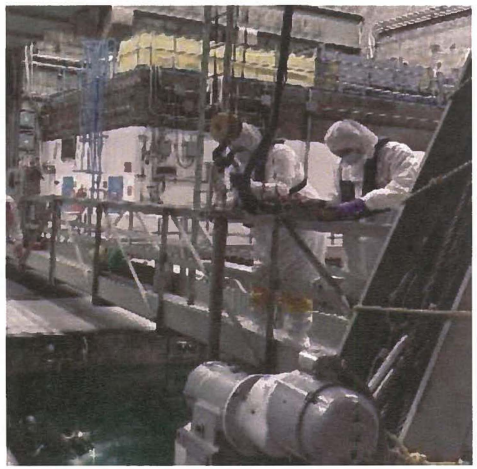
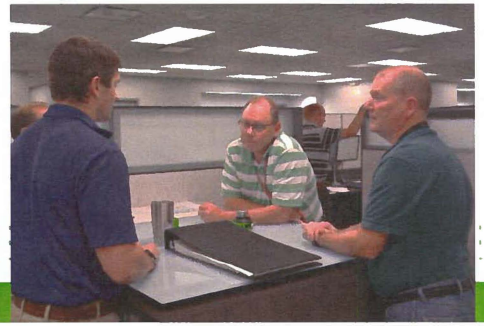
Callaway Plant Unit 1
Presentation Information for Planned Pre-Application Meeting
(Public Meeting)

43 pages follow this cover sheet





Ameren Missouri

Callaway Energy Center

Pre-Application Meeting for License Amendment Associated with Transition to Advanced Westinghouse Fuel, Updated Analysis Methods, and Increase in Allowable Fuel Burnup

Public Meeting Portion

March 4, 2025

Introductions and Purpose

Ameren MISSOURI | Callaway Energy Center

- Describe the purpose of today's meeting
- Describe the desired outcomes of today's meeting
- Introduction of Meeting Participants

Agenda

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- Project Scope and Amendment Scope
- One Time Engineering Project Details
  - Updated Fuel Design
  - Updated Analysis Methods
  - An increase in the allowable fuel burnup
- Current TS and Proposed TS Changes
- LAR Timing Specifics
- Discussion and Feedback
- Closing remarks / Summary of Public Meeting
- Transition to Closed Meeting

Project Scope and Amendment Scope

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- Ameren has undertaken a comprehensive project that has three major themes:
  - Transition to an upgraded fuel design
  - Adoption of improved analysis methods
  - Implementation of an increase in allowable fuel burnup
- The project benefits include:
  - More robust fuel assembly with improved debris mitigation features
  - Improved fuel performance properties, cladding oxidation properties
  - Improved fuel utilization
  - Adoption of future-compatible analysis methods
  - Resolves outstanding NSAL issues associated with ECCS analyses

Project Scope and Amendment Scope (Cont.)

Ameren MISSOURI | Callaway Energy Center

- Transition to an upgraded fuel design includes:
  - **PRIME™** design features
  - **ADOPT™** fuel
  - **AXIOM®** cladding
- Adoption of improved analysis methods includes:
  - 3D Rod Ejection
  - PAD5
  - **FSLOCA™** evaluation methodology
- Implementation of an increase in allowable fuel burnup includes:
  - Allow peripheral fuel assemblies to exceed 62 GWd/MTU burnup

PRIME™ Design Features

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- Low Tin **ZIRLO™** mid grids and intermediate flow mixing grids
- Reinforced dashpot in guide thimble tubes
  - Incorporates a double tube design to further improve dimensional stability and stiffness in the lower portion of skeleton.
- PRIME Bottom Nozzle
  - With the incorporation of a lower pressure drop adapter plate and an innovative debris filter side-skirt, the decreased flow resistance allows a higher proportion of flow through the fuel assembly while mitigating debris migration between fuel assemblies.

