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AUG 1 5 2013

10 CFR 50.55a

LR-N13-0171

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: **Response to Request for Additional Information – Relief Request SC-I4R-133, Alternative Repair for Service Water System Piping**

References:

(1) PSEG letter LR-N13-0064, "Request for Relief from ASME Code Defect Removal for Service Water Buried Piping," dated April 3, 2013, ADAMS Accession No. ML13093A382

(2) NRC letter to PSEG, "Salem Nuclear Generating Station, Units 1 and 2 – Request for Additional Information Re: Relief Request SC-I4R-133 (TAC Nos. MF1375 and MF1376)," dated June 5, 2013, ADAMS Accession No. ML13137A488

In Reference 1, PSEG Nuclear LLC (PSEG) requested NRC approval of proposed relief request SC-I4R-133 for Salem Generating Station, Units 1 and 2 (Salem). 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.

In Reference 2, the NRC staff provided PSEG with a Request for Additional Information (RAI) regarding the Reference 1 relief request. Enclosure 1 to this submittal provides the responses to the RAI.

There are no commitments contained in this letter.

If you have any questions or require additional information, please do not hesitate to contact Ms. Emily Bauer at 856-339-1023.

Sincerely,

Paul R. Duke, Jr.
Manager – Licensing

Enclosure 1 – Response to Request for Additional Information

cc: Mr. W. Dean, Administrator, Region I, NRC
Mr. J. Hughey, Project Manager, NRC
NRC Senior Resident Inspector, Salem
Mr. P. Mulligan, Manager IV, NJBNE
Mr. L. Marabella, Corporate Commitment Tracking Coordinator
Mr. T. Cachaza, Salem Commitment Tracking Coordinator

Response to Request for Additional Information

Design

RAI 1:
Provide legible design drawings that show plant-specific dimensions of the items (components) of the bell-and-spigot joint before and after the repair using the WEKO seal. If available, provide 3-dimensional perspective drawings to help the NRC staff to visualize the joint configuration. The drawing should also include the harness assembly.

PSEG Response to RAI 1:
Detailed design drawings with plant-specific dimensions of the bell-and-spigot joint before the repair using the WEKO seal are not available. Figure 1 of Attachment 1 provides specific dimensions for the WEKO seals.

3-dimensional perspective drawings of the bell-and-spigot joint and the WEKO seal are not available.

RAI 2:
Provide a detailed drawing of the square head set screws (bolts) and the spigot gasket (not a part of the WEKO seal) showing how the bell and spigot are connected to each other. These drawings will help the NRC staff understand how the pipe loading is distributed and evaluate any potential leak path through the joint.

PSEG Response to RAI 2:
Attachment 1, Figure 2 is Interpace Drawing E-4-2253, which is the detailed drawing of the square head set screws (i.e., bell bolts)[1]. A detailed design drawing of the spigot gasket is not available (note that a description of the gasket material is provided in the response to RAI 3). The gasket is an o-ring with a circular cross section that fits into the notch around the circumference of the spigot ring. A sketch of a typical PCCP joint with WEKO seal installed is shown in Figure 4 of Attachment 1 for illustrative purposes. In the installed joint, the gasket seals the gap between the bell ring and the smaller diameter spigot ring, which slides inside the bell ring. There are 24 bell bolts distributed around the bell ring circumference. Each bell bolt is threaded through the bell ring and inserted radially until it contacts the outside diameter of the spigot ring (See Figure 4 of Attachment 1). Note that the bell bolts are not threaded into the spigot, nor are they tightened to load the spigot radially. In the event that adjacent piping segments were to expand, the bell bolt would contact the raised spigot ring end (i.e., the bolt stop), preventing separation of the joint. In effect, the bell bolt would act as shear restraint to prevent joint separation.

RAI 3:
Figures 1 and 2 show a spigot gasket that is located near the set screws and a fillet weld connecting the bell to the steel cylinder.

a. *Discuss the gasket material and its potential degradation mechanism.*
b. *Discuss whether the spigot gasket will be replaced when the bell thickness is reduced due to corrosion because the ground water may leak into the pipe through the gap that may be created between the gasket and the reduced bell thickness.*
c. *Specify the size of the fillet weld.*

[1] The terms "set screws" and "bell bolts" are used interchangeably.

PSEG Response to RAI 3:

a. The gaskets installed during original installation of the SW piping were manufactured in accordance with AWWA C301-64, Section 3.4, which specifies vulcanized first grade crude oil or synthetic rubber. The material must satisfy the requirements of ASTM D573 for accelerated aging testing. With a substantial number of these gaskets in service for over thirty years, no evidence of leakage due to gasket degradation has been identified at Salem Generating Station. The original gasket specification used by the OEM (Interpace Corporation) during construction is not available. However, the current owner of the Interpace PCCP design (Hanson Pressure Pipe) has provided a current gasket specification for use in the PCCP design installed at Salem, including that the elastomer is Polyisoprene.

b. The spigot gaskets were installed between the overlapping bell and spigot rings during plant construction. They cannot be removed and replaced without destruction of the adjacent piping sections, due to the overlapping nature of segmented piping. As discussed above, PSEG Nuclear has not identified instances of leakage due to degradation of the joint gasket. However, installation of the WEKO seal would prevent leakage between the pipe exterior and interior. In addition, cleanup and re-coating of the joint performed during WEKO seal installation will prevent additional degradation of the joint.

c. The bell and spigot rings were welded to the pipe liner and covered in concrete and mortar during fabrication of the pipe segment at the time of original construction. The size of the fillet weld is not identified in available design documentation. During fabrication, the joint was hydrostatically tested in accordance with the design code to demonstrate its ability to serve as a pressure boundary. Note that PSEG Nuclear has not identified any degradation of installed piping at Salem affecting the fillet weld region.

RAI 4:
The fillet weld is sandwiched and enclosed between the concrete and mortar coating.

a. Discuss whether the fillet weld has ever been examined. If not, discuss how the fillet weld can be ensured to maintain its structural integrity to support the piping loads without nondestructive examinations.
b. What would the implications on structural integrity be if the fillet weld could not be relied upon?

PSEG Response to RAI 4:

a. The fillet weld has not been examined since installation. Because of the mortar on the exterior and the concrete on the interior, the fillet weld is protected from degradation by corrosion. PSEG Nuclear periodically inspects the inside surface of the Service Water supply piping. Failure of the piping structural elements, such as the steel liner or fillet weld, would result from corrosion caused by exposure to service water that penetrated the concrete core on the interior of the steel cylinder through cracks. Internal inspections have not identified damage to the concrete core that would indicate that the liner has been exposed to service water.

b. During normal operation, axial pipe loads are carried by the external harness assembly. Circumferential (i.e., hoop) and radial pressure loads carried by the pipe liner and bell/spigot rings could potentially be transferred through the fillet weld, which is considered part of the pressure boundary. Degradation of the fillet weld sufficient to adversely impact the pressure carrying capability of the pipe would allow loads within the design envelope to result in overstress, which could cause (or exacerbate) cracking in the concrete core.

If the harness assembly was not available and the fillet weld could not be relied upon, the joint could not carry axial load. However, no damage has been observed inside or outside of the pipe that suggests that the fillet weld cannot be relied upon.

RAI 5:
Figures 1 and 2 identify an area in the joint as "Bell core hold-back shape assumed 1" offset." It appears that the 1-inch gap would form an enclosure once the WEKO seal is installed. The ground water may leak into the 1-inch gap space and eventually leak into the crevice between the stainless steel backing plate and the inside pipe wall. This may cause corrosion of the stainless steel backing plate underneath the rubber seal. The stainless steel is susceptible to stress-corrosion cracking in chlorine and high-stressed environment. Discuss whether the WEKO seal design has considered the potential for the ground water leaking into the pipe through the degraded joint and cause corrosion of the backing plate of the WEKO seal.

