TELECOMMUNICATIONS - VRLA BATTERY MAINTENANCE, TESTING AND REPLACEMENT

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This paper describes a step by step program of methods and procedures for maintaining the VRLA battery systems in the Local Exchange Carrier Central Office and Outside Plant Telecommunication Cabinet environments. Embracing these methods and procedures allows the user to obtain maintenance and test data indicating the current battery system condition and predictions for remaining battery service life. The paper is organized as outlined below:

- Introduction, Background, Purpose, VRLA Usage, Service Life, Factors Contributing To Failure
- Testing Methods and Test Equipment
- Battery Warranty Administration and Servicing
- Acceptance Testing
- Periodic Maintenance and Testing Routine (Action Steps)
- Procedures For Establishing Baseline Cell Resistance
- Thermal runaway – Immediate Actions
- Cell Resistance Test Set Battery Connections – Diagrams
- Summary and Conclusions
- Terms / Definitions

INTRODUCTORY COMMENTS: This battery maintenance and testing program is designed and applied to each type of battery system used in our network (VRLA and Vented Lead Calcium). Although it is clearly understood that capacity load testing is the tried and true method of determining the battery's actual remaining capacity, our program pointedly avoids the use of capacity load testing. Instead, for our applications we are confident that this program (described herein) provides the significant pieces of information and data needed to make informed and timely decisions – without true cell capacity testing. (Note: capacity testing is very specialized and for telephone applications it can require a very large amount of resources to carry out.)

BACKGROUND: With the continuing field reports of very short service life and sudden (unpredictable) failures associated with VRLA Battery systems, we (the company) determined to look for the highest quality battery system(s) and the best means to cost effectively test and maintain these systems. Under our control are the operation, maintenance, handling and testing of these battery systems – as well as the physical environment they are housed in. Will our ability to have control of these factors affect (optimize) the service life and provide predictive data about the condition of the battery? We think the answer is YES. Consequently we developed or put together a simple routine (set of procedures) that is easily carried out and provides that feedback which is needed. By feedback I mean the data that indicates the current condition of the battery system and useful information about the remaining life of the system.

PURPOSE: Establish an accurate, manageable and cost efficient battery maintenance program for the acceptance testing, routine maintenance and testing, and the replacement of valve regulated lead acid (VRLA) battery systems deployed and used in the Telephone Company Central Office (controlled) environment and the Outside Plant Cabinet (non-controlled) environment.

This standardized maintenance and test program when implemented and followed provides the most economical and efficient use of manpower to optimize VRLA battery life, prevent telecommunications equipment service outages, battery emergencies, and eliminate or reduce the early procurement of replacement battery systems. These methods and procedures must provide data to indicate the *Current Condition* of the battery system(s), and predictive data to gauge the *Remaining Useful Service Life* of the battery system(s).

VRLA BATTERY USAGE:

☑ The deployment and use of the VRLA battery system has increased rapidly due to the higher energy density of the VRLA battery system and battery manufacturer promise(s) of high cycling, low maintenance and long service life. Typically the VRLA battery system has a smaller footprint and can be deployed into smaller spaces, as compared to a flooded battery system of equal energy storage capacity.

☑ In our (local exchange carrier) telephone company approximately 25% of the central office, remote central office, and other controlled environment office (approx. 300–350) locations contain VRLA battery systems. In the Outside Plant Cabinet non-controlled environment, 100% of our cabinets (approx. 10,000) contain VRLA battery systems.

SERVICE LIFE:

☑ The controlled environment VRLA battery systems have typically been marketed as 12 – 20 year life battery systems. This company's experience with VRLA battery systems has indicated that after **5-8 years** of service, the *battery system* can no longer maintain greater than 80% capacity, and replacement is necessary.

☑ The non-controlled environment (outside plant) VRLA battery systems have typically been marketed as 5 - 15 year life battery systems. This company's experience with these OSP VRLA battery systems has indicated that after **1-3 years** of service, the *battery system* can no longer maintain greater than 80% capacity, and replacement is necessary.

