VIRGINIA ELECTRIC AND POWER COMPANY
RICHMOND, VIRGINIA 23261

May 13, 2002

U.S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, D.C. 20555

Serial No. 02-305
NL&OS/ETS R0
Docket Nos. 50-338
50-339
License Nos. NPF-4
NPF-7

Gentlemen:

**VIRGINIA ELECTRIC AND POWER COMPANY (DOMINION)
NORTH ANNA POWER STATION UNITS 1 AND 2
PROPOSED LOCA MODELING APPROACH FOR TRANSITION TO
FRAMATOME ANP ADVANCED MARK-BW FUEL**

On April 16, 2002, Dominion and Framatome ANP met with NRC Staff to provide an update on the ongoing transition to Advanced Mark-BW fuel at North Anna Power Station as described in the North Anna license amendment request dated March 28, 2002. Dominion and Framatome ANP presented detailed material concerning the proposed approach for LOCA analyses to demonstrate compliance with 10 CFR 50.46. The presentation included several modeling changes to the approved Framatome ANP models licensed under the provisions of 10 CFR 50, Appendix K. In an April 19, 2002 teleconference, the NRC Staff (Mr. F. Akstulewicz and Mr. S. Monarque) informed Dominion that the requested review completion date of January 31, 2003 could not be met. Subsequently, Dominion and Framatome developed a simplified approach to demonstrate compliance of the Advanced Mark-BW fuel to 10 CFR 50.46 in anticipation that review of a reduced scope evaluation might be accomplished within the requested schedule.

The attachment presents a discussion of the proposed modeling approach and the basis for this revised approach as well as a summary of the justification for the requested changes. The remaining items requiring NRC review are a subset of the changes proposed at the April 16, 2002 meeting. We request that the NRC reassess the proposed reduced scope alternative to determine whether this approach can be accomplished within the schedule identified in our original letter. Additional technical

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detail, including supporting data and calculations, will be forwarded to the NRC after concurrence is obtained that review of the reduced scope approach is achievable. NRC review and approval of the proposed license amendment is requested by January 31, 2003.

If you have any further questions or require additional information, please contact us.

Very truly yours,

Leslie N. Hartz
Vice President – Nuclear Engineering

Attachment

Commitments made in this letter: None

cc: U.S. Nuclear Regulatory Commission
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Attachment

Proposed Modeling Approach for Demonstrating Compliance with 10 CFR 50.46 For Transition to Advanced Mark-BW Fuel

North Anna Power Station Units 1 and 2
Virginia Electric and Power Company
(Dominion)

Proposed Modeling Approach for Demonstrating Compliance with 10 CFR 50.46 Transition to Advanced Mark-BW Fuel

Introduction:

Framatome ANP is supplying fuel for the March 2003 reload of Virginia Electric and Power Company's (Dominion's) North Anna Power Station, Unit 1. On April 16, 2002, Dominion and Framatome ANP met with representatives of the Nuclear Regulatory Commission (NRC) to discuss the generic and North Anna specific LOCA evaluation techniques to be included in the licensing submittal for this reload. During the meeting the following nine items were listed as requiring NRC review.

1. BEACH Reflood Heat Transfer Modifications
2. Core Peaking Factors for LOCA Evaluation
3. Energy Deposition Factor
4. Average Core Energy Representation
5. Minimum Containment Backpressure Calculation
6. REFLOD3B Carryout Rate Fraction
7. End of Transient Justification
8. Oxide Calculations
9. SBLOCA Noding

Each item represents or contains a departure from an NRC approved LOCA evaluation model or a plant specific calculation conducted within the framework of the evaluation model and, therefore, would likely require NRC review. These items provide model performance that is required for long-term operation of the North Anna plants. The analytical approach was designed to conform with Dominion's current licensing and plant control approaches and to address other concerns raised by the NRC.

