April 14, 2000

Mr. Nathan L. Haskell, Director
Licensing and Performance Assessment
Palisades Plant
27780 Blue Star Memorial Highway
Covert, MI 49043

SUBJECT: PALISADES PLANT - ALTERNATIVE TO DEFER REPAIR OF SPENT FUEL POOL HEAT EXCHANGER E-53A NOZZLE WELD (TAC NOS. MA8434 AND MA5711)

Dear Mr. Haskell:

By letter dated February 11, 2000, you submitted a revised Relief Request No. 14 (RR-14) for the inservice inspection (ISI) program for the Palisades Plant. Your letter of February 11, 2000, superseded an earlier application for relief, dated May 17, 1999, in its entirety. Your letter of October 19, 1999, provided additional information to support RR-14.

RR-14 proposes an alternative to the requirements of the American Society of Mechanical Engineers' Boiler and Pressure Vessel Code (ASME Code) regarding the repair of a flaw in the inlet nozzle-to-shell weld for spent fuel pool heat exchanger E-53A. Your inspection during plant operation has revealed evidence (dry boric acid residue) of slight leakage at this nozzle-to-shell weld. You seek relief to complete the current operating cycle because the ASME Code does not provide for operation with through-wall leakage. On the basis of your structural analysis and inspection results, which show that the inlet nozzle is acceptable for continued service, your proposed alternative would provide for deferring the repair until the refueling outage scheduled for 2001. You request NRC staff approval of RR-14 pursuant to 10 CFR 50.55a(a)(3)(ii) because compliance with the ASME Code requirements would result in undue hardship and unusual difficulty without a compensating increase in the level of quality and safety.

The NRC staff has reviewed RR-14, including your flaw evaluation methodology and its application to the inlet nozzle-to-shell weld of spent fuel pool heat exchanger E-53A. The enclosure is our safety evaluation, which concludes that the Palisades Plant can be safely operated without repair of the weld until the 2001 refueling outage. Therefore, the NRC staff approves RR-14 as requested. This approval is subject to the conditions that (1) visual testing (VT-2) inspections shall be conducted on the nozzle connection at least monthly until repairs are performed, and (2) leakage from either weep hole shall not exceed a measurable leak flow rate of 0.000165 gpm (37 ml/hr). The heat exchanger nozzle shall be restored to full ASME Code compliance, either upon the conclusion of the 2001 refueling outage or promptly upon a measurable leakage exceeding 0.000165 gpm, whichever occurs first.

This completes our efforts under TAC No. MA8434 (and superseded TAC No. MA5711 that was based upon your initial application dated May 17, 1999). If you have questions regarding this matter, please contact Darl Hood at (301) 415-3049 (e-mail: dsh@nrc.gov).

Sincerely,

/RA/

Claudia M. Craig, Section Chief, Section 1
Project Directorate III
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket No. 50-255

Enclosure: Safety Evaluation

cc w/encl: See next page

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Claudia M. Craig, Section Chief, Section 1
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Division of Licensing Project Management
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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

RELATED TO INSERVICE INSPECTION PROGRAM RELIEF REQUEST RR-14, REVISION 1

PALISADES PLANT

DOCKET NO. 50-255

1.0 INTRODUCTION

By letter dated February 11, 2000, Consumers Energy Company (the licensee) submitted a revised request seeking relief from the American Society of Mechanical Engineers' Boiler and Pressure Vessel Code (ASME Code) requirements regarding evidence of a through-wall flaw indication discovered in the lower weep hole of the reinforcement pad of the spent fuel pool heat exchanger (SFPHX) E-53A inlet nozzle-to-shell weld for the Palisades Plant.[1] The discovery occurred when the plant was operating at power. Because the ASME Code does not provide for continued operation with a through-wall flaw, the licensee proposed an alternative to the ASME Code to defer repair until completion of the current operating cycle in the year 2001. The requested alternative was identified as Relief Request No. 14 (RR-14).

The SFPHX shell, nozzle, and the reinforcing pad over the suspected flawed weld are all made of Type 304 stainless steel. Flaw characterization using ultrasonic testing (UT) would not produce meaningful results using conventional methods because an air gap exists between the reinforcing plate and heat exchanger head. Further, the loading and the location of the subject weld would make Mode-II (shear) fracture the dominating phenomenon, and ASME Code Section XI flaw evaluation methodologies are not suitable for this application. Paragraph IWB-3522.1 of Section XI of the ASME Code requires a Code repair (Paragraph IWB3142.3), an analytical evaluation (Paragraph IWB-3142.4), or a replacement (Paragraph IWB-3142.5) of the component with indications. The licensee is seeking approval to defer complying with the ASME Code at the present time since, as provided by 10 CFR 50.55a(a)(3)(ii), prompt compliance would create a hardship or unusual difficulty without a compensating increase in the level of quality and safety. The licensee states that the affected shell head of the SFPHX will be replaced during the 2001 outage to restore the heat exchanger nozzle to ASME Code compliance.

