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February 5, 1997

1CAN029702

U. S. Nuclear Regulatory Commission
Document Control Desk
Mail Station P1-137
Washington, DC 20555

Subject: Arkansas Nuclear One - Unit 1
Docket No. 50-313
License No. DPR-51
Additional Information Related to Inservice Inspection of Once Through Steam Generator Tubes (TAC. No. M97485)

Gentlemen:

On November 21, 1996, Entergy Operations submitted a report required by Arkansas Nuclear One, Unit 1 (ANO-1) Technical Specification 4.18.6 providing the results of the inservice inspection of the once through steam generator (OTSG) tubes conducted during the thirteenth refueling outage (1CAN119605). A request for additional information, based upon the NRC Staff's review of the report, was received by Entergy Operations on January 7, 1997 (1CNA129603). Attached is the information requested.

If you have any questions concerning this submittal, please contact me.

Very truly yours,

Dwight C. Mims

Dwight C. Mims
Director, Nuclear Safety

DCM/jjd

attachment

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Response to NRC Request for Additional Information Related to Inservice Inspection of the Once Through Steam Generator Tubes

1. **Please discuss the types of coils used in the motorized rotating pancake coil probe (MRPC) (e.g., mid-range 0.115-inch pancake coil).**

RESPONSE:

The examinations on the roll transitions, dents, wedge region, lane and wedge borders, and nonquantifiable and distorted signal bobbin indications were completed using a Zetec MRPC-520-3C-52PH probe. The coils contained within the probe included 0.115" unshielded pancake, axial, and circumferential directed coils. Frequencies of 300, 200, 100, and 10 kHz were used to conduct the examinations. A 0.080" shielded coil was used for the depth sizing of tube support plate wear indications. All MRPC production exams were conducted with a pull speed of 0.2 inch per second and a rotational speed of 300 rpm, except for the roll transition examinations which were at 0.1 inch per second and 300 rpm. The instrument sampling rate was set at 400 samples per second which allowed a minimum of 30 samples per helical inch to be achieved.

The sleeve transitions were examined with a Zetec once through steam generator (OTSG) 3331-2-A Sleeve Plus Point probe at frequencies of 250, 150, 120, and 75 kHz. The probe houses a low frequency Plus Point coil and utilizes a gimbaled shoe design for optimum surface riding capability. The rotational and pull speeds used were 300 rpm and 0.1 inch per second, respectively.

The MRPC probes used during the thirteenth refueling outage (1R13) met the qualification requirements of Appendix H of the EPRI PWR Steam Generator Tube Examination Guidelines.

2. **For the tubes in the "A" and "B" OTSG with free-span axial indications at dented locations, please state whether these indications were found during routine examinations using bobbin coil probe and/or the MRPC probe. Please discuss the nature and the size estimates made for these degraded conditions (i.e., address the structural and leakage integrity of these indications). For the dents with degraded indications, discuss the "size" of the dents with indications in comparison with the size of other dents in the steam generators. Discuss the expansion criteria used and the technical basis for the criteria.**

RESPONSE:

A MRPC sample inspection of dented locations was performed in response to Generic Letter 95-03 (letter dated October 12, 1995 (0CAN109506). The sample examined consisted of the following:

- A 10% sample of known dings at the 15th tube support plate (TSP) and the upper tubesheet. The sample concentrated on the largest dings at these elevations, as determined by bobbin coil signal amplitudes.

- A 10% sample of the lower tubesheet dings concentrating on the largest dings at this elevation, as determined by bobbin coil signal amplitudes.

No indications were identified in this inspection. One indication was identified in a dented location during the 100% bobbin examination. Since this indication was found as part of a 100% inspection, no expansion was necessary. Subsequent diagnostic testing with MRPC allowed further characterization of the indication which confirmed the existence of an axially oriented crack associated with a restriction in the tube (ding).

The bobbin examination identified the indication as outside diameter (OD) initiated with an associated depth of 87% through wall (TW) on the 600 kHz bobbin channel. Historical records show the ding was present as far back as 1982. The MRPC examination confirmed the indication to be OD initiated and located at an offset of approximately 35 degrees relative to the tube axis. The axial length of the crack, in respect to the tube axis, is approximately 1.15", with a total crack length of approximately 1.34".

