Understanding Long-Term Corrosion of Alloy 22 Container in the Potential Yucca Mountain Repository for High-Level Nuclear Waste Disposal

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The robustness of the outer container of a waste package (WP), in a potential geologic repository for high-level nuclear waste (HLW) disposal at Yucca Mountain (YM), Nevada, may be one important attribute to secure long-term HLW isolation. The outer container may be constructed of Alloy 22, a corrosion resistant Ni-Cr-Mo alloy that exhibits very low corrosion rates in the absence of environmental conditions promoting localized corrosion. General corrosion rates could increase substantially in the case of passive film instability, depending on environmental conditions and material alteration states during the disposal period. Similarly, localized corrosion, in the form of crevice corrosion, could be due to film instability in occluded environments in crevices. Higher general corrosion rates or increased susceptibility to crevice corrosion may lead to a shorter WP lifetime, possibly causing radionuclide release to the geosphere.

This paper presents factors potentially relevant to (i) long-term persistence of the passive film, (ii) susceptibility and propagation of crevice corrosion, and (iii) subsequent total-system consequences of radionuclide release. These technical assessments are intended to prepare for reviewing any U.S. Department of Energy's license application for a potential YM repository. Sustained loss of passivity could be due to changes in structure or chemistry of the passive film, possibly driven by environment. For example, the passive film may become unstable due to (i) anodic sulfur segregation at the metal–film interface, (ii) internally induced stress resulting from the overgrowth of passive film, and (iii) accumulation of corrosion products causing local alteration of the solution chemistry or large cathodic surface area. Localized corrosion is feasible if solutions develop on the WP that have high ratios of chloride to inhibitor (e.g., nitrate, bicarbonate, sulfate) concentrations at temperatures close to the boiling point of pure water, in tight crevices. If initiated, localized corrosion could rapidly propagate, stifle, or even repassivate depending on the environmental conditions. If localized corrosion propagates, it is envisioned that WP damage front would be restricted to small areas. This paper presents literature review, simplified calculations, and limited test data, to assess loss of passivity scenarios and WP damage due to crevice corrosion. A total-system performance assessment model was used to better understand the potential importance of these processes in the potential YM repository.

Disclaimer: 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 a license application for a geological repository at Yucca Mountain. This paper is also an independent product of the CNWRA and does not necessarily reflect the view or regulatory position of the NRC.