December 3, 1986

Docket No. 50-313

LICENSEE: ARKANSAS POWER AND LIGHT COMPANY FOR ARKANSAS NUCLEAR ONE, UNIT 1

SUBJECT: SUMMARY OF MEETING OF NOVEMBER 20, 1986, WITH AP&L CONCERNING THE WELD DEFECTS IDENTIFIED DURING THE ISI OF "A" REACTOR COOLANT PUMP CASING

Introduction

At our request the staff held a meeting with Arkansas Power and Light Company (AP&L) to identify the information which the staff needed to resolve the RCP casing weld flaw issue on "A" RCP and "B" RCP for Arkansas Nuclear One, Unit 1 (ANO-1) and to review the radiographs of the weld defects identified in "A" & "B" RCP casings. The meeting was held at the ANO-1 site on November 20, 1986. Enclosure 1 identifies the attendees of the meeting. In parallel and independent of this meeting, upon the licensee's request, the project manager allowed selected AP&L personnel to read a draft safety evaluation of the OTSG tube sleeving issue. Enclosure 2 is the draft SE of the OTSG tube sleeving issue which was made available for reading by the licensee.

Background

During the current refueling outage for ANO-1, Arkansas Power and Light Company disassembled and inspected "A" Reactor Coolant Pump in response to their commitment to perform inspections of the RCP shafts and impeller cap screws and torque pins. With the rotating assembly of the pump removed from the pump casing, the licensee performed the 10-year inservice inspection of the pump casing. Radiography of one vertical weld in the pump casing showed a weld defect about six inches long, which exceeded both fabrication and inservice acceptance standards. On comparing the radiograph with a computer enhancement of the original radiograph of this weld, the licensee determined that the weld defect has been in the pump casing since the initial operation. Further, the weld defect has not changed. The licensee has also reviewed a computer enhancement of the original radiograph of the welds of RCP "B" and discovered a defect. The ASME Code does not address a situation such as described. The Code would assume that an unacceptable preservice defect would be removed. The Code specifies actions required for inservice discovered defects which include analyses of the weld defects and augmented inspection plans for the affected pumps and the other pumps. The licensee has submitted fracture mechanics analyses of the "A" and "B" pump weld defects, but did not identify the defects as inservice defects and thus did not propose additional action. The staff has indicated that the flaws must be considered inservice discovered flaws and the Code provisions followed for inservice identified flaws. The staff meeting with the licensee on November 20, 1986, was intended to view the radiographs and other techniques for examining the welds and to discuss what is further needed by the staff to resolve this issue before startup of ANO-1, which is currently planned for December 2, 1986.

Discussion

The licensee was requested to submit on Monday November 24, a submittal which would include the following:

1. The UT techniques which were applied to "A" RCP
2. Supplements to the fracture mechanics analyses for "A" & "B" RCPs.
3. The UT techniques which were applied to "B" RCP
4. A discussion of what was done on the inspection of "A" & "B" RCPs.
5. Description of an augmented inspection plan for "A" RCP casing.
6. A request for relief from inspecting the "B" RCP casing as required by the ASME Code. The licensee will propose another method and schedule of inspecting the "B" RCP casing which would consist of UT or other techniques which would be acceptable for ISI examination without dissassembly of the pump.

The licensee submitted a letter on November 24, 1986, which covered the the issues discussed at the meeting of November 20, 1986 and can be used as a reference for this summary of the meeting.

The radiographs of the "A" RCP casing welds of the concerned area were reviewed and the staff confirmed the conclusions of the licensee concerning whether the flaws were preservice or inservice. The staff also reviewed the preservice radiographs of the "B" RCP casing weld in question and confirmed the conclusions of the licensee regarding this weld. The staff concluded that the licensee characterized the welds properly. The licensee did not grind smooth the area for UT examination since the weld areas had been ground and appeared to be smooth enough for good UT examination. Of 212 radiographs of RCP casing welds, the licensee examined 45 which previously showed indications or the density of the film indicated a need. The examinations consisted of computer enhanced techniques as was done on the welds of concern. The staff requested a 100% computer enhancement of the "B" RCP casing welds. The RCP casings were all static cast by Byron Jackson in their plant in New York.

