July 12, 2007

Mr. Bruce H. Hamilton
Vice President, Oconee Site
Duke Power Company LLC
7800 Rochester Highway
Seneca, SC 29672

SUBJECT: OCONEE NUCLEAR STATION, UNIT 1 - REPLACEMENT STEAM GENERATOR RELIEF REQUEST 04-ON-007, REVISION 1 (TAC NO. MD2510)

Dear. Mr. Hamilton:

In your letter dated July 6, 2006, and supplemented by letter dated May 29, 2007, you submitted Relief Request No. 04-ON-007, Revision 1, which involves eight welds that were completed during the replacement of steam generators A and B on Unit 1. You requested relief from the American Society of Mechanical Engineers, *Boiler and Pressure Vessel Code,* Subparagraph NB-4232.1 because the as-built weld geometries do not meet the 3:1 taper requirements. Enclosed is our safety evaluation that concludes the proposed alternative provides an acceptable level of quality and safety. Therefore, pursuant to the 50.55a(a)(3)(i)of title is of the Code of Federal Regulations, the Nuclear Regulatory Commission staff authorizes the proposed alternative to Oconee Nuclear Station, Unit 1, for the remainder of plant life.

Sincerely,

/RA/

Evangelos C. Marinos, Chief
Plant Licensing Branch II-1
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-269

Enclosure:
Safety Evaluation

cc w/encl: See next page

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

STEAM GENERATOR REPLACEMENT PROGRAM RELIEF REQUEST 04-ON-007,

REVISION 1

DUKE ENERGY CORPORATION

OCONEE NUCLEAR STATION, UNIT 1

DOCKET NO. 50-269

1.0 INTRODUCTION

By letter dated July 6, 2006, supplemented by letter dated May 29, 2007, Duke Energy Corporation (Duke, the licensee) submitted Relief Request 04-ON-007, Revision 1, requesting Nuclear Regulatory Commission (NRC) approval of an alternative to an American Society of Mechanical Engineers (ASME), *Boiler and Pressure Vessel Code* (Code) Case requirement for the Oconee Nuclear Station, Unit 1 (Oconee Unit 1). The request for relief is from ASME Code, Section III, 1983 edition, subparagraph NB-4232.1 that requires at least a 3:1 straight line taper over the width of the finished weld to allow the weld to resemble a counterbore. The request is associated with the replacement of steam generators A and B, and applies to the eight welds, 1-RC-289-1V through 1-RC-289-8V. This relief is requested for the remainder of plant life.

2.0 BACKGROUND

During the replacement of steam generators A and B on Unit 1, the licensee discovered that the as-built weld configurations at several locations on the reactor coolant system piping do not meet the taper requirements on the inside diameter (ID) of the welds as stipulated in paragraph NB-4232.1 of the ASME Code. The licensee stated that the actual geometry over the width of the weld resembles a counterbore rather than the taper required by the ASME Code. The licensee further indicated that ferritic filler material was applied to the counterbore area on the ID, and then cladding was applied as a weld metal overlay on the ID.

3.0 REGULATORY REQUIREMENTS

The inservice inspection (ISI) of ASME Code Class 1, 2 and 3 components in nuclear plants is to be performed in accordance with the ASME Code, Section XI and applicable editions and addenda as required by Section 50.55a(g) of Title 10 of the *Code of Federal Regulations* (10 CFR), except where specific relief has been granted by the Commission pursuant to 10 CFR 50.55a(g)(6)(i). The regulation in 10 CFR 50.55a(a)(3) states “Proposed alternatives to the requirements of paragraphs (c), (d), (e), (f), (g), and (h) of this section or portions thereof may be used when authorized by the Director of the Office of Nuclear Reactor Regulation. The

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applicant shall demonstrate that (i) the proposed alternatives would provide an acceptable level of quality and safety, or (ii) compliance with the specified requirements of this section would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety."

The Oconee replacement steam generators were designed to the 1989 ASME Code. The reactor coolant system piping was requalified to the 1983 Code during the steam generator replacement project. Therefore, this relief request references the requirements of ASME Code, Section III 1983 edition, no addendum, with respect to the affected piping welds.

