June 2, 2004

MEMORANDUM TO: Lakshminaras Raghavan, Chief
Project Directorate Section III-1
Division of Licensing Project Management

FROM: Terence L. Chan, Chief */RA/*
Piping Integrity and NDE Section
Materials and Chemical Engineering Branch
Division of Engineering

SUBJECT: SAFETY EVALUATION FOR POINT BEACH NUCLEAR PLANT, UNIT 1 FIRST REVISED ORDER EA-03-009 DATED FEBRUARY 20, 2004, RELAXATION REQUEST, EXAMINATION COVERAGE FOR REACTOR PRESSURE VESSEL HEAD PENETRATION NOZZLES (TAC NUMBER MC2532)

On February 20, 2004, the NRC issued the First Revised Order EA-03-009 (the Order) that superceded the original NRC Order EA-03-009 dated February 11, 2003. The First Revised Order continues to impose 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 (ASME) Code in accordance with 10 CFR 50.55a(a)(3).

By letter dated March 30, 2004 as supplemented by letters dated, May 14, May 15, and May 21, 2004, Nuclear Management Company, LLC (the licensee or NMC) submitted a request for relaxation from certain nondestructive examination requirements of the Order for the Point Beach Nuclear Plant, Unit 1 reactor vessel head penetration nozzles. Specifically, the licensee requested relaxation on the examination distance below the J-groove weld for 17 nozzles. In addition, the licensee's request also included relaxation for a radial arc of 60 degrees on nozzle 33 for the full length of the Order required examination area. The licensee subsequently performed additional work and obtained the required coverage for nozzle 33. Therefore, relaxation for coverage limitations on nozzle 33 is not required.

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Based on the attached evaluation, the staff has found the licensee's request for relaxation for the 17 nozzles is acceptable, with a condition. The staff based its evaluation on the licensee's deterministic evaluations based on the methodology in WCAP-14000, Revision 1, "Structural Integrity Evaluation of Reactor Vessel Head Penetrations to Support Continued Operation: Point Beach Units 1 & 2." The staff did not review the Structural Integrity Associates Report SIR-04-032, Revision 0, "Probabilistic Fracture Mechanics Analysis of CRDM Inspection Alternatives at Point Beach Unit 1," (Enclosure II of letter dated March 30, 2004) as part of its evaluation. This action completes the technical review for TAC number MC2532.

Docket No.: 50-266

Attachment: As stated

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* see previous concurrence

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
NUCLEAR MANAGEMENT COMPANY, LLC
POINT BEACH NUCLEAR PLANT, UNIT 1
DOCKET NUMBER 50-266

1.0 INTRODUCTION

By letter dated March 30, 2004, as supplemented by letters dated, May 14, May 15 and May 21, 2004, Nuclear Management Company, LLC (the licensee or NMC) submitted a request for relaxation from certain nondestructive examination requirements of the First Revised NRC Order EA-03-009 (hereinafter referred to as Order) for the Point Beach Nuclear Plant, Unit 1 (PB-1) reactor vessel head penetration nozzles.

The Order, issued on February 20, 2004, requires 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 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 10 CFR 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 PB-1 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 First Revised Order:

(a) Bare metal visual (BMV) examination of 100% 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 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 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 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.

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

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

2.1 First Revised Order Requirements for Which Relaxation is Requested

The licensee requested relaxation to implement an alternative to the requirements of Section IV, paragraph C.(5)(b)(i) and C.(5)(b)(ii), of the First Revised Order for RPV head penetration nozzles at PB-1. Specifically, the licensee requested relaxation on the examination distance below the weld. The request also included relaxation on a radial arc of 60 degrees on nozzle 33 for the full length of the Order required examination area. The licensee subsequently performed additional work and obtained the required examination coverage for nozzle 33. Therefore, the staff did not review the justification for relaxation of nozzle 33.

2.2 Licensee's Proposed Alternative

The licensee seeks relaxation from the First Revised NRC Order EA-03-009, dated February 20, 2004, where inspection coverage is limited on 17 reactor VHP nozzles with respect to nondestructive examination (NDE), specifically ultrasonic testing (UT) below the J-groove weld.

The licensee was able to meet the Order requirements of Section IV, paragraph C.(5)(b)(i) for 32 of the 49 RVP nozzles and the 1 vent line penetration. The examination distances below the J-groove weld for the other 17 RVP nozzles are listed below in Table 1.

TABLE 1

Nozzle Number	Nozzle Angle	Minimum ID distance below weld on down-hill side as measured (inches)	Minimum OD distance below weld on down-hill side as measured (inches)	Minimum OD Distance Below weld on the down-hill side less 0.03" instrument uncertainty (inches)
4	19.4	1.394	1.0	0.97
11	28.1	1.394	1.0	0.97
12	28.1	1.074	0.68	0.65
13	28.1	1.124	0.73	0.70
15	31.8	1.394	1.000	0.970
16	31.8	0.974	0.58	0.55
18	29.9	1.394	1.0	0.970
19	29.9	1.394	1.0	0.97
20	29.9	0.834	0.44	0.41
22	31.8	1.404	1.01	0.98
24	31.8	1.074	0.680	0.65
25	31.8	1.394	1.0	0.97
27	36.9	1.344	0.95	0.92
28	36.9	0.924	0.53	0.5
29	36.9	1.164	0.77	0.74
30	36.9	1.174	0.78	0.75
31	36.9	1.134	0.740	0.71

2.3 Licensee's Basis for Relaxation

The NRC Order requires that ultrasonic or surface examination extend to two inches below the J-groove weld or one 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 identified seventeen nozzles which could not be examined to the nozzle end on the OD surface due to the blind zone. This distance was less than one inch below the toe of the J-groove weld. The amount of unscanned area is a function of the Areva blade tool and the distance the nozzles extend beyond the toe of the weld. The Areva blade tool has a blind zone at the nozzle end. The blind zone has a height of 0.4 inches on the OD of the Nozzle. The ID of the nozzle can be scanned to the nozzle end.