ADOPT™ Fuel

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- Reason for change:
  - Improved fuel cycle economics due to 2% density increase
- WCAP-18482-P-A approved ADOPT fuel in November 2022
- Licensed for use in all PWR reactor designs
  - Compatible with NRC-approved zirconium based cladding materials, including AXIOM
  - Existing NRC-approved analytical methods and models are appropriate for ADOPT fuel designs
  - Will comply with the limitation and condition by utilizing 3D rod ejection and RG 1.236

AXIOM® Fuel Rod Cladding

Ameren MISSOURI | Callaway Energy Center

- Reason for change:
  - Improved corrosion resistance and reduced hydrogen pickup
  - Reduced cladding creep and growth
- WCAP-18546-P-A, March 2023
  - Applicable to all current Westinghouse PWR fuel designs
  - New models and methods developed as necessary for some of the properties different from existing cladding
  - Existing NRC-approved safety analysis methods are compatible with AXIOM
  - Compatible with conventional and ADOPT fuel pellets

3-Dimensional Rod Ejection Methodology (3DRE)

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- Uses 3D core kinetics
- NRC approved methodology
  - WCAP-15806-P-A, "Westinghouse Control Rod Ejection Accident Analysis Methodology Using Multi-Dimensional Kinetics"
- Similar approach as for **AP1000®** PWR Core Reference Report
  - WCAP-17524-P-A, "AP1000 Core Reference Report"
  - This used the interim limits described in NUREG-0800, Rev. 3
- Uses AXIOM limit for rod ejection and models
  - WCAP-18546-P, "Westinghouse **AXIOM** Cladding for Use in Pressure Water Reactor Fuel"

3-Dimensional Rod Ejection Methodology (3DRE)

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- Transient Fission Gas Release Model
  - Based on limiting enthalpy rise calculations
- High Temperature Cladding Failure Limit
  - Based on limiting rod internal pressure PAD5 calculations
- PCMI Failure Criterion
  - Based on limiting PAD5 corrosion calculations
- Other Limits from RG 1.236
  - DNBR failure for non-prompt critical initiated events
  - Burnup dependent fuel melt failure criterion
- This analysis will confirm AST dose analysis inputs
- Coolability limits on fuel melt and peak enthalpy will be met
- Peak reactor coolant pressure < ASME Service Limit C

Fuel Performance and Design Model (PAD5)

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- The impacts of the fuel product change have been assessed using the latest fuel performance models (PAD5).
  - ADOPT Fuel Pellets
  - AXIOM High Performance Fuel Cladding Material
  - Incremental Extension of Burnup Limit
- These methodologies and fuel products have been approved by the NRC:
  - WCAP-17642-P-A, "Westinghouse Performance Analysis and Design Model (PAD5)"
  - WCAP-18482-P-A, "Westinghouse Advanced Doped Pellet Technology (ADOPT) Fuel"
  - WCAP-18546-P-A, "Westinghouse AXIOM Cladding for Use in Pressurized Water Reactor Fuel"
  - WCAP-18446-P-A, "Incremental Extension of Burnup Limit for Westinghouse and Combustion Engineering Fuel Designs"

Fuel Performance and Design Model (PAD5)

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- The use of both integrated fuel burnable absorbers (IFBA) and Gadolinia fuel burnable absorbers (Gd_2O_3) have also been assessed.
- Callaway-specific evaluations have shown that all fuel performance design limits are met and are expected to remain met on a reload-specific basis

FSLOCA Evaluation Methodology

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- FULL SPECTRUM™ Loss-of-Coolant Accident (FSLOCA™) Evaluation Model (EM) analysis and LOCA incremental burnup extension analysis were completed using NRC-approved methods:
  - WCAP-16996-P-A, Revision 1, "Realistic LOCA Evaluation Methodology Applied to the Full Spectrum of Break Sizes (FULL SPECTRUM LOCA Methodology)"
  - WCAP-18482-P-A, "Westinghouse Advanced Doped Pellet Technology (ADOPT) Fuel"
  - WCAP-18546-P-A, "Westinghouse AXIOM Cladding for Use in Pressurized Water Reactor Fuel"
  - WCAP-18446-P-A, "Incremental Extension of Burnup Limit for Westinghouse and Combustion Engineering Fuel Designs"

