UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO RESOLUTION OF BULLETIN 88-02

INDIANA & MICHIGAN POWER COMPANY

D. C. COOK NUCLEAR PLANT, UNIT NO. 1

DOCKET NO. 50-315

1.0 INTRODUCTION

On February 5, 1988, the staff issued NRC Bulletin 88-02, "Rapidly Propagating Cracks in Steam Generator Tubes." Indiana & Michigan Power Company (the licensee) responded to that bulletin by letter dated March 31, 1988, AEP:NRC:1056. In their response, they concluded that D. C. Cook Unit 1 showed evidence of service-induced tube denting and provided, as required by Bulletin 88-02, Action Item C, their program for minimizing the probability of tube rupture. On September 29, 1988, the staff transmitted a request for additional information (RAI) concerning their implementation of Bulletin 88-02. They responded by letter dated January 26, 1990, AEP:NRC:1056A, in which they stated that their original analysis was incorrect and that service-induced denting had, in fact, not occurred in the D. C. Cook Unit 1 steam generators. By letter dated May 9, 1990, the staff transmitted a second RAI concerning the licensee's revised response. They responded to the request by letter dated June 5, 1990, AEP:NRC:bI. The staff and its contractor (Oak Ridge National Laboratory (ORNL)) reviewed the June 5, 1990 submittal and presented their concerns in a letter to the licensee dated August 9, 1991. In response to the staff's concerns and subsequent verbal communications, the licensee forwarded the eddy current graphics for a select number of tubes to allow the staff and its contractor to review them. The forwarded eddy current data has been reviewed and the findings are presented herein.

2.0 DISCUSSION

As detailed in NRC Bulletin 88-02, the staff concluded that the presence of the following conditions could lead to a rapidly propagating fatigue failure such as that observed at North Anna Unit 1 on July 15, 1987:

(1) Denting at the upper support plate
(2) A fluid-elastic stability ratio approaching that for the tube that ruptured at North Anna
(3) Absence of effective anti-vibration bar (AVB) support

In NRC Bulletin 88-02, denting, was defined to include evidence of upper support plate corrosion and the presence of magnetite in the tube-to-tube support plate crevices, regardless of whether there was detectable distortion of the tubes. For plants that had found denting, the NRC requested specific actions to be taken as detailed in paragraph C of Bulletin 88-02.

The licensee provided eddy current data for staff evaluation to demonstrate that service-induced denting has not occurred at Unit 1. The staff and its contractor have reviewed the eddy current data provided by the licensee to determine if denting as defined in NRC Bulletin 88-02 has occurred. The findings of this evaluation are detailed below.

2.1 EVALUATION OF EDDY CURRENT DATA

The evaluation conducted consisted of reviewing eddy current test signals for 129 tube-to-tube support plate intersections in 28 tubes from each of the four steam generators at D. C. Cook 1. The final analysis was made on only 21 intersections from 3 tubes in 3 of the 4 steam generators. The eddy current data from the remaining 25 tubes was not used due to poor signal quality on the 10 KHz absolute channel from both the standard tube support ring and the tube supports in the steam generator. While only a few tubes were used in the evaluation, these tubes are considered to be representative of all of the tubes in the steam generator. In addition, the 10 KHz absolute signal from all of the 28 tubes showed indications of magnetite. The 10 KHz absolute and differential signals were used to come to the conclusions presented below, since the 10 KHz signal is the lowest frequency typically used and it is the most sensitive to the ferromagnetic material on the tube outer surface and it is not nearly as sensitive to defects in the tube or other nonferromagnetic deposits. The 10 KHz signal, therefore, can be used to monitor tube supports, the tubesheet, and magnetite growth.

Based on the review of the data cited above, the staff and its consultant have concluded that there is magnetite in the tube-to-tube support plate crevices. This conclusion is based on the following:

1. The ratio of the height to the width of the 10 KHz differential signal was greater for the scan from the steam generator tube support plate than it was for the standard tube support scan.

2. The 10 KHz differential signal rotates when compared to the standard scans.

3. The 10 KHz absolute signal becomes fatter when compared to the standard tube support scan indicating that there is more magnetite at the top of the tube support plate than at the bottom of the tube support plate. This was noticed both in the 1989 and the 1990 data reviewed. Due to distortion present in the scans of the standard tube, each individual tube was compared to the standard scan.

4. The amplitude of the 10 KHz differential signal is only about 60% of that of the standard scan, indicating that the support hole (the distance between the tube and tube support plate) in the generator is larger than the support hole in the standard. This effect has been observed in a number of operating plants. The larger support hole in the generator may be due to the corrosion of the ferromagnetic steel tube support plate; however, the larger support hole does not preclude the presence of magnetite in the crevice between the tube support plate and the tube. A combination of the presence of magnetite and the absence of the ferromagnetic steel (from the tube support plate) results in the signal being smaller.

Upon review of the eddy current data provided, the following general observations were made by the staff and its consultant:

1. A distortion of the 10 KHz signal has been observed when the bobbin coil probe speed is increased from 12 inches per second to 24 inches per second. The distortion observed occurs when using magnetic bias probes manufactured by EchoRam and to a lesser extent by Zetec manufactured probes. The distortion observed has been reported to decrease as the frequency used for the inspection increases; however, the 10 KHz frequency (a relatively low frequency for eddy current inspections) is the best frequency for detecting and measuring ferromagnetic properties without being influenced by variations in conductive deposits and defects on the outer surface of the tube. If the techniques developed by Westinghouse and ORNL for detection of magnetite are going to be more successfully applied, the distortion of the 10 KHz signal should be eliminated/minimized. The distortion could be minimized by reducing the probe speed to 12 inches per second, using probes without magnetic bias, or determining the frequency at which the effect vanishes and repeating the Westinghouse and ORNL studies at this frequency.

2. Several scans of the standard tube support made in the 1989 inspection had distortion present to some extent on all frequencies used. The standard tube support should be examined to locate the source of this distortion. Since the signal from the standard tube support is used in the 400/100 KHz differential mix, a high quality (low distortion) standard tube support signal must be used to ensure effective mixing at the tube support plates. This standard should have been replaced and any tubes scanned with the defective standard reinspected. The difference in the amplitude between the steam generator tube support plate signal and the standard tube support ring could have an effect on the mix. The fact that the signal is larger on the standard tube support ring than on the tube support plates in the steam generator could lead to an increase in the mix residual. There is presently no requirement that the standard support ring hole inner diameter be machined so that it matches the signal from the tube support plate hole inner diameter, but this should be considered by the licensee.

3.0 CONCLUSION

The staff concludes based on the analysis presented above that there is evidence of the presence of magnetite in the tube-to-tube support plate crevices. Therefore, the staff concludes that the D. C. Cook, Unit 1 steam generators contain denting as defined in paragraph A of the Actions Requested section of NRC Bulletin 88-02. Based on this finding and consistent with NRC Bulletin 88-02, the staff requests that the licensee submit a written report detailing the status of their compliance with the actions specified in paragraph C of the Actions Requested section of NRC Bulletin 88-02 for minimizing the potential for rapidly propagating fatigue failures such as the one that occurred at North Anna 1.

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