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BWR Burnup Credit Update

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Introduction

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- The purpose of this work is to study factors that are important to BWR BurnUp Credit (BUC) analyses for SNF storage and transportation casks
- BUC is taking credit for the reduction in reactivity as the result of the net reduction of fissile nuclides and the production of actinide and fission produce neutron absorbers of fuel
- Interim Staff Guidance No. 8 (ISG-8) Rev. 3 provides guidance for reviews of PWR BUC applications
- Staff would like to update Storage and Transportation SRPS to include review guidance for BWR BUC applications. Current approvals for BWR fuel assume fresh fuel

Burnup Credit in PWR vs. BWR Casks

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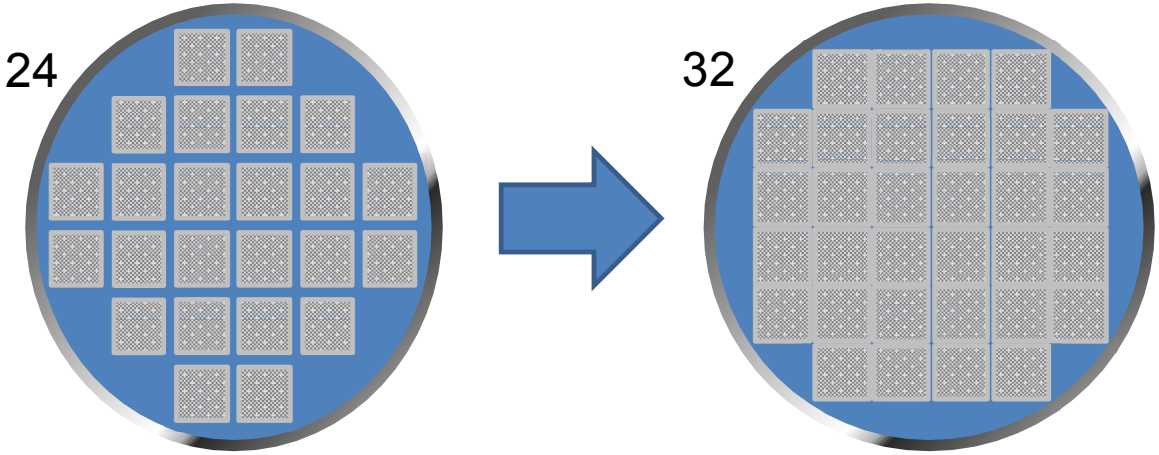
PWR:



BWR:

- Higher initial enrichment
- Lower ^{10}B in absorber panels
- Reconfiguration under accident conditions

