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

August 26, 2009

Mr. J. R. Morris
Site Vice President
Catawba Nuclear Station
Duke Energy Carolinas, LLC
4800 Concord Road
York, SC 29745

SUBJECT: CATAWBA NUCLEAR STATION, UNIT 2, REQUEST FOR RELIEF 09-CN-002 REGARDING WELD BUILDUP ON REACTOR VESSEL HOT-LEG NOZZLES (TAC NO. ME1073)

Dear Mr. Morris:

By letters to the U.S. Nuclear Regulatory Commission (NRC), dated April 2, 2009, as supplemented by letter dated April 7, 2009, Duke Energy Carolinas LLC (the licensee), submitted Request for Relief (RR) No. 09-CN-002, which requested NRC staff approval to utilize an alternative to certain requirements of the American Society of Mechanical Engineers (ASME) *Boiler and Pressure Vessel Code* (Code) Case N-638-1 to apply weld buildup on three of the four reactor vessel hot-leg nozzles at Catawba Nuclear Station, Units 1 and 2 (Catawba 1 and 2). The ASME Code of record for the current third 10-year inservice inspection (ISI) interval at Catawba 1 and 2 is Section XI, 1998 Edition, through 2000 addenda. This is the edition for the Repair/Replacement and ISI Programs.

The NRC staff has reviewed the licensee's submittal and, based on the information provided in the licensee's RR, the NRC staff has determined that the proposed alternative provides an acceptable level of quality and safety. Therefore, pursuant to Title 10 of the *Code of Federal Regulations*, Part 50, Section 50.55a(a)(3)(i), the NRC staff authorizes the use of the proposed alternative to install weld buildup on the hot-leg nozzles B, C, and D at Catawba Unit 2.

All other requirements of ASME Code, Section XI, for which relief has not been specifically requested, remain applicable, including third-party review by the Authorized Nuclear Inservice Inspector.

Verbal relief was authorized by the NRC staff for Catawba 2 during a teleconference with the licensee on April 8, 2009.

If you have any questions, please call Jon Thompson of my staff at 301-415-1119.

Sincerely,

Undine Shoop, Acting Chief
Plant Licensing Branch II-1
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket Nos. 50-414

Enclosure:
As stated

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

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

OF THIRD 10-YEAR INTERVAL INSERVICE INSPECTION

REQUEST FOR RELIEF NO. 09-CN-002

DUKE ENERGY CAROLINAS, LLC

CATAWBA NUCLEAR STATION, UNIT 2

DOCKET NOS. 50-414

1.0 INTRODUCTION

By letters to the U.S. Nuclear Regulatory Commission (NRC) dated April 2, 2009 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML090970285), and April 7, 2009 (ADAMS Accession No. ML091000654), Duke Energy Carolinas, LLC (the licensee), submitted Request for Relief (RR) 09-CN-002 to allow modifications to certain requirements of Code Case N-638-1 of the American Society of Mechanical Engineers (ASME) *Boiler and Pressure Vessel Code* (Code), Section XI, to apply weld buildup on three of the four reactor vessel hot-leg nozzles at Catawba Nuclear Station, Unit 2, (Catawba 2) during the Spring 2009 refueling outage (end of cycle 16).

By letters dated November 6, 2008 (ADAMS Accession No. ML083150630), and January 16, 2009 (ADAMS Accession No. ML090230172), the licensee submitted RR 09-CN-002 to install full structural weld overlays (FSWOLs) on Alloy 82/182 dissimilar metal butt welds (DMWs) of the reactor pressure vessel (RPV) hot-leg nozzles at Catawba 2. The licensee proposed to apply FSWOLs to the four DMWs, part of nozzles and pipe, and safe ends during the Catawba 2 Spring 2009 refueling outage. During the initial weld overlay installation, the licensee found cracking in the Alloy 52M and/or buffer layer on the safe end and pipe side of the hot-leg nozzle configuration. The licensee decided to cease the overlay installation.

Subsequently, the licensee ultrasonically examined (UT) the DMWs to satisfy industry commitments per "Material Reliability Program, Primary System Piping Butt Welds Inspection and Evaluation Guideline (MRP-139)," July, 2005, Electric Power Research Institute (EPRI). To facilitate a qualified UT examination, the licensee removed applied weld deposit over the DMW to allow access from the outside diameter of RPV hot-leg nozzles. The licensee removed all weld deposits on RPV hot-leg nozzle A. However, to minimize excessive personnel radiation dose, the licensee proposed to leave a portion of the deposited weld metal on the external surface of the RPV hot-leg nozzles B, C, and D.

