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SUBJECT: Forwards Westinghouse & Exxon evaluations re potential impact of using clad swelling & fuel blockage models presented in draft NUREG-0630 on LOCA analysis.

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WISCONSIN PUBLIC SERVICE CORPORATION

P.O. Box 1200, Green Bay, Wisconsin 54305

January 8, 1980

Darrel G. Eisenhut, Acting Director
Division of Operating Reactors
Office of Nuclear Reactor Regulation
Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Mr. Eisenhut:

Docket 50-305
Operating License DPR-43
Clad Swelling and Fuel Blockage Models

In response to the concerns raised by the staff regarding the above referenced subject, WPS commissioned Westinghouse Electric Corporation and Exxon Nuclear Company, Inc., to perform the analyses which would address those concerns. We received the Westinghouse analysis late yesterday and the Exxon analysis today and have not had sufficient time to review them in detail. To the best of our knowledge, these analyses are correct and contain the information necessary to answer the concerns of the staff. We have attached a copy of these analyses to this letter.

Sincerely yours,

E.R. Mathews

E. R. Mathews, Vice President
Power Supply & Engineering

rgm

Attach.

Subscribed and Sworn to
Before Me This 7th Day
of January 1980

Jerome O Lewis

Notary Public, State of Wisconsin

My Commission Expires
2-6-83

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ATTACHMENT 1

A. Evaluation of the potential impact of using fuel rod models presented in draft NUREG-0630 on the Loss of Coolant Accident (LOCA) analysis for KEWAUNEE.

This evaluation is based on the limiting break LOCA analysis identified as follows:

BREAK TYPE - DOUBLE ENDED COLD LEG GUILLOTINE

BREAK DISCHARGE COEFFICIENT 0.4

WESTINGHOUSE ECCS EVALUATION MODEL VERSION FEBRUARY 1978

CORE PEAKING FACTOR 2.27

HOT ROD MAXIMUM TEMPERATURE CALCULATED FOR THE BURST REGION OF THE CLAD - 1839 °F = PCT_B

ELEVATION - 6.0 Feet.

HOT ROD MAXIMUM TEMPERATURE CALCULATED FOR A NON-RUPTURED REGION OF THE CLAD - 2197 °F = PCT_N

ELEVATION - 7.5 Feet

CLAD STRAIN DURING BLOWDOWN AT THIS ELEVATION 3.8 Percent
MAXIMUM CLAD STRAIN AT THIS ELEVATION - 6.5 Percent

Maximum temperature for this node occurs when the core reflood rate is ([redacted]/LESS) than 1.0 inch per second and reflood heat transfer is based on the ([redacted]/STEAM COOLING) calculation.

AVERAGE HOT ASSEMBLY ROD BURST ELEVATION - N/A Feet

HOT ASSEMBLY BLOCKAGE CALCULATED - 0.0 Percent

1. BURST NODE

The maximum potential impact on the ruptured clad node is expressed in letter NS-TMA-2174 in terms of the change in the peaking factor limit (FQ) required to maintain a peak clad temperature (PCT) of 2200°F and in terms of a change in PCT at a constant FQ. Since the clad-water reaction rate increases significantly at temperatures above 2200.°F, individual effects (such as ΔPCT due to changes in several fuel rod models) indicated here may not accurately apply over large ranges, but a simultaneous change in FQ which causes the PCT to remain in the neighborhood of 2200.°F justifies use of this evaluation procedure.

From NS-TMA-2174:

For the Burst Node of the clad:

- $0.01\ \Delta FQ \rightarrow \sim 150^{\circ}F$ BURST NODE ΔPCT

- Use of the NRC burst model could require an FQ reduction of 0.015

- The minimum estimated impact of using the NRC strain model is a required FQ reduction of 0.03.

