April 18, 2017

Mr. Gary Peters, Director
Licensing and Regulatory Affairs
AREVA Inc.
3315 Old Forest Road
Lynchburg, VA 24501

SUBJECT: REQUEST FOR ADDITIONAL INFORMATION RE: AREVA INC. TOPICAL REPORT ANP-10297P(A), REVISION 0, SUPPLEMENT 1, "THE ARCADIA® REACTOR ANALYSIS SYSTEM FOR PWRs METHODOLOGY DESCRIPTION AND BENCHMARKING RESULTS" (CAC NO. MF6469)

Dear Mr. Peters:

By letter dated June 26, 2015 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML15187A263), AREVA Inc. (AREVA) submitted for U.S. Nuclear Regulatory Commission (NRC) staff review and approval Topical Report ANP-10297P-A, Revision 0, Supplement 1, "The ARCADIA® Reactor Analysis System for PWRs Methodology Description and Benchmarking Results Topical Report." Upon review of the information provided, the NRC staff has determined that additional information is needed to complete the review. On March 23, 2017, Nathan Hottle, AREVA Product Licensing Manager, and I agreed that the NRC staff will receive the response to the enclosed request for additional information (RAI) questions within 60 days from the date of this letter.

If you have any questions regarding the enclosed RAI questions, please contact me at 301-415-4053.

Sincerely,

/RA/

Jonathan G. Rowley, Project Manager
Licensing Processes Branch
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

Project No. 728

Enclosure:
RAI Questions (Non-Proprietary)

SUBJECT: REQUEST FOR ADDITIONAL INFORMATION RE: AREVA INC. TOPICAL REPORT ANP-10297P(A), REVISION 0, SUPPLEMENT 1, "THE ARCADIA® REACTOR ANALYSIS SYSTEM FOR PWRs METHODOLOGY DESCRIPTION AND BENCHMARKING RESULTS" (CAC NO. MF6469)
DATED: APRIL 18, 2017

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REQUEST FOR ADDITIONAL INFORMATION

RELATED TO TOPICAL REPORT ANP-10297P(A), REVISION 0, SUPPLEMENT 1,

"THE ARCADIA® REACTOR ANALYSIS SYSTEM FOR PWRs

METHODOLOGY DESCRIPTION AND BENCHMARKING RESULTS,"

AREVA INC.

CAC NO. MF6469

RAI-1

Section 2.6.1 of the TR discusses the implementation of a model in APOLLO2-A for the generation of spacer grid form functions. These spacer grid form functions are used to produce spacer grid factors that mimic the behavior fuel assembly spacer grids have on assembly flux distributions and pin power in both steady state and transient core calculations. However, the actual nature of the spacer grid form functions and how they produce grid factors is not discussed in sufficient detail for the NRC staff to assess the range of applicability of the functions or the physical principles they utilize. Provide a mathematical description of the form functions, the grid factors, and the shape of the grid effect. If the form functions are comprised of a series of parameters (e.g., parameters describing flux suppression up/downstream of the grid), then also provide a mathematical description of how these parameters are generated.

RAI-2

Section 2.6.1 indicates that **[**

]?

RAI-3

Section 3.2.2 of the TR discusses multi-group power form functions. However, the actual form of the functions is not presented. Power form functions are discussed in Section 3.7 of the original ARCADIA TR ANP-10297P-A (Ref. 1), specifically Equation 3-51, but these power functions are not multi-group. Confirm whether the power form functions presented in the original ARCADIA TR are the same power form functions used in ARCADIA Supplement 1 and, if applicable, indicate how they have been modified to accommodate a multi-group approach.

RAI-4

Section 3.6 of the TR discusses the incorporation of a control rod cusping model to overcome the "cusping" effect in axial flux distribution that results from performing volume-weighting of cross-sections in partially rodded nodes. The NRC staff understands the approach described in the TR and the equations presented, but there are no qualification results presented to justify the model's performance and correct implementation in the code. Provide before and after axial flux distribution plots and a brief description justifying the model's qualification.

RAI-5

Section 3.9 of the TR describes how penalization of sensitive parameters is necessary for applying appropriate biasing, and how modifications were made to ARTEMIS™ to allow for adjustments of reactivity parameters and penalization of thermal-hydraulic and thermal-mechanical parameters. However, the modifications made to ARTEMIS™, the list of parameters that will be penalized, and how any penalization will be performed was not discussed. Before the NRC staff can assess the acceptability of these modifications with respect to ARCADIA®, this information must be supplied. Provide a discussion regarding how ARTEMIS™ was modified to allow adjustments of parameters, the parameters that will be adjusted and/or penalized, and the criteria guiding the penalization.