For the subject 17 nozzles, the licensee volumetrically examined the full distance on the ID of the nozzle, but not the OD below the J-groove weld. The licensee used deterministic fracture mechanics to justify that a flaw would not grow to the toe of the weld in one cycle of operation for the limiting nozzle (nozzle 20).

The licensee determined the time for a worst-case flaw to grow to the toe of the weld would be approximately 2.5 EFPY. PB-1 operates on an 18-month cycle and will be replacing the RPV head during the next refueling outage scheduled for Fall 2006.

2.4 Evaluation

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

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 on the OD (approximately 0.4 inches). To perform additional examinations on this small region would not provide any increase in the level of quality and safety. To perform a surface examination such as penetrant examination, would incur unnecessary radiation dose to employees and would not provide significant information due to the short examination distance.

The phenomenon of concern is primary water stress corrosion cracking (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 staff used the stress profiles, based on the licensee's finite element analysis of the VHP nozzles at PB-1, and estimated that the stresses decrease to 20 ksi or less at the examination distances obtained for 11 out of the 17 VHP nozzles with limited examination coverage below the J-groove weld. Of the six VHP nozzles to which the ID and OD stresses were not less then 20 ksi at the examination distance, (nozzle numbers 16, 20, 28, 29, 30, and 31) the limiting

nozzle (nozzle number 20) decreased to approximately 20 ksi on the ID of the weld and was less than 30 ksi on the OD of the weld at the distance examined (the staff used the data supplied in the May 14, 2004 submittal for hoop stresses on the 28.2 and 43.5 degree nozzles for its estimates). The nominal yield strength of the VHP nozzles at PB-1 varies from 40.5 ksi to 60 ksi. 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 regions were examined by the licensee for the subject 17 nozzles. In addition, the staff finds that the higher stress (30 ksi) on the OD of nozzle number 20 at a distance of 0.41 inch below the weld is less than the yield stress and, therefore, the likelihood of crack initiation at that location is low.

The 0.41 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 licencee's analysis shows that a postulated flaw located at or below 0.41 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 was described in WCAP-14000, Rev. 1, "Structural Integrity Evaluation of Reactor Vessel Upper Head Penetrations to Support Continued Operation: Point Beach Units 1 and 2." The licensee's deterministic flaw tolerance evaluation showed that the assumed through-wall flaw would take over 2.5 EFPY to reach the J-groove weld.

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 (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 committed to revise its analysis to incorporate an acceptable crack growth formula as described below in its letter dated May 21, 2004:

> If the NRC staff finds that the crack-growth formula in industry report MRP-55 is unacceptable, NMC shall revise its analysis that justifies relaxation of the Order within 30 days after the NRC informs NMC of an NRC-approved crack growth formula. If NMC'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 NMC 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, NMC 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 inspections must be based on an acceptable crack growth rate formula.

The licensee inspected all penetrations using a volumetric ultrasonic (UT) examination including a UT leak path assessment. The UT examination covered the area from two inches above the J-groove weld down to the nozzle end.

No supplemental examinations were performed on the OD surface of the VHP nozzles to cover the small unexamined region (0.4 inches) that was not covered by UT examination. The staff finds that additional examination on the OD surface would be a hardship without a compensating increase in the level of quality or safety.

Based upon the information above, the staff finds that the licensee's 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 OD surface on the bottom of the nozzles (0.4 inch) to comply with the First Revised Order requirements would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety. The staff's evaluation is based on the licensee's deterministic evaluations using the methodology in WCAP-14000, Revision 1, "Structural Integrity Evaluation of Reactor Vessel Head Penetrations to Support Continued Operation: Point Beach Units 1 & 2." The staff did not review the Structural Integrity Associates Report SIR-04-032, Revision 0, "Probabilistic Fracture Mechanics Analysis of CRDM Inspection Alternatives at Point Beach Unit 1," (Enclosure II of letter dated March 30, 2004) as part of this safety evaluation.

3.0 CONCLUSION

The staff concludes that the licensee's examinations of the subject 17 VHP nozzles at PB- 1 from 2 inches above the J-groove weld to the level below the weld as identified in Table 1 provides reasonable assurance of the structural integrity of the RPV head, VHP nozzles and welds at PB-1. 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, pursuant to Section IV, paragraph F, of the First Revised Order EA-03-009 dated February 20, 2004, the staff authorizes the proposed alternative inspection for the subject 17 VHP nozzles at PB-1 subject to the following condition:

> If the NRC staff finds that the crack-growth formula in industry report MRP-55 is unacceptable, NMC shall revise its analysis that justifies relaxation of the Order within 30 days after the NRC informs NMC of an NRC-approved crack growth formula. If NMC'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 NMC 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, NMC 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 inspections must be based on an acceptable crack growth rate formula.

As stated in the licensee's RAI response dated May 21, 2004, the licensee committed to comply with the condition language as stated above should the crack-growth formula be found unacceptable to the NRC staff.