



**INDUSTRIAL BATTERY**  
**Service Manual**

*Operation and maintenance  
for motive power batteries*



[www.dekabatteries.com](http://www.dekabatteries.com)

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## INTRODUCTION

Storage batteries do not store electrical energy, but convert electrical energy into chemical energy which is slowly accumulated as the charge progresses. A battery in use is said to be on discharge. During discharge, the chemical energy stored in the battery is converted into usable electrical energy.

A lead-acid motive power battery supplies direct current (DC) power to electric lift trucks, tractors and pallet trucks. This type of battery consists of a metal tray containing cells, connected in series. These batteries come in a wide variety of shapes, sizes, voltages and ampere-hour capacities.

Each cell in a motive power battery contains positive and negative plates. All of the positive plates are joined in parallel to the positive post and strap, to form a positive group. The negative plates also are joined in parallel to the negative post and strap to form a negative group. These groups are separated and insulated from one another and they are immersed in a solution of sulfuric acid and water, called electrolyte. These groups of plates, separators, posts and straps are called an element and it is contained in an acid-proof plastic jar.

The cutaway illustration (Fig. A-1) shows the construction of an East Penn battery cell. Each positive plate consists of a lead-alloy grid structure which is filled with a paste of active material, made from lead oxide. The active material is forced into the positive grid structure during manufacturing and is held firmly to the grid by a system of vertical and horizontal glass fiber mats, which reinforce and insulate the positive plate. A retainer and bottom shield encase each positive plate and mat assembly to help prevent short circuits.

The negative plate also consists of a lead alloy grid structure that is filled with active material. But because negative plates undergo much less active material shedding, no reinforcing glass fiber mats are needed. Separators provide insulation between the positive and negative plates. The positive and negative plates are connected to their respective posts by positive and negative straps.

A more detailed description of battery construction appears in Section I.

Manufactured using the world's most modern computer integrated manufacturing techniques...

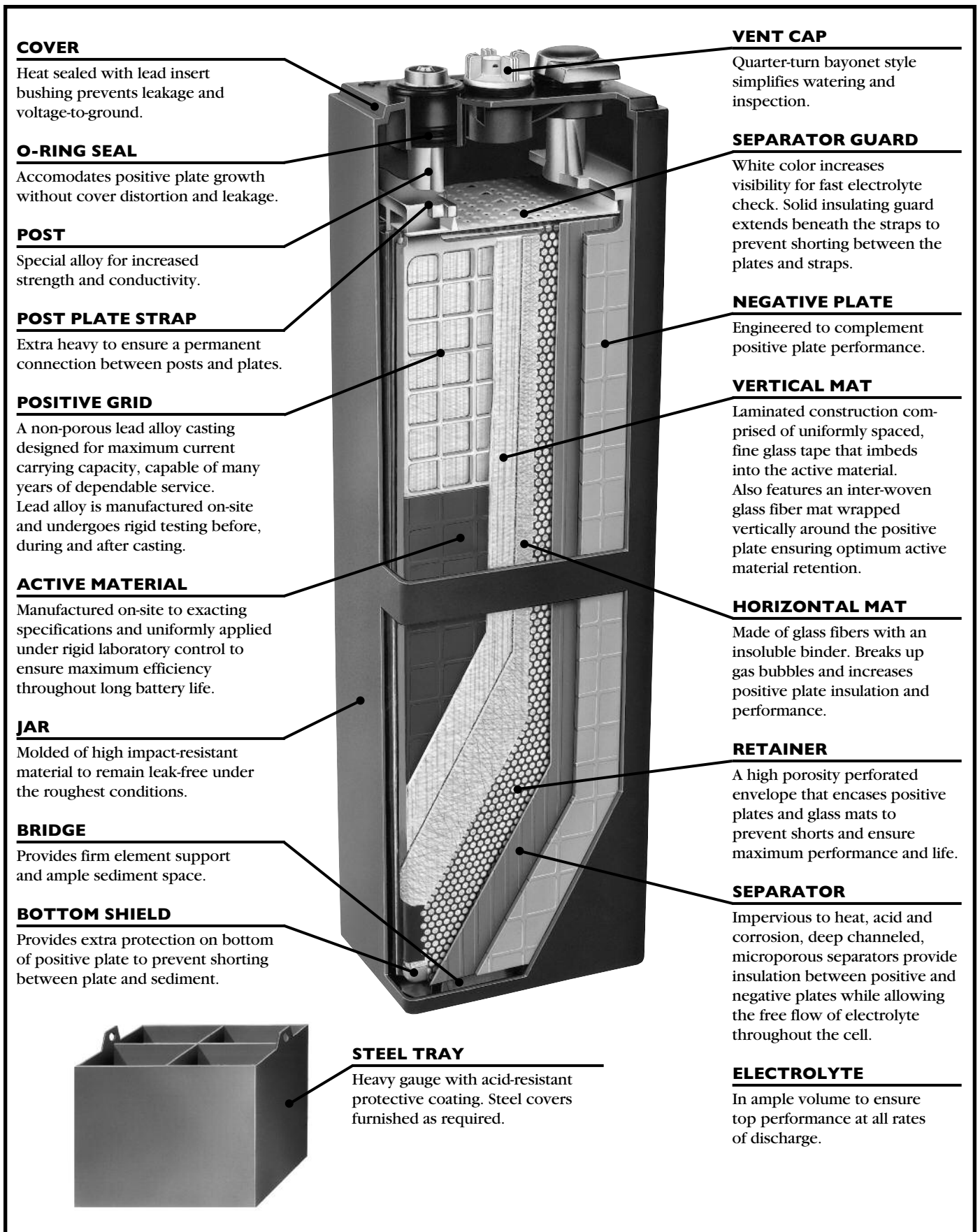


Fig. A-1

# SECTION I - THEORY OF OPERATION/BATTERY CONSTRUCTION OF LEAD ACID STORAGE BATTERIES

## Theory of Operation

### Discharging/Recharging Characteristics

In a fully charged condition the active material in the positive plate is lead peroxide ( $PbO_2$ ) and the active material in the negative plates is sponge lead ( $Pb$ ). The electrolyte has maximum sulfuric acid content and its temperature corrected specific gravity ranges should comply with the manufacturer's recommended full charge specific gravity specifications (See Table 1-1 ). (See Table 3-1 - shown on page 14 - Specific Gravity Temperature Corrections).

Battery Type	Recommended Specific Gravity Range @ 77°F/25°C
Standard "D" Series	1.280 - 1.295
Maintenance Saver "M" Series	1.245 - 1.255
Max Powr "P" Series	1.320 - 1.330
Diesel Starting "DL/DLU" Series	1.245 - 1.255
Hydra Saver "H" Series	1.295 - 1.305

Table 1-1

When fully charged, each cell has a voltage of approximately two (2) volts on open circuit. However, a cell may have a voltage from 2.12 to 2.70 volts while being charged. A cell develops a voltage potential when two dissimilar metals are immersed in a suitable electrolyte. The two metals used in lead-acid cells are lead peroxide ( $PbO_2$ ) and sponge lead ( $Pb$ ), and the electrolyte is dilute sulfuric acid ( $H_2SO_4$ ). This combination of dissimilar metals and electrolyte results in a voltage potential of nominally two (2) volts per cell and their potential ability to deliver this voltage under varying load and for varying periods of time.

When a battery is discharged, the internal components of each cell undergo chemical changes (Figure I-1). During the discharge cycle, the composition of the positive plates changes from lead peroxide ( $PbO_2$ ) to lead sulfate ( $PbSO_4$ ) and the negative plates from sponge lead ( $Pb$ ) to lead sulfate ( $PbSO_4$ ). The sulfate on both the positive and negative plates comes from the sulfuric acid in the electrolyte solution combining chemically with the active material of the plates. This chemical reaction reduces the sulfuric acid content in the electrolyte. The specific gravity of the electrolyte is reduced and approaches that of water (1.100). Cell voltage decreases during the discharge because the two (2) dissimilar metals ( $PbO_2$ ) and ( $Pb$ ) are becoming more similar ( $PbSO_4$ ).

During charging, the discharging reaction is reversed and the chemical energy is restored. The lead sulfate on the positive plates converts back to lead peroxide ( $PbO_2$ ) and the lead sulfate on the negative plates converts back to sponge lead ( $Pb$ ). The released sulfate returns to the electrolyte solution, increasing the sulfuric acid content, which in turn increases the specific gravity. When these electrochemical reactions are complete, the cell is again fully charged.

During charging, hydrogen gas is formed on the negative plates and oxygen is formed on the positive plates. This explosive gas mixture is vented from the battery through the vent/filler caps. THE WARNINGS (SHOWN ON PAGE 5) APPLY TO ALL CELLS OR BATTERIES.

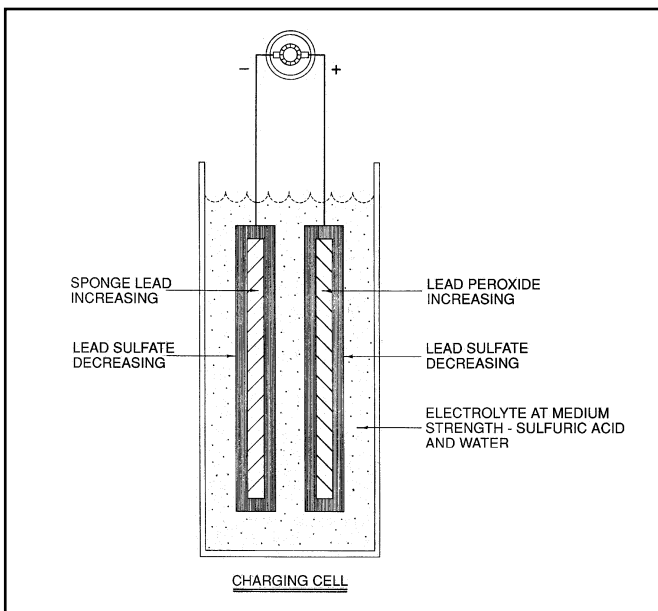
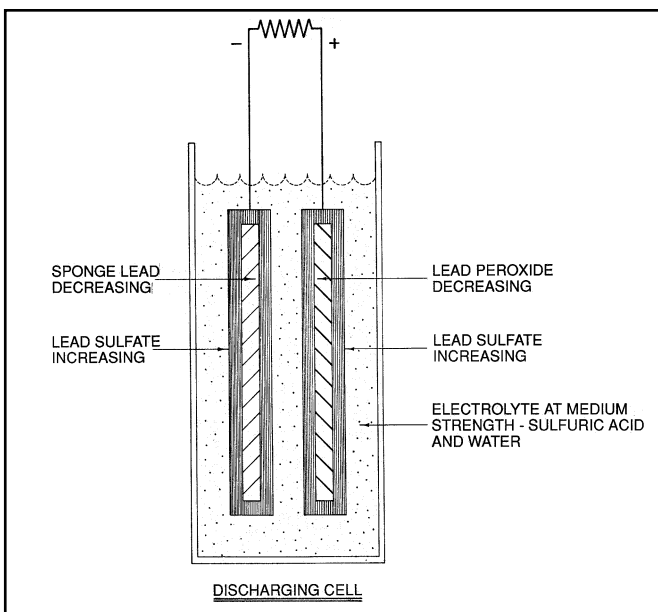


Fig. I-1

### Battery Ratings

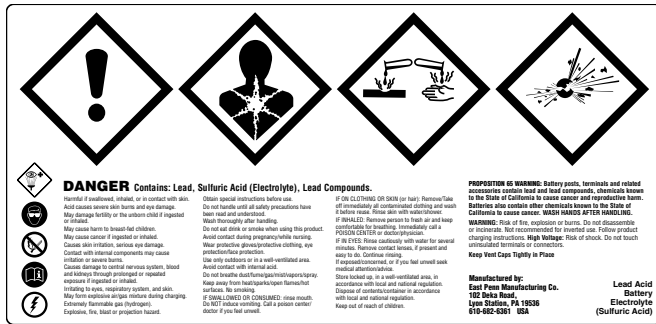
A single lead-acid cell does not have sufficient power to handle most requirements. However connecting a number of cells together in series results in a battery capable of supplying higher power demands.

### Battery Voltage

The number of cells is determined by the required nominal operating voltage of the equipment. Since each cell has a nominal voltage of two (2) volts, a 36 volt industrial truck will require an 18-cell battery (18 cells x 2 volts/cell = 36 volts).

# SECTION I - THEORY OF OPERATION/BATTERY CONSTRUCTION OF LEAD ACID STORAGE BATTERIES (cont.)

## Danger



See P.23 for full warranty information.

**HYDROGEN GAS FROM THE BATTERY OR CELL CAN EXPLODE. DO NOT SMOKE, USE AN OPEN FLAME, OR CREATE AN ARC OR SPARKS IN THE VICINITY OF INDIVIDUAL CELLS OR BATTERIES. VENTILATE WELL WHEN IN AN ENCLOSED SPACE AND WHEN CHARGING.**

**THIS BATTERY OR INDIVIDUAL CELL CONTAINS SULFURIC ACID WHICH CAUSES SEVERE BURNS. DO NOT GET IN EYES, ON SKIN OR ON CLOTHING. IN CASE OF CONTACT, FLUSH IMMEDIATELY WITH CLEAN WATER. OBTAIN MEDICAL ATTENTION IF EYES ARE AFFECTED.**

**PERSONAL SAFETY EQUIPMENT IS RECOMMENDED WHEN WORKING WITH BATTERIES AND SHOULD BE USED IN ACCORDANCE WITH LOCAL REQUIREMENTS; SAFETY GLASSES, GOGGLES OR A FACE SHIELD. RUBBER OR PLASTIC GLOVES AND A RUBBER OR PLASTIC APRON ARE ITEMS OFTEN USED IN THIS TYPE OF WORK. EQUIPMENT WHICH WILL PROTECT THE EYES FROM ACID SPLASHES IS THE MOST IMPORTANT SINCE THE EYES CAN BE SERIOUSLY AFFECTED IN A VERY SHORT TIME.**

## Ampere Hour (AH)

The electrical capability of a storage battery is usually expressed in ampere-hours. The ampere-hour capacity is the number of ampere-hours which can be delivered under specified conditions of temperature, rate of discharge, and final voltage. Basically, ampere-hours are determined by multiplying the number of amperes which the battery will deliver by the number of hours during which the current is flowing. Example: 100 amperes x 6 hours to 1.70 volts per cell = 600 ampere-hours (six hour rate). The size and number of plates which make up the element then determine total cell or battery capacity. Due to the variety of job requirements batteries are produced with many different sizes of cells.

## Kilowatt Hours (KWH)

Battery capacity is also expressed in kilowatt-hours (KWH), which is the product of ampere x time x average volts per cell during discharge. Example: 100 amps x 6 hours x 1.930 average volts per cell = 1,158 watt hours ÷ 1000 = 1.158 KWH. For an 18-cell battery, the capacity would be 1.158 x 18 = 20.84 KWH. Increasing or decreasing the size of the cells or the number of cells in the battery can vary the kilowatt-hour rating.

## Positive Plate Capacity

Positive plate capacity is the ampere delivery for a fixed period of time (usually six hours) for a particular size positive plate. A Deka D100 type positive plate has the capability of delivering 16.66 amperes for six hours or 100 ampere hours (16.66 x 6 = 100 AH) to a final voltage of 1.70. Increasing or decreasing the number of positive plates in the cell can vary this ampere-hour rating or capacity. In the previous examples, the battery is an 18-cell, D100-13 plate unit. To determine the number of positive plates in each cell, subtract one from the total number of plates in the cell and divide by two. Example:  $13 - 1 = 12 \div 2 = 6$  positive plates per cell; 6 positive plates x 100 ampere-hours each = 600 AH. The use of a different type of positive plate, such as a D75 or D125, will respectively decrease or increase the ampere-hour capacity. The above ratings are based on an electrolyte temperature of 77°F/25°C with a full charge specific gravity at battery nameplate rating.