FSLOCA Evaluation Methodology

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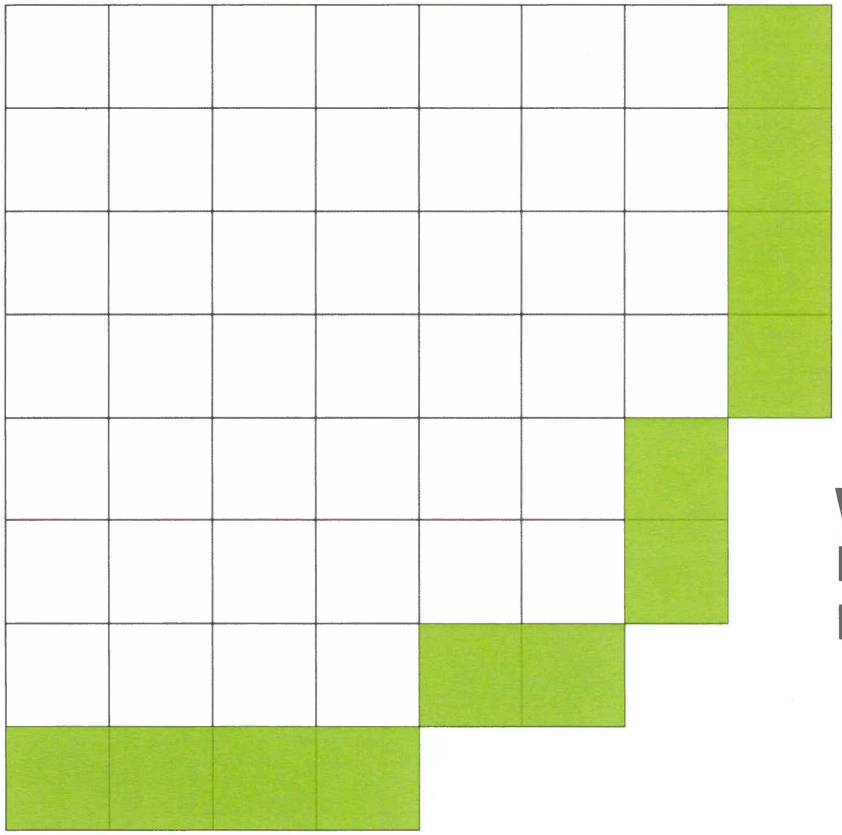
- Analysis addresses new fuel product (ADOPT fuel, AXIOM cladding)
  - During first transition cycle (Cycle 29), current fuel product (UO_2 fuel, **ZIRLO®** cladding) will be covered by existing NOTRUMP and BASH LOCA analyses
  - During second transition cycle (Cycle 30), current fuel product will be placed in non-limiting locations compared to new fuel product, and FSLOCA EM analysis will cover all fuel
  - Analysis does not support extending current fuel product beyond current burnup limits (i.e., > 62 GWd/MTU)
- Current F_Q limit and existing LOCA methodologies will be retained in the COLR for Cycle 29
  - Will be removed from the COLR after Cycle 29

Incremental Burnup: Overview



Incremental burnup allows for an increase in the rod average burnup limit for rods in peripheral assemblies beyond current licensed limits

WCAP-18446-P/NP-A: Incremental Extension of Burnup Limit for Westinghouse and Combustion Engineering Fuel Designs

- NRC-approved in June 2024
- Approved topical report issued August 2024

Incremental Burnup: Applicability

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- Maximum of 5 w/o enrichment
  - Callaway fuel will not exceed 5 w/o enrichment
- All currently manufactured fuel assembly designs, including **PRIME** fuel features
  - Callaway will load Performance+ fuel with **PRIME** design features
- **ZIRLO®**, **Optimized ZIRLO™**, and **AXIOM** cladding
  - Callaway will load fuel with **AXIOM** cladding
- Standard UO_2 and **ADOPT** fuel pellets
  - Callaway will load fuel with **ADOPT** fuel pellets

