November 7, 2003

Mr. James F. Mallay, Director
Regulatory Affairs
Framatome ANP
3315 Old Forest Road
P.O. Box 10935
Lynchburg, Virginia 24506-0935

SUBJECT: ISSUANCE OF REVISED SAFETY EVALUATION FOR REFERENCING OF APPENDICES H AND I TO BAW-10166-P-A, "BEACH – BEST ESTIMATE ANALYSIS CORE HEAT TRANSFER, A COMPUTER PROGRAM FOR REFLOOD HEAT TRANSFER DURING LOCA" (TAC NO. MC0341)

Dear Mr. Mallay:

In a letter dated July 11, 2003, the NRC staff issued its safety evaluation (SE) for acceptance for referencing Appendices H and I to BAW-10166-P-A. In a letter dated August 8, 2003, Framatome ANP expressed concerns relating to the staff's SE associated with the issues of downcomer boiling and carrying out analyses to quench. The enclosed SE revises the text associated with the issues of downcomer boiling and carrying out analyses to quench. The revised discussion more clearly indicates that these issues are beyond the scope of the BEACH review, but pertain to the overall loss-of-coolant accident (LOCA) methodology, of which the BEACH code is a component. Therefore, these issues will be considered as issues within the context of the overall LOCA methodology. The staff is not reissuing the Technical Evaluation Report (TER) prepared by our contractor, Information Systems Laboratories, that was attached to the SE issued with our July 11, 2003, letter since there were no changes made to the TER. Please replace the SE issued with our July 11, 2003, letter with the enclosed SE and include this letter as part of the accepted version of the topical report.

Pursuant to 10 CFR 2.790, we have determined that the enclosed SE does not contain proprietary information. However, we will delay placing the SE in the public document room for a period of ten working days from the date of this letter to provide you with the opportunity to comment on the proprietary aspects only. 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 2.790.

Sincerely,

/RA by S. Dembek for/

Herbert N. Berkow, Director
Project Directorate IV
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Project No. 728

Enclosure: Safety Evaluation

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*For previous concurrences
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REVISED SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

APPENDICES H, "BEACH CODE BENCHMARK AT HIGHER INITIAL CLADDING TEMPERATURES" AND I, "REVISED FLOODING RATE BOUNDS"

TO BAW-10166-P-A, "BEACH – BEST ESTIMATE ANALYSIS CORE HEAT TRANSFER, A COMPUTER PROGRAM FOR REFLOOD HEAT TRANSFER DURING LOCA"

FRAMATOME ANP

PROJECT NO. 728

1.0 INTRODUCTION

BEACH is a Framatome ANP computer code which calculates core heat transfer during the reflood phase of a loss-of-coolant accident (LOCA) transient. It is a constituent of the Framatome ANP approved 10 CFR Part 50, Appendix K LOCA analysis methodology. By letter dated December 10, 2001, Framatome ANP requested NRC review and approval of Appendices H and I to the Framatome ANP BEACH program described in Topical Report BAW-10166-P-A. Appendix H provides justification for a higher initial cladding temperature at the start of reflood and Appendix I provides justification for a lower instantaneous flooding rate during reflood.

2.0 REGULATORY EVALUATION AND BACKGROUND

BEACH is an approved model consistent with Section 50.46(a)(i) of Title 10 of the Code of Federal Regulations (10 CFR). Framatome ANP has proposed Appendices H and I to BEACH, so that it can apply its large break (LB) LOCA methodology to plants whose calculated characteristic response to a licensing basis LBLOCA can include lower reflood rates and/or higher initial cladding temperatures at the start of reflood than previously approved for application of the Framatome ANP LBLOCA methodology.

In its review, the staff with the assistance of its contractor, Information Systems Laboratories, Inc. (ISL), considered test data consistency to which Framatome ANP referred, regulatory precedent, and ongoing generic technical issues in drawing its conclusions.

