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United States Nuclear Regulatory Commission
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RESPONSE TO NRC BULLETIN 2002-01 – REQUEST FOR ADDITIONAL INFORMATION REGARDING REACTOR PRESSURE VESSEL HEAD DEGRADATION AND REACTOR COOLANT PRESSURE BOUNDARY INTEGRITY
SALEM GENERATING STATION UNITS 1 AND 2
FACILITY OPERATING LICENSES NOS. DPR-70 AND DPR-75
DOCKET NOS. 50-272 AND 50-311

On March 18, 2002 the NRC issued Bulletin 2002-01, "Reactor Pressure Vessel Head Degradation and Reactor Coolant Pressure Boundary Integrity." This bulletin was issued to require pressurized-water reactor (PWR) addressees to submit:

1) Information related to the integrity of the reactor coolant pressure boundary including the reactor pressure vessel head and the extent to which inspections have been undertaken to satisfy applicable regulatory requirements, and

2) The basis for concluding that plants satisfy applicable regulatory requirements related to the structural integrity of the reactor coolant pressure boundary and future inspections will ensure continued compliance with applicable regulatory requirements.

PSEG Nuclear, LLC (PSEG) provided response to Bulletin 2002-01 by letter LR-N02-0178, *Response To NRC Bulletin 2002-01, Reactor Pressure Vessel Head Degradation and Reactor Coolant Pressure Boundary Integrity,* dated May 15, 2002

By letter dated November 22, 2002, the NRC requested additional information concerning PSEG's Boric Acid Corrosion (BAC) control program. This letter provides the requested information.

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PSEGs BAC Control Program consists of several Operations and Inservice Inspection (ISI) procedures, periodic walkdowns, and leakage detection systems. The purpose of the program is threefold:

1. Find RCS leaks, and boric acid deposits,
2. Evaluate and assess equipment condition, and
3. Address the leakage/boric acid finding(s) in PSEG's Corrective Action Program.

Based on the above, PSEG believes that the current BAC Control Program provides reasonable assurance of our ability to detect, evaluate, and correct Reactor Coolant System (RCS) leakage in a timely fashion.

Nevertheless, PSEG is currently evaluating and actively participating in industry efforts to address issues regarding RCS degradation due to boric acid corrosion, to ensure that the PSEG program is consistent with industry recommendations.

Attachment 1 to this letter addresses the information requested in the NRC's nine questions.

PSEG has not identified any instances of degradation of associated components or dissimilar metal welds containing Alloy 600/82/182.

Commitments made in this response are outlined in Attachment 2.

Should you have any questions regarding this response, please contact Michael Mosier at (856) 339-5434.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on January 24, 2003

Sincerely,

John Carlin
Vice President – Engineering

Attachments

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REQUEST FOR ADDITIONAL INFORMATION (RAI)

REGARDING BORIC ACID CORROSION CONTROL PROGRAMS

SALEM GENERATING STATION, UNIT NOS. I AND 2

DOCKET NOS. 50-272 AND 50-311

1. **Provide detailed information on, and the technical basis for, the inspection techniques, scope, extent of coverage, and frequency of inspections, personnel qualifications, and degree of insulation removal for examination of Alloy 600 pressure boundary material and dissimilar metal Alloy 82/182 welds and connections in the reactor coolant pressure boundary (RCPB). Include specific discussion of inspection of locations where reactor coolant leaks have the potential to come in contact with and degrade the subject material (e.g., reactor pressure vessel (RPV) bottom head).**

   Administrative procedures NC.NA-AP.ZZ-0027 (Q), *Inservice Inspection Program* and SC.RA-AP.ZZ-0021 (Q), *ISI Group Examination and Test Activities*, and the associated Salem Unit 1 and 2 ISI Program Long Term Plans govern the inservice inspection program for Salem Generating Stations Units 1 and 2.

