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SUBJECT: Submits results of analysis in response to Action Item 3 of NRC Bulletin 88-008.

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DUKE POWER

December 29, 1989

U.S. Nuclear Regulatory Commission
Document Control Desk
Washington, DC 20555

Subject: Oconee Nuclear Station, Units 1, 2, and 3
Docket Nos. 50-269, -270, -287
Thermal Stresses in Piping Connected to Reactor
Cooling System (NRC Bulletin 88-08)

Gentlemen:

The purpose of this letter is to submit the results of our analysis in response to Action Item 3 of the NRC Bulletin 88-08 concerning thermal stresses in piping connected to reactor cooling system. The information provided in Attachment to this letter completes my response to all actions required by the bulletin.

My letters of October 6, 1988, March 10, 1989, July 7, 1989 and December 15, 1989 provided responses to Action Items 1 and 2 and a preliminary bounding analysis in response to Action Item 3 for all Oconee Units. The results of the preliminary bounding analysis submitted in my letter of March 10, 1989 provided assurance of near term piping integrity until the completion of our detailed analysis by December of 1989. The results of our final analysis (Attached) of the identified piping susceptible to the kind of thermal stresses described in NRC Bulletin 88-08 confirm the structural integrity of the piping for the 40 years licensed life of Oconee Units 1, 2 and 3.

I declare under penalty of perjury that the statements set forth therein are true and correct to the best of my knowledge.

Very Truly Yours,

Hal B. Tucker

Hal B. Tucker

MAH/kbc

cc: Mr. P. H. Skinner
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ATTACHMENT

Duke Power Company

Oconee Nuclear Station

Response to NRC Bulletin 88-08 Dated June 22, 1988

Duke Power Company

Oconee Nuclear Station

Response to NRCB 88-08 Dated June 22, 1988

1.0 INTRODUCTION

This report summarizes the activities and findings of Duke Power in response to NRC Bulletin 88-08 for the Oconee Nuclear Station, Units 1, 2 and 3. Bulletin 88-08, Thermal Stresses in Piping Connected to the Reactor Coolant System, issued on June 22, 1988 identified a potential generic problem associated with an incident at Farley Nuclear Plant. The incident which was first reported in NRC Information Notice 88-01 involved a through wall pipe crack in a six inch diameter Emergency Core Cooling System line. The crack was attributed to high cycle thermal fatigue resulting from valve leakage. The bulletin identified certain actions and reporting requirements for the licensees. Subsequent Supplements 1, 2 and 3 to NRC Bulletin 88-08 provided additional information. Supplement 1, dated June 24, 1988, reported a pipe crack in a similar six inch diameter line of the Tihange Unit 2 reactor in Belgium. Supplement 2, dated August 4, 1988, emphasized the need for enhanced ultrasonic testing (UT) and for experienced examination personnel to detect cracks in stainless steel piping. Supplement 3, dated April 11, 1989, provided information on a through wall pipe crack in the eight inch diameter residual heat removal line of a foreign reactor. Supplement 3 also emphasized the need for sufficient review of the RCS to identify any connected, unisolable piping that could be subjected to thermal stratification; and, again emphasized the importance of taking action, where such piping is identified, to ensure that the piping will not be subjected to unacceptable thermal stresses. Supplements 1, 2 and 3 imposed no new requirements and the actions requested in NRC Bulletin 88-08 remained unchanged.

2.0 Bulletin 88-08 Required Actions

The following paragraphs provide a discussion of specific Action Items requested by NRC Bulletin 88-08 and Duke's response to each specific item.

2.1 Action Item 1

Action Item 1 requested that licensees review the systems connected to the RCS to determine whether unisolable sections of piping connected to the RCS can be subjected to unanalyzed and unacceptable thermal stresses resulting from valve leakage.

The completed review for the Oconee Nuclear Station identified portions of the emergency injection lines of the High Pressure Injection (HPI) system as the only unisolable piping potentially susceptible to unacceptable thermal stresses resulting from the type of event described in NRC Bulletin 88-08. A detailed description of this review was provided in Duke's response to this item, dated October 6, 1988.

2.2 Action Item 2

Action Item 2 requested that licensees inspect any unisolable sections of piping connected to the RCS that may have been subjected to excessive thermal stresses to provide assurance that there are no existing flaws.

Duke's review of portions of the HPI lines for all three Oconee units identified certain piping welds for an augmented inspection. These welds, which are the only geometric discontinuities, and their heat-affected zones were determined to be the critical locations for the type of event described in Bulletin 88-08. Each identified weld on the HPI lines for all units received a full volumetric ultrasonic inspection of the weld and base material. The results of inspection of six identified piping welds for Unit 1 and eight piping welds for Unit 2 were provided in Duke's responses to this item, dated March 10, 1989 and July 7, 1989, respectively. The examination of seven identified welds for Unit 3 was completed recently, during the EOC-11 refueling outage and the results were reported in a Duke letter dated December 15, 1989. The examination of the identified welds found no reportable indications in any of the HPI lines for all three Oconee units.

