ATT-TELCO-002-217-061

CO POWER: Central Office Battery Maintenance

Battery Maintenance Practices For Flooded, Valve Regulated Lead Acid Batteries and Nickel Cadmium Batteries for Engine Start and Central Office power applications.

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INTRODUCTION

This document provides maintenance procedures for flooded lead acid batteries, Valve Regulated Lead-Acid (VRLA) batteries and Nickel-Cadmium (NiCad) batteries used in telecommunications Central Offices (COs), Standby Engine starting batteries or remote terminal sites. Procedures listed in Sections 2. through 5. and Section 6. apply specifically to flooded batteries. Procedures listed in Sections 6. and 8. apply specifically to VRLA batteries. However, most procedures are common to both flooded and VRLA batteries. Procedures listed in Sections 2. and 3. and 9. are specific to NiCad batteries. NiCad batteries can now be deployed in small central office applications and must not be mixed with other battery types. Maintenance procedures written by each region should be used in conjunction with or supersede this document.

The words "battery(ies)" 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 familiar with all safety procedures for telecommunications power plants.

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

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 remote terminal locations that have limited ventilation and access because they evolve less hydrogen than flooded batteries and do not contain large amounts of liquid electrolyte.

CAUTION:
Before performing any maintenance work on batteries, the maintenance person needs to read, understand and apply all information and guidelines provided within this document to prevent a battery explosion or other hazard.

CAUTION:
Personnel to have and use the appropriate Personal Protective Equipment (PPE) and Safety Gear: 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 batteries containing electrolyte, or any activity that requires exposure to shock from batteries, breakers, fuses etc. All jewelry, necklaces, earrings, bracelets, watches, and loose hanging items shall be removed prior to working around power equipment. For additional information on proper safety precautions when taking measurements and working with batteries refer to the appropriate

sections included in this document.

No Job Is So Important And No Service So Urgent - That We Cannot Take Time To Perform Our Work Safely.

Table 1: Special Instructions for this Procedure

Required	Company	Go To Section
YES	ATT East	2
YES	ATT Midwest	2
YES	ATT Southwest	2
YES	ATT West	2

1. Reason For Current Issue

Issue 17 of this document was published on 8/2/06, refer to Section 14. for these recent changes.

- Recent issues of this document have been inadvertently created to correct format problem, Section 15.3.4., Figure 7.
- Whole document - format changes to entire document.
- Introduction - Deleted last sentence referencing the two VRLA technologies, Absorbed and Gel, that come in many sizes and are manufactured by many suppliers.
- Table 1. - Changed SBC tag to ATT tag for each region.
- Section 2.4.1. - Added a comment to replace battery spill/containment items as needed.
- Section 3. - Added additional information to correct any abnormalities when conducting a visual inspection.
- Section 3.2.1. - Reorganized section regarding battery maintenance forms references.
- Section 3.2.2. - Reorganized section and added information for temperature effects on lead acid batteries.
- Section 3.2.2. - Added new Table 7. titled Effects of Temperature on Lead Acid Cells.
- Section 3.3. - Added new information to determine if micro-ohm or conductance tests should be performed versus re-torquing of battery connections.
- Section 3.3. - Added numeric list and new Table 8. and on what steps are required to check for corrosion and to either clean, or replace intercell connectors and hardware.

- Section 3.3.1. - Added new information for corrosion concerns.
- Section 3.3.5. - Added new PID for NO-OX-ID “A-Special”.
- Section 3.3.5.1. - Deleted Section 3.3.6. and added new subsection titled Application of Corrosion Preventative for Saft NiCad Batteries.
- Section 3.3.5.1. - Added new ordering information to obtain NOX-RUST X110 corrosion preventative. And additional information about NO-OX-ID A-Special and NO-OX-ID A-Special WW on Saft Batteries.
- Section 3.6.2.2. - Added two manufacturers that can provide acid resistant tape for temporary repair of battery containers.
- Section 3.6.3. - Added additional information to check for battery movement.
- Section 3.6.3.1. - Added new section titled Intercell Spacers.
- Section 3.7. - Added additional information to review electrolyte levels.
- Section 3.7.1. - Added additional comment for cells requiring make up water on a regular basis.
- Section 3.8. - Added information to this section.
- Section 3.8.2. - Added information to this section.
- Section 3.10.4. - Added new section titled Hydration.
- Section 3.11 - Added comments to define “bowing” and “swelling”.
- Section 4.1. - Added comment on what action to take if battery discharge has to be terminated.
- Section 5. - Added new information about intercell and battery capacity testing.
- Section 5. - Changed milli-ohmmeter reference to micro-ohm reference.
- Section 6. - Deleted reference to SR-TSY-001307 (Issues 1-4 non-intrusive testing) as it is not available in APEx under the Telcordia section.
- Section 6. - Added additional information.
- Section 6.1. - Added new section titled Additional Information - Battery Conductance Testing and Intercell Connection Measurements.
- Section 7. - Added additional cautions if battery reversal is encountered.
- Section 8.8. - Added additional information referencing Sections 5. and 6.
- Section 8.9. - Added additional information to this section including exercising extreme care if abnormal high temperature cells have been identified.
- Section 9.7. - Rephrased last bullet item to ensure a tight seal.

- Section 9.7. - Added information on how to order some of the Saft watering kits and associated equipment.
- Section 9.9. - Added URL link to APEx regarding Saft battery information.
- Section 9.13. - Added additional information to determine if Saft battery string/cell is near end of life.
- Section 10. - Added electrolyte temperature item in Table 13. and specific gravity item in Table 14.
- Section 11. - Table 17. - Added column for Charger Current measurements.
- Section 11.1. - Added new section for Engine Start Battery Measurements.
- Section 12. - Battery forms updated.
- Section 12.1. - Added new section titled Form Instructions to explain how to fill out fields in the battery forms.
- Section 15. - Updated information and tables for whole section.
- Section 15.2. - Added new information on what to do if the battery discharge test has to be terminated.
- Section 15.3.4. - Added micro-ohms unit reference in Table 21.
- Section 16. - Added new section titled Additional Information on Battery Maintenance which includes new sections on DLRO testing. in Section 16.1.
- Section 17. - Added new section titled Acknowledgements to recognize contributors and support to this document.
- Acronyms A.1. - Added more acronyms.

2. Safety

CAUTION:
Personnel to have and use the appropriate Personal Protective Equipment (PPE) and Safety Gear: 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 batteries containing electrolyte, or any activity that requires exposure to shock from batteries, breakers, fuses etc. All jewelry, necklaces, earrings, bracelets, watches, and loose hanging items shall be removed prior to working around power equipment. For additional information on proper safety precautions when taking measurements and working with batteries refer to the appropriate sections included in this document.

No Job Is So Important And No Service So Urgent - That We Cannot Take Time To Perform Our Work Safely.

This section describes important safety and environmental management information when performing maintenance procedures on batteries and other related activities in the power environment. This information originates from the Corporate Safety and Environmental Management web sites (URLs), for more information, refer to the following:

- http://worksafe.sbc.com/ .
- http://em.sbc.com/ .

In addition, other important links are referenced in this section and throughout the document with respect to Safety and EM concerns.

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.

Personal Protective Equipment (PPE) 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.

In addition to PPE, it is strongly recommended not to wear clothing made with synthetic materials. Clothing should primarily be made of cotton fabrics or other natural fibers. Technicians should also wear long sleeve shirts and long pants, to minimize exposure to electrolyte and other concerns. Check with local policies for proper attire when working in central office/power areas.

Technicians should also be aware of loose clothing and ensure that clothing is properly fitted to prevent entanglement in rotating machinery or accidental contact with electrolyte.

In addition, it is referenced in Section 3.1. to have available rubber overshoes.

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 ground point of a grounded rack, grounded battery terminal or nearby intercell connector on a nominal 24 or 48 VDC plant to discharge the static electricity from your body.

CAUTION:
Before performing maintenance on batteries, firmly touch the grounding connection of the battery stand or ESD grounding point, if provided, to discharge static electricity. Only perform this action momentarily before beginning work or subsequent work on batteries.

2.2. Electrical Shock and Burns Protection

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

Tools used on batteries **MUST** be factory insulated, and only trained personnel that understand the potential hazard of handling Lead Acid and NiCad batteries should be allowed to perform the battery maintenance work. Tools wrapped with tape are not approved for work around power equipment, the requirement for insulated tool guidelines are referenced in the following document:

- http://apex.sbc.com/bookview/bookview.jsp?bookname=ATT-TP-76300&showid=null

All double insulated tools should meet industry insulation requirements of 1000 VAC and 1500 VDC.

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.

When performing testing and maintenance on power equipment, the appropriate level of safety gear and PPE is required depending upon the level of activity performed. Safety gloves and insulating blankets are described in the following web site:

- http://apex.sbc.com/bookview/bookview.jsp?bookname=ATT-TELCO-002-216-225

2.3. First Aid

Safety information for all employees is described in the following web site link:

- http://worksafe.sbc.com/ .

Information in this web site include how to order First Aid kits, job aids, practices and policies, and other important information. Refer to the Safety Work-Safe web site for items not discussed in the following sections for additional information with respect to batteries and other power equipment.

Additional links found within the Safety web site include the following links and are meant to help employees follow safe work procedures but are not inclusive of all safety practices.

- http://worksafe.sbc.com/jobaids.htm - this site contains job aids for batteries, engine rooms, eye protection, First Aid, Hand/Power tools, Hearing Protection, etc.
- http://worksafe.sbc.com/MSDS.pdf .
- http://www.ussafety.com/sbc/ .
- http://worksafe.sbc.com/practices.htm - this site contains information for Hazard Recognition and First Aid ordering information.

2.3.1. 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.

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

2.3.1.1. 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.

Information to order Eye Wash Stations and Replacement Solution can be found at the following web site:

- http://apex.sbc.com/bookview/bookview.jsp?bookname=ATT-PAN-SAFETY-2004-0001

2.4. Neutralizing Agents

When the decision is made to **neutralize an electrolyte spill of ONE Gallon or less**, the following sections 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 PPE and observe all safety guidelines for the cleanup.

2.4.1. Electrolyte Spills (Acid and Alkaline)

WARNING:
A majority of batteries deployed in our network are lead acid type batteries and the electrolyte is acidic. However, with the addition of NiCad batteries being deployed, the electrolyte is alkaline. Extreme care should be used when responding to an electrolyte spill, different procedures apply to acidic versus alkaline electrolyte.

If the amount of electrolyte spilled exceeds one gallon, then all efforts should be directed at containing the spill using the AT&T 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, the phone number is listed at the end of this paragraph. 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. The contact number for Environmental Management is 1-866-492-6836 (1-866- I Want EM). Contact information can also be found at the Environmental Management web site:

- http://em.sbc.com/

The Ramsey First Responder Acid Spill Containment Kit (FR-912 series) are designed to neutralize and absorb Sulfuric, Hydrochloric, Phosphoric, and Nitric acids. The acid absorber is a light brown powder in color and has no odor. Following the safety procedures for the material to be neutralized is considered the appropriate safety precautions for handling this product. Disposal of the product should follow our current guidelines for hazardous waste.

The kit is available in three (3) sizes. The standard kit FR-912 contains 48 lbs. of acid absorber with the ability to absorb 2 gallons of battery acid. The mid range kit FR-912-210 contains 210 lbs. of acid absorber for 12 gallons of battery acid and the large kit FR-912-300 contains 300 lbs. of acid absorber for 17 gallons of battery acid. The kits are identical in components with the exception of the FR-912-300 kit that contains personal safety gear for two technicians.

The Ramsey Spill Containment kit shall be the product of choice for all locations using flooded lead acid battery technology. The number of kits required at each site will be up to the discretion of the Network Operations personnel, but meet the minimum standards as outlined in the operational practices. Also check with Local, State and Federal regulations to determine if more material is required than what our guidelines stipulate. Engineering guidelines stipulate that a minimum of one kit per power plant (or floor) be available to network operations for the clean up of at least one battery jar based on the largest battery type in the power plant. Typically, the FR-912-210 will be purchased for Central Office locations housing where 1680 ampere hour batteries are the largest battery on site, the FR-912-300 would be needed in locations where the 3000/4000 ampere hour batteries are utilized and the FR-912 would be applicable to smaller fiber or repeater sites with single power plants where 600 ampere hour batteries or smaller are in service.

An exception can be allowed for the FR-912-210 kit and will be left up to the discretion of the Network Operations personnel, if there are space limitations or weight concerns, instead of one FR-912-210 kit, procure one FR-912 kit and four RG-3050 pails and place safely and accordingly per power plant (or floor).

In addition to the sulfuric acid containment kits (FR-912 series), Ramsey has provided a NiCad clean up kit. Feature and function mirror the acid spill kit, but is designed specifically for Nickel Cadmium battery products. The FR-914 and NS-640 kits are only for use with NiCad batteries. NiCad product labeling will always be bright orange where sulfuric products are safety yellow. AT&T practices and policies for the deployment of the products shall be follow the same guidelines as listed.

The following table lists some of the more important products that are needed for acid spill and containment but does **not** list all of the items that are required, for the complete list of all items available, refer to the PAN document:

- http://apex.sbc.com/bookview/bookview.jsp?bookname=ATT-TELCO-PAN-2002-3031

If any of the following items (including other clean-up and containment items listed in above PAN) require replacement either through use, damage, or some other concern, order replacement items per local requirements.

Table 2: Acid Neutralizing Absorption Ordering Supplies - partial list of essential items for battery spill containment supplies

Battery Type	Item	Part Number	Quantity	Price	PID or SSI Number
Lead Acid	48 lbs Neutralizing Acid Absorber Kit	FR-912	Complete Set of 1	$327.25	300020419
Lead Acid	210 lbs Neutralizing Acid Absorber Kit	FR-912-210	Complete Set of 1	$480.00	300020427
Lead Acid	300 lbs Neutralizing Acid Absorber Kit	FR-912-300	Complete Set of 1	$649.00	301026860
Lead Acid	Neutralizing Acid Absorber - 48 lbs, pail container	RG-3050	Set of 1	$85.00	300020492
Lead Acid	Dolly for FR-912-210 & FR-912-300	RM-2640	Set of 1	$49.95	300058377
Nickel Cadmium	NiCad Spill Kit* (30 lb. Kit) Weight refers to amount of Neutralizing Absorber. Sized for start batteries.	NS-640	Complete Set of 1	$135.15	301062543
Nickel Cadmium	NiCad Spill Kit* (45 lb. Kit) Weight refers to amount of Neutralizing Absorber. Sized for Large battery strings.	FR-914	Complete Set of 1	$335.75	301062550
Nickel Cadmium	Neutralizing Absorber 45 lbs.	RG-4045	Set of 1	$89	301117537
Nickel Cadmium	Neutralizing Absorber 200 lbs.	RG-40200	Set of 1	$380	301117529

The AT&T 13 State Battery Spill Response Procedure can be found at:

- http://em.sbc.com/Topic/Batteries/BatterySpillResponseProcedure.pdf

Additional battery cleanup information can also be found on the Environmental Management web site, such as for NiCad batteries at:

- http://em.sbc.com/Topic/Batteries/batteries.html#other

Additional information can also be found in the following AT&T Practice ATT-TELCO-002-217-299 and associated PAN (ATT-TELCO-PAN-2002-3031) for Acid Clean-up and Containment and how to procure Ramsey Group products, see the following web sites:

- http://apex.sbc.com/bookview/bookview.jsp?bookname=ATT-TELCO-002-217-299&showid=null
- http://apex.sbc.com/bookview/bookview.jsp?bookname=ATT-TELCO-PAN-2002-3031

2.4.2. 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. Treat the clothing as hazardous waste and dispose using acid resistant disposal bags or containers, these bags or containers should be supplied with the Ramsey Group Acid Spill and Containment kit, if not available or if more are needed, refer to Section 2.4.1. and the associated web sites to order additional material. Contact Environmental Management for removal or other concerns with contaminated material, see Section 2.4.1. for contact information.

2.5. 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 must 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.

CAUTION:
Before performing any maintenance work on batteries, the maintenance person needs to read, understand and apply all information and guidelines provided within this document to prevent a battery explosion or other hazard.

Nickel Cadmium (NiCad) Batteries - Check that the flame-arresting vents are tightly fitted and that there are no deposits on the vent cap. If whitish deposits are evident, these are carbonates and do affect the operation of the battery, these can be clean with a wet towel, do not use detergents, chemicals, or cleaning aids.

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

2.5.1. 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.

2.5.2. 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 maintenance on batteries, firmly touch the grounding connection of the battery stand or ESD grounding point, if provided, to discharge static electricity. Only perform this action momentarily before beginning work or subsequent work on batteries.

2.5.3. Charging and Discharging

Under normal float, discharge, and recharging 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.

2.5.3.1. 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 3.2. for voltage levels.

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.

2.5.4. 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 3.3.3 .

2.5.5. 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. Contact your local manager responsible for power with this concern, and it may be necessary to contact the battery manufacturer directly to obtain a replacement vent funnel. This replacement item is not stocked nor is there an available PID number for replacement. For additional support, contact your local Power Support.

2.5.6. 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.

2.5.7. Test Leads

CAUTION:
Observe the following precautions when making electrical measurements when using a Digital Multi-Meter (DMM) or other test sets (this list may not include all precautions, refer to the test meter manufacturer documentation for additional information).

CAUTION:
For all work and test activities, safety should be practiced at all times. When performing maintenance and tests, personnel must have the appropriate level of Personnel Protection Equipment (PPE).

- Do not use the meter if it is damaged. Before you use the meter, inspect the case. Look for cracks or missing plastic. Pay particular attention to the insulation surrounding the connectors.
- Use caution during the test process to prevent test leads from accidentally touching or grounding.
- Secure connections at the meter end.
- Inspect the test leads for damaged insulation or exposed metal. Check the test leads for continuity. Replace damaged test leads before you use the meter.
- Use caution during the testing process, connect the common test lead before you connect the live test lead. When you disconnect test leads, disconnect the live test lead first, then common lead last.
- When using the probes, keep your fingers behind the finger guards on the probes.
- To avoid false readings, which could lead to possible electric shock or personal injury, replace the batteries as soon as the low battery indicator appears.
- Do not use the meter if it operates abnormally. Protection may be impaired. When in doubt, have the meter serviced.
- Always observe proper polarity. For measurement being performed, ensure probes and settings are correct for test being performed, i.e. whether it be measuring voltage, continuity, amperage, etc.
- In no case should the test lead connections at the meter end be removed without first disconnecting the test leads from the element being tested (e.g. battery, cell, other electrical equipment).
- The test lead connections from the element being tested (e.g. battery, cell, other electrical equipment) should be removed immediately after each reading is taken.

3. Maintenance Procedures

NOTE:
Safety and environmental concerns are detailed in **Section 2.** of this document, review this section before performing any maintenance activities listed in this Maintenance section and other sections throughout this practice.

This section will outline maintenance procedures to maintain optimal battery operation. Proper maintenance will prolong the life of the battery and ensure that it will satisfy its design requirements. A good maintenance program will also help determine when to replace batteries.

Prior to detailed maintenance activities, a **general visual inspection** will provide an overall assessment.

- General appearance and cleanliness of battery, battery rack and battery area.
- Electrolyte levels.
- Any cracks in cell containers or spillage of electrolyte.
- Cell or jar case swelling.

If any abnormalities are observed, such as spilled electrolyte or low electrolyte levels, correct as soon as possible following all safe work procedures. Notify your local management and other appropriate groups (such as EM for electrolyte spills) as necessary. Refer to **Section 2.4.** for information on electrolyte spills and Section 3.7. for information on electrolyte levels. Refer to **Section 3.11.** for any concerns if the cell or jar case is beginning to swell, additional consideration for this condition could be temperature related, refer to **Section 3.8** .

Detailed maintenance schedules are listed in **Section 10.** and will identify the appropriate references throughout this section and subsequent sections to maintain battery condition.

