Prairie Island Nuclear Generating Plant (PINGP)

Pre-Application Meeting

April 14, 2015

Nuclear Fuel Design Transition to Include Integral Fuel Burnable Absorber (IFBA)

Agenda

- Purpose / Objectives / Principles
- Current Condition
- Merits of IFBA-Gad
- Scope of Licensing
- Spent Fuel Pool (SFP) Criticality Analysis
- Schedule
- Conclusion / Summary

Meeting Purpose

- Describe an Xcel Energy initiative to use IFBA and Gadolinium (Gad) neutron absorbers in the Westinghouse 422 Vantage Plus (422V+) fuel assembly design for PINGP operations and fuel storage
- Describe preliminary evaluation of the effects of this proposed change and the extent of NRC review that may be required

Meeting Objectives

- Common understanding of licensing scope
- Common understanding of schedule
- NRC feedback
- NRC expectations for submittal content
- Actions

Principles

- Maintain nuclear safety margins
- Reliable power in the Midwest Region
- High confidence in refueling cycle timing
- Reduce spent fuel inventory
- Maintain regulatory margin
- No impact on plant operations
- No new impact on storage (human factors)

Current Condition

PINGP Description

- 2-reactor site
- 2-loop Westinghouse NSSS
- Vantage 422+ with **Optimized ZIRLO**™ Fuel
    - Previously-used grid and nozzle designs
- Gadolinium burnable poison
- Currently operating 18-23 month cycles

XcelEnergy

Current Condition

PINGP Spent Fuel Pool (SFP) Description

- Criticality Safety Analysis approved in 2013
- Compliant to DSS-ISG-2010-01
- No credit for SFP neutron absorber (Boraflex)
- Subcriticality criteria met by reactivity balancing ("checkerboarding")

Xcel Energy

Current Condition

Independent Spent Fuel Storage Installation

- Site-specific license for TN-40 cask storage
- IFBA-Gad not specifically licensed
- 10-year decay time requirement for spent fuel

Design Optimization

Xcel Energy and Westinghouse investigated optimizing the Prairie Island fuel management while maintaining the current reload plan

- Maintain or improve safety margins
- Minimize assemblies requiring storage
- Maximize fuel cycle economics

Design Optimization

Gad alone has negative impact on economics

- Displaces uranium, decreasing core loading
- Residual reactivity hold down at end-of-cycle
- Requires additional assemblies to be loaded each cycle or increased fuel enrichment
- Reduced gad loading results in unacceptably high soluble boron concentrations

Design Optimization

IFBA Description: Advanced fuel development program in the early 1980s led to development of a thin ZrB_2 coating on the UO_2 pellet as the optimum design

- Integral to fuel rod, no separate component handling
- Complete depletion, no residual penalty
- No residual poison, no displaced uranium
- Dilute absorber, low power peaking
- ZrB_2 extensively used in Westinghouse PWRs today