On April 19, 2002, the NRC staff informed Dominion that they would be unable to support Dominion's requested review schedule (January 31, 2002). To respond to the NRC's identified concerns and facilitate a schedule improvement, Dominion and Framatome ANP have developed a minimum set of items from those proposed on April 16, thereby reducing the required review scope. This alternate, reduced scope approach is presented herein for consideration.

Basis for Revised Approach:

To reduce the NRC review scope, the revised plan for the licensing calculations will make maximum use of the approved Framatome ANP LBLOCA evaluation model and the existing licensing basis for the North Anna plants. This reduced scope approach provides reduced, but acceptable, operational flexibility and a reduced margin to acceptance criteria for at least the initial cycle of operation. Dominion has reduced the radial peaking limit, $F_{\Delta H}$, from 1.60 to that of the current cycle, 1.55. This enables the

use of the core peaking distribution approved within the current Framatome LBLOCA evaluation model (i.e., no differentiation between the hot pin and the hot assembly peaking) and eliminates the peaking factor change and review. With the application of the existing evaluation model and analysis practice, there will be no change to the average core initialization or the approved energy deposition factors and, therefore, no review required. An example of reduced margin to acceptance criteria involves continued use of the overly conservative calculation for whole-core oxidation included in the currently approved Framatome ANP evaluation model. The expected core-wide oxidation prediction is between 0.8 and 0.9 percent. This eliminates the need for a review of a change in the core-wide oxidation calculation methodology. Dominion has also decided that no SBLOCA analysis will be submitted for the initial fuel transition. This eliminates the need for NRC review of the change associated with SBLOCA nodalization.

Proposed LOCA Modeling Approach:

Considering the change in approach outlined above, the LOCA calculations can be performed largely within the framework of the currently approved LOCA evaluation model. The remaining review categories are listed below, followed by a discussion of the proposed approach for each item.

1. BEACH Reflood Heat Transfer Modifications
2. Minimum Containment Backpressure Calculation
3. REFLOD3B Carryout Rate Fraction
4. End of Transient Justification
5. Application of Current UFSAR SBLOCA Analysis

- BEACH Reflood Heat Transfer Modifications

  In December 2001, two new appendices for the BEACH topical report (BAW-10166) were submitted to the NRC for approval (Reference 1). These appendices provided experimental benchmarks to justify the expansion of the ranges of applicability of the code. Appendix H justifies the use of BEACH under conditions where the cladding temperature at the beginning of reflood is greater than 2000°F and Appendix I justifies the application of the code to flooding rates as low as 0.3 inches per second. Although only Appendix I is required for the North Anna analysis, both appendices are currently under NRC review. Completion of this review is necessary to support the North Anna review.

- Minimum Containment Backpressure Calculation

  The containment pressure used for LOCA calculations of peak cladding temperature is calculated under assumptions designed to minimize pressure so as to minimize flooding rates. The Framatome ANP evaluation model (Reference 2) for

recirculating steam generator (RSG) plants dictates that the containment pressure for the original LOCA calculations be used, provided the mass and energy release rates for the new LOCA calculations are demonstrated to be comparable to those for the original LOCA. If this cannot be demonstrated, a plant specific containment pressure calculation will be performed. For North Anna, the UFSAR LOCA calculations indicate termination of the LOCA transient at 240 seconds. The Framatome ANP calculations indicate a cladding temperature and core quench behavior that requires calculations to be carried out beyond the 240 seconds of the original LOCA calculations. This necessitates creation of an alternate containment pressure transient for use by Framatome ANP. To appropriately model the North Anna containment system behavior, a complete minimum containment backpressure analysis will be performed. This calculation and its use require the NRC's review because the specific method has not been approved within the Framatome ANP RSG evaluation model.

