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REGION I

Report No. 50-272/87-35; 50-311/87-35

Docket No. 50-272 and 50-311

License No. DPR-70 and DPR-75

Licensee: Public Service Electric & Gas
80 Park Plaza
Newark, New Jersey 07101

Facility Name: Salem Nuclear Generating Station-Units 1 & 2

Inspection At: Hancock's Bridge, New Jersey

Inspection Conducted: November 30, 1987 - December 4, 1987

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Inspection Summary: Inspection on November 30, 1987 - December 4, 1987
(Report Numbers 50-272/87-35 and 50-311/87-35

Areas Inspected: This special inspection was conducted to evaluate the present integrity of the safety related electrical distribution system with respect to protection from loss of more than one train of safety related equipment due to a common mode failure. This inspection reviewed the adequacy of Safety related breaker coordination, breaker and fuse sizing, voltage studies and emergency diesel generator loading analysis.

Results: During the inspection of the licensee's review of breaker coordination for safety related systems the team found that the overall scope of work was sufficiently comprehensive to address the issue of breaker coordination adequacy. The inspection team reviewed the licensee's planned status of safety related breaker coordination for restart of both units and had no exceptions to the licensee's plan. The team reviewed the area of emergency diesel generator (EDG) loading during postulated LOCA conditions and identified the need for documented engineering analysis to support the procedural guide lines provided to operators for ensuring that EDG load limits are not exceeded.

One item on EDG loading analysis and one item on undervoltage analysis remain unresolved.

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Attachments

1.0 Introduction and Background

The electric power systems (onsite and offsite) are important to the safety of a nuclear power plant and must be designed and maintained accordingly. The safety function of each electric system (assuming the redundant system is not functioning) is to provide sufficient capacity and capability of electric power for the safe operation of the plant under all operating modes including anticipated operational occurrences and postulated accidents. To achieve this safety function, 10 CFR 50, Appendix A, General Design Criterion 17 - Electric Power Systems, specifies design requirements concerning system capacity, independence, redundancy, availability, and reliability. Further, General Design Criterion 18 - Inspection and Testing of Electric Power Systems, specifies design requirements concerning provisions for their periodic inspection and testing.

The Salem 1&2 Final Safety Analysis Report (FSAR), Section 8, Electric Power Systems, describes how these design requirements are met. It also specifies the licensee's commitments with respect to the applicable Regulatory Guides (RGs) and industry standards such as the Institute of Electrical and Electronics Engineers (IEEE). The licensee's electric power systems, as originally designed (i.e., prior to the issuance of the Operating License) were reviewed by the NRC against these requirements and commitments. This review was conducted prior to licensing the facility.

Following the issuance of the Operating License, plant modifications can be made which involve significant changes in the configuration of the electric power systems. These modifications may involve substantial load growth of the electric power systems. As a result, lacking adequate controls, the electrical power systems may be loaded to their rated capacity, or overloaded. This may adversely affect the functioning of protective relays and coordination of the interrupting devices. Load growth may also create bus undervoltage conditions which may trip out or damage motors, resulting in unnecessary bus transfers, or cause other operational transients. Therefore, plant modifications should be evaluated to assure that their effect does not violate the requirements of General Design Criteria 17 and 18, and FSAR commitments, before the modifications are implemented.

Other types of significant changes in the configuration which might adversely affect the performance of electric power systems are: a transfer of a large load from one bus to another; replacement of system components such as breakers, fuses, or motors with a component having different functional characteristics; and changes in the set point of protective relays or breakers. All such changes should be evaluated by the licensee for potential problems.

In September 1987, the NRC performed an inspection of the licensee's compliance with the 10 CFR 50 Appendix R requirements, (Inspection Report 50-272;311/87-11). During this inspection it was determined that some uncertainties existed as to the extent of electrical breaker coordination in areas affecting the safety related and safe shutdown electrical distribution systems. The licensee committed to promptly review and address this concern.

2.0 Purpose and Scope

The principal purpose of this special electrical inspection was to assess the adequacy of breaker coordination at Salem Units 1 & 2 with respect to the integrity of the safety related electrical distribution systems and their role in responding to plant emergencies. The criteria utilized in this aspect of the inspection was to assess whether or not the status of plant breaker coordination at Salem Units 1 & 2, prior to restart, could result in the loss of more than one train of safety related equipment during a common mode failure. This inspection also included reviews of breaker and fuse sizing; design change packages; field installations; maintenance practices; voltage studies and emergency diesel generator (EDG) loading.

3.0 Inspection Methodology

The team reviewed the adequacy of the safety related electrical distribution system with respect to the following factors affecting system availability: (1) selectivity among the various protective devices which respond to overloads and short circuits, in order to ensure that the minimum of unfaulted load is interrupted; (2) reasonable sensitivity and speed of response of the protective devices, considering the characteristics and criticality of the protected equipment; (3) accuracy of the coordination curves in representing the types, ratings, and settings of the devices actually present in the plant; (4) adherence to the principal that no single failure (including a failure of a circuit breaker, fuse, protective relay, instrument transformer, etc.) can disable more than one redundant safe-shutdown train; (5) assurance that faults in non-Class 1E parts of the power system cannot credibly degrade Class 1E power availability; and (6) absence of apparent credible common-cause multi-train failure modes in those cases where complete selective coordination cannot practically be achieved.

A selected sample of Class 1E and Non 1E buses was walked down to collect the as built data on relay set points, load configuration and equipment rating. This data was compared to electrical one line drawings, relay setpoint calculations and load studies. The licensee analyses on selected protective relaying and breaker coordination was reviewed and field verified to determine the electrical system capability to limit the effects of electrical faults. Since these electrical faults can be caused by both internal and external hazards, installations suceptible to such damage were reviewed. Even though the Salem station is not committed to the requirements of Regulatory guide 1.75 on separation, the independence of the electrical train between safety trains and to nonsafety trains, was reviewed to establish the reliability of the electrical system.

A sample of significant electrical modifications were reviewed in detail. The purpose of this review was to verify that appropriate controls for the assurance of quality were in effect and that adequate safety evaluations were performed by the licensee to ensure that no unreviewed safety questions (10 CFR 50.59) exist. The modification program was reviewed to verify that the appropriate maintenance attributes are transferred into the applicable procedures.

The onsite electrical power systems, emergency diesel generator and the 125V Batteries loading calculations were reviewed to verify the systems' capacity to respond to design basis events. The dynamic part of the electrical system as documented in the licensee studies was verified to assess the system capability to respond to transient undervoltage, bus transfer, starting of large motors etc.

The summary of the inspection findings is given in Section 4, and the details of the inspection findings are provided in Section 5 of this report.

4.0 Summary of Inspection Findings

During the inspection of the licensee's review of breaker coordination for safety related systems, the team found that the overall scope of work was sufficiently comprehensive to address the issue of breaker coordination adequacy. In particular, the licensee's review included not only safety related circuit breakers, but also an adequate review of the potential impact of breaker coordination involving non-safety related circuits.

The licensee's technical review work was generally thorough and based on sound technical judgement. In certain instances the team raised questions - that are documented in the inspection report - about analyses that had not been performed at the time of the inspection. In each case, the licensee's response resulted in satisfactory resolution of the item. Also, since the licensee's overall analysis of the breaker coordination issue was in its final stages, but not as yet completed, these items are not being reported as omissions on the part of the licensee.

