PowerSafe

Safety, Storage, Operating and Maintenance Manual

VRLA Battery Systems
DDm, DDS, DGX, DDV and SC

EnerSys
Power/Full Solutions

Publication No. US-VR-OM-001 February 2003

PowerSafe

Safety, Storage, Operating And Maintenance Manual

VRLA Battery Systems
DDm, DDS, DGX, DDV and SC

When working with any EnerSys Modular Battery System, be sure to refer to the Installation Manual specified for that system and Rack Assembly Instructions included in the rack shipment.

EnerSys
Power/Full Solutions™

This manual provides full instructions regarding safety, storage, operation and maintenance for EnerSys valve-regulated lead acid batteries, as well as certain installation considerations. To maximize safety and performance, read the accompanying *Installation Manual* thoroughly. Failure to observe the precautions as presented may result in injury or loss of life.

Please check our website for literature updates.
www.enersysinc.com

GENERAL SAFETY INSTRUCTIONS

Warnings in this manual appear in any of three ways:

Danger

The danger symbol is a lightning bolt mark enclosed in a triangle. The danger symbol is used to indicate imminently hazardous situations, locations and conditions which, if not avoided, WILL result in death, serious injury and/or severe property damage.

Warning

The warning symbol is an exclamation mark in a triangle. The warning symbol is used to indicate potentially hazardous situations and conditions which, if not avoided COULD result in serious injury or death. Severe property damage COULD also occur.

Caution

The caution symbol is an exclamation mark enclosed in a triangle. The caution symbol is used to indicate potentially hazardous situations and conditions which, if not avoided may result in injury. Equipment damage may also occur.

Other warning symbols may appear along with the *Danger* and *Caution* symbols and are used to specify special hazards. These warnings describe particular areas where special care and/or procedures are required in order to prevent serious injury and possible death:

Electrical warnings

The electrical warning symbol is a lightning bolt mark enclosed in a triangle. The electrical warning symbol is used to indicate high voltage locations and conditions that may cause serious injury or death if the proper precautions are not observed.

Explosion warnings

The explosion warning symbol is an explosion mark enclosed in a triangle. The explosion warning symbol is used to indicate locations and conditions where molten, exploding parts may cause serious injury or death if the proper precautions are not observed.

IMPORTANT SAFETY INSTRUCTIONS

DANGER

A battery can present a risk of electrical shock and high short circuit current.

The following precautions should be observed when working with batteries.

1. Verify that the Uninterruptible Power Supply (UPS) is off and that the power cord is disconnected from the power source.
2. Remove watches, rings or other metal objects.
3. Use tools with insulated handles to prevent inadvertent shorts.
4. Wear rubber gloves and boots.
5. Do not lay tools or metal parts on top of batteries.
6. Determine if the battery is inadvertently grounded. If inadvertently grounded, remove source of ground. Contact with any part of a grounded battery can result in electrical shock. The likelihood of such shock will be reduced if such grounds are removed during installation and maintenance.
7. Verify circuit polarities before making connections.
8. Disconnect charging source and load before connecting or disconnecting terminals
9. Valve-regulated lead acid (VRLA) batteries contain an explosive mixture of hydrogen gas. Do not smoke, cause a flame or spark in the immediate area of the batteries. This includes static electricity from the body.
10. Use proper lifting means when moving batteries and wear all appropriate safety clothing and equipment.
11. Do not dispose of lead acid batteries except through channels in accordance with local, state and federal regulations.

IMPORTANT SAFETY INSTRUCTIONS

SAVE THESE INSTRUCTIONS

This manual contains important instructions for valve-regulated lead acid battery systems that should be followed during the installation and maintenance of the battery system.

Only a qualified EnerSys sales/service representative who is knowledgeable in batteries and the required precautions should perform servicing of the batteries. Keep unauthorized personnel away from batteries.

Caution Misuse of this equipment could result in human injury and equipment damage. In no event will EnerSys be responsible or liable for either indirect or consequential damage or injury that may result from the use of this equipment.

Caution Do not dispose of the batteries in a fire. The batteries may explode.

Caution Do not open or mutilate the batteries. Released electrolyte is harmful to the eyes and skin and may also be toxic.

Warning This unit contains sealed lead acid batteries. Lack of preventative maintenance could result in batteries exploding and emitting gasses and/or flame. An authorized, trained technician must perform annual preventative maintenance.

Warning Failure to replace a battery before it becomes exhausted may cause the case to crack, possibly releasing electrolytes from inside the battery and resulting in secondary faults such as odor, smoke and fire.

Warning Installation and servicing of batteries should be performed by personnel knowledgeable about batteries and the required precautions. Keep unauthorized personnel away from the batteries.

Warning Proper maintenance to the battery system of this unit must be done by a qualified service technician. This is essential to the safety and reliability of your Uninterruptible Power Supply (UPS) system.

When working with any EnerSys Modular Battery System, be sure to refer to the Installation Manual specified for that system and Rack Assembly Instructions included in the rack shipment.

TABLE OF CONTENTS

1.0 GENERAL INFORMATION

1.1 Introduction

EnerSys modular valve-regulated lead acid (VRLA) batteries have unique features that make them easy to install and maintain. These batteries are composed of absorbed glass mat (AGM) separators with flat plates and/or gelled electrolyte with tubular positive plates.

The AGM retains the acid between the plates to ensure long float service. In the case of gelled acid, the acid is retained in a gel medium; thus, maximum contact with the plates ensures long float service in cycling applications. Furthermore, the tubular positive plate design holds the active material in position, providing excellent high cycling ability (1200 cycles to 80% DOD). Both utilize gas recombinant technology to minimize maintenance.

