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JUN 29 1984

Mr. Robert W. Browning
Director, Division of Waste Management
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Browning:

The U.S. Department of Energy (DOE) has reviewed the Nuclear Regulatory Commission (NRC) draft technical position on waste package reliability (NUREG-0997, May 1983). This draft technical position presents a logical approach for determining the reliability of the waste package. Such guidance is particularly welcome as the performance of the waste package is a key element in the overall capability of the repository system to mitigate the release of radionuclides to the accessible environment.

As a result of the review, we would like to offer some comments on some of the positions taken by the NRC in this draft document. Many of the comments center around the absence in the technical positions of explicit allowance for other methodologies to determine reliability estimates of the waste package, particularly in the area of probabilistic analyses. In some cases, lack of data may prevent the formulation of probability functions for some parameters, while in other cases some of the simplified models advocated are not sufficiently rigorous to obtain accurate results. Flexibility in applying models which are most appropriate to the analyses being performed is needed to avoid these problems. The DOE has been developing, and will continue to develop, methods to analyze the reliability of a waste package on a project-specific basis. As these methodologies become available, they will be transmitted to the NRC as alternatives for consideration in revising this draft technical position. These considerations and other more specific comments are more fully discussed in the enclosure.

Because of the importance of waste package reliability, the DOE would like to discuss these comments with the NRC and reach agreement on comment disposition. We will contact you to arrange for a meeting on this subject.

Sincerely,

Ralph Stein

for J. William Bennett
Acting Associate Director
Office of Geologic Repository
Deployment
Office of Civilian Radioactive
Waste Management

Enclosure

DOE COMMENTS ON NUREG-0997
NRC DRAFT TECHNICAL POSITION ON
WASTE PACKAGE RELIABILITY, MAY 1983

General Comments

1. The calculational and analytical examples given propose methodologies that may not represent the best or most appropriate approach for repository licensing. The technical position should not limit the approach, but rather allow the use of techniques most appropriate to the particular problem. While the use of a series of Monte Carlo runs based upon Latin Hypercube Sampling in which parameters are treated as random variables has many good features, the NRC should clearly delineate the limitations as well as the strengths of these techniques in the position.

2. The position should include the use of in-depth sensitivity analyses to identify key parameters affecting degradation and possible failure of the waste package. Techniques such as stepwise regression and/or partial correlation are available to do this.

3. The use of "relatively simple algorithms" (p. 14) may introduce more uncertainty than is desired. In performance assessment analyses, simple models are often used so that Latin Hypercube Sampling may be used. In this case, it appears that the models are being forced to fit a desired statistical technique.

4. The rigor required in reliability analyses may not be possible with present models and with anticipated limits on the availability of data. The number of runs required to achieve useful results using the sample reliability analysis given in the technical position could be unattainable. It will probably not be possible to analyze available corrosion data with the rigor assumed in the position. Also, available leaching data may be far too few, too scattered, and show the effect of too many variables to enable this type of reliability analysis. It should be noted that many existing computer programs are set up such that calculations using probability distributions of the input data would not be economical. For example, the Latin Hypercube Sampling (LHS) is not suitable for a computer program with many variables such as WAPPA. This program has too many parameters for LHS to handle directly. Therefore, this position should be revised to explicitly state that the methods presented are an approach, and other analytical approaches to reliability analyses that are more appropriate for the available data and analytical models being used are allowed.

5. Although the NRC regulations are based on failure of the engineered system, this technical position is directed only to the reliability of the waste package. There is no indication of how to factor this analysis into an engineering system failure analysis.

6. Statistical issues and concepts are not treated as rigorously and precisely as they should be. One example of this is the weakness of definitions in Section 1.2. Suggested alternatives are given under

specific comments. Other important statistical concepts such as significance level and confidence level should be more clearly defined and characterized. The concept of confidence level associated with a reliability estimate should be presented in terms of parameter estimation. To do this, reliability estimates should be defined as estimates of percentiles of life distributions. Similarly, tests of significance (hypothesis testing) should carefully be defined in the context of their application in this document.

