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December 10, 1979

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

Attention: Office of Nuclear Reactor Regulation
Mr. Richard P. Denise
Acting Assistant Director for Reactor Safety

Reference: (1) License No. DPR-3 (Docket No. 50-29)
(2) D. A. Powers and R. O. Meyer, "Cladding Swelling and Rupture Models for LOCA Analysis," DRAFT NUREG 0630, November 8, 1979.
(3) USNRC (R. P. Denise) letter to YAEC, "Request for Review of DRAFT NUREG 0630," November 8, 1979.
(4) YAEC letter to USNRC, RE: "Evaluation of Cladding, Swelling and Rupture Models," November 2, 1979.
(5) YAEC letter to USNRC, RE: "Evaluation of Cladding, Swelling and Rupture Models (Addendum)," November 20, 1979.
(6) Personal Communication, A. Husain to D. A. Powers, RE: "Rupture, Swelling, and Blockage Correlations for Yankee Rowe Cycle 14 LOCA Evaluation," November 30, 1979.
(7) A. Husain et al., "Application of Yankee-WREM-Based Generic PWR ECCS Evaluation Model to Maine Yankee", YAEC-1160, July 1978.
(8) USNRC letter to YAEC, "Evaluation of Topical Report YAEC-1160," January 17, 1979.
(9) USNRC (D. G. Eisenhut) letter to YAEC, "Additional Information from Vendors and Fuel Suppliers on Cladding Heating-Rate Dependent Burst Temperature Effects," November 27, 1979.

Dear Sir:

Subject: Technical Review of DRAFT NUREG 0630

On November 1, 1979, engineers from YAEC attended an USNRC information meeting to discuss recently developed staff views on cladding rupture, swelling, and coolant blockage which could result from reactor accidents. On November 8, 1979, a draft NUREG report on this subject[2] was transmitted with a request for our technical critique and evaluation.[3] This letter responds to that request and addresses the topics for discussion suggested within it.

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Appendix A (Attachment 1) presents our generic evaluation of DRAFT NUREG 0630. Additional information concerning specific application of DRAFT NUREG 0630 models with respect to the licensed Yankee Rowe ECCS models for cladding swelling and rupture has been presented to the staff[4,5]. In summary, the generic evaluation by YAEC recommends:

1. The experimental program should not be limited in scope of temperature and pressure conditions, but should continue to focus on providing a test matrix for qualifying LOCA predictive models.

2. Data in the high temperature/low pressure burst regime for slow-ramp conditions are required.

3. Data qualification with respect to measurement techniques, accuracy, and interpretation of each of the experimental data sets should be included in the final report.

4. Apparent discrepancies in data within experimental data sets used in the report should be identified, discussed, and resolved.

5. Statistical evaluation of the rupture correlation demonstrates bias toward underprediction of the burst temperature, especially at low cladding heatup rates. Such an analysis should be included in the final report.

6. The difference in temperature measurement techniques for the experiments comprising the data base should be identified. An attempt should be made to examine these differences and to quantify resultant temperature uncertainties.

7. The rupture temperature/pressure correlation extrapolation to the high temperature regime is not qualified by any data in the slow ramp range. The correlation in this regime, especially for low ramp rates, should be re-examined.

8. Isothermal data may not be appropriate and should be re-examined for applicability.

9. Accuracy of cladding heat-up rates should be re-examined for each data set and identified in the report.

10. Applicability of direct electrical heating experimental results for burst temperature/pressure prediction <u>only</u> should be re-examined.

11. The derived rupture correlation should be quantitatively compared to Hagrman's failure criterion.

12. Reference to Chung and Kassner experiments should be deleted in determination of cladding strain. Temperature regimes of strain peaks and valleys should be derived from fundamental Zircaloy property/performance and from the current, applicable data base.

13. Magnitudes of peaks and valleys in cladding strain versus temperature curves should be derived from the current, applicable data base with attention focused on inconsistencies, uncertainties, and accuracies of the data sets.

14. The derivation of the assembly blockage correlation should recognize the systematic locations of rupture in the ORNL MRBT data sets and the effects of assembly spacer grids.

The following section summarizes our response to the topics for discussion suggested in Reference 3. Where appropriate, applicable sections are referenced from Appendix A to provide additional discussion.

1. Confirm that the Zircaloy cladding models displayed in Section 4.0 and which are referenced in Section 5.0 are the models that are used in your licensing LOCA analyses. Confirm that your models have been displayed accurately (i.e., to within $\pm$ 5%). If you are unable to respond affirmatively to the above requests, provide the appropriate references and describe the discrepancies.

