NMC
Committed to Nuclear Excellence

Palisades Nuclear Plant
Operated by Nuclear Management Company, LLC

February 27, 2006

10 CFR 50.55a

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555

Palisades Nuclear Power Plant
Docket 50-255
License No. DPR-20

Response to RAI on Request for Relief from ASME Section XI Code Requirements for Repair of Reactor Pressure Vessel Head Penetrations

By letter dated October 11, 2005, Nuclear Management Company, LLC (NMC) requested relief from certain sections of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code in the event a reactor vessel head penetration nozzle was in need of a repair at the Palisades Nuclear Plant (PNP).

By letter dated February 1, 2006, the NRC issued a request for additional information (RAI) on the subject relief requests. An additional question, Question 10, was sent via electronic mail on February 14, 2006. Enclosure 1 contains the NMC response to the RAI.

Attachment 1 contains Framatome Document 32-5059512-00, "Palisades CEDM and ICI Nozzle IDTB Repair PWSCC Life Evaluation," dated March 10, 2005 (Proprietary). Also included in Attachment 1 is a Framatome Affidavit. Because Attachment 1 contains information proprietary to Framatome ANP Inc, it is supported by an affidavit signed by Framatome, the owner of the information. The affidavit sets forth the basis on which the information may be withheld from public disclosure by the Commission and addresses with specificity the considerations listed in 10 CFR 2.390.

NMC requests that Attachment 1, which is proprietary to Framatome, be withheld from public disclosure in accordance with 10 CFR 2.390. Correspondence regarding the supporting Framatome affidavit should be addressed to G.F. Elliott, Manager, Product Licensing in Regulatory Affairs, Framatome ANP Inc, 3315 Forest Road, P.O. Box 10935, Lynchburg, Virginia, 24506-0935.

Attachment 2 contains Framatome Document 86-9012791-000, "Palisades CEDM and ICI Nozzle IDTB Repair PWSCC Life Evaluation," dated February 10, 2006 (Non-Proprietary).

A047

Summary of Commitments

This letter contains no new commitments and no revisions to existing commitments.

Paul A. Harden
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Nuclear Management Company, LLC

Enclosure (1)
Attachments (2)

CC Administrator, Region III, USNRC
Project Manager, Palisades, USNRC
Resident Inspector, Palisades, USNRC

ENCLOSURE 1
RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION
PALISADES NUCLEAR PLANT

NRC Request

Nuclear Management Company's (NMC's) letter of October 11, 2005, requested relief from certain sections of the American Society of Mechanical Engineers (ASME) Code in the event a reactor vessel (RV) head penetration nozzle was in need of a repair at the Palisades Nuclear Plant. To complete its review of the submittal, the staff requests the following additional information.

1. *Enclosure 1, page 1. NMC said that an analysis of a non-abrasive water jet machining (non-AWJM) conditioned repair showed that a crack in the nozzle will not grow to 75 percent through-wall in 5.04 effective full power years (EFPY) for a repaired control rod drive (CRD) nozzle, and 5.13 EFPY for a repaired incore instrumentation nozzle. These periods are beyond the duration for the relief request, which will conclude on December 12, 2006. Therefore, NMC determined that AWJM conditioning was unnecessary in the repair process. The staff is not clear why AWJM conditioning is not needed if the periods for a 75 percent through-wall crack are beyond the duration of the relief request. Will NMC examine the nozzles periodically to assure that cracks will not develop, and the inspection frequency will be shorter than 5.04 and 5.13 EFPY? Please clarify.*

NMC Response

1. The reactor pressure vessel (RPV) head at Palisades Nuclear Plant (PNP) required repair of CRD nozzles 29 and 30 during the 2004 refueling outage. Therefore, the First Revised Order EA-03-009, "Issuance of First Revised Order Establishing Interim Inspection Requirements for Reactor Pressure Vessel Heads at Pressurized Water Reactors," Section IV.C.(1), dated February 20, 2004, requires that inspections be performed on the repaired RPV head penetration nozzles that establish a new pressure boundary every refueling outage. If any CRD or ICI penetration nozzles require repairs during the 2006 refueling outage, these repairs will also require inspections on a frequency of each refueling outage to meet the requirements of EA-03-009, until the RPV head is replaced at PNP. The refueling outage frequency and thus the required inspection period is approximately every 18 months at PNP, which is shorter than the analyzed time required for a crack in the non-AWJM conditioned repair to grow to 75 percent through-wall in a CRD nozzle (5.04 EFPY) or an ICI nozzle (5.13 EFPY).