Structural integrity of the flaw was addressed to ensure that an adequate margin of safety exists against a potential tube rupture. The methodology used to address tube integrity includes a pressure test conducted on the flaw using the Framatome Technologies Inc. (FTI) in-situ pressure test chamber with a high volume pump. Following the guidance in Regulatory Guide (RG) 1.121 and the ASME Code, a pressure of 3 times normal operating differential pressure (3ΔP) was used. For ANO-1 this pressure is 3765 psi. The desired test pressure of 4500 psi was chosen as a conservative bound; however, the maximum pressure obtained due to equipment limitations was 3500 psi. Since structural integrity under a 3ΔP condition could not be directly proven, the calculated burst pressures are relied upon to demonstrate RG 1.121 integrity. For a 100% TW flaw 0.28" in length, the calculated burst pressure is 4509 psi which exceeds the 3ΔP limit of 3765 psi.

An estimation of leak rates were developed using the full tube length in-situ pressure test results. EPRI report NP-6864-L was developed to calculate leakrates for indications in the tubesheet. The formulas in this report were adjusted for the freespan area by not taking credit for the restriction of the tubesheet. A pressure of 2900 psi was obtained during the pressure test in order to bound accident leakage conditions. At this pressure a leak rate of 0.8 gpm was measured. Using the adjusted EPRI leak rate formulas at 2900 psi the estimated 100% TW crack length was calculated to be 0.208", which correlates well with the MRPC measured length of the crack which was 100% TW (0.28").

The information obtained from the eddy current profiling was used to calculate the projected leakage during accident conditions. The accident condition (main steam line break or MSLB) pressure differential at Arkansas Nuclear One, Unit 1 (ANO-1) is 2525 psi. Using this ΔP value, the calculated leak rate for the 0.28" 100% TW flaw is 1.4 gpm. The leakage calculations used are based on flow choking in the crack area (which is a result of the 600 degree primary coolant flashing to steam when it reaches saturation pressure traveling through the crack). The measured leakage of 0.8 gpm (from the in-situ test) and calculated value of 1.4 gpm are well within the normal power operations capacity of the ANO-1 makeup system (165 gpm).

3. **Discuss the nature of the indications detected in the sleeved portion of the tubes (including both parent tube and the sleeve) and at the upper roll transition (e.g., an axially oriented defect indicative of primary water stress corrosion cracking). Discuss the structural and leakage integrity of these indications.**

RESPONSE:

Sleeve Indications

A 100% Plus Point inspection of the inservice sleeve roll transitions was performed in 1R13. Ten sleeved tubes were identified with degradation type indications. Nine of the indications were determined to be in the parent tubing, while the last one was in the sleeve. Of the nine indications in the parent tubing, six were circumferential and three were axial. The single sleeve indication was circumferential. The following table provides a summary of the tubes and indications. The attached figure depicts the locations of the indications.

Tube ID	Indication	Wall	Indication Location
A-75-17	SCI	Tube	Upper Lower Roll, Upper Transition (1)
A-102-4	SCI	Tube	Upper Roll Expansion (2)
A-79-1	MAI	Tube	Upper Roll, Upper Transition (3)
A-81-1	MAI	Tube	Upper Roll, Upper Transition (3)
A-82-3	SCI	Tube	Upper Roll Expansion (2)
A-79-5	SCI/SVI	Tube	Upper Roll, Lower Transition (4)
B-73-50	SAI	Tube	Upper Roll Expansion (2), (31" Sleeve)
B-81-18	SCI	Tube	Upper Roll, Upper Transition (3)
B-88-5	SCI	Tube	Upper Roll, Upper Transition (3)
B-129-7	SCI	Sleeve	Lower Lower Roll, Upper Transition (5)

SCI - Single Circumferential Indication
MAI - Multiple Axial Indication
SVI - Single Volumetric Indication
SAI - Single Axial Indication

Upper Lower Roll, Upper Transition Indication (1): The single indication detected in this region of the sleeve was in the parent tube. The pressure boundary in this region of the sleeve consists of the combined wall thickness (.079") of the tube and sleeve. Conservatively assuming that the tube defect was a complete sever, the remaining sleeve wall thickness of 0.45" is more than adequate to maintain integrity for 3ΔP loadings. Qualification testing for the OTSG sleeve conservatively simulated the tube in a severed condition between the two roll regions and utilized 3ΔP loading conditions. The testing produced a maximum end-of-life leak rate of 11.39 ml/hr (5.0×10^{-5} gpm) and an average leak rate of 3.51 ml/hr (1.55×10^{-5} gpm) for the sleeve.

