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Central Office Battery Maintenance

Central Office Battery Maintenance Practices For Flooded and Valve Regulated Lead Acid Batteries (CO Power)

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INTRODUCTION

This document provides maintenance procedures for flooded lead acid batteries and Valve Regulated Lead-Acid (VRLA) batteries used in telecommunications Central Offices (COs), Standby Engine starting batteries or remote electronic sites (RES). Procedures listed in Sections l through 4 and Section 6 apply specifically to flooded batteries and procedures listed in Sections 5 and 7 apply specifically to Valve Regulated Lead Acid (VRLA) batteries. However, most procedures are common to both flooded and VRLA batteries. Maintenance procedures written by each region should be used in conjunction with or supersede this document.

The words "battery(s)" and "cell(s)" will be used interchangeably throughout this document.

This document does not cover installation procedures for battery strings; those procedures are contained in local test and acceptance documents. All maintenance work performed on batteries MUST be done by qualified technicians that are totally familiar with all safety procedures for telecommunications power plants.

Batteries used in COs include: KS-20472 pure lead Cylindrical/Round cells (manufactured by AT&T), and Rectangular cells with either lead-antimony or lead-calcium technology which are manufactured many suppliers.

Batteries used in Standby Engines for starting or control functions are manufactured by various companies. Starting battery strings can be found in 12 volts (engines under 100kW), 24 volt (most common), 32 volt (older KS sets) and rarely in 120 volt configurations.

VRLA batteries are mainly used in RES that have limited ventilation and access because they evolve less hydrogen than flooded batteries and do not contain large amounts of liquid electrolyte. There are two VRLA technologies, Absorbed and Gel, that come in many sizes and are manufactured by many suppliers.

Table 1.

Table 1. SPECIAL INSTRUCTIONS FOR THIS PROCEDURE

Required	Company	Go To Section
YES	Ameritech (AIT)	1
YES	Nevada Bell (PB)	1
YES	Pacific Bell (PB)	1

YES	Southern New England Telephone (SNET)	1
YES	Southwestern Bell Telephone (SWBT)	1

1. REASON FOR REISSUE

Issue Number	Date Modified	Brief Description of Changes	Author
1	10/30/02	Establish 13 State Central Office Power Document and 13 State Standard Battery Forms	Don Buell

1.1. Revisions to this issue

1.2. Safety

1.2.1. Electrolyte Corrosion and Bodily Protection

Battery electrolyte is extremely corrosive to most materials and human tissue. Therefore, extreme care must be taken when working around batteries or handling battery electrolyte. Most metal, vegetable and animal products are corroded by electrolyte, unless the electrolyte is promptly neutralized.

Protective equipment such as rubber gloves, rubber aprons, full face mask, or splash-proof goggles must be worn when performing any activity that involves the handling of electrolyte, batteries containing electrolyte, or any maintenance activity that requires exposure to shock or electrolyte from these batteries.

Avoid creating sparks, including those from static electricity, or the use of an open flame near batteries because the gases inherent to batteries are explosive when sufficiently concentrated. Before performing each maintenance operation, firmly touch a grounded rack or an intercell connector near the grounded end of the battery to discharge the static electricity from your body. The use of a wrist/ankle conductive strap connected to the grounded battery stand is also acceptable

CAUTION: BEFORE PERFORMING MAINTENANCE ON BATTERIES, FIRMLY GROUND YOURSELF TO THE GROUNDING CONNECTION OF BATTERY STAND OR ESD GROUNDING POINT TO DISCHARGE STATIC ELECTRICITY

1.2.2. Electrical Shock and Burns Protection

All lead-acid batteries have enormous short circuit capability. Extreme care should be exercised to avoid shorting out battery terminals. Shorting a battery (or battery plant) with noninsulated tools can cause service interruptions, arcing and sparks which may lead to an explosion and possible injury.

Tools used on batteries **MUST** be insulated, and only trained personnel that understand the potential hazard of handling the Lead Acid batteries should be allowed to perform the battery maintenance work. Tools wrapped with tape are not approved for work around power equipment, reference TP76300MP Section B. In addition, any conducting articles on wrists, legs, waist, neck or head should be removed to prevent accidental shorts.

Whenever it is necessary to work on a rack of batteries that cannot be reached from the floor, the use of a wooden or a fully insulated ladder is advised.

1.3. FIRST AID

1.3.1. Electrolyte Splashes and Burns

Electrolyte in the eyes or on the skin is very serious and requires immediate action. In case of electrolyte splash, use an eyewash kit and solution. If these are not available, use the following procedures:

- Remove electrolyte splashed on the skin immediately by flushing the affected area with large amounts of plain tap water

- Remove electrolyte in the eyes by pouring water into the inner corner of the eye and allowing at least 1 quart of water to run over the eye and under the eyelid. A nearby drinking fountain may be used for this purpose

  Consult a physician, preferably an eye specialist, as soon as possible.

1.3.2. Mounting Eyewash Kits

In areas where eyewash kits and eyewash solutions are used, containers may be mounted on building columns, along walls or at the end of battery stands. An eyewash kit must be within easy reach (approximately 12 feet) from any point in the battery area and should be mounted within easy reach without opening doors, climbing ladders or using stools. The eyewash kit must be separated from other containers in the battery area to minimize the selection of the wrong container in an emergency.

1.4. Neutralizing Agents

When the decision is made to **neutralize an electrolyte spill of ONE Gallon or less**, the following paragraphs provide important information on the neutralizing agents and hazards associated with their use.

Danger: Electrolyte and electrolyte mixed with neutralizing agents are both conductive; therefore, they can cause electrical shorts and voltage hazards if they come in contact with live AC power circuits. Before neutralizing any spillage, take a moment to make certain that voltage hazards do not exist. Take appropriate action if a hazard exists, to first secure the site before neutralizing the electrolyte. Wear protective equipment and observe all safety guidelines for the cleanup

1.4.1. Acid Spills

If the amount of electrolyte spilled exceeds one gallon, then all efforts should be directed at containing the spill using the SBC approved acid spill kits. On site neutralization of acid for significant (greater than 1 gallon) spills is not recommended to be performed by site personnel. If feasible and safe to do so, an attempt to contain significant spills can be made and the Regional Environmental Management group immediately be notified. It is important to note the absorbed acid on which neutralization may have been attempted may or may not be neutralized. The absorbed, un-neutralized acid is hazardous waste and must be disposed of in accordance with Local, State, and Federal regulations. It is important that the Regional Environmental

Management group be notified of all acid spills. They will handle clean up, disposal and reporting of the spill as appropriate. There are different contact numbers for each region, SWBT, PAC/NB, SNET and AIT. The contact numbers can be found at the Environmental Management web site. http://em.sbc.com/

1.4.2. Contaminated Clothing

Contaminated clothing must be removed at once and the affected skin washed with flowing water for at least 15 minutes. If irritation or discomfort persists, consult a physician. Neutralized contaminated clothing can be disposed of in plant trash.

1.5. Explosion Precautions

The primary safety feature to prevent a battery explosion is the ceramic vent funnel (sometimes called a flame arrester or anti-explosion vent funnel) which **MUST** be installed on each battery. A battery **SHALL NOT** be charged or moved without a properly functioning ceramic vent in place.

The mixture of hydrogen and oxygen gasses given off during charge due to electrolysis of the water can be an explosive mixture if there is sufficient concentration. A mixture of hydrogen and oxygen is explosive if the hydrogen concentration exceeds 4% by volume.

CAUTION: To prevent an explosion, the electrolyte level should never be allowed to drop below the end of the anti-explosion funnel. The electrolyte level shall be maintained above the minimum mark on the battery container at all times.

Note: Before performing any maintenance work on batteries, the maintenance person shall be totally familiar with this document to prevent a battery explosion.

The following sections provide precautions and procedures that should **ALWAYS** be followed

1.5.1. Hydrogen & Oxygen Gases

All lead-acid batteries contain hydrogen, oxygen and nitrogen gases, even under open circuit conditions. If not permitted to escape, these gases can build up to explosive concentrations in approximately 1 week for pure lead or lead-calcium batteries, and in as little as 2 days for lead-antimony batteries. **NEVER** seal lead-acid batteries under any circumstances. When handling, storing, or shipping lead-acid batteries, refer to the manufacturer's documents for proper procedures.

1.5.2. Static Electricity Sparks

Take precautions against static sparks, especially while taking hydrometer or thermometer readings or when installing new vents of any type while batteries are in service. Sparks can also arise from a static charge that is developed when the battery is moved against another surface (e.g. slid along the floor or the battery stand/rack shelf). These precautions should always be observed because a cover seal leak, post seal leak, or a cracked container, will bypass the anti-explosion vent feature. Where static electricity is a problem, leather-soled shoes are recommended. Also, a slightly damp cloth, rather than a dry cloth, should be used to wipe plastic containers.

Danger: Avoid creating sparks or the use of an open flame near batteries since the gas generated by batteries is highly explosive. Before performing each work operation, firmly touch a grounded rack or frame to discharge the static electricity from your body or wear a conductive wrist/ankle strap connected to the grounded battery stand.

1.5.3. Charging and Discharging

Under normal float, discharge, and recharge conditions, no explosion hazard exists with properly vented pure lead batteries and lead-calcium batteries. However, all lead-antimony batteries may contain an explosive atmosphere even under normal float charge conditions. Nevertheless, it is prudent to take precautions against static sparks at all times.

1.5.3.1. Boost Charging

For boost charge procedures, see the charger manufacturer's documentation. If more than 30% of the cells in the string appear to require boost charging, the plant voltage may be too low. See Section 2.2 for voltage

Danger: During and for at least 24 hours after the end of a boost charge (2.25 volts or greater), an explosive concentration of hydrogen gas exists. For maximum safety, do not handle (avoid all contact with) batteries on boost charge. To prevent the possibility of an explosion, mark the electrolyte level on the battery container prior to boost charging. Boost charge the battery but, after the charge is finished, do not move the battery until the electrolyte returns to its original level

1.5.4. Battery Connections

Do not loosen or remove battery connections while batteries are gassing or discharging unless it is absolutely necessary. If a connection must be removed during this period, follow the precautions specified in Section 2.3.3.

1.5.5. Electrolyte Overflow

Electrolyte overflow from the vent funnel is caused by clogged vents. This condition represents an explosion hazard and the vent funnel MUST be replaced immediately.

1.5.6. Battery Terminal Ends

The positive (+) and negative (-) ends of battery strings shall not be adjacent to each other to eliminate the possibility of accidental shorts. Adjacent batteries in a string must not be allowed to touch each other.