PSEG Response to RAI 5:
The stainless steel backing plate is not susceptible to stress corrosion cracking, because it will not be in a high-stressed environment and the temperature under normal operation is low. General corrosion of the backing plate is not expected to be a concern, because of the corrosion resistance of stainless steel. Further, ground water is far less aggressive than service water. During internal inspections to date, there has not been evidence of groundwater intrusion.

In addition, prior to installation of the WEKO seal, the interior of the bell and spigot joint is cleaned and re-coated to prevent additional degradation or groundwater ingress into the 1-inch gap between the joints. The exterior of the joint is sealed by a Ram-Neck coating, which prevents ingress of groundwater.

RAI 6:
Section 4 states that the degradation of the joint is due to corrosion of the carbon steel bell and spigot components caused by exposure to either service water or ground water.

- a. *List specific joint items (e.g., set screws, wires, gasket, and steel cylinder) besides the bell and spigot that could be degraded and their potential degradation mechanism.*
- b. *Provide the average and maximum corrosion rate of the bell-and-splgot joint based on operating experience in the nuclear and non-nuclear industry in the similar operating conditions.*

PSEG Response to RAI 6:
a. Carbon steel components exposed to ground water or service water are potentially subject to degradation by corrosion. Components in Figures 1 and 2 of the relief request are dispositioned as follows:

- The bell and the edge of the spigot are exposed to service water in the joint gap and are susceptible to corrosion. If the bell were fully corroded, the wire wraps behind the bell would then be exposed to service water and therefore susceptible to corrosion.
- The exterior of the joint is sealed by a Ram-Neck coating, which prevents ingress of ground water (Vendor Technical Document (VTD) 325626), thereby protecting the spigot, the edge of the bell, and the bell bolts (set screws).

- The steel cylinder and pre-stress wires are protected from corrosion by the mortar layer on the exterior of the pipe and the concrete layer on the interior of the pipe.
- The welded wire fabric is also protected by mortar and concrete layers. The function of this component was to prevent shrinkage cracking during construction. The welded wire fabric does not serve a structural purpose and is not germane to this relief request.
- As discussed in the response to RAI 3, with a substantial number of gaskets in service for over thirty years, no evidence of leakage due to gasket degradation has been identified at Salem Generating Station.

b. Specific corrosion rate data on bell and spigot joints elsewhere in the industry are not available. Historically, PSEG Nuclear has assumed a conservative corrosion rate for uncoated carbon steel in brackish water of 4 to 10 mils per year. It is noted that exposed surfaces of the joint are normally coated, so joint materials would not have degraded at this corrosion rate from the time of plant construction.

RAI 7:
Section 5.2 states that joints with bell wall thickness less than 0.1 inches are required to be repaired and that if the bell thickness is between 0.042 inches and 0.1 inches, a WEKO seal with backing plate will be used to perform the repair, although inspection of the harness assembly for axial capacity is not required. Section 5.2 further states that if the bell thickness is below 0.042 inches, the WEKO seal with backing plate will be installed and the harness assembly is required to be inspected.

a. Justify why the harness assembly does not need to be inspected for axial capacity if the bell thickness is between 0.042 inches and 0.1 inches. The NRC staff finds that when the bell thickness is degraded, the harness assembly needs to be ensured to carry the axial pipe load to maintain a defense-in-depth protection.
b. Justify why the WEKO seal can be used to repair the joint when the bell thickness falls below 0.042 inches.
c. Discuss the bell thickness beyond which the WEKO seal cannot be used to repair a degraded joint.
d. Discuss how the bell thickness is measured during an inspection.
e. Discuss the design and nominal thickness of the bell and spigot.
f. Discuss whether the above acceptance criterion (0.1 and 0.042 inches) also applies to the spigot wall thickness. That is, if the spigot thickness is reduced to the acceptance limit (even if the bell thickness is not reduced to the acceptance limit), is the joint required to be repaired?
g. If the bell or spigot thickness is reduced, discuss whether the bell bolts (set screws) need to be re-torqued to reduce the gap between the bell and spigot.
h. Discuss whether the proposed WEKO seal can only be applied at the bell-and-spigot joint of the pre-stressed concrete cylinder pipe (PCCP) and not on any other area or region of the PCCP.

PSEG Response to RAI 7:
The bell and spigot joint provides a portion of the pressure boundary for the buried piping. In addition, an external harness assembly is in place to carry axial pipe loads. In the event of a failure of the harness assembly, the bell and spigot joint would extend until the edge of the spigot ring gasket retainer contacts the set screws. At this point, axial piping loads would be carried by the bell and spigot rings, transferred through shear of the set screws. The WEKO seal with backing plate carries the pipe joint hoop loads, but not the axial loads. Use of the

WEKO seal as a pressure boundary component requires either the external harness assembly or the bell and spigot joint itself to carry the axial pipe loads.
Responses to specific NRC questions are as follows:

a. Calculations (VTD 326511; Calculation 0108-012-0333, Section 3.1; S-C-SW-MEE-1975) have demonstrated that a bell thickness of 0.042 inch is sufficient to restrain the limiting design axial loads, so reliance on the harness bolts is not necessary. Therefore, PSEG Nuclear considers that inspection of the harness bolts is not required unless the bell thickness is below 0.042 inch. If bell thickness is between 0.042 inch and 0.1 inch, PSEG Nuclear will evaluate the specific joint condition and configuration to determine whether additional actions are necessary to repair the joint in addition to installing a WEKO seal.

b. If the bell thickness is less than 0.042 inch, the bell cannot carry the design axial loads and the external harness assembly is instead relied on. To ensure that the harness bolts can perform this function, PSEG Nuclear would require an inspection of the harness bolts if the measured wall thickness were below 0.042 inch.

c. The WEKO seal can be used as a repair for remaining bell thickness of less than 0.042 inch in localized areas, including completely corroded (i.e., thickness of 0 inch), provided that the harness assemblies are intact.

d. The protocol for inspecting the buried SW piping has evolved since inspections began in the early 2000's. Initially, ultrasonic testing was used to measure the thickness of the bell band in each bell-and-spigot joint. However, this required significant effort to prepare the surfaces and perform the inspections. The current protocol uses a combination of Broadband Electromagnetic (BEM) scanning and ultrasonic testing. BEM scanning (an eddy current technique that can be used to inspect ferrous pipe) is used to identify thinning of the bell bands that merits detailed evaluation. The detailed evaluation of a thinned band is based on ultrasonic testing of the bell band.

e. The nominal thickness of the bell with design tolerance is 0.312 ± 0.010 inch (Vendor Drawing D-4-394). The nominal thickness of the spigot with design tolerance is 0.375 ± 0.010 inch (Vendor Drawing 12760-A).

f. While the inspection criteria discussed above could be applied to the spigot ring (the bell and spigot provide essentially the same structural function), the inside of the spigot ring is protected by the concrete core (and the gasket to some extent) and largely not exposed to the service water environment. The only portion of the spigot that is exposed to service water is the edge, which is not part of the load path.

g. The bell bolts (i.e., set screws) are not torqued and are unloaded during normal operating conditions. The two mating pipe segments are normally positioned such that the bell bolts do not engage the bolt stop. In the event of failure of the harness assembly, the bell bolts are threaded through the bell ring and function as shear pins to prevent excessive joint extension.

   In addition, the portion of the bell that houses the bell bolts is not exposed to service water due to the presence of the gasket; therefore, degradation in that region is not likely. Reduction of bell thickness in the region exposed to service water would not affect the position of the bell or the bolt stop[2], so these components could still perform their intended function of bearing axial loading provided that the bell thickness is adequate. The bolt stop (which is 0.625 inch thick) would not corrode before the bell thickness reaches the minimum thickness (i.e., 0.042 inch) where axial strength capacity (and therefore bell bolt performance) is credited.

h. This relief request is only applicable to WEKO seals used at bell-and-spigot joints. Application of WEKO seals in other locations (e.g., for flanged joints) is outside the scope of this relief request.

