Licensing Considerations for Future Nuclear Fuel Cycles

Dry Cask Storage and Transportation Considerations for New Fuel Designs

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- Early engagement on transportation packages and storage casks
- Transportation to (fresh fuel) and from (spent fuel) the reactor facility
- Storage at Independent Spent Fuel Storage Installation (ISFSI) (post-spent fuel pool)
NRC and Transportation

- NRC co-regulates transportation with the Department of Transportation
- Package performance standards for Type AF and Type B packages are in Title 10 of the *Code of Federal Regulations* (CFR) Part 71
Transportation Packages

• Type A fissile package
  – Less than a Type B quantity (less than $A_2$ value in 10 CFR Part 71 Table A-1)
  – $A_2$ value for Uranium with enrichment ≤20 weight percent $^{235}$U is unlimited (see Table A-1)

• Type B package
  – Greater than $A_2$ value from 10 CFR Part 71 Table A-1
  – Enrichments >20 weight percent $^{235}$U, mass dependent
Transportation Packages

- Current transportation in NRC-approved packages
  - UF$_6$
  - UO$_2$ pellets and powder
  - Fresh fuel assemblies and loose rods
  - Spent fuel
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 test
  – 40-inch puncture test
  – 30 minute fire at 1475 °F
  – Immersion test
Transportation Package Approval Criteria

• Package performance criteria
  – Criticality safety
    • Single package
    • Array of packages
  – Shielding
    • Dose rates in 10 CFR 71.47
  – Containment – Type B packages only
    • Leakage rate testing for Type B packages (10 CFR 71.51)
Spent Fuel Storage

- Post-spent fuel pool storage
- Dry cask storage licenses
  - Specific license
  - General license
- Regulations for storage of spent fuel at an independent spent fuel storage installation are in 10 CFR Part 72
Dry Cask Storage

- Normal conditions of storage
- Off-normal condition
- Accident conditions
- Safety Criteria
  - Confinement
  - Direct radiation dose
  - Criticality safety
Storage Conditions

- Normal Conditions
  - Temperature
  - Solar insolation

- Off-Normal Conditions
  - Extreme Temperatures
  - Partial Vent Blockage

- Accident Conditions
  - Drop
  - Tipover
  - Fire

- Natural Phenomena
  - Earthquake
  - Tornado
  - Flood
**Benchmarking**

> 5.0 Weight Percent

**Code Validation:**

- **0%**: LEU powder / pellet packages, UF₆, UO₂(NO₃)₂, fresh fuel assemblies, spent fuel assemblies
- **5%**: Longer irradiation cycles, ATF
- **20%**: Advanced reactor fuel (MSR, SFR, HTGR)
- **93%**: Research reactor fuel, fresh or spent (TRIGA, MTR, etc.)
- **100%**: Some research reactor fuel, fresh or spent, HEU powder / pellet / metal packages
NRC Review Time for Transport and Storage Applications

• Amendments
  – Fresh fuel transport package – up to 1 year
  – Spent fuel transport package – 1 to 2 years
  – Spent fuel storage cask – 1 to 2 years

• New package designs
  – Fresh fuel transport package – 1 to 1.5 years
  – Spent fuel transport package – 2 years
  – Spent fuel storage cask – 2 years
Summary

• Early engagement on design and certification strategy
• Performance-based regulations are sufficient to certify transportation packages for new fuel designs
• Completed reviews to add three accident tolerant fuel designs as transportation package contents
Abbreviations

• ISFSI - Independent Spent Fuel Storage Installation
• CFR – Code of Federal Regulations
• NRC – Nuclear Regulatory Commission
• LEU/HEU – Low/High Enriched Uranium
• UO$_2$(NO$_3$)$_2$ - Uranyl nitrate
• UF$_6$ – Uranium Hexafluoride
• UO$_2$ – Uranium dioxide
Abbreviations

• MSR – Molten Salt Reactor
• SFR – Sodium Fast Reactor
• HTGR – High-Temperature Gas-Cooled Reactor
• TRIGA – Training, Research, Isotopes, General Atomics
• MTR – Materials Test Reactor
• ATF – Accident Tolerant Fuel
Questions??