NMC
Committed to Nuclear Excellence

Prairie Island Nuclear Generating Plant
Operated by Nuclear Management Company, LLC

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U S Nuclear Regulatory Commission
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PRAIRIE ISLAND NUCLEAR GENERATING PLANT
DOCKET 50-282
LICENSE No. DPR-42
RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION REGARDING LOWER ROW TUBE DENT ROOT CAUSE ANALYSIS (TAC NO. MB8715)

By letter dated April 25, 2003, Nuclear Management Company, LLC, (NMC) submitted the root cause analysis report for Unit 1 lower row tube denting identified during the 2002 Unit 1 refueling outage. By letter dated August 26, 2003, the Nuclear Regulatory Commission (NRC) submitted a Request for Additional Information (RAI), in which they requested answers to ten questions associated with the root cause analysis report. The attachment to this letter includes the NMC answers to the NRC's questions.

This letter contains no new commitments and no revisions to existing commitments.

Richard Graham for

Joseph M. Solymossy
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CC Regional Administrator, USNRC, Region III
Project Manager, Prairie Island Nuclear Generating Plant, USNRC, NRR
NRC Resident Inspector – Prairie Island Nuclear Generating Plant

Attachment

A001

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ATTACHMENT

NUCLEAR MANAGEMENT COMPANY, LLC

PRAIRIE ISLAND NUCLEAR GENERATING PLANT
DOCKET 50-282

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION
PRAIRIE ISLAND UNIT 1
LOWER ROW TUBE DENT ROOT CAUSE ANALYSIS

7 pages follow

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION
PRAIRIE ISLAND UNIT 1
LOWER ROW TUBE DENT ROOT CAUSE ANALYSIS

Requested Information

1. *On page 1, it is stated that no degradation was found in any of the dented locations of rows 1 and 2 tubes. The staff is not clear as to the licensee's inspection scope to make this determination. Discuss the inspection scope and strategy of rows 1 and 2 dents during 2001 and 2002 inspection, including the number of rows 1 and 2 tubes that were inspected in 2001 and 2002 and by which eddy current probe.*

Response

The inspection scope in 2001 was 100% of all active row 1 and 2 U-bends with the rotating +Pt.™ coil from the seventh tube support plate on the hot leg side through the seventh tube support plate on the cold leg side both prior to and after U-bend heat treatment. By default, any dent signal regardless of voltage was inspected with the rotating +Pt.™ coil at the seventh tube support plate. In addition, the straight tube portions of 100% of all active row 1 and 2 tubes were inspected from the seventh tube support plate through the tube end with the bobbin coil prior to heat treatment. Based on the bobbin coil result, any dent signal greater than or equal to 5.0 Volts (where 5.0 Volts was the recording threshold for dents) at a tube support plate was subsequently inspected with the rotating +Pt.™ coil. After U-bend heat treatment, 100% of all active row 1 and 2 U-bends were inspected as a minimum from the seventh tube support plate on the hot leg side through the seventh tube support plate on the cold leg side with a small diameter bobbin probe to verify a heat treatment signal was present.

The inspection scope in 2002 was 100% of all active row 1 and 2 U-bends with the rotating +Pt.™ coil from the seventh tube support plate on the hot leg side through the seventh tube support plate on the cold leg side. By default, any dent signal regardless of voltage was inspected with the rotating +Pt.™ coil at the seventh tube support plate. In addition, the straight tube portions of 100% of all active row 1 and 2 tubes were inspected from the seventh tube support plate through the tube end with the bobbin coil. Based on the bobbin coil result, any dent signal greater than or equal to 5.0 Volts (where 2.0 Volts was the recording threshold for dents) at a tube support plate was subsequently inspected with the rotating +Pt.™ coil.

Requested Information

2. *Page 2, first paragraph, last sentence. It is stated that "...For a circumferentially uniform geometry change of about 1 mil, bobbin dent signal exceeding 6 volts are expected..." (1) Discuss the technical basis of this statement. (2) Discuss whether this is a generic statement that is applicable to all Westinghouse steam generator tubes, or whether this statement is applicable only to the heat treated rows 1 and 2 tubes in the Prairie Island steam generators. (3) The statement could be interpreted as that if there is a dent-like signal less than 6 volts (e.g., near 2 volts) that the tube could have a geometry change of 0.3 mil (i.e., a dent). Therefore discuss the*

threshold of a dent classification in terms of bobbin voltage and in terms of geometry change. (This question is related to question 4 below)

Response

The amplitude of 6 Volts related to a 1 mil uniform dent is based on laboratory eddy current work. The statement is generic for 7/8 x 0.050 inch wall tubing and has no relation to heat treatment. The intent of this statement was to relate potential tube geometry deformations to the reported bobbin dent amplitudes in light of very little visual dent evidence from the +Pt.™ terrain plot. If the source of the bobbin signal truly is related to a geometry deformation, the magnitude of deformation is extremely small.

