# INSTRUCTIONS FOR INSTALLATION, OPERATION, AND MAINTENANCE OF LEAD-ACID BATTERIES IN MOTIVE POWER SERVICE

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## 1. SAFETY PRECAUTIONS

a. Explosion can result from the gases produced by a battery:

1. Do not smoke, use an open flame, or create arcs or sparks in the vicinity of a battery.

2. Only charge a battery in a well-ventilated area with the cover of battery or compartment raised for maximum ventilation.

3. Do not charge the battery at a current greater than 5 amps per 100 amp-hours capacity at the end of charge.

4. Every battery gives off hydrogen and oxygen during recharge. Most of the gassing occurs after the 80% point has been reached. As the breakdown of water occurs oxygen and hydrogen are produced. The concentration of the gasses is proportional to the current being delivered to the battery.

To calculate the hydrogen produced use the following formula, and ventilate the area as required. Hydrogen must be ventilated in order to avoid an explosion. Hydrogen concentrations of 4% or greater will cause an explosion. When calculating assume all chargers in finish rate at same time.

The National Fire Protection Association (NFPA) allows up to 1% concentration. Make sure the ventilation system can remove the hydrogen before it reaches concentrations of 1% within the charging area.

Formula
0.00027 x (finish rate) x (number of cells) = cu. ft. of hydrogen produced per min.

5. The ventilation system must also be designed to provide removal of hydrogen and excess heat from the area directly above charging batteries. Inlet air ducts should be placed at shoulder height or lower so as to provide air movement across the charging room and across batteries. Failure to properly ventilate charging areas may result in employee complaints of heat and “battery odor”.

b. Severe burns can be caused by the sulfuric acid contained in the batteries covered by these instructions:

1. Do not get acid in eyes, on skin or clothing. In case of contact, flush immediately and thoroughly with clean water for at least 15 minutes. Obtain medical attention when eyes are affected.

2. In handling sulfuric acid, wear a face shield, plastic or rubber apron, and gloves. Avoid spilling acid.

3. PRO WASH™ neutralizing and cleaning solution or bicarbonate of soda solution (one pound to a gallon water) will neutralize any acid accidentally spilled. Apply the PRO Wash solution until it turns yellow (bicarbonate of soda solution stops bubbling), then rinse with clear water. Do not allow any of this solution to enter the cells.

When diluting concentrated acid, always add acid to water, never vice versa. Pour slowly and stir constantly, to avoid excessive heat or violent chemical reaction.

4. Batteries and sulfuric acid should be handled only by persons who have been instructed on the potential chemical hazards, in accordance with the OSHA 29 C.F.R. 1910.1200, Hazard Communication Standard. Refer to EnerSys Material Safety Data Sheet (MSDS) for lead-acid batteries.

c. The battery is electrically live at all times:

1. Keep the top of the battery clean and dry to prevent ground shorts and corrosion.

2. Do not lay metallic objects on the battery; insulate all tools used in working on the battery to prevent short circuits. Also remove all jewelry before working on the battery.

3. Be especially careful when working on battery terminal connections. Do not connect any two or more terminals together unless the connection is a proper and correct electrical one.

d. When lifting the battery, observe the following precautions:

1. Unless completely insulated lifting beams are available, temporarily cover the exposed metal components of the cells with an insulating material (plywood, thick rubber, etc.) to reduce the risk of a short circuit from the chain or hooks.

2. Use a lifting device with two hooks which are electrically insulated from each other to prevent short circuits.

3. Follow the instructions on handling loads covered in OSHA 29 C.F.R. 1910.179(n).

e. Keep the vent plugs firmly in place at all times except when adding water or taking hydrometer and temperature readings.

f. Only personnel who have been trained in battery installation, charging and maintenance should be allowed to work on the battery.

# 2. SPILLS AND RECYCLING

a. Spills of sulfuric acid should be handled with consideration for the following:

1. Do not touch spilled material without appropriate personal protective equipment (e.g., face shield, acid resistant gloves, etc.).

2. If possible, stop the flow of spilled acid with sand or other non-combustible absorbent and/or neutralize with bicarbonate of soda, lime or other neutralizing agent.

3. Place spill residue into compatible containers. If spill occurs from a battery, waste should be tested for presence of hazardous constituents prior to disposal.

4. Do not allow the discharge of any electrolyte or acid into sanitary or storm sewers.

5. Spills which enter the environment (through sewers, waterways or soil) must be reported, as applicable, to city, state, or federal environmental agencies as necessary.

6. Spills which occur during transportation of batteries should be reported to CHEMTREC (1-800-424-9300) a 24-hour service for emergency assistance.

b. Handling and storage of new and used (spent) batteries:

1. Batteries and battery components should be handled only in accordance with the safety procedure outlined in Section 1.

2. All batteries, as well as other hazardous substances, should be stored under cover and on an impervious surface with adequate containment to prevent dispersion of contaminants to the environment.

3. Batteries and acids should be stored away from sewer and storm drains and from sources of heat (see Section 19).

4. Leaking or cracked batteries and cells should be contained to prevent further leakage.

5. Generally, there are no storage time restrictions for batteries or for spent lead-acid batteries which are destined for recycling. However, state regulations and local fire and health ordinances should be consulted for special restrictions on the storage of hazardous substances, including batteries and acid.

6. Sulfuric acid is listed as an extremely hazardous substance under the federal Emergency Planning and Community Right-to-Know Act (EPCRA). Notification and/or reporting to federal, state and local agencies may be

The threshold planning quantity (TPQ) for sulfuric acid is 1,000 pounds.

c. Recycling:

1. Spent lead-acid batteries which are destined for recycling are not regulated under federal hazardous waste regulations or by most state regulations. Contact your state environmental agency for additional information.

2. Under federal land ban restrictions and individual state battery recycling laws, spent lead-acid batteries can be disposed of only by recycling/reclamation at permitted secondary lead smelters or other authorized recycling facilities. Spent batteries should be sent only to facilities which have obtained EPA or state hazardous waste permits for the storage of spent batteries prior to recycling. Call 800-538-3627 for EnerSys Battery Recycling.

3. Acid which is removed from spent batteries may be regulated hazardous waste. Facilities which generate spent acid may be subject to state or federal regulations for large or small quantity generators applicable to labeling, manifesting, transportation and reporting.

# 3. INTRODUCTION

The battery-operated electric vehicle fills a unique position in the constantly enlarging field of materials handling.

