

December 11, 2007

Mr. Charles D. Naslund  
Senior Vice President and Chief Nuclear Officer  
Union Electric Company  
Post Office Box 620  
Fulton, MO 65251

SUBJECT: CALLAWAY PLANT, UNIT 1 - REQUEST TO RELAX REQUIREMENT ON  
NONDESTRUCTIVE EXAMINATION OF REACTOR PRESSURE VESSEL  
HEAD PENETRATION NOZZLES IN FIRST REVISED ORDER EA-03-009 (TAC  
NO. MD5620)

Dear Mr. Naslund:

By letter dated May 18, 2007 (ULNRC-05416), the Union Electric Company (UEC) 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 the Callaway Plant, Unit 1 (Callaway). The First Revised Order dated February 20, 2004, superseded the Order EA-03-009 dated February 11, 2003. UEC agreed to comply with the First Revised Order in its letter dated March 5, 2004 (ULNRC-04957) and submitted its 60-day report for the First Revised Order in its letter dated July 9, 2007 (ULNRC-05426). This is UEC's relief request I3R-07.

In Section IV.C(5)(b) of the First Revised Order, licensees including UEC were given three options in performing the required nonvisual NDE of each VHP nozzle. In accordance with Section IV.F of the Order, UEC requested, in its May 5, 2007, letter, relaxation of this requirement for the NDE inspections of VHP nozzles numbered 74 through 78 in that UEC has proposed an alternative to the examination requirements in the First Revised Order, for the five nozzles, that provides an acceptable level of quality and safety. In its supplemental letter dated July 9, 2007, UEC reduced the VHP nozzles that needed the relaxation of the Order to only VHP nozzles numbered 74 and 77.

Based on the enclosed safety evaluation, the NRC staff concludes the following: (1) the proposed alternative inspection by UEC for VHP nozzles numbered 74 and 77 to perform an ultrasonic examination from 2 inches above the highest point of the root of the J-groove weld to the maximum extent practical, but not less than 0.30 inches below the toe of J-groove weld on the downhill side, provides reasonable assurance of the structural integrity of the VHP nozzles; (2) further inspections of these two VHP nozzles by UEC 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) UEC has demonstrated in its letters good cause for its requested

C.D. Naslund

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relaxation from the Order. Based on these conclusions, the NRC staff authorizes, pursuant to Section IV.F(2) of the Order, the proposed alternative inspection of the VHP nozzles numbered 74 and 77.

Sincerely,

/RA/

Thomas G. Hiltz, Chief  
Plant Licensing Branch IV  
Division of Operating Reactor Licensing  
Office of Nuclear Reactor Regulation

Docket No. 50-483

Enclosure: Safety Evaluation

cc w/encl: See next page

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**\*SE input memo**

OFFICE	NRR/LPL4/PM	NRR/LPL4/LA	DCI/CPNB/BC	OGC	NRR/LPL4/BC
NAME	JDonohew	JBurkhardt	TChan*	BKlukan	THiltz
DATE	11/09/07	11/8/07	10/23/07	11/20/07	12/11/07

**OFFICIAL RECORD COPY**

Callaway Plant, Unit 1

cc:

John O'Neill, Esq.  
Pillsbury Winthrop Shaw Pittman LLP  
2300 N. Street, N.W.  
Washington, D.C. 20037

Mr. Keith A. Mills, Supervising Engineer  
Regional Regulatory Affairs/Safety Analysis  
AmerenUE  
P.O. Box 620  
Fulton, MO 65251

U.S. Nuclear Regulatory Commission  
Resident Inspector Office  
8201 NRC Road  
Steedman, MO 65077-1302

Mr. Les H. Kanuckel  
Manager, Quality Assurance  
AmerenUE  
P.O. Box 620  
Fulton, MO 65251

Missouri Public Service Commission  
Governor Office Building  
200 Madison Street  
P.O. Box 360  
Jefferson City, MO 65102-0360