## Specific Gravity

The term *specific gravity* describes the ratio of the density of electrolyte to the density of water. Electrolyte weighing 1.2 times as much as the same volume of water has a specific gravity of 1.200. The full charge specific gravity of a cell is a matter of design and depends on several factors. The specific gravity must be high enough to contain the amount of sulfuric acid necessary to meet the chemical needs of a cell. If the sulfuric acid content is too high, damage may result to the cell. Since the acid content of the electrolyte decreases linearly as the cell is discharged, the decrease in specific gravity is directly proportionate to the amount of ampere-hours removed (refer to Table 3-2, page 15).

The specific gravity at any point in the discharge indicates the depth of discharge and can be translated into ampere-hours removed. A cell having a full charge specific gravity of 1.290 and a final specific gravity of 1.140 will have a specific gravity drop of 150 points. Example: Assume the specific gravity is 1.190 at the end of the discharge. That is 100 points specific gravity below the full charge gravity; therefore,  $\frac{100}{150} = 67\%$  discharged of rated capacity. Allow at least one hour after end of discharge for the electrolyte to diffuse and give a true reading corrected to 77°F/25°C.

The linear relation of specific gravity to state of discharge can be used in tests to determine power consumption or capacity required. Tests of this kind can be made to demonstrate that a lift truck may require a larger capacity battery to do the job, and can lead to the solution of a problem.

## Specific Gravity During Recharge

The rise in specific gravity during recharge is not uniform or proportional to the amount charge returned in ampere-hours. During the early part of the charge, there is no gassing action to mix the electrolyte with the heavier acid being released from the plates. The heavier sulfuric acid will lay on the bottom. A hydrometer reading which draws electrolyte from the top of the cell does not indicate the true specific gravity or actual state of charge. During the gassing portion of the charge, the sulfuric acid mixes, and the specific gravity rises rapidly to full charge value.

## SECTION I - THEORY OF OPERATION/BATTERY CONSTRUCTION OF LEAD ACID STORAGE BATTERIES (cont.)

### Battery Construction

#### Grid Casting - Positive and Negative Grids

A plate consists of a cast lead-alloy grid structure into which lead oxide pastes are applied. Since lead by itself would be too soft and flexible to make a grid, a certain amount of antimony is added to the grid to prevent it from sagging or warping. The grids are then cast by pouring the molten alloy into grid molds.

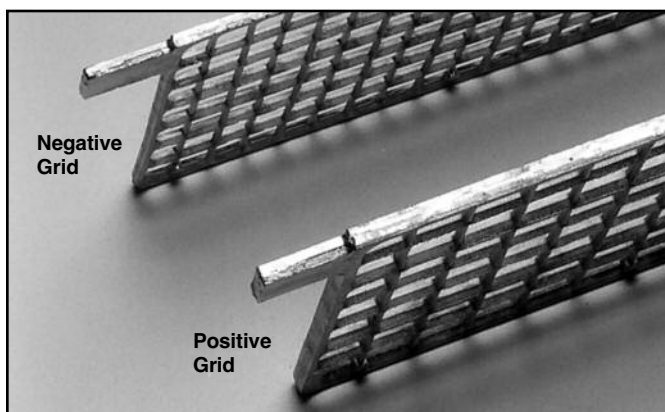


Fig. I-2

Due to the increased amount of chemical activity that takes place on the positive grids during charging and discharging, positive grids are more heavily constructed than negative grids (Fig. I-2).

#### Apply Active Material

After the grids have been cast, the lead oxide pastes are applied. The lead oxide applied to the negative grid contains an expander to produce sponge lead. The positive plate contains a putty-like mixture of lead, lead oxide, lead sulfate and water. Because proper pasting is critical to battery performance, East Penn uses highly sophisticated, computer-controlled pasting machines to consistently apply paste to exact thicknesses and weight.

#### Curing and Drying

After the plates are pasted, they must be cured and dried in a rigidly controlled environment. This securely binds the active material to the grid and produces a smooth, uniform plate. The active material, now highly porous, allows the electrolyte to penetrate freely so it can produce maximum conductivity between the paste and the grid for high cell efficiency. Because the curing and drying process is so important to cell efficiency and battery life, East Penn has invested in humidity and temperature-controlled curing ovens (Fig. I-3), which produce the highest quality plates in the industry.

#### Plate Formation

The cured plates must now undergo a formation charge, which transforms the previously inert material on the positive plates into lead peroxide and the material on the negative plates into sponge lead. The plates are lowered into a forming tank filled with dilute sulfuric acid, then temporarily connected to a lead bar, and given a computer-controlled forming charge. Individual plate formation allows the entire row of plates to be formed at uniform temperatures, which will enhance battery performance



Fig. I-3

and life. The formed plates become darker and are individually inspected (Fig. I-4 and Fig. I-5) to be sure that each one is perfect. This is important because many other companies form their plates in the battery, or in groups of cells, resulting in temperature variation between plates, and they can't individually inspect each one.

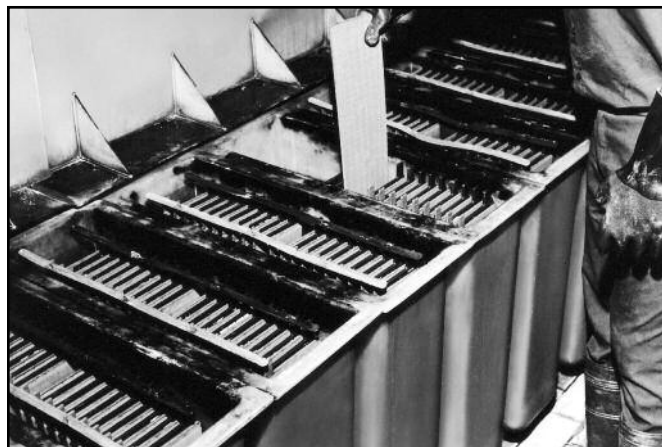


Fig. I-4



Fig. I-5

#### Wrapping Positive Plates

The active material of positive plates (lead peroxide) is subject to shedding as a cell goes through its normal discharge/recharge cycle. The small particles that are shed settle to the bottom of the cell. To keep the active material firmly on the positive plates,

## SECTION I - THEORY OF OPERATION/BATTERY CONSTRUCTION OF LEAD ACID STORAGE BATTERIES (cont.)

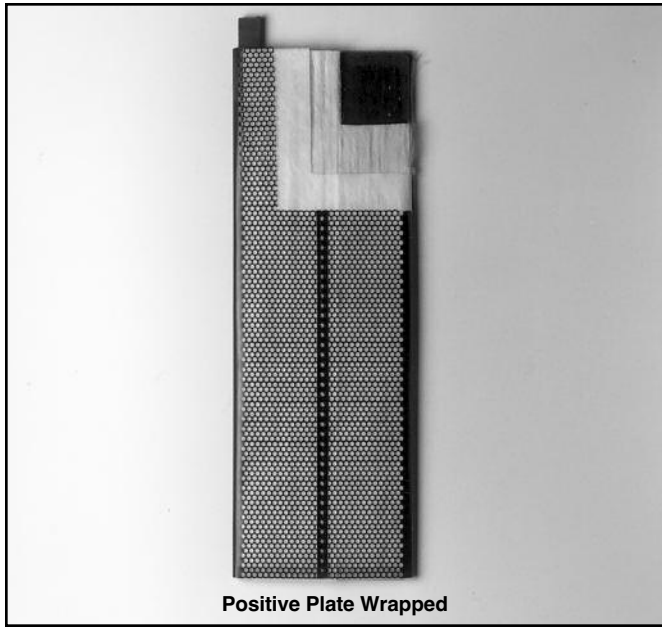


Fig. I-6

they are “wrapped” with various retaining devices including glass fiber mats, fiberglass tape and a retainer/bottom shield (Fig. I-6).

The positive plates are first wrapped with a vertical mat, which consists of fiberglass tape and interwoven glass fibers. The glass fibers imbed into the active material, strengthening in a way similar to reinforcing rods in concrete. A horizontal glass fiber mat is then wrapped around the plate to break up any gas bubbles and increase the plate’s insulation. The wrapped plate is then encased in a perforated plastic retainer envelope that firmly holds the glass wraps in contact with the plate while allowing the free flow of electrolyte to the plate. A bottom plate boot is added to prevent the sediment in the sediment chamber from contacting the bottom of the positive and negative plates and shorting out the cell.

### Assembling An Element

A group of positive and a group of negative plates are stacked with separators, inserted between each positive and negative

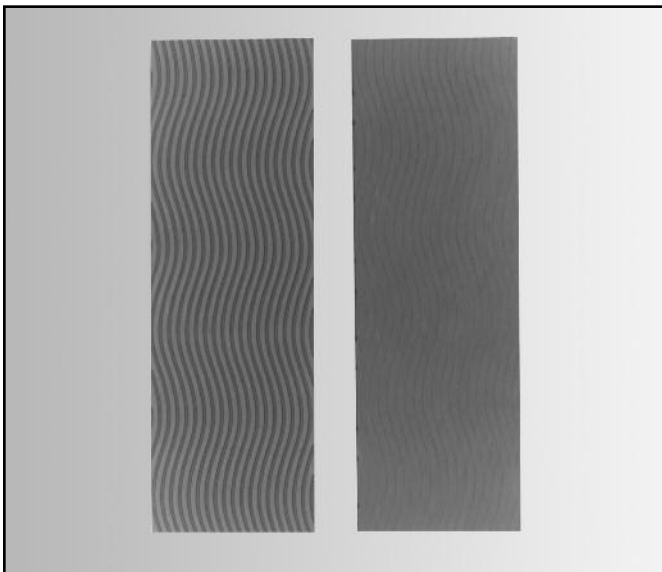


Fig. I-7

plate, to the desired cell size. Both outside plates are negative, therefore the number of plates per cell is always an odd number, with each cell having one more negative than positive plate.

The separators used to insulate the positive plate from the negative plate are grooved on one side and flat on the other (Fig. I-7). The grooved side faces the positive plate. The flat side faces the negative plate because the sponge lead of the negative plate would expand if it faced into the grooved side. In some cases, positive plates can be inserted into separator sleeves, which are two separators joined at the sides.

When assembling the stack of plates and separators into an element, a post plate strap is welded onto the positive plate lugs and another one is welded onto the negative plate lugs. At the same time, positive and negative posts are welded onto the proper plate straps. A perforated plastic moss shield is placed on top of the assembled plates (Fig. I-8). The moss shield also protects the tops of the plates and separators and permits the gas bubbles to get up to the surface of the electrolyte.

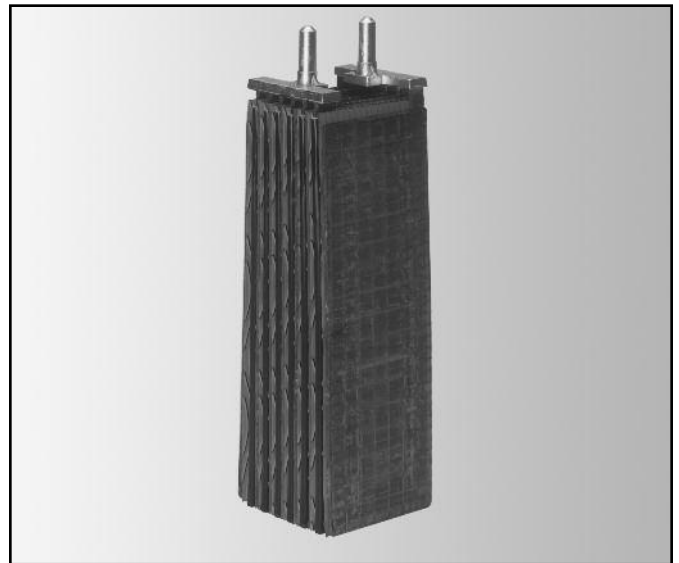


Fig. I-8

### Finishing the Cell Assembly

A finished cell consists of an element inserted into a high-impact plastic jar with a cover (Fig. I-9). Before the element goes into the jar, a sediment bridge is installed to give the element firm support and provide a place for sediment to settle.

After the completed element is inserted into the jar, a high impact plastic cover is placed on top and heat sealed onto the jar. The cover’s positive and negative terminals have a lead post bushing attached and are welded firmly to the element’s posts.

Each finished cell is air tested to ensure an air tight cover-to-jar and post-to-bushing seal. The air test can also detect any leaks in the high impact plastic jar.

## SECTION I - THEORY OF OPERATION/BATTERY CONSTRUCTION OF LEAD ACID STORAGE BATTERIES (cont.)

### Assembling into Trays

To create a battery, a specific amount of completed cells (element, jar and cover) are inserted into a steel tray. Spacer material may be added between the cells and tray to assure a tight assembly.

East Penn will assemble batteries with or without a hot asphalt based sealing compound that is poured in the channels between cells, per customer request. East Penn recommends that sealing compound be used because it prevents dirt and flushed electrolyte from draining between the cells and tray. This internal build up of corrosive material over time could cause cell or tray damage and result in voltage shorts to ground that adversely effect lift truck electrical controls. Once all the jars have been sealed into the tray, intercell connectors are attached (Fig. I-10). Electrolyte is then added to the cells and the battery is moved to the boosting room for a final charge.

### Battery Finishing and Shipping

After the boost charge, the battery is sent to the finishing line, where cables and connectors are attached according to the buyer's layout specifications (Fig. I-11). The battery is then weighed, thoroughly cleaned, and inspected. Actual battery service weight and the tray drawing number are stamped on the steel tray, and all battery identification labels, warning labels, plaques, and service stickers are affixed to the tray.

The finished battery is wrapped in plastic and palletized. Shipping information and instructions are included with the battery before shipment and a "corrosive" label is attached to all wet (containing electrolyte) shipments.

All East Penn employees are extremely proud of the products that they produce. You can be assured that the highest quality materials and workmanship were used to manufacture your battery.



Fig. I-10



Fig. I-11



Fig. I-9



## SECTION II – BATTERY SAFETY

**DANGER** Contains: Lead, Sulfuric Acid (Electrolyte), Lead Compounds.

**Hazard of asphyxiation, irritation, or in contact with skin:**  
Acid causes severe burns and eye damage.  
May damage fertility or the unborn child if inhaled or absorbed.  
May cause cancer if inhaled or absorbed.  
Causes skin irritation, eye irritation, and contact with internal components may cause irritation of internal organs.  
Causes damage to central nervous system, blood and kidney through prolonged or repeated exposure if inhaled or absorbed.  
Irritating to eyes, respiratory system, and skin.  
May form explosive air/gas mixture during charging.  
Contains flammable gas (hydrogen).  
Explosion, fire, blast or projection hazard.

**Other special instructions before use:**  
Do not breathe acid or other vapors from this product.  
Wash thoroughly after handling.  
Do not eat, drink or smoke when using this product.  
Avoid contact during pregnancy/while nursing.  
Wash protective clothing thoroughly after use.  
Avoid contact with internal acid.  
Do not breathe fumes from charging equipment.  
Keep away from heat/petroleum based surfaces.  
Do NOT inhale vapors. Call a poison center/doctor if you feel unwell.

**Preparation of asphyxiation, irritation, or in contact with skin:**  
If you DROWNED OR DIED or have "Respiratory Failure" immediately get compressed oxygen and fresh air.  
If you have severe irritation, immediately call a POISON CENTER or doctor/pharmacist.  
If you have severe irritation with redness for several minutes, remove contact lenses, if present and easy to do. Continue rinsing.  
If you feel unwell seek medical attention/attention.  
Store sealed in a well-ventilated area, in accordance with local and national regulations.  
Observe all construction and in accordance with local and national regulations.  
Keep out of reach of children.

