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AUTH.NAME AUTHOR AFFILIATION
FITZPATRICK,E. Indiana Michigan Power Co. (formerly Indiana & Michigan Ele
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SUBJECT: Provides summary of results of actions taken subsequent to identification of as-built deficiency in RHR east & west heat exchanger configuration.

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Indiana Michigan
Power Company
One Summit Square
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Donald C. Cook Nuclear Plant Unit No. 2
Docket No. 50-316
License No. DPR-74
SUMMARY REPORT OF UNIT 2 RESIDUAL HEAT REMOVAL (RHR)
HEAT EXCHANGER OPERABILITY EVALUATIONS

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, D.C. 20555

Attn: T. E. Murley

April 19, 1991

Dear Dr. Murley:

The purpose of this letter is to provide a summary of the results of the actions taken subsequent to our identification of an as-built deficiency in the Unit 2 RHR east and west heat exchanger configuration. Specifically, in June 1990, we found that the upper lateral restraint on both the east and west heat exchangers had not been installed (a condition that apparently existed since the original construction of Unit 2). Our initial operability determination, performed with the assistance of an outside contractor, Stevenson and Associates (S&A), concluded that both Unit 2 RHR heat exchangers would have performed their required safety function following a design basis earthquake (DBE) in the as-found configuration. However, due to differences in pipe routing between the two heat exchangers, our level of confidence in the initial operability determination for the east heat exchanger led us to declare it inoperable to initiate immediate corrective action. The Unit 2 east RHR heat exchanger was returned to its originally intended design configuration within 72 hours of discovery of the as-built deficiency. Restoration of the west heat exchanger to its originally intended design configuration was completed within approximately three days following the correction of the east heat exchanger installation deficiency. All activities performed from the time of discovery of the installation deficiencies through completion of the necessary corrective actions were communicated to NRC Region III as they occurred. Documentation of our initial operability determinations was provided to Region III for review in late June 1990.

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Concurrent with our initial operability evaluation we requested our contractor (S&A) to perform a detailed analysis of the Unit 2 RHR heat exchanger as-found configuration in order to confirm our initial conclusions regarding heat exchanger operability. The S&A analytical work was completed in February 1991, and presented to NRR and Region III representatives in attendance at meetings conducted February 1, 1991 and March 5, 1991, at the Region III offices and NRR respectively.

S&A performed two sets of analyses with regard to the RHR heat exchanger as-found configuration. The first of the analyses was performed on the basis of current engineering approaches as outlined in NUREG/CR-0098. This analysis showed that, with the Unit 2 RHR heat exchangers in their as-found configuration, the system would have performed its safety function had there been a DBE. The results therefore confirmed the conclusions of our initial operability evaluation.

The second analysis performed by S&A was to compare the as-found RHR heat exchanger configurations to the UFSAR design basis under DBE loading. The math model used for this analysis consisted (for both the east and west heat exchangers) of the RHR heat exchanger vessel itself, the vessel supports and both the tube side and the shell side piping extended to include at least two pipe supports in each orthogonal direction. Under DBE conditions, the applicable design basis taken from Section 2.9 of our UFSAR is for support stresses to be "within yield after load redistribution" and for piping and vessels to "...retain their contents and allow fluid flow." In addition, the combination of longitudinal membrane plus bending stresses in piping is limited to 1.8 times the allowable stress at temperature taken from USAS B31.1 Code for Pressure Piping, 1967 Edition.

For purposes of this analysis a composite damping value for the system was computed based on a 1% damping for the heat exchanger vessel and 5% damping for the concrete support pedestal and the embedded anchor bolts. These damping values were taken from Table 5.2-4 of the UFSAR where 1% and 5% are specified for welded structural steel assemblies and conventional reinforced concrete structures above grade respectively. Piping was not included in the calculation of composite damping. Therefore, the "interim acceptance criteria" damping for piping was not used in calculating the composite damping.

The concept of inelastic seismic response spectra, as presented in NUREG/CR-0098, was used to account for the change in inertial loads and load redistribution in the second analysis. This is considered to be consistent with the "within yield after load redistribution" design criteria of the UFSAR. This approach is considered to be a conservative, cost-effective alternative to a more expensive non-linear time history analysis.

The results of the seismic analysis showed the maximum anchor bolt strain to be 0.00519 in/in. Stresses on the piping, pipe supports and heat exchangers remained in the elastic range. These results are within the UFSAR design bases of "within yield after load redistribution" for supports and demonstrate that under DBE loads the piping and heat exchangers "retain their contents and allow fluid flow." In addition, the highest calculated stress in the systems was 22.9 ksi which is within the UFSAR limit of 1.8 times the allowable stress at temperature, or approximately 27 ksi in this case. Overall, therefore, the S&A analysis showed that in the as-found configuration the Unit 2 east and west RHR heat exchangers would have been within the UFSAR design basis under DBE loading conditions.

In the March 5, 1991, meeting conducted at the NRR White Flint offices several concerns were raised regarding the analytical methods applied in the analysis to confirm conformance with UFSAR design criteria. These concerns and our responses are provided below.

1) Concern:

Appropriateness of application of UFSAR design criteria for the anchor bolts, specifically the damping value used and potential damage to the bolts.

Response:

The anchor bolts are deeply embedded down to the bottom of the slab through the concrete pedestal and, as such, they are an integral part of the concrete structure. Thus, the use of 5% damping as specified in the UFSAR is considered appropriate. (NUREG/CR-0098 recommends damping values of 7 to 10 percent for reinforced concrete at or just below yield point.) In addition, the anchor bolts are made of ASTM A36 carbon steel which is a very ductile material. With the maximum strain shown to be on the order of 0.5% (much lower than the 2% strain limit recognized in NUREG-1061, Vol. 2 as being sufficient to conservatively prevent failure from tensile plastic instability or low-cycle fatigue) fatigue failure is not a concern here.

2) Concern:

The use of the different damping values for different component types.

Response:

Damping is a measure of the ability of a structural component to dissipate energy. It depends on the inherent material property as well as the state of strain of the

component. Use of the composite modal damping by calculating the damping average (weighted by the strain energies) of the components has been well established and is recommended by NRC Standard Review Plan 3.7.2 and ASCE 4-86.

3) Concern:

The use of the interim acceptance criteria damping value for piping in the analysis of conformance to the UFSAR design basis.

Response:

In the computation of the composite damping the piping was not included, therefore the interim acceptance criteria damping was not used. (This confusion was due to an error in the presentation at the meeting of March 5, 1991.)

4) Concern:

The effect of the RHR heat exchangers pounding on the concrete pedestal and the bolt anchorage.

Response:

The pounding effect of the exchanger is not significant because of the small displacement involved (on the order of 1/8 of an inch). The estimated impact energy is approximately 210 ft-lb which is equivalent to an average man jumping down onto the concrete pedestal from a height of 18 inches. This impact energy is negligible compared to the capacity of the concrete pedestal and/or the supporting floor slab.

This document has been prepared following Corporate procedures that incorporate a reasonable set of controls to ensure its accuracy and completeness prior to signature by the undersigned.

Sincerely,

E. E. Fitzpatrick

E. E. Fitzpatrick
Vice President

ldp

cc: D. H. Williams, Jr.
A. A. Blind - Bridgman
J. R. Padgett
G. Charnoff
A. B. Davis - Region III
NRC Resident Inspector - Bridgman
NFEM Section Chief