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SUBJECT: LER 80-011/01T-0: on 800625, during preparation of manway studs for reuse on 3A once-through steam generator, nine studs found cracked. Cause unknown, although evidence indicates crack propagation is assisted by SCC.

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NOTES: M Cunningham: all amends to FSAR & changes to Tech Specs.

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DUKE POWER COMPANY  
OCONEE UNIT 3

Report Number: R0-287/80-11

Report Date: July 16, 1980

Occurrence Date: June 25, 1980

Facility: Oconee Unit 3, Seneca, South Carolina

Identification of Occurrence: Cracked Studs on OTSG Primary Manway

Conditions Prior to Occurrence: Cold Shutdown

Description of Occurrence:

During the preparation of the studs for reuse on the 3A Once-Through-Steam Generator (OTSG), a stud from the lower primary manway was visually found to be cracked. Further investigation of all 64 primary manway studs (16 studs on each of four manways) on both 3A and 3B OTSG's, using both visual and ultrasonic inspection techniques, revealed a total of eight additional cracked studs. One of these was found on the 3B upper primary manway, while all of the remaining cracked studs were found to be on the 3A lower primary manway.

Apparent Cause of Occurrence:

The exact cause of the stud cracking has not been conclusively defined. Eight of the cracked studs and two used studs from Unit 3 that indicated no cracks were sent to Babcock & Wilcox's Lynchburg Research Center (LRC) for metallurgical examination. The two-inch diameter primary manway studs are made of a high strength, low alloy bolting material, SA-320 GR-L43 (AISI-4340). A number of possible causes have been suggested, ranging from low cycle fatigue to stress corrosion cracking (SCC). However, the most likely cause has not been established yet and B&W is continuing its examination.

Based on the results of the examination to date, the following conclusions have been reached:

1. Evidence exists to show that crack propagation in two cracked studs destructively examined at the LRC was assisted by SCC. The principal cause of the crack initiation has yet to be determined. Item 1 under "Corrective Actions" addresses the continuing examination of the Oconee studs.
2. Investigation to date has not revealed any evidence that the stud cracking is an apparent materials problem. Review of the heat lot numbers for the studs has indicated that the cracked studs were not limited to a single heat lot number. All of the cracked studs came from two heat lot numbers, both of which were supplied as part of the original equipment. Item 2 under "Corrective Actions" addresses the continuing of investigation in this area.

3. The sensitivity of the high-gain ultrasonic (UT) examination technique applied at Oconee 3 (ASME Section V examination) has been determined at the LRC. The results of this testing indicate that a minimum crack depth of 0.100 inch could be detected. Item 3.a under "Corrective Actions" addresses the proposed use of a more sensitive UT technique.
4. Based on calculations, the brittle fracture critical flaw size (0.126 inch deep) can be detected by standard and high-gain UT methods. Calculations show that a SCC critical flaw size (0.027 inch deep) might not be detected by the UT methods. However, a code safety factor of 2.25 on critical flaw size is included in the calculations. Exclusion of this factor of safety results in a flaw size that approaches the detectability of the most sensitive UT method investigated by the LRC. Item 3.a under "Corrective Actions" addresses the proposed use of a more sensitive UT technique which is expected to detect crack sizes of approximately the critical flaw size for SCC even when including the safety factor.
5. Investigation of Duke Power Company's manway installation procedures as a possible contributor to the stud cracking has been inconclusive. Records indicate that the lower primary manway on the 3A OTSG has only been opened three times. In each instance, retorquing followed after the first heatup and cooldown of the system. All procedures reviewed were found to be in general agreement with the steam generator instruction manual supplied by B&W. However, details of the manner in which these procedures are performed and the resulting contributions, if any, to the stud cracking concern have not been determined. Items 4 and 5 of "Corrective Actions" address proposed actions to minimize the possibility of contributing to stud cracking during the performance of manway installation and removal procedures.