Callaway Fuel Product Consistent with Topical Report Applicability

Incremental Burnup: Conclusions

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- Fuel assembly design is generically approved within the topical report
- LAR submittal to the NRC will include the following
  - Demonstration that fuel rods with a rod average burnup exceeding 62 GWd/MTU will not rupture during a LOCA will be provided in the submittal
  - Assessment of high burnup fuel rod performance for non-LOCA transients
  - Analysis demonstrating compliance with the acceptance criteria in RG 1.236 for reactivity-insertion accidents Callaway fuel will not exceed 5 w/o enrichment
- All applicable limitations and conditions (L&Cs) described in Section 4.0 of the SER for the topical report are met
  - LAR submittal will include justification of how L&Cs were met

Licensing Precedent

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- **ADOPT fuel pellet**
  - Turkey Point Nuclear Generating Unit Nos. 3 and 4 (ADAMS Accession No. ML23320A028)
    - Proposed the incorporation of ADOPT into the licensing basis
    - SER issued February 2025 (ADAMS Accession No. ML25021A184)
  - Byron Unit 2 LTA Program (ADAMS Accession No. ML19038A017)
  - Vogtle Unit 2 LTA Program (ADAMS Accession No. ML23093A028)
    - Included ADOPT pellets enriched up to 6 w/o

Licensing Precedent

Ameren MISSOURI | Callaway Energy Center

- **AXIOM** cladding
  - Turkey Point Nuclear Generating Unit Nos. 3 and 4 (ADAMS Accession No. ML23320A028)
    - Proposed the incorporation of AXIOM into the licensing basis
    - Included exemption request from certain requirements of 10 CFR 50.46 to support application of AXIOM cladding
    - SER issued February 2025 (ADAMS Accession No. ML25021A184)
  - VC Summer LTA Program (ADAMS Accession No. ML05004029)
  - Millstone 3 LTA Program (ADAMS Accession No. ML16189A104
  - Byron Unit 2 LTA Program (ADAMS Accession No. ML19038A017)

Licensing Precedent

Ameren MISSOURI | Callaway Energy Center

- **FSLOCA**
- Content for the **FSLOCA** analysis will be similar to that provided by the following:
  - Watts Bar Nuclear Plant, Units 1 and 2 (ADAMS Accession No. ML21034A169)
  - Turkey Point Nuclear Generating Unit Nos. 3 and 4 (ADAMS Accession No. ML22028A066)

- **PAD5**
- Revised Reactor Core Safety Limit 2.1.1.b peak fuel centerline temperature in accordance with WCAP-17642-P-A, Revision 1, "Westinghouse Performance Analysis and Design Model (PAD5)"
  - Millstone Power Station Unit 3 (ADAMS Accession No. ML21326A099)
  - Turkey Point Nuclear Generating Unit Nos. 3 and 4 (ADAMS Accession No. ML19031C891)

Licensing Precedent

Ameren MISSOURI | Callaway Energy Center

- **3DRE**
  - Turkey Point Nuclear Generating Unit Nos. 3 and 4 (ADAMS Accession No. ML22028A066)
    - Justified applying the 3DRE methodology to address RG 1.236

- **Incremental Extension of Burnup Limit**
  - This is the first application of the approved methodology

OTE Project – Ameren Scope

Ameren MISSOURI | Callaway Energy Center

- NRC approval needed for new Peak Post-LOCA Containment Pressure, Pa, reflected in TS 5.5.16, "Containment Leakage Rate Testing Program"
  - ECCS evaluation model changes have resulted in updated mass and energy release values
  - Ameren has performed calculations using GOTHIC Version 8.3
  - Pa, will increase above the current value of 48.1 psig to 49.2 psig
  - Well below containment design pressure of 60 psig

OTE Project – Ameren Scope (Cont.)

