Attachment 6

Discussion of Proposed License Changes

for North Anna 2

(Non-Proprietary Version)

DISCUSSION OF CHANGES

INTRODUCTION

In 1997, irradiation of four (4) lead test fuel assemblies fabricated by Framatome Advanced Nuclear Power[1] began in North Anna Unit 1. The U.S. Nuclear Regulatory Commission (NRC) originally granted license conditions and associated exemptions to the Code of Federal Regulations for North Anna Units 1 and 2 that approved the use of these lead test assemblies (LTAs) for up to three operating cycles, with the lead rod burnup not to exceed 60,000 MWD/MTU (Reference 1). These LTAs have now completed three cycles of operation, achieving assembly average burnups of about 52,300 MWD/MTU.

Virginia Electric and Power Company[2] now proposes irradiating one of these assemblies for a fourth cycle, to an assembly burnup approaching 70,000 MWD/MTU. This proposed irradiation goes beyond the conditions originally allowed by Reference 1, in terms of the total number of operating cycles and cumulative burnup. The lead test assembly also uses cladding materials (alloys M4 and M5) not specifically discussed in North Anna Unit 2 Technical Specification 5.3.1 or Section 4.2.1 of the North Anna Updated Final Safety Analysis Report (UFSAR), which both indicate the cladding material of the North Anna fuel is Zircaloy-4 or ZIRLO. NRC approval of the proposed LTA operation, in the form of a license condition, will therefore be required. North Anna Unit 2 Technical Specification 5.3.1 and Section 4.1 of the North Anna UFSAR incorporate provisions to allow irradiation of a small number of lead test assemblies in the core, so no Technical Specifications or UFSAR changes are required for the proposed program. Irradiation of this fuel assembly to a high burnup will provide data on fuel and structural materials performance that will support industry goals of extending the current fuel burnup limits, and will provide data to address NRC questions related to fuel performance behavior at higher burnups. The data will also help confirm the applicability of nuclear design and fuel performance models at extended burnups, and may provide information to support dry cask storage of fuel that has achieved extended burnups.

Our current plan is to irradiate one of these lead test assemblies for a fourth cycle by placing it in the center position of the North Anna 2 Cycle 16 core. This cycle is currently scheduled to begin operation in October 2002.

The proposed license condition and exemptions to the Code of Federal Regulations have been reviewed, and have been determined to qualify for categorical exclusion from an environmental assessment as set forth in 10 CFR 51.22(c)(9). Therefore no environmental impact statement or environmental assessment is needed in connection with the approval of the proposed license condition and exemptions.

---

[1] Framatome Advanced Nuclear Power was previously known as Framatome Cogema Fuels, and will be identified simply as "Framatome" for the remainder of this discussion.

[2] The license for North Anna Units 1 and 2 is currently held by the Virginia Electric and Power Company. A submittal has been made to the NRC to change the licensee name to Dominion Generation Corporation. Although this submittal has not yet been approved, the utility design organization supporting the North Anna units now does business as Dominion Generation, and will be identified as "Dominion" throughout this discussion.

BACKGROUND

Framatome began an advanced alloy program in 1987 to develop fuel rod cladding and structural tube materials for high burnup application. This program involved extensive testing of several candidate alloys, with two alloys -designated M4 and M5[3]- being selected for further characterization on the basis of their superior performance in both in-core and ex-core testing. Demonstration assemblies that included fuel rods with cladding fabricated from both alloys were irradiated in three European reactors as well as in Duke Energy's McGuire Unit 1. Irradiation of these advanced alloys is continuing in additional European reactors and in Three Mile Island Unit 1 (TMI) in the United States. Four M5 fuel rods have recently begun a fourth operating cycle at Three Mile Island, and are expected to achieve rod average burnups of approximately 63,000 to 69,000 MWD/MTU by the time they are discharged in the fall of 2003 (Reference 2).

The design of the four Framatome lead test assemblies, previously irradiated in North Anna Unit 1, was based on the Framatome Mark-BW fuel assembly design which had previously been irradiated in other Westinghouse-designed reactors. However, the North Anna LTAs incorporated several advanced design features, including: an advanced (fine mesh) debris filter bottom nozzle, mid-span mixing grids (MSMGs), a floating top end grid (on two of the assemblies), a quick disconnect top nozzle, and use of an advanced zirconium-based alloy, M5, for the fuel assembly structural tubing. The majority of the fuel rods also had cladding fabricated from M5, although two assemblies each contained a limited number of fuel rods with cladding fabricated with a second advanced zirconium-based alloy, M4. Detailed descriptions of the assemblies and the evaluations performed to support their original use in North Anna Units 1 and 2 are given in References 4 and 5. NRC approval to irradiate the four Framatome lead test assemblies with the advanced cladding materials for up to three operating cycles was received in a license condition issued in May of 1997 (Reference 1), and the assemblies were irradiated in North Anna Unit 1 Cycles 13 through 15 (June 1997 through September 2001). Alloy M5 has since been approved by the NRC for use in reload batches of fuel (Reference 3).

The goal of the original LTA program at North Anna was to provide additional information on the behavior of the Framatome advanced cladding materials under the moderately severe commercial operating conditions typically experienced by fuel in the North Anna cores, as well as to demonstrate the performance of the Framatome fuel assembly advanced mechanical design features under in-reactor conditions. The assemblies were irradiated for three cycles in a manner that is representative of typical reload fuel use at North Anna Units 1 and 2, and achieved assembly average burnups of about 52,300 MWD/MTU (lead rod burnup of about 56,000 MWD/MTU).

Post irradiation examinations (PIE) of the lead test assemblies were performed during the program as permitted by the North Anna refueling schedules. Control rod drag was measured after each of

[3] M5 is a registered trademark of Fragema (France). Note that in the previous licensing submittals for the North Anna lead test assemblies (References 4 and 5), alloys M4 and M5 were designated as Alloy 4 and Alloy 5, respectively.

the three operating cycles. Additional examinations have included full length visual inspections, measurements of fuel assembly length and bow, oxide measurements on fuel rods and guide thimbles, and shoulder gap measurements (fuel rod length determination).

Based on the PIE testing to date, the primary candidate for use for a fourth cycle is Assembly FM3, which has a [

]. All four LTAs have comparable operating histories and burnups, and any evaluations described in this discussion are applicable for any of the four assemblies.

The NRC has also imposed a lead rod burnup limit of 60,000 MWD/MTU on North Anna which will be exceeded if one of the Framatome lead test assemblies is irradiated for a fourth cycle. The fuel burnup limit at North Anna resulted from a March, 1981 request to increase the North Anna maximum fuel enrichment to 4.1 weight percent U^{235}. It was recognized that this enrichment increase would allow an eventual increase in the discharge fuel burnups, and the NRC Safety Evaluation Report that allowed implementation of this change limited the fuel to a batch average burnup of 37,000 MWD/MTU. In late 1983, we requested removal of this batch average burnup limit, citing a Westinghouse topical report supporting higher burnups. The NRC concluded that it was appropriate to increase the limit to 45,000 MWD/MTU, but not remove the restriction entirely, as NRC review of the Westinghouse topical report was still in progress. This batch average burnup restriction was unchanged when the NRC approved an increase in the North Anna maximum fuel enrichment to 4.3 weight percent U^{235} in 1990.

In 1992, citing the NRC's approval of the Westinghouse high burnup topical report, we again requested that the NRC remove the batch average burnup restriction that had been imposed on the North Anna and Surry units. Upon review of our request, the NRC increased the batch average restriction to 50,000 MWD/MTU or above, provided that the maximum rod average burnup of any fuel rod is no greater than 60,000 MWD/MTU (References 6 and 7). This lead rod burnup restriction was not changed when the North Anna fuel enrichment limit was again increased in 2001 to its current value of 4.6 weight percent U^{235} (Reference 8). Because this burnup restriction is not explicitly stated in the North Anna Unit 1 and Unit 2 License Conditions or Technical Specifications, it was incorporated into Section 4.3.1.1 of the North Anna UFSAR to ensure that it is not exceeded when reload design evaluations are performed. The proposed irradiation of a lead test assembly to extended burnups at North Anna therefore requires NRC approval to exceed this restriction on lead rod burnup.

PROPOSED LICENSE CONDITION

The Design Features section of the North Anna Unit 2 Technical Specifications (Technical Specification 5.3.1) and Section 4.1 of the North Anna UFSAR allow for irradiation of a small number of lead test assemblies in non-limiting core locations with NRC approval. A license condition is being requested for North Anna Unit 2 to approve continued irradiation of one Framatome lead test assembly for one additional cycle, to lead rod burnups not to exceed 75000

MWD/MTU, as discussed in this submittal. This license condition would be a new North Anna Unit 2 license condition. No changes to the Technical Specifications or UFSAR are required.

REQUEST FOR EXEMPTIONS

As it was previously noted for the original use of the Framatome lead test assemblies at North Anna, several sections of the Code of Federal Regulations discuss cladding material. Specifically, Title 10 CFR 50.46(a)(1)(i) states that

> "Each boiling and pressurized light-water nuclear power reactor fueled with uranium oxide pellets within cylindrical zircaloy or ZIRLO cladding must be provided with an emergency core cooling system (ECCS) that must be designed so that its calculated cooling performance following postulated loss-of-coolant accidents conforms to the criteria set forth in paragraph (b) of this section. ECCS cooling performance must be calculated in accordance with an acceptable evaluation model and must be calculated for a number of postulated loss-of-coolant accidents of different sizes, locations, and other properties sufficient to provide assurance that the most severe postulated loss-of-coolant accidents are calculated."

Section 10 CFR 50.46 goes on to delineate specifications for peak cladding temperature, maximum cladding oxidation maximum hydrogen generation, coolable geometry, and long-term cooling.

Similarly, 10 CFR 50.44 (a) states that

> "Each boiling or pressurized light-water nuclear power reactor fueled with oxide pellets with cylindrical zircaloy or ZIRLO cladding, must, as provided in paragraphs (b) through (d) of this section, include means for control of hydrogen gas that may be generated, following a postulated loss-of-coolant accident (LOCA)..."

Since 10 CFR 50.46 and 10 CFR 50.44 specifically refer to fuel with Zircaloy or ZIRLO cladding, the use of a fuel assembly with alloys that do not conform to either of these two designations will require temporary exemptions from these sections of the code.

In addition, Title 10 CFR 50, Appendix K, paragraph I.A.5 states,

> "The rate of energy release, hydrogen generation, and cladding oxidation from the metal water reaction shall be calculated using the Baker-Just equation."

Since the Baker-Just equation was originally developed for the use of Zircaloy cladding, the use of a lead test assembly with advanced zirconium-based alloys also requires an exemption from this section of the code. Framatome has conducted high temperature oxidation testing to demonstrate that the Baker-Just equation can be used to conservatively predict the metal-water reaction rates in alloy M5 (Reference 9). In the absence of similar testing for alloy M4, an exemption from 10 CFR 50 Appendix K is required for irradiation of a Framatome lead test assembly using this material as one of the fuel rod cladding materials.

Although exemptions to these regulations are required because of the specific wording in the Code of Federal Regulations, the intent of these regulations will still be satisfied for the extended burnup operation of a Framatome LTA using fuel rods with M4 and M5. Specifically:

- The underlying purpose of 10 CFR 50.46 is to ensure that nuclear power facilities have adequately demonstrated the cooling performance of their Emergency Core Cooling System (ECCS). The effectiveness of the ECCS at North Anna Unit 2 will not be affected by the insertion of a single lead test assembly for a fourth operating cycle. Due to similarities in material properties of the two Framatome advanced alloys to Zircaloy-4, the ECCS performance in North Anna Unit 2 will not be adversely affected by the presence of the lead test assembly. Consequently, the use of the advanced zirconium-based claddings in one fuel assembly will not have a detrimental impact on the performance of the North Anna core under LOCA conditions.

- The intent of 10 CFR 50.44 is to ensure that there is an adequate means of controlling generated hydrogen. One source of the hydrogen produced in a post-LOCA scenario comes from a metal-water reaction. The Baker-Just equation was developed to assess the metal-water reaction rate for Zircaloy-4, but has also been confirmed to conservatively assess the metal-water reaction rates for Framatome's advanced zirconium-based alloys. Therefore, the amount of hydrogen generated by metal-water reaction in these materials will be within the design basis for North Anna Unit 2, and existing plant specific analyses for the total hydrogen generation following a LOCA will remain applicable for a core containing the Framatome lead test assembly.

- The intent of Paragraph I.A.5 of Appendix K of 10 CFR Part 50 is to apply an equation for rates of energy release, hydrogen generation, and cladding oxidation from a metal-water reaction that conservatively bounds all post-LOCA scenarios. Application of the Baker-Just correlation has been demonstrated to be conservative for the M5 alloy (Reference 9). The correlation also conservatively bounds the use of the M4 alloy due to the similarity between the alloy composition and Zircaloy-4.

Therefore, the intent of 10 CFR 50.46, 10 CFR 50.44, and 10 CFR Part 50 Appendix K will continue to be satisfied for the planned operation of the lead test assembly for an additional cycle, without compromising the safe operation of the reactor.

Finally, the NRC Safety Evaluation Report (SER) which approved the current Dominion reload nuclear design methodology (VEP-FRD-42 Rev. 1-A) concluded that the report is "...acceptable for referencing by Virginia Power in licensing Westinghouse supplied reloads of Westinghouse supplied reactors" (Reference 11). A revision of the Reload Nuclear Design Methodology topical report has been submitted to the NRC to document changes to the methodology implemented under 10 CFR 50.59, and to qualify the methodology for use with reload batches of Framatome fuel (References 12 and 13). Pending NRC review and approval of this revised topical report, we also request NRC concurrence to apply our standard reload design methodology to the North Anna Unit 2 core containing the Framatome lead test assembly.[4] Operation of a Framatome lead test fuel assembly to high burnup in North Anna Unit 2 will not affect the ability of our reload methodology to predict the core performance or conservatively assess the core response to accident scenarios.

