NRC-00-047

Public Service

Wisconsin Public Service Corporation
(a subsidiary of WPS Resources Corporation)
Kewaunee Nuclear Power Plant
North 490, Highway 42
Kewaunee, WI 54216-9511
920-388-2560

June 15, 2000

10 CFR 50.73

U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, D.C. 20555

Ladies/Gentlemen:

Docket 50-305
Operating License DPR-43
Kewaunee Nuclear Power Plant
Reportable Occurrence 2000-006-00

In accordance with the requirements of 10 CFR 50.73, "Licensee Event Report System," the attached Licensee Event Report (LER) for reportable occurrence 2000-006-00 is being submitted.

Sincerely,

for

Mark L. Marchi
Vice President-Nuclear

TPO/jmf

Attach.

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

IE22

RGN-001

NRC FORM 366 U.S. NUCLEAR REGULATORY COMMISSION
(6-1998)

LICENSEE EVENT REPORT (LER)

(See reverse for required number of digits/characters for each block)

APPROVED BY OMB NO. 3150-0104 EXPIRES 06/30/2001

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TITLE (4)

Intergranular Attack and Intergranular Corrosion Cracking of Tubes in Steam Generators Results in Category C3

EVENT DATE (5)			LER NUMBER (6)			REPORT DATE (7)			OTHER FACILITIES INVOLVED (8)	
MONTH	DAY	YEAR	YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	MONTH	DAY	YEAR	FACILITY NAME	DOCKET NUMBER 05000
05	15	2000	2000	– 006 –	00	06	15	2000	FACILITY NAME	DOCKET NUMBER 05000

OPERATING MODE (9)	N	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)(2)(v)		50.73(a)(2)(i)		50.73(a)(2)(viii)
			20.2203(a)(1)		20.2203(a)(3)(i)	X	50.73(a)(2)(ii)		50.73(a)(2)(x)
			20.2203(a)(2)(i)		20.2203(a)(3)(ii)		50.73(a)(2)(iii)		73.71
			20.2203(a)(2)(ii)		20.2203(a)(4)		50.73(a)(2)(iv)	X	OTHER
			20.2203(a)(2)(iii)		50.36(c)(1)		50.73(a)(2)(v)		Specify in Abstract below or in NRC Form 366A
			20.2203(a)(2)(iv)		50.36(c)(2)		50.73(a)(2)(vii)		

LICENSEE CONTACT FOR THIS LER (12)

NAME	TELEPHONE NUMBER (Include Area Code)
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COMPLETE ONE LINE FOR EACH COMPONENT FAILURE DESCRIBED IN THIS REPORT (13)

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

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

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

On May 15, 2000, with the plant in refueling shutdown, the 2000 in-service inspection of Steam Generator (SG) tubes was completed. The in-service inspection found 105 tubes in SG A, and 25 tubes in SG B which were either considered defective or preventatively plugged. In accordance with the Kewaunee Nuclear Power Plant (KNPP) technical specifications (TSs), SG A was categorized as C-3 in the hot leg tubesheet crevis region. In SG B, the initial sample of Westinghouse Hybrid Expansion Joint (HEJ) Laser Weld Repaired (LWR) sleeved tubes 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 hybrid expansion joint (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 were plugged or repaired. 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.

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Description of Event

On May 15, 2000, with the plant in refueling shutdown, the in-service inspection of steam generator [SG] tubes [TBG] was completed for the 2000 refueling outage.

The Kewaunee Nuclear Power Plant (KNPP) steam generators (SG) 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, sleeving and sleeve repair efforts have been required in each SG. Prior to the 2000 refueling outage, SG A contained 801 plugged tubes and 1754 sleeved tubes (930 Westinghouse mechanical sleeves, 356 Westinghouse laser weld repaired mechanical sleeves, and 468 ABB Combustion Engineering welded sleeves). SG B contained 716 plugged tubes and 1723 sleeved tubes (1371 Westinghouse mechanical sleeves, 288 Westinghouse laser weld repaired mechanical sleeves, and 64 ABB Combustion Engineering welded sleeves). The combined equivalent plugging percent for the two SGs was 24.62 percent.