Therefore, the maximum penalty for the Hot Rod burst node is:

$$\Delta PCT_1 = (.015 + .03)\ (150^{\circ}F/.01) = 675^{\circ}F$$

Margin to the 2200°F limit is:

$$\Delta PCT_2 = 2200.^{\circ}F - PCT_B = \underline{\ 361\ }\ ^{\circ}F$$

The FQ reduction required to maintain the 2200°F clad temperature limit is:

$$\Delta FQ_B = (\Delta PCT_1 - \Delta PCT_2)\ \left(\frac{.01\ \Delta FQ}{150^{\circ}F}\right)$$

$$= (\underline{675} - \underline{361})\ \left(\frac{.01}{150}\right)$$

$$= \underline{\ .021\ }$$ (but not less than zero).

2. <u>NON-BURST NODE</u>

The maximum temperature calculated for a non-burst section of clad typically occurs at an elevation above the core mid-plane during the core reflood phase of the LOCA transient. The potential impact on that maximum clad temperature of using the NRC fuel rod models can be estimated by examining two aspects of the analyses. The first aspect is the change in pellet-clad gap conductance resulting from a difference in clad strain at the non-burst maximum clad temperature node elevation. Note that clad strain all along the fuel rod stops after clad burst occurs and use of a different clad burst model can change the time at which burst is calculated. Three sets of LOCA analysis results were studied to establish an acceptable sensitivity to apply generically in this evaluation. The possible PCT increase resulting from a change in strain (in the Hot Rod) is +20.°F per percent decrease in strain at the maximum clad temperature locations. Since the clad strain calculated during the reactor coolant system blowdown phase of the accident is not changed by the use of NRC fuel rod models, the maximum decrease in clad strain that must be considered here is the difference between the "maximum clad strain" and the "clad strain at the end of RCS blowdown" indicated above.

Therefore:

$$\Delta PCT_3 = \left(\frac{20^{\circ}F}{.01 \text{ strain}}\right) (\text{MAX STRAIN} - \text{BLOWDOWN STRAIN})$$

$$= \left(\frac{20}{.01}\right) (\underline{.045} - \underline{.038})$$

$$= \underline{\quad 54 \quad}$$

The second aspect of the analysis that can increase PCT is the flow blockage calculated. Since the greatest value of blockage indicated by the NRC blockage model is 75 percent, the maximum PCT increase can be estimated by assuming that the current level of blockage in the analysis (indicated above) is raised to 75 percent and then applying an appropriate sensitivity formula shown in NS-TMA-2174.

Therefore,

$$\Delta PCT_4 = 1.25^{\circ}F \; (50 - \text{PERCENT CURRENT BLOCKAGE}) + 2.36^{\circ}F \; (75-50)$$

$$= 1.25 \; (50 - \underline{\quad 0 \quad}) + 2.36 \; (75-50)$$

$$= \underline{\quad 121 \quad} {}^{\circ}F$$

If PCT_N occurs when the core reflood rate is greater than 1.0 inch per second $\Delta PCT_4 = 0$. The total potential PCT increase for the non-burst node is then

$$\Delta PCT_5 = \Delta PCT_3 + \Delta PCT_4$$

Margin to the 2200°F limit is

$$\Delta PCT_6 = 2200^{\circ}F - PCT_N$$

The FQ reduction required to maintain this 2200°F clad temperature limit is (from NS-TMA-2174)

$$\Delta FQ_N = (\Delta PCT_5 - \Delta PCT_6) \left(\frac{.01 \Delta FQ}{10^{\circ}F \; \Delta PCT}\right)$$

ΔFQ_N = <u>0.17</u> but not less than zero.

The peaking factor reduction required to maintain the 2200 °F clad temperature limit is therefore the greater of ΔFQ_B and ΔFQ_N,

or; $\Delta FQ_{PENALTY}$ = 0.17

B. The effect on LOCA analysis results of using improved analytical and modeling techniques (which are currently approved for use in the Upper Head Injection plant LOCA analyses) in the reactor coolant system blowdown calculation (SATAN computer code) has been quantified via an analysis which has recently been submitted to the NRC for review. Recognizing that review of that analysis is not yet complete and that the benefits associated with those model improvements can change for other plant designs, the NRC has established a credit that is acceptable for this interim period to help offset penalties resulting from application of the NRC fuel rod models. That credit for two, three and four loop plants is an increase in the LOCA peaking factor limit of 0.12, 0.15 and 0.20 respectively.

