April 3, 2006

Mr. Paul A. Harden
Site Vice President
Nuclear Management Company, LLC
Palisades Nuclear Plant
27780 Blue Star Memorial Highway
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SUBJECT: PALISADES NUCLEAR PLANT — REQUEST FOR AUTHORIZATION TO USE ALTERNATIVES TO ASME CODE, SECTION XI, IWA-3300, IWB-3142.4, IWB-3420, AND IWB-3613 FOR REACTOR PRESSURE VESSEL HEAD PENETRATION REPAIR (TAC NO. MC8604)

Dear Mr. Harden:

Your letter of October 11, 2005, submitted two requests for relief from certain sections of the American Society of Mechanical Engineers *Boiler and Pressure Vessel Code* (ASME Code), Section XI, 1989 Edition, for reactor vessel closure head (RVCH) penetration repair. Specifically, Relief Request No. 1 pertained to ASME Code, Section XI, IWA-4120, “Rules and Requirements.” Relief Request No. 2 was concerned with ASME Code, Section XI, IWA-3300, “Flaw Characterization,” IWB-3142.4, “Acceptance by Analytical Evaluation,” IWB-3420, “Characterization,” and IWB-3613, “Acceptance Criteria for Flanges and Shell Regions Near Structural Discontinuities.” This authorization pertains to Relief Request No. 2. Relief Request No. 1 will be handled under separate correspondence.

Relief Request No. 2 applies to the repair of control rod drive and incore instrumentation nozzle penetrations on the RVCH in the event that a nozzle penetration requires repair at the Palisades Nuclear Plant. We have completed our review of Relief Request No. 2, and conclude that complying with the ASME Code, Section XI requirements regarding flaw characterization and successive examinations of the remnant J-groove welds is impractical for the Palisades Nuclear Plant. We also conclude that the proposed alternatives provide reasonable assurance of structural integrity. Therefore, pursuant to Title 10 of the *Code of Federal Regulations* 50.55a(g)(6)(i), Relief Request No. 2 is granted through the end of the third 10-year inservice inspection interval.

Nuclear Management Company's (NMC's) fracture mechanics analyses showed that for the incore instrumentation nozzle repair, the RVCH meets the requirements of ASME Code, Section XI, Subarticle IWB-3612, for 5 years. If an incore instrumentation nozzle is repaired, NMC is required to submit to the NRC for review and approval additional analyses or plans for corrective actions to demonstrate that the RVCH satisfies the requirements of Subarticle IWB-3612 beyond 5 years. Enclosed is our safety evaluation.

Sincerely,

/RA/

L. Raghavan, Branch Chief
Plant Licensing Branch III-1
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-255

Enclosure:
Safety Evaluation

cc w/encl: See next page

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

REQUEST FOR AUTHORIZATION TO USE ALTERNATIVES TO ASME CODE, SECTION XI,

IWA-3300, IWB-3142.4, IWB-3420, AND IWB-3613 FOR REACTOR

PRESSURE VESSEL HEAD PENETRATION REPAIR

NUCLEAR MANAGEMENT COMPANY

PALISADES NUCLEAR PLANT

DOCKET NO. 50-255

1.0 INTRODUCTION

Nuclear Management Company, LLC's (NMC's) letter of October 11, 2005, as supplemented February 27, 2006, requested relief from certain sections of the 1989 Edition of American Society of Mechanical Engineers *Boiler and Pressure Vessel Code* (ASME Code), Section XI. Relief Request No. 2 pertained to the repair of the control rod drive (CRD) and incore instrumentation (ICI) nozzle penetrations on the reactor vessel closure head (RVCH) at the Palisades Nuclear Plant. NMC planned to inspect the RVCH, CRD nozzle penetrations, and ICI nozzle penetrations during the 2006 refueling outage at the Palisades Nuclear Plant, in accordance with Nuclear Regulatory Commission (NRC) Order, EA-03-009, "Issuance of First Revised NRC Order (EA-03-009) Establishing Interim Inspection Requirements for Reactor Pressure Vessel Heads at Pressurized Water Reactors," dated February 20, 2004. NMC submitted this request in the event that a RVCH nozzle penetration requires repair at the Palisades Nuclear Plant.