The licensee's review of the safety related breaker coordination issue did not identify any instances where the absence of complete coordination between breakers would compromise the safety related electrical distribution system in terms of losing more than one train of safety related equipment from a common mode failure. Recognizing the merits of increased breaker coordination, the licensee did take the initiative to increase the margins of safety in a number of instances by modifying breaker internal components in some cases and adding circuit fuses in others, thereby increasing the degree of coordination between certain breakers. The inspection team reviewed the licensee's status of safety related breaker coordination for restart and had no exceptions to the licensee's plan.

The inspection team also reviewed the status of other electrical areas of interest at Salem in connection with the on-going electrical distribution system review program initiated by the licensee during the past year. A summary of team findings, observations and licensee commitments is as follows:

At the time of this inspection the licensee identified a potential problem with motor control center (MCC) bus voltages under postulated degraded grid and loss-of-coolant accident (LOCA) conditions such that certain safety related equipment might not be operable. This item was identified as a part of the licensee's on-going program of review of the Salem station electrical distribution system. The licensee committed during this inspection to complete their analysis of this area and make any necessary system changes before restart of each Unit. This report includes an unresolved item (UNR) on this subject in section 5.5.

The team reviewed the area of emergency diesel generator (EDG) loading during postulated LOCA and loss of offsite power conditions and identified the need for documented engineering analysis to support the procedural guidelines provided to operators for ensuring that EDG load limits are not exceeded. While the emergency procedures provide operators with the load limit and guidance in support of manual load swap so as to maintain loading within the limit, there was no licensee analysis that demonstrates the capacity of the EDGs as sufficient to envelope all the design basis loading requirements. This report includes an Unresolved Item (UNR) on this subject in section 5.7.

The team noted that the breaker coordination curves associated with the reactor coolant pumps exhibit some overlap in a small portion of the range of current values on the breaker characteristic curves and recommended that the licensee review the feasibility of relay adjustments to eliminate this condition and thereby improve the coordination for these breakers. The licensee committed to do this.

In the team's review of administrative controls for breaker trip device set points, it was determined that the licensee's Maintenance Management Information System (MMIS) - which is in the final stages of program establishment - will be the controlling source for these set points and historical data. The licensee committed to have either the applicable portion of MMIS or alternate controlled one line diagrams marked up to reflect all set points prior to unit restart.

With respect to station electrical load growth control, the licensee stated that the new Administrative Control of Design and Configuration Change Program will control all future major electrical modifications and configuration changes currently being controlled by procedure GMB-EMP-009. The licensee committed to having the new program in effect in January 1988.

5.0 Details of Inspection of Electric Power Systems

5.1 Breaker Coordination

5.1.1 13KV and 4KV Balance of Plant Buses

The plant electrical system receives power through the auxiliary power transformers and station power transformers. When the station is generating less than approximately 38% power, the power supply is only through station power transformers. The power feed for the station transformers come from 13 kilo Volt ring bus located within the Salem station protected area which is fed from several power sources. During any plant condition station power transformers supply both Class 1E and non 1E buses rated at 4160 V. The reliability of this offsite power supply is critical to the safety of the plant operation. The reliability is enhanced through a fully coordinated electrical protection system.

The non safety part of the electrical system is connected to the group buses identified as E, F and G. These buses primarily serve the balance of plant equipment, that are not critical to the shut down of the station. This equipment is more susceptible to failures due to internal and external hazards. The faults generated by those failures have to be promptly isolated to limit the possibility of loosing the offsite power supply. In order to verify this function, the team selected non safety bus 26, and reviewed the protective relaying and coordination.

The team walked down the 26 Vital bus (Non 1E bus) and verified the protective relay setpoints on both feeder breakers and the reactor coolant pump breaker. Based on the present relay settings, the licensee generated the coordination curves. The team reviewed the coordination drawing 1 HAKRCPE dated December 2, 1987, and concluded that Bus 26 had complete coordination. However, some specific comments on margin between the protective characteristic curves are addressed in Section 5.6.

The ground fault protection of the subject buses was also reviewed to verify coordination. The team reviewed the ground protection coordination curve 1HAKRCPG dated December 2, 1987. This drawing established full coordination from 4160 volt group bus to 13800 Volt ring bus in the switch yard. The team also reviewed 'The Relay Test Order' for Station Power Transformers 22 and 21. The team did not observe any deficient conditions.

5.1.2 Safety Related 4KV Buses and Below

The licensee has embarked on a major program of modifications to the electrical protection subsystem of the Salem auxiliary power system. This involves a completely new coordination study which requires the re-setting of many of the protective relays and circuit breaker trip units in the system as well as the replacement of a number of low-voltage breaker magnetic series trips with static trip units and the addition or replacement of fuses in cases where essential coordination cannot otherwise be achieved. Except where specifically noted in the discussion below, all of the elements of this program are scheduled for completion before the Salem plant is re-started.

The following is the team's evaluation of the level of auxiliary power system protective device coordination which will be achieved when all planned modifications are completed.

Complete coordination will be achieved among all 4160 V AC Class 1E protective relays (including both phase over current and ground-fault relaying), and between the 4160 V relays and the trip units of the low-voltage power circuit breakers in the 480 V and 240 V AC distribution substations. In many cases this will require the replacement of the existing magnetic series trip units with static trips. The trip replacement program is in progress, and is concentrating on the most-critical breakers first. (A few breakers may not be completed until after restart because of component coordination pending replacement.)

Complete coordination will be achieved between the main and feeder power circuit breakers in the Class 1E low-voltage ac (480 and 240 V) distribution substations through re-setting and/or trip unit replacement. As above, a few trip devices may be replaced after restart if satisfactory coordination can temporarily be achieved with the existing trip units and necessary parts are not immediately available.

Coordination among low-voltage (480 V and 240 V AC,) Class 1E molded-case circuit breakers and fuses will continue to be imperfect at levels of short circuit current which exceed the instantaneous tripping current of the "upstream" breaker.

However, in the large majority of such cases non selectivity will only occur in case of severe short circuits near the motor control centers and distribution panels involved. Such faults are extremely improbable in view of the current-limiting effects of arc and ground-return-path impedances, and the fact that all of the potential fault locations where the available current is sufficient to trip both breakers are within "protected areas" as defined above. Furthermore, the inspection team walked down the selected areas of multi-train electrical circuits where lack of complete coordination existed. As a current feasibility study so indicates, the licensee may correct some of these cases by replacing the downstream breakers with units having smaller ratings. Otherwise, a justification will be prepared for the miscoordination conditions.

In the remaining non selectivity cases, the devices involved are for a dedicated service. Therefore, which device operates first is irrelevant to the availability of the circuit involved. The licensee will also justify the continuation of these conditions.

In general, no significant discrepancies were observed.

5.1.3 DC System Circuit Breaker and Fuse Coordination

Several aspects of the Class 1E 125 VDC and 28 VDC systems were examined during the inspection. These included breaker/fuse coordination, battery capacity, and a field inspection of various DC Electrical Distribution Panels, Cabling and batteries.