7. References to "possible" and "impossible" failure modes are not appropriate for reliability analyses. Failure modes may be significant or insignificant, or probable and improbable.

8. The methods proposed in this technical position may have application to the site and seal subsystems, and ultimately to the entire isolation system. A separate technical position, or an expansion of this technical position extending this methodology to these areas as one of several acceptable approaches, is recommended.

SPECIFIC COMMENTS ON NRC DRAFT TECHNICAL POSITION ON WASTE PACKAGE RELIABILITY, NUREG-0997

Page	Section	Comment
1	1.1	The first paragraph states in part "...tne waste package will contain the waste for 300 to 1,000 years (depending on the thermal load to the geologic repository)..." The parenthetical statement appears to relate waste package life solely to the thermal environment. The intent of this statement should be clarified.
1	1.1	The third paragraph refers to EPA standards for overall reliability of the repository system which may have been established for guidance in determining waste package reliability. As the overall reliability has not been determined in the EPA standard, there is no guidance for waste package reliability.
2	1.2	"Confidence Parameter" appears to be a term created for this technical position that is unfamiliar to the DOE. Either clarification or deletion is recommended.
2	1.2	As indicated in general comment six, the definitions should be strengthened. The following modified definitions are suggested alternate definitions to those given in the position that would strengthen and clarify the statistical concepts. These definitions are typical of those to be found in standard text book or reference books on probability and statistics.

Sample Space: The set of all possible outcomes of an experiment or trial.

Event: Any subset of the sample space.

Random Variable: A numerical-valued function defined on a sample space, or a variable whose values are predicted by probabilistic means (either for convenience in modelling or because a deterministic model for its variation is unavailable).

Probability (of an event): There are different philosophies regarding the appropriate definition of probability. The following is a widely accepted standard definition of what is meant by the probability of an event. Let A be an event of sample space S and suppose the experiment which generates the outcome in S is repeated n times (n independent trials). Let Y be the number of times that A occurs in the n trials. Then the probability of the event A, P(A), is defined as

$$P(A) = \lim_{n \to \infty} \left(\frac{x}{n}\right)$$

That is, the quantity $P(A)$ is the limit (as $n \to \infty$) of the sequence of relative frequencies $\left(\frac{x}{n}\right)$

Distribution Function (of a random variable): The (cumulative) distribution function, $F_Y(x)$, of the random variable Y is a function defined for every real number, x, as the probability that Y does not exceed x; in symbols.

$$F_Y(x) = P\,[Y \geq x]$$

Probability Density Function (of a random variable): For a large class of probability distributions, including those that arise in reliability considerations, there exists a function, $f_Y(x)$, such that

$$F_Y(x) = P\,[Y \leq x\,] = \int^{x} f_Y(x)dx$$

The function $f_Y(x)$ is called the probability density function of the random variable Y.

3	1.3	The first full sentence on page 3 indicates that all the probabilities, and any sensitivities that could be developed, are scenario dependent. In statistical jargon, this fact should be emphasized in terms of conditional probabilistics in the conclusion on page A.20. Otherwise, it may result in a misunderstanding of the 2 percent failure probability presented.
4	1.3	In item 4 and other locations throughout the report, emphasis is given to the development of probability densities for the inputs. The data that will be available may be too sparse or scattered and thus make this impractical. It may not be possible to decide with any confidence which probability density best fits the available data. Rigorous probability densities should be developed only when necessary.
5	2.1	Adequate alternatives to failure mode and effects analysis (item 4) are available and their use should be allowed in the position.
5	2.1	In item 2 (and under 2.1.2, page 6) "bind" should be "bound".
6	2.1.2	Ground-water flux and flow mechanisms should be added to the list of environmental factors of concern. This is necessary to account for sealing failures in shafts and boreholes.

