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UNITED STATES NUCLEAR REGULATORY COMMISSION

Protecting People and the Environment

Advanced Fuels: Fuel Cycle Licensing

Brian Smith

Deputy Director

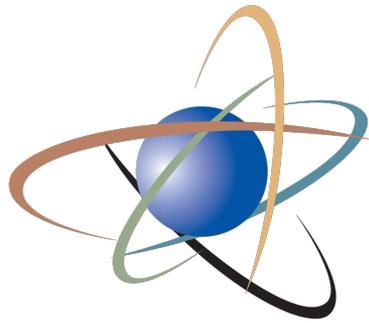
Division of Fuel Cycle Safety, Safeguards, and
Environmental Review

Fuel Enriched to Greater than 5%

- For existing facilities wanting to handle or produce fuel over 5% enrichment
 - Potential change in facility categorization (i.e. Cat. III to Cat. I) resulting in enhanced security and MC&A requirements.
 - Lack of criticality safety benchmarks for use in validation report for determining margin of sub-criticality.
 - Increased margin of safety may be required

Non-UO₂ Fuel

- Example: metal, uranium-silicide, molten salt
- License amendment required (new process)
 - Potential change in facility categorization (i.e Cat. III to Cat. I) resulting in enhanced security and MC&A requirements.



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Transportation of Advanced Reactor Fuels

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Division of Spent Fuel Management

Office of Nuclear Material Safety and Safeguards

U.S. Nuclear Regulatory Commission NRC

June 13, 2017

NRC and Transportation

- NRC co-regulates transportation with the Department of Transportation
- Package performance standards for Type AF and Type B packages are in 10 CFR Part 71

Transportation Packages

- Type B package
 - Greater than a Type A quantity of radioactive material (see 10 CFR Part 71 Table A-1)
 - Enrichments >20 weight percent (w/o) ^{235}U , mass dependent
 - Downblended or reprocessed uranium
 - MOX fuel
- Type A fissile package
 - Less than a Type A quantity
 - Unirradiated uranium fuel with enrichment ≤ 20 w/o ^{235}U has unlimited A_2

Transportation

- Current transportation in NRC-approved packages for front end of fuel cycle
 - UF_6
 - UO_2 pellets and powder
 - Fresh fuel assemblies and loose rods

