FRAMATOME ANP

An AREVA and Siemens company

FRAMATOME ANP, Inc.

September 3, 2003
NRC:03:054

Document Control Desk
ATTN: Chief, Planning, Program and Management Support Branch
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Request for Additional Information - BAW-10241(P) Revision 0, "BHTP DNB Correlation Applied with LYNXT"

Ref.: 1. Letter, James F. Mallay (Framatome ANP) to Document Control Desk (NRC), "Issuance of BAW-10241P, 'BHTP DNB Correlation Applied with LYNXT,' for Review and Acceptance," NRC:02:065, December 19, 2002.

Ref.: 2. Letter, James F. Mallay (Framatome ANP) to Document Control Desk (NRC), "Request for Additional Information - BAW-10241(P) Revision 0, 'BHTP DNB Correlation Applied with LYNXT'," NRC:03:035, June 6, 2003.

In Reference 1, Framatome ANP submitted the report BAW-10241(P) for review and approval. In Reference 2, Framatome ANP provided responses to an initial set of questions. Additional questions were discussed in a telephone call with the NRC on August 27, 2003. A set of responses to these questions is provided in Attachment A to this letter. Proprietary and non-proprietary versions of the attachment are provided.

Framatome ANP considers some of the information contained in the attachments to this letter to be proprietary. The affidavit provided with the original submittal of the reference report (Reference 2) satisfies the requirements of 10 CFR 2.790(b) to support the withholding of this information from public disclosure.

Very truly yours,

Gerald J Holm for

James F. Mallay, Director
Regulatory Affairs

Enclosures

cc: D. G. Holland
Project 728

T007

Response to RAI on BAW-10241(P) "BHTP DNB Correlation Applied with LYNXT"

Question 1: *Please provide the following information:*

1) *the LYNXT-predicted local conditions for the 1481 CHF test statepoints,*
2) *a short description of the BHTP correlation optimization process,*
3) *the reference for the correlation coefficient optimization process, and*
4) *a statement that the process and results are documented in an auditable calculational analysis.*

Response 1: For each set of Mark-B-HTP spacer grid bundle test data, the LYNXT code was used to predict the local thermal-hydraulic conditions (mass velocity, thermodynamic quality, heat flux, and pressure) axially along the test section heated length. The predicted local conditions at the point of detected burnout are provided in Table 1. Note that these predicted local conditions using the LYNXT code differ only slightly from the predicted local conditions contained in Table 3.8 of Reference 1 for the development of the HTP CHF correlation using the XCOBRA-IIIC code. The maximum and minimum values from Table 1 were used to establish the BHTP correlation range of applicability shown in Table 1.1 of Reference 2.

The local conditions data from each CHF test statepoint form the data base for the BHTP CHF correlation. These data (mass velocity, thermodynamic quality, heat flux, pressure, local thermodynamic quality and axial location) were used to determine the coefficients of the BHTP CHF correlation. The method used for coefficient determination is a least squares fit that minimizes the deviation of the predicted CHF to the measured CHF ratio (P/M) around a mean of 1.0.

If the correlation (equation) is linear, any fitting technique is suitable. If it is multi-part or highly non-linear, more sophisticated techniques must be used. The Linearization and Sequential Optimization technique (Reference 3) was specifically developed for use with the optimization of multi-part non-linear correlations such as the BWCMV (Reference 4), the BWU (Reference 5), and BHTP (Reference 2) CHF correlations. In Reference 3, the example of the BWCMV correlation optimization is shown, however, the technique was subsequently adapted to the BWU and BHTP correlation forms.

All of the BHTP coefficients were re-optimized with the exception of those in the FDF (Fuel Design Factor) term that includes coefficients b_7 through b_{14}. The BHTP correlation optimization is documented in a Framatome ANP calculational file and is available for NRC review.