C. The peaking factor limit adjustment required to justify plant operation for this interim period is determined as the appropriate ΔFQ credit identified in section (B) above, minus the $\Delta FQ_{PENALTY}$ calculated in section (A) above (but not greater than zero).

FQ ADJUSTMENT = 0.12 - 0.17

= -0.05

This evaluation indicates that the allowable peaking factor limit is

2.27 - 0.05 = 2.22

for Westinghouse fuel.

ATTACHMENT

In response to NRC concerns, this letter provides specific information on the impact of the newly proposed NRC Clad Swelling and Rupture Model [1] on ENC's ECCS analyses for Kewaunee. The difference between peak cladding temperatures calculated with the NRC model and the ENC model is quite small and the ENC calculated total peaking limit of 2.21 for Kewaunee continues to be valid.

The change in calculated peak clad temperature (PCT) for ENC fuel at Kewaunee when the NRC model for clad swelling and rupture is used in place of the ENC model is an increase of less than 2.0°F (Table 1). The calculation is for the ENC CD=0.4 DECLG limiting break at Kewaunee [2]. This increase in PCT is small compared to the approximately 70°F margin in ENC's ECCS analysis to the limiting PCT of 2200°F. The present sensitivity calculations were made in accordance with ENC's approved WREM-IIA PWR ECCS Evaluation Model [3,4,5,6]. The fuel rod internal pressure corresponds to the ENC model [7] for nominal conditions. In view of the continued (≈70°F) margin to a PCT of 2200°F with the NRC clad swelling and rupture model, the current total peaking limit of 2.21 for ENC fuel at Kewaunee insures conformance to 10 CFR 50.46.

References

1. D. A. Powers and R. O. Meyer, "Cladding Swelling and Rupture Models for LOCA Analysis," Draft NUREG-0630, November 8, 1979.

2. "ECCS Analysis for Kewaunee using ENC WREM-IIA PWR Evaluation Model," XN-NF-79-1, January 1979.

3. "Exxon Nuclear Company WREM-Based Generic PWR ECCS Evaluation Model Update ENC WREM-IIA," XN-NF-78-30, August 1978.

4. "Exxon Nuclear Company WREM-Based Generic PWR ECCS Evaluation Model," XN-75-41:

   a. Volume I, July 1975
   b. Volume II, August 1975
   c. Volume III, Revision 2, August 1975
   d. Supplement 1, August 1975
   e. Supplement 2, August 1975
   f. Supplement 3, August 1975
   g. Supplement 4, August 1975
   h. Supplement 5, Revision 5, October 1975
   i. Supplement 6, October 1975
   j. Supplement 7, November 1975.

5. "Exxon Nuclear Company WREM-Based Generic PWR ECCS Evaluation Model Update ENC WREM-II," XN-76-27, July 1976; Supplement 1, September 1976; Supplement 2, November 1976.

6. "Exxon Nuclear Company WREM-Based Generic PWR ECCS Evaluation Model Update ENC WREM-IIA: Responses to NRC Request for Additional Information," XN-NF-78-30(A) & XN-NF-78-30, Amendment 1(A), May 1979.

7. "Flow Blockage and Exposure Sensitivity Study for ENC D. C. Cook Unit 1 Reload Fuel Using ENC WREM-II," XN-76-51; Supplement 1, January 1977; Supplement 2, February 1978; Supplement 3, April 1978.

EFFECT OF NRC RUPTURE AND FLOW BLOCKAGE MODEL ON THE ENC ECCS ANALYSIS FOR KEWAUNEE

Total Peaking, F_q	2.21
Heatup Rate at Rupture ($^oC/S$)	7.0
PCT Impact of NRC Model vs ENC Model	$+1.7^oF$