Requested Information

3. *Page 3, 2 paragraph. It is stated that in Table 2, the bobbin data collected in the 2001 inspection after heat treatment indicates that almost all rows 1 and 2 tubes show the presence of dent-like signals at hot leg tube support plate numbers 6 and 7; however, only voltage greater than 2 volts were reported. The staff is not clear as to the extent of the denting in rows 1 and 2 tubes.*

   a. *Provide the number of rows 1 and row 2 tubes that were heat treated in the U-bend region in 2001.*

   b. *Discuss how many rows 1 and row 2 tubes that have a dent-like signal less than 2 volts.*

   c. *Discuss whether the voltage of those less than 2 volt dent-like signals identified in the 2001 inspection have changed in the 2002 inspection. The staff assumes that all the dent-like signals, regardless of voltage, were inspected in 2002.*

   d. *Explain why dent-like signals less than 2 volts were not reported.*

Response

Table 2 does provide the extent of the bobbin coil reportable dent population in accordance with Prairie Island eddy current procedures. The statement in the report is based on a Westinghouse re-evaluation of the small diameter bobbin coil data used post U-bend heat treatment and is only qualitative in nature.

a. All active row 1 and 2 U-bends were heat treated in 2001.

b. It is unknown exactly how many row 1 and 2 tubes have dent-like signals less than 2.0 Volts as the reporting requirement at the time was greater than or equal to 2.0 Volts.

c. There were no dent signals reported in the 2001 inspection less than 5.0 Volts. There were no dent signals reported in the 2002 inspection less than 2.0 Volts. A direct comparison of dent voltages between the 2001 post heat treatment data set and the 2002 data set is not advisable due the differences in probe diameters used.

d. The bobbin coil is qualified for detecting stress corrosion cracking in the presence of dents less than 2.0 Volts.

Requested Information

4. *Page 3, 3rd paragraph. It is stated that "...the signal that were generally near ~2 volts and hence would generally not be called as a dent..." The staff is not clear how the licensee calls or classifies a dent. Discuss the criteria for calling a dent.*

Response

The Prairie Island eddy current bobbin coil analysis procedure used during 2001 required reporting of dents at equal to or greater than 5.0 Volts. The Prairie Island eddy current bobbin coil analysis procedure used during 2002 required reporting of dents at equal to or greater than 2.0 Volts. The change in philosophy was based on lessons learned from recent experience at Comanche Peak.

Requested Information

5. *On page 8, it is stated that although tube buckling would not be projected, buckling loads were determined to be very near the critical values.*

   a. *Provide the tube buckling loads and critical values.*

   b. *Discuss whether the tube buckling loads were calculated based on the design accident loads and the critical values were calculated based on the minimum material property (i.e., worst case scenario) values.*

   c. *Discuss whether all rows 1 and 2 tubes experience the same buckling load or only certain tubes. The eddy current data show that some tubes have higher dent voltage than others, which may imply that the buckling loads could be a contributor to the size of dents, i.e., higher buckling loads result in larger dents.*

Response

a. The critical buckling load for the condition where the tube is wedged in the tube support plates (TSPs) has been calculated to be 783 pounds. The axial force in the tube that occurs during the heat treatment process was calculated to be 725 pounds. Hence buckling is not projected to occur.

b. These buckling loads do not occur during operation of the steam generator but occur during the actual heat treatment process. Hence, these loads are not based on the design accident loads, but are a result of loadings occurring during a maintenance/repair operation. Any postulated compressive load applied to the tube during heat treatment is relieved after the tube cools to ambient temperatures, thus the postulated loads are not permanent. The load calculated in the response to question 5a is expected to bound any operating or accident condition.

c. Note in the response to question 5a that the maximum postulated compressive load is less than the critical buckling load; therefore, buckling will not occur. Therefore, any postulated applied compressive load is not related to development of a dent signal at an upper TSP. The buckling calculation was performed for the maximum temperature range associated with the process. Although the heater wattage settings are different for row 1 and row 2, these different settings are required in order to obtain the desired temperature ranges necessary for the heat treatment process for each row. This is a result of differences in how the thermal energy is radiated between row 1 and 2 tubes and the neighboring tubes. (Row 1 does not have any inboard neighbors, while row 2 has inboard neighbors, hence the emissivity of these tubes would be different.) Since the actual temperature of the tube would be a function of the actual tube characteristics, (i.e., tube is shiny, or black, or partially black, etc.) the actual temperature could be lower than the maximum value used in the calculation. Hence, there may be some row-wise variation that is a function of actual conditions that could influence the buckling load. It must also be noted that the row-wise variation in tube temperature could also result in changes in crevice deposits. These changes in crevice deposits could also influence the denting signals.

