Lucent Technologies
Bell Labs Innovations

Enhanced VR Series Batteries
KS-23619

Product Manual
Select Code 157-622-011
Comcode 107817074
Issue 5
December 1998

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Notice:
Every effort was made to ensure that the information in this document was complete and accurate at the time of printing. However, information is subject to change.

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1 Introduction

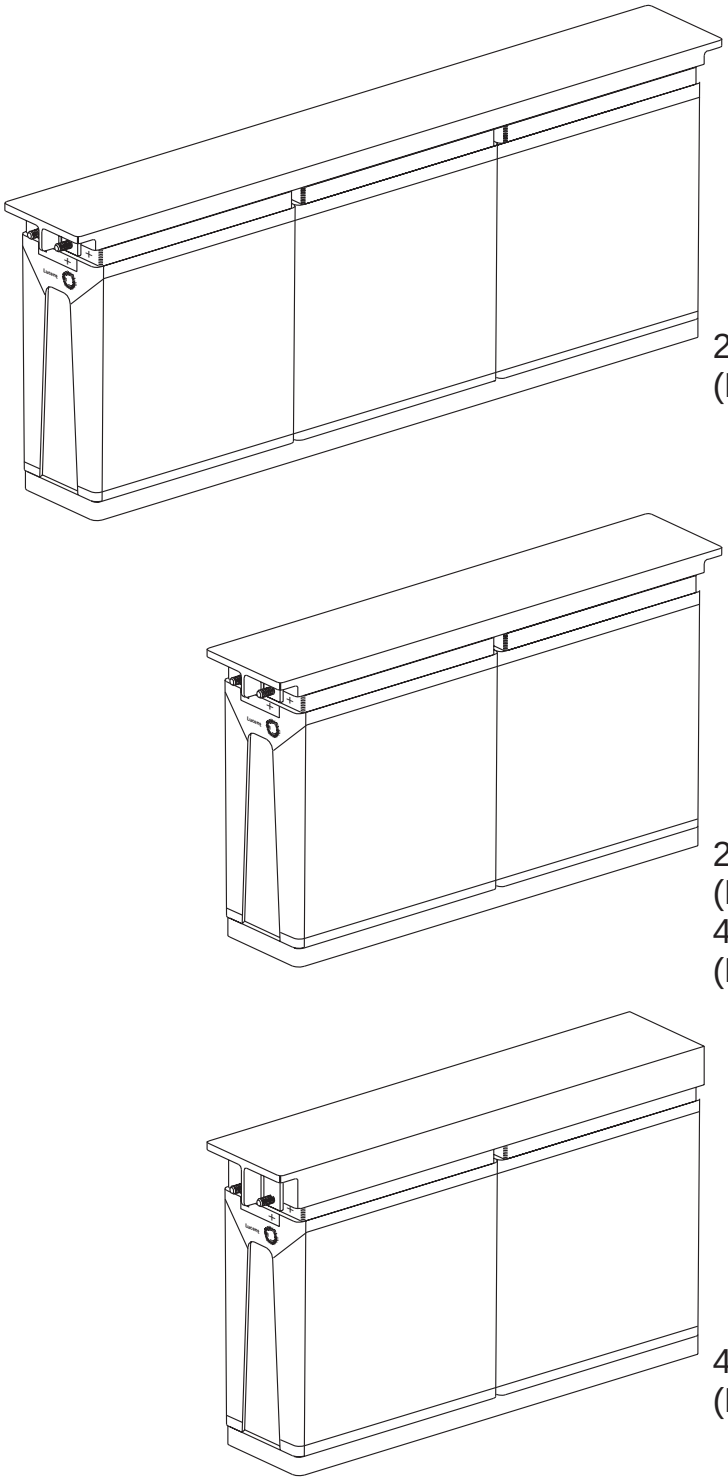
Enhanced VR Batteries

This product manual (Select Code 157-622-011) provides information on Lucent Technologies' Enhanced VR Series batteries, which are available in both 2- and 4-volt models. The Enhanced VR Series battery is a stationary, valve-regulated, rechargeable, lead-acid battery designed by Bell Laboratories, an acknowledged leader in technology, research, and design of power systems.

Lucent Technologies' power products have proved their field reliability by providing dependable standby reserve power for the telecommunications industry for decades. All battery components and manufacturing processes meet Lucent Technologies' strict specifications and quality standards.

Especially useful in applications where space is limited and minimal maintenance is desired, the Enhanced VR Series batteries are an excellent choice for remote-switching offices and subscriber loop applications (such as Lucent Technologies' SLC®96 and Series 5 carrier systems), 80E Bulk Power Cabinets, space-restricted power locations, customer premises applications, small- to medium-sized central offices, electric utility substations, and cellular sites.

Figure 1-1 illustrates the different models of the Enhanced VR Series batteries.



2 Volt, 375 Ah Battery
(Model 2VR375E)

2 Volt, 250 Ah Battery
(Model 2VR250E)
4 Volt, 125 Ah Battery
(Model 4VR125EL)

4 Volt, 125 Ah Battery
(Model 4VR125E)

Figure 1-1: Enhanced VR Batteries (Shown with Metal Sleeve)

Customer Training

Lucent Technologies offers customer training on many Power Systems products. For information call 1-972-284-2163. This number is answered from 8:00 a.m. until 4:30 p.m., Central Time Zone (Zone 6), Monday through Friday.

Customer Service

For customers in the United States, Canada, Puerto Rico, and the US Virgin Islands, call 1-800-THE-1PWR (1-800-843-1797). Services provided through this contact include initiating the spare parts procurement process for out of service emergencies, ordering Lucent Technologies documents, and providing other product and service information.

For other customers worldwide, call 001-972-840-0382. This number is answered from 8:00 a.m. until 4:30 p.m., Central Time Zone (Zone 6), Monday through Friday.

Technical Support

Technical support for Lucent Technologies customers is available around the world during the normal product warranty period and also while specific contractual agreements extend this service.

For customers in the United States, Canada, Puerto Rico, and the US Virgin Islands, call 1-800-CAL-RTAC (1-800-225-7822) to contact a product specialist to answer your technical questions and assist in troubleshooting problems.

For other customers worldwide, contact your local field support center or your sales representative to discuss your specific needs.

Product Repair and Return

Repair and return service is provided for Lucent Technologies customers around the world. For customers in the United States, Canada, Puerto Rico, and the US Virgin Islands, call 1-800-255-1402 for information on returning of products for repair.

For other customers worldwide, contact your sales representative to discuss your particular circumstances.

Warranty Service

For warranty service worldwide, contact your Warranty Service Manager (WSM). The WSM serves specific customer-groups, who have taken ownership of the product. For product

conformance issues prior to customer ownership, contact your local customer service.

2 Product Description

Overview

A 2-volt 125Ah cell is the building block used to construct the Enhanced VR Series family of batteries. These modules may be mounted in a variety of ways to meet individual customer needs.

The valve-regulated design and construction of the Enhanced VR Series batteries prevents electrolyte leakage and minimizes water loss and maintenance throughout the design life. During normal operation, oxygen is generated at the positive electrode and hydrogen is generated at the negative electrode. In conventional (flooded) lead-acid cells, these electrochemical reactions result in water loss from the electrolyte. The self-resealing pressure release safety valves in Enhanced VR Series batteries are designed to aid in the electrochemical recombination of nearly all the oxygen within the battery. In addition, the safety valves prevent the build-up of excessive internal pressure.

Like other Lucent Technologies valve-regulated batteries, the Enhanced VR batteries' pure lead positive grid is the key to a slow, uniform growth rate that promotes longer life. This slow growth rate, combined with extremely low water loss, allows the cell to maintain capacity over its 20-year design life at room temperature operation.

The Enhanced VR batteries are ideal for most operating environments because of its leakproof seals, high-strength, flame-resistant PPO/PS jar and cover, low gassing rate, and high energy density. The patented metal sleeves improve heat dissipation and add dimensional support to the battery at the higher operating temperatures.

The Enhanced VR Series batteries comply with the requirement for sealed battery/cell pressure release test of UL924, Standard

for Emergency Lighting and Power Equipment, and UL1989, Standard for Standby Batteries.

Features

- Bell Laboratories' patented lead/tin alloy post, leakproof post seal, and valve-regulated design require minimal maintenance.
- An Enhanced VR battery consists of compact, modular cells that permit up to 750Ah of 48V battery reserve (at a 10-hour rate) to be installed in a single VR battery stand.
- The totally front-access, modular design allows easy installation and growth. In addition, the removable handle facilitates battery replacement, if required.
- Flame-retardant (UL 94 V-O flammability rating) PPO/PS jar and cover material together with metal cell sleeves support longer life by providing jar rigidity for higher-temperature applications.
- Each 2-volt, 125Ah cell contains a pressure-regulating vent located in the jar cover. The vent is covered with a porous plastic disk that acts as a flame arrestor. In multi-cell configurations, the vents and flame arrestors are hidden from view by the bus bar cover.

Specifications

Battery Serial Number

Each battery has its own serial number printed on the front label. The serial number format consists of a letter code followed by ten digits. The letter identifies the supplier as well as the manufacturing location. The first four digits indicate the year and the month of manufacture; the remaining digits are the serial number.

L9504123456 means that this battery was manufactured in April 1995, and has a serial number of 123456.

Batteries

Table 2-A outlines the weight, physical dimensions, ampere-hour rating (measured at the 10-hour rate), and the recommended float voltages for the Enhanced VR modules.

Table 2-A: Enhanced VR Battery Specifications

Model**	Width in. (mm)	Height in. (mm)	Depth in. (mm)	Weight lb. (kg)	Ah Rating	Float Voltage*
2VR250E	3.54 (89.9)	9.36 (237.7)	16.78 (426.2)	53-55 (24-25)	250	2.25 - 2.27
2VR375E	3.54 (89.9)	9.36 (237.7)	24.5 (622.3)	80-83 (36-38)	375	2.25 - 2.27
4VR125E	3.54 (89.9)	9.90 (251.1)	15.5 (397.7)	53-55 (24-25)	125	4.50- 4.54
4VR125EL	3.54 (89.9)	9.36 (237.7)	16.78 (426.2)	53-55 (24-25)	125	4.50- 4.54

*With no temperature compensation (see Table 7-A for details).

**Batteries with 250Ah and 375Ah ratings have only the low profile top cover and are available in one height size (9.36"). The 4VR125E battery with 125Ah rating has the high profile top cover and a height of 9.90". The 4VR125EL battery with 125Ah rating has the low profile top cover and a height of 9.36".

3 Ordering Information

Configurations

A 2-volt, 125Ah cell is the building block used to construct the Enhanced VR family of batteries. These modules may be mounted in a variety of ways.

- 2VR250E, 2VR375E, or 4VR125EL batteries are mounted in a J85504C-1 VR battery stand to create 24- and 48-volt stand-alone strings.
- Installed in a four-shelf battery stand, these batteries are used as an integral part of the Lucent Technologies Evolutionary Control System (ECS) J85500D-2 and J85500D-3 battery plants.
- 2VR250E, 2VR375E, or 4VR125EL batteries are mounted using special shelving in a standard 23-inch SLC 96/5 network bay frame (J85500D-2 or J85500D-3 applications).
- 4VR125E modules are mounted in the bottom of a Lucent Technologies 80-type (A, D, E, G) cabinet.

The 4VR125E, 4VR125EL, 2VR250E, and 2VR375E battery modules are shipped with insulated terminals. Nuts, washers, inter-module and inter-tier connectors, as well as lifting handles and NO-OX-ID “A” compound, are packaged in a separate container on the shipping pallet.

In addition, an optional configuration for a 23-module operation is available for RSM or ORM switching applications having a maximum input voltage requirement of 53 volts. This configuration is not available for the 4VR125E or 4VR125EL.

A spacer module is available in the 2VR250E and 2VR375E configurations to fill the void left when a 23-module, 48-volt battery string is used. The 23-module string allows for a lower float voltage required by some systems, such as remote switch module (RSM) or optical remote module (ORM) switching applications.

Battery Modules

Use Table 3-A to order the various enhanced VR battery modules. The comcode is a 9-digit number used in ordering the product. The "KS" numbers and their associated list numbers refer to the Lucent Technologies documents that specify the design and manufacture of each model.

Table 3-A: Enhanced VR Battery Modules

Description	Model Number*	Without Metal Sleeve**		With Metal Sleeve***	
		Comcode	KS-23619	Comcode	KS-23619
4 Volt, 125Ah Battery	4VR125E			407435833	List 22
2 Volt, 375Ah Battery	2VR375E	407411065	List 13	407435825	List 23
Spacer Module for 2VR375E	N/A	407436484	List 14	407436518	List 24
2 Volt, 250Ah Battery	2VR250E			407435841	List 26
4 Volt, 125Ah Low Profile VR Battery	4VR125EL			407435858	List 27
Spacer Module for 2VR250E	N/A			407436583	List 28

*The model number identifies an individual battery. The first character represents the module's voltage. "VR" signifies valve regulated. The next three digits give the module's capacity at the 10-hour rate. Therefore, a 2VR375 is a 2 -volt, valve-regulated battery module with a nominal capacity of 375 ampere-hours at the 10-hour rate.

**Without Metal Sleeve = operate in air conditioned environments maintained below 90° F. Non-metal enclosed EVR batteries are no longer offered except for replacement.

***With Metal Sleeve = operate in other environments under recommended maximum temperature.

4 Safety and Environmental

Safety Symbols

Safety Precautions

Read the following safety precautions carefully before attempting to handle, unpack, and install the batteries. Fully brief everyone with access to battery areas, or who are working near or with batteries, on the hazards associated with lead-acid batteries. Additional information can be found in the Material Safety Data Sheet (MSDS) in Section 11 of this product manual.