**PROPOSITION 65 WARNING:** Battery posts, terminals and related accessories contain lead and lead compounds, chemicals known to the State of California to cause cancer and reproductive harm. Batteries also contain other chemicals known to the State of California to cause cancer. Wash hands after use.  
**WARNING:** Risk of fire, explosion or burns. Do not disassemble or short circuit. See instructions for internal use. Follow product charging instructions. **High Voltage:** Risk of shock. Do not touch disconnected terminals or connectors.  
**Keep Vent Caps Tightly in Place**

**Manufactured by:**  
East Penn Manufacturing Co.  
100 Oaks Road,  
Leno, Ontario, PA 19038  
610-482-6361 USA

**Lead Acid Battery Electrolyte (Sulfuric Acid)**

See P.23 for full warranty information.

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

**Consult SDS for additional precautions and first aid measures. SDS sheets can be obtained at [www.eastpennmanufacturing.com](http://www.eastpennmanufacturing.com)**

When used properly, a lead-acid motive power battery is a safe, dependable source of electrical power. However, if proper care and safety precautions aren't exercised when handling a battery, it can be an extremely dangerous piece of equipment.

There are four hazardous elements in a lead-acid battery: sulfuric acid, explosive gases, electricity, and weight.

### Hazardous Elements

**Sulfuric Acid:** The electrolyte in a lead-acid storage battery is a diluted solution of sulfuric acid and water. Although the acid content in the solution is only about 37%, it's still a strong corrosive agent and can burn skin and eyes and eat holes in many types of fabric. (See Wearing Protective Clothing.)

Specific Gravity Reading	% Acid Content by Weight
1.280	37.40
1.290	38.55
1.325	42.50

**Explosive Gases:** When a lead-acid battery is being charged, it produces an explosive mixture of hydrogen and oxygen gases. Make sure that all vent caps are unclogged and securely attached so that any gas is safely vented from the battery. Never smoke, use an open flame or create an arc or sparks on or near a battery without first eliminating explosive gases from the cells you're working on. (See Gas Purging — Section VI.)

**Electricity:** An electric shock hazard exists for persons who contact live parts of batteries when the voltage is over 50 volts. The higher the voltage, the greater the electric shock hazard. In addition, metallic objects coming in contact with exposed cell connectors will cause a short and can become very hot. Even shorts involving a single cell can become hot enough to cause severe burns.

**Weight:** The average lift truck battery weighs more than 2,000 pounds. Obviously it can cause serious injury if it isn't handled carefully during installation, removal or transport. Use proper lifting equipment and techniques at all times.

### Wearing Protective Clothing

When working on or near batteries, always wear proper protective clothes including a face shield, safety glasses, long-sleeved shirt, acid-resistant boots and gloves. Do not wear any metal jewelry because it can short circuit a battery and become extremely hot if it accidentally contacts exposed intercell connectors. Refer to detailed warnings, Section I, Page 5.

### Lifting Batteries

Chain hoists used to handle batteries should be equipped with a non-metallic container or bucket to prevent the chains from dangling and possibly causing a short by coming in contact with exposed intercell connectors on the battery top. If no protection is available, cover the battery with a non-conducting insulating material such as plywood or heavy plastic.

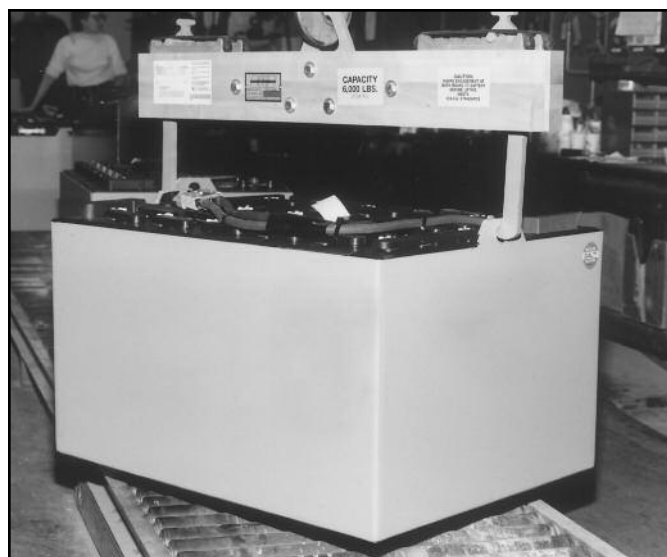


Fig. II-1

Always use the proper lifting equipment to reduce the risk of tray damage, shorting and possible injury. A wood insulated battery lifting beam used with an overhead hoist is the safest way to move a battery (Fig. II-1). An insulated lifting beam, with hooks that fit properly into the lifting ears in the tray, can be used with almost any type of overhead hoist. Be sure the lifting hooks align perfectly with the battery lifting ears. Misaligned hooks can cause battery lifting ear damage and could disengage while the battery is being lifted.

### Using the Battery as a Counterbalance

In order for most lift trucks to operate safely, the battery is used to counterbalance the carried load. Therefore, a new or different battery must fall within the recommended battery weight range. This battery weight information is found on the nameplate of the truck. A battery's service weight is usually stamped on the tray near one of the lifting holes. A battery that's too heavy or too light can change the truck's center of gravity and cause it to be unstable. It's the user's responsibility to be sure that this weight is in the proper range.

## **SECTION II – BATTERY SAFETY (cont.)**

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### **CHARGING BATTERIES**

---

#### ***Charging Areas – Proper Equipment***

All plants should have designated charging areas, especially if they change batteries at the end of each shift. These areas should have proper battery handling equipment including overhead hoists, lifting beams, battery racks and cranes, and the area must be well ventilated.

A source of running water nearby is desirable and a water hose at the filling operation is recommended.

Racks used in the charging area must be insulated to prevent any sparking. The battery rack supports must also be suitably insulated or made of non-conducting material.

The floors in battery and charging rooms should have an acid-resistant coating and be sloped toward a sump. They should always be washed with clean water after an acid spill. The spill should be neutralized with a non-corrosive, water based neutralizing chemical that is user safe and environmentally compliant.

Hand-operated fire extinguishers should be available in all charging areas even if the areas are equipped with automatic sprinkler systems. For information on extinguisher class, size and mounting locations, consult local fire authorities or your insurance carrier.

#### ***Charging Areas – Proper Ventilation***

The charging area must be properly ventilated, either naturally or with a ventilation system. When installing a ventilation system, a number of factors must be considered, including the number and size of batteries being charged at one time and the size, height and air-tightness of the room

Ventilation is considered satisfactory if the hydrogen concentration doesn't exceed 2% in any one location. Concentrations of more than 4% are explosive and dangerous. A number of instruments, such as combustible gas indicators and flammable vapor indicators, are available for continuous automatic analysis of hydrogen content in the air.

Always keep tray covers and truck compartment covers open when charging a battery. This helps cool the battery and disperse the gases.

#### ***Connecting/Disconnecting Charger***

Always turn the charger OFF before connecting or disconnecting a battery. Live leads can cause arcing and sparking, which could cause an explosion if battery gases are present. In addition, the contact surfaces of the plugs or connectors will become pitted over time.

#### ***Sparks, Open Flames***

Because of the explosive gas mixtures generated while charging batteries, anything that could ignite the gas, such as sparks, open flames, an electrical arc, smoking, etc., must be prohibited in the charging areas. To serve as a prominent reminder, "NO SMOKING" signs should be posted in all charging areas.

### **HANDLING ACID**

---

#### ***Pouring Acid***

Use a carboy tinter or safety siphon when removing acid from a carboy container. The venting device in a carboy prevents splashing. Carboys should be stored in a cool place away from direct sunlight. (Note: Use proper eye protection, protective clothing and equipment.)

#### ***Mixing Electrolyte***

Mix electrolyte in a heat and acid-resistant container. Always pour acid into water. Never pour water into acid because a violent chemical reaction can occur. Pour the acid slowly and stir the mixture so the acid doesn't settle on the bottom.

When using high specific gravity acid (above 1.400), take special precautions because it can be extremely dangerous. (Note: Use proper eye protection, protective clothing and equipment.)

Store acid and electrolyte solutions in covered containers made of lead, glass or acid-resistant plastic. Keep the containers in a cool, dry area away from direct sunlight.

**Important - only the most experienced battery technicians should be allowed access to sulfuric acid and allowed to add acid for cell equalization purposes.**

#### ***First Aid for Acid Splash***

**Eyes:** Flush immediately with gently running water for at least 15 minutes, then see a doctor as quickly as possible. For contact lens wearers, remove the lens before the eyes are flushed. A buffering or neutralizing agent shouldn't be used in the eyes without the approval of medical or safety personnel.

**Skin:** Wash affected area under running water and apply a chemical burn treatment. Severe burns require immediate medical attention.

**Clothing:** If large areas of clothing have been splashed or soaked, the clothing must be removed and the acid must be neutralized with a non-corrosive, water based neutralizing chemical that is user safe and environmentally compliant and then rinsed under running water. If the clothing is rinsed quickly enough, the chances of damage to the material are lessened.

Acid-resistant boots should always be checked before wearing to be sure that there are no acid puddles inside.

## SECTION II – BATTERY SAFETY (cont.)

### Eye Wash and Emergency Shower Facilities

Emergency eye wash and acid neutralization facilities should be located in the immediate work area for easy access. The three most popular types of eye wash and acid neutralizing equipment are the chemical burn station, deluge shower, and eye wash fountain.



Fig. II-2

1. A **chemical burn station** (Fig. II-2) is used in smaller battery charging and repair areas. The station consists of a wall-mounted plastic squeeze bottle that contains a buffering solution for treating acid burns on skin, eyes and clothing. This inexpensive equipment should be used only where acid with a specific gravity lower than 1.400 is used. A buffering or neutralizing agent shouldn't be used in the eyes without the approval of medical or safety personnel.

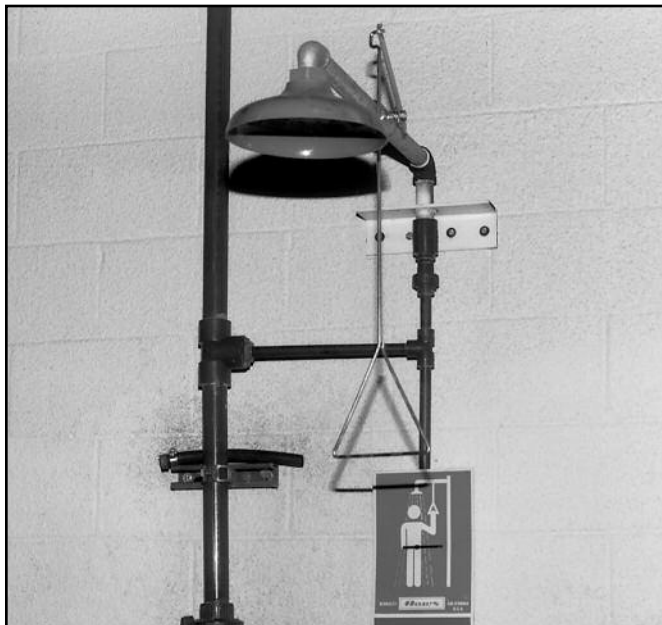


Fig. II-3

2. A **deluge shower** (Fig. II-3) should be used where high specific gravity acid (above 1.400) is handled. The shower uses a handle or foot treadle to turn on a powerful water stream that can wash acid from skin and clothes.



Fig. II-4

3. An **eye wash fountain** (Fig. II-4) should be used wherever batteries and/or acid is handled, regardless of the acid's specific gravity. This device produces two streams of water so that both eyes can be flushed simultaneously.

### Neutralizing Acid and Electrolyte

For cleaning batteries, non-corrosive, water based battery cleaning products are all that should be used. For user safety and environmental regulatory compliance, the cleaning liquid should contain no hazardous chemical ingredients. Even some products labeled "Battery Cleaner" must be avoided because of hazardous ingredients and damage to batteries and related equipment.

Acid spills are common in battery rooms. When acid spills occur it is critical to minimize:

1. Health and safety risk to personnel and the environment.
2. Damage to batteries, equipment, and surrounding surfaces.
3. Time to neutralize, absorb, and clean-up.
4. Disposal costs of waste materials.
5. Regulatory compliance risks and fines.

Neutralizing acid absorbers and spill kits have the performance attributes required when dealing with acid spills. The pH neutral dry and non-hazardous waste is easy to sweep-up and dispose as non-hazardous waste.

## SECTION II – BATTERY SAFETY (cont.)

### Repairing Batteries

Keep in mind several safety points when repairing batteries:

1. Never work on a battery while on charge or discharge. Always disconnect it from the charger or truck first.
2. Always remove vent caps before beginning work.
3. Always remove gas from all battery cells before beginning work (see Gas Purging – Section VI).
4. Use caution when melting sealing compound. Melted compound is extremely hot and can cause severe burns if not properly handled (see Sealing Compound – Section VI).
5. To prevent possible short circuits, use insulated tools whenever you are working on a battery. If possible, cover the terminals and connectors with an insulating material such as plywood or heavy plastic, if the battery being worked on does not have intercell connector and terminal shrouds installed.

For more detailed information on safety battery repair procedures, see Section VI – Battery Repair.

## SECTION III – INSTALLATION AND USE

### Receiving a Battery

After receiving a battery, examine the crate and pallet for signs of damage. If you see any wet spots, the battery may have been tipped or damaged during transit. Be careful when handling a crate or packing material that's contaminated with spilled electrolyte. Chemical burns can result if skin or clothing comes in contact with the spillage. *Follow the precautions listed under "Handling Acid" – Section II.*

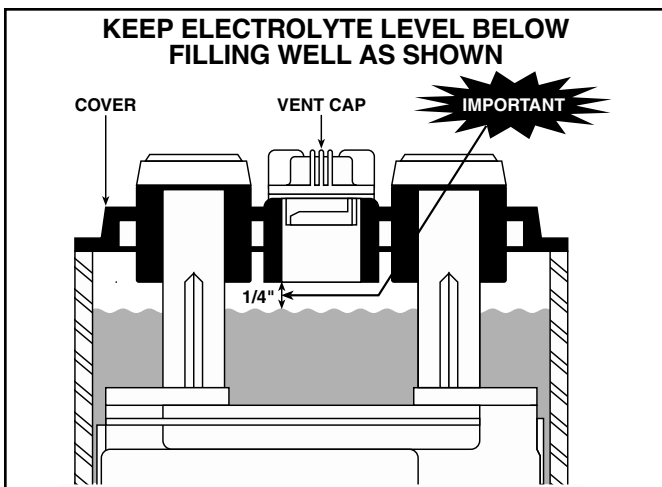


Fig. III-1

Every cell should be inspected to be sure that the electrolyte level is above the moss guard (Fig. III-1). If the electrolyte level is slightly below the moss guard in any cell, it can be raised by transferring a small amount of acid from higher level cells within the battery by using a syringe or hydrometer.

If a large amount of liquid is required to raise the level, the cell jar may be damaged. Inspect the packing material under the tray for signs of leakage. All damaged components should be inspected by your East Penn agent or representative.

