FLOODED
LEAD ACID

IRONCLAD®

Flooded
Lead-Acid Batteries

OWNER'S MANUAL

EnerSys®
Power/Full Solutions

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CONTENTS

INTRODUCTION

The information contained in this document is critical for safe handling and proper use of the Deserthog® battery for powering electrical industrial trucks. It contains a global system specification as well as related safety measures, codes of behavior, a guideline for commissioning and recommended maintenance. This document must be retained and available for users working with and responsible for the battery. All users are responsible for ensuring that all applications of the system are appropriate and safe, based on conditions anticipated or encountered during operation.

This owner's manual contains important safety instructions. Read and understand the sections on safety and operation of the battery before operating the battery and the equipment into which it is installed.

It is the owner's responsibility to ensure the use of the documentation and any activities related thereto, and to follow all legal requirements applicable to themselves and the applications in the respective countries.

This owner's manual is not intended to substitute for any training on handling and operating the industrial truck or Deserthog® battery that may be required by local laws and/or industry standards. Proper instruction and training of all users must be ensured prior to any contact with the battery system.

For service, contact your sales representative or call:
1-800-ENERSYS (USA) 1-800-363-7797
www.enersys.com

Your Safety and the Safety of others is Very Important

⚠ WARNING You can be killed or seriously injured if you don't follow these instructions.

Safety Precautions

- Explosion can result from the gases produced by a battery:
  - Do not smoke, use an open flame, or create arcs or sparks in the vicinity of a battery.
  - Only charge a battery in a well-ventilated area with the cover of the battery or compartment raised for maximum ventilation.
  - Do not charge the battery at a current greater than 5 amps per 100 amp-hours capacity at the end of the charge.
  - 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 gases 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.
    Formula
    .00027 x (finish rate) x (number of cells) = cu. ft. of hydrogen produced per min.
    Hydrogen must be ventilated to avoid an explosion. When calculating, assume all chargers are finish rate at the 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.
  - The ventilation system must also be designed to remove fumes and excess heat from the area directly above the charging batteries. Inlet air ducts should be placed at shoulder height or lower to provide air movement across the charging room and batteries. Failure to properly ventilate charging areas may result in employee complaints of heat and "battery odor" and may affect charger components.

- Only personnel who have been trained in battery installation, charging, and maintenance should be allowed to work on the battery. Read these instructions in their entirety before performing any work on or around batteries.

- Keep the vent plugs firmly in place at all times except when adding water or taking hydrometer and temperature readings. Keep all factory-installed insulators in place to prevent the exposure of live electrical parts.

- Severe burns can be caused by the sulfuric acid contained in the batteries' electrolyte covered by these instructions:
  - Batteries and sulfuric acid should be handled only by persons who have been instructed on the potential chemical hazards, following OSHA 29 C.F.R. 1910. 1200, Hazard Communication Standard. Refer to EnerSys® Safety Data Sheet (SDS) for lead-acid batteries.
  - In handling sulfuric acid, wear a face shield, plastic, or rubber apron, and gloves. Avoid spilling acid.
  - Do not get acid in the eyes, on the skin, or on clothing. In case of contact, flush immediately and thoroughly with clean water for at least 15 minutes. Obtain medical attention when eyes are affected.
  - PRO SERIES® battery wash neutralizing and cleaning solution, or sodium bicarbonate solution (1 lb./1 gal.), will neutralize any accidentally spilled acid. Apply the PRO SERIES® battery wash solution until it turns yellow (sodium bicarbonate solution stops bubbling), then rinse with clean 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 reactions.

- The battery is electrically live at all times:
  - Keep the top of the battery clean and dry to prevent ground shorts and corrosion.
  - Do not lay metallic objects on the battery; insulate all tools used in working on the battery to prevent short circuits. Remove all jewelry before working on the battery.
  - Be especially careful when working on battery terminal connections. High voltage capable of electric shocks or burns may be present. Make sure all terminal connections are properly insulated for safety.

Safety Precautions (cont.)

- When lifting the battery, observe the following precautions:
  - Follow the instructions on handling loads covered in OSHA 29 C.F.R. 1910. 1798(n).
  - Use a lifting device with two hooks that are electrically insulated from each other to prevent short circuits. Use a lifting beam that is completely insulated if possible, like a PRO SERIES® adjustable lifting beam.
  - When completely insulated lifting beams are not 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.

