September 27, 2004

Mr. Mano K. Nazar
American Electric Power
Senior Vice President and Chief Nuclear Officer
Indiana Michigan Power Company
Nuclear Generation Group
500 Circle Drive
Buchanan, MI 49107

SUBJECT: DONALD C. COOK NUCLEAR PLANT, UNIT 2 - RELAXATION OF THE REQUIREMENTS OF FIRST REVISED ORDER (EA-03-009) REGARDING REACTOR PRESSURE VESSEL HEAD INSPECTIONS DATED FEBRUARY 20, 2004 (TAC NO. MC3074)

Dear Mr. Nazar:

The U. S. Nuclear Regulatory Commission (NRC) issued the First Revised Order Modifying Licenses (Order) EA-03-009 on February 20, 2004. The Revised Order EA-03-009 superseded the original Order Modifying Licenses (Effective Immediately) EA-03-009, dated February 11, 2003. The Order imposes requirements for pressurized-water reactor licensees to inspect reactor pressure vessel (RPV) heads and associated penetration nozzles as stated in Section IV.C.(5), (a) and (b). Section IV.C.(5)(b)(i), (ii) and (iii) mandate requirements for nondestructive examination of each penetration. Section IV.F of the Order states that requests for relaxation associated with specific penetration nozzles will be evaluated by the NRC staff using its procedure for evaluating proposed alternatives to the American Society of Mechanical Engineers Code in accordance with Title 10 of the *Code of Federal Regulations* (10 CFR), Section 50.55a(a)(3).

By letter dated April 30, 2004, as supplemented by letter dated June 24, 2004, the Indiana Michigan Power Company (the licensee), submitted a request for relaxation from certain nondestructive examination requirements of the Order for the Donald C. Cook Nuclear Plant, Unit 2 (Cook 2), reactor vessel head penetration nozzles. Specifically, you requested relaxation to implement an alternative to the requirements of Section IV, paragraphs C.(5)(b)(i) and C.(5)(b)(ii) of the Order for the examination distance below the toe of the J-groove weld on the reactor pressure vessel head penetration nozzles at Cook 2.

The NRC staff has completed its review and concludes, as documented in the enclosed safety evaluation, that you have demonstrated that compliance with the Order for the RPV nozzles specified would have resulted in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

The NRC staff has found your request for relaxation of the Order acceptable, with a condition. Therefore, pursuant to Section IV, Paragraph F, of the Order, the NRC staff finds there is good cause shown to relax the Order and authorizes the proposed relaxation of the examination area for the specified nozzles, 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 Order 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 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 not exceeded during the current 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 cycle for RPV head penetrations must be based on an acceptable crack growth rate formula.

The NRC staff based its evaluation on the licensee's deterministic evaluations based on the methodology in WCAP-14118, Revision 7, "Structural Integrity Evaluation of Reactor Vessel Head Penetrations to Support Continued Operation: D.C. Cook Units 1 and 2 ."

If you have any questions concerning this matter, please contact Mr. Fred Lyon at (301) 415-2296.

Sincerely,

/RA/

William H. Ruland, Director
Project Directorate III
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket No. 50-316

Enclosure: Safety Evaluation

cc w/encl: See next page

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

FIRST REVISED ORDER MODIFYING LICENSES (EA-03-009) RELAXATION REQUEST

ALTERNATE EXAMINATION COVERAGE

FOR REACTOR PRESSURE VESSEL HEAD PENETRATION NOZZLES

INDIANA MICHIGAN POWER COMPANY

DONALD C. COOK NUCLEAR POWER PLANT, UNIT 2

DOCKET NO. 50-316

1.0 INTRODUCTION

By letter dated April 30, 2004, as supplemented June 24, 2004, the Indiana Michigan Power Company, (the licensee), submitted a request for relaxation from certain nondestructive examination requirements of the First Revised Order, EA-03-009 for the Donald C. Cook Nuclear Power Plant, Unit 2 (Cook 2), reactor pressure vessel (RPV) head penetration nozzles.

The First Revised Order Modifying Licenses, EA-03-009 (hereinafter referred to as Order), issued on February 20, 2004, requires specific examinations of the RPV head and vessel head penetration (VHP) nozzles of all pressurized-water reactor plants. Section IV, Paragraph F, of the Order states that requests for relaxation of the First Revised 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 Code in accordance with Title 10 of the *Code of Federal Reuglations* (10 CFR), Section 50.55a(a)(3). Section IV, Paragraph F, of the First Revised 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 First Revised Order for specific nozzles would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

For Cook 2, and similar plants determined to have a high susceptibility to primary water stress corrosion cracking (PWSCC) in accordance with Section IV, paragraphs A and B of the Order, the following inspections are required to be performed every refueling outage in accordance with Section IV, paragraph C.(5)(a) and paragraph C.(5)(b) of the Order:

(a) Bare metal visual examination of 100 percent of the RPV head surface (including 360° 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 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 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 of the Order). 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 of the Order).

(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 (ID) surfaces of the nozzle must be examined.

2. On nozzle material above the J-groove weld, surface examination of the ID surface of the nozzle is permitted provided a surface examination of the J-groove weld is also performed.