Call your East Penn representative immediately. In the meantime, keep the damaged cell's vent cap tightly in place and protect the floor from acid leakage. *Do not attempt to discharge or charge the battery.*

### Temporary Storage

When it is fully charged and the electrolyte is at the proper level, the battery can be stored for up to a year. It should be stored in a cool, dry, well-ventilated area away from direct sunlight. If the battery must be stored for several months or longer,

Temperature Effect on Specific Gravity of New Batteries Stored on Open Circuit

Temperature (Degrees Fahrenheit)	Maximum Loss of Specific Gravity Per Day
120	.004
100	.003
80	.001
50	.0005

a freshening charge (see "Placing a Wet Charged Battery in Service") should be given whenever the specific gravity falls below 1.240 or every six weeks. If the average storage temperature is below 68°F (20°C), check the specific gravity at least once every two months. If the temperature is above 68°F (20°C), check it every month.

Batteries in steel trays without covers should be covered with a non-conductive material to protect them from dirt, moisture, etc. A flat sheet of rigid plastic or plywood will work well. Do not drape flexible plastic sheeting over batteries because it might trap explosive gases underneath.

*Note: If batteries must be stored for more than one year, consult the manufacturer.*

### Placing a Wet Charged Battery in Service

Give a freshening charge to a new battery before putting it into service. Charge the battery until the specific gravity and all cell voltages have stabilized. The full charge specific gravity is 1.280 to 1.295 when temperature corrected to 77°F (25°C). Ideally, the battery should be cool; less than 90°F (32°C), when it's installed in the vehicle. Check the manufacturer's specifications for full charge specific gravity on high gravity battery types.

When installing a battery, make sure that the battery compartment is clean, corrosion-free and the ventilation openings aren't obstructed or blocked off.

To lift the battery, use a lifting beam and an overhead hoist (see "Lifting Batteries" – Section II). Set the battery securely in the compartment and block it into position. Some vehicles have adjustable clips for blocking the battery into place. The battery should not be wedged tightly into the compartment because clearance for expansion must be provided. However, clearance can't exceed 1/2" between the block or clip and the battery tray (Fig. III-2).



Fig. III-2

Be sure all vent caps are in place because electrolyte from uncapped cells can corrode the tray and vehicle.

### Placing a Dry Charged Battery in Service

*Note: The activation of dry charged batteries is an involved process which should be handled by trained personnel. For a thorough explanation, refer to East Penn's "Procedure for Activating Dry Charged Industrial Cells and Batteries," which is supplied with every dry charge battery.*

A dry charged battery is a fully charged battery from which all the electrolyte has been removed. Because it's essential to keep these batteries in the dry state until ready for use, they should be stored in a cool, dry, low-humidity area with their vent caps and protector cap and plugs tightly in place until ready for use. When reactivated, install as described in "Placing a Wet Charged Battery in Service."

### Cycling Characteristics

Every time a battery is discharged and then recharged it's called a cycle. An average battery lasts 1,500 to 1,800 cycles, or 5 to 6 years. (Actual battery life depends on battery type, the severity of use, and how the battery was maintained while in service.)

As a battery discharges, the voltage normally drops slowly at first and then more rapidly toward the end of the discharge. Battery temperature, on the other hand, rises during discharge, although the increase isn't as high as it is during charging. The amount of temperature increase depends on ambient temperature, ampere discharge rate, and the amount of heat dissipation (which varies according to battery type).

To obtain maximum service life, batteries should be operated at 115°F (46°C) or lower, and they shouldn't be discharged to below 80% of rated capacity. Frequent over-discharging can drastically shorten battery life.

One way to prevent over-discharging is to be sure that the ampere-hour (A.H.) capacity rating of the battery is high enough for the battery's work load. The battery will over-discharge if its workload exceeds its capacity. For heavy-duty applications, a higher capacity battery — such as East Penn's MAX POWER battery — may solve frequent over-discharge problems. To determine if a higher capacity battery is right for your needs, contact your East Penn agent or representative.

### Operation of the Battery

There are several factors that effect the operation of the battery concerning its ability to deliver capacity and life expectancy. Many chemical reactions are effected by temperature, and this is true of the reaction that occurs in a storage battery. The chemical reaction of a lead-acid battery is slowed down by a lowering of the electrolyte temperature that results in less capacity. A battery that will deliver 100% of rated capacity at 77° F will only deliver 65% of rated capacity at 32°F. See Table 3-1, for specific gravity and on charge cell voltage temperature correction.

### Specific Gravity and On-Charge Cell Voltage Temperature Correction

**EXCESSIVE HEAT** will contribute greatly to reducing battery life by corroding the positive grids and excessive gassing which loosens active material in the plates, especially the positive plate. Over charging is the most common contributing factor to excessive temperatures and gassing in a battery. A properly rated and matched charger will help to avoid the problem of overcharging.

**CONSISTENT UNDERCHARGING** of a battery will gradually run down the cells and result in one or more cells becoming completely discharged before the others, and may become reversed. Capacity and life expectancy are greatly reduced by undercharging. Equalizing charges to return the cells to a normal condition should be part of a weekly maintenance schedule.

**OVERDISCHARGING** can also cause permanent damage to the battery. Recharging is more difficult and more time consuming. Often complete recharge is not attained and the undercharged battery is placed into service. Consequently, it is over discharged to a lower limit resulting in loss of capacity and premature battery failure. Optimum battery life can be aided by limiting the depth of discharge to 80% of its rated capacity.

A good battery maintenance program is necessary to protect life expectancy and capacity of the battery. A more detailed discussion of battery maintenance can be found in Section IV of this manual.

## BATTERY CHARGING

### Basic Charging Facts

Proper charging is essential for maximum battery life. In general, the proper charging rate for lead-acid batteries is any rate which doesn't produce temperature higher than 115°F (46°C), and any rate which doesn't cause excessive gassing.

When a discharged battery is initially placed on charge, it draws a current equal or close to the charger's maximum output. As the battery's voltage rises, the charger output should adjust to the changing voltage to assure a safe, efficient charging rate during all stages of the charge.

With today's automatic start/stop charges, under and overcharging are virtually eliminated. These "smart" charges have computerized control units that can determine when a battery is fully charged and then automatically terminate the charge cycle. For example: The charger delivers a "maximum" start rate of 20 amps per 100 A.H. of rated capacity. As the voltage rises to 2.37 volts @ 77°F (25°C) per cell, the gassing voltage of the battery is held constant until the charge rate tapers down to 5 amps per

## SECTION III — INSTALLATION AND USE (cont.)

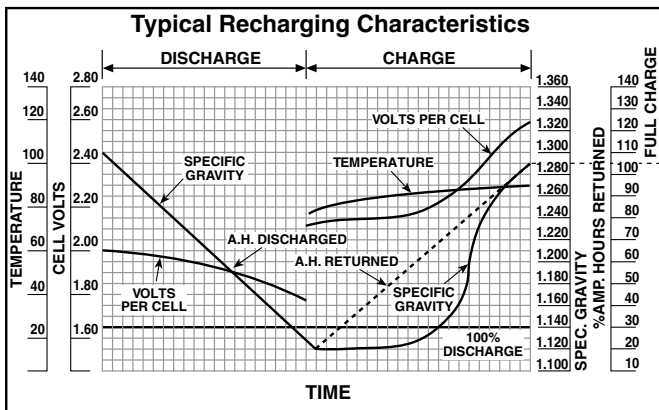


Fig. III-3

100 A.H. This finish rate is held constant until the charger automatically shuts off. Charger start rates should not be more than 20 amps per 100 A.H. of rated capacity, and the finish rates not less than 5 amps per 100 A.H. @ 2.60 V.P.C. (Fig. III-3).

The above requirements will return a discharged battery to full recharge. See your East Penn representative for details. Periodic inspection and adjustment of automatic charges should be done by a qualified electrician.

### Specific Gravity Temperature Correction

Specific gravity measurements are based on a cell temperature of 77°F (25°C). In order to obtain an accurate specific gravity measurement, the hydrometer reading must be adjusted based on the temperature of the electrolyte. A good rule of thumb for temperature correction is to add 4 points of specific gravity (.004) for each 10 degrees Fahrenheit over 77°F and to subtract 4 points for each 10 degrees under 77°F.

See table 3-1 — Specific Gravity Temperature Correction

### Charging Methods

There are two important types of charge that are used for lead-acid Industrial batteries: Standard Recharge (Cycle Charge) and Equalizing Charge. (A third type of charge, the Freshening Charge, is explained in "Placing a Wet Charged Battery in Service").

**Standard Recharge** — After a battery has undergone a normal full shift and has been fully discharged to a recommended 80% of rated capacity, it must undergo a complete, or standard, recharge. Normally, a standard recharge is based on an 8-hour charging cycle.

**Equalizing Charge** — Due to a slight difference in the construction of each battery cell, some cells take less charge than others. An occasional equalizing charge will correct these cell-to-cell imbalances and bring all cells up to the same capacity. An equalizing charge is simply a 3-hour continuation of the standard recharge at no more than the battery's finish rate. A minimum 3 amp per 100 A.H. equalize charge rate is necessary to receive the full benefit of the equalize charge. A lower equalize charge rate will require a longer equalize charge period.

The best way to determine if the battery needs an equalizing charge is to check the specific gravity readings for each cell. If there is more than 0.020 specific gravity unit variation between any two cells, the battery should be equalized. A good rule of thumb is to equalize the battery once each week.

See table 3-2 — Specific Gravity vs. Percent Discharge

Specific Gravity Temperature Corrections			
Electrolyte Temperature		Specific Gravity Correction	On-Charge Cell Voltage Correction
Fahrenheit	Celsius		
130	54	+0.022	+0.18
127	53	+0.020	+0.17
124	51	+0.019	+0.16
121	49	+0.018	+0.15
118	48	+0.017	+0.14
115	46	+0.016	+0.13
112	44	+0.014	+0.12
109	43	+0.013	+0.11
106	41	+0.012	+0.10
103	39	+0.011	+0.09
100	38	+0.009	+0.08
97	36	+0.008	+0.07
94	34	+0.007	+0.06
91	33	+0.006	+0.05
88	31	+0.004	+0.04
85	29	+0.003	+0.03
82	28	+0.002	+0.02
79	26	+0.001	+0.01
76	24	—	—
73	23	-.002	-.01
70	21	-.003	-.02
67	19	-.004	-.03
64	18	-.005	-.04
61	16	-.006	-.05
58	14	-.008	-.06
55	13	-.009	-.07
52	11	-.010	-.08

Table 3-1

### The Charging Process

During the charging process, the sulfate in the battery plates, which accumulated during discharge, is driven back into the electrolyte. This increases the specific gravity and brings the on-charge voltages up to 2.50-2.70 volts per cell, depending on the age of the battery. (See "Discharging/Charging Characteristics" in Section I).

As the battery approaches full charge, the charging rate must be reduced to the battery's finish rate. The finish rate is that current which can be used safely on the battery anytime charging is required, and which can be continued after the completion of the charge without causing excessive gassing or high temperatures. East Penn's official finish rate in amps is equal to 5% of the amp hour capacity at the 6 hour rate. The finish rate is on the nameplate of all East Penn batteries.

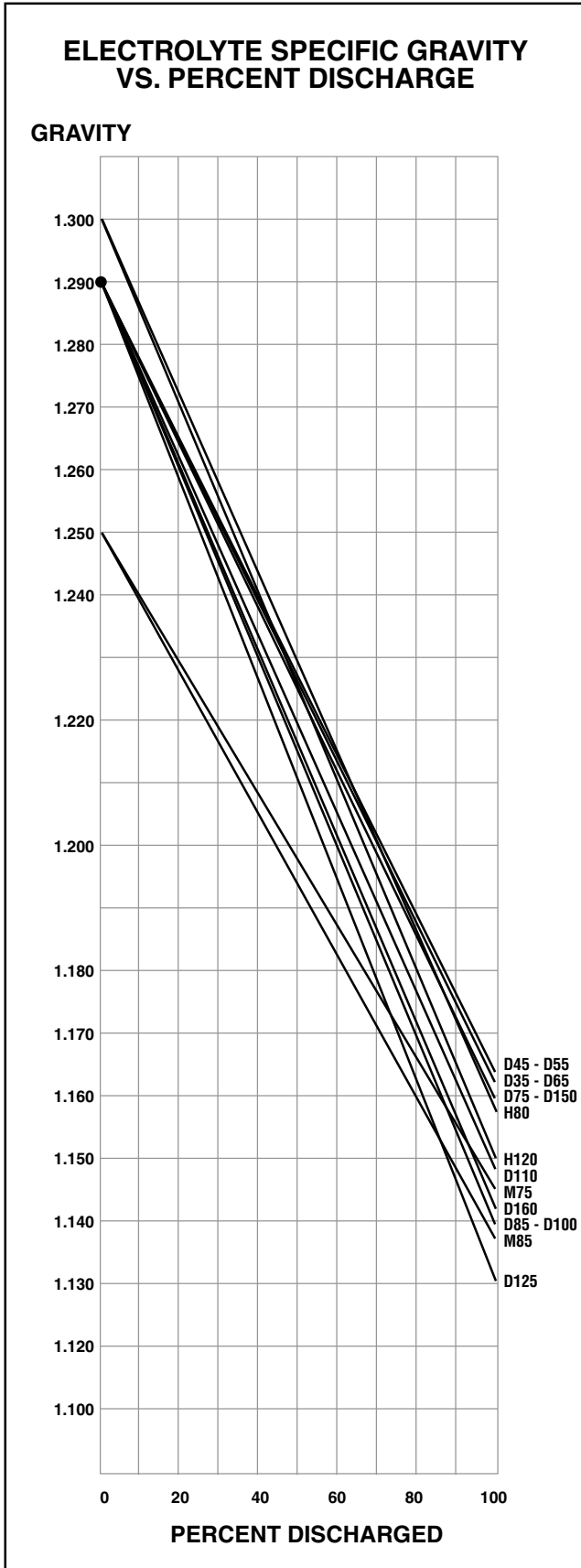
Normally, a battery will be properly charged if the charging equipment is in good working condition and the battery is "healthy". A fully charged battery will have the following characteristics while on charge:

- Stable on charge battery voltage
- Gassing freely
- Charger current readings have leveled off to finish rate
- Temperature-corrected specific gravity has stopped rising

See table 3-1 for specific gravity temperature corrections.

**SECTION III — INSTALLATION AND USE (cont.)**

**D and M Series**



**MAX POWR Series**

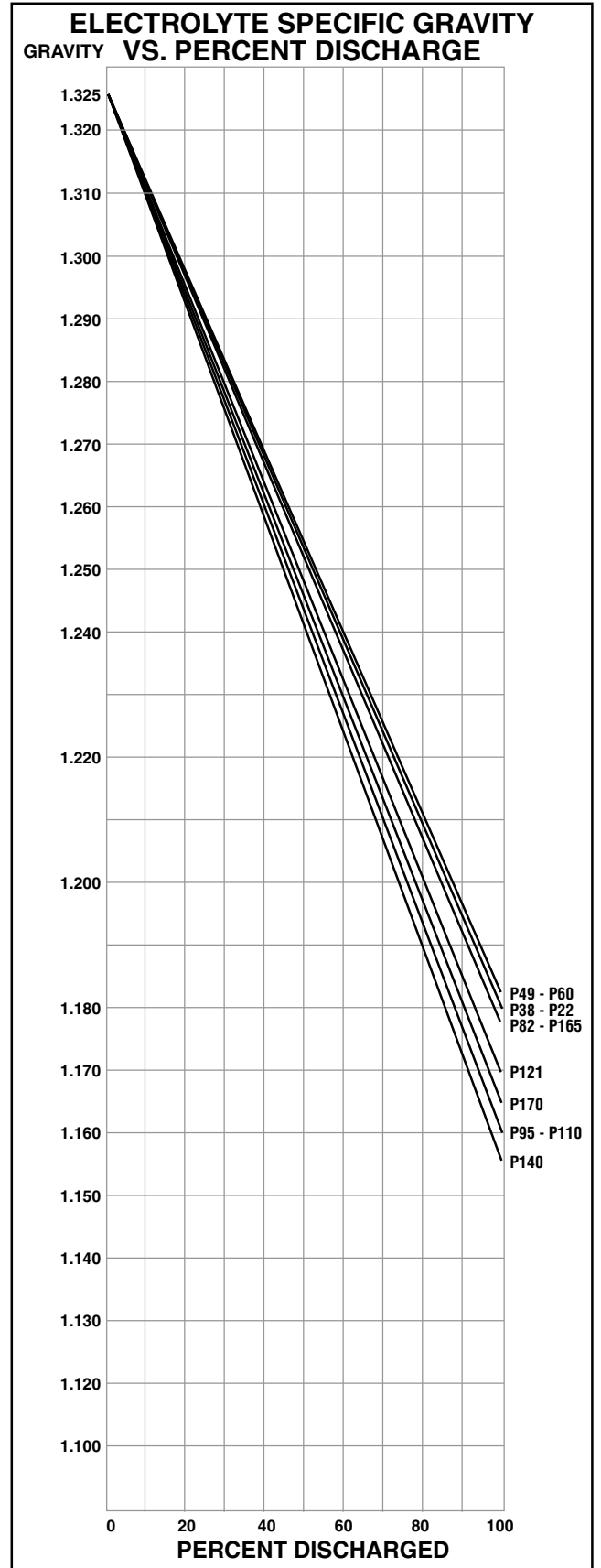


Table 3-2

## SECTION III — INSTALLATION AND USE (cont.)

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### Improper Charging

Improper charging reduces battery capacity and life.