SAFETY SIGNIFICANCE SUMMARY

The extended burnup of one Framatome lead test assembly will be fully addressed as part of the North Anna 2 Cycle 16 Reload Safety Evaluation. The same fuel assembly and fuel rod design criteria that must be met for normal operation of Framatome fuel will be shown to be satisfied for the planned fourth cycle of operation. Detailed thermal hydraulic evaluations have previously demonstrated that the North Anna core can be conservatively modeled as a full core of Westinghouse fuel (Reference 4), so use of a Framatome lead test assembly has no impact on the reload thermal hydraulic methods. A cycle specific nuclear design evaluation will be performed to demonstrate that a North Anna 2 Cycle 16 core containing a Framatome lead test assembly will meet all applicable design criteria, and will not adversely impact plant operation. The safety analyses of record are expected to remain applicable for the North Anna 2 Cycle 16 core. Cycle specific evaluations will be performed as necessary - e.g. for the control rod ejection transient and the Loss of Coolant Accidents - to confirm that the existing analyses based on the resident Westinghouse fuel design conservatively bound use of the Framatome lead test assembly. If the cycle specific evaluations are unable to demonstrate that any criterion will be satisfied, or indicate that the safety analyses of record will not bound the operation of the fourth cycle of operation for the Framatome lead test assembly, the assembly will not be irradiated and an alternate loading pattern will be developed for the North Anna 2 Cycle 16 core.

EVALUATION OF PROPOSED EXTENDED BURNUP PROGRAM

1. Lead Test Assembly Design Description

The lead test assembly to be irradiated for a fourth cycle at North Anna is one of four assemblies that were supplied by Framatome. The overall design is similar to the 17x17 standard lattice Mark-BW design made by Framatome specifically for use in Westinghouse reactors.

The lead test assembly design for North Anna (Figure 1.1) also incorporated several advanced components and features. These features are summarized below, and are described in detail in Reference 4.

1.1 Alloy M4 and M5 Fuel Rods

The fuel rod design for the North Anna lead test assemblies is very similar to the fuel rods in both the resident Westinghouse fuel and the Framatome Mark-BW fuel design. The primary difference is the use of two advanced zirconium-based alloys, M4 and M5, as cladding materials. Assembly

[4] If NRC review and approval of this revised topical report is completed prior to the start of North Anna 2 Cycle 16, no special concurrence will be required to apply our standard methodology to evaluations of the lead test assembly.

FM3 contains sixteen rods composed of M4 alloy, which are uniformly spaced around the periphery of the assembly, as shown in Figure 1.2. The cladding for the remaining fuel rods is M5. Except for the use of different cladding materials, the M4 and M5 fuel rod designs are identical.

Each fuel rod consists of a 144 inch stack of UO_2 pellets in a 0.374 inch diameter seamless tube made of M4 or M5. Zircaloy endcaps are welded to the cladding at each end, and the rods are prepressurized with helium. The fuel rods in the North Anna LTAs use a larger pellet diameter (0.3225 inch) and thinner cladding wall thickness (0.0225 inch) than used on typical Framatome Mark-BW fuel rods, but the dimensions are comparable to those found in the resident Westinghouse fuel. The design density of the fuel pellets in the LTAs was 96% theoretical density (TD), which is the same as for the Mark-BW fuel design, but slightly higher than the nominal UO_2 density in the resident Westinghouse fuel rods. The nominal enrichment of the fuel in the lead test assemblies, 4.2 w/o ^{235}U, is also typical of reload fuel assemblies for North Anna. A detailed description of the fuel rod design is given in Reference 4.

1.1.1 Cladding Materials

Alloys M4 and M5 are zirconium based alloys that were developed for high burnup, low corrosion, and low growth applications. Alloy M5 is a proprietary variant of Zr-1%Nb, while alloy M4 is a quaternary alloy consisting primarily of zirconium with small amounts of tin, iron, and vanadium. The compositions and material properties for alloys M4 and M5 are summarized in Reference 4.

Both materials have been used as cladding materials for fuel rods in demonstration assemblies in several European reactors, as well as in several U.S. reactors. The use of M5 cladding for reload batches of fuel has been approved by the NRC (Reference 3), with six reload batches having been delivered to U. S. reactors through the end of 2001. Demonstration programs are also continuing to operate M5 rods to higher burnups. Fuel rods with M5 cladding have completed three cycles of operation in Three Mile Island Unit 1 and North Anna Unit 1. A program is currently in progress at Three Mile Island to irradiate a small number of fuel rods for a fourth cycle, to burnups of about 63 to 69 GWD/MTU. Fuel rods with M5 cladding have also achieved burnups in the 53 to 58 GWD/MTU range in some European reactors, with one program in progress expected to achieve end of life burnups approaching 80 GWD/MTU. Fuel rods with M4 cladding have completed multiple cycles of operation at McGuire Unit 1 and Three Mile Island Unit 1, as well as at North Anna. Rods with M4 cladding have also been irradiated in several European reactors, where a small number of rods have reached burnups as high as 62 GWD/MTU.

Post irradiation examination data have shown that the uniform corrosion rate and irradiation growth for both M5 and M4 are approximately half that observed for low tin Zircaloy-4. No significant differences have been identified in the mechanical performance of fuel rods using M4 and M5 cladding.

Hot cell examinations have shown that M5 has a hydrogen pickup fraction about half that of Zircaloy-4, while the M4 hydrogen pickup fraction is about the same as for Zircaloy-4. However, because M4 has a significantly lower corrosion rate than Zircaloy-4, hydrogen accumulation in the M4 cladding is less than in Zircaloy-4.

1.2 Top and Bottom Nozzles

The Framatome LTA design incorporates a quick disconnect top nozzle assembly, which provides for easy removal and reattachment of the top nozzle with no loose parts. The top nozzle plate also utilizes a modified flow hole pattern that provides a larger flow area, and thus a lower pressure drop, than the traditional Framatome design. The LTA top nozzles use fuel assembly holddown spring sets with 4-leaf springs, versus 3-leaf springs on the Mark-BW design, to counteract the anticipated pressure drop associated with the use of mid-span mixing grids (MSMGs, described in Section 1.4 below) at the maximum flow conditions conservatively considered for the North Anna units.

The bottom nozzle on each LTA contains a fine mesh debris-filtering plate that is supported by a structural frame. Approximately 9000 mesh openings, each nominally 0.055 inch square, assure that the fuel rods are protected from debris throughout the design life of the fuel assemblies. The plate also provides a seating surface for the fuel rods, transmitting loads from the fuel rods to the structural frame. Debris-filtering bottom nozzles of this same design have been successfully incorporated on reload batches for Duke Energy's McGuire and Catawba reactors.

1.3 Guide Thimbles

The guide thimbles and instrument tube are dimensionally identical to those in the Framatome Mark-BW17 design, and are comparable to those found on older Westinghouse fuel assemblies used at North Anna (i.e., 17x17 LOPAR assemblies, with Inconel mid-grids). The only difference from the Mark-BW design is that the LTA guide thimbles and instrument tube were fabricated from Alloy M5.

The LTA guide tubes are connected to the top nozzle by a Type 304L stainless steel quick disconnect sleeve that is attached to the upper end of each guide thimble by a mechanical swage. An internally threaded end plug is also welded to the lower end of the thimble tube. A guide thimble bolt that engages the threads in this lower end plug connects the guide thimble to the bottom nozzle.

1.4 Spacer Grids

The LTA design incorporates a total of 11 grids. As shown in Figure 1.1, these include (from the bottom of the assembly to the top): an Inconel 718 bottom end grid, one vaneless Zircaloy-4 intermediate grid, five Zircaloy-4 intermediate grids with mixing vanes, three Zircaloy-4 mid-span mixing grids (MSMGs) located between the top four vaned intermediate grids, and an Inconel 718 top end grid.

The Inconel end spacer grids on the LTA are identical to those on the standard Mark-BW design. On the LTA that we currently plan to use for a fourth operating cycle, the end grids are also attached to the guide tubes in the same manner as on the Mark-BW design to prevent axial motion of these grids.

The Zircaloy intermediate spacer grids are the same design used on the Mark-BW fuel design except for a slight modification to the vane pattern. Like the Mark-BW fuel, the North Anna LTA design uses a vaneless intermediate grid in the lowest grid position (just above the bottom end grid), while the other five intermediate grids in the higher heat flux regions possess flow mixing vanes to improve DNB performance. The resident Westinghouse fuel utilizes mixing vane grids at all six intermediate grid locations.

Another standard Mark-BW design feature used on the lead test assemblies was the "floating" mid-grid design, whereby gaps were left between the grids and their restraining feature at time of fabrication. This allows the intermediate spacer grids to move axially upward, following the movement of the fuel rods as they grow due to irradiation, until burnup effects have significantly relaxed the Zircaloy spacer grids. This restraint system minimizes both slip loads in the fuel assembly and stresses in the fuel rods. Zircaloy restraining ferrules are attached to eight selected guide thimbles above each intermediate grid to limit the amount of axial movement. A ferrule is also attached to the instrument tube below the intermediate spacer grids (as well as the top end grid) to prevent downward motion of the grids.

The outer grid straps on both the intermediate and end grid designs have generous lead-in vanes and recessed weld land areas that aid in guiding the grids and fuel assemblies past projecting surfaces during handling.

Three mid-span mixing grids (MSMGs) are located mid-way between the upper four intermediate vaned grids to provide additional flow mixing in the high heat flux region of the fuel assembly. These grids are fabricated of Zircaloy-4, but use thinner and shorter strips than are used for the intermediate vaned grids. The MSMGs provide no grip force on the fuel rods, and so are designated as non-contacting grids. These grids have a slightly smaller envelope than the structural grids to eliminate mechanical interaction with adjacent fuel assemblies. (The resident Westinghouse fuel assemblies do not have grids at the MSMG elevations.) The MSMGs are rigidly attached to the guide thimbles, and are attached to different guide thimbles than the floating intermediate grids.

2. Mechanical Design Evaluation

2.1 Fuel Assembly

The original mechanical design calculations performed to support the use of the four Framatome lead test assemblies at North Anna considered four cycles of operation, to a lead rod burnup of [ ] MWD/MTU. A preliminary estimate indicates the lead rod burnup at the end of North Anna 2 Cycle 16 may approach 73 GWD/MTU, so the effects of a higher burnup must be addressed.

The mechanical design assessment of the lead test assembly to support a fourth operating cycle at North Anna will be performed by Framatome as part of the North Anna 2 Cycle 16 reload analysis. This assessment will consist of evaluations and analyses, supported by post irradiation examinations of the North LTAs performed to date, as well as additional examinations being completed in early 2002. Other information on Framatome fuel performance, including the M4 and M5 alloys, that has been obtained subsequent to the original LTA implementation at North Anna, will also be incorporated into the evaluation as appropriate.

The following sections summarize the aspects of the fuel design that will be addressed by Framatome, including: fuel assembly and fuel rod mechanical design; interfaces with reactor internals, resident fuel, fuel handling equipment and fuel storage racks; and fuel rod design criteria. The impact of extended burnup is addressed for each area, and additional evaluations or analyses that will be performed by Framatome to support the planned operation are identified.

2.1.1 Test Programs

2.1.1.1 Design Verification Testing

The Framatome LTA fuel design was supported by two comprehensive test programs to verify and characterize the mechanical and thermal-hydraulic performance (Reference 4). Full-scale prototype verification testing included environmental (life and wear), flow-induced vibration, mechanical static and dynamic behavior, RCCA drop time, and pressure drop tests. In addition to the full-scale prototype testing, various components were also characterized via mechanical testing, including the spacer grid static and dynamic crush strength, holddown spring assembly compression, mid-span mixing grid connection, and top nozzle quick disconnect attachment. The debris filter bottom nozzle assembly was also tested for debris filtering efficiency and pressure drop characteristics. The results of all prototype characterization testing have been incorporated into the various analytical models that will support use of an LTA for a fourth operating cycle to extended burnup.

2.1.1.2 PIE Results for North Anna Lead Test Assemblies

Post irradiation examinations were performed on the North Anna lead test assemblies after the first two cycles of operation. Some measurements were also performed when the LTAs were discharged from their third operating cycle in September 2001, although the third cycle PIE exams will not be completed until early 2002. The scope of the PIE testing that has been performed to date on these assemblies is summarized in Table 2.1.

The PIE tests on the North Anna LTAs have obtained data that support evaluations of the irradiation behavior of the two alloys used for the fuel rod cladding, the behavior of the M5 guide thimbles, the performance of the mid-span mixing grids, and the design of the top nozzle quick disconnect attachment. The results of these examinations are briefly summarized below.

Post-irradiation examinations to date have shown good results, confirming the existing M5 alloy database. After two cycles of operation, the maximum oxide thickness on the M5 fuel rods was approximately [ ] microns, which is consistent with other M5 corrosion data. The maximum oxide thickness on the M4 fuel rods was approximately [ ] microns, which again is comparable to other examination results for M4 fuel rods. At a comparable burnup, the maximum oxide thickness of Zircaloy-4 fuel rods is typically about [ ] microns. Additional fuel rod oxide measurements are being performed during the third-cycle PIE campaign in 2002, including measurements of M4 cladding oxidation. Based on the North Anna results to date and fuel rod oxide data from other measurements on the advanced cladding alloys, fuel rod corrosion is expected to remain low, and no corrosion or hydrogen pickup concerns are anticipated for the projected fourth cycle lead rod burnup of about 73 GWD/MTU.

The fuel rods in the Framatome LTAs have shown improved performance in rod growth, which is consistent with other data on these advanced alloys. The fully recrystallized M4 and M5 alloys continued to exhibit the advantages of that structure with respect to both growth and creep. After three irradiation cycles, the fuel rod growth was [ ] than the growth of cold-worked, stress-relieved Zircaloy-4 clad at comparable burnups. [ ].

The use of M5 guide thimbles in the North Anna LTAs has also resulted in lower fuel assembly growth than observed for fuel with Zircaloy-4 guide thimbles. After three cycles of operation and an assembly average burnup of about 52 GWD/MTU, [ ]. Typical Zircaloy-4 fuel assembly growth at comparable burnups is about [ ].

Additional measurements are being performed prior to irradiating one of the LTAs for a fourth cycle. This campaign, being conducted in early 2002, is designed to include measurements of: [ ]. Comparable examinations are planned on the four-cycle LTA after it is discharged from North Anna 2 Cycle 16.

2.1.2 Compatibility with Core Components, Handling Equipment and Resident Fuel

The Framatome lead test assemblies were designed for full compatibility with the North Anna mechanical interfaces, including core internals, control rods and other insert components, resident fuel, and shipping and handling equipment. The compatibility of the assemblies has been demonstrated through three successful cycles of operation at North Anna.

A fourth irradiation cycle for one assembly is not expected to compromise any compatibility interface. The primary areas that may be affected by the operation to high burnup are: mechanical interfaces affected by fuel assembly axial growth, such as interfaces with the core plates, handling and storage equipment, and adjacent fuel assemblies; fuel rod growth and available gap to the top nozzle; and interfaces affected by growth of the spacer grids, which can affect the fuel assembly lateral envelope.

