January 27, 2003

Mr. Mano Nazar
Site Vice President
Prairie Island Nuclear Generating Plant
Nuclear Management Company, LLC
1717 Wakonade Drive East
Welch, MN 55089

SUBJECT: PRAIRIE ISLAND NUCLEAR GENERATING PLANT, UNIT 2 - NRC STAFF FOLLOW-UP OF STEAM GENERATOR TUBE INSPECTION ACTIVITIES DURING RECENT REFUELING OUTAGE (TAC NO. MB4012)

Dear Mr. Nazar:

On April 22, 2002, the Nuclear Regulatory Commission (NRC) staff sent you a letter regarding recent steam generator tube inspections you performed at the Prairie Island Nuclear Generating Plant, Unit 2. The NRC staff's review efforts to date in this area are documented in a letter dated April 12, 2002 (ADAMS Accession No. ML021050465). As noted in the letter, the NRC staff raised a concern regarding the procedures for addressing noise in the eddy current test data in the U-bend region of low row tubes. The NRC staff expressed an interest to better understand your methodology for ensuring flaw detection in the U-bend region of low row tubes with high eddy current noise levels. As a result, the NRC staff conducted site visits on April 30 and May 1, 2002. Enclosed is a summary report of the site visits.

The NRC staff summarized its recommendations at the conclusion of the visits as follows:

(1) The methods for evaluating the detectability of a given flaw signal against a given noise background need to be improved. The validity of super-positioning techniques (flaw signal plus noise) needs to be demonstrated for each application.

(2) Your estimate of the "must detect" voltage involves significant uncertainty. A more robust supporting data set is needed. In addition, crack-length estimates should consider industry-wide experience in addition to Prairie Island experience.

This completes the NRC staff's efforts under TAC No. MB4012. If you have any questions regarding this matter, please contact me at (301) 415-1446.

Sincerely,

/RA/

John G. Lamb, Project Manager, Section 1
Project Directorate III
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket No. 50-306

Enclosure: Summary of NRC Staff Site Visits

cc w/encl: See next page

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cc:

J. E. Silberg, Esquire
Shaw, Pittman, Potts and Trowbridge
2300 N Street, N. W.
Washington, DC 20037

Site Licensing Manager
Prairie Island Nuclear Generating Plant
Nuclear Management Company, LLC
1717 Wakonade Drive East
Welch, MN 55089

Adonis A. Neblett
Assistant Attorney General
Office of the Attorney General
455 Minnesota Street
Suite 900
St. Paul, MN 55101-2127

U.S. Nuclear Regulatory Commission
Resident Inspector's Office
1719 Wakonade Drive East
Welch, MN 55089-9642

Regional Administrator, Region III
U.S. Nuclear Regulatory Commission
801 Warrenville Road
Lisle, IL 60532-4351

Administrator
Goodhue County Courthouse
Box 408
Red Wing, MN 55066-0408

Commissioner
Minnesota Department of Commerce
121 Seventh Place East
Suite 200
St. Paul, MN 55101-2145

Tribal Council
Prairie Island Indian Community
ATTN: Environmental Department
5636 Sturgeon Lake Road
Welch, MN 55089

Mr. Roy A. Anderson
Executive Vice President and
Chief Nuclear Officer
Nuclear Management Company, LLC
700 First Street
Hudson, WI 54016

Nuclear Asset Manager
Xcel Energy, Inc.
414 Nicollet Mall
Minneapolis, MN 55401

SUMMARY OF NUCLEAR REGULATORY COMMISSION STAFF SITE VISITS

ON APRIL 30 AND MAY 1, 2002

REGARDING DETECTABILITY OF CRACKS IN

PRAIRIE ISLAND NUCLEAR GENERATING PLANT, UNIT 2

STEAM GENERATOR TUBE U-BENDS

1.0 INTRODUCTION

The Nuclear Regulatory Commission (NRC) staff (Emmett Murphy, Cauis Dodd, and Tae J. Kim) met with the Nuclear Management Company, LLC (NMC or the licensee) on April 31 and May 1, 2002, at the Prairie Island Nuclear Generating Plant (PINGP) site to discuss NRC staff questions relating to the licensee's capability to detect structurally significant stress-corrosion cracks (SCCs) in the steam generator (SG) small radius U-bends at PINGP Unit 2. Specifically, the NRC staff sought to understand the basis for the licensee's eddy current data quality (i.e., noise) acceptance criteria implemented during the February 2002 inspection at PINGP, Unit 2, and the adequacy of these criteria in ensuring that potentially structurally significant crack indications in the small radius U-bends would be detectable for noise levels just meeting the acceptance limit. The NRC staff's findings from this trip are documented herein.

