SCE&G
A SCANA Company

South Carolina Electric & Gas Company
P.O. Box 88
Jenkinsville, SC 29065
(803) 345-4040

Ollie S. Bradham
Vice President
Nuclear Operations

August 15, 1988

Document Control Desk
U. S. Nuclear Regulatory Commission
Washington, DC 20555

Subject: Virgil C. Summer Nuclear Station
Docket No. 50/395
Operating License No. NPF-12
Single Cell Battery Charging
(TAC No. 68045)

Gentlemen:

Attached are the responses to the NRC staff request for additional information regarding the use of single cell battery chargers at the Virgil C. Summer Nuclear Station. These responses were requested by the staff in a letter dated June 27, 1988.

Should you desire additional information or desire a meeting on this issue, please call at your convenience.

Very truly yours,

O. S. Bradham

MDB/OSB:df
Attachment

c: D. A. Nauman/O. W. Dixon, Jr./T. C. Nichols, Jr./J. G. Connelly, Jr.
E. C. Roberts
W. A. Williams, Jr.
J. N. Grace
J. J. Hayes, Jr.
General Managers
C. A. Price/R. M. Campbell, Jr.
R. B. Clary
K. E. Nodland
J. C. Snelson
G. O. Percival
R. L. Prevatte
J. B. Knotts, Jr.
M. D. Blue
D. O. Hicks
NSRC
NPCF
RTS (NRR 880003)
File (819.38)

A001
1/1

RESPONSES TO NRC QUESTIONS ON THE SINGLE CELL BATTERY CHARGING SYSTEM

QUESTION 1

What programs are in place (such as a trending program) to determine if a cell(s) that repeatedly requires equalization should be replaced?

RESPONSE

Existing programs that monitor battery status are surveillance testing, planned preventative maintenance tasks and non-conformance evaluations. If a problem with an individual cell exists, the problem would be identified and resolved under these programs. There is no formal trending program that reviews individual cell data.

QUESTION 2

How many hours on the average during the year is it expected that the 40 volt charger will be connected to either safety-related battery? Is there a limit on the number of hours that the 40 volt charger is permitted to be connected?

RESPONSE

It is estimated that the single cell battery charger (SCBC) would be connected no longer than 100 hours per year on each safety-related battery bank; however, no limit has been placed on the number of hours the SCBC can be connected to the battery banks. There is a seven day Technical Specification surveillance requirement on the battery banks, but in order to perform this surveillance, the SCBC would have to be disconnected from the safety-related battery bank.

QUESTION 3

If an insulation blanket is used over the safety-related battery bank while placing an equalization charge using the 40 volt charger, what procedures insure that the battery does not become overheated due to the blanket?

RESPONSE

Electrical Maintenance Procedure (EMP) 115.004, "Individual Cell Charging Procedure," is being revised to not allow rubber blankets to be placed in such a manner that would block ventilation passages.

QUESTION 4

What protection is there to detect and isolate a high impedance fault between the 40 volt battery charger and the isolation fuses if the fault limits the current to a value less than the fuse rating?

RESPONSE

Cabling for the SCBC was designed to minimize faults. The cables between the SCBC and the isolation fuse panels are run totally in conduit thus minimizing the possibility of mechanical damage. The positive and negative pole cables are purchased nuclear-safety-related, and are run in separate conduits except for the short runs between the SCBC, a terminal box and the charging cables disconnect switches. The cables in the isolation fuse panels and disconnect switches are arranged and spaced so as to maintain a minimum of 5" spacing where possible between cables of the opposite dc pole.

The 125V dc system is an ungrounded system. One cable failing to ground would not cause a fault/overload condition. Both the positive and negative cables must fail for a fault condition.

The 125V dc system is equipped with ground indicating lights in the main control room. Depending on the number of cells under equalizing charge by the SCBC and the fault impedance, there may be a discernable difference between the intensity of the two ground indicating lights prompting operator action. (Note that normal SCBC operation will not produce an intensity difference between the ground indicating lights).

Battery cell degradation due to a high impedance fault is improbable due to the following:

- Positive and negative cables must fail simultaneously.
- Cables are run in conduit only.
- The majority of the cable length is run in separate conduits for each pole.
- Cables are separated by a minimum 5" spacing where possible in the disconnect switches and fuse panels.
- The probability of a high impedance fault itself is low.
- Fault detection by the ground indicating lights.

It is therefore concluded that the concern regarding high impedance faults is adequately addressed.

QUESTION 5

The 10 CFR 50.59 assessment of the 40 volt charger states that the charger will not act as a short because the output resistors plus the circuit resistance will limit the current to an insignificant amount. What is considered to be an insignificant amount?

RESPONSE

In the case of a loss of input ac to the SCBC, the worst case current from the battery bank to the SCBC has been calculated to be 7.9 amps due to the effect of the output resistors and circuit resistance. This worst case value was based on the following conservative assumptions.

