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ACCESSION NBR:9405310124 DOC.DATE: 94/05/23 NOTARIZED: NO DOCKET # FACIL:50-305 Kewaunee Nuclear Power Plant, Wisconsin Public Servic 05000305 AUTH.NAME AUTHOR AFFILIATION ROZELL,D.L. Wisconsin Public Service Corp. SCHROCK,C.A. Wisconsin Public Service Corp. RECIP.NAME RECIPIENT AFFILIATION

SUBJECT: LER 94-004-00:on 940422, in-service insp found 77 tubes in SG A & 28 tubes in SG B defective.Caused by outside diameter intergranular attack & outside diameter cracking.Corrective action:all defective tubes were plugged.W/940523 ltr.

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May 23, 1994

10 CFR 50.73

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Ladies/Gentlemen:

Docket 50-305 Operating License DPR-43 Kewaunee Nuclear Power Plant Reportable Occurrence 94-004-00

In accordance with the requirements of 10 CFR 50.73, "Licensee Event Report System," the attached Licensee Event Report for reportable occurrence 94-004-00 is being submitted.

Sincerely,

C.a. Schock

C. A. Schrock Manager-Nuclear Engineering

RTS/cjt

Attach.

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

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

On April 22, 1994, with the plant in refueling shutdown, the in-service inspection and resultant plugging of Steam Generator (SG) tubes was completed for the 1994 refueling outage. The in-service inspection found 77 tubes in SG A and 28 tubes in SG B which were considered defective. In accordance with the Kewaunee Nuclear Power Plant (KNPP) technical specifications (TSs), SG A was categorized as C-3, since more than 1% of the inspected tubes were considered defective in the sleeve upper expansion joint region. As required by KNPP's TS, this Licensee Event Report provides the required 30 day written report to the Nuclear Regulatory Commission.

The predominant SG tube degradation mode at KNPP is outside diameter intergranular attack and outside diameter intergranular stress corrosion cracking (IGA/IGSCC). In accordance with KNPP's TS, all defective tubes were plugged. This increased the overall equivalent plugging percentage from 10.37 percent to 11.87 percent for the 1994-1995 operating cycle.

The secondary side boric acid and Morpholine (or alternative amine) addition programs will continue during the 1994-1995 operating cycle to reduce the caustic environment and corrosion/erosion on the secondary side.

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Description of Event

On April 22, 1994, with the plant in refueling shutdown, the in-service inspection and resultant plugging of steam generator [SG] tubes[TBG] was completed for the 1994 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 mches into the tubesheet. As a result of tube degradation, significant plugging and sleeving efforts have been required in each SG. At the start of the 1994 refueling outage, SG A contained 251 plugged tubes and 2172 sleeved tubes (2160 Westinghouse mechanical sleeves and 12 Combustion Engineering welded sleeves). SG B contained 266 plugged tubes and 2102 sleeved tubes (2098 Westinghouse mechanical sleeves and 4 Combustion Engineering welded sleeves). The combined equivalent plugging percent for the two SGs was 10.37 percent.

The planned KNPP 1994 SG eddy current examination program was as follows:

- 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 (tube end cold).

3. A cross wound bobbin coil examination of 10% of the in-service sleeves.

4. Motorized Rotating Pancake Coil (MRPC) examination of all distorted and undefined indications

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identified from the bobbin coil exam.

- MRPC examination of all open row 1 U-bends and 30% row 2 U-bends to detect potential inner diameter cracking.
- 6. MRPC inspection of the upper and lower expansion joints of 10% of the sleeves.

Due to indications detected during the sleeved tube examination, the inspection scope was modified as follows:

- The cross-wound examination of the entire sleeve length was reduced from 10% to 3% (item 3, above)
- Increased MRPC examination of the Westinghouse mechanical sleeves' upper expansion joints from 10% to 100% (item 6, above).
- 3. Increased MRPC examination of the sleeve lower expansion joints from 10% to $\geq 21\%$ (item 6, above).

The Kewaunee Nuclear Power Plant (KNPP) Technical Specification (TS) 4.2.b.2.a requires the initial examination to include at least 3 percent of the non-repaired tubes and at least 3 percent of the repaired tubes in each SG. Since the examination included 100 percent of the unplugged, unsleeved tubes through their entire length, 100 percent of the unsleeved sections of the sleeved tubes, and 3 percent of the in-service sleeves through their entire length, the examination program satisfies KNPP TS requirements.