1.5.7. Test Leads

Observe the following precautions when making voltage measurements:

- Use caution during the test process to prevent test leads from accidentally touching or grounding.
- Secure connections at the meter end.
- Always observe proper polarity.
- In no case should connections at the meter end be removed without first disconnecting the test leads from the battery.
- The test lead connections at the battery should be removed immediately after each reading is taken

2. Maintenance Procedures

2.1. Tools Materials and Test Equipment

The following tools, materials and test equipment should be available

TOOLS:

- Wire brush

- 3M ScotchBrite or equivalent.

- Stiff nylon bristle brush

- Small paint or typewriter brush

- Flashlight, regular or angular, having plastic or rubber housing

- Cotton swabs

- Six Point Single-end Box Wrenches having handles insulated with two coatings of a high dielectric vinyl plastic or of the following sizes: 1/2 Inch, 9/16 Inch, 5/8 Inch, 3/4 Inch, 13/16 Inch, 7/8 Inch, 15/16 Inch, 1 Inch, 1-1/16 Inch and 1-1/8 Inch

- 3-inch and 6-inch Wrench Extension

- Insulated torque wrench, (inch-pound)

- Eyewash Solution

- Acid-resistant gloves and apron

- Rubber Overshoes

- Safety Hard Hat

- Chemical Safety, Splash Proof Goggles

- Wiping Cloth

- Container (glass, glazed, porcelain, plastic rubber, earthenware or lead-for handling electrolyte or water)

- Glass or Plastic Funnel

- Heavy Duty Paper Wiper

- Acid-resistant industrial tape (2-inch wide)

- Portable battery charger

- Materials

  - Soda ash

  - Congo Red

  - Distilled or Deionized Water

  - NO-OX-ID Regular (A) or Special Compound - see local requirement

- TEST EQUIPMENT

  - Digital Multimeter with millivolt resolution, accurate to 0.02 percent on a 10 volt full scale or better

  - Hydrometer (for low-gravity batteries)

  - Alcohol thermometer

  - DC Clamp Ammeter

  - Optional: Midtronics CTM-100 test set or equivalent

2.2. Float Voltage

It is extremely important to maintain a battery plant at its proper float voltage. These voltages are shown in Table 3, 4 and 5. Any upward adjustment to these levels should be coordinated with the local Maintenance Engineer/Power Technical Support to protect the power plant and served equipment.

Table 3.
Table 3Float Voltage 52.08 Central Office CDO, CEV, RT Applications

Battery Type	Float Voltage (Volts/Battery)	Range (Volts/ Battery)	Float Voltage (Volts/Plant 48V)	Float Voltage (Volts/Plant 24V)	Float Voltage (Volts/Plant) 130V
Lead Calcium	2.17 ± 0.05	2.12 - 2.22	52.08	26.04	Voltage Calculated based on configuration of plant
Lead (Round Cell)	2.17 ± 0.05	2.12 - 2.22	52.08	26.04	
Lead Antimony	2.17 ± 0.05	2.12 - 2.22	52.08	26.04	
Nickel Cadmium Qty of Cells [nn]	1.43 ± 0.03	1.40 - 1.46	54.34 [38 Cells]	27.17 [19 Cells]	
Valve Regulated	2.25± 0.05	2.20 - 2.30	54.00 (24 Cell)51.75 (23 Cell)	27.00	

Table 4Float Voltage 52.80 Central Office CDO, CEV, RT Applications

Battery Type	Float Voltage (Volts/Battery)	Range (Volts/ Battery)	Float Voltage (Volts/Plant 48V)	Float Voltage (Volts/Plant 24V)	Float Voltage (Volts/Plant) 130V
Lead Calcium	2.20 ± 0.05	2.15 - 2.25	52.80	26.40	Voltage Calculated based on configuration of plant
Lead (Round Cell)	2.20 ± 0.05	2.15 - 2.25	52.80	26.40	
Lead Antimony	2.17 ± 0.05	2.12 - 2.22	52.08	26.04	

Nickel-Cadmium Qty of cells {nn}	1.43 ± 0.03	1.40 - 1.46	54.34 [38 cells]	27.17 Configuration [19 cells]	
Valve Regulated	2.25 ± 0.05	2.20 - 2.30	54.00 (24 cell) 51.75 (23 cell)	27.00	

Table 5Float Voltage Standby Engine Starting, Control and Station Battery Applications

Battery Type	Float Voltage (Volts/Battery)	Range (Volts/ Battery)	Float Voltage (Volts/Plant 12v)	Float Voltage (Volts/Plant 24V)	Float Voltage (Volts/Plant 32V/48V)
Lead Acid Flooded (Auto/Truck) See Manufacture Specifications	2.25 ± 0.05	13.20 - 13.80 per 12V Battery Container	13.50	27.00	36.00/NA
Valve Regulated (Mtce-Free)	2.27 ± 0.05	13.20 - 13.80 per 12V Battery Container	13.62	27.24	36.32/54.48
Valve Regulated (Spiral Plate)	2.25 ± 0.05	13.20 - 13.80 per 12V Battery Container	13.50	27.00	36.00
Caterpillar HO See Manufacture Specifications	2.30 ± 0.05	13.60 - 14.10 per 12V Battery Container	13.80	27.00	36.80
Nickel Cadmium Qty of Cells [nn]	1.43 ± 0.03	1.40 - 1.46 per Cell	[10] 14.30	[19] 27.20 [20] 28.60	[25] 35.80 [27] 38.60

2.2.1. Measurement Methods

A digital multimeter with millivolt resolution is suitable to measure the battery voltage. However, it is necessary to periodically check for voltmeter accuracy and calibration. Test lead connections at the battery should be removed immediately after each reading is taken and in no case should the meter connections be removed first. Voltage readings should always be taken with the voltmeter leads connected directly to the positive and negative battery posts of the battery when making individual cell readings. Do not connect the leads to the intercell connectors. When taking battery string float voltage readings the multimeter **Positive lead** should be connected on the **Positive post** of cell number one and the **Negative lead** should be connected on the **Negative post** of the last cell in the string. Multimeter and battery string polarity should be strictly adhered to.

Battery readings should be recorded on the String Storage Battery Record. For 24 volt or 48 volt plants use new form SBC5330 (Appendix F), for VRLA use new form SBC5331(Appendix F) and for 130 volt plants use existing form SBC6506 (Appendix D). Forms SBC5330 and SBC5331 (Appendix F) are available in electronic format at the SBC INSO web site. http://inso.sbc.com/powerhome/POWERhome.htm#Battery

CAUTION: Extreme care should be taken to prevent accidental grounding or touching of multimeter leads during the measurement process. Lead connections at the meter should be checked and secured prior to taking measurements

2.2.2. Effects of Electrolyte Temperature on Float Voltage.

Float voltage varies with electrolyte temperature but not significantly if the electrolyte temperature range is between 71° and 83°F. If the electrolyte temperature exceeds these limits, the adjustment value is 1.0mv/6°F, referenced at 77°F

A low electrolyte temperature inhibits chemical action, slows down diffusion by making the electrolyte more viscous, and increases the internal resistance of the battery. The resulting change in voltage can usually be disregarded

A high electrolyte temperature has the opposite affect to that of a low electrolyte temperature. Again, the changes in voltage can usually be disregarded except on discharge, at substantial rates, in high ambient temperature environments.

2.2.3. Deviation from Float Voltage and Corrective Actions

If the float voltage is not correct, the following should be checked first:

- Rectifier voltage: Low or high voltage batteries may be due to incorrect average battery float charge voltage. Check to see if the average battery float charge voltage for your power plant is as listed in Tables 3, 4, 5. Make appropriate rectifier adjustments as necessary.

- Battery temperature variations: Improper battery voltage conditions may result from temperature variations between batteries in the same string. This is most likely to occur in multitier arrangements. The warmer batteries (top tier) will have a lower float voltage. If the difference between the warmest and coolest battery, in any string, is more than 5°F, appropriate ventilation should be provided to correct the situation.

- Battery manufacturers: Batteries made by different manufacturers may have different float charge characteristics. Check to be sure that all batteries in a string are from the same manufacturer. If not, contact your Common System Engineer for clarification.

- Battery types: Lead, lead-calcium and lead-antimony may have different float characteristics. Check battery identification labels to be sure that all batteries within a string are of the same type. Never mix different type(s) in the same string.

  If the above conditions are not the cause of the float voltage deviation, check the following:

- **Battery voltage high**: In general, batteries operating slightly above the required voltage limit do not indicate a trouble condition. Any flooded batteries floating at a voltage higher than 2.27 volts for a 52.08 plant, 2.30 volts for a 52.80 plant should be inspected for evidence of the loss of one or more plates from the battery circuit. Replace any batteries that show the loss of plates.

  If visual inspection is not feasible or does not reveal evidence, a discharge test should be run on the flooded battery(s) in question. If the capacity is low, the battery(s) should be replaced. If both visual inspection and capacity test do not indicate a trouble condition, no action needs to be taken. However, special attention should be given to the voltage measurements log (SBC6506). Replace the battery if the float voltage continues to increase.

- **Battery voltage low**: For batteries that were float charging within the required range at the previous annual voltage reading, float voltages less than 2.12 volts for a 52.08 plant, 2.15 volts for a 52.80 plant (for flooded batteries) indicate a severe abnormality (possibly a short circuit). The condition should be reported; follow the recommended guidelines established in your region to report and replace the defective battery. Flooded batteries with voltages between 2.12 and 2.14 volts for a 52.08 plant, 2.15 and 2.17 volts for a 52.80 plant should be boost charged as soon as possible using a simple battery charger.

Warning: Read Section 1.5.3 Charging and Discharging before boost charging.

- If the batteries are still low after boost charge or if the batteries return to an abnormally low float voltage within a year after boost charge, the batteries should be replaced. If the batteries return to abnormally low-voltage conditions at any time exceeding 1 year after boost charge, boost charge again. When the battery voltage is below the required minimum float voltage but over 2.14 volts for a 52.08 plant, 2.17 volts for a 52.80 plant , further tests need to be performed. A discharge capacity test should be given 6 months after boost charging if a low-voltage condition still exists. Replace batteries only if discharge tests show low capacity.

