OPPD
Omaha Public Power District
444 South 16th Street Mall
Omaha NE 68102-2247

July 31, 1996
LIC-96-0104

U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
Mail Station PI-137
Washington, D.C. 20555-0001

References:
1. Docket No. 50-285
2. NRC Generic Letter 95-03, *Circumferential Cracking of Steam Generator Tubes*, dated April 28, 1995
3. Letter from OPPD (T. L. Patterson) to NRC (Document Control Desk) dated June 23, 1995
4. Letter from NRC (L. R. Wharton) to OPPD (T. L. Patterson) dated June 27, 1996

Subject: Response to Request for Additional Information (RAI) for Generic Letter (GL) 95-03, *Circumferential Cracking of Steam Generator Tubes* (TAC No. M92243)

On July 2, 1996, the Omaha Public Power District (OPPD) received the NRC's RAI relative to OPPD's GL 95-03 response provided in Reference 3. Attached please find OPPD's response to this RAI.

If you should have any questions, please contact me.

Sincerely,

T. L. Patterson
Division Manager
Nuclear Operations

TLP/dll
Attachment

c: Winston and Strawn (w/o Attachment)
L. J. Callan, NRC Regional Administrator, Region IV
L. R. Wharton, NRC Project Manager
W. C. Walker, NRC Senior Resident Inspector

A001/1

OMAHA PUBLIC POWER DISTRICT
FORT CALHOUN STATION, UNIT 1

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION (RAI)
GENERIC LETTER 95-03, *CIRCUMFERENTIAL CRACKING OF STEAM GENERATOR TUBES*

NRC Request No. 1

The following areas have been identified as being susceptible to circumferential cracking:

a. Expansion transition circumferential cracking
b. Small radius U-bend circumferential cracking
c. Dented location (including dented TSP) circumferential cracking
d. Sleeve joint circumferential cracking

In your response, areas b and d were not specifically addressed. Circumferential cracking has been observed in the U-bend portion of a retired Combustion Engineering steam generator. In addition, recirculating steam generators designed by another vendor have experienced circumferential cracking in the U-bend portion of tubes with small radius U-bends and at dented locations. Please submit the information requested in Generic Letter (GL) 95-03 per the guidance contained in the GL for these areas (and any other area susceptible to circumferential cracking). The staff realizes that some of the above areas may not have been addressed since they may not be applicable to your plant; however, the staff requests that you clarify this (e.g., no sleeves are installed; therefore, the plant is not susceptible to sleeve joint circumferential cracking).

The above response should clarify the inspections performed at these locations during the prior tube inspection outage and should clarify the inspections to be performed in the upcoming tube inspection outages, if applicable.

OPPD's Response:

b. Small Radius U-bend Circumferential Cracking

Inspections in the small radius U-bends of rows 1 through 4 in the Fort Calhoun Station (FCS) steam generators (SGs) since 1990 have typically consisted of approximately a 20% sample with a bobbin coil probe.

All tubes in rows 1 through 4 have been tested with a bobbin coil probe since 1990 and no anomalous conditions associated with any kind of cracking (axial or circumferential) have been found. Several other Combustion Engineering (CE) plants have recently performed Rotating Pancake Coil (RPC) examinations in small radius U-bends in currently operating SGs and no circumferential cracking has been reported in bends during these exams. Although industry experience indicates that circumferential cracking in the U-bends of the FCS SGs is unlikely, OPPD plans to inspect the small radius U-bends in 20% of the tubes in rows 1 through 4 in each SG during the Fall 1996 Refueling Outage. The exams will be performed with an appropriate rotating type probe suitable for detection of circumferential cracks.

d. Sleeve Joint Circumferential Cracking

No sleeves are installed in the FCS SGs; therefore, FCS is not susceptible to sleeve joint circumferential cracking.

NRC Request No. 2:

It was indicated that during the next outage, 20 percent of the dents greater than 5.0 volts at the lowest tube support plate on the hot-leg side will be inspected with a probe suitable for detecting circumferential cracks. Provide the procedures used for sizing the dents (i.e., 4.0 volts on 4-20 percent through-wall ASME holes at 550/130 mix). In addition, clarify the past inspection scope for dented locations.

Future inspection plans for dented (>5V) intersections concentrate on the lowest hot-leg tube support plates. A large dent at an upper tube support plate may be more significant in terms of corrosion susceptibility as a result of higher stresses than a small dent at a lower tube support plate even though the temperature is lower at the upper tube support plate. Given this, discuss the basis for the proposed sample strategy given that cracking depends on many factors including temperature and stress levels.