Regional Administrator, Region IV  
U.S. Nuclear Regulatory Commission  
611 Ryan Plaza Drive, Suite 400  
Arlington, TX 76011-4005

Mr. H. Floyd Gilzow  
Deputy Director for Policy  
Department of Natural Resources  
P.O. Box 176  
Jefferson City, MO 65102-0176

Mr. Rick A. Muench  
President and Chief Executive Officer  
Wolf Creek Nuclear Operating Corporation  
P.O. Box 411  
Burlington, KA 66839

Certrec Corporation  
4200 South Hulen, Suite 422  
Fort Worth, TX 76109

Technical Services Branch Chief  
FEMA Region VII  
2323 Grand Boulevard, Suite 900  
Kansas City, MO 64108-2670

Mr. Dan I. Bolef, President  
Kay Drey, Representative  
Board of Directors Coalition for the  
Environment  
6267 Delmar Boulevard  
University City, MO 63130

Mr. Lee Fritz, Presiding Commissioner  
Callaway County Courthouse  
10 East Fifth Street  
Fulton, MO 65251

Mr. David E. Shafer  
Superintendent, Licensing  
Regulatory Affairs  
AmerenUE  
P.O. Box 620  
Fulton, MO 65251

Manager, Regulatory Affairs  
AmerenUE  
P.O. Box 620  
Fulton, MO 65251

Mr. Keith G. Henke, Planner  
Division of Community and Public Health  
Office of Emergency Coordination  
930 Wildwood P.O. Box 570  
Jefferson City, MO 65102

Director, Missouri State Emergency  
Management Agency  
P.O. Box 116  
Jefferson City, MO 65102-0116

Mr. Scott Clardy, Director  
Section for Environmental Public Health  
P.O. Box 570  
Jefferson City, MO 65102-0570

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION  
RELATED TO RELAXATION REQUEST FOR FIRST REVISED ORDER EA-03-009  
ALTERNATE EXAMINATION COVERAGE FOR  
REACTOR PRESSURE VESSEL HEAD PENETRATION NOZZLES  
UNION ELECTRIC COMPANY  
CALLAWAY PLANT, UNIT 1  
DOCKET NO. 50-483

1.0 INTRODUCTION

By letter dated May 18, 2007 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML071500203), the Union Electric Company (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 the Callaway Plant, Unit 1 (Callaway). The First Revised Order EA-03-009 dated February 20, 2004, superseded the Order EA-03-009 dated February 11, 2003. The licensee agreed to comply with the First Revised Order in its letter dated March 5, 2004 (ADAMS Accession No. ML040760795). This is the licensee's relief request I3R-07.

In Section IV.C(5)(b) of the First Revised Order, licensees including the licensee were given three options in performing the required nonvisual NDE of each VHP nozzle. See Section 2.0 of this safety evaluation (SE). In accordance with Section IV.F of the Order, the licensee requested, in its May 5, 2007, letter, relaxation of the requirement for the NDE inspections of VHP nozzles numbered 74 through 78 in that the licensee has proposed an alternative to the examination requirements in the First Revised Order, for the five nozzles, that provides an acceptable level of quality and safety.

The licensee submitted its 60-day report for the First Revised Order in its letter dated July 9, 2007 (ADAMS Accession No. ML071980370). The report detailing the results of the examinations conducted in the spring 2007 refueling outage and was submitted in accordance with Section IV.E of this Order. This letter reduced the number of VHP nozzles to be considered in this request for relaxation of the Order to only VHP nozzles numbered 74 and 77.