RAI 8:
The WEKO seal is attached to the inside surface of the pipe by the retaining bands which may degrade and lose their strength overtime. As a consequence, the retaining bands, the rubber gasket and backing plate may fall from the pipe inside wall into the flow stream.

a. Discuss the safety consequences of the loose WEKO seal parts in the flow stream that may either block the water flow or damage downstream equipment or components.
b. Identify the potential safety-related systems and non-safety-related systems that support the safety-related systems downstream of the service water piping that may be affected by the loose seal parts.
c. Discuss how the operator can determine if the service water flow has been changed as a result of loose WEKO seal parts falling in the flow stream.

PSEG Response to RAI 8:
The retaining bands used with this WEKO seal design are made of AL6XN, which has outstanding resistance to degradation from exposure to brackish water. This position is supported by the NRC's Generic Aging Lessons Learned Report, which does not require inspections of buried AL6XN piping, because of its excellent durability. PSEG Nuclear considers that a failure mode involving degradation of the AL6XN retaining bands by aging to the point where they can no longer serve their design function is not credible. However, PSEG Nuclear still plans to perform periodic inspections of all WEKO seals to confirm the condition of each WEKO seal.

PSEG Nuclear has inspected WEKO seals that have been in-service in the Service Water piping to assess the serviceability of WEKO seals. Inspections performed after six years of service identified no degradation of the WEKO seal assembly, including the retaining bands. In this context, PSEG Nuclear responds to the RAI questions as follows:

a. If Service Water system flow were impeded, the safety consequence would be a reduction in the capability to provide cooling water to systems/components that rely on the Service Water system for cooling.

b. Affected systems would include the Containment Building Ventilation System, the Emergency Diesel-Generator System, the Chilled Water System, the Control Air System, the Component Cooling System, the Auxiliary Building Ventilation System, the Safety Injection System, the Chemical and Volume Control System, and the Auxiliary Feedwater System.

[2] The bolt stop is the thicker portion of the spigot that engages the bell bolts when the joint is fully extended.

c. The postulated failure would result in reduced service water flow. This condition would decrease flow rate, increase pressure, and increase temperature in the Service Water system. In addition, temperature would increase in systems that rely on cooling from the Service Water system. Operators could use one or more of these indications to diagnose the presence of a blockage in the service water system.

RAI 9:
Figure 1 identifies an item as "Cylinder to spigot connection Unknown, assumed butt welded." However, Section 5.1.1, page 3 states that the spigot is welded to the cylinder. Clarify how the steel cylinder is connected to the spigot.

PSEG Response to RAI 9:
The spigot is welded to the steel cylinder. The type of weld is not known, but is assumed to be a butt weld. Connection of the bell and spigot to the pipe steel cylinder is a feature of the original design and does not impact the functionality of the WEKO seal repair.

Analysis

RAI 10:
Provide NRC staff access to References 7.3, 7.4, 7.5, 7.6, 7.7, 7.8, 7.9, 7.10 and 7.11.

PSEG Response to RAI 10:
PSEG has provided the NRC staff with access to 7.3, 7.4, 7.5, 7.6, 7.7, 7.8, 7.9, 7.10, and 7.11 separately.

RAI 11:
Section 5.3.2 states that ethylene propylene diene monomer (EPDM) rubber sheet is aging resistant.

a. *Discuss how many years and under what pressure the EPDM rubber sheet is qualified (EPDM is qualified up to 200 degrees F).*
b. *Provide the design and normal operation temperature and pressure of the service water supply and discharge piping.*

PSEG Response to RAI 11:
a. Vendor information states that WEKO seals are capable of performing their design function for an operating pressure of at least 300 psi and is rated for exposure to seawater up to 200°F. These conditions bound the design pressure and temperature of the service water piping of 200 psig and 160°F[3]. In addition, note that the maximum service water inlet temperature is 90°F. The EPDM is rated excellent for resistance to aging and PSEG Nuclear expects that it will function at least through the existing plant license (i.e., through August 2036 for Unit 1; through April 2040 for Unit 2). PSEG Nuclear notes that EPDM with comparable material properties used for a nearly identical application in another utility has a credited service life of 50 years (ADAMS Accession No. ML13141A270), which exceeds the maximum service time for a WEKO seal at Salem through the remainder of the existing license for each plant (i.e., 34 years for WEKO seals installed in Unit 1 in 2002 through end of plant life in 2036).

[3] The 160°F design temperature applies for service water return from the containment fan cooling units, which are designed to cool containment following a LOCA. The design temperature for return piping from other service water heat loads is 120°F.

b. Per the pipe specification (S-C-MPOO-MGS-0001), the Service Water header piping design pressure is 200 psig and the design temperature is 160°F. The normal operating temperature of the SW inlet piping ranges from 28°F in the winter to 90°F in the summer. Normal SW discharge temperature is approximately 5°F to 10°F higher than the supply temperature. Normal operating pressure of the supply piping ranges from 105 psig to 125 psig, while the discharge piping pressure is typically close to atmospheric (approximately 0 psig).

RAI 12:
The relief request states that the harness assembly and the bell bolts will provide longitudinal strength (axial loading) for the joint. Identify which components of the joint support the hoop stresses (radial loadings).

PSEG Response to RAI 12:
For the original design, the bell ring supports hoop and radial loads applied at the area of concern (i.e., the portion of the bell ring that is exposed to service water). With the WEKO seal installed, the stainless steel backing plate will support hoop and radial loading.

RAI 13:
Section 5.3.1 states that axial piping loads due to internal pressure or seismic are carried by the external harness assembly and that the bell bolts provide axial restraint in the event of a failure of the harness assembly. The NRC staff believes that in addition to the bolts that provide axial restraint, the bolt holes in the bell, and the spigot (i.e., the bell cross-sectional thickness in the vicinity of the bolt holes) also provide axial restraint. If there is degradation on these components, how is the degradation assessed to ensure structural integrity?

PSEG Response to RAI 13:
PSEG Nuclear agrees with the NRC conclusion that degradation of the bell and spigot load path components could adversely affect the structural integrity of the pipe. However, other than the inside surface of the bell ring and edge of the spigot, the joint is protected from exposure to service water or ground water with the concrete core, gasket, and Ram-Neck sealant on the outside of the joint. PSEG Nuclear has inspected the interior of the pipe, including the bell ring ID, to identify and assess degradation. In addition, degradation of the bell ring would likely be limiting with respect to corrosion:

- Conditions at the surface of the bell are much more conducive to corrosion, because there are no barriers to ingress of service water and egress of water containing corrosion products. For service water to reach the bolts, bolt holes, or the portions of the spigot that are part of the load path, the water would have to transit the interfacial gap between the bell and the spigot and also the gasket (which is intended to provide a water tight seal).

- Even if the corrosion rates were identical, the bell ring has the lowest material thickness and would still be structurally limiting. The nominal thickness of the portion of the bell ring that is inspected is 0.312 inch. This thickness is less than the thickness of the portion of the bell ring with bolt holes (0.687 inch), the diameter of the bolts (0.75 inch), or the thickness at the narrowest portion of the spigot (0.375 inch).

PSEG Nuclear has developed the WEKO seal (with structural backing) repair method to address degradation of the bell ring, which has been observed during periodic inspections. Use of the WEKO seal repair method could likely be applied to address degradation of different bell and spigot joint components, although this would require additional evaluation and is outside the scope of this relief request.

RAI 14:
Section 5.3.1 states that the bell-and-spigot joints form the piping pressure boundary and are designed to provide 2 inches of axial deflection and one degree of articulation.

