Proprietary Information
Withhold from Public Disclosure Under 10 CFR 2.390
This letter is decontrolled when separated from Enclosure 1

Tennessee Valley Authority, 1101 Market Street, Chattanooga, Tennessee 37402

CNL-16-084

May 20, 2016

10 CFR 50.90

ATTN: Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Browns Ferry Nuclear Plant, Units 1, 2, and 3
Renewed Facility Operating License Nos. DPR-33, DPR-52, and DPR-68
NRC Docket Nos. 50-259, 50-260, and 50-296

Subject: **Proposed Technical Specifications (TS) Change TS-505 - Request for License Amendments - Extended Power Uprate (EPU) - Supplement 16, Responses to Requests for Additional Information**

References:

1. Letter from TVA to NRC, CNL-15-169, "Proposed Technical Specifications (TS) Change TS-505 - Request for License Amendments - Extended Power Uprate (EPU)," dated September 21, 2015 (ML15282A152)

2. Letter from NRC to TVA, “Browns Ferry Nuclear Plant, Units 1, 2, and 3 - Request for Additional Information Related to License Amendment Request Regarding Extended Power Uprate (CAC Nos. MF6741, MF6742, and MF6743),” dated May 6, 2016 (ML16119A133)

By the Reference 1 letter, Tennessee Valley Authority (TVA) submitted a license amendment request (LAR) for the Extended Power Uprate (EPU) of Browns Ferry Nuclear Plant (BFN) Units 1, 2 and 3. The proposed LAR modifies the renewed operating licenses to increase the maximum authorized core thermal power level from the current licensed thermal power of 3458 megawatts to 3952 megawatts. During the technical review of the LAR, the Nuclear Regulatory Commission (NRC) identified the need for additional information. The Reference 2 letter provided NRC Requests for Additional Information (RAIs) related to nuclear performance and codes. The due date for the responses to the NRC RAIs provided by the Reference 2 letter is May 23, 2016. The enclosures to this letter provide the responses to the RAIs included in the Reference 2 letter.

Enclosure 1 provides the responses to the NRC RAIs from Reference 2. AREVA considers portions of the information provided in Enclosure 1 to this letter to be proprietary and, therefore, exempt from public disclosure pursuant to 10 CFR 2.390, Public inspections, exemptions, requests for withholding. An affidavit for withholding information, executed by AREVA, is provided in Enclosure 3. A non-proprietary version of the RAIs and responses are provided in Enclosure 2. Therefore, on behalf of AREVA, TVA requests that Enclosure 1 be withheld from public disclosure in accordance with the associated AREVA affidavit and the provisions of 10 CFR 2.390.

TVA has reviewed the information supporting a finding of no significant hazards consideration and the environmental consideration provided to the NRC in the Reference 1 letter. The supplemental information provided in this submittal does not affect the bases for concluding that the proposed license amendment does not involve a significant hazards consideration. In addition, the supplemental information in this submittal does not affect the bases for concluding that neither an environmental impact statement nor an environmental assessment needs to be prepared in connection with the proposed license amendment. Additionally, in accordance with 10 CFR 50.91(b)(1), TVA is sending a copy of this letter to the Alabama State Department of Public Health.

There are no new regulatory commitments associated with this submittal. If there are any questions or if additional information is needed, please contact Edward D. Schrull at (423) 751-3850.

I declare under penalty of perjury that the foregoing is true and correct. Executed on the 20th day of May 2016.

Respectfully,

J. W. Shea
Vice President, Nuclear Licensing

Enclosures:

1. ANP-3487P, Responses to RAIs for Browns Ferry Nuclear Plant EPU Submittal - Nuclear Performance and Code Review Branch (Proprietary version)
2. ANP-3487NP, Responses to RAIs for Browns Ferry Nuclear Plant EPU Submittal - Nuclear Performance and Code Review Branch (Non-proprietary version)
3. AREVA Affidavit

cc:

NRC Regional Administrator - Region II
NRC Senior Resident Inspector - Browns Ferry Nuclear Plant
State Health Officer, Alabama Department of Public Health (w/o Enclosure 1)

Withhold from Public Disclosure Under 10 CFR 2.390

ENCLOSURE 1

ANP-3487P, Responses to RAIs for Browns Ferry Nuclear Plant EPU Submittal - Nuclear Performance and Code Review Branch

(Proprietary version)

ENCLOSURE 2

ANP-3487NP, Responses to RAIs for Browns Ferry Nuclear Plant EPU Submittal - Nuclear Performance and Code Review Branch

(Non-proprietary version)

Responses to RAIs for Browns Ferry Nuclear Plant EPU Submittal - Nuclear Performance and Code Review Branch

ANP-3487NP
Revision 0

May 2016

AREVA Inc.

