

U.S. NUCLEAR REGULATORY COMMISSION  
REGION I

Report No. 50-272/87-02  
50-311/87-02

Docket Nos. 50-272  
50-311

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

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: Hancocks Bridge, New Jersey 08038

Inspection Conducted: January 12-16, 1987

Inspectors: *Karl J. Manoly* 2/20/87  
K. A. Manoly, Lead Reactor Engineer date

Approved by: *Jack Strosnider* 2/20/87  
J. Strosnider, Chief Materials and date  
Process Section, EB

Inspection Summary: Inspection on January 12-16, 1987 (Report  
Number 50-272/87-02 and 50-311/87-02)

Areas Inspected: A routine, announced inspection was conducted by a region-based inspector of licensee activities in response to several open items addressed in Inspection No. 272/86-07 and 311/86-07 relating to NRC/IE Bulletins 79-02 and 79-14. The inspection also included a review of the following:

- o Approach and criteria used for the design and evaluation of safety related piping and support systems.
- o Interface between the mechanical and civil/structural disciplines during the process of design modification.

Results: Three violations and two unresolved items were identified.

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## DETAILS

### 1. Persons Contacted

#### 1.1 Public Service Electric and Gas Company

- \*B. Preston, Manager Licensing & Regulation
- \*D. Falvey, Principal Engineer
- \*A. Kao, Principal Engineer
- \*T. Taylor, Manager Engineering and Plan Betterment Controls
- \*F. Sullivan, Principal Engineer - Civil Engineering
- \*M. Gray, Licensing Engineer
- M. Raps, Senior Engineer
- W. Rodgers, Senior Designer
- K. Mathur, Senior Engineer
- R. Crapo, Group Head-Civil Engineering

#### 1.2 Franklin Research Center

H. Fishman, Principal Engineer, Engineering Mechanics

#### 1.3 U.S. Nuclear Regulatory Commission

\*K. Gibson, Resident Inspector

\*Denotes persons present during the exit meeting on January 16, 1987

### 2.0 Followup on Outstanding Inspection Findings

#### 2.1 (Open) Unresolved Item (272 and 311/86-07-01)

This item was related to the control of the Nuclear Engineering Design (NED) generated mechanical and civil calculation records. When the item was identified, the records were not fully maintained by the NED file system in accordance with procedure GM8-EMP-005 for "Design Calculations". Further, the designated storage facility did not appear to satisfy the requirements of ANSI N45.2.9 regarding the storage and maintenance of quality records.

The licensee's response to the identified item involved two actions:

- Revision of procedure "GM8-EMP-005" to satisfy ANSI N45.2.9 requirements.
- Transfer of the design calculation records to the new Central Records Facility (CRF) as required by the revised procedure above.

Implementation of the second action was not completed as the CRF was not ready to accept and maintain the subject records. The licensee indicated that the transfer of these records to the CRF would be completed by the second quarter of 1987.

The inspector reviewed Revision 1 of procedure GM8-GMP-005 and noted that it required the Engineering and Plant Betterment (E&PB) controls configuration management group to enter the calculation into the E&PB data base and send a legible copy of the calculation for microfilming to the CRF in accordance with the procedure for record management (VPN-MSP-07).

The inspector audited the current storage facility for the calculation records and verified that: (1) the documents were kept in cabinets with locks; (2) records of pipe support hardcopy calculations and pipe stress microfilm were adequately maintained; (3) design records were tracked and logged; and (4) sign-off forms were used for accountability of records removed from the facility.

The inspector noted that the licensee actions in this regard, when fully implemented, would be in compliance with the requirements of ANSI N45.2.9. The unresolved item will remain open, however, pending completion of the transfer of calculation records to the CRF by the end of the second quarter of 1987 according to licensee's commitment.

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

The issue of concern in this item was related to the extensive use of U-bolts and straps as piping anchors at both units of Salem Station. The licensee's action in this regard was reviewed in NRC Inspection No. 272 and 311/86-07. The item was open pending the licensee's commitment to perform (1) QC verification of selected U-bolt piping anchors torquing in the Chemical and Volume Control (CVC) system in the proximity of the charging pumps and (2) generic evaluation of locally induced stresses in piping as a result of pretension loads of U-bolt anchors.

The licensee action to the first concern included the determination of U-bolt torquing for four (4) piping anchor assemblies in Unit #1 and three (3) assemblies in Unit #2. The verification was performed using a special test procedure (No. S-C-N100-NFD-0367) prepared for this purpose. Table 2-1 identifies the anchor assemblies verified by QC for magnitudes of existing torque in relation to the test torque. Of the twenty-nine (29) measurements performed, five were below 50% and seven below 75% of the test torque value.