The CRD and ICI nozzle penetrations are attached to the interior surface of the RVCH by J-groove welds. The J-groove welds are fabricated with Alloy 82/182 material. The CRD and ICI nozzles are fabricated with Alloy 600 material. Both of these alloys have been found to be susceptible to primary water stress corrosion cracking (PWSCC). NMC has developed the inside-diameter temper bead (IDTB) method to repair the degraded nozzle(s). With this method, the degraded nozzle is cut a few inches above the J-groove weld inside the RVCH penetration, and the lower part of the nozzle (the degraded part) is removed from the penetration. The upper part of the nozzle remains in service. The replacement nozzle is inserted into the RVCH penetration, rolled, and joined with the remnant nozzle by a new weld inside the RVCH penetration. The replacement nozzle is fabricated with Alloy 690 material, which is more resistant to PWSCC than Alloy 600 material. The new weld is fabricated with Alloy 52/152 material, which is more resistant to PWSCC than Alloy 82/182 weld material. The original J-groove weld will not be removed nor examined in the future.

The IDTB repair method requires relief from certain requirements in Section XI of the ASME Code. NMC's letter of August 2, 2004, submitted the original Relief Request Nos. 1 and 2. The NRC staff approved the original Relief Request Nos. 1 and 2 by letter dated November 8, 2004, (ADAMS Accession ML043090191). Relief Request No. 1 is related to the welding procedures of the RVCH nozzle repair. Relief Request No. 2 is related to the evaluation of potential flaws in the remnant J-groove weld, and successive examinations of the weld.

As a result of its experience with the repair of two CRD nozzles during the 2004, refueling outage, NMC proposed a revision to the NRC-approved Relief Request Nos. 1 and 2. This safety evaluation is related to the revised Relief Request No. 2, only. The NRC staff will address Relief Request No. 1 separately.

The differences between the previously approved Relief Request No. 2 and the proposed version are that NMC will not perform chamfering grinding of the remnant J-groove weld in future nozzle repairs, and NMC proposes alternative acceptance criteria to the ASME Code, Section XI, IWB-3613, "Acceptance Criteria for Flanges and Shell Regions Near Structural Discontinuities."

2.0 REGULATORY EVALUATION

The inservice inspection of ASME Code Class 1, Class 2, and Class 3 components is to be performed in accordance with the ASME Code, Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components," and applicable edition and addenda as required by Title 10 of the *Code of Federal Regulations* (10 CFR) 50.55a(g), except where specific relief has been granted by the Commission pursuant to 10 CFR 50.55a(g)(6)(i). Paragraph 10 CFR 50.55a(g)(6)(i) states that ". . .the Commission will evaluate determinations . . . that [ASME] code requirements are impractical. The Commission may grant such relief and may impose such alternative requirements as it determines is authorized by law and will not endanger life or property or the common defense and security, and is otherwise in the public interest giving due consideration to the burden upon the licensee that could result if the requirements were imposed on the facility."

Pursuant to 10 CFR 50.55a(a)(3), alternatives to the requirements of paragraph (g) may be used, when authorized by the NRC, if the applicant demonstrates that: (i) the proposed alternatives would provide an acceptable level of quality and safety, or (ii) compliance with the specified requirements would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

Pursuant to 10 CFR 50.55a(g)(4), ASME Code Class 1, 2, and 3 components (including supports) will meet the requirements, except the design and access provisions and the preservice examination requirements, set forth in the ASME Code, Section XI to the extent practical within the limitations of design, geometry, and materials of construction of the components. Paragraph 10 CFR 50.55a(g)(4) requires that inservice examination of components and system pressure tests conducted during the first 10-year inspection interval and subsequent inspection intervals comply with the requirements in the latest edition and addenda of Section XI of the ASME Code. The latest edition and addenda of Section XI of the ASME Code is incorporated by reference in 10 CFR 50.55a(b), 12-months prior to the start of the 10-year inspection interval.