Question 2: *Please provide the basis of the 405 statepoints acknowledged in the Response to Question 3 in the previous RAI for BAW-10241.*

Response 2: To compare the thermal-hydraulic performance for the Mark-B-HTP spacer grid relative to the Mark-B spacer grid (in the response to question 3 of the RAI for BAW-10241P, Reference 6), Framatome ANP provided a DNBR comparison of a core using the BHTP CHF correlation (for a Mark-B-HTP spacer grid) to the BWC CHF correlation (for a Mark-B grid). Since a thorough comparison of the performance of the two spacer grid designs would involve DNBR predictions extending from approximately the correlation design limits to much higher DNBR predictions, Framatome ANP selected a broad set of operating statepoint conditions.

Framatome ANP had developed a set of 405 such statepoints that were used in establishing a statistical design limit (SDL) using statistical core design (SCD) methodology. Each statepoint was defined by the core power (Q), the core flow (W), the core inlet temperature (T), the core outlet pressure (P), and the radial (R) and axial heat (A, Z) output distribution of each of the fuel assemblies in the core. The ranges of these independent variables are shown below for a 177 fuel assembly core. These values are not CHF test data but are potential conditions that an operating core could encounter during operation.

Variable	Minimum Value	Nominal Value	Maximum Value
Q – Power	50	95	140
W – Flow	65	95	125
P – Pressure	1800	2200	2600
T - Temperature	40	75	110
R – Radial Peak	1.1	1.5	1.9
A – Axial Peak	1.1	1.5	1.9
Z – Axial Location	0.2	0.5	0.8

Q = Percent of Nominal Core Power
W = Percent of Nominal RCS Flow
P = Core Exit Pressure, psia
T = Inlet Temperature Subcooling, F
R = Normalized Maximum Radial Pin Peaking Factor
A = Normalized Maximum Axial Pin Peaking Factor
Z = Normalized Location of A

The fact that the figure in the response to question 3 in Reference 6 shows that they are strongly correlated (that is when the BWC MDNBR for that statepoint increases the BHTP MDNBR for that statepoint increases and vice versa) indicates that each correlation is performing without bias with respect to the absolute MDNBR level. The 405 statepoints are documented in a calculational file available for NRC review.

References

1. EMF-92-153(P)(A), *HTP: Departure From Nucleate Boiling Correlation For High Thermal Performance Fuel*, March 1994.

2. BAW-10241P, *BHTP DNB Correlation Applied With LYNXT*, December 2002.

3. D. A. Farnsworth, "Linearization and Sequential Optimization of Nonlinear Empirical Correlations," *Advances in Mathematics, Computations, and Reactor Physics*, Vol. 2, International Topical Meeting, 1991.

4. BAW-10159P-A, *BWCMV, Correlation of Critical Heat Flux in Mixing Vane Grid Fuel Assemblies*, July 1990.

5. BAW-10199P-A, *The BWU Critical Heat Flux Correlations*, August 1996.

6. Letter, James F. Mallay (Framatome ANP) to Document Control Desk (NRC), "Request for Additional Information - BAW-10241(P) Revision 0, 'BHTP DNB Correlation Applied with LYNXT'," NRC:03:035, June 6, 2003.

Table 1
Summary of Results for BHTP Database in BAW-10241P

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Table 1
Summary of Results for BHTP Database in BAW-10241P

Test	Run No.	Local Quality	Local Mass Flux [Mlb/h/ft2]	Exit Pressure [psia]	Inlet Enthalpy [Btu/lb]	Measured Heat Flux [Mbtu/h-ft2]	Calculated Heat Flux [Mbtu/h-ft2]	P/M Ratio	Predicted Elevation [in]	Faxial
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Test	Run No.	Local Quality	Local Mass Flux [Mlb/h/ft2]	Exit Pressure [psia]	Inlet Enthalpy [Btu/lb]	Measured Heat Flux [Mbtu/h-ft2]	Calculated Heat Flux [Mbtu/h-ft2]	P/M Ratio	Predicted Elevation [in]	Faxial
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Test	Run No.	Local Quality	Local Mass Flux [Mlb/h/ft2]	Exit Pressure [psia]	Inlet Enthalpy [Btu/lb]	Measured Heat Flux [Mbtu/h-ft2]	Calculated Heat Flux [Mbtu/h-ft2]	P/M Ratio	Predicted Elevation [in]	Faxial
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