U.S. NUCLEAR REGULATORY COMMISSION
REGION I

Report No. 50-272/86-07
50-311/86-07

Docket No. 50-272
50-311

License No. DPR-70
DPR-75 Priority -- Category C

Licensee: Public Service Electric and Gas Company

P. O. Box 236

Hancocks Bridge, New Jersey 08038

Facility Name: Salem Nuclear Generating Station Unit 1 & 2

Inspection At: Hancock's Bridge, New Jersey

Inspection Conducted: February 24-28, 1986

Inspector: Kent A. Manoly 4/3/86
K. A. Manoly, Lead Reactor Engineer date

Approved by: J. Wiggins 4/3/86
J. Wiggins, Chief date
Materials and Processes Section, EB

Inspection Summary: Inspection on February 24-28, 1986 (Report Number 50-272/86-07 and 50-311/86-07)

Areas Inspected: Routine, announced inspection by a region-based inspector of licensee actions in response to several open items identified in inspection Nos. 272/84-05 and 311/84-05 relating to NRC/IE Bulletins 79-02 and 79-14. The inspection also included a review of licensee activities related to the following:

- NRC/IE Bulletin 79-07
- Assessment of LER's between 1981 and 1985 concerning piping failures.

Results: One violation and one unresolved item were identified.

DETAILS

1. Persons Contacted

1.1 Public Service Electric and Gas Company

*J. N. Leech, Manager, Licensing and Regulation
*R. A. Burricelli, General Manager, E&PB
*D. Jage, Assistant General Manager, E&PB
*D. Falvey, Principal Stress Engineer
*R. Patwell, Senior Staff Engineer-Licensing & Regulation
*B. Gura, Manager-Engineering
M. Raps, Senior Engineer
*B. Stanley, Manager-Salem Systems
*B. Rodgers, Lead Designer Supports
T. Shome, Senior Designer-Civil
D. Patel, Chief Designer-Civil/Struct.
D. Bhavnani, Senior Staff Engineer-Stress
K. Mathor, Senior Engineer-Stress
B. Hall, Manager Rel & Assmt
N. D. Mistry, Senior Staff Engineer, Supports
T. N. Taylor, Manager Nuclear Engineering Control
J. Rowey, Senior Staff Engineer
H. Berrick, Principal Engineer-Salem Systems

1.2 Franklin Research Center

H. Fishman, Principal Engineer, Engineering Mechanics

1.3 USNRC

*T. Kenny, Senior Resident Inspector

*Denotes persons which were present during the exit meeting.

2.0 Follow-up on Outstanding Inspection Findings

2.1 (Closed) Violation (272 and 311/84-05-01)

The violation was related to the lack of review and control over the PSE&G engineering procedure titled "Criteria for Calculating Expansion Bolt Loads with Flat Plate Supports". The procedure was used by the engineering group at PSE&G for performing the evaluation of base plate flexibility for pipe support systems and the calculation of anchor bolt loads as required in the NRC/IE Bulletin 79-02.

PSE&G response to the violation was outlined in a letter on May 10, 1984 which included the corrective steps taken and those which were underway to prevent recurrence.

The licensee's corrective action involved the issuance of procedure "GM8-EMP-005, Design Calculations" which superseded "Document Control Section 4", and" Design Input, Section 8" which were in place during the NRC inspection when the violation was identified. The inspector performed a review of the above procedure which addressed the control of design calculations prepared by the Nuclear Engineering Department (NED) to comply with the requirements of ANSI Standard N45.2.11. In addition, the inspector performed a review of the following training records:

- Training of NED personnel on August 9, 1984 regarding Design Calculation Procedure GM8-EMP-005 and the summary of requirements from Regulatory GUide 1.64 and ANSI Standard N45.2.11.

- Training of NED personnel on August 14, 1984 regarding Design Verification Procedure GM8-EMP-006 and 10 CFR Part 21 (meeting record No. S-C-A900-NNM-0325).