Design Optimization

IFBA alone has limited reactivity control

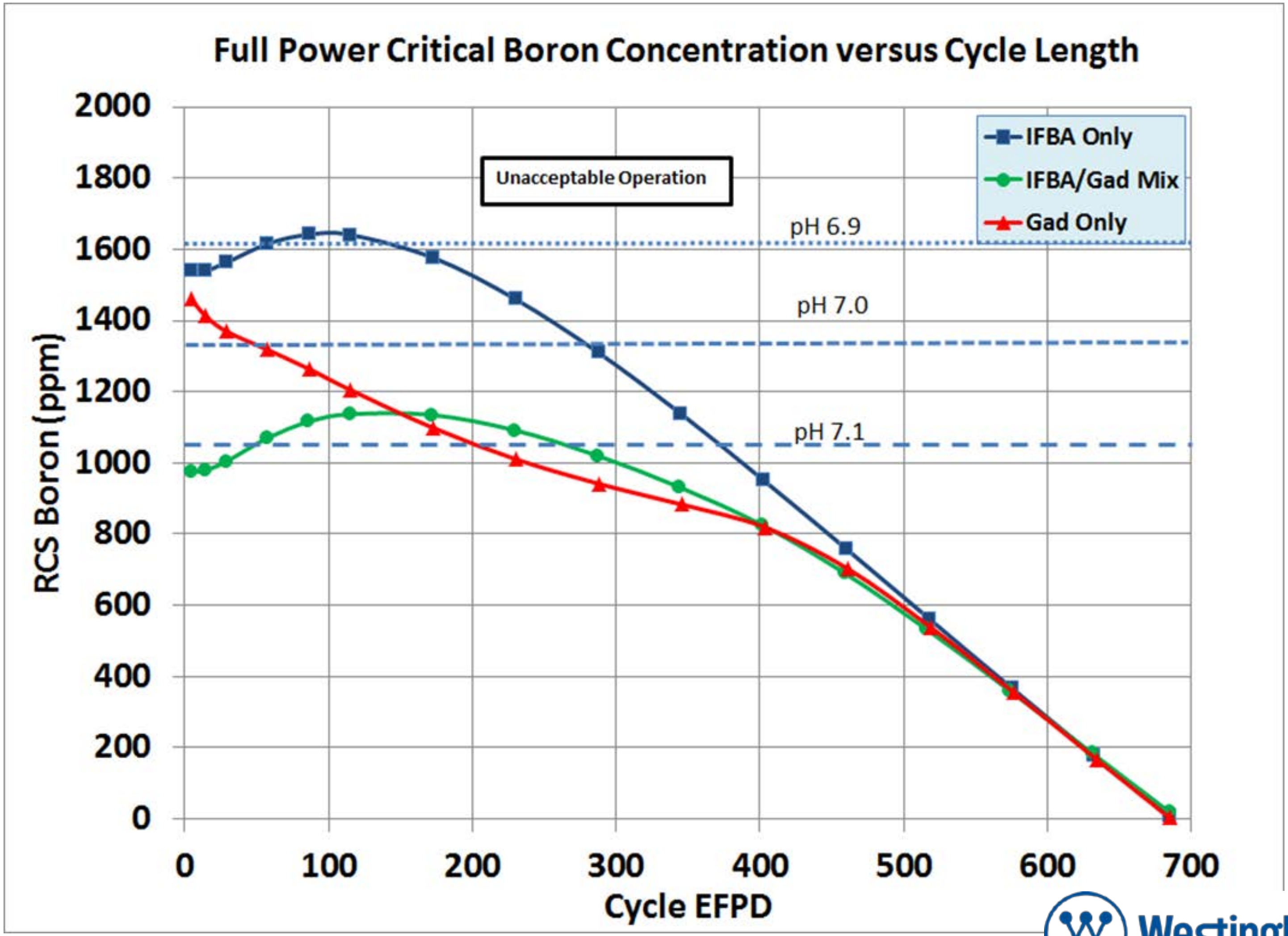
- Provides diminishing reactivity hold down over cycle
- IFBA depletion rate higher at Beginning of Cycle (BOC)
- Results in soluble boron increases at BOC
- Loading IFBA alone results in unacceptably high soluble boron concentrations

Merits of IFBA-Gad

IFBA-Gad combination optimizes all three parameters

- IFBA and Gad not in the same fuel pin
- Combination maximizes or maintains safety margins
- IFBA provides the necessary cycle length benefit to reduce assembly loading and maximize fuel economics
- Gad provides the necessary reactivity hold down to obtain acceptable soluble boron concentrations
- Both IFBA and Gad have extensive operating experience

Merits of IFBA-Gad



Fuel Storage Considerations

ISFSI will not require amendment until 2032

- 2018 First IFBA-Gad fuel load
- 2022 First discharge of IFBA-Gad (2 cycles)
- 2032 First IFBA-Gad in storage (10 yr decay)

Spent Fuel Storage Requirements

- 39 fewer spent fuel assemblies over plant life
- 1 fewer spent fuel cask

Scope of Licensing

Preliminary TS / 50.59 Reviews of IFBA-Gad

- Reactor operations
- SFP operations

Preliminary Conclusion: License Amendment for

- SFP Criticality Technical Specification (TS) changes

Scope of Licensing

<u>TS Review - Reactor</u>

No TS changes for fuel design change

- TS 2.1.1.2.b Gad thermal conductivity penalty is unchanged
- TS 4.2.1 description does not constrain IFBA

