UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

August 20, 2010

Mr. Eric McCartney, Vice President
H. B. Robinson Steam Electric Plant,
Unit No. 2
Carolina Power & Light Company
3581 West Entrance Road
Hartsville, South Carolina 29550-0790

SUBJECT: H. B. ROBINSON STEAM ELECTRIC PLANT, UNIT NO. 2–CORRECTION TO SAFETY EVALUATION OF RELIEF REQUEST NO. RR-22, REACTOR PRESSURE VESSEL BOTTOM MOUNTED INSTRUMENTATION PENETRATION INSPECTIONS (TAC NO. ME4037)

Dear Mr. McCartney:

By letter dated July 2, 2010, the U.S. Nuclear Regulatory Commission (NRC) staff issued a safety evaluation related to the NRC's authorization of a proposed alternative ultrasonic testing qualification process in lieu of American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section XI, Appendix VIII required by ASME Code Case N-722 (N-722), "Additional Examinations for PWR [pressurized-water reactor] Pressure Retaining Welds in Class 1 Components Fabricated with Alloy 600/82/182 Materials, Section XI, Division 1." N-722 is endorsed in Title 10 of the *Code of Federal Regulations*, Section 50.55a(g)(6)(ii)(E)(1). The NRC's safety evaluation was in response to your request dated June 7, 2010, as supplemented by letters dated June 14, and June 29, 2010.

Subsequently, your staff notified the NRC of statements in the safety evaluation that required clarification. Although the visual examinations of the bottom mounted instrumentation nozzles identify leaking j-groove welds as well as defects in the nozzles (indicated by the presence of boric acid formations on the surface of the nozzles), the surface of the j-groove welds themselves are not visible during the visual examinations. A corrected safety evaluation is enclosed.

The corrections do not change the authorization of the requested relief or the conclusion reached by the associated safety evaluation. If you have any questions, please contact me at 301-415-2788.

Sincerely,

Tracy Orf, Project Manager
Plant Licensing Branch II-2
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-261

Enclosure:
Corrected Safety Evaluation

cc w/enclosure: Distribution via Listserv

UNITED STATES
NUCLEAR REGULATORY COMMISSION
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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO RELIEF REQUEST NO. RR-22

FOR THE FOURTH 10-YEAR INSERVICE INSPECTION INTERVAL

BOTTTOM MOUNTED INSTRUMENTATION PENETRATION INSPECTIONS

CAROLINA POWER & LIGHT COMPANY

H. B. ROBINSON STEAM ELECTRIC PLANT, UNIT NO. 2

DOCKET NO. 50-261

1.0 INTRODUCTION

By letter dated June 7, 2010 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML101600320), and supplemented by letters dated June 14, 2010 (ADAMS Accession No. ML101680404), and June 29, 2010, Carolina Power and Light Company, the licensee, doing business as Progress Energy Carolinas (PEC), submitted relief request RR-22 from certain qualification requirements of the American Society of Mechanical Engineers (ASME), Boiler and Pressure Vessel Code (Code), Section XI, "Rules for Inservice Inspection (ISI) of Nuclear Power Plant Components," at H.B. Robinson Steam Electric Plant, Unit 2 (HBRSEP). Specifically, PEC proposed an alternative ultrasonic testing (UT) qualification process in lieu of ASME Code, Section XI, Appendix VIII (Appendix VIII) required by ASME Code Case N-722 (N-722), "Additional Examinations for PWR [pressurized-water reactor] Pressure Retaining Welds in Class 1 Components Fabricated with Alloy 600/82/182 Materials, Section XI, Division 1." N-722 is endorsed in Title 10 of the *Code of Federal Regulations* (10 CFR) 50.55a(g)(6)(ii)(E)(1). The request is for the fourth 10-year inservice inspection (ISI) interval refueling outage 26 that began in April 2010.

