

Monthly Letter Report for January 1986

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TASK 1 - Review of Waste Package Data Base

Reviews reported previously are in various stages of updating. Interactions continue with Pickelsimer, Haller, Corning, et al., as possible outside reviewers for reports that contain data on zircaloy, glass leaching, and other subjects outside the expertise of the previously identified NBS HLW program staff.

Weekly meetings were held to resolve the questions that arose as reviewers used our prototype data review sheets, which were first submitted by the contractor, C. Messina, last month. This month the contractor completed phases 2 and 3 of the contract for the development of a database in support of the HLW program effort. Deliverables received included:

1. Appropriate formats for output reports suitable for use with the DBMS Revelation, containing logically grouped sets of fields.
2. Prototype HLW Data Review Sheets for recording waste package information.

These deliverables were developed by cooperative efforts of this contractor and NBS reviewers.

A preliminary set of three NBS reviews was sent to WERB to initiate the process of development of procedures for publication approval of NBS reviews of DOE reports.

SRP

A review of the following SRP report was initiated this month as part of our preparation for the NRC/SRP Workshop described below:

Jansen, G. 1984: "Expected Waste Package Performance for Nuclear Waste Repositories in Three Salt Formations," BMI/ONWI (MS-623SS).

BWIP

No reviews were initiated during this month.

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NNWSI

Reviews were initiated this month on the following NNWSI reports:

"FY1985 Status Report on Feasibility Assessment of Copper-Base Waste Pkg.....Tuff Repository," R. D. McCright, UCID-20509.

Two NNWSI reports under consideration for review are as follows:

UCRL-15723, "NNWSI Waste Form Test Method for Unsaturated Disposal Conditions", J.K. Bates & T. J. Gerding, March 1985.

UCRL-92096, "Derivation of a Waste Package Source Term for NNWSI from the Results of Laboratory Experiments," V. Oversby and C. Wilson, Sept. 1985.

TASK 2 - Identification of Additional Data Required and Identification of Tests to Generate the Data

Copies of the Report of the DOE Ad Hoc Corrosion Panel were distributed to all members of NBS staff for informal review to be conducted in conjunction with their work on this task.

TASK 4 - General Technical Assistance

The ASTM Subcommittee C26.06 on Nuclear Waste Management met on January 17, 1986 in New Orleans, and in conjunction with these meetings, a seminar was held by their High-Level Task Force. The objectives of this task force are to support the subcommittee's interest in the development of guidelines for predictive or accelerated testing of materials used in the high-level waste package (HLWP) for deep geological disposal. This was the first of at least three seminars planned to support the aims of this task force. Meeting notes, a journalistic report on this seminar, taken by C. Interrante are attached to this report.

SALT Meetings

The DOE/NRC Salt Repository Project (SRP) Workshop was held at Battelle Columbus on January 22-24, 1986. The attached report on that meeting is a synopsis of the meeting topics and the comments of NBS workers on the issues relevant to the waste package. The NBS workers who attended this workshop are C.G. Interrante, M.J. Kaufman and R.D. Shull.

NRC Workshop on Model Validation

On January 29th in Bethesda, U. Bertocci and E. Escalante attended a workshop on "Validation of Mathematical Models for Waste Repository Performance Assessment -- Confidence Building Through Synthesis of Experiments and Calculations." A report of their observations at that meeting is appended to this report. Dr. Bertocci also participated as a panelist in a panel discussion at that meeting.

Meeting Notes Taken at a
Seminar on Predictive Testing
January 17, 1986, Sheraton-New Orleans
(9:00a.m. to 1:00p.m.)

Opening remarks were given by Ed Kuhn, Co-chairman of the High-Level Task Force of ASTM C26-07, Subcommittee on Nuclear Waste Management. His remarks and those of the other speakers are paraphrased here, and a few observations and comments from the writer of this report are interjected.

He indicated that, at this meeting, there is a concensus group of about 25 workers representing laboratories, industries, and government; these workers can provide favorable impetus to the HLW Program by efforts aimed at development of predictive accelerated testing for the HLW package. The hope is that standards can be developed and these will pave the way to speedier licensing of HLW repositories. While technical problems are expected to be difficult, predictive testing has been done, within ASTM, by NASA, and in military programs, so this is not an unexplored area.

