UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

September 19, 2011

Mr. Thomas Joyce
President and Chief Nuclear Officer
PSEG Nuclear LLC
P.O. Box 236, N09
Hancocks Bridge, NJ 08038

SUBJECT: SAFETY EVALUATION OF RELIEF REQUESTS REGARDING PRESSURE TESTING OF SERVICE WATER SYSTEM BURIED PIPING - SALEM NUCLEAR GENERATING STATION, UNIT NOS. 1 AND 2 (TAC NOS. ME4861 AND ME4862)

Dear Mr. Joyce:

By letter dated October 12, 2010, as supplemented by letter dated July 21, 2011, PSEG Nuclear LLC (PSEG) submitted relief requests S1-I4R-102 and S2-I3R-104 for Salem Nuclear Generating Station (Salem), Unit Nos. 1 and 2, respectively. The proposed reliefs would allow PSEG to use an alternative examination of buried piping in the service water system in lieu of system pressure tests required by American Society of Mechanical Engineers (ASME) *Boiler and Pressure Vessel Code* (Code), Section XI, IWA-5244(b)(1).

The U.S. Nuclear Regulatory Commission staff has completed its review of the subject relief requests as documented in the enclosed Safety Evaluation (SE). Our SE concludes that the proposed alternative provides reasonable assurance of the structural integrity of the subject components. Furthermore, the NRC staff concludes that the licensee's compliance with the ASME Code requirements would result in hardship without a compensating increase in the level of quality and safety. Therefore, pursuant to 10 CFR 50.55a(a)(3)(ii), the proposed alternative is authorized for the remainder of the fourth 10-year inservice inspection (ISI) interval for Salem Unit No. 1, and for the remainder of the third 10-year ISI interval for Salem Unit No. 2.

All other requirements of the ASME Code, Section XI for which relief has not been specifically requested remain applicable, including a third party review by the Authorized Nuclear Inservice Inspector.

If you have any questions concerning this matter, please contact the Salem Project Manager, Mr. Richard Ennis, at (301) 415-1420.

Sincerely,

Harold K. Chernoff, Chief
Plant Licensing Branch I-2
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket Nos. 50-272 and 50-311

Enclosure: Safety Evaluation

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO RELIEF REQUESTS S1-I4R-102 and S2-I3R-104

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 October 12, 2010, as supplemented by letter dated July 21, 2011 (Agencywide Documents Access and Management System (ADAMS) Accession Nos. ML102920465 and ML112030205, respectively), PSEG Nuclear LLC (PSEG, the licensee) submitted relief request relief requests S1-I4R-102 and S2-I3R-104 for Salem Nuclear Generating Station (Salem), Unit Nos. 1 and 2, respectively. The proposed reliefs would allow PSEG to use an alternative examination of buried piping in the service water (SW) system in lieu of system pressure tests required by American Society of Mechanical Engineers (ASME) *Boiler and Pressure Vessel Code* (Code), Section XI, IWA-5244(b)(1).

Relief request S1-I4R-102 is for the fourth 10-year inservice inspection (ISI) interval at Salem Unit No. 1 which began on May 20, 2011, and is scheduled to end on May 20, 2021. Relief request S2-I3R-104 is for the third 10-year ISI interval at Salem Unit No. 2 which began on November 27, 2003, and is scheduled to end on November 27, 2013.

2.0 REGULATORY EVALUATION

The ISI of ASME Code Class 1, 2, and 3 components is to be performed in accordance with Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components," 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 relief has been granted by the Nuclear Regulatory Commission (NRC or the Commission) pursuant to 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, 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) must meet the requirements, except the design and access provisions and the preservice examination requirements, set forth in the ASME Code, Section XI, to the extent practical within the limitations of design, geometry, and materials of construction of the components. The regulation requires that inservice examination 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.

As stated above, the subject relief requests are for the fourth 10-year ISI interval at Salem Unit No. 1 and for the third 10-year ISI interval at Salem Unit No. 2. The Code of Record for the Salem Unit No. 1 fourth 10-year ISI interval is the ASME Code, Section XI, 2004 Edition, no Addenda. The Code of Record for the Salem Unit No. 2 third 10-year ISI interval is the ASME Code, Section XI, 1998 Edition through 2000 Addenda.