2.0 REGULATORY REQUIREMENTS

Inservice inspection of ASME Code Class 1, 2, and 3 components is to be performed in accordance with Section XI of the ASME Code, and applicable addenda, as required by 10 CFR 50.55a(g), except where specific relief has been granted by the Commission pursuant to 10 CFR 50.55a(g)(6)(i). The regulation at 10 CFR 50.55a(a)(3) states that alternatives to requirements of paragraph (g) may be used, when authorized by the NRC, if PEC demonstrates that: (i) the proposed alternatives 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. PEC submitted the subject request for authorization of an alternative, pursuant to 10 CFR 50.55a(a)(3)(ii).

Pursuant to 10 CFR 50.55a(g)(4), ASME Code Class 1, 2, and 3 components (including supports) must meet the requirements, except the design and access provisions and the preservice examination requirements, set forth in the ASME Code, Section XI, 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, which was 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 ASME Code of Record for HBRSEP is the 1995 Edition with 1996 Addenda of Section XI.

3.0 LICENSEE'S PROPOSED ALTERNATIVE

3.1 ASME Code Component Affected

The ASME Code components affected by PEC's proposed alternative are the (50) reactor vessel bottom mounted instrument (BMI) nozzles at HBRSEP.

3.2 ASME Code Requirements

10 CFR 50.55a(g)(6)(ii)(E)(1) states, in part, "All licensees of pressurized water reactors shall augment their ISI program by implementing N-722."

Footnote 1 to 10 CFR 50.55a(g)(6)(ii)(E) requires that "For inspections to be conducted every refueling outage and inspections conducted every other refueling outage, the initial inspection shall be performed at the next refueling outage after January 1, 2009. For inspections to be conducted once per interval, the inspections shall begin in the interval in effect on January 1, 2009, and shall be prorated over the remaining periods and refueling outages in this interval."

N-722, Table 1, Footnote 5, states that "An ultrasonic examination (UT), performed from the component inside or outside surface in accordance with the requirements of Table IWB-2500-1 and Appendix VIII (1995 Edition with the 1996 Addenda or later) shall be acceptable in lieu of the [visual examination] VE requirements of this table."

3.3 Duration of the Alternative

HBRSEP requested approval of this alternative for use in the fourth 10-year ISI interval, refueling outage 26.

3.4 Licensee's Proposed Alternatives to ASME Code Case N-722

PEC will examine the BMI head penetration nozzle from the inside surface using UT examination techniques. Instead of qualifying the UT examination technique in accordance with the requirements of ASME Section XI, Appendix VIII (1995 Edition with the 1996 Addenda or later) as required by N-722, PEC proposed using UT techniques that were demonstrated by the vendor at the Electric Power Research Institute (EPRI) Nondestructive Examination (NDE) Center. These UT techniques are described in EPRI's Materials Reliability Program (MRP) document: MRP-166, "Demonstration of Equipment and Procedures for the Inspection of Alloy 600 Bottom Mounted Instrumentation (BMI) Head Penetrations," dated March 2006. PEC's vendor (AREVA) supplemented MRP-166 with an equivalency demonstration that is described in the vendor's document 51-9137268-000.

The equivalency demonstration compared MRP-166 demonstrations performed from the inside diameter (ID) surface on 0.600-inch bore, BMI mockups with demonstrations performed from the ID surface on 0.460-inch bore, BMI mockups.

