CATEGORY 1

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RECIP.NAME RECIPIENT AFFILIATION

SUBJECT: LER 96-006-00:on 961018,intergranular attack & stress corrosion cracking of tubes occurred in both SG resulting in Category C-3 due to outside diameter IGA/IGSCC.All tubes classified as defective will be repaired.W/961115 ltr.

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NRC-96-123

November 15, 1996

10 CFR 50.73

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
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Ladies/Gentlemen:

Docket 50-305
Operating License DPR-43
Kewaunee Nuclear Power Plant
Reportable Occurrence 96-006-00

In accordance with the requirements of 10 CFR 50.73, "Licensee Event Report System," the attached Licensee Event Report (LER) for reportable occurrence 96-006-00 is being submitted.

Sincerely,

M. L. Marchi
Manager - Nuclear Business Group

SLB/jmf

Attach.

cc - INPO Records Center
US NRC Senior Resident Inspector
US NRC, Region lII

190067

NRC FORM 366 (5 92) U.S. NUCLEAR REGULATORY COMMISSION

APPROVED BY OMB NO. 3150-0104
EXPIRES 5/31/95

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LICENSEE EVENT REPORT (LER)

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FACILITY NAME (1)	DOCKET NUMBER (2)	PAGE (3)
Kewaunee Nuclear Power Plant	05000305	1 OF 10

TITLE (4) Intergranular Attack & Intergranular Stress Corrosion Cracking of Tubes in Both Steam Generators Results in Category C-3

EVENT DATE (5)			LER NUMBER (6)			REPORT NUMBER (7)			OTHER FACILITIES INVOLVED (8)	
MONTH	DAY	YEAR	YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	MONTH	DAY	YEAR	FACILITY NAME	DOCKET NUMBER
									N/A	05000
10	18	96	96	-- 006 --	00	11	15	96	FACILITY NAME	DOCKET NUMBER 05000

OPERATING MODE (9)	N
POWER LEVEL (10)	000

THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR §: (Check one or more) (11)

	20.402(b)		20.405(c)		50.73(a)(2)(iv)		73.71(b)
	20.405(a)(1)(i)		50.36(c)(1)		50.73(a)(2)(v)		73.71(c)
	20.405(a)(1)(ii)		50.36(c)(2)		50.73(a)(2)(vii)	X	OTHER
	20.405(a)(1)(iii)		50.73(a)(2)(i)		50.73(a)(2)(viii)(A)		(Specify in Abstract below and in Text, NRC Form 366A)
	20.405(a)(1)(iv)	X	50.73(a)(2)(ii)		50.73(a)(2)(viii)(B)		
	20.405(a)(1)(v)		50.73(a)(2)(iii)		50.73(a)(2)(x)		TS 4.2.b.7.c

LICENSEE CONTACT FOR THIS LER (12)

NAME	TELEPHONE NUMBER (Include Area Code)
SL Bernhoft	414-433-1416

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

CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO NPRDS		CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO NPRDS
B	AB	SG	W120	Y						

SUPPLEMENTAL REPORT EXPECTED (14)				EXPECTED SUBMISSION DATE (15)	MONTH	DAY	YEAR
X	YES (If yes, complete EXPECTED SUBMISSION DATE)		NO		01	30	97

ABSTRACT (Limit to 1400 spaces, i.e., approximately 15 single-spaced typewritten lines) (16)

On October 18, 1996, with the plant in refueling shutdown, the 1996 in-service inspection of Steam Generator (SG) tubes was completed. The in-service inspection of the Westinghouse hybrid expansion joint (HEJ) sleeves found 907 sleeved tubes in SG A, and 587 sleeved tubes in SG B which were considered defective. In accordance with the Kewaunee Nuclear Power Plant (KNPP) technical specifications (TSs), SG A and B were categorized as C-3, in the sleeve upper expansion joint region. In addition, the in-service inspection of the SG A hot leg tubesheet crevice region found 11 tubes which were considered defective, and the SG A tubesheet crevice region was categorized as C-3. This Licensee Event Report provides the required 30 day written report to the Nuclear Regulatory Commission.

