Maintenance Series Handbook
MS-11

Industrial Storage Batteries

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Maintenance Series Handbook MS-11
Industrial Storage Batteries

Transmittal Letter 3
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A. Explanation

This handbook is a complete revision of the MS-11 Handbook, Industrial Storage Batteries. It reflects changes and more definitive statements regarding the storage and maintenance of lead-acid flooded and Valve Regulated Lead Acid (VRLA) commonly known as Gel cell and Absorbed Glass Mat (AGM) storage batteries. It will be available on the MTSC web site at https://www1.mtsc.usps.gov in PDF.

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C. Rescissions

Please discard all previous TLs of this handbook.

D. Comments and Questions

Suggestions for improving this handbook are solicited from all sources. To provide comments and suggestions, or to report handbook errors, use the Handbook Comment selection on the MTSC Feedback link at https://www1.mtsc.usps.gov/. This handbook will be updated as future needs demand.

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SECTION 1

INTRODUCTION

1.1 THE STORAGE BATTERY

This manual will mainly deal with two types of storage batteries, lead-acid flooded and Valve Regulated Lead Acid (VRLA) commonly known as Gel cell and Absorbed Glass Mat (AGM). These are the main batteries employed for electric vehicles and lifts known as Powered Industrial Vehicles (PIV) or Mobile Powered Equipment (MOPE) in the U.S. Postal Service.

An electric accumulator, or cell, is a galvanic cell sufficiently chemically reversible to permit recharging electrically. Storage batteries are a group of such cells. Energy, put in as electricity, is stored as chemical energy, and delivered again as electricity. The process of putting energy into the battery is termed "charging" and when delivering energy, it is "discharging".

The cell is composed of plates, separators, electrolyte, cell case, cover with posts, and vent caps. The positive electrode or plate is cathodic during discharge so that electrons enter it to bring about a chemical reduction. When charging, an anodic reaction or oxidation occurs and the electrons leave the plate.

The negative plate functions as an anode during discharge and a cathode during charge with a corresponding electron exchange and chemical reduction. Plates of like polarity are connected in parallel by a plate strap. Two assemblies with their straps, each of different polarity, along with their separators form the element. The element with its electrolyte, cell case, cover with posts and vent cap constitute the cell unit. In turn, cells of the same kind can be joined by connectors to form a battery.

Capacity of a battery means the quantity of electricity which can be taken from the battery over a definite time period. The capacity is measured either in ampere hours or in the amperes of current it will deliver continuously for a definite time before the voltage lowers below a useful value. Capacity depends on the type of battery, its construction, the size of the plates, and how many plates are in each cell. Capacity is increased by using cells of greater capacity rather than parallel connection, which increases reliability somewhat, but the increase in the number of cells increases the total battery weight. Battery voltage is determined by series connection of individual cells.

The industrial storage battery differs from automotive batteries in that it is a primary source whereas the automotive battery is designed for intermittent duty as an auxiliary to another power source (a generator or alternator). Consequently, the cell structure and elements of an industrial storage battery are more durable and, hence, much more costly. With proper care the total life of an industrial storage battery should range from 4 to 10 years depending on how they are used (number and depth of cycles) and the maintenance performed. With improper use and maintenance these figures will be significantly reduced. Normally, a battery is considered as having reached the end of its economical life when it can no longer deliver 80 percent of its capacity.

1.2 ADVANTAGES OF BATTERY POWER

Electric motors operating from storage batteries are often used to provide motive power, and are preferred over other sources of motive power such as the internal combustion engine, because they offer the following advantages:

- Little or no noise
- No air pollution
- High conversion efficiency
- No vibration
- Reduced maintenance costs and longer life
- Ability to deliver high torque at low speed
- Reduced fire hazard

The problems and dangers caused by exhaust fumes and sparks, as from internal combustion engine power, are not present; consequently, a battery powered truck can be operated indoors in many places where a gasoline or diesel powered truck would be prohibited.

The maintenance cost for the electric vehicle or unit is usually less than that for an internal combustion unit due to the less complex drive system; an electric drive motor compared to an internal combustion engine.

The battery powered truck, however, is entirely dependent on the state of the battery. Without the battery, the truck is "dead", when the battery is in a poor condition, the truck operates poorly. It is necessary, therefore, that each day the operators or other responsible personnel ensure that the battery is up to full power and ready for use.

SECTION 2

GENERAL INFORMATION

2.1 TYPES OF BATTERIES

The U.S. Postal Service uses primarily two types of storage batteries in industrial trucks: lead-acid flooded and VRLA (Valve Regulated Lead Acid) commonly known as Gel cell and AGM (Absorbed Glass Mat). These two types each require different charging and maintenance procedures which are discussed separately in following sections. The following instructions, however, apply to both.

2.2 SAFETY AND FIRST AID

The principal hazards of battery charging operations are explosion, acid burns, lifting strains, electric shock, slips, and falls.

