



NRC Regulatory Perspective on Criticality Safety in Fissile Material Transportation and Spent Fuel Storage

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American Nuclear Society Winter Meeting
Washington, DC
October 30, 2017



Overview

- Background
- Regulations and Guidance
- Criticality Validation Issues
- Draft Validation Guidance
- Part 71 Rulemaking
- Conclusion

Background

Division of Spent Fuel Management:

- Within the Office of Nuclear Material Safety and Safeguards (NMSS)
- Transportation of Radioactive Material – 10 CFR Part 71
- Storage of Spent Nuclear Fuel – 10 CFR Part 72



Background

Division of Spent Fuel Management

- ~70 staff, including 11 dedicated to shielding and criticality analysis (Criticality, Shielding, and Risk Assessment Branch)
- Handle around 80-100 licensing actions per year
 - General and site-specific Part 72 licenses
 - Type B and AF transportation package designs

Regulations

Transportation:

- §71.55 – single package subcritical
- §71.59 – arrays of packages subcritical; determine Criticality Safety Index for accumulation control

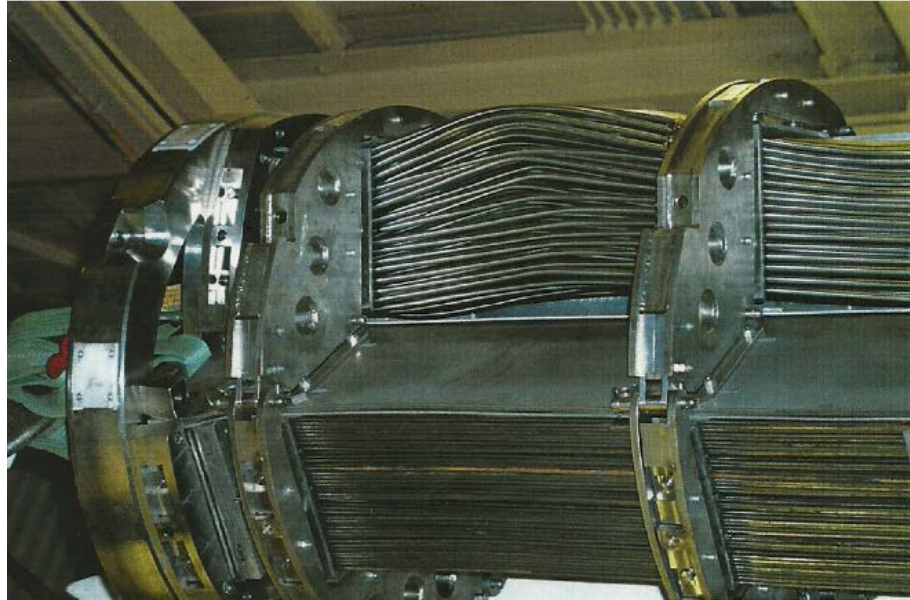
Storage:

- §72.124 – subcritical under normal, off-normal, and hypothetical accident conditions
 - Double contingency
 - Favorable geometry and/or fixed neutron absorbers
 - Criticality monitoring

Guidance

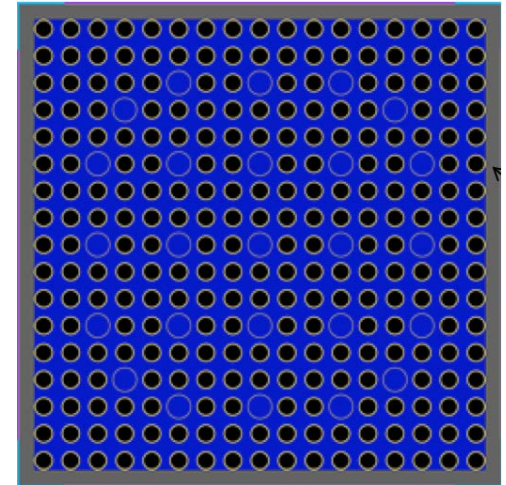
- Standard Review Plans (NUREGs-1536, -1567, -1609, and -1617)
- NUREG/CR-5661, *Recommendations for Preparing the Criticality Safety Evaluation of Transportation Packages*
- NUREG/CR-6361, *Criticality Benchmark Guide for Light Water Reactor Fuel in Transportation and Storage Packages*
- NUREG/CR-6698, *Guide for Validation of Nuclear Criticality Safety Calculational Methodology*
- Burnup Credit:
 - NUREG/CR-7108 – Isotopic depletion
 - NUREG/CR-7109 – Criticality

