Millstone Power Station, Unit 3
New Fuel Storage and Spent Fuel Pool Criticality Safety Analysis
Proposed License Amendment Request

NRC Pre-Submittal Meeting

July 17, 2025

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Agenda

- High Level Proposed Changes
- Current Configuration & Proposed Changes
- Analysis Components
- Criticality Analysis Checklist

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Purpose & Note

Purpose

Discuss key analysis considerations to create a higher quality submittal and a more efficient NRC review

Focus on technical assumptions and justifications, especially for new topics arising from LEU+ and HBU fuel

Note

This pre-submittal meeting is being held earlier than usual. Proposed changes in this presentation are what is currently anticipated, but they could change in the future.

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High Level Changes

- Driver for LAR: 24 Month Cycles
- Maximum U-235 Enrichment: 6.5 wt%
- Maximum Credited Burnup: ~60 GWD/MTU
- Relevant Fuel Assembly Changes:
  - Fatter Fuel Pellet
  - Slightly Denser Fuel
  - Advanced Cladding Material
- Storage Rack Changes: None
- Schedule:
  - Submit LAR – June 2026
  - Review Complete – December 2027 (18-month review)
  - 24-month Initial Startup – May 2028

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Summary of Expected TS Changes

- TS 3/4.9.13: Defines regions and requirements
  - Revise to reflect new analysis
- Figures 3.9-1: Defines Region 1 subregions
  - Revise for new Region 1 subregions
- Figures 3.9-2 and 3.9-3: Region 2 and 3 Burnup Curves
  - Update for new burnup curves
- TS 5.6.1: Description of regions and requirements
  - Revise to reflect new analysis
- TS Markups are not currently available

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CURRENT CONFIGURATION & PROPOSED CHANGES

Spent Fuel Pool – Current Description

- New Fuel Storage Racks
  - 12x8 array of cells
  - Cell pitch of 22-1/8” North-South, 24-1/16” East-West
  - Dry Boral sheets about every other row
- SFP, Region 1
  - Boral, flux trap rack design
  - Requires no burnup
  - Purpose: Store all fuel including fresh and fuel that is reused in the core
- SFP, Region 2
  - Boral, non-flux trap or “egg-crate” rack design
  - Requires some burnup
  - Purpose: Store all discharge fuel
- SFP, Region 3
  - Uncredited Boraflex, flux trap rack design
  - Requires the most burnup
  - Purpose: Store most discharge fuel

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New Fuel Storage Racks

Current Configuration

- Max Enrichment: 5.00 wt%
- BP not credited
- No empty cell credit
- Limiting scenario: water moderated

Proposed Changes

- Max Enrichment: 6.50 wt%
- Minimum Gad or IFBA loading required
  - Gad requirement mimics transportation cask requirements[1]
- No empty cell credit
- Limiting scenario: water moderated

[1] NRC FORM 618, "CERTIFICATE OF COMPLIANCE FOR RADIOACTIVE MATERIAL PACKAGES", Cert. No. 9319, Rev. 14, Docket No. 71-9319, Package ID USA/9319/B(U)F-96, NRC Accession No. ML23033A348.

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Spent Fuel Pool – Region 1

Current Configuration

- Region 1A
  - Fresh, no BP max enrichment: 4.75 wt%
  - BP or burnup credit for enrichments up to 5.00 wt%
- Region 1B
  - Max enrichment: 5.00 wt%
  - Credits neutron leakage at the SFP rack and wall boundary
  - No BP or empty cell credit

Proposed Changes

- Region 1N
  - Max Enrichment: 6.50 wt%
  - Credits empty cells (3-out-of-4 configuration)
  - No BP credit
- Region 1S
  - Fresh, no BP max enrichment: 4.70 wt%
  - No empty cell credit
  - BP credit for enrichments up to 6.50 wt%

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Spent Fuel Pool – Region 2

Current Configuration

- Max enrichment: 5.00 wt%
- Burnup credit curve
  Max required BU: ~40 GWD/T
- No Decay Credit
- Optional control rod credit to replace burnup credit
- No Empty Cell Credit

Proposed Changes

- Max enrichment: 6.50 wt%
- Burnup credit curve
  Max required BU: ~50 GWD/T
- Decay Credit Curves
  (~2 and 8 Years)
- Optional control rod credit to reduce burnup credit
- No Empty Cell Credit
- Partial Credit for Fuel Blankets
  (6” @ 5.0 wt%)