Undercharging can cause residual sulfation to remain on plates, reducing cell performance. Sulfation also slowly occurs when batteries are stored for months without receiving periodic freshening charges. The cells of a sulfated battery give low specific gravity and voltage readings. It's difficult to bring a heavily sulfated battery back to full charge and doing so will develop high temperatures. (See "Correction of Sulfated Cells" — Section IV.)

Undercharging also results in insufficient gassing, which creates a high acid content at the bottom of the cell, eventually leading to sulfation on the bottom part of the negative plates. This condition can be corrected by periodic equalizing charges.

Although all batteries are overcharged to an extent during every charge cycle, severe overcharging results in excessive gassing and very high battery temperatures — both of which are damaging to the battery. Battery temperatures should not exceed 115°F (25°C) during charging.

Excessive gassing occurs when a high charging rate is continued after the battery has been brought to its gassing voltage (2.37 volts per cell nominal). A noticeable bubbling of electrolyte can be seen, accompanied by high electrolyte temperature. Because the gas is released from the electrolysis of water, excessive gassing results in unusually high water usage. (See the Troubleshooting Chart at the end of Section IV for additional causes and remedies.)

For reduced maintenance and long, trouble-free battery life, make sure all your batteries are properly charged. If you're having trouble correcting any problems, contact your East Penn agent or representative.

## SECTION IV — BATTERY MAINTENANCE AND TROUBLESHOOTING

---

Proper maintenance is essential to obtain long life and maximum efficiency from any Industrial battery. Carefully following a scheduled maintenance routine will help increase battery performance and prolong service life.

One of the keys to an effective battery maintenance program is to maintain an accurate records system of battery cycles and maintenance/repair work for each battery. A records system is particularly important for operations that use a large number of batteries.

If you don't already have one, these procedures should help you create a reliable records system:

1. Assign a code/identification number to each battery and charger. Use a multiple digit-system if you have several different sizes or types of batteries. Prefixes or suffixes can be used to identify batteries by size, voltage, shift, lift truck, etc.
2. Designate a "pilot cell" for each battery. Record the specific gravity, voltage and temperature of the pilot cell when the battery is first received and equalized, and **before and after each charge**. The readings taken on the pilot cell are considered to represent the specific gravity, voltage and temperature of all the cells. **Always**

### Charging Safety

There are several important safety precautions that should be taken when charging a battery:

- **Do not use open flames when checking the electrolyte levels in storage batteries.**
- **Keep all open flames, sparks and matches away from the charging area. DO NOT SMOKE around the charging area.**
- **Only properly trained personnel should charge batteries.**
- **Before a battery is removed from a truck, or charged in a truck, the truck's electrical circuit should be open, the battery should be unplugged from the truck, and the wheels should be chocked. (If removing the battery from the truck, be sure to use proper lifting methods and equipment.)**
- **The charger should be OFF before connecting it to the battery.**
- **All mechanical connections on the battery and charger should be tight. Loose connections can overheat and cause arcing that could cause a gassing cell to explode, or cables to become hot to the touch.**
- **Covers on battery trays should be kept open while charging to promote cooling and allow gas to escape. If the battery remains in the truck during charging, keep the battery compartment cover and battery tray cover open.**
- **Vent plugs should be kept firmly in place at all times to minimize electrolyte spray when the battery gasses.**
- **The charger should be OFF before disconnecting the battery.**
- **The charger connector shall not be plugged into the lift truck connector under any circumstances.**

**use the same cell for the pilot cell.** The pilot cell should be positioned near the center of the battery and can be identified with a marking of some sort on the intercell connector shroud or cell cover.

3. At least once each month, measure and compare the specific gravity of all the cells. The readings should be uniform from cell to cell. If the specific gravity readings fall 20 points (0.20) below the nominal specific gravity reading of 1.290, the electrolyte levels should be checked and brought up to a uniform level before checking for a second time. If, at any time, the readings are 20 points (.020) greater than the nominal specific gravity readings of 1.290, or the range of the on-charge cell voltage readings is more than 0.15 volts, the battery could be showing signs of cell failure. Contact your authorized Deka Service Representative.
4. Remember to accurately record the number of cycles, specific gravity, temperature and voltage readings; and all maintenance and repair information for every battery. THE DAILY BATTERY RECORD (Fig. IV-1) is an example of a basic record-keeping form. You should use a form that best fits your operation's individual needs. It is also recommended that the identification number of the charger used to charge the battery be recorded.





## SECTION IV — BATTERY MAINTENANCE AND TROUBLESHOOTING (cont.)

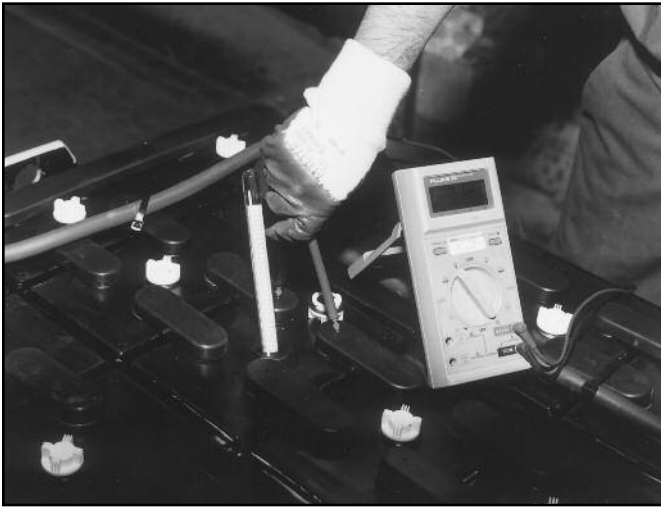


Fig. IV-3

Always record basic data gathered during routine inspections. The first step is to visually inspect the battery.

### Look for:

- Corrosion on the tray, terminals or intercell connectors.
- Leaks or damage to the tray.
- Damaged cable leads, terminals or connections.
- Damaged, clogged or missing vent caps.

Repair or replace any damaged parts (see Section V — Battery Repair) and thoroughly clean the battery. (Battery cleaning is covered in detail later in this section.) In case of serious damage or for major repairs, contact your nearest authorized East Penn representative.

Before taking any specific gravity or voltmeter readings, the battery should be fully charged, but then placed on charge again and allowed to charge for a minimum of 15 minutes. Take specific gravity and voltage readings for each cell and record the readings on your battery inspection form. Use the battery's positive terminal cell as cell #1 and follow the intercell connectors to the last cell (the battery's negative terminal cell). Look for any unusual readings that might indicate a problem cell.

### Adding Water/Adjust Electrolyte Levels

Batteries normally lose a certain amount of water due to evaporation and electrolysis during charging. It's very important not to allow the electrolyte level in any cell to drop below the top of the separator protector, since low levels can damage the plates and shorten life. It's equally important to avoid overfilling the cells, as electrolyte will be forced out of the vent caps during charging onto the top of the battery, causing tray corrosion and reducing battery capacity.

Only approved water should be used to water cells because certain impurities and chemicals found in tap water can be harmful to batteries. Tap water in certain areas of the country is unsuitable at any time, while in other areas it may be satisfactory only during certain seasons. If the water in your area isn't suitable, use distilled or de-ionized water. The National Electrical Manufacturers Association (NEMA) standards for maximum allowable impurities are:

Total Solids	350 PPM (parts per million)
Chlorides and C1	25 PPM
Nitrates as NO3	10 PPM
Iron as FE	4 PPM

If you have any doubts about the suitability of your water, contact your local authorized Deka Representative who can arrange to have a water sample sent to East Penn's lab for analysis, for a nominal fee.

Water should only be added to batteries while the batteries are on charge and gassing or as soon after recharge as possible. This will prevent overfilling because the electrolyte is at its maximum level during this time. To prevent low electrolyte levels, frequent checks should be made and water should be added when necessary.

The electrolyte level should be maintained between the low level at the perforated separator protector and the high level at the bottom of the vent well opening of the cover. The manufacturer's specific gravity recommendations always are determined with the electrolyte at the high level.

How a watering schedule is determined depends on the type of battery, frequency of charge, temperature of the battery, and age and condition of the battery. Excessive water loss may be caused by shorted or weakened cells, excessive charging rates, or the charger not shutting off automatically. Cells that continually lose excessive amounts of water should be checked for possible internal damage.

### Battery Cleaning Wash Unit

A well maintained battery is a clean battery. Routine cleanings should be done once a month on the average, to prevent tray



Fig. IV-4

corrosion and help keep the battery operating at peak efficiency. More frequent cleaning may be needed if batteries are being operated in a very dusty or dirty environment.

For general cleaning, use a non-corrosive, water-based battery cleaner. For user safety and environmental regulatory compliance the battery cleaner should contain no hazardous chemical ingredients.

The Deka Battery Cleaning System, is a state-of-the-art process that completely cleans and neutralizes batteries, while safely processing the wash water to meet EPA and DOT requirements. No contaminants are discharged into water supplies or the soil; all materials in the treated wash water are completely encapsulated and removed from the facility. Contact your East Penn representative for more detailed information.

Most batteries have intercell connectors and terminals covered

## SECTION IV – BATTERY MAINTENANCE AND TROUBLESHOOTING (cont.)

with plastic shrouds. These should be removed prior to battery cleaning and immersed in the cleaning solution.

**MAKE SURE ALL VENT PLUGS ARE TIGHTLY IN PLACE WHEN CLEANING OR WASHING BATTERIES.** Check the gas escape holes in the vent plugs for dirt clogs.

For maximum effectiveness, the solution should be applied with a clean, non-metallic brush, so it can be worked under the terminals and intercell connectors to remove dirt and neutralize any excess acid (Fig. IV-4). Use a low pressure hose to rinse the battery with water until all traces of solution and loose dirt are removed.

Before placing the cleaned battery back in service, rinse and attach the intercell connector and terminal shrouds. All excess rinse water should be removed from the battery top with a low pressure air hose or allowed to air dry.

### **Performing a Test Discharge**

To determine if a battery can deliver its rated capacity, a test discharge, or capacity test, can be performed. This test helps determine the “health” of a battery and whether or not it should be replaced.

Only experienced battery technicians should be allowed to prepare a battery for discharge testing and to conduct the actual discharge test.

The test is conducted by discharging a fully charged battery at the six hour rate until the battery voltage drops to a final voltage of 1.70 volts per cell, times the number of cells in the battery. The six hour rate in amps is a number equal to the rated capacity at the six hour rate divided by six hours.

By noting the time elapsed between when the battery was put on discharge and when the final voltage was reached, you can determine whether the battery is delivering its rated capacity:

1. Give the battery an equalizing charge and adjust the specific gravity to the manufacturer’s specification, with the electrolyte level at the bottom of the vent well. Always temperature correct the gravity readings.
2. Start the test and record the starting time.
3. Record individual cell voltages and overall battery voltages during the first hour at 10 minutes, 30 minutes and then 60 minutes. After the first hour, take hourly readings until the first cell voltage reaches 1.75 volts per cell. From this point on, record the voltage of the cells every 5 minutes.
4. Carefully monitor the voltage of the low cells and as the voltage of each cell drops below termination value, record the time.
5. When the majority of the cells reach termination value, stop the test. Don’t let any cells go into reversal.
6. Use this formula to calculate capacity delivery:

$$\frac{\text{minutes to final voltage}}{360 \text{ minutes} \times 100}$$

For example, if the test was terminated after 336 minutes, the capacity percentage would be 93%

7. After termination of the test, immediately record the specific gravity of each cell. If all the cells have uniform specific gravity and the battery delivers 80% or more of its rated capacity, 288 minutes, it can be returned to ser-

vice. If the test indicates that less than 80% of the battery’s rated capacity is being delivered, the battery should be either repaired or replaced, depending upon its age and overall condition.

For more detailed information on capacity testing, contact East Penn Manufacturing Company or your local authorized Deka Representative.

### **Correcting a Sulfated Battery**

If batteries are not operating full shifts, heat while on charge and after charge, and if temperature corrected specific gravity readings are below the manufacturer’s specifications, the batteries may be sulfated.

To restore a sulfated battery to good condition, carefully follow this procedure:

1. Thoroughly clean the battery.
2. Add water to bring the electrolyte to the proper level in all cells.
3. Charge the battery at the prescribed finishing rate until the specific gravity shows no change for a three-hour period with readings taken hourly. Record on-charge voltage and specific gravity readings. Temperature correct the specific gravity readings using the chart (Table 3-1) in Section III. If the temperature rises to above 115°F (46°C) at any time, stop the charger and allow the battery to cool to 90°F (32°C) or lower, then continue the charge and monitor the specific gravity as described above. If the charger is automatic, be sure it is capable of charging the battery at the prescribed finish rate. A constant current charger that can maintain the correct finish rate is preferred. If the battery is badly sulfated, the specific gravity may only rise 30 to 40 points (0.30 to 0.40) during the first charge.
4. Fully discharge the battery.
5. Repeat step #3 until the specific gravity remains unchanged for three hours. In extreme cases of sulfation, two or more discharges and recharges, per the above instructions, may be necessary to restore the battery to full capacity. (Percent capacity capable of being restored is a function of overall battery age and condition). If the battery hasn’t responded, it may be sulfated beyond repair and should be replaced. If the specific gravity rises to within ten points of a fully charged battery, then place the battery back into normal service.
6. Before condemning the battery, one last check should be made to make sure the battery has not simply lost acid by dumping or over-filling. Adjust the specific gravity to the manufacturer’s specification (see Table 4-1 - Procedure for Adjusting the Specific Gravity of the Electrolyte of a Battery).

Conduct a capacity test. If the battery delivers over 90% of its rated six hour capacity, the battery may be returned to service. If the capacity on discharge remains low, the battery should be replaced.

**IMPORTANT** - Only experienced battery technicians should perform the above technique.

## SECTION IV — BATTERY MAINTENANCE AND TROUBLESHOOTING (cont.)

**Table 4-1**

PROCEDURE FOR ADJUSTING THE SPECIFIC GRAVITY  
OF THE ELECTROLYTE OF A BATTERY

1. When it is necessary to raise or lower the specific gravity of the electrolyte of a battery to the manufacturer's recommended specific gravity, follow the procedure given below.
2. The recommended specific gravity for some of the Deka industrial battery styles is shown in Table 1. For example, a 12-D85-13 battery would have a recommended specific gravity of 1.290.
7. Care should be taken during equalizing charging and acid adjustment charging to make sure that the electrolyte temperature does not exceed 115°F.

