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

April 8, 2014

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

SUBJECT: SALEM NUCLEAR GENERATING STATION, UNITS 1 AND 2 - SAFETY EVALUATION OF RELIEF REQUEST NO. SC-I4R-133 FOR THE ALTERNATIVE REPAIR FOR SERVICE WATER SYSTEM PIPING (TAC NOS. MF1375 AND MF1376)

Dear Mr. Joyce:

By letter dated April 3, 2013,[1] as supplemented by letters dated August 15, 2013, January 8, 2014, February 27, 2014, and March 26, 2014,[2] Public Service Enterprise Group Nuclear LLC (PSEG) submitted relief request SC-I4R-133, to propose an alternative to the requirements of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (ASME Code), Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components," for the repair of buried portions of the service water system piping at Salem Nuclear Generating Station, Units 1 and 2 (Salem 1 and 2). Specifically, pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) 50.55a(a)(3)(ii), the licensee requested to use the proposed alternative in relief request SC-I4R-133 to repair bell and spigot joints in the buried portions of service water system piping in lieu of the defect removal requirements in the ASME Code, Section XI, Subparagraph IWA-4422.1.

The Nuclear Regulatory Commission (NRC) staff has completed its review of this relief request and determined that the proposed alternative, as conditioned within the safety evaluation, provides reasonable assurance of structural integrity and leak tightness of the buried portion of the 11, 12, 21, and 22 nuclear service water supply and discharge headers at Salem 1 and 2. The NRC staff finds that complying with the specified ASME Code requirements would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety. Therefore, the NRC staff authorizes the proposed alternative for the remainder of the fourth 10-year inservice inspection (ISI) intervals at Salem 1 and 2, which are scheduled to end on May 20, 2021, and November 27, 2023, respectively. The details of the NRC staff's review are included in the enclosed safety evaluation.

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

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[1] Agencywide Documents and Access Management System (ADAMS) Accession No. ML13093A382.
[2] ADAMS Accession Nos. ML13227A338, ML14016A123, ML14058A228, and ML14085A482, respectively.

If you have any questions concerning this matter, please contact the Salem Project Manager, Mr. John Lamb, at (301) 415-3100 or via e-mail at John.Lamb@nrc.gov.

Sincerely,

Meena Khanna, 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

cc w/encl: Distribution via Listserv

UNITED STATES
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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO RELIEF REQUEST NO. SC-I4R-133

ALTERNATE REPAIR FOR BURIED SERVICE WATER PIPING

PSEG NUCLEAR LLC

SALEM NUCLEAR GENERATING STATION, UNITS 1 AND 2

DOCKET NOS. 50-272 AND 50-311

1.0 INTRODUCTION

By letter dated April 3, 2013,[1] as supplemented by letters dated August 15, 2013, January 8, 2014, February 27, 2014, and March 26, 2014,[2] Public Service Enterprise Group Nuclear LLC (PSEG) submitted relief request SC-I4R-133, to propose an alternative to the requirements of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (ASME Code), Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components," for the repair of buried portions of the service water system piping at Salem Nuclear Generating Station, Units 1 and 2 (Salem 1 and 2). Specifically, pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) 50.55a(a)(3)(ii), the licensee requested to use the proposed alternative in relief request SC-I4R-133 to repair bell and spigot joints in the buried portions of service water system piping in lieu of the defect removal requirements in the ASME Code, Section XI, Subparagraph IWA-4422.1.

2.0 REGULATORY REQUIREMENTS

By the letter dated April 3, 2013, the licensee submitted the relief request pursuant to 10 CFR 50.55a(a)(3)(i). By the letter dated January 8, 2014, in response to the U.S. Nuclear Regulatory Commission (NRC) staff's request for additional information, the licensee requested the NRC staff consider the relief request pursuant to 10 CFR 50.55a(a)(3)(ii) and provided the hardship justification of repairing the service water piping in accordance with the ASME Code, Section XI.

Pursuant to 10 CFR 50.55a(g)(4), "Inservice Inspection Requirements," 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, to the extent practical within the limitations of design, geometry, and materials of construction of the components.

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[1] Agencywide Documents Access and Management System (ADAMS) Accession No. ML13093A382
[2] ADAMS Accession Nos. ML13227A338, ML14016A123, ML14058A228, and ML14085A482, respectively.

Enclosure

The regulations in 10 CFR 50.55a(a)(3) state, in part, that alternatives to the requirements of paragraph (g) of 10 CFR 50.55a may be authorized by the NRC, if the licensee demonstrates (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.

