



UNITED STATES  
NUCLEAR REGULATORY COMMISSION  
WASHINGTON, D.C. 20555-0001

September 11, 2023

Ms. Gayle Elliot, Director  
Licensing and Regulatory Affairs  
Framatome Inc.  
3315 Old Forest Road  
Lynchburg, VA 24501

SUBJECT: REQUEST FOR U.S. NUCLEAR REGULATORY COMMISSION  
CONFIRMATION THAT A CHANGE TO THE ARCADIA® CODE SYSTEM IS  
WITHIN THE SCOPE OF APPROVED METHODS IN FRAMATOME, INC.  
TOPICAL REPORT, ANP-10297, REVISION 0, SUPPLEMENT 1P-A,  
REVISION 1, "THE ARCADIA® REACTOR ANALYSIS SYSTEM FOR PWRs  
METHODOLOGY DESCRIPTION AND BENCHMARKING RESULTS"  
(EPID L-2023-TOP-0019)

Dear Ms. Elliot:

By letter dated February 9, 2023 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML23046A093), Framatome, Inc. (Framatome) submitted a request for NRC confirmation (ADAMS Package No. ML23046A120) that a change to the ARCADIA® Code System (ARCADIA®) is within the scope of the approved methodology described in Topical Report (TR) ANP-10297, Revision 0, Supplement 1P-A, Revision 1, "The ARCADIA® Reactor Analysis System for PWRs [Pressurized Water Reactors] Methodology Description and Benchmarking Results" (ADAMS Package No. ML21071A062).

Description and benchmarking of ARCADIA® was presented in TR ANP-10297P-A, Revision 0, "The ARCADIA® Reactor Analysis System for PWRs Methodology Description and Benchmarking Results," (the original ARCADIA® TR, ADAMS Accession No. ML14195A145). The original ARCADIA® TR was approved for use by the NRC in February 2013. ANP-10297P-A, Revision 0, Supplement 1P-A, Revision 1 (Supplement 1) is the first supplement to the original ARCADIA® TR and was approved for use by the NRC in August 2018.

Framatome requested confirmation that a minor change to ARCADIA® is consistent with the approved methodology described in Supplement 1. Supplement 1 builds on the approved methodology described in the original ARCADIA® TR. In some cases, Supplement 1 defers to the original ARCADIA® TR for description and validation of models and methods. In particular, the change to ARCADIA® described in Enclosure 1 of the February 9, 2023, letter (Confirmation Request Letter) relates to the reflector cross-section methodology, which is discussed in the original ARCADIA® TR. Therefore, NRC staff assessed the change to the reflector cross-section methodology for consistency with the methodology described in the original ARCADIA® TR as supplemented by Supplement 1.

Section 3.9.3, “Code Modification Change Process” of the NRC staff’s safety evaluation (SE) for Supplement 1 discusses the changes that may be made to ARCADIA® without prior NRC review and approval and the requirements necessary for such changes. As discussed in the NRC staff’s SE, while the NRC staff understands the desire to maintain a code as state-of-the-art, the NRC staff must balance this with sufficient regulatory oversight to ensure that core analysis codes provide acceptable results and that all applicable regulatory requirements are met. Hence, the requirements for changes to ARCADIA® without prior NRC review and approval consist of, among others, that the change must be consistent with the methodology described in the TR (in this case, the original ARCADIA® TR as supplemented), that the change does not invalidate the NRC staff’s SE, and that the validation suite of acceptance criteria (Table 10-2 of Supplement 1) continue to be met. Additionally, Section 3.9.3 of the NRC staff’s SE for Supplement 1 indicates changes to ARCADIA® could be considered consistent with the methodology described in the TR even if they would result in a change to the description of the methodology provided in the TR, but in such instances NRC concurrence will be necessary to conclude as such.