   Due to the discovery of the leak path indications and subsequent repairs during the 2004 Refueling Outage, the Palisades Nuclear Plant RPV head is now in the High Susceptibility category, as defined by the First Revised Order EA-03-009. Therefore, future outage inspections will be conducted per Section IV.C.(1) of the First Revised Order.

NRC Request

2. *Enclosure 2, page 1. NMC said that extensive radiological dose was received during the nozzle repair due to the chamfering process. Provide the dose measurement.*

NMC Response

2. Extensive dose was received during the repair of RPV head penetrations 29 and 30, due to the required chamfer grinding. The table below describes the dose performance and radiological conditions for this work.

Total Person – Rem to chamfer grind 29 and 30	5.994 Rem
Total Person – Hours to chamfer grind 29 and 30	34.6 Hours
Highest Dose rate as seen via remote monitoring	8.320 Rem/hour
Maximum dose received by an individual on a single entry	882.8 mrem
Radiological conditions: highest contact dose rates	Up to 9.8 Rem/hour
Radiological conditions: highest general area dose rates for this task	6.2 Rem/hour
Radiological conditions: contamination levels	7 - 12 Rad/hr/ smearable

NRC Request

3. *Enclosure 2, page 3, Item 4. NMC proposed to use the 2005 Addenda of ASME Section XI, 2004 Edition where the code allows the ratio of the maximum applied stress intensity factor and the available fracture toughness based on crack initiation (K_{IC}) for the corresponding crack tip temperature be less than $\sqrt{2}$ at a temperature for RT_{NDT} [reference temperature]. The proposed criterion is not the same as the requirements in ASME Section XI, IWB- 3613(a), which require that for conditions < 20 percent of design pressure, the ratio of the maximum applied stress intensity factor and the available fracture toughness based on crack arrest (K_{Ia}) for the corresponding crack tip temperature be < $\sqrt{2}$ at a temperature of RT_{NDT} + 60 °F.*

   (a) *The NRC has not accepted the 2004 Edition and 2005 Addenda in Title 10, Code of Federal Regulation, Part 50 (10 CFR 50.55a).*

   The NRC staff has not completed its review of the 2004 Edition of the Code as part of updating 10 CFR 50.55a. Therefore, please reference documents other than the 2004 Edition and 2005 Addenda of ASME Section XI to support your technical basis in Item 4.

NMC Response

3. (a) For linear elastic fracture mechanics (LEFM) evaluations, ASME Section XI, Article IWB-3612, 1989 Edition requires that a safety factor of $\sqrt{10}$ be used when comparing the applied stress intensity factor to the crack arrest fracture toughness (K_{Ia}). ASME Section XI, Article IWB-3613(a), 1989 Edition provides acceptance criteria for shell regions near structural discontinuities, which include the intersections of nozzles and pressure vessel shells per Code Interpretation IN 03-013 (applicable to the 1989 Code edition through the 2001 Edition with the 2003 Addenda). Per IWB-3613(a), at pressures below 20% of the design pressure and temperatures not less than RT_{NDT} + 60°F, K_I is limited to $K_{Ia}/\sqrt{2}$. At low pressure and temperature conditions near the end of cooldown, the present flaw evaluations will be based on alternate evaluation standards. Listed below are the alternate criteria that will be used in the present flaw evaluations.

1. The temperature requirement will be changed from RT_{NDT} + 60°F to RT_{NDT}.

This is consistent with current pressure-temperature limit criteria in the 1989 Edition of Section XI, Appendix G, Article G-2222(c) for shell regions near geometric discontinuities, and in 10CFR50, Appendix G, Table 1, Item 2.a for the closure flange region prior to core criticality.

