Consumers Power
POWERING MICHIGAN'S PROGRESS
Palisades Nuclear Plant: 27780 Blue Star Memorial Highway, Covert, MI 49043

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June 27, 1995

U S Nuclear Regulatory Commission
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DOCKET 50-255 - LICENSE DPR-20 - PALISADES PLANT
RESPONSE TO GENERIC LETTER 95-03 - CIRCUMFERENTIAL CRACKING OF STEAM GENERATOR TUBES

Generic Letter 95-03, entitled "Circumferential Cracking of Steam Generator Tubes", was received in a letter from the NRC dated April 28, 1995. The generic letter notifies the industry about the recent steam generator tube inspection findings at the Maine Yankee Atomic Power Station. The generic letter also requires that licensees implement certain actions supporting justification for continued operation of the plant and submit, to the NRC, a response providing the information requested in the generic letter. Attachment 1 to this letter provides the information requested by Generic Letter 95-03.

SUMMARY OF COMMITMENTS

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

Kurt M Haas
Plant Safety and Licensing Director

CC Administrator, Region III, USNRC
NRR Project Manager, USNRC
NRC Resident Inspector - Palisades

Attachment

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CONSUMERS POWER COMPANY

To the best of my knowledge, information and belief, the contents of this submittal are truthful and complete.

By _____
Thomas J Palmisano, Plant General Manager

Sworn and subscribed to before me this 27th day of June 1994.

_____
Alora M Davis, Notary Public
Berrien County, Michigan
Acting in Van Buren County, Michigan
My commission expires August 26, 1999

[SEAL]

ATTACHMENT 1

CONSUMERS POWER COMPANY
PALISADES PLANT
DOCKET 50-255

RESPONSE TO GENERIC LETTER 95-03
CIRCUMFERENTIAL CRACKING OF STEAM GENERATOR TUBES

10 Pages

RESPONSE TO NRC GENERIC LETTER 95-03

CIRCUMFERENTIAL CRACKING OF STEAM GENERATOR TUBES

NRC REQUESTED INFORMATION

(1) All addresses are requested to submit a safety assessment justifying continued operation that is based on the evaluations performed in accordance with Requested Actions (1) and (2).

CPCo RESPONSE

Safety Assessment

Together, the measures and practices described in the following paragraphs have greatly reduced Palisades' susceptibility to circumferential cracking and increased the sensitivity and responsiveness to a primary-to-secondary steam generator tube leak or tube rupture. Based on these observations, which are summarized below, it is concluded that Palisades does not impose an undue risk to the health and safety of the general public or site personnel resulting from circumferential cracking of the steam generator tubes:

- Replacement steam generators with less than 4 EFPYs
- Reduced hot leg temperature that appears to retard the onset of circumferential cracking
- Tightly controlled secondary side chemistry regime which helps to minimize tube degradation
- Use of MRPC technology qualified to EPRI Appendix H Guidelines (Reference a) and Qualified Data Analysts for the detection of circumferential cracking
- Threshold of detection for qualified MRPC technology and inferred crack growth rate that provides a high level of confidence that the presence of circumferential cracking will be detected well in advance of reaching Regulatory Guide 1.121 criteria (Reference c).
- Defense-in-depth operating practices that provide added sensitivity and timely response to a steam generator tube leak or tube rupture.

The following is a detailed description of the requested actions (1 & 2) taken as requested by the Generic Letter.

NRC REQUESTED ACTION

1. *Evaluate recent operating experience with respect to the detection and sizing of circumferential indications to determine the applicability to their plant.*

CPCo ACTION TAKEN

1. The recent operating experience at the Maine Yankee Nuclear Plant demonstrated how ineffective eddy current test procedures over time led to a potential safety issue with the unrecognized propagation of circumferential cracking in their steam generator tubing. The Generic Letter requests that we determine if we may have had ineffective eddy current test procedures and could be operating with unidentified and, therefore, unmonitored circumferential cracking.

