FRAMATOME ANP

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FRAMATOME ANP, Inc.

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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. Fax, Brian Benney for Drew Holland (NRC) to Jerry Holm (Framatome ANP), "Request for Additional Information Relating to Review of Framatome ANP Licensing Topical Report BAW-10241P, 'BHTP DNB Correlation Applied with LYNXT,' " April 25, 2003.

Ref.: 2. 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.

In Reference 1, The NRC requested additional information to facilitate the completion of its review of the Framatome ANP topical report BAW-10241(P). Responses to this request are provided in two attachments--one proprietary and one non-proprietary.

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 S Holm for

James F. Mallay, Director
Regulatory Affairs

Enclosures

cc: D. G. Holland
Project 728

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

Question 1: *Provide a detailed sketch to show the definition of DHYD, FDF, FPBZ, LEN, SP, and WPR. Also, provide a CD to cover all approved methodologies used to support this licensing topical report including EMF-92-153(P), HTP, Addendum 1 and pp. 599-601 of Annals of Mathematical Statistics, Vol. 29, No. 2, June 1958.*

Response 1: The definitions of these parameters are provided in Section 2 of the topical report. [

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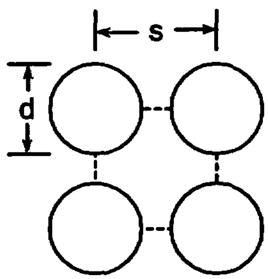
[redacted]

Example: 4 Heated Rods



Heated Rod Diameter: d

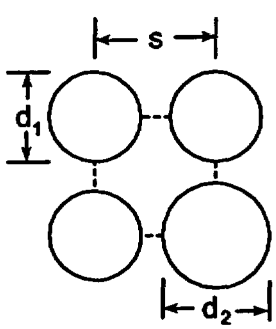
Lattice Pitch: s

Flow Area: $A = s^2 - \frac{\pi}{4} d^2$

Wetted Perimeter: $P_w = \pi d$

Heated Perimeter: $P_h = \pi d$

Example: 3 Heated Rods and 1 Guide Tube



Heated rod diameter: d_1

Guide tube diameter: d_2

Flow Area: $A = s^2 - \frac{\pi}{16}\left(3d_1^2 + d_2^2\right)$

Wetted Perimeter: $P_w = \frac{\pi}{4}\left(3d_1 + d_2\right)$

Heated Perimeter: $P_h = \frac{3\pi}{4} d_1$

Figure 1 Examples Showing Definition for DHYD and WPR

Figure 2 Illustration of Definitions for LEN and SP

Figure 3 Definition of FPBZ

Question 2: *Provide rational for submitting this topical report, which is similar to EMF-92-153(P)(A) Supplement 1, HTP: Departure from Nucleate Boiling Correlation for High Thermal Performance Fuel and identify the difference between these two topical reports.*

Response 2: The topical report BAW-10241P was submitted to obtain NRC approval for the BHTP correlation as implemented in the LYNXT code. The topical report EMF-92-153(P)(A) and Supplement 1 was submitted and received NRC approval for the use of the HTP correlation in the XCOBRA-IIIC code. [

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Question 3: *Describe the difference between the HTP grid for Mark-B/HTP fuel design and the Mark-B grid on Mark-B10 fuel design and provide the testing data to show any improvement of the thermal-hydraulic performance for the HTP grid relative to the Mark-B grid.*

Response 3: The primary difference between the mechanical designs for the earlier Mark-B grid design and the HTP grid on the Mark-B/HTP fuel design is the fuel rod mechanical contact region. The Mark-B grid, typically identified as a Mark-B10 grid to acknowledge the use of Zircaloy-4 strip material, utilizes a combination of hard stops and spring stops to hold the fuel rod within the grid as seen in Figure 4. The Mark-B10 grid design is a standard non-mixing vaned spacer.

Figure 4 Top View of Section of Mark-B10 Spacer Grid

The HTP grid used on the Mark-B/HTP fuel assembly design utilizes flow channels to retain the fuel rod within the grid as seen in Figure 5.

Figure 5 Top View of Section of HTP Spacer Grid

The thermal-hydraulic performance of the Mark-B10 spacer grid is given by the BWC CHF correlation. The BWC correlation is documented in BAW-10143P-A[1] and is based on seven separate CHF tests (601 data).

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1 BAW-10143P-A, "BWC Correlation of Critical Heat Flux," Babcock & Wilcox, Lynchburg, Virginia, April 1985.

Figure 6 Comparison between BHTP and BWC DNB Performance

Question 4: *Describe schematically the fuel rod failures that occurred in the core baffle of B&W 177-FA plants and physically identify the cause and the corrective action based on any plant data relative to the proposed methodology.*

Response 4: The fuel rod failures have occurred in assemblies on the periphery of the core next to the core baffle at baffle penetrations (LOCA holes and baffle slots). The LOCA holes are present to enhance flow to the core during a LOCA. The baffle slots provide a mechanical benefit during the LOCA event. These baffle penetrations allow cross flow between the region behind the core baffle and the core which can cause vibration in the fuel rod. The vibration of the fuel rods has led to a small number of fuel failures, no more than 0 to 2 rods per cycle (a total of 12 spacer grid fretting failures have occurred in B&W 177 plants for fuel utilizing zircaloy spacer grids which were introduced in 1984). The location of the assemblies which typically may have fuel failures is shown in Figure 7. The fuel rod failures occur on the periphery of the assembly adjacent to the baffle penetrations.

