October 1, 2003

Mr. Roy A. Anderson
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Post Office Box 236
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SUBJECT: SALEM NUCLEAR GENERATING STATION, UNIT NOS. 1 AND 2 - RISK-INFORMED INSERVICE INSPECTION PROGRAM (TAC NOS. MB7537 AND MB7538)

Dear Mr. Anderson:

By letter dated January 21, 2003, as supplemented on July 1, 2003, PSEG Nuclear, LLC submitted a request for approval of an alternative risk-informed inservice inspection (RI-ISI) program for the Salem Nuclear Generating Station, Unit Nos. 1 and 2 (Salem), Inservice Inspection (ISI) Program. The proposed RI-ISI program at Salem is limited to certain American Society of Mechanical Engineers Boiler and Pressure Vessel Code Class 1 and 2 welds.

The Salem RI-ISI program was developed in accordance with Electric Power Research Institute Topical Report TR-112657, Revision B-A, using the Nuclear Energy Institute's template methodology. The U.S. Nuclear Regulatory Commission (NRC) staff has completed its review of the proposed RI-ISI program. As documented in the enclosed Safety Evaluation, the staff concludes that the proposed alternative will provide an acceptable level of quality and safety. Therefore, pursuant to Title 10 of the *Code of Federal Regulations*, Section 50.55a(a)(3)(i), the NRC staff authorizes the proposed alternative for the third 10-year ISI interval at Salem, Unit No. 1, and the second 10-year ISI interval at Salem, Unit No. 2.

Sincerely,

/RA/

James W. Clifford, Chief, Section 2
Project Directorate I
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket Nos. 50-272 and 50-311

Enclosure: As stated

cc w/encl: See next page

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Unit Nos. 1 and 2

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO THE RISK-INFORMED INSERVICE INSPECTION PROGRAM

FOR ASME CODE CLASS 1 AND 2 PIPING WELDS

PSEG NUCLEAR, LLC

SALEM NUCLEAR GENERATING STATION, UNIT NOS. 1 AND 2

DOCKET NOS. 50-272 AND 50-311

1.0 INTRODUCTION

By letter dated January 21, 2003, as supplemented on July 1, 2003, PSEG Nuclear, LLC (PSEG or the licensee), proposed a risk-informed inservice inspection (RI-ISI) program as an alternative to a part of the current Inservice Inspection (ISI) Program at the Salem Nuclear Generating Station, Unit Nos. 1 and 2 (Salem). The scope of the RI-ISI program is limited to the inspection of American Society of Mechanical Engineers (ASME) Code Class 1 and 2 piping (Categories B-F, B-J, C-F-1, and C-F-2 welds).

PSEG's RI-ISI program was developed in accordance with the methodology contained in the Electric Power Research Institute's (EPRI's) report EPRI TR-112657, Rev. B-A, which was previously reviewed and approved by the U.S. Nuclear Regulatory Commission (NRC or Commission) staff. The RI-ISI program proposed by PSEG is an alternative pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR), Section 50.55a(a)(3)(i). The licensee requested the proposed alternative for the third 10-year ISI interval at Salem, Unit No. 1, and the second 10-year ISI interval at Salem, Unit No. 2.

2.0 REGULATORY EVALUATION

The ISI of the ASME Code Class 1, 2, and 3 components is to be performed in accordance with Section XI of the ASME Code and applicable edition and addenda as required by Title 10 of the *Code of Federal Regulations* (10 CFR) Section 50.55a(g), except where specific written relief has been granted by the Commission in accordance with 10 CFR 50.55a(g)(6)(i). Pursuant to 10 CFR 50.55a(a)(3), alternatives to the requirements of paragraph (g) may be used, when authorized by the NRC, Director of the Office of Nuclear Reactor Regulation, if the licensee demonstrates that: (i) the proposed alternatives would provide an acceptable level of quality and safety, or (ii) compliance with the specified requirements would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