Poison

POISON

CAUSES SEVERE BURNS

Valve-regulated batteries contain toxic materials (lead, lead compounds, and sulfuric acid). Do not incinerate or mutilate. Avoid contact with skin, eyes, or clothing. Recycle batteries in approved reclamation centers according to local, state, and federal regulations.

All lead-acid batteries contain electrolyte (sulfuric acid and water), a highly corrosive substance. Lucent Technologies valve-regulated batteries are designed so that the electrolyte is absorbed by the plates and separators. Electrolyte ordinarily should not leak outside the battery container. However, it is possible that certain types of physical damage and/or abusive charging may force small quantities of electrolyte outside the battery container.

Lucent Technologies valve-regulated batteries are safe; however, accidents can occur.

- When handling batteries or cells, wear protective equipment (e.g., acid resistant rubber gloves, acid resistant rubber aprons, and impact-resistant, splash-proof goggles or full face mask).

- Even when not handling batteries, wear splash-proof and impact-resistant goggles while working around batteries or on equipment containing batteries.

The MSDS in Section 11 contains information that everyone needs to understand before having access to the batteries, such as: health hazard summary, first aid procedures, fire and explosion hazard data, reactivity data, special protection information, environmental information (spill clean-up and disposal), and special precautions.

The following items can be ordered from Lucent Technologies. These items should be available to anyone working around batteries. The local, state, or federal codes for certain installations may require some of these items to be installed and/or kept at the installation site.

- Protective gear

- Acid spill clean-up and management kits

- Battery cleaning and maintenance kits

Electrical Hazard

WARNING

ELECTRICAL HAZARD

In addition to proper job training and safety procedures, the following are some basic precautions that should always be followed when working with or around batteries (including equipment connected to batteries):

- Always use insulated tools.
- Never place uninsulated metal objects on top of a battery.
- Remove all metal jewelry such as rings, watches, bracelets, long necklaces, and any other metallic items.
- Do not short circuit the battery.
- Insure proper polarity when making connections.
- Wear eye protection.

Batteries differ from other sources of power in that they are delivered to the points of installation as live units. A battery gives no indication by its appearance of the potential energy stored in it. Batteries have enormous short circuit capability that can result in serious burns or create dangerous projectiles from the object causing the short circuit.

- Exercise extreme care to avoid any short circuits across the battery terminals.
- In a grounded battery system, use extreme care not to short any metal objects from the ungrounded battery terminal to ground (which can include the equipment metal chassis, building structure, cable racks, etc.).
- Even a single battery poses a potentially high energy hazard if shorted. Shorting a battery may result in explosion of the battery, injury to personnel, and damage to equipment. A tool or other metal object causing the short may be thrown or vaporized due to the energy produced by the battery or system.

A single battery is typically at low voltage; however, batteries connected together in a system can pose a shock hazard in addition to an energy hazard. When interconnection of the batteries creates a hazardous voltage supply, post appropriate warnings in the end systems or installations. All systems and/or installations should consider the need for additional markings based on the use of the battery, industry standards, and local, state, and federal regulations.

Battery Gases

DANGER

RISK OF EXPLOSION

- Battery gases can be highly explosive. NO sparks, including sparks generated by electrostatic discharge (ESD), or open flame are allowed near battery modules. Do not smoke around batteries. Make sure the battery area is properly ventilated before performing any work.
- Do not place batteries in a sealed enclosure. Even enclosures with ventilation need to be properly evaluated to assure hydrogen will not accumulate to explosive levels.

Valve-regulated batteries are designed to minimize the amount of oxygen and hydrogen gas released from the battery under normal conditions. However, abnormal conditions, such as high temperature, abnormal charging, shorted cells, etc., can produce greater amounts of gas. Even batteries under open circuit conditions can produce gas. If not permitted to escape, this gas can build up to explosive concentrations. Refer to Section 7, *Operation*, for more information on gassing rates.

- ALWAYS place batteries in a well-ventilated area.
- NEVER place batteries in a sealed enclosure.
- Make sure the area is properly ventilated before performing any work.
- Since gas generated by batteries is explosive, avoid creating sparks (including those from static electricity), the use of an open flame, or smoking near the batteries.

- Before performing any work operation, follow proper ESD protection procedures to discharge the static electricity from your body.

- Never tamper with or block the vent caps of batteries. Damaged or clogged vent caps may result in an explosion due to excessive internal pressure. Such an explosion could short circuit other battery modules, result in a fire, injure personnel, or cause damage to equipment.

- Never charge a battery that is visibly damaged or frozen (typically at temperatures less than -40°C or -40°F).

- Be alert to procedures that may create potential hazards, such as creating sparks next to the batteries. Some examples:

  – Avoid disconnecting the circuit at the battery terminals while the battery is being discharged or charged.

  – Avoid making connections at the battery terminal with the other end connected to a load or charging system (unless the circuit has been verified to be open).

  – If there are no devices for opening the circuit before disconnecting or connecting the battery, here are some suggested procedures:

    - Make sure the free end of any wire connected to the batteries is insulated until it is ready to be connected to the load or charger or immediately after being disconnected from the load or charger.

    - Connect to the battery terminals first before connecting to the load or charging system.

    - Disconnect at the load or charger first before disconnecting at the battery terminals.

Freshly charged batteries may produce explosive gas.

- Avoid handling a freshly charged battery within 24 hours after removing the charge. If it must be handled, use extreme caution and avoid any sparks or touching the battery in the area of the vents.

To direct attention to the possible source of danger from battery gases, post one or more warning signs, lettered in large characters, in a conspicuous location near the batteries.

First Aid

Refer to the MSDS in Section 11 for first aid procedures.

Lifting Information

Refer to "Unpacking and Handling" in the Installation section of this product manual for specific handling instructions.

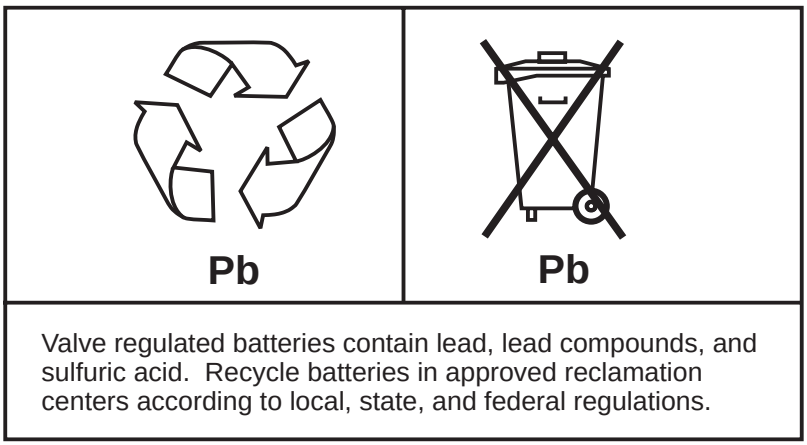
Transportation and Handling

New batteries are shipped meeting United Nations standard, DOT, IATA, IMDG, and other State and Government regulations.

Old/used batteries should be considered as Hazardous Waste and transported according to respective DOT, EPA, OSHA, and other governing regulations or guidelines for Hazardous Waste.

Environmental

Do not discard batteries in trash cans.



5 Battery Storage

State of New Battery

The Enhanced VR battery is shipped in the charged state. The open circuit voltage for a fully charged battery is approximately 2.15V/cell.

Storage Conditions

- Store batteries in an upright position in a dry and cool environment without exposure to direct sunlight.
- Provide adequate ventilation during storage.
- Do not stack pallets of batteries on top of each other during storage.

Storage Time

Batteries may suffer irreversible capacity loss during long open circuit stand. The maximum that a charged battery may remain on open circuit is 6 months at 77°F. The open circuit time should not exceed 4 months if the storage temperature exceeds 90°F. The “charge by” date stamped on the shipping container is the date the battery has been on open circuit for 6 months. If batteries cannot be installed within this time period, follow the procedures outlined in Table 6-A, “Initial Charging,” and record the actions taken until normal installation can be initiated.

6 Installation

Introduction

This section describes the procedures for installing the Enhanced VR Series batteries. Please review the safety precautions in Section 4 before handling the batteries.

Installation Tools, Materials, and Test Equipment

The following tools, materials, and test equipment are recommended for installation, operation, maintenance, and testing of the batteries:

- Chemical and impact resistant safety goggles and safety hard hat
- Acid resistant gloves, rubber overshoes, and apron
- Lime and/or soda (sodium bicarbonate or sal soda)
- Class C fire extinguisher
- Cleaning cloth
- Insulated socket and a torque wrench capable of measuring 60 inch pounds
- Insulated nut driver
- Combination wrench set, screwdrivers
- Sandpaper or abrasive cloth
- Thermocouple-based or infrared-based temperature measuring device
- Digital multimeter (DMM) with an accuracy of 0.05 percent on the dc scale
- DC power source capable of supplying 2.5 volts per 2VR250E or 2VR375E battery or 5.0 volts per 4VR125E battery

Product Manual

One product manual is included with each pallet of batteries. Order additional product manuals by calling Customer Service

at 1-800-THE-1PWR (1-800-843-1797). Specify Select Code 157-622-011.

Unpacking and Handling

Use appropriate material handling equipment to ensure personnel safety and equipment protection while installing the batteries. Move crated batteries to a convenient predetermined area where the appropriate unpacking and handling equipment and tools are available.

Safe Handling

The Enhanced VR battery case is designed with a V-groove in the front and the rear of the battery for lifting with removable handles (furnished with the batteries). These handles slide into the V-groove specifically for grasping the battery module. See Figure 6-1.

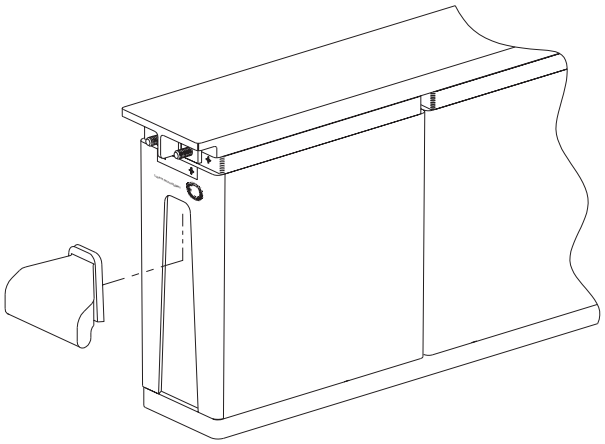


Figure 6-1: Enhanced VR Battery Handle

Caution

To avoid breakage, never attempt lifting an Enhanced VR battery by the white top protective cover. Lift Enhanced VR batteries only with the furnished handles.

Specific Unpacking Instructions

Inspect the battery visually for shipping damage before it is completely unpacked. If it is determined that the battery should be returned to the manufacturer, it will be easier to return at this point than if the battery has been completely unpacked.

1. Examine the shipping container and record any signs of external damage.

2. Search for any indications of acid spillage during shipment. Record any indications of acid spillage on the bill of lading before signing.

Note

Acid spillage is a valid criterion for rejection of product.

In case of acid spillage, refer to the Material Safety Data Sheet in Section 11 for instructions regarding cleanup and disposal. After unpacking, immediately check again for electrolyte spills.

Warning

Wear an eye protection device and acid resistant rubber gloves when cleaning up electrolyte spills. Wash hands and face thoroughly after use.

3. Check batteries for fractured containers and covers. Batteries with fractured containers and covers are defective and must not be used.

Note

Fractured cases and covers are valid criteria for rejection of product.

If a battery is found to be damaged when received, a claim can be initiated for replacement. The battery must be shipped back in its original carton.

4. Check the contents of the package against the packing list. Report any missing parts immediately.

5. The packing list includes the order number. Record this number on the "Installation and Maintenance Record." The order number for new batteries must be recorded on this form for use in warranty validation.

6. Battery module terminals are precoated with NO-OX-ID A® at the time of manufacture. Ordinarily they

will not require cleaning and recoating. Clean the contact surface areas of exposed copper post terminals with a dry non-abrasive cloth and recoat only if they appear dirty.

7. If the case is dirty when removed from the shipping container, clean the case with a cloth dampened with water before installing it in the battery stand.

Caution

Use only water to clean batteries.

8. While unpacking batteries for installation in the intended site, mark each battery with a number using an indelible-ink magic marker. Note its corresponding number and serial number in the appropriate column under "Voltage Measurements on Individual Batteries" on the Installation and Maintenance Record (see Section 10).

9. Identify all batteries that will be used for monitoring battery temperatures. Temperature measurements should be made on one of the middle batteries of a string. If a single shelf is provided for a string, monitor any one of the middle batteries. If more than one shelf of batteries is provided for a string, monitor the middle battery of each shelf. If more than one stand is provided, monitor the middle battery of each shelf on each stand. Decide on which batteries will be used to represent battery temperature and note their numbers in the "Battery Number" column on the "Temperature Measurements on Selected Batteries" portion of the Installation and Maintenance Record. This will ensure that the same batteries will be used for all future measurements.

Battery String Location

Environmental Requirements

The operating environment must comply with the National Electric Code Article 110, "Requirements for Electrical Installations," and Article 480-8, "Battery Locations," and any applicable state and local regulations.

The Enhanced VR batteries, like all lead-acid batteries, are affected by the ambient temperature. Maintain a low ambient

temperature and/or install a temperature compensation device that adjusts rectifier float voltages in response to high battery temperature.

Note

Lucent Technologies strongly recommends a temperature compensation device in high-temperature environments. Failure to use such a device may result in high battery temperature that can cause premature battery failure and may reduce or void the warranty.

