

March 20, 2008

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

SUBJECT: CATAWBA NUCLEAR STATION, UNIT 2, REQUEST TO RELAX  
NONDESTRUCTIVE EXAMINATION OF REACTOR PRESSURE VESSEL  
HEAD PENETRATION NOZZLES IN FIRST REVISED ORDER EA-03-009  
(TAC NOS. MD7722, MD7723, MD7724, MD7725 AND MD7726)

Dear Mr. Morris

By letter dated October 30, 2007, Duke Power Company LLC (Duke Power LLC, the licensee) requested the relaxation of certain requirements in the first revised Nuclear Regulatory Commission (NRC) Order EA-03-009 (the first revised Order) regarding the nondestructive examination (NDE) of reactor pressure vessel head penetration (VHP) nozzles below the J-groove for Catawba Nuclear Station, Unit 2 (Catawba 2). The first revised Order dated February 20, 2004, superseded Order EA-03-009 dated February 11, 2003. The licensee agreed to comply with the first revised Order in its letter dated March 9, 2004.

In Section IV.C(5)(b) of the first revised Order, licensees including Duke Power LLC were given three options in performing the required nonvisual NDE of each VHP nozzle. In accordance with Section IV.F of the Order, in its October 30, 2007, letter, the licensee requested relaxation of this requirement for the NDE inspections of VHP nozzle numbers 74, 75, 76, 77 and 78 until inspection technology is developed to a state where the examination volume for this nozzle can be extended to be in full compliance with the Order.

Based on the enclosed safety evaluation, the NRC staff concludes that: (1) the licensee's proposed alternative inspection for VHP nozzle numbers 74, 75, 76, 77 and 78 to perform an ultrasonic examination from 2 inches above the highest point of the root of the J-groove weld to the lowest elevation below the J-groove weld that can be practically inspected, but not less than 0.7 inches provides reasonable assurance of the structural integrity of the VHP nozzle; (2) further inspections of the VHP nozzle in accordance with Section IV.C(5)(b) of the first revised Order would result in hardship without a compensating increase in the level of quality and safety; and (3) the licensee has demonstrated good cause for its requested relaxation from

J. Morris

-2-

the Order. Based on these conclusions, the NRC staff authorizes, pursuant to Section IV.F(2) of the first revised Order, the proposed alternative inspection of the VHP nozzles 74, 75, 76, 77 and 78.

Sincerely,

**/RA/**

Melanie Wong, Chief  
Plant Licensing Branch II-1  
Division of Operating Reactor Licensing  
Office of Nuclear Reactor Regulation

Docket No. 50-414

Enclosure:  
Safety Evaluation

cc w/encl: See next page

J. Morris

-2-

the Order. Based on these conclusions, the NRC staff authorizes, pursuant to Section IV.F(2) of the first revised Order, the proposed alternative inspection of the VHP nozzles 74, 75, 76, 77 and 78.

Sincerely,

**/RA/**

Melanie Wong, Chief  
Plant Licensing Branch II-1  
Division of Operating Reactor Licensing  
Office of Nuclear Reactor Regulation

Docket No. 50-414

Enclosure:  
Safety Evaluation

cc w/encl: See next page

**DISTRIBUTION:**

Public	RidsAcrsAcnwMailCenter
LPL2-1 R/F	RidsRgn2MailCenter(JMoorman)
RidsNrrDorlLpl2-1 (MWong)	RidsNrrDciCpnd(KHoffman)
RidsNrrPMJStang (hard copy)	RidsOgcRp
RidsNrrLAMO'Brien (hard copy)	MCox, EDO RGN II
RidsNrrCpnb(TChan)	

ADAMS Accession No. ML080520175

\*transmitted by memo dated

OFFICE	NRR/LPL2-1/PM	NRR/LPL2-1/LA	NRR CPNB/BC	OGC	NRR/LPL2-1/BC
NAME	JStang	MO'Brien	TChan*	BMizuno	MWong
DATE	3/3/08	3/3/08	01/31/08	3/18/08	3/20/08

OFFICIAL RECORD COPY

cc:

Site Vice President  
Catawba Nuclear Station  
Duke Power Company, LLC  
4800 Concord Road  
York, SC 29745

