Conte, Richard

From: OHara, Timothy RI
Sent: Friday, April 23, 2010 7:08 AM
To: howard.berrick@pseg.com
Cc: Conte, Richard; Gray, Harold; Burritt, Arthur; Schroeder, Daniel; Tsao, John; Lupold, Timothy
Subject: Question On Unit 1 Past operability FEA

Howard,

Can you please let me know if the Unit 1 AFW piping degradation condition would have passed an FEA with the pressure at the plant design value of 1950 psia?

Additionally, has an FEA been completed on the 1" Control Air system piping failure on Unit 1?

Thanks.

Tim OHara

C/92

Gray, Harold

From:	Burritt, Arthur RI
Sent:	Friday, April 23, 2010 10:32 AM
To:	Balian, Harry; Cline, Leonard; DeBoer, Joseph; Douglas, Christopher; Ennis, Rick; Johnson, Jonathan; Kern, Ludwig; Miller, Ed; Moore, Ross; Patel, Amar; Raymond, William; Schroeder, Daniel; Turilin, Andrey; Welling, Blake
Cc:	OHara, Timothy; Conte, Richard; Gray, Harold; Cahill, Christopher
Subject:	Branch 3 Status - 4/23/10
Attachments:	B3-Status 4-23-10.doc

See attached

Key Salem AFW Next Steps:

NRC Next Steps:

- Confirm the PSEG risk assessment to delay AFW testing is reasonable - Cahill
- Confirm the finite element analysis for the unit 1 as found condition is acceptable including the use of appropriate methods and assumptions – Conte/O'Hara/HQ
- Confirm the technical evaluation that supports 1275 psig is bounding (including a faulted S/G scenario) – Hansell/Silk
- Evaluate the Unit 2 AFW extent of condition operability assessment (focus on the differences between Unit 1 & 2) – Schroeder/O'Hara
- Follow-up on the control air coating concern at the support clamp – O'Hara/Gray
- Evaluate ongoing AFW piping replacements on Unit 1 – O'Hara
- Evaluate repairs to the control air system on Unit 1 – O'Hara

AFW Information Needs

- Design records for as installed piping on Unit 1 & 2 (not found as of yet, still looking)
- Unit 1 AFW past operability assessment
- Unit 1 AFW as found condition finite element analysis
- Unit 2 AFW operability determination

**************Long Text Object Identification**************
Order 000070108698 Operation 0110
****

70108698 0110 Unit 1 AFW Past Operability Evaluation - Engineering

Title: Salem U1 Past Operability Buried AFW Pipe - Past Operability Determination

Reason for Evaluation / Scope:

As part of planned buried pipe inspections during the Salem Unit 1 refueling outage S1R20, guided wave inspection of the buried 4 inch Auxiliary Feedwater (AFW) piping that supplies the #12 and #14 steam generators identified localized wall thinning in several regions where more detailed examination was necessary. These piping regions were excavated and revealed significant external corrosion on the AFW buried piping. Straight beam ultrasonic measurements were then taken to determine the pipe wall thickness profile. The corrosion exceeded the design minimum wall criteria. This finally lead to excavating all the AFW buried pipe, which exposed general exterior corrosion and wall thinning affecting all of the buried AFW piping.

This evaluation reviews the impact in terms of past operability of the discovery of the non-conforming Salem Unit 1 AFW buried piping that was below design minimum wall thickness.

Background Information

The buried AFW pipes that connect to the #12 and #14 main feedwater lines in the outer penetration area (OPA) travel approximately 30 feet underground along the edge of the containment building before entering the OPA at elevations 94' 8" (#12) and 96' 2" (#14).

The piping is 4-inch NPS, Schedule 80, A106 Gr B seamless carbon steel. It is classified as Nuclear 3, Seismic Category I. Per the Pipe Specification S-C-MPOO-MGS-0001, SPS 54E, the system design Pressure-Temperature limit is 1950 psi at 140 F. The nominal wall thickness is 0.337 inches ± 12.5%.

