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PSEG Nuclear LLC

10 CFR 50.55a

April 7, 2022
LR-N21-0052

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555-0001

Salem Generating Station Units 1 and 2
Renewed Facility Operating License Nos. DPR-70 and DPR-75
NRC Docket Nos. 50-272 and 50-311

Subject: Request for Relief from ASME Code Defect Removal for Service Water Buried Piping

In accordance with 10 CFR 50.55a(z)(2), PSEG Nuclear LLC (PSEG) hereby requests NRC approval of a proposed alternative to the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components," on the basis that removal of the specified defect constitutes a hardship without a compensating increase in quality and safety. Specifically, the proposed relief will allow Salem to repair bell and spigot joints in the buried portions of Service Water System piping in lieu of defect removal requirements in ASME Section XI, IWA 4422.1.

The proposed relief request SC-I5R-221 for Salem Units 1 and 2 is provided in Attachment 1. PSEG requests approval of the proposed request for implementation in the 5th Ten Year Inservice Inspection (ISI) interval.

There are no regulatory commitments contained in this letter. Should you have any questions concerning this matter, please contact Brian Thomas at 856-339-2022.

Sincerely,

Jennings, Jason

Digitally signed by Jennings, Jason
Date: 2022.04.07 11:55:35 -04'00'

Jason Jennings
Director – Site Regulatory Compliance
PSEG Nuclear LLC

Attachment 1: 10 CFR 50.55a Request for Alternative SC-I5R-221

cc: Administrator, Region I, NRC
NRC Senior Resident Inspector, Salem
James Kim, Project Manager, NRC
Ann Pfaff, Manager, NJBNE
Corporate Commitment Tracking Coordinator
Site Commitment Tracking Coordinator

10 CFR 50.55a Request for Relief SC-I5R-221

10 CFR 50.55a Request No. SC-I5R-221
Request for Relief for Defect Removal for Service Water Buried Piping
Salem Units 1 and 2
Proposed Alternative in Accordance with 10 CFR 50.55a(z)(2)
Hardship or Unusual Difficulty without Compensating Increase in Level of Quality or Safety

1.0 ASME CODE COMPONENTS AFFECTED:

Code Class:	Class 3
Description:	Buried portions of the 11, 12, 21, 22 Nuclear Service Water (SW) Supply and Discharge Headers
Examination Categories:	D-B
Item Numbers:	D2.10

2.0 APPLICABLE CODE EDITION AND ADDENDA:

The fifth (5th) ISI Interval Code of record for Salem Units 1 and 2 is the 2013 Edition of the ASME Boiler and Pressure Vessel Code, Section XI, Division 1, "Rules for Inservice Inspection of Nuclear Power Plant Components."

3.0 APPLICABLE CODE REQUIREMENT:

ASME Section XI, IWA 4422.1, provides requirements for defect removal that must be satisfied as part of a repair implemented in accordance with IWA-4000. The proposed repair method for degraded bell and spigot joints in buried portions of concrete pipe does not satisfy this requirement. Instead, the proposed repair provides an alternate load path to ensure the structural adequacy of the degraded area, in addition to eliminating the degradation/growth mechanism.

4.0 REASON FOR REQUEST:

This request is to allow for the continued use of a mechanical repair, WEKO seal with structural backing plate (referred to as a structural WEKO seal through the remainder of this document), to restore the pressure boundary integrity of degraded bell and spigot joints in the SW supply and discharge headers.

PSEG's request for the use of structural WEKO seals was approved for the 4th 10-Year ISI interval on April 8, 2014, (Reference 9.11), including an inspection of the repaired joint every 36 months. The original relief request was submitted on April 3, 2013 (Reference 9.12) and supplemented by letters dated August 15, 2013 (Reference 9.13), January 8, 2014 (Reference 9.14), February 27, 2014 (Reference 9.15), and March 26, 2014 (Reference 9.16).

Under the preventative maintenance (PM) program, Salem routinely monitors and inspects SW and related Ultimate Heat Sink (UHS) components in accordance with the requirements of NRC Generic Letter (GL) 89-13 (Service Water Problems Affecting Safety Related Equipment). Previous inspections of the SW piping at

Salem Units 1 and 2 have identified bell band thinning due to corrosion in some bell and spigot joints.

All pre-stressed concrete cylinder pipe (PCCP) bell and spigot joints in the SW systems of both Salem Units 1 and 2 have been cleaned and recoated, and sealed by water-tight WEKO seals. The integrity of these seals is tested by applying air pressure to a valve contained in each seal and checking with snoop or other soap and water solution, indicating whether the seal has the capacity to leak water into the joint or not. Salem's history with the WEKO seals is that they have been robust and have not demonstrated degradation; however, in the event that a leaking WEKO seal is found, the WEKO seal is to be removed, the joint inspected, and a new regular or structural WEKO seal applied.

PSEG has long been aware of the deleterious nature of the Delaware River upon the carbon steel used for original construction in the piping and components of Salem's safety-related SW system. The steel bell extensions, which override the spigots of adjoining pipe sections in the joints of the intake and return PCCP straight and Special piping, were originally exposed to SW flow, and are the focus of this relief request. Typical pipe joints are shown in Figures 1 and 2.

AWWA C301-64, the original construction code for the buried PCCP in the Salem SW system, does not provide guidance for an appropriate repair for degraded bell and spigot joints other than digging up and replacing. The repair requested by PSEG, and previously authorized by the NRC, per above, has been designed and evaluated using applicable requirements from both the original construction code and the ASME Boiler and Pressure Vessel Code, Section III, in accordance with IWA-4221(c). The degraded pipe with repair installed satisfies applicable requirements of the original construction code, ASME Section III, and the Owner's Design Specification. However, installation of the repair has not and does not remove the defect as described in IWA-4422.1. Instead, the repair provides an alternate load path to ensure structural adequacy of the repaired pipe in addition to eliminating additional degradation or expansion of the degraded region to the fullest extent possible, by drying, coating, and sealing out water from the inside of the pipe. The sealant originally applied to the external portion of the joint, 'Ram Nek' coating, will remain and at such times as a joint is exposed externally, will be checked for continuity.

