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Radionuclide Release in Performance Assessment Under Future Waste Management Scenarios

David Pickett[1] and Tae Ahn[2]

[1]Center for Nuclear Waste Regulatory Analyses (CNWRA®)
Southwest Research Institute®
San Antonio, Texas, U.S.A.
[2]U.S. Nuclear Regulatory Commission (NRC), Office of Nuclear Material Safety and Safeguards, Division of High-Level Waste Repository Safety
Washington, DC, U.S.A.

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Outline

- Introduction
- Waste Forms
- Inventories
- In-Package Environment
- Discussion
- Conclusions

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Introduction

- As part of an effort to create a more efficient regulatory structure for the backend of the nuclear fuel cycle, NRC is identifying regulatory and technical issues relevant to potential alternatives for the disposal of the nation's high-level nuclear waste (HLW) and spent nuclear fuel (SNF)
- These efforts are in response to potential policy changes in the ultimate disposition of SNF and HLW
- One of the technical issues being currently reviewed in this context: waste form degradation and radionuclide release

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Radionuclide Release

- Radionuclide release abstraction is a key component of performance assessment for deep geologic nuclear waste disposal
- Future directions in nuclear power generation and SNF and HLW management in the United States may necessitate evaluating release from waste packages of different designs, containing a wider variety of waste forms, than have been previously considered

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Radionuclide Release

Important release-relevant waste characteristics potentially affected by changes in HLW and SNF management include

- Physical or chemical material properties of waste form, waste package, and waste package internals
- Secondary features such as fractures
- Cladding protection
- Reduction/oxidation state of groundwater, including radiolysis
- Formation of gaseous radionuclides

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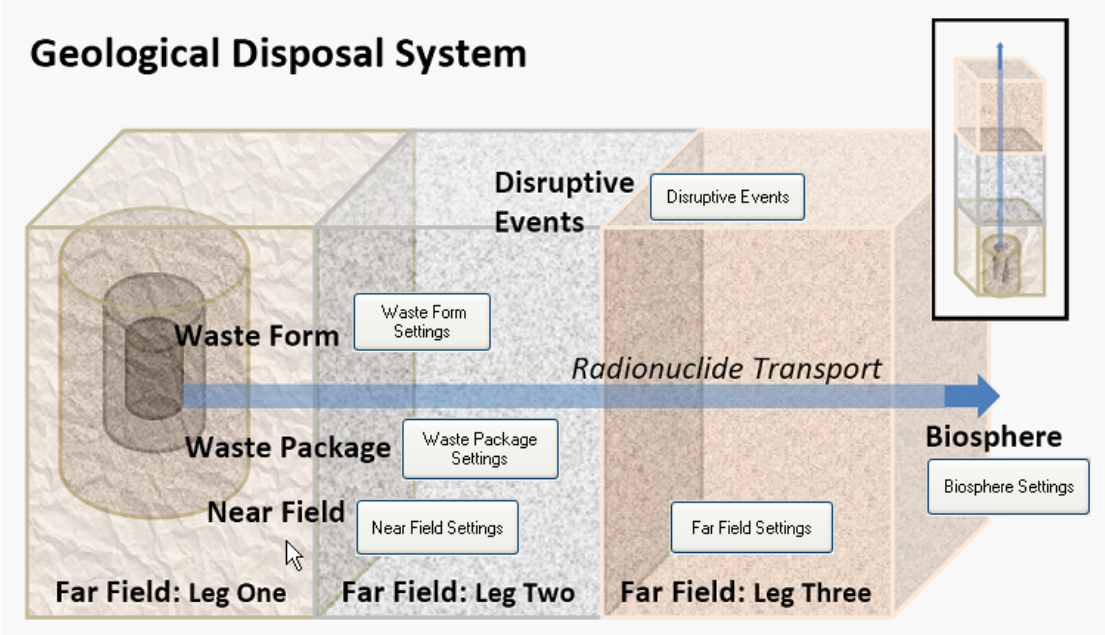
β-SOAR

- NRC/CNWRA generic performance assessment model β-SOAR
- Waste form component (includes radionuclide release) discussed by T. Ahn in this conference



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Waste Form Types

- β-SOAR generic model considers
  - SNF (commercial and mixed oxide)
  - HLW glass from reprocessing
  - User-defined HLW
- Future additional types?
  - DOE SNFs
  - Higher burnup SNF
  - Higher load HLW glass
  - Ceramic
  - Metallic

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Waste Form Types: Factors Affecting Release

- Burnup effects on SNF condition
- Radionuclide loading effects on HLW glass condition and inventory
- Ceramic and metallic waste forms
  - Redox sensitivity?
  - Radionuclide loading

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Inventories

- Extended storage — decay
- Burnup
- Reprocessing
  - Radionuclide mix
  - Loading in waste
- Release characteristics of different fractions
  - Grain boundary
  - Fuel-cladding gap
  - Matrix

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In-Package Environment

- Aqueous chemical characteristics dependent on degradation of waste forms and other materials (e.g., inner container, criticality control, spacers)
  - pH
  - Oxidation-reduction potential
  - Ionic strength
  - Major ions
- Heat generation and radiolysis
- Water pathways
- Sorptive surfaces
  - Mineralogy
  - Surface area

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In-Package Environment

- Qualitative ranking of material effects on in-package environment, most to least
  - Cementitious
  - Carbon steel
  - SNF
  - Stainless steel, metallic reprocessing waste
  - Glass or ceramic reprocessing waste
  - Copper, titanium, aluminum alloys, Zircaloy
  - Highly corrosion-resistant alloys
- Conversely, more reactive material will have shorter term effects

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Other Factors

- Extended storage effects on SNF
- Transportation (e.g., cladding)
- Temperature (extended storage, burnup)
- Waste package lifetime and extent of damage

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Performance Assessment Implications

- Congruent release?
- Instantaneous or rapid release fractions
- Solubility-limited versus degradation-limited release
- Cladding protection
- Waste form dissolution kinetics
- Radiolysis
- Aqueous buffering by, and reactions among, waste form and in-package components
- In-package transport pathways
- Transport pathway through failed waste package

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Conclusions

In developing methods for simulating and evaluating radionuclide release from potential HLW and SNF disposal facilities, it is important for implementers and regulators to consider how radionuclide releases might be affected by potential differences in

- Waste management practices
- Waste forms
- Waste package materials and designs, and
- In-package environments

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