New Fuel Type and Vendor for LaSalle and Quad Cities

NRC Pre-Submittal Meeting
May 27, 2021

Agenda

- Meeting Objectives
- Project Purpose / Background Information
- Overview of Proposed Licensing Amendment Requests (LARs)
  - Criticality Safety Analysis Methodology Change (LaSalle, Quad Cities)
  - Vendor Transition now using GNF Methods (Quad Cities)
  - Improved Scram Speeds (Quad Cities)
- Licensing Schedule and Outage Needs
- Summary and Wrap-up

Meeting Objectives

- Present information to NRC to enable a clear understanding of the overall projects and proposed site-specific LAR submittals
- Obtain feedback from the NRC on the proposed LARs to ensure initial submittals address the full desired scope of topics and thus minimize the need for future RAIs
- Mutual understanding of the proposed schedule and corresponding outage need date in order to ensure adequate NRC resource availability

Project Purpose/Background Information

Exelon is transitioning all BWRs in the fleet (except NMP1) to GNF's latest fuel design, GNF3.

- Plants currently licensed to GNF methods are covered under the 50.59 process.
- Quad Cities is not currently licensed to GNF methods; thus, the vendor transition requires a LAR.

In conjunction with the fuel type change, there is a plan to change the criticality safety analysis methodology at LaSalle and Quad Cities.

The topical reports referenced in this presentation, except for GESTAR II, have not been previously approved by the NRC.

Planned LAR Submittals

LaSalle:

1. Criticality Safety Analysis Methodology Change and Admin. Controls Update

Quad Cities:

1. Criticality Safety Analysis Methodology Change
2. Vendor Transition now using GNF Methods
3. Improved Scram Speeds

Overview– CSA Methodology Change

Purpose: Align criticality safety analysis (CSA) methodology with fuel vendor to optimize core design

– GNF performed criticality safety analysis for GNF3 fuel and a legacy bounding bundle per NEI 12-16 guidance

- Planned changes in analysis methodology
- New fuel vault is now covered through GESTAR II compliance for the GNF3 fuel

CSA Methodology Change and Admin. Controls Update – LaSalle

Spent Fuel Pool Criticality Safety Analysis (NEDC-33931P)

- Utilize GNF methodology to analyze GNF3 fuel and bound all legacy fuel stored in LaSalle's spent fuel pools

New Fuel Vault Criticality Safety Analysis (NEDE-24011-P-A)

- Utilize GESTAR II methodology for validating new fuel vault (NFV) criticality safety for GNF3 fuel stored in GE-designed NFV racks.

Technical Specification (TS) Section 4.3.1.1

- Revise TS 4.3.1.1.a to remove additional description required for Framatome methodology
- Revise TS 4.3.1.1.d to change the governing k_{inf} limit structure according to the new CSA basis

Technical Specification Section 5.6.5.b

- Revise TS 5.6.5.b to remove all Framatome methodology references

LaSalle Proposed TS 4.3.1.1 Change

4.3 Fuel Storage

4.3.1 Criticality

4.3.1.1 The spent fuel storage racks are designed and shall be maintained with:

a. $k_{eff} \leq 0.95$ if fully flooded with unborated water, which includes an allowance for uncertainties as described in ~~either: (1)~~ Section 9.1.2 of the UFSAR~~, or (2) AREVA NP Inc. Report No. ANP-2843(P), "LaSalle Unit 2 Nuclear Power Station Spent Fuel Storage Pool Criticality Safety Analysis with Neutron Absorbing Inserts and Without Boraflex," Revision 1, dated August 2009, for the Unit 2 spent fuel storage racks with rack inserts~~.

b. A nominal 6.26 inch center to center distance between fuel assemblies placed in the storage racks.

c. For Unit 2 only, spent fuel shall only be stored in storage rack cells containing a neutron absorbing rack insert. The neutron absorbing rack inserts shall have a minimum certified ^{10}B areal density greater than or equal to 0.0086 grams $^{10}B/cm^2$. The approved inserts are those described in Attachment 4 to the letter from P. Simpson to the NRC, dated October 5, 2009.

d. Fuel assemblies having a maximum k_{inf} of 1.275 in the normal reactor core configuration at cold conditions.~~The combination of U-235 enrichment and gadolinia loading shall be limited to ensure fuel assemblies have a maximum k-infinity of 0.9185 for all lattices in the top of the assembly, a maximum k-infinity of 0.8869 for all lattices in the intermediate portion of the assembly, and a maximum k-infinity of 0.8843 for all lattices in the bottom of the assembly as determined at 4°C in the normal spent fuel pool in rack configuration. The bottom, intermediate, and top zones are between 0" 96", 96" 126", and greater than 126" above the bottom of the active fuel.~~

LaSalle Proposed TS 5.6.5.b Change

5.6.5 CORE OPERATING LIMITS REPORT (COLR) (continued)

4. The Rod Block Monitor Upscale Instrumentation Setpoint for the Rod Block Monitor—Upscale Function Allowable Value for Specification 3.3.2.1.

