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LPDR- WM-10 (2)
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March 16, 1987

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

Dear Mr. Chang:

VOUCHER FOR PROFESSIONAL SERVICES

Attached are the original and required two copies of the voucher for my professional services March 2-12, 1987.

I have now worked 76 days of the 130-day limit.

My activities covered by the current voucher were:

3/2	Research in NRC Library, Bethesda
3/3	Work in Poisson mathematics
3/4	Methodology for salt/tuff
3/5	Review of Demo Report; review of BWIP Design and Development Plan
3/9 3/10	Continued mathematical research
3/11 3/12	Overall review of where we are and where we should go from here

Very truly yours,

Kenneth W. Stephens

Kenneth W. Stephens

Attachment
V9

Review of NBS Semiannual Report 3/16/87

Kenneth W. Stephens

Background

These comments are based on my review of the March 2, 1987 Draft Semiannual Report for the project "Evaluation and Compilation of DOE Waste Package Test Data" (FIN A-4171-7).

General Comments

This report presents the results of a great deal of careful, thorough work by the NBS people. For areas in which our work overlaps, my observations and conclusions agree with theirs.

Comments on particular topics are included below.

Corrosion Rates

On page 5, in a section dealing with stainless steel corrosion for the tuff project, the NBS reviewers observed that corrosion rates were calculated under the assumption that corrosion was uniform. This seems to be the starting point for corrosion studies in all three repository projects. This assumption is so pervasive that the corrosion researchers sometimes depart from scientific objectivity with respect to the observation of non-uniform corrosion. The NBS reviewers should continue to be vigilant in looking for such (perhaps unintentional) biases in the DOE work.

Alternate Materials for Salt Containers

On page 10, the NBS reviewers discuss alternate materials for the salt containers. A great deal of work in that area has been done by the Germans, who have had considerable success. There were some good papers on the subject at Waste Management 86 in Tucson.

The paper entitled, "Results of Engineering Developments for the Direct Disposal of Spent Fuel", by P. Arntzen, et al, starting on page 527 (Volume 2) of the Proceedings, summarizes the German corrosion testing program.

Leaching from Glass Waste Forms

In the MCC section beginning on page 17 and in other parts of

the report, leaching from the glass waste forms is discussed. About three years ago, a researcher at Oak Ridge created quite a stir with his publication of data showing that the rate of leaching from lead-phosphate glass is a small fraction of that inherent in the candidate DOE glasses. At the time, I was intrigued by that report, and I investigated the DOE reaction. I was somewhat displeased to discover that the DOE people appeared to have dismissed the lead-phosphate results out of hand, without what I consider sufficient grounds. I finally concluded that DOE had already chosen its glass, had invested a great deal of money at Savannah River in the processing facility, and had no intention of opening up the topic for discussion.

To DOE, it is probably a closed case. However, this topic is fertile ground for some critic to attack DOE during the licensing process and accuse them of being less than objective. Accordingly, I recommend that the future NBS work on glass include at least a screening review of the work on lead-phosphate glasses so that NRC can be prepared for the eventual controversy.

Missing Information?

At the bottom of page A-1 in the first Waste Package Data Review there appears to be some missing information, perhaps a whole page. There are redundant headings on pages A-1 and A-2.

There is a similar problem at the bottom of page A-2 and the top of page A-3.

Applicability of Data to Licensing

Each of the Data Reviews indicates whether the data are "key data" or "supporting data". To my knowledge, all the data are marked as "supporting". This raises the question as to what will constitute key licensing data. This question has concerned me for some time, but I have never been able to find a satisfying answer.

Recently, I came across a BWIP document that provides an answer: (SD-BWI-PBD-001) BWIP Mined Geologic Disposal System Design and Development Plan, November 1986. In that report, BWIP discusses the various design phases and says that one is called the Licensing Application Design (LAD) phase, which will not start until after the Advanced Conceptual Design report is issued. Further, BWIP says that LAD will be applied to only those items that are on the Q-List.