In 2002, an analysis was performed that determined bell plates which had degraded to a uniform (mean of circumferential measurements) thickness of 0.100 inches were fully capable of performing all design functions without use of the exterior harness bolts, and required no further repair; however, PSEG recognized that corrosive degradation had indeed been taking place in all of the joints, which would eventually lead to joint failure without intervention. To this end, the pipe joints of the SW intake and return piping have been dried, coated, and a protective WEKO seal installed. This comprises 223 seals on the SW supply pipe joints, installed from 2002 – 2010, and 212 seals on the SW discharge header pipe joints, installed from 2012 – 2018. Of this number, there are three structural WEKO seals (note one structural WEKO installed for design configuration consistency not as a result of bell degradation) in the supply header piping, and six structural WEKO seals in the discharge header piping.

In 2005, a refinement was calculated that determined that if the external harness bolts (which provide axial strength to the piping) were failed then the axial load of the pipe at design pressure could be borne by the bell and spigot alone. For steel with 25,000 psi yield, a bell cross-sectional area of 3.62 sq. in. is required (allowing for null measurements or through wall locations) for this axial load which equates to a uniform (mean of circumferential measurements) thickness of 0.042 inches for a 28 in. diameter cylinder.[1] A total cross-sectional area of steel greater than 3.62 sq. in. ensures adequate axial strength in the joint, without the need to inspect the harness assembly, including any potential null measurements in thickness or through-wall conditions. Such a joint would require a structural WEKO seal repair which incorporates a steel backing plate to spread the internal hoop loading on the joint, and to prevent further corrosive degradation. If a joint was inspected and found to have less than the required axial load bearing capacity (i.e., below 3.62 sq. in) then the external harness bolts would require inspection to prove that the axial loads were being carried by the harness bolts without placing stress on the bell housings.

Based on the inspection results of the bell and spigot joint, PSEG has determined that joints with uniform (mean of circumferential measurements) steel wall thickness less than 0.1 inch are not capable of performing their design function and must be repaired. In the event that a degraded joint is identified, PSEG proposes to repair the joint by:

1. Cleaning and re-coating the degraded portion of the bell band to prevent future corrosion.

2. Ensuring the degraded joint is capable of carrying the pipe design axial loading through either measurement of the bell wall thickness (and verification against established acceptance criteria) or by visual inspection of the external harness assembly (which is designed and fabricated to carry the longitudinal pipe loads) to verify that it is intact and functional. If the bell wall thickness acceptance criterion for axial load carrying capability [3.62 sq in cross-sectional area or 0.042 inch thickness if uniformly corroded] is not met, verification that the harness assembly is intact is required to demonstrate the joint is capable of carrying the longitudinal pipe load. Additional details and bases are provided in Section 5.3.

3. Installing a Structural WEKO seal with steel backing plate over the joint inside diameter to: (a) provide transfer forces away from potentially degraded pipe joints to adjacent PCCP pipe, (b) to support the seal, preventing any creep into voids in the pipe joint, and (c) prevent additional exposure of the joint to the SW environment.

Detailed evaluation of the repair authorized in 2014 demonstrates that the repair provides reasonable assurance of structural integrity and leak tightness in accordance with 10 CFR 50.55a(z)(2) and that replacement would be a hardship as discussed below.

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[1] Note that the spigot is not exposed to Service Water, and started service with thicker cross-sectional area; therefore, is not of concern as is the bell.

There are no repair or replacement designs for buried PCCP bell and spigot components qualified for use in nuclear safety-related applications. The only alternative to eliminate the flaw in a degraded bell and spigot joint is to replace the PCCP segment. Due to the nature of the pipe design (overlapping segments), direct replacement with an identical pipe section is not possible and would necessitate development of an alternate design.

Internal SW piping inspections are completed during refueling outages. If a degraded joint was found, the defect removal requirements of ASME Section XI, IWA-4422.1 would require emergent replacement of the joint, along with a length of adjacent piping. The Salem SW bell and spigot piping is laid out and constructed with specific interlocking connections. Any bell and spigot requiring replacement would have to be physically cut out and have flanged sections installed.

Since much of the SW piping is buried (approximately 8 feet below grade), a large excavation would most likely be required for the joint replacement. Sections of the SW piping are located under the Independent Spent Fuel Storage Installation (ISFSI) turning pads and the SW accumulator tank buildings, which would potentially have to be dug up. Additionally, the redundant SW headers for both Salem units are located in close proximity to each other, which could result in PSEG having to uncover the operating header to make a repair on the header that is out of service. Completing the repair using the proposed alternative in lieu of defect removal requirements in ASME Section XI, IWA-4422.1 would reduce the inoperability time of the impacted SW 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.

Completing the emergent replacement of a degraded joint during a refueling outage presents potential safety concerns, increased SW header inoperability, and outage duration impact. The proposed alternative of installing a structural WEKO seal can be completed in a timely fashion during a refueling outage and provides reasonable assurance of bell and spigot joint structural integrity.

5.0 PROPOSED ALTERNATIVE AND BASIS FOR USE:

5.1 Current Service Water Piping Design Description

The buried SW piping at Salem Units 1 and 2 consists of 24 inch internal diameter concrete piping with an integral steel core. The PCCP pipe segments are connected to each other with bell and spigot joints to provide adequate flexibility (extensibility and articulation) to accommodate pipe movement during operation and design basis scenarios.

The PCCP installed 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 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. These components are referred to as "Specials."

In both cases, external harness bolts are installed, over the entire linear length of the pipe, which carry the axial load.

A description of the two joints (PCCP-PCCP and PCCP-Special) and harness bolt configuration follows.