5. The OPRM setpoints for the trip function for SR 3.3.1.3.3.

b. The analytical methods used to determine the core operating limits shall be those previously reviewed and approved by the NRC, specifically those described in the following documents:

~~1. ANF-524(P)(A), "ANF Critical Power Methodology for Boiling Water Reactors."~~

~~2. ANF-913(P)(A), "COTRANSA 2: A Computer Program for Boiling Water Reactor Transient Analysis."~~

~~3. ANF-CC-33(P)(A), "HUXY: A Generalized Multirod Heatup Code with 10 CFR 50, Appendix K Heatup Option."~~

~~4. XN-NF-80-19(P)(A), "Advanced Nuclear Fuel Methodology for Boiling Water Reactors."~~

~~5. XN-NF-85-67(P)(A), "Generic Mechanical Design for Exxon Nuclear Jet Pump BWR Reload Fuel."~~

~~6. EMF-CC-074(P)(A), Volume 4 "BWR Stability Analysis: Assessment of STAIF with input from MICROBURN-B2."~~

~~7. XN-NF-81-58(P)(A), "RODEX2 Fuel Rod Thermal-Mechanical Response Evaluation Model."~~

~~8. XN-NF-84-105(P)(A), "XCOBRA-T: A Computer Code for BWR Transient Thermal-Hydraulic Core Analysis."~~

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LaSalle Proposed TS 5.6.5.b Change (cont.)

5.6.5 CORE OPERATING LIMITS REPORT (COLR) (continued)

~~9. EMF-2209(P)(A), "SPCB Critical Power Correlation."~~

~~10. ANF-89-98(P)(A), "Generic Mechanical Design Criteria for BWR Fuel Designs."~~

~~11~~1. NEDE-24011-P-A, "General Electric Standard Application for Reactor Fuel."

~~12. NFSR-0091, "Benchmark of CASMO/MICROBURN BWR Nuclear Design Methods."~~

~~13. EMF-85-74(P)(A), "RODEX2A (BWR) Fuel Rod Thermal-Mechanical Evaluation Model."~~

~~14. EMF-2158(P)(A), "Siemens Power Corporation Methodology for Boiling Water Reactors: Evaluation and Validation of CASMO-4/MICROBURN-B2."~~

~~15. NEDC-33106P, "GEXL97 Correlation for Atrium-10 Fuel."~~

~~16. EMF-2245(P)(A), "Application of Siemens Power Corporation's Critical Power Correlations to Co-Resident Fuel."~~

~~17. EMF-2361(P)(A), "EXEM BWR-2000 ECCS Evaluation Model."~~

~~18. NEDO-32465-A, "BWR Owners' Group Reactor Stability Detect and Suppress Solutions Licensing Basis Methodology and Reload Applications," August 1996.~~

~~19. ANF-1358(P)(A), "The Loss of Feedwater Heating Transient in Boiling Water Reactors."~~

CSA Methodology Change – Quad Cities

Spent Fuel Pool Criticality Safety Analysis (NEDC-33932P)

- Utilize GNF methodology to analyze GNF3 fuel and all legacy fuel stored in Quad Cities' spent fuel pools

New Fuel Vault Criticality Safety Analysis (NEDE-24011-P-A)

- Utilize GESTAR II methodology for validating NFV criticality safety for GNF3 fuel stored in GE-design NFV racks

Technical Specification Section 4.3.1.1

- Revise TS 4.3.1.1.c to change the governing k_{inf} limit structure according to the new CSA basis

Quad Cities Proposed TS 4.3.1.1 Change

4.3.1 Criticality

4.3.1.1 The spent fuel storage racks are designed and shall be maintained with:

a. $k_{eff} \leq 0.95$ if fully flooded with unborated water, which includes an allowance for uncertainties as described in Section 9.1.2 of the UFSAR;

b. A nominal 6.22 inch center to center distance between fuel assemblies placed in the storage racks;

Fuel assemblies having a maximum k_{inf} of 1.29 in the normal reactor core configuration at cold conditions

c. ~~The combination of U-235 enrichment and gadolinia loading shall be limited to ensure fuel assemblies have a maximum k infinity of 0.8991 as determined at 4°C (39.2°F) in the normal spent fuel pool in rack configuration~~; and

d. The installed neutron absorbing rack inserts having a Boron-10 areal density ≥ 0.0116 g/cm^2.

