U. S. NUCLEAR REGULATORY COMMISSION

REGION I

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| License Nos. | DPR-70<br>DPR-75 | |
| Licensee: | Public Service Electric and Gas Company | |
| | P. O. Box 236 | |
| | Hancocks Bridge, New Jersey 08038 | |
| Facility Name: | Salem Nuclear Generating Station - Units 1 and 2 | |
| Inspection At: | Hancocks Bridge, New Jersey | |

Inspection Conducted: February 16, 1988 - March 21, 1988

Inspectors: T. J. Kenny, Senior Resident Inspector

Approved by: P. D. Swetland 3/25/88

P. D. Swetland, Chief, Reactor Projects Section No. 2B, Projects Branch No. 2, DRP — date

Inspection Summary:
Inspections on February 16, 1988 - March 21, 1988 (Combined Report Numbers 50-272/88-08 and 50-311/88-08)

Areas Inspected: Routine inspections of plant operations including: operational safety verification, maintenance, surveillance, review of special reports, licensee event followup, storage battery adequacy audit (temporary instruction 87-07), and assurance of quality. The inspection involved 105 inspector hours by the resident NRC inspector.

Results: This report documents a Unit trip on Unit 1 during physics testing and the apparent failure of a reactor trip breaker on Unit 2. The report also documents the results of a battery adequacy audit. Two licensee identified violations were noted in Section 6 involving not staggering surveillance tests for redundant components, and missed grab samples for steam generator blowdown discharges.

# DETAILS

## 1. Persons Contacted

Within this report period, interviews and discussions were conducted with members of licensee management and staff as necessary to support inspection activity.

## 2. Operational Safety Verification (71707, 71709, 71710 and 71881)

2.1 Documents Reviewed

- Selected Operators' Logs
- Senior Shift Supervisor's (SSS) Log
- Jumper Log
- Radioactive Waste Release Permits (liquid & gaseous)
- Selected Radiation Work Permits (RWP)
- Selected Chemistry Logs
- Selected Tagouts
- Health Physics Watch Log

2.2 The inspector conducted routine entries into the protected areas of the plants, including the control rooms, Auxiliary Building, fuel buildings, and containments (when access is possible). During the inspection activities, discussions were held with operators, technicians (HP & I&C), mechanics, security personnel, supervisors, and plant management. The inspections were conducted in accordance with NRC Inspection Procedures 71707, 71709, 71710, and 71881 and affirmed the licensee's commitments and compliance with 10 CFR, Technical Specifications, License Conditions, and Administrative Procedures.

No violations were identified.

2.2.1 Engineered Safety Feature (ESF) System Walkdown: (71710)

The inspectors verified the operability of the selected ESF system by performing a walkdown of accessible portions of the system to confirm that system lineup procedures match plant drawings and the as-built configuration. This ESF system walkdown was also conducted to identify equipment conditions that might degrade performance, to determine that instrumentation is calibrated and functioning, and to verify that valves are properly positioned and locked as appropriate. The Intermediate Head Safety Injection System (Unit 2) and Auxiliary Feedwater System (Unit 1) were inspected. No deficiencies were identified.

## 2.3 Inspector Comments/Findings:

The inspector selected phases of the units' operation to determine compliance with the NRC's regulations. The inspector determined that the areas inspected and the licensee's actions did not constitute a health and safety hazard to the public or plant personnel. The following are noteworthy areas the inspector researched in depth:

### 2.3.1 Unit 1

The refueling outage was completed and on February 2, 1988, the unit was brought critical to conduct low power physics testing.

On February 19, 1988, the licensee identified a lower than normal megger reading (resistance to ground) on rod drive mechanism 1SA2 (a rod in Shutdown Bank A). The rod was operable and the licensee decided to proceed with physics testing in order to complete the outage. It was anticipated that the rod drive mechanism would be replaced at a later date.

On February 24, 1988, at 4:36 a.m., the reactor tripped from 2% power due to a high flux trip on channel N35 (intermediate range). The trip signal was caused when an instrument technician failed to follow a procedure and pulled the fuses on that channel before placing the trip channel in bypass.

The technician had been working on channel N35 prior to the trip and spikes were seen on the average reactor coolant temperature reference signal in the control room. The Shift Supervisor directed the technician to investigate the relationship between the work being performed on channel N35, and the Tave deflections. The technician failed to follow the procedure to place the trip channel in bypass prior to removal of the fuse. Subsequent investigation produced the following facts:

- The experienced technician was preoccupied with the Tave interference with channel N35 and was trying to figure out the connection. He admitted to having the procedure but not returning to the correct step in the procedure, "Place the channel in bypass" and proceeded to remove the instrument fuses thus causing the trip.

- The licensee is committed to the INPO Human Performance Evaluation System (HPES) to investigate plant occurrences. This was the first case to be evaluated and will be reviewed by the resident inspector when available.

- The spikes in the Tave program were subsequently attributed to a faulty RTD in No. 13 hot leg. The RTD's, which were installed during the outage have two elements (primary and secondary). The primary was found deficient and the secondary was connected in its place. The system has functioned normally since the change was made.

This item remains unresolved pending completion of these actions and NRC review of the Licensee Event Report. (UNR 272/88-08-01)

During the shutdown, rod drive mechanism 1SA2 was replaced.

The unit was taken critical on February 26, 1988, and returned to service on February 28, 1988 following the completion of low power physics testing.

On February 29, 1988, a primary to secondary leak was discovered in the No. 13 steam generator. Power ascension was stopped and power was stablized at 80%. With steady state conditions, the leak rate was calculated to be between 40 and 50 gallons per day (gpd). The unit resumed power ascension to full power at a rate of 1% per hour with close monitoring of the leak rate. The leak rate stabilized at 150 gpd at 100% power with the licensee sampling the blowdown on a two hour basis. As of March 21, the leak rate has decreased to 25-50 gpd. Blowdown and air ejector monitors have remained constant throughout this period. The licensee is continuing to sample the steam generator and evaluate the results. Procedures are in place to define a course of action should the leak propagate.

At the end of this report period the unit was at 100% power.

2.3.2 Unit 2

The unit began this report period at 100% power and continued operation at full power throughout the period. At 11:25 a.m. on February 17, 1988, the licensee made a one hour notification to the NRC, stating that "B" reactor trip breaker did not open within 10 cycles during the performance of a monthly surveillance. The undervoltage trip attachment would have opened the breaker in 83 cycles, but the shunt attachment opened the breaker in 2 cycles. The breaker was replaced with "A" bypass reactor trip breaker which had tested satisfactorily. The licensee then declared "B" reactor trip breaker operable at 12:47 p.m. on February 17, 1988. Subsequent investigation by the licensee, as observed by the resident inspector, indicated that the breaker functioned properly, but the computer time sequencer may have printed an erroneous reading on the sequence of events recorder. The licensee performed the following:

- M3Q3 Maintenance Procedure to test DB-50 Westinghouse breakers. The test was performed three times and the results were the same as the "as left" condition of the breaker recorded from the previous test, which had been performed one month earlier.
- Tests to try and duplicate the sequence of events from the computer were unsuccessful, however, the licensee removed the card, cleaned and tightened the connectors, and replaced and tested the card.
- All tests were inconclusive as to why the computer or breaker had failed the test so the licensee replaced the undervoltage trip device and retested the breaker.

2.3.3 Both Units

On February 16, 1988, Mr. Steven E. Miltenberger relieved Mr. Corbin A. McNeill as Chief Nuclear Officer. Mr. Miltenberger will assume the title of Vice President and Chief Nuclear Officer and will report to PSE&G chief executive officer, Mr. James Ferland, on nuclear operation matters. Mr. McNeill has taken a position with the Philadelphia Electric Company.

No violations were identified.

## 3. Maintenance Observations (62703)

The inspector reviewed the following safety related maintenance activities to verify that repairs were made in accordance with approved procedures and in compliance with NRC regulations and recognized codes and standards. The inspector also verified that the replacement parts and Quality Controls utilized on the repairs were in compliance with the licensee's QA program.

Unit 1

| Work Order Number | Maintenance Procedure | Description |
|---|---|---|
| 880108061 | 1PD-14.1.003 Removal and Replacement of necessary equipment from the reactor vessel head to replace 1SA2 Magnetic Jack.<br><br>1PD-8.2.001 Electronic check (megger) of newly installed Magnetic Jack.<br><br>IC1.4.003 Rod Testing and IRPI Checks. | Replacement of Magnetic Jack for rod 1SA2. |

Unit 2

| Work Order Number | Maintenance Procedure | Description |
|---|---|---|
| 880217714 | M3Q-2 Reactor Trip Breaker Lubrication and Testing A11-1 Calibration Verification of the Shore Stake tool (crimping tool). | Replacement of the undervoltage coil and retesting of reactor trip breaker "B" SN 02YN219-6. |

No violations were identified.

4. Surveillance Observations (61726)

During this inspection period, the inspector reviewed in-progress surveillance testing as well as completed surveillance packages. The inspector verified that the surveillances were performed in accordance with licensee approved procedures and NRC regulations. The inspector also verified that the instruments used were within calibration tolerances and that qualified technicians performed the surveillances.

The following surveillances were reviewed:

Unit 1

SP(O)4.7.6.1a Control Room Ventilation - Tests and verifies the Emergency Control Room Area Air Conditioning System in accordance with (IAW) Technical Specification 4.7.6.1a.

SP(O)4.8.1.1.1b — Bus Transfer - Tests the operability of the bus transfer device from the vital bus source to the alternate source, IAW Technical Specification 4.8.1.1.1b.

SP(O)4.8.2.3.1 — DC Breaker Alignment - Verifies the three DC busses' breaker alignment, IAW Technical Specification 4.8.2.3.1.

Unit 2

SP(O)4.0.5-P-RH (21) — Tests the operability of No. 21 Residual Heat Removal Pump, IAW Technical Specification 4.0.5.

SP(O)4.3.3.7 — Post Accident Monitoring - Tests and verifies post accident monitoring instrumentation operable, IAW Technical Specification 4.3.3.7.

No violations were identified.

5. Review of Periodic and Special Reports (90713)

Upon receipt, the inspector reviewed periodic and special reports. The review included the following: inclusion of information required by the NRC; test results and/or supporting information consistent with design predictions and performance specifications; planned corrective action for resolution of problems, and reportability and validity of report information. The following periodic reports were reviewed:

- Unit 1 Monthly Operating Report - February, 1988
- Unit 2 Monthly Operating Report - February, 1988
- Special Report 88-02, Unit 2. This report documents the licensee's actions connected with the "B" reactor trip breaker. This incident is discussed in Section 2 of this report. The inspector has no further questions at this time.

No violations were identified.

6. Licensee Event Report Followup (90712)

The inspector reviewed the following LER's to determine that reportability requirements were fulfilled, immediate corrective action was taken, and corrective action to prevent recurrence had been accomplished in accordance with Technical Specifications.

Unit 1

88-001-00 Diesel Generator Day Tanks Do Not Meet Seismic Criteria

This LER discusses the discovery and repair of improperly welded diesel generator day tanks. During a system walkdown for the preparation of a Probabilistic Risk Assessment (PRA), it was discovered that the structural welds that attached the day tank to the base were not properly made. The welds were not long enough to satisfy the seismic criteria. The welds were subsequently repaired and are now in compliance with the seismic criteria. The licensee is in the process of identifying how the discrepancy occurred. Unit 2 tanks were checked, and they were within specifications. The inspector has no further questions at this time.

88-002-00 Tavg Deviation on All Channels Due to Design

This LER discusses the discovery and repair of a manufacturer's design modification of a component used with RTDs recently installed for measuring reactor coolant temperature. When the RTDs were placed in service, a 5 degree F deviation was noted which caused the licensee to enter technical specification action statement 3.0.3 (motherhood) for forty minutes. The subsequent investigation revealed the following:

- All of the RTDs utilized a low level amp which compensates for signal loss due to hundreds of feet of cable losses.

- The low level amp had a pre-installed jumper across the temperature compensation circuit. This circuit was not identified to the licensee.

- The 5 degrees F difference in readings between wide range and narrow range reactor coolant temperature did not become evident until temperature went above 530 degrees F which is the beginning of the narrow range reading.

- All RTDs had been replaced during the refueling outage, and all tracked together.

- Testing prior to heatup was done with the RTD and compensator disconnected. This is a normal practice.

- The licensee removed the jumper in the low level amp, and the component responded properly and tracked with narrow range temperature.

The licensee has corresponded with the Manufacturer, informed other utilities through INPO "note pad", modified the design prior to installation into Unit 2, informed maintenance personnel and updated their ordering system for replacement parts.

The inspector has no further questions.

88-003-00 Reactor Trip on a False Intermediate Range - High Flux Signal Due to Personnel Error

This LER event is discussed in Section 2 of this report. The inspector has no further questions.

Unit 2

88-003-00 Technical Specification (TS) Table 3.3-12 Action 27 Not Complied With Due To Personnel Error

This LER discusses missed periodic samples of the radiation monitoring system (Blowdown From "C" Steam Generator) as required by an action statement. The cause was identified as a communication and training problem between an instrument technician and the shift supervisor. The technician had discovered, while working on the high pressure regulator in the system, that the low pressure regulator was also inoperable. He failed to communicate this properly to the shift supervisor and did not inform his immediate supervisor. As a result, the system was returned to service without the low pressure regulator in service, thus there was no flow through the detector. This is not evident in the control room area and the system appeared normal. During the period with no samples, downstream detectors in the main blowdown header did not detect any radioactivity. The licensee has conducted "workshop" type training sessions with I&C technicians to discuss the event and operations management has reviewed the event with shift supervisors. The licensee is also investigating the need to change applicable procedures to prevent recurrence of the event. The inspector determined that this event represents a licensee identified violation of TS 3.3-12, for which no further action is required. (NV4 311/88-08-02)

88-004-00 Technical Specification Surveillance 4.3.2.1.1 Not Performed on a Staggered Basis - Inadequate Administrative Control

This LER discusses the lack of staggering of testing of relays within the safeguards equipment cabinet as per technical specifications. Technical specifications require staggering to minimize the probability of multiple failure during accident conditions. The licensee performed the tests on both A and B trains and did not stagger the testing. The root cause has been identified in the computer system that is to date incapable of scheduling staggered surveillances. The licensee has identified other systems that require staggering and will address them manually. The licensee is also investigating the feasibility of changing the computer program to accommodate the required scheduling. The inspector determined that this event represents a licensee identified violation of TS 4.3.2.1(1), for which no further action is required. (NV4 311/88-08-03)

7. Region I Temporary Instruction 87-07, Storage Battery Adequacy Audit (71707)

This instruction was issued to gather information on storage batteries. The following are the questions asked the licensee and their responses. The following format lists the questions as a group, followed by the licensee's response.

A. General Battery Information

Document the below information for batteries which carry vital loads.

(1) Qualified, or design, seismic life

(2) Qualified, or design, electrical life

(3) Age

(4) Time in service

(5) Plans for replacement

A.1 "Nuclear Environmental Qualifications Report QR-2-27504" dated June 1984 describes the method used for the qualification of Salem's batteries and battery racks. (See Attachment 1).

A.2 The qualification of the battery's electrical life is described in the same report mentioned in A.(1). Qualified and design electrical life is based on previous natural and accelerated aging tests conducted on type L. C. cells of identical and similar material and design. All accelerated (thermal) aging was conducted at a controlled test chamber temperature of 160 degrees F ± 2 degrees F. The test cells were float charged during the accelerated aging process. The qualified electrical and seismic life is more than 20 years based on this report.

A.3 The age of the oldest cells contained within each of the class IE batteries is as follows:

| | |
|---|---|
| 1A 28 VDC | 17 years |
| 1B 28 VDC | 17 years |
| 1A 125 VDC | 3 months |
| 1B 125 VDC | 1 month |
| 1C 125 VDC | 4 years |

| | |
|---|---|
| 2A 28 VDC | 16 years |
| 2B 28 VDC | 16 years |
| 2A 125 VDC | 17 years |
| 2B 125 VDC | 16 years |
| 2C 125 VDC | 3 years |

A.4 Although the time in service is less than the actual age of the batteries, the licensee assumes the two to be the same since this gives a conservative estimate of battery service time.

A.5 As can be seen in answer 1-3; 4 batteries have already been replaced within the last 4 years. The remaining batteries will be replaced within the next 2 refueling outages for each unit.

B. Previous Licensee Actions

Identify actions taken on the following IE Information Notices: 83-11, Possible Seismic Vulnerability of Old Lead Storage Batteries; 84-83, Various Battery Problems; 85-74, Station Battery Problems; and 86-37, Degradation of Station Batteries.

B.1 Attachment 4 contains PSE&G's responses to these IE Notices.

C. Seismic Lifetime and Qualification

For batteries supplying vital loads, identify the following information.

(1) Licensee and/or manufacturer's establishment of seismic lifetime. This maybe through documentation allowing verification by competent personnel other than the qualifiers and containing design specifications, the qualification method, results, and justifications (ref: IEEE 535-1986).

(2) Seismic qualification maintenance. Identify how the criteria for assuring that the battery and rack will maintain seismic qualification are defined, available, and used for periodic inspections and cell replacements. Identify the criteria for determination of seismic end of life based upon the inservice condition of the battery.