TABLE I

Battery Style or Type	Recommended Specific Gravity at 77°F
D prefix	1.290
H prefix	1.300
M prefix	1.250
P prefix	1.325
DL/DLU	1.250

3. This specific gravity is always determined when the battery is fully charged, with the electrolyte level at the bottom of the vent well tube while the battery is on charge at the finish rate or less.
4. The term "finish rate" refers to a constant charging rate in amps which is equal to 5% (.05) of the rated six hour capacity (8 hour for diesels) of the battery. For example, the finish rate of a D100-13 battery with a rated 6 hour capacity of 600 AH (ampere hours) would be:  $600 \times .05 = 30$  amps.
5. The battery should first be given an equalizing charge to make sure it is fully charged. An "equalizing charge" is an extended charge at the finish rate after completion of a regular charge. Usually 3 or 4 hours until four voltage and specific gravity readings, corrected for temperature, taken 1/2 hour apart, remain constant.
6. Since the electrolyte temperature will affect the on-charge voltage and specific gravity readings, all readings must be corrected for temperature to a standard 77°F. Refer to Section III, Table 3-1, Specific Gravity Temperature Corrections.
8. As it is necessary to add acid to the cell in order to raise the specific gravity of the electrolyte, sulfuric acid of 1.400 specific gravity shall be used. It should be remembered that 1.400 specific gravity sulfuric acid has an acid content of 50.5% by weight and is potentially a very dangerous material to the person using it. All standard safety precautions should be taken, especially those which will protect personnel from splashes into the eyes and onto the skin. Acid resistant gloves, apron, boots, face shield and /or goggles should be standard equipment. Running water from a hose and/or ready access to an eye-wash fountain is important for safety.
9. With the battery on charge at a constant finish rate, remove between a 1/4" to 1/2" of electrolyte with a syringe for every 5 points of change required. This is only a rough approximation since the amount of change will vary with every cell type with a greater change on the shorter cells and a smaller change on the taller cells. Replace the electrolyte removed with 1.400 specific gravity sulfuric acid. Continue to charge the battery after acid addition until the specific gravity becomes constant, about 1/2 to 1 hour.
10. Repeat the above procedure until the specific gravity of the electrolyte, corrected for temperature, reaches the desired value.
11. If the specific gravity must be lowered instead of raised, water can be used instead of 1.400 specific gravity acid in the procedure given above.

## SECTION IV — BATTERY MAINTENANCE AND TROUBLESHOOTING (cont.)

**Table 4-2**  
STORAGE BATTERY TROUBLESHOOTING CHART

Symptoms	POSSIBLE CAUSE	POSSIBLE REMEDY
Battery overheats during charge	<ol style="list-style-type: none"> <li>1. Malfunctioning Charging Equipment</li> <li>2. Charging equipment out of adjustment</li> <li>3. Defective or weak cell(s)</li> <li>4. Battery worn out and beyond economical repair</li> <li>5. High resistance connection within battery</li> <li>6. Low electrolyte level</li> <li>7. Battery charged in the vehicle with battery compartment closed or the tray cover closed</li> <li>8. Battery over 100 degrees F when placed on charge</li> </ol>	<ol style="list-style-type: none"> <li>1. Replace or repair defective charger parts (timer, voltage sensitive relay, control board, etc.)</li> <li>2. Adjust start and/or finish charging rates</li> <li>3. Replace or repair problem cell(s)</li> <li>4. Replace battery</li> <li>5. Check for hot wires, cells, intercell connectors, charging plugs, etc. Repair or replace defective component(s)</li> <li>6. Add water; just cover separator protector when discharged</li> <li>7. Open the compartment during charge or charge the battery out of the unit with the tray cover opened</li> <li>8. Allow battery to cool below 90 degrees F before charging</li> </ol>
Battery overheats during charge	<ol style="list-style-type: none"> <li>1. See causes 3 through 8 above</li> <li>2. Worn out bearings, brakes dragging, or other vehicle problem causing high discharge rates</li> <li>3. Overdischarge of battery</li> </ol>	<ol style="list-style-type: none"> <li>1. See remedies 3 through 8 above</li> <li>2. Repair or replace defective unit problems</li> <li>3. a. Require drivers to return battery for recharge when vehicle begins to slow down. b. Put more batteries into service</li> </ol>
Battery not completing full work shift	<ol style="list-style-type: none"> <li>1. Battery not fully charged before placed into operation</li> <li>2. Weak, leaking or defective cell(s) in battery</li> <li>3. Ground or shorts in the battery</li> <li>4. Battery worn out and beyond economical repair</li> <li>5. Battery too small for job</li> <li>6. Electrical or mechanical problem</li> </ol>	<ol style="list-style-type: none"> <li>1. See that battery has reached full charge specific gravity before placing into operation</li> <li>2. Repair or replace cell(s) or battery</li> <li>3. Remove grounds or shorts</li> <li>4. Replace battery with equal or higher capacity battery</li> <li>5. a. Replace battery with one having higher capacity b. Purchase extra batteries (with higher capacity if possible) and change them more frequently</li> <li>6. Troubleshoot vehicle and repair</li> </ol>

**SECTION IV – BATTERY MAINTENANCE AND TROUBLESHOOTING (cont.)**

**Table 4-2 – Cont.**

<b>Symptoms</b>	<b>POSSIBLE CAUSE</b>	<b>POSSIBLE REMEDY</b>
Low electrolyte	1. Cracked or broken Jar(s) (Look for electrolyte puddles on floor)	1. Replace jar(s) and adjust gravity
	2. Cell missed when watered	2. More careful attention when watering
	3. Defective or weak cell(s)	3. Repair or replace cell(s)
	4. Frequent overcharge	4. See items 1 and 2 in “Battery Overheats During Charge”
	5. Battery not regularly watered	5. Water battery regularly
Unequal cell voltages	1. Grounds in battery	1. Clean battery
	2. There is a “tap” off the battery for auxiliary equipment (radio, light, etc.)	2. a. Use dropping resistor instead of tap b. Equalize battery regularly
	3. Battery sluggish due to lack of work	3. Give battery a deep discharge and equalizing charge
	4. Leaking cell or cover	4. Replace jar or cover and adjust gravity
	5. Defective or weak cell(s)	5. Repair or replace defective cell(s)
	6. Battery worn out and beyond economical repair	6. Replace the battery
	7. Acid loss in few cells by tipping battery over	7. Adjust specific gravity

# BASIC RULES FOR BATTERY CARE AND MAINTENANCE

**RULE 1: BE CAREFUL! ALWAYS WEAR FACE SHIELD OR SAFETY GLASSES WHEN WORKING ON OR NEAR BATTERIES!**



**DANGER** Contains: Lead, Sulfuric Acid (Electrolyte), Lead Compounds.

Harmful if swallowed, inhaled, or in contact with skin. Acid causes severe skin burns and eye damage. May damage fertility or the unborn child if ingested or inhaled. May cause harm to breast-fed children. May cause cancer if ingested or inhaled. Causes skin irritation, serious eye damage. Contact with internal components may cause irritation or severe burns. Causes damage to central nervous system, blood and kidneys through prolonged or repeated exposure if ingested or inhaled. Irritating to eyes, respiratory system, and skin. May form explosive air/gas mixture during charging. Extremely flammable gas (hydrogen). Explosive, fire, blast or projection hazard.

Obtain special instructions before use. Do not handle until all safety precautions have been read and understood. Wash thoroughly after handling. Do not eat drink or smoke when using this product. Avoid contact during pregnancy/while nursing. Wear protective gloves/protective clothing, eye protection/face protection. Use only outdoors or in a well-ventilated area. Avoid contact with internal acid. Do not breathe dust/fume/gas/mist/vapors/spray. Keep away from heat/sparks/open flames/hot surfaces. No smoking. IF SWALLOWED OR CONSUMED: rinse mouth. Do NOT induce vomiting. Call a poison center/doctor if you feel unwell.

IF ON CLOTHING OR SKIN (or hair): Remove/take off immediately all contaminated clothing and wash it before reuse. Rinse skin with water/shower. IF INHALED: Remove person to fresh air and keep comfortable for breathing. Immediately call a POISON CENTER or doctor/physician. IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. If exposed/concerned, or if you feel unwell seek medical attention/advice. Store locked up, in a well-ventilated area, in accordance with local and national regulation. Dispose of contents/container in accordance with local and national regulation. Keep out of reach of children.

**PROPOSITION 65 WARNING:** Battery posts, terminals and related accessories contain lead and lead compounds, chemicals known to the State of California to cause cancer and reproductive harm. Batteries also contain other chemicals known to the State of California to cause cancer. **WASH HANDS AFTER HANDLING.**

**WARNING:** Risk of fire, explosion or burns. Do not disassemble or incinerate. Not recommended for inverted use. Follow product charging instructions. **High Voltage:** Risk of shock. Do not touch uninsulated terminals or connectors.

**Keep Vent Caps Tightly in Place**

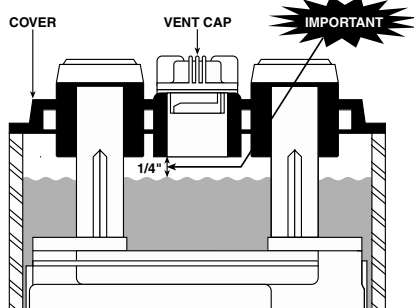
**Manufactured by:**  
East Penn Manufacturing Co.  
102 Deka Road,  
Lyon Station, PA 19536  
610-682-6361 USA

**Lead Acid  
Battery  
Electrolyte  
(Sulfuric Acid)**

## PROVIDE ADEQUATE VENTILATION WHEN CHARGING

**RULE 2: Keep battery tops clean and dry.**

**RULE 3: Check battery electrolyte level weekly.**



### KEEP ELECTROLYTE LEVEL BELOW FILLING WELL AS SHOWN

Add approved water to 1/4" below vent well only at the end of charge. Filling to this level before charging will cause acid overflow. Acid attacks external battery parts. Any acid loss from the battery will result in power loss and shortened life.

**RULE 4: Make sure charger is OFF before connecting or disconnecting the battery to prevent dangerous sparks.**

**RULE 5: Use proper size charger and follow charger instructions carefully.**

**RULE 6: Recharge FULLY after each duty cycle. Avoid partial recharging.**

**RULE 7: Remove vent caps only when checking or filling. KEEP CAPS ON when battery is in use, on charge and when cleaning battery top.**

**RULE 8: Batteries with steel covers should be recharged with covers in the open position.**

**RULE 9: Be careful...first and last.**

Fig. IV-1

## SECTION V – VALVE REGULATED LEAD-ACID BATTERIES



Fig. V-1

In the lead-acid battery, according to basic electrochemical principals, complete sealing cannot be accomplished because the generation of hydrogen cannot be completely avoided. The valve has to open periodically to let small amounts of gas, mainly hydrogen, escape from the cell. Otherwise, the internal pressure would exceed tolerable limits. Gradual water loss is connected with this gas evolution, and this water loss causes slight changes in the cell parameters during service life. But the rate of water loss can be kept so low that the initial amount of electrolyte is sufficient for a service life of five years or more.

Valve-regulated lead-acid batteries can be constructed using gelled electrolyte as well as absorbent glass mat separators (AGM). Which immobilizing method is used, often depends upon the application and manufacturer. For deep cycle applications such as motive power, gelled electrolyte is more suitable. The gelled electrolyte requires a separator to prevent short-circuits between the electrodes. This additional separator causes additional resistance. Therefore, the internal resistance of comparable batteries is slightly higher with gelled electrolyte, thus such batteries are not as suitable in extreme high load current with short duration requirements such as UPS applications.

### Operation of a Gel Cell

During the overcharge period of the recharge, oxygen is generated from the positive plates in all lead-acid batteries. This oxygen is trapped in the gel cell by a special vent valve forcing the oxygen to the negative plate through tiny fissures or cracks in the gelled electrolyte. When the oxygen contacts the negative active mass (sponge lead), it oxidizes the negative active mass to lead oxide. The lead oxide reacts with the sulfuric acid to form lead sulfate and water. At the same time, during the charging process, this lead sulfate is converted back to sponge lead and sulfuric acid. This "recombination" process prevents water loss.

The vent valve is critical to the performance of the gel cell. The cell must maintain a positive internal pressure. Otherwise, the oxygen will escape, and the cell will dry out and not perform.

In addition the valve must safely release any excess pressure that may be produced during overcharging, or else the cell would be irreparably damaged.

It's important to note that a gel cell must never be opened once it leaves the factory. Opening the cell will allow excess atmospheric oxygen to enter the cell and discharge the negative plates. This will cause an imbalance that will destroy the recombination chemistry. This imbalance of chemistry will permanently damage the cell beyond repair.

### Charging a Gel Cell

While our gel cell will accept a charge extremely well due to its internal resistance, any battery will be damaged by continual under-or overcharging. Capacity is reduced and life is shortened.

Abusive overcharging is especially harmful to gel cells because of their sealed design. Abusive overcharging dries out the electrolyte by driving the oxygen and hydrogen out of the battery through the sealing vents. Performance and life are reduced.

If a battery is continually undercharged, a power-robbing layer of sulfate can build up on the positive plate, which acts as a barrier to electron flow. Premature plate shedding can also occur. Performance is reduced and life is shortened.

Therefore, it is critical to use a charger that limits voltage to 2.55 volts per cell at 77°F ± 2° at the end of charge. If the charger can reduce the voltage as the temperature rises, or increase the voltage as the temperature decreases, this will help to prevent under-or overcharging. The warranty is void if improperly charged. The supplied on board charger for Gelmate, or the Ultra Charger with the D.S.G. Sealed Lead-Acid Battery charge curve profile, or any other EPM-approved motive power gel cell charger must be utilized to recharge gel cell batteries. Constant current charges or ferroresonant charges should NEVER be used on gel cell batteries. (See Fig. V-2).