Whether it be in a manufacturing plant, on a railway platform, in a mine, or in airline ground support equipment, these battery-propelled vehicles have advantages over other means of transporting equipment.

The vital power source of these vehicles is a storage battery. The most reliable, yet simple, portable power package. The purpose of this manual is to provide a better understanding of the characteristics, operation, and care of this battery so that all of its advantages and economies may be realized.

# 4. FUNDAMENTALS

**Battery:** A device for converting chemical energy into electrical energy. All batteries are made up of individual compartments called *cells*, connected in series, so their individual voltages add up. Size, internal design and materials used control the amount of energy available from each cell. A *lead-acid battery* is a number of cells or containers filled with a mixture of sulfuric acid and water called electrolyte. The *electrolyte* covers vertical plates made of two types of lead. Chemical action between the acid and the lead creates electrical energy.

**Volt, *V*:** A fork lift's running speed and its lifting speed are determined by a battery's voltage. And since each cell in a lead-acid battery has 2 volts, multiply the number of cells by two and you know the voltage. Thus, it automatically follows: the more cells, the higher the voltage, the faster the fork lift's speed.

**Ampere,** *A*: An ampere is the standard measure of the amount of electric current. The amount or flow can be large (amperes) or small (milliamperes). Flashlight batteries are measured in milliamperes. Lift truck batteries are measured in amperes. While it's important to match battery amperage with the total amperage requirements of a fork lift truck, you still won't know if you have enough current to keep a truck running a full shift. You will know if you next consider a battery's ampere-hour rating.

**Ampere-hour,** *A.H.*: The higher a battery's ampere-hour capacity, the longer a fork lift will run. How long is always specified along with the ampere-hour rating on the battery label. For example, 680 ampere hours (A.H.) *at the six hour rate* means three things: First, 680 A.H. is the total capacity of the battery. Second, if the fork lift's motor and attachments draw 113 amperes continuously for six hours, the battery will be completely drained of usable power in six hours. And third, if the forklift's motor and attachments draw only 90 amperes continuously, the battery will provide energy for almost 8 hours and have a power to spare. Obviously, a battery that's not completely drained during its work shift has an improved life span over a battery that is. (To maximize the life of your battery it should not be discharged below 80% depth of discharge.) Now, by taking

what you know about a battery's volts, amps, and ampere-hours, you're ready to easily change those numbers into the final key concept, watts.

**Watt,** *W*: Using battery voltage or amperage alone doesn't tell you enough about the battery. Multiplying those two values together does. The answer you get is a battery's wattage: the electrical power a
battery can provide. Every 1,000 watts is a kilowatt, or KW. Then, for example, when your forklift needs 10KW of continuous power for a 6-hour shift, you need a battery that provides 60 kilowatt-hours (60KWH) of energy.

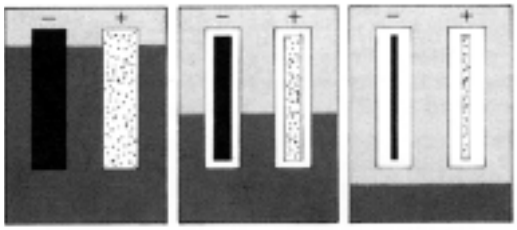
## OTHER IMPORTANT BATTERY CONCEPTS

**Cycle:** Every time a battery is charged and then discharged in use is one cycle. Battery life is usually measured in cycles. 1,200 to 1,500 cycles, or 5 to 6 years, is about the average battery's life. However, battery maintenance and charging procedures will either prolong or shorten battery life, depending on how well recommended procedures are followed. EnerSys will provide training aids and materials whenever asked. Also, when a battery's average voltage measures less than 2.08 volts (open circuit - after a full charge) times the total number of cells, the battery either needs repair or has reached the end of its life. To be sure the situation isn't the result of a maintenance problem, call your lift truck dealer or EnerSys representative.

**Specific Gravity:** As a battery is used, the sulfuric acid in the electrolyte changes into another chemical when it combines with the active material. As a result there's less and less power-generating sulfuric acid as the battery is discharged. When the battery is recharged, the sulfuric acid returns.

**FIGURE 1**

**CHARGED/**




| **RECHARGED** | **DISCHARGING** | **DISCHARGED** |
|---|---|---|
| 1.300 Specific Gravity | 1.200 Specific Gravity | 1.120 Specific Gravity |

| | |
|---|---|
| Sponge Lead | Water |
| Lead Peroxide | Lead Sulfate |
| Sulfuric Acid | |

The hydrometer detects the chemical change by measuring the ratio of sulfuric acid to water. In addition, temperature also affects a battery's specific gravity. Temperatures above and below 77° F require correction of the hydrometer reading. EnerSys can provide a thermometer which shows how much to correct for the temperature at your location.

**Gassing:** Gassing occurs when chemical activity and heat build up during overcharge, the last 20% of a normal charging cycle. The water in the electrolyte inside the battery breaks down into hydrgen and oxygen. When this happens, electrolyte will bubble and expand, causing the battery to overflow if any cell was previously filled with too much water. Inexperienced maintenance personnel should never try to replace lost sulfuric acid. In addition, even worse than overwatering is underwatering. If electrolyte isn't at

# 5. CONSTRUCTION

Fig. 2 illustrates the construction of a typical motive power cell of the tubular design.

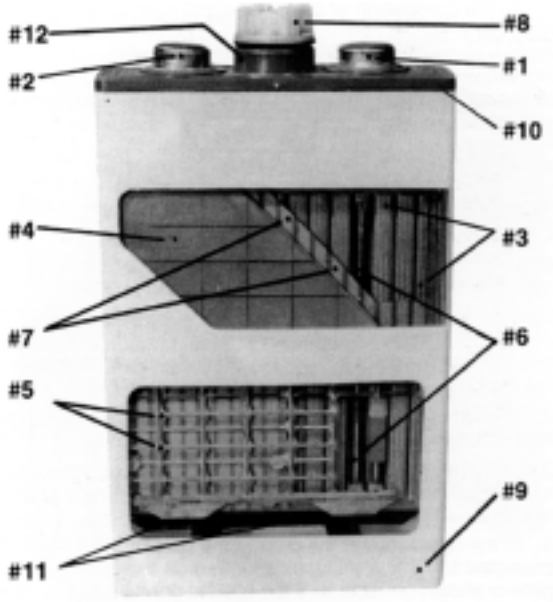



**Figure 2**

Call-outs as follows:

| | |
|---|---|
| 1. Positive Post | 7. Separator |
| 2. Negative Post | 8. Vent Cap |
| 3. Positive Plate | 9. Jar |
| 4. Negative Plate | 10. Cover |
| 5. Negative Grid | 11. Bridge |
| 6. Positive Spine | 12. Vent Well |

# 6. INSPECTION OF THE BATTERY UPON RECEIPT

a. Examine for physical damage or loss of electrolyte.

b. Report actual or suspected damage to carrier.

c. Give battery an equalizing charge. (See Section 13.)

d. Check electrolyte levels IMMEDIATELY after charge and add water if needed.

e. When adding water, the electrolyte height should be as specified in Section 17.