The original construction code for the Palisades Nuclear Plant is ASME Code, Section III, 1965 Edition, including addenda through winter 1965. The inservice inspection code of record for the third 10-year interval is the 1989 Edition of ASME Code, Section XI, no addenda.

3.0 TECHNICAL EVALUATION

3.1 Components for Which Relief Is Requested

The components for which relief is requested are the 45 CRD and 8 ICI nozzle penetrations attached to the RVCH.

3.2 Applicable ASME Code Edition and Addenda

The applicable code edition and addenda for the RVCH penetration is the 1989 Edition of the ASME Code, Section XI, with no addenda.

3.3 Applicable ASME Code Requirement

The applicable code requirement for RVCH penetration repair is ASME Code, Section XI, Subarticle IWB-2500, Examination Category B-E, "Pressure Retaining Partial Penetration Welds in Vessels," Items B4.12 and B4.13. This requirement applies to the inservice examinations of the CRD and ICI nozzle-to-RVCH welds. Subarticles IWA-3300, “Flaw Characterization,” IWB-3142.4, “Acceptance by Analytical Evaluation,” and IWB-3420, “Characterization,” apply to any flaws discovered during inservice inspection. Subarticles IWB-3612 and IWB-3613 give acceptance criteria for the analytical evaluation of flaws that, in this case, are assumed to exist in the remnant of the J-groove weld material. Specifically:

1. Subarticle IWA-3300(b) contains a requirement for flaw characterization.

2. Subarticle IWB-3142.4 allows for an analytical evaluation to demonstrate that a component is acceptable for continued service. It also requires that components found acceptable for continued service by analytical evaluation be subsequently examined in accordance with Subarticles IWB-2420(b) and (c).

3. Subarticle IWB-3420 requires the characterization of flaws in accordance with the rules of Subarticle IWA-3300.

4. Subarticle IWB-3613(a) requires that, for conditions < 20 percent of design pressure, the ratio of the maximum applied stress intensity factor (K_I) and the available fracture toughness based on crack arrest (K_{Ia}) for the corresponding crack tip temperature be < %2 at a temperature of RT_{NDT} + 60 degrees F (nil-ductility transition reference temperature).

5. Subarticle IWB-3613(b) requires that, for normal conditions, the ratio of the maximum applied stress intensity factor and the available fracture toughness based on K_{Ia} for the corresponding crack tip temperature be < %10.

3.4 NMC's Proposed Alternatives

1. In lieu of ASME Code, Section XI, Subarticle IWA-3300(b), NMC assumed that a conservative, worst-case flaw existed in the remnant J-groove weld that extends from the weld surface to the RVCH low-alloy steel base material interface. Appropriate fatigue analyses have been performed based on that flaw to establish the minimum remaining service life of the RVCH. This alternative applies to the CRD and ICI nozzle repairs.

2. In lieu of ASME Code, Section XI, Subarticle IWB-3142.4, successive examinations will not be performed because analytical evaluation of the worst-case flaw has been performed to demonstrate the acceptability of continued operation, and the impracticality of performed any subsequent inspection that would be able to characterize any remaining flaw. This alternative applies to the CRD and ICI nozzle repairs.

3. In lieu of ASME Code, Section XI, Subarticle IWB-3420, a conservative worst-case flaw shall be assumed to exist and appropriate fatigue analyses have been performed based on that flaw. This alternative applies to the CRD and ICI nozzle repairs.

4. In lieu of ASME Code, Section XI, Subarticle IWB-3613(a), NMC proposes to use the 2005 Addenda of ASME Code, 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 < %2 at a temperature of RT_{NDT}. This alternative applies only to the CRD J-groove fracture mechanics evaluation.

5. In lieu of ASME Code, Section XI, Subarticle IWB-3613(b), NMC proposes to use elastic plastic fracture mechanics (EPFM) acceptance criteria to evaluate flaw stability with safety factors of 3 on primary (pressure) stresses and 1.5 on secondary (residual plus thermal) stresses. This alternative applies only to the CRD J-groove fracture mechanics evaluation.

