July 17, 2006

Mr. Michael R. Kansler
President
Entergy Nuclear Operations, Inc.
440 Hamilton Avenue
White Plains, NY 10601

SUBJECT: RELAXATION OF FIRST REVISED ORDER ON REACTOR VESSEL NOZZLES, INDIAN POINT NUCLEAR GENERATING UNIT NO. 3 (TAC NO. MD0501)

Dear Mr. Kansler:

In a letter dated March 15, 2006, Entergy Nuclear Operations, Inc. (the licensee), submitted a request for relaxation regarding the inspection of reactor pressure vessel (RPV) head and penetration nozzles at Indian Point Nuclear Generating Unit No. 3 (IP3). The relaxation was requested from the interim inspection requirements in the Nuclear Regulatory Commission's (NRC's) First Revised Order Modifying Licenses, EA-03-009, dated February 20, 2004 (First Revised Order).

The NRC staff has reviewed the licensee's requested relaxation to implement certain alternatives to the requirements of the First Revised Order at IP3. Specifically, the licensee proposed relaxation from the inspection coverage for the nondestructive examination, using ultrasonic testing techniques or eddy current testing techniques of RPV head penetration nozzles, that is limited by a threaded section that is less than the 1-inch lower boundary limit specified in Section IV, paragraph C.5.(b), of the First Revised Order. The results are provided in the enclosed safety evaluation (SE).

For the examination coverage regarding the RPV penetration nozzles, the NRC staff has concluded for IP3 that the proposed alternative examinations provide reasonable assurance of the structural integrity. Further inspections of these nozzles in accordance with Section IV, paragraph C.5(b), of the First Revised Order would result in hardship without a compensating increase in the level of quality and safety. Therefore, in accordance with Section IV, paragraph F, of the First Revised Order, the NRC staff authorizes the proposed relaxation and alternative inspection for the RPV head penetration nozzles at IP3 for the life of the Order, subject to the condition specified in the SE.

If you should have any questions, please contact John Boska at 301-415-2901.

Sincerely,

/RA/

Catherine Haney, Director
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-286

Enclosure:
As stated

cc w/encl: See next page

If you should have any questions, please contact John Boska at 301-415-2901.

Sincerely,

/RA/

Catherine Haney, Director
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELAXATION OF FIRST REVISED ORDER MODIFYING LICENSES, EA-03-009

EXAMINATION COVERAGE FOR REACTOR PRESSURE VESSEL

HEAD AND PENETRATION NOZZLES

INDIAN POINT NUCLEAR GENERATING UNIT NO. 3

ENTERGY NUCLEAR OPERATIONS, INC.

DOCKET NO. 50-286

1.0 INTRODUCTION

On February 20, 2004 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML040220181), the Nuclear Regulatory Commission (NRC) issued the First Revised NRC Order Modifying Licenses, EA-03-009 (First Revised Order), requiring specific examinations of the reactor pressure vessel (RPV) head and vessel head penetration (VHP) nozzles of all pressurized-water reactor (PWR) plants. Section IV, paragraph F, of the First Revised Order states that requests for relaxation of the 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 Boiler and Pressure Vessel Code (ASME Code) in accordance with Section 50.55a(a)(3) of Part 50 of Title 10 of the *Code of Federal Regulations* (10 CFR 50.55a(a)(3)). Section IV, paragraph F, of the 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.

For Indian Point Nuclear Generating Unit No. 3 (IP3) and similar plants that were determined to have a high susceptibility to primary water stress-corrosion cracking (PWSCC) in accordance with Section IV, paragraphs A and B, of the First Revised Order, the following inspections are required by the Order to be performed such that both the requirements of Section IV, paragraphs C.5(a) and C.5(b) are satisfied each refueling outage:

(a) Bare metal visual [BMV] examination of 100 percent of the RPV head surface (including 360E around each RPV head penetration nozzle). For RPV heads with the surface obscured by support structure interferences which are located at RPV head elevations downslope from the outermost RPV head penetration, a

bare metal visual inspection of no less than 95 percent of the RPV head surface may be performed provided that the examination shall include those areas of the RPV head upslope and downslope from the support structure interference to identify any evidence of boron or corrosive product. Should any evidence of boron or corrosive product be identified, the licensee shall examine the RPV head surface under the support structure to ensure that the RPV head is not degraded.

(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 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 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 that 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.