   Exam Scope, Extent of Coverage

   PSEG conducts nondestructive examinations (NDE) of Alloy 600 pressure boundary materials and dissimilar metal Alloy 82/182 welds in accordance with the requirements of American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (BPVC) Section XI Rules for Inservice Inspection of Nuclear Power Plant Components1995 Edition, 1996 Addenda (Salem Unit 1) and 1986 Edition (Salem Unit 2). ASME XI requires NDE to be performed in accordance with IWB–2500 and IWC-2500 Tables IWB-2500-1 and IWC-2500-1 per the requirements of IWB-1220 and IWC-1220, Components Exempt from Examination, for class 1 and 2 components.

   PSEG conducts system pressure testing (VT-2 leakage exams) of class 1, 2 and 3 systems and components in accordance the requirements imposed by ASME Section XI paragraph IWA-5110 (a) and regulatory commitments made to NUREG-0578, TMI-2 Lessons Learned Task Force Status Report and Short-Term Recommendations, for those borated systems and components located within the Auxiliary building.

   The Salem ISI Program Long Term Plans contain twenty four (24) Alloy 600/82/182 components identified as ASME Section XI Examination Category B-F, Pressure Retaining Dissimilar Welds in Vessel Nozzles

Item Number B5.10, and B5.70, Nozzle to Safe End Butt Welds, for vessels whose nominal pipe size is greater than 4 inches in diameter. Salem Unit 2 has eight (8) nozzle to safe-end connections of the steam generator and eight (8) reactor pressure vessel hot and cold legs possessing weld-buttering material of metal Alloy 82/182. Salem Unit 1 has eight (8) reactor pressure vessel nozzle to safe-end connections that possess weld-buttering material of metal Alloy 82/182. The replaced Salem Unit 1 steam generators' nozzle to safe-end welds do not possess weld buttering material of Alloy 82/182.

In addition to the ASME required examinations, PSEG performs Bare Metal Visual (BMV) head examinations of the reactor pressure vessel (RPV) closure head penetrations containing Alloy 600/82/182 welds to detect the evidence of boric acid corrosion and wastage of the closure head's carbon steel base material. The exams are conducted in accordance with procedure SC.RA-IS.RC-0001 (Q), *Vessel Head Penetration Examination.*

Exam Frequency

ASME XI NDE exams are scheduled and conducted in accordance with the requirements of ASME XI IWB-2412 and Table IWB-2412-1, and IWC-2412 and Table IWC-2412-1, for class 1 and 2 components. This requires inspection of 16-34% of the selected examinations by the end of the 1st period, 50-67% by the end of the 2nd period and 100% by the end of the ten-year interval (3rd period) as defined by 10CFR50.55a.

The VT-2 leakage exams are conducted in accordance with ASME Section XI Examination Category B-P, All Pressure Retaining Components, and are required to be completed at the conclusion of each refueling outage during plant start up (approximately every 18 months). Class 2 and 3 system pressure tests are conducted in accordance with C-H and D-B, All Pressure Retaining Components, and are required to be completed prior to the conclusion of each period (approximately every 36 months). In addition, system pressure tests required by NUREG-0578 are completed approximately every 18 months for those systems and components located within the Auxiliary building, including the Mechanical Penetration areas.

The BMV head exams are conducted during each refueling outage in accordance with the Salem Units 1 and 2 ISI Program Long Term Plans and commitments made in response to NRC Bulletin 2002-01 and 2002-02.

Degree of Insulation Removal

Reflective mirror type insulation that is located on pressure boundary piping and reactor pressure vessel closure head components is removed to grant access to perform the non-visual NDE examinations. This insulation is not typically removed to support VT-2 leakage exams unless evidence of leakage is noted during the conduct of the examination or in the following cases:

- Visual examination (VT-1) of class 1 valve bolting connections are inspected to detect evidence of wastage of the mechanical connections that may have resulted from boric acid coming in contact with the bolting material. These exams are conducted during each refueling outage prior to start-up in accordance Salem's ISI Program Long Term Plans and NRC approved relief requests SC-RR-A1 (TAC Nos. MB5569 and MB5570) and SC-RR-A6 (TAC Nos. MB6091 and MB6092).

