AUDIT PLAN FOR EXELON GENERATION COMPANY, LLC.

LICENSE AMENDMENT REQUEST TO UTILIZE TVEL TVS-K LEAD TEST ASSEMBLIES

AT BRAIDWOOD STATION, UNITS 1 AND 2

RENEWED FACILITY OPERATING LICENSE NOS. NPF-72 AND NPF-77

EPID NO. L-2018-LLA-0208

1.0 INTRODUCTION

By letter dated July 19, 2018, as supplemented on October 19, 2018 (Agencywide Documents Access and Management System (ADAMS) Accession Nos. ML18204A169 and ML18296A288), Exelon Generation Company, LLC (EGC) submitted a license amendment request to add a license condition to the Braidwood Station Operating Licenses for Units 1 and 2, which would authorize the use of up to eight Joint Stock Company "TVEL" (fuel company subsidiary of Rosatom) TVS-K lead test assemblies (LTAs) in non-limiting reactor core locations for operation and evaluation.

LTAs, by definition, have not been fully qualified for licensing applications due to the limited availability of data to validate the behavior of a new fuel assembly design in the reactor operating environment. In order to provide a means for collecting this data, the NRC may allow licensees to load a limited number of LTAs in non-limiting locations. The licensee must be able to demonstrate that the plant will be operated safely while the LTAs are in the core. Typically, licensees will do this by showing that the licensing basis analyses are applicable to the LTAs and remain bounding for operation with the LTAs, or that the limitations on the number of LTAs and locations where they are loaded are sufficient to accommodate uncertainties in the data or applicability of the methodology.

EGC chose to utilize the latter approach for the thermal limits imposed on the fuel, and the former approach for the remaining fuel related parameters important for the reload safety analyses. Specifically, EGC contracted Global Nuclear Fuel – America, LLC (GNF-A) to perform a thermal limits evaluation that would be used to demonstrate that the heat flux hot channel factor (F_Q) and nuclear enthalpy rise hot channel ($F\Delta H$) for the TVS-K LTAs are at least 5% below the limiting co-resident Westinghouse fuel at all times for hot full power conditions. All other key fuel assembly design parameters, such as thermal hydraulic characteristics and structural characteristics, were developed to use directly in the reload licensing analyses or to show that the reload licensing analyses would be applicable to the TVS-K LTAs.

The proposed approach to demonstrate reasonable assurance that the TVS-K LTAs can be safely operated is somewhat unusual in that the engineering services vendor responsible for evaluation of the TVS-K LTAs (GNF-A), the fuel vendor (TVEL), and the licensing methodology vendor (Westinghouse) represent three different entities. As a result, the TVS-K LTAs are not the only novel aspect to the analyses and evaluations performed in support of this LAR. In many

cases, the demonstrations provided by EGC rely on combinations of methodologies from more than one vendor.

The NRC staff has determined that an audit, following Office of Nuclear Reactor Regulation Office Instruction LIC-111, “Regulatory Audits,” will be beneficial in identifying additional information required to complete the review.

2.0 REGULATORY AUDIT BASES

EGC intends to operate the TVS-K LTAs at Braidwood Station under the provision in TS 4.2.1, “Fuel Assemblies,” which allows for a limited number of LTAs in nonlimiting core positions. As such, the LTAs are not subject to the restriction that limits fuel designs to those analyzed with applicable NRC staff approved codes and methods. However, the overall core loading must still be capable of meeting regulatory requirements. A discussion of the relevant regulatory requirements follows, however, the interpretation of applicability to the TVS-K LTAs depends on the amount of available data, conservatism, confidence in the analytical methods being used, and engineering judgement necessary to make a finding of reasonable assurance that the regulatory requirements are met for the overall core loading.

Several regulatory requirements apply to fuel loaded in the core, as discussed in Section 4.2 of the Standard Review Plan. Most of the relevant criteria for the TVS-K LTAs correspond to General Design Criteria (GDCs) listed in Title 10, “Energy,” of the *U.S. Code of Federal Regulations* (CFR), Part 50, “Domestic Licensing of Production and Utilization Facilities,” Appendix A, “General Design Criteria for Nuclear Power Plants,” namely, GDC 2, “Design bases for protection against natural phenomena,” GDC 10, “Reactor design,” GDC 19, “Control room,” and GDC 35, “Emergency core cooling.” The applicability of each GDC to Braidwood Station operations with TVS-K LTAs is discussed below.

- GDC 2 – the TVS-K LTAs should not experience deformation as a result of seismic events that impedes the ability of the safety systems to adequately cool the core.