3.0 TECHNICAL EVALUATION

3.1 Appendix H Maximum Initial Cladding Temperature at the Start of Reflood

Since 1990, the BEACH code has been limited in its application of maximum initial cladding temperature to a range of 950 to 1640°F. This limitation was based upon the range of maximum initial cladding temperatures for the tests to which Framatome ANP (then

Babcock & Wilcox [B&W]) had benchmarked BEACH in 1990. BEACH Appendix H proposes to extend the upper limit from 1640 to 2045°F. Appendix H supports this with comparisons to FLECHT Test 34420, in which BEACH predictions compared well with or bounded FLECHT results for several key parameters at temperatures up to 2045°F. Based on this successful comparison to applicable test data, the staff finds the proposed raising of the maximum initial cladding temperature limit for BEACH applicability acceptable. This is discussed in Section 2.3 of the attached ISL Technical Evaluation Report (TER).

3.2 Lower Instantaneous Flooding Rate During Reflood

Since 1990, the BEACH code has been approved for application in post-LOCA situations with reflood rates between 0.5 and 10 inches per second. BAW-10166-P-A, Appendix I proposes to lower the minimum reflood rate applicability limit from 0.5 inches per second to 0.3 inches per second, based on an extrapolation of FLECHT data. The review of this proposal involved several related issues, which are discussed in Sections 3.2.1 through 3.2.2 of this safety evaluation (SE) and Section 2.0 of the TER.

3.2.1 Reflood Rates Equal to or Greater than 0.4 Inches per Second

Framatome ANP provided comparisons of BEACH-calculated results to FLECHT and FLECHT-SEASET test data to demonstrate that BEACH applies to reflood rates lower than the existing 0.5 inches per second limit. Most of the test data were for reflood rates of 0.4 inches per second. BEACH conservatively overpredicted the data for all but two of these tests. The two exceptions were for tests with data found by Framatome ANP and ISL to be questionable due to bundle distortion. In Section 2.0 of its TER, ISL found that these comparisons demonstrated acceptable BEACH capability for reflood rates greater than or equal to 0.4 inches per second up to the previous upper reflood limit for BEACH (10.0 inches per second). The staff agrees with the ISL conclusion, based on acceptable comparisons to applicable test data.

3.2.2 Reflood Rates from 0.3 Inches Per Second to 0.4 Inches Per Second

Framatome ANP provided comparisons to two gravity FLECHT tests, 3215B and 3316B, with reflood rates between 0.3 and 0.4 inches per second. BEACH conservatively overpredicted the tests by 200 to 300°F; however, the measured peak cladding temperatures (PCTs) for these tests (1600°F) were non-prototypically low for a nuclear reactor with such a low flooding rate. In its technical evaluation, ISL found that BEACH's capability had been acceptably demonstrated. However, Section 2.0 of the TER states that this conclusion needs to be confirmed in view of concerns discussed in Section 3.3 below. The staff agrees with the ISL conclusion. Also, given the staff's present uncertainty regarding the applicability of data obtained from only two tests with non-prototypically low PCTs, the staff concludes that BEACH application for calculated reflood rates less than 0.4 inches per second has not been adequately demonstrated at this time.

3.3 BEACH Convective Heat Transfer Model

Framatome ANP compared the BEACH-calculated reflood convection heat transfer coefficient to FLECHT data without accounting for the fact that the FLECHT heat transfer data includes rod-to-rod radiative effects as well as convective heat transfer effects. Section 2.2 of the ISL

TER discusses this inconsistency and postulates that the BEACH convection heat transfer coefficients might be significantly overestimated. However, the staff finds that in the reflood studies performed by Framatome ANP to justify reflood rates down to 0.4 inches per second, the BEACH code (including the non-conservative convective heat transfer model) adequately predicts the FLECHT data. The staff attributes the adequate comparison to the offsetting effect of inherent Appendix K conservatisms in the overall model. The conservatisms in the overall model are a function of user selected options, such as the values of the common block variables that specify the global quench and heat transfer options, and the nodalization and geometrical modeling approach (e.g., loss coefficients) used. Therefore, the staff approves BEACH (including the use of the current heat transfer model) for reflood rates down to 0.4 inches per second provided the same global quench and heat transfer options and nodalization and geometrical modeling approaches are employed as were used in the analytical comparisons to the supporting test data.

