APPENDIX E

REACTOR COOLANT SYSTEM ASYMMETRIC LOADS EVALUATION PROGRAM

FINAL REPORT

CALVERT CLIFFS 1&2
FORT CALHOUN
MILLSTONE 2

POWER SYSTEMS
COMBUSTION ENGINEERING, INC.

APPENDIX E

REACTOR COOLANT SYSTEM

ASYMMETRIC LOADS

FINAL REPORT

ECCS ANALYSIS APPROACH WITH REDUCED AREA COOLANT CHANNELS IN PERIPHERAL ASSEMBLIES

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for

CALVERT CLIFFS 1 & 2

FORT CALHOUN

MILLSTONE 2

June 30, 1980

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E.1.0 INTRODUCTION AND SUMMARY

The ECCS performance evaluations demonstrating conformance with 10CFR50.46, which presents the NRC Acceptance Criteria for Emergency Core Cooling Systems for Light Water Cooled Reactors(1), are presented in References 2 through 5. These references provide analyses for Calvert Cliffs Units 1&2, Millstone 2, and Ft. Calhoun. The purpose of this supplementary analysis is to demonstrate acceptable ECCS performance with reduced area coolant channels assumed in the peripheral fuel assemblies. While demonstrating acceptable ECCS performance, the intent of this analysis is to also show that the current licensing analysis, pertaining to the hottest fuel rod in the core, is more limiting than that for the hottest rod in a peripheral assembly with reduced area coolant channels. Since this evaluation is to apply to the above plants, a generic analysis was performed. The method of analysis is discussed in the following sections.

E.2.0 METHOD OF ANALYSIS

In the C-E ECCS evaluation model(6,7), the CEFLASH-4A(8) computer program is used to determine the primary system thermal hydraulic behavior during the blowdown period, and the COMPERC-II(9) program is used to describe the system behavior during the refill and reflood periods. The resulting transient parameters from these computer programs, describing the thermal and hydraulic behavior of the primary system, supply the input to the STRIKIN-II(10) program which is used to calculate the hot rod peak clad temperature and peak local clad oxidation percentage.

The objective of the analysis is to demonstrate that the ECCS performance for a peripheral assembly with reduced area coolant channels is less limiting than a hot rod in a channel without any reduction in flow area. To accomplish this objective it is necessary to evaluate the performance of the limiting fuel rod in the peripheral assembly containing reduced area fuel channels. In evaluating the performance of the limiting fuel rod in the peripheral assembly, blowdown refill/reflood, and temperature calculations were performed using the computer programs described above based on a conservative set of input assumptions. The conservative assumptions are employed in the analysis so that the results will conservatively bound the response for the Calvert Cliffs Units 1&2, Millstone 2, and Ft. Calhoun plants. The details of these assumptions and the analytical methods employed in this analysis are discussed in the subsections below.

E.2.1 Blowdown Hydraulics

The blowdown portion of the transient was analyzed using the CEFLASH-4A computer program. In the CEFLASH-4A calculation, the peripheral assembly was explicitly represented with a 10% reduction in total assembly cross sectional flow area. This reduction in peripheral assembly flow area conservatively exceeds the maximum expected deformation since the testing program identified this maximum blockage to be 9%. This deformation was also assumed to occur along the entire length of the assembly to minimize the flow in this region. In addition, the power level of the peripheral assembly was conservatively assumed to be at the core average power level. This assumption is conservative since the peripheral assemblies are approximately 5% to 10% lower than that for the core average which results in maximizing the heat addition to this region.

In performing the blowdown calculation, the Calvert Cliffs plant, a representative 2700 Mwt class NSSS, is used. This plant was chosen since its' core power level is highest of all the plants considered in this evaluation.

E.2.2 Refill/Reflood Hydraulics

Since the containment pressure and core average reflood rates are unaffected by the flow area reduction in a single peripheral assembly, no new COMPERC-II calculations were necessary. As a consequence, the COMPERC-II refill/reflood hydraulics calculations from a representative 2700 Mwt class NSSS, presented in Reference 10, was chosen for use in this portion of the evaluation. This particular analysis was chosen since the evaluation resulted in the lowest containment pressure, the lowest reflood rate, and hence the lowest reflood heat transfer coefficients, for the plants considered in this report.

E.2.3 Temperature Analysis

The STRIKIN-II and PARCH computer programs were used to evaluate the temperature transient and peak local clad oxidation percentage for the hottest rod in the peripheral assembly.

For conservatism, in modeling rod-to-rod thermal radiation, the power distribution surrounding the hot rod in the peripheral assembly was assumed to be a relatively flat distribution. As a consequence, the rods surrounding the hot rod in the peripheral assembly will be very nearly the same temperature as the hot rod during the entire transient thereby minimizing the benefits from rod-to-rod thermal radiation.

In evaluating the response of the hottest rod in the peripheral assembly, the channel surrounding this rod was assumed to be reduced in flow area with percentage reductions in the range from 0 to 35%. The maximum reduction in single channel flow area of 35% is conservative since it exceeds the maximum expected flow area reduction of 34% obtained from the testing program. To evaluate the performance of the hottest peripheral assembly fuel rod, temperature calculations using the STRIKIN-II code was performed at various channel flow areas with percentage reductions up to 35%. The results will be presented as a curve of allowable linear heat rate, for a peripheral assembly, as a function of percent reduction in single channel flow area for the hottest pin in this assembly. Figure E-1 illustrates the expected relationship between linear heat rate or kw/ft limit and percent channel flow area reduction for the peripheral assembly.

E.3.0. REFERENCES

1. Acceptance Criteria for Emergency Core Cooling Systems for Light-Water Cold Nuclear Power Reactors, Federal Register, Vol. 39, No. 3 - Friday, January 4, 1974.
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5. OPPD letter, W. Jones to R. Reid, dated February 12, 1980.

6. CENPD-132, "Calculative Methods for the CE Large Break LOCA Evaluation Model", August 1974 (Proprietary).

CENPD-132, Supplement 1, "Updated Calculative Methods for the CE Large Break LOCA Evaluation Model", December 1974 (Proprietary).

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10. CENPD-135, "STRIKIN, A Cylindrical Geometry Fuel Rod Heat Transfer Program, April 1974 (Proprietary).

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FIGURE E-1

EXPECTED RESULTS

COOLABILITY STUDY