- *a. Discuss if a 2-inch deflection occurs (the NRC staff interprets this as a 2-inch axial separation at the joint), whether water in the pipe would leak into or out of the joint.*
- *b. After the WEKO seal is placed in service, if the joint experiences 2 inches of axial deflection, discuss whether the WEKO seal will also be stretched for 2 inches along with the joint.*
- *c. If the pipe contracts after the expansion, discuss whether the WEKO seal will also contract (I.e., would the WEKO seal move axially with the joint like an accordion?).*
- *d. In this scenario, a gap may be created between the WEKO seal and the concrete inside surface as a result of the joint expansion and contraction. The ground water may leak into the pipe through the bell-and-spigot joint. Discuss the potential for this scenario and the associated consequences.*

PSEG Response to RAI 14:

a. The bell and spigot joint has been designed to accommodate 2 inches of axial motion without adversely affecting the pressure boundary integrity or leak tightness of the joint.

b. The WEKO seal design uses an EPDM elastomer for sealing the joint and is designed to accommodate axial deflection or rotation of the joint. PSEG Nuclear Calculation S-1-SW-MDC-1906 documents qualification of the WEKO seal for the buried SW piping design conditions. In the event of axial joint extension, the EPDM seal would stretch to accommodate the movement.

c. If the joint contracts after the expansion, the WEKO seal gasket material will elastically contract.

d. Consistent with the original design, excessive extension of the bell and spigot joint is prevented by the bell bolts and the harness assembly. Ground water leakage into the joint is precluded by (1) the Ram-Neck sealant applied on the exterior of the joint and (2) the gasket seal at the interface between the bell portion and the spigot portion. The function of the WEKO seal is to carry the SW internal pressure load and prevent exposure of the bell to the SW environment. The SW piping would remain capable of performing its design function. Furthermore, if groundwater were to breach these barriers and migrate between the WEKO seal and the concrete pipe wall, extended exposure to a thin layer of stagnant ground water would not have a substantial effect on the integrity or performance of the WEKO seal, the backing plate, or the pipe wall.

RAI 15:
The last paragraph on page 10 states that WEKO seals have been installed as a preventive measure at all joints in the service water supply headers.

- *a. Identify what inspections of the bell-and-spigot joints were conducted at the time of installation and the results of the inspections.*
- *b. Clarify whether the WEKO seals were credited as structural components for the joint or if they were preventive measures to reduce degradation of the bell-and-spigot joint.*

c. *Provide the year when the WEKO seals were installed and how many seals were installed.*
d. *Clarify whether the proposed alternative will be applied to the service water discharge piping only because the WEKO seals have already been installed at all bell-and-spigot joints in the service water supply headers.*
e. *For WEKO seals that have already been installed, will they be removed and the bell-and-spigot components inspected to the proposed standards in this relief request and then reinstalled? If not, what is the plan for inspection of the existing seals and bell-and-spigot components?*
f. *Have there been inspections of the WEKO seals subsequent to their installation? If so, provide the inspection criteria and the results of the inspections.*

PSEG Response to RAI 15:

a. The protocol for inspecting the buried SW piping has evolved since inspections began in the early 2000's. Initially, ultrasonic testing was used to measure the thickness of the bell band in each bell-and-spigot joint. However, this required significant effort to prepare the surfaces and perform the inspections. The current protocol, which was adopted in 2004, uses a combination of Broadband Electromagnetic (BEM) scanning and ultrasonic testing. BEM scan is an eddy current technique that can be used to inspect ferrous pipe without the need for surface preparation; it is commonly used to inspect water mains and sewer pipe. The BEM scan is used to identify thinning of the bell bands that merits detailed evaluation. The detailed evaluation of a thinned band is based on ultrasonic testing of the bell band. The most recent BEM scan results indicated the following:

- In the No. 11 supply header, the lowest apparent thickness on any joint was 0.168 inch. This joint had an average apparent wall thickness of 0.220 inch.
- In the No. 12 supply header, the lowest apparent thickness on any joint was 0.168 inch. This joint had an average apparent wall thickness of 0.240 inch.
- In the No. 21 supply and discharge headers, the lowest apparent thickness on any joint was 0.119 inch. This joint had an average apparent wall thickness of 0.149 inch.
- In the No. 22 supply and discharge headers, the lowest apparent thickness on any joint was 0.123 inch. This joint had an average apparent wall thickness of 0.185 inch.

b. With the exception of one joint in the #12 supply header, all of the WEKO seals were installed as preventive measures to prevent further degradation. In the #12 header, a WEKO seal with structural backing plate was installed at a single joint with a cracked bell band that leaked.

Additionally, degradation in one joint in the #11 inlet header was identified during the Spring 2010 outage, requiring installation of a WEKO seal with structural backing plate. In this instance, the structural backing plate was credited as a structural component on an interim basis. The buried pipe segment containing the degraded joint was replaced in the Spring 2013 outage. While a WEKO seal has been installed in this joint as a preventative measure, it is no longer credited as a structural measure.

c. PSEG Nuclear has installed WEKO seals in service water (SW) piping at Salem over the following timeline:

- 2002 - Installed three WEKO seals in the #12 SW supply header. One of the seals was placed at a joint with a cracked bell band that leaked as a structural repair.

- Spring 2008 - Installed WEKO seals over 58 joints in the #21 SW supply header and 53 joints in the #22 SW supply header.
- Fall 2008 - Installed WEKO seals over 53 joints in the #12 SW supply header. (Inspected and retained the existing 3 WEKO seals that were installed in 2002.)
- 2010 - Installed WEKO seals over 56 joints in the #11 SW supply header.
- 2012 - Installed WEKO seals over 23 joints in a portion of the #22 SW discharge header including the piping beneath the tanks on the west side of the Auxiliary Building back to the penetration into the Auxiliary Building. (This is the only portion of the #22 SW discharge header that is accessible for internal inspection.)

d. The proposed alternative applies to joints in both the supply and discharge Service Water piping.

e. WEKO seals that have already been installed will not be removed so that bell and spigot joints can be re-inspected. PSEG Nuclear performed inspections of the bell and spigot joints prior to installing the existing WEKO seals. The criteria applied in those inspections are the same as the criteria proposed in the relief request. Hence, the joints complied with the proposed standards when the WEKO seals were installed.

f. PSEG Nuclear has performed follow-up inspections of WEKO seals in all four service water supply headers. In 2008, during installation of the WEKO seals in the No. 12 header, PSEG Nuclear inspected the three WEKO seals that were previously installed in 2002. The follow-up inspections consisted of a pressure test and a visual inspection, which is the same as the post-installation inspections (see RAI 22). No problems were identified during the follow-up inspections of the three WEKO seals, which had been in-service for six years. WEKO seals installed in 2008 or later were inspected after being in-service for three years. No degradation was identified during these inspections.

RAI 16:
The fourth paragraph on page 10 states that the maximum shear stress in the push tab welds during installation is 66 percent of the allowable stress. Identify the push tab welds in the design drawings with respect to the WEKO seal assembly and provide a detailed sketch of the push tab itself.

PSEG Response to RAI 16:
Figures 3 and 5 of Attachment 1 to this document show the push tabs (also called press tabs) and the push tab welds on a retaining band used for a WEKO Seal assembly.

RAI 17:
The WEKO seal has 4 retaining bands to attach the rubber gasket seal to the inside surface of the pipe.

a. Provide the radial force that the retaining bands will exert to the inside surface of the pipe wall in order to attach the rubber gasket to the inside pipe wall.
b. The retaining bands will exert a tensile load on the inside surface of the pipe, which is covered with concrete. Tensile loading is not favorable for concrete as concrete cannot support tensile loads. The pre-stressed wires that wrap the steel cylinder provide compressive load on the concrete. Demonstrate by analysis that the compressive loading of the wires exceed the tensile loading of the retaining bands such that the concrete would not be negatively affected by the tensile loading of the retaining bands.

PSEG Response to RAI 17:

a. The maximum radial force that the retaining bands will exert to the inside surface of the pipe wall is 7,178 lbf (VTD 325595).

b. PSEG Nuclear evaluated the impact of the WEKO seal retaining bands on tensile stresses in the concrete core, steel cylinder, and cover mortar. The results of the evaluation showed that stresses in the pipe remain below applicable acceptance criteria. The pre-stressing margin available to zero concrete compressive stress on the host pipe due to retaining band installation is 24.57% of the working tensile resistance (VTD 325595). Therefore, installation of the retaining bands will not damage the host pipe.

Installation

RAI 18:
Describe the installation of the WEKO seal in detail.