This Q-List, which includes items important to safety, waste

isolation, or retrievability, is under preparation, but NRC has not seen it. The Site Characterization Plan (SCP) will supposedly include the first presentation of the Q-List outside DOE.

Minor Editorial Comments

There are spelling errors on pages i, 3, 35, and A-46.

Confirm the spelling of "Pahute" in the penultimate paragraph on page A-17. As I recall, there are some geologic features in the area that are spelled slightly differently.

Summary of Recent Work 3/12/87

Kenneth W. Stephens

Background

Some of the work I do for NRC is in discrete chunks, and the output is self-explanatory. Much of my work, however, is in support of the long-term objective of providing NRC with good performance assessment methodology. Summarized below is some of the recent work that falls into that category.

Salt/Tuff Differences

The waste package performance assessment methodology we developed at The Aerospace Corporation and continue now as NRC consultants uses BWIP for the first implementation. Recently, I have examined what may be required to apply that methodology to the salt and tuff projects.

In principle, the overall philosophy of using a statistical approach to waste package performance assessment is generic and can be applied well to all three repositories. The basic approach is simple--calculate individual package performance (lifetime and radionuclide releases), and make the extension to the collective assemblage of packages in the repository. That should apply equally well to all repositories.

The first step is to examine the performance assessment approach used by each of the DOE projects.

What DOE is Doing

The BWIP approach is clearly understood by us, and we are in basic agreement with the philosophy and most of the implementation. The situation is less clear for the salt and tuff projects.

In the salt project, the original performance assessment approach was to use purely deterministic methods as implemented in the WAPPA code. About two years ago, ONWI began to reexamine that approach, but there is still no clear picture of what the salt program intends to do. Recently, the project began to recognize that corrosion may be the weak link in the waste package performance determination. Consequently, the salt project remains in a state of flux. One way to deal with their difficulties would be to adopt a probabilistic approach to get around the problem of the high-magnesium brine (major impact, but perhaps unlikely).

Performance assessment for the tuff project is equally unclear at this time. The project originally saw the unsaturated zone as their salvation. Under the original assumptions about radionuclide transport, it might have been possible to assume that all the containers fail and still meet the NRC and EPA requirements. Recent developments have shown that this is not the case and that the tuff performance assessment may have to be more sophisticated. A new, significantly different approach is rumored to have been developed and is supposedly under review by DOE headquarters. So far, no details have leaked out.

It may be necessary for the tuff program to adopt some sort of probabilistic approach similar to what has been done at BWIP.

Differences Among the Three Media

There are some real differences among the three geologic media that should be considered for our purposes.

If the flow of groundwater is either upward (as in basalt) or downward (as in tuff), the transport within the repository is essentially all through the thin plane (one package thick) and not horizontally through the collection of packages. This simplifies the extension of the calculations from one package to the repository scale, and is essentially the approach we have chosen to use for BWIP.

The situation for salt is different. If there were gross flow of groundwater within the salt deposit, it would have been washed away long ago. The transport of water is presumed to be through brine migration. It may take the salt project considerable time to determine whether there is a preferred direction of brine movement once packages have failed and radionuclides have been released.

Summary

It appears that the general approach we are using can apply to all three media. The specific implementation for individual waste package lifetime will require that the modeling and input data be media-specific. That will require work, but should be straightforward. The lack of good process modeling that affects DOE affects us as well.

Aside from the necessity to apply media-specific modeling and data inputs, the calculation of waste package lifetime and radionuclide releases is a workable challenge. For the reasons stated above, the repository-scale approach may have to be different for salt.

Synergistic Effects Among Waste Packages

Recently, I have explored synergistic effects that might be present among the waste packages in the repository. To the best of our knowledge, all three repository projects make two basic assumptions: 1) the failure mechanisms that apply to one package apply to all the other packages in the repository, and 2) failure of a particular package does not increase the likelihood of failure for other packages.