The primary focus of this inspection was to determine if adequate coordination existed between the DC overcurrent protective devices such that a common mode failure would not cause the loss of more than one of the three independent DC power sources. The licensee contracted with an outside source to perform a detailed study of the DC system and the results are contained in Document Number P1-183545-E05-1, Salem 1 and 2 125 Volt Battery Study, and P1-183545-E11-02, Salem 1 and 2 DC and 120 Volt AC Coordination Study. These documents were reviewed in their "draft" form. The licensee is in the process of validating the data and making corrections where necessary.

The methodology for calculating short circuit currents was reviewed and found to be acceptable. The contribution of the battery charger filter capacitors to available short circuit current was not initially considered, however, the licensee evaluated the question and determined that the current limiting circuit within the charger would ensure short circuit currents are within the bounds of those used for the original calculations.

The calculations identified numerous DC circuits which did not have full coordination between protective devices over the entire range of the available current. In some instances, the licensee is making modification to improve the margins of safety. For example, diesel generator field flashing circuits are being modified by the addition of a fuse in series with the circuit breaker to provide full coordination.

There are seven inverter circuits for each SALEM unit which do not completely coordinate with the main battery fuses for a phase to phase short circuit at the bus. The licensee has addressed these circuits in the safety evaluation report (SER) and determined that no circuit modifications are warranted due to the fact that:

a) The equipment and cables are located in a protected area resulting in a low probability of this type of fault occurring in a common mode fashion affecting more than one train.

b) If such a fault did occur and the fuses blew, the battery charger would continue to power the bus, and

c) The operators have blown fuse indications in the main control room and thus would be immediately aware of the problem and could initiate corrective action.

During review of the Unit 1 125 VDC one line electrical diagram (DWG. 203007) the inspector questioned whether the battery charger output circuit breaker has been reviewed with respect to coordination with the main battery fuses such that a fault within the charger would not result in a blown fuse and result in the loss of the entire DC bus. The licensee determined that coordination for these breakers had not been reviewed and subsequently found that similar to the inverter feeds, full coordination was not present. The inspector verified the physical configuration of the battery chargers with respect to the DC bus to confirm the licensee's determination that there is no common cause which would lead to the simultaneous loss of more than one DC bus due to the absence of total coordination. The licensee included these cases in the SER.

The other area of concern in the DC systems is that of lack of full coordination between the 100 amp main circuit breaker in the DC distribution panels and the branch circuit breakers. In both the 125 VDC and 28 VDC systems a fault in a branch circuit occurring in close proximity to the distribution panel could result in both the branch circuit breaker and the panel main circuit breaker opening. The postulated fault current decreases with distance from the distribution panel due to the added circuit resistance in the cabling. Full coordination is achieved for faults approximately 30 feet away from distribution cabinet. The licensee has determined that in all cases full coordination is achieved before the cabling leaves the protected confines of the auxiliary relay room within which the distribution cabinets are located.

Again there are no credible postulated common mode causes within the auxiliary relay room which would lead to the simultaneous loss of more than one distribution cabinet. Walkdowns of the auxiliary room and cabling were performed by the inspectors and did not reveal any common mode hazards.

The inspection also included a review of the battery capacity. The draft copy of electrical consultant study P1-183545-E05-1 indicated potential discharge rates which would exceed the capacity of the installed 125 VDC batteries. A more detailed load analysis is being performed by the licensee and the initial calculations indicate that the capacity is adequate. The inspector reviewed the methodology and assumptions being used by the licensee's engineers and determined that the values being used are more realistic than the consultant study and they are conservative values. A detailed load study for the 28 VDC batteries has not been performed at this time but preliminary calculations do not indicate there will be a problem with the discharge rate.

A walkdown was performed to verify that only the loads shown on the electrical drawings were connected and that all temporary circuits were removed. No discrepencies were noted for the sample of panels inspected.

The inspector also verified that the licensee was reviewing circuit loading with respect to potentially excessive voltage drops which could affect individual component operability. The electrical consultant study indicated that voltage drops in excess of 10% of rated battery voltage may occur for some loads. The licensee reviewed and reperformed calculations using more realistic parameters confirmed that adequate operating voltage would be available to all components.

5.2 Short Circuit Analyses

5.2.1 Inspection Scope, Approach, and Criteria.

The inspection team evaluated the AC and DC short circuit calculations for the Salem plant auxiliary power systems, which are contained in calculation nos. P1-183545-E03-1 Rev. 0 and P1-183545-E06-1, Rev. 0, and P1-183545-E06-1, Rev. 0.

All of these analyses were prepared by a contractor and are currently under review and revision by the licensee. The revisions will consist exclusively of the correction of over-conservative assumptions which lead to overstatements of available short circuit currents. The team concluded that the preliminary contractor calculations bound the results of the revised calculations.

The inspection approach consisted of reviewing the input data, assumptions, and methodology of the calculations, including "talking through" the methodology with the cognizant licensee and/or contractor engineers; evaluating all results for plausibility; and numerically checking a small random sample of calculations.

The basic evaluation criteria for the short circuit analyses were the following: (1) application of proper calculation methodologies as defined in the applicable industry standards, primarily IEEE Std 141, ANSI C37.010, ANSI C37.13, and NEMA AB-1; (2) use of worst-case plant configuration and impedance data; (3) use of conservative assumptions and approximations in the absence of specific plant data; and (4) adequacy of confidence level of data.

5.2.2 AC System Calculations, P1-183545-E03-1.

These calculations were performed using the contractor's validated short-circuit computer software, and cover all significant Class 1E and non-1E AC busses at the 13.8 KV, 4160 V, 480 V, and 240 V levels. They cover four cases involving all combinations of power supply from the station unit auxiliary transformers or the station power transformers (off-site power), and the presence or absence of three 4 KV circulating water pumps per unit. Three-phase impedanceless faults were also considered. The cases in which the six circulating water pumps are powered from the Hope Creek station rather than the Salem 4160 V group busses reflect the current plant configuration.

The information on key assumptions in the preliminary contractor calculation report was not in final form, however sufficient information was stated to show that a number of very conservative approximations were used, such as the assumption that all low-voltage distribution substation busses are loaded 100% with running motors. This conservatism results in a substantial overstatement of short circuit currents, especially at the 480 V and 240 V levels, and more than compensates for any possible non-conservative errors in cable lengths, etc. The licensee has identified a number of overconservatisms in the AC short circuit analysis and referred the calculation back to the contractor for revision. The team reviewed the licensee's comments on the calculations and concur that, when incorporated, they will make the analysis fully acceptable.

5.2.3 DC System Calculations

5.2.3.1 125 V Vital DC System Calculations, P1-183545-E05-1

The preliminary DC 125 V short circuit calculations were performed manually, and covered all 125 V DC distribution panels and other significant locations. While this calculation is acceptable with respect to conservatism and methodology, the licensee has identified several overly-conservative assumptions made by the contractor which led directly to an indication of excessive circuit breaker interrupting duties at several locations. The calculations are under revision using walkdown-derived cable lengths, current vendor data on battery internal resistance, etc., which the licensee expects will demon-strate that the apparently deficient breakers are actually satisfactory. The team reviewed the licensee's planned revisions, and agreed that they will improve the realism of the results while retaining adequate conservatism.