FACTORS CONTRIBUTING TO EARLY BATTERY SYSTEM FAILURES:

1. In a telephone company many of the VRLA battery systems are staged in warehouses ("cold storage") for periods of time ranging from One Day up to One Year. During cold storage the battery systems are not charged. Instead, the battery self discharges which can lead to a shortened service life if not recharged properly when placed into service.

2. The VRLA battery system is typically placed into service without performing the necessary Acceptance Testing Procedures (battery system integrity testing).

3. Standard battery testing equipment and maintenance routines have not been well developed nor standardized throughout the company.

4. Extended high temperatures will rapidly degrade the service life of the battery. The temperatures in the OSP Cabinet battery housings typically are not well regulated and can reach 120 – 140 Degrees F for extended periods of time. The OSP Cabinet typically has poor insulating characteristics and very high thermal radiation. Case in point: During a big snow and very cold temperatures in the Northeast a few years ago, this particular cabinet's exterior and the immediate surrounding area were clear and dry, while all around there was 15 inches of snow covering the landscape.

TESTING METHODS AND TEST EQUIPMENT: Network and maintenance technicians shall conduct battery testing and maintenance routines based upon internal DC Cell Resistance testing.

TEST METHOD: DC CELL RESISTANCE	TEST EQUIPMENT: ALBER CELLCORDER

The DC Cell Resistance battery tests are conducted on a ***Three Times Per Year*** *(4-month intervals)* schedule to provide trended data and pass/fail data. This test data will be used to indicate battery condition and determine the required actions:

(a) The battery condition is good. Continue testing after four months.
(b) The battery condition is defective while battery is under warranty. Replace under warranty.
(c) The battery condition is defective and battery is out of warranty coverage. Replace battery.
(d) The battery condition is uncertain. Perform Load test to determine true capacity level.

After completing test routines, the resulting test and maintenance data will be submitted to the maintenance supervisor for review, analysis, and record keeping.

BATTERY WARRANTY ADMINISTRATION AND SERVICING: *Warranty servicing* agreements have been established with battery suppliers that specify the warranty replacement of battery systems based on Defective *DC Cell Resistance* measurements. Submitting defective Cell Resistance data to the battery manufacturer will facilitate servicing of the battery warranty. The data must include at least *two consecutive* cell resistance readings. Upon receipt of valid data, the battery supplier will ship replacement battery systems.

BATTERY ACCEPTANCE (INTEGRITY) TESTING: The acceptance testing procedure is critical to battery life, and is simple to perform. Done correctly, the battery integrity testing ensures the battery is at 100% capacity and state of charge when placed into service (excepting battery systems that are factory defective or have suffered irreversible damage from extended periods of "cold storage"). Upon initial battery installation, or after replacing the battery plant, all battery system(s) must be tested for battery system integrity.

(1) During battery installation, write the in service installation date on each battery block. A label on the battery block provides pertinent battery information and a designated space for writing the in-service date.

(2) During battery installation, lightly coat the battery post and clamps with NO-OX ID grease.

(3) During battery installation, insure the clamps and battery inter cell connections are tightened and torque is applied per manufacturer specifications.

(4) After battery installation is complete and system power applied, then read and record the battery string float voltage using a Digital Volt Ohmmeter. The correct battery string float voltage setting is listed in TABLE A -- DC POWER PLANT VOLTAGES.

(5) Apply an initial boost (*equalizing*) charge to the battery system as follows:

(a) Apply an Equalize Charge ONLY IF the battery has been in cold storage (without charge) for a period of 90 days or longer.

(b) Apply an Equalize Charge ONLY as specified or prohibited per the battery manufacturer's installation instructions.

(c) Administer the Equalizing Charge by adjusting the battery charger (rectifier) float voltage to 56 Volts for a period of 12 – 16 hours. After charging at 56 Volts for 12 – 16 hours, adjust the battery charger set voltage back down to normal float voltage (54 Volts).

(6) After completing the equalize charging in Step 5, wait at least 48 hours but not longer than 168 hours before completing the remaining battery readings (steps 7-12). If no equalize charge was applied (Step 5), then complete the remaining steps directly.