3.0 LICENSEE'S PROPOSED ALTERNATIVES

3.1 System/Component(s) For Which Relief Is Requested

Description:	Buried portions of the 24" inside diameter 11 and 12 SW supply headers (Salem Unit No. 1) and the 21 and 22 SW supply headers (Salem Unit No. 2). The approximate lengths are: 11 SW Header Supply - 642 feet 12 SW Header Supply - 629 feet 21 SW Header Supply - 635 feet 22 SW Header Supply - 578 feet
Code Class:	3
Examination Category:	D-B in Table IWD-2500-1
Item Number:	D2.10 in Table IWD-2500-1

3.2 ASME Code Requirements

ASME Code, Section XI, IWD-2500 states that all pressure-retaining components shall be tested at the frequency and examined by the methods specified in Table IWD-2500-1. Table IWD-2500-1, Examination Category D-B, Item D2.10, requires that a system leakage test be conducted with a VT-2 visual examination once each inspection period per IWD-5221. IWD-5221 requires that the system be tested at the system pressure obtained while the system or portion of the system is in service performing its normal operating function or at the system pressure developed during a test conducted to verify system operability. When a VT-2 visual examination cannot be performed on buried components, IWA-5244(b)(1) allows the examination requirements to be satisfied by either a system pressure test that determines the rate of pressure loss for components that are isolable by means of valves or, alternatively, by a test that determines the change in flow between the ends of the buried components.

3.3 Licensee's Basis for Requesting Relief

The pressure drop test and the alternative change in flow test required by IWA-5244(b)(1) cannot be performed on the SW system in its present configuration. The valves installed in the SW system that would isolate the piping for pressure drop testing are butterfly valves and are not capable of the leak-tightness required to perform the test. Extensive modifications, including removing the system from operation and installing blind flanges to allow for system isolation for pressure testing, would be required. In order to perform the change in flow test, flow measuring devices would need to be installed. However, there are no locations available for installation of flow measuring devices near the buried portions of the SW system that would be capable of measuring flow with sensitivity adequate for comparing flow at the inlet and outlet of headers. Performance of either of these tests would require extensive system modifications and would constitute a hardship.

3.4 Licensee's Proposed Alternative

The licensee's letter dated October 12, 2010, stated that the proposed alternative for testing the buried portion of SW piping in lieu of performing the periodic test required by IWA-5244(b)(1) shall consist of:

(1) A visual examination of the ground surface areas (includes surfaces of asphalt or other pavement materials) above all SW piping buried in soil shall be performed during all current and subsequent inspection outages to detect evidence of through-wall leakage in the buried components. The system shall have been in operation at nominal operating conditions for at least 24 hours prior to performing the visual examinations, in lieu of performing the periodic test required by IWA-5244(b)(1). The ASME Section XI [C]ode only requires a pressure test once each period. Since the SW system is in-service for extended periods of time, any leakage would be readily identified by plant personnel performing routine inspections during rounds.

(2) Visual examination of the inside surface of all SW buried piping are performed to ensure that piping is unobstructed and any evidence of piping degradation is identified and is evaluated or repaired.

The licensee requests approval of this alternative pursuant to 10 CFR 50.55a(a)(3)(ii).

4.0 NRC STAFF EVALUATION

4.1 Hardship Evaluation

As discussed above in Section 3.2 of this Safety Evaluation (SE), when a VT-2 visual examination cannot be performed on buried components, IWA-5244(b)(1) allows the examination requirements to be satisfied by either a system pressure test that determines the rate of pressure loss for components that are isolable by means of valves or, alternatively, by a test that determines the change in flow between the ends of the buried components.

In order to perform a test that determines the rate of pressure loss, the segment under test must be isolated. The licensee states that the butterfly valves installed in the SW system are not capable of the leak-tightness required to perform a pressure drop test. As a result, the IWA-5244(b)(1) requirements to perform a pressure drop test cannot be met without extensive system modifications, including removing the system from operation and installing blind flanges. The NRC staff finds that the extensive system modifications required to meet the ASME Code pressure test requirements would present a hardship.

As an alternative to the pressure drop test, the ASME Code, IWA-5244(b)(1), allows measurement of the change in flow between the ends of the buried components using flow meters at each end of the buried segment. The licensee states that there are presently no locations available for installation of flow measuring devices in the SW system near the buried portions that would be capable of measuring flow with sensitivity adequate for comparing flow at inlet and outlet of headers. The NRC staff finds that the extensive system modifications required to install flow meters to meet the ASME Code flow test requirements would present a hardship.