3.1. Tools Materials and Test Equipment

The following tools, materials and test equipment should be available:

Tools

- Acid-resistant gloves and apron.
- Acid-resistant industrial tape (2-inch wide), available from Ramsey Group.
- Chemical Safety, Splash Proof Goggles.
- Container (plastic or rubber for handling electrolyte or water).
- Cotton swabs.
- Eyewash Solution.
- Factory insulated torque wrench, (inch-pound).
- Flashlight, regular or angular, having plastic or rubber housing.

- Heavy Duty Paper Wipes.
- Lint-free untreated wiping cloth.
- Plastic Funnel.
- Portable battery charger.
- Rubber Overshoes.
- Six Point Single-end factory insulated Box Wrenches and sockets in 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, 1-1/8 Inch and 10 mm.
- Small paint brush.
- Stiff nylon bristle brush.
- Watering system for Saft NCX series NiCad battery systems.
- Wire brush (to be used only to remove corrosion on metal stands and shelves).
- 3M ScotchBrite or equivalent.
- 3-inch and 6-inch factory insulated Wrench Extension.

NOTE:
Requirement for insulated tool guidelines are referenced in http://apex.sbc.com/bookview/bookview.jsp?bookname=ATT-TP-76300&showid=null , in addition all double insulated tools should meet industry insulation requirements of 1000 VAC and 1500 VDC.

Materials

- Congo Red (0.1 percent aqueous solution).
- Cotton swabs.
- Distilled Water.
- NO-OX-ID A-Special compound - see local requirement.
- For NiCad only: NOX-RUST X110.
- Sodium Bicarbonate (baking soda).

NOTE:
For complete battery containment electrolyte kits or for individual containment items, refer to Section 2.4.1.

Test Equipment

- Alcohol thermometer.
- DC Clamp Ammeter.
- Digital Multimeter (DMM) with millivolt resolution, accurate to 0.02 percent on a 10 volt full scale or better (Fluke 189, Fluke 867B).
- Hydrometer (appropriate scale for the electrolyte under test).
- Thermal Scanner - Raytek Raynger ST60XXUS Portable Non-Contact Thermometer or equivalent (Required for VRLA, optional for other battery types). This unit is available through Aproms, the PID for this unit is 701225443.
- Optional: AC-DC Hall Effect current-transformer clamp-on accessory probe for use with DMM.
- Optional: AC-DC Current Clamp-on meter.
- Optional: Alber SCT-200 Single Cell Test and Charge System.
- Optional: Individual cell voltage logging test set (Explorer Technology Group Volt-Logger DLV-30).
- Optional: DC Clamp-on Milliamp-meter.
- Optional: Digital hydrometer.
- Optional: Midtronics Conductance Test Set, Alber Cellcorder.
- Optional: Refractometer (Misco).

3.2. Float Voltages and Other Battery Conditions

It is extremely important to maintain a battery plant at its proper float voltage. These voltages are shown in Tables 3., 4., 5. and 6. Any adjustment to these nominal voltage levels should be coordinated with the local Power Support to protect the power plant and served equipment.

This section will also address float/charging current for starting batteries for standby engines and turbines in Section 3.2.5.

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

Battery Type	Float Voltage (Volts/Cell)	Range (Volts/Cell)	Float Voltage (Volts/Plant 48V)	Float Voltage (Volts/Plant 24V)	Float Voltage (Volts/Plant) 130V and 140V
Lead Calcium	2.17 (+/- 0.05)	2.12 - 2.22	52.08	26.04	See Note .
Lead (Round Cell)	2.17 (+/- 0.05)	2.12 - 2.22	52.08	26.04	See Note .
Lead Antimony	2.17 (+/- 0.05)	2.12 - 2.22	52.08	26.04	See Note .

NOTE:
There are 130 volts nominal and 140 volt nominal battery strings deployed throughout the network. For non-switched 130 volt plants, there are 66 cells with a float voltage of 143.22 volts. In addition there are still 130 volt end-cell switched plants with 61 cells with typically 2 groups of 4 cells per group for end-cells, the string floats at 132.37 volts and the end-cell groups with a float voltage of 8.68 volts. For 140 volt plants, there are 70 cells with a float voltage of 151.90 volts.

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

Battery Type	Float Voltage (Volts/Cell)	Range (Volts/Cell)	Float Voltage (Volts/Plant 48V)	Float Voltage (Volts/Plant 24V)	Float Voltage (Volts/Plant) 130V and 140V
Lead Calcium	2.20 (+/- 0.05)	2.15 - 2.25	52.80	26.40	N/A
Lead (Round Cell)	2.20 (+/- 0.05)	2.15 - 2.25	52.80	26.40	N/A

Table 5: Float Voltage voltages using Valve Regulated Lead Acid and Nickel Cadmium Batteries in Central Office CDO, CEV, RT Applications

Battery Type	Float Voltage (Volts/Cell)	Range (Volts/Cell)	Float Voltage (Volts/Plant 48V)	Float Voltage (Volts/Plant 24V)
Valve Regulated (note # of cells)	2.25 (+/- 0.05)	2.20 - 2.30	54.00 (24 cells), 51.75 (23 cells)	27.00
Nickel Cadmium (note # of cells)	1.43 (+/- 0.03)	1.40 - 1.46	54.34 (38 cells), 52.91 (37 cells)	27.17 (19 cells)

Table 6: Float Voltage Standby Engine Starting, Control and Station Battery Applications

Battery Type	Float Voltage (Volts/Cell)	Range (Volts/Container)	Float Voltage (Volts/Plant 12V)	Float Voltage (Volts/Plant 24V)	Float Voltage (Volts/Plant 32V)	Float Voltage (Volts/Plant 48V)
Lead Acid Flooded (Auto/Truck) See Manufacturer Specifications (see **NOTE: 1.**)	2.25 (+/- 0.05)	13.20 - 13.80 per 12V Battery Container	13.50	27.00	36.00, n/a	54.00
Valve Regulated (Mtce-Free) (see **NOTE: 1.**)	2.27 (+/- 0.05)	13.20 - 13.80 per 12V Battery Container	13.62	27.24	36.32/54.48	54.48
Valve Regulated (OPTIMA BlueTop: SC34M or SC31DM) (see **NOTE: 2.**)	2.25 (+/- 0.05)	13.20 - 13.80 per 12V Battery Container	13.50	27.00	36.00	54.00
Caterpillar HO See Manufacturer Specifications (see **NOTE: 1.**)	2.30 (+/- 0.05)	13.60 - 14.10 per 12V Battery Container	13.80	27.00	36.80	54.00
Nickel Cadmium (Saft) (note # of cells) (see **NOTE: 2.**)	1.43 (+/- 0.03)	1.40 - 1.46 volts per Cell	14.30 (10 cells)	27.17 (19 cells), 28.60 (20 cells)	35.75 (25 cells), 38.61 (27 cells)	54.34 (38 cells), 52.91 (37 cells)

NOTE:
1. Flooded Lead Acid and Maintenance Free start batteries are no longer approved for replacement. Existing flooded lead acid and other maintenance free batteries have a typical life expectancy of 2 years in **telecom service** applications and should not remain in service longer than 3 years from the installation date. Approved replacement should either be the OPTIMA BlueTop or the Saft NiCad listed in the above table based upon engine size.

For OPTIMA BlueTop information, see the following document:

- http://apex.sbc.com/bookview/bookview.jsp?bookname=ATT-TELCO-PAN-2003-3329&showid=null

For Saft NiCad engine starting information, see the following document:

- http://mechteam.sbc.com:8080/docs/PANs/20001161.pdf

NOTE:
2. The OPTIMA BlueTop life expectancy in typical **telecom service** is 6 years. The Saft engine start battery life expectancy in typical **telecom service** exceeds 20 years.

3.2.1. 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, refer to Section 2.5.7. for additional meter-use precautions.

The following forms should be used for battery maintenance.

- For flooded lead acid batteries, 24 volt or 48 volt plants, use the form Flooded String Storage Battery Record - ATT 5330.
- For VRLA, use the form VRLA String Storage Battery Record - ATT 5331.
- For CO NiCad batteries, use the form NiCad String Storage Battery Record - ATT 5332.
- For 130 volt plants, use the form 130V String Storage Battery Record - ATT 6506.
- For 140 volt plants, use the form 140V String Storage Battery Record - ATT 6507.

To print or save a copy of each form *double click* on the form web link in Section 12. or copy and paste the URLs contained in Section 12. into your web browser address field. Other battery maintenance forms are available in this section in addition to the forms listed above.

All forms are also available on the AT&T Operations Staff - Provisioning & Translations Support web site:

- http://inso.sbc.com/power.cfm

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.

3.2.2. Effects of Electrolyte Temperature on Float Voltage.

The lead acid battery is an electrochemical device where heat accelerates chemical activity and cold slows it down. Lead acid batteries are rated for optimum performance at 77 degrees Fahrenheit (F) (25 degrees Celsius (C)).

Float voltage varies with electrolyte temperature but not significantly, if the electrolyte temperature range is between 71 and 83 degrees F (between 21.7 to 28.3 degrees C).

If the normal operating temperature of the electrolyte is outside the range listed above, refer to local management responsible for power and local Power Support before making any adjustment to float voltage, the following corrections may be used to determine if an equalize charge is required or other corrective action:

- To correct float voltages for temperatures below 77 degree F, add 3 millivolts (mV) for each degree F from 77 degrees (or add approximately 5.4 mV per degree C from 25 degrees C).
- To correct float voltages for temperatures above 77 degree F, subtract 3 millivolts (mV) for each degree F from 77 degrees (or subtract approximately 5.4 mV per degree C from 25 degrees C).

Temperatures can affect battery performance and operation, for electrolyte temperatures other than 77 degrees F, then the following concerns apply. A low electrolyte temperature inhibits chemical action, slows down diffusion by making the electrolyte more viscous, and increases the internal resistance of the battery. Minor changes in voltages due to ambient temperature variations can be expected and do not require voltage adjustment.

A high electrolyte temperature has the opposite affect to that of a low electrolyte temperature. Again, minor changes in voltage can be expected and do not require voltage adjustment.

In summary, if electrolyte temperatures are other 77 degrees F, the following table describes the effects of temperature on cell operation. If nominal office temperature changes, which could affect battery performance, contact local manager responsible for power or local Power Support for guidance.

Table 7: Effects of Temperature on Lead Acid Cells

Cell Function	Increase in Temperature from 77 degrees F	Decrease in Temperature from 77 degrees F
Amount of current to required to float cells at 2.17 or 2.20 volts	Increases	Decreases
Capacity	Increases	Decreases
Cell Resistance	Decreases	Increases
Cell Voltage (Constant Charge Current)	Decreases	Increases
Charge Current (Constant Charge Voltage)	Increases	Decreases
Chemical Activity	Increases	Decreases
Electrolyte Specific Gravity	Decreases	Increases
Float Voltage	Increases	Decreases
Life Expectancy	Decreases	Increases
Maintenance Requirements	Increases	Decreases
Water Loss	Increases	Decreases

NiCad Batteries: For best performance and maximum service life batteries should be kept between the ambient temperature ranges of 50 degrees F and 86 degrees F. If the temperature is outside of these listed values, contact local management responsible for power or local Power Support for guidance.

3.2.3. Deviation from Float Voltage and Corrective Actions for Lead Acid Batteries

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. and 6. 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 multi-tier 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 degrees 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(ies) in question. If the capacity is low, the battery(ies) 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 ATT 6506. 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 2.5.3. 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.

- Abnormal conditions: Batteries may exhibit other conditions of abnormal behavior which may not be listed above, refer to local manager responsible for power or local Power Support for guidance.

NOTE:
Log and record all deviations and corrective actions taken.

3.2.4. Deviation from Float Voltage and Corrective Actions for Nickel Cadmium Batteries

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 5. and 6. 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 multi-tier 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 degrees F, appropriate ventilation should be provided to correct the situation.
- Battery manufacturers: Saft is the only NiCad battery manufacturer currently approved for use, 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: 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**: The normal float voltage for a NiCad Saft NCX battery cell is 1.43 VPC, any cells within a NiCad string with a voltage of 1.53 VPC or higher should be monitored closely. Visually observe for any abnormal conditions, and contact your local manager responsible for power or local Power Support with this concern if the voltage remains at or above this level for more than a week and refer to the manufacturer for additional support.

  For additional information, see Section 9.5.1.1 .

- **Battery voltage low**: Any cell within a Saft NiCad NCX battery string should not have a float voltage of 1.33 VPC or lower. If cells are observed to be floating at 1.33 VPC or lower, visually observe for any abnormal conditions, and contact your local manager responsible for power or local Power Support with this concern if the voltage remains at or below this level for more than a week and refer to the manufacturer for additional support. It may be necessary to perform a boost charge, perform this activity with careful observation and monitoring. It also be necessary to perform this activity by removing this string from the plant and performing a recharge test, see Section 9.13. for additional information.

  For additional information, see Section 9.5.1.2 .

- 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.
- Abnormal conditions: Batteries may exhibit other conditions of abnormal behavior which may not be listed above, refer to local manager responsible for power or local Power Support for guidance.

NOTE:
Log and record all deviations and corrective actions taken.

3.3. 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 connections (intercell and cable) shall be properly torqued to the manufacturers specification for the battery type at installation.

Cable and intercell connections require annual inspection and this can be performed in a variety of ways. Whichever method is to be used, exercise a careful and systematic approach to ensure optimal connection integrity. This can be accomplished by checking these connections using either an Albers test set, a Midtronics test set, performing a re-torque using an insulated torque wrench, or Digital Low Resistance Micro-Ohm meter (DLRO) test.

Cables and intercell connections should be checked for looseness annually and the preferred method is to use either an Albers or Midtronics test set. Refer to the following list for additional information for each method:

- If an Albers test set is available, use this test set to perform cell resistance and intercell connection resistance tests. Refer to **Sections 6. and 6.1.** for more information. Perform corrective actions as needed after measurements performed.
- If a Midtronics test set is available, use this test set to perform “jar and strap” cell conductance and intercell connection resistance tests. Refer to **Sections 6. and 6.1.** for more information. Midtronics uses the terms jar and strap, where jar is the cell or battery case, and strap is more commonly known as an intercell connector. Perform corrective actions as needed after measurements performed.
- If these test sets are not available, re-torque intercell connections on an annual basis using an insulated inch-pound torque wrench, refer to Table 9. for re-torque values. If the battery type is not listed in this table, refer to the manufacturer for torque and re-torque values. **Do not over-torque**.
- If a Digital Low Resistance Micro-Ohm meter is available, use this test set to measure intercell connection resistance. Refer to **Section 5.** and **Section 16.1.** on how to perform this test. Perform corrective actions as needed after measurements performed.

CAUTION:
Torque and Re-torque of cables and intercell connectors require the use of an insulated inch-pound torque wrench. Determine proper torque for each cable connection and intercell connector and set the torque wrench to that calibrated setting. When using torque wrench, and the torque value is achieved, the wrench will click.

Do not exceed this torque value. Refer to Section 3.3.2. for battery hardware torque values.

Sections 3.3.1. through 3.3.5. provide information on what action and corrections are necessary if corrosion is present or some other concern is identified. If the intercell connectors and hardware require replacement or if the intercell connectors and hardware require to be disassembled, cleaned, reassembled. Use the following steps as a guide on what corrective action is required for the problem encountered:

1. **If Intercell connectors show signs of corrosion**, these intercell connectors may require replacement or may require to be disassembled, cleaned, reassembled and retested. Refer to Sections 3.3.1. for more information if corrosion is suspected on the post and intercell connections and hardware. If intercell connectors and hardware require replacement, use the following Step #2. If intercell connectors and hardware can be cleaned, use the following Step #3.

Before proceeding to intercell corrections listed in Step #2 or #3, note following cautions and note battery string number and post type to perform tasks before proceeding.

CAUTION:
Exercise safe work procedures at all times, wear safety glasses/goggles, use PPE and insulating blankets as appropriate.

CAUTION:
If a battery string must be disconnected from the charging system (buss work), disconnect end cell conductors in safest fashion, securely isolate and insulate to avoid any shock hazards. Disconnect return conductors first, the battery conductors second.

CAUTION:
When re-connection is to be made, an external charger can be used to recharge the string to string float voltage and re-connection can be made. Connect battery conductors first, return conductors second. An alternate method is to adjust plant controller to lower voltage (or possibly turn off one rectifier at a time) before re-connections can be made. In either case, must use DMM(s) to measure voltage difference, do not make any connections unless voltage difference is less than 0.05 volts. Enlist aid from local Power Support to perform this task.

CAUTION:
When intercell connections are opened, voltage is present on adjacent cells and a potential shock hazard may therefore exist.

Table 8: Battery String Configuration and Post Type

1.	**If a single string present, cells with two posts.**	You must contact local manager responsible for power and local Power Support to obtain assistance.
2.	**If a single string present, cells with four posts.**	You must contact local manager responsible for power and local Power Support to obtain assistance.
3.	**If multiple strings present, cells with two posts.**	Contact local manager responsible for power and local Power Support. The string should be disconnected from charging system and intercell tasks performed. Or a bypass procedure can be performed, enlist aid of local Power Support. Once tasks are complete, verify intercell connections are less than 0.05 volts before reconnecting, and verify string connections to charging system is less than 0.05 volts. In either case, if voltage difference is greater than 0.05 volts, contact local Power Support for assistance.
4.	**If multiple strings present, cells with four posts.**	Contact local manager responsible for power and local Power Support as needed, only work on one set of intercell connectors at a time. Open one set of intercell connectors and perform tasks. A bypass procedure can also be performed, enlist aid of local Power Support. Before reconnecting intercell connectors, verify with DMM that voltage difference is less than 0.05 volts. If voltage difference is greater than 0.05 volts, contact local Power Support for assistance.

2. **If the intercell connector(s) require replacement:**

Use this procedure if corrosion is present. If some other concern is identified. Or if Albers, Midtronics or DLRO testing determine that replacement is required.

A. Report concern to local manager responsible for power, if needed, for help in obtaining replacement intercell connectors and associated hardware.

B. Note number of strings and post types as listed in the above Table 8. and proceed accordingly, if single string present **STOP**.

C. Once replacement items have been obtained, continue with the replacement.

D. Use double insulated tools.

E. **Do not open any battery connection while batteries are gassing, recharging or discharging**. Only perform these procedures on float.

F. Disassemble and remove old intercell connectors and hardware. The bypass procedures do not typically need to be performed as described in Sections 3.3.3., 3.3.3.1. and 3.3.3.2. but if they do need to be performed, obtain assistance from local Power Support. Do not perform bypass if batteries are gassing, recharging or discharging, only on float.

G. Remove old NO-OX-ID Corrosion Inhibitor from battery posts and clean battery connections as described in Section 3.3.4.

H. Coat new intercell connectors ends and battery posts with new NO-OX-ID A-Special Corrosion Inhibitor, refer to Section 3.3.5.

I. Assemble new intercell connectors and hardware and gently hand tighten before performing torque, note orientation of washers, refer to Section 3.3.2. for cautions when performing connection tightness.

J. Use factory insulated inch pound torque wrench and torque new intercell connectors and hardware using initial torque values, **do not over-torque**. Use Table 9. for battery type or refer to battery manufacturer for these torque values.

K. Retest intercell connector if Albers, Midtronics or DLRO tests were initially performed.

L. Restore battery string to service, follow all safe work procedures and verify with DMM before making any connections. Note above cautions and table.

3. **If the intercell connectors require cleaning, then intercell connectors and associated hardware will need to be removed:**

Use this procedure if corrosion is present and replacement may not be required. If some other concern is identified. Or if Albers, Midtronics or DLRO testing determine that cleaning is required.

A. Inform local manager responsible for power that this task will need to be performed.

B. Note number of strings and post types as listed in the above Table 8. and proceed accordingly, if single string present **STOP**.

C. **Do not open any battery connection while batteries are gassing, recharging or discharging**. Only perform these procedures on float.

D. Use double insulated tools.

E. Disassemble and remove old intercell connectors and hardware. Bypass procedures do not typically need to be performed as described in Sections 3.3.3., 3.3.3.1. and 3.3.3.2. but if they do need to be performed, obtain assistance from local Power Support. Read and understand Section 3.3.3. Do not perform bypass if batteries are gassing, recharging or discharging, only on float.