PSEG Response to RAI 18:
The PSEG Nuclear maintenance procedure for installing a WEKO seal, SH.MD-SP.SW-0009(Q), Service Water Pipe Repair Using Internal Seal, has been provided the NRC staff separately.

RAI 19:
Clarify whether a compound or coating is applied to the interface between the EPDM rubber gasket (edge) and the pipe inside surface to minimize leakage to the backing plate and through the seal assembly.

PSEG Response to RAI 19:
There are no compounds or coatings applied to the interface areas noted in this RAI to minimize leakage. The EPDM rubber gasket interfaces directly with the pipe inside surface. The design does not require a compound or coating. A lubricant or soap is sometimes used to lubricate the WEKO seal to assist with installation in the pipe. These products were chosen for their compatibility with the WEKO seal (i.e., they do not degrade the WEKO seal).

RAI 20:
The ends of the EPDM gasket have grooves. Discuss the function of these grooves.

PSEG Response to RAI 20:
A retaining band is placed directly over these grooves at each end of the WEKO seal. The high contact pressure exerted by the retaining bands deforms the grooves, providing a leak tight seal and thus prevents process fluid (service water) from seeping into the crevice under the WEKO seal. This leak tight seal is validated after WEKO seal installation via the seal pressure test, as described in RAI 22.

RAI 21:
Clarify whether a sealant will be used between the backing plate and the pipe inside surface.

PSEG Response to RAI 21:
No sealant is specified for the surface between the backing plate and the pipe inside surface. However, small amounts of quick-dry mortar can be used to hold backing plates in place, provided the mortar is applied smooth and thin to prevent damage to the WEKO seal. Also, a lubricant or soap is sometimes used to lubricate the WEKO seal to assist with installation in the

pipe. These products were chosen for their compatibility with the WEKO seal (i.e., they do not degrade the WEKO seal).

Examinations

RAI 22:
Discuss the acceptance examination and associated acceptance criteria of the WEKO seal assembly.

a. *That is, what and how to examine the installed WEKO seal for acceptance?*
b. *What are the criteria to accept or reject an installed WEKO seal for service?*

PSEG Response to RAI 22:

a. PSEG Nuclear performs a visual inspection and a pressure test of installed WEKO seals to confirm that they are acceptable for service. The WEKO seal pressure test (i.e., the leak check of individual WEKO seals) is performed at a pressure of 5 psig. The Service Water Pipe Repair Using Internal Seal procedure (SH.MD-SP.SW-0009(Q)) does not specify a hold time for this test. A visual examination of the WEKO seal from the interior of the pipe is required for the pressure test, because a soap and water solution is used to detect leakage.

b. For the visual inspection, the inspector checks for evidence that installation was performed correctly (e.g., restraining bands are tight). For the pressure test, the acceptance criterion is no leakage when a soap and water solution is placed over the entire seal and the space behind the seal is pressurized to 5 psig.

RAI 23:
Section 5.4 discusses post-installation pressure testing.

a. *Provide the pressure that will be used in the pressure testing and the associated hold time.*
b. *Clarify whether a visual examination of the repaired joint will be performed as part of the pressure testing.*
c. *List the subarticle(s) of the ASME Code, Section XI, that the pressure testing will be performed in accordance with.*

PSEG Response to RAI 23:
PSEG Nuclear performs a WEKO seal (non-section XI) pressure test as part of installation to check for leaks in individual WEKO seals (see RAI 22). Pressure testing of the joint, to satisfy ASME Code Section XI, is performed as part of normal system operation.

a. Service Water normal system pressure will be used for the test pressure with a 10 minute hold time, if the external portion of the repaired joint is exposed for direct visual examination. If the repaired joint is not excavated, provisions in Relief Request S1-I4R-102 (ADAMS Accession No. ML112420175) or S2-I4R-124 (ADAMS Accession No. ML13101A266, pending approval) will be used, which requires a 24 hour hold time.

b. If the repaired joint is excavated, a VT-2 visual examination of the repaired joint will be performed as part of the pressure testing, once the system is pressurized and prior to back-filling the excavation.

c. Pressure testing will be performed in accordance with ASME Code Section XI Subarticles IWA-5211(a), IWA-5213(b), IWD-5210(b)(1), and/or Relief Request S1-I4R-102 (ADAMS Accession No. ML112420175) for Unit 1, or Relief Request S2-I4R-124 (ADAMS Accession No. ML13101A266, pending approval) for Unit 2, in-lieu of IWA-5244(b).

RAI 24:
Section 5.4 states that periodic inspections of the degraded joint and the installed WEKO seal will be performed in conjunction with Generic Letter (GL) 89-13, "Service Water System Problems Affecting Safety-Related Equipment".

a. Clarify whether after installing the WEKO seal, the degraded portion of the buried pipe will be exposed (i.e., the excavation will not be backfilled) so that the repaired joint is accessible for periodic inspections for the remaining life of the repair.
b. Discuss the inspection techniques that will be used in the periodic inspections of the repaired joint and the WEKO seal, what items will be inspected, whether the inspection will be performed from the inside or outside surface of the pipe, and what are the acceptance criteria of the inspection.
c. Provide references for the acceptance criteria to disposition the inservice inspection results.
d. Discuss how often the repaired joint will be inspected as part of the GL 89-13 inspections.

PSEG Response to RAI 24:
a. Installation of the mechanical repair system (WEKO seal with structural backing plate) to restore load carrying to address bell band degradation does not necessarily require that the joint be excavated to expose the pipe and the harness bolts. The decision of whether to excavate the pipe joint for external inspection relates to whether axial loads for accident conditions are being carried by the joint or the harness bolts.

- If the bell thickness is at least 0.042 inch, the design function of the joint to carry the axial load under design basis conditions is maintained. Therefore, it is not necessary to excavate the pipe to allow visual inspection of the harness assembly.
- If the bell thickness is less than 0.042 inch, the joint can no longer carry the axial load under design basis conditions. The harness assembly, which is credited for only normal conditions, must carry the axial loads under both normal conditions and design basis conditions. In this case, the pipe must be excavated so that the harness assembly can be inspected to confirm it can carry the required load.

If the pipe is excavated for external inspection, PSEG Nuclear will backfill the excavated area following inspection. Backfilling the excavated area is necessary for: (1) tornado missile protection of the pipe; (2) industrial safety (an open trench is a safety concern); and (3) continuity of business operations (an open trench impedes vehicular traffic on-site). Any future inspection of a repaired joint needing access to the harness assembly or the external surface of the pipe will require that the pipe be excavated at that time.

b. Periodic inspections will include a visual examination of the WEKO seal and a pressure test. (See RAI 22.) The acceptance criterion for the visual examination is no apparent degradation. The acceptance criterion for the pressure test is no leakage.

c. The procedure and the acceptance criteria for the pressure test were provided by the WEKO seal manufacturer, Miller Pipeline Corporation and incorporated into PSEG Nuclear

Procedure SH.MD-SP.SW-0009(Q). The procedure and acceptance criteria are the same as for original installation (see RAI 22).

d. A repaired joint will be inspected commensurate with the frequency of other WEKO seals in accordance with the GL 89-13 program. The current inspection frequency for WEKO seal inspections is every 36 months. PSEG notes that inspections to date have shown that WEKO seals are in excellent condition after six years. If technically justified, PSEG Nuclear may extend the inspection frequency in the future.

RAI 25:
The NRC staff finds that it is appropriate to inspect the harness assembly when the WEKO seals are installed, and periodically thereafter.

a. Provide the plans for future inspections of the harness assembly after the seals are installed.
b. Provide justification if this is not an examination requirement of the proposed alternative.

PSEG Response to RAI 25:
The buried concrete pipe used in the Salem SW system has redundant means of carrying the axial loads on the pipe; the joint (bell bolts engaging with the limit stop on the spigot), and the external harness assembly. The design basis for the pipe is as follows.

- The external harness assembly carries the axial loads during normal operation.
- The joint carries the axial load under accident conditions. In this case, the bell bolts engage with the stop on the spigot to limit the axial motion of the pipe.