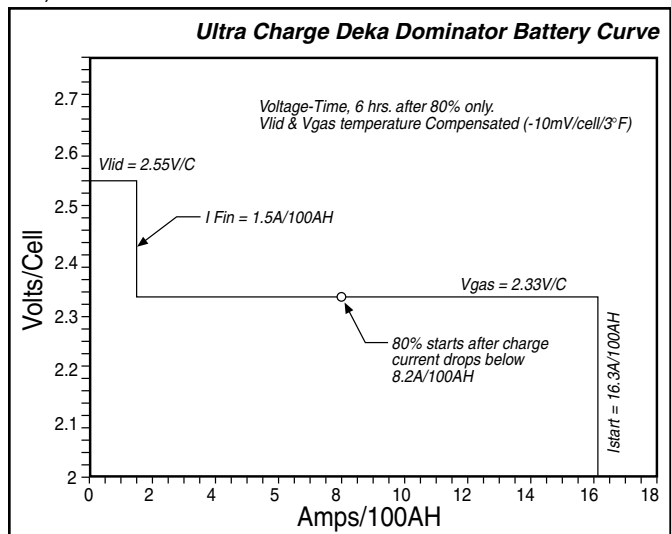


Fig. V-2



# **OPERATING INSTRUCTIONS**

## **SEALED VALVE REGULATED LEAD ACID (SVRLA) GELLED ELECTROLYTE BATTERIES**

**WARNING:** *Charging shall be performed by using only the supplied on-board charger for Gelmate, or the Ultra Charge Charger with the D.S.G. Sealed Lead-Acid Battery charge curve profile, or any other EPM-approved motive power gel electrolyte charger.*

*The valve-regulated vent should not be removed. Removal of the vent will adversely affect the battery's life and performance.*

*The battery's warranty will be void if these guidelines are not followed.*

1. Upon receipt of the battery, if there are signs of rough handling, or exposed electrolyte, or loose or missing vent(s), file a claim with the carrier and advise your East Penn representative.
2. Check the nameplate of your charger against the nameplate of the battery to make sure they both show the same voltage and that the six-hour ampere hour capacity of the battery falls within the recharge range of the charger.
3. The "Battery Type Identification" shown on the battery (E, EO), should match the "Battery Type Identification" specified on the truck nameplate.
4. Make sure that the battery "SERVICE WEIGHT," which is stamped below the lifting hole in the steel tray, falls within the battery weight range shown on the truck nameplate. East Penn Manufacturing Co., Inc. cannot be responsible for determining that the battery weight is sufficient to counterbalance your particular truck.
5. The battery should receive an equalizing charge prior to placing the battery into service. The battery shall be charged by using the supplied charger. The equalizing charge is complete when the charger automatically terminates. No other charger should be used unless approved by East Penn. Doing so will void the warranty. If the voltage falls below 2.14 volts or at a minimum of every 6 weeks the battery should receive a freshening charge.
6. The battery shall be placed on charge at the end of the work shift and the charge should continue until the charger terminates the charge automatically. All vents should be unobstructed and securely tightened. The steel tray cover or the truck compartment should be kept open during the entire duration of charge.
7. Overcharging and undercharging a sealed gel electrolyte battery will greatly affect the life of the battery.
8. Measuring the open circuit voltage provides a way to determine the state of charge of the battery. The open circuit voltage shall be taken with a voltmeter. Voltage measurements should be taken no earlier than 4 hours on open circuit following a charge.

### **STATE OF CHARGE VS. OPEN CIRCUIT**

% Charge	Open Circuit Voltage
100 .....	2.15 – 2.18
75 .....	2.12
50 .....	2.07
25 .....	2.01
0 .....	1.97

9. EPM recommends when lifting a battery that an insulated lifting beam be used. Also, make certain that the lifting hooks are the correct size and are properly aligned with the holes in the lifting ears of the tray prior to hoisting a battery.

## **MAINTENANCE INSTRUCTIONS**

### **SEALED VALVE REGULATED LEAD ACID (SVRLA) GELLED ELECTROLYTE BATTERIES**

***WARNING: Always wear safety glasses when working around batteries!  
Keep sparks and flames away! The valve regulated pressure relief valve should never be removed or loosened!***

1. The top of the battery should be kept clean and dry at all times. Simply clean the top of the battery with a damp cloth. The valve regulated vent and shroud shall remain on the battery at all times.
2. The cables and connectors should be inspected monthly for exposed copper wires, frayed or cracked insulation, loose connections, or pitted contacts, and repaired as required.
3. Be especially careful to keep metallic objects off the top of the battery. Any metal touching two or more connectors may cause a short circuit resulting in an arc or spark which ignites battery gasses explosively.
4. The output rate and voltage of the charger should be checked periodically. Make certain that the DC voltage and ampere hour range of the charger match the nameplate information on the battery.
5. Depending on the type of service, it will be necessary to give the battery an equalizing charge every one to four weeks. Set the charger to the equalize position.

<b>Type</b>	<b>Plates per Cell</b>	<b>5</b>	<b>7</b>	<b>9</b>	<b>11</b>	<b>13</b>	<b>15</b>	<b>17</b>	<b>19</b>	<b>21</b>	<b>23</b>	<b>25</b>	<b>27</b>	<b>29</b>	<b>31</b>	<b>33</b>
<b>G45</b>	6 Hr. A. H. Rating	—	—	180	225	270	315	360	405	—	—	—	—	—	—	—
<b>G75</b>	6 Hr. A. H. Rating	150	225	300	375	450	525	600	675	750	825	900	975	1050	1125	1200
<b>G105</b>	6 Hr. A. H. Rating	—	—	—	525	630	735	840	—	—	—	—	—	—	—	—

## SECTION VI — BATTERY REPAIR

### *Repair or Replace?*

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 or 2 years old (300 - 600 cycles), if it hasn't been severely overcharged or overdischarged, and if the estimated repair costs don't exceed 25% of the replacement cost, 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 totalling 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 East Penn battery repair facility or arrange to have an East Penn 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.**

### *Gas Purging*

Before beginning cell/jar replacement, remove the vent caps from the damaged cell and all surrounding cells and give trapped gas time to dissipate. Flush any remaining explosive gases out of the cell by fanning the vent well opening with a stiff piece of plastic or cardboard. Do not use compressed air as the force of the air stream may splash electrolyte out of the cell and into the face or eyes (Fig. VI-1).

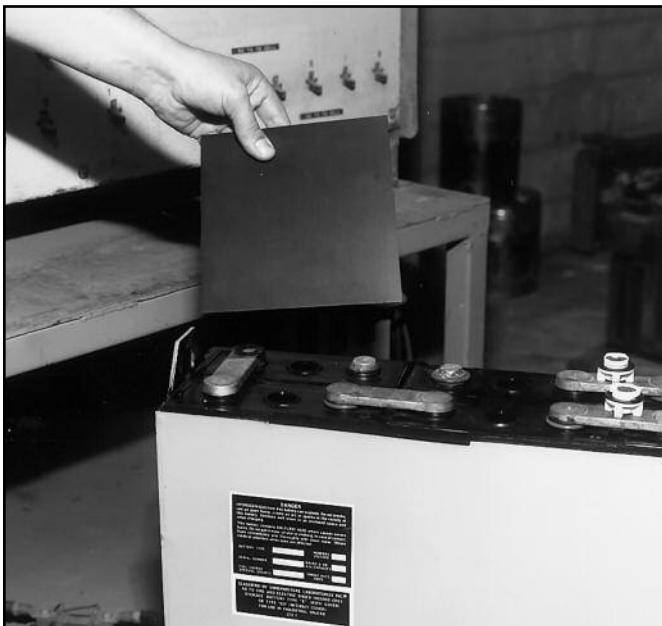


Fig. VI-1

After all the gas has been removed, cover the vent holes or the SVLRA valve/vent with a damp cloth and continue with the repairs.

### *Removing Connectors*

To remove a complete cell (jar, element and cover) from a battery or to remove an element from a jar, you first have to take off the intercell connector shrouds from the cell(s) being removed. Then remove the intercell connectors, connecting those cells to the rest of the battery, with a drill. Use a special East Penn post saver drill, which will drill through the connector but leave the center of the post in place (Fig. VI-2).



Fig. VI-2

Be careful that lead curls from the drilling don't cause short circuits or drop into neighboring cells. After drilling is completed, lift connector off with a pair of pliers.

### *Removing a Cell*

The vast majority of batteries being manufactured today incorporate a heat bonded cover-to-jar seal. The cover and jar material is polypropylene. This design is easily distinguishable because the vent well lip is almost flush with the top of the cover.

A few manufacturers continue to use the older compound cover-to-jar seal. The cover is a hard rubber material and can be identified by the very high vent well lip. The cover sets down inside of the jar and the seal is made with a hot asphalt material.

If the battery being repaired has the older cover-to-jar asphalt seal, proceed as follows. After all connectors have been removed from the cell, separate the cell from the tray and from the surrounding cells by cutting through the sealing compound with a warm putty knife or similar tool. (Fig. VI-3). Work the tool down to the cover/jar seal. When all sealing compound has been removed around the cell, attach post lifters to the negative posts and use a block and tackle or a lifting beam to lift the cell from the battery (Fig. VI-4). Never lift a cell or an element by the positive posts. Always use the negative posts.

## SECTION VI — BATTERY REPAIR (cont.)



Fig. VI-3

Once the cell has been removed, inspect the jar for leakage and replace it if necessary. Be sure to clean the tray bottom and side area before replacing the cell. Neutralize any acid or corrosion (see Neutralizing Acid and Electrolyte — Section II) and scrape off any residue.



Fig. VI-4

If removing a heat bonded cover-to-jar designed cell, it is important to note that some manufacturers add a compound pour between cells and the tray edge, in addition to the heat bonded cover-to-jar feature. If the battery being repaired has the compound pour, proceed as explained in this section for the compound cover-to-jar seal design. If the heat bonded cell is in a battery without the additional compound pour, simply proceed to remove the cell as instructed in this section without having to remove the compound seal.

### ***Removing an Element***

If the jar is known to be serviceable, it may not be necessary to remove the complete cell. Usually only the element, complete with cover, has to be pulled. This can only be done however, on those batteries containing a compound type cover-to-jar seal. On these, after removing intercell connectors, draw a warm putty knife through the sealing compound close to the inside jar wall. Use the post lifters and hoist to raise the element, with cover in place, first to drain position, and then up and out of the jar.

When pulling an element from a cell which has been removed from a battery, use jar hold-down clamps.

The most common type of cover-to-jar seal is a heat bonded or seal design. The bottom perimeter surface of the cover and top perimeter surface of the jar are simultaneously melted, then fused together by a heat sealing machine. With this design, if an internal cell defect occurs, the complete cell must be pulled and cover-to-jar seal cut or sawed to permit removal of the ele-

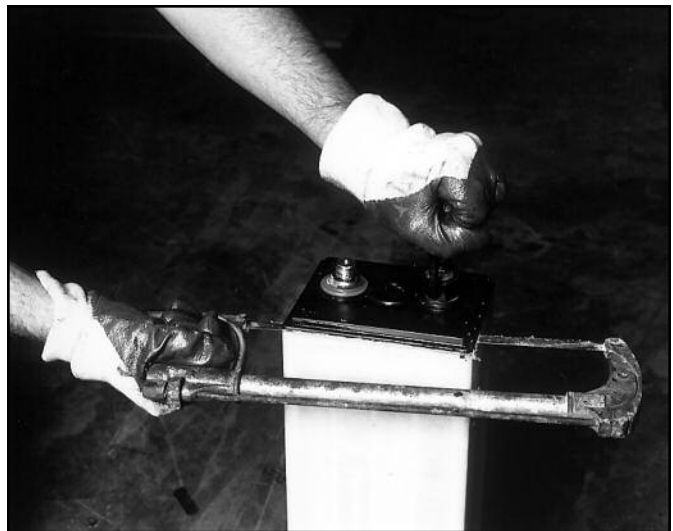


Fig. VI-5

ment (Fig. VI-5). If care is taken in cutting the cover-to-jar seal, these components can be used again when reassembling the cell. Otherwise both a new cover and jar may be needed to complete the reassembly.

## SECTION VI — BATTERY REPAIR (cont.)

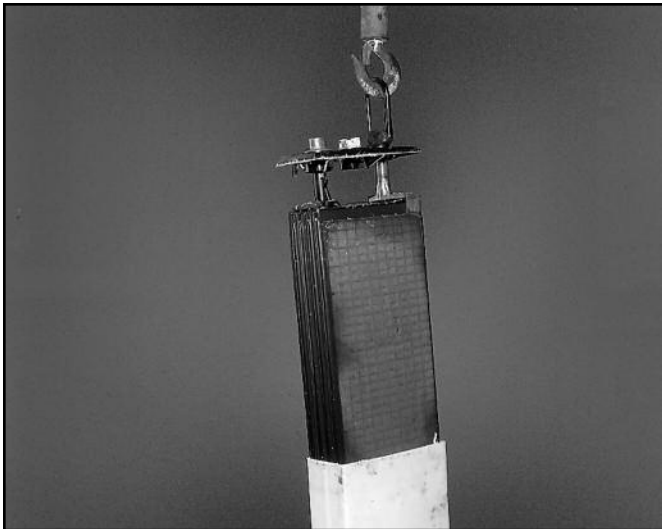


Fig. VI-6

When removing an element, lift it halfway out of the jar and hold it at this position until most of the electrolyte has drained off (Fig. VI-6). Then raise the element to clear the top of the jar. Do not, unless absolutely necessary, expose an element to air longer than five minutes. Oxygen in the air combines with the active material in the negative plates, causing them to oxidize and heat. If the exposure persists, negatives will discharge. While the element is out of the jar, check the sediment chamber in the bottom of the jar. If it is full of sediment material, the cell will probably have to be replaced, if not now, in the near future.

Plate and separator edges may be inspected while the element is suspended above the jar. A more thorough inspection of separators, plate insulation, grids, and active materials may be indicated. If so, lay the element on its side on a clean non-metallic surface. The plates should be at right angles to the table surface so the element can be fanned slightly to permit the removal of separators if required (Fig. VI-7).



Fig. VI-7

When reinstalling separators, make certain that the flat side of the separator is against the negative plate and the ribbed side is facing the positive. They should be pushed up until they are flush with the bottom of the element and they should project equally on each side of the plates.

Before installing an element in a previously used jar, wash out any sediment which may have accumulated in the bottom of the jar and clean all compound from around the inside of the top edge (if the battery has a compound seal).

Clamp the element, if necessary, when reinstalling it in the jar. Make certain the element is entering the jar properly and that the plates are at right angles to the plate rest support ribs in the bottom. When installing an element with a hard rubber, compound sealed cover attached, use a putty knife to guide the lip of the cover past the top edges of the jar.

### Reassembling the Battery

If the cell being reassembled, has a heat seal cover-to-jar design, and if care was taken cutting the seal when removing the element, the cover and jar can probably be heat sealed again. If not, a new cover and jar will be needed. Be sure to reinstall the cover with the positive post(s) protruding through the cover post holes marked positive (+). If the cell design incorporates floating positive post seals, push them down firmly over the positive posts until they seat flush on top of the cover after sealing the cover to the jar. Some designs have lead inserts or bushings already molded into both the negative and positive cover post holes. In both cases, these floating post seals and/or lead cover bushings are welded or burned to the terminal posts to prevent electrolyte leakage around the posts using a post burning ring (Fig. VI-8). Before using an open flame to weld the posts and cover bushings, you must once again eliminate any gas from the repaired cell and all surrounding cells. (See Gas Purging in this section.)



Fig. VI-8

Since special techniques must be used when resealing the cover to jar, East Penn recommends that these cover-to-jar seals not be repaired in the field. Instead, such repairs should be made in authorized East Penn service stations only.

If the cell being reassembled has the sealing compound, cover-to-jar seal, an asphalt type compound is applied to seal the cover to the jar. These covers will have lead bushings molded into both the positive and negative posts. Be sure to reinstall the cover with the positive post(s) protruding through the cover post holes marked positive (+). These cover bushings are welded or burned to the terminal posts to prevent electrolyte leakage around the posts, using a post burning ring.

## SECTION VI — BATTERY REPAIR (cont.)

Cells from which elements were pulled, or which had damaged jars or covers replaced, should be given an equalizing charge and acid should be adjusted immediately following repair and before they are returned to service.

When installing repaired cells or new cells back into the battery, use post lifters, attached to the negative posts, and a block and tackle or lifting beam to lower the cell into the tray (Fig. VI-9). Be sure the polarity is correct when you reassemble the battery - cell terminals should be matched positive (+) to negative (-) and negative (-) to positive (+) with connecting cells.