# 7. MOIST/DRY CHARGED BATTERIES

1. Moist charged batteries are electrically live upon receipt, even before filling with electrolyte. Do NOT lay any metallic objects on the battery.

2. Moist charged batteries or cells should be activated (unsealed, filled with electrolyte and charged) only when ready to be placed in service. Until ready for use, they must be stored in a cool, dry, low humidity location with the pressure relief valves/vent plugs tightly in place. Moist charged cells must be activated within 24 hours of the loosening/breaking of the seal of the pressure relief valves/vent plugs.

**CAUTION:** IF THE EXISTING VENT PLUG HAS A LABEL MARKED "DO NOT REMOVE", STOP ALL ACTIVITY AND CALL YOUR LOCAL ENERSYS REPRESENTATIVE.

3. To prepare for use carefully remove the sealed PRV (pressure relief valve) using an approved tool or if necessary a widegrip pliers, taking care not to damage the cell vent well exteri-or. THROW AWAY THE PRESSURE RELIEF VALVE/VENTPLUG. Fill all cells with electrolyte 0.015 sp. gr. lower than the nominal operating gravity.

4. Give the battery an equalizing charge but keep resetting the charger to the equalize position until the specific gravities remain constant for a period of three hours. At no time should battery temperature be allowed to exceed 110°F (43°C).

5. At the completion of the charge, the specific gravities of all cells corrected to 77°F (25°C) should be as specified on the battery nameplate or shown in Table 3. If the specific gravity is higher, remove some electrolyte and replace with water; if lower, remove some electrolyte and replace with higher specific gravity electrolyte. Any specific gravity adjustments should be made with the charger on equalize in order to mix the electrolyte properly. Removed electrolyte must be disposed of in strict accordance with all environmental regulations. **CAUTION:** ELECTROLYTE CONTAINS SULFURIC ACID WHICH CAN CAUSE BURNS AND IS CORROSIVE.

6. Upon completion of the above steps, apply a standard vent cap to all cells.

# 8. INSTALLATION OF BATTERIES

a. The battery compartment in the vehicle should be ventilated and designed in a manner to keep out water, oil, dirt and other foreign matter. Drainage holes should be located in the floor of the battery compartment. Consult with your vehicle dealer if any question arises.

b. When lifting the battery, use an EnerSys PRO Series Adjustable Lifting Beam which exerts a vertical pull on the lifting tabs only.

c. The battery should be blocked, not wedged, to allow 1/8" minimum clearance on all sides for easy removal from the battery compartment.

d. During transit and storage a battery may have lost some of its charge. Give it an equalizing charge before putting the battery in service. (See Section 14.)

e. If any connections on the battery itself are bolted together, make them clean and bright, using care not to remove the lead coating from any lead-plated copper parts. Coat the surfaces to be bolted together with No-Oxide grease. Due to vibration, handling and heating during operation bolted connections loosen over time. Re-tighten them at least twice yearly using an appropriately set torque wrench.
No intermediate “taps” or connections should be made at other than the main terminal of the battery. Any lower voltage device should be supplied through a series resistor or from a separate source. Any such device connected to an intermediate point of a battery and/or overcharging the remainder can void your warranty. **TAPPING THE BATTERY SHORTENS ITS LIFE BY UP TO THREE YEARS.**

f. Storage - see Section 21.

# 9. FAST CHARGING AND OPPORTUNITY CHARGING PROCEDURES

If a single battery is being used in a lift truck for multiple shifts or is partially recharged during breaks, lunches, and other idle periods, it may be in a fast charge or opportunity charge mode of operation.

Opportunity charging can be used to keep the battery’s state of charge above 50% during the daily discharge cycle thereby allowing the battery to maintain higher voltages during the shift and improve truck performance. The total accumulated discharged ampere-hours should not exceed 80% of the batteries designed capacity rating. Discharge of more than 80% of the batteries designed capacity rating in a 24-hour period will shorten battery life. If engaging in opportunity charging, the battery must be returned to nameplate specific gravity at least once per week. However, more frequent recharges to nameplate specific gravity is desirable. Charge rates during opportunity charging should not exceed 25 amps per 100 amps of a battery’s nameplate capacity. Under the opportunity charging procedures outlined in this paragraph, standard battery warranties apply.

Fast charging is intended to extend a battery’s run-time diring a shift or day. A typical fast charging system will provide charge rates from 25 to 50 amps per 100 amps of a battery’s nameplate capacity. Fast charging requires special chargers that can monitor and manage battery temperatures during charge, assure a battery is recharged to at least 90% state of charge on a daily basis, and provide an equalizing charge at least once per week. Also, a fast charge battery should be designed to accept higher charge current and to manage heat that may be created by higher charging rates. A fast charge system, including the battery and charger, should be designed to accept no more than 160% of the battery’s 6-hour capacity rating on a shift day. Under fast charging procedures outlined in this paragraph, fast charging warranties apply.

Consult your EnerSys representative to avoid problems or very short battery life.

# 10. OPERATION

a. Full charge gravity of a new battery will be specified on the nameplate located on the side of the battery tray. Full charge gravity will be affected by temperature, acid level, and battery age. If acid is lost from overfilling, full charge gravity and capacity will be lowered.

b. Under normal conditions, only add water. **NEVER** add acid or other solutions to the cells.

c. Keep the plugs and receptacles in good condition. When disconnecting battery from the truck or charger, pull on the receptacle **not the cable**. When disconnecting from a charger, assure that the charger is off first otherwise arcing will result. Arcing can cause battery explosion, sulfation damage to connector contacts, and charger components.

# 11. TEMPERATURES

a. Low Temperatures. The capacity of a storage battery is reduced at low temperatures due to the increased viscosity and resistance of the electrolyte. An approximation of this reduction in capacity for batteries of these types is shown below.