2.0 REGULATORY EVALUATION

The First Revised Order requires specific examinations of the reactor pressure vessel (RPV) head and VHP nozzles of all pressurized-water reactor plants. Section IV.F of this Order states that requests for relaxation of the First Revised Order associated with specific penetration

nozzles will be evaluated by the NRC staff using the procedure for evaluating proposed alternatives to the American Society of Mechanical Engineers (ASME) Code in accordance with Part 50, Section 55a, paragraph (a)(3) of Title 10 of the *Code of Federal Regulations* (10 CFR). Section IV.F of this Order states that a request for relaxation regarding inspection of specific 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 Order for specific nozzles would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

The licensee calculated that Callaway RPV head will have accrued three effective degradation years in accordance with Section IV.A of the First Revised Order. Therefore, pursuant to Section IV.B of this Order, Callaway is categorized as having a low susceptibility to primary water stress-corrosion cracking (PWSCC). For Callaway 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 this Order:

- (b) For each penetration, perform a non-visual NDE 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 1.0-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 1.0-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 RELAXATION REQUEST FOR RPV HEAD PENETRATION NOZZLES

By letter dated May 18, 2007, the licensee requested relaxation of the First Revised Order to implement an alternative to the requirements of Section IV.C.(5)(b) of this Order for five RPV head penetration nozzles numbered 74 through 78 at Callaway. The alternative request number I3R-07, is Attachment 1 to the letter. Attachments 3 and 4 to the letter are the AREVA Calculations, "Callaway CRDM [Control Rod Drive Mechanism] Hypothetical Flaw Evaluations," AREVA NP Document No. 32-9046889-002 (non-proprietary) and No. 32-9045288-002 (proprietary).

The NRC staff agreed to withhold the information, designated as proprietary in the AREVA NP Document No. 32-9045288-002 (proprietary), from the public in its letter to the licensee dated October 4, 2007 (ADAMS Accession No. ML072700046).

#### 3.1 First Revised Order Requirements for Which Relaxation is Requested

Compliance with Section IV.C of the First Revised Order requires, in part, that inspections in accordance with Section IV.C.(5)(b) of this Order be performed by February 11, 2008, for low susceptibility plants, similar to Callaway.

The licensee has requested relaxation from the examination requirements in Section IV.C.(5)(b) of the First Revised Order. The specific relaxation requested is identified in the next section of this SE.

#### 3.2 Licensee's Proposed Alternative

In its application, the licensee seeks relaxation from the First Revised Order to revise the minimum volumetric inspection coverage requirement below the J-groove weld for five penetration nozzles to the lowest elevation that can be practically inspected, but not less than 0.39 inches. The licensee identified a limitation to complete ultrasonic examination coverage to meet the requirements to the Order.

### 3.3 Licensee's Basis for Proposed Alternative

It is the licensee's relaxation request to perform the volumetric examination of the penetration nozzle below the J-groove weld required by the First Revised Order to the lowest elevation that can be practically inspected, but not less than 0.39 inches, for five penetration nozzles numbered 74 through 78. The licensee proposed to utilize inspection option (b)(iii), listed in Section 2.0 of this SE, and will achieve volumetric and surface coverage 2 inches above the J-groove weld down to the lowest elevation that can be practically inspected, but not less than 0.39 inches. The licensee stated that a distance of 0.39 inches on the penetration nozzle below the J-groove weld was chosen because it encompasses all areas on the nozzle which have a residual stress of greater than or equal to 20 ksi.

The licensee contracted for a structural integrity evaluation for penetration nozzles of an angle consistent with the five penetration nozzles numbered 74 through 78. The contractor's reports are Attachments 3 and 4 to the licensee's application. A series of crack-growth calculations were performed to demonstrate that more time in effective full power years (EFPY) 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. Callaway is in the low susceptibility category; therefore, in accordance with the Order, nonvisual NDE will be performed once every four refueling outages or within seven calendar years, whichever is less. The licensee stated that the calculations showed that volumetric inspection coverage of the penetration nozzle below the J-groove weld to a distance of 0.39 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 Electric Power Research Institute Materials Reliability Program (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 reactor coolant system pressure boundary. The results demonstrate that the extent of the proposed inspection coverage would provide reasonable assurance of the structural integrity of the five penetration nozzles numbered 74 through 78 under the inspection frequency of the Order, which is not being changed.