Current indications are that these are not bad assumptions. In principle, one can choose parameters such that the calculation of package performance is conservative, even though all packages are presumed to be essentially identical. The projects recognize that there can be differences in the environment to which individual packages are exposed, but the approach is generally to assume a conservative set of conditions that applies to all the packages.

To our knowledge, none of the projects have examined synergistic effects of packages on other packages to any degree, nor do they intend to. The modeling at BWIP considers the collective thermal effects from the packages, but there is no attempt to hypothesize other effects.

In examining possible synergistic effects, I concluded that possible mechanisms are:

- Heat effects of a package that extend to the location of other packages.
- Heat-related impact on chemical parameters that affect package lifetime or radionuclide transport.
- Heat-related impact on physical parameters such as density.
- Impact on radionuclide transport, caused by chemical releases from the packages
  - solubility
  - chemically-altered diffusion effects
  - pH
  - corrosion products
  - chemical effects of released nuclides

The waste management literature contains virtually no discussion of synergistic effects, and very little consolidated information on the above topics. Our work has shown that radionuclide transport can be significantly affected by parameters such as pH and solubility. Thus, in principle at least, individual packages can affect what happens to the

releases from the other packages. However, given the sorry state of knowledge regarding major phenomena such as corrosion, it is probably not prudent to dwell on synergistic effects until the big players are under control. We must recognize that this means we must be vigilant in reviewing sensitivity studies to be alert to situations in which the analysis may not be sufficiently conservative to encompass synergistic effects.

In summary, the issue of synergistic effects has not really been dealt with by DOE, and we are not really in a position to do much developmental work in that direction.

Documentation of Our Work in the Form of a NUREG

It is desirable to document our work so that it is of maximum benefit to NRC and anyone else who needs it. One way to do that is through a NUREG or NUREG/CR document. Within the past few days, I have considered what might be involved.

The Methodology Report was published as a NUREG/CR and is in wide circulation. The Demonstration Report, presented to NRC just before we left Aerospace was issued as an Aerospace report, but not as a NUREG/CR. This raises several options for documenting our collective work.

One Large Document

Even though we are working as individual consultants and not for a single corporate entity, our work is all related to waste package performance assessment, i.e., it is a direct extension of our earlier work at Aerospace. One possibility is to prepare a single document that assembles our collective work.

This document could include an updated version of the Demonstration Report, results from recent implementations of the methodology, user manuals,and new work related to specific items such as engineered barriers.

Unfortunately, the nature of our current activities with NRC, the fact that we are not centralized (either organizationally or physically), and our personal situations make the preparation of a large document very difficult.

I recently reviewed the Demonstration Report to see what would be involved in an update. It would require a considerable effort to incorporate the demo work that was done after the report was prepared. In addition, the whole document needs revision in terms of how it presents the information. The work summarized in the document is first-rate, but the report was prepared under a tight deadline that did not allow the incubation and rewrite that would have been desirable. If the

Demonstration Report is revised, it should probably be done by a single individual rather than the committee that prepared it originally.

The preparation of a formal NUREG document requires a great deal of work. Aside from the challenges of our physical separation, it would take a sizeable portion of our remaining allotted time just to prepare the document. Given our situation, it is not clear that we will all be in a position to devote the necessary time. If our participation in the Center were a foregone conclusion, our effort in the interim could be devoted to a large NUREG. Realistically speaking, we cannot wait until the end of June to explore alternative employment. Such alternatives may materialize before then and may cause attrition in the team.

Smaller Documents

In view of the difficulties involved in producing a single, large document, it may be desirable to limit any documentation to smaller reports relating to specific aspects of the work. The User Manuals are an example. As necessary, other reports could be written.

One advantage of this approach is that individuals could write reports dealing with their own work, without the massive coordination required when the document is a communal effort.

Summary

We must remember that any time we spend in producing documentation is time that is not available for the basic work. The appropriate mix is something that NRC and the consultants should discuss.

My personal feeling is that we should not attempt to produce a large swan-song document. It was not planned as part of our consulting work, and would require an effort that may not be available.

