STPNOC Planned License Amendment Request: Technical Specification 5.3.2, Control Rod Assemblies

STP Participants:

Michael Murray, Regulatory Affairs Manager

Roland Dunn, Nuclear Fuel and Analysis Manager

Michael Berg, Design Engineering Manager

Duane Gore, Reactor Analysis Supervisor

Charles Albury, Reactor Analysis Supervising Engineer

Jose Rocha, Design Engineering I&C Supervisor

Wendy Brost, Licensing Engineer

STPNOC/NRC Pre-Submittal Meeting

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Objectives

- Describe STP's path forward
- Provide a description of the Unit 1 D-6 Control Rod Drive Mechanism (CRDM) issue
- Provide overview of physical configuration changes to support future operation
- Discuss impact on Chapter 15 Safety Analyses
- Provide overview of expected License Amendment Request (LAR) content
- Discuss planned submittal date and need date
- Answer NRC questions

Current Configuration

- Rod Cluster Control Assembly (RCCA) and associated drive shaft at core location D-6 have been removed
  - Flow restrictor and thimble plug installed
- Control power to stationary, moveable, and lift coils for D-6 as well as display and alarm functions have been removed
- Approved to operate Unit 1 in this condition through current fuel cycle (Cycle 20)

STP's Path Forward

- Consequences and uncertainty associated with CRDM replacement are considered significant
  - Requires special tooling and processes that currently do not exist
  - RCS pressure boundary cutting and welding
- Analyses demonstrates that STP can design future cores with 56 control rods maintaining appropriate safety margins
- Path forward is a permanent change to the design and licensing basis of the Unit 1 reactor to operate with 56 Control Rods

Overview of Proposed Change

- Requesting proposed amendment to allow Unit 1 to operate with 56 full-length control rod assemblies
- Proposed change to TS 5.3.2 (change bar on right):

