Advanced Fuel Cycle Waste Management Considerations

December 4, 2020

Stuart T Arm, PhD
Senior Technical Advisor, Radiochemical Flowsheets
The Paradigm Delta

• Advanced fuel cycles are fundamentally different from today’s paradigm
  ▪ Calls for new ways to think about waste management
    ✓ Holistically think about processing, packaging, transportation, interim storage and disposal

• Molten Salt Reactors are the extreme example:
  ▪ Liquid versus traditional solid fuel
    ✓ Online fuel processing for neutronics management
    ✓ Noble gas and solids management
    ✓ Requires processing for stabilization
  ▪ Allow for accumulation of fission products
    ✓ Reactor components likely need replacement before fuel
  ▪ Low pressure with concomitant design differences to solid-fueled reactors
    ✓ Higher radiation fields

• Generally, advanced fuel cycles are characterized by higher burnup with concomitant higher fission product and actinide inventories
Waste Processing & Form

• Many options for waste processing and waste forms. How do we judge them?

• Criteria used to evaluate waste forms for defense HLW in 1979/80:
  
  ▪ Waste form performance
    ✓ Potential for minimizing leachability
    ✓ Suitability for prediction of long-term behavior
    ✓ Sensitivity of properties to radiation
    ✓ Sensitivity to thermal and mechanical history
    ✓ Potential for favorable geologic interactions
    ✓ Thermal conductivity
  
  ▪ Waste processing
    ✓ Potential for achieving a uniform product
    ✓ Potential for quality assurance for licensing and regulation
    ✓ Sensitivity to waste composition
  
  ▪ Technical maturity
    ✓ Not a formal criterion but influenced final selection for borosilicate glass
Waste Processing & Form

• Augment criteria with 40 years experience related to:
  ▪ Containment and confinement
  ▪ Criticality control for storage, transportation, and disposal
  ▪ Chemical and physical durability
  ▪ Thermal considerations
Waste Management R&D Strategy

• Adapt to current waste management infrastructure for easier implementation of advanced fuel cycles?
• Or challenge it to change to maximize benefit of advanced fuel cycles?
• Holistically consider:
  ▪ Processing
  ▪ Form
  ▪ Packaging
  ▪ Transportation
  ▪ Interim storage
  ▪ Disposal engineering
Potential Target Areas for Future MSR Waste Management R&D

• Reactor operations:
  ▪ Neutron moderator(s) tolerant to radiation and high temperatures (alternative to graphite) for application in variable spectrum MSRs
  ▪ New concepts for remote, long-handled tooling and radiation-resistant electronics
  ▪ Integrated capture and storage of fission product noble gases (e.g., radiation-tolerant sorbents)

• Waste processing:
  ▪ Salt dehalogenation processes
  ▪ Integration of lithium-7 and chlorine-37 recovery and recycle into waste processing approaches

• Waste forms
  ▪ Phosphate and silicate waste form evaluations for dehalogenated salt streams

• Fuel
  ▪ Strategies for chlorine-37 isotopic enrichment
Discussion
Advanced Fuel Cycle Waste Management Considerations

December 4, 2020

Stuart T Arm, PhD
Senior Technical Advisor, Radiochemical Flowsheets