Research Reactor Spent Fuel Management

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IAEA Safety Standards Related to Spent Fuel

- Safety of Research Reactors, IAEA Safety Standards, Safety Requirements # NS-R-4, 2005, (Sections 7-65 to 7-70)
- Operation of Spent Fuel Storage Facilities IAEA Safety Guide Safety Series #117, 1994
- Design of Spent Fuel Storage Facilities, IAEA Safety Guides, Safety Series #116, IAEA 1994
- Core Management and Fuel Handling for Research Reactors, IAEA Safety Guide, # NS-G-4.3, 2008

Safety Objectives

- Ensure sub-criticality at all times
- Minimize potential for physical defects/damage and chemical damage to fuel assemblies and cladding
- Ensure adequate heat removal
- Ensure that personnel radiation exposure and fission product release is kept ALARA by minimizing time and dose

Historical Overview

- Spent fuel has been stored under water in most research reactors
- Some dry storage systems are in use

Historical Overview (continued)

- Majority of MS are not reprocessing spent fuel
- Many MS have returned the spent fuel back to the country of origin after conversion of their research reactors from HEU to LEU
- Storage durations are frequently much longer than originally anticipated

Potential Destinations

- Interim wet storage (in reactor pool or in dedicated pool)
- Interim dry storage (in Country)
- Reprocessing
- Shipment back to country of origin
- Final long term dry storage

Petten HFR spent fuel example

- First critical: 1961
- Over past 8 years about:
  ~600 plate fuel elements placed in dry storage in Holland (interim transport containers)
- ~500 elements shipped back to the Country of Origin (US)

Requirements for Operation, Inspection and Handling

Limiting Conditions for Operation:

- **Subcriticality**
  - maximum allowable enrichment
  - minimum allowable concentration of neutron poisons
  - restrictions on movement and storage configuration
  - restrictions of moderator
  - fuel assembly characteristics

Requirements for Operation, Inspection and Handling (continued)

Limiting Conditions for Operation:

- Radiation

- Maximum allowable fuel burn up
- Minimum allowable storage pool water level
- Maximum activity concentrations in pool water
- Requirements for storage area radiation monitors and alarms
- Maximum radiation fields at shipping/transfer cask/flask surface

Requirements for Operation, Inspection and Handling (continued)

Limiting Conditions for Operation:

- **Heat Removal**

- maximum and minimum water temperature, with cooling system availability if necessary
- assume minimum decay time after discharge from reactor
- maximum shipping/transfer cask/flask surface temperature

Requirements for Operation, Inspection and Handling (continued)

Storage pool water chemistry specifications needed to:

- prevent fuel corrosion
- prevent microbiological growth
- ensure water clarity is adequate to allow visual inspection of fuel assemblies

Requirements for Operation, Inspection and Handling (continued)

Chemical parameters for periodic sampling and/or on-line monitoring of storage pool water:

- pH
- conductivity
- halogen ions
- turbidity
- organics
- boron concentration limits if dissolved poison is used (to prevent precipitation at a low temperature)

Requirements for Operation, Inspection and Handling (continued)

Operational Alarms:

- Unauthorized access
- Pool water level: high and low
- Pool water temperature: high and low (for poisons)
- Purification system loss of flow
- Area radiation monitors
- Loss of room ventilation flow

Requirements for Operation, Inspection and Handling (continued)

Corrective actions for damaged fuel:

- Establish activity levels to initiate investigative action for suspected fuel damage
- Inspection activities to identify damaged fuel assemblies
- Remedial actions (encapsulation/canning)
- Implement lessons learned

Requirements for Operation, Inspection and Handling (continued)

Inspection activities for storage pool:

- Suspected damaged fuel should be assumed to be damaged unless confirmed by inspection and activity release checks
- Fuel storage rack clearances should be checked for adequacy (distortion and or corrosion) to prevent jamming of assemblies
- Distortion, swelling or bowing of fuel assemblies should be checked before insertion into fuel racks

Requirements for Operation, Inspection and Handling (continued)

Inspection/monitoring activities for storage pool:

- Periodic check on leak integrity of pool liner or pool walls (if concrete)
- Storage pool water make up rate should be carefully monitored to identify any chronic leakage
- Makeup water quality (for leakage and /or evaporation) shall be specified

Requirements for Operation, Inspection and Handling (continued)

Inspection/monitoring activities for pool storage building:

- Fuel handling tools facilities should be maintained for normal transfer operations
- Pool building services should be continually available, particularly if the reactor is in long term shutdown status (electrical, compressed air, purification, heating, lighting, ventilation, air conditioning, drainage, remote and local monitoring and alarms)

Requirements for Operation, Inspection and Handling (continued)

Spent Fuel Handling:

- All standard movement, handling, storage and inspection of spent fuel should use approved procedures and qualified/tested equipment
- Procedures (and tools) should be available for potential anticipated operational occurrences and accidents with handling and storage of fuel (criticality accident, dropped fuel, internal floods)
- Handling and storage area for spent fuel should be secured against unauthorized access and unauthorized removal

Requirements for Operation, Inspection and Handling (continued)

Spent Fuel Handling:

- Tools to allow dropped assemblies to be retrieved should be available
- Neutron absorbers may be required for the storage (absorber plates/soluble absorbers)
- Procedures to monitor/inspect integrity of absorbers are important

Requirements for Operation, Inspection and Handling (continued)

Spent Fuel Handling:

- Crane or other operations over pool storage should be prohibited unless specifically authorized
- Lifting restricted to a minimum height for safety
- Check that all lifting devices are maintained for operation
- Communication with outside building should be available.

Requirements for Operation, Inspection and Handling (continued)

Spent Fuel Handling:

- Access to normally unused pool area should always utilize the ‘buddy’ principle
- Housekeeping should ensure that minimal amount of loose objects and material is stored in the pool area
- Contingency plan for secondary encapsulating cans, in event of damaged fuel elements

Preparation of Spent Fuel for Shipment

- Management system in place for preparation of shipment of fuel assemblies

  (licensed transport cask available, loading and handling procedures, time schedule for handling and transport, shipping license requirements)

- Fuel removed only with authorization, identifying assembly, irradiation history, destination, and subsequent controls during/after shipment

Preparation of Spent Fuel for Shipment

- Confirm that existing building facilities will be adequate for shipping process:
  - shipping door size,
  - vehicle entry,
  - crane lifting height
  - crane load lift capability
  - shipping cask/flask manoeuvrability

Preparation of Spent Fuel for Shipment (continued)

- A non-active trial and a training exercise should be conducted for the overall shipping process if this is new or has not been performed for many years

- All casks previously used should always be checked for contamination, radiation fields and content upon arrival at site

Conclusion

- Final destination of spent fuel should be clearly defined
- Storing spent fuel for long period after the final shutdown of a research reactor presents heavy operational constraints.
- Shipping back the spent fuel to the country of origin is an adequate and recommended solution adopted in many Member States.