3.5 NMC's Basis for the Proposed Alternatives

NMC's proposed alternatives are based on fracture mechanics evaluations performed by Framatome Advanced Nuclear Products, AREVA Document 51-5047343-03, "Palisades CRDM & ICI Nozzle IDTB Repair - Life Assessment Summary," dated June 23,2005. The non-proprietary summary report is provided in NMC's October 11, 2005, submittal. The fracture mechanics evaluations assess the structural integrity of the remnant J-groove weld in the RVCH without the need to perform successive examinations.

The remaining non-chamfered J-groove weld in the CRD nozzles was analyzed by postulating a radial crack in the J-groove weld and butter, and evaluating fatigue crack growth into the low-alloy steel head. Since a hypothetical flaw in the J-groove weld cannot be sized by currently available nondestructive examination techniques, NMC assumed that the "as-left" condition of the remaining J-groove weld includes degraded or cracked weld material extending through the entire J-groove weld and Alloy 182 butter material. NMC further postulated that a small fatigue initiated flaw forms in the low alloy steel head and combines with the PWSCC in the weld to form a large radial corner flaw, which propagates into the RVCH by fatigue crack growth under cyclic loading conditions.

NMC also performed an analysis of the ICI nozzle which demonstrated that a postulated radial crack in the remnants of the original J-groove weld and butter would satisfy the 1989 ASME Code, Section XI criteria (IWB-3612) for 5 years of operation, when the ratio of material fracture toughness to applied stress intensity factor would be 3.16 (or %10). This ratio is the maximum permitted by IWB-3612.

3.6 <u>Duration of Proposed Alternative</u>

NMC requested approval of the proposed alternative for the remainder of the third 10-year interval of the inservice inspection which will conclude on or before December 12, 2006.

3.7 <u>Staff Evaluation</u>

3.7.1 <u>Impracticality Findings</u>

The original repair method requires chamfer grinding of the CRD remnant J-groove weld to remove potential cracks. In the repair of CRD Nozzles 29 and 30 in 2004, NMC personnel received extensive dose during the chamfering process. NMC reported that the chamfering of the two nozzles took about 35 hours and the total person-rem for the chamfering process was about 6 rem. The maximum dose received by an individual on a single entry was about 880 mrem. The highest contact dose rates and general area dose rates were 9.8 rem/hour and 6.2 rem/hour, respectively. The staff concludes that the radiological doses experienced by the NMC personnel in the 2004 repair of the two nozzles is a hardship.

After a nozzle is repaired, the remnant J-groove weld no longer falls under IWB-2500, Examination Category B-E, Item B4.12, and becomes a non-pressure retaining weld and part of the base metal. The new repair weld is treated as the pressure retaining weld and is considered to fall under Examination Category B-E, Item B4.12. The original function of the CRD J-groove weld is no longer required. Using an assumed worst-case crack size in the remnant J-groove weld, NMC's analyses ensure that unacceptable crack growth into the RVCH does not occur within the next 27 years. Therefore, according to NMC, chamfer grinding has been determined to be unnecessary in the repair process for CRD nozzles.

NMC contends that ultrasonic examination of any flaws in the original J-groove weld region is ineffective and impractical due to the configuration of the RVCH. The angle of incidence from the outer surface of the RVCH base material does not permit perpendicular interrogation by ultrasonic shear wave techniques of circumferentially oriented flaws. Also, the physical proximity of the nozzle does not allow for longitudinal scrutiny of the area of interest. If examination of the J-groove weld were to be attempted from the inner diameter of the head, the cladding would provide an acoustic interface which severely limits a confident examination of the weld material. Radiographic testing of the weld area is also ineffective due to orientation of circumferentially-oriented flaws being perpendicular to the beam of gamma- and x-rays. In addition, surface examinations will not provide any useful volumetric information. Therefore, NMC requested to leave the original J-groove weld in service without successive examinations. The staff concludes that NMC has provided sufficient information to support its argument that it is impractical to perform examinations or chamfering grinding on the remnant J-groove weld in a repaired RVCH nozzle.