EnerSys batteries utilize calcium alloy grids (NO cadmium) which float at a lower current than antimony (Sb). Lower float currents, in conjunction with superior and uniform thermal management, reduce the chances of thermal runaway. (Temperature compensation chargers are also recommended.)

EnerSys VRLA batteries typically do not require special battery rooms because excess hydrogen is not emitted under normal operating conditions. In addition, the modules make installation fast and easy.

1.2 Precautions

BEFORE UNPACKING, STORING, HANDLING, INSTALLING, OPERATING OR PERFORMING MAINTENANCE ON THE ENERSYS VRLA BATTERY SYSTEM:

READ
THE FOLLOWING
INFORMATION THOROUGHLY!

It is important to read, understand and strictly follow the instructions in this manual.

If the following precautions are not fully understood, or if local conditions are not covered, contact your nearest EnerSys sales/service representative for clarification or call the corporate office number listed on the back of this manual and ask for EnerSys Integrated Systems and Services.

Also, refer to all applicable federal, state and local regulations and industry standards.

YOU SHOULD BE TRAINED IN HANDLING, INSTALLING, OPERATING AND MAINTAINING BATTERIES BEFORE YOU WORK ON ANY BATTERY SYSTEM.

1.3 Service

Should you require installation supervision, service, parts, accessories or maintenance; EnerSys has a nationwide service organization to assist with your new battery purchase.

Please call your nearest EnerSys sales/service representative for more information or call the corporate office number listed on the back of this manual and ask for EnerSys Integrated Systems and Services.

2.0 SAFETY

2.1 General

EnerSys valve-regulated lead acid batteries are reduced-maintenance batteries that operate on recombinant principles and are safer than conventional "wet cell" lead-acid batteries.

Under **NORMAL** operating conditions and use, their design features:

- minimize hydrogen gas release
- virtually eliminate acid misting
- essentially eliminate leakage

Under **ABNORMAL** operating conditions or as a result of damage, abuse and/or misuse, the potentially hazardous conditions of hydrogen gassing, acid misting and leakage may occur.

YOU SHOULD BE **TRAINED** IN HANDLING, INSTALLING, OPERATING AND MAINTAINING BATTERIES BEFORE YOU WORK ON ANY BATTERY SYSTEM.

You MUST understand the risk of working with batteries and BE PREPARED and EQUIPPED to take the necessary safety precautions. If not, contact EnerSys Integrated Systems and Services.

2.2 Safety Equipment and Clothing

When working with any battery system, be sure you have the necessary tools and safety equipment, including but not limited to:

- insulated tools
- rubber gloves
- fire extinguisher
- rubber apron
- safety goggles
- acid spill cleanup kit
- face shields
- emergency eye wash and shower, if available

ALWAYS:

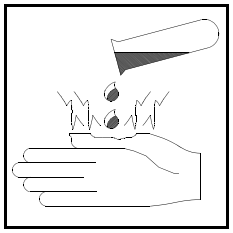
- remove all jewelry (i.e., rings, watches, chains, etc.)
- keep sparks, flames and smoking materials away from the battery

NEVER lay tools or other metallic objects on the battery modules.

Using the correct tools and wearing proper safety equipment will help prevent injury should an accident occur.

2.3 Safety Precautions

2.3.1 Sulfuric Acid Burns



Because VRLA cells are sealed, they normally do not present an acid danger. However, they do contain sulfuric acid, which can cause burns and other serious injuries.

Always wear protective clothing AND use the correct safety tools.

In case of **SKIN CONTACT** with sulfuric acid, **IMMEDIATELY**

1. **REMOVE** contaminated **CLOTHING**
2. **FLUSH** the area **THOROUGHLY** with **WATER**
3. Get **MEDICAL ATTENTION**, if required.

In case of **EYE CONTACT** with sulfuric acid, **IMMEDIATELY**

1. **FLUSH THOROUGHLY** for at least 15 minutes with large amounts of **WATER**.
2. Get **MEDICAL ATTENTION**.

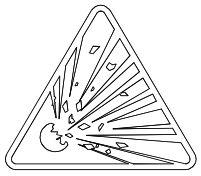
In case of sulfuric acid **CONTACT WITH CLOTHING OR MATERIAL, IMMEDIATELY**

1. **REMOVE** CONTAMINATED CLOTHING.
2. Apply a solution of sodium bicarbonate solution (1.0 lb/1.0 gal or 0.5 kg/5.0 liters of water) on the clothing or material.
3. Apply the solution until bubbling stops, then rinse with clean water.

NOTE: In case of a sulfuric acid **SPILL**, bicarbonate of soda or an emergency spill kit should be within the battery room in accordance with OSHA regulations 1910.178g2.

2.3.2 Explosive Gases

Batteries can generate gases which when released, can explode, causing blindness and other serious personal injury.



Always wear protective clothing and use the correct safety tools.

Eliminate any potential of sparks, flames or arcing.

IN CASE OF FIRE: To extinguish a fire in a battery room containing lead-acid batteries, use a CO_2, foam or dry-chemical extinguishing medium. Do NOT discharge the extinguisher directly onto the battery. The resulting thermal shock may cause cracking of the battery case/cover.

SPECIAL PROCEDURES:

If batteries are on charge, shut off power. Use positive-pressure, self-contained breathing apparatus. Wear acid resistant clothing. Water applied to electrolyte generates heat and causes it to splatter.

TOXIC FUMES:

Burning plastic may cause toxic fumes. Leave area as soon as possible if toxic fumes are present. Wear breathing apparatus if required to remain in the area.

2.3.3 Electrical Shocks and Burns

Multi-cell battery systems can attain high voltage and/or currents. Do NOT touch uninsulated batteries, connectors or terminals. To prevent serious electrical burns and shock, use EXTREME CAUTION when working with the system.

