July 11, 2003

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

SUBJECT: ACCEPTANCE 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. MB7549)

Dear Mr. Mallay:

In a letter dated December 10, 2001, Framatome ANP requested NRC approval of proposed Appendices H, "BEACH Code Benchmark at Higher Initial Cladding Temperatures," and I, "Revised Flooding Rate Bounds," to the Framatome ANP BEACH code described in BAW-10166-P-A. Your letter stated that, "Appendix H to BAW-10166PA 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."

The NRC performed its review of the submittal with the assistance of its contractor, Information Systems Laboratories, Inc. (ISL). The staff concludes that a higher initial cladding temperature limit at the start of reflood as proposed in Appendix H is acceptable. The staff also concludes that some lowering of the instantaneous flooding rate during reflood limit proposed in Appendix I can be permitted. These conclusions are discussed in the enclosed safety evaluation (SE), which also identifies related technical issues, and proposes limitations and conditions.

These limitations and conditions stem from lack of assessment of the minimum reflood droplet size and the convective heat transfer model over expanded ranges of conditions. Associated issues with these models were resolved for the range of reflood rates approved in this SE. The SE also identifies the issue of downcomer boiling that is currently being addressed in a generic manner.

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.

We do not intend to repeat our review of the matters described in the subject report, and found acceptable, when the report appears as a reference in license applications, except to ensure that the material presented applies to the specific plant involved. Our acceptance applies only to matters approved in the report.

In accordance with the guidance provided on the NRC website, we request that Framatome ANP publish an accepted version within three months of receipt of this letter. The accepted version shall incorporate (1) this letter and the enclosed SE between the title page and the abstract, (2) all requests for additional information from the staff and all associated responses, and (3) a "-A" (designating "accepted") following the report identification symbol.

Should our criteria or regulations change so that our conclusions as to the acceptability of the report are invalidated, Framatome ANP and/or the applicants referencing Appendices H and I to BEACH will be expected to revise and resubmit their respective documentation, or submit justification for the continued applicability of the Appendices without revision of their respective documentation.

Sincerely,

/RA by Stephen 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

In accordance with the guidance provided on the NRC website, we request that Framatome ANP publish an accepted version within three months of receipt of this letter. The accepted version shall incorporate (1) this letter and the enclosed SE between the title page and the abstract, (2) all requests for additional information from the staff and all associated responses, and (3) a "-A" (designating "accepted") following the report identification symbol.

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Sincerely,

/RA by Stephen 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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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. As stated in the ISL TER, Section 3.0, Item 7,

this issue is not resolved at this time. The staff does not require resolution of this issue to support its acceptance of BEACH discussed herein because the BEACH convection heat transfer model does not affect the code acceptability for the reflood rates (greater than or equal to 0.4 inches per second) approved in this SE. This acceptability is based primarily on code comparison to data at these reflood rates.

3.4 Droplet Diameter

During the review of the FTI 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 agrees with the ISL recommendation since the recommendation is consistent with applicable test data. This issue is not resolved at this time, however, the staff does not require resolution of this issue to support its acceptance of BEACH discussed herein because the BEACH minimum calculated droplet size does not affect the code acceptability for the reflood rates (greater than or equal to 0.4 inches per second) approved in this SE. This acceptability is based primarily on code comparison to data at these reflood rates.

3.5 Containment Pressure

Since 1990, the approved containment backpressure range for BEACH application has been from 15 to 73 psia, based on an extrapolation of the containment backpressure range for FLECHT tests, consistent BEACH performance over that range, and that approximately 15 psia was anticipated to be the lowest containment backpressure for an ice condenser containment. Section 2.1 of the ISL TER discusses the lower containment backpressure limit. Though data for this pressure range is sparse (FLECHT Test 0791), BEACH did conservatively predict the PCT for that test. Based on the test comparison, Section 3.0, Item 3, of the ISL TER proposes that the lower pressure limit for BEACH application be 14.7 psia, corresponding to the test pressure. The staff agrees with the ISL finding.

4.0 OTHER ITEMS DISCUSSED IN THE ISL REPORT

The Framatome ANP topical report discusses and makes recommendations regarding three other items which, though strongly related to the issues of the present review (Sections 3.1 to 3.5), are not within the scope of this safety evaluation. The following items are discussed below.

4.1 Downcomer Boiling

Section 3.0, Item 5, of the ISL TER proposes a course of action to address downcomer boiling. The staff is currently addressing the issue of downcomer boiling on a generic basis with all vendors and all plants. This SE requires the capability of the BEACH methodology to carry out analyses to a stable and enduring core quench. This requirement may be part of the generic

issue resolution. However, this SE does not exempt the BEACH methodology from any other requirement that may be imposed by the generic issue resolution.

4.2 Carrying Out Analyses to Quench

Section 3.0 of the ISL TER recommends that, "Analyses are carried out until the entire core has quenched and has been reduced to acceptably low cladding temperatures. Peak local and core wide oxidation percentages should be computed until the cladding temperature response no longer contributes to oxidation." Section 50.46(b) of 10 CFR also requires that LOCA analyses be completed to the time of quenching.

During the review, the staff determined that the Framatome ANP methodology was unable to complete its analysis to the time of quenching for plants with reflood pressures less than atmospheric pressure. This problem was caused by an ancillary code that supplies boundary conditions for BEACH calculations, which is outside the scope of this SE. The NRC staff concurs with ISL's recommendation, and therefore, any plant specific implementation of the Framatome ANP methodology must demonstrate core quenching.

4.3 Interim Model

Section 3.0 of the ISL TER proposes an interim model to address the issue discussed in Section 3.2.2 of this SE. An unpedigreed patchwork model would be useful for performing assessments of errors or changes in accordance with 10 CFR 50.46(a)(3)(i) and (ii). However, licensees must use approved methodologies in conformance with best estimate guidance or with 10 CFR Part 50, Appendix K, to perform LOCA "analyses of record" in conformance with 10 CFR 50.46(a)(1)(i) or (ii). Therefore, any methodology used by a licensee to address 10 CFR 50.46(a)(1)(i) or (ii), patchwork or otherwise, would have to be approved by the NRC for that use, and would no longer be "unpedigreed." The staff does not endorse the suggestion to use an unpedigreed patchwork model to address 10 CFR 50.46(a)(1)(i) or (ii).

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 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) is acceptable based on acceptable comparisons to applicable test data. (Section 3.2.1 of this SE)

3. A lower containment pressure limit for BEACH application of 14.7 psia is acceptable, based on comparison to an applicable test performed at that test pressure. (Section 3.5 of this SE)

4. 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)

5. The BEACH convective heat transfer model issue is not resolved at this time, but its resolution is not needed to support the findings of this SE. (Section 3.3 of this SE)

6. Implementation of a 0.5 minimum droplet size in BEACH remains an issue at this time, but its resolution is not needed to support the findings of this SE. (Section 3.4 of this SE)

7. In plant analyses, BEACH calculations must be carried out to sustain core quench in accordance with the requirements of 10 CFR 50.46. (Section 4.2 of this SE)

8. To the extent that downcomer boiling causes BEACH to be unable to complete its calculations to final core quench (code stability), the downcomer boiling issue must be resolved for plant-specific calculations. Additionally, Framatome ANP must correct BEACH to satisfy requirements as dictated by the issue of downcomer boiling (code accuracy). (Section 4.1 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