To verify the implementation of the procedures to the design activities which are being conducted by the NED personnel, the inspector reviewed a sample of piping stress and pipe support design packages for the CVC piping system. The design documents reviewed are identified below:

- Calculation No. 5672235 (Stress)
- Calculation No. 2A-CVCA-1279 (Anchor)
- Calculation No. 2A-CVCG-1402 (Guide)
- Calculation No. 2A-CVCS-1424 (Support)
- Calculation No. 2A-CVCG-1430 (Guide)
- Calculation No. 2A-CVCS-1428 (Support)

Resulting from the review of the design control procedures currently in place and the sample design documents, the inspector determined that the licensee corrective action was adequate to resolve and close the identified violation.

The inspector identified however, that procedure "GM8-EMP-005" did not address the requirements of ANSI N45.2.9 for collection, storage and maintenance of quality assurance records. Section 8.10 of the procedure stated that the originator should send the original and one copy of the calculation to Manager-Nuclear Engineering Control (NEC), except for the Nuclear Engineering Design (NEDD) generated mechanical and civil calculations, in which case the originator would send the original to the NEDD file system. The inspector was concerned that the files maintained by NEDD would be less protected and controlled than those maintained by NEC. The licensee indicated that this finding was recognized by its staff and that the Engineering and Plant Betterment Dept. (E&PB) was in the process of implementing the transfer of stress calculation records to the new Control Records Facility (CRF) which was established to satisfy the requirements of ANSI N45.2.9. The licensee further indicated that the E&PB

procedure controlling the preparation, approval, and issue of calculations will be revised to reflect the transfer of records to the CFR. This item is unresolved pending licensee implementation of the above commitments and NRC review (272 and 311/86-07-01).

2.2 (Closed) Unresolved Item (272 & 311/84-05-02)

This item is concerned with the definition of flexibility for pipe support base plates in the procedure used by PSE&G entitled "Criteria For Evaluating Expansion Bolt Loads with Flat Plate Supports".

Plates with ratio of overhanging plate dimension to plate thickness exceeding the value of (5) were defined as flexible. Plates with flexibility ratio less than (5) were considered as rigid. The inspector reviewed the licensee's response to the unresolved item. The response identified the Technical Report 3501-1 issued by Teledyne Engineering Services (TES) on August 10, 1979 as the basis for the above flexibility ratio. The report presented the results of generic finite element analyses of base plates in the form of curves correlating plate thicknesses to anchor bolt loads when the plate is subjected to axial tension and bending loads. The curves cover base plate configurations with four and six bolts connected to structural attachments of wide flange and channel shapes. By inspection of these curves, it was possible to determine where the response of bolts to the applied loadings changes from linear to non-linear. This change point was used to define the limit of plate rigidity. The flexibility ratio of (5) was determined to be reasonably accurate to define this limit for base plates with wide flange, tube steel or channel attachments. The licensee response was considered adequate to close this unresolved item.

2.3 (Closed) Unresolved Item (272 and 311/84-05-03)

The issue of concern in this unresolved item is addressed in detail in section 3 of this report.

2.4 (Open) Unresolved Item (272 and 311/84-05-04)

This item was related to the extensive use of U-bolts and straps as piping anchors at both units of Salem Station. The licensee had identified 497 and 607 anchors in units 1 and 2 respectively. The unresolved item had identified two concerns. The first was related to the capability of these anchor configurations to develop the required axial and torsional restraint to piping systems. The second concern was related to the induced localized stresses on the piping by U-bolts and straps when used as anchors. An evaluation of these stresses was required to insure that allowable limits were not exceeded.

