June 13, 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: USE OF ALTERNATIVE FOLLOWING WELD REPAIR OF REACTOR VESSEL HEAD-TO-CONTROL ROD DRIVE MECHANISM, REQUEST FOR RELIEF NO. 01-06 (TAC NO. MB1895)

Dear Mr. McCollum:

By letter dated May 7, 2001, as superseded May 15, 2001, and as supplemented May 22 and 23, 2001, Duke Energy Corporation requested relief for Oconee Nuclear Station, Unit 2, from certain American Society of Mechanical Engineers Boiler and Pressure Vessel Code (Code) inservice inspection requirements associated with the repair of selected control rod drive mechanism (CRDM) Numbers 4, 6, 18 and 30 nozzle-to-reactor vessel head welds.

Based on the enclosed safety evaluation, the staff has concluded that performance of Code-required radiographic examinations of the subject weld volumes, liquid penetrant examination of the preheat area after a 48-hour hold time, and liquid penetrant examination during welding would result in hardship or unusual difficulty for the licensee without a compensating increase in the level of quality and safety. Therefore, the staff authorizes use of ultrasonic examination as an alternative to the Code-required radiographic examinations for CRDM Numbers 4, 6, 18 and 30 nozzle-to-reactor vessel head weld repairs pursuant to 10 CFR 50.55a(a)(3)(ii).

Sincerely,

/RA/

Richard L. Emch, Jr., Chief, 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

June 13, 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: USE OF ALTERNATIVE FOLLOWING WELD REPAIR OF REACTOR VESSEL HEAD-TO-CONTROL ROD DRIVE MECHANISM, REQUEST FOR RELIEF NO. 01-06 (TAC NO. MB1895)

Dear Mr. McCollum:

By letter dated May 7, 2001, as superseded May 15, 2001, and as supplemented May 22 and 23, 2001, Duke Energy Corporation requested relief for Oconee Nuclear Station, Unit 2, from certain American Society of Mechanical Engineers Boiler and Pressure Vessel Code (Code) inservice inspection requirements associated with the repair of selected control rod drive mechanism (CRDM) Numbers 4, 6, 18 and 30 nozzle-to-reactor vessel head welds.

Based on the enclosed safety evaluation, the staff has concluded that performance of Code-required radiographic examinations of the subject weld volumes, liquid penetrant examination of the preheat area after a 48-hour hold time, and liquid penetrant examination during welding would result in hardship or unusual difficulty for the licensee without a compensating increase in the level of quality and safety. Therefore, the staff authorizes use of ultrasonic examination as an alternative to the Code-required radiographic examinations for CRDM Numbers 4, 6, 18 and 30 nozzle-to-reactor vessel head weld repairs pursuant to 10 CFR 50.55a(a)(3)(ii).

Sincerely,

/RA/
Richard L. Emch, Jr., Chief, 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

<u>Distribution:</u>
PUBLIC
PD II-1 Rdg.
RidsNrrDlpmLpdii1 (paper copy)
RidsNrrLACHawes (paper copy)
DNaujock (paper copy)
RidsNrrPMDLaBarge (paper copy)
RidsOgcRp
RidsAcrsAcnwMailCenter
RidsRgn2MailCenter
GHill(2)
SRosenberg,EDO
RHaag,RII

ADAMS ACCESSION NUMBER: ML011640161 *See previous concurrence

OFFICE	PM:PDII/S1	LA:PDII/S1	DE/EMCB	OGC	SC:PDII/S1
NAME	DLaBarge	CHawes	TChan*	RHoefling*	REmch
DATE	06/12/01	06/12/01	5/31/01	6/4/01	06/12/01