By letter dated March 18, 2005 (ADAMS Accession No. ML050770010) just prior to the IP3 spring 2005 refueling outage (3R13), the NRC authorized the following for IP3:

1. Examination of 5 RPV penetrations (74, 75, 76, 77, and 78) from 0.96 inch below the lower point at the toe of the J-groove weld rather than from 1.0 inch below the lower point at the toe of the J-groove weld due to interference from the threaded region of the penetration tube.
2. BMV examination of no less than 95 percent of the RPV head surface (versus the 100 percent specified in the Order) due to interference from the insulation support ring. This relaxation applies to all future BMV inspections.
3. Non-visual NDE of 40 nozzles rather than all 78 nozzles as the other 38 nozzles received non-visual NDE during the 3R12 refueling outage in spring 2003.

By letter dated April 4, 2005 (ADAMS Accession No. ML050940136), the NRC authorized the examination of 36 head penetrations (including penetrations 74, 75, 76, 77, and 78 previously approved by NRC letter dated March 18, 2005) from 0.45 inch below the lower point at the toe of the J-groove weld rather than from 1.0 inch below the lower point at the toe of the J-groove weld due to the as-found condition of the interference from the threaded region of the penetration tube.

By letter dated March 15, 2006 (ADAMS Accession No. ML060960068), Entergy Nuclear Operations, Inc. (Entergy or the licensee) requested relaxation to implement an alternative to the requirements of Section IV, Section C.5(b) of the First Revised Order for additional RPV head penetration nozzles at IP3. The specific relaxation requested is provided below.

2.0 FIRST REVISED NRC ORDER EA-03-009 RELAXATION REQUEST FOR EXAMINATION COVERAGE FOR REACTOR PRESSURE VESSEL HEAD AND PENETRATION NOZZLES

2.1 First Revised NRC Order Requirements for Which Relaxation is Requested

The licensee has requested relaxation from Section IV, paragraph C.5(b) of the First Revised NRC Order. The specific relaxation is identified below.

2.2 Licensee's Proposed Alternative

The licensee seeks relaxation from the Order where inspection coverage is limited by a threaded section which is less than the 1 inch lower boundary limit specified in Section IV, paragraph C.5(b) of the First Revised NRC Order for RPV head penetration nozzles at IP3, with respect to NDE. The licensee stated that relaxation is requested from Section IV, paragraph C.5(b) of the Order from 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 tension or greater (see Figure IV-2 of the First Revised Order).

The licensee proposes to perform ultrasonic testing (UT) from the inside surface of each RPV head penetration nozzle (i.e. nozzle base material) from 2 inches above the J-grove weld and extending down the nozzle to at least the top of the threaded region or further down the threaded region to the extent allowed by technology and geometry, but in all cases achieving the minimum requirements specified in Table 1. Although not presently planned, the licensee states that they may choose to perform eddy current testing (ECT) in lieu of UT of the wetted surface excluding any threaded surfaces and the chamfer region in selected nozzles. If ECT is performed, the minimum requirements of Table 1 will still apply. The 3R14 refueling outage is currently scheduled for March 2007. The subsequent non-visual NDE inspection of the RPV head is currently planned for the spring of 2009 during the 3R15 refueling outage. The licensee has stated that IP3 is now a high susceptibility category plant, although IP3 was in the moderate susceptibility category for previous refueling outages.

2.3 Reason for Relaxation Request

The licensee stated that the proposed alternative provides an acceptable level of quality and safety.

2.4 Licensee's Basis for Proposed Alternative

The licensee stated that the design of the RPV head penetration nozzles at IP3 includes a threaded section, approximately 3/4-inch long, at the bottom of the nozzles. The dimensional configuration at some nozzles is such that the distance from the lowest point at the toe of the J-groove weld to the bottom of the scanned region is less than the 1 inch lower boundary limit specified in Section IV, paragraph C.5(b) of the First Revised NRC Order. Review of the previous NDE data showed that in some cases, 1 inch coverage cannot be achieved. However, the licensee will attempt to maximize coverage to comply with the First Revised NRC Order.

UT from the inside surface of the threaded region of the nozzle is partially achievable by new scanning techniques. ECT probes are not capable of examining the threaded surfaces. The licensee has stated that dye penetrant testing (PT) of the threaded surfaces is possible. However, it would require personnel to be located under the RPV head for surface cleaning and penetrant testing operations and would result in significant personnel radiation exposure. Based on previous IP2 experience, a PT of a weld performed under the RPV head on an indication would result in a person-rem exposure of approximately 1.7 rem. Hence, the licensee has proposed UT from the inside surface of the threaded region of the nozzle to remotely inspect the portion of the nozzle below the J-groove weld to minimize radiation exposure to the inspection personnel.

