August 30, 2013

Mr. Joseph W. Shea
Vice President - Nuclear Licensing
Tennessee Valley Authority
1101 Market Street LP 3D-C
Chattanooga, TN 37402-2801

SUBJECT: BROWNS FERRY NUCLEAR PLANT, UNITS 1, 2, AND 3, REQUEST FOR ADDITIONAL INFORMATION FOR TECHNICAL SPECIFICATION CHANGE TS-478 REGARDING ADDITION OF ANALYTICAL METHODOLOGIES TO TS 5.6.5 FOR BROWNS FERRY NUCLEAR PLANT UNITS 1, 2, AND 3, AND REVISION OF TS 2.1.1.2 FOR BFN UNIT 2 (TAC NUMBERS MF0877, MF0878 AND MF0879)

Dear Mr. Shea:

By letter dated February 28, 2013, Tennessee Valley Authority (TVA), requests an amendment to the Renewed Facility Operating License Numbers DPR-33, DPR-52 and DPR-68 for the Browns Ferry Nuclear Plant (BFN) Units 1, 2, and 3 respectively. The proposed license amendment request will add three additional AREVA methodologies to the list of approved methods to be used in determining core operating limits in the core operating limits report. In addition, the amendment request will implement a change to the safety limit minimum critical power ratio value for BFN Unit 2. The proposed change will support a planned transition to AREVA ATRIUM 10XM (XM) fuel design. TVA intends to transition BFN Unit 2 to XM design starting with Cycle 19 (spring 2015), Unit 3 in spring 2016 followed by Unit 1 in fall of 2016.

A response to the enclosed request for additional information (RAI) is needed before the Nuclear Regulatory Commission staff can complete the review. This request was discussed with Mr. Thomas Hess of your staff on August 6, 2013, and it was agreed that TVA would respond by September 30, 2013.

The NRC staff considers that timely responses to RAIs help ensure sufficient time is available for staff review and contribute toward the NRC's goal of efficient and effective use of staff resources.

If you have any questions, please contact me by phone at (301) 415-1447 or e-mail at Farideh.Saba@nrc.gov.

Sincerely,

/RA/

Farideh E. Saba, Senior Project Manager
Plant Licensing Branch II-2
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket Nos. 50-259, 50-260, and 50-296

Enclosure:
Request for Additional Information

cc: Distribution via Listserv

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ADAMS Accession No.: ML13224A088 ***by memorandum**

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DATE	08/20/13	08/20/13	08/09/13	08/09/13	08/30/13

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REQUEST FOR ADDITIONAL INFORMATION REGARDING

TECHNICAL SPECIFICATION CHANGE TS-478 REGARDING ADDITION OF ANALYTICAL

METHODOLOGIES TO TS 5.6.5 FOR BROWNS FERRY NUCLEAR PLANTS (BFN) UNITS 1,

2, AND 3 AND REVISION OF TS 2.1.1.2 FOR BFN UNIT 2

TENNESSEE VALLEY AUTHORITY

BROWNS FERRY NUCLEAR PLANT, UNITS 1, 2, AND 3

DOCKET NOS. 50-259, 50-260, AND 50-296

By letter dated February 28, 2013 (Reference 1), Tennessee Valley Authority (TVA), requests an amendment to the Renewed Facility Operating License Numbers DPR-33, DPR-52 and DPR-68 for the Browns Ferry Nuclear Plant (BFN) Units 1, 2, and 3, respectively. The proposed license amendment request (LAR) will add three additional AREVA methodologies to the list of approved methods to be used in determining core operating limits in the Core Operating Limits Report (COLR). In addition, the amendment request will implement a change to the Safety Limit Minimum Critical Power Ratio (SLMCPR) value for BFN Unit 2. The proposed change will support a planned transition to AREVA ATRIUM-10XM (XM) fuel design. TVA intends to transition BFN Unit 2 to XM design starting with Cycle 19 (spring 2015), Unit 3 in spring 2016 followed by Unit 1 in fall of 2016.

