REGULATORY PERSPECTIVE ON COMPUTER CODE VALIDATION FOR BURNUP CREDIT CRITICALITY ANALYSES FOR SPENT NUCLEAR FUEL TRANSPORTATION PACKAGES

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Overview

• Background
  – Regulations, History, Need for Burnup Credit

• Current Staff Guidance
  – ISG 8, Rev. 2

• ISG 8 Revision Considerations
  – New data available for depletion code benchmarking
  – New data available for criticality evaluation code benchmarking
  – Sources of critical benchmarks
    • New critical experiments added to the IHECSBE
    • Use of CRC data
    • Use of HTC and fission product data
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 made with the conservative fresh fuel assumption
  - Easy to demonstrate compliance with regulations
  - Severely limit the cask capacity
  - Unnecessarily conservative design

- Basis of Interim Staff Guidance (ISG-8)
  - Reactivity reduction as a result of burnup
Interim Staff Guidance 8

- “Burnup Credit in the Criticality Safety Analyses of PWR Spent Fuel in Transport and Storage Casks”
  - Accept burnup credit for actinides only
  - Code validation data were very limited for both:
    - Isotopic concentration prediction computer code
    - Criticality evaluation computer code

- Revision 2 published in 2002
  - Based on available validation data
  - Fission products as additional margin
Interim Staff Guidance 8 – Revision 2

• Sources of data for isotopic validation
  – Trino Vercellese, Turkey Point, Obrigheim, H.B. Robinson-2, Yankee Rowe, Calvert Cliffs, and Takahama-3

• Sources of data for criticality validation
  – Fresh UO$_2$
  – Fresh MOX
ISG-8, Revision 3

• NRC is considering revising the acceptance criteria for burnup credit to include fission products

• Areas to be examined

  – Isotopic benchmarking – new data and computational techniques available

  – Criticality computer code validation – new critical experiments
Major actinides: $^{235}\text{U}$, $^{238}\text{U}$, $^{238}\text{Pu}$, $^{239}\text{Pu}$, $^{240}\text{Pu}$, $^{241}\text{Pu}$, $^{242}\text{Pu}$, and $^{241}\text{Am}$

- represent roughly 75% of the net reduction in reactivity due to burnup

Major fission products: $^{149}\text{Sm}$, $^{143}\text{Nd}$, $^{103}\text{Rh}$, $^{151}\text{Sm}$, $^{133}\text{Cs}$, and $^{155}\text{Gd}$

- represent roughly the remaining 25% of the net reduction in reactivity

Other minor actinides and fission products
Currently reviewing available additional 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)
- REBUS Program
ISG-8, Rev. 3 – Data Sources for Criticality Computer Code Validation

• French Haut Taux de Combustion (HTC) critical experiment data
• Critical experiments in the IHECSBE
• Commercial Reactor Critical state points
ISG-8, Rev. 3, Criticality Computer Code Validation – HTC Data

  – Similar to spent UO$_2$ fuel in storage and handling operations
  – Adds significant amount of criticality data to existing UO$_2$ and MOX experiments used for burnup credit criticality validation
  – Supports the basis for actinide burnup credit
ISG-8, Rev. 3, Criticality Computer Code Validation - IHECSBE

- Critical experiments in the IHECSBE
  - LEU-COMP-THERM-050, IPSN-SRSC of Valduc CEA (France)
  - LEU-COMP-THERM-079, Sandia National Laboratories
  - LEU-MISC-THERM-005, Tokai Research Establishment of (JAERI)
  - A few other publically available critical experiments (LEU-MISC-THERM-001, 002, and 003, for example)
ISG-8, Rev. 3, Criticality Computer Code Validation – CRC Data

• Use of CRC data
  – Supplement to laboratory critical benchmark experiments
  – Includes all isotopes produced during irradiation
  – EOC criticals are similar to spent fuel casks in terms of isotopic composition
  – CRCs are very different from the casks in terms of temperature, moderator density, poison plates, and soluble boron (BOC and MOC) CRCs
ORNL is developing a new method of propagating nuclear data uncertainties into a $\Delta k_{\text{eff}}$ estimate of bias and uncertainty due to fission product criticality evaluation

Will validate this approach using publicly available fission product critical experiments
Summary

• Burnup credit increasingly sought by industry to maximize the capacity of spent fuel transportation packages

• Code validation is a critical part of burnup credit criticality analyses

• NRC is working to expand the technical basis for accepting burnup credit for fission products

• Newly available radiochemical assay and critical experiment data, as well as new analytical techniques, will be used as part of the technical basis
Thank You