The licensee embarked on a quality assurance controlled testing and analytic program which was performed by Franklin Research Center (FRC) to quantitatively determine the support characteristics for selected configurations. The testing phase consisted of measuring the load-deformation characteristics of nine different U-bolt anchor assemblies for 2, 4 & 6 inch diameter piping. Each assembly was subjected to axial, torsional and lateral loads. The licensee indicated that the maximum test loads were determined based on review of applicable piping evaluations and selection of the maxima. The inspector reviewed the final report F-6070-001, "Analysis and Testing of U-Bolt Assemblies", in part, and held discussions with cognizant licensee and FRC representatives regarding the performance of the test and other technical issues of concern. The inspector determined that the licensee's testing and analysis program was reasonably adequate to address the overall concern regarding the capability of U-bolt configurations to perform as six way restraints.

Two concerns remained unresolved, however, as a result of this review. The first is related to the magnitude of pretension load applied in each leg of the tested U-bolt assembly. The report identifies the amount of torque applied prior to, and controlled during the test performance for various size U-bolts. Corresponding pretension loads were analytically derived from the applied torque for each size. Since the frictional restraint of U-bolt anchor assemblies is related to the amount of pretension applied, a verification of the measured torque on existing U-bolt anchor installations is required to fully predict their performance. The second concern, which was identified in inspection 84-05, regarding the evaluation of induced localized stresses in piping systems, was partially addressed for some anchor assemblies evaluated by the licensee contractor (Stone and Webster).

With regard to the first concern, PSE&G committed to performing a QC verification of five existing U-bolt anchor installations in the Chemical and Volume Control (CVC) system in proximity of the charging pump. The CVC system was selected for sampling of U-bolt anchors on vibrating piping systems with the highest probability for loss of pre-tension. Measurements of existing torque on these anchors will be performed during the upcoming outage in April 1986. The piping anchors selected for this purpose are:

1A-CVCA-635
1A-CVCA-631
1A-CVCA-458
1A-CVCA-488
1A-CVCA-489.

The licensee indicated that a generic evaluation of locally induced stresses in piping as a result of pretension loads from U-bolt anchors is currently in progress to resolve the second concern.

This unresolved item will therefore remain open pending licensee response to the identified concerns and NRC review.

2.5 (Closed) Unresolved Item (272 & 311/84-05-05)

This item is related to the previous unresolved item which addressed the use of U-bolt and strap assemblies as piping anchors. The concern was related to the stiffness provided by these assemblies, which are significantly different from those used in the piping stress analysis. Justification was required to demonstrate that allowable code limits were not exceeded when actual anchor support stiffnesses were used in the piping analysis. The FRC final report identified that both analytic and testing data were utilized in the derivation of the (6 X 6) flexibility matrix for the 6" diameter U-bolt anchor. For the 2" and 4" U-bolt anchors, test results were used to determine the flexibility terms in t he axial (along the pipe centerline), torsional and lateral directions. The missing terms in the flexibility matrix for the 2" and 4" U-bolts anchors were estimated from correlations with the 6" assemblies. The flexibility matrices for various anchor assemblies were inverted to obtain the corresponding stiffness matrices. The FRC report provided the flexibility and stiffness characteristics for the following assemblies:

- 2", 4" & 6" diameter Standard U-Bolt
- 2", 4 & 6" diameter Standard U-bolt with Vee-Notch
- 2 & 4" diameter U1 type clamp
- 6" diameter U2 type clamp

The inspector reviewed the results of a comparative study performed for two typical piping models analyzed using full anchor constraint and derived stiffness matrices for the standard 6" U-bolt assembly. The study provided the following major conclusions:

- The U-bolt translational stiffness was fairly high when compared to full anchor. The angular flexibility, however, contributed to the major difference in response between the anchor and stiffness matrix models.

- In both dead weight and thermal analyses, the maximum piping stresses were reduced. The reduction in thermal stresses was much more significant. A shifting of maximum stresses was also observed from the immediate vicinity of the U-bolt to the elbow.

- The piping analysis for the Y-direction earthquake indicated a rise in the stresses for the stiffness matrix model by approximately 10%. The increase was attributed to the difference in modal frequencies between the two models.