5.1.1 Pre-Stressed Concrete Joint Configuration

A sketch of a typical PCCP bell and spigot joint is shown in Figure 1. The key elements of the pre-stressed concrete bell and spigot joint are as follows:

- A concrete core 1.5 inches thick is spun inside a steel cylinder 0.1345 inch thick (10 gage). The concrete core has an inside diameter of 24 inches and an outside diameter of 27 inches.
- The steel cylinder is wrapped with tensioned steel wire to pre-stress the concrete core and the steel cylinder. The wires are 0.162 inch in diameter (8 gage) and are installed with a tensile stress of 173,250 psi. The wire is wrapped 22.4 times per axial foot on the liner.
- After the cylinder/concrete core is pre-stressed, mortar is painted on the cylinder OD to protect the wires and cylinder. The mortar is nominally 13/16 inch thick.
- At one end of the pipe, a steel spigot (0.375 in. thick) is welded to the end of the cylinder. The spigot includes a groove for installation of an O-ring seal.
- At the other end of the pipe, a steel bell (0.312 in thick) is welded to the end of the cylinder. The steel bell includes 24 bell bolts (0.75 inch-10UNC-2A) around the circumference. The bell bolts provide longitudinal strength for the joint in the event of failure of the harness bolt assembly. The steel bell is pre-stressed with three wraps of wire. The first two wraps are placed at half load (i.e. a wire stress of 86,625 psi). The mortar over the joint is approximately 2.2 inches thick and includes a 13 gage (0.092-inch diameter) 2-inch x 2-inch wire mesh over the bell to prevent shrinkage cracking during fabrication. This mesh provides negligible structural strength to the joint.

5.1.2 “Special” Joint Configuration

A sketch of a typical special joint is shown in Figure 2 (Note that the figure shows the configuration for both the bell and spigot when used with non pre-stressed pipe - "specials." This is provided for convenience; only one side of the joint would typically use a special). The key elements of the special bell and spigot joint are as follows:

- The inside of the pipe is lined with 1-inch thick concrete inside a 0.5 inch thick steel cylinder. The concrete core has an inside diameter of 24 inches and an outside diameter of 27 inches.
- The steel cylinder is not pre-stressed with wire.
- The outside of the steel cylinder is coated with mortar painted on the cylinder OD

to protect the cylinder. The mortar is nominally 13/16 inch thick.
- At one end of the pipe, a steel spigot is welded to the end of the cylinder. A grooved ring holding a pressure retaining gasket is welded to the spigot.
- At the other end of the pipe, a steel bell is welded to the end of the cylinder. The steel bell includes 24 bell bolts (3/4 inch) around the circumference. Approximately 2.2 inches of mortar is applied to the bell OD and includes a 13 gage (0.092-inch diameter) 2-inch x 2-inch wire mesh over the bell to prevent shrinkage cracking during fabrication. This mesh provides negligible structural strength to the joint.

5.1.3 Harness Bolt Assembly Configuration

Harness bolts are installed externally, over the length of the pipe, which are designed to bear the entire axial load. Each bell and spigot joint was installed with the spigot inserted several inches into the bell. The joints are designed and installed to permit up to two inches of axial extension, corresponding to 1° of articulation. The twenty-four ¾-inch bell bolts are not normally engaged with the shear edge of the spigot (See Figure 1); i.e. they do not react to the axial pipe loads—such loads are intended to be carried by the external harness bolts.

Special joints, which are installed at elbows, end pieces, and other locations where the piping run starts, stops, or changes direction, as well as specified straight PCCP sections, include two external harness assemblies, one on each side of the pipe joint. The harness bolts are 2-inches in diameter, with a minimum tensile strength of 98 ksi. The harness bolts are attached to the pipe using heavy hex nut and clevis arrangements. They are of various lengths, normally exceeding 20 feet, incorporate all joints, and each includes a breakaway coupling ensuring breakage if the axial force exceeds 175,000 lbf. Typical harness bolt assembly arrangements are shown in Figures 3 & 4.

As can be seen clearly from Figure 4, determination of whether a harness bolt is serviceable is not merely a matter of digging down at a pipe joint; extensive excavation would be required should such an examination be required.

The responses to RAI 25 and 26 of Reference 9.13 and RAI-34 of Reference 9.15 provide additional information regarding the inspection of harness bolting and the operating experience of the harness bolts with respect to corrosion. Since this initial information was provided in References 9.13 and 9.15, PSEG had excavated a portion of the buried SW discharge piping in order to install valves in the discharge piping to allow for conduct of internal inspection of the discharge piping. During this excavation, harness bolting was exposed with no degradation issues noted.