Ameren MISSOURI | Callaway Energy Center

- NRC approval needed for adoption of Regulatory Guide 1.183 Revision 1 alternative source terms
  - Necessary to support the implementation of the incremental increase in burnup
  - Seek NRC approval for a subset of the analyses specified in RG 1.183 Rev 1
  - Callaway adoption of Revision 0 of RG 1.183 was approved by the NRC in 2023
  - No associated TS changes. TS Bases changes will be made under the TS Bases Control Program during implementation
  - RADTRAD-NAI input and output files for analyzed events will be available for audit
  - Will retain the CLB approach for equipment qualification source term
    - Evaluated consistent with the RG 1.183 Rev. 0 submittal

OTE Project – Ameren Scope (Cont.)

Ameren MISSOURI | Callaway Energy Center

Adoption of Regulatory Guide 1.183 Revision 1 - Continued

- Revision 1 Source terms applied to:
  - 15.4.8 Spectrum of Rod Cluster Control Assembly Ejection Accidents
  - 15.6.5 Loss-of-Coolant Accidents Resulting From A Spectrum of Postulated Piping Breaks Within the Reactor Coolant Pressure Boundary
  - 15.7.4 Fuel Handling Accidents

- No longer analyzed:
  - 15.3.3 Reactor Coolant Pump Shaft Seizure (Locked Rotor)

OTE Project – Ameren Scope (Cont.)

Ameren MISSOURI | Callaway Energy Center

Adoption of Regulatory Guide 1.183 Revision 1 - Continued

- Revision 0 Source terms retained for:
  - 15.1.5 Steam System Piping Failure
  - 15.2.6 Loss of Nonemergency AC Power to the Station Auxiliaries
  - 15.6.2 Break in Instrument Line or Other Lines From Reactor Coolant Pressure Boundary That Penetrate Containment
  - 15.6.3 Steam Generator Tube Failure

OTE Project – Ameren Scope (Cont.)

Ameren MISSOURI | Callaway Energy Center

Adoption of Regulatory Guide 1.183 Revision 1 - Continued

- Technical Evaluations for AST: Continued
  - Atmospheric Dispersion Factors
    - Meteorological data used is same as in the approved analyses of record
    - Changing one onsite release-receptor pair associated with the FHA; other receptor pairs consistent with that approved for initial AST IAW RG 1.183 Rev. 0
  - Core Inventory
    - Updated core inventory corresponding with the incremental burnup limits

OTE Project – Ameren Scope (Cont.)

Ameren MISSOURI | Callaway Energy Center

Adoption of Regulatory Guide 1.183 Revision 1 - Continued

LAR will contain:

- RG-1.183 Rev. 1 Conformance Tables
  - Addresses all positions in RG 1.183 Rev. 1 (including DID and safety margins) like Rev. 0 submittal
- Input Comparison Tables
  - Changes from Rev. 0 submittal to CLB will be described with comments

Preliminary AST results not yet available

OTE Project – Ameren Scope (Cont.)

Ameren MISSOURI | Callaway Energy Center

Expected question:

- Criticality Safety Analyses for the New and Spent Fuel Storage Facilities have been evaluated
  - Acceptable under 10 CFR 50.59
  - Compliant with NEI 12-16, Rev. 4
  - Compliant with RG 1.240, Rev. 0

Current TS and Proposed TS

Ameren MISSOURI | Callaway Energy Center

- **TS 2.1.1, "Reactor Core SLs" [Safety Limits]**
- **Current TS:**

In MODES 1 and 2, the combination of THERMAL POWER, Reactor Coolant System (RCS) highest loop average temperature, and pressurizer pressure shall not exceed the limits specified in the COLR; and the following SLs shall not be exceeded:

2.1.1.1 For Westinghouse fuel, the departure from nucleate boiling ratio (DNBR) shall be maintained ≥ 1.17 for the WRB-2 DNB correlation.