A DMW is a weld that joins two pieces of metals that are not of the same material. In the proposed alternative, the dissimilar metal weld joins the ferritic reactor vessel hot-leg nozzle to the austenitic stainless steel safe end. The dissimilar metal weld itself is made of nickel-based Alloy 82/182 material.

2.0 BACKGROUND

Pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) Section 50.55a(g)(4), Class 1, 2, and 3 components (including supports) of the ASME Code must 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 (ISI) 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.

Pursuant to 10 CFR 50.55a(a)(3) alternatives to requirements may be authorized by the NRC staff if the licensee 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.

The ASME Code of record for the current third 10-year ISI interval at Catawba 2 is Section XI, 1998 Edition, through 2000 addenda for the Repair/Replacement and ISI Program.

3.0 REGULATORY EVALUATION

3.1 RR 09-CN-002

3.1.1 ASME Code Components Affected

The ASME Code components associated with this request are the RPV hot-leg nozzles B, C, and D. The affect piping is ASME Class 1 component. The examination is Category B-P and the Code Item Number is B 15.10 for pressure retaining boundary. No relief is requested from the pressure retaining boundary testing requirements. This alternative is to apply weld buildup on the three RPV hot-leg nozzles. The applicable items and descriptions are:

Component	System	Pipe Size	Comment
RPV Hot-Leg Nozzle	B Loop	Nominal 29" ID, 2.625 " wall thickness	LAS nozzle/ Alloy 81-182 weld /SS safe end
RPV Hot-Leg Nozzle	C Loop	Nominal 29" ID, 2.625 " wall thickness	LAS nozzle/ Alloy 81-182 weld /SS safe end
RPV Hot-Leg Nozzle	D Loop	Nominal 29" ID, 2.625 " wall thickness	LAS nozzle/ Alloy 81-182 weld /SS safe end

LAS = low alloy steel, SA-508 Class 2 (P-3). SS = stainless steel.

3.1.2 Applicable Code Edition and Addenda

Catawba 2 is currently in the third 10-year ISI interval. The ASME Code of record for the current 10-year ISI interval is Section XI, 1998 Edition through 2000 Addenda. This is also the edition used for the Repair/Replacement Program.

3.1.3 Applicable Code Requirement

ASME Code, Section XI, 1998 Edition through 2000 Addenda, Article IWA-4000, "Repair/Replacement Activities".

ASME Code, Section III, 1974 Edition, no Addenda for Catawba 2 Class 1 piping.

ASME Code, Section III, 1971 Edition through Winter 1972 Addenda for Catawba 2 Reactor Vessel design and fabrication.

ASME Code, Section III, 1989 Edition No Addenda – Duke Welding Program for all units at all sites.

3.1.4 Proposed Alternative

The licensee proposed to use Code Case N-638-1 as an alternative to the requirements of ASME Code, Sections III and XI. In applying the code case, the licensee proposed three modifications to Code Case N-638-1 for the weld buildup on the subject nozzles. The weld buildup will meet applicable design rules of ASME Section XI and the Construction Code as required by IWA-4000 of the ASME Code, Section XI. Welding and examination requirements for the weld deposits will meet the requirements of ASME Code Case N-638-1 with the three modifications as discussed in Attachment 1 of the submittal dated April 2, 2009.

3.1.5 Duration

The weld was deposited on the subject hot-leg nozzles at Catawba 2 at the end of cycle 16 during the spring 2009 refueling outage.

3.2 <u>NRC Staff Technical Evaluation</u>

The weld buildup on the RPV hot-leg nozzles was deposited based on the ambient temperature temper bead welding per Code Case N-638-1. When applying this code case, the licensee deviated from three requirements of the code case with modifications which are discussed below.

Modification 1

Code Case N-638-1, paragraph 1.0(a), limits the maximum area of an individual weld covering ferritic base metal to 100 square inches. In Attachment 1 to the RR, the licensee proposed to limit the surface area to 500 square inches. In the April 7, 2009, letter, the licensee stated that the width of the weld deposit on the nozzle was originally predicted to be about 3.5 inches. The adjacent weld deposit to the DMW was removed for approximately 1.5 inches to facilitate the ultrasonic examination. Therefore, the width of the remnant weld deposit on the nozzles is about 2 inches. Multiplying the width to the circumference of the nozzle, the total weld buildup area on the subject nozzles is about 200 square inches.