5.2.3.2 28 V Vital DC System Calculations, P1-183545-E06-1

The preliminary 28 V DC calculations initiated by the licensee were also performed manually. The team found them technically satisfactory, and take no exception to the conclusion that there are no short-circuit-current problems at the 28 V DC level.

5.3 Breaker and Fuse Sizing

5.3.1 AC Breakers (13 KV, 4 KV BOP, 4 KV Safety Related and Below)

As part of the short circuit analysis discussed in Section 5.2 of this report, the licensee evaluated the sizing of the AC breakers (momentary and interrupting rating) by comparison with the calculated short circuit currents. The above analysis, in summary indicates that the existing AC breakers at Salem are adequately sized for carrying the momentary and interrupting short circuit currents, for the case in which the six Salem circulating water pumps (CWPs) are supplied from Hope Creek. However, the design margin is relatively small for the 4 KV breakers. For the case in which the CWPs are supplied from Salem, the analysis determined that the 4 KV breaker readings are inadequate to withstand and/or interrupt the available short circuit current when operating in certain configurations. The details of the adequacy of the breaker sizing under the two cases discussed above are shown in Section 3.0 of the licensee analysis.

The team reviewed the licensee analysis and noted its conclusions. It should be emphasized that the analysis is in its draft form and the licensee is still evaluating its conclusions.

5.3.2 DC System Circuit Breaker and Fuse Sizing

The inspectors also reviewed a sample of the 125 VDC system circuit breakers and fuses for proper sizing and interrupting capacity.

The draft copy of study P1-18345-E05-1 contains short circuit calculations for the 125 VDC circuits and compared these values to the ratings for the corresponding circuit breaker and fuse interrupting capacities. The inspector reviewed this report and also examined a sample of the DC electric diagrams to verify all the loads were included in the study and also performed a field walkdown to verify the drawing accuracy with respect to actual connected loads on the DC panels. The study performed by the licensee's contractor indicated that the interrupting capacity of the 1200 A battery fuses and the auxiliary shutdown system distribution cabinet circuit breakers may not be adequate for the calculated available short circuit amperage. The inspector discussed these concerns with the licensee staff and was provided with adequate resolution that the fuses and circuit breakers were in fact satisfactory.

Within the scope of this review the inspector had no further concerns.

5.4 Review of Design Change Packages (DCPs)

5.4.1 Administrative Controls

The team reviewed the administrative control documents listed in Attachment 2 to ascertain that adequate assurances of quality, in accordance with the requirements of 10 CFR 50 Appendix B, exist for the safety related activities associated with the modification of the electrical power systems. These include:

- Design and Design Change Control (This includes specifications, drawings, procedures and instructions. Controls include selection and review for suitability of design change packages for their safety-related administrative controls and independent design verification).

- Document Control (This includes drawings, procedures, and instructions, and changes to these documents).

- Post-Modification Testing (Written test procedures incorporating requirements and acceptance criteria; documentation and evaluation of test results).

The licensee's QA program and administrative controls were reviewed with an emphasis on plant modification activities which could potentially affect the safety functions of the electric power systems. Individual DCP reviews are covered in Section 5.4.2. The teams findings with respect to overall administrative controls in this area are as follows:

Engineering and Plant Betterment Department procedure GMP-EMP-009, Operational Design Change Control was reviewed. The subject procedure is the controlling document for all engineering design changes for the station. The team noted that the procedure does not clearly define the requirements for updating the Maintenance Management Information System (MMIS). The licensee stated that a new program identified as the Administrative Control of Design and Configuration Change is in final draft. The program which is scheduled for implementation in January 1988, will replace the GM8-EMP-009 procedure for major modifications. Requirements for the updating of MMIS data band on design changes is clearly identified in the new documents. The team verified that administrative control of load changes will be accomplished through the Discipline Design Consideration Check List for Electrical, which is part of the Administrative Control of Design and Configuration Change program.

5.4.2 Design Change Packages (DCPs) and Safety Evaluations

A sample of modifications involving significant changes in the configuration of electric power systems was selected for detailed review. The scope of review included a verification that:

- The Administrative Controls described in Section 5.4.1 above were effectively practiced during the implementation of the modifications.

- Adequate safety evaluations were performed to ensure that no unreviewed safety questions (10 CFR 50.59) exist.

- Independent design verifications were performed as required.

- Adequate post-modification tests were performed and the test results met the acceptance criteria.

- The modifications involving a major change in the configuration of the electrical power systems were further reviewed in detail to determine the extent of the change and its potential effect on the safety functions of these systems. This also determines the need to perform revised load studies to verify that the new configuration will adequately perform its intended safety functions.

A complete list of DCPs reviewed is included in Attachment 2 Section 2. Of all the DCPs reviewed, two need particular mention as they relate to significant load changes (increase or decrease) at Salem 1 and 2. The first DCP, 2EC-01381-A, involved replacement of 3 condensate pumps in each unit with higher horse power pumps (3000 HP Vs 4000 HP) to eliminate frequent outages caused by low feed pump suction pressure. The licensee indicated that a static type of electrical load study was performed at the time this design change was implemented in 1985. This study concluded that the increased loading is within the capability of the Auxiliary Power Transformers (APTs) which normally power the station in-house loads. However, it could overload the Station Power Transformers (SPTs), which is not the normal source of power for the station in-house loads under summer (hot) weather conditions if the units are operating at full load. A limited dynamic (short circuit) study was also done at this time which indicated an increase in short circuit currents caused by the change. This could result in exceeding the interrupting capacity of the pump breakers by approximately two percent.

A licensee evaluation on the subject (S-2-E130-EEE-023, dated May 9, 1984) concluded that because of the conservative nature of this study, no electrical system modifications are required. However, the team considers that the situation clearly indicated a need to perform a detailed integraded dynamic study (short circuit, breaker sizing, and coordination studies etc.) of the Salem electrical distribution system at that time. Such a study, if it had been done, would have identified the station overloading problems under dynamic conditions and the undervoltage problems such as those experienced during the August 26, 1986 event (refer to Inspection Report 50-311/86-26, for details). This concern further re-enforces the need to administratively control such significant load changes and to perform the required static and dynamic studies, as was discussed further in Section 5.4.1 of this report.

The second significant DCP reviewed (1SM-0194 for Salem-1, and 2SM-0194 for Salem-2) involved transfer of six Circulating Water Pumps (CWPs) (three per unit at 2000 HP per pump) from the Salem electrical distribution system to the Hope Creek system. This modification was completed in January 1987 as a temporary change to eliminate the overloading/undervoltage problems at the Salem units so that the units could continue to operate until a final solution is arrived at. The licensee indicated that this temporary change could be the final solution.

A recent short circuit study (P1-183545-E02-1 dated July 1, 1987) indicates that, with the CWPs fed from Hope Creek, the overloading/undervoltage problems at Salem would be eliminated (refer to Section 5.2 of this report, for a discussion of this study). Further, this also would reduce the short circuit current levels to within the rating of the breakers (refer to Section 5.3.1 of this report, for a discussion of the breaker sizing).