Battery temperatures above 77°F (25°C) decrease battery life while increasing battery capacity. For battery temperatures lower than 77°F (25°C) the capacity will decrease, but battery life will not be adversely affected. Battery temperatures within the same string must be maintained uniformly.

Caution

Operating Lucent Technologies Enhanced VR batteries for any significant interval of time outside the recommended voltages and/or temperatures will cause reduced performance and premature failure and may reduce or void the warranty.

When batteries are installed where they will be exposed to heat radiation or direct sunlight, provide shields for the radiators or blinds for the windows to maintain a low battery temperature. In particular, the top row of a multi-tiered stand is apt to have a higher environmental temperature than the bottom. Where necessary, use fans or other means of ventilation to minimize the temperature variation.

Mixing Batteries in a String

Note

To insure maximum battery performance, do not mix Enhanced VR Series batteries and non-VR batteries in a string.

As batteries age, their characteristics change. As a general practice it is not recommended to mix new batteries with older batteries in a string. A weak battery in a string can cause the entire string to fail prematurely.

Initial Charging

To ensure full charge and adequate initial performance, store and maintain batteries according to instructions in Section 5, *Battery Storage*, and use the guidelines in this section to charge the batteries at the time of installation.

The purpose of an initial charge is to compensate for self discharge that occurred in the interval between manufacture and installation. Under normal circumstances, the battery will regain most of its capacity after several hours float charge; 90% capacity should be obtained within 24 hours of float charge.

Before installing the battery modules into the VR battery stand, the voltage of each module should be measured. Any module voltage of less than 2 volts (4 volts for 4VR125E and 4VR125EL) should be rejected.

To compensate for self discharge during storage, all battery modules should be fully charged before being put into service. Table 6-A shows the proper initial charging conditions.

Table 6-A: Initial Charging

Battery Condition	Action
All batteries have similar date codes and storage histories and none are more than 6* months old or they have been maintained according to the "Battery Storage" section of this product manual.	Make voltage and polarity checks as described later in this section and connect string(s) to plant. Charge at the recommended float voltage from 48 hours before switching into service.
The batteries have dissimilar date codes (more than one month apart) and they are within the required recharge period (charge-by date).	Preferably the initial charging should be conducted at a warehouse with good ventilation. Using an external charger**, charge string at 2.35 volts per 2-volt battery or 4.70 volts per 4-volt battery until all modules have voltages within ±0.05 volts of 2.35 volts (for 2-volt battery) or within ±0.10 volts of 4.70 volts (for 4-volt battery). Do not charge for more than 48 hours at 2.35 volts. Reduce the charge voltage to the recommended float voltage from Table 7-A for an additional 24 hours before putting into service. Install batteries and make voltage and polarity checks as described in the following section, and connect string(s) to plant. If the strings have already been installed at the site, follow the above procedure and use the rectifier as the charger. Ensure good ventilation at the site. Reduce the charging time at 2.35 volts to no more than 24 hours.
The batteries are older than 6* months or have not been maintained according to the "Battery Storage" section of this product manual.	Do not install. Replace batteries.

*If storage temperature exceeds 90° F (32° C), then open circuit time should not exceed 4 months.

**The charger must have overcurrent protection in its output, must be able to remain across the modules in case of an ac power failure, and should not have crowbar protection. (Crowbar protection is an option used on some commercial portable power supplies that clamps a short across the output leads of the rectifier when the rectifier senses a higher voltage at the load than it is generating. This feature should not be used with batteries).

Placing a Battery String Into Service

Batteries should be in service within 48 hours of initial charge. If a battery is left on open circuit for more than 48 hours after the initial charge, treat it as if it had never received an initial charge.

Since battery performance is based on the output at the battery terminals, the shortest electrical connection between the battery system and the operating equipment results in the maximum total system performance.

Cable size should be specified and installed that will maintain appropriate voltage drop between the battery system and the operating equipment. Excess voltage drop will reduce the desired reserve time of the battery system.

When paralleling valve-regulated batteries, the capacity, arrangement, and external circuit length should be identical for each battery. Wide variations in the battery circuit resistance can result in unbalanced charging (i.e., excess charging current in some batteries and undercharging in others). As a result, cell failures in one battery string and subsequent loss of performance capabilities of that string will result in higher loads in the other parallel string(s), which may exceed the ratings of the battery connections. This can damage the battery and dramatically shorten battery life.

Installation Records

The “Installation and Maintenance Record” (see Section 10) is required for warranty validation. The installer should use this form to record the following measurements.

Voltage Measurements

Before connecting parallel strings together or individual strings to the plant bus, make the following voltage measurements:

1. Measure individual battery voltage. Replace any 2VR250 or 2VR375 battery with a voltage less than 2.0 volts or any 4VR125 battery with a voltage less than 4.0 volts.

2. Measure across the string to verify that the batteries are connected properly and that the polarity is correct. The string voltage should be equal to the sum of the individual battery readings recorded above.

3. Measure across the plant charge and discharge battery buses. The voltage difference between the string and plant should not exceed 0.05 volts unless the plant is at 0 (zero)

volts because the chargers are turned off. If a larger differential exists, the string should be charged at the plant voltage (or the plant voltage lowered) until the voltage differential is less than 0.05 volts. This should prevent arcing during the final connection.

4. After the battery strings have been connected to the plant bus for one hour, make the final reading to record voltages of individual batteries. (See "Individual Battery Voltages" in Section 8, *Maintenance,* for measurement procedure.) Record these in the Installation and Maintenance Record.

A DMM (digital multimeter) is suitable for battery voltage readings. The accuracy of an equivalent meter should be 0.05 percent on the dc scale. The meter must be checked periodically for accuracy and calibration.

Caution

Exercise extreme caution when making voltage readings to prevent accidental grounding or shorting of leads during measuring operations. Connections at the meter must be secure and free of any possibility of touching or becoming grounded. Never remove connections at the meter end without first disconnecting the test leads from the battery. Remove test lead connections at the battery immediately after each reading is taken. Review the safety precautions in Section 4.

After recording these initial measurements, the installer should turn the Installation and Maintenance Record over to the maintenance organization as part of their permanent records. See Section 8, *Maintenance,* for maintenance routines and measurements that must be recorded.

7 Operation

Lead-acid Battery Gassing Rate

This section provides general information and guidelines for estimating the hydrogen gassing rates of lead-acid batteries on charge. It is beyond the scope of this document to provide the detailed methods or the engineering design required to maintain safe levels of hydrogen in battery enclosures.

All lead-acid batteries generate hydrogen and oxygen gas at the negative and positive plates, respectively. The generation of these gases occurs during all conditions of use, including charge, discharge, and while on open circuit during storage. The rate of gas generation on discharge and open circuit is generally very small but cannot be completely ignored. For this reason, never place lead-acid batteries in an air-tight enclosure. Explosive mixtures of hydrogen in air are present when the hydrogen concentration exceeds four (4) percent by volume. The concentration of oxygen does not significantly change the lower explosive limit of hydrogen in air, and, therefore, only hydrogen will be considered here.

If the concentration of hydrogen in air exceeds four (4) percent by volume, there is a risk of explosion if the gas is ignited. Therefore, to provide a margin of safety, lead-acid battery areas must be ventilated to limit the accumulation of hydrogen gas under all anticipated use conditions to a recommended maximum of one (1) percent of the total free volume in the enclosed battery area.

In flooded lead-acid batteries, gassing rates approach the theoretical values calculated from the dissociation of water. In valve-regulated lead-acid batteries (VRLA) the recombination of oxygen gas at the negative electrode results in reduced oxygen and hydrogen evolution from the battery. Generally, VRLA batteries evolve from less than 1% to 20% of the hydrogen

produced by flooded lead-acid batteries under similar charging currents, and are designed to achieve greater than 95% recombination efficiency at normal float charge and temperature. However, charging at voltages greater than the nominal float voltage, charging at elevated temperatures, shorted cell(s), and a number of other possible conditions may result in significantly greater charging current and hydrogen gassing. It is important to note that the hydrogen gassing rate at 0% recombination, the worst case condition, is the same for both flooded and valve-regulated technologies at equivalent charging currents and temperatures.

From electrochemical theory, if all the charging current is used to generate gas, each cell will generate 0.016 cubic feet of hydrogen per hour, per ampere of charging current at 77°F (25°C) and one atmosphere pressure. For example, a 48V string of lead-acid batteries requiring 1 ampere of float current at 77°F can produce as much as 0.4 cubic feet of hydrogen per hour (0.016ft3/hr x 1 ampere x 24 cells), or as little as 0.004 cubic feet per hour at 99% recombination efficiency, a factor of 100 difference.

The quantity of fresh air required to maintain an explosion-safe environment in the battery area (enclosure) will vary greatly depending on many factors including, but not limited to, the age and condition of the battery, the number of cells in the battery area, the battery temperature, and the current flowing through the batteries. Therefore, the design of a ventilation system for batteries in a specific application requires careful consideration of factors other than the gassing rate of new batteries in typical operation. Typical gassing rates may be useful as a “best case” condition, but cannot adequately address “worst case” or any other operating condition that may occur during the service life of the battery.

Service Life

Since battery temperature exceeding 77°F (25°C) will decrease expected life by approximately 50% for each 15°F (8.33°C) increase in average temperature, it is important to consider the temperature of the battery environment when designing equipment or determining battery life expectancy.

Charging

In order to reduce the effects of sustained high temperature operation, the battery float voltage should be reduced at higher battery temperatures. This adjustment is performed in systems

with either a step or a slope compensation device. For systems without such a device, it is recommended that the float voltage be reduced by 3mV/°C/module for the 2VR250E or 2VR375E and 6mV/°C/module for 4VR125E or 4VR125EL for temperatures above 25°C (77°F).

Caution

Failure to reduce float voltages in systems without temperature compensation may result in premature failure or thermal run-away.

Caution

Operating Lucent Technologies Enhanced VR batteries for any length of time outside the recommended voltages and/or temperatures will result in reduced performance and premature failure and may reduce or void the warranty.

Battery String Float Voltage

It is extremely important to maintain the battery at the proper float voltage. The string float voltage is determined by the number of battery modules in the string and by the type of temperature compensation device employed in the system. The battery string float voltage can be calculated as follows:

Battery String Float Voltage = recommended battery float voltage x number of modules

Table 7-A shows the recommended uncompensated string voltage with these two features as well as without any type of temperature compensation.

Table 7-A: Recommended String Float Voltages

Temperature Compensation Feature	Module Type	23-Module Plants		24-Module Plants	
		Volts/Module	Volts/String	Volts/Module	Volts/String
None or Step	2VR250E	2.25	51.75 ± 0.23	2.25	54.00± 0.24
	2VR375E				
Slope	2VR250E	2.27	52.21 ± 0.23	2.27	54.48± 0.24
	2VR375E				
Temperature Compensation Feature	**Module Type**			**12-Module Plants**	
				Volts/Module	**Volts/String**
None or Step	4VR125E			4.50	54.00± 0.24
	4VR125EL				
Slope	4VR125E			4.54	54.48 ± 0.24
	4VR125EL				

Charging Voltage Ripple

The amount of ac voltage ripple present on the charging voltage for the battery can seriously affect battery performance. Excessive ripple could result in sharply reduced battery life and increased gassing rates. Refer to "Lead-acid Battery Gassing Rate."

Both the amplitude and frequency of the ripple affect the degree of battery degradation. As a guideline, the charging voltage ripple for the Enhanced VR Series battery should not exceed 10mV peak to peak per cell or last longer in duration than 8mSec.

Caution

AC charging ripple greater in magnitude than 10mV peak to peak per cell or longer in duration than 8mSec should not be used without prior consent of Lucent Technologies; failure to comply can void the warranty.

Battery and Ambient Temperatures

Ambient temperature can affect the capacity and life of the Enhanced VR battery. The temperature that has the most direct effect is the battery's internal temperature. All valve-regulated lead-acid batteries use oxygen recombination technology, which generates more heat than conventional flooded batteries. As a result, the battery temperature is often higher than the ambient temperature.

The Warranty Period outlined in Section 12 is based on the battery temperature, not the ambient temperature. Maintain a low battery temperature by adjusting the ambient environment temperature and/or air ventilation. (See Section 6, "Environmental Requirements.")

Caution

Operating Lucent Technologies Enhanced VR batteries for any length of time outside the recommended voltages and/or temperatures will cause reduced performance and premature failure and reduce or void the warranty.

Since hot air rises, the top row of a multi-tiered stand configuration is likely to have higher temperatures than the bottom row. When necessary, use fans or other means of ventilation to minimize temperature variations between modules in the same string.

Caution

Lucent Technologies strongly recommends a temperature compensation device in high-temperature environments. Failure to use such a device may result in high battery temperature that can cause premature battery failure and reduce or void the warranty.

Capacity

The capacity of a battery module or a string is expressed as a percent of its rated value. For example, if a module is discharged at the 5-hour rate and it lasts 5.25 hours before reaching 1.75 volts, it is said to have 105% of its rated capacity.

Temperature Correction for Capacity

The capacity of a module varies slightly with temperature. For every 1°C (2°F) increase in temperature, there is a corresponding 0.5% increase in capacity. To correct the 1.75 volt capacity to 25° C (77° F), add or subtract the correction factor determined from Figure 7-1. Use the temperatures recorded at the beginning of the discharge.

Example

The ambient temperature at start of discharge was 19.4°C (67°F) and the discharge to 1.75 volts at the 5-hour rate (300 minutes) lasted 292.5 minutes. The uncorrected capacity is 97.5%, i.e., [(292.5/300) x 100 = 97.5%]. From Figure 7-1, K (the correction factor) equals a positive 2.5% correction at

67°F (19.4° C). Therefore, the temperature-corrected capacity is 97.5% + 2.5% = 100% (full capacity).

Note

When the ambient temperature is above 25°C (77°F), subtract the correction factor and vice versa.