Response to Item 1

The Zircaloy cladding models used by YAEC for the LOCA evaluation of Yankee Rowe Cycle 14 were transmitted to the staff[6] following the request for this information by D. A. Powers on November 29, 1979. YAEC understands that this information would be included in the final report and would like the opportunity to confirm that the models will be presented accurately. The models do pertain specifically to the Yankee Rowe Cycle 14 analysis and should be identified as such. Recently, YAEC has obtained a generically licensed LOCA model to be used for Maine Yankee LOCA analysis[7,8]. The cladding models in this generically approved model are the same as those in the WREM package.

2. The location, magnitude, and shapes of superplastic strain peaks and low-ductility valleys cannot be determined precisely from prototypical rod burst tests because there are too few such experiments with enough controlled variables. Do you have any information that would suggest altering the shapes and magnitudes of the strain and blockage correlation curves?

Response to Item 2

YAEC does not possess proprietary data related to this concern. Reference should be made to Appendix A, Sections 3.2 and 3.3 for detailed comments on the derived shapes and magnitudes of these curves.

3. Most of the recent (since 1974) prototypical data were supported by public funds and are publicly available. It therefore appears practical and beneficial to develop standardized rupture temperature, strain, and blockage curves. The curves in the report (or modifications that we might make) could serve as an interim licensing standard, and an industry standards committee could develop revised curves based on present and future research results.

4. It may be appropriate to require that approved vendor cladding models be revised to conform with the correlations that will appear in the final version of the report. If your present models are in agreement with, or conservatively overpredict, the NRC correlations over the range of temperature and stress of interest, and if you wish not to change your present curves, your ECCS model revision could simply consist of explicit limits on the range of applicability of your correlations.

Response to Items 3 and 4

Standardized rupture temperature, strain, and blockage curves such as those presented in the report restrict technical model development and improvement by confining appropriate data analysis to a prescribed acceptable data base and by presupposing the derived correlations to represent accurately the physical phenomena over large ranges of appropriate independent variables. Although most of the recent data are publicly available, applicants should be allowed to employ all data available to them and generate new data for the development of correlations. This procedure provides incentive for improving the state-of-knowledge for these phenomena. Applicants should be allowed to develop and justify their own correlations applicable to the appropriate regime of their own plants.

Model conservatisms are not always consistent or readily apparent and should be analyzed in view of the specific application. For instance, conservative predictions for cladding temperature are not necessarily assured when a correlation which predicts large cladding strains is used and cladding rupture is not predicted to occur.

5. The alpha-plus-beta strain and blockage "valleys" portray a real phenomenon, but the exact location of the very steep sides of the valley may be unknowable for real LOCA conditions. Sensitivity analyses could be done to account for uncertainties in the location of the curves and in prediction of the rupture temperature and stress, but this would have the effect of narrowing the allowable calculated valley and creating a pseudo singularity in the analysis. It might be better for the licensing analysis to be insensitive to this feature.

Response to Item 5

This suggests that best-estimate philosophy is to be combined with evaluation model techniques for LOCA analysis. Evaluation models incorporating these real phenomena have been acceptable; the new data and analyses presented in the DRAFT REPORT support these models.

6. The on-going NRC research program has produced data over a wide range of conditions. Based on discussions with those performing licensing LOCA analyses, it appears that the actual range of interest may be quite narrow, and that the future program could be beneficially focused on a narrower range.

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Response to Item 6

Based upon information supplied in additional submittals to the staff and transmitted on November 27, 1979[9], the range of interest with respect to fuel cladding temperature and stress conditions at rupture is not narrow, but quite large. At Yankee Rowe, the applicable burst temperature/stress correlations lie in the high temperature regime (1000°C or greater). Whereas, the calculated temperature ramp rate for Yankee Rowe may be classified as slow, the on-going NRC research program has produced no new data corresponding to this anticipated range of conditions. Considering the differences in BWR versus PWR fuel and ECCS designs, a narrow focus is not recommended. Based upon vendor and fuel supplier responses, the regime of slow cladding heatup rates requires additional investigation.

YAEC trusts that this discussion in conjunction with the attached technical critique is responsive to your requests. We disagree with suggestions presented in Discussion Topics 3 through 6 for the reasons provided above and in Appendix A. If you have any questions regarding this letter or the attached DRAFT NUREG 0630 technical review, please feel free to contact Dr. Stephen P. Schultz or Dr. Ausaf Husain of our Nuclear Engineering and Development Department.

Sincerely yours,

YANKEE ATOMIC ELECTRIC COMPANY

D. E. Vandenburgh

D. E. Vandenburgh
Sr. Vice President

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Attachment

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