TABLE A -- DC POWER PLANT VOLTAGES					
			BATTERY VOLTAGE		
SYSTEM VOLTAGE	NUMBER OF UNITS	CELL TYPE	FLOAT	EQUALIZE	END VOLTAGE MINIMUM
PER 12V BLOCK PER –48V STRING	1 4	VRLA (HIGH GRAVITY) VRLA (HIGH GRAVITY)	13.50 54.0	14.00 56.0	10.8 43.2
PER 6V BLOCK PER –48V STRING	1 8	VRLA (HIGH GRAVITY) VRLA (HIGH GRAVITY)	6.75 54.0	7.00 56.0	5.40 43.2
PER 2V CELL PER -48V STRING	1 24	VRLA (HIGH GRAVITY) VRLA (HIGH GRAVITY)	2.25 54.0	2.30 55.20	1.88 45.12
PER 2V CELL PER -48V STRING	1 24	VRLA (LOW GRAVITY) VRLA (LOW GRAVITY)	2.20 52.8	2.30 55.20	1.88 45.12

CAUTION: *Online Equalize battery voltages must never reach load equipment high voltage operating limits.*

1. The battery voltages are measured at the battery terminals or the BTBA.

2. The end voltage minimum is the battery end-of-discharge voltage.

(7) Applying Voltage Temperature Compensation adjustments:

(a) If the battery charger has an automatic voltage temperature compensating system, technicians must insure that the sense lead is placed at the battery in accordance with the manufacturer's instructions. Caution: Any system that automatically temperature compensates the float voltage must not allow the cell voltage to fall below:

(i) 2.21V per cell (53.04V per string) for 1.300 Specific Gravity battery systems. This applies to ALL VRLA battery systems except as described in (ii).

(ii) 2.16V per cell (51.80V per string) for the C&D LST and Liberty 2000 HDL, 1.245 (Low) Specific Gravity battery systems.

When the automatic voltage temperature compensating system does not meet this low voltage parameter – *the compensation module must be disabled.*

(b) In systems without automatic compensation (no sense leads), technicians should manually adjust the float voltage setting as specified below in Table B:

Table B Temperature Compensated Float Voltage Settings		
Battery Temperature (F)	Float Voltage Setting (V)	Float Voltage Setting (V) For LST and Liberty 2000 HDL Series
110 and Higher	53.1	51.8
105	53.2	52.0
100	53.4	52.2
90	53.9	52.7
80	54.0	52.8
70	54.2	53.0
60 and Lower	54.5	53.3

Note: The instructions in step (7), and Table B above, apply to both OSP and Central Office environments.

(8) Remove and wipe clean any grease or moisture from the battery post and connecting hardware.

(9) Read and record the individual cell or battery unit voltage with the Cellcorder.

(10) Take initial cell resistance measurements using the Cellcorder test set. Also read the inter cell or strap resistance (when applicable). Write the cell resistance measurement into the space provided on the label affixed to each battery block.

(11) Check to insure the cell resistance readings are close to the *BASELINE VALUES* specified by the Manufacturer. If any reading is greater than 40% above or below, then immediately retest to verify reading. After a retest, if cell resistance readings are still greater than 40%, the cell is defective. Contact the manufacturer for cell replacement.

(12) Lightly coat the battery post, clamp and connecting hardware with NO-OX ID grease.

ACCEPTANCE COMPLETE

PERIODIC MAINTENANCE AND TEST ROUTINE (ACTION STEPS): This battery testing routine and procedures are to be repeated every 4 months.

The battery charge current (float current) level is an indicator of the battery cell's state of health. If the battery is experiencing thermal problems or other internal problems, the float current in the battery cell (and string) can increase dramatically. The **float current limit (FCL)** of the battery is reached when the float current exceeds 200mA per 100 Amp Hour (AH) of battery capacity **(FCL = AH/500).** Exceeding this level of float current indicates a serious problem and will require further testing immediately. Exception: *Higher currents exceeding the Float Current Limit are normal during an equalizing charge or during a recharge following an AC outage and battery discharge.*

1. Determine the battery ampere-hour (AH) capacity by reading it directly off the battery block / sticker. Calculate the battery float current limit (FCL = AH / 500).