3.5 Licensee's Reason for Request

The applicable N-722 VE requirement cannot be performed on all BMI nozzles due to the presence of corrosion products and boric acid residue that was determined to be previously identified leakage from the reactor cavity. The residue is broad and diffuse and has the appearance of a film with no significant dimensions. There are no formations of popcorn, stalactites, balls, or spaghetti that would indicate an active boric acid leak from the penetration. The existence of corrosion products and boric acid residue masked the area of VE interest on 16 of the 50 BMI nozzles. Cleaning the surface for a VE would incur increased dose by plant personnel and result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

N-722 provides a UT option, although Appendix VIII provides no supplement for BMI qualification of procedures, equipment, and personnel. Relief from ASME Code, Section XI, Appendix VIII (Appendix VIII) is requested on the basis that no Appendix VIII supplement exists For PEC to comply with N-722 UT requirement, the ASME Code would have to develop and approve a new Appendix VIII supplement for BMI configurations using a time consuming consensus process. The absence of Appendix VIII qualification criteria for BMI nozzle configurations has created an industry problem in satisfying the timeliness for completing the required BMI examinations. PEC complemented the 34 successful VE with UT examinations of all 50 BMI nozzles from the inside diameter.

PEC has contacted the EPRI NDE Center to request they consider a performance demonstration initiative to address the absence of BMI qualification criteria in Appendix VIII. EPRI is an industry initiative for resolving issues associated with the domestic nuclear power plants. Extending HRBSEP's current outage, while the industry is developing a supplement for Appendix VIII BMI qualifications, would result in a hardship and unusual difficulty without a compensating increase in the level of quality and safety.

3.6 Licensee's Basis and NRC Staff's Evaluation

The BMI nozzle configuration consists of an austenitic nozzle penetrating through the bottom head of a reactor pressure vessel (RPV). The nozzle is j-groove welded to the RPV inside surface using austenitic weld metal. The material commonly used for BMI nozzle is Alloy 600 and for the welding is Alloy 82/182. This material is susceptible to primary water stress-corrosion cracking (PWSCC) in PWRs. To mitigate PWSCC in BMI's, the industry developed N-722, which provides examination requirements. N-722 has VE requirements with the option of using UT volumetric in lieu of VE.

PEC is examining the BMI nozzles with UT performed from the inside nozzle surface. N-722 requires that UT satisfy Appendix VIII requirements. Appendix VIII provides performance demonstration criteria for screening procedure capabilities and personnel UT skills. Appendix VIII qualifications are based on performance demonstrations that consist of representative mockups containing a statistically significant number of representative flaws conducted as a blind performance demonstration that is overseen by an independent third party. The performance demonstration results are screened against uniform acceptance criteria and recorded for future referencing. Procedures and personnel satisfying the acceptance criteria are qualified. The procedure qualification also includes the equipment used for the performance demonstration (i.e., make, model, manufacturer, and control settings).

Currently, Appendix VIII has 14 supplements qualifying the UT examination techniques in different applications. However, none of the supplements are applicable to small diameter, BMI nozzle configurations. PEC proposed following the technical guidance of MRP-166 as modified for smaller bore nozzles. MRP-166 uses a methodology similar to the above-described Appendix VIII methodology.

3.6.1 Demonstration Mockups and Process

PEC proposed using examination techniques demonstrated on 0.600-inch bore, BMI nozzle mockups constructed to simulate in the field configurations. The demonstrations were documented in MRP-166. The demonstration was independently administered by EPRI personnel at AREVA's facility. The process was separated into two demonstration phases: an open phase and a blind phase. During the open phase, AREVA was allowed access to the flaw information in one open mockup and a partial-scale mockup with discontinuities in the nozzle and weld volumes. The purpose of the open phase was for AREVA to develop their UT procedures. Data collected on the open mockups were reviewed by EPRI personnel to determine if AREVA was prepared to continue with the blind phase of the demonstration. These open mockups included configurations that represented the Westinghouse 3 and 4 loop plant designs. The BMI nozzle mockups used for the blind demonstration included a full-scale mockup for the Westinghouse 3 and 4 loop designs. HBRSEP uses a Westinghouse 3 loop design.