For non-sleeved tubes, the predominant degradation mode is outside diameter (OD) intergranular attack and OD intergranular stress corrosion cracking. For degradation occurring in the HEJ sleeves, the predominant degradation mode is circumferential stress corrosion cracking initiated on the inside diameter (ID) of the parent tube. In accordance with KNPP's TS, all defective tubes will be plugged or repaired. KNPP is currently continuing with its refueling outage; the final number of repaired and plugged tubes will be reported within 30 days following the completion of the repairs. The secondary side boric acid and Morpholine (or alternative amine) addition programs and molar ratio control will continue during the next operating cycle to reduce the caustic environment and corrosion/erosion of the secondary side components.

Description of Event

On October 18, 1996, with the plant in refueling shutdown, the in-service inspection of steam generator [SG] tubes [TBG] was completed for the 1996 refueling outage.

The Kewaunee Nuclear Power Plant (KNPP) steam generators (SGs) are Westinghouse model 51. The tubes are constructed of mill-annealed inconel 600 and are partially rolled for a length of 1.5 to 2.5 inches into the tubesheet. As a result of tube degradation, significant plugging and sleeving efforts have been required in each SG. Prior to the 1996 refueling outage, SG A contained 771 plugged tubes and 1702 sleeved tubes (1690 Westinghouse mechanical sleeves and 12 Combustion Engineering welded sleeves). SG B contained 518 plugged tubes and 1870 sleeved tubes (1866 Westinghouse mechanical sleeves and 4 Combustion Engineering welded sleeves). The combined equivalent plugging percent for the two SGs was 21.32 percent.

The planned KNPP 1996 SG eddy current examination program for each SG was:

1. A 100% bobbin coil examination through the entire length of all tubes not previously plugged or sleeved.
2. A 100% bobbin coil examination of all sleeved tubes from the top of the sleeve around the U-bend to the end of the tube.
3. Rotating probe examination of all open row 1 and row 2 U-bends and 20% of the row 3 U-bends.
4. Rotating probe examination of 100% of the inservice sleeve upper expansion joints.
5. Rotating probe examination of 100% of the hot leg tubesheet crevice region.

Based on the above listed examination scope, KNPP Technical Specification (TS) 4.2.b.2.a requirements were satisfied.

The eddy current examination of the hot leg tubesheet crevice region in SG A (915 tubes) found 11 tubes which were classified as defective (Single Axial Indications (SAI) or Multiple Axial Indications (MAI)). These tubes were removed from service. Since greater than 1% of the examined tubes were considered defective (categorized as C-3), the Nuclear Regulatory Commission (NRC) was notified at 0946 hours on October 18, 1996 as required by KNPP TS 4.2.b.7.c and 10 CFR 50.72(b)(2)(i). The eddy current examination of the hot leg tubesheet crevice region in SG B (1000 tubes) found 4 tubes which were classified as defective (SAI or MAI) and were removed from service.

During the 1996 refueling outage, the EF* tubesheet alternate repair criteria was implemented in accordance with TS 4.2.b.6. The EF* criteria was applied via rerolling to 23 tubes in SG A, and 14 tubes in SG B. In addition, a 2 volt alternate repair criteria (ARC) was applied to indications (attributable to ODSCC) found within the tube support plates. The ARC was implemented in accordance with TS 4.2.b.5. The eddy current examination of the tube support plates found 0 indications in SG A, and 5 indications in SG B that did not satisfy the ARC and were removed from service. To support the industry database for tube support plate alternate repair criteria, one tube containing two tube support plate intersections was removed from the SG B cold leg for destructive analysis.

During the 1996 inspection, the Rotating Plus Point probe was used to inspect the upper and lower hybrid expansion joints (HEJs) of the Westinghouse sleeves and the weld zone region for CE TIG welded sleeves. One CE TIG welded sleeve was confirmed to have a weld zone indication (WZI); this tube was plugged. The remaining 15 CE TIG welded sleeves had no reported WZIs and were left in service.