7	Table 1	The inclusion of leaching assumes saturation under the general usage of the term. Degradation modes and environmental factors for the unsaturated conditions are also needed. For instance, other degradation modes may become operative under the expected environmental conditions. The "D" factor (pressure and stress fields) is only important with regard to the waste form condition after the containment period in the unsaturated setting, and/or if a canister failure occurs coinciding with collapse of emplacement hole walls or flooding of the hole so that lithostatic or hydrostatic stresses can be transmitted to the canister and waste form.
9	Table 2	Is "resilience" to hydrothermal alteration the intended word?
11	2.1.7	Design reliability specifications, although useful, are not required by 10 CFR 50 Appendix B, ANSI N 45.2 or ANSI NQA-1.
12	3.0	The first and last paragraphs on the page refer to the completeness of the review of reliability considerations and completeness of phenomena considered in failure mode analysis. Even after completion of design and formulation, it will never be possible to prove that all failure modes have been considered by repeated review by competent technical persons because of the possibility of the unknown, never-before-thought-of phenomenon. Potential failure modes must continually be scrutinized by such persons. Also, the energy and thought focused on completeness must not detract from that needed to examine the more probable failure modes.
13	3.2	Introduction of an extra random variable to account for model uncertainty seems to be an unrealistic means for approaching this problem. It would be simply a "fudge factor" that would carry little information and be difficult to qualify and/or defend in terms of the desired answer. Analytical treatment of uncertainty by developing an equation/model to describe and test components of the overall model uncertainty would provide more useful information because components of uncertainty associated with various parts of the system model could be identified. If retained, the important statistical properties of the extra random variable should be described and demonstrated in the example.
13	3.2	Paragraph 3 could be interpreted to allow a Monte Carlo simulation as an alternative process to the introduction of the extra random variable described in the previous paragraph. This should be clarified.
14	3.2.1	(First paragraph) To obtain significant levels of the regression coefficients, one must assume the errors are normally distributed. So if one does study the distribution of the errors and determines they are non-normal, then the significance levels are not valid. In other words, what is

being requested may not be appropriate. Some equations will be developed as "conceptual models" for processes where only a few actual data points are known, or perhaps are known for conditions outside the range of conditions expected in the repository. In this case, a complete descriptive statistical analysis would not be justified, but rather non-parametric assessments could be used to establish some degree of confidence in the results.

14	3.2.1	(Second paragraph) One-dimensional temperature models may not be adequate to simulate the temperature profile. This is another example of forcing the model to fit a desired statistical technique. Models should not be simplified without sufficient justification.
16	3.2.3	Something is missing in the second sentence, first paragraph.
A-1	App. A	The illustrative example utilizes different methods of establishing input data for the Monte Carlo sampling approach, ranging from rigorous statistical analysis of experimental data to subjective consensus. These methods were chosen on the basis of judgement of the adequacy of the data base and of the behavior of a particular input variable. The position should contain more definitive guidance with respect to the acceptability of this approach.
A-2	A.3.1	Although codes such as HEATING 6 are too complicated to use in a Monte Carlo type simulation, they could be useful. A comprehensive adjoint sensitivity analysis could be performed on HEATING 6 to determine the key parameters needed in the simplified model and to provide a defensible means of evaluating the simplified model.
A.9	A.3.2.2	The linear regression that relates uniform corrosion to time may be too simple.
A.20	A.3.3.1	(Last paragraph) The assumption of a near stagnant solution source term should be considered in future corrosion tests.
A.21	A.3.3.1	The comments on leaching rate should include consideration of individual isotopic and synergistic effects.
A.30	A.5	In the first major paragraph, the number of coincident failures, both canister and release rate, should be noted and discussed. The duality of failure mode has been observed previously in the review of the Sandia studies and is a weakness in this approach. Also, in using the approach of randomly selecting parameter values over assigned ranges, it is possible that two or more parameters could be given values which are physically incompatible (e.g., high porosity and low flow rate). Consequently, results from such single calculations would not be valid. In particular, some apparent (calculated) failures may in fact be impossible or at least highly improbable.

A.30	A.5	(Second paragraph) The point is made that 2 percent failure probability means that there is a 2 percent chance that <u>all</u> canisters will fail. This would be a very serious failure for a repository and may be unacceptable. Consequently, this failure analysis needs to be examined and discussed in greater detail.
A.32	Table A.5.1	Hydraulic conductivity is represented here by a uniform distribution. The DOE believes that a lognormal distribution is more appropriate.