Request for Additional Information (RAI) by Nuclear Performance and Code Review Branch (SNPB)

SNPB RAI-1 ANP-3159P, Section 1.0

It has been stated in your LAR submittals that TVA intends to continue use of blended low enriched uranium (BLEU) for the manufacture of fuel pellets for the ATRIUM 10XM fuel design.

(a) Apart from the difference in density of the BLEU fuel from commercial grade fuel, list other differences in the BLEU fuel such as isotopic composition, physical properties, and neutronics characteristics from the commercial grade fuel.

(b) If the isotopic content of the BLEU fuel is different from that of the commercial grade fuel, what is the impact on the buildup of various uranium isotopes during the depletion of the fuel?

SNPB RAI-2 ANP-3159P

Section 3.2.3 of ANP-3159P, page 3-5 indicates that “LHGR [linear heat generation rate] margins are provided along with uncertainties due to channel bow for input to the statistical analysis.” Provide details of how the channel bow uncertainties are incorporated in to the statistical analysis.

SNPB RAI-3 ANP-3159P

Section 3.2.7 of ANP-3159P indicates that a program is in progress to monitor crud buildup and oxidation as water chemistry changes are implemented.

(a) Provide details of this program.

(b) Provide details as to how the guidance on treatment of corrosion, crud, and hydrogen content per NUREG-0800 Standard Review Plan (SRP), Section 4.2 is satisfied, and

(c) In ANP-3159P Section 3.2.7, it is stated, in part, that as a result of concerns that were raised on the effect of non-uniform corrosion, such as spallation, and localized hydride formations on the ductility limit on cladding, a regulatory commitment was made to reduce the limit oxide limit to the value in Reference 3 that is listed for ANP-3159P. Provide details of how this regulatory commitment to reduce the oxide limit to the value specified in Reference 3 of ANP-3159P is implemented at BFN Units 1, 2, and 3.

SNPB RAI-4 ANP-3082P

Thermal hydraulic compatibility and characterization analyses have been performed and the results are summarized in ANP-3082P. The transition cores for the Browns Ferry units consist of ATRIUM 10 with both Standard FUELGUARD (SFG) and Improved FUELGUARD (IFG) lower tie plates. Provide a detailed description of the differences between SFG and IFG with respect to their geometry (preferably using drawings), contribution to the pressure drop and contribution to thermal margin performance by the improvement in design of the FUELGUARDs.

SNPB RAI-5 ANP-3082P Section 3.4, ANP-3150P, Section 3.3.5

It is stated in the above section that the rod closure due to rod bow was assessed for impact on thermal margins.

(a) Describe how the CPR penalty was determined as function of exposure,

(b) Provide an assessment of how the thermal margin calculations are affected by the rod bow at various exposures,

(c) Justify your prediction that less rod bow for ATRIUM 10XM than for ATRIUM 10 by showing typical analysis/calculations, and provide how the rod bow behavior is impacted by fuel burnup.

SNPB RAI-6 ANP-10307PA, Section 2.2, Channel Bow

It has been stated in Section 2.2.1 the channel growth correlation used to determine the channel bow magnitude is a continuous function of fast fluence from the beginning to the end of life. The model coefficients were computed using databases consisting of channel length measurements acquired by AREVA from European Boiling Water Reactors (BWRs) and from Pressurized Water Reactor guide tube data.

(a) Provide supporting details to demonstrate that the above mentioned channel bow database is applicable to Browns Ferry units' operating conditions.

(b) During review of Brunswick Steam Electric Plant (BSEP) ATRIUM 10XM fuel transition LAR, the Nuclear Regulatory Commission (NRC) staff determined that the predictive model for channel bow was validated against an empirical data that was not bounding of BSEP's expected performance. To resolve this issue, the licensee for BSEP agreed to increase the channel bow uncertainty in the SLMCPR calculation for the most severely deflected fuel channels. In view of the excessive channel bow that occurred at BSEP a license condition was proposed for BSEP Units 1 and 2 in connection with the use of AREVA channel bow model outside the range of the channel bow measurement database from which its uncertainty was quantified (Reference: Letter, BSEP 13-0002, from Michael J. Annacone (Duke Energy) to NRC, "Supplement to License Amendment Request for Addition of Analytical Methodology Topical Report to Technical Specification 5.6.5, CORE OPERATING LIMITS REPORT (COLR), and Revision to Technical Specification 2.1.1.2 Minimum Critical Power Ratio Safety Limit," Duke Energy, January 22, 2013.) Confirm whether a similar license condition is required for the BFN Units 1, 2, and 3.

