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Mr. O.L. Olson
Project Manager
Basalt Waste Isolation Project Office
U.S. Department of Energy
P.O. Box 550
Richland, WA 99352

Dear Mr. Olson:

Enclosed are our follow-up comments on the Barrier Materials Test Plan (BMTP), SD-BWI-TP-022, which was discussed during the BWIP/NRC workshop held in Gaithersburg on May 8 and 9, 1984.

Our comments are presented in the attachment to this letter in two sections. Section A provides considerations which NRC used to review the BMTP and identifies seven major topics of review. Section B includes specific comments on the seven major topics identified in Section A. The topic of geochemistry in Section B is intended to discuss specific elements which are normally considered to be geochemistry topics. These geochemistry elements are discussed in the review because of their direct influence on the waste package environment. Options for the waste package design may very well be provided by results of testing planned for these geochemistry elements.

Of the comments we provide BWIP in Section B, we consider the following to be the most important: (1) the unproven assumption of a return to a reducing environment shortly after repository closure and (2) the lack of relation of this test plan to waste package performance assessment and the waste package design.

Regarding comment (1), we do not find enough discussion on validating data to exclude consideration of an oxic environment for the waste package at closure. We consider that, from the results of the testings planned, it may not be possible to validate the assumed reducing environment.

Regarding comment (2), the BMTP noted the omission of the performance evaluation and waste package design sections. We do not agree with BWIP that performance evaluation methodologies do not have to be considered in evaluating whether the planned tests are pertinent to performance assessment even though the tests planned are generic in nature. We are concerned that without the benefit of knowing the full relationship between testing and waste package performance evaluation methodologies, a lot of the data collected may not be acceptable for license application. Given the already tight schedule BWIP has, it is important to make sure that all data collected will be accepted for license application and that minimum time will be spent on repeating tests.

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In conclusion, we suggest that the following be done to improve the BMTP:

1. Justify the assumption of a reducing environment for the waste package by referencing analytical work done on existing data. The work referenced should provide best estimates of the redox environment at closure, the time it takes to reach a stabilized redox level after repository closure and the effects this stabilized redox level has on the dominant failure modes of waste package components. If existing data do not fully support the assumed reducing environment, it will be necessary for BWIP to plan for tests in an oxic environment also.

2. Make provision in the BMTP to relate the planned testing to waste package performance assessment. This may be done by formalizing the interaction of the planning of the BMTP tests and the development of analytical techniques in waste package performance evaluation. The interaction should allow periodic review and modification of the barrier material test program and the waste package performance evaluation program to satisfy each others needs. The BMTP should also clearly define the performance allocation (or goal) for each waste package component (waste form, overpack and packing) so that NRC can evaluate the adequacy of the tests.

If you have any questions on the content of this letter and the enclosure, please call Kien Chang at (FTS) 427-4538.

Sincerely,

Joseph E. Kennedy
for

Robert J. Wright
Senior Technical Advisor
Repository Projects Branch
Division of Waste Management

Attachment:
As stated

OFC	WMEG	WMEG	WMGT	WMRP	WMRP	WMEG
NAME	KCChang:gh	TCJohnson	DBrooks	RWright	HMiller	LBarrett
DATE	11/ /84	11/ /84	11/ /84	11/ /84	11/ /84	11/ /84

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Follow-up Comments on the BMTP

Section A

The following considerations were used to guide NRC's review of BWIP's - BMTP.

1. Relevance of BMTP's tests and data to performance objectives for waste package stated in 10CFR60 and to the waste package issues stated in NRC's DSCA (NUREG-0960).

   The performance objectives are stated in § 60.111, 60.112 and 60.113. Other requirements related to the waste package are:

   § 60.135, Criteria for the Waste Package and its Components.
   §§ 60.137 and 60.140, Performance Confirmation
   § 60.142, Design Testing
   § 60.143, Monitoring and Testing of Waste Packages
   §§ 60.150 and 60.151, Quality Assurance

   The waste package issues are stated in Appendix C of NUREG-0960 (enclosure 1). Following issuance of NUREG-0960 in November 1982, NRC/BWIP meetings were held at Richland in June 13-17, 1983 to discuss NRC issues from the DSCA having significant impacts on the BWIP and BWIP's disposition and responses to NRC comments from Chapters 1 through 11 of the DSCA. These were documented in typed tabular forms dated May 25, 1983 and were supplemented by hand written notes made in the June meeting. An item of first priority identified in the June meeting is re-stated in enclosure 2.