2.0 BACKGROUND

The capability of licensee inspection programs to detect structurally significant SCCs in small radius U-bends has been an area of focus for the NRC staff since the SG tube failure event at the Indian Point Nuclear Plant, Unit 2, in February 2000 where the presence of large noise signals during earlier inspections had masked the presence of a precursor signal at the location which ultimately failed.

Past U-bend cracking activity for the SGs at both PINGP Units 1 and 2 have involved only sporadic instances of no more than one tube with indications reported during a given outage. A total of five tubes with U-bend indications were reported at PINGP Unit 1 during the 2001 refueling outage inspection. Two tubes with U-bend indications have been found at PINGP Unit 2, the most recent a 1.7 volt circumferential indication at the tangent point intradose with a measured arc-length of 66 degrees. No U-bend indications were observed at Unit 2 during the most recent February 2002 refueling outage inspection.

The February 2002 inspection program for the small radius U-bends included a 100-percent inspection with the mid-range plus point coil (300 and 400 KHz). The noise acceptance criteria were initially based on the average noise levels present in the Electric Power Research Institute Examination Technique Specification Sheet qualification data set, consistent with the criteria implemented at Unit 1 during the 2001 refueling outage inspection. These included, in part, limits of 1.09 volts peak-to-peak (pp) at 300 KHz at the U-bend apex and 1.49 volts pp at 300 KHz at the U-bend tangent points. If these criteria were exceeded, a high frequency coil inspection was performed. The noise criteria for the high frequency inspection included, in part,

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1.56 volts pp at 800 KHz at the apex and 2.5 volts pp at the tangent points. If the high frequency noise criteria were exceeded for any tubes, the 300 KHz data were reevaluated using a band pass filter and the 300 KHz noise criteria were applied.

However, during the February 2002 inspection, 45 tubes were found to exhibit noise exceeding these criteria. To avoid having to plug all of these tubes, the licensee updated its previous analysis on the “must detect” indication voltage necessary to ensure tube integrity and concluded that the “must detect” voltage at 300 KHz is 2 volts, compared to earlier estimates which ranged to 1.5 volts for cracks not exceeding 0.6 inches in length, to ensure that the three times normal operating pressure criterion would be met over the next operating cycle. Therefore, the licensee revised the noise criteria for the U-bend apex location, which included increasing the 1.09 volt pp criterion for 300 KHz to 2 volts. Only seven tubes were unable to satisfy the revised criteria and were plugged.

The licensee maintains that flaw detection is not simply a function of signal-to-noise ratio, but is also a function of the type of noise. The licensee stated that in high frequency random noise, a signal-to-noise ratio of two may be necessary for reliable detection of flaws. The licensee states, however, that the noise in the PINGP U-bends is low frequency cyclic noise that is very repeatable from one scan line to the next and is primarily associated with tube ovality. Under these circumstances, the licensee believes that a signal-to-noise ratio of 0.5 is adequate for reliable detection.

3.0 MEETING DISCUSSION

The licensee began the meeting with a presentation of “basics” pertaining to eddy current signal analyses, and the effects of noise on flaw detection. The licensee then discussed and later demonstrated the use of the EPRI noise widget which was used by the licensee to verify that the “must detect” flaw voltage was detectable for the worst-case low row U-bend noise at PINGP, Unit 2. The noise widget has the ability to add noise from one section of the tube back to the same tube at another location. It can also add random noise. The tube used was one with an axial crack detected in 1997. The crack indication was 2.17 volts pp at 300 KHz. The licensee took noise that was on one section of the tube, increased this noise, and moved it to the tube section containing the indication. This increased the noise level at the crack location to about 2.5 volts pp, and the indication was still detectable.