Spills and Recycling

- Spills of sulfuric acid should be handled with consideration for the following:
  - Do not touch spilled materials without appropriate personal protective equipment (e.g. face shield, acid-resistant gloves, etc.).
  - If possible, stop the flow of spilled acid with sand or other non-combustible absorbent. Neutralize with PRO SERIES® battery wash or other neutralizing agent.
  - Place spill residue into compatible containers. If a spill occurs from a battery, waste should be tested for the presence of hazardous constituents before disposal.
  - Do not allow the discharge of any electrolyte or acid into sanitary or storm sewers.
  - Spills that enter the environment (through sewers, waterways, or soil) must be reported, as applicable, to city, state, and/or federal environmental agencies as necessary.
  - Spills which occur during the transportation of batteries should be reported to CHEMTREC (1-800-424-9300) – a 24-hour service for emergency assistance.
- Handling and storage of new and used (spent) batteries:
  - Batteries and battery components should be handled only following the safety procedure outlined in the Safety Precautions section.
  - 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 containments to the environment.
  - Batteries and acids should be stored away from sewer and storm drains and from sources of heat.
  - Leaking or cracked batteries and cells must be contained to prevent further leakage.
  - Generally, there are no storage time restrictions for batteries or for spent lead-acid batteries that 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.
  - 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 required if the threshold planning quantity (TPQ) of sulfuric acid is exceeded, which is 1,000 pounds.
- Recycling:
  - 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 environment agency for additional information.

Spills and Recycling (cont.)

- 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 that have obtained EPA or state hazardous waste permits for the storage of spent batteries before recycling. Call 1-800-EnerSys for EnerSys® Battery Recycling.
- Acid that is removed from spent batteries may be regulated as hazardous waste. Facilities that generate spent acid may be subject to state or federal regulations for large or small quantity generators applicable to labeling, manifesting, transporting, and reporting.

Fundamentals

Battery: a device for converting chemical energy into electrical energy. All batteries are made up of individual compartments called cells, connected in series. Size, internal design, and the materials are used to control the amount of energy available from each cell. A lead-acid battery is several cells 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 electrolyte and the lead creates electrical energy.

Volt (V): the standard measure of electrical potential. A DC forklift's running speed and lifting speed are determined by a battery's voltage. AC forklifts typically draw a consistent level of power (Watts) from the battery, which means higher voltage batteries will require lower current draws to do the same work (Watts = Volts x Amperes). The advantage of higher battery voltages in AC lift trucks is lower ampere draws, leading to extended run times. Since each cell in a lead-acid battery has approximately 2 volts, multiply the number of cells by 2 to determine the terminal (overall) voltage. Forklifts are rated for a specific voltage battery.

Ampere (A): 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 battery current is measured in amperes. While it is important to match battery size with the maximum amperage requirements of a forklift truck, the most important factor to keep a truck running for an entire shift is the total capacity the battery has available, i.e. Ampere-hours.

Ampere-hour (Ah): the amount of current the battery can supply, multiplied by the length of time the battery is discharged. The higher a battery's

Fundamentals (cont.)

ampere-hour capacity, the longer a forklift will run. The amp-hour capacity varies with the length of the discharge. American forklift battery manufacturers rate their battery at the 6-hour rate. For example, a hypothetical battery has a rating of 680 ampere-hours (Ah) at the 6-hour rate. By dividing 680 Ah by 6 hours, a discharge rate of 113 amperes is determined. This means that if a forklift's motor and attachments draw 113 amperes continuously, the battery will be completely drained of usable power in 6 hours. To maximize the life of your battery, it should not be discharged below 80% depth of discharge.

Watt (W): the standard measure of electrical power. Multiplying volts by amperes determines watts. Every 1,000 watts is a kilowatt (kW). The total capacity available from a battery can be determined by multiplying wattage by the length of the discharge. For example, if your forklift needs 10 kW of continuous power for a 6-hour shift, you need a battery that provides 60 kilowatt hours (60 kWh) of energy.

