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June 27, 2005
NRC:05:037

Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Comments on Draft Safety Evaluation for Appendix A to BAW-10241(P), Revision 1, "Extension of the BHTP Correlation Ranges"

Ref. 1: Letter, Robert A. Gramm (NRC) to Jerald S. Holm (FANP), "Draft Safety Evaluation for Framatome ANP (FANP) Appendix A to Topical Report (TR) BAW-10241(P), Revision 1 'Extension of the BHTP CHF [Critical Heat Flux] Correlation Ranges,' for Review (TAC No. MC8374)," June 2, 2005.

The NRC issued a draft safety evaluation on Appendix A to BAW-10241(P), Revision 1, and requested that Framatome ANP review for any factual errors or clarity concerns. Framatome ANP has reviewed the draft SER provided in Reference 1. The SER contains minor errors and clarifications that we recommend correcting. A marked up copy of the pages in the draft SER containing the errors is provided in Attachment A. Attachment B provides a summary table of the clarifications.

Sincerely,

Ronnie L. Gardner

Ronnie L. Gardner, Manager
Site Operation and Regulatory Affairs

Enclosures

cc: M. C. Honcharik
Project 728

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Attachment A

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

DRAFT SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

APPENDIX A TO BAW-10241(P), REVISION 1,

"EXTENSION OF THE BHTP CORRELATION RANGES"

FRAMATOME ANP

PROJECT NO. 728

1.0 INTRODUCTION

By letter dated March 11, 2005 (Reference 1), Framatome ANP (FANP) submitted Appendix A to Topical Report (TR) BAW-10241(P) (Reference 2), "Extension of the BHTP CHF [critical heat flux] Correlation Ranges." This submittal proposes the extension of the range of applicability of the independent variables in the BHTP CHF correlation. The extended range of applicability of the correlation is required because the currently approved ranges will be exceeded in future plant-specific analyses.

2.0 REGULATORY EVALUATION

The primary purpose of the nuclear fuel in operating nuclear reactors is to generate heat. This heat, generated from nuclear fission, must be transferred from the fuel pellet to the surrounding cladding and coolant. In order to maintain safe operation of pressurized light water reactors, the subcooled flow boiling that occurs must be maintained in the nucleate boiling regime. The point at which the boiling regime changes from nucleate boiling to film boiling is defined as the departure from nucleate boiling (DNB). The heat flux at this point is called the CHF. In the film boiling regime, the rate of heat transfer from the fuel cladding is dramatically reduced, resulting in a rapid increase in cladding temperature that can compromise cladding integrity.

In a reactor core, many parameters have an effect on the actual point at which DNB or CHF occurs. Core flow rate, coolant pressure, and thermodynamic quality can all cause changes in the CHF value. Because of this complexity, no mechanistic model presently exists that fully describes the physical phenomena, making it impossible to predict the CHF with 100 percent accuracy. To obtain a reasonable prediction, the relationships between the relevant independent variables and actual experimental CHF observations have been correlated. The range of applicability of the independent variables in these correlations is based solely on the range over which the actual experimental CHF observations were recorded.

General Design Criterion (GDC) 10 of Appendix A to Part 50 of Title 10 of the *Code of Federal Regulations* states that "the reactor core ... shall be designed with appropriate margin to assure that specified acceptable fuel design limits are not exceeded during any condition of normal operation, including the effects of anticipated operational occurrences [AOO]."

NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants," (SRP) Section 4.2, "Fuel System Design" and Section 4.4, "Thermal and Hydraulic Design," give the criteria and practices found acceptable by the Nuclear Regulatory Commission (NRC) staff for meeting GDC 10.

In terms of the specific evaluation of Reference 2, as stated in SRP sections 4.2 and 4.4, the NRC staff finds that the CHF correlations should be developed such that there is a 95 percent probability at the 95 percent confidence level that the hot rod in the core does not experience DNB during normal operation or AOOs.

3.0 TECHNICAL EVALUATION

The BHTP CHF correlation is based on a set of data points from multiple CHF tests conducted at the Columbia Heat Transfer Facility. In addition to these data, additional data points were also obtained in some of the tests, but were not utilized in establishing the correlation. These "new" data were filtered to ensure that they adequately represented the full range of fuel design parameters. What resulted was a new data base consisting of data points indicating measured CHF values for local conditions of 1400 psia and ranging over the proposed upper quality and lower mass velocity regions.

In this TR, FANP desires extensions of the lower limit of pressure, the upper and lower limits of thermodynamic quality, and the lower limit for mass velocity. The vendor used three approaches to justify extending the range of applicability of these independent variables in the BHTP CHF correlation. First, the existing correlation is applied only to an expanded data set and shown to be conservative over the expanded range of data. Second, the conservatism of extrapolating beyond the data base is shown. This second approach is applied to extrapolations to low quality values. Third, a technique to calculate conservative CHF values when outside the range of data is described. This third approach is used when pressure higher than the upper pressure limit is encountered.

INSERT A ~~BAW-10156-A, Revision 1, "LYNXT Core Transient Thermal-Hydraulic Program," (Reference 3) provided the original data. The original data of Reference 3 and the new data are plotted against thermodynamic quality by FANP to justify extending the limits of upper quality, lower pressure, and lower mass velocity.~~ The new data are shown to be generally conservative with respect to the original data. The predicted CHF to measured CHF (P/M) ratios were plotted over the respective ranges of each of the independent variables. These plots showed no biasing trends and an average P/M ratio less than 1.0, implying predictive conservatism in the extended regions. The NRC staff used the tables and graphs provided by FANP in Reference 2 to independently confirm these results and found that they were acceptable. Therefore, the NRC staff concludes that the new data at 1400 psia provide sufficient verification that the BHTP CHF correlation can adequately predict CHF in the proposed extended regions of upper quality, lower pressure, and lower mass velocity.