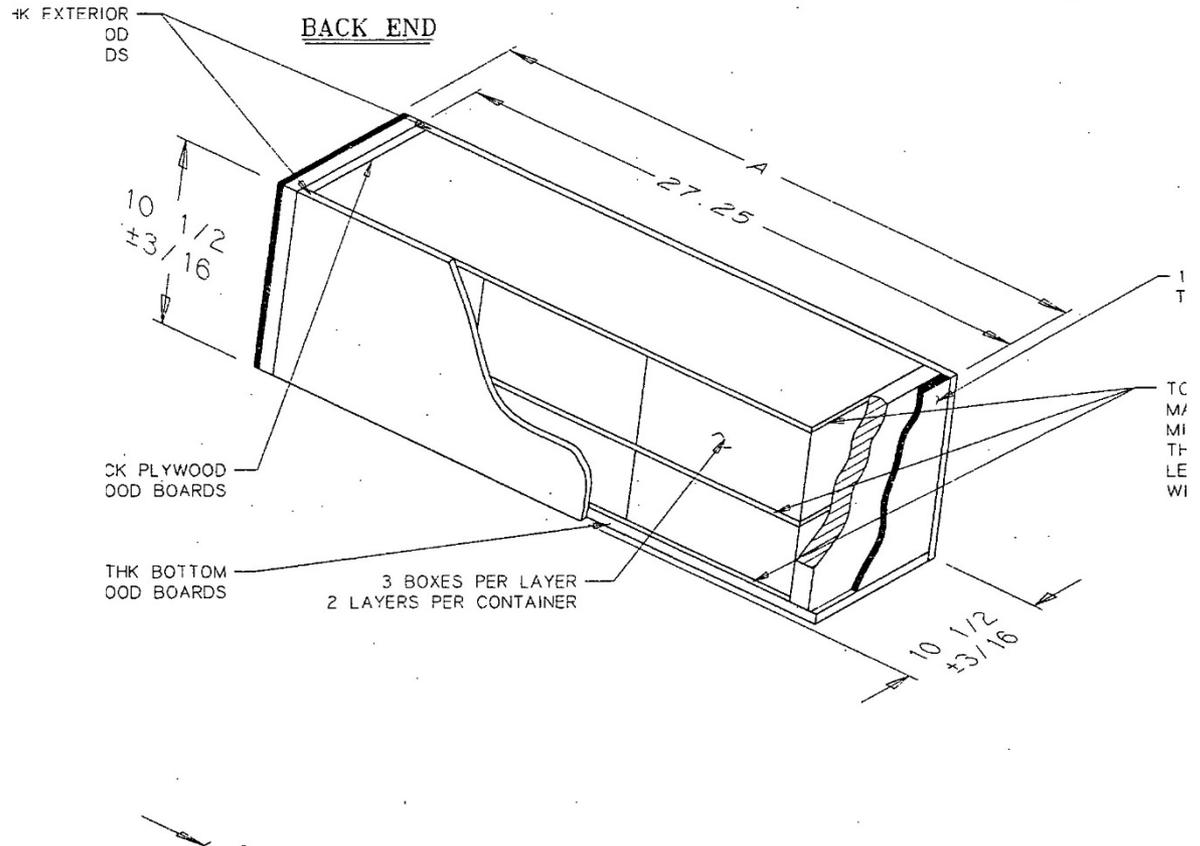
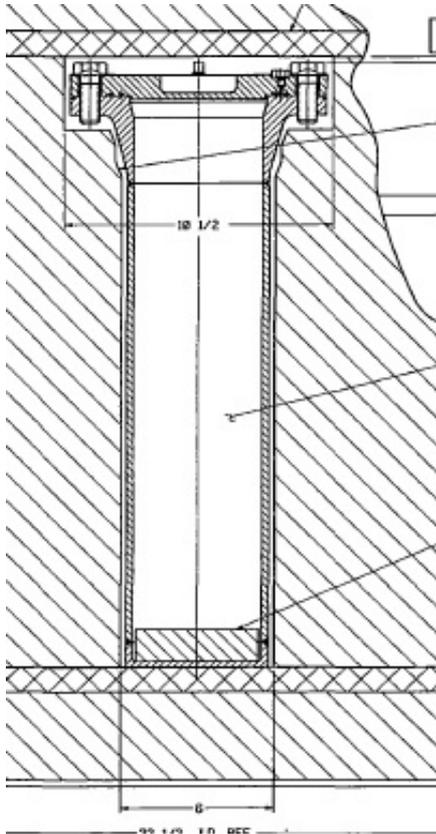
Transportation Tests

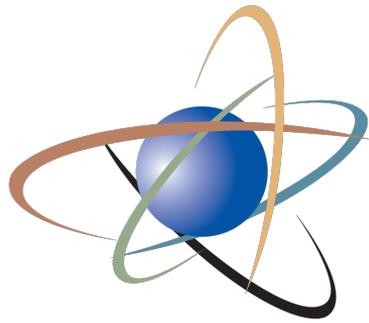
- Normal conditions of transport (10 CFR 71.71)
 - Hot and cold temperatures
 - Reduced and increased external pressure
 - Vibration
 - Water spray
 - Free drop (1 to 4 ft)
 - Corner drop
 - Compression Test
 - Penetration Test
- Hypothetical accident conditions (10 CFR 71.73)
 - 30-foot drop onto unyielding surface
 - 40-inch drop onto a steel puncture pin
 - 30-minute fully engulfing 1475° F fire
 - Immersion Test
 - 50 feet for all packages
 - 3 feet for fissile material packages

Transportation Packages

- Package performance criteria after the tests and conditions for normal conditions of transport and hypothetical accident conditions
 - Criticality safety
 - Single package
 - Array of package
 - Containment – Type B packages only
 - Leakage rate testing for Type B packages (10 CFR 71.51)
 - Shielding
 - Dose rates in 10 CFR 71.47

Enrichment vs Quantity





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Accident Tolerant Fuels: Part 50 LTA Regulatory Pathway

Fuel Cycle Information Exchange

June 13th

Josh Whitman

Reactor Systems Engineer

U.S. Nuclear Regulatory Commission

LTR/LTAs play an important role in seeking NRC approval for new design features by

- 1) demonstrating in-reactor performance,
- 2) providing pool-side, post-irradiated examination (PIE) data collection for in-reactor characterization, and
- 3) providing irradiated material for subsequent hot-cell examination and research.

