NRC FORM 195 (2-76)

U.S. NUCLEAR REGULATORY COMMISSION

DOCKET NUMBER 50-269/270/287

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TO:	FROM:	DATE OF DOCUMENT
Mr. A. Schwencer	Duke Power Company Charlotte, North Carolina William O. Parker, Jr.	5/11/77
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DESCRIPTION	ENCLOSURE
Ltr. trans the following:	Consists of requested additional information to allow assessment of the Oconee steam generator tube leak occurrences.....
(1-P)	(8-P)

PLANT NAME:

Oconee Units 1-2-3

RJL

FOR ACTION/INFORMATION

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NRC FORM 195 (2-76)

DUKE POWER COMPANY
POWER BUILDING
422 SOUTH CHURCH STREET, CHARLOTTE, N. C. 28242

WILLIAM O. PARKER, JR.
VICE PRESIDENT
STEAM PRODUCTION

TELEPHONE: AREA 704
373-4083

May 11, 1977

Director
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Attention: Mr. A. Schwencer, Chief
Operating Reactors Branch #1

Re: Oconee Nuclear Station
Docket Nos. 50-269, -270, -287

Dear Sir:

Your letter of April 5, 1977 stated that certain additional information was necessary to allow your assessment of the Oconee steam generator tube leak occurrences. This information is attached per your request.

Very truly yours,

William O. Parker, Jr.

MST:vr

Attachment

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION
RELATED TO OCONEE STEAM GENERATORS

QUESTION 1

It was stated during the meeting on February 15, 1977, that defective and plugged tubes were stabilized down to the top support plate if the defect was found near the top tube sheet. Assess the consequence of possible failures of these defective tubes at lower or un-stabilized sections.

RESPONSE:

The tube stabilization procedure prevents the possibility of primary to secondary system leakage. A stabilized tube is plugged at the lower tube sheet using conventional techniques. The stabilizer end fitting is welded into place and serves as the tube plug at the upper tube sheet elevation. This plugging process isolates the generator tube from primary system flow. Consequently, a postulated failure of a stabilized tube would not result in a primary to secondary system leak.

The tube stabilizer being approximately 109 inches long, extends through the 14th support plate by 2 to 3 inches. Secondary side flow below the 14th support is characterized as having no cross flow components. (In fact, even that region between the 15th and 14th support plates experiences little, if any, cross flow). As a result, that portion of the generator tube which has not been stabilized should not experience any significant excitation. Therefore, the failure of a tube below the stabilizer is unlikely.

QUESTION 2

Provide a re-evaluation of past ECT records to show whether or not there were tube defects that might have led to initiation of tube cracking.

RESPONSE:

Eddy-current data taken during both normal inservice inspection and tube leak outages have been reviewed and evaluated by B&W. It has been our experience that although the Eddy-Current technique is very useful for identifying tube abnormalities during rapid scanning, it will not totally characterize a flaw with respect to its type, shape, orientation or potential for failure. With specific regard to the possibility of identifying impending failures at Oconee, our experience to date would indicate that no direct correlation between eddy-current indication and tube failures exists at this time. Because of this limitation, and our own needs for information of this nature, a decision was made to obtain a generator tube sample which would provide greater insights into this matter.

Due to the history of the recent tube failures at the Oconee Site, B&W's efforts have been initially concentrated in the "open tube lane" area of the generator at an elevation which is between the 15th support plate and the upper tube sheet. It is in this area that results from eddy-current examinations indicate tube-to-tubesheet and tube-to-tube-support plate responses which differ from those generally observed in the tube bundle. Because of this distinction and the incidence of "lane tube" failures, tube 77/25 from the Oconee 1-B generator was removed for detailed laboratory examination to ascertain the true significance of the eddy-current indications.

The results of this examination have not yet been finalized. Detailed investigations and evaluations are currently underway to clarify any anomalies and to determine if they could possible relate to the tube failure problems being encountered. Some lab simulation and comparison work has been completed. On this basis, it appears that the upper tube sheet signal being detected is caused by a slight groove or indentation, (≈ 1.0 mil.). in the tube at the O.D. surface.