Cycle: Every time a battery is charged and then discharged in use is one cycle. Battery life is usually measured in cycles. In a one-shift-per-day operation, a battery designed for 1,200 to 1,500 80% discharge cycles should last 5 or 6 years. 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 requested. 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 is less and less power-generating sulfuric acid as the battery is discharged. When the battery is recharged, the sulfuric acid returns.

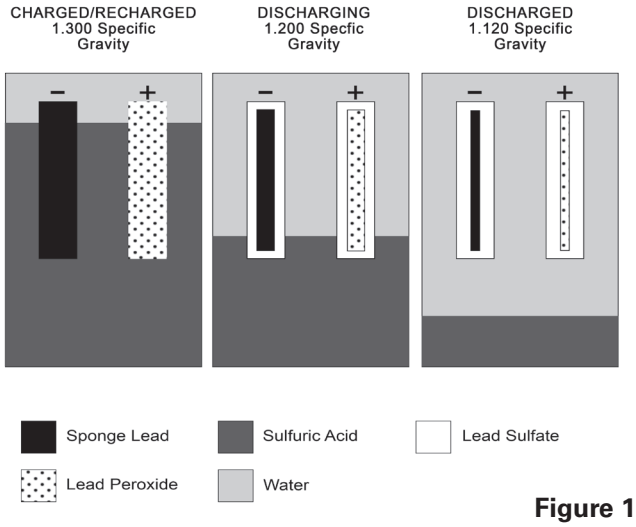

Figure 1

Figure 1: 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 that shows how much to correct for the temperature at your location.

Gassing: Gassing occurs when the battery does not accept some or all of the charge current. This normally occurs during the last 20% of a charging cycle. The water in the electrolyte inside the battery breaks down into hydrogen 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. Under-watering is even worse than over-watering. The electrolyte level must be above the cell's separator protector during charging and use. Otherwise, part of the plates will be unused. The battery will then overheat and gas more violently. The exposed plates will eventually dry out and become permanently damaged. Scheduled maintenance must be performed if a battery is to work to its full rated capacity.

Construction

Figure 2: Illustrates the construction of a typical motive power cell of the tubular design.

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

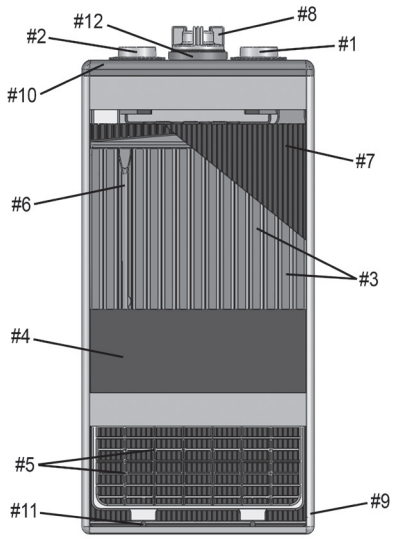

Figure 2

Inspection of the Battery Upon Receipt

- Examine for physical damage or loss of electrolyte.
- Report actual or suspected damage to the carrier.
- Give the battery an equalizing charge. (See Charging Characteristics section).
- Check electrolyte levels IMMEDIATELY after charge and add water if needed.
- When adding water, the electrolyte height should be as specified in the Watering section.

Moist-Charged Batteries

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

Moist-Charged Batteries (cont.)

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

- To prepare for use, carefully remove the sealed PRV (pressure relief valve) using an approved tool or, if necessary, a wide-grip pliers, taking care not to damage the cell vent well exterior. THROW AWAY THE PRESSURE RELIEF VALVE/VENT PLUG. Fill all cells with electrolyte 0.015 sp. gr. lower than the nominal operating gravity.
- Give the battery an equalizing charge, but keep resetting the charger to the equalized position until the specific gravities remain constant for three hours. At no time should battery temperature be allowed to exceed 110°F (43°C).
- After 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 Specific Gravities table, on page 12. 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 to mix the electrolyte properly. Removed electrolyte must be disposed of in strict accordance with all environmental regulations.
- Upon completion of the above steps, apply a standard vent cap to all cells.