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Spent Fuel Pool – Region 3

Current Configuration

- Max enrichment: 5.00 wt%
- Burnup credit curve
  Max required BU: ~53 GWD/T
- Decay Credit (3 - 25 Years)
- No Control Rod Credit
- No Empty Cell Credit

Proposed Changes

- Max enrichment: 6.5 wt%
- Burnup credit curve
  Max required BU: ~60 GWD/T
- Decay Credit Curve (~4 Years)
- No Control Rod Credit
- Empty Cell Credit
  (8-out-of-9 configuration)
- Partial Credit for Fuel Blankets
  (6” @ 5.0 wt%)
- Maintain current TS for fuel received before 2028
  - Transition to new TS as more 24-month fuel is stored in Region 3

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ANALYSIS COMPONENTS

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Analysis Codes

- Reactivity Code
  - SCALE 6.2.3
  - KENO-V.a criticality calculation module
  - ENDF/B-VII.1 252 group cross section library
- Depletion & Decay Code
  - CASMO5
  - CASMO5 default cross section library (primarily ENDF/B-VII.1)

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Code Benchmark Analysis

- Criticality Code (SCALE) Benchmark
  - Similar to previous Dominion Energy submittals
  - Follows NUREG/CR-6698 methodology
  - Added 72 critical experiments with U-235 enrichments from 5.70 – 7.00 wt%
  - Increased EALF range in analysis
- Depletion/Decay Code (CASMO5) Benchmark
  - For burnups ≤60 GWD/T, use 5% uncertainty
    - Use RG 1.240 as justification
  - For burnups >60 GWD/T, use 5% uncertainty
    - Use trends from CASMO Topical Report supplement as justification
    - This may not be required as credited burnups may be ≤60 GWD/T

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Composite Bounding Assembly Model

- Composite Assembly Dimensions
  (e.g. clad OD, pellet OD, guide tube dimensions)
  - Confirmed bounding by sensitivity cases
- Modeled BP Cutback Length (ends of rod w/out BP)
- Modeled Fuel Blankets
  - Fuel enriched ≤5.0 wt%: No blankets
  - Fuel enriched >5.0 wt%: 6 inch, 5.0 wt%, solid pellet
- Grids Modeled as Water
  - Compliant with NEI 12-16 (50 ppm of boron reserved)
- Bounding Depletion Conditions Used

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Advanced Fuel Features

- Doped Pellets
  - None in anticipated fuel
  - Modeling fuel with no dopant and bounding fuel density
- Cladding & Grid Composition
  - Future fuel using Zr-based alloys M5 and Q12
  - Bounded by modeling cladding as pure Zr
- Clad Coatings – None
- Top and Bottom Nozzles & rod plenum regions – Small changes that are unimportant to analysis

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Geometric Changes with Burnup

- Fuel vendor research shows advanced cladding and grid materials are more resistant to geometric changes than current materials

- The criticality safety analysis will bound advanced cladding by using grid growth and clad creep-down relationships from the current material ZIRLO

