September 20, 2005

Mr. Ronnie L. Gardner
Manager, Site Operations
and Regulatory Affairs
Framatome ANP
3315 Old Forest Road
Lynchburg, VA 24501

SUBJECT: FINAL SAFETY EVALUATION FOR TOPICAL REPORT BAW-10243(P), "STATISTICAL FUEL ASSEMBLY HOLD DOWN METHODOLOGY" (TAC NO. MC4531)

Dear Mr. Gardner:

By letter dated September 21, 2004, Framatome ANP (FANP) submitted Topical Report (TR) BAW-10243(P), "Statistical Fuel Assembly Hold Down Methodology," to the U.S. Nuclear Regulatory Commission (NRC) staff. By letter dated August 25, 2005, an NRC draft safety evaluation (SE) regarding our approval of BAW-10243(P) was provided for your review and comments. FANP had no comments on the draft SE.

The NRC staff has found that BAW-10243(P) is acceptable for referencing in licensing applications for all pressurized-water reactor designs to the extent specified and under the limitations delineated in the TR and in the enclosed final SE. The final SE defines the basis for acceptance of the TR.

Our acceptance applies only to material provided in the subject TR. We do not intend to repeat our review of the acceptable material described in the TR. When the TR appears as a reference in license applications, our review will ensure that the material presented applies to the specific plant involved. License amendment requests that deviate from this TR will be subject to a plant-specific review in accordance with applicable review standards.

In accordance with the guidance provided on the NRC website, we request that FANP publish accepted proprietary and non-proprietary versions of this TR within three months of receipt of this letter. The accepted versions shall incorporate this letter and the enclosed final SE after the title page. Also, they must contain historical review information, including NRC requests for additional information and your responses. The accepted versions shall include a "-A" (designating accepted) following the TR identification symbol.

If future changes to the NRC's regulatory requirements affect the acceptability of this TR, FANP and/or licensees referencing it will be expected to revise the TR appropriately, or justify its continued applicability for subsequent referencing.

Sincerely,

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

Project No. 728

Enclosure: Final SE

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Sincerely,
/RA/
Herbert N. Berkow, Director
Project Directorate IV
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Office of Nuclear Reactor Regulation

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Enclosure: Final SE

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

TOPICAL REPORT BAW-10243(P)

"STATISTICAL FUEL ASSEMBLY HOLD DOWN METHODOLOGY"

FRAMATOME ANP

PROJECT NO. 728

1.0 INTRODUCTION AND BACKGROUND

By letter dated September 21, 2004 (Reference 1), as supplemented by letter dated April 15 and July 5, 2005 (References 2 and 3), Framatome ANP (FANP) requested review and approval of topical report (TR) BAW-10243(P), "Statistical Fuel Assembly Hold Down Methodology." The TR describes a statistical methodology to calculate net assembly holddown (NHD) force. Employing a probabilistic (Monte-Carlo) propagation of uncertainties, the statistical methodology is used to demonstrate that the fuel assembly design provides sufficient net downward force to counteract the vertical hydraulic lift force created by the core flow rate so that the fuel assembly remains in a seated position during normal operation and anticipated transients. Current methods employ a deterministic treatment of uncertainties which may lead to actual fuel assembly compressive forces greater than necessary (to counteract uplift forces), which could promote assembly distortion.

2.0 REGULATORY EVALUATION

Regulatory guidance for the review of fuel system designs and adherence to applicable Title 10 of the *Code of Federal Regulations* (10 CFR), Part 50, Appendix A, General Design Criteria (GDC) is provided in NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants" (SRP), Section 4.2, "Fuel System Design" (Reference 4). In accordance with SRP Section 4.2, the objectives of the fuel system safety review are to provide assurance that:

a. the fuel system is not damaged as a result of normal operation and anticipated operational occurrences (AOOs),
b. fuel system damage is never so severe as to prevent control rod insertion when it is required,
c. the number of fuel rod failures is not underestimated for postulated accidents, and
d. coolability is always maintained.

