NRC/NEI Meeting on Spent Fuel Storage and Transportation Licensing and Technical Issues

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NRC/NEI Meeting

- **Purpose**
  - To provide an opportunity for communicating Part 71 and 72 licensing and technical issues.
- **Expected Outcome**
  - To reach an understanding of the issues and the process for addressing them.

Issues for Today

- Burnup Credit
  - Part 71/72 vs. Part 50
  - Burnup measurement
- Other Issues for roundtable discussions
  - Damaged fuel (ISG-1)
  - Control of cask licensing basis
  - Risk informing the regulations and review guidance
  - 72.48 guidance and implementation
  - Part 72 licensing and renewal period (SECY-06-152)

Part 71/72 vs. Part 50

- Casks (Part 71/72)
  - Generic analyses
  - Generic in-core depletion parameter values used
  - Analyses must bound all plants and fuel designs
  - Multiple environments – storage, transport, pools
  - Intermittent monitoring of closure system only
  - Stored and transported in open environment
  - Mobile and passive system
- Spent Fuel Pools (Part 50)
  - Plant Specific Analyses
  - Site-specific in-core depletion data available
  - Analyses specific to that plant and associated fuel designs
  - Single environment – spent fuel pools
  - Continuous monitoring of most of the components
  - Maintained in closed, confined, and controlled environment
  - Stationary and active system

Part 71/72 vs. Part 50

- Site-specific vs. generic analyses
  - Under part 50, site-specific fuel depletion history is available for storage racks burnup credit analyses
  - Under Part 71/72, generic fuel depletion analyses are used for generic cask designs
  - Under Part 50, site-specific reactor restarts can be used to confirm or fine-tune the criticality computer code predictions over the years
  - Under Part 71/72, there are no confirmation of predicted k_{eff} for storage or transport casks flooded with fresh water

Part 71/72 vs. 50 (criteria)

Part 71/72

–Actinides reactivity credit

– No Fission product reactivity credit yet

– 75% to 90% credit for fixed neutron absorbers no surveillance program is feasible

➔Fresh water in-leakage under Part 71. Under Part 72, soluble boron in pools can be relied on as a control to maintain subcriticality during fuel loading/unloading

Part 50

– Actinides reactivity credit

– Fission product reactivity credit

–Full credit for fixed neutron absorbers with surveillance program

➔ Soluble boron provides defense-in-depth to prevent criticality

Why the Difference

- Full vs. partial burnup credit
  - Under Part 71/72, K_{eff} for casks with non-site specific spent fuels need to be calculated by quantifying the biases and uncertainties, through applicable benchmarks, with higher accuracy because casks:
    - In an open environment
    - Susceptible to fresh water in-leakage
    - No soluble boron available for defense in-depth

BENCHMARKING

- Determining the Bias and Uncertainty of the Code Calculations for a Specific Application, i.e., Need to establish the systematic error (consistent offset) and bias uncertainty of the code calculations.

BURNUP CALCULATIONS

- Two-Step Process for More Rigorous Benchmarking
- Depletion Codes
  - Isotopic Content
- Criticality Codes
  - Determine k-effective