TABLE 2-1

Hanger Mark No.	Pipe Size	Bolt Diameter	No. of Bolt Measurements	No. of bolts measuring below designated percentage of test torque		
				50%	75%	100%
1-CVCA-634	4"	1/2"	4	2	1	-
1-CVCA-635	4"	1/2"	4	1	1	-
1A-CVCA-489	3"	1/2"	4	1	1	-
1A-CVCA-488	3"	1/2"	4	-	2	-
2A-CVCA-488	3"	1/2"	3	1	2	-
2A-CVCA-489	3"	1/2"	4	-	-	-
2A-CVCA-635	4"	1/2"	4	-	-	-

To address the above finding and the need to ensure that existing anchor installations are capable of providing the required piping restraint, the licensee developed an inspection program of U-bolt piping anchor assemblies at Units 1 and 2. The inspector reviewed the proposed ISI program and identified three concerns which the licensee agreed to address in the final procedure:

1. U-bolt anchor assemblies will be inspected to the torque values utilized in the testing performed by Franklin Research Center for bolt diameters up to 1". Technical justification would be required for deviation from these values and for establishing test torque values of bolts 1 1/4" and 1 1/2" in diameter.
2. The ISI program will establish a baseline for torque values of safety related U-bolt piping anchor assemblies in Units 1 and 2. Verification of baseline values for the first one-third of anchors tested will be performed in subsequent ISI. Evaluation of the second ISI torque values will determine the need for continuation of the program.
3. The ISI program will include all large bore piping U-bolt anchor assemblies (2 1/2" and larger) in Units #1 and 2.

Regarding the second concern, the inspector was informed that the evaluation of locally induced stresses from U-bolt anchors on piping has just begun and is expected to be completed by the end of the second quarter of 1987. This item will remain unresolved pending licensee's completion of the proposed ISI program and evaluation of locally induced stress on piping at U-bolt anchor locations.

### 2.3 (Closed) Violation (272 and 311/86-07-02)

The violation was related to identified discrepancies in the criteria used by PSE&G and Associated Technologies Inc. (ATI) for the evaluation of pipe support base plate flexibilities and anchor

bolt loads in response to I.E. Bulletin 79-02. The procedures used in performing the evaluation were found to underestimate anchor bolt loads when compared to more accurate analytical techniques in one case and to ignore base plate flexibilities in the other.

The licensee's corrective action included evaluation of the 404 baseplates analyzed by PSE&G and ATI for I.E. Bulletin 79-02. The evaluation revealed that 379 baseplates were acceptable as designed based on: reevaluation under IEB 79-07 by other than PSE&G or ATI; reevaluation under a Design Change Request (DCR) by other than PSE&G or ATI; and loads on the referenced plates which were of a low enough magnitude that simplified evaluation was acceptable. Of the remaining 25 baseplates, reanalysis revealed that two RHR support baseplate anchor bolts had factors of safety less than four as required by the bulletin. Continued operation of Unit #2 was considered acceptable since the anchor bolt factors of safety exceeded the magnitude of two. The supports were subsequently modified during the outage of Unit #2 in October 1986.

To assess the licensee's corrective action, the inspector performed the following:

1. Review of a random sample of pipe support packages from the 404 support baseplates evaluated by the licensee during this effort. The sample included the following supports:  
2A-CCG-444; 2A-CVCS-422A;  
2A-CVCG-449; Multiple P12-SWG-46 and P1-SWG-82;  
2A-CWA-234; 2A-CCS-410;  
2A-MSA-124; 2A-CSS-168;  
2A-SIG-184; and 2C-23 SIG-708
2. Review of the safety impact report (S-C-A900-MSE-0386-0) which provided justification for continued operation due to identified inadequacies of the baseplate calculations.
3. Review of procedure GM8-EMP-006 for design verification.
4. Review of calculation for modified hanger supports No. 2A-RHRA-183 and 2C-RHG-13 as a result of the reduced anchor bolts safety factors.
5. Visual inspection of the above modified supports to verify their conformance to the modification drawings.

No discrepancies were identified as a result of the records review and support modification examination. The violation is therefore closed.

3. Review of Approach and Criteria for Design and Evaluation of Piping Support System

A review of the design procedures and criteria governing activities performed by the mechanical piping and support groups of the E&PB department was conducted during this inspection. The objective of the review was to ensure that the necessary procedures for performing design and evaluation of piping and support systems were established and controlled. It was also intended to verify that the approaches used were consistent with FSAR commitments and acceptable engineering principles for performing these activities in areas where no specific guidance was provided in the FSAR document. The review also involved discussions with cognizant licensee representatives in this area regarding several technical and programatic issues.

