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Palisades Nuclear Plant
Operated by Nuclear Management Company, LLC

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Supplement to Request for Relief from ASME Section XI Code Requirements for Repair of Reactor Pressure Vessel Head Penetrations (TAC No. MD3082)

By letter dated September 15, 2006, Nuclear Management Company, LLC (NMC) requested relief from certain sections of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel (B&PV) Code, Section XI, 2001 Edition with addenda through 2003, for the Palisades Nuclear Plant (PNP).

By electronic mail dated February 8, 2007, the NRC requested information in regards to the use of plane-strain fracture toughness versus crack arrest toughness. On February 22, 2007, a teleconference was held with the NRC staff, and it was determined that a supplement was needed to the September 15, 2006, letter. Enclosure 1 provides the supplement for PNP.

Summary of Commitments

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

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Nuclear Management Company, LLC

Enclosure (1)

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

ENCLOSURE 1
SUPPLEMENT TO REQUEST FOR RELIEF FROM ASME SECTION XI CODE REQUIREMENTS FOR REPAIR OF REACTOR PRESSURE VESSEL HEAD PENETRATIONS PALISADES NUCLEAR PLANT

By letter dated September 15, 2006, NMC requested relief from ASME Section XI, Paragraph IWB-3613(a) which requires that, for conditions <20% of design pressure, the ratio of the maximum applied stress intensity factor and 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. The controlling low temperature condition for the control rod drive (CRD) analysis occurs during cooldown at a temperature of 70°F, which is well below RT_{NDT} + 60°F, or 132°F. Using an available fracture toughness based on crack arrest (K_{Ia}), the ratio of $K_{Ia}/K_I(ae)$ would be 1.32, which is less than the required margin of $\sqrt{2}$.

By electronic mail dated February 8, 2007, the NRC requested information in regards to the use of plane-strain fracture toughness (K_{IC}) versus (K_{Ia}). On February 22, 2007, a teleconference was held with the NRC staff, and it was determined that a supplement was needed to the September 15, 2006, letter.

NMC is providing the following basis in regards to the use of the K_{IC} versus $K_{Ia.}$

For linear elastic fracture mechanics (LEFM) evaluations, ASME Section XI, Article IWB-3612, 2001 Edition with the 2003 Addenda, 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), 2001 Edition with the 2003 Addenda, 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 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 barely below the K_{Ic} curve, 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}).