Always wear protective clothing and use nonconductive or insulated safety tools when working with ANY battery system.

Remove all jewelry that could produce a short circuit.

BEFORE working on the system:

1. Disconnect ALL loads and power sources to the battery. Use appropriate lockout/tagout procedures.

2. If working on an assembled battery system, sectionalize (interrupt the battery sections) into safe working voltage levels.

3. Check the battery system grounding. Grounding of the battery system is NOT recommended. However, grounding of the rack is recommended.

IF BATTERY SYSTEM IS GROUNDED: (system is intentionally grounded by connecting a battery terminal to ground)

1. an increased shock hazard exists between the terminal of opposite polarity and ground, (i.e., dirt and acid on top of battery cell touching rack).

2. if an unintentional ground develops within the already grounded system, a short circuit may occur and cause explosion or fire.

IF BATTERY SYSTEM IS UNGROUNDED:

1. if an unintentional ground develops within the system, an increased shock hazard exists between the terminal of opposite polarity and ground.

2. if a second unintentional ground develops within the already unintentionally grounded system, a short circuit may occur and cause explosion or fire.

Therefore, should you be required to work on a grounded battery system, make absolutely sure you use the correct safety precautions, equipment and clothing.

IMPORTANT!

If you have ANY question concerning safety when working with the battery system, contact your nearest EnerSys sales/service representative to clarify any of the noted safety precautions, or call the corporate office number listed on the back of this manual and ask for EnerSys Integrated Systems and Services.

3.0 INSPECTING BATTERY SHIPMENT

3.1 General

Precautions have been taken to pack the battery units, individual cells or cabinets containing batteries for shipment to ensure their safe arrival. However, upon receipt, you should inspect for evidence of damage that may have occurred during transit.

WARNING

During inspections, take precautions against electrical shock. You are handling LIVE batteries.

3.2 Visible External Damage

IMMEDIATELY upon delivery (while the carrier representative is still on-site), inventory all materials against the Bill of Lading and inspect for visible external damage.

Check material quantities received against the Bill of Lading, including the number of battery pallets and the number of accessory boxes.

Note any:

- damage to packing material.
- wetness or stains, indicating electrolyte leakage.

If damage is noted:

1. Make a descriptive notation on the delivery receipt before signing.
2. Request an inspection by the carrier.
3. File a damage report.

3.3 Concealed Damage

Within **15 days of receipt**, unpack the cells/batteries and check for concealed damage. Remember, you are handling a **LIVE** battery. Take precaution against a shock hazard. Follow all safety precautions as noted in Section 2.0.

Note any:

- damage to packing material.
- wetness or stains, indicating electrolyte leakage.

If damage is noted:

1. Request an inspection by the carrier.
2. File a concealed-damage claim.

Check the received materials against the detailed packing list to verify receipt of all materials in the quantities specified.

For export, the cells may be packed in wooden boxes which must be opened completely and carefully, and the cells then handled as described hereafter. See Section 6 for unpacking and handling.

DELAY IN NOTIFYING THE CARRIER MAY RESULT IN LOSS OF YOUR RIGHT TO REIMBURSEMENT FOR DAMAGES. Refer to the Bill of Lading, if, when performing the parts inventory, you are unsure about the appearance of a part.

If you have any questions concerning potential damages, contact your nearest EnerSys sales/ service representative, or call the corporate office number listed on the back of this manual and ask for EnerSys Integrated Systems and Services.

4.0 BATTERY STORAGE BEFORE INSTALLATION

4.1 General

Batteries should be unpacked, installed and charged as soon as possible after receipt. However, if this is impractical, follow the instructions below for storing the battery before installation.

4.2 Storage Location

1. Store batteries indoors in a clean, dry and cool location. Storage at higher temperatures will result in accelerated rates of self-discharge and possible deterioration of battery performance and life.

2. Do **NOT** stack pallets. **DAMAGE MAY OCCUR AND THE WARRANTY MAY BE VOIDED.**

3. The maximum storage time from shipment to initial charge is six months for batteries stored at ambient temperatures no warmer than 77°F (25°C). For storage temperatures greater than 77°F (25°C), the battery must be recharged one (1) month sooner for every 5°F (3°C) increase above 77°F (25°C). See Table 4.1.

TABLE 4.1	
STORAGE TEMPERATURE	**STORAGE TIME**
32°F (0°C) to 50°F (10°C)	9 months
51°F (11°C) to 77°F (25°C)	6 months
78°F (26°C) to 92°F (33°C)	3 months

If storage time exceeds the storage time recommended in Table 4.1, give the battery a *freshening charge* before the end of the recommended storage interval. See Section 7 for charging information.

EnerSys VRLA DDm, DDS and DDV batteries must be charged in the horizontal position. Charging in the vertical position could void the warranty.

4. Repeat the *freshening charge* for each additional storage interval until the battery is installed.

   Storage at higher temperatures will result in accelerated rates of self-discharge and possible deterioration of battery performance and life. Storage times exceeding the above may result in plate sulfation, which may adversely affect electrical performance and expected life.

5. Maximum total storage time prior to installation is two (2) years from date of shipment from the factory to the customer. *Freshening charges* are required before the end of the storage time period, or more frequently, as noted in Table 4.1.

6. **FAILURE TO CHARGE AS NOTED VOIDS THE BATTERY'S WARRANTY.**

4.3 Advance Preparation

If storage time is likely to be exceeded, make advance preparation to have an adequate charger available and adjacent to an appropriate AC supply voltage. Positioning of the cells to accept temporary intercell connectors is another consideration of advance planning. Keep cells on styrofoam pads until the cells are installed on the rack (when applicable).

