Mr. W. R. McCollum, Jr.
Vice President, Oconee Site
Duke Energy Corporation
7800 Rochester Highway
Seneca, SC 29672

November 21, 2001

SUBJECT: OCONEE NUCLEAR STATION, UNIT 2 RE: SAFETY EVALUATION OF THE FLAW EVALUATION FOR DETECTED SUBSURFACE FLAW IN STEAM GENERATOR 2A TUBESHEET WELD (TAC NO. MB2394)

Dear Mr. McCollum:

By letter dated July 12, 2001, you submitted a flaw evaluation on a subsurface flaw in the vicinity of the Oconee Unit 2A steam generator tubesheet-to-shell weld, 2-SGA-WG60. The flaw had been identified on May 17, 2001, using ultrasonic examination. The flaw evaluation was based on the criteria of IWB-3612 of Section XI of the 1989 American Society of Mechanical Engineers (ASME) Code.

We have reviewed your submittal and our Safety Evaluation is enclosed. We have determined that the evaluation is in accordance with the ASME Code and that the unit could be operated with this flaw. However, if the next inspection period according to IWB-2420 falls before the replacement of this steam generator, currently scheduled for 2004, the area shall be reexamined.

Sincerely,

/RA/

Leonard N. Olshan, Project Manager, Section 1
Project Directorate II
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket No. 50-270

Enclosure: As stated

cc w/encl: See next page

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

OCONEE NUCLEAR STATION, UNIT 2

FLAW EVALUATION ON A SUBSURFACE FLAW IN THE 2A STEAM GENERATOR WELD

DUKE ENERGY CORPORATION

DOCKET NO. 50-270

1.0 INTRODUCTION

On May 17, 2001, Duke Energy Corporation (the licensee), while performing an ultrasonic (UT) examination of the Oconee Unit 2A steam generator tube sheet-to-shell weld 2-SGA-WG60, identified a subsurface flaw. The flaw did not meet the acceptance criteria of IWB-3500 of Section XI of the 1989 American Society of Mechanical Engineers (ASME) Code. In accordance with the guidance contained in Generic Letter 91-18, the licensee evaluated the flaw. Since the flaw met the acceptance criteria of IWB-3600, the licensee concluded that the steam generator was operable, and could be operated with this flaw until 2004 when the steam generator will be replaced, By letter dated July 12, 2001, the licensee submitted the flaw evaluation for Nuclear Regulatory Commission review.

2.0 LICENSEE'S EVALUATION

The licensee's UT examination characterized the subsurface flaw as having a depth of 0.5 inch and length of 5 inches in the circumferential direction. The flaw is located at 2.8 inches from the outside diameter of the upper shell of the steam generator with a shell thickness of 6.625 inches. The material of the upper shell is SA-212-B, which is equivalent to SA-516, Gr. 70. The licensee used 28.1 ksi for the yield strength and 18.7 ksi for the stress intensity S_m for this material under a conservatively assumed operating temperature of 600 °F. The RT_{NDT} of the shell material was assumed to be 60 °F, which bounds the tested ferritic materials. The licensee used this RT_{NDT} value and the lower bound fracture toughness curves from Figure A-4200-1 of Section XI of the ASME Code to determine the K_{Ia} and K_{Ic} values for the fracture mechanics analysis.

The licensee's flaw evaluation started with the initial flaw geometry of 0.5 inch in depth and 5 inches in length. Fatigue crack growth analysis was then performed separately for the normal/upset and the emergency/faulted conditions to predict the final crack geometries for these two loading cases at the end of 12 cycles of normal heatup and cooldown. In each fatigue cycle, the applied K was first calculated using Appendix A methodology of Section XI of the ASME Code. To complete the fatigue cycle, the licensee calculated the difference between the maximum and the minimum applied Ks, and used the fatigue crack growth rate from Figure A-4300-1 for a subsurface flaw in an air environment to calculate the crack growth and the new crack geometry . This process was repeated, and the crack geometry was revised until all cycles and transients had been exhausted. The licensee also calculated the ratios of K_{Ia} and K_{Ic}

to applied K values for both ends of the final crack geometry in the through-the-thickness direction for the normal/upset and emergency/faulted conditions. Residual stresses were determined to be low or negative and were not considered in the fatigue growth and the applied K calculation for the final flaw geometry. These ratios were then compared to 3.16 for the normal/upset condition and 1.41 for the emergency/faulted condition specified in IWB-3612. The results indicated that the margins (ratios) for all cases far exceed the required margins. Hence, the licensee concluded that the affected steam generator with the flaw indication could be operated for at least two fuel cycles until the 2004 refueling outage.

3.0 STAFF'S EVALUATION

The licensee used appropriate material data in its flaw evaluation because the yield strength and the stress intensity S_m for the shell material was from the ASME Code for a conservatively assumed operating temperature, and the RT_{NDT} of the shell material was the upper bound value for tested ferritic materials. Applying the conservative RT_{NDT} value to the ASME lower bound fracture toughness curves to determine the K_{Ia} and K_{Ic} values for the steam generator shell material is also appropriate because the steam generator shell material is a typical ferritic material.

For the subsequent flaw evaluation, the licensee used the acceptance criteria of IWB-3612. These criteria are for flaw evaluations based on linear elastic fracture mechanics (LEFM). Since the steam generator shell material is a typical ferritic material, using LEFM is the most conservative methodology for this application. The licensee's fatigue crack growth analysis is also acceptable because assuming 12 cycles of normal heatup and cooldown for two fuel cycles is conservative, and using the fatigue crack growth rate from Figure A-4300-1 for a subsurface flaw in an air environment is appropriate.

As was mentioned above, the licensee determined that the residual stresses are small and need not be considered in the applied K calculations. This determination was based on Ferrill's work on residual stress measurements in a weldment. Ferrill's work on weld residual stresses has been widely referenced in literature and is the basis for the peak residual stress stated in WRC-175, which the staff applied frequently in the review of submittals involving fracture mechanics. The staff determined that the licensee has applied Ferrill's results adequately, and the residual stresses are low or compressive and need not be considered. It should be pointed out that the licensee's fracture toughness margin of 9.58 versus 3.16 for the worst transient is sufficient to account for the uncertainties associated with the differences in geometry and heat treatment between Ferrill's test and this application.

Since the calculated ratio of K_{Ia} to the applied K for the final crack geometry is greater than 3.16 for the normal/upset condition and the calculated ratio of K_{Ic} to the applied K is greater than 1.41 for the emergency/faulted condition, the staff agrees with the licensee's conclusion that the affected steam generator with the flaw indication could be operated for at least two fuel cycles until 2004 refueling outage. The licensee's results using limit load analysis also support this determination.

4.0 CONCLUSION

The licensee's flaw evaluation methodology is consistent with the flaw evaluation procedure in the ASME Code, and the resulting margins exceed the acceptance criteria in the Code. Therefore, the licensee submittal is acceptable, and the affected steam generator with the flaw indication could be operated for at least two fuel cycles until the 2004 refueling outage. However, if the next inspection period according to IWB-2420 falls before the replacement of this steam generator, currently scheduled for 2004, the area containing this subsurface flaw shall be reexamined.

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Date: November 21, 2001

Oconee Nuclear Station

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