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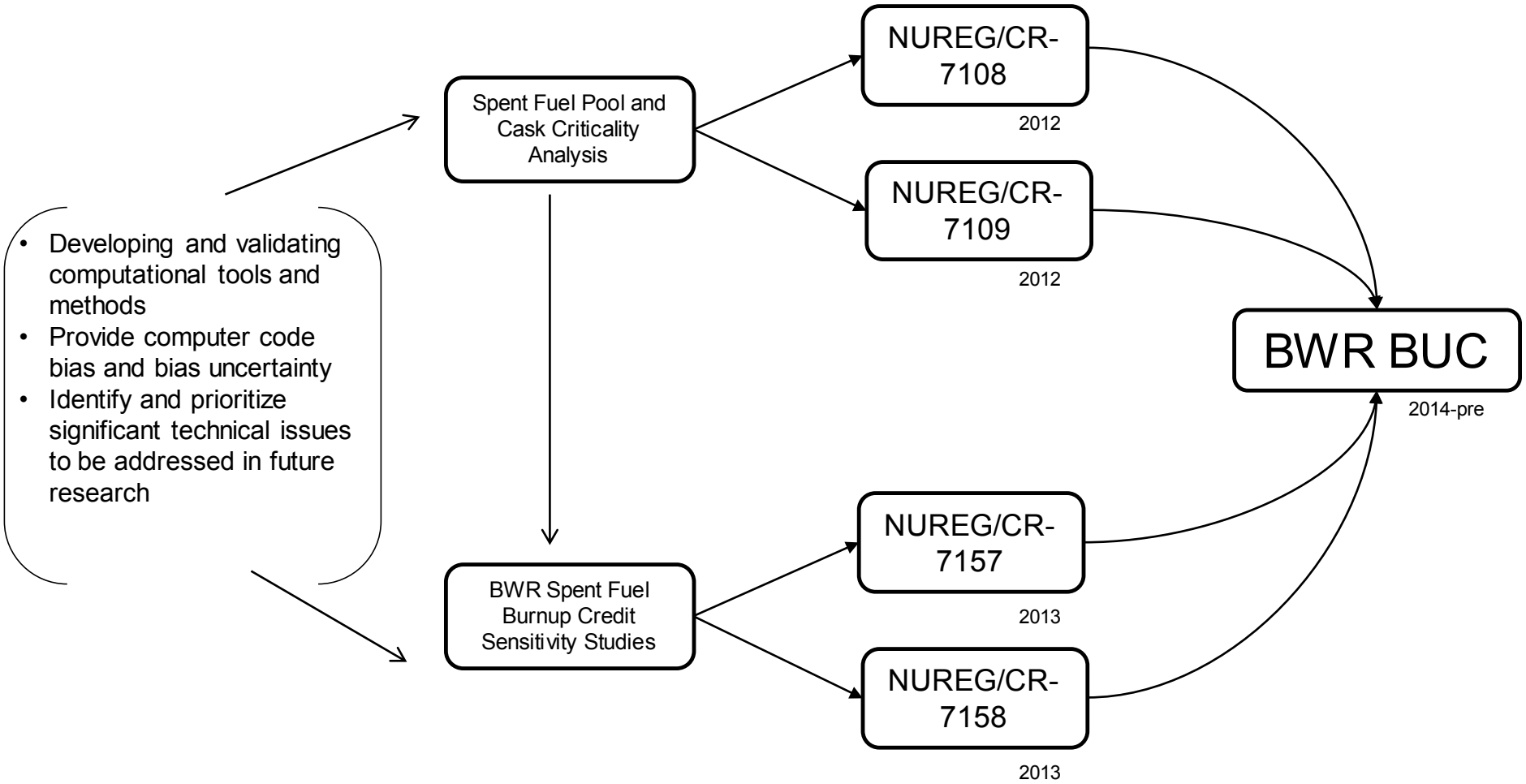
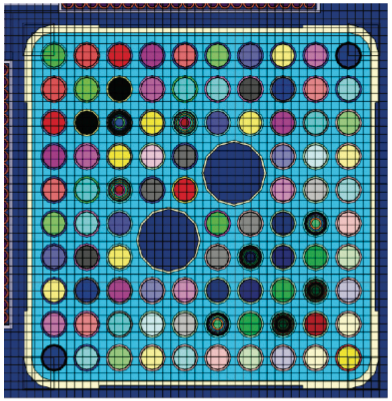
Previous BWR Burnup Credit Research

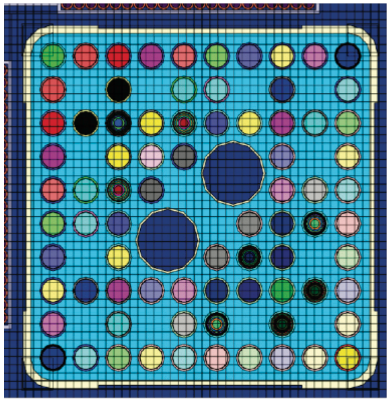


BWR BUC Challenges

- Fewer applicable radiochemical assay and criticality experimental data
  - Current research includes participation in the REGAL experimental program
- More complex fuel design and irradiation history compared to PWRs
  - Partial length rods
  - Radial and axial enrichment variation
  - Control blade insertion
  - Void profile



