August 30, 2000

Mr. James F. Mallay
Director, Nuclear Regulatory Affairs
Siemens Power Corporation
2101 Horn Rapids Road
Richland, WA 99352

SUBJECT: ACCEPTANCE FOR REFERENCING OF SIEMENS POWER CORPORATION TOPICAL REPORT EMF-2245(P), REVISION 0, "APPLICATION OF SIEMENS POWER CORPORATION'S CRITICAL POWER CORRELATIONS TO CO-RESIDENT FUEL" (TAC NO. MA6438)

Dear Mr. Mallay:

The subject topical report was submitted by Siemens Power Corporation (SPC) by letter dated August 11, 1999. This topical report presents two processes for the application of an approved SPC critical power correlation to pre-existing co-resident fuel, when an SPC fuel design is introduced into a reload core. One process is a generic extension of a previously approved SPC methodology. The second process describes a new method to use an approved SPC critical power correlation to directly evaluate available experimental heat transfer data specific to the co-resident fuel to determine a specific set of critical power correlation additive constants for the co-resident fuel. These processes may be used by SPC and/or licensees (under Generic Letter 83-11, Supplement 1, "Guidelines for Qualifying Licensees to Use Generically Approved Analysis Methods" guidelines) to conservatively apply approved SPC critical power correlations to co-resident fuel from prior reloads.

The staff has reviewed the topical report and finds it acceptable for referencing in licensing actions as stated in the enclosed safety evaluation (SE).

Pursuant to 10 CFR 2.790, we have determined that the enclosed SE does not contain proprietary information. However, we will delay placing the SE in the public document room for a period of ten (10) working days from the date of this letter to provide you with the opportunity to comment on the proprietary aspects only. If you believe that any information in the enclosure is proprietary, please identify such information line by line and define the basis pursuant to the criteria of 10 CFR 2.790.

The staff will not repeat its review and acceptance of the matters described in the report, when the report appears as a reference in license applications, except to assure that the material presented is applicable to the specific plant involved. Our acceptance applies only to the matters described in the report.

In accordance with the procedures established in NUREG-0390, the NRC requests that SPC publish accepted versions of the report, including the safety evaluation, in the proprietary and non-proprietary forms within 3 months of receipt of this letter. The accepted versions shall incorporate this letter and the enclosed evaluation between the title page and the abstract. The accepted versions shall include a "-A" (designating accepted) following the report identification symbol. The accepted versions shall also incorporate all communications between SPC and the staff during this review.

Should our criteria or regulations change so that our conclusions as to the acceptability of the report are no longer valid, SPC and the licensees referencing the topical report will be expected to revise and resubmit their respective documentation, or to submit justification for the continued effective applicability of the topical report without revision of their respective documentation.

Sincerely,

/RA by Michael T. Masnik for/

Stuart A. Richards, Director
Project Directorate IV and Decommissioning
Division of Licensing Project management
Office of Nuclear Reactor Regulation

Project No. 702

Enclosure: Safety Evaluation

In accordance with the procedures established in NUREG-0390, the NRC requests that SPC publish accepted versions of the report, including the safety evaluation, in the proprietary and non-proprietary forms within 3 months of receipt of this letter. The accepted versions shall incorporate this letter and the enclosed evaluation between the title page and the abstract. The accepted versions shall include an "-A" (designating accepted) following the report identification symbol. The accepted versions shall also incorporate all communications between SPC and the staff during this review.

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Sincerely,
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Stuart A. Richards, Director
Project Directorate IV and Decommissioning
Division of Licensing Project management
Office of Nuclear Reactor Regulation

Project No. 702

Enclosure: Safety Evaluation

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

TOPICAL REPORT EMF-2245(P), REVISION 0,

"APPLICATION OF SIEMENS POWER CORPORATION'S CRITICAL POWER

CORRELATIONS TO CO-RESIDENT FUEL"

SIEMENS POWER CORPORATION

PROJECT NO. 702

1.0 BACKGROUND

By letter of August 11, 1999 (Reference 1), Siemens Power Corporation (SPC) requested NRC review of EMF-2245(P) Revision 0, "Application of Siemens Power Corporation's Critical Power Correlations to Co-Resident Fuel." All recent SPC critical power correlations (e.g., ANFB, SPCB series) use a basic functional relationship between boiling transition and nominal fuel bundle operating conditions of coolant inlet mass flow rate, pressure and inlet enthalpy. This is accomplished by determining correlation coefficients fit to measured critical heat flux data, with specific additive constants used to account for specific fuel design features. In this approach, local effects due to such factors as flow channel geometry, radial power distribution, axial power distribution, and grid spacer design use a prescribed formula, correlated by means of a local energy balance term and a set of empirical additive constants on this term.

