September 17, 2003

Mr. James F. Mallay
Director, Regulatory Affairs
Framatome ANP
3815 Old Forest Road
Lynchburg, VA 24501

SUBJECT: SAFETY EVALUATION – REVISION TO FRAMATOME ANP TOPICAL REPORT EMF-2209(P)(A), REVISION 1 (TAC NO. MB9719)

Dear Mr. Mallay:

By letter dated June 20, 2003, Framatome ANP (FANP) submitted a revision to Topical Report (TR) EMF-2209(P), Revision 1, "SPCB Critical Power Correlation," to the NRC for review and approval. "SPCB Critical Power Correlation" designates a critical power correlation for boiling water reactors originally developed by Siemens Power Corporation. The submittal describes modifications to the NRC-approved Siemens Power Corporation critical power correlation in the region of the uranium blanket at the top six inches of the fuel. The revision will enhance the behavior of the SPCB correlation in the reflector region of the fuel while reducing some of the conservatism inherently built into the correlation in the region.

The NRC staff has completed its review of the revision to the TR and FANP's response to the staff's July 14, 2003, request for additional information (RAI). The TR is acceptable for referencing in licensing applications to the extent specified and under the limitations delineated in the report and in the associated NRC staff's safety evaluation, which is enclosed. The safety evaluation defines the basis for acceptance of the TR.

If the NRC staff’s criteria or regulations change so that its conclusion in this letter, that the TR is acceptable, is invalidated, FANP and/or the applicant referencing the TR will be expected to revise and resubmit its respective documentation, or submit justification for the continued applicability of the TR without revision of the respective documentation.

In accordance with the guidance provided on the NRC website, we request that FANP publish an accepted version within three months of receipt of this letter. The modifications in the current submittal would be implemented as modifications in the documentation of the original TR (EMF-2209(P)(A), Revision 1). FANP would modify the footnote on page 2-8 of that TR to specify the maximum value of the Omega Function and would add a footnote on page 2-8 to specify the maximum value of the Tong Factor. FANP shall incorporate (1) this letter and the enclosed SE with the initial SE between the title page and the abstract, (2) all RAIs from the staff and all associated responses into a revised report and publish the revised report as EMF-2209(P)(A), Revision 2. The proposed modifications will have no effect on the statistical aspects of the SPCB data base evaluations, and hence, will not impact the minimum critical power ratio safety limit in any way. The actual statement of the amended footnote is provided in your letter dated June 20, 2003.

Pursuant to 10 CFR 2.790, we have determined that the enclosed safety evaluation does not contain proprietary information. However, we will delay placing the safety evaluation in the public document room for a period of ten 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.

We do not intend to repeat our review of the matters described in the subject topical report and found acceptable, when the report appears as a reference in license applications, except to ensure that the material presented applies to the specific plant involved. Our acceptance applies only to matters approved in the report.

In the event that any comments or questions arise, please contact Drew Holland at (301) 415-1436.

Sincerely,

/RA/

Herbert N. Berkow, Director
Project Directorate IV
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Project No. 728

Enclosure: Safety Evaluation

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Enclosure: Safety Evaluation

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

REVISION TO TOPICAL REPORT EMF-2209(P)(A), REVISION 1

"SPCB CRITICAL POWER CORRELATION"

FRAMATOME ANP

PROJECT NO. 728

1.0 BACKGROUND

By letter dated June 20, 2003, (Reference 1), Framatome-ANP (FANP) submitted a revision to Topical Report (TR) EMF-2209(P)(A), Revision 1, "SPCB Critical Power Correlation," to the NRC for review and approval. "SPCB Critical Power Correlation" designates a critical power correlation for boiling water reactors originally developed by Siemens Power Corporation. The submittal describes a modification to the NRC-approved Siemens Power Corporation B (SPCB), critical power correlation (Reference 2) in the region of the uranium blanket at the top six inches of the fuel. The revision will enhance the behavior of the SPCB correlation in the reflector region of the fuel, while reducing some of the conservatism inherently built into the correlation in that region. Upon review of the SPCB critical power correlation, the staff asked specific questions regarding the determination of the maximum value for the Tong Factor as well as the maximum value for the Omega Function in a request for additional information (RAI) (Reference 3). The staff also met with FANP in Richland, Washington on July 22, 2003, and July 23, 2003, to discuss FANP’s responses to the RAIs (Reference 4).