The 1983 edition of ASME Code, Section XI, IWA-4120(a) states "Repairs shall be performed in accordance with the Owner's Design Specification and the original Construction Code of the component or system. Later Editions and Addenda of the Construction Code or of Section III, either in their entirety or portions thereof, and Code Cases may be used." The construction code for the Unit 1 reactor coolant pressure boundary piping (RCPB) is the United States of America Standards (USAS) B31.7 Class 1 criteria. The licensee evaluated the RCPB piping, including the steam generator nozzle welds, to the 1983 edition of the ASME Code during the steam generator replacement project. Paragraph NB-4232 of the 1983 edition of the ASME Code specifies alignment requirements for welds when components are welded from two sides. NB-4232.1 requires that offsets be faired to at least a 3:1 taper over the width of the finished weld.

4.0 LICENSEE'S BASIS FOR THE PROPOSED ALTERNATIVE

The licensee stated that deviations from standard code configurations for welds and other piping components are allowed as long as the stress analysis performed in accordance with NB-3640 reflects the actual as-built configuration and still meets the Code allowable stresses and fatigue limits. The licensee performed additional analyses to demonstrate the adequacy of the as-built weld configuration.

The licensee indicated that the as-built weld geometries did not meet the specific geometric requirements of ASME Code Subsubarticle NB-3680, and, therefore, were not covered by the stress indices used in the NB-3650 analysis of the steam generator nozzle welds. The licensee performed supplemental finite element analyses to demonstrate the conservatism of the stress indices used in the NB-3650 evaluation of the steam generator nozzle welds.

The licensee also indicated that the cladding thickness was in excess of 10 percent of the wall thickness at some locations. ASME Code subparagraph NB-3122.3 requires that the effect of the cladding be considered in the thermal analysis and the stress analysis for cases where the cladding thickness is in excess of 10 percent of the wall thickness. The licensee accounted for the additional stresses caused by the cladding.

Based on the above discussion, the licensee concluded that the reconfigured weld joint is acceptable from a stress/fatigue perspective for the remaining plant life.

5.0 NRC STAFF'S EVALUATION

The rules provided in Subarticle NB-3600 are normally used to qualify ASME Code Class 1 RCPB piping components. These rules consist of simplified equations to account for the design loading conditions that incorporate stress indices to account for the specific geometry of various piping components. The Code equations are provided in Subarticle NB-3650 and the indices are provided in Subarticle NB-3680 of the Code. The NB-3650 equations use B, C and K indices to account for the component geometries. These indices apply to primary, primary plus secondary, and peak stresses, respectively. The geometry of the piping components must satisfy the conditions provided in the Code in order for the stress indices to be valid.

The licensee used the stress indices provided in NB-3680 to evaluate the steam generator nozzle welds. Since the as-built configuration of the weld did not satisfy the taper requirements in NB-4232.1, the licensee performed supplemental finite element analyses of the as-built configuration to justify the conservatism of the B and C indices that were used in the ASME Code qualification of the steam generator nozzle. The results of the licensee's finite element analyses confirm that the B and C indices used to evaluate the steam generator nozzle welds are conservative. The NRC staff finds that the licensee's finite element analyses provide an adequate technical basis to validate the use of the B and C indices in the ASME Code qualification of the steam generator nozzle as-built weld configuration.

The licensee indicated that the Code-required calculation of peak stress intensity range (the K indices are applicable to the peak stress intensity calculation) was performed in accordance with subparagraph NB-3653.2 and the cumulative usage factor was determined in accordance with subparagraphs NB-3653.3, NB-3653.4 and NB3653.5. In addition, the relief request also indicated that in cases where the cladding thickness was in excess of 10 percent of the combined thickness, the additional stresses were accounted for, as required by subparagraph NB-3122.3.

The NRC staff requested that the licensee explain in detail how the additional stresses due to the cladding were calculated in those areas where the cladding exceeded 10 percent of the thickness. The NRC staff requested that the licensee show how these cladding stresses were used in the calculation of peak stress intensity. The NRC staff also requested that the licensee provide a comparison of the calculated peak stress intensity determined by finite element analysis with the peak stress intensity calculated using ASME NB-3650 procedures, as provided in the certified design report, at the location where the cladding exceeded 10 percent of the thickness.