To meet the requirements of GDC 10 as it relates to Specified Acceptable Fuel Design Limits for normal operation, including AOOs, fuel system damage criteria should be given for all known damage mechanisms. SRP Section 4.2.II.A.1.(g) states:

Worst-case hydraulic loads for normal operation should not exceed the holddown capability of the fuel assembly (either gravity or holddown springs). Hydraulic loads for this evaluation are reviewed as described in SRP Section 4.4.

The NRC staff's review of BAW-10243(P) ensures that application of the statistical fuel assembly holddown (SHD) methodology to fuel assembly designs will satisfy this regulatory criteria at a 95/95 percent level of protection and confidence.

3.0 TECHNICAL EVALUATION

The net force on the fuel assembly consists of the downward force of the fuel assembly holddown spring, the downward force of the weight of the fuel assembly, the upward buoyancy force of the water, and the upward force imposed on the fuel assembly by the coolant flow. The fundamental equation for calculating NHD force in BAW-10243(P) is identical to those employed for current fuel assembly designs. In response to a request for additional information (RAI) concerning the pedigree of these governing equations (RAI #5, Reference 2), FANP responded that the governing equations "are identical in form for both the deterministic and statistical analyses" and that the "difference in application is the propagation of uncertainties through the equations." In response to RAI #2b (Reference 2), FANP stated that the fundamental equation "has been used by Framatome ANP for deterministic calculations and contains all the axial forces acting on the fuel assembly." Further, FANP states that the "SHD methodology provides a means of statistically accommodating uncertainties that avoids the overly-conservative compounding of uncertainties that can lead to excessive forces on the fuel assembly design that could potentially lead to distortion." Based on review of Section 4.0 of BAW-10243(P) and response to these RAIs, the NRC staff finds the governing equations used to calculate NHD force acceptable, because the equations account for all the axial forces.

Section 9.0 of BAW-10243(P) defines the analysis process for determining the NHD force using the probabilistic methods. The first step is defining the statepoints for evaluation, which is discussed in Section 6.0 of BAW-10243(P). A series of statepoints covering a wide range of plant operating conditions at different burnup steps are investigated in order to identify the limiting statepoint. Limiting statepoints often include (1) isothermal reactor coolant pump startup (e.g., 85 EF) at end-of-life, and (2) steady-state design overpower (e.g., 125 percent) full flow conditions at end-of-life. When the core is composed of different fuel designs, the limiting fuel assembly for each fuel design will be determined for each of the statepoints.

The next analytical step is to quantify the nominal value and uncertainty distribution for each of the variables and propagate the uncertainties. FANP noted that the propagation of uncertainties technique was initially reviewed and approved by the NRC staff for departure from nucleate boiling (DNB) analyses in BAW-10170P-A (Reference 5). Similar to BAW-10170P-A, the input variable uncertainties are assumed to be either normally or uniformly distributed. Section 5.0 of BAW-10243(P) states "if the normal distribution cannot be verified for a given uncertainty, the uniform distribution can be conservatively substituted for propagation." In response to an RAI on the treatment of uncertainties (RAI #1, Reference 2), FANP stated that the normal distribution is verified with the standard D prime test which requires a sample size of at least 50. The NRC staff has previously approved the use of the D prime normality test (Section 2.2 of Reference 5).

In response to an RAI (Reference 3), FANP identified that the W test, which is a widely accepted normality test, may be used to verify normality on smaller data sets (< 50 data). This approach is consistent with NUREG-1475. In a supplemental description of the methodology (Reference 3), FANP also mentioned that a data set could be propagated as normal, even if this data set failed a normality check, provided the measured standard deviation was penalized by the ratio (3.5/3.0). Based upon the information presented in Reference 3 that FANP's approach is consistent with NUREG-1475, the NRC staff finds this approach acceptable.