The eddy current examination results of the sleeve upper HEJs in SG A (1690 tubes) found 907 tubes (53.7%) with circumferential indications in the parent tube at the lower transition of the upper roll expansion within the pressure boundary defined in TS 4.2.b.4.b. The eddy current examination results of the sleeve upper HEJs in SG B (1866 tubes) found 587 tubes (31.5%) with circumferential indications in the parent tube at the lower transition of the upper roll expansion within the pressure boundary defined in TS 4.2.b.4.b. TS 4.2.b.4.b defines the pressure boundary for parent tube indications within the HEJ region in terms of a diameter difference between the sleeve hardroll peak diameter and the diameter at the elevation of the parent tube indication (PTI). As these indications are within the pressure boundary, they were classified as defective. Since greater than 1% of the examined tubes were considered defective (categorized as C-3), the NRC was notified at 1625 hours on October 7, 1996, as required by KNPP TS 4.2.b.7.c and 10 CFR 50.72(b)(2)(i).

Due to indications detected during the Westinghouse HEJ sleeved tube examination, seven sleeve/tube sections were removed for further evaluation.

The overall examination results for 1996 outage found 923 tubes (35.27 percent of tubes inspected) in SG A and 598 tubes (20.84 percent of tubes inspected) in SG B which met the KNPP definition of defective. According to the KNPP TS 4.2.b.7.a, following each in-service inspection, the number of tubes which require plugging or repairing shall be reported to the Nuclear Regulatory Commission (NRC) within 30 days. The C-3 category requires:

1. Prompt notification of the NRC (TS 4.2.b.7.c).
2. A written follow-up to the NRC (TS 4.2.b.7.c).
3. Plugging or repair of all defective tubes (Table TS 4.2-2).
4. An examination of additional tubes in the affected areas if the sample size is less than 100 percent in the affected area (Table TS 4.2-2).
5. Increasing the required SG inspection frequency to once per twenty months (TS 4.2.b.3.b).

This Licensee Event Report satisfies the 30 day reporting requirement of KNPP Technical Specifications 4.2.b.7.a and 4.2.b.7.c. KNPP is currently continuing with its refueling outage and it is anticipated that all defective Westinghouse HEJ sleeved tubes will be repaired. All unsuccessful repairs to Westinghouse HEJ sleeved tubes will be plugged prior to returning the KNPP to operation. All defective non-sleeved tubes have been plugged. WPSC will provide the final number of repaired and plugged tubes, as well as the overall equivalent plugging percentage, within 30 days following the completion of the repairs.

Cause of Event

The majority of the SG tube degradation in the non-sleeved locations is most likely due to outside diameter intergranular attack and outside diameter intergranular stress corrosion cracking (IGA/IGSCC). This assumption is based on the analysis of two tubes pulled from KNPP's SG during the 1990 outage, three tubes pulled from KNPP's SG during the 1993 outage, eddy current signals, and industry experience with similar SGs. Outside diameter IGA/IGSCC is usually associated with a restricted geometry; e.g., the tube sheet crevice, tube support plate crevice or a sludge pile, and with a caustic environment; i.e., a pH greater than ten.

During the 1995 refueling outage, portions of 3 sleeved tubes were extracted from the B SG hot leg. These tubes were examined by non-destructive and destructive examination techniques to determine actual tube/sleeve joint condition relative to eddy current results and degradation mode. The results of this examination concluded that the parent tube cracking in the upper sleeve joint was circumferential PWSCC on the inner diameter of the parent tube. The parent tube cracking was most likely caused by high residual stresses as a result of the sleeve installation process. Due to the number of new indications detected during the 1996 inspection, seven additional sleeve joint samples were removed. Five of these samples will be destructively tested prior to plant startup; the other two will be archived.