Associate General Counsel and Managing  
Attorney  
Duke Energy Carolinas, LLC  
526 South Church Street - EC07H  
Charlotte, North Carolina 28202

Regulatory Compliance  
Duke Energy Corporation  
4800 Concord Road  
York, South Carolina 29745

North Carolina Municipal Power  
Agency Number 1  
1427 Meadowwood Boulevard  
P.O. Box 29513  
Raleigh, North Carolina 27626

County Manager of York County  
York County Courthouse  
York, South Carolina 29745

Piedmont Municipal Power Agency  
121 Village Drive  
Greer, South Carolina 29651

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

NCEM REP Program Manager  
4713 Mail Service Center  
Raleigh, North Carolina 27699-4713

North Carolina Electric Membership Corp.  
P.O. Box 27306  
Raleigh, North Carolina 27611

Senior Resident Inspector  
U.S. Nuclear Regulatory Commission  
4830 Concord Road  
York, South Carolina 29745

Assistant Director  
Division of Waste Management  
Bureau of Land and Waste Management  
Dept. of Health and Environmental Control  
2600 Bull Street  
Columbia, South Carolina 29201-1708

Manager  
Nuclear Regulatory Issues  
and Industry Affairs  
Duke Energy Corporation  
526 South Church Street  
Mail Stop EC05P  
Charlotte, North Carolina 28202

Saluda River Electric  
P.O. Box 929  
Laurens, South Carolina 29360

Vice President  
Customer Relations and Sales  
Westinghouse Electric Company  
6000 Fairview Road  
12th Floor  
Charlotte, North Carolina 28210

Owners Group (NCEMC)  
Duke Energy Corporation  
4800 Concord Road  
York, South Carolina 29745

Senior Counsel  
Duke Energy Carolinas, LLC  
526 South Church Street - EC07H  
Charlotte, NC 28202

Catawba Nuclear Station, Units 1 & 2

Page 2 of 2

cc:

Division of Radiation Protection  
NC Dept. of Environment, Health,  
and Natural Resources  
3825 Barrett Drive  
Raleigh, North Carolina 27609-7721

Group Vice President, Nuclear Generation  
and Chief Nuclear Officer  
P.O. Box 1006-EC07H  
Charlotte, NC 28201-1006

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION  
FIRST REVISED ORDER EA-03-009 RELAXATION REQUEST  
ALTERNATE EXAMINATION COVERAGE FOR  
REACTOR PRESSURE VESSEL HEAD PENETRATION NOZZLES  
CATAWBA NUCLEAR STATION, UNIT 2  
DUKE POWER COMPANY LLC  
DOCKET NO. 50-414

1.0 INTRODUCTION

By letter dated October 30, 2007 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML073060211), Duke Power Company LLC, (the licensee) requested the relaxation to implement an alternative to the requirements of Section IV.C(5)(b) of the First Revised Order (first revised Order) for reactor pressure vessel (RPV) head penetration (VHP) nozzles at Catawba Nuclear Station, Unit 2 (Catawba 2). The first revised Order dated February 20, 2004, superceded the Order EA-03-009 dated February 11, 2003. The licensee agreed to comply with the first revised Order in its letter dated March 9, 2004 (ADAMS Accession No. ML040760744).

2.0 REGULATORY REQUIREMENTS

The first revised Order requires specific examinations of the VHP nozzles of all pressurized-water reactor plants. Section IV.F of the first revised Order states that requests for relaxation of the Order associated with specific penetration nozzles will be evaluated by the Nuclear Regulatory Commission (NRC) staff using the procedure for evaluating proposed alternatives to the American Society of Mechanical Engineers (ASME), *Boiler and Pressure Vessel Code* (Code) in accordance with paragraph 50.55a(a)(3) of Part 50 of Title 10 of the *Code of Federal Regulations* (10 CFR), Section 50.55a(a)(3)). Section IV.F states that a request for relaxation regarding inspection of specific VHP nozzles shall address the following criteria: (1) the proposed alternative(s) for inspection of specific nozzles will provide an acceptable level of quality and safety, or (2) compliance with this first revised Order for specific nozzles would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