- Bare Metal Visual (BMV) head examinations of the reactor pressure vessel (RPV) closure head penetrations containing Alloy 600/82/182 welds to detect the evidence of boric acid corrosion and wastage of the closure head's carbon steel base material are completed each refueling outage.

Inspection Techniques

The exam techniques include surface (liquid penetrant testing), volumetric (ultrasonic testing) and visual testing for leakage during the conduct of system pressure tests or bare metal visual exams. NDE exams are conducted in accordance with NDE Level III reviewed and approved procedures that have been prepared in a manner consistent with ASME Section XI IWA-2200, Examination Methods, Section V applicable articles requirements, industry practices, and the criteria described within 10CFR.50.55a related to Appendix VIII for ultrasonic examinations.

Since 2000, PSEG has elected to complete an augmented visual examination of each dissimilar metal reactor coolant system vessel nozzle to safe-end and safe-end to pipe weld. These exams are conducted in conjunction with the scheduled RPV in-vessel ultrasonic examinations conducted at the conclusion of the ten-year interval.

Personnel Qualification

Personnel performing NDE are qualified and certified in accordance with administrative procedure SH.ER-AS.ZZ-0001 (Q), *Qualification and Certification Program for Nondestructive Examination (NDE) Personnel*, which is written to meet the requirements of ASNT-CP-189, 1991 edition, SNT-TC-1A, 1984 edition, and ASME Section XI Appendix VIII, as modified by 10CFR50.55a final rulemaking. Qualification and certification of NDE personnel includes written examinations for general principles and specific procedure knowledge, and practical demonstration of their capabilities to detect discontinuities.

Additional Information

PSEG has submitted a plan to implement a risk informed ISI program starting with 2R13 in the fall 2003 and 1R16 in the spring 2004. A sampling of these same dissimilar metal 82/182 welds has been included within the scope of this effort to address potential concerns for primary water stress corrosion cracking (PWSCC).

PSEG continues to evaluate and verify its component weld design configurations and material composition in order to determine the need for additional augmented NDE exams. The RPV bottom head is discussed in response to question 5.

2. **Provide the technical basis for determining whether or not insulation is removed to examine all locations where conditions exist that could cause high concentrations of boric acid on pressure boundary surfaces or locations that are susceptible to primary water stress corrosion cracking (Alloy 600 base metal and dissimilar metal Alloy 82/182 welds). Identify the type of insulation for each component examined, as well as any limitations to removal of insulation. Also include in your response actions involving removal of insulation required by your procedures to identify the source of leakage when relevant conditions (e.g., rust stains, boric acid stains, or boric acid deposits) are found.**

The Salem design utilizes both reflective mirror and blanket types of insulation on reactor coolant pressure boundary components. PSEG's practice is to remove insulation from the exterior surface of pressure vessels and piping to grant sufficient access to complete nondestructive examinations (liquid penetrant testing, magnetic particle testing, radiography, and ultrasonic testing). Each refueling outage the insulation is removed from ASME XI Class 1 valves and piping flanges as identified within the Salem Unit 1 and 2 ISI Program Long Term Plans possessing mechanical connections (bolting) to perform a visual inspection of the connection. These inspections assure the integrity of the bolting installed is acceptable and that no unacceptable wastage due to boric acid leakage has occurred. These exams are conducted in accordance with an NRC approved relief request associated with system pressure testing of ASME XI Category B-P, and approved relief requests SC-RR-A1 (TAC Nos. MB5569 and MB5570) and SC-RR-A6 (TAC Nos. MB6091 and MB6092).

In addition, PSEG performs BMV examinations of the RPV closure head penetrations in accordance with procedure SC.RA-IS.RC-0001 (Q), *Vessel*

Head Penetration Examination, during each refueling outage. In order to support this examination, the insulation and the head's shroud is lifted and the reflective mirror insulation is removed to grant full access for the qualified examiners to conduct visual examinations of each head penetration.