By letter dated May 29, 2007, the licensee provided its response to the NRC staff's request. This response indicated that the cladding stresses were evaluated by calculating the shear stress between the carbon steel and the stainless steel cladding. No peak stress index (K index) was applied to the calculated shear stress. The shear stress was then added to the remaining peak stress for the fatigue evaluation. The NRC staff believed that the licensee should have applied the K_3 index to calculate the peak stress at the interface between the cladding and the base material in accordance with subparagraph NB-3653.2. The basis for the NRC staff's concern was that the ferritic weld was left in the as-welded condition and, as a consequence, the interface between the two materials contained a rough surface that caused a stress intensification. The licensee did not agree with the NRC staff's position.
The NRC staff developed a finite element model of nozzle weld area using ANSYS Version 10 in order to resolve the concern. The model was developed to determine whether a stress

intensification would exist at the interface between the carbon steel and the stainless steel cladding if the interface contained a geometric discontinuity. The model was not intended to be an exact representation of the Oconee Unit 1steam generator nozzle weld because the NRC staff did not have the detailed weld profile at the interface. The purpose of the NRC staff model was to determine whether the licensee should have applied the K_3 index to calculate the peak stress at the interface between the cladding and the base material.

The model dimensions were developed by scaling the dimensions of the finite element shown in Figure 1 of Enclosure B to the licensee's May 29, 2007, letter. The NRC staff's model included the 3:1 taper on the outside surface of the nozzle, a small concavity on the inside surface and a nominal cladding thickness of 1/8 inch. The model used axisymmetric elements subjected to a uniform temperature change from 70 to 650 °F. The maximum thickness of the stainless steel cladding was assumed to be 0.643 inch with a uniform depth at the weld joint. The model contained an abrupt geometric transition at the bottom edge of thick portion of the stainless steel cladding to simulate the geometric discontinuity at the interface between the cladding and the as-welded ferritic material.

The results of the analysis indicated that a stress intensification exists in the ferritic material at the edge of the thick area of the stainless steel cladding. The maximum stress intensity in the ferritic material is approximately 45 ksi. This stress intensity is 50 percent greater than the stress intensity reported by the licensee. On the basis of its calculation, the NRC staff concludes that the licensee should have applied the ASME Code K_3 index to calculate the peak stress intensity, caused by differential thermal expansion, at the interface of the ferritic base material and the stainless steel cladding.

The licensee reported a peak stress of 124 ksi and a fatigue usage factor of 0.16 at the nozzle weld joint. The NRC staff calculated a revised peak stress of approximately 150 ksi by multiplying the licensee's reported peak stress of 30 ksi at the cladding interface by the ASME Code K_3 index of 1.87. The corresponding fatigue usage factor is approximately 0.25, which is still below the ASME Code allowable limit of 1.0.

The NRC staff finds that the licensee's evaluation of the steam generator nozzle weld joints, as supplemented by the NRC staff's evaluation described above, demonstrates that the as-built configuration of the steam generator nozzle weld joints provides sufficient design margin against failure and fatigue cracking due to the design loads and, therefore, provides an acceptable level of quality and safety. The licensee should correct the existing calculation for the steam generator nozzle welds to account for the K_3 index as described above.

The NRC staff also requested that the licensee indicate whether the current weld configurations, for each of the welds covered by this relief request, can be 100-percent inspected in accordance with the requirements of ASME Section XI. The licensee stated in its May 29, 2007, letter that all weld joints covered by the relief request can be 100-percent inspected in accordance with ASME Section XI requirements. The NRC staff finds this response acceptable.

6.0 CONCLUSION

Based on the above evaluation, the NRC staff concludes that the proposed alternative, as discussed in the licensee's request for relief, provides an acceptable level of quality and safety. Therefore, the proposed alternative is authorized pursuant to 10 CFR 50.55a(a)(3)(i) for the duration of plant life for Oconee Unit 1.

All other ASME Code Section XI requirements for which relief was not specifically requested and approved in this relief request remain applicable.

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Date: July 12, 2007

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