June 12, 2001

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

SUBJECT: OCONEE NUCLEAR STATION, UNIT 2 RE: REQUEST FOR RELIEF NO. 2001-07: USE ALTERNATIVES TO ASME SECTION XI, IWA-4500(e)(2), IWA-4532.2(d), AND IWA-4500(d)(1)(b) FOR REACTOR VESSEL HEAD WELD CONTROL ROD DRIVE MECHANISM REPAIR (TAC NO. MB1896)

Dear Mr. McCollum:

By letter dated May 8, 2001, Duke Energy Corporation, the licensee, submitted a request for relief from the temperature measuring requirements of Section IWA-4500(e)(2); from the post-weld temperature maintenance requirements of Section IWA-4532.2(d); and from the procedure qualification requirements of Section IWA-4500(d)(1)(b) imposed by the American Society of Mechanical Engineers (ASME) Code, Section XI, 1992 edition. In a telephone conversation with the licensee on May 10, 2001, the NRC requested additional information concerning this request. Subsequently, the licensee submitted another letter dated May 12, 2001, that provided the requested information and replaced the earlier request in its entirety. Pursuant to 10 CFR 50.55a(a)(3)(ii), the licensee has requested the use of alternatives to Sections IWA-4500(e)(2), IWA-4532.2(d), and IWA-4500(d)(1)(b) of the ASME Code for the repair of control rod drive mechanism (CRDM) Nozzle Numbers 4, 6, 18, and 30 and their associated welds on the Oconee Nuclear Station, Unit 2 reactor pressure vessel head.

The staff has evaluated the licensee's request and concluded that acceptable alternative weld repair criteria have been provided. Therefore, pursuant to 10 CFR 50.55a(a)(3)(ii), the request for relief is authorized since the licensee has demonstrated that the proposed alternative would provide an acceptable level of quality and safety and that compliance with the specified requirements would result in hardship or unusual difficulty. The staff's safety evaluation is enclosed.

Sincerely,

/RA/

Richard L. Emch, Jr., Section Chief, Section 1
Project Directorate II
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket No. 50-270

Enclosure: Safety Evaluation

cc w/encl: See next page

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Oconee Nuclear Station

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

REQUEST FOR RELIEF TO USE ALTERNATIVES TO ASME SECTION XI

IWA-4500(e)(2), IWA-4532.2(d), AND IWA-4500(d)(1)(b)

OCONEE NUCLEAR STATION, UNIT 2

DUKE ENERGY CORPORATION

DOCKET NUMBER 50-270

1.0 INTRODUCTION

By letter dated May 8, 2001, Duke Energy Corporation, the licensee, submitted a request for relief from the temperature measuring requirements of Section IWA-4500(e)(2); from the post-weld temperature maintenance requirements of Section IWA-4532.2(d); and from the procedure qualification requirements of Section IWA-4500(d)(1)(b) imposed by the American Society of Mechanical Engineers (ASME) Code, Section XI, 1992 edition. In a telephone conversation with the licensee on May 10, 2001, the NRC requested additional information concerning this request. Subsequently, the licensee submitted another letter dated May 12, 2001, that provided the requested information and replaced the earlier request in its entirety. Pursuant to 10 CFR 50.55a(a)(3)(ii), the licensee has requested the use of alternatives to Sections IWA-4500(e)(2), IWA-4532.2(d), and IWA-4500(d)(1)(b) of the ASME Code that are being used for repair of control rod drive mechanism (CRDM) Nozzle Numbers 4, 6, 18, and 30 and their associated welds on the Oconee Unit 2 reactor pressure vessel head.

Section IWA-4500(e)(2) specifies that the maximum interpass temperature shall be 450°F for temper bead welds and that thermocouples and recording instruments shall be used to monitor the process temperatures. The licensee has proposed that the requirement for monitoring of the welding interpass temperature be eliminated.

IWA-4532.2(d) specifies that the weld area shall be maintained at a temperature of 450-550°F for a minimum holding time of four hours when welding to P3 materials. The licensee has proposed an alternate to this requirement.

IWA-4500(d)(1)(b) specifies that the welding parameters used in the actual weld shall be equivalent to those parameters in the Procedure Qualification Report (PQR). The PQR was qualified with the post-weld heat soak heat temperature of between 450 to 550°F for a period of two hours. A post-weld heat soak temperature of 300°F for a period of four hours will be used for the actual weld to be applied to the repair areas.