F. Remove old NO-OX-ID Corrosion Inhibitor from battery posts and clean battery connections as described in Section 3.3.4.

G. Coat intercell connectors ends and battery posts with new NO-OX-ID A-Special Corrosion Inhibitor, refer to Section 3.3.5.

H. Re-assemble intercell connectors and hardware and gently hand tighten before performing torque, note orientation of washers, refer to Section 3.3.2. for cautions when performing connection tightness.

I. Use factory insulated inch pound torque wrench and torque intercell connectors and hardware using initial torque values, **do not over-torque**. Use Table 9. for battery type or refer to battery manufacturer for these torque values.

J. Retest intercell connector if Albers, Midtronics or DLRO tests were initially performed.

K. Restore battery string to service, follow all safe work procedures and verify with DMM before making any connections. Note above cautions and table.

NiCad Batteries: Inspect all intercell connectors and hardware for signs of heat-related discoloration resulting from loose hardware. NiCad hardware should be properly torqued upon installation, and whenever disassembly for cleaning or service is necessary. Routine re-torquing is not necessary, as the posts, intercell connectors, washers and other hardware are steel, and are not subject to "cold flow". Initial torque values are included in the O&M manual.

3.3.1. Post/Intercell Connector Corrosion

Battery connection hardware shall be free from corrosion. Corrosion from electrolyte leakage can occur by careless handling of the hydrometer syringe when measuring the specific gravity. If this occurs, and intercell connectors and associated hardware have only have a slight amount of corrosion from accidental electrolyte spillage, refer to Step #1 (note Table 8. and Cautions) and Step #3 as described in Section 3.3. on how to clean intercell connectors and hardware. 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, may require the intercell connectors and hardware be replaced and all associated surfaces treated with NO-OX-ID A-Special. Use the procedures described in Step #1 (note Table 8. and Cautions) and Step #3 as described in Section 3.3. on how to replace the intercell connector(s). If the post seals continue to leak, compromising the intercell connectors, the end-plates or other battery hardware, refer the problem to your local manager responsible for power or local Power Support group.

If the intercell connectors and end-plates show exposed copper, these components will require replacement.

NiCad Batteries: A white substance (carbonates) resembling corrosion can appear at the terminals, particularly on the (+) positive terminals. It is the result of gasses evolved from the cell during operation which carries a negative charge, and is therefore attracted to the positive terminals. This substance is soluble in water, and should be cleaned or removed with a cloth and clear water, no solvents or detergent. Do not use metal brushes or hard bristles that can damage the protective coatings on the terminal or intercell links.

Additional information for round cell post inspections using the hook-and-look procedure is described in **Section 3.4.1**
.

3.3.2. Connection Tightness

If a micro-ohmmeter measurement or conductance test cannot be performed, annual re-torquing should be performed on intercell connections. Use the re-torque values listed in the following table.

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

If it is necessary to replace the intercell connectors and hardware, 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 Table 9. below. Use an inch-pound insulated torque wrench to measure the torque. If not listed below, refer to manufacturer's specification for proper torque values.

NiCad Batteries: Routine re-torquing is not necessary, as the posts, intercell connectors, washers and other hardware are steel, and are not subject to "cold flow". Initial torque values are included in the O&M manual. Check torque if battery has a problem, indications can be consistent loss of water, unusual float current, and/or unusual float voltage reading.

Table 9: Torque Recommendations

		Stainless Steel Connectors		Lead Encapsu-lated 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	100	100
	KS 15544 List 508P	110	100	100	100
	KS 15544 List 508	110	100	100	100
Exide	KS 15544 List 508	125	115	100	80
	FTC21 GU Series	125	115	N/A	N/A
Gould	KS 15544 List 508	150	125	100	80
Globe	KS 15544 List 508	150	125	125	100
Absolyte	ALL	100	80	N/A	N/A
Lucent	VR	60	50	N/A	N/A
C&D	Liberty (Sealed)	165	125	N/A	N/A
Chloride	All	48	48	N/A	N/A
Deka/Unigy	All	100	80	N/A	N/A

3.3.3. Opening Battery Connections

If intercell connectors needs cleaning or replacement, a bypass procedure is typically not required. **Do not open any battery connection while batteries are gassing, recharging or discharging. Only perform these procedures on float.**

CAUTION:
Before performing bypass procedures, contact local Power Support for assistance. Use the procedures in Sections 3.3.3.1. and 3.3.3.2.

3.3.3.1. Batteries 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 1. 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.

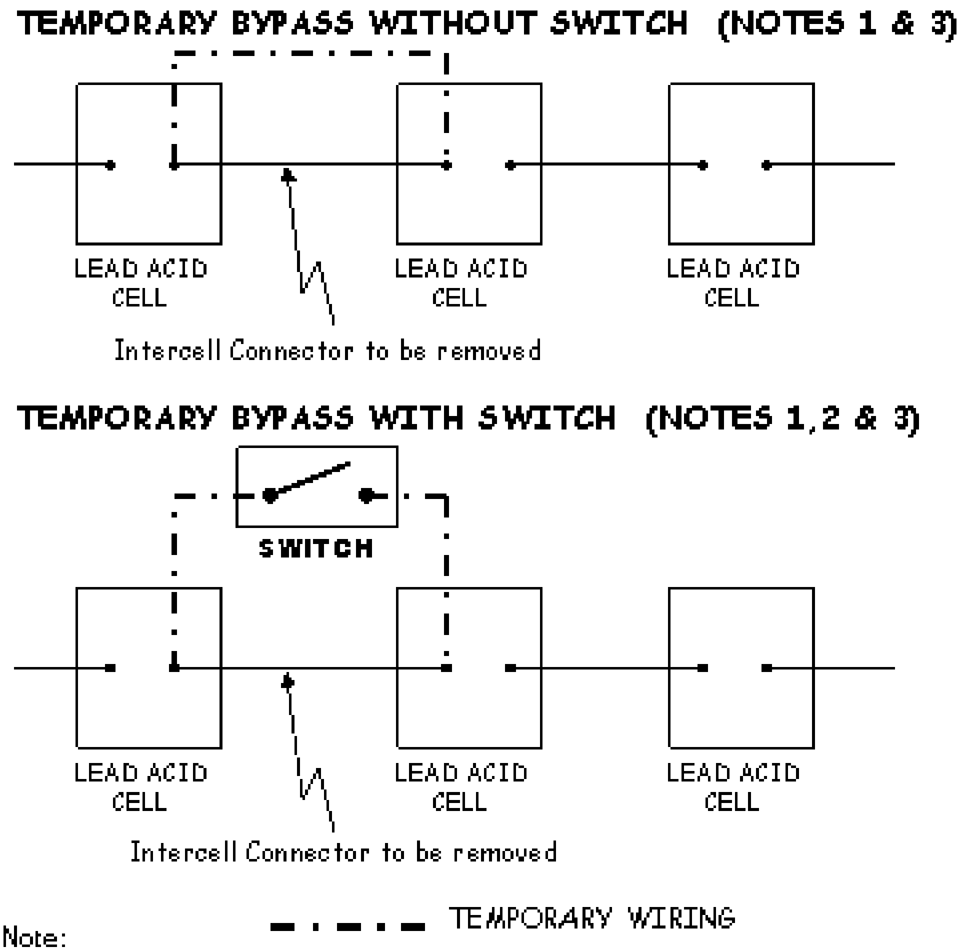
3.3.3.2. Batteries with four posts

The switch or bypass conductor illustrated in Figure 1. is not absolutely required for batteries having four posts. The switch or bypass conductor is required for power plants only having a single battery string application. 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.

The following illustrates the Temporary Inter-battery bypass.

Figure 1: Temporary Inter-battery bypass



Note:

1) Current rating of wire and switch must be capable of carrying the load current.

2) All exposed connections to the switch shall be insulated to prevent accidental contact to any grounded surface.

3) Before connecting temporary bypass conductor to the posts, the existing connections of the intercoil connector to the posts must be positively confirmed.

3.3.4. 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 which will also remove NO-OX-ID. **Do not use a wire brush**.

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

NiCad Batteries: Terminals and connectors should be kept clean and any spillage during maintenance should be wiped off with a clean cloth. The battery can be cleaned using water. Do not use a wire brush or a solvent of any kind.

3.3.5. Application of NO-OX-ID "A-Special" Corrosion Inhibitor

For lead acid batteries, use NO-OX-ID A-Special for the application on battery posts and connections, the NO-OX may be applied using gloved fingers to check smoothness and then apply a thin coat to the battery posts. Instead of gloved fingers, a small brush or other method may be used to apply grease. The thin coating of NO-OX should extend approximately 1/2 inch beyond the post when the intercell connector is installed.

NO-OX-ID A-Special can be ordered through the Aproms Procurement system. The PID number is 401990783, it comes in an 8 oz. tube, and the price is $5.89.

3.3.5.1. Application of Corrosion Preventative for Saft NiCad Batteries

Saft NiCad batteries employ a variety of corrosion preventives/inhibitors, check with local Power Support or the local Saft representative to what was installed on the Saft battery strings at initial installation and how to remove, repair and apply to the battery posts and intercell connectors if corrective action is required.

NOX-RUST X110 is one type of corrosion preventative used, the NOX-RUST X110 may be applied with a small brush or other method may be used to apply fluid. The thin coating of NOX-RUST X110 should extend approximately 1/2 inch beyond the post when the intercell connector is installed.

NOX-RUST X110 can be ordered directly from Saft America, Inc. Part number: 80-02986-01. The description is: Preventative rust, rust, 60 CC (NOX RUST). The price is $2.00. Phone number: 800-308-9041.

The URL for Saft is:

- http://www.saftbatteries.com/000-corporate/include-content/index_gb.html

Another type of corrosion inhibitor that may be used is NO-OX-ID A-Special and if used can be applied in the same manner as for lead acid batteries.

Another type of corrosion inhibitor, that may be applied to new Saft Battery installations installed after August 15, 2006, NCX installations is to use NO-OX-ID A Special WW (Waterworks) Corrosion Inhibitor for battery posts and intercell connections.

Do not mix any of the above mentioned corrosion inhibitors on the Saft NiCad strings requiring corrections, determine which type is to be used and apply to affected cell(s)/string(s).

3.4. 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 A-Special 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 local manager responsible for power or local Power 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.

3.4.1. Round Cell Post Inspection

The hook-and-look procedure is described in the following when using the AT&T R-4940 Boot Lifting Hook for AT&T

KS 20472 Round Cells.

The KS 20472 List 1,2,3, and 4 BellCells (Round Cells) manufactured by AT&T have a defective epoxy material at the interface of the positive post and the jar cover seal. This condition has led to a positive post corrosion problem in the subject cells. Later KS 20472 cells carry the List 1s, 2s, 3s, 4s designation and are not subject to the problem. All of the List 1, 2, 3, and 4, cells must be inspected at six month intervals for the degree of corrosion on the post/cover interface.

The post/cover interface is covered with a black rubber boot. The R-4940 Boot Lifting Hook is a tool designed to lift the boot for inspection. The tool consists of a non-conductive polycarbonate hook with a non-conducting fiber handle. All of the subject batteries should have had the boots raised for inspection several years ago. The following instructions cover use of the tool.

To use the hook to raise the rubber boot:

- Wear splash proof goggles, rubber gloves and rubber apron.
- Discharge static electricity on your person by grounding yourself (touch any grounded rack or frame) before touching a battery.
- Remove the small black cap on top of the cell jar that is closest to the positive post by turning the cap counterclockwise.
- Manipulating the hook is quite awkward and takes a little practice. Use a water dampened cloth to cover the opening as you insert the hook into the opening. The end of the hook is then slid under the rubber boot and the boot is lifted over the post/cover interface. You may have to lift the boot at several points to raise it over the post/cover interface. Once the boot is lifted, leave it over the post/cover interface for future inspections. Extract the hook while squeezing it through the damp cloth, replace the small black cap.

The corrosion will be located at the bottom of the PVC (polyvinyl chloride) cylindrical sleeve, part of the jar cover, that covers the positive lead post as it descends into the battery.

The corrosion or epoxy extrusion will usually cause the bottom of the sleeve to flare outward.

Cells will also exhibit blisters of corrosion on the post at and under the bottom of the sleeve.

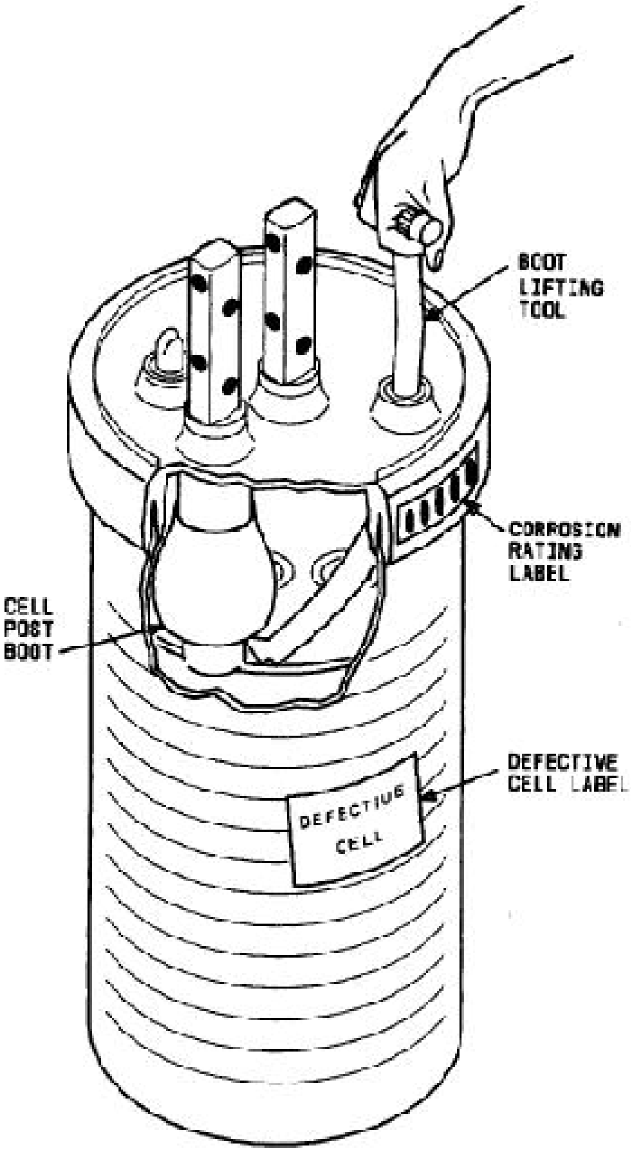
The degree of PVC flaring and the size of the blisters vary from cell to cell. Severe cases warrant replacement of the battery.

Listed below are the conditions that warrant battery replacement. If you inspect a cell that meets the criteria, report the matter to your local manager responsible for power or your local Power Support:

- Flaring of the PVC sleeve that has cracked the sleeve in the vertical or horizontal direction.
- The bottom of the sleeve appears irregular and is sloughing PVC or epoxy into the cell.

- Corrosion blisters that are greater than 1/2 inch across.

Figure 2: Round Cell Hook and Look Procedure



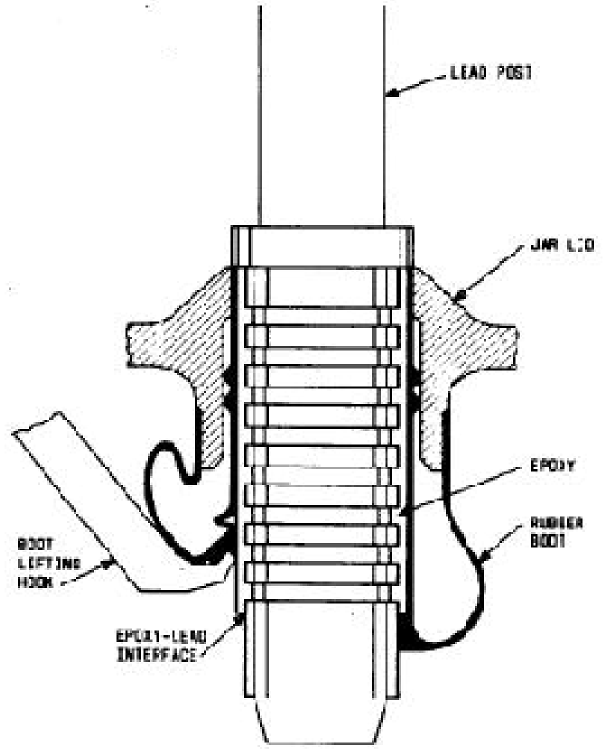


Fig. 4—Cell Post Showing Placement of Boot Lifting Hook

For additional information for KS0472 Lists 1,2,3, and 4 round cell positive post inspection and rating procedures refer to BSP 157-629-702, Paragraph 3.03, the migrated URL link is as follows:

- http://apex.sbc.com/vendor2/mig/bsp/data/bsp1/157/629702/629702.pdf

3.5. 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 sodium bicarbonate (baking 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.

NiCad Batteries: Vents caps can be rinsed in clean water if cleaning is required.

3.6. 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.

NiCad Batteries: Containers and tops can be carefully cleaned using water.

3.6.1. 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.

3.6.2. 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.

3.6.2.1. Handling Major Cracks

If the amount of electrolyte spilled exceeds one gallon, then all efforts should be directed at containing the spill using the AT&T approved acid spill kits. On site neutralization of acid for significant spills is not recommended. A significant spill should be referred to Environmental Management for containment. EM will contain, absorb, and transfer to an appropriate container, then 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. The emergency contact number for Environmental Management is 1-866-492-6836 (1-866 I WANT EM). Additional information can be found at the Environmental Management web site:

- http://em.sbc.com/

The AT&T 13 State Battery Spill Response Procedure can be found at:

- http://em.sbc.com/Topic/Batteries/BatterySpillResponseProcedure.pdf

3.6.2.2. 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.

For assistance in handling a minor battery jar crack, contact your local manager responsible for power or local Power Support representative.

Use the following procedures when temporarily sealing plastic jar cracks:

1. Cover open cracks temporarily with a length 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 sodium bicarbonate (baking soda) solution. Immediately wipe dry.

4. Remove protection strip applied in Step 1.

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 a minimum of 1 inch. A backup piece of tape for extra support can be used to cover the initial piece, especially where compound angles demand tape stretching.

Two acid-resistant tapes that can be used to perform temporary repair can be obtained directly from their manufacturer's and are listed as follows:

1. Part number 502 Vinyl Tape 3 inch roll. From Acutape Corporation, 10 Gold Street, Norwalk, CT 06850. Phone number: 800-722-0133. http://www.acutape.com/ .

2. Part number AC-360 Tape, Vinyl. From The Ramsey Group, Inc., 32 Old Shoals Road, Arden, NC 28704. Phone number: 828-684-2257. http://www.ramsey-group.com/acidresistanttape.htm .

3.6.3. 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.

Concern for battery movement is higher for high seismic areas, such as in California. For all seismic areas, battery spacing shall be checked after each earthquake or severe shock if foamed plastic spacers (intercell spacers) are not used. Use caution, as recommended in Section 2.4.1., to handle the neutralization of the electrolyte after an earthquake.

If any of these conditions have occurred, contact local manager responsible for power or local Power Support for guidance.

3.6.3.1. Intercell Spacers

Intercell spacers shall be made of fire-resistant and anti-static material and are inserted between each battery cell to restrict movement and help keep cells optimally positioned.

If intercell spacers are present, perform visual inspections of the following if any abnormal conditions have occurred, such as a seismic event:

1. Verify intercell spacer is present and properly centered between each cell or jar.
2. Verify the intercell spacer is not deteriorating (broken, crumbling, warped, etc.).
3. If cell or jar movement has occurred, verify the space between each of the end-rails and the end battery cells/jars is less than or equal to 3/16 of an inch or a value specified by the manufacturer.

If any damage has occurred to the intercell spacers or if movement has occurred, contact local manager responsible for power or local Power Support for guidance.

