U. S. NUCLEAR REGULATORY COMMISSION

REGION III

Report No.: 50-255/89032(DRS)

Docket No.: 50-255 License No.: DPR-20

Licensee: Consumers Power Company
1945 West Parnall Road
Jackson, MI 49201

Facility Name: Palisades Nuclear Generating Plant

Inspection At: Palisades Site, Covert, MI 49043

Inspection Conducted: October 19-20, December 6-7, 14, and 20, 1989

Inspector: [signature] for J. F. Schapker — 1/10/90 Date

Approved By: [signature] D. H. Danielson, Chief, Materials & Processes Section — 1/10/90 Date

Inspection Summary

Inspection on October 19-20, December 6-7, 14, and 20, 1989 (Report No. 50-255/89032(DRS))

Areas Inspected: Routine announced inspection of eddy current examination (ET) of steam generator tubing (73753), review of ET procedures, data review and evaluation (73755) and licensee action in response to previously identified inspection findings (92702).

Results: No violations or deviations were identified within the areas inspected. The inspector noted the following:

- Eddy current examination detected significant increases in circumferential cracking of steam generator tubing. Due to the status of degradation of the steam generator tubes, the licensee is planning steam generator replacement at the next refueling outage (Fall of 1990).

- The licensee's corrective action in reply to a previous NRC finding (Violation 50-255/88022-01) was incomplete. Further action by the licensee is required to resolve this finding.

DETAILS

1. Persons Contacted

   Consumers Power Company (CPCo)

   *J. G. Lewis, Technical Director
   *D. J. Malone, Licensing Analyst
   *B. V. VanWagner, ISI Supervisor
   *W. E. Nummerdor, Senior QA Consultant
   *C. S. Kozup, Technical Engineer
   K. V. Cedarquist, Senior Engineer
   S. R. Wellman, NDT Project Supervisor
   R. D. Orosz, Engineering and Maintenance Manager

   Allen Nuclear Associates (ANA)

   B. L. Curtis, President, ECT-Level III

   U. S. Nuclear Regulatory Commission (U. S. NRC)

   *J. K. Heller, Resident Inspector

   Other members of the plant staff and contractors were also contacted.

   *Denotes those present at the exit interview.

2. Licensee Action on Previously Identified Inspection Findings

   a. (Open) Violation (255/88004): Inadequate quality verification resulting in misplugged or defective tube plugs.

      Background

      Numerous discrepancies with respect to tube plugging have been identified since 1983. Included are misplugged tubes, defective plug welds and incomplete plug welds.

      The licensee's quality verification process appeared inadequate to assure that these deficiencies were identified and corrected. As part of the licensee's commitment to assure that all misplugged tubes had been identified and corrected, the licensee committed to review existing video tapes of the tube sheet. If the video tape review was inadequate to assure that the tube plugging was performed correctly, a 100% tube sheet verification via video camera in both "A" and "B" steam generators would be conducted.

      Inspection

      The NRC inspector reviewed corrective action documents concerning inadequate quality verification of steam generator tube plugging

(E-PAL-89-001E). Corrective actions taken in response to this violation were deemed adequate for future steam generator tube plugging.

However, corrective actions taken to assure that all previously plugged tubes were correct were not apparent. During the current outage a tube sheet scan was performed on "A" and "B" steam generator hot legs. The results of this examination disclosed no discrepancies for misplugged tubes but identification of a drawing error disclosed that two tubes were incorrectly indicated as being plugged. Review of the plugged tube list indicated the tubes were not required to be plugged. The drawing was subsequently corrected. Cold leg visual scans for leakage only were performed, but did not involve inspection for misplugged tubes since entry into the cold leg side was not planned for the current eddy current inspection.

The licensee's ISI supervisor informed the NRC inspector that CPCo had performed a review of the cold leg side via video tapes from previous outages and confirmed that no misplugged tubes exist in the cold legs. However, no documentation was produced to verify that this action was completed and the corrective action documents did not reference this review.