- REFLOD3B Carryout Rate Fraction

  REFLOD3B can experience numerical instability for certain evaluation conditions. During selected circumstances such as if the upper plenum was previously superheated, liquid carryout to the upper plenum can lead to rapid desuperheating and liquid vaporization sufficient to generate pressure spikes resembling steam explosions, which cause numerical instabilities in the model. The approved version of the code included a resolution to this problem that involved logic to force sufficient liquid into the upper plenum to maintain a saturated condition. However, this approach involves overriding the calculation of carryout that would result from applying the FLECHT-SEASET-based correlation (CRFCKN) in REFLOD3B. This was a conservative solution because the excess carryout, if present, would be vaporized in the steam generators and increase steam binding. For the low containment pressure 3-loop North Anna design, the degree of conservatism imposed is excessive. The deviation of REFLOD3B from its FLECHT-SEASET-based carryout rate fraction correlation (CRFCKN) is substantial and sustained in the simulation, leading to a significant reduction in core flooding rates during middle reflood (after the initial stabilization of the flooding rate) with the possibility of decreasing core liquid inventories. This is an inappropriate and unintended consequence of forcing sufficient carryout to maintain a saturated upper plenum. As a correction, Framatome ANP has installed an option to suspend the forced saturation of the upper plenum and allow carryout to be determined solely by the CRFCKN carryout rate fraction correlation. This approach allows superheat in the upper plenum without creating numerical instabilities because, for the North Anna units, there is no excess water carried into the superheated region.

- End of Transient Justification

  The Framatome ANP LBLOCA evaluation model has not been optimized for the post peak-cladding-temperature phase of the accident and behavior during this period is extremely conservative. For high-pressure containments or plants with low steam binding, this is not a serious deficiency. However, the REFLOD3B (reflood hydraulics) downcomer model cannot simulate a two phase mixture, and for the North Anna reactor coolant system in combination with the low containment pressure, REFLOD3B calculates that the downcomer fluid becomes two phase before significant post peak cooling has occurred. The calculated post peak cladding temperature transient is only an artifact of the model. More reasonable predictions based on alternative deterministic approaches, best estimate modeling, or experimental observations show that the core will be quenching and that all cladding temperatures will be near the quench temperature before the REFLOD3B simulation becomes inappropriate. All of these simulations consider and appropriately represent the occurrence of boiling in the downcomer and lower head. These other simulations justify ending the LOCA simulation at the time REFLOD3B predicts a saturated downcomer. Core oxidation at that time will be used to predict maximum local and core-wide oxidation values for comparison to the criteria of 10 CFR 50.46.

- Application of Current UFSAR SBLOCA Analysis

  The evaluation of the SBLOCA is largely an issue of coolant tracking within the reactor coolant system (RCS) so that an appropriate core mixture height versus time can be predicted. The behavior of the RCS depends on system design and plant power and is essentially independent of the detailed fuel assembly design. The cladding temperature predicted for SBLOCA will differ between two different fuel designs only if something in the design alters the local steam heat transfer prediction or the core volume available for liquid retention. If, for example, the fuel rod diameter were to be decreased substantially without a reduction in local power, the application of the same heat transfer coefficient would remove less energy per degree of temperature difference and a cladding temperature increase would be expected. No such differences exist between the Westinghouse resident fuel and the fuel to be supplied by Framatome ANP. All of the significant coolant distribution determinants have been effectively evaluated by an approved SBLOCA evaluation model as documented in the North Anna UFSAR. Thus, the application of those results to the reload cycle with Framatome ANP fuel is justifiable and will be used for the first transition cycle.

Justification for Proposed Modeling Approach:

Each of the review items will require some level of justification. Dominion and Framatome ANP intend to provide this as follows.

- BEACH Reflood Heat Transfer Modifications

  Several experimental benchmarks of BEACH predictions within the extended applicability ranges have been provided in Appendices H and I submitted in Reference 1. The trending of BEACH predictions within the extended range has been established and shown to be physically sensible. This material is considered sufficient to justify approval of extensions of the applicable ranges for initial temperature and flooding rate.