Pursuant to Section IV.B of the first revised Order, Catawba 2 is categorized as having a low susceptibility to primary water stress corrosion cracking (PWSCC). For Catawba 2 and similar plants determined to have a low susceptibility to PWSCC in accordance with Sections IV.A, IV.B, and IV.C.(3) of the first revised Order, the following inspection is required to be performed by February 11, 2008, in accordance with Section IV.C.(5)(b) of the first revised Order:

- (b) For each penetration, perform a nonvisual NDE [nondestructive examination] in accordance with either (i), (ii), or (iii):
- (i) Ultrasonic testing of the RPV head penetration nozzle volume (i.e., nozzle base material) from 2 inches above the highest point of the root of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) to 2 inches below the lowest point at the toe of the J-groove weld on a horizontal plane perpendicular to the nozzle axis (or the bottom of the nozzle if less than 2 inches [see Figure IV-1]); Or from 2 inches above the highest point of the root of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) to one inch below the lowest point at the toe of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) and including all RPV head penetration nozzle surfaces below the J-groove weld that have an operating stress level (including all residual and normal operation stresses) of 20 ksi [kilopounds per square inch] tension and greater (see Figure IV-2).

In addition, an assessment shall be made to determine if leakage has occurred into the annulus between the RPV head penetration nozzle and the RPV head low-alloy steel.

- (ii) Eddy current testing or dye-penetrant testing of the entire wetted surface of the J-groove weld and the wetted surface of the RPV head penetration nozzle base material from at least 2 inches above the highest point of the root of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) to 2 inches below the lowest point at the toe of the J-groove weld on a horizontal plane perpendicular to the nozzle axis (or the bottom of the nozzle if less than 2 inches [see Figure IV-3]); Or from 2 inches above the highest point of the root of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) to one inch below the lowest point at the toe of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) and including all RPV head penetration nozzle surfaces below the J-groove weld have an operating stress level (including all residual and normal operation stresses) of 20 ksi tension and greater (see Figure IV-4).
- (iii) A combination of (i) and (ii) to cover equivalent volumes, surfaces, and leak paths of the RPV head penetration nozzle base material and J-groove weld as described in (i) and (ii). Substitution of a portion of a volumetric exam on a nozzle with a surface examination may be performed with the following requirements:
1. On nozzle material below the J-groove weld, both the outside diameter and inside diameter surfaces of the nozzle must be examined.
  2. On nozzle material above the J-groove weld, surface examination of the inside diameter surface of the nozzle is permitted provided a surface examination of the J-groove weld is also performed.

3.0 TECHNICAL EVALUATION OF FIRST REVISED NRC ORDER EA-03-009  
RELAXATION REQUEST FOR EXAMINATION COVERAGE FOR REACTOR  
PRESSURE VHP NOZZLE NUMBERS 74, 75, 76, 77 AND 78

3.1 First Revised Order Requirements for which Relaxation Is Requested

Section IV.C of the first revised Order requires, in part, that inspections per Section IV.C(5)(b) of the Order be performed by February 11, 2008, for low-susceptibility plants such as Catawba 2. In its letters, the licensee has requested relaxation from the requirements in Section IV.C(5)(b), as identified below.

3.2 Licensee's Proposed Alternative

The licensee seeks relaxation from the First Revised NRC Order EA-03-009 (Order), dated February 20, 2004, to revise the minimum volumetric inspection coverage requirement below the J-groove weld for five penetration nozzles, specifically five thermocouple head penetrations at Catawba 2 to the top of the tapered region on the inside diameter (I.D.) of the nozzle as identified in the table below.

Nozzle Penetration Number	Lower Bound Inspection Plane <sup>1</sup>
74	0.93"
75	0.87"
76	0.70"
77	0.90"
78	0.87"

<sup>1</sup>refers to the location of the lower bound inspection plane expressed as the distance of the thermocouple tapered ID chamfer region from the lowest point at the toe of the J-Groove weld

The licensee identified a limitation to complete ultrasonic examination coverage to meet the requirements to the First Revised Order.

The licensee requests this relaxation be granted for the end-of-cycle sixteen refueling outage inspection and all future inspections where UT examination techniques are used to inspect the RPV head nozzle in response to the requirements of First Revised Order EA-03-009.

