Nuclear Operating Company

August 31, 2022
Pre-Submittal Meeting

Updated Main Steam Line Break and Locked Rotor Dose Consequence Analysis to Address Extended Cooldown Timelines

Overview

- *Background*
- *Purpose*
- *Overview of Analytical Approach*
- *General Model Changes from CLB*
- *Model Changes for MSLB*
- *MSLB Results*
- *Model Changes for LRA*
- *LRA Results*
- *Conclusion*

Common Acronyms:

ANCC = Asymmetric Natural Circulation Cooldown
AST = Alternate Source Term
CLB = Current Licensing Basis
LOOP = Loss of Offsite Power
LRA = Locked Rotor Analysis
MSLB = Main Steam Line Break
PORV = Power Operated Relief Valve
SG = Steam Generator

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Background – What is ANCC?

- In the early 2000s STP and the industry recognized that loop flow stagnation could occur during asymmetric natural circulation cooldown (ANCC) with higher cooldown rates for the event with one or more steam generators not available for cooling.
- If a natural circulation cooldown is initiated at too high a rate using the active SGs, the transfer of heat to the secondary side of the “Inactive Loop” SGs (those in which the SGs do not remove energy from the RCS) will lag the conditions in the remainder of the RCS, such that the density driving head from the downcomer/core region portion is negated.
- As the RCS flow in the inactive loops slows down, it can eventually stop or stagnate because of this excessive cooldown in this limiting plant configuration.
- Cooldown rates were reduced in ANCC to prevent loop flow stagnation, which results in an extended cooldown timeline.

Background – STP Licensing Basis

- STP implemented AST in 2008 (ML080160013) assuming 8-hour cooldown timelines for many non-LOCA design basis accidents.
- In 2018, Callaway issued LER 2018-002-0 which identified the impact the reduced cooldown rate had on post-accident cooldown timelines for MSLB.
- STP identified that this issue was applicable to our MSLB dose analysis.
- The ANCC issue also impacts Locked Rotor due to the limiting single failure.
- Increased dose consequences have been determined to exceed the “more than minimal” threshold for 50.59 applicability.

