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Attachment A

End to 9-21-82 memo to Bell fm Cook

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

AUG 20 1982

MEMORANDUM FOR: Robert F. Cook, NMSS
High-Level Waste Licensing
Management Branch

FROM: Michael B. McNeil
Waste Management Branch
Division of Health, Siting,
and Waste Management

SUBJECT: IMPRESSIONS OF BWIP TECHNICAL PROGRAM

While I have not yet had time to digest all the documents I got at BWIP, and will communicate with you in detail on specific points, I would like to give you some overall impressions.

1) The Cr-Mo low alloy wrought steels which have been considered for the containers seem to have been chosen to minimize uniform corrosion and without adequate consideration of welding problems. Since the containers will have to be welded shut and since most people who have looked at steel containers (including me) think that the major problem will be localized corrosion, these are not the most appropriate choices. The emphasis on wrought steel seems to be a path-of-least resistance choice, since so many more data are available on wrought steel; even if BWIP continues to treat containers as pressure vessels (an approach that causes me concern) it is not at all clear that the optimum thickness will be one which can be best made from wrought product, and of course a wrought steel container has welds at both ends. This is a situation I view with alarm since I think the waste form will be severely fragmented and will offer a percolation path through the waste in the event of weld failure.

2) It is not always useful to try to analyze pitting corrosion in terms of some multiple of uniform corrosion rates (see, for example, work by Uhlig and others on passivation of copper alloys, reviewed in my 1973 paper in the NBS/ONR symposium on marine corrosion). Pitting corrosion can be severe when uniform corrosion rates are extremely small. BWIP seems to ignore pits as stress risers.

3) Pouring the glass into a 304L thin skin canister and then welding the canister shut will lead to severe sensitization. Even if the bulk stainless is cathodic with respect to the carbon steel (overpack) container, I am not sure the grain boundaries will be, and the resistance difference because of the gap between the stainless and the carbon steel may lead to severe attack on grain boundaries irrespective of the carbon steel

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potential. BWIP and DOE claim no resistance to corrosion for the stainless, but still if I were to design the 2-container system I would try to use an inner container which would be less vulnerable. Hastelloy is the obvious choice since the temperature of the glass excludes brasses and bronzes.

4) It is apparent that the hydrology of the site is really critical to the radionuclide containment over the longer term, and I believe this must be looked at very carefully. My concern is that BWIP is going to be taking chances on the form, container, and backfill resting on the assumption that the hydrology will protect the accessible environment, and this attitude makes a really high level of confidence in the hydrology essential.

5) There are not adequate data on radionuclide solubilities, especially if one assumes that the groundwater chemistry may vary significantly from one part of the repository to another. Collecting these data is expensive and time consuming, and the past attitude of many parts of DOE ("let DOE/BES do it - they are the research arm" - which I have heard repeatedly) is not satisfactory when BES has its own financial problems and everybody else is trying to push programs off on them. DOE needs to stop passing the buck and get moving.

6) The presence of so much CH_4 may be a hazard in tunnelling operations.

By and large, I felt that BWIP technical staff have a clear comprehension of their problems and are very willing to deal with them in a way that should be satisfactory.

The question is whether DOE will commit the resources and whether BWIP management have the foresight and care to ensure that all the individual issues must be nailed down.

M B McNeil

Michael B. McNeil
Waste Management Branch
Division of Health, Siting,
and Waste Management

cc: D. Alexander
J. Davis
K. Kim
B. Wright (NMSS)

Attachment B

BROOKHAVEN NATIONAL LABORATORY

MEMORANDUM

DATE: August 25, 1982

TO: File

FROM: Karl Swyler

SUBJECT: Report on BWIP briefing meeting at Rockwell/Hanford.

On August 9-12, 1982, a meeting was held on the Hanford reservation between Rockwell/Hanford personnel, NRC staff members, and representatives from NRC contractors. The purpose was to obtain background on preliminary information which would expedite NRC review of the forthcoming BWIP Site Characterization Report (SCR). This report is presently being drafted by BWIP personnel at Hanford, and its submission to NRC for comment is scheduled for mid-November, 1982.

The NRC/NRC contractor contingent was functionally divided into two groups. One group was charged with concentrating on design basis information in the SCR relative to the waste package. The second group was primarily concerned with the characterization of near-field geochemistry. The writer was invited to attend as a member of the "waste package" group, specifically concerned with the effects of radiation on the waste package performance.