   BWIP also documented progress of disposing NRC concerns in a document titled "Status of Nuclear Regulatory Commission Concerns Pertaining to the Site Characterization Report" SD-BWI-DIC-001 dated September 1, 1983. Among the concerns which remain unresolved are those identified in enclosure (3).

   At the request of DOE, Richland Operations; Pacific Northwest Laboratory (PNL) has reviewed the available data on the use of Hanford basalt as a nuclear waste repository. The resulting letter report dated November 1983 was screened by NRC for waste package related topics (enclosure 4). During the BWIP/NRC geochemistry workshop of January 1984, several topics were considered to require follow-up discussing in BWIP/NRC waste package meeting. These topics are included in enclosure 5.

2. What scenario and waste package design(s) is the BMTP based on? Determine if the planned tests will provide sufficient data to address the dominant failure scenarios for the waste package.

   The subject of failure scenarios (both anticipated and unanticipated) was not specifically discussed in the BMTP. Since the publication of the report "Waste Package Conceptual Designs for a Nuclear Repository in Basalt" (RHO-BW-CR-136P/AESD-TME-3142 Oct. 1982), there has been no

discussion on the changes to the waste package conceptual design. Therefore for the purpose of this NRC review, the reference design described in the October 1982 report is considered to be the latest conceptual design and that only a non-site specific (generic to basalt type of repository) and anticipated scenario is assumed. Nevertheless both anticipated and unanticipated events must be considered in siting as stated in 10CFR60 § 60.122. Until the dominant overall repository failure scenarios are better understood and defined by BWIP, the planned tests must provide sufficient flexibility in scope to account for all dominant waste package failure modes.

3. Determine if the tests will yield sufficient data for an independent assessment of waste package performance and an independent development of a performance model.

   NRC staff considers that unless the failure processes are very well understood, in which case a deterministic performance model can be developed to predict waste package performance, it may require a large number of long time tests to address the waste package performance with the development of a probabilistic model. A review of data sufficiency of the BMTP is hampered by omission of the performance evaluation and design development sections of the BMTP. The BMTP is thus reviewed by NRC considering the adequacy of the data to be collected for NRC's assessment of waste package performance and possible NRC's development of a performance model.

4. Does NRC agree with the test details and experimental set-ups and test conditions defined in the plan? If not, identify the shortcomings and propose improvements.

   NRC does not find enough test details on test conditions in the BMTP. The test details may however be provided by the large number of documents referenced by the BMTP. For the purpose of this review, the NRC staff will concentrate on overall experimental approach proposed by the plan and will review the test details when they are available (e.g., test procedures and test specifications).

5. Determine if the test schedule is realistic. This aspect of the plan is reviewed with the NWPA schedule in mind.

6. Determine if the test sequence is logical.

7. Geochemistry topics related to waste package environment and waste package performance evaluation.

   With the considerations discussed above, seven topics have been identified for NRC review of BMTP. These are listed and discussed in Section B of this attachment.

SECTION B

TOPICS for NRC REVIEW of BWIP's BMTP

1. BWIP's Statistical Test Design

   This constitutes Appendix A of BMTP. It is part of BWIP's effort to resolve one of the "open issues" documented in SD-BWI-DIC-001 (p. III-198 Item 1).

2. BWIP's Rationale and Approach on Testing.

   These are Appendices B and C of BMTP: Appendix B "Scientific Rationale for Waste/Barrier/Rock Interaction Testing" (The Ostwald Step Rule) and Appendix C "Approach to Waste/Barrier/Rock Interaction Testing."

3. Corrosion Tests and Data

   Three areas related to corrosion will be discussed:

   (a) Basalt's redox environment pertinent to corrosion testing,

   (b) Tests and data on localized corrosion and hydrogen-related degradation mechanism and

   (c) Mechanistic understanding of corrosion.