Based on the above analysis, and subject to the following technical evaluation, the NRC staff finds that regulatory authority exists to authorize an alternative to Subparagraph IWA-4422.1 of Section XI of the ASME Code, as requested by the licensee.

3.0 TECHNICAL EVALUATION

3.1 ASME Code Component Affected

The affected components are buried portions of the 11, 12, 21, and 22 nuclear service water supply and discharge headers (piping) at Salem 1 and 2. These buried pipes are classified as ASME Code Class 3, examination category D-B, item number D2.10. These items consist of 24-inch inside diameter (ID), 27-inch outside diameter pre-stressed concrete cylinder pipe (PCCP).

The PCCP consists of a spun concrete core inside a 10-gage carbon steel cylinder. Pre-stressing wire is wrapped around the cylinder and tensioned, placing the steel cylinder and core into compression. Mortar is applied to the outside of the pipe to protect the wire and carbon steel cylinder from damage and corrosion. In locations where the use of pre-stress wire is not feasible (e.g., elbows, tees, and flange adapters), the 10-gage cylinder and pre-stress wire is replaced with a thicker steel cylinder.

The PCCP segments are connected to each other with bell and spigot joints. These joints provide flexibility (extensibility and articulation) to accommodate pipe movement during operation and design basis scenarios. Axial piping loads are, in practice, carried by a series of harness bolts which span the bell and spigot joints between piping segments. Harness bolts range from a few feet in length up to 48 feet in length, depending on the pipe configuration. Long harness bolts may consist of up to three sections of 2 inch diameter threaded rod joined together by couplings. For regulatory purposes, however, bell bolts are credited with the safety function of carrying the axial piping loads due to normal operating and seismic conditions. As described below, under certain conditions addressed by this relief request, the safety function of carrying axial piping loads will shift from the bell bolts to the harness bolts.

3.2 Applicable Code Edition and Addenda

The Code of record for the fourth 10-year ISI interval at Salem Unit 1 is the ASME Code, Section XI, 2004 Edition. The fourth 10-year ISI interval for Salem Unit 1 began on May 20, 2011, and ends on May 20, 2021.

Salem Unit 2 began its fourth 10-year ISI interval on November 27, 2013, and ends on November 27, 2023. The Code of record for the fourth 10-year interval ISI program at Unit 2 is also the 2004 Edition of Section XI.[3]

American Water Works Association (AWWA) C301-64 is the original construction code for the buried PCCP at both plants.

3.3 Applicable Code Requirement

ASME Code, Section XI, Subparagraph IWA-4000 requires degraded Class 3 piping to be either repaired or replaced. Specifically IWA-4422.1 requires that the piping defect be removed as part of the repair process.

3.4 Duration Of The Proposed Alternative

The licensee requested authorization of the alternative repair for the remainder of plant life for Salem 1 and 2. However, the NRC will only consider the proposed relief request for the remainder of the fourth 10-year ISI interval at both units. Once the alternative is installed during the fourth 10-year ISI interval, the installed alternative may remain in place for the life of the plant. Should the licensee desire to install the alternative during a subsequent 10-year ISI interval, the licensee must seek authorization from the NRC staff for that interval.

3.5 Proposed Alternative

In its request, the licensee proposed a repair method which is not in accordance with ASME Code Section XI, Subparagraph IWA-4422.1, in that the proposed repair method does not remove the existing defect from the pipe as part of the repair process. The proposed relief request uses a WEKO seal with a stainless steel backing plate to restore pressure boundary integrity of degraded bell and spigot joints for the subject piping. This request does not apply to other joints such as flanged joints. The licensee's proposed repair method includes the following steps or processes (unless otherwise stated, all actions occur from the ID of the pipe):

a. Identify degraded piping joints by visual inspection

b. Clean the joint and quantify degradation by inspection of that portion of the bell housing which is accessible from the ID of the pipe using nondestructive examination techniques.

c. Categorize the repair based on the thickness of the bell housing:

    i. Bell housing thickness greater than the minimum wall thickness of 0.1 inches. All code requirements met. Use of this relief request is not required.

    ii. Bell housing thickness greater than 0.042 inches but less than 0.1 inches. ASME Code requirements for axial loads are met. ASME Code requirements for circumferential loads are not met. Repair the joint using the WEKO seal.