WARNING

Employees must be equipped with goggles, face shield, acid-resistant rubber gloves, acid-resistant rubber aprons, and acid-resistant rubber boots with non-slip soles. Always refer to updated safety procedures to EL-801 – Supervisor's Safety Handbook.

The safety aspects cannot be overstressed to personnel working around batteries. The electrolyte for the lead-acid battery is sulfuric acid and can be extremely hazardous to handle. In Gel cell or AGM the electrolyte is suspended in a gel or a fiberglass mat (AGM) and the batteries are sealed.

WARNING

Procedures within this handbook may expose employees to hazardous voltages. Before performing these types of procedures employees must don Electrical Work Plan (EWP) Personal Protective Equipment (PPE) in accordance with the current EWP MMO. Failure to comply may cause injury or death.

2.2.1 Acid Burns

NOTE

Supplies of neutralizing agents for first aid should be kept close at hand for immediate use.

Acid burns to the skin should be quickly flushed with water for at least 15 minutes and then a solution of sodium bicarbonate (baking soda) 1 Tsp to 8 oz water placed on the affected area or use pre-prepared solution designed for this purpose . The victim should then be sent to a doctor for medical attention.

2.2.2 Eyes

If electrolyte solution is splashed in the eyes, IMMEDIATELY flush for no less than forty-five minutes during which time the local Emergency Medical Services (EMS) must be called. DO NOT ADMINISTER ANY NEUTRALIZING SOLUTIONS TO THE EYES.

NOTE

First aid neutralizing agents for lead-acid batteries should be kept close at hand for immediate use. Also, suitable eye wash apparatus should be available in case of electrolyte being splashed into the eyes. If electrolyte solution is splashed in the eyes, DO NOT DELAY SEEKING MEDICAL TREATMENT.

Smoking or any open flame is not allowed in the battery charging room. Explosion proof flashlights must be used to inspect the height of the electrolyte if automatic filling devices are not used. The hydrogen generated during charging of lead-acid batteries can be very explosive. The battery room must be properly ventilated to prevent the build-up of hydrogen in the area.

NOTE

Appropriate signs must be posted to indicate no smoking, the requirement for personal protective equipment, and location of eye wash station, deluge shower equipment.

Properly designed and maintained lifting devices, (see MMO bulletin titled Preventive Maintenance Guidelines for Hoists) should be available for handling the heavy batteries. Care should be exercised in the handling of the large batteries because of the weight involved.

WARNING

Dropping one of these batteries could cause serious injury or death to battery shop personnel.

NOTE

Sulfuric acid or electrolyte solution should not be used by maintenance personnel to maintain flooded lead acid batteries. The only allowable additive to be used to adjust electrolyte levels is distilled or deionized water.

Never place a tool or other piece of metal on a battery. A dangerous short circuit may result. Also, for the same reason, do not wear watches, or jewelry when working with batteries.

2.3 BATTERY CARE

Keep the battery clean and dry, especially the top end of the terminals. These terminals must not become corroded. On lead-acid batteries, a thin coating of dialectric grease should be applied to the terminals. All vent plugs and caps must be kept tight during cleaning.

Maintain the electrolyte at the proper level by adding water at regular intervals. Do not overfill. The solution level will rise during charging when the battery "gasses", and the electrolyte will overflow unless the solution is kept at the level specified by the battery manufacturer. Care in maintaining the proper level will avoid the necessity of adding electrolyte and will help prevent the corrosion of battery tray and truck compartment. An automatic cell filler is recommended for use to prevent overfilling.

Dirt impurities in water affect the life and performance of batteries. In many locations local tap water can be used; however, distilled or de-ionized water is preferred. Reference should be made to manufacturer's data on their recommendations and warranty provisions concerning water that is used.

2.4 CHARGING PRECAUTIONS

The following precautions must be observed during charging in addition to those set forth above:

1. Assure adequate ventilation. The cover of the battery compartment must be raised to assist in the dissipation of heat. The electrolyte temperature should not exceed 115°F. Use forced ventilation to aid in maintaining temperatures. Local exhaust ventilation in the form of a hood, or general dilution ventilation of 2 cubic feet per minute per square foot of floor space is adequate.
2. Before turning on the charger, make sure the proper charger is connected to the battery, the charger is properly set for the particular battery and the battery electrolyte is at the proper level.
3. Do not disconnect the battery before powering down the charger.
4. The rectifier covers should always be on when equipment is in operation.
5. Adjustments or repairs should not be made without first disconnecting the charger from its power supply and the battery.
6. Charging plugs and receptacles should be properly locked and all other connections tightly secured.
7. Soldering or lead burning must not be performed in the charging area.
8. Never use alternating current for charging batteries directly.
9. Be careful about overcharging batteries. This can permanently damage the batteries.