Nature of Changes

Item	Section(s) or Page(s)	Description and Justification
1	All	Initial Issue

Contents

Figures

Nomenclature

Abbreviation	Description
AFC	Advanced Fuel Channel
BFN	Browns Ferry Nuclear Plant
BLEU	Blended Low Enriched Uranium
CGU	Commercial Grade Uranium
CHF	Critical Heat Flux
CLTP	Current Licensed Thermal Power (3458 MWt)
CPR	Critical Power Ratio
EPU	Extended Power Uprate (3952 MWt)
LAR	License Amendment Request
LOCA	Loss of Coolant Accident
MAPLHGR	Maximum Average Planar Linear Heat Generator Rate
MCPR	Minimum Critical Power Ratio
MWt	Mega-Watt thermal
NRC	Nuclear Regulatory Commission
OBE	Operating Basis Earthquake
PWR	Pressurized Water Reactor
RAI	Request for Additional Information
RPV	Reactor Pressure Vessel
SSE	Safe Shutdown Earthquake
SNPB	Nuclear Performance and Code Review branch
SRP	Standard Review Plan
TCD	Thermal Conductivity Degradation
TS	Technical Specifications
TVA	Tennessee Valley Authority
UFSAR	Updated Final Safety Analysis Report

1.0 Introduction

In Reference 1, the Tennessee Valley Authority (TVA) submitted a license amendment request (LAR) to modify the operating license for the Browns Ferry Nuclear Plant (BFN) for an extended power uprate (EPU). The amendment, if approved, would allow for an increase in the licensed reactor thermal power from the current licensed thermal power (CLTP) of 3458 MWt to a new licensed thermal power of 3952 MWt, approximately 120% of the original licensed thermal power (OLTP) of 3293 MWt. Reference 2 provided supplemental information including revised versions of some of the Enclosures supporting the LAR.

The Nuclear Regulatory Commission (NRC) staff has determined that additional information is needed to complete their review of the BFN EPU LAR. This document contains only the responses to the Request for Additional Information (RAI) that contains AREVA content. Portions of some of the responses in this document have been provided by TVA. Where indicated, other responses are provided by TVA separate from this document.

References:*

1. Letter, JW Shea (TVA) to USNRC, “Proposed Technical Specifications Change to TS-505 – Request for License Amendments – Extended Power Uprate”, CNL-15-169, September 21, 2015. (Accession Number ML15282A152)

2. Letter, JW Shea (TVA) to USNRC, “Proposed Technical Specifications (TS) Change TS-505 – Request for License Amendments – Extended Power Uprate (EPU) – Supplement 2, MICROBURN-B2 Information”, CNL-15-250, December 15, 2015. (Accession Number ML15351A113)

3. XN-NF-75-32(P)(A) Supplements 1 through 4, *Computational Procedure for Evaluating Fuel Rod Bowing*, Exxon Nuclear Company, October 1983. (Base document not approved.)

4. EMF-95-52(P) Revision 1, *Fuel Design Evaluation for Siemens Power Corporation ATRIUM™-10 BWR Reload Fuel*, April 1998, transmitted to the NRC by Siemens Power Corporation Letter, “Design Evaluations for SPC ATRIUM™-9B and ATRIUM™-10 Fuel”, April 8, 1998, NRC:98:021).

5. ANP-3385(P) Revision 1, *Mechanical Design Report for Browns Ferry Units 1, 2 and 3 Extended Power Uprate (EPU) ATRIUM-10 Fuel Assemblies*.

6. ANP-3386(P) Revision 1, *Mechanical Design Report for Browns Ferry Units 1, 2 and 3 Extended Power Uprate (EPU) ATRIUM 10XM Fuel Assemblies*.

* The RAI question references are not located within this document.

7. XN-NF-82-06(P)(A) Supplement 1 Revision 2, *Qualification of Exxon Nuclear Fuel for Extended Burnup,* Supplement 1, *Extended Burnup Qualification of ENC 9x9 BWR Fuel*, Advanced Nuclear Fuels Corporation, May 1988.

8. EMF-85-74(P), Revision 0, Supplement 1(P)(A) and Supplement 2(P)(A), *RODEX2A (BWR) Fuel Rod Thermal-Mechanical Evaluation Model,* Siemens Power Corporation, February 1998.

9. EMF-93-177(P)(A), Revision 1, *Mechanical Design for BWR Fuel Channels*, August 2005.

10. ANF-89-98(P)(A), Revision 1, Supplement 1, *Generic Mechanical Design Criteria for BWR Fuel Designs*, May 1995.

11. EMF-92-116, Revision 0, *Generic Mechanical Design Criteria for PWR Fuel Designs*, February 1999.

12. EMF-2971(P), Revision 1, *Mechanical and Thermal-Hydraulic Design Report for Browns Ferry Unit 3 Batches BFC-1 and BFC-1A ATRIUM-10 Fuel Assemblies,* January 2004.

13. EMF-3114(P), Revision 0, *Mechanical and Design Report for Browns Ferry Unit 2 Batch BFE2-14 ATRIUM-10 Fuel Assemblies*, September 2004.

14. ANP-2537(P), Revision 0, "Mechanical Design Report for Browns Ferry Unit 2 Reload BFE2-15 ATRIUM-10 Fuel Assemblies," May 2006.