<u>SNPB RAI-7 ANP-3082P, Section 3.5</u>

Discuss the impact on bypass exit subcoding while transitioning between transition core combination of AREVA fuel and GE14 to a full core ATRIUM 10XM fuel design at BFN units.

<u>SNPB RAI-8 ANP-3082P, Section 3.2</u>

Table 3.4 of ANP-3082 provides input conditions for thermal hydraulic compatibility analysis for two of the statepoints 100 percent power/100 percent flow and 62 percent power/37.3 percent flow.

(a) Provide the basis for the thermal margin analysis performed at 62 percent power/37.3 percent flow statepoint and

(b) Justify why the analysis was not done at 100 percent power/105 percent flow as indicated in Figure 1.1, BFN Power Flow Map -100 percent original licensed thermal power (OLTP) of ANP-3167(P), BFN Unit 2 Reload Safety Analysis.

<u>SNPB RAI-9 ANP-3150P, Section 3.3.1, Table 3.1</u>

Provide details of the procedure, assumptions, methodology and results for the "stress evaluations" that were performed to confirm the design margin and to establish a baseline for adding accident loads for the determination of loading limits on fuel assembly components.

<u>SNPB RAI-10 ANP-3150P, Section 3.4.4</u>

(a) Describe AREVA ATRIUM 10 and ATRIUM 10XM fuel assemblies' dynamic structural response to combined seismic/loss-of-coolant accident (LOCA) loadings. Provide details of the model used for assembly with and without a fuel channel, acceleration used in the calculations, uncertainty allowances in the calculations, and results with margin to established limits.

(b) Provide details of the testing done to obtain the dynamic characteristics of the fuel assembly and spacer grids under varying conditions of stiffness, natural frequencies and damping values with and without the fuel channel. Provide details of the evaluation of BFN ATRIUM 10/ATRIUM 10XM fuel assembly structural response to externally applied forces (seismic and LOCA) and show how the acceptance criteria in NUREG-0800, Chapter 4.2, Appendix A, Section IV are satisfied.

SNPB RAI-11 ANP-3170P Section 3.1

The core average gap conductance used in COTRANSA2 system calculations and the hot channel gap conductance used in XCOBRA-T hot channel calculations are obtained from RODEX2 calculations. The sensitivity to conductivity and gap conductance for Anticipated Operational Occurrence (AOO) analyses is in the opposite directions for the core and the hot channel. This means that putting more energy into the coolant (higher thermal conductivity/higher gap conductance) is nonconservative for the system calculation but conservative for the hot channel calculations. Provide, with quantitative examples, how these competing effects between the core and hot channel calculations are balanced to minimize the overall impact of thermal conductivity degradation.

SNPB RAI-12 ANP-3145P, ANP-2637 Section 3.0

Nuclear core design analyses establish operating margins for minimum critical power ratio (MCPR), maximum average planar LHGR (MAPLHGR), and LHGR. Two exposure dependent LHGR limits are established for each fuel design; one a steady state operating fuel design limit (FDL) and the other for the protection against the power transient (PAPT) limit.

(a) Provide the details of the FDL and PAPT limits as a function of exposure and show that sufficient margin exists between the steady state and transient LHGR limits,

(b) Show that the transient LHGR design limit satisfies the strain and fuel overheating design criteria.

(c) Confirm that the fuel Thermal Conductivity Degradation (TCD) with exposure has been taken into account in generating/adjusting the LHGR limits.

(d) Section 2.0 of ANP-3145P suggests that for a complete description of fresh reload assemblies, see Reference 6, which is listed as ANP-3144(P) Revision 0, Nuclear Fuel Design Report BFE-19 LAR ATRIUM 10XM, August 2012. This report is not available to the NRC staff. Please submit a copy of this report to the NRC or provide a complete description in your response.