2.1.2.1 Fuel Assembly Axial Growth

The original design analysis for the Framatome lead test assembly (discussed in Reference 4) used a growth rate of [ ] of the [ ]. This growth rate conservatively bounded the expected growth of the LTAs, and was used to verify the acceptability of the axial interfaces, such as closure of the gap between the fuel assembly and the upper internals. PIE measurements on the North Anna LTAs show the assemblies have experienced [ ] in length after the three cycles of operation. [ ]. Thus, conditions after the fourth operating cycle remain enveloped by the original design analyses, and compatibility with all external axial interfaces including reactor core plates, handling and storage equipment, and adjacent fuel assembly spacer grids will be maintained. The assembly being irradiated for a fourth cycle will not be in a rodded location in the core, so there are no concerns about the fuel assembly height affecting the ability to latch the control rod at high burnups.

Fuel assembly growth increases the holddown spring compression and load, but is offset by irradiation relaxation of the spring material. The original design analysis for the Framatome lead test assemblies used conservative assumptions to determine the holddown load required to prevent fuel assembly hydraulic lift, and sufficient holddown margin exists in the analysis to accommodate the effects of operation for a fourth operating cycle. [

].

2.1.2.2 Fuel Rod Growth

The Framatome LTAs for North Anna were originally designed with sufficient fuel rod shoulder gap to accommodate a lead rod burnup of [ ] GWD/MTU, with an end of life margin of about [ ] inch. Measurements on the assemblies at the end of their third operating cycle have shown that the original design analysis assumptions were conservative, and that sufficient fuel rod shoulder gap exists to support the projected end of life conditions for a fourth operating cycle.

2.1.2.3 Spacer Grid Growth

The intermediate and mid-span mixing grids on the North Anna lead test assemblies were fabricated from the same low-tin Zircaloy-4 material presently used for the grids on all Framatome fuel designs. Irradiation induced growth of Zircaloy-4 results in increases in envelope dimensions at high burnups, particularly for the upper grids, which accumulate higher neutron fluences and are exposed to higher fluid temperatures.

The LTA grid envelope during a fourth irradiation cycle is not expected to exceed the available fuel assembly-to-fuel assembly gaps in core. The Framatome LTA will be located in the center core location. This location, which is in the middle of the longest rows of fuel assemblies in the core, provides the largest available accumulated core gap to accommodate grid growth.

The acceptability of the spacer grid growth for the fourth irradiation cycle will be confirmed by use of existing Framatome Zircaloy-4 grid growth data in conjunction with third-cycle PIE measurements for the North Anna LTAs. The Framatome grid growth models will be conservatively extrapolated to the projected end of life burnup to verify the acceptability of the envelope interfaces for in-core use, as well as with fuel handling equipment and the spent fuel storage racks.

2.1.3 Structural Integrity – Normal Operation

The structural integrity of the Framatome lead test fuel assembly design was originally evaluated for both normal operation and faulted conditions (Reference 4). This structural integrity will be maintained, and all mechanical criteria will be satisfied for a fourth cycle of operation for one of these lead test assemblies. The original design loads and design corrosion values envelope those that the LTA has experienced to date and will experience during the fourth irradiation cycle. The low growth of the fuel assembly coupled with the continued relaxation of the holddown spring results in lower axial loads than those used in the original LTA design analysis. The low corrosion of the advanced fuel rod cladding alloys provides sufficient margins for operating to the projected end of life burnup. Non-zirconium alloy components such as the top and bottom nozzles and connections are non-limiting components for extended burnup operation, and will maintain sufficient structural margins throughout the fourth irradiation cycle.

2.1.3.1 Fretting Wear Resistance

The performance of the LTA spacer grid designs was originally demonstrated by a series of tests. Out-of-core flow induced vibration and life and wear testing indicated that the LTAs would experience minimal rod wear at all spacer grid locations, including the mid-span mixing grids. The Zircaloy intermediate spacer grids on the North Anna LTAs are the same design used on Mark-BW fuel, except for a slight modification to the vane pattern. The Mark-BW grids have operated in several Westinghouse-designed units for multiple cycles, with no history of grid to rod fretting failures.

The performance of the LTAs at North Anna through three operating cycles has been consistent with these test results and previous Framatome experience. Individual fuel rods have not been inspected for wear. However, in-mast sipping during core offloads has confirmed that no fuel failures have occurred in these assemblies, including following one cycle of operation in core baffle locations where grid to rod fretting defects have routinely occurred in the resident Westinghouse fuel design.

Fuel rod-to-grid contact forces should not change during a fourth cycle of operation, since the Zircaloy-4 grid soft stops will have reached the maximum expected amount of irradiation relaxation by about the end of the first operating cycle. In addition, the maximum fuel rod clad diameter creepdown was predicted during the first cycle of operation. After this point is reached, the increasing fuel rod clad diameters will increase the grid softstop deflection and thus the fuel rod contact force, although the effect is minimal. Therefore, fuel rod contact forces should remain within the range of those experienced during previous operating cycles, and no degradation of fuel rod-to-grid fretting performance is anticipated.

2.1.3.2 Fuel Assembly Distortion

The Framatome LTAs have not exhibited excessive fuel assembly distortion through three cycles of operation. The LTAs were placed in control rod locations during the second irradiation cycle, and beginning of cycle rod drop testing showed no obvious difference in the control rod drop times for these assemblies compared to the resident fuel. Control rod drag tests have also been performed on the LTAs in the spent fuel pool following each irradiation cycle. Lower drag forces were measured after three cycles of operation than had been measured after two cycles, indicating a reduction in fuel assembly distortion in the third cycle. The drag tests have demonstrated that the magnitude of fuel assembly bow in the Framatome fuel assembly design is sufficiently low that no adverse effect is expected on the functional performance of insert components.

After three cycles of operation, [

], so no concern for fuel assembly distortion exists. It may also be noted that the Framatome lead test assembly that will be irradiated for a fourth cycle will be placed in the center of the North Anna 2 Cycle 16 core. This is not a rodded location, and there are currently no plans to place any other insert component in the center assembly during this cycle.

2.1.3.3 Top Nozzle Attachment

The Framatome LTA fuel design uses a reconstitutable, quick-disconnect top nozzle. This design includes a stainless steel sleeve that is attached to the guide thimble by mechanical deformation, and which is attached to a locking ring contained within the top nozzle.

The functional torques required to rotate the locking ring were measured after the second irradiation cycle. The torques were within expected ranges, and no anomalies were identified.

Although the joint of the top nozzle sleeve to the guide tube is similar to a joint that failed on a Westinghouse fuel assembly at North Anna in March, 2001, the joint on the Framatome LTA is not susceptible to the intergranular stress corrosion cracking (IGSCC) failure mechanism that has been identified as the cause of the North Anna top nozzle separation. The Framatome fuel assembly uses type 304L stainless steel sleeves, which have a lower carbon content that the type 304 stainless steel sleeves that failed. Type 304L stainless steel is more resistant to IGSCC. In addition, there were no LTA fabrication conditions, such as heat treatments that would sensitize the material, that might degrade the IGSCC resistance of the stainless steel sleeves on the Framatome assemblies.

Mechanically deformed joint designs with similar geometries and materials have also been used extensively for Framatome fuel in France with no problems. Reactor water chemistry controls that closely follow the EPRI guidelines are utilized at the North Anna plants to mitigate any concerns with IGSCC. There have also been no recent chemistry excursions in the North Anna spent fuel pool that would increase the potential for IGSCC of the mechanical joint of the stainless steel sleeves to the guide thimbles.

2.1.3.4 Holddown Springs

The holddown springs and clamp screws have been shown to operate sufficiently after three cycles of operation. The springs were designed conservatively to accommodate the additional hydraulic lift of the mid-span mixing grids. Conservative assumptions were utilized in the design analyses. The actual spring load will be confirmed as part of the PIE following the third irradiation cycle. A subsequent holddown evaluation prior to the fourth irradiation cycle of the LTA will confirm the margin to prevent fuel assembly lift.

The spring clamp screws on the Framatome LTAs are made of Inconel 718. This material is not sensitive to clamp screw cracking problems exhibited by some other fuel designs that used Inconel 600 screws. Inconel 718 clamp screws have been used successfully with no failures in the Framatome Mark-BW fuel as well as in other Framatome fuel designs in Europe. A fourth cycle of operation will have a negligible effect on the holddown spring and clamp screw margins to design limits.

2.1.4 Seismic and LOCA Mechanical Evaluation

The fuel assembly is designed to ensure control rod insertion and maintain a coolable geometry for faulted conditions. The original evaluations of the Framatome lead test assemblies specifically addressed the mixed core horizontal seismic and LOCA loads, and a separate vertical LOCA analysis was also performed (Reference 4). It should also be noted that the Framatome LTA will not be placed in a rodded location for its fourth operating cycle, so the extended burnup of this assembly will not affect control rod insertion in North Anna 2 Cycle 16.

The structural integrity of the LTA will be maintained for a fourth irradiation cycle. The maximum guide thimble oxide measured after the second irradiation cycle was [ ]. Additional guide thimble oxide measurements are planned for the PIE campaign being conducted in early 2002 to confirm the continued low oxidation rate. With low oxidation levels, the guide thimble structural margins are expected to remain basically unchanged from the original analysis.

Oxidation of the grids, which are fabricated of Zircaloy-4, will reduce the thickness of the grid straps, and so can adversely affect grid strength. However, the effects on grid strength due to a reduction in grid thickness will be offset by the increase in the material yield strength that occurs upon irradiation. Oxide measurements of the LTA grids are planned as part of the 2002 PIE program to verify that excessive oxidation has not occurred.

The limiting LTA grid margins are based on fuel assembly faulted condition loads for a short fuel assembly row. In its fourth operating cycle, the Framatome LTA will be placed in the center core location, which is in the center of a row of 15 fuel assemblies. The fuel assembly faulted condition loads are lower for the longer fuel assembly rows than for the short row configuration on which the design margins were based. In addition, the original analyses of the LTA grids showed the limiting faulted condition grid loads to be less than the unirradiated grid elastic load limit, considering the worst case transition core configuration. Therefore, sufficient margin exists in the grid design to ensure that the structural integrity of the LTA and a coolable core geometry will be maintained for the fourth cycle of operation.

2.2 Fuel Rod Design

The same fuel rod design criteria that are normally evaluated by Framatome for reload fuel will be assessed for the fourth cycle of operation of the lead test assembly. The evaluations of these criteria are discussed below. The impact of extended fuel assembly burnup on fretting wear and fuel rod growth allowances were discussed in Sections 2.1.3.1 and 2.1.2.3, respectively. All fuel rod design criteria will be shown to be satisfied for the planned operation.

2.2.1 Rod Internal Pressure

Fuel rod thermal performance analyses, including evaluation of the end of life rod internal pressure, will be performed for the operation of the Framatome LTA in North Anna 2 Cycle 16 as part of the cycle specific reload design calculations. The rod internal pressure evaluations will be performed with the NRC-approved TACO3 fuel rod thermal performance code (References 14 and 15). If the NRC's Safety Evaluation Report on the COPERNIC code (Reference 16) is issued before these cycle specific analyses are performed, it is also possible that this code may be used. However, use of either of these models and their associated methods to evaluate the fourth cycle of operation of the lead test assembly will require their application to burnups beyond Framatome's current licensed burnup limits.

The maximum fuel rod internal pressure at the end of the fourth operating cycle will be determined using actual power history information for the first three operating cycles. The projected power history and axial flux shapes (both steady state and transient shapes) for the fourth operating cycle will be generated by Dominion as part of the normal reload design process for North Anna 2 Cycle 16. This information will be generated in a manner consistent with Framatome's NRC-approved methodologies, using Dominion's standard design codes. The fuel rods in the Framatome lead test assembly will be required to remain below the Framatome criterion for operation above system pressure defined in Reference 15.

2.2.2 Fuel Rod Cladding Stress and Strain

The fuel rod cladding for the Framatome LTA was evaluated for the stresses induced during operation. Generic stress analyses performed by Framatome were reviewed, and were determined to bound the projected end of life conditions for the M4 and M5 rods in the lead test assemblies after a fourth cycle of operation. [

]. Based on the results of the generic analysis, the M4 and M5 clad fuel rods in the North Anna lead test assemblies were determined to retain margin to the allowable stress limits for the proposed operation to extended burnup.

[

]. The evaluation of the M4 and M5 fuel rods for this limiting condition was performed as part of the original design analysis for the Framatome lead test assemblies (Reference 4).

It has therefore been concluded that the M4 and M5 clad fuel rods in the North Anna lead test assemblies will not be adversely impacted by any stresses resulting from the proposed operation, and will retain margin [ ] throughout the proposed operation to extended burnup in North Anna 2 Cycle 16.

As part of the original design calculations (Reference 4), the LTA fuel rods were also analyzed to determine the [

]. The LTA fuel rods will demonstrate acceptable fuel rod cladding transient strain performance, to burnups beyond the projected North Anna 2 Cycle 16 lead rod burnup.

2.2.3 Fuel Rod Oxidation and Hydriding

As discussed in Section 1.1.1, both the M4 and M5 fuel rod cladding materials exhibit a strong resistance to corrosion. Previous irradiation experience with these claddings has shown the corrosion to be less than one half the corrosion of low-tin Zircaloy claddings. The projected upper limit on the end of life corrosion for the LTA fuel rods after a fourth operating cycle is about [ ]. This limit is based on the present database of M5 corrosion measurements and the operating conditions at North Anna. [ ]. These levels of corrosion and associated hydriding will not adversely affect the structural integrity of the fuel rod during its design lifetime. It is concluded that the M5 and M4 claddings will exhibit acceptable oxidation and hydriding performance for the LTA projected lead rod burnup of about 73 GWD/MTU.

2.2.4 Fuel Rod Cladding Fatigue

An analysis of the fuel rod total fatigue usage factor has been performed by Framatome using the methodology of Reference 9 and the procedures outlined in the ASME Code. [

].

The analysis assumed a fuel rod lifetime of [ ], with the total number of Condition I, II and III events being taken from Table 5.2-4 of the North Anna UFSAR. This assumed lifetime bounds the operational lifetime of the LTA rods that will operate for a fourth cycle. The analysis also assumed conservative inputs for cladding thickness, oxide layer buildup, external pressure, internal fuel rod pressure and differential temperature across the cladding.