The RPV lower head is covered by reflective mirror insulation. This insulation is not normally removed during the performance of VT-2 exams or operations walkdowns unless there are signs of leakage. These visual exams are conducted at close range using additional lighting. PSEG has not identified any signs of active or inactive leakage of the lower head penetrations. The lower head insulation does not lend itself to removal due the design configuration.

At each RPV lower head instrument penetration tube, a gap exists between the tube and insulation that is filled with stainless steel wool. This gap provides an adequate clearance to visually examine the penetration for evidence of leakage. If active leakage had been present, opaque, white or rust colored crystal stalactites would provide contrast against the existing background, and would likely be observed. These conditions have not been seen.

If any active leakage were present, either from the vessel penetrations themselves or from some other location, the ventilation in the bottom vessel area would not be able to mask this leakage and prevent it from being detected on the in-core penetrations below the insulation.

It is noted that there have been no known instances of primary water stress corrosion cracking (PWSCC) of the Inconel 600 bottom vessel penetrations or Inconel 82/182 welds in any PWR, foreign or domestic.

Procedure SH.RA-IS.ZZ-0005 (Q), *VT-2 Visual Examination of Nuclear Class 1, 2 and 3 Systems*, requires the insulation to be removed when borated water leakage is discovered to evaluate the condition of the base material and other adjacent areas. This procedure incorporates guidance from EPRI Technical Report 1000975, *Boric Acid Corrosion Guidebook, November 2001*. Acceptance criteria are contained in the visual inspection procedure. The presence of discoloration or residue on surfaces examined is given particular attention to detect evidence of boric acid accumulation from borated reactor coolant leakage. When VT-2 visual inspections are conducted, examiners are required to note all sources of identified leakage. This can include leakage from flanges, valve packing, and threaded pipe caps.

3. **Describe the technical basis for the extent and frequency of walkdowns and the method for evaluating the potential for leakage in inaccessible areas. In addition, describe the degree of inaccessibility, and identify any leakage detection systems that are**

being used to detect potential leakage from components in inaccessible areas.

During plant shutdowns various walkdowns are performed. PSEG Operations department personnel perform walkdowns of containment upon descension and ascension into Mode 3 in accordance with the requirements of S1.OP-PT.CAN-0001 (Q), and S2.OP-PT.CAN-0001 (Q), *Containment Walkdown.* ISI department personnel perform system pressure test visual examinations in accordance with ASME XI requirements and SH.RA-IS.ZZ-0005 (Q), *VT-2 Visual Examination of Nuclear Class 1, 2 and 3 Systems.* These examinations are typically conducted within containment every 18 months in support of scheduled refueling outages. If for some reason a forced shutdown were to occur, then S1.OP-PT.CAN-0001 (Q), or S2.OP-PT.CAN-0001 (Q), *Containment Walkdown*, would be required to be completed if a walkdown was not previously completed within the prior 30 days.

Walkdowns also occur during normal plant operations. Areas located inside of containment but outside of the containment's bioshield (annulus area) receive a weekly walkdown by operations department personnel. Walkdowns of the areas located inside of the containment's bioshield are typically inaccessible during normal station operations due to concerns for personnel radiation exposure and heat stress resulting from elevated temperatures. Therefore exams of these areas are limited to Mode 3.

Areas located outside of containment, such as the Auxiliary Building and the Mechanical Penetration Areas, normally receive daily walkdowns of accessible areas by operations department personnel and periodic walkdowns of systems by ISI personnel. Operators also regularly perform visual examinations for leaks outside containment and leakage tests in accordance with SC.SA-AP.ZZ-0051 (Q), *Leakage Monitoring Program.* This procedure requires operations to be cognizant of any leaks observed during rounds and to document any deficiencies using the Corrective Action Program.

ASME Section XI system pressure tests and nondestructive examinations are conducted in accordance with the requirements imposed by IWA-2430, IWB-2412, IWC-2412, and IWD-2412. Class 1 system pressure tests are conducted in accordance with Examination Category B-P, All Pressure Retaining Components, and are required to be completed at the conclusion of each refueling outage during plant start up (approximately every 18 months). Class 2 and 3 system pressure tests are conducted in accordance with C-H and D-B, All Pressure Retaining Components, and are required to be completed prior to the conclusion of each period (approximately every 36 months). In addition, system pressure tests required by NUREG-0578 are conducted approximately every 18 months for those systems and components located within the Auxiliary building including the Mechanical Penetration areas.