At a **fully charged state**, normal battery operating temperatures range between 65º F and 85º F. An elevated battery temperature can indicate internal cell problems if the battery temperature **is elevated above** the ambient surrounding air temperature. *Note however, that the battery cell temperatures will be elevated if the battery is being recharged following an AC outage or battery discharge.*

2. Read and record the ambient (surrounding) air temperature using an Infrared Pistol Digital Thermometer (or equivalent temperature-sensing device).

3. Remove and wipe away any grease or moisture from the battery post, clamp and connecting hardware.

4. Read each battery unit (block) temperature by sensing the temperature on the case and at the negative terminal post using the Infrared Thermometer. Record the maximum single battery block temperature from within the system.
   (a) If any battery block temperature is higher than the surrounding air temperature by more than FIVE Degrees F, proceed and complete Step 5. THEN STOP AND IMMEDIATELY notify supervisor of the elevated temperature and the float current measurements.

5. Using a Clamp-on Amp Meter (zeroed and calibrated), measure the battery DC float current in each string and record the value(s).

6. Check the DC float current reading against the calculated Float Current Limit (FCL).
   (a) If the DC float current reading is normal (or below the FCL) proceed directly to Step 7.
   (b) If the DC float current reading is above the FCL -- AND – is higher than 5 Amps, this battery system is entering an unstable thermal condition, or is already in a state of thermal runaway. IMMEDIATELY PERFORM *THERMAL RUNAWAY – IMMEDIATE ACTION STEPS 1 – 6.*

(Note: during battery recharging the battery current readings will be higher than the normal and should not be interpreted as out of range.)

7. Measure the total battery string voltage using a digital multi meter.

8. Using the voltage measurement obtained in step 7, apply Voltage Temperature Compensation adjustments as required:

   (a) If the battery charger has an automatic voltage temperature compensating system, technicians must insure that the sense lead is placed AT THE BATTERY in accordance with the manufacturer's instructions. CAUTION: Any system that automatically temperature compensates the float voltage must not allow the cell voltage to fall below:

      (i) 2.21V per cell (53.04V per string) for Normal (or high) 1.300 Specific Gravity battery systems. This applies to ALL VRLA battery systems except as described in (ii).

      (ii) 2.16V per cell (51.80V per string) for the C&D LST and Liberty 2000 HDL 1.245 (Low) Specific Gravity battery systems.

      When the automatic voltage temperature compensating system does not meet this low voltage parameter – *the compensation module must be disabled.*

   (b) In systems without automatic compensation (no sense leads), MANUALLY ADJUST the float voltage setting as specified by the standard voltage settings listed in Table B.

9. Measure the battery string voltage using the digital multi meter. Record the result.

10. Measure and record each cell (or battery unit) voltage, using the Cellcorder test set.

11. Conduct a Cell Resistance test across the positive and negative terminal of each cell or battery unit, using the Cellcorder. When connected with three clamps, the test automatically measures the strap inter-cell resistance between each battery jar (See Cellcorder connection diagram).

12. Record the results on the *Test Form* and submit to the maintenance supervisor after each reading. Also, dump the test data stored in the Cellcorder onto a PC and save to a floppy diskette. Forward this data to the maintenance supervisor.

13. When testing yields any readings above the Upper Limit Value listed in the Cell Resistance Tables OR, when exceeding 50% above the baseline average (as described below), these battery units or cells are considered defective. Notify the battery manufacturer immediately for cell replacement under warranty.

FOUR MONTH ROUTINE - ACTION STEPS COMPLETE

PROCEDURES FOR ESTABLISHING BASELINE CELL RESISTANCE (IF NO DATA IS AVAILABLE): If no valid cell resistance baseline data is available for the battery model under test, then the cell resistance readings for each unit or cell in the battery string will be *trended* to establish the **baseline** and **boundary** value(s). Specifically, the **Two** lowest readings in the string averaged together will become the **baseline** value for the batteries in this string. Without neither reference data nor any other indications of poor battery health, this **baseline** value will represent the resistance reading for healthy units (or cells) - for this string only. *If there are multiple battery strings, then take the lowest of all of the string averages and use this lowest string average as the baseline value to judge all other batteries against (in this location only).* Each battery unit reading 25% or more above this **baseline** value is to be considered questionable (and is likely defective). A 50% variance from this **baseline** is considered a Defective Unit (or Cell) and must be replaced.