Corrected capacity = Measured Capacity * [1 - 0.0025 (Temp°F - 77°F)]

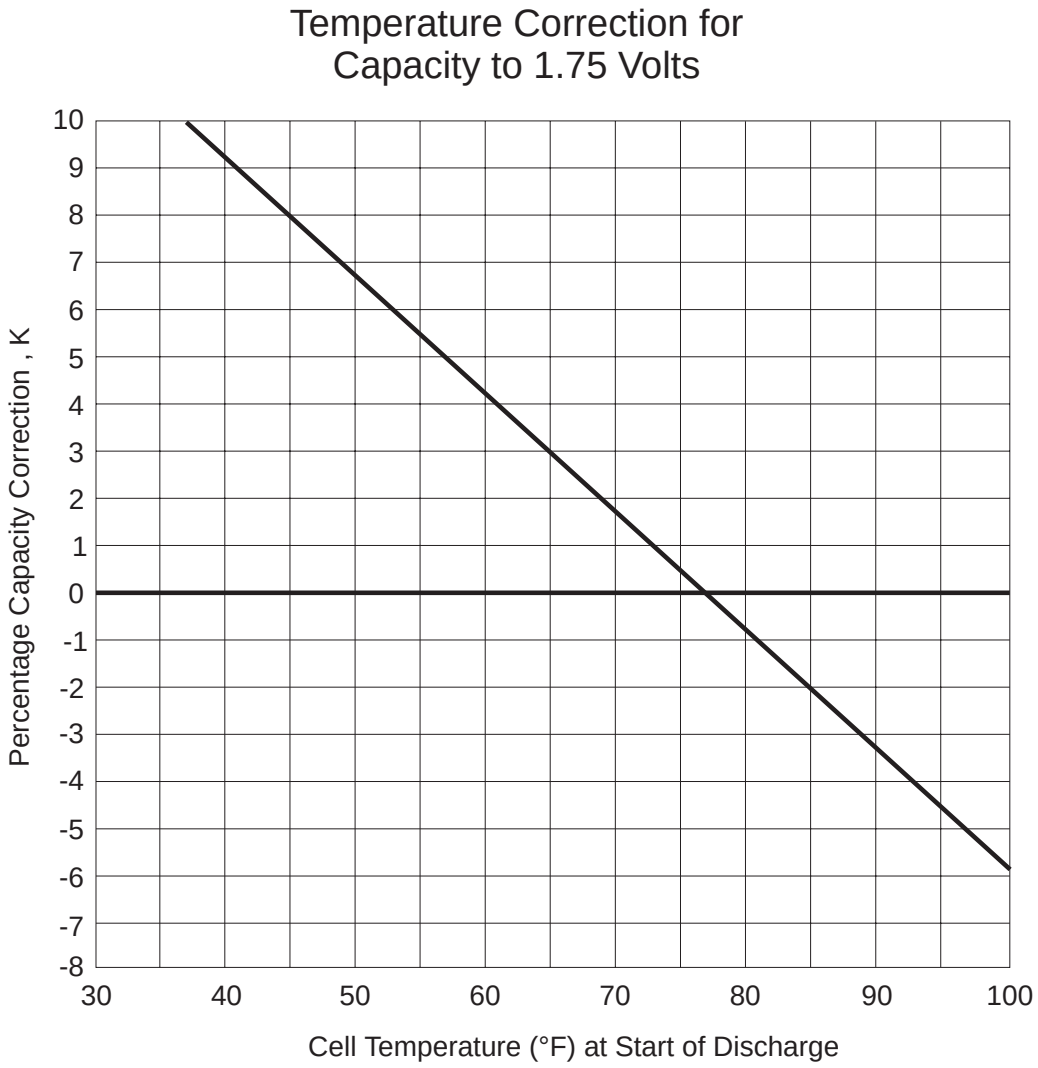


Figure 7-1: Temperature Correction Chart

Discharge Capacity Test

Since the Enhanced VR batteries are long-life batteries, this test is not required as a routine maintenance procedure. However, a discharge test is the best way to determine if sufficient reserve power is available.

The discharge capacity test should be run directly off float charge. Modules to be tested should be on float for at least one month without a power failure exceeding 30 minutes.

There are several different methods that can be used in testing the capacity of the string. In general, the more definitive the test, the longer and more difficult it is to perform.

If it is determined that a discharge test should be part of the maintenance program, carry out the test consistently from site to site and interval to interval. This way, comparisons and trends will be easier to evaluate. In selecting a test, the choices are as follows:

- single battery module or string
- partial or full discharge
- constant or variable load

The easiest test to run is to shut off the ac power and let the plant load discharge the batteries until 20% to 50% of the capacity has been removed. The disadvantage of this type of test is that the current may not be constant throughout the discharge, from interval to interval, or from site to site. You can overcome this disadvantage by adding an external load to the bus. You can adjust this load throughout the discharge to maintain a constant current.

In light of the above, a one-hour augmented plant load discharge is the preferred routine maintenance test. The one-hour discharge rate to 1.90 volts is a reasonable value since it will leave approximately 60% reserve at a lower rate. You should only perform a single-string, off-line, five-hour rate to 1.75 volt discharge test whenever you need a very accurate appraisal of the capacity. Do not use it on a routine basis. To carry out a discharge test properly, measure and record the time, current, module voltages, ambient temperature, and battery temperature at the start and periodically throughout the test. To achieve reasonable accuracy, the thermometer should be accurate to within 2 degrees Fahrenheit. Measure the current and time to an accuracy of 1% and the module voltage to the nearest millivolt.

Recharge After Discharge

Recharge should be carried out at the normal float voltage of 2.25 volts per 2VR250E or 2VR375E module or 4.5 volts per 4VR125E or 4VR125EL module or temperature-compensated voltage. The recharge should begin as soon as possible after the discharge.

Boost Charge

Boost charging the Enhanced VR Series batteries is not recommended without the concurrence of Lucent Technologies. Call 1-800-225-7822 for technical assistance.

During a boost charge, water loss due to electrolysis is greatly increased. In valve regulated, lead acid cells, frequent or prolonged boost charges can result in premature failure caused by cell dry-out. Boost charging at elevated battery temperatures can be especially detrimental to the batteries.

8 Maintenance

Maintenance Schedule

Proper maintenance ensures good performance, provides an opportunity to view trends as they develop, and ensures that the product remains under warranty coverage.

Table 8-A lists the required routines and intervals for maintaining the Enhanced VR batteries. "Paragraph Reference" refers to the procedures for performing the routines that follow the table. (The procedures and intervals are the same for all models of the Enhanced VR Series battery.)

Table 8-A: Maintenance Routines

Required			
Routine	**Action**	**Interval**	**Paragraph Reference**
Individual Battery Voltages	Measure/Record	Quarterly	"Individual Battery Voltages"
Battery Temperature	Measure/Record	Quarterly	"Measuring Battery Temperatures"
String Current Measurement	Measure/Record	Quarterly	"String Current Measurement"
Inter-module Connections of Module and Rack	Inspect	Quarterly	"Inspection and Cleaning"
	Clean	As needed	"Inspection and Cleaning"
	Retorque	As needed	"Retorquing Inter-battery Connections"
Note: Failure to adhere to these maintenance schedules and to record results will void the warranty.			

Maintenance Routines

When performing any maintenance activities, it is essential to follow all safety procedures outlined in Section 4.

Warning

An explosion could occur when sparks are created near the battery string. Use insulated tools and discharge all static electricity from your body before performing any work.

Section 10, *Installation and Maintenance Record*, contains a form for recording the measurable parameters noted in Table 8-A. The maintenance person taking these measurements should include the date on which measurements were taken as well as their initials. This information will aid in establishing trends that can be used to determine overall health of the batteries. The completed forms will be used for any future warranty claims.

Individual Battery Voltages

Caution

Exercise extreme caution when making voltage readings to prevent accidental grounding or shorting of leads during measuring operations. Connections at the meter must be secure and free of any possibility of touching or becoming grounded. Never remove connections at the meter end without first disconnecting the test leads from the battery. Remove test lead connections at the battery immediately after each reading is taken. Review the safety precautions in Section 4.

Using a calibrated digital voltmeter with at least two-digit accuracy, measure the voltage across each battery terminal to ensure they are floating properly. Record the data in the space provided on the “Voltage Measurements on Individual Batteries” portion of the Installation and Maintenance Record.

When making voltage measurements, please note the following:

- Readings on 2VR250E or 2VR375E should be within ±0.05 volts of the average or ±0.100 volts of the average for the 4VR125E or 4VR125EL module.

- Battery float voltage readings are affected by discharges and recharges. These readings must be taken when the

batteries have been on continuous, uninterrupted float operation for at least one month.

Measuring Battery Temperatures

Make temperature measurements using calibrated equipment, such as an infrared-based or thermocouple-based measuring device. Make all measurements on the negative terminal of the selected batteries. If using a thermocouple device, place the sensor on the negative terminal of the battery and wait a few seconds for the meter to stabilize. Note the measured value in the appropriate column on the "Temperature Measurement on Selected Batteries" portion of the Installation and Maintenance Record.

String Current Measurement

Use a calibrated DMM and current probe placed around a string cable to make individual battery string current measurements. Note the measured value in the appropriate column in the "String Float Current Measurements" portion of the Installation and Maintenance Record.

Inspection and Cleaning

A visual inspection of the battery plant should be done on a quarterly basis. If necessary, the battery modules and racks can be cleaned using a soft cloth dampened in water or approved battery-cleaning solution. The inter-battery connections should be inspected for corrosion. Report any sign of acid or corrosion to Lucent Technologies.

Retorquing Inter-battery Connections

The 4VR and 2VR batteries are made from 2-volt, 125Ah cells connected in series or parallel, respectively. These connections are made during manufacturing and should never need retorquing under normal circumstances.

The inter-battery connections are made during installation and will require periodic retorquing. Using an insulated 7/16-inch socket, retorque these connections to 60 inch-pounds.

Caution

Over-tightening of the inter-module connectors could strip the bolt and/or nut threads, resulting in loose connections.

Flame Arrestor Vent Feature

The vent and flame arrestor are maintenance free and do not require attention under normal circumstances. However, do NOT allow gas vents to become clogged or excessive internal pressure may result.

Battery Replacement

Note

To insure maximum battery performance, do not mix Lucent Technologies Enhanced VR Series batteries with other types of batteries.

As batteries age, their characteristics change. As a general practice it is not recommended to mix new batteries with older batteries in a string. A weak battery in a string can cause the entire string to fail prematurely.

However, should it become necessary to replace one or more battery modules in a battery string, charge the replacement module(s) according to Table 6-A. Following the initial charge, the module(s) should be kept on continuous float at 2.25 volts per 2VR batteries or 4.50 volts per 4VR batteries until the replacement can be made. The time between discontinuing the float charge and the completion of replacement should not exceed 24 hours.

Caution

Make sure the batteries are at equal float charge before connecting them into a string.

Alternatively, you may install the replacement module(s) in the string and then give it (them) an initial charge using a portable charger for the full length of time given in Table 6-A. When you replace a battery module in an existing string, you can transfer it without removing the string from the plant bus. Connect a 12-volt automotive battery in parallel with the 12-volt group that brackets the defective battery, using a suitable length of cable.

This method is demonstrated in Figure 8-1 for 2VR375E modules installed in a SLC framework.

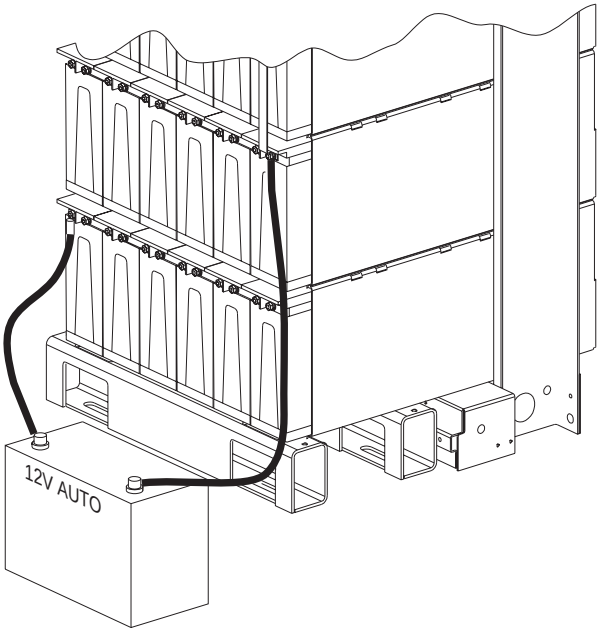


Figure 8-1: Replacing a Battery Module

9 Discharge and Power Data

Constant Current Discharge Data

Tables 9-A to 9-C and Figures 9-1 to 9-8 display constant current discharge data at 25°C (77°F) for Lucent Technologies Enhanced VR batteries. The numbers in the tables represent the discharge current for a particular reserve time to the corresponding end cell voltage. The capacity in ampere-hours is obtained by multiplying the discharge current by the reserve time.

The data in these tables were derived from discharge data that were temperature corrected assuming a temperature correction factor of 0.25% per degree Fahrenheit. For temperatures above 77°F, adjust the discharge times by adding 0.25% per degree Fahrenheit. For temperatures below 77°F, adjust the discharge times by subtracting 0.25% per degree Fahrenheit.

The data in these tables represent a minimum of 100% capacity between the first and last terminals of the battery string and do not include any connections between the battery and the load.

