



Realism and Robustness in Criticality Safety for Spent Nuclear Fuel Transportation: A Regulatory Perspective

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Overview

- Background
 - Regulations, History, Need for Burnup Credit
- Current Staff Guidance
 - ISG 8, Rev. 2 and Industry Standards
- Guidance Revision Considerations
 - Depletion benchmarking, Criticality benchmarking, Burnup Confirmation

Background: Regulations

- Title 10 of the Code of Federal Regulations Part 71, “Packaging and Transportation of Radioactive Material”
 - 71.55(b): subcritical with water leakage into containment system
 - 71.83: values of unknown properties of fissile material contents assumed to be those resulting in maximum reactivity

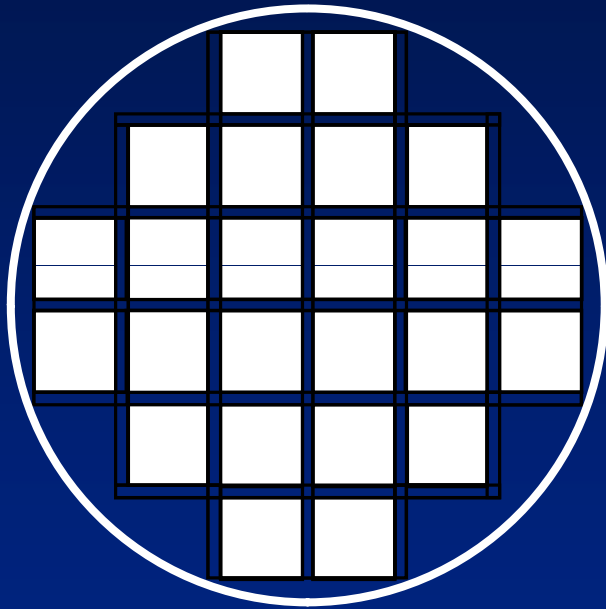




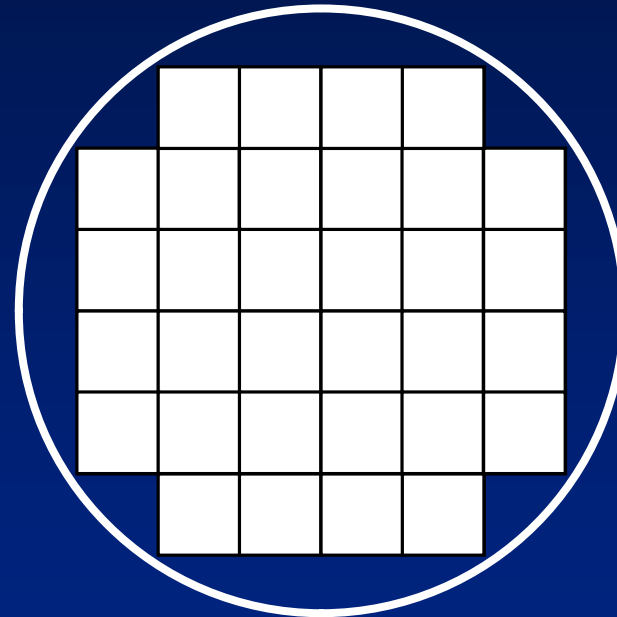
Background: History

- Criticality safety analyses typically have been performed with the conservative assumption that fuel is unburned (fresh fuel).
- Basis of Interim Staff Guidance (ISG-8)
 - Efforts toward the use of more efficient spent fuel transportation packages
 - Credit for the reduction in reactivity that occurs as a result of burnup