15. XN-81-51(P)(A), *LOCA-Seismic Structural Response of an Exxon Nuclear Company BWR Jet Pump Fuel Assembly*, May 1986.

16. XN-NF-84-97(P)(A), *LOCA-Seismic Structural Response of an ENC 9x9 BWR Jet Fuel Assembly*, August 1986.

17. XN-NF-85-67(P)(A), Revision 1, *GENERIC MECHANICAL DESIGN FOR EXXON NUCLEAR JET PUMP BWR RELOAD FUEL,* September 1986.

18. ANP-2860P Revision 2, Supplement 2P, Revision 1, *Browns Ferry Unit 1—Summary of Response to Requests for Additional Information, Extension for Use of ATRIUM 10XM Fuel for Extended Power Uprate,* August 2015.

19. NRC 2012, "NUCLEAR FUEL THERMAL CONDUCTIVITY DEGRADATION EVALUATION FOR LIGHT WATER REACTORS USING AREVA CODES AND METHODS (TAC NO. ME5178)," Letter from T. J. McGinty (NRC) to P. Salas (AREVA), March 23, 2012.

20. IN 2009-23, NUCLEAR FUEL THERMAL CONDUCTIVITY DEGRADATION, US Nuclear Regulatory Commission, ML091550527, October 8, 2009.

21. AREVA 2009, "Information Transmittal Regarding Requested White Papers on the Treatment of Exposure Dependent Fuel Thermal Conductivity Degradation in Legacy Fuel Performance Codes and Methods," Letter from R. Gardner (AREVA) (NRC:09:069) July 14, 2009.

22. ANP-3248P Revision 1, *AREVA RAI Responses for Browns Ferry ATRIUM 10XM Fuel Transition*, AREVA NP Inc., September 2013.

23. ANP-2833P Revision 0, *Mechanical Design Report for Browns Ferry Unit 1 Reload BFE1-9 ATRIUM-10 Fuel Assemblies*, September 2009.

24. Letter from J. W. Shea, TVA to NRC, "Technical Specification Change TS-478 - Addition of Analytical Methodologies to TS 5.6.5 for Browns Ferry 1, 2, and 3, and Revision of TS 2.1.1.2. for Browns Ferry 2 in Support of ATRIUM-10 XM Fuel Use at Browns Ferry," dated February 28, 2013. (ADAMS Accession # ML 13070A307)

25. Letter from F. E. Saba, NRC to TVA, "Browns Ferry Nuclear Plant, Units 1, 2 and 3 - Issuance of Amendments Regarding Technical Specification (TS) Change TS-478 Addition of Analytical Methodologies to TS 5.6.5 and Revision of TS 2.1.1.2 for Unit 2, dated July 31, 2014. (ADAMS Accession # ML 14113A286)

2.0 RAIs and Responses

2.1 *SNPB RAI-1*

SRP Chapter 4.2 stipulates, "Dimensional changes, such as rod bowing or irradiation growth of fuel rods, fuel assemblies, control rods, and guide tubes, should be limited to prevent fuel failures or a situation in which the thermal-hydraulic limits established in Section 4.4 are exceeded."

Section 3.3.5 of Attachment 24 of the LAR (ANP-3386P) (Reference 6) states that "Rod bow is calculated using approved model described in Reference 4." Reference 4 in Attachment 24 is XN-NF-75-32(P)(A) (Reference 7 in this document) Supplements 1 through 4. Reference 4 indicates that "Base document not approved."

a. Justify the use of the methodology in XN-NF-75-32(P)(A) for evaluation of the ATRIUM 10 and ATRIUM 10XM fuel designs, which were developed after the approval of the XN-NF-75-32(P)(A). Also, justify the application of this methodology for EPU conditions.

b. Provide details of the results of the rod bow analysis that produced sufficient margins for the ATRIUM-10 and ATRIUM 10XM under EPU conditions.

AREVA Response a.

The base document XN-NF-75-32 (computational procedures for evaluating fuel rod bowing (AXIBOW)) was not approved because it introduced a computational model to estimate fuel rod bow. The NRC staff considered mechanistic models not acceptable at the time and requested an empirical model based on fuel rod bow measurements. As a consequence, AREVA submitted an empirical model to estimate rod bow in Supplement 1 of XN-NF-75-32. This Supplement 1, together with the rest of the Supplements (Reference 3) were approved by the NRC. In the evaluation of rod bow, AREVA uses the approved empirical method of XN-NF-75-32(P)(A) Supplement 1. This method provides means for it to be applied to other designs such as ATRIUM-10 and ATRIUM 10-XM. The NRC approved methodology is discussed in SNPB RAI-1b. It is important to note that the methodology is based on an empirical correlation of fuel rod gap closure versus fuel assembly average exposure; therefore, changes in power conditions such as EPU do not impact the rod bow predictions.

AREVA's model application for ATRIUM-10 type fuel was presented in an **[**

] to the NRC (Reference 4). The Minimum Critical Power Ratio (MCPR) penalty (decrease in MCPR) versus rod bow (% closure) for the ATRIUM-10 fuel design is presented in

Figure 2. To assure that this model is conservative, AREVA ran a **[**

]. The result of that test is shown in Figure 2. As is seen from the plot, AREVA **[**

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AREVA Response b.