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[1] The licensee observed a slight residue of light-colored materials such as would exist after evaporation of water with boric acid content. The dry residue is evidence that there has been some leakage from a small flaw in the nozzle-to-vessel weld. The licensee states that there is currently no evidence of any moisture at the weep hole, and that inspections to date have shown no indication of any change since the initial discovery.

To support the request, the licensee has applied an alternative flaw evaluation methodology. The NRC staff has reviewed the licensee's alternative methodology and evaluation, primarily to determine if prompt compliance with the ASME Code would result in a compensating increase in the level of quality and safety.

The licensee's letter dated February 11, 2000, superseded an earlier application for relief dated May 17, 1999, in its entirety. By letter dated October 19, 1999, the licensee provided additional information in support of RR-14.

2.0 COMPONENT DESCRIPTION

SFPHX E-53A is an ASME Code Class 3 component used to remove heat from the fuel pool, with component cooling water normally providing the cooling medium. As shown in Final Safety Analysis Report (FSAR) Figure 9-8, "Piping & Instrument Diagram -- Spent Fuel Pooling Cooling System," it is the lower of two heat exchangers arranged in series. In addition to the discussion in FSAR Section 9.4, "Spent Fuel Pooling Cooling System," the licensee provided the following description in its letter of February 11, 2000:

> The spent fuel pool heat exchanger is a shell and tube heat exchanger. The tube-side water communicates with the spent fuel pool. At each end of the heat exchanger, there are heads with nozzles connecting to the spent fuel pool cooling piping.
>
> The heads are made of SA-240, Type 304 stainless steel. The cylindrical head has an inside diameter [ID] of 25 inches and a wall thickness of 3/16 inch. The horizontal nozzle, from the side of the cylindrical head, is SA-312, Type 304 made from 12.75-inch OD [outer diameter] and 0.18-inch thick wall pipe. The reinforcing pad around the nozzle is SA-240, Type 304. The reinforcing pad has a thickness of 0.25 inches and extends 2.5 inches radially beyond the outer radius of the nozzle, welded to the nozzle and shell with 1/4-inch structural fillet welds. The nozzle, with a SA-182 F304 flange, extends 7.5 inches beyond the ID of the cylindrical head.
>
> The reinforcing pad has two 3/8-inch weep holes located at 6 and 12 o'clock on the nozzle.
>
> The spent fuel pool side of the heat exchanger has a design pressure of 125 psig and design temperature of 150°F. The maximum expected inlet/outlet temperatures of the spent fuel cooling water are 125°F in/110°F out, respectively. Actual operating pressures as documented in Technical Specification Surveillance Procedure RT-71H, "Spent Fuel Pool System, Class 3 Inservice Test," range from 40 to 80 psig. As required by Technical Specification 3.8.5, fuel pool temperature is limited to 150°F or less when fuel is in the North Tilt Pit.

3.0 LICENSEE'S REQUESTED ALTERNATIVE AND BASES

Paragraph IWB-3522.1, "Visual Examination, VT-2," of Section XI of the ASME Code requires a Code repair (Paragraph IWB3142.3), an analytical evaluation (Paragraph IWB-3142.4), or a replacement (Paragraph IWB-3142.5) of all pressure retaining components with relevant indications, including leakage from noninsulated components. However, 10 CFR 50.55a(a)(3)(ii) permits alternatives to the ASME Code requirements when "compliance with the

specified requirements of this section would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety."

On the basis of structural analysis, the licensee is seeking approval of an alternative in accordance with the provisions of 10 CFR 50.55a(a)(3)(ii) to comply with Paragraph IWB-3522.1[2] of Section XI of the ASME Code so that the plant may continue operating without repair of the SFPHX E-53A inlet nozzle-to-shell weld until completion of the 2001 refueling outage. The licensee proposes to perform monthly VT-2 inspections during this interim period of operation and ensure that leakage corresponding to the maximum leak rate associated with a critical flaw size is not exceeded.