3.3 Licensee's Basis for Proposed Alternative

The licensee states, the configuration of the five thermocouple head penetrations (Nos. 74 through 78) for Catawba 2 does not allow a complete volumetric examination as required by the Order, due to the physical configuration of the nozzle and the limitations of the UT equipment. The bottom end of this nozzle is externally threaded and internally tapered. Loss of UT probe coupling due to the internal taper and/or disruption of the UT signal due to the external threads prevents UT data acquisition. The dimensional configuration at this location is such that the distance from the lowest point at the toe of the J-groove weld to the top of the tapered region is less than the one inch specified in IV.C.5(b)(i) and IV.C.5(b)(ii) of the First Revised Order.

It is the licensee's relaxation request to perform the volumetric examination of the penetration nozzles below the J-groove weld required by the Order to the top of the tapered region, but not less than 0.7 inches, for penetration nozzle numbers 74 through 78. The licensee will utilize inspection option (b)(i) and will achieve volumetric coverage 2 inches above the J-groove weld down to the lowest elevation that can be practically inspected, but not less than 0.7 inches.

The licensee stated a manual examination of this inspection volume would require an entry into a very high radiation zone with a general area dose rate of 3 rem/hour. Furthermore, removal of the housing guide and attachment welds would be necessary to allow access for supplemental liquid penetrant or manual ultrasonic examinations. Entries into this radiation area for these tasks would involve a very large radiation exposure without a significant benefit.

The licensee fully examined the remaining 73 head penetrations, in accordance with the Order with no evidence of PWSCC. Also, although not credited in the evaluation described below a significant portion of the wall thickness in the tapered region has been examined using the rotating inspection head of the AREVA ultrasonic system. No recordable indications were identified in this uncredited partial examination volume below the lower bound plane established by the vertex of the I.D. taper.

The licensee contracted for a structural integrity evaluation for Catawba 2 penetration nozzles. The licensee's October 30, 2007, letter included a series of crack growth calculations performed to demonstrate that more than 7 years of operation would elapse before a postulated flaw in the unexamined area of the penetration nozzle would propagate into the pressure boundary formed by the J-groove weld. Catawba 2 is in the low susceptibility category, therefore, in accordance with the Order, nonvisual NDE will be performed once every four refueling outages or within 7 calendar years whichever is less. The calculations showed that volumetric inspection coverage of the penetration nozzle below the J-groove weld to a distance of 0.7 inches would conservatively bound a 7-year inspection frequency.

The methodology and the technical basis of the crack growth calculation was based on the flaw evaluation guidelines provided in Footnote 1 of the Order and the PWSCC crack growth rate recommended in MRP-55 Revision 1. The results of the conservative flaw propagation calculation indicate that, even if a flaw were to occur in the region of the penetration nozzle not being inspected, there would be adequate opportunity for detection prior to the crack reaching the RCS pressure boundary. The results demonstrate that the extent of the proposed inspection coverage would provide reasonable assurance of the structural integrity of penetration nozzle numbers 74, 75, 76, 77 and 78 under the inspection frequency of the Order.

### 3.4 NRC Staff's Evaluation

The NRC staff's review of this request was based on criterion (1) of Section IV.F of the Order, which states:

Compliance with this Order for specific nozzles would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

The licensee proposed an alternative inspection for the five thermocouple head penetration nozzles to volumetrically examine each nozzle from 2 inches above the weld down to the top of

the tapered region on the inside diameter of the penetrations with a minimum required inspection distance of 0.7 inches below the J-groove weld. The baseline volumetric examination of these nozzles was performed in the fall of 2007. The Order required inspection coverage of at least 1 inch below the J-groove weld. This coverage was obtained for all of the other nozzles. Therefore, there was no limitation from performing the Order required volumetric inspections for these penetration nozzles. However, inspection coverage for penetration nozzle numbers 74 through 78 was limited to the top of the tapered region. Therefore, NRC staff will review, and consider for approval, the proposed alternative for only the penetration nozzles which have a physical limitation to performing the Order required inspection, namely penetration nozzle numbers 74 through 78.

Full inspection coverage was not achievable for penetration nozzle numbers 74, 75, 76, 77 and 78 because of nozzle end geometry. The geometry of the nozzle ends makes inspection in accordance with the Order difficult and would involve a hardship including increased personnel radiation dose due to performing other Order permissible surface examinations to achieve full coverage. The NRC staff's evaluation focuses on the issue of whether there is a compensating increase in the level of quality and safety, such that these nozzles should be inspected in accordance with the Order despite this hardship.