When boiling water reactor (BWR) reload fuel supplied by SPC is loaded into a reactor core, the critical power performance of both the co-resident fuel (remaining from prior reloads) and the new SPC reload fuel must be evaluated on a consistent and conservative basis. The fuel rod and bundle configuration for the SPC reload fuel and the prior co-resident fuel may physically differ in fuel lattice design (e.g., 9x9 versus 10x10 rod array), and bundle design (grid spacer design, part length rods, etc.). In such cases, measured critical power data for the specific co-resident fuel design parameters may not be contained in the SPC critical power correlation verification and validation data base. Therefore, a consistent methodology for evaluating the critical power performance of each different fuel design must ensure that the use of a specific SPC critical power correlation will conservatively determine the performance of the co-resident fuel design. SPC proposes to accomplish this either by an indirect or a direct evaluation process.

Topical Report EMF-2245(P) describes the processes for the application of approved SPC BWR critical power correlations to the co-resident fuel remaining from prior reloads. One process is a generic extension of a previously approved co-resident methodology (Reference 2). The other process describes the use of an approved SPC critical power correlation to directly evaluate experimental heat transfer data, specific to the co-resident fuel, to determine the appropriate set of additive constants for the co-resident fuel.

The indirect process is used when co-resident fuel critical power correlation coefficients (and uncertainty) is available to SPC and/or the licensee, but the underlying experimental critical power data for the co-resident fuel design is not available. The direct process is used when sufficient experimental critical power data for the co-resident fuel design is available to SPC and/or the licensee.

The two processes described in this topical report are intended for application only for previously exposed co-resident fuel to confirm that sufficient margin to the safety limit exists for both the co-resident fuel and the SPC fuel. These processes and analyses are not applicable (nor required) for support of lead test assembly evaluations.

2.0 EVALUATION

The SPC BWR critical power correlations are designed for application to steady-state and transient critical heat flux (CHF) safety evaluations for SPC BWR fuel designs. The SPC correlations are developed to predict the limiting fuel rod in a bundle and to account for specific fuel design bundle geometry and local spacer effects on the critical power by deriving a set of constants, typically referred to as "Additive Constants," one constant for each rod in the bundle. Each individual fuel bundle design requires a unique set of additive constants.

The SPC critical power correlations are empirically derived expressions with coefficients that are a function of the operating parameters: local coolant enthalpy, coolant mass flow, and pressure. The input operating parameters span the range of pressure, mass velocity, and inlet subcooling covering the expected operating and accident conditions. The correlation coefficients are based on local coolant conditions predicted from both uniform and non-uniform axial power distribution test data. The correlations include correction factors to account for specific geometry and non-uniform axial power distributions that deviate from the correlation test data conditions.

The low-flow and high-flow behavior of the correlation are captured by refining the parameters in the correlation equations. These parameters address the impact of variations in the local enthalpy from the planar average enthalpy. One of these parameters characterizes fuel rod local behavior, such as enthalpy rise, and also factors additive constants into the correlation. The additive constants account for the fuel bundle geometry and spacer effects on the critical power behavior of the bundle.

2.1 Indirect Correlation Application

The indirect correlation application (ICA) process is used when either no experimental critical heat transfer data are available to SPC or to the licensee for the co-resident fuel or when insufficient data are available for the range of conditions for which the SPC correlation is to be applied. This process involves generically expanding the application of a previously approved co-resident methodology, which was used for the approved ANFB correlation (Reference 3), to allow using other approved SPC critical power correlations which use additive constants.

The ICA process is applied to previously exposed co-resident fuel by:

1. Determining additive constants for co-resident fuel with insufficient or no experimental data in the SPC or licensee data base for the specific SPC critical power correlation to be used, but for which a calculated critical power data base (with uncertainties) from another approved correlation is available,

2. Performing a rigorous statistical evaluation of the approved critical power correlation for the co-resident fuel design to determine its standard deviation for the predicted critical power ratio data base, and

3. Using appropriate co-variance, calculate a combined standard deviation as the product of two random variables: (a) the ratio of the SPC correlation standard deviation to the approved co-resident fuel design standard deviation, and (b) the co-resident fuel correlation standard deviation.

The additive constant uncertainty for the co-resident fuel to be applied by the SPC critical power correlation [for use in the approved SPC safety limit methodology (Reference 4)] is determined from the above combined standard deviation, conservatively adjusted by the specific SPC critical power correlation uncertainty standard deviation, and the additive constant uncertainty standard deviation for the data obtained for all designs tested and included in the correlation data base.

2.2 Direct Correlation Application

The direct correlation application process is used to determine the additive constants and the additive constant uncertainties for an experimentally tested co-resident fuel design, based on sufficient experimental critical power data, which is available to the licensee and/or SPC. This process uses an approved SPC critical power correlation with approved procedures to directly evaluate the experimental critical heat transfer data specific to the co-resident fuel in order to determine the set of additive constants for the co-resident fuel and to determine the behavior of the SPC correlation over the range of conditions used to obtain the data.

This process is applied to previously exposed co-resident fuel by:

1. Determining the additive constants for co-resident fuel when sufficient experimental critical heat transfer data for the co-resident fuel is available to SPC and/or the licensee, but which data have not yet been evaluated with a specific approved SPC critical power correlation,

2. Performing a rigorous statistical evaluation of the approved SPC critical power correlation used for the co-resident fuel design to determine the standard deviation of the correlation from the experimental critical power ratio data and of the additive constants within the evaluated data base,

3. Evaluating the application process for the co-resident fuel critical power correlation to determine that no unexpected trends are observed, and

4. Ensuring that the co-resident critical power experimental data ranges are adequate for the intended evaluations and are comparable to those used to develop the SPC critical power correlation.