In the area of pipe support design, the following concerns were identified:

1. The inclusion of self weight excitation of pipe support frames in design load combinations was not addressed in the pipe support criteria or performed during the course of design. The lack of evaluation of seismic stresses from self weight excitation in both restrained and unrestrained directions leads to underestimation of computed resultant stresses in piping support's components, and to the potential reduction of design safety margins below allowable code limits. The licensee's acknowledged the inspector's technical concern. However, no specific plan was provided for its resolution. This item is unresolved pending licensee evaluation and NRC review (272 and 311/87-02-01).
2. The criteria for design of pipe supports (Specification No. S-C-MB00-MDS-043) referenced the use of PSE&G mechanical standards for load capacities of U-bolt and strap support components. The criteria were not specific regarding the standards intended for use. The inspector reviewed a design document which provided the basis for the analytically derived load capacity allowables and the instruction for their application in design activity. The foregoing document was not controlled. The licensee acknowledged the need for inclusion of U-bolt and strap load capacities in the pipe support criteria.
3. Section 10.4 of the pipe support criteria addressed the evaluation of local stresses in piping walls at location of integral attachments using ASME Code Cases N-392 and N-318-1. The criteria did not address the requirement for evaluation of locally induced stresses at U-bolt anchor supports. The inspector noted that two approaches were considered by the licensee for determination of loads in U-bolt anchors. Evaluation of local piping stresses at U-bolt anchor locations was performed

using an approach described in a textbook, Formulas For Stress and Strain (by R. J. Roark, McGraw Hill, 5th edition). The licensee acknowledged the apparent inconsistency between the approach described in the criteria and the one being utilized in the evaluation of local piping stresses. The need to document the approach for determination of U-bolt anchor loads was also acknowledged.

Findings No. 2 & 3 above are violations of Criterion VI of 10 CFR 50, Appendix B, and section 7.6 of PSE&G's procedure for Operational Quality Assurance Program which requires the establishment of measures to control the issuance of documents, including changes thereto, which prescribe all activities affecting quality. (Violation 272 and 311/87-02-02)

4. Section 10.1 of the pipe support criteria required checking of pipe support displacements and rotations under applied design loads to ensure that their magnitudes were acceptable in accordance with approved pipe support evaluation. The criteria did not address or provide quantitative acceptance criteria for performing the required check.

In the area of piping stress analysis the following findings were identified:

5. A documented criteria for the performance of piping stress analysis was not yet established. A check list containing some basic analytical guidance was presented by the licensee as being utilized by the piping stress group. The licensee further indicated that the development of piping stress criteria was planned by the end of the second quarter of 1987.

Findings No. 4 & 5 above, are violations of Criterion V to 10 CFR 50, Appendix B, and section 7.5 of PSE&G's procedure for Operational Quality Assurance Program which requires that activities affecting quality be prescribed by, and accomplished in accordance with, documented instructions and procedures, of a type appropriate to the circumstances. Criterion V also requires these procedures to include appropriate quantitative or qualitative acceptance criteria. (Violation 272 and 311/87-02-03)

6. The approach used for piping stress analysis is based on considering support hangers, guides and anchors as infinitely rigid in the restrained directions. Though the approach was considered conservative for the evaluation of piping thermal loading conditions, it could result in underestimation of seismic piping responses. Utilization of infinitely rigid supports in the piping analysis process is considered a gross simplification, particularly for hangers with actual stiffnesses which are orders of magnitude below those which could be reasonably assumed to be infinitely rigid.

In a related matter, a comparative analysis was performed for one piping configuration (Calcs. No. 567349, 567350 and 567351) to evaluate the effects of using infinitely rigid anchors in the piping analysis. The piping re-analysis utilized the anchor's stiffness

matrix, derived from Franklin Research (FRC) Report No. F-6070-001 (Section 2.4 of NRC Inspection Report No. 272 and 311/86-07), for this purpose. Upon review of the piping re-analysis, the inspector noted that five hangers on the system were modeled as infinitely rigid. Though some increases in the anchors' reactions were identified, the validity of the results were considered questionable as a result of the identified approximation.

The concern regarding support's stiffnesses and their effect on results of piping analysis was acknowledged by the licensee.