2.1.1.2 For Westinghouse fuel, the peak fuel centerline temperature shall be maintained < 5080°F, decreasing by 58°F per 10,000 MWd/MTU of burnup.

2.1.1.3 For Framatome GAIA fuel, the DNBR shall be maintained ≥ 1.12 for the ORFEO-GAIA DNB correlation.

2.1.1.4 For Framatome GAIA fuel, the peak fuel centerline temperature shall be maintained< 4901"F, decreasing linearly by 13.7°F per 10,000 MWd/MTU of burnup.

Current TS and Proposed TS (continued)

Ameren MISSOURI | Callaway Energy Center

- **TS 2.1.1, "Reactor Core SLs" [Safety Limits]**
- **Proposed TS:**

In MODES 1 and 2, the combination of THERMAL POWER, Reactor Coolant System (RCS) highest loop average temperature, and pressurizer pressure shall not exceed the limits specified in the COLR; and the following SLs shall not be exceeded:

2.1.1.1 For Westinghouse fuel, the departure from nucleate boiling ratio (DNBR) shall be maintained ≥ 1.17 for the WRB-2 DNB correlation.

2.1.1.2 For Westinghouse non-ADOPT™ fuel, the peak fuel centerline temperature shall be maintained < 5080°F, decreasing by 58°F per 10,000 MWd/MTU of burnup.

2.1.1.3 For Westinghouse ADOPT™ fuel, the peak fuel centerline temperature shall be maintained < 5080°F, decreasing by 9°F per 10,000 MWd/MTU of bumup.

2.1.1.~~3~~4 For Framatome GAIA fuel, the DNBR shall be maintained ≥ 1.12 for the ORFEO-GAIA DNB correlation.

2.1.1.~~4~~5 For Framatome GAIA fuel, the peak fuel centerline temperature shall be maintained< 4901"F, decreasing linearly by 13.7°F per 10,000 MWd/MTU of burnup.

Current TS and Proposed TS (continued)

Ameren MISSOURI | Callaway Energy Center

- **TS 4.2.1, "Fuel Assemblies"**
- **Current TS:**
  - The reactor shall contain 193 fuel assemblies. Each assembly shall consist of a matrix of zircaloy, **ZIRLO**™ or M5® clad fuel rods with an initial composition of natural or slightly enriched uranium dioxide {UO_2) as fuel material. Limited substitution of fuel rods by zirconium alloy or stainless steel filler rods may be used in accordance with approved applications of fuel rod configurations. Fuel assemblies shall be limited to those fuel designs that have been analyzed with applicable NRC staff approved codes and methods and shown by tests or analyses to comply with all safety design bases. A limited number of lead test assemblies that have not completed representative testing may be placed in nonlimiting core regions.

Current TS and Proposed TS (continued)

Ameren MISSOURI | Callaway Energy Center

- **TS 4.2.1, "Fuel Assemblies"**
- **Proposed TS:**
  - The reactor shall contain 193 fuel assemblies. Each assembly shall consist of a matrix of zircaloy, ZIRLO™, ~~or~~ M5® or AXIOM™ clad fuel rods with an initial composition of natural or slightly enriched uranium dioxide {UO_2), with or without dopants, as fuel material. Limited substitution of fuel rods by zirconium alloy or stainless steel filler rods may be used in accordance with approved applications of fuel rod configurations. Fuel assemblies shall be limited to those fuel designs that have been analyzed with applicable NRC staff approved codes and methods and shown by tests or analyses to comply with all safety design bases. A limited number of lead test assemblies that have not completed representative testing may be placed in nonlimiting core regions.