DEPLETION BENCHMARKS

- Measured Assays
  - Irradiation History
  - Actinides
  - Fission Products

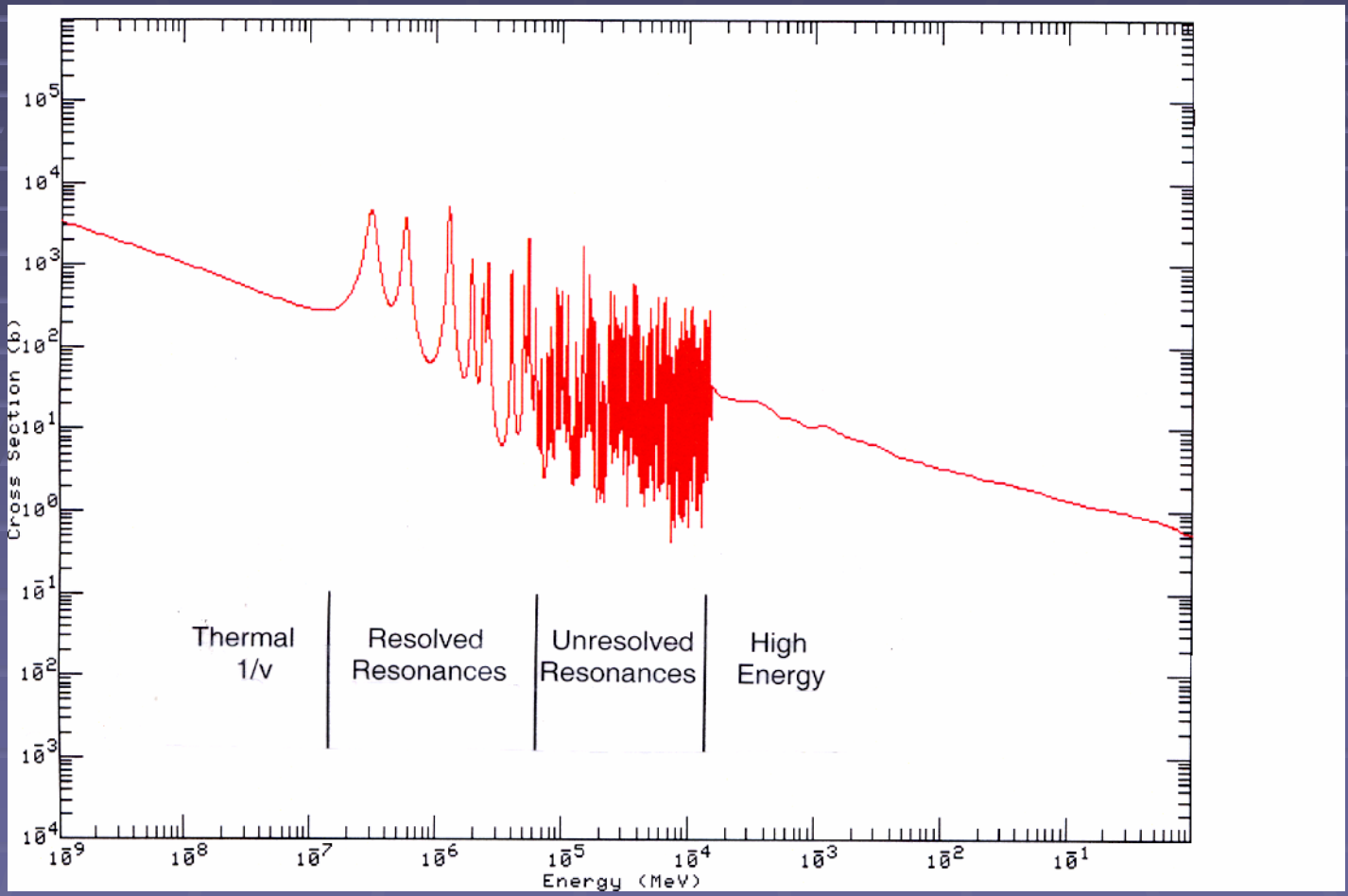
CRITICALITY BENCHMARKS

- Critical Experiments
  - Code Performance
  - Modeling Approach & Code Options
  - Nuclear Cross Section Data

BENCHMARKS MUST REPRESENT THE APPLICATION

- Material Content
  - Fissile Isotopes
  - Absorber Isotopes
  - Moderator
- Geometry/Configuration
  - Spatial Variations
- Neutron Spectrum
  - Test the Proper Cross Section Region

NEUTRON CROSS SECTION DEVELOPMENT (^{241}Am)