Installation of Batteries

- 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 questions arise.
- When lifting the battery, use a PRO SERIES® adjustable lifting beam, which exerts a vertical pull on the lifting tabs only.
- The battery should be blocked, not wedged, to allow 1/8" minimum clearance on all sides for easy removal from the battery compartment. Excessive clearance will allow the battery to move inside the battery compartment, which may cause damage.
- 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 Charging Characteristics section).
- If any connections on the battery itself are bolted together, make them clean and bright, eing careful not to remove the lead coating from any lead-plated copper parts. Coat the surfaces to be bolted together with NO-OX grease. Torque all bolted connections to 120 in-lbs, unless otherwise specified. 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 other than at 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 can void your warranty.

TAPPING THE BATTERY SHORTENS ITS LIFE BY UP TO THREE YEARS.

- Storage – refer to the Storage section.

Fast Charging and Opportunity Charging

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 30% depth of discharge during the daily discharge cycle, thereby reducing or even eliminating the need to change out spent batteries in a heavy single-shift or multi-shift operation. Opportunity chargers need to limit battery gassing to one hour per 24-hour period (except for the equalizing charge). The total accumulated discharged ampere-hours should not exceed 120% of the battery's designed capacity rating per day. Discharge of more than 120% of the battery's designed capacity rating in a 24-hour period will shorten battery life. Charge rates during opportunity charging should not exceed 25 amps per 100 amp-hours of a battery's nameplate capacity. Under the opportunity charging procedures outlined in this paragraph, special opportunity battery warranties apply.

Fast charging is intended to extend a battery's run time during a shift or day. A typical fast charging system will provide charge rates from 26 to 50 amps per 100 amp-hours of a battery's nameplate capacity. Fast charging requires special chargers that can monitor and manage battery temperatures during charge, limit battery gassing to no more than one hour per 24-hour period (except for the equalizing charge), assure a battery is recharged to at least 90% state of charge daily, and automatically 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 utilize no more than 160% of the battery's 6-hour capacity rating in a shift day. Under the fast charging procedures outlined in this paragraph, special fast-charging warranties apply.

If engaging in opportunity charging or fast charging, the battery must be returned to nameplate-specific gravity at least once per week (equalizing charge). However, a daily recharge to nameplate-specific gravity is desirable.

Operation

- The full-charge specific gravity of a new battery will be specified on the nameplate located on the side of the battery tray. Full charge specific gravity will be affected by temperature, acid level, and battery age. If acid is lost from overfilling, full charge specific gravity and capacity will be lowered.
- Under normal conditions, only add water. NEVER add acid or other solutions to the cells.
- Keep the plugs and receptacles in good condition. When disconnecting the battery from the truck or charger, pull on the receptacle, not the cable. When disconnecting from a charger, ensure that the charger is off first; otherwise, arcing will result. Arcing can cause battery explosion and damage to connector contacts and charger components.

Temperatures

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.

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 the charge, resulting in lower charge currents and a longer recharge time. Undercharging could occur unless charger adjustments are made to compensate.

There is little danger of freezing 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.

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

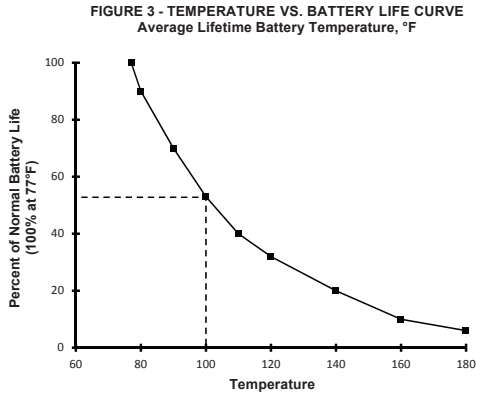

Figure 3

In sub-freezing temperatures, water should be added just before charging is completed to ensure 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.

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

- Avoid over-discharging.
- Charge in a cool location.
- Supply ample ventilation during charge by always opening the battery compartment or battery cover and circulating air by fans if necessary.
- Allow the battery to cool down after charge before putting it back in service

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.

DISCHARGE & CHARGING

Discharge Characteristics

- 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. This point typically occurs at 80% depth of discharge.
- 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. 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.
- 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 are dependent on the following conditions: ambient temperatures, battery design and layout, and battery discharge rate.
- As mentioned, a battery should not be discharged beyond the point where the cells approach exhaustion. This is referred to as over-discharging, and can have very harmful results, particularly if repeated for several days or cycles. Over-discharge can be avoided by using a properly calibrated 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.