Figure 7 Fuel Assembly Locations Where Fuel Rods Have Failed Due to Flow-Induced Vibration

The fuel rod failures provide the motivation for using the Mark-B/HTP fuel design in a B&W plant. No fuel rod failures due to fretting have ever occurred at an HTP spacer location since the introduction of the HTP fuel assembly design.

Question 5: *Justify the need to use LYNXT code for the proposed licensing topical report relative to XCOBRA-IIIC code. Please identify the differences in relation to the data bases to support the code development and verification, assumptions, ranges of the application, and expected results of the analysis under same conditions between the proposed licensing topical reports using LYNXT code and the HTP DNB correlation using XCOBRA-IIIC and describe in details the reason causing the differences, if any.*

Response 5: The LYNXT code is part of the approved BAW-10179P-A methodology. Two basic approaches exist to use the HTP DNB correlation for analyses in conjunction with BAW-10179P-A. The first is to incorporate the XCOBRA-IIIC code and HTP DNB correlation into the BAW-10179P-A methodology. This approach requires changes to XCOBRA-IIIC to interface with the remainder of the methods in BAW-10179P-A. The second approach is to implement the BHTP DNB correlation into the LYNXT code. Framatome ANP chose to pursue the second approach in order to maintain consistency with the methods in BAW-10179P-A.

The XCOBRA-IIIC code is described in XN-NF-75-21(P)(A) and the LYNXT code is described in BAW-10156-A Rev. 1. The codes are similar since they were both derived from the COBRA series of codes.

The database used to verify that the codes can predict the critical heat flux of the HTP fuel assembly design is the same. To provide an indication of the performance difference between the BHTP correlation/LYNXT code package and the HTP correlation/XCOBRA-IIIC code package, the four lowest MDNBR points from the statistical core design analysis shown in Figure 6 are chosen for comparison. The MDNBR, pressure, mass flux, and quality for these four points are shown under "Statistical Core Design" in Table 1. The closest match to the geometry used for the statistical core design is HTP Test 49. The key geometrical differences are shown in Table 2. The four closest statepoints from Test 49, by pressure, mass flux, and quality, are provided in Table 1 to compare the relative performance of the codes. [

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Table 1 Comparison of Critical Heat Flux between BHTP/LYNXT and HTP/XCOBRA-IIIC

Table 2 Comparison of Geometry between First Application of Mark-B/HTP and HTP Test 49

Question 6: *It appears that the entire data bases used for EMF-92-153(P)(A) are the same one obtained from [ ] experimental test programs performed at the Columbia University, which are also used for the proposed BHTP topical report. Please demonstrate the applicability of these data bases to BHTP with respect to any or no minor fuel design changes. Also, describe the axial power shapes used in the tests if available and their direct impact on the development of the BHTP DNB correlation relative to the correction factor used for non-uniform power shape conditions, and any plan for the future testing to verify the accuracy and conservatism of the BHTP DNB correlation with respect to with and without any fuel design changes.*

Response 6: The HTP spacer design has not been changed in a functional sense since the original database was developed. Thus, no new DNB tests have been performed. The range of design characteristic to which the HTP DNB correlation is applicable was defined in the SER for EMF-92-153(P)(A) and Supplement 1 (Table 2 in the SER) and is repeated in BAW-10241P.

The motivation for submitting the topical report BAW-10241P at this time is to support an initial plant specific application at a B&W plant. The values of the fuel design parameters for the first expected use of the topical report BAW-10241P are: fuel rod diameter =.430 inches, fuel rod pitch = .568 inches, axial spacer span = 19.34 inches, hydraulic diameter = .525 inches, heated length = 143 inches. These parameter values are within the range specified in Table 2 of the SER for EMF-92-153(P)(A) and Supplement 1 and in Table 1.2 of BAW-10241P. It is anticipated that the BHTP correlation will be applied to any fuel assembly design using the HTP spacer grid with fuel design parameters that falls within the specifications shown on page 1-3 of BAW-10241P.

The axial power shapes used in the test are described in EMF-92-153(P)(A) and Supplement 1 (Table 3.4 on page 34). The axial correction factor is the same for the correlation as implemented in LYNXT and XCOBRA-IIIC. The statistical evaluation of the correlation presented in BAW-10241P includes the effect of the axial shapes as represented in the DNB tests.

There are no current plans for further testing of the HTP spacer as currently configured.