To represent field conditions, the mockups were fabricated with realistic weld geometries and distortion caused by the J-groove welding. The mockups were manufactured at the EPRI NDE Center using a combination of electrical discharge machining (EDM) and cold isostatic processing (CIP), to simulate the acoustic responses of actual cracks. These mockups contained both axial and circumferential oriented cracks which were located in critical locations from a structural and leakage integrity perspective. Specifically, the cracks were located in the penetrating nozzle above, below, and over the j-groove weld. The mockups contained cracks originating from the ID and outside diameter (OD) nozzle surfaces. The crack lengths were 70 mm (2.76 inches) and less, and the crack depths ranged up to 100% through-wall.

The j-groove weld itself is not part of the demonstrations. To include j-groove weld in the demonstration would necessitate new mockups with representative cracks, and PEC's vendor would have had to develop UT techniques for examining the j-groove weld. Extending the current outage to develop mockups and examination techniques for a UT demonstration of the j-groove weld would result in a hardship and unusual difficulty for PEC without a compensating increase in the level of quality and safety.

The manufacturing process for creating representative cracks using CIP to squeezed EDM notches was previously demonstrated to deliver UT responses similar to those of real flaws removed from service. By a letter dated March 26, 2008, EPRI provided EPRI Report 1015143: "Nondestructive Evaluation: Comparison of Field and Manufactured Flaw Data in Austenitic Materials," that contained information on comparing UT CIP notch responses to PWSCCs in a control rod drive mechanism nozzle penetration at the Bugey Nuclear Power Plant in France. When the UT CIP squeezed EDM notch responses were compared with a PWSCC flaw from the Bugey plant, they were found to give similar forward scatter time-of-flight diffraction (TOFD) UT responses. Typically, the radius of the squeezed CIP EDM notch tips used in control rod drive mechanism nozzle mockups and BMI mockups are 10 microns, which is smaller than the notch tips required by ASME Section XI, Appendix VIII. The amplitude of the UT tip responses varied only slightly. This was determined to be primarily due to minor variations in surface condition and UT coupling. The signal-to-noise ratios were also very similar. There was only a small difference observed between the echo-dynamic characteristics of the simulated and field-removed cracks.

PEC determined that UT techniques demonstrated in MRP-166 were effective in detecting and sizing BMI tube ID and OD initiated cracks as well as locating cracks with respect to the j-groove weld connecting the nozzle to the RPV bottom head but not in the j-groove weld. The MRP-166 demonstration was conducted from the ID on 0.600-inch bore, BMI nozzle mockups. The HBRSEP Westinghouse 3 loop design has 0.460-inch bore, BMI nozzles. To demonstrate equivalency, AREVA used the same scanning equipment from the MPR-166 demonstrations but changed the transducers design for 0.460-inch bore, BMI nozzles. The 0.460-inch bore transducer responses were initially demonstrated on a calibration block containing 12 notches that were orientated axially and circumferentially at various depths from the OD and ID. A blind demonstration was performed on a 0.460-inch bore, BMI nozzle mockup that contained a number of different crack types for evaluating examination effectiveness. PEC concluded that the blind demonstration was effective but could use further development to optimize length and through-wall extent sizing.

Based on this information, the NRC staff believes that the mockups were representative of PWR BMI nozzles for detecting PWSCC. The cracks built into the blind 0.460-inch bore, BMI mockup represented the range of cracks that could affect structural integrity. The crack types produce responses representative of actual PWSCC. The use of blind demonstrations on representative mockups using representative cracks evaluated by an independent third (EPRI) party is similar to the methodology applied by Appendix VIII.

3.6.2 TOFD UT Inspection Techniques

During all of the BMI nozzle performance demonstrations, the volumetric inspections were performed by AREVA using time of flight diffraction (TOFD) UT techniques. The UT technique's probe has two TOFD transducer pairs; one for the axial beam, and the other for the circumferential beam directions. Each transducer pair utilizes transmitting and receiving transducers that are arranged to insonify the entire BMI nozzle wall. The energy from the transmitting transducer is diffracted or reflected from crack tips that send a portion of the energy to the receiving transducer. The returned energy is then analyzed by an experienced TOFD ASME Code qualified analysis. Crack detection and sizing is determined by measuring the travel time of the diffracted signals off of the crack tips. From the known geometry of the probe set up and measured beam path lengths, the location of the crack tips can be determined by geometrical calculations. The TOFD UT technique uses axial beams for detecting circumferential cracks and circumferential beams for detecting axial cracks.