As described in Section 3.3.5 of References 5 and 6, the method from Reference 3 is used to estimate rod bow on AREVA boiling water reactor (BWR) designs.

The current AREVA methodology for evaluating the impact of rod bow on thermal margins is composed of two steps:

1. **[**

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The predicted gap closure versus exposure for ATRIUM 10XM is shown in Figure 1 (dashed red line).

2. **[**

] A correlation to predict the Critical Power Ratio (CPR) reduction due to the reduction in rod-to-rod spacing was approved during the approval process for extended burnup of AREVA BWR fuel designs (Reference 7). The correlation of MCPR penalty versus gap closure is shown in Figure 2.

For the representative transition EPU cycle, the core consists of two reloads of ATRIUM 10XM (a 1st and 2nd cycle fuel designs) and approximately 108 third cycle ATRIUM-10 assemblies. The following table is developed using the 2 step process described above to determine the appropriate MCPR penalty required to account for the effects of rod bow. The assembly with the highest average exposure and the assembly with the minimum CPR is obtained at the last exposure step of the cycle.

	Assembly Average Exposure (GWd/MTU)	Rod Bow MCPR Penalty	Minimum CPR
ATRIUM-10	**[**		**]**
ATRIUM 10XM 2nd cycle	**[**		**]**
ATRIUM 10XM 1st cycle	**[**		**]**

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Rod bow is not considered an important phenomenon in determining the linear heat generation rate power limit; therefore, is not explicitly represented in the RODEX4 methodology.

Any impact of rod bow on the MAPLHGR limit evaluations would be to the pin power distribution. [

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Figure 1 Predicted Gap Closure versus exposure for ATRIUM 10XM and ATRIUM-10A designs

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Figure 2 MCPR Penalty versus Fuel Rod Gap Closure

2.2 *SNPB RAI-2*

SRP Section 4.4 indicates "Problems affecting DNBR [Departure from Nucleate Boiling Ratio] or CPR [Critical Power Ratio] limits, such as fuel densification or rod bowing, are accounted for by an appropriate design penalty which is determined experimentally or analytically."

Section 3.4 of ANP-3327P (Reference 8) discusses the impact of rod bow on thermal margins. Provide the procedure and results from the assessment of the impact of rod bow on thermal margin. Also provide quantitative results of the CPR penalty as a function of the exposure and fractional rod closure during the EPU conditions.

AREVA Response

The response for this RAI is provided in the response developed for SNPB RAI-1b.

2.3 *SNPB RAI-3*

Section 3.4.4 of ANP-3386P (Reference 6) summarizes the evaluations performed for the fuel under combined seismic/loss of coolant accident (LOCA) loadings for structural integrity.

a. *Provide details of the model used for the ATRIUM-10 and ATRIUM 10XM assemblies with and without a fuel channel, acceleration used in the calculations, uncertainty allowances in the calculations, and results with margin to established limits under the EPU conditions.*

b. *Provide details of the evaluation of both fuel assemblies structural response to externally applied forces during seismic and LOCA during the EPU conditions and show how the acceptance criteria in SRP Chapter 4.2, Appendix A, Section IV are satisfied.*

AREVA Response

A plant specific analysis was not performed because it was not required. ANF-89-98, Section 3.2.7 (Reference 10) discusses seismic/LOCA methodology with plants that have an existing seismic/LOCA analysis. A change in fuel assembly design may not necessitate a full reanalysis if it can be shown that the fuel design is dynamically similar to the fuel assembly design in the Reactor Pressure Vessel (RPV) seismic analysis of record. A comparison between fuels **[**

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The operating power level has no influence on the accelerations or dynamic forces applied to the fuel during a seismic event, and therefore the existing seismic analysis of record is applicable to EPU conditions. The fuel acceleration from this analysis for Operating Basis Earthquake (OBE) is **[ ]** and for Safe Shutdown Earthquake (SSE) this value is **[ ]**. The SSE acceleration can be applied to the ATRIUM-10 and ATRIUM 10XM designs if **[ ]**.

The first reload of the ATRIUM-10, documented in EMF-2971(P) Revision 1 conservatively assumed EPU conditions and concluded that the **[ ]**. Thus, the existing reactor seismic analysis of record was not reanalyzed for the ATRIUM-10 and remained applicable for BFN Unit 3 reload (Reference 12) and follow on reloads (References 13, 14, and 23) referenced in BFN UFSAR (Updated Final Safety Analysis Report) Amendment 26.

Regarding the ATRIUM 10XM, the structural response to combined seismic/LOCA loadings assessed at EPU conditions **[ ]**. The current reload of the ATRIUM 10XM is supplied with the same **[ ]** Advanced Fuel Channel (AFC) as the ATRIUM-10 design, with a fuel assembly **[ ]**. This results in a **[ ]** accepted designs at BFN. Thus, the **[ ]** and the channeled fuel assembly will experience an SSE acceleration of **[ ]**.

The table below compares the dynamic properties of the GNF analyzed fuel of record, the ATRIUM-10 and ATRIUM 10XM.