- The 125V dc charger is in service with the volts per cell assumed to be the maximum float value of 2.25V.

- The number of cells connected to the SCBC is the maximum allowable of 17.

- Fuse, disconnect switch, terminal block and other cable contact resistances are assumed to be negligible.

The calculated maximum current of 7.9 amps will not damage any equipment. The drain on the battery would be 47.4 amp-hours (AH) (6 hours maximum between SCBC checks x 7.9 amps) with the 125 V dc charger in service. 47.4 AH is 4.5% of the connected cell's 1050 AH capacity. This is less than the battery reserve capacity of 9.32% for the 1A battery and 16.96% for the 1B battery.

The 47.4 AH battery cell discharge is a worst case drain since no credit is taken for any recharging occurring as a result of the 125V dc charger remaining in service. The trickle current from the 125V dc charger is assumed to be negligible; therefore, the amp-hour input (recharge) to a battery cell is also assumed to be negligible.

If input ac is lost to both the SCBC and the 125V dc charger, the current drain drops to 7.4 amps due to lower volts per cell. The battery design is to provide power for 2 hours without charging. The drain on the battery from the SCBC in this case is 14.8 AH (2 hours x 7.4 amps) which is 1.4% of a cell's 1050 AH capacity.

QUESTION 6

The 10 CFR 50.59 assessment states that each cell of the battery can withstand 2.9 volts @ 52.5A for approximately 24 hours. However, the isolation fuses are rated at 150 amperes. What protects the battery against equalization currents between 52.5 and 150 amperes in the event that the voltage regulator controls partially fail?

RESPONSE

If a battery cell is fully charged and at 2.9V, the current passed through the cell in an attempt by the charger to raise the cell voltage past 2.9V will generate heat and breakdown water through electrolysis. The battery vendor, C&D Batteries, Inc., calculated that a cell passing 150 amps would take approximately eight hours to reach the cell's low water level if it was initially at its proper water level. Below the low water level, cell damage could occur and outgassing could be a problem as the water level eventually drops below the cell's flame arrestor rendering it no longer functional.

Therefore to assure a battery cell will not be damaged due to a maintained equalizing current of 150 amps, a battery check is required every 6 hours. This 6 hour figure provides margin relative to the 8 hours required to reach a battery cell's low water level noted previously.

QUESTION 7

It is understood that administrative controls will be used to check every six hours against an overvoltage to the battery cells while using the 40 volt charger. What assessment has been made to determine the effect of a six hour maximum overvoltage condition?

RESPONSE

In a calculation similar to the one in the previous question, C&D Batteries has calculated that a battery cell can withstand a 2.9V and 52.5 amp condition for up to 24 hours. Therefore, an adequate safety margin exists between the 6 hour battery check and the 24 hour withstand expectancy. (NOTE: Due to a cell's physical characteristics, 2.9V is the maximum that can appear across its terminals.)

QUESTION 8

What procedural steps are followed to insure that the station battery and its individual cells are operable after removing the 40 volt charger?

RESPONSE

Electrical Maintenance Procedure (EMP) 115.004, "Individual Cell Charging Procedure," controls the use of the SCBC including administrative requirements such as battery cable separation criteria and equipment time interval checks to ensure the operability of the station battery. Upon removal of the SCBC from the station battery, EMP-115.004 requires a set of battery data be obtained using EMP-115.011, "Battery Inspection" to determine the as-left condition of the station battery. Acceptance criteria for individual cell voltages (≥2.13V dc), electrolyte level, electrolyte specific gravity, and electrolyte temperature (≥65°F) is contained in EMP-115.011.

QUESTION 9

Have the fuse cabinets, cable racks and their mountings (in the battery rooms) been seismically qualified? In particular, what assurance is there that the cable racks will not tear loose and directly or indirectly fault the battery?

RESPONSE

The SCBC system has been seismically designed and installed. The SCBC stand, cable rack, local panels, disconnect switches, terminal box, and fuses in local panels and components in other panels were all seismically mounted. The conduit clamps, expansion bolts, SCBC stand and cable rack steel and hardware were purchased nuclear-safety-related.

Based on the preceding items, seismic or anti-falldown concerns have been adequately addressed in the SCBC system design.

QUESTION 10

Please send a copy of the pages from the instruction manuals 1MS94B-245 and 300 that discuss the conditions for beginning or ending and equalization charge.

RESPONSE

The instruction manual pages requested by the NRC are attached.

IMS 94B-245

SECTION VI
OPERATION

6.0 OPERATION

6.1 FLOAT CHARGING AND BATTERY LIFE

Most stationary batteries are continuously connected to control circuits which must be energized at all times. This is accomplished by connecting the battery in parallel with a continuously operating charger and the desired load circuits. The charger is then adjusted to a voltage which will enable the battery to obtain just enough current to keep it fully charged. Under certain conditions, such as with lead-antimony batteries and lead-calcium batteries that are floated below recommended voltages, periodic equalizing charges may be necessary. The charger also furnishes current for the connected load. This is called float operation. It assures a fully charged battery for any emergency service. **Maximum battery life is obtained in full float service.** If occasional discharges are experienced, battery life will decrease in proportion to the frequency and depth of these discharges.