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SECTION 3

LEAD-ACID BATTERIES

3.1 DESCRIPTION

This type battery has plates of lead and lead compound with a sulfuric acid solution as electrolyte. Specifically, the active material of the positive plate is lead peroxide and that of the negative plate is sponge lead. A lead antimony grid structure contains the active material in both the positive and negative plate and further carries the electric current from the active material to the plate straps and cell terminals. There are several types of cell design, but the two basic types in general use are the flat-pasted plate and the multi-tubular positive plate design. In both designs, plate groups are assembled permitting a compact assembly of the cells when grouped to make a battery achieve the desired voltage and ampere hour capacity.

3.2 GENERAL ADVANTAGES AND DISADVANTAGES

The main advantages of the lead-acid battery are their ampere-hour watt-burn efficiency, and relative long life. The life depends, as is the case for most type of batteries, on the type of construction, i.e., pasted, tubular, or plate, and on the severity of service, ranging from 3 to 15 years. Lead-acid batteries do not have the resistance to mechanical maltreatment. The cell containers are usually made of hard rubber and the grid material in the electrodes is a lead alloy. Of the lead-acid batteries, the tubular designed is preferred for applications in which mechanical shocks and vibrations are severe. The only way to test a maintenance free wet cell is by using a voltmeter and load test. Any of the maintenance free type batteries that have a built in hydrometer (black/green window) will show the condition of the cells. Consult manufacturer’s guide for testing and maintaining maintenance free or sealed batteries.

NOTE

If lead-acid batteries are stored in discharged state, sulfation can occur and result in deteriorated battery performance.

3.3 CHARACERISTICS

The lead-storage battery has many good characteristics making it popular for numerous applications. The nominal voltage being 2 volts per cell; thus a 36-volt battery requires 18 cells. The specific gravity changes in direct proportion to the electrical charge. As a result the charge can be determined readily with a hydrometer. Since the electrolyte reacts chemically during the charge-discharge cycle, its strength varies. Because of this the electrolyte can freeze during winter conditions if the battery is nearly discharged. In a gel cell or AGM the battery condition will be noted by a readout on the charger.

3.4 DISCHARGE CHARACTERISTIC

3.4.1 Voltage

The "open circuit" cell voltage of a lead-acid battery is 2.10 volts (for acid of 1.265 Sp. Gr.). The voltage is a function of the strength of the electrolyte used and this is true regardless of the cell size. On discharge, however, the voltage (average voltage per cell is 1.93 to 1.98) is influenced by the size of the cell as well as by the state of charge at the beginning of discharge, the rate of discharge, the electrolyte temperature and the design and construction of the battery.

3.4.2 State of Discharge

The state of discharge of a lead-acid battery can be accurately determined using a hydrometer and making corrections for deviations of the electrolyte temperature from the standard (26.7°C or 80°F). The temperature correction amounts to about 0.004 Specific Gravity, sometimes referred to as 4 "points" of "gravity" for each 10°F (5.5°C) change in temperature. At ordinary temperatures it is not usually necessary to make adjustments to the hydrometer readings, but at extreme temperatures the correction can be important. This correction is required because the acid volume expands due to the heat and will not be as dense. It will not raise the hydrometer float as high, and this will cause the reading to be low. When the acid is cooled, the acid shrinks in volume and becomes denser which causes the hydrometer to rise higher and read too high.

Some hydrometers have a small thermometer and a correction scale built into them so that the temperature correction can readily be made. If this type unit is not available, a battery thermometer should be used. It should be of the mercury-in-glass type, have a scale reading at least 125°F (51.7°C) and be designed for not over a 1-inch bulb immersion. Certain conditions often cause misinterpretation of the hydrometer readings. Gravity readings may be misleading if taken just after a battery has been discharged at a high rate. The high discharge rate weakens the acid in and adjacent to the plates, and until this weak acid has had time to mix with the remaining stronger acid in the cell, the reading taken at the top of the cell will indicate a higher state of charge than really exists. The acid mixes slowly and may take several hours before an accurate reading can be taken. Due to the nature of the chemical reaction on discharging, the battery becomes susceptible to damage by freezing. The electrolyte will start to freeze at temperatures indicated below in Table 3-1. The listed temperatures indicate the approximate points where ice crystals begin to appear in the solution and, will not freeze solid until a lower temperature is reached. Solid freezing can crack the container and damage the plates. It is best to keep the batteries at least 3/4 charged during winter weather.

Table 3-1. Specific Gravity

Specific Gravity	Freezing Temperature
(26.7°C)	Corrected to 80°F
1.265	-71.3°F (-57°4 C)
1.250	-62°F (-52.2°C)
1.200	-16 F° (-26.7°C)
1.150	+5°F (-15°C)
1.100	+19 F° (-7.2°C)

3.4.3 Rate Effects

High discharge rates affect the lead-acid batteries much more than the alkaline systems. There is a rapid fall-off of capacity on the lead-acid cells as soon as the current exceeds the 5 or 10-hour rate. This is caused by the limited time available for diffusion of the sulfuric acid and also by the increasing sulfation on the surface of the plates at higher rates.