The licensee determined that they needed relief from the requirements of the inspection of the "B" pump but would comply with the Code with regards to the requirements for "A" pump. A fracture mechanics analysis in compliance with the Code would be submitted for "B" pump weld defect. This was acceptable by the staff.

Guy S. Vissing, Project Manager
PWR Project Directorate #6
Division of PWR Licensing - B

Enclosures: As stated

See comments to be included

PWR#6	PWR#6	PWR#6	AD:PWR-B	PWR#6
GVissing	CMcCracken	GEdison	DCrutchfield	JStolz
12/1/86	12/1/86	12/2/86	12/3/86	12/4/86

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Enclosure 1

ATTENDANCE LIST
FOR MEETING WITH ARKANSAS POWER & LIGHT
CONCERNING RCP CASING WELD FLAW ISSUE
NOVEMBER 20, 1986

Name	Organization
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L. B. Marsh	NRR/PWR-B/EB
R. J. Wright	NRR/PWR-B/EB
C. Y. Cheng	NRR/PWR-B/EB
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Ray Reamey	AP&L/Welding Engineer
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Mike Hocker	B&W Nuclear Power Div.
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J. E. Cavender	Duke Power Company
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L. D. Gilbert	NRC RIV
W. D. Johnson	NRC SRI
Dan Howard	AP&L/ANO Sp. Projects
George Woerner	AP&L/Nuclear Engr
Dan Spond	AP&L/L. Rock
Bickie Cocanougher	AP&L/ANO Sp. Projects

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

DRAFT

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

SUPPORTING AMENDMENT NO. TO FACILITY OPERATING LICENSE NO. DPR-51

ARKANSAS POWER AND LIGHT COMPANY

ARKANSAS NUCLEAR ONE, UNIT NO. 1

DOCKET NO. 50-313

1.0 INTRODUCTION

By letter dated April 1, 1986, Arkansas Power and Light Company (AP&L or the licensee) requested amendment to the Technical Specifications (TSs) appended to Facility Operating License No. DPR-51 for Arkansas Nuclear One, Unit No. 1 (ANO-1). Supporting information was provided by letters dated August 22, October 14 and October 23, 1986. The proposed amendment would (1) allow the sleeving of steam generator tubes and (2) modify the designation of those areas identified as special groups in the steam gererators where imperfections have previously been found. The licensee plans to conduct steam generator tube sleeving in ANO-1 prior to startup for Cycle 8 operation which is planned for early December 1986.

2.0 BACKGROUND

As a result of degradation in the ANO-1 Once Through Steam Generators, (OTSGs) a substantial number of tubes with eddy current indications in excess of the 40% through-wall plugging limit have been removed from service. The suspected mechanism affecting the tubes in the upper tube sheet (UTS) region is intergranular attack (IGA) caused by concentrated chemical contaminants which have been carried by moisture in the steam flowing up through the tube lane region.

The lane region is cooler than the surrounding area due to reduced heat flux and flow resistance. Therefore, more moisture is in the steam in this region. The contaminants carried by this moisture are deposited in the upper tube sheet region. Plugging the tubes in the lane region increases the area of reduced heat flux, thereby increasing the number of tubes affected by moisture in the steam. This aggravates the condition by increasing the amount of contaminants carried by the steam and deposited on the tubes in the UTS region.

To address this problem, AP&L initiated a Steam Generator Integrity Program in 1983. The goal of this program is to identify and initiate changes which will assure that the existing OTSGs can be used for the life of the facility without increased risk to the health and safety of the public or reduction in the unit's performance.

One portion of this program is a Steam Generator Sleeving Qualification

(Proprietary information removed)

Draft

Program which would provide sufficient justification to allow a large-scale sleeving program at ANO-1. The installation of sleeves in the affected tubes should decrease the lane region degradation rate by preventing additional loss of heat transfer area. In addition, the sleeve material has better corrosion resistance than the original tubes. This Qualification Program, which consists of the tests and analyses and development of general design criteria for the Babcock & Wilcox (B&W) OTSG sleeves, is contained in B&W report BAW-1823P, "Once-Through Steam Generator Mechanical Sleeve Qualification." Our evaluation of this report (Reference 2) which included the following areas, was completed in November 1984.