In general it is customary that a stationary battery will not experience any more than 200 discharge cycles evenly distributed throughout its useful life. Frequent or greater depths of discharge can shorten service life to 10 years or even less even with proper maintenance and operating conditions. Use Table I and Table II to set float potentials, while adjusting to the higher float value when more frequent discharges are anticipated. For example, batteries for photovoltaic service should be charged at the maximum allowable potential.

TABLE I

LEAD-ANTIMONY CELLS

CHARGE VOLTAGE PER CELL (VPC) (1.210 Specific Gravity)			
INITIAL		FLOAT	EQUALIZE
VPC	HOURS	VPC	VPC
2.39	40	2.15 to 2.17	2.33 for 8 to 24 hours
2.36	60		
2.33	110		
2.30	168		
2.24	210		

If lead-calcium the following table applies:

TABLE II

LEAD-CALCIUM CELLS

CHARGE VOLTAGE PER CELL (VPC)				
SP. GR. OF CELLS	FLOAT VPC		INITIAL/EQUALIZE (VPC)	
	MIN.	NOMINAL	MIN.ACCEPTABLE VPC	NOM. VPC
1.170	2.14	2.17-2.22	2.10	2.29-2.34
1.210	2.17	2.20-2.25	2.13	2.33-2.38
1.225	2.18	2.22-2.27	2.15	2.36-2.40
1.250	2.20	2.25-2.30	2.18	2.38-2.43
1.275	2.23	2.29-2.34	2.20	2.40-2.46
1.300	2.27	2.33-2.38	2.23	2.45-2.50

6.2 EQUALIZING CHARGE

This is a charge given at a voltage higher than the nominal float charge for a definite number of hours depending upon the value of the charge voltage. Its purpose is to compensate for any irregularities that may have occurred among cells in the battery from causes such as a low float voltage for a prolonged period of time due to faulty adjustment of the charger, or for a panel voltmeter which is improperly calibrated on the high side. It is also useful in restoring the battery to a full charge in a minimum time after an emergency discharge. (See Tables I and II for equalize voltages.)

NOTE: Minimum acceptable voltage is the point at which plans should be made to provide an equalizing charge. It does not imply that the battery is malfunctioning or that it will not provide power if called upon. Some equipment may not have equalizing potentials available. In such cases a single cell charger with complete AC line isolation may be paralleled across the affected cell while still a part of the overall battery to provide an over voltage to that cell. Use the equalize voltage setting as shown in Tables I and II. Do not be alarmed if such charging must continue for several weeks, particularly in consideration that the currents actually passing through the cells are very small. Consult your C&D Sales/Service agent who is able to answer your specific questions, or obtain the necessary information.

6.3 VOLTMETER CALIBRATION

Panel voltmeters used for float charging circuits should be kept in accurate calibration by checking with a known standard at least every twelve months. Always measure battery voltage at the battery terminals and compare this reading with the panel meter to eliminate line drop. Battery voltage should always be measured with modern digital voltmeters of at least 3½ digit display and .25% accuracy. (See Tables I and II for float voltages.) This type of instrumentation is particularly useful in recording individual cell potentials.

6.4 LEAD-ANTIMONY BATTERIES

Lead-antimony batteries require an equalizing charge about every three months to one month as the batteries change electrochemically from new to old, respectively.

6.5 LEAD-CALCIUM BATTERIES

Usually lead-calcium batteries do not need equalizing charges when floated at the recommended voltage as indicated in Table II. However, lead-calcium batteries which operate at the minimum float value should be given an equalizing charge whenever the lowest cell in the string drops more

IMS 94B-245

than 0.04 volts below minimum float voltage or to the minimum acceptable voltage in Table II.

6.6 BATTERIES FOR PHOTOVOLTAIC SERVICE

Batteries for photovoltaic service have a less defined discharge/recharge regime and as such must be observed after the average full charge state. If it is determined that a cell(s) have fallen more than 0.04 volts below normal float it may be necessary to add additional solar panels or reduce the load demand. Check the solar panel for dirt accumulation or possible malfunction of panel or controls. Equalize charge from auxiliary equipment is always a good solution if the equipment is available. Charge at the highest equalize potential found in Table II.

6.7 ENGINE STARTING BATTERIES

Certain C&D stationary batteries (MHCSD, etc.) are used in engine cranking power for large diesel powered generators. The frequency of such discharges and the depth is unpredictable, but the service must be regarded as heavy cycle service. As such cell(s) will become out of line with normal float potential. The solution is to provide equalize charge at the highest practical potential shown in Tables I and II.

