



Watts Bar Nuclear Plant Unit 2  
Pre-Submittal Meeting for Proposed License Amendment  
Request Regarding the use of PAD4TCD in the Large  
Break Loss of Coolant Accident Analysis

January 25, 2018

# Agenda

- Opening Remarks
- Original Watts Bar Unit 2 (WBN 2) Large Break Loss of Coolant Accident (LBLOCA) Analysis
- PAD4 Thermal Conductivity Degradation (PAD4TCD)
- Nuclear Regulatory Commission (NRC) Approval of PAD4TCD
- Revised LBLOCA Analysis
- Key Points in the Proposed PAD4TCD License Condition LAR
- Licensing Schedule Overview
- Proposed License Condition Change
- Schedule for Submittal
- Summary and Closing Remarks

# Original WBN 2 LBLOCA Analysis

- Information Notice (IN) 2009-23: Nuclear Fuel TCD
  - Pellet thermal conductivity decreases as burnup increases
  - Consequently, stored energy in the pellets increases as burnup increases
- Original WBN 2 LBLOCA analysis used PAD 4 that did not model TCD
- Concern was that the higher burnup fuel would have a higher peak clad temperature (PCT) than fresh fuel when the effects of TCD are modeled in the fuel performance code

# PAD4TCD

- To address the concern with the original LBLOCA analysis
  - A revised fuel performance code (PAD4TCD) was developed that explicitly modeled the effect of TCD on fuel pellet stored energy
  - The LBLOCA was revised to determine the PCT for burned fuel using PAD4TCD
- The revised LBLOCA analysis accounted for reduced peaking in the burned assemblies
- The revised LBLOCA analysis determined that fuel in its 2<sup>nd</sup> cycle of operation produced the highest PCT
- Fuel in its 2<sup>nd</sup> cycle of operation had the highest PCT due to a relatively small amount of reduced peaking being credited in the analysis



## NRC Approval of PAD4TCD

- NRC reviewed the TCD model in PAD4TCD and concluded there is good agreement of the temperature dependent and exposure dependent coefficients between PAD4TCD and FRAPCON-3.4 thermal conductivity models
- NRC also compared PAD4TCD fuel rod temperature predictions to the Halden high burnup fuel temperature measurements and found good agreement
- NRC concluded that PAD4TCD adequately accounts for TCD
  - Safety Evaluation Report (SER) on Original License
  - SER on Current License Condition

# Revised LBLOCA Analysis

- Revised LBLOCA analysis credits reduced peaking for fuel in its 2<sup>nd</sup> and 3<sup>rd</sup> cycle of operation
- The reduced peaking partially offsets the lower thermal conductivity of the higher burnup fuel so the temperature / stored energy of the higher burnup fuel is similar to that of fresh fuel
- As part of the core design process for each cycle, analysis checks are in place that ensure the peaking limits for the higher burnup fuel are less than used in the LBLOCA analysis

## Key Points in the Proposed PAD4TCD License Condition LAR

- PAD4TCD adequately accounts for the effect of TCD on fuel rod temperature and stored energy
- LBLOCA analysis, as described in the WBN dual-unit Updated Final Safety Analysis Report (UFSAR), includes the effect of TCD on higher burnup fuel to determine limiting PCT
- Checks in the core design process ensure the peaking limits used in the UFSAR LBLOCA analysis for higher burnup fuel are not exceeded
- The LBLOCA PCT is sufficiently low (1766°F as compared to 2200°F) that there are no concerns that LBLOCA PCT will exceed regulatory limits should a newer fuel performance code be used (i.e., PAD 5)
- No new technical content

# Replacement of PAD4TCD with PAD 5 in the LOCA Analysis

- TVA will update the LBLOCA analysis to use newer, recently approved fuel performance code PAD 5 (as part of the recently approved full spectrum LOCA (FSLOCA) Evaluation Methodology)
- The LBLOCA analysis using PAD 5 will be for both WBN 1 & 2 with replacement steam generators (RSGs)
  - WBN 1 has RSGs
  - WBN 2 currently has smaller, older steam generators than the RSGs
- The LBLOCA analysis using PAD 5 will be submitted in June 2019
  - Effective for Unit 1 upon NRC approval
  - Effective for Unit 2 upon replacement of the original steam generators



## WBN Unit 2 TPBAR LAR

- Department of Energy (DOE) Tritium requirements drive TVA schedule
- Tritium Production Burnable Absorber Rod (TPBAR) LAR
  - Submitted on December 20, 2017
  - Approval requested by May 31, 2019
  - Based on currently approved LOCA analyses
- Load TPBARs for WBN 2 Cycle 4 (November 2020)
- Schedule allows time for Cycle 4 fuel design and fabrication

# WBN Units 1&2 FSLOCA LAR

- WBN 1 has RSGs
- WBN 2 RSGs planned for operation in Cycle 5
- FSLOCA analysis that is bounding for both units with RSGs will be complete by December 2018
- FSLOCA LAR submittal following Unit 2 TPBAR LAR approval
- Approval requested by March 2021
- Implementation in Unit 1 Cycle 18 (October 2021) and Unit 2 Cycle 5 (June 2022)

# Licensing Schedule Overview

ID	Task Name	2018				2019				2020				2021				2022				2023			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
2	WBN 2 TPBAR LAR – NRC Review																								
3	WBN 2 Cycle 4 Fuel Design, Fab & Delivery																								
4	WBN 1&2 RSG FSLOCA LAR Development																								
5	WBN 1&2 RSG FSLOCA LAR – NRC Review																								
6	WBN 1 Cycle 17																								
7	WBN 1 Cycle 18																								
8	WBN 2 Cycle 4 (w/ TPBARs)																								
9	WBN 2 RSG Installation																								
10	WBN 2 Cycle 5																								

# Proposed License Condition Change

- Currently, WBN Unit 2 Operating License, License Condition 2.C(4) states that “PAD4TCD may be used to establish core operating limits for Cycles 1 and 2 only. PAD4TCD may not be used to establish core operating limits for subsequent reload cycles.”
- The proposed change reads as follows: “PAD4TCD may be used to establish core operating limits until the WBN Unit 2 steam generators are replaced with steam generators equivalent to the existing steam generators at WBN Unit 1.”

## Schedule for Submittal

- PAD4TCD LAR will be submitted in February 2018
- Request NRC approval within one year of submittal date to support WBN Unit 2 Cycle 3 operation

## Summary and Closing Remarks

- The WBN 2 LBLOCA analysis adequately accounts for the effects of TCD and evaluates higher burnup fuel to determine the limiting PCT
- The core design process ensures that the power peaking for fuel in its 2<sup>nd</sup> and 3<sup>rd</sup> cycle of operation remains below the power peaking limits used in the UFSAR LBLOCA analysis
- WBN 2 has a very low LBLOCA PCT so any increase in PCT resulting from an LBLOCA analysis that uses the new fuel performance code PAD 5 can be accommodated without approaching the PCT acceptance criteria
- No safety concern exists with maintaining the current LBLOCA analysis until the WBN 2 steam generators are replaced