Pursuant to 10 CFR 50.55a(g)(4), ASME Code Class 1, 2, and 3 components (including supports) shall meet the requirements, except the design and access provisions and the pre-

service examination requirements, set forth in the ASME Code, Section XI, "Rules for Inservice Inspection (ISI) of Nuclear Power Plant Components," to the extent practical within the limitations of design, geometry, and materials of construction of the components. The regulations require that the ISI of components and system pressure tests conducted during the first 10-year interval, and subsequent intervals, comply with the requirements in the latest edition and addenda of Section XI of the ASME Code incorporated by reference in 10 CFR 50.55a(b), 12 months prior to the start of the 120-month interval, subject to the limitations and modifications listed therein. The components (including supports) may meet the requirements set forth in subsequent editions and addenda of the ASME Code incorporated by reference in 10 CFR 50.55a(b), subject to the limitations and modifications listed therein, and subject to the Commission's approval.

Salem, Unit No. 1, started its third 10-year ISI interval on May 19, 2001. The applicable edition of the ASME Code, Section XI, for the third 10-year ISI interval at Salem, Unit No. 1, is the 1995 edition through the 1996 addenda. Salem, Unit No. 2, started its second 10-year ISI interval on May 10, 1992. Due to an extended shutdown of approximately 27 months, the licensee has extended the 10-year interval of Salem, Unit No. 2, through its fall 2003 outage. The applicable edition of the ASME Code, Section XI, for the second 10-year ISI interval at Salem, Unit No. 2, is the 1983 edition through the summer 1983 addenda.

The NRC staff reviewed and evaluated the licensee's proposed RI-ISI program pursuant to 10 CFR 50.55a(a)(3), including those portions related to the applicable methodology and processes contained in EPRI TR-112657, Revision B-A, "Revised Risk-Informed Inservice Inspection Evaluation Procedure," dated January 2000, based on guidance and acceptance criteria provided in Regulatory Guide (RG) 1.174, "An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis," July 1998; RG 1.178, "An Approach for Plant-Specific Risk-Informed Decision Making: Inservice Inspection of Piping," September 1998; and in NUREG 0800, "Standard Review Plan," (SRP) Chapter 3.9.8.

3.0 TECHNICAL EVALUATION

3.1 Proposed RI-ISI Program Approach

PSEG proposed to use an RI-ISI program for ASME Code Class 1 and 2 piping (Examination Categories B-F, B-J, C-F-1, and C-F-2 welds), as an alternative to the ASME Code, Section XI, requirements. The Code requires, in part, that for each successive 10-year ISI interval, 100% of Category B-F welds and 25% of Category B-J welds for the Code Class 1 non-exempt piping be selected for volumetric and/or surface examination based on existing stress analyses and cumulative usage factors. For Category C-F welds, 7.5% of non-exempt welds are selected for volumetric and/or surface examination. The licensee's proposed alternative follows the NRC-approved RI-ISI process and methodology delineated in EPRI TR-112657, Rev. B-A. By assessing piping failure potential and piping failure consequences, and performing probabilistic risk assessment (PRA) and safety significance ranking of piping segments, the number of inspection locations is significantly reduced. However, the program retains the fundamental requirements of the Code, such as inspection methods, acceptance guidelines, pressure testing, corrective measures, documentation requirements, and quality control requirements. Thus, ISI program requirements of other non-related portions of the ASME Code, Section XI, are unaffected.

In its January 21 and July 1, 2003, letters, PSEG stated that the augmented ISI program for flow accelerated corrosion (FAC), implemented in response to NRC Bulletin 89-08, "Erosion/Corrosion - Induced Pipe Wall Thinning," is not changed by the proposed RI-ISI program. Salem had previously met its commitment to NRC Bulletin 88-08, "Thermal Stresses in Piping Connected to Reactor Coolant System," by performing augmented examinations on specified piping locations that were considered subject to thermal fatigue. This issue has been subsumed by the RI-ISI program because the potential for thermal fatigue in piping is explicitly considered during the application of the RI-ISI process.