Guided Wave inspections of the Salem Unit 1 AFW buried piping revealed regions of degraded pipe wall thinning. Follow-up excavations unearthed more piping showing heavy external uniform corrosion. The apparent cause of the corrosion was the improper application (or lack) of the specified pipe coatings, X-Tru-Coat, an adhered polyethylene protection system, and Bitumastic, which was specified per drawings and pipe specifications to be applied at the welded joints. Careful visual inspections of the excavated piping revealed a lack of coating. The only remnant of coating found was a portion of coal tar which was approximately 9 inches in length and 7 inches in circumference. This piece of coating was in the shape of the 4 inch AFW piping and conformed to that same profile.

Using the Guided Wave inspection results to target three specific areas (limiting measurements 12AF, 0.152 inch; 14AF, 0.160 inch; and 14AK, 0.166 inch wall) of buried AFW piping for excavation and examination, NDE Services initially performed confirmatory UT measurements on 378 grid areas. Approximately 76 percent of these UT measurements were non-conforming, having a minimum wall thickness less than the design minimum wall thickness of 0.278 inches. Based on these initial findings, the entire accessible portions of AFW buried pipe in Salem Unit 1 were excavated. A second set of UT measurements was then taken on a 1-inch by 1-inch grid for the full circumference of the pipe along the entire length of exposed AFW buried pipe (limiting measurement AF13T, 0.141 inch wall). The following numbers of UT readings were taken:

#14 AFW Line (Upper Pipe): 8,904 readings total. 1,194 are below 0.278"

#12 AFW Line (Lower Pipe): 8,852 readings total. 192 readings are below 0.278"

Finally a third sample set of UT measurements was taken of the bottoms of AFW buried pipe that rest on the construction aid supports (hangers), from which the overall worst case derived (14AF4T/14AF5T, 0.077 inch wall).

In summary, the worst case UT measurements, those having the least minimum wall thickness, were as follows:

For the #12 AFW buried piping, a 55 percent loss (0.152 inches).
For the #14 AFW buried piping, an approximately 78 percent loss (0.077 inches).

Removal of sections of the buried AFW piping in Salem Unit 1 during the S1R20 outage and subsequent visual examinations have validated that the identified corrosion is external.

Further examinations have also revealed evidence of the X-Tru-Coat on the through-wall portions of the buried AFW piping where it passes into the fuel transfer tube area (FTTA).

The coating system was not found on the remaining buried portions of these lines, which validates that the observed heavy general corrosion is due to a lack of coating.

The ground fill of the AFW piping is not a harsh environment (harsh with regard to coating), and there does not appear to be a correlation between the missing or deteriorated coating and the buried pipe environment.

Past Operability Evaluation

As part of the planned inspections of buried pipe, the Buried Pipe Program requested that the #12 and #14 Auxiliary Feedwater (AFW) buried piping be inspected during the Salem Unit 1 refueling outage 1R20. The buried AFW piping runs underground from the Mechanical Penetration to the Outer Penetration Area, passing alongside the west end of the Containment from north to south. [Dwg. 207483] The buried portions of AFW pipe are downstream of the AFW SG Level Control valves 12AF21 through 14AF21 for the motor-driven AFW pumps (MDAFPs) and the AFW SG Level Control valves 12AF11 through 14AF11 for the turbine-driven AFW pump (TDAFP) and are upstream of the 12AF23 through 14AF23 AFW SG Inlet Stop Check valves. [Drawing. 205236]

The minimum wall thickness (t_{min}) for the buried AFW pipe is governed by the ANSI B31.1, 1967 Edition, Power Piping code, Equation 104.1:

$t_{min} = PD / 2(SE+PY)$

$= 1950*4.5 / 2(15000+1950*0.4) = 0.278$ inches

Where pipe outside diameter (D) = 4.5 inches, design Pressure (P) = 1950 psi, and SE is the material allowable of 15000 psi for seamless pipe, and Y = 0.4 per the ANSI B31.1.

