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Ltr to
EAW BNL

DRAFT

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DRAFT

STAFF TECHNICAL POSITION

ON WASTE PACKAGE RELIABILITY

1. Document needs Table of Contents
2. Retrievability is mentioned in passing (p 53, para. 2) but safe retrieval of canisters is not addressed in terms of design evaluation or performance confirmation.
3. The temperature dependance of the material properties is not sufficiently or explicitly emphasized.
4. Certain sentences are extremely long and ambiguous. Clarity of these sentences needs to be improved.
5. The report should have a glossary.
6. There is no FSAR as such or Standard Review Plan.
7. Add:
   (a) "Reliability of" to titles for sections

   2.1.1
   2.1.2
   2.1.3
   2.1.4
   2.3.1
   2.3.2

   (b) "Reliability" to titles for sections 2.2 and 2.3

Introduction

The Code of Federal Regulations in the proposed part (10 CFR 60) requires that the applicant for a license to operate a High Level Waste Repository demonstrate that his design of the repository including the design of the packaging of the waste, as well as the proposed operating procedures, are such that there is reasonable assurance that the repository so designed can be operated without significant incremental risk to the public resulting from releases of radioactivity to the accessible environment, and includes the criteria of 1000 year containment and an annual release rate not to exceed 10^{-5} of the inventory.

This Draft Staff Technical Position aims to clarify the information and analyses that would be expected of the applicant to substantiate the safety of the design and that will be part of the basis for the eventual finding by the NRC that the repository can be operated without undue risk to the public.

Due to the preliminary state-of-the-art of prediction of risk for a repository system to operate within the frame of existing regulations, generally accepted methods have not been developed and tested to the extent that a body of precedent exists for use as example and as reference. Furthermore, the confidence with which the prediction of risk from a repository can be made may not be as high as ~~it~~ would be desirable. However, the methods and overall approach of Probabilistic Risk Analysis (PRA) are useful as a vehicle to identify, organize and convey the information required to satisfy the criterion of reasonable assurance.

The concept of reliability of the repository to comply with the regulatory requirements serves the purposes of providing a unified approach to the evaluation of assurance, of providing a logical framework for systematic analysis of the design, and of supplying rules and criteria to test the relevancy

define this term (glossary)

and relative importance of the various phenomena, components and procedures which individually and in combination determine the capability of a proposed repository system to perform its fundamental function of isolation of the radioactivity from the accessible environment.

In broad terms, the proposed approach for demonstrating the reliability of the waste package can be described as consisting of the following several steps:

1. Identifying the types of known failures that, on the basis of engineering judgement, are ~~physically~~ possible for the waste package in the environment. This is done on the basis of an exhaustive review of the relevant literature and exploratory experimentation under the guidance of general principles and existing knowledge of failure types in other systems which have points of similarity with the system under consideration. The process of identification is complete when an independent review fails to reveal new ~~physicurity~~ possible failure types.

2. Evaluation and preliminary dismissal of those processes which are physically possible under some conditions but physically impossible under the repository conditions. For example, a type of corrosion of metallic components may be possible in a salt environment but ~~may be judged to be~~ not possible in ~~the environment of~~ a ~~cavity in~~ basalt environment. This process is complete when all failure types previously identified are either dismissed or explicitly retained for further analysis. The reasons for dismissal in each case are documented with defensible arguments, and in sufficient detail so as to facilitate subsequent reviews and possible reevaluations.

3. For each of the failure types retained for further analysis, a model is constructed. The model describes the immediate results of the failure, ~~and~~ the conditions which may lead to the failure, predicts when the failure may occur and ~~how~~.

The model required is not necessarily a scientific model which could predict from first principles a phenomenon such as corrosion of a metal, which is practically impossible. The model is simply a clear prescription to predict behavior. One example may be: a relief valve

A model which does not have some scientific basis will not have credibility in the scientific community.

contradiction in terms!

fails to reseat once every 10 operations, at random. Other examples may be: a given metallic component in a given environment will stand without failure by corrosion for a period which is normally distributed with a mean of X years and a variance of Y years.

The nature of the failures, the state of knowledge, and the role of the individual failure in the overall failure of the repository dictates the level of detail required and the uncertainty which is tolerable.

of model construction

The justification will necessitate use of scientific principles; thus this statement conflicts with statement at bottom of pp 2.

This process is complete when for each of the failure modes there is a model and the justification of the model is documented, not only as to values but as to statistical uncertainty and distribution forms.

See A

this will require models based on scientific principles

4. The parameters describing the environmental conditions of the repository, which are relevant to the selected models, need to be defined and their values, probability distribution forms, and statistical ~~parameters~~ properties measured or calculated.

of defining the parameters

models will be needed for this

This process is complete when all the links between observable and measurable parameters of the repository system are identified, their values and uncertainties ~~are~~ obtained, their probability distributions ascertained and justified, and the parameters and models are rendered consistent in the sense that all parameters required in the models of part three are covered in part four.

5. Once the set of parameters and models is available, they are combined in a scheme that serves to explore all interactions and predict failure probabilities.