4.2 Proposed Alternative and Precedent

As described in Section 3.4, the licensee has proposed an alternative to the system pressure test requirements for the piping segments listed in SE Section 3.1. In lieu of the ASME Code-required pressure drop or flow tests, the licensee proposes to perform visual examinations of the ground surface areas above all SW buried piping with the system having been in operation for at least 24 hours prior to performing the visual examination. This examination is to be performed during all current and subsequent inspection outages to detect evidence of through-wall leakage. The licensee states that since the SW system is in-service for extended periods of time, any leakage would be readily apparent to plant personnel performing routine inspections during rounds.

In addition to the visual examination of the ground surfaces, the licensee proposes to perform a remote visual inspection of the inside surface of the subject SW buried piping every 36 months (i.e., one of the two headers for each unit is inspected each refueling outage) to ensure that the piping is unobstructed and to identify any evidence of piping degradation. In its letter dated July 21, 2011, the licensee stated that the visual inspection consists of accurately documenting visible deterioration along the pipe inside surface, with the location of as-found anomalies marked, photographed or videoed for future surveys and tracking. The buried pipe internal visual inspections are focused on locating cracking of the inner concrete core. WEKO-Seals, which have been installed in the bell and spigot joints of all 4 SW supply nuclear headers, are inspected for nicks, tears, or any other damage indicative of deterioration.

The NRC staff notes that similar proposed alternatives have been authorized by the NRC staff, as noted in the licensee's relief request submission. However, the previously-authorized alternatives have dealt with cast iron or carbon steel piping, and the subject piping is pre-stressed concrete cylinder pipe (PCCP). The construction and properties, most significantly failure mode, of PCCP are significantly different than that of other piping materials. Corrosion in carbon steel SW pipe is frequently the result of pitting where the pits are usually small in lateral dimension. As a result, the pipe will leak significantly before the structural integrity of the pipe is challenged. Such leakage can be readily detected by frequent walk downs. The walk downs have been credited by the NRC staff for inspection of Class 3 pipe where performance of pressure or flow tests would present a hardship. Wall thinning of carbon steel pipe by generalized corrosion is a slow process that can be monitored by wall thickness measurements, allowing the structural integrity of the pipe to be ensured. In comparison, a dominant PCCP failure mode is corrosion of the pre-stressing wires outside of the metal cylinder, resulting in their failure and catastrophic pipe rupture without significant prior leakage (Reference 3). As a result, the precedents cited by the licensee do not directly support the proposed alternative for the subject PCCP.

4.3 Description of SW Piping

In its letter dated July 21, 2011, the licensee stated that the subject SW piping primarily consists of lined cylinder pre-stressed concrete cylinder pipe (LC-PCCP) that was fabricated to American Water Works Association (AWWA) standard C-301-64, and also includes non-PCCP end pieces and fittings called "specials." LC-PCCP consists of a thin steel cylinder lined with centrifugally cast concrete. The concrete core is pre-stressed by steel wire helically wrapped around the steel cylinder, and a cement mortar coating is applied around the pipe to protect the wire against corrosion. In standard commercial PCCP, the internal pressure load is carried by the pre-stressing wires and the steel cylinder only forms a barrier against leakage. The 16-foot sections (sticks) of PCCP with bell and spigot ends are connected with bell-bolt joints and external harness assemblies. The external harness assemblies are located at 3 o'clock and 9 o'clock along the length of the pipe sections to help resist axial loads. The "specials" are non-pre-stressed 1/2"-thick steel pipe with a nonstructural interior and exterior mortar coating for corrosion protection.

If several pre-stressing wires within a small area of the PCCP corrode and fail, the local load carrying capacity is compromised and sudden catastrophic rupture can occur with little prior leakage. Although the pre-stressing wires are protected from corrosion by the cement mortar coating on the outside of the pipe, in cases where soil corrosivity is high, corrosion of the pre-stressing wires can occur.

4.4 Evaluation of Salem PCCP

In its letter dated July 21, 2011, the licensee stated that the soil corrosivity has been evaluated using AWWA C-105 Soil Test Evaluation of the pH, sulfide, and moisture content readings. The licensee stated that the results of this evaluation show that the soil has a very low corrosivity. The NRC staff has evaluated the soil corrosivity using the values of pH, sulfide and moisture content supplied by the licensee and concludes that the soil has a very low corrosivity.