Footnote 3 of the Order provides specific criteria for examination of repaired VHP nozzles.

2.0 ORDER RELAXATION REQUEST FOR EXAMINATION COVERAGE FOR REACTOR PRESSURE VESSEL HEAD PENETRATION NOZZLES

2.1 Order Requirements for Which Relaxation is Requested

The licensee requested relaxation to implement an alternative to the requirements of Section IV, paragraphs C.(5)(b)(i) and C.(5)(b)(ii) of the Order for RPV head penetration nozzles at Cook 2. Specifically, the licensee requested relaxation on the examination distance below the toe of the J-groove weld.

2.2 Licensee's Proposed Alternative

The licensee proposes the following alternative:

Alternative A: For RPV control rod drive mechanism head penetration nozzles in the 45.8, 47.0, and 50.5 degree rows that have a downhill side distance of less than 1.0 inch but greater than 0.5 inches between the lowest point on the toe of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) and the top of the chamfer and threads, the portion of the nozzle below the J-groove weld shall be examined using ultrasonic testing of the volume and/or eddy current testing or dye penetrant testing of the wetted surfaces, down to the top of the chamfer and threads.

Alternative B: For the RPV control rod drive mechanism head penetration nozzle in the 47.0 degree row that has a downhill side distance of less than 0.5 inches between the lowest point on the toe of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) and the top of the chamfer and threads, the portion of the nozzle below the J-groove weld shall be examined using ultrasonic testing of the volume and/or eddy current testing or dye penetrant testing of the wetted surfaces down to 0.6 inches below the lowest point at the toe of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis).

2.3 Licensee's Basis for Relaxation

The Order requires that ultrasonic or surface examination extend to 2 inches below the J-groove weld or 1 inch below the J-groove weld and including all VHP nozzle surfaces below the J-groove weld that have an operating stress level (including residual and normal operation stresses) of 20 ksi tension and greater or to the bottom of the nozzle.

The licensee is proposing an alternative to the above requirements because, for some nozzles, compliance with the revised order would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

The outside surface of the bottom of all the control rod drive mechanism nozzles are threaded (with a chamfer at the top of the threads) for approximately 0.75 inches. Ultrasonic testing of the chamfered and threaded portions of the nozzle with the PCS24 probe that has been used in previous inspections could produce multiple reflections and tip diffraction signals, resulting in scans that are difficult or impossible to read. At this time, an ultrasonic probe capable of obtaining readable scans of chamfered and threaded portions of the nozzle is not available. Development, qualification, and implementation of an eddy current probe capable of examining the chamfered and threaded surfaces of nozzles would result in a significant testing period and expense. Dye penetrant testing of chamfered and threaded surfaces is possible, however the licensee estimates that dye penetrant testing of these surfaces would involve approximately 400 person-millirem per nozzle.

The licensee stated that due to the geometry involved in the vertical nozzles penetrating the hemispherical RPV head, the minimum distance between the toe on the bottom of the J-groove weld and the top of the chamfer and threads occurs on the "downhill" side of each nozzle. The toe on the bottom of the J-groove weld on the "uphill" side of the three outer rows is at least 4 inches above the toe on the bottom of the J-groove weld on the downhill side. Estimates from the previous inspections of Cook 2 nozzles indicate that, for seven nozzles, the distance below the toe on the bottom of the J-groove weld on the downhill side of the nozzle that is inspectable by ultrasonic or eddy current testing is less than the 1.0 inch criterion specified in the second options of Section IV.C(5)(b)(i) and Section IV.C(5)(b)(ii) of the revised order. These seven nozzles are located on the outer three rows (45.8 degrees, 47.0 degrees, and 50.5 degrees from the RPV head vertical centerline). For six of these nozzles (Penetrations 63, 66, 68, 70, 72, and 76), this distance is less than 1.0 inch but greater than 0.5 inches, with the distance on the most limiting of the six nozzles (Penetration 63) estimated as 0.68 inches. This nozzle is located in the 45.8 degree row. The seventh nozzle (Penetration 73) has an estimated distance of 0.36 inches between the toe on the bottom of the J-groove weld and the top of the chamfer and threads on the downhill side. This nozzle is located in the 47.0 degree row. The tolerance on the above stated distances is estimated to be plus or minus 10 percent.

The licensee's submittal described the use of Cook 2 specific crack growth curves and stress curves to demonstrate that a through-wall axial flaw could be as close as 0.5 inches below the toe of the J-groove weld on the downhill side of the nozzles in the outer three rows, without growing to reach the weld during one cycle of operations, and that tensile stresses in the nozzle are less than 20 ksi at distances greater than approximately 0.6 inches below the toe of the J-groove weld. Therefore, the licensee states that the expenditure of additional time, resources, and personnel radiation exposure to inspect the chamfered and threaded areas in order to comply with the 1.0 inch criterion specified in the second options of Section IV.C(5)(b)(i) and Section IV.C(5)(b)(ii) of the revised order would not provide a compensating increase in the level of quality and safety.

The licensee requests the proposed alternative apply during the period in which the revised NRC Order EA-03-009 is in effect.

