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Stephens & Associates
10424 Windfall Court, Damascus, Maryland 20872 (301) 253-5576

August 21, 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 August 4-21, 1987.

I have now worked 12 days of the 130-day limit.

My activities covered by the voucher are described in the attached Progress Report. My report on the Oak Ridge NUREG/CR review was delivered separately.

Very truly yours,

Kenneth W. Stephens

Attachment
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PROGRESS REPORT
Kenneth W. Stephens
August 4-21, 1987

Introduction

During this reporting period, the new consulting year was initiated. Major activities included review of Oak Ridge NUREG/CR work, review of information on BWIP and recent DOE interpretations of NRC requirements, review of tuff performance assessment work, review of salt documents, and initiation of work on the synergistic effects of waste packages. Each of these is discussed below.

Review of Draft Oak Ridge NUREG/CR

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While at The Aerospace Corporation in 1986, we reviewed the draft, and our comments were incorporated into the NRC comments. It appears that Oak Ridge was responsive to most of the comments. Additional revision may be needed in some areas, particularly the Appendix on brine migration.

Review of Cook Memo and Attachments

The June 26, 1987 memorandum from F.R. Cook to R.E. Browning contained a number of observations and recommendations related to BWIP. The memo also included information related to the Licensing Assurance Review of the BWIP draft SCP.

I am attaching my comments on the Cook memo. He raised some important points. Also, it is gratifying to see that the LAR (DOE peer review) raised many of the same issues that have concerned us over the past several years.

Modification of NRC Performance Assessment Methodology for Tuff

One of our consulting tasks concerns the modification of the performance assessment methodology for use with tuff. That work has begun, and we are gathering relevant information.

I just received a copy of UCRL-53761, "Waste Package Performance Assessment: Deterministic System Model Program Scope and Specification", W.J. O'Connell and R.S. Drach, dated

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October 1986 but just recently released. This well-written report provides a previously unavailable window into the performance assessment strategy to be used in the tuff program.

The overall project strategy is to start with a deterministic WAPPA-like model and develop a code called PANDORA (Performance Assessment of NNWSI Design Omitting Random Aspects). Later, a second series of computer programs will be developed "to assess the reliability of waste package performance". The stated intent is to design this deterministic model to be "conservative, possibly by orders of magnitude".

The report discusses how the model is based on the generalized WAPPA approach by having a driver model and separate models dealing with radiation, thermal, mechanical, waste package environment, and corrosion issues. As with WAPPA, the tuff model will be based on extensive use of precalculated look-up tables, supposedly based on experimental data.

The model will include only general corrosion, although the report says that non-uniform corrosion will be considered in later models.

It is clear from the report that the project has reviewed WAPPA extensively and is well aware of the deficiencies, such as those Brookhaven and we observed over the past two years while working for NRC. The report contains a good description of the models to be used, including equations.

One of our challenges in modeling thermal aspects of the tuff waste package is the air gap between the rock and the canister. The tuff project has already done that, and the model is described in the report.

In summary, the tuff project is pursuing a strategy far different from that of BWIP. Whereas BWIP is using a probabilistic approach from the start, the tuff project is starting with deterministic modeling and leaving open the possibility of having probabilistic models in the future. I suspect the tuff philosophy is based on a genuine belief that this admittedly simplified approach can be justified as being highly conservative. If that is the case and if the project can live with the associated design and construction implications, the complications of probabilistic modeling can be avoided.

This approach, however, is based on a set of assumptions related to the package environment, the relevant failure modes, and the geologic setting. If the assumptions are not satisfied, it may be difficult to justify the belief that the results will be conservative.

Review of Simulation Model for Salt Repository Operations

As part of our continuing review of the salt repository project, I routinely receive ONWI documents. One such document is BMI/ONWI-648, "SIMREP 1.1--A Simulation Model for Repository Operations", June 1987, Percy S. Tarapore, et al.

This report is interesting from several standpoints. Although it covers repository loading operations rather than long-term performance, it does illustrate the following:

- ONWI is now thinking seriously about probabilistic techniques. The simulation uses a stochastic Monte Carlo approach.
- ONWI is taking special care in handling and documenting code changes to prevent the sort of mess experienced earlier with multiple versions of WAPPA.
- This simulation code has been modified for use on a PC-AT as well as a mainframe computer. The report discusses some of the fine points of the modifications. Their experience may be helpful in our adaptations for the PC.

Synergistic Effects of Multiple Waste Packages

Most of our waste package work to date, as well as that of DOE, has concentrated on performance assessment for individual packages. The releases for the entire repository have been calculated through straightforward extrapolations to large numbers of packages, i.e., a homogeneous Poisson process has been assumed.

Recently, I have begun an examination of possible synergistic effects among multiple packages--effects that could affect the total releases. The initial literature search disclosed that very little work has been done on this subject. I am now reviewing work on coupled processes that may be relevant and will include the results in subsequent reports.

K. Stephens

Review of June 26, 1987 Memorandum
F.R. Cook to R.E. Browning

Introduction

The subject memorandum contained a number of observations and recommendations related to BWIP and the attached comments from the DOE Licensing Assurance Review of draft Site Characterization Plan material. Mr. Cook's memorandum covered some important points. My comments on the four DOE interpretations and the BWIP material are included below.

Substantially Complete Containment

I agree with Mr. Cook. Parts of the DOE interpretation are inconsistent with the NRC philosophy inherent in 10 CFR 60. The NRC limits are based on the premise that radioactive materials should be contained during the containment period and released slowly thereafter. The NRC assumption (reasonable) is that the engineered barriers should be expected to perform better during the containment period than after.

Whereas the NRC post-containment limit is based on 10^{-5} of the amount of radioactivity remaining at the end of the containment period, the DOE interpretation would permit releases during the containment period to be 10^{-5} of the total inventory present in that year.