QUESTION 3

Due to failure in all the affected units at nearly the same point in time, indicate any change in operating procedures or other possible incidents that might have led to tube failures in Oconee steam generators.

RESPONSE:

Reviews of current operational practices have been conducted to determine if they could possibly be causing or contributing to recent OTSG tube failures. No definite correlations have been noted. However, one item has been identified as possibly being related to tube failures, the increased frequency of testing turbine stop and control valves. Prior to July, 1975, the turbine stop and control valves were tested monthly. Since that time, these components have been tested daily and weekly respectively in accordance with the vendor recommendation. Recent tests have confirmed that the cycling of these components induces pressure transients in the steam generators.

Further tests and analyses of the possibility of this being the cause of tubing failures are in progress. Presently, the frequency of testing of turbine stop and control valves have been reduced to monthly, and is being performed at reduced power, in conformance with Oconee technical specification until the evaluation is completed.

QUESTION 4

Indicate any plan to perform ECT examinations of periphery tubes.

RESPONSE:

For the six generators at the Oconee site, two leaking tubes (tubes 114/109 and 32/13 of Unit 1B) have been experienced which were not on the "open lane". Both of these tubes are within 6 tubes of the periphery of the tube bundle. Each has been "stabilized".

Other significant experience with tubes in the "peripheral region" (within approximately 10 tubes of the periphery) would be the plugging or stabilization of tubes 113/110, 33/14, 2/7, 2/8, and 101/4 which were non-leakers but which had significant eddy-current indications.

Normal inservice inspection has been performed on all generators at Oconee. Specifically, two ISI's on Oconee Unit 1 and one each of Units 2 and 3 have been conducted. This constitutes the inspection of approximately 3,600 tubes. Of these, roughly 1000 should have been within the "peripheral region" of the tube bundle.

In the course of investigating the leak of tube 31/13, eddy-current analysis of approximately 100 additional tubes in the "peripheral region" were conducted. Further investigation of the peripheral area will be conducted as considered appropriate.

QUESTION 5

Provide analytical calculations and/or tests to justify that the crack length, in the circumferential directions, associated with the proposed leakage rate will not increase in an unstable fashion under normal operating and accident conditions.

RESPONSE:

All of the defects which have been visually observed at the Oconee site have been circumferential cracks of varying length. One of these failed tubes, tube 77/23 of generator 2B, was removed for detailed examination. Evidence obtained from the fracture surface of this tube indicates that from an initiation site of unknown origin the crack propogated as a thru-wall defect due to the application of a high cycle fatigue loading. It was deduced that approximately 1×10^5 to 3×10^5 cycles were required for the crack to travel its total observed length of roughly 240°. The only known source of loading which would involve this number of cycles is flow induced virbration. This would occur with most prominence in the fundamental mode of the tube, or at a frequency of about 40 Hz. From this information, it is apparent that an initial defect would propogate to a detectable leak in approximately 1 to 2 hours.

Since the propogating mechanism is flow induced vibration, the defect is not "stable". It will rapidly progress around the curcumference of the tube as long as there is flow of sufficient energy to drive it. However, the crack formed will produce an identifiable leak and the unit will be shut down promptly. Therefore, the probability of the occurence of a major accident during the time between leak and shutdown is low.

QUESTION 6

During the recent meeting with the NRC staff, it was indicated that there is 0.4% sulphur content in the sediment deposits. Provide an assessment on the effect of the high sulphur content to the tubes in terms of possible chemical reactions.

RESPONSE:

As part of the overall examination plan being conducted, chemical analysis was performed on deposit samples removed from the tube surfaces. The results of these analyses revealed the deposit to be primarily iron oxide as magnetite. Other elements were present only as minor constituents of the deposits with no deleterious amounts of contaminants noted. The analyses revealed sulfur levels in the deposits typically to be below the 0.2% detection limit with one value reported to be 0.4%. These sulfur contents in the CRUD are lower that typical sulfur levels measured in as-fabricated vessels. The sulfur levels in as-fabricated units have been shown to be acceptable over a wide range of operating conditions. Thus, the levels of sulfur found in the tube deposits are not considered consequential in terms of tube corrosion.