Full



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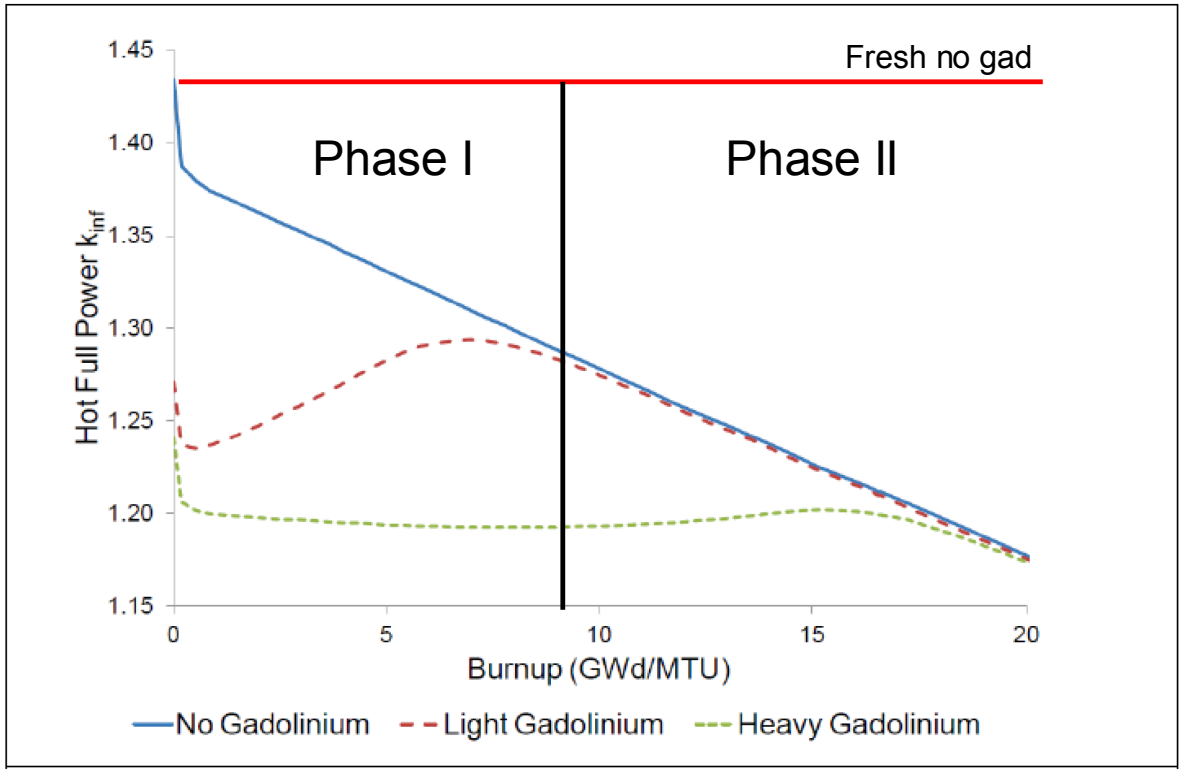
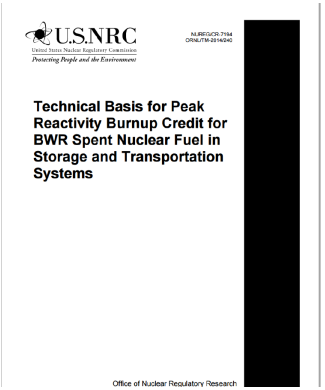
BWR Burnup Credit Research



Depletion comparison of fuel without Gd and with two different Gd loadings

- "fresh fuel no-Gad" assumption very conservative
- Peak reactivity is the result of Gd burn. Enrichment alone not appropriate to characterize BWR fuel reactivity.
- The factors that affect gadolinium depletion are the most important parameters for peak reactivity analyses

Phase I – Peak Reactivity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NUREG/CR-7194
ORNL/TM-2014/240