3.2 Proposed Changes to the ISI Program

The scope of the licensee's proposed RI-ISI program is limited to ASME Code Class 1 and Class 2 piping welds for the following Examination Categories: B-F for pressure-retaining dissimilar metal welds in vessel nozzles; B-J for pressure-retaining welds in piping; C-F-1 for pressure-retaining welds in austenitic stainless steel or high alloy piping; and C-F-2 for pressure-retaining welds in carbon or low alloy steel piping. The RI-ISI program is proposed as an alternative to the existing ISI requirements of the ASME Code, Section XI. A general description of the proposed changes to the ISI program is provided in Sections 3 and 5 of the licensee's submittal.

Based on its review, the NRC staff determined that the proposed RI-ISI program is consistent with the guidelines contained in EPRI TR-112657, which state that industry and plant-specific piping failure information, if any, is to be utilized to identify piping degradation mechanisms and failure modes, and consequence evaluations are to be performed using PRAs to establish piping segment safety ranking for determining new inspection locations. Thus, the NRC staff concludes that the licensee's application of the EPRI TR-112657 approach is an acceptable alternative to the current Salem piping ISI requirements with regard to the number, locations, and methods of inspections, and provides an acceptable level of quality and safety pursuant to 10 CFR 50.55a(a)(3).

System pressure tests and visual examination of piping structural elements will continue to be performed on all Class 1, 2, and 3 systems in accordance with the current ASME Code, Section XI, ISI program for Salem.

3.3 RI-ISI Program Intervals

The NRC staff considers that it is more desirable to begin implementation of an RI-ISI program for piping at the start of a plant's 10-year ISI interval, consistent with the requirements of the ASME Code and addenda committed to by the licensee in accordance with 10 CFR 50.55a. However, the implementation may begin at any point in an existing interval, as long as the examinations are scheduled and distributed consistent with the ASME Code requirements (e.g., the minimum examinations completed at the end of the three inspection periods under ASME Code, Section XI, Inspection Program B should be 16%, 50%, and 100%, respectively, and the maximum examinations credited at the end of the respective periods should be 34%, 67%, and 100%, respectively).

The NRC staff also views that RI-ISI program inspections at multiple-unit sites should be on the same interval start and end dates. This can be accomplished by either implementing the RI-ISI program at the beginning of the interval or merging the RI-ISI program into the ISI program for

the balance of the inspections, if the RI-ISI program is to begin during an existing ISI interval. One reason for this view is that it eliminates the problem of having different Codes of record for the RI-ISI program and for the balance of the ISI program. A potential problem with using two different interval start dates, and hence two different Codes of record, would be having two sets of repair/replacement rules depending upon which program identified the need for repair (e.g., a weld inspection versus a pressure test).

The licensee has planned for complete implementation of the RI-ISI program for Salem, Unit No. 1 during the start of its third ISI interval which began on May 19, 2001. The licensee plans to implement the RI-ISI program for Salem, Unit No. 2 during the last period of its second interval which began on May 10, 1992. Because the examination schedules and distribution are largely unaffected by implementing the RI-ISI during the last period of the second ISI interval at Salem, Unit No. 2, and is, thus, consistent with the ASME Code requirements, the NRC staff finds this acceptable.

3.4 Engineering Analysis

In accordance with the guidance provided in RGs 1.174 and 1.178, the licensee should perform an engineering analysis of the proposed changes using a combination of traditional engineering analyses and supporting insights from the PRA. PSEG elaborated as to how the engineering analyses conducted for the Salem RI-ISI program will ensure that the proposed changes are consistent with the principles of defense-in-depth, and that adequate safety margins will be maintained. This is accomplished by evaluating a location's susceptibility to a particular degradation mechanism and then performing an independent assessment of the consequence of a failure at that location.