4. Packing Tests and Data

5. Overall Data Sufficiency for Waste Package Performance Assessment.

6. Test Schedule and Test Logic and

7. Geochemistry

The seven topics stated above are discussed in this section under the headings of "Comments," "Significance of Comments" and "Suggestions to Resolve the Comments."

BWIP'S STATISTICAL TEST DESIGN

APPENDIX A "STATISTICAL TEST DESIGN"

Comments

The BMTP proposes using full and fractional factorial design of experiments for screening tests, for tests to obtain empirical models, and for accelerated aging tests.

In principle both full and fractional factorial design of experiments constitute acceptable approaches as long as they are backed by sound statistical analyses. In particular factorial techniques are especially useful at the screening stage. Modeling requires higher level experimenting and an analysis of the statistical uncertainty of the data and models. The BMTP does not address uncertainty analysis.

Statistical design is certainly acceptable for accelerated aging tests. In these cases it is important to show that the mechanisms to be investigated are not replaced by other mechanisms due to the selected, abnormal stress levels.

Significance of Comments

It is not clear from the document whether uncertainty analysis will be performed. The proposed methodology has the potential for such an analysis.

NRC will need an uncertainty analysis of the data and models in order to judge compliance with 10CFR60.

Suggestions to Resolve the Comments

Along with test results DOE should also provide test plans and analyses detailing

A. the parameters scoped for, indicating as well if some particular parameters were dismissed a priori and why

B. Rationale why a specific number of levels was selected

C. Rationale in assigning level values

D. Error tolerance for each level value

E. Experimental error analysis where appropriate. This should address accuracy and precision of measurements. Furthermore, any regression or FIT should have an analysis of confidence of FIT.

BWIP'S RATIONALE AND APPROACH ON TESTING

SCIENTIFIC RATIONALE FOR WASTE/BARRIER/ROCK

INTERACTION TESTING (APPENDIX B)

Comments

The Ostwald Step Rule may eventually prove to be an acceptable approach for estimating long term controlled release.

However, possible problems associated with the Step Rule which should be addressed in a test program include:

(a) The Step Rule, strictly speaking, is only valid for a closed isothermal system. In a basalt repository there will be mass flow in and out of the waste package. Flow rate effects should, therefore, be evaluated.

(b) As a waste package cools, the solubilities of some radionuclides could increase because of inverse temperature effects.

(c) The Step Rule, as stated in (a) above is valid for a closed system containing a constant inventory of atoms. This is not the case in a waste package because of transmutation. Thus it is possible that a phase rich in radionuclide X could become more soluble as X begins to transmute to Y.

(d) Alpha radiation damage in a precipitated phase could cause an increase in solubility because of the formation of amorphous material. Also if alpha damage gives a large increase in the stored energy in a phase it may cause dissolution.

(e) The Step Rule describes the progression of precipitation in groundwater and is therefore concerned with major element geochemistry. Radionuclides on the other hand are present as trace elements in precipitating phases. Thus the solubility of various radionuclides will probably be determined by the major non-radioactive elements present in a phase.

Significance of Comments

The comments above show that the fundamental bases for the applicability of the Step Rule are questionable for the BWIP repository system. Comprehensive testing will be needed to establish shortcomings in the Step Rule so that deficiencies can be accommodated and conservative estimates of solubility are obtained for performance assessment and licensing.

Suggestions to Resolve the Comments

BWIP should include in their Test Plan a specific program to determine how groundwater flow, alpha radiation of precipitation phases, transmutation in

precipitated phases, and possible inverse temperature effects control solubilities.

In addition to tests to measure solubility from undersaturated solutions as planned for in the BMTP, it will be important for BWIP to measure solubilities from the oversaturated direction using a technique similar to Fullam's (Scientific Basis for Nuclear Waste Management V, North Holland, 1982, p. 173) in which saturation is achieved at a higher temperature. The resultant solution should be cooled and maintained at the test temperature prior to solubility measurements. This type of thermal change is similar to that found in a repository. Fullam found that these solubilities were much higher than those obtained from strictly isothermal experiments. He suggested that under isothermal conditions, solubilities could actually increase with time which is not in accordance with the Step Rule. The BMTP, Appendix B should include a discussion to address the applicability of the Step Rule when the effects of transmutation of elements and alpha radiation on phase stability are considered.