6.8 RECHARGE FOLLOWING EMERGENCY DISCHARGE

Batteries left in the discharged state for periods of time may sulfate, or in the case of severe discharge, hydrate which is a state of complete failure. Hydration will be discussed in Section 10.5.

Both lead-antimony and lead-calcium batteries should be recharged as quickly as practical following an emergency discharge. Where conditions permit, this can be done by raising the bus voltage to the maximum allowed by the other circuit components but not to exceed the values listed in Tables I and II. If charging at equalize voltage is impractical, recharge at float voltage.

6.9 WATER ADDITIONS

In addition to normal evaporation, as batteries are floated and charged, a small quantity of the water in the electrolyte is broken down into hydrogen and oxygen by the charging current. These gases are dissipated through the flame arrestor. As this takes place, the electrolyte level gradually drops so that from time to time it is necessary to replace this loss with water. Keep the electrolyte level between the high and low level lines by adding approved or distilled water as required. Refer to Section 4.9: "Adjusting Electrolyte Level and Watering of Battery" to better understand the rate of water loss and the quality of water which must be used for water additions.

Along with cell voltage, specific gravity records must include the amount and date of water additions.

6.10 CLEANING — DO'S AND DON'TS

Wipe the outside of the cells as necessary with a water-moistened cloth to remove dust and ordinary dirt. If electrolyte is spilled on the covers, neutralize it with a cloth moistened with a solution of baking soda and water mixed in the proportion of one pound of soda to one gallon of water. When fizzing stops as fresh soda solution is applied, wipe with a water-moistened cloth to remove all traces of soda.

Never use solvents, detergents or other cleaning compounds or oils, waxes or polishes on the plastic containers or covers since such materials may attack the plastic and cause it to craze or crack. Always keep the connectors and posts corrosion-free and coated with NO-OX-ID grease or corrosion resistant oil. The covers and containers should be clean and dry at all times.

C&D is presently supplying some stationary batteries encased in clear polycarbonate plastic containers which can be identified by their appearance. (Their color is generally water-white, although when viewed from an angle they have a bluish tint.) They are extremely acid resistant, free from internal stresses and have superior impact resistance.

CAUTION
CLEANING POLYCARBONATE JARS

Clean or wash the polycarbonate containers with clear water only.

Neutralize acid spills with a solution of sodium bicarbonate (baking soda). Never use ammonia, soda ash, sodium hydroxide or any strong alkalies. If alkalies are inadvertently spilled on the containers, they should be immediately washed off with water.

6.11 CHECKING CONNECTIONS

NOTE: Many protective coatings designed to inhibit corrosion of connecting terminals contain chlorinated solvents which may be harmful to the battery and particularly to the cover and plastic container for the cells. C&D Batteries recommends the exclusive use of NO-OX-ID grease or special corrosion resistant oil supplied for the battery by C&D Batteries and available upon order for subsequent scheduled maintenance.

Maintenance of connections is one of the most important tasks for which the user is responsible. A loose or corroded connection can often develop a high resistance circuit. If a high current load is suddenly required from the battery an extremely large amount of power can be dissipated at the connection, often leading to a melt-down of the post and possible ignition of the cover of the cell or other neighboring parts. Only you the user can inspect and maintain connection integrity. It is recommended that all electrical connections associated with the battery be inspected routinely at least four times yearly and retorqued as required to the torque values given in Table I of Section 4.6 titled "Subse-

IMS 94B-245

quent Retorquing". Remember connections tend to work loose and lead has a physical property of "cold flow". **Do not** overtorque, however, since this will stress and distort the post and cause accelerated cold flow of the lead post.

CAUTION

Maintenance of connections, both tightness and cleanliness, is essential to safe operation of a battery. This is not the responsibility of C&D Batteries but that of the user, as an integral part of battery maintenance.

6.12 RECORDS

A record of the battery operation is invaluable (see Fig. 21 as sample) in helping to determine causes for associated equipment difficulties; for checking on maintenance procedures; and for indicating remedial action when necessary. At periodic intervals, which will necessarily vary with location and system routines, the following information should be recorded and reported to the supervising authority: date; date and description of last equalizing charge (if lead-antimony); battery floating voltage; pilot cell hydrometer reading; pilot cell temperature; and quantity of water added.

Periodically, read and record individual cell specific gravities and voltages and note any unusual conditions.

If irregularities occur, consult the nearest C&D Sales/Service agent and send a copy of the latest report c/o C&D Power Systems, Technical Services Department, 3043 Walton Road, Plymouth Meeting, PA 19462. Indicate whom you have called upon from the C&D Sales/Service directory and when he visited your facility for inspection.

1M5948-245

SECTION XII

CONDENSED INSTRUCTIONS FOR INSTALLATION AND OPERATION

CAUTION:

WET BATTERIES must be placed on charge within three months if lead-antimony or six months if lead-calcium from time of shipment from factory.

DRY-CHARGED BATTERIES must be properly activated and charged within 12 months. See RS-758 or Section VIII in 12-800.