C.1 Wyle Test Report No. 46661-1 for LC-33 (see Attachment 1) cells seismic qualification test indicates that these batteries, after being subjected to a multi-frequency qualification test (5 O.B.E, prior to one D.B.E), has proven that their rated capacity was well above 80% throughout the test program.

C.2 Seismic qualification documentation plus visual inspection of the battery cells on a weekly and quarterly basis provides adequate assurance that the battery cells are seismically qualified. Also, if visual examination of the rack shows no signs of deterioration due to corrosion and if all nuts, bolts, clamps and miscellaneous hardware are tight, the battery rack is assumed acceptable based on the original seismic qualification report. If visual damage of the battery rack or battery is found, either a replacement of the damaged component would occur or a safety evaluation by a qualified engineer would be necessary for continued use. See Attachment 2 for a safety evaluation example.

D. Electrical Sizing and Qualification

For batteries supplying vital loads, identify the following information.

(1) Confirmation that the battery size is sufficient to handle the load profile with a suitable margin.

(2) The means of tracking and control of battery loads such that the batteries and their replacements will have sufficient capacity throughout design life. This should assume that worst case electrolyte temperature and other worst case conditions exist when the battery is called upon to perform its design function.

(3) The provisions for consideration of the effect of jumpered out cells upon the ability of a battery to perform under worst case conditions.

D.1 Preliminary calculations have been completed by the Engineering and Plant Betterment Department. Final calculations by Ebasco are in progress.

D.2 Presently there isn't any formal method of tracking and controlling battery loads, other than the design change process which would require any changes to be compared with current specifications to ensure that the design loading is not exceeded. A computerized DC bus load monitoring system, where loads and margins will be available on demand, is presently being developed.

D.3 Engineering Safety Evaluation S-2-E200-NSE-221, (Attachment 3) indicates that the No. 2B 125V DC battery will operate as required with cell No. 36 jumpered out. (% capacity for battery with cell No. 36 out of service is 101%). The final Ebasco battery capacity calculation mentioned in D.(1) will also address this issue.

E. Battery Ventilation and Protection From Ignition Hazards

For batteries carrying vital loads, identify the following.

(1) The provisions for assuring adequacy battery ventilation during normal operation, outages, charging, and discharge.

(2) Adequacy of checks of battery ventilation flow.

(3) Adequacy of controls over battery ventilation impediments such as enclosing the battery space or its ventilation with plastic sheeting, or any other ventilation obstructions, during outages and other periods.

(4) Adequacy of hydrogen detection equipment and its calibration and use, or of the technical justification for not using such equipment.

(5) Knowledge of the hydrogen hazard on the part of plant management, operating shift management, and personnel who access the battery spaces.

(6) Prohibition of hot work and smoking in battery spaces, including checking the spaces for the residue of such activity.

(7) Assurance that battery cells are secured, with post-to-case and top-to-jar seals tight. Thermometers should not be left in cells after temperatures are measured. Caps on the filler openings should be properly secured when not required to be off. (Cells should be vented only through the flash arrestors.)

(8) The means of assuring proper elimination of water-carrying pipes (e.g., HVAC lines) from battery spaces, especially those which may carry salt water.

(9) The means of positive control over the quality of water added to the batteries to assure that the manufacturer's recommendations or an appropriate licensee standard are met or exceeded.

(10) The assurance of elimination of combustibles, and loose equipment and conductors, from battery spaces.

E.1 The following calculations demonstrate the size of the fan required in each battery room in order to prevent 1% of hydrogen (H2) accumulation during the following conditions:

a. Charging the battery
b. Normal operation
c. Discharging the battery

Maximum release of $H_2$ per cell per hour = 0.0112 CF

Maximum release of $H_2$ per hour per 60 cells = 0.0112 C.F.H x 60

Maximum release of $H_2$ per hour per 60 cells = .672 C.F.H of $H_2$

Amount of fresh air needed $X = \frac{.672 \text{ C.F.H}}{.01} = 67.2 \text{ C.F.H}$

In minutes $X = \frac{67.2 \text{ C.F.H}}{60} = 1.12$ C.F.M OF fresh air

E.2 All battery testing and maintenance procedures instruct personnel to periodically check exhaust fan operation while working on batteries.

E.3 As part of the license requalification training, licensed operators are instructed on the importance of battery room ventilation. In addition, the operators log the operation of the battery room exhaust fans on a daily basis.

Maintenance personnel are guided by maintenance procedures which mention the importance of maintaining battery room ventilation.

All other personnel that may be exposed to storage batteries are given the opportunity to use the Nuclear Department Safety Manual which has a section on safety considerations when dealing with storage batteries.

E.4 Existing plant procedures do not call for the use of hydrogen detection equipment. Existing procedures call for maintaining ventilation equipment in an operable condition to guard against hydrogen gas buildup.

One fan with a 400 CFM displacement capacity is installed in 3 of the battery rooms. A fan with a 250 CFM displacement is installed in the fourth battery room. The calculations in E.(1) indicate that the installed battery room fans with a 400/250 CFM capacity displacement are more than adequate to ventilate the rooms. Therefore, hydrogen detection capability is not necessary.

E.5 As previously discussed in Item E.(3), plant personnel who work with the batteries are given the necessary training to ensure that they are aware of the importance of proper ventilation to eliminate the possibility of explosion from a hydrogen buildup concurrent with a spark.

E.6 There are red warning signs in each of the battery rooms prohibiting sparks or open flames. The battery maintenance procedures warn against smoking/sparks in the battery area and also require a check for cleanliness, and cleaning if necessary.

When hot work is to be performed in the battery room, only qualified personnel are allowed to conduct this type of work with the ventilation fan in operation.

E.7 The battery maintenance procedures require visual inspection of all battery cells for cracked or leaking jars, and any signs of electrolyte wetting at the battery post seal.

E.8 Inspection of the class IE battery spaces has indicated that there are no water carrying pipes in any of these areas. An adjacent room for the non-class IE 250 VDC battery has an eyewash station which has a water supply line.

E.9 When water is required to be added to the battery cells to maintain the proper level, it is taken from the station demineralized water system. Attachment 5 shows the Salem Station Water Quality Standard for demineralized water and the frequency of sampling to ensure these standards are met. Power System Inc. (battery manufacturer) will be contacted to make sure these standards meet or exceed the manufacturers' requirements.

E.10 All battery maintenance procedures call for the elimination of non-essential materials and cleaning of the battery area when required. The most frequently performed procedure is M3M which is done on a weekly basis.

F. Electrolyte Temperature Control

For batteries supplying vital loads, identify the adequacy of the following.

(1) Avoidance of localized heat sources such as direct sunlight, radiators, steam pipes, and space heaters.

(2) That the location/arrangement provides for no more than a 5 degree F difference in cell temperature, as confirmed by measurements representative of operating conditions. If this is not the case, then the licensee and manufacturer should have identified the consequent impact on expected battery and individual cell capacity and life, and surveillance procedures should reflect the additional allowable temperature variation.

F.1 None of the Class IE battery spaces have contact with localized heat sources such as direct sunlight, radiators, steam pipes and space heaters.

F.2 The service and capacity test maintenance procedures have demonstrated that individual cells do not experience greater than 5 degrees F difference/cell during float operation prior to discharge.

G. Charging

For batteries carrying vital loads, identify the adequacy of the following.

(1) Provision for a freshening charge after more than 3 months of being on open circuit, unless determined by the manufacturer to be unnecessary to assure rated capacity throughout life.

(2) Accomplishment of equalizing charges at 18 month intervals, and when the corrected specified gravity (SG) of an individual cell is more than 10 points (0.010) below the average of all the cells, and when the average corrected SG of all cells drop more than 10 points below the average installation value, and if any cell voltage is below 2.13V. (Specific manufacturer's provisions and assessment may allow the non-performance of some of these recommended charges, or may provide different criteria.)

(3) Control over battery water quality such that specified purity is confirmed before addition, that water added just prior to charging is added only to bring the electrolyte up to the prescribed minimum (to prevent overflow during charging), and that water added after and between charges does not bring the level above the prescribed maximum (unless manufacturer's instructions provide for other water addition measures).

(4) That routine float and final end of charge SGs not be taken before 72 hours of float operation after completion of the charge and the last water addition, unless the manufacturer's instructions provided otherwise. (The need is for measurement of representative cell levels and average them).

(5) Establishment and maintenance of float voltage in accordance with the manufacturer's instructions.

(6) Assurance that single-cell charger use does not violate Class 1E independence from non-class 1E equipment.

G.1 The battery manufacturers' recommendations are followed for maintaining a cell which has been shipped to the site but has not yet been put in service. An official station procedure to govern this activity does not presently exist and the licensee recognizes this to be a deficiency that requires correction.

G.2 An equalizing charge is performed at least every eighteen months as part of the battery service or capacity tests. An equalizing charge could be performed on a more frequent basis if required. All battery cells are monitored on a quarterly basis for determining cell voltages per technical specifications are at least 2.13 V per cell under float charge with no cell less than .27 volts below the original acceptance test. Also, the specific gravity corrected to 77 degrees F and full electrolyte level, is verified not to be less than 1.200 and shall not have decreased by more than .02 from previous reading as required by technical specifications.

G.3 The battery service and capacity test maintenance procedures provide guidance for the addition of demineralized water to cells. Cell level adjustment is made 24 to 72 hours after equalize charging to replace electrolyte lost during recharge and to help preclude the chance of overflow during the equalize charging.

G.4 The existing battery service test procedures require 24 to 72 hours of float charge before taking SG's and ICV's while our existing capacity service test procedures requires 72 hours before taking SGs and ICVs. The licensee currently has developed a draft procedure for the battery service test which will require 72 hours of float charge before taking SGs and IVCs.

G.5 The battery maintenance procedures list the nominal float voltage per cell to be 2.20 VDC to 2.25 VDC.

G.6 The existing single cell battery charge maintenance procedure does not give specific instructions regarding channel separation. This subject will be further reviewed so that the appropriate action can be taken.

H. Performance Tests and Replacement Criteria

For batteries carrying vital loads, identify the following.

(1) Initial acceptance testing which demonstrates the ability of the batteries to meet the manufacturer's rating.

(2) Service testing which demonstrates the ability to carry the load profile with an appropriate margin for worst case conditions, including end of life loss of capacity under the worst case electrolyte temperature.

(3) Accomplishment of a performance test (capacity test discharge) within the first two years of service and at 5 year intervals until signs of degradation are evident or 85% of the qualified service life is reached.

(4) Annual performance testing of batteries which show signs of degradation or which have reached 85% of the qualified service life is reached.

(5) End of electrical life criteria which consider the rapid end of life drop-off in capacity, worst case state of charge during float service, worst case electrolyte temperature, current DC loads, and the time needed to replace the battery while it can still handle worst case conditions.

H.1 All class IE battery acceptance tests have shown 100% or greater capacity.

H.2 The existing service testing of station batteries is in the midst of being upgraded although the existing service test demonstrates the battery to be capable of performing its required function. Technical specification changes may be required to support the service test revision.

H.3 The battery capacity maintenance procedure M3A did not address acceptance testing although records indicate acceptance testing has been done in the past. Tests are directed to be done every 60 months until capacity is less than 90% at which time the system engineer should be notified so that the appropriate action can be taken. If capacity is less than 85%, the senior shift operator as well as the system engineer are notified. Maintenance procedure M3A will be revised to include the requirement for acceptance testing.

H.4 Since the system engineer by procedure has been notified when battery capacity has reached 90%, he would consult IEEE Standard 450 for other information. IEEE 450 states that performance testing should be increased to once a year for a battery with 85% capacity. Therefore, it is reasonable to assume that this approach would be taken unless the vendor recommended otherwise.

H.5 An initial study was recently completed by the Engineering and Plant Betterment Department (E&PB) on battery capacity based on aging degradation and temperature correction. It was determined that adequate capacity existed on class IE systems. A more detailed study is currently underway.

I. Other Safety-Significant Wet Cell Batteries

For safety-significant wet cell batteries not used for vital loads, show how the maintenance program periodically determines the ability to perform the design function and provides for timely replacement of batteries and for maintaining associated equipment (e.g., chargers).

I.1 Other safety significant batteries such as the one used for the security system are currently being studied by E&PB.

8. Assurance of Quality

During this inspection period assurance of quality was evidenced by the Quality Assurance inspectors that witnessed the installation of the new control rod drive mechanism (1SA2) and the testing and refurbishment of "B" reactor trip breaker. Both maintenance evolutions were completed properly the first time and tested by the procedure successfully. Quality assurance was also evident in the licensee's responsible approach and reporting of primary to secondary leakage (identified in Section 2 of this report). The leak was reported promptly and monitored in accordance with procedures. A clear and concise record has been kept for inspector audits.

Some personnel errors have been identified within this report and this areas continues to be an area of concern. However, the licensee has acted on correcting the communications and personnel error problems by first instituting the INPO Human Performance Evaluation System which will identify what the licensee can do to further reduce the aforementioned problems; and second, by conducting counseling and enhancing training in the personnel and communications areas.

9. Unresolved Items

Unresolved items are matters about which more information is required in order to ascertain whether they are acceptable, deviations or violations. Unresolved items are discussed in section 6 of this report.

10. Exit Interview (30703)

At periodic intervals during the course of the inspection, meetings were held with senior facility management to discuss the inspection scope and findings. An exit interview was held with licensee management at the end of the reporting period. The licensee did not identify 2.790 material.

ALLIED C&D Power Systems

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ALLIED C&D Power Systems

## 1.0 INTRODUCTION

This report presents the Nuclear Environmental Qualification of C & D POWER SYSTEMS LC-33 stationary battery and two step battery rack for the Salem Nuclear Generating Station.

Qualification is provided in accordance with Public Service Electric & Gas Co. P.O. No. 923023 and 932407 requirements as well as the guidelines set forth in IEEE Standards 323-1974, 344-1975 and 535-1979.

The basis for qualification is a review and analysis of previous test data; including the results from thermal and natural aging, seismic test and analysis, and battery capacity tests.

ALLIED C&D Power Systems

## 2.0 DESCRIPTION OF EQUIPMENT

The equipment qualified by this report is the 125 volt dc LC-33 battery and two step battery racks for the Salem Nuclear Power Station.

2.1 The LC-33 battery cell consists of pasted plates with lead calcium alloy grids encased in a vented container. Sixty individual two-volt cells, series connected with bolted connectors, comprise the 125 volt battery. The electrolyte is a sulfuric acid and water solution with a nominal fully charged specific gravity of 1.210 ± .010 at 77°F. The LC-33 battery cell is further described in C & D BATTERIES Drawing No. K-5103 and Section 12-333 which appear in Figures 2.1 and 2.2.

2.2 The two step battery racks consist of steel support frames of welded angle construction, insulated steel cell support and restraint rails, flat steel cross braces and Grade 5 hardware. The battery rack and cell arrangement is fully described in Drawing No. M-8586 which appears in Figure 2.3.

2.3 The LC-33 battery and two step battery racks must be installed and operate in accordance with the requirements set forth in C & D BATTERIES Section 12-800, "Stationary Battery Installation and Operating Instructions", and IEEE Std 484-1981.

2.4 Periodic maintenance and testing shall meet the requirements set forth in IEEE Std 450-1980.

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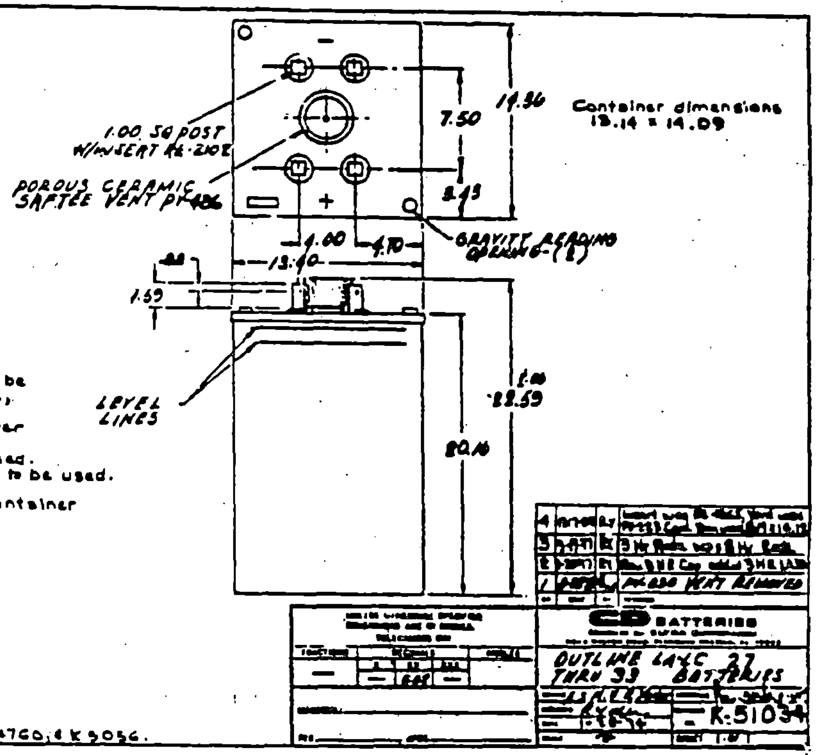
| TYPE | B/M NO | AMS CAP 3 HRS | WGT. WET | ELECTRO /CELL |
|---|---|---|---|---|
| LA-27 | 12902 | 1600 | 350 | 98 |
| LC-27 | 12903 | | | |
| LA-29 | 12904 | 1690 | 367 | 96 |
| LC-29 | 12905 | | | |
| LA-31 | 12906 | 1811 | 384 | 94 |
| LC-31 | 12907 | | | |
| LA-33 | 12908 | 1932 | 401 | 92 |
| LC-33 | 12909 | | | |




Notes:

1. Container material shall be Polycarbonate, but if not available, San. shall be used.

2. Prefix before B/M No. on order indicates:

"S" San container to be used.