OPPD's Response:

The calibration method which has been used to measure dents involves placing the dent from the American Society of Mechanical Engineers (ASME) Standard in the window, adjusting the phase such that the initial signal excursion is to the right at 180 ± 5 degrees, and setting the voltage such that one volt corresponds to a one mil radial reduction. Dents are measured on the 400 kHz absolute frequency. The exams at the lowest tube support on the hot-leg side (H1) during the 1996 inspection will include 20% of the known dents greater than 5 volts using this measurement technique as well as a 20% sample of the known dents at H1 which are less than 5 volts.

During the inspections from 1985 through 1990, 100% of the tubes in rows 74 and above, which is the most severely dented region in the FCS SGs, as well as samples of tubes which contain dents below row 74, were inspected with a bobbin coil probe. Since 1990, in addition to random samples which have included dented tubes, 218 tubes which have dents sufficiently large such that they restrict passage of the 0.560 inch bobbin coil probe have been inspected each refueling outage with the 0.540 inch bobbin coil probe to monitor dent progression. No progression of denting has been noted during these exams. Additionally, 57 dents ranging from 0.6 volts to 13.1 volts were inspected on the hot-leg side of SG RC-2B with RPC in 1993, and 44 dents ranging from 0.7 volts to 15.5 volts were inspected on the hot-leg side of SG RC-2A with RPC in 1995. No cracks were found during these exams.

Since it is conceivable that a large dent at an upper tube support may be more significant in terms of corrosion susceptibility as a result of higher stresses than a small dent at a lower tube support, OPPD plans to perform exams of some of the largest dents on the hot-leg side of each SG. A 20% sample of the dents on the hot-leg side of each SG equal to or exceeding 10 mils will be inspected using an appropriate rotating type probe suitable for detection of circumferential cracks. This exam will give added assurance that circumferential cracking is not occurring at the dents in the FCS steam generators, since a sample of the most highly stressed dented intersections will be inspected.

<u>NRC Request No. 3</u>:

Clarify the past inspection scope for the rotating pancake coil (RPC) examinations performed at the expansion transition. Specifically state the percentage of tubes examined during the last outage. In addition, clarify if the percentages cited in your response are of all the tubes in the SG or are of the "accessible" tubes.

It was indicated that the inspection of tubes in rows 1 through 18 with rotating probe technology is impossible due to the presence of an orifice plate. You further state that if circumferential cracking were occurring you would expect to observe it outside this region for several reasons including the lower temperatures for these tubes. Discuss the difference in temperature that is expected at the expansion transition region for tubes in rows 1 through 18 when compared to the expansion transition region of other tubes. Discuss whether the tubes in rows 1 through 18 are in the sludge pile area (if such an area exists at Fort Calhoun). In addition, discuss if any of the tubes in rows 19 and higher are in the sludge pile area, if applicable.

Reference to an 8x1 probe was made with respect to inspecting the hot-leg expansion transition region for tubes behind the orifice plate during the next outage. Discuss the qualification of this probe.

The sample scope expansion criteria for expansion transition indications depends, in part, on whether 10 or more tubes contain cracks. Provide the basis for this criteria. Address whether this criteria meets or exceeds the expansion criteria contained within the technical specifications.

OPPD's Response:

In 1992, 1001 tubes were inspected in each SG at the top of the hot-leg tubesheet with the Motorized Rotating Pancake Coil (MRPC). This is 20% of all tubes in each SG. The scope of the 1993 MRPC exam at the top of the hot-leg tubesheet was 1002 tubes in RC-2A (20% of all tubes in RC-2A) and 850 tubes in RC-2B (17% of all tubes in RC-2B). In 1995, the hot-leg top of tubesheet MRPC exam included 1929 tubes in RC-2A (39% of all tubes in RC-2A) and 2085 tubes in RC-2B (42% of all tubes in RC-2B).

It is OPPD's position that since the orifice plates limit flow to the tubes in rows 1 through 18, less heat flux is present over the entire length of these tubes; therefore, it is likely that the hot-leg expansion transitions in rows 1 through 18 would be somewhat cooler than the expansion transitions elsewhere in the SGs. Due to the uncertainty in the actual temperature differences which may be encountered behind the orifice plates with respect to elsewhere in the SG and the potential susceptibility of these tubes to circumferential cracking, the decision has been made to completely remove the existing orifice plates from both SGs. This will allow 100% of all open tubes in each SG to be inspected at the hot-leg expansion transition with a rotating probe suitable for detection of circumferential cracks during the 1996 Refueling Outage. New orifice plates will then be installed after SG tube inspection and repair work is complete to maintain Reactor Coolant System (RCS) total flow equivalent to current conditions. Because the orifice plates will be removed to allow inspection with rotating probe technology, inspections with an 8x1 probe are no longer planned. Therefore, qualification of the 8x1 probe is not applicable.