SPECIFIC GRAVITIES @ 77°F			
Cell Type	Fully Charged	80% Discharge*	100% Discharge*
E-55L	1.315	1.170	1.130
E-75L	1.315	1.170	1.130
E-75	1.280	1.175	1.140
E-90	1.280	1.150	1.120
E-90D	1.280	1.155	1.125
E-100	1.315	1.150	1.110
E-100X	1.280	1.130	1.090
E-110	1.315	1.155	1.115
E-100D	1.280	1.155	1.125
E-125	1.280	1.150	1.120
E-125D	1.280	1.155	1.125
E-140	1.300	1.145	1.100
E-140X	1.280	1.140	1.105
E-155	1.315	1.155	1.115

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

Charging Equipment

- Battery charging should be accomplished with an electronically controlled charger that will regulate current and voltage. Refer to the Lead-Acid Battery Charging Specifications table, on page 14, for proper charge rates, times, and charge intervals.
- When the discharged battery is placed on charge, the battery will draw a relatively high current, which will be at or close to the maximum output 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.
- When charging any industrial battery, only use an approved charger that is capable of returning a discharged battery's specific gravity back to its nameplate rating within 8 hours. Several chargers offered by EnerSys will accomplish this requirement. Some charger technologies, such as ferro-resonant, will not adequately charge

Charging Equipment (cont.)

a Deserthog® tubular battery and will result in undercharging and short life. Please contact an EnerSys representative for more information.

- Although several chargers meet the mentioned general requirements above, not all chargers are equal. Contact your local EnerSys representative for more details.

Charging Characteristics

- 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 125˚F.

- Every effort should be made to ensure that the battery receives the proper amount of charge. Consistent under-charge and/or excessive over-charge will contribute to internal battery problems that will cause a loss of capacity and reduction of life.
  - 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 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 are desirable.
  - Stratification – Caused by insufficient gassing at the end of the charge. Little or no mixing of electrolyte will 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.

- Overcharge
  - Overcharge is uneconomical from a power standpoint and wastes electrical energy while running the risk of permanent damage to the battery.
  - 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.
  - It creates dangerously high battery temperature, which significantly shortens normal battery life if repeated instances occur above 125°F. (See **Figure 3** in the Temperatures section.)
  - Higher temperatures tend to reduce the battery voltage on the charge, permitting higher current flow from the charger and further raising the cell temperatures. Battery temperature at the end of charge should not exceed 125˚F.
  - Should excessive battery temperature occur with some frequency, call your local EnerSys representative for assistance.
  - When the battery reaches full charge, the charge should be stopped. No amount of overcharging can increase battery capacity.

- When charging batteries while they are in the vehicle, ensure proper ventilation. Open the battery cover, if so equipped, as well as the battery compartment cover of the vehicle. Disregarding these recommendations can cause pockets of hydrogen to remain in the vehicle or battery, increasing the risk of explosions when the vehicle is put into use.

- The extra effort to ensure proper charging is well spent because it will result in trouble-free battery performance, reduced maintenance, and long battery life.

- Equalizing charge
  - Equalizing charge is necessary to bring a battery to a state of full charge to avoid excess sulfation and unbalanced cells. Equalizing charges must be done according to EnerSys specifications, and excessive overcharges must be avoided.
  - Equalizing charge should be performed once weekly according to the Lead-Acid Battery Charging Specifications table, on page 14.
  - Ensure battery temperature is 90˚F or lower before initiating an equalization. Equalizing should be scheduled at a time when water can be added at the end of equalizing or as soon as possible thereafter.

Maintenance

- Specific records should be maintained for each battery in your fleet. These records will provide a means of identifying batteries that may need repair or adjustment, have a charger problem, or which have reached the end of their useful life. Such records also help ensure warranty protection.
- Where more than several batteries are in use, each one should be identified with a permanent number assigned when received. That number should be 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.
- After each battery is received and equalized, record the corrected specific gravity of each cell. This serves as a reference for comparison with later readings.
- 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% discharge (see the table in the Discharge Characteristics section). If the 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.
- 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, more frequent readings can be initiated. The final determination for the frequency of hydrometer readings should depend on your experience and advice from your local EnerSys representative.

