



SYSTEMS SUPPORT, INC.

Scientific Consulting

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17 December 1987

88.rbm.17

Mr. K. C. Chang
Mail Stop 623-SS
U. S. Nuclear Regulatory Commission
Washington, DC 20555

Dear Kien:

**Services Rendered on High Level Waste Repository
Performance Assessment Development 11/30/87-12/13/87**

During the referenced period I have worked primarily on studying the problems of container corrosion and the models that have been proposed for inclusion in CONVO.

Corrosion Modeling

Some additional information has been received on the corrosion of copper in an air/steam environment, which tends to corroborate the data published by Yunker at the higher of the two temperatures (150 C) at which his experiments were carried out. In contrast to Yunker, other information indicates that following the formation of a very thin layer of Cu₂O, a thick layer of CuO is formed. (See C. Boyars letter of 11 Dec 1987). At low temperature CuO only is formed at a rate that is logarithmic with time.

A logarithmic time dependence implies that the rate equation is of the form;

$$R = \frac{K}{t_0} e^{-x/k}$$

where k is a constant, x is the thickness of the corrosion layer, t is time and t₀ is some initial time at which the thickness of the layer is x₀.

This equation has a familiar form. It occurs in radioactive decay, as well as for first order chemical reactions. But in both these cases the rate is an exponential function of time. The observed rate can be understood if it is recognized that the instantaneous rate at which the thickness increases must be equal to the instantaneous rate of concentration decrease of a reacting substance at the interface between the corrosion layer and metallic surface. If the reaction that results in this decrease in concentration is of the first order, then an exponential dependence of concentration results.

The difficulty with this approach is that it assumes that the

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concentration gradient in the corrosion layer is a constant that is independent of the thickness of the layer, a situation that is approximately true only when the gradient of concentration is small. This implies that diffusion is not the rate controlling step, although it still must be invoked in order for a concentration gradient to exist. In essence diffusion is very fast compared to the kinetics of the reaction, but not so fast that a quasi-linear concentration as a function of thickness does not occur. This is an approximation that must break down as the thickness grows large and diffusion begins to compete with the reaction kinetics. This situation can be described by the appropriate differential equations, but the solution is complex and usually is dealt with using numerical methods.

In my previous submission (Letter Report 88.rbm.14, 2 Dec 1987) I presented an equation for low temperature corrosion of copper that was a linear function of time based on the data of Yunker and Glass. The data is equally consistent with a logarithmic function of time because of the spread in the data. Presumably if the time for the experiments was greatly extended, the expected logarithmic behavior would become evident. The data does indicate a very low corrosion rate which would decrease still further for times long compared to the one year of these experiments.

Clearly the question of corrosion of copper in the tuff environment is a complex one for which much more data is required before a satisfactory model can be developed. But the available data and models suggest that copper will perform adequately in the tuff environment even using models that appear greatly to overestimate the corrosion rate.

I expect to continue to concentrate on the various corrosion issues for the tuff environment during the next month. Also Dr. Boyars has obtained most of the relevant thermodynamic data for the stress corrosion of stainless steels and I will review this data, perform some preliminary calculations to insure that the results are consistent and arrange the data in a form that will simplify their codification and use in a module suitable for inclusion in CONVO.

Other Information

I am enclosing three copies of the voucher for professional services for your approval. As of 14 November 1987 I have charged 57.5 days against the total of 130 authorized.

If you have any questions, please feel free to call me.

Sincerely,


Robert B. Moler