OFFICIAL RECORD COPY

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

THIRD TEN-YEAR INTERVAL INSERVICE INSPECTION PROGRAM PLAN

REQUEST FOR RELIEF NO. 01-06

DUKE ENERGY CORPORATION

OCONEE NUCLEAR STATION, UNIT 2

DOCKET NO. 50-270

1.0 INTRODUCTION

The inservice inspection (ISI) of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (Code) Class 1, 2, and 3 components is to be performed in accordance with Section XI of the ASME Code and applicable edition and addenda as required by Title 10 of the *Code of Federal Regulations* (10 CFR) Section 50.55a(g), except where specific written relief has been granted by the Commission pursuant to 10 CFR 50.55a(g)(6)(i). 10 CFR 50.55a(a)(3) states in part that alternatives to the requirements of paragraph (g) may be used, when authorized by the NRC, if the licensee demonstrates that: (i) the proposed alternatives would provide an acceptable level of quality and safety, or (ii) compliance with the specified requirements would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

Pursuant to 10 CFR 50.55a(g)(4), ASME Code Class 1, 2, and 3 components (including supports) will meet the requirements, except the design and access provisions and the preservice examination requirements, set forth in the ASME Code, Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components," to the extent practical within the limitations of design, geometry, and materials of construction of the components. The regulations require that inservice examination of components and system pressure tests conducted during the first 10-year interval and subsequent intervals comply with the requirements in the latest edition and addenda of Section XI of the ASME Code incorporated by reference in 10 CFR 50.55a(b) 12 months prior to the start of the 120-month interval, subject to the limitations and modifications listed therein. The ISI Code of record for Oconee Nuclear Station, Unit 2, third 10-year interval is the 1989 Edition of the ASME Code. The components (including supports) may meet the requirements set forth in subsequent editions and addenda of the ASME Code incorporated by reference in 10 CFR 50.55a(b) subject to the limitations and modifications listed therein and subject to Commission Approval.

By letter dated May 7, 2001, as superseded May 15, 2001, and as supplemented May 22 and 23, 2001, Duke Energy Corporation (the licensee) submitted Relief Request No. 01-06, requesting relief from Code-required radiographic testing (RT) of the subject weld volumes, liquid penetrant testing (PT) of the preheat area after a 48-hour hold time, and PT during welding for the repair of the nozzle-to-reactor pressure vessel (RPV) head welds on control rod drive mechanism (CRDM) Numbers 4, 6, 18 and 30 during the third 10-year ISI interval at the Oconee Nuclear Station, Unit 2.

2.0 RELIEF REQUEST 01-06, REPAIR OF SELECTED CRDM NOZZLE-TO-REACTOR VESSEL HEAD WELDS

Pursuant to 10 CFR 50.55a(a)(3)(ii), the licensee proposed alternatives to certain Code-required examinations of repair welds made to CRDM nozzle numbers: 4, 6, 18 and 30 during refueling outage 18.

3.0 CODE REQUIREMENTS FOR WHICH RELIEF IS REQUESTED

The Construction Code for Oconee, Unit 2, is the 1965 Edition with Summer of 1967 Addenda. The licensee selected to use a more current edition of the Code referenced in the 10 CFR 50.55a(b) for the examination of the repair. The Code for repair and construction examinations is the 1989 Edition of Section III with no addenda, and the Code for pre-service and inservice examinations of the repair is the 1992 Edition of Section XI with on addenda.

Section XI, Paragraph IWA-4170(d) requires that an item to be used for replacement may meet all or portions of the requirements of later Editions and Addenda of the Construction Code or Section III when the Construction Code was not Section III. Also, Paragraph NB-5245 of Section III requires that partial penetration joints be examined progressively using either magnetic particle testing or PT methods. The increments of the examinations shall be the lesser of ½ of the welded joint thickness or ½ inch. The surface of the finished weld shall also be examined by either method.

Section XI, Paragraph IWA-4500(e)(2) of Section XI identifies the preheat area that applies to the inspection following the repair as the area of 1½ times the component thickness or 5 inches, whichever is less.

Section XI, Paragraph IWA-4533 of Section XI requires that the weld repair as well as the preheated band shall be examined by the PT method after the completed weld has been at ambient temperature for at least 48 hours. The repaired region shall be examined by the RT method and, if practical, by the ultrasonic testing (UT) method following repair of dissimilar materials using the temper bead process in accordance with IWA-4530.