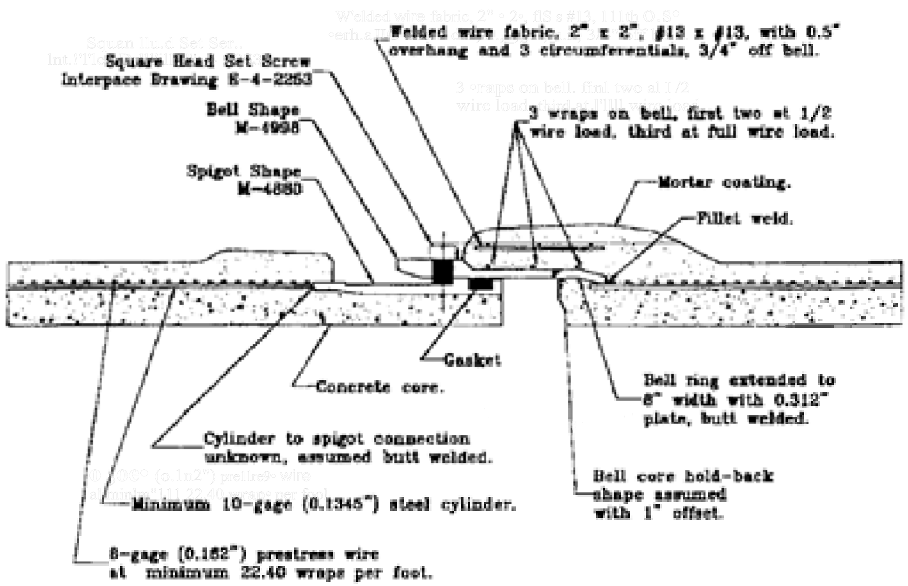

Figure 1 - Typical PCCP Joint Configuration

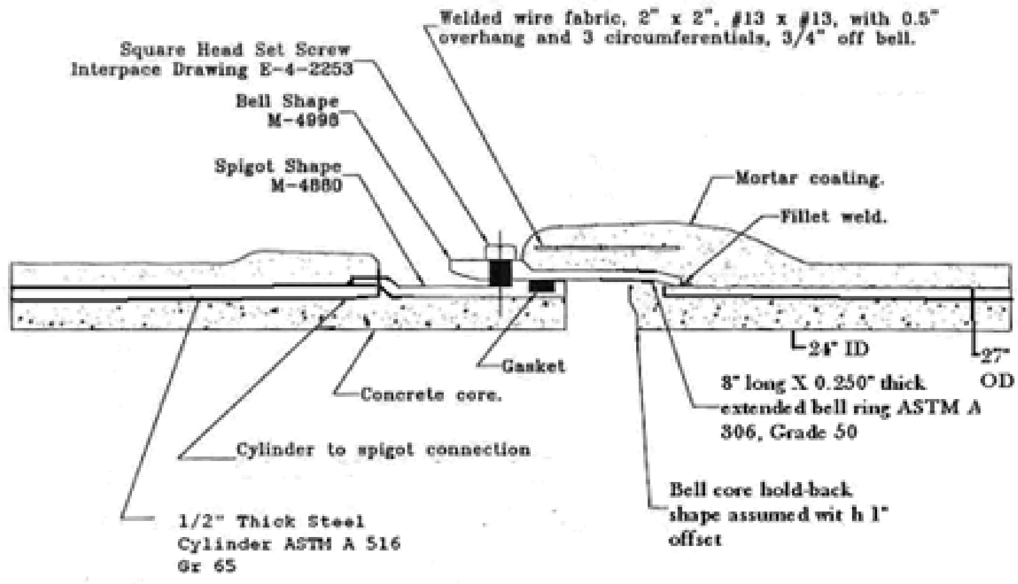

Figure 2 - Typical Special Joint Configuration

Note: This figure shows a non pre-stressed "special" bell connected to a non pre-stressed "special" spigot. This configuration is not installed, but is shown for compactness (i.e., to present both the "special" bell and spigot configurations in one figure).