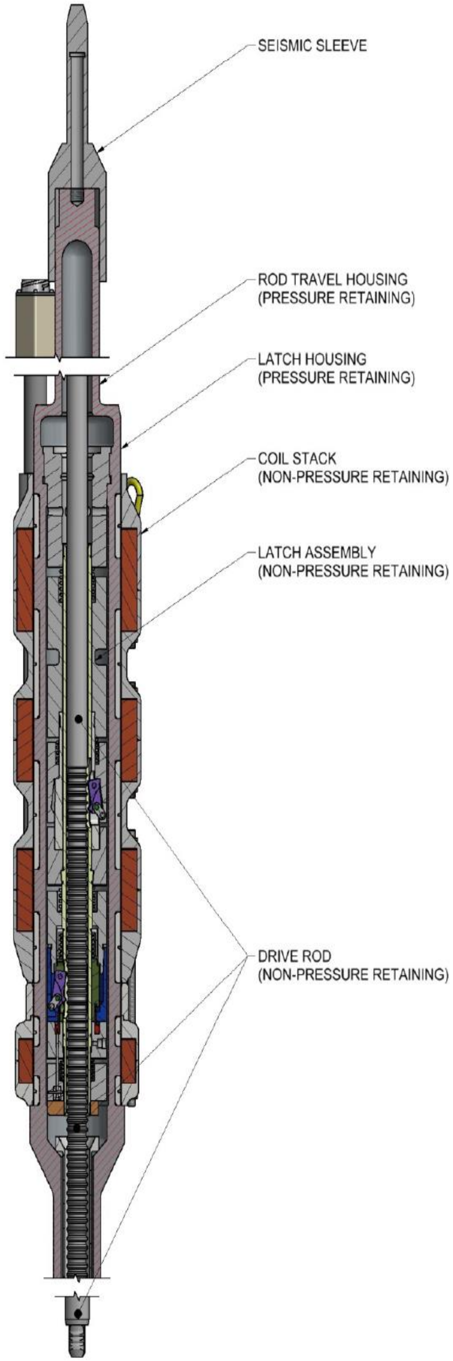
CONTROL ROD ASSEMBLIES

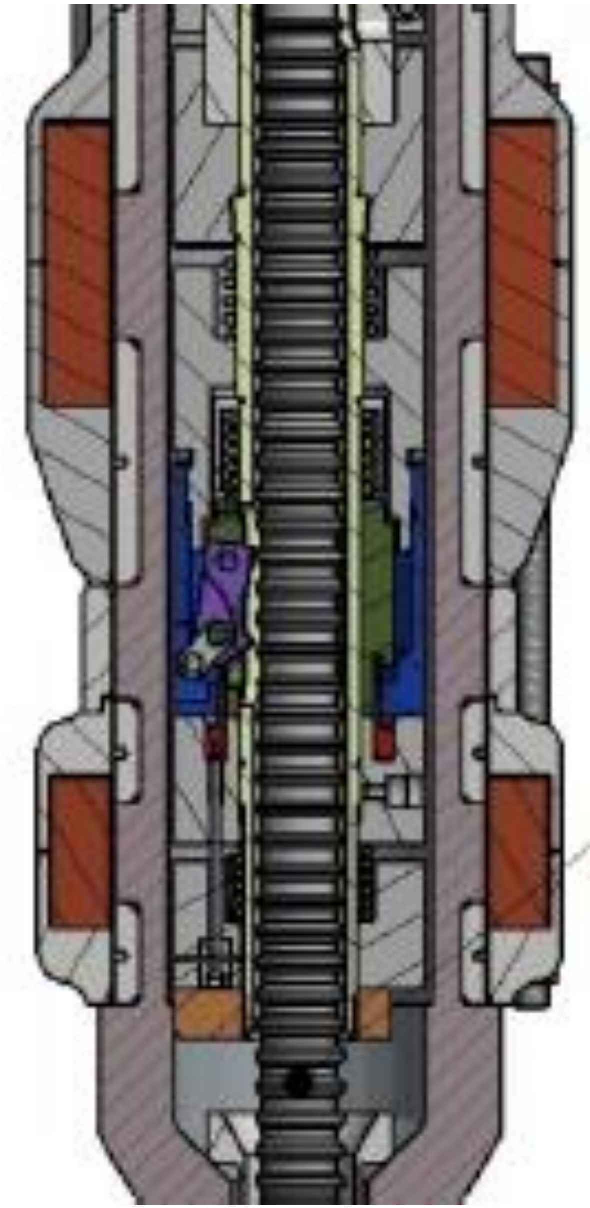
5.3.2 The Unit 1 core shall contain 56 full-length control rod assemblies with no full-length control rod assembly installed in core location D-6. The Unit 2 core shall contain 57 full-length control rod assemblies. The full-length control rod assemblies shall contain a nominal 158.9 inches of absorber material. The absorber material within each assembly shall be silver-indium-cadmium or hafnium. Mixtures of hafnium and silver-indium-cadmium are not permitted within a bank. All control rods shall be clad with stainless steel tubing.

Overview of Proposed Change

- There is no methodology change involved with this change to the TS
- The proposed change would apply to Unit 1 only
- TS design description that specifies 57 control rods will remain unchanged for Unit 2

Background – CRDM Description





Background – Rod Holdout Lock Ring

- Deformation in D-6 Rod Holdout lock ring
- Initiated in 2012 during rod control sequencing while unlocking control rods
- Source of sequencing issue has been addressed with a design change