3.7. Electrolyte Level

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

The electrolyte level will be visually checked as a regular routine every four months and may be noted as well during general inspections (typically on a monthly basis). If an extended discharge has not occurred and an visual inspection indicates a need for make up water to be added, the electrolyte level shall have make up water added using either distilled or deionized water (see sections 3.7.2. and 3.7.3.), per local requirements. This should be performed as soon as possible, using safe work procedures. Additional cautions to perform this task are listed in this section and throughout the rest of this document.

PPE 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.

NiCad Batteries: Visually check the electrolyte level. Never let the level fall below the minimum level mark. Use only distilled water to top-off to safe electrolyte level.

The Saft NCX-series batteries use a hydraulic tubing system and electrolyte levels are not easily verifiable by visual inspection. Refer to Section 9.7 .

3.7.1. 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 may be required at regular intervals for specific locations as these cells use up electrolyte at a higher than normal rate. If this occurring, note overall battery condition and review cell and string float voltage. Refer to local management manager responsible for power or local Power Support if this condition accelerates electrolyte usage or other abnormal conditions.

3.7.2. Distilled Water

Distilled water should be used for electrolyte make up.

CAUTION:
The use of any water other than distilled may void the warranty of the battery, and possibly produce detrimental effects on the life of the battery.

3.7.3. Deionized Water

Deionizing systems are still used and should be equipped with a filter to remove sediment and with an organic removal resin to remove soluble organic materials from the water.

CAUTION:
Refer to manufacturer's documentation if deionized systems are used and follow recommendations for maintenance of systems, including filters, and for electrolyte make up.

3.7.4. Maintaining the Electrolyte Level

To maintain the battery electrolyte level, proceed as follows:

- **Use only distilled or deionized water to bring electrolyte up to the required level(Do notoverfill).** When the actual electrolyte temperature is below 50 degrees 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 batteries 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 possibility of electrolyte contamination.

3.8. Electrolyte Temperature

The following sections are primarily for lead acid batteries. Additional information of temperature effects on lead acid batteries is discussed in **Section 3.2.2.** and for NiCad batteries in **Section 9.11** .

3.8.1. Temperature Range

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

3.8.2. 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 degrees 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.

It is recommended to record electrolyte temperature readings during the coldest and warmest times of the year. Refer to Section 10., Table 13. for recommended intervals.

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.

3.8.3. Temperature in Multi-tier Battery Stands

The top row of multi-tier 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 degrees 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.

3.8.4. Freezing of Electrolyte

The electrolyte in any battery must be maintained above the freezing temperature relative to its specific gravity as shown in Table 10. 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 degrees 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 10: Freezing Temperature of Lead Acid Battery Electrolyte

Specific Gravity at 25 C (77 degrees F)	Freezing Temperature		Specific Gravity at 25 C (77 degrees F)	Freezing Temperature	
Lead & Lead Cal.	C	F	VRLA	C	F
1.030	-1.11	+30	1.240	-46.7	-52
1.060	-3.33	+26	1.270	-65	-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	N/A	N/A	N/A
1.210	-30.6	-23	N/A	N/A	N/A

3.9. Specific Gravity

Specific gravity of batteries should be checked after installation. For lead calcium and lead antimony batteries, check specific gravity if individual cell float voltage is below normal. See Section 3.2. 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 for Central Office, CDO, CEV and RT applications. Specific Gravity readings will be used for trouble test only.

NOTE:
Specific Gravity readings are required on a routine basis for the Standby Engine Flooded Batteries.

3.9.1. 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.

3.9.2. Digital Hydrometer and Refractometer Usage

Digital hydrometers can be used to check specific gravity and temperature of flooded lead acid batteries. Some digital hydrometers can also measure the specific gravity and temperature of NiCad batteries. The Saft batteries discussed in this document typically do not require specific gravity readings.

Digital hydrometers are an optional piece of test equipment as listed in Section 3.1. and are efficient way of performing specific gravity and temperature measurements. If used, exercise care and caution to avoid spillage onto the battery container or connections. Digital hydrometers may require calibration using an electrolyte of known specific gravity. Follow manufacturer instructions when used and ensure that all cleaning and storage procedures are followed.

Refractometers are an optional piece of test equipment as listed in Section 3.1. and can also be used to measure specific gravity. Only a few models are available, one manufacturer is mentioned in Section 3.1 .

Refractometers can also be used to measure engine coolant freeze point and glycol concentration. If used, exercise care and caution to avoid spillage onto the battery container or connections. Follow manufacturer instructions when used and ensure that all cleaning and storage procedures are followed.

3.9.3. Specific Gravity Readings

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, and should be avoided.

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 11. 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 11: 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

3.9.3.1. 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.

3.9.3.2. 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.

3.9.4. 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 degrees 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 degrees F that the electrolyte temperature is above 77 degrees F or by subtracting 1 point (0.001) for each 3 degrees F that the electrolyte temperature is below 77 degrees F. See Table 12.

Table 12: 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	N/A	N/A

3.9.5. Specific Gravity Out of Range

Typically, 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 indicates a drop of 25 points below nominal value. If the specific gravity is still low after boost charging, or if the condition reappears within a year of boost charging, contact your local manager responsible for power or local Power Support group.

WARNING:
Read Section 2.5.3. Charging and Discharging before boost.

3.10. Lead Sulfate Crystals

During normal discharge of a battery, lead sulfate is formed. If a battery is permitted to discharge, habitually under charged, or is neglected, the sulfate crystal formation will be visually evident. Sulfation will reduce the capacity of the battery.

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.

3.10.1. 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 1: 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.

3.10.2. 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 your local manager responsible for power or local Power Support.

3.10.3. 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(ies) measure 2.09 volts or less and the battery is heavily crystalline, the battery is shorted and should be reported to your local manager responsible for power or local Power Support.
- **Battery Temperature Variation**: Measure temperatures of batteries in each tier of the string to determine the extremes of temperature differences. Temperature differences of 5 degrees 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 degrees 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(ies) should be boost charged with a single cell 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(ies) should be reported to your local manager responsible for power or local Power Support group. Copies of the battery records should accompany that report.

WARNING:
Read Section 2.5.3. Charging and Discharging before boost charging.

3.10.4. Hydration

Another condition that may occur when a battery has been over-discharged and left in a discharged state without a timely recharge may permanently damage the cell(s), this condition is known as “hydration”. This is a phenomenon in which the specific gravity of the electrolyte has been reduced to a level so low that it permits the lead components to dissolve into the electrolyte, totally destroying the cell.

This chemical reaction forms many compounds and salts generically referred to as hydrate, these compounds clog separator pores and, upon recharge, react to form metallic lead. A white residue ring will appear about midpoint around the interior of the cell. This will create thousands of short circuit paths and the effect of these short circuits may go unnoticed unless there is a slight increase in charging current. If this occurs, as the reaction continues, the short circuits become so extensive it is almost impossible to keep the cells charged. Finally, the cell experiences total failure.

3.11. Positive Plate Growth And Bowing (Rectangular Batteries)

Plate growth and bowing can be gauged by eye. Only the positive plates are expected to grow (or swell). 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. This is known as "bowing" and is an internal condition when viewing the end of the battery jar.

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.

If positive plate growth is occurring, this could cause the cell or jar to "swell", the jar case can expand or bulge, grow past the separators, and exert pressure on the inner walls of the jar. This deformation of the jar case is sometimes referred to as "swelling" and is an external visual indication.

Check the jar tops and post seals for separation.

If these conditions are occurring, refer to local management responsible for power for guidance.

3.12. Negative Plates (Rectangular Batteries)

The outside negative plates may 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. An 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 monitored. Perform voltage and specific gravity measurements to ensure the cell remains within limits and shows no declining trend. In case of doubt, run a capacity discharge test.

3.13. 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 sodium bicarbonate (baking 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 sodium bicarbonate (baking 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 petroleum 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.

4. 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.

Follow all safe work procedures when conducting discharge tests described in this section, review Section 2. , this includes using proper PPE, recognizing ESD requirements, electrolyte and gassing concerns and exercising other safe work procedures. In addition to safe work procedures and concerns listed in Section 2. of this document, refer to the manufacturer's documentation when conducting the following discharge procedures to insure personnel safety and to avoid battery and equipment hazards.

Observe and practice proper polarity of tests leads, connections, and use of discharge equipment.

Discharge Procedures are also included in Section 15 .

4.1. Introduction

The Battery Discharge procedures are designed to ensure that:

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

The Battery Discharge procedures must be thoroughly understood before beginning any procedure. The Battery Discharge Test step procedures are included in Section 15 . 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 cell drops below 1.90 volts. For NiCad batteries, with 38 cells ensure string voltage does not fall below 46.5 volts or 1.18 VPC. If using 37 cells, MPVC will be 1.21 volts.
- Any of the intercell connectors are not conducting properly. (Intercell connector procedures are described in Section 5. and Section 15.)

  If any of the above events occur, restore the rectifiers. Initiate corrective action once the battery string(s) has returned to nominal float voltage. If battery string(s) cannot be returned to service, immediately contact local manager responsible for power and local Power Support for guidance.

  If a commercial power failure has occurred, review office status and contact the NSAC or equivalent network monitoring center. Review the Central Office Power Failure Instructions for additional information.

  - http://apex.sbc.com/bookview/bookview.jsp?bookname=ATT-TELCO-002-200-442&showid=null

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. Refer to Section 15. for step-by-step procedures for completing the Battery Discharge 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.

4.1.1. 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. AT&T recommends the discharge test be performed every year as part of the annual Power Evaluation. A link to the ATT 6558 Power Evaluation form is included in Section 12 . If however the annual power review is not performed the manufactures minimum requirements listed below should be followed.

Additional information can be found in the following document, Central Office Power Equipment Load Test and Operational Review Trial, the web site is:

- http://apex.sbc.com/bookview/bookview.jsp?bookname=ATT-TELCO-002-217-157&showid=null

(Round Cells) 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.

4.1.2. 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:

- Individual cell readings should be taken and logged.
- Intercell connectors should be checked for proper torque, or if available, perform intercell connector resistance,

see Section 3.3. Perform any corrective actions before performing discharge test, all deviations should be logged and monitored.

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. Refer to step procedures included in Section 15. The Battery Discharge Test & Intercell Connector Log should be used for recording all information gathered during the discharge test. A link to Form ATT 6556 Battery Discharge Test & Intercell Connector Log is provided in Section 12 .

NOTE:
If individual cell voltage readings are below the normal operating range a single cell discharge test should be preformed. The discharge test set manufacturer's 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 form ATT 6557 - 5 Hour Battery Discharge Form. A link to this form is provided in Section 12 .

4.2. Single Cell Discharge Test

CAUTION:
Follow all safety precautions listed in this document. This test can only be performed on flooded lead acid cells. Contact your local manager responsible for power or local Power Support **before** performing this test.

A single cell or several cells in a battery string based upon observation and logs may indicate that it is near end-of-life or have insufficient capacity. Discharge testing may be used to determine optimum time for replacement. Older discharge test sets can be used if still available and in proper working condition, however, an alternative test set is listed in Section 3.1. under Test Equipment. This optional test set is the Alber SCT-200 Single Cell Test and Charger System. The Alber SCT-200 may also be used to recharge the cell after a discharge test.

Follow test equipment documentation when performing these tests. Determine end cell voltage (e.g. 1.9 or 1.75 volts) prior to performing discharge test and monitor voltage closely for duration of procedure. Record date of test and duration in minutes of procedure.

The discharge test should be run directly off float voltage without prior boost charge to battery string. Cells to be tested shall have been on float for at least 3 months without a boost charge and where a power failure exceeding 30 minutes has not occurred within past 6 weeks.

For a working cell, perform a visual observation of cell before test.

The terminal connections between the cell to be tested and the discharger test set leads must be thoroughly cleaned before use.

Record and log the following prior to the discharge test and immediately after the discharge test:

- String voltage.
- Cell float voltage.
- Electrolyte temperature.

Monitor and record cell voltage and electrolyte temperature before and after the test procedure.

If more than one cell is to be discharged tested, the discharge test procedure should be performed one cell at a time, the overall string monitored and maintained at float voltage before proceeding to the next cell to be tested. Follow test set documentation and battery manufacturer documentation to recharge cell that has undergone a discharge test procedure before proceeding to next cell.

If several cells are to be tested, for example two cells can be tested using the Alber SCT-200 unit, the string should be disconnected from the power plant and the testing performed. If only a single string is present, contact local manager responsible for power and local Power Support for guidance to determine cell(s) condition and possible replacement.

After testing is performed, review results and determine if cell(s) require replacement or have sufficient capacity for continued use. Maintain observation of the cell(s) at a maximum of 4 month intervals.

5. Testing of Intercell Connectors

Intercell connectors are the metallic straps interconnecting one cell in a battery string to the next cell. A poor connection (or connections) could reduce the reliability of the overall battery string. Inter-tier and inter-row connections, with or without connection plates, should also be considered when performing intercell connection measurements.

Intercell connection testing can be performed using a variety of methods, the preferred methods are discussed in **Sections 6.** and **Section 6.1.** and provides information about non-intrusive (battery conductance) testing and includes information on intercell connection resistance using Albers and Midtronics test sets. Battery conductance testing is optional but can be performed along with the intercell connection testing.

It is recommended to establish a baseline upon initial installation of intercell resistance measurements using consistent test methods. Whether this can be performed at the initial installation or at a later date, record the baseline readings and retain for the life of the batteries, to be used as a reference point for all future readings.

The intercell resistance (micro-ohm) values should be consistent over time. If retests are trending towards higher resistance values, this could indicate corrosion or loose connections that could affect performance.

Intercell connection resistance will vary with cell size, connection type and the number of intercell connectors used.

One type of micro-ohm resistance measurements that can be used is using a digital micro-ohm meter, commonly known as a Digital Low Resistance Micro-Ohm meter (DLRO). A more detailed discussion on this optional type of testing is provided in **Section 16.1 and 16.1.1** . If DLRO type testing is required, contact local Power Support for assistance.

If DLRO testing is to be performed on cable and intercell connections, note the following danger and warning statements.

DANGER:
When using a DLRO, do not perform these measurements across the battery cell, only across the intercell connectors between two cells. Testing across the cell(s) may cause personal injury, damage to the test meter and may damage the cell(s). Refer to Figure 9. for the correct way to perform these measurements and note the improper methods.

These measurements shall be performed during float operation. If a compete evaluation of the battery string is required including discharge tests, this information is detailed in Section 15. of this document.

NOTE:
If corrective action is required, such as the intercell connections require re-torquing, replacement or just need to be cleaned, refer to Sections 3.3. through 3.3.5. for more information.

6. Testing Of Batteries

This section will discuss non-intrusive testing of battery cells to determine battery capacity, non-intrusive testing is sometimes referred to as battery conductance testing. Section 6.1. will provide more detail on this type of testing and will include information on intercell connection resistance measurements.

Field data has shown active testing by partially discharging Valve Regulated Lead Acid (VRLA) 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.

Non-intrusive testing of VRLA and Lead Acid Flooded Cell batteries involves the measurement of battery conductance. At least one commercially available non-intrusive test instrument is currently approved and can be used for that purpose. The Midtronics model CTM-100.

The method of non-intrusive testing provides a correlation between capacity and conductance to project the useful life of the battery. The Midtronics CTM-100 Micro Celltron Battery Conductance Tester and the Midtronics MICRO400 Engine Starting Battery Tester are approved for use in AT&T. See PAN 20001080 for the CTM-100 unit, this can be found in APEx under "Vendor Docs":

- http://apex.sbc.com/archived_docs_frame.jsp

For the Midtronics MICRO400, refer to the following:

- http://mechteam.sbc.com:8080/docs/PANs/20001077%20.pdf

Enlist the aid of local manager responsible for power or local Power Support on how to procure one of these meters or an equivalent.

NOTE:
This type of testing should not be performed on NiCad batteries.

6.1. Battery Conductance Testing and Intercell Connection Measurements

The primary test sets available to perform battery conductance tests are manufactured by Albers and Midtronics, these test sets can also be used to determine intercell connection resistances. The Albers test set is used to measure the internal resistance of the cell (and intercell connectors) and will display units in micro-ohms. If the Midtronics test set is used, it performs basically the same type of tests but uses different technology and uses the terminology "jar and strap" tests (the word strap and intercell connector are used interchangeably). The Midtronics will display the units in siemens or mhos. Siemens and mhos are identical and are the inverse of ohms. Basically, conductance is the reciprocal (inverse) of electrical resistance.

The test sets made by Albers and Midtronics each use different measuring technology and the measurements obtained from each will not be (inversely) identical. Whichever test set is used, note the parameters of what is being tested to ensure that measurements obtained are consistent.

Because of the high number of cells and intercell connectors present, these test sets have well defined set up features and memory storage for data collected. This data is stored and can be printed out or transferred to a company computer using the software and hardware provided with the test sets.

There are several different test sets available from each of these companies depending upon which vintage of test set available. Note how many test leads are available and refer to the test set documentation on how to properly make connections with test leads, these sets can have two test leads up to four test leads. Care should be taken when connecting test leads to battery posts so as not to damage the posts and intercell connectors.

Before battery conductance testing is to be performed, it should be determined what items are to be tested:

1. What type of set is to be used: Albers or Midtronics.
2. The test set used will determine if units obtained will be in micro-ohms or in siemens (mhos).
3. Then determine what tests are to be performed:

    A. Testing the intercell connectors only.

    B. Testing the battery capacity and intercell connectors.

    C. Testing the battery capacity only.

Some additional information about these test sets include the following, in addition to measuring micro-ohms/conductance they can also measure cell voltage and temperature. Typically these meters can measure one cell up to approximately eight cells (or 2 volts to 16 volts) including the intercell connectors, these test sets cannot measure the whole string. These meters are able to measure and store this information up to several hundred cells and intercell connectors in the order in which they were measured.

Refer to the test set manufacturers documentation for more information on how to use these sets.

Use the following steps to perform these tests (as appropriate for test set used), exercise care when performing these measurements to determine battery capacity (and intercell connection resistance measurements):

1. Use proper PPE including safety glasses/goggles.
2. Set up meter to coincide with items to be tested, see above list.
3. Do not stand directly over the cells when performing these measurements. Use correct polarity of test probes.
4. For test set used, ensure number of test leads needed and note proper connection points. Use extreme care with test leads/probes and correct method of making contact with test leads/probes.
5. Use terminal battery posts for test lead contact points. Avoid using the bolt head as a contact point as this will add resistance to the measurement.

6. Be consistent with your measurements, measure at the same connection points throughout whole process.

7. Take care in performing these tests, there are a great number of items being repetitively tested and the idea is to look for trending in these measurements.

8. If test set reading indicates cell and/or intercell connector failing test, retest and compare measurements.

9. For Midtronics jar (conductance) measurements, the following URL link may be used to determine if the battery jar (cell) is within limits, refer to the battery manufacturer for additional information as needed. Retest, and if it falls outside of limits a second time, refer this to your local management responsible for power and local Power Support for guidance.

   - http://www.midtronics.com/conductance_Industrial.html

10. For Albers battery cell resistance measurements, the following criteria is used:

    - After establishing a good baseline value for cells under test, if a cell's internal resistance increases by 25 percent above this baseline, the cell has failed the test. Retest, and if it falls outside of limits a second time, refer this to your local management responsible for power and local Power Support for guidance.

11. For the intercell connection resistances, depending on the meter used and how the micro-ohm resistance values are presented, the following criteria may be used to determine if the intercell connectors require corrective action (additional information is referenced in **Section 15.3.4.** , including Figures 7. and 8.):

    - Micro-ohm resistance values that are greater than 60 micro-ohms.
    - Or greater than 30 micro-ohms above the average.
    - Size and quantity of intercell connectors will affect the resistance readings. Engineering judgment may be required to determine whether corrective action is necessary.

    Failing either criteria will require the intercell connectors and hardware to be disassembled, cleaned, reassembled and retested. Use initial torque values and apply NO-OX-ID A-Special Corrosion Inhibitor to intercell connectors and posts. See Sections 3.3. through 3.3.5. for more information. In some cases, the intercell connectors and hardware will need to be replaced, refer to Sections 3.3. through 3.3.5.