The AREVA TOFD UT technique is sensitive to both ID and OD initiated cracks in the BMI nozzles. A lateral wave is used to detect surface breaking cracks on the ID. The TOFD energy wave creates a strong back wall reflection off of the OD that is monitored for evidence of OD initiated cracks. The portion of OD tubing connected to the j-groove weld is reviewed for evidence of diffracted crack signals.

The data is collected using an automated UT system and scanner that encodes the probe position and integrates this information with the TOFD data. The data is used to develop displays of the returned energy for an analyst to identify and characterize detected cracks, if any.

The NRC staff considers TOFD UT inspection techniques appropriate for detecting potential ID or OD initiated cracks in BMI nozzles. These techniques have been successfully used for inspection of control rod drive mechanism nozzle configurations which are similar to the smaller bore BMI nozzles.

3.6.3 Demonstration Results

The blind demonstration using AREVA's TOFD UT technique on Westinghouse 3 and 4-loop nozzle mockups resulted in the detection of all cracks greater than 10% through-wall. This included ID and OD connected cracks ranging to 100% through-wall extent. The AREVA TOFD UT technique was demonstrated to be successful in determining the orientation of all cracks longer than 0.2-inch, but was inconsistent in determining the orientation of shorter cracks. The AREVA TOFD UT technique was able to locate the cracks reasonably close to their true location. The blind demonstration on the 0.460" bore, BMI mockup indicated that crack length and through-wall extent sizing could use further development to optimize crack orientation and location.

The NRC staff considers that the most important attribute for inspection of components susceptible to PWSCC is detection. Due to the high growth rate of PWSCC, any BMI nozzle that is determined to have PWSCC would require further evaluation and possible repair since it would be difficult to justify continued operation along with the burden of successive inspections. The NRC staff has concluded from the results of the AREVA TOFD UT technique demonstration that there is reasonable assurance that UT would be capable of detecting detrimental PWSCC and would provide reasonable assurance of structural integrity of the BMI nozzle configurations.

3.6.4 Recording Criteria

The recording criteria are defined in detail in the AREVA examination procedure. Indications detected within the nozzle wall are considered recordable indications. Guidance is provided for discrimination between PWSCC type responses and fabrication flaw (including cracks) responses. The characteristics, orientation, and location of flaws (including cracks) relative to the j-groove weld fusion line are used for discriminating between fabrication and service-related flaws (including cracks). Cracks that disrupt the lateral wave or produce backwall responses are reported. Cracks in the nozzle wall adjacent to the j-groove weld are also recorded. Flaws (including cracks) are dispositioned as either fabrication flaws or service-related cracks. Fabrication flaws and service-related cracks were in the MRP-166 mockups that were used by AREVA to demonstrate their TOFD UT technique.

The NRC staff considers the criteria for recording and distinguishing between service-related cracks and fabricated flaws (including cracks) to be logical and appropriate. The existence of service-related cracks would require licensee action and a record of fabricated flaws (including cracks) would provide information useful for future examination result comparisons. These criteria are consistent with criteria NRC staff has previously determined to be acceptable.

3.6.5 Personnel Training

PEC provided information to the NRC staff on the training and qualification requirements for TOFD UT data acquisition and analysis personnel. Data analysis personnel are qualified to have a minimum UT Level II certification in accordance with AREVA's written practice and have documented training in the TOFD UT technique or a valid performance demonstration qualification for an automated UT procedure using the TOFD UT technique.

- BMI acquisition personnel receive a minimum of 16 hours of documented training that covers the setup and operation of the TOFD UT equipment in accordance with the examination procedure.