3.4 Droplet Diameter

During the review of the Framatome ANP BEACH proposals, the staff and ISL noted apparent anomalies in the comparisons of BEACH predictions to test data. ISL investigated the matter and confirmed that BEACH was allowed to calculate droplet sizes smaller than could be supported by the body of test data. This would permit BEACH to predict heat transfer non-conservatively, particularly at very low flooding rates. ISL recommended that a 0.5 mm minimum droplet size limit be incorporated into BEACH to prevent calculation of droplet sizes smaller than justified by the applicable test data. ISL discusses this in Sections 2.1 and 3.0 of the TER. The staff does not believe this droplet limitation is necessary because the BEACH code adequately predicted the FLECHT data. The conservatisms in the overall model and the ability of the model to properly simulate hot rod/assembly conditions at reflood rates greater than or equal to 0.4 inches per second are a function of user selected options, such as the values of the common block variables that specify the global quench and heat transfer options, and the nodalization and geometrical modeling approach (e.g., loss coefficients) used. Therefore, the staff approves BEACH (including the lack of a minimum droplet size limitation) for reflood rates down to 0.4 inches per second provided the same global quench and heat transfer options and nodalization and geometrical modeling approaches are employed as were used in the analytical comparisons to the supporting test data.

4.0 OTHER ITEMS DISCUSSED IN THE ISL REPORT

The ISL report discusses and makes recommendations regarding downcomer boiling and carrying out the analyses to quench. These issues are not within the scope of the BEACH code review. These issues are relevant to the overall Framatome ANP LOCA methodology, of which the BEACH code is a component. The resolution of these issues will be addressed within the context of the overall Framatome ANP LOCA methodology.

5.0 CONCLUSIONS

The staff concludes the following based on its review of the Framatome ANP proposal and the recommendations contained in the ISL TER:

1. The raising of the maximum initial cladding temperature limit for BEACH applicability to 2045°F as proposed by Appendix H is acceptable, since BEACH predictions compared well with or bounded FLECHT Test 34420 results for several key parameters at temperatures up to 2045°F. (Section 3.1 of this SE)

2. Application of BEACH (including the use of the current heat transfer model and the lack of a minimum droplet size limitation) for reflood rates greater than or equal to 0.4 inches per second up to the previous upper reflood limit for BEACH of 10.0 inches per second is acceptable. This approval is based on acceptable comparisons to applicable test data and is conditional on the use of the same global quench and heat transfer options and nodalization and geometrical modeling approaches as were used in the analytical comparisons to the supporting test data. (Sections 3.2.1, 3.2.2 and 3.2.3 of this SE)

3. BEACH application for calculated reflood rates less than 0.4 inches per second is not acceptable at this time. (Section 3.2.2 of this SE)

The accepted ranges for BEACH analyses are:

	PRIOR	PRESENT
Peak Power	0.4 - 1.0 kw/ft	0.4 - 1.0 kw/ft (unchanged)
Containment Pressure	15 - 73 psia	14.7 - 73 psia
Maximum Initial Cladding Temperature	950 - 1640°F	950 - 2045°F
Core Inlet Subcooling	0.0 - 180°F	0.0 - 180°F (unchanged)
Flooding Rate	0.5 - 10.0 in/sec	0.4 - 10.0 in/sec
Grid Flow Blockage	0.0 - 0.55	0.0 - 0.55 (unchanged)
Rupture Flow Blockage	0.0 - 0.60	0.0 - 0.60 (unchanged)

Attachment: Technical Evaluation Report

Principal Contributor: F.Orr

Date: July 11, 2003