Table 9-A: 2VR375E Constant Current Discharge Data

Hours Reserve @ 77° F	End Volts per Battery							
	1.75	1.80	1.82	1.84	1.86	1.88	1.90	1.92
1	161.8	150.6	144.7	137.9	131.4	129.1	119.6	109.0
3	84.1	82.8	81.7	80.2	78.4	76.2	73.3	70.0
5	61.7	61.0	60.3	59.3	58.1	56.4	54.0	51.0
8	44.5	43.7	43.3	42.8	41.9	40.8	39.2	37.4
10	37.8	37.3	36.9	36.5	35.9	35.0	33.8	32.4
15	28.5	28.1	28.0	27.6	27.2	26.6	25.7	24.9
20	22.5	22.3	22.1	21.9	21.5	21.1	20.4	19.6
24	19.4	19.2	19.1	18.9	18.5	18.2	17.6	16.9

Table 9-B: 4VR125EL Constant Current Discharge Data

Hours Reserve @ 77° F	End Volts per Battery							
	1.75	1.80	1.82	1.84	1.86	1.88	1.90	1.92
1	55.1	52.1	50.3	48.2	45.9	43.6	42.2	38.8
3	28.1	27.7	27.5	27.0	26.5	25.8	24.9	23.6
5	20.6	20.4	20.2	19.9	19.5	19.0	18.3	17.2
8	14.8	14.6	14.5	14.3	14.1	13.7	13.2	12.6
10	12.6	12.4	12.3	12.2	12.0	11.7	11.4	10.9
15	9.4	9.3	9.2	9.1	9.0	8.9	8.6	8.3
20	7.5	7.4	7.4	7.3	7.2	7.0	6.8	6.6
24	6.5	6.4	6.4	6.3	6.2	6.1	5.9	5.7

Table 9-C: 2VR250E Constant Current Discharge Data

Hours Reserve @ 77° F	End Volts per Battery							
	1.75	1.80	1.82	1.84	1.86	1.88	1.90	1.92
1	107.9	100.4	96.5	91.9	87.6	86.1	79.7	72.7
3	56.1	55.2	54.5	53.5	52.3	50.8	48.9	46.7
5	41.1	40.7	40.2	39.5	38.7	37.6	36.0	34.0
8	29.7	29.1	28.9	28.5	27.9	27.2	26.1	24.9
10	25.2	24.9	24.6	24.3	23.9	23.3	22.5	21.6
15	19.0	18.7	18.7	18.4	18.1	17.7	17.1	16.6
20	15.0	14.9	14.7	14.6	14.3	14.1	13.6	13.1
24	12.9	12.8	12.7	12.6	12.3	12.1	11.7	11.3

Constant Current Discharge Data to 1.75 Volt per Battery End-Point for Lucent Technologies Enhanced VR Series Battery

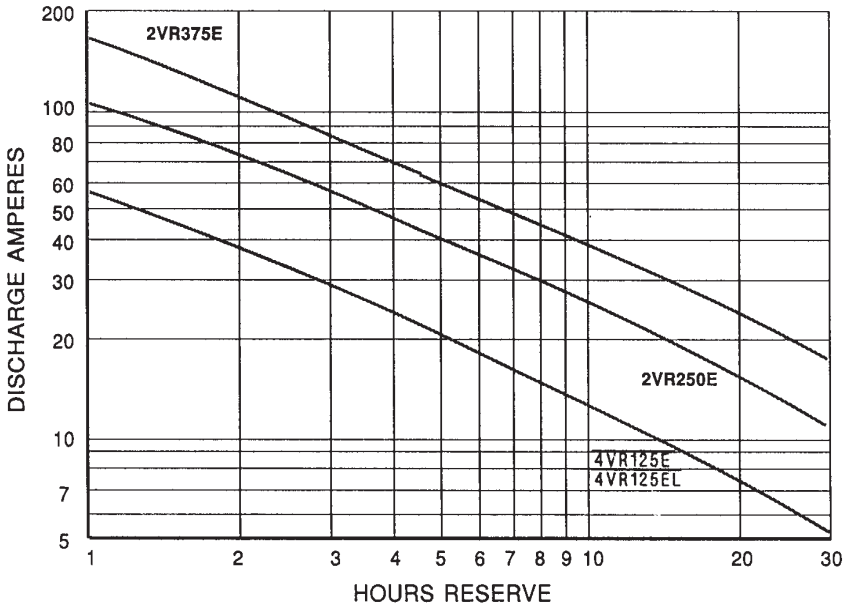


Figure 9-1: Constant Current Discharge Data to 1.75 Volts

Constant Current Discharge Data to 1.80 Volt per Battery End-Point for Lucent Technologies Enhanced VR Series Battery

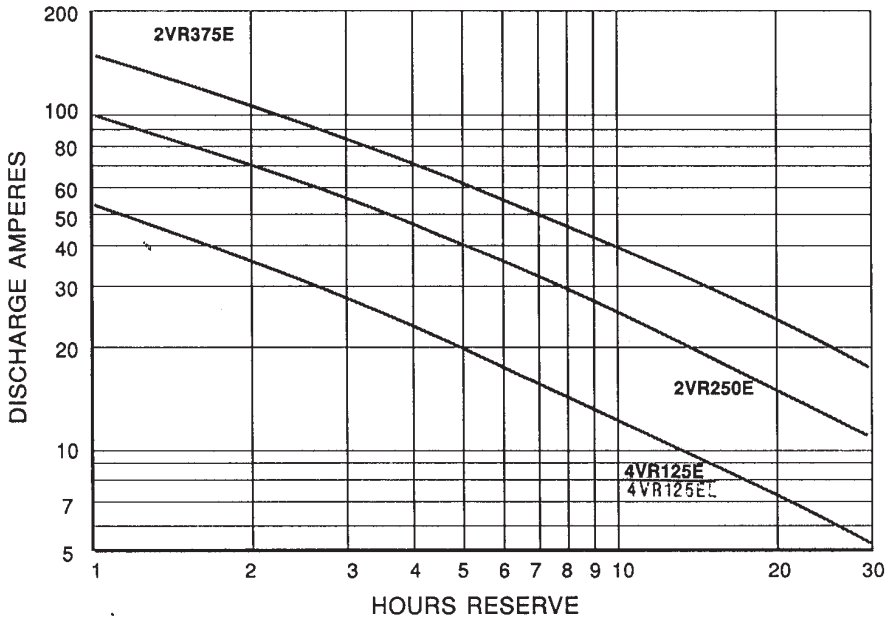


Figure 9-2: Constant Current Discharge Data to 1.80 Volts

Constant Current Discharge Data to 1.82 Volt per Battery End-Point for Lucent Technologies Enhanced VR Series Battery

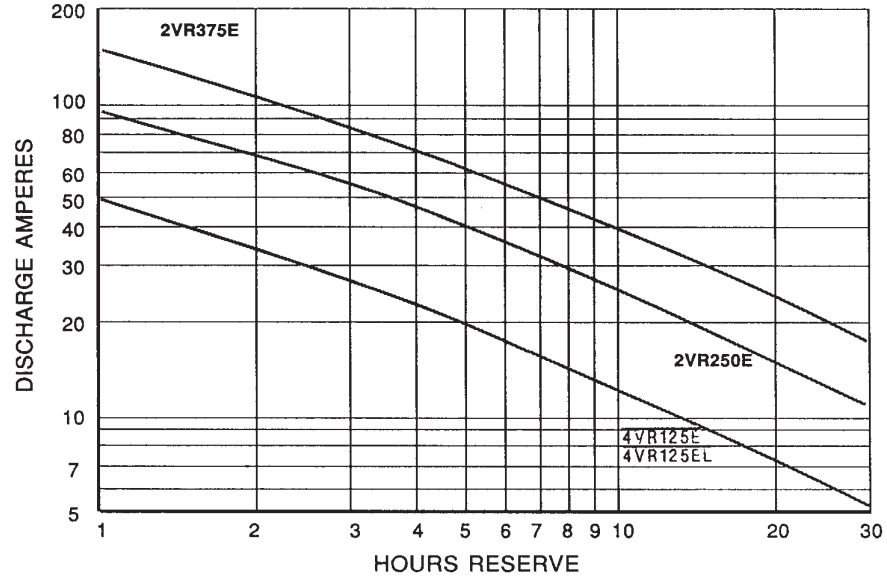


Figure 9-3: Constant Current Discharge Data to 1.82 Volts

Constant Current Discharge Data to 1.84 Volt per Battery End-Point for Lucent Technologies Enhanced VR Series Battery

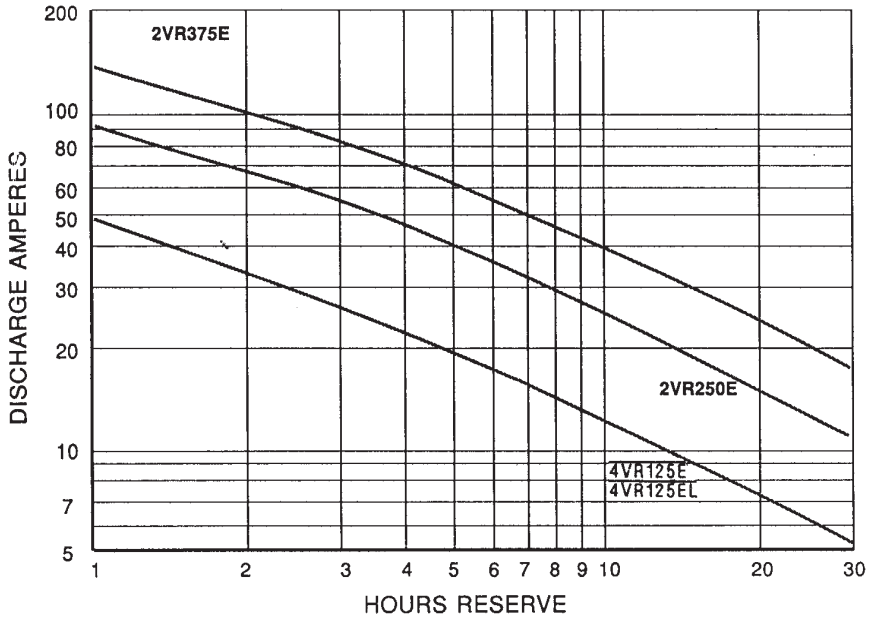


Figure 9-4: Constant Current Discharge Data to 1.84 Volts

Constant Current Discharge Data to 1.86 Volt per Battery End-Point for Lucent Technologies Enhanced VR Series Battery

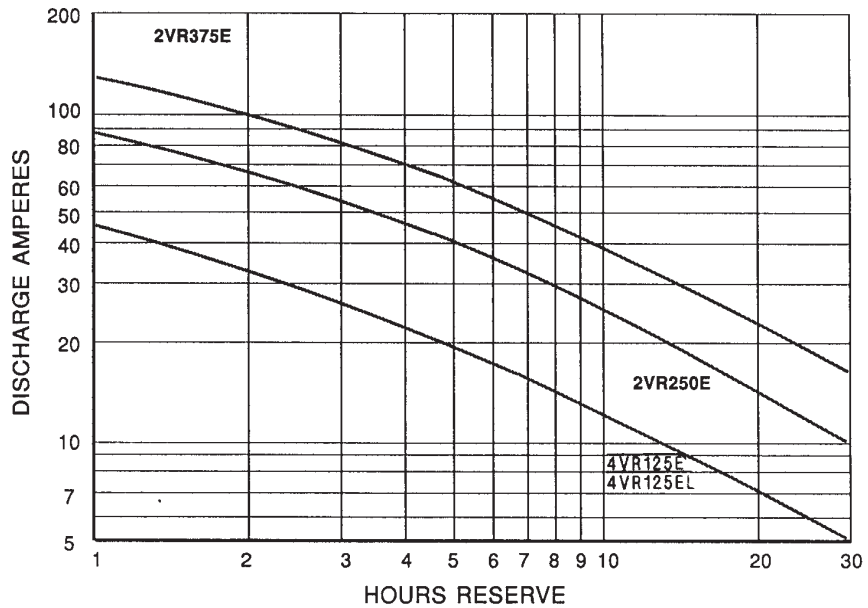


Figure 9-5: Constant Current Discharge Data to 1.86 Volts

Constant Current Discharge Data to 1.88 Volt per Battery End-Point for Lucent Technologies Enhanced VR Series Battery

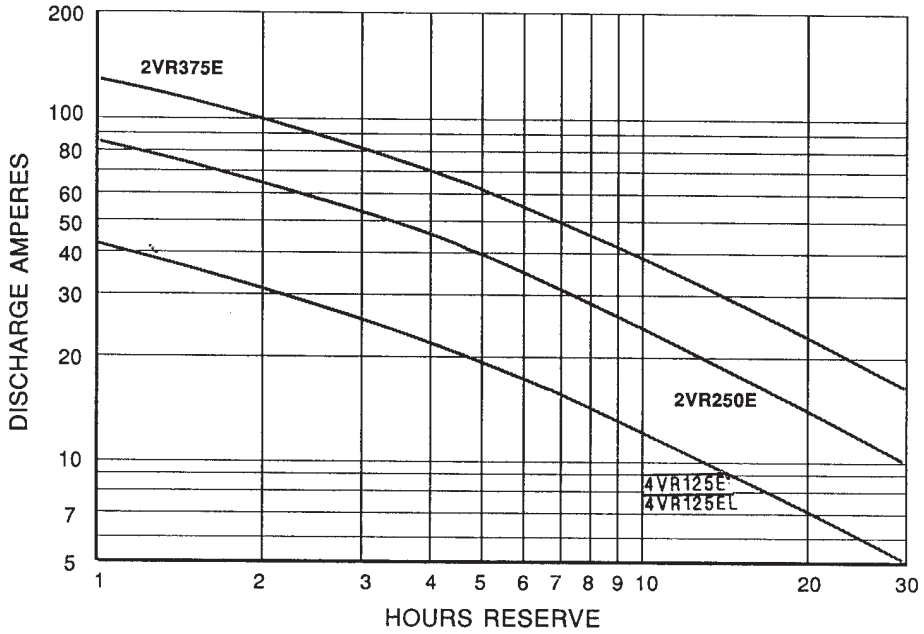


Figure 9-6: Constant Current Discharge Data to 1.88 Volts

Constant Current Discharge Data to 1.90 Volt per Battery End-Point for Lucent Technologies Enhanced VR Series Battery