3.7.2 <u>Alternative to Subarticles IWA-3300(b), IWB-3142.4, and IWB-3420</u>

ASME Code, Section XI, Subarticle IWA-3300(b) requires that potential flaws in a component be characterized by inspection. Subarticle IWB-3142.4 requires that components containing relevant conditions shall be acceptable for continued service if an analytical evaluation demonstrates acceptability of the components. Components accepted for continued service, based on an analytical evaluation, shall be subsequently examined. Subarticle IWB-3420 requires that each detected flaw, or group of flaws, shall be characterized by the rules of Subarticle IWA-3300 to establish the dimensions of the flaws.

In lieu of the above requirements, NMC assumed a worst-case radial flaw in the J-groove weld of the CRD and ICI nozzles, and that the entire J-groove weld and butter are cracked due to PWSSC. The crack was assumed to extend from the weld surface to the interface between the butter and the base metal of the RVCH. NMC also calculated the crack growth into the base metal of the RVCH. The staff concludes that the alternative to Subarticles IWA-3300(b), IWB3142.4, and IWB-3420 is acceptable because NMC has performed a flaw evaluation using the worst-case flaw and the analysis demonstrates that the structural integrity of the RVCH is acceptable.

3.7.3 Alternative to Subarticle IWB-3613(a)

ASME Code, Section XI, Subarticle IWB-3600 provides requirements on the evaluation of flaws in components. NMC proposed using the acceptance criteria in Subarticle IWB-3613(a) of the 2005, Addenda to the 2004, Edition of ASME Code, Section XI, for its flaw evaluation. However, the code of record for the third inspection period at the Palisades Nuclear Plant is the 1989 Edition of ASME Code, Section XI. The acceptance criteria in Subarticle IWB-3613(a) of the 1989 Edition are different from those in the 2005 Addenda to the 2004 Edition of ASME Code, Section XI.

In its February 1, 2006, letter, the staff asked NMC to clarify why it requested relief from Subarticle IWB-3613(a) of the 1989 Edition of the ASME Code, Section XI. In its February 27, 2006, letter, NMC responded that the controlling low temperature condition for cracking occurs during cooldown at a temperature of 70 degrees F, which is below an RT_{NDT} + 60 degree F value of 132 degrees F. Furthermore, using an available fracture toughness based on crack arrest (K_{Ia}), NMC calculated the ratio $K_{Ia}/K_I(a_e)$ (where $K_I(a_e)$ is the stress intensity factor for an effective crack size) to be 1.32. This value is less than the required margin of %2, or 1.41. This calculation shows that the RVCH nozzle will not be able to satisfy the required safety margin of Subarticle IWB-3613(a) of the 1989 Edition. Therefore, relief from the ASME Code is required.

In its February 1, 2006, letter, the staff questioned the validity of using the 2005 Addenda to the 2004 Edition of ASME Code, Section XI, in the relief request because the NRC has not adopted the 2005 Addenda to the 2004 Edition of ASME Code, Section XI, pursuant to 10 CFR 50.55a. The staff advised NMC that the 2005 Addenda to the 2004 Edition of ASME Code, Section XI, cannot be used to support the relief request. NMC's February 27, 2006, letter, indicated that for linear elastic fracture mechanics (LEFM) evaluations, Subarticle IWB-3612 of the 1989 Edition of ASME Code, Section XI, requires that a safety factor of %10 be used when comparing the applied stress intensity factor to K_{Ia}. Subarticle IWB-3613(a) in the 1989 Edition provides acceptance criteria for shell regions near structural discontinuities, which include the intersections of nozzles and pressure vessel shells. Subarticle IWB-3613(a) specifies that at pressures below 20 percent of the design pressure, and at temperatures greater than or equal to RT_{NDT} + 60 degrees F, K_I is limited to K_{Ia}/%2. At the low pressure and temperature conditions near the end of cooldown, NMC's flaw evaluations is based on alternate criteria.