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There are no specific criteria with respect to comparing dynamic properties for BWR fuel. AREVA defines this threshold as **[**

] of the analyzed design. This threshold for dynamic compatibility has been used in both PWR and BWR evaluations and is documented in the RAI responses and SER of EMF-92-116, Revision 0 (Reference 11).

Because the ATRIUM 10XM is found to be dynamically similar to the analyzed fuel of record, the margin to results are found by comparing ATRIUM 10XM acceleration limit of **[** **]** to the **[** **]**. This provides a **[**

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The fuel assembly analysis design criteria are established in ANF-89-98(P)(A) (Reference 10). The **[** **]** is used as the design input to a static finite element analysis of the ATRIUM-10 fuel assembly components (load chain, fuel rods, water channel, tie plates, and spacer grids) that demonstrates acceptance to American Society of Mechanical Engineers (ASME) mechanical design criteria in a seismic event. The analysis also confirms that the fuel channel is the limiting component; documented in the current and historical topical reports, (References 9, 15, and 16). Therefore, if the fuel channel limit is not exceeded, the fuel assembly components will not exceed allowable design limits. For added conservatism the Finite Element Analysis (FEA) static analysis model assumes **[**

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The ATRIUM-10 fuel assembly component analysis **[**

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allowable stress or load limits for the ATRIUM 10XM were updated to new limits based on testing of ATRIUM 10XM components. This information is tabulated in Reference 6, Table 3-1, Criteria Section 3.4.4.

Any uncertainty presented in the analyses is accommodated by a large degree of conservatism given a **[ ]** applied to the fuel channel and the fuel assembly.

While a full test campaign was conducted for the ATRIUM 10XM, channeled and un-channeled, no dynamic testing conducted on the ATRIUM 10XM was used to support the transition to the ATRIUM 10XM at BFN in regards to the structural response of the fuel.

Testing was utilized to determine the ATRIUM 10XM fuel assembly component allowable loading for the spacer grid and tie plates. The dynamic properties, e.g., fuel channel stiffness and mass, of the fuel assembly was calculated and verified through testing for both a channeled and un-channeled assembly and was used for comparison between the ATRIUM-10 and ATRIUM 10XM. However, comparison of the dynamic properties between legacy fuel and the ATRIUM 10XM was calculated. The full array of testing conducted for the ATRIUM 10XM design is discussed in Section 4.0 of (Reference 6).

Fuel assembly acceptance criteria per the Standard Review Plan (SRP) are listed in ANF-89-98 and the design report using the same numbered criteria sections; Table 7.3 in ANF-89-98 and in Table 3-1, 3-2 and 3-3 in (Reference 6). Acceptance criteria of Section IV, Appendix A of the SRP Chapter 4.2 are addressed in Table 3-1, Criteria Section 3.4.4 and 3.5 (Reference 6).

2.4 ***SNPB RAI-4***

Section 3.1 of ANP-3385P (Reference 9) describes a method to determine the Gadolinia power history.

a. Provide a basis for the process used for the determination of the gadolinia power history.

b. Why the process described in ANP-3385P is limited to peaking factors calculated for the central lattices of the fuel assembly? Explain.

AREVA Response a.

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AREVA Response b.

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2.5 ***SNPB RAI-5***

Section 3.2.4 of ANP-3385P (Reference 9) states that "the fuel centerline temperature is evaluated using the RODEX2A code for both normal operating conditions and AOOs."

RODEX2A code is a legacy code that does not explicitly treat fuel thermal conductivity as a function of burnup (TCD) and is less conservative above ~35 GWd/MTU burnup. Provide justification for using RODEX2A code for evaluating fuel centerline temperature. Also, please describe whether any modification/augmentation of RODEX2A have been done in order to correct this deficiency of the lack of TCD treatment.

AREVA Response

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2.6 ***SNPB RAI-6***

Table 3.2, "Design duty cycles for cyclic fatigue evaluation of ANP-3385P," lists Load Follow among other processes. Assuming that the licensee plans to implement the load following of the BFN Units, respond to the following request:

Provide a discussion of the impact of load follow at the BFN units on their operation due to the following:

a. Effect of change in moderator temperature and moderator flow on reactivity due to load follow,

b. Effect of change in fuel temperature on reactivity due to load follow,

c. Change in power distribution in the core due to load follow,

d. Impact of power changes on xenon distribution and the subsequent xenon induced reactivity changes due to load follow, and

e. Impact on fuel performance parameters such as pellet-cladding-interaction, stress corrosion cracking, dimensional changes in fuel pellets, fission gas release and rod internal pressure due to load following.

AREVA Response

TVA does not intend to operate the Browns Ferry units in load following mode (provided by TVA).

The duty cycles were selected to provide challenging operation from a cyclic fatigue perspective.

2.7 *SNPB RAI-7*

It is stated in Section 1.0 of ANP-3388P (Reference 10) that "for equilibrium cycle and Cycle 19 of Unit 3, approximately 30 percent of the fuel assemblies in each reload batch are composed of BLEU (blended low enriched uranium)."