2.3. Battery Connections

Batteries shall be properly spaced to accommodate the intercell connectors. Sizable terminating cables and interior cables for the string shall be supported to minimize stress against the battery posts and its seals. All connection (intercell and cables) shall be properly torqued to the manufacturers specification for the battery size. For the of purpose of scheduled routines cables should be checked for looseness and intercell connector torque should be checked annually. All connections shall be protected by a anti-corrosion compound coating. Before disconnecting an intercell connector, follow the recommended procedures as outlined in 2.3.3

2.3.1. Post /Intercell Connector Corrosion

Battery connection hardware shall be free from corrosion. Corrosion from electrolyte leakage will not normally occur except by careless handling of the hydrometer syringe when measuring the specific gravity. The positive post seal can also leak and attention must be focused on this problem. Green or blue copper-sulfate on a component, usually an intercell connector or post, indicates that electrolyte has penetrated the lead coating and is reacting with the copper. Any such component, other than a post, should be replaced and all associated surfaces treated. If the post seals continue to leak, refer the problem to your Maintenance Engineer/Power Technical Support group.

Round Cell Post Inspection: For KS0472 L1 round cell positive post inspection and rating procedures refer to BSP 157-629-702, Paragraph 3.03

2.3.2. Connection Tightness

Over tightening of the intercell connectors can strip the bolt and/or nut threads or damage the battery post resulting in a loose connection.

Install the intercell connectors by using one intercell connector on each side of the post. Ensure the sharp edge of the stamped steel washer is facing away from the intercell connector. The diameter of the washer should be nearly the same as the width of the intercell connector. Do not use undersized washers, because this will distort the intercell connector and cause increased resistance in the connection.

First, hand tighten the nuts and then carefully torque each connection to the battery manufacturer's recommended specification listed in Appendix A. Use an inch-pound insulated torque wrench to measure the torque.

2.3.3. Opening Battery Connections

Follow the manufacturer's instructions before loosening or removing battery connections, especially while batteries are gassing or discharging.

If the manufacturer's documents are not available, use the procedures in the next two sections.

2.3.3.1. Battery with two posts

When opening or replacing connections on batteries with only two posts, a bypass procedure should be employed similar to the one illustrated by Figure l. Connect a temporary switch or a properly sized bypass (insulated conductor) from post to post across the intercell connector that is to be removed. The purpose of the switch/bypass connection is to eliminate a potential arcing hazard and to prevent possible loss of service in case commercial ac power fails while the intercell connector is disconnected. The switch should remain open until the 2 post connections have been completed then it should be closed before opening or replacing the battery connections. If a bypass conductor is used in lieu of the switch setup the intercell connections must be positively confirmed before proceeding with the 2 post connections. The size of the switch strap and temporary wiring must be sufficient to carry the load under commercial ac power failure conditions.

Use of the switch or bypass conductor is mandatory for all plants powering office equipment that may be adversely affected by rectifier noise or transients (likely to be present when the battery is not solidly connected).

CAUTION: The temporary switch or bypass conductor should be used, and the switch contacts kept closed at all times while working on single-string battery plants, even when parallel intercell connections are used. The switch/bypass conductor arrangement will guard against possible broken post, connection corrosion, or loose connection on the (parallel) intercell and posts.

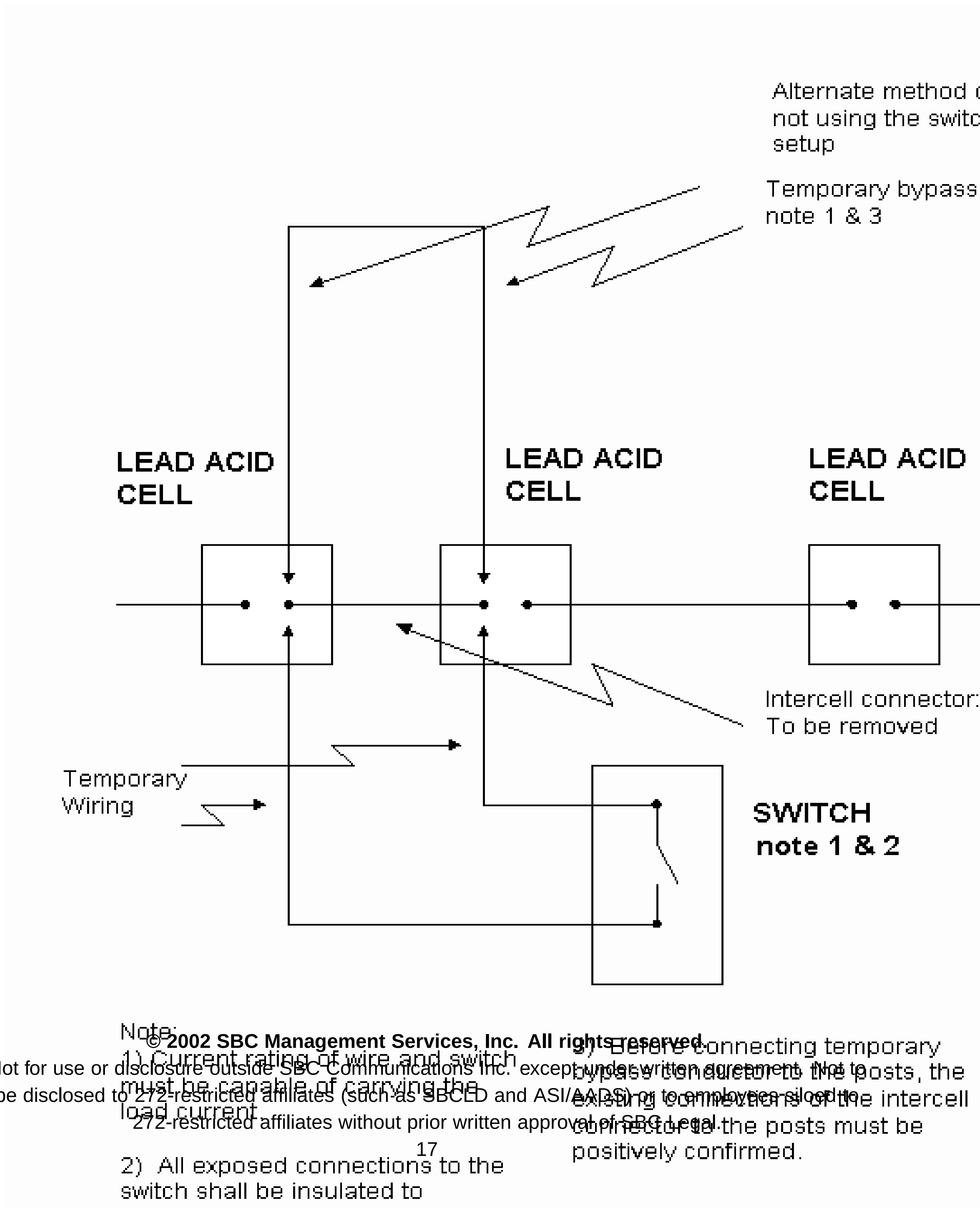
2.3.3.2. Batteries with four post

The switch or bypass conductor illustrated in Figure 1 is not absolutely required for batteries having four posts. Verify that float current does flow through both intercell paths (A - D, A1 - D1, see Figure 1) with a clamp-on current meter before removing the connectors from one pair of posts. Do not loosen the connectors on the parallel pair. Perform the necessary maintenance task and replace the connectors and then proceed to the other set.

Note: If it is necessary to break all connectors to a 4-post battery simultaneously, the use of a temporary switch or bypass conductor is mandatory

Figure 1 Temporary Interbattery bypass

Figure 1. CAPTION



2.3.4. Cleaning Battery Connections

The intercell connectors are lead coated copper bars and some battery posts have copper inserts. When cleaning posts and intercell connectors, take care not to expose the copper because this will accelerate corrosion. Buff all battery posts and intercell connectors with a nonmetallic scouring pad or stiff nylon bristle brush. **Do not use a wire brush.**

Clean and neutralize all posts and intercell connectors with a cloth dampened in a solution of soda ash and water (1.5 gallon of water to 1 pound of soda ash). Do not allow the neutralizing solution to enter the battery. After neutralization, wipe the area with a cloth dampened in clear water.

2.3.5. Application of NO-OX-ID Grease

For NO-OX-ID Regular: Indirect heat must be applied to the grease before it is used on the battery posts. Using an electric hot plate, place the NO-OX-ID container in a pan of water and heat the grease to a cream-like consistency. The grease can also be heated by placing the container on top of a soldering iron holder.

CAUTION: Do not use an open flame or direct heat on the can of NO-OX-ID

An insulating varnish will be formed if the grease is overheated or boiled and should be discarded. Using a clean paint brush, completely coat all battery posts and the ends of the intercell connectors with a thin layer of the NO-OX-ID. The coating of grease should extend approximately 1/2 inch beyond the post seal when the intercell connector is installed.

NO-OX-ID Special: Rub grease between the gloved fingers to check smoothness and then apply a thin coat to the battery posts. The thin coating of grease should extend approximately 1/2 inch beyond the post seal when the intercell connector is installed.

2.4. Battery Seals

Because of stresses caused by vertical plate growth, jar-cover seals may in time crack, separate and leak. A leaking jar-post seal can be an early indication of this problem. Where batteries have leaking or cracked jar-cover seals, experience has indicated that an intercell short can develop from the leaking electrolyte that may cause either a fire, explosion, or both.

A faulty jar-cover or post seal with electrolyte leakage can be confirmed with the following procedure.

- Perform a visual inspection of the seals around the battery posts and cover areas to determine if there are any signs of electrolyte seepage.

- If a leak is confirmed, the top of the jar cover, cover seal, and post should be thoroughly cleaned using the following procedure:

  First remove any NO-OX-ID-A from the discolored area on the post. The discolored area is to be neutralized with a strong neutralizing solution applied with a cloth, followed with a rinse with a rag wetted with clean water. Using a soft stainless steel brush, obtainable through C&D Power Systems as C&D Part #RJ-75, clean the area until the metal is shiny. Do not reapply NO-OX-ID after the test is completed in order to facilitate clearer observations. After the post is cleaned, allow the cell to stand for four weeks. The cell is not to be disturbed during the test period (i.e. do not check specific gravity, etc.).

  After the waiting period, again inspect the suspect post (s) for discoloration. If no discoloration has reappeared, the post seal is in satisfactory condition. However, if the discoloration has reappeared, check the problem area with a Congo Red solution. Congo Red is an indicator for acid, and will turn from red to blue in its presence. Wipe the problem area with a swab wetted with the indicator solution. **If the swab turns blue, the discoloration is the result of acid leakage. The cell is defective and Maintenance Engineer/Power Technical Support should be notified.** If the swab remains red, the stain is the result of something other than acid leakage, such as heavy oxidation on the post due to the absence of NO-OX-ID. In this case, the post seal is in satisfactory condition. A white appearance on the swab will indicate the presence of excess neutralizing solution left over from the cleaning procedure.

2.5. Anti-Explosion Features

Ceramic vents, domes, and plastic vents, should not be painted, varnished, or greased and should be free of dirt. If the vent becomes clogged it **Must Be Cleaned Immediately** to prevent an explosion or electrolyte overflow, due to the internal pressure.