The KNPP spring 2000 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. A 20% rotating probe examination of inservice ABB Combustion Engineering TIG welded sleeves.
4. A 100% rotating probe examination of all inservice Westinghouse mechanical sleeve upper expansion joints.
5. A 20% rotating probe examination of all inservice Westinghouse mechanical sleeves.
6. A 100% rotating probe examination of all open row 1 and row 2 U-bends and 20% of the row 3 U-bends, from the seventh hot leg tube support plate to the seventh cold leg tube support plate, conducted with a mid-frequency (300 kHz) +Point rotating probe.

7. A 100% rotating probe examination of all open row 1 and row 2 U-bends and 20% of the row 3 U-bends, from the seventh hot leg tube support plate to the seventh cold leg tube support plate, conducted with a high-frequency (800 kHz) +Point rotating probe.
8. A 100% rotating probe examination of all non-sleeved hot leg tubes, from the end of the tube to approximately four inches above the secondary face of the tubesheet.
9. A 20% rotating probe examination of inservice Westinghouse mechanical sleeve laser weld repairs, from two inches above the top of the sleeve to the bottom of the sleeve.
10. A 20% ultrasonic examination of in service Westinghouse mechanical sleeve laser weld repairs.
11. Supplemental rotating coil examinations of ambiguous signals, as required.

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

<u>2000 Inspection Results</u>

During the course of the spring 2000 eddy current examination of the KNPP SGs, it was identified that greater than 1% of the Laser Weld Repaired (LWR) sleeved tubes in SG B were classified as defective. Since greater than 1% of the examined tubes were considered defective (categorized as C-3), the Nuclear Regulatory Commission (NRC) was notified at 0959 hours on May 2, 2000 as required by KNPP TS 4.2.b.7.c and 10 CFR 50.72(b)(2)(i).

The eddy current examinations of SG A (prior to SG repair operations) were completed on May 8, 2000. Considering the inspection results, it was identified that greater than 1% of the non-sleeved and non-plugged tubes within the hot leg tubesheet crevice region in SG A were classified as defective. Since greater than 1% of the examined tubes were considered defective (categorized as C-3), the Nuclear Regulatory Commission (NRC) was notified at 1053 hours on May 8, 2000 as required by KNPP TS 4.2.b.7.c and 10 CFR 50.72(b)(2)(i).

All tubes classified as defective in both SGs (21 in SG A and 14 in SG B) were either removed from service via plugging or repaired via tubesheet sleeving in accordance with TS 4.2.b.4.a. Additional tubes were removed from

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service as a preventative measure (92 tubes in SG A and 13 tubes in SG B). No tubes were removed for destructive analysis. A total of 15 tubes in SG A and 18 tubes in SG B were recovered via tubesheet sleeving. As a result of tube plugging, repairs and recovery, the combined equivalent tube plugging percentage following the spring 2000 inspection and repair program is 26.05%. Tube degradation reported during the spring 2000 eddy current inspection is described below.

Tube Support Plate Intersections

The 2 volt alternate repair criteria (ARC) was applied to indications (attributable to Outside Diameter Stress Corrosion Cracking (ODSCC)) found within the tube support plate intersections. The ARC was implemented in accordance with TS 4.2.b.5. The eddy current examination of the tube support plate intersections found 341 indications in SG A and 862 indications in SG B. Of these, 1 indication in SG A (3.42 volts) and 1 indication in SG B (due to the inability to inspect with the required 0.720 inch diameter bobbin probe) did not satisfy the ARC. Both tubes were removed from service. The average voltage was 0.57 volts for SG A and 0.60 volts for SG B, which is consistent with previous inspections in which the 2 volt ARC was implemented. Augmented testing included plus point examinations of all dents greater than 5 volts, rotating pancake coil (RPC) testing of indications with a phase angle corresponding to a depth >40% through wall and large mix residual signals. There were no indications reported in the dented tube intersections or in the large mix residuals. For those tubes RPC tested based on phase, all but three tube locations in SG B were reported containing indications suggestive of ODSCC, in which the 2-volt alternate repair criteria could be applied. The three tube locations in which ODSCC could not be confirmed were volumetric in nature and were removed from service.