In accordance with 10 CFR 50.55a (a)(3)(ii), proposed alternatives to the regulations in 10 CFR 50.55a paragraphs (c), (d), (e), (f), (g), and (h) may be used when authorized by the NRC as long as the applicant demonstrates that compliance with the specified requirements would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

The staff has reviewed and evaluated the licensee's request and supporting information on the proposed alternative to the Code requirements for Oconee Unit 2 for repairs associated with CRDM Nozzle Numbers 4, 6, 18, and 30, pursuant to the provisions of 10 CFR 50.55a(a)(3)(ii), as described below.

2.0 BACKGROUND

During regular inspections of the Unit 2 reactor pressure vessel (RPV) head during a refueling outage, small amounts of boron were discovered emanating from the CRDM nozzle interface with the outside radius at the top of the RPV head for CRDM Nozzle Nos. 4, 6, 18, and 30. This pressure boundary degradation was reported to the NRC on April 28, 2001, in accordance with I0 CFR 50.72(b)(3)(ii). Non-destructive examinations of the base metal, weld, nozzles and other areas have been used to help identify the leakage path.

Experience gained from the repairs to the Oconee, Units 1 and 3 CRDM nozzles indicated that more remote automated repair methods were needed to reduce radiation dose to personnel performing the repairs. Therefore, for the Oconee Unit 2 repairs, a remote semi-automated repair method was used for each of the subject nozzles.

3.0 DISCUSSION

3.1 Licensee's Basis for Relief Request

3.1.1 IWA-4500(e)(2)

IWA-4500(e)(2) requires that the maximum interpass temperature be controlled and limits the maximum temperature to 450°F. It also specifies that thermocouples and recording instruments shall be used to monitor the process temperatures.

Due to the difficulty in placing thermocouples at Oconee, direct monitoring of the interpass temperature is not practical. In lieu of monitoring the interpass temperature via adjacent thermocouples, the licensee performed a calculation to justify the actual interpass temperature at the weld location based on a maximum allowable welding heat input, weld bead placement, travel speed, and conservative preheat temperature assumptions. The calculation supports the conclusion that using the maximum heat input through the third layer of the weld, the interpass temperature returns to the preheat temperature. Heat input beyond the third layer will not have a metallurgical affect on the low alloy steel heat affected zone (HAZ).

The calculation is based on a typical inter-bead time interval of five minutes. The five-minute inter-bead interval is based on the time: 1) required to explore the previous weld deposit with remote cameras, 2) to shift the starting location of the next weld bead circumferentially away from the end of the previous weld-bead, and 3) to shift the starting location of the next bead axially to ensure a 50 percent weld bead overlap required to properly execute the temper bead technique.

The licensee used a welding mockup on a full size RPV head to demonstrate the welding technique described in the submittal. During the mockup, thermocouples were placed to monitor the resistance heating of the head. These locations have been retained for the actual repairs. During the mockup, thermocouples were placed on the outside diameter of the RPV head within a 5-inch band surrounding the CRDM nozzle. Three other thermocouples were placed on the reactor vessel head inner diameter. One of the three thermocouples was placed 1-1/2 inches from the CRDM penetration. The other inner diameter thermocouples were placed at the edge of the 5-inch band surrounding the CRDM nozzle approximately opposite each other. During the mockup, all thermocouples fluctuated less than 15°F throughout the 18-hour welding cycle. Based on past experience, the licensee believes that the temperature fluctuation was due more to the resistance heating variations than the low heat input from the welding process.

In summary, controlling the parameters determined by the referenced calculation will assure that the maximum interpass temperature is not exceeded and thus provides an acceptable level of quality and safety.

3.1.2 IWA- 4532.2(d)

The 450-550°F post-weld heat soak requirement is stated in IWA-4532.2(d) to assure that no delayed cold cracking in the ferritic steel HAZ occurs. The weld consumables to be used will consist of bare wire with no hygroscopic flux. The preheat temperature of 300°F will be maintained during the post-weld soak for four hours. The combination of the low moisture absorbing weld process and maintaining the post-weld soak temperature at 300°F for four hours will eliminate the possibility of hydrogen induced cracking.

Industry experience has found that delayed hydrogen cracking requires a hydrogen concentration above about 5ml/100g of deposited weld metal and a weld and HAZ with low ductility/toughness. Delayed hydrogen cracking tends to occur in carbon and alloy steel welds produced by processes which use a flux. The flux in these processes can pick up moisture that breaks down during welding to produce atomic hydrogen. The atomic hydrogen is partially absorbed by the weld metal and HAZ. Absorption of hydrogen, in sufficient quantity in low ductility material may cause delayed hydrogen cracking. The gas tungsten arc weld (GTAW) process uses Argon gas as the shielding medium, a non-hygroscopic gas.