Make every effort to get the battery connected to the charger before expiration of the storage period, thereby avoiding the additional labor cost of preliminary freshening charges.

WARNING

FAILURE TO CHARGE AS NOTED VOIDS THE BATTERY'S WARRANTY.

BEFORE INSTALLATION
READ THIS SECTION THOROUGHLY.

5.0 INSTALLATION CONSIDERATIONS

5.1 General

If you have any questions concerning the installation considerations, contact your EnerSys sales/ service representative for clarification or call the corporate office number listed on the back of this manual and ask for EnerSys Integrated Systems and Services.

When planning the system space requirements, consider the following:

- space
- environment
- temperature
- distance from operating equipment
- ventilation
- battery system configuration
- floor loading
- floor anchoring

Table 5.1 will assist you to ensure that all requirements for installation location are considered.

TABLE 5.1

CONSIDERATION	RECOMMENDATION
Space	Aisle space should be in accordance with the National Electric Code (NEC) Article 110-16 or local codes. Clearance from wall/equipment - 4" (10 cm) minimum
Environment	Clean, cool and dry. The location should be selected to keep water, oil, and dirt away from all cells.
Temperature	Ambient temperature between 72°-78°F (23°-26°C). Elevated temperatures reduce operating life. Lower temperatures reduce battery performance. Minimize temperature variations between the cells. (To avoid temperature variation between the cells, do NOT locate the battery near HVAC ducts or exhausts, heat sources (i.e., equipment that generates heat) or direct sunlight.

TABLE 5.1 (continued)	
CONSIDERATION	**RECOMMENDATION**
Ventilation	No special battery room or ventilation is required. However, do NOT install in an airtight enclosure.
Grounding	It is recommended that the modules or racks be grounded in accordance with NEC and/or local codes.
Floor	Reasonably level. Shimming up to 1/4" (6 mm) maximum to level battery front to rear and side to side. Capable of supporting the weight of the battery as well as any auxiliary equipment.
Anchoring	**All** installations should be floor anchored. Anchoring should meet all local, state, federal codes and industry standards. **Floor anchoring and its design are the responsibility of the installer.** Ensure **seismic** requirements are considered.
Proximity to Electronic Equipment	EnerSys VRLA batteries may be installed next to electronic equipment, unless it generates heat.

5.2 Considerations for Connecting the Battery System to Operating Equipment

The battery has been sized based on a specific load (amps or KW) for a specific run time to a specific end voltage. Consult with the system/equipment supplier to determine these parameters, because battery performance is based on these values, which are measured at the battery terminals.

Therefore, ensure that the load cables:

- between the battery and its load are the shortest routing possible to the terminal, allowing sufficient additional cable (about 6" [15 cm]) for connect/disconnect.
- are the proper size to minimize the voltage drop between the battery output terminals and the load.
- are connected to the terminal plate (NEVER connect the load cable(s) directly to the battery terminal).

To select the proper cable size:

1. Determine the cable size necessary to carry the design load.
2. Calculate the voltage drop of the cable between the battery terminal plate and the operating equipment.
3. Increase cable size to achieve the allowable voltage drop.

Cable selection should provide no greater voltage drop than required between the battery system and the operating equipment as determined by the equipment/system supplier. Excessive voltage drop will reduce the desired support time of the battery system.

5.3 Considerations for Parallel Installation

If it is necessary to connect the battery system in parallel to obtain sufficient capacity, cable connections to each of the parallel strings are important. If parallel connection is required, do NOT exceed five strings in parallel.

To obtain:

- proper load sharing on the discharge
- satisfactory recharge
- the same float voltage for each string,

cables from the batteries to the load must be:

- as short as possible (equal to the longest intercell connector).
- of equal lengths to the load.
- of sufficient ampacity (cable ampacity should not be exceeded).

6.0 UNPACKING AND HANDLING FOR INSTALLATION

6.1 General

Battery modules are shipped upright on pallets. All accessories for installation and use are supplied as optional prepackaged kits and are shipped on separate pallet(s) and/or in box(es). Cells may be packed in wooden boxes, which must be opened completely and carefully. The cells **must then be handled as described in the appropriate Installation Manual**.

DO NOT lift any cell by the terminal posts as this will void the warranty. When lifting large cells/units with crane, hoist or similar device, use lifting belt(s) and protective styrofoam shipping cover(s) provided (when applicable).

DO NOT attempt to remove the pressure relief valves or vent covers as this will void the warranty. Attempted removal may also damage the vent and prevent proper functioning of the battery.

6.2 Accessories

CHECK accessory package with Packing List/Bill of Material to ensure completeness. VERIFY QUANTITY OF ITEMS WITH THE *PACKING LIST*. DO NOT proceed with installation until all accessory parts are available.

Accessories are packed in a separate carton and may include, but are not limited to, the following:

TABLE 6.1

ACCESSORIES	CHECK IF RECEIVED
Connector Hardware (in a plastic bag) • Intercell Connectors • Nuts • Bolts • Washers	
Lifting Straps	
Lifting Platform - Height adjustable lifting platform for supporting cells at module level.	
Base-beams	
Terminal Plate Kits	
Terminal Plate Connectors	
Cell Number Set	
Mounting Hardware	
Miscellaneous: • Brackets • Specialty Items	
Rack	
NO-OX-ID Grease	
Rack Assembly Instructions	
Assembly Drawing	
Bill of Materials	
Installation Manual	

6.3 Recommended Installation Equipment and Supplies

Before working with the battery system, be sure that you have the proper protective clothing, safety equipment and insulated tools as specified in Section 2.0.