The maximum calculated fatigue usage factor was well below Framatome's maximum allowable fatigue usage factor of [ ]. It is therefore concluded that acceptable margin to the fatigue usage limit exists to support operation of an LTA for a fourth cycle of irradiation.

2.2.5 Plenum Spring Solid Height

The fuel rod design must provide sufficient plenum space to ensure the spring does not go solid due to fuel stack expansion. If the spring were to go solid, it would prevent free expansion of the fuel pellets, and could also apply higher than normal loads on the clad to end plug weld.

Framatome performed a calculation for the LTA fuel rod design using the maximum predicted fuel stack expansion concurrently with the worst case cladding and plenum spring dimensions. It was determined that sufficient plenum space is provided that the plenum spring will not be compressed to its solid height for the projected end of life burnup of approximately 73 GWD/MTU.

2.2.6 Fuel Rod Cladding Creep Collapse

The Framatome LTA fuel rod design was analyzed for cladding creep collapse using the CROV code and methods outlined in Reference 18. [

]. It was determined that the creep collapse lifetimes of the LTA fuel rods are greater than the projected lead rod burnup at the end of the proposed fourth cycle of irradiation.

3.0 Thermal Hydraulic Evaluation

Detailed thermal hydraulic evaluations were performed to support the use of the four Framatome LTAs with resident Westinghouse fuel in previous North Anna cores (Reference 4). These analyses were performed by Framatome using NRC-approved models and methods, and included evaluations of unrecoverable core pressure drop, hydraulic lift forces, inter-bundle crossflow, and DNB performance.

The hydraulic compatibility, DNB performance, and rod bow evaluations in Reference 4 are briefly summarized below. These evaluations remain applicable for irradiation of a single lead test assembly to high burnup, and there are no plans to repeat these analyses. Cycle specific calculations will be performed to address the effects of high burnup on the fuel temperature calculations.

3.1 Hydraulic Compatibility

The Framatome LTA and resident Westinghouse fuel assemblies are hydraulically similar with the exception of a slightly smaller thimble tube diameter for the recent Westinghouse fuel designs and higher grid pressure drop for the LTA design. The LTA also incorporates three mid-span mixing grids, which are not utilized on the resident fuel design.

The hydraulic compatibility analyses previously performed by Framatome for the LTA design (Reference 4) concluded that:

- There is only a small difference between the predicted pressure drops for a full core of fuel of the LTA design and a full core of the resident fuel design. These two cases bound the operation of a single lead test assembly in a core of the resident Westinghouse fuel.

- The lift performance of the resident fuel is insignificantly affected by the presence of a lead test assembly. The lift forces for the LTA design were considered in the design of the lead test assembly holddown springs.

- Span average crossflows for a single Framatome LTA in a core of Westinghouse fuel assemblies are sufficiently low to preclude unacceptable flow induced vibration of the fuel rods.

- The effect on the overall core bypass flow is negligible.

Evaluations of hydraulic compatibility are primarily dependent on the geometry of the fuel assemblies and the flow conditions in the core. The LTA design for high burnup operation is unchanged from that evaluated in Reference 4, nor have there been any design changes to the resident Westinghouse fuel that would affect the compatibility calculations. Because the LTAs were previously licensed for use in either North Anna unit, the calculations assumed flow conditions that bounded the conditions in North Anna Units 1 and 2. The hydraulic compatibility evaluations summarized in Reference 4 therefore remain applicable for the use of a single lead test assembly in a core of Westinghouse fuel in North Anna Unit 2.

3.2 DNB Performance

To demonstrate that the DNB performance of the Mark-BW17 lead test assembly design is non-limiting, calculations were performed by Dominion for the resident Westinghouse fuel and by Framatome for the mixed core configuration using the applicable statistical DNBR methodologies and CHF correlations. [

]. These calculations, described in Reference 4, demonstrated that the lead test assembly design has more margin to the applicable DNB limit than the resident Westinghouse fuel has to its limit.

The plant parameter ranges and uncertainties used in the DNB evaluation in Reference 4 have been reviewed and determined to remain applicable for North Anna 2 Cycle 16. Neither the fuel designs nor the plant parameters that affect this analysis have changed, and the peaking factors in the reinserted LTA will also be significantly less than those considered in the original design. Therefore, the conclusions of the original DNB evaluation for the Framatome lead test assembly design remain applicable for operation of one of those assemblies to high burnup in North Anna 2 Cycle 16.

It is therefore concluded that cycle specific DNB analyses for North Anna 2 Cycle 16 and UFSAR non-LOCA analyses with DNB acceptance criteria that assume a full core of Westinghouse fuel will be conservative for a North Anna core containing the lead test assembly.

3.3 Rod Bow

Fuel rod bow is driven by the irradiation growth of the fuel rods and friction with the supporting guide structure. The fuel rods in the lead test assembly that will be irradiated for a fourth cycle use

Alloys M4 and M5 for the fuel rod cladding. These materials have both demonstrated low growth characteristics, which is advantageous in minimizing fuel rod bow. The Framatome lead test assemblies use essentially the same grid designs and fuel rod dimensions as the Mark-BW fuel, so similar grid forces are exerted on the fuel rods. Each design is self-consistent in the use of materials for fuel rods and guide thimbles, with the Mark-BW fuel using Zircaloy-4 cladding and guide thimbles, and the lead test assemblies using M4 and M5 (or all M5) cladding in skeletons with M5 guide thimbles. It is therefore appropriate to apply fuel rod bow penalties to the lead test assemblies in the same manner they are applied to the Mark-BW fuel design.

For Mark-BW fuel, the phenomenon of fuel rod bowing is included in DNBR safety analysis by assessing a DNBR penalty. However, no DNBR penalty is assessed for burnups greater than 24 GWD/MTU since design peaking factors cannot be reached. As the Framatome LTAs have already achieved burnups over 52 GWD/MTU, there will be no rod bow impact on the DNBR evaluation for the fourth cycle of operation of an LTA.

3.4 Impact on Reload Evaluation Methodology

The analyses previously performed by Framatome demonstrated that use of a lead test assembly in a core of Westinghouse fuel will have a negligible impact on the core pressure drop, hydraulic lift forces on the resident fuel, span average crossflow, and overall core bypass flow. The DNB performance of the lead test assemblies is bounded by the DNB performance of the resident Westinghouse fuel. Therefore, cycle specific thermal hydraulic evaluations for North Anna cores containing the high burnup Framatome lead test assembly can conservatively be modeled as a homogeneous core of Westinghouse fuel assemblies. There is no impact on the models or methods normally used by Dominion to perform thermal hydraulic analyses of the core, and no transition core penalties must be applied.

3.5 Fuel Rod Heat Rate to Melt

Because the melting temperature of UO_2 decreases with burnup, operation to high burnup requires that the potential for fuel melt be reassessed. The fuel temperatures for the high burnup lead test assembly will be evaluated using Framatome's TACO3 fuel rod thermal performance code (Reference 14). The peak local power at which fuel melt is predicted to begin will be determined as a function of burnup. The results of these calculations will be used to show that the minimum power at which fuel melting will occur exceeds the maximum local power that may be reached by the fuel rods in the high burnup lead test assembly during normal operation and Condition II transients. Because this evaluation relies on cycle specific calculations of the peak local powers in the high burnup fuel assembly, this evaluation will be performed as part of the normal reload design process for North Anna 2 Cycle 16.

The effect of burnup on the fuel melting temperature also has the potential to affect safety analyses, as discussed in Sections 5 and 6 below.

4.0 Neutronic Performance

Consistent with References 11 and 12, a nuclear design evaluation will be performed for North Anna 2 Cycle 16 to demonstrate that the reload core containing a Framatome lead test assembly operating to high burnup will meet all applicable design criteria. This evaluation will be performed under the normal reload design process and schedule, and will be documented in the cycle specific Reload Safety Evaluation.

4.1 Impact of Framatome Assembly on Core Design

The physical differences between the Framatome lead test assembly and the resident Westinghouse fuel are small. As for the previous three cycles of irradiation for the Framatome LTAs, the cycle specific neutronic calculations for the fourth cycle of operation of one of the LTAs will account for the effects of the composition of the M4 and M5 fuel rod cladding materials and the use of M5 for the guide thimbles and instrument tube. The presence of the Zircaloy-4 mid-span mixing grids and the impact of the higher nominal fuel density will also be incorporated into the analyses.

As a result of the general physical similarity to the resident Westinghouse fuel designs, the LTA has essentially the same neutronic behavior as the resident fuel assemblies. On an equal enrichment basis, the lead test assembly initially exhibited reactivity similar to the resident Westinghouse fuel. Due to the higher uranium loading (primarily the result of a higher nominal fuel density), the rate of depletion of reactivity is slightly smaller for the LTA than for the majority of the fuel in the North Anna core. This difference is explicitly modeled in the cycle specific neutronic calculations and does not adversely impact plant operation.

Changes to the neutronic model inputs necessary to model the physical differences between the lead test assemblies and the resident Westinghouse fuel assemblies are similar to those used for previous Westinghouse fuel product changes, and are of a smaller magnitude than was necessary for many of the Westinghouse fuel product changes. It was concluded in Reference 4 that both the Nuclear Design Reliability Factors normally used for core design calculations and the methods and models used to verify local rod powers for Relaxed Power Distribution Control analyses remain valid for use with the Framatome LTA design. The core reactivity coefficients and nuclear performance for the three North Anna cores containing the Framatome LTAs were not noticeably different from recent reload cores consisting of all Westinghouse fuel, confirming the applicability of Dominion's standard reload core design models and methods to cores containing a Framatome lead test assembly.

The Framatome lead test assembly was irradiated in high power locations for its first two operating cycles, and was placed in a low power location on the periphery of the core for its third operating cycle. This irradiation history is typical for fuel assemblies that operate for three cycles in the North Anna units. For the fourth operating cycle, the LTA will be located in the center of the core. Although this is typically a moderately high power location, because of the relatively low reactivity of the LTA after three cycles of operation, the assembly power will average only about 0.85 times the core average power over the length of the cycle. To minimize the effect of the presence of a very low reactivity assembly in the center of the core on the overall cycle reactivity, the enrichment of the fresh fuel assemblies for Cycle 16 is being increased slightly (0.05 weight percent U^{235}). The enrichment of these fresh fuel assemblies will still remain below the current enrichment limit of 4.6 weight percent U^{235}. The radial and axial power peaking factors for North Anna 2 Cycle 16 will remain consistent with other recent North Anna core designs.

Because of its core location and low reactivity, the lead test assembly will not experience the highest fuel rod power density in Cycle 16. The LTA will also not be limiting with respect to any safety analysis limit for North Anna 2 Cycle 16, meaning that F_Q and $F_{\Delta H}$ margins will be preserved for the LTA and no reactor safety or operating limits will be modified to accommodate the higher burnup of this assembly.

4.2 Applicability of Core Design Models to Extended Burnups

The nuclear design evaluation for North Anna 2 Cycle 16 will be performed by Dominion using our standard calculation methods and procedures. The nuclear design model used by Dominion (PDQ) accurately modeled the Framatome lead test assemblies for the first three cycles of operation. Scoping calculations were performed to confirm that PDQ will also perform acceptably at high burnups. Based on the absence of any unusual behavior or adverse trends in these scoping calculations, PDQ is also expected to accurately model the Framatome LTA for the fourth operating cycle. Dominion also has previous experience modeling extended burnup fuel at North Anna, successfully using our standard design models and calculation methods to model a small number of Westinghouse fuel rods that operated to burnups comparable to the expected end of life burnup of the Framatome lead test assembly.

4.3 Spent Fuel Pool Impact

As noted in Reference 4, the use of the Framatome lead test assembly has no significant impact on spent fuel pool calculations. A new analysis of the North Anna spent fuel pool has been approved by the NRC (Reference 8) since approval was initially received to irradiate the Framatome LTAs. This new spent fuel pool analysis has been reviewed, and it has been confirmed that sufficient margin exists to accommodate the effects of the fuel assembly design differences, including the higher nominal density, of the Framatome fuel design.

The North Anna Technical Specification 3/4.7.15 now includes fuel storage restrictions that are based on the burnup and initial enrichment of the fuel. The Framatome lead test assemblies have already accumulated sufficient burnup that they may be placed in any fuel storage location in the North Anna spent fuel pool. Operation for a fourth cycle will decrease the reactivity of the fuel assembly, and so will not affect the storage requirements for the assembly.

With respect to potential impact on the spent fuel pool heat load, the major contributor to the heat load immediately after the core offload is decay heat from short-lived isotopes. During normal operation, these isotopes tend to reach an equilibrium condition that is primarily dependent on the operating power of the fuel, and the concentrations do not change significantly with burnup. Therefore a high burnup assembly operating at less than the core average power will not affect the limiting case analysis currently described in Section 9.1.3.3 of the North Anna UFSAR. The decay heat load on the spent fuel pool is also checked as part of each Reload Safety Evaluation. If the operation of a lead test fuel assembly to high burnup could lead to conditions that would adversely affect the decay heat load on the pool, the effect would be detected as part of the North Anna 2 Cycle 16 cycle specific reload evaluation, at which time the heat load can be reassessed if necessary.

A portion of the spent fuel pool heat load is due to long-term decay heat from assemblies stored in the spent fuel pool. This long-term decay heat load is caused by longer lived actinides, which increase with burnup. Therefore, higher fuel burnups will slightly increase this contribution to the pool heat load. However, under the proposed program only one assembly will reach high burnup. Since one assembly represents such a small fraction of the total number of fuel assemblies in the spent fuel pool, the ultimate impact of a high burnup Framatome lead test assembly on the long-term decay heat contribution to the spent fuel pool heat load is expected to be negligible. In addition, it should be noted that for the limiting case analysis discussed in Section 9.1.3.3 of the UFSAR, the heat contribution from such older fuel is itself only a small portion of the total spent fuel pool heat load. It is therefore concluded that the storage of a high burnup Framatome lead test assembly in the spent fuel pool after its final discharge will not affect the spent fuel pool heat load analysis currently described in the North Anna UFSAR.