Visual inspections during sludge lancing provide indication whether significant sludge piles exist in the FCS SGs. As part of the sludge lancing program, cameras allow visual verification that the spray from the high pressure nozzle passes all the way through the tube bundle from the annulus to the blowdown lane during lancing operations. Visual verification of the spray passing through the bundle at the secondary face of the tubesheet indicates that no significant sludge pile is present in either SG. If sludge piles did exist, they would be expected in some number of tubes in rows 1 through 18, as well as in some tubes outside this region, since sludge piles are typically present in the central region of the tube bundle at other plants.

Since top of tubesheet circumferential cracking is a temperature sensitive degradation mechanism, it is expected that a significant amount of circumferential cracking would be encountered on the hot-leg side of the SG prior to the onset of circumferential cracking on the cold-leg side. This is supported by industry experience at other CE units where large numbers of circumferential cracks exist in the hot-leg expansion transitions, and relatively few, if any, exist in the cold-leg expansion transitions.

In the initial GL 95-03 response, OPPD planned to inspect a 20% sample of the hot-leg expansion transitions in the FCS SGs, which would encompass 1001 tubes in each SG. Finding 10 tubes with circumferential cracks in a given SG would be the threshold of passing into category C-3 due to having 1% of the inspected tubes defective. At this point, cracking on the hot-leg would be considered extensive and the sample would be expanded to the cold-leg. This position is supported by the recently approved Revision 4 of the *EPRI PWR Steam Generator Tube Examination Guidelines* which states that "for temperature sensitive degradation mechanisms...(at) expansion transitions,...examinations may be limited to reactor coolant inlet locations until C-3 conditions...are encountered, after which outlet location sampling is recommended immediately or, at a minimum, at the next outage."

OPPD plans to use the cold-leg expansion guidance provided in *EPRI PWR Steam Generator Tube Examination Guidelines*, Revision 4 for the 1996 Refueling Outage. However, since the initial GL 95-03 response, OPPD has elected to perform a 100% examination of the hot-leg expansion transitions rather than a 20% sample. Therefore, expansion into the cold-leg after finding 10 circumferential cracks in the hot-leg is significantly more conservative than what is published in Revision 4 of the EPRI guidelines. This expansion philosophy is in accordance with the FCS Technical Specifications which state that "the second and third sample inspections (i.e., the expansions), if required, may be less than the entire tube length inspection provided the inspection concentrates on those areas of the tube sheet array and on those portions of the tube where defects were previously detected." Industry experience indicates that significant cracking (i.e., a C-3 condition) would be expected in the hot-leg prior to the onset of cracking in the cold-leg. Therefore, the Technical Specification requirements are met by expanding into the cold-leg after a C-3 condition is experienced in the hot-leg.

NRC Request No. 4:

During the Maine Yankee outage in July/August 1994, several weaknesses were identified in their eddy current program as detailed in NRC Information Notice 94-88, "Inservice Inspection Deficiencies Result in Severely Degraded Steam Generator Tubes." In Information Notice 94-88, the staff observed that several circumferential indications could be traced back to earlier inspections when the data was reanalyzed using terrain plots. These terrain plots had not been generated as part of the original field analysis for these tubes. For the rotating pancake coil (RPC) examinations performed at your plant at locations susceptible to circumferential cracking during the previous inspection (i.e., previous inspection per your Generic Letter 95-03 response), discuss the extent to which terrain plots were used to analyze the eddy current data. If terrain plots were not routinely used at locations susceptible to circumferential cracking, discuss whether or not the RPC eddy current data has been reanalyzed using terrain mapping of the data. If terrain plots were not routinely used during the outage and your data has not been reanalyzed with terrain mapping of the data, discuss your basis for not reanalyzing your previous RPC data in light of the findings at Maine Yankee.

Discuss whether terrain plots will be used to analyze the RPC eddy current data at locations susceptible to circumferential cracking during your next SG tube inspection (i.e., the next inspection per your Generic Letter 95-03 response).

OPPD's Response:

During the 1992 and 1993 MRPC exams at locations susceptible to circumferential cracking, terrain plots were not routinely used to analyze the eddy current data. As a result of the experiences at Maine Yankee in 1994, the FCS MRPC data were reanalyzed prior to the 1995 FCS Refueling Outage to ensure that no cracks were missed in 1992 or 1993. No cracking was identified in the 1992 or 1993 data during this review. The *Fort Calhoun Site Specific Data Interpretation Guidelines* were updated prior to the 1995 inspection to require the use of terrain plots during all RPC exams. Terrain plots were used during analysis of all 1995 RPC data and will also be used to analyze RPC data during the 1996 FCS SG inspection.

References

A. *EPRI PWR Steam Generator Tube Examination Guidelines*, Revision 4, Volume 1

B. Fort Calhoun Station Technical Specification 3.17, *Surveillance Requirements - Steam Generator Tubes*