THE U.S. NUCLEAR REGULATORY COMMISSION OFFICE OF NUCLEAR MATERIAL SAFETY AND SAFEGUARDS REVIEW OF THE U.S. DEPARTMENT OF ENERGY'S KEY TECHNICAL ISSUE AGREEMENT RESPONSES RELATED TO THE POTENTIAL GEOLOGIC REPOSITORY AT YUCCA MOUNTAIN, NEVADA: CONTAINER LIFE AND SOURCE TERM 2.01 AND 2.02

1.0 INTRODUCTION

By letters dated December 9, 2003, and July 2, 2004, the U.S. Department of Energy (DOE) submitted a report Technical Basis Document No. 6: Waste Package and Drip Shield Corrosion and Appendix K (Bechtel SAIC Company, LLC, 2003, 2004a). The data and analyses contained in the technical basis document were provided to satisfy the informational needs of numerous Key Technical Issue (KTI) agreement items pertaining to the environmental degradation of the waste package and drip shield materials and to respond to issues raised by the U.S. Nuclear Regulatory Commission (NRC) related to corrosion processes and the designs of the waste package and drip shield at the potential repository at Yucca Mountain, Nevada. In addition, by letter dated May 28, 2004, DOE submitted a report KTI Container Life and Source Term (CLST) 2.01 (Bechtel SAIC Company, LLC, 2004b), to address Agreement CLST.2.01. Appendix A of this report is titled, "Drip Shield Structural Response to Rockfall" (Bechtel SAIC Company, LLC, 2004c). Information included in these reports (Bechtel SAIC Company, LLC, 2003, 2004a,b,c) was requested by NRC during previous technical exchanges in September 2000, February 2001, July 2001, August 2001, and September 2001. Specific agreements addressed in this NRC review of the information provided by DOE in the technical basis document include CLST.2.01 and 2.02 (Schlueter, 2000).

2.0 AGREEMENTS

The wording of the agreements are as follows:

CLST.2.01

"Either provide documentation using solid element formulation, or provide justification for not using it, for the drip shield–rockfall analysis. DOE stated that shell elements include normal stresses and transverse stresses in the calculations and provide more accurate results for thin plates and use far fewer elements. Therefore, shell elements will be used instead of solid elements. This justification will be documented in the next revision of AMR ANL–XCS–ME–000001, Design Analysis for the Ex-Container Components, prior to LA."

CLST.2.02

"Provide the documentation for the point loading rockfall analysis. DOE stated that point loading rockfall calculations will be documented in the next revisions of AMRs ANL–XCS–ME–000001, Design Analysis for the Ex-Container Components, and ANL–UDC–MD–000001, Design Analysis for UCF Waste Packages, both to be completed prior to LA."

Enclosure

3.0 RELEVANCE TO OVERALL PERFORMANCE

CLST.2.01 and 2.02 Agreements are related to mechanical degradation of the waste package and the drip shield as a result of mechanical loading, including rockfall, seismic events, and drift degradation. The waste package, composed of the containers and the waste forms, is the primary engineered barrier controlling the release of radionuclides from spent nuclear fuel and high-level waste glass. Mechanical loading of the waste package may result in plastic deformation and the formation of residual stresses that can promote stress corrosion cracking or failure of the waste package. Fabrication processes, such as cold working, welding, and postweld heat treatments, may alter the mechanical properties (i.e., yield and tensile strengths and ductility) of the waste package materials.

Drip shield performance is an important factor regarding safety because the drip shields are incorporated into the design of the engineered barrier system to limit the amount of water contacting the waste package as a result of dripping and damage to the waste package from rockfall. The presence of drip shields will delay the contact of seepage water with the waste package surface, which could result in a longer container lifetime. In addition, once the containers are breached, the amount of water available for the dissolution of spent nuclear fuel and high-level waste glass and advective transport of the released radionuclides could be limited, even through the drip shield may be partially damaged.

NRC has performed a risk insights analysis that indicates mechanical disruption of the waste package has a medium significance to waste isolation (NRC, 2004). Mechanical failure of the waste package will allow water to contact the waste forms and the release of radionuclides. The transport of water and the release rate of the radionuclides may be restricted by size of the failure apertures. In addition, the number of waste packages affected also will limit the radionuclide release rate. The integrity of the drip shield also has a medium significance to waste isolation because, while intact, the drip shield will limit the quantity of water contacting the waste packages and waste forms and limit the formation of aggressive environments on the waste package surfaces.