Analysis of Event

This report is being submitted in accordance with KNPP TS 4.2.b.7.a which requires a report to be submitted to the NRC within thirty days of completing the in-service inspection of the SGs. The following table provides a historical summary of the number of the SG tubes plugged and sleeved each year prior to the 1996 refueling outage:

	Steam Generator A						Steam Generator B					
	Plugged Tubes		Recovered Tubes			Repaired Tubes	Plugged Tubes		Recovered Tubes			Repaired Tubes
	Un-Sleeved (A)	Sleeved (B)	Unplugged & Sleeved ●	Unplugged (non- sleeved) (D)	Unplugged (sleeved) (E)	Sleeved Tubes (F)	Un-Sleeved (A)	Sleeved (B)	Unplugged & Sleeved ●	Unplugged (non- sleeved) (D)	Unplugged (sleeved) (E)	Sleeved Tubes (F)
1983	23						50					
1984	9						17					
1985	26						22					
1986	26						46					
1987	44						79					
1988	17					990	26					950
1989	21					883	31					815
1990	114	8				0	103	6				0
1991	63	11	150			172	77	8	246			122
1992	17	13	0			12	19	16	0			4
1993	6	3	0			0	7	5	0			0
1994	21	56	0			0	9	19	0			0
1995	46	433	0	17	19	0	40	229	0	29	16	0
Total Tubes Plugged (1)	771						518					
Total Tubes Sleeved (2)		1702						1870				

Notes: 1. Total Tubes Plugged = $\sum(A) + \sum(B) - \sum(C) - \sum(D) - \sum(E)$
2. Total Tubes Sleeved = $\sum(C) + \sum(E) + \sum(F) - \sum(B)$

KNPP is currently continuing with its refueling outage, and it is anticipated that all defective Westinghouse HEJ sleeved tubes will be repaired. All unsuccessful repairs to Westinghouse HEJ sleeved tubes will be plugged prior to returning the KNPP to operation. All defective non-sleeved tubes have been plugged. WPSC will provide the final number of repaired and plugged tubes, as well as the overall equivalent plugging percentage, within 30 days following the completion of the repairs.

Corrective Actions

In accordance with KNPP's TS, all tubes classified as defective will be plugged or repaired.

Sludge lancing was conducted during the 1996 refueling outage to reduce the amount of sludge and to remove contaminants from the tubesheet. A secondary side boric acid addition program continues to be implemented to reduce the caustic environment in the tube crevices and prevent tube support plate denting. The program includes boric acid soaks at low power levels and on line boric acid addition at normal power levels. Evidence indicates that boric acid may reduce the crack growth rate. Also, a secondary side morpholine addition (or alternative amine) program continues to be implemented. Morpholine addition minimizes the corrosion/erosion in the two-phase steam piping. Sludge (corrosion product) transport into the steam generators is thereby minimized and results in a decreased sludge pile.

A molar ratio control program is also used at KNPP. This is accomplished by adding ammonium chloride to the secondary side to control the molar ratio. This is designed to maintain a neutral pH in the tubesheet crevice environment.

Additional Information

Equipment Failure: Westinghouse Model 51 steam generator tubes. The tubing is mill annealed Inconel 600.

Similar Events:

1. LER 95-001, Intergranular Attack and Intergranular Stress Corrosion Cracking Of Tubes In Both Steam Generator Results In Category C-3.
2. LER 94-004, Intergranular Attack and Intergranular Stress Corrosion Cracking Result In Defective Steam Generator Tubes.
3. LER 93-004, Intergranular Attack and Intergranular Stress Corrosion Cracking Results in Both Steam Generators Being Categorized as C-2.
4. LER 92-006, Intergranular Attack and Intergranular Stress Corrosion Cracking Results in Both Steam Generators Being Categorized as C-3.
5. LER 91-005, Intergranular Attack and Intergranular Stress Corrosion Cracking Results in Both Steam Generators Being Categorized as C-3.

6. LER 90-005, Intergranular Attack and Intergranular Stress Corrosion Cracking Result in Defective Steam Generator Tubes.

7. LER 89-007, Intergranular Attack and Intergranular Stress Corrosion Cracking Result in Defective Steam Generator Tubes.

8. LER 88-003, Intergranular Attack and Intergranular Stress Corrosion Cracking Result in Defective Steam Generator Tubes.

9. Letter from D.C. Hintz (WPSC) to G.E. Lear (NRC) dated April 23, 1986.

10. LER 85-06, Steam Generator Tube Plugged in Incorrect Location.

11. Letter from C.W. Giesler (WPSC) to S.A. Varga (NRC) dated May 1, 1984.