[3] ADAMS Accession No. ML13088A219.

iii. Bell housing thickness less than 0.042 inches. ASME Code requirements for axial and circumferential loads are not met. Repair the joint using the WEKO seal.

d. For Category c.ii and c.iii repairs (WEKO seal installation):

- Apply sealant in degraded joint.
- Apply coating to the sealant.
- Install stainless steel backing plate.
- Install rubber seal material.
- Install 4 AL6XN retaining rings.

e. For Category c.iii repairs only (in addition to the seal installation):

- Excavate outside of pipe.
- Visually inspect outside of degraded pipe joint.
- Visually inspect harness bolts.
- If the entire harness bolt has not been exposed for visual inspection, to the maximum extent possible, nondestructively examine those portions of the harness bolts which have not been visually inspected.
- If indicated by the inspection results, excavate entire harness bolt and visually inspect.

f. Pressure test the repaired pipe

g. Inservice Inspections of the installed WEKO seal:

- Inspect the installed seal every 36 months
- If technically justified, inspection frequency may be extended.
- Monitor service water system per NRC Generic Letter (GL) 89-13, "Service Water Problems Affecting Safety Related Equipment."[4]

3.6 Licensee's Technical Basis

In its relief request and response to the NRC staff's requests for additional information, the licensee provided a significant amount of information in support of its proposed alternative. For the purposes of this SE, the licensee's information will be categorized based on issues which the NRC finds to be critical to the authorization of the proposed alternative. These categories are:

a. Structural integrity, hoop loads
b. Structural integrity, axial loads
c. Leak tight integrity of the pipe
d. Long term reliability of the joint

[4] ADAMS Accession No. ML081090381.

a. Structural integrity, hoop loads

In support of its contention that the proposed alternative is acceptable, the licensee provided stress calculations based on the construction code and ASME Code, Sections III and XI. The stress calculations are related to hoop loading and have considered loads from normal operation, accident, and seismic conditions. The licensee contends that these calculations demonstrate that, for bell housing thicknesses greater than 0.1 inches, the piping is structurally sound relative to hoop loads. In instances in which the bell housing is less than 0.1 inches, the licensee contends that these calculations demonstrate that the joint would not support the hoop loads. The licensee also contends that, irrespective of the bell housing thickness, the proposed repair provides adequate strength to meet all hoop loads. In support of these calculations, the licensee proposed to verify the thickness of the bell housing by nondestructive examination at the time of installation.

b. Structural integrity, axial loads

In support of its contention that the proposed alternative is acceptable, the licensee provided stress calculations based on the construction code and ASME Code, Sections III and XI. The stress calculations are related to axial loading and have considered loads from normal operation, accident, and seismic conditions. In instances in which the bell housing exceeds 0.042 inches, the licensee contends that these calculations demonstrate that the bell bolts are structurally sufficient to carry the required axial loads. For instances in which the bell housing is less than 0.042 inches, the licensee contends that bell bolts will not adequately support axial loads. In instances where the bell housing is less than 0.042 inches, the licensee contends that these calculations demonstrate that the harness bolts are structurally sufficient to carry the required axial loads.

In support of relying on the bell bolts to carry axial loads, the licensee proposed to verify the thickness of the bell housing by nondestructive examination at the time of installation. In support of relying on the harness bolts to carry axial loads, the licensee proposed to verify the thickness of the harness bolts by visual examination and, as necessary by nondestructive examination. The licensee also provided information indicating that even if the harness bolts (which are coated) corroded at the rate of buried, uncoated steel at the site, the ability of the harness bolts to carry the required axial loads would not be challenged.

The licensee stated that a WEKO seal can be installed only if the axial load is carried by either the bell and spigot joint or the harness assembly. The licensee noted that if both the bell-and-spigot joint and the harness assembly are degraded to the point that they cannot carry the axial load, the axial load capability will need to be restored with a pipe replacement, repair of the bell and spigot joint, repair/replacement of the degraded components of the harness assembly, or another suitable approach.

c. Leak tight integrity of the pipe

In support of its contention that the proposed alternative is acceptable, the licensee indicated that the primary leak boundary of the proposed repair was a rubber seal which was compressed against the existing mortar lining of the PCCP by 4 expandable metallic rings. The licensee

proposed that the compression of the rubber seal by the four metallic rings would create a leak tight boundary between the rubber seal and the pipe material. In addition to the primary seal, the licensee indicated that the proposed repair also included additional sealing materials which would resist leakage, should any occur at the primary leak boundary. Additionally, the licensee indicated that the repaired joint would be pressure tested to demonstrate that it was leak tight.

d. Long term reliability of the joint

In support of the concept that the repaired joint would continue to be structurally sufficient and leak tight the licensee provided information indicating:

1. That the repaired joints will be inspected every 36 months in conjunction with inspections performed in accordance with the licensees NRC GL 89-13 program.

