VIRGINIA ELECTRIC AND POWER COMPANY
RICHMOND, VIRGINIA 23261

August 2, 2002

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

Serial No. 02-167C
Docket Nos. 50-338
50-339
License Nos. NPF-4
NPF-7

Gentlemen:

VIRGINIA ELECTRIC AND POWER COMPANY
NORTH ANNA POWER STATION UNITS 1 AND 2
SMALL BREAK LOCA EVALUATION IN SUPPORT OF
PROPOSED TECHNICAL SPECIFICATIONS CHANGES AND EXEMPTION REQUEST
USE OF FRAMATOME ANP ADVANCED MARK-BW FUEL

In a March 28, 2002 letter (Serial No. 02-167), Virginia Electric and Power Company (Dominion) requested: 1) an amendment to Facility Operating License Numbers NPF-4 and NPF-7 for North Anna Power Station Units 1 and 2, and 2) associated exemptions from 10 CFR 50.44 and 10 CFR 50.46. The amendments and exemptions will permit North Anna Units 1 and 2 to use Framatome ANP Advanced Mark-BW fuel. This fuel design has been evaluated by Framatome and Dominion for compatibility with the resident Westinghouse fuel and for compliance with fuel design limits. The attachment to this letter documents the assessment of small break LOCA phenomena for the Advanced Mark-BW fuel. This information is provided in accordance with the proposed documentation for the transition effort as stated in our June 19, 2002 letter (Serial No. 02-305A). The remainder of the documentation required to establish compliance with the emergency core cooling system requirements of 10 CFR 50.46 for the transition to Advanced Mark-BW fuel will be submitted in separate correspondence as soon as possible.

As indicated in our June 19, 2002 letter, the approach taken relies upon application of the existing UFSAR analysis performed for the Westinghouse fuel. The attachment to this letter describes the assessment performed to determine the impact of fuel design effects upon small break LOCA phenomena. It is concluded that the existing small break LOCA analysis contained in the North Anna UFSAR is valid and provides a conservative representation of Advanced Mark-BW fuel.

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As noted in previous correspondence, the initial reload batch of Advanced Mark-BW fuel is currently planned for North Anna Unit 1 Cycle 17, which is scheduled to begin operation in April 2003. We continue to request your assistance to achieve this reload schedule.

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

Very truly yours,

L. N. Hartz
Vice President - Nuclear Engineering

Attachment

Commitments made in this letter: None

cc: U.S. Nuclear Regulatory Commission
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COMMONWEALTH OF VIRGINIA)
)
COUNTY OF HENRICO)

The foregoing document was acknowledged before me, in and for the County and Commonwealth aforesaid, today by Leslie N. Hartz, who is Vice President - Nuclear Engineering, of Virginia Electric and Power Company. She has affirmed before me that she is duly authorized to execute and file the foregoing document in behalf of that Company, and that the statements in the document are true to the best of her knowledge and belief.

Acknowledged before me this 2nd day of August, 2002.

My Commission Expires: May 31, 2006.

Vicki L. Hull

Notary Public

(SEAL)

ATTACHMENT

Small Break LOCA Evaluation of Advanced Mark-BW Fuel
Framatome Fuel Transition Program

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

A SMALL BREAK LOCA EVALUATION OF ADVANCED MARK-BW FUEL FOR APPLICATION TO NORTH ANNA POWER STATION UNITS 1 AND 2

Framatome ANP will be delivering Advanced Mark-BW reload fuel to the North Anna Power Station (NAPS) Units 1 and 2 starting in the first quarter of 2003. The units are Westinghouse-designed, three-loop plants operating at a rated thermal power of 2,893 MWt. The plants have conventional ECCS systems and dry, sub-atmospheric containment buildings. In accordance with 10 CFR 50.46 and 10 CFR 50, Appendix K, an evaluation of ECCS performance is being performed for the Framatome ANP fuel.

One component of the overall LOCA evaluation is a small break LOCA (SBLOCA) assessment. The North Anna evaluation for SBLOCA follows a course employed (and approved by the NRC) in two prior transitions to Framatome ANP fuel for plants with recirculating steam generators (References 1 and 2). The approach involves demonstrating that the current Westinghouse SBLOCA licensing basis is equally applicable to Framatome ANP Advanced Mark-BW reload fuel. The potential impact of design feature differences between North Anna Improved Fuel (NAIF) and Advanced Mark-BW fuel on SBLOCA transient behavior was assessed. It was concluded that the existing SBLOCA analysis provides a conservative representation of Advanced Mark-BW fuel.

SBLOCA Transient Description

SBLOCA transients can be characterized as developing in five distinct phases: (1) subcooled depressurization, (2) pump/loop flow coastdown and natural circulation, (3) loop draining, (4) vessel/core boil-off, and (5) long-term cooling. These five transient phases are examined in the following paragraphs. This transient characterization provides a framework in which to evaluate the effects of fuel assembly design differences (between NAIF and Advanced Mark-BW fuel) on SBLOCA for the NAPS units.