Background: Burnup Credit Need



**24-Assembly Basket
without Burnup Credit**



**32-Assembly Basket
with Burnup Credit**



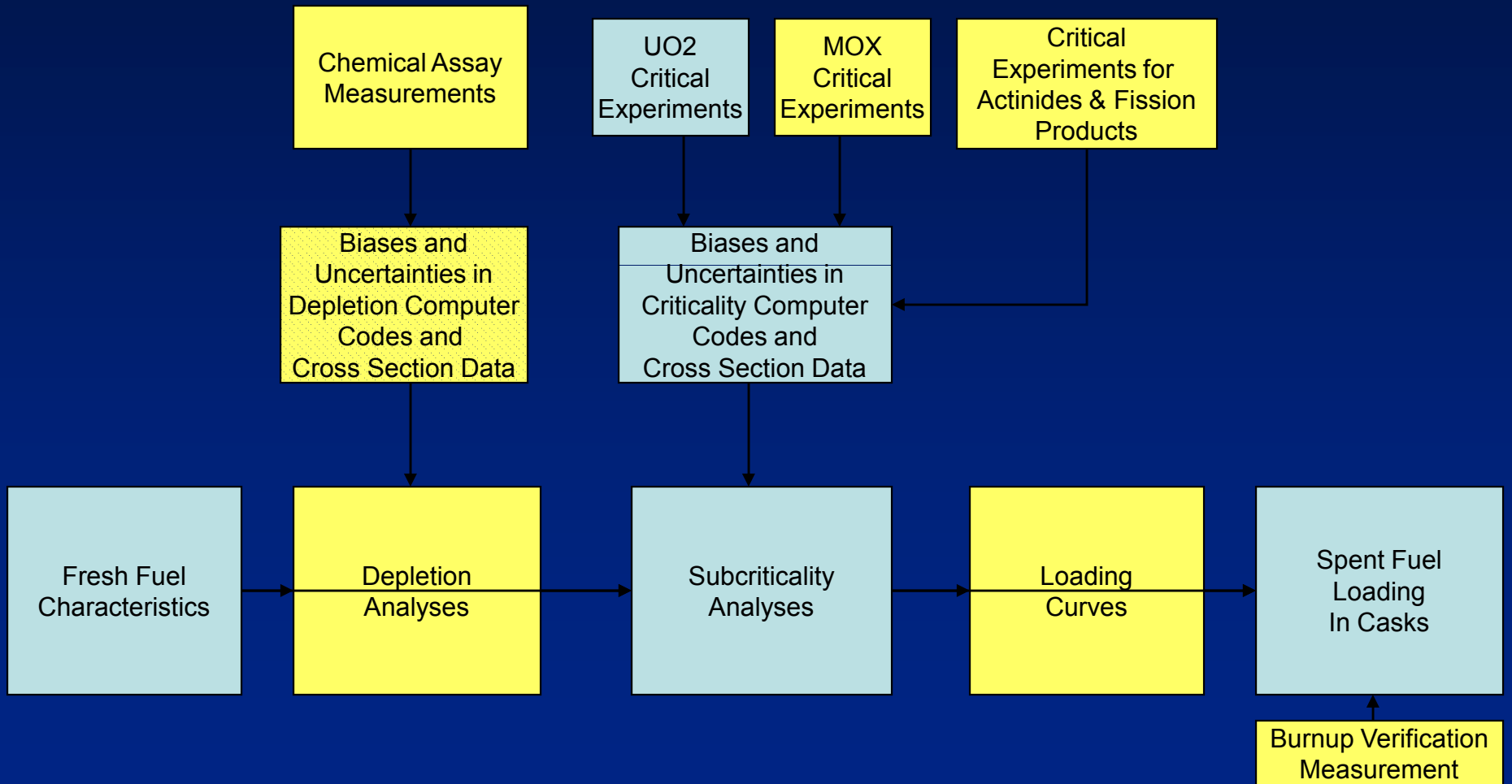
Interim Staff Guidance 8

- “Burnup Credit in the Criticality Safety Analyses of PWR Spent Fuel in Transport and Storage Casks”
- Revision 2 published in 2002
 - (<http://www.nrc.gov/reading-rm/doc-collections/isg/isg-8R2.pdf>)
 - Actinide-only based on available validation data
 - Fission products to provide additional margin
 - Confirmatory burnup measurement consistent with IAEA TS-R-1

Interim Staff Guidance 8 (cont'd)

- Actinides represent roughly 75% of the net reduction in reactivity due to burnup
 - Major actinides: ^{234}U , ^{235}U , ^{238}U , ^{238}Pu , ^{239}Pu , ^{240}Pu , ^{241}Pu , and ^{242}Pu
- Fission products represent the remaining roughly 25% of the net reduction in reactivity
 - Major fission products: ^{149}Sm , ^{143}Nd , ^{103}Rh , ^{151}Sm , ^{133}Cs , and ^{155}Gd

Criticality Safety for Spent Fuel Casks (fresh fuel assumption vs. burnup credit)





Considerations for ISG-8, Revision 3

- NRC is considering revising the acceptance criteria in order to expand burnup credit for transportation packages to include fission products
- Efforts are being examined in the following areas
 - Isotopic benchmarking – new data and computational techniques available
 - Criticality computer code validation
 - Burnup confirmation - potential alternatives to measurement



Considerations for Revision 3 – Isotopic Benchmarking

- Currently reviewing available additional burnup radiochemical assay data for depletion code validation
 - ARIANE and REBUS UOX Fuel Programs
 - Vandellós II Reactor
 - Calvert Cliffs, Takahama, and Three Mile Island Reactors
 - Malibu Program (UO₂ Fuel)



Considerations for Revision 3 – Criticality Computer Code Validation

- NUREG/CR-6979, “Evaluation of the French Haut Taux de Combustion (HTC) Critical Experiment Data”
 - Similar to spent UO₂ fuel in storage and handling operations
 - Adds criticality data to that from existing experiments used for criticality validation
 - Supports the basis for actinide-only burnup credit



Considerations for Revision 3 – Burnup Measurements

- NUREG/CR-6955, “Criticality Analysis of Assembly Misload in a PWR Burnup Credit Cask”
- Draft NUREG on information related to spent fuel burnup confirmation
- NRC Office of Research evaluating misload probability

Considerations for Revision 3 – Burnup Measurements

- Potential for misload analysis in lieu of measurement is being considered
 - Sensitivity of a cask design can be an indicator of how sensitive a system is to a misload
 - Should cover the discharged population
 - Misload analyses performed in lieu of measurement would be expected to be coupled with applicable administrative procedures



Summary

- Burnup credit increasingly sought by industry to maximize the capacity of spent fuel transportation packages
- Burnup credit criticality analysis and validation much more complicated than for fresh fuel assumption
- Crediting fission products can increase the fraction of the discharged fuel population that can be transported in high capacity transportation packages
- NRC working to expand the technical basis for burnup credit to allow some credit for fission products and provide alternatives to confirmatory burnup measurements