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The eddy current examination of the hot leg tubesheet crevice region found 15 tubes in SG A and 7 tubes in SG B which were classified as defective (Single Axial Indications (SAI), Multiple Axial Indications (MAI) or greater than 50% through-wall). In accordance with KNPP TS's, these tubes were plugged.

The eddy current examination of the tube support plate regions found 13 tubes in SG A and 3 tubes in SG B which were classified as defective (Single Axial Indications (SAI), Multiple Axial Indications (MAI) or greater than 50% through-wall). In accordance with KNPP TS's, these tubes were plugged.

During the 1994 inspection, a newly developed MRPC probe was used to inspect the upper and lower hybrid expansion joints (HEJs) of the Westinghouse sleeves. The initial eddy current MRPC examination results of the sleeve upper HEJs in SG A (10% or 226) found 7 tubes (3.1%) with circumferential indications in the parent tube at the lower transition of the upper roll expansion (refer to attached Figure 1). TS Figure 4.2-1 specifies that tube plugging limits apply to both the installed sleeve and the parent tube in this region. Therefore, these indications were classified as defective. Since greater than 1% of the examined tubes were considered defective (categorized as C-3), the scope of the inspection for the affected region was expanded to include 100% of the remaining sleeve upper HEJs (2160 total tubes) in SG A as required by KNPP TS Table 4.2.b.5.c. The initial examination results identified 53 tubes as being defective. Later evaluations determined that the indications in five of the 53 tubes were located at the lower hydraulic expansion and below the area that would require plugging as specified in TS Figure 4.2-1. As a result, the

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final examination results for SG A found 48 tubes to be classified as defective. In accordance with KNPP TS's, these tubes were plugged.

Based on the results from the SG A inspection, it was decided to increase the inspection scope from 10% to 100% of the upper HEJs in SG B (2098 total tubes). The NRC was notified at 2000 hours on April 16, 1994 when the analysis of SG B eddy current results determined that the upper HEJ region in SG B inet the criteria for classification as C-3. The examination of SG B found 24 tubes (1.1%) to be defective. One of the tubes had a pluggable indication in the expansion region above the upper hard roll, while the other 23 tubes had indications in the expansion region below the upper hard roll. Later evaluations determined that the indications in 6 of the 23 tubes were located at the lower hydraulic expansion and below the area requiring plugging as specified in TS Figure 4.2-1. In accordance with KNPP TSs, 18 tubes were plugged.

The initial eddy current examination MRPC results of the sleeve lower HEJs in SG A (10% or 226) found 2 tubes (0.88%) with indications in the parent tube. TS Figure 4.2-1 specifies that tube plugging limits apply to both the installed sleeve and the parent tube in this region. The two indications found in the lower sleeve expansion joint placed this region in the C-2 category which requires expanded scope to a minimum of 21% (454 tubes). When 488 total lower sleeve expansion joints had been inspected (22.6%) the lower sleeve joint indication totals were reconsidered for categorization. The number of lower joint indications was reduced to one (0.20%) based on analyst resolution and further inspection of the lower HEJ was not required. Later evaluations determined that the indication did not meet the KNPP TS definition as defective.

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This indication was characterized as a scratch resulting from the plug removal process, therefore the associated tubes were not plugged.

Based on the results from the SG A inspection, it was decided to increase the scope of inspection from 10% to a minimum of 21% of the lower HEJs in SG B (441 minimum tubes). After 755 tubes had been inspected (36%) the examination identified 5 sleeves with lower HEJ indications. This was below the 1% criteria for 100% scope expansion for the lower sleeve expansion joint region. Later evaluations determined that the 5 indications did not meet the KNPP TS definition as defective. Again, these indications were characterized as scratches resulting from the plug removal process, therefore the associated tubes were not plugged.

The Combustion Engineering welded sleeves in SG A were also inspected, but no indications were found. Since there were no indications in the 12 Combustion Engineering welded sleeves in SG A, the 4 Combustion Engineering welded sleeves in SG B were not inspected.

This was the first time that this MRPC probe, specifically designed for sleeve joint inspection, was used in the United States and the first time circumferential indications in the HEJs have been detected at KNPP. The results of this inspection were discussed with the NRC on April 19, 1994 in Washington, D.C.

In addition to the eddy current examination results, one sleeved tube in SG A hot leg was identified with potential leakage during a visual scan of the tubesheet. Eddy current results from this tube identified an

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inadequate lower hard roll on the sleeve. This tube was removed from service.