In addition to the above concern, an error was noted in the formulation of flexibility matrices for U-bolt anchor assemblies in FRC report No. F-6070-001 referenced above. A zero flexibility was provided for the translation in the Y-direction due to unit load in same direction ( $F_{22}$  term) for a U-2 type anchor on a 6" diameter pipe (Table A-4 of the report). The stiffness matrix was derived by partitioning of the flexibility matrix and use of an infinite stiffness in the corresponding  $D_{22}$  term. The apparent discrepancy was determined to be the result of computing piping translation at a location other than at the U-bolt restraint point. The above observation is applicable to all analytically derived U-bolt anchor assembly stiffnesses matrices. This discrepancy had not been identified by the licensee and it did not appear that the FRC report had received a detailed review by the licensee. This discrepancy requires the licensee's evaluation prior to incorporation of U-bolt anchor stiffnesses in the stress analysis of piping system. This item is considered unresolved pending licensee response and NRC review (272 and 311/87-02-04).

#### 4.0 Review of Interfaces Between Design Organizations

The interface between the mechanical and civil/structural groups during the process of design change of piping and support systems was examined in this inspection. The programmatic requirements addressing interfaces among design organizations were described in the following documents:

- Design Memoranda (DM) Procedure No. GM8-EMP-017: Section 8.1 of the procedure requires the originator and/or discipline sponsors of a design change to review the interface requirements for design inputs applicable to the DM.
- Operational Design Change Control Procedure No. GM8-EMP-009: Section 8.5 of the procedure addresses the requirements for preparation of Design Memoranda per the above procedure. Section 8.5 of the procedure also addresses the development of the unified interdisciplinary engineering instructions per Exhibit 14 of the procedure.
- Design Verification Procedure No. GM8-EMP-006: Section 9.1 of the procedure requires the verifier to ensure that interface requirements among disciplines were adequately satisfied. A check in the "yes" column opposite item 6 on the Design Verification Record (DVR) form signifies satisfaction of this requirement.

The inspector reviewed a record of the design modifications performed during the Unit 2 outage. The following activities were examined for potential interface between the Mechanical (piping and supports) and the Civil/Structural groups:

1. DCR No. 2EC-01691 and 2EC-01692 for replacement of existing Carbon Steel service water (SW) system piping with stainless steel material. Reanalysis of the S.W. piping resulted in physical modification of the following supports:

2P-21 SWS-1	2P-21 SWG-6
2P-21 SWS-2	2P-21 SWG-9
2P-21 SWS-3	2P-22 SWG-14
2P-21 SWG-10	2P-22 SWG-13

The support modification involved additional attachments to the building structure. The DCR was initiated in July 1983 and was completed in October 1984. The inspector was informed that the Civil/Structural group was not identified in the design interface since the activity was performed prior to the issuance of Revision 0 of Procedure GM8-EMP-009 for design change control. Thus, the addition of eight piping support attachment loads to the building was not evaluated or monitored by the responsible discipline group.

2. DCR No. 2EC-02236 for modification of pipe support No. 2C-23RHG-13 in the RHR system. The modification was initiated as a result of NRC Violation No. 272 and 311/86-07-02 (Section 7.3 of this report) and required the addition of a brace to the support. to the containment floor at elevation 77'-11". The DCR was initiated by the mechanical group and completed in August 1986. Upon review of the DCR package, the inspector noted that the interface with the civil/structural group was not identified in the DM.

The unified interdisciplinary instruction sheet provided references to applicable PSE&G installation drawings and other installation related instructions. However, it did not address the requirement for evaluation or monitoring of additional support attachment loads to the building structure as a result of the modification via an interface with the structural discipline.

The above examples identify two design change activities involving the addition of load attachments to the building structure without the involvement of the structural discipline in the monitoring or evaluation of the affected elements. Though the design change in the first example was completed prior to the issuance of specific procedures addressing the interface requirements in the design process, the failure to identify the need for interface among the mechanical and structural groups in both examples is indicative of a programmatic weakness in this regard. In connection with this finding, the inspector noted that the evaluation of building steel was referenced in the specification for pipe support design

as the responsibility of the Civil/Structural group. It was noted, however, that a uniform approach did not exist for the transmittal of piping support and other mechanical component loads to the Civil/Structural group for evaluation of the effects of these loads on the building structure. The licensee acknowledged the inspector's observation and proposed to add a requirement in the pipe support criteria specification for transmitting all support reaction loads to the Civil/Structural group. The above finding is a violation of Criterion III to CFR 50, Appendix B which requires the establishment of measures for the identification and control of design interfaces, and of PSE&G's procedure VPN-QAP-01 which requires, in section 7-3, the timely update of records and affected documents following design change implementation to reflect as-built configuration (311/87-02-05).

5. Unresolved Items

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

The unresolved items identified during this inspection are discussed in paragraph 3 of this report.

6. Exit Interview

The inspector met with licensee representatives (denoted) in paragraph 1) at the conclusion of the inspection of January 16, 1987, 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.