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Influence of Groundwater Flow Rate on Nuclide Releases from Pyro-processed Waste Repository

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1. Introduction

Since the early 2000s several template programs for the safety assessment of a high-level radioactive waste repository as well as a low- and intermediate level radioactive waste repository systems have been developed by utilizing GoldSim[1] and AMBER[2] at KAERI [3-6]. Very recently, another template program for a conceptual hybrid-typed repository system, called “A-KRS” in which two kinds of pyroprocessed radioactive wastes, low-level metal wastes and ceramic high-level wastes that arise from pyroprocessing of PWR nuclear spent fuels has been developed and are to be disposed of by separate disposal strategies. The A-KRS is considered to be constructed at two different depths in geological media: 200m depth, at which a possible human intrusion is considered to be limited after closure, for the pyroprocessed metal wastes with lower or no decay heat producing nuclides, and 500m depth, believed to be in the reducing condition for nuclides with a rather higher radioactivity and heat generation rate. This program is ready for total system performance assessment which is able to evaluate nuclide release from the repository and farther transport into the geosphere and biosphere under various normal, disruptive natural and manmade events, and scenarios that can occur after a failure of waste package and canister. To quantify a nuclide release and transport through the possible various pathways especially in the near-fields of the A-KRS repository system, some illustrative evaluations have been made through the study. Even though all parameter values associated with the A-KRS were assumed for the time being, the illustrative results should be informative since the evaluation of such releases is very important not only in view of the safety assessment of the repository, but also for design feedback of its performance.

2. Modeling Methodology

The storage can for metal wastes are to be disposed of and then buffered by sodium bentonite blocks in total two disposal tunnels at the depth of 200m which will be backfilled later by mixture of bentonite and crushed rock. In GoldSim modeling, these tunnels are discretized into several compartments ready for diffusive transport in and among them, modeled as shown in Fig. 1 (left). Two principal release pathways from the tunnels are set in place, as shown in the figure: These are the upper crown pathway and the base and side pathway, both of which reach to the near-field transport. Diffusional transport only was considered between the upper and lower parts of the silo. All releases from the tunnels are collected at the outlet of the near-field, where they are later transported farther into the natural far-field area.

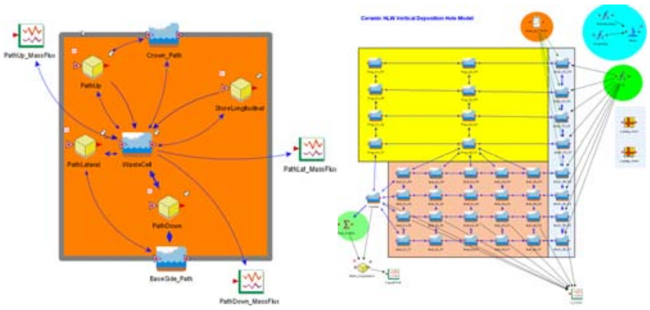

Fig. 1. Source term modeling (left: metal waste; right: ceramic waste)

For the ceramic wastes, modeled as shown in Fig. 1 (right), which are regarded as high-level wastes, are disposed of in tunnels constructed at the depth of 500m which look quite similar to those shown in Swedish KBS-3 vertical concept with the same buffering and backfilling process. Each overpack that has 14 canisters is to be displaced in the deposition hole under the bottom of the tunnel. For both type of repositories at each different depth, normally and commonly, once a leakage from a damaged radioactive waste package of a metal storage can and a canister and through tiny holes happens, nuclides will spread out to the buffer material surrounding a can and a canister, as well as the backfill or crushed rock region in the tunnel before farther transporting into the flowing groundwater in the internal fractures and the major water conducting features (MWCFs) of the far-field area of the repository. And then the nuclides will finally reach the human environment by passing over the geosphere-biosphere interface for an exposure to human bodies.

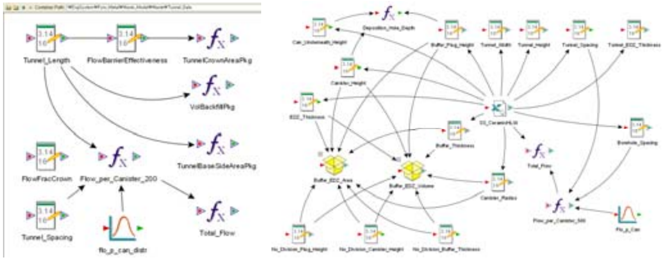

Fig. 2. Probabilistic Modeling for flow rates per can and canister (left: metal waste; right: ceramic waste)

3. Illustrations

The scenario considered here is a normal case, under which nuclides are released by groundwater that normally flows along their own preferential pathways after release from each repository. Through this study a probabilistic behavior of nuclide releases from the near-field has been investigated as shown in Fig. 3. Each two nuclides are selected to see the influence of groundwater flow per can and canister from each two repositories at the different depths.

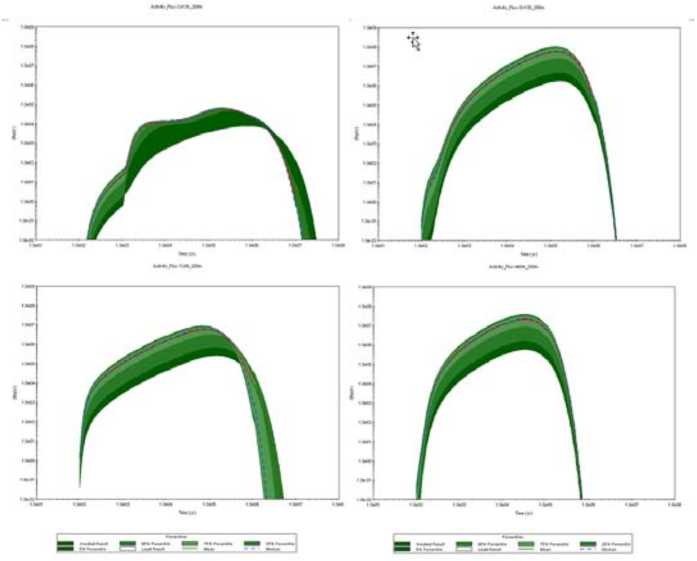

Fig. 3. Breakthrough curves for release rates of ^{135}Cs and ^{126}Sn from the metal waste repository at 200m and ^{99}Tc and ^{94}Nb from the ceramic waste repository at 500m (Monte Carlo sampling from normal rate×Uniform[0.01,100])

As is seen in Fig. 3, both for two repositories, nuclide releases from the near-field seem to be sensitive to some extent to the change of flow rate per can and canister.

References

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