Because the buried AFW pipe is continuously supported, the deadweight and seismic loads are considered minimal. Therefore, the minimum wall thickness determined by using the design pressure is too restrictive with respect to determining operability. Instead, the Maximum Credible Operating Pressure (MCOP) was developed based on all AFW system operating conditions, and was used to evaluate t_{min} for the buried AFW pipe. Technical Evaluation 70108698-0100 determined that all AFW conditions that the MCOP for the buried Auxiliary Feedwater piping is conservatively bounded by 1275 psi. The corresponding minimum wall thickness based on a MCOP pressure of 1275 psi is 0.185 inches.

$1275*4.5 / 2(15000 + 1275*0.4) = 0.185$ inches using MCOP

The 0.185 inch minimum wall thickness was originally increased 12 mils to provide an allowance for an additional cycle of operation based on an assumed maximum corrosion rate of 8 mils per year. [Ref. NUCR 70103767] The intent was to replace any section of buried pipe that had a minimum wall less than 0.198 inches. In addition, all of the AFW buried piping, remnant and replacement, was to be re-coated before being buried again. However, as more UT measurements came in, it became clear that all of the buried AFW pipe should be replaced. DCP 80101382 was written to replace the inaccessible sections of AFW buried piping near and below the Fuel Transfer Tube and ECP 80101381 was written to replace the accessible portions of the AFW buried piping. Thus, all the AFW buried piping was replaced.

Additional UT measurements were taken from the bottom of the AFW buried pipe where it rested on carbon steel construction aides (hangers). These areas were added due to the inability of the Guided Wave technology to distinguish the boundary between the pipe and hanger metal and were thus suspect. During the inspection and UT measurements of these areas, the greatest pipe wall loss was discovered on the #14 AFW discharge line. A localized area having a minimum wall thickness measurement of 77 mils, the flaw was 0.25 inches in diameter and 0.75 inches in length before the surrounding pipe material increased to greater than 150 mils.

Upon discovery of these limited extreme localized areas of loss, Engineering requested Structural Integrity Associates, Inc. (SIA) to perform a rigorous Finite Element Analysis (FEA) of the AFW buried pipe using the most limiting cases (12AF, 14AF, 14AK, AF13T, and AF4T.AF5T) from the complete set of UT measurements. The SIA report, "ASME Code, Section III Design Analysis Evaluation of 4-inch Auxiliary Feedwater Piping," details the results of the FEA. The technical approach used was to assume that although piping may have localized thinned regions that violate the design t_{min} requirements, the non-uniform wall thickness of the pipe cross-section may still be shown to meet the design stress allowable. The approach is similar to the basis for qualifying pipe penetrations using branch reinforcement rules in the ASME Code and is possible for pipe sections exhibiting thinning when a remaining wall greater than t_{min} surrounds the thinning region. Note that the FEA did not use the Piping Specification SPS 54E design pressure for the piping but instead used the MCOP from Technical Evaluation 70108698-0100. An additional 35 psi was conservatively added to the MCOP at Design Engineering's request to provide operating margin.

The buried AFW pipe at Salem Unit 1 was designed to the t_{min} requirement given in the B31.1 Power Piping Code that does not provide specific criteria for evaluation of non-uniform wall thickness or thinning. However, guidance for stress analysis may be derived from the ASME Code, Section III, which can be used to supplement the B31.1 requirements.

Design requirements for Class 3 piping are provided in ND-3600 of the ASME Code, Section III, Division 1, 2004 Ed. Alternate methods are allowed under Section ND-3611.3, which permits use of a more rigorous piping design analysis such as NB-3200 to calculate stresses required to satisfy ND-3600 requirements. The calculated stresses must be compared to the allowable stresses in ND-3600. Thus to show acceptance of the degraded piping having a non-uniform pipe wall, the design loadings are determined using the design analysis methods in NB-3200. A finite element model is implemented incorporating the irregular pipe section profile defined by the UT thickness measurements. Current ASME Code allowable stresses are based on a factor of 3.5 on tensile strength instead of the factor of 4 as used in Salem's B31.1 Code of Construction.