5.0 Non-LOCA Safety Evaluations

5.1 Impact of Framatome Fuel Assembly Design on Evaluations

The impact of the Framatome lead test assembly design features on the North Anna non-LOCA safety analyses was addressed as part of the original evaluation supporting the use of 4 such assemblies (Reference 4). The majority of the design features of the Framatome LTAs are identical or comparable to those on the Westinghouse North Anna Improved Fuel (NAIF) design. The primary differences of the Framatome LTA design, and how they compare to the NAIF design, are:

1. Increased fuel assembly pressure drop
2. Reduced fuel average temperature
3. Presence of Mid-Span Mixing Grids (MSMGs)
4. Increased guide thimble tube inner and outer diameter
5. [ ]

The non-LOCA events were considered in two broad categories: events with a DNB acceptance criterion, and events with all other acceptance criteria.

Analyses were performed that demonstrated the DNB analyses performed for full cores of NAIF assemblies provide bounding results for application to the Framatome LTA design. Therefore, existing non-LOCA event analyses for North Anna having a DNB acceptance criterion are conservative for the LTA design.

For non-LOCA events that do not have a DNB acceptance criterion, the only key parameters affected are those used as inputs for performing a detailed cladding temperature calculation: the Locked Rotor and Rod Ejection events. Assessment of the specific differences between the Framatome LTA and the Westinghouse NAIF designs (Reference 4) concluded that the existing analyses performed for the NAIF design are applicable for the Framatome lead test assemblies in North Anna.

The impact of operating a fuel assembly to extended burnup is addressed below.

5.2 Impact of High Burnup Fuel Assembly on Evaluations

The non-LOCA analyses were reviewed to assess which accidents could be affected by operation of a fuel assembly to extended burnup. The one physical property affected by the fuel burnup that has the potential to affect safety analyses is the melting temperature of UO_2, which decreases with burnup. For most Condition III and Condition IV transients, the fuel temperatures remain far below the fuel melting temperature, so operation to high burnup will not affect the analyses of record.

One notable exception is the control rod ejection transient. For the rod ejection accident at North Anna, limited melting (<10% of the pellet) is predicted to occur at the hot spot in the core. The analysis of this accident is based on conditions in the peak rod in the core, which is typically a fresh or once burned fuel rod. However, because the melting point of UO_2 decreases with burnup, a cycle specific evaluation will be performed to support the operation of an extended burnup lead test assembly for a fourth operating cycle, to confirm that the presence of the high burnup rods does not affect the North Anna analysis of record for the rod ejection transient. This is not expected to present any difficulty, as the fuel rods in the high burnup assembly will be operating at less than the core average power. Also, the predicted effect of an ejected rod tends to be very localized, and the LTA location in the center of the core is well away from core locations that have historically been limiting for the rod ejection transient at North Anna. The base analysis for this accident is therefore not expected to be affected by the presence of a high burnup assembly in the center of the core.

An additional consideration for this evaluation is that, based on results of recent tests at the CABRI test loop, the current coolability criterion of 280 cal/g for the reactivity insertion accidents has been challenged for fuel at high burnups. Significant fuel dispersal was measured in high burnup fuel at reactivity insertion rates of approximately 100 cal/g. Most of these failures were in fuel with significant oxide spallation. The NRC and the industry are continuing to evaluate the appropriate criteria for fuel with significant burnup. The EPRI-sponsored Robust Fuel Program (RFP) is proposing a 120 cal/g failure limit for unspalled clad, and a higher limit for advanced cladding materials. In the absence of new Regulatory Guides or other published limits that are appropriate for the high burnup Framatome lead test assembly, cycle specific evaluations supporting operation of the LTA to an assembly average burnup approaching 70 GWD/MTU in North Anna 2 Cycle 16 will demonstrate compliance with the proposed RFP criteria. It is expected that the maximum reactivity insertion experienced by the LTA - with advanced alloy cladding, and no evidence of oxide spallation after three operating cycles - during a rod ejection accident will be significantly less than the proposed EPRI limit for unspalled Zircaloy-4 clad.

If the cycle specific evaluation for North Anna 2 Cycle 16 determines that the current rod ejection analysis is affected by the presence of the high burnup fuel, or the RFP guidelines are not satisfied, consistent with the requirements of 10 CFR 50.59 either a new analysis will be performed and appropriate NRC approval obtained, or the assembly will be removed from the core loading pattern, as discussed in Section 8 below.

5.3 Radiological Consequences

The proposed high burnup program at North Anna will not affect normal radiological plant effluents. A report has been submitted to the NRC to allow both PWR and BWR utilities to justify the operation of limited scope lead test assemblies to high burnups (lead rod burnups of 75 GWD/MTU) on a 10 CFR 50.59 basis (Reference 19). This report, which is currently under NRC review, notes that the effects of high burnups on source terms and the associated doses have been discussed in previous submittals (Reference 20). These evaluations determined that operation to high burnups increases the inventory of certain long lived fission products such as Cs^{134} and Cs^{137}, but even with routine operation of entire reload batches to high burnup and no changes in the reactor coolant cleanup, there would be only a small increase in the annual release of these isotopes. Even assuming extended burnup of a Framatome LTA results in some increased contribution to the core inventory of long-lived isotopes, with only a single assembly operating to high burnup (about 0.6% of the fuel rods in the core) there will be no measurable increase in the levels of these isotopes in the coolant, and no effect on normal operating plant releases.

The accidents where the radiological consequences may be impacted by the presence of a high burnup fuel assembly fall into three categories: the fuel handling accident; accidents with cladding failure only; and accidents with both cladding failure and fuel melt.

The fuel handling accident involves a single fuel assembly. The analysis of this accident for North Anna follows NRC Regulatory Guide 1.25, and is based on a limiting assembly operating at 1.65 times the core average power. The analysis assumes the accident occurs 100 hours after the reactor shuts down (even though the North Anna Technical Specifications currently prohibit fuel movement until 150 hours after shutdown), and assumes the cladding of all rods in the fuel assembly is damaged. The effective decontamination factor assumed for iodine releases in the analysis of record (DF=100) is also consistent with Regulatory Guide 1.25. Because operation of the Framatome LTA to extended burnup may result in a higher than normal end of life cold rod internal pressure, an assessment will be performed for this assembly to confirm that the use of this decontamination factor remains conservative for the Framatome LTA after a fourth cycle of operation.

The doses from the fuel handling accident are primarily due to short lived iodine and noble gas isotopes. Because of their short half lives, the quantities of these isotopes present in the fuel-to-clad gap of the fuel rods tend to reach an equilibrium between production and decay during operation, so that the isotopic inventory available for release is primarily a function of operating power and decay time after operation rather than cumulative burnup. For the Framatome LTA, the assembly average power during North Anna 2 Cycle 16 will be less than the core average power, and thus well within the assumed power for analysis of the fuel handling accident. Consequently, the activity releases that would result from damage to the rods in this assembly would be considerably lower than those determined for the North Anna analysis of record for this accident.

For accidents such as the steam generator tube rupture (SGTR) and the main steam line break (MSLB), no fuel failures are predicted to occur as a consequence of the accident, and the calculated doses are based on failures that exist at the time of the accident. For North Anna, analyses of loss of flow accidents show that the minimum departure from nucleate boiling ratio (DNBR) does not decrease below the limit, so no cladding failure or release of fission products is expected. For the current North Anna locked rotor accident (LRA) NSSS thermal-hydraulic analysis, no fuel rods are predicted to experience DNB. However, the offsite dose calculation for the LRA conservatively assumes failure and gap activity release for 13% of the fuel rods. (The 13% value is based on an analysis of the LRA that has been superseded.) In general, any failures during a LRA would be expected to occur in high power locations because high power fuel rods are more likely to enter a boiling regime during a transient. The fuel rods in the high burnup Framatome lead test assembly, operating at powers below the core average power, would not be expected to fail for this accident scenario. In addition, releases for the LRA involve only gap activity which, as discussed above for the fuel handling accident, is primarily a function of operating power rather than cumulative burnup. Since current analyses predict no other fuel rod failures during the LRA, even if all the fuel rods in the high burnup assembly should fail for some unanticipated reason, there would be no impact on the current dose calculations for this accident.

The third class of accidents encompasses those accidents that predict both cladding failure and some degree of fuel melt. These include the large break loss of coolant accident (LBLOCA), small break loss of coolant accident (SBLOCA) and the rod ejection accident. Dose calculations for these accidents are bounded by the evaluation of the LBLOCA, which conservatively assumes damage to the entire core. The North Anna LBLOCA analysis follows the guidelines of Regulatory Guide 1.4, which requires the dose calculations be based on specific distributions of the core inventory of fission products (not just the material present in the fuel-to-clad gap). As for most accidents, the doses are primarily due to short lived iodine and noble gas isotopes, and the core inventory of these isotopes is a function of operating power rather than cumulative burnup. The core operating limits and setpoints will not be affected by the presence of the high burnup Framatome lead test assembly, so the operation of the North Anna 2 Cycle 16 core will be comparable to previous North Anna cores in terms of average operating powers and total core inventory. The presence of a single high burnup fuel assembly will not result in any change to the calculated releases in accidents involving damage to a significant portion of the fuel in the core.

The current rod ejection analysis for North Anna has demonstrated that the upper limit in fission product release as a result of fuel rods entering departure from nucleate boiling amounts to 10% of the core inventory. As discussed above in Section 5.2, the rods most likely to enter a boiling regime during transient core conditions are those operating at high powers, so the rods in the high burnup Framatome LTA (operating powers below the core average power) are not expected to be among those that would fail for this accident. In addition, as part of the Reactivity Insertion Accident (RIA) issue that was raised in the fall of 1994, the Nuclear Energy Institute (NEI) issued a position letter to the NRC (Reference 21) that concluded that high burnup fuel failures would have a minimal impact on doses for a rod ejection accident because of conservative assumptions in the dose assessment. Based on the information in this position letter, and the use of the high burnup LTA in an unrodded core location in North Anna 2 Cycle 16, it is concluded that the proposed operation of this assembly will not contribute to the radiological consequences of a rod ejection accident.

5.4 Conclusions of Non-LOCA Accident Assessment

There are only a limited number of design features used as key inputs to non-LOCA accident analyses that differ between the Framatome LTA fuel assembly and the resident NAIF design. The original evaluation of these specific differences to support the use of 4 Framatome lead test assemblies in North Anna concluded that licensing analyses performed for the NAIF design will be applicable for the operation the LTA fuel design.

Operation of one of these assemblies to high burnup has the potential to affect the analysis of the rod ejection accident because operation to high burnup reduces the fuel melt temperature. A cycle specific analysis of this accident will be performed as part of the North Anna 2 Cycle 16 reload safety evaluation to confirm that the presence of the high burnup LTA does not affect the current analysis of this accident for North Anna.

The operation of a single Framatome LTA for a fourth cycle, to an assembly average burnup of about 70 GWD/MTU, will not result in a measurable impact on normal operating plant releases, and will not increase the predicted radiological consequences of accidents postulated in Chapter 15 of the UFSAR.

6.0 LOCA/ECCS Evaluation

The resident fuel at North Anna Units 1 and 2 is the North Anna Improved Fuel (NAIF) design supplied by Westinghouse Electric Company. The fuel is similar to and compatible with the Westinghouse VANTAGE 5H design. Compliance with 10 CFR 50.46 for the use of this fuel has been demonstrated by calculations performed by Dominion using Westinghouse's NRC-approved evaluation model and methods, and documented in Sections 15.3 and 15.4 of the North Anna Units 1 and 2 UFSAR (Reference 22). Calculations will be performed by Framatome to demonstrate that the existing North Anna calculations based on the NAIF assemblies conservatively bound the LOCA performance of the Framatome lead test assembly to be irradiated for a fourth cycle in North Anna 2 Cycle 16.

In 1996, several confirmatory large break LOCA (LBLOCA) calculations were performed for this assembly demonstrating that the evaluations of the NAIF assemblies bounded the LTA LOCA performance (Reference 4). Because licensing of the LTA was accomplished by comparison with the Westinghouse NAIF fuel, the LOCA calculations supported assembly exposure to about [ ] GWD/MTU. With the fourth cycle of operation, the Framatome LTA exposure will reach about 70 GWD/MTU, with lead rod burnups of about 73 GWD/MTU. Calculations will therefore be performed by Framatome to demonstrate that the NAIF licensing calculations continue to bound the LTA LOCA performance to the 73 GWD/MTU range. The NAIF LBLOCA analysis of record will then also demonstrate that the reinserted Framatome lead test assembly meets the criteria of 10 CFR 50.46.

For a Small Break LOCA, compliance with 10 CFR 50.46 will be shown by validating that the calculations performed in support of the NAIF design are wholly applicable to the Framatome lead test assembly even at the higher burnup. This approach is possible because small breaks are plant system determinant and not dependent on fuel assembly design for reasonably equivalent designs. Thus, for the entire LOCA spectrum, it will be shown that the NAIF licensing calculations represent a conservative analysis for licensing the operation of the Framatome lead test assembly at higher burnup.

6.1 Calculation Inputs and Assumptions

The LBLOCA analysis performed to support the licensing of this lead test assembly will be done with the Framatome NRC-approved evaluation model (Reference 23) as interpreted in a letter to the NRC dated February 29, 2000 (Reference 24). The NRC has determined the Framatome interpretation in this letter is an Evaluation Model change and is in the final stages of issuing its SER. Actual release of the SER is expected before the end of 2001. The evaluation of cladding temperature transients and local oxidation will be performed with three computer codes, which are interconnected as depicted in Figure 6.1. The RELAP5/MOD2-B&W code calculates system thermal hydraulics and cladding temperature responses, including the hot channel, during blowdown. The thermal hydraulic transient calculations are continued within the REFLOD3B code to determine refill time and core reflooding rates. The BEACH code determines the hot pin cladding temperature response during refill and reflood.

6.1.1 Inputs and Assumptions

At the start of the fourth operating cycle the LTA will have a burnup of about 52 GWD/MTU. Although it will be loaded next to four fresh assemblies, the LTA is not expected to be able to generate the local power peaking necessary to challenge the LOCA acceptance criteria of 10 CFR 50.46. The premise of the evaluation to be performed is that the LOCA results for the LTA will be substantially less severe than those for the NAIF fuel because of the reduced peaking of this assembly. The ability to achieve an acceptable result with this approach will depend on three factors:

1. the maximum pin radial peaking for the LTA at the Limiting Conditions for Operations (LCOs) is about 25 percent below the core LCO limit,

2. the internal pin pressure does not lead to an early blowdown swelling and rupture, and

3. the increase in fuel temperature and fuel temperature burnup bias does not affect the calculation result beyond the benefit of the reduced power.