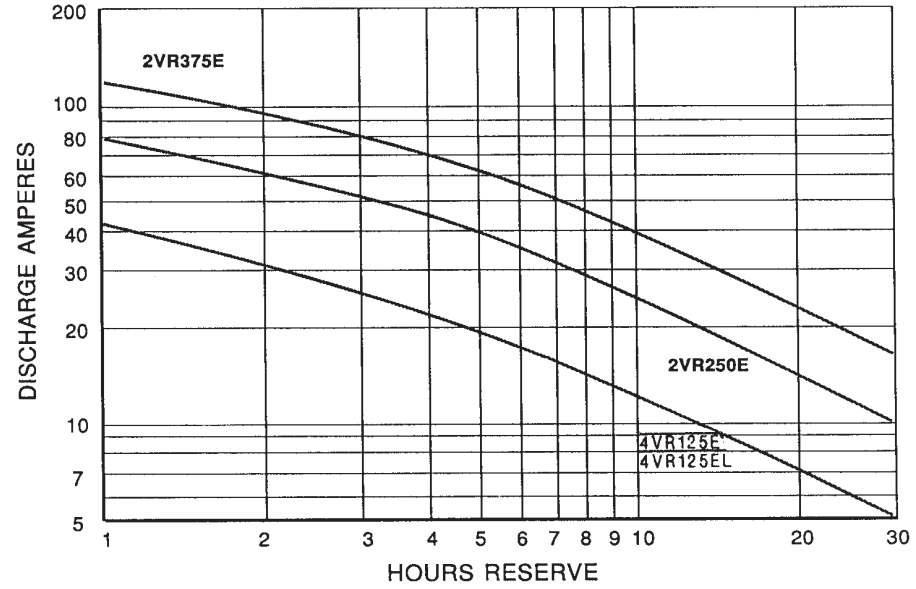


Figure 9-7: Constant Current Discharge Data to 1.90 Volts

Constant Current Discharge Data to 1.92 Volt per Battery End-Point for Lucent Technologies Enhanced VR Series Battery

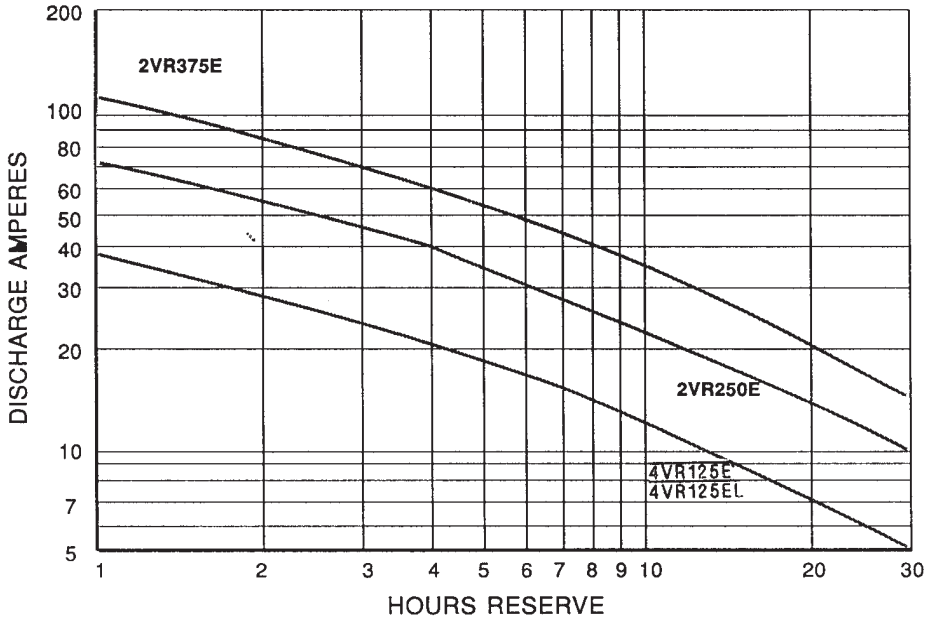


Figure 9-8: Constant Current Discharge Data to 1.92 Volts

Constant Power Discharge Data

Tables 9-D through 9-F and Figures 9-9 through 9-16 show the constant power discharge data for Lucent Technologies Enhanced VR batteries. The data in the tables represent the discharge wattage for a particular reserve time to the corresponding end battery voltage.

Table 9-D: 2VR375E Constant Power Discharge Data

Hours Reserve @ 77° F	End Volts per Battery							
	1.75	1.80	1.82	1.84	1.86	1.88	1.90	1.92
1	368.4	362.4	357	354	348	341.4	333	323.4
3	199.5	196.5	195	192.9	189.3	184.5	176.4	171
5	132	131.1	129.9	129	127.5	125.4	123	118.8
8	94.5	93.3	92.1	90.6	88.5	85.8	82.5	79.2
10	76.5	75.9	75.6	75	74.1	72.6	70.8	68.1
15	58.2	57.9	57.6	57.3	57	56.1	55.2	53.7
20	49.2	48.6	48.3	47.7	47.1	46.2	45	42.9
24	41.1	40.8	40.5	40.2	39.6	38.1	36.6	34.5

Table 9-E: 4VR125EL Constant Power Discharge Data

Hours Reserve @ 77° F	End Volts per Battery							
	1.75	1.80	1.82	1.84	1.86	1.88	1.90	1.92
1	122.8	120.8	119	118	116	113.8	111	107.8
3	66.5	65.5	65	64.3	63.1	61.5	58.8	57
5	44	43.7	43.3	43	42.5	41.8	41	39.6
8	31.5	31.1	30.7	30.2	29.5	28.6	27.5	26.4
10	25.5	25.3	25.2	25	24.7	24.2	23.6	22.7
15	19.4	19.3	19.2	19.1	19	18.7	18.4	17.9
20	16.4	16.2	16.1	15.9	15.7	15.4	15	14.3
24	13.8	13.6	13.5	13.4	13.2	12.7	12.2	11.5

Table 9-F: 2VR250E Constant Power Discharge Data

Hours Reserve @ 77° F	End Volts per Battery							
	1.75	1.80	1.82	1.84	1.86	1.88	1.90	1.92
1	245.6	241.6	238	236	232	227.6	222	215.6
3	133	131	130	128.6	126.2	123	117.6	114
5	88	87.4	86.6	86	85	83.6	82	79.2
8	63	62.2	61.4	60.4	59	57.2	55	52.8
10	51	50.6	50.4	50	49.4	48.4	47.2	45.4
15	38.8	38.6	38.4	38.2	38	37.4	36.8	35.8
20	32.8	32.4	32.2	31.8	31.4	30.8	30	28.6
24	27.6	27.2	27	26.8	26.4	25.4	24.4	23

Constant Power Discharge Data to 1.75 Volt End-Point for Lucent Technologies Enhanced VR Series Batteries

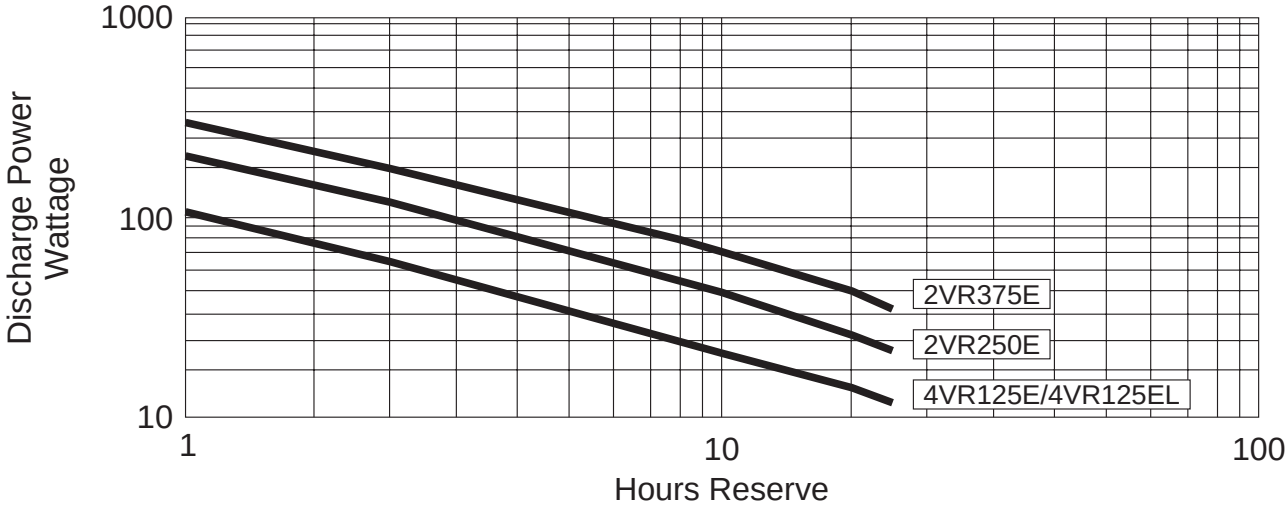


Figure 9-9: Constant Power Discharge Data to 1.75 Volts

Constant Power Discharge Data to 1.80 Volt End-Point for Lucent Technologies Enhanced VR Series Batteries

