November 9, 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 ADDENDUM 3 TO TOPICAL REPORT BAW-10199(P), "THE BWU CRITICAL HEAT FLUX CORRELATIONS" (TAC NO. MC4262)

Dear Mr. Gardner:

By letter dated August 17, 2004, Framatome ANP (FANP) submitted Addendum 3 to Topical Report (TR) BAW-10199(P), "The BWU Critical Heat Flux Correlations," to the U.S. Nuclear Regulatory Commission (NRC) staff. By letter dated September 29, 2005, an NRC draft safety evaluation (SE) regarding our approval of Addendum 3 to BAW-10199(P) was provided for your review and comments. On October 12, 2005, Gayle Elliot, of FANP, informed the NRC staff that FANP had no comments on the draft SE, via a telephone conversation.

The NRC staff has found that Addendum 3 to BAW-10199(P) is acceptable for referencing in licensing applications for pressurized-water reactors with Mark B11 spacer grid 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, Deputy Director
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

Project No. 728

Enclosure: Final SE

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, Deputy Director
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

Project No. 728

Enclosure: Final SE

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ADAMS ACCESSION NO.: ML053040256 **NRR-043** ***No substantive changes**

OFFICE	NRR/PSPB/PM	NRR/LPLG/LA	SRXB-A/SC*	NRR/PSPB/BC(A)	NRR/DPR/DD
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DATE	11/3/05	11/2/05	9/12/05	11/7/05	11/9/05

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

ADDENDUM 3 TO TOPICAL REPORT BAW-10199(P)

"THE BWU CRITICAL HEAT FLUX CORRELATIONS"

FRAMATOME ANP

PROJECT NO. 728

1.0 INTRODUCTION AND BACKGROUND

By letter dated August 17, 2004 (Reference 1), Framatome ANP (FANP) requested NRC review of Addendum 3 to topical report (TR) BAW-10199(P) “The BWU Critical Heat Flux Correlations,” that was included as an enclosure to its August 17, 2004, letter. Addendum 3 consists of Appendix I, “The BWU-B11R CHF [Critical Heat Flux] Correlation for the Mark-B11 Spacer Grid.” The original BWU CHF correlation (Reference 2) was developed and applied to three types of pressurized-water reactor (PWR) spacer grids: the BWU-Z correlation for the Mark-BW17 design, the BWU-I correlation for Inconel mixing vane spacer grids other than the high performance Mark-BW17 design, and the BWU-N correlation for all non-mixing vane designs. The Mark-B11 design was qualified for CHF analysis with the BWU-Z CHF correlation with a simple multiplier on the calculated CHF in Addendum 1 to BAW-10199-P-A (Reference 3). The Mark-BW17 mid-span mixing (MSM) design was qualified for CHF analysis with the BWU-Z CHF correlation with a different multiplier on the calculated CHF in Addendum 2 to BAW-10199-P-A (Reference 4).

The purpose of Addendum 3 to TR BAW-10199(P) is to justify a dedicated CHF correlation with its specific applicability range, based on the CHF database for the Mark-B11 15x15 spacer grid design.

The NRC staff reviewed Addendum 3 to TR BAW-10199(P) and supplemental letters dated March 2 and August 18, 2005 (References 5 and 6, respectively), provided by FANP in response to the NRC staff requests for additional information (RAI).

2.0 REGULATORY EVALUATION

Section 50.36 of Title 10 of the *Code of Federal Regulations* (10 CFR) requires that safety limits be included in the plant-specific technical specifications. Pursuant to 10 CFR Part 50, Appendix A, General Design Criterion (GDC) 10, "Reactor design," the reactor core and associated coolant, control, and protective systems, are required to be designed with an appropriate margin to assure that specified acceptable fuel design limits are not exceeded during any condition of normal operation, including anticipated operational occurrences. To ensure compliance with GDC 10, the NRC staff confirmed that the vendor performed the

departure from nucleate boiling (DNB) analyses using NRC-approved methodologies as described in NUREG-0800, "Standard Review Plan," Section 4.4.

3.0 TECHNICAL EVALUATION

A technical review of Reference 1 was performed to assess the suitability of the database used to develop the BWU-B11R CHF correlation and evaluate the methodology.

3.1 Suitability of the Database

The full 222 point database from five different Mark-B11-CHF tests (from test sections 26.0, 27.1, 28.0, 29.0, and 30.0) performed at the Columbia University Heat Transfer Research Facility was used to develop the BWU-B11R CHF correlation. The bundle condition CHF test data for the Mark-B11 design were reported in Reference 3. This 216 point database reflected the deletion of three outliers and three out-of-range conditions in order to adjust the database to the BWU-Z CHF correlation using the multiplier.