Therefore, the harness assembly is not credited with performing a safety function, as it relates only to normal operation. The harness assembly is only credited with a safety function if the bell band is degraded to the point that it cannot carry the axial load (i.e., less than 0.042 inch thick). Before a harness assembly can be credited for accident conditions, it must be inspected to confirm that it is in satisfactory condition.

a. Inspection of the harness assemblies is not included in the scope of the periodic inspections of the buried SW piping because they are not credited with a safety function. Instead, the inspections focus on the bell bands (which are accessible from inside the pipe). The harness assemblies are inspected under only the following scenarios.

- The Buried Pipe Program includes requirements to perform external inspections of the buried Salem SW pipe on a sampling basis, as well as opportunistically (i.e., when it is excavated for other reasons). The scope of these inspections includes the harness assemblies.
- If the harness assembly is to be credited with a safety function due to degradation of the bell band, the harness assembly will be inspected to confirm that it is in good condition and can carry the required load. After the mechanical repair system (WEKO seal with structural backing plate) is installed, the harness assembly will be inspected periodically to ensure that it can still carry the required load. The inspection interval will be determined based on the condition of the harness assembly upon initial inspection.

b. Historically, inspections of buried carbon steel components at Salem and Hope Creek that were properly coated have indicated no signs of degradation. This applies to inspections of the harness assemblies at Salem.

- 2002: Inspection of the harness assemblies on the No. 12 supply header at the location of leaking bell-and-spigot joint identified no signs of corrosion of the harness bolts or the clevis.
- 2010: Inspection of the harness assemblies on the No. 11 supply header identified no signs of corrosion of the harness bolts.
- 2011: Inspection of the harness assemblies on the No. 21 discharge header identified no signs of corrosion of the harness bolts.
- 2013: Recent inspection of harness bolt assemblies on a segment of No. 11 supply header that was replaced were consistent with the previous inspection in 2010.

PSEG Nuclear notes that the inspections in 2010 and 2011 identified some shear bolts in the breakaway couplings that had sheared. In these cases, the breakaway couplings were replaced. Inspection of the shear bolts did not identify loss of cross-section due to corrosion. Further, since the harness bolts are only credited for normal operation, the safety function of the pipe during accident conditions would not have been degraded.

The body of evidence to date is that the harness assemblies have not experienced corrosion, even when in close proximity to a leaking bell-and-spigot joint. This proves the effectiveness of the measures implemented during original plant construction. Beyond the inspections discussed in response to RAI 25(a), PSEG Nuclear considers that no additional inspections would be warranted based on (1) the 30+ years of service with minimal degradation, (2) site experience with other buried components with decades of use with minimal degradation, and (3) recoating of any portion of the harness assembly after the initial inspection, as needed, will arrest further degradation.

RAI 26:
Section 5.4 states that the external harness assembly will also be periodically inspected in the area of the repaired joint, if credited for axial load carrying capability.

a. If degradation of the harness assembly exists, what are the criteria used to accept for further use?
b. Does this criterion take into account degradation that exists in the bell and-spigot joint? If not, justify.

PSEG Response to RAI 26:
a. There are two acceptance criteria for the harness bolts to confirm that they can satisfy the design requirements of the piping specification (S-C-MPOO-MGS-0001):

- The minimum diameter of the harness bolts is 1.07 inches.
- The minimum thickness of the harness lug bolting plate is 0.46 inches.

These criteria were determined analytically in VTD 325626. The harness bolt design includes a breakaway coupling that ensures that the harness bolt will fail at less than 175 kips and permit extension of the joint (S-C-MPOO-MGS-0001). If degradation of the coupling is apparent, PSEG Nuclear will either perform a detailed evaluation of the coupling in its as-found condition or replace components.

b. Yes. The acceptance criteria for the harness assemblies take no credit for any axial load being carried in the bell and spigot joint; hence, there is no limitation on the bell band thickness inherent in the above criteria.

RAI 27:
The NRC staff finds that if both the harness assembly and the joint are degraded, there is no defense-in-depth to maintain the structural integrity of the joint. As stated in the relief request, the WEKO seal does not carry pipe axial loads.

a. Discuss what instances the harness assembly is not credited for axial load carrying capability.
b. Justify why the WEKO seal can be used at a location when both the bell and-spigot joint and harness assembly are degraded.

PSEG Response to RAI 27:

a. The buried concrete pipe used in the Salem SW system has redundant means of carrying the axial loads on the pipe: the joint (bell bolts engaging with the limit stop on the spigot) and the external harness assembly. The design basis for the pipe is as follows.

- The external harness assembly carries the axial loads during normal operation.
- The joint carries the axial load under accident conditions. In this case, the bell bolts engage with the stop on the spigot to limit the axial motion of the pipe.

Therefore, the harness assembly is not credited with performing a safety function as it relates only to normal operation. The harness assembly is only credited with a safety function if the bell band is degraded to the point that it cannot carry the axial load (i.e., less than 0.042 inch thick).

b. The WEKO seal (with structural plate backing) provides hoop strength and a leakage boundary; it does not provide any axial strength. A WEKO seal can be used only if the axial load is carried by either the bell-and-spigot joint or the harness assembly. 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. Potential approaches for restoring the axial load capability include: replacement of the pipe section, repair of the bell-and-spigot joint, repair/replacement of the degraded components of the harness assembly, or another suitable approach.

RAI 28:
Section 5.4 states that VT-2 examination of the exposed portion of piping is to be performed any time external harness assembly inspections are performed.

a. Explain how often the harness assembly is inspected.
b. Discuss what the harness assembly inspection criteria and acceptance criteria are for the harness assembly inspection.

PSEG Response to RAI 28:

a. The harness assemblies are inspected under only the following scenarios.

- The Buried Pipe Program includes requirements to perform external inspections of the buried Salem SW pipe on a sampling basis, as well as opportunistically (i.e., when it is excavated for other reasons). The scope of these inspections includes the harness assemblies.

- If the harness assembly is to be credited with a safety function due to degradation of the bell band, the harness assembly will be inspected to confirm that it is in good condition and can carry the required load. After the mechanical repair system (WEKO seal with structural backing plate) is installed, the harness assembly will be inspected periodically to ensure that it can still carry the required load. The inspection interval will be determined based on the condition of the harness assembly upon initial inspection.

b. VTD 325626 discusses a visual inspection of the harness bolt assemblies to assess the condition of the coating and the general condition of the harness bolts, clevis, and couplings. Acceptance criteria for this visual inspection include the following:

- Coating intact. Following the inspection, the bolt, clevis, and couplings are re-coated as necessary to prevent future corrosion.
- No obvious degradation of harness bolt coupling. If thinning or degradation of the coupling is apparent, PSEG Nuclear would either perform a detailed evaluation of the coupling in its as-found condition or replace components.
- No significant thinning or other degradation of harness bolts, nuts, or clevis, including clevis attachment welds (where exposed). If significant thinning or degradation is apparent, PSEG Nuclear would perform more detailed inspections, as discussed below.

The harness assembly inspections cover the harness bolt and the clevis (lug bolting plate). The principal concern is reduction in the cross sectional area due to corrosion. The following acceptance criteria apply:

- The minimum diameter of the harness bolts is 1.07 inches.
- The minimum thickness of the harness lug bolting plate is 0.46 inches.
  These criteria were determined analytically in VTD 325626.

<u>Regulatory Issues</u>

RAI 29:
The NRC staff understands that for Unit 2, the fourth 10-year inservice inspection (ISI) interval starts on November 27, 2013, and ends on November 27, 2023, as stated in the licensee's fourth 10-year ISI submittal dated June 7, 2012. Provide the beginning and end dates for the fourth 10-year ISI interval for Unit 1.

PSEG Response to RAI 29:
The fourth 10-year ISI interval for Salem Unit 1 began on May 20, 2011 and ends on May 20, 2021.

RAI 30:
Confirm that the proposed relief request will be effective starting the fourth 10 year ISI interval at both units.

