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Subject: Arkansas Nuclear One - Unit 1
Docket No. 50-313
License No. DPR-51
Licensee Event Report 50-313/97-001-00

Gentlemen:

In accordance with 10CFR50.73(a)(2)(i)(B), enclosed is the subject report concerning Once Through Steam Generator tube surveillance requirements.

Very truly yours,

Dwight C. Mims

Dwight C. Mims
Director, Nuclear Safety

DCM/tfs

enclosure

1/1
Ltr

140068

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NRC FORM 366 (5-92) U.S. NUCLEAR REGULATORY COMMISSION

# LICENSEE EVENT REPORT (LER)

APPROVED BY OMB NO. 3150-0104
EXPIRES 5/31/95

ESTIMATED BURDEN PER RESPONSE TO COMPLY WITH THIS INFORMATION COLLECTION REQUEST: 50.0 HRS. FORWARD COMMENTS REGARDING BURDEN ESTIMATE TO THE INFORMATION AND RECORDS MANAGEMENT BRANCH (MNBB 7714), U.S. NUCLEAR REGULATORY COMMISSION, WASHINGTON, DC 20555-0001, AND TO THE PAPERWORK REDUCTION PROJECT (3150-0104), OFFICE OF MANAGEMENT AND BUDGET, WASHINGTON, DC 20503.

| FACILITY NAME (1) | DOCKET NUMBER (2) | PAGE (3) |
|---|---|---|
| Arkansas Nuclear One - Unit 1 | 05000313 | 1 OF 7 |

TITLE (4) Inconsistencies Between Once Through Steam Generator Tube Destructive Examination Results and Intergranular Attack Flaw Sizing Qualification Data Caused The Possibility That Tubes Were Left In Service With Flaws Exceeding The Technical Specification Limit

| EVENT DATE (5) | | | LER NUMBER (6) | | | REPORT DATE (7) | | | OTHER FACILITIES INVOLVED (8) | |
|---|---|---|---|---|---|---|---|---|---|---|
| MONTH | DAY | YEAR | YEAR | SEQUENTIAL NUMBER | REVISION NUMBER | MONTH | DAY | YEAR | FACILITY NAME | DOCKET NUMBER |
| 04 | 08 | 97 | 97 | 001 | 00 | 05 | 07 | 97 | FACILITY NAME | DOCKET NUMBER |

| OPERATING MODE (9) | N | THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR: (Check one or more) (11) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| POWER LEVEL (10) | 100 | | 20.402(b) | | 20.405(c) | | 50.73(a)(2)(iv) | | 73.71(b) |
| | | | 20.405(a)(1)(i) | | 50.36(c)(1) | | 50.73(a)(2)(v) | | 73.71(c) |
| | | | 20.405(a)(1)(ii) | | 50.36(c)(2) | | 50.73(a)(2)(vii) | | OTHER |
| | | | 20.405(a)(1)(iii) | X | 50.73(a)(2)(i) | | 50.73(a)(2)(viii)(A) | | Specify in Abstract Below and in Text |
| | | | 20.405(a)(1)(iv) | | 50.73(a)(2)(ii) | | 50.73(a)(2)(viii)(B) | | |
| | | | 20.405(a)(1)(v) | | 50.73(a)(2)(iii) | | 50.73(a)(2)(x) | | |

LICENSEE CONTACT FOR THIS LER (12)

| NAME | TELEPHONE NUMBER (Include Area Code) |
|---|---|
| Thomas F. Scott, Nuclear Safety and Licensing Specialist | 501-858-4623 |

COMPLETE ONE LINE FOR EACH COMPONENT FAILURE DESCRIBED IN THIS REPORT (13)

| CAUSE | SYSTEM | COMPONENT | MANUFACTURER | REPORTABLE TO NPRDS | | CAUSE | SYSTEM | COMPONENT | MANUFACTURER | REPORTABLE TO NPRDS |
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| SUPPLEMENTAL REPORT EXPECTED (14) | | | | EXPECTED SUBMISSION DATE (15) | MONTH | DAY | YEAR |
|---|---|---|---|---|---|---|---|
| | YES | | NO | | | | |
| X | (If yes, complete EXPECTED SUBMISSION DATE) | | | | 06 | 30 | 97 |


ABSTRACT (Limit to 1400 spaces, i.e., approximately 15 single-spaced typewritten lines) (16)

On April 8, 1997, ANO-1 discovered that inconsistencies between destructive examination results of three Once Through Steam Generator (OTSG) tubes and previous qualification data used for sizing intergranular attack (IGA) flaws in the upper tubesheets created the possibility that tubes had been left in service during a refueling outage in the fall of 1996 with defects exceeding the through-wall limit contained in technical specifications (TS). The sizing technique had been qualified in accordance with EPRI guidelines. Technical Specification 3.0.3 was entered, with actions delayed per 4.0.3, until enforcement discretion was obtained from the NRC. A request for an exigent TS change was submitted to allow operation for the remainder of the current cycle with IGA flaws in the upper tubesheet exceeding the TS limit. The root cause evaluation is in progress but has not been completed. A supplement will be submitted to provide the root cause and corrective actions. Tubes that could remain in service with flaws in excess of the limit were determined not to represent a structural or leakage concern.

A. Plant Status

At the time this condition was discovered, Arkansas Nuclear One Unit 1 (ANO-1) was operating in normal steady-state conditions at 100 percent power.

B. Event Description

On April 8, 1997, ANO-1 discovered that inconsistencies between destructive examination results of three Once Through Steam Generator (OTSG) [AB] tubes and previous qualification data used for sizing intergranular attack (IGA) flaws in the upper tubesheets created the possibility that tubes had been left in service during a refueling outage in the fall of 1996 with defects exceeding the through-wall limit contained in technical specifications (TS).

Intergranular Attack (IGA) is known to be present above the 15th tube support plate (TSP) within the ANO-1 OTSGs as verified by destructive examination (DE) from previous tube pulls. IGA is a damage mechanism caused by corrosion of the material grain boundaries. The corrosion resulted from contaminants introduced on the tubing during the early years of plant operation. The contaminant causing IGA of the ANO-1 tubing is sulfur resulting from thermal decomposition of ion exchange resins. The ANO-1 IGA can be categorized as volumetric, or "patch-like", with no specific orientation. Since discovery, there has been no evidence of leakage from IGA flaws at ANO-1.

During the 1R13 refueling outage in September and October of 1996, an eddy current (EC) technique was employed to depth size the IGA. This technique had been qualified per Appendix "H" of the EPRI "PWR Steam Generator Tube Examination Guidelines," Revision 4 dated June 1996. Compliance with the EPRI guidelines was considered an acceptable method to qualify non-destructive examination (NDE) techniques for the detection and sizing of damage mechanisms, and the guidelines were the only qualification technique available at that time. This technique was used to depth size all IGA flaws within the upper tubesheet (UTS) using the bobbin coil. During this inspection, 25 percent of all indications detected within the UTS region by bobbin coil were examined using a rotating pancake coil (RPC) to characterize these flaws. All IGA indications between the 15th TSP and the secondary face of the UTS were removed from service by plugging. All UTS IGA indications with a depth size of greater than or equal to 40 percent through-wall (TW), as determined by the qualified sizing technique, were also removed from service by plugging.

During 1R13, three tubes with bobbin indications within the UTS were removed from the "B" OTSG for future development of Alternate Repair Criteria (ARC) and to further support the qualified EC sizing technique. Two of the three tubes contained flaws that would have required repair. The third tube was near the repair limit and may have been preventively repaired. The tubes were selected on the basis of

their containing multiple indications with depths representative of the average indication depths as sized by EC. After bursting the tubes in the laboratory, the flaws were examined and sized. If a flaw was not opened by the burst of the tube it was bent open for destructive examination. The DE results were not consistent with the previous qualification data of the bobbin coil for sizing IGA flaws in the UTS. The flaw depths did not correlate well with the depths sized by using the qualified EC technique. Nevertheless, the entire data set, including the results of the most recent outage, still satisfies the qualification requirements of Appendix "H". As a result of this condition, it is possible that tubes were left in service with through-wall defects greater than the technical specification plugging limit.

C. Root Cause

The root cause evaluation has been initiated but is not complete. Work is in progress by Framatome Technologies Inc. (FTI) and Westinghouse to compare the 1997 tube pull analysis data to previous ANO-1 and Crystal River tube pull analysis data. This comparison is expected to determine if differences in the IGA morphology exists. Further analysis of the technique used to size the flaws will also be performed to determine if errors exist and to better calibrate it. It appears that the root cause may be related to the inability of the bobbin coil to depth size very tight corrosion depths since the 1997 tube pull analysis revealed very tight, deep flaws within the patch IGA. This report will be supplemented to provide the results of the root cause evaluation. The supplement is expected to be submitted by June 30, 1997.

D. Corrective Actions

At 2012 on April 8, 1997, both OTSGs were administratively declared inoperable and TS 3.0.3 entered with actions delayed as allowed by TS 4.0.3. A request for enforcement discretion was verbally approved by the Nuclear Regulatory Commission (NRC) at 1535 on April 9, 1997, at which time the TS was exited. A letter (1CAN049702) documenting the enforcement discretion request was submitted on April 9, 1997. The duration of the discretion is until May 7, 1997, or until the NRC Staff acts upon a proposed exigent TS change request, whichever occurs first. On April 11, 1997, ANO-1 submitted a letter (1CAN049703) requesting an exigent TS change to allow tubes with IGA flaws greater than 40 percent TW in the OTSG UTS to remain in service for the remainder of the current operating cycle.

ANO-1 had previously implemented shutdown limits for primary-to-secondary leakage that are more restrictive than TS limits. A review of the extensive measures previously taken by ANO-1 to enhance the operators' abilities to detect and respond to OTSG tube leakage indicated that no additional compensatory measures were necessary to address the surveillance deficiency.

Other corrective actions are expected to be identified as part of the root cause evaluation.

E. Safety Significance

The subject EC sizing technique was employed for IGA defects within the UTS. All UTS IGA indications with a depth size of greater than or equal to 40 percent TW were removed from service by plugging the affected tubes.

The three UTS IGA tube samples removed during 1R13 were subjected to room temperature burst testing. Burst testing was performed separately within the flawed and unflawed regions of the tube samples. No simulated tubesheet was employed during the tests. The tests were performed using bladders in the flawed region. No foils or lateral restraint systems were used. The burst pressures for the flawed regions were between 10,000 and 11,000 psig. The unflawed regions burst at pressures between 10,700 and 11,200 psig. For ANO-1 OTSGs, structural integrity is conservatively demonstrated by pressurizing the tubing to three times normal operating differential pressure. This pressure for ANO-1 is 3,765 psig. The burst testing results indicate that substantial structural margin exists.

In 1996, to support ANO's study of IGA, burst testing of pre-defected tubes was completed by FTI. The burst testing consisted of nine tubes containing through-wall drilled holes up to 0.5 inches in diameter and one tube containing no defects placed within a simulated tubesheet. Nine of the specimens burst at pressures greater than or equal to 10,941 psig. Each tube burst outside the tubesheet within the non-defected portion of the tubes. One tube reached a pressure of 9,577 psig but did not burst due to bladder leakage. These test results indicate that the tubesheet provides sufficient support to preclude tube rupture within the tubesheet.

The tube samples removed from ANO-1 in 1996 included eleven IGA indications in the UTS. Since it was confirmed that the inservice IGA indications are volumetric, bobbin amplitude (voltage) was used as a bounding parameter. The eddy current responses from these flaws were compared with the population of inservice IGA indications to determine how representative the flaws were of those remaining in service. The 600 KHz bobbin coil signal amplitude of flaws in tubes that were pulled during 1996 ranged from 0.46 to 2.69 volts. Of the 470 inservice IGA indications, all are bounded by the 2.69 volt value.

Additionally, a comparison of RPC data was performed to further substantiate that the pulled tube flaws bound those indications remaining in service. The RPC data collected for the tube pull samples resulted in a maximum flaw extent of 0.16 inches. RPC signal information was collected on 118 indications within the UTS. Ten of the largest RPC voltage indications were examined to determine the length-by-width extent by RPC. The largest RPC extent for those IGA indications left in service was 0.14 inches. Therefore, it is concluded that the inservice IGA indications are bounded by those tube samples that were destructively examined.

Structural integrity of the tubing within the tubesheet is assured based upon demonstration of the following:

A. The actual tube samples removed from ANO-1 during 1R13 exhibited burst pressures that substantially exceeded the required structural limit.

B. The structural support provided by the tubesheet precludes tube rupture.

C. The inservice IGA indications are bounded by those flaws contained in the tube samples that were pulled.

The IGA patches destructively examined were not through-wall; therefore, normal operating pressures did not result in through-wall leakage. This was evident during inservice inspection of the tubing in which no indications of residual leakage was noted. A comparison of 1R12 and 1R13 refueling outage EC signatures indicates that the IGA exhibited little or no growth. Comparison of inspection data prior to the 1R12 refueling outage supports this conclusion. Additionally, during May 1996, "B" OTSG tubing was subjected to a differential pressure of approximately 2,100 psid for several hours as a result of a feedwater transient. No immediate increase in primary-to-secondary leakrate was noted during the event or following startup. The primary-to-secondary leakrate did increase by approximately 18 gpd three days following startup; however, none of the leakage detected during the 1R13 refueling outage was from IGA flaws. It is concluded that leakage through IGA flaws in the UTS is highly unlikely at Main Steam Line Break (MSLB) pressures due to the flaw morphology. The near MSLB differential pressure that occurred in May 1996 caused no resultant leakage.

Conditional core damage probability is the increase in core damage frequency due to a given condition other than that assumed for the base Probabilistic Risk Assessment (PRA). The PRA assumed that the tube integrity is such that no OTSG tube rupture would be induced due to transient conditions. The limiting licensing basis transient which could most adversely affect the tubes by creating a high differential pressure across the tubes is a MSLB accident. This accident could produce a tube differential pressure of up to 2,500 psid. The tube sample burst pressures were well above pressures which would be seen in a limiting MSLB accident. Thus, the likelihood of tubes rupturing is not increased because of the larger than expected flaw sizes due to IGA in the UTS. This situation has been qualitatively assessed and the conditional core damage probability for this condition is estimated to be inconsequential.

The limiting licensing basis accident with respect to dose consequences from induced tube leakage is the MSLB accident. This accident assumes a total leakage of 1 gpm with 1 percent failed fuel in the core. However, OTSG tube leakage is procedurally limited to 0.1 gpm during normal operation. Even though leakage is not expected to occur, MSLB induced tube leakage has been conservatively estimated to be

0.53 gpm on the affected steam generator. The following assumptions were made concerning the number of flaws and associated leakage:

1) Since OTSG "A" has the largest number of IGA patch indications (285), it was chosen as the affected generator bounding OTSG "B" with only (185) indications.

2) Half of the indications were assumed to leak under MSLB conditions.

3) Representative leakage values for axial flaw lengths were utilized to bound the leakage expected from IGA patches.

4) The longest IGA length calculated from RPC data was applied to the 50 percent population assumed to leak.

5) The flaws were assumed to grow in length an additional 25 percent over the cycle.

6) Fifty percent of the flaw length was assumed to be 100 percent TW in depth.

Since there are 285 indications, half of this value is approximately 143. The longest length in the axial plane was 0.14 inches. When increased by 25 percent, this yields a flaw length of:

0.14 inches * (1.25) = 0.175 inches

If 50 percent of the length is assumed to be 100 percent TW:

0.175 inches * (0.5) = 0.0875 inches

Using leakage curves developed for OTSGs for axial flaws, the leakage from a single flaw (0.0875 inches, 100 percent TW) is determined to be 0.0025 gpm. To compensate for normal operating temperature the value is multiplied by 1.47 to yield a final leakage of 0.003675 gpm per flaw. This value is then multiplied by the number of potential leaking flaws to give a total leakage of:

143 flaws * 0.003675 gpm/flaw = 0.53 gpm

When the estimated leakage in the affected OTSG is added to that which is allowed by procedure, the total leakrate is expected to be no greater than 0.63 gpm. Since the assumed leakrate is greater than the conservative calculation, the current licensing basis assumption of 1 gpm remains bounding.

The subject flaws do not represent a structural or leakage concern. Therefore, the presence of inservice upper tubesheet IGA defects with through-wall extents that may exceed the technical specification plugging limit does not pose a concern relative to the health and safety of the public.

F. Basis for Reportability

The inservice inspection of ANO-1 OTSGs is conducted in accordance with Technical Specification 4.18. Specification 4.18.2 states, "Inservice inspection of steam generator tubing shall include non-destructive examination by eddy-current testing or other equivalent techniques." Specification 4.18.3 requires that a minimum sample size be examined in accordance with specification 4.18.5. Specification 4.18.5.b states, "The steam generator shall be determined operable after completing the corresponding actions (plug or sleeve all tubes exceeding the plugging limit and all tubes containing through-wall cracks) required by Table 4.18-2." Table 4.18-2 requires "defective" tubes to be plugged or sleeved. Specification 4.18.5 contains definitions of "defect" and "plugging limit" that require tubes containing imperfections of a depth greater than or equal to 40 percent of the nominal tube wall thickness to be sleeved or removed from service. Since tubes containing IGA defects exceeding that value were possibly left in service, this constitutes an operation prohibited by technical specifications that is reported in accordance with 10CFR50.73(a)(2)(i)(B).

Both OTSGs were administratively declared inoperable and TS 3.0.3 was entered at 2012 on April 8, 1997. Actions were deferred as allowed by TS 4.0.3 for 24 hours in order to process a request for enforcement discretion. Entry into TS 3.0.3 is also reportable in accordance with 10CFR50.73(a)(2)(i)(B) as an operation prohibited by technical specifications.

G. Additional Information

There have been no similar conditions reported as Licensee Event Reports by ANO.

Energy Industry Identification System (EIIS) codes are identified in the text as [XX].