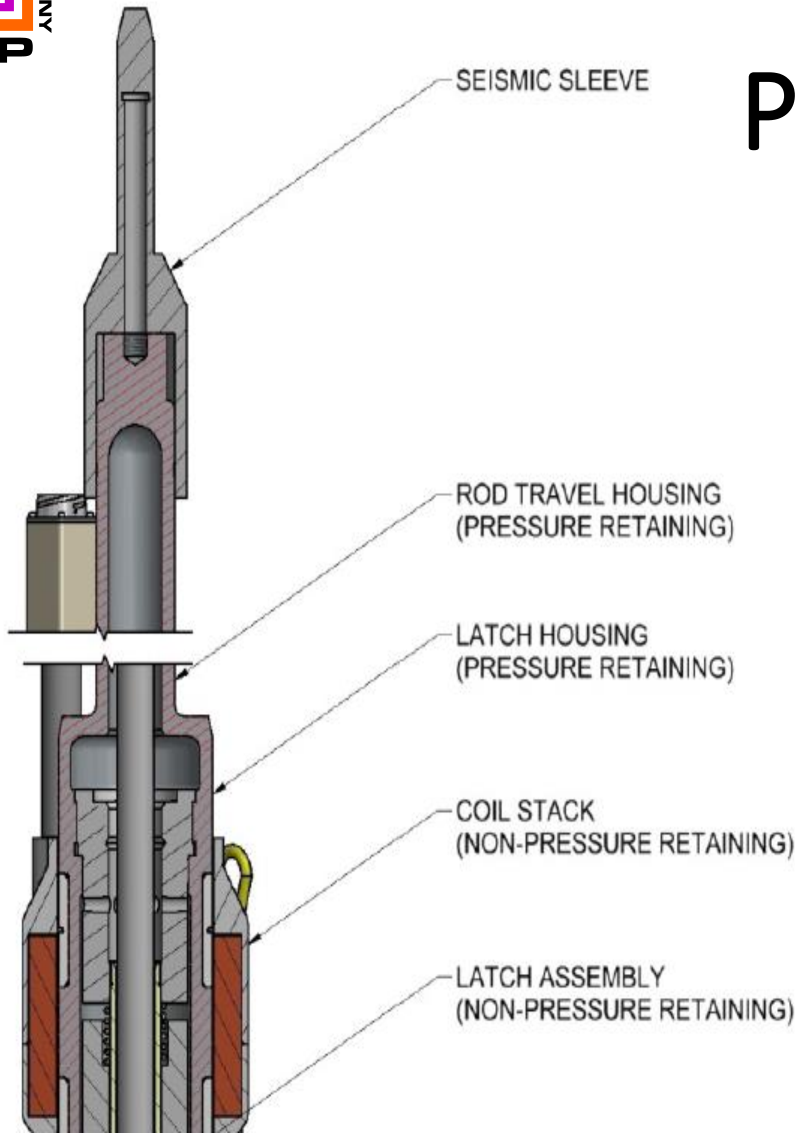
Extent of Condition

- Deformation on lockout ring is only seen on Unit 1 Rod D-6 CRDM
- Extent of condition – other 56 rods unaffected
  - Visual inspection has been performed on other 56 CRDMs
  - CRDM monitoring (coil traces) indicate other 56 CRDMs are operating reliably
- Plans for future monitoring
  - On startup: CRDM testing, rod drop timing testing
  - Periodic control rod exercise at power
  - Continue to evaluate coil traces
- Unit 2 CRDMs have been visually inspected and continue to be monitored and indicate reliable operation

Decision Inputs – Repair Evaluation

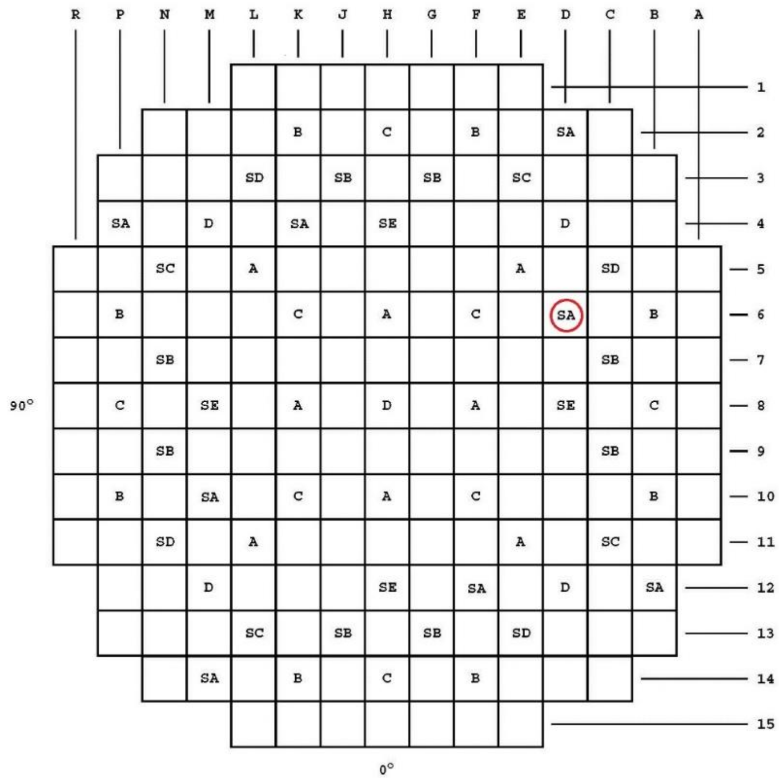
- Replacing D-6 CRDM
  - First of a kind evolution in the US (butt weld instead of canopy seal weld)
  - Post-repair maintenance testing
- Consequences and uncertainty associated with CRDM replacement are considered significant
  - Requires special tooling and processes that currently do not exist
  - RCS pressure boundary cutting and welding