"C" Polycarbonate container to be used.

Example: S12902 San Container

C12902 Polycarbonate container

This dwg. replaces dwgs. K4719, K4760, & K5056.

Figure 2.1 LC-33 Cell Outline Dimensions

12-333

C&D POWER SYSTEMS

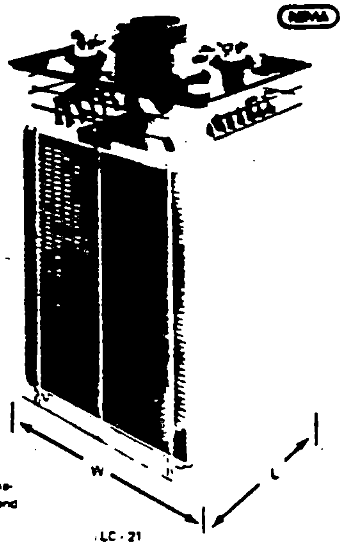
# LC - Lead Calcium
# LA - Lead Antimony

## SPECIFICATIONS

| PLATES | Height | Width | Thickness |
|---|---|---|---|
| Positive | 15" (381 mm) | 12" (305 mm) | 0.312" (7.9 mm) |
| Negative | 15" (381 mm) | 12" (305 mm) | 0.210" (5.3 mm) |
| Outside Negative | 15" (381 mm) | 12" (305 mm) | 0.130" (3.3 mm) |

SPECIFIC GRAVITY . . . . . 1.210 nominal at 77°F (25°C)
CONTAINER† . . . . . . . . . Transparent thermoplastic
CELL COVER . . . . . . . . . Thermoplastic
SEPARATORS . . . . . . . . . Microporous
RETAINERS . . . . . . . . . Fibrous glass matt
ELECTROLYTE HEIGHT ABOVE PLATES . . . . . . . 2.88" (73 mm)
WITHDRAWAL TUBES . . . . Two per cell
SEDIMENT SPACE . . . . . . 0.63" (16 mm)
TERMINALS . . . . . . . . . Four 1" (25 mm) square posts per cell. (Copper inserts are used on cells with 19 thru 33 plates.)
VENT CAPS . . . . . . . . . Flame arrestor type

†OPTIONS
Container . . . . . . . . . Transparent polycarbonate containers. Flammability—self extinguishing per ASTM D635-68 and ULT group 94 VE-2. Oxygen index per ASTM D2863-70 ≥ 25.C.




LC - 21

| Type of Cell | | Nominal Capacities to 1.75 VPC @ 77°F (25°C) (Includes Connector Voltage Drop)* | | | | | | Overall Dimensions | | | Approx. Wt. (lbs) (kg) | | Elect. per Cell (lbs) (kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Ampere Hours | | | Amperes | | | | | | | | |
| Calcium | Antimony | 8 Hrs | 3 Hrs | 1 Hr | 30 Min | 15 Min | 1 Min | L (in.) (mm) | W (in.) (mm) | H (in.) (mm) | Wet Filled | Dry Packed | |
| LC 13 | LA 13 | 900 | 737 | | | | | 7.63 194 | | | 196 88.9 | 211 [illegible] | 86 [illegible] |
| LC 15 | LA 15 | 1050 | 860 | | | | | 7.63 194 | | | 210 95.3 | 225 [illegible] | 80 [illegible] |
| LC 17 | LA 17 | 1200 | 983 | | | | | 7.63 194 | | | 224 [illegible] | 240 [illegible] | 58 26 |
| LC 19 | LA 19 | 1350 | 1106 | | | | | 8.86 226 | | | 254 [illegible] | 274 [illegible] | 70 [illegible] |
| LC 21 | LA 21 | 1500 | 1228 | | | | | 8.86 226 | | | 270 [illegible] | 290 [illegible] | 67 [illegible] |
| LC 23 | LA 23 | 1650 | 1350 | | | | | 10.63 [illegible] | 14.13 359 | 22.63 575 | 310 [illegible] | 330 [illegible] | 84 38 |
| LC 25 | LA 25 | 1800 | 1475 | | | | | 10.63 [illegible] | | | 325 [illegible] | 345 [illegible] | 82 [illegible] |
| LC 27 | LA 27 | 1950 | 1600 | | | | | 13.19 335 | | | 350 [illegible] | 373 [illegible] | 98 [illegible] |
| LC 29 | LA 29 | 2030 | 1680 | | | | | 13.19 335 | | | 367 [illegible] | 390 [illegible] | 96 [illegible] |
| LC 31 | LA 31 | 2175 | 1811 | | | | | 13.19 335 | | | 384 [illegible] | 407 [illegible] | 94 [illegible] |
| LC 33 | LA 33 | 2320 | 1932 | | | | | 13.19 335 | | | 401 [illegible] | 424 | 92 [illegible] |

Note: Electrolyte weighs approximately 10 lbs. per gallon (1.210 sp.gr. per liter).
*Data based on discharge from float at 77°F (25°C) for a minimum of 72 hours.

Figure 2.2 LC Type Cell Design Characteristics

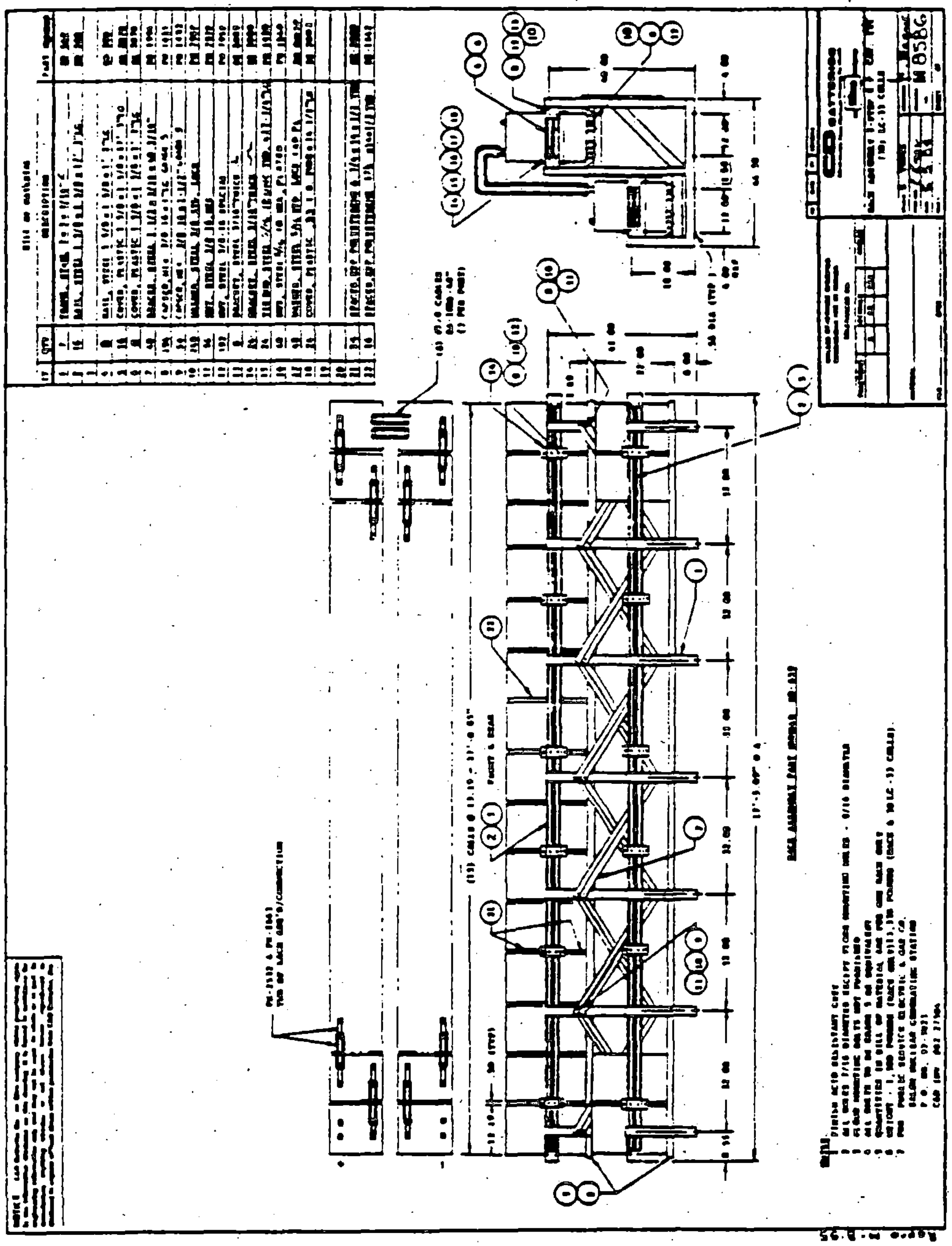


Figure 2.3 30 Cell LC-33 Battery Arrangement and Battery Rack Outline Dimensions

## 3.0 PERFORMANCE REQUIREMENTS

3.1 The battery, when installed and maintained in accordance with the guidelines set forth in C & D BATTERIES' Drawings and Instructions, and the IEEE Standards 450 and 484, shall remain functional for a period of 20 years from the date of shipment.

The battery shall, at any time during its qualified life, be capable of supplying the specified design loads without the voltage at the battery terminals falling below 105 volts while experiencing any single or combination of the following environmental conditions.

a. Ambient temperature range of +77°F to +90°F and an annual average temperature of +80 °F or less.

b. Relative humidity from 0% to 100%.

c. Seismic events of the specified intensities.

3.2 The battery racks shall be capable of supporting the battery cells and their interconnecting

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3.2 (Continued)

devices without damage or interruption of circuit continuity, and shall maintain structural integrity and support function throughout the life of the battery, and during and following specified Operating Basis and Design Basis Earthquakes.

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# 4.0 ENVIRONMENTAL QUALIFICATION

## 4.1 Electrical

Since battery capacity is increased at temperatures above 77° F, and decreases at temperatures below this value, the worse case condition for the battery to deliver the specified design currents is at the minimum battery room ambient temperature of 77° F.

The battery must also be capable of supplying the design loads throughout its qualified life, and therefore must have adequate design margin so that if capacity has degraded to 80% of the original published ratings (end of service life), the design loads will still be supplied for the prescribed times without battery voltage falling below the minimum specified value of 105 volts.

Battery sizing calculations are shown in Figure 4.1, and show the LC-33 battery has adequate margins to meet these requirements. For reference, the LC-33 cell discharge characteristics are shown in Figure 4.2, and selected capacities to 1.75 average volts per cell are given in TABLE 1.

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# BATTERY SIZING WORKSHEET

Reference: IEEE Std 485-1983
SIZED BY: GW
DATE: 13 Jan 86

PROJECT: Salem Nuclear Power Plant

| LOWEST DESIGN TEMPERATURE | 77°F | MINIMUM DESIGN CELL VOLTAGE | 1.75 | SIZING BASIS: PLATE NOMENCLATURE | LC |
|---|---|---|---|---|---|

| LOAD PERIOD | LOAD (AMPERES) | CHANGE IN LOAD (AMPERES) + values | CHANGE IN LOAD (AMPERES) − values | DURATION OF LOAD PERIOD (MINUTES) | TIME TO END OF SECTION (MINUTES) | CAPACITY: AMPERES PER POS PLATE | REQUIRED SECTION CELL SIZE POSITIVE PLATES + values | REQUIRED SECTION CELL SIZE POSITIVE PLATES − values |
|---|---|---|---|---|---|---|---|---|
| SECTION 1 - First Period Only - If 2 is Greater than 1, go to SECTION 2 | | | | | | | | |
| 1 | 1825 | 1825 | | 1 | 1 | 139.2 | 13.11 | |
| | | | | | | Sec. 1 Total | 13.11 | |
| SECTION 2 - First 2 Periods Only - If 3 is Greater than 2, go to SECTION 3 | | | | | | | | |
| 1 | 1825 | 1825 | | 1 | 120 | 50.3 | 36.28 | |
| 2 | 735 | | 1090 | 119 | 119 | 50.3 | | 21.67 |
| | | | | | | Sec. 2 Sub Tot. | 36.28 | 21.67 |
| | | | | | | Total | 14.61 | |
| SECTION 3 - First 3 Periods Only - If 4 is Greater than 3, go to SECTION 4 | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | Sec. 3 Sub Tot. | | |
| | | | | | | Total | | |
| RANDOM EQUIPMENT LOAD(S) (IF APPLICABLE) | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |

(For sizing SECTIONS 4 thru 8, use reverse side)

| | | |
|---|---|---|
| MAXIMUM SECTION SIZE | 14.61 | |
| + RANDOM LOAD SIZE | N/A | |
| = BASE DESIGN SIZE | 14.61 | |
| BASE DESIGN MULTIPLIERS: | x TEMPERATURE CORRECTION | 1.00 |
| | x DESIGN MARGIN | 1.00 |
| | x AGING FACTOR * | 1.00 |
| | = NUMBER OF POSITIVE PLATES | 14.61 |
| REQUIRED CELL SIZE | 15 | POSITIVE PLATES |
| REQUIRED CELL MODEL | LC-31 | |

* Margins for capacity reduction during service life is assumed to have been applyed to the specified loads. LC-33 has a 9.5% design margin.

Figure 4.1 LC-33 Sizing Calculations

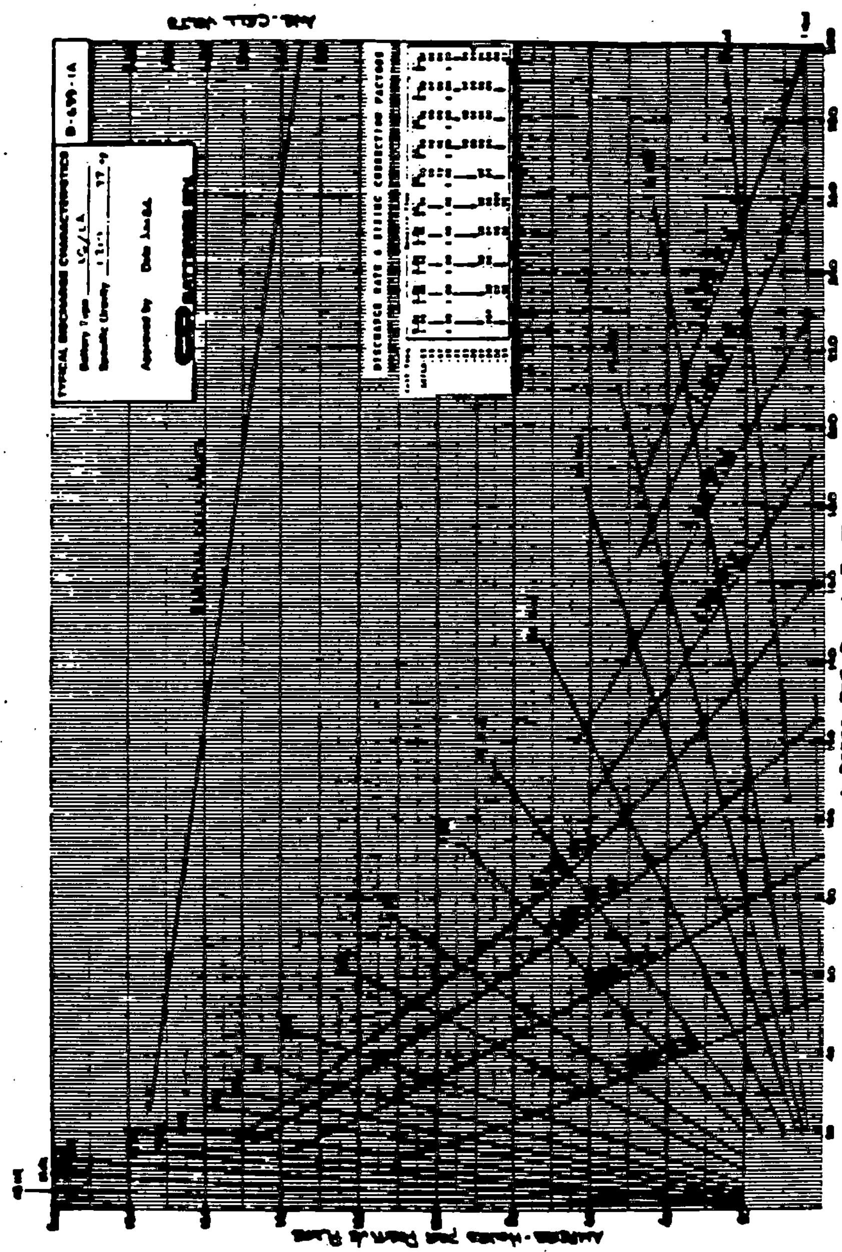


Figure 4.2 LC-33 Discharge Characteristics

| RESERVE TIME | AMP HOUR CAPACITY | DISCHARGE AMPERES |
|---|---|---|
| 8 Hr | 2320 | 290 |
| 6 Hr | 2196 | 366 |
| 3 Hr | 1857 | 619 |
| 2 Hr | 1610 | 805 |
| 1 Hr | 1163 | 1163 |
| 1 Min | 37 | 2227 |

TABLE 1 Discharge Capacities and Rates for the LC-33 Battery to 1.75 Average Volts per Cell

## 4.2 Battery Life

Twenty year qualified life is based on previous natural and accelerated aging tests concucted on LC cell types of identical and similar material and design.