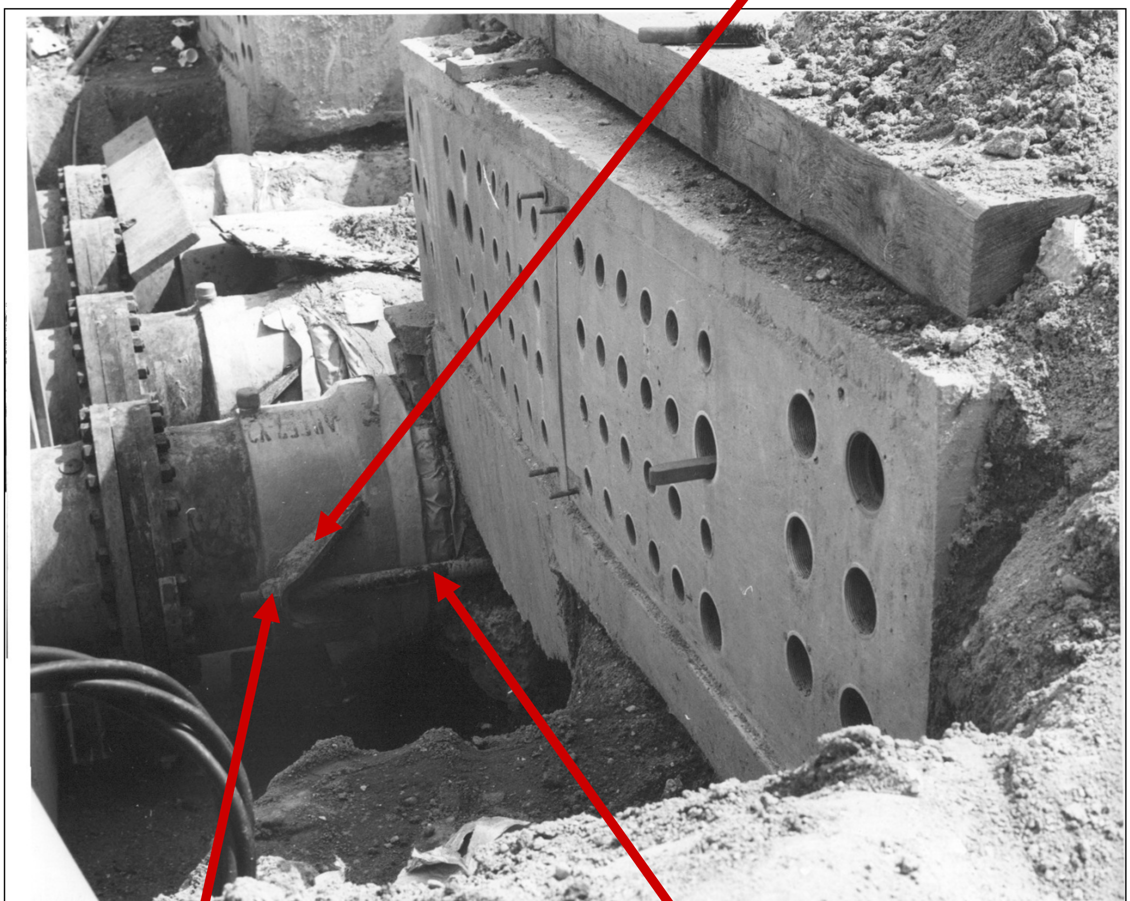

Figure 3 - Photograph of Harness Bolt Anchorage

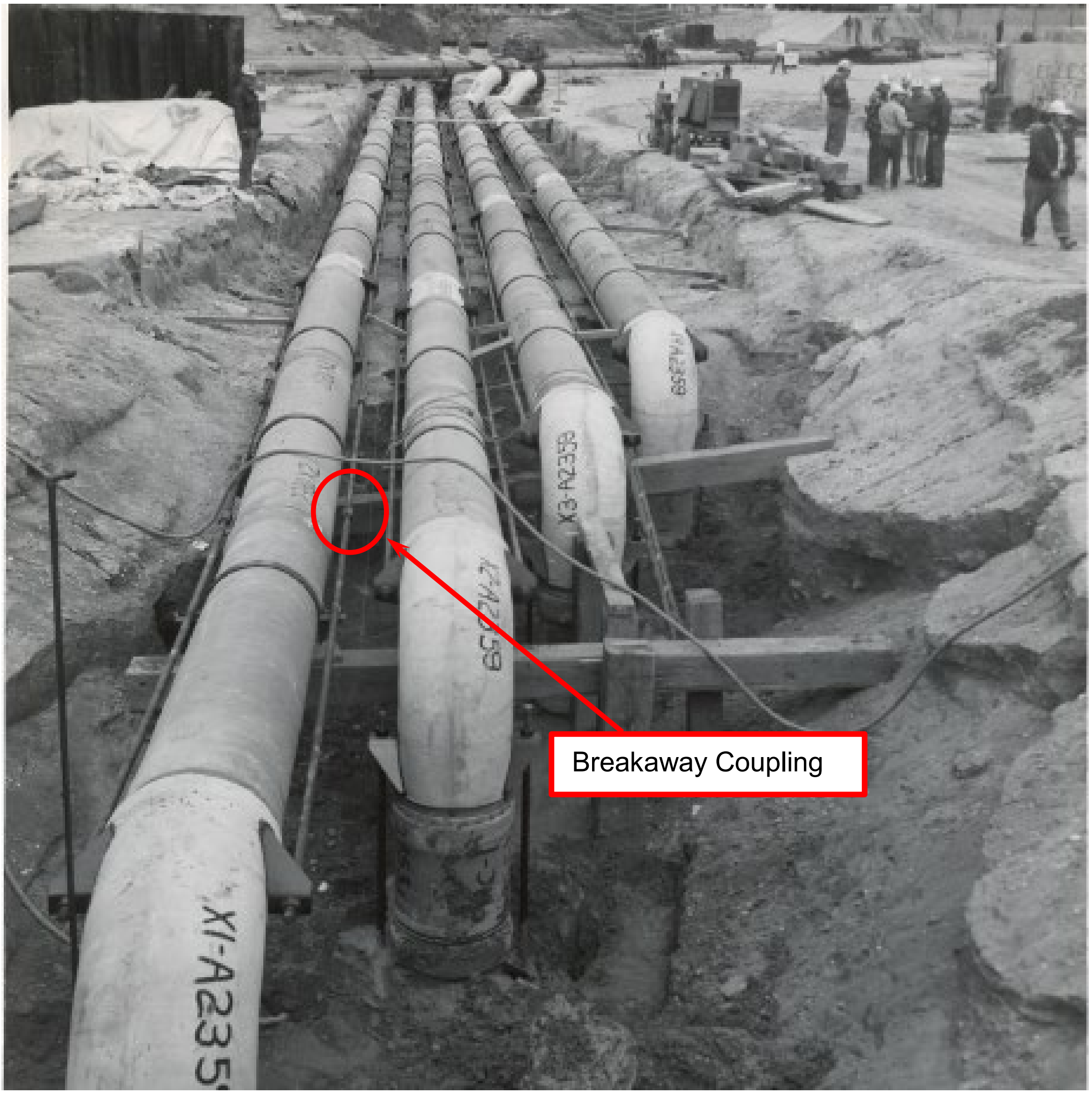

Figure 4 1972 Construction Photo of Service Water Return Piping Showing Harness Bolts with Breakaway Couplings

5.1.4 Joint Function

The bell and spigot joints are designed to flex up to 1° of articulation, accommodating approximately 2 inches of movement of the bell over the spigots; however, the pipes are effectively fixed in place by packed soil surrounding them, and a complete lack of external rotational force. The axial forces are intended to be carried entirely by the harness bolts, which are designed such that an axial force of 175,000 pounds will cause specially designed breakaway couplings to fail with ensuing pipe movement in the event of a seismic disturbance of sufficient strength.

5.2 Description of Proposed Repair/Alternative

For those joints which are found not to have been water-tight during their 36-month physical inspection, as evidenced by air leakage from the WEKO seal during testing, PSEG Nuclear will remove non-functional seals and replace them, repairing bell and spigot joints found to have degraded a below the criteria described below through use of the structural WEKO seal mechanical repair system installed on the inside diameter of the pipe, covering the degraded joint to prevent exposure to the SW environment and providing pressure boundary integrity. This method of repair was previously authorized by the NRC on April 8, 2014 for the 4th 10-Year ISI interval (Reference 9.11).

Use of the WEKO seal with structural backing plate is based on the following bell wall thickness acceptance criteria:

- Wall thickness > 0.1 inch - Structural evaluation of the bell and spigot joint has demonstrated that a minimum general (mean of circumferential measurements) bell wall thickness of 0.1 inches provides sufficient capacity for all design pipe loads (both axial and hoop). Failure to meet this criterion indicates additional strengthening of the joint is required.
- Wall thickness > 0.042 inches (a bell cross-sectional area of 3.62 sq. in. is required allowing for null measurements or through wall locations) - Structural evaluation of the bell and spigot joint shows that with a minimum general (mean of circumferential measurements) bell wall thickness of 0.042 inches (a bell cross-sectional area of 3.62 sq. in.), the joint is capable of carrying the design axial pipe load without crediting the external harness assembly. Therefore, a measured mean bell wall thickness between 0.042 inches and 0.1 inches requires repair with a structural WEKO·seal to restore load-bearing integrity. Inspection of the harness assembly for axial capacity is not required, since the cross-sectional area of the bell housing steel is sufficient in its own right to react to the axial loads.
- A measured general (mean of circumferential measurements) bell wall thickness below 0.042 inches (a bell cross-sectional area of less than 3.62 sq. in. allowing for null measurements or through wall locations), requires both installation of the WEKO seal with backing plate and inspection of the harness assembly to ensure it is intact and capable of carrying the design pipe load.