Background – Pressure Boundary



- Components being removed are internal to the RCS pressure boundary
- Pressure boundary: butt weld between CRDM latch housing and rod travel housing

Control Rod Configuration



Bank Identifier	Number of Locations	Bank Identifier	Number of Locations
A	8	SA	8
B	8	SB	8
C	8	SC	4
D	5	SD	4
		SE	4

- Rod D-6 is a Shutdown Bank rod normally positioned fully withdrawn at power
- 57 Total Control Rods
  - 29 Control Bank Rods
  - 28 Shutdown Bank Rods

Physical Configuration Changes to Support Future Operation (50.59)

- Change the plant computer rod supervision program (software) to remove input from D-6 to rod deviation alarm
- Spare in place the cabling for the D-6 CRDM, Digital Rod Position Indication (DRPI), and RHO cabling
- Existing guide tube flow restrictor remains in place to maintain flow characteristics
  - Continuing to evaluate for any potential long-term effects of the D-6 removal design change

Thermal Hydraulic Impacts

- Thimble plug will be removed to reduce fuel component handling during core refueling
  - Analysis performed to support removal
  - Causes very small increase in core bypass flow, remains bounded by safety analysis flow

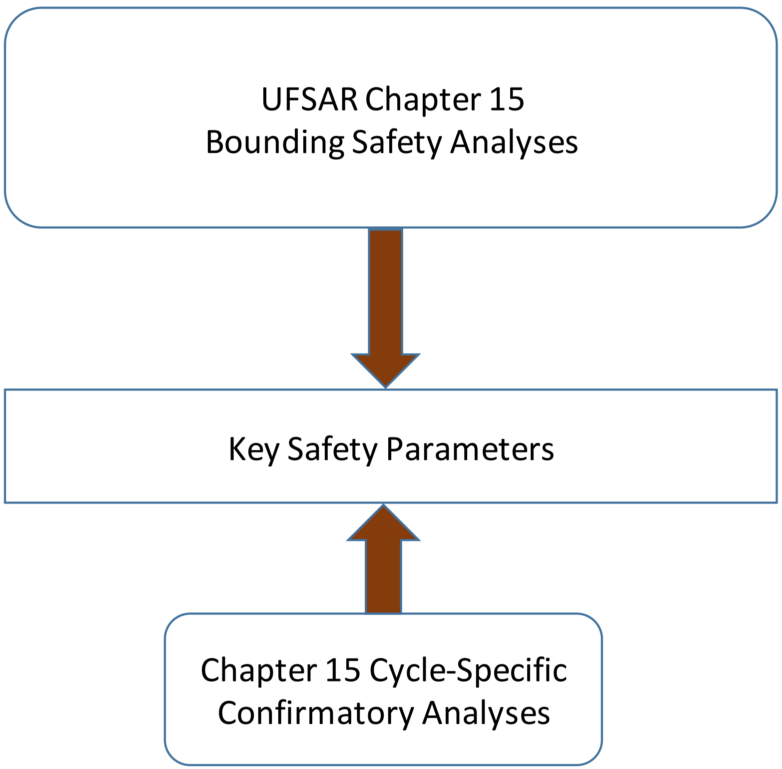
Seismic and Structural Impacts

- Dynamic analysis (seismic and loss of coolant accident forces) of the CRDM that was performed using the reactor equipment system model remains valid after removal of the D-6 control rod drive shaft and RCCA
  - Drive shaft does not provide stiffening function – free motion