The following is a list of equipment typically recommended for installation of an EnerSys VRLA Battery System.

TABLE 6.2

EQUIPMENT RECOMMENDED	CHECK IF ON HAND
Forklift or Portable Lift Crane	
Chalk Line	
Torpedo Level (Plastic)	
Torque Wrench (10-200 in-lbs)	
Torque Wrench (50-100 ft-lbs)	
Floor Anchors (User-supplied per battery system and stress analysis)	
Floor Shims (User-supplied)	
3/8" Drive Ratchet Wrench with Minimum 3" Extension With 3/8" thru 11/16" and M6, M8 and M10 Sockets	
Box Wrenches (3/8" to 11/16" and M6, M8 and M10)	
Screwdrivers	
Wipes, Paper or Cloth	
Stiff-Bristle Nonmetallic Brush/Pad	
Tape Measure (Nonmetallic)	
Safety Equipment and Clothing	
Small Paintbrush	
Standard Allen Wrench Set	
NO-OX-ID Grease	

Be sure you have all the proper protective clothing and safety tools and equipment on hand before starting the installation.

7.0 INITIAL and/or FRESHENING CHARGE

Batteries lose some initial charge during shipment and storage. Depending on storage time, a battery may require a *freshening charge*. See Section 4.0 for battery storage times.

Constant voltage is the ONLY charging method allowed. Confirm that your charger bus is a constant voltage type. (Most modern chargers are the constant voltage type.)

1. Determine the maximum voltage that may be applied to the system equipment (or maximum charger voltage if load is not yet connected). Refer to the recommendations of the manufacturer/supplier of system equipment, connected to DC bus.

2. Divide the maximum total system voltage by the number of cells (not units) connected in series. This is the maximum volts per cell that may be used for the initial charge. **Do NOT exceed 2.35 volts per cell.**

Table 7.1 lists recommended initial charge voltages per cell and charge time for the initial charge. Select the HIGHEST voltage the system allows for the initial charge without exceeding 2.35 volts per cell.

TABLE 7.1

CELL VOLTS Initial Charge	TIME (Hours) Temp. 60°-90°F (16°-32°C)	TIME (Hours) Temp. 40°-59°F (5°-15°C)	TIME (Hours) Temp. < 39°F (<4°C)
2.27	60	120	240
2.30	48	96	192
2.32	24	48	96
2.35	12	24	48

3. Connect battery positive (+) terminal to charger bus positive (+) terminal.

4. Connect battery negative (-) terminal to charger bus negative (-) terminal.

5. Raise the voltage to the maximum value permitted by the equipment as shown in Table 7.1. **Do NOT exceed 2.35 volts under any conditions.**

6. When charging current has decreased and stabilized (i.e., no further reduction for three hours), charge for the hours shown in Table 7.1, or until the lowest cell voltage ceases to rise.

Monitor the battery temperature during the charge. If the cell/battery temperature exceeds 105°F (40°C) stop the charge immediately and allow the temperature to decrease below 90°F (32°C). Failure to follow this warning may result in severe overcharge and damage to the cell/battery.

8.0 OPERATION

8.1 General

The sealed design of the VRLA batteries makes it impossible to measure specific gravity as a state-of-charge indicator. The state-of-charge can be identified to some degree by the amount of charging current going to the battery.

8.1.1 Determining the State-of-charge

The following method can be used to determine the state-of-charge of the battery.

1. Place the battery on charge/recharge following a discharge.

Read the ammeter.

The charging current will be a combination of the load current plus the current necessary to charge the battery.

2. The battery becomes fully charged when the current to the battery starts to decrease and stabilize.

3. When the current level remains constant for three consecutive hours, the state-of-charge is approximately 95 to 98%. Full charge can be assumed.

For most requirements, the battery is ready for use.

8.2 Float Operation

In this type of operation, the battery and the critical load circuits are continuously connected in parallel with a constant voltage charger. The charger should be capable of:

- charging the battery from the discharged condition while supplying the DC power to the connected DC load
- providing the required constant float voltage
- providing voltage for equalizing the battery

It is highly recommended that the battery be charged with a temperature compensated charger with adjustment as stated in Table 8.1. If a temperature compensated charger is not used, manual adjustments must be made according to Table 8.1.

TABLE 8.1

AVERAGE AMBIENT TEMPERATURE		RECOMMENDED FLOAT VOLTAGE
°F	°C	VOLTS PER CELL
25	-4	2.33
35	2	2.33
45	7	2.32
55	13	2.30
65	18	2.28
77	25	2.25
85	29	2.23
95	35	2.21
105	41	2.19
115	46	2.17
125	52	2.17

Float voltage sustains the battery in a fully charged condition and makes it available to assume the emergency power requirements in the event of an AC power interruption or charger failure.

Constant voltage output charging equipment is recommended. This type of charger, properly adjusted to the recommended float voltages, and the following recommended surveillance procedures will assist in obtaining consistent serviceability and optimum life.

8.2.1 Float Charge Method

A float charge is given after the battery has been given its initial charge. To perform a float charge, follow the procedure below after the battery has been given its initial charge:

1. Determine that the VOLTS PER CELL nominal value is within the 2.23 to 2.27 range. This can be done by measuring the total battery string voltage and dividing by the number of cells in the string. Make sure the voltage does NOT exceed the maximum voltage for the connected load.

2. Adjust the charger to provide the recommended float voltage **at the battery terminals.** Do NOT use float voltages HIGHER or LOWER than those recommended. Otherwise reduced battery life or reduced capacity will result.