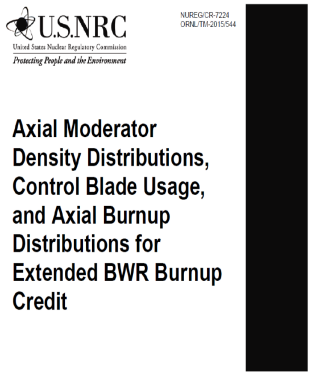
Technical Basis for Peak Reactivity Burnup Credit for BWR Spent Nuclear Fuel in Storage and Transportation Systems

Office of Nuclear Regulatory Research

April 2015

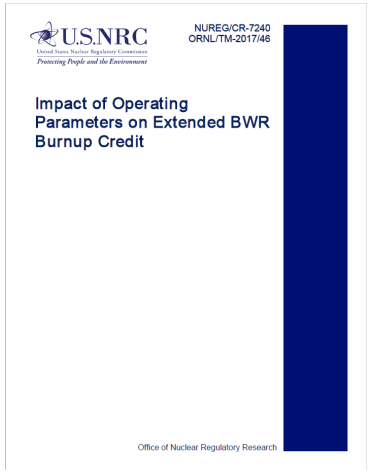
- Work performed under contract through NRC Office of Nuclear Regulatory Research in two phases
- Phase I
  - A technical basis for applying peak reactivity methods for BWR BUC in SNF storage and transportation casks (NUREG/CR-7194)
  - Examines fuel assembly lattice design and operating parameters relevant to fuel burned near peak reactivity
  - Validation for reactivity calculations
  - Validation of depleted isotopic inventories at burnups associated with peak reactivity

Phase II – Beyond Peak



- Phase II (Tasks 3-5 – NUREG/CR-7224)
  - Evaluates the impact of the following phenomena:
    - Axial moderator density distributions
    - Control blade usage
    - Axial burnup profiles
  - The objective of the study is to:
    - Identify limiting conditions and assumptions that can be used for regulatory guidance
    - Understand reactivity effects of major irradiation parameters and the margin present in peak reactivity BUC

Phase II – Beyond Peak, Cont'd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NUREG/CR-7240
ORNL/TM-2017/46