12. If possible, perform these measurements for inter-tier or inter-row connections (with or without connection plates) and record. The micro-ohm resistance values will be different from that of the intercell connection values, look for trending from past tests or other similar battery strings. Record these measurements as well and correct as needed.

> **NOTE:**
> While micro-ohm or conductance measurements are performed during normal float operation, thermal scan and current measurements methods shall be performed during the actual battery discharge test. In addition to the information being provided here, more information on how to perform these tests are outlined in **Section 15.3.4** .

7. 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(ies) 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 (non)-reversed 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.

7.1. Identification of a Reversed Battery(ies)

> **NOTE:**
> If you encounter a reversed battery condition contact your local manager responsible for power and local Power Support immediately for assistance.

If a battery is suspected of being reversed, perform the following steps with guidance and assistance from local Power Support, **exercise extreme care**:

- Follow all safety procedures with DMM and note polarity of test leads. See Section 2.5.7 .
- If at any time a battery cell reads more than 2.5 volts, that battery(ies) has been reversed and corrective action is required. Consult with local Power Support and Power COE.

- 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.

8. 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. through 6., most paragraphs in this section refer to detailed procedures covered by an earlier section.

8.1. Electrical Shocks and Burns Protection

Before any work is performed on VRLA batteries, the same safety guidelines listed in **Section 2.** shall apply.

8.2. Neutralizing Agents

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. Additional information is referenced in Section 2.4.1 .

8.3. Tool Materials and Test Equipment

Follow the equipment list specified in Section 3.1 .

8.4. Float Current

The float current should be checked at least once a month. Refer to the manufacturer's literature.

8.5. Float Voltage

VRLA 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 degrees F. Refer to **Section 3.2.** and **Table 5** .

8.5.1. Deviation from Float Voltage and Corrective Action

Section 3.2.3. contains details of possible float voltage deviation conditions. If these are not the cause of the problem, then read the following sections, Section 8.5.1.1. and Section 8.5.1.2.

8.5.1.1. Battery Voltage High

VRLA 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(ies) in question. If the capacity is low, the batteries 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.

8.5.1.2. Battery Voltage Low

For batteries that were float charging within the required range at the previous annual voltage reading, float voltages less than 2.20 volts indicate a severe abnormality (possibly a short circuit). **Shorted batteries can lead to thermal runaway**. See Caution note immediately.

CAUTION:
The condition should be immediately reported to your local manager responsible for power or local Power Support for correction and possible replacement.

8.6. Battery Connections

Section 3.3. details all the maintenance procedures for battery connections that are applicable to both flooded and VRLA batteries, further information will be provided in Sections 5. and 6.

8.7. Battery Re-sealable Gas Vents

In VRLA batteries, each battery has an individual re-sealable 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 3.4. 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.

8.8. Battery Container

VRLA batteries with severe cracked or broken cases are not to be treated (except for absorbing electrolyte pools) by AT&T 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.

8.9. Surface Temperature

The use of a thermal scanner 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(ies) that is 8-10 degrees 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(ies) is replaced or other cause(s) is found.

A thermal scanner is available to order in the above Test Equipment section in **Section 3.1** to perform these thermal measurements.

DANGER:
Contact your local manager responsible for power and local Power Support immediately if any cell(s) temperature abnormality is found.

The local manager responsible for power and local Power Support will provide guidance on what corrective actions are to be taken, exercise extreme care. If this concern has been found in the performance of normal maintenance, note this concern, date, name of technician and all corrective actions taken.

8.10. Freezing of Electrolyte

The approximate electrolyte freezing temperature of a fully charged VRLA is -95 degrees 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. For additional information, refer to Section 3.8.4.

8.11. Discharge Capacity Test

Refer to Section 4. for discharge capacity test procedures.

8.12. Testing of VRLA

Follow testing procedures in Section 5.

9. Nickel Cadmium Batteries

The use of NiCad batteries in small central office applications is considered acceptable assuming the power plant can accommodate the voltage increase. The NiCads provide an acceptable alternative to flooded lead acid batteries where there is limited floor space and/or power demands will be limited. The NCX series is used for central office applications.

CAUTION:
When used, NiCads shall not be mixed with any other battery technology within the same power plant.

NiCad batteries are also used for engine start batteries, this is primarily the SPH series.

9.1. Electrical Shocks and Burns Protection

Before any work is performed on NiCad batteries, the same safety guidelines listed in **Section 2.** shall apply.

9.2. Neutralizing Agents

The electrolyte for Nickel Cadmium batteries is an alkaline aqueous solution and is different from that of the lead acid battery electrolyte and requires different procedures to contain. Ramsey Group has provided a NiCad acid spill and containment kit. Feature and function mirror the acid spill kit, but is designed specifically for Nickel Cadmium battery products. The FR-914 and NS-640 kits are only for use with NiCad batteries, to order, refer to **Table 2.** in Section 2.4.1. NiCad product labeling will always be bright orange where sulfuric products are safety yellow. AT&T practices and policies for the deployment of the products shall follow the same guidelines as referenced in Section 2.4.1 .

9.3. Tool Materials and Test Equipment

Follow the equipment list specified in Section 3.1 .

If working on Saft batteries, will need a factory insulated 10 mm socket and torque wrench. All tools must be factory double insulated as defined in Section 3.1.

9.4. Float Current

Float current for each string needs to be checked and recorded monthly, see Section 12. and refer to ATT 5332 - NiCad String Storage Battery Record for the form download. In addition, cell voltage readings may not be able to be performed on a regular maintenance schedule as strings may be secured in a bolted arrangement and normally inaccessible. Current readings will be more important to monitor overall battery condition. A DC Clamp-on milliamp-meter should be used to perform this measurement.

The current measurement can be performed at any safe convenient or accessible point in the string.

Initial float current for the Saft NCX series are as follows, these values are based upon manufacturer recommendations using a base calibration of 104 degrees F (40 degrees C), this temperature is used as an average as these types of batteries are deployed not only in central offices but also in Electronic Equipment Enclosures which are subject to much greater temperature extremes:

- 80 milli-amps for the NCX-80.
- 125 milli-amps for the NCX-125.
- 160 milli-amps for the NCX-160.

The Saft NCX series batteries may be approaching end of life and may require replacement if the float current measurements increase to or remain above the following values:

- 450 milli-amps for the NCX-80.

- 650 milli-amps for the NCX-125.
- 850 milli-amps for the NCX-160.

9.5. Float Voltage

Table 5. listed in Section 3.2. indicate that NiCad battery strings will have a float voltage of 54.34 volts not 52.08 or 52.80 volts.

CAUTION:
NiCad battery types shall not be mixed with other battery types.

Cell float voltage for NiCads is 1.43 volts per cell, a 38 cell string will float at 54.34 volts. Most central office strings will utilize 38 cells, however, in limited applications it may occur that only 37 cells are used and the string voltage will be 52.91 volts.

NiCad batteries are charged using constant voltage charging.

The float voltage range for the Saft NCX series is 1.40 to 1.46 VPC according to the manufacturer, refer to Table 5 . If floated below 1.43 VPC average, the battery string may require more than 24 hours to recharge to full capacity after a deep discharge. If floated above 1.43 VPC average, water usage may increase and may be necessary to replenish the electrolyte as often as every 6 months.

9.5.1. Deviation from Float Voltage and Corrective Action

Section 3.2.4. contains details of possible float voltage deviation conditions. If these details do not explain the problem, refer to Section 9.5.1.1. and Section 9.5.1.2.

9.5.1.1. Battery Voltage High

The normal float voltage for a NiCad Saft NCX battery cell is 1.43 VPC, any cells within a NiCad string with a voltage of 1.53 VPC or higher should be monitored closely. Visually observe for any abnormal conditions, and contact your local manager responsible for power or local Power Support with this concern. Refer to the manufacturer for additional support.

Occasional overcharging of NiCads batteries will not harm the operation of these cells. If this occurs, identify the cause and correct as soon as possible to normal operation. After a discharge of a NiCad system, power plant recharging will be constant voltage. The duration of discharge will determine how long it will take to recharge these systems.

9.5.1.2. Battery Voltage Low

NiCad batteries are extremely robust, NiCads can be discharged to zero (0) volts per cell (VPC) and may even reverse. Cells discharged to zero volts or reversed can be brought back to normal or near normal float volt and capacity. Take extreme care when recharging these cells as high current charging could cause hazardous gassing or electrolyte spillage. If cell voltage should fall to zero volts or reverse, contact your local manager responsible for power or local Power Support with this concern and refer to the manufacturer for additional support.

Any cell within a Saft NiCad NCX battery string should not have a float voltage of 1.33 VPC or lower. If cells are observed to be floating at 1.33 VPC or lower, visually observe for any abnormal conditions, and contact your local manager responsible for power or local Power Support with this concern and refer to the manufacturer for additional support. It may be necessary to perform a boost charge, perform this activity with careful observation and monitoring. It may also be necessary to perform this activity by removing this string from the plant and perform a recharge test, see Section 9.13. for additional information.

On discharge, operating voltage for Saft NCX in central office installations shall use a MVPC of 1.18 VDC per cell.

For engine start batteries using NiCad batteries, the voltage may actually drop below 1 volt per cell. Initially, the cell voltage may drop to as low as 0.65 VPC (known as the locked-rotor or breakover/valley voltage) and as soon as the engine starts rotating, the cell voltage will be much higher but could be 0.85 VPC at the end of the starting cycle.

9.6. Battery Connections

Sections 3.3. and 3.3.1. describe applicable maintenance procedures for battery connections. Refer to the manufacturer's installation and operation literature.

CAUTION:
For Saft NiCad battery systems, Anderson or similar type quick disconnect connectors are Not Approved For Use in Central Office applications.

9.7. Hydraulic Tubing System

NCX battery strings are equipped with a hydraulic tubing system. This system serves to vent the battery system through a single flame arrestor and acts with the Central Watering System (CWS) as a central point for watering. Visually inspect the hydraulic tubing system hoses and connections once a month, refer to following list.

- Is the tubing system free from kinks.

- Is all tubing above the top of the battery and is it free from traps (low spots).
- Is the flame arrestor installed at the positive string battery terminal, and is a shut-off assembly installed at the negative string terminal.
- Are all tubing connections made with clamps or tie wraps (to ensure tight seal).

Manufacturer guidelines suggest typical watering of the batteries every five years. AT&T requires watering annually.

When performing watering of battery strings, will need to connect the NCX watering kit to the string. The NCX watering kit comes in two types, one is gravity fed, the other has a low pressure pump. The water container of the gravity kit will need to be elevated about 2 feet above the batteries. Use distilled water only.

Water usage may increase and may be necessary to replenish the electrolyte as often as every 6 months, if float voltage remains above 1.43 VPC average.

Saft sometimes uses the term WFS which is basically interchangeable with the term CWS. WFS stands for Water Filling System.

Information on how to order some of the Saft watering kits and associated equipment in the following list, note the PID numbers as these items can be ordered from the ATT Procurement (Aproms) website:

- Watering Kit (gravity feed), PID: 301167201, Saft part number: 80-03514-01.
- Tubing Kit (for watering kit), PID: 301167219, Saft part number: 80-03515-01.
- 5 Gallon Carboy (for watering kit), PID: 301167227, Saft part number: 80-03513-01.
- Pump Aided Water Filling Cart (110VAC); Fills 1 to 5 batteries, PID: 301167235, Saft part number: 80-03610-01.
- De-ionizer Column, PID: 301167243, Saft part number: 80-03602-01.
- De-inoizer Cartridge, PID: 301167250, Saft part number: 80-03599-01.

9.8. Engine Start Battery Electrolyte

Saft SPH series batteries are used for engine starting and control battery purposes.

Visually inspect electrolyte levels, and replenish with distilled water only to maintain electrolyte within minimum and maximum level marks.

9.9. Battery Vents

For Saft NCX batteries, depending upon the battery cell/jar configuration, there is a central flame arrester vent for these systems. Refer to manufacturer literature for more information.

Additional information can be found on AT&T APEX vendor documentation web site, look for Saft:

- http://apex.sbc.com/vendor_docs_frame.jsp?front

9.10. Battery Container

NiCad batteries can be stored up to two years. Do not expose batteries to direct sunlight.

For NiCad batteries, a white substance resembling corrosion can appear at the terminals, particularly on the (+) positive terminals. It is the result of gasses evolved from the cell during operation which carries a negative charge, and is therefore attracted to the positive terminals. This substance is soluble in water, and should be cleaned or removed with a cloth and clear water, no solvents or detergent.

9.11. Electrolyte Temperature

For NiCad batteries, the best performance and maximum service life batteries should be kept between the ambient temperature ranges of 50 degrees F and 86 degrees F. NiCad batteries can handle a large temperature variation without permanent damage, if temperatures occur outside of these values check the battery vendors documentation for additional direction.

9.12. Freezing of Electrolyte

For NiCad batteries, the electrolyte concentration does not change during charge or discharge, there is no risk for unexpected freezing.

9.13. Discharge Capacity Test

Refer to Section 4. for discharge capacity test procedures.

CAUTION:

NiCads can be discharged to a functional operating voltage of 1.1 to 1.15 VPC (41.8 or 43.7 volts per string, respectively). However, this should be avoided as the minimum plant voltage can not be below 44.64 volts, monitor NiCads strings, with 38 cells, on discharge and ensure string voltage does not fall below 44.64 volts or 1.18 VPC. If using 37 cells, MPVC will be 1.21 volts.

CAUTION:
If a Saft NiCad NCX battery string is suspected of being near end of life, the string must be disconnected from service to evaluate the string or cells for suitability for continued use.

Some concerns that could require the battery string/cells to be near end of life include the following but are not limited to these concerns:

- Abnormal voltage readings that cannot be corrected, see Section 9.5. for more information.
- Current readings are abnormally high while on float, see Section 9.4.
- Discharge tests indicate reduced capacity.
- Electrolyte usage increases.

9.14. Testing of NiCad

Conductance testing is **not** recommended for NiCad batteries.

10. Maintenance Schedules

The following tasks in this maintenance schedule are listed in **ATT 5330 - Flooded String Storage Battery Record** form.

Table 13: Maintenance Schedules

Section	Maintenance Task **Flooded** Battery	Frequency
3.	Visual Inspection	1 Month
3.2.	Float Voltage (Battery String)	1 Month
3.2.	Float Voltage (Individual Cell)	4 Months
3.3.	Battery Connection	4 Months
3.3.2	Intercell/Cable Mechanical Torque	12 Months ***
3.4.	Jar-Cover and Post Seals	4 Months
3.6.	Battery Container	4 Months
3.7.	Electrolyte Level	4 Months
3.8.2.	Electrolyte Temperature Readings	4 Months
3.10.	Lead Sulfate Crystal Inspection	4 Months
3.11.	Plate Growth and Bowing Inspection	4 Months
3.12.	Negative Plate Inspection	4 Months
3.13.	Racks, Stands and Battery Container Cleaning	4 Months
2.5.3.1.	Boost Charge	If Required *
4.	Discharge Test	12 Months **
5.	Intercell Connector Test	Minimum every 12 Months ***

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

** Discharge tests will be preformed during the annual power review. A link to the ATT 6558 Power Evaluation form is included in Section 12 .

*** Refer to Section 3.3. to determine which method to apply.

The following tasks in this maintenance schedule are listed in the **ATT 5335, 5336 and 5337** forms.

Table 14: Maintenance Schedules

Section	Maintenance Task **Engine Starting** Battery	Frequency
3.	Visual Inspection	1 Month
3.2.	Float Voltage (Battery String)	1 Month
3.2.	Individual Cell Voltage - (NiCad)	4 Months
3.2.	Battery Case Voltage - (Optima) *	4 Months
3.3.	Battery Connection	6 Months
3.7.4.	Electrolyte Level	1 Month
3.9.3.	Specific Gravity Readings	4 Months
3.13.	Racks, Stands and Battery Container Cleaning	6 Months

* Existing VRLA or flooded lead acid engine starting batteries, until planned replacement. See http://apex.sbc.com/bookview/bookview.jsp?bookname=ATT-TELCO-PAN-2003-3329& and/or http://mechteam.sbc.com:8080/docs/PANs/20001161.pdf .

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

The following tasks in this maintenance schedule are listed in **ATT 5331 - VRLA String Storage Battery Record** form.

Table 15: Maintenance Schedules

Section	Maintenance Task **VRLA Battery**	Frequency
3.	Visual Inspection	1 Month
8.4.	Plant Current	1 Month
8.5.	Float Voltage (Battery String)	1 Month
8.5.	Float Voltage (Individual Cell)	4 Months
8.6.	Battery Connection	4 Months
8.7.	Battery Re-sealable Gas Vents	4 Months
8.8.	Battery Container	4 Months
8.9.	Surface Temperature	4 Months
3.13.	Racks, Stands and Battery Container Cleaning	4 Months
3.3.2.	Intercell/Cable Mechanical Torque	12 Months ***
4.	Discharge Test	12 Months **
5.	Intercell Connector Test	12 Months ***
6.	Testing of Batteries	12 Months **
2.5.3.1.	Boost Charge	If Required *

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

** Discharge tests will be preformed during the annual power review. A link to the ATT 6558 Power Evaluation form is included in Section 12 .

*** Refer to Section 3.3. to determine which method to apply.

The following tasks in this maintenance schedule are listed in **ATT 5332 - NiCad String Storage Battery Record** form.

Table 16: Maintenance Schedules

Section	Maintenance Task **NiCad Battery**	Frequency
3.	Visual Inspection	1 Month
9.5.	Float Voltage (Battery String)	1 Month
9.11.	Battery Temperature	1 Month
9.4.	Plant Current	1 Month
9.7.	Hydraulic Tubing Inspection	1 Month
9.5.	Float Voltage (Individual Cell)	4 Months
9.6.	Battery Connection	4 Months
9.9.	Battery Central Flame Arrester Vents	4 Months
9.10.	Battery Container	4 Months
3.13.	Racks, Stands and Battery Container Cleaning	4 Months
9.13.	Discharge Test	12 Months ***
3.2.4.	Boost Charge	If Required **
3.3.2.	Intercell/Cable Mechanical Torque	If Required *
3.3.2.	Intercell Connector Test	If Required *
9.14.	Conductance Testing of Batteries	N/A

* Not necessary unless determined by suspicion that battery has a problem, indications can be consistent loss of water, unusual float current, and/or unusual float voltage reading.

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

*** Discharge tests will be preformed during the annual power review. A link to the ATT 6558 Power Evaluation form is included in Section 12 .

11. Engine Start Battery Maintenance

NOTE:
AT&T East has System Automation utilized to complete performance testing of Standby Engine Start batteries but may use following procedures as required.

The following maintenance items are based on the type of Standby Engine Start Batteries deployed. This section will also discuss assessing the condition of the engine start batteries. These tests include conductance testing (non-intrusive), locked rotor or valley voltage (intrusive), and will describe an engine start battery crank testing procedure.

This section also applies to start battery systems used for Standby Turbine Gear Reduction Units.

Table 17: Engine Start Battery Maintenance

Battery Type	Maintenance Items to perform on Engine Start Battery Types							
	Voltage Testing	Charging Current Measure-ment	Clean	Neutralize	Conduct-ance Testing	Verify the posts and connections are clean and tight	Specific Gravity per manufac-turer spe-cifications	Visually check and re-plenish Electro-lyte to specified level
Flooded NiCad	X	X	X	X				As needed.
Sealed (includes Optima)	X	X	X	X	X	X		
Flooded Lead Acid	X	X	X	X	X	X	X	As needed.

11.1. Engine Start Battery Measurements

This section addresses measurements that are performed for battery charging systems for standby engine battery systems. Not all measurements described in the following are applicable to all battery types deployed in the AT&T network. For example, specific gravity measurements cannot be performed on sealed VRLA type batteries.