The licensee further indicated that because the Hope Creek electrical distribution system was originally designed for a two unit station, it has adequate spare capacity to feed the Salem CWPs. A licensee evaluation (H-1-MCXX-ESE-0631, dated January 16, 1987) concluded that the additional loading on the Hope Creek system will not affect the system operation detrimentally.

5.5 Voltage Study of Salem Electrical Distribution System

On August 26, 1986, a reactor trip occurred at Salem Unit 2 which was shortly followed by a safety injection actuation and a subsequent false loss of offsite power to the safety related buses. The continued operation of Salem Units 1 and 2 following the above event was justified by returning the plant loads to within the values identified in the 1981 degraded grid voltage analysis when both Salem units were in operation, units loads were administratively limited to approximately 82% reactor power. At this power level the station electrical loads were within the limits of the 1981 degraded grid voltage analysis. This load reduction was accomplished by removing non-essential equipment from service. It was the licensee's intention to continue operating in this mode until additional transient analysis could be completed and a long term corrective action plan could be formulated.

Subsequent to the above, the licensee initiated efforts to look at various options which could allow Salem units to return to full generating capacity. The option selected involved transfer of six circulating water system pumps from the Salem electrical distribution system to the Hope Creek system. The transfer was accomplished by routing a 13KV feeder from the Hope Creek switchyard to the Salem switchyard. A transient analysis of the Salem electrical distribution system was performed which verified that the above configuration would not cause a repeat of the August 26, 1986 event. In addition, the second level of undervoltage relay (degraded grid) settings were changed from 91% to 91.6% of the design voltage. The licensee intends to operate Salem Units 1 and 2 in this design configuration (feeding six Salem circulating water pumps from Hope Creek switchyard) until long term corrective actions to improve the station electrical distribution system voltages are implemented.

During this inspection at Salem, the licensee reported the existence of degraded voltage at various motor control centers (MCC's) which could affect safety related equipment operability. This was recently identified as a result of the licensee's ongoing program to improve station electric distribution system voltages at Salem Units 1 and 2. An engineering evaluation revealed that, if a LOCA occurred coincident with a degraded grid voltage. (4KV system operating just above the second level of undervoltage relay setting of 91.6%), certain plant MCC's could experience a bus voltage as low as 87.5% of the nominal voltage. Additionally, the feeder circuits from the MCC to the load (motors) will experience an additional 1% drop. This low voltage condition could impair the operation (starting) of safety related equipment. It could also cause stalling of operating equipment connected to these MCC's.

The licensee has confirmed based on review of various motor specifications and motor speed torque curves with respect to pump or fan speed curves that the Salem motors will start at 80% of the rated voltage. The industry practice is to have 90% of the design voltage for continuous operation. In addition, the licensee evaluated the affect of this degraded voltage at the control circuits of the safety related motors. It was determined that certain contactor coils would not have sufficient voltage (pull-in) to start safety related motors.

In view of the above, it appears that this design deficiency in the degraded grid voltage protection system has existed for some time at Salem Units 1 and 2. The engineering evaluations are continuing to determine how this undervoltage problem at Salem can be resolved. The licensee is looking at various options such as changing load taps on 4.16KV/230V transformer, adding interposing relays in the control circuits or increasing size of circuit cables. The licensee has committed to resolving this issue before restart. The staff will review and evaluate the undervoltage voltage problem at Salem when the licensee's studies are completed and documented.

This is Unresolved Item No. 87-35-02.

5.6 Protective Relaying

5.6.1 Over Current Protection

The protective relay coordination study is primarily centered on the trip characteristics of the largest load on the bus and the feeder to that bus. This review was to address the other safety significant loads, its protection coordination and to determine if the existing setpoints are adequate to perform its safety function.

The team randomly selected the following loads at various voltage levels to examine the protective relaying.

A. <u>4160V Loads</u>

2A	Containment Spray pump	400HP
1A	Safety Injection pump	400HP
1A	Aux. Feed pump	600HP
1B	Charging pump	600HP
1A	Service Water pump	1000HP
	Reactor Coolant pump	600HP

B. <u>480V Loads</u>

2A	Boric acid pump	15HP
1A	Aux. bldg. exhaust fan	75HP
1B	Aux. bldg. exhaust fan	75HP
1A	Chiller	100HP

Field verification and the review of the protective system characteristic curves confirmed that the above loads were adeouately protected and coordinated. The team reviewed the Reactor Coolant Pump protection coordination curves 1HAK RCPE dated December 2, 1987. The margin between the motor overcurrent relay and the feeder overcurrent relay trip characteristic at the given setting was minimum. The licensee is considering to increase this margin by adjusting the tap and the time dial setting. No other deficiencies were identified.

5.6.2 <u>Ground Fault Protection</u>

The safety related AC electrical system is grounded only at the 4160 Volt level. Ground fault protection is provided for Reactor Coolant pump, safety injection pumps, service water pumps and containment spray pumps. These pumps use two sizes of induction motors namely 1000 horse power and 400 horse power. The protection provided for these motors are similar.

The team reviewed the ground fault protection coordination curve 1HAKRCPG dated December 2, 1987, and concluded that the protection is adequate and properly coordinated.

5.7 Emergency Diesel Generator Loading

The team reviewed the loads on the safety bus and the emergency loading of the diesel generator to assess the present adequacy of the emergency diesel generator capacity.

The Salem Unit 1 and 2 plants each have three emergency diesel generators which are designed to perform their safety function assuming any 2 of the 3 diesels are operating during an accident. The diesels are rated as follows at 0.8 power factor:

2600 KW - Continuous

2750 KW - 2000 Hours

3100 KW - 30 Minutes

Safety Evaluation CD-SE-7 dated September 17, 1976 and "Design Analysis and Evaluation of Salem Standby AC Power Supple Adequacy", Report #CD-M-66 Rev 1 dated January 12, 1981, were reviewed. In the CD-M-66 evaluation the licensee states that the highest short-term load on the diesel generators is approximately 2772 KW which slightly exceeds the 2000 hour rating. This loading would be for less than one hour. Also under a LOCA and Loss-of-Offsite Power (LOOP) condition, with the failure of #13 component cooling pump to start, the long term loading could be a maximum of 2626 KW, slightly exceeding the continuous rating. The report states that the loading analysis was conservative and that actual loads should be lower than estimated. However, no further calculations were provided which would refine the assumptions used and demonstrate that loadings would in fact be within the diesel ratings.

Even though the team recognizes the conservatism in the calculations, a complete analysis is necessary to determine the actual loading of the generator. The licensee was in the process of reanalyzing the diesel loading during the inspection and preliminary calculations indicated that a diesel generator overloading condition would not occur during accident conditions. It was also noted that the Emergency Operating Procedures did provide direction for the plant operators as to which loads should be stopped to allow starting other required loads without exceeding the diesel load rating.

Although preliminary calculations and procedures do not indicate an overload problem would exist, the licensee could not provide a detailed analysis and associated diesel generator load profile to demonstrate that diesel generator loading will not be a problem under the worst case combination of an accident with the concurrent single failure of a component (which would cause diesel generator loading to be at a maximum).

Even though, as indicated above, the emergency procedures give guidance to the operators for swapping loads and remaining below a specified EDG loading level, the licensee should have a documented analysis supporting the diesel generator capability to respond to the worst analyzed accident with a concurrent single failure and that the issued emergency procedures are consistant with this analysis. This is an Unresolved Item No. UNR 87-35-01.

