Nuclear Waste Package Mockups: A Study of *In-situ* Redox State

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The proposed Yucca Mountain Repository (YMR), located in southern Nevada, is to be the first facility in the U.S. for the permanent disposal of high-level radioactive waste and spent nuclear fuels. Performance assessments have indicated that among the major radionuclides contributing to dose to a Reasonably Maximally Exposed Individual are Np, Tc, and I. These three radionuclides are mobile in most geochemical settings, and therefore sequestering them within the repository horizon would provide an effective limit to their migration. Corroding steel may offset radionuclide transport processes within the proposed waste packages at YMR by retaining radionuclides, creating locally reducing conditions, and reducing porosity. Ferrous iron containing materials such as magnetite have been shown to reduce UO_2^{2+} to $UO_{2(s)}$, and some ferrous iron-bearing ion-exchange materials have been shown to adsorb radionuclides and heavy metals (e.g. green rust). Locally reducing conditions may lead to the reduction and subsequent immobilization of problematic dissolved species such as TcO_4^-, NpO_2^+, and UO_2^{2+} and can also inhibit corrosion of spent nuclear fuel. Water occluded during corrosion produces bulky corrosion products, and consequently less porosity is available for water and radionuclide transport. The focus of this study is on the nature of Yucca Mountain waste package corrosion products and their effects on local redox conditions, radionuclide transport, and porosity. In order to measure *in-situ* redox, six small-scale (1:40) waste package mockups were constructed using A516 and 316 stainless steel, the same materials as the proposed Yucca Mountain waste packages. The mockups are periodically injected with a simulated groundwater and the accumulated effluent and corrosion products are evaluated for their Fe(II)/Fe(III) content and mineralogy. Oxygen fugacities are then calculated and, thus, *in-situ* redox conditions are determined. Early results indicate that corrosion products are amorphous Fe-oxyhydroxides, and nanocrystalline goethite and magnetite. That information together with the measured Fe(II)/Fe(III) ratios in the mockup effluent constrain the oxygen fugacity to a minimum of 10^{-38} atm, many orders of magnitude below ambient. These results and their impact on radionuclide migration from YMR will be discussed.