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ANP-2789(NP)
Revision 0

ATRIUM™ 10XM Lead Test Assemblies for LaSalle Unit 2

AREVA

December 2008

AREVA NP Inc.

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Nature of Changes

Item	Page	Description and Justification
1.	All	This is the initial release.

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Tables

Nomenclature

ASTM	American Society for Testing and Materials
BOL	beginning of life
BWR	Boiling water reactor
CHF	critical heat flux
Cp	specific heat or heat capacity
CPR	critical power ratio
EOC	end of cycle
EOL	end of life
FGR	fission gas release
GWd/MTU	gigawatt days per metric ton of initial uranium
LAR	license amendment request
LHGR	linear heat generation rate
LSA2-13	LaSalle Unit 2 Cycle 13
LTA (LUA)	lead test (use) assembly
MOX	mixed oxide
NAF	neutron absorber fuel (e.g., Gadolinia doped fuel)
NRC	Nuclear Regulatory Commission, U. S.
PCI	pellet-to-cladding-interaction
PLFR	part length fuel rods
RXA	fully recrystallized annealed cladding
SAFDL	specified acceptable fuel design limits
SPCB	Siemens power critical heat flux correlation for BWRs
SRA	Stress relieved annealed cladding
UTL	upper tolerance limit
UTP	upper tie plate

1.0 Introduction

Exelon Generation Company (Exelon) plans to insert eight (8) ATRIUM™* 10XM Lead Test Assemblies (LTA) supplied by AREVA NP Inc.† for operation in LaSalle Unit 2 Cycle 13 (LSA2-13). The LSA2-13 LTA program is a component of AREVA's comprehensive testing and irradiation program designed to qualify the ATRIUM 10XM fuel assembly design for reload supply within the U.S. AREVA's roadmap for new fuel design introduction is described in the Nuclear Regulatory Commission (NRC) approved "Generic Mechanical Design Criteria for BWR Fuel Designs" topical report, Reference 1. Per Reference 1, the AREVA process for introducing new design features involves prototype testing and/or lead test assemblies prior to full reload implementation and continuing irradiation surveillance programs including post irradiation examinations to confirm fuel assembly performance. In accordance with the NRC guidance of Reference 2, the provision has been made in the LaSalle Unit 2 Technical Specifications to accept a limited number of lead test assemblies that have not completed representative testing provided they are placed in non-limiting core regions.

Exelon will insert the ATRIUM 10XM LTAs according to the provisions of 10CFR50.59. The cycle specific analyses provided by AREVA in the reload licensing documentation are to be used by Exelon for performing the 10CFR50.59 evaluation for the LSA2-13 reload and to update the core operating limits report. Based on the licensing analyses performed by AREVA the LaSalle ATRIUM 10XM LTAs meet the relevant design criteria of Reference 1 and are suitable for irradiation in Cycle 13 and beyond for LaSalle Unit 2.

This report is provided to the NRC for information purposes to provide: a description of the LaSalle ATRIUM 10XM LTAs; a summary of the testing performed in support of the LTAs; a summary of the licensing analyses performed for the LTAs using NRC-approved models and methods which demonstrate compliance to the approved design criteria; and, a description of the recommended post irradiation examinations to be considered with respect to the LTAs. The scope of this report is limited to the LSA2-13 ATRIUM 10XM LTA program. Per Reference 1, prior to full reload implementation of the ATRIUM 10XM, AREVA will provide the NRC with a

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† AREVA NP Inc. is an AREVA and Siemens company.

comprehensive report demonstrating compliance with the Reference 1 design criteria on a reload basis.

2.0 Design Description of the ATRIUM 10XM

The LTAs described herein share many of the same proven design features of AREVA's current ATRIUM-10 fuel design that is in broad use in BWR plants. A summary of the ATRIUM 10XM mechanical design that will be used in near future reload applications is given in this section. The LaSalle LTAs incorporate a limited number of fuel rods which incorporate special design features in addition to the standard ATRIUM 10XM design. These special design features are expected to provide results which will be incorporated in longer term fuel design implementation. This section also includes a description of these special features.

2.1 *ATRIUM 10XM Mechanical Design*

The ATRIUM 10XM fuel bundle shares the same general geometry as the ATRIUM-10 fuel assembly design that is co-resident in the core. This geometry consists of a 10x10 fuel lattice with a square internal water channel that displaces a 3x3 array of rods. Relative to the ATRIUM-10 fuel, the ATRIUM 10XM incorporates the following key design differences:

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Table 2.1 lists the key design parameters of the ATRIUM 10XM fuel assembly and compares them to the co-resident ATRIUM-10 design.