5.8 Breaker and Protective Relay Maintenance

5.8.1 Setpoint and Configuration Control.

The licensee is in the process of establishing a computerized system to maintain the configuration of breaker and protective relay set points. The present plan is to have this program in place before Salem 2 restart. This program is identified as Maintenance Management Information System (MMIS). The MMIS data base will be the source for breaker and relay set points with back up data available on controlled one line diagrams. The MMIS data base is capable of generating the maintenance instructions with the applicable variables. Currently the licensee relies on the following documentation for maintenance:

- For all breaker protective devices, current and historical data is recorded and retrievable on Maintenance Procedure M&Q-Test Data Sheets.

- Trip settings for the recently installed SS5 solid state trip devices are identified on 230V-Vital Bus one line diagrams.

- Set points for OD-3 electro-mechanical trip breakers are also identified on the 230 V-Vital Bus diagrams.

5.8.2 Maintenance Activities

The inspector reviewed documentation controlling the installation of SS-5 type breaker overload driven and associated over load device set points for breaker locations 2B8Y and 2B13Y.

The inspector field verified over current relay set point changes at 4KV vital bus 4160/480 and 4160/230V transformers. The setpoint changes were accomplished in accordance with relay department procedure No. 4N-1, as part of Design change Request 1EC-2292. Additionally the inspector verified the setpoint data on drawing G01242A 1382 IR. No discrepancies were observed.

6.0 Independent Measurements and Calculations

One of the major areas where the licensee determined that full over current protection coordination could not be achieved is in the DC distribution that originated from the distribution panels located in the Relay room. The team performed an analysis to assess the impact of this lack of full coordination.

The objective of the analysis was to arrive at the cable length at which the circuit will become coordinated for a fault at that location. This is the result of the cable resistance that is added in series to the fault current for a short circuit simulated away from the distribution panel. The breaker coordination curve 1A1D1AAE dated October 1, 1987 indicates the distribution circuit to be coordinated with the upstream breaker when the fault current does not exceed 500 Amperes.

The calculation of cable length using this short circuit current and unit resistance of the cable, indicates that the DC circuits of ANG #14 wire will be coordinated at a distance of 35.5 feet for panel 2AA. The licensee had subsequently added this calculation into the Salem 1&2 DC and Vital AC coordination study P1-18345-E11 Revision 2.

All of the cables that leave their distribution panels are routed in a mild and seismically qualified area equipped with a fire detection and suppression system for a length of approximately 50 feet before they leave the Relay room. This room houses only control equipment which is very unlikely to cause any significant internal hazards that can propogate deleterious effects to multiple trains. Based on there facts, the team concluded that the lack of full coordination for DC distribution circuits does not compromise the integrity of the DC safety related electrical distribution system.

7.0 Unresolved items

Unresolved items are matters for which more information is required in order to ascertain whether they are acceptable, violations, or deviations. Two unresolved items are discussed in sections 5.5 and 5.7 of this report.

8.0 Exit Interview

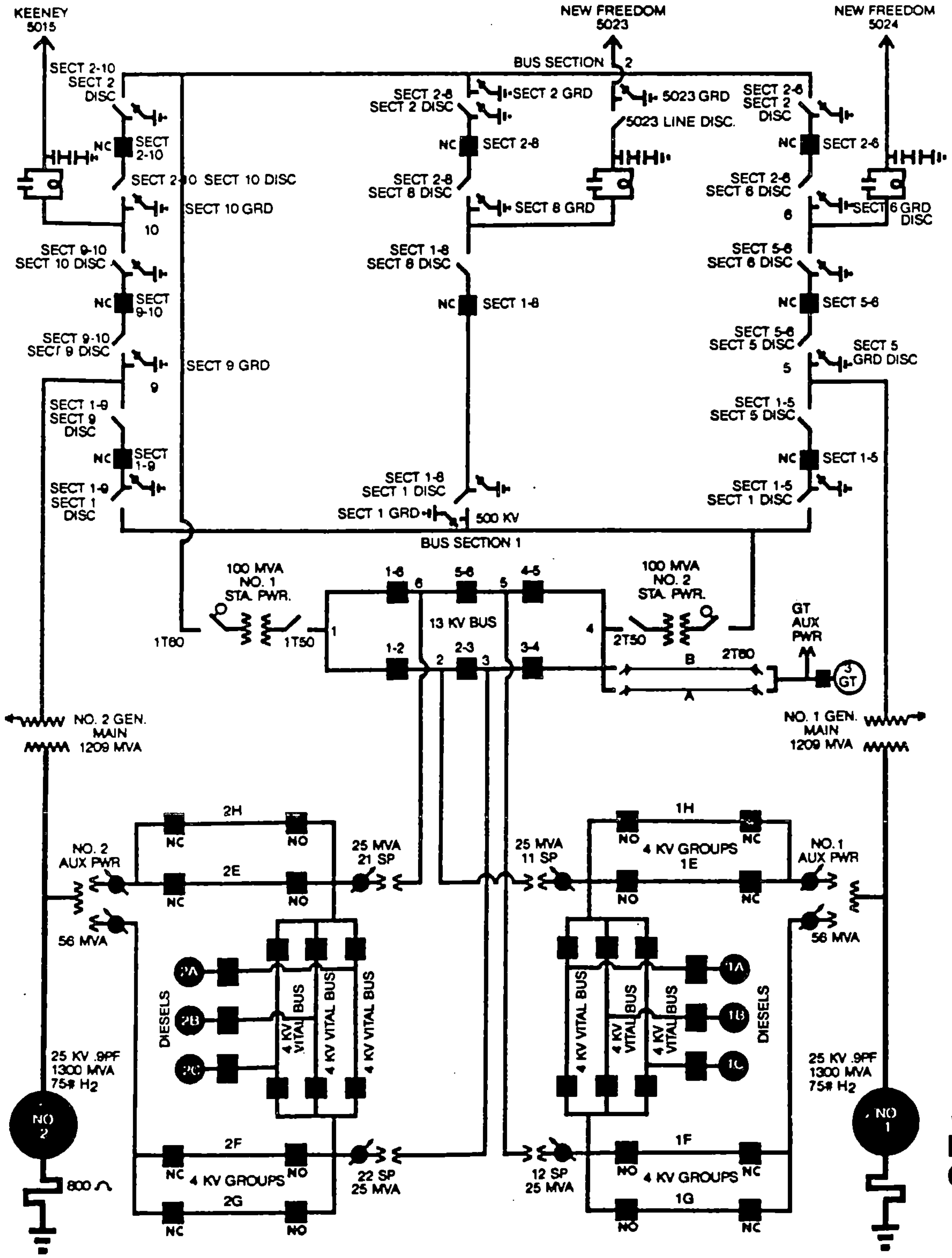
Attachment 4 is the list of persons contacted during the inspection. At the conclusion of the inspection on December 4, 1987, the inspection team met with the licensee representatives, denoted in Attachment 3. The team leader summarized the scope and findings of the inspection at that time.