Is the 30 percent BLEU fuel that will be introduced into Unit 3 for Cycle 19 higher than the BLEU percent for the ATRIUM 10XM fuel transition for the Unit 3 in 2013 LAR? If this percentage is higher than the percentage of BLEU fuel in 2013 fuel transition, what is the impact on the buildup of various uranium isotopes during the depletion of the fuel? Also discuss the impact of the various uranium isotopes on reactivity.

AREVA Response

BFN reactors currently use 100% Blended Low Enriched Uranium (BLEU) assemblies in their cores. The fuel cycle design included as part of the ATRIUM 10XM fuel transition LAR was also based upon a core in which all assemblies contained BLEU. However, by the time EPU is implemented, the available stockpile of BLEU material will not be adequate to continue supporting this quantity of BLEU loading. For this reason, a reduced fraction of BLEU was included in the equilibrium and transition core designs supporting the BFN EPU LAR. This reduced BLEU loading was provided as representative of potential BFN EPU cores that contain BLEU and is not meant to establish either an upper or lower bound of allowable BLEU content for BFN.

In the previously approved LAR supporting methodology additions for the ATRIUM 10XM fuel design, the NRC reviewed the continued use of BLEU at BFN. Specifically, in Reference 22 the response to RAI-1 discusses the differences between Commercial Grade Uranium (CGU) and BLEU. The primary discussion points can be summarized as:

- Both CGU and BLEU are subject to the same maximum U^{235} enrichment of 4.95%.
- There is no difference chemically.
- The isotopes of Uranium have the same electronic signature so substitution of one isotope for another does not constitute a point defect or change the local electronic configuration.
- Thermal conductivity and mechanical properties are not impacted.
- The primary difference is that BLEU has a higher concentration of U^{234} and U^{236} isotopes.
- The primary difference in neutronic characteristic is driven by the presence of a higher concentration of U^{236} which has a neutron poisoning impact. Because the maximum U^{235} enrichment remains the same, the net impact is reduction in overall reactivity of the fuel.

This reduction in reactivity is illustrated in Figure 3 for lattices with the same enrichment and Gadolinia distributions (i.e., the only difference is the presence of U^{234} and U^{236} in the BLEU lattice).

- The CASMO-4/MICROBURN-B2 code system explicitly models and tracks the U^{234} and U^{236} isotopes as well as the impacts on other uranium and fissile isotopes. The isotopic concentrations of the U^{234} and U^{236} isotopes are explicitly included in the design and licensing process. Figure 4 illustrates the difference in isotopic buildup and depletion for the same comparison lattices used in the previous reactivity comparison. Figure 5 provides a similar comparison for the fissile isotopes.

The figures provided in this response are the same as those previously provided in Reference 22. The previous response remains applicable to the use of BLEU in BFN at EPU conditions.