Fuel Reconfiguration

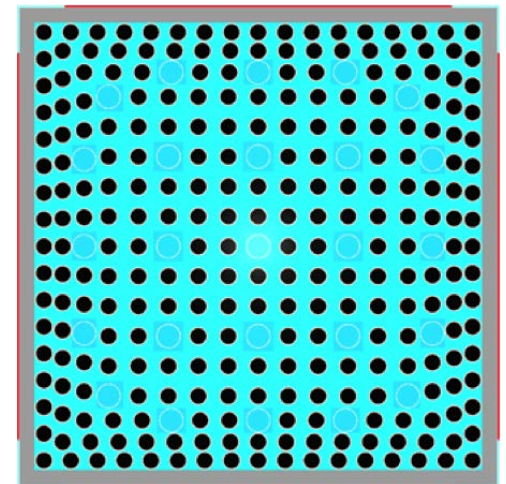


Fresh Fuel Drop Test

NUREG/CR-7203: A Quantitative Impact Assessment of Hypothetical Spent Fuel Reconfiguration in Spent Fuel Storage Casks and Transportation Packages



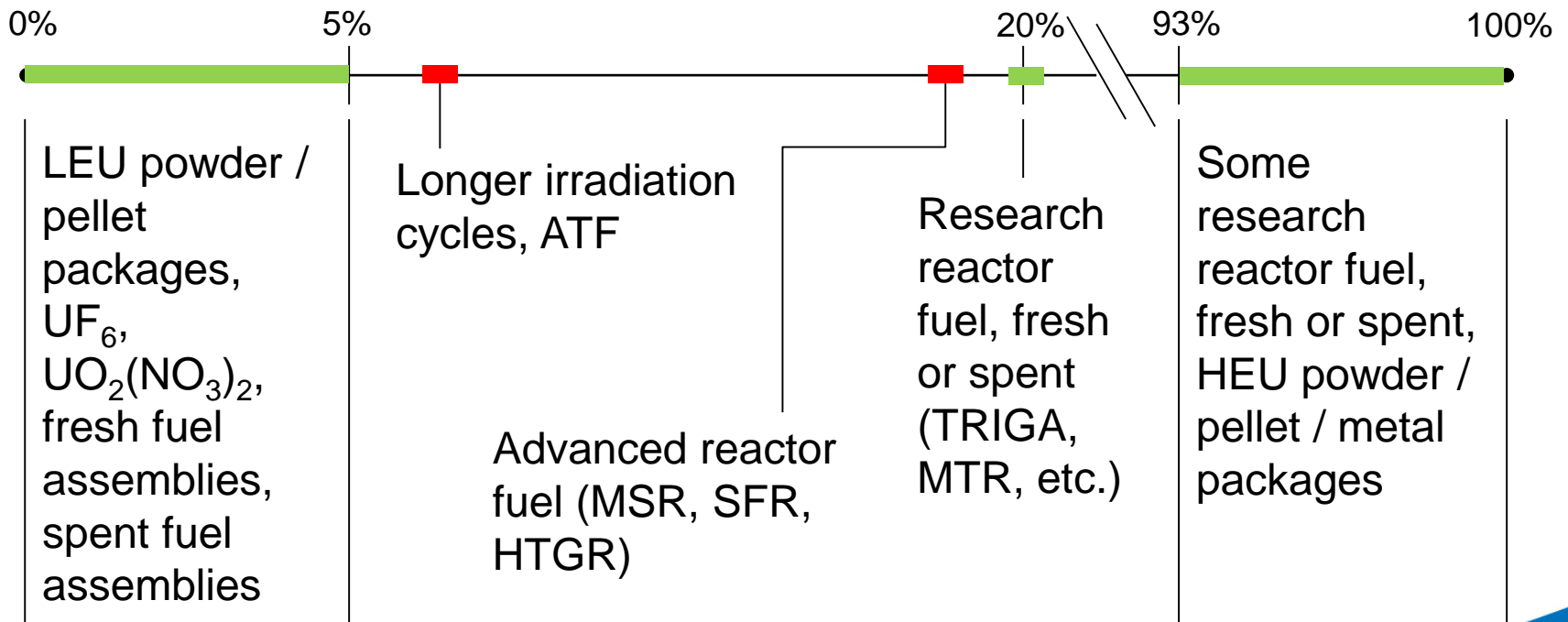
Uniform Pitch Expansion



Non- Uniform Pitch Expansion

>5.0 Weight Percent

Code Validation:

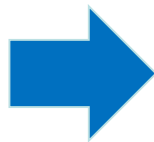
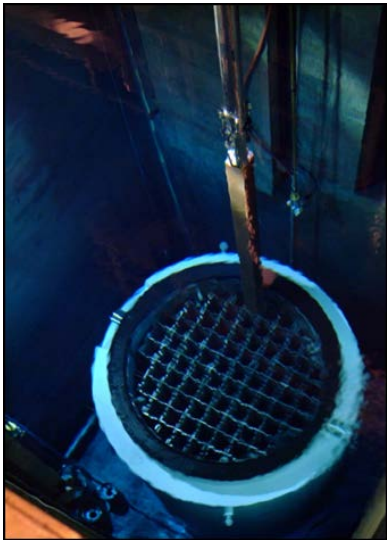


Part 71/72 Interface

High-Capacity PWR Cask Criticality Safety Criteria:

Storage:

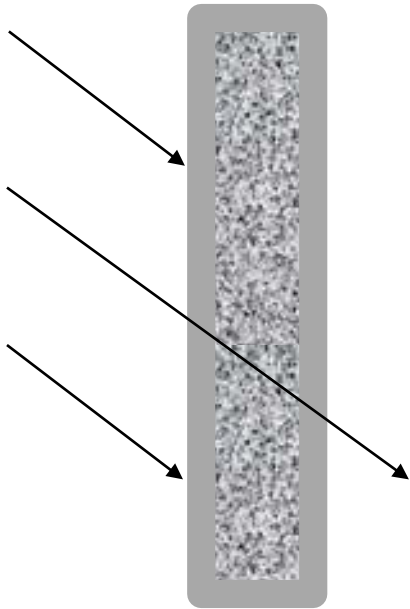
- <5.0% Initial enrichment
- Minimum soluble boron during loading



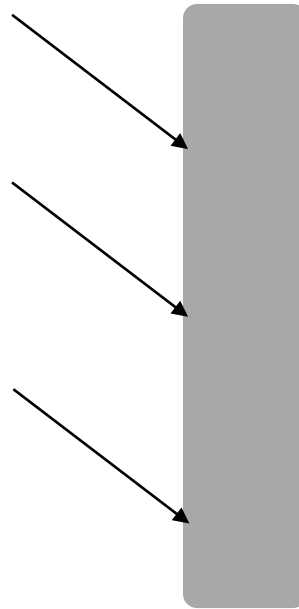
Transportation:

- <5.0% Initial enrichment
- >45 GWd/MTU burnup
- Cooling time
- Limits on irradiation parameters:
 - Soluble boron
 - Specific power
 - Moderator temp.
 - Fuel temp.

Neutron Absorber Credit



75% Credit for large B_4C particle absorber plates, which may have streaming-type effects



90% Credit uniform absorber plates, with comprehensive fabrication testing – 10% retained to cover lack of validation for highly loaded absorbers

NUREG/CR-6845: *Sensitivity Analysis Applied to the Validation of the ^{10}B Capture Reaction in Nuclear Fuel Casks – 2004*

- Used S/U methods to determine applicability of existing ^{10}B experiments to validate highly loaded panels
- Mature codes, new data – re-evaluate?

Draft Validation NUREG/CR



- Consolidate and update previous validation guidance
 - Experiment selection
 - Trending analysis
 - Applicability of validation to safety analysis
 - Extrapolation of bias and uncertainty
 - Identification of validation gaps and weaknesses
 - Documentation
- Provide additional guidance
 - Use of trending analysis results
 - Acceptable confidence levels for normality/trending
 - Handling of validation gaps and weaknesses
 - Use of S/U and other new methods
 - Potential impact of correlated experiments

10 CFR Part 71 Rulemaking

Harmonization with IAEA SSR-6 (2012, 2018) – expected final rule in 2021

- 10 CFR 71.15 – Exemptions from classification as fissile material
- 10 CFR 71.22 and 71.23 – Fissile material general licenses
- Coordinated with DOT
- Issues Paper 11/15/2016: ADAMS ML16299A298

Conclusions

- Number of criticality safety issues in fissile material transportation and storage
- Many of them can be potentially solved or mitigated with new codes, data, and modeling techniques
- New validation guidance forthcoming
- Transportation rulemaking upcoming – looking for stakeholder engagement