2. This repair method has already been used for 6 years in other service water piping systems (where structural integrity of the pipe was not impaired) and no failures of the repair have been observed.

3. The rubber sealing material used in the repair has a design life (per the manufacturer) of at least 50 years.

4. The stainless steel backing plate, which is the primary component providing structural integrity relative to hoop stresses, is not subject to corrosion or cracking due to either leakage of service water out of the pipe or intrusion of ground water into the pipe.

5. For joints that are excavated, the external joint gap will be resealed as needed to prevent intrusion of groundwater and potential degradation of the joint from the soil side.

6. The corrosivity of ground water to buried steel in the soil is low.

7. Detachment of the rubber from the pipe is not expected due to the characteristics of the rubber, as well as the presence of the retaining bands.

8. Detachment of the rubber, should it occur, is not expected to cause a loss of safety function of the relevant piping systems because such an event would be detected in downstream equipment in sufficient time to permit the issue to be mitigated.

3.7 NRC Staff Evaluation

As stated above, the NRC staff finds that issues ‘a’ through ‘d’ above are critical to the authorization of the proposed alternative. The NRC staff reviewed the information provided by the licensee with reference to whether each of these issues had been sufficiently addressed.

a. Structural integrity, hoop loads

The NRC staff reviewed the structural hoop stress calculations provided by the licensee and confirmed that the calculations were conducted in accordance with accepted methods. The NRC staff reviewed the results of those calculations and reached a conclusion identical to that of the licensee (i.e., that ASME Code requirements for hoop stresses are met when the bell housing thickness exceeds 0.1 inch, are not met for bell housing thicknesses of less than 0.1 inches, and are met when the repair is in place irrespective of the thickness of the bell housing). The NRC staff further finds that measurement of the thickness of the bell housing at the location and manner proposed will provide an acceptable representation of the thickness of the housing for use in the calculations. The NRC staff, therefore, finds that the proposed alternative will provide reasonable assurance of the structural integrity of the repaired pipe relative to hoop loads.

b. Structural integrity, axial loads

The NRC staff reviewed the axial stress calculations provided by the licensee and confirmed that the calculations were conducted in accordance with accepted methods. The NRC staff reviewed the results of those calculations and reached a conclusion identical to that of the licensee (i.e., in instances in which the bell housing exceeds 0.042 inches the bell bolts are structurally sufficient to carry the required axial loads and in instances where the bell housing is less than 0.042 inches the harness bolts are structurally sufficient to carry the required axial loads).

The NRC staff also reviewed the process by which the licensee proposes to ensure that the harness bolts have not corroded beyond the maximum allowable amount to allow the bolts to carry the required axial loads. The NRC staff notes that, when new, the harness bolts were coated with a corrosion resistant coating and were 2 inches in diameter. In order to carry the required axial loads, the harness bolts should be slightly more than 1 inch in diameter. If the coating was removed from a harness bolt, then corrosion may occur. However, based on the corrosion observed on uncoated, buried steel pipe at the site, the minimum expected diameter for a harness bolt from which the coating was removed at time of installation would be approximately 1.5 inches. Inspections of harness bolts conducted to date by the licensee have generally indicated no degradation of the coating and the bolts have been near nominal thickness.

In addition to the above analysis, the NRC staff notes that for each instance where the bell housing is less than 0.042 inches, the licensee proposes to excavate and visually examine all harness bolts uncovered by the excavation and, as necessary, nondestructively inspect, to the maximum extent possible, harness bolts which remain buried. The licensee stated that, depending on the results of the inspections, additional excavation would be conducted.

At this time, a demonstrated nondestructive inspection technique for conducting the proposed nondestructive inspection of the harness bolts does not exist. As such, the NRC views the proposed nondestructive inspection as supporting information to confirm the corrosion analysis described above. In the absence of detailed corrosion rate information, the nondestructive examination would not necessarily provide reasonable assurance of the structural integrity of the harness bolt.