Requested Information

6. *Pages 9 and 10. In its root cause analysis, Westinghouse stated that it appears that the dent like signals were a result of the heat-treatment process. Other licensees have performed in-situ heat treatment to their low row U-bend regions; however, the staff is not aware extensive tube denting in the low row U-bend regions of other licensees' steam generators.*

   a. *Discuss whether the tube denting phenomena in rows 1 and 2 tubes in the Prairie Island steam generators have occurred in the Westinghouse steam generators in other nuclear plants.*

   b. *Discuss whether Westinghouse has notified all relevant licensees regarding tube denting after heat treatment in the Prairie Island nuclear plant.*

c. *Discuss whether Westinghouse has modified its heat treatment procedures to minimize future tube denting in steam generators.*

d. *Discuss whether the heat treatment performed in Prairie Island is consistent with the heat treatment performed in other licensees' steam generators.*

Response

No similar occurrences of dent-like signals at the uppermost TSP have been reported at other plants that have performed U-bend heat treatment (UBHT). Other licensees have not been notified of this event since all licensees with SGs that have performed UBHT perform 100% +Pt.™ inspection of Row 1 and 2 U-bends at each outage, and the uppermost TSP is included in this inspection. As all Row 1 and 2 uppermost TSPs are inspected at each outage, any postulated mechanism that could result in degradation of the tube would be identified. UBHT has been performed since approximately 1985, with the last field application prior to Prairie Island occurring in the 1995 time frame. There have been no industry reports of abnormal degradation at the uppermost support plate in Rows 1 or 2. The UBHT process performed at Prairie Island is consistent with all past efforts.

Requested Information

7. *Pages 9 and 10. During heat treatment of the U-bend region, a tube will expand in the diametral (circumferential) and longitudinal (axial) direction. If the clearance between the tube and tube support plate (TSP) is smaller than the circumferential thermal expansion, denting will result. The axial thermal expansion can cause tube buckling if the tube is locked at any of the TSP intersections, not just at TSP No. 7. Westinghouse stated that there is no evidence of significant deposit in crevice of TSP; therefore, tube may not be locked. However, the staff is not clear whether Westinghouse has examine the eddy current data of all TSP intersections (from number 1 to number 7) to determine no significant deposit at TSP No. 1 to TSP No. 7. A tube may be locked at lower TSP which may produce buckling at TSP 7.*

   a. *Discuss whether a calculation was performed to determine the diametral expansion of the tube is within the clearance of the tube and TSP intersection.*

   b. *Discuss whether eddy current data were studied to confirm that no significant deposits were present from TSP No. 1 to TSP No. 7 in the dented tubes.*

Response

As Nuclear Management Company, LLC, performs a 100% +Pt.™ examination of all Row 1 and 2 U-bends at each outage, the crevice deposit conditions are moot with regard to the issue at hand. It should be noted that 4 tubes were reported with dents at the uppermost support plate in the range of 3 to 5 Volts, prior to heat treatment. The dent amplitude of these tubes did not change due to heat treatment. If a

clearance issue existed, it would have been more evident in these tubes by significant changes in the dent amplitudes. The minimum tube to TSP clearance is 0.016 inches. For an assumed tube temperature of 1400°F, the diameter growth due to thermal expansion is 0.010 inches. At the TSP elevation, the tube temperature will be less than the temperature at positions adjacent to the heater element. Thus, postulated tube diameter change is less than the minimum tube to TSP clearance. If the tube at the TSP is 200°F less than at the heater, then the diameter change is approximately 0.008 inches. If it were postulated that diametrical expansion is the cause of the dent signal, upon cooling, the contact forces that caused the dent signal would be relieved. Thus, these intersections are not similar to classical dent conditions where the contact forces that cause the denting are present during operating conditions.

As the tube temperature along its axial length drops quickly with increasing distance from the heater, any postulated compressive loads introduced by the applied temperature are also significantly reduced, and thus, no buckling potential exists at lower spans. Note that the response to question 5 indicates that buckling will not occur.

Requested Information

8. *On page 11, it is stated that "...Whether or not signals are actual tube deformations, or are a result of some other mechanism, such as crevice deposit changes as a result of high temperature exposure, cannot be made without further information..." Discuss what information is needed for the root cause analysis.*

Response

There are no further plans to investigate this phenomenon as no useful information can be developed that would result in an increase in the plant safety.

Requested Information

9. *Pages 13 and 14. Tables 1 and 2 show that of the 28 tubes identified with dents, only 4 tubes are from row 1 and 24 tubes are from row 2. (1) Explain why row 2 tubes are more susceptible to denting than row 1 tubes. (2) There seems to be a specific area of the row 1 and 2 tubes that are susceptible to denting because majority of the row 2 dents (19 tubes) are located in the tubes with high column numbers (column 52 and higher). Explain why dents occur in tubes with high column numbers. These two observations may provide insights to the root cause of denting.*

Response

Any potential column preference is likely related to a specific heater, not any condition within the SG.

Requested Information

10. Page 14, Table 2. It is shown that the bobbin voltages of many dents in the 2002 data have decreased as compared to the corresponding voltages in the 2001 data. It is also shown that there are two dents in the row 2 tubes before heat treatment. (1) Explain the cause of the decrease in the dent voltages. (2) Discuss whether the U-bend regions of the higher row tubes (i.e., row 3 tubes and higher) were inspected to determine whether dents are occurring in higher rows in light of 2 dents before heat treatment.

Response

(1) The decrease in voltage from 2001 to 2002 is the result of the use of a different diameter probe in 2001. Probes of varying sizes may or may not produce similar dent voltage responses.

(2) At Prairie Island, 100 percent of the tubing in rows 3 through 46 was inspected with bobbin coil in both the 2001 and 2002 inspections.