Need for Predictive Testing

Dan Mertz (Battelle NW) spoke on the need for ASTM Guidelines for Predictive Testing: The 300 to 1000 year requirement of 10 CFR 60 is somewhat unprecedented. Usually inspections can be made during the "service" life of a component or system. Therefore, reliability of the predictive methods and of the data are most cogent here. The methods of prediction are complicated by the myriad of materials currently under consideration. The variation in temperature over the service period is another complicating factor. Corrosion rates often decrease with time, and one conservatism that can be used is to assume a lower corrosion rate than predicted. But changes in mechanisms, etc., which may occur over time, introduce a degree of uncertainty to the predictions.

Models - Testing should fit a best available model. DOE is working on models in the areas of pitting, electrochemistry, thermodynamics, transport processes, radiolysis, and rock-water interactions.

ASTM can be effective in this program because it is a voluntary and public organization and it is not milestone driven. Further, it has nationwide recognition as an unbiased body. Subcommittee C26.07 should draft guidelines, obtain Society (ASTM) acceptance of them and thus furnish guidelines to support project license applications.

NRC Perspective

Kio-Kim (NRC) spoke briefly and discussed ways in which ASTM standards have been used in licensing in the past. The HLW program is very difficult, as the complexities of the waste-package systems are such as to make the problems here more difficult for ASTM or any workers. His remarks were supportive of the proposition that ASTM involvement could render valuable assistance to the process of licensing.

Tim Johnson (NRC) briefly discussed the engineered barriers system, including some geochemical considerations. The precedents for the use of standards (ASME, AISI, ASTM) in licensing procedures of the past speak favorably for development and use of appropriate standards for this application.

The DOE test program should be based on fundamental understandings of the degradation mechanisms. It should involve testing that is conducted on a conservative basis; the environmental envelope should be wide, at least initially. Appropriate tests to assure performance confirmation during the period up to permanent closure of the repository should be conducted. A program that

supports these three elements is needed in a favorable licensing application. Important points that should be considered for standards for this application were named:

- a. Definition of standard environmental test conditions.
- b. Development of test methods oriented toward understanding the pertinent degradation mechanisms.
- c. Development of accelerated test methods applicable to the materials used in waste package and EBS components.
- d. Development and qualification of test methods and instrumentation for in-site confirmatory testing.
- e. Reliability evaluations of standard test methods.
- f. Appropriate duration of tests.

The NRC has actively participated in numerous standards development activities in the past, and in this area, DOE and this program can benefit from ASTM standards development.

Siva Gopal on the ONWI (Salt) Program

S. Gopal indicated that accelerated tests may violate assumptions built into the test. Further, predictive modeling has inherent extrapolational errors. A report on general corrosion of low-carbon steel has been written and is currently under peer review. Testing will be the next step. Accelerated testing implies that no mechanistic change occurs with time and that the data (short time) applies to and is valid for longer times. But the mechanism may change when a parameter (like temperature) is changed, and this may yield data that is inappropriate.

Uncertainties associated with extrapolation of 5-year data to 300 or 1000y performance must be dealt with carefully. One must understand the effect of time at values of time that are unavailable to the experimentalist. Thus, there exists a dilemma.

He concluded by indicating that a site-specific plan for salt has been developed.

Patricia Salter on the BWIP spoke (Basalt) Program

Data must be collected between now and 1990 to develop the supporting data needed in a license application. This opens the question of the extent to which ASTM standards can be used in this data-collection process.

Geochemical Parameters on repository isolation performance was reviewed; mentioned were temperature, pressure, host rock (basalt), Eh (redox potential), pH, and groundwater composition. The conceptual design for this waste package was briefly discussed, and the functions of each component of the waste package for BWIP were briefly reviewed.

For protective testing, short-term tests are used (1) to develop conceptual models on the degradation behavior and (2) as a data base for performance assessment, e.g., to furnish data on effects of overstressing. Peer review is conducted on this work.

In addition, 1 to 50 year long-term bench scale (1/2 to 1/4 size) testing is done. Testing in situ is probably not practical, as the time required to obtain a measurable effect may be excessive. This long-term testing work will permit

validation of the computer codes and the data base. With the expectations that the data will be complete, probabilistic performance assessments can be conducted. Thus, reasonable assurance of performance is to be demonstrated.

Various waste-package-container testing is underway on corrosion resistance, cracking resistance and assurance of uniform corrosion. Nonuniform loading is taken into account.

Packing-material testing is aimed at diffusion (transport) of the radionuclides released. The radionuclide release testing centers on base-state concentrations. Nuclides will saturate the water and then will precipitate as secondary phases.