Background – STP Licensing Basis

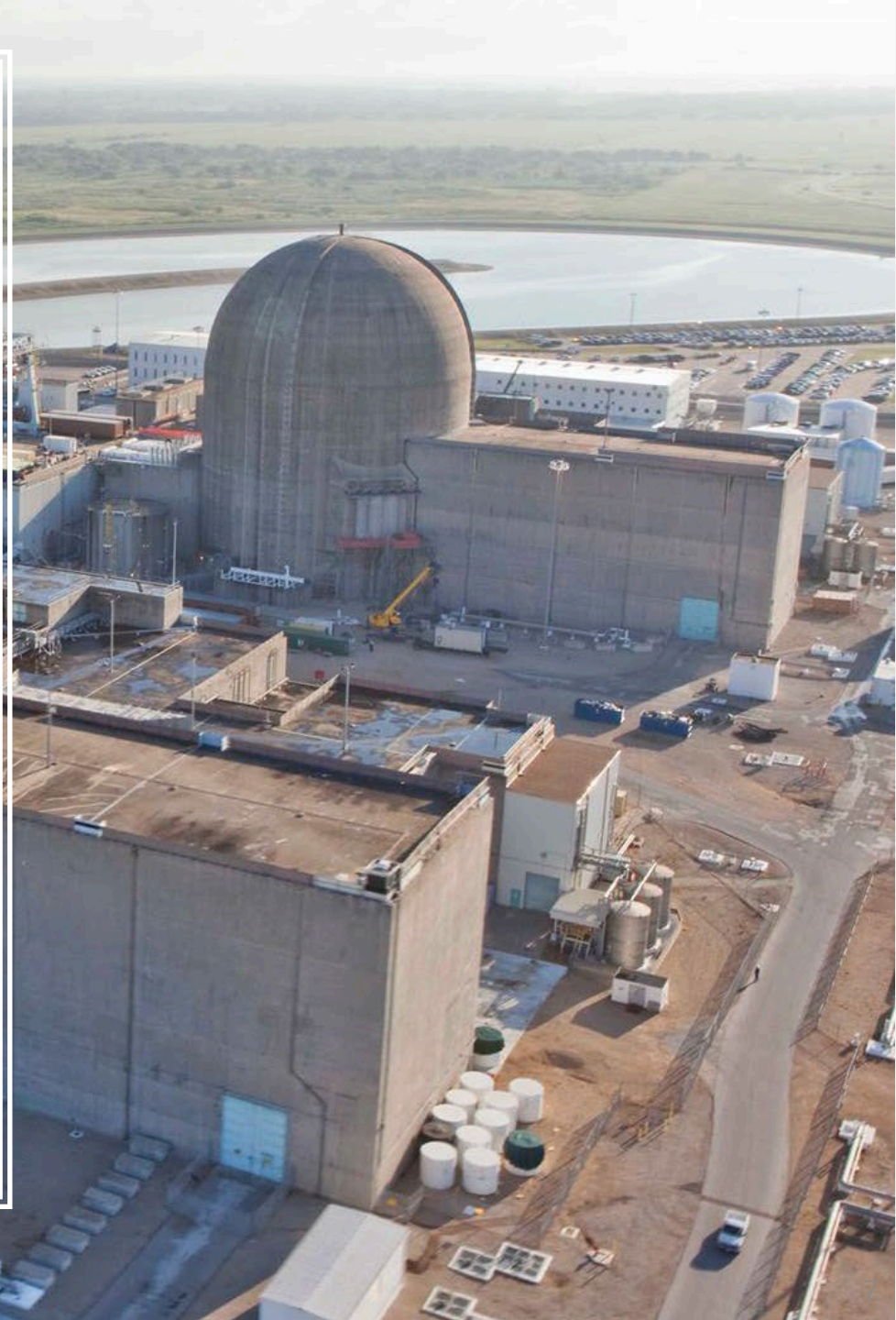
- The following Technical Specifications remain unchanged:
  - TS 3.4.8, RCS DEI-131 ≤ 1 µCi/gm
    DEI-131 ≤ 60 µCi/gm, 48 hour LCO (Pre-Accident Spike)
  - 6.8.3.o(b)(2), Accident induced Primary to Secondary Leakage ≤ 1 gpm
  - TS 3.7.1.4 Secondary System DEI-131 ≤ 0.1 µCi/gm

