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June 12, 2002

U. S. Nuclear Regulatory Commission
Document Control Desk
Mail Station OP1-17
Washington, DC 20555

Subject: Arkansas Nuclear One - Unit - 2
Docket No. 50-368
License No. NPF-6
Licensee Event Report 50-368/2002-001-00

Dear Sir or Madam:

In accordance with 10CFR50.73(a)(2)(ii)(A), enclosed is the subject report concerning leakage through the Reactor Coolant System pressure boundary. The enclosure contains no commitments.

Sincerely,

Glenn R. Ashley
for
Sherrie R. Cotton
Director, Nuclear Safety Assurance

SRC/dh

enclosure

IE22

cc: Mr. Ellis W. Merschoff
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NRC FORM 366 (1-2001) U.S. NUCLEAR REGULATORY COMMISSION

APPROVED BY OMB NO. 3150-0104 EXPIRES 6-30-2001

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LICENSEE EVENT REPORT (LER)

FACILITY NAME (1)	DOCKET NUMBER (2)	PAGE (3)
Arkansas Nuclear One - Unit 2	05000368	1 OF 5

TITLE (4) Reactor Coolant System Pressure Boundary Leakage Due To Primary Water Stress Corrosion Cracking Of Pressurizer Heater Sleeves

EVENT DATE (5)			LER NUMBER (6)			REPORT DATE (7)			OTHER FACILITIES INVOLVED (8)	
MO	DAY	YEAR	YEAR	SEQUENTIAL NUMBER	REV NO	MO	DAY	YEAR	FACILITY NAME	DOCKET NUMBER
04	15	2002	2002	001	00	06	12	2002	FACILITY NAME	DOCKET NUMBER

OPERATING MODE (9)	5	THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR: (Check one or more) (11)							
POWER LEVEL (10)	000		20.2201(b)		20.2203(a)(3)(i)		50.73(a)(2)(i)(C)		50.73(a)(2)(vii)
			20.2201(d)		20.2203(a)(3)(ii)	X	50.73(a)(2)(ii)(A)		50.73(a)(2)(viii)(A)
			20.2203(a)(1)		20.2203(a)(4)		50.73(a)(2)(ii)(B)		50.73(a)(2)(viii)(B)
			20.2203(a)(2)(i)		50.36(c)(1)(i)(A)		50.73(a)(2)(iii)		50.73(a)(2)(ix)(A)
			20.2203(a)(2)(ii)		50.36(c)(1)(ii)(A)		50.73(a)(2)(iv)(A)		50.73(a)(2)(x)
			20.2203(a)(2)(iii)		50.36(c)(2)		50.73(a)(2)(v)(A)		73.71(a)(4)
			20.2203(a)(2)(iv)		50.46(a)(3)(ii)		50.73(a)(2)(v)(B)		73.71(a)(5)
			20.2203(a)(2)(v)		50.73(a)(2)(i)(A)		50.73(a)(2)(v)(C)		OTHER
			20.2203(a)(2)(vi)		50.73(a)(2)(i)(B)		50.73(a)(2)(v)(D)		Specify in Abstract or
									NRC Form 366A

LICENSEE CONTACT FOR THIS LER (12)	
NAME	TELEPHONE NUMBER (Include Area Code)
A. J. Hawkins, Nuclear Safety and Licensing Specialist	479-858-5589

COMPLETE ONE LINE FOR EACH COMPONENT FAILURE DESCRIBED IN THIS REPORT (13)

CAUSE	SYSTEM	COMPONENT	MANU-FACTURER	REPORTABLE TO EPIX		CAUSE	SYSTEM	COMPONENT	MANU-FACTURER	REPORTABLE TO EPIX

SUPPLEMENTAL REPORT EXPECTED (14)				EXPECTED SUBMISSION DATE (15)	MO	DAY	YEAR
	YES (If yes, complete EXPECTED SUBMISSION DATE)	X	NO				

ABSTRACT (16)

On April 15, 2002, with the plant in cold shutdown for refueling, five Pressurizer heater sleeves were found to be leaking. Leakage was identified by small amounts of boron discovered at the sleeve penetration interfaces. A sixth leaking heater sleeve was identified on April 30, 2002, during heatup from the outage. The root cause evaluation concluded that the failure mechanism for all six leaking heater sleeves was Primary Water Stress Corrosion Cracking (PWSCC) of Alloy 600 material. Inspection of the Pressurizer base metal area surrounding each sleeve indicated that no boric acid wastage had occurred. The leaks were repaired using ASME Code-qualified Mechanical Nozzle Seal Assemblies. All Pressurizer and hot leg nozzles were re-inspected following repair and heatup. No additional leakage was identified. Routine visual inspections were determined to be adequate to detect future similar leakage.