In addition to these walkdowns and surveillances, several systems are used to identify RCS leaks and aid in locating boric acid deposits. Both units employ the following leak detection systems

- The containment atmospheric particulate radioactivity monitor, R11A – monitored continuously.
- The containment atmospheric gaseous radioactivity monitor, R12A – monitored continuously.
- The containment sump level monitoring system – monitored at least once per 12 hours.
- The containment fan cooler condensate flow rate monitoring system – monitored continuously.
- The reactor coolant drain tank level monitoring system – monitored at least once per 24 hours.
- The reactor sump level monitoring system – monitored at least once per 24 hours.
- The RCS water inventory balance – monitored once every 24 hours.
- The reactor head flange leakoff system – monitored at least once per 24 hours.
- The safety injection accumulator levels – monitored once every 12 hours.

4. **Describe the evaluations that would be conducted upon discovery of leakage from mechanical joints (e.g., bolted connections) to demonstrate that continued operation with the observed leakage is acceptable. Also describe the acceptance criteria that were established to make such a determination. Provide the technical basis used to establish the acceptance criteria. In addition,**

   a. **if observed leakage is determined to be acceptable for continued operation, describe what inspection/monitoring actions are taken to trend/evaluate changes in leakage, or**

   b. **if observed leakage is not determined to be acceptable, describe what corrective actions are taken to address the leakage.**

Upon discovery of leakage, initial evaluation is conducted in accordance with the corrective action program to determine operability.

Presently, there is no programmatic guidance describing what the evaluation entails. PSEG is currently developing guidance to evaluate boric acid corrosion and leakage. This guidance will be in place by Salem refueling outage 2R13, October 2003.

When an evaluation is deemed necessary to continue operation with observed leakage from mechanical joints, the evaluation would be completed using engineering judgment, which may incorporate the guidance provided by the EPRI Boric Acid Corrosion Guidebook, Revision 1.

If leakage occurs at a bolted connection in a borated system, per code one of the bolts covered with boron is removed, visually examined (VT-3), and evaluated in accordance with ASME Section XI IWA-3100 and SH.RA-IS.ZZ-0003 (Q), VT-3 Visual Bolting Examination. If, through physical assessment of the component (visual, NDE, or measurement), it is determined that there is no apparent damage to the component, the component is considered acceptable. For any NDE technique, no indications shall exceed the limits of the Code in effect for the component/part.

If observed leakage is determined to be acceptable for continued operation, the component would be added to the list of leaks maintained by Operations that counts towards the Updated Final Safety Analysis Report (UFSAR) Emergency Core Cooling System (ECCS) leakage limit of 3800 cc/hour (UFSAR sections 6.3.2.11 and 15.4.1), if applicable.

PSEG personnel conduct periodic walk downs of station equipment to monitor changes in leakage. In addition, diversion of the leakage using drip bags, hoses, etc., is completed to prevent continued contact with susceptible materials and provide contamination control.

If observed leakage is determined not to be acceptable, minor component adjustments are made, if possible, to reduce the leakage rate to an acceptable amount and reduce the rate of material corrosion. Typical adjustments would include tightening valve packing and flange bolting. If this cannot be done or the leakage will exceed the UFSAR ECCS leak rate limits, the component is removed from service and repaired.