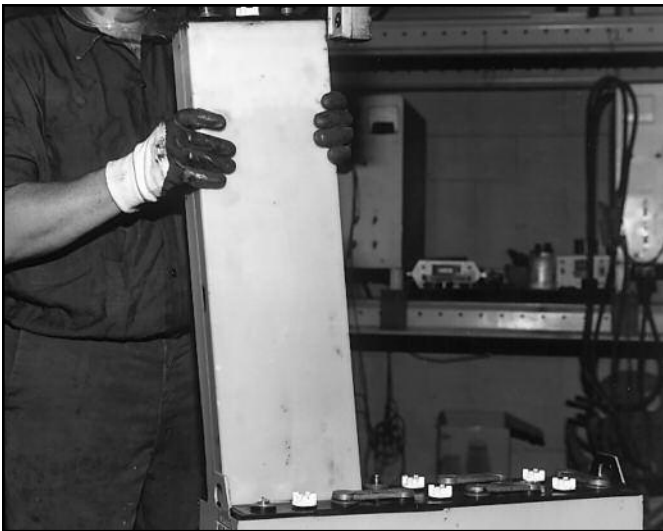


Fig. VI-9

### **Attaching Intercell Connectors**

Use a wire brush to clean the posts and the connectors that will be reattached to the cells. Have the vent caps in place during wire brushing - do not allow lead particles or pieces of the wire brush to fall into the cells. Clean all lead chips and wire pieces from the battery top before proceeding. Install the connectors and then use a connector button mold and a torch to melt the connectors to the posts (Fig. VI-10). Again, take the necessary precaution to remove trapped explosive gases before using an open flame on top of the battery. (See Gas Purging this section.)



Fig. VI-10

### **Replacing Acid and Charging**

When replacing electrolyte in a repaired cell, use only sulfuric acid that has the same specific gravity as the acid in the majority of the other cells. Fill the cell to 1/4" below the vent well and then replace the vent cap. Put the battery on an equalizing charge, make another check of the specific gravity and electrolyte level in each cell, and then return the battery to service.

## GLOSSARY

**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** Process for making a dry charged cell functional by introducing electrolyte.

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

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

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

**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. See also "AMPERE-HOUR METER".

**Ampacity** Current carrying capacity in amperes.

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

**Ampere-Hour** A measure of the volume of electricity, being one ampere for one hour, or 3600 coulombs. It is used to express battery capacity, and is registered by an ampere hour meter, or is obtained by multiplying the current in amperes by the length of time that the current is maintained.

**Ampere-Hour Capacity** The number of ampere-hours which can be delivered under specified conditions as to temperature, rate of discharge, and final voltage.

**Ampere-Hour Efficiency** 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 instrument that registers the quantity of electricity in ampere-hours.

**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.

**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.

**Boost Cells** Cells with higher capacity than the tests cells which are used to help maintain constant discharge current in a manual discharge test.

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

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

**Bridge** The ribs or elements supporting structure, 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 parts such as plates, straps, connector; by means of heat and in some cases, additional metal 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 stick of convenient size 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 (Cd)** A metallic element highly resistant to corrosion, used as a protective plating on certain steel parts and fittings.

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

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

**Capacity**  
See "AMPERE HOUR CAPACITY".

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

**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 of plastic or glass used to ship acid.

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

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

**Cell (Storage)** A storage (secondary) cell is an electrolytic cell for 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 sulfate, while the negative plates contain a maximum of sponge lead and a minimum of 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 ready to deliver current.

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

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

**Charging Rate** 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 electric current is intended to flow. The continuous path of an electric current.

**Compound** An asphaltic, pitchlike material used as a cover-to-jar battery sealant.

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

**Constant Potential Charge**  
See "CONSTANT VOLTAGE CHARGE".

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

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

## GLOSSARY (cont.)

**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 are burned the element posts thereby creating an effective acid-creep resistant seal.

**Curing** Chemical conversion process which changes lead oxides and sulfuric acid to mixtures of tetrabasic lead sulfate, other basic lead sulfates, basic lead carbonates, etc., which consequently will form desired structures of Pb or PbO<sup>2</sup> on negative or positive plates during formation.

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

**Cut-Off Voltage**  
See "FINAL VOLTAGE".

**Cutting (of acid)** The dilution of a more concentrated solution of sulfuric acid to a lower concentration.

**Cycle** A discharge and its subsequent recharge.

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

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

**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** The conversion of the chemical energy of the battery into electrical energy.

**Discharged** The condition of a storage cell when as the result 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.

**Dry Charging** Manufacturing process whereby charged plates are washed free of acid and then dried.

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

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

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

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

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

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

**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 rate of charge expressed in amperes to which the charging current for some types of lead batteries is reduced near the end of charge to prevent excessive gassing and temperature rise.

**Fixed Resistance Discharge** A discharge in which the cell or battery is discharged through a fixed resistive load. The current being allowed to fall off as the terminal voltage decreases.

**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.

**Float Charging** Application of a recharge at a very low rate and accomplished by connection to a buss whose voltage is slightly higher than the open circuit voltage of the battery.

**Flush** To add water to a cell.

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

**Foot** Portion(s) of the grid projecting from the bottom edge, used for support of the plate group.

**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 batteries in storage to replace the standing loss and to ensure that every plate in every cell is periodically brought to a full state of charge.

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

**Gang Vent** Vents for usually three adjacent cells which are connected to a common manifold. Typically used on SLI's.

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

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

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

**Gravity** Refers to specific gravity.

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

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

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

**Hand Stand** Manually operated casting mold into which lead or alloy is manually poured.

**High Impact Rubber**  
See RESIN RUBBER.

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

**H<sup>2</sup>SO<sup>4</sup>** Chemical symbol for Sulfuric Acid.

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

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

**Hydroset** Curing process for negative and positive plates, wherein free lead in the paste is oxidized and total free lead is reduced to a few per cent.

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

**Initial Voltage** 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** A bushing of lead or lead alloy molded or sealed into cell covers, forming the post hole, and to which the post is burned to create a creep-resistant cover-to-post seal.

**Intercell Connector** Conductor of lead, lead alloy or lead plated copper which is used to connect two battery cells.



## GLOSSARY (cont.)

**Internal Resistance** The resistance within the 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.

**Jackstraw Mats**  
See GLASS MATS.

**Jar** Cell container, made by injection molding, rota-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 cutout 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)** Chemical element used in lead-acid batteries (with sulfuric acid and other materials).

**Lead Burning** 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 the 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. Its formula is  $PbO_2$ .

**Lead Plated Part** A metallic part that has had a thin protective layer of metallic lead electrodeposited on its surface.

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

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

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

**Level Lines** Horizontal lines molded and/or painted near tops of battery jars, which indicate minimum and maximum electrolyte level.

**Life** Number of years of satisfactory float operation or number of charge-discharge cycles for motive power operation.

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

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

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

**Machine Casting** A fully or semi-automatic grid or small parts casting operation.

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

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

**Marine Battery** A battery designed for ship-board installation to provide energy for cranking service and the operation of emergency lighting, alarm, and communication equipment.

**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.

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

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

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

**Mold Spray**  
See MOLD COAT.

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

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

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

**Negative Plate** Consists of the grid and active material to which current flows from the external circuit when the battery is discharging.

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

**OHM** A unit of electrical resistance.

**One Shot Formation** Jar formation under conditions where 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 voltage at its terminals when no appreciable current is flowing.

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

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

**Panel** Casting consisting of two or more grids which has been made simultaneously in a single mold.

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

**Parallel Connection** See PARALLEL ASSEMBLY.

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

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

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

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

**Pb** Chemical symbol for lead.

## GLOSSARY (cont.)

**PbO** Chemical symbol for litharge.

**PbO<sub>2</sub>** Chemical symbol for lead peroxide (dioxide).

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

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

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

**Plate** A pasted grid, either formed or unformed.

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

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

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

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

**Positive Plates** Consists of the grid and the active material from which current flows to the external circuit when the battery is discharging.

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

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

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

**Potential**  
See VOLTAGE.

**Primary Cell**  
See CELL PRIMARY.

**Pure Lead**  
See PIG LEAD.

**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 specified cut off voltage.

**Rate of Charge**  
See "STARTING RATE" "FINISHING RATE".

**Raw Plate** An unformed plate.

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

**Red Lead (Pb<sub>3</sub>O<sub>4</sub>)** 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.

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

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

**Rib** A vertical or 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** 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 from the plates and found in the bottom of cells.

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

**Self Discharge** Loss of charge due to local action.

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

**Separator Protector**  
See "MOSS SHIELD".

**Shedding** Loss of active material from the plates.

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

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

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

**Smelting** The process by which the major portion of lead and antimony are recovered from scrapped batteries and battery manufacture 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 formation and tank formation.

**Soda Ash** Sodium Carbonate (Na<sup>2</sup>CO<sup>3</sup>), used to neutralize effluents containing sulfuric acid, or acid spills.

**Spine** Cast Pb alloy conductor for tubular positive plate.

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

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

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

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

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

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

**Stationary Battery** A stationary battery is a storage battery designed for service in a permanent position.

**Strap** Precast or cast-on piece of lead or lead alloy used to connect plates into groups and to connect the groups to the post.

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

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

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

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

**Sulfuric Acid (H<sup>2</sup>SO<sup>4</sup>)** The principal acid compound of sulfur. Sulfuric acid of a high purity and in dilute form is the electrolyte of lead-acid storage cells.

**Tank Formation** The electrolytic processing of plates in large tanks of acid, at a point of manufacture prior to assembly. See also "FORMATION" "DUMMY FORMATION".

## GLOSSARY (cont.)

**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 of which is connected to the terminal post of a battery, the other end being 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** Steel enclosure for motive power battery cells.

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

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

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

**TVR** A temperature compensating voltage relay used in charging equipment.

**Two Rate Charging** An automatically controlled constant current or modified constant potential charging procedure. The charge is begun at a fairly high rate and is automatically reduced to a lower rate when the counter voltage rises to a predetermined level.

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

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

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

**Uncharged and Moist** A condition in which a battery or cell may be shipped to a customer. Adopted by BCI and indicates that the battery is assembled with formed plates and moist or wet wood separators, without electrolyte. Filling and a long charge are required.

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

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

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

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

**Vent Assembly** A cell venting device consisting of a ceramic vent stone and filler funnel assembled on a threaded or a quarter turn bayonet base.

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

**Vent Cap**  
See VENT PLUG.

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

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

**Verticals** The vertical bars of members or members in a pasted plate grid.

**Volt** The practical unit of measurement of electro-motive force or potential difference required to send a current of one ampere through a resistance of one ohm.

**Volt Efficiency** The ratio of the average voltage of cell or battery during discharge to the average voltage during its subsequent recharge.

**Voltage** The difference of potential which exists between the terminals of a cell or battery, or any two points of an electrical circuit.

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

**Voltmeter** An instrument for measuring voltage.

**Watering** Adding water to battery electrolyte to replace electrolysis and evaporative losses.

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

**Watt-hour** A measure of energy or work accomplished, being 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 number of watt-hours which can be delivered under specific conditions as to 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.

**Watt-hour Meter** A watt-hour meter is an electric motor that measures and registers electrical energy in watt-hours (or kilowatt hours).

**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.

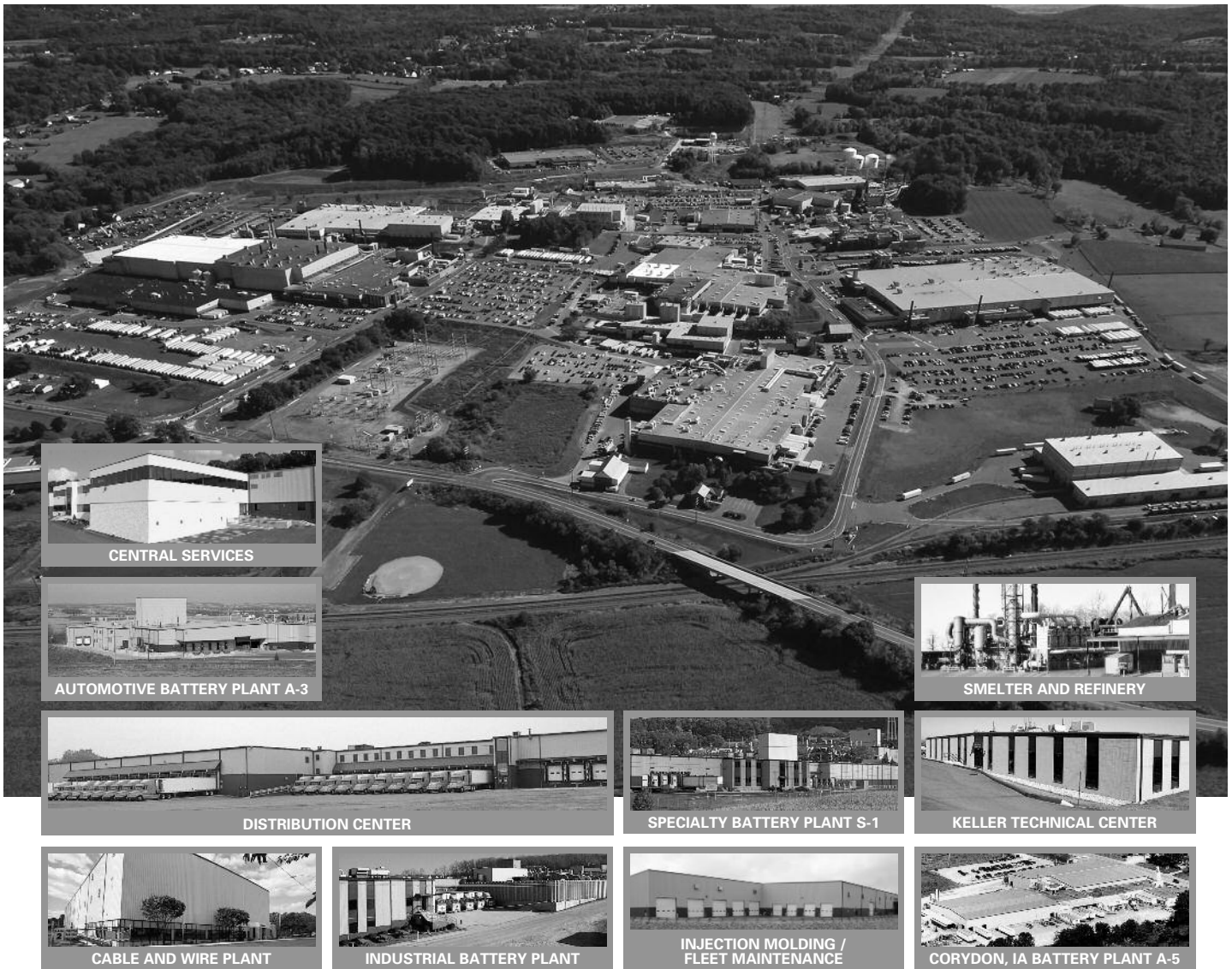
**Wrapping** Assembly operation wherein motive power positive plates are covered by silver, glass mat, and retainer.











## World's Largest and Most Modern Single-Site Battery Manufacturing Facility

Since 1946, East Penn has been producing high quality batteries and battery accessories for the automotive, commercial, marine, industrial, stationary, and specialty markets.

Facilities at its 520-acre manufacturing complex at Lyon Station, PA include four automotive battery plants, an industrial battery plant, a specialty battery plant, a state-of-the-art oxide facility, an innovative recycling infrastructure, and dozens of vertically integrated capabilities and other support facilities. An additional manufacturing facility in Corydon, IA helps accommodate widespread growth. East Penn owns and operates a wire, cable, and battery accessory plant and a multiple facility distribution center just miles away from its Lyon Station complex.

New high-tech facilities and computer monitoring and control systems have made the company an industry leader in advanced battery manufacturing.

East Penn's quality manufacturing is recognized worldwide and has met the global requirements of ISO 9001 and ISO/TS 16949 certification standards. East Penn is also a leader in innovative recycling and has met global environmental requirements of ISO 14001 certification standards.

Staffed with a long-term management team, East Penn is an independent company committed to the future and dedicated to producing high-class products and service to assure complete satisfaction, above and beyond the industry standard, to our partners and customers worldwide.



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