APPROACH TO WASTE/BARRIER/ROCK INTERACTION TESTING

(APPENDIX C)

Comments

Figure C-1 (Appendix C) outlines the BWIP approach to waste/barrier/rock interaction testing.

This approach is logical but it is not clear whether, in fact, the BMTP specifies tests under the conditions described in Figure C-1.

It must be recognized that there is a spectrum of water chemistries around the waste package and this spectrum varies with time and temperature. For example, Figure C-1 seems to indicate that there is a unique water B chemistry in the packing throughout the packing. This is highly unlikely since water entering the packing from the hard rock will be low in constituents from bentonite/water reactions, whereas water approaching the container will contain large quantities of these constituents together with modified amounts of the dissolved solids that were present in the original water which entered the packing. There is, therefore, a spectrum of water chemistries in the packing material. This is also true for packing materials on the "downstream" side of the waste package.

If a test program is used in which, for example, a metal is corroded in the presence of a mixture of basalt/benonite/Grande Ronde water (Figure 5-13 of BMTP) it will not give the appropriate water chemistry for container corrosion.

Page 5-81 (Top) states "Tests will be conducted in autoclaves containing synthetic Grande Ronde basalt groundwater, crushed basalt rock, and bentonite." This is not appropriate since the water first contacting an actual container will be significantly different than Grande Ronde water.

Significance of Comments

The use of test procedures which do not employ anticipated water chemistries, etc., may yield data on corrosion, source term speciation, solubilities, and sorption which do not conservatively estimate waste package performance. Such data may not be acceptable for licensing.

Suggestions to Resolve the Comments

Before running interaction tests involving groundwater and components of the waste package, tests should be conducted to determine water chemistries using procedures which accurately reflect their sequential development. These may then be compared with BWIP type tests data using static systems in which various combinations of package components are reacted together in a non-sequential manner. A possible sequence of experiments is given below:

(a) High-temperature water/basalt tests at one atmosphere to allow precipitation of dissolved salts from Grande Ronde water during the repository operation period.

(b) Interaction of this modified basalt with water under hydrothermal conditions to determine the likely chemistry of water entering the packing.

(c) Carry out high temperature/column test if feasible to determine how the water chemistry is changed as the water approaches the container.

(d) Use this water chemistry for container corrosion tests.

(e) Determine how water chemistry changes during corrosion and use this water chemistry for water solubility tests.

(f) Compare all of this water chemistry with those obtained in static tests for appropriate combinations of packing materials.

A similar set of experiments could be carried out for the chemistries of waters which are "downstream" from the waste.

BWIP'S REDOX ENVIRONMENT PERTINENT TO CORROSION TESTING

Comments

The BWIP testing program is based on the assumption that the groundwater will be anoxic except for a brief period immediately following closure and that for corrosion (and other) testing purposes one can assume that all significant processes are governed by a very reducing E_h which will prevail in the near-field environment.

There are a number of factors which make this assumption questionable:

(a) Gamma radiaton and, after breach, alpha radiation, will continuously generate oxidizing species by radiolysis of water.

(b) Hydrogen produced by radiolysis and corrosion may dissolve in the containers and may also escape because of its high diffusivity. Oxygen and peroxide species produced by radiolysis can be significant.

(c) The presence of methane is irrelevant because of its very sluggish oxidation kinetics in aqueous environments.

(d) The buffering capacity of basalt is limited to surfaces. New surfaces generated during mining will have been exposed to air during the operational period; old surfaces (pores and existing cracks) will have been exposed to groundwater over geologic times.

(e) It is not clear that the concept of a system master E_h will be useful in predicting localized corrosion behavior.