2. The fracture toughness requirement will be changed from $K_{Ia}/\sqrt{2}$ to $K_{Ic}/\sqrt{2}$.

The crack arrest toughness, K_{Ia} (or K_{IR}), was originally used in the 1974 Code edition to provide additional margin thought to be necessary to cover uncertainties, as well as a number of postulated (but un-quantified) effects. The use of the crack arrest toughness for determining the condition for fracture initiation was a conservative assumption to address the possibility of local areas of low fracture toughness in weldments. The philosophy of using K_{Ia} conservatively assumes that the fracture event is one of arresting a dynamic running crack from an area of local embrittlement. Significantly more information is now known about these uncertainties and effects such that the fracture toughness requirements can be changed.

For nuclear plants, transient conditions are generally slow, so that stress conditions are quasi-static for a stationary flaw. For these transient conditions, the rate of change of pressure and temperature are several orders of magnitude lower than those associated with dynamic conditions associated with crack arrest testing. The only time when dynamic loading can occur and where the dynamic/arrest fracture toughness, K_{Ia}, should be used is when a crack is propagating. Whereas this situation may be postulated during accident conditions for assessing the potential for crack arrest, it is not a credible scenario for crack initiation. Therefore, use of the static lower bound fracture toughness, K_{Ic}, is more technically correct for evaluating the potential for crack initiation.

Since the original formulation of the K_{Ia} and K_{Ic} fracture toughness curves in 1972, the fracture toughness database has increased by more than an order of magnitude, and both K_{Ia} and K_{Ic} remain lower bound curves. In addition, the temperature range over which the data have been obtained has been extended to include both higher and lower temperatures than the original database. Only a few data points fall below the K_{Ic} curve, and just barely, providing a high degree of confidence for using K_{Ic} to predict crack initiation.

The concern that there could be a small, local zone in a weld or heat-affected zone of the base material that could pop-in and produce a dynamically moving cleavage crack is not warranted based on test data. After over 30 years of research on reactor pressure vessel steels fabricated under tight controls, micro-cleavage pop-in has not been found to be significant. Researchers have not been able to produce a catastrophic failure of a vessel, component, or even a fracture toughness test specimen in the transition temperature region. Thus it is overly conservative to use the lower bound K_{Ia} curve to address the effect of this postulated condition on crack initiation.

The change from K_{Ia} to K_{Ic} has already been implemented in the 2001 edition of Section XI, Appendix G for determining pressure-temperature limits. The use of K_{Ic} in the flaw acceptance criteria of IWB-3613(a) is therefore consistent with the latest fracture toughness requirement in Section XI, Appendix G.

Therefore stress intensity factors will be limited to $K_{Ic}/\sqrt{2}$ for low temperature conditions when the pressure is less than 500 psia and the temperature is at least 72 °F (RT_{NDT}).

NRC Request

(b) *Please show why the postulated flaw in the remnant J-groove weld could not meet the requirements in IWB-3613(a) of the 1989 edition of the ASME Code Section XI, which is the code of record, to establish the basis for the relief.*

NMC Response

(b) The controlling low temperature condition occurs during cooldown at a temperature of 70 °F, which is below RT_{NDT} + 60 °F, or 132 °F. Furthermore, using an available fracture toughness based on crack arrest (K_{Ia}), the ratio $K_{Ia}/K_I(a_e)$ would be 1.32, which is less than the required margin of $\sqrt{2}$, or 1.41.

NRC Request

(c) *Please demonstrate that your proposed criterion provides sufficient margin such that the structural integrity of the RV head will not be compromised. Confirm that the proposed criterion applies only to the RV head, not to the nozzles.*

NMC Response

(c) Refer to 3(a). The proposed criterion under IWB-3610 applies to the ferritic steel reactor vessel head material.

NRC Request

4. *Enclosure 2, page 4, 3rd paragraph. Discuss whether hydrostatic pressure was applied to the crack face, and whether a plastic zone correction factor was included in the flaw evaluation of the remnant J-groove weld.*

NMC Response

4. Hydrostatic pressure is not a design condition for the repaired nozzle. If the question is whether pressure is applied to the crack face, the answer is yes. The pressures listed in the flaw evaluation, AREVA Document # 32-5061353-00, tables (e.g., Table 3: 235, 2085, 2085, 295, and 0 psig) were entered into the ANSYS input files as an added crack face stress.