If the combined effects of these three factors produce acceptable results, the LOCA results for the LTA will be shown to have substantial margin to the LOCA results for the NAIF fuel, and the spectrum and sensitivity study simplifications described herein will be appropriate. If the combination of these three factors does not produce an acceptable result, operation of the LTA for a fourth cycle may require additional studies or compliance with local power level limitations to demonstrate that the LOCA results for the NAIF fuel remain bounding.

The basic LOCA input model to be used for evaluation of the LTA will be the same model that will be used to support licensing of reload batches of Framatome fuel for North Anna. (Use of the

Framatome fuel design for reload fuel batches is scheduled to begin at North Anna 1 in 2003.) Appropriate fuel parameter adjustments will be made to this model to represent the reinserted LTA. Selected model parameters and their treatment for the LTA analysis are:

1. Power Level - The plant is assumed to be in steady-state operation at 2951 MWT (102% power).

2. Total System Flow - The initial RCS flow is 289,100 gpm.

3. Fuel Parameters – Fuel conditions used will be suitable for the LTA for exposures between [ ] GWD/MTU operating under the core conditions imposed by the LCOs.

4. ECCS - The ECCS flows are based on the assumption of a single active failure that takes one complete train of ECCS out of service. This is the worst case assumption for the North Anna LOCA calculations for the NAIF fuel.

5. The value of F_Q will bound the expected LTA peak local power for operation within the Technical Specifications LCO conditions.

6. The LTA calculations will be performed for the upflow baffle gap configuration of North Anna 1 and the results will be compared to Dominion calculations for the NAIF fuel for this same baffle gap configuration. The difference between this configuration and the downflow configuration of North Anna 2, as determined by Dominion's sensitivity studies, will be applied to assure that the LTA LOCA results remain conservatively bounded by the North Anna 2 analysis of record.

7. The moderator density reactivity coefficient is based on beginning-of-cycle conditions to minimize negative reactivity.

8. The NRC-approved model for M5 cladding rupture will be used (Reference 9).

9. Both the structural grids and the mid-span mixing grids (MSMGs) are explicitly modeled using the Framatome evaluation model grid modeling approach.

6.1.2 Reactor Core Modeling

For the LTA simulation, the average core will be modeled as all Framatome-supplied fuel with the pressure drop adjusted to represent the NAIF fuel to determine the mixed core effect on the LTA. Because only one Framatome assembly will be irradiated in North Anna 2 Cycle 16, there will be no effect on the analysis of record for the NAIF fuel. The LTA submodel will use a spatially refined core model capable of simulating the MSMGs.

6.1.3 Cladding Oxidation and Swelling and Rupture Models

As described in earlier sections, the Framatome LTA that is to be irradiated in North Anna 2 Cycle

16 incorporates two zirconium-based cladding alloys (M4 and M5) that do not fall within the Zircaloy specification. In Reference 4, it was shown that Zircaloy-based LOCA fuel performance models and criteria could be reasonably applied to these materials. Validation comprised high temperature oxidation, cladding brittle fracture, and cladding swelling and rupture testing. The results showed that the Baker-Just oxidation correlation is conservative for the advanced zirconium alloys, and that the oxidation limit for brittle fracture is the same for these alloys as for Zircaloy. In 1998, Framatome submitted a topical report that provided additional testing and justification for M5, including an M5 specific swelling and rupture model (Reference 9). Because M5 comprises the majority of the cladding material in the LTA, this NRC approved model will be employed for the LOCA calculations on the LTA in North Anna 2 Cycle 16.

The additional exposure of the assembly does not affect these models because, during the course of a LOCA, the cladding temperature will increase to near or above the phase change temperature, undergoing recrystallization and removing any radiation damage. This leaves only oxidation and hydrogen pickup as potential burnup related concerns that could affect the modeling. The M5 and M4 alloys experience substantially lower operational corrosion and hydrogen pickup than Zircaloy-4 (Reference 9), and for exposures up to [ ] GWD/MTU the M5 and M4 values will be lower than current licensing limits for Zircaloy-4. Thus, the models developed and approved for M5 will be sufficient for assuring acceptable performance of these alloys up to and beyond the proposed 73 GWD/MTU exposure.

6.2 Sensitivity Studies

The analysis performed to support the operation of an LTA for a fourth cycle in North Anna 2 Cycle 16 will use sensitivity studies performed for the original LOCA analysis of the Framatome lead test assemblies in North Anna to identify the worst case break. The combination of local power peaking, internal pin pressure, and initial volumetric average fuel temperature selected for the calculations will bound the conditions expected during the operation of the assembly to 73 GWD/MTU. The initial hot pin fuel temperature produced by TACO3 (Reference 14) will [

]. These considerations are appropriate because the calculations are expected to predict relatively low cladding temperatures. If this is not the case, the inputs will be adjusted based on additional sensitivity studies or the allowable assembly operational power (to remain bounded by the analysis of the NAIF fuel) may be reduced.

The initial pin pressure associated with the high burnup fuel has the potential to lead to the calculation of a blowdown rupture of the hot assembly. This would bring into consideration a Framatome Evaluation Model SER limitation, which calls for additional crossflow resistance sensitivity studies. The limitation is applicable to the calculation of potentially limiting cladding temperature responses but is not considered necessary for calculations that show large margins to the criteria. If the expected margins are demonstrated by the calculations for the LTA in North Anna 2 Cycle 16, no additional crossflow resistance studies will be performed. However, if the calculations do not demonstrate the expected margins, these sensitivity studies will be performed.

6.3 Comparison Calculation and Verification of K_z Curve

The K_z curve used in the North Anna analyses of record for the resident Westinghouse fuel design will be applied for the LTA, and a comparison will be made of the calculated axial peak temperatures near the [ ] core elevation. Again this approach is appropriate based on the expected cladding temperatures. If the temperatures are not substantially below the existing predictions for the resident fuel, a specific upper elevation peaked calculation will be made for the LTA.

6.4 Compliance with 10 CFR 50.46

6.4.1 Temperature and LOCA Oxidation Criteria

The worst case LOCA result published for North Anna, 2013 F, is for a 6-foot axial peak. This result is based on the downflow baffle gap configuration that exists in North Anna Unit 2. The comparative case for the upflow configuration at North Anna Unit 1 is 1975 F. These results will be compared with the results of the LTA calculations. A similar comparison will be made for the local oxidation. Because of the reduced power at which the pins in the LTA will operate, it is expected that the calculations will show considerable margin for the Framatome lead test assembly, in which case the evaluations of the resident NAIF fuel can be conservatively applied to demonstrate compliance of the LTA with the criteria of 10 CFR 50.46.

6.4.2 Whole-Core Oxidation and Hydrogen Generation

The North Anna calculation for core wide oxidation will not change because of the inclusion of one Framatome-supplied lead test assembly. Therefore, the prediction of acceptable core wide oxidation for the full NAIF core also demonstrates that the core with the one Framatome LTA will also meet this 10 CFR 50.46 criterion.

6.4.3 Core Geometry

The fourth acceptance criterion of 10 CFR 50.46 states that calculated changes in core geometry shall be such that the core remains amenable to cooling. The calculations to be performed for the LTA will directly assess the alterations in geometry for the LTA that result from the worst case break LOCA. The remainder of the core will be unaffected by the presence of one Framatome LTA. Therefore, the coolable geometry requirements of 10 CFR 50.46 will be met for the core and the LTA, and the core will be demonstrated to remain amenable to cooling following a LOCA.

6.4.4 Long-Term Cooling

The fifth acceptance criterion of 10 CFR 50.46 requires that the calculated core temperature be maintained at an acceptably low value, and decay heat be removed for the extended period of time required by the long-lived radioactivity remaining in the core. This criterion is a system level criterion and independent of the fuel being used in the core. There are no system level changes introduced with this reload that would alter the long term cooling process. Therefore, the calculations and arguments presented to license North Anna remain valid with the Framatome LTA operational in the core.

6.5 Small Break LOCA

The current licensing bases for the North Anna plants comprise a spectrum of large and small break loss-of-coolant accidents (LOCAs) analyzed by Dominion and documented in Section 15.3 of the UFSAR (Reference 22). For operation of North Anna 2 with one extended burnup lead test assembly, Framatome will reanalyze the worst case break LBLOCA transient. Reanalysis of the small break LOCA for operation with a Framatome LTA is not required since SBLOCA evaluations are unaffected by the design differences between the LTA and the resident Westinghouse fuel assemblies. Thus, the reference UFSAR analyses remain the bases for plant licensing for use of the reinserted LTA in North Anna 2. This is particularly true for this LTA which will operate at substantially reduced local powers and not be able to achieve the cladding temperatures of the surrounding fresh assemblies.

6.6 Mixed Core Considerations

The LOCA analyses being performed to support the fourth cycle of operation of the Framatome LTA will assume that the entire core is comprised of assemblies of the Framatome design. However, the pressure drop of the average core – that is, all of the assemblies in the core except the LTA – will be adjusted to match the pressure drop for the resident Westinghouse fuel at North Anna. This will directly assess the mixed core effect on the LTA. The presence of a single Framatome LTA in the center of the core will not cause mixed core effects in the NAIF fuel assemblies.

6.7 LOCA/ECCS Summary and Conclusion

Calculations will be performed to demonstrate the LOCA performance of the single extended burnup lead test assembly in North Anna will be bounded by existing analyses performed for the resident Westinghouse NAIF fuel design. The calculations for the LTA will be performed with the NRC-approved Framatome LOCA evaluation model, and will show that the five criteria of 10 CFR 50.46 are met for the North Anna core containing the extended burnup LTA. The normal Reload Safety Evaluation will therefore treat the North Anna 2 Cycle 16 core in the same manner as a full reload of the resident fuel design (Westinghouse NAIF assemblies).

7. Applicability of Standard Reload Design Methodology

Dominion performs reload safety evaluations using a bounding analysis method as described in Topical Report VEP-FRD-42 Rev. 1-A (Reference 11). This methodology defines a set of key analysis parameters that fully describe a valid conservative safety analysis ("reference analysis"). If all key analysis parameters for a reload core are conservatively bounded by the corresponding parameters in the reference analysis, the reference safety analysis is bounding, and further evaluation is not necessary. When a key analysis parameter is not bounded, further review is considered necessary to ensure that the required safety margin is maintained. This last determination is made through either a complete reanalysis of the accident, or through a simpler, though conservative, evaluation process using known parameter sensitivities.

The NRC Safety Evaluation Report (SER) approving use of the normal reload nuclear design methodology in Reference 11 concludes that the report is "...acceptable for referencing by Virginia Power in licensing Westinghouse supplied reloads of Westinghouse supplied reactors." Two additional statements in the summary of the NRC's evaluation of the report also specifically address the applicability of this methodology to only Westinghouse fuel:

> "Although Virginia Power expects the methods presented in VEP-FRD-42 to be, in principle, valid for both Westinghouse/non-Westinghouse fuel mixes as well as cores designed by other vendors for use in Westinghouse designed plants, it is clear that the methodology presented is closely related to the Westinghouse methodology, and is applicable in its present form only to Westinghouse supplied reloads of Westinghouse nuclear plants."

and

> "Since the Virginia Power safety evaluation process utilizes the bounding concept using calculational methods that are acceptable by themselves, we find the general methodology used by Virginia Power acceptable for the safety evaluation of reload cores. However, the clear dependence of VEP-FRD-42 on Westinghouse methodology precludes the application of VEP-FRD-42 in its present form to non-Westinghouse or mixed cores."

Other than the similarity of our methodology to that of our current fuel vendor, no specific details are presented to clarify what concerns the NRC may have regarding application of our current reload methodology to fuel supplied by other vendors. No similar statements are found in the SERs for our topical reports on specific analytical models or methods.

Dominion recognizes that fuel products supplied by different vendors could conceivably differ dramatically in design from our current fuel. However, use of the Framatome lead test assembly in North Anna 2 Cycle 16 will not result in a significant change to the core. The lead test assembly is designed to be similar to the resident Westinghouse fuel, and a single assembly will be operated to high burnup. The LTA will also be placed in a core location where it does not experience the highest fuel rod power density, to ensure that existing safety analyses remain applicable.

The North Anna lead test assembly fuel design is an extension of Framatome's Mark-BW fuel design, which was designed specifically for use in Westinghouse units and for compatibility with the resident fuel in those units. As shown in Reference 4, the physical dimensions of this assembly and the fuel rods are very similar to those of the resident Westinghouse fuel. Evaluations of the mechanical fuel performance are performed by the fuel vendors (Framatome for the lead test assembly, and Westinghouse for the normal reload fuel).

Physical differences in the lead test assembly design that could affect core reload neutronic calculations such as the slightly higher uranium loading, the chemical composition of the cladding, and the presence of additional material in the active fuel regions (the mid-span mixing grids) are readily incorporated into our core design models. The core reactivity coefficients and nuclear performance for the three completed North Anna cycles where the four Framatome LTAs were irradiated were not noticeably different from recent reload cores consisting of all Westinghouse fuel, confirming the applicability of Dominion's standard reload core design models and methods to cores containing a Framatome lead test assembly.

Thermal hydraulic analyses of the lead test assembly design were performed by Framatome using their NRC-approved models and methods to support the initial irradiation of the LTAs. It was determined that use of the four lead test assemblies had a negligible impact on core thermal hydraulic evaluations, and that North Anna cores containing these assemblies can conservatively be modeled as a homogeneous core of Westinghouse fuel. Therefore use of one of these lead test assemblies for an additional cycle will have no impact on our standard reload thermal hydraulic evaluations.

Sensitivity of core transients to changes in the key analysis parameters defined for the current safety analyses (Reference 11) will remain the same for the Framatome fuel design due to the small difference from the Westinghouse fuel design. The impact of the lead test assembly design on both LOCA and non-LOCA accident analyses has been considered, by Framatome and by Dominion using appropriate input provided by Framatome, respectively. The analyses of record, which are based on the Westinghouse fuel design, are expected to remain applicable for cores incorporating the lead test assemblies. Cycle specific evaluations will continue to verify that the assumed values for any key analysis parameters are not exceeded for North Anna 2 Cycle 16. There are no differences between the Framatome LTA and Westinghouse fuel designs that would result in new failure mechanisms, increase the consequences of previously considered accident scenarios, or interfere with safe operation of the core. Therefore, incorporation of this assembly into the North Anna 2 Cycle 16 core will not affect the ability of our current reload methodology to conservatively assess the core response to accident scenarios.

