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Department of Nuclear Energy

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Subject: Recent Observation of Secondary Side Corrosion at Prairie Island 2

Dear Vic:

By telephone last week, Herbert Conrad of your branch asked me to look into the available information on the role of the secondary water chemistry at Prairie Island 2 on the type of corrosive degradation occurring on the steam generator tubes. While at Westinghouse last week, at the request of S. S. Pawlicki and V. Noonan, I discussed the subject with W. D. Fletcher, R. T. Begley, E. L. Morgan, and A. Klein of Westinghouse. Despite (or possibly as a result of) the extensive hearings on the steam generator integrity of the two Prairie Island units, these two units have been models of careful operation for secondary water chemistry since their initial start up. Prairie Island 2 started up in 1975 on an all volatile chemistry and added, perhaps as a result of the Appeals Board hearings, condensate demineralization in 1977. Since this full flow demineralization was added at a later date than start up of the plant, it is on a by-pass line to the original feedwater piping.

You may recall that a large primary to secondary leak developed in Prairie Island Unit 2 as a result of a metal spring from the blowdown system being left trapped between the tubes and the wrapper. Fretting of the Inconel from vibration of the spring created a large hole. In January, 1980, the utility inspected the peripheral tubes in both the cold and hot leg sides of all steam generators in this unit to determine if there were more foreign objects present that

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might cause subsequent degradation. They found, to their surprise, on the cold leg side of the tubes, a large number of tube-tube support plate indications on the first two tube support plates only, and one small leak in the tube sheet crevice. All indications found were on the cold leg, mostly on the first five rows of tubes from the outermost row. The pattern appears to be similar in each of the steam generators at Prairie Island 2. In this unit, flow is baffled, so that approximately 80% of the feedwater comes in on the hot leg side of the steam generator in order to promote lateral flow across the top of the tube sheet from the hot to the cold leg side. Only 20% is designed to come in on the cold leg, although Westinghouse suspects that flow distribution may be closer to 65-35%.

In 1980, Westinghouse examined one tube pulled from the plant which had defects at both the first and the second tube support plates. These defects resembled equiaxed large pits, roughly triangular in shape, approximately 3/8" in diameter, and centered exactly in the tube support plate and on the same side of the tube in both tube support plates. When the tube was removed, it was found to be loose: there was no denting in the plant and the tube slipped out easily. Similar problems have not yet been observed in Unit 1. Prairie Island 2 has a history of resin bead intrusion and inverse hideout of sulfate. While I was not shown sufficient detail of the chemistry to determine how extensive these observations were, any evidence of sulfate in this hideout suggests resin beads may have been trapped in crevices in the system and decomposed locally to cause pitting.

In January, 1980, Westinghouse recommended discontinuation of use of the demineralizers and a flushing program to remove as much of the sulfate as was possible; however, small amounts of sulfate inverse hideout have continued to be observed, although the data were described by Westinghouse as being not as quantitative at time of shutdown as one might desire. During the February, 1981 reinspection of Prairie Island 2, not only were new indications found but there appeared to be a continuation of growth of old non-plugged defects. In 1980, the plugging criterion was approximately 45% thru-wall for these defects. Defects left behind appear to have grown by approximately 10% during that year. It is not known, of course, when these defects initiated. If we assume they initiated at the time of the first resin breakthrough, then January, 1980, corresponds roughly to two years operation; during the one year operation since then, the maximum growth has been in the order of 10%, which suggests (marginally) that the rate of defect growth is decreasing. However, there are enough uncertainities in the eddy current measurements in this range, particularly for the small defects that remained unplugged in the system a year ago that this conclusion is at best questionable.

The current inspections of Prairie Island 2 are now suggesting there are defects developing in the anti-vibration bar area. This unit uses a square chromized Inconel anti-vibration bar, and each tube touches the anti-vibration bars four times in going around the U-bend. These defects appear to be concentrated in the outermost part of the bundle in the central section. Prairie Island has not yet committed itself to removing tubes for examination either in the anti-vibration bar area or in the tube support plates. There is some interest on the part of Westinghouse in determining what is causing the defects in the AVB's; i.e. could they be simply further evidence of the same type of pitting that we are seeing in the first and second tube support plates (but not in higher support plates) or are they in fact a fretting and wear problem? (The absence of denting in these steam generators could leave the tubes freer to vibrate!)

In our work for the Department of Energy, Division of Basic Energy Sciences, we ran a few simple experiments on the role of resin beads on depassivating Inconel surfaces in a crevice using the a.c. polarization corrosion monitor we developed initially for EPRI. A copy of a paper based on this work is enclosed for your information. The observation in our laboratory was that a bead, on reaching a hot steaming crevice, would melt and remain present in that location causing immediate depassivation of the Inconel in that area, and ultimately, a pitting phenomenon. The photographs shown me by Westinghouse are quite similar in appearance to the type of pitting we developed in our laboratory. Therefore, it is reasonable to assume that resin beads may have contributed to this problem. It seems ironical that Prairie Island 2, which has no copper in the system, stainless steel condensers, and meticulous monitoring of water chemistry, should be the one unit to have suffered from this particular phenomenon; the Prairie Island units have to date been a shining example of what we thought was the proper way to operate nuclear steam generators in order to avoid corrosion problems. It may be that a carefully monitored all-volatile treatment, in a system that is Cu free, is a better solution to the overall problem than attempting to use demineralizer resins, which have a long history of breakthrough into steam generators.

I think NRC should request from the utility information on the findings of their current inspection program with particular emphasis on the proposed remedial actions they intend to take. I do not believe that small diameter pits such as this represent a major safety problem in terms of producing defects that would burst open and allow massive leakage during a design basis accident, since the maximum diameter of the pits is less than 1/2", and they are located in the tube-tube support plate crevice where bulging would be restrained. Further, the average rate of pit growth is low enough at the present time to permit selection of a plugging criterion based on Reg. Guide 1.121.

If you wish me to review this situation further or obtain information directly from the utility on their water chemistry program, please let me know.

Sincerely,

John R. Weeks, Leader
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JRW:ob
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