3. Check and record battery terminal voltage monthly for accurate calibration.

4. If the VOLTS PER CELL average voltage is above or below the range recommended in Procedure 1, adjust the charger to provide proper voltage as measured **at the battery terminals.**

When the **DDm, DDS, DDV** and **SC**-type cells are new, expect to see variations in float voltage from cell to cell within a string. These cells voltages should be within ±0.09 volts of the nominal setting). After one year in service, the DDm, DDS and DDV-type cells will float within ±0.05 volts of the nominal setting.

When the **DGX**-type cells are new, expect to see variations in float voltage from cell to cell within a string (within ±0.13 volts of the nominal setting). After six months in service, the cells will float within ±0.08 volts, and after one year, ±0.06 volts of the nominal setting.

8.3 Equalizing Charge

Under NORMAL conditions an equalizing charge is NOT required. An equalizing charge is a special charge given to a battery when nonuniformity in voltage has developed between cells. It is given to restore all cells to a fully charged condition.

Nonuniformity of cells may result from:

- low float voltage due to improper adjustment of the charger.
- a panel voltmeter that reads high, resulting in a low charger output voltage.
- selection of too low a float voltage.
- variations in cell temperatures in the series at a given time, due to environmental conditions or module arrangement. The maximum cell-to-cell temperature difference is 5°F (3°C). If cell temperature is the problem, review the location instructions in Section 5.0 to ensure proper location of the battery system.

An equalizing charge should be given when:

- the float voltage of any cell is less than 2.17 volts per cell.
- the float voltage range after six months is OUTSIDE the ±0.08 volts of the nominal setting.

Do **NOT** equalize **DDS, DDm, DDV** and **SC**-type cells if they are within the following voltage limits:

New ±0.09 volts of the nominal value, as determined in Section 8.2.1, Procedure No.1.

After one year ±0.05 volts of the nominal value, as determined in Section 8.2.1, Procedure No.1.

Do **NOT** equalize **DGX**-type cells if they are within the following voltage limits:

New ±0.13 volts of the nominal value, as determined in Section 8.2.1, Procedure No.1.

After six months ±0.08 volts of the nominal value, as determined in Section 8.2.1, Procedure No.1

After one year ±0.06 volts of the nominal value, as determined in Section 8.2.1, Procedure No.1

8.3.1 Equalizing Charge Method

Constant voltage charging is the method for giving an equalizing charge. To perform an equalizing charge, follow the procedure below:

1. Determine the maximum voltage that may be applied to the system equipment.

2. Divide this voltage by the number of cells connected in a series.
This is the MAXIMUM VOLTS PER CELL to be used for the equalizing charge.
This number should NOT exceed 2.35 VOLTS PER CELL average.

3. Use Table 8.2 to determine the equalize charge time.

The times listed are the number of hours to charge the battery system AFTER the charge current has been stabilized for three hours.

Stabilization occurs when the current level remains constant for three hours.

TABLE 8.2

CELL VOLTS	**TIME (hours) AFTER CURRENT STABILIZATION** (3 hours without change) AT AMBIENT TEMPERATURES FROM 70-90°F (21-32°C)	**TIME (hours) AFTER CURRENT STABILIZATION** (3 hours without change) AT AMBIENT TEMPERATURES FROM 55-69°F (13-20°C)
2.32	24	48
2.35	12	24

During charge, if the cell/battery temperature exceeds 105°F (40°C) stop the charge immediately and allow the temperature to decrease below 90°F (32°C). Failure to follow this warning may result in severe overcharge and damage to the cell/battery.

9.0 BATTERY TAPS

Connections made to a battery for tapping a certain group of cells to provide a voltage other than the total battery voltage is NOT recommended and can **void the warranty**. Tapping results in an imbalance of the system during charging and discharging, causing unsatisfactory operation.

10.0 PILOT CELL

One cell in a battery is usually selected as a pilot cell. It becomes an indicator of the general condition of the entire battery with regard to voltage, gravity, and temperature. Designate as the pilot cell the cell with the lowest cell voltage in the series string following the initial charge. Pilot cell readings serve as an interim indicator between regularly scheduled voltage and gravity readings of the complete battery. The temperature sensor should be connected to the negative post of the pilot cell.

Read and record the pilot cell voltage on a monthly basis between regularly scheduled individual cell readings.

11.0 MAINTENANCE

Batteries lose some initial charge during shipment and storage. Depending on storage time, a battery may require a freshening charge. See Section 4.0 for battery storage times.

11.1 Battery Cleaning

Observe the battery for cleanliness at regular intervals. Keep cell terminals and connectors free of corrosion. Terminal corrosion could adversely affect the performance of the battery, and it could present a safety hazard.

11.1.1 Standard Cleaning

To perform a standard cleaning of the battery, follow the procedures below:

1. Disconnect the battery.
2. Wipe off any accumulation of dust on the cell covers with a cloth dampened in clean water.

Do NOT use any type of oil, solvent, detergent, petroleum-based solvent or ammonia solution to clean the jars or covers. These materials will have an adverse affect and cause permanent damage to the battery jar and cover and will void the warranty.

11.1.2 Corrosion Cleaning

To clean mild corrosion from the battery:

1. Disconnect the battery.
2. Remove corrosion by wiping with a cloth dampened with bicarbonate of soda solution [mix 1 gallon (4l) of water with 1 lb. (500g) of bicarbonate of soda]. Follow with a cloth dampened with clear water.
3. Dry with a clean cloth.
4. With a small paintbrush, apply a light coat of heated NO-OX-ID grease to the entire bolted connection.

11.1.3 Heavy Corrosion Cleaning

If routine cleaning of the bolted connections has been neglected, heavy post corrosion may occur. This will require a major cell post cleaning job requiring the unbolting and removing of the connectors. The performance of the battery under load could be adversely affected, and this condition could present a safety hazard.

