

September 29, 2005

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

SUBJECT: DRAFT SAFETY EVALUATION FOR ADDENDUM 3 TO TOPICAL REPORT
BAW-10199(P), "THE BWU CRITICAL HEAT FLUX CORRELATIONS" FOR
REVIEW (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 for review. Enclosed for FANP's review and comment is a copy of the NRC staff's draft safety evaluation (SE) for the TR.

Pursuant to Section 2.390 of Title 10 of the *Code of Federal Regulations* (10 CFR), we have determined that the enclosed draft SE does not contain proprietary information. However, we will delay placing the draft SE in the public document room for a period of 10 working days from the date of this letter to provide you with the opportunity to comment on the proprietary aspects. 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 2.390. After 10 working days, the draft SE will be made publicly available, and an additional 10 working days are provided to you to comment on any factual errors or clarity concerns contained in the draft SE. The final SE will be issued after making any necessary changes and will be made publicly available. The NRC staff's disposition of your comments on the draft SE will be discussed in the final SE.

R. Gardner

-2-

To facilitate the NRC staff's review of your comments, please provide a marked-up copy of the draft SE showing proposed changes and provide a summary table of the proposed changes.

If you have any questions, please contact Michelle C. Honcharik at 301-415-1774.

Sincerely,

/RA by D. Collins for/

Robert A. Gramm, Chief, Section 2
Project Directorate IV
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Project No. 728

Enclosure: Draft SE

R. Gardner

-2-

To facilitate the NRC staff's review of your comments, please provide a marked-up copy of the draft SE showing proposed changes and provide a summary table of the proposed changes.

If you have any questions, please contact Michelle C. Honcharik at 301-415-1774.

Sincerely,
/RA by D. Collins for/

Robert A. Gramm, Chief, Section 2
Project Directorate IV
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Project No. 728

Enclosure: Draft SE

DISTRIBUTION:
PUBLIC (No DPC for 10 working days)
PDIV-2 Reading
RidsNrrDlpmLpdiv (HBerkow)
RidsNrrDlpmLpdiv2 (RGramm)
RidsNrrPMMHonchariik
RidsNrrLADJohnson
RidsOgcRp
RidsAcrsAcnwMailCenter
FAkstulewicz
THuang
DMcCain
RidsNrrDlpmLpdiv1 (DTerao)

ADAMS ACCESSION NO.: ML052760140 **NRR-043** ***No substantive changes**

OFFICE	PDIV-1/PM	PDIV-1/LA	SRXB-A/SC*	PDIV-1/SC	PDIV-2/SC	PDIV/D
NAME	MHoncharik	DJohnson	FAkstulewicz	DTerao	DCollins for RGramm	HBerkow
DATE	9/20/05	9/21/05	09/12/05	9/21/05	9/28/05	9/29/05

OFFICIAL RECORD COPY

DRAFT 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 1.0 INTRODUCTION AND BACKGROUND

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

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

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

21 2.0 REGULATORY EVALUATION

22 Section 50.36 of Title 10 of the *Code of Federal Regulations* (10 CFR) requires that safety limits
23 be included in the plant-specific technical specifications (TS). Pursuant to 10 CFR Part 50,
24 Appendix A, General Design Criterion (GDC) 10, "Reactor design," the reactor core and
25 associated coolant, control, and protective systems, are required to be designed with an
26 appropriate margin to assure that specified acceptable fuel design limits are not exceeded
27 during any condition of normal operation, including anticipated operational occurrences. To
28 ensure compliance with GDC 10, the NRC staff confirmed that the vendor performed the
29 departure from nucleate boiling (DNB) analyses using NRC-approved methodologies as
30 described in NUREG-0800, "Standard Review Plan," Section 4.4.

1 3.0 TECHNICAL EVALUATION

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

4 3.1 Suitability of the Database

5 The full 222 point database from five different Mark-B11-CHF tests (from test sections 26.0,
6 27.1, 28.0, 29.0, and 30.0) performed at the Columbia University Heat Transfer Research
7 Facility was used to develop the BWU-B11R CHF correlation. The bundle condition CHF test
8 data for the Mark-B11 design were reported in Reference 3. This 216 point database reflected
9 the deletion of three outliers and three out-of-range conditions in order to adjust the database to
10 the BWU-Z CHF correlation using the multiplier.

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

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

26 3.2 Methodology Evaluation

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

37 The NRC staff has reviewed the methodology and its application, and found that the
38 methodology is acceptable since the approach was previously approved in References 2 and 3.
39 Based on the results of the NRC staff review, the proposed range of applicability for the design
40 limit DNB ratio (DNBR) in Table I-6 of Addendum 3 to TR BAW-10199(P) was revised as: 1.81

1 for pressures from 315 to 594 psia, 1.20 for pressures from 595 to 999 psia, and 1.145 for
2 pressures from 1000 to 2425 psia because of higher standard deviation from low pressure CHF
3 data (Reference 6).

4 4.0 CONCLUSION

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

10	Pressure, psia	315 to 2425
11	Mass Velocity, Mlb/hr-ft ²	0.377 to 3.095
12	Quality at CHF	less than 0.6025
13	Spacer Grid	FANP Mark-B11
14	Design Limit DNBR	1.145 for 1000 psia # P # 2425 psia
15		1.20 for 595 psia # P # 999 psia
16		1.81 for 315 psia # P # 594 psia
17	Analysis Code	LYNXT
18	Correlation Coefficients	Table I-5 of Addendum 3 to TR BAW-10199(P)

19 5.0 REFERENCES

- 20 1. Letter from James F. Mallay (FANP) (NRC:04:028) to USNRC, Request for Review and
21 Approval of Addendum 3 to BAW-10199(P) "The BWU Critical Heat Flux Correlations,"
22 dated August 17, 2004, including enclosures. Agencywide Documents Access and
23 Management System (ADAMS) Accession No. ML042990352.
- 24 2. BAW-10199P-A, "The BWU Critical Heat Flux Correlations," August 1996. Legacy
25 Library ADAMS Accession No. 9609040275.
- 26 3. BAW-10199P-A, Addendum 1, "The BWU Critical Heat Flux Correlations: Applications
27 of the BWU-Z CHF Correlations [to Mark B11 and Mark BW17 MSM Designs],"
28 December 2000. ADAMS Accession No. ML003777250.
- 29 4. BAW-10199P-A, Addendum 2, "Application of the BWU-Z CHF Correlation to the Mark
30 BW17 Fuel Design with Mid-Span-Mixing Grids," September 2002. ADAMS Accession
31 No. ML022560115.
- 32 5. Letter from Jerald S. Holm (FANP) (NRC:05:014) to USNRC, Response to Request for
33 Additional Information Regarding Addendum 3 to BAW-10199(P) "The BWU Critical
34 Heat Flux Correlations," March 2, 2005. ADAMS Accession No. ML050670446.
- 35 6. Letter from Ronnie L. Gardner (FANP) (NRC:05:054) to USNRC, Response to a
36 Request for Additional Information Regarding Addendum 3 to BAW-10199(P) "The
37 BWU Critical Heat Flux Correlation," August 18, 2005. ADAMS Accession No.
38 ML052340488.

39 Principal Contributor: T. Huang

40 Date: September 29, 2005