The total examination results found 77 tubes (2.45 percent of tubes examined) in SG A and 28 tubes (0.90 percent of tubes examined) in SG B which met the KNPP definition of defective. According to the KNPP TS 4.2.b.5.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.5.c).
- 2. A written follow-up to the NRC (TS 4.2.b.5.c).
- 3. Plugging or repair of all defective tubes (TS Table 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 (TS Table 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 Specification 4.2.b.5.a and 4.2.b.5.c and, as described later in this report, all tubes classified as defective were plugged. The SGs will be reexamined during the 1995 refueling outage.

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The SG tube examination results for the 1994 refueling outage are summarized in the following table:

AREA	No. of Tubes		
	SG A	SG B	
Top of Tubesheet - Cold Leg Side	0	0	
Cold Leg Support Plates	1	0	
Hot Leg Support Plates	12	3	
Top of Tubesheet - Hot Leg Side	0	0	
Hot Leg Tubesheet Crevice	15	7	
Upper Sleeve Expansion Joint	48	18	
Lower Sleeve Joint Leakage	1	0	
TOTAL	77	28	

Plugged Tube Locations, 1994 Refueling Outage

Note: Tubes with multiple indications were only counted once in the first applicable listed area.

Cause of Event

The majority of the SG tube degradation at KNPP is likely caused by 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.

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During the 1990 Refueling Outage portions of two SG tubes were extracted from the B SG hot leg. The tubes were examined by non-destructive and destructive examination techniques. Both tubes had axial crack networks within the tubesheet crevice region. The cracking was caused by outside diameter intergranular stress corrosion. The crack morphology had some intergranular attack characteristics. It was concluded that an alkaline crevice environment was associated with the stress corrosion.

During the 1993 refueling outage, portions of 3 tubes were extracted from the B SG cold leg which included a total of 5 tube support plate intersections. These tubes were examined by non-destructive and destructive examination techniques to determine actual tube condition relative to eddy current results. Similar conditions were found for the three SG tubes' sections as was found for the tube sections removed and examined in 1990.

This inspection with the MRPC probe specifically designed for sleeve joint inspection identified indications at the upper and lower HEJs. The indications at the lower HEJs have been characterized as scratches caused from the plug removal process. Kewaunee personnel researched the sleeving history of the tubes with indications in the upper HEJs, but a definite pattern or trend could not be identified. The exact cause of these indications is not yet known.

NRC FORM 366A U.S. NUCLEAR REGULATORY COMMISSION APPROVED BY OMB NO. 3150-0104 (5-92) **EXPIRES 5/31/95** ESTIMATED BURDEN PER RESPONSE TO COMPLY WITH THIS INFORMATION COLLECTION REQUEST 50.0 HRS FORWARD COMMENTS REGARDING BURDEN ESTIMATE TO THE INFORMATION AND RECORDS MANAGEMENT BRANCH (MNBB 7714), U.S. NUCLEAR DEPUTY SOUTH OF THE DEPUTY OF THE DOT AND TO LICENSEE EVENT REPORT (LER) **TEXT CONTINUATION** REGULATORY COMMISSION, WASHINGTON, DC 20555-0001, AND TO THE PAPERWORK REDUCTION PROJECT (3150-0104), OFFICE OF MANAGEMENT AND BUDGET, WASHINGTON, DC 20503 FACILITY NAME (1) LER NUMBER (6) DOCKET NUMBER (2) PAGE (3) SEQUENTIAL REVISION YEAR NUMBER NUMBER 05000305 10 OF 13 Kewaunee Nuclear Power Plant 94 004 00

TEXT (If more space is required, use additional copies of NRC Form 366A) (17)

Analysis of Event

This report is being submitted in accordance with KNPP TS 4.2.b.5.a which requires a report to be submitted to the NRC within thirty days of completing the in-service inspection and plugging of the steam generators.

The following table provides a historical summary of the number of the SG tubes plugged and sleeved each

year:

	Steam Generator A				Steam Generator B				
	Plugged Tubes		Unplugged & Sleeved		Plugged Tubes		Unplugged		
	Un- Sleeved (A)	Sleeved (B)	(recovered) Tubes (C)	Sleeved Tubes (D)	Un- Sleeved (A)	Sleeved (B)	& Sleeved (recovered) Tubes (C)	Sleeved Tubes (D)	
1983	23				50				
1984	9				17				
1985	26				22				
1986	26				46				
1987	44				79				
1988	17			990	26			950	
1989	21			8 83	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	
Total Tubes Plugged ⁽¹⁾		328				294			
Total Tubes Sleeved ⁽²⁾	2116					2083			