4.0 LICENSEE'S PROPOSED ALTERNATIVE TO CODE

4.1 In lieu of the progressive examination requirements of the 1989 Edition of Section III, Paragraph NB-5245, the licensee proposed an enhanced visual observation during the welding process and UT and PT examinations of the finished weld.

4.2 In lieu of the examination area requirements of the 1992 Edition of Section XI, Paragraph IWA-4500(e)(2), the licensee proposed an examination of the weld repair area using UT and PT.

4.3 In lieu of the RT requirements of the 1992 Edition of Section XI, IWA-4533, the licensee proposed alternative UT and PT examinations on the finished weld.

4.4 In lieu of the post-weld hold time requirement of the 1992 Edition of Section XI, IWA-4533 (at least 48-hour hold time after reaching ambient temperature) prior to performing a PT examination, the licensee proposed an alternative post-weld heat soak at 300°F for 4 hours, followed by a 6-hour cool-down to 125°F, followed by a post-weld ambient hold of at least 35 hours until UT.

5.0 <u>LICENSEE'S BASES FOR ALTERNATIVE</u>

The licensee stated that the proposed alternative for the repair of the subject CRDM nozzles will significantly reduce radiation dose to repair personnel. The total radiation dose for the remote semi-automated repair method is projected to be between 25 and 30 REM. In contrast, it is projected that using the Units 1 and 3 manual repair method for Unit 2 would result in a total radiation dose of 125 REM.

For the repair process being used on the Oconee Unit 2 RPV head, application of progressive surface inspection techniques, as required by (the 1992 Edition, Section XI,) IWA-4170(d), would required additional under-head entries. These additional entries would result in an estimated dose increase of 3 REM.

The 1992 Edition of ASME Section XI, IWA-4170(d) permits the use of later editions and addenda of the construction Code for replacement. The 1989 Edition of ASME Section III, paragraph NB-5245 requires a progressive surface examination of partial penetration welds to insure sound weld metal. The welding will be monitored using a remote enhanced video camera with resolution capability to resolve a ½ mil diameter color contrast wire. The temper-bead process used for this repair would require a volumetric examination per the welding rules provided in ASME Section, IWA-4533. The intent of this examination is to confirm that the weld metal buildup, the fusion zone, and the parent metal opposite the weld are free of lack of fusion and laminar defects. The proposed UT examination can examine the new pressure boundary weld volume with the exception of a tapered region. The finished weld surface will receive a liquid prenetrant examination. These inspections, along with steps taken to ensure quality during welding discussed later, provide assurance that unacceptable flaws in the new pressure boundary welds can be detected.

The configuration of the new pressure boundary welds limits the ability to examine the band area defined by IWA-4500(e)(2). IWA-4500(e)(2), defines a band around the weld repair of at least 1-1/2 times the component thickness or 5 inches, whichever is less, that shall be preheated and maintained at a minimum temperature, based on the welding process to be utilized. Due to the thickness of the RPV head, the 5-inch minimum is utilized for definition of the band area. The Code-required pre-heat area is not applicable to the repair area configuration. The licensee is proposing to examine the new pressure boundary weld and surrounding area with UT, PT, visual examination (VT), and combinations of these methods.

The UT examination techniques are based upon industry practice for the examination of austenitic weld materials. The UT examinations consist of a combination of a 2.25 Mhz 0 degree dual focused longitudinal wave and 45 degree and 70 degree dual focused refracted longitudinal wave search units. The 0 degree longitudinal wave is performed to detect any lack of bond areas between the weld and original parent materials, inter-bead lack of fusion, and any laminar type cracking within the base material of the examination volume. The 45 and 70 degree search units are used to detect welding defects such as cracks or lack of fusion between weld beads. The UT will be able to examine 70 percent of the surface and 83 percent of the heat affected zone (HAZ) in the base metal.