Overview - Vendor Transition to GNF Methods at Quad Cities

Purpose: Capture impacts due to change in reload fuel type that require NRC review.

- Exelon does not intend to submit 'mock reload' results
  - Transition and equilibrium cycles will be crediting GESTAR II as the licensing basis for reloads that contain GNF3 fuel. No deviations from standard GNF methods will be taken.

- Technical Scope of LAR
  - GNF developed the GEXL98 critical power correlation for ATRIUM 10XM fuel
  - Exelon revised the AST calculations to incorporate the GNF3 fuel type
    - Dose consequence impacts
    - Environmental Qualification impacts
  - Framatome used RODEX2A + TCD penalties methodology to develop thermal-mechanical limits for ATRIUM 10XM fuel

Vendor Transition to GNF Methods at Quad Cities (cont'd)

GEXL98 Correlation (NEDC-33930P)

- Quad Cities intends to use GNF methodologies to determine overall core operating limits for cycles containing GNF3 fuel. This change requires an additional analytical critical power (CP) correlation for analyzing the Framatome ATRIUM 10XM fuel with the GNF methodology.
  - GEXL98 CP correlation uses the same functional form as previous GEXL correlations.
    - Total uncertainty in the GEXL98 correlation predictions for ATRIUM 10XM fuel is similar to the NRC-approved total uncertainty for GEXL96 correlation predictions for ATRIUM-9B fuel.
  - Small extrapolations of the GEXL98 correlation's range of application do not involve significant increase in the risk of boiling transition occurring for conditions in the extrapolated regions.
- TS 5.6.5.b revised to incorporate new analytical method for developing core operating limits

Quad Cities Proposed TS 5.6.5.b Change

5.6 Reporting Requirements

5.6.5 CORE OPERATING LIMITS REPORT (COLR) (continued)

3. The LHGR for Specification 3.2.3.

4. Control Rod Block Instrumentation Setpoint for the Rod Block Monitor—Upscale Function Allowable Value for Specification 3.3.2.1.

5. The OPRM setpoints for the trip function for SR 3.3.1.3.3.

b. The analytical methods used to determine the core operating limits shall be those previously reviewed and approved by the NRC, specifically those described in the following documents:

1. NEDE-24011-P-A, "General Electric Standard Application for Reactor Fuel."

2. NEDO–32465-A, "Reactor Stability Detect and Suppress Solutions Licensing Basis Methodology for Reload Applications," August 1996.

3. CENPD-300-P-A, "Reference Safety Report for Boiling Water Reactor Reload Fuel."

4. WCAP-16081-P-A, "10x10 SVEA Fuel Critical Power Experiments and CPR Correlation: SVEA-96 Optima2."

5. WCAP-15682-P-A, "Westinghouse BWR ECCS Evaluation Model: Supplement 2 to Code Description, Qualification and Application."

6. WCAP-16078-P-A, "Westinghouse BWR ECCS Evaluation Model: Supplement 3 to Code Description, Qualification and Application to SVEA-96 Optima2 Fuel."

7. WCAP-15836-P-A, "Fuel Rod Design Methods for Boiling Water Reactors – Supplement 1."

8. WCAP-15942-P-A, "Fuel Assembly Mechanical Design Methodology for Boiling Water Reactors Supplement 1 to CENPD-287."

9. CENPD-390-P-A, "The Advanced PHOENIX and POLCA Codes for Nuclear Design of Boiling Water Reactors."

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10. NEDC-33930P," GEXL98 CORRELATION FOR ATRIUM 10XM FUEL," February 2021

Exelon Generation

Vendor Transition to GNF Methods at Quad Cities (cont'd)

Revise AST post-LOCA Dose Analysis (QDC-0000-N-1481)

- Input changes:
  - All parameters, except those explicitly related to the core inventory, are identical to what was used in the previously submitted version of the AST post-LOCA dose consequence analysis (submitted March 31, 2020).
  - The change in core inventory (due to GNF3 fuel introduction) resulted in an increase in post-LOCA dose consequences that remain within regulatory acceptance limits, but are considered a 'more than minimal increase'

- Methodology changes:
  - None

Vendor Transition to GNF Methods at Quad Cities (cont'd)

RODEX2A + Thermal Conductivity Degradation Penalties (ANP-3918P)

- In support of the legacy ATRIUM 10XM bundles during mixed core operation, Framatome provided thermal-mechanical limits for GNF's use based on calculations performed using a modified RODEX2A methodology.
  - RODEX2A method previously approved by the NRC for use at Quad Cities is modified for the inclusion of thermal conductivity degradation (TCD) effects.
  - TCD modification methodology previously shared with the NRC but was separate from the RODEX2A approval.