In its supplemental letter dated July 9, 2007, the licensee reduced the VHP nozzles that needed the relaxation of the Order to only VHP nozzles numbered 74 and 77.

### 3.3 NRC Staff 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 five penetration nozzles to volumetrically examine each nozzle from 2 inches above the weld down to the maximum extent practical with a



minimum required inspection distance of 0.39-inch below the J-groove weld. The baseline volumetric examination of these five nozzles was performed in the spring of 2007. The Order required inspection coverage of at least 1.0-inch below the J-groove weld and, as stated in the letter dated July 9, 2007, this was obtained for three of the nozzles numbered 75, 76, and 78. Therefore, there was no limitation from performing the Order-required volumetric inspections for these penetration nozzles. However, inspection coverage for penetration nozzles numbered 74 and 77 was limited to 0.67-inch and 0.83-inch below the J-groove weld, respectively, because the weld buildup on the downhill side of the nozzles and the geometry of the nozzle ends limits the inspection coverage. Therefore, the NRC staff evaluated the proposed alternative for only two penetration nozzles that have a physical limitation to performing the Order-required inspection, namely, penetration nozzles numbered 74 and 77.

The full inspection coverage required by the Order was not achievable for the two penetration nozzles numbered 74 and 77. The weld buildup on the downhill side of the nozzle and the geometry of the nozzle ends makes inspection in accordance with the Order difficult for these nozzles and having the licensee correct these impediments to full inspection coverage would involve a hardship to the licensee, including increased personal radiation dose due to performing other Order-permissible surface examinations to achieve full inspection 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 Callaway, 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 May 18, 2007, of the representative penetration nozzles at Callaway, shows that most residual stresses decrease significantly at short distances below the J-groove weld. The residual hoop stress falls to less than 20 ksi at a distance of 0.39 inches from the downhill side (the most limiting) of the penetration nozzle. 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 0.39-inch 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 staff's assessment of the licensee's conclusion is based on data analysis of the crack-growth predictions. NRC staff performed an independent crack-growth calculation, the results of which support the licensee's analysis. Therefore, NRC staff concurs with the licensee's conclusion that a crack located beyond 0.39-inch below the J-groove weld would take more than 7 years to reach the J-groove weld.

As Callaway, is in the low susceptibility category, nonvisual NDE will be performed every four (4) refueling outages or seven (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 ultrasonic test examination below the J-groove weld for five penetration nozzles to the maximum extent practical with a minimum inspection distance of 0.39-inch below the J-groove weld, provides reasonable assurance that these safety issues are addressed at Callaway. The additional surface examination on the inside diameter only of the penetration nozzle from a depth of 0.39 inches to the required length stated in the Order is not necessary to provide this reasonable assurance.

Additional surface examination could be performed of the remaining surface area 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 surface 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 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

In its application dated May 18, 2007, the licensee requested relief from the examination coverage requirements in the First Revised NRC Order EA-03-009 dated February 20, 2004, for nozzle penetrations numbered 74 through 78; however, in its letter dated July 9, 2007, the licensee identified that nozzle penetrations numbered 75, 76, and 78 did meet the requirement in the Order for 1.0-inch below the J-groove weld. Therefore, relief from the requirements in the Order was only needed for the two nozzle penetrations numbered 74 and 77.

Based on its review of the letters dated May 18 and July 9, 2007, the NRC staff concludes that the licensee's proposed alternative inspection, to perform the ultrasonic testing of two penetration nozzle numbered 74 and 77 at Callaway, to the maximum extent practical below the J-groove weld, with a minimum inspection distance of 0.39 inches, 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 the First Revised Order would result in hardship without a compensating

increase in the level of quality and safety. Therefore, the NRC staff concludes that the licensee has demonstrated good cause for relaxation, and, pursuant to Section IV.F, of the First Revised Order, authorizes the proposed alternative inspection as stated above at Callaway Plant, Unit 1, until the First Revised NRC Order EA-03-009 is replaced or rescinded.

Principal Contributor: Jay Collins

Date: December 11, 2007