Anti-Vibration Bar (AVB) Wear

A total of 466 indications of AVB wear were reported. In SG A, 118 indications of AVB wear were reported. 112 of the 118 indications had reported depth ≤20% throughwall, with the largest reported depth at 35% through wall (TW). In SG B, 348 indications of AVB wear were reported. All but one of the indications had reported depth ≤20% throughwall; the largest reported depth was reported at 25% through wall. No tubes were removed from service based on AVB wear.

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Westinghouse Hybrid Expansion Joint (HEJ) Mechanical Sleeves

Eddy current examination results of the sleeve upper HEJs found no tubes in SG A and 1 tube in SG B 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.c. TS 4.2.b.4.c defines the pressure boundary for parent tube indications within the HEJ region in terms of a minimum non-degraded (i.e., no detectable degradation in the parent tube) hardroll length of 0.95 inch (inclusive of NDE uncertainty) as measured from the bottom of the hardroll upper transition. As the one indication in SG B was within the pressure boundary, it was classified as defective and was removed from service. No degradation was detected in the sleeve lower joints or in the sleeve straight lengths.

ABB Combustion Engineering TIG Welded Sleeves

This sleeve population included both 27-inch tubesheet sleeves and 39-inch tubesheet sleeves. No degradation was reported in the TIG welded sleeves as a result of this inspection.

Row 1, 2 and 3 U-Bends

One axially oriented indication of Primary Water Stress Corrosion Cracking (PWSCC) was detected in the row 1 U-bend region in SG A. Seventeen outside diameter (OD) signals in 6 tubes were also identified in the low row u-bend regions. These OD signals were assigned an SAA (Single Axial Anomaly) indication code. This indication code was used because the characteristics of the signals were not typical of ODSCC and a historical review of the locations of the OD signals showed that the signals had been present in previous inspections. All indications within the low row U-bend region identified above were removed from service. In addition to the tubes identified above, Wisconsin Public Service Corporation (WPSC) elected to remove the remaining active row 1 tubes from service based on information gathered to date on the Indian Point Unit 2 SG experience. This population consisted of 34 tubes in SG A and 7 tubes in SG B. In addition, WPSC employed a zero tolerance threshold regarding data quality for U-bend rotating examinations. U-bend data was required to be free of probe skip/stall signals for both the mid frequency and high frequency examinations. Tubes not meeting this requirement were removed from service as a precautionary measure. A total of 39 tubes in SG A and 4 tubes in SG B were removed from service as a result of data quality issues.

Hot Leg Open Tubesheet Crevice

Based upon the results of the eddy current inspection, the principal degradation mechanisms that affected the Kewaunee steam generators during Cycle 23 were tubesheet-related. Eight tubes (9 indications) in SG A and 4 tubes (4 indications) in SG B were identified as containing axially oriented ODSCC in the hot leg tubesheet crevice region. In addition, 7 tubes (7 indications) in SG A and 1 tube (1 indication) in SG B were identified as containing PWSCC in the hot leg tubesheet roll or roll transition regions. One of these indications in SG A was circumferentially oriented. The remaining PWSCC indications were axially oriented. No indications were detected at the top of the tubesheet. Of the 15 tubes considered defective in SG A, 5 were repaired by sleeving in accordance with TS 4.2.b.4.a. The remaining 10 were removed from service. Of the 5 tubes considered defective in SG B, 2 were repaired by sleeving in accordance with TS 4.2.b.4,a. The remaining 3 were removed from service. The number of indications reported in the hot leg tubesheet crevice region is consistent with the two previous inspections. In addition, two tubes in SG A were reported with indications of possible loose parts. Subsequent visual examinations from the SG secondary side identified the presence of a hollow, cylindrical object wedged between the two tube locations. Retrieval attempts were unsuccessful and the two tubes were removed from service as a precautionary measure.

Westinghouse HEJ Sleeve Laser Weld Repair (LWR) Region

No tubes in SG A and 2 tubes in SG B contained indications in the laser weld region. As a result, SG B was classified as C-3 as the inspection scope was expanded to include 100% of all LWR sleeves in SG B. No additional LWR indications were reported in the expanded sample. Historical data review for these two locations revealed the presence of the flaw signal from the 1998 inspection. However, the flaw signal was not reported during the 1998 inspection. There was no change in signal amplitude at these two locations between the 1998 and 2000 inspections. Both tube locations with indications in the weld described above were removed from service. Ultrasonic examinations of the installed LWRs were acceptable, with little to no change from the baseline ultrasonic data.