5. **Explain the capabilities of your program to detect the low levels of reactor coolant pressure boundary leakage that may result from through-wall cracking in the bottom reactor pressure vessel head incore instrumentation nozzles. Low levels of leakage may call into question reliance on visual detection techniques or installed leakage detection instrumentation, but has the potential for causing boric acid corrosion. The NRC has had a concern with the bottom reactor pressure vessel head incore instrumentation nozzles because of the high consequences associated with loss of integrity of the bottom head nozzles. Describe how your program would evaluate evidence of possible leakage in this instance. In addition, explain how your program addresses leakage that may impact components that are in the leak path.**

The bottom reactor pressure vessel head (insulation, penetrations and general area) is visually examined by Operations at the beginning and end of every outage (unless a walkdown was completed within the prior 30 days) and by ISI at the end of every refueling outage. If any active leakage were present, boric acid crystals would be seen on the penetrations themselves. The gap between the in-core penetrations and the bottom head insulation, as described in response to Question 2, provides an adequate clearance to visually examine for evidence of leakage. Also, the ventilation in the bottom vessel area would not be able to mask this leakage and prevent it from being detected on the in-core penetrations below the insulation.

If leakage were found it would be evaluated using the guidance being developed by PSEG based on available industry guidance. This guidance will include evaluating impacts to components in the leakage pathway.

6. **Explain the capabilities of your program to detect the low levels of reactor coolant pressure boundary leakage that may result from through-wall cracking in certain components and configurations for other small diameter nozzles. Low levels of leakage may call into question reliance on visual detection techniques or installed leakage detection instrumentation, but has the potential for causing boric acid corrosion. Describe how your program would evaluate evidence of possible leakage in this instance. In addition, explain how your program addresses leakage that may impact components that are in the leak path.**

   The methods with which low levels of reactor coolant pressure boundary leakage are detected in PSEG's boric acid corrosion program are detailed in the answer to question 3 above. This includes a combination of on-line monitoring and trending and regular walkdowns (on-line and outage) and ISI inspections. The evaluation methodology for discovered leakage, as described in the answer to Question 4 for mechanical joints, applies to all leaks including those resulting from through-wall cracking of components and small diameter nozzles.

7. **Explain how any aspects of your program (e.g., insulation removal, inaccessible areas, low levels of leakage, evaluation of relevant conditions) make use of susceptibility models or consequence models.**

   Inspections implemented for the reactor vessel closure heads of Salem Units 1 and 2 have been determined using the susceptibility ranking methodology developed by the EPRI Materials Reliability Program (MRP). PSEG does not make use of susceptibility or consequence models for any other aspects of the boric acid corrosion control program.

8. **Provide a summary of recommendations made by your reactor vendor on visual inspections of nozzles with Alloy 600/82/182 material, actions you have taken or plan to take regarding vendor recommendations, and the basis for any recommendations that are not followed.**

   The Salem Unit 1 and 2 reactor vendor, Westinghouse Electric Company, has not provided any recommendations on visual inspections of nozzles with Alloy 600/82/182.

9. **Provide the basis for concluding that the inspections and evaluations described in your responses to the above questions comply with your plant Technical Specifications and Title 10 of the *Code of Federal Regulations* (10CFR), Section 50.55(a), which incorporates Section XI of the American Society of Mechanical Engineers Code by reference. Specifically, address how your boric acid corrosion control program complies with ASME Section XI; paragraph IWA-5250 (b) on corrective actions. Include a description of the procedures used to implement the corrective actions.**

   PSEG tests, inspections, and evaluations described previously ensure compliance with station Technical Specifications and 10CFR50.55a that incorporates Section XI of the American Society of Mechanical Engineers (ASME) Code by reference. The tests, inspections, and evaluations conducted help to assure the timely identification and correction of borated water leakage.

   Salem's boric acid corrosion control program complies with ASME Section XI; paragraph IWA-5250 (b) for necessary corrective actions. SH.RA-IS-ZZ-0005 (Q) requires PSEG to locate the sources of observed leakage, repair/replace buried piping whose leakage losses exceed allowable requirements, remove bolting adjacent to the source of leakage to perform visual examination to detect any evidence of degradation, and repair/replace components that exceed wall loss reduction of greater than 10%.

Commitments Being Made In this Response

As part of the response to the request for additional information PSEG commits to the following:

1. PSEG is currently developing guidance to evaluate boric acid corrosion and leakage. This guidance will be in place by August 29, 2003 to support the October 2003 Salem 2R13 refueling outage.