Summary of Structural Integrity Associates (SIA) Finite Element Analysis Report

Per the ASME Code:

> *"The specific design requirements of ND-3600 are based on a simplified engineering approach. A more rigorous analysis such as described in NB-3600 or NB-3200 may be used to calculate the stresses required to satisfy these requirements. These calculated stresses must be compared to the allowable stresses in this Subsection. In such cases, the designer shall include the appropriate justification for the approach taken in the Certified Design Report."*

Thus, NB-3200 design by analysis is employed. Based on the linear-elastic finite element analysis results which showed that the thinned section of pipe (0.077 inch) was bounding, it was required to perform additional analysis only for that section of pipe in order to show operability. The more rigorous analysis employed is described in Section NB3228.1, Limit Analysis. Specifically Section NB-3228.1 states that limits on Local Membrane Stress

Intensity need not be satisfied at a specific location if it can be shown by limit analysis that the specified loadings do not exceed two-thirds of the lower bound collapse load. Also, NB-3228.1 states that the yield strength to be used in this calculation is 1.5 S_m. In this evaluation, the value of yield strength is equal to 1.5 S, where S is taken as the value of S_h, 15.0 ksi, from the original 1967 B31.1 Power Piping Code. Thus, a yield strength of 22.5 ksi is used.

The thinned section of pipe is modeled using the as-found wall thickness values for the region specified in S-TODI-2010-0005 which includes a minimum wall thickness of 0.077 inches. A pressure load of 1.5 times the PSEG specified operating pressure is applied (1943 psi = 1.5*[1310psia-14.7psi]) to the pipe per the more rigorous methodology to ensure that the operating pressure remains less than two-thirds of the failure pressure (1943 * 0.667 = 1295 psi).

The results of the finite element analysis show that the thinned pipe in this section remains structurally stable at 1.5 times the PSEG specified operating pressure and therefore passes the limit load analysis.

MPR's independent Review of SIA's Finite Element Analysis Report

MPR Associates was contracted to perform an independent, third party review of SIA's Finite Element Analysis that was performed to address external wall thinning of buried Auxiliary Feedwater (AF) piping at Salem Unit 1. The SIA calculation concludes that the degraded piping was operable prior to replacement during the current refueling outage. MPR's review focused on the approach, bases for assumptions and design inputs, and conclusions of the SIA calculation. MPR found the approach and conclusions of the subject calculation to be reasonable, and concur with the calculation conclusion that the degraded AF piping was operable prior to its recent replacement.

Extent of Condition

Because the Salem Unit 1 AFW discharge piping to the #11 and #13 steam generators runs from Containment to the Mechanical Penetration to the Pipe Alley to the Auxiliary Building, it is neither buried nor subject to the same corrosive environment as the AFW discharge lines to the #12 and #14 Steam Generators. The Buried Pipe Program inspection examined the Control Air (CA) and Station Air (SA) piping buried with the AFW pipe. A small pinhole leak was found in the CA pipe and was repaired to original condition. The overall condition of the CA and SA pipe was found with the protective coating intact and not degraded in the fashion as seen by the AFW pipe.

In operating Modes 5, 6, and Defueled, AFWS has no required safety function. The decay heat removal safety function is provided by the Residual Heat Removal (RHR) system. The AFWS does provide a means for refilling the secondary side of the SGs after eddy current testing and removal of the SG nozzle dams is complete. The secondary side water provides an additional heat sink in case of a loss of RHR cooling. In Mode 4 when RCS temperature is greater than 212°F but less than 350°F, the SGs can provide for decay heat removal if shutdown cooling is lost. Finally, in Modes 1 through 3, Technical Specification 3/4.7 Plant Systems, LCO 3.7.1.2, Auxiliary Feedwater System, requires at least three independent Auxiliary Feedwater pumps and their flow paths be operable to ensure that the RCS can be cooled down to a hot leg temperature less than 350°F in the event of a loss of offsite power (LOOP). This permits entry into the shutdown cooling mode of operation for the RHR system if RCS pressure is less than 340 psig.