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NARRATIVE (17)

A. Plant Status

At the time this condition was discovered, Arkansas Nuclear One Unit 2 (ANO-2) was in cold shutdown, Mode 5, with a scheduled refueling outage in progress. The Reactor Coolant System (RCS) [AB] was in reduced inventory with the Pressurizer [AB] drained. An additional leaking heater sleeve was identified during heatup from the outage, with the RCS at 545 degrees F and 2200 psi.

B. Event Description

Six Alloy 600 heater sleeves were found to be leaking in the ANO-2 Pressurizer. Five of these heater sleeves were identified on April 15, 2002, during plant cooldown. The remaining leaking heater sleeve was found on April 30, 2002, during plant heatup.

On April 15, 2002, following shutdown for a scheduled refueling outage, visual inspections of the RCS were conducted for evidence of boron in accordance with NRC Generic Letter 88-05, "Boric Acid Corrosion of Carbon Steel Reactor Pressure Boundary Components in PWR Plants." The initial inspection was conducted with the insulation remaining on the Pressurizer lower head. Five Pressurizer heater sleeve penetrations were determined to be leaking. Small amounts of boron were discovered at each of the five sleeve penetration interfaces.

The insulation was removed from the heater sleeves and bottom head of the Pressurizer and the heater sleeves were re-inspected. This inspection confirmed that only the five heater sleeves were leaking. Inspection of the Pressurizer base metal area surrounding each sleeve indicated that no boric acid wastage had occurred.

On April 30, 2002, during plant heatup, a structural integrity inspection was conducted. Plant operators observed a residue on another Pressurizer heater sleeve that appeared to be dry boron. The operators concluded that the residue was caused by an RCS leak, but the leak was not active. No boric acid wastage was present in the Pressurizer base metal area surrounding the heater sleeve.

As a result of the discovery of this leakage, all Pressurizer and hot leg nozzles were re-inspected to verify RCS nozzle integrity. The Pressurizer heater sleeves were inspected again following repair and heat-up to normal operating pressure and temperature conditions. No additional leakage was identified.

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C. Root Cause

The root cause of leakage for all six Pressurizer heater sleeves was determined to be Primary Water Stress Corrosion Cracking (PWSCC).

The heater sleeves in the ANO-2 Pressurizer were fabricated from Alloy 600, which is known to be susceptible to PWSCC. The Pressurizer heater sleeves were welded with a J-groove weld between the sleeve and the Alloy 600 weld metal cladding inside the bottom head. All of the sleeves were from one heat of cold-drawn and low-temperature annealed material. Previous laboratory analysis of this material revealed extensive carbide precipitates that were not coincident with the grain boundaries. The carbides were intragranular and along prior grain boundaries that existed before the mill anneal heat treatment. The material exhibited a small grain microstructure and a relatively high yield strength that causes it to be susceptible to PWSCC.

During fabrication the Pressurizer heater sleeves were mechanically reamed to remove local high spots resulting from weld shrinkage and distortion and were not stress relieved after installation. This imposed additional inner diameter surface stresses and susceptibility to axial PWSCC.

The normal operating temperature for the Pressurizer (approximately 657 degrees F) increases the susceptibility of Alloy 600 heater sleeves to PWSCC, particularly when other material conditions (reaming, poor microstructure, high yield strength) are present.

PWSCC is a failure mechanism that is dependent on time of operation as well as on temperature, stress, and material condition. A load limit finite stress analysis was performed that indicated that the sleeves closest to the center of the Pressurizer have higher maximum stresses and are, therefore, more susceptible to PWSCC. This analysis is consistent with the location of most heater sleeves that have failed since a mid-cycle outage in July 2000.