A mock-up, representative of the final repair configuration, was used to demonstrate the UT capability to detect indications at the triple point and for underbead cracking. A portion of the Midland RPV closure head, complete with a CRDM nozzle was used for the mock-up. The materials of the Midland RPV closure head and CRDM nozzles are very similar to those of Oconee Unit 2. This mock-up was machined and welded using the same processes that are being used for the described repairs.

IWA-4533 also specifies that the weld region shall undergo volumetric examination after the weld repair area has been at ambient temperature for a minimum of 48 hours. The 48-hour hold time is specified to assure that no delayed cold cracking in the ferritic steel HAZ has occurred. The weld consumables to be used in the new pressure boundary weld 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.

The Electric Power Research Institute (EPRI) performed tests where argon shielding gas was bubbled through a cylinder of water and then mixed with welding grade argon having a dew point of -70°F to produce a gas measure with dew point from -60°F to +60°F. The tests showed that welder grade argon can tolerate concentrations of moisture introduced during the welding process. This dew point produced hydrogen levels of 4.6 ml hydrogen per 100g of welded material. The EPRI work further showed that a (Code-required) 450°F post-weld heat soak would reduce the already low hydrogen content to infinitesimally small values. It takes 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 75 percent of any hydrogen that is present.

The geometry of the RPV head and the orientation of the inner bore of the CRDM nozzles make effective radiographic examination impractical. The thickness of the RPV head limits the sensitivity of the detection of defects in the new pressure boundary weld. The density changes between the base and weld metal and residual radiation from the base metal would render the film image inconclusive. It is proposed that examinations by the ultrasonic method be used in lieu of examinations by the radiographic method defined by IWA-4533.

6.0 EVALUATION

The licensee identified boron deposits on CRDM Numbers 4, 6, 18 and 30 nozzle-to-RPV head welds, which indicated leakage at these welds. The licensee performed VT and PT examinations on these welds and found one circumferential and 36 axial cracks. The cracks originated at the CRDM nozzle-to-weld interface and penetrated into the CRDM nozzles. The licensee removed the cracks by machining the CRDM nozzles to a location above the affected area. After verifying that the cracks were removed, the licensee re-established the pressure boundaries between the CRDM nozzles and RPV head with partial penetration welds. The welds were installed using a qualified temper-bead process.

The licensee used 152 Inconel (Alloy 690) weld material for the repairs, which constitutes dissimilar metal welds with the carbon steel RPV head material and the Alloy 600 CRDM nozzles. The repairs are for the remaining life of the RPV head that is scheduled to be replaced during refueling outage 20, approximately 3 years from now. The licensee determined that the resulting ASME Section III weld repairs could not be nondestructively examined (NDE) according to the requirements of 1989 Edition, Section III, Paragraph NB-5245 and the 1992 Edition, Section XI, Paragraphs IWA-4533 and IWA-4500(e)(2). The staff's evaluation of the licensee's proposed alternatives to the Code follows.

6.1 IWA-4533, Alternative to RT

The repaired configurations are not amenable to RT. RT is used to identify flaws by detecting changes in material density. These changes can be due to differences in thickness or physical density as compared to the surrounding material. RT is not appropriate for these repairs because the welds connecting the CRDM nozzle-to-RPV head are not full penetration welds. The gap between the CRDM nozzles and RPV head would mask flaws in that location, and the weld depth contour would vary, creating density changes. Also the repair welds to the CRDM nozzles are not accessible from two directions for film and source placement. In order to use RT, the CRDM nozzle-to-RPV head welds would have to be redesigned, which would result in extensive through-wall repairs that would subject the vessel to internal stresses and subject personnel to large radiation doses. Moreover, the results of an RT would be questionable because of density changes between the base and weld metal, and residual radiation from the base metal would render the film image inconclusive.