The overall examination results for the spring 2000 outage found 21 tubes (0.81 percent of tubes inspected) in SG A and 14 tubes (0.52 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 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).

The NRC was notified at 0959 hours on May 2, 2000, upon identification of the C-3 classification for the LWR sample results in SG B. The sample population was expanded to include 100% of the installed LWR tubes in SG B. The NRC was notified at 1053 hours on May 8, 2000, upon identification of the C-3 classification for the hot leg tubesheet crevice results in SG A. Since 100% of the affected population was examined, no sample expansion was necessary. This Licensee Event Report satisfies the 30 day reporting requirement of KNPP TS 4.2.b.7.a and TS 4.2.b.7.c. All defective tubes have been plugged or repaired. As KNPP plans on replacing its SGs in September 2001, no subsequent scheduled inservice examination of the existing SGs will be performed. In the event SG replacement is delayed, WPSC will re-evaluate the need to perform a subsequent inservice examination in accordance with TS 4.2.b.3.b.

A tube recovery program was also initiated to regain additional plugging margin. As part of this effort, plugs were removed from previously plugged tubes, the tubes were re-examined, and tubesheet sleeves were installed. A total of 15 tubes in SG A and 18 tubes in SG B were returned to service.

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 tubes pulled from the KNPP SGs during the 1990, 1993 and 1996 outages, eddy current signals, and industry experience with similar SGs. Outside diameter IGA/IGSCC is usually associated with a restricted geometry; e.g., the tubesheet 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. 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.

The two indications in the SGB laser welds reported during the 2000 inspection were present in the 1998 inspection data but were not reported. The indications were likely not reported as a result of inadequate analyst training. The laser weld repairs are unique to KNPP; as a result, eddy current analysts do not routinely analyze eddy current data from laser weld repairs. For plant specific examinations such as this, analysts are typically trained and tested on plant specific examinations prior to the inspection. During the 1998 outage a high frequency plus point probe was utilized for the first time during inspection; as a result, no data was available prior to the start of the 1998 inspection for the analysts to review. High frequency plus point data was available prior to the 2000 inspection and each analyst was subject to a performance demonstration, inclusive of laser weld repaired tubes, prior to analyzing any data. It is likely that the training provided prior to the 2000 examination on laser weld repaired tubes significantly increased analyst awareness and the resulting ability to report indications in laser weld repaired tubes.

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Analysis of Event

The eddy current examination results were reviewed to determine the structural significance of all of the indications that were detected, relative to the requirements of the KNPP TS, NRC Regulatory Guide 1.121, NRC Generic Letter 95-05 and NEI 97-06.

Tube Support Plate Intersections

For the as-found tube support plate indications, the end of cycle probability of burst was calculated to be 3.89×10^{-5} for SG A and 3.64×10^{-5} for SG B. These values are significantly less than the limiting probability of burst (1.0×10^{-2}) stated in NRC Generic Letter 95-05. The as-found conditional leak rate under a postulated steam line break was determined to be 0.28 gpm for SG A and 0.80 gpm for SG B, significantly less than the Kewaunee allowable of 3.69 gpm.

Cold Leg Tube Support Plate Thinning

Three indications of possible cold leg thinning in three tubes were detected in SG B. The largest of these had an estimated depth of 71%TW by the bobbin coil inspection. For cold leg thinning with an axial extent of 0.34", the condition monitoring limit is 67.2%TW. This is determined by taking the structural limit of 83.6%TW and subtracting the material property and NDE uncertainties. Despite the fact that this indication exceeded the condition monitoring depth limit, it did not require in situ pressure testing based on the small axial and circumferential extent measurements. This cold leg thinning indication was also not considered for in situ leak testing based mostly on the relatively small voltage for this indication. This indication measured 0.77 volts with the bobbin coil and 0.35 volts with Plus Point. These voltages are much smaller when compared to the typical cold leg thinning indications at other 51-series plants. During a recent inspection at another plant, no cold leg thinning indications exceeded 50%TW, but the average voltage for the indications between 40%TW and 50%TW was 2.42 volts from the bobbin coil. This shows the relatively high voltage response which is typical of volumetric calls with significant depth. Since the 71%TW call at Kewaunee has a bobbin voltage of only 0.77 volts, the 71%TW measurement is believed to be an abnormality due to the distortion of the bobbin signal. For these reasons, this location was not selected for in situ leak testing.