**TABLE 1**

| Internal Temperature of Cell (°F) | Percent Capacity |
|---|---|
| 77 | 100 |
| 60 | 95 |
| 40 | 87 |
| 20 | 73 |

This, of course, refers to the actual temperature of the cell and not the ambient temperature. Thus a battery may be operated in quite low ambient temperatures for short periods without the actual battery temperature falling to a point where the capacity is seriously curtailed. For example, batteries used in cold storage plants or similar locations will deliver close to normal capacity if they are moved into warmer areas for charging and whenever not in actual use.

Low temperatures also increase the battery voltage on charge, resulting in lower charge currents, and a longer recharge time. Undercharging could occur unless charger adjustments are made to compensate for it.

There is little danger of freezing of the battery electrolyte in temperate climates unless the battery is completely discharged. At the temperatures shown in the following table, the electrolyte will not freeze unless the specific gravity is lower than indicated.

**TABLE 2**

| Battery Specific Gravity (Corrected to 77°F) | Freezes @ or Below Degrees F. |
|---|---|
| 1.080 | +20 |
| 1.130 | +10 |
| 1.160 | 0 |
| 1.180 | -10 |
| 1.200 | -20 |
| 1.215 | -30 |
| 1.225 | -40 |

In sub-freezing temperatures, water should be added **just before charging is completed** to insure prompt mixing with the electrolyte. Otherwise it may freeze on the surface before mixing. No permanent harm results from low temperature operation as long as freezing is avoided.

b. High temperatures have an adverse effect and all practical means should be employed to keep the battery temperature at normal values:

- Avoid overdischarging
- Charge in cool location
- Supply ample ventilation during charge by always opening battery compartment or battery cover and circulating air by fans if necessary
- Allow battery to cool down before starting charge.

The effect of temperature on battery life on any lead acid truck battery is shown below.

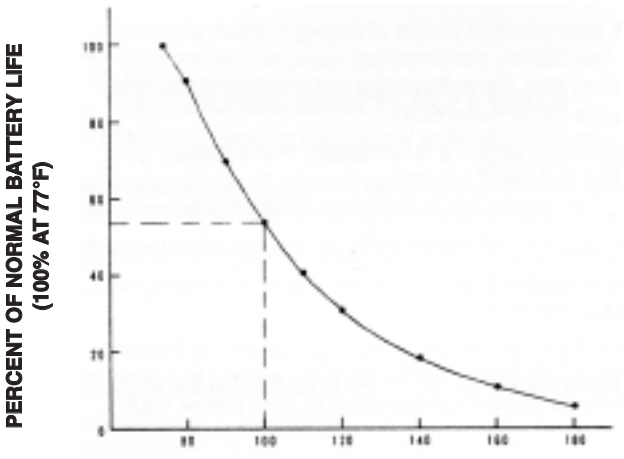



**Figure 3 - Temperature vs. Battery Life Curve**

***EXAMPLE:*** If the average lifetime temperature of the battery is 100°F, it will result in a battery life of approximately 53% as compared to 100% at 77°F.

# 12. DISCHARGE CHARACTERISTICS

a. In general, a battery may be discharged without harm at any rate of current it will deliver, but the discharge should not be continued beyond the point where the cells approach exhaustion, or where the voltage falls below a useful value.

b. Discharging at a constant current value, the initial voltage will depend on the rate of discharge and the normal characteristic of the cell. As the discharge continues, the cell voltage will slowly decrease during the first 70 to 80 percent of the total time period. It will then fall more rapidly, passing over the “knee” of the curve to the “final” voltage as full time and capacity are reached. This “knee” is more pronounced at low rates of discharge.

c. During discharge there is normally a rise in battery temperature, depending on the ambient temperature, on the rate of discharge and the type of battery assembly from the standpoint of heat dissipation. The higher the ampere discharge rate, the greater the temperature rise effect. During discharge, a battery’s temperature will normally rise. The speed and magnitude of this temperature rise is dependent on the following conditions:

- ambient temperatures
- battery design and layout,
- and battery discharger rate.

Batteries subject to high discharge rates will incur higher temperature increases.

d. As mentioned, a battery should not be discharged beyond the point where the cells approach exhaustion. This is referred to as “overdischarging” and can have very harmful results, particularly if repeated for several days or cycles. Overdischarge can be avoided by using a lift interrupt device. When installed on the vehicle, the lift interrupt device gives a constant readout of battery condition and locks out the lift mechanisms as the battery approaches 80% depth of discharge.

**TABLE 3**
**SPECIFIC GRAVITIES @ 77°F**

| *Cell Type* | *Fully Charged* | *80% Discharge** | *100% Discharge** |
|---|---|---|---|
| E-55L | 1.315 | 1.160 | 1.120 |
| E-75L | 1.315 | 1.160 | 1.120 |
| E-75 | 1.280 | 1.160 | 1.130 |
| E-460 | 1.280 | 1.140 | 1.105 |
| E-85 | 1.280 | 1.150 | 1.120 |
| E-85D | 1.280 | 1.140 | 1.110 |
| E-100 | 1.315 | 1.155 | 1.115 |
| E-100X | 1.280 | 1.130 | 1.090 |
| E-110 | 1.315 | 1.155 | 1.115 |
| E-100D | 1.280 | 1.145 | 1.115 |
| E-125 | 1.280 | 1.140 | 1.105 |
| E-125D | 1.280 | 1.130 | 1.100 |
| E-140 | 1.280 | 1.140 | 1.105 |
| E-140X | 1.280 | 1.140 | 1.105 |
| E-155 | 1.315 | 1.150 | 1.100 |

*These values are for discharging at the 6 Hr. rate, read immediately at the completion of the discharge and corrected to 77°F.

# 13. CHARGING EQUIPMENT

a. Battery charging should be accomplished with an electronically controlled charger.

b. When the discharged battery is placed on charge, the battery will draw a relatively high current which will be at or close to the capacity of the charger. Within a few minutes, the current will adapt itself to the state of discharge of the battery, remaining high if the battery is considerably discharged or decreasing to a low rate if the battery is only partially discharged. The charging rate should be controlled by a control unit.

c. When charging any industrial battery, only use an approved charger that is capable of returning a discharged battery’s specific gravity back to it’s nameplate rating within an 8 hour period. Several chargers offered by EnerSys will accomplish this requirement. Some charger technologies, such as ferro-resonant, will not adequately charge and EnerSys Ironclad tubular battery and will result in undercharging and short life. Please consult an EnerSys representative for more information.

d. Although a number of chargers meet the mentioned general requirements above, not all chargers are equal. Contact your local EnerSys representative for more details.