   Based on the information provided here and in response to the second requested action from the Generic Letter, we have determined that no short term safety concerns exist with regards to circumferential cracking at the Palisades Plant. We have relatively new steam generators, operating at a relatively low T_{ave} system temperature, with excellent chemistry controls to help assure that we are at the low end of susceptibility for creating conditions where circumferential cracking would exist. We also believe that the eddy current test techniques that we have used in the past and continue to use will successfully identify circumferential cracking if it occurs. Therefore, the scenario described in the Generic Letter is not applicable to the Palisades Plant at the present time. In the future, the scenario will become more applicable as the EFPYs of operation on the steam generators increases, as we have identified one area of the C.E. steam generators that could be susceptible to circumferential cracking.

   1.A **Palisades Steam Generator Specifics**

   The Palisades steam generators were replaced during the 1990-1991 Refueling Outage. Palisades just completed its third fuel cycle with the replacement steam generators. Below is a list of selected design and operating parameters specific to the Palisades replacement steam generators.

   Steam Generator - C.E. model 70277
   Tube Design - vertical U-tube
   Tube Quantity - 8219 per steam generator
   Tube Material - Inconnel 600
   Tube Size - .750" O.D. , .042" wall thickness
   Tube Expansion Type - explosively expanded
   Tube Supports - egg-crate supports on vertical runs
   scallop support bars on horizontal runs
   EFPY - 3.30 years as of May 28, 1995
   T- Hot - 581 degrees F at 100% power

1.B Secondary Side Chemistry Regime

The steam generator secondary side chemistry regime in place at Palisades since replacing steam generators is as follows:

a. Feedwater corrosion product transport to the S/Gs is minimized through the use of the following:

- elevated morpholine (10-15 ppm)
- elevated hydrazine (100-120 ppb)
- rigid pH control (9.8-10.0)
- rigid condensate dissolved oxygen control (<1.0 ppb)

The resulting feedwater iron concentrations have been below industry averages (typically <1.0 ppb).

b. Boric acid is fed while at power to neutralize crevice pH.

c. Sodium/chloride molar ratios are controlled through sodium minimization efforts. The result has been operating molar ratios 0.8 - 1.0, with hideout return molar ratios at approximately 1.0.

d. Electrochemical potentials are minimized, again through the use of elevated feedwater hydrazine.

e. Operating chemistry contaminant concentrations are minimized through aggressive efforts to eliminate ingress to the system.

1.C Operating Experience for C.E. Steam Generators

Based on current industry operating experience for C.E. steam generators (Table 1 of Reference b), all reported circumferential cracks for in-service steam generators are located at the top of the tube sheet and on the hot leg side (hereafter referred to as hot leg TTS). Cracks can be OD and / or ID initiated. Effective Full Power Years (EFPY) at the time circumferential cracks are first discovered range between 4 and 12 EFPYs and tend to be a function of hot leg operating temperature. Palisades currently operates with a hot leg operating temperature in the range of 581 to 585 degrees F. Recent data presented by the C.E. Owners Group - Steam Generator Task Force shows hot leg operating temperatures for all other C.E. PWRs to range between 593 and 621 degrees F with an average hot leg operating temperature of 605 degrees F. To date, circumferential cracking has not been identified at tube support plate intersections or in low row U-bends for inservice C.E. steam generators.

1.D **Applicability to Palisades Steam Generators**

The Palisades steam generators contain similarities to other C.E. plants where circumferential cracking has been identified in the hot leg TTS region. These similarities include the use of mill annealed alloy 600 tube material and explosively expanded tube to tubesheet bonding, both of which may be a contributing factor in the development of circumferential cracking in this region. As a result of these similarities, it can be concluded that the Palisades steam generators could potentially develop circumferential cracks at the hot leg TTS region. However, the likelihood that this degradation mechanism is occurring at Palisades is considered to be quite low based on the low EFPY, low T-hot operating temperature, and current Palisades chemistry regime designed to minimize tube degradation. As mentioned in the above paragraph, circumferential cracking has not been identified at tube support plate intersections or in low row U-bends for inservice C.E. steam generators and these are not considered areas of susceptibility applicable to Palisades. Furthermore, the Palisades steam generators do not contain sleeved tube repairs. Sleeved tube repairs have been an area of concern in regard to circumferential cracking at various non C.E. pressurized water reactors.