In its response to a request for further information on the treatment of uncertainties, FANP submitted supplemental information (Reference 3). In FANP's response, the treatment of variable uncertainties with data and without data is defined. A protection level of 95 percent for any given variable uncertainty is the standard requirement and part of the basis for the propagation of uncertainties methodology. Note that a less strict application is credited for dimensional tolerances (i.e., assumed 3 σ distribution). This is judged acceptable, based upon tight manufacturing techniques, as supported by the data provided for fuel assembly height and spring height (Reference 3). FANP's supplemental text also describes the conservative treatment of skewed, biased, or uneven variable uncertainties.

In response to an RAI concerning the use of a nominal fuel assembly weight with no uncertainty (RAI #7, Reference 2), FANP provided measured data demonstrating that the variability was insignificant. Based on this data, the NRC staff finds the use of a nominal fuel assembly weight acceptable.

In response to an RAI concerning an adjustment of assembly pressure drop based on flow ratio (RAI #9, Reference 2), FANP stated that the fuel assembly hydraulic resistance, at a given statepoint, could be corrected for the small variations in core volumetric flow. FANP also stated that small variations in the inlet temperature, at a given statepoint, could be adjusted by a simple density ratio. Based on this response, the NRC staff accepts the methods used to adjust inlet temperature and hydraulic resistance over the small range of propagation around the base case for a given statepoint.

The third analytical step is to perform a hydraulic evaluation of the core using an NRC-approved thermal-hydraulic code. The core is modeled with the plant-specific fuel cycle core configuration, including the inlet flow distribution applicable to the plant design, to obtain the pressure drop across the various fuel assemblies (RAI #6, Reference 2).

The final analytical step is to use the propagation model to determine the NHD force for each fuel assembly design at each of the statepoints. From these calculated values, the minimum NHD value with the statistical protection at the 95 percent level with 95 percent protection is selected. For example, the minimum NHD force applying a population of 10,000 data points, results in the following 95/95 level of protection,

$$NHD_{95/95} = NHD_{mean} - 1.67\ (\sigma_{NHD})$$

The fuel assembly design has adequate hold down when the limiting condition 95/95 NHD is positive.

In response to an RAI concerning the application of the SHD methodology to non-FANP fuel designs (RAI #8, Reference 2), FANP stated that the non-FANP vendor or the utility would be required to furnish sufficient information on the non-FANP fuel design for the SHD methodology to be applied. If sufficient information was unavailable, FANP would incorporate conservative assumptions to ensure that at least a 95/95 level of protection was maintained.

4.0 CONCLUSION

Based upon a review of the methods described in BAW-10243(P) (Reference 1) and in response to RAIs (References 2 and 3), the NRC staff finds the SHD methodology acceptable.

5.0 REFERENCES

1. Letter from J. F. Mallay (FANP) to U.S. Nuclear Regulatory Commission, "Request for Review and Approval of BAW-10243(P) 'Statistical Fuel Assembly Hold Down Methodology,'" dated September 21, 2004. Agencywide Documents Access and Management System (ADAMS) Accession No. ML042960502.

2. Letter from J. S. Holm (FANP) to U.S. Nuclear Regulatory Commission, "Response to a Request for Additional Information Regarding BAW-10243(P), Revision 0, 'Statistical Fuel Assembly Hold Down Methodology,'" dated April 15, 2005. ADAMS Accession No. ML051090330.

3. Letter from R. L. Gardner (FANP) to U.S. Nuclear Regulatory Commission, "Additional Information for the Review of BAW-10243(P), Revision 0, 'Statistical Fuel Assembly Hold Down Methodology,'" dated July 5, 2005. ADAMS Accession No. ML051890342.

4. NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants," Section 4.2, "Fuel System Design," Draft Revision 3, April 1996.

5. Letter from U.S. Nuclear Regulatory Commission to J. H. Taylor (B&W), "Acceptance for Referencing of Topical Report BAW-10170P, 'Statistical Core Design for Mixing Vane Cores', Dated September 1987," September 14, 1988. ADAMS Legacy Library Accession No. 8809200162.

Principal Contributor: P. Clifford

Date: September 20, 2005