Table 2.1 ATRIUM 10XM Key Design Parameters

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3.0 LTA Special Features

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4.0 LTA Licensing Analysis

AREVA currently performs the reload licensing analysis in support of operation of LaSalle Unit 2. For Cycle 13 operation a fresh reload batch size of 312 ATRIUM-10 assemblies will be loaded co-resident with the 8 ATRIUM 10XM lead test assemblies. The final core configuration will also utilize 305 ATRIUM-10 and 139 GE14 irradiated assemblies in the core.

The reload safety analysis to support operation of LaSalle Unit 2 Cycle 13 is documented in Reference 3. The nuclear, thermal hydraulic, transient and accident analyses have explicitly modeled the ATRIUM 10XM fuel with NRC-approved analytical models. In addition to this, the analyses which verify the mechanical design criteria are satisfied for the ATRIUM 10XM LTAs being loaded in this cycle are documented in Reference 4.

4.1 *Fuel Mechanical Design Analysis*

The ATRIUM 10XM LTAs rely on the use of structural and fuel rod components similar to those in current operation with the ATRIUM-10 fuel design. Therefore, the mechanical design of the LTAs was evaluated according to the AREVA BWR generic mechanical design criteria (Reference 1). The generic design criteria have been approved by the U.S. Nuclear Regulatory Commission (NRC) and the criteria are applicable to the subject design.

4.1.1 Evaluation of Standard LTA Design Features

Since the basic fuel design of the LTAs is similar to the ATRIUM-10 design currently in operation, the mechanical analyses for the LTAs have been performed using NRC-approved design analysis methodology (References 5, 6, 7, 8 and 9).[

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The analyses are documented in Reference 4 and demonstrate that the mechanical criteria applicable to the design are satisfied when the fuel is operated at or below the linear heat generation rate (LHGR) limits presented in that reference for normal operation and anticipated operational occurrences (AOOs).

[4.1.2

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4.2 *Design Verification Testing*

Significant testing has already been performed on the LTA design to ensure mechanical integrity, thermal hydraulic compatibility and critical power performance. This section summarizes the extent and results of this testing.

4.2.1 Mechanical Testing

The AREVA testing and inspection requirements are essential elements in assuring conformance to the Reference 1 design criteria. As shown in Table 4.1, the comprehensive suite of mechanical testing was performed for the ATRIUM 10XM fuel design. The resulting component parameters either directly demonstrate compliance with the Reference 1 criteria or are input to the design calculations. Results from the test based mechanical analyses are presented in Reference 4 and demonstrate that the mechanical design criteria are satisfied and that the ATRIUM 10XM fuel assembly meets all mechanical compatibility requirements for use in LaSalle Unit 2.

Table 4.1 ATRIUM 10XM Mechanical Testing

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4.2.2 Thermal Hydraulic Compatibility

Consistent with the AREVA approved methodology, the ATRIUM 10XM fuel assembly has undergone a pressure drop test in AREVA's Portable Hydraulic Test Facility (PHTF). The component loss coefficients from this pressure drop test have been used to explicitly model the ATRIUM 10XM design in both the neutronic and safety analysis for LSA2-13 and future cycles. Thus, consistent with the AREVA NRC-approved methodology, the thermal hydraulic characteristics of the bundle have been explicitly modeled in all analyses.

The results of the thermal hydraulic compatibility of the LTAs are documented in Reference 11. The ATRIUM 10XM LTA have been determined to be hydraulically compatible with the coresident fuel designs for the entire range of the licensed power-to-flow operating map. The coresident hydraulic fuel types are the GE14 fuel loaded in Unit 2 Cycle 11 and the ATRIUM-10 fuel loaded in Unit 2 Cycle 12 and Cycle 13. Detailed calculation results supporting this conclusion are provided in the reference. The ATRIUM 10XM LTA are geometrically different from the coresident ATRIUM-10 and GE14 designs, but hydraulically the designs are compatible. The overall pressure drop of the ATRIUM 10XM LTA is between the pressure drop of ATRIUM-10 and GE14 fuel assemblies.

Core bypass flow (defined as leakage flow through the LTP flow holes, channel seal, core support plate, and LTP-fuel support interface) is not adversely affected by the 8 ATRIUM 10XM LTA. Analyses demonstrate the 8 ATRIUM 10XM LTA satisfy the design criteria discussed in Section 3.0 of the reference for the expected core power distributions and core power/flow conditions encountered during operation.

4.2.3 Critical Power Performance

The critical power performance of the ATRIUM 10XM LTAs will be determined based on a conservative application of the NRC-approved SPCB correlation (Reference 12). [

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4.3 ***Neutronic Analysis***

The current approved neutronic methodology, Reference 13, remains applicable to the ATRIUM 10XM leads since they are not significantly different in terms of geometry than the ATRIUM-10 fuel design. All of the Reference 13 SER restrictions are met by the ATRIUM 10XM design.