This process uses approved SPC processes and procedures to evaluate the co-resident fuel experimental critical power data. Since the data is normally proprietary to the co-resident fuel vendor, the licensee is responsible for determining the additive constants and uncertainties using the approved SPC procedures. As discussed below, the licensee must be qualified to perform this process.

2.3 Technology Transfer Requirement

Licensees may be responsible for and participate in the analyses required for either the indirect or the direct correlation process. Therefore, it is necessary that these licensees fully understand the process, methodology and procedures used, and are capable of independently performing or reviewing the evaluations. SPC has described their technology transfer program (Reference 5), which the licensees must successfully complete in order to perform their own thermal-hydraulic calculations using the SPC SPCB correlation and the SPC XCOBRA-T transient code (Reference 6) in support of reload analyses. The overall process consists of training, benchmarking, and change control. In addition, SPC described the process for a licensee to implement a new correlation (e.g., SPCB). This process includes performance of an independent benchmarking calculation by SPC for comparison to the licensee-generated results to verify that the critical power (CP) correlation is properly applied.

Generic Letter (GL) 83-11, Supplement 1 (Reference 7) provides guidelines for qualifying licensees to use NRC-approved analysis methods. The lead licensee for application of this topical report has committed to implement these guidelines for safety analyses using SPC methodology to apply approved SPC critical power correlations to co-resident fuel (Reference 8). The staff has reviewed the SPC process and licensee commitments and finds this acceptable since training, bench-marking and change control have been adequately addressed, as required by GL 83-11, Supplement 1.

2.4 Summary

The two processes described in this topical report are based on approved SPC methodologies and procedures. Therefore, their application by SPC to previously exposed co-resident fuel in safety analyses for mixed reload cores is acceptable to the staff. Participation by the licensee in the safety analyses is controlled by the stipulation that licensee involvement be performed in accordance with the guidelines of GL 83-11, Supplement 1. This ensures that adequate licensee training, code benchmarking and change control are maintained. This is acceptable to the staff.

3.0 CONCLUSION

The staff has reviewed the processes and evaluations described in Topical Report EMF-2245(P), Revision 0, "Application of Siemens Power Corporations's Critical Power Correlations to Co-Resident Fuel." The staff also reviewed the limitations imposed on licensee application of SPC CP correlations, as discussed in the staff's SE for Topical Report EMF-2209(P)

(Reference 9) for the latest approved SPC CP correlation (SPCB). The staff also reviewed the lead licensee's commitment to apply GL 83-11 Supplement 1 guidelines with the topical report and concludes that, as discussed above, Topical Report EMF-2245(P) is acceptable for referencing in licensing applications, subject to the following condition:

> Technology transfer to licensees who may be responsible for using these processes will be accomplished through SPC and licensee procedures consistent with the requirements of GL 83-11, Supplement 1. This process includes the performance of an independent bench-marking calculation by SPC for comparison to licensee-generated results to verify that the application of SPC CHF correlations is properly applied for the first application by a licensee.

4.0 REFERENCES

1. Letter from J. F. Mallay (SPC) to U. S. NRC, "Request for Review of EMF-2245(P) Revision 0, 'Application of Siemens Power Corporation's Critical Power Correlations to Co-Resident Fuel,'" NRC:99:034, August, 11, 1999.

2. EMF-1125(P)(A), Supplement 1, Appendix C, "ANFB Critical Power Correlation Application for Co-Resident Fuel," Siemens Power Corporation, August 1997.

3. ANF-1125(P)(A) and Supplements 1 and 2, "ANFB Critical Power Correlation," Advanced Nuclear Fuels Corporation, April 1990.

4. ANF-524(P)(A), Revision 2 and Supplements 1 and 2, "ANF Critical Power Methodology for Boiling Water Reactors," Advanced Nuclear Fuels, November 1990.

5. Letter from J. F. Mallay (SPC) to the U.S. Nuclear Regulatory Commission, "SER Conditions for EMF-2209(P) Revision 1, SPCB Critical Power Correlation," April 24, 2000.

6. XN-NF-84-105(P)(A), "XCOBRA-T: A Computer Code for BWR Transient Thermal-Hydraulic Core Analysis," Exxon Nuclear Company, Richland, WA 99352, February 1987.

7. Generic Letter 83-11, Supplement 1, "Guidelines for Qualifying Licensees to Use Generically Approved Analysis Methods," June 24, 1999.

8. Letter from M. A. Krupa (EOI) to U.S. NRC, "Implementation of GL 83-11, Supplement 1, for Co-Resident Fuel CPR Calculations," August 4, 2000.

9. Letter from U.S. NRC to J. F. Mallay (SPC), "Acceptance for Referencing of Licensing Topical EMF-2209(P), Revision 1, 'SPCB Critical Power Correlation'", July 3, 2000.

Principal Contributor: E. Kendrick

Date: August 30, 2000