# 14. CHARGING CHARACTERISTICS

a. Only EnerSys approved charging methods should be used. To maximize life, charging should not result in excessive gassing during the initial stages of charge. In addition, the charging method should keep end-of-charge temperature below 110˚F.

b. Every effort should be made to ensure that the battery receives the proper amount of charge. Consistent undercharge and/or excessive overcharge will contribute to internal battery problems with a loss of capacity and reduction of life.

c. 1. Sulfation - Residual sulfation remains in the plates if the battery is not fully charged to nameplate specific gravity or allowed to remain partially discharged for an extended period of time. This results in reduced performance and life. All motive power batteries must be returned to nameplate specific gravity at least once per week. However, more frequent recharges to nameplate specific gravity is desirable.

2. Stratification - Caused by insufficient gassing at end of charge. Little or no mixing of electrolyte will thus create a higher concentration of electrolyte at the bottom of the cell compared to the top. This will eventually lead to sulfation of the bottom of the negative plate with subsequent fall off of performance and capacity.

d. Overcharge

1. It is uneconomical from a power standpoint and wastes electrical energy while running the risk of permanent damage to the battery.

2. Excessive gassing, producing hydrogen and oxygen, not only increases the frequency of water additions to the battery but also increases an explosion hazard significantly over normal and safe charge conditions.

3. It creates dangerously high battery temperature which significantly shortens normal battery life if repeated instances occur above 110°F. (See Figure 3 in Section 11.)

Higher temperatures, that is 15-20°F above the maximum allowable temperature at the start of the charge, tend to reduce the battery voltage on charge permitting higher current flow from the charger and further raising the cell temperatures. Battery temperature at the end of charge should not exceed 110°F. To assure this, batteries should not be put on charge above 90°F.

Should excessive battery temperature occur with some frequency, call your local EnerSys representative for assistance.

4. Unless charging under an opportunity or fast charging method as described in Section 9 of this manual, make sure the battery is not being charged more then once per day. When the battery reaches full charge, the charge should be stopped. No amount of overcharging can increase battery capacity.

e. When charging batteries while they are in the vehicle, assure proper ventilation and follow the manufacturers instructions. Open the battery cover, if so equipped, as well as the battery compartment cover of the vehicle. Not following these recommendations can cause gaspockets to remain in the vehicle or battery giving rise to possible explosions when the vehicle is put into use.

f. Extra care spent in proper charging is effort well worth it in trouble free battery performance, reduced maintenance and long battery life. For information regarding charging room layouts, refer to EnerSys Form 8041.

g. Equalizing charge. It is necessary that a battery be brought to a state of full charge in order to avoid excess sulfation, yet appreciable overcharge must also be avoided.

1. Light Depth of discharge (50% or less) equalize bi-weekly.

2. Medium Depth of discharge (60%) equalize weekly and recharge every 48 hours.

3. Heavy Depth of discharge (80% or greater) or battery temperature exceeding 100°F equalize weekly, but allow sufficient time for battery temperature to drop below 100°F.

# 15. MAINTENANCE AND RECORDS

Specific records should be maintained for each battery in your fleet. These records will provide a means of identifying batteries which may need repair adjustment, charger problem or which have reached the end of their useful life. Such records also help assure **warranty protection**. To assist your record keeping, EnerSys has developed Form 5847 (see sample on page 11 of this manual). You may copy Form 5847 to establish your own “Battery Log Book.”

a. Where more than several batteries are in use, each one should be identified with a permanent number assigned when received. That number should be plainly painted or stamped on the battery. If a large number of batteries are involved, including several sizes or types, various groups can be given prefixes or suffixes to identify size, voltage or shift.

b. After each battery is received and equalized, record the corrected specific gravity of each cell. This serves as reference for comparison with later readings.

c. In a new application the depth of discharge should be checked for several weeks to determine whether it is within a safe range. This is done by reading the specific gravity of a particular cell (or cells) at the beginning and end of the discharge. This daily discharge should not exceed 80% (see Table 3). If final corrected specific gravity is below 80%, there is a problem. Call your vehicle dealer or local EnerSys representative. The “pilot cell(s)” used for such purposes should be changed at monthly intervals, as frequent hydrometer readings may noticeably reduce their specific gravity through inadvertent losses.

d. While the record sheet can accommodate daily specific gravity readings for up to a month, EnerSys recommends quarterly specific gravity readings once the duty cycle and depth of discharge meet the criteria contained herein. When a gravity reading indicates an irregularity, then more frequent readings can be initiated. The final determination for frequence of hydrometer readings should depend on your past experience and advice from your local EnerSys representative.

# 16. DETERMINATION OF CAPACITY

a. A battery's capacity will, of course, decrease toward the end of its life. Assuming no specific cause of trouble, this will be a gradual decrease and ample warning of limiting capacity will be evidenced by the slowing of the truck or other vehicle toward the end of the day's work.

b. A battery is usually considered to be at the end of its usefulness when its capacity decreases below 80% of normal rating. However, it can sometimes be transferred to a smaller job and thus give additional life and service.

c. Since the average motive power battery passes a “test” every day by performing its regular work, it is seldom necessary to conduct a formal test of its capacity. Also, most users do not have the facilities to do this conveniently or accurately. If any such testing is desired, consult your EnerSys Representative regarding equipment and procedure.

# 17. TROUBLESHOOTING

The following conditions are usually indications of approaching trouble.