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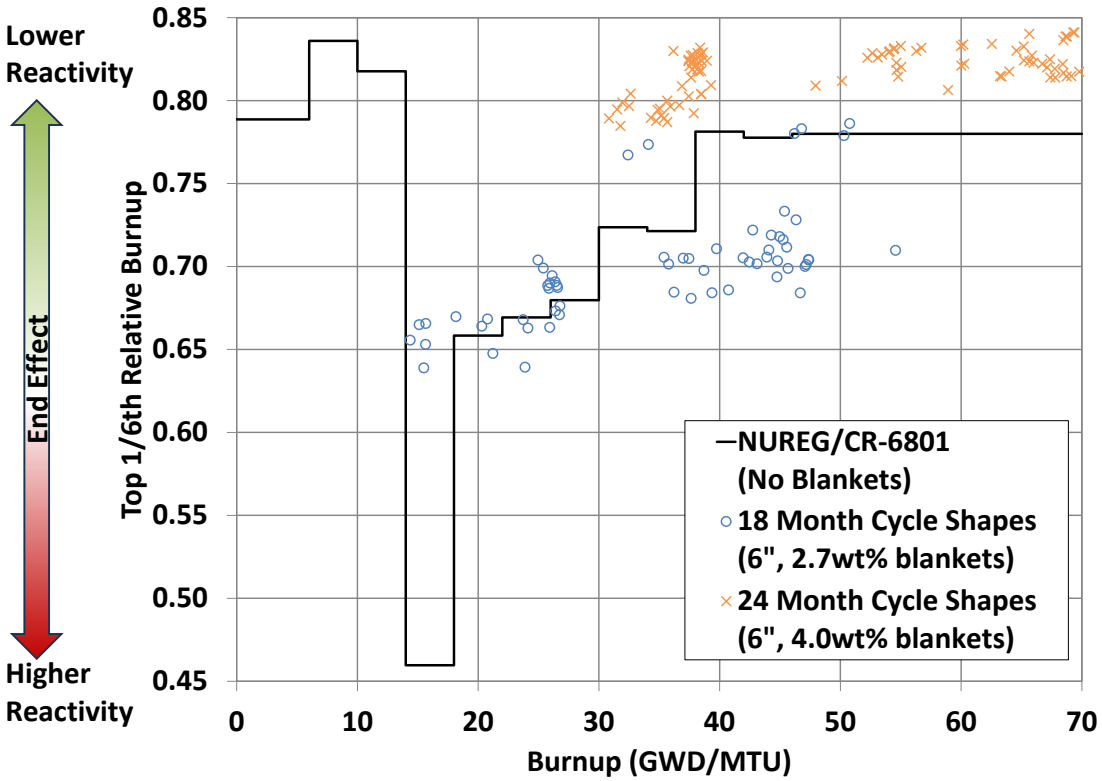
Axial Burnup Shapes

- Use NUREG/CR-6801 axial burnup shapes
- Justify by comparing to axial shapes of 24-month cycle models to NUREG shapes
- Preliminary Results: Even with blankets, NUREG shapes are bounding



Eccentric Positioning

- Added as a bias to the maximum k-eff calculation

- Several different configurations test cases will be shown in submittal
  - Particularly important for cases where the model is not uniform (e.g. empty cells or New Fuel Storage Racks)
  - SCALE fission density distribution visual aids will help justify bounding configuration

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Burnable Poisons

- Burnable poison credit for New Fuel Storage Racks and Region 1
- Region 1 will ensure BP burnup peak reactivity will not result in violating limits by:
  - Showing BP loading is small enough to never increase reactivity OR
  - Requiring a small amount of BU if not fresh fuel

Burnable Poison Locations

- BP locations in fuel lattice restrictions:
  - IFBA must use standard pin patterns as will be stated in the LAR
  - Gad can be placed in any symmetric pattern
    - Base case uses a standard pattern, then calculates a bias by running a set of other reasonable patterns and calculating a Δk

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Multiple Misload Accident

- Spent Fuel Pool TS Boron Concentration: 2600 ppm (Not Changing)
  - Subtracting 50 ppm in model per NEI 12-16

- Will likely require some amount of burnup
  - Plan to use the “clean vs. dirty” argument to preclude fresh fuel in Region 2 and 3
  - Will discuss fuel movement training in LAR

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Aging Management Program

- Current BORAL program
  - Coupon surveillances
  - Surveillance interval NEI 16-03 compliant
    5 years for known degradation or mechanisms
    10 years for documented stable material
  - Program described in FSAR
- No change planned

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Retained Margins

- NRC administrative retained margin of 0.01 ΔK reserved to account for minor issues discovered during review

- Identified Dominion retained margin will potentially be used in future fuel or plant changes in accordance with 10 CFR 50.59

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Criticality Analysis Checklist

- See attached completed checklist
- Some items not included or not applicable
  - Justification or explanation provided

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Schedule

- Submit LAR – June 2026
- Review Complete – December 2027
  (18-month review)
- 24-month Cycle Initial Startup – May 2028

QUESTIONS?

Acronyms & Definitions

- BP – Burnable Poison (synonymous with Burnable Absorber)
- FSAR – Final Safety Analysis Report
- GWD/T – Gigawatt-Day per Metric Ton of Uranium
- Gad – Gadolinia Burnable Poison
- HBU – High Burnup Fuel
- IFBA – Integral Fuel Burnable Absorber
- LAR – License Amendment Request
- LEU+ - Fuel enriched between 5 – 10 wt%
- MPS3 – Millstone Unit 3
- TS – Technical Specifications
- wt% - U-235 weight percent enrichment