3.4.4 Temperature Effects

As discussed earlier, the capacity of most batteries vary with the temperature; greater capacity at higher temperatures and lower capacity at lower temperatures. The operational life increases with an increase in temperature in the usual working range. Above 115°F (47°C) the negative plate limits the life because of capacity losses through sludge formation. The lead-acid battery can be harmed if the operating temperature is too high.

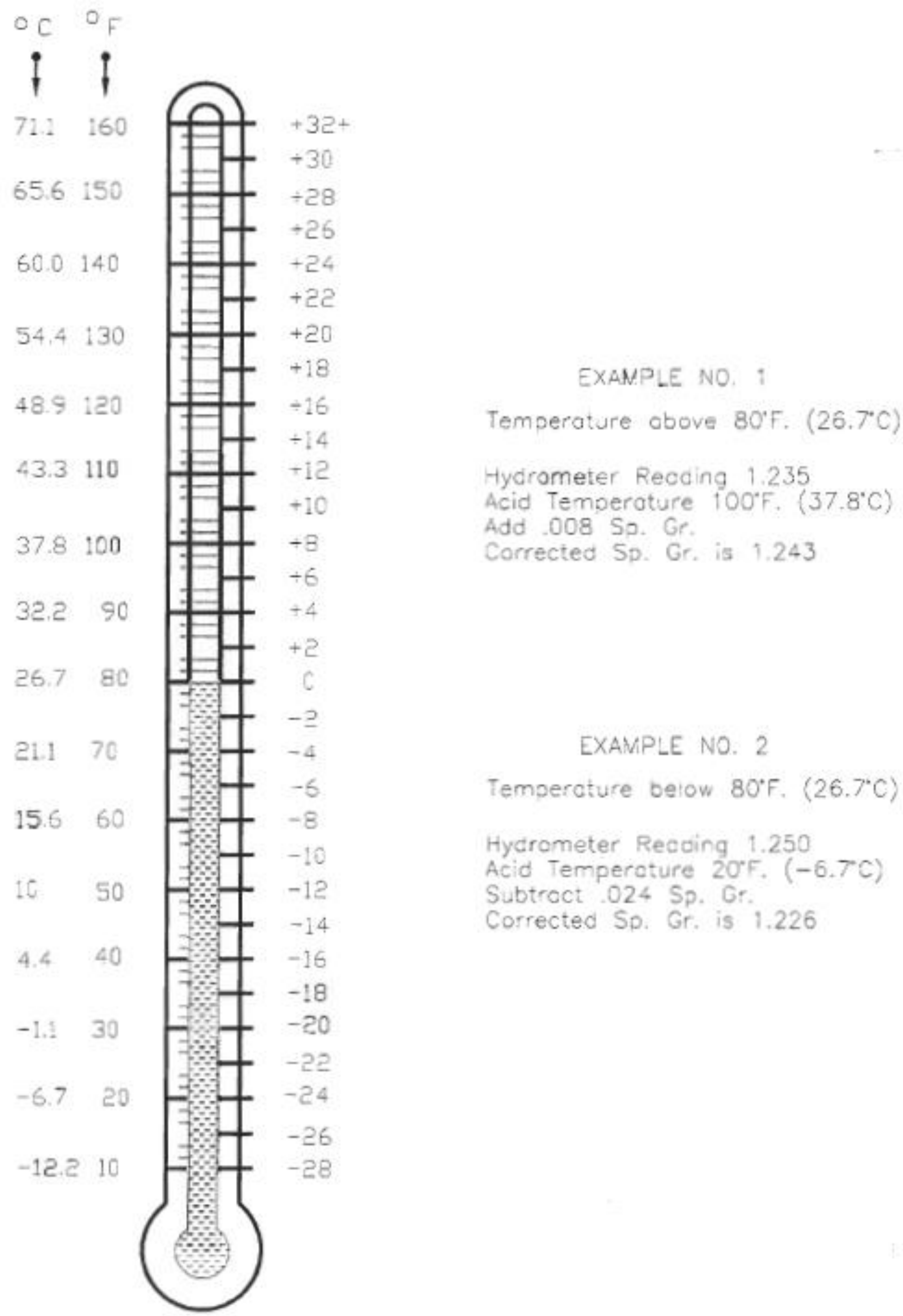

Figure 3-1. Temperature Effects

3.5 CHARGE CHARACTERISTICS

A lead-acid battery may be charged at any rate which does not allow the electrolyte temperature of any cell to exceed 115°F (47°C) or does not cause excessive loss of electrolyte. Where the battery is badly sulfated, it should be charged at a specified low rate. See Paragraph 3.6.4 on sulfated batteries. When the plates are fully discharged, the plates are heavily sulfated; that is, a large portion of each plate is converted to lead sulfate. Large electric current values can now be absorbed during recharging with little generation of heat or gas. However, as the charging progresses and the sulfate returns to the solution, the chemical action must be slowed down. If not, the water will decompose to hydrogen and oxygen, "gassing" will begin, and the electrolyte will begin to overheat, warping and shortening the life of the plates. When a battery is fully charged, any further charging, however small, will produce gassing. When completing a charge, the rate may be reduced to such a low value that the small amount of gassing which results is harmless. This low, safe rate is called the "finishing" rate.