A DESCRIPTION OF THERMAL RUNAWAY: A fully charged cell or string of cells at normal float voltage will begin to use a higher float current than is normal (normal = 50mA per 100 AH). Consequently, these cells begin heating up to abnormally high internal temperatures. As the heating occurs, the cell requires more charge current to sustain the chemical heating process, which further heats the cell and every cell in the string. As the process continues, the battery temperature continues to increase while drawing higher and higher amounts of charge current. If this process is not stopped, the VRLA battery system can melt down. If the battery cell jar cases and covers are not made of flame retardant materials, an ignition, fire, and / or explosion(s) can occur. This can occur in as little as 6-10 hours from the onset of Thermal Runaway. Thermal Runaway is an undetectable condition unless technicians are present to monitor cell temperatures and float current levels, *or a remote monitoring system is installed.*

THERMAL RUNAWAY – IMMEDIATE ACTIONS

1. Immediately reduce the Battery Charger FLOAT VOLTAGE Setting to 48.0 VDC.

2. Using the Clamp-on Amp Multi Meter, repeat the float current reading twice, at 2-minute intervals. Conduct this float current reading procedure in each battery string that has an elevated float current. If the battery string current decreases by 1.0 Ampere or more, repeat this procedure twice over. After completing this, if any battery string float current remains above 1.0 Ampere, proceed immediately to step 3 below. Otherwise, if the final battery string current measurement is now below 1.0 Ampere, call the maintenance supervisor to determine what further actions are needed.

3. If the DC bus contains one or more healthy battery strings, DISCONNECT only the battery string(s) in thermal runaway.

4. If ALL the battery strings have measured currents exceeding 3.0 – 5.0 Amps (indicating early stages of thermal runaway) install and parallel a temporary battery. Once the temporary battery is paralleled, then DISCONNECT the existing battery systems from the DC bus.

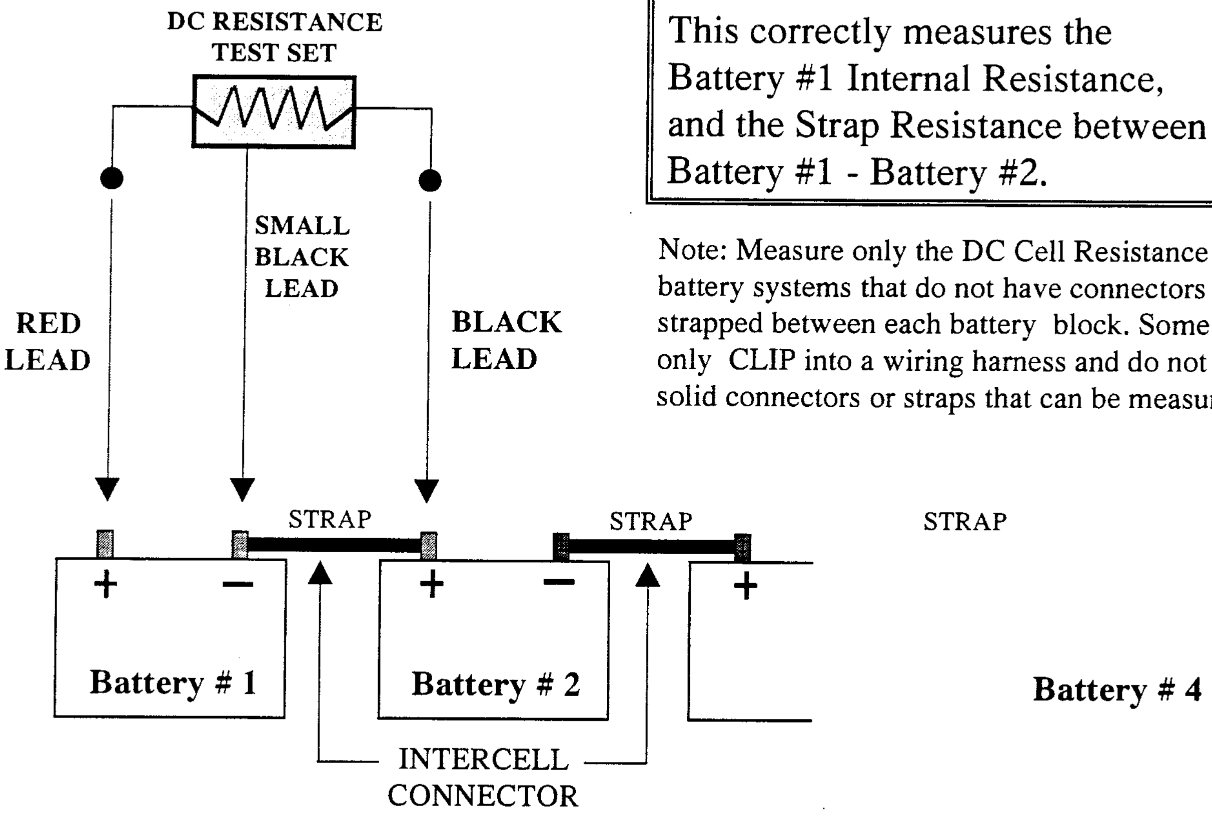
5. If paralleling a temporary battery IS NOT POSSIBLE, then lift and insulate the NEGATIVE cable connecting each battery string to the DC bus. This action will remove each battery string from service, while the battery chargers are still supplying DC power to the telecommunications load.