Vents of the bayonet type or screw type can be removed by turning counterclockwise. Neutralize vents in a weak soda solution and clean with water and brush if they become clogged. For ceramic vents which are cemented to the battery cover, follow the recommended procedures in the manufacturers document for replacement.

2.6. Battery Containers

Battery Containers Electrolyte leakage can cause short circuits and corrosion of terminals and intercell connectors. It is also a potential fire hazard. Containers and covers shall be free from cracks and leakage or spillage of electrolyte. Leaky or cracked jars should be replaced.

CAUTION: Plastic battery containers can be damaged by cleaning with solvents or petroleum based cleaners

Do not expose or clean plastic containers with petroleum or solvents such as kerosene, gasoline or petroleum spirits which is the solvent in most cleaning compounds as well as the thinner in most waxes and polishes. Petroleum spirits and solvents seek out points of residual stress, causing cracks, crazing, and eventual failure. Do not use commercial detergents on plastic jars because this can lead to crazing or cracking of the jars. Use water that is suitable for battery electrolyte to clean the plastic battery jars. To remove spilled epoxy from the jar, allow it to dry, then scrape it off.

2.6.1. Battery Straps

Internal to the battery jar, the upper edges of the positive plates are burned into a lead bar which is called a "strap". In some designs, the straps are adjacent to the plastic jar wall. In others, the strap is located inward from the wall and has individual plate hangers hung into a plastic jar. These straps can grow enough to apply pressure to the jar. Where either the strap or the plastic hanger is nosing on the jar wall, flattened air bubbles are usually evident. Visual inspection of each battery can detect this growth.

For round batteries, the straps are oriented in a vertical position and the growth of the straps should not cause a problem for the jar.

2.6.2. Crazing, Cracking and Electrolyte Leakage Detection

Jar cracks are usually preceded by crazing of the jar at the plate or strap pressure point. Crazing is hard to see but shows up under a light beam as a group of hairline cracks. For safety, use a flashlight housed in a nonconducting material (plastic or rubber) when examining the batteries.

Cracks due to plate or strap growth may occur in the jar cover and extend over to the jar. Replace cracked or leaking containers. When the cracks are above the electrolyte level, leakage may not occur but the explosion-proof vent is bypassed. It is important to detect cracks and to order replacement batteries before leaks occur. Where cracks are below the electrolyte level, but not leaking, it is only a matter of time before continued strap or plate growth will cause leakage.

2.6.2.1. Handling Major Cracks

If the amount of electrolyte spilled exceeds one gallon, then all efforts should be directed at containing the spill using the SBC approved acid spill kits. On site neutralization of acid for significant spills is not recommended. A significant spill should be absorbed, transferred to an appropriate container, and transported off-site for neutralization. It is important to note the absorbed acid may or may not be neutralized. The absorbed or neutralized acid is hazardous waste and must be disposed in accordance with Local, State, and Federal regulations. It is important that the Regional Environmental Management group be notified of any acid spill. They will handle disposal and reporting of the spill as appropriate. There are different contact numbers for each region, SWBT, PAC/NB, SNET and AIT. The contact numbers can be found at the Environmental Management web site. http://em.sbc.com/

2.6.2.2. Emergency Repair of Minor Cracks

Cracks in the covers of batteries should be temporarily sealed with acid-resistant tape, when possible, while awaiting battery replacement. The container surface should be cleaned and neutralized before the temporary repair is made. The tape should be an acid-resistant, thick vinyl industrial tape. Use the following procedures when temporarily sealing plastic jar cracks:

1. Cover open cracks temporarily with a narrow strip of acid-resistant tape prior to cleaning to eliminate accidental contamination of the electrolyte by cleaning or neutralizing solutions.

2. Wipe the surface carefully with a soft, clean absorbent material, such as a paper wipe, to remove any accumulations of grease or other foreign materials. Care must be taken not to spread any greasy material over the surface to be coated.

3. Clean the surface carefully, using a clean wipe dampened with water or weak soda ash solution. Immediately wipe dry.

4. Remove protection strip applied in Step l.

5. Cut the acid-resistant tape to appropriate size, allowing for a small portion of tape at each end for handling (to prevent finger contact with the adhesive). Apply the tape to the cracked area, assuring that the tape extends beyond the crack in all directions with a minimum overlap of 1/2 inch. A backup piece of tape for extra support can be used to cover the initial piece, especially where compound angles demand tape stretching.

2.6.3. Spacing Between Containers

Batteries, especially those with flexible intercell connectors, should be checked for proper spacing to prevent the possibility of shorts or fire which can occur if terminal details extend beyond the battery cover. Use extreme care to avoid shorts when moving the batteries.

Battery spacing shall be checked after each earthquake or severe shock if foamed plastic spacers are not used. Use caution, as recommended in Section 1.4.1, to handle the neutralization of the electrolyte after an earthquake.

2.7. Electrolyte Level

Under normal circumstances, the electrolyte level shall be between the maximum and minimum markings. The electrolyte level shall never fall below the minimum level except when the electrolyte temperature is below 50°F or the battery is in a discharged stage.

Protective equipment such as rubber gloves, rubber aprons, full face mask or splash-proof goggles MUST be worn when performing any activity that involves handling electrolyte, batteries containing electrolyte, or any maintenance activity that requires exposure to shock or electrolyte contact from these batteries.

2.7.1. Electrolyte Level Markings

Most batteries are equipped with horizontal lines which indicate the minimum and maximum electrolyte levels. The drop rate for the electrolyte will vary considerably depending upon battery design and operating and atmospheric conditions. The addition of water must be at regular intervals as required at a specific location.

2.7.2. Deionized / Distilled Water

Deionized / Distilled Water Deionized or distilled water which meet the requirements in Table 6 is satisfactory for battery use. Deionizing systems should be equipped with a filter to remove sediment and with an organic removal resin to remove soluble organic materials from the water.

Table 6.
Table 6 Maximum Allowable Impurities in Water for Batteries

Type of Impurity	PPM or mg/liter (by weight)	Percent
Tolal Solids	500	0.0500

Fixed Solids	350	0.0350
Organic and Volatile Matter	50	0.0050
Chloride	25	0.0025
Iron	4	0.0004
Nitrates and Nitrates	15	0.0015
Ammonia	5	0.0005
Manganese	0.07	0.000007

Warning: Interchanging hydrometers, funnels and other battery tools between battery types (i.e. lead, lead-calcium, lead-antimony) will result in contamination of the electrolyte.

2.7.3. Maintaining the Electrolyte Level

To maintain the battery electrolyte level, proceed as follows

- **Use only distilled. water or deionized water to bring electrolyte up to the required level (Do not overfill)** . When the actual electrolyte temperature is below 50°F, do not raise the electrolyte level appreciably above the minimum level. This helps to prevent an overflow on charge
- Acid electrolyte shall not be added to any battery as a substitute for adequate charging. Do not contaminate the electrolyte of batteries by using electrolyte from different type batteries (i.e. lead, lead-calcium or lead-antimony batteries).
- **Use the vent funnel on the battery to fill the battery to the proper level**.
- Lead acid engine starting battries should be filled to the base of the fill tube.
- If for some reason, excessive electrolyte is required to be taken from the jar, then under no circumstances shall the electrolyte be disposed of in a manner that may result in environmental pollution or damage to equipment. The electrolyte should be properly neutralized before disposal.

Warning: Never insert a thermometer into the electrolyte withdrawal tube or use a mercury-filled thermometer to take temperature measurements. Mercury

thermometers may contaminate the electrolyte. To avoid the possibility of shorting the battery, do not use metal-tipped thermometers

NOTE: as a good practice, always use a dedicated thermometer, hydrometer and funnel for each string of batteries. This will eliminate the electrolyte contamination possibility.

2.8. Electrolyte Temperature

2.8.1. Temperature Range

The best electrolyte temperature range, considering both life and capacity, is from 65°F to 80°F. Temperatures lower than 65°F are objectionable because of lowered battery capacity. Temperatures higher than 80°F will result in increased positive plate corrosion and decreased battery life. Electrolyte temperature shall not exceed 110°F at any time (rectangular batteries may exceed this temperature on initial charge)

2.8.2. Individual Battery Temperature

To measure individual battery temperature, insert the thermometer into the battery through the vent funnel. Completely submerge the bulb of the thermometer in the electrolyte for at least 2 minutes before taking a reading. If there is insufficient clearance to insert the thermometer without removing the battery from the rack or cabinet, an approximation of the battery temperature may be obtained by laying the thermometer on top of the battery for at least 10 minutes before taking the reading. Pilot batteries shall always be configured so that thermometers can be inserted into the electrolyte. Thermometers in which the indicating liquid has separated shall not be used and should be discarded.

The use of a thermometer with a surface temperature probe or thermocouple on the external surface of the battery container is useful in detecting any temperature abnormality among batteries within the same string. The advantage of using such a device is that it gives an indication of the approximate electrolyte temperature without dipping the thermometer into the electrolyte. Any battery that is 5°F over the average temperature of the rest of the batteries in the string shall have its float voltage checked and visually inspected for any obvious physical cause of the higher temperature.

CAUTION: Do not adhere surface probes or thermocouples to the jar surface because some adhesives may contain material that can stress crack the container in time.

2.8.3. Temperature in Multitier Battery Stands

The top row of multitier stands is apt to have higher temperatures than the bottom row Where possible, electrolyte temperature of batteries within the same string should be within 5°F of each other. Use of fans, blinds on windows, or heat shields between batteries and radiators minimize temperature variations between batteries in the same string.

2.8.4. Freezing of Electrolyte

The electrolyte in any battery must be maintained above the freezing temperature relative to its specific gravity as shown in Table 7. Freezing will cause damage which may not be immediately apparent. Under normal circumstances, a charged lead or lead calcium battery will freeze if the electrolyte temperature dips below -23°F. Therefore, if the batteries are charged, the possibility of freezing is very remote. But if the danger of electrolyte freezing is possible, immediate steps should be taken to provide special enclosures, insulation, or heaters as necessary

Table 7.
Table 7 Freezing Temperature of Lead-Acid Battery Electrolyte

Specific Gravity at 25.0°C (77°F)	Freezing Temperature °C | °F	Specific Gravity at 25.0°C (77°F)	Freezing Temperature.°C ...°F
Lead & Lead Cal.		VRLA	
1.030	-1.11| +30	1.240	-46.7| -52
1.060	-3.33|+26	1.270	-65.0|-85
1.090	-6.6|+20	1.283	-72.8|-99
1.120	-8.8|+16	1.300	-73.3|-100
1.150	-13.3|+8	1.330	-53.3|-64
1.180	-19.9|-4		
1.210	-30.6|-23		

2.9. Specific Gravity

Specific gravity of batteries should be checked after installation. For lead calcium and lead antimony batteries, check specific gravity when the float voltage is below normal. See Section 2.2.1 for normal float voltage values.