The licensee indicated the proper documentation is available and would be retrieved and furnished for the NRC inspector's review. This violation will remain open pending review by the NRC of the licensee's corrective action documentation for verification of correct plugging in the cold leg tube sheets of the "A" and "B" steam generators.

b. (Closed) Open Item (255/88022-02): Control Rod Drive Mechanism Cracking

Background

In December 1986, with the plant in a hot shutdown condition (i.e., 530°F, 2150 psia), engineering walkdowns identified control rod drive mechanism (CRDM) Number 101 (head position 25) to be exhibiting primary coolant system leakage of approximately 0.12 gallons per minute. The CRD seal housing (SEAL AA) was removed from the reactor head and, during bench testing, exhibited leakage from the drive shaft tube penetration. Subsequently, on December 16, 1986, dye penetrant inspections identified positive circumferential indications around the inner diameter of the motor tube sleeve.

On December 17, 1986, due to positive dye penetrant indications on CRD seal housing 101, an additional six seal housings were dye penetrant tested per ASME Section XI. No similar positive indications were noted.

On December 19, 1986, CRD seal housing 101 was sent to Combustion Engineering to determine the primary failure mechanism via destructive and metallurgic examinations. A records search initiated by both the licensee and the vendor indicated that CRD seal housing 101 was one of three spare CRD seal housings procured from Combustion Engineering in 1977. Also indicated was that the seal housings were manufactured from the same heat of materials and comprised the entire manufacturing lot. The remaining seal housings were determined to be on the reactor head in positions 23 and 28.

On January 7, 1987, CRD seal housings 102 and 103 (head positions 23 and 28 respectively) were removed and dye penetrant tested. Both seal housings exhibited positive indications similar to CRD seal housing 101. Subsequently, both seal housings were sent to Combustion Engineering for further examination.

On January 9, 1987, due to the additional findings on seal housings 103 and 102, and per ASME Section XI, five additional CRD seal housings were removed and dye penetrant tested. No similar positive indications were noted.

The Combustion Engineering destructive and metallurgical analyses indicated that the axial and circumferential cracking existing on the inner diameter of the motor tube sleeve was a result of transgranular stress corrosion cracking.

During the refueling outage of 1988, as part of the long term corrective actions taken in response to the indications noted above, six additional CRD seal housings (Serial Numbers 2966-02, 09, 34, 35, 36, 44 and 45) were removed and dye penetrant tested. On September 21, 1988, test results revealed that five of the six CRD seal housings exhibited positive indications similar to those found in 1986. Seal housing 35 did not exhibit unacceptable indications, while seal housing 02 contained a positive 360 degree indication.

Due to the positive indications noted in the 1988 sample, the remaining 39 CRD seal housings on the reactor head were removed and dye penetrant tested (PT). As a result of these inspections, six additional CRD seal housings (Serial Numbers 2966-11, 14, 27, 30, 41, and 50) were found to exhibit positive indications. Therefore, a total of 11 out of the 45 CRD seal housings tested in 1988 failed the PT examination. Between the identification of the 1986 and 1988 positive dye penetrant indications, 13 CRD seal housings were inspected with no evidence of indications. Ten of these 13 housings were again inspected in 1988 and again, no evidence of indications were noted. The remaining three housings not reinspected are spares that were not in service. These spare housings had been rebuilt and inspected in March 1986.

Repair of the CRD seal housings was pursued in accordance with ASME Section XI via a honing process. As a result of this process, the indications were characterized to typically be 0.003 to 0.004 inches in depth. The maximum indication depth has been determined to be 0.012 inches. In addition to these repair efforts, CRD seal housing 02 was sent to Combustion Engineering for destructive examination and testing. In order to provide assurance that the honing process was completely removing the existing indications, a fluorescent dye penetrant test (FPT) procedure was developed.

The nine previously repaired CRD seal housings were again removed from the reactor head and the FPT performed. This testing revealed that indications remained within several seal housings. A review of previous standard dye penetrant tests revealed a good correlation between remaining indications and those originally identified. These remaining indications were then removed by localized grinding efforts and the seal housings reexamined using the FPT. This further testing revealed no remaining indications. The total maximum depth of material removed to eliminate these indications was 0.015 inches. The NRC inspector observed the FPT and mechanical processing to remove the defects.