Accelerated testing involves increases in the values of temperature, surface areas and/or flow rates. The use of these increased values can be done only on a selected basis. Their suitability can be decided only on a case by case basis, as the individual test and the effects of the changes (the increased values of the parameters) are understood. In concluding, she indicated that pitting studies are conducted for BWIP at Rockwell Science and Westinghouse Hanford.

Dan McCright (LLNL) on the NNWSI (tuff) Program

The Yucca Mountain site in Nevada was discussed as an unsaturated site without the hydrostatic or lithostatic conditions that prevail at the other sites. Again, temperature was shown as an important variable, with a 250°C expected maximum for the container.

The package would be above 100°C, for 1000 years for spent fuel and for over 100 years for defense waste. The J-13 well water was characterized as being low in ionics, chlorides, and with a dominant cation of sodium.

The conceptual reference design for spent fuel and for defense and commercial low-level waste were mentioned. Stainless steels 304L, 316L, 321, 347 and Incoloy 825 were mentioned along with copper and copper-base alloys. Carbon steel was mentioned as a liner material. The problems with and the relative merits of the stainless steels and Incoloy 825 were discussed.

Degradation processes were quickly reviewed: Corrosion/oxidation responses, environmental and material factors, pitting, crevice attack, sensitization. Austenite stability was briefly discussed: The 304L stainless is metastable and the austenite to martensite transformation may occur. The added nickel in the Incoloy tends to preclude this transformation for the 825. The 321 and 316 stainless grades have retained ferrite and some reduced tendency for transformation, but the ferrite and its effects on performance must be considered. Failure mechanisms and local corrosion were mentioned as important factors of concern and study, in their program.

Corrosion concerns for copper and copper-base alloys were mentioned. These materials were presented as having less vulnerability to localized attack.

This program's general procedures for generating a corrosion database was mentioned. One plan for extrapolation is to use the 3 to 5-year data to make the first decade of extrapolation to 30 to 50 years. Some testing could be done alongside of the buried waste. The electrochemistry which drives corrosion processes, is a primary emphasis in the program. By 1987, they wish to narrow the materials selection down to 2 materials. Materials tests guide this work. Coupon tests, stressed and pre-stressed tests, tubular-specimen tests, electrochemical tests (in and out of a radiation field), and calculational aspects of sensitization are being reviewed.

Art Brown on Crystalline Repository

The last formal presentation was brief. It was given by Art Brown of Battelle Columbus Laboratories, who spoke on the crystalline repository as the second of the repositories, which would go into effect about 6 years after the first one. Their program looks at numerous rock bodies and it is leading to the selection of 12 rock bodies in 7 states. A schedule for the Crystalline Repository Project's waste package development was outlined. The test plan for materials begins in 1988 or 1989. They plan to use the data, and other information, developed in the other project offices.

The C26.07 Chairman, Dick Blauvelt, indicated that he would send copies of transparencies presented here to all participants. The last week in July '86 is the planned time for the next meeting of this task force; that meeting may be in Seattle, Washington.

Planning and Discussion--Predictive Testing for HLWP

Dan Mertz (BNL), Co-chairman of the High-Level Task Force, led a brief discussion on the objectives of the High-Level Task Force, in view of some objections to ASTM involvement that had been raised earlier by P. Salter (BWIP). Naomi Abraham (DOE/OCRWM) indicated that she would bring the proposal for ASTM involvement to DOE officials for their review and comments.

Dan Mertz further indicated that a general guideline, rather than a myriad of test procedures, may be feasible. Details were not very explicit, except that such guidelines might apply to all repositories. Patricia Salter indicated that DOE workers have concluded that such a generic approach would not work; and due to this, site-specific tests are being developed within the DOE Project Offices.

In response to a question on the purpose of this (ASTM) work, Dan Mertz indicated that the work of the High-Level Task Force can be to increase the credibility of this (DOE and NRC) work. From the presentations, and the discussions that followed, I concluded that the question that seemed to loom was whether or not DOE would be willing to participate in the work of this ASTM Task Force aimed at the development of standards for predictive accelerated testing for the HLW package. Dan Merz indicated that the work of the next few weeks may furnish a better outline of the objectives of this group and how those objectives may be accomplished. While NRC-related workers generally expressed their interest and made favorable remarks, like ASTM standards would be an aid in smoothing the path for a successful license application, the DOE-related workers were concerned that the ASTM procedures are slow, the test procedures would be available after the fact, and the DOE Project Offices are already doing everything that will be needed for development of the data required in a successful license application.