6. If Steps 4 and 5 are not possible, AND ALL battery strings are in a full state of thermal runaway (indicated by float currents exceeding 6 - 8 Amps), a battery charger shutdown is necessary to avoid the expulsion of sulfurous oxide, hydrogen gas, acid, a potential fire or explosion. Caution: carrying out this action will cause you to lose the switch and interrupt service. Consult with the Network Operations Center, and your supervisor before continuing. When directed, proceed by turning off the AC inputs to all battery chargers and shutting off the DC output on each charger. Then disconnect the battery cabling between the battery and the DC bus. (Note: be sure to insulate each battery cable).

END OF REQUIRED ACTION STEPS

CELL RESISTANCE TEST SET BATTERY CONNECTIONS

Diagram of the Alber CellCorder CLC-200 Test Set Connections. This correctly measures the Battery #1 Internal Resistance, and the Strap Resistance between Battery #1 - Battery #2.



Note: Measure only the DC Cell Resistance on OSP battery systems that do not have connectors bolted or strapped between each battery block. Some systems only CLIP into a wiring harness and do not have solid connectors or straps that can be measured.

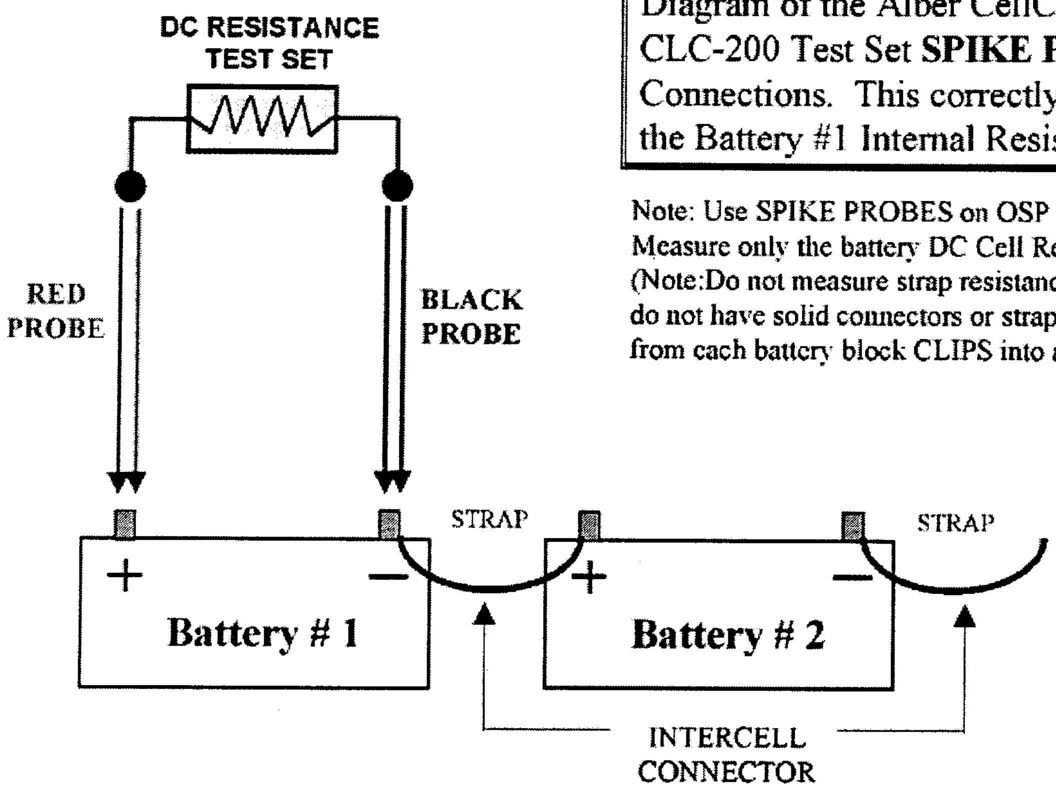
The diagram above depicts the correct method of connecting to the battery using the Three Clamp test cable set. This measures both the DC Cell Resistance and the inter-cell strap resistance (at the same time). The Cellcorder reads the DC Cell Resistance and Inter-cell strap resistance simultaneously, then stores and displays these readings along with the cell float voltage for battery unit.

Note: The correct labeling of the Battery Block is very important. By standard convention, the most positive terminal (on battery block #1) in the battery string always is connected to the positive DC bus and therefore labeled Battery Block #1. The most negative terminal in the battery string (negative terminal on the last battery block) is always connected to the negative DC bus and therefore is labeled as Battery Block #4 in a string using 12V battery blocks (or battery block #24 in a 24 cell string).