The briefing began with a series of overview presentations by Rockwell staff aimed at familiarizing the NRC and its representatives with present design concepts for BWIP. The stated BWIP approach is to first concentrate on determining the environment of the waste package, and then tailoring the waste package to perform acceptably in this environment. Consequently, at this stage of development, the majority of emphasis has been placed on characterizing the geochemistry and hydrology of the host rock, as opposed to detailed performance evaluation of potential. This initial geochemistry and hydrologic characterization has led to some modifications in waste package design philosophy. Specifically, the present design basis incorporates the following concepts:

1. Shortly after repository closure, oxygen fugacity will be reduced to a low value by geochemical reactions with the basalt. These reactions, evidently involving oxidation of iron contained in the basalt, should maintain a strongly reducing environment ($Eh \sim -0.45$) over the lifetime of the repository.

2. Under the anticipated conditions of Eh, pH, groundwater flow rate and geochemistry, radionuclide release from the waste form will be limited by the solubility of individual radionuclides in basaltic groundwater. Specifically, the "source term" for radionuclide release from a dissolving (glass) waste form may be conservatively modeled by considering the flow of a certain volume of groundwater at the solubility limited radionuclide concentration.

These concepts are reflected in the present repository conceptual design in several ways. Overall performance assessment presently incorporates a computer code which is still under development. Thus far this code has been used largely for sensitivity analysis, and we understand that these results will not be specifically described in the SCR. The methodology, however, is of interest. The approach is to carry out radionuclide transport calculations, assuming various values for radionuclide solubility, repository groundwater flow, etc. to identify those cases when solubility limited transport through the geomedia cannot achieve compliance with EPA release criteria. Presumably, these cases will then be used to further define containment requirements on the engineered system.

In this context, key features and performance objectives of the reference waste package design in the SCR may be summarized as follows:

1. Three types of waste form are contemplated: commercial HLW glass, defense HLW glass and spent fuel. The prototype for commercial HLW glass is PNL 77-260. The defense HLW glass prototype will be a Savannah River Plant formulation. There do not appear to be any design criteria specifically regulating radionuclide release from the waste form. While extensive leach rate data exist for waste glasses, such data are considered by BWIP personnel of questionable applicability to long term performance assessment. Instead, emphasis is placed on radionuclide solubility limits achieved when waste form materials react hydrothermally with basaltic groundwater. Here, the present data base is very limited.

2. The container is designed to withstand hydrostatic pressure (~1600 psi) for 1000 years after emplacement. The anticipated reducing environment permits the use of mild steel (ASTM 1018-1020) as a container material with adequate corrosion resistance. The design is based on a requirement that after 1000 years, the container should be sufficiently thick to satisfy an ASME boiler code requirement at the indicated pressure. The design thickness of 1 1/4 inches includes an allowance of 0.5-inch for corrosion. The (very preliminary) corrosion allowance is simply based on a linear extrapolation of weight loss data for pipes buried in soil.

3. A conceptual backfill design was described consisting of a 75% crushed basalt, 25% sodium bentonite mixture, 6-inches thick. One scheme is to blow this backfill material around waste containers in horizontal emplacement. It is not clear, at present, how heavily the reference backfill design will figure in the upcoming SCR. In general, the backfill is expected to perform at least four functions:

- Limit (by virtue of swelling of the bentonite clay) the transport of water to and from the waste container.
- Maintain a strongly reducing environment in the immediate vicinity of the container and waste form (by virtue of the crushed basalt component).
- Retard the transport of radionuclides by sorptive processes in the bentonite clay component.
- Transfer sufficient heat to maintain temperatures within design limits.

The present reference design includes a backfill temperature limit of 300°C under these conditions. This limitation is imposed to ensure little hydrothermal alteration of the backfill. Based on a Darcian flow model and currently available backfill permeability data, a 6-inch thickness of (fully swollen) backfill is considered sufficient to provide diffusion controlled mass transport under anticipated repository conditions.

Using retardation factors derived from K_d measurements for various radionuclides in bentonite clay, breakthrough times have been calculated in the diffusion controlled transport limit. The expression used is apparently similar to that obtained at Sandia and elsewhere under similar assumptions. In particular, the calculation assures an input radionuclide concentration which is constant with time, as a first approximation to solubility limited behavior of a dissolving waste form. For a 6-inch backfill thickness, preliminary sorption data are said to indicate 5% breakthrough times of more than 1000 y for Cs, Sr and Np, and more than 300 y for Pu, under anoxic conditions.

The backfill is also expected to be a controlling factor in the resaturation behavior, i.e., the manner in which the waste container is exposed to water following repository closure. The most plausible resaturation scenario was not determined.

