A Compartment Model for Nuclide Release Calculation in the Near– and Far–field of a HLW Repository

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1. Introduction

The HLW–relevant R&D program for disposal of high–level radioactive waste has been carried out at Korea Atomic Energy Research Institute (KAERI) since early 1997, from which a conceptual *Korea Reference Repository System* for direct disposal of nuclear spent fuel is to be introduced by the end of 2007. Apreliminary reference geologic repository concept considering such established criteria and requirements as spent fuel and generic site characteristics in Korea was roughly envisaged in 2003 (Kang et al., 2002). According to above basic repository concept, which is much similar to that of Swedish KBS–3 repository, nuclide release from the near–field system has been investigated through the previous study by calculating some possible nuclide fluxes through several possible conduits as shown in Fig. 1 (Lee et al., 2004).

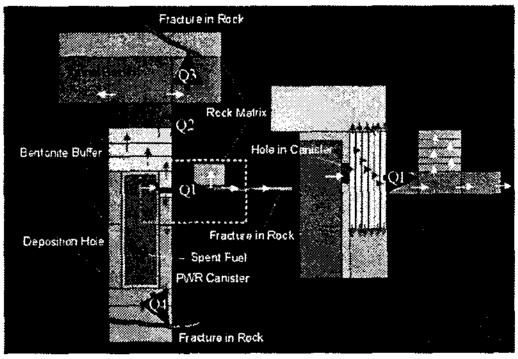

Fig. 1. Schematic near– and far–field system domain.

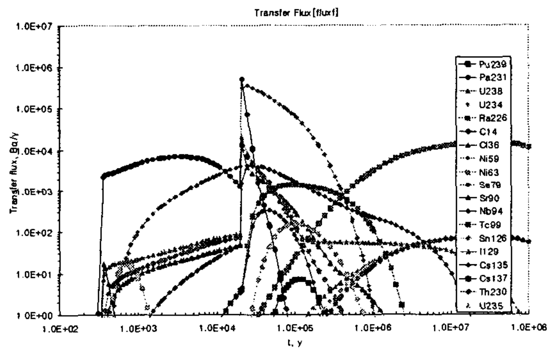

Fig. 2. Nuclide fluxes from the far–field of the HLW repository (suddenly changing hole area @10^4years).

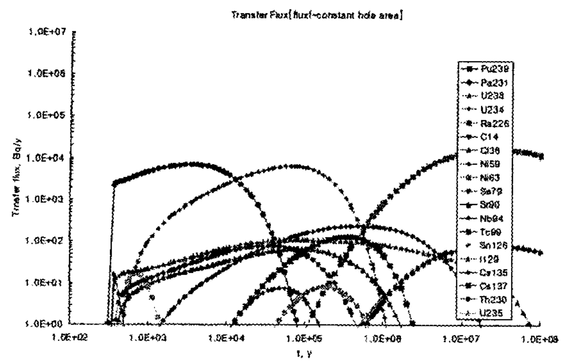

Fig. 3. Nuclide fluxes from the near-field of the HLW repository (constant hole area).

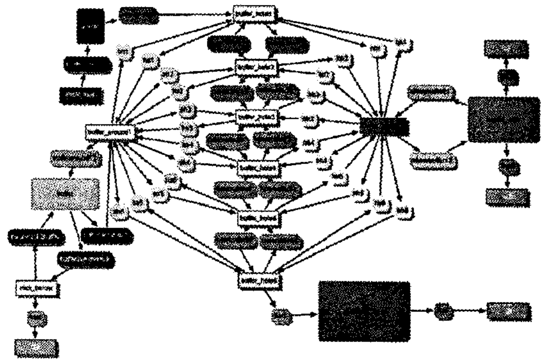

Fig. 4. Compartment modeling for nuclide release calculation.