The limiting SBLOCA event begins with a subcooled reactor coolant system (RCS) depressurization. Depressurization continues until the primary system pressure reaches the saturation pressure associated with the initial hot leg temperature. During this depressurization phase, the low-pressure reactor trip and ECCS injection trip signals are generated. Reactor coolant pumps trip (either manually or in response to loss-of-offsite power). This initiates the pump and loop flow coastdown period.

Following reactor trip, the core power drops sharply. The initial forced flow and subsequent coastdown flow provide continuous heat removal via the steam generators. Thus, the initial stored energy, and the core power and decay heat during this transient phase are rejected directly to the steam generators. The pump coastdown and natural circulation flows during the second transient phase are sufficient to prevent critical heat flux (CHF) from occurring in the core. Consequently, the fuel pins are cooled toward the quasi-steady temperature distribution required to simply conduct and convect the decay heat energy from the pins. The pin temperatures approach the RCS saturation temperature. Loss of continuous loop flow marks the end of this second transient phase.

The third transient phase is characterized as a period of loop draining. During this period, the system reaches a quiescent state in which core decay heat, break flows, pumped ECCS injection, and steam generator heat transfer combine to control the development of steam-water mixture levels within the RCS. The system inventory distribution is a strong function of the system geometry and break location. RCS liquid inventory will continue to decrease until component mixture levels provide a continuous path through which to vent steam produced in the core. Relief of core-produced steam allows the RCS to further depressurize and enter the boil-off mode.

The development and timing of events that mark the end of loop draining and the onset of core boil-off are governed by break location. For hot leg breaks, a continuous core steam-venting path is readily established. For cold leg breaks, a significant system inventory loss is required to establish a steam vent path. The limiting SBLOCA occurs in the cold leg pump discharge piping. In these breaks, liquid inventory is lost until primary levels descend to the pump suction piping spill-under elevation, which is the low point in the cold leg pump suction piping. This trap (loop seal) must be cleared of liquid to establish a steam-venting path to the break. Since the loop seal elevation is located slightly above the core mid-plane, the core collapsed liquid level is depressed by the manometer pressure balance imposed by RCS geometry. Once the loop seals clear, a steam-venting path is established and the residual liquid inventory in the pump discharge and downcomer regions drains into the core region.

The onset of the boil-off period typically coincides with the beginning of a final saturated depressurization. Voiding at the break increases the leak volumetric flow rate. This ultimately depressurizes the system until the accumulator fill pressure is reached or the pumped ECCS injection matches core steaming. During this period, the reactor vessel mixture level may drop into the heated core region. The fuel pin clad temperature excursions calculated for the upper core elevations are maximized by the assumption of a bounding, core outlet-skewed axial power distribution.

The clad temperature excursion is arrested as the combined ECCS flows exceed the core decay heat level and the final core refill begins. The suppression of core steam production further depressurizes the RCS. This increases ECCS injection flow and hastens core refill. Eventually the RCS will depressurize to the containment pressure and the core will refill. At this point, the start of long-term cooling is established and the transient mitigated.

Fuel Design Effects

SBLOCA transients are controlled primarily by system design and core decay heat levels. Fuel assembly design influences calculated events only to the extent that it affects overall system behavior. In that regard, differences between the Advanced

Mark-BW and resident NAIF assemblies should not materially affect the bounding SBLOCA transients set forth in the North Anna UFSAR (Reference 3). The Framatome ANP and Westinghouse assemblies have important commonalties: clad OD and ID, and pellet OD. They also differ in several areas: mid-span mixing grids (MSMGs), unrecoverable pressure drops across the assemblies, initial fuel temperature, clad material, and initial pin backfill pressure. The impact of these variations, with respect to the controlling aspects of the SBLOCA transient, is evaluated below.

The incorporation of MSMGs into the Advanced Mark-BW design creates three effects regarding application of the UFSAR SBLOCA analysis: 1) core CHF performance is improved, 2) convective heat transfer is improved, and 3) the core pressure drop is increased. With MSMGs present, the fuel critical heat flux is higher in the MSMG region than it is at the same location in NAIF. Thus, the Advanced Mark-BW fuel is less likely to experience a departure from CHF during the flow coastdown phase than NAIF. This makes the application of the NAIF calculations to the Advanced Mark-BW fuel during this transient phase conservative. The effect of the MSMGs on convective heat transfer is important in the upper steam-cooled regions of the core during the core-uncovering phase. In this phase, steam generated in the core below the mixture cools the upper core by convection. During this period, two parameters control clad temperature: vapor temperature and the differential temperature between the vapor and the cladding. The vapor temperature is controlled by the decay heat rate and is not influenced by fuel assembly design differences. The heat transfer coefficient near the MSMGs, however, increases with the result that the differential temperature between the clad and the vapor is decreased. Thus, the Advanced Mark-BW fuel will be somewhat lower in temperature near the MSMGs than NAIF and the application of the NAIF calculations to the Advanced Mark-BW fuel is conservative.

