Abstract for submission to the subject category on Engineered Systems at the 13th International High-level Radioactive Waste Management Conference (IHLRWMC): Albuquerque, New Mexico, USA, April 10-14, 2011

Model Abstraction of Waste Form Degradation in Alternative Disposal Site

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Abstract

Recently, the U.S. Nuclear Regulatory Commission (NRC) has been developing a computer model, *beta-Scoping of Options and Analyzing Risk* (β-SOAR) model. β-SOAR is designed to provide the NRC staff timely risk and performance insights for a variety of potential high-level radioactive waste (HLW) disposal options. The source term of β-SOAR is developed primarily based on the type of waste form, important radionuclides, initial radionuclide inventory, and degradation rate of various waste forms. This paper describes how the relevant complex process models related to source term are abstracted for the simple model for system implementation. The abstracted simple model was exercised with β-SOAR to check its reasonableness with respect to the characteristics of waste form and disposal environments.

The waste forms considered are commercial spent nuclear fuel (SNF), spent mixed oxide fuel (sMOX), and vitrified HLW glass. This choice considered the option of SNF reprocessing. Important radionuclides considered in the model were based on literature information on (i) performance assessments of various candidate disposal systems in the world, (ii) difference in the inventory of SNF and waste from recycled SNF, (iii) various burnup, or (iv) waste loading. The radionuclide inventory considered includes fission and activation products, and actinides. Radionuclides are assumed to be uniformly distributed in atomic form in the matrix of all waste forms. Some fractions of radionuclides are segregated in the gap (between waste form and cladding) and grain boundaries of commercial SNF and sMOX. The degradation rate of radionuclides in the matrix is determined by the matrix dissolution rate. It is assumed that all waste forms dissolve at relatively slow rate in the reducing aqueous environment that is assumed to form by the time the waste package fails. The assessment of dissolution rate in the initially oxidizing aqueous environment or long-term radiolysis effects were also considered. Segregated radionuclides, mainly fission and activation products, are assumed to be released instantaneously. There are a number of flexibilities that can be approximated in the model, including the relative amounts of various waste forms, waste loading, cladding protection, and radiolysis effects.

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Fifteen radionuclides were considered in the model. They are Pu-238, 239, 240, 241, U-232, 233, 234, 235, 236, 238, Np-237, C-14, Cs-135, I-129, Tc-99. Preliminary β-SOAR exercise outputs indicate that the major dose contributors in the reducing aqueous environments are fission and activation products (i.e., I-129, Cs-135, and C-14). The obtained dose from the exercise is in the same range of those from the literature data under similar conditions of the environment and waste form. In the reducing aqueous environment, the actinides (e.g., Pu, U, or Np) solubilities are assumed to be very low, and the release of fission and activation product is controlled by the slow degradation rates of waste form. Ceramic and metallic waste forms are assumed to behavior similar to HLW glass.