Safety Analysis – Overview

- Basis of Methodology
- Description of Methodology
- Impact of permanent removal of D-6 RCCA
  - Nuclear (Core) Design Analyses
  - Non-LOCA Transient Analyses
  - LOCA Analyses

Safety Analysis – Basis of Methodology

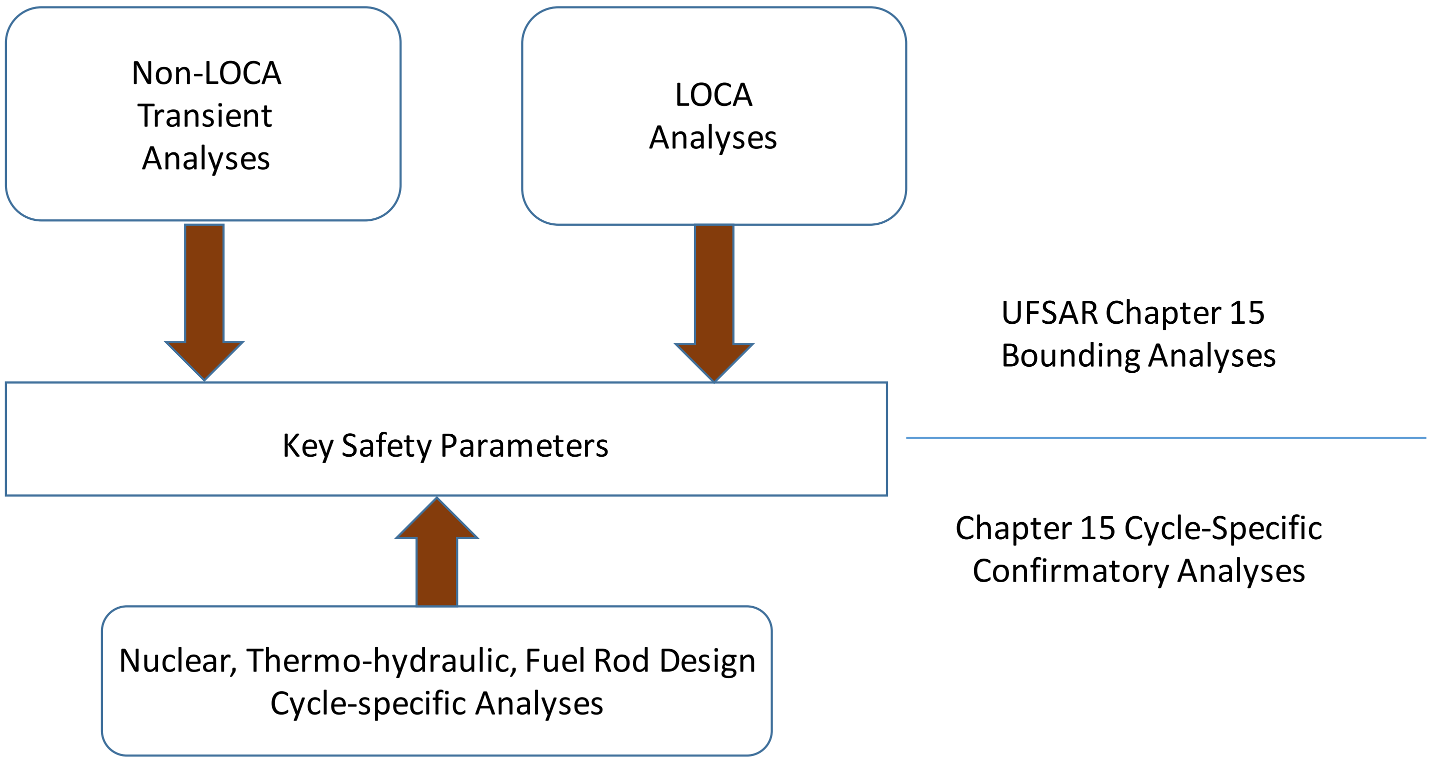


- STP Reload Safety Analysis uses NRC approved methodology:
    - WCAP 9272-P-A, “Westinghouse Reload Safety Evaluation Methodology”, July 1985