A revision of our Reload Nuclear Design Methodology topical report has been submitted to the NRC to document changes to the methodology implemented under 10 CFR 50.59, and to qualify the methodology for use with full reload batches of Framatome fuel that are very similar in design to the lead test assembly (References 12 and 13). Review of this revised topical report is not yet complete. However, if NRC review and approval of this revised topical report is completed prior to the start of North Anna 2 Cycle 16, no special concurrence will be required to apply this standard design methodology to the lead test assembly.

8. Loading Pattern Alternatives

The current plans for a fourth cycle of operation for a Framatome lead test assembly are to irradiate Assembly FM3 in North Anna 2 Cycle 16. Measurements on the North Anna lead test assemblies after three cycles of operation have shown that use of Alloy M5 guide thimbles results in sufficiently low assembly growth to support the proposed operation without considering any added benefit that may be provided by the floating top grid feature. A decision was therefore made to proceed with an LTA that has the standard top grid restraint (either Assembly FM1 or FM3) for the fourth operating cycle. Assembly FM3 was selected as the primary candidate because it will provide an opportunity to obtain extended burnup data on Alloy M4 as well as Alloy M5 fuel rod cladding.

Although some examinations were performed in the fall of 2001 when the Framatome lead test assemblies were discharged from their third operating cycle, data from detailed third cycle post irradiation examinations on the Framatome lead test assemblies will not be available until additional examinations are completed in early 2002. [

]. Because assemblies FM1 and FM3 have been irradiated as symmetric partners for three cycles, the two assemblies have comparable operating histories and burnups. Evaluations described in this discussion are therefore applicable to both assemblies.

If the detailed poolside examinations indicate a concern about operation of the LTA design for a fourth cycle, or if the analyses performed as part of the cycle specific reload design calculations indicate that the lead test assembly does not satisfy the criteria for continued irradiation in North Anna 2 Cycle 16, including the requirements of 10 CFR 50.59, a lead test assembly will not be used in Cycle 16. Instead, a once burned assembly, currently operating in the center core location in North Anna 2 Cycle 15, would be placed in the center of the core. It is likely that changes will also be required to the burnable poison assemblies used for reactivity control. Replacement of the low reactivity lead test assembly with a once burned assembly would necessitate a complete core redesign to ensure that all normal reload design criteria, including F_Q and $F_{\Delta H}$ limits, are satisfied.

To minimize the potential for a significant redesign effort late in the normal reload design process, sufficient analyses must be completed by mid-April 2002 to assess the feasibility of proceeding with a loading pattern for North Anna 2 Cycle 16 that incorporates a Framatome lead test assembly in the center core location. The NRC is therefore being requested to provide a preliminary assessment of the acceptability of irradiating the lead test assembly for an additional cycle by the same date, so a decision can be made by Dominion on whether to proceed with detailed analyses for the pattern incorporating the Framatome lead test assembly.

9. Safety Review

From the evaluation presented in this discussion, it is concluded that neither the use of the one of the Framatome lead test assemblies for a fourth cycle at North Anna, nor the use of Dominion's standard reload design methodology to evaluate the core in which this assembly is irradiated, are expected to compromise the safe operation of the plant. Cycle specific reload calculations to confirm this conclusion will be performed and documented as part of the normal Reload Safety Evaluation.

The lead test assembly is one of four Framatome LTAs that have operated for three cycles in North Anna Unit 1. Past operating experience with these assemblies has demonstrated that the assembly design is fully compatible with the core internals, resident fuel, fuel insert components, and fuel handling equipment. The same fuel assembly and fuel rod design criteria that must be met for normal operation of Framatome fuel will be shown to be satisfied for the fourth cycle of operation of one of the LTAs in North Anna 2 Cycle 16. This may be accomplished by reference to completed generic evaluations that bound the LTA design and operating conditions, or by cycle specific evaluations. Measurements from post irradiation examinations will also be used, when appropriate, to demonstrate that the fuel assembly performance to date is consistent with or bounded by design models and assumptions.

Detailed thermal hydraulic evaluations were performed to support the use of the four Framatome LTAs with resident Westinghouse fuel in previous North Anna cores (Reference 4). These analyses were performed by Framatome using NRC-approved models and methods, and included evaluations of unrecoverable core pressure drop, hydraulic lift forces, inter-bundle crossflow, and DNB performance. These evaluations remain applicable for irradiation of a single LTA to high burnup, and demonstrate that the North Anna core can be conservatively modeled as a full core of Westinghouse fuel. Consequently, there is no impact on our standard reload thermal hydraulic evaluations.

A cycle specific nuclear design evaluation will be performed for North Anna 2 Cycle 16 to demonstrate that the reload core containing a Framatome lead test assembly operating to high burnup will meet all applicable design criteria. This evaluation will be performed under the normal reload design process and schedule, and will be documented in the cycle specific Reload Safety Evaluation. The physical differences between the Framatome lead test assembly and the resident Westinghouse fuel are small, and will be explicitly modeled in the neutronic calculations, and do not adversely impact plant operation. Because of its core location and low reactivity, the lead test assembly will not experience the highest fuel rod power density in Cycle 16. The LTA will also not be limiting with respect to any safety analysis limit for North Anna 2 Cycle 16. Scoping calculations have also confirmed that the nuclear design model used for standard reload calculations will perform acceptably at high burnups. There will be no adverse impact on the operation of the plant or the ability to predict either normal core performance or core response to accident scenarios.

For non-LOCA events having a DNB acceptance criterion, the analyses of record are conservative for the LTA design. For non-LOCA events that do not have a DNB acceptance criterion, the only events affected by the presence of a Framatome fuel assembly are those for which a detailed cladding temperature calculation is performed, i.e., the Locked Rotor and Rod Ejection events. Assessment of the specific differences between the Framatome LTA and the resident Westinghouse designs (Reference 4) concluded that the existing analyses performed for the Westinghouse fuel are applicable for Framatome lead test assemblies in North Anna.

The non-LOCA safety analyses with no DNB acceptance criterion may be affected by the fuel burnup because the melting temperature of UO_2 decreases with burnup. For most Condition III and Condition IV transients, the fuel temperatures remain far below the fuel melting temperature, so operation to high burnup will not affect most of the analyses of record. The exception is the control rod ejection transient, for which a cycle specific evaluation will be performed as part of the normal reload design to ensure that the analysis of record remains applicable.

For the large- and small-break LOCA analyses, evaluations will be performed by Framatome to demonstrate that the existing North Anna calculations based on the resident Westinghouse fuel conservatively bound the Framatome lead test assembly to be irradiated for a fourth cycle.

The radiological consequences will not be impacted by the presence of one high burnup Framatome fuel assembly in the core. For the fuel handling accident, the activity releases that would result from damage to the LTA fuel rods would be considerably lower than those determined for the North Anna analysis of record for this accident because of conservatisms in the analysis. One cycle specific calculation will be performed for this accident, to confirm that the decontamination factor assumed for iodine releases in the analysis of record remains conservative for the Framatome LTA after a fourth cycle of operation. For other accidents, either no fuel failures are predicted to occur (e.g., steam generator tube rupture and main steam line break) or there will be no impact on the current dose calculations for the accident (locked rotor). The presence of a single high burnup fuel assembly will not result in any change to the calculated releases in accidents involving damage to a significant portion of the fuel in the core, such as the LOCA accidents. The use of one high burnup LTA in an unrodded core location will also not contribute to the radiological consequences of a rod ejection accident.

The operation of one Framatome LTA to high burnup will not affect the safe operation of the plant:

- The core design is similar to other recent reloads for North Anna Units 1 and 2, and all applicable design and licensing basis criteria will be shown to be satisfied for North Anna 2 Cycle 16. Adherence of the fuel and the cycle specific core design to these criteria will preclude new challenges to systems and components that could create the possibility of a new type of accident.

- Operation of one assembly to high burnup will not adversely affect the ability of existing components and systems to mitigate the consequences of any accident.

- Cycle specific analyses will be performed to confirm that the integrity of the fuel rod cladding as a fission product barrier will not be challenged. The radiological consequences of accidents previously evaluated in the North Anna UFSAR will remain applicable for the extended burnup operation of this assembly.

- Due to similarity in physical design, the Framatome lead test assembly will be handled, and will operate, in the same basic manner as the resident Westinghouse fuel assemblies, so no new single failure mechanisms will be introduced by operation of this assembly for a fourth cycle. The fuel assembly will be verified to remain compatible with the other fuel in the core, the core internals, and handling and storage systems at the extended burnup, and all normal design criteria will be satisfied, so no new failure modes will be created.

- The North Anna 2 Cycle 16 core will be designed to operate within the normal limits on core operation defined in the North Anna Technical Specifications.

Confirmation that high burnup operation of one lead test assembly does not affect the safe operation of the plant will be completed as part of the cycle specific reload calculations, and so addressed as part of the normal Reload Safety Evaluation. If the cycle specific evaluations are unable to demonstrate that any criterion will be satisfied, or indicate that the safety analyses of record will not bound the operation of the fourth cycle of operation for the Framatome lead test assembly, the assembly will not be irradiated and an alternate loading pattern will be developed for the North Anna 2 Cycle 16 core.

ENVIRONMENTAL ASSESSMENT

This license condition and the associated exemptions from the Code of Federal Regulations to allow the operation of one Framatome lead test assembly to high burnup in North Anna 2 Cycle 16 meet the eligibility criteria for categorical exclusion from an environmental assessment set forth in 10 CFR 51.22(c)(9), as discussed below:

(i) The license condition and associated exemptions from the Code of Federal Regulations involve no Significant Hazards Consideration.

As discussed in the attached evaluation of the Significant Hazards Consideration, irradiation of one Framatome lead test assembly to high burnup at North Anna will not involve a significant increase in the probability or consequences of an accident previously evaluated. The possibility of a new or different kind of accident from any accident previously evaluated is also not created, and the proposed irradiation does not involve a significant reduction in a margin of safety. Therefore the proposed use of the Framatome lead test assembly meets the requirements of 10 CFR 50.92(c) and does not involve a significant hazards consideration.

(ii) There is no significant change in the types or significant increase in the amounts of any effluents that may be released offsite.

The Framatome lead test assembly that is irradiated for a fourth cycle in North Anna 2 Cycle 16 is very similar in design to the resident fuel in the core, and will be handled and operated in the same manner as the other fuel assemblies in the North Anna Unit 2 core. Adherence to the fuel design criteria, verified as part of the cycle specific reload evaluation, will ensure the integrity of the cladding as a fission product barrier for the planned operating conditions. There will be no measurable increase in the isotopic levels in the coolant associated with the normal operation of this assembly, and so no effect on normal operating plant releases. As discussed in this evaluation, the radiological consequences of accident scenarios described in Chapter 15 of the North Anna Units 1 and 2 UFSAR will also not be significantly impacted by the presence of one high burnup fuel assembly in the core. Therefore, irradiation of this assembly to high burnup will not significantly change the types, or significantly increase the amounts, of effluents that may be released offsite.

(iii) There is no significant increase in individual or cumulative occupational radiation exposure.

The Framatome lead test assembly is functionally identical to the resident fuel, and will be handled, operated, and stored in the same manner as the other fuel assemblies in the North Anna Unit 2 Cycle 16 core. Operation of one fuel assembly to high burnup will not significantly affect the plant operating conditions, and the core will be designed and operated in accordance with the North Anna Unit 2 Technical Specifications limitations. Cycle specific reload evaluations will verify that fuel rod design criteria are satisfied, ensuring that cladding integrity is maintained. Operation of one assembly to high burnup will not significantly increase the radiation levels of the fuel, so individual and cumulative occupational exposures are unchanged.

Based on the above, the proposed use of the Framatome lead test assembly does not have a significant effect on the environment, and meets the criteria of 10 CFR 51.22(c)(9). It is concluded that the proposed license condition and associated exemptions from the Code of Federal Regulations qualify for a categorical exclusion from a specific environmental review by the Commission, as described in 10 CFR 51.22.

SUMMARY

One Framatome lead test assembly (LTA) that has been irradiated for three cycles in North Anna Unit 1 is scheduled to be irradiated for one additional cycle in North Anna 2 Cycle 16. NRC approval, in the form of a license condition and exemptions to the Code of Federal Regulations, will be required to irradiate the fuel assembly for several reasons:

- The use of zirconium-based alloys M4 and M5 as fuel rod cladding materials is not covered by North Anna Unit 2 Technical Specifications, which indicate that the fuel rod cladding in North Anna Unit 2 fuel is fabricated from Zircaloy or ZIRLO.

- The NRC Safety Evaluation Report on Dominion's current design models and methods restricts their use to Westinghouse supplied fuel.

- Use of an LTA for a fourth operating cycle will involve irradiation to burnups in excess of the 60000 MWD/MTU lead rod burnup limit imposed on North Anna by the NRC, as identified in Section 4.3.1.1 of the North Anna UFSAR.

- Sections 50.46 and 50.44 of Title 10 of the Code of Federal Regulations continue to refer only to fuel with Zircaloy or ZIRLO cladding, and Appendix K of 10 CFR 50 requires that an equation that was originally developed for the use of Zircaloy cladding be applied to the evaluation of the fuel. Because the fuel rods in the lead test assembly have cladding made of alloys that do not conform to either of these two designations, use of the LTA in North Anna 2 Cycle 16 will require temporary exemptions from these sections of the Code.

The extended burnup of the Framatome lead test assembly will be fully addressed as part of the North Anna 2 Cycle 16 Reload Safety Evaluation. However, preliminary evaluations indicate that the LTA will remain acceptable from a fuel assembly and fuel rod mechanical standpoint, and will remain compatible with the reactor internals, resident fuel and insert components, fuel handling equipment and fuel storage racks. All normal Framatome fuel rod design criteria will be satisfied, and the safety analyses of record are expected to remain applicable for the North Anna 2 Cycle 16 core.

Operation of this assembly to high burnup in the North Anna 2 Cycle 16 core is not anticipated to result in the acceptable safety limits for any postulated accident to be exceeded, and will not affect normal operation of the plant or plant safety systems. Therefore the safe operation of the plant will not be compromised, and irradiation of the assembly to high burnup will not result in a significant hazards consideration, as defined in 10 CFR 50.92.

If the cycle specific evaluations are unable to demonstrate that a design criterion will be satisfied, or indicate that the safety analyses of record will not bound the operation of the fourth cycle of operation for the Framatome lead test assembly, the assembly will not be irradiated and an alternate loading pattern will be developed for the North Anna 2 Cycle 16 core.