The licensee explains that the ASME Code requirements would result in the following undue hardship and unusual difficulty without a compensating increase in the level of quality and safety:

> The Code imposes corrective action for leakage regardless of the circumstances. The leak at the nozzle connection of the E-53A inlet nozzle was discovered during plant operation. The Code does not allow the Owner to accept through-wall leakage, even though the component is still acceptable for continued service.
>
> The most efficient means of restoring the heat exchanger nozzle to Code compliance is to replace the affected shell head. Preparation of the associated design change and procurement documents is best performed in a controlled manner according to outage planning milestones. It is estimated that this process will take eight months to a year to complete. Purchase of a replacement shell head should allow repairs to be made without installation of a temporary spent fuel cooling system. Repairs made without a temporary cooling system are best scheduled immediately prior to a refueling outage when spent fuel decay heat is at a minimum.

Therefore, the licensee proposes the following alternative:

> Plant Auxiliary Operators are certified in accordance with ANSI N45.2.6 as Visual Examination VT-2, Level 2 Examiners. A periodic action will be scheduled to inspect this connection at an initial frequency of monthly.
>
> Leakage from either weep hole shall be limited to less than or equal to a measurable leak flow rate of 0.000165 gpm or 37 ml/hr, based on the maximum leak rate associated with a critical flaw size. If leakage exceeds 0.000165 gpm (37 ml/hr), the heat exchanger nozzle shall be promptly repaired.
>
> The heat exchanger nozzle shall be restored to full Code compliance by the conclusion of the 2001 refueling outage.

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[2] For ASME Code Class 3 components, Article IWB-3000 is referenced for the acceptance standards in the 1989 edition of the ASME Code, Section XI. Paragraph IWB-3522.1 states: "Visual Examination, VT-2. The following relevant conditions that may be detected during the conduct of system pressure tests shall require correction ... prior to continued service: (a) leakage from noninsulated components (IWA-5241); ..."

4.0 EVALUATION

4.1 Licensee's Flaw Sizing and Flaw Evaluation

The licensee has evaluated the potential degradation mechanisms that could result in a through-wall leak and discussed their likelihood of occurrence. The mechanisms include intergranular stress corrosion cracking (IGSCC) and fatigue. IGSCC was judged to be insignificant because the SFPHX inlet lines are operated at 150°F or less. For fatigue evaluation, the licensee considered loading due to pump vibration and seismic events and determined to use 50 pressure startup cycles and 50 seismic cycles. On the basis of this assumption and an initial crack length of 4.5 inches, the licensee predicted a crack growth of 0.007 inch.

The licensee determined the initial crack length, 4.5 inches, by an alternative methodology because it is difficult to characterize flaws in stainless steel components using UT or other types of inspection techniques, especially when the flawed weld is located behind a stainless steel reinforcing pad. The alternative methodology is similar to the leakage flaw size determination in the leak-before-break (LBB) methodology. The licensee first estimated the leakage by a mass transfer calculation assuming that the bottom and sides of the vent hole were wet and the surrounding air was dry. The licensee then modified the leakage by considering natural convection and density differences across the surface. Finally, a factor of 50 was applied to arrive at a leakage rate of 694 lb/year (0.000165 gpm). Using the computer program, pc-LEAK,[3] which is similar to the Pipe Crack Evaluation Program (PICEP) developed by the Electric Power Research Institute, the licensee calculated the flaw size corresponding to this leakage rate to be 4.5 inches.

The licensee then employed a limit load analysis of Appendix C of Section XI of the ASME Code with one half of the allowable flow stress to calculate the allowable flaw size. The evaluation used the safe shutdown earthquake load for the faulted condition and the higher safety factor of 2.77 for the normal operating condition. Because the welding process was not known, the licensee conservatively assumed that the weld was shielded metal arc welding (SMAW) and applied the "Z factor"[4] for SMAW welds in its evaluation. In this manner, the licensee calculated the allowable flaw length to be 16.4 inches. Since the predicted crack growth of 4.507 inches (4.5 inches + 0.007 inch) is less than the allowable flaw length of 16.4 inches, the licensee concluded that the Palisades Plant can be operated without repair of the SFPHX E-53A inlet nozzle-to-shell weld until 2005.

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[3] Structural Integrity Associates, Inc., Program pc-Leak, "Calculation of Leakage Rates From Through-wall Cracks," Version 2.0.

[4] When determining the allowable flaw length, a "Z factor" is applied for flux welds (SMAW) to account for the fact that the weld metal is less ductile and may not reach fully plastic action before the flaw becomes unstable.

4.2 Licensee's Consequences Evaluation

The licensee also performed a consequences evaluation. From this evaluation, the licensee concluded that even a complete failure of the nozzle-to-vessel weld would not result in failure of the nozzle assembly. The licensee also concluded that failure of the degraded nozzle would not result in unacceptable equipment flooding or the uncovering of spent fuel.