By my calculations, radioactive decay alone decreases the total inventory by a factor of 50 in the first 100 years after emplacement and a factor of 1000 in the first 500 years. This illustrates the reasoning for substantially complete containment for the first few hundred years.

The 10^{-5} criterion for post-containment release rate is itself somewhat stringent, given that it is based on the inventory present at the end of the containment period. Unless justification can be found for relaxing this post-containment requirement it seems unreasonable to permit the major relaxation inherent in the DOE interpretation.

The letter transmitting the DOE interpretation says that the DOE Office of Geologic Repositories is preparing a companion document detailing the rationale and bases for the interpretation. The estimated availability date was listed as June 1987. If NRC has not reviewed the document, it is essential that the document be examined. It is not possible in

an engineering sense to expect 100 percent of the waste packages to have 100 percent containment for 1000 years. Nevertheless, it should be possible for DOE to achieve better containment than would be permitted by their proposed interpretation. Some alternatives are:

- Change Objective 1 to a sliding scale, e.g.,

  99 percent of containers for 100 years
  95 percent of containers for 300 years
  80 percent of containers for 1000 years

  This would have the advantage of preventing large amounts of early failures while inventory is high, yet it would still provide some flexibility.

- Change Objective 2 to permit a cumulative release during the containment period of no greater than the amount that would be released if the release rate were based on 10^{-5} of the inventory at the end of the containment period. This cumulative release would, of course, depend on the failure scenario assumed in Objective 1.

- Change Objective 3 to restrict the release rate to 10^{-5} of the inventory at the end of the containment period.

- Define "substantially complete containment" through probability, e.g.,

  - 99 percent probability that the packages will last 300 years, and

  - 95 percent probability that the packages will last 1000 years.

Boundary of the Engineered Barrier System

It is clear that for the SCP, DOE is accepting the NRC interpretation of the EBS boundary. Nevertheless, DOE wants to retain the option of redefining the boundary at a later date. That is their privilege under NRC licensing rules, although NRC is not necessarily obligated to accept the DOE position--only to listen objectively to the arguments.

At this time, DOE does not know definitively whether they will be able to meet 10 CFR 60 limits under the current boundary definition. If the analyses and site characterization efforts show that the limits can be met without additional credit, DOE is likely to accept the current definition of the boundary.

However, if they cannot show that the limits can be met with sufficient margin to account for uncertainties, DOE is likely to push hard for redefinition.

I have examined some of the licensing proceedings for reactor licensing, and there are instances in which the Atomic Safety and Licensing Boards have required the NRC Staff to relax positions such as the one defining the EBS boundary. In those instances, the point of contention was frequently a judicially perceived inconsistency between the NRC interpretation of words (such as "underground facility") and the interpretation of a layman.

It does not take much stretch of the imagination to have a scenario in which a licensing Board accepts the DOE interpretation, i.e., that the "underground facility" includes some reasonable envelope outside the waste packages themselves. If that were to materialize, the Board would be likely to be influenced by the fact that waste package releases at the waste package boundary are highly dependent on the nature of the host rock. Our own work for NRC has confirmed the influence of the rock on releases at the package boundary.

My reason for raising these points is that NRC should reexamine the basis for its position on EBS boundary definition while it considers the other DOE interpretations. They are actually interrelated.

Disturbed Zone

I presume the DOE material will be reviewed by the NRC staff for consistency with the staff position on the subject. From my reading of the DOE interpretation, it was not clear whether the interpretation is consistent with the NRC position.

Anticipated and Unanticipated Processes and Events

Based on a quick reading, the DOE interpretation seems reasonable in general.

Apparently, DOE intends to use probabilistic tools as part of their analysis of human intrusion scenarios. However, they will not explicitly incorporate the results into the overall probability distribution showing the likelihood of meeting NRC and EPA limits. We are in the process of implementing discrete events into the overall probability distributions, and we believe our efforts will be successful. We recognize nevertheless that the challenge will be the generation of meaningful input data. The outcome is likely to be quite sensitive to the assumptions used in generating input data.

I am not sure why DOE intends to exclude the intrusion probabilities from the overall distribution. The subject merits further discussion with DOE.

The final paragraph of the DOE writeup (page 10) is quite good. They recognize that when uncertainties are present, the numerical cutoff between anticipated and unanticipated is fuzzy and that additional consideration may be advisable.

Licensing Assurance Review

I have reviewed the material Mr. Cook included on the DOE Licensing Assurance Review of BWIP.

The LAR seems to have been quite thorough, and the comments raise some issues that are likely to have major impact on the project. It is gratifying to see that the LAR committee comments address issues we have considered important during our review of BWIP work over the past several years. These include items such as:

- pitting corrosion
- corrosion under oxidizing conditions
- effect of packing on corrosion
- packing performance
- impact of uncertainties
- radiolysis effects
- effect of container fabrication on lifetime
- necessity for systematic, top-down licensing approach
- long-term extrapolation of short-term data
- necessity for characterizing composition of real packing

In addition, the LAR committee raised some issues that bear watching in the future, especially during SCP review:

- possible superiority of copper containers
- adequacy of BWIP performance assessment writeups
- relevance of convective transport
- moisture in containers (from fuel rods)
- temperature effects from early package failures
- temperature effects on release rate
- validation of BWIP performance assessment modeling
- concentration of impurities in packing (from boiling)
- effects of hydrogen on package materials

We will monitor these issues as they develop.

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Wm-RES
WM Record File
A4165

WM Project 10,11,16
Docket No.

PDR ✓
LPDR ✓ (B, N, S)

Distribution:
Chang

(Return to WM, 623-SS)

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