2.3 Action Item 3

Action Item 3 requested that licensees plan and implement a program to provide continuing assurance that the piping identified in Action Item 1 is not subjected to combined cyclic and static thermal and other stresses that could cause fatigue failure during the remaining life of the unit.

In response, Duke defined and submitted to NRC by a letter dated March 10, 1989 a phased approach program for the Oconee units to address this item. The program included the following components:

1. A bounding analysis of the pipings which may be susceptible to thermal stresses as a result of thermal stratification. The piping of concern was identified within Duke's October 6, 1988 letter.

2. Instrumentation of both Unit 1 HPI emergency injection lines to detect stratified temperature conditions. These lines were identified as the only lines which may be susceptible to the type of events described in NRC Bulletin 88-08.

3. Collect and evaluate the data from the Unit 1 instrumented HPI pipings. The data collected will include heatup, cooldown and steady-state operation.

4. Determine and implement the most effective means of providing the long term assurance of piping integrity for all Oconee Units pursuant to Item 3 of the bulletin.

Implementation of all phases of this program are described in the following paragraphs.

2.3.1 Bounding Analysis

A bounding analysis to determine whether an event of the type described in the bulletin could possibly produce unacceptable stresses for pipings identified as being susceptible to thermal stresses has been completed. A summary of this analysis was provided in Attachment 1 to Duke's letter dated March 10, 1989. The bounding analysis did not show complete code compliance for a 40 year fatigue life. However, coupled with the results of the Unit 1 inspection the bounding analysis provided assurance of near term piping integrity for at least two additional cycles for Units 1, 2 and 3 and formed a justification for continued operation until the completion of the program by December 1, 1989 to address Item 3 of the bulletin.

2.3.2 Instrumentation

As noted in Duke's letter of March 10, 1989, two Unit 1 emergency injection lines were instrumented during the Unit 1 EOC-11 refueling outage. These lines which were identified as susceptible to thermal stresses were initially instrumented with six thermocouples 3 inches downstream of valves HP-152 and HP-153. Three thermocouples were positioned at each location in a vertical plane around the outside of the pipe. Nine additional thermocouples were added in early March, 1989 during an unscheduled Unit 1 mini-outage. These additional thermocouples were installed upstream of valves HP-152 and HP-153.

2.3.3 Data Collection and Analysis

Collection of temperature data began during the Unit 1 heatup following the EOC-11 refueling outage as well as through the cooldown during an unscheduled shutdown in early March 1989 and continued periodically during the normal operation. Therefore, the collected data provide representation for heatup, cooldown and normal modes of operation.

A calculation was completed to review the temperature data collected and to reduce the temperature data into a representative thermal load on the piping. The temperature data was first reduced as shown in Figure 1. Unit 1 was then compared to Units 2 and 3, comparing HPI system design, system operation, piping layout and valves. The calculation concluded that Unit 1 was similar in all respects to Units 2 and 3. The observed temperatures were conservatively modified into the thermal piping load shown in Figure 1.

The HPI piping for all three units was then reanalyzed for the calculated thermal load. Using the assumptions in Figure 1 and the methodology of ASME Section III, Paragraph NB-3653, 1986 Edition with 1987 Addenda, the usage fatigue factor was then calculated. The maximum cumulative usage factor calculated for all of the Oconee HPI piping components was 0.81. Considering the conservatism of the assumptions used in the analysis, as indicated in Figure 1, the results adequately confirm the structural integrity of the HPI lines for the 40 years life of the plant. Also, the HPI line pipe supports have received a preliminary review for the effects of the calculated thermal load. The review indicated that all of the HPI pipe supports were acceptable for the increased thermal loads and displacements.

2.3.4 Continuing Assurance of Piping Integrity

The HPI piping reanalyses described above provide assurance of long term integrity. However, as an additional precautionary measure and to further assure long term integrity of these lines, ten welds per unit on the HPI lines have been identified for future In-Service-Inspections. The welds are to be inspected once per inspection period (i.e., three inspections per ten year interval) using the same enhanced UT Technique used for inspections required by Bulletin 88-08.

2.4 NRC Bulletin 88-08, Supplement 3

A separate review was performed in regards to Supplement 3 of Bulletin 88-08, although no specific required actions are identified in this supplement. Supplement 3 concerns piping thermal stratification that occurred because of intermittent valve leakage across the seat of a limit set gate valve through the packing gland leak-off line. Valves set to close on a limit control switch position setting may not achieve full wedging contact on both sides of the gate valve disc with the valve seat. Differential pressure will hold the disc against the downstream seat and leave a gap with the upstream seat. When the packing leak occurred, thermal expansion caused the disc to expand and seal off the gap and stop flow. Cooldown reversed the process and a cyclic pattern was set up leading to a fatigue process.