123-GROUP LIBRARY PERFORMANCE

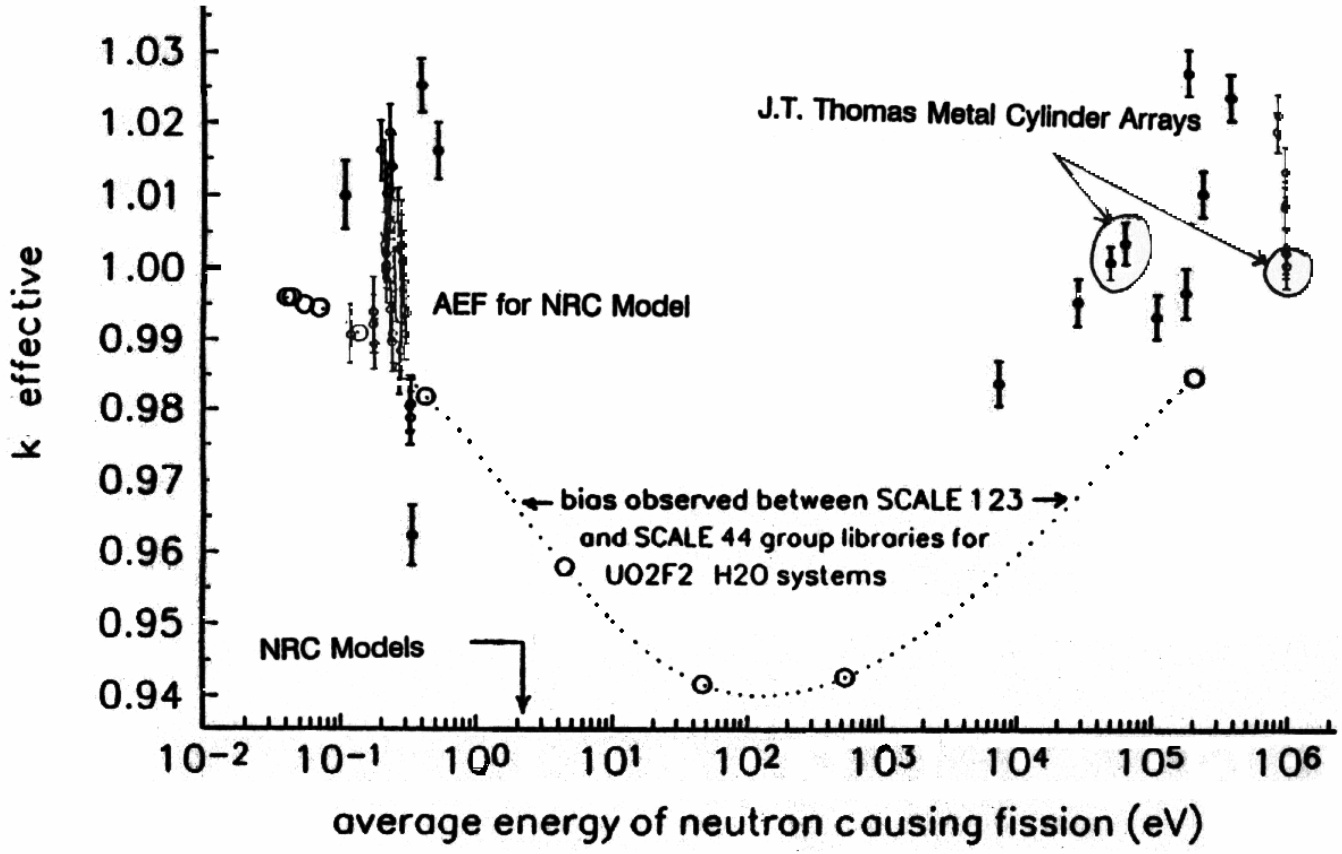


Figure 4 SCALE 123-group validation results for highly enriched uranium cases

CASKS vs. REACTOR CRITICALS (CRCs)

- Temperatures – 275^{o} K vs. 570^{o} K
- Beginning of Cycle – All Fuel is 3rd Cycle vs. 1/3 Fresh, 1/3 One Cycle, 1/3 Two Cycle
- BOC – Boron Concentration is 0 vs. High
- Poison Plates vs. Infinite Lattice (Isotropy)
- Benchmarking Two Step vs. One Step
- Isotopic Content – Long- vs. Short-lived
- Can't Use CRC Alone

CORE PHYSICS CODE LIMITATIONS

- One step benchmarking has limitations
- Can't infer that a good final answer validates all intermediate and input values
- Burnup is a proxy for fuel reactivity

CURRENT AVAILABLE ASSAY DATA

- Actinides
  - Data from 8 Reactors
  - Other
- Fission Products
  - Calvert Cliffs
  - Takahama
  - Other
- TMI

CURRENT AVAILABLE CRITICAL DATA

- Fresh UO_2
- MOX – Pre 1977
- Reactor Startup and Shutdown – CRCs
- Sandia ^{103}Rh
- French ^{149}Sm
- French Actinide – DOE (not yet released)

DATA NEEDED FOR BURNUP CREDIT

- Isotopic Assay Data
  - Fission Products
  - Combined Actinides and Fission Products
- Critical Experiments
  - Fission Products
  - Integrated Isotopes
- Applicability of Benchmarks

FUNDAMENTAL CONSIDERATIONS

- Must Validate the Correct Cross Section Region(s)
- Part 71 Requires Fresh Water Flooding
- Lack of Mitigating/Monitoring Systems
- No Shutdown Mechanism Designed
- Commission Policy of No Inadvertent Criticalities
- NRC Still Endorses Defense in Depth and Safety Margin In Addition to PRA Considerations

Measurements

- Reduce the probability of misloads in casks
  - misloads shown to be credible event
  - potential to reduce probability
  - identify systematic loading errors
- Quantify the uncertainty in reactor burnup records
  - varies from site to site and over time
  - difficult to provide bounding uncertainty for population of fuel assemblies

Measurements

- Relative vs. absolute measurements
- Criticality safety based on measured quantities, not estimates
- Inspection and verification to ensure presence of poisons
- Recommended by RG 3.71 and required by international standards (IAEA TS-R-1)

Fuel Handling

- Misloads in Spent Fuel Pools
  - Easily corrected when discovered
  - High ^{10}B ppm in pool = large margin on k_{eff}
- Misloads in Dry Storage Casks
  - Not easily corrected
  - Large margin on k_{eff} with fresh fuel assumption
  - More likely with more complicated loading patterns

Measurements & Fuel Handling

- Conclusions:
  - Cask misloads are credible and should be considered in BUC analyses
  - Assembly burnup measurements should be performed to confirm assigned burnup loading value and to prevent misloads to the extent possible