The cause of the indications identified in 1986 has been attributed to transgranular stress corrosion cracking. However, the initiating factor of the transgranular stress corrosion cracking could not be determined. There is evidence of a contaminant being present on the fracture surface; however, the specific contaminant could not be determined. Metallurgical analyses of the housing indicate that the primary elements identified are consistent with those found in Type 304 stainless steel and dye penetrant fluid and developer. Additional elements were identified which are known to promote transgranular stress corrosion cracking (i.e., potassium) in stainless steel; however, no explanation for their presence could be determined. Nor could an exact correlation be derived between their existence and the cracking. The presence of the contaminant and evidence of transgranular stress corrosion cracking originally appeared to be an isolated case, associated with the manufacturing lot comprised of CRD seal housings 101, 102 and 103.

The positive dye penetrant indications exhibited on the 11 CRD seal housings discovered in September 1988 have again been attributed to transgranular stress corrosion cracking. This conclusion was primarily derived from data taken and analyses performed by Combustion Engineering during destructive testing of CRD seal housing 102. These efforts focused on evaluating stresses imposed by shrink fitting and welding processes during manufacturing, and operating stresses normally imposed. Analyses concluded that there is no evidence of fatigue cracking and that the indications are transgranular in nature. Although no traces of corrosive contaminant were identified in the 1988 sampling, it is assumed that the crack initiation and subsequent growth was accelerated by the presence of a contaminant. This was due to the fact that the steady stresses computed would not otherwise be anticipated to result in the cracking exhibited.

All 45 CRD seal housings currently installed on the reactor head were PT examined.

Inspection

The NRC inspector reviewed the licensee's augmented inspection plan for examination of the CRD seal housings. Each refueling outage the licensee will examine the previously cracked housings and replace if cracks are present. In addition, all of the previously cracked housings will be replaced at a rate of three housings per outage. The remaining CRD seal housings will be inspected in accordance with the ASME Code Section XI requirements.

The licensee's corrective action was adequate to assure that all of the cracked CRD seal housings were identified. Root cause analyses, repair, and planned replacement of the cracked CRD housings will assure the safety objectives of regulatory requirements and the ASME Code are being met.

3. Inspection of Steam Generator Tubing

Background

Following plant startup on March 1, 1989, primary to secondary leakage was detected. Operation of the plant with an average calculated leak rate of .015 gallons per minute continued until October 1, 1989, when Palisades was shut down to repair suspect Westinghouse mechanical tube plugs, and perform eddy current (ET) examinations as previously committed to the NRC. During the operations of the plant since March 1, 1989, the licensee reduced power (to 80%) to maintain leakage below levels as required by the administrative controls committed to the NRC.

The licensee has experienced rapid degradation of steam generator (SG) tubing over the last two years. Leaks due to circumferentially cracked tubes in SG "B" hot leg at tube support plates 3 and 13 have occurred, causing forced outages and extensive repair and evaluation.

The licensee employed the services of MPR Associates to perform a support plate stress evaluation. The purpose of the evaluation was to identify tubes within the SG which are most susceptible to circumferential stress corrosion cracking. Stress and deflection analyses of the support plates, the location of tube support plate flow circulation holes and the recent history with respect to tube leaks and tube cracking were taken into consideration in completing the evaluation.

The MPR Associates evaluation concluded that the high probability stress areas for inducing circumferential corrosion cracking was in the hot leg at support plates 3 and 13. Consequently, the licensee committed to provide the NRC with the final eddy current inspection scope for this mid-cycle outage. Previous discussions with the NRC's NRR staff concluded that the licensee would inspect all of the tubes recommended by MPR Associates in their support plate stress evaluation report (MPR-1125 Palisades Steam Generator Proposed Eddy Current Inspection Plan, May 1989).

The scope consisted of inspecting 1006 tubes in "A" steam generator hot leg and 783 tubes in "B" steam generator hot leg. All of these tubes were inspected with the 8 x 1 probe. A subset of these tubes which are located near previous leakers were inspected with the motorized rotating pancake coil (MRPC) at support plates 3 or 13. The MRPC was used to inspect 239 tubes in "A" hot leg and 94 tubes in "B" hot leg.