   A plastic zone correction factor was included in the flaw evaluation of the remnant J-groove weld.

NRC Request

5. *Enclosure 3, page 3. Reference 7, AREVA Proprietary Document 32-5059512-00, "Palisades CEDM [control element drive mechanism] and ICI [in-core instrumentation] Nozzle IDTB [inner-diameter temper bead] Repair PWSCC [primary-water stress corrosion cracking] Life Evaluation," March 2005, contains flaw evaluations of non-AWJM to the nozzles. Please provide Reference 7 to the NRC.*

NMC Response

5. AREVA Proprietary Document 32-5059512-00, "Palisades CEDM and ICI Nozzle IDTB Repair PWSCC Life Evaluation," dated March 2005, is provided as Attachment 1. Attachment 2 provides the Non-Proprietary version of the evaluation.

NRC Request

6. *Enclosure 3, page 4. In the 2nd paragraph, NMC said "...postulated flaws in the CRDM [control rod drive mechanism] J-groove weld and butter are acceptable for 27 years of operation ...." In the 3rd paragraph, NMC said "...the results showed that the postulated radial crack in the Alloy 182 J-groove weld and butter would be acceptable for 5 years of operation for an ICI nozzle...."*

   (a) *Discuss why there is a large difference in periods of acceptability between the CRDM nozzle and ICI nozzle.*

NMC Response

(a) There are two major sources for the large difference in the design lives for the two nozzles: geometric considerations and analytical methods. The ICI nozzle has both a larger repair bore diameter and a greater height for the remaining J-groove weld than the repaired CRDM nozzle. The larger bore tends to increase pressure stresses and the deeper weld results in a large flaw size, both of which contribute to higher stress intensity factors at the crack tip and hence, reduced design life. Furthermore, the conservative LEFM approach utilized for the ICI nozzle is more sensitive to nozzle configuration than the elastic-plastic fracture mechanics (EPFM) analysis method used for the CRDM nozzle.

NRC Request

(b) *The staff understands that in NMC's flaw evaluations, the remnant J-groove weld was assumed to be cracked in its entirety, and the tip of the initial crack was assumed to be located at the boundary between the weld and the RV head. The crack was assumed to propagate into the RV head, and the goal was to determine the structural integrity of the RV head. Therefore, it is not clear whether the acceptable periods of operation discussed in the above statement refer to the remnant J-groove welds or the RV head. Please clarify the above statements.*

NMC Response

(b) The goal of the remnant J-groove flaw evaluations was to investigate the structural integrity of the RVH; i.e., the pressure boundary for the repaired nozzle in the vicinity of the remaining weld. The acceptable periods of operation refer to the RVH.

NRC Request

7. *NMC's RV head penetration nozzle relief request of August 2, 2004, said "if the IDTB weld repair is not abrasive water jet machining (AWJM) remediated, the life expectancy relative to PWSCC is conservatively estimated at 1.3 effective full power years (EFPY) for a CRD nozzle and 1.5 EFPY for an ICI nozzle. If AWJM*

is used, the life expectancy relative to PWSCC is conservatively estimated at 53 EFPY for CRD and ICI nozzles." NMC's relief request of October 11, 2005, said "the life expectancy of the non-AWJM conditioned IDTB weld repair relative to PWSCC is conservatively estimated at 5.04 effective full power years (EFPY) for a CRD nozzle and 5.13 EFPY for an ICI nozzle." Please explain the change in the current method used to analyze the life expectancy of non-AWJM versus the method used in the previous relief request.

NMC Response

7. In the August 2004 submittal, the contingency IDTB modification included planned AWJM remediation, but also included a conservative simplistic life assessment of a non-remediation modification. This assessment was for comparative and informative purposes, and considered immediate PWSCC crack initiation, ASME Section XI acceptance criteria, and a constant rapid crack growth rate independent of stress intensity (K_I). In the October 2005 submittal, AWJM of a contingency modification was not planned and the minimum design life of a non-AWJM IDTB modification was two fuel cycles. The life assessment utilized in the October 2005 submittal was quantitative and considered immediate PWSCC crack initiation, weld residual and operating throughwall stress distributions, ASME Section XI acceptance criteria, and K_I based crack growth using MRP-55 rev01 Alloy 600 crack growth rates. Thus, the time for an immediately initiated PWSCC crack was calculated to be 5.04 EFPY compared to the earlier 1.3 EFPY assessment for the CRDM nozzle. Note that reinspection of any repaired/modified CRDM nozzle is required at every refueling outage per EA-03-009, thus adding an additional level of confidence that the IDTB modification will operate as designed.