SEMINAR C26.07

TUESDAY JAN 14 1984

PREDICTIVE/ACCELERATED TESTING

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DOE/NRC SALT WASTE PACKAGE WORKSHOP
January 22-24, 1986
Battelle Columbus Laboratories, Columbus, Ohio

The DOE/NRC Salt Repository Project (SRP) Workshop was held at Battelle Columbus on Jan. 22-24, 1986. The attached report on that meeting is a synopsis of the meeting topics and the comments of NBS workers on the issues relevant to the waste package. The NBS workers who attended this workshop are C.G. Interrante, M.J. Kaufman and R.D. Shull.

General

The meeting was attended by staff members from DOE, SRP/ONWI, NRC and their contractors in addition to State representatives from both Mississippi and Louisiana. The meeting consisted of presentations by SRP personnel and subsequent discussions related to waste package design and performance for disposal in a salt repository. At the conclusion of the meeting, NRC and DOE produced a summary which expressed the concerns of the two agencies and the possible limitations of the program at its present state.

Wednesday, January 22

Waste Package Program (K. Wu)

K. Wu briefly outlined the agenda for the meeting, described the structure of the SRPO and made some introductory remarks concerning the purpose and goals of the workshop.

Waste Package Program Approach and Strategy (John Carr)

John Carr made a fairly comprehensive presentation describing the approach and strategy of the entire Salt Repository Project. He described what DOE believed to be "expected behavior" and how the program was more or less centered on such, as well as some alternate "unexpected" scenarios. The three major issues of the so-called expected behavior were identified: (1) the quantity of brine that will interact with the waste package, (2) the rate of brine arrival, and (3) the porosity/permeability of the packing and corrosion product layers. Based on the expected conditions, he described the SRP's philosophy for choosing ASTM A216-77 carbon steel for the outer container (overpack). This selection was based on the conclusion that this material will undergo general corrosion in brine but that the corrosion will be limited in extent due to the limited quantity of brine expected to be available. Furthermore, the choice of carbon steel over more corrosion-resistant materials was made because of the former's lower susceptibility to non-uniform corrosion mechanisms, e.g. pitting.

Comments: As will become clear later, the NRC, NBS, and the State representative from Louisiana had serious reservations concerning the validity of the "expected conditions". For example, it was pointed out that the assumption of uniform corrosion might not be valid since there is no reason to expect that the brine which does reach the overpack will be uniformly distributed. Furthermore, the Louisiana State representative

mentioned that there was a reasonable amount of data that indicated that the amount of brine in the salt mines under consideration could be substantial, especially if the canisters are placed in regions where the frequency of brine pockets is substantial. Obviously, further work is required to substantiate the validity of these expected conditions.

Waste Package Design Concept (J.R. Schornhorst)

Jim Schornhorst described SRP's waste package design and performance criteria in some detail. He covered the functions of the various elements: waste form, canister, container, packing, fabrication, assembly, emplacement, and retrieval for both spent fuel and defense high level waste.

In addition, he described areas where major uncertainties existed. The site-specific salt and brine properties, brine migration (quantity, rate, effect of interbeds), corrosion (minor constituents, time) and radionuclide release (salt permeability, waste form release, solubilities, colloids). He also discussed the expected advantages and disadvantages of horizontal vs. vertical emplacement. Finally, he described SRP's program concerning alternate materials for the overpack and the anticipated problems with them.

Comments: Again, there was some discussion concerning the validity of the "expected conditions" on which much of the material selection was based, and NRC indicated that validation of each assumption was required. In addition, it became clear that very little work had been performed on the alternate materials which were mentioned. It was our conclusion that further work was needed in this area so that, should the C-steel be found unsuitable, SRP would not have to start the whole characterization process over again.

Waste Package Environment (J. Cunnane and L. Pedersen)

Drs. Cunnane and Pedersen described the environmental aspects of the waste package design. These included the initial conditions (lithology, hydrology, brine chemistry, pressure and temperature), the expected behavior of temperature and radiation fields and the effects of these on borehole closure and waste package loading, thermal and radiation effects on brine and salt, and brine migration.

Comments: Again it was pointed out that there is potentially a much greater brine concentration in the salt mines than SRP has considered. Should this be the case, then it is not at all clear that the present design would be acceptable.

Quality Assurance and Peer/Technical Review (M. Golis, D. Bradley, and W. Harrison)

The authors described the mechanisms of quality assurance for the Salt Repository Project including internal technical review by SRP and its contractors as well as external peer review.