Use the following forms for standby engine battery maintenance:

- ATT 5335 - Standby Engine Flooded Start Battery Record. See Note 1. underneath Table 6.
- ATT 5336 - Standby Engine Flooded NiCad Start Battery Record.
- ATT 5337 - Standby Engine VRLA/Sealed Start Battery Record.

11.1.1. Float Voltage

Float voltage measurements shall be performed on standby engine battery systems, these include measurements on the following:

- Individual cells.
- Battery - multiple cells in one jar.
- Entire string.

When performing voltage measurements, a DMM should be used, exercise caution and use proper PPE. In some cases, individual cell measurements cannot be performed, measure battery cells/jars as applicable and note on forms. Compare measurements performed with a DMM on the entire string to the battery charger voltage meter indication, if a substantial voltage difference is noted, refer this to the local manager responsible for power or Power Support for guidance.

Refer to Table 6. for float voltages and ranges for each battery type.

11.1.2. Standby Engine Battery Charger Current

All standby generator systems have start batteries that maintain a continual float charge by applying a small amount of current, these charger systems maintain optimal voltage of the start batteries. They also recharge the batteries after engine start procedures have occurred. These charging systems have meter indication for voltage and in most cases for current.

If these chargers have a meter indication for current, note this current (amps) reading in the following forms for standby generator battery maintenance.

11.1.3. Specific Gravity Measurements

Specific Gravity measurements shall only be performed on Standby Engine Flooded Batteries. Use proper PPE including wearing safety glasses/goggles, using rubber gloves, standing on a safety insulating blanket and other appropriate safety measures. Exercise care when performing these measurements:

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.

WARNING:
Do not perform these measurements during an engine start attempt or immediately after a starting procedure has occurred.

11.2. Conductance Testing of Engine Start Batteries

Conductance testing of the engine start batteries can be performed during trouble shooting analysis and may be performed as part of an Operational Review.

Non-intrusive testing of VRLA and Lead Acid Flooded Cell batteries involves the measurement of battery conductance and provides a correlation between capacity and conductance to project the useful life of the battery. The Midtronics CTM-100 Micro Celltron Battery Conductance Tester and the Midtronics MICRO400 Engine Starting Battery Tester are approved for use in AT&T. For information on the CTM-100, see the following:

- http://apex.sbc.com/archived_docs_frame.jsp - this document is located in the Telco Archived Docs section in APEx.
- http://apex.sbc.com/vendor_docs_frame.jsp?front - this document is located in the Vendor Docs section in APEx, look under the Midtronics tab.

For the Midtronics MICRO400:

- http://mechteam.sbc.com:8080/docs/PANs/20001077%20.pdf

CAUTION:
All safety procedures must be followed.

Follow Midtronics guidelines when performing conductance testing.

This type of testing should not be performed on NiCad batteries.

NOTE:
The following two procedures (Sections 11.3. and 11.4.) may be used as additional methods to determine battery condition.

11.3. Locked Rotor Voltage (Valley Voltage) Testing Procedure

CAUTION:
All safety procedures must be followed.

This basic procedure is used to determine the minimum voltage during starting cycle.

When conducting this test, turn off AC power to the engine start battery charger.

- Place DMM in Min/Max mode in appropriate voltage range.
- Connect test leads to battery starter leads, ensure proper polarity.
- Initiate engine start procedure from engine control panel.
- Record voltage readings and replace engine start batteries if they fall below manufacturer guidelines. Follow all safe procedures, if batteries are to be replaced. Conduct test again with new, approved, start batteries.

NOTE:
Refer to engine manufacturer for engine starter and controller recommendations for minimum voltage allowed.

- Remove test leads after each test procedure.
- Restore AC power to battery charger after each test procedure.

11.4. Engine Start Battery Crank Testing Procedure

CAUTION:
All safety procedures must be followed. Do not stand over the start batteries for these tests.

This procedure provides a method to determine start battery condition and can identify defective or end-of-life batteries in need of replacement. This test requires that the engine-alternator be allowed to crank without firing, by shutting off the fuel supply, or other means. This test incidentally allows testing of the Overcrank alarm.

This procedure requires the use of two Fluke 189 DMMs, one to measure and record voltage, and the other to measure and record the output from a Fluke i1010 current clamp-on attachment. Both meters should be in logging mode to perform this test.

Ensure proper connections of the two Fluke 189 DMMs to the engine start batteries. Refer to your local manager responsible for power or local Power Support for additional information on this procedure.

The standby batteries will exhibit four voltage conditions during a start cycle (this cycle will repeat as the engine continues starting attempts). When conducting this test, turn off AC power to the engine start battery charger. After these tests are performed, restore engine to normal configuration.

- Initial (float or open-circuit) voltage.
- Locked-rotor voltage.
- Cranking voltage.
- Open-circuit voltage.

In addition, the amperage will follow three conditions at onset of a starting attempt.

- At rest the initial current is zero (or very near).
- Instantaneous locked-rotor current.
- Cranking current.

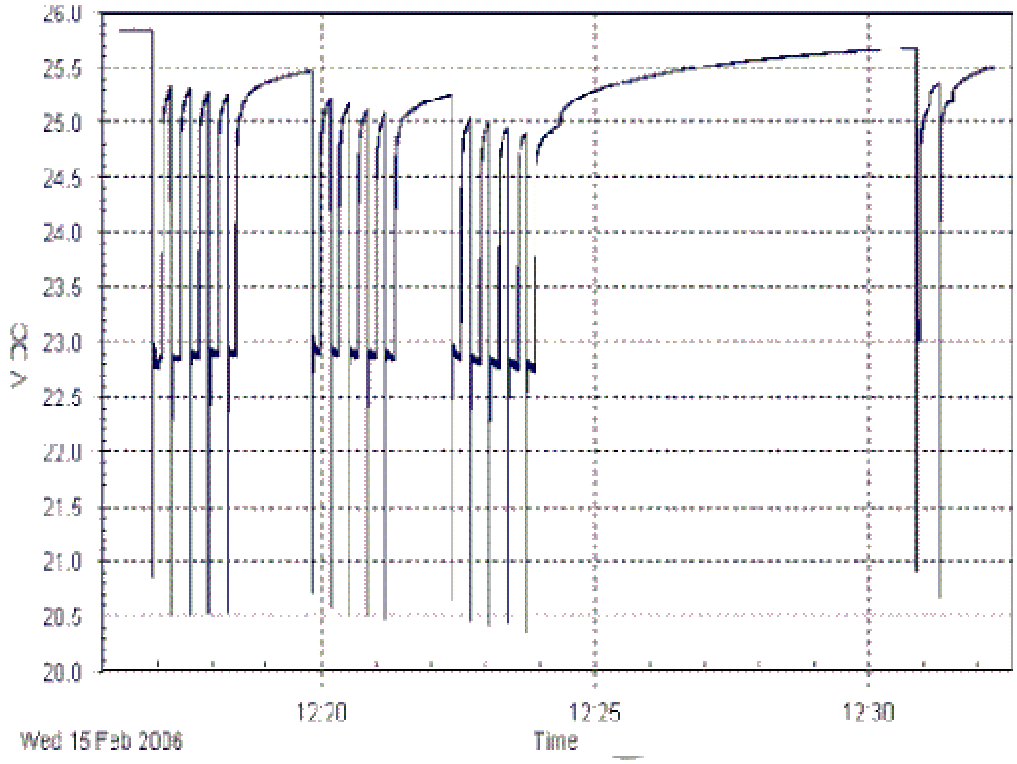
  Then return to zero current. This cycle will repeat as the engine continues starting attempts.

Within a variety of engine controllers, there can be a continuous starting attempt or a series of starting cycles. For the engine under test, the type will need to be known to accurately perform this evaluation.

CAUTION:
After tests are performed, all engine controls and circuit breakers must be returned to normal positions. The set should be started to confirm normal operation. On-set and remote panels must be in auto position, ready to serve state. Verify all local and remote power alarms are cleared.

An example of a starting cycle is discussed in the following: a set was configured for five crank intervals of 10 seconds each, separated by four resting intervals of 10 seconds each, for a total 90 seconds from the beginning of test to the occurrence of Overcrank shutdown. Between each attempt, a rest period of 2 to 3 minutes is allowed. Data acquired from the two Fluke meters should be viewed by using the interactive software to provide a graph. An example of these cranking voltage and current graphs are shown as follows:

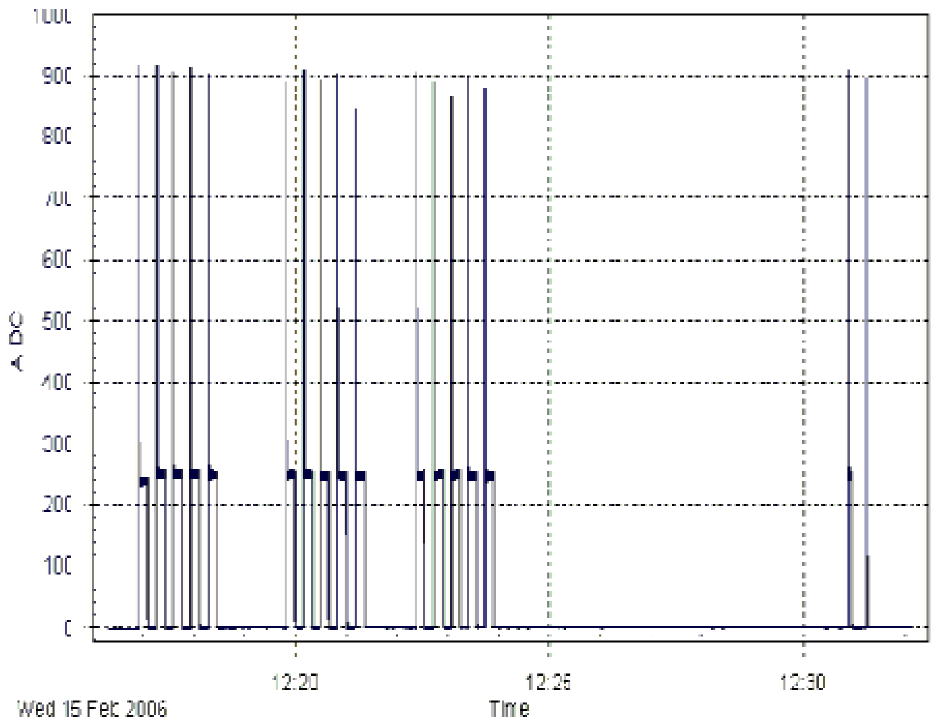
Figure 3: Cranking Voltage Example



Start Time		2/15/2006 12:16
Stop Time		2/15/2006 12:32
Elapsed Time		0:15:59
Interval		0:00:01
Total readings		995
Input Events	36 (Setting when uploaded: 4%)	
Intervals		959

Scaling	(none)	
High	Average	Low
25.853 V DC	24.943 V DC	20.356 V DC

Figure 4: Cranking Current Example



Start Time		2/15/2006 12:16
Stop Time		2/15/2006 12:32
Elapsed Time		0:15:50
Interval		0:00:01
Total readings		995
Input Events	45 (Setting when uploaded: 4%)	
Intervals		950
Scaling	0.001 V DC = 1 A DC (Offset: -0.0025 V DC)	

High	Average	Low
916.7000 A DC	43.6564 A DC	-1.7000 A DC

Locked-rotor voltage should be reviewed to confirm that the minimum voltage remains well above the engine-alternator controller low voltage requirements, if the starting battery also provides control voltage.

Refer to manufacturer or your local manager responsible for power or local Power Support for additional support in evaluating start battery condition.

12. URLs for all Forms

CAUTION:
All forms should be saved locally before populating information directly into the electronic form.

For a Print/Save copy of the forms go to:

- ATT 5330 - Flooded String Storage Battery Record.

  http://inso.sbc.com/13s/power/ATT5330.xls

- ATT 5331 - VRLA String Storage Battery Record.

  http://inso.sbc.com/13s/power/ATT5331.xls

- ATT 5332 - NiCad String Storage Battery Record.

  http://inso.sbc.com/13s/power/ATT5332.doc

- ATT 5335 - Standby Engine Flooded Start Battery Record.

  http://inso.sbc.com/13s/power/ATT5335.doc

- ATT 5336 - Standby Engine Flooded NiCad Start Battery Record.

  http://inso.sbc.com/13s/power/ATT5336.doc

- ATT 5337 - Standby Engine Optima Start Battery Record.

  http://inso.sbc.com/13s/power/ATT5337.doc

- ATT 6506 - String Storage Battery Record.

  http://inso.sbc.com/13s/power/ATT6506.doc

- ATT 6507 - 140V String Storage Battery Record.

http://inso.sbc.com/13s/power/ATT6507.doc

- ATT 6556 - Battery Discharge Test and Intercell Connector Log.

  http://inso.sbc.com/13s/power/ATT6556.xls

- ATT 6557 - 5 Hour Rate Battery Discharge Form.

  http://inso.sbc.com/13s/power/ATT6557.doc

- ATT 6558 - Power Evaluation.

  http://inso.sbc.com/13s/power/ATT6558.doc

- ATT 6559 - BDFB Validation Worksheet.

  http://inso.sbc.com/13s/power/ATT6559.xls

- Battery Reserve Calculation Spreadsheet.

  http://cowest.sbc.com/orgs/power/info_page/Brsv1.xls

12.1. Form Instructions

The forms listed above require a variety of information to be placed to identify the office where the tests are being performed, list battery types, battery string identification, battery manufactured dates, measurements performed and other relevant information. Information for the fields and measurements to be performed are essentially the same for each form posted above, the following lists each field name and the information that should be entered. Not all forms have identical requirements.

- ATTUID: Employee Identification, typically 6 characters in length.
- Battery Charger Float (V): For standby engine start/control batteries, measure the battery string and compare to voltage meter indication and record.
- Battery ID: List which battery is being tested.
- Battery Manufacturer: List battery manufacturer.
- Battery MFR./Model #: List battery manufacturer and the model of the battery/cell type.
- Capacity: For rectifiers, list amperage output.
- CELL: A single jar or unit containing one set of positive and negative electrodes and electrolyte.
- CELL ID: Cell identification, indicates cell designation in battery. Nomenclature is usually a numerical sequence starting with the numeral 1. In some cases, for engine start systems, may use alpha-numeric characters to identi-

fy each cell.

- CELL TEMP: List electrolyte temperature of battery cell in degrees Fahrenheit (F).
- Charger Current Reading (A): For standby engine start/control batteries, record current meter indication in amps (if meter indication available).
- City: List the city that the central office is located.
- CLLI: Common Language Location Identity code. An 10-13 character code that identifies a central office.
- DATE (Date): List date of routine being performed. Depending upon field entered, will either be in month/day format or month/day/year format.
- Electrolyte Level: For flooded lead acid and NiCad battery cells, to determine correct electrolyte fluid levels is maintained between minimum and maximum fill lines.
- Engine ID: Identify which engine is having its battery system routined. Typically, most central offices have only one standby engine/turbine generator system.
- FVPC: Final Volts Per Cell, lowest voltage measured at end of battery discharge test.
- Hydraulic System Tubing: For Saft NCX type battery systems, part of central watering system.
- Install Date: Record installation date these batteries were installed.
- KW: Kilowatt, power rating or capacity.
- Market Area: List the region of this central office.
- MODEL or TYPE or KS-LIST: List model or type of battery deployed, list Kearney Specification if being deployed.
- NOMINAL (Nominal voltage): List the desired float voltage of the cell or battery being tested, refer to Tables listed in Section 3.2.
- Peak Load: List highest average daily load in amps.
- PLANT ID: List power plant identification information.
- Power Plant Code: List power plant identification or designation.
- RECORD YEAR: List the year on the form of these battery routines being performed. See Year.
- Remarks: Describe problems that have been found, any irregularities and actions that have been taken.
- Surface Temperature: List external cell temperature of battery cell/jar in degrees Fahrenheit (F).
- State: List the state that the central office is located.
- STRING: List battery string identification information.

- Type: Multiple meanings, can be for power plant type or battery cell type or power equipment type.
- Turnaround voltage: This is also known as minimum voltage or Coup De Fouet voltage.
- VOLT: List either string voltage of battery string or individual cell voltage. Some batteries have multiple cells within one battery jar/casing. List appropriate voltage in these fields.
- Year: List the year that the battery form is being used to complete these routines. See RECORD YEAR.

13. Contact List

Entries include Regional Contacts.

Table 18: Regional Contacts

Name	SBCUID	Phone #	Department/Responsibility	Region
Mike Andrews	ma1520	405-291-2620	Mgr. Network Mtce.	Southwest
Mitch Boothe	mb1514	530-888-2085	Senior Technical Manager	West
J. Charles Bush	jb3834	210-886-4851	Senior Manager - Technical Support	Southwest
Tom Butler	tb1428	559-228-7039	Senior Technical Manager	West
Dennis Cassidy	dc2759	661-631-3367	Area Manager Statewide Pwr	West
David Elmore	de4988	817-338-7008	Area Manager LFO	Southwest
Bill Fisher	bf4929	501-373-3006	Training & Development Manager	Southwest
Tom Johnston	wj3762	330-835-1535	Senior Technical Manager	Midwest
Christopher Locke	cl1696	860-344-5209	Manager - Technical Support/Analysis	East
Randy McIlwain	lm1496	409-985-9343	Manager - LFO	Southwest
John Messina	jm4735	860-344-5242	Sr. Tech Consultant Eng. Mtce. & Trans. Eng.	East
Alexander Novak	an1718	916-972-5883	CO Power, Operations Staff	13 State O
Roger A. Odle	ro2572	916-972-4535	Mtce. Engineer	West
Tom Patterson	tp3854	314-957-0904	Area Manager Network Maintenance.	Southwest
Russ Reddemann	rr3245	608-274-3449	Associate Director-Frame/Power/Switch Support	13 State O
Bubba Safford	ns4447	214-286-2101	Senior Mgr. Tech Support	Southwest
SBC Midwest Power Control Center Mgr.		312-829-9980		Midwest
Rick Shaw	rs6431	501-373-1160	Senior Manager Technical Support	Southwest
Michael Wooding	mw2479	860-344-5447	Manager - Central Office	East

14. Revision Log

This section logs all revisions by document issue.

14.1. Issues 18 and 19, 11/16/06 and 11/17/06

To correct an APEx format problem with Figure 7., in Section 15.3.4.

14.2. Issue 17, 8/2/06

- SBC logo has been changed to AT&T logo at the top of this document.
- Whole document - SBC forms linked from this document have been changed to reference new AT&T labeling.
- Section 3. - Added verbiage to outline entire section and general information for visual observations to be performed.
- Section 3.1. - Added optional test equipment referencing Alber single cell tester.
- Section 3.3. - Added reference to using Alber and Midtronics test set for battery cable and intercell connections.
- Section 3.4.1. - New section added to expand on round cell post inspection.
- Section 3.4.1. - Added new figure for round cell post inspection.
- Section 4. - Added comments to follow safe work procedures when performing discharge tests.
- Section 4.1. - Added comments for NiCad batteries indicating MVPC.
- Section 4.2. - Added new section Single Cell Discharge Test.
- Section 8.9. - Changed section title from Electrolyte Temperature to Surface Temperature.
- Section 10. - Added URL links from maintenance schedules to forms listed in Section 12.
- Section 10. - Made changes to all four Maintenance Schedules to update format, frequency and section references.
- Section 11. - Added Note for SBC East engine start battery testing.
- Section 11.1. - Added Note to indicate Sections 11.2. and 11.3. may be used as additional methods to determine battery condition.
- Section 12. - Changed all of the Forms from the old SBC titles to new ATT designations. Made minor changes to each form to reflect updated document title. Updated all of the URL links to each of these forms and along with this asked the INSO Website administrator to place these updated forms on the INSO Power website.
- Section 12. - Added URL link for ATT 6559 - BDFB Validation Worksheet.