CELL RESISTANCE TEST SET BATTERY CONNECTIONS

Diagram of the Alber CellCorder CLC-200 Test Set **SPIKE PROBE** Connections. This correctly measures the Battery #1 Internal Resistance.

Note: Use SPIKE PROBES on OSP battery systems. Measure only the battery DC Cell Resistance. (Note:Do not measure strap resistance. Most systems do not have solid connectors or straps, or the wiring from each battery block CLIPS into a wiring harness.)



When using the Spiked Probe test cable set there are just Two Test leads (probes). This measures only the DC Cell Resistance. This is typically used on smaller (outside plant cabinet) batteries, which normally use cables or some other wiring interface for inter-cell series connections. The Spiked Probes can also be used on large battery systems.

Note: Care must be taken to insure that firm probe to battery post connections are made and sustained for 5 seconds during each resistance test.

SUMMARY AND CONCLUSIONS:

This approach to maintenance of VRLA battery systems simply ensures that several basic and important factors are routinely tested and monitored:

- ✓ The battery system is equalize or boost charged when needed.
- ✓ The battery charger set voltage is always optimal for the battery.
- ✓ The battery float current and temperature are routinely monitored.
- ✓ Thermal instability and runaway battery conditions are controlled and monitored (to some degree).
- ✓ The internal DC cell resistance is measured against an Established Baseline.
- ✓ Inter Cell strap resistance is measured.
- ✓ The battery terminals and hardware are maintained properly (clean, greased, tight).

Warranty Adjustments: The methods and procedures in this program mention warranty adjustments based on defective cell resistance readings. This has been established through contractual agreements that our company has established with specific battery manufacturers. The Baseline Cell Resistance value is measured and established at the factory by the Battery Manufacturer. It is then also corroborated in the field during acceptance and subsequent routine testing.