Instead of performing RT examinations, the licensee has proposed to examine the welds using UT and PT. UT is used to identify features that reflect sound waves. The degree of reflection depends largely on the physical state of matter on the opposite side of the reflective surface and, to a lesser extent, on specific physical properties of the matter (density). For example, sound waves are almost completely reflected at metal-gas interfaces and partially reflected at metal-to-solid interfaces. Discontinuities that act as metal-gas interfaces, such as cracks, laminations, shrinkage cavities, and bonding faults, are easily detected. Inclusions and other metal inhomogeneities can also be detected by partial reflection of the sound wave.

The proposed UT examinations will be performed using 0 degree, 45 degrees, and 70 degrees dual focus refracted longitudinal wave transducers. The 0 degree transducer is used to detect laminar flaws such as lack-of-bond between the weld and original parent material and inter-bead lack-of-fusion. The 45 and 70 degrees transducers are used to detect welding defects such as lack-of-fusion between weld beads and cracks perpendicular with the weld surface and cracks in the HAZ of the base metal. The UT examination is performed from the inside of the CRDM in two axial and two circumferential directions. The UT will essentially examine 70 percent of the weld surface, 83 percent of the HAZ in the base metal, and the weld metal in between these two locations. Essentially 100 percent of the weld volume and HAZ will be examined for circumferential flaws in one direction. For this configuration, the staff concludes that the UT examination will perform an acceptable alternative volumetric examination of the weld and HAZ.

6.2 IWA-4500(e)(2) and IWA-4533, Alternative Preheat Band Area

The licensee performed a post-weld heat treatment at a temperature of 300°F for 4 hours at the same area that was preheated (the lower post-weld heat treatment was authorized in request for relief No. 01-07). The purpose of the post-weld heat treatment is to allow dissolved gases from the welding process to escape the weldment. To keep the dissolved gases at a minimum, the licensee used a low hydrogen weld rod that was shielded in argon during the welding process in conjunction with the post-weld heat treatment.

To satisfy the PT examination requirement for the weld repair and preheated band area, the licensee proposed a PT of an alternative examination area redefined to accommodate the CRDM nozzles-to-RPV head weld configuration and welding technique (essential variables) for their specific application. This redefined area contained the weld repair, base metal HAZ, and a portion of the preheated band area. The portion of the preheat band area not examined was furthest away from the weld. The weld and portion of preheat area that the licensee did examine in conjunction with the other NDE examinations discussed herein would have revealed any evidence of cracking, if cracks were present.

6.3 IWA-4533, Alternative to 48-Hour Ambient Temperature

The 48-hour hold time after welding at ambient temperature before performing PT examinations requirement of the Code provides time for cold cracks and other latent cracking mechanisms to grow if conditions for cracking existed in the weldment. Cold cracks are hydrogen-induced cracks associated with multiple-pass welding that is applied with insufficient preheating of the base material or weld metal. Cold cracks are located in the HAZ of the weld bead layers and of the base material. The cracks occur from the effects of hydrogen embrittlement in predominantly martenistic, coarse-grain material that is subjected to internal stresses. They are short, shallow cracks positioned perpendicular to the weld bead direction and embedded below the weld/base metal surface. As residual hydrogen from the welding process diffuses into the cracks, they may grow and open to the surface. Since the cracks are both subsurface and surface breaking, the combination of UT and PT would increase the likelihood of detecting the cracks, as compared to just a PT examination. The licensee proposed alternative of post-weld heat treating the subject area for 4 hours at 300°F followed by a minimum 6-hour cool down to 125°F followed by a minimum 35-hour hold time before commencing UT and PT examinations would allow for the detection of any cracks that would be detectable by the 48-hour hold time at ambient temperature with a PT examination. Therefore, the proposed alternative will provide assurance that cracking will be detect, if present.

6.4 NB-5245, Alternative to Progressive Examination

The required progressive examination during the partial penetration welding process exposes NDE personnel to high radiation dosage. As an alternative to the Code-required examinations, the licensee proposed monitoring welding with a remote enhanced video camera system. The video camera is capable of resolving the image of a ½ mil diameter color contrast wire. Because the welding will be under constant surveillance, any abnormalities in the weld, such as slag, voids, and cracks would be observed. After completing the weld and allowing the weldment to cool to ambient temperature, the licensee examined at least 73 percent of the weld volume with UT and the weld + HAZ surface with PT. The examination performed during and after welding provides the assurance that flaws, if present, are detected.