FANP examined the extension of the BHTP CHF correlation to verify that it is conservative for each approved assembly geometry. The examination was performed for each test section, since each test section represents a single geometry. The comparison indicates that in no case does the differing geometry produce a non-conservative trend when the BHTP correlation is applied to the extended data. Therefore, FANP concluded that the entire set of extended data

INSERT A

THE BHTP CHF CORRELATION IS APPLIED USING THE LYNXT CODE (REFERENCE 3). THE ORIGINAL CHF DATA OF REFERENCE 3 AND THE NEW DATA ARE PLOTTED AGAINST THERMODYNAMIC QUALITY BY FANP TO JUSTIFY EXTENDING THE LIMITS OF UPPER QUALITY, LOWER PRESSURE, AND LOWER MASS VELOCITY.

can be used to conservatively extend the range of independent variables of the BHTP CHF correlation. The NRC staff reviewed data provided by FANP in Reference 2 to independently confirm this conclusion and has found that it is acceptable.

4.0 CONCLUSION

In References 1 and 2, FANP requested to extend the range of applicability of the independent variables of the BHTP CHF correlation (i.e. the lower limit of pressure, the upper and lower limits of thermodynamic quality, and the lower limit of mass velocity). The NRC staff has reviewed and confirmed the data provided in Reference 2 by FANP. Based on the NRC staff's independent analysis detailed in Section 3.0 of this safety evaluation (SE), the NRC staff finds FANP's extensions of the range of applicability of the independent variables acceptable, within the limits and conditions provided in Section 4.0 of this SE.

5.0 CONDITIONS AND LIMITATIONS

The NRC staff has reviewed Reference 2 and assessed the acceptability of the justifications therein for extending the range of applicability of the BHTP CHF Correlation Ranges. The NRC staff concludes as follows:

(1) Based on the comparisons with the additional data, the quantitative statistical assurances continue to be met by the correlation in the regions of lower pressure, higher quality, and lower mass velocity. Therefore, the independent variables of the BHTP CHF Correlation can be extended as depicted in Table 1.

Table 1

Range of Independent Variables for the BHTP CHF Correlation with the Extension of the Upper Quality, Lower Mass Velocity, and Lower Pressure Limits

Independent Variable	As Approved		Extended	
	Minimum Value	Maximum Value	Minimum Value	Maximum Value
System Pressure, psia	1775	2425	*1385*	2425
Mass Velocity, $Mlb/hr\text{-}ft^2$	0.897	3.549	*0.492*	3.549
Thermodynamic Quality	-0.130	0.344	-	*0.512*

(2) Actions for analyzing the operating conditions outside of the approved ranges of the maximum pressure (2425 psia) but less than 2600 psia are stated below.

- When pressures greater than the pressure limit of 2425 psia but less than 2600 psia are encountered, all of the local coolant conditions are calculated at the upper pressure limit of 2425 psia using the NRC-approved LYNXT thermal-hydraulic code and then used in the calculation of the BHTP CHF.

- Extrapolations below the minimum quality range are performed with no lower limit, consistent with EMF-92-153(P)(A) Revision 1, "HTP: Departure from Nucleate Boiling Correlation for High Thermal Performance Fuel" (Reference 4).

These methods were put forth in Reference 4. Any other extrapolation requires a plant-specific review.

5.0 REFERENCES

1. Letter from J.S. Holm, FANP, to NRC, "Request for Approval of Appendix A to BAW-10241 (P), Revision 1, 'Extension of the BHTP CHF Correlation Ranges'," March 11, 2005 (Non-Proprietary version) (Agencywide Documents Access Management System Accession No. ML050750124).

2. Appendix A to TR BAW-10241(P), "Extension of the BHTP CHF Correlation Ranges," FANP, March 2005.

3. BAW-10156-A, Revision 1, "LYNXT Core Transient Thermal Hydraulic Program," FANP, August 1993.

4. EMF-92-153(P)(A), Revision 1, "HTP: Departure from Nucleate Boiling Correlation for High Thermal Performance Fuel," FANP, January 2005.

5. BAW-10241(P)(A), "BHTP DNB CORRELATION APPLIED WITH LYNXT," SEPTEMBER 2004.

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Date: June 2, 2005

Attachment B

SUMMARY TABLE OF PROPOSED CHANGES

PAGE NO.	LINE(S) NO.	PROPOSED CHANGE AND REASON
2	26 – 29	Omit the first two sentences and replace with Insert A. Framatome ANP requests the text be changed to properly link the original CHF data to Reference 5 and the correlation application code to Reference 3. In Reference 5, the CHF data are provided with the thermodynamic quality computed using the LYNXT code for the BHTP correlation. The original HTP CHF bundle data can be traced to Reference 4, however, the thermodynamic quality values for the BHTP correlation data base initially appear in Reference 5.
4	6	Change "5.0" to "6.0" for editorial accuracy.
4	17	Add Reference 5. This reference can be used to support the existing text acknowledgement of the original data that are plotted in Appendix A and discussed above.