The effect of core pressure drop on the SBLOCA calculation is encompassed by the existing UFSAR analysis. Realistically, the use of MSMGs will decrease the core flow by one or two percent and cause a small increase in the core outlet temperature. Analytically, however, SBLOCA evaluations are performed using a design flow assumption that is substantially reduced from the actual plant flow. Because the analytical assumptions for the initial system flow encompass the expected system flow, the existing SBLOCA calculation remains applicable to the Advanced Mark-BW fuel.

Changes in the initial fuel temperature (stored energy) add or subtract overall RCS energy. The initial fuel energy is removed from the fuel pin during the reactor coolant pump coastdown phase and rejected from the system via the steam generators. Therefore, the initial fuel stored energy has virtually no impact beyond the loop coastdown period. The core energy release during the loop draining and boil-off mode will be identical to that in the current licensing basis.

Both the Advanced Mark-BW and the NAIF assemblies use advanced cladding material (i.e., M5™ for the Framatome ANP fuel and ZIRLO™ for NAIF). The materials are comparable to each other, exhibiting analogous physical properties. The required Baker-Just oxidation model is conservative for both materials, and both materials can be simulated with NUREG-0630 type swelling and rupture models. The rupture temperature curves are similar and the rupture strain correlations exhibit similar trends. Thus, due to material commonalties, no SBLOCA analysis impact would be anticipated.

The Advanced Mark-BW fuel pin backfill pressure is similar, but somewhat less than NAIF. The internal gas pressure can affect fuel/cladding gap dimensions and rupture time. During the initial phase of the accident, the fuel temperature decreases rapidly (within a fraction of a minute following reactor trip) to a level consistent with the rejection of decay heat. The cladding temperature also decreases and approaches the system saturation temperature. Hence, the impact of small gap differences is negligible.

The fuel pin internal gas pressure effect on rupture favors rupture in NAIF over the Advanced Mark-BW fuel. NAIF fill pressure is somewhat higher than that of the Advanced Mark-BW fuel and it would remain so during a SBLOCA transient. Hence, the Framatome ANP fuel would not cause an occurrence of clad rupture where none was predicted for the higher pressure NAIF assembly. Moreover, the limiting UFSAR SBLOCA transients do not predict clad rupture. Thus, the NAIF SBLOCA licensing base is conservative for application to the Framatome ANP fuel.

Finally, SBLOCA-imposed plant operating limits, including maximum allowable total peaking, will not be altered due to the use of Framatome ANP fuel. Thus, the axial power profile used in the existing SBLOCA analysis remains bounding. This assures that the thermal load imposed on the fuel during a temperature excursion remains conservatively modeled. The thermal results, in terms of cladding temperatures, for the current UFSAR evaluations are, therefore, conservative for Advanced Mark-BW fuel.

In summary, core resistance variations will not affect loop flows such that the controlling hot leg temperature or CHF points are altered. The steam generator heat removal rate during the flow coastdown period will compensate for any initial fuel stored energy fluctuations. All controlling parameters in the phases following the pump coastdown and natural circulation phase will be unchanged. Therefore, since the overall RCS geometry, initial operating conditions, licensed power, and governing phenomena are effectively unchanged, the existing UFSAR calculations should remain bounding for operation of the NAPS units with Framatome ANP-supplied Advanced Mark-BW fuel.

Current UFSAR Results

The UFSAR small break accident calculations for the NAPS units are not the limiting LOCA transients, according to the predictions of the NOTRUMP and LOCTA-IV computer codes. The calculated results documented in the current North Anna UFSAR predict peak SBLOCA cladding temperatures of about 1,700°F. All parameters are well within the acceptance criteria limits of 10 CFR 50.46. Even wide variations in SBLOCA results would not cause the SBLOCA to be limiting. Thus, considerable margins exist such that variations in the SBLOCA results would not alter either the plant technical specifications or operating procedures.

Compliance with Acceptance Criteria

The existing SBLOCA calculations contained in the North Anna UFSAR are valid and bounding for the Framatome ANP Advanced Mark-BW fuel. The reactor coolant system, decay heat levels, and other system controlling parameters remain unchanged by the reload fuel. A significant safety margin exists between the calculated results and 10CFR50.46 limits. Design differences between the Westinghouse and Framatome ANP fuel do not substantially alter the results of SBLOCA evaluations. Adequate core cooling has been demonstrated by the existing analysis and does not need to be repeated due to the change in fuel vendors. The current SBLOCA calculations remain valid for the NAPS fuel reloads supplied by Framatome ANP. The current UFSAR assessment remains as the SBLOCA analysis of record for demonstrating compliance with the criteria of 10CFR50.46.

References

1. BAW-10174A, Revision 1, "Mark-BW Reload LOCA Analysis for the Catawba and McGuire Units," September 1992.

2. Letter: Roby Bevan (NRC) to James E. Cross (Portland General Electric Company), "NRC Staff Evaluation of Topical Report BAW-10177 (TAC No. 80468)," September 24, 1991.

3. NAPS UFSAR, Revision 37.