The team leader and the licensee discussed the contents of this inspection report to ascertain that it did not contain any proprietary information. The licensee agreed that the inspection report may be placed in the Public Document Room without prior licensee review for proprietary information (10 CFR 2.790).

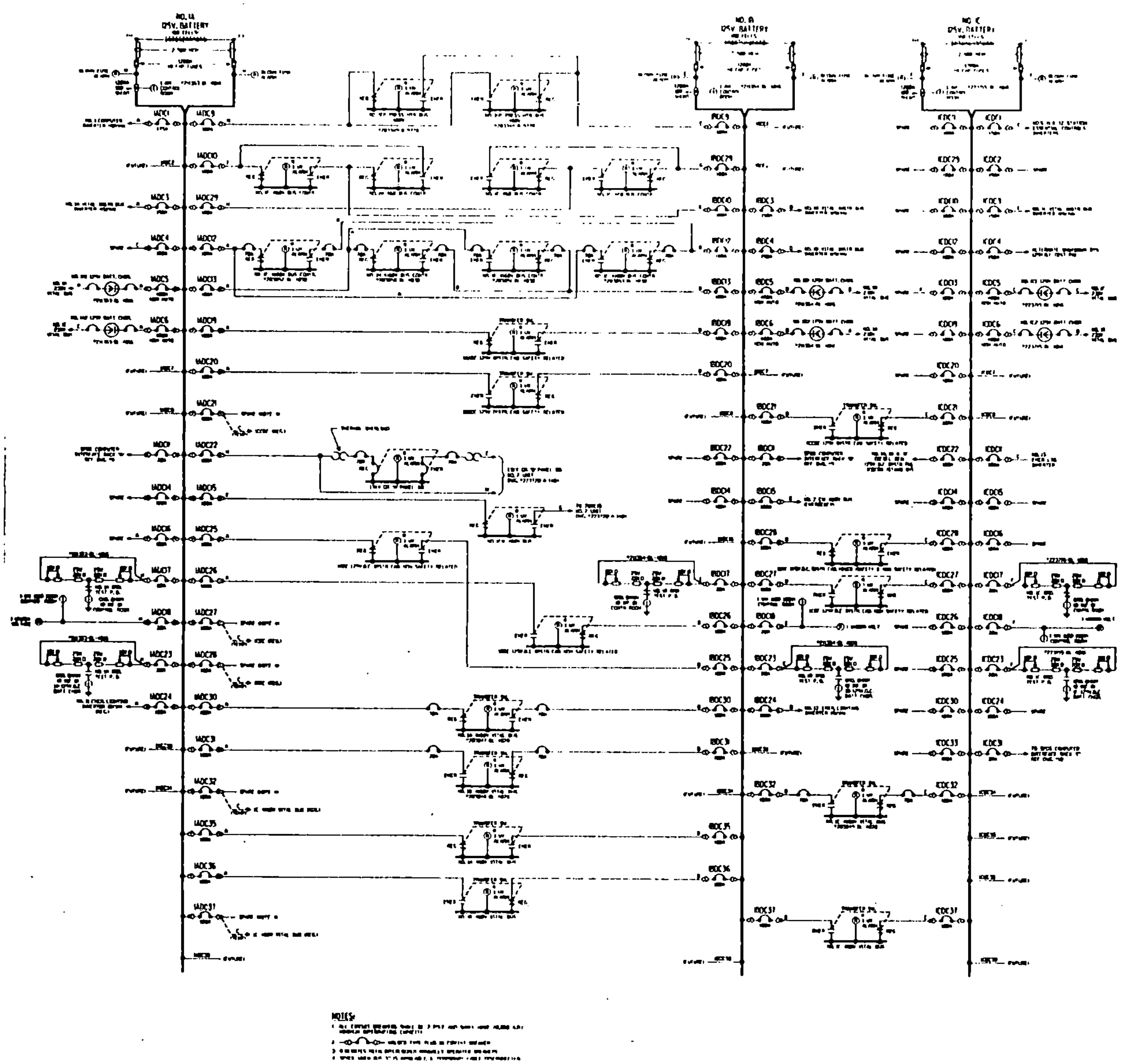
No written material was provided to the licensee by the team.

Attachment 1

Simplified Sketchs of Salem 1 & 2 Electrical Distribution System



SALEM
ELECTRICAL ONE LINE (AC)



REVISION 7
JULY 22, 1987
Ref. Dwg. 203007 A-8789-17

PUBLIC SERVICE ELECTRIC AND GAS COMPANY
SALEM NUCLEAR GENERATING STATION

125 V.D.C. ONE LINE
Unit 1

Updated FSAR Sheet 1 of 1
Fig 8.3-7

Attachment 2
Documents Reviewed

Doc. No.	Title	Revision
1. Drawings		
601701-A-1305	Salem/Hope Creek Nuclear G S -500, 13.8 KV Elementary One Line Diagram	0
203000-A-8789	No. 1 & 2 Units Generators & Main Transformers - One Line Control Diagram	19
203001-A-8789	No. 1 Unit 4160V Group Buses One Line Diagram	12
203002-A-8789	No. 1 Unit 4160V Vital Buses One Line Diagram	9
203003-A-8789	No. 1 Unit 460V & 230V Vital and Non-Vital Bus One Line Control Diagram	16
203004-A-8789	No. 1 & 2 Units 13 KV Switchgear One Line Control Diagram	6
203061-A-8789	No. 2 Unit 4160V Vital Buses One Line Diagram	8
203062-A-8789	No. 2 Unit 4160V Group Buses One Line Diagram	8
203063-A-8789	No. 2 Unit 460V & 230V Vital and Non-Vital Bus One Line Control Diagram	11
DWG #221408 1AADC	125 V.D.C. Distribution Cabinet Wiring	12
DWG #211342	No. 1A-125V DC Bus Wiring Diagram	9
DWG #203007	Unit 1 125 V.D.C. One Line Electrical Diagram	18

Attachment 2
Documents Reviewed

2. Design Change Packages (DCPs)

Doc. No.	Title	Revision
1SM-0194	Temporary Power for Circulators (Unit 1)	0
2SM-0194	Temporary Power for Circulators (Unit 2)	0
2EC-01381-A	Condensate and Feedwater System, Removal of the Existing Condensate Pumps and Installation of Higher Horsepower Motors	0
2EC-01896	Upgrade the Fast Transfer on Vital Buses on Undervoltage Conditions	0
2EC-02210	Replace Existing Diesel Generator Differential Relays Type 12 CFD 12 (not Seismically Qualified in the De-energized Condition) with IJD Type Relays or SA-1 Type Relays	0
2EC-02240	Disconnect and Remove the Existing No. 22 Westinghouse 25 MVA Station Power Transformer in Switchyard, Install a Spare General Electric 28 MVA Transformer on the Existing 22 SPT Mounting Pad.....	0
2EC-02263	Install Two (2) 70A and Four (4) 15A Seismically Qualified 125 VDC Molded Case Circuit Breakers. The Circuit Breakers will be wired into the existing Diesel Generator 125 VDC Control power and field flashing circuits...	0
2EC-02291	230V Trip Elements Are to be Replaced	0
2EC-02292	Overcurrent Relay Setpoint Changes	0
2EC-02271	Rewire Undervoltage Relays (91%) to Bus PTs, Add New Relay and Resistor at Vital Buses	0

