DOE/RW/00134--M97-024
CONF-980906--

Performance Assessment of DOE Spent Nuclear Fuel and Surplus Plutonium

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INTRODUCTION

Yucca Mountain, in southern Nevada, is under consideration by the U. S. Department of Energy (DOE) as a potential site for the disposal of the nations radioactive wastes in a geologic repository. The wastes consist of commercial spent fuel, DOE spent nuclear fuel (SNF), high-level waste (HLW), and surplus Plutonium.

The DOE was mandated by Congress in the fiscal 1997 Energy and Water Appropriations Act (P. L. 104-206) to complete a viability assessment (VA) of the repository in September of 1998. The assessment consists of a preliminary design concept for the critical elements of the repository, a total system performance assessment (TSPA), a plan and cost estimate for completion of the license application, and an estimate of the cost to construct and operate the repository.

This paper presents the results of the sensitivity analyses that were conducted to examine the behavior of DOE SNF and Plutonium waste forms in the environment of the base case repository that was modeled for the TSPA-VA. Fifteen categories of DOE SNF and two Plutonium waste forms were examined and their contribution to radiation dose to humans was evaluated.

DESCRIPTION OF ACTUAL WORK

The repository for the TSPA-VA base case contains 70,000 metric tons heavy metal (MTHM) composed of 63,000 MTHM of commercial spent fuel, 2,333 MTHM of DOE SNF, and 4,667 MTHM of HLW. The areal mass loading of the repository is 85 metric tons uranium (MTU) per acre based on commercial spent fuel. This thermal loading was used to develop the thermal and thermal hydrologic conditions used to analyze waste package failure within the near-field repository environment. Once the waste packages fail the release of radionuclides is described by a dissolution model for the waste form and by transport through the engineered barrier system. The radionuclides are then transported through the unsaturated zone and the saturated zone to a location where they are assumed to reach humans through ground water pumped from a well 20 kilometers down gradient from Yucca Mountain.

All of the individual categories of DOE SNF are not explicitly represented in the TSPA-VA base case. For the base case a surrogate radionuclide inventory and dissolution model was used that was developed based on the results of the 1997 TSPA[1]. For the sensitivity analyses the categories of DOE SNF and the Plutonium waste forms were assumed to be placed in the environment of the base case repository and the resulting dose was analyzed and compared to that from an equivalent amount of commercial spent fuel, except for the non-fuel waste form. The dose from the composite of the DOE SNF was also compared to that from the entire repository.

DISCLAIMER

The categories of DOE SNF analyzed in the TSPA-VA are:

Category 1	Uranium metal spent fuel
Category 2	Uranium-Zirconium alloy spent fuel
Category 3	Uranium-Molybdenum alloy spent fuel
Category 4	Uranium oxide spent fuel
Category 5	Uranium oxide-disrupted clad spent fuel
Category 6	Uranium-Aluminum alloy spent fuel
Category 7	Uranium silicide spent fuel
Category 8	High-integrity Uranium-Thorium carbide spent fuel
Category 9	Low-integrity Uranium-Thorium carbide spent fuel
Category 10	Uranium and Uranium-Plutonium carbide spent fuel
Category 11	Mixed oxide spent fuel
Category 12	Uranium-Thorium oxide spent fuel
Category 13	Uranium-Zirconium hydride spent fuel
Category 15	Navy spent fuel
Category 16	Miscellaneous spent fuel

Category 14, sodium-bonded spent fuel, was not analyzed because it is expected to be treated.

The two Plutonium waste forms analyzed are mixed oxide spent fuel (MOX) from a pressurized water reactor (PWR) and a ceramic plutonium waste form encapsulated in HLW glass (can-in canister ceramic). The dose attributed to these waste forms was analyzed separately and in combination.

RESULTS

The results of the comparison of the composite of DOE SNF to an equivalent amount of commercial spent fuel show that the dose histories are similar over the 100,000 year time period analyzed. The dose from the composite is about two orders of magnitude lower than that from the entire repository. This result should not be unexpected because of the similarity of the results from the composite and an equivalent amount of commercial spent fuel (i.e., the DOE SNF, on an MTHM basis, represents about one twenty seventh of the spent fuel in the repository). The amount of HLW used for co-disposal of the high- and moderate-enriched DOE SNF was shown not to contribute significantly to the dose history from the entire repository.

Sensitivity analyses indicated that only six of the 15 categories of DOE SNF contributed significantly to the dose from the composite of all of the DOE SNF. These analyses justify the surrogate radionuclide inventory and dissolution model used to incorporated the DOE fuel into the base case for the TSPA-VA.

The results of analyses of Plutonium waste forms were similar to those of previous analyses[2]. They show that the dose attributed to these waste forms is insignificant. The dose from MOX spent fuel was found to be nearly identical to that from an equivalent amount of commercial spent fuel that it is assumed to replace in the repository. The dose attributed to the can-in-canister ceramic, which is assumed to be added to the repository, was found to be negligible (i.e., about the same as the

HLW used to encapsulate it).

REFERENCES

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Report Number (14) DOE/RW/00134--M97-024
CONF-980906--

Publ. Date (11) 199801
Sponsor Code (18) DOE/RW, XF
UC Category (19) UC-800, DOE/ER

DOE