1. Leak-tight integrity
2. Pullout strength of sleeves
3. Joint expansion tests
4. Flow-induced vibration effects
5. Effect of sleeve installation on adjacent sleeves
6. Thermal/hydraulic effects of sleeving
7. Structural and functional integrity of sleeves and compliance with ASME Code requirements

Based on this review, staff found the licensee's sleeve/tube qualification program acceptable for a proposed demonstration sleeving of ten tubes at ANO-1. However, additional tests were recommended prior to approval of large scale sleeving. These additional tests were reported by the licensee in the present submittal (Reference 1) and are addressed in this evaluation. The licensee has also included B&W Report BAW-1832P, reviewed earlier as stated above, with the present submittal.

3.0 EVALUATION

3.1 Effect Of Corrosion On The Sleeved Joint

Corrosion propagation during normal operation due to increased residual stress and during wet lay-up were investigated on a mechanically sleeved ANO-1 OTSG tube.

To perform this test, a specimen was fabricated from a portion of a tube pulled from the ANO-1 B-OTSG in January 1983 on which IGA was observed. The specimen was fabricated using the process developed for field installation. The specimen was exposed in an autoclave at approximately [ ] to an environment that contains [ ] the typical feedwater contaminants concentrations. A tensile load of approximately [ ], and an internal pressure of about [ ] was placed on the expanded joint for the 2000 hour duration of the test. Upon completion of this phase of the test, one of the two expanded joints was removed for metallurgical examination while the other joint was replaced in the autoclave in wet lay-up conditions for 500 hours. This joint was then removed from the autoclave and metallurgically examined with a scanning electron microscope for evidence that the existing IGA had not progressed during the testing.

Examination of test specimens showed that the depth of IGA in specimens removed from the autoclave for operational and wet lay-up simulation was the same as was found in the specimens prior to the test. This test in conjunction with information previously reported, shows that corrosion propagation is not likely to increase significantly in the rolled joint during normal operation and wet lay-up. Other slower corrosion mechanisms such as corrosion due to cyclic stresses are not likely to be aggravated by the sleeving process. The ten demonstrated sleeves installed earlier will be monitored closely to provide an advance warning of possible corrosion propagation due to unforeseen mechanisms.

Additional data on the effects of roller expanding sleeves inside OTSG tubes affected by intergranular corrosion on the outer surface was obtained by B&W on contract to AP&L. The ANO-1 tube samples, each [ ], were cut from a previously pulled ANO-1 tube. The samples were obtained from a portion of the tube adjacent to an area known to have IGA present on the outer tube surface.

The inner surfaces of the tube samples were chemically decontaminated to eliminate the need for rolling under hot cell conditions. [ ] and the IGA categorized for post rolling comparisons. Upon completion of the tube [ ] decontamination, a sleeve was roll expanded into each tube sample to the maximum qualified expansion. The tube samples were examined by eddy current testing (ETC), diameter measurements, metallography and scanning electron microscopy both prior to and after roller expanding a sleeve to characterize the effects of sleeve installation on existing IGA. [ ]. The data obtained from this test served as the baseline for comparison to the corrosion test discussed earlier.

In addition to these B&W corrosion tests, Westinghouse also performed tests for AP&L on actual ANO-1 tubing to determine the effects of two different types of sleeving processes. To accomplish this, a detailed characterization of the existing conditions was performed on tubing removed from the ANO-1 OTSGs. The characterization included non-destructive examinations (NDE), analysis of [ ] deposits, microexamination and sensitization testing. Sleeving was then performed using both mechanical and braze processes. The mechanical process used by Westinghouse, although not exactly like that used by B&W, is very similar. After each step in the sleeving process, the outer surface of the tube was examined and photographed. From their observation, it was determined that the sleeving process did not widen any IGA areas, such as to make them detectable by eddy current, radiography, or visual inspection.