AVB Wear

A total of 466 indications of AVB wear were detected. The deepest of these indications was measured as 35% throughwall. The structural limit for AVB wear assuming uniform thinning is 58%TW. Subtracting for material property and NDE uncertainties at 90% probability and 50% confidence yields a condition monitoring limit of 52.8%TW. Therefore, the largest of the AVB wear indications is below the condition monitoring limit. Therefore, no in situ pressure testing of these indications was required and is not considered as a potential leakage contributor.

Westinghouse Hybrid Expansion Joint (HEJ) Mechanical Sleeves

One parent tube indication (PTI) was detected in an HEJ sleeved tube in SG B (R35 C55). There were additional parent tube signals (410 in SG A and 222 in SG B) that did not require repair based on being located outside of the defined parent tube pressure boundary of the HEJ sleeve. The defined parent tube pressure is based on a 0.95" roll length between the PTI and the upper edge of the hard roll transition. The PTI within the parent tube pressure boundary was relatively small in voltage and coverage area. The depth of this indication was estimated to be greater than 70%TW. Although the axial and circumferential extents of this indication were below their respective structural limits, this flaw was in situ pressure tested since the EPRI screening criteria does not specifically address sleeve-related degradation. No leakage or rupture was observed at test pressures corresponding to normal operating and 1.43 times steam line break differential pressures. No burst occurred at three times normal operating differential pressure. A comparison between the pre- and post-in situ eddy current results showed no significant change in the eddy current signals.

Parent tube cracking in HEJ sleeves has been occurring at KNPP for the last few operating cycles. The leakage contribution of these flaws has been tested by Westinghouse in mockup conditions and from pulled tubes. The leakage through flawed HEJ tube samples removed from KNPP has been determined to be 0.0005 gpm per sleeve. Conservatively applying this value to all of the HEJ in each steam generator gives a total expected leak rate much less than 1.0 gpm. However, KNPP elects to conservatively apply a 1.0 gpm leak rate to the entire population. This is a very conservative estimate of SLB leakage through the population of flawed HEJ tubes, since the majority of the HEJ's are unflawed in both steam generators.

Low Row U-bend PWSCC

One indication of low radius u-bend PWSCC was detected. This indication in SGA R1 C38 was axially oriented and was measured as 0.32" in length. This is below the structural limit of 0.38", but the sizing uncertainties are not well defined for this degradation in this region. This, in conjunction with the recent Indian Point 2 experience, was adequate reason for in situ pressure testing of this indication, even though it did not require testing per the EPRI screening criteria for in situ testing. No leakage or rupture was observed at test pressures corresponding to normal operating and 1.43 times steam line break differential pressures. No burst occurred at three times normal operating differential pressure. A comparison between the pre- and post-in situ eddy current results showed no significant change in the eddy current signals.

Low Row U-Bend Axial Anomalies

Seventeen OD signals in 6 tubes were called in the low row u-bend regions. These OD signals were assigned an SAA (Single Axial Anomaly) indication code. This indication code was used because the characteristics of the signals were not typical of ODSCC and a historical review of the locations of the signals showed that the signals had been present in previous inspections. These indications were also detected with the bobbin coil. The largest voltage indication detected was a 1.25 volt indication in SG B R3 C78. This is well below the voltage threshold ($V_{THR\text{-}L}$ = 5.75V) for possible in situ leak testing of axial flaws. Despite the fact that none of these indications met the first screening criterion for in situ leak testing, all of these indications were in situ pressure tested. No leakage or rupture was observed at test pressures corresponding to normal operating and 1.43 times steam line break differential pressures. No burst occurred at three times normal operating differential pressure. A comparison between the pre- and post-in situ eddy current results showed no significant change in the eddy current signals.