With the exception that it was detected during heatup, leakage from the sixth Pressurizer heater sleeve was similar to that of the other heater sleeves. It is believed that cooldown thermal stresses at the beginning of the outage placed the J-groove weld region of that Pressurizer heater sleeve in a tensile stress condition, creating a through-wall breach of an existing PWSCC crack. Subsequent heat-up with the existence of a through-wall crack resulted in leakage and the boric acid residue being found on the heater sleeve.

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Due to the similarities of the six leaking heater sleeves to the twelve leaking heater sleeves found during the mid-cycle outage of July 2000, it was determined that neither nondestructive examination nor laboratory sampling was required to confirm the cause of leakage.

All Pressurizer heaters were inspected during the previous refueling outage and no leaks were identified; therefore, the boric acid leakage had developed since December 2000.

D. Corrective Actions

The leaking Pressurizer heater sleeves were repaired using a Mechanical Nozzle Seal Assembly (MNSA2) designed to replace the function of partial penetration J-groove welds that attach Alloy 600 nozzles or heater sleeves to the Pressurizer. The MNSA2 provides a mechanical seal against leakage and positively captures the nozzle, preventing ejection in the unlikely event of complete 360-degree weld failure. The MNSA2 was designed as an ASME Section III, Class 1, safety-related primary pressure boundary. The NRC approved use of the MNSA2 for two refueling cycles. Material testing verified compatibility of the MNSA2 with the pressure boundary materials and environment.

ANO is developing a long range plan for the examination and any necessary repairs of the remaining Pressurizer heater sleeves.

E. Safety Significance

Based on previous experience, leakage from the six Pressurizer heater sleeves was determined to be due to axial cracking of the heater sleeve. Axial cracking will not lead to an axial rupture of the sleeve. Flaws leading to leaks are expected to remain in an axial orientation. Although there exists a theoretical likelihood for the existence of circumferential flaws, the propensity for these flaws to cause a complete circumferential failure leading to the ejection of a heater sleeve within one operating cycle is remote.

Even though ANO continues to identify the presence of PWSCC cracking on heater sleeves, it is believed that future flaws will remain axial within a given outage cycle and that this does not represent a structurally significant condition. Therefore, there is no imminent need to perform additional repairs of non-leaking nozzles or to conduct more frequent inspections of the nozzles.

For these reasons, the overall safety significance of this condition was determined to be minimal.

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F. Basis for Reportability

Using the guidance from Section 3.2.4 of NUREG-1022, "Event Reporting Guidelines - 10CFR50.72 and 50.73," the identified leaks were considered a serious degradation of a principal safety barrier. Discovery of the first five leaking Pressurizer heater sleeves was reported to the NRC Operations Center at 1104 CDT on April 15, 2002, in accordance with 10CFR50.72(b)(3)(ii)(A). At 1801 on April 30, 2002, a Notification of Unusual Event was declared due to leakage indication from an additional heater sleeve. A report was made to the NRC Operations Center at 1813 CDT in accordance with 10CFR50.72(a)(1)(i) and 10CFR50.72(b)(3)(ii)(A). This report is submitted in accordance with 10CFR50.73(a)(2)(ii)(A).

G. Additional Information

ANO has reported as Licensee Event Reports (LERs) five conditions involving RCS pressure boundary leakage attributed to PWSCC of Alloy 600 material. In LER 50-313/90-021-00 (letter 1CAN019112 dated January 21, 1991), ANO-1 reported leakage from an Alloy 600 Pressurizer level sensing nozzle. In LER 50-313/2000-003-00 (letter 1CAN030001 dated March 16, 2000), ANO-1 reported leaking welds for RCS hot leg level instrumentation nozzles. In LER 50-313/2001-002-00 (letter 1CAN050101 dated May 8, 2001), ANO-1 reported a leaking control rod drive mechanism nozzle. In LER 50-368/87-003-01 (letter 2CAN088801 dated August 12, 1988), ANO-2 reported leaking Pressurizer heater sheaths. And, in LER 50-368/2000-001-00 (letter 2CAN080011 dated August 29, 2000), ANO-2 reported leaking Pressurizer heater sleeves and an RCS resistance temperature detector nozzle. Corrective actions for these conditions were not intended to prevent recurrence of PWSCC in Alloy 600 material that is subject to this failure mechanism.

Energy Industry Identification System (EIIS) codes are identified in the text as [XX].