The licensee stated that the buried PCCP at Salem Unit Nos. 1 and 2 has no known history of failure or degradation due to pre-stressing wire breaks or cylinder degradation since it was installed in the 1972-1973 time span. In addition, there has been no degradation of external concrete coating discovered during excavations to date and only superficial degradation of internal concrete lining has been identified during Generic Letter 89-13 inspections. The licensee's examination of the external surfaces of the carbon steel pipe wall penetration spool showed that the piping was in very good condition, and ultrasonic testing showed a minimum thickness reading of 0.531" or 106% of the nominal 0.500" wall, supporting the low soil corrosivity evaluation. Based on the results of the licensee's examinations and the soil low corrosivity discussed above, the NRC staff concludes there is reasonable assurance of the structural integrity of the pre-stressing wires.

The licensee stated that the subject PCCP sticks are fabricated with an upgraded 10 gauge (0.1345 inches) steel cylinder, as compared to a standard commercial grade 16 gauge (0.0598 inches) steel cylinder. The 10-gauge steel cylinder alone nearly meets the ASME B31.1 design minimum wall requirement for operating pressure of the SW piping without considering the load carrying capacity of the pre-stressing wires. The licensee stated that there is a factor of safety of 2.24 against burst pressure for the 200 psi design pressure and a factor of safety of 2.99 for the 150 psi operating pressure for the steel cylinder alone. The NRC staff finds that although the SW piping at Salem Unit Nos. 1 and 2 is classified as PCCP, the properties and failure mode should more closely resemble those of traditional carbon steel pipe.

The NRC staff notes that rupture of the subject SW pipe would require significant generalized corrosion of the steel cylinder, and the voluminous products from such corrosion would likely be readily apparent during visual examination of the concrete liner. Furthermore, the staff expects that there would be extensive water leakage prior to rupture and that leakage should be readily detected during normal walk downs. A previous NRC staff SE of the PCCP at Salem Unit No. 1 (Reference 4) also concluded: "[e]xtensive experience with this type of piping has shown that corrosion of the reinforcing tendons and 10 gauge steel liner would result in noticeable water leakage prior to rupture. Consequently, it is very unlikely that a piping failure would result in a total loss of service water before the licensee could initiate a controlled shutdown of the plant."

The NRC staff concludes that the combination of low soil corrosivity, high load carrying capacity of the 10 gauge steel cylinder, a service history without failure or significant degradation, visual internal inspection on alternating trains each refueling outage, and periodic walk downs of the surface above the pipe provide reasonable assurance of structural integrity of the SW PCCP, and that performance of the ASME Code-required leak down or flow tests would require extensive modification of the SW system, resulting in hardship without a compensating increase in the level of quality and safety.

5.0 CONCLUSION

Based on the considerations discussed in SE Section 4.0, the NRC staff concludes that the proposed alternative provides reasonable assurance of the structural integrity of the subject components. Furthermore, the NRC staff concludes that the licensee's compliance with the ASME Code requirements would result in hardship without a compensating increase in the level of quality and safety. Therefore, pursuant to 10 CFR 50.55a(a)(3)(ii), the proposed alternative is authorized for the remainder of the fourth 10-year ISI interval for Salem Unit No. 1, and for the remainder of the third 10-year ISI interval for Salem Unit No. 2.

All other requirements of the ASME Code, Section XI for which relief has not been specifically requested remain applicable, including a third party review by the Authorized Nuclear Inservice Inspector.

6.0 REFERENCES

1. PSEG letter (LR-N10-0361) dated October 12, 2010, "Request for Relief from ASME Code Pressure Test for Service Water Supply Buried Piping" (ADAMS Package Accession No. ML102920465).

2. PSEG letter (LR-N11-0163) dated July 21, 2011, "Response to Draft NRC Request for Additional Information Regarding Relief Request Nos. S1-14R-102 and S2-13R-104 for ASME Code Pressure Test for Service Water Supply Buried Piping" (ADAMS Accession No. ML112030205).

3. AWWA Research Foundation report dated 2008, "Failure of Prestressed Concrete Cylinder Pipe," prepared by A. Romer, D. Ellison, G. Bell, B. Clark.

4. NRC letter dated December 27, 2001, "Salem Nuclear Generating Station, Unit No. 1, Issuance of Amendment Re: Emergency Request For Change To Technical Specification (TS) 3/4.7.4, Service Water System (TAC No. MB3528)" (ADAMS Accession Number ML013540096).

Principal Contributor: J. Wallace

Date: September 19, 2011

If you have any questions concerning this matter, please contact the Salem Project Manager, Mr. Richard Ennis, at (301) 415-1420.

Sincerely,
/RA/
Harold K. Chernoff, Chief
Plant Licensing Branch I-2
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-272

Enclosure: Safety Evaluation

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