4.3 NRC Staff's Evaluation

The NRC staff agrees with the licensee's conclusion that the flaw originated from a fabrication defect and has grown through-wall by fatigue. This is supported by the licensee's qualitative evaluation of various flaw initiation and growth mechanisms. In estimating the fatigue loading and cycles for the prediction of crack growth potential, the licensee assumed 50 pressure startup cycles and 50 seismic cycles. This is acceptable because the average of 50 startups per year is conservative, and the seismic load is normally not considered in fatigue growth analysis.

In determining the initial flaw size, the licensee used an alternative similar to the leakage flaw size determination in the LBB methodology. The licensee estimated the leakage rate first, then employed a computer program, pc-LEAK, to calculate the flaw size corresponding to the leakage rate. In its letter dated October 19, 1999, the licensee provided information regarding the leakage rate calculation and the validation of the pc-LEAK computer program. The NRC staff considered the leakage rate calculation based upon mass transfer to be empirical. However, a factor of 50 that was applied to the leakage rate was sufficient to contain uncertainties associated with the empirical approach. In validating the pc-LEAK computer program, the licensee demonstrated in the attachment to its letter dated October 19, 1999 (see Response to NRC Question 2, including Figure 2-3, "Crack Opening Area for Circumferential Crack," and Figure 2-5, "Crack Opening Area for Axial Crack") that the crack opening areas from pc-LEAK are comparable to those from PICEP. The licensee also demonstrated (see Figure 2-4, "Leak Rate for Circumferential Crack," and Figure 2-6, "Leak Rate for Axial Crack") that pc-LEAK would predict a larger flaw than PICEP for the current case of low leak rate (<0.1 gpm). Hence, using pc-LEAK is conservative. On this basis, the NRC staff finds that the predicted leakage rate of 694 lb/year, and the alternative of using pc-LEAK to predict initial flaw size, are reasonable.

The licensee employed limit load analysis of Appendix C with 0.5 material stress allowable (S_m) to calculate the allowable flaw size. Based on the schematic of the SFPHX E-53A inlet nozzle in the submittal, the staff determined that the fracture phenomenon is of Mode II (i.e., a phenomenon dominated by shear). Currently, the ASME Code does not have rules for a Mode II type of fracture. In its letter dated October 19, 1999, the licensee provided detailed formulation for the limit load analysis for the piping weld subjected to shear. The licensee has demonstrated that the limit load solution for the shear dominated piping weld can be reduced to the same form of the Appendix C methodology, except for the use of $0.5S_m$ instead of S_m. Hence, the NRC staff finds the licensee's limit load analysis to be rigorous.

To complement the alternative methodology, the licensee proposed to conduct VT-2 visual inspections at an initial frequency of monthly. The NRC staff believes that these additional inspections are significant complements to the licensee's flaw evaluation, as the inspections can provide early warning to anything that may not have been anticipated and included in the analysis. Therefore, the NRC staff finds that the licensee shall maintain the VT-2 inspection frequency to be no less than monthly until the nozzle repair/replacement has been completed.

In addition, the licensee's "Discussion of Consequences" in the February 11, 2000, application for relief demonstrated that even a complete failure of the nozzle-to-vessel weld would not result in failure of the nozzle assembly and the failure of the degraded nozzle would not result in unacceptable equipment flooding or uncovering spent fuel. The NRC staff has reviewed the licensee's consequence evaluation and finds it to be acceptable.

5.0 CONCLUSION

On the basis of the above evaluation, the NRC staff concludes that the Palisades Plant can be safely operated without repair of the weld until the conclusion of its 2001 refueling outage. The NRC staff further concludes that compliance with the ASME Code requirements before the scheduled 2001 refueling outage would result in hardship and would not have a compensating increase in the level of quality and safety. Therefore, the NRC staff approves RR-14 pursuant to 10 CFR 50.55a(a)(3)(ii). This approval is subject to the conditions that (1) visual testing (VT-2) inspections shall be conducted on the nozzle connection at least monthly until the nozzle is restored to full ASME Code compliance, and (2) leakage from either weep hole shall not exceed a measurable leak flow rate of 0.000165 gpm (37 ml/hr). The heat exchanger nozzle shall be restored to full ASME Code compliance, either upon the conclusion of the 2001 refueling outage or promptly upon a measurable leakage exceeding 0.000165 gpm, whichever occurs first.

Principal Contributor: S. Sheng

Date: April 14, 2000