The industry's technical basis for a larger weld surface area than the 100-square-inch area is provided in "Justification for the Removal of the 100 Square Inch Limitation for Ambient

Temperature Temper Bead Welding on P-3 Material", EPRI-NP-1011898, February 2005. The report describes the technical justification for allowing increased overlay areas up to 500 square inches. The report notes that the original limit of 100 square inches in Code Case N-638-1 was arbitrary. It cites evaluations of a 12-inch diameter nozzle weld overlay to demonstrate adequate tempering of the weld heat affected zone, residual stress evaluations demonstrating acceptable residual stresses in weld overlays ranging from 100 to 500 square inches, and service history in which weld repairs exceeding 100 square inches were NRC staff-approved and applied to DMW nozzles in several boiling-water reactors and pressurized-water reactors. Some of the cited repairs are greater than 15 years old, and have been inspected several times with no evidence of any continued degradation.

EPRI Report 1014351, "Repair and Replacement Applications Center: Topical Report Supporting Expedited NRC Review of Code Cases for Dissimilar Metal Weld Overlay Repairs, December 2006," also provided basis for the larger weld area. Additional justification provided in the presentation slides entitled, "Bases for 500 Square Inch Weld Overlay Over Ferritic Material," was provided to the NRC staff in a public meeting held on January 10, 2007, (ADAMS Accession No. ML070470565). The industry provided results of finite element analyses demonstrating that the stresses of a nozzle with the 500-square inch weld area will not adversely affect the integrity of the pressurizer nozzle. Based on a review of the information provided, the NRC staff finds that the proposed 500-square-inch weld area limit over the ferritic base metal is acceptable.

Modification 2

Code Case N-638-1, paragraph 4.0(b), requires that the final weld surface and a band around the area defined in paragraph 1.0(d) of the code case be examined using a surface and UT method when the completed weld has been at ambient temperature for at least 48 hours. Code Case N-638-1, paragraph 1.0(d), requires that prior to welding the area to be welded and a band around the area of at least 1.5 times the component thickness or 5 inches, whichever is less shall be at least 50 degrees F. The proposed modification specifies that the required liquid penetrant examination of paragraph 4.0(b) be performed only on the weld deposit, not the base metal area surrounding the weld buildup.

The NRC staff questioned the licensee why the base metal area surrounding the weld buildup will not be inspected in light of hot cracking found at the toe of the weld overlay during the installation. In the April 7, 2009, letter, the licensee responded that a liquid penetrant test (PT) was performed on the remnant weld and adjacent base metal over an area at least ½ inch inboard and outboard of the weld deposit. The NRC staff found that surface examination of the ½ inch inboard and outboard of the weld deposit is acceptable because the NRC staff finds that the ½ inch base metal area will provide sufficient area for the detection of potential cracking in the base metal and weld metal. The NRC staff has accepted the same ½-inch examination area in weld overlay RRs from other licensees.

Modification 3

Code Case N-638-1, paragraph 4.0(c) requires temperature monitoring by welded thermocouples per IWA-4610(a) of the ASME Code, Section XI. The licensee did not use thermocouples to monitor weld interpass temperature. Instead, the proposed modification specifies that preheat and interpass temperature for the weld pad will be measured on a test coupon that is equal to or less than the thickness of the item to be welded. The maximum heat input of the welding procedure shall be used in the welding of the test coupon. The licensee stated that this modification is necessary because due to the location of the repair and area radiation dose rate, the placement of welded thermocouples for monitoring weld interpass temperature is determined to be not beneficial based on dose savings.

In NRC staff-approved weld overlay RRs from other licensees, the NRC staff has required the use of direct temperature measurements (e.g., pyrometers, temperature indicating crayons, and thermocouples). If direct measurement is impractical, the NRC staff has allowed the use of heat-flow calculations or test coupons to obtain interpass temperature measurements. The NRC staff does not object to the use of test coupons for the preheat and interpass temperature at Catawba 2 because of high radiation dose concerns. Therefore, the NRC staff finds Modification 3 acceptable.

In addition to the above three modifications, the licensee also provided the following information regarding the remnant weld overlay.

The licensee stated that three layers of Alloy 52M filler material were applied using an ambient temper bead weld technique on RPV hot-leg nozzles B, C, and D. The licensee's initial plan was for these layers to extend approximately 3.5 inches axially on the nozzle upstream from the DMW. This surface was subsequently prepared for a liquid PT and UT examination and is, therefore, less than the nominal three layer thickness.