Hot Leg Tubesheet Crevice ODSCC

All of the reported hot leg tubesheet ODSCC indications were detected in the crevice region. No indications were detected at the top of the tubesheet or in the sludge pile region above the tubesheet. Since all of these indications were contained within the tubesheet, tube rupture is not a concern. The numerous ODSCC indications in the crevice were also evaluated with respect to leakage. All of the detected crevice indications were axially-oriented. Per the EPRI In-Situ pressure Test Guidelines, if a certain threshold voltage is not exceeded, then in situ leak testing is not required. This threshold voltage (V_{THR-L}) was determined to be about 5.75 volts. The largest recorded voltage for the OD crevice indications was 0.70 volts. This is well below the voltage threshold. Therefore, there is negligible leakage potential and in situ leak testing was not required.

Hot Leg Crevice Roll Transition Axial PWSCC

Axial PWSCC was detected in the roll or roll transition regions of seven tubes during the R23 inspection. This type of tube damage mechanism has affected many Series 51 steam generators and most implement a re-roll repair method to establish a new pressure boundary above the cracks. The leak tightness of these types of indications is greatly affected by the fact that they occur in the crevice region that is tightly packed with secondary side deposits, and that they occur in the roll region of the tube that is expanded into the tubesheet. Since all of these indications were contained within the tubesheet, tube rupture is not a concern. The largest voltage indication detected was a 2.17 volt indication in SG A R12 C10. This is well below the voltage threshold (V_{THR-L} = 5.75V) for possible in situ leak testing of axial flaws.

Hot Leg Crevice Roll Transition Circumferential PWSCC

One indication of circumferentially-oriented PWSCC (SG A; R33 C24) was detected in the roll region during the R23 inspection. This indication had a large voltage response (12.72 volts) but measured only 49 degrees in circumferential extent and 73%TW maximum depth. The first screening criterion for leak testing of circumferential flaws is based on voltage. This criterion requires testing if the voltage exceeds a value (V_{LL}) corresponding to a large leakage potential (>10% of the site allowable leakage). This voltage value was not available. However, since this indication was located in the roll region, the potential for significant leakage does not exist. This is due to the fact that this indication was located 0.65" below the roll transition. Therefore, not only does the tightly-packed crevice inhibit leakage, but the 0.65" of good roll above this indication also minimizes the leakage potential. The second screening criterion is also voltage-based and is set at the voltage that corresponds to a probability of leakage of 25%. This value was also not available. Therefore, it was assumed that this voltage was exceeded. The third screening criterion is based on the maximum depth. The maximum depth of this indication was measured as 73%TW. Per EPRI Report TR-107197-P1, "Depth Based Structural Analysis Methods for SG Circumferential Indications", if there are no crack segments deeper than 80%TW, then the probability of leakage is zero.

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Therefore, 80%TW was used as the screening threshold for maximum depth (MD_{THR-L}) and, per the EPRI screening criteria, in situ leak testing was not required for this indication.

Westinghouse HEJ Sleeve LWR Indications

Two indications attributed to installation-induced cracking in the weld region were detected in HEJ sleeves that had been repaired by a laser weld. Both of these indications were detected in welds that were applied in the hard roll region of the sleeves. Both of these tubes were in situ pressure tested. No leakage or rupture was observed at test pressures corresponding to normal operating and 1.43 times steam line break differential pressures. No burst occurred at three times normal operating differential pressure. A comparison between the pre- and post-in situ eddy current results showed no significant change in the eddy current signals.

Cumulative Leakage Assessment for All Damage Mechanisms

The leakage contribution of each tube damage mechanism is added together to determine the cumulative postulated leak rate during a SLB event for a given steam generator. The total leakage is estimated at 1.28 gpm for SG A and 1.80 gpm for SG B. These values include the assumption that the HEJ sleeved tubes (defective and non-defective) will contribute a 1.0 gpm of leakage under SLB conditions. The only other leakage contribution comes from the leak rate calculations performed for the voltage-based repair criterion for ODSCC at the support plates. This total leakage is well below the 3.69 gpm limit established for KNPP necessary to meet off-site dose limits under a postulated end of cycle main steam line break accident.