WARNING

The gases coming from a charging battery are a mixture of hydrogen and oxygen, and will explode if a spark or flame is brought too near them. When they explode, they usually spray out the acid in the cells possibly getting in the eyes of personnel in the immediate area. To help prevent these gases from building up, the room or area in which batteries are being charged should be well ventilated. In order to avoid sparks, do not disturb connections to the batteries while they are being charged; first turn the charger switch off. Small quantities of hydrogen gas can be given off at the negative plate even when the cells are not being charged, so care should be exercised at all times. Care should also be taken to avoid ignition of hydrogen gas by static electricity. If acid should contact eyes, skin, or clothing, flush immediately with large amounts of water. In case of eye contact, see a physician immediately.

3.6 CHARGING

3.6.1 Charging Rate

A lead-acid battery requires a high starting rate of charging: 3 to 4-1/2 times the finishing rate. As a rule, the finishing rate is 6 amperes per 100 ampere-hour capacity so the starting rate is, therefore, 18 to 27 amperes per 100 ampere-hour capacity. For correct charging the starting rate must taper to the finishing rate as the battery approaches full charge, with either a gradual tapering or a sharp reduction in rate at a specified voltage. It is important that the reduction to a finishing rate be accomplished automatically, eliminating human errors. Proper charging requires returning the proper number of ampere-hours to the battery without excessive gassing, overcharging or raising the electrolyte temperature to above 115°F (47°C). Batteries are usually recharged in 8 hours, however, a longer time period can be used at a lower charge rate.

3.6.2 Methods of Charging

3.6.2.1 Constant Potential Charging

This type of charge begins at a high rate and as the battery voltage builds up the charge rate tapers to a lower value depending on the design of the charger and the condition of the battery. Batteries that are in good condition are not harmed by this type of charging, but badly sulfated batteries may not come up to a full charge on this type of charge. Temperature of the battery may rise very quickly and it should be watched carefully.

3.6.2.2 Constant Current Charging

This method of charging is the established method where the internal cell condition is not known and where a diagnosis of the trouble is being made. As with other types of charging, the electrolyte temperature should be watched. The battery will start to gas as it approaches full charge. When this is observed, hydrometer readings should be made and when the specific gravity ceases to rise for three successive hourly made readings the battery is considered fully charged. Overcharging causes decomposition of water and deterioration of positive plate grids.

3.6.2.3 High-Rate Fast Charging

The fast or booster charge is made only when it is not possible or practical to give the battery a routine charge. It should be done only to prevent over discharge of the battery. The booster charge is of high rate and short duration. They are usually made when necessary during a lull in the work cycle of the equipment, during lunch time or between shifts, for instance. As with the other type charges, watch the battery temperature carefully.

3.6.2.4 Equalizing Charge

In normal service, a lead-acid battery should receive an equalizing charge twice a month to assure that maximum capacity is available when needed. An equalizing charge should restore all cells in the battery to a fully charged condition. If the battery requires less than one charge a week, every third charge should be an equalizing charge. To give a battery an equaling charge after the route charge, continue the charge at the finishing rate, until the specific gravity of all cells stops increasing for a period of 2 hours. This will normally take from 3 to 4 hours. In cases where the battery has been out of service for a long period, continue the equalizing charge until all cells are gassing freely and until 4 consecutive hourly specific gravity readings show no further increase.

3.6.3 Pilot Cell

In a normal battery, individual cells are uniform and approximately alike. Under normal operation, it is not necessary to record or observe the specific gravity of each cell when checking them daily or weekly. Select one cell as a "pilot cell", and check its specific gravity, assuming that the other cells of the battery are equal to it. As a precaution select a different cell from time to time as your pilot cell. At the end of a regular charge, observe the specific gravity of the pilot cell. If this value is approximately 10 points below that obtained from the equalizing charge and the charge is completed in an 8-hour period, it is satisfactory. The end of the charge rate, however, should not be higher than the published finishing rate for the battery; if it is no more than 30 percent below the published finishing rate, it is satisfactory.

3.6.4 Sulfated Batteries

3.6.4.1 Lead Sulfate Formation

When a battery is not charged properly or is left standing in a discharged condition, an abnormal amount of lead sulfate is formed on the plates and closes the pores of the plates. When this occurs, the chemical reactions within the battery are reduced and a loss of capacity results. The cells in a sulfated battery give low voltage and specific gravity readings and the battery will not become fully charged after normal charging.

3.6.4.2 Causes of Sulfation

- Undercharging or not performing an equalizing charge periodically.
- Remaining in a partially or complete discharged condition. Batteries should be recharged as soon as possible after discharge and no battery should be allowed to stand in discharged condition for more than 24 hours (or when temperatures are below freezing because of the freeze damage hazard).
- Low electrolyte level. This allows the plates to become exposed to air, allowing the sulfate to harden.