The mechanical repair system (WEKO seal with structural backing plate) provides hoop and radial strength and leak-tightness at the joint and prevents exposure of the degraded joint to SW. The WEKO seal repair does not provide any axial strength to the joint. The structural WEKO seal, shown in Figure 5, is held in place with four retaining bands. Key elements of the Structural WEKO seal are:

- A 316 stainless steel backing plate is centered over the joint gap and covered by an EPDM double-wide rubber seal. The thickness of the backing plate is determined based on the width of the gap that the plate is covering (Reference 9.8 shows that a 3/16 inch plate thickness is sufficient for the maximum gap size of three inches).

- Two 2-inch wide, 1/8 inch thick radially expanding retaining bands are installed at each end of the seal. The outer set of retaining bands, which are forced against the seal using a hydraulic expander, compress the seal into the concrete core while the inner set of bands compresses the seal and steel sleeve into the core. This design allows for both radial and axial growth in the pipe.

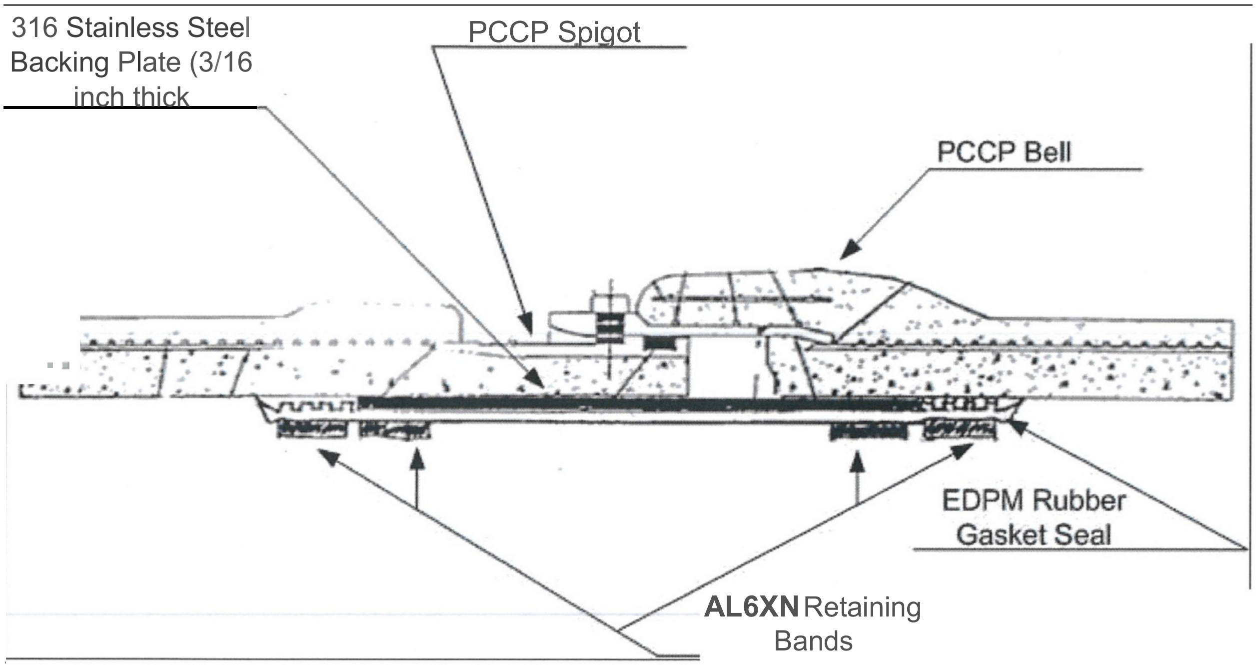

Figure 5 - Double-Wide WEKO Seal Configuration

5.3 Basis for Use

5.3.1 Bell-and-Spigot Joint Design Requirements

Design requirements for PCCP bell and spigot joints installed in the SW headers are provided in pipe specification S-C-MPOO-MGS-0001 and evaluation S-C-SW-MEE-1975 (References 9.2 and 9.10). The SW design pressure and temperature are 200 psig and 160°F, respectively. The bell and spigot joints form the piping pressure boundary and are designed to provide two inches of axial deflection and one degree of articulation. Axial piping loads due to internal pressure or seismic shifting are carried by the external harness assembly. The bell bolts, identified as set screws in Figures 1 and 2, provide axial restraint in the event of a failure of the harness assembly. The harness assembly is designed to carry the full design basis seismic loading.

5.3.2 Repair Design Evaluation

The installed-WEKO seal assembly (with backing plates) provides three key benefits:

- Restoration of the pressure boundary with the installed backing plates.
- Maintenance of required joint flexibility.
- Elimination of future bell or spigot degradation by (1) cleaning the components and

applying protective epoxy coating, and (2) preventing additional exposure to the brackish SW environment.

Axial pipe loads are not carried by the WEKO seal repair. Implementation of the WEKO seal repair requires verification that the pipe joint (bell and/or harness assembly) is capable of carrying the axial pipe load. This is accomplished through measurement of the bell wall or inspection of the external harness assembly, as described in Section 5.2.