Scope of Licensing

<u>50.59 Review - Reactor</u>

No new material interactions, no new type of failure

- Fabrication processes are unchanged
- Use existing Gad and IFBA specifications, good OE

No increased probability of failure (e.g., clad failure)

- Clad, geometry, weight, strength is same

No increased consequence of failure

- Radiological source term change is insignificant

Scope of Licensing

Conclusion - Reactor

- No TS changes required
- No 50.59 criteria exceeded
- Prior NRC approval not required for reactor operations

Scope of Licensing

TS Review - SFP

- TS do not constrain fuel design in SFP
- Coefficients in TS Table 4.3.1 will change slightly

Table 4.3.1-3

For Fuel Not Operated In Units 1 & 2 Cycles 1 - 4
Coefficients to Calculate the Minimum Required Fuel Assembly Burnup (Bu) as a Function of Decay Time and Enrichment (En)

Fuel Category	Decay Time	Coefficients			
		A_1	A_2	A_3	A_4
2	0	-0.669	9.018	-32.080	33.507
3	0	-0.120	1.300	5.006	-18.765
	5	-0.167	1.766	3.085	-16.141
	10	-0.218	2.249	1.405	-14.163
	15	-0.281	2.949	-1.267	-10.873
	20	-0.401	4.237	-5.881	-5.513
4	0	1.355	-14.866	62.715	-72.624

Bu = A1*En3 + A2*En2 + A3*En + A4

Scope of Licensing

50.59 Review - SFP

No increased probability of failure (e.g., drop, clad failure)

- Clad, geometry, weight, strength, decay heat are same

No increased consequence of failure

- Radiological source term change is insignificant

Methods of Evaluation

- Same calculational framework (WCAP-17400-P)

Scope of Licensing

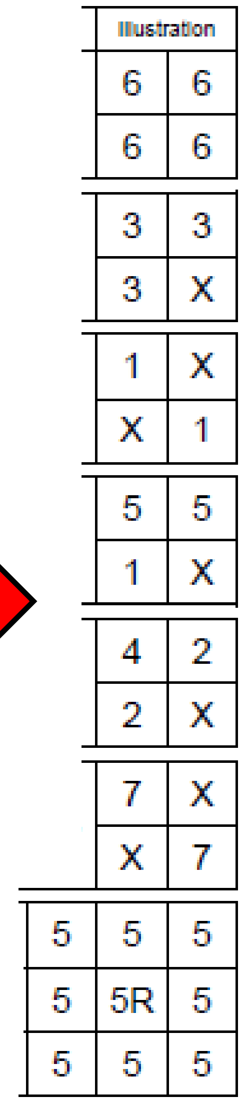
Conclusion - SFP

- No 50.59 criteria exceeded
- TS (Table 4.3.1) changes required
- Prior NRC approval required for criticality function

Background – LAR Scope

<u>No Complicating Factors</u>:

- <u>No</u> significant change in fuel design
- <u>No</u> credit for neutron poison inserts
- <u>No</u> rerack, no rack design changes
- <u>No</u> new SFP loading restrictions
- <u>No</u> New Fuel Vault analysis



Licensing Schedule

11/2015	Submit SFP Criticality LAR
11/2017	License Amendment
8/2018	Receipt of IFBA-Gad Fuel

Outline

- Supplement Scope
- Comparison with Current Analysis of Record
- Compliance to DSS-ISG-2010-01 (ISG)
- Summary
- Conclusions

Spent Fuel Criticality Analysis

Supplement Scope

- Supplement WCAP-17400 (AoR) w/ IFBA-Gad
- Incorporate multiple misload accident
- Retain compliance with ISG
- Determine TS impacts

Spent Fuel Criticality Analysis

Analysis-of-Record (AoR) WCAP-17400

- Approved in 2013
- Compliant to ISG
- 422V+ is limiting fuel design
- IFBA-Gad fuel not specifically addressed