All accelerated (thermal) aging was conducted at a controlled test chamber temperature of 160 °F $\pm$2° F. The test cells were float charged at this temperature for a period not less than 200 days, which is the equivalent of 20 years service at a 77°F operating temperature. This is in accordance with the IEEE Std 535-1979 aging factor of 10 days equals one year for lead calcium cells.

After thermal aging of the test cells, capacity testing was conducted at discharge rates identical to those prior to aging. Capacity at the end of the thermal aging program remained greater than 80% of the initial published ratings for all cells.

Original C & D BATTERIES test data, as summarized in TABLE 2, confirm these aging factors. The tests were performed on new and field service lead calcium battery cells during a period

4.2 Battery Life (continued)

between 1959 and 1967 and confirm the temperature versus life relationship for the lead acid, lead calcium alloy battery. A graph depicting battery life versus electrolyte temperature is drawn from this test data and is shown in Figure 4.3.

Included as part of the qualification program that forms the basis of this report were naturally aged (25 years of service) lead calcuim cells.

| TEMPERATURE OF TEST | LIFE, AT TEMPERATURE | LIFE, CALCU-LATED @ 77°F |
|---|---|---|
| 160°F | 0.58 | 21.2 |
| 160 | 0.56 | 20.4 |
| 160 | 0.53 | 19.3 |
| 160 | 0.55 | 20.1 |
| 145 | 0.76 | 14.5 |
| 145 | 0.79 | 15.8 |
| 145 | 0.94 | 19.3 |
| 145 | 1.02 | 21.0 |
| 130 | 2.15 | 22.6 |
| 130 | 1.94 | 20.0 |
| 130 | 2.33 | 24.1 |
| 130 | 2.30 | 23.8 |
| 115 | 4.05 | 24.0 |
| 115 | 4.08 | 24.0 |

TABLE 2 Life Testing Results For Lead Calcuim Batteries

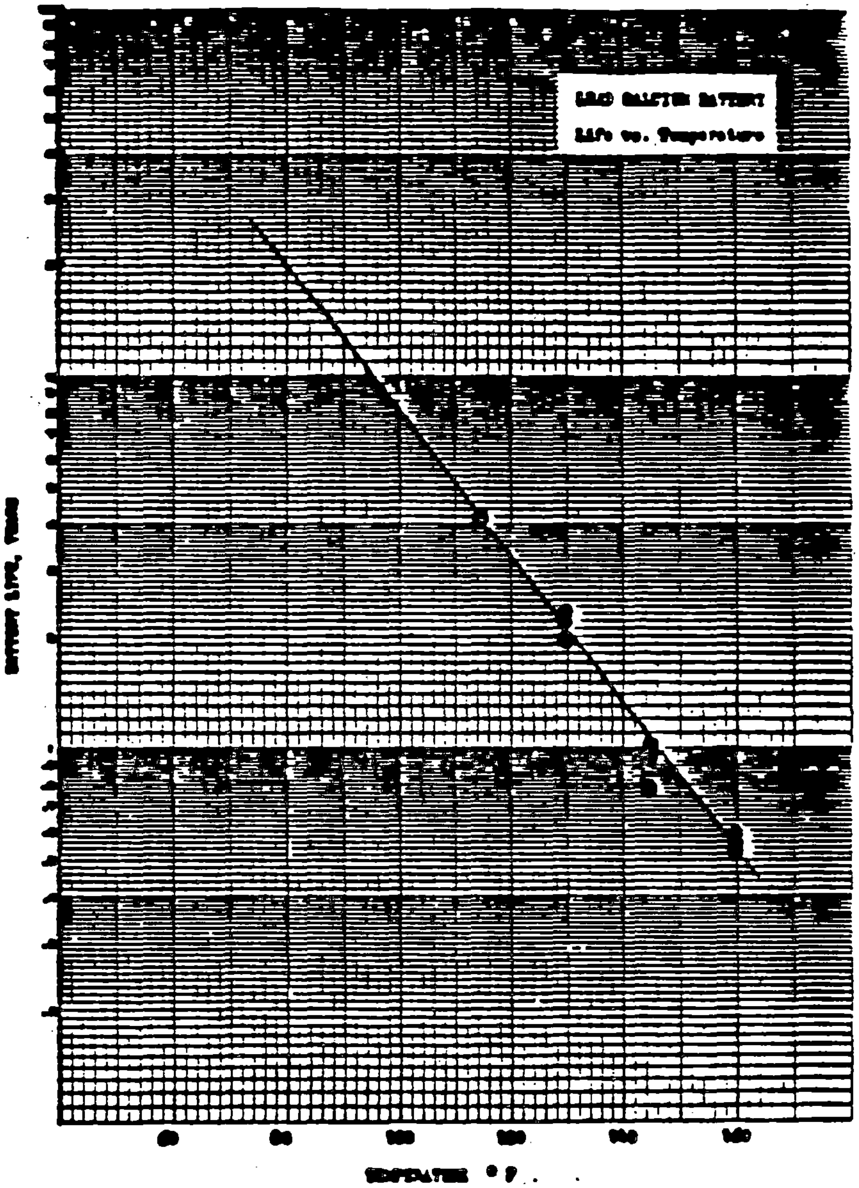


Figure 4.3 Battery Life vs. Temperature

## 4.3 Seismic Testing

Seismic qualification of the LC-33 battery is based on previous qualification testing of various LC type battery cells including the LC-33 cell.

Seismic qualification of the battery rack is based on previous testing and analysis conducted on a two step battery rack identical in design and material as the Salem battery rack. Figure 4.4 and 4.5 show the two step test rack and mounted test cells as it existed for simulated seismic testing.

The construction and operating characteristics of the tested battery cells are identical to the Salem battery. Component location and material employ the same overall geometry to carry loads as the Salem Nuclear Generating Station LC-33 battery. For a comparison of the battery cell dimensions and construction features between the Salem LC-33 battery and the seismically tested cells upon which qualification is based, refer to Figure 4.6.

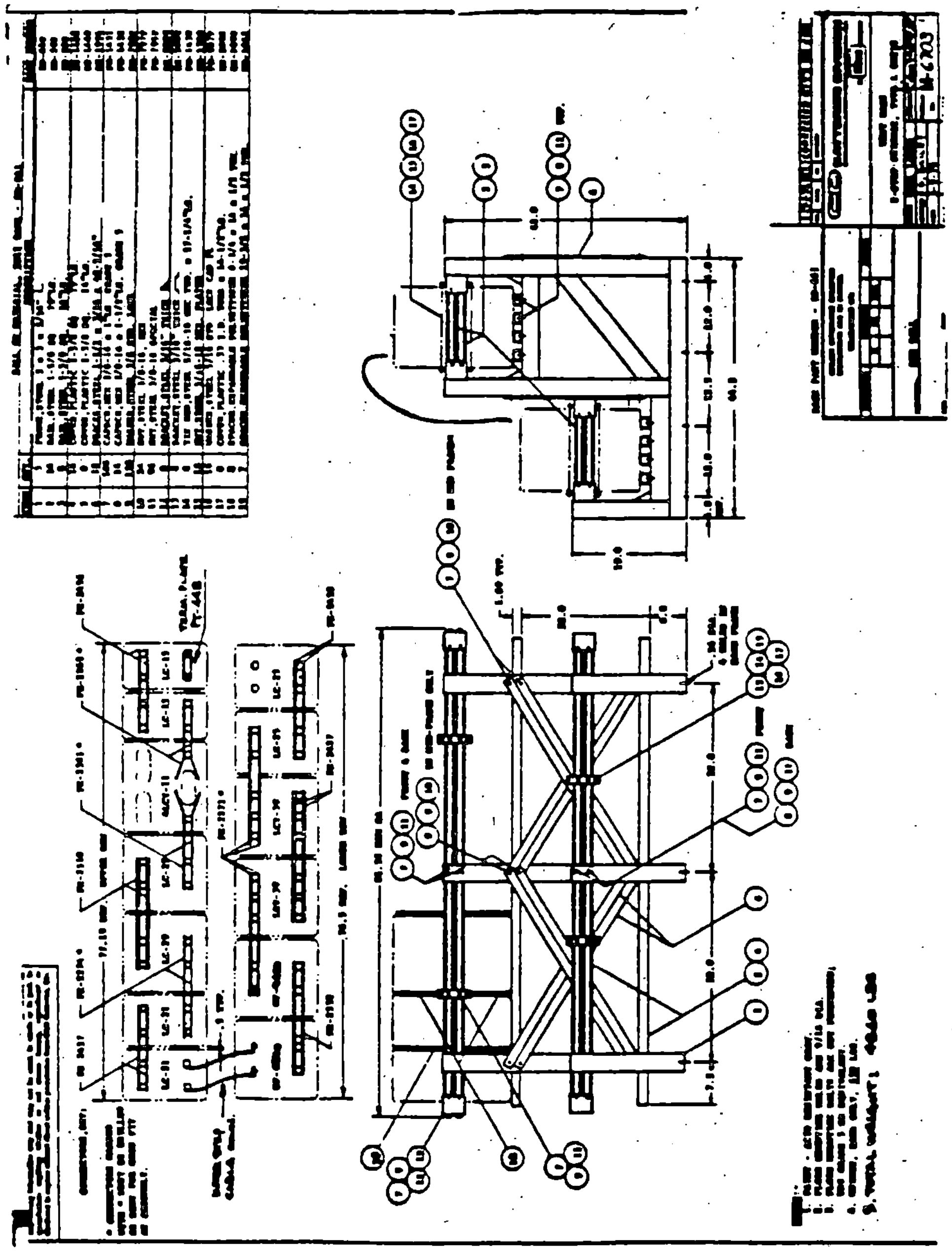


Figure 4.4 Two Step Test Rack and LC Type Test Cells for WYLE Test No. 43450-1

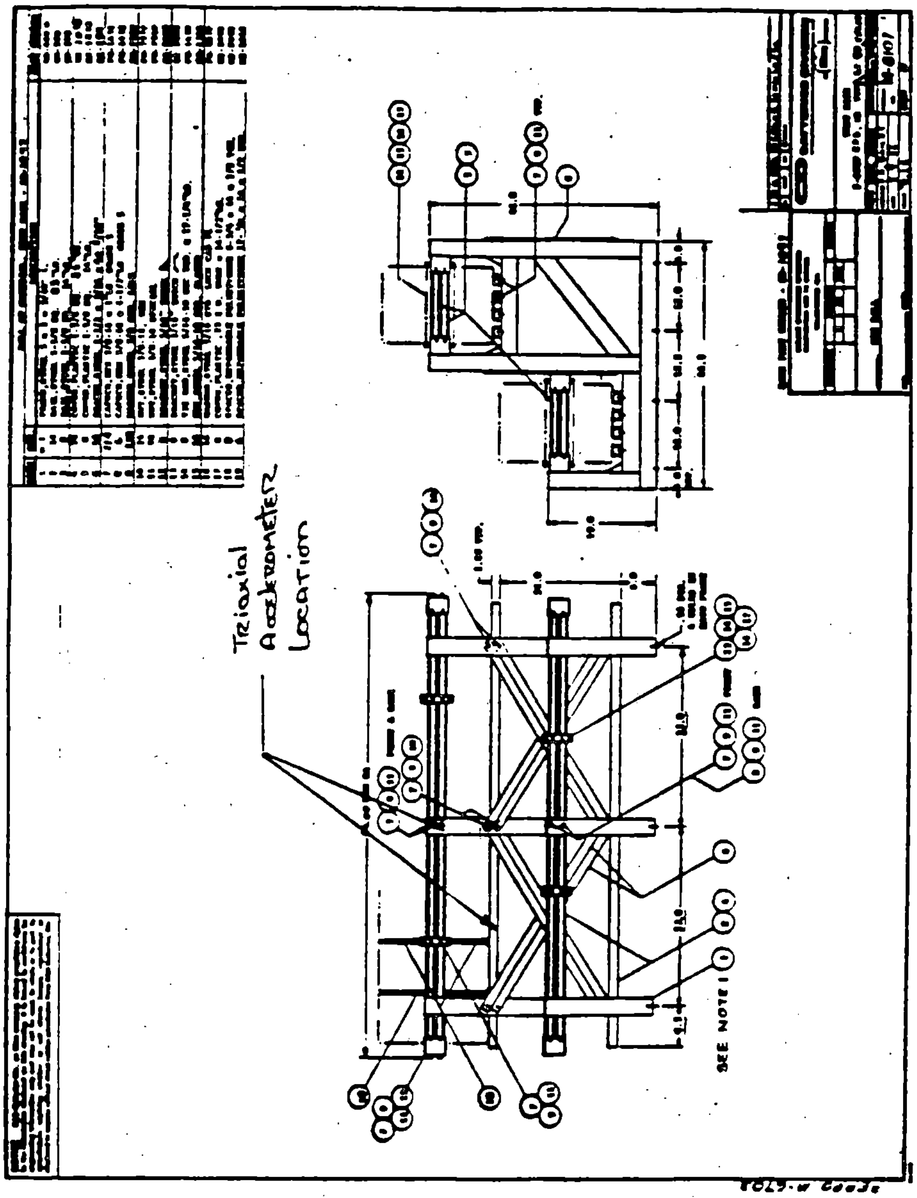



Figure 4.5 Two Step Test Rack With 12 LC-33 Cells for WYLE Test No. 46661-1

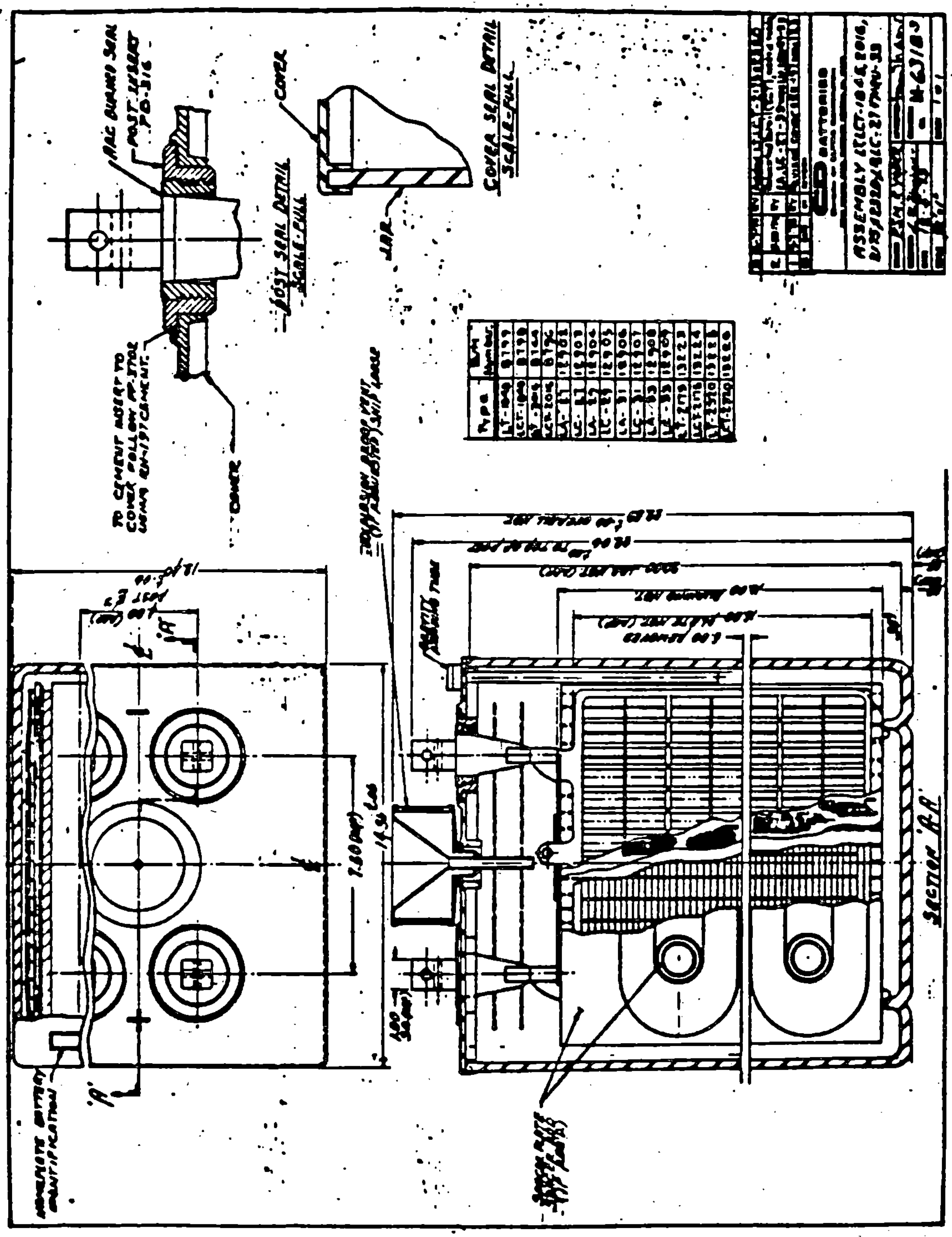



Figure 4.6 Construction Details for LC-33 and Re-jarred CT-1440

4.3 Seismic Testing (continued)

For the purpose of this report we will compare test data from two previously conducted seismic qualification test programs. The battery cell types seismically tested are listed in TABLE 3.

