Performance Assessment of a High-Level Waste Repository: Sensitivity to Environmental Factors and Radionuclide Inventories

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REPOSITORIES AS COMPONENTS

A radioactive waste repository can be one of many or one of few components in the nuclear fuel cycle. Nuclear fuel cycle models range from the inefficient but cost-effective once-through cycle to innovative approaches involving reprocessing, transmutation of waste through fast breeder reactors, and an expanding plethora of exciting options. Regardless of fuel cycle complexity, the current state of the science and technology behind the fission-based nuclear power fuel cycle dictates that fission products must be removed from spent fuel at some point.

Since fission products can remain radioactive and harmful to the surrounding environment for tens of thousands of years, it is critical to consider the complexities of both natural and engineered components of any repository. If a computer model is used to simulate the performance of the repository, it becomes important to understand what values are assumed in that model and what effect an incorrect initial guess might have on the model's output. For example, a key question in determining radiation dosage to the surrounding environment is: what are the initial radionuclide inventories? Over tens of thousands of years, other uncertain variables such as water seepage rates and corrosion rates become increasingly important.

YUCCA MOUNTAIN REPOSITORY

The Yucca Mountain Project (YMP) is the USA's first attempt at long-term storage of High-Level Radioactive Waste (HLW). YMP seeks to incorporate HLW currently stored at over one hundred temporary sites into one repository, built in rock above the water table. Since a goal of YMP is to minimize dangers associated with long-term storage of HLW, it is important to estimate the dose rate to which current and future generations will be subjected.

Uncertainty exists as to the initial radionuclide inventories that will be stored, and it is reasonable to perform a variety of sensitivity analyses to indicate how assumed initial concentrations affect the projected dose rate to future generations. The dose rate to the maximally exposed individual is calculated based on the Simplified Total System Performance Assessment (STSPA), a model developed by Golder Associates, Inc, Booz-Allen Hamilton, Stone and Webster, and the University of Nevada Reno. The model runs on the basis of GoldSim, a user-friendly graphics-based simulation tool.

This evaluation will examine the effects of varying iodine-129 and neptunium-237 initial concentrations by two and three orders of magnitude. Such analysis indicates the consequences of incorrect estimates in the radionuclide inventories. By varying the estimated values, trends in the projected performance are observed and analyzed. The lifetime of the repository is simulated to indicate the radiation dose rate to the maximally exposed individual; it is assumed that if the maximally exposed individual would not be harmed by the annual dose, the remaining population will be at even smaller risk. The determination of what maximum levels of exposure are safe is problematic, and the results from the simulations as compared against various regulatory limits are discussed.

This sample performance assessment may provide insight as to the degree of robustness of this particular high-level waste repository. It is also interesting to compare the long-term effects of this repository against a repository which incorporates reprocessing and other waste minimization techniques.