The licensee performed PT and UT on the remnant weld deposit on the nozzles and found no recordable or rejectable indications at these locations. The acceptance criteria for the UT were in accordance with NB-5330 of the ASME Code, Section III. The acceptance criteria for the PT were in accordance with NB-5350 of the ASME Code, Section III.

The licensee also inspected the DMW, similar metal welds, safe ends, and pipe associated with the hot-leg nozzles after the weld overlays were removed from their surfaces. The licensee stated that there were no recordable or rejectable indications identified in the DMW, base materials, safe-ends, or piping. The inspection results have been dispositioned in accordance with ASME Code and industry commitments.

The licensee performed analyses to satisfy the allowable stresses of ASME Code, Section III, to ensure the subject nozzles are left in an acceptable condition. The Section III stress calculation provided a bounding condition for the remnant weld overlay on the three hot-leg nozzles. This allows some flexibility in the field to minimize dose-intensive hand grinding so that the in-field conditions are acceptable within the bounding condition. This bounding condition included angle of slope of the toe of the remnant weld. The Section III stress calculation included bounding information on the amount of overlay material to remain on any hot-leg nozzle. The Section III stress calculations will be available onsite for review prior to Mode 4 operation.

The NRC staff had a concern about the slopes at the toe of the remnant weld because a slope with a large angle with respect to the outside surface of the nozzle at the toe is not desirable as it may cause stress concentrations. In the April 7, 2009, letter, the licensee stated that the taper at the end of weld buildup, if greater than 30 degrees, will be analyzed in accordance with

ASME Section III. The calculation will include analysis to support the use of slopes at the toe of the weld greater than 30 degrees to ensure that the toe of the weld is within ASME Code-allowable conditions. The licensee stated that the ASME stress analysis bounds the worst as left taper at the toe of the weld remnant.

As an independent verification, the NRC staff asked the licensee the weight of the weld buildup on the subject nozzles. In the April 7, 2008, letter, the licensee stated that the remaining weld deposit is expected to be on the order of 2 inches long by 0.275 inches thick and extends for the full circumference of the pipe. For a density of 0.293 pounds/cubic inch, an approximate 200 square inch surface area, and an assumed 0.275 inch thickness, this equates to less than 20 pounds. This additional mass is insignificant when compared to the weight of the nozzle. The NRC staff finds that the weight of the remnant welds on the subject nozzles is small as compared to the weight of the nozzle. Therefore, the impact of the weight of the remnant weld on the nozzles should be insignificant.

The NRC staff also asked the licensee whether a residual stress analysis was performed to demonstrate that the weld buildup will not affect the nozzles. In the April 7, 2008, letter, the licensee responded that the residual stress analysis of the revised nozzle configuration is based on a 3-D finite element model using the ANSYS computer program to determine thermal and mechanical stresses, consistent with previously approved overlay applications on the Catawba 2 pressurizer. The residual stress analysis will be completed within 45 days of the unit returning to service. The NRC staff finds that the licensee is performing the residual stress calculations to show that the remnant welds will not affect the stresses in the nozzle adversely. The issue of whether a residual stress analysis will be performed is resolved.

The NRC staff finds that RR 09-CN-002 acceptable because (a) the modifications to Code Case N-638-1 are acceptable, (b) the impact of the remnant weld buildup on the nozzle will be minimal because the amount of, and the area covered by, the remnant weld overlays on the subject nozzle are not significant as compared to the nozzle itself, and (c) the licensee has performed and is performing stress analyses to ensure the subject nozzles will be within the ASME Code, Section III, allowable stresses.

4.0 CONCLUSION

The NRC staff has reviewed the licensee's submittal and determined that RR 09-CN-002 will provide an acceptable level of quality and safety for the operation of the subject reactor vessel hot-leg nozzles. Therefore, pursuant to 10 CFR 50.55a(a)(3)(i), the NRC staff authorizes the use of RR 09-CN-002 for weld buildup on the reactor vessel hot-leg nozzles B, C and D for the third 10-year ISI interval at Catawba 2.

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

Principal Contributors: J. Tsao, DCI/CPNB

Date of Issuance: August 26, 2009

If you have any questions, please call Jon Thompson of my staff at 301-415-1119.

Sincerely,

/RA/

Undine Shoop, Acting Chief
Plant Licensing Branch II-1
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket Nos. 50-414

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