UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION
MAINE YANKEE ATOMIC POWER COMPANY
MAINE YANKEE ATOMIC POWER STATION
DOCKET NO. 50-309
MODIFIED METHOD FOR CEA EJECTION ANALYSIS
(YAEC-1464)

1.0 SUMMARY OF TOPICAL REPORT

This report describes the current Yankee Atomic Electric Company (YAEC) methodology for analyzing a control element assembly (CEA) ejection accident for the Maine Yankee nuclear plant. This report also includes a description of the modifications made to the current methodology used to analyze a CEA ejection accident in Maine Yankee.

The modified YAEC methodology, which will be used in future CEA ejection analysis to predict fuel enthalpy and temperature, differs from the current methodology primarily in two ways. First, the modified methodology incorporates spatial Doppler reactivity feedback effects. Secondly, the modified methodology adjusts the static, post ejected power peaking factor to account for the effect of local power flattening in the vicinity of the peak.

The verification and conservatism of the modified method are evaluated by benchmark comparisons with three-dimensional, space-time kinetics calculations for both full power and zero power initial conditions. The three-dimensional analyses were performed by CE using the HERMITE computer code which has been approved by the staff.

2.0 STAFF EVALUATION

The staff has reviewed the subject report, including the mathematical models and analytical procedures and methods. The CHIC-KIN computer code is the principal calculational tool. A point kinetics analysis is used to calculate the core average nuclear power during a CEA ejection transient. The hot spot (hottest

fuel pin) enthalpy and temperature transients are determined from a hot channel thermal-hydraulic calculation. This is the usual procedure used by the nuclear industry to analyze the spatially dependent transient with a point kinetics model and has been found to be acceptable and usually conservative.

Since CHIC-KIN uses a point kinetics neutronics model, the effect of locally peaked core flux shapes due to the CEA ejection is not included in the Doppler reactivity calculation. Therefore, a spatial Doppler weighting factor is used to modify the Doppler reactivity feedback. These weighting factors take the form of multipliers which, when applied to the single channel Doppler feedback reactivity, provide the effective core-wide feedback reactivity for the appropriate flux shape. The STRIKIN point kinetics code and the TWIGL two-dimensional kinetics code were used by CE to obtain the Doppler weighting factors. For each ejected CEA, a weighting factor on the Doppler feedback was varied until STRIKIN yielded the same core average energy generation as TWIGL during the transient. This resulted in a set of weighting factors as a function of ejected CEA worth. Since TWIGL is a two-dimensional spatial kinetics code, it accounts for the highly localized reactivity effects of a CEA ejection accident more realistically than a point kinetics calculation and is therefore an acceptable method for determining the Doppler weighting factor.

In addition to the spatial reactivity feedback effects, there is also a spatial effect at the hot spot due to the flattening of the prompt radial flux distribution which is not properly accounted for by static calculations such as those obtained by the PDQ computer code. YAEC has modified their calculational method to account for this local power flattening by applying reduction factors (K-factors) to the post-ejected peaking factor derived from static calculations. These K-factors were derived from comparisons between the hot spot integrated power using a static (non-Doppler flattened) flux peak to the hot spot integrated power calculated by the space-time code TWIGL.

YAEC has compared the results of benchmark calculations using the modified method described above to higher order space-time calculations using HERMITE.

The comparison shows that the core average power calculated by the modified YAEC method using CHIC-KIN is conservative relative to a more realistic three-dimensional, space-time HERMITE calculation. The modifications are, therefore, acceptable.

3.0 EVALUATION PROCEDURE

The staff has reviewed the report within the guidelines provided by Sections 4.3 and 15.4.8 of the Standard Review Plan (NUREG-75/087) and by Regulatory Guide 1.77. Part of the staff's review was based on familiarity with and comparison of similar analyses for control rod ejection transients provided in topical reports by other PWR vendors. The staff also had the benefit of a phone conversation with Maine Yankee and YAEC as well as responses to a request for additional information.

4.0 REGULATORY POSITION

The subject report (YAEC-1464) provides an acceptable method for predicting fuel enthalpy and fuel and clad temperature during a CEA ejection accident for the Maine Yankee Plant. The staff, however, notes the following two items of exception:

1. <u>Clad Failure</u>

   For a CEA ejection event, the staff has traditionally assumed for dose calculational purposes that clad failure occurs for those fuel rods which experience DNB. This report assumes the number of fuel rods experiencing clad failure are those with radially averaged fuel enthalpies greater than 200 calories per gram. Although the staff agrees that a fuel energy deposition criterion in terms of enthalpy may be a better measure of fuel cladding failures than DNB for a CEA ejection accident, it believes that 200 calories per gram is too high a criterion. For previous CEA ejection analyses which did not use a clad failure criterion acceptable to the

staff, it has assumed 10% as the amount of failed fuel in the dose calculations. As shown in the Maine Yankee Cycle 8 reload report, fuel failures of approximately 10% result in radiological consequences for a CEA ejection accident which meet the guideline values of 10 CFR Part 100, thereby satisfying the dose criteria for CEA ejection accidents.

2. Pressure Surge

Although the staff presently requires the pressure surge due to a CEA ejection event to be calculated and shown to be below "Service Limit C" as defined in Section III of the ASME Boiler and Pressure Vessel Code, this calculation was not a part of the Maine Yankee licensing basis. Therefore, the calculation of this pressure surge is not addressed by YAEC and will be assumed to be beyond the scope of this topical report.

Principal Contributor:
L. I. Kopp, DSI

Date: July 1, 1985