WARNING:

Electrolyte is an acid and can cause severe burns. Always wear protective clothing such as a rubber apron, safety goggles and rubber gloves when working around batteries.

1. **RECEIVING** - If packing material shows evidence of physical damage or spillage of electrolyte make notation on bill of lading before signing. Check electrolyte level in each cell. It should be between low and high level lines. If more than ½" of plate surface has been exposed to air, the cell has suffered permanent damage and should be replaced.

2. **INSTALLATION** - Locate battery in a cool, clean, dry place so no cells are affected by radiators, heaters, or pipes. Arrange cells on rack so they can be connected positive to negative throughout. Connections between cells must be clean, dry, free of acid and coated with NO-OX-ID grease or corrosion resistant oil before bolting together. See Section IV, "Installation of Cells", of Section 12-800.

3. **CONNECTING BATTERY TO CHARGER** - Only direct current (DC) is used for charging. Connect battery positive terminal to charger positive terminal and battery negative terminal to charger negative terminal.

4. **WATERING** - Add approved or distilled water after charging and as required to keep electrolyte level between high and low level lines on container.

5. **CLEANING** - Keep outside of cells clean and dry by wiping with a water damp cloth as required and dry. Neutralize any acid on covers or connectors with a cloth moistened with a solution of baking soda and water, then wipe off all traces of soda. **NEVER USE ANY SOLVENTS, CLEANING COMPOUNDS, OILS, WAXES OR POLISHES ON PLASTIC CONTAINERS OR COVERS SINCE SUCH MATERIALS MAY ATTACK THE PLASTIC AND CAUSE IT TO CRAZE OR CRACK. DO NOT USE ANTI-CORROSION AEROSOL SPRAYS ON CONNECTIONS.**

PURPOSE AND METHODS OF CHARGING (REFER TO TABLES I & II)

INITIAL CHARGE -

A. Lead-Antimony Types (1.210 nominal specific gravity) - Give initial charge not later than three months after battery has been shipped and at highest voltage permitted by connected load. Table I shows various suggested voltages and corresponding time.

B. Lead-Calcium Types (Check nominal specific gravity shown on nameplate on top of cells before proceeding.) Charge at highest voltage per cell permitted by connected load (equalize value if possible) until voltage of lowest cell stops rising and then continue for an additional 24 hours. If lead-calcium cells are to be floated at the recommended voltage they will automatically receive their initial charge at this voltage, providing they have not been on open circuit for more than six months. If on open circuit longer than six months they should be given an extended equalizing charge. Contact your local C&D representative or the C&D Technical Services Department for more information.

FLOAT CHARGING - Float batteries continuously after the initial charge from a voltage-regulated DC supply bus at the values in Tables I and II. (Use recommended float voltage value unless other circuit components make it necessary to use the minimum float voltage values.) Check panel voltmeter against a known standard annually and calibrate if necessary.

EQUALIZING CHARGES - Compensate for irregularities in floating. Equalize charges are also required if cells reach critical voltages listed in Table II. Raise bus voltage to values shown in Tables I and II. Continue charge at these elevated values until lowest cell reads within 0.05 volts of the average of the cells in the lead calcium battery. Lead-antimony cells are equalized regularly at intervals of one to three months and are charged at equalize potential for eight to 24 hours.

FINISH RATES - Normal finish rates are 5A/100 AH of the eight hour capacity or 6A/100 AH of the three hour capacity. Finish rate currents are utilized in constant current charging for initial charging of dry charged cells and special remedial charging techniques. Float and equalize currents are considerably lower current values.

TABLE I

LEAD-ANTIMONY CELLS

CHARGE VOLTAGE PER CELL (VPC) (1.210 Specific Gravity)			
INITIAL		FLOAT	EQUALIZE
VPC	HOURS	VPC	VPC
2.39	40	2.15 to 2.17	2.33
2.36	60		for 8 to 24 hours
2.33	110		
2.30	168		
2.24	210		

TABLE II

LEAD-CALCIUM CELLS

SP. GR. OF CELLS	CHARGE VOLTAGE PER CELL (VPC)			
	FLOAT VPC		INITIAL/EQUALIZE (VPC)	
	MIN.	NOMINAL	MIN. ACCEPTABLE VPC	NOM. VPC
1.170	2.14	2.17-2.22	2.10	2.29-2.34
1.210	2.17	2.20-2.25	2.13	2.33-2.38
1.225	2.18	2.22-2.27	2.15	2.36-2.40
1.250	2.20	2.25-2.30	2.18	2.38-2.43
1.275	2.23	2.29-2.34	2.20	2.40-2.46
1.300	2.27	2.33-2.38	2.23	2.45-2.50

IMS94B-300

SECTION VI
OPERATION

6.0 OPERATION

6.1 FLOAT CHARGING AND BATTERY LIFE

Most stationary batteries are continuously connected to control circuits which must be energized at all times. This is accomplished by connecting the battery in parallel with a continuously operating charger and the desired load circuits. The charger is then adjusted to a voltage which will enable the battery to obtain just enough current to keep it fully charged. Under certain conditions, such as with lead-antimony batteries and lead-calcium batteries that are floated below recommended voltages, periodic equalizing charges may be necessary. The charger also furnishes current for the connected load. This is called float operation. It assures a fully charged battery for any emergency service. **Maximum battery life is obtained in full float service.** If occasional discharges are experienced, battery life will decrease in proportion to the frequency and depth of these discharges.