#### Analysis of Occurrence:

The cracking of the primary manway studs on the OTSG's is considered by Duke Power Company to be a potential degradation of the reactor coolant pressure boundary and is therefore reportable pursuant to Technical Specification 6.6.2.1.a(3).

In the event that a stud fails during plant operation, leakage of the reactor coolant from the associated manway could occur. Such leakage could be detected by standard RCS leakage detection methods before the conditions deteriorated into a transient state. Failure of a larger number of manway studs may increase the amount of leakage and would therefore be detected earlier. B&W has performed an engineering calculation which indicates that at least partial primary manway closure would be maintained with the complete failure of up to five adjacent primary manway studs. This calculation assumes that the remaining manway cover studs are not cracked. However, the simultaneous failure of five adjacent studs on the same primary manway is considered to be highly unlikely. Furthermore, considering that the studs are visually inspected during every refueling outage, the probability of a large number of failed studs occurring during plant operation is considered to be very small. Item 6 under "Corrective Actions" addresses an evaluation being performed to better quantify the leakage resulting from failed studs.

Potential consequences have been evaluated which are related to the resulting loads on the steam generator supports and restraints during depressurization. The reaction load on the steam generator supports and restraints are bounded by analysis reported in the Oconee Nuclear Station Final Safety Analysis Report. A guillotine break would result in more severe support loadings than depressurization through a manway opening.

Based on the analysis of this occurrence, Duke Power Company considers that continued operation of the plant will present no significant hazard to the health and safety of the public.

Corrective Action:

Before Unit 3 returned to service, all of its OTSG primary manway studs were replaced with new studs that had been ultrasonic and magnetic particle tested. The primary manway studs on the Unit 1 OTSG's were also ultrasonic tested in early July and found to have no cracks. Similar testing will be performed on Unit 2 during the next available outage.

Other corrective actions are being pursued and evaluated to reduce the probability of stud failure during plant operation:

1. Further metallurgical examination of the Unit 3 cracked studs is being pursued to verify material properties and to further investigate the cause of the crack initiation.
2. Stud material documentation for Oconee Units 1, 2, and 3 will continue to be researched to explore the possibility of anomalies in the stud materials.
3. The following changes to the techniques presently used for stud inspection are being reviewed and evaluated. Inclusion of these changes in future refueling inspection programs, as well as any other revision suggested by the results of the other investigations, will be determined after a thorough evaluation of each revision has been completed.
  - (a) An ultrasonic technique for inservice examination of bolts and studs has been preliminarily evaluated. This technique is significantly more sensitive than the ASME Section V examination. It appears to have the capability of detecting stress corrosion cracks of the critical size ( $\sqrt{0.030}$ ).

The technique, which involves calibration on the bolt or stud threads, has been used for locating service failures at other locations. A program is underway to completely qualify the technique inhouse.

- (b) The swap out of entire sets of studs during inspections is being evaluated as a means to allow additional testing of the studs before reinstallation.
  - (c) The performance of elongation tests on the studs before reuse is being evaluated.

4. The Oconee Nuclear Station procedures and the B&W instruction manuals regarding manway installation and removal are being reviewed to determine possible additions and improvements in the instructions detailing torquing techniques as well as the inspection and treatment of studs. Further review will evaluate the possible use of stud tensioning instead of torquing.
5. Information concerning the manner in which installation and removal procedures were performed on Unit 3 will continue to be gathered and reviewed to establish the effects, if any, on stud cracking.
6. An evaluation is being performed to estimate the primary leakage associated with the deflection of the primary manway cover resulting from the failure of five adjacent studs. This will provide useful information in defining the detectability of such leakage as well as the time required for such a condition to be identified.
7. Stud lubricants are being assessed to determine if an improved lubricant exists that does not dry out during system operation and that has better corrosion inhibitors.

Babcock and Wilcox is assisting Duke Power Company in the investigative efforts and evaluations discussed above to determine the generic implications, if any, of this occurrence.

**LICENSEE EVENT REPORT**

**EXHIBIT A**

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