PREDICTING THE CORROSION PERFORMANCE OF HIGH-LEVEL NUCLEAR WASTE CONTAINERS

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The safe disposal of high-level nuclear wastes requires its isolation from the humanly accessible environment until radioactive decay reduces the toxicity to low levels. This requires periods of many thousands of years (up to 10^5 years depending on the type of waste). Internationally, various geologic formations, including fractured rock (USA), solid granite (Sweden, Canada), salt domes (Germany) and clay deposits (Belgium, Switzerland) are being contemplated as potential disposal sites.

In all these locations, the natural barrier provided by the geologic formation will be supplemented by a series of engineered barriers. Within this series, only the metallic container, in which the waste is to be sealed, has the capability to function as an absolute barrier. Consequently, the corrosion performance of these containers will be very important in determining the overall performance of the disposal vault. The choice of material varies from site to site depending on the anticipated exposure conditions, and selected materials include carbon steels (cost and operating experience), copper (thermodynamic stability under non-oxidizing conditions), and Ti and Ni-Cr-Mo alloys (enduring passivity under oxidizing conditions).

Because of the extremely long time scales involved, predicting the corrosion performance of these containers poses a special challenge. Clearly, laboratory experimentation and corrosion testing experience cannot fully justify that such a period of containment is feasible, and long-term performance can only be assessed based on corrosion models. Many different approaches to modeling have been adopted, from mixed-potential deterministic[1-3] to empirically probabilistic[4,5].

Irrespective of their form, these models must encompass a number of key features:

1. They must be coupled to the evolution of the disposal site environment which will change from initially warm and aggressive to eventually more benign;
2. They must be sufficiently rigorous conceptually that their abstraction into the simple form required for incorporation into a very large disposal site performance assessment models does not render them meaningless;
3. Both conceptual uncertainties and limitations on available parameter values must be reflected in the model predictions.

Research in this area has been in progress for over 25 years. This paper will review the progress made internationally over that period of time. The bases for materials selection will be discussed, but the major emphasis will be on discussions of the modeling formats adopted and the experimental methods used to generate the necessary databases, particularly those involving electrochemical techniques. The essential process of model abstraction, by which complex conceptual models are simplified for incorporation into assessment codes, will also be discussed.

References

1. G.P.Marsh and K.J.Taylor, Corrosion Science 28,289 (1988)
2. D.D.Macdonald and M.Urquidi-Macdonald Corrosion 46, 380 (1990)
3. F.King "A Copper Container Corrosion Model for the In-room Emplacement of Used CANDU Fuel", Atomic Energy of Canada Limited Report, AECL-11552 COG-96-105 (1996)
4. D.W.Shoesmith, B.M. Ikeda and D.M.LeNeveu Corrosion 53,820 (1997)
5. D.W.Shoesmith and J.R.Massari "Predicted Performance of the Engineered Barrier System in the Yucca Mountain Repository", Proceedings of the Nineth International High-Level Radioactive Waste Management Conference, American Nuclear Society, La Grange Park, IL, Paper E-7-2 (2001).