Safety Analysis – Description of Methodology

- Methodology establishes a bounding safety analysis
  - The performance and safety requirements are met through applicable acceptance limits, for example:
    - Minimum Departure from Nucleate Boiling Ratio (DNBR)
    - Maximum allowable fuel temperature
    - Maximum allowable reactor coolant system pressure
  - The bounding analyses are described in the UFSAR Chapter 15

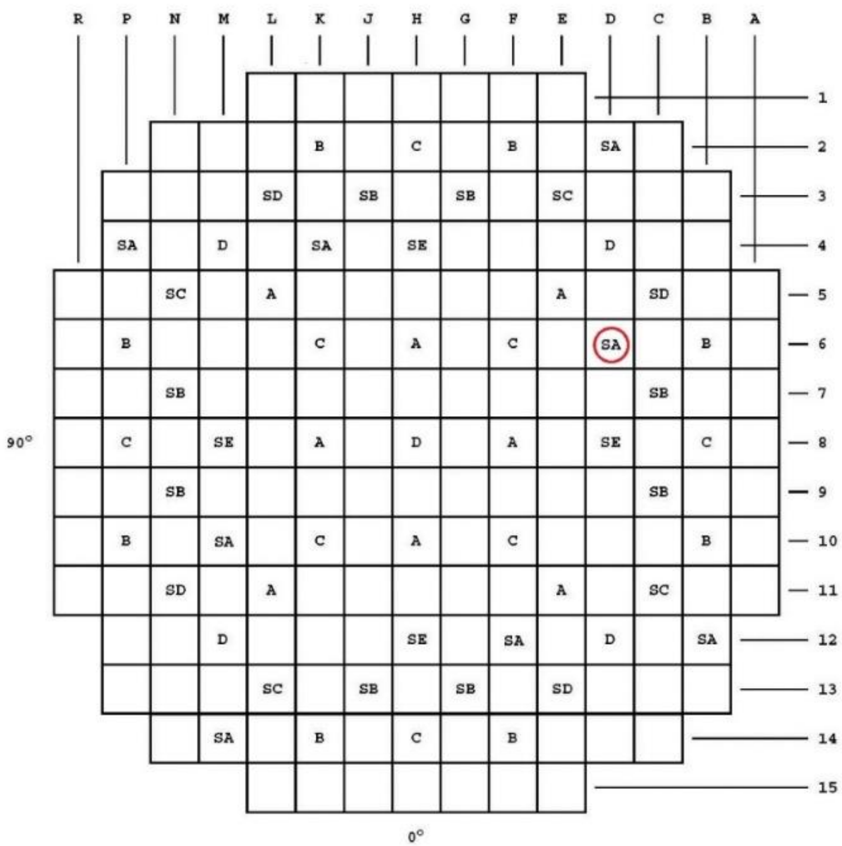
Safety Analysis –
Safety Analysis Relationships



Safety Analysis – Methodology

- Chapter 15 analyses are evaluated
  - Results presented in Chapter 15 are based on bounding reference core
  - Cycle-specific information is verified against reference core to ensure Chapter 15 results remain bounded

Impact on Safety Analyses



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- Power distribution within the reactor core during operation is negligibly impacted
  - Rod D-6 is a Shutdown Bank RCCA normally positioned withdrawn at power

Impact of D-6 Removal on Safety Analysis

- The removal of Control Rod D-6 could impact key safety parameters assumed in the UFSAR Chapter 15 analysis:
  - Available shutdown margin and most reactive stuck rod worth
  - Boron worth when all RCCAs are inserted
  - Rod worth of the adjacent RCCAs when all RCCAs are inserted
  - Trip reactivity as a function of time
  - Most positive moderator density coefficient (MDC)

