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FROM: Michael J. Bell, Chief
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SUBJECT: REVIEW OF "TOTAL-SYSTEM PERFORMANCE ASSESSMENT FOR YUCCA MOUNTAIN - SNL SECOND INTERATION (TSPA-1993), SAND 93-2675, APRIL 1994"

Enclosed is the ENGB staff review of the subject DOE report [Total-System Performance Assessment for Yucca Mountain - SNL Second Iteration (TSPA-1993)]. It includes four comments and one question. The format used for the enclosure is consistant with Revision 2 of the "Review Plan for the NRC Staff Review of DOE Study Plan" dated March 4, 1993.

/S/

Michael J. Bell, Chief
Engineering and Geosciences Branch
Division of Waste Management, NMSS

Enclosure: As stated

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SECTION 13.2.4.1 Container corrosion
SECTION 19.2 Waste-package data and near-field processes
SECTION 20.3 Source Term

COMMENT 1

Section 13.2.4.1 states that estimates of long-term localized pitting corrosion rates for Alloy 825 were obtained by eliciting the values from experts to fit the Poisson model of pitting corrosion. To account for the uncertainty that the realistic environments of the repository are unknown at this time, three sets of pitting-rate distributions have been elicited. It is also assumed equally likely that the true mean rate of pit growth could be greater than or less than the true mean rate used. This approach reflects little mechanistic understanding of the pitting process and therefore may not be adequate to address the uncertainty of how good the estimates will be for long-term pit projections.

BASIS

Aqueous environments vary in the repository. For instance, groundwater chemistry may vary over time [1]. However, localized corrosion of container is not expected to occur in all aqueous repository environments. One of the criteria for the choice of waste package container material is resistance to corrosion. It is therefore uncessarily conservative to consider corrosion if environmental conditions do not lead to corrosion.

RECOMMENDATION

Consistent with the suggestion stated in Section 19.2 and Section 20.3, future localized corrosion models should include mechanistic understanding of the process. For instance, pitting corrosion model should account for conditions for initiation of pits and environmental conditions and chemistry which would perpetuate or halt the process of pitting (e.g. pitting potential).

REFERENCE

[1] Walton J. C., Effects of Evaporation and Solute Concentration on Presence and Composition of Water in and around the Waste Package at Yucca Mountain, Waste Management, Vol. 13, 193 (1993).

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SECTION 13.2.4 Container failure
SECTION 20.3 Source term

COMMENT 2

These sections state that detailed corrosion modes of containers will be treated in future versions of the study. Extensive knowledge bases in corrosion failure are available in literature. Corrosion modes that may accelerate container failure should be addressed.

BASIS

Localized corrosion and environment-assisted cracking are generally known to accelerate container failure. Pitting corrosion was the only localized corrosion treated in the study. We can consider crevice corrosion with backfill materials or environment-assisted cracking with internal or external stress. Additionally, dry oxidation may not be uniform. For instance, dry oxidation data in the 100° to 250° C ranges are almost nonexistent. To obtain a penetration equation for dry oxidation for this temperature range, data at elevated temperatures, 454° to 538° C, are often extrapolated. In an extended period, preferential oxidation of grain boundaries may occur at repository temperatures [1]. In aqueous environments, localized corrosion modes should be assessed in realistic groundwater chemistry including nitrate and sulfate ions. Groundwater may also be altered by evaporation [2].

RECOMMENDATION

In future performance studies, include all localized failure modes of containers.

REFERENCES

[1] Rothman M.F., <u>Oxidation Resistance of Gas Turbine Combustion Materials</u>, Gas Turbine Conference and Exhibit, Houston, Texas, March 18-21, 1986.

[2] J. C. Walton, Effects of Evaporation and Solute Concentration on Presence and Composition of Water in and around the Waste Package at Yucca Mountain, Waste Management, Vol.13, 193 (1993).

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SECTION 14.6.2 Gaseous release

COMMENT 3

The calculated C-14 releases (Figure 14-30) do not comply with old EPA criteria. Therefore, alternate and more sophisticated models are needed for the C-14 source term.

BASIS

The study assumes that C-14 is released at oxidation rates of spent fuel (SF) matrices. The implicit premises for this assumption are:

(a) oxygen diffusion responsible for SF oxidation can be regarded as C-14 diffusion because of their similar atomic sizes; or
(b) C-14 diffuses out from SF matrices as soon as SF matrices are oxidized.

Neither of these premises is realistic. For instance, if carbides are present or molecular C-14 such as $^{14}CO_2$ forms during SF oxidation, C-14 releases can decrease significantly. The premises are also for dry oxidation conditions. Under aqueous conditions, C-14 is likely to be released as SF matrices dissolve. In this case, the release rate of C-14 can also be retarded, as for example, by the formation of calcium-bearing phases.

RECOMMENDATION

Incorporate realistic models for the C-14 source term. For instance, the models should account for the role of C-14 compounds such as carbides, oxidized gases or calcite.

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SECTION 14.6.1 Aqueous release
SECTION 20.4 Aqueous flow and transport

COMMENT 4

Aqueous radionuclide releases (Figures 14.25, 14.28) are below the old EPA limits in this code. There are possibilities that realistic models for the source term may alter the results.

BASIS

As radionuclides form complexes or colloids, retardation in radionuclide migration may not become significant. For instance, negatively charged ions will not be sorbed easily on negatively charged host rocks. Additionally, colloids can carry large amounts of radioactivity [1]. Therefore, it is important to incorporate speciation and colloid formation in the future. The study states that future work will include the effects of colloids. In this future work, speciation, and sorption of colloids and species should be treated additionally. These properties should be also from realistic groundwater chemistry including nitrate or sulfate. The groundwater may also be altered by evaporation [2] or radiolysis [1].

RECOMMENDATION

Future revision of the code should incorporate species, colloids, and effects of variability in groundwater chemistry.

REFERENCES

[1] P. A. Finn, J. K. Bates, J. C. Hoh, J. W. Emery, L. D. Hafenrichter, E. C. Buck, and M. Gong, Elements Present in Leach Solutions from Unsaturated Spent Fuel Tests, Mat. Res. Soc. Symp. Proc., Vol.333, pp.399 (1994).

[2] J. C. Walton, Effects of Evaporation and Solute Concentration on Presence and Composition of Water in and around the Waste Package at Yucca Mountain, Waste Management, Vol.13, 193 (1993).

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SECTION 1.3.2 Addressing issues related to design
SECTION 19.3 Repository and waste-package design

QUESTION 1

What evaluation strategies are being considered in the study to ensure long-term criticality safety of the repository ?

BASIS

Criticality safety is required of all systems and operations of the repository (10 CFR 60.131(b)(7)). There is no discussion in the TSPA on how the study will address the performance aspect of this requirement.

RECOMMENDATION

In future performance studies, address how long-term criticality is precluded or how its occurrence is not important to safety for postclosure period.