Significance of the Comments

If the testing program is based on the assumptions that the groundwater is anoxic and that all significant processes are controlled by a very reducing E_h, there is considerable risk that DOE may not have sufficient data to support their license application because it may not be possible to provide reasonable assurance of the validity of the assumptions. In this case, in the absence of test data under more oxidizing conditions, the ability of the waste package to meet the requirements of 10 CFR 60 will not have been demonstrated.

The assumption that groundwater will be anoxic for all or most of the post-closure period will result in lower estimates of container corrosion (especially localized forms of corrosion for which the availability of dissolved oxygen is important), lower rates of dissolution of the waste form and enhanced sorption of soluble radionuclides by the packing material.

Suggestion to Resolve the Comments

Corrosion data for each potential failure mechanism (uniform corrosion, pitting corrosion, hydrogen embrittlement, etc.) should be collected under the most unfavorable conditions for the particular failure mechanism consistent with what is certainly known about the environment (e.g., hydrogen damage should be collected under the most reducing plausible conditions, whereas pitting corrosion

data should in general be taken under the most oxidizing plausible conditions). At the same time, of course, DOE retains the option of demonstrating that the environment will be characterized by some fixed E_h, that there is sufficient buffering capacity to maintain this E_h during the relevant storage period, and that this E_h does in fact control the significant processes.

Furthermore, DOE needs to collect more mechanistic data so as to permit confidence in extrapolations and interpolations. It should be borne in mind that <u>any</u> extrapolation or interpolation involves the assumption that there is no significant change in mechanism, and that such an assumption must almost always be based on considerable detailed mechanistic knowledge.

LOCALIZED CORROSION

Comment

The plan for experimental studies on localized corrosion and hydrogen-related degradation mechanisms needs to be described in detail.

Significance of the Comment

It appears that if reasonable care is taken with the choice of site and with container design and manufacture, the most probable cause of container failure will be some sort of localized corrosion (or possibly hydrogen-related degradation), quite likely at a weldment. Unlike general corrosion, these types of failure mechanisms often depend strongly on variations in the concentrations of alloying elements (e.g., the stress corrosion cracking behavior of low-carbon steels in some environments depends strongly on C content; pitting behavior of some steels is severely aggravated by minor quantities of Cu, S, and possibly P), as well as on metal cleanliness, thermal history, and texture.

Suggestions to Resolve the Comment

The appropriate test plans need to be developed. The test plans should include more careful specification of alloy chemistry, cleanliness, thermal history and the fabrication and joining processes to be employed than is typically necessary for general corrosion.

OBTAINING A MECHANISTIC UNDERSTANDING

Comments

The BMTP states (p. 5-72) that, "a mechanistic understanding of container materials behavior is essential, "but does not describe the method with which BWIP plans to obtain such an understanding.

Significance of the Comments

Such an understanding is essential to clearly determine the extrapolation of data and reasoning from one set of conditions to another. Since BWIP cannot possibly blanket all imaginable conditions with tests, such extrapolation will be necessary.

Suggestions to Resolve the Comments

The amount of mechanistic understanding necessary for a particular component will be proportional to the degree of reliance assigned to that component in the forthcoming BMTP performance assessment analysis. Therefore the performance assessment analysis should not only address the reliability assigned to the particular waste package components but also describe the plans (detailed test procedures) by which the appropriate degree of mechanistic understanding will be achieved.

PACKING TESTS AND DATA

PACKING MATERIAL CONSIDERATIONS

Comments

The packing material program needs clarification with respect to defining tests spanning anticipated conditions. Also it seems that some BWIP tests are of limited importance to licensing. Specific comments include:

(a) Need to determine the physical characteristics and uniformity of full scale emplaced packing to ensure that laboratory tests are conducted on appropriate material.

(b) Alpha irradiation damage may change the permeability and sorptive capacity of packing.

(c) BWIP should address the differences in the performance of packing for a range of container failure times. This is important because 1000-year old packing may behave better or worse than 300 year old packing with respect to permeability, solubility of radionuclides, sorptive capacity, etc.

(d) Need to address the adequacy of dry packing material conditions to cover potential problems associated with low thermal conductivity and the peak temperature of N300°C in the packing and waste form following closure and before resaturation.

