

REQUEST FOR ADDITIONAL INFORMATION (RAI)
Volume 3—Postclosure Chapter 2.2.1.3.4—Radionuclide Release Rates and Solubility
Limits—4th Set (RAIs 1 through 3)
(DEPARTMENT OF ENERGY’S SAFETY ANALYSIS REPORT Section 2.3.7)

RAI #1

Explain why the igneous scenario TSPA model does not consider potential generation of greater quantities of waste form colloids in the igneous intrusive case, relative to the nominal case.

Basis: The response to RAI 3.2.2.1.3.4-1-002 and RAI 3.2.2.1.3.4-1-002 Supplemental Question explains that the igneous intrusive modeling case generally has generation of greater quantities of colloids than the nominal case because the igneous intrusion modeling case results in a higher rate of advection. The higher water volume from the higher rate of advection gives greater quantities of colloids at fixed concentrations in the aqueous phase.

Colloids could form in greater quantities for other reasons; for example:

1. Large settled particles of oxidized commercial and DOE spent nuclear fuels with a large total surface area could form, as summarized in the RAI responses. These oxidized particles could continue to dissolve (NRC 2008, page 8) at high rates in later seepage water due to their high total surface area. This further dissolution of oxidized spent fuel could result in the faster formation of stable phases such as schoepite in precipitates or colloids.
2. HLW glass could become altered by hydration in the early humid environments. The hydrated alteration layer will remain on the glass surface until contacted and transported by later seepage water [after BSC, 2004, p. 6-30]. This fast dissolution and transport of the alteration layer may result in the faster formation of stable crystalline phases such as smectite in precipitates or colloids.
3. There are considerable uncertainties in the interaction of waste form and dike, including chemical reactions of waste form with metals and basalt magma (SNL, 2007, 6.4.8.3.3). It is not clear how these interactions, and their likelihood, might affect colloid generation and colloid mass concentrations. The interacted phases may further dissolve and become more stable phases in precipitates or colloids.

Lastly, it is unclear how the colloid release model was stochastically treated in terms of the igneous event probability in the igneous scenario TSPA model.

References:

BSC. 2004. “Defense HLW Glass Degradation Model.” ANL-EBS-MD-000016 REV 02. Las Vegas, Nevada: Bechtel SAIC Company

SNL. 2007. “Dike/Drift Interactions.” MDL-MGR-GS-000005 REV 02 ERD 1. Las Vegas, Nevada: Sandia National Laboratories

U.S. Nuclear Regulatory Commission. 2008. "Dissolution Kinetics of Commercial Spent Nuclear Fuels in the Potential Yucca Mountain Environment." NUREG-1914. Washington, DC: U.S. Nuclear Regulatory Commission.

RAI #2

Explain the basis for the range of stainless steel corrosion rates used to calculate corrosion product formation in the corrosion product domain (SNL, 2007) and why this range does not lead to underestimated advective releases. Explain why the minimum and mean values of the lognormal distribution are reasonable during the performance assessment period.

Basis: The stainless steel corrosion rate is used in the EBS radionuclide transport abstraction to calculate the formation rate of corrosion products in the corrosion product domain. Greater accumulation of these corrosion products results in greater radionuclide sorption and pH buffering capacity; the limited pH range, in turn, affects radionuclide solubilities and colloid stability. (A different range of stainless steel corrosion rates is used in the in-package chemistry abstraction; this RAI does not address that particular range.)

For the stainless steel corrosion rate, DOE adopted a lognormal distribution ranging from 0.01 to 0.51 $\mu\text{m}/\text{yr}$ for this rate (SNL, 2007, page 6-94). The minimum value was based on the mean Alloy 22 corrosion rate and is higher than the lowest measured rates for stainless steel compiled by DOE (Aqueous Corrosion Rate AMR); this compilation reports values as low as 0.0007 $\mu\text{m}/\text{yr}$ for 316L stainless steel in freshwater at 29.5°C. DOE acknowledged the possibility that they could be overestimating rates (and, therefore, corrosion product mass accumulation rates) for long time periods, during which corrosion rates could decrease, but concluded that the resulting higher modeled diffusive release rates would "tend to offset the overestimated retardation of radionuclides by sorption onto corrosion products. Thus, diffusive releases of radionuclides are not necessarily underestimated if corrosion rates are overestimated" (SNL, 2007, page 6-94). It is not clear if this reasoning would apply also to conditions, such as in the igneous intrusion case and during general corrosion, under which advective releases far exceed diffusive releases. Staff needs to understand DOE's justification, under advective conditions, for adopting minimum and mean stainless steel corrosion rates that may overestimate the time-dependent availability of corrosion products in the corrosion product domain.

Reference:

SNL. 2007. "EBS Radionuclide Transport Abstraction." ANL-WIS-PA-000001. Rev. 03. ERD 01. Las Vegas, Nevada: Sandia National Laboratories.

RAI #3

Clarify the technical basis for imposing the pH buffering capacity of corrosion products as soon as a waste package is breached.

Basis: The pH in the corrosion product domain is modeled on the basis of control by surface complexation reactions on steel corrosion products. Because stainless steel corrosion rates are relatively slow, it is possible that there could be a substantial period of time after waste package breach before corrosion products have accumulated sufficiently to control pH. Staff needs to understand whether DOE could be overestimating the pH buffering capacity of corrosion products during the stainless steel corrosion period.