Impact on Safety Analyses – Shutdown Margin

- Shutdown Margin used in the End-of-Life (EOL) Hot-Zero Power (HZP) Main Steam Line Break remains bounding
  - Bounding analysis for shutdown margin

Unit 1 Cycle	Burnup (MWD/MTU)	RCCA Condition	Calculated SDM (pcm)	Margin (%)
17	20400	D-6 present	2708	108
		D-6 removed	2276	75
18	19450	D-6 present	2430	87
		D-6 removed	2089	61
19	19400	D-6 present	2273	75
		D-6 removed	1968	51
20	18610	D-6 present	2432	87
		D-6 removed	2173	67

Impact on Safety Analyses – Boron Worth

- Potential impact to the chemical and volume control system (CVCS) malfunction resulting in a Reactor Coolant System (RCS) boron dilution in Modes 3, 4, and 5
- Rod removal increases boron worth for the all-rods inserted condition
- Analysis conservatively determines a boron worth with all rods out, therefore there is no impact with D-6 removed from the core

Impact on Safety Analyses – Rod Worth of Adjacent RCCAs

- Removal of Rod D-6 results in a small increase for the rod worth of the adjacent control rods with all RCCAs inserted, however
  - No impact to the fuel acceptance limits
    - Uncontrolled RCCA bank withdrawal from a subcritical or low power startup conditions and spectrum of rod ejection accidents because shutdown banks are withdrawn
    - Therefore D-6 will not add positive reactivity
  - Impacts DNBR for Main Steam Line Break, however, DNBR limit is confirmed acceptable on a cycle-specific basis

Impact on Safety Analyses – Rod Ejection Accident

- Rod Ejection N-2 Subcriticality (EOC)
  - The safety limit for subcriticality is $k_{eff} \leq 0.999$, which is met by determining N-2 rod worth is less than actual SDM + worst stuck rod worth * 0.9
  - A multi-cycle margin analysis was performed and demonstrates sufficient margin
  - Future cycles will be evaluated to ensure this limit can be met without RCCA D-6 present

Impact on Safety Analyses – Rod Ejection Accident

- Rod Ejection N-2 Subcriticality (EOC)

Unit 1 Cycle	Burnup (MWD/MTU)	RCCA Condition	N-2 Rod Worth (pcm)	Actual SDM+ WSRW * 0.9 (pcm)	Margin (%)
17	20400	D-6 present	2342	3529	34
		D-6 removed	2928	3292	11
18	19450	D-6 present	2273	3301	31
		D-6 removed	2815	3053	8
19	19400	D-6 present	2337	3187	27
		D-6 removed	2747	2937	6
20	18610	D-6 present	2175	3308	34
		D-6 removed	2659	3096	14

Impact on Safety Analyses – Trip Reactivity

- Removal of Rod D-6 reduces the total trip reactivity and the trip reactivity as a function of rod position
- A multi-cycle margin analysis was performed and demonstrates sufficient margin for total trip reactivity
- Cycle-specific analyses will be performed to ensure trip reactivity values assumed in the bounding Chapter 15 safety analyses are satisfied

Impact on Safety Analyses – Trip Reactivity (HZP)

- End-of-Cycle (EOC) HZP Trip Reactivity Following Rod Ejection
  - Safety limit is 2000 pcm for HZP

Unit 1 Cycle	Burnup (MWD/MTU)	RCCA Condition	Trip Reactivity (pcm)	Margin (%)
17	20400	D-6 present	3317	66
		D-6 removed	2605	30
18	19450	D-6 present	3145	57
		D-6 removed	2504	25
19	19400	D-6 present	2983	49
		D-6 removed	2449	22
20	18610	D-6 present	3240	62
		D-6 removed	2630	31

Impact on Safety Analyses – Trip Reactivity (HFP)

Unit 1 Cycle		RCCA Condition	Trip Reactivity (pcm)	Margin (%)
17	BOC	D-6 present	5211	30
		D-6 removed	4716	18
	EOC	D-6 present	5433	36
		D-6 removed	4854	21
18	BOC	D-6 present	5037	26
		D-6 removed	4543	14
	EOC	D-6 present	5268	32
		D-6 removed	4719	18
19	BOC	D-6 present	5071	27
		D-6 removed	4574	14
	EOC	D-6 present	5038	26
		D-6 removed	4489	12
20	BOC	D-6 present	5112	28
		D-6 removed	4625	16
	EOC	D-6 present	5256	31
		D-6 removed	4663	17

