

Corrosion of Carbon Steel and Copper Waste Containers in Reducing Environment

Xihua He¹, Jude McMurry¹, and Tae Ahn²

¹Center for Nuclear Waste Regulatory Analyses (CNWRA®)
Southwest Research Institute®
San Antonio, Texas 78238, USA

²U.S. Nuclear Regulatory Commission (NRC)
Washington, DC 2055-0001, USA

Contact: X. He, xhe@swri.org, Telephone: +1-210-522-5194

Copper and carbon steel are being considered as candidate materials for waste packages in geological disposal systems for high-level radioactive waste. Copper is reported to exhibit either a very low corrosion rate when exposed to groundwater or, theoretically, to experience no corrosion when it is in thermodynamic equilibrium within a reducing environment. Carbon steel is a corrosion-allowance material that is reported to have low corrosion rates (several micrometers per year) in simulated reducing groundwater, such that a carbon steel waste package could last for thousands of years. This paper reports independent analyses of copper and carbon steel waste package materials based on literature review and experimental studies.

Experimental tests of general corrosion and hydrogen generation for copper samples were conducted under anoxic conditions using a saline synthetic groundwater based on reference compositions for deep groundwaters in crystalline rocks of the Canadian Shield. Results have indicated that copper corrosion rates in O₂-free waters (less than 10 ppb) could be higher than results reported in the literature at this O₂ level and that hydrogen could be generated from the corrosion process. This observation differs from statements in the literature that copper would experience little to no corrosion in a reducing environment.

A literature review and experimental studies were conducted on carbon steel to examine uncertainties associated with processes and models for an alkaline reducing environment, which could occur in the presence of concrete overpack. Experimental tests have confirmed low uniform corrosion rates in an alkaline reducing environment at a pH of about 12 and detected hydrogen produced from the passive dissolution process. Chloride had the least depassivation effect and sulfide had the most depassivation effect on carbon steel passivity in this alkaline reducing environment. Thiosulfate was intermediate between these two. An analysis of the experimental data and the results will be presented in the paper.

This abstract is an independent product of the CNWRA and does not necessarily reflect the view or regulatory position of the NRC. The NRC staff views expressed herein are preliminary and do not constitute a final judgment or determination of the matters addressed or of the acceptability of any licensing action that may be under consideration at the NRC.