Lead-Acid Battery Charging Specifications

Battery Type (Charge Type)	Flooded (8 HR Charge)	Flooded (Opportunity Charge)	Flooded (Fast Charge)
Start Charge Rate*	15-20%	15-25%	26-50%
Finish Charge Rate*	4.0-5.0%	4.5-5.0%	5.0%
Charge Interval	Daily	Opportunity	Opportunity
Equalizing Charge Rate*	4.5-5.0%	4.5-5.0%	2.0-3.0%
Equalize Time on Charge	3 Hours	3-7 Hours	10-12 Hours
Equalize Interval	Weekly	Weekly (minimum)	Weekly (minimum)

*Percentage of the battery's 6-hour nameplate ampere-hour capacity rating (ampere output)

Troubleshooting

The following conditions are usually indications of approaching trouble.

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

*For specific gravity adjustments, contact your local EnerSys representative.

Determination of Capacity

- 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 toward the end of the day's work (DC motor) or shortened run times (AC motor).
- A battery is usually considered to be at the end of its usefulness when its capacity decreases below 80% of the normal rating. However, it can sometimes be transferred to a smaller job and thus give additional life and service.
- Since the average motive power battery passes a "test" every day by performing to 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 conventionally or accurately. If any such testing is desired, consult your EnerSys Representative regarding equipment and procedure.

Watering

- Use only approved water that is 1) distilled water; 2) demineralized 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. The addition of acid, commercial additives, or foreign material may void your warranty.
- If there is some doubt as to whether the water being used is suitable for use in lead-acid storage batteries, obtain an analysis from a qualified laboratory; otherwise, distilled or deionized water should be used. Deionized water is available by using the PRO SERIES® water deionizer.
- The Water Impurity Chart shows the maximum allowable impurities.

Water Impurity Chart

Requirements	Maximum Allowable Limits in Parts Per Million (ppm)
Total Solids	350
Fixed Solids	200
Organic and Volatile	150
Iron	4
Chloride	25
Ammonium (NH_4)	5
Nitrates (NO_2)	10
Nitrates (NO_3)	10
Manganese	0.07
Calcium and Magnesium	40

- An EnerSys-approved 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 following **Figure 4**, on the next page.
- Another convenient way to ensure proper fill levels is the use of a single-point watering (SPW) system. The PRO SERIES® single-point watering systems are efficient methods of watering a battery. These reliable quality systems allow the operator to fill to the proper level each time.

Watering (cont.)

- Water should only be added to the battery when it is near the end of charge and gassing. As the electrolyte is at its maximum level during this time, it is a certainty that the level established by the addition of water will not be exceeded at any other time, and overflow of the electrolyte (flooding) will never occur. When watering near or at the end of the charge, sufficient water should be added to bring the level of the electrolyte between its upper limits. See **Figure 4** for details.

- It is often inconvenient or impossible to be present at the end of the 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.

- 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 the watering gun to fill to the maximum possible height.
  2. Water while the battery is on charge and gassing.
  3. Do not add water until an actual visual inspection shows the top of separators 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.

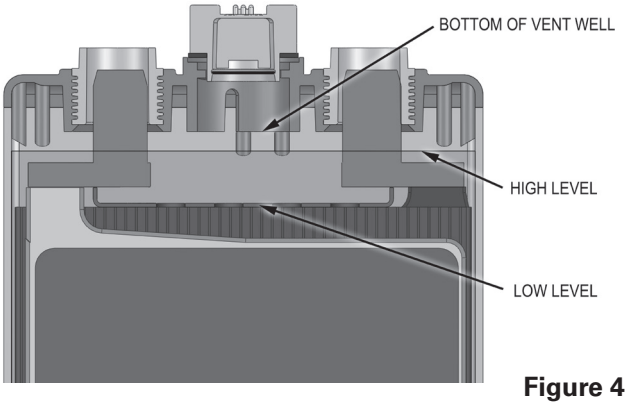

Figure 4

- 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.

⚠ CAUTION Avoid overfilling as it will cause overflow (flooding) of electrolyte, resulting in loss of electrolyte, tray corrosion, ground paths, and loss of capacity.