- The RODEX2A fuel rod thermal-mechanical analysis code is used to analyze the fuel rod for fuel centerline temperature, cladding strain, rod internal pressure, cladding collapse, cladding fatigue and external oxidation.

Vendor Transition to GNF Methods at Quad Cities (cont'd)

Related Analyses Updates (50.59 scope)

- Design Basis Core Inventories for Quad Cities GNF3 Equilibrium Core
  - Calculation documents a bounding core inventory for Quad Cities Units 1 and 2 for GNF3 equilibrium core based on a combination of core average exposure and enrichment data

- AST Control Rod Drop Accident
  - Core inventory updated due to GNF3 fuel introduction
  - Dose result increase remains within regulatory limits and meet minimal increase standard in 10 CFR 50.67

- AST Fuel Handling Accident
  - Core inventory updated due to GNF3 fuel introduction
  - Dose results are bounded by the current licensing basis dose consequences

- Environmental Qualification Impacts
  - Core inventory updated due to GNF3 fuel introduction
  - LAR will summarize impacts, if any, but EQ documentation will be updated separately

Overview– Improved Scram Speeds at Quad Cities

Purpose: Revise control rod scram times to improve ASME overpressure limit margin

- Revised scram times based on actual scram time performance
- GNF performed an evaluation to characterize the impact of scram speed times on ASME dome pressure overpressure results. When previously under GNF methods, Quad Cities had little margin to the limit. The introduction of GNF3 fuel may further challenge that margin.
  - TS Table 3.1.4-1 revised with improved scram speed insertion times
- Plant operation should not be impacted

Quad Cities Proposed TS 3.1.4 Changes

Table 3.1.4-1 (page 1 of 1)
Control Rod Scram Times

NOTES

1. OPERABLE control rods with scram times not within the limits of this Table are considered "slow."

2. Enter applicable Conditions and Required Actions of LCO 3.1.3, "Control Rod OPERABILITY," for control rods with scram times > 7 seconds to 90% insertion. These control rods are inoperable, in accordance with SR 3.1.3.4, and are not considered "slow."

PERCENT INSERTION	SCRAM TIMES[a][b] (seconds) when REACTOR STEAM DOME PRESSURE ≥ 800 psig
5	~~0.48~~ 0.45
20	~~0.89~~ 0.85
50	~~1.98~~ 1.80
90	~~3.44~~ 3.00

(a) Maximum scram time from fully withdrawn position based on de-energization of scram pilot valve solenoids at time zero.

(b) Scram times as a function of reactor steam dome pressure when < 800 psig are within established limits.

Licensing Schedule and Outage Needs

- Submit LARs according to schedule outlined below

Plant/LAR	LAR Submittal	NRC Approval	Implementation Need Date
LaSalle/CSA	July 2021	August 2022	November 2022
Quad Cities/CSA	July 2021	August 2022	January 2023
Quad Cities/GNF3 Transition	September 2021	October 2022	January 2023
Quad Cities/Scram Speeds	December 2021	January 2023	March 2023

Summary and Wrap-up

Summary

- Transition to GNF CSA methodology at LaSalle and Quad Cities:
  - Improve core design efficiency by removing unnecessary conservatism due to vendor 'A' CSA for vendor 'B' fuel
  - Simplify the design basis for CSAs for GNF fuel types
    - Spent fuel storage limits are more straightforward to confirm
    - New fuel storage is validated via GESTAR II compliance

- Elimination of unused methodologies from LaSalle TS:
  - Clarify the design basis by referencing GESTAR II only

- GEXL98 CP correlation at Quad Cities:
  - Allow GNF to utilize the critical power correlation for ATRIUM 10XM fuel during transition cycles licensed under GNF methods

- RODEX2A with TCD penalties methodology at Quad Cities:
  - Allow GNF to apply Framatome-developed thermal-mechanical limits to ATRIUM 10XM without modification during transition cycles licensed under GNF methods

Summary and Wrap-up

Summary (cont.)

- Revision of the AST post-LOCA calculation at Quad Cities:
  - Allow GNF3 results to be implemented into the UFSAR/licensing basis

- Improved scram times at Quad Cities:
  - Ensure sufficient ASME overpressure analysis margin using GNF methods exists with the introduction of GNF3 fuel
  - Have no expected impact on current plant performance

Open Discussion