14.3. Issue 16, 4/21/06

- Abstract - Added Nickel Cadmium batteries reference to allow deployment in central offices.
- INTRODUCTION - Added Nickel Cadmium (NiCad) reference in Introduction.
- Section 2. - Added Caution note for battery maintenance activities.
- Section 2.1. Caution note - Added additional word momentarily before initiating battery maintenance for ESD equalization.
- Section 2.2. - Added reference to use proper factory insulated tools.
- Section 2.2. - Added URL link to Safety Gloves and Mats.
- Section 2.3. - Added URL links to Work-Safe web site.
- Section 2.3.2. - Added URL link to Eyewash Stations and Replacement Solutions.
- Section 2.4.1. - Added additional URL links for Acid Clean-up and Containment for batteries.
- Section 2.4.1. - Added additional information for battery spill containment information and added new Table 2. to order supplies.
- Section 2.5. - Expanded comments to ensure maintenance person be familiar with all aspects of this document.
- Section 2.5.7. - Added additional precautions when using test meters.
- Section 3.1. - Revised Tools, Materials and Test Equipment lists to bring up to date.
- Section 3.2. - Removed VRLA and NiCad references out of Tables 3. and 4., created new Table 5. for VRLA and NiCad.
- Section 3.2. - Made minor clarifications to Tables 3., 4., 5. and 6. for plus/minus voltage range in the first column, added Note references, and number of cells references.
- Section 3.2.1. - Rearranged format to identify battery maintenance forms.
- Section 3.2.3. - Added reference this section is for Lead Acid batteries only.
- Section 3.2.4. - Added new section for NiCad Batteries.
- Section 3.3.1. - For round cell post inspection, added migrated URL link to BSP 157-629-702, Paragraph 3.03.
- Section 3.3.5. - Removed older NO-OX references and use only NO-OX-ID A -Special Corrosion Inhibitor for battery posts and connections.
- Section 3.3.6. - New section added for Application of NOX-RUST X110 - Corrosion Preventative for NiCad batteries.
- Section 3.7.2. - Removed Table - Maximum Allowable Impurities in Water for Batteries when using deionized water.

- Section 3.7.3. - Added section for Deionized Water.
- Section 4.1.1. - Added URL link to Central Office Power Equipment Load Test and Operational Review Trial - SBC-002-217-157.
- Section 9. - New section added for Nickel Cadmium (NiCad) batteries.
- Section 10. - Added Table 14. for NiCad battery routine maintenance schedule.
- Sections 11.2. and 11.3. - Added new sections for Engine Start Battery testing procedures.
- Section 12. - Added forms download and URL link for NiCad battery string in CO applications.
- Section 15.3.1., Step 10 - updated 1.89 MVPC to correct 1.86 MVPC.
- Section 15.4.3. - Deleted repeated step procedure, added in Step 6, Lock Out/Tag Out comment in Note.
- Acronyms A.1. - Added several document specific acronyms.
- Whole document - Changed Table identifiers to correct sequence.
- Whole document - Other changes to improve overall document format.

14.4. Issue 15, 12/02/05

Issued to change contact information

14.5. Issues 6-14, 12/01/05

This revision was written to correct miss numbering of Issue Numbers caused by a software bug. CO Power was added to the title to help with Title key word searches.

14.6. Issue 5, 11/21/05

Issue 5 was edited to include references to the new Battery Discharge Test procedures from Intercell Connector Testing Section 4., add Maintenance matrix on Engine Start batteries (Section 11.) , to include Optima. Issue also adds detailed procedures for Battery Discharge Testing in Section 14. NOTE: Section 14. will be either incorporated into the Battery Maintenance document or removed based on the outcome of the Central Office Load Test and Operational Review Trial http://apex.sbc.com/bookview/bookview.jsp?bookname=ATT-TELCO-002-217-157&showid=null . All other reason for revisions and issue numbers are included in Section 14.

14.7. Issues 1-4, 10/30/02

Revision History not Available

15. Appendix Step Procedures for Battery Plant Discharge Test

This section provides background information and detailed procedures for the Battery Plant Discharge Test. The Battery Plant Discharge Test will use forms:

- ATT 6556, Battery Discharge Test and Intercell Connector Log http://inso.sbc.com/13s/power/ATT6556.xls .
- ATT 6559, BDFB Validation Worksheet http://inso.sbc.com/13s/power/ATT6559.xls .

CAUTION:
Personnel to have and use the appropriate Personal Protective Equipment (PPE) and Safety Gear: 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 batteries containing electrolyte, or any activity that requires exposure to shock from batteries, breakers, fuses etc. All jewelry, necklaces, earrings, bracelets, watches, and loose hanging items shall be removed prior to working around power equipment. For additional information on proper safety precautions when taking measurements and working with batteries refer to the appropriate sections included in this document.

No Job Is So Important And No Service So Urgent - That We Cannot Take Time To Perform Our Work Safely.

15.1. Background

The following procedures are designed to ensure batteries are functioning properly, and have their required capacity. The procedures also verify battery posts and intercell connectors have not deteriorated.

15.2. Special Instructions, Precautions and Procedures

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.

NOTE:

The **Local Standby Power Operating Procedures** and the procedures identified in other sections of this document should be used in conjunction when performing the Battery Discharge tests for additional information on safety, measurement criteria and corrective actions.

CAUTION:
It is important the LFO understands appropriate methods to terminate any test in the most expeditious and risk-free way. If any of the following conditions are encountered while performing the tests, the test should be terminated as expeditiously as appropriate by restoring the rectifiers. Initiate corrective action once the battery string(s) has returned to nominal float voltage. If battery string(s) cannot be returned to service, immediately contact local manager responsible for power and local Power Support for guidance.

- There is a Commercial Power Failure.
- The difference between the highest voltage reading and the lowest voltage reading of all of the cells in a string is greater than 0.1 volt during discharge.
- Individual cell reading indicates a defective battery.
- If the voltage of any individual cell drops below 1.90 volts.
- Any of the intercell connectors are not conducting properly as described in Section 15.3.4.

If a commercial power failure has occurred, review office status and contact the NSAC or equivalent network monitoring center. Review the Central Office Power Failure Instructions for additional information.

- http://apex.sbc.com/bookview/bookview.jsp?bookname=ATT-TELCO-002-200-442&showid=null

CAUTION:
Power routines can potentially impact network reliability. The routine should be performed by knowledgeable and experienced personnel. It is important the LFO understands appropriate methods to terminate any test in a low risk and expeditious way.

NOTE:
The following procedure identified in Table 19. will direct the individual on when to complete each segment of the Battery Discharge Test:

Table 19: Procedures for Completing the Battery Discharge Test

1	• Obtain form http://inso.sbc.com/13s/power/ATT6559.xls , BDFB Validation Worksheet. • Obtain form http://inso.sbc.com/13s/power/ATT6556.xls , Battery Discharge Test and Intercell Connector Log. Multiple copies of the Battery Discharge Test and Intercell Connector Log may be required depending on the battery plant configuration and the number of plants at the location. Fill in all non measurement information, plant ID's and string ID's etc. on both forms, read Section 15. entirely and caution below before beginning any procedures.
CAUTION: Once the Preliminary Procedures and Pre-Discharge testing of Section 15. have been started the technician will need to have ample time available to perform the Battery Plant Discharge Test.	
2	• Perform the Preliminary Procedure Validations and Measurements contained in the Estimating Reserve Capacity Section 15.3.1 . • Perform the BDFB Validation in Section 15.3.2 . • Perform the Individual Cell and Battery String readings in Section 15.3.3 . • Perform the Pre-Discharge Passive Tests for Batteries, InterCell Connector and Connections in Section 15.3.4 . *You will NOT be performing the tests identified in Section 15.3.5., these tests will be completed DURING DISCHARGE.*
3	Perform the Battery Plant Discharge Test Procedure **Section 15.4.** • For each battery plant discharge test to be performed, refer to appropriate ATT 6556 form and list discharge data. **NOTE:** Clamp-On Ammeter and Thermal Scan tests in **Section 15.3.5.** **will be performed while in discharge**, the individual will be directed to complete these tests within the Battery Plant Discharge Procedure.

15.3. Preliminary Procedures

15.3.1. Estimating Reserve Capacity

Estimate the Battery Reserve Capacity is greater than regional requirements necessary to conduct the Battery Discharge Test. Although batteries will only be on discharge approximately thirty minutes it is necessary to verify the site has at least **four (4)** hours of estimated battery capacity. **(Illinois requires 5 hours of estimated battery reserve capacity).**

The Excel based http://cowest.sbc.com/orgs/power/info_page/Brsv1.xls can be used to estimate the existing reserve capacity for the battery plant prior to running the Battery Discharge test. The spreadsheet can calculate battery reserve for offices with multiple models of batteries.

CAUTION:
The spreadsheet will not work for VRLA batteries.

NOTE:
If the plant contains VRLA batteries or battery types other than those contained on tab 2 of the spreadsheet consult Power Engineering for battery reserve estimates for your specific site from Power Pro. If the user has any question relative to the use of the spreadsheet or field population, consult Power Engineering for battery reserve estimates for your specific site from Power Pro.

NOTE:
The user may print or save (local PC) the completed calculations for a specific site as desired.

Follow the following steps to complete Estimating Reserve Capacity:

1. After accessing the form fill in the fields identified below. Steps 2., 3. and 4. are not necessary to perform the calculation.
2. (Optional) Fill in the Office with the Central Office CLLI.
3. (Optional) Fill in the Plant with the Battery Plant to Estimate.
4. (Optional) Fill in the Date.
5. (Mandatory) Fill in the LOAD (amperes) with the measured LOAD for the Office.

6. (Mandatory) Fill in the number of strings in #of Strg field for the first battery model type.

7. (Mandatory) Fill in the Battery Data Model (you can search for the Battery Data Model by selecting the **Index** tab of the spreadsheet. Once the battery type is found copy and paste the Battery Model from the **Index** tab to the Battery Data Model on the Entry Sheet tab (the index tab and the entry sheet tab are shown in the graphic below).

Figure 5: Section of Battery Reserve Calculation Spreadsheet

8. (Mandatory) If the Plant has more than one battery type fill in the #of Strg and Battery Data Model for the second type. Continue until all battery types for the specific plant are identified.

9. The value for Constant Pwr Load should be YES (default).

10. The value for MVPC should be left at the standard value of 1.86 (default) unless your specific site has a different Minimum Volts Per Cell (refer to Power COE Engineer for this information).

11. The value for NORMAL TEMP can be left at 77 degrees F (default) unless the normal temp is different.

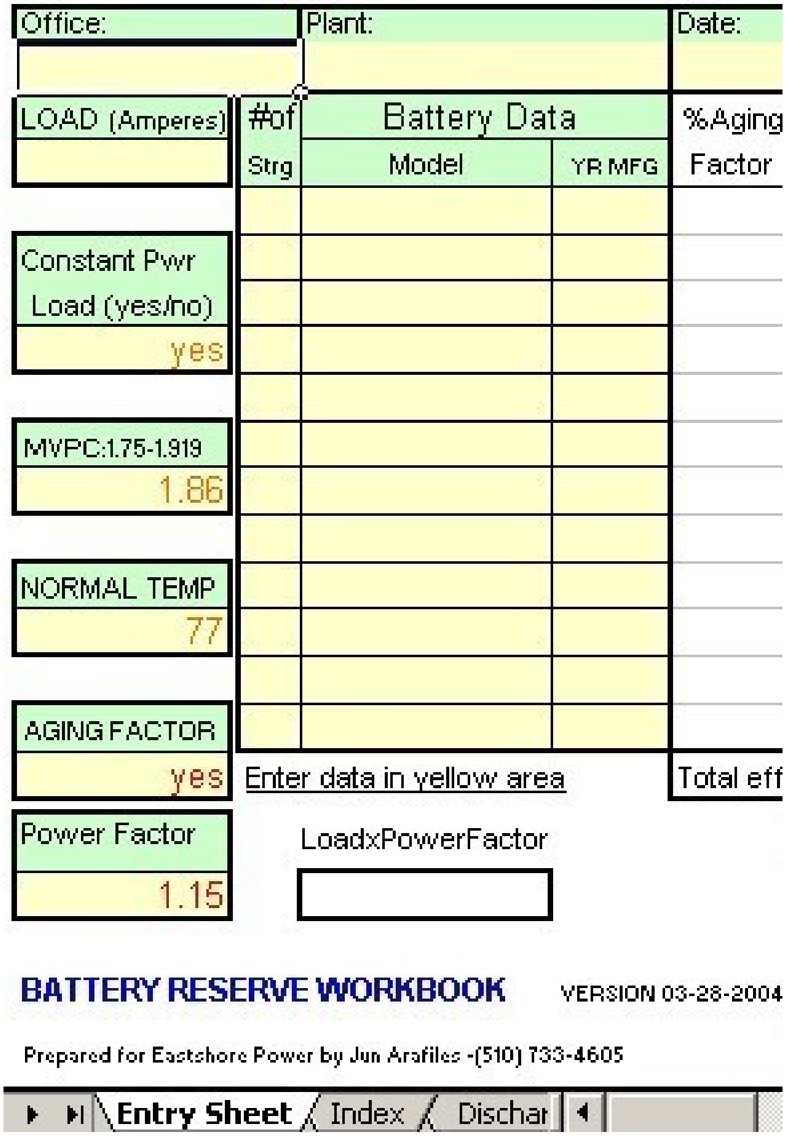
12. AGING FACTOR can be set to yes (default) if the year of battery manufacturing is known. If left as yes also put the year manufactured in the Battery Data YR MFG field next to the appropriate battery type. If the year is not known set AGING FACTOR to NO.

13. Compensation Factor can be set to 1.15 (default). This factor is used in this spreadsheet to help determine power fail drain/load.

14. After populating the (mandatory) fields for all battery strings associated with one plant, read the Reserve Hours: (BLUE BOX.)

15. Verify the office has more than 4 HOURS *(5 HOURS for ILLINOIS)* estimated reserve.

Figure 6: Section of Battery Reserve Calculation Spreadsheet



- http://cowest.sbc.com/orgs/power/info_page/Brsv1.xls

Continue with the next Section 15.3.2 BDFB Validation

15.3.2. BDFB Validation

Before beginning any discharge, the supply fuse capacities must be validated for each load of each BDFB served by the affected plant or plants. This validation must be documented on form ATT 6559, BDFB Validation Worksheet:

- http://inso.sbc.com/13s/power/ATT6559.xls

NOTE:
Two formats of the form are available, Tab 1 titled E-input - will allow the user to auto calculate , or Tab 2 titled Paper input - can be used for printing which must be manually calculated.

The BDFB load (amperage) shall be measured in one of three ways:

- If the BDFB is equipped with a panel meter, the load may be read from the panel meter (BDFB), it is recommended that a clamp-on ammeter be used if the equipment meter has not been calibration verified in the past 12 months.
- If the BDFB is fed from a power-plant monitored fuse, the load reading may be read from the Power-plant controller (CNTRL).
- If neither of the above methods are available, then a clamp-on ammeter will have to be used, either at the PBD, or if cable separation or clearance is an issue at the BDFB, this can be done in conjunction with volt drop measurements (PBD).

CAUTION:
If the measured current for any of the loads is greater than 50% of the capacity rating of the associated fuse, the planned Battery Discharge must be canceled until the condition is corrected. The Power Central Office Engineer must be notified.

The BDFB Volts drop shall be measured in the following way:

- At the PBD, on the load side of the service distribution breaker or fuse for each load.
- At the BDFB on the line side cable from the PBD for each load.

Table 20: BDFB Validation Procedure

1	Record the BDFB number (bay number) for each BDFB in the appropriate row of ATT 6559 - BDFB Validation Worksheet
2	Find the supply fuse for each load on the Power Board. Record the PBD number, PNL-panel number, POS-fuse position identity, and SIZE-fuse/breaker size for each of these fuses/breakers in the appropriate columns on the BDFB Validation Worksheet form ATT 6559. Note that the fuse/breaker position numbers and sizes are written side by each in the oversized boxes so that each BDFB takes up one block on form for up to 6 loads.
3	Record the actual amperage readings for each load in the appropriate column. **Record them in the row that corresponds with the method of measurement.** That is if the measurement came from the BDFB meter, record it in row labeled BDFB meter, if it came from the Plant Controller, record it in row labeled CNTRL meter, and if using the clamp on method record readings in the row labeled PBD/clamp-on. **NOTE:** Meters need Annual calibration, and may not always be accurate, if there is any doubt, or it has been over 12 months since the Panel meter was last calibrated , you will want to use all three methods. Record all readings and place calibration stickers on meters as appropriate.
4	At the PBD, using Volt meter set to <60VDC, to the 0.01 scale (VDC). Place negative (black) lead on the Battery Return Bus or bar metal surface frame ground and place the positive (red) lead on the load side of the fuse/breaker and for each load, record readings in the appropriate row labeled PBD Volts with a DMM meter.
5	At the BDFB using Volt meter, place negative (black) lead on the Battery Return Bar, or bare metal surface frame ground and place positive (red) lead on the line side (feeder from PBD) primary service cable for each load. Record volts readings for each load in row labeled BDFB Volts with a DMM meter.
6	Subtract the volts readings for each load taken in step 5 from the volts readings for each load taken in step 4. Based on the measurements described in steps 4 and 5, total allowable loop voltage drop should not exceed 1 volt. If the **total allowable loop voltage drop is equal to or greater than 1 volt, do not perform the battery discharge test**, make a note in comments field and escalate to supervisor/power engineering.
7	The comments field on the BDFB Validation worksheet may be used to record any unusual or troublesome conditions which may have been observed regarding the BDFB or any readings taken.
8	**Continue with the next Section 15.3.3. Individual Cell and Battery String Voltage Readings**

15.3.3. Individual Cell and Battery String Voltage Readings

Individual cell readings should be taken and logged on form http://inso.sbc.com/13s/power/ATT6556.xls , Battery Discharge Test and Intercell Connector Log. 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 end 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.

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.

When taking battery string float voltage readings with a DMM, the 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. DMM and battery string polarity should be strictly adhered to at all times. Record all readings in form ATT 6556.

If a problem is identified, discontinue the procedure and refer to Section 3.2.3. for corrective action.

If no problems exist or all problems have been corrected, Continue with the next Section 15.3.4. Testing of Batteries Intercell Connectors.

15.3.4. Testing of Batteries Intercell Connectors

All pre-discharge measurements will be completed during normal battery float operation.

The Best Practice Power Committee highly recommends completion of Test #1 below. If the test equipment for PRE-DISCHARGE Test #1 is not available, the technician can instead perform the PRE-DISCHARGE Test #2. **If the test equipment identified in Test #1 and Test #2 is not available the technician should perform PRE-DISCHARGE Step #3.**

1. Test #1 - PRE-DISCHARGE: **The Midtronics Conductance Test Set or Alber Cellcorder are strongly recommended for use in completing the pre-discharge passive testing of batteries intercell connectors and connections.** Use of either the Midtronics Conductance Test Set or the Alber Cellcorder are recommended because of their ability to validate battery capacity as well as test intercell connectors and connections. The Midtronics and Alber sets are easier to use and will substantially reduce testing time. Continue with **Test #1 or Test #2 continued** below. See sections 5. and 6. for more information.

2. Test #2 - PRE-DISCHARGE: If the Midtronics or Alber sets are not available use of a micro-ohmmeter test set is allowed but is substantially limited in it's testing capabilities (i.e. intercell connectors only). The standard digital volt-ohmmeter like the Fluke 8060A, Fluke 189 or equivalent is not suitable for performing this test. A micro-ohmmeter that offers low ac test signals and measures without the interference of the DC current should be used for verifying intercell connection integrity. Continue with **Test #1 or Test #2 continued** below. See sections 5. and 16.1. for more information.

3. Step #3 - PRE-DISCHARGE: If the test sets identified in Test #1 and Test #2 are not available, Perform a visual

check and torque all battery connectors. If Step #3 is used, when complete return to Table 19. step 3 . See section 3.3. for more information.

Test #1 or Test #2 continued - Follow the suggested measurement sequence outlined in Table 21. below to record all 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 Table 20. as a guide for the taking measurements. With all intercell connectors in place measure post to post resistance, refer to Figure 7. for 4 post batteries and Figure 8. for 2 post batteries. If any measurement is outside the acceptable level identified in the table, log the intercell connection measurement as a deviation on the Battery Discharge Test & Intercell Connector Log section D and correct (see note below).