In general it is customary that a stationary battery will not experience any more than 200 discharge cycles evenly distributed throughout its useful life. Frequent or greater depths of discharge can shorten service life to 10 years or even less even with proper maintenance and operating conditions. Use Table I and Table II to set float potentials, while adjusting to the higher float value when more frequent discharges are anticipated. For example, batteries for photovoltaic service should be charged at the maximum allowable potential.

TABLE I

LEAD-ANTIMONY CELLS

CHARGE VOLTAGE PER CELL (VPC) (1.210 Specific Gravity)			
INITIAL		FLOAT	EQUALIZE
VPC	HOURS	VPC	VPC
2.39	40	2.15 to 2.17	2.33 for 8 to 24 hours
2.36	60		
2.33	110		
2.30	168		
2.24	210		

If lead-calcium the following table applies:

TABLE II

LEAD-CALCIUM CELLS

CHARGE VOLTAGE PER CELL (VPC)				
SP. GR. OF CELLS	FLOAT VPC		INITIAL/EQUALIZE (VPC)	
	MIN.	NOMINAL	MIN. ACCEPTABLE VPC	NOM. VPC
1.170	2.14	2.17-2.22	2.10	2.29-2.34
1.210	2.17	2.20-2.25	2.13	2.33-2.38
1.225	2.18	2.22-2.27	2.15	2.36-2.40
1.250	2.20	2.25-2.30	2.18	2.38-2.43
1.275	2.23	2.29-2.34	2.20	2.40-2.46
1.300	2.27	2.33-2.38	2.23	2.45-2.50

6.2 EQUALIZING CHARGE

This is a charge given at a voltage higher than the nominal float charge for a definite number of hours depending upon the value of the charge voltage. Its purpose is to compensate for any irregularities that may have occurred among cells in the battery from causes such as a low float voltage for a prolonged period of time due to faulty adjustment of the charger, or for a panel voltmeter which is improperly calibrated on the high side. It is also useful in restoring the battery to a full charge in a minimum time after an emergency discharge. (See Tables I and II for equalize voltages.)

NOTE: Minimum acceptable voltage is the point at which plans should be made to provide an equalizing charge. It does not imply that the battery is malfunctioning or that it will not provide power if called upon. Some equipment may not have equalizing potentials available. In such cases a single cell charger with complete AC line isolation may be paralleled across the affected cell while still a part of the overall battery to provide an over voltage to that cell. Use the equalize voltage setting as shown in Tables I and II. Do not be alarmed if such charging must continue for several weeks, particularly in consideration that the currents actually passing through the cells are very small. Consult your C&D Sales/Service agent who is able to answer your specific questions, or obtain the necessary information.

6.3 VOLTMETER CALIBRATION

Panel voltmeters used for float charging circuits should be kept in accurate calibration by checking with a known standard at least every twelve months. Always measure battery voltage at the battery terminals and compare this reading with the panel meter to eliminate line drop. Battery voltage should always be measured with modern digital voltmeters of at least 3½ digit display and .25% accuracy. (See Tables I and II for float voltages.) This type of instrumentation is particularly useful in recording individual cell potentials.

6.4 LEAD-ANTIMONY BATTERIES

Lead-antimony batteries require an equalizing charge about every three months to one month as the batteries change electrochemically from new to old, respectively.

6.5 LEAD-CALCIUM BATTERIES

Usually lead-calcium batteries do not need equalizing charges when floated at the recommended voltage as indicated in Table II. However, lead-calcium batteries which operate at the minimum float value should be given an equalizing charge whenever the lowest cell in the string drops more

IMS94B-300

than 0.04 volts below minimum float voltage or to the minimum acceptable voltage in Table II.

6.6 BATTERIES FOR PHOTOVOLTAIC SERVICE

Batteries for photovoltaic service have a less defined discharge/recharge regime and as such must be observed after the average full charge state. If it is determined that a cell(s) have fallen more than 0.04 volts below normal float it may be necessary to add additional solar panels or reduce the load demand. Check the solar panel for dirt accumulation or possible malfunction of panel or controls. Equalize charge from auxiliary equipment is always a good solution if the equipment is available. Charge at the highest equalize potential found in Table II.

6.7 ENGINE STARTING BATTERIES

Certain C&D stationary batteries (MHCSD, etc.) are used in engine cranking power for large diesel powered generators. The frequency of such discharges and the depth is unpredictable, but the service must be regarded as heavy cycle service. As such cell(s) will become out of line with normal float potential. The solution is to provide equalize charge at the highest practical potential shown in Tables I and II.