PSEG Response to RAI 30:
The proposed relief request will be effective starting the fourth 10-year ISI interval at both units.

Figures

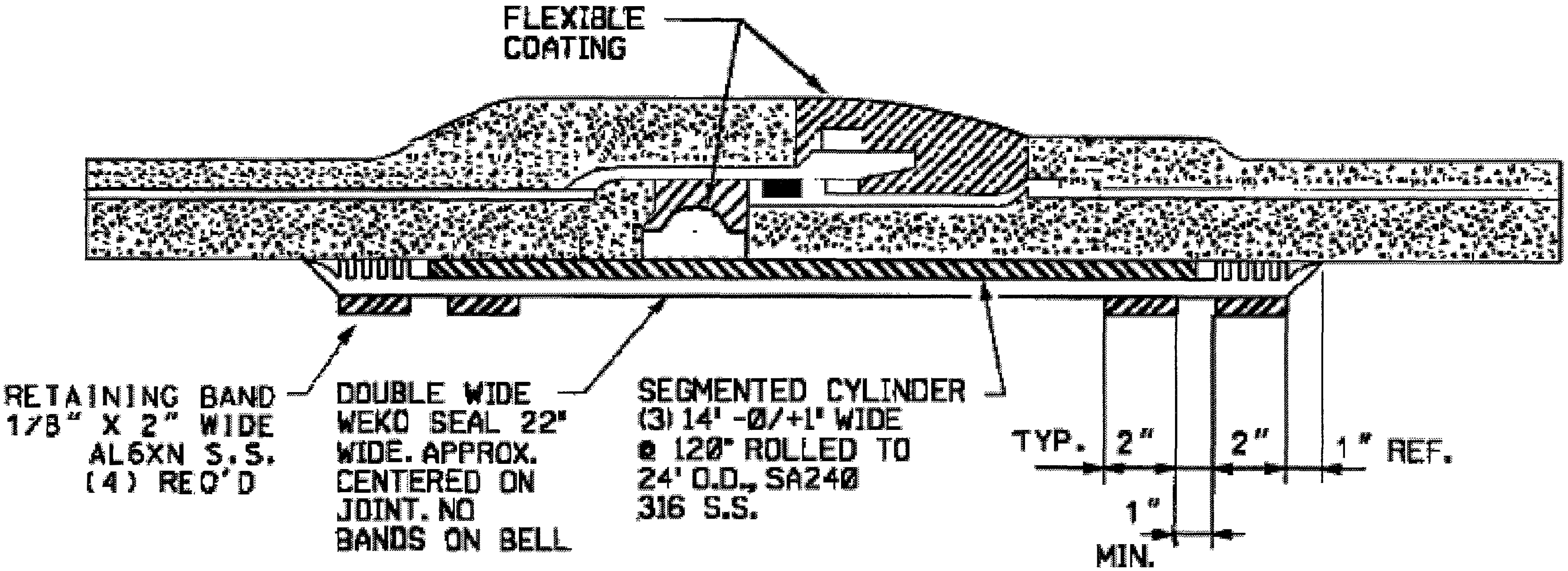


Figure 1. Detailed Drawing of WEKO Seal

Figures

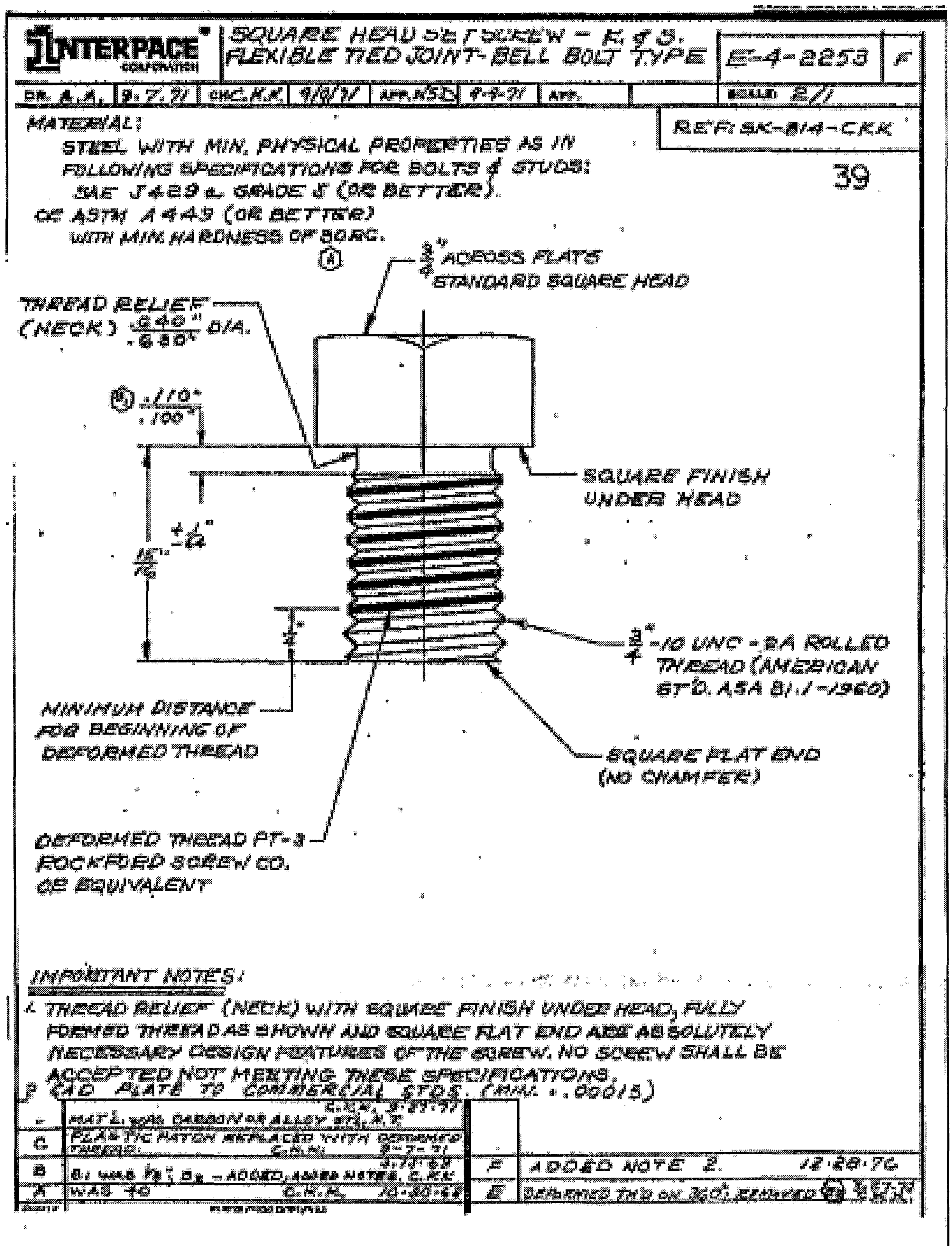
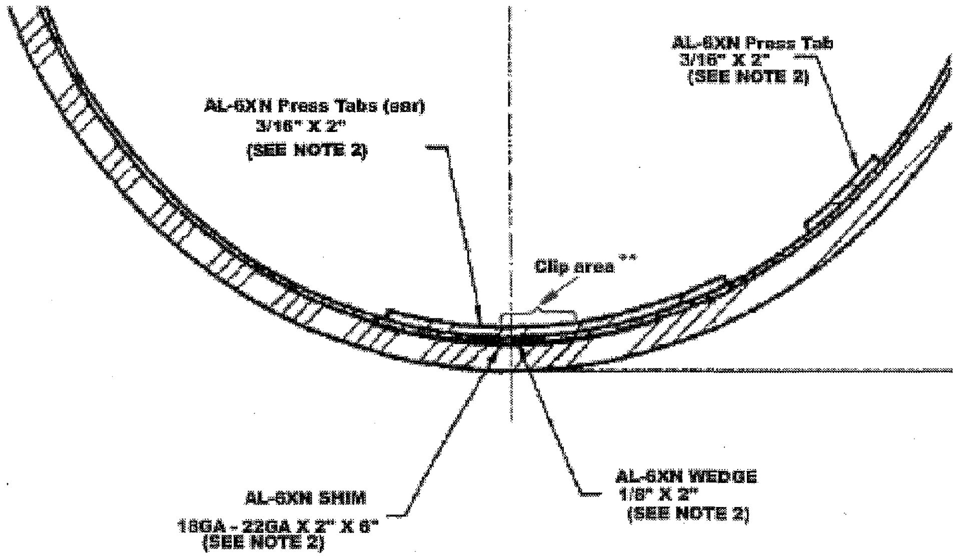


Figure 2. Detailed Drawing of Set Screws

Figures



NOTE 2:

Material specifications for all AL-6XN steel (5% Molybdenum Austenitic stainless steel) - (Bands, Push Tabs, Wedges, Shims and Test Valves).