Figure 4: 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. The high-level line is 1/4" below the bottom of the vent well.

Cleaning

⚠ WARNING Do NOT use any type of oil, organic solvent, alcohol, detergent, strong acids, strong alkalis, petroleum-based solvent or ammonia solution to clean the jars or covers. These materials may cause permanent damage to the battery jar and cover and will void the warranty.

- Check the battery for cleanliness at regular intervals. When necessary, dust or other material that has accumulated should be removed by cleaning the battery. Make sure vent plugs are in place when cleaning or neutralizing a battery.

- Electrolyte spilled on the battery cell covers, trays, or battery compartment never dries or evaporates. It causes paths to ground and corrodes any metal parts. For light cleaning, regular use of a neutralizing cloth such as PRO SERIES® battery wipes may help remove these harmful deposits.

- Washing is recommended at least twice yearly. A clean battery is an indication of good maintenance and increases battery life. To both clean and neutralize your battery, use PRO SERIES® battery wash.

Cleaning (cont.)

This spray-on premixed cleaning solution changes color as it neutralizes electrolyte or acids. Use this cleaner or sodium bicarbonate and water (1.0 lb./1.0 gal.) any time you see electrolyte on top of the battery. If any corrosion exists on metal parts of the tray or compartment, repaint with acid-resistant paint after cleaning.

- For large installations, a "washstand" should be provided with a water hose and adequate drainage. It should include a container for the cleaner, brushes, etc.
- 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 make sure that they are not clogged with dirt. Wash all vent plugs yearly or as needed by immersing them in a bucket of water and wiping clean.

Storage of Batteries

- Batteries should be stored in a clean, dry, and well-ventilated location away from radiators or heating ducts, etc. Do not store in direct sunlight.
- Before storing, it is necessary that the battery is fully charged and the electrolyte is at the proper level. Disconnect leads or cable connections to prevent possible added loss of charge during prolonged storage period. Do not remove electrolyte or dismantle the battery.
- If storage temperature is 80˚F or higher, check specific gravity at least monthly. If lower than 80˚F, check every two months. Whenever specific gravity falls to about 1.240 or below, give the battery an equalizing charge as discussed in the Charging Characteristics section.
- Fully charge, equalize, and water the battery before returning to service from storage.

Accessories

Certain accessories and tools are desirable for routine work in the charging room. The following items are recommended for every charging room:

- PRO SERIES® alarm hydrogen detector #099140. This alarm will monitor the hydrogen emitted from batteries while gassing during charge and provide ventilation and warning before explosive levels are reached (as the National Fire Protection Agency recommends). Call your local EnerSys representative for options and accessories.
- PRO SERIES® hydrometer #13142 (up to 1.300 SG). 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 the two tables in the Temperatures and Discharge Characteristics sections. Special floats are available for different specific gravity scales.
- PRO SERIES® thermometer #88330. Quickly takes the internal temperatures of a single cell. Assures that you have a method to check that charge temperatures have not exceeded 125˚F (see Charging Characteristics section).
- PRO SERIES® battery watering gun #PSI-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. PRO SERIES® flip top vent cap #811112 makes watering a snap when used with a watering gun.
- PRO SERIES® wash light #94883-4QT. This unique cleaner/neutralizer solution is a premixed liquid in a spray bottle that neutralizes spilled electrolyte (acid) as it cleans and degreases your battery. In addition, the liquid turns from red to yellow, giving a positive indication when a corrosive acid has been neutralized. Four one-quart bottles per package.
- PRO SERIES® safety kit #85879 provides all the personal protective equipment necessary to satisfy OSHA regulations.
- PRO SERIES® clean battery maintenance kit #853630 and PRO Wipes #WSC-304-HDW. These products will help maintain a clean battery.
- PRO SERIES® 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

EnerSys also offers the following items that are useful in the operation of batteries:

- PRO SERIES® 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.
- PRO SERIES® battery lifting beam #PSBEAM-4PL. Adjusts to fit batteries from 21" to 42" 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.
- PRO SERIES® HydroFill™ 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 approved water. The cart comes complete with DC motor, battery, charger, and a 10-gallon tank.

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