Previous Order inspections at Catawba 2, including bare metal visual inspection above the RPV head, indicate no evidence of head material wastage or leaking penetrations. The NRC staff's review of the evaluations and analyses performed by the licensee in support of this request is described below.

The stress profile for these penetration nozzles, based on data provided in the licensee's letter dated October 30, 2007, of the penetration nozzles at Catawba 2, shows that most residual stresses decrease significantly at short distances below the J-groove weld. The stresses fall to less than 20 ksi at a distance of 0.42 inches from the downhill side (the most limiting) of the penetration nozzles. Since the stress level at the unexamined area is low, initiation of a crack is very unlikely. Operating experience also indicates that locations with this low stress level have been much less susceptible to cracking.

The licensee's analysis used the methodology described in Footnote 1 of the Order and conservative criteria to set the necessary height of the examination. The analysis assumed a minimum volumetric inspection distance of 0.70 inches below the toe of the J-groove weld. Further, it postulated a through-wall crack in the unexamined area and showed that it would take the crack more than 7 years to reach the J-groove weld. The NRC staff's assessment of the licensee's conclusion is based, in part, on the verification of the stress profiles and crack growth predictions provided with the letter of October 30, 2007. Therefore, NRC staff concurs with the licensee's conclusion that a crack located beyond 0.70 inches below the J-groove weld would take more than 7 years to reach the J-groove weld.

Catawba 2, is in the low susceptibility category, and nonvisual NDE will be performed every 4 refueling outages or 7 calendar years whichever is less. The NRC staff finds the licensee's proposed alternative which allows 7 years of operation between Order required examination periods to be adequate. Therefore, an inspection frequency based on the licensee's crack growth assessment above provides a reasonable basis for the proposed alternative inspection.

The safety issues that are addressed by the First Revised NRC Order EA-03-009 are degradation (corrosion) of the low-alloy steel RPV upper head, reactor coolant pressure boundary integrity and ejection of the RPV upper head penetration nozzle due to circumferential cracking of the nozzle above the J-groove weld. The licensee's proposed alternative inspection, to perform the UT examination below the J-groove weld for penetration nozzles 74, 75, 76, 77 and 78 to the top of the tapered region, with a minimum inspection distance of 0.7 inches below the J-groove weld, provides reasonable assurance that these safety issues are addressed at Catawba 2. The additional examination of the penetration nozzles from the top of the tapered region to the required length stated in the Order is not necessary to provide this reasonable assurance.

Additional manual ultrasonic or surface examination could be performed of the remaining portion of the penetration nozzle to increase the inspection coverage to the full Order requirement; however, these additional inspections would require extensive work in very high radiation fields. The staff finds that performing these additional examinations would result in hardship through significant radiation exposure without a compensating increase in the level or quality or safety.

Based upon the information above, the NRC staff finds that the licensee's proposed alternative examination is acceptable as it provides reasonable assurance of the structural integrity of the RPV upper head, associated penetration nozzles and J-groove welds. Further inspections to comply with the Order requirements would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety. Therefore, the licensee has demonstrated good cause for relaxation from the requirements of the First Revised NRC Order EA-03-009 dated February 20, 2004.

#### 4.0 CONCLUSION

The NRC staff concludes that the licensee's proposed alternative inspection, to perform the ultrasonic testing of penetration nozzle numbers 74, 75, 76, 77 and 78 at Catawba 2, from 2 inches above the J-groove weld down to the top of the tapered region, but not less than 0.7 inches below the bottom of the J-groove weld, provides reasonable assurance of the structural integrity of the RPV upper head, associated penetration nozzles and J-groove welds. Further inspections of these penetration nozzles in accordance with Section IV.C.(5)(b), of First Revised NRC Order EA-03-009 dated February 20, 2004, would result in hardship without a compensating increase in the level of quality and safety. Therefore, the licensee has demonstrated good cause for relaxation, and pursuant to Section IV.F, of First Revised Order EA-03-009 dated February 20, 2004, the staff authorizes the proposed alternative inspection as stated above at Catawba 2, until First Revised NRC Order EA-03-009 is replaced or rescinded.

Principal Contributor: Keith Hoffman

Date: March 20, 2008