Several schemes are possible. If the failures tend to be mainly due to a combination of unfavorable circumstances ~~but rather deterministic~~ that may occur in nature, then a scheme to predict failures and probabilities, such as a Monte-Carlo propagation of probabilities through the use of a phenomenological model, would be desirable, and could be practical and acceptable. On the other hand, if the failures are of a purely stochastic nature, as they tend to be in well de-

See B

clarify for readers who are not modellers.

signed complex engineering systems, a fault tree or event tree scheme may be more appropriate.

Since the design of high level waste repositories is at this time in a fluid state, the overall scheme can not be identified at this time. However, ~~it appears as if a Monte Carlo error propagation approach~~ a model that assigns random probabilities to naturally occurring, unfavorable events would be practical to use with some of the repository concepts now under consideration.

The ~~above~~ 5-step scheme described above is a linear or sequential scheme, ~~with well~~ defined steps to be completed before going to the next step. This is not the sequence in which the information will be developed. The repository designer would work along a parallel scheme, since his choices are multiple and quite interdependent. The scheme presented in this DSTP is the sequence of elements that would be assembled for review and evaluation, and is not the sequence of actions expected of the high level repository designer to develop the information required to justify the design.

The demonstrated level of reliability of the waste package that will be considered as satisfactory, for the criterion of reasonable assurance, is not defined at this time, ~~other than by~~ the fundamental consideration that the risk associated with the operation of the repository should be comparable to presently accepted risks to the public associated with operation of comparable components of the nuclear fuel cycle. Since the waste package is part of a redundant system, the other part being the geological formation, it is expected that the reliability values expected of the waste package, in respect to the criteria of containment and release, would not be at a level comparable to reliability expected of complete systems such as nuclear power reactors in respect to core melt-down. Similarly, the consequences of a failure to meet the requirements of containment and maximum release appear to present a limited threat to the public, since failure of a waste form (such as borosilicate glass) to limit the release to 10^{-5} does not appear to involve a discontinuity of release, which suggests a continuum of consequences rather than a jump.

Therefore, the expected level of reliability of a waste package will be comparable to that of one of the reactor safety systems.

should serve as a preliminary guide

underground facility as the

only

the

should be clarified

There may be a contradiction between these two statements.

for predicting the reliability of the waste package

2. Regulatory Position

Std Format is not developed yet.

2.1 Information Required For Evaluation Of Reliability

(10 CFR 60.21)

Purpose and Applicability

The applicant will submit to NRC a Safety Analysis Report (SAR) in accord with the requirements of the Code of Federal Regulations. This report will conform to the guidelines of the Standard Format.

All beyond here and up to Section 2.1.1 should be deleted

This Standard Format will be used to establish a uniformity in ~~safety analysis reports~~ SAR's submitted as part of the applications for construction and operating licenses for a ~~High Level Waste~~ HLW Repository and to indicate the information to be subsequently outlined in the reports.

The principal purpose for the preparation and submittal of an SAR is to inform the NRC of the characteristics of the repository and its anticipated performance under both pre-closure and post-closure conditions.

The information provided in the SAR must be sufficient to enable the NRC to determine whether a repository can be designed and constructed such that its performance will result in no undue risk to the health and safety of the public as specified by 10 CFR 60.

Prior to submitting the SAR, the applicant should have conducted an evaluation of the repository and its proposed site in sufficient detail to substantiate its integrity.

our Design Section has restricted this statement.

The Standard Format identifies the principal detailed information that is required by the NRC staff in its evaluation of the application. This format will help assure the completeness of the information provided, will assist the regulatory staff and others in locating the information, and will aid in shortening the time needed for the review process. The Standard Format applies to both a Preliminary Safety Analysis Report (PSAR) and a Final Safety

The material on pages 5-8 adds nothing to a document on reliability of the waste package; therefore, page 5-8 should be deleted.

So

The prediction of reliability of the waste package will be a part of the SAR

malysis Report (FSAR), but if a specific criterion applies only to the FSAR, it will be so indicated in the text with (FSAR) at the end of the text criterion as guidance of a specific statement. If a certain section is applicable only to or FSAR it may be indicated by including (FSAR) following the heading.

Although the specific information identified in the Standard Format will be in reference to a particular Nuclear Waste Repository waste package for a (e.g. corrosion resistant canister, overpack, backfill which constitutes a three barrier concept), the general format and content for the presentation of information should also be applicable to repositories of different types and configurations waste packages for.

The information indicated in the Standard Format is a minimum for an SAR. It is recognized that all the information that may be required to complete the staff review (or all the information that has been presented in previous SARs) is not identified explicitly, and the applicant should include additional information in the SAR, as appropriate. In this regard it is the applicant's responsibility to be aware of current areas of concern to the regulatory staff and subjects where insufficient information is being provided, as indicated by questions associated with other applications, and to address these in the SAR.