Current TS and Proposed TS (continued)

Ameren MISSOURI | Callaway Energy Center

- **TS 5.5.16, "Containment Leakage Rate Testing Program"**
- **Current TS:**

  a. …

  b. The peak calculated containment internal pressure for the design basis loss of coolant accident, Pa, is 48.1 psig.

  c. …

Current TS and Proposed TS (continued)

Ameren MISSOURI | Callaway Energy Center

- **TS 5.5.16, "Containment Leakage Rate Testing Program"**
- **Proposed TS:**

a. …

b. The peak calculated containment internal pressure for the design basis loss of coolant accident, Pa, is ~~48.1~~ 49.2 psig.

c. …

Current TS and Proposed TS (continued)

Ameren MISSOURI | Callaway Energy Center

- **TS 5.6.5, "Core Operating Limits Report (COLR)"**
- **Current TS:**

a. …

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. WCAP-9272-P-A, "WESTINGHOUSE RELOAD SAFETY EVALUATION METHODOLOGY."
2. WCAP-10216-P-A, "RELAXATION OF CONSTANT AXIAL OFFSET CONTROL AND FQ SURVEILLANCE TECHNICAL SPECIFICATION."
3. WCAP-10266-P-A, "THE 1981 VERSION OF WESTINGHOUSE EVALUATION MODEL USING BASH CODE."
4. …

Current TS and Proposed TS (continued)

Ameren MISSOURI | Callaway Energy Center

- **TS 5.6.5, "Core Operating Limits Report (COLR)"**
- **Proposed TS:**

a. …

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. WCAP-9272-P-A, "WESTINGHOUSE RELOAD SAFETY EVALUATION METHODOLOGY."
2. WCAP-10216-P-A, "RELAXATION OF CONSTANT AXIAL OFFSET CONTROL AND FQ SURVEILLANCE TECHNICAL SPECIFICATION."
3. Note – only valid through the conclusion of operating cycle 29.
   WCAP-10266-P-A, "THE 1981 VERSION OF WESTINGHOUSE EVALUATION MODEL USING BASH CODE."
4. …

Current TS and Proposed TS (continued)

Ameren MISSOURI | Callaway Energy Center

- **TS 5.6.5, "Core Operating Limits Report (COLR)"**
- **Proposed TS: Continued**

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:

6. …

7. Deleted ~~WCAP-10851-P-A, "IMPROVED FUEL PERFORMANCE MODELS FOR WESTINGHOUSE FUEL ROD DESIGN AND SAFETY EVALUATIONS."~~

8. Deleted ~~WCAP-15063-P-A, "WESTINGHOUSE IMPROVED PERFORMANCE ANALYSIS AND DESIGN MODEL (PAD 4.0)."~~

9. …

Current TS and Proposed TS (continued)

Ameren MISSOURI | Callaway Energy Center

- **TS 5.6.5, "Core Operating Limits Report (COLR)"**
- **Proposed TS: Continued**

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:

15. …

16. WCAP-18546-P-A, "Westinghouse AXIOM® Cladding for Use in Pressurized Water Reactor Fuel."

17. WCAP-18446-P-A, "Incremental Extension of Burnup Limit for Westinghouse and Combustion Engineering Fuel Designs."

18. WCAP-16996-P-A, "Realistic LOCA Evaluation Methodology Applied to the Full Spectrum of Break Sizes (FULL SPECTRUM LOCA Methodology)."

LAR specifics

- Structure
  - Follows the NEI 06-02 standard format
  - Provides the summary and detailed descriptions, technical evaluation, regulatory evaluation, environmental considerations and references
  - Marked-up TS, clean TS, marked-up TS Bases (for information), and marked-up FSAR for 3DRE (Callaway-specific rod ejection accident analysis)
  - Exemption Request for AXIOM fuel
  - Proprietary content under separate Enclosures with Affidavit(s)
  - All supporting documents, calculations, procedures and reports would be available during the Audit

LAR specifics (continued)

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- Timeline:
  - Estimated Submittal Date: Early May 2025
  - Requested Approval Date: September 2026
  - Implementation Date: Prior to start of Operating Cycle 29 following Refueling Outage 28

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Discussion and Feedback

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Closing Remarks and Summary

Transition to Closed Meeting for Proprietary content discussion


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