Moisture contaminated shielding gas or high humidity environments may introduce hydrogen into GTAW welds. The Electric Power Research Institute (EPRI) performed tests with moisture contaminated argon shielding gas. At very high moisture contents (+60°F dew point) the measured hydrogen concentration in test welds was 4.6 ml/100g of weld metal (Reference 1). This value falls within the extra low hydrogen range specified by the American Welding Society.

The EPRI work further showed that a 450°F post-weld heat soak would reduce the already low hydrogen content to infinitesimally small values. Work by Coe and Moreton (Reference 2) determined that it takes only 0.3 hours at 450°F to remove 95 percent of any hydrogen present. At 300°F, the diffusivity rate measurements showed that only 0.7 hours is required to remove 95 percent of any hydrogen that is present. The licensee's proposed alternative will hold the post-weld heat soak at 300°F for four hours.

In addition to the data discussed above, Framatome-ANP has qualified the GTAW temper-bead process in support of ASME approval of Code Case N-606-1, “Similar and Dissimilar Metal Welding Using Ambient Temperature Machine GTAW Temper-Bead Technique for BWR CRD Housing/Stub Tube Repairs.” The supporting welding Procedure Qualification Report (PQRs) for this work were supplied with the request for relief. These qualifications were performed at room temperature with cooling water to limit the maximum interpass temperature to a maximum of 100°F. These qualifications were performed on the same P-3 Group-3 base material as proposed for the Oconee Unit 2 repairs, using the same filler material; i.e., Alloy 52, with low heat input controls similar to those proposed for the Oconee Unit 2 repairs. The qualifications did not include a post weld heat soak.

In summary, the data provided indicate that the potential for post welding hydrogen cracking is remote for the GTAW process. The National Board Inspection Code does not require the post-weld heat soak when using electrodes with a supplemental hydrogen designation of H8 (8ml/100g). Additionally, the 1998 with 2000 addenda of ASME Section XI has eliminated the 450°F post weld heat soak for the GTAW process in favor of a 300°F post weld heat soak. Finally, the Framatome-ANP qualifications for the BWR CRD housing/stub tube repairs provide justification for reducing the post weld soak temperature to 300°F for the Oconee Unit 2 repairs.

3.1.3 IWA-4500(d)(1)(b)

IWA-4500(d)(1)(b) specifies that the welding parameters used in the actual weld shall be equivalent to those parameters in the PQR. The PQR was qualified with the post-weld heat soak heat temperature of between 450 to 550°F for a period of two hours. A post-weld heat soak temperature of 300°F for a period of four hours will be used for the actual weld to be applied to the repair areas.

The PQR was performed in accordance with Code Case N-432, Revision 0, “Repair Welding Using Automatic or Machine Gas Tungsten-Arc Welding (GTAW) Temper Bead Technique, Section XI, Division 1,” prior to the incorporation of machine welding into Section XI. Code Case N-432, Revision 0 requires a post weld heat soak temperature of between 450 and 550°F for a period of two hours, whereas the procedure to be used for this welding will use a post-weld heat soak temperature of 300°F for a period of four hours.

In ASME Section IX it is not clear as to whether post weld soak temperature is an essential variable. ASME Section IX, QW-407, makes Post Weld Heat Treatment (PWHT) an essential variable. However, it must be realized that the intent of PWHT is to affect the mechanical or metallurgical properties of the material. The continuation or elevation of the preheat following temper-bead welding applications is performed to remove hydrogen. As shown above, the GTAW process produces little or no hydrogen. The post-weld heat soak required by ASME Section XI does not relieve residual stresses or affect the metallurgical properties of the weld or the base material. It is contended that the “techniques described for the repair” described in IWA-4500(l)(b) are those aspects that affect the mechanical or metallurgical properties of the weld or base material. These aspects include such parameters as heat input, bead thickness, and bead overlap, but do not include post weld hydrogen removal.

In summary, as discussed above, reducing the post-weld heat soak temperature to 300°F for four hours will be as effective as the Code requirement in removing hydrogen. As such, the licensee believes that the disagreement between the PQR and the actual weld process is of minimal technical consequence. Consequently, the staff has determined that the welding procedure as described will provide an acceptable level of quality and safety.