NOTE: Per the May 1998 revision of this practice, Specific Gravity readings are no longer required on a routine basis. Specific Gravity readings will be used for trouble test only

2.9.1. Assembling Hydrometer Syringe

To assemble the hydrometer, perform the following steps:

1. Remove any mold seam excess from those surfaces of the rubber parts that will fit against the glass barrel.

2. Before assembling any rubber parts to the glass barrel, wrap several thickness of heavy cloth around the barrel to protect hands.

3. Always wet the rubber parts with clean water and that portion of the glass barrel where the fitting is to take place prior to assembly.

4. Fit the rubber parts to the glass barrel.

Warning: **Goggles should be worn during hydrometer assembly to protect eyes from splashing electrolyte and possible broken glass. Extreme care should always be taken when assembling the hydrometer syringe.**

2.9.2. Specific Gravity Readings

Take specific gravity readings before adding water or charging. After adding water or charging, lead-antimony batteries will regain their full charge specific gravity in about 2 weeks and lead-calcium batteries will regain their full charge specific gravity in about 10 weeks. Each battery should read as shown in Table 8. When taking readings, exercise care to ensure that the top of the hydrometer float does not touch the stop in the hydrometer bulb since this would cause an erroneous reading.

Table 8.
Table 8 Specific Gravity

Specific Gravity	Minimum Float (Volts per battery)	Float Range (Volts per battery)
1.215	2.13	2.13 - 2.21
1.225	2.19	2.22 - 2.27

1.250	2.21	2.25 - 2.30
1.300	2.27	2.33 - 2.38

2.9.2.1. For Batteries With Electrolyte Withdrawal Tubes

To take specific gravity readings perform the following steps. This procedure should prevent battery electrolyte from splattering from the flexible hydrometer tube during handling.

1. Insert the hydrometer flexible tube into the battery water filler funnel (not the small withdrawal tube located on the corner of a rectangular cell cover). Depress hydrometer bulb

2. With bulb still depressed, insert the flexible tube into the battery withdrawal tube located in the corner of the battery cover. Releasing the bulb will draw battery electrolyte into the hydrometer.

3. Carefully remove the hydrometer and read the specific gravity number on the float at the surface of the electrolyte.

4. Place the flexible tube of the hydrometer in the water filler funnel of the battery and depress the bulb to release the electrolyte.

2.9.2.2. For Batteries Without Electrolyte Withdrawal Tubes

Take the specific gravity readings with the following procedures:

1. Insert the hydrometer flexible tube into the opening used for the addition of water.

2. Slowly fill and empty the hydrometer several times before recording any readings in order to wet the float, mix the electrolyte and equalize the temperature of the hydrometer and the electrolyte. Avoid dripping and spraying electrolyte from the hydrometer tube.

CAUTION: Do not remove explosion proof vent for gaining access to the electrolyte

2.9.3. Effects of Temperature on Specific Gravity

Specific gravity varies with temperature. Specific gravity and electrolyte temperature readings must be taken within a few minutes of each other. Some thermometers have scales for correcting to the proper reference temperature of 77°F. If a thermometer with a correction scale is not available, calculate the correct specific gravity by adding 1 point (0.001) to the measured value for each 3°F that the electrolyte temperature is above 77°F or by subtracting 1 point (0.001) for each 3°F that the electrolyte temperature is below 77°F. See Table 9.

Table 9.
Table 9 Specific Gravity Adjustment Factor

Electrolyte Temperature (°F)	Adjustment Add to Measured S.G.	Electrolyte Temperature (°F)	Adjustment Add to Measured S.G.
60 - 62	-0.005	80 - 82	+0.001
63 - 65	-0.004	83 - 85	+0.002
66 - 68	-0.003	86 - 88	+0.003
69 - 71	-0.002	89 - 91	+0.004
72 - 74	-0.001	92 - 94	+0.005
75 - 79	0		

2.9.4. Specific Gravity Out of Range

Specific gravity measurements below 1.210 for round cells and 1.180 for rectangular cells are rare and indicate that the battery is self-discharging and consequently losing capacity. Boost charge a battery when specific gravity is below the required minimum. If the specific gravity is still low after boost charging, or if the condition reappears within a year of boost charging, contact your Maintenance Engineer/Power Technical Support group

Warning: Read Section 1.5.3 Charging and Discharging before boost

2.10. Lead Sulfate Crystals

During normal discharge of a battery, lead sulfate is formed. If a battery is permitted to stand completed discharged, or habitually under charged, or neglected, the sulfate crystals will reach a point where the pores of the positive plates will become filled and reduce the capacity of the battery.

The presence of crystals is not normally an indication that the battery is incapable of providing adequate capacity and corrective action is not an urgent item. A crystalline battery will suffer an immediate loss of approximately 5 percent of its rated capacity. Any further decay in capacity will depend upon the precise cause of the crystalline condition. The best way to assess the ability of a crystalline battery to deliver capacity is to make a specific gravity reading. If the specific gravity is in the normal range of 1.210 to 1.220 (Round Cells), or 1.180 to 1.225 (Rectangular Cells) , then the total capacity loss remains at approximately 5 percent due to the crystallization.

Concern for the ability of a crystalline battery to deliver reasonable capacity should begin when the specific gravity falls below the expectable range for that type of cell.

The useful life of crystalline batteries will be lower than normal batteries due to the increased corrosion and growth of the crystalline positives and so the condition should be corrected as soon as possible

2.10.1. Inspection of Batteries

After initial charge, there should be no lead-sulfate crystals or gray coloration present on the black or dark brown vertical positive plates or columns when examined with a flashlight. The flashlight should be held close to the jar wall at an angle of approximately 45 degrees. The vertical columns should be totally free of any diamond-like lead-sulfate crystals or gray colorations. The disappearance of lead-sulfate crystals normally occurs in three distinct phases

- Phase l: Black and crystalline
- Phase 2: Gray and lightly crystalline
- Phase 3: Black or dark brown and crystal free

  The disappearance of lead-sulfate crystals or gray coloration can occur from top to bottom during initial charge. To insure the absence of lead-sulfate crystals or gray coloration, inspection for crystals should cover the whole exposed plate surface.

  If lead-sulfate crystals appear within a 10-week period of normal float operation after installation of the battery plant, the defective batteries should be replaced. This condition should be reported to your maintenance and common system engineering groups. Check with the SME regarding specific warranty clauses for replacement of batteries.

2.10.2. Sulfation Corrective Actions

If lead-sulfate crystals appear on all batteries in a string, and the problem is not attributed to shorted batteries or battery temperature variation, the following should be checked:

- Rectifier Voltage: The appearance of lead-sulfate crystals may indicate a low battery plant float voltage. Check to see if the battery plant float voltage is correct. Make appropriate rectifier adjustments, if necessary.

- Plant Discharge: A battery discharge resulting from a power failure or other reasons may produce lead-sulfate crystals on the batteries. This is normal with all lead-acid batteries since lead-sulfate is the material produced when a lead-acid battery is discharged. If the cause of the lead-sulfate crystals is a recent discharge, the crystals will disappear when the batteries have been fully recharged on float (usually within 2 weeks). Check plant records to determine if a discharge has occurred. Always log all AC power failure alarms in the battery maintenance records. Another method of determining if a plant discharge has occurred, is to measure battery specific gravity. Specific gravity should be between 1.170 and 1.230. Readings of 1.170 or below are a clear indication that a plant discharge has occurred.

- If the presence of lead-sulfate crystals on all batteries in a string is not attributable to a plant discharge or improper rectifier voltage, the condition should be reported to maintenance Engineering.

2.10.3. Lead Sulfate Crystals Appear On A Few Batteries

If lead-sulfate crystals appear on one or a few batteries in a string, the following actions should be taken.

- (Plant Discharge) Check to see if a plant discharge has occurred.

- (Shorted Battery) Measure the battery voltage. If the crystalline battery(s) measure 2.09 volts or less and the battery is heavily crystalline, the battery is shorted and should be reported to Maintenance Engineer/Power Technical Supporting.

- (Battery Temperature Variation) Measure temperatures of batteries in each tier of the string to determine the extremes of temperature differences. Temperature differences of 5°F or more between batteries in a string can result in a float problem for the warmer batteries which would result in the appearance of lead-sulfate crystals. If temperature differences in excess of 5°F are found, appropriate ventilation should be provided to correct the condition.

  If the problem is not attributable to a shorted battery or battery temperature variations the battery(s) should be boost charged with a single battery charger. The boost charge should continue for at least 24 hours after the lead-sulfate crystals have disappeared. Upon completion of the boost charge, allow the battery to float in the string. After returning the battery to float, it is not unusual for the battery voltage to be temporarily low (approximately 2.09 volts). The battery voltage should increase over a period of weeks. Do not move the battery until the electrolyte returns to its original level. If lead-sulfate crystals reappear, the battery(s) should be reported to your Maintenance Engineer/Power Technical Support group. Copies of the battery records should accompany that report.

Warning: Read Section 1.5.3 Charging and Discharging before boost charging.

2.11. Positive Plate Growth And Bowing (Rectangular Batteries)

Plate growth and bowing can be gauged by eye. Only the positive plates are expected to grow. When new, the positive plate edges do not project beyond the separators. As growth progresses, the plate edges will gradually grow out past the separators and eventually touch the inner wall of the jar. Further plate growth will apply pressure to the jar wall which may be indicated by nosing of the plate edges or flattening of the black plastic wrapper (where so equipped) against the jar wall. Plate growth will also occur in the vertical plane, and in some designs, apply pressure on the cover in an upward direction or grow vertically downward and touch the plastic jar ridge used for positioning or supporting the negative plate. An estimate of plate growth can be obtained by comparing the position of the lower edge of the positive plates with the bottom of the adjacent negative plates which do not grow.

2.12. Negative Plates (Rectangular Batteries)

The outside negative plates have one surface visible. With aging, the outer surfaces can shrink or crack heavily separating the active material from the lead grid structure, thus degrading electrical contact. A one hour discharge capacity test will determine whether or not the battery should be replaced.

Needle growth or other crystalline-looking growths, have been observed on the negative plates of some batteries. No serious effect on battery performance is expected unless these growths lengthen to the point of contacting the positive plates. Although needle growth does not normally cause trouble, batteries showing needles should be carefully checked to insure that voltage and specific gravity remain within limits and show no declining trend. In case of any doubt, run a capacity discharge test.