6.8 RECHARGE FOLLOWING EMERGENCY DISCHARGE

Batteries left in the discharged state for periods of time may sulfate, or in the case of severe discharge, hydrate which is a state of complete failure. Hydration will be discussed in Section 10.5.

Both lead-antimony and lead-calcium batteries should be recharged as quickly as practical following an emergency discharge. Where conditions permit, this can be done by raising the bus voltage to the maximum allowed by the other circuit components but not to exceed the values listed in Tables I and II. If charging at equalize voltage is impractical, recharge at float voltage.

6.9 WATER ADDITIONS

In addition to normal evaporation, as batteries are floated and charged, a small quantity of the water in the electrolyte is broken down into hydrogen and oxygen by the charging current. These gases are dissipated through the flame arrestor. As this takes place, the electrolyte level gradually drops so that from time to time it is necessary to replace this loss with water. Keep the electrolyte level between the high and low level lines by adding approved or distilled water as required. Refer to Section 4.9: "Adjusting Electrolyte Level and Watering of Battery" to better understand the rate of water loss and the quality of water which must be used for water additions.

Along with cell voltage, specific gravity records must include the amount and date of water additions.

6.10 CLEANING — DO'S AND DON'TS

Wipe the outside of the cells as necessary with a water-moistened cloth to remove dust and ordinary dirt. If electrolyte is spilled on the covers, neutralize it with a cloth moistened with a solution of baking soda and water mixed in the proportion of one pound of soda to one gallon of water. When fizzing stops as fresh soda solution is applied, wipe with a water-moistened cloth to remove all traces of soda.

Never use solvents, detergents or other cleaning compounds or oils, waxes or polishes on the plastic containers or covers since such materials may attack the plastic and cause it to craze or crack. Always keep the connectors and posts corrosion-free and coated with NO-OX-ID grease or corrosion resistant oil. The covers and containers should be clean and dry at all times.

C&D is presently supplying some stationary batteries encased in clear polycarbonate plastic containers which can be identified by their appearance. (Their color is generally water-white, although when viewed from an angle they have a bluish tint.) They are extremely acid resistant, free from internal stresses and have superior impact resistance.

CAUTION
CLEANING POLYCARBONATE JARS

Clean or wash the polycarbonate containers with clear water only.

Neutralize acid spills with a solution of sodium bicarbonate (baking soda). Never use ammonia, soda ash, sodium hydroxide or any strong alkalies. If alkalies are inadvertently spilled on the containers, they should be immediately washed off with water.

6.11 CHECKING CONNECTIONS

NOTE: Many protective coatings designed to inhibit corrosion of connecting terminals contain chlorinated solvents which may be harmful to the battery and particularly to the cover and plastic container for the cells. C&D Batteries recommends the exclusive use of NO-OX-ID grease or special corrosion resistant oil supplied for the battery by C&D Batteries and available upon order for subsequent scheduled maintenance.

Maintenance of connections is one of the most important tasks for which the user is responsible. A loose or corroded connection can often develop a high resistance circuit. If a high current load is suddenly required from the battery an extremely large amount of power can be dissipated at the connection, often leading to a melt-down of the post and possible ignition of the cover of the cell or other neighboring parts. Only you the user can inspect and maintain connection integrity. It is recommended that all electrical connections associated with the battery be inspected routinely at least four times yearly and retorqued as required to the torque values given in Table I of Section 4.6 titled "Subse-

IM-S94B-380

quent Retorquing". Remember connections tend to work loose and lead has a physical property of "cold flow". **Do not** overtorque, however, since this will stress and distort the post and cause accelerated cold flow of the lead post.

CAUTION

Maintenance of connections, both tightness and cleanliness, is essential to safe operation of a battery. This is not the responsibility of C&D Batteries but that of the user, as an integral part of battery maintenance.

6.12 RECORDS

A record of the battery operation is invaluable (see Fig. 21 as sample) in helping to determine causes for associated equipment difficulties; for checking on maintenance procedures; and for indicating remedial action when necessary. At periodic intervals, which will necessarily vary with location and system routines, the following information should be recorded and reported to the supervising authority: date; date and description of last equalizing charge (if lead-antimony); battery floating voltage; pilot cell hydrometer reading; pilot cell temperature; and quantity of water added.

Periodically, read and record individual cell specific gravities and voltages and note any unusual conditions.

If irregularities occur consult the nearest C&D Sales/Service agent and send a copy of the latest report c/o Technical Services Department, Stationary Batteries, C&D Batteries, 3043 Walton Road, Plymouth Meeting, Pennsylvania 19462. Indicate whom you have called upon from the C&D Sales/Service directory and when he visited your facility for inspection.