WYLE TEST NO. 43450-1

| CELL TYPE | | QTY | CAPACITY | RATE | JAR MATERIAL * |
|---|---|---|---|---|---|
| 4LCY-11 | (unaged) | 1 | 330 AH | 1 Hr | SAN |
| LC-15 | (unaged) | 2 | 1050 AH | 8 Hr | PC |
| LC-21 | (20 yr thermal) | 2 | 1500 AH | 8 Hr | PC |
| LC-25 | (unaged) | 2 | 1800 AH | 8 HR | SAN |
| LC-29 | (unaged) | 2 | 1008 AH | 1 Hr | PC |
| LCY-39 | (unaged) | 2 | 1330 AH | 1 Hr | PC |
| CT-1440 | (25 yr natural) | 2 | 1440 AH | 8 HR | PC |

WYLE TEST NO. 46661-1

| | | | | | |
|---|---|---|---|---|---|
| LC-33 | (unaged) | 12 | 1816 AH | 4 Hr | PC |

* SAN is Styrene-acrylonitrile
PC is Polycarbonate

TABLE 3 LC Type Cells Seismically Proof Tested in Two Step Racks

4.3 Seismic Testing (continued)

The CT-1440 cell type referenced in TABLE 3 was a 29 plate cell, 25 year old at the time of the seismic test, that was manufactured in 1951 as part of a 60 cell lead calcium battery. At that time, the cells were encased in hard rubber jars and had a nomenclature of RCT-1680 - rated 1680 ampere hours at the 8 hour rate of discharge to 1.75 average volts per cell. The battery was purchased by the BELL TELEPHONE SYSTEM and installed in their Pennypacker Exchange Office in Philadelphia, PA as an emergency power source, where the battery operated fcr 17 trouble-free years.

In 1968, when the Exchange was being enlarded, the battery was re-aquired by C & D BATTERIES. It was stored for one year until the Plymouth Meeting, PA headquarters building was completed, and, in the spring of 1970, it was installed there for use as an emergency lighting system.

For the purpose of this test and for future visual observation, the elements of two cells were removed from their original containers and placed in transparent plastic containers with plastic covers, and a bottowm plate support system similar to that employed in currently

4.3 Seismic Testing (continued)

produced LC type cells. In order to facilitate the jar transfer, two positive plates and two negative plates were removed, de-rating the cells from 1680 AH to 1440 AH capacity.

The seismic test results as they apply to this report are discussed in the following sections.

4.3.1 Effect on Battery Capacity

The LC type battery cells, including the LC-33, seismically tested were subjected to capacity tests prior to, and following the seimic test programs. These capacity tests were performed in accordance with the applicable precedures described in IEEE Std 450.

All unaged cells were at 100%, or greater, rated capacity prior to the start of the test program and remained so throughout.

All aged cells retained capacities greater than 80% of published ratings throughout the test program.

4.3.1 Effect on Battery Caapcity (continued)

ATTACHMENT 1 includes the pre-seismic and post-seismic capacity test results for each of the cell types tested.

4.3.2 Sesimic Test Procedure

Sixteen cells, from the largest to the smallest of the LC type, including the naturally aged CT-1440 cells were mounted in the normal manner and connected in series on a two step battery rack. This battery and rack assembly was then subjected to simulated seismic testing at WYLE LABORATORIES in Huntsville, AL, with results as given in WYLE Test Report No. 43450-1.

Twelve LC-33 cells were mounted and interconnected in the normal manner in a two step battery rack. The cells were then subjected to simulated seismic testing at WYLE LABORATORIES in Huntsville, AL, with results as given in WYLE Test Report No. 46661-1.

Each of the test racks were mounted directly to the WYLE test table:

For WYLE Test No. 43450-1, the rack assembly

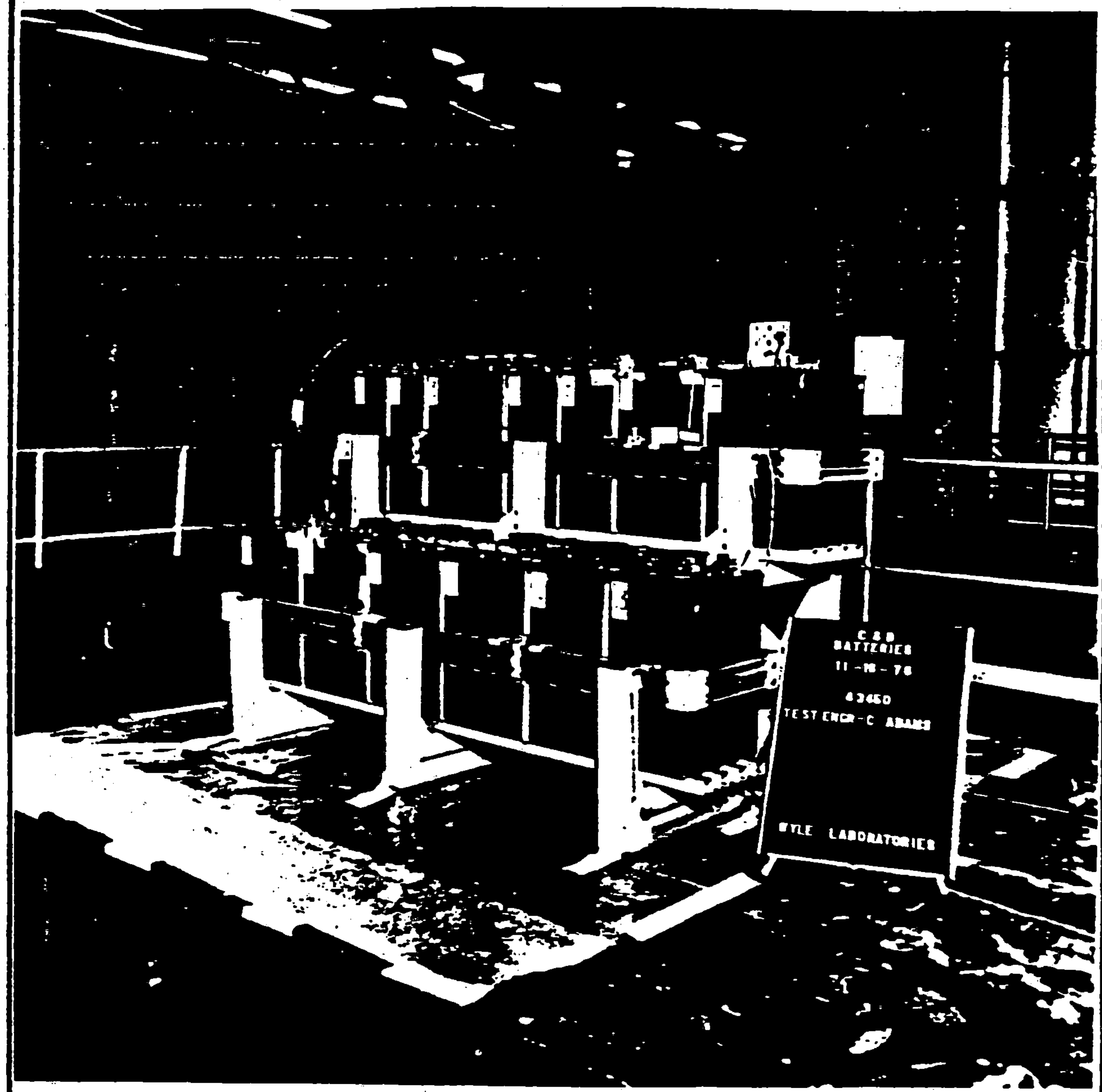
4.3.2 Seismic Test Procedure (continued)

was bolted directly to the test table at each bolting location in the rack foundation using 1/2 inch SAE Grade 5 bolts. This procedure was used for each test orientation. Photograph 1 shows the test rack and cells as mounted on the WYLE test table.

For WYLE Test No. 46661-1, the rack assembly was welded to a separate WYLE tube steel test frame using 3/16 inch welds 4 inches long or shorter. There were 24 welds on the rack base using E-7018 low hydrogen electrodes. The test frames were welded to the seismic table with their longitudinal axis at 45° to the table's direction of motion and were symmetric with the table's center. Reference Photograph 2.

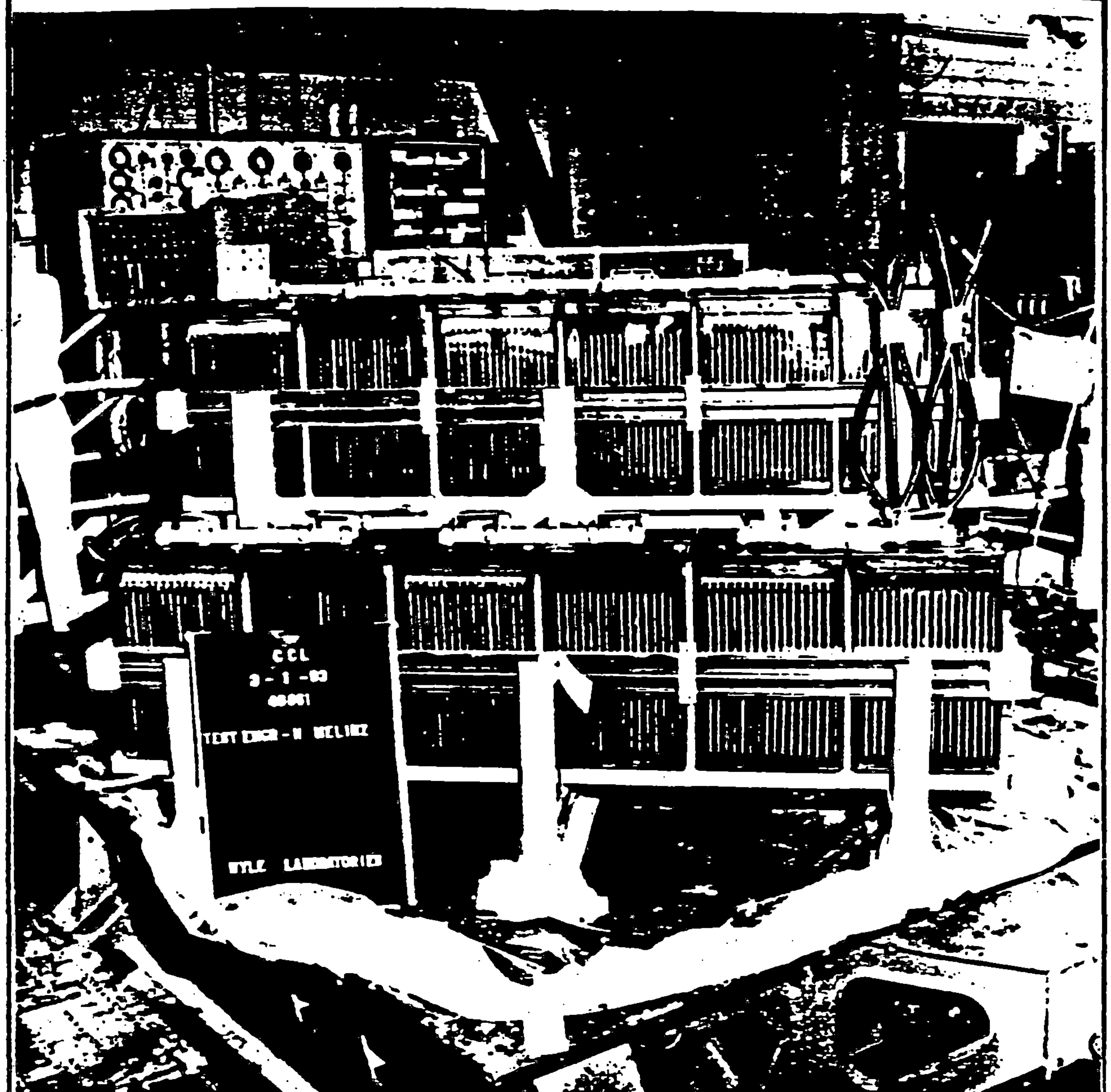
One vertical and one horizontal control accelerometer were mounted on the test table. TRS plots were taken from these control accelerometers at the time of the tests for each axis.

The battery rack and battery cells were instrumented with horizontal and vertical response accelerometers in various locations to determine equipment responses.




PHOTOGRAPH 1

SPECIMEN MOUNTED ON THE TEST TABLE
FOR SIDE-TO-SIDE/VERTICAL BIAXIAL TESTING




PHOTOGRAPH 2

SPECIMEN 1 INSTALLED ON THE WYLE MULTI-AXIS
SEISMIC SIMULATOR FOR ORIENTATION 1 TESTING

4.3.2 Seismic Test Procedure (continued)

The battery cells were connected in series to a resistive load of approximately 20 amperes during all phases of the seismic tests. The battery output voltage and current were recorded on an oscillograph recorder during the seismic test programs. These monitoring channels were used to determine electrical continuity, current and voltage levels, and to detect any spurious operation before, during and after the test programs.

Testing consisted of a low-level resonance search, followed by random multifrequency qualification tests. Qualification tests consisted of five (5) Operating Basis Earthquake (OBE) tests prior to one (1) Design Basis Earthquake (DBE) test. The duration for each test was 30 seconds.

ATTACHMENT 2 contains the WYLE Test Procedure, Transmissibility Plot, DBE Test Response Spectrum and Equipment Calibration List for WYLE Test No. 43450-1.

4.3.2 Seismic Test Procedure (continued)

ATTACHMENT 3 contains the WYLE Test Procedure, Transmissibility Plot, DBE Test Response Spectrum and Equipment Calibration List for WYLE Test No. 46661-1.

## 5.0 TEST RESULTS

The battery cells and the battery rack successfully completed the simulated seismic test programs. Test results and post-test inspection showed that they possessed sufficient integrity to withstand, without compromise of structure of function, the seismic test environments. The oscillograph records did not indicate any spurious or improper operation or deviation in the output voltage/current levels of the battery, either during of after the seismic excitation.

Post-seismic capacity tests conducted on the battery cells yielded capacities essentially identical to those recorded prior to the seismic test programs. Unaged cells retained capacities of 100% or greater. The 25 year old naturally aged test cells delivered capacities over 80% of their rating.

Although these qualification programs were not specifically performed as proof tests for the Salem battery and battery rack, its applicability is demonstrated due to the identical design of all LC type battery cells and two step battery racks.

## 5.0 TEST RESULTS (continued)

The WYLE seismic Test Response Spectra (TRS) from Report Nos. 43450-1 and 46661-1 completely envelop the Salem Required Response Spectra (RRS) at all test frequencies, therefore these tests will serve as a qualification for the LC-33 battery and two step battery rack. Figures 5.1 through 5.4 show the DBE horizontal and vertical TRS from both WYLE tests versus the Salem RRS.

