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Nuclear-Waste-Package Program for High-Level Isolation in Nevada Tuff

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NUCLEAR WASTE PACKAGE PROGRAM FOR HIGH-LEVEL-WASTE ISOLATION IN NEVADA TUFF

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Our laboratory has recently begun studies for a nuclear waste package appropriate to tuff at the Nevada Test Site (NTS). This is one part of a total Nevada Nuclear Waste Storage Investigation (NNWSI), the other parts consisting of geology-hydrology investigations (US Geological Survey); site geochemistry and mineralogy (Los Alamos National Laboratory); site thermomechanical characteristics, suitability, environment, and repository design, and project overview (Sandia); project management (Nevada Operations Office, DOE). Under a contract with the Office of Nuclear Waste Isolation (ONWI), Westinghouse is responsible for waste package design for all geological media and sites, including Nevada tuff.

There are several unique characteristics of the tuff site. Tuff has good sorption properties for radionuclides, especially the porous zeolite-containing tuffs. NTS already has nuclear debris underground from many years of underground nuclear tests. It is a geographically isolated site owned by the Federal Government and has favorable groundwater hydrology, including a deep water table. Apparently suitable horizons for a waste repository exist above and below the water table, and either may be chosen deeply buried below the surface. Groundwater appears to be mildly oxidizing, and so materials must be chosen with this in mind.

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The objective of the waste package program is to insure that a package is designed suitable for a repository in tuff that meets performance requirements of the NRC. In brief, the current (draft) regulation requires that the radionuclides be contained in the engineered system for 1000 years, and that, thereafter, no more than one part in 10^5 of the nuclides per year leave the boundary of the system.

As conceived, the waste package consists of a central canister containing either processed high level nuclear waste encapsulated in glass or ceramic, or spent nuclear fuel elements. In turn the canister is surrounded successively by a corrosion-resistant barrier ("overpack") and a "backfill" which couples to the host rock.

Our planned materials program includes corrosion studies of suitable overpack metals, adaptation or development of (compacted) backfill materials that will withstand a hydrothermal environment without degradation for long periods, and appropriate modeling to determine long-term performance. Materials testing will be done in a thermal environment of simulated tuff groundwater under normal and accelerated conditions, viz., at temperatures up to 250-300^{o}C. The objective is to understand the mechanism of corrosion or degradation so that model predictions of long-term behavior are credible.

Other work to be done includes interaction tests among components of the waste package and radiation effects tests to determine component long-term compatibility in the anticipated environment.

Studies completed as of this writing are thermal modeling of waste packages in a tuff repository and analysis of sodium bentonite as a potential backfill material. Both studies will be presented. Thermal calculations coupled with analysis of the geochemical literature on bentonite indicate that extensive chemical and physical alteration of bentonite would result at the high power densities proposed (ca. 2 KW/package and an areal density of 25 W/m^2), in part due to compacted bentonite's relatively low thermal conductivity when dehydrated ($\sim$ 0.6 ± 0.2 W/m^oC). Because our groundwater contains K+, an upper hydrothermal temperature limit appears to be 120-150^oC. At much lower power densities (less than 1 KW per package and an areal density of 12 W/m^2), bentonite may be suitable.

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