U.S. EPR
Design Certification Review
RLBLOCA Methodology

AREVA NP Inc. and the NRC
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Objective

Describe the proposed strategy for addressing NRC concerns, and thus reduce the magnitude of proposed PCT adjustments, while preserving overall DC review schedule.

Requirements for Proposed Approach

- Changes or additional information should not generate more RAIs
- Changes should reflect options already indicated by NRC staff as viable
- Schedule for implementation should support submittal of revised topical report and FSAR Chapter 15 large break LOCA calculations to support current Chapter 15 review schedule
- Reduction of PCT adjustments, not necessarily elimination

Agenda

- ▶ **Where we are today** — **Bert Dunn**
- ▶ **Issues** — **Bert Dunn**
  - ◇ **Initial stored core energy**
    - Burnup-dependent initial stored energy
    - Initial stored energy in average and peripheral assemblies
    - Burnup-dependent fuel conductivity in transient calculations
  - ◇ **Lower plenum refill and core flow oscillations**
  - ◇ **Nitrogen injection**
  - ◇ **Accumulator liquid temperature**
  - ◇ **Decay heat sampling**
- ▶ **Summary and next steps** — **Sandra Sloan**

Where We Are Today

- Incorporated changes to-date:

RAI	Change
10	Treated core power deterministically using maximum measurement uncertainty, i.e. 100.48% of rated power or 4612 MWt.
21	Evaluated 124 cases instead of present 59 cases.
22	Considered only loss-of-offsite power (LOOP) conditions.
23	Used a revised U.S. EPR ICECON containment model.
24	Changed upper bound of containment temperature sampling range to 131°F.
30	Changed application of Forslund-Rohsenow. Contribution of Forslund- Rohsenow with 0.7 to 0.9 void fraction interpolation range limited to 15% or less.
33	Set decay heat multiplier to 1.06.

Where We Are Today

Comparison of original and test of changes to-date

As reported in:	Cycle	PCT, °F	Total Oxidation, %	Max Oxidation, %
ANP-10278P, U.S. EPR FSAR	Equilibrium	1425	< 0.01	0.2354
U.S. EPR FSAR	First	1531	< 0.01	0.8836
Test of changes to-date	Equilibrium	~1750	< 0.01	~2.0

Proprietary Session

NRC Concerns on Fuel Rod Model

- RODEX3 hot pin burnup-dependent temperature predictions
- Initial stored energy in average and peripheral assemblies
- Transient and steady state fuel conductivity

Hot Pin Initial Stored Energy

- **NRC concern: Hot pin initial stored energy is too low**
- **Proposed approach**
  - **Evaluate NRC predictions of PCT impact**
    - Review NRC RELAP5 calculations with RODEX4 conductivities
    - Determine centerline fuel temperatures from NRC calculations
  - **Evaluate PCT impact of 300°F increase in centerline fuel temperatures**
  - **Develop fit of RODEX3 to RODEX4 database with rod IFA 432 removed**
  - **Options**
    - Implement burnup-dependent conductivity adjustment, or
    - Define modified PCT adjustment

Impact of increase of 300°F in Fuel Centerline Temperature – Preliminary Results

Initial Stored Energy in Average and Peripheral Assemblies

- NRC concern: Combined region initial stored energy under predicted
- Proposed approach

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Transient and steady state fuel conductivity

- NRC concern: Burnup-dependent fuel conductivity adjustment not included in transient calculations
- Proposed approach
  - [ ]

Transient and steady state fuel conductivity

Lower Plenum Refill and Core Flow Oscillations

- **NRC Concern: Coolant enters core before lower plenum is water solid**
- **Proposed approach**
  - **Assess gas incursion and boiling phenomena**
  - **Sensitivity studies to determine PCT impact**
    - Steam-only containment
    - Lower plenum nodalization

Lower Plenum Refill and Core Flow Oscillations

Lower Plenum Refill and Core Flow Oscillations

- Lower plenum noding study
- 1 to 2 nodes

Nitrogen Injection

- NRC concern: S-RELAP5 code does not appropriately respond to nitrogen injection under certain conditions.
  - Impact: Higher-than-expected RCS pressurization prediction for certain cases
- To address this issue, the cases submitted as part of sample problem in ANP-10278P were rerun with no nitrogen injection.
  - Accumulators isolated when close to empty.
    - Similar to a study conducted in response to RAI-28 on ANP-10278P
    - Overall impact on PCT is not significant
- Proposed approach
  - Isolate accumulators near the end of liquid injection

Case 44 – Preliminary Results

Case 18 – Preliminary Results

Nitrogen Injection – Preliminary Results

Accumulator Temperature

- NRC concern: Accumulator temperature is sampled to too low a value
  - RLBLOCA model applies the sampled value of the containment temperature to:
    - Accumulators
    - Containment vapor and liquid
  - The containment temperature is sampled from 59°F to 131°F.
    - Lower bound from Technical Specification minimum temperature for IRWST (Technical Specification Surveillance Requirements (SR) 3.5.4.1).

Accumulator Temperature

- Proposed approach is to use a revised sampling range
  - Lower bound - 80 to 90°F (nominal temperature in accessible space at accumulator elevation)
  - Upper bound: 131°F
  - Flat distribution based on sensitivity study

Preliminary Sensitivity of PCT to Proposed Temperature Distribution

Decay Heat Sampling

- AREVA NP's earlier agreement to use a deterministic treatment of decay heat is not consistent with a best estimate model
  - Sampling of ANSI/ANS 5.1-1979 standard is justified by comparison to best estimate decay heat curve
    - ORIGEN calculation for equilibrium cycle
  - If ANSI/ANS 5.1-1979 as applied by AREVA NP is greater than the ORIGEN best estimate calculations, sampling remains conservative

Revised Decay Heat Evaluation ORIGEN Parameters

- ORIGEN parameters to review and establish
  - Enrichment
  - Fuel powers
  - Fuel temperature
  - Irradiation history
  - 30 day updates for cross sections
- Desired result
  - Bound of best estimate decay heat rate including actinides

RLBLOCA – Decay Heat

Potential Cumulative PCT Impact

Item	Proposed PCT Adder ,°F	PCT Adjustment After Improvements, °F
Cumulative Effect	~600	~275
PCT (current FSAR = 1531°F)	~2130	~1806

Summary

- Proposed approach involves:
  - Straight-forward modification of analytical approach
  - Providing additional information to support reduction in PCT penalty
- Changes in methodology will be documented in Revision 1 of the topical report
- Chapter 15 FSAR large break LOCA calculations will be updated
- AREVA to keep NRC informed of status

AREVA's objective is to obtain a prediction of PCT which appropriately reflects the design margin of the U.S. EPR and the application of a realistic analytical method.

Next Steps

- Request fuel temperature results from NRC analysis
- Status meetings, early October and early November 2009
- Submit Revision 1 of topical report and updated FSAR LBLOCA analysis, January 2010
- Post submittal meeting, February 2010
- NRC requested to notify AREVA immediately if the proposed approach at any time jeopardizes the overall DC review schedule