NRC REQUESTED ACTION

2. *On the basis of the evaluation in item (1) above, past inspection scope and results, susceptibility to circumferential cracking, threshold of detection, expected or inferred crack growth rates, and other relevant factors, develop a safety assessment justifying continued operation until the next scheduled steam generator tube inspections are performed.*

CPCo ACTION TAKEN

2.A Past Inspection Scope

The steam generators that are currently in use at Palisades were installed in the fall of 1990. A preservice 100% eddy current inspection was performed in April of 1990 prior to the units being installed. The preservice inspection indicated there were no active degradation mechanisms present within the steam generators prior to service. However, a large number of manufacturing type indications were found in the free span of the tubing. To confirm these indications, several tubes were removed and evaluated to determine the cause of the eddy current responses. It was verified that these responses were caused by the manufacturing process of removing slight surface imperfections with a buffing tool. This causes slight tube wall thinning in these areas. Of the indications that were identified, none exceeded the $\geq$40% thru-wall plugging criteria

required by the Palisades Technical Specification. Prior to the installation of these steam generators, the manufacturer advised Consumers Power Company that the area around the center stay region was potentially susceptible to fretting wear at the batwing locations. This region was preventively plugged prior to installation. Inspections were also performed at the top of the tube sheet for about 110 tubes in each steam generator using the 8X1 probe. No degradation mechanisms were identified in this area.

After one cycle of operation of the new steam generators (1992 Refueling Outage), a 20% random inspection program of bobbin eddy current was performed in each steam generator, along with any prior tubes with indication ≥20% thru-wall. The 20% random pattern examination indicated that the condition of both steam generators has remained constant since the preservice inspection in April of 1990. All previously identified reportable indications were found to be unchanged since the previous inspection.

After two cycles of operation of the new steam generators (1993 Refueling Outage), a 20% random inspection program of bobbin eddy current was performed in each steam generator along with any prior tubes with indication ≥20% thru-wall. One tube was plugged due to fretting wear in the batwing support area. In addition to the bobbin eddy current inspections, approximately 200 inspections were performed at the hot leg top-of-tubesheet area to specifically look for the onset of circumferential cracking. The probe used was the two coil MRPC. No cracking indications were identified.

Historical inspection results for the Palisades replacement steam generators are summarized below:

Preservice (April 1990)

Steam Generator A

Full length bobbin coil examinations	7911 tubes
8X1 examinations	111 tubes
MRPC	1 tube at vertical support

Steam Generator B

Full length bobbin coil examinations	7910 tubes
8X1 examinations	110 tubes
MRPC	None

1992 Refueling Outage

20% full length bobbin examinations on both steam generators A and B. No pluggable indications were identified.

No top-of-tubesheet examinations were performed

1993 Refueling Outage

20% full length bobbin examinations on both steam generators A and B. One pluggable indication was found in the A steam generator due to fretting wear at the batwing support area.

Approximately 200 hot leg top-of-tubesheet examinations were performed in each steam generator to determine if degradation was occurring in this area. The probe used was the two coil MRPC probe. No cracking indications were identified.

2.B Past Inspection Results

Inspection results from MRPC examinations performed in 1993 did not indicate the presence of circumferential cracking at the hot leg TTS region. These past inspection results, coupled with a low EFPY and low hot leg operating temperature, provide some degree of confidence that this degradation mechanism has not begun to occur at Palisades. In an effort to increase this degree of confidence, Palisades will perform top-of-tubesheet examinations on 20% of the tubes in each steam generator during the Palisades 1995 Refueling Outage, using the Zetech 3-coil MRPC probe supplemented with the Zetech plus-point probe.

2.C Susceptibility To Circumferential Cracking

Industry experience has shown that C.E. steam generators are susceptible to circumferential cracking at the top of the tube sheet on the hot leg side of the tube sheet. This is the area where we would expect to find circumferential cracking if it were to occur in the Palisades steam generators.