- GDC 10 – the thermal limits imposed on the TVS-K LTAs should provide reasonable assurance of adequate thermal mechanical performance during normal operation (including anticipated operational occurrences).

- GDC 19 – any potential release from the TVS-K LTAs during accident conditions should not result in radiation exposures in the control room exceeding regulatory limits.

- GDC 35 - the cladding and fuel should not fail in a way that prevents adequate cooling of the core during loss of coolant accidents (LOCAs).

10 CFR 50.46 provides additional requirements related to emergency core cooling system (ECCS) performance to maintain adequate cooling of the core following postulated LOCAs. These requirements are satisfied for the TVS-K LTAs if no fuel damage occurs during the

design basis accident which results in a core geometry that prevents adequate cooling. This may generally assumed to be the case if all parameters that affect the consequences of a LOCA can reasonably be expected to be bounded by the co-resident fuel.

10 CFR 50.67 and 10 CFR 100.11 provide requirements for radiological dose consequences, which may be satisfied for the TVS-K LTAs if reasonable assurance exists that any radiological release from the LTAs due to postulated accidents would not result in the total release at Braidwood Station exceeding its site-specific design limit.

10 CFR 50.68 provides requirements to maintain adequate subcriticality for fuel stored within the spent fuel pool. In particular, storage of the TVS-K LTAs under conditions consistent with the spent fuel pool criticality licensing analysis of record should reasonably be expected to not result in a k-effective increase beyond the limit established by the regulatory requirements.

The NRC staff will audit the evaluations and analyses performed to support loading of the TVS-K LTAs at Braidwood Station, to identify appropriate additional information to request for submittal. Such information would be that required to determine (1) whether the proposed combinations of methodologies are appropriate for their intended implementation, and (2) whether reasonable assurance exists that Braidwood Station can operate safely with the TVS-K LTAs loaded as specified.

10 CFR 50, Appendix B, provides requirements for Quality Assurance for Nuclear Power Plants, including that applied to the design, fabrication, construction, and testing of structures, systems, and components of the facility.

3.0 REGULATORY AUDIT SCOPE/OBJECTIVES

The NRC staff understands that EGC and their contractors plan to deliver a presentation with an overview of the topics of interest, as listed below. The presentation is expected to provide a framework to allow NRC staff to have a structured discussion about specific aspects of the LAR with EGC, GNF-A, and TVEL staff, as appropriate. EGC and their contractors may determine whether the requested information would be most efficiently conveyed as part of the presentation or by referring NRC staff to specific documents made available during the audit. If necessary, separate presentations, breakout sessions, and/or document review sessions should be planned to protect inadvertent sharing of proprietary information with a different vendor.

At the conclusion of the audit, an exit meeting will be held to summarize additional information, if any, that EGC will be requested to submit to continue the review. Other appropriate next steps may be discussed, as well.

3.1. TVS-K LTA THERMAL MECHANICAL ANALYSIS METHODOLOGY

The supplement to the LAR provides a summary of how different cladding and fuel properties for the TVS-K LTAs are addressed in the PRIME methodology. Provide a description of the manufacturing processes and specifications used to fabricate the E110opt cladding, $(U,Gd)O_2$

and UO_2 pellets and a comparison of the material characteristics relative to the materials included in the PRIME validation database previously reviewed by the NRC. Discuss how the $(U,Gd)O_2$ and UO_2 materials will perform differently from the materials already considered as part of the prior validation of PRIME. Include any relevant operating experience with the TVS-K fuel in non-US plants.

For each cladding or fuel property of interest where TVS-K specific data was available and used to develop a TVS-K specific correlation, provide plots comparing the data points against the correlation as incorporated into PRIME. Provide test reports or similar documents for the NRC staff to review, as desired, to understand how the data was developed.

3.2. THERMAL HYDRAULIC COMPATIBILITY EVALUATION

Discuss the evaluations performed to confirm thermal hydraulic compatibility of the TVS-K LTAs in the Braidwood core, including changes in assembly flow rate, bypass flow, cross flow, and fuel rod vibration. Indicate whether any modifications were made to the models used in reload licensing analyses to accommodate the impact of the TVS-K LTAs.

3.3. CRK CRITICAL HEAT FLUX CORRELATION

Summarize the testing performed to support the CRK CHF correlation, including diagrams of the testing apparatus, and graphically depict a comparison of the measured and predicted CHF data based on the CRK CHF correlation. Discuss any differences between the test configuration and the TVS-K fuel design, including the geometry and location of the grids. Provide documentation for the CHF testing and validation of the CRK CHF correlation for NRC staff to review.