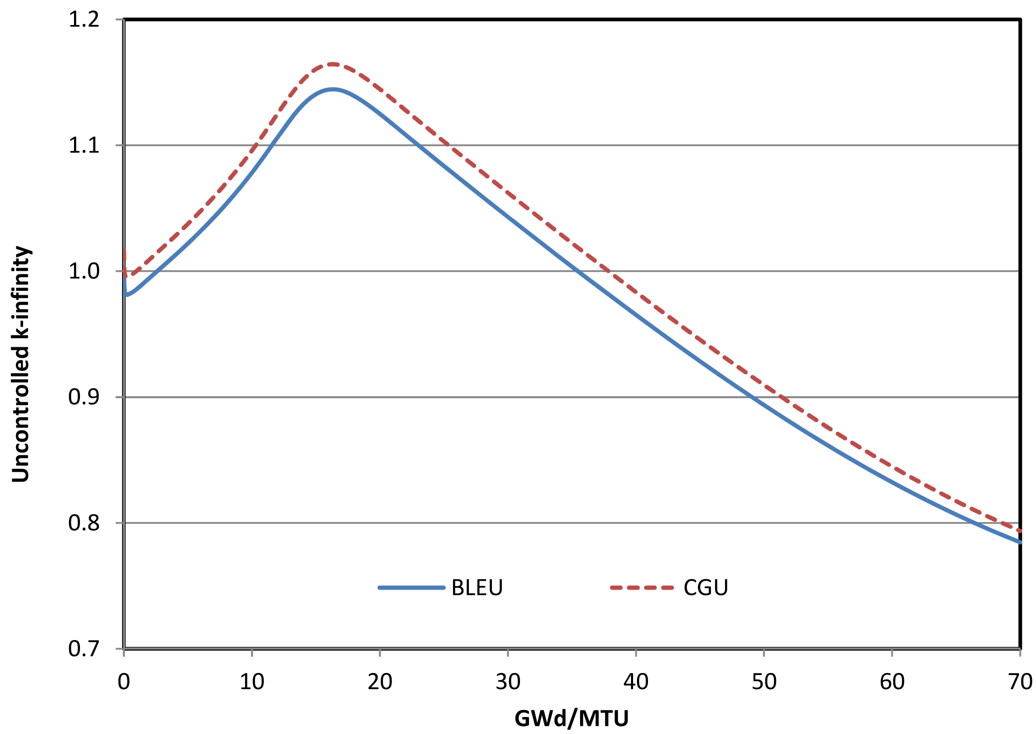

Figure 3 Lattice Reactivity Comparison at Same Enrichment

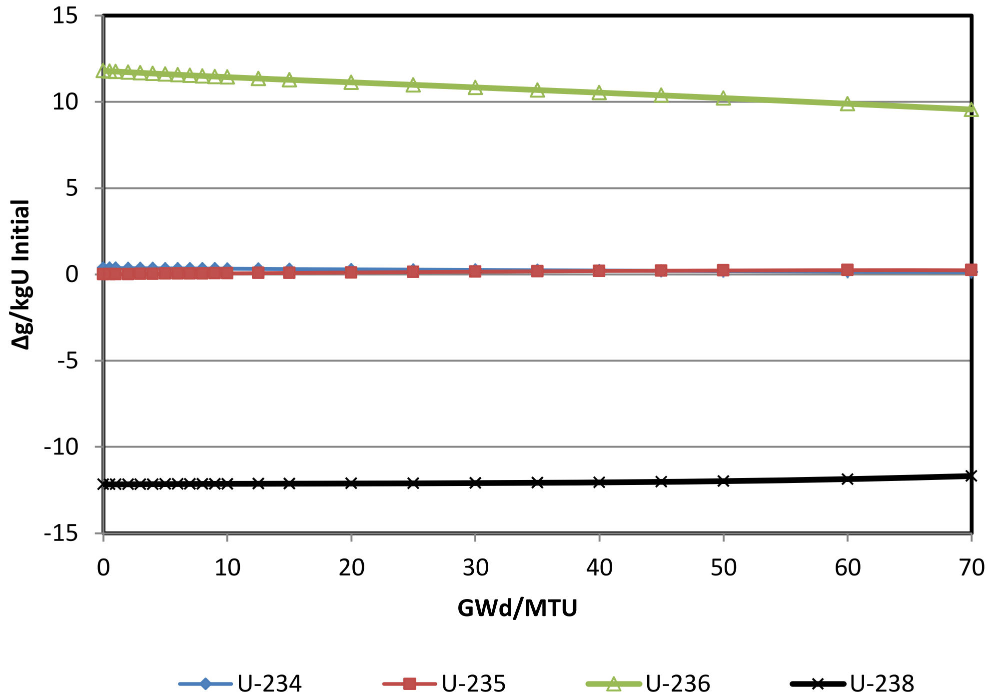

Figure 4 Isotopic Depletion Variation, BLEU-CGU

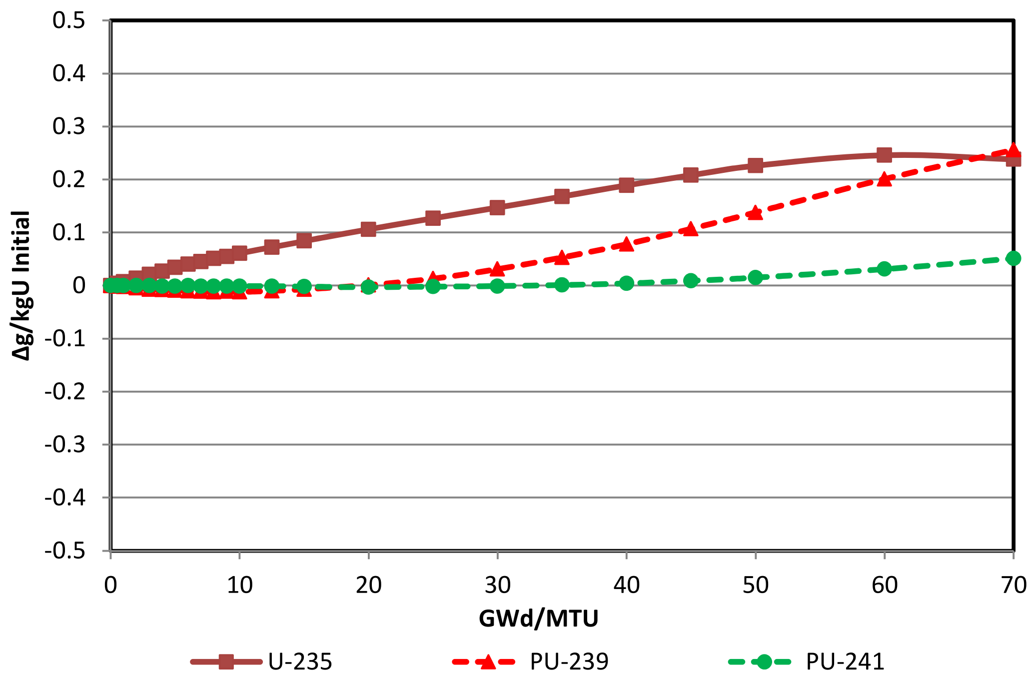

Figure 5 Fissile Isotope Variation, BLEU-CGU

2.8 *SNPB RAI-8*

The licensee is using the ACE ATRIUM 10XM correlation (ANP-10298PA, Revision 0 (Reference 11) and ANP 3140P (Reference 12)) for the ATRIUM 10XM fuel design and the SPCB correlation (EMF-2209PA) (Reference 13) for the co-resident ATRIUM-10 fuel design. However, NRC has approved the ACE ATRIUM-10 correlation (ANP-10249PA (Reference 13) as revised) for the ATRIUM-10 fuel design with revised additive constants as per EMF 2209PA. Please provide justification for the use of SPCB correlation for ATRIUM-10 instead of the approved ACE ATRIUM-10 correlation with revised additive constants.