* Contact your local EnerSys Service Representative

**TABLE 4 - TROUBLESHOOTING CHART**

| CONDITION | CAUSE | SOLUTION* |
|---|---|---|
| Unequal or low specific gravities | a. Electrolyte spillage during watering<br>b. Electrolyte flooding<br>c. Insufficient charge<br>d. Internal short | a. Avoid overwatering, neutralize & clean.<br>b. Water cells during end of charge.<br>c. Extend charging time.<br>d. Replace cell. |
| Excessive water requirement | a. Overcharging<br><br>b. Jar leakage | a. Select a properly sized charger. Check charging time and average battery temperature.<br>b. Replace or repair cell. |
| Excessive cell temperatures | a. Overcharging<br>b. Battery overworked<br>c. Battery being charged more than once per day.<br>d. Battery temperature too high at start of charge.<br>e. Shorted cell(s) | a. Check charger size and charging time.<br>b. Reduce to one cycle/day or 300/year maximum.<br>c. Reduce charging to once per day.<br>d. Allow battery to cool down before starting charge.<br>e. Replace defective cell(s). |
| Poor truck performance | a. Battery undersized<br>b. Undercharged battery<br>c. Discharge indicator malfunction<br>d. Defective charging connector<br>e. Excessive loss of electrolyte | a. Install higher capacity battery.<br>b. Extend charging time.<br>c. Reset discharge indicator for 80%.<br>d. Replace or repair cable and/or connector.<br>e. Adjust gravities at state of full charge. Check for leakage. |

# 18. WATERING

a. Use only approved water. That is 1) distilled water; or 2) de-mineralized water; or 3) local water that has been approved for use in batteries. Never add acid, commercial additives or other foreign material to the battery. Addition of acid, commercial additives or foreign material may void your warranty.

b. If there is some doubt as to whether the water being used is suitable for use in lead-acid storage batteries, an analysis should be obtained from a qualified laboratory, otherwise, distilled or deionized water should be used. Deionized water is available by using the EnerSys PRO Clear Deionizer #94866.

c. Table 5 shows the maximum allowable impurities.

d. An EnerSys Watering Gun is a convenient and accurate tool to aid in watering as it fills to a pre-selected height and automatically shuts off; however, care must be taken to adjust the watering gun so it will water cells to levels in accordance with Figure 6.

**TABLE 5 - WATER IMPURITY CHART**

| Requirements | Maximum Allowable Limits | |
|---|---|---|
| Total Solids* | 350.0 | |
| Fixed Solids* | 200.0 | Parts |
| Organic and Volatile* | 150.0 | |
| Iron | 4.0 | Per |
| Chloride | 25.0 | |
| Ammonium ($NH_4$) | 5.0 | Million |
| Nitrites ($NO_2$) | 10.0 | |
| Nitrates ($NO_3$) | 10.0 | (P.P.M.) |
| Manganese | 0.07 | |
| Calcium and Magnesium | 40.0 | |

* ASTM Spec. D-1888-67 Method A, or equal.

e. Another convenient way to ensure proper fill levels is the use of a single point watering (SPW) system. The EnerSys Battery Irrigation System or EZ Fill System are effecient methods of watering a battery. These reliable quality systems allow the operator to fill to the proper level each and every time.

f. Water should only be added to the battery when it is near the end of charge and gassing or as closely as possible to the end of charge time. As the electrolyte is at its maximum level during this time, it is a certainty that the leve established by the addition of water will not be exceeded at any other time and overflow of the electrolyte (flooding) will never occur. Fill to 1/4" below the bottom of the vent well at the end of charge. See Figure 6 for details.

g. It is often inconvenient or impossible to be present at the end of charge to perform watering. In this case, it is recommended that the battery be watered as soon as possible after the termination of charging, as in this way levels will still be near the maximum and the danger of over- or under-watering is minimized. Fill to the lower limit in this case.

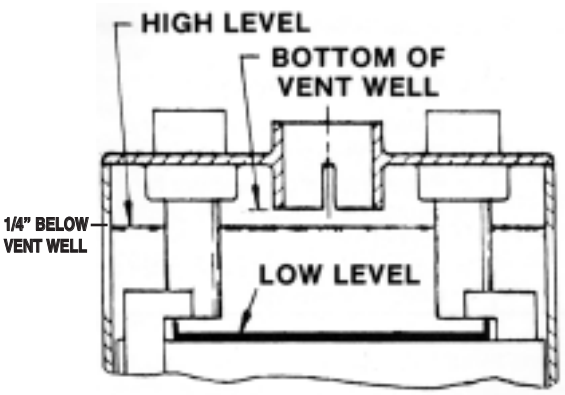
h. In Motive Power Service the **real** need to add water may vary from weekly to quarterly depending on application, battery temperature, and battery design. To extend this interval to the maximum period possible follow these steps:

1. Adjust cell filler to fill to maximum possible height.
2. Water while battery is on charge and gassing.
3. Do not add water until actual visual inspection shows top of separators/plates is visible.
4. A Battery Water Monitor is an excellent way to indicate when water is needed.
5. Once a repetitive routine is established, water your battery at that interval.

i. Should the battery start to use excessive water look for any of the following problems: charger not shutting off automatically, charging rate exceeds rate on battery nameplate, one cell shorted or weakened.

j. Caution - Avoid overfilling as it will cause overflow (flooding) of electrolyte resulting in loss of electrolyte, tray corrosion, ground paths, and loss of capacity or working ability.

**Figure 6 - Sketch showing permissible high and low limits of electrolyte level. High level marker indicates proper level immediately after charging. Low level marker indicates immediately after charging watering is required.**




# 19. CLEANING

a. Check the battery for cleanliness at regular intervals. When necessary, dust or other material which has accumulated should be removed by cleaning the battery.

b. Electrolyte spilled on the battery cell covers, trays or battery compartment, never dries or evaporates. It causes grounds and corrodes any metal parts. For light cleaning, regular use of a neutralizing cloth such as PRO Wipes #853638 may help remove these harmful deposits.

c. To both clean and neutralize your battery use EnerSys PRO Wash Cleaner/Neutralizer #94883. This spray on premixed cleaning solution changes color as it neutralizes electrolyte or acid. Use this cleaner or bicarbonate of soda and water (1.0 lb./1.0 gal.) any time you see electrolyte on the battery top. **(MAKE SURE VENT PLUGS ARE IN PLACE WHEN CLEANING OR NEUTRALIZING YOUR BATTERY.)**

If any corrosion exists on metal parts of the tray or compartment, clean as above and repaint with acid-resistant paint.

d. For large installations a "washstand" should be provided with water hose and adequate drainage. It should include a container for the cleaner, brushes, etc.

A periodic washing is recommended at least twice yearly. A clean battery is an indication of good maintenance and increases battery life.

e. Be sure to keep vent plugs in place and tight at all times, to avoid loss of electrolyte due to gassing or spillage. The gas-escape holes in the vent plugs should be examined to see that they are not clogged with dirt. Wash all vent plugs yearly or as needed by immersing in a bucket of water and wiping clean.