<u>REFERENCES</u>

1. Letter from Gordon E. Edison (U. S. Nuclear Regulatory Commission) to J. P. O'Hanlon (Dominion), "North Anna Units 1 and 2 – Issuance of Amendments Re: Demonstration Fuel Assemblies (TAC Nos. M96530 and M96531)," May 9, 1997.

2. Letter from James A. Hutton (AmerGen Energy Company) to U. S. Nuclear Regulatory Commission, "Three Mile Island, Unit 1 (TMI Unit 1), Operating License no. DPR-50, Docket No. 50-289, Proposed Irradiation of Fuel Rods Beyond Current Lead Rod Burnup Limit," January 18, 2001.

3. Letter from Stuart A. Richards (U. S. Nuclear Regulatory Commission) to T. A. Coleman (Framatome Cogema Fuels), "Revised Safety Evaluation (SE) for Topical Report BAW-10227P: 'Evaluation of Advanced Cladding and Structural Material (M5) in PWR Reactor Fuel' (TAC No. M99903)," February 4, 2000.

4. Letter from James P. O'Hanlon (Dominion) to U. S. Nuclear Regulatory Commission, "North Anna Power Station Units 1 and 2 – Proposed Technical Specifications Change – Use of Lead Fuel Assemblies with Advanced Cladding Material," Serial Number 96-409, September 4, 1996.

5. Letter from J. P. O'Hanlon (Dominion) to U. S. Nuclear Regulatory Commission, "North Anna Power Station Units 1 and 2 – Supplemental Information Concerning Core Design Margins and Fuel Management for Use of FCF Lead Test Assemblies," Serial Number 96-409A, February 3, 1997.

6. Letter from Stephen Monarque (U. S. Nuclear Regulatory Commission) to David A. Christian (Dominion), "North Anna Power Station, Units 1 and 2 – Issuance of Amendments Re: Technical Specifications Changes to Increase Fuel Enrichment and Spent Fuel Pool Soluble Boron and Fuel Burnup Credit (TAC Nos. MB0197 and MB0198)," June 15, 2001.

7. Letter from Leon B. Engle and Bart C. Buckley, Sr. (U.S. Nuclear Regulatory Commission) to W. L. Stewart (Dominion), "Surry, Units 1 and 2, and North Anna, Units 1 and 2 – Removal of 45,000 MWD/MTU Batch Average Burnup Restriction (TAC Nos. M87767, M87768, M87812, and M87813," December 14, 1993.

8. Letter from Leon B. Engle and Bart C. Buckley, Sr. (U.S. Nuclear Regulatory Commission) to W. L. Stewart (Dominion), "Surry, Units 1 and 2, and North Anna, Units 1 and 2 – Removal of

45,000 MWD/MTU Batch Average Burnup Restriction (TAC Nos. M87767, M87768, M87812, and M87813," April 20, 1994.

9. David B. Mitchell and Bert M. Dunn, "Evaluation of Advanced Cladding and Structural Material (M5) in PWR Reactor Fuel," BAW-10227P-A, February 2000.

10. Letter from Gordon E. Edison (U. S. Nuclear Regulatory Commission) to J. P. O'Hanlon (Dominion), "North Anna Units 1 and 2 – Exemption from 10 CFR 50.44, 10 CFR 50.46, and Appendix K to 10 CFR 50 for Demonstration Fuel Assemblies (TAC Nos. M96530 and M96531)," May 9, 1997.

11. "Reload Nuclear Design Methodology," VEP-FRD-42, Rev. 1-A, September 1986.

12. "Reload Nuclear Design Methodology," VEP-FRD-42, Rev. 2, September 2001.

13. Letter from Leslie N. Hartz (Dominion) to U. S. Nuclear Regulatory Commission, "North Anna Power Station Units 1 and 2, Surry Power Station Units 1 and 2, Dominion's Reload Nuclear Design Methodology Topical Report," Serial Number 01-623, October 8, 2001.

14. "TACO3 - Fuel Pin Analysis Computer Code," BAW-10162P-A, October 1989.

15. "Fuel Rod Gas Pressure Criterion (FRGPC)," BAW-10183P-A, July 1995.

16. "COPERNIC Fuel Rod Design Computer Code," BAW-10231P, September 1999.

17. ASME Code, Section III, Division I, Subsection NG, Boiler and Pressure Vessel Code, 1980.

18. "Program to Determine In-Reactor Performance of BWFC Fuel Cladding Creep Collapse," BAW-10084P-A, July 1995.

19. "Limited Scope High Burnup Lead Test Assemblies," WCAP-15604-NP, Revision 0, October 2000.

20. S. L. Davidson (Ed.) et al., "VANTAGE+ Fuel Assembly Reference Core Report," WCAP-14342-A (Non-Proprietary), April 1995.

21. Letter from A. Marion (NEI) to R. Jones (NRC), transmitting "NEI Response to NRC Staff's Request for Information on Reactivity Insertion Accidents," December 28, 1994.

22. Updated Final Safety Analysis Report - North Anna Power Station, Units 1 and 2, Docket Nos. 50-338 and 50-339.

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

24. Letter from J. J. Kelly (Framatome Technologies) to U.S. NRC Document Control Desk, "Modeling Refinements to Framatome Technologies' RELAP5-Based Large Break LOCA Evaluation Models – BAW-10168 for Non-B&W-Designed, Recirculating Steam Generator Plants and BAW-10192 for B&W-Designed, Once-Through Steam Generator Plants," FTI-00-551, February 29, 2000.

25. "Extended Burnup Evaluation", BAW-10186P-A, Revision 1, April 2000.

Table 2.1
Scope of PIE Testing on Framatome Lead Test Assemblies

Inspection	Number of Assemblies Examined in PIE Campaign			EOC-3 Additional PIE (2002 Campaign)
	EOC-1	EOC-2	EOC-3	

Table 6.1
Plant Parameters and Operating Conditions

Reactor Power	102% of 2893 MWT
Nominal Pressurizer Operating Pressure	2250 psia
System Flow	289,100 gpm
Hot Leg Temperature	620 F
Cold Leg Temperature	552 F
Fuel Pin Outside Diameter	0.374 inch
Average Linear Power Generation Rate	5.9 kW/ft

Figure 1.1
Lead Test Assembly Design
(from Reference 1)

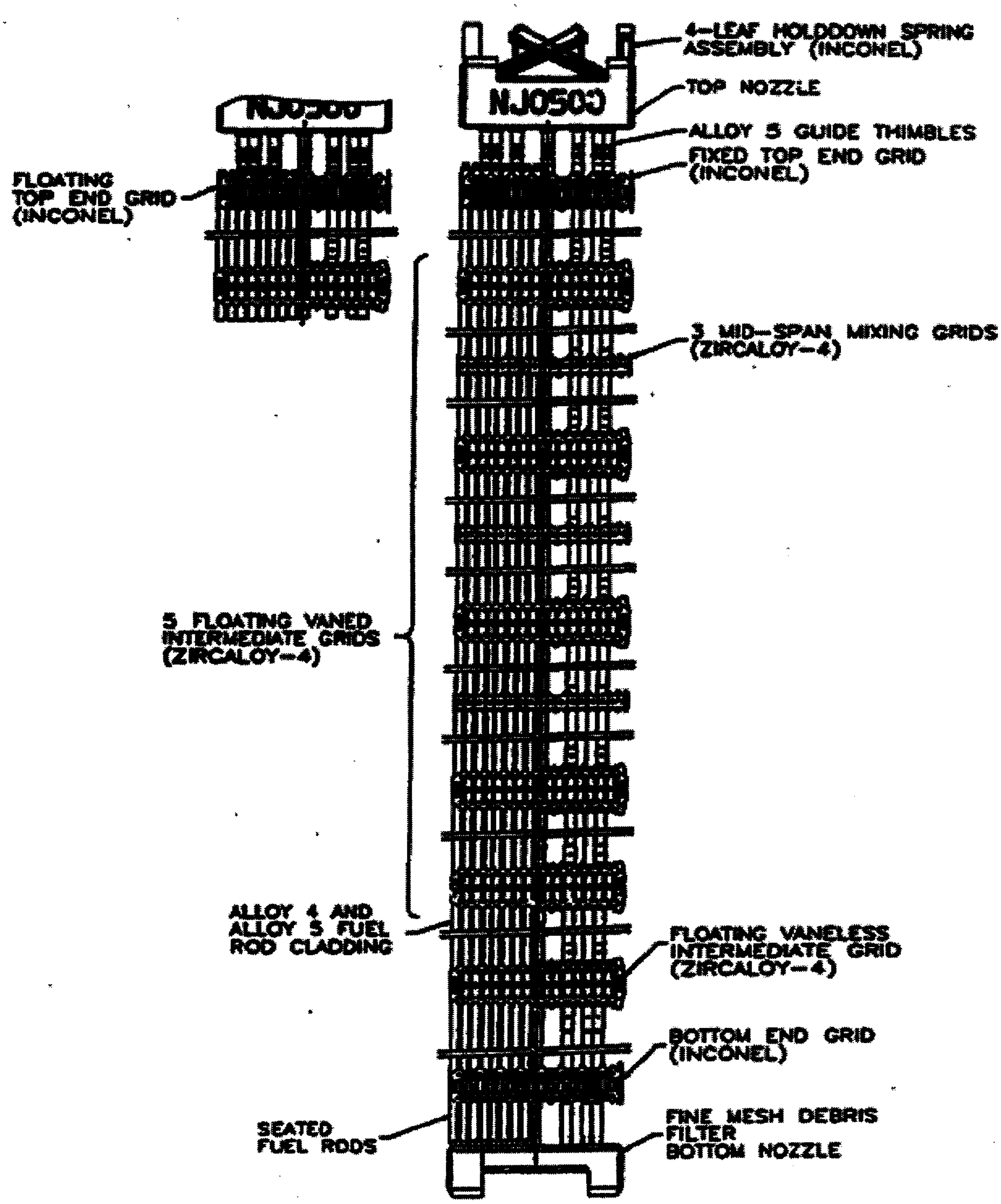


Figure 1.2
M4 Fuel Rod Locations in Lead Test Assemblies FM3 and FM4

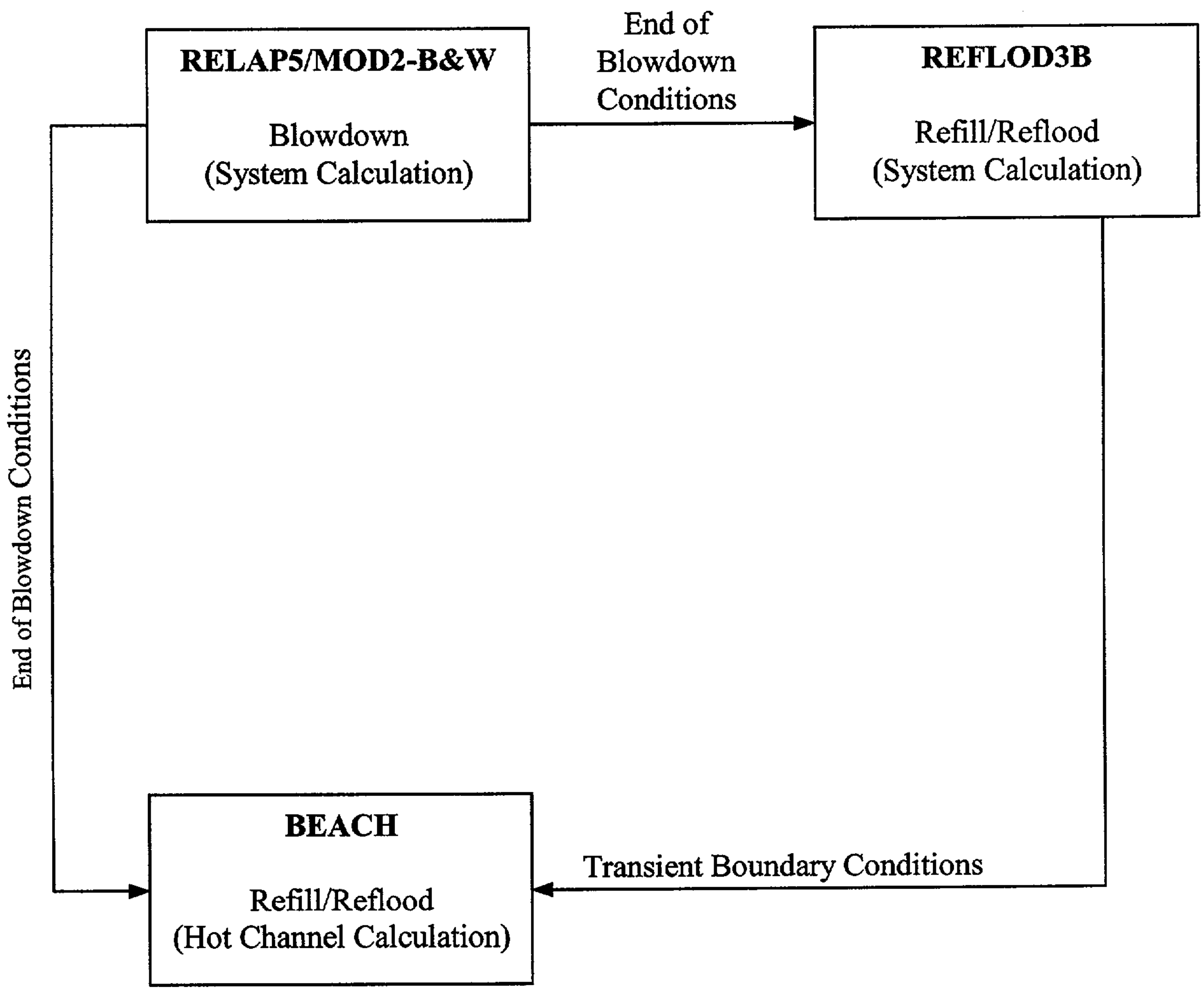
FACE 4

M4				M4				M4				M4				M4	1
																	2
					TT			TT			TT						3
			TT										TT				4
M4																M4	5
		TT			TT			TT			TT			TT			6
																	7
																	8
M4		TT			TT			TT			TT			TT		M4	9
																	10
																	11
		TT			TT			TT			TT			TT			12
M4																M4	13
			TT										TT				14
					TT			TT			TT						15
																	16
M4				M4				M4				M4				M4	17
R	P	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A	

FACE 2

Figure 6.1

RSG LOCA EM Computer Code Interface Diagram



Attachment 1

Discussion of Proposed License Changes

for North Anna 2

(Proprietary Version)