6.5 Summary

The licensee stated that the RPV head will be replaced during refueling outage 20 that is tentatively scheduled for 2004. The current RPV head has been in service since 1973. It took 28 years for the environment at the partial penetration welds connecting the subject CRDM nozzles to the RPV head to develop through-wall cracks. The licensee intends to operate with the repaired CRDM nozzle-to-RPV head welds approximately one tenth of the time it took for the cracking to be detected in the original welds before replacing the RPV head on Unit 2. Therefore, the environment at the repaired CRDM nozzles-to-RPV head welds is not conducive to through-wall crack growth before the RPV head will be replaced by the licensee. The staff did not review the section of the submittal pertaining to the analytical model and associated calculations for formation and crack growth.

Based on the accumulative examinations of UT, PT, and VT as discussion above and the short time before Oconee Unit 2, replaces it RPV head, the staff believes that compliance with the Code requirements in NB-5245, IWA-4533, and IWA-4500(e)(2) of the selected CRDM nozzles-to-RPV head welds would result in hardship or unusual difficulty for the licensee without a compensating increase in the level of quality and safety. The licensee's proposed alternative will provide a reasonable alternative to Code-requirements for identifying detrimental flaws for the CRDM nozzles-to-RPV head weld configurations.

7.0 CONCLUSION

For the subject weld repairs to CRDM Nozzle Numbers 4, 6, 18 and 30, the staff concludes that compliance with the Code requirements to perform radiographic examinations of the weld volumes, liquid penetrant examination of the preheat area after a 48-hour hold time, and liquid penetrant examination during welding would result in hardship or unusual difficulty for the licensee without a compensating increase in the level of quality and safety. Therefore, pursuant 10 CFR 50.55a(a)(3)(ii), the staff authorizes the proposed alternative for Oconee Nuclear Station, Unit 2, subject CRDM nozzle-to-RPV head welds.

Principal Contributor: Donald G. Naujock

Date: June 13, 2001

cc:
Ms. Lisa F. Vaughn
Legal Department (PBO5E)
Duke Energy Corporation
422 South Church Street
Charlotte, North Carolina 28201-1006

Anne W. Cottingham, Esquire
Winston and Strawn
1400 L Street, NW
Washington, DC 20005

Manager, LIS
NUS Corporation
2650 McCormick Drive, 3rd Floor
Clearwater, Florida 34619-1035

Senior Resident Inspector
U. S. Nuclear Regulatory
Commission
7812B Rochester Highway
Seneca, South Carolina 29672

Virgil R. Autry, Director
Division of Radioactive Waste Management
Bureau of Land and Waste Management
Department of Health and Environmental
Control
2600 Bull Street
Columbia, South Carolina 29201-1708

Mr. Michael A. Schoppman
Framatome ANP
1911 North Ft. Myer Drive
Suite 705
Rosslyn, VA 22209

Mr. L. E. Nicholson
Compliance Manager
Duke Energy Corporation
Oconee Nuclear Site
7800 Rochester Highway
Seneca, South Carolina 29672

Ms. Karen E. Long
Assistant Attorney General
North Carolina Department of
Justice
P. O. Box 629
Raleigh, North Carolina 27602

Mr. C. Jeffrey Thomas
Manager - Nuclear Regulatory
Licensing
Duke Energy Corporation
526 South Church Street
Charlotte, North Carolina 28201-1006

Mr. Richard M. Fry, Director
Division of Radiation Protection
North Carolina Department of
Environment, Health, and
Natural Resources
3825 Barrett Drive
Raleigh, North Carolina 27609-7721

Mr. Peter R. Harden, IV
VP-Customer Relations and Sales
Westinghouse Electric Company
5929 Carnegie Blvd.
Suite 500
Charlotte, North Carolina 28209