The inspector determined that the slight increase in seismic stresses did not represent a significant concern since the piping seismic analysis at Salem Station is based on a conservative 0.5% damping for the Safe shutdown Earthquake (SSE).

The inspector had no further questions regarding this issue. This item is therefore closed.

2.6 (Closed) Unresolved Item (272 and 311/84-05-06)

This item included two areas of concern in the licensee activities relating to the testing program of concrete expansion anchors in response to action No. 4 in I.E. Bulletin 79-02. The test results reviewed in inspection No. 84-05 were incomplete and no evidence was provided to ensure that the test sampling was in conformance with acceptable methods identified in Appendix A of the Bulletin. Further, it was not evident that the licensee's testing had considered worst case situations where expansion anchors were embedded in concrete topping.

The inspector reviewed several documents provided by the licensee in response to the first concern. The documents included:

1. Outline of test program for concrete expansion anchors for Units No. 1 and 2 (Response Supplement I to IEB 79-02).

2. SGS/M-106 & SGS/M-107 "Program for Compliance with Design and Installation Review per NRC IEB 79-02" for Salem Stations Units No. 1 and 2.

3. Appendix I to SGS/M-DM106 and SGS S/M-DM107 "Procedures for Test Loading Pipe Support Base Plates Employing Concrete Anchors" for Units No. 1 and 2 respectively.

4. Appendix I, Revision No. 2 to SGS/M-DM-106 and SGS/M-DM-107 "Procedure for Verification of Wedge Setting of Concrete Anchor Bolts" for Units No. 1 and 2 respectively.

5. Quality Assurance Instruction QAI 7.5 "Statistical sampling Inspection and Surveillance.

6. Detail Specification No. 79-6293 "Procedure for Verification of Wedge Setting on Hilti Kwik Bolts" Salem Station Units No. 1 and 2.

7. Pull test data sheets for Units No. 1 and 2.

8. Transmittals on December 12, 1979 and June 23, 1980 with enclosures identifying all Operational Design Change Notices (ODCN's) issued for the repair or modification of deficient concrete anchor bolts identified as part of the response to I.E Bulletin 79-02 for Units No. 1 and 2.

The procedure in document No. 4 above identified the number of anchor bolts in each Seismic Category I system, the required sample size to be tested for achieving the 95% confidence level, and the acceptable reject rate. A 100% testing of all bolts in the system was required when the reject rate exceeded the acceptable limit identified for that system. The basis for the sampling technique was provided in document no. 5 above.

The total number of support modifications performed in response to I.E. Bulletin 79-02 and 79-07 was 892 for Unit No. 1 and 993 for Unit No. 2. The information provided by the licensee was considered adequate to address the first concern in this unresolved item.

With regard to the identification of expansion anchors in finish concrete (topping), the licensee provided an analysis which was documented in an evaluation report No. S-C-MP00-MSE-256. The analysis indicated that a review of all floor mounted supports in both units was performed and a total of 18 supports was identified (13 in unit No. 1, and 5 in unit No. 2) where anchor bolts were embedded either completely in topping or partially embedded in the structural concrete without enough embedment depth. The evaluation excluded supports subject to tension loads equal to or less than 60 lbs. PSE&G performed a visual inspection on all identified supports and a test loading on four of the supports in Unit No. 1. The bolt deflections in the tested supports were well within the test acceptance criteria. The inspector also reviewed all visual examination reports for the supports identified in Units No. 1 and 2.

The information provided by PSE&G was considered adequate to address both concerns in this unresolved item. This item is therefore closed.

2.7 (Closed) Unresolved Item (272 and 311/84-05-07)

Two concerns were included in this item. The first, which involved the basis for ATI's (licensee contractor) base plate flexibility criteria, is addressed in Section 3 of this report. The second concern was related to the criteria used by PSE&G contractor Burns and Roe (B&R) for the evaluation of base plate flexibility and its limitation to the use of angle and channel shapes as base plates.