(e) Need to explain the logic for conducting static diffusion/transport tests for radioactive tracers in a gamma field with hydrothermally altered packing (Figure 5-19 of BMTP). With the exception of premature overpack failure, the gamma effects during the controlled release period should be negligible.

However, it is necessary to run these tests for packing material that has been both radiolytically and hydrothermally aged.

Significance of the Comments

The use of high integrity laboratory samples of packing material will probably give better performance compared to actually emplaced packing. Data obtained will therefore be non-conservative and of limited value for licensing.

Alpha damage may become significant after many thousands of years so that solubilities and controlled release rates for radionuclides are increased in the very long term.

Also, the performance of unnecessary tests will probably reduce efforts in areas where important licensing data are needed.

Suggestions to Resolve the Comments

(a) NRC requests a description of current work on full-scale emplaced packing material. This will enable NRC to determine whether the

required packing densities and porosities can be achieved, and if the planned tests on packing are acceptable. BWIP should also consider the testing of samples taken from packing core which has been emplaced by the recommended packing procedure.

In figure 5-19, BWIP has a task to "perform static diffision testing of radioactive tracer in a gamma field with hydrothermally altered packing". This is not appropriate. During the controlled release period, gamma radiation is essentially absent. Thus the test material should be hydrothermally altered while being irradiated, and then tested in a non-radiation environment.

(b) The effects of long-term alpha radiation should be addressed by BWIP. Actinide-doped water passing through packing material will not cause much radiation damage to bentonite or basalt surface in short term tests. Therefore, BWIP should consider testing a packing material that has received significant doses of alpha radiation prior to testing for radionuclide sorption behavior.

It is possible that after, say, 5,000 years the bentonite has suffered so much alpha radiation damage that the controlled release rate will be greatly increased because of higher permeability and decreased radionuclide sorption.

(c) BWIP should consider the implications of containment failure times on packing materials performance. Presumably, the number of colloids and particles in the packing will decrease as the containment time increases due to their transport by repository water. Thus interactions of radionuclides with packing material starting after 300 years and after 1,000 years could yield quite different transport rates. The BWIP tests should, therefore, evaluate the rate of colloid/particle formation, their transportation rate, and how these influence radionuclide transport rates over the controlled release period.

(d) It is not clear from the write-up if the dry packing test conditions cover the potential problem of low thermal conductivity and the resulting peak temperatures of 300°C in both the packing and the waste form following closure and before resaturation.

Low thermal conductivity conditions in the dry packing could produce temperatures above the design limit of the packing and perhaps the waste form (Ref. Westinghouse 1982). This might result in some degradation of the packing's ability to swell upon resaturation.

It is suggested that the packing test section write-up be revised to cover this potential problem. Under the test conditions for dry packing thermal conductivity (Table 5-17) it is suggested that an extended range of temperatures (perhaps to 370°C) and packing densities would improve the thermal property data base in this important design area. Swelling tests should also cover this extended temperature range to ensure availability of swelling data on dried packing material.

Ref. RHO-BW-CR-136 P, Waste Package Conceptual Designs for a Nuclear Repository in Basalt, Oct. 1982 (Westinghouse Electric Corp.)

PERFORMANCE ASSESSMENT

Comments

The Current version of the BMTP does not contain the information necessary to establish the relationship between the test program and the performance assessment that will eventually use the data from the tests.

Significance of Comments

A primary objective of the test program is to provide data to support the performance assessment necessary for meeting NRC and EPA licensing requirements. The performance assessment techniques used by BWIP may influence how BWIP collects the data. Accordingly, understanding how the data will be used in performance assessment is essential to the NRC review of the adequacy of the BMTP.

Suggestions to Resolve the Comments

Because the performance assessment section of the BMTP will not be added until the September 1984 revision, it would be very helpful if the NRC were provided with an advance summary of the BWIP performance assessment approach. In particular, it is desirable to have information such as whether the approach will be stochastic, deterministic, or some combination, the role of uncertainty and sensitivity analysis in deciding future tests and whether the approach will use large consolidated models or smaller models whose results are combined using professional judgement.