SNPB RAI-13 ANP-3148P, Section 3.3

Describe how the hot excess reactivity and shutdown margin are maintained per Technical Specification values during the transition cycles and during the equilibrium cycle of operation of the Browns Ferry units.

SNPB RAI-14 ANP-3140, Section 3

In BWR terminology, assembly critical power is defined as the minimum assembly power that results in onset of Boiling Transition (BT) (dryout) at any location in the assembly. The acceptance criterion related to BT in BWRs is that the limiting value of Minimum Critical Power Ratio (MCPR) such that at least 99.9 percent of the fuel rods in the core are not expected to experience BT during normal operation and AOOs. The SLMCPR is determined such that at least 99.9 percent of the fuel rods in the core are expected to avoid BT if the MCPR is greater than or equal to the SLMCPR. The SMPCPR methodology uses a critical power correlation to calculate CPR for a fuel assembly based on thermal hydraulic conditions and power distribution in the assembly.

(a) Section 3.3.1 of ANP-3140P describes how an additive constant (that accounts for local effects such as spacing and geometry) is determined based on predictions of the critical power correlation and comparisons to test data. Figure 3-2 of ANP-3140P identifies the test bundle where majority of the rods were dryout was observed. Explain how the test results (with majority rods in dryout) are used in the accurate determination of CPR correlation additive constants?

(b) Figure 3-5 of ANP-3140P lists additive constants comparison of original ACE/ATRIUM 10XM and revised ACE/ATRIUM 10XM. Section 3.3.4 indicates that the observed changes in additive constants are generally small. However, a random check by staff on the changes in additive constants has shown that the changes vary from 2 percent to 80 percent in magnitude. Please explain why there are larger variations contrary to what is stated in Section 3.3.4.

SNPB RAI-15 ANP-3140, Section 5.0

Provide a detailed summary of the K-factor method that is described in Section 5 of ANP-3140. If the methodology appears in an NRC-accepted topical report, please refer to the topical report and identify the appropriate sections of the topical report that discuss the K-factor method.

SNPB RAI-16, ANP-3152, ANP-3167P

While reviewing ANP-3167P, Browns Ferry Unit 2 Cycle 19 Reload Analysis, the NRC staff noticed that the Reference 7 listed in Section 9.0 of ANP-3167P, ANP-3153(p) Browns Ferry Units 1, 2 and 3 LOCA-ECCS [emergency core cooling system] Analysis MAPLHGR Limit for ATRIUM 10XM Fuel, is NOT included in your LAR package. Submit this reference to the NRC for staff's review and evaluation of LOCA-ECCS analysis with the MAPLHGR limits for the ATRIUM 10XM fuel design.

SNPB RAI-17, ANP-3152P Section 2.0

Provide detailed summary results of the analyses that are referred to in the second and third sentences of page 2-2.

SNPB RAI-18, ANP-3152P, ANP-3170P

RODEX4 computer code was used to assess the potential impact of exposure (burnup) degradation of UO_2 thermal conductivity (TCD) on the fuel parameters and this assessment was used to make adjustments to input for RODEX2 TCD with exposure that was used in the LOCA analysis.

a) Provide details of the adjustments made to RODEX2 input for LOCA analysis.

b) Provide a discussion of impact of gap conductance between the fuel pellet and the cladding on ECCS performance analysis results resulting from fuel thermal conductivity degradation with exposure and irradiation effects on the ceramic fuel.

SNPB RAI-19, ANP-3152

Figure 6.19 of ANP-3152P illustrates the variation of cladding temperature with time for the limiting recirculation line break. The cladding temperature experiences the first peak at around 190 seconds into the transient. Please explain the cause of this intermediate temperature peak.

SNPB RAI-20, ANP-3152, Section 8.0

Explain the basis for applying a factor of 0.85 multiplier to the two-loop operation (TLO) MAPLHGR limit for the single-loop operation (SLO) Single failure-Battery (DC) power board A (SF-BATT|BA) LOCA analysis.