2.4 Evaluation

The NRC staff's review of this request was based on criterion (2) of paragraph F of Section IV 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.

In its April 30, 2004 letter, the licensee seeks relaxation from the Order, where inspection coverage is limited at the bottom of the RPV head penetration nozzles due to the outside surface of the bottom of all the control rod drive mechanism (CRDM) nozzles being threaded with a chamfer at the top of the threads. The chamfer and threads cause difficulties for nondestructive examination, including ultrasonic testing, eddy current testing, and dye penetrant testing. Estimates from the previous inspection of the nozzles at Cook 2 indicate that, for seven nozzles, the distance below the toe of the bottom of the J-groove weld on the downhill side of the nozzle that is inspectable by ultrasonic or eddy current testing is less than the 1.0 inch criterion specified in the second options of Section IV.C(5)(b)(i) and Section IV.C(5)(b)(ii) of the Order.

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 to inspect chamfered and threaded areas in order to comply with the 1.0 inch criterion for some of the outer row penetrations. The licensee's proposal provides for additional examination on nozzles that result in examination distances less than 0.5 inches below the toe of the J-groove weld. The performance of a surface examination, such as a penetrant examination on all nozzles for which an examination distance of 1.0 inch below the J-groove weld using automated ultrasonic testing or eddy current testing is not achievable, would result in unnecessary radiation exposure to employees and would not provide significant additional information.

The phenomenon of concern is PWSCC, which typically initiates in the areas of highest stress. The area of CRDM penetrations 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 NRC staff used the hoop stress profiles, based on the licensee's finite element analysis of the head penetration nozzles at Cook 2, and estimated that the stresses decrease to 20 ksi or less at 0.5 inches below the toe of the J-groove weld for the outer three rows of penetrations. The licensee's proposed alternative includes provisions to supplement examinations to obtain a minimum distance of 0.6 inches below the toe of the J-groove weld for nozzles that receive an automated examination distance less than 0.5 inches. The stress level of 20 ksi is a conservative value below which PWSCC initiation is unlikely and is referenced in the Order. Crack initiation would be more likely to occur at the weld region where the stresses are higher. These higher stress regions are able to be examined by the licensee as observed during the Cook 2 previous inspection.

The 0.5 inch inspection distance of the limiting nozzle base material below the attachment weld is supported by the licensee's crack growth analysis. The results of the licensee's analysis show that a postulated flaw located at or below 0.5 inch below the J-groove weld would not propagate to the toe of the J-groove weld within the next operating period. The licensee's flaw evaluation was performed by postulating an axial through-wall flaw in the assumed area of

missed coverage below the weld. The methodology is described in WCAP-14118, Revision 7, “Structural Integrity Evaluation of Reactor Vessel Upper Head Penetrations to Support Continued Operation: D.C. Cook Units 1 and 2." The licensee's deterministic flaw tolerance evaluation showed that a limiting assumed through-wall flaw at 0.5 inches below the J-groove weld for a 45.8, 47.0 or 50.5 degree nozzle would take approximately 2.3 effective full-power years (EFPY) to reach the J-groove weld. The licensee estimated a typical operating cycle for Cook 2 to be 1.35 EFPY. Therefore, an examination that extended to only 0.5 inches below the toe of the J-groove weld would provide almost 1 EFPY of margin against flaw propagation to the toe of the J-groove weld.

The licensee’s analysis used the crack growth formula in Electric Power Research Institute Report Material Reliability Program (MRP) report MRP-55, “Material Reliability Program (MRP) Crack Growth Rates for Evaluating Primary Water Stress Corrosion Cracking (PWSCC) of Thick Wall Alloy 600 Material (MRP-55), Revision 1.” The NRC staff has performed a preliminary assessment of the crack growth rate, but has not yet made a final determination on the acceptability of the subject industry report. 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 stated in its submittal dated April 30, 2004:

> 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 Order 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 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 the current or 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 acceptable crack growth rate formula.

Based upon the information above, the NRC staff finds that the licensee’s proposed examinations to the extent described above is acceptable as it provides reasonable assurance of the structural integrity of the RPV head, VHP nozzles and welds. Further inspections of the bottom of the nozzles to comply with the Order requirements would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety. The NRC staff's evaluation is based on the licensee's deterministic evaluations using the methodology in WCAP-14118, Revision 7, "Structural Integrity Evaluation of Reactor Vessel Head Penetrations to Support Continued Operation: D. C. Cook Units 1 and 2.”

3.0 CONCLUSION

The NRC staff concludes that the licensee's proposed alternative for the examination of the VHP nozzles at Cook 2, provides reasonable assurance of the structural integrity of the RPV head, VHP nozzles and welds at Cook 2. Further inspections of these VHP 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 without a compensating increase in the level of quality and safety. Therefore, for good cause shown, and pursuant to Section IV, Paragraph F, of the Order, the NRC staff authorizes the proposed alternative inspection for the VHP nozzles at Cook 2, 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 Order 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 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 the current or 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 acceptable crack growth rate formula.

Principal Contributor: A. Keim

Date: September 27, 2004

cc:

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