In addition, it would be desirable to know the codes to be used and the role of uncertainty and sensitivity analysis. In the event the particular BWIP performance assessment techniques have not been chosen, a discussion of the alternatives under consideration and a summary of their basic characteristics would be helpful.

DATA SUFFICIENCY

Comments

The BMTP draft in the present form (even with logic charts and work breakdown charts) does not provide a summary list of planned tests and test plan schedules that can be readily interpreted. The use of bounding or conservative values is not mentioned; testing appears to be oriented toward developing best-estimates.

Significance of Comment

The lack of this list of tests leaves NRC without an idea of when tests will be done and when data will be available e.g. Will individual test plans be available to NRC for constructive comment before tests are performed? When after the tests are completed will the data be available for similar NRC comment before follow-on tests are started? Knowledge of the bounds on data accuracy is essential for NRC performance assessment. If it is not possible to develop defensible best-estimates, bounding or conservative valves will be easier to obtain.

Suggestions to Resolve the Comments

Add lists of summary tests matrix charts and test and report schedules. With respect to data collection and presentation, it is suggested that while developing best-estmates for test data, BWIP should define bounds for these data especially for those data for which best-estimates are not defensible.

TEST SCHEDULE-TEST LOGIC

LOGIC/SCHEDULAR DIAGRAMS

Comments

It is recognized that Logic Diagrams are very difficult to prepare with respect to defining appropriate test programs and test conditions. This arises because waste package designs determine the test materials, test temperature, water chemistries, etc., but these designs can only be optimized if appropriate test data are obtained. Thus there will need to be many interactions in design and testing programs before a finalized design can be specified and its performance determined.

The BWIP Logic Diagrams, however, do not detail decision points at which modified test conditions will have to be used. It appears that the container corrosion, the packing material and the waste form programs will proceed independently with no formal interaction, using a range of preselected tests conditions, rather than periodically modified ones. It is also not clear how BWIP will choose between the many possible combinations of experimental parameters and analytical tests figures, given in the summary tables, as the work proceeds.

Significance of Comments

It seems that the BWIP Logic and Schedular Diagrams assume fully successful progress in all aspects of the individual programs. NRC is concerned that the discovery of a new important test environment may invalidate much of the early data. This would detrimentally affect the BWIP schedule and NRC's associated licensing activities.

Suggestions to Resolve the Comments

NRC suggests that in periodic BWIP/NRC workshops that BWIP give status reports on progress to date. BWIP should outline possible contingency plans for minimizing schedular delays if there are significant changes in tests that are currently specified in the BMTP.

BWIP should consider the inclusion of test matrices and "decision trees" in the final version of the BMTP.

KEY RADIONUCLIDE LIST

GEOCHEMISTRY

COMMENT

- 0 SOME RADIONUCLIDES WILL BE MUCH MORE IMPORTANT THAN OTHERS IN CONTRIBUTING TO RADIOACTIVITY RELEASE TO THE ENVIRONMENT

- 0 BWIP HAS NOT PUBLISHED THE SUPPORTING DOCUMENTATION SHOWING HOW THIS LIST WAS DEVELOPED

SIGNIFICANCE OF COMMENT

- 0 THE BMTP CONTAINS A KEY RADIONUCLIDE TABLE ON PAGE 5-49

- 0 THE LIST WILL HELP DIRECT THE BWIP EXPERIMENTAL EFFORT

SUGGESTIONS

- 0 THE ASSUMPTIONS AND CALCULATIONS USED TO DEVELOP THIS LIST SHOULD BE DOCUMENTED FOR REVIEW AND ANALYSIS

OSTWALD STEP DIAGRAM AS A MODEL FOR RADIONUCLIDE SOLUBILITY LIMITS

COMMENT

- 0 THE OSTWALD STEP DIAGRAM IS CLEARLY NON-CONSERVATIVE FOR THE PREDICTION OF RADIONUCLIDE SOLUBILITY LIMITS

SIGNIFICANCE OF COMMENT

- 0 APPENDIX B OF THE BMTP ATTEMPTS TO USE THIS AS PROOF THAT ANY RADIONUCLIDE CONCENTRATION VALUE MEASURED AT ANY TEST TIME WOULD EITHER STAY THE SAME OR DECREASE WITH TIME, I.E., THAT ANY TEST VALUE WILL BE CONSERVATIVE