2.13. Cleaning Procedures For Racks, Stands And Batteries

Battery racks, stands, cabinets, etc., should be wiped at regular intervals with a cloth dampened in a weak soda solution and then with a cloth dampened in water. Corrosion on metal battery stands should be cleaned with a metal brush. The corroded area should be wiped clean with a cloth dampened with a weak soda solution, followed by a cloth dampened in clean water. The wire brush may also be used to remove old paint prior to repainting. Since corrosion may be due to battery leakage, all batteries near such corrosion should be inspected for electrolyte leakage.

Danger: **When using a metallic wire brush to remove corrosion, on battery stands and racks, do not allow the wire brush to be brought in close proximity to battery posts and intercell.**

Warning: **Where static electricity is a problem, a slightly damp cloth, rather than a dry cloth, should be used to wipe plastic containers. To discharge static electricity from body, touch any grounded rack or frame.**

Warning: **Plastic battery containers can be damaged by cleaning with solvents or petroleum based cleaners**

Do not expose or clean plastic containers with petrolatum or solvents such as kerosene, gasoline or petroleum spirits which is the solvent in most cleaning compounds as well as the thinner in most waxes and polishes. Petroleum spirits and solvents seek out points of residual stress, causing cracks, crazing, and eventual failure. Do not use commercial detergents on plastic jars as this can lead to crazing or cracking of the jars. Use only clean water for the battery jars To remove spilled epoxy from the jar, allow it to dry, then scrape it off.

3. Discharge Capacity Test

CAUTION: **When performing Battery Plant discharge testing, consideration should be given to the potential impact on customer service, possibly conducting the test in the Maintenance Window. An experienced power maintenance person should perform the test.**

3.1. Introduction

The following procedures are designed to ensure that:

- Batteries are functioning properly, and have their required capacity
- Battery posts and intercell connectors have not deteriorated

The following operation procedures must be thoroughly understood before beginning any procedure. If the actual plant load is being used for the discharge test, the test should only be performed when the load is within 25% of the office Average Busy Season/Busy Hour

(ABSBH) load. If a Power Systems Monitor (PSMC) is monitoring the plant load, the High Average load can be used instead of the ABSBH.

If, at any time during the test, any of the following conditions occur, the test should be terminated immediately:

- There is a Commercial Power Failure.
- The difference between the highest voltage reading and the lowest voltage reading of all of the batteries is greater than 0.1 volt.
- The voltage of any battery drops below 1.90 volts.
- Any of the intercell connectors are not conducting properly. (Intercell connector procedures are described in Section 4)

There are two possible methods for performing the battery discharge tests. Single or multiple string plants can be tested by discharging the batteries into the office load. To perform this test, turn off all rectifiers and allow the served equipment to provide a load for the battery test. For plants with parallel battery strings, the test can be performed off line by removing one string of batteries and discharging it into a load box.

CAUTION: Battery strings removed from the plant load for test must be recharged before being reconnected to the power plant.

3.1.1. Discharge Test Frequency

An initial discharge test is recommended on each new string of batteries as part of the installation process. This discharge test will be used to establish a baseline for future tests. SBC recommends the discharge test be performed every year as part of the annual Power Evaluation (Appendix E). If however the annual power review is not performed the manufactures minimum requirements listed below should be followed.

(Round Batteries) Will be discharge tested once every five years for the first twenty years, once every three years for the next twelve years, and once every other year for the remaining life of the battery.

(Rectangular Flooded Batteries) Will be discharge tested once every five years for the first ten years, then once every other year for the remainder of the life of the battery.

(Valve Regulated Lead Acid (VRLA) Batteries) Will be tested based on the manufacturer's projected life of the batteries. The test frequency will be once every five years for the first 2/3 of the batteries projected life. Thereafter, every year until the battery is replaced.

3.1.2. Duration of Discharge Test

The duration of the discharge test is recommended to be a minimum of 30 minutes, or follow the established discharge guidelines of your market area. Prior to performing the discharge test the following procedures should be performed:

- Specific gravity readings should be taken and logged
- Individual cell readings should be taken and logged
- Intercell connectors should be checked for proper torque, (Deviations should be logged)

During the discharge test, it is necessary to take overall battery plant voltage readings. These readings should begin immediately after the plant goes on discharge. Readings should be taken at one minute intervals for the first five minutes, and at five minute intervals for the remainder of the discharge test. It is important, to check the current output of each string of batteries in the plant with a clamp-on ammeter. It is further recommended that a thermal scan test be performed on the intercell connectors. Both of these tests should be performed during the discharge test. The BATTERY DISCHARGE TEST & INTERCELL CONNECTOR LOG (FIGURE 2) should be used for recording all information gathered during the discharge test. Form SBC-6556 BATTERY DISCHARGE TEST & INTERCELL CONNECTOR LOG can be obtained from the SBC INSO web site. http://inso.sbc.com/13s/power/Figure2.doc.

NOTE: If specific gravity or individual cell voltage readings are below the normal operating range a single cell discharge test should be preformed. The discharge test set manufactures' instructions for testing should be followed using the battery manufacture specifications for the type of cell being tested. If a cell is determined to be defective local maintenance and common system engineering personnel should be notified. Discharge test results should be recorded on the Hour Rate Battery Discharge Capacity Test Form (Appendix C).

4. Intercell Connector Test

Intercell connectors and their connections to the battery can be checked during normal float condition, or under a discharge condition. The milliohmmeter measurement method shall be performed during float operation, the thermal scan and current measurements methods shall be performed during a discharge test.

There are three methods for checking the intercell connectors and its connections. The method used will be determined by the test equipment available, the number of pairs of intercell connectors between batteries and their accessibility. The methods below are presented in order of their preference.

1. Milliohmmeter or microohmmeter that offers low ac test signals and can measure µ? without the interference of the dc current shall be used for measurement of intercell connection integrity. Measurements can be performed under normal float condition. Simply follow the suggested measurement sequence outlined in Table 10 and record all the milli ? measurements. Readings must be taken between each battery post and all intercell connectors associated with that post. Readings can be recorded on blue line using Figure 2 as a guide for taking measurements. Once all the measurements are completed, the data will present the high resistance connection(s). If these connections are out of the acceptable range they should be logged as deviations on "The Battery Discharge Test & Intercell Connector Log" form SBC6556 and corrected.

With all intercell connectors in place, refer to Figure C, measure post to post (A to D), then (A1 to Dl). Both measurements shall be less than 60 µ?. The measurement between diagonal posts A to Dl or Al to D shall be less than 75 µ?. If any one of the three measurements exceed the specified values (60 µ? for post to post or 75 µ? between diagonal posts), the intercell connection(s) to the posts shall be corrected. Depending on the cause of the high resistance, follow procedures outlined in Section 2.3 to disconnect, clean, neutralize, re-grease the post, and properly torque the connections. Recheck the measurements before moving on to the next intercell connection.

Table 10.
Table 10 Intercell Connectors Measurement Sequence

Measurement Sequence	Connection Point
Post to Post	A to D

Post to Post	Al to Dl
Post to Post	A to Dl Or Al to D

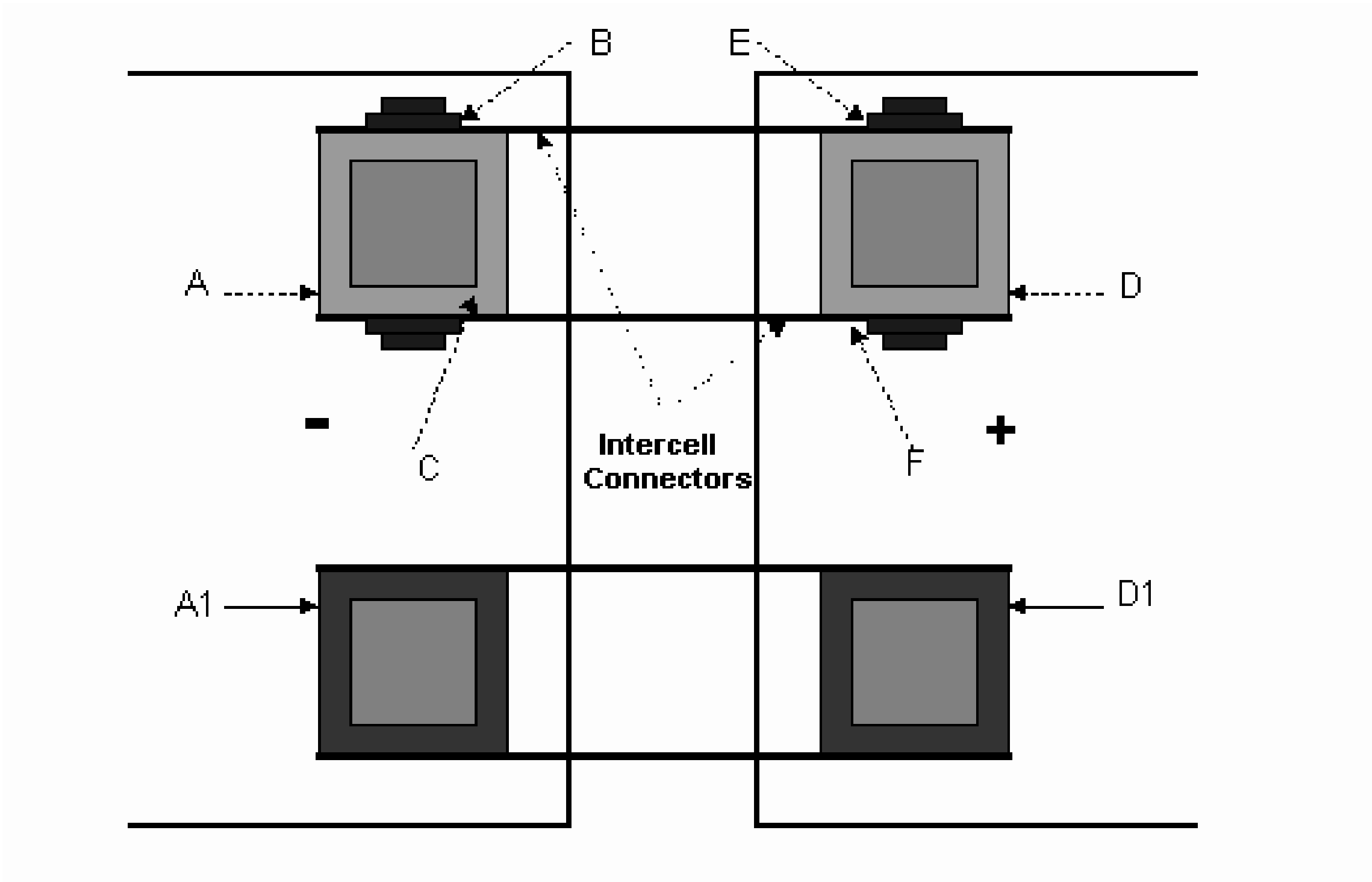
All high resistive connections shall be cleaned and corrected. The discharge test should then be rescheduled, allowing time for the plant to stabilize. For Round Batteries (two post), use the procedure as previously listed for milli- or micro-ohmmeter. The acceptable reading shall be 40-60 µ? for post A to post D. If the reading exceeds 60 µ?, the connection must be cleaned and rechecked. Depending on the cause of the high resistance, follow procedures outlined in Section 2.3 to disconnect, clean, neutralize, re-grease the post and properly torque the connections. Recheck the measurements before moving on to the next intercell connection.