Residual stress measurements, determined by [ ] testing, were performed on Westinghouse brazed sleeves and on Westinghouse mechanically expanded sleeves using ANO-1 OTSG tubing. It was verified that the tube [redacted] residual stresses from roller expansion and brazing process are significantly low and are considered acceptable for a sleeve design.

3.2 Sleeves Installed on Degraded Tubes

The licensee performed tests to determine whether mechanical sleeves installed in the free span of OTSG tubes which have as much as [redacted] degradations have a reasonable chance of satisfying the qualification program requirements for strength and leak tightness.

This was a simplified test which used OTSG tube specimens which had been machined to [redacted] to represent tubing with [redacted] IGA. Two high yield [redacted] tubes were each sleeved by rolling [redacted] in the free span and the assemblies were subjected to incremental axial loads while the joint slippage and leakage under 1600 psi internal pressure were measured.

Ultimate failure of the first of the two specimens tested occurred in the thin portion of the tube at [redacted]. This indicates that the sleeve joint is stronger than the tube and both can withstand the maximum axial load of [redacted]. which would result from accident conditions. The second specimen did not fail at an axial load of [redacted]., but was not pulled to failure.

The first specimen had a maximum leakage of [redacted] at normal operating conditions. Ten thousand of these joints would total [redacted], less than [redacted] of the 1.0 gpm Technical Specification limit. At accident conditions the leakage would increase to about [redacted] of the Technical Specification limit.

The leakage from the second specimen was unusually high at normal operating conditions, decreased and then increased at accident loads. The roll in this specimen was found to be defective and the data from this specimen was disregarded.

3.3 Inspectability and Plugging Limit for Sleeves

Even with the state-of-the-art ECT techniques, the inspection of the rolled transition zones where the sleeve/tube joints are made and the parent tubes at the sleeve's lower end, is difficult. The ability to detect [redacted] through-wall defects in all regions of the sleeve and parent tube has been demonstrated using existing ECT techniques. The ability to detect [redacted] through-wall penetrations has been demonstrated for all regions of the sleeve/tube combination with the exception of the tube at the sleeve end. The large signal produced by the inner diameter transition at the end of the sleeve masks the signal for the [redacted] through-wall tube inspection.

The licensee performed calculations to determine the minimum acceptable wall thickness for degraded sleeves (Reference 3). They have proposed a plugging limit of 40% for both tubes and sleeves. Staff has reviewed these calculations and finds the 40% limit acceptable for all defects with the exception of circumferential cracks.

The minimum acceptable wall thickness for degraded sleeves was determined in accordance with the allowable stress and pressure limits of ASME Section III and NRC Regulatory Guide 1.121. Primary membrane stress, burst pressure, and fatigue analyses were considered for normal operation, and primary membrane stress, burst pressure, collapse pressure, and primary membrane plus bending stresses were considered for postulated accident conditions. In addition, primary plus thermal stresses were evaluated.

The minimum sleeve wall thickness was calculated for these eight different acceptance criteria. For the expected type of defects, the limiting required minimum wall was found to be 0.0131 inch. This thickness is necessary to resist collapse under the external pressure resulting from a LOCA and represents 30% of the original [ ]. Thus, a [ ] or greater through-wall defect would require that a sleeve be removed from service. This compared to a [ ] defect limit for the OTSG tubes. It is to be noted that allowances for ECT uncertainty and possible tube degradation between inspections have to be incorporated into these values to obtain the plugging limit specified in the Technical Specifications.

The sleeve must be bent and straightened for installation in the outermost OTSG tubes. This results in a slightly elliptical cross section, which was evaluated for buckling pressure. The maximum expected ovality (i.e., difference in extreme ODs at any one cross section) was found to be [ ] based on sample dimensions. The critical external pressure depends on the material yield strength. For material with yield strength of [ ], the critical external pressure is [ ] for the sleeve and [ ] for the tube, indicating that the sleeve can sustain about [ ] times the external pressure of the tube. Under the maximum secondary pressure of [ ] with no primary pressure, neither tube nor sleeve would collapse. In the event water gets trapped between the OTSG sleeve and tube, the sleeve would become more elliptical or distort into a [ ] cross section with each successive heatup to accommodate the increased water volume. Continued one-way leakage, although unlikely, would eventually leave the sleeve subject to collapse in the event of a sudden loss of primary pressure such as a LOCA. However, the annular pressure increase is more likely to blow out the corrosion products which plugged the leak than to collapse the sleeve. Thus, the likelihood of sleeve collapse is very small.