Material Assessment

Qualification of the WEKO seal for use in the Salem SW system is provided in Vendor Technical Document (VTD) 325595 (Reference 9.4), which provides the basis for material acceptability. The installed WEKO seal assembly consists of:

- An EPDM rubber sheet that is resistant to seawater up to 200°F, provides excellent serviceability in cold water, and is aging resistant. In addition, EPDM has good resistance to sodium hypochlorite, which is used in the SW system to control bio-fouling.
- 3/16 inch thick 316 stainless steel backing plates. The backing plates are isolated from the SW environment by the EPDM seal, precluding degradation due to microbiologically induced corrosion (MIC), a known degradation mechanism in the SW environment.
- The retaining bands, which are exposed to the SW environment, are fabricated from UNS 08367, a stainless steel alloy containing 6% Molybdenum (Common trade name: AL6XN). This metal is the material of choice for use in the Salem SW system due to its excellent corrosion/erosion resistance in that environment.

As discussed in the response to RAI 5 of Reference 9.13, the stainless steel backing plate is not susceptible to stress corrosion cracking.

Hydraulic Assessment

Installation of the WEKO seal increases the hydraulic resistance of the piping by a very small amount. An evaluation of the impact of WEKO seal installation on SW system performance concluded that SW flow requirements are satisfied with sufficient margin (Reference 9.9). As part of the modification process, the SW system thermal hydraulic model (Reference 9.5) has been reviewed and updated, incorporating the increased frictional resistance, to ensure configuration management control.

Structural Assessment

PSEG has completed installation of WEKO seals at every PCCP joint of both intake and return of SW. Eight have been structural repairs made in accordance with the authorization of April 8, 2014 (Reference 9.11). The operating experience has been excellent. Calculations have been performed to demonstrate that the WEKO seal design is structurally adequate under design basis and service conditions. In addition, the impact of the WEKO seal on stresses in the adjacent PCCP has been evaluated (Reference 9.6). Key evaluations and conclusions are summarized below.

- The WEKO seal satisfies applicable design requirements under seismic loading.
- The seismic acceleration required to unseat the seal assembly is 68.3g, compared to the maximum ground acceleration of 0.2g (Reference 9.4).
- Installation of the seal assembly will not adversely affect the pipe joint's ability to permit seismically induced angular or axial deflections (Reference 9.4). This conclusion has been supplemented by qualification testing provided in Reference 9.7, which demonstrates that a bell and spigot joint with the WEKO seal installed could accommodate maximum expected deflections.

- Structural evaluation of the WEKO seal closure mechanism (retaining bands and push tab) based on installation and design loads is documented in References 9.4 and 9.7:
  - Maximum compressive stress on the retaining band is 64% of yield strength.
  - Maximum contact pressure at the retaining band of 309 psi is less than the critical buckling pressure of 418 psi.
  - Maximum shear stress in the push tab welds during installation is 66% of the allowable stress.
  - The impact of thermal expansion on retaining ring is negligible, based on a temperature difference of 90°F.

- Bending stress in the backing plate is evaluated in References 9.4 and 9.6. These calculations show that the bending stress satisfies applicable acceptance criteria (Stress Index=0.85) assuming a 3/16 inch plate and the maximum bell-to-spigot gap.

- The stability of the WEKO seal under hydrodynamic loading is evaluated in Reference 9.7. The evaluation concludes that the friction load due to a single retaining band is sufficient to resist hydrodynamic loads. WEKO seals have been installed as a preventative measure at all joints in the SW supply and return headers. Visual inspections completed during GL 89-13 inspections have shown that of the more than 200 WEKO seals installed over a twelve year period, they have remained intact and serviceable.

- The WEKO seal (with steel backing plate) does not carry axial piping loads. As such, use of this repair to restore pressure boundary integrity (excluding axial loads) requires verification that the joint remains capable of carrying axial pipe loads. Finite element analyses were performed and demonstrate that both configurations of the bell and spigot joint (PCCP and Special) are capable of carrying the design basis axial pipe load with a minimum cross-sectional steel area of 3.62 sq. inches (mean bell wall thickness of 0.042 inches) (References 9.3 and 9.8). As such, installation of a WEKO seal (with structural backing) in a joint with mean bell wall thickness less than 0.042 inches (a bell cross-sectional area less than 3.62 sq. allowing for null measurements or through wall locations) requires verification that the harness assembly is intact and capable of carrying the design axial pipe load. The harness assembly is designed to carry axial pipe loads; axial loads would only be carried by the bell and spigot if the harness assembly failed.

- A finite element analysis of the PCCP joint including WEKO seal was performed to evaluate the impact of WEKO seal installation on PCCP stresses (Reference 9.6). Key conclusions of this evaluation are:
  - The minimum net compressive stress in the core (1,114 psi) is greater than the applicable AWWA C304 acceptance criterion (271 psi). Therefore, installation of the WEKO seal does not result in unacceptable loss of compression in the concrete core under design pressure conditions.
  - The maximum principal tensile stresses in the mortar, which is installed after pre-stressing of the core and is not in compression, is 185 psi, which is less than the applicable AWWA C304 acceptance criterion of 470 psi. Therefore, installation of the WEKO seal will not overstress the mortar, demonstrating that serviceability of the mortar will not be impacted.

Leak tight integrity

For providing a fluid boundary for the SW system, the WEKO seal repair combined with the remaining portion of the bell and spigot joint and the sealing of the exterior of the joint as discussed in RAI 6 of Reference 9.13 and RAI 31 of Reference 9.14, prevents both water ingress and egress from the joints.

For joints that are excavated, the external joint will be resealed as needed to prevent intrusion of groundwater.

WEKO Seal Performance History

The historical performance of the WEKO seal was provided in the original relief request and response to RAIs 8 and 11 of Reference 9.13. Since the approval of the 4th 10-year interval relief request in 2014, PSEG has completed the installation of the WEKO seals with 220 seals installed in the SW supply header joints and 212 seals installed in the SW discharge header joints. PSEG tests the integrity of the WEKO seals on a current 3 year interval as part of the GL 89-13 program by performance of a pressure test as discussed in further detail in response to RAI 24 of Reference 9.13. No issues have been noted during the pressure tests performed to date that would indicate a leaking WEKO seal.