IMS 94B-300

SECTION XII

CONDENSED INSTRUCTIONS FOR INSTALLATION AND OPERATION

CAUTION:

WET BATTERIES must be placed on charge within three months if lead-antimony or six months if lead-calcium from time of shipment from factory.

DRY-CHARGED BATTERIES must be properly activated and charged within 12 months. See RS-758 or Section VIII in 12-800.

WARNING:

Electrolyte is an acid and can cause severe burns. Always wear protective clothing such as a rubber apron, safety goggles and rubber gloves when working around batteries.

1. RECEIVING - If packing material shows evidence of physical damage or spillage of electrolyte make notation on bill of lading before signing. Check electrolyte level in each cell. It should be between low and high level lines. If more than ½" of plate surface has been exposed to air, the cell has suffered permanent damage and should be replaced.

2. INSTALLATION - Locate battery in a cool, clean, dry place so no cells are affected by radiators, heaters, or pipes. Arrange cells on rack so they can be connected positive to negative throughout. Connections between cells must be clean, dry, free of acid and coated with NO-OX-ID grease or corrosion resistant oil before bolting together. See Section IV, "Installation of Cells", of Section 12-800.

3. CONNECTING BATTERY TO CHARGER - Only direct current (DC) is used for charging. Connect battery positive terminal to charger positive terminal and battery negative terminal to charger negative terminal.

4. WATERING - Add approved or distilled water after charging and as required to keep electrolyte level between high and low level lines on container.

5. CLEANING - Keep outside of cells clean and dry by wiping with a water damp cloth as required and dry. Neutralize any acid on covers or connectors with a cloth moistened with a solution of baking soda and water, then wipe off all traces of soda. **NEVER USE ANY SOLVENTS, CLEANING COMPOUNDS, OILS, WAXES OR POLISHES ON PLASTIC CONTAINERS OR COVERS SINCE SUCH MATERIALS MAY ATTACK THE PLASTIC AND CAUSE IT TO CRAZE OR CRACK. DO NOT USE ANTI-CORROSION AEROSOL SPRAYS ON CONNECTIONS.**

PURPOSE AND METHODS OF CHARGING (REFER TO TABLES I & II)

INITIAL CHARGE

A. Lead-Antimony Types (1.210 nominal specific gravity) - Give initial charge not later than three months after battery has been shipped and at highest voltage permitted by connected load. Table I shows various suggested voltages and corresponding time.

B. Lead-Calcium Types (Check nominal specific gravity shown on nameplate on top of cells before proceeding.) Charge at highest voltage per cell permitted by connected load (equalize value if possible) until voltage of lowest cell stops rising and then continue for an additional 24 hours. If lead-calcium cells are to be floated at the recommended voltage they will automatically receive their initial charge at this voltage, providing they have not been on open circuit for more than six months. If on open circuit longer than six months they should be given an extended equalizing charge. Contact your local C&D representative or the C&D Technical Services Department for more information.

FLOAT CHARGING - Float batteries continuously after the initial charge from a voltage-regulated DC supply bus at the values in Tables I and II. (Use recommended float voltage value unless other circuit components make it necessary to use the minimum float voltage values.) Check panel voltmeter against a known standard annually and calibrate if necessary.

EQUALIZING CHARGES - Compensate for irregularities in floating. Equalize charges are also required if cells reach critical voltages listed in Table II. Raise bus voltage to values shown in Tables I and II. Continue charge at these elevated values until lowest cell reads within 0.05 volts of the average of the cells in the lead calcium battery. Lead-antimony cells are equalized regularly at intervals of one to three months and are charged at equalize potential for eight to 24 hours.

FINISH RATES - Normal finish rates are 5A/100 AH of the eight hour capacity or 6A/100 AH of the three hour capacity. Finish rate currents are utilized in constant current charging for initial charging of dry charged cells and special remedial charging techniques. Float and equalize currents are considerably lower current values.

TABLE I

LEAD-ANTIMONY CELLS

CHARGE VOLTAGE PER CELL (VPC) (1.210 Specific Gravity)			
INITIAL		FLOAT VPC	EQUALIZE VPC
VPC	HOURS		
2.39	40	2.15 to 2.17	2.33 for 8 to 24 hours
2.36	60		
2.33	110		
2.30	168		
2.24	210		

TABLE II

LEAD-CALCIUM CELLS

CHARGE VOLTAGE PER CELL (VPC)				
SP. GR. OF CELLS	FLOAT VPC		INITIAL/EQUALIZE (VPC)	
	MIN.	NOMINAL	MIN. ACCEPTABLE VPC	NOM. VPC
1.170	2.14	2.17-2.22	2.10	2.29-2.34
1.210	2.17	2.20-2.25	2.13	2.33-2.38
1.225	2.18	2.22-2.27	2.15	2.36-2.40
1.250	2.20	2.25-2.30	2.18	2.38-2.43
1.275	2.23	2.29-2.34	2.20	2.40-2.46
1.300	2.27	2.33-2.38	2.23	2.45-2.50