3.2 Licensee's Request for Relief

Based on the above discussion, the licensee has determined that compliance with portions of IWA-4500(e)(2) constitute a hardship per 10 CFR 50.55a(a)(3)(ii). It is physically impossible to locate thermocouples adjacent to the new pressure boundary weld region to monitor interpass temperature. The proposed techniques to control welding input provide an acceptable level of quality and safety. The repair plans for Oconee Unit 2 seek to reduce exposures by instituting semi-automated remote processes. These plans require relief from some code welding process requirements as noted herein. The use of the semi-automated repair process is dependent on approval of this request. Should this request for relief not be approved, the total radiation exposure to perform the repairs using manual processes would increase from an estimated 21 REM (using semi-automated processes) to approximately 125 REM for the manual repair processes that was used on Oconee Unit 3. The manual CRDM nozzle repairs performed on Oconee Unit 3 resulted in whole body exposures of 282 REM. The licensee believes the alternatives described in the submittal will provide an acceptable level of quality and safety when compared to the code requirements to directly monitor weld interpass temperature.

The licensee has determined that compliance with portions of IWA-4532.2(d) constitute a hardship per 10 CFR 50.55a(a)(3)(ii). Industry studies have shown that reduction of the post-weld heat soak temperature to 300°F does not affect the quality and safety of the weld. Current National Board Inspection and ASME Codes have lowered the post-weld heat soak temperature. Rejection of this request would result in a delay in startup from the outage of approximately ½ day and a 5 percent increase in the radiation dose planned for the CRDM nozzle repair. The licensee has stated that the alternative described will provide an acceptable level of quality and safety when compared to the code requirements for the post-weld heat soak temperature.

The licensee also stated in the submittal that compliance with portions of IWA-4500(d)(1)(b) constitutes a hardship per 10 CFR 50.55a(a)(3)(ii). Qualification of the welding process with the alternate post-weld soak temperature of 300°F will delay startup from the refueling outage by approximately six weeks. As noted herein, the requirement to use a post-weld soak temperature of 450°F does not increase the level of quality and safety compared to the 300°F post-weld soak temperature. Industry studies have shown that using lower post-weld soak temperatures provide acceptable results. Therefore, the difference between the post-weld soak temperature of the PQR and the actual welding post soak temperature are of minimal technical consequence and will not affect the quality and safety of the new pressure boundary welds.

4.0 EVALUATION

The staff has evaluated the licensee's request and supporting information on the proposal to eliminate the requirement for direct measurement of the 450°F maximum welding interpass temperature as required by Section IWA-4500(e)(2) ASME Section XI and, based on the following considerations, the staff has concluded that the information supplied by the licensee provides an acceptable alternative to direct weld interpass temperature measurement:

- The placing of thermocouples in direct proximity to the welds for monitoring of the interpass temperature is very difficult;

- A calculation of the temperature rise has been performed to show that the maximum interpass temperature will not be exceeded;

- Thermocouples will be placed at locations near the area of repair welding;

- A full size mockup of the closure head was used to demonstrate the welding technique would assure that the maximum interpass temperature will not be exceeded; and

- The total radiation exposure to perform the repairs using manual processes would be greatly increased if this request is not approved.

The staff has also evaluated the licensee's request and supporting information on the proposal to use an alternate to IWA-4532.2(d), which specifies that the weld area shall be maintained at a temperature of 450-550°F for a minimum holding time of 4 hours when welding to P3 materials. The proposal is that the preheat temperature of 300°F will be maintained during the post-weld soak for four hours instead of 450-550°F for 4 hours. Based on the following considerations, the staff has concluded that the information supplied by the licensee provides an acceptable alternative to the maintenance of a temperature of 450-550°F for a minimum holding time of 4 hours.

- Industry studies have shown that reduction of the post-weld heat soak temperature to 300°F does not affect the quality and safety of the weld;

- The 1998 Edition of the ASME Code with the 2000 Addenda of Section XI has eliminated the 450°F post weld heat soak for the GTAW process in favor of a 300°F post weld heat soak;

- Procedure qualifications have been performed at lower temperatures than the 300°F proposed; and

- Rejection of this request would result in a delay in startup from the outage of approximately ½ day and a 5 percent increase in the radiation dose planned for the CRDM nozzle repair.

Finally, the staff has evaluated the licensee's request and supporting information on their proposal to avoid qualification of the welding procedure at the lower 300°F post-weld soak temperature. In the submittal, the licensee states that in some opinions IWA-4500(d)(1)(b) might require qualification of the welding procedure at the lower post-weld soak temperatures. The staff has concluded that the elimination of the procedure qualification at the lower 300°F post-weld soak temperature is acceptable, based on the following considerations:

- Industry studies have shown that reduction of the post-weld heat soak temperature to 300°F does not affect the quality and safety of the weld;

- Acceptable procedure qualifications have been performed at temperatures lower than the 300°F to be used in the repair welds;

- The difference between the post-weld soak temperature of the PQR and the actual welding post soak temperature is of minimal technical consequence; and

- Qualification of the welding process with the post-weld soak temperature of 300°F would delay startup from the refueling outage by approximately six weeks.