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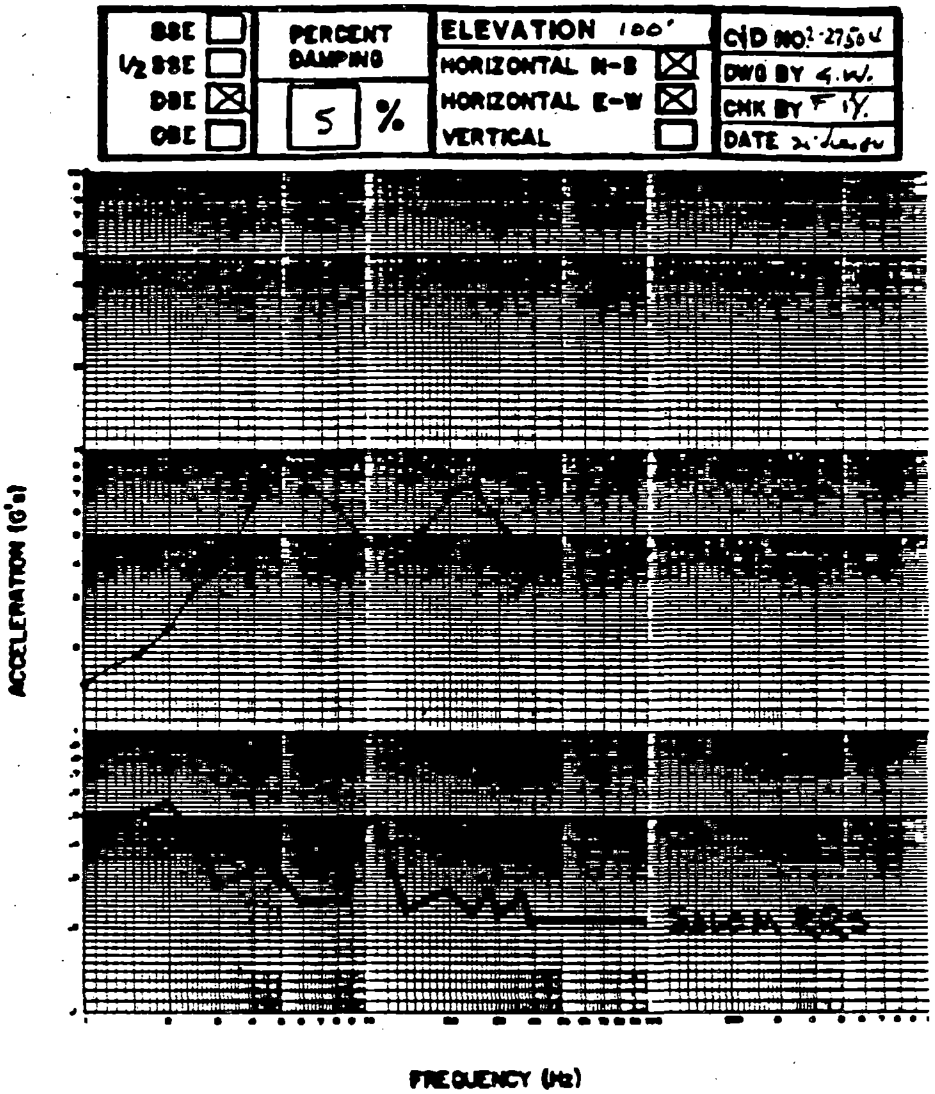


Figure 5.1 WYLE Test No. 43450-1
Horizontal TRS vs. Salem RRS

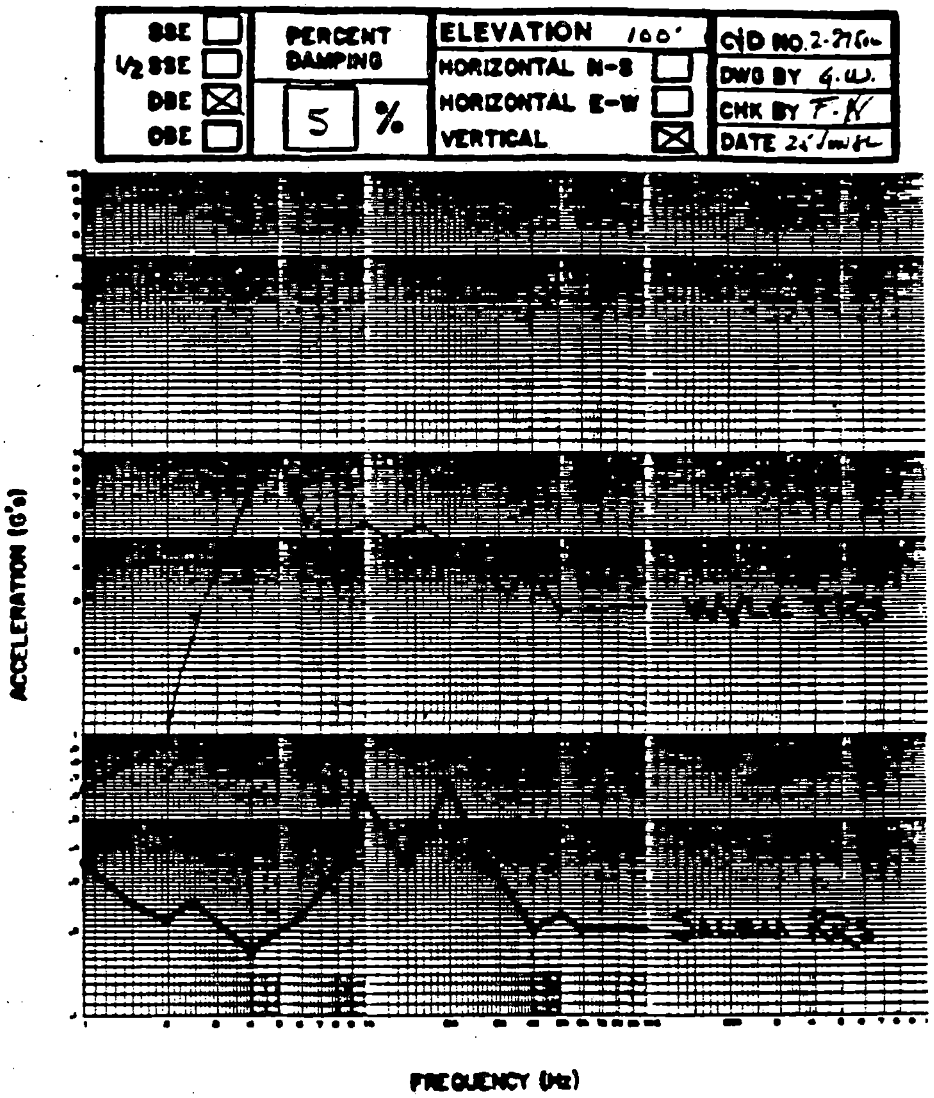


Figure 5.2 WYLE Test No. 43450-1
Vertical TRS vs. Salem RRS

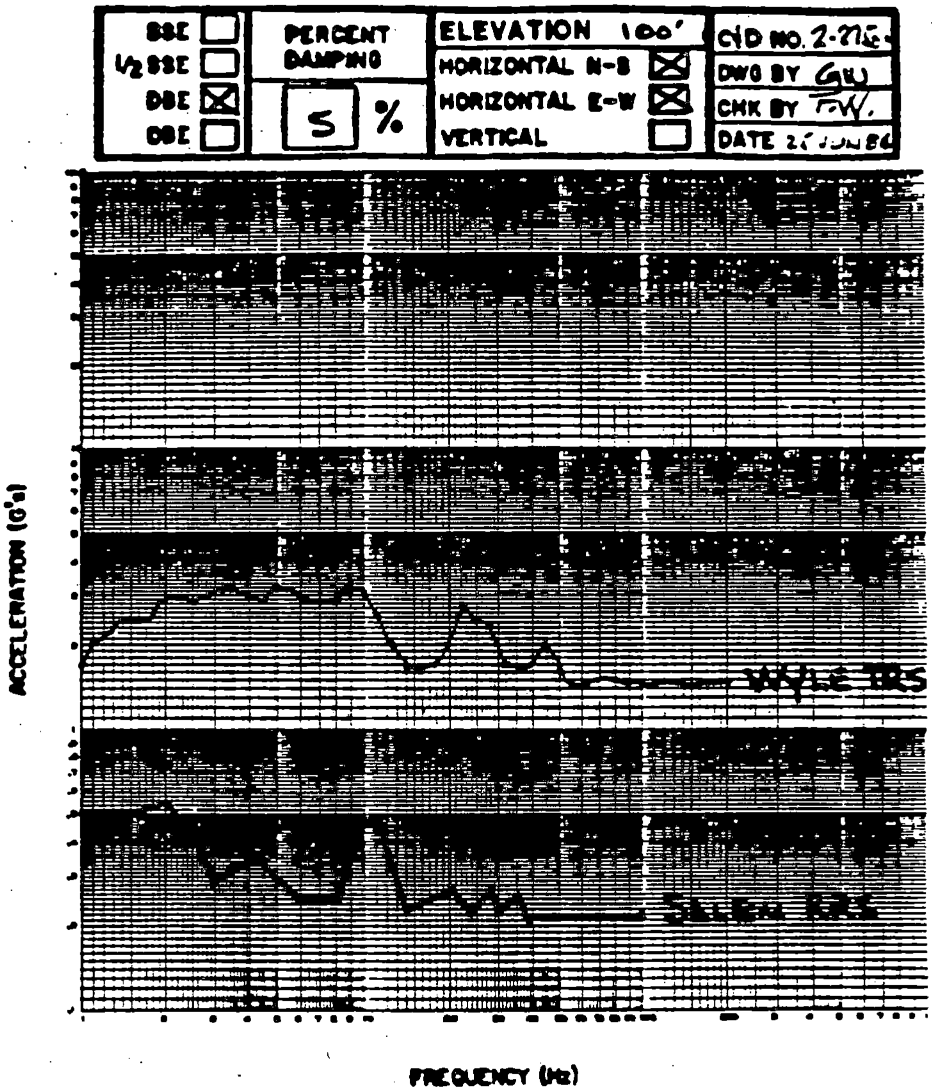


Figure 5.3 WYLE Test No. 46661-1
Horizontal TRS vs. Salem RRS

ALLIED C&D Power Systems

| | | | |
|---|---|---|---|
| SSE ☐ | PERCENT DAMPING | ELEVATION 100' | C/D NO. 2-7164 |
| ½ SSE ☐ | | HORIZONTAL N-S ☐ | DWG BY G.W. |
| DBE ☒ | 5 % | HORIZONTAL E-W ☐ | CHK BY F.W. |
| OBE ☐ | | VERTICAL ☒ | DATE [illegible] |

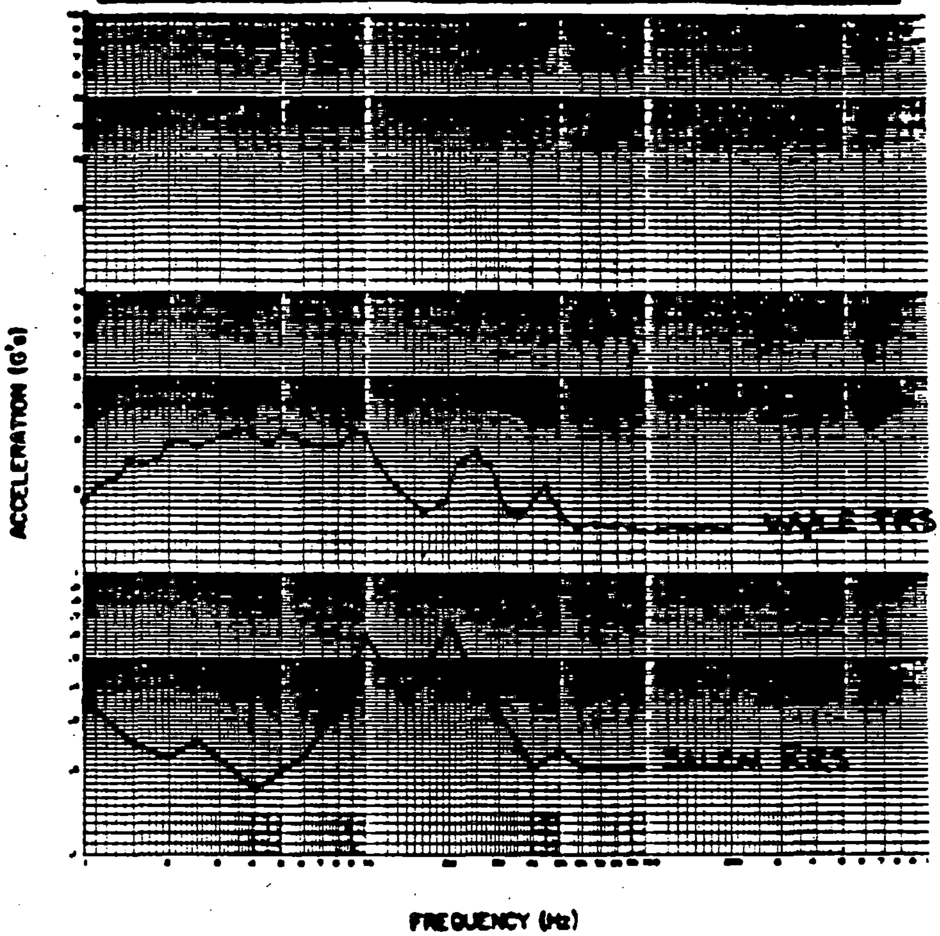


Figure 5.4 WYLE Test No. 46661-1
Vertical TRS vs. Salem RRS

## 6.0 CONCLUSIONS

The 125 volt, 60 cell LC-33 battery and two step battery racks are environmentally qualified for a period of 20 years, when maintained in accordance with recommended and approved procedures, for service in a mild environment outside primary containment areas of the Salem Generating Plant.

Previous Nuclear Environmental Qualification testing of LC type battery cells and two step battery racks demonstrate that they possess sufficient design margin and integrity to withstand without compromise of structure or electrical function, the environment of the Salem Nuclear Generating Station.

# 7.0 JUSTIFICATIONS

## 7.1 Battery

The Salem LC-33 battery is qualified by similarity based on type testing and by actual testing of the LC-33 battery. The test programs included unaged and aged battery cells. TABLE 4 shows the physical similarity of the plates of all the test cells.

| PLATE NOMENCLATURE | HEIGHT | WIDTH | PLATE THICKNESS |
|---|---|---|---|
| CT | 13.25" | 11.5" | 0.266" (Pos.), 0.180" (Neg.) |
| LC | 15.00" | 12.0" | 0.312" (Pos.), 0.210" (Neg.) |
| LCY | 15.00" | 12.0" | 0.250" (Pos.), 0.180" (Neg.) |

**TABLE 4 Comparison of LC Type Plates Seismically Tested**

ALLIED C&D Power Systems

7.1 Battery (continued)

All test cells were constructed with lead calcium grids and employed equal or identical construction materials and features.

Comparing the Salem LC-33 battery with any of the LC type cells and particularly with the naturally aged CT-1440 test cells is justified because degradation (embrittlement) of the positive plates is the predominant failure mode in lead acid storage batteries; and since the float charging current is proportional to positive plate capacity - and life is proportional to positive plate thickness - the corrosion rate of the plate grid structure will be identical and the CT-1440 and LC-33 battery will degrade at the same rate since both positive plates are the same material and design.

The thickness of the CT positive plate is less than that of the LC positive plate, therefore, the ability of a naturally aged CT-1440 battery to successfully withstand a seismic test demonstrates that a naturally aged LC-33 would be able to withstand the same seismic loads since the CT plates are in a mechanically weaker condition. The testing of unaged LC-33 cells

ALLIED C&D Power Systems

7.1 Battery (continued)

is therefore justified by the successful completion of the seismic test by the aged CT-1440 battery cells.

Non-metallic components: polycarbonate cell containers, styrene cell covers, polystyrene flame arrestor vents and cell spacers, polyethylene rack rail covers, and the 600 volt 90°C rated neoprene insulation of the interstep cable connectors are judged to be age-insensitive to the mild environmental conditions of the Salem battery room, and will have a qualified life equal to that of the battery plates.

Metallic components such as the steel battery rack members, the coated and insulated copper connectors and the connecting hardware are known to be age-insensitive to the specified environment and will have a qualified life exceeding that of the battery plates.

7.2 Battery Rack

Qualification of the Salem battery rack is

7.2 Battery Rack (continued)

based on similarity to a representative rack previously tested.

Justification for testing a two-bay rack to qualify a six-bay rack is accomplished by showing the structural behavior of a two-bay model to that of a five-bay model. The results from two finite analyses from Reference 4 are compared to demonstrate seismic equivalence between typical two-bay and five-bay racks. The finite element analysis were performed using the computer program STARDYNE. STARDYNE is a well known, well documented proprietary computer program widely accepted for this type of analysis by both industry and the Nuclear Regulatory Commission.

The results of the analyses compared are the equipment natural frequencies and beam stresses from statically applied 1.0 g seismic loads in each of the three directions. These results are chosen for comparison because they present the dynamic and structural response of the mathimatical models. The complete results, with a description of the analyses are contained in Reference 4.

7.2 Battery Rack (continued)

Figures 7.1 and 7.2 present the natural frequencies of the two-bay and five-bay mathematical models. The natural frequencies closely agree, and thus, the battery racks for the Salem Generating Station will have natural frequencies equal to the tested rack.

TABLE 5 presents a comparison of the beam member stresses. The three directions of seismic load were combined by the SRSS method. No appreciable difference in stress occurs between the two-bay model and the five-bay model. Each bay has identical bracing in each direction. Additional bays provide their own bracing. The WYLE TRS are shown to completely envelop the Salem RRS, therefore, the two-bay rack is structurally adequate and represents accurately the behavior of the six-bay Salem Generating Station battery rack.