Instead of referencing the 2005 Addenda of the ASME Code, NMC proposed to use the following alternate criteria in the flaw evaluations:

1. The temperature requirement will be changed from RT_{NDT} + 60 degrees F to RT_{NDT}. NMC stated that this alternative is consistent with current pressure-temperature limit criteria in the 1989 Edition of ASME Code, Section XI, Appendix G, Article G-2222(c) for shell regions near geometric discontinuities, and in 10 CFR Part 50, 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}/%2 to K_{IC}/%2.

NMC stated that the crack arrest toughness, K_{Ia} (or K_{IR}), was originally used in the 1974 Edition of the ASME Code, Section XI, to provide additional margin thought to be necessary to cover uncertainties, as well as a number of postulated (but un-quantified) effects. Using 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} is conservative because it assumes the fracture event as one of arresting a dynamic running crack from an area of local embrittlement.

According to NMC, nuclear plant 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 dynamic loading 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.

NMC stated that 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 as 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 slightly below the K_{IC} curve, providing a high degree of confidence that K_{IC} can be used to predict crack initiation.

NMC stated that the concern that there could be a small, local zone in a weld or heat-affected zone of the base material that could develop 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, the initiation of micro-cleavage pop-in has not been found to be significant. According to NMC, 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.

NMC stated that the change from K_{Ia} to K_{IC} has already been implemented in the 2001 Edition of ASME Code, Section XI, Appendix G, for determining pressure-temperature limits for the reactor coolant system. The use of K_{IC} in the flaw acceptance criteria of Subarticle IWB-3613(a) is consistent with the fracture toughness requirement in the 2001 Edition of the ASME Code, Section XI, Appendix G. Therefore, applied stress intensity factors are limited to K_{IC}/%2 for low temperature conditions when the pressure is less than 500 pounds per square inch atmosphere (psia) and the temperature is at least 72 degrees F (which is the RT_{NDT} of the RVCH base metal).

The NRC staff notes that the proposed alternative is not as conservative as Subarticle IWB-3613(a) of the 1989 Edition of the ASME Code, Section XI. As NMC stated above, the change from K_{Ia} to K_{IC} has been implemented in the 2001 Edition of ASME Code, Section XI, Appendix G. The use of RT_{NDT} has been accepted in the 1989 Edition of ASME Code, Section XI, Appendix G, for shell regions near geometric discontinuities, and in 10 CFR Part 50, Appendix G, Table 1, Item 2.a, for the closure flange region. However, it is not evident to the NRC staff that the ASME Code, Section XI, Appendix G is applicable to the requirement of Subarticle IWB-3613(a) in the flaw evaluation of the RVCH. The method in ASME Code, Section XI, Appendix G, is related to the flaw evaluation in the reactor vessel beltline base metal and welds, which have different loading conditions and degradation mechanism (i.e., neutron irradiation embrittlement) from those of the RVCH base metal.

The NRC staff concludes that the proposed alternative would not significantly affect the structural integrity of the CRD nozzle or RVCH. The staff's conclusion is based on the following observations:

1. Under the proposed alternative, the required margin is reduced from 1.41 to 1.32, which is about 6 percent reduction. This is a small reduction.

2. NMC's fracture mechanics evaluation assumes conservatively that the entire remnant J-groove weld is cracked, and that the crack propagates into the RVCH.

3. The proposed alternative is limited in application because it is applicable only to the fracture mechanics analysis of the postulated flaw in the CRD J-groove weld propagating into the RVCH.

4. Relief Request No. 2 applies only to the third inservice inspection interval which ends on December 12, 2006. Therefore, the proposed alternative has a limited applicability period.

3.7.4 <u>Alternative to IWB-3613(b)</u>

In lieu of the LEFM acceptance criteria in Subarticle IWB-3613(b) of the 1989 Edition of ASME Code, Section XI, NMC proposed to use the EPFM acceptance criteria to evaluate flaw stability with safety factors of 3 on primary (pressure) stresses and 1.5 on secondary (residual plus thermal) stresses. The NRC's letter of September 29, 2004, approved the same alternative safety factors for the CRD nozzle repairs for Arkansas Nuclear One, Unit 1(ADAMS Accession No. ML042730013).