PSEG's proposed RI-ISI program at Salem is limited to ASME Code Class 1 and 2 piping welds. The licensee stated in its submittal that other non-related portions of the ASME Code will be unaffected by this program. Piping systems defined by the scope of the RI-ISI program were divided into piping segments. Pipe segments are defined as lengths of pipe whose failure leads to similar consequences and are exposed to the same degradation mechanisms. That is, some lengths of pipe whose failure would lead to the same consequences may be split into two or more segments when two or more regions are exposed to different degradation mechanisms.

The licensee's January 21, 2003, submittal states that failure potential categories were generated utilizing industry failure history, plant-specific failure history, and other relevant information using the guidance provided in EPRI TR-112657. The degradation mechanisms identified in the submittal include thermal fatigue including thermal stratification, cycling and striping (TASCS) and thermal transients, intergranular stress-corrosion cracking (IGSCC), and FAC. The licensee stated in Section 2.2 of its submittal that the augmented inspection program for FAC is relied upon to manage this mechanism and is not changed by the RI-ISI program.

Section 3 of the licensee's submittal describes a deviation to the EPRI RI-ISI methodology for assessing the potential for TASCS that was implemented by the licensee for Salem Unit Nos. 1 and 2. The methodology for assessing TASCS in the Salem RI-ISI submittal is the same as the Materials Reliability Project (MRP) methodology in EPRI TR-1000701, "Interim Thermal Fatigue Management Guideline (MRP-24)," dated January 2001. The NRC staff reviewed PSEG's methodology and screening criteria. The licensee provided additional considerations

for determining the potential for TASCS. These considerations include piping configuration and potential turbulence, low flow conditions, valve leakage, and heat transfer due to convection. The NRC staff finds these considerations are appropriate for determining the potential for TASCS. The licensee further stated in its July 21, 2003, letter that final MRP guidance on the subject of TASCS will be incorporated into the Salem RI-ISI application if different than the criteria currently used. The NRC staff also finds this acceptable.

3.5 Probabilistic Risk Assessment

The Salem Individual Plant Examination (IPE) was submitted in July 1993. The NRC staff's safety evaluation report (SER) for the IPE, dated March 21, 1995, concluded that the Salem IPE satisfied the intent of Generic Letter (GL) 88-20, "Individual Plant Examination for Severe Accident Vulnerabilities." The NRC staff's SER did not report any significant weaknesses in the review of the Salem IPE. The licensee updated the probabilistic safety analysis (PSA) twice; the first update was Revision 2 and the second was Revision 3. A Westinghouse Owner's Group PSA Peer Certification Review was performed on the draft of the Revision 3 PSA in December of 2001. The final version of Revision 3 resolved the major certification comments. The RI-ISI program calculations are based on Revision 3 of the Salem PSA. The licensee stated that the core damage frequency (CDF), based on Revision 3 of the Salem PSA, is 4.472E-5/year and the large early release frequency (LERF) is 4.89E-6/year.

The NRC staff did not review the PSA analysis to assess the accuracy of the quantitative estimates. The NRC staff recognizes that the quantitative results of the PSA are used as order-of-magnitude estimates for several risk and reliability parameters used to support the assignment of segments into three broad consequence categories. Inaccuracies in the models or in assumptions large enough to invalidate the broad categorizations developed to support the RI-ISI should have been identified during the NRC staff's or the licensee's reviews of the IPE and the PSA. The licensee's model updates provided further opportunities to identify and correct errors. Minor errors or inappropriate assumptions will affect only the consequence categorization of a few segments and will not invalidate the general results or conclusions. The NRC staff has not identified any issues relating to the adequacy of the licensee's PSA that would adversely affect the proposed RI-ISI program.

The degradation category and the consequence category were combined according to the approved methodology described in EPRI TR-112657 to categorize the risk significance of each segment. The risk significance of each segment is used to determine the number of weld inspections required in each segment.