2. Thermal Scanner Method - Another method to test intercell connectors is to use a thermal scanner. The thermal scanner detects the heat dissipation of each intercell connector. Using this method, the intercell connectors on each battery should be scanned. Temperature readings should be recorded on blue line. Intercell connectors with readings ten or more degrees (F) higher than the rest of the connectors indicates a problem with that intercell connector. These deviations should be recorded on " The Battery Discharge & Intercell Connector Log". If a problem is found, the discharge test should be terminated and the intercell connector problem corrected. The battery plant should be allowed time to reach normal float voltage before the discharge test is restarted.

3. Clamp-on Ammeter Method - If the battery string has a double set of intercell connectors, a clamp-on ammeter can be used to measure the current flow in each pair of connectors. The current readings of each pair of intercell connectors should be recorded on blue line. A comparison should be made between the A and B intercell connector on a battery by battery basis. If the difference between the two intercell connectors is greater than ten amps, the discharge test should be terminated and the intercell connector problem corrected. Each failing pair of connectors should be logged as a deviation on 'The Battery Discharge Test & Intercell Connector Log." The battery plant should be allowed time to reach normal float voltage before the discharge test is restarted.

Figure C Milliohmmeter Connection for Intercell Connector Measurements

Figure 2. CAPTION



If any failure condition exists during the test, it must be corrected immediately either by established maintenance procedures or an engineering complaint. Discharge information from the test should be retained as part of the permanent office record. The information for a string of batteries should be retained at the office until the batteries are removed. When a string of batteries is removed, all local central office data for those batteries should be destroyed. Battery discharge information should also be forwarded to your common system engineering group. The discharge information will be used by the common system engineering group to determine when a string of batteries should be replaced.

5. Passive Testing Of Batteries

Field data has shown active testing by partially discharging Valve Regulated Lead Acid batteries, at a high rate for a short period of time, can give erroneous results. This may allow the acceptance of batteries that are below the acceptable capacity level. Some VRLA batteries with increased specific gravity, due to the loss of water, would indicate a higher open circuit voltage than a battery with the proper electrolyte. This scenario could fool the test instrument by indicating a battery with acceptable capacity was just tested although the capacity was low.

Passive testing of VRLA batteries involves the measurement of battery resistance that is determined by the electrolyte and its specific gravity. At least two commercially available passive test instruments are currently available and can be used for that purpose. Midtronics model CTM-100 and Biddle Battery Impedance Test Equipment (BITE™). Midtronics measures the conductance of the batteries and Biddle sends 60 Hz through the batteries to determine battery resistance

The method of passive testing is still at a development stage, however the results indicate promising correlation of capacity and conductance or resistance. Further validation to establish the correlation between change in capacity and the change in resistance is a must before full scale deployment. The Midtronics CTM-100SBC Micro Celltron Battery Conductance Tester and the Midtronics MICRO400 Engine Starting Battery Tester are approved for use in SBC. See PAN 20001080 for the CTM-100 and PAN 20001077 for the Midtronics MICRO400.

For more information regarding passive testing, see **SR-TSY-001307 (Issues 1-4).**

6. Battery Reversal

Battery reversal may occur when a battery plant is allowed to discharge in excess of its rated capacity. Since stationary lead-acid batteries are generally designed with excessive negative plate capacity, the positive plates in a battery can undergo reversal without the battery showing an actual reversal of battery polarity. The possibility of reversing a battery(s) should be suspected whenever a battery plant is discharged below an average of 1.75 volts per battery. If any battery reads 1.0 volt or less toward the end of discharge, the positive plates of that battery may have been reversed, and the battery may present a problem on recharge. A reversed battery typically has a high resistance because the specific gravity is very low, and the voltage will be extremely high if the battery is recharged at normal rates. For severely reversed batteries, it is not unusual to obtain voltages in excess of 4 volts when the battery is being recharged in series with nonreversed batteries at 2.17 volts per battery average. At such high voltages, battery temperature increases rapidly and irreparable damage can be caused. Consequently, reversed batteries must be recharged slowly and with caution in order to avoid high temperatures.

6.1. Identification of a Reversed Battery(s)

If a battery is suspected of being reversed, perform the following steps:

- Measure and record the battery voltage and plant load prior to restoring the rectifiers. Record the date and time for the start of the battery discharge and when the rectifiers were restored. Whenever possible, record the plant load profile during the discharge.
- For rectangular batteries, immediately after restoring the rectifiers, measure individual battery voltages. For Round batteries, measure individual battery voltages after approximately 15 minutes of recharge.
- Thereafter, measure individual battery voltages hourly for a period of 5 hours.
- If at any time a battery(s) reads more than 2.5 volts, that battery(s) has been reversed and corrective action is required. Contact local Maintenance Engineer/Power Technical Support.

6.2. Corrective Action for Reversed Batteries in Single String Battery Plant

Corrective action for reversed batteries in a single string battery plant is as follows:

l. Control the rectifier(s) output voltage so that the highest battery does not exceed 3.0 volts and electrolyte temperature does not exceed 110°F.

2. The voltage of the highest battery(s) should begin to decrease as this battery(s) begins to accept a charge. The time required for this to occur can vary from several minutes to weeks, depending upon the degree of reversal. As the voltage of the high battery(s) gradually decreases, gradually increase the rectifier(s) output voltage (not exceeding the recommended volts per battery) while still maintaining the high-voltage battery(s) below 3.0 volts and/or 110°F.

3. When all battery(s) are reasonably uniform in voltage; i.e., all in the range of 2.07 to 2.27 volts, and the recharge current is less than 5 amperes, the string shall be given an equalizing charge.

CAUTION: Before raising the rectifier output voltage, you must check and be certain not to exceed the upper voltage limit that the Switching/Transmission equipment can tolerate.

6.2.1. For Rectangular Batteries

The equalizing charge shall consist of a standard measured end initial charge at 2.5 volts per battery as described in Practice 157-601-201 for AT{Undeclared entity} batteries. For this charge, stability has been reached if the corrected specific gravity, based on hydrometer readings at the top of battery, is 1.180 or higher for a low-gravity battery, or 1.270 or higher for a high-gravity battery. After this charge, the battery capacity may be even higher than before the reversal, but there may also be internal damage such as cracked plates and loosened active material. Batteries that have been reversed should be watched more carefully during the remainder of their service life.

The above equalizing charge will require bringing in an auxiliary string of batteries so that the string to be charged can be disassociated from the working plant. If this is not possible, the equalizing charge can be performed on an individual battery basis using a single battery charger.

6.2.2. For Round Batteries

The equalizing charge shall be carried out at 2.5 to 2.7 volts per battery until all diamond-like lead-sulfate crystals on the positive plate vertical columns have disappeared and shall be continued for at least 12 additional hours beyond the point of crystal disappearance. Inspection for lead-sulfate crystals is done with a flashlight as described in Section 2.10.1. The equalizing charge will require bringing in an auxiliary string of batteries and spare charging equipment so that the string to be charged can be disassociated from the working plant. If this is not possible, the equalizing charge can be performed on an individual battery basis using a single battery charger.

6.3. Corrective Action For Battery Plants With Parallel Strings

The corrective action for a battery plant with parallel strings is as follows:

- If all battery strings have reversed batteries, follow the procedures outlined in Section 6.2.
- If all battery strings do not have reversed batteries, disconnect the string(s) with reversed batteries from the power plant and follow the procedures outlined in Section 6.2.
- If the reversed batteries fail to respond to the corrective actions outlined above, report the problems to your local Maintenance Engineer/Power Technical Support group.

6.3.1. Contingencies for Reversed Battery(s)

If the reverted battery(s) fails to respond to the above procedures, any of the following may be attempted.

1. Shunting Around Reversed Battery(s): Shunt around the high-voltage battery(s) which will allow maximum recharge current to flow through the nonreversed battery(s). This may be done by paralleling the high-voltage battery with a suitably sized resistor or with a single battery discharge unit in order to maintain the high-voltage battery(s) between 2.0 and 3.0 volts. Once the nonreversed batteries have been recharged, the shunt can be removed from the battery(s) and then be charged with a single battery charger at 2.5 volts at the highest available current for rectangular batteries and 2.5 to 2.7 volts at the highest available current for Round Batteries. The above shunting procedures become impractical if more than two batteries have reversed in a string.

2. Disconnecting Reversed Battery(s) From String: Disconnect the reversed battery(s) from the string and charge it individually or in parallel at 2.5 volts. Meanwhile, charge the non-reversed batteries in series at 2.5 volts per battery for rectangular batteries and 2.5 to 2.7 volts per battery for Round Batteries.

3. After Steps 1. and 2. have been successfully applied, an equalizing charge must be applied as described in Section 6.2, Step 3.

7. Valve Regulated Lead Acid Batteries

CAUTION: These Valve Regulated Lead Acid Battery Procedures Do Not Apply To UPS Applications.

This section identifies and lists the limits applicable for maintaining VRLA batteries. Since the majority of the maintenance procedures are common between flooded and VRLA batteries, instead of repeating the tests that were presented in Sections 2-5, most paragraphs in this section refer to detailed procedures covered by an earlier section. The bracketed (section or paragraph) number after each Section heading is the referenced paragraph that contains details.

7.1. Electrical Shocks and Burns Protection (1.2)

Before any work is performed on VRLA batteries, the same safety guidelines listed in 1.2 shall apply.

7.2. Neutralizing Agents (1.4)

To neutralize VRLA batteries, the same solutions, neutralizing procedures, and precautions that apply to flooded batteries shall apply. However, the electrolyte is more concentrated than the electrolyte in flooded batteries and may require more neutralizer than normally expected.

7.3. Tool Materials and Test Equipment

Follow the equipment list specified in Section 2.