The licensee identified that the large majority of pipe supports evaluated by B&R in response to IEB 79-02 had angle and channel base plates. In the four cases where pipe support connections to concrete involved shapes other than angle or channel shapes, a detailed finite element analysis using the "ANSYS" computer code was performed. Pipe support connections to concrete involving flat base plates were analyzed using Teledyne's "Baseplate" program.

The inspector reviewed B&R's procedure No. PSP-001, which was used for simplified concrete anchor bolt analysis. The approach outlined in the criteria is based on the use of magnification factors for

determining anchor bolt loads computed from conventional methods. Magnified bolt loads were used for verification of stresses in the structural shape connection. The magnification factors were developed for various size structural angle and channel shapes subject to bending and tensile loads at several locations along the centerline. The computer program "ANSYS" was utilized in developing the factors identified above.

The inspector also conducted a review of sample evaluation packages performed by B&R. The packages reviewed are identified below:

- Hanger No. P-11S1A-19 - Safety Injection System (Unit #1)
- Hanger No. 2A-SWG-137 - Service Water System (Unit #2)
- Hanger No. 2A-SIG-184 - Safety Injection System (Unit #2)
- Hanger No. 2C-21SIS-189 - Safety Injection System (Unit #2)
- Hanger No. 2C-SIS-N9 - Safety Injection System (Unit #2)

The licensee's response and the design documents reviewed were considered adequate to close this item.

3. Review of I.E. Bulletin 79-02 Activities Performed by PSE&G and Associated Technologies, Inc. (ATI)

Activities performed by PSE&G and ATI in response to IE Bulletin 79-02 were reviewed in inspection No. 84-05. Unresolved items 84-05-03 and 84-05-07 were identified as a result of concerns relating to the technical adequacy of the criteria used by both organizations and the extent to which these criteria were used in the evaluation of base plate flexibility as required in the first action item of the Bulletin.

The inspector reviewed the study performed by PSE&G engineering staff in February 1984 in response to the first unresolved item. The study provided a comparison between the results of anchor bolt loads computed using PSE&G criteria and those computed using more accurate finite element analyses performed by PSE&G and Teledyne Engineering in 1979, utilizing industry wide bench-mark ANSYS computer code. The study included three typical base plate configurations with symmetrical four bolt patterns connected to wide flange, channel and angle shapes. In all three cases, PSE&G criteria were found to underestimate the magnitude of some bolt loads when compared to the more exact analyses identified above. The underestimates ranged from about 10 to 200%. (The wide flange case involved a bolt load whose load changed from compression to tension). A review of sample base plate evaluation packages performed by PSE&G in 1979, indicated that the engineering staff interpretation of the criteria was consistent with that used in the PSE&G study in 1984.

As a result of using PSE&G criteria in performing pipe support base plate flexibility evaluations, appropriate factors of safety, as derived from more accurate analytical techniques, were not provided.

With regard to the second unresolved item, the procedure used by ATI for the evaluation of base plate flexibility was found to be inaccurate in that it considered pipe support base plates designed to the requirements of the AISC Manual of Steel construction for column base plates to be rigid. The AISC procedure addressed the design of column base plates subjected to compressive loading. The formulation provided in the AISC for determining column base plate thickness accounts only for the allowable bearing pressure on concrete. The inspector noted that the AISC approach, therefore, does not address the requirement in tne Bulletin regarding the incorporation of base plate flexibility into the calculation of anchor bolt loads in tension. Further, the inspector performed a review of the following base plate calculation packages performed by ATI in response to the Bulletin:

- Calculation No. 5672301-2-RHRA-35
- Calculation No. 567362-2A-CCS-53A
- Calculation No. 567533-2-RHRG-22-40
- Calculation No. 567889-2A-SWS-219
- Calculation No. 567889-2A-SWG-233
- Calculation No. 5672301-2RHRG-30
- Hanger No. 2RHRG-34
- Hanger No. 2C-23RHG-15

Though the applied loads on the pipe supports identified above were generally insignificant except in one case (2-RHRG-22-40), none of the calculations had included any consideration of base plate flexibility in the determination of anchor bolt load.