The ARCADIA® reflector cross-section methodology utilizes a one-dimensional (1D) fuel-reflector interface model called Equivalent Reflector Model 1 (ERM<sub>1</sub>). Within the methodology, APOLLO2-A (the ARCADIA® lattice physics code) is used to solve the neutron transport equation for the ERM<sub>1</sub> and obtain a heterogeneous response matrix that relates surface fluxes to currents. ARTEMIS™ (the ARCADIA® three-dimensional (3D) core-simulator code) is then used to solve the same problem with homogenized regions using neutron diffusion theory. The homogenized problem is then forced to preserve the heterogeneous response matrix, yielding a set of cross-sections for use in the nodal solver that mimic the detailed transport theory reflector response. This approach required some corrections to account for two-dimensional (2D) effects.

Enclosure 1 of the Confirmation Request Letter describes the change to the ARCADIA® reflector cross-section methodology, which consists of extending the ERM<sub>1</sub> to a 2D model called ERM<sub>4</sub>. Enclosure 1 identifies this change in the geometric model renders corrections for 2D effects unnecessary, but the approach of preserving the heterogeneous response matrix in the homogenized problem remains the same. Enclosure 1 also indicates that validation of the modified reflector cross-section methodology with the ERM<sub>4</sub> was performed using many of the same code-to-code comparisons and plant data comparisons as the ERM<sub>1</sub> in the original ARCADIA® TR, and similar results were obtained. Further, Enclosure 1 identifies that all ARCADIA® startup physics test comparisons and core follow comparisons were redone with the ERM<sub>4</sub>-derived reflector cross-sections, and all results were within applicable criteria. Per Enclosure 1, Framatome indicates that these results meet the requirements specified in Section 3.9.3 of the NRC staff’s SE for Supplement 1 to justify the change.

On August 18<sup>th</sup>, 2023, NRC staff conducted a virtual audit with Framatome to ensure correct understanding of the change discussed in Enclosure 1 to the Confirmation Request Letter and verify the validation results for the ERM<sub>4</sub> and ARCADIA®. NRC staff identified that the change would result in textual changes to the as-described reflector cross-section methodology in the original ARCADIA® TR. However, the NRC staff finds that these textual changes are minor; the material that would undergo textual changes consists largely of the corrections needed to ensure the 1D ERM<sub>1</sub> reflector model better approximates a 2D solution, and this material intrinsically becomes unnecessary with the 2D ERM<sub>4</sub>. The remaining textual changes impact the dimensional description of the model and the specified size of the heterogeneous response matrix, both of which inherently follow from the shift to a 2D geometric model. Aside from these textual changes, the overall approach of the reflector cross-section methodology remains the same, including conserving the heterogeneous response matrix and the determination of

reflector cross-sections. The NRC staff's SE for the original ARCADIA® TR discusses the adequacy of the overall reflector cross-section methodology, which is maintained with the change to ERM<sub>4</sub>, and the adequacy of the 2D corrections, which are not necessary when utilizing a 2D model. Therefore, the staff concludes the change to the reflector cross-section methodology does not invalidate the SE approving the original ARCADIA® TR as supplemented. During the audit, NRC staff verified that the validation results for the ERM<sub>4</sub> reflector cross-section methodology are comparable with the validation results for the ERM<sub>1</sub> reflector cross-section methodology. The NRC staff also that verified the ARCADIA® validation suite of acceptance criteria (Table 10-2 of Supplement 1) continues to be met. Therefore, the NRC staff confirms the change to the reflector cross-section methodology is within the scope of the approved original ARCADIA® TR as supplemented by Supplement 1.

In the next revision of Supplement 1, NRC staff requests that Framatome include this letter in the revised document and include revisions to reflect the NRC staff's concurrence of the change to the reflector cross-section methodology, as applicable.

Please contact Ngola Otto at 301-415-6695 or via e-mail at [Ngola.Otto@nrc.gov](mailto:Ngola.Otto@nrc.gov) with any questions you may have regarding this letter.

Sincerely,

*/RA/*

Gerond George, Chief  
Licensing Projects Branch  
Division of Operating Reactor Licensing  
Office of Nuclear Reactor Regulation

Docket No. 99902041

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 (EPID L-2023-TOP-0019) DATED SEPTEMBER 11, 2023

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**ADAMS Accession No.: ML23234A126 (Letter); ML23234A160 (package); \*via email,**

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