- BMI analysis personnel receive a minimum of 16 hours of documented training on reactor head penetration nozzle examination techniques or have a minimum of 200 hours of documented reactor head penetration nozzle analysis experience. Data analysis personnel are required to demonstrate an understanding of the techniques described within the procedure and the ability to perform data analysis to the satisfaction of a Level III examiner experienced in the reactor head penetration nozzle analysis.

Although Appendix VIII specific requirements for BMI nozzle qualifications are not in existence, the certification and training provided BMI nozzle examiners using the AREVA TOFD UT technique require skills and knowledge similar to an Appendix VIII qualification. These examiners should be capable of qualifying to an Appendix VIII performance demonstration screening criteria, if one existed. PEC's certification and training requirements for Level II and III examiners of BMI nozzles provide a level of proficiency that could rival an Appendix VIII qualification and is acceptable.

3.6.6 Procedures

The MRP-166, 0.600-inch bore, BMI nozzle, open mockup demonstrations were used to develop the inspection procedures and the blind demonstrations were used to show procedure effectiveness (procedure 54-ISI-167-00, "Remote Ultrasonic examination of Bottom Reactor Head Penetrations," and revision 54-ISI-167-01). The lessons learned during these demonstrations were used to update the procedure (54-ISI-167-02) in July 2004. Since the demonstration in 2004, upgrades were made to the UT system software and instrument hardware. These changes did not affect the essential variables used during the MRP-166 demonstrations.

For the current examination, a revision to the procedure was made that incorporated the smaller 0.460-inch bore, BMI nozzle (latest revision 54-ISI-167-03). The revised procedure was used for open and blind demonstrations on 0.460-inch bore, BMI mockups. The 0.460-inch bore, BMI mockup demonstrations were used for a comparison study of equipment, technique, and procedure capabilities with the capabilities that AREVA demonstrated on the larger 0.600" BMI mockups. The comparison was documented in AREVA document 51-9137268-000, "Capability Study." Based on this comparison, PEC concluded that the probe in the demonstration of the 0.460-inch bore nozzle and associated equipment settings produced equivalent results as the probe used for the 0.600-inch bore nozzle demonstrations.

Since the procedure was demonstrated on a 0.460-inch bore BMI mockup containing representative cracks administered as a blind test by an independent third party, the staff considers the AREVA TOFD UT procedure (54-ISI-167-03) acceptable.

4.0 CONCLUSION

Based on the above discussion, the VE performed on 34 of the BMI nozzle surfaces, the limited VE of the remaining 16 BMI nozzle surfaces, and the proposed UT qualification alternative described in RR-22 for examinations performed from the ID on all fifty (50) 0.460-inch bore BMI nozzles in lieu of the UT requirement in N-722 for Appendix VIII qualification will provide reasonable assurance of structural integrity of the BMI nozzle configurations. Applying the examination requirements of N-722 (removing the existing corrosion products for the BMI surfaces that resulted from reactor cavity leakage in order to perform complete VE of the nozzle surfaces or to conduct volumetric nozzle examinations using Appendix VIII qualified UT techniques) would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety. Pursuant to 10 CFR 50.55a(a)(3)(ii), the staff authorizes the proposed alternative, RR-22, for HBRSEP. This alternative applies to the fourth 10-year ISI interval, Refueling Outage 26.

All other ASME Code, Section XI requirements for which relief was not specifically requested and approved in this relief request remain applicable, including third party review by the Authorized Nuclear Inservice Inspector.

Principal Contributor: Donald G. Naujock

Date: August 20, 2010

The corrections do not change the authorization of the requested relief or the conclusion reached by the associated safety evaluation. If you have any questions, please contact me at 301-415-2788.

Sincerely,

/RA/

Tracy Orf, Project Manager
Plant Licensing Branch II-2
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-261

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Corrected Safety Evaluation

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