Oconee sets up their valves to close on torque control rather than limit. The electric motor operator forces the valve disc into the seat until a predetermined torque thrust is obtained. This forces full wedging contact with both sides of the valve seat. The only gate valve not set in this manner is the block valve (RC-4) for the Power Operated Relief Valve. This valve is on a vertical line off the top of the pressurizer steam space and is continuously bathed in the Pressurizer steam. It would not be subject to thermal stratification. In addition, the packing gland leak-off taps are plugged at Oconee. Thus, for the above reasons, Oconee units are not subject to the valve leakage thermal stratification problem identified in Supplement 3 to Bulletin 88-08.

3.0 <u>Other Related Activities</u>

All of the systems attaching to the Reactor Coolant System have been reviewed for the potential of thermal stratification. The system review which is independent of Duke's response to Bulletin 88-08 and its supplements was performed as part of a plant wide design study of thermal stratification. The system review was performed by the responsible engineer for each system with attention given to experienced valve leakage problems or other maintenance problems which could lead to thermal stratification. The valve leakage potential was emphasized for check valves and control valves. Normally closed gate and ball valves with no history of leakage problems were not considered as having significant leakage. The systems review conducted for the Oconee thermal stratification design study identified three areas for further analysis. Two of the three are connected to the RCS and include a portion of the Low Pressure Injection System and the auxiliary pressurizer spray line. The stratification design study is still in progress. The systems have been reviewed, but final disposition and analysis of the systems identified is still in progress. Current design study schedule calls for completion by July 1, 1991. Additionally, during the next Unit 1 refueling outage, we intend to instrument a portion of the Unit 1 LPI system and the auxiliary pressurizer spray line to detect thermal stratification. Duke will monitor the instrumentation results through the next fuel cycle; and, evaluate and analyze the data collected in accordance with the schedule established for the design study. However, it should be noted that all the activities related to this design study including instrumentation of the Unit 1 LPI system and the auxiliary pressurizer spray line, although related to the concerns of Bulletin 88-08, are not required by the bulletin and should not be construed as new commitments.

4.0 Conclusion

The actions taken in response to Bulletin 88-08 provide the necessary continuing assurance of piping integrity for the piping that is not isolable from the Reactor Coolant System. While some unexpected temperature data was observed on the Oconee Unit 1 HPI line, analysis shows that the thermal load corresponding to the unexpected temperature data does not compromise the structural integrity of the piping for the licensed life of the plant. The focus of attention at Oconee is currently being directed away from the HPI lines toward the other lines (i.e., pressurizer spray line) identified, independently of our response to Bulletin 88-08, as areas for potential thermal stratification.

In addition to the completed actions in response to Bulletin 88-08 and the ongoing activities described in this report, Oconee is attuned to industry activities on this issue. We are paying special attention to EPRI Program RP3153 - "Thermal Stratification in Horizontal Lines" and to the B&W Owners Group and Westinghouse Owners Group findings in support of RP3153. We will continue to take whatever actions are necessary to deliver safe and reliable electric power.

Figure 1
Parametric Comparison of
Cyclic Thermal Stratification Data
"Analyzed" vs. "Observed"

Quantity	Preliminary Bounding Analysis	Actual Observed	As used in Final Fatigue Evaluation
Maximum rate of temperature change at outside surface	200°F/min	110°F/min (Note 1)	156°F/min
Maximum temperature difference from top of pipe to bottom of pipe; and, shape of gradiant	200°F stepped at the three o'clock position	120°F linear from top-to-bottom	150°F linear form top-to-bottom (Note 2)
Number of applied cycles	1 cycle / 2 minutes	1 cycle / 20 minutes	1 cycle / 10 minutes
	=143,000 cycles/yr	=14,300 cycles/yr	=28,600 cycles/yr (Note 3)

Notes:

1. This maximum value was observed only once, during the unexpected reactor shutdown on 3/1/89. The high rate of temperature change was accompanied by a total elimination of the thermal stratification. A more representative value to associate with the 20 minute period cycles would be on the order of 10°F/min. The conservative 156°F/min used in the analysis corresponds to the heat transfer coefficient calculated based on Farley data in Bulletin 88-08.

2. The 120°F maximum top-to-bottom temperature difference was observed at only one location on the piping, immediately down stream of valve 1HPI-152. At a point approximately ten feet upstream of valve 1HPI-152 (measured along the pipe and away from the RCS) the temperature decays to a point that stratification should not be significant. But for analysis purposes the maximum temperature difference of 120°F is rounded up to 150°F. This full 150°F stratification gradient is applied to the horizontal piping over the length of piping from points twenty-feet upstream of valves HP-152, 153 to the pipe-to-RCS nozzle weld points.

3. The minimum cycle time actually observed was 20 minutes. The maximum number of cycles observed in any two hour period was 5, corresponding to 24 minute cycles; and, the maximum number of cycles observed during any eight hour period was 9, corresponding to 53 minute cycles. To account for the fact that the cycle time could potentially worsen the minimum observed cycle time (20 min) was cut in half, to 10 minutes. In light of the actual observed data, assuming one cycle every 10 minutes over the life of the plant is considered conservative. One cycle every 10 minutes corresponds to 2.1×10^6 cycles over the forty year life of the plant.