AREVA Response (Provided by TVA)

Two correlations are licensed for application to ATRIUM 10 fuel. These are the SPCB correlation (EMF-2209PA Rev. 3) and the ACE ATRIUM 10 correlation (ANP-10249P-A Rev. 2). Each of these correlations utilizes its own licensed additive constants.

The approach for calculating the critical power ratio of the co-resident ATRIUM-10 fuel in Browns Ferry units with ATRIUM-10 XM reloads was specified in the license amendment request associated with the transition to the ATRIUM-10 XM fuel type (Reference 24). The amendment stated that co-resident ATRIUM-10 fuel would be evaluated using the SPCB correlation. This was the approach taken by the plant identified as a precedent application in Reference 24. The Nuclear Regulatory Commission acknowledged in the subsequent Safety Evaluation Report (SER) that the SPCB correlation would be acceptable for the purpose of evaluating critical power ratio in the co-resident ATRIUM-10 fuel (Sections 3.3.3 and 3.7.2 of the Reference 25 SER).

Any legacy ATRIUM-10 fuel in Browns Ferry Extended Power Uprate (EPU) cores would be third cycle fuel, loaded in non limiting locations near the edge of the core. There is no economic benefit or other incentive to warrant pursuing a change to the Technical Specifications to add the ACE ATRIUM-10 methodology.

ENCLOSURE 3

AREVA Affidavit

A F F I D A V I T

COMMONWEALTH OF VIRGINIA)
) ss.
CITY OF LYNCHBURG)

1. My name is Morris Byram. I am Manager, Product Licensing, for AREVA Inc. (AREVA) and as such I am authorized to execute this Affidavit.

2. I am familiar with the criteria applied by AREVA to determine whether certain AREVA information is proprietary. I am familiar with the policies established by AREVA to ensure the proper application of these criteria.

3. I am familiar with the AREVA information contained in the topical draft report ANP-3487P, Revision 0, "Responses to RAIs for Browns Ferry Nuclear Plant EPU Submittal – Nuclear Performance and Code Review Branch," and referred to herein as "Document." Information contained in this Document has been classified by AREVA as proprietary in accordance with the policies established by AREVA Inc. for the control and protection of proprietary and confidential information.

4. This Document contains information of a proprietary and confidential nature and is of the type customarily held in confidence by AREVA and not made available to the public. Based on my experience, I am aware that other companies regard information of the kind contained in this Document as proprietary and confidential.

5. This Document has been made available to the U.S. Nuclear Regulatory Commission in confidence with the request that the information contained in this Document be withheld from public disclosure. The request for withholding of proprietary information is made in accordance with 10 CFR 2.390. The information for which withholding from disclosure is

requested qualifies under 10 CFR 2.390(a)(4) "Trade secrets and commercial or financial information."

6. The following criteria are customarily applied by AREVA to determine whether information should be classified as proprietary:

(a) The information reveals details of AREVA's research and development plans and programs or their results.

(b) Use of the information by a competitor would permit the competitor to significantly reduce its expenditures, in time or resources, to design, produce, or market a similar product or service.

(c) The information includes test data or analytical techniques concerning a process, methodology, or component, the application of which results in a competitive advantage for AREVA.

(d) The information reveals certain distinguishing aspects of a process, methodology, or component, the exclusive use of which provides a competitive advantage for AREVA in product optimization or marketability.

(e) The information is vital to a competitive advantage held by AREVA, would be helpful to competitors to AREVA, and would likely cause substantial harm to the competitive position of AREVA.

The information in this Document is considered proprietary for the reasons set forth in paragraphs 6(b), 6(c), and 6(d) above.

7. In accordance with AREVA's policies governing the protection and control of information, proprietary information contained in this Document has been made available, on a limited basis, to others outside AREVA only as required and under suitable agreement providing for nondisclosure and limited use of the information.

8. AREVA policy requires that proprietary information be kept in a secured file or area and distributed on a need-to-know basis.

9. The foregoing statements are true and correct to the best of my knowledge, information, and belief.

[signature]

SUBSCRIBED before me this 10th day of May, 2016.

[signature]

Sherry L. McFaden
NOTARY PUBLIC, COMMONWEALTH OF VIRGINIA
MY COMMISSION EXPIRES: 10/31/18
Reg. # 7079129

SHERRY L. MCFADEN
Notary Public
Commonwealth of Virginia
7079129
My Commission Expires Oct 31, 2018