REVIEW BY THE U.S. NUCLEAR REGULATORY COMMISSION OFFICE OF NUCLEAR MATERIAL SAFETY AND SAFEGUARDS OF THE U.S. DEPARTMENT OF ENERGY AGREEMENT RESPONSES RELATED TO THE POTENTIAL GEOLOGIC REPOSITORY AT YUCCA MOUNTAIN, NEVADA: KEY TECHNICAL ISSUE AGREEMENT FOR EVOLUTION OF THE NEAR-FIELD ENVIRONMENT (ENFE.2.07)

1.0 INTRODUCTION

The U.S. Nuclear Regulatory Commission (NRC) issue resolution goal during this interim prelicensing period is to ensure the U.S. Department of Energy (DOE) has assembled sufficient information about a given issue for NRC to accept a potential license application for review. Resolution by NRC during prelicensing does not prevent anyone from raising any issue for the NRC staff consideration during the licensing proceedings. Further, resolution of an issue by NRC during the prelicensing period does not prejudge the NRC staff evaluation of the issue during the licensing review. Issues are resolved by NRC during prelicensing when the staff has no further questions or comments about how DOE is addressing an issue. Pertinent new information could raise new questions or comments about a previously resolved issue.

By letter dated August 12, 2004, DOE submitted a letter with an enclosure, Role of Chemical Processes, Their Coupling Effects, and Bounding Conditions for In-Drift Water Compositions Affecting Drip Shield and Waste Package Corrosion (Response to Evolution of the Near-Field Environment (ENFE).2.07, Additional Information Needed), which provided information to support closure of the subject agreement. The information was requested by NRC during a previous technical exchange in January 2001 (Reamer, 2001) and in a letter requesting additional information (Schlueter, 2003). In its transmittal letter, DOE recommended agreement ENFE.2.07 be closed because the information NRC requested had been provided.

2.0 WORDING OF THE AGREEMENT

The agreement reads (Reamer, 2001):

“Identify specific coupling relationships that are included and excluded from TSPA, including Onsager couples, and give technical bases for their inclusion or exclusion. The DOE will identify specific coupling relationships that are included and excluded from TSPA, including Onsager couples, and give the technical basis for inclusion and exclusion. This information will be documented in a revision to the Engineered Barrier System Degradation, Flow, and Transport PMR (TDR–EBS–MD–000006), expected to be available by September 2001.”

The request for additional information reads (Schlueter, 2003):

“The NRC’s intent in this agreement was to obtain reasonable assurance that no near-field processes or chemistries omitted from testing or modeling could lead to significantly shorter waste canister lifetimes. DOE’s response to ENFE Agreement 2.07 lacks an analysis of the role of chemical reactions in drip shield and waste package corrosion. While it is appropriate for DOE to consider changes in chemical environment due to chemical transport, a variety of solid phase-gas-water interactions might occur in concert with changing thermal hydrological conditions and alter the waste package chemical environment. NRC expects DOE to provide technical bases for electrochemical and microbial processes, rates of reactions, mass balance,

probability considerations, and temporal and spatial distributions of processes and conditions on scales important to performance. In addition, in addressing chemical couples that were included or excluded from the determination of important near-field chemical environments, DOE should discuss the effects of coupled near-field processes and conditions on waste package and drip shield corrosion.

Additionally, NRC notes that a May 13, 2003, presentation to the Nuclear Waste Technical Review Board by Mark Peters of Los Alamos National Laboratory described the character of the in-drift environment. Among other topics, the presentation covered the three abstracted temperature regions of the drift environment, the chemical evolution of the drift environment, the chemical divide theory, observed water chemistries, in-drift water chemistry modeling and validation, and the investigation of deliquescence during dryout temperature. This presentation provided clarification of the DOE method of characterizing the near-field environment. The environment is modeled using TOUGHREACT and EQ3/6. The modeling produced a range of bounding in-drift water compositions, which DOE consolidated into 11 bins. DOE should consider addressing ENFE.2.07 in the context of providing the technical basis for the consolidation or establishment of the 11 bins. This approach would need to address the couples considered, the range of chemistries considered, the rationale for including or excluding couples and chemistries, and the limitations of any codes used to develop the bins."