The 8 x 1 probe is qualified for the detection of circumferential cracks. It is not, however, qualified to size intergranular attack (IGA) or wastage type defects. During the inspection, based on past experience with the 8 x 1 probe, a large number of "noncrack" indications were expected to be identified with the 8 x 1 probe in regions of IGA or wastage. In order to ensure these indications do not represent true degradation growth or exceed the plugging criteria, the licensee inspected 10% of the tubes which contain "noncrack" indications (minimum of 100 tubes) with a bobbin probe. Any indication which exceeded the Palisades Technical Specification for plugging was plugged. The 540 SFW bobbin probe with the MIZ-12 tester was used in lieu of the MIZ-18/580 bobbin to obtain a comparison with previous ET results. The licensee recently qualified the Zetec MIZ-18 to perform the SG tubing examination, which was utilized for the 8 x 1 and MRPC examinations.

Initial ET examination as described above detected seven crack-like indications, including two leakers which were identified by leak tests previously in the "B" SG. Each tube with crack-like indications was plugged and bounded by ET examination of two rings of tubes adjacent to it. No tubes were found in "A" SG hot leg which contained crack indications. The MIZ-12 540 SFW bobbin inspection for "non-crack" defects did not detect any further degradation in the sample of 100 tubes selected for examination.

Subsequent to the hot leg ET examination, the licensee performed tubesheet visual scans (for leakage only) of "A" and "B" SG cold legs. "A" SG cold leg visual examination revealed a region of wetness close to the divider plate. Fifteen tubes adjacent to the wet area of the tubesheet were examined using the 8 x 1 probe. Five tubes were identified with possible crack-like indications. ET with the MRPC probe of these five tubes confirmed three crack indications. Each of these tubes had been last inspected in August 1983 with no apparent degradation present at the third support plate.

The licensee expanded the ET examination to include all tubes located within three rings of the degraded tubes in "A" SG cold leg (77 tubes) and all tubes in rows 12 - 14, adjacent to the divider plate, in quadrants 1 and 4 of SG "A" cold leg. The results from this ET sample detected 17 additional crack-like indications using the 8 x 1 probe. With the three previous indications, 19 were located at support plate 3 and one at support plate 7. Of these indications, nine were dispositioned with the MRPC ET probe as satisfactory, with 11 crack-like indications confirmed as defects. Further expansion of the examination included: all tubes in rows 15 - 16 in SG "A" cold leg and in rows 12 - 14 in "A" hot leg. One potential crack-like indication was found in rows 15 - 16 in quadrant 4; the inspection scope was expanded to rows 17 - 18 in that quadrant. No further crack indications were found. The licensee employed MPR Associates to perform further review to provide a crack mechanism assessment using the eddy current data.

The assessment, performed by MPR Associates, determined two probable mechanisms responsible for the cracking found in the cold legs; in-plane loads due to severe denting and out-of-plane loads due to thermal expansion stresses. The average denting values for the third support plate based on December 1987 profilometry inspection indicates significantly high denting. The third support plate does not have flow circulation holes, which provides some stress relief, and the tubes adjacent to the areas of plugged are subjected to higher thermal expansion stresses, particularly the short radius tubes which have the hottest primary water at the cold leg tube sheet. Most of the tubes in rows 1 - 12 are plugged causing the unplugged tubes close to the divider plate to see the highest out-of-plane loads due to thermal expansion.

The second most probable area of high stress was determined to be the tubes located in the lug regions of the tube support plates. The restraining force of the lug, in addition to thermal expansion stresses between the "cold" lug and a hot tube make it a high suspect area.

MPR Associates recommended further ET samples at the lug regions of support plate 3. The licensee performed ET of six tubes at each of the five lug regions at support plate 3 of SG "A". No crack-like indications were found in these inspections.

In summary, the "A" SG hot leg inspection had covered 1,017 tubes specifically targeted by the original MPR inspection plan plus 130 tubes along the divider plate, plus a five percent random sample for a total of 22.7 percent of the tubes inspected with no cracks identified. The "A" SG cold leg inspection had covered 360 tubes along the divider plate, 29 tubes at the lugs and a five percent random sample. A total of 12 crack-like indications were detected in the cold leg (one leaker) primarily at support plate 3.

