½ percent to 12 percent. 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 to improve the properties of the cast part.

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) A battery made of 3 or 6 cells used for starting, lighting, and ignition of automobiles, trucks, buses, etc.

Average Voltage – The average voltage of a storage battery is the average value of the voltage during the period of charge or discharge.

Barium Sulfate – An inorganic component in many expander formulations.

Battery (Storage) – A storage battery is 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.

Bayonet Vent – A term originally applied to a design of quarter turn vent plug, the lower portion of which resembles a bayonet, both in appearance and locking arrangement.

Boot – A plastic piece used at the foot of plate, especially a wrapped plate, for retention and insulation.

Bridge – The ribs or elements structure, which is molded or cut to fit into the bottom of a ribless jar or container in order 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 and in some cases additional metal, which is supplied by a stick called a burning strip.

Burning Center – The center-to-center distance between adjacent plates of the same polarity.

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

Button – The finished "button shaped" area produced on the top surface of a connector or terminal by the post burning operation.

Cadmium – A metallic element highly resistant to corrosion used as a protective plating on certain steel parts and fittings.

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

Capacity – See Ampere-Hour Capacity

Capacity Test – A test where the battery is discharged at constant current, at room temperature, to a cutoff voltage of usually 1.70 volts/cell.

Carbon Black – Finely divided carbon, obtained by burning a gaseous hydrocarbon under controlled conditions, which is used as an ingredient in negative expanders.

Carbon Burning Outfit – A metallic rod and insulated handle, mounting a pointed carbon rod; used for lead burning on service locations where the usual gas flame equipment is not available.

Carboy – A large cylindrical container or bottle made of plastic or glass used to ship acid.

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

Cell (Storage) – A storage (secondary) cell is an electrolytic cell due to the generation of electric energy, in which the cell, 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.

Charged – The condition of a storage cell when at its maximum ability to deliver current. The positive plate contains a maximum of lead peroxide and a minimum of sponge lead and sulfate and the electrolyte will be 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 is ready to deliver current.

Charging – The process of converting electrical energy to stored chemical energy. In the lead-acid system, charging converts the lead sulfate in the plates to lead peroxide or lead.

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 housing both positive and negative leads.

Circuit – A system of electrical components through which an electrical current is intended to flow. The continuous path of an electric current.

Compound – An asphaltic, pitch like material used as a cover-to-jar sealant.

Constant-Current Charge – A constant-current charge of a storage battery is 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 finishing rate.)

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

Container – The 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 or container and through which extend the posts and the vent plug.

Cover Inserts – Lead or lead alloy rings, which are molded or sealed into the cell cover and to which the element posts are burned thereby creating an effective acid-creep resistant seal.

Creepage – Creepage is 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 – The 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 the flow of electricity, normally expressed as amperes, like the flow of a stream of water.

Cut-off Voltage – See "Final Voltage"

Cycle – A discharge and its subsequent recharge.

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

Deep Discharge – The removal of up to 80% of the rated capacity of a cell or battery.

Dead Top – A system of encapsulating intercell connectors with compounds, such as epoxy, or polyurethane, to prevent accidental intercell shorts from external sources.

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

Diesel Starting Battery – Batteries that are used to crank diesel engines. This function is similar to a gasoline engine's application, except that greater demands are made for cranking power, and ignition is accomplished by the engine's heat, without any further need for electric current.

Direct Current – (DC) A direct current is a unidirectional current, in which the changes in value are either zero or so small that they may be neglected.

Discharge – Discharge of a storage battery is the conversion of the chemical energy of the battery into electrical energy.

Discharged – The condition of a storage cell when, as the results of delivering current, the plates are sulfated, the electrolyte is exhausted, and there is little or no potential difference between the terminals.

Discharge Rate – Batteries discharged to meet any time rate between 3 hours and 8 hours are considered as having been normally discharged.

Efficiency – The efficiency of a storage battery is 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 – The electrochemical reaction which causes the decomposition of a compound, either liquid or molten in solution.

Electrolyte – Any substance which disassociates into two or more ions when dissolved in water. Solutions of electrolyte conduct electricity and are decomposed by it. I the battery industry the word "electrolyte" implies a dilute solution o sulfuric acid.

Element – An assembly of a positive plate group, a negative plate group and separators.

End Gravity – The specific gravity of a cell at the end of a prescribed (usually 6 to 8 hours) discharge.

Energy Density – The ratio of battery energy content in watt-hours to battery weight or volume.

Envelope – See perforated retainer.

Equalizing Charge – An equalizing charge of a storage battery is an extended charge, which is given to a storage battery to insure the complete restoration of active materials in all the plates in the cells.

Expander – An addition agent either organic or inorganic or a mixture of both to be blended with the other ingredients for 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.

Ferroresonant Charger – A constant voltage power supply containing a special transformer-capacitor combination. Which changes operating characteristics as current draw is varied, so that the output voltage remains constant.