A review of the operating environment further alleviates concerns for the low sulfur levels present in the deposit. Operating experience has indicated sulfur to be a problem with Alloy 600 tubing at low temperatures, primarily under improper wet layup conditions in steam generators. At these lower temperatures sulfur can be present in the reduced species which can produce intergranular attack of Alloy 600 under certain conditions. Proper wet layup chemistry control, as specified for the Oconee steam generators, provides sufficient control to avoid this potential corrosion problem. Additionally, there has been no evidence of sulfur induced corrosion of Alloy 600 steam generator tubes at operating temperatures. Such corrosion is not expected with the alkaline pH levels maintained in the feedwater and the imporbability of reduced sulfur species being present at operating temperatures.

Based on the above, the sulfur levels seen in the tube deposits are not of concern because of the low levels present and once through steam generator operating conditions.

QUESTION 7

Provide the micro-hardness test results of both virgin and cracked tubes to determine any evidence of plastic cyclic straining that may initiate the cracks.

RESPONSE:

B&W has performed a significant amount of micro-hardness testing of virgin Alloy 600 tubing as part of their original OTSG materials evaluation program. There is an inherently large amount of scatter in micro-hardness testing because of the localized nature of the test. Results, therefore, are best evaluated in terms of average results. In all, 27 different tubes were evaluated in these tests. The tubes tested were taken from production tubes and are representative of those used in the Oconee once-through steam generators. Results on the virgin tubes reveal knoop hardness values ranging from 165 to 222.

Micro-hardness tests were recently performed on the two tube samples, tubes 77/23 and 77/27 which were removed from Oconee 2B generator for detailed examination. On tube 77/23, the tests were run on a specimen approximately 1/2 inch up from the fracture surface. On tube 77/27, the tests were run on a specimen which would be located approximately 8 inches down from the tube to tube sheet interface. Sets of measurements on a transverse section of the specimen were taken as a radial function of position at 5 mils from the inside surface, at the center of the tube wall and at 5 mils from the outside surface. Five azimuthal locations were selected; 0°, 60°, 120°, 180° and one randomly selected angle. Also, an additional set of measurements were taken across the tube wall of a longitudinal section of the specimen. The results of this investigation are provided in Table I. As can be seen, the hardness does not vary appreciably between tubes 77/27 and 77/23 at the locations tested.

It should be noted that the results tabulated in Table I are fickers hardness numbers. Although it may not be technically correct to compare knoop and fickers hardness data directly, the method utilized in each of these procedures is sufficiently close to justify a comparison for our purposes at this time. The results show that the data taken from virgin specimens compares well with that taken from tubes 77/23 and 77/27.

B&W is currently planning to perform additional micro-hardness tests on other pieces of the Oconee generator tube samples. This more extensive test program will provide data which is directly comparable and should be vital in establishing wheter or not any local plastic cycling has occurred.

QUESTION 8

Provide accident consequence analyses assuming:

a. A certain number of tube failures, that can be tolerated, concurrent with a LOCA.

b. The equivalent number of tubes failures that can be tolerated during a MSLB in terms of off site dosage.

RESPONSE:

A study has been made of the environmental consequence of a steam line break accident followed by the rupture of a steam generator tube such that a large primary-to-secondary leak rate (640gpm) exists in the affected staam generator. The 640 gpm leak rate is at reactor operating temperature and is approximately equivalent to the Oconee FSAR leak rate of 435 gpm at the density for cold conditions. For this analysis it is assumed as in the Oconee FSAR Section 14.1.2.9, that the reactor coolant leakage continues unabated for three hours before the reactor coolant system can be cooled down and the leakage terminated. In evaluating the environmental consequences, the Oconee FSAR Section 2.3 meterology was used, that is for a ground level release from 0 to 2 hours, the atmospheric dispersion factor (X/Q) at the exclusion area boundary is 1.16×10^{-4} sec/m^3. The reactor coolant system iodine inventory is based on 1.0% defective fuel and the source terms from the Oconee FSAR Section 11.1. The reactor coolant iodine concentration is 4.6 μCi/cc of dose-equivalent I-131. The thyroid dose at the exclusion area boundary was calculated as follows:

The steam generator tube rupture causes all of the iodine activity in the entire reactor coolant to be released through the steam line break directly to the atmosphere. It was assumed that there was no further release of iodine from the fuel into the reactor coolant as a result of the steam line break transient. It was also conservatively assumed that the entire iodine release occured over a two-hour time period. The resulting thyroid dose at the exclusion area boundary is 91 rem. Therefore, the entire reactor coolant volume with an iodine inventory corresponding to 1.0% defective fuel can be released directly to the atmosphere via ruptures in one or more steam generator tubes following a steam line break since the resulting thyroid dose is well below the 10CFR100 guideline of 300 rem.

B&W has no approval procedures and methods for calculating the consequences of a LOCA with a steam generator tube rupture. Conservative hand calculations have been performed which estimate that offset failure of three steam generator tubes would result in minimal impact on peak cladding temperature calculations. The effect of three tube failures on peak containment pressure would be insignificant.

In the LOCA analysis performed to show compliance of the ECC systems to 10CFR50.46 for the Oconee plants, no credit was taken for steam flow through the loops during the reflooding phase of the transient. It has been postulated that a loop seal may occur in the pump suction piping that will prevent loop venting. However, calculation performed with the CRAFT code show that no loop seal is present at the end of blowdown. If loop venting was used in the reflooding analysis, flooding rates would increase 70% over the valves used to demonstrate compliance to 10CFR50.46. Therefore, if a realistic calculation of the reflooding phase was performed for the Oconee plants, offset rupture of 20 or more tubes could probably be tolerated without affecting the present Oconee LOCA limits.

QUESTION 9

Provide analytical and/or test data to assure tube integrity by demonstrating the capability of degraded tubes (circumferentially partial cracked tubes) to withstand accident induced loads. NRC's positions on this matter were delineated in Regulatory Guide 1.121 which was published for comment in August 1976.

RESPONSE:

As has been previously established, refer to Item 5, a small defect induced in the tube rapidly propagates by flow induced vibration to a crack with a detectable leakage rate. This "fast break" phenomenon and resultant plant shutdown procedure constitutes sufficient assurances that the chances of a "degraded" tube being subjected to accident loading conditions is low.

Small defects which are in the process of forming but which has not yet propogated to a detectable leak do not substantially affect the gross structural integrity of the tube. Consequently, loads induced during an accident condition should not cause a tube which is in this particular state to fail.

QUESTION 10

Indicate B&W's on-going and planned future programs associated with tube failute, i.e., tests on mechanical strengths and fatigue strengths of degraded tubes.

RESPONSE:

On February 15, 1977, a meeting was held in Bethesda, Md. between representatives of the NRC, Duke Power and B&W. At that time, the status of the tube leak problem at Oconee Units 1, 2 and 3 was discussed at length. Involved in that discussion was a presentation which related B&W's current and on-going programs associated with the resolution of the tube failutes. Results presently at hand were provided for the detailed visual, chemical and metallographic investigations being conducted as part of B&W's total investigative study.

With regard to future plans, Duke Power and B&W identified that at the first available opportunity, another generator tube would be removed for detailed examination. This operation has been completed and our investigations are currently underway. Specific areas such as mechanical and fatigue strength tests on actual tube samples are being contemplated. As sample data and design information currently exists in the literature with respect to these properties, this type of test information is not viewed as being imperative at this time. However, these tests would provide confirmatory type data which could then be used as verification for the present "design" information.

TABLE 1

MICROHARDNESS RESULTS

Specimen #	Orient	Test Location	DPH 0°	DPH 60°	DPH 120°	DPH 180°	DPH Random
27M-1	Trans.	ID	200	229,214	201	122	232
"	"	Center	166,162,178	167	178,170	203	174
"	"	OD	184	168,188	211	170	172
27M-1	Long.	ID					175
"	"	Center					160
"	"	OD					170
23T-3	Trans.	ID	188	188	190	191	194
"	"	Center	212,186	202	169,184,184	191	182
"	"	OD	191	194	214	191	183
23T-3	Long.	ID					197
"	"	Center					169
"	"	OD					183