3.0 TECHNICAL INFORMATION PROVIDED IN DOE'S AGREEMENT RESPONSE

DOE's response provided in the enclosure to its August 12, 2004, letter focused on the couplings that could affect the physical and chemical environments of the waste package and drip shield. DOE described its technical bases for the establishment of the potential aqueous chemistry environments mentioned in the Nuclear Waste Technical Review Board presentation. DOE provided an overview of its approach to defining the temporal evolution of the thermal-hydrological environment in the drift and surrounding rock mass, the in-drift chemical environment during the period when the drift wall temperature is above the boiling point of water and seepage into the drifts is precluded, and the in-drift chemical environment during the period when the drift wall temperature is below the boiling point of water and seepage into the drifts is possible. The overview included a discussion of the approach used to establish the 11 bins of seepage water chemistry. DOE described how the thermal-hydrological modeling, the thermal-hydrological-chemical seepage modeling, and the in-drift chemistry modeling were integrated in total system performance assessment. This integration allowed various processes—evaporation, condensation, salt deliquescence, liquid and vapor mass transport, mineral precipitation and dissolution, chemical divides, porosity changes, and other processes—to be coupled. In addition, DOE provided its technical bases for excluding potential effects on the waste package chemical environment of processes such as gamma radiolysis, microbial interaction, electric fields caused by Compton electron scattering, physical separation of salts, and electrochemical processes on the metal substrate.

4.0 NRC EVALUATION AND COMMENT

Relevance to Repository Performance

The degradation of the drip shields and waste packages depends on the in-drift physical and chemical environments. The chemistry of water seeping into the drift and contacting the drip shield and waste package is considered to have high significance to waste isolation (NRC, 2004). Various coupled thermal-hydrological-chemical processes can affect the in-drift physical and chemical environments and the potential for corrosion of the engineered materials. Coupled processes that potentially could affect the in-drift environment should be considered in total system performance assessment such that the performance of the engineered barriers is not overestimated.

Result of the NRC Review

Agreement ENFE.2.07 was developed to provide a preliminary indication that DOE has considered important coupled processes when predicting the chemical and physical environments important to drip shield and waste package corrosion. The information provided by DOE in an enclosure to its August 12, 2004, letter focused on couplings that could affect the physical and chemical environments of the drip shield and waste package, as described in the NRC letter (Schlueter, 2003). DOE provided its technical basis for the 11 bins of seepage water chemistry and described the couples considered in total system performance assessment, the range of in-drift water chemistries, and the rationale for including or excluding couples and chemistries. A discussion of limitations and uncertainties of the codes used to develop the seepage water bins was provided in the reports referenced in the enclosure. For example, uncertainties and limitations of the in-drift precipitates and salts model are discussed in Bechtel SAIC Company, LLC (2003) and limitations of the EQ3/6 code, the software used to develop the model, are discussed in the EQ3/6 user's guide (Wolery, 1992a,b). The uncertainties and limitations of the thermal-hydrological-chemical model are discussed in Bechtel SAIC Company, LLC (2004). Based upon review of the information provided, NRC considers agreement ENFE.2.07 complete.

5.0 SUMMARY

NRC reviewed DOE's response to key technical issue agreement ENFE.2.07 provided in an enclosure to the August 12, 2004, DOE letter. On the basis of this review and notwithstanding new information that could raise new questions or comments concerning this agreement, NRC considers the DOE response satisfies the intent of agreement ENFE.2.07.

6.0 STATUS OF THE AGREEMENT

Based on the preceding review, the information DOE provided satisfies the intent of the agreement. Therefore, NRC considers agreement ENFE.2.07 complete and has no further questions at this time. Although the agreement is considered complete, NRC will make its final determination about any issues relevant to licensing during review of the potential license application.

7.0 REFERENCES

Bechtel SAIC Company, LLC. "Drift-Scale Coupled Processes (DST and THC Seepage) Models." Rev. 2, Errata 2. Las Vegas, Nevada: Bechtel SAIC Company, LLC. 2004.

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NRC. "Risk Insights Baseline Report." ML040560126. Washington, DC: NRC. April 2004. <www.nrc.gov/ waste/hlw-disposal/reg-initiatives/resolve-key-tech-issues.html>

Reamer, C.W. "U.S. Nuclear Regulatory Commission/U.S. Department of Energy Technical Exchange and Management Meeting on Evolution of the Near-Field Environment (January 9–12, 2001)." Letter (January 26) to S. Brocoum, DOE. Washington, DC: NRC. 2001. <www.nrc.gov/waste/hlw-disposal/public-involvement/mtg-archive.html#KTI>

Schlueter, J.R. "Pre-Licensing Evaluation of Evolution of the Near-Field Environment (ENFE) Key Technical Issue (KTI) Agreements 2.07 and 2.08." Letter (October 21) to J.D. Ziegler, DOE. Washington, DC: NRC. 2003. <www.nrc.gov/waste/hlw-disposal/public-involvement/ mtg-archive.html#KTI>

Wolery, T.J. "EQ3NR, A Computer Program for Geochemical Aqueous Speciation–Solubility Calculations: Theoretical Manual, User's Guide, and Related Documentation (Version 7.0)." UCRL–MA–110662 Part III. Livermore, California: Lawrence Livermore National Laboratory. 1992a.

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