The NRC staff finds that the proposed safety factors of 3 on primary stresses, and 1.5 on secondary stresses, are acceptable for Palisades when compared to the safety factor of / 10, which is required by Subarticle IWB-3613(b), since NMC's fracture mechanics analysis (as discussed below) shows the following:

1. The allowable J-integral value for the RVCH base metal is higher than the applied J-integral value at the crack tip, which indicates that the RVCH base metal has sufficient resistance to crack propagation.

2. NMC's EPFM analysis shows that the safety factor for secondary stresses do not deviate significantly from those of Subarticle IWB-3613(b).

3. NMC conservatively modeled the weld residual stresses in its flaw evaluation.

3.7.5 <u>Fracture Mechanics Calculations</u>

As discussed above, NMC assumed a worst-case initial flaw occurring in the CRD remnant J-groove weld (not chamfered) (i.e., the entire remnant J-groove weld and butter are cracked). The tip of the initial crack is located on the boundary between the butter and the RVCH base metal. The flaw was assumed to grow into the RVCH base metal by fatigue. NMC calculated the K_I for the crack using three-dimensional finite element analysis for cracks extending to the butter/head interface and applying both residual and operating stresses for each of eight analyzed transients. For each increment of crack growth, stress intensity factors were increased by the square root of the ratio of the postulated flaw sizes. This is a conservative approximation since both the residual stresses and the thermal gradient stresses decrease in the direction of crack propagation. NMC included a plastic zone correction factor, and pressure was applied to the crack face in its flaw evaluation. Flaw growth into the RVCH base metal was calculated to be 0.610 inch on the uphill side of the CRD nozzle, and 0.324 inch on the downhill side of the CRD nozzle. The RVCH thickness in the nozzle region is 8.875 inches, including cladding.

To determine the stability of the final flaw on the uphill side and downhill side of the CRD nozzle penetration, NMC used the EPFM. At operating temperatures when EPFM is the appropriate analysis method, a J-integral/tearing modulus (J-T) diagram was used to evaluate flaw stability with safety factors of 3 on primary (pressure) stresses and 1.5 secondary (residual plus thermal) stresses.

NMC found that for the CRD J-groove weld, the highest crack tip K_I occur during cooldown when the pressure is still 2085 pounds per square inch gage (psig) and the temperature decreases to 400 degrees F. At these conditions, NMC showed that the applied J-integral is less than the J-integral for the material. NMC also demonstrated flaw stability by showing that the applied tearing modulus is below the tearing modulus for the material. As a final check on the EPFM analysis, the applied J-integrals for safety factors of 1.5 on pressure and 1.0 on residual and thermal loads are compared to the J-integral for the material at a crack extension of 0.1 inch. For this case, NMC determined that the applied J-integrals on the uphill side and downhill side of the CRD nozzle are both less than the required J-integral for the material.

At low temperature conditions near the end of cooldown, LEFM is the appropriate method for the flaw evaluation of the remnant J-groove weld at the CRD nozzle. However, the Subarticle IWB-3613 required fracture toughness margin may not be satisfied if the residual stresses in the J-groove weld are significant, as was the case for the Palisades CRD J-groove weld flaws.

NMC performed additional analyses for larger flaw sizes to demonstrate that the fracture toughness margin is adequate while still considering residual stress. NMC calculated new crack sizes by reviewing stress contour plots and selecting crack extensions that would locate the uphill and downhill crack fronts in regions of compressive residual stress. On the uphill side, NMC extended the crack to 1.25 inches beyond the butter. A larger crack extension of 2.5 inches was required on the downhill side to extend the crack into the compressive residual stress field. The controlling low temperature condition occurs at the end of cooldown when the temperature is about 70 degrees F with a pressure of 295 psig. The K_{IC} fracture toughness at this temperature is 53.1 ksi %in. At the larger crack sizes, NMC calculated the applied stress intensity factors to be 29.5 ksi %in on the uphill side and 28.5 ksi%in on the downhill side. Both of these values are less than the K_{IC}/%2 acceptance criterion of 37.5 ksi%in. NMC's fracture mechanics analyses showed that postulated flaws in the CRD J-grooved weld and butter are acceptable for 27 years of operation, which is from present to the end of the license renewal period.