The licensee also expanded the scope of the ET in the "B" SG cold leg. Initial ET detected 24 crack-like indications in rows 12 - 14. The sample was expanded into rows 15 - 16 in which 10 additional crack-like indications were found. Further ET was performed in rows 17 - 18 of quadrants 1 and 4 where an additional 16 crack-like indications were found causing ET scope expansion to rows 19 - 20. No indications were found in these two rows. A total of 50 crack-like indications were found in rows 12 - 18. The licensee subsequently performed a five percent random inspection in "B" SG cold leg and rows 12 - 14 in "B" SG hot leg. No additional indications were found in "B" SG hot leg. The "B" SG cold leg ET detected five additional crack-like indications. Four of these indications were located at tube support plate 4 and one at support plate 3. Each of these tubes had been ET examined during August of 1988 with no defects detected at that time. The licensee performed ET of the tubes' two rings surrounding these 5 defective tubes; no additional indications were found in this sample. The licensee made the decision to ET an additional six percent random sample in the "B" SG cold leg. No additional crack-like indications were found in this sample.

Following recommendations from the NRC made during ongoing status briefings, the "B" cold leg examination was expanded to further bound the five tubes with crack-like indications found in the original five percent random sample (189 tubes).

ET crack-like indications were detected in seven tubes in support plate 3 lug region. The sample was expanded to include two rings of tubes surrounding the defective tubes. No additional crack-like indications were detected. No additional ET examinations were made.

A total of 27 tubes were plugged in the "A" SG of which 11 contain crack indications. In the "B" SG, 118 tubes were plugged, of which 69 contained crack indications. Tubes adjacent to the leakers or containing cracks in excess of 80 degrees circumferentially were also plugged.

The licensee contacted NRR (EMTB) through the NRR Project Manager and reported the results of the above examinations throughout the inspection. Through conference calls with NRR, inspection results and engineering submittals, the licensee's eddy current examination was judged adequate to assure reliability for safe operation to the next refueling outage where the replacement of the Palisades SG's are planned (Fall of 1990).

Inspection

The NRC inspector observed eddy current examinations in progress, reviewed the ET inspection program, ET inspectors' certifications, data analysis guidelines for the ET at Palisades, and certification/calibration of ET equipment. The NRC inspector did not observe the ET performed throughout the outage due to other commitments. However, the inspector contacted NRR (EMTB) and site personnel throughout this period to keep current on the ET examination results at Palisades. Subsequently, the NRC inspector reviewed the ET data and concurred with reported results.

A total of 1,473 tubes (22.7 percent) were examined in SG "A" hot leg, 714 tubes (11 percent) in the cold leg, 939 tubes (15 percent) in the "B" SG hot leg, and 1,425 tubes (23 percent) in the cold leg.

The licensee plans to limit plant operation to a maximum of 80 percent of rated power until SG replacement in the Fall of 1990. The Palisades Technical Specifications (TS) limits primary to secondary system leakage to 0.3 gallons per minute. However, the licensee has committed to an administrative limit of 0.05 gallons per minute during plant operations. Based on the licensee's adherence to the administrative primary to secondary leakage limits and reduced power operation, the safety significance of possible cracking in additional tubes not inspected is reduced. Analysis performed by the licensee (CPCo to NRC submittal dated April 19, 1984 and MPR analyses of May 1989) indicated throughwall cracking will develop leakage and be detected by installed plant equipment prior to a crack reaching a critical circumferential length. Therefore, the safety significance of possible cracked tubing is conservative in that leakage will preclude the tube failure by a safe margin (leak before break analyses).

The licensee's ET was performed in accordance with approved procedures which comply with ASME Section XI requirements, ET inspectors' qualifications, and certifications complied with ASNT TC-1A requirements.

No violations or deviations were identified.

4. Exit Meeting

The inspector met with licensee representatives (denoted in Paragraph 1) on December 7, 1989, and during a subsequent telecon with Mr. B. V. VanWagner on December 14, 1989, and at the conclusion of the inspection via telephone with Ms. K. V. Cedarquist on December 20, 1989. The inspector summarized the scope and findings of the inspection activities. The licensee acknowledged the inspection findings. The inspector also discussed the likely informational content of the inspection report with regard to documents or processes reviewed by the inspector. The licensee did not identify any such documents/processes as proprietary.