Review of Recent BWIP Acquisitions 3/12/87

Kenneth W. Stephens

Background

In the course of my work, it is necessary for me to keep up with what is happening at BWIP. I routinely receive the BWIP Accessions Lists from the project, and I order documents as necessary. Recently, I ordered three such documents. My review comments are included below.

BWIP Mined Geologic Disposal System Design and Development Plan, SD-BWI-PBD-001, November 1986.

This document presents overall guidance for taking generic and specific design criteria through the various development phases. It establishes guidance for tradeoff studies and design methodology.

The design process is divided into four phases: Conceptual Design (for the SCP), Advanced Conceptual Design (ACD), License Application Design (LAD), and Final Procurement and Construction Design (FCPD).

Although the whole process is of interest to NRC, the LAD phase is of critical importance. It is during this phase that BWIP establishes the basis for information required in the Safety Analysis Report (SAR). License Application Design provides complete construction and procurement drawings, specifications, schedules, and cost estimates for all systems, structures or facilities that have been determined to be important to safety, important to waste isolation, or important to retrievability. That is, LAD is applied to all items on the Q-List. Items not on the Q-List are completed during the later FPCD phase.

I checked with the NRC Repository Projects Branch concerning the timing for these phases. Although the DOE scheduling is not really firm at this time, it is clear that the schedule for issuance of the Site Characterization Plan (SCP) has now slipped to late August, or perhaps later. This means that the LAD phase will not begin for some time (after completion of the ACD report).

The Q-List is the key to BWIP licensing application philosophy, but it is not yet available to NRC. Supposedly, the first version external to DOE will be included in the SCP. The NRC staff should monitor the Q-List carefully.

The document being reviewed (SD-BWI-PBD-001) discusses postclosure performance assessment in a very general way. The reader is referred to the BWIP Performance Assessment Program Plan for further details. The latest publicly available version of this Plan is about four years old and does not reflect the evolution that has occurred. The NRC staff will want to watch for its successor, which is rumored to be under internal DOE review at this time.

The BWIP Decision Support Process (DSP) is also discussed in SD-BWI-PBD-001. The DSP is a formalized mechanism for making decisions and documenting their resolution for cases in which there are significant tradeoffs and more than one technical solution to a design or engineering problem.

Once DSP is deemed to be necessary, there is a formal process for resolution. Documentation is considered a vital part of that process and includes:

- Why the DSP was initiated
- The required objectives
- Assumptions
- Attributes considered (cost, safety, etc.)
- Alternatives considered
- Models used in the DSP
- The decision matrix and description of the analysis

These items involve issues of interest to NRC. The NRC staff should monitor any DSP documentation that is issued. At this time, I can find no such reports either in the BWIP literature or within NRC.

Computational Brief for SCP/Thermal Conductivity, CB-0632, December 1986.

These computational briefs are the BWIP means of documenting calculations associated with the design and licensing process. I reviewed it to get a feel for the degree to which BWIP calculations are performed and reviewed.

The assumptions, references, and calculations were carefully handled and clearly documented. It is easy for an external reviewer to assess the acceptability of the calculations.

Documentation of the peer review process is also included in these computational briefs. The reviewer's qualifications are discussed, his comments are presented, and the resolution is discussed.

Any NRC staff members who have detailed questions concerning the BWIP design should avail themselves of these computational

briefs, which are easily obtained.

Computational Brief--Structural Criterion for Waste Package Container, CB-0109, February 1984.

This computational brief illustrates one of the many situations in which BWIP has examined the impact of design changes. It deals with the pros and cons of changing the existing design criterion (a relatively conservative ASME criterion) to either a slightly relaxed version proposed by Westinghouse, or a significantly changed version developed within BWIP.

The analysis, which is clearly documented, showed that the Westinghouse version is achievable as an ASME code case without much difficulty. More significant was the result for the relaxed version, which would cut the margin of safety by 1/3 but only reduce the cost of the package by 1/7.