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November 20, 1979

United States Nuclear Regulatory Commission
Washington, D. C. 20555

Attention: Office of Nuclear Reactor Regulation
Mr. Darrell Eisenhut
Acting Director

Reference: (1) License No. DPR-3 (Docket No. 50-29).
(2) YAEC letter to USNRC, RE: "Evaluation of Cladding, Swelling and Rupture Models," dated November 2, 1979.
(3) DRAFT NUREG 0630 dated 11/8/79, entitled, "Cladding Swelling and Rupture Models for LOCA Analysis".
(4) XN-76-27, "Exxon Nuclear Company WREM-Based Generic PWR ECCS Evaluation Model Update ENC-WREM-II, July 1976.

Dear Sir:

Subject: Evaluation of Cladding, Swelling and Rupture Models

This letter is an addendum to one submitted to you on November 2, 1979, Reference 2. It is written in response to additional questions raised by your staff concerning the handling of cladding heatup rate dependence in YR's licensed ECCS models for cladding swelling and rupture. The following comments are hopefully responsive to your questions:

- At Yankee Rowe, the applicable burst temperature/stress correlations lie in the high temperature regime (1000°C or greater). This is due to the relatively low fill gas pressure in the Yankee Rowe fuel. In this burst temperature range, rupture temperature is extremely sensitive to clad ΔP (e.g., to engineering hoop stress).

- Calculated ramp temperatures for Yankee Rowe at burst are low, approximately 5.3. °C/sec.

- At present, Yankee uses a WREM correlation, modified for Yankee Rowe geometry, of burst temperature vs. stress. Yankee's burst strain vs. stress correlation overpredicts the strain compared to WREM. These correlations are not ramp-rate dependent. With regard to burst

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temperature, we currently perceive the correlations of burst temperature vs. stress to be applicable to all ramp rates for high temperature rupture. With regard to burst strain, composite correlations that envelope the slow-ramp and fast-ramp NRC draft correlations of burst strain vs. temperature may or may not be conservative depending upon whether one calculates clad rupture.

- o This perception of ramp rate insensitivity at high temperatures may be modified as more data in the low heatup ramp rate, high burst temperature region is assessed. There appears to be a rate dependence associated with lower temperature burst. However, no clear justification exists for extrapolation of low ramp-rate/low temperature rupture data to high temperature rupture conditions. On one hand, multiple rod burst data from experiments done in steam appear to be limited to high (28°C/sec.) temperature ramps in this high temperature region. On the other hand, limited data from single rod tests in vacuum, for example, indicate that ramp dependence at high temperatures could be possible.

- o Yankee has assessed the impact of utilizing the NRC draft curves associated with slow ramp rate effects (reference 3) by performing TOODEE-2 calculations covering the exposure distribution for the remainder of the present cycle. These calculations have been performed in the following manner:

  (1) The NRC 0°C/sec curve for burst temperature vs. stress was modified to reflect Yankee's rate of 5.3°C/sec. by interpolating between the 0°C/sec. and the 28°C/sec. correlation used in reference 3.

  (2) The slow-ramp burst strain curve (Figure 6 of reference 3) was used in TOODEE-2 although no data points are shown in the high temperature region.

  (3) The slow-ramp local flow blockage curve of reference 3 was used along with the ENC-WREM-II (reference 4) flow rate multiplier curves associated with 20% reduction in flow area, consistant with the predictions of the slow-ramp local blockage curve.

  Based on this analysis, Yankee has concluded that full power operation by the plant for the remainder of the present cycle is unaffected by the inclusion of the slow ramp rate draft correlations in the YAEC licensed LOCA model. A reduction in licensed linear heat rate would be indicated, however. Specifically, for fresh fuel at its present exposure, a linear heat rate of 9.607 kw/ft meets Appendix K criteria with the TOODEE-2 modifications noted above; 9.550 kw/ft is needed for full power operation. This fuel is currently licensed at 10.7 kw/ft at the present exposure. For the high power exposed fuel, 9.575 kw/ft meets Appendix K and 9.401 kw/ft is needed for full power operation; 10.25 kw/ft is currently licensed. End of cycle points are unaffected from those previously submitted to the Commission. We should like to emphasize that

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we do not necessarily support the validity of the correlations of reference 3 and that their applicatior ..ld severly derate Yankee Rowe's operation at the beginning of cycle conditions. No time has been available to QA these analyses.

- If there is little heatup-rate dependence of rupture temperature for high temperature failure, one could assess the possible impact of lo temperature rate tube rupture for Yankee Rowe applications by correlating all the 0^oC/sec. data as well as the 28^oC/sec. data for rupture temperature $\geq 1000^oC$. A quadratic fit through this data set yields the following correlation: $T_R = 2217.75 - 1.629\ \Delta P + 0.001\ \Delta P^2$ ($R^2 = 0.975$; T_R in degrees F, ΔP in psid.).

  Substituting this correlation into TOODEE-2, along with the composite strain correlation of reference 3, one finds that the peak clad temperature for fresh fuel at 6,000 MWD/MTU (the most limiting point in the exposure region considered above) is 11^oF less than Yankee's current licensed model predicts.

  These considerations lead Yankee to conclude the following:

  (1) Ramp dependent concerns associated with cladding swelling and rupture models should not affect plant operation for the remainder of the present cycle.

  (2) Based on our present evaluation of the data of reference 3, (and in part on the paucity of data appropriate to cladding swelling and rupture regimes at Yankee Rowe,) we conclude that Yankee's current licensed model is appropriate.

  (3) Continuing acquisition and evaluation of new data, particularly in the low ramp rate, high temperature region is required. During 1980, Yankee will be approaching the NRC with a rod heatup model to replace TOODEE-2 as part of our licensed ECCS codes. This model will address all available data.

  (4) Particular attention should be placed on the strain at burst data and its relationshp to rupture via clad pressure and temperature effects.

If you have any questions regarding this letter, please feel free to contact Dr. Ausaf Husain or Dr. Stephen P. Schultz of our Nuclear Engineering and Development Department.

Sincerely yours,

YANKEE ATOMIC ELECTRIC COMPANY

D.E. Vandenburgh

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Senior Vice President

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