- Trip Reactivity (HFP)
  - The HFP Trip Reactivity value assumed in the Rod Ejection analysis is 4000 pcm

Impact on Safety Analyses – Moderator Density Coefficient (MDC)

- The safety limit is 0.54 Δk/gm/cc
- The most positive MDC is conservatively calculated assuming all rods in the core
- Impact on the MDC calculation for removal of D-6 removal is very small
- Cycle-specific nuclear design analysis confirms the safety limit is met

Impact on Safety Analyses – LOCA Analyses

- Small Break (SB) LOCA
  - Assumptions
    - Flow restrictor in RCCA guide tube is in place
    - No explicit assumption on number of RCCAs
- Large Break (LB) LOCA and LOCA Forces
  - Assumptions
    - Flow restrictor in RCCA guide tube is in place
    - No reliance on insertion or number of RCCAs
- Operation with D-6 removed does not impact the SBLOCA, LBLOCA and LOCA Forces provided that:
  - A flow restrictor remains installed at that location
  - Adequate shutdown margin is calculated for each cycle

Impact to UFSAR Chapter 15 Accident Analyses Summary

- Bounding Chapter 15 Analyses reported in the UFSAR do not assume the number or configuration of RCCAs in the reactor core
- Cycle-specific analyses performed in accordance with WCAP-9272 will confirm bounding Chapter 15 analyses reported in the UFSAR remain satisfied
    - Effects on available shutdown margin
    - Rod worth of the adjacent control rods
    - Boron worth
    - Trip reactivity
    - Most positive MDC
- Impact on DNBR will be evaluated on a cycle-specific basis in accordance with WCAP-9272 to confirm current safety analysis limits continue to be met
- Postulated accidents dependent on core power distributions while at power are not impacted
- Therefore, the removal of RCCA D-6 does not adversely impact the results presented in Chapter 15

Regulatory Evaluation

- Requesting proposed amendment to allow Unit 1 to operate with 56 control rods
- No other changes to STP TS required
- Applicable General Design Criteria will be reviewed and are expected to be satisfied
- These items will be discussed in the proposed LAR

Proposed LAR Content – Technical Evaluation

- System description
- Current licensing basis
- Impact on the safety analysis
  - Methodology overview
  - Impact on safety parameters
  - Impact on bounding UFSAR Chapter 15 accident analyses
- Field work required to permanently remove Control Rod D-6 from service
- Evaluation of potential design impacts
  - Thermal-hydraulic
  - Seismic and structural

Overview of Proposed Change

- Proposed change to TS 5.3.2 (change bar on right):

CONTROL ROD ASSEMBLIES

5.3.2 The Unit 1 core shall contain 56 full-length control rod assemblies with no full-length control rod assembly installed in core location D-6. The Unit 2 core shall contain 57 full-length control rod assemblies. The full-length control rod assemblies shall contain a nominal 158.9 inches of absorber material. The absorber material within each assembly shall be silver-indium-cadmium or hafnium. Mixtures of hafnium and silver-indium-cadmium are not permitted within a bank. All control rods shall be clad with stainless steel tubing.

Summary Conclusions

- Utilizing current core design methodologies, future cores will be designed to remain within the criteria established in the current Chapter 15 Accident Analysis
  - Appropriate safety margins maintained with 56 control rods
- TS will be changed to describe Unit 1 as having 56 control rods
  - No other TS affected
- Instrumentation setpoints and trip settings will not be affected
- No new operator actions are proposed
- Input will be provided for No Significant Hazards Consideration determination

Proposed Schedule

- Submit LAR to NRC March 17, 2016
- Approval of the proposed amendment is requested by March 2, 2017
    - Prior to the beginning of refueling outage 1RE20
- Implementation will be prior to restart of Unit 1 Cycle 21

Additional Questions and Action Recap