Conclusions / Findings:

Despite being found in a degraded condition, the AFWS has always performed its safety and design functions in the past. No evidence has been found of a through wall flaw in the piping surveyed. The piping has maintained structural integrity during normal operation. The limiting design basis accident, the steam line break (SLB) inside containment event from which the MCOP pressure is derived, has yet to occur. The results of the SIA FEA support the conclusion that the generalized corrosion observed has not yet degraded the pipe wall below a minimum thickness that would make it inoperable or subject to failure. The system is degraded but operable. Per the SIA analysis, the existing AFWS #12 and #14 buried pipe is capable of operating for one more cycle if re-coated properly to ensure a minimal, near zero corrosion rate. MPR's independent Review of SIA's Finite Element Analysis Report on past-operability found the approach and conclusions of the subject calculation to be reasonable, and concurred with the calculation conclusion that the degraded AF piping was operable prior to its recent replacement.

Based on the above information it is concluded that there are no past operability concerns associated with Salem Unit 1 AFW piping found below minimum wall. This past operability evaluation shows that the operability concerns associated with Salem Unit 1 AFW piping found below minimum wall are unfounded. Therefore, there is no past operability concerns associated with the Salem Unit 1 AFW piping found below minimum wall. This evaluation was reviewed with Operations and Safety and they concur with the conclusions.

Reference Documents:

Technical Specifications Section(s):

T/S 3/4.7 Plant Systems, LCO 3.7.1.2, Auxiliary Feedwater System

UFSAR Section(s):

10.4.7.2, Auxiliary Feedwater System
15.2.8, Loss of Normal Feedwater
15.2.9, Loss of Offsite Power to Station Auxiliaries (LOP)
15.3.1, Loss of Reactor Coolant from Small Ruptured Pipes (SBLOCA)
15.4.1, Major Reactor Coolant System Pipe Ruptures (LBLOCA)
15.4.2, Major Secondary System Pipe Rupture (MSLB)
15.4.3, Major Rupture of Main Feedwater Line (FWLB)
15.4.4, Steam Generator Tube Rupture (SGTR)

Other:

Technical Evaluation 70108698, Rev. 0
ANSI B31.1, 1967 Ed., Power Piping
S-C-MP00-MGS-0001, SPS54, Rev. 6, Piping Schedule, Auxiliary Feedwater
S-C-AF-MDC-0445, Rev. 3, Auxiliary Feedwater System Hydraulic Analysis
S-C-A900-MDC-005, Rev. 0, Pipe Wall Thickness Calculations
SC.DE-BD.AF-0001(Q), Rev. 0, Auxiliary Feedwater System
[Structural Integrity Associates Calculation, "ASME Code, Section III, Design by Analysis Evaluation of a 4-inch Auxiliary Feedwater Piping" (draft provided under S-TODI-2010-0005)
SCI-94-877 LTR dated 12/16/1994 - Excavated Auxiliary feedwater Piping Walkdown/Disposition of Coating Requirements
MPR Associates to Mr. Mohammad Ahmed, "Review of Degraded AFW Piping Past-Operability Evaluation", dated 24 April 2010.

PREPARER: **Michael Crawford** — **Date: See SAP**
Robert Down — **Date: See SAP**

INDEPENDENT REVIEWER: **Gary Luh** — **Date: See SAP**

APPROVED: **Lane Oberembt** — **Date: See SAP**

Tech Eval prepared

**************Long Text Object Identification**************
Order 000070108698 Operation 0050 Confirmation 0008163337
Confirmation counter 00000001 Long text
****

Document #: 70108698-0050

TITLE: Maximum Pressure in Underground Auxiliary Feedwater Piping

REASON FOR EVALUATION / SCOPE:

Degradation was found in the underground Auxiliary Feedwater (AFW) piping prior to entering the Outer Penetration Area per Notification 20456999. This is the supply piping to 12 & 14 Steam Generators (SGs), downstream of the AFW pumps. This Technical Evaluation determines the maximum potential pressure in this piping for input into a subsequent evaluation on minimum wall.