NOTE

It is very difficult to determine when sulfation begins in a battery. It can be detected in the early stages by performing periodic equalizing charges and comparing specific gravity and voltage readings.

- High specific gravity. Usually, the higher specific gravity of a fully charged cell, the greater is the possibility of sulfation. Cells having a specific gravity of more than 0.015 above average are likely to incur sulfation.
- High temperatures. High temperatures increase the rate of sulfation, especially in an idle, partially discharged battery.

3.6.4.3 Treatment of Sulfated Batteries

Since there is such a variation in the types of batteries each cannot be discussed in detail in this manual. The manufacturer's maintenance manual should be followed and referenced for detailed instructions for the handling of sulfated batteries. The below listed procedure is a general guideline for a flooded wet cell battery.

1. Clean the battery.
2. Bring the electrolyte up to the proper level by adding water.
3. Charge the battery at the designated finishing rate until the full ampere-hour capacity has been put into the battery based on the six hour rate. If a cell voltage drops 0.20 volts or more than the average cell voltage it should be removed/repaired. Watch the electrolyte temperature and reduce the charge if it rises above 110°F (43°C).
4. Continue to charge the battery at the finishing rate (after completion of the full ampere-hour capacity charge) until the specific gravity shows no charge over a four-hour period (readings taken hourly). Make a record of the corrected specific gravity and voltage readings.
5. Test procedure to follow:

a. Conduct a test discharge and record time the test is started.

b. At specified intervals, individual cell voltages and overall battery voltage are recorded. The first readings are taken at 15 minutes after starting test and then at each hour (from starting time) until voltage of any one cell reaches 1.75 volts (termination voltage is 1.70 volts). At this time start taking voltage readings at 15 minute intervals.

c. Make a record of the time when each cell voltage goes below the termination value.

d. Stop the discharge when most of the cells reach termination voltage but before any single cell goes into reversal.

e. As soon as the discharge test is completed, record the specific gravity of each cell. These readings will show if the cells are uniform or that one or more cells are low in capacity. If the specific gravity is uniform and delivers 80 percent or more of its rated capacity, return the battery to service (after normal recharging).

f. If the battery doesn't deliver 80 percent of its rated capacity, continue the discharge (without adjusting the discharge rate) until one or more cells reach 1.0 volt.

g. Recharge the battery again as per paragraph 4.

h. Discharge again as per paragraph 5a to 5f. If the battery reads at least 80 percent capacity, recharge and put it back into service. If it does not, repeat recharging and test procedures.

i. Upon failing the discharge test the third time the battery is sulfated to the point that no further action is warranted and it should be replaced.

3.7 SERVICING

3.7.1 Adding Water

Consult the battery manufacturer's instruction and see that the proper level of electrolyte is maintained in battery cells by the addition of distilled or approved water. Inspect the solution level of each cell; if one cell has a consistently lower level than others, examine this cell for leakage. Normally, the cell level will be about the same for all cells. Use gravity battery filler or preferably the battery manufacturer’s recommended filler of the particular battery. Never add water during or immediately after charging; add water before charging only and be sure that too much water is not added.

Normally, a battery will remain clean and dry on top. If the top of the battery is wet shortly after it is charged, it indicates that too much water has been added, resulting in slight overflowing of cells during charge.

3.7.2 Measuring Specific Gravity

A specific gravity reading of all cells should be taken at least twice a year, after a thorough equalizing charge. The readings should be recorded. The gravity reading should be corrected for the temperature of electrolyte as shown in Paragraph 3.4.2. This correction can be made conveniently with a lead-acid battery thermometer which includes a correction scale along the side of the temperature scale. The state of charge is directly indicated by the specific gravity reading. The gravity readings often indicate early troubles that can be corrected before becoming serious. Low gravity in one cell indicates a leaky container, faulty cell, or clogged vent. If this low reading is accompanied by a low voltage, internal trouble is indicated. Usually, low gravity of all cells indicates the need for an equalizing charge. If both the voltage and specific gravity fail to respond to an equalizing charge, the battery should be examined more thoroughly and possibly replaced.

3.7.3 Adjusting Specific Gravity

Under normal operation it seldom is necessary to adjust the fully charged specific gravity of the lead-acid battery. Do not be misled by a cracked hydrometer float giving a low reading. Check low readings several times to be certain the hydrometer is in good condition. Making adjustments should be done only upon the specifications of the battery manufacturer.

3.7.4 Raising Specific Gravity

If it becomes necessary to raise specific gravity by adding sulfuric acid contact the battery manufacturer for servicing.

3.7.5 Electrolyte

In the rare event that electrolyte solution is required to raise the specific gravity, the local Safety Office must be consulted and all current OSHA and environmental regulations must be strictly adhered to. Only a certified person may perform this task.

NOTE

If battery is accidentally turned over and electrolyte is lost, proceed as follows: the HAZMAT Spill response team, environmental coordinator, and facility safety must be immediately notified. All cleanup and disposal must be done in accordance with current environmental and safety guidelines as noted on USPS Sustainability Group's Environmental Compliance Bulletin (ECB) web page.