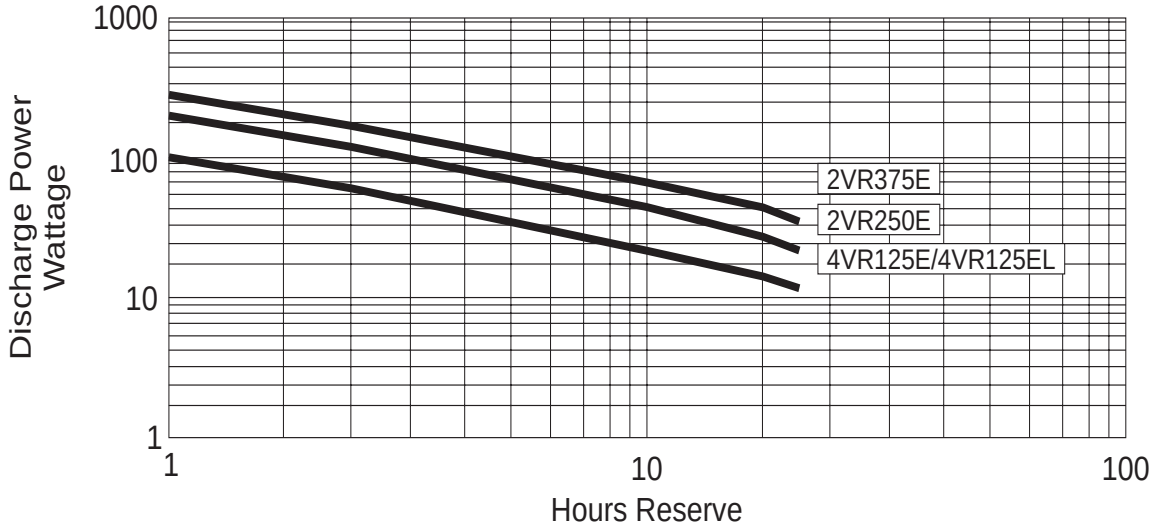


Figure 9-10: Constant Power Discharge Data to 1.80 Volts

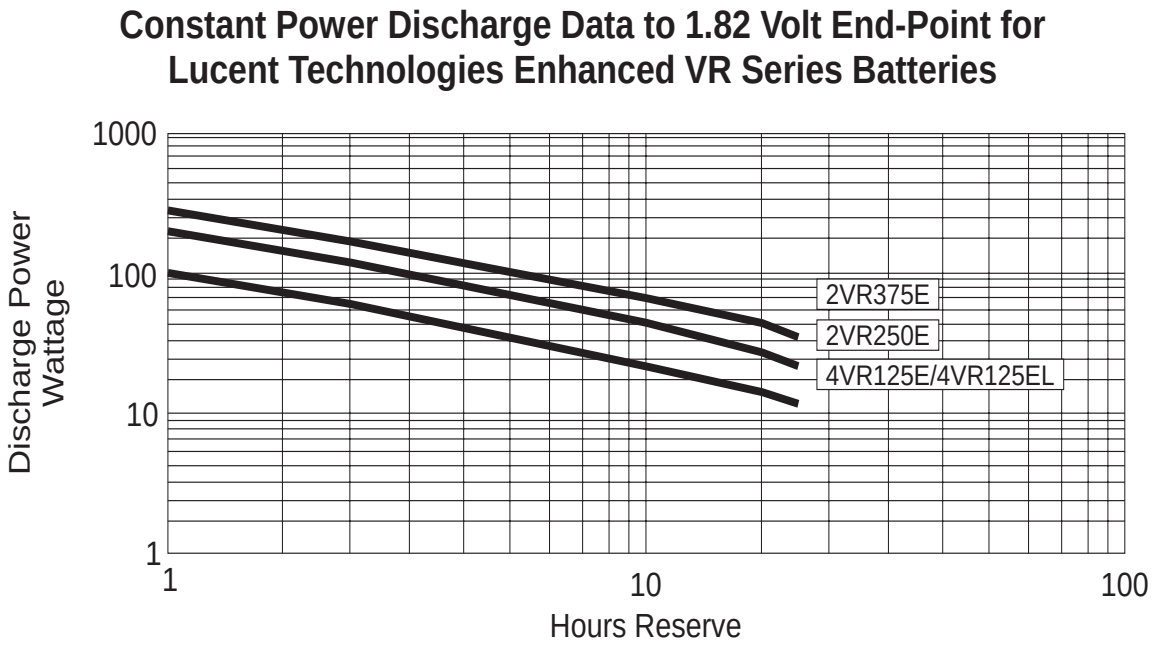


Figure 9-11: Constant Power Discharge Data to 1.82 Volts

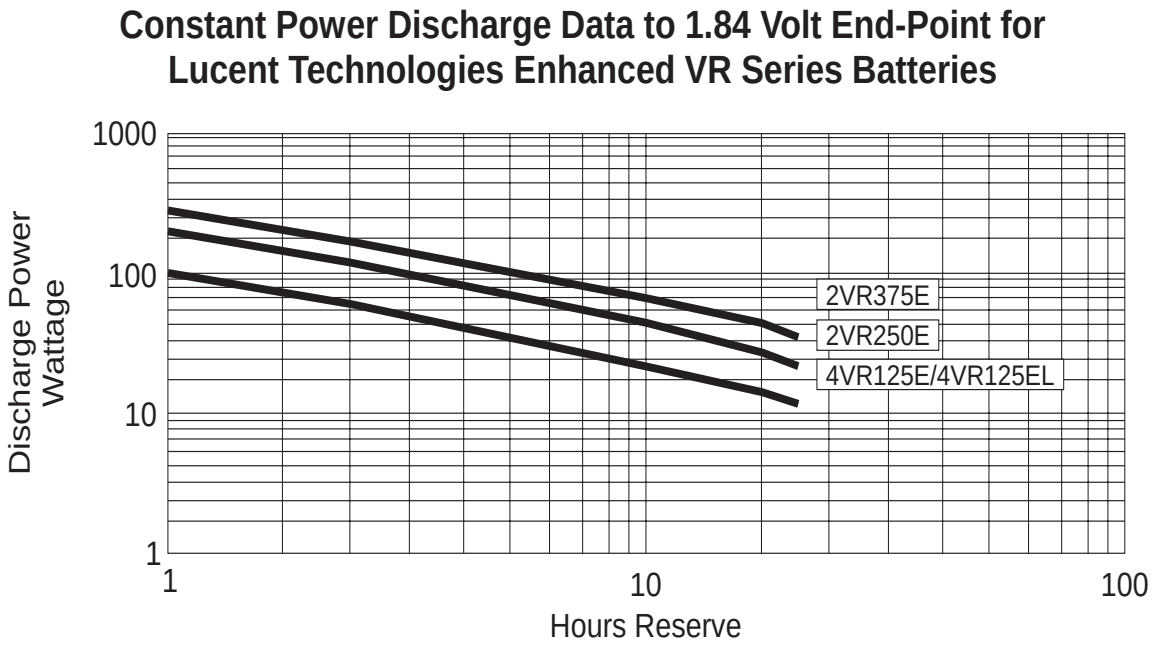


Figure 9-12: Constant Power Discharge Data to 1.84 Volts

Constant Power Discharge Data to 1.86 Volt End-Point for Lucent Technologies Enhanced VR Series Batteries

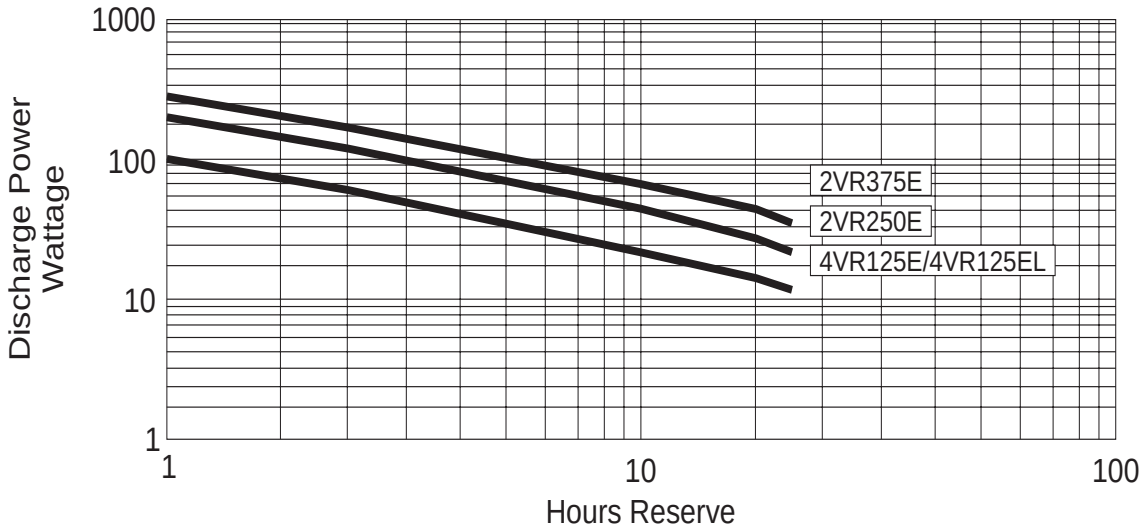


Figure 9-13: Constant Power Discharge Data to 1.86 Volts

Constant Power Discharge Data to 1.88 Volt End-Point for Lucent Technologies Enhanced VR Series Batteries

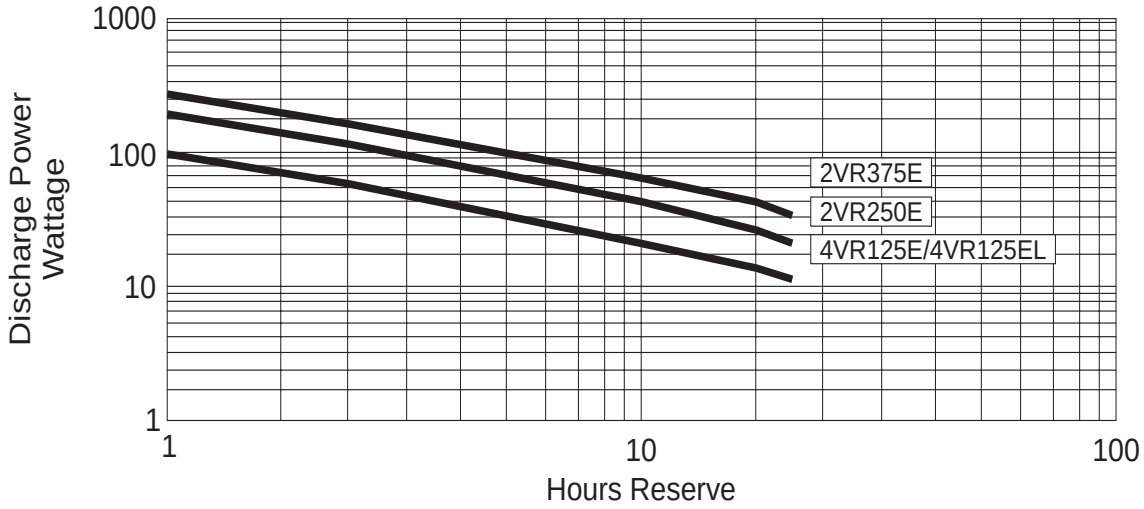


Figure 9-14: Constant Power Discharge Data to 1.88 Volts

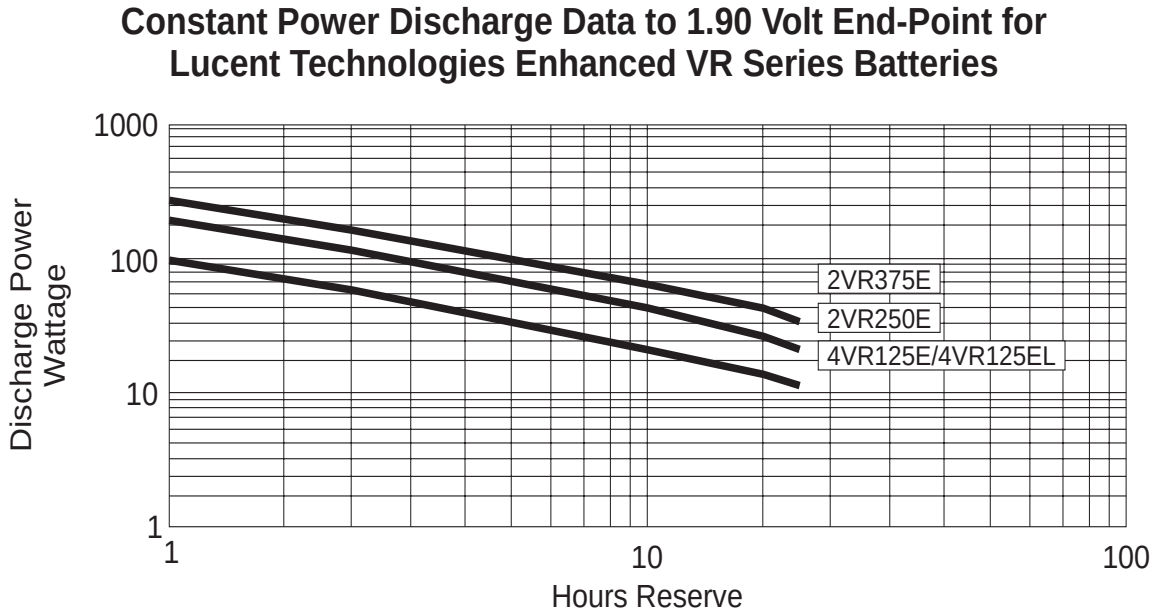


Figure 9-15: Constant Power Discharge Data to 1.90 Volts

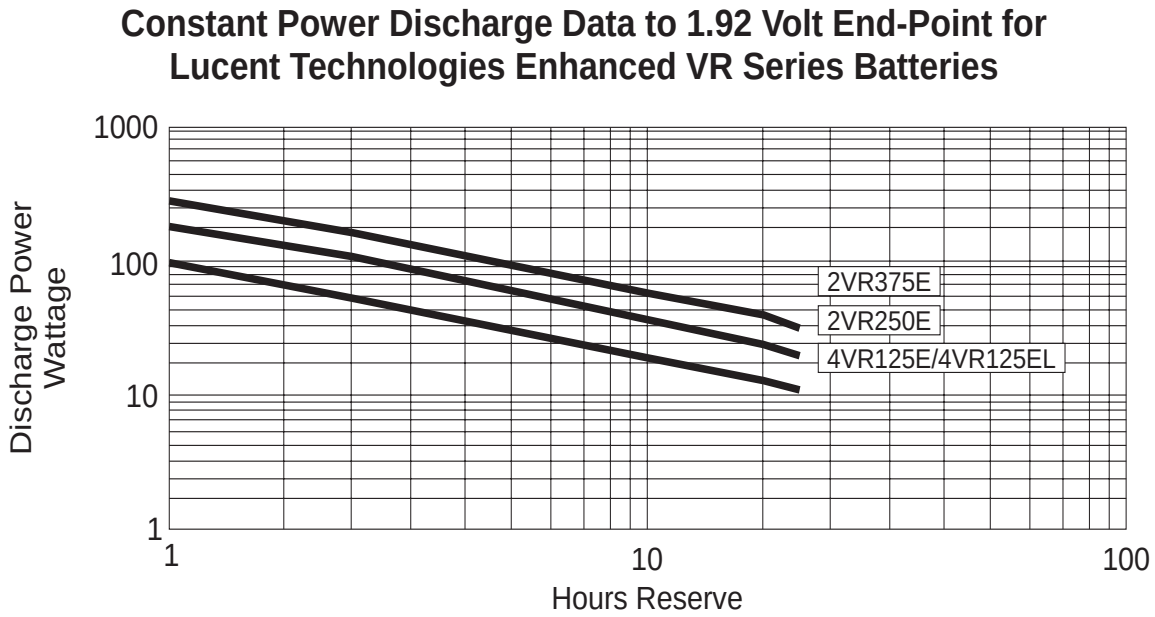


Figure 9-16: Constant Power Discharge Data to 1.92 Volts

High Discharge Rate Performance

The Enhanced VR battery is also appropriate for applications requiring high discharge rate performance. Table 9-G lists 1-minute and 5-minute rates to 1.75 volts per battery at 77° F. These data have been adjusted for intercell and/or interior connector losses, but not for connections between the battery and the load.

Table 9-G: High Discharge Rate Performance

Module	End Voltage/Battery	Reserve @ 77° F	
		1 minute	5 minutes
2VR375E	1.75 Volts	570 amperes	495 amperes
2VR250E	1.75 Volts	370 amperes	320 amperes
4VR125EL	1.75 Volts	185 amperes	160 amperes

10 Installation and Maintenance Record

The form in this section should be reproduced and used as the Installation and Maintenance Record for batteries.

Note

Failure to adhere to the maintenance schedules and routines described in the *Maintenance* section of this product manual will void the product warranty and may result in reduced performance of your batteries.

The battery installer should follow the instructions in Section 6, "Unpacking and Handling" and "Installation Records," to begin the recordkeeping. **The installer should then turn these records over to the Maintenance organization, who becomes responsible for taking the measurements detailed in this section and for maintaining the form.** If a warranty claim is made, the Maintenance organization will be required to show the "Installation and Maintenance Record" to support the claim.

Refer to Section 8, *Maintenance*, for required actions and measurements.

Installation and Maintenance Record (Page 1)

Company Name: _____ Site Address: _____ Battery Type: _____

String Voltage: _____ Voltage across charge and discharge buses: _____ Voltage Difference: _____

If the voltage difference between the string and the charge/discharge buses is less than 0.05V, the system is ready. Make individual battery voltage measurements and record in the table below.