2.D Threshold of Detectability / Inferred Crack Growth Rate

MRPC technology currently used at Palisades is qualified to EPRI Appendix H Guidelines (Reference a), for detection of primary and secondary side stress corrosion cracking. To be qualified to EPRI Appendix H, the technique must demonstrate an 80% probability of detecting cracking defects of $\geq$60% thru-wall with a 90% confidence level on suitable test specimens. The actual field performance for qualified MRPC technology has been shown to exceed this minimum criteria. There is currently no site-specific data pertaining to crack growth rate at Palisades. However, data from one other C.E. plant (Table 5 of Reference (b), "Circumferential Cracking Growth Rate Data") shows a statistical mean crack growth rate of 11.17% thru-wall per EFPY. Table 2 of Reference (b) "Pulled Tube Examination Results for CE Steam Generators" and Table 3 of Reference (b) "In-Situ Pressure Test Results for CE Steam Generators" show that tubes with average depth thru-wall defects as high as 97%

with a 360 degree length have not exceeded Regulatory Guide 1.121 (Reference c) limit for structural integrity when subjected to burst testing or insitu-pressure testing. When applied to Palisades, the following conclusion can be reached: With the interval between steam generator inspections equal to one fuel cycle (1.25 EFPYs), and applying an inferred crack growth rate of 11.17% per EFPY, and assuming the use of conventional MRPC technology qualified to EPRI Appendix H Guidelines (Reference a), a high degree of confidence exists that the presence of circumferential cracking would be detected well in advance of becoming structurally significant or exceeding Regulatory Guide 1.121 criteria (Reference c).

2.E Operating Practices

Susceptibility to steam generator tube circumferential cracking is reduced at Palisades by the implementation of an aggressive secondary side chemistry regime coupled with a low hot leg operating temperature and low EFPY.

Since the replacement of the steam generators in 1991, Palisades has operated with a PCS hot leg temperature in the range of 581 to 585 degrees F. Recent data presented by the CE Owners Group - Steam Generator Task Force indicates that a correlation may exists between the PCS hot leg temperature and the onset of circumferential cracking of steam generator tubes. According to this data, the onset of circumferential cracking can be plotted on a curve of hot leg temperature versus effective full power years (EFPY) of operation. According to the data trend, C.E. plants that typically operate with a hot leg temperature of 600 degrees F or less have not experienced the onset of circumferential cracking for at least 10 EFPYs.

Since the replacement of the Palisades steam generators in 1991, Palisades has maintained excellent control of secondary side chemistry, almost completely eliminating any raw water in-leakage from the condenser. Reduced secondary side sludge build up above the tube-sheet has been one of the positive results of this effort. In addition, secondary side chemistry monitoring has shown secondary side hide-out returns to be minimal. These positive efforts implemented in the secondary side chemistry program do much to inhibit steam generator tube degradation.

2.F Defense-In-Depth

Palisades has also taken measures to ensure prompt detection and response to a steam generator tube leak or tube rupture, should one occur. Palisades has implemented a number of operational and procedural safeguards to ensure that the onset of primary-to-secondary leakage would be quickly detected and accurately quantified. At Palisades, several methods are used to detect and monitor primary-to-secondary leakage. The earliest warning of a primary-to-secondary tube leak is

provided by off-gas monitor RIA-0631. This monitor typically operates with alert and alarm set-points adjusted to detect very low leak rates. Additionally, steam generator blowdown tank vent monitor RIA-2320 and daily secondary side chemistry grab samples serve as a backup to the off gas monitor as well as a means of cross checking any leakage indication. Once primary-to-secondary leakage is confirmed, off-normal operating procedures would be invoked to implement the proper corrective action. In addition to these defense-in-depth operating practices, steam generator tube leakage and tube rupture scenarios are a routine part of the Palisades simulator training process for all control operators.

NRC REQUESTED INFORMATION

(2) All addressees are requested to submit a summary of the inspection plans developed [in accordance with Requested Action (3) above] and a schedule for the next planned inspection.

CPCo RESPONSE

The next steam generator tube inspection will occur during the 1995 refueling outage which began on May 22, 1995. The scope of the tube inspections will be; (1) full tube length bobbin inspection on a random 20% of the tubes in each steam generator followed by, (2) hot leg TTS MRPC inspections for the same 20% sample selected for the bobbin inspections, and (3) hot leg TTS inspections using the Zetech plus point probe on 320 tubes per steam generator selected from the 20% MRPC sample.

The following is a detailed description of the requested action (3) taken as requested by the Generic Letter.