3.7.6 Lowering Specific Gravity

Keep the specific gravity of a fully charged battery as close as possible at 1.265 to 1.280; 1.310 is the highest specific gravity allowed before taking steps required to lower it. This high value of 1.310 should only be observed when the electrolyte levels are at their lowest point, which is about the top of the separators. To lower the specific gravity, remove some of the electrolyte and replace it with distilled water. Ensure electrolyte solution is dispososed in accordance with all EPA and local regulations. Normally, one-eighth inch of electrolyte replaced by distilled water will lower the specific gravity 3 to 5 points.

3.7.7 Periodic Maintenace

Refer to the current MMO Guidelines for Creating Detailed Local Building and Building Equipment Maintenance Preventive Maintenance Checklists.

3.8 STORAGE

Store lead-acid batteries for limited periods of time under 4 months charged and wet. Before storing, check electrolyte levels and give the battery an equalizing charge. When possible, it is advisable to keep the room cool although temperatures below 25°F (-2°C) are not recommended. When possible, give the battery an equalizing charge once a month during the period of storage. Prior to placing the battery back in active service, give it a thorough equalizing charge.

If special charging equipment has been provided to maintain the batteries by the trickle charge method, adjust the trickle charge rate so that 2.22 volts per cell are maintained continuously during period of storage. Check the electrolyte level at monthly intervals and add water to the cells as required to maintain the level above top of separator.

SECTION 4

GEL CELL AND AGM BATTERIES

4.1 DESCRIPTION

The Absorbed Glass Mat (AGM) construction allows the electrolyte to be suspended in close proximity with the plates active material. This enhances both the discharge and recharge efficiency. Common manufacturer applications include high performance engine starting, power sports, deep cycle, solar and storage battery. The larger AGM batteries are typically good deep cycle batteries and they deliver their best life performance if recharged before allowed to drop below the 50% discharge rate. Deep Cycle AGM batteries made before approximately 2005 must be discharged to a rate of at least 60% to achieve 300 or more cycles. Newer AGM batteries have been developed that last approximately 8 years and resist the negative consequences of battery memory effect.

The Gel Cell is similar to the AGM style because the electrolyte is suspended, but different because technically the AGM battery is still considered to be a wet cell. In a Gel Cell, the electrolyte is suspended. The electrolyte in a Gel Cell has a silica additive that causes it to set up or stiffen. The recharge voltage on this type of cell is lower than the other styles of lead acid battery. This is probably the most sensitive cell in terms of adverse reactions to over-voltage charging. Gel Batteries are best used in very deep cycle application and may last a bit longer in hot weather applications. If an incompatable battery charger is used on a Gel Cell battery poor performance and premature failure may occur.

4.2 GENERAL ADVANTAGES AND DISADVANTAGES

In AGM sealed batteries, the acid is absorbed between the plates and immobilized by a very fine fiberglass mat. No silica gel is necessary. This glass mat absorbs and immobilizes the acid while still keeping the acid available to the plates. This allows a fast reaction between acid and plate material. The AGM battery has an extremely low internal electrical resistance. This, combined with faster acid migration, allows the AGM batteries to deliver and absorb higher rates of amperage than other sealed batteries during discharging and charging. In addition, AGM technology batteries can be charged at normal lead-acid regulated charging voltages, therefore, it may not be necessary depending on the manafucture’s design to recalibrate charging systems or purchase special chargers.

The Gel Cell and the AGM batteries are specialty batteries that typically cost substantially more than a premium wet cell; however they are safer and can offer a lower Total Cost of Ownnership (TCO). They store well and do not tend to sulfate quite as fast as wet cell. Most Gel Cell and some AGM batteries require special charging rate, especially the deep cycle models.

The Gel Cell and AGM batteries are maintenance free. Since the battery system is designed to eliminate the emission of gases, the volume of free electrolyte (battery acid) that could be released is very small. Therefore there is no need to check the level of the electrolyte or top off water lost due to electrolysis. They are leak-proof and will not leak even if the container is cracked or broken. In these sealed lead-acid batteries, a glass-mat separator absorbs the electrolyte and holds it between the lead plates. Since the acid electrolyte is held by the absorbent mat, the battery will not leak or spill. They can operate in a variety of temperatures from very low to very high (between -40°F to 140°F) and may last a bit longer in hot weather applications than other batteries. Since minimal off gases are produced charging can be performed outside of a dedicated battery room in a well ventilated area. Additionally, these batteries can also be used in places where water for wet cells batteries may not be available.

4.3 CHARACTERISTICS

Gel cell batteries are low maintenance as the electrolyte does not have to be checked and they are leak proof. They also allow charging in poorly ventilated areas. There is very little chance of acid spills or leakage even when the case has been damaged.

4.4 CHARGE CHARACTERISTICS

A battery charger specifically designed for a Gel Cell or AGM Battery must be used. When the battery is charged inappropriately, such as in the case of flooding with a charge rather than slowly charging the battery, it can rupture or break apart. This is caused by a buildup of gases, which increase and eventually break through the case that seals the gel material inside the battery.