Upper Roll Expansion (2); Upper Roll, Upper Transitions (3); Upper Roll, Lower Transition (4): These indications were detected in the parent tubing in the upper rolled joint of the tube and sleeve. The indications would be precluded from burst at 3ΔP based on the increased wall thickness of the pressure boundary. Additionally, tubes with flaws constrained within the tubesheet have been tested by EPRI and the B&W Owners Group without bursting. Any leakage associated with these indications under accident conditions would be limited by the interference fit between the tube expansion and the tubesheet, and is not expected to contribute to the total accident leak rate. The sleeve qualification testing showed that the majority of sleeve leakage is attributed to the lower freespan roll region of the sleeve, not the tubesheet rolled region.

Lower Lower Roll, Upper Transition (5): This indication was detected in the sleeve in the upper transition of the lower roll. This indication is typical of an installation anomaly that has been identified in post-installation eddy current examinations of newly installed I-690 sleeves in other OTSGs. These types of sleeve inner diameter (ID) indications have been re-created in mock-up testing by Framatome Technologies, and were mainly due to the heel of the roller catching or dragging on the transition during the retraction of the tool. However, because this sleeve had been in service since October, 1988, and was fabricated of I-600, a material more susceptible to primary water stress corrosion cracking (PWSCC) degradation, the affected tube was conservatively removed from service. Based on the eddy current testing results from 1R13, no indications were reported in the parent tube in the vicinity of the reported sleeve indication. The parent tube therefore maintains its ability to withstand the primary-to-secondary pressure differential. Failure of the tube by burst is therefore precluded.

If the indication in the sleeve represents a real defect, then a possible primary-to-secondary leak path exists. The leak would be limited by the upper lower roll joint, and based on qualification testing would not be considered to challenge the operating limits of the plant.

Roll Transition Indications (Parent Tubing)

A 21% sample of tubes were inspected with a MRPC in the hot leg upper roll transitions in 1R13. Axially oriented and volumetric indications were detected during the inspection resulting in the removal of 24 total tubes from service (14 in the "A" and 10 in the "B" OTSG). The axial indications were attributable to PWSCC in the roll transition region of the tubes, while the volumetric indications were OD initiated. EPRI testing and B&W Owners Group OTSG tube integrity program testing has verified that axial indications constrained within the tubesheet will burst at pressures much larger than $3\Delta P$ limit of RG 1.121. The rolled joint interference fit for indications within the roll and the tube-to-tubesheet diametral clearances for those indications in, or below, the roll transition provide substantial restraint for precluding tube burst at the location of the flaw. For axial indications in the roll transition, tube burst below the burst pressure for an unflawed tube is precluded by the constraint of the tube radial displacement when the cracked section of the tube remains within the tubesheet and the diametral gap is less than 0.03". The maximum diametral clearance in a typical OTSG tubesheet is 0.015 to 0.021". The leakage of these types of indications is also affected by their containment within the tubesheet. Leakage performance was evaluated using the EPRI methodology for PWSCC in roll transitions included in report NP-6864-L. These indications were conservatively assumed to be 100% TW, even though expansion transition sizing techniques only reported one indication as being throughwall. Utilizing these methods, the total calculated MSLB leak rate for the indications in these 24 tubes is 0.357 gpm.

4. **Discuss the nature of the axial indications at the lower tubesheet as determined from non-destructive examination. For example, address whether the indications were in the sludge pile region, above the top of the tubesheet, in the crevice region, etc. Discuss the structural and leakage integrity of these indications.**

RESPONSE:

The axial indications at the "B" OTSG lower tubesheet were in the sludge pile region approximately 0.25" above the lower tubesheet face. Nine tubes were identified as having axially oriented OD indications. All indications were identified by bobbin coil and subsequent MRPC examination. The tube locations were identified in a region between Rows 24 and 31 and Tubes 35 to 40, which suggests a localized problem, either a localized aggressive sludge or tube material issue.

The axial length of the indications ranged in size from 0.17" to 0.44", with maximum depths ranging from 81% to 98% TW and average depths ranging from 71% to 86% TW, based upon the field MRPC data. Two tubes, 27-36 and 31-40, had multiple axial indications (3 and 2, respectively) and were removed for laboratory examination and destructive examinations. These tube locations were noticeably damp during the inspection process; therefore, some portion of the indications were truly throughwall. The laboratory testing and destructive examination is currently in progress, and will provide the true impact of these indications on tube structural integrity, from burst and leakage standpoints. The results of these examinations will be provided to the NRC.

5. **The inspection report stated that the sleeve indications were considered as artifacts from the sleeve installation and/or also due to enhanced eddy current testing method. It also stated that the sleeve inspection techniques prior to 1995 were not considered adequate for detection of these types of indications. Provide the basis for the two statements. Provide any laboratory testing and/or available laboratory test data which would support the above statements.**

RESPONSE:

These indications were detected during a Plus Point coil examination of the sleeved tubes during 1R13. Six of the tubes containing indications were not previously inspected with the Plus Point coil; therefore, a meaningful comparison cannot be made. Because these six indications are in the parent tube wall, it is not certain that these indications are truly an installation anomaly; therefore, these tube locations were removed from service.