FANP stated in Reference 5 that the full set of 222 data points were re-correlated for the proposed BWU-B11R correlation to see if the entire database of 222 points could be successfully fit. FANP concluded that the final form required the deletion of only one outlier, which is 8.6 standard deviations below the mean ratio of measured-to-predicted (M/P) CHF and is much more than 3.5 standard deviations from the mean M/P CHF ratio of the correlation database. It is common practice in CHF correlation development to exclude data whose M/P CHF ratio deviates more than 3.5 standard deviations from the mean M/P CHF ratio of the correlation database, which implies a probability of approximately 0.1 percent that the data point is actually in the database without error.

The NRC staff has reviewed the subject report (Reference 1) and the responses to the NRC staff RAIs (References 5 and 6), and found that the justification for the database used for the proposed new correlation without a multiplier is acceptable because: 1) an approved methodology (Reference 2) is used, and 2) selecting 3.5 standard deviations from the mean M/P CHF ratio of the correlation database meets a design criterion that 99.9 percent of rods would not experience a DNB, which is a conservative approach.

3.2 Methodology Evaluation

Reference 2 describes the CHF correlation in terms of: uniform heat flux, non-uniform flux shape factor, length-spacing factor, optimized coefficients for the BWU correlation, and the use of CHF equations in reactor design. The same approach is applied to Addendum 3 to TR BAW-10199(P) for the Mark-B11 spacer grid. The only differences in this proposed correlation are elimination of a multiplier, F_{B11}, and development of a stand-alone correlation using the same approach stated in Reference 2 using the database for the Mark-B11 spacer grid only. FANP proposed a pressure-dependent design limit in response to the NRC staff's concerns on the sparse low pressure CHF data. The values of the design limit are given in page A-3 of Reference 6, based on the approved methodology of Reference 2 as a function of a standard deviation from a specific group of data in specific pressure ranges.

The NRC staff has reviewed the methodology and its application, and found that the methodology is acceptable, since the approach was previously approved in References 2 and 3. Based on the results of the NRC staff review, the proposed range of applicability for the design limit DNB ratio (DNBR) in Table I-6 of Addendum 3 to TR BAW-10199(P) was revised as: 1.81 for pressures from 315 to 594 psia, 1.20 for pressures from 595 to 999 psia, and 1.145 for pressures from 1000 to 2425 psia because of higher standard deviation from low pressure CHF data (Reference 6).

4.0 CONCLUSION

The NRC staff has reviewed the subject report (Reference 1) and the responses to the NRC staff RAIs (References 5 and 6) and determined that Addendum 3 to BAW-10199(P) "The BWU Critical Heat Flux Correlations," is acceptable. The NRC staff has concluded that Addendum 3 to TR BAW-10199(P) is acceptable with a range of applicability given below (as stated in References 1 and 6).

Pressure, psia	315 to 2425
Mass Velocity, Mlb/hr-ft^2	0.377 to 3.095
Quality at CHF	less than 0.6025
Spacer Grid	FANP Mark-B11
Design Limit DNBR	1.145 for 1000 psia # P # 2425 psia 1.20 for 595 psia # P # 999 psia 1.81 for 315 psia # P # 594 psia
Analysis Code	LYNXT
Correlation Coefficients	Table I-5 of Addendum 3 to TR BAW-10199(P)

5.0 REFERENCES

1. Letter from James F. Mallay (FANP) (NRC:04:028) to USNRC, Request for Review and Approval of Addendum 3 to BAW-10199(P) "The BWU Critical Heat Flux Correlations," dated August 17, 2004, including enclosures. Agencywide Documents Access and Management System (ADAMS) Accession No. ML042990352.

2. BAW-10199P-A, "The BWU Critical Heat Flux Correlations," August 1996. Legacy Library ADAMS Accession No. 9609040275.

3. BAW-10199P-A, Addendum 1, "The BWU Critical Heat Flux Correlations: Applications of the BWU-Z CHF Correlations [to Mark B11 and Mark BW17 MSM Designs]," December 2000. ADAMS Accession No. ML003777250.

4. BAW-10199P-A, Addendum 2, "Application of the BWU-Z CHF Correlation to the Mark BW17 Fuel Design with Mid-Span-Mixing Grids," September 2002. ADAMS Accession No. ML022560115.

5. Letter from Jerald S. Holm (FANP) (NRC:05:014) to USNRC, Response to Request for Additional Information Regarding Addendum 3 to BAW-10199(P) "The BWU Critical Heat Flux Correlations," March 2, 2005. ADAMS Accession No. ML050670446.

6. Letter from Ronnie L. Gardner (FANP) (NRC:05:054) to USNRC, Response to a Request for Additional Information Regarding Addendum 3 to BAW-10199(P) "The BWU Critical Heat Flux Correlation," August 18, 2005. ADAMS Accession No. ML052340488.

Principal Contributor: T. Huang

Date: November 09, 2005