4.5 STORAGE

Before storing, give the battery an equalizing charge. When possible, it is advisable to keep the room cool although temperatures below 25°F are not recommended. When possible, give the battery an equalizing charge once a month during the period of storage. Prior to placing the battery back in active service, give it a thorough equalizing charge.

SECTION 5

CHARGERS

5.1 TYPES OF CHARGERS

GEL CELL and AGM must be attached to the correct charger otherwise battery damage may occur. Since there is such a variation in the equipment each cannot be discussed in detail in this manual. The manufacturer's maintenance manual should be followed and referenced for detailed instructions on trouble shooting and adjustments. If the equipment cannot be properly adjusted by "in-house" personnel because of a lack of tools or instruments, the battery or charger manufacturer representative should be contacted. The charging equipment must be of proper design and calibrated properly for the batteries being charged. Improper charging can affect battery life and increase costs. Proper maintenance should be performed on the chargers to keep them in good operating condition.

5.2 CYCLE CHARGING

5.2.1 Method of Charging

The cycle-charging system is used for batteries on traction duty, charging partially or completely discharged batteries. Most cycle-charging units are designed to charge an individual battery. Sometimes a "sequence control" is added to enable the charging of two batteries, one after another, without manual attention. Often when large numbers of batteries are in use, a multi-circuit charging system is installed with a large generator providing power to individual charging panels. In the multi-circuit system, the rectifier provides a constant DC voltage on the bus throughout its load range.

Each battery is connected to this bus through a ballast resistor of such size that the current throughout the charge is sufficiently close to the average value. Individual chargers are designed to deliver a nominally constant charging rate. A small reduction in current occurs during the charge, starting 20 to 25 percent above the average value and finishing about the same amount below.

5.2.2 Termination of Charge

Charging can be terminated automatically by one of the following methods, depending on the types of cell used and the charging equipment available. The use of ‘smart chargers’ will eliminate the need for the following charger instructions.

This method employs a sensitive voltage relay and a time switch. During the charging process there will be a gradual rise in battery voltage that can be sensed by the voltage relay. The value represents a certain state of charge. The relay starts the time switch which is preset to run a specified time and then stop the charge. Since the voltage of a battery on charge is affected by temperature, the relay must be temperature compensated to correspond with the characteristic of the battery.

5.2.2.1 Time Switch

A time switch is set for the total charging time required by the amount of discharge.

5.2.2.2 Ampere-hour Meter

The meter is connected in the battery circuit at all times. When the battery is charged, the meter indicators reverse their direction of movement. The meter can be designed to stop the charge when it comes fully charged.

5.3 OPPORTUNITY CHARGING

Innovations in battery technology currently allow for opportunity charging. Equipment such as Automated Guided Vehicles (AGV's) can be directed to opportunity charging stations when not being utilized to move Mail containers. There are also batteries available for Powered Industrial Vehicles (PIV's) which can be opportunity charged during idle periods such as operator lunches or breaks. These batteries may be charged on the workroom floor and can minimize or eliminate the need for a dedicated battery room. This technology also can reduce the time required for charging and changing industrial storage batteries while maintaining optiminal performance of PIV's. Lead Acid Batteries do not support opportunity charging. Updated information on these new technologies and batteries is available in the AS-503 Standard Design Criteria and EBUY website.

5.4 BATTERY SHOP EQUIPMENT

Besides the battery chargers, the hydrometer and the thermometer are two of the most important pieces of equipment in the battery shop. Both instruments should be handled properly to minimize damage and should be kept clean and dry. Occasionally, the hydrometers should be taken apart and the float and inside of the barrel cleaned. The cabling, receptacles, and plugs of the charging equipment should be kept clean and in good repair. This electrical equipment should not be used if damaged or badly worn.

Proper ventilation must be maintained at all times in the battery charging room. Use forced ventilation to aid in maintaining temperatures in accordance with ASHRAE 62 as noted in *MS-49*. Vents must be kept clean and unblocked. Sail switches should shut down all chargers when air flow is deficient.

5.4.1 Battery Shop Maintenance

- Acid Neutralization Pit: Reference the current Acid Pit, Grease Trap, and Oil/Water Separator Maintenance MMO for maintenance requirements and procedures.
- Battery Hoist: Reference the current Hoist Preventive Maintenace MMO for maintenance requirements and procedures.
- Battery and charger racks should be inspected and cleaned as needed. The rollers should move freely to facilitate battery handling.

APPENDIX A

STATE OF CHARGE AND SPECIFIC GRAVITY READING

Table A-1. Specific Gravity

Specific Gravity	State of Charge
1.280	108%
1.270	94%
1.260	87%
1.250	80%
1.240	73%
1.230	67%
1.220	60%
1.210	53%
1.200	47%
1.190	40%
1.180	33%
1.170	27%
1.160	20%
1.150	13%
1.140	7%
1.130 and below	0%