Voltage Measurements on Individual Batteries												
		Measurement Date										
		Initials										
Battery Number	Serial Number	Order Number										

Installation and Maintenance Record (Page 2)

Company Name: _____ Site Address: _____ Battery Type: _____

Temperature Measurements on Selected Batteries											
	Measurement Date										
Battery Number	Initials										

String Float Current Measurements											
	Measurement Date										
Battery Number	Initials										

Battery Capacity Measurements							
Test Date	Battery Temperature	Start Voltage (Vdc)	End Voltage (Vdc)	Test Current (A)	Test Start Time	Test End Time	Percent Capacity

Installation and Maintenance Record (Page 3)

Date	Comments

11 Material Safety Data Sheet

This section contains the Material Safety Data Sheet for the Enhanced VR batteries.

Lucent Technologies
Bell Labs Innovations

ID: 11109

MATERIAL SAFETY DATA SHEET

Lucent Technologies
600 Mountain Avenue
Murray Hill, NJ 07974

Issue Date: 09/09/98
Issue Number: 10
Supersedes Date: 01/28/98

Non-Emergency Telephone # 908-582-3700
Emergency Telephone # 800-424-9300 (CHEMTREC)
Use CHEMTREC only in the event of chemical emergencies involving a spill, leak, fire, exposure, or accident involving chemicals.
Reason for Re-Issue: Update name, remove comcodes, change transportation data

I. PRODUCT IDENTIFICATION

Product Name: Battery, EVR Series KS-23619
Chemical Name/Synonym: Sealed, Lead Acid Battery
HMDB Number: 11109
Label Codes
Health: 3 - Corrosive
Fire: 0 - Non-flammable
Reactivity: 2 - Moderately reactive

II. HAZARDOUS INGREDIENTS

Component	CAS #	%	TLV(ACGIH)	PEL(OSHA)
Polyethylene and other non-hazardous ingredients	--------	10-14	N/A	N/A
*Lead oxide	1317-36-8	17-20	.05 mg/m^3	.05 mg/m^3
*Lead	7439-92-1	51-54	.05 mg/m^3	.05 mg/m^3
*Lead sulfate	7446-14-2	N.D.	.05 mg/m^3	.05 mg/m^3
**Sulfuric acid	7664-93-9	18-20	1 $mg/m^{3,1}$	1 mg/m^1

[1]**STEL (ACGIH):** 3 mg/m^3 [1]**STEL (OSHA):** N/A

Comments: The data presented refer primarily to the acid electrolyte since this compound poses the predominant immediate hazard associated with this product. *These chemicals are subject to Section 313 Title III SARA Reporting Requirements. **This chemical in its existing form is not subject to Section 313 Title III Reportable Requirement. However, if the use of this product results in aerosol formation of this chemical, then the aerosol of this chemical is subject to SARA 313 Title III Reportable Requirements.

III. PHYSICAL PROPERTIES

Appearance/Odor: Acid electrolyte is clear with a slight acrid odor.
Specific Gravity: 1.30
Boiling Point: > 219 °F
Vapor-Pressure: > 11 mm Hg at 68 °F
Evaporation Rate : < 1
% Volatiles by Volume: N/A
Vapor Density (Air=1): 3.4
Melting Point: -17 °F
Solubility in Water: Soluble
pH: < 1

IV. HEALTH HAZARD SUMMARY

Primary Routes of Exposure

Oral: **Skin:** X **Eye:** X **Inhalation:** X

Effects of Overexposure:

None during normal conditions of use. The electrolyte is corrosive to skin, eyes, and mucous membranes. Repeated or prolonged inhalation of mists can cause inflammation of the upper respiratory tract and chronic bronchitis; pulmonary edema and death may occur from severe exposures. Early symptoms of lead intoxication include a persistent metallic taste, vomiting, diarrhea or constipation, and severe abdominal pain. Continued exposures may result in muscle weakness and fatigue, nerve system damage, paralysis, liver and kidney damage, anemia, anorexia, and adverse reproductive and developmental effects.

Listed as a Carcinogen or Potential Carcinogen By the Following Agencies?

NTP: No **IARC:** Yes **OSHA:** No

Toxicity Study Information:

Only select Registry of Toxic Effects of Chemical Substances (RTECS) data are presented here. Consult latest issue for more information.

Sulfuric acid: The International Agency for Research on Cancer (IARC) has classified "strong inorganic acid mist containing sulfuric acid" as a Category I carcinogen, a substance that is carcinogenic to humans. This classification does not apply to liquid forms of sulfuric acid contained within a battery. The inorganic acid mist is not generated under normal use of this product. Misuse of the product such as overcharging, may result in generation of sulfuric acid mist.

Lead-TC_{LO}: .01 mg/m^3, human, inhalation; TD_{LO}: 450 mg/kg/yr, human, oral. Reported to cause chromosomal aberrations in human and animal cells. Causes reproductive and developmental effects in experimental animals.

According to the International Agency for Research on Cancer (IARC) Monograph Supplement (1987), there is inadequate evidence for the carcinogenicity of lead in humans. Lead and inorganic lead compounds are classified as group 2B carcinogens by IARC. OSHA regulated (29 CFR 1910.1025)

Lead sulfate-LD_{LO}: 2 g/kg, dog, oral; LD_{LO}: 30 g/kg, guinea pig, oral. Positive sister chromatid exchange assays in human and animal cells.

The lead and lead sulfate contained in this product pose a minimal hazard because they are enclosed. A lead hazard may result during recycling or if battery is discarded improperly.

V. FIRST AID PROCEDURES

Eye: In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Get medical attention immediately.

Skin: In case of contact, immediately flush skin with plenty of soap and water for at least 15 minutes while removing contaminated clothing and shoes. Get medical attention immediately. Wash clothing before reuse.

Inhalation: If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention.

Ingestion: If swallowed, do NOT induce vomiting. Give victim a glass of water. Call a physician immediately. Never give anything by mouth to an unconscious person.

Notes to physician: None

VI. FIRE AND EXPLOSION HAZARD DATA

Flash Point: N/A **Autoignition Temp:** N/A
Flammable Limits: LEL: N/A **UEL:** N/A

Extinguishing Media: For small fires use carbon dioxide, dry chemical. For large fires, flood area with large quantities of water, while suppressing vapors with waterfog/spray.

Special Firefighting Procedures: Cool battery exterior with water to prevent rupture. Firefighters should wear positive pressure self-contained breathing apparatus and thermal protective clothing to avoid toxic and corrosive mists, vapors, and possibly lead fumes.

Unusual Fire and Explosion Hazards: Sulfuric acid, especially when diluted with water, can react with metals to produce flammable gas. Remove all sources of ignition and ventilate area if battery is ruptured or recharging.

VII. REACTIVITY DATA

Stability: Stable

Conditions to Avoid: Prolonged overcharging; sources of ignition. Do not allow metallic articles to simultaneously contact the negative and positive terminals of the battery.

Incompatibility (Materials to Avoid): Combustibles, organic materials, strong oxidizers and reducing agents, strong acids and bases, active metals, water. Carbides, chlorates, nitrates, picrates, fulminates, halides, halogenates, peroxides, sulfides, potassium, sulfur, nascent hydrogen.

Hazardous Decomposition Products:

Sulfuric acid: Sulfur oxides, sulfuric acid mist, nascent hydrogen.

Lead compounds: Presence of nascent hydrogen may generate toxic arsine gas.

Thermal decomposition of battery casing may produce nitrogen oxides and cyanides.

Hazardous Polymerization: Will not occur

Conditions to Avoid: None

VIII. SPECIAL PROTECTION INFORMATION

Ventilation: General ventilation should be adequate under normal conditions of use.

Respiratory Protection: Respirators are not required under normal conditions of use. Use NIOSH approved respirator for acid mist if PEL or TLV is exceeded when handling electrolyte.

Protective Gloves: Protective gloves are required if exposure to electrolyte is possible. Neoprene, rubber, or polyethylene types are suggested.

Eye Protection: Chemical splash goggles or full face shield is required if exposure to electrolyte is possible.

Other Clothing and/or Equipment: Eyewash and safety shower should be available for immediate use. Rubber boots and rubber apron in accordance with potential for electrolyte exposure. Long legged and long sleeved clothing.

IX. ENVIRONMENTAL INFORMATION

Steps to be Taken in Case Material is Released or Spilled: If an acid spill is external to the battery, cover spill with clay or other recognized acid absorbing agent. Neutralize the acid with sodium bicarbonate (baking soda) or other recognized neutralizer. In an emergency sand, ashes, or gravel can be used to cover spill, and soda ash or lime used to neutralize acid; such substances should not be used on the battery itself as they can cause damage to it. Do not flush with water, even after acid has been neutralized.

Waste Disposal Method: Contains lead. Dispose of according to all applicable regulations.

TSCA Status: All components appear on the TSCA chemical substance inventory.

Shipping Information: USDOT/IATA: Name: Battery, Wet, Non-spillable **Class:** 8 **ID#:** UN2800 **PG:** III
This battery meets the DOT requirements for non-spillable batteries as specified in 49CFR173.159(d) and IATA requirements for non-spillable batteries as specified in packing instruction 806. This battery does not meet the IATA/A67 Provision.

X. SPECIAL PRECAUTIONS

Storage and Handling Requirements:

Store in a cool, dry, well ventilated area. Protect batteries from physical damage. All lead acid cells have enormous circuit capability. Extreme care should be exercised to avoid shorting of cell terminals. When working around cells remove rings, wrist watches, necklaces, metal bracelets, belt buckles, etc. Explosive hydrogen gas may be generated during charging. Avoid creating sparks, keep away from sources of ignition and ventilate area during charging.

N.D. = Not Determined **N/A** = Not Applicable.

12 Product Warranty

Enhanced VR Batteries Product Warranty:

A. Seller warrants to customer that:

1. As of the date title to product sold (Product) passes, Seller will have the right to sell, transfer, and assign such product, and the title conveyed by Seller shall be good;

2. Upon shipment, Product will be free from defects in material and workmanship, and will conform to Seller's specification.

B. The Warranty periods and conditions applicable to new products are listed in Table 12-A:

Table 12-A: New Battery Warranty Periods and Conditions

Warranted Life	Annual Average of Daily Maximum Battery Temperature (see Note)	Full Replacement	Pro-Rata Replacement
20 years	77°F (25°C)	5 years	15 years
12 years	90°F (32°C)	3 years	9 years
4 years	110°F (43°C)	2 years	2 years
2 years	122°F (50°C)	1 year	1 year
Note: Operating the Enhanced VR battery for any length of time above 77°F (25°C) will result in reduced performance and premature failure. The battery may operate for a short period of time between 51°C and 65°C; however, operation or storage for any length of time above 122°F (50°C) will void the product warranty.			

Temperature and maintenance records shall be maintained by Customer in accordance with Seller's published instructions in the *Maintenance* section of this manual. Failure to do so may void the warranty.

- End of life is defined as 80% of rated capacity (see *Operation* section for Discharge Capacity Test).
- Cycles and discharge depth shall not exceed:
  - 400 Cycles during Warranted years of life with an 80 percent discharge depth.

The Warranty Period commences on the date of shipment.

C. If, during the Warranty Period and under the Warranty Conditions, a defect or nonconformity is identified in a Product and Customer notifies Seller in writing of such defect or nonconformity, and follows Seller's instructions regarding return of defective or nonconforming Products, Seller shall, at its option, either replace such Product without charge or provide a credit as specified in the pro-rata replacement section of this warranty.

   If notification of defect is:

   - Within the years of the full replacement portion of the Warranty, Seller will, at its option, either replace the Product or provide a 100 percent credit based on the lesser of either current price or original purchase price. Credit will be applied to a replacement Lucent Technologies product.
   - Within the years of the pro-rata replacement portion of the Warranty, Seller will, at its option, either replace the Product or provide a credit based on the following pro-rata formula: C = [(WR - ML)/WR] x PR

     where: C = Credit
     ML = Months of Life Obtained
     PR = Current Replacement Billing Price
     WR = Warranted Months of Life as determined in paragraph “B”.

     Credit will be applied to a replacement Lucent Technologies product.

D. If Seller has elected to replace a defective Product, the cost of removal and the reinstallation shall be borne by

Customer. Products returned for replacement will be accepted by Seller only in accordance with its instructions for such returns. The transportation expense and risk of loss associated with returning such Product to Seller shall be borne by Customer. Seller shall bear the cost of transportation and risk of loss of the replacing Product to the destination originally designated by Customer at time of purchase. When Seller has elected to replace Product or give credit, Product shall remain the Customer's property to be disposed of in accordance with Federal, State, and local regulations for hazardous materials.

E. If Seller determines that a Product for which warranty service is claimed is not defective or nonconforming, Customer shall pay or reimburse Seller for all costs of handling, inspecting, testing, disposal, and transportation, and, if applicable, traveling and related expenses.

F. Seller makes no warranty with respect to defective conditions or nonconformities resulting from actions of anyone other than Seller or its subcontractor, caused by any of the following: modifications, misuse, neglect, accident, or abuse; improper wiring, repairing, alteration, installation, storage, or maintenance; use in a manner not in accordance with Seller's specifications, or operating instructions, or failure of Customer to apply previously applicable Seller modifications and corrections. In addition, Seller makes no warranty with respect to Products which have had their serial numbers or month and year of manufacture removed or altered.

G. This warranty shall run only to Customer who is a direct purchaser from the Seller.

THE FOREGOING WARRANTIES ARE EXCLUSIVE AND IN LIEU OF ALL OTHER EXPRESS AND IMPLIED WARRANTIES, INCLUDING BUT NOT LIMITED TO WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. CUSTOMER'S SOLE AND EXCLUSIVE REMEDY SHALL BE SELLER'S OBLIGATION TO REPLACE OR CREDIT AS SET FORTH PREVIOUSLY IN THIS WARRANTY.