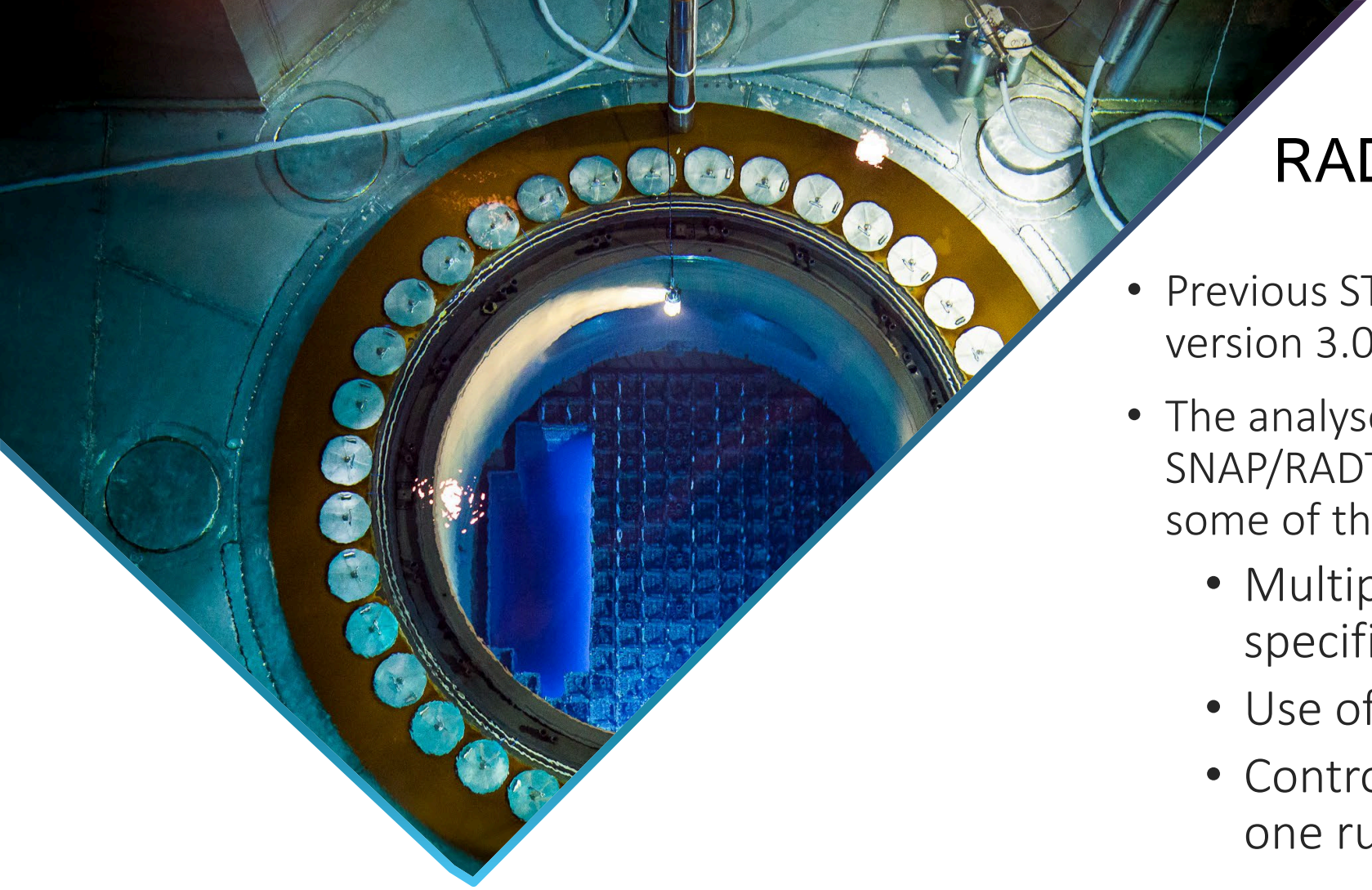
Purpose of this Submittal

- The intent of the submittal is for approval to adopt re-analysis of the existing design basis AST calculations for MSLB and LRA using the ANCC thermal-hydraulic analyses and the existing isotopic inventories to evaluate the dose effects of the extended cooldown on our existing accident analyses.
- The overall intent is to retain as much of the existing design bases as possible while addressing the impact of extended cooldown times for these two accident analyses.
- We also intend to leverage the improvements in dose analysis codes from RADTRAD 3.03 (used for our current analyses) to SNAP/RADTRAD 5.0.2 with respect to modeling multiple control room compartments, utilization of pathway filtration to model iodine partitioning, and the capability to model multiple sources to calculate accident doses with explicitly calculated steam generator isotopic inventories.
- We also ask for approval to employ these modeling improvements to the existing AST calculations as they are revised in the future.

Overview of Analytical Approach

- The ANCC cooldown timeline for MSLB and LRA were revised from 8 hours to 28 hours.
- This includes time for
  - Initial stabilization
  - Boration
  - Cooling down at the minimum procedural rate.
- RETRAN models were developed for the transient
  - Accurately calculate steam release during the transient for the slower cooldown.
  - Determine the time to reach RHR cut-in condition.
- Stay within our existing license bases wherever possible.





RADTRAD Version Change

- Previous STP AST analysis utilized RADTRAD version 3.0.3.
- The analyses for the planned submittal use SNAP/RADTRAD 5.0.2 and take advantage of some of the improvements.
  - Multiple Source Distributions specified (RCS and SG are different).
  - Use of ICRP-38 built-in libraries
  - Control Room and TSC modeled in one run.

Limiting Single Failure

- In both MSLB and LRA analyses, the assumed single failure is a failure of ESF Actuation Signal A which results in the failure of automatic start for motor driven Train A Auxiliary Feedwater (AFW) pump and of turbine driven Train D AFW pump.
- For MSLB the faulted line is assumed to be in Train B or Train C. To achieve a cooldown on 2 of 4 Steam Generators, AFW flow from the faulted train is cross-connected to the Train A Steam Generator within 30 minutes.
- For LRA, no cross connection is required (although available), and both Train A and Train D Steam Generators eventually steam dry while the plant cools down on Train B & C Steam Generators.
- For LRA, there is no open fault in any of the Steam Generators. The PORVs on Train A and Train D are only opened as necessary for pressure control.