Reference 2 is the TR originally submitted by the Siemens Power Corporation and approved by the NRC in July 2000. The TR described the methodology behind the development and application of the SPCB critical power correlation to FANP ATRIUM-9B and ATRIUM-10 fuel designs.

Application of the SPCB correlation to D-lattice plants indicated that the correlation is overly conservative for nuclear designs with top natural uranium blankets. This conservatism arises from deriving the SPCB correlation without accounting for the effect of the natural uranium at the top six inches of the fuel rods. Although reflector blankets have always been a part of FANP boiling water reactor (BWR) designs, the details of the power distributions within the reflector region were not fully considered in development of the SPCB Revision 1. Reference 1 proposes revisions to two parameters within the correlation to fully account for the natural uranium in the reflector blanket, and without affecting the correlation behavior in the remaining areas of the fuel.

2.0 REGULATORY EVALUATION

Title 10 of the Code of Federal Regulations (10 CFR) Section 50.34, "Contents of Applications; Technical Information," requires that safety analysis reports be submitted that analyze the

design and performance of structures, systems, and components provided for the prevention of accidents and the mitigation of the consequences of accidents. As part of the core reload design process, licensees (or vendors) perform reload safety evaluations to ensure that their safety analyses remain bounding for the design cycle.

To confirm that the analyses remain bounding, licensees confirm that key inputs to the safety analyses are conservative with respect to the current design cycle. If key safety analysis parameters are not bounded, reanalysis or reevaluation of the affected transients or accidents is performed to ensure that the applicable acceptance criteria are satisfied.

Reference 1 describes FANP’s methodology for implementing two improvements to the existing SPCB critical power correlation. Since the NRC staff has previously reviewed and approved the SPCB correlation, the staff's review of Reference 1 focused on the two improvements in the application of the critical power correlation to FANP ATRIUM-9B and ATRIUM-10 fuel. There are no specific regulatory requirements or guidance available for the review of TR revisions. As such, the staff reviewed the revisions based on the technical merit and its compliance with any applicable regulations.

The staff validated that the Tong Factor and Omega Function are appropriately defined and that the data supports the proposed modifications.

3.0 TECHNICAL EVALUATION

FANP developed the SPCB correlation to address the critical power behavior of the Siemens Power Corporation ATRIUM-9B and ATRIUM-10 fuel designs. The SPCB correlation is applicable in steady-state, transient, and loss-of-coolant accident critical heat flux (CHF) calculations for the ATRIUM-9B and ATRIUM-10 fuel designs.

Typically, natural UO_2 blankets are added to BWR fuel to prevent neutron leakage and improve fuel cycle economics. As FANP pointed out in Reference 4, replacing the top and bottom 6 inches of the active fuel with a natural uranium blanket reduces the overall enrichment of the bundle.

In theory, moving more U-235 toward the center of the core improves U-235 utilization by reducing neutron leakage out of both the top and bottom of the enriched fuel. The top blanket is worth more than the bottom blanket in enrichment savings, since most neutronic activity occurs in the top of the core. However, relatively little power is produced in natural UO_2 blankets themselves.

Natural blankets have always been a part of FANP BWR designs. However, FANP did not fully consider the details of the blanket power distributions when developing the SPCB CHF correlation. Unlike the enriched sections of the fuel assembly, where the radial enrichment distribution is tailored to minimize radial peaking factors, the natural blankets utilize a uniform radial enrichment. The result is that the local peaking depends primarily on the moderator distribution in the vicinity of the blanket.

After investigation of Reference 2, FANP determined that the correlation is overly conservative in the top six inches of the fuel rod when a natural uranium blanket is present. This

conservatism arises from the fact that the test data used for deriving the Omega Function did not appropriately account for the non-linearity of the data in the top six inches of the fuel. The two parameters (the Tong Factor and the Omega Function) within the correlation are revised, but not the correlation itself. In developing the technical basis for the Tong Factor and Omega Function in the SPCB Revision 1 correlation, FANP did not make full use of the available raw test data. Framatome ANP assigned a bounding fixed value to the Omega Function, while in actuality the test data suggested that the factor should be non-linear.

For a D-lattice plant with asymmetric water gaps between assemblies, the relative local peaking and consequently the maximum lattice F-effective can be quite high despite the low planar powers. The high F-effectives for the D-lattice natural blanket, coupled with the unbounded Tong Factor result in the assembly being limited by the natural blanket region.