4.0 RESULTS OF THE NRC REVIEW

CLST.2.01 and 2.02 Agreement are included in the integrated subissue for degradation of engineered barriers. These agreements resulted from a staff review of DOE documentation that is consistent with Review Method 2 in Section 2.2.1.3.2.2 of NRC (2003). The NRC review of the response for these agreements also was conducted in accordance with the aforementioned review method. This review method includes an evaluation of the sufficiency of the experimental data to support parameters used in conceptual models and process-level models. Results of the NRC review of DOE’s response to CLST.2.01 and 2.02 are provided in Sections 4.1 and 4.2.

4.1 CLST.2.01

The focus of CLST.2.01 was to ensure the model used to assess the effects of rockfall on the drip shield considers the range of possible material responses and interactions. DOE’s response (Bechtel SAIC Company, LLC, 2004a,b) indicates that the current finite-element representations used for the analysis of rockfalls on the drip shields are entirely composed of solid elements. In addition, DOE indicated any future evaluation that may use shell elements will be adequately justified for the appropriate use of such elements. These analyses provide the residual stress values that are used in the assessment of postclosure stress corrosion susceptibility of the drip shield.

Based on the NRC review of DOE's response to Agreement CLST.2.01 in accordance with methods discussed in the appropriate section of NRC (2003, Section 2.2.1.3.2.2, Review Method 2), NRC found DOE's response to the agreement to be satisfactory.

4.2 CLST.2.02

Agreement CLST.2.02 is focused on the analysis of rockfall on the waste package during the preclosure period and on the drip shield during the postclosure period. DOE indicated the waste package is not breached by bounding preclosure point-loading rockfalls. In addition, such rockfalls occurring during the postclosure period do not result in immediate breach of the drip shield. These rockfall events can deform the drip shield and result in the formation of regions with high residual stress susceptible to stress corrosion cracking. DOE indicated that advection through the crack network is predicted to be negligible as a consequence of the small crack apertures near crack tips, the high tortuosity and roughness of the cracks, the infilling of cracks with corrosion products, and the potential for crack plugging from evaporation-induced precipitation during a time period of a few hundred years.

Rockfall point-loading on the drip shield is only relevant within the middle nonlithophysal rock unit. Only 15 percent of the repository footprint is expected to be within this particular rock unit. Moreover, rock blocks within this rock type that are large enough to cause appreciable damage to the engineered barriers system are relatively few in number. Therefore, this potential form of mechanical disruption will have a negligible effect on postclosure performance.

Based on the NRC review of DOE's response to Agreement CLST.2.02 in accordance with methods discussed in the appropriate section of NRC (2003, Section 2.2.1.3.2.2, Review Method 2), NRC found DOE's response to the agreements to be satisfactory.

5.0 SUMMARY

NRC reviewed DOE's KTI agreement responses within the report to determine whether any important aspect of Agreements CLST.2.01 and 2.02 were excluded from the response. Notwithstanding new information that could raise new questions or comments concerning these agreements, the information provided satisfies the intent of the agreements. On the basis of this review, NRC agrees with DOE that the information assembled in response to Agreements CLST.2.01 and 2.02 satisfies the intent of these agreements.

6.0 STATUS OF THE AGREEMENTS

Based on the preceding review, NRC agrees with DOE that the information provided with respect to Agreements CLST.2.01 and 2.02 satisfies the intent of the agreements. Therefore, NRC considers Agreements CLST.2.01 and 2.02 to be closed.

7.0 REFERENCES

Bechtel SAIC Company, LLC. "Transmittal of Appendix K, Technical Basis Document No. 6: Waste Package and Drip Shield Corrosion." Rev. 1, Addressing Key Technical Issue (KTI) Agreements Related to CLST.2.02, 2.08, and 2.09. Las Vegas, Nevada: Bechtel SAIC Company, LLC. 2004a.

———. "Transmittal of Information on CLST Key Technical Issue (KTI) Agreement CLST.2.01." Las Vegas, Nevada: Bechtel SAIC Company, LLC. 2004b.

———. "Drip Shield Structural Response to Rockfall." 000–00C–SSE0–00300–000–00A. Las Vegas, Nevada: Bechtel SAIC Company, LLC. 2004c.

———. "Technical Basis Document No. 6: Waste Package and Drip Shield Corrosion." Rev. 1. Las Vegas, Nevada: Bechtel SAIC Company, LLC. 2003.

NRC. "Risk Insights Baseline Report." ML040560162. Washington, DC: NRC. April 2004.

———. NUREG–1804, "Yucca Mountain Review Plan—Final Report." Rev. 2. Washington, DC: NRC. July 2003.

Schlueter, J. "U.S. Nuclear Regulatory Commission/U.S. Department of Energy Technical Exchange and Management Meeting on CLST (September 12–13, 2000)." Letter (October 4) to S. Brocoum, DOE. Washington, DC: NRC. 2000.