The overview presentations described above served to establish a frame of reference for individual discussions between NRC/NRC contractor representatives and Rockwell personnel. These discussions were concerned with establishing the data base and analytic procedures used in support of the present design/characterization, and with identifying further informational needs. The writer was not involved in all of these discussions, particularly those dealing with geochemical and hydrolysis considerations. From this perspective the writer's experience in these discussions may be summarized as follows:

- Overall repository performance: The present conceptual design relies heavily on the properties of the geomedium to provide the primary means of radionuclide containment. Key properties in this regard include groundwater flow velocities and hydrology of the mined repository, and the ability of the basalt to maintain a low Eh environment. While both of these properties remain to be further defined, certain points are noteworthy. For example, the present evidence for low Eh conditions in groundwater at the repository horizon is largely inferential. It has not yet been possible to directly measure the Eh in groundwater obtained from the repository horizon. Presently, Eh data are largely based on the coexistence of certain mineral phases or "couples" present in basaltic groundwater samples, and on preliminary measurements of oxygen uptake by crushed basalt in a hydrothermal environment. Establishing the correspondence between these laboratory evaluations and ambient conditions at depth (i.e., validating the analysis) was agreed to be a central issue for further study. At the same time, the reliability with which repository groundwater flow rates can be (or need to be) bounded will presumably be an important issue, particularly since test drillings indicate that certain regions of dense basalt strata may be less thick than anticipated.

- Waste form: The shift in emphasis from leachability to solubility is said to change the radionuclide release scenario from dynamically varying, time dependent behavior requiring extrapolation to a steady state situation which can be characterized in terms of thermodynamic data. The present emphasis is to determine the solubility limits for various radionuclides when waste from materials are dissolved in basaltic groundwater. Since only very limited data are presently available, this is to be the subject of a fairly extensive program of hydrothermal tests. In the solubility limited scenario, radionuclides released from the dissolving waste form will be largely incorporated in secondary mineral phases which are said to be in or near equilibrium with the local environment. These secondary phases will, in effect, serve as alternate waste forms. Consequently, some characterization of these secondary phases will be necessary to evaluate their durability over a range of (changing) repository conditions. This is also to be undertaken in the hydrothermal testing program. It was not immediately obvious how extensive a characterization of secondary phases will be required to provide an adequate data base.

The solubility limited scenario does not rule out the possibility of radionuclide transport in particulate or colloidal forms. Again, very little direct information is presently available. The possibility of colloidal or particulate transport is to be explicitly studied in the hydrothermal test program.

As mentioned earlier, the present concept does not explicitly give credit to the waste form as maintaining a barrier to radionuclide release. The solubility limited picture has several attractive features, among them not requiring that the waste form maintain its leach resistance under hydrothermal conditions. However, should further study indicate the need for additional confinement in certain cases, (e.g., nuclides such as Se and Tc, extreme flow rates, particulate transport, etc.), it was pointed out that data on the rate at which the waste form dissolves might also be useful.

- Container: The design basis for the container is still very preliminary and as indicated earlier does not rely on site-specific data. Hydrothermal scoping experiments are presently under way investigating corrosion of mild steel in basaltic water. These indicate that corrosion may be retarded by formation of a protective film. No rigorous basis has yet been proposed to extrapolate such short term corrosion data to times of interest in the repository environment. This must await the completion of more sophisticated electrochemical corrosion tests following the scoping measurements. Scoping studies have not yet included coupons contacted with backfill or in a partial steam environment.

- Backfill: Key informational needs identified for backfill include thermal conductivities, permeabilities, and swelling behavior. This information is to be generated by direct measurement over the next few years. K_d values for various radionuclides are presently available in sodium bentonite which has been hydrothermally treated, and preliminary hydrothermal experiments on the chemical stability of crushed basalt have been carried out and secondary phases characterized. Efforts are under way to validate these accelerated tests by comparing the alteration products to those found in natural conditions.

Backfill properties (wet and dry thermal conductivity, wet and dry permeability at elevated temperature, etc.) are expected to play an important role in establishing the resaturation scenario. At present, this is not well defined, and is to be studied by direct experiment. Presently at least a partial steam environment seems a real possibility.

Presumably, it will also be necessary to establish under what conditions (if any) the backfill could be exposed to a wet/dry cycle.

o Radiation effects. Radiation effects data under site specific conditions were identified by SWIP personnel as a critical need to establish preliminary design requirements. Thus far, such site specific considerations have not been undertaken and, presumably, will not be treated in the SCR. The effect of ionizing radiation on near-field Eh and pH conditions, and its subsequent effect on corrosion, solubility, K_d, etc. has not yet been considered in detail. Some information along these lines is to be generated in hot cell hydrothermal experiments where the irradiation is produced by small samples of fully loaded waste form material.

KS:gfs