Criterion III of Appendix B to 10 CFR50, requires the establishment of measures to assure that applicable design bases for important to safety structures and components are correctly translated into procedures and instructions. The measures established by PSE&G in this instance were ineffective in that they did not adequately incorporate pipe support base plate flexibility into the calculation of anchor bolt loads, as demonstrated in PSE&G and ATI procedures. This is a violation of Criterion III (272 and 311/86-07-02).

4.0 Review of I.E. Bulletin 79-07 activities

The seismic stress analysis of safety related piping systems in response to I.E. Bulletin 79-07 at Units No. 1 and 2 was addressed in Safety Evaluations by the Office of Nuclear Reactor Regulation (NRR). The Safety Evaluation for Unit No. 1 was performed in supporting Amendment No. 20 to the facility Operating License No. DPR-70 and for Unit No. 2 in Supplement No. 5 to NUREG-0517 titled "Saftey Evaluation Report Related to the Operation of Salem Station Unit No. 2". Both safety evaluations had indicated the staff's agreement with the licensee's revised method for the re-evaluation of all safely related piping systems at Unit No. 1 and

2 which were analyzed using the computer code PIPDYN II. The revised method involved the use of the individual X, Y and Z earthquake responses previously calculated by PIPDYN II and the manual combination of the above intermodal responses by the SRSS method.

The inspector performed a review of a random sample of pipe stress load sheets to verify their conformance to the revised combination method. The load sheets reviewed were:

- Calculation No. 2671510, Chilled Water System, Unit #1
- Calculation No. 267272, Aux. Feed Water System, Unit #1
- Calculation No. 267150GG, Main Steam to Aux. F.W. Pump, Unit #1
- Calculation No. 267204E, Residual Heat Removal System, Unit #1
- Calculation No. 267204F, Residual Heat Removal System, Unit #1
- Calculation No. 5671223, Safety Injection System, Unit #2
- Calculation No. 5672301, Residual Heat Removal System, Unit #2
- Calculation No. 5671225, Safety Injection System, Unit #2
- Calculation No. 567524, Spent Fuel Cooling System, Unit #2

In addition the inspector performed a review of sample design packages of multiple pipe supports which were performed in response to IEB. 79-07. The design documents reviewed are:

- Calculation No. CM-B18-106E & CM B17-4-1065: Reactor Containment Annulus Area
- Calculation No. PM-S-W-78-2111: South Penetration Area in Unit #2
- Calculation No. AM-100-DG2A-5140: Auxiliary Bldg. in Unit #2.

No discrepancies were identified during this review. The Bulletin is therefore closed for both units.

5.0 Review of QA activities

Engineering related activities performed by Engineering and Plant Betterment Department were evaluated during this inspection as part of the follow-up review on violation 84-05-01 in Section 2.1 above. This evaluation was limited to activities performed by the mechanical engineering group in the piping and pipe support areas. The evaluation addressed the implementation of ANSI standards N45.2.9 and N45.2.11 to the above activities. No violations were identified, however one unresolved item was noted as indicated in Section 2.1.