Question 7: *It appears that the 13% band does not bound data shown in Figures 3.10 (Test 52), 3.12 (Test 56), 3.19 (Test 68) and 3.20 (Test 69). Please provide the bases: (1) to conclude that the ideal versus fitted lines is within a 13% band including the origin of the 13% limit lines; and (2) to justify the conservative nature of the fit and its significant impact on the correlation safety limit.*

Response 7: [

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Question 8: *Provide: (1) plant specific application of the proposed BHTP submittal with respect to the safe reactor operation; (2) the interrelation of the final 95/95 safety limit for the BHTP correlation with the other reactor operating parameters as far as an input to the core monitoring system or equivalent monitoring system in the control room for operator actions; and (3) description of the actions to be taken if the plant operating outside the approved ranges stated in Tables 1.1 and 1.2.*

Response 8: The BHTP correlation, as defined in BAW-10241P, will be used in conjunction with the methodology and safety criteria described in BAW-10179P-A, "Safety Criteria and Methodology for Acceptable Cycle Reload Analyses" to support plant Technical Specification limits which are based on DNBR analyses. A separate submittal has been made to incorporate BAW-10241P into BAW-10179P once BAW-10241P has been approved.

The steady-state and transient DNB analyses are still in progress for the first batch implementation of the Mark-B/HTP fuel design at a B&W plant. However, the process used to demonstrate safe reactor operation is consistent with BAW-10179P-A and discussed below.

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The DNB analyses are being performed in accordance with the statistical core design methodology defined in BAW-10187P-A. A Thermal Design Limit (TDL) has been set well above the Statistical Design Limit (SDL) to provide DNB margin to offset the DNB transition core penalty for the Mark-B/HTP fuel design with adequate remaining DNB margin to offset other cycle-specific needs. The flexibility to accommodate cycle-specific needs using the margin afforded with the TDL is discussed in Section 5 of BAW-10187P-A.

The DNB-based safety limit for the first plant to use the Mark-B/HTP fuel design will conservatively represent the allowable pressure-temperature conditions for the transition core situations (Mark-B10 fuel with Mark-B/HTP fuel), as well as the full core situation (all Mark-B/HTP fuel). The limiting DNB transients for Condition I/II events will be shown to have acceptable DNB performance or DNB predictions greater than the TDL. The DNB performance of the limiting DNB Condition III event will be used to demonstrate acceptable radiological consequences for the small permissible fraction of fuel failure.

Operational and safety limits are being set for core power level, axial power imbalance, control rod insertion, and maximum rod relative power ($F_{\Delta H}$) to preserve acceptable DNB performance based on the BHTP correlation predictions. In addition, a variable low pressure trip function provides protection to assure the plant does not reach or exceed the DNB-based safety limit of the Technical Specifications. The above operational and safety limits govern the core operational flexibility available to the plant operators.

The DNB-based operational and safety limits established for the plant provide hot pin/hot subchannel protection for acceptable plant operation based on the local coolant conditions satisfying the correlation range of applicability defined in Table 1.1 of BAW-10241P. In establishing these limits, conservative actions have been used for the treatment of low quality and high pressure when local coolant conditions fall outside of the application ranges for the limiting hot rod/hot subchannel. These actions are consistent with those defined for the HTP correlation in EMF-92-153(P), Addendum 1. However, there are less limiting situations when plant operation can occur outside the correlation range of applicability (Table 1.1) at conditions that are substantially less severe than the conditions used in establishing the safety and operational limits. For example, the lower limit of the local coolant quality for BHTP, -0.130, can be exceeded when fuel rods are operating at reduced power levels and/or lower coolant temperatures are encountered. These situations cannot be limiting with respect to the DNBR criterion and thus the issue of the correlation range of applicability is not pertinent (and thus does not need to be addressed).

The BHTP correlation range of applicability, stated in Table 1.1 of BAW-10241P, for local coolant conditions, is used in establishing the DNB-based limits associated with the above described operational and safety limits. For example, the plant will trip before reaching the minimum or maximum local coolant pressure values in Table 1.1. The DNB-based safety limit and the allowable maximum rod relative power ($F\Delta H$) limits (commonly referred to as Maximum Allowable Peaking limits) used to set the axial power imbalance and control rod insertion limits are all based on the BHTP correlation performance predictions for the limiting hot rod/hot subchannel within the application ranges defined in Table 1.1 using the conservative actions from EMF-92-153(P) Addendum 1 where appropriate.

The BHTP correlation range of applicability, stated in Table 1.2 of BAW-10241P, for fuel design parameters is verified prior to performing any DNB analyses using the BHTP correlation. It is a fundamental requirement that the fuel design parameter ranges for the CHF correlation database must be representative of the fuel design for which the correlation is applied. Once it is concluded the BHTP correlation is applicable to the fuel design relative to the fuel design parameters in Table 1.2, no further verification is necessary.

Question 9: *Compare the performance of the BHTP correlation against that of the ANFP correlation and demonstrate that the predictions by the use of the BHTP correlation are as or more conservative than those obtained with the ANFP correlation over the range of applicability of ANFP.*

Response 9: The ANFP correlation is no longer used in the United States. The HTP correlation in EMF-92-153(P)(A) and Supplement 1 is the base for the BHTP DNB correlation as implemented in BAW-10241P. A comparison of the results from the HTP correlation as implemented in XCOBRA-IIIC (EMF-92-153(P)(A) and Supplement 1) and the BHTP correlation as implemented in LYNXT (BAW-10241P) is provided in the response to Question 5.