AL-6XN materials can be modified (cut) on job to accommodate field conditions.

Liquid joint lubricant to assist in installation of the AMEX-10/WEKO seal and bands shall be a non-toxic vegetable based lubricating gel (i.e. Ease-On Pipe Lubricant or site approved equivalent).

** = See Steps 5.3.18 and 5.4.35 for clip referred to in this Attachment.

Figure 3. WEKO Seal Installation Details

Figures

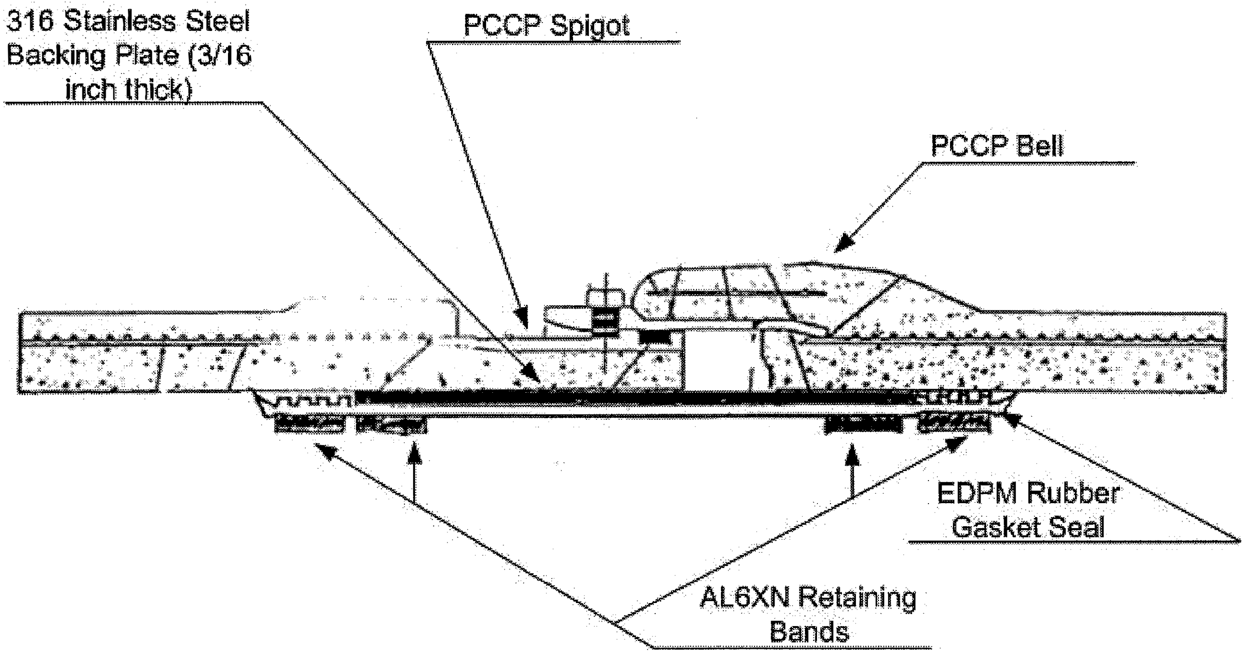


Figure 4. PCCP Joint with WEKO Seal (Typical)

Figures

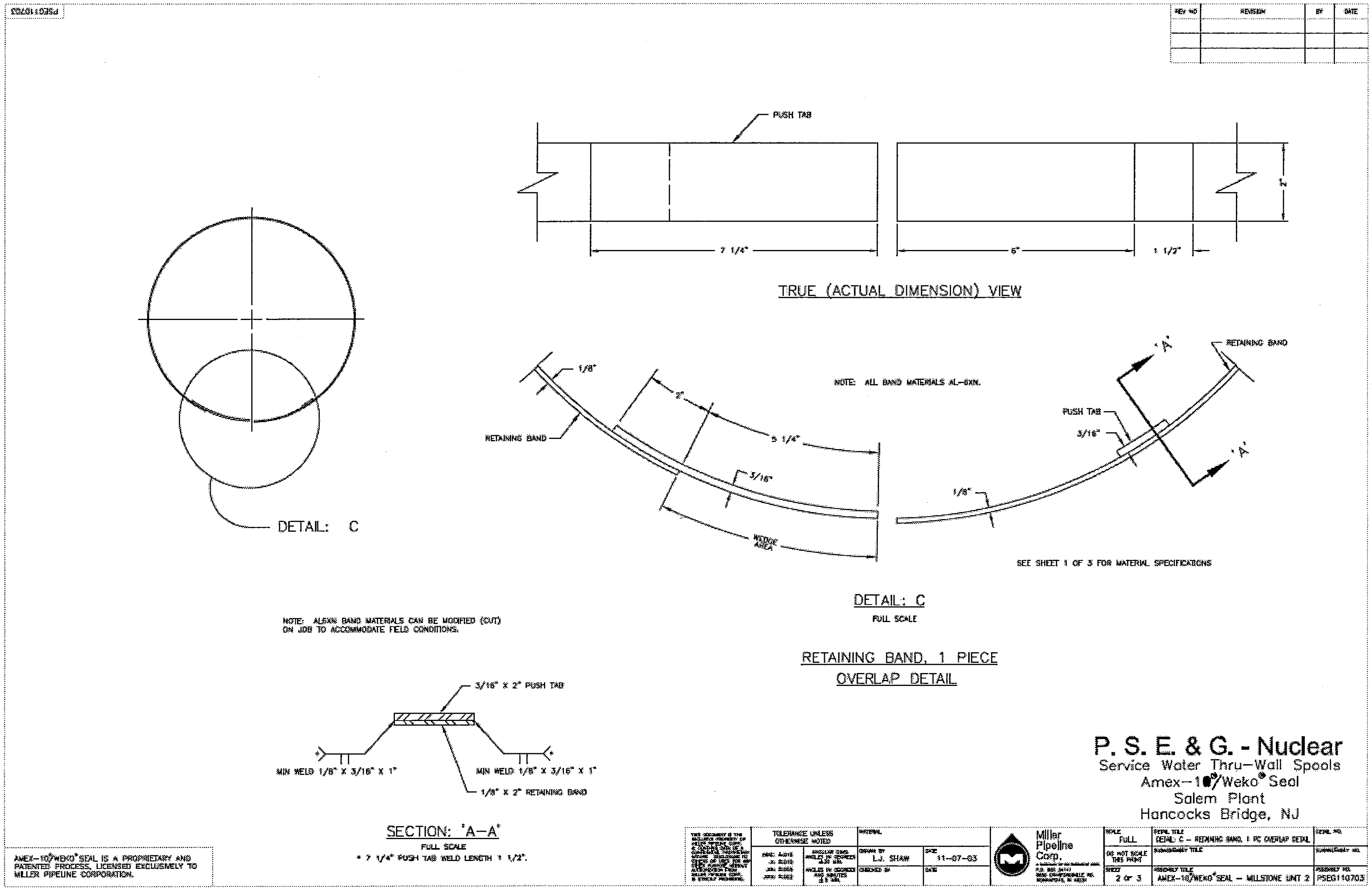


Figure 5. Push Tab Details