3.4. TVS-K LTA THERMAL HYDRAULIC ANALYSIS METHODOLOGY

Provide an overview of the VIPRE model used to analyze the TVS-K LTAs and the thermal limits evaluation performed to ensure that the TVS-K LTA thermal limits are at least 5% less limiting than the leading co-resident Westinghouse fuel. Make all calculation files and reports associated with the VIPRE modeling and thermal limits evaluation available to the NRC staff for auditing, along with supporting documentation that may be necessary to interpret the information in the calculation files (e.g., VIPRE-01 user's manual).

3.5. SEISMIC ANALYSIS METHODOLOGY AND TVS-K LTA INPUTS

Provide descriptions of the testing equipment and protocols used to develop all of the needed parameters for the fuel assembly structural response analyses. Discuss how the acceptance criteria and testing configuration are consistent with the Westinghouse licensing basis methodology, including any relevant uncertainties. Provide the testing documentation for review by the NRC staff.

3.6. TVS-K LTA FUEL HANDLING AND STORAGE

Provide the results of the sensitivity study performed to assess whether the spent fuel pool criticality analysis of record bounds the TVS-K fuel, and discuss how any expected differences in manufacturing tolerances and uncertainties for the TVS-K fuel would compare to the margin to the regulatory limit.

Discuss how the increased uranium mass for the TVS-K LTAs is accounted for in the postulated release inventory associated with a fuel assembly drop accident.

3.7 QUALITY ASSURANCE

Provide an overview of the quality assurance organization that demonstrates that 10 CFR 50, Appendix B, Criterion I, “Organization,” is met. Specifically, that the persons and functions have the required authority and organizational freedom and have direct access to the levels of management necessary to perform their functions.

Provide an overview of the project design control that demonstrate that 10 CFR 50, Appendix B, Criterion III, “Design Control,” is met. Specifically, that measures are established to assure that regulatory requirements and the design basis are correctly translated into specification, procedures, drawings, and instructions. Also, that design interfaces are established to provide for verifying or checking the adequacy of the design.

Provide an overview of the procurement document control that demonstrate that 10 CFR 50, Appendix B, Criterion IV, “Procurement Document Control,” is met. Specifically, that measures are established to assure that regulatory requirements, design basis, and other requirements are referenced in the documents for procurement of material, equipment and services.

Provide an overview of the control of nonconformances that demonstrate that 10 CFR 50, Appendix B, Criterion XV, “Nonconforming Materials, Parts, or Components,” is met. Specifically, that measures are established to prevent their inadvertent use or installation.

Provide an overview of the planned audits and surveillance that demonstrate that 10 CFR 50, Appendix B, Criterion XVIII, “Audits,” is met.

Provide an overview of the procedures and requirements that demonstrate that 10 CFR 21, “Reporting of Defects and Noncompliance,” is met.

Documents for auditor review, if available, include:

1. GNF-A QA manual
2. GNF-A Quality Assurance Project Plan, if there is one
3. GNF-A Audits of TVEL for this project, last 2 audits
4. GNF-A annual evaluation(s) of TVEL for this project

5. GNF-A Procurement order(s) for this project, TVEL
6. Exelon QA Manual
7. Exelon or NUPIC Audits of GNF-A and TVEL for this project, last 2 audits
8. Exelon annual evaluation(s) of GNF-A and TVEL for this project
9. Exelon Procurement order(s) for GNF-A and TVEL, as applicable
10. TVEL QA manual

4.0 TEAM ASSIGNMENTS

The following personnel will be supporting the review:

NAME	AFFILIATION
Scott Krepel	Technical Reviewer, NRC/NRR/Division of Safety Systems
Paul Clifford	Senior Technical Advisor, NRC/NRR/Division of Safety Systems
Reed Anzalone	Technical Reviewer, NRC/NRR/Division of Safety Systems
Jonathan Ortega-Luciano	Reactor Operations Engineer, NRC/NRO/Division of Construction Inspection and Operational Programs

5.0 LOGISTICS AND SCHEDULE

The audit will take place on February 11 through 15, 2019. The location is the GNF facilities at 3901 Castle Hayne Road in Wilmington, NC. The schedule provided below is only a rough guide; the actual duration of the presentation and review/discussion periods will depend on the progress that the staff makes in addressing the topics of interest.

Monday, February 11, 2019:

- Introductions
- Preliminary Presentation
- Begin Document Review & Discussions (if presentation is completed)
- Summary Meeting/Actions

Tuesday-Thursday, February 12-14, 2019:

- Document Review & Discussions
- Summary Meeting/Actions

Friday, February 15, 2019:

- Complete Document Review & Discussions
- Exit Meeting