NOTE:
Depending on the deviation,

- The technician should follow the procedures outlined in Section 3.3. to disconnect, clean, neutralize, re-apply NO-OX-ID A-Special and properly torque the connections.

  OR

- The technician should refer the deviation to the next level of support for resolution (for example your local manager responsible for power or local Power Support).

Recheck the measurements before moving on to the next intercell connection. All high resistive connections shall be corrected before continuing.

When all measurements are complete return to Table 19. step 3 .

Table 21: Intercell Connectors Measurement Sequence

Test Set Used	Measurement Sequence	Connection Point	Four Post Batteries (micro-ohms)	Two Post Batteries (micro-ohms)
Midtronics		A to D		
Midtronics		A1 to D1		not applicable
Alber		A to D		
Alber		A1 to D1		not applicable
Micro Ohmmeter	Post to Post	A to D	< 60	40-60
Micro Ohmmeter	Post to Post	Al to Dl	< 60	not applicable
Micro Ohmmeter	Post to Post	A to Dl or A1 to D	< 75	not applicable

Figure 7: Connections for Intercell Connector Measurement of 4 Post Batteries

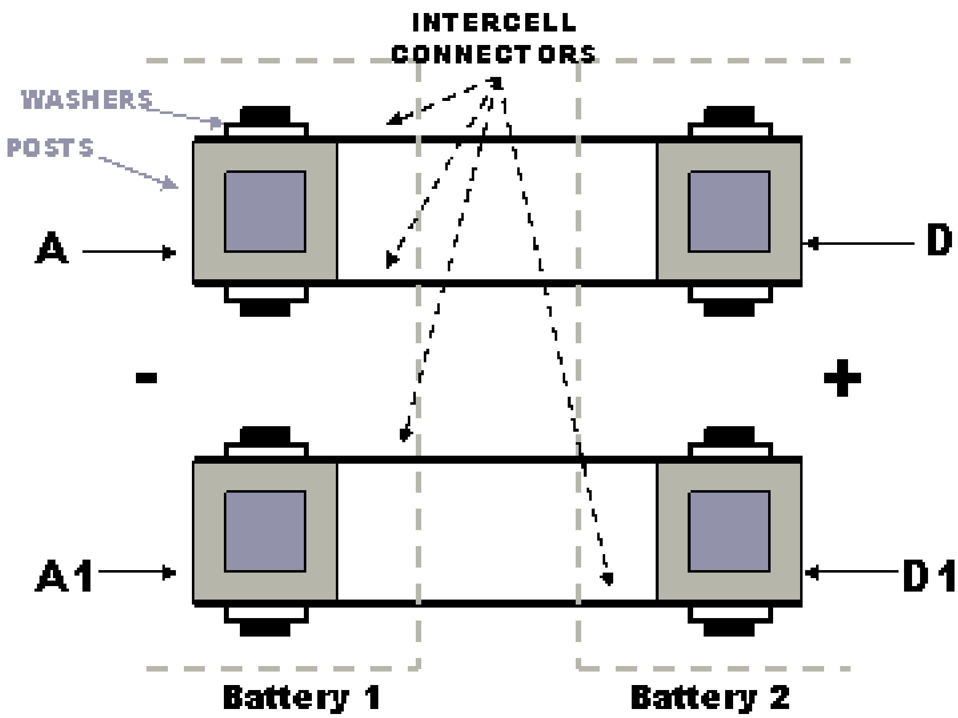
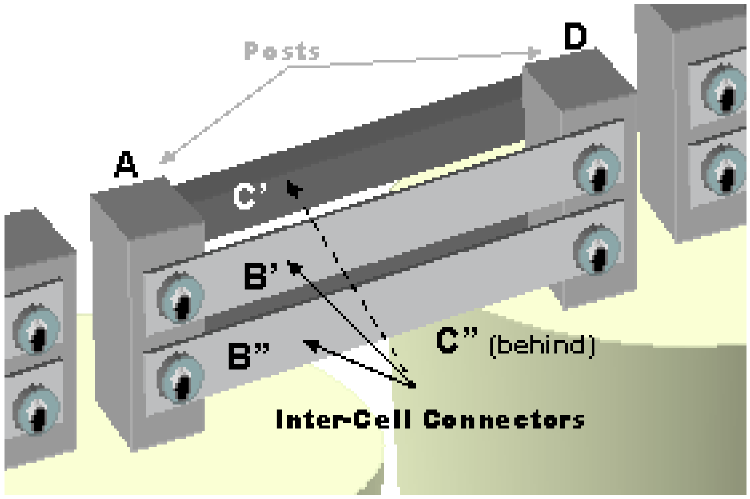


Figure 8: Connections for Intercell Connector Measurement of 2 Post Batteries



15.3.5. Battery and Intercell Connector Tests (During Battery Discharge)

NOTE:
This test will only be performed **During the Battery Discharge Test**. **Do not perform this test until directed to do so** in the Battery Plant Discharge Procedure.

NOTE:
Maintenance Note: If any deviation is encountered during the test, the discharge test should be terminated and the problem corrected. Follow the established maintenance procedures outlined in Section 3.3. to disconnect, clean, neutralize, re-apply NO-OX-ID A-Special and properly torque the connections or refer to the next level of support (whichever local operations dictate be done). The battery plant should reach normal float voltage before the discharge test is restarted. Recheck the measurements before moving to the next set of inter-tier, inter-row or bus-bar cables. All deviations and any solutions for each failure should be logged in Section D. on form http://inso.sbc.com/13s/power/ATT6556.xls , Battery Discharge Test & Intercell Connector Log. Information and results from the discharge test should be retained with the batteries as part of the permanent office record. Deviations which cannot be resolved will require further investigation by the METS or Power CO Engineer. The Power CO Engineer will use all Battery Discharge results for determining when a string of batteries should be replaced.

All of these tests are strongly recommended to be performed during discharge and are described in the following steps.

1. Discharge Test #1: Individual Cell readings taken after Coup de Fouet.

2. Discharge Test #2: Clamp-On Ammeter - Testing of inter-row, inter-tier and bus-bar cables during discharge. Measurements should be made based on physical battery configuration where inter-tier/inter-row cabling exists (for example between batteries 6-7, 12-13, 18-19). The current for each set of inter-tier, inter-row and bus bar cables should be within 10% of each other cable measurements at those test point. Any measurement which exceeds +/- 10% tolerance will require problem resolution. Follow the **MAINTENANCE NOTE** above for problem resolution. Note all deviations and any solutions on the ATT 6556 form section E.

3. Discharge Test #3: Clamp-On Ammeter - Comparison testing of battery strings during discharge. Battery strings with like Amp Hour (AH) ratings will be compared to one another. Each combined string's current should be within 10% of the other like string's currents.

NOTE:
Deviations greater than 10% can be influenced by cable resistance (length to bus bars/distribution) or age/type of batteries. If these influences are the known cause, log the deviation on form ATT 6556 and continue with testing.

Any comparative measurement which exceeds +/- 10% tolerance with unknown influence should be noted as deviations on the Battery Discharge Test & Intercell Connector Log ATT 6556. These deviations will require further investigation by the METS or Power CO Engineer. Most string deviations will not have a significant enough impact on overall plant voltage to abort the discharge test. Aborting the test will only occur if plant voltages drop below the acceptable levels identified in Table 22. Battery Plant Discharge Test Procedure - see DANGER note .

4. Discharge Test #4: Thermal Scanner - The thermal scanner will be used on the intercell connectors of each battery to detect heat dissipation. Perform the thermal scan toward the end of the discharge to give current flow time to heat up the resistive connections. If the thermal scan is done too soon, hot spots could develop later and be missed. Temperature readings should be recorded on blue line. Intercell connections which exhibit a 10 degree Fahrenheit rise over ambient indicates a potential problem. Monitor the connection closely to make sure the temperature does not continue to rise. If it continues to rise, the discharge test should be stopped and the problem resolved. Follow the **MAINTENANCE NOTE** above for problem resolution. Note all deviations and any solutions on the ATT 6556 form section F.

NOTE:
Thermal scanner measurements can deviate from test set to test set, it is important the individual uses the thermal scanner consistently and within the defined focal length for the test set throughout testing. Measurements should be made as close as practical and safe.

Continue the 5 minute interval Battery Plant Discharge Test Measurements and Readings.

15.4. Battery Plant Discharge Test

15.4.1. Background

The following operational 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.

CAUTION:
It can take 24 to 72 hours to fully recharge the batteries to 100% capacity.

15.4.2. Special Instructions, Precautions

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. The **tests during discharge will require multiple people** to perform tasks simultaneously. The Battery Discharge Test & Intercell Connector Log, Form http://inso.sbc.com/13s/power/ATT6556.xls should be used for recording all information gathered during the discharge test. The duration of the discharge test is recommended to be a minimum of 30 minutes (or the duration established by regional discharge guidelines).

NOTE:
If the building contains more than one DC power-plant, perform this procedure on only one power-plant at a time. Multiple forms may be required.

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

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

measurements.

CAUTION:
Personnel to have and use the appropriate Personal Protective Equipment (PPE) and Safety Gear: 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 batteries containing electrolyte, or any activity that requires exposure to shock from batteries, breakers, fuses etc. All jewelry, necklaces, earrings, bracelets, watches, and loose hanging items shall be removed prior to working around power equipment. For additional information on proper safety precautions when taking measurements and working with batteries refer to the appropriate sections included in this document.

15.4.3. Procedure for Battery Plant Discharge Test

Table 22: Battery Plant Discharge Test Procedure

1	Obtain the http://inso.sbc.com/13s/power/ATT6556.xls form, Battery Discharge Test & Intercell Connector Log. Record the beginning DC plant voltage and current readings on the form.
2	Multiple individuals will need to be available to complete all discharge test routines and measurements.
	DANGER: Ensure the voltages at the PLANT do not drop BELOW the following specified levels anytime throughout the test. If at anytime the voltages reach these levels, discontinue the test immediately, restore all rectifiers and escalate to the CO Power Engineer or METS for trouble analysis and resolution. • 23.00 VDC on 24 Volt plant. • 46.00 VDC for 48 Volt plant. • 126.00 VDC for 130 Volt plant. • 130.00 VDC on 140 Volt plant.
3	Identify the normal operating mode of the Power Plant AC Inverter(s). The normal operating mode is identified by observing the Input Selected Indicator. Typical primary operating modes can be AC Line or DC.
4	If the inverters are in AC Line mode, place the inverters into DC mode. Verify the inverters are functioning properly in DC Mode before continuing.
5	If the office contains 48 V DC Emergency Lighting, then activate all the Emergency Lighting. **NOTE:** The lighting may be controlled by one or more automatic contactors containing a test switch, or in smaller offices the emergency lighting may be directly controlled by one or more manual switches.
6	With a technician monitoring the plant voltage turn off rectifiers associated with the power plant. **NOTE:** This is best accomplished at the PDSC by turning off the **AC input** breakers or removing fuses that feed the rectifiers.
7	Begin recording the DC plant voltage and plant current on form ATT 6556. • Take readings at one minute intervals for the first five minutes. • Continue recording readings at five minute intervals for the remainder of the discharge test.

	A Fluke 189 or equivalent may be used for continuous measurement and logging.
8	The following steps are described in Section 15.3.5. , as discharge is occurring, perform the following measurements: • Perform individual cell voltage readings after Coup de Fouet described in Step 1. • Using the Clamp-On Ammeter perform the inter-tier, inter row, bus-bar and battery string current measurements identified in Step 2. - Discharge Test #1 Clamp-On Ammeter. • Using the Clamp-On Ammeter, measure each battery strings and compare as described in Step 3. - Discharge Test #2 Clamp-On Ammeter.
9	If the thermal scanner is available an individual will need to be available to check for heat dissipation and hot spots using the Thermal Scanner as described in: • Section 15.3.5. , Step 4. - Discharge Test #3 Thermal Scanner. This test should be performed toward the end of the battery discharge test.
10	Record any deviations observed during the Clamp-on Ammeter and Thermal Scanner tests on the Battery Discharge Test & Intercell Connector Log form ATT 6556 in Section D & E.
11	The next step will be decided based on the office configuration and the number of battery plants associated with an engine. Complete step A. or step B. as applicable to the office. A. **If the office has multiple power plants and it is not logistically possible to leave ALL rectifiers off,** complete each battery plant discharge (steps 1-10), **Restoring the rectifiers after discharge of each power plant.** Continue until all plants are complete. When complete with all power plants continue to step #12 of this procedure. B. **If rectifiers can remain off until ALL battery plant discharges are complete:** complete each battery plant discharge (steps 1-10). Do not restore rectifiers until all plants are complete. When complete restore all rectifiers and continue to step #12 of this procedure.
12	If the inverters were originally set to AC Line mode, they will need to be placed back into AC Line mode at completion.
13	At the conclusion of the tests, all completed forms ATT 6559, and ATT 6556 should be copied. Three copies should be made, one should be sent to the Power COE, one to Power Support and one copy retained in the office files. (copying and distribution can be done via email, if feasible).

16. Additional Information on Battery Maintenance

This section will provide additional information on various topics to optimally maintain batteries located in our network locations.

16.1. DLRO Testing

An optional method to test intercell connections using a Digital Low Resistance Micro-Ohm meter is described in the following. This type of testing can also be used on other types of conductive connections if problems are suspected in the power environment. Exercise extreme care when using this type of meter and ensure that operation of this type of meter does not affect overall equipment (or associated quipment) operation.

DLRO testing can be used to measure intercell connector resistances, either as an independent set of tests or it can be used to validate other types of conductance testing performed to be able to compare and evaluate overall intercell connector reliability.

Contact local Power Support for assistance on DLRO testing if intercell connection testing or other low resistance testing is be performed.

16.1.1. Intercell Connection Measurements using a DLRO

A poor connection (or connections) could reduce the reliability of the overall battery string. Inter-tier and inter-row connections, with or without connection plates, should also be considered when performing intercell connection measurements. Additional information about non-intrusive (battery conductance) testing is provided in **Section 6.** and **Section 6.1.** and will include information on intercell connection resistance.

For intercell connection measurements, it is recommended to establish a baseline upon initial installation. Whether this can be performed at the initial installation or at a later date, record the baseline readings and retain for the life of the batteries, to be used as a reference point for all future readings.

The intercell resistance (micro-ohm) values should be consistent over time. If retests are trending towards higher resistance values, this could indicate corrosion or loose connections that could affect performance.

Intercell connection resistance will vary with cell size, connection type and the number of intercell connectors used.

DANGER:
When using a DLRO, do not perform these measurements across the battery cell, only across the intercell connectors between two cells. Testing across the cell(s) may cause personal injury, damage to the test meter and may damage the cell(s). Refer to Figure 9. for the correct way to perform these measurements and note the improper methods.

WARNING:
Do not use a standard DMM to perform intercell resistance measurements.

NOTE:
Do not perform these tests unless the battery has been on float for 48 hours.

Use the following steps to perform these tests, exercise care when performing intercell connection resistance measurements:

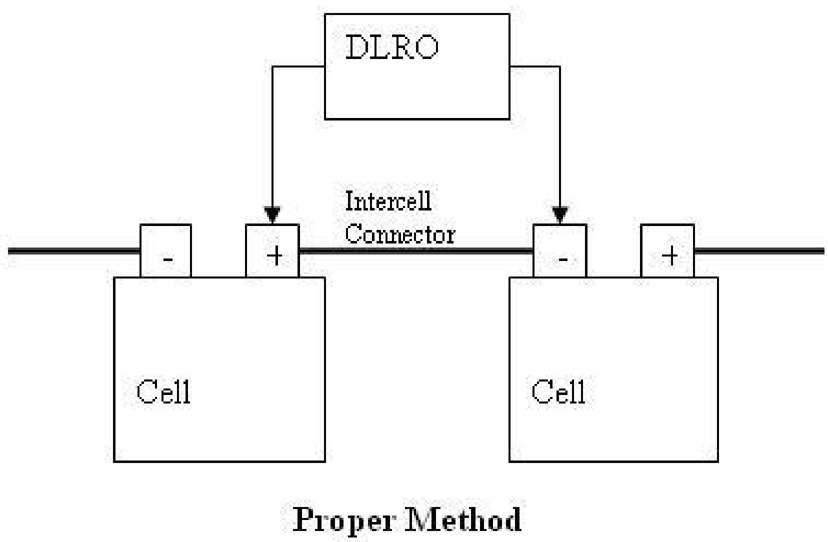
1. Use proper PPE including safety glasses/goggles.
2. Do not stand directly over the cells when performing these measurements. The test leads/probes should be perpendicular to the posts.
3. Use caution during the testing process, note polarity of test leads before making measurements. refer to test set manufacturer literature for test lead usage.
4. Test intercell connectors between battery cells, not across battery cell.
5. Test lead/probe contact points:
    - Terminal battery posts. Post of first cell to the adjacent post of next cell.
    - If the test lead cannot make contact to the post, use the terminal hardware. Avoid using the bolt head as a contact point as this will add resistance to the measurement.
6. Refer to Figure 9. below for proper method.
7. Be consistent with your measurements, measure at the same connection points throughout whole process.
8. Record measurements.
9. Take care in performing these tests, there are a great number of items being repetitively tested and the idea is to look for trending in these measurements.
10. Review the measurements for the entire string after they are taken, use the following criteria to determine if the intercell connectors require corrective action:
    - Micro-ohm resistance values that are greater than 60 micro-ohms.

- Or greater than 30 micro-ohms above the average.
- Size and quantity of intercell connectors will affect the resistance readings. Engineering judgment may be required to determine whether corrective action is necessary.

  Failing this criteria will require the intercell connectors and hardware to be disassembled, cleaned, reassembled and retested. Use initial torque values and apply NO-OX-ID A-Special Corrosion Inhibitor to intercell connectors and posts. See Sections 3.3. through 3.3.5. for more information. In some cases, the intercell connectors and hardware will need to be replaced, refer to Sections 3.3. through 3.3.5.

11. Perform these measurements for inter-tier or inter-row connections (with or without connection plates) and record. The micro-ohm resistance values will be different from that of the intercell connection values, look for trending from past tests or other similar battery strings. Record these measurements as well and correct as needed.

Figure 9: Correct DLRO Measurement



These measurements shall be performed during float operation. If a compete evaluation of the battery string is required including discharge tests, this information is detailed in Section 15. of this document.

17. Acknowledgements

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- Bubba Safford - Senior Manager Technical Support.
- Rick Shaw - Senior Manager Technical Support.

Acronyms

A.1. Document Specific Acronyms

This section lists acronyms that are used in this document.

ABSBH - Average Busy Season/Busy Hour load.

Ah - Amp hour or Ampere hour (battery capacity).

BDFB - Battery Distribution Fuse Bay.

C - Celsius, in degrees (i.e. 25 degrees C), unit of temperature.

CC- Cubic Centimeter, unit of volume, 1 CC equals 1 milliliter.

Coup de Fouet - The French term Coup de Fouet (stroke of a whip) is the name given to the transient response (voltage dip) of the cell (or battery) when it is taken off float and used to supply the load current. On discharge, the battery supplies the load current; the voltage rapidly drops, then sharply rises to an initial voltage.

DMM - Digital Multi-Meter.

EM - Environmental Management.

F - Fahrenheit, in degrees (i.e. 77 degrees F), unit of temperature.

mm - millimeter.

mV - millivolt.

MVPC - Minimum Volts Per Cell.

NiCad - Nickel Cadmium.

PDB - Power Distribution Board.

PDSC - Power Distribution Service Cabinet.

PPE - Personal Protective Equipment.

SI - International System of Units.

UPS - Uninterruptible Power Supply.

URL - Universal Resource Locator, commonly known as web site link or location.

VPC - Volts Per Cell.

VRLA - Valve Regulated Lead-Acid.

WFS - Water Filling System.

A.2. Network Acronyms Dictionary

APEX - Advanced Publishing Express.

http://apex.sbc.com/bookview/bookview.jsp?bookname=ATT-000-000-020&showid=null