As specified in Section 3.7 of EPRI TR-112657, the licensee evaluated the change in risk expected from replacing the current ISI program with the RI-ISI program. The calculations estimated the change in risk due to removing locations and adding locations to the inspection program. The expected change in risk was quantitatively evaluated using the "Simplified Risk Quantification Method" described in Section 3.7 of EPRI TR-112657. For high consequence category segments, the licensee used the conditional core damage probability (CCDP) and conditional large early release probability (CLERP) based on the highest estimated CCDP and CLERP. For medium consequence category segments, bounding estimates of CCDP and CLERP were used. The licensee estimated the change in risk using bounding pipe failure rates from the EPRI methodology.

The licensee performed its bounding analysis with and without taking credit for an increased probability of detection (POD). In its submittal, the licensee estimated the system level and aggregate change in CDF and LERF for each unit. The aggregate change in risk estimates are provided in the following table.

Unit	Change in CDF		Change in LERF	
	With increased POD	Without increased POD	With increased POD	Without increased POD
Unit No. 1	-1.58E-07/year	2.43E-09/year	-1.58E-08/year	2.43E-10/year
Unit No. 2	-3.12E-07/year	-1.36E-07/year	-3.12E-08/year	-1.36E-08/year

The NRC staff finds the licensee's process to evaluate and bound the potential change in risk reasonable because it accounts for the change in the number and location of elements inspected, recognizes the difference in degradation mechanism related to failure likelihood, and considers the effects of enhanced inspection. System level and aggregate estimates of the changes in CDF and LERF are less than the corresponding guideline values in EPRI TR-112657. The NRC staff finds that redistributing the welds to be inspected, with consideration of the safety-significance of the segments, provides assurance that segments whose failure could have a significant impact on plant risk receive an acceptable, and often improved, level of inspection. Therefore, the NRC staff concludes that the implementation of the RI-ISI program, as described in the licensee's submittal, will have a small impact on risk consistent with the guidelines of RG 1.174.

3.6 Integrated Decisionmaking

As described in PSEG's proposed alternative, the licensee will use an integrated approach in defining the proposed RI-ISI program by considering in concert the traditional engineering analysis, risk evaluation, and the implementation and performance monitoring of piping under the program. This approach is consistent with the guidelines of RG 1.178.

The selection of pipe segments to be inspected, using the results of the risk category rankings and other operational considerations, is described in Section 3.5 of the licensee's submittal. Tables 3.5-1 and 3.5-2 of the licensee's submittal provide the number of locations and inspections by risk category for the various Salem, Unit Nos. 1 and 2, systems respectively. Tables 5-2-1 and 5-2-2 provide a comparison of the number of inspections required under the existing ASME Code, Section XI, ISI program with the alternative RI-ISI program for Salem, Unit Nos. 1 and 2, respectively. The risk impact analysis results for each system at Salem, Unit Nos. 1 and 2, are provided in Tables 3.6-1 and 3.6-2, respectively.

The EPRI report describes targeted examination volumes (typically associated with welds) and methods of examination based on the type(s) of degradation expected. The licensee recognizes these guidelines in the submittal. The NRC staff has reviewed these guidelines and has determined that, if implemented as described, the RI-ISI examinations should result in improved detection of service-related degradations over those currently required by ASME Code, Section XI.

The NRC staff finds that the location selection process is acceptable since it is consistent with the process approved for EPRI TR-112657, takes into account defense-in-depth, and includes inspections in all systems subjected to degradation mechanisms in addition to those covered by augmented inspection programs.

The objective of the ISIs required by ASME Code, Section XI, is to identify conditions (i.e., flaw indications) that are precursors to leaks and ruptures in the pressure boundary that may impact plant safety. Further, since the risk-informed program is based on inspection for cause, element selection should target specific degradation mechanisms. Chapter 4 of EPRI TR-112657 provides guidelines for the areas and/or volumes to be inspected, as well as the examination method, acceptance standard, and evaluation standard for each degradation mechanism. Based on its review of the cited portion of the EPRI report, the NRC staff concludes that the examination methods for the proposed RI-ISI program are appropriate since they are selected based on specific degradation mechanisms, pipe sizes, and materials of concern, and will, therefore, appropriately identify precursor conditions to leaks and ruptures in the pressure boundary.