# 20. ADJUSTING SPECIFIC GRAVITY

Acid or electrolyte should never be added to a cell without first making sure that charging will not restore the gravity to normal values. Therefore, a cell or a battery should first be given a thorough equalizing charge. See Section 14.g. The equalizing charge should continue until there is no change in specific gravity for 3 consecutive hourly readings. Never make a gravity adjustment on a cell which does not gas freely on charge.

If after the equalizing charge, the specific gravity (corrected for temperature) of any cells is lower than the normal gravity shown on the nameplate or in the instruction book, the specific gravity of the low cells should be adjusted to normal in the following manner:

a. Put battery on charge again at the finish rate, so as to have the cells gassing for thorough mixing. Make sure all cells are gassing before starting a gravity adjustment.

b. From the low reading cells draw off electrolyte down to the splash cover. Replace slowly with electrolyte of 1.400 specific gravity. NEVER USE ACID OF HIGHER SPECIFIC GRAVITY THAN 1.400. In adding acid to the cells, pour it in slowly.

c. Wait 20 minutes for the added electrolyte to become thoroughly mixed by the gassing charge and then read the specific gravities. If the gravity of any cell is still below normal, repeat the process. Repeat as many times as necessary to restore gravity to normal. When gravity has apparently been adjusted to within the proper limits, continue the charge at the finishing rate for an additional hour for thorough mixing of the electrolyte.

d. If the corrected specific gravity of any cells is higher than normal, proceed as follows:

As the battery charges, withdraw from the cell a small amount of the electrolyte and replace with water, repeating at 20-minute intervals, if necessary, until the desired reading is obtained.

On completion of the gravity adjustment, record the voltage of all cells while still on charge at the finishing rate, and then stop the charge. In about 20 minutes after stopping the charge record the gravity of all cells and the electrolyte temperature of at least two or three cells.

**NOTE:** Specific gravity changes with temperature. Normal values are at 77°F . This should be kept in mind when reading specific gravity and proper correction should be made to judge normal values. For each 3° above 77°F **ADD** 0.001 to the measured Sp. Gr. For each 3° below 77°F **SUBTRACT** 0.001.

# 21. STORAGE OF BATTERIES

a. Batteries should be stored in a clean, cool, dry and well ventilated location away from radiators or heating ducts, etc., and protected from exposure to direct sunlight.

b. Before storing, it is necessary that the battery be **fully charged** and the electrolyte at the proper level. Disconnect leads or cable connections to prevent use or possible added loss of charge during prolonged storage period. Do not remove electrolyte or dismantle the battery.

c. If storage temperature is 80°F or higher, check gravity at least monthly, if 50°F, or lower, every two months. Whenever gravity falls to about 1.240 or below, give equalizing charge as in Section 13.g and also before returning to service.

# 22. ACCESSORIES

Certain Accessories (tools) are necessary or desirable for routine work in the charging room. We feel the following are the minimum number of tools for every charging room.

a. EnerSys PRO Alarm Hydrogen Detector #801550. This alarm will monitor the hydrogen emitted from batteries while gassing during charge, and provide for ventilation and warning before explosive levels are reached (as the National Fire Protection Agency recommends).

b. EnerSys Hydrometer #13142 (up to 1.300 Sp. Gr.). These devices accurately and quickly measure the concentration of acid in the electrolyte. Required to properly check full recharge, depth of discharge or freezing points as shown in Tables 2 and 3. Special floats available for different specific gravity scales.

c. EnerSys Thermometer #88330. Quickly takes the internal temperature of single cell. Assures that you have a method to check that charge temperatures have not exceeded 110°F (see para. 10.a).

d. EnerSys Watering Guns EZ Fill #50092755 or PRO Fill #92755. This tool allows manual pre-selection of internal watering height and when connected to a standard pressurized watering system automatically shuts off water flow. Flip Top Vent Cap #811112 makes watering a snap when used with watering guns.

e. EnerSys PRO Wash Light #94883-4QT. This unique cleaner/neutralizer solution is a pre-mixed liquid in a spray bottle which neutralizes spilled electrolyte (acid) as it cleans and degreases your battery. In addition, the liquid turns from red to yellow giving a positive indication any corrosive acid has been neutralized.

f. EnerSys PRO Safety Kit #85879 provides all the personal protective equipment necessary to satisfy OSHA regulations.

g. EnerSys PRO Clean Battery Maintenance Kit #85363 and PRO Wipes #85368. These products will help to maintain a clean battery.

h. EnerSys Emergency Spill Kits meet OSHA requirements 1910.178 (g)(2). Available in three convenient sizes: 853610 30 gallon, 853615 15 gallon, or 853620 6 gallon.

### OTHER OPTIONAL ACCESSORIES:

Other tools may be needed in your operation because of the way your company uses batteries. EnerSys also offers the following:

i. EnerSys Pro-Meter #94870. This shirt pocket sized meter is versatile for 13 ranges in AC, DC and OHM readings. It has an audible continuity signal and is accurate to 0.75%. Ideal for the person who wants to do basic battery or charger troubleshooting.

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j. EnerSys Battery Lifting Beam. Adjusts to fit batteries from 28" TO 43" long. Necessary in any shop where batteries are charged or where the user needs a safe method to lift the battery out of the vehicle.

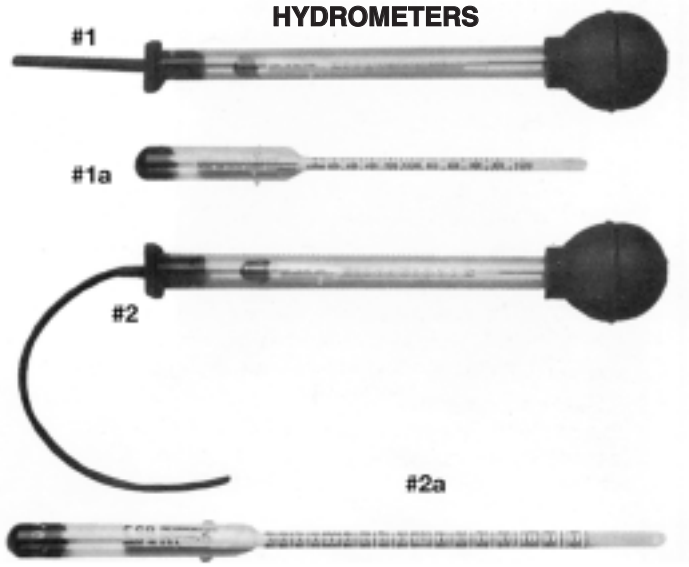
k. EnerSys Portable Watering Cart #502056. Our portable watering cart is ideal for locations with no pressurized water or where a method is needed to quickly water batteries with distilled water. Cart comes complete with DC motor, battery, charger, and 10 gallon tank.