Impact of Operating Parameters on Extended BWR Burnup Credit

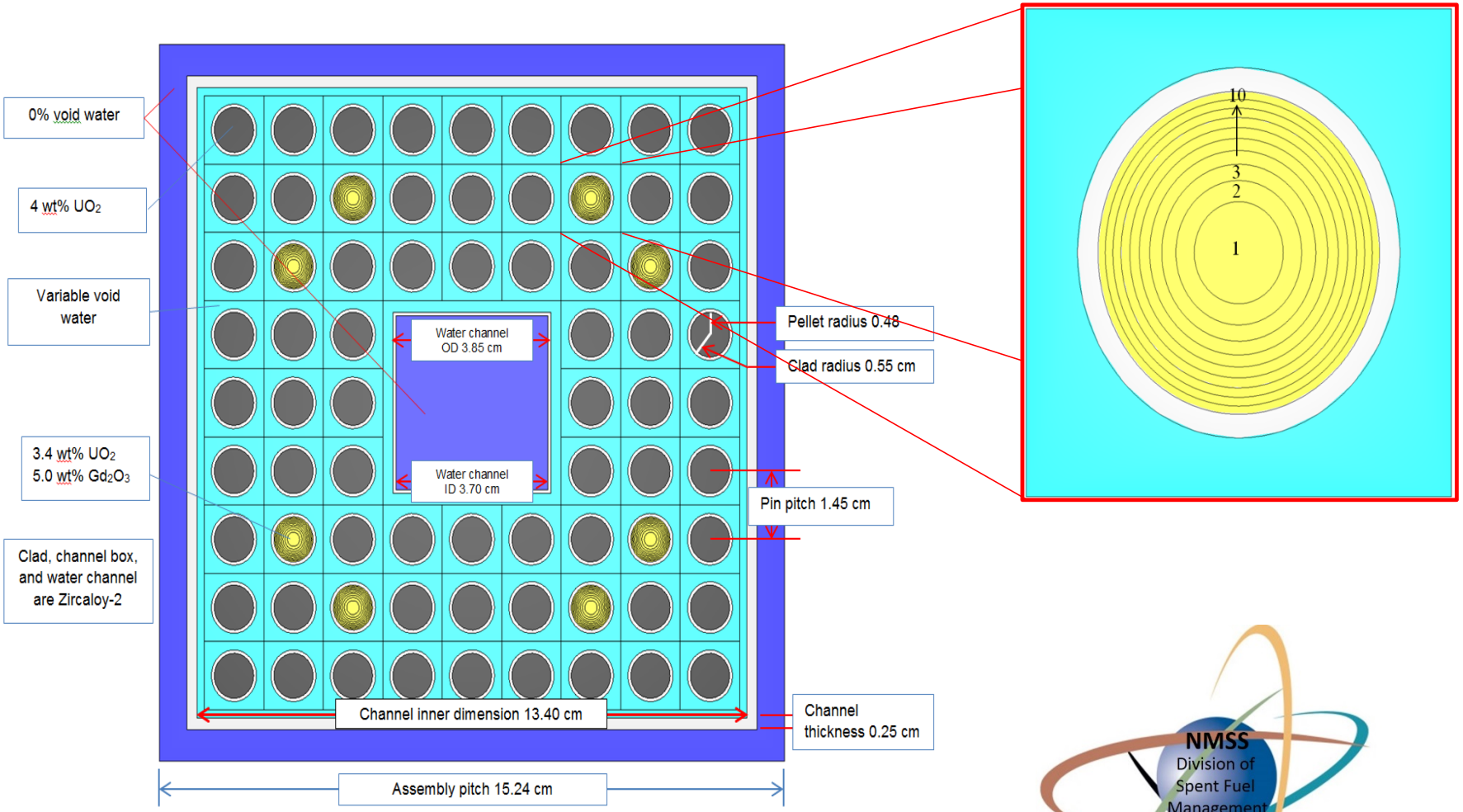
Office of Nuclear Regulatory Research

- Draft NUREG/CR-7240
- Objective of the study is twofold:
  - Determine the impact of "medium" importance operating parameters
    - Fuel temperature
    - Specific power
    - Operating history
    - Bypass flow density
  - Determine the impact of correlated operating parameters, e.g., impact of control blade insertion on void distribution and fuel temperature

Remaining Phase II Research

- Task 8: Review adequacy of currently available radiochemical assay data to support extension of BWR BUC to higher burnups
- Task 9: review the adequacy of currently available critical experiments data to support extension of BWR BUC to higher burnups
- Task 10: Generate a similar document to that which was carried out for PWR BUC to form the basis of an ISG or a revision to the Standard Review Plan

International BWR BUC Activity



International BWR BUC Activity, Cont'd

CODE	LIBRARY
Scale 6.1.1 / 6.1.2 / 6.2 / 6.2.1	ENDFB/VII.0 continuous ENDFB/VII.0 238-group ENDFB/V.0 44-group ENDFB/VII.1 56-group ENDFB/VII.1 252-group
APOLLO2-A1.21.0	JEFF 3.1. 281-group
SERPENT 2.1.24	ENDFB/VII.0 continuous
SWAT4	JENDL-4 continuous
MOTIVE 0.4.1	ENDFB/VII.1 continuous
VESTA	JEFF3.2 continuous ENDFB/VII.1 continuous
CASMO4	JEFF2.2
MCNP6	ENDFB/VII.1 continuous
HELIOS 1.11/1.12	ENDFB/VI.0 47-group ENDFB/VII.0 190-group
ALEPH-2.6.3	JEFF3.1.2 continuous

- 25 sets of results from 9 countries and 12 institutions have submitted results
- Draft benchmark report completed by July, 2018

Summary

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- NRC currently engaging in research to further its knowledge of peak reactivity credit and full BWR BUC
- Current results will help develop staff guidance for the allowance of burnup credit for BWR spent fuel in storage casks and transportation packages
- Phase I complete and Phase II in progress, SRP revision on BWR BUC expected in 2019
- NRC involved in international BWR burnup credit research