SNPB RAI-21, ANP-3152

Explain the impact on LOCA (ECCS performance) analysis and Title 10 of *Code of Federal Regulations*, Section 50.46 acceptance criteria for BFN Units 1, 2, and 3 coastdown operation with final feedwater temperature reduction (FFTR) as well as operation with feedwater heaters out-of-service (FHOOS).

SNPB RAI-22, ANP-3167P, Section 4.2

BFN Unit 2 Cycle 19 SLMCPR calculated from Reference 12 (ANP-10307P) resulted in a value of 1.04 for TLO and a value of 1.05 for SLO and listed in Reference 8 (Document No. 51-9191258-001). These SLMCPR values are conservatively increased to 1.06 for TLO and 1.08 for SLO. Provide basis for the adoption of these new values.

cSNPB RAI-23, ANP-3167P, Section 4.3

Provide a summary of the analysis and results for BFN units operation with FFTR and FHOOS that complies with the licensing requirements for the Option III (Oscillation Power Range Monitor (OPRM)) stability solution. Also provide details and results for the analysis that supports BFN operation with backup stability protection regions, if the Option III OPRM system is declared inoperable.

SNPB RAI-24, ANP-3167P, Section 5.1.3

For feedwater controller failure (FWCF) event scenario, Figure 5.4 (Percent Rated Versus Time) indicates a sharp spike in relative rated power to about 375 percent and a simultaneous sharp reduction in relative steam flow at about 15 seconds into the event. Please describe the cause of this behavior during the FWCF event.

SNPB RAI-25, ANP-3167P, Section 6.1

Section 6.1 reports that ATRIUM 10XM LOCA analysis for BFN Units PCT is 1903 ^{o}F and the peak local metal water reaction is 1.16 percent. However, ANP-3152P, Browns Ferry Units 1, 2 and 3 LOCA Break Spectrum Analysis for ATRIUM 10XM Fuel, Table 6.1 reports that the PCT is 1909 ^{o}F and the maximum local cladding oxidation is 1.20 percent. Clarify the discrepancy between the information on LOCA results from these two documents.

SNPB RAI-26, ANP-3172P, Section 7.1

Table 7.1 lists the ASME Overpressurization analysis results for maximum vessel pressure for lower-plenum and the maximum dome pressure. Please specify whether the pressure results include any other analysis/measurement uncertainties in addition to the 7 pounds per square inch increase that binds a bias in the void-quality correlations as indicated.

RAIs by Reactor Systems Branch (SRXB)

SRXB RAI-1

In page 2 of Enclosure to the LAR, it was stated,

> The current ACE correlation for XM fuel has an identified deficiency. The deficiency involves a nonconservatism in the axial averaging process used to determine the K factor, which is an input to the correlation. … TVA is including a BFN specific ACE supplement in Attachments 27 and 28.

Did the deficiency in the current ACE correlation identified above impact BFN Unit 2 Cycle 19 SLMCPR values? If it did, was the updated methodology as provided in the generic and/or BFN-specific ACE supplements used for BFN Unit 2 Cycle 19 SLMCPR calculation? Explain if updated ACE correlation was not used.

SRXB RAI-2

Since Unit 2 Cycle 19 core is expected to include both ATRIUM-10 and ATRIUM 10XM fuel designs, which fuel design is more limiting from the standpoint of SLMCPR, and why?

SRXB RAI-3

Regarding the calculations performed for Unit 2 Cycle 19 reload safety analysis, as provided in ANP-3167(P), Revision 0, AREVA NP Inc., November 2012 (Attachment 12), confirm that most recently approved methodologies were used, including RODEX4, which accounts for the degradation of thermal conductivity with increasing fuel burnup using upper limit on calculated clad oxide thickness, and the updated methodology for ACE correlation that addresses a nonconservatism in the axial averaging process used to determine the K factor, which is an input to the correlation (as discussed in page 2 of Enclosure to the LAR). If the most recently updated and approved methodologies were not used for BFN Unit 2 Cycle 19 reload safety analyses, then please provide justification.