NRC Request

8. *On Page 8 of 16 of Enclosure 1 to its October 11, 2005, submittal, NMC lists the differences between its alternative and the requirements of Code Case N-638, "Similar and Dissimiliar Metal Welding Using Ambient Temperature Machine GTAW [Gas Tungsten Arc Welding] Temper Bead Technique." In paragraph d) on this page, NMC discusses its impact-property testing. NMC indicates that the RT_{NDT} is 30 degrees F, but in the next sentence states that the RT_{NDT} + 60 degrees is 30 degrees F. Please explain this inconsistency.*

NMC Response

8. A negative sign was inadvertently left out of the first of the two referenced sentences. The sentences in paragraph d) on Page 8 of 16 of Enclosure 1 should have read as follows:

"During the Charpy impact testing portion of the qualification process, the reference temperature (RT_{NDT}) was determined to be - 30°F. At RT_{NDT} + 60°F temperature (+30°F), the average of the HAZ absorbed energy Charpy impact tests was greater than the average of the unaffected base material."

NRC Request

9. In the same paragraph d) as discussed above, NMC said that it did not meet the requirements of N-638 2.1 (j), but it conducted additional testing, as permitted by NB-4335.2, "Impact Tests of Heat Affected Zone," because the mils lateral expansion results were not acceptable. Please confirm that all requirements for impact testing of the heat affect zone as described in NB-4335.2 have been met.

NMC Response

9. Yes, the requirements for impact testing of the heat affected zone as described in NB-4335.2 have been met.

NB-4335.2 (b)(2) states the following:

"If the average Charpy V-notch lateral expansion for the heat affected zone of (b)(1) above is less than that for the unaffected base material, and the qualification test meets the other criteria of acceptance, the Charpy V-notch test results may be recorded on the Welding Procedure Qualification Record. Data shall then be obtained as specified in (b)(3) below to provide an additive temperature for any base material for which the welding procedure is being qualified, and shall be included. Alternatively, the welding procedure qualification may be rewelded and retested."

NB-4335.2(b)(3) was met with an additive temperature to the base material RT_{NDT} on which welding is to be performed of + 5°F. The average heat affected zone (HAZ) mils lateral expansion at + 35°F was equal to the average unaffected base metal mils lateral expansion at + 30°F for AREVA Procedure Qualification Record PQ7183-03.

NRC Request

10. Pages 6 and 7 of RR from ASME Code, Section XI, IWA-4120, Rules and Requirements. for RPV Head Pene. Repair:

NMC says NB-4622.1 1 (f) establishes requirements for the procedure qualification test plate relative to the P-Number and group number and the PWHT of the materials to be welded. The proposed alternative meets and exceeds those requirements except that the root width and included angle of the cavity are stipulated to be no greater than the minimum specified for the repair. In addition, the location of the V-notch for the Charpy test specimen is more stringently controlled in the proposed alternative than in NB-4622.11 (f).

Explain why NMC can't meet the root and included angle requirement, and explain why NMC's alternative provides an acceptable level of quality and safety. In NMC's previous request that the staff granted, NMC stated the proposed alternative complied with the requirements of NB-4622.11 (f).

NMC Response

10. After subsequent review of the identified wording above, clarification is required. The identified wording above, from NMC's submittal dated October 11, 2005, should be replaced with the following paragraph.

    NB-4622.11 (f) establishes requirements for the procedure qualification test plate relative to the P-No. and Group Number and the post-weld heat treatment of the materials to be welded. The proposed alternative meets and exceeds those requirements with the additional requirements that the root width and included angle of the cavity are stipulated to be no greater than the minimum specified for the repair. In addition, the location of the V-notch for the Charpy test specimen is more stringently controlled in the proposed alternative than in NB-4622.11(f).

    For clarification, the root width and included angle of the qualification test plate do meet the requirements of NB-4622.11(f).