# 23. TOOLS

### BURN CUTTERS


1. BURN CUTTER 3/4 IN. - cat. #41039
2. BURN CUTTER 1 IN. - cat. #80298

### HYDROMETERS



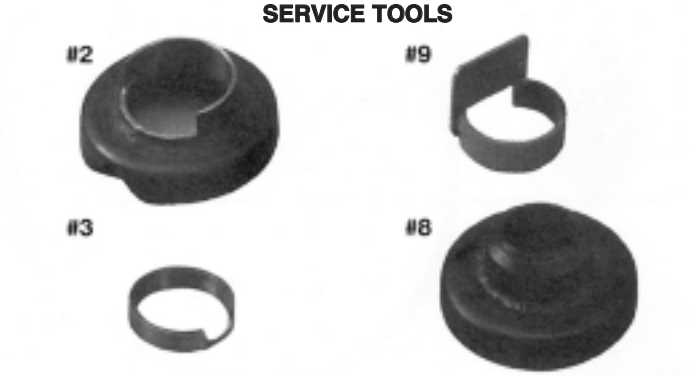

a. EnerSys Hydrogen Detector #801550.

1. SHORT STEM Sp. Gr. 1100-1300 - cat. #13142
   a. FLOAT - 1100-1300 Sp. Gr. - cat. #13090
   b. FLOAT - 1050-1380 Sp. Gr. - cat. #84599
2. LONG STEM Sp. Gr. 1050-1380 - cat. #84598
   a. FLOAT - 1050-1380 Sp. Gr. - cat. #84599
   *b. BARREL - cat. #84600

*3. LONG STEM Sp. Gr. 1100-1300 - cat. #81332
   *a. FLOAT - 1000-1300

*NOT SHOWN

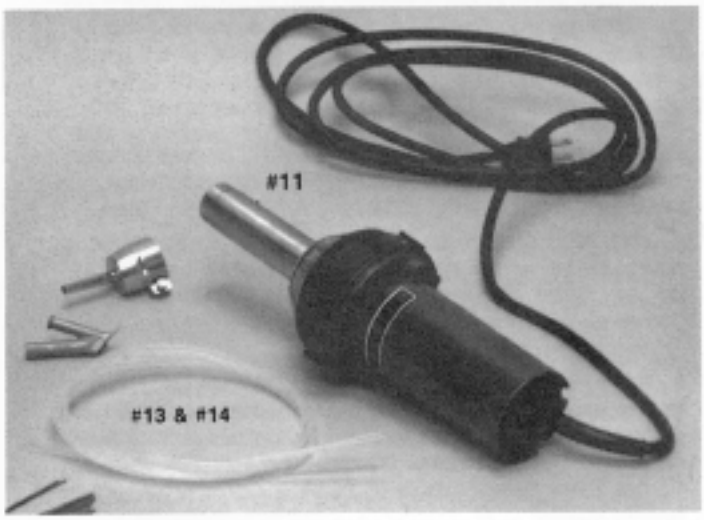
### SERVICE TOOLS

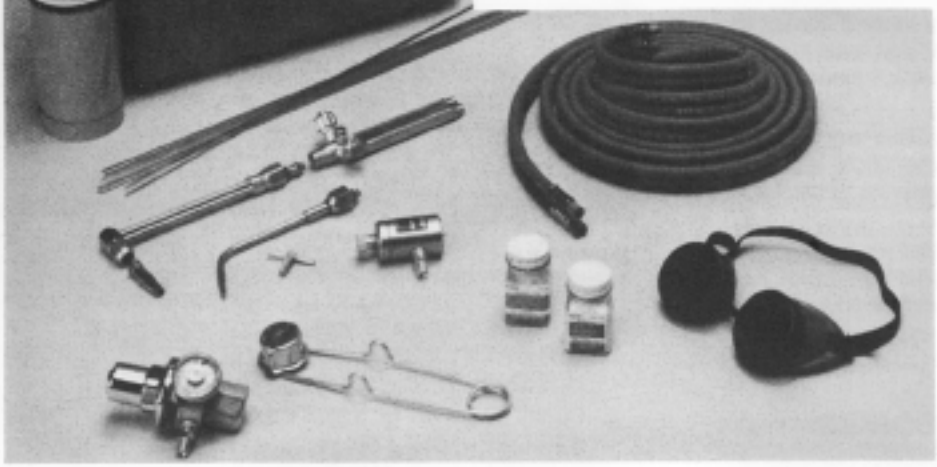


## SERVICE TOOLS








*1. CELL LIFTER - Belt type cat. #SS-5746
2. CROSS LINK PUDDLING DAM - cat. #SS-5749
3. CABLE LUG PUDDLING DAM - cat. #SS-5747
*4. CONNECTOR PUDDLING DAM - cat. #SS-5745 (2 hole)
5. CONNECTOR PUDDLING DAM - cat. #SS-5745-1 (4 hole)
6. CONNECTOR PUDDLING DAM - cat. #SS-5745-2 (4 hole)
7. CONNECTOR PUDDLING DAM - cat. #SS-5745-3 (4 hole)
8. POST BURNING RING DAM - cat. #SA-60485
9. BURNING DAM - cat. #SS-60321
10. TOTE WELD OUTFIT - cat. #TW840-4474
11. PORTABLE PLASTIC WELDER - cat. #Vari-FL-SFT
12. CELL PRESSURE TESTER MP - cat. #83763
13. PLASTIC WELDING ROD 1/8
14. PLASTIC WELDING ROD 5/32
*15. CELL PULLER Pos. 76669
*16. CELL PULLER Neg. 76670

*NOT SHOWN

# Battery Record

Battery No.

| Start of Charge | | | | | | End of Charge | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Date | Hour | From Truck | Gravity Pilot | Charger No. | Operator | Date | Hour | Gravity Pilot | Temperature | Operator | Remarks |
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FORM 5847

Insert “W” in remarks when water is added.
Insert “E” in remarks when equalizing charge is given.
Insert “C” in remarks when battery is cleaned or washed.

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www.enersysmp.com
mpe@enersys.com