Cell Resistance and Predictive Data: Cell resistance is not the only determining factor to knowing a battery's condition, but it does provide a very good indicator of the battery's relative state of health. While not *directly* proportional to cell capacity, cell resistance is a very ACCURATE means of measuring CHANGES in the battery's condition. Consequently, if diligence is taken to establish the Baseline Value of a healthy cell, then the user will know the relative condition (and capacity) of the battery as time and testing indicate changes. By tracking the changes over periodic testing intervals, the user establishes data to indicate/correlate the Percentage of Cell Resistance change to the Percentage of Cell Capacity change. Arguably, a 25% - 45% change in Cell Resistance correlates to a 20% - 30% change in Cell Capacity. This of course allows the user to know the current battery condition and to predict with some accuracy the remaining life and capacity.

Economics of the Maintenance Program: This set of maintenance and testing routines will rely upon a technician's availability or ability to reach (all) the locations requiring service. The telephone technician routinely visits the Cabinet or Office to perform service and routines on telecommunications equipment. This provides a regular and periodic opportunity for battery system maintenance to be performed manually during these visits. This takes away the need to make a special trip dedicated only for battery maintenance. Hence, the economics of travel and time are minimized while the battery routine itself is normally very brief.

Remote Battery Monitoring: This paper's approach to battery maintenance does not take into consideration a remote battery-monitoring program. Remote monitoring appears to be a very attractive method of automating and accomplishing most of what these routines now specify to be done manually. However, there are some questions and issues with remote battery monitoring that we have not studied thoroughly. Some of them are: the cost of equipment, physical space requirements for the monitoring components, dedicated communication facilities for reporting the monitored information, resources for receiving and interpreting reported information, and accuracy of measurements (i.e. float current). Note: Approximately 85% of our locations are OSP remote terminal cabinets which make some of these issues more difficult to overcome (as compared to office locations).

Closing Comments: The most difficult part has been getting this program started. The technicians in the various districts, states, and regions around the country have formerly used their own methods / procedures and their own preferences with various types of test equipment. Having written and published the detailed procedural steps (like those contained in this paper) and getting the cooperation and partnership from battery suppliers has made this a successful standard throughout the network. The technicians absolutely love having a step by step set of procedures that are easily followed and provide immediate and useful feedback during the battery testing. This program is still taking hold and is not yet fully implemented everywhere, but is already beginning to pay dividends.

The biggest benefit is having an absolute standard procedure that all can follow. Along with that, we build a repository of data on each type of battery in use. This allows us to accurately know that for a given % change in the test readings, this translates to a specific % change in battery system (or cell) capacity.

TERMS / DEFINITIONS:

Valve Regulated Lead Acid (VRLA): VRLA battery systems capture and absorb the liquid electrolyte in glass mats placed between the lead battery plates. During charge and discharge reaction cycles the internal gases recombine which helps maintain desired levels of electrolyte and specific gravity. Internal pressure is regulated through a pressure relief valve, which opens to expel hydrogen gases when the internal pressure exceeds normal levels.

Float Current Limit (FCL): A non standard term indicating our own (company) designated "upper limit" for battery current at float voltage. The **FCL** of the battery is reached when the float current exceeds 200mA per 100 Amp Hour (AH) of battery capacity or FCL = AH/500. Exceeding this level of float current indicates a serious problem and is a "red flag" for the technician testing the battery.

Controlled Environment: An environment whose temperature and humidity can be controlled to the desired levels.

Non-Controlled Environment: An environment whose temperature and humidity cannot be controlled. A typical Telecommunications Outside Plant cabinet is a non-controlled environment where temperatures can reach or exceed 140 Degrees Fahrenheit.

Battery Float Voltage: The float voltage is that voltage, which provides the correct amount of battery charge current to maintain an optimal state of charge in the battery cell. The battery float voltage is measured at the battery system terminals and set at the battery charger (equal to the battery charger set voltage minus the voltage drops between charger and battery terminals.

Baseline DC Cell Resistance: The measured cell resistance value that represents a healthy battery (at 100% capacity).

DC Cell Resistance: The internal resistance of the battery is determined by loading the cell, discharging the battery, releasing the load, and measuring the voltage and current during the recovery. The ratio of the measurements provides the Cell Resistance. Also referred to as an Ohmic measurement.

Defective Battery Capacity: 80% is the battery capacity level at which the battery is considered defective – for warranty consideration.