Upon receipt of an application, the regulatory staff will perform a preliminary review to determine if the SAR provides a reasonably complete presentation of the information that is needed to form a basis for the finding required before issuance of a permit or license. The Standard Format will be used by the staff as a guideline to identify the type of information needed, unless there ~~is good~~ are compelling reasons for not doing so. If it does not provide a reasonably complete presentation of the necessary information, further review of the application will not be initiated until a reasonably complete presentation is provided. The information provided in the SAR should be up-to-date with respect to the state of technology for nuclear waste repositories and should take into account recent changes in NRC regulations and guides and in industry codes and standards, the results of recent developments in repository containment, and experience in the construction and performance of repositories.

The design information provided in the SAR should reflect the most advanced state of design at the time of submission. If certain information identified in the Standard Format is not yet available at the time of submission of a PSAR because the design has not progressed sufficiently at the time of writing, the following should be included in the PSAR: the criteria and bases being used to develop the required information, the concepts and/or alternatives under consideration, and the schedule for completion of the design, and submission of the missing information. In general, the PSAR should describe the preliminary design of the repository in sufficient detail to enable a definitive evaluation by the regulatory staff as to whether the repository can be constructed and exist without undue risk to the health and safety of the public. Similarly, the FSAR should describe in detail the final design of the repository as constructed.

Changes from the criteria, designs and bases included in the PSAR, as well as any new criteria, designs and bases, should be identified in the FSAR. The reasons for and safety significance of each change should be discussed.

It is recognized that in many cases the applicant may wish to include appendices in the SAR to provide supplemental information not explicitly identified in the Standard Format. Some examples of such information are:

(1) summaries of the manner in which the applicant has treated matters addressed in NRC Guidelines or proposed regulations, and
(2) supplementary information regarding calculational methods or design approaches used by the applicant or its agents.

The applicant should strive for clear, concise presentations of the information provided in the SAR. Confusing or ambiguous statements and unnecessarily lengthy descriptions do not contribute to expeditious technical reviews. Claims of adequacy of designs or design methods should be supported by technical bases.

It is not the intent of the Standard Format to require duplication of information. Similar or identical information may be requested in various sections because it is relevant to more than one portion of the repository, however, this information, if appropriately referenced and identified in the applicable places of the SAR need not be repeated. For example, where diagrams for the same plan are requested in more than one section in the Standard Format, duplicate diagrams need not be submitted provided that all the information requested in all subsections is submitted and appropriately identified and referenced.

Where numerical values are stated, the number of significant figures given should reflect the accuracy or precision to which the number is known. Where possible, estimated limits of error or uncertainty should be given.

Abbreviations should be consistent throughout the SAR, and should be consistent with generally accepted usage. Any abbreviations, symbols or special terms not in general usage or unique to the proposed repository should be defined in each section of the SAR where they are used.

How about a glossary or dictionary

Drawings, maps, diagrams, sketches, and charts should be employed where the information can be presented more adequately or conveniently by such means. Due ~~concern~~ care should be taken to assure that all information presented in drawings is legible, symbols are defined, and drawings are not reduced to the extent that visual aids are necessary to interpret pertinent items of information presented ~~in the drawings~~.

Reports or other documents that are referenced in the text of the SAR should be listed at the end of the section in which they are referenced. In cases where proprietary documents are referenced, a non-proprietary summary description of the document should also be referenced.

The SAR should follow the numbering system of the Standard Format at least down to the level of subsections. For example, subsection 2.1.3 of the SAR should provide all the information requested within subsection 2.1.3 of the Standard Format.

This is a discussion of format and does not belong here. It should be deleted.

2.1.1 Package Design

and provides further containment of the waste.

According to 10 CFR 60, the waste package includes,

(1) The waste form which consists of the radioactive waste materials and any associated encapsulating or stabilizing materials.

(2) The container which is the first major sealed enclosure that ~~holds~~ contains the waste form.

(3) Overpacks which consist of any ~~buffer material~~, additional vessel receptacle, wrapper, box or other structure, that ~~is~~ are both within and an integral part of a waste package. ~~The overpack encloses and protects the waste form so as to meet the performance objectives.~~

(4) The packing material fills the annular space between the waste package and the host rock. The packing material controls the flow of ground water to the waste package.

This constitutes ~~three~~ four major barriers.

Several alternatives now exist concerning the nature of these barriers, therefore the following necessary criteria for ~~risk~~ reliability predictions will be general in nature. (A specific package ~~will be~~ is used in the sample problem in Appendix A).

In the SAR the applicant will submit drawings and schematics along with the dimensions of each barrier and the material specifications.

define, i.e., of what?

Of considerable importance are the overall dimensions of the repository, however the dimensions and configurations of each separate barrier should also be shown preferably about the axis of symmetry.

abrupt reference to predictive models

A close-up view of the model along with the zoning used in the vicinity of the repository should also be submitted.

It is recognized that a conceptual design of the repository will require certain guiding features which can be either simple or complex.

controls the chemistry of ground water that reaches the waste package and retards the transport of radionuclides from the waste package after containment is breached

It is not clear whether this pertains to a simulation using numerical analysis.