WEKO Seal Installation

The installation process of the WEKO seals is discussed in detail in the response to RAIs 16, 17, 18, 19, 20, 21, 22, and 23 of Reference 9.13.

5.4 Conditions for Using Alternate Repair Method

Installation of the WEKO seal mechanical repair system with steel backing plate to restore pressure boundary integrity of a degraded bell and spigot joint has the following conditions for use:

- Prior to installation of the WEKO seal, the degraded joint must be thoroughly cleaned and re-coated with an approved epoxy sealant. Cleaning and re-coating, in conjunction with seal installation, prevents future exposure of the joint to the SW environment, ensuring that there will be no additional degradation of the joint.
- Following installation of the WEKO seal with steel backing plate, pressure testing of the repaired SW joint (i.e., with WEKO seal and structural backing installed) is required.
- The WEKO seal with steel backing plate does not carry axial piping loads. Use of the repair system as a structural repair with mean bell wall thickness less than 0.042 inches (a bell cross-sectional area less than 3.62 sq. allowing for null measurements or through wall locations) requires visual inspection of the external harness assembly to ensure it is intact and functional. If through wall leakage exists, inspection of as much of the harness bolts that may have been affected by the SW leaking from the joint will be performed. Additionally, a VT-2 examination of the exposed portion of piping is to be performed for evidence of leakage after the repair is made.
- Periodic inspections, once per three years, of all joints and the installed WEKO seals will be performed in conjunction with GL 89-13 inspections to ensure that (1) degradation of the joints has not taken place, and (2) the WEKO seals are intact and undamaged. If at any time, an external harness assembly is exposed, an examination of the rod and underlying exposed joint externals will also be accomplished.

Conclusion

The installation of the proposed repair provides a robust and reversible method to repair degradation of bell and spigot joints in the SW buried piping which provides reasonable assurance of structural integrity and leak tightness. Therefore, PSEG requests that the U.S. NRC authorize this proposed alternative in accordance with 10 CFR 50.55a(z)(2).

6.0 DURATION OF PROPOSED ALTERNATIVE:

The proposed alternative is requested for Salem Units 1 and 2 for the 5th inspection intervals, currently scheduled to end on December 31, 2030. Once installed, the proposed alternative will remain in place for the life of the plant.

7.0 Precedent:

The proposed alternate method of repair was previously authorized by the NRC for Salem Units 1 and 2 on April 8, 2014 for the 4th 10-Year ISI interval (Reference 9.11).

8.0 ACRONYMS:

ASME	American Society of Mechanical Engineers
CFR	Code of Federal Regulations
ISI	Inservice Inspection
MIC	Microbiologically influenced corrosion
NRC	Nuclear Regulatory Commission
PCCP	Pre-stressed Concrete Cylinder Pipe
PFM	Probabilistic fracture mechanics
SCC	Stress corrosion cracking
SW	Service Water

9.0 REFERENCES:

9.1 Salem Generating Station Updated Final Safety Analysis Report.
9.2 Specification S-C-MPOO-MGS-0001, "Salem Piping Specification," Revision 19, Contains Schedule SPS2B, "Underground Service Water, Fresh and Salt Water in Yard (Including Fire Protection)," Revision 4.
9.3 VTD 326511, Sheet 1, "Evaluation of Salem PCCP Service Water Pipe," Revision 1.
9.4 VTD 325595, "Qualification of Internal Mechanical Seal Assembly," Revision 1, Contains Proto-Power Corporation Calculation 02-043, "Qualification of Internal Mechanical Seal Assembly," Revision A.
9.5 Calculation S-C-SW-MDC-1967, "Service Water System Thermal Hydraulic Model," Revision 7.
9.6 VTD 327717, Sheet 1, "Evaluation of WEKO Seals on Bell and Spigot Joints," Revision 1.
9.7 Calculation S-1-SW-MDC-1906, "Salem Service Water Underground Pipe Repair," Revision 1.
9.8 VTD 325626, Sheet 0, "MPR-2449: Evaluation of Salem Station Concrete Service Water Pipe Specials," Revision 1.
9.9 Modification 80105766, Revision 0, Supplement 01, "Sensitivity Analysis with Added WEKO Seal Resistance," Revision 0.
9.10 Evaluation S-C-SW-MEE-1975, "Salem Units 1 and 2 Concrete Service Water Pipe Joints Acceptance Criteria," Revision 0.
9.11 NRC to PSEG, “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. MF1875 and MF1376),” dated April 8, 2014 (ADAMS Accession No. ML14097A029)

9.12 PSEG Letter LR-N13-0064 to NRC, "Request for Relief from ASME Code Defect Removal for Service Water Buried Piping," dated April 3, 2013 (ADAMS Accession No. ML13093A382)
9.13 PSEG Letter LR-N13-0171 to NRC, "Response to Request for Additional Information – Relief Request SC-I4R, Alternative Repair for Service Water System Piping," dated August 15, 2013 (ADAMS Accession No. ML13227A338)
9.14 PSEG Letter LR-N13-0302 to NRC, "Response to Request for Additional Information (RAI 31 and RAI 32) – Relief Request SC-I4R-133, Alternative Repair for Service Water System Piping," dated January 8, 2014 (ADAMS Accession No. ML14016A123)
9.15 PSEG Letter LR-N14-0047 to NRC, "Response to Request for Additional Information (RAI 33 – RAI36) – Relief Request SC-I4R-133, Alternative Repair for Service Water System Piping," dated February 27, 2014 (ADAMS Accession No. ML14058A228)
9.16 PSEG Letter LR-N14-0092 to NRC, "Response to Request for Additional Information (RAI 37) – Relief Request SC-I4R-133, Alternative Repair for Service Water System Piping," dated March 26, 2014 (ADAMS Accession No. ML14085A482)