Spent Fuel Criticality Analysis

Analysis-of-Record (AoR) WCAP-17400

- Important technical conclusions
  - Ignores gadolinia; shown to be conservative
  - Up to 100 MWd/MTU rodded operations in SER
  - Fission product worth addressed in RAIs
  - Annular axial blankets conservatively modeled as solid
  - Confirmation of design basis fuel type (422V+)

Spent Fuel Criticality Analysis

- Objectives of the SFPC Analysis Supplement
  - Evaluate the impact of a new burnable absorber (BA) design on the discharge reactivity
  - Minimize impact on AoR (supplement format)
- Methods to be used in the analysis
  - Based on current AoR calculational framework
    - Selection of depletion calculation inputs
    - Development of biases & uncertainties
    - Accidents, interface conditions & soluble boron credit analysis

Spent Fuel Criticality Analysis

Analysis Supplement Scope

- Configurations: no changes
- IFBA-Gad 422V+ Fuel
  - No credit for gadolinia
  - Planned max 120 IFBA pattern
  - Cycle Avg Boron: 900 ppm to 1000 ppm
  - Fuel Density: 98% TD
  - Axial burnup and moderator temperature profiles
  - Blankets fully enriched

Spent Fuel Criticality Analysis

- AoR depletion calculations based on burnup bins of 0-18, 18-30, 30-38, 38-48, and > 48 GWD/MTU
  - Limiting burnup profiles from the AoR to be checked against IFBA-Gad design profiles
  - Uniform profile considered
- The following slides outline potential impacts related to ISG

Spent Fuel Criticality Analysis

ISG Criteria

- 2a - 5% decrement method for depletion uncertainty – same as AoR methodology
- 2b - Nominal values may not be appropriate, discuss selected values
  - – PINGP IFBA-Gad supplement analysis
    - Updated conservative average cycle soluble boron concentration
    - Increase in fuel theoretical density

Spent Fuel Criticality Analysis

ISG Criteria

- 2c – Consider Burnable Absorber Usage
  - IFBA-Gad rods conservatively modeled during depletion, no pool credit for residual absorber
- 2d – Consider Rodded Depletion
  - No change expected due to IFBA-Gad fuel

Spent Fuel Criticality Analysis

ISG Criteria

- 3a - Select limiting axial burnup profile using NUREG-6801 or plant-specific data
  - Use bounding profile from AoR site-specific burnup profiles and IFBA-Gad design profiles
  - An axially-uniform profile will be considered and used at those burnups if/when it is limiting
  - Determine appropriate limiting moderator temperature profiles (distributed and uniform profile)

Spent Fuel Criticality Analysis

<u>ISG Criteria</u>

- 3b - Modeling SFP racks including geometry and neutron absorbers – same as AoR Methodology
- 3c – Interfaces – no methodology impact
- 3d – Normal Conditions – no impact expected
- 3e – Accident Conditions
  - Incorporation of multiple misload event
  - No other changes from AoR methodology

Spent Fuel Criticality Analysis

ISG Criteria (Section 4)

- Validation of Codes
  - Code validation suite addresses ISG
  - No impact to the AoR

Spent Fuel Criticality Analysis

WCAP Supplement Format

- IFBA-Gad evaluation as WCAP-17400 Supplement
  - Generate of burnup limits for IFBA-Gad with current configurations
  - Evaluate normal conditions
  - Evaluate interface conditions
  - Update accident analysis – Including multiple misload analysis
  - Soluble boron credit (normal and accident conditions)

Spent Fuel Criticality Analysis

Spent Fuel Criticality Analysis Summary

- Addition of IFBA (IFBA/IFBA-Gad design) to AoR
- Analysis remains in alignment with ISG
- Supplement to WCAP-17400 will evaluate impact of IFBA-Gad fuel (introduction of IFBA)
  - Updated burnup limits
  - Updated soluble boron requirements for normal and accident conditions

Spent Fuel Criticality Analysis

In Conclusion

- SFP criticality analysis supplement will:
  - Conservatively bound proposed future operating conditions with regards to IFBA & IFBA-Gad fuel
  - Address NRC Staff expectations (ISG)

Summary of Actions

- Xcel Energy Actions
  - Points of Emphasis for LAR content
- NRC Actions

Summary

Summary

1. Submit LAR 11/2015
2. Include NRC expectations
3. Other actions