Attachment 2
Documents Reviewed

Doc. No.	Title	Revision
3. Engineering/Safety Evaluations		
H-1-MCXX-ESE-0631	Justification for feeding 6 Salem Circulating Water Pumps from Hope Creek's 13KV Ring Bus	0 (Jan. 16, 1981)
S-C-F300-MEE-025	Integrated System Summary of the Condensate Pump Upgrade to Improve Feed Pump Suction Pressure Conditions	(August 14, 1984)
S-2-E130-EEE-023	Engineering Evaluation of Existing Station Power Distribution System to Support Upgraded Condensate Pump Motors	0 (May 9, 1984)
4. Correspondence		
NLR-N87013	Letter from C.A. McNeill, Jr. to NRC Subject: August 26, 1986 Reactor Trip and False Blackout Signal at Salem Unit No. 2 - Status of Corrective Actions, Salem and Hope Creek Generating Stations	January 30, 1987
NLR-N87187	Letter from C.A. McNeill, Jr. to NRC Subject: Request for Directionary Enforcement, Tech. Spec. 3.8.1.1, Facility Operating License DPR-75	October 13, 1987
NLR-N87186	Letter from C.A. McNeill, Jr. to NRC Subject: 10 CFR 50 Appendix R Safety Evaluation, Salem 1 and 2	October 1, 1987

Attachment 2
Documents Reviewed

5. Studies and Analyses

Doc. No.	Title	Revision
P1-183545-E02-1	Salem Nuclear Generating Station; 13.8 KV, 4:16KV and LV Systems Short Circuit & Motor Starting Study	July 1, 1987
PTI Report No. R8-87	Salem Nuclear Plant Short Circuit Study	February 1987
P1-183545-E03-1	13,8 KV, 4.16KV, and LV Systems Short Circuit & Motor Starting Study	0 7-1-87
P1-183545-E05-1	Salem 1 and 2 125 Volt Battery Study	0 Undated Draft
P1-183545-E06-1	Salem 1 & 2 28 Volt Battery Study	0 Undated Draft
Raughby Study	Salem Auxiliary Power System Intrim Study Part 1	
P1-183545-E03-2	U80 & 240V Vital Area Systems Voltage Drops	
P1-183545-E11-2	Salem 1 and 2 DC and 120 Volt Vital AC Coordination Study	Draft
	Bus 'B' Load Analysis	Draft
P1-183545-E05-1	Salem 1 and 2 125 Volt Battery Study	Draft
CD-SE-7	Integrated Safeguards Operation During Postulated Design Basis Events	N/A
CD-M-66	Design Analysis and Evaluation of Salem Standby AC Power Supply Adequacy	1
N/A	125 VDC Battery Capacities	Draft 11/30/87

Attachment 2
Documents Reviewed

	Doc. No.	Title	Revision
5.	Studies and Analyses		
	IV-16,3,1	Emergency Power-Diesel Operation	9
	EOP-LOPA-1 Table A	Safeguard Loading Sequence	0
6.	Maintenance Procedures		
	GM8-EMP-009	Operational Design Change Control	Rev. 2
	M3J	4KV and 13KV Breaker Timing	9
	M3Q	230 and 460 Volt K-Series Breaker Overload Test	8
	M3Q-4	230/460 V ITE K1600 Circuit Breaker Periodic Maintenance	0
	M3Q-5	230/460 ITE K225 and K600 Circuit Breaker Periodic Maintenance	1
	M3Q-6	230 and 460 Volt ITE K-Series Breaker Maintenance	1
	M3T	Under Voltage and Under Frequency Trip Check and Time Response Surveillance Test	16
	M3U	Safeguard Equipment Control System Output Relay Time Response Surveillance Test	10
	M3D	4KV and 13KV Magne-Blast Circuit Breaker Inspection and Test	10
	M4H-1	Installation and Removal of FS-195 Fire Wrapping For Cable Tray and Cables.	
	DE-WB.ZZ-0001 thru 0005	Administrative Control of Design and Configuration Change	Draft

Attachment 2
Documents Reviewed

Doc. No.	Title	Revision
6. Maintenance Procedures (Continued)		
87 1115068 & 69	Work Orders	
IEC-2292	Design Change Request 4KV Vital Buses	
4 N1-1	Subsection of Relay Manual	

Attachment 3
Persons Contacted

1. Public Service Electric and Gas Company

*S. E. Miltenberger, V. P. Nuclear Operations
*J. T. Boettger Assist, Assistant V. P. Operations Support
*Bruce A. Preston, MGR-LIC & REG
*L. A. Reiter, GM-Lic & Reliability
*L. K. Miller, MGR-Nuclear Engr Svcs.
*W. Pavincich, Principal Engineer
*R. W. Skwarek, Project Manager-Special Projects
*M. Rosenzweig, Mgr-QA Engr. & Procurement
*M. Morroni, Tech Dept I&C Electrical Eng
*V. J. Polizzi, Project Manager-H. C.
*R. W. Chranowski, Lead Engineer
*L. G. Hajos, Sr. Staff Engineer
*M. L. Burnstein, Principal Engineer Offsite Safety Review
*E. A. Liden, MGR-Offsite Safety Review
*M. K. Gray, Licensing Engineer
*G. A. Roggie, Salem Station Licensing Engineer
*R. Donges, Licensing Engineer
*R. Mollica, Elec. Design
*R. Swartzwelder, Licensing Engineer
*C. W. Lambert, Sciences-Manager
*D. W. Dudson, Licensing Engineer
W. G. Drummond, Senior Staff Engineer
C. W. Hotz, Relay Department
S. W. Hooks, Maintenance Supervisor
R. A. Burrigelli, GM-Etpb
W. Moo, Electrical Engineer, Consultant
D. J. Vito, Senior Licensing Engineer
D. E. Vangeputte, Licensing Engineer
M. A. Mortarulo, Senior Engineer Systems
M. E. Woloski, Senior Staff Engineer

2. United States Nuclear Regulatory Commission

*W. V. Johnston, Acting Director, Div. of Reactor Safety
*E. C. Wenzinger, Chief, Branch No. 2, Div. of Reactor Projects
*P. W. Eselgroth, Acting Tech. Assistant, Div. of Reactor Safety
*S. V. Pullani, Senior Operations Engineer, Div. of Reactor Safety
*T. Koshy, Reactor Engineer, Div. of Reactor Safety
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*T. J. Kenny, Senior Resident Inspector Salem, Div. of Reactor Projects
*K. H. Gibson, Resident Inspector Salem, Div. of Reactor Projects
*O. Chopra, Lead Electrical Engineer, Nuclear Reactor Regulation
*N. R. Trehan, Electrical Engineer, Nuclear Reactor Regulation
*L. L. Scholl, Resident Inspector, Div. of Reactor Projects
R. McFadden, Chief Electrical Engineer, Science Applications International Corporation

3. State of New Jersey

*L. A. Hamersky, Supervisor Nuclear Engineering, Bureau of Nuclear Engineering
*W. Cristali, Nuclear Engineer, Bureau of Nuclear Engineering

*Denotes those present at the Exit Meeting held on December 4, 1987.