With regard to the ICI nozzle analysis, NMC also determined if the degraded ICI J-groove weld material could be left in the reactor vessel head, without conducting any successive examinations to size any flaws that might remain following the repair. It was postulated that a radial flaw in the Alloy 182 weld metal would propagate by PWSSC through the weld and butter to the interface with the low alloy steel head, where the flaw would blunt and arrest. To reduce the size of the postulated flaw, the repair design specifies that the inside corner of the ICI J-groove weld be chamfered. The results of NMC's analysis for the ICI nozzle demonstrate that a postulated radial crack in the remnants of the original J-groove weld and butter would satisfy IWB-3612 of the 1989 Edition of the ASME Code Section XI for 5 years of operation.

In its February 1, 2006, letter, the staff asked NMC to explain the large difference in period of acceptability between the CRD nozzle (27 years) and ICI nozzle (5 years). In its February 27, 2006, letter, NMC explained that the large difference in periods of acceptability can be attributed to geometric considerations and analytical methods. The ICI nozzle has both a larger repair bore diameter and a greater height for the remnant J-groove weld than the repaired CRD nozzle. The larger bore tends to increase pressure stresses and the deeper weld results in a large postulated 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 used for the ICI nozzle is more sensitive to nozzle configuration than the EPFM analysis method used for the CRD nozzle.

The NRC staff agrees that NMC used a conservative approach (LEFM) to obtain a short period of 5 years for the acceptability of the RVCH given that the entire remnant J-groove weld is assumed to crack. However, NMC's fracture mechanics analyses does show that for the ICI nozzle repair, the RVCH satisfies the requirements of Subarticle IWB-3612 only for 5 years. Therefore, if an ICI nozzle is repaired, NMC is required to submit additional analyses or plans to take corrective actions to demonstrate that the RVCH satisfies the requirements of Subarticle IWB-3612 beyond the 5-year period.

On the basis of NMC's fracture mechanics analyses, the NRC staff concludes that (1) successive examinations of the remnant J-groove weld are not needed because the worst-case flaw in the remnant J-groove weld is demonstrated, by analysis, to be acceptable, (2) removing the chamfer grinding for the remnant J-groove weld at the CRD nozzle is acceptable, and (3) according to NRC Order EA-03-009, Palisades falls into the high susceptible plant due to the indications found in the CRD nozzles. For a high susceptible plant, the Order requires all CRD and ICI nozzles at the Palisades Nuclear Plant be inspected in every refueling outage, even after the nozzles have been repaired.

4.0 CONCLUSION

The NRC staff finds that compliance with the ASME Code requirements regarding flaw characterization and successive examinations of the remnant J-groove welds is impractical for the Palisades Nuclear Plant. Therefore, pursuant to 10 CFR 50.55a(g)(6)(i), Relief Request No. 2 is granted from the requirements of Subarticles IWA-3300, IWB-3142.4, IWB-3420, IWB-3613(a), and IWB-3613(b) of ASME Code, Section XI, pertaining to the remnant J-groove welds of the control rod drive nozzles and incore instrumentation nozzles in the RVCH at the Palisades Nuclear Plant through the end of the third 10-year inservice inspection interval.

NMC's fracture mechanics analyses showed that for the ICI nozzle repair, the RVCH meets the ASME Code Section XI, Subarticle IWB-3612, for 5 years. If an ICI nozzle is repaired, NMC is required to submit to the NRC for review and approval additional analyses or plans for corrective actions to demonstrate that the RVCH satisfies the requirements of IWB-3612 beyond 5 years. Based on the above, the staff concludes that the proposed alternative provides reasonable assurance of structural integrity.

This grant of the relief is authorized by law and will not endanger life or property or the common defense and security, and is otherwise in the public interest giving due consideration to the burden upon the licensee that could result if the requirements were imposed on the facility.

All other requirements of the ASME Code, Sections III and XI, for which relief has not been specifically requested and approved remain applicable, including third party review by the Authorized Nuclear Inservice Inspector.

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