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Department of Nuclear Energy

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Everett A. Wick
High Level Waste
Technical Dev. Branch
Division of Waste Management
Mail Stop SS 965
U. S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Everett,

Attached is a Letter Report with some thoughts about the BWIP facility, introducing a problem area which, as far as one can determine from reading the Site Characterization Report, has not been addressed by DOE.

Sincerely,

Cesar Sastre
Head, HTGR Safety Div.

CS:ep
enc.
cc. R. Browning, NRC
R. Cook, NRC
M. Knapp, NRC
D. Schweitzer, BNL

00135

LETTER REPORT ON THE REVIEW OF BWIP SITE CHARACTERIZATION

C. Sastre

In connection with the task on waste package reliability, we have briefly reviewed the document DOE/RL82-3, Site Characterization Report for the Basalt Waste Isolation Project, to see if there are phenomena described or implied in that analysis which impinges on waste package reliability.

We want to call your attention to the problem of water migration into the emplacement hole, its evaporation and the heat transfer condition of the canister. The temperature field and fluid flow around the canister emplacement time can present special safety issues that the above report does not address.

Consider the situation just at the time of emplacement. The rock has been perforated, and the surface of the horizontal borehole where the canister is to be placed is oozing water. This is so because there is some 1% porosity in the basalt, and the rock is under a hydraulic head of about 1000 m, which should be the absolute pressure of the water in the rock pores some distance away from the free surface of the rock at the borehole. This pressure differential leads to the perspiration at the surface. The rate of perspiration at the surface depends on the permeability of the rock, the hydraulic head and the geometry in the near vicinity of the emplacement hole. One should expect to have a stronger effect at points in the emplacement hole which are removed from the access gallery.

When the waste is emplaced, the temperature starts to go up. BWIP calculations show predicted temperatures of the order of 200°C in 10 years at the emplacement hole surface. As the temperature of the surface of the emplacement hole increases, the viscosity of the water will change, which will affect somewhat the perspiration rate.

When the surface temperature (which is determined by the heat load, conduction through the rock and convection due to the flow of water through the pores in a temperature gradient) reaches the saturation temperature of the water at the surface of the emplacement hole, which is at near atmospheric pressure, the evaporation rate will increase giving a cooling effect, through the latent heat of evaporation. The system could stop there if the perspiration rate is appropriate for such steady state solution, or the surface may exceed the boiling point of water if the heat input is not compensated by the evaporation of water and a drying zone may develop.

If a drying zone develops, the evaporation will occur inside the rock and the pressure in the region where rapid evaporation occurs will be determined by the friction loss due to the flow of steam through the rock pores and the hydrostatic pressure. The rate of evaporation will be determined by the heat flow into the zone and the cooling due to evaporation. Notice that the hydrostatic pressure of the water deep into the rock can be balanced only through friction losses due to flow of water or steam through the porous medium.

In one extreme, if the perspiration rate is high enough, the system is essentially water cooled. On the other extreme, the system dries up and essentially no steam goes into the emplacement hole. Each canister produces about 5 Kw which corresponds to a water evaporation rate of the order of 7 liters of water per hour converted to steam per canister.

The water contains about 1 gr of solids in solution per liter. Therefore, we deposit 7 grams of solids per hour per canister. If the water ingress per canister is more than the evaporation rate, then the hot water will drain out. If the water ingress is much less than the potential evaporation rate, then the solids will be deposited somewhere inside the basalt and will plug the pores. If the pores get plugged, the pressure in the rock could increase to the hydrostatic head of 1000 meters of water at the boundary where the water is evaporating, which might stress the rock locally.

A local plugging of the pores of the rock is interesting because it may lead to an improvement of the rock by reduction of porosity, but conceivably if it ocurrs closely to the surface of the rock over a wide area, can lead to local concentration of stresses in the rock and to spallation and release of loose debris into the emplacement hole. Certainly the plugging of holes, if it occurs, would result in a preferential ingress of water into the emplacement hole through the wider cracks since in them the flow of water might be sufficient to cool the rock and prevent evaporation and salt deposition.

One would expect that the evaporation of the water would result in a fractionation of the solids, perhaps depositing the silica first and leaving the clorides and sulfates in the solution to reach the canister. If the rate of water ingress is intermediate, we might find a liquid in the emplacement hole which is saturated in salts or a canister covered with a loose crust. In 10 years each canister is capable of evaporating enough water for a deposit of 610Kg of solids per canister. This might have two implications. First, the canister may be really in saturated brine instead of pure basalt water which has implications on the corrosion of the canister and on the behavior of the bentonite in the backfill and near rock. Second, the salt deposited on the canister may have a loose structure with poor heat transfer characteristics leading to a higher temperature than predicted with clean surfaces.

This suggest that the problem of water seepage with evaporation and solids deposition should be modeled in detail to estimate the canister temperatures during the initial period, for the BWIP design. This problem will require attention as long as the waste loadings used in the design are as high as are being proposed in this design.

December 3, 1982
CS:ep

cc.	R. Browning	NRC
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