The NRC staff reviewed the February 2002 signal responses for five of the noisiest U-bends meeting the revised noise criteria. The NRC staff noted that the general noise characteristics of the tubes in 2002 are different than was observed in 1997, most likely due to the thermal stress relief of the inner row U-bends performed insitu in May 2000. The 1997 noise tended to be more sinusoidal in nature, similar to wall thickness variations around the tube circumference. The noise in 2002 looked more similar to defect signals initiating on the inner surface of the tube with a depth of about 30 percent. It is the NRC staff’s belief that flaw detectability in the current noise environment at PINGP Unit 2 is not as good as that which existed in 1997. The NRC staff did not identify any flaw-like indications during its review of the noisiest tubes, suggesting that if flaws were in fact present on these tubes, they were likely less than 20 percent to 40 percent through-wall.

The NRC staff commented on limitations of the EPRI noise widget. In particular, the NRC staff noted that ideally one should be able to superimpose a flaw signal from one tube with noise signals from various locations from another tube, even for tubes involving different calibrations. The licensee also presented its revised analysis supporting 2 volts pp as the minimum “must detect” indication at 300 KHz. Previous analyses for PINGP Unit 1 were based on a correlation of calculated burst pressures for measured crack sizes at Indian Point Unit 2 as a function of crack voltage response and crack length. The licensee estimated the upper 95th percentile crack length to be 0.6 inches based upon the distribution of crack lengths for previously observed U-bend indications at both PINGP units. For crack lengths of 0.6 inches, the licensee calculated a “must detect” voltage of about 1.65 volts based on the Indian Point Unit 2 data. Cracks less than 0.6 inches do not have a “must detect” voltage since the burst pressure would always exceed the 3 delta P criterion, irrespective of crack depth. The revised analysis is based on primary water SCC (PWSCC) samples for dented tube supports which were used to support the PWSCC alternate repair criteria at Sequoyah and Diablo Canyon and results in a “must detect” voltage of 2 volts for cracks lengths of 0.6 inches. The licensee defended its use of this data set on the basis that (1) it is a more extensive data set than the Indian Point Unit 2 data, (2) the signals in the data set appear to be representative of the U-bend indications at PINGP, (3) the relationship between voltage and crack size (or burst strength) may be somewhat unique for Indian Point Unit 2 by virtue of the cracks being driven by stress associated with an applied displacement of the legs of the U-bend, and (4) the Indian Point Unit 2 crack size measurements were particularly imprecise because of the very high noise levels at that site. A third extensive data set, PWSCC samples for dented egg crate supports, was not used in determining the “must detect” voltage. This latter data set was for different size tubing, and the licensee concluded that there was too much uncertainty to attempt adjusting this data to reflect the tubing size at PINGP.

The NRC staff noted that the tube that ruptured at Indian Point Unit 2 had a crack with a response of 2.3 volts at the preceding inspection (only slightly larger than the licensee’s 2 volt “must detect” voltage estimate) and which, on the basis of hindsight, had a severely degraded burst pressure (about 3000 psi) at that time. The licensee responded that this crack was quite long, about 2.4 inches in length. Although the “must detect” voltage is less than 2 volts for this crack length, the large length of the crack is believed to be related to the unique circumstance at Indian Point Unit 2 where the primary driving force for the stress causing the crack was the applied U-bend leg displacement caused by hour glassing of the upper support plate rather than simply residual stress in the U-bends as a result of the bend fabrication process, as is believed to be the case at PINGP.

The NRC staff commented that although it has not reviewed the “must detect” voltage methodology in detail, the methodology on its face appears to be a clever, innovative approach to ascertaining minimum detection requirements for cracks. However, the NRC staff concluded it had significant reservations with respect to the conservatism of the license’s estimate of a 2 volt “must detect” voltage. The NRC staff’s primary concern is that it is not clearly known just how representative the data base for PWSCC at dented tube support plates is of U-bend cracks at PINGP in terms of the relationship among burst pressure, crack voltage response, and crack length. A more robust data set is needed, including U-bend samples with cracks. The NRC staff also noted that industry-wide data shows that PWSCC caused by residual stresses in the U-bends range to well beyond 1 inch in length and should not be ignored given the very limited number of U-bend cracks to date for PINGP. The “must detect” voltage decreases with crack length beyond 0.6 inches.

The NRC staff summarized its recommendations as follows at the conclusion of the meeting:

(1) The methods for evaluating the detectability of a given flaw signal against a given noise background need to be improved. The validity of super-positioning techniques (flaw signal plus noise) needs to be demonstrated for each application.

(2) The licensee's estimate of the "must detect" voltage involves significant uncertainty. A more robust supporting data set is needed. In addition, crack-length estimates should consider industry-wide experience in addition to PINGP experience.