LANCZOS ANALYSIS OF A 2 BAY LC-25 BATTERY RACK

M O D A L   E X T R A C T I O N   D A T A

| MODE NO | EIGENVALUE (OMEGA**2) | NATURAL FREQUENCY | PERIOD | GENERALIZED WEIGHT | MAX TRANSLATION NODE-DOF | VALUE | --- M O D A L   W E I G H T S --- (PERM. WGT. & PARTICIPATION FACTORS**2) X1 | X2 | X3 | |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 7222.13 | 13.525 | .0739 | 1705.00 | 103-1 | 1.0000 | 3969.27670 | 8.12630 | .06366 | 12.0 |
| 2 | 9969.10 | 15.891 | .0629 | 2152.08 | 126-2 | 1.0000 | 226.22687 | 2754.51168 | 4.93368 | 12.0 |
| 3 | 10593.2 | 16.381 | .0610 | 2393.60 | 127-2 | 1.0000 | 681.09067 | 693.78470 | .20666 | 12.0 |
| 4 | 12548.0 | 17.828 | .0561 | 1962.51 | 128-2 | 1.0000 | 261.99688 | 3.32210 | .07686 | 12.0 |
| 5 | 25062.2 | 25.196 | .0397 | 2631.02 | 126-1 | 1.0000 | 27.01915 | 12.63033 | .07375 | 12.4 |
| 6 | 28373.6 | 26.809 | .0373 | 854.289 | 66-2 | 1.0000 | 1.18958 | 1007.21668 | 5.01743 | 12.0 |
| 7 | 31545.0 | 28.268 | .0354 | 971.886 | 91-3 | 1.0000 | .05786 | .01967 | .00113 | 7.7 |
| 8 | 31656.6 | 28.317 | .0353 | 976.353 | 75-3 | 1.0000 | .00169 | .14695 | .00902 | 8.0 |
| 9 | 32917.9 | 28.876 | .0346 | 1178.95 | 94-3 | 1.0000 | .00259 | .01070 | .00636 | 9.7 |
| 10 | 32931.6 | 28.882 | .0346 | 1185.31 | 84-3 | 1.0000 | .01891 | .08671 | .00874 | 9.0 |

THE FOLLOWING ARE APPROX. EIGENVALUES FOR WHICH MODES WERE NOT REQUESTED.

| | | | |
|---|---|---|---|
| 11 | 36214.6 | 30.639 | 8.4 |
| 12 | 43303.7 | 33.150 | 7.2 |
| 13 | 45883.6 | 34.092 | 6.5 |
| 14 | 51987.2 | 36.288 | 9.6 |
| 15 | 55688.4 | 37.498 | 9.5 |
| 16 | 67045.3 | 41.210 | 9.7 |

LANCZOS REDUCED MATRIX SIZE (DOF) = 33
APPROX. MAXIMUM EIGENVALUE(OMEGA**2)= .13999E+06

***NOTE*** THE LAST COLUMN IN THE TABLE ABOVE IS RELATED TO EIGENVALUE ACCURACY BOUNDS.

Figure 7.1 Natural Frequencies of a Two-Bay, Two Step Battery Rack Completely Loaded with LC-25 Batteries

LANCZOS ANALYSIS OF A 5 BAY LC-25 BATTERY RACK

M O D A L   E X T R A C T I O N   D A T A

| MODE NO | EIGENVALUE (OMEGA**2) | NATURAL FREQUENCY | PERIOD | GENERALIZED WEIGHT | MAX TRANSLATION NODE-DOF | VALUE | --- MODAL WEIGHTS --- (GEN. WGT. * PARTICIPATION FACTOR**2) X1 | X2 | X3 | |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 7231.20 | 13.534 | .0739 | 2903.15 | 245-1 | 1.0000 | 6171.61770 | 177.06076 | .01037 | 12.0 |
| 2 | 8852.06 | 14.975 | .0668 | 3083.53 | 200-2 | 1.0000 | 219.06950 | 6326.96570 | 18.29000 | 12.0 |
| 3 | 9637.09 | 15.625 | .0640 | 3106.91 | 296-2 | 1.0000 | 15.01616 | 9.75030 | .00905 | 12.0 |
| 4 | 11532.7 | 17.092 | .0585 | 2908.31 | 282-2 | 1.0000 | 65.57706 | 665.13667 | .07141 | 12.0 |
| 5 | 12127.0 | 17.527 | .0571 | 6293.95 | 296-1 | 1.0000 | 3972.20087 | .07653 | 2.00266 | 12.0 |
| 6 | 15907.2 | 20.111 | .0497 | 2765.27 | 282-2 | 1.0000 | 33.67600 | .22506 | .07216 | 12.0 |
| 7 | 23203.9 | 24.275 | .0412 | 1509.93 | 249-2 | 1.0000 | 2.30150 | 1781.36062 | 1.79655 | 12.0 |
| 8 | 23879.4 | 24.594 | .0407 | 1658.00 | 251-2 | 1.0000 | 6.03760 | 130.66207 | .00008 | 12.0 |
| 9 | 25037.0 | 25.183 | .0397 | 4165.00 | 267-2 | 1.0000 | 9.03664 | 51.70376 | .00955 | 12.0 |
| 10 | 27911.0 | 26.589 | .0376 | 1776.51 | 262-2 | 1.0000 | 1.66905 | 461.65116 | 6.06766 | 12.0 |
| 11 | 30295.5 | 27.702 | .0361 | 2270.51 | 290-2 | 1.0000 | .10111 | 90.66256 | 1.10081 | 12.0 |
| 12 | 30822.1 | 27.942 | .0358 | 2237.20 | 219-3 | 1.0000 | .01617 | 3.66718 | 166.61327 | 11.6 |
| 13 | 30906.6 | 27.971 | .0358 | 2328.30 | 296-3 | 1.0000 | .00118 | .96378 | 13.11012 | 10.0 |
| 14 | 31602.6 | 28.303 | .0352 | 2258.72 | 232-3 | 1.0000 | .00007 | .05606 | .00922 | 9.0 |
| 15 | 31608.5 | 28.305 | .0352 | 2267.60 | 216-3 | 1.0000 | .00041 | .36395 | .00363 | 9.7 |
| 16 | 33930.1 | 29.317 | .0341 | 1253.21 | 227-3 | 1.0000 | .07196 | .05690 | .02706 | 10.0 |
| 17 | 36026.5 | 29.520 | .0339 | 1266.63 | 201-3 | 1.0000 | .00325 | .00000 | .01066 | 8.0 |
| 18 | 36019.5 | 30.206 | .0331 | 1030.65 | 266-2 | 1.0000 | .00750 | .00661 | .23066 | 7.0 |
| 19 | 37107.1 | 30.691 | .0326 | 1106.50 | 227-3 | 1.0000 | .00666 | .00603 | .01235 | 7.0 |
| 20 | 37310.5 | 30.742 | .0325 | 1204.20 | 193-3 | 1.0000 | .00170 | .00630 | .01303 | 6.3 |

THE FOLLOWING ARE APPROX. EIGENVALUES FOR WHICH MODES WERE NOT REQUESTED.

| MODE NO | EIGENVALUE (OMEGA**2) | NATURAL FREQUENCY | |
|---|---|---|---|
| 21 | 61933.9 | 32.991 | 8.0 |
| 22 | 66021.6 | 33.566 | 7.7 |
| 23 | 67026.0 | 34.513 | 5.5 |

LANCZOS REDUCED MATRIX SIZE (DOF) = 58
APPROX. MAXIMUM EIGENVALUE (OMEGA**2) = .305326E+08

***NOTE*** THE LAST COLUMN IN THE TABLE ABOVE IS RELATED TO EIGENVALUE ACCURACY BOUNDS.

Figure 7.2 Natural Frequencies of a Five-Bay, Two Step Battery Rack Completely Loaded with LC-25 Batteries

| | TWO-BAY | | FIVE-BAY | |
|---|---|---|---|---|
| COMPONENT | BEAM | STRESS (PSI) | BEAM | STRESS (PSI) |
| Frame | 48 | 34,068 | 102 | 33,179 |
| Support Rail | 99 | 3,883 | 249 | 3,861 |
| Side Rail | 104 | 9,453 | 260 | 9,620 |
| Brace | 131 | 6,061 | 314 | 4,957 |

TABLE 5 Comparison of Member Stresses for Two-Bay and Five-Bay, Two Step Battery Racks for LC Type Cells

## 8.0 LIST OF REFERENCES

1. PUBLIC SERVICE ELECTRIC & GAS CO., Purchase Order No. 923023 dated 22 May 1984; Specification No. 72-1308 dated 27 December 1972; Specification No. 68626 dated 15 November 1968.

2. WYLE LABORATORIES, Seismic Simulation Test Report No. 43450-1, 7 December 1976, "Seismic Simulation Test Program On A Battery Rack And Batteries".

3. WYLE LABORATORIES, Seismic Simulation Test Report No. 46661-1, 17 March 1983, "Seismic Simulation Test Program On Two Battery Racks".

4. CORPORATE CONSULTING & DEVELOPMENT CO., LTD., Report No. A-379-81-01, 20 May 1982, "Seismic Qualification Report of 3DCU-5, KC-19 and LC-25 Battery Racks and Cells for Susquehanna S.E.S. Units 1 & 2".

5. C & D BATTERIES, Battery Laboratory Test Nos. VL-765-03, 2049, VL-762-02, VL-762-03, 1996, V78-14, and 2827.

6. IEEE Std 323-1974, IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations.

7. IEEE Std 344-1975, IEEE Recommended Practices for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations.

8. IEEE Std 450-1980, IEEE Recommended Practices for Maintenance, Testing, and Replacement of Large Lead Storage Batteries for Generating Stations and Substations.

8.0 LIST OF REFERENCES (continued)


9. IEEE Std 484-1981, IEEE Recommended Practice for Installation of Large lead Storage Batteries for Generating Stations and Substations.

10. IEEE Std 535-1979, IEEE Standard for Qualification of Class 1E Storage Batteries for Nuclear Power Generating Stations.

11. PUBLIC SERVICE ELECTRIC & GAS CO., PURCHASE ORDER No. 932407 dated 14 NOV 84; Specification No. 72-1308 dated 27 December 1972; Specification No. 68626 dated 15 November 1968.

ATTACHMENT 1 (Contin. .)

TO: M. Rosenzweig
QA Engineering & Procurement Engineer

FROM: R. F. Crapo
Principal Engineer - Civil Group

SUBJECT: QUALIFICATION REPORT OF CLASS 1E STATION BATTERIES AND BATTERY RACKS SUBMITTED BY ALLIED C&D POWER SYSTEMS, REPORT NO. QR2-27504

DATE: January 28, 1985

The Civil Group has reviewed and approves the above vendors' report and finds that their input and methodology meet all required seismic criteria for Salem Units 1 and 2 and the conclusions seem reasonable and correct.

R. F. Crapo

RFC:cbp

C: J. Hannwacker
R. Gura
CARMS - B1-16

EA2

ATTACHMENT 2

PSEG

S-2-E200-NSE-222


Date Sept. 29, 1983

Public Service Electric and Gas Company P.O. Box 236 Hancocks Bridge New Jersey 08038

Nuclear Department

TITLE: SEISMIC CAPABILITY OF EMERGENCY BATTERY RACK WITH 1 CELL REMOVED FROM UPPER TIER

## 1.0 PURPOSE

The purpose of this safety evaluation is to document the continued seismic capability of the emergency battery racks after the removal of a single battery from one of the upper racks.

## 2.0 REFERENCES

2.1 Deficiency Report MD 83-3018

2.2 C & D calcium battery type LCU-33 (Wgt 400 lbs.) and C&D two step battery rack.

## 3.0 DISCUSSION

Removal of a battery in the upper tier of a two tier rack does not impair its ability to resist seismic induced stresses. Rather, it lowers the stresses in the rack by removing the mass (400 lbs.) from the top of the rack, which is the position which induces the highest stresses in the rack.

However, since the space left open by the removal of a battery would allow the remaining batteries to possibly shift horizontally on the racks during a seismic event, the space should be filled by a dummy battery of the same physical dimensions (it could be made of wood) and any filling between batteries re-inserted in order to provide laterial restraint to all the remaining batteries on the upper tier of the particular rack in question.

## 4.0 CONCLUSION

Battery can safely be removed and left out providing lateral restraint to the remaining batteries in the rack is provided.

## 5.0 REVIEW AND APPROVAL

David K. Harding 10/4/83
Systems Analysis Group

RFC/cbp
EN8

R. F. Crapo
Originator

F. J. Parkell
Verifier

Robert Crapo 9/30/83
Group Head

[signature]/HBB
Manager - Plant Engineering

Public Service Electric and Gas Company P.O. Box 236 Hancocks Bridge, New Jersey 08038

Nuclear Department

TLE: ENGINEERING SAFETY EVALUATION
VERIFICATION OF INTEGRITY OF NO. 2B 125V BATTERY WITH
CELL #36 REMOVED FROM SERVICE.

1.0 PURPOSE:

To verify that No. 2B 125V Battery retains its integrity with cell #36 removed from service.

2.0 SCOPE:

This safety evaluation applies only to No. 2B 125V Battery.

3.0 REFERENCE:

1. Technical Specification, Section 4.8.2.3.2.
2. Maintenance Procedure M3A, Battery Discharge Test for 125V DC Battery, Technical Specification 4.8.2.3.e, dated January 9, 1981 (attached).
3. Deficiency Report - DR No. MD83-3018, dated 9/20/83.
4. Engineering Safety Evaluation - Seismic Capability of Emergency Battery Rack with 1 Cell Removed from Upper Tier (attached).

4.0 DISCUSSION, DESCRIPTION, TEST, ETC.:

During the startup of Unit 2, cell #36 of the 60 cell No. 2B 125V Battery was found to have developed a hair line crack of approximately two inches on the underside of the jar causing electrolyte to seep through (Ref. 3) and making it necessary to remove the cell from the battery. The resulting space shall be filled with a suitable wooden form approximating the outline dimensions of the cell. A seismic evaluation (Reference 4) was performed on the 59 cell battery configuration and the result showed that the seismic integrity is maintained.

Date: 10/3/83

The electrical integrity of the 59 cell battery configuration is substantiated as follows:

Enclosure 3 of Reference 2 indicates the individual cell voltages after performing the prescribed discharge test on the subject battery. At the end of 120 minutes (Column 12) the overall battery voltage was found to be 107.33 volts with the corresponding voltage of cell #36 to be 1.80 volts. Subtracting cell #36 voltage from the measured terminal voltage results in a new battery voltage of 105.53 volts which fulfills the requirements of Reference 2 (105 volts), and therefore No. 2B 125V Battery will operate as required with cell #36 out of service.

$$\% \text{ Capacity} = \frac{\text{Time in minutes to reach low limit} \times K}{1.2}$$

Where K is the temperature correction factor (Reference 2).

% Capacity For battery with cell # 36 out of service $= \frac{120 \times 1.01}{1.2} = 101\%$

JH:dh/dl

J. Hammacher 10/4/83
Originator

Verifier

O. M. Korn 10.4.83
Originator's Group Head

D.K. Harding 10/4/83
Systems Analysis Group

HBB 10/4/83
Manager - Nuclear Plant Engineering

PSE&G

Public Service Electric and Gas Company P.O. Box 236 Hancocks Bridge New Jersey 08038

Nuclear Department

TO: B. Preston
Manager - Nuclear Licensing and Regulation

FROM: A. Nassman
Acting Manager - Plant Engineering

SUBJECT: ENGINEERING EVALUATION FOR INFORMATION NOTICE IEN-84-83, 85-74 VARIOUS BATTERY PROBLEMS AND 86-37 DEGRADATION OF STATION BATTERIES

DATE: September 11, 1986

Attached is the Engineering Department's Engineering Evaluation for the above referenced Information Notice. It is for your use and information.

WDG:ld
Attachment

C
1 General Manager - Nuclear Quality Assurance
1 General Manager - Nuclear Services
1 General Manager - Salem Operations
1 Assistant General Manager - Project Services
1 Manager - Nuclear Systems Engineering - Salem
1 Manager - Plant Engineering
1 Manager - Engineering
1 Manager - Nuclear Engineering Design
2 Manager - Engineering & Plant Betterment Controls
1 On-Site Safety Review Engineer - Salem
1 Manager - Station QA - Salem
1 Salem Operations Response Coordinator
1 TDR

cdWGD/1

Public Service Electric and Gas Company P.O. Box 236 Hancocks Bridge, New Jersey 08038

Nuclear Department

TITLE: ENGINEERING EVALUATION FOR INFORMATION NOTICES IEN 84-83, 85-74: VARIOUS BATTERY PROBLEMS AND 86-37 DEGRADATION OF STATION BATTERIES

1.0 PURPOSE

The purpose of this Engineering Evaluation is to document the Nuclear Engineering Department's response to the above referenced Information Notices.

2.0 SCOPE

The scope of this Engineering Evaluation covers the Salem Unit 1 and 2 Battery systems.

3.0 REFERENCES

3.1 Information Notice IEN 84-83 and 85-74, Various battery problems.

3.2 Battery discharge test maintenance procedure M3A.

3.3 Surveillance testing and preventive maintenance of station batteries maintenance procedure M3M.

3.4 Single cell battery charge maintenance procedure M3M-1.

3.5 Battery 18 month surveillance maintenance procedure M3V.

3.6 Information Notice IEN 86-37: Degradation of Station Batteries.

4.0 DISCUSSION

4.1 The subject Information Notices express concerns about the pot[illegible]l for significant degradation of safety associated w[illegible]ious battery related problems. The p[illegible]/resolutions are as follows:

4.[illegible] Overloading DC Buses - the addition of new loads to the dc system reduced the battery capability to provide power for eight hours as specified by the Technical Specification.