The reduced section modulus of the expanded region has only a minor impact ( ] the minimum wall thickness requirement from [ ] for the unexpanded sleeve to [ ] for the roller expanded portion of the sleeve for the accident loads associated with a Main Feedwater Line Break plus Safe Shutdown Earthquake). The analysis shows the minimum wall thicknesses necessary to resist collapse under the external pressure resulting from a LOCA (limiting event) are [ ] for the unexpanded portion of the sleeve and [ ] for the roller expanded portion of the sleeve. Both of these values correspond to a [ ] through-wall defect.

The sleeve wall thickness required to satisfy the primary plus thermal stresses during postulated accident conditions also results in a sleeve wall thickness requirement of about 30% wall thickness for all defects except circumferential cracks. To account for thermal loads, defect limits were based on B&W tensile tests (Reference 4) in which tube specimens with machined defects were pulled to failure by tensile fracture. Staff evaluation of this test data indicates that defects including axial cracks [ ] through-wall would satisfy the acceptance criteria. However, circumferential cracks [ ] in extent and of the same depth might result in tube failure. In fact, much shallower circumferential cracks fail to meet the criteria. In addition, there is a greater propensity for crack propagation and tube failure due to flow-induced vibration in this region. For these reasons, and due to the uncertainties in sizing defects between [ ] in the entire sleeve/parent tube region as discussed earlier, the staff has taken the position that detection of any circumferential crack in the sleeves would require plugging of tubes. While the licensee's submittal does not explicitly state this, it is our understanding based on telephone conversations with the licensee that all tubes/sleeves with circumferential cracks will be plugged.

3.4 Impact Of Sleeving On The ANO-1 FSAR Safety Analyses

The licensee (AP&L) has reviewed the impact on the ANO-1 FSAR safety analyses of sleeving 5,000 tubes per steam generator. The sleeving results in a slight reduction in heat transfer due to the air gap between the sleeve and the steam generator tube. There is also a small increase in the primary side pressure drop through the steam generator due to the smaller tube diameters in the sleeved tubes. Analysis by AP&L has also shown that the effect of installing 5,000 sleeves in each generator would be a reduction in steam superheat temperature of approximately 7.7°F at full power and a reduction in primary flow of less than 1%. This reduction in superheat requires an additional 1% full feedwater flow in order to remove the same amount of primary energy.

For overcooling events, the FSAR analysis assumed that the feedwater flow increased during the event in order to conservatively increase the heat removal by the steam generator. Therefore, sleeving does not impact the safety analysis since the heat removal due to a 1% increase in feedwater flow is conservatively bounded by the heat removal rates assumed in the analysis of overcooling events.

For some overheating events such as the loss of main feedwater, the FSAR analysis assumed that the heat transfer in the steam generator is significantly reduced. The slight reduction in heat transfer coefficient along the sleeved tubes is much smaller than the reduction assumed in the FSAR analysis and, therefore, does not impact the analysis assumptions. Other overheating events which are initiated in the primary system, such as the control rod withdrawal event, are not affected by sleeving since the initial heat transfer rate is held constant throughout the event and overall total steady state steam generator heat transfer is unaffected by tube sleeving.

Previous generic evaluations of the effect of steam generator tube plugging have shown that there is a negligible impact on LOCA results due to a 2.5% reduction in RCS flow. The licensee has indicated that a similar magnitude of tube sleeving would result in only a 1% reduction in RCS flow. Therefore, the generic LOCA analysis accounting for tube plugging conservatively bounds that which accounts for tube sleeving. The licensee has also specifically considered the concern of steam binding in the steam generator affecting the reflood phase of the large break LOCA and has found no impact due to tube sleeving.