To perform the heavy corrosion cleaning, follow the procedure below.

1. Unbolt and remove connectors.
2. Apply a solution of bicarbonate of soda and water to the cell posts and connectors to neutralize the corrosion (as described in Section 11.1.2).
3. Clean the contact surfaces by rubbing the surface of post or terminal and lead-plated contact surfaces with a stiff-bristle nonmetallic brush/pad. Exercise care so you **do NOT remove the lead plating on the connectors, terminal plates or lugs, exposing copper.**
4. Bolt all intercell connectors.

   Install as follows:

   a) Intercell Connector
   b) Flat Washer
   c) Lock Washer
   d) Bolt

WARNING

Stamped flat washers may have one sharp edge. Install the washer with the sharp edge away from the lead-plated copper intercell connector to avoid damaging the lead plating.

REFER TO APPROPRIATE INSTALLATION MANUAL FOR ADDITIONAL INFORMATION.

5. Install all connections finger-tight to allow for some adjustment of position.
6. After all connections are completed, torque to original installation specifications.
7. Recoat the contact surfaces with a thin application of the NO-OX-ID grease, heated to a liquid form and applied with a small paintbrush.

11.2 Test Procedures

11.2.1 Procedure for Battery Capacity Tests

Use the following test procedure or use the test procedure described in IEEE std. 1188.

An equalizing charge, as described in Section 8.3, must have been given within the last 7 days. (Battery should be returned to float for 7 days before the test.)

1. Make sure all battery connections are clean, tight and free of corrosion.

2. While the battery is on float read and record voltage of each cell, temperature of at least every tenth cell and battery terminal float voltage.

3. Disconnect the battery charger.

4. Select the discharge rate based upon the critical load and time period. The test discharge current is equal to the rated discharge current divided by the K Factor (see Table 11.1) for the initial battery temperature.

5. With the variable load bank having an ammeter in series and a voltmeter across the battery terminals, connect the load, simultaneously starting the timing device. Maintain the correct current while periodically reading and recording total battery voltage. When the minimum total voltage has been reached, it is desirable to read and record each cell voltage including an intercell connector.

6. Observe the battery for intercell connector heating.

7. Calculate the capacity using the following formula:

$$\% \text{ Capacity at } 77°F\ (25°C) = \frac{Ta}{Ts} \times 100$$

Where Ta = test discharge time to specified voltage.
Where Ts = rated discharge time to specified voltage.

8. Recharge the battery, preferably using an equalizing charge (Section 8.3) to minimize the recharge time.

K TABLE TABLE 11.1		
Initial Temperature		Factor K
(°C)	(°F)	
16.7	62	1.098
17.2	63	1.092
17.8	64	1.086
18.3	65	1.080
18.9	66	1.072
19.4	67	1.064
20.0	68	1.056
20.6	69	1.048
21.1	70	1.040
21.7	71	1.034
22.2	72	1.029
22.8	73	1.023
23.4	74	1.017
23.9	75	1.011
24.5	76	1.006
25.0	77	1.000
25.6	78	0.994
26.1	79	0.987
26.7	80	0.980
27.2	81	0.976
27.8	82	0.972
28.3	83	0.968
28.9	84	0.964
29.4	85	0.960
30.0	86	0.956
30.6	87	0.952
31.1	88	0.948
31.6	89	0.944
32.2	90	0.940
32.8	91	0.938
33.4	92	0.936

11.3 Maintenance Records

A complete recorded history of the battery operation is essential for obtaining satisfactory performance. Good records will show when corrective action may be required to eliminate possible charging, maintenance or environmental problems.

Should you have ANY questions concerning how to perform the required maintenance, contact your nearest EnerSys sales/service representative or call the corporate office number listed on the back of this manual and ask for EnerSys Integrated Systems and Services.

Accumulate and permanently record the following data for review by supervisory personnel so that any necessary remedial action may be taken:

1. Upon completion of the initial charge and with the battery on float charge at the proper voltage for one (1) week, read and record the following:
    - individual cell or unit voltages (volts)
    - cell-to-cell connection resistance (ohms)
    - terminal connection resistance (ohms)
    - ambient temperature in the immediate battery environment (°F or °C)

NOTE: Some internal failure modes of cell types DDm, DDS, DDV, and DGX cannot be detected by cell or unit voltage measurements. IEEE-1188,1996 recommends taking an internal ohmic measurement of the cell/unit at quarterly intervals. These internal ohmic measurements, when compared with baseline value or the average value, may indicate the beginning of a problem inside the cell. Then corrective actions can be taken to avoid battery system failure. EnerSys recommends that you follow IEEE-1188 standards for internal ohmic measurements for VRLA cell types.

2. Every 12 months, read and record the following:
    - individual cell or unit voltages (volts)
    - cell-to-cell connection resistance (ohms)
    - terminal connection resistance (ohms)
    - ambient temperature in the immediate battery environment (°F or °C)

    Any connection resistance that exceeds the base value by more than 20% should be corrected by the procedures of Section 11.
3. If corrosion is present in the connections, clean according to Section 11.1.
4. Whenever the battery is given an equalizing charge, an additional set of readings should be taken and recorded.

THE ABOVE FREQUENCY OF RECORD TAKING IS THE ABSOLUTE MINIMUM TO PROTECT THE WARRANTY. This data will be required for any warranty claim made on the battery. For system protection and to suit local conditions/requirements, more frequent readings (quarterly) are desirable.

Sample record charts are provided on the following pages. Make a copy of the chart to use for your permanent records.