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

Final Voltage – The cut-off 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 expresses 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.

Flaming – A method used to improve the surface of a cast lead or lead alloy part or of trimmed battery sealing compound, in which a flame is passed over the surface causing the material to melt and flow smoothly together.

Flat Plate – A general term referring to pasted plates.

Flush – Over watering causes the acid to be flushed out.

Flying Leads – Any fixed terminal cable in which the terminal or plug end of the cable if 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 peroxide being formed in the positive plates and sponge lead in the negative plates.

Formed – Plates that have undergone formation are known by this term.

Freshening Charge – A charge given to 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 when the cells are fully charged and properly leveled.

Gassing – Gassing is the evolution of gases from one or more of the electrodes during electrolysis.

Gelled Electrolyte – Electrolyte which has been immobilized by the addition of silica powder or other gelling agents.

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

Gravity – Refers to the specific gravity.

Gravity Drop – The number of point reduction or drop that the specific gravity of the electrolyte makes upon discharge of the cell.

Grid – A grid is 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 one type (positive or negative) which are burned to a post and strap.

High Rate – While on charge, any rate higher than the normal finishing rate.

H2SO4 – The chemical symbol for sulfuric acid.

Hydration (Lead) – The 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 a white coating on both plate groups and separators in a cell.

Hydrometer – A device used to indicate density or specific gravity of electrolyte solutions.

Hydroset – A curing process for negative and positive plates, wherein free lead in the paste is oxidized and total free lead is reduced to a few percent.

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 flowed for a sufficient period for the rate of change of voltage to become practically constant.

Insert – The abusing of lead or lead alloy molded or sealed into cell covers, forming the posthole, and to which the post is burned to create a creep-resistant cover-to-post seal.

Intercell Connector – A conductor, made of lead, lead alloy or lead plated copper, which is used to connect to battery cells.

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

Jar – A cell container, made by injection molding, roto-molding, or thermo-forming.

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

Jumper – A short length of conductor used to connect or output part of an electrical circuit.

Kilovolt – (kV) One thousand volts.

Kilowatt – (kW) One thousand watts.

Kilowatt Hours – (kWh) A measure of energy or work accomplished, being 1000-watt hours.

Lamp Black – Finely powdered carbon, used as an ingredient in negative plate expander.

Lead – (Pb) The chemical element used in lead-acid batteries (with sulfuric acid and other materials).

Lead Burning – The welding of lead or lead alloy parts.

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 alloys.

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

Lead Peroxide – A brown oxide of lead which is the active material in a fully formed positive plate.

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 reaction of sulfuric acid on oxides of lead or lead metals itself.

Level Indicator – A float, mounted in a float tube, or similar indication of the electrolyte level.

Life – The number of years of satisfactory float operation or the number of charge-discharge cycles for motive power operation.

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

Local Action – Local action in a battery is 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 – The portion of grid used for support of the plate group, usually along the top edge of the grid, as “hanging lug”. Also, tab on grid is used for connection of a plate to a strap and other plates.

Maintenance Free Battery – A battery which requires no addition of water, no boost charges, etc. This typically requires a non-antimonial or low-antimonal grid alloy, sealed cell design, or low-loss venting.

Manual Discharge - A 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 final voltage. With fixed resistance loads, boost cells are used to keep the discharge rate fairly constant as the test cells voltages drop fairly rapidly near the final voltage. Electronic load manual discharges generally do not require boost cells.

Microporous Separator – Either a veneer or a grooved type separator made of any material in which the pores are numerous and microscopically small.

Mine Locomotive Battery – A cycle service battery designed to operate mine locomotive, trammer, shuttle cars, and tunnel haulage equipment.

Millivolt – (MV) One thousandth part of a volt.

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. This may cause a short circuit within a cell.

Moss Shield – A plastic or hard rubber perforate sheet which insulates the gaps between the negative plates and the positive strap, and between the 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 Plates – The negative plate of a storage battery consists of the grid and active material to which current flows from the external circuit when the battery is discharging.

Negative Terminal – The negative terminal of a battery is the terminal toward which current flows (as ordinarily conceived) in the external circuit from the positive terminal.

OHM – A unit of electrical resistance.

One Shot Formation – Jar formation under conditions where the end of formation specific gravity is equal to the operating specific gravity.

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 open circuit voltage of a battery is the voltage as its terminals when no appreciable current is flowing.

Organic Expander – An expander formulation which typically contains barium sulfate and a lignin type organic compound, along with small amounts of other materials.

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

Panel – A casting consisting of two or more grids which has been made simultaneously in a single mold.

Partition – An interior dividing wall in a tray or container.

Paste – A 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 – The battery assemble operation wherein paste is applied to grids by hand or by a machine.

Pb – The chemical symbol for lead.

PbO – The chemical symbol for litharge.

PbO2 – The chemical symbol for lead peroxide (dioxide).

Pellet – The portion of pasted material contained in a 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 layer of glass insulating material.

Peroxide – See Lead Peroxide.

Pig – A cast bar of lead or lead alloy.

Pig Lead – A grade of highly refined unalloyed lead.

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

Polarity – The polarity of a battery is an electrical condition determining the direction in which the current tends to flow. By common usage the discharge current is said to flow from the positive electrode through the external circuit.

Positive Plates – The positive plate of a storage battery consists of the grid and the active material from which current flows to the external circuit when the battery is discharging.

Positive Terminal – The positive terminal of a battery is the terminal from which current flows (as ordinarily conceived) through the external circuit to the negative terminal when the cell discharges.

Post – A terminal or other conductor which connects the plate group strap to the outside of the cell.

Post Builder – A ring shaped mold used to repair damaged battery posts.

Potential – See Voltage.

Rated Capacity – The ampere-hours 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 cut off voltage.

Rate of Charge – See Starting Rate and Finishing Rate

Raw Plate – An unformed plate.

Rectifier – A rectifier is 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 used in making active material.

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

Retainer – A sheet of glass mat, perforated or slotted rubber 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 – Reversal of a storage battery is a change in normal polarity of the cell or battery.

Rib – A vertical of nearly vertical ridge of a grooved separator or spacer.

Run Down – A small portion of metal that has dropped on to a plate, group or element in the course of burning. It may result in a short circuit.

Sealing – A manufacturing operation for attaching covers to jars by cement, sealing compound or thermal fusion.

Sealing Compound – An asphalt mixture of several types, differing in heat resistance, adhesion, and resistance to shearing. It is used for sealing cell covers to the jars or containers. See Compound.

Secondary Lead – Reclaimed lead as opposed to virgin lead.

Sediment – The leady sludge or active material shed by the plates and found in the bottom of the 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 – The loss of charge due to local action.

Separator- A separator is 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.

Separator Protector – See Moss Shield.

Service Life – See Life.

Shedding – The loss of active material from the plates.

SLI Battery – A battery for automotive use in starting, lighting and ignition.

Sliver, Slyver – Extremely fine, parallel glass fibers used, next to positive plates 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 plates are soaked in sulfuric acid after pasting. Soaking provides a protective surface and also a supply of sulfate helpful in jar and tank formation.

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

Spalling – The shedding of active material, usually positives, during formation due to incomplete or improper plate curing.

Spine – Cast PB alloy conductor used for tubular positive plates.

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

Stacking – The 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.

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.

Strap – A precast or cast-on piece of lead or lead alloy used to connect plates into groups and to connect the groups to the posts.

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 lead sulfate on a plate or cell as a result of discharge, self-discharge, or pickling.

Sulfuric Acid – (H2SO4) The principal acid compound of sulfur. Sulfuric acid of a high purity and in a dilute form is the electrolyte of lead-acid storage cells.

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 terminals of a battery are the points at which the external circuit is connected.

Terminal Cable – A length of insulated cable, one end is connected to the terminal post of a battery and the other end is fitted with a suitable device (plug, receptacle, lug, etc.) for connection to an external circuit.

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

Tray – A steel enclosure for motive power cells.

Treeing – The growth of a lead dendrite or filament through a hole, crack, or large pore of a separator, whereby the cell is sort circuited.

Trickle Charge – A trickle charge of storage batteryis 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 – A positive battery plate made from a cast spine and porous tubes, which are filled with paste or dry oxide.

Uncharged – A term used to describe the condition of a battery assembled with formed plates but not yet having received its initial charge. This type of battery is classified as either uncharged and moist or uncharged and dry.

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.

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

Vent Cap – See Vent Plug.

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

Vent Well – The hole or holes in a cell cover through which gas escapes, fluids are added or the electrolyte 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.

Voltage – The difference of potential which exists between the terminals of a cell or battery, or any two points of an electric current.

Voltage Range – The difference between the maximum and minimum cell voltages that exist within a battery or a string of cells, when all of cells the are charging or discharging.

Voltmeter – An instrument for measuring voltage.

Watering – Adding water to a battery's electrolyte to replace losses caused by electrolysis and evaporation.

Watt – A measure of electric power. The product of amperes and volts.

Watt-hour – A measure of energy of work accomplished being the product of the rate of work in watts and the time in hours, or the product of ampere-hours and the average voltage.

Watt-hour Capacity – The watt-hour capacity of a storage battery is the number of watt-hours, which can be delivered under specific conditions, such as temperature, rate of discharge and final voltage.

Watt-hour Efficiency – The watt-hour efficiency of a storage battery is the energy efficiency expressed as the ratio of the watt-hour output to the watt-hours of the recharge.

Wet Shelf Life – The period of time a wet secondary cell can be stored before its capacity has fallen to the point that the cell cannot be easily recharged.

Wrapping – The assembly operation where motive power positive plates are covered by silver, glass mat, and retainer.