Operational Leakage Assessment

Operational leakage is continually monitored during plant operation at full power. KNPP utilizes EPRI guidelines for monitoring primary to secondary leakage in KNPP procedures and Technical Specifications. The shutdown requirements for normal power operation are 150 gpd leakage, or 75 gpd leakage sustained for one hour, or 75 gpd leakage with a rate of increase of 30 gpd/hr over a 30-minute interval. These provisions provide for enhanced margin against gross tube failure at normal operation as well as additional margin against 10CFR100 dose limits due to accident leakage. Kewaunee was experiencing leak rates of between 8 and 9 gpd prior to shutdown at EOC-23. This leakage did not require any power reductions since the action levels requiring power reductions

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do not start until the leakage reaches 75 gpd. Based on the in-situ leak testing performed during the 2000 refueling outage, the operational leakage performance criteria were met.

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. Table 1 provides a historical summary of the number of the SG tubes plugged and sleeved each year.

Corrective Actions

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

Sludge lancing was conducted during the 2000 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.

FACILITY NAME (1)	DOCKET (2)	LER NUMBER (6)			PAGE (3)
		YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	
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TEXT *(If more space is required, use additional copies of NRC Form 366A)* (17)

Additional Information

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

Similar Events:

1. LER 98-015-00, Intergranular Attack and Intergranular Stress Corrosion Cracking of Tubes in Both Steam Generators Results in Category C-3.
2. LER 96-006-01, Intergranular Attack and Intergranular Stress Corrosion Cracking of Tubes in Both Steam Generators Results in Category C-3.
3. LER 95-001, Intergranular Attack and Intergranular Stress Corrosion Cracking of Tubes in Both Steam Generator Results in Category C-3.
4. LER 94-004, Intergranular Attack and Intergranular Stress Corrosion Cracking Result in Defective Steam Generator Tubes.
5. LER 93-004, Intergranular Attack and Intergranular Stress Corrosion Cracking Results in Both Steam Generators Being Categorized as C-2.
6. LER 92-006, Intergranular Attack and Intergranular Stress Corrosion Cracking Results in Both Steam Generators Being Categorized as C-3.
7. LER 91-005, Intergranular Attack and Intergranular Stress Corrosion Cracking Results in Both Steam Generators Being Categorized as C-3.
8. LER 90-005, Intergranular Attack and Intergranular Stress Corrosion Cracking Result in Defective Steam Generator Tubes.
9. LER 89-007, Intergranular Attack and Intergranular Stress Corrosion Cracking Result in Defective Steam Generator Tubes.
10. LER 88-003, Intergranular Attack and Intergranular Stress Corrosion Cracking Result in Defective Steam Generator Tubes.
11. Letter from D.C. Hintz (WPSC) to G.E. Lear (NRC) dated April 23, 1986.
12. LER 85-06, Steam Generator Tube Plugged in Incorrect Location.
13. Letter from C.W. Giesler (WPSC) to S.A. Varga (NRC) dated May 1, 1984.

ATTACHMENT

Letter from M. L. Marchi (WPSC)

To

Document Control Desk (NRC)

Dated

June 15, 2000

Reportable Occurrence 2000-006-00, Table 1

TABLE 1

	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 (C)	Unplugged (non- sleeved) (D)	Unplugged (sleeved) (E)	Sleeved Tubes (F)	Un- Sleeved (A)	Sleeved (B)	Unplugged & Sleeved (C)	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	-	-	-	-	930
1989	21	-	-	-	-	883	31	-	-	-	-	815
1990	114	8	-	-	-	-	103	6	-	-	-	-
1991	63	11	150	-	-	172	77	8	246	-	-	122
1992	17	13	-	-	-	12	19	16	-	-	-	4
1993	6	3	-	-	-	-	7	5	-	-	-	-
1994	21	56	-	-	-	-	9	19	-	-	-	-
1995	46	433	-	17	19	-	40	229	-	29	16	-
1996	35	370	62	-	275	-	22	352	-	-	107	-
1998	17	28	-	-	83	30	7	11	38	-	49	22
2000	53	53	15	-	-	5	15	10	18	-	-	2
Total Tubes Plugged (1)	892						723					
Total Tubes Sleeved (2)			1720						1733			

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