DETAILED EVALUATION:

Auxiliary Feedwater Operation:

The AFW System provides flow to the SGs during plant cooldown and startup conditions for decay heat removal when the Main Feedwater (MFW) System is out of service. The AFW System also provides flow to the SGs during transient conditions such as Steam Line Break (SLB), Feedwater Line Break (FLB), Small Break Loss of Coolant Accident (SBLOCA), Loss of Normal Feedwater (LONF), Loss of Offsite Power (LOOP) and Station blackout (SBO). The system consists of two Motor Driven AFW Pumps (MDAFPs), each of which feeds two SGs, and one Turbine Driven AFW Pump (TDAFP), which feeds all four SGs. During plant cooldown and startup, operators manually control AFW flow via the AF21 control valves for the MDAFPs and via the AF11 control valves for the TDAFP. During transient conditions, the AF21 control valves are in automatic and control to maintain MDAFP discharge pressure; the AF11 control valves are full open.

The maximum potential pressure in the system would be with all the AFW pumps deadheaded. However, this is an unrealistic condition. The actual maximum system pressure is a function of the maximum potential SG pressure. Per Reference 3, the maximum SG pressure is assumed to be the lowest Main Steam (MS) safety valve setting (1070 psig - Reference 2) plus 3% accumulation, or 1102 psig (1117 psia).

The maximum system pressure would occur with all three pumps running on their design performance curves. Reference 3 provides a hydraulic analysis for the system transient conditions, using the AFW System hydraulic model. The SLB Inside Containment transient is analyzed with this pump alignment for two conditions - no failures and MDAFP runout protection failure, which is a failure of one of the AF21 valves to the full open position. The actual maximum pressure in a particular SG supply line would occur for a failure of an AF21 valve to the full closed position, which maximizes pressure in the SG supply line that remains aligned to the associated MDAFP. This condition was not analyzed in Reference 3 as the parameter of concern was maximum total SG flow. As such, additional cases were run with 11AF21 closed, to maximize pressure in the 12 SG supply piping (Case A), and with 13AF21 closed, to maximize pressure in the 14 SG supply piping (Case B). For conservatism and simplicity, it was assumed that the remaining AF21 valves are full open. In reality they would be throttled to maintain MDAFP discharge pressure; however, determining their position is an iterative and cumbersome process. Case 4 from Reference 3 Proto-Flo database S-C-AF-MDC-0445-R3.DBD was modified accordingly. The pressure in the underground piping is assumed to be that from the nearest upstream node in the model, which are the tie-ins between the MDAFP and TDAFP discharges in the Auxiliary Building. The resulting pressures at these nodes are 1259 psia (1244 psig) for 12 SG supply (Case A) and 1270 psia (1255 psig) for 14 SG supply (Case B). The Proto-Flo output reports are included as Attachments 1 and 2, respectively. 1275 psia

During normal plant cooldown and startup, it is unlikely all three AFW pumps would be running. Furthermore, the AF21s and/or AF11s are manually throttled to control cooldown rate and/or maintain SG level, which reduces the downstream pressure and thus the pressure in the buried piping. Therefore, this condition is bounded by the SLB transient condition with respect to pressure in the buried piping.