Plant procedures require AP&L to measure primary system flow at the beginning of each fuel cycle to verify that the actual flow is in excess of that assumed in the plant safety analyses. These procedures also contain surveillance requirements to monitor primary flow several times per day. Therefore, any flow degradation due to sleeving would be detected to ensure that the existing plant safety analyses remain valid and bounding.

3.5 Conclusions

Review of the additional corrosion tests performed by the licensee shows that corrosion propagation is not likely to increase significantly in the rolled sleeve joint during normal operation and wet lay-up. Other slower corrosion mechanisms such as corrosion due to cyclic stresses are also not likely to be aggravated by the sleeving process. The tube residual OD stresses from rolled expansion and brazing process are low and are considered acceptable for a sleeve design.

The results of the licensee analysis indicate that the minimum required sleeve wall for normal and accident conditions is [inch which permits sleeve defects less than [through-wall. Licensee analysis is in compliance with the requirements of ASME Code Section III and NRC Regulatory guide 1.121. Allowing an additional margin of 10% for continued degradation and 20% for uncertainty in eddy current measurements, the licensee's proposed 40% plugging limit for sleeves is acceptable for all defects with the exception of circumferential cracks. Any detectable circumferential crack in the tube/sleeve region would require plugging of the tube.

Based on a review of the results of the supplemental corrosion tests, sleeve plugging analyses and the sleeve tube qualification program reviewed earlier, the staff finds sufficient justification to allow a large scale sleeving program at ANO-1.

Based on the above evaluations, the thermal-hydraulic effects of sleeving up to 5,000 ANO-1 steam generator tubes with 80-inch long sleeves per generator will have a minimal and acceptable effect on plant operation and the existing FSAR safety analyses will continue to bound normal and abnormal plant conditions.

4.0 ENVIRONMENTAL CONSIDERATION

This amendment involves a change in the installation or use of a facility component located within the restricted area as defined in 10 CFR Part 20. We have determined that the amendment involves no significant increase in the amounts, and no significant change in the types, of any effluents that may be released offsite, and that there is no significant increase in individual or cumulative occupational radiation exposure. The Commission has previously issued a proposed finding that this amendment involves no significant hazards consideration and there has been no public comment on such finding. Accordingly, this amendment meets the eligibility criteria for categorical exclusion set forth in 10 CFR 51.22(c)(9). Pursuant to 10 CFR 51.22(b), no environmental impact statement or environmental assessment need be prepared in connection with the issuance of this amendment.

5.0 CONCLUSION

We have concluded, based on the considerations discussed above, that: (1) there is reasonable assurance that the health and safety of the public will not be endangered by operation in the proposed manner, and (2) such activities will be conducted in compliance with the Commission's regulations and the issuance of this amendment will not be inimical to the common defense and security or to the health and safety of the public.

Dated:

Principal Contributors: J. Rajan, G. Vissing, L. Kopp

REFERENCES

1. Letter from T. Gene Campbell, AP&L, to J. F. Stolz, NRC, requesting Technical Specification change to allow steam generator tube sleeving, dated April 1, 1986.

2. Letter from John F. Stolz, NRC, transmitting Amendment No. 86 to Facility Operating License No. DPR-51 for Arkansas Nuclear One, Unit 1, to Mr. John M. Griffin, AP&L, dated November 3, 1984.

3. B&W Report 32-1147602-02 "177 OTSG Tube/Sleeve Loads," in support of the 40% plugging criteria submitted as attachment to letter from J. Ted Enos, AP&L, to J. F. Stolz, NRC, dated October 14, 1986.

4. Letter from J. Ted Enos, AP&L to J. F. Stolz, NRC, dated October 23, 1986, including Attachment 1 (Rupture Test Data of Damaged Alloy 600 OTSG Tubing), and Attachment 2 (Collapse Test Data on Damaged Alloy 600 OTSG Tubing).

5. Letter from T. Gene Campbell, AP&L to J. F. Stolz, NRC, transmitting safety review regarding the accident analyses of the FSAR.

MEETING SUMMARY DISTRIBUTION

Licensee: Arkansas Power & Light Company

*Copies also sent to those people on service (cc) list for subject plant(s).

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