SUGGESTIONS

- BWIP SHOULD CONSIDER:
  - 0 THAT THE OSTWALD STEP DIAGRAM HAS ONLY BEEN VALIDATED FOR SILICATE MATERIALS
  - 0 THAT THE OSTWALD STEP DIAGRAM IS ONLY APPLICABLE IF A SOLID PHASE OF THE RADIONUCLIDE PRECIPITATES
  - 0 THAT IF RADIONUCLIDES ARE REMOVED FROM SOLUTION BY INTERSTITIAL SUBSTITUTION INTO OR SORPTION ONTO POORLY CRYSTALLINE SILICATES, THE RADIONUCLIDES MAY BE RELEASED TO THE SOLUTION AT A LATER TIME WHEN THE SILICATES RECRYSTALLIZED TO MORE STABLE, BETTER ORDERED MINERALS, I.E., THE RADIONUCLIDE CONCENTRATION MAY <u>INCREASE</u> WITH TIME, NOT DECREASE

- THESE ARGUMENTS ARE STRICTLY VALID ONLY FOR A CLOSED SYSTEM, AND THE OSTWALD STEP DIAGRAM MAY BE INAPPLICABLE TO FLOWING OPEN SYSTEMS

REDOX POTENTIAL OF BASALT/GROUNDWATER SYSTEMS

COMMENT

- IN MANY PLACES THE BMTP STATES THAT THE TEST E_H WILL BE MEASURED AND/OR CONTROLLED

SIGNIFICANCE OF COMMENT

- THE SYSTEM E_H WILL AFFECT THE VALENCE OF THE RADIONUCLIDES
- IN GENERAL, REDUCED RADIONUCLIDES MAY BE LESS SOLUBLE AND/OR MORE STRONGLY ADSORBED
- IT IS UNCERTAIN IF A SYSTEM MASTER E_H IS EFFECTIVE, OR EVEN IF MEANINGFUL E_H VALUES CAN BE MEASURED IN SOME EXPERIMENTS
- THE SYSTEM E_H OR REDOX CONDITION TO BE EXPECTED IN THE ENGINEERED FACILITY OR THE SITE HOST ROCKS THROUGH REPOSITORY TIME HAS NOT BEEN WELL ESTABLISHED
- EMPLOYMENT OF ADDED CHEMICAL REDUCTANTS MAY POORLY MODEL HETEROGENEOUS BASALT/GROUNDWATER SOLUTE REACTIONS

SUGGESTIONS

BWIP SHOULD RECONSIDER:

- IF IT IS CONSERVATIVE TO ATTEMPT TO CONTROL TEST E_H AT SOME PRECONCEIVED VALUE

- IF IT CAN BE PROVEN THAT A MASTER E_H EXISTS FOR TESTS, I.E., THAT ALL REDOX COUPLES IN THE TEST ARE AT THE SAME E_H CONDITION

- IF ANOXIC CONDITION (AIR EXCLUDED) TESTS WITHOUT DELIBERATE E_H CONTROL MAY NOT BETTER MODEL EXPECTED REPOSITORY CONDITIONS THAN TESTS HELD AT PREDETERMINED E_H VALUES

- IF MEASUREMENT OF E_H PROVES DIFFICULT OR UNCERTAIN, IS SUCH MEASUREMENT NECESSARY FOR LICENSING

- IF THE EXPECTED REDOX CONDITION (OR E_H) CAN BE PREDICTED FOR THE ENGINEERED FACILITY AND THE SITE THROUGH TIME WITH THE PRESENT INFORMATION ABOUT BASALT PHASES, RADIOLYTIC EFFECTS, ETC.

- IF EXPERIMENTAL RESULTS PREVIOUSLY OBTAINED IN THE PRESENCE OR HYDRAZINE (RADIONUCLIDE SORPTION VALVES) ARE CONSERVATIVE AND ACCEPTABLE FOR LICENSING APPLICATION