6.0 Review of Piping Failures at Salem Units No. 1 and 2

Prior to conducting this inspection, the inspector performed a review of approximately 50 Licensee Event Reports (LER's) relating to minor piping

failures in the past six years at both Units of Salem Station. An attempt was made to identify a trend in the LER's for possible identification of common mode failure. The major causes for failure were found to be resulting from:

-- Plugging (silt, shell fish, crud, etc.)
-- Vibration induced failure
-- Corrosion
-- Welding of dissimilar metals
-- Other unrelated failures

The major systems affected by the above failures were grouped as follows:

-- Component Cooling Water (CCW) including heat exchanges (CCHX)
-- Charging Pumps (CH)
-- Containment Fan Coil Unit (CFCU)
-- Chemical and Volume Control (CVC)
-- Diesel Generator
-- Reactor Coolant System (including Steam Generator)
-- Auxiliary Feed Water (AFW)
-- Safety Injection (SI)
-- Boric Acid Storage Tank
-- Fire Suppression System
-- Turbine Generator
-- Feedwater

A correlation between the failure causes and the systems or components in which the reported failures took place, revealed that the majority of events could be grouped as:

- Service water related failures affecting several systems.

- Vibration induced failures in the CVC/SI system caused by the Charging/Safety Injection Pumps.

The inspector discussed the above findings with cognizant licensee staff to identify whether there was a program in place for examining LER's which could provide assistance in identification of the root causes and subsequent remedial actions.

Although PSE&G did not perform a formal trending analysis of these LER's, it was evident that the two most common modes of failure identified above were well recognized and many actions had been implemented or planned to address the common initiating causes. Details of failure causes and corrective actions were provided by the licensee and are presented in the following subsections. The inspector concluded that the licensee actions taken or planned reasonably addressed this problem area.

No violations were identified.

6.1 Service Water Related Failures

The system has experienced material problems since the Salem Station went into commercial operation. The system functions as a heat removal source for the CCHX, Diesel, CFCU, SI and CH pump lube oil coolers, room coolers, chiller condensers and the turbine area. With the exception of the turbine area, the system is classified as safety-related, Seismic Category I and ASME Class III.

Studies performed by the licensee, in-house, and by outside consultants, had identified the following primary causes:

- Silt induced erosion to equipment and lining.
- Corrosion attack to base material as a result of lining deterioration.
- Vibration induced fatigue failure to small bore vent and drain lines.
- Cavitation (lining and piping failure downstream of control valve.
- Crevice corrosion in the weld area and in stagnant area (behind gasket)
- Equipment and piping failure due to erosion (service water pumps, strainers, pipe areas downstream of pressure reduction valves).
- Exce sive silt accumulation in stagnant area (instrumentation and diesel area)
- Micro-biologically induced corrosion (MIC)
- Expansion joint aging
- Biofouling (by barnacles and shell growth)
- Galvanic action in bi-metallic areas

The licensee indicated that significant progress had been made in the following areas to mitigate or eliminate these problems:

- Biofouling problem
- Silt plugging and accumulation in the system
- Silt induced erosion to equipment and piping
- Heat exchanger reliability performance tracking
- Cavitation
- Expansion joint aging problems
- Alternate design to eliminate inherent system design problem

The licensee provided the following details of corrective action taken in different areas:

1. A continuous chlorination program has been adhered to since 1983, with an increase in chlorine level, to eliminate the growth of marine organisms. All major headers have been inspected during subsequent

outages to verify the effectiveness of the program. No equipment failures due to marine life or silt plugging have occurred since the implemenation of this program.

2. A program has been in place to perform a high flow flush through heat exchangers on a periodic basis to preclude accumulation of silt and/or marine growth. Heat exchanger performance parameters are monitored during this flush for indication of reduced flow.

3. During the 5th refueling, a random "RT" inspection of stainless steel, (Type 316 with Inconel 625) welds on the No. 12 CCHX piping revealed that severe corrosion pitting was occurring in the stainless steel base metal at the heat affect zone. Action was taken to replace the stainless steel pipe material with carbon steel pipe lined with polyethylene.