In summary, the licensee has demonstrated that compliance with the requirements of Sections IWA-4500(e)(2), IWA-4532.2(d), and IWA-4500(d)(1)(b) of ASME Section XI would result in an unusual difficulty in completing the weld repairs to the Oconee Unit 2 CRDM nozzles without a compensating increase in the level of quality and safety. Therefore, pursuant to 10 CFR 50.55a(a)(3)(ii), the relief request is authorized since the applicant has demonstrated that the proposed alternatives would provide an acceptable level of quality and safety and that compliance with the specified requirements would result in hardship or unusual difficulty.

5.0 CONCLUSION

The staff has concluded that the licensee's proposed request for relief from Section IWA-4500(e)(2) ASME Section XI, which requires the direct measurement of the 450°F maximum interpass temperature, provides an acceptable alternative for the repair of CRDM Nozzle Numbers 4, 6, 18, and 30. A calculation of the temperature rise has been performed to show that the maximum interpass temperature will not be exceeded. A full size mockup of the closure head has been used to demonstrate that the welding technique would assure that the maximum interpass temperature will not be exceeded. Thermocouples will be placed at locations near the area of repair welding to control preheat and interpass temperature. Based on the fact that the placing of thermocouples in direct proximity to the welds for monitoring of the interpass temperature is very difficult, the licensee has demonstrated that compliance with the requirement of direct measurement of the 450°F maximum interpass temperature as required by Section IWA-4500(e)(2) in ASME Section XI would result in an unusual difficulty in performing the repair weld to the Oconee Unit 2 CRDM nozzles without a compensating increase in quality and safety.

The licensee also proposed to use a preheat temperature of 300°F that will be maintained during the post-weld soak for 4 hours instead of the IWA-4532.2(d) required post-weld soak of 450-550°F for 4 hours for repairs to CRDM Nozzle Numbers 4, 6, 18, and 30 . This alternative temperature for the post weld soak has been reviewed by the staff and is acceptable. Industry studies have shown that reduction of the post-weld heat soak temperature to 300°F does not affect the quality and safety of the weld. Current National Board Inspection and ASME Codes have lowered the temperature of the 450°F post-weld heat soak. Procedure qualifications have been performed at lower temperatures than the 300°F proposed. Compliance with the requirement of a post-weld soak at 450-550°F for 4 hours as required by Section IWA-4532.2(d) in ASME Section XI would delay restart from the outage of approximately ½ day and a 5 percent increase in the radiation dose planned for the Oconee Unit 2 CRDM nozzle repair. Therefore, the staff has concluded that compliance would result in an unusual hardship without a compensating increase in quality and safety.

Finally, the staff has evaluated the licensee's request and supporting information proposing to avoid qualification of the welding procedure at the lower 300°F post-weld soak temperature for the repairs to CRDM Nozzle Numbers 4, 6, 18, and 30. Industry studies have shown that reduction of the post-weld heat soak temperature to 300°F does not affect the quality and safety of the weld. Acceptable procedure qualifications have been performed at temperatures lower than the 300°F to be used in the repair welds. Qualification of the welding process with the alternate post-weld soak temperature of 300°F would delay restart from the refueling outage by approximately six weeks. Therefore, the staff has concluded that the elimination of the procedure qualification at the lower 300°F post-weld soak temperature is acceptable.

Therefore, pursuant to 10 CFR 50.55a(a)(3)(ii), the requests for relief for CRDM Nozzle Numbers 4, 6, 18, and 30 are authorized since the licensee has demonstrated that the proposed alternatives would provide an acceptable level of quality and safety and that compliance with the specified requirements would result in hardship or unusual difficulty.

6.0 REFERENCES

1. Electric Power Research Institute (EPRI), Document TR103354, "Temperbead Welding Repair of Low Alloy Pressure Vessel Steels; Guidelines," December 1993, Chapter 2, "Diffusion of Hydrogen in Low Alloy Steel," D. Gandy & S. Findland

2. Journal of Iron and Steel Institute, April 1966, "Diffusion of Hydrogen in Low Alloy Steel," pages 366- 370, F.R. Coe and B.A. Moreton

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Date: June 12, 2001