3.7 Implementation and Monitoring

Implementation and performance monitoring strategies require careful consideration by the licensee and are addressed in Element 3 of RG 1.178 and SRP 3.9.8. The objective of Element 3 is to assess the performance of the affected piping systems, under the proposed RI-ISI program, by implementing monitoring strategies that confirm the assumptions and analyses used in the development of the RI-ISI program.

The licensee stated that upon NRC staff approval of the RI-ISI program, procedures that comply with the EPRI TR-112657 guidelines will be prepared to implement and monitor the RI-ISI program. The licensee confirmed in its letter dated July 1, 2003, that the applicable portions of the ASME Code, such as inspection methods, acceptance guidelines, pressure testing, corrective measures, documentation requirements, and quality control requirements would be retained.

PSEG stated in Section 4 of its January 21, 2003, submittal that the RI-ISI program is a living program and its implementation will require feedback of new relevant information to ensure the appropriate identification of safety significant piping locations. The submittal also states that, as a minimum, the licensee will review and adjust risk ranking of piping segments on an ASME-period basis and that significant changes may require more frequent adjustment as advised by way of NRC bulletins, GLs, or industry and plant-specific feedback.

Section 3.5.1 of PSEG's submittal provided information on the engineering evaluations and additional examinations that will be performed if unacceptable flaws or relevant conditions are found during examinations. The licensee stated that the evaluations will include whether or not other elements in the segment or additional segments are subject to the same root cause conditions. Additional examinations will be performed on these elements in high or medium risk significant segments up to a number equivalent to the number of elements required to be inspected on the segment or segments scheduled for the current outage. If unacceptable flaws or relevant conditions are again found similar to the initial problem, the remaining elements identified as susceptible will be examined. By letter dated July 1, 2003, the licensee stated that if flaws are found during a sample expansion, as discussed in Section 3.5.1 of the licensee's

submittal, the second set of additional examinations will also be performed during the current outage.

The proposed periodic reporting requirements meet existing ASME Code requirements and applicable regulations and, therefore, are considered acceptable. The NRC staff finds that the proposed process for the RI-ISI program updates meets the guidelines of RG 1.174 which provide that risk-informed applications should include performance monitoring and feedback provisions; therefore, the licensee's proposed process for program updates is acceptable.

4.0 CONCLUSION

In accordance with 10 CFR 50.55a(a)(3)(i), proposed alternatives to ASME Code requirements may be used when authorized by the NRC when the applicant demonstrates that the alternative provides an acceptable level of quality and safety. In this case, the licensee's proposed alternative is to use the risk-informed process described in the NRC-approved EPRI TR-112657. As previously discussed, the NRC staff concludes that the licensee's proposed RI-ISI program, as described in its January 21 and July 1, 2003, letters, will provide an acceptable level of quality and safety pursuant to 10 CFR 50.55a with regard to the number of inspections, locations of inspections, and methods of inspections.

Based on its review of the licensee's proposed RI-ISI program, the NRC staff concludes that the program is an acceptable alternative to the current ISI program, which is based on ASME Code, Section XI, requirements for Class 1 and Class 2 welds. Therefore, pursuant to 10 CFR 50.55a(a)(3)(i), the NRC staff authorizes the proposed alternatives on the basis that the request provides an acceptable level of quality and safety. This Safety Evaluation authorizes application of the proposed RI-ISI program for the third 10-year ISI interval for Salem, Unit No. 1 and the third period of the second 10-year ISI interval for Salem Unit No. 2. Activities associated with this alternative are subject to review by the Authorized Nuclear Inservice Inspector.

Principal Contributors: R. Davis
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Date: October 1, 2003