4. To combat erosion problems in the system, most system heat exchanger tubing has been upgraded as detailed below:

   a. Unit 1 room cooler tubing was upgraded from CuNi to AL6X during 5th refueling outage
   b. Six (6) Unit 2 room coolers have been upgraded to AL6X (2nd refueling). The remaining five (5) will receive the same upgrading during the 3rd refueling outage.
   c. All chiller condensers have been replaced with titanium tubing since 1979.
   d. No. 11, 12 and 22 component cooling heat exchangers have been upgraded from 90-10 CuNi to titanium.
   e. All CFCU's heat exchangers have been upgraded from 90-10 CuNi to AL6X (motor coolers included).
   f. Various safety related pump oil coolers and the Diesel lube oil and jacket water coolers are scheduled for retubing during their respective Unit refueling outages replacing existing materials with titanium material.

5. To preclude silt accumulation and plugging, all CFU instrumentation lines receive flushing once a week.

6. System strainers are inspected on a rotational basis during the outages for erosion damage. The damaged parts are replaced or rebuilt and then coated with Belzona. In addition, to assure longevity, new strainers with better erosion/corrosion resistant material and more efficient strainer performance are being bought.

7. All unnecessary cavitrol bundles (cavitation control devices) were removed for valves SW223 and SW57 to preclude system clogging. The necessary bundles to alleviate cavitation problems were inspected during the outages and all damaged parts replaced.

8. To further combat erosion problems, all piping of high velocity areas has been or will be replaced by SS316 material.

9. To increase pump resistance to erosion and performance, a service water pump modification program has been instituted to replace all Navy Gun metal parts with Nickel Aluminum Bronze.

10. To address the problems with expansion joint material service life, shelf life and installation requirements, a field directive was initiated and a maintenance procedure is in place to inspect all expansion joints and replace, as required, during upcoming outages. In addition, an evaluation has been made and a design change is currently in progress to replace some expansion joints with hard piping.

11. In view of the frequent small bore vent and drain leakage, studies have been made to determine the root cause of failures. A Field Directive was given to the station to perform inspection on the system vent and drain lines inside the containment. This procedure is in the process of being performed.

12. In addition to the above service water activities, a study is currently being performed independently, by an outside consultant (AE), to recommend solutions to the existing problems. Some problem root causes have been identified to the AE, along with some recommended solutions such as system depressurization and small bore re-design.

6.2 Vibration Induced Failures in the CVC/SI Systems

Several failures were identified in the CVC System letdown line and reciprocating charging pump suction and discharge lines. The safety evaluations performed by the licensee have attributed the cause of these failures to the following:

- Pipe vibration caused by system operation
- Quick operation of valves led to water hammer in the CVC letdown line
- Long unsupported vent and drain connections with relatively large valve masses in the letdown line
- High pulsating pressure causing piping vibration and fatigue failures on the suction and discharge side of the positive displacement charging/SI pumps.
- Insufficient net positive suction head causing cavitation on the suction side of the charging/SI pumps.

The corrective actions taken were summarized by the licensee as follows:

- Regulating the operating speed of air operated valves in the letdown line to control the speed of flow and minimize or eliminate the water hammer problem
- Modifying vent and drain piping by supporting the valves from their respective headers
- Shortening vent and drain lines and changing location of valves to reduce moment arms
- Replacing piping with higher schedule piping
- Modifying pipe routing by eliminating loops
- Installing pulsation dampeners on the suction and discharge sides of the CH/SI pumps.
- Field Directive, in October 1985, for implementation of an NDE program for piping and pipe hangers in portions of the CVC and SI systems which are susceptible to failure based on operating experience

In addition, the licensee is planning to use suction stabilizers on the suction side of the charging pumps to minimize vibration.

7. Unresolved Items

Unresolved items are matters about which more information is required in order to ascertain whether they are acceptable, violations or deviations.

Unresolved items identified during this inspection are discussed in paragraph 2 above.

8. Exit Interview

The inspector met with licensee representatives (denoted) in paragraph 1) at the conclusion of the inspection on February 28, 1986, at the Salem plant. The inspector summarized the findings of the inspection. The licensee acknowledged the inspector's comments. At no time during this inspection was written material provided to the licensee by the inspector.