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Representation of Copper and Carbon Steel Waste Package Degradation in a Generic Performance Assessment Model

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Abstract

Copper and carbon steel are being considered as candidate materials for waste packages in high-level waste geological disposal systems in several countries. If used in a high-level waste geological disposal system, the waste packages could undergo chemical degradation (corrosion) when contacted by groundwater. The waste package lifetime could be a key factor to limit radionuclide release to the biosphere. Accordingly, an evaluation of waste package material degradation due to corrosion and the impacts on disposal system performance is necessary. Performance assessment models are commonly used to evaluate consequences of radionuclide release. The U.S. Nuclear Regulatory Commission (NRC) joined with Center for Nuclear Waste Regulatory Analyses (CNWRA), has been developing a generic performance assessment model, named beta-Scoping of Options and Analyzing Risk (beta-SOAR) with the intention to provide risk and performance insights for a variety of potential high-level radioactive waste geological disposal concepts.

In this paper, processes related to corrosion of copper and carbon steel are discussed, as well as their simplified representation in the generic performance assessment model. Factors such as corrosion rate and extent of waste package damage are discussed in the context of information gained from international high level waste programs. The corrosion mechanisms considered in the development of the performance assessment model include general and localized corrosion. Information on general corrosion rates was input to the model in the form of distribution functions to account for uncertainty in the rates and uncertainty in the environmental setting. Localized corrosion was considered to be either a non-uniform type of general corrosion (i.e., unevenly distributed corrosion attack on the waste package surface) for copper or to take the form of pitting corrosion for carbon steel. Therefore localized corrosion for these two materials was represented by an adjustment in the magnitude of general corrosion rates, accomplished by applying an enhancement factor to the base general corrosion rates. Under reducing conditions, general corrosion would be expected to be the dominant corrosion mode. Long-term prediction of sulfide-enhanced general corrosion rate of copper is discussed as a dominant corrosion process during the anoxic (oxygen-free) period. After emplacement and closure, an effect of a short-term oxidizing environment on corrosion rates is also discussed. Examples of the use of corrosion analyses in the performance assessment, in the form of simplified approaches to estimate waste package failure times, are presented, together with the influence of these failure times on radionuclide release.

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