The licensee performed stress analysis and crack-growth evaluations for postulated through-wall axial flaws extending upwards from the nozzle towards the lower J-groove weld. The time to reach the lowest point at the toe of the J-groove weld is greater than 2 effective full-power years (EFPY) based on a minimum inspection coverage below the J-groove weld for all the penetration nozzles as indicated in Table 1. The stress analysis consisted of a three-

dimensional elastic-plastic finite element analysis that considered all the pertinent loadings on the penetrations. The three-dimensional finite element model used to obtain the stresses was comprised of iso-parametric brick and wedge elements. The penetration nozzle, weld metal, cladding, and vessel head were modeled in accordance with the relevant material properties. The most important loading conditions were found to be those which normally exist on the penetration nozzle in the majority of the cases. These loadings included pressure and temperature loadings associated with the steady state operation condition. In addition, the residual stresses from the weld fabrication process were also considered.

The licensee has stated that based on the results of the stress analysis, the service life required for any of the upper crack tips to reach the lowest point of the toe of the J-groove weld for all the penetration nozzles exceeded 2 EFPY. The time duration between the inspection cycles is each refueling outage (2 years for IP3) in accordance with the NRC First Revised Order for high category plants. Therefore, as a screening rule, if the inspection coverage of Table 1 is achieved below the J-groove weld on the downhill side of the head penetration nozzles in 3R14, the upper crack tip of any undetected axial through-wall flaw in the region not being inspected is not expected to reach the lowest point of the toe of the J-groove weld in less than 2 EFPY, or before the subsequent 3R15 inspection. The licensee has stated that the intent of the requirements in the NRC First Revised Order will be met.

2.5 Evaluation

Although the licensee's submittal stated that their proposed alternative provides an acceptable level of quality and safety, which falls under the provisions of criterion (1) of paragraph F of Section IV of the Order, the NRC staff's review of this request was based on criterion (2) of paragraph F of Section IV of the Order, which the NRC staff considered to be more appropriate to the circumstances. Criterion (2) 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.

Within the context of the licensee's proposed alternative examination of the RPV head penetration nozzles, the licensee has demonstrated the hardship that would result from implementing examinations to the bottom end of these nozzles. The licensee identified the hardship by stating the design of the RPV head penetration nozzles includes a threaded section, approximately 3/4-inch long, at the bottom of the nozzles. The dimensional configuration at some of the nozzles is such that the distance from the lowest point at the toe of the J-groove weld to the bottom of the scanned region (essentially the start of the threaded region) is less than the 1-inch lower boundary limit specified in Section IV, paragraph C.5(b) of the First Revised Order. ECT would not provide meaningful results in the threaded region. PT of the threaded surfaces is possible, but results in very high doses to inspection personnel. UT from the inside surface of the threaded region using new vendor scanning techniques may provide meaningful results. In all cases, the minimum UT coverage specified in Table 1 will be achieved.

The phenomenon of concern is PWSCC, which typically initiates in the areas of highest stress. The area of RPV head penetration nozzles that has the highest residual stress is the area adjacent to the J-groove attachment weld. Therefore, it is most likely that PWSCC will initiate in an area adjacent to the J-groove attachment weld.

The licensee proposed to examine the minimum distance of the nozzle base material below the J-groove attachment weld to the top of essentially the start of the threaded region, which varies for each nozzle as is identified in Table 1. The licensee has stated that based on the results of the stress analysis, the service life required for any of the upper crack tips to reach the lowest point of the toe of the J-groove weld for all the penetration nozzles exceeded 2 EFPY. The time duration between the inspection cycles is each refueling outage (2 years for IP3) in accordance with the NRC First Revised Order for high category plants. IP3 has been categorized by the licensee as a high susceptibility category plant. Therefore, as a screening rule, if the inspection coverage of Table 1 is achieved below the J-groove weld on the downhill side of the head penetration nozzles in 3R14, the upper crack tip of any undetected axial through-wall flaw in the region not being inspected is not expected to reach the lowest point of the toe of the J-groove weld in less than 2 EFPY, or before the subsequent 3R15 inspection. Hence, the intent of the requirements in the NRC First Revised Order is met.

The licensee's analysis used the crack-growth formula in Electric Power Research Institute (EPRI) Report Material Reliability Program (MRP) Report MRP-55, "Material Reliability Program Crack Growth Rates for Evaluating Primary Water Stress Corrosion Cracking of Thick Wall Alloy 600 Material (MRP-55), Revision 1." Should the NRC staff determine the crack-growth formula used by the licensee to be unacceptable, the licensee has committed to revise its analysis to incorporate an acceptable crack-growth formula as described below.