BATTERY MAINTENANCE REPORT — DDm, DDS, DDV, DGX, and SC

COMPANY _____ **DATE** ___/___/___ **PAGE** 1 of _____

ADDRESS _____ **BATTERY LOCATION and/or NUMBER** _____

No. of CELLS _____ **TYPE** _____ **DATE NEW** ___/___/___ **DATE INSTALLED** ___/___/___ **SERIAL NO.** _____

SYSTEM VOLTAGE _____ **TEMPERATURE** _____ **CHARGER VOLTAGE** _____ **CHARGER CURRENT** _____

Cell to Cell Resistance	Cell No.	Volts	Terminal Connection Resistance	Cell to Cell Resistance	Cell No.	Volts	Terminal Connection Resistance	Cell to Cell Resistance	Cell No.	Volts	Terminal Connection Resistance	Cell to Cell Resistance	Cell No.	Volts	Terminal Connection Resistance
—	1			—	31			—	61			—	91		
	2				32				62				92		
	3				33				63				93		
	4				34				64				94		
	5				35				65				95		
	6				36				66				96		
	7				37				67				97		
	8				38				68				98		
	9				39				69				99		
	10				40				70				100		
	11				41				71				101		
	12				42				72				102		
	13				43				73				103		
	14				44				74				104		
	15				45				75				105		
	16				46				76				106		
	17				47				77				107		
	18				48				78				108		
	19				49				79				109		
	20				50				80				110		
	21				51				81				111		
	22				52				82				112		
	23				53				83				113		
	24				54				84				114		
	25				55				85				115		
	26				56				86				116		
	27				57				87				117		
	28				58				88				118		
	29				59				89				119		
—	30			—	60			—	90			—	120		

BATTERY MAINTENANCE REPORT — DDm, DDS, DDV, DGX, and SC

COMPANY _____ **DATE** ____/____/____ **PAGE** 2 of _____

Cell to Cell Resistance	Cell No.	Volts	Terminal Connection Resistance	Cell to Cell Resistance	Cell No.	Volts	Terminal Connection Resistance	Cell to Cell Resistance	Cell No.	Volts	Terminal Connection Resistance	Cell to Cell Resistance	Cell No.	Volts	Terminal Connection Resistance
—	121			—	151			—	181			—	211		
	122				152				182				212		
	123				153				183				213		
	124				154				184				214		
	125				155				185				215		
	126				156				186				216		
	127				157				187				217		
	128				158				188				218		
	129				159				189				219		
	130				160				190				220		
	131				161				191				221		
	132				162				192				222		
	133				163				193				223		
	134				164				194				224		
	135				165				195				225		
	136				166				196				226		
	137				167				197				227		
	138				168				198				228		
	139				169				199				229		
	140				170				200				230		
	141				171				201				231		
	142				172				202				232		
	143				173				203				233		
	144				174				204				234		
	145				175				205				235		
	146				176				206				236		
	147				177				207				237		
	148				178				208				238		
	149				179				209				239		
—	150			—	180			—	210			—	240		

ADDITIONAL COMMENTS: _____

_____

12.0 TEMPORARY NON-USE (EXTENDED OUTAGE)

12.1 Installed/out-of-service System

If an INSTALLED battery is expected to STAND IDLE longer than the storage period recommended for the storage temperature (see Table 4.1 on page 9), treat as follows:

1. Before taking the battery out of service, give it an equalizing charge according to Section 8.3.1.
2. After the charge, open the connections at the battery terminals to remove load from the battery.
3. Throughout the extended non-use period, give the battery an equalizing charge before the end of the recommended storage intervals noted in Table 4.1. Disconnect the battery from the charger between equalizing charges.

12.2 Return to Service

To return the battery to normal service,

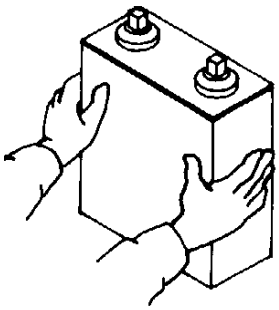
1. Reconnect the battery, the load and charger.
2. Give the battery an equalizing charge as described in Section 8.3.1.
3. Return the battery to float operation.

NOTES

PRECAUTIONS*

1. Do Not bring any heat or flame source near battery.
2. Do Not remove pressure relief valves.

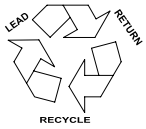
DO NOT PUSH ON CENTER
TO POSITION BATTERY



USE EDGE OF MODULE
WHEN POSITIONING BATTERY

3. Do Not lift any cells by the terminal posts.
4. Do Not tamper with seal nuts on the cell post.
5. Do Not remove lead coating from post or connectors and expose any bare copper.
6. Do Not allow cell temperature to exceed 105°F during charging.
7. Do Not clean cell with anything other than water/bicarbonate of soda.
8. Do Not over torque connections.
9. Do Not store VRLA type batteries for over six months without charge, at normal temperatures.

* These are only a few of the precautions. Please read all accompanying literature thoroughly for specific safety and installation information.



When ordering new batteries, also remember to properly recycle your old lead batteries. Federal and state regulations require lead-acid batteries be recycled. EnerSys' nationwide service organization can arrange pickup, transportation to and recycling at any one of our company affiliated smelters. Call 1-800-972-7372 for more information.

ISO 9000™

Please check our website for literature updates.

Publication No. US-VR-OM-001 February 2003

EnerSys™
Power/Full Solutions™

EnerSys Inc.
P.O. Box 14145
Reading, PA 19612-4145
USA
Tel: +1-610-208-1991
+1-800-538-3627

EnerSys EMEA
Brussels, Belgium
Tel: +32 (0)2 247 94 47

EnerSys Asia
Guangdong, China
Tel: +86 755 2689 3639

Represented by: