NRC FORM 366 U.S. NUCLEAR REGULATORY COMMISSION
(4-95)

LICENSEE EVENT REPORT (LER)

APPROVED OMB NO. 3150-0104
EXPIRES: 04/30/98
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FACILITY NAME (1)	DOCKET NUMBER (2)	PAGE (3)
Oconee Nuclear Station, Unit 2	05000270	1 of 11

TITLE (4) Operation With Steam Generator Tube Indications In Excess Of Limits Due To Manufacturing Error

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(S)
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03	30	98	98	-	01	-	00	04	29	98		05000

OPERATING MODE (9)	N	THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR (*Check one or more of the following*) (11)					
POWER LEVEL (10)	0	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 (*Specify in Abstract below and in Text, NRC Form 366A*)
		20.405(a)(1)(iii)	X	50.73(a)(2)(i)(B)		50.73(a)(2)(viii)(A)	
		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)

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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	

SUPPLEMENTAL REPORT EXPECTED (14)			EXPECTED SUBMISSION DATE (15)	MONTH	DAY	YEAR
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ABSTRACT (*Limit to 1400 spaces, i.e. approximately fifteen single-space typewritten lines*) (16)

On March 30, 1998, Oconee Units 1 and 3 were operating at 100% Full Power and Unit 2 was defueled for a refueling outage. During eddy current testing (ECT) of the 2A Once Through Steam Generator (OTSG), it was discovered that 5 tubes are mis-positioned, such that a tube in the upper tube sheet (UTS) does not exit the corresponding tube hole in the lower tube sheet (LTS). The UTS and LTS tube holes at co-ordinates for two of these tubes were plugged the previous outage due to ECT indications that may have exceeded the Technical Specification (TS) repair limit. However, due to the mis-positioned tubes, four different tubes were actually plugged on one end each, leaving the flawed tubes in-service as a pressure barrier. Therefore, Unit 2 may have operated in deviation from TS from May 5, 1996, to March 15, 1998. The root cause of this event is Manufacturing, Fabrication Deficiency. Evaluations concluded that the Unit 2 tubes were past operable and Units 1 and 3 are currently operable, even assuming similar discrepancies exist on those units. Unit 2 OTSGs have been inspected for additional mis-positioned tubes. All five affected tubes were plugged. Tube position verification will be performed on Units 1 and 3 OTSGs during upcoming refueling outages.

BACKGROUND

Oconee Nuclear Station uses the Babcock and Wilcox (B&W) Nuclear Steam Supply System [EIIS:AC], which includes two Once Through Steam Generators (OTSGs) [EIIS:SG], for primary to secondary heat transfer. The B&W OTSG is a vertical, straight tube heat exchanger. The OTSGs are 73 feet tall, and approximately 13 feet in diameter. Inside the OTSG shell, there is an upper tube sheet, 15 tube support plates, a lower tube sheet, and 15531 tubes per steam generator. See Attachment A.

The tube sheets are two feet thick and the tubes are nominally 0.625 inches in diameter. During construction, the tube sheets were drilled, individual tubes were inserted in one tube sheet, passed through openings in the tube support plates to the other tube sheet, through the other support plate, and then rolled in place and seal welded. They were manufactured in Barberton, Ohio, by B&W. Framatome Technologies Inc. subsequently acquired this division of B&W.

For identification purposes, tubes are designated by row and tube co-ordinates. The row numbers start on one edge of the tube sheet and tube numbers start at the beginning of each row and count up. See Attachment B. By design, the tubes go "straight" through the OTSG, such that a tube should penetrate the upper and lower tube sheets at the same co-ordinates. All tube inspections and repairs are accomplished using the assumption that these tube locations are as designed. Tube examinations are often executed by running different test probes from the upper and lower tube-sheets. Tube repair, by plugging, requires locating the tube end location from each tube-sheet and removing the tube from service by installing a plug at each end. For each activity, the positive identification of the tube by its co-ordinates on the respective tube-sheet is essential. There is not a requirement that the tube be verified to be in the same tube "hole" in each tube-sheet.

Technical Specification (TS) 3.1.1(b) requires one OTSG to be operable when the Reactor Coolant System (RCS) [EIIS:AC], temperature is above 250F. TS 3.4.1(b) requires two emergency feedwater [EIIS:BA], flow paths to be operable when the RCS temperature is above 250F. Since the OTSG is part of the emergency feedwater flow path, this implies that the second

OTSG must also be operable. TS 3.1.6 requires initiation of unit shutdown if OTSG tube leakage exceeds 150 gallons per day.

TS 4.17 establishes the OTSG inservice test requirements, which include eddy current testing. TS 4.17.5 defines: "Repair Limit means the imperfection depth beyond which the tube shall be either removed from service by plugging or repaired by sleeving or re-rolling because it may become unserviceable prior to the next inspection; it is equal to 40% of the nominal tube or sleeve wall thickness."

DESCRIPTION OF EVENT

On the night shift of March 29-30, 1998, Oconee Units 1 and 3 were operating at 100% Full Power and Unit 2 was defueled for a refueling outage. During eddy current testing (ECT) inspections of the 2A Once Through Steam Generator (OTSG), obstructions were encountered in two of the tubes around locations 21-28 and 23-31. A Problem Investigation Process (PIP) report was initiated at 0900 hours on March 30, 1998.

Discovery of this problem centered around 2 tubes which had axial ECT indications in the freespan area between tube support plates last ONS-2 outage (2EOC15). Due to the location and type of indication, the depths of these two indications were difficult to quantify. The decision was made to treat these two indications as exceeding the Technical Specification (TS) repair limit and plug the tubes. When tubes are plugged, both ends are plugged, based on the tube co-ordinates. In this case the "plugged" locations were 21-28 and 23-31.

By inserting a probe in a given tube hole in the upper tube sheet (UTS) and verifying where it either exited the lower tube sheet (LTS) or encountered an obstruction, the investigation determined that five tubes exited the UTS in a different location (co-ordinate). These five tubes are "rotated" or mis-aligned at some point along their axial length in the OTSG, such that, for a given tube hole in the UTS, the tube does not match up to the corresponding tube hole in the LTS. See Attachment B. This type of error could only have occurred during original fabrication of the OTSG prior to shipment to Oconee.

Framatome Technologies Inc. (Lynchburg, VA) was contacted to review fabrication documents for any records of tubes being inserted in the incorrect tube sheet holes and for any other relevant details on the OTSG fabrication process. They were unable to find any documentation to indicate that these mis-positioned tubes were identified as such during fabrication. Framatome was also requested to assist in an operability evaluation.

The five affected tubes in the 2A OTSG are at UTS locations 21-28, 21-29, 22-30, 22-31, and 23-31. The relationship is that the tube in location 21-29 in the UTS comes out in location 22-31 in the LTS. Location 22-31 in the UTS is 23-31 in the LTS, 23-31 in the UTS is 22-30 in the LTS, 22-30 in the UTS is 21-28 in the LTS, and 21-28 in the UTS is 21-29 in the LTS.

Therefore, during 2EOC15, rather than plugging both ends of two tubes, four tubes were plugged at only one end. Although there would have been no flow through these four tubes, they were subjected to Reactor Coolant System fluid and pressure during the last operating cycle. The two tubes with defects possibly exceeding TS 4.17 repair limits remained in service as pressure boundaries from May 7, 1996, when Unit 2 returned to operation at the end of 2EOC15 Refueling Outage, until March 15, 1998, when Unit 2 reached cold shutdown for the current 2EOC16 refueling outage.

A current operability for Units 1 and 3 was initiated at 1900 hours on March 30, and approved on April 4, 1998, which conservatively assumed similar mis-positioned tubes on those units. This evaluation determined that Units 1 and 3 are operable.

A past operability evaluation was performed for tubes 21-28 and 23-31, the two tubes which had indications and which were intended to be removed from service during 2EOC15. The evaluation addressed the following issues:

- Tube structural loading as a result of being mispositioned
- The potential for a plug to become a loose part
- The integrity of the tubes during accident conditions.

Tube Structural Loading Assessment

The issue was that the mis-alignment, which must occur between the tube sheet and a tube support plate or between two tube support plates, might impose unacceptable stresses on the affected tubes or other OTSG components. Structural effects of the tube mis-positioning have been evaluated by Framatome Technologies for all loading conditions. A detailed review of the geometry using a minimum span length of 35 inches and tube-sheet pitch of 0.875 inches results in effective change in tube length of 0.01 inches and an offset angle of less than 1.5 degrees. The conclusion of the Framatome Technologies assessment was that all existing documentation concerning the integrity of the tubes, sleeves, plugs, shell, etc. remain valid and are applicable to the mis-positioned tubes.

Potential Loose Part Assessment

The issue was that a plug might become a loose part in the primary system as a result of only one end of a tube being plugged. It was verified during this refueling outage that all four plugs were in place. Therefore, none of the four plugs became a loose part. Additionally, the two tubes with repairable indications and plugged at the end in the lower tube sheet (LTS), were in-situ pressure tested to Main Steam [EIIS:SB], Line Break (MSLB) accident and three (3) times normal operating differential pressure (DP) conditions. There was no plug movement nor observable leakage from the plugs. Testing performed in the past by Framatome at DPs of up to 12,750 Psig showed that all tested plugs remained in the tube sheet, with only minimal plug motion. These test conditions bound all possible secondary to primary pressure DPs during any normal operating or accident condition.

Excessive Leakage or Tube Integrity Assessment

The issue was that the flaws which produced the previously observed ECT indications might have further degraded during the fuel cycle, such that one or both of the tubes might have burst during a design basis event. In-situ pressure tests were performed on the two tubes, 21-28 and 23-31 in the 2A OTSG, which contained the flaws but had remained in-service as a pressure barrier during the past operating cycle.

For Oconee, the limiting accident condition is a MSLB. Additionally, a structural criterion requires that the tube will not burst at 3 times the normal DP between the primary and secondary sides.

In support of this evaluation, these two tubes were pressure tested at DPs, corrected for material and operating conditions, to represent the MSLB DP and three times normal operating DP (3XDP).

Both tubes exhibited zero leakage at the MSLB DP test pressure (2575 psi). One tube (21-28) exhibited zero leakage at 3XDP test pressure of 3825 psi. Tube 23-31 experienced a pressure surge during testing at 3825 psi, after which it leaked. Due to the leak and capacity limitations of the test pump, it could only be pressurized to 2750 psi, at which point the leak rate was 3.7 gpm. The relatively low volume of leakage flow (3.7gpm) established that the tube did not burst, and, therefore, would not have burst during a design basis event.

Based on these assessments, the operability evaluation concluded that the 2A OTSG was operable during the past cycle (cycle 16).

After this in-situ testing, the five mis-aligned tubes were plugged to remove them from service.

Additionally, a special "freepath" test program was devised which inspected for additional mis-positioned or mis-aligned tubes in Unit 2. The inspection inserted an ECT probe into a tube and verified that it exited at the expected location. Due to available clearances, it is impossible for two adjacent tubes to "swap" positions. Mismatched tube ends can occur in a minimum grouping of 3, of which at least one must be in a second row. Therefore, it was possible to verify all the tubes in an OTSG by inspecting every other row and tubes immediately adjacent to any discovered mis-positioned tube.

Prior to the next refueling outage, Duke Power will evaluate the necessity for similar inspections on Units 1 and 3. Since the tube stress analysis by Framatome indicates that the stress on mis-positioned tubes is not an operability issue, additional administrative controls to assure proper tube identification during inspections and repairs may be an adequate alternative.

CONCLUSION

The root cause of this event is Manufacturing Deficiency. Five tubes were discovered to be mis-positioned. Because these tubes were mis-positioned, normal processes for controlling the plugging of degraded tubes were ineffective, and Oconee Unit 2 operated during the past fuel cycle with two tube defects which potentially exceeded Technical Specification limits. A review by Framatome Technologies was unable to identify any record of this defect during fabrication of the 2A Once Through Steam Generator (OTSG). Therefore, no lower level root cause can be determined.

During Unit 3 EOC1 refueling outage, in the mid-1970's, a manufacturing defect was discovered on the Unit 3A OTSG. Approximately 70 tubes were omitted from the 3A OTSG, and the corresponding upper and lower tube sheet holes were welded shut. When notified by Duke Power, Babcock and Wilcox (B&W) determined that one of the tube sheets had been drilled using a superseded version of a paper tape program for their automated drilling machine. As a result, the affected tubes could not be aligned and inserted properly and were, therefore, omitted. Although that problem was documented in internal B&W records, the drawings and manuals provided by B&W to Duke Power had not been revised to document the omitted tubes.

No other manufacturing deficiencies in B&W OTSGs are known.

Due to the fact that this was a deficiency from original fabrication, which occurred prior to initial Unit 2 startup in 1973, no corrective actions from previous events would have prevented this event. Therefore, it is considered non-recurring.

There were no radioactive releases, personnel injuries, or equipment failures associated with this event.

CORRECTIVE ACTION:

Immediate:

1. Performed tube position verification of affected and surrounding tubes to confirm apparent mismatch of tubes.

2. Informed Framatome Technologies Inc. (Lynchburg, VA) of the finding. Requested that fabrication documents be searched for any relevant information on details of the steam generator fabrication process and any records of tubes being inserted in the incorrect tube sheet holes.

3. The Babcock and Wilcox Owners' Group Steam Generator Committee chairman was notified to share this finding with utility committee representatives (Arkansas Nuclear One, Davis-Besse, Three Mile Island, and Crystal River).

Subsequent:

1. Current operability evaluations for Units 1 and 3 and a past operability for Unit 2 were performed.

2. A Nuclear Network message was issued on April 15.

3. All five mis-positioned tubes were plugged at both ends to remove them from service.

4. Tube position verification by "Freepath" inspection of Unit 2 Once Through Steam Generators (OTSGs) was performed to assure no other mis-positioned tubes exist.

Planned:

1. Tube position verification will be performed on Units 1 and 3 OTSGs during upcoming refueling outages. Prior to the next refueling outage, Duke Power will evaluate the options for one-time position verification inspections of all tubes on Units 1 and 3. If one-time inspections are not performed, additional administrative/procedural controls will be in place to assure proper tube identification during inspections and repairs.

Planned corrective action 1 is considered to be a NRC Commitment Item. This is the only NRC Commitment item contained in this LER.

SAFETY ANALYSIS:

This event involved operation of Unit 2 for fuel cycle 16 (from May 7, 1996 until March 15, 1998) with 2 Once Through Steam Generator (OTSG) tubes in service with Eddy Current Testing (ECT) indications potentially exceeding the Technical Specification (TS) repair limit.

If one or both of the tubes had degraded to the point of significant Reactor Coolant System (RCS) leakage, the leakage would have been detected and the unit would have been shutdown if the leakage approached the TS limit of 150 Gallons per day. A minor leak (approximately 2 to 4 gallons per day) was observed during this operating cycle, but bubble testing during the outage identified a leaking tube unrelated to this event.

The worst case safety concern would be that, due to continued operation with indicated flaws potentially in excess of the TS repair limit, additional degradation might occur such that one or both tubes might rupture during a design basis event. However, since one end on each of the two tubes was plugged, the result would still be equivalent to one double ended rupture. The Oconee Updated Final Safety Analysis Report (UFSAR), Chapter 15 accident analysis specifically addresses rupture of one tube. In addition, the main steam line break analysis in the UFSAR discusses the beyond design basis event of multiple tube failures.

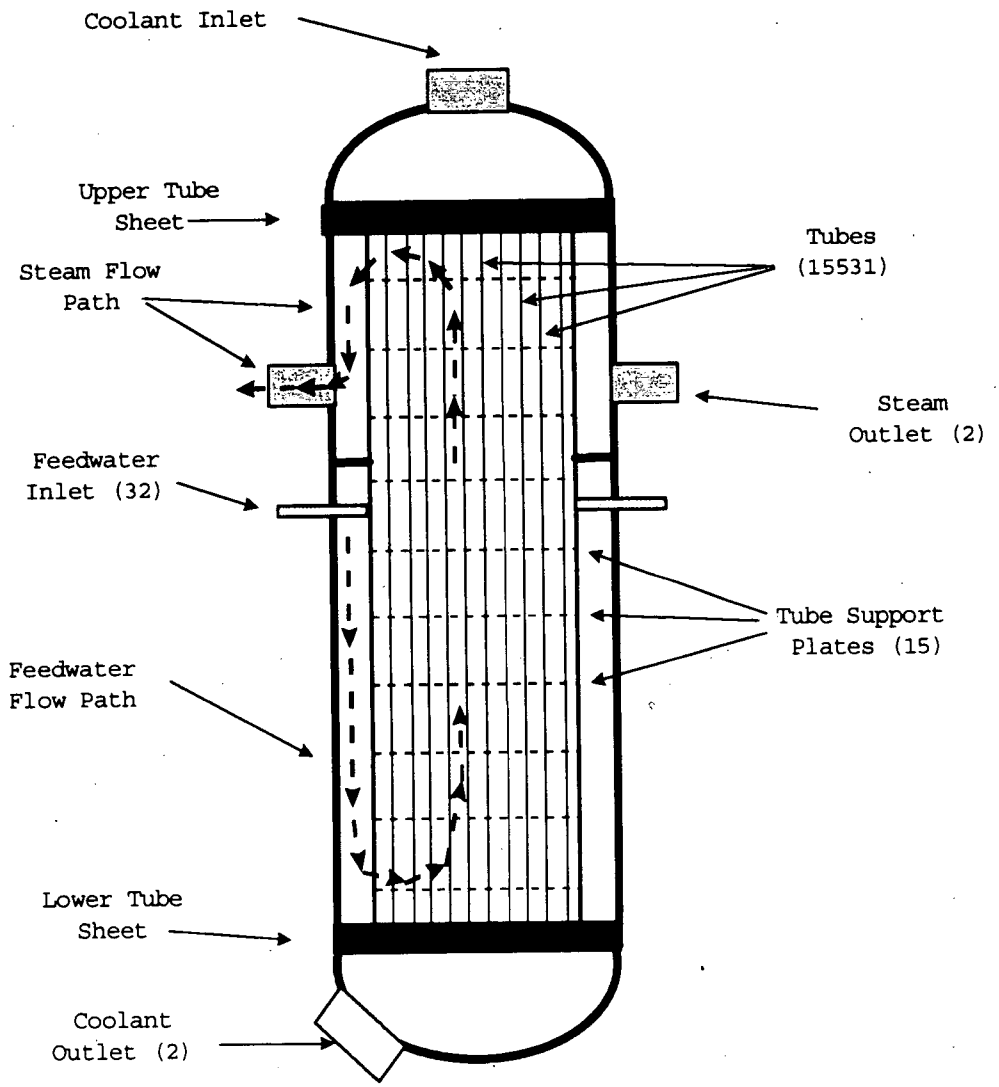
Furthermore, Duke Power performed an operability evaluation, supported by in-situ pressure testing of the affected tubes and input from Framatome Technologies, Inc., which demonstrated that these tubes would not have ruptured during a design basis event. It also addressed the possibility of ejection of the tube plugs and concluded that ejection would not occur.

In summary, even though Unit 2 operated with two tubes with ECT indications potentially exceeding the TS repair limit, testing and analysis indicate that no failures of these tubes would be expected, even in a design basis event. Even if a failure did occur, the result would still be bounded by analyses in the UFSAR. Therefore, there were no safety consequences resulting from this event and the health and safety of the public was not affected.

Attachment A

Oconee Unit 2A OTSG

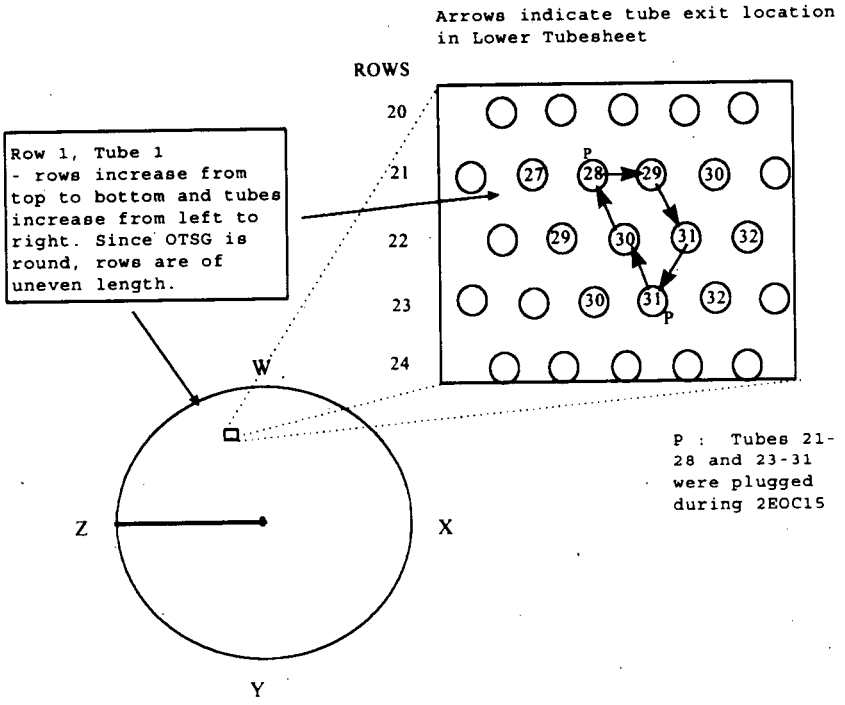
Vertical Cross Section



Attachment B

Oconee Unit 2A OTSG

Upper Tube Sheet View



Axis = W, X, Y, Z