Comments: A potential concern that NBS and NRC had with the QA program was the fact that it appeared that SRP is planning to utilize peer review as a means of reaching conclusions in important areas where sufficient data are clearly unavailable. Obviously, it is important for the SRP to utilize such peer review for the design of "critical experiments", where such data are unavailable, rather than making definitive conclusions that have not been substantiated.

Thursday, January 23

Performance Assessment of Waste Packages.

(J. Kircher, G. Raines, V. McCauley, and G. Jansen)

The authors described the strategies being utilized for performance assessment as follows: role of performance assessments and strategies; approach to treatment of uncertainties and interfaces with design and testing; development of submodels and verification and validation; and status of integrated waste package modeling.

Comments: None

Waste Package Containment

(J. Perrin, R.E. Westerman and W. Kahn)

The authors described the function of the waste package and the design criteria for their selection of the primary and alternate container materials. As mentioned above, the selections were based on the expected conditions where all the brine is expected to react in a uniform manner. In addition, Westerman of PNL described the results of the various experimental tests which had been conducted in support of the selection of the ASTM A216 steel. Finally, the various uncertainties associated with the design selection were pointed out.

Comments: Again, the canister design was based on expected behavior with little consideration of alternate scenarios. Furthermore, it became evident that the amount of effort being spent on alternate back-up materials was inadequate for development of an acceptable alternate. Other points which we feel are important follow:

1. Any test plans for corrosion and embrittlement studies should include assessments of the behavior of the weld metal and the heat-affected zone, in addition to the base metal.

2. The fugacity of hydrogen should be assessed, if possible, for the metal-environment systems being considered so that the possible effects of hydrogen may be assessed. Hydrogen attack and embrittlement, either of which decrease structural integrity, and hydrogen pressurization, which could lead to bursting, are not to be dismissed until the fugacity has been properly estimated.

3. Tests should be conducted to substantiate or disprove the assumption of uniform corrosion of the canister. Until this has been resolved, the SRP should continue to consider the possibility of localized corrosion mechanisms in their design.

Waste Package Release
(G. McVay and W. Kahn)

McVay and Kahn described the various scenarios concerning the release of radionuclides in potential environments. In addition, they discussed the major uncertainties and issues related to radionuclide release.

Comments: None

Friday: January 24

Planned Activities of the Waste Package Program
(J. Carr)

John Carr described the work scheduled to take place in the next 15 months in the various areas described above.

Comments: Concerning the plan to initiate long-term (5 years) uniform corrosion tests, it was pointed out that these should be started as soon as possible. In addition the SRP should also begin similar long-term tests on the alternate materials such as TiCode 12. SRP agreed but felt that such testing should wait until a specific site had been selected.

Report on Jan.29, 1986 Workshop on
Model Validation
- Engineered Barriers -

Only one of the speakers presented material related to the corrosion of metals underground, but it was clear from the discussions that corrosion was a concern.

The first speaker, C. L. Carnahan (LBL) described the data requirements of his model for evaluating the effects of temperature, pressure, and composition on transport processes in the backfill material. At this point in the modeling, only general trends can be obtained, and thus, all data were presented in unitless quantities.

The second speaker, C. Radke (LBL), described chemical reactions that could be expected in the backfill over time. Both Carnahan and Radke stressed that their results were limited by a lack of reliable information from the field that could be used for verification of their findings.

The third speaker, A. Markworth (BCL), described a model for pitting corrosion and briefly expressed his thoughts on other corrosion processes that could be expected over the lifetime of the waste package. He presented data suggesting that pit growth would occur during a cooling down period, as moisture begins to condense on the waste containers. This period of condensation would eventually lead to passivation of, for example, stainless steel. However, he pointed out that the few pits that might remain after this passivating period would grow rapidly. Nevertheless, when provided with fictitious, but reasonable data, he was unwilling to hazard an estimate of the units of time for the events that his model provided.

The last scheduled speaker was not in attendance, so the material on leaching and dissolution was presented by Markworth. The description of water chemistry is based on the WATEQ model, and suggests that the concentration of silicon increases as the pH of the Basalt ground water increases.

Each member of the panel presented a short (5 min) description of their work. The presentation by M. Molecke of Sandia National Labs was particularly interesting because he described a BWIP test site where a full-size simulation of a repository has been built. He described the design of the waste container canisters and the measurements made at this site. Up to now, the assumption has been that the levels of moisture flow are extremely low, however, his measurements indicate that flow rates may be quite high. For example, Molecke has collected as much as 12 gallons of brine in 6 months! This testing program will certainly provide some very useful information.