The above analysis is based on the potential for corrosion of the harness bolts by ground water, not the raw water contained within the pipe. Buried steel components, such as a harness bolt with a damaged coating, are expected to corrode somewhat more rapidly than when exposed to the ground water at the plant site. As a result, in the event that this proposed alternative is used in response to a through-wall leak and it is necessary to rely on the harness bolt to carry axial loads, the above corrosion rate analysis is not valid.

Therefore, as a condition to the proposed alternative, under the scenario described above (i.e., through-wall leak in which harness bolts are relied upon for carrying axial loads), it will be necessary for the licensee to visually inspect as much of the harness bolts as may have been affected by the raw water leaking from the pipe. The licensee acknowledged this condition in its supplemental letter dated March 26, 2014.

Based on the above analysis, including the specified condition, the NRC staff finds that the proposed alternative will provide reasonable assurance of the structural integrity of the repaired pipe relative to axial loads.

c. Leak tight integrity of the pipe

The NRC staff reviewed the information submitted by the licensee in support of its contention that the proposed alternative would make the repaired joint leak tight. In that assessment, the NRC staff found the licensee's assertions that the rubber seal was constructed from a durable material and that the compression of the rubber into the pipe wall by the metallic rings would form a leak tight seal to be reasonable. Additionally, the NRC staff found the licensee's assertion regarding improved leak tightness of the repair afforded by joint cleaning and preparation as well as additional sealing materials to be reasonable. The NRC staff also found that the successful completion of a pressure test at the time of installation would confirm the initial leak tightness of the proposed alternative. Based on the above analysis, the NRC staff finds that the proposed alternative will provide reasonable assurance of the leak tightness of the repaired pipe.

d. Long term reliability of the joint

The NRC staff reviewed each of the items addressed in Section 3.6 above. The NRC staff found no reason to object to the factual nature of each of these statements. In combination, the NRC staff finds these items to be sufficient to provide reasonable assurance of the continued structural integrity of pipe joints repaired in accordance with the proposed alternative.

With regard to hardship of performing an ASME Code repair in lieu of the WEKO seal, the licensee stated that much of the service water piping is buried and would require extensive excavation to replace the bell and spigot joint in accordance with the ASME Code. Sections of the service water piping are located under the Independent Spent Fuel Storage Installation turning pads and the service water accumulator tank buildings, which would potentially have to be excavated. Additionally, the redundant service water headers for both Salem units are located in close proximity to each other, which could result in uncovering the operating header to make a repair on the header that is out of service. The licensee noted that completing the repair using the proposed alternative in lieu of the ASME Code repair would reduce the inoperability time of the impacted service water header. The excavation and joint replacement would require an emergent design change package, extensive vendor support, and would present industrial safety concerns due to the potentially large excavation. Based on the above, the NRC staff finds that to repair/replace the degraded bell and spigot joint in accordance with the ASME Code, Section XI, would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

In summary, the NRC staff concludes that the WEKO seal will isolate the degraded bell and spigot joint from service water and support the hoop stresses to maintain the structural integrity and leak tightness of the repaired bell and spigot joint.

4.0 CONCLUSION

As set forth above, the NRC staff finds that the proposed alternative, subject to the condition specified above, provides reasonable assurance of structural integrity and leak tightness of the buried portion of the 11, 12, 21, and 22 nuclear service water supply and discharge headers at Salem 1 and 2. The NRC staff finds that complying with the specified ASME Code requirements would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety. Accordingly, the NRC staff concludes that the licensee has adequately addressed all of the regulatory requirements set forth in 10 CFR 50.55a(a)(3)(ii). Therefore, the NRC staff authorizes the proposed alternative for the remainder of the fourth 10-year ISI intervals at Salem 1 and 2, which are scheduled to end on May 20, 2021, and November 27, 2023, respectively. Once the alternative is installed during the fourth 10-year ISI interval, the installed alternative may remain in place for the life of the plant. Should the licensee desire to install the alternative during a subsequent 10-year ISI interval, the licensee must seek authorization from the NRC staff for that interval.

All other ASME Code, Section XI requirements for which relief was not specifically requested and approved in the subject request for relief remain applicable, including third party review by the Authorized Nuclear In-service Inspector.

Principal Contributors: David Alley
John Tsao

Date: April 8, 2014

If you have any questions concerning this matter, please contact the Salem Project Manager, Mr. John Lamb, at (301) 415-3100 or via e-mail at John.Lamb@nrc.gov.

Sincerely,

/ra/

Meena Khanna, Chief
Plant Licensing Branch I-2
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket Nos. 50-272 and 50-311

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