Notes: 1. Total Tubes Plugged = $\Sigma(A) + \Sigma(B) - \Sigma(C)$

2. Total Tubes Sleeved = $\Sigma(C) + \Sigma(D) - \Sigma(B)$

U.S. NUCLEAR REGULATORY COMMISSION

LICENSEE EVENT REPORT (LER) TEXT CONTINUATION

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

ESTIMATED BURDEN PER RESPONSE TO COMPLY WITH THIS INFORMATION COLLECTION REQUEST: 50.0 HRS FORWARD COMMENTS REGARDING BURDEN ESTIMATE TO THE INFORMATION AND RECORDS MANAGEMENT BRANCH (MNBB 7714), U.S. NUCLEAR REGULATORY COMMISSION, WASHINGTON, DC 20555-0001, AND TO THE PAPERWORK REDUCTION PROJECT (3150-0104), OFFICE OF MANAGEMENT AND BUDGET, WASHINGTON, DC 20503.

FACILITY NAME (1)	DOCKET NUMBER (2)		PAGE (3)		
	05000005	YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	
Kewaunee Nuclear Power Plant	05000305	94	- 004 -	00	11 OF 13

TEXT (If more space is required, use additional copies of NRC Form 366A) (17)

The current equivalent plugging percentage increased from 10.19 percent to 12.39 percent in SG A and from 10.55 percent to 11.35 percent in SG B. Since KNPP's Updated Safety Analysis Report (USAR), assumes a plugging level of 13.94 percent per SG, these new plugging percentages remain well within acceptable limits. Therefore continued operation of the plant with an overall equivalent plugging level of 11.87 percent does not represent a significant hazard to the health and safety of the public.

Corrective Actions

In accordance with KNPP's TS, all tubes classified as defective were plugged.

Sludge lancing was conducted during the 1994 refueling outage to reduce the amount of sludge and to remove contaminants from the tube sheet. 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.

In addition Kewaunee is continuing to evaluate repair alternatives for the sleeved tubes with indications in the upper HEJ.

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NRC FO	DRM 366A U.S. NUCLEAR REGULATORY COMMISSION			APPROVED BY OMB NO. 3150-0104 EXPIRES 5/31/95				
LICENSEE EVENT REPORT (LER) TEXT CONTINUATION				ESTIMATED BURDEN PER RESPONSE TO COMPLY WITH THIS INFORMATION COLLECTION REQUEST 50.0 HRS FORWARD COMMENTS REGARDING BURDEN ESTIMATE TO THE INFORMATION AND RECORDS MANAGEMENT BRANCH (MNBB 7714). U.S. NUCLEAR REGULATORY COMMISSION, WASHINGTON, DC 20555-0001, AND TO THE PAPERWORK REDUCTION PROJECT (3150-0104), OFFICE OF MANAGEMENT AND BUDGET, WASHINGTON, DC 20503.				
	FACILITY NAME (1)	DOCKET NUMBER (2)		LER NUMBER (6) SEQUENTIAL	PAGE (3)			
Kewa	unee Nuclear Power Plant	05000305	94	NUMBER - 004 -	NUMBER 00	12 OF 13		
Additi	xe space is required, use additional copies of NRC Form 366A) (17)							
Equip	Equipment Failure: Westinghouse Model 51 steam generator tubes. The tubing is mill annealed inconel 600.							
Similar Events:								
1.	LER 93-004, Intergranular Attack and Intergranular Stress Corrosion Cracking Results in Both Steam							
	Generators Being Categorized as C-2.							
2.	LER 92-006, Intergranular Attack and Intergranular Stress Corrosion Cracking Results in Both Steam							
	Generators Being Categorized as C-3.							
3.	LER 91-005, Intergranular Attack and Intergranular Stress Corrosion Cracking Results in Both Steam							
	Generators Being Categorized as C-3.							
4.	LER 90-005, Intergranular Attack and Intergranular Stress Corrosion Cracking Result in Defective							
	Steam Generator Tubes.							
5.	LER 89-007, Intergranular Attack and In	tergranular Stress (Corrosi	on Cracking	Result in	Defective		
	Steam Generator Tubes.							
6.	LER 88-003, Intergranular Attack and Intergranular Stress Corrosion Cracking Result in Defective							
	Steam Generator Tubes.							
7.	Letter from D.C. Hintz (WPSC) to G.E. Lear (NRC) dated April 23, 1986.							
8.	LER 85-06, Steam Generator Tube Plugged in Incorrect Location.							
9.	Letter from C.W. Giesler (WPSC) to S.A. Varga (NRC) dated May 1, 1984.							

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