Auxiliary Feedwater System Testing:

MDAFP and TDAFP full flow testing to the SGs is performed per References 7 & 8 during each Refueling Outage. The highest pump discharge pressure occurs for the TDAFP test. The TDAFP discharge pressure was originally base lined at 1250 psig in 1998 (WO #960829007). Since then the TDAFP discharge pressure has varied been between 1235 and 1248 psig. These pressures are bounded by the limiting SLB Case from above (Case B, 13AF21 fails closed). Furthermore, similar to normal plant cooldown and startup, the AF21s and AF11s are manually throttled during testing to set the required flow, and so the pressure in the buried piping to 12 and 14 SGs would be even less. Therefore, full flow testing is bounded by the SLB transient condition. During quarterly surveillance testing (References 4-6), the AF21s and AF11s are closed, with flow going through the respective pump recirculation line, and thus is not applicable to this evaluation.

Main Feedwater Operation:

During normal plant operation, the MFW System provides flow to the SGs, and the AFW System is isolated from the SGs. During this condition, there is a potential for back leakage through the AF23 stop check valves, which are located just upstream of the AFW tie-ins to the MFW System. A leak check of these valves is performed quarterly per Reference 9. Trending of past test results finds no indication of significant leakage past these check valves. Test results found AFW line pressures typically around 25-30 psig with a MFW pressure of around 835-845 psig. A couple exceptions were for the test on 8/30/09, where the 12AF23 upstream pressure was 150 psig, and for the test on 3/1/10, where the 11AF23 and 12AF23 upstream pressures were about 115 psig. If these couple results were an indication of actual leakage, the AFW line pressure was still significantly below the MFW line pressure. Thus, even if the MFW System flow was low, with corresponding higher system pressure, the resulting AFW line pressure with any leakage past 12AF23 would still be very low compared to that with the AFW System in service.

CONCLUSIONS/FINDINGS:

The maximum potential pressure in the buried AFW piping during an accident is 1259 psia (1244 psig) for 12 SG supply and 1270 psia (1255 psig) for 14 SG supply. This occurs for a SLB Inside Containment transient with a single failure of an AF21 valve to the closed position, at the maximum potential SG pressure. For conservatism, the maximum operating line pressure in the buried AFW piping is set at 1275 psia

REFERENCES:

1. P&ID 205236, Revision 54, Unit 1 Auxiliary Feedwater

2. P&ID 205203, Sheet 1, Revision 77, Unit 1 Main, Reheat & Turbine By-Pass Steam

3. S-C-AF-MDC-0445, Revision 3, Auxiliary Feedwater System Hydraulic Analysis

4. S1.OP-ST.AF-0001, Revision 15, Inservice Testing - 11 Auxiliary Feedwater Pump

5. S1.OP-ST.AF-0002, Revision 16, Inservice Testing - 12 Auxiliary Feedwater Pump

6. S1.OP-ST.AF-0003, Revision 38, Inservice Testing - 13 Auxiliary Feedwater Pump

7. S1.OP-ST.AF-0005, Revision 11, Inservice Testing Auxiliary Feedwater Valves Mode 4-6

8. S1.OP-ST.AF-0007, Revision 19, Inservice Testing Auxiliary Feedwater Valves Mode 3

9. S1.OP-ST.AF-0006, Revision 10, Inservice Testing Auxiliary Feedwater Valves

10. UFSAR Section 10.4.7.2, Auxiliary Feedwater System; Section 15, Accident Analysis

ATTACHMENTS

1. Case A Proto-Flo Ouput Reports: SLB Inside Containment with 11AF21 Failing Close
2. Case B Proto-Flo Ouput Reports: SLB Inside Containment with 13AF21 Failing Close

NOTE: The complete Technical Evaluation, including attachments, has been submitted to Records Management, Document Number 70108698.

CO-PREPARER: Kevin King Date: See SAP

INDEPENDENT REVIEWER: Michael Crawford Date: See SAP

APPROVED: Alan Johnson Date: See SAP

An Assessment of "ASME Code, Section III, Design by Analysis Evaluation of a 4-inch Auxiliary Feedwater Piping" for Salem Generating Station, Unit 1.