The three remaining parent tube indications did have previous Plus Point data from 1R12. Two of these indications were detected and identified in the previous inspection, but were believed to be attributed to sleeve installation. No attempt has been made to recreate these types of parent tube indications in a mock-up. The tube containing the remaining indication was reported as having no detectable degradation in 1R12. This call was confirmed after reviewing the 1R12 data.

The single indication that was determined to be in the sleeve ID was present in the previous outage's Plus Point data, and is typical of an installation anomaly that has been identified in post-installation eddy current examinations of newly installed I-690 sleeves in other OTSGs. Since this sleeve had been in service since October, 1988, and was fabricated of I-600, a material more susceptible to PWSCC degradation, this tube was conservatively removed from service.

The qualification of the OTSG sleeve included a baseline inspection by a rotating cross wound probe. The rotating cross wound probe is, by its design, unreliable in the detection of circumferential flaws. Prior to 1R12, this probe was used to examine all inservice OTSG sleeves. This inspection technique was qualified for the detection of repairable indications in the pressure boundary portion of the sleeve or sleeve/tube combination. Testing has shown that the Plus Point coil has a better detection threshold and increased sensitivity and thus was selected as the technique to use for future inspection of OTSG sleeves.

The staff recognizes that several tube sections were removed for destructive examination during this outage and that the results will be provided to the NRC when available. However, the above questions apply to the results from the non-destructive examination of the tubes. Discuss the schedule for the examination of the pulled tube sections. As discussed during a telephone conversation during the outage, discuss whether detailed non-destructive examination results for the pulled tubes will be provided prior to commencing destructive examination.

RESPONSE:

The ANO-1 tube pull samples have been received by Westinghouse, receipt inspected and radiography performed. Leak and burst testing is scheduled to completed the week of January 27, 1997, with results provided by February 3, 1997. Burst testing will immediately follow the leak testing. Destructive examination will begin following the conclusion of burst testing. Results of the examinations will be provided to the NRC.

Detailed non-destructive examination results for the pulled tubes are shown in the following table.

ARKANSAS NUCLEAR ONE
1R13 TUBE PULL
PRE-PULL EDDY CURRENT RESULTS

SG	ROW	TUBE	LOCATION	CODE	BOBBIN % TW	BOBBIN VOLTAGE	MRPC FLAW LENGTH INCHES	MRPC MAX DEPTH %TW	MRPC AVG DEPTH %TW	REMARKS
B	27	36	LTS + 0.23"	OD MAI	80	23.58	0.31"	93	84	0.115" Pancake Coil
			LTS + 0.23"	OD MAI	80	23.58	0.25"	88	77	
			LTS + 0.23"	OD MAI	80	23.58	0.25"	87	77	
B	31	40	LTS + 0.16"	OD MAI	89	10.22	0.44"	92	86	0.115" Pancake Coil
			LTS + 0.16"	OD MAI	89	10.22	0.33"	80	71	
B	53	116*	UTE - 1.31"	ID SAI	N/A	N/A	0.22"	83	72	0.115" Pancake Coil
			UTE - 1.35"	ID SAI	N/A	N/A	0.22"	86	63	Plus Point Coil
			UTE - 1.35"	ID SAI	N/A	N/A	0.19"	79	58	0.080" Pancake Coil
B	79	63**	UTS + 3.81"	N/A	13	1.87	N/A	N/A	N/A	
			UTS + 4.40"	N/A	27	2.69	N/A	N/A	N/A	
			UTS + 2.89"	N/A	32	2.33	N/A	N/A	N/A	
			UTS + 4.05"	N/A	35	0.46	N/A	N/A	N/A	
			UTS + 3.42"	N/A	38	1.5	N/A	N/A	N/A	
B	80	18**	UTS + 7.55"	N/A	3	0.58	N/A	N/A	N/A	
			UTS + 11.90"	N/A	34	1.04	N/A	N/A	N/A	
			UTS + 8.93"	N/A	38	0.52	N/A	N/A	N/A	
			UTS + 6.71"	N/A	40	1.62	N/A	N/A	N/A	
B	83	47**	UTS + 6.52	N/A	36	0.75	N/A	N/A	N/A	

* - Roll Transition
** - MRPC Not Performed

Typical OTSG Sleeve Arrangement