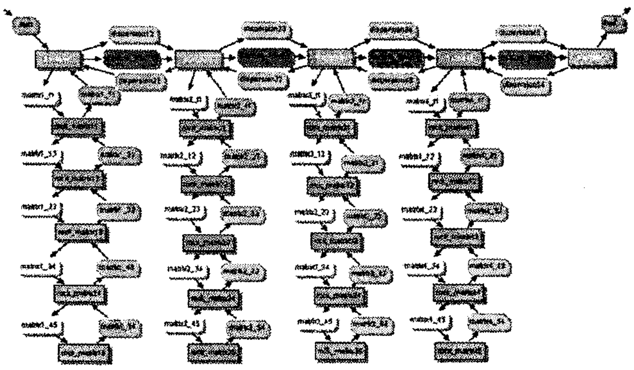

Fig. 5. Compartments for geosphere.

Not only to demonstrate how much a reference repository is safe in the generic point of view with several possible scenarios and cases associated with a preliminary repository concept by conducting calculations for nuclide release and transport in the near- and far-field components of the repository, even though sufficient information has not been available that much yet, but also to show a appropriate methodology by which both a generic and site-specific safety assessment could be performed for further in-depth development of Korea reference repository concept, nuclide release calculation study for various nuclide release cases is mandatory. To this end a similar study done and yet limited for the near-field release case has been extended to the case including far-field system by introducing some more geosphere compartments. Advective and longitudinal dispersive nuclide transports along the fracture with matrix diffusion as well as several retention mechanisms and nuclide ingrowth has been added.

2. Release calculation

For normal case assuming or taking reasonably all the values of input parameters from various sources several quantitative calculation and comparisons among various release pathways are made through this study as similarly done for KBS−3 type repository (Lindgren and Lindstrom, 1999; Hedin, 2002; Maul et al., 2003) and for the previous study. Such near−field barriers as canister, surrounding buffer, and excavation damaged zone as well as far−field geosphere components including fractured host rock and outer tunnel part of the repository are modeled as independent compartments accounting for their geometry and materials through which nuclides released from the canister are transferred and transportedto the biosphere(even the biosphere has not been included yet).

Most transfers between each near−field compartment are specified in terms of resistances between adjacent two compartments which is given by $\Omega^{ij}=\frac{1}{2A^{ij}}\left(\frac{d^i}{D^i}+\frac{d^j}{D^j}\right)$ where A^{ij} = common area between the two compartment, A = area perpendicular to transport direction, D = effective diffusion coefficient, and d = length of the compartment in the direction of transportexcept for transfer resistances from the source term as well as to far−field geosphere both of which are differently approached. The associated transfer rate between compartments i and j is then given by $\lambda^{ij}=\frac{1}{\phi^i R^i V^i \Omega^{ij}}$ where ϕ^i =compartment porosity, R^i = retardation, and V^i = compartment volume.

Illustration of part of some quantitative estimation of nuclide release are shown in Figs.2 and 3, each of which has different canister hole size and both of which show very typical breakthroughs for typical keynuclides under consideration of the material balance over each compartment to the other compartments as introduced in Figs. 4 and 5.

In most cases transfers between each far−field compartment are specified in the same manner to the near−field case of previous study. For compartment in contact with water flowing fractures in the rock, diffusive transport is determined by an equivalent flow rate, Qeq, which is a fictitious rate visualized as the groundwaterflow rate that carries away dissolved nuclides with the concentration at the compartment interface, from which the flow resistance is obtained as $\Omega_{i,flowingwater}=\frac{1}{D\sqrt{2\pi A_{hole}}}$ where A = hole area. And also for the transfer into a fracture which is extremely narrow in view of buffer medium around the canister, by calculating the nuclide flow rate due to diffusion, transfer resistance at the mouth of the fracture can be obtained as $\Omega_{i,fracture}=\frac{\left(\frac{F_{x,0}}{b}\right)b}{DA_f}$ where $\left(\frac{F_{x,0}}{b}\right)b$ is as estimated by Neretnieks (1986) and Af = fracture opening area contacting buffer.