NRC REQUESTED ACTION

3. *Develop plans for the next steam generator tube inspections as they pertain to the detection of circumferential cracking. The inspection plans should address, but not be limited to, scope (including sample expansion criteria, if applicable), methods, equipment, and criteria (including personnel training and qualification).*

CPCo ACTION TAKEN

3.A Schedule

The next steam generator tube inspection at Palisades will occur during the Palisades 1995 Refueling Outage. The Palisades 1995 Refueling Outage began on May 22, 1995, with steam generator tube inspection activities scheduled to begin approximately July 9, 1995.

3.B Scope

The scope of steam generator tube inspections for the Palisades 1995 Refueling Outage will be, (1) full length bobbin inspection on a random 20% of the tubes in each steam generator followed by, (2) hot leg TTS MRPC inspections for the same 20% sample selected for bobbin inspections, and (3) hot leg TTS inspections using the Zetech plus-point probe on 320 tubes per steam generator selected from the 20% MRPC sample. The 20% inspection sample is based on EPRI recommendations (Reference d) and provides a high degree of confidence that the presence of circumferential cracking, if it exists, will be detected. A different random 20% sample is selected each refueling outage such that all inservice tubes are inspected by the end of each fifth refueling outage. The Zetech plus-point probe inspection is being performed to provide supplemental data to the MRPC inspections and to provide a means of characterizing any indications received during MRPC inspections.

3.C Method

The hot leg TTS MRPC inspections will specifically look for the existence of circumferential tube cracking at the tube-sheet transition region which is that region of the tube considered to be susceptible to circumferential cracking. The tube inspections will be performed by Westinghouse. The specific probe types will be the Zetech three coil MRPC probe used for the 20% baseline screening and the Zetech plus-point probe used on a supplementary sample of 320 tubes per steam generator. The Zetech plus-point probe will also be used to characterize any indications identified with the Zetech three coil probe. All associated hardware and software used during this inspection will be qualified to EPRI Appendix H Guidelines (Reference a).

3.D Analyst Qualifications / Procedures

The analyst training and qualification program for the Palisades 1995 Refueling Outage includes testing of the analyst's ability to detect and size actual MRPC circumferential crack signals. During performance of the MRPC hot leg TTS inspections, analysts will be using Westinghouse procedures and Palisades site specific guidelines which call upon the analyst to be both aware of and sensitive to various elements, such as electrical noise and signal interference, which may challenge the analyst's ability to recognize a circumferential crack indication. Analysts will be required to view C-scan plots on all MRPC signals. C-scan plots provide a three dimensional view of the inspection signal that assists the analyst in evaluating the examined area.

3.E Expansion / Repair Plan

Any eddy current indication identified as a crack will be

structurally evaluated for proper repair. This criteria will hold true of any identified crack regardless of size. If a single crack is identified during hot leg TTS inspections, the sample size will be increased to 100% of the hot leg TTS for the affected steam generator. If cracking is found to be widespread, the sample size will be expanded to include 20% cold leg TTS in the affected steam generator. Sample expansion for non-crack defects will be based solely on Palisades Technical Specification 4.14 which places the inspection results into categories C-1, C-2, or C-3, depending on the number of degraded or defective tubes that are discovered. Palisades Technical Specifications assigns a specific sample expansion size for each inspection results category.

3.F Conclusion

The Palisades steam generator tube inspection plan described in the preceding paragraphs will provide a high level of confidence that circumferential cracking will be detected if it exists. This high degree of confidence is based on; 1) the use of MRPC technology qualified to EPRI Appendix H Guidelines (Reference a) supplemented by the Zetech plus point probe, 2) the use of Qualified Data Analysts, and 3) by the 20% random sample plan being implemented. Furthermore, our intent to implement the proper repair method reduces the probability of encountering a primary-to-secondary steam generator tube leak or tube rupture.

REFERENCES

(a) PWR Steam Generator Examination Guidelines, Revision 3, EPRI Report NP-6201.

(b) Letter from ABB (Philip Richardson) to NEI (C. Callaway) dated May 25, 1995; Subject: CEOG Experience Summary Regarding Circumferential Cracking of Steam Generator Tubes

(c) Regulatory Guide 1.121 "Bases for Plugging Degraded PWR Steam Generator Tubes"

(d) Letter from EPRI (C.S. Welty) to NEI (C. Callaway) dated May 26, 1995: Subject; NDE/ISI for Circumferential Cracking