Background

The licensee identified localized wall thinning in several regions of the buried auxiliary feedwater (AFW) piping at Salem Generating Station, Unit 1, based on the guided wave technology. The licensee excavated the affected piping regions and found significant external corrosion. Subsequently the licensee inspected the affected piping segments using straight beam ultrasonic testing to determine the pipe wall thickness. Several measurement locations showed pipe wall thicknesses less than the design minimum wall thickness. The licensee performed stress calculations to demonstrate that the degraded AFW piping still meets allowable stresses of the ASME B31.1 Code of Construction and that the piping was operable during past operation.

Discussion

Under ASME Section XI, a planar or laminar flaw is dispositioned by the acceptance standards of IWB-3515. If the flaw is within the acceptance standards of IWB-3515, the flaw can be left in service. If the flaw exceeds IWB-3514, the flaw may be accepted by analysis of IWB-3600 followed by 3 successive examinations. A pipe that contains a flaw that exceeds IWB-3600 will need to be repaired or replaced. The ASME Code, Section XI, is stringent in that it minimizes flaws from growing uncontrollably to rupture. A pin hole leak that is caused by wall thinning, in general, does not lead to pipe rupture [I believe that a pipe rupture is defined as when the leak rate from a crack is so large that the pump cannot provide sufficient makeup to achieve the intended function of the pipe]. Salem's AFE pipe degradation mechanism is wall thinning.

The ASME Code, Section XI, does not have requirements for analyzing wall thinning condition except in Code Case N-513-2. However, N-513-2 is not applicable to high energy line such as AFW line.
Code Case N-561-2, Alternative Requirements for Wall Thickness Restoration of Class 2 and High Energy Class 3 Carbon Steel Piping, provides guidance for high energy Class 3 piping. However, the NRC has not approved N-561 in Regulatory Guide 1.147, Revision 15.

Therefore, the licensee used the rules of the ASME Section III to satisfy 10 CFR 50.55a. Under the ASME Code, Section III, the same pipe would not need to be repaired as long as the pipe satisfies the allowable stresses of NB-3200 or NB-3600. The AFW piping is ASME Class 3 pipe and should follow the rule of ND-3000 for piping design. However, the licensee selected the rules of Class 1 piping, (i.e., NB-3200 and/or NB-3600) because rules in NB-3000 provide more detailed analysis procedures and allowables.

The licensee analyzed five pipe segments, 12AF, 14AF, 14AK, AF13T, AF4T/AF5T. The resultant stresses are shown on Pages 11 to 13 and page 16 of the report. As shown on those pages, each of the pipe segments has certain locations that exceed the allowable stresses. However, when the licensee linearized the stresses in all the nodes in the model and calculated a single stress, the linearized stress for each of the pipes is within the allowable as shown in Table 1 (page 8). In other words, even though localized stress at certain node in each of the pipes exceeds the allowable stress, the overall (global) stress of each of the pipe are within the allowable.

The licensee did not use the as-found pipe wall thickness (the thinnest wall thickness) for the entire pipe in calculating the stresses. For example, the licensee did not use 0.077 inch to calculate the stress for the entire pipe segment. Instead, the licensee used the as-found wall thickness (0.077 inch) to calculate the local stresses at the node (location) where the wall thinning was found. For other nodal points of the pipe, the licensee used the nominal thickness or as-found pipe thickness at those nodes which may not be degraded. Although some pipe locations have severe wall thinning degradation, the licensee was able to demonstrate that the structural integrity of the pipe as a whole is acceptable.

Conclusion

The staff finds that the degraded AFW piping satisfies the requirements of ASME Code, Section III, NB-3213.10, NB-3221.2, and NB-3228.1. However, the staff concludes that the subject AFW piping is operable but degraded.

Recommendations

1. Page 4, last paragraph. The licensee stated that the worst wall thickness is 0.077 inch. Confirm that the minimum allowable pipe wall thickness is 0.190 inch as shown on page 5, second paragraph.

2. The stress analysis needs to include detailed pipe wall thickness measurements in all 5 subject AFW pipes so that the reviewer can understand the extent of the wall thinning.