Existing Regulatory Provisions

- Plant Technical Specification allow for the irradiation of a **limited** number of LTAs in **nonlimiting** core regions

Standard Technical Specifications:

Fuel assemblies shall be limited to those fuel designs that have been analyzed with applicable NRC staff approved codes and methods and shown by tests or analyses to comply with all fuel safety design bases. A limited number of lead test assemblies that have not completed representative testing may be placed in nonlimiting core regions.

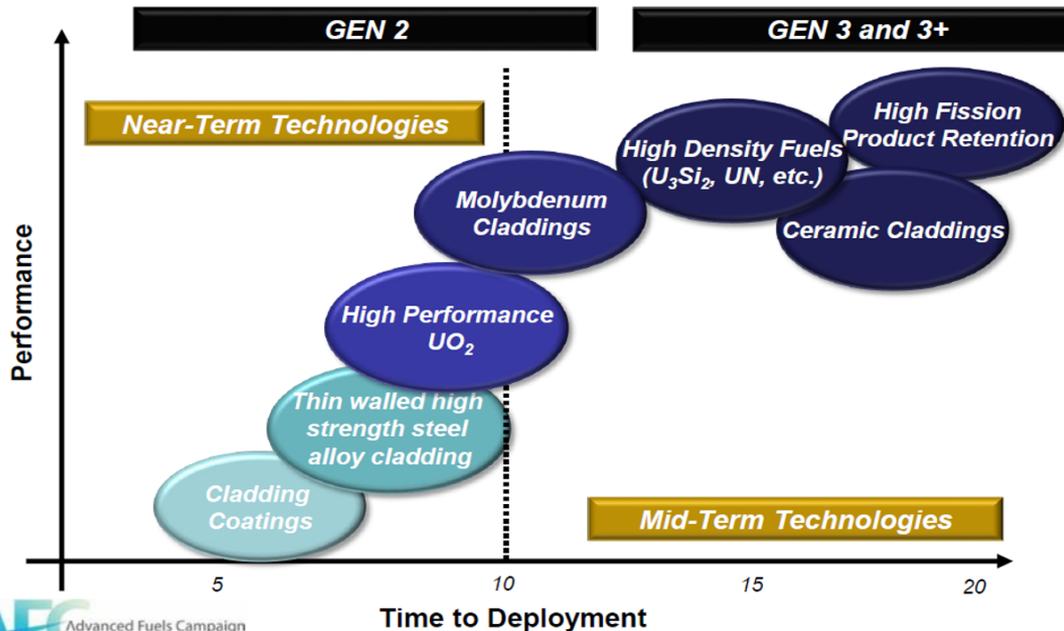
- The number of LTAs considered a reasonable “limited” number would tend to increase with the level of confidence with in-reactor performance
- The level of confidence increases with irradiation experience acquired through test reactors and LTA programs and the characterization of irradiated properties and performance.

Design-Specific Considerations

- Initial confidence level and associated “limited” quantity determination based on design-specific attributes and degree of departure from proven fuel designs



A variety of technologies are under study as possible ATF



Note: Lightbridge fuel design is not within the scope of the DOE EATF Program

§ 50.46/50.46c LTA Exemption

- Applicability of 50.46 limited to UO₂ pellets within cylindrical zircaloy or ZIRLO cladding
 - 50.46 does not provide a means to comply with GDC-35 for any other fuel system combination
- 50.46c recognizes that plant Technical Specifications allow for the irradiation of LTR/LTAs
 - 50.46c provides technology-neutral performance requirements to comply with GDC-35
- An exemption to 50.46/50.46c is not required for LTR/LTAs irradiated under Technical Specification provisions
 - Safety assessment must address GDC-35 via knowledge of fuel performance under LOCA conditions and determination of limited quantity and nonlimiting core location

§ 50.68 LTA Exemption

- An exemption from 50.68 criticality accident requirements may be required for ATF designs with U-235 enrichment above 5.0 wt%

§ 50.68(b) Each licensee shall comply with the following requirements in lieu of maintaining a monitoring system capable of detecting a criticality as described in 10 CFR 70.24:

(7) The maximum nominal U-235 enrichment of the fresh fuel assemblies is limited to five (5.0) percent by weight.