General Modeling Comparison

Item	Current Basis	Submittal
Release Termination	All releases terminate at RHR entry, except SG flow orifices at 36 hours.	All releases terminate at RHR entry, except SG flow orifices at 36 hours.
Accident Duration (to RHR entry)	8 hours	28 hours
Isotopics	Isotopic inventory was in user-created files, as was the dose conversion factors (DCFs) and daughter products, etc.	Used ICRP-38 internal to the code, including daughter products and DCFs.

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MSLB Modeling Differences

Iodine Spiking (Coincident Spike)	8 hours, as specified in RG 1.183 R0.	8 hours, as specified in RG 1.183 R0. RG 1.183 iodine spiking duration discusses 8 hours or less if site inventory is demonstrated as exhausted. Spike duration has no apparent relation to assumed 8 hour cooldown.

MSLB Modeling Differences

Item	Current Basis	Submittal
SG Models	3 SGs intact 1 SG faulted and AFW isolated.	2 SGs intact and cooling 1 SG faulted and AFW isolated. 1 SG with AFW unavailable and isolated (except for pressure control).
Primary to secondary leakage	1 GPM: 0.65 gpm to 3 intact SGs, 0.35 gpm to faulted SG, modeled direct to environment	1 GPM: 0.65 gpm to 2 active SGs. 0.35 gpm to 1 faulted SG and 1 inactive SG, which is modeled as a direct to environment release.

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MSLB Results (subject to Final Approval)

	Reg Guide 1.183 Limit		Current RADTRAD 3.03		SNAP/RADTRAD	
Location	Coincident	PE	Coincident	PE	Coincident	PE
EAB	2.5	25	0.85	0.105	0.80	0.067
LPZ	2.5	25	0.66	0.061	0.95	0.068
CR	5	5	1.7	0.155	2.90	0.205
TSC	5	5	1.65	0.149	2.83	0.200

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Model Changes for LRA

Item	Current Basis	Submittal
SG Models	4 SGs intact 1 SG assumed to have uncovered tubes, with 0.35 gpm RCS leakages flashing directly to steam and assumed released to environment.	2 SGs intact and cooling plant through PORV. 2 SGs dry out and become inactive. The PORVs are only open for pressure control afterwards.
0.35 gpm Direct to Environment Release Duration	8 hours	12 hours (See next slide.)
Isotopic Inventory	User-defined.	Used internal ICRP-38 library. The internal library is missing entries for Kr-89 and Xe-137, so these isotopes were not used in the ANCC calculation.

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Model Changes for LRA

Two SGs modeled as a single volume, actively cooled. The 0.65 gpm primary to secondary leakage modeled as mixed into this SG volume and released with steam for 0 to 28 hours.

Two SGs modeled as inactive with steam released through PORVs until dry, then for pressure control (otherwise isolated).

The 0.35 gpm primary to secondary release assumed to flash is released for 12 hours from start of accident, 6 hours committed time plus 6 hours discretionary margin. The committed 6 hour interval is driven by bounding the primary to secondary release modeled through the inactive SG volume when PORV is actually open.

Unlike the MSLB, the LRA primary to secondary release assumed to flash only has a release path to the environment when the PORVs open for pressure control, making the inactive SG volume act as an accumulator. This must be bounded by the minimum primary to environment release time.

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LRA Results

	Reg Guide		Asymmetric
Location	1.183 Limit	Current	Analysis
EAB	2.5	1.9	1.82
LPZ	2.5	1.5	1.62
CR	5	3.9	4.54
TSC	5	3.7	4.41

Conclusion

- The updated MSLB and LRA analyses for extended cooldown timelines retain most of the original AST licensing basis assumptions.
- The updated analyses retain adequate conservatisms and show that the AST acceptance criteria are met.
- The SNAP\RADTRAD modeling approach utilized for these models may be used when updating other dose analyses.

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Questions?