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Mr. K. C. Chang
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U. S. Nuclear Regulatory Commission
Washington, DC 20555

Dear Kien:

Services Rendered on High Level Waste Repository
Performance Assessment Development: 8/1/87-8/16/87

During this reporting period I devoted a portion of my time preparing the graphs in the Demonstration Report for final preparation in publication quality format. All the graphs will be done in a uniform style. Also I have reviewed the revised and edited versions of the appendices and have returned them to our typist for final corrections and printing in final form. Finally I have begun revising the main text to delete the present chapter 2, incorporate the essential features in chapter and to renumber the remainder and generate a new table of contents.

My major efforts have been to review a number of reports from the tuff repository project provided by Lawrence Livermore Laboratories. The most significant of these is a report by W. J. O'Connell and R. S. Drach[1] in which, for the first time, an explicit assessment aproach is discussed.

The approach taken in this report is not probabilistic at the present time, but it is clear by implication that a probabilistic approach will be taken in the future. The intent of the present deterministic approach is to attempt to understand interactions among the various modules (radiation, thermal, mechanical, corrosion, etc.) and to provide some experience and guidelines for the next generation of assessment models and codes.

The present models and codes contains some notable conculusions. The authors examined the WAPPA code and noted many of the serious flaws that the Aerospace group had previously pointed out. They concluded that the WAPPA code was not useful for their purposes although they considered it a good shopping list of concepts that should be considered.

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1 O'Connell, W.J. and R.S. Drach, "Waste Package Performance Assessment: Deterministic System Model Program Scope and Specification", UCRL-53761 October 1976.

One of the serious flaws in WAPPA is the treatment of radiation build-up factors in radial geometry which is incorrect. The LRL PANDORA code corrects this flaw and produces a dose rate at the surface of the container using an analytical approach that is based on a more complex calculation using the MORSE-L code. The analytical approach is capable of interpolating radiation effect for different times, burn-ups and initial fuel loading based on the original runs carried out using the ORIGEN-II code. This procedure is similar to the one that is used in the CONVO code in which a response surface is used to generate thermal histories. The response surface approach is the more efficient of the two methods and often is the more precise because interpolations are not constrained to be linear as is the case for the LLL approach.

PANDORA has made a notable advance in the calculation of the thermal history of a container in the tuff environment. Again an analytical approach is used. It is based on a much more complex calculation that includes convection and radiation. The authors point out that the analytical model also includes convection but is a steady-state solution. This approach is justified on the basis that it is conservative except for very early times. Their tests of the steady-state approximation show that it works quite well and is an accurate approximation of the horizontal axisymmetric finite length emplacement geometry with a cylindrical air gap.

At present there is no corrosion model incorporated in PANDORA. Uniform corrosion of stainless steels is not considered to be significant and localized corrosion studies have not progressed to the point that a model can be constructed. The authors discuss the approach to setting up quasi-models of localized corrosion models. These models would be in the form of environmental conditions scenarios which if encountered would lead to localized corrosion of some range of severity. This is an approach that is acceptable in the absence of more realistic models. It amounts to developing a semi-quantitative description of engineering judgement.

The most notable new information that has been presented by this report is the ability to carry out reasonable thermal history calculations using an analytical approach that approximates the more detailed numerical approaches. If on futher analysis this approach apprears to be a reasonable one, it would merit futher analysis and incorportation into the CONVO code, possibly modified to use the response surface approach.

This report merits a more thorough review than has been performed and should be studied by both L. Zaremba and G. Fuller to assess its merits in their areas of expertise.

A draft report[2] from Battelle Columbus Laboratories on the subject of pitting corrosion in low-carbon steels was received and reviewed in some detail. The report demonstrates several points. First, they note that in the basalt groundwater environment pitting is expected. They also show that an active wall pit will propagate at a very low rate compared to an enert wall pit. They carry out experiments in which artificial pits are allowed to propagate under a variety of conditions. They achieve active pit propagation by creating the appropriate environment in the artificial pit by filling them with a paste consisting of Fe_3O_4 and 0.1M HCl. The pits themselves are quite large compared to normally observed pits.

It is not surprising that they observe that active wall pits do not propagate as rapidly as enert wall pits. The mechanisms that limit the current in a pit are well known and were originally postulated in order to account for the fact that the current in a shallow pit would be very large (many amps) unless a limiting mechanism is present. The important question is whether or not the walls of pits in low carbon steel will be enert or active. This paper does not answer this question satisfactorily. The work of Marsh[3] in a similar environment in which no artificial pit enhancement was used appeared to demonstrate that enert wall pit did form in low carbon steel. The rates of propagation observed was quite consistent with that observed by Beavers et al for putatively similar pit depths. The mechanism for propagation would seem to be mass transport just as observed in other studies and Beavers et al acknowledge this.

If the pit has an active wall it is clear that pit propagation can occur only at rates that approximate the rate of uniform corrosion under the same conditions. In other words an active wall pit is a contradiction. There is no mechanism for its formation in the first place, other than during an initial period in which the walls, such as they are, are not active. Thus active wall pits would seem to be more reasonably described as locally enhanced general corrosion. When such regions overlap it become difficult if not impossible to distinguish localized from general corrosion, and perhaps the correct approach is to treat it as general corrosion.

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2 Beavers, John A., Nell G. Thompson and Alan J. Markworth, "FPit Propagation of Carbon Steel In Groundwater" undated report

3 G. P. Marsh et al, "Evaluation of the Localised Corrosion of Carbon Steel Overpacks for Nuclear Waste Disposal in Granite Environments" in Scientific Basis for Nuclear Waste Management IX, Lars O. Werme, ed <u>Materials Research Society Symposia Proceedings</u> <u>50</u> (1986) 421-428

Beavers et al allude to a pitting model but do not present one. Such a model, if it is mechanistic would be most interesting. I continue to believe that a statistical model of pitting will be required because it is highly unlikely that a mechanistic model of pit initiation will be developed. A model of pit propagation may be developed but it too is likely to include a statistical feature to account for the fact that a pit may become enert for a period and then return to active growth.

I will continue to pursue the question of a mechanistic based statistical model of pitting corrosion in the expectation of developing or adapting a model for inclusion in the CONVO code. I expect to look specifically at the question of stress corrosion in stainless steels in the immediate future.

I am enclosing three (3) copies of the Voucher for Professional Services for your approval.

If you have any questions please call me at any time.

Sincerely,

Robert B. Moler

Robert B. Moler

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