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The core has been designed such that the ATRIUM 10XM leads will be in non-limiting core bundle power locations. The Cycle 13 core loading plan results in the LTAs being calculated to have substantial margin to the core CPR and LHGR limiting fuel assemblies.

Calculations of core shutdown margin explicitly model the LTAs for this cycle and show adequate shutdown margin throughout the cycle.

4.4 *Safety Analysis*

For LaSalle Unit 2 Cycle 13, current NRC-approved methods have been applied in the safety analyses performed for the LTA assemblies. The geometric, nuclear, and hydraulic characteristics of the LTA assemblies have been explicitly modeled and are fully supported by the current NRC-approved safety analysis methods. The currently approved methods have been demonstrated as being applicable for evaluating the performance of LTAs in the areas of critical power performance, [ ]

4.4.1 Anticipated Operational Occurrences

Based on the modeling of the LTAs their impact has been explicitly incorporated into the cycle specific transient and accident analyses. From these analyses the power dependent limits developed for ATRIUM-10 fuel bound the ATRIUM 10XM fuel, thus the $MCPR_p$ limits and $LHGRFAC_p$ multipliers established for the ATRIUM-10 fuel are conservatively applied to the ATRIUM 10XM fuel. The flow dependent MCPR limits developed for ATRIUM-10 fuel did not bound the ATRIUM 10XM fuel; however since the ATRIUM 10XM fuel is being loaded in low power locations, the $MCPR_f$ limits established for the GE14 fuel are being conservatively applied to the ATRIUM 10XM fuel. The flow dependent $LHGRFAC_f$ multipliers developed for ATRIUM-10 fuel bound the ATRIUM 10XM fuel, thus the $LHGRFAC_f$ multipliers established for the ATRIUM-10 fuel are being conservatively applied to the ATRIUM 10XM fuel.

4.4.2 Accident Analyses

4.4.2.1 LOCA Analysis

LOCA analyses have been performed for the LTAs. [

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4.4.2.2 Control Rod Drop Analysis

The cycle specific analysis for control rod drop has explicitly included the modeling of the LTAs and has demonstrated that the maximum deposited enthalpy is less than the NRC limit of 280 cal/g and that the number of fuel rods which exceed the damage threshold is within that used in performing the radiological assessment for this event. Due to the placement of the LTAs in low power locations none of the damaged rods resulting from the CRDA analysis are in the LTAs.

4.4.2.3 Fuel Handling / Cask Drop Accident

An explicit analysis has been performed for the LTAs to demonstrate that the radiological doses are well within the guidelines specified in 10 CFR 100 as well as the radiological safety limits defined in NUREG-0800 Section 15.7.4 for the fuel handling accident and well within the acceptance criteria for the cask drop accident.

4.4.3 Stability Analyses

The NRC-approved STAIF computer code (Reference 14) has been used in the core hydrodynamic stability analyses to define the BSP region boundaries. This cycle specific analysis has included explicit modeling of the LTAs and has shown acceptable results.

In addition to inclusion of the LTAs in the cycle specific analysis, a comparative stability analysis has been performed to assess the relative stability performance of the ATRIUM 10XM fuel to the current ATRIUM-10 fuel. The result of the comparative analysis is that the ATRIUM 10XM fuel design is at least as stable as the ATRIUM-10 fuel design.

4.4.4 Fuel Shipping and Storage Analyses

The ATRIUM 10XM assemblies have been shown to meet the fuel design limitations for the new fuel vault and the spent fuel BORAL storage racks (Unit 1). AREVA has shown that the LTAs meet the design limitations for the spent fuel pool Boraflex racks (Unit 2) assuming a 52.3% level of Boraflex degradation.

The LTAs meet the requirements for shipping in either the SP-1 or RAJ-II shipping containers

5.0 Operating Experience

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Table 5.1 Operating Experience with Advanced ATRIUM-10 Features (Status December 2007)

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6.0 Post-Irradiation Examinations

A key objective of an ATRIUM 10XM LTA program at LaSalle is to obtain performance data for these fuel assemblies. The scope of the proposed post irradiation examination is provided in Table 6.1.

Table 6.1 Post-Irradiation Examination of ATRIUM 10XM LTAs

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7.0 References

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2. Supplement 1 to Generic Letter 90-02, "Alternative Requirements for Fuel Assemblies in the Design Features Section of Technical Specifications," USNRC, July 31, 1992.

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8. XN-NF-85-74(P)(A), RODEX2A (BWR) Fuel Rod Thermal-Mechanical Evaluation Model, Exxon Nuclear Company, August 1986.

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10. ANP-2682(P) Revision 0, *LaSalle Unit 2 Cycle 13 ATRIUM 10XM Lead Test Assemblies*, AREVA NP, February 2008.

11. ANP-2767(P) Revision 0, *Thermal Hydraulic Design Report for LaSalle ATRIUM 10XM Lead Test Assemblies*, AREVA NP, November 2008.

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