7.4. Float Voltage (Refer to paragraph 2.2)

Valve Regulated batteries shall have nominal float voltage of 2.25 +/-0.05 volts/battery. The range of the float voltage is (2.20-2.30), referenced at a temperature of 77°F.

7.4.1. Deviation from Float Voltage and Corrective Action

Paragraph 2.2.3 contains details of possible float voltage deviation conditions. If these are not the cause of the problem, then read the following sections.

7.4.1.1. Battery Voltage High

Valve regulated batteries should not float higher than 2.35 volts. If that happens, the battery shall be visually inspected for evidence of a lost plate(s) from the battery circuit or a leaking valve. If inspection is not feasible or does not reveal evidence, a discharge test should be run on the VRLA battery(s) in question. If the capacity is low, the battery(s) should be replaced. If both visual inspection and capacity test do not indicate a trouble condition, no action needs to be taken. However, special attention should be given to the regular voltage measurements log. Replace the battery if the float voltage continues to increase.

7.4.1.2. Battery Voltage Low

For batteries that were float charging within the required range at the previous annual voltage reading, float voltages less than 2.15 volts indicate a severe abnormality (possibly a short circuit). **Shorted batteries can lead to thermal runaway**. The condition should be immediately be reported to Maintenance Engineer/Power Technical Support for correction and possible replacement.

7.5. Battery Connections (2.3)

Section 2.3 details all the maintenance procedures for battery connections that are applicable to both flooded and VRLA batteries.

7.6. Battery Resealable Gas Vents (2.4)

In VRLA batteries, each battery has an individual resealable vent. Under normal conditions, the valve is sealed to ensure gas recombination, but if the VRLA battery is subjected to abusive voltage or temperature conditions, the valve will vent the excessive pressure in the battery and reseal itself. During the maintenance routine, if the view of the valve is not obstructed, it shall be inspected for electrolyte leakage and evidence of cracked or excessive deformation of the valve.

Take appropriate action to neutralize the electrolyte or replace the battery/module if a malfunctioning valve is suspected. Follow procedures listed in Section 2.4 for the detection and neutralization of the leaked electrolyte. If extensive neutralization or battery disconnection is required, an auxiliary string and possibly a portable generator should be used as standby for the equipment while the main battery is being serviced.

7.7. Battery Container

VRLA batteries with severe cracked or broken cases are not to be treated (except for absorbing electrolyte pools) by SBC company personnel. Atmospheric oxygen can react with the active materials in these batteries, since their seals have been comprised, and create a potential hazard. Only the manufacturer’s personnel should handle these cracked batteries which must be replaced. Excessive deformation of the case shall be noted, and battery voltage, as well as temperature under float, shall be verified to be within limits. Minor cracks on the container can be temporarily repaired with acid-resistance thick vinyl industrial tape. Details procedures are listed in Section 2.6.2.2.

7.8. Electrolyte Temperature

The use of a thermometer with a surface temperature probe or thermocouple on the external surface of the battery container is useful in detecting any temperature abnormality among VRLA batteries within the same string. Any battery(s) that is 8-10°F over the ambient temperature of the rest of the batteries of the string shall have its float voltage checked and visually inspected for any obvious physical cause of the higher temperature. If the temperature of the battery is continually increasing above the ambient and the float voltage of the string voltage is constant, a suspected thermal runaway condition may be in the making; check the rectifier voltage and temporarily secure the condition by reducing the plant and string voltage until the shorted battery(s) is replaced or other cause(s) is found.

7.9. Freezing of Electrolyte (reference section 2.8.4)

The approximate electrolyte freezing temperature of a fully charged VRLA is -95°F. A problem occurs, however, when the batteries are discharged, since the freezing point becomes higher as the battery is discharged, and could freeze at a much higher value if the battery continues to be discharged. If the danger of electrolyte freezing is possible, immediate steps should be taken to provide special enclosures, insulation or heaters as necessary. Otherwise electrolyte freezing will cause damage which may not be immediately apparent.

7.10. Discharge Capacity Test (3.0)

Refer to section 3 for discharge capacity test procedures.

7.11. Passive Testing of VRLA (5.0)

Follow passive testing procedures in section 5.

8. Maintenance Schedules

Table 11.
Table 11 Maintenance Schedules

Paragraph	Maintenance Task **Flooded** Battery	Frequency
2.2	Float Voltage (Battery String)	1 Month
2.2	Float Voltage (Individual Cell)	4 Months
2.3	Battery Connection	4 Months

	Visual Inspection	4 Months
2.3.2	Intercell/Cable Mechanical Torque	12 Months
2.4	Jar-Cover and Post Seals	4 Months
2.6	Battery Container	4 Months
2.7	Electrolyte Level	4 Months
2.10	Lead Sulfate Crystal Inspection	4 Months
2.11	Plate Growth and Bowing Inspection	4 Months
2.12	(Vertical Plates Only)	
2.13	Racks, Stands and Battery Container Cleaning	4 Months
1.5.3.1.	Boost Charge	If Required **
3	Discharge Test	12 Months ***
4	Intercell Connector Test	Minimum every 12 Months

Paragraph	Maintenance Task **Engine Starting** Flooded Battery	Frequency
2.2	Float Voltage (Battery String)	1 Month
2.2	Float Voltage (Individual Cell)	4 Month
2.3	Battery Connection	4 Month
	Visual Inspection	4 Month
2.7.3	Electrolyte Level	1 Month*
2.13	Racks, Stands and Battery Container Cleaning	4 Month

NOTE:
* Determined by suspicion that battery has a problem, indications can be consistent loss of water, and unusual float voltage reading.

** Must be disconnected from string before Boost Charging the battery.

*** Discharge tests will be preformed during the annual power review. The Annual Power Evaluation Procedure is attached in Appendix E.

CAUTION: These Valve Regulated Lead Acid Battery Routines Do Not Apply To UPS Applications

Paragraph	Maintenance Task **VRLA Battery**	Frequency
7.4	Float Voltage (Battery String)	1 Month
7.4	Float Voltage (Individual Cell)	4 Month
7.5	Battery Connection	4 Month
	Visual Inspection	4 Month
2.3.2	Intercell/Cable Mechanical Torque	12 Month
7.6	Battery Resealable Gas Vents	4 Month
7.7	Battery Container	4 Month
7.8	Electrolyte Temperature	4 Month
2.13	Racks, Stands and Battery Container Cleaning	4 Month
1.5.3.1	Boost Charge	If Required **
3	Discharge Test	12 Months ***
4	Intercell Connector Test	12 Months
5	Passive Testing of Batteries	12 Months***

* Determined by suspicion that battery has a problem, indications can be consistent loss of water, and unusual float voltage reading.

** Must be disconnected from string before Boost Charging the battery.

*** Discharge tests will be preformed during the annual power review. The Annual Power Evaluation Procedure is attached in **Appendix E**.

9. CONTACT LIST

Possible entries include Regional Contacts, or web page references for contact names.

Optional: Author may add links to separate document or contact list.

NAME	SBCUID	PHONE #	DEPARTMENT/RESPONSIBILITY
Don Buell	db1898	847-248-5078	Assoc Dir NGT. Network Services Staff
John Messina	jm4735	860-344-0297	Sr. Tech Consultant Eng. Mtce. & Trans. Eng.
Mike Andrews	ma1520	405-290-6579	Mgr. Network Mtce.
Don Boucher	db4494	785-749-7107	Mgr. Network Mtce.
J. Charles Bush	jb3834	210-222-7617	Sr. Tech. Consultant Mtce. Engineering
SBC Ameritech Power Control Center Mgr.		312-829-9980	
Bubba Safford	ns4447	214-286-2329	Senior Mgr. Tech Support
Roger A. Odle	ro2572	858-886-3021	Mtce. Engineer
Bryan Tomlinson	bt1761	713-961-2022	Mgr. Network Mtce.
Tom Patterson	tp3854	314-957-0904	Area Manager Network Maintenance.
Terry Trucks	tt3355	314-301-5248	Area Manager Network Engineering
Tom Johnson	tj3762	330-835-1535	Manager Network Reliability Ameritech

ACRONYMS

A.1 DOCUMENT SPECIFIC ACRONYMS

This section lists acronyms that are used in this document only.

APEx - Advanced Publishing Express

A.2 NETWORK ACRONYMS DICTIONARY

Refer to SBC-000-000-020, Network Acronyms Dictionary.

ATTACHMENT 1 - APPENDIX A - Battery Connections Torque Requirements

Appendix A
Appendix A Battery Connections Torque Requirements

		Stainless Steel Connectors		Lead Encapsulated Connectors	
Battery Vendor	Battery Type	Initial (in/Lbs.)	RE Torque (in/Lbs)	Initial (in/Lbs.)	RE Torque (in/Lbs)
C & D	KS 20472 List 1	150	125	125	115
	KS 20472 List 2	150	125	125	115
	KS 20472 List 3	150	125	125	115
	KS 20472 List 4	150	125	125	115
	KS 20472 List 1S	150	125	125	115
	KS 20472 List 2S	150	125	125	115
	KS 20472 List 3S	150	125	125	115
	KS 20472 List 4S	150	125	125	115
C&D	MCT II	110	100	110	100
	KS15544 List 508P	110	100	110	100
	KS15544 List 508	110	100	110	100
Exide	KS15544 List 508	125	115	100	80
	FTC21 GU Series	125	115	NA	NA
Gould	KS15544 List 508	150	125	100	80
Globe	KS15544 List 508	150	125	125	100
Absolyte	All	100	80	NA	NA
Lucent	VR	60	50	NA	NA
C&D	Liberty (Sealed)	165	125	NA	NA

Chloride	All	48	48	NA	NA
Deka/Unigy	All	100	80	NA	NA

ATTACHMENT 2 - Appendix C 5 HOUR RATE BATTERY DISCHARGE CAPACITY TEST RECORD FORM

For a Printable copy of Appendix C go to: http://inso.sbc.com/13s/power/AppendixC.doc

ATTACHMENT 3 - Appendix D String Storage Battery Record

For a printable copy of Appendix D go to: http://inso..com/13s/power/AppendexD.doc

ATTACHMENT 4 - Appendix E Power Evaluation

For a printable copy of Appendix E go to: http://inso.sbc.com/13s/power/AppendixE.doc

ATTACHMENT 5 - Appendix F Forms For Flooded String and VRLA Batteries

For a printable copy of Appendix F go to:

Flooded String Storage Battery Record SBC 5330 http://inso.sbc.com/13s/power/AppendixF1.doc

VRLA String Storage Battery Record SBC 5331 http://inso.sbc.com/13s/power/AppendixF2.doc