For a C-lattice plant the results show similar trends but are not as exaggerated. C-lattice plants exhibit the same unbounded Tong behavior. The local pin-peaking of the C-lattice for the natural lattice is not as great as that of the D-lattice; therefore, the F-effective is not as limiting for the C-lattice as for the D-lattice.

FANP determined that the Tong Factor, as defined by equations 2.14 and 2.15 in Reference 2, was the source of the observed behavior. Specifically, the Tong Factor was observed to take on values significantly larger than is typically observed for other axial shapes used in the correlation data base for the exit plane. The sudden increase in the Tong Factor in the six inch blanket results in a calculated critical power for the top node which is overly conservative.

The reduced axial power peaking in the top blanket also introduces a step change in the Omega Function as defined in equation 2.15 of Reference 2. While the Omega Function was forced to assume a fixed value in the original correlation, the locally computed values as a function of mass flow, may drop significantly below the minimum value imposed on the function as defined in RAI response #8 of Reference 4. The value of the Omega Function has an inverse relation to memory length/effect. Memory length refers to the influence of the upstream thermal hydraulic behavior on the local heat flux. A larger value of memory length implies a greater importance of upstream fluid conditions. The evaluation process typically performs evaluations on a six-inch increment. If the memory effect is characterized by some length at one location, then the memory effect at the next location should not be characterized by a memory length that is more than six inches longer.

The SPCB correlation originally accounted only for the observation that the Omega Function should be no less than some minimum value on an absolute basis for the entire database. The insertion of natural uranium in the last 6 to 12 inches of the assembly leads to step changes in the Omega Function that mathematically suggest an increasingly longer memory effect for the natural uranium nodes, well beyond the added 6 inches per node when compared to upstream values. This suggested an improved definition for the Omega Function incorporating values of Omega that bound the correlation data base but allow variation of the minimum value as a function of mass velocity as illustrated in Figure 2 of Reference 1.

The staff examined the literature that describes the development and application of both the Tong Factor and the Omega Function (Reference 2) and the data that FANP used to develop the initial correlation during an onsite audit. After reviewing the responses to the staff's RAI and examining the proposed changes to the Tong Factor and Omega Function at the FANP Richland site, the staff has concluded that the proposed values provide a conservative limit when compared to the data, and the proposed modifications to equations 2.14 and 2.15 are acceptable. Further, the staff agrees with the proposed means of implementing these modifications in the revised TR.

Generic Letter 88-16, "Removal of Cycle-Specific Parameter Limits from Technical Specifications," outlined a process that licensees could use to move cycle-specific parameters from the plant-specific TSs to a licensee-controlled document entitled the Core Operating Limits Report (COLR). A necessary element of that process was that licensees include specific types of methodologies (i.e., revision changes) into the TSs. This TR is one such methodology that is required to be listed in the TSs.

4.0 LIMITATION AND CONDITION

Application of this correlation and the proposed revisions to fuel designs other than the ATRIUM-9B and ATRIUM-10 designs requires prior staff approval.

5.0 CONCLUSION

The staff has reviewed FANP's submittal and supporting documentation. Based on the considerations above, the staff has concluded that the proposed revision to TR EMF-2209(P) (A), Revision 1, "SPCB Critical Power Correlation," is acceptable for use in licensing applications for FANP ATRIUM-9B and ATRIUM-10 fuel designs only.

6.0 REFERENCES

1. Letter from J. F. Malley to the U.S. Nuclear Regulatory Commission, "Request for Review of a Revision to EMF-2209(P)A), Revision 1," June 20, 2003.

2. EMF-2209(P)A), Revision 1, "SPCB Critical Power Correlation," July 2000.

3. Fax from U.S. Nuclear Regulatory Commission, "Request for Additional Information (RAI) to Topical Report EMF-2209(P), 'SPCB Critical Power Correlation,' Revision 1," July 14, 2003.

4. Letter from J. F. Malley to the U.S. Nuclear Regulatory Commission, "Responses to Additional Information (RAI) to Revision to Topical Report EMF-2209(P)(A), 'SPCB Critical Power Correlation,' Revision 1," July 25, 2003.

Contributors: Patricia Henry
Anthony Attard

Date: September 17, 2003