PSE&G Response - Overloading DC Buses: Per the Technical Specification, an eight (8) hour service test is required to be performed on the 125 VDC and 28 VDC batteries at least once every 18 months shutdown. The battery capacity is to be adequate to supply and maintain in operable status all of the actual emergency loads for a minimum of eight (8) hours.

This test is conducted per Maintenance Procedure M3V. This procedure prohibits testing of a battery if other batteries of the same voltage do not meet the requirements of the Technical Specifications. In addition, the procedure provides directions on securing the test for reasons other than reaching the eight (8) hour limit.

If the test is secured for any reason other than the successful completion of the test, a Deficiency Report is written addressing the problem.

Based upon successful completion of their tests, it has been proven that the station batteries have adequate capacity to handle the actual loads that would be required in an emergency.

4.1.2 Solvent Induced Case Cracking - cracking attributed to the use of a solvent trichloroethylene used to clean the battery part of anticorrosion (no-oxid "A") grease.

The application of a hydrocarbon-based grease to the vinyl straps on the battery racks caused the battery case to crack.

PSE&G Response - This problem is addressed in Field Directive No. S-C-E200-EFD-0318-Inspection Criteria and Required Corrective Action for Station Batteries. Section 4.0 point of inspection, item 4.2.4 "NOTE: Never use any solvents, cleaning compounds, oil, waxes, or polishes to clean the battery containers or covers or to remove NO-OX-ID grease or contamination from post or connectors."

4[illegible] The licensee had no records of battery charging following the completion of battery discharge test and consequently the time and date the batteries were returned to service could not be determined. The licensee also failed to correct specific gravity measurements for electrolyte temperature and level.

PSE&G Response - Maintenance procedure M3V-Battery 18 month surveillance has sign-off blocks for all critical steps; the date and time are also procedure requirements. The procedure corrects for specific gravity, temperature and electrolyte levels as required.

4.1.4 The licensee had no written procedures for conducting charges of the station batteries.

PSE&G Response - Maintenance procedure M[illegible]-1-Single Cell Battery Charge addresses the charging of a single cell (28, 125, and 250V) battery.

4.1.5 The battery performance discharge test was performed improperly because the test was stopped before reaching the minimum specified voltage.

PSE&G Response - Battery Discharge Test procedure M3A eliminates the possibility of this occurring. Item 9.2.6 states that "The discharge is to be maintained until one of the following limits is reached:

Low Cell Voltage - 1.25 VDC

Low Battery Voltage

| 28V | 125V | 250V |
|---|---|---|
| 22.8V | 105V | 210V |

It also notes the following, "the discharge is to be stopped immediately when the limiting voltage is reached".

The procedure has sign-off blocks for these steps.

4.1.6 There were no station procedures for maintaining station batteries in accordance with the battery vendor's manual or IEEE Std. 450-1975.

PSE&G Response - All the aforementioned procedures are utilized to maintain the station batteries; the procedures were developed from manufacturers operation manual and IEEE standard 450-1975 requirements.

4.1.7 The intercell resistance values of the batteries were not compared with the previous values to determine when corrective action was required.

PSE&G Response - Battery 18 month surveillance procedure - M3V requires cell to cell and terminal connection resistance to be recorded. The resistance values must be less than or equal to the established acceptance criteria of .01 ohms.

4.1.8 The licensee did not always conduct equalizing charges when required; nor did the licensee have procedures for monitoring the progress of an equalizing charge or determining when the charge should be terminated.

PSE&G Response - The weekly preventive maintenance and surveillance requirements of maintenance procedures M3M and the 18 month surveillance procedure M3V assure that the batteries are adequately charged. If a battery cell requires charging maintenance procedure M3M-1 will be invoked; this procedure monitors the progress of the charge and determines when the charge is sufficient.

4.1.9 Surveillance procedures for the 60-month rated-capacity discharge test did not conform to IEEE std. 450-1975 because the test was terminated at the end of 8 hours, instead of when the terminal voltage fell to the minimum specified value (usually 1.75 volts per cell).

PSE&G Response - Same response as item 4.1.5.

4.1.10 The licensee's procedures did not require that the average specific gravity be calculated and compared to the technical specification acceptance criteria.

PSE&G Response - Maintenance Procedure M3M (Reference No. 3.3) requires that the Technical Specification acceptance criteria be met; the requirements are incorporated into the procedure as surveillance requirements.

4.1.11 The battery capacity tests required by the Final Safety Analysis Report (FSAR) and IEEE Std. 450-1980 were not performed.

PSE&G Response - The battery capacity test requirement is covered in maintenance procedure M3A-Battery Discharge Test.

4.1.12 The pilot cells were not being changed on a yearly basis, as recommended by the vendor's technical instructions.

PSE&G Response - Pilot cell maintenance is covered in our surveillance testing and preventive maintenance (M3M) procedure. The procedure details weekly and quarterly preventive maintenance and surveillance.

4.1.13 The station engineer responsible for the technical aspects of battery operation, maintenance, and surveillance did not receive surveillance results and data sheets on a routine basis.

PSE&G Response - The PSE&G maintenance department retain files on all battery test and inspections.

4.1.14 Station batteries exhibited flaking of the cell plates and flaking of the plate's hook area where the plates connect to the cell posts.

PSE&G Response - This problem is addressed in Field Directive No. S-C-E200-EFD-0318 Inspection Criteria and Required Corrective Action for Station Batteries, Section 4, Item 4.2.7 addresses this problem. "The cell shall be checked for flaking positive plates and straps...The cell shall be inspected to determine if any flaking has bridged the plates."

## 5.0 CONCLUSION

The aforementioned battery maintenance procedures provide the guideline for surveillance, testing, and preventive maintenance of station batteries. These maintenance procedures eliminate the occurrence of the outlined problems.

There is no action required.

## 6.0 SIGNATURES

Walter G Drummond 8/28/86
Origina[redacted] Date

[illegible] 8/28/86
Verifier Date

L. C[redacted]n - 9/6/86
Origi[redacted]roup Head/Date

[illegible] 9/8/86
Manager - Plant Engineering Date

C.W. [illegible] 9/8/86
Group Head - SAG Date

PSE&G

ENGINEERING AND PLANT BETTERMENT DEPARTMENT
DESIGN VERIFICATION RECORD

GM8-EMP-006

**PART A**

SUBJECT: ENGINEERING EVAL FOR IEN NOTICE: VARIOUS Battery Problem

DISCIPLINE(S): MECH: ____ EL/I&C: X STRUCT: ____

DOES THIS DESIGN CONTAIN ASSUMPTIONS REQUIRING LATER CONFIRMATION? ____ YES X NO

ORIGINATOR (PRINT): WAlter G. DRUMMOND

Walter G Drummond 7/1/86
ORIGINATOR'S SIGNATURE / DATE

DOCUMENTS TO BE VERIFIED — REV.

DCR/DCP NO. (IF APPL.) ____

INPUT DOCUMENTS — REV.

**PART B**

L. G. HAJOS
Verifier Assigned (Print)

Assigned By: L. P. CORCETO 7/1/86
Date

**PART C** METHOD OF VERIFICATION

- ☐ Design Review/Document Review
- ☐ Alternate Calculation
- ☐ Qualification Testing

EXTENT OF VERIFICATION

- ☐ Identical to Previously Verified Design (Identify)
- ☐ Similar to Previously Verified Design (Identify)
- ☐ New (no identical or similar design)

FOR ITEMS VERIFIED BY DESIGN REVIEW, CHECK BELOW, "YES," "NO," OR "N/A" IF NOT APPLICABLE. PROVIDE ADDITIONAL COMMENTS, IF NEEDED, IN PART E. SEE REVERSE SIDE FOR COMPLETE QUESTION.

| DESIGN REVIEW QUESTIONS | YES | NO | N/A |
|---|---|---|---|
| 1. Appropriate design input? | ✓ | | |
| 2. Adequacy of Assumptions? | ✓ | | |
| 3. QA Requirements? | | | ✓ |
| 4. Codes, standards, regulatory requirements? | | | ✓ |
| 5. Construction and Operating Experiences? | | | ✓ |
| 6. Design Interface Requirements? | | | ✓ |
| 7. Appropriate Design Method? | | | ✓ |
| 8. Reasonable Output? | ✓ | | |
| 9. Proper Compone[redacted]ation? | ✓ | | |

| DESIGN REVIEW QUESTIONS | YES | NO | N/A |
|---|---|---|---|
| 10. Material Compatibility | ✓ | | |
| 11. Maint. Reqmts. Accessibility | ✓ | | |
| 12. ISI Requirements? | | | ✓ |
| 13. Radiation Protection? | | | ✓ |
| 14. Inclusion of Acceptance Criteria? | ✓ | | |
| 15. Test Requirements | ✓ | | |
| 16. Handling, Storage, Cleaning and Shipping Requirements? | ✓ | | |
| 17. Identification Requirements? | ✓ | | |
| 18. Record Preparation, Review Approval and Retention Requirements? | ✓ | | |

**PART D** Verifier [redacted] being independent of the design effort, identified [redacted] "A" (Documents to be verified). Verifier further [redacted] all comments regarding the design effort have [redacted] resolved and that the document is verified.

L. Hajos 7/1/86
Verifier Signature / Date

**PART E** (Use additional sheets if required)

GM8-EMP-006 Exhibit 1 (Rev. 1 NED/S 12"-13

## DESIGN REVIEW QUESTIONS

1. WERE THE INPUTS CORRECTLY SELECTED AND INCORPORATED INTO DESIGN?

2. ARE ASSUMPTIONS NECESSARY TO PERFORM THE DESIGN ACTIVITY ADEQUATELY DESCRIBED AND REASONABLE? WHERE NECESSARY, ARE THE ASSUMPTIONS IDENTIFIED FOR SUBSEQUENT REVERIFICATIONS WHEN THE DETAILED DESIGN ACTIVITIES ARE COMPLETED?

3. ARE THE APPROPRIATE QUALITY AND QUALITY ASSURANCE REQUIREMENTS SPECIFIED?

4. ARE THE APPLICABLE CODES, STANDARDS AND REGULATORY REQUIREMENTS INCLUDING ISSUE AND ADDENDA PROPERLY IDENTIFIED AND ARE THEIR REQUIREMENTS FOR DESIGN MET?

5. HAVE APPLICABLE CONSTRUCTION AND OPERATING EXPERIENCE BEEN CONSIDERED?

6. HAVE THE DESIGN INTERFACE REQUIREMENTS BEEN SATISFIED?

7. WAS AN APPROPRIATE DESIGN METHOD USED?

8. IS THE OUTPUT REASONABLE COMPARED TO INPUTS?

9. ARE THE SPECIFIED PARTS, EQUIPMENT, AND PROCESSES SUITABLE FOR THE REQUIRED APPLICATION?

10. ARE THE SPECIFIED MATERIALS COMPATIBLE WITH EACH OTHER AND THE DESIGN ENVIRONMENTAL CONDITIONS TO WHICH THE MATERIAL WILL BE EXPOSED?

11. HAVE ADEQUATE MAINTENANCE FEATURES AND REQUIREMENTS BEEN SPECIFIED AND ARE ACCESSIBILITY AND OTHER DESIGN PROVISIONS ADEQUATE FOR PERFORMANCE OF NEEDED MAINTENANCE AND REPAIR?

12. HAS ADEQUATE ACCESSIBILITY BEEN PROVIDED TO PERFORM THE IN-SERVICE INSPECTION EXPECTED TO BE REQUIRED DURING THE PLANT LIFE?

13. HAS THE DESIGN PROPERLY CONSIDERED ALARA REQUIREMENTS REGARDING RADIATION EXPOSURE TO THE PUBLIC AND PLANT PERSONNEL?

14. ARE THE ACCEPTANCE CRITERIA INCORPORATED IN THE DESIGN DOCUMENTS SUFFICIENT TO ALLOW VERIFICATION THAT DESIGN REQUIREMENTS HAVE BEEN SATISFACTORILY ACCOMPLISHED?

15. HAVE ADEQUATE PRE-OPERATIONAL AND SUBSEQUENT PERIODIC TEST REQUIREMENTS BEEN APPROPRIATELY SPECIFIED?

16. ARE ADEQUATE HANDLING, STORAGE, CLEANING AND SHIPPING REQUIREMENTS SPECIFIED?

17. A[illegible]ATE IDENTIFICATION REQUIREMENTS SPECIFIED?

18. A[illegible]EMENTS FOR RECORD PREPARATION, REVIEW, APPROVAL, RETENTION, E[illegible]ATELY SPECIFIED?

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Considerations for determining credit to be taken for similar or identical standardized or proven designs (See Sections 6.8 and 8.1.3):

1. The pertinent design inputs, including environmental conditions, of the standardized/proven design are applicable to the current design.

2. Known problems affecting the standardized/proven design and their effects on other features have been considered.

3. The standardized/proven design and associated verification are adequately documented and filed with the current design.

PUBLIC SERVICE ELECTRIC AND GAS COMPANY
NUCLEAR DEPARTMENT

DATE: April 13, 1983
RESPONSE DUE: N/A

TO: E. A. Liden
Manager - Nuclear Licensing and Regulation

FROM: L. A. Reiter
Manager - Nuclear Systems Engineering

SUBJECT: NRC INFORMATION NOTICE [redacted]
POSSIBLE SEISMIC VULNERABILITY OF
OLD LEAD STORAGE BATTERIES

**Discussion:**

As summarized in the above Information Notice, no seismically induced battery failure has occurred to date. The NRC is considering research that will define the seriousness of age related seismic vulnerability of lead storage batteries.

At this time, sufficient information is not available to determine either the seriousness of battery seismic vulnerability or a course of corrective action and/or plant specific battery vulnerability evaluation processes. Further regulatory guidance on the issue is required.

A copy of this notice is being forwarded to Plant Engineering for information.

RLG 9r
REF:tap

CC: R. L. Gura
A. Korn
D. K. Harding
SAG File - IE Notices

GM7 1

MANAGER
NUCLEAR LICENSING
AND REGULATION
E. A. LIDEN
NOTED
1983
REFER TO NUCLEAR LICENSING
AND REGULATION
COPIES
DUE
FILE APR 18 1983

ENTERED IN DCTS
DATE
BY

PSE&G

Public Service Electric and Gas Company P.O. Box E Hancocks Bridge, New Jersey 080

Salem Generating Station

MANAGER
NUCLEAR LICENSING
AND REGULATION
E. A. LIDEN
NOTED ..........
15 1983
REFER TO ..........
COPIES ..........
DUE ..........
FILE 18.3

April 8, 1983

To the Manager - Nuclear Licensing and Review

IE NOTICE 83-11, POSSIBLE SEISMIC VULNERABILITY OF OLD LEAD STORAGE BATTERIES

The Maintenance Department performs inspection of batteries in accordance with the following schedule.

| | | |
|---|---|---|
| 60 month | - | Test discharge of 28V - 125V batteries |
| 18 month | - | Test discharge of 250V batteries |
| 18 month | - | Visual inspection of plates - all cells 28V, 125V and 250V |
| 18 month | - | 8 hour connected load service test - 28V and 125V |
| 90 day | - | Test all cells 28V, 125V and 250V batteries |
| 7 day | - | Test of pilot cells only 28V, 125V and 250V batteries |

There have been no failures attributable to the causes identified in this IE Notice, however, we have changed cells due to individual cell voltage and specific gravity problems.

No. 2 250V battery presently has a cell jumpered out due to low individual cell voltage.

Maintenance Procedure M3-M specifically states that a visual inspection for any abnormalities and deterioration shall be performed in accordance with the above schedule of inspections.

H. J. Midura

General Manager -
Salem Operations

KW:kls

DEMINERALIZED WATER SYSTEM

| TABLE S-10 | | DEMINERALIZED WATER TANKS | |
|---|---|---|---|
| ANALYSIS | SPECIFICATIONS | FREQUENCY | REMARKS |
| pH | 6.0 - 8.0 | 2/W | |
| Spec Cond | ≤0.1 µS/cm | 2/W | Westinghouse Specification. |
| O2 | ≤100 ppb | 2/W | Westinghouse Specification. |
| Cl | ≤150 ppb | 2/W | |
| Na | ≤5 ppb | 2/W | |
| F | ≤10 ppb | Whenever Cl exceeds limit | Westinghouse Specification. |
| SiO2 | ≤10 ppb | 2/W | Westinghouse Specification. |
| Al | ≤20 ppb | 1/M | Westinghouse Specification. |
| Ca | ≤5 ppb | 1/M | Westinghouse Specification. |
| Mg | ≤5 ppb | 1/M | Westinghouse Specification. |
| TOC | ≤100 ppb | 1/M | Westinghouse Specification. |
| Susp Solids | ≤50 ppb | 1/W | Westinghouse Specification. |
| Tritium | | As Req'd | |

| TABLE S-11 | | CATION BED INFLUENT | |
|---|---|---|---|
| ANALYSIS | SPECIFICATIONS | FREQUENCY | REMARKS |
| Composite | | 1/Q | Vendor Analysis. |