- Minimum Containment Backpressure Calculation

  The containment pressure calculations will use the NUREG 0800, Standard Review Plan Section 6.2.1.5 guidance for determining minimum backpressure. The containment code, CONTEMPT, is approved for such calculations within the Framatome ANP BWNT LOCA evaluation model for B&W-designed plants (Reference 3). A full description of the approach and its relationship to established and approved procedures will be provided to the NRC for review.

- REFLOD3B Carryout Rate Fraction

  The REFLOD3B benchmarks provided to the NRC for the original code approval have been reviewed to determine if they were impacted by the forced carryout constraint applied to resolve the original numerical instability. It has been determined that the constraint was not in effect during the benchmark prediction. Framatome will document that the original benchmarks are applicable to the non-constrained code version and that the suspension of the constraint for application to North Anna is justified.

- End of Transient Justification

  Calculations will be performed for North Anna with alternative methods capable of predicting downcomer behavior and the distribution of reactor coolant. These calculations demonstrate that, even with a two phase mixture in the downcomer, the cladding temperatures are not affected sufficiently to produce a second reflood peak and are reduced to near quench conditions at the time of the proposed end of the transient. These methods will be provided with benchmark predictions from UPTF and possibly Semi-Scale to establish their validity. Further, direct extension of available experimental results will be used to demonstrate the conservatism

embodied in Framatome ANP's LBLOCA model and to justify ending the transient. These supplemental calculations and benchmark predictions will form the basis for concluding that results obtained from the Framatome ANP LBLOCA evaluation model are conservative and are appropriate for a model licensed under provisions of 10 CFR 50, Appendix K.

- Application of Current UFSAR SBLOCA Analysis

  A comparison between the current resident fuel design and the Framatome ANP fuel design will be provided to identify any differences in design that could impact SBLOCA calculations. Each significant difference will be evaluated for impact on the calculations and the results used to estimate the behavior of the new fuel. The only difference anticipated is the incorporation of mid-span-mixing grids (MSMGs) in the upper grid spans of the Framatome ANP fuel. This change increases the core pressure drop by about 10 percent and generates added flow turbulence, which increases heat transfer. During core uncovering the core liquid is basically stagnant and the core pressure drop is insignificant and inconsequential. The MSMGs would be expected to generate additional turbulence in the steam cooling region leading to improved heat transfer and somewhat lower cladding temperatures for the Framatome ANP fuel. Because the SBLOCA is not limiting for North Anna and the resultant PCTs are several hundred degrees below the 10 CFR 50.46 criterion, it is unnecessary to reanalyze the SBLOCA licensing basis for this reload. This position can be further substantiated by SBLOCA calculations performed by Framatome ANP. Those calculations demonstrate that the existing analysis bounds the results predicted by Framatome ANP.

Conclusion:

In response to the discussions at the April 16 meeting, the proposed review scope will be reduced by eliminating the peaking factor change, the energy deposition factor change, the revised approach to determining the initial condition of the average core, the change to the method of predicting core-wide oxidation, and the change to the SBLOCA noding. This results in LBLOCA calculations that are largely based on a currently approved LBLOCA evaluation model. The significant remaining issue is the determination of the end of the simulation and the predicted oxidation values used in comparison with the oxidation criteria of 10 CFR 50.46. The reduced review scope in conjunction with further downcomer condition evaluations presents a solid LBLOCA evaluation upon which the licensing of the first cycle of Framatome ANP fuel for the North Anna plants can be based. For subsequent cycles, the inherent margins of this approach will be evaluated to determine whether revised LOCA assessments are warranted.

References:

1. Letter, James F. Mallay to USNRC, "Request for Review of Appendices H and I to BAW-10166," NRC:01:050, December 10, 2001.

2. BAW-10168P-A, "RSG LOCA - BWNT Loss-of-Coolant Accident Evaluation Model for Recirculating Steam Generator Plants," Revision 3, December 1996.

3. BAW-10192P-A, "BWNT LOCA – BWNT Loss-of-Coolant Accident Evaluation Model for Once-Through Steam Generator Plants," Revision 0, June 1998.