RAI-6

Section 3.10 of the TR describes incorporation of time-step control during transient calculations via use **[**

]. The NRC staff is familiar with a similarly-described time-step control method from AREVA's AURORA-B methodology (Reference 2), but without confirmation of any ARCADIA®-specific differences between the implementations, the NRC staff cannot independently rule-out time-step related code convergence issues. Confirm whether the time-step control approach used in ARCADIA® is different from that of AURORA-B and, if so, provide a description of how time steps are chosen for the **[**

]. In either case, what are the ranges of time-steps allowed?

RAI-7

Section 3.13 of the TR describes the incorporation into ARTEMIS™ of an excore detector model that makes use of a set of weighting factors to calculate the excore detector response. The model also makes use of a temperature decalibration model. However, the formulation of the weighting factors and the temperature decalibration model are not provided. Without this information, the NRC staff cannot assess the adequacy of the excore detector model. Provide a mathematical description and a discussion of how the weighting factors are determined and how the temperature decalibration model functions.

RAI-8

Table 8-1 in Section 8.2.1 of the TR lists the "Observed" and "Measured" deviations for a number of Babcock and Wilcox Company (B&W) 1980's critical core configurations, both of which are used to determine the uncertainty due to calculations alone. The Observed Deviations are actually generated from ARCADIA®-predicted results that are presented in Figures 4-5 through 4-10 of the TR. These figures also include the B&W experimental data from which, presumably, the Measured Deviations are generated. However, when utilizing the experimental data presented in the figures, the NRC staff was unable to reproduce the Measured Deviations presented in the table. One possible explanation is that a lower-sided 95 percent tolerance limit on the standard deviation of the experimental data may have been used when producing the Measured Deviations in the table. This would result in a maximized calculation uncertainty. However, when determining the confidence interval that covers 99 percent of the data with a 95 percent confidence, the NRC staff found the values presented in Table 8-1 appear to be off by a factor of 10. Given this discrepancy, the NRC staff cannot confirm the accuracy of the supplied data and therefore cannot confirm the magnitude of the uncertainty due to ARCADIA®'s calculations. Provide a description of how the Measured Deviations in Table 8-1 were generated. Include in the description whether a tolerance interval was used, what percentage of the data the interval covers, and the confidence level used when performing the calculation. Additionally, confirm whether or not the experimental B&W 1980's Critical Core data provided in Figure 4-5 through 4-10 are the same data used to generate the Measured Deviations in Table 8-1. If these data were not used in the generation of the Measured Deviations, provide a copy or a reference to the actual data used.

RAI-9

Sections 8.3.1 and 8.3.3 of the TR state that global and local uncertainty components associated with the MEDIAN reconstruction methodology are combined to estimate "the Normal Uncertainty and Non-Parametric Uncertainty." However, the exact approach used to combine the uncertainty components and estimate the Normal and Non-Parametric uncertainties is not explicitly stated. Provide a discussion of, or a reference to, the technique used to combine the uncertainty components.

RAI-10

Section 8.1 of the TR states that when determining 95/95 (95 percent confidence for 95 percent of the data) tolerance limits "Monte Carlo simulations are performed on the actual distributions to obtain a 95/95 tolerance limit which does not require the data to be normally distributed." This is also known as a Non-Parametric Uncertainty analysis. The NRC staff has investigated this technique and found that the results of this process are sensitive to the manner in which the input distributions are sampled. Specifically, sampling from a reduced range of the input distributions, such as within plus or minus 2 sigma ($\pm 2\sigma$), does not reasonably predict the 95/95 tolerance limit that is produced when sampling from the full range of the input distributions. When performing the Non-Parametric Uncertainty analysis for production cases, what is the range AREVA will use when sampling the input distributions?

REFERENCES

1. ANP-10297P-A, Revision 0, "The ARCADIA® Reactor Analysis System for PWRs Methodology Description and Benchmarking Results," February 2013, (ADAMS Accession No. ML14195A147 / ML14195A152 (Publically Available / Non-Publically Available)).

2. ANP-10300P, Revision 0, "AURORA-B: An Evaluation Mode for Boiling Water Reactors; Application to Transient and Accident Scenarios," December 2009, (ADAMS Accession No. ML100040158 / ML100040159 (Publically Available / Non-Publically Available)).