> If the NRC staff finds that the crack-growth formula in industry report MRP-55 is unacceptable, the licensee shall revise its analysis that justifies relaxation of the First Revised NRC Order dated February 20, 2004, within 30 days after the NRC informs the licensee of an NRC-approved crack-growth formula. If the licensee's revised analysis shows that the crack-growth acceptance criteria are exceeded prior to the end of the then current operating cycle, this relaxation is rescinded and the licensee shall, within 72 hours, submit to the NRC written justification for continued operation. If the revised analysis shows that the crack-growth acceptance criteria are exceeded during the subsequent operating cycle, the licensee shall, within 30 days, submit the revised analysis for NRC review. If the revised analysis shows that the crack-growth acceptance criteria are not exceeded during either the current operating cycle or the subsequent operating cycle, the licensee shall, within 30 days, submit a letter to the NRC confirming that its analysis has been revised. Any future crack-growth analyses performed for this and future cycles for RPV head penetrations must be based on an NRC approved crack-growth formula.

The licensee committed to the above requirement in the application. Based on the NRC staff's current experience, the NRC staff considers this crack-growth formula to be acceptable for this application.

Based on the information above, the NRC staff concludes that performance of UT from the inside surface of each RPV head penetration nozzle (i.e. nozzle base material) from 2 inches above the J-grove weld and extending down to the threaded region or further down the threaded region to the extent allowed by technology and geometry, but in all cases achieving the minimum requirements specified in Table 1, is acceptable. ECT of the wetted surface excluding any threaded surfaces and the chamfer region in lieu of UT is also acceptable, as long as the minimum requirements of Table 1 are met.

3.0 CONCLUSION

The NRC staff concludes that the licensee's proposed alternative examination of the RPV penetration nozzles from the minimum distance (specified by Table 1 for each individual nozzle penetration) below the lowest point at the toe of the J-groove weld, which is the top of the threaded region, provides reasonable assurance of the structural integrity of the RPV head, RPV penetration nozzles, and welds, since the licensee's crack-growth analysis indicates that it will take more than 2 EFPY for a crack to propagate to the point of allowing reactor coolant system pressure boundary leakage from the RPV head nozzles. Subsequent NDE inspections will be accomplished within 2 EFPY. Further inspections of these RPV penetration nozzles in accordance with Section IV, paragraph C.5(b), of the First Revised NRC Order EA-03-009, dated February 20, 2004, would result in hardship and excessive personnel radiation exposure without a compensating increase in the level of quality and safety. Therefore, pursuant to Section IV, paragraph F, of the First Revised NRC Order EA-03-009, dated February 20, 2004, the NRC staff authorizes the proposed alternative inspection for the RPV penetration nozzles listed in Table 1 at IP3 for the life of the Order, subject to the following condition:

> If the NRC staff finds that the crack-growth formula in industry report MRP-55 is unacceptable, the licensee shall revise its analysis that justifies relaxation of the First Revised Order dated February 20, 2004, within 30 days after the NRC informs the licensee of an NRC-approved crack-growth formula. If the licensee's revised analysis shows that the crack-growth acceptance criteria are exceeded prior to the end of the then current operating cycle, this relaxation is rescinded and the licensee shall, within 72 hours, submit to the NRC written justification for continued operation. If the revised analysis shows that the crack-growth acceptance criteria are exceeded during the subsequent operating cycle, the licensee shall, within 30 days, submit the revised analysis for NRC review. If the revised analysis shows that the crack-growth acceptance criteria are not exceeded during either the current operating cycle or the subsequent operating cycle, the licensee shall, within 30 days submit a letter to the NRC confirming that its analysis has been revised. Any future crack-growth analyses performed for this and future cycles for RPV head penetration nozzles must be based on an NRC approved crack-growth rate formula.

Principal Contributor: B. K. Singal

Date: July 17, 2006

TABLE 1

IP3 RPV Head Penetrations - Minimum Coverage Requirements Below J-Groove Weld

Nozzle Penetration No.	Angle of Incidence (Degrees)	[(1)]Minimum Required UT Coverage Below J-Groove Weld with >2 EFPY by Crack-Growth Evaluation (Inches)	Time (EFPY) to Reach the Lowest point of the Toe of the J-Groove Weld
1 through 29	0 to 24.8	0.4	3.0
30 through 69	26.2 to 38.6	0.4	2.7
70 through 73	44.3	0.3	3.0
74 through 78	48.7	0.3	4.4

Note:
(1) Length below the lowest point at the toe of the J-Groove weld